BOREAS
Experiment Plan

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BOREAS EXPERIMENT PLAN

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Appendix B: BOREAS Emergency Procedures and Guidelines for SSA and NSA

BOREAS EMERGENCY PROCEDURES - Northern Study Area (NSA)

The areas covered in this guide are:

1. **MEDEVAC**; instructions on procedures for contacting emergency services and guiding them to the site.
2. **RADIO-PHONE LINK**; how to connect to the telephone system using your hand-held radio.
3. **OTHER NUMBERS**; Towing, hospitals, etc.

1.	MEDEVAC

A COPY OF THIS PACKAGE IS WITH THOMPSON EMERGENCY SERVICES

Call BOREAS Operations and give location and other details. If you cannot contact BOREAS Operations, use your radio to make an emergency phone call, (see section 2).

Most of the BOREAS NSA sites are off Route 391. Three sites are close to Route 391 for helicopter or road ambulance pickup; one is some distance from the road (old black spruce) and has direct helicopter access. Details of road and trail access are provided below.

Milepost distances are provided for road access to the Tower Flux sites in the table below. **Site entrances are marked by 4"x4" posts about 7' tall and are clearly visible from Rt. 391**. The marker posts are bright green, with orange stripes at the top, and an identifying number. The number reflects mile posts distance, in kilometers from Thompson.

VOR/DME (aviation navigational aid) numbers are provided for helicopter access. Note that the "road access" VOR/DME co-ordinates correspond to the milepost locations.

SITE NAME	SITE POSITION VOR-DME	ROAD ACCESS VOR-DME	MARKER POSTS (km)	
Young Jack Pine-YJP	280-16.5	**281-16.3**	38.9	1
Fen-Fen	280-21.1	**281-21.2**	47.6	2
Old Black Spruce-OBS	**270-22.6**	276-23.4	52.9	3
Old Jack Pine-OJP	278-28.6	**278-27.6**	61.6	4

MISSION MANAGER RESPONSE TO A BOREAS CALL FOR MEDEVAC

(1) Determine whether the medevac can be done by road ambulance or Helicopter.

(2) If road ambulance, call Thompson emergency services at 677-7911 and direct dispatcher to the site. The service has a copy of a map of the NSA and instructions on how to get to the Tower Flux (TF) sites.

(3) If a helicopter is required, call the Thompson emergency services number anyway so they can ready a trauma team if necessary. Ask them where and when the helicopter should pick up the trauma team. Tell them that you will then try to get a helicopter from Canadian Helicopters or Custom Helicopters. Then call:

Canadian Helicopters:	778-5049, 778-5962 office hours
	778,8991, 778-7196 otherwise
Custom Helicopters:	677-3720, 677-9525 office hours
	677-3566, 778-7745, 677-9731 otherwise

Tell them:

(a) Where the patient is to be picked up, give site name and VOR/DME co-ordinates. The best helo pick-up points are the road access for YJP, FEN and OJP. The on-site pad is best for OBS. The VOR/DME coordinates for these best pickup points are marked in bold above.
(b) Where to pick up the trauma team if they are available.
(c) Where to pick up a BOREAS guide if necessary (i.e. at BOREAS-Study Area Headquarters (SAHQ) in Keewatin Air).

Payment details are to be worked out after the medevac. No committments can be made by the Mission Manager (MM) or Study Area Manager (SAM) for a given individual. It all depends on insurance, nationality, etc. Don't worry, they will get paid.

2. RADIO-PHONE LINK

You can use your radio to make an emergency call:

- Select Channel 3
- Hold key down, transmit for 5 seconds.
- Manitoba Tel Operator will come on line. If operator does not come on line, then remove the antenna from your radio and hook into the tree antenna that is located on all Northern Flux Tower sites. If you are not at a flux site, then walk to an area of higher elevation, or climb a tree, tower, hut, or vehicle and retransmit. Operator will ask for registry and code number.
- Respond: Prince Albert Registry, code number JW2 9062.
- Give operator the number you want to call (Thompson Emergency Services is 677-7911)

3. OTHER NUMBERS

Hospital	677-2381
Towing	778-8290
Weather Office	677-4969

BOREAS EMERGENCY PROCEDURES - Southern Study Area (SSA)
The areas covered in this guide are:

1. **MEDEVAC**; instructions on procedures for contacting emergency services and guiding them to the site.
2. **RADIO-PHONE LINK**; how to connect to the telephone system using your hand-held radio.
3. Emergency radio monitoring.
4. **OTHER NUMBERS**; Towing, hospitals, etc.

1. MEDEVAC

A COPY OF THIS PACKAGE IS WITH PRINCE ALBERT EMERGENCY SERVICES

Call BOREAS Study Area Headquarters (SAHQ) and give location and other details. If you cannot contact BOREAS SAHQ, use your radio to make an emergency phone call, (see section 2 on next page).

There are five principal BOREAS sites to the north of Prince Albert, each of which has a tower structure, instrument huts and trail access from the nearest road. One site (Old Aspen - OA) is in the Southern end of Prince Albert National Park and the other four (Old Jack Pine - OJP; Young Jack Pine - YJP; Fen - Fen; Old Black Spruce - OBS) are located in the Candle Lake area. All of the sites have helicopter access and the Candle Lake sites are all located close to roads. Details of road and trail access are provided in the attachment.

Site entrances from the roads are marked by 4"x4" posts about 7' tall and are clearly visible from the road. The posts are bright green, with orange stripes at the top and an identifying number.

VOR/DME (aviation navigational aid) numbers are provided for helicopter access. Note that the "road access" VOR/DME co-ordinates correspond to the road trail junctions referred to in the package.

SITE NAME	SITE POSITION VOR-DME	ROAD ACCESS VOR-DME
Old Aspen - OA	308-31	303-29
Fen - Fen	032-52	033-52
Young Jack Pine - YJP	031-54	031-55
Old Jack Pine - OJP	028-55	029-56
Old Black Spruce - OBS	011-50	010-51

MISSION MANAGER RESPONSE TO A BOREAS CALL FOR MEDEVAC

(1) Determine whether the medevac can be done by road ambulance or Helo. (The OA site has a very long access trail so ambulance access may be impractical. There is a clearing just to the east of the OA - tower for Helo access. The Candle Lake sites are more easy to access by road but are roughly one hours drive from Prince Albert).

(2) If road ambulance, call Prince Albert emergency services, 764-6455 and direct dispatcher to the site. The service has a copy of a map of the SSA and instructions on how to get to the TF sites.

(3) If Helo is required, call the Prince Albert Emergency number (764-6455) anyway so they can ready a trauma team if necessary. Ask them where and when the Helo should pick up the trauma team. Tell them that you will then try to get a helicopter from Athabaska Airways. Then call Athabaska Airways, 764-1404. If there is no immediate answer wait for the taped message which will give the emergency (overnight) number.

Tell them:

(a) Where the patient is to be picked up, give site name and VOR/DME co-ordinates. The best helo pick-up points are the road access for YJP, FEN and OBS and in clearings to the east of OJP and OA.
(b) Where to pick up the trauma team if they are available.
(c) Where to pick up a BOREAS guide if necessary (at SAHQ in Candle Lake.

Payment details are to be worked out after the medevac. No committments can be made by the Mission Manager (MM) or Study Area Manager (SAM) for a given individual. It all depends on insurance, nationality, etc. Don't worry, they will get paid.

2. RADIO-PHONE LINK

You can use your radio to make an emergency call: NOTE: Coverage is limited; see diagram:

- Select Sasktel channel
  3 if in the Prince Albert National Park (PANP)
- 11or 13 if in Candle Lake or White Gull Basin Area.
- Hold key down, transmit for 5 seconds.
- Operator will come on line and will ask for registry and code number.
- Respond: Prince Albert Registry, code JW2 9062.
- Give operator number (P.A. Emergency Services is 764-6455)

3.	EMERGENCY RADIO MONITORING

The radio is monitored 24 hours a day by the Radio Branch in Prince Albert and by the Fire Management Control Center during the daylighted hours. If you are out of telephone range or the BOREAS Operations is not responding, you may call out for emergency help until one of the above agencies responds. The Radio Branch has a copy of the BOREAS Tower Flux sites and can assist you in getting emergency help.

4.	OTHER NUMBERS

Hospitals	764-1551, 922-2605
Towing (Candle Lake)	929-4662 (W)
	929-3149 (H)

Appendix C: BOREAS Check-In/Check-Out Procedures

BOREAS IFC Initial Check-in/Check-out and Registration:

On arrival to the northern or southern study areas, please report to the Study Area Headquarters (SAHQ) for registration. The registration process will consist of the following and should take no more than 30 minutes.

1) Please provide the operations center with the following information for each person :

Name
Team number
Description of vehicle and licence plate number
Name of place where staying : local telephone number and room number
Date of anticipated departure
Work address
Contact name and number - in case of emergency

Note : It is the responsibility of the team leader that all participants within his/her group be registered with the SAHQ.

2) Pick-up an updated copy of emergency procedures.

3) Pick-up a copy of BOREAS daily check-in/Check-out procedures and final check-out procedures.

4) Pick-up a copy of updated telephone lists of general BOREAS numbers as well as a listing of current BOREAS participants.

5) Check-out a ground radio (generally the team leader will do this) - staff will provide instructions on operation if needed.

6) Check-out any needed keys.

As part of the registration procedure, BOREAS staff will also show investigators the facilities of the SAHQ(location of the fax machine, computers, copiers, telephones, etc ....).

The operations center will generally be open from 8:00 AM to 6:00 PM- local time during the IFCs.

BOREAS Daily Check-in/Check-out :

This daily process is necessary for two reasons. In case of an emergency (fire, storm, medical, mechanical, etc...), BOREAS staff needs to know where everyone is and secondly if someone is trying to contact you, we need to know where you are to complete a successful exchange of information.

1) Turn on radio before leaving or enroute for the field in the morning and contact the SAHQ. Transmit the following information : name, group, (names of participants within your group, vehicle description; if different from initial registration at SAHQ), destination and expected arrival back to your accommodations.

2) Keep your radio on: Radio checks will be made throughout the day by the SAHQ.

3) If your team moves from one destination to another during the day, inform the SAHQ.

4) Radio or telephone in by 2 PM local time your plans for the next day. This information will be used at the nightly BOG meeting. If you want to work at PANP the next day, be sure to inform the SAM.

5) Please contact the SAHQ when you leave the study area en route for town/accomodations either by radio or telephone.

6) Unaccounted personnel at the end of the day will require the study area manager (SAM) to organize a search.

7) There will be time-coincident nightly meetings at both SAHQs - (8PM : southern and 9PM : northern) providing a synoptic weather discussion and forecast, brief updates of team activities of the day , planned team activities for the following day and a mission managers report of general BOREAS items.

BOREAS IFC Check-Out Procedure :

All registered personnel should go through a check-out procedure at the SAHQ. If this is not possible, please telephone information in to the SAHQ. This will consist of the following:

1) Provide name, team number.

2) Turn in radio if one was issued to you.

3) Turn in any keys that were issued to you.

4) Please check with secretary for any outstanding messages/faxes that may have arrived duting your visit.

5) If storage of equipment is necessary, please see BOREAS staff for details.

6) If you are the team leader and your team is leaving, please see the mission manager or the study area manager for any remaining details that may need to be addressed before your departure.

7) Have a safe trip back.

Thanks for your cooperation.

Appendix D: BOREAS Inter-IFC Survival Guides

BOREAS INTER-IFC-94 SURVIVAL GUIDE (NSA)

A. HELP WITH SITE INFRASTRUCTURE

Dan Hodkinson (NASA/GSFC) will coordinate any significant work that needs doing on site. Call 301/286-3621 or 301/286-3720.

B. BEFORE YOU LEAVE FOR HOME

- Check with Dan Hodkinson about shutting down the site.
- Tell him when you are leaving.
- Give your radio back in.
- Turn in keys.

C. STORING MATERIAL OVER THE WINTER

Material can be stored at the back of the Keewatin Airlines Hangar at Thompson Airport. Please contact Keewatin Air (204-677-3333) to arrange a time for dropping off.

D. EMERGENCIES AND EMERGENCY PHONE CALLS

(1) Medevac information is provided in Appendix B.

(2) You can use your radio to make an emergency call:
- Select Channel 3
- Hold key down, transmit for 5 seconds.
- Manitoba Tel Operator will come on line and will ask for registry and code number.
- Respond: Prince Albert Registry, code number JW2 9062.
- Give operator the number you want to call (Thompson Emergency Services is 677-7911)

(3) Gil's Towing (24 hours) 778-8290

E. WEATHER INFORMATION

Thompson Weather Office: 677-6900
Taped Hourly Update 677-4969

BOREAS INTER IFC-94 SURVIVAL GUIDE (SSA)

A. HELP WITH SITE INFRASTRUCTURE

Mary Dalman (PANP) will co-ordinate any significant work that needs doing on site. Call 306-663-5322.

B. BEFORE YOU LEAVE FOR HOME

- Check with Mary Dalman about shutting down the site.
- Tell her when you are leaving.
- Turn in radio and keys to Mary Dalman.

C. STORING MATERIAL OVER THE WINTER

Paddockwood School has space to store materials. To arrange space and drop-off times call:

Bob STEVENSON 306-989-2142
or
Jim BRUCE 306-764-8941, 1511
306-922-3054

D. EMERGENCIES AND EMERGENCY PHONE CALLS

(1) Medevac information is provided in the EXPLAN Appendix B.

(2) You can use your radio to make an emergency call:

- Select channel 3 if in PANP
  11 or 13 if in Candle Lake or White Gull Basin Area.
- Hold key down, transmit for 5 seconds.
- Operator will come on line and will ask for registry and code number.
- Respond: Prince Albert Registry, code JW2 9062.
- Give operator number (P.A. Emergency Services is 764-6455)

(3) The radio is monitored 24 hours a day by the Radio Branch in Prince Albert. If you are out of telephone range, please call out for emergency assistance. The Radio Branch has a map of the BOREAS sites and can get you emergency help.

(4) Towing: 929-4662 (W), 929-3149(H)

E. WEATHER INFORMATION

Prince Albert Weather Office: 953-8640

Appendix E: Customs and Shipping Information, Shipping Destinations, Importation of Samples, Immigration Formalities

E-1 Customs and Shipping Information

BOREAS TRANSPORTATION AND IMPORTATION OF EQUIPMENT INTO CANADA

BOREAS has been granted a Remission Order in Council by Customs and Excise Canada allowing U.S. and International equipment to pass through customs exempt from duty, customs and GST charges.

Exemption only applies to equipment that will be returning to place of origin upon completion, (i.e. can not be sold or enhanced in Canada).

Please indicate BOREAS somewhere on your packages. It would be very helpful both for the people shipping your equipment who identify with the project name but not your name, and it would be useful for the people at the receiving end who will be storing your equipment. See section three of this appendix (F.3) for names and addresses of shipping destinations. **NO** C.O.D. shipments!

OPTIONS FOR INVESTIGATORS BRINGING EQUIPMENT INTO CANADA

1) Self Importation (you accompany the equipment)

- required at point of entry:

  a) letter of remission,

  b) letter of GST remission,

  c) certification note (P.C. Order 1990-2848),

  d) memorandum D21-4-1,

  e) a **detailed** list of equipment specs, value, serial numbers, duration in Canada, etc. (e.g., a detailed invoice).

f) It is possible to go this alone and do the paperwork yourself, but it's probably not worth the time and hassle. If you do, be prepared for significant delays, especially if you are bringing numerous pieces of equipment with you. A broker is highly recommended for smooth passage. One that is aware of and has been formerly used by BOREAS:

A.D. Rutherford and Co. Ltd.
910 Ferry Road
Winnipeg Int'l Airport
P.O. Box 2189
Winnipeg, Manitoba R3C 3R5
contact: Royal Unruh ph (204) 783-7096
fax (204) 783-1449
(can arrange brokerage at all border crossings)

2) Ground Transportation (unaccompanied)

- required with shipment:

a) same as previous (a-e),

b) broker is highly recommended for smooth passage, (see item 1f above for contact)

c) expect warehouse charges and storage charges,

d) to minimize delays ensure that carrier/courier move directly between origin and destination, and is able to track your shipment. Try to find a shipper who will arrange brokerage as well.

3) Air Freight with Emery Worldwide through Winnipeg, Manitoba

Contact: Mr. Brian Raymond
EMERY WORLDWIDE
General Manager
Unit 7, 2021 Sargent Avenue
Winnipeg, Manitoba
R3H 0Z8
ph: (204) 775-2676

a) quotes for cost and time to move your equipment can be obtained from Emery if you can provide shipping weight and volume. Despite a misunderstanding in the past, the quote will be from customer point of origin to site destination (Paddockwood, Keewatin, or Gardewine).

b) please contact Brian as soon as possible to make him aware of any particular needs or concerns you have.

c) if you are the least bit suspicious that your equipment could be classified as hazardous materials (gas powered generators are), contact Brian as soon as possible to verify. This equipment will require special paperwork and handling. If you don't have the proper paperwork, your shipment will not be there when you want it.

advantages of using Emery:

- customs clearance and brokerage services included, storage at Winnipeg Airport provided at no additional cost,
- no weight restrictions,
- single point of contact for all shipments in and out of Canada.
- oversize and hazardous material handling
- single invoice billing
- Emery can provide ground transportation

4) Other

- If the option you plan to use does not fit into one of the above categories, most of the information given still applies,

    a) anything moving across the border is going to require items a-e listed in 1 above.

    b) provide your carrier or shipping department with this information and they should have everything they need to clear it through customs. Please call either Jaime Nickeson or Gillian Traynor if you have any questions.

Jaime Nickeson	GSFC	(301) 286-3373
		FAX 1757
Gillian Traynor	CCRS	(613) 947-1292
		FAX 1406

You will find as part of this Appendix, items 1a, b, c, d included in the following pages.

Canadian customs may not be all you need to be concerned with. It is a good idea to register your equipment with U.S. customs before departing. You may have done this already if you have previously traveled internationally with your equipment. In particular, U.S. Customs wants to see proof that foreign made items were with you when you exited the U.S. This can be done easily at your local customs office ahead of time by taking either your equipment, a receipt, or some kind of proof that you own the equipment (if you do not take the equipment, the papers you take to customs must include the manufacturer serial number). The form you need is called customs form 4455 and is called a certificate of registration. Having this form will help you when you go through U.S. customs on your return to the states. If your equipment is not registered, your shipping document, with serial numbers, should be enough proof to show that you are returning to the U.S. only with equipment you brought in to Canada. Be prepared to pay duties on equipment purchased in Canada when totals exceed $400.

Revenue Canada Customs and Excise
Revenu Canada Douanes et Accise

Ottawa, Canada
K1A 0L5

July 6, 1992

6E-F-60358

(CRL)

4589-3

Energy, Mines and Resources Canada,
Surveys, Mapping and Remote Sensing Sector,
Canada Centre for Remote Sensing,
Applications Division,
1547 Merivale Road,
Ottawa, Ontario
K1A 0Y7

Attention: Mrs. Cindy De Cuypere
Canadian Administrator for BOREAS

Subject: BOREAS importations,
Joint Canada-United States Government
Projects Remission Order, P.C. 1990-2848.

Dear Mrs.. De Cuypere:

This refers to your facsimiles of November 15 and 21, 1991, addressed to Mr. R.R. Teal, in which you request our authorization to consider the research project BOREAS (Boreal Ecosystems-Atmosphere Study) for duty relief under the Joint Canada-United States Government Projects Remission Order, P.C. 1990-2848.

As per your documentation, BOREAS is an international cooperative field and analysis research project which is jointly sponsored by the U.S. National Centre for Atmospheric Research (NCAR) under contract to the National Aeronautics and Space Administration (NASA; a U.S. government agency) and the Canadian government departments of Energy, Mines and Resources, Forestry, Environment, and Agriculture. We are pleased to advise you that this study is considered to be a joint Canada and United States project and falls within the provisions of the Joint Canada-United States Government projects Remission Order, P.C. 1990-2848 (copy attached).

Canada

Department of National Revenue (Customs and Excise)
Ministère du Revenu national (Douanes et Accise)

Under this order, goods which are, or will become the property of the U.S. government may be imported into Canada by the U.S. government or its authorized agent, or a Canadian Government Department or Crown Corporation acting on behalf of the U.S. Government.

Please note that the relevant memorandum D21-4-1 is under revision, however, the instructions contained therein remain in effect and it will be necessary for you to provide a list of imported goods with the customs accounting document bearing the certificate as specified in paragraph 7 to the memorandum D21-4-1. You are required to submit a copy of this letter to each accounting document or refund claim.

I hope this information will be assistance to you.

Yours truly,

Claude Levesque,
Drawbacks and Refunds Policy Unit,
Duties Relief Programs.

c.c.: Mrs. J. Hoople, Tax Policy Officer, Customs & Excise

Revenue Canada Customs and Excise
Revenu Canada Douanes et Accise

Ottawa, Canada
K1A 0L5

March 22, 1993

4589-3 (TE)

Jaime Nickeson
BOREAS Project

Dear Jaime,

This letter is in response to our conversation regarding the importation of articles for use in the BOREAS Project.

Claude Levesque has already given you a letter, authorizing your organization to import articles under the Joint Canada-United States Government Projects Remission Order. During our conversation, you asked whether this authorization under the order would remit duty as well as G.S.T.

I have discussed this project with Joanne Hoople of our Excise branch, Should you wish to receive relief from domestic purchases, you must contact Ms. Hoople directly for correct procedures and approval, Mr. Levesque's letter of authorization includes remission of G.S.T. for articles at the time of importation.

I trust this letter will clarify this issue, and help to make your importations smoother. Should you have any questions regarding this order or letter of authorization, please contact me at (613) 954-6888.

Sincerely,

B. T. (Tim) Elliott
Duties Relief Programs

cc: C. Levesque

Canada

Department of National Revenue (Customs and Excise)
Ministère du Revenu national (Douanes et Accise)

CANADA

PRIVY COUNCIL • CONSEIL PRIVÉ

P.C. 1990-2848
21 December, 1990

(T.B. Rec. 815437)

HIS EXCELLENCY THE GOVERNOR GENERAL IN COUNCIL, considering that it is in the public interest, on the recommendation of the Minister of National Revenue and the Treasury board, pursuant to section 23 of the Financial Administration Act, is pleased hereby to revoke the remission granted under Part I of Order in Council P.C. 1960-1600 of November 25, 1960, and to make the annexed Order respecting the remission of duties, including the tax imposed under Division III of Part IX of the Excise Tax Act, and the taxes imposed under any other part of that Act, paid or payable on goods, real property or services for use in joint Canada-United States Government projects, in substitution therefor.

CERTIFIED TO BE A TRUE COPY - COPIE CERTIFIÉE CONFO

CLERK OF THE PRIVY COUNCIL - LE GREFFIER DU CONSEIL P

National Aeronautics and
Space Administration

NASA

Goddard Space Flight Center
Greenbelt, Maryland
20771

Reply to Attn of: 923 May 3, 1993

Attn: Revenue Canada
Customs and Excise
Re: Memorandum D21-4-1
Exemption certificate
From: Piers Sellers
NASA
BOREAS Project Scientist

To Whom It May Concern,

I hereby certify that the articles or goods herein described are to be used as part of the BOREAS experiment which falls within the provisions of the Joint Canada-United States Government projects Remission Order. The BOREAS investigators are funded by the U.S. or Canadian government and the equipment being imported is for use solely and exclusively in this joint U.S.-Canada BOREAS experiment and are exempt from customs duties and excise taxes.

BOREAS Project
Project or Contract Identification

(signed)
Authorized Representative or Agent

E.2 Shipping Destinations

Northern Study Area
Arrangements have been made for two receiving "depots" in the NSA, one for field equipment and one for lab equipment.

Field Equipment	Lab Equipment
BOREAS Project	BOREAS Project
Keewatin Air	Gardewine North
Thompson Airport	136 Hayes Road
Thompson, Manitoba	Thompson, Manitoba
CANADA R8N 1N7	CANADA R8N 1M3
ATTN: John Leschied	ATTN: Debbie Baggott
(204) 677-3333	(204) 778-8311

Southern Study Area
All field and lab equipment should be shipped to the following address in the SSA:

BOREAS Project
c/o Paddockwood School
Paddockwood, Saskatchewan,
CANADA S0J 1Z0
ATT: Bob Stevenson
(306)989-2142, or
Jim Bruce
Shop: 306/764-8941
Office: 306/764-1511
Home: 306/922-3054

Equipment sent to these people will be stored in a secured area out of the weather until you arrive to retrieve it. Contact with these people prior to shipping would be advisable. Please try to make your contacts during civilized hours (i.e. figure out the time difference before phoning Bob Stevenson).

Circular
Q-330.300-1
Soil (6-93)

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Federal Building
Hyattsville, Maryland 20782

IMPORTING FOREIGN SOIL

The animal and plant health inspection service (APHIS) is the agency within the U.S. Department of Agriculture charged with enforcing quarantine regulations designed to protect U.S. agriculture from the introduction of potentially destructive plant and animal pests and diseases.

Soil is strictly controlled under APHIS quarantine regulations because it can readily provide a pathway for the introduction of a variety of dangerous organisms into the United States. Pest and disease concerns associated with soil include animal and plant viruses, bacteria, and fungi; as well as nematodes, noxious weeds, and certain life stages of destructive exotic insects.

Soil cannot be adequately and practically inspected for the spectrum of organisms which might be harmful. For this reason, **the movement of soil into the United States from foreign sources is prohibited, and movement within the continental U.S. is restricted unless authorized by APHIS under specific conditions and safeguards.**

The following discussions will provide detailed information about the authorizations provided by APHIS for soil movement.

Scope of the Regulations:

Title 7 of the Code of Federal Regulations (CFR), Part 330.300 describes the authority for APHIS policies and procedures related to the importation of soil from foreign sources as well as from Hawaii, Guam, Puerto Rico, and the U.S. Virgin Islands, but not including soil from Canada unless imported from Newfoundland or the Land District of South Saanich on Vancouver Island of British Columbia.

Regulated items include materials such as topsoil, forest litter, compost, humus, earthworm castings, and any of a variety of items composed of largely unidentifiable plant parts or mixtures of organic and inorganic ingredients which are capable of supporting biological activity and therefore capable of providing the means for carrying and introducing harmful pests or diseases.

Items which are outside the scope of the regulations include; pure sand, clay, talc, or other pure mineral articles, as well as rocks, gravel and ore which are not contaminated with soil or organic debris. Peat is also unregulated, provided it is pure.

Cosmetic mud and other mud products may also be exempt from regulation. However, mud products must be processed to a smooth consistency and visibly free of contaminants. Mud which has not been commercially processed, must be smooth, uncontaminated, and accompanied by foreign certification stating that the mud was taken from a source at least 7 feet below the water surface.

Materials such as those described above can be considered outside the scope of APHIS soil regulations. However, such items remain subject to inspection at the U.S. port of arrival.

All shipments must be inspected to establish the nature and identity of the imported material and verify that the shipment is free of pests and prohibited contaminants. Any shipment or portion of a shipment may be refused or require treatment based upon inspection findings.

Therefore, non-soil items should be absolutely pure, with no visible signs of soil, insects, organic debris, or prohibited contaminants. Items which appear soil-like are regulated as soil unless determined to be exempt based upon inspection.

Canadian Soil

Soil from Newfoundland and from that portion of the Municipality of Central Saanich in the Province of British Columbia east of the West Saanich Road, Canada is regulated as foreign soil. Soil from other parts of Canada may be imported into the U.S. subject only to inspection and verification of the origin.

Domestic Soil

Soil from Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands is handled as foreign soil and is authorized movement into the continental U.S. under the provisions described for foreign soil.

Domestic soil (from within the continental U.S.) may be restricted movement from specific areas under APHIS quarantine regulations. When required by quarantine, the movement of domestic soil may be authorized through the development of a compliance agreement established between the local APHIS office and the person or firm responsible for handling the soil.

Persons desiring more information related to the movement of domestic soil are encouraged to contact the local Plant Protection and Quarantine(PPQ) office and State agricultural officials. The PPQ Permit Unit in Hyattsvile, Maryland can help identify appropriate offices. The telephone number for the Permit Unit is Area Code (301) 436-8645.

Hawaii and Puerto Rico

Soil shipments from Hawaii and Puerto Rico are treated and/or authorized by PPQ in Hawaii or Puerto Rico before being released for movement to the continental United States.

Israel

Small amounts of soil from Israel may be authorized for importation without treatment at the port of entry. A special permit is required, and shipments must be accompanied by a certificate which states that the soil is non-agricultural and has been heat treated in Israel.

U. S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Federal Building
Hyattsville, Maryland 20782

Circular
Q.37-19
05/93

CANADIAN PLANT PROPAGATING MATERIAL - ENTRY REQUIREMENTS

Plants originating in the Province of Newfoundland* and the Land District of South Saanich (Province of British Columbia)*, are subject to special requirements.

Certain genera of palm plants are prohibited - please see enclosed Part 319.37, pages 5-9.

All Citrus and Citrus relatives are prohibited.

The material listed below is either prohibited entry or subject to written permit requirements. When reference is made to more that one footnote, both restrictions apply, except when noted otherwise. Seeds are not included unless specifically mentioned.

Abelmoschus (seeds)	*(15)*
Allium sativum (garlic) (bulbs)	*(16)*
Berberis (barberry)	*(1,11)*
Bromeliads	*(17)*
Castanea (chestnut)	*(8)*
Castanopsis (chinquapin)	*(9)*
Chaenomeles	*(3)*
Corn seed	*(12)*
Corylus	*(2)*
Cydonia (quince)	*(3)*
Hibiscus (seeds)	*(15)*
Humulus (Hops)	*(1)*
Mahoberberis	*(1,11)*
Mahonia	*(1,11)*
Malus (apple, crabapple)	*(3)*
Pinus (pine)	*(4)*
Planera (waterelm)	*(10)*
Prunus (almond, apricot) cherry, peach, plum)	*(3)*
Prunus seeds	*(14)*
Pyrus (pear)	*(3)*
Ribes (currants and gooseberries)	*(6)*
Rubus (blackberry, boysen-berry, dewberry, raspberry)	*(1,13)*
Ulmus (elm)	*(10)*
Vitis (grape)	*(7)*
Zelkova	*(10)*

(1) Enterable under post entry quarantine permit for detention growing on premises controlled by the importer.

*See page 3.

(2) Written permit required when originating from provinces east of Manitoba if destined to Oregon, or Washington. Enterable without permit from provinces west of and including Manitoba if destined to Oregon or Washington, and from all Canadian provinces when destined to other States.

(3) (Chaenomeles, Cydonia, Malus, Prunus, Pyrus) Certified materials enterable under written permit when accompanied by a valid Canadian phytosanitary certificate. Malus from British Columbia is subject to special certification, permit, and entry requirements.

(4) (Pinus) All pines are enterable under written permit when destined to the States of California, Idaho, Montana, Oregon, and Utah. 5-leaved pines are enterable under written permit when destined to Wisconsin. No permit required when destined to States other than preceding.

(5) Reserved.

(6) (Ribes) Written permit required for entry from all Provinces of Canada of Ribes spp. plants and seeds destined to Massachusetts. New York, West Virginia, and Wisconsin. No permit required for other destinations.

(7) (Vitis) Enterable under written permit for all states. Also, subject to virus indexing when destined to California, Oregon, and Washington.

(8) (Castanea) Prohibited entry.

(9) (Castanopsis) Written permit required when destined to California or Oregon. No permit required for other destinations.

(10) (Planera, Ulmus, Zelkova) Written permit required when destined to California, Nevada, or Oregon. No permit for other destinations.

(11) (Berberis, Mahoberberis, Mahonia) Entry restricted to plants of those species and varieties which have been designated as resistant to black stem rust. All other species and varieties are not admissible. All seed is prohibited entry.

(12) Subject to Quarantine 41 restrictions. Special certification for European corn borer may be required. Written permit required.

(13) (Rubus) Permit and postentry quarantine unless at the time of arrival in the United States the phytosanitary certificate of inspection accompanying the plants contains an additional declaration that the articles were found by the Plant Protection Service of Canada to be free of Rubus stunt agent based on visual examination and indexing of the parent stock.

(14) (Prunus) Seeds enterable under written permit when destined to the States of Colorado, Michigan, New York, Washington, and West Virginia. No permits are required for other destinations. Prunus seeds in the subgeneus Cerasus require certification that plum box (Sharka) virus does not occur in the country where the seed was grown.

(15) (Abelmoschus, Hibiscus) Seeds are subject to treatment upon arrival at a Plant Protection and Quarantine inspection stations. Written permit required.

(16) (Allium sativum) Bulbs require a written permit.

(17) (Bromeliads) When destined to Hawaii, subject to postentry quarantine restrictions. Written permit required.

All plants, plant parts, seeds, and bulbs not previously mentioned by be imported without written permit.

A phytosanitary certificate should accompany the shipment; however, a phytosanitary certificate is not required for noncommercial lots of houseplants. Houseplants are defined as those plants that have been grown or are obviously intended for growth in a residence (except ACitrus3 spp.). A phytosanitary certificate is required for outdoor plants such as trees and shrubs which are normally grown outside.

Mail shipments of admissible plants from Canada which are not subject to written permit requirements may be addressed directly to the recipient. Green-and-yellow mailing labels are not longer required. Such parcels must be plainly labeled to identify the contents.

*All admissible plants from Newfoundland and the portion of the Municipality of Cenral Saanich in the Province of British Columbia east of the West Saanich Road must be free of soil and accompanied by a Canadian phytosanitary certificate. Postentry quarantine provisions will apply when applicable. No written permit is required except for plants and seeds listed on the first page. Also, any exceptions stated in the is circular will apply.

PLEASE PRINT

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS

APPLICATION FOR PERMIT TO IMPORT PLANTS OR PLANT PRODUCTS

1. DATE OF APPLICATION

2. PLANTS OR PLANT PRODUCTS TO BE IMPORTED

COUNTRY OF ORIGIN (If Canada, give city and province. If Mexico, give State. Make separate entry for each country.) A	QUANTITY AND NAMES OF PLANTS OR PLANT PRODUCTS Scientific (Botanical) or English names must be included (Colloquial names are not acceptable). List whether seeds, bulbs, plants, cuttings, cut flowers, fruits, etc. Indicate whether for planting, consumption or other purposes. B	U.S. PORT OR PORTS OF ARRIVAL IF SHIPPED OTHER THAN BY MAIL C

Use the reverse side if more space is needed, and check box ☐

3. CHECK MEANS OF IMPORTATION
SURFACE MAIL OR PARCEL POST ☐ AIR MAIL OR AIR PARCEL POST ☐ TRUCK, RAIL OR WATER FREIGHT ☐ AIR FREIGHT ☐ BAGGAGE OR CAR ☐

4. APPROXIMATE DATE OF DEPARTURE FROM U.S.A.

ARRIVAL DATE

5. ARE OTHER IMPORTATIONS CONTEMPLATED WITHIN THE NEXT TWO YEARS YES ☐ NO ☐

ANSWER 6, 7, 8, AND 9 ONLY IF IMPORTED MATERIAL WILL BE RESHIPPED TO ANOTHER COUNTRY

6. RESHIPMENT WILL BE BY
AIR ☐ WATER ☐ RAIL ☐ TRUCK ☐

7. UNDER THE FOLLOWING TYPE CUSTOMS ENTRY
IE ☐ T & E ☐

8. PORT OF EXIT FROM UNITED STATES

9. COUNTRY OF FINAL DESTINATION

10. PRINT NAME AND UNITED STATES ADDRESS OF APPLICANT
(Including street address, P.O. Box, if any, and Zip Codes.)

13. FORWARD THIS APPLICATION TO

U.S. Department of Agriculture, APHIS
Plant Protection and Quarantine Programs
Permit Unit
Federal Building
Hyattsville, Maryland 20782

11. SIGNATURE OF APPLICANT

12. TELEPHONE NO. *(Include Area Code)*

PPQ FORM 587 (MD) (6/77) PREVIOUS EDITION MAY BE USED UNTIL EXHAUSTED

☆ U.S. G.P.O. 1977-720-353/3251

E.4 Immigration Formalities

The agreement signed between Canada and the United States for BOREAS is reproduced in Appendix F. This forms the basis for some of the special arrangements made vis-a-vis the waiving of work permit fees, etc. All U.S. PI's should have received a letter like the example attached on the next page - this plus the agreement should prevent you from being stuck with a work permit charge or related hold-ups at immigration. If you don't have such a letter, contact Gill Traynor at the BOREAS Secretariat 613/947-1292.

Natural Resources Canada
Surveys, Mapping and Remote Sensing Sector
Canada Centre for Remote Sensing
588 Booth Street
Ottawa, Ontario
K1A 0Y7

Ressources naturelles Canada
Secteur des levés, de la cartographie et de la télédétection
Centre canadien de télédétection
588, rue Booth
Ottawa (Ontario)
K1A 0Y7

May 1, 1994

To whom this may concern,

This letter is to certify that Dr. Piers J. Sellers is an approved Boreal Ecosystem-Atmosphere Study (BOREAS) Principal Investigator BOREAS is a joint U.S. - Canada research project to study the interactions between the boreal forest and the atmosphere. The BOREAS field campaigns will be conducted in Canada in the regions of Prince Albert, Saskatchewan, and Thompson, Manitoba. U.S. - Canada cooperation for BOREAS has been formalized through a Government-to-Government Agreement. The Agreement requires that arrangements be made for free customs clearance of equipment and data and that immigration documentation fees (i.e., work permits) be waived for persons working on BOREAS. These provisions are to be applied to Dr. Piers J. Seller's travel to and from Canada for participation in BOREAS.

Letters for BOREAS Co-Investigators signed by the above-named Principal Investigator and attached to this letter will extend the above provisions to the named Co-Investigator(s).

Sincerely,

Leo Sayn-Wittgenstein
Director-General, Canada Centre for Remote Sensing

cc: NASA/YSE/Dr. Diane E. Wickland

Canada

Appendix F: Agreement between United States and Canada

This agreement plus a letter like the example shown in Appendix E-4 should permit the waiving of work permit charges for U.S. Investigators.

AGREEMENT
BETWEEN
THE GOVERNMENT OF CANADA
AND
THE GOVERNMENT OF THE UNITED STATES OF AMERICA
ON COOPERATION IN THE
BOREAL ECOSYSTEM-ATMOSPHERE STUDY (BOREAS)

ACCORD
ENTRE
LE GOVERNMENT DU CANADA
ET
LE GOUVERNEMENT DES ETATS-UNIS D'AMERIQUE
CONCERNANT LA COOPERATION DANS LE CADRE DE
L'ETUDE DE L'ATMOSPHERE ET DES ECOSYSTEMES BOREAUX (BOREAS)

WHEREAS:

The Government of Canada and the Government of the United States, herein referred to as "the Parties," have identified a mutual interest in conducting a joint study to better understand the interaction between the boreal forest biome and the atmosphere; and

The Parties wish to establish a framework for cooperation;

The Parties, therefore, agree as follows:

ARTICLE 1

PURPOSE

The purpose of this Agreement is to provide the basis for cooperation between Energy, Mines and Resources (EMR), a department of the Government of Canada, and the National Aeronautics and Space Administration (NASA), an agency of the Government of the United States of America, herein referred to as "the Participants", regarding the joint Canada-U.S. Boreal Ecosystem-Atmosphere Study (BOREAS).

ARTICLE 2

OBJECTIVES

A. The Parties shall undertake BOREAS to study the interactions between the boreal forest biome and the atmosphere in order to clarify the roles of these interactions in global change. The study will focus on processes that can be appropriately addressed in a one-year intensive field measurement project supported by three to four years of less intensive in situ and remote sensing monitoring.

B. The specific objectives of BOREAS are:

1. to improve understanding of the biological and physical processes and states which govern the exchanges of carbon, water, trace gases, energy, and heat between boreal forest ecosystems and the atmosphere with particular reference to those processes and states that may be sensitive to global change;

2. to develop the use of remote sensing techniques to transfer understanding of the above processes from local scales to regional scales; and

3. to provide personal development, research, and educational opportunities for individual researchers sponsored by both Parties participating in BOREAS.

ARTICLE 3

PARTICIPATION

A. The Parties shall conduct BOREAS as part of the U.S. and Canadian Global Change Research Programs. The goals and objectives of BOREAS are compatible with and have been endorsed by the International Geosphere-Biosphere Programme (IGBP) and the International Satellite Land Surface Climatology Project (ISLSCP) of the World Climate Research Program (WCRP). Preliminary scientific planning has determined that BOREAS will be a joint U.S.-Canada initiative in which NASA will lead the U.S. participation in this study and will coordinate the involvement of the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and the National Science Foundation (NSF). The Canada Centre for Remote Sensing (CCRS) of the Surveys, Mapping, and Remote Sensing Sector will act on behalf of EMR to implement the Canadian contributions to this study. CCRS has been designated to lead the Canadian participation in the study in cooperation with the Canadian BOREAS Coordinating Committee (CBCC). The CBCC will coordinate the involvement of Forestry Canada, Environment Canada, Agriculture Canada, the National Research Council of Canada (NRC), and the Natural Sciences and Engineering Research Council of Canada (NSERC).

B. BOREAS will consist of a three t four year period of low level in situ monitoring observations of two boreal forest biome sites in central Canada. These roughly 400-600 square kilometer sites are the Prince Albert National Park region in Saskatchewan and the Nelson House region near Thompson, Manitoba. In the summer of 1993, one pilot intensive observation campaign was conducted. In 1994, up to five intensive field campaigns will be conducted to cover mid-winter, spring thaw, an early, mid-, and late growing season conditions. These intensive field campaigns will involve approximately 75 Principal Investigator-led international teams, extensive in situ observations at each site, several U.S. and Canadian remote sensing aircraft, and satellite observations. It is planned to base the smaller aircraft (e.g., NASA helicopter and C-130) at Prince Albert and Thompson, the larger aircraft (e.g., NASA DC-8) at Saskatoon and/or Churchill, and the NASA ER-2 at Spokane, Washington,

C. A data and information system, the BOREAS Information System (BORIS), will be established to provide the BOREAS Science Team members with a data system from which data for the whole project may be queried, accessed, and extracted. Participating scientists will be expected to submit their data to BORIS in a timely fashion. All those participating in BOREAS shall have access to BORIS and all BOREAS data distributions will be through BORIS, or through the long-term archive to follow BORIS.

ARTICLE 4

RESPONSIBILITIES OF THE PARTICIPANTS

A. NASA, for its part, will use its best efforts to ensure fulfillment of the following responsibilities:

1. Participants with CCRS in the planning of the coordinated U.S. and Canadian aircraft and ground-based measurements to be obtained in order to fulfill the scientific objectives of the joint mission;

2. Coordinate the involvement of other U.S. agencies in BOREAS;

3. Arrange, jointly with the participating Canadian agencies, for the provision of required lodging for the U.S. component of the joint team;

4. Provide NASA aircraft equipped with instrumentation for the BOREAS study. Additionally, arrange for proper operational and associated ground support for the NASA aircraft, and coordinate flight of the other U.S. aircraft (e.g., aircraft provided by NOAA, the National Center for Atmospheric Research (NCAR), and the University of Wyoming) participating in the campaign;

5. Organize and conduct the BOREAS aircraft expeditions in consultation with EMR;

6. Provide certain Core Measurements for BOREAS (through in-house labor or contracted support), including agreed-upon surface measurements, tower-based measurements, automatic meteorological stations, aircraft remote sensing measurements and in situ measurements, satellite data, and Geographic Information System (GIS) components. These will be provided in accordance with applicable U.S. laws and NASA data policies;

7. Process, correct, quality assure, and document agreed-upon Core Measurements data and deliver them to the BORIS in a timely fashion;

8. Coordinate and execute agreed-upon joint instrument calibration and comparison experiments and analyses;

9. Participate jointly with CCRS and the other participating agencies in the analysis and publication of the data and results obtained from this cooperative project;

10. Support, staff, and manage the U.S. BOREAS Project Office, including the BORIS;

11. Provide funding for U.S. proposals and sponsor the participation of the foreign scientists selected under the joint U.S.-Canada solicitations for scientific participation in BOREAS; and

12. Provide certain support services to be performed in Canada in fulfillment of the objectives of BOREAS. These services include, but are not limited to, the following: BOREAS infrastructure, trails, vehicles, aerial photography, flux towers, site research facilities (including laboratory and storage space); site managers, liaison-field support, field site security, and labour at the study sites. NASA will procure these support services through CCRS by separate contract or other appropriate agreement. In connection with such a procurement, NASA will not pay as an allowable cost, salaries of Canadian government employees.

B. EMR, for its part, will use its best efforts to ensure fulfillment of the following responsibilities:

1. Participate with NASA in the planning of the coordinated U.S. and Canadian aircraft and ground-based measurements to be obtained in order to fulfill the scientific objectives of the joint mission;

2. Coordinate the involvement in BOREAS of Environment Canada, Forestry Canada, Agriculture Canada, the NRC, and other Canadian participants, and provide a link for discussions with the NSERC;

3. Obtain from Canadian authorities necessary authorization in order to conduct the subject scientific project. In addition, EMR will assist and guide NASA in complying with Canadian government legislation and regulations with respect to aircraft activities and surface level operations.

4. Arrange, jointly with NASA, for the provision of required lodging for the Canadian component of the joint team;

5. Provide CCRS aircraft equipped with instrumentation for the BOREAS study. Additionally, arrange for proper operational and associated ground support for the CRS aircraft and coordinate other Canadian aircraft (e.g., aircraft provided by the Institute of Aerospace Research (IAR) Twin Otter and the Ontario Center for Remote Sensing's Navajo Chieftain) participating in the campaign;

6. Participate with NASA and the other participating agencies in the organization and conduct of the BOREAS aircraft expeditions.

7. Coordinate the provision of meteorological data provided by Environment Canada, including satellite cloud images, and assistance in forecasting, for planning of aircraft missions for the duration of the BOREAS mission;

8. Provide or arrange for the provision of certain core measurements for BOREAS (through in-house labor or contracted support), including agreed-upon surface measurements, tower-based measurements, automatic meteorological stations, aircraft remote sensing measurements and in situ measurements, satellite data, and GIS components. In particular, provide agreed-upon Landsat Thematic Mapper (TM), Multispectral Scanner System (MSS) and Advanced Very High Resolution Radiometer Local Area Coverage (AVHRR LAC) data. These will be provided in accordance with Canadian data distribution agreements with satellite operators and data distributing companies;

9. Process, correct, quality assure, and document agreed-upon core measurement data and deliver them to the BORIS in a timely fashion;

10. Coordinate and execute agreed-upon joint instrument calibration and comparison experiments and analyses;

11. Participate jointly with NASA and other participating agencies in the analysis and publication of the data and results obtained from this cooperative project;

12. Support, staff, and manage the Canadian BOREAS Secretariat;

13. Provide funding for CCRS proposals selected under the joint U.S.-Canada solicitations for scientific participation in BOREAS and communicate information on the funding commitments of the other Canadian agencies involved in BOREAS; and

14. On behalf of NASA, arrange for the provision of the support services to be performed in Canada in fulfillment of the objectives of this Agreement, as described in paragraph A.12 of NASA's responsibilities above, pursuant to the requirements of a contract or other appropriate arrangement entered into with NASA.

ARTICLE 5

PROJECT MANAGEMENT

The Participants' technical points-of-contact to be responsible for coordinating the agreed-upon functions and responsibilities of each Participant are as follows:

The NASA technical point-of-contact:

Manager
Terrestrial Ecology Program
Science Division
Office of Mission to Planet Earth
NASA Headquarters
Washington, DC 20546
USA
TEL: (202) 358-0272
FAX: (202) 358-2771

The EMR technical point-of-contact:

Director General
Canada Centre for Remote Sensing
Energy Mines and Resources Canada
588 Booth street
3rd Floor, Room 327
Ottawa, Ontario K1A 0Y7
CANADA
TEL: (613) 947-1222
FAX: (613) 947-1382

ARTICLE 6

FUNDING ARRANGEMENTS

Each Party agrees to bear the costs of discharging its respective responsibilities as outlined above under this Agreement. The activities o the parties and the participants under this Agreement are subject to the availability of appropriated funds.

ARTICLE 7

PUBLIC INFORMATION

The Parties agree that the release of public information regarding this project may be made by the appropriate Party for its own portion of the program as desired and insofar as participation of the other Party is involved, after suitable consultation.

ARTICLE 8

SCIENTIFIC DATA

The Parties agree that there shall be no period of exclusive use of BOREAS data by the BOREAS Science Team. The BOREAS investigators shall have a reasonable period of time from the completion of the BOREAS field expedition to perform documentation, verification, and correction of their data prior to public release of the data sets. Each BOREAS investigator shall be expected to provide copies of the data collected to BORIS for deposit in the BORIS archive on a schedule that shall permit the archive to be released to the international scientific community as soon as possible, and in accordance with the data handling procedures adopted by the BOREAS Science Team

The Parties agree that the results of the investigations shall be made available to the scientific community in general through publication in appropriate journals or other established channels. In the event such reports or publications are copyrighted, the parties shall have a royalty-free right under the copyright to reproduce, use, and distribute such copyrighted work for their own purposes.

ARTICLE 9

INVENTION AND PATENT RIGHTS

The parties agree that nothing in the Agreement shall be construed as granting or implying any rights to, or interest in, patents or inventions of the parties or their contractors or subcontractors.

ARTICLE 10

LIABILITY

The Parties agree that, with respect to activities undertaken pursuant to this Agreement, neither Party shall make any claim against the other with respect to injury or death of its own or its contractors' or subcontractors' employees or investigators' employees or with respect to damage of any kind to or loss of its own or its contractors' or subcontractors' or investigators' property caused by either Party, or the Party's contractors, subcontractors or investigators, whether such injury, death, damage or loss arises through negligence or otherwise, except in the case of willful misconduct. The Parties agree, in the event of damage to third parties for which there is liability under national or international law, to consult promptly as to the possibility of an equitable sharing of any payments that have been or may be agreed in settlement.

This cross-waiver of liability shall not be applicable to claims between a Party and its contractors and subcontractors or to claims made by a natural person.

ARTICLE 11

IMMIGRATION DOCUMENTATION, AIRPORT AND CUSTOMS FEES

Both Parties will make best efforts, as appropriate, to arrange for the appropriate governmental authorities to waive any immigration documentation fees for persons working on BOREAS; to waive any landing, navigation, airways or airport entry and departure fees for aircraft required for BOREAS; and to provide free customs clearance of equipment and data required for BOREAS.

ARTICLE 12

EXCHANGE OF TECHNICAL DATA AND GOODS

Each Party shall furnish to the other Party only those technical data and goods necessary to fulfill the responsibilities of the furnishing party under this Agreement. It is the intent of the Parties to effect such a transfer without restrictions as to use or disclosure, subject to the following:

1. In the event a Party finds it necessary to furnish technical data in carrying out its responsibilities under this Agreement that are proprietary, and for which protection is to be maintained, such technical data shall be marked with a notice indicating that it shall be used and disclosed by the receiving Party and its contractors and subcontractors only for the purposes of fulfilling the receiving Party's responsibilities under this Agreement, and that the technical data shall not be disclosed or retransferred to any other entity without prior written permission of the furnishing Party. The receiving Party agrees to abide by the terms of the notice, and to protect any such marked technical data from unauthorized use and disclosure.

2. In the event a Party finds it necessary to transfer technical data and goods in carrying out its responsibilities under this Agreement that are export-controlled, the furnishing Party shall mark such technical data with a notice and identify such goods. The notice or identification shall indicate that such technical data and goods shall be used and such technical data shall be disclosed by the receiving Party and its contractors and subcontractors only for the purpose of fulfilling the receiving Party's responsibilities under this Agreement. The notice or identification shall also provide that such technical data shall not be disclosed, and such technical data and goods shall not be retransferred, to any other entity without prior written permission of the furnishing Party. The Parties shall abide by the terms of the notice or identification and shall protect any such marked technical data and identified goods. Nothing in this article requires the Parties to transfer technical data and goods contrary to national laws or regulations related to export controls or control of classified data.

3. The Parties are under no obligation to protect any unmarked technical data or unidentified goods.

ARTICLE 13

SETTLEMENT OF DISPUTES

The Parties agree that any disputes as to interpretation or implementation of this Agreement shall be resolved through consultation between the parties. The dispute shall be first referred to the NASA Associate Administrator for Mission to Planet Earth and the Assistant Deputy minister (Surveys, Mapping and Remote Sensing) of EMR for resolution. Any dispute which cannot be resolved at this level shall be referred to the NASA Administrator and the Deputy Minister of EMR for settlement.

ARTICLE 14

AMENDMENTS

This Agreement may be amended by written consent of the Parties.

ARTICLE 15

ENTRY INTO FORCE AND TERMINATION

This Agreement shall enter into force upon signature. It shall remain in force for three years after the completion of the final BOREAS campaign. Either Party may terminate this Agreement upon ninety day's written notice following consultation with the other Party.

Appendix G : Accomodations

NSA - Thompson

	Telephone	Fax
Mystery Lake Hotel	204/778-8331	204/778-4193
Keewatin Com. College	204/677-6462	--
Meridian Inn	204/778-8387	204/677-4087
Country Inn	204/778-8879	204/677-3225
Burntwood Hotel	204/677-4551	204/778-6219

SSA - Prince Albert

Prince Albert Inn	306/922-5000	306/922-2224
Marlboro Inn	306/763-2643	306/763-6336
South Hill Inn	306/922-1333	306/763-6408
Imperial 400 Motel	306/764-6881	306/763-6533
Sprucewood Lodge & Guest Lodge	306/929-2002	(same #)

SSA - Candle Lake

Snow Castle Lodge	306/929-2174	306/929-2191
Ship's Lantern	306/929-4555	306/929-3044
Minowukaw Lodge & Joe's Cabin	306/929-4619	none

SSA - Waskesiu Lake

Armstrong Hillcrest Cabins	306/663-5481	306/663-5481 (same #)
Waskesiu Lake Lodge	306/663-5311	306/663-5543
Hawood Inn	306/663-5911	306/663-5219

SSA - Christopher Lake

TF-1 Cabin	306/982-4326
TF-1 Cabin	306/982-4429
TF-1 Cellular Phone	306/981-7192

Appendix H: BOREAS Guidelines for the Conduct of Investigators in the Field for the Northern and Southern Study Areas

PREAMBLE: On arrival in the field, every BOREAS Investigator and staff member becomes an ambassador for the project. Both northern and southern study areas are traditionally used and highly valued by local peoples. Public.and professional interest in the project is high. As a "leading edge" environmental research project, BOREAS is expected to be exemplary in its project execution and operating protocols. Global altruism aside, the success of BOREAS will be measured as much by the deportment and actions of individuals in the field, as by the quality of science produced. The following guidelines have been developed in good faith to assist with achievement of BOREAS objectives, and require the full cooperation of all parties.

1.0 ACCESS TO NORTHERN STUDY AREA (NSA) SITES: NELSON HOUSE	
Investigators would do well to remember that boreal ecosystems have been utilized for millennia by aboriginal peoples whose very existence has depended on the development of an intimate relationship with the land, and a thorough appreciation for the intrinsic harmony binding ecosystem components.	
Traditional land use present and past	1.1 Investigators should familiarize themselves with traditional land use activities in the area and respect the rights of traditional users conducting subsistence harvest and other cultural activities. Map available from BORIS. 1.2 The Nelson House First Nation (NHFN) conducts spiritual ceremonies periodically at or near Mile 20 of highway #391. **Please do not disturb.** 1.3 First nation's cultural features encountered could include artifacts and burial sites. Do not disturb under any circumstances; but do inform the Nelson House Chief or council of any suspected find. The significance of artifacts or features is greatly diminished if disturbed from the environmental context.
Security and logistics	1.4 No sites have gates; all sites except the beaver pond have locked huts. Hut keys are available from the site captains or from the site manager "off season" or study area manager during field campaigns. 1.5 Two ARGOs will be available for use on NSA sites, one dedicated to OBS, the second a "floater" as needed. Contact site manager or study area manager.

2.0 ACCESS TO SOUTHERN STUDY AREA (SSA) SITES: (FEN, YJP, OJP, OBS)	
Security and logistics	2.1 Access to FEN, YJP, OBS is controlled by locked gates keyed alike. Keys will be made available through the SSA project office in Candle Lake, or in "off season" through the site manager. OJP is indefensible, with access available by several logging roads, hence no gate. Hut keys are available as above, with site Captains having executive powers for use. 2.2 Speed limit is 15 km/hr on all access trails for investigator and wildlife safety. Reduced speed will minimize vehicle damage and save on trail repairs. 2.3 Site visits should be coordinated to allow researchers to travel together whenever possible to minimize the number of vehicles parked at the trail head. 2.4 An ARGO will be used at the OBS site to transport equipment. A boardwalk provides pedestrian access.

3.0 GENERAL GUIDELINES FOR ALL SITES	
Check-In & Out Procedure	3.1 All investigators must notify the Site Manager "off season" or heck-in- and out at the Operations Center during field campaigns.
Wildlife	3.2 Black Bears, Elk and Moose are common in the study areas, and are dangerous. Bear sightings should be documented and reported. 3.3 All investigators are to make themselves familiar with bear country etiquette. Read available brochures like "You are in bear country" provided by Parks Canada. 3.4 A wildlife reporting sheet will be posted inside one hut at each site, to be maintained daily by investigators. 3.5 Incidents of injured wildlife, damage to property, or perceived behavioral threat to persons are to be reported immediately to the BOREAS Operations and site manager. Provincial Conservation Officers or national park Wardens will be notified of potential problems or incidents. 3.6 Do not feed, harass or entice wildlife. Some species are notorious equipment wreckers while others like fox and skunk are known rabies carriers.

3.0 GENERAL GUIDELINES FOR ALL SITES (continued)	
Waste Management	3.7 Use of pit privies is mandatory. Investigators are responsible for maintaining the facilities and plumbing in a working manner. 3.8 Grey water is to be disposed of only in a designated pit on site. This involves soapy wash water only, uncontaminated with chemicals. 3.9 All garbage is to be transported from the site on a daily basis, and disposed of appropriately in a regional landfill or recycling repository. Sorted aluminum, tin, glass and paper are collected at Waskesiu Lake, Christopher Lake and Prince Albert. Hazardous goods or containers must be deposited at a registered facility. 3.10 Burning of garbage or other waste is not acceptable.
Food Management	3.11 Unattended lunches are an invitation for unwanted wildlife encounters. Food is to be kept on-person or within hard-sided buildings. Bears have no respect for tents and other fabric property. 3.12 Overnight storage of food is not acceptable.
Water supplies	3.13 Local natural water bodies may not be used for potable or wash water.
Firearms	3.14 Firearms are not permitted within BOREAS operating areas.
Camping	3.15 Camping at flux tower sites (except PANP Aspen) may be permitted at the discretion of the flux sites captains. Provincial and National Park facilities are located within a reasonable commute of all sites.
Flux site etiquette	3.16 Vehicle and foot traffic is restricted to specific boardwalks and routes to reduce site disturbance. Foot trail networks and restricted areas will be identified at each flux site by Site Captains. 3.17 Smoking and fires are not permitted at flux sites. 3.18 Site Captains have supreme authority and must be contacted about all activities at that flux site. 3.19 All flagging at flux sites must be labelled with team ID (eg. TE-1) and date, otherwise it is fair game for removal.
Chemical handling, storage, disposal	3.20 Canadian Transport of dangerous goods, Canada Labour Code and WHMIS protocols are to be followed, in addition to applicable industry codes of good practice. (WHMIS - Workplace Hazardous Material Information System). 3.21 Site Captains are responsible for maintaining a spill contingency capability for all chemicals used at their respective sites.
Fuel Spills	3.22 BOREAS is responsible for providing a fuel spill contingency plan including containment capability for sites powered by generators. 3.23 Investigators using sites shall familiarize themselves with action protocols in the event of a fuel spill, to ensure that proper authorities are notified immediately.

3.0 GENERAL GUIDELINES FOR ALL SITES (continued)	
Cultural resources	3.24 Any artifacts observed are not to be disturbed or moved. Observations may be reported to local authorities which may be the Nelson House First Nation office, Prince Albert National Park or the respective provincial museums of natural history.
Public communication	3.25 Investigators should endeavour to transfer information to the local public in the form of a community presentation or other means. Communicating project science in lay terms will help to foster local support for BOREAS.
Safety	3.26 Standard first aid equipment will be available at each site. Site captains are to note any deficiencies and to report accidents/incidents. 3.27 Site captains shall see that potential safety hazards (including fire) are identified and abated, and to develop site-specific emergency communication protocols and evacuation procedures which are to be posted in a prominent place. 3.28 Investigators should travel and conduct fieldwork in pairs for safety. 3.29 Articles of bright clothing (blaze orange, red, or white) should be worn in the field to identify yourself as a non-game species. Legal sustenance harvest, licensed hunting and poaching are common in all BOREAS operating areas, year-round.
Fire Protection	3.30 Site Captains are to ensure that their site has adequate fire protection. 3.31 Forest Fire hazard condition reports by provincial authorities should monitored and investigators aware of any prohibitions. Exercise care at all times, even the hot exhaust pipes of a parked car can ignite dry fuels. 3.32 Any suspected smoke sources spotted in the forest should be reported to the Provincial and National Park authorities without delay.
Self-sufficiency & medevac procedures	3.33 Investigators are expected to arrive in the field fully prepared for work with minimal or no support. The boreal forest is a wet, cold, buggy place abounding in creatures sharp in tooth and claw, so dress accordingly. All investigators shuld read and carry a copy of the BOREAS Medevac Procedures.

4.0 ACCESS TO PRINCE ALBERT NATIONAL PARK	
Parks Canada appreciates and supports the efforts of BOREAS investigators towards understanding the functioning of boreal ecosystems. The privilege to study undisturbed protected ecosystems comes at a cost: the responsibility to ensure that BOREAS activities do not compromise national parks values. Parks Canada has undertaken the unprecedented step of amending park land use zoning to accommodate study site development and access. Consequently Parks Canada credibility is at issue with stakeholders, including the broader research community. BOREAS Investigator deportment and example will have direct bearing on future research opportunities in Canadian national parks.	
Permit requirement	4.1 Principal investigators or BOREAS staff conducting research within the national park must hold a valid *Research and Collection permit* authorized by the park superintendent, and comply with permit conditions. Contact Mary Dalman to obtain one in advance. 4.2 Permit holders are responsible for the conduct of their field parties and compliance with park regulations. 4.3 Any change in the scope of the research proposal or location(s) of work as specified in the research permit must be approved by the park superintendent and the permit amended accordingly.
Access: Fish Lake trail (5.5 km)	4.4 The locked gate at the Fish Lake trail juncture with gravel highway 240 regulates site access to ensure infrastructure security and experiment integrity. The Fish Lake trail is open to the public for wilderness hiking /cycling /skiing/ equestrian experiences. 4.5 Vehicle access is restricted to BOREAS investigators and staff with permits. Vehicles are not permitted on the Fish Lake Trail beyond the ATV trailhead. 4.6 The gate is to be kept locked at all times. Keys are available through the Site Manager (PANP). 4.7 The speed limit at all times is 15 km/hr. 3.8 Respect the rights of self-propelled wilderness travellers: vehicles shall yield the right of way at all times. When encountering equestrian users, passenger vehicles shall pull off to the side of the trail and shut off their engine, to allow the horse(s) to pass, before continuing. 4.9 The Fish Lake trail may be temporarily closed to motor vehicle access under some circumstances, including extended wet summer weather or spring thaw causing very soft surface conditions; or when winter snowfall accumulation is suitable for ski trail tracking. 4.10. Winter use is restricted to ski travel, unless authorized by the site manager to transport equipment.

4.0 ACCESS TO PRINCE ALBERT NATIONAL PARK (continued)	
Parking	4.11 Parking is permitted along the edge of the Fish Lake trail and at the gravel pit located 500m south of the Foot/ATV trail head. 4.12 No parking is permitted within 10m of the Foot/ATV trail, to allow for unloading. 4.13 A designated vehicle turn-around is to be used.
Foot/ATV trail (1.5 km)	4.14 No passenger vehicles permitted on this trail under any circumstances. 4.15 Foot travel is the primary and preferred access. 4.16 4-wheel ATV may be used to transport bulky or heavy equipment if required. 4.17 Provincial law requires the use of helmets for ATV or over-snow machines
Camping	4.18 Camping is not permitted at the Aspen flux site. Measurements requiring overnight use of the site must be registered in advance with the Site Manager.
Aircraft overflights	4.19 Low level flights should be minimized particularly on weekends, and avoid developed areas including picnic and campgrounds at Waskesiu Lake and townsite, and Namekus, Trappers and Sandy Lakes.
Firearms	4.20 Firearms are not permitted under any circumstances.

Appendix I: BOREAS Auxiliary Site Directions

Northern Study Area (NSA) Auxillary Sites

Site ID	Species	Age Class	Productivity Class	Directions (road distances are imprecise - see text)
Q1V2M	Mixed	??	Low-High	From int. of Rt.391 and Rt.375 go 23.6 km S on 375 to tie-in-pt; 100m @ 77° to pt. 1; 100m @ 77° to pt. 2; 100m @ 77° to pt. 3; 100m @ 77° to pt. 4.
S9P3A	Aspen	Intermediate	Medium	From int. Hwy 391 and Nelson House access road go W 3.5 km to tie-in-pt on N side of rd, on E end/crnr of rd clearance/ditch; 110m @ 358° to pt. 1; 142m @ 40° to pt. 2; 158m @ 40° to pt. 3.
T0P5M	Mixed	??	High	From int. of int. Hwy 391 and Nelson House access road go 2.25 km W to tie-in-pt on N side of rd - bndry meets rd clearance; 142m @ 19.5° to pt. 1; 158m @ 57° to pt.2; 71m @ 39° to pt. 3; 111m @ 79° to pt. 4.
T0P7S	Black Spruce	Mature	Low	Go 0.6 km S of int. Hwy 391 and Nelson House access road to tie-in-pt @ SW crnr of square clearing ; 63m @ 240° to pt. 1; 111m @ 360° to pt. 2; 111m @ 343° to pt. 3; 82m @ 22° to pt. 4.
T0P8S	Black Spruce	Mature	??	From int. of Rt.391 and Gillam Road go W 45.9 km to tie-in-pt @ SE crnr of clearing w/ circ. depression (int Rt.391 and Nelson House access road); 79m @ 164° to pt. 1; 111m @ 252° to pt. 2; 111m @ 232° to pt. 3.
T5Q7S	Black Spruce	Mature	High	From int. of Rt.391 and Gillam Road go W 49.7 km to tie-in-pt @ NW crnr of clearing on N side of 391 (15.1 km E of int Rt.391 and Nelson House access road); 79m @ 300° to pt. 1; 110.6m @ 20° to pt. 2; 189.6m @ 54° to pt. 3.
T8Q9P	Jack Pine	Intermediate	Medium	From int. of Rt.391 and Gillam Road go W 45.9 km to tie-in-pt @ int of west edge of rect clearing N of 391 road clearance (17.5 km E of int Rt.391 and Nelson House access road);
T9Q8P	Jack Pine	Intermediate	Low	From int. of Rt.391 and Gillam Road go W 46.0 km to tie-in-pt @ intersect of 391 and rd to gravel pit, near NE crnr of stand 144 (23.7 km E of int Rt.391 and Nelson House access road); 63.2m @ 104° to pt. 1; 189.6m @ 64° to pt. 2; 252.8m @ 75° to pt. 3.
T6R5S	Black Spruce	Intermediate	High	From int. of Rt.391 and Gillam Road go W 39.6 km to tie-in-pt 160m to E of where line intersects 391 (23.8 km E of int Rt.391 and Nelson House access road); 63m @ 183° to pt.1; 111m @ 184° to pt. 2; 111m @ 184° to pt. 3.
T7R9S	Black Spruce	Disturbed	Low	From int. of Rt.391 and Gillam Road go W 35.2 km to tie-in-pt on S side of rd, opp NW crnr of access rd (to tower) and 391; 142m @ 208° to pt. 1; 79m @ 194° to pt. 2.
T7S9P	Jack Pine	Intermediate	Medium	From int. of Rt.391 and Gillam Road go W 25.1 km to tie-in-pt @ intersect of temp. rd. w/clearance; 316m @ 266° to pt. 2; 158m @ 330° to pt.1; from pt. 2 go 158m @ 186° to pt. 3.
T8S9P	Jack Pine	Disturbed	Low	From int. of Rt.391 and Gillam Road go W 25.1 km to tie-in-pt @ SE crnr of flask-shaped clearing, on trail leading to SE; 79m @ 116° to pt.1; 158m @ 116° to pt. 2; 158m @ 116° to pt. 3.

Northern Study Area (NSA) Auxillary Sites

Site ID	Species	Age Class	Productivity Class	Directions (road distances are imprecise - see text)
T6T6S	Black Spruce	Intermediate	Low	From int. of Rt.391 and Gillam Road go W 18 km to tie-in-pt adj. to oblong clearing (on S side of 391), on N side of rd (~6.1 km W of access to spiritual area); 142.2m @ 184° to pt. 1; 110.6m @ 270° to pt. 2; 110.6m @ 250° to pt. 3.
T7T3S	Black Spruce	Mature	Low	From int. of Rt.391 and Gillam Road go W 20.7 km to tie-in-pt @ red flag opp of rd. clearance to where NW crnr of oblong clearing (on S side of 391) (~8.8 km W of access to spiritual area); 79m @ 34° to pt. 1; 95m @ 118° to pt. 2; 95m @ 118° to pt. 3.
T8T1P	Jack Pine	Disturbed	Low	From int. of Rt.391 and Gillam Road go W 23.4 km to tie-in-pt @ SW crnr of gravel pit, on N side of 391; 95m @ 322° to pt.1; 142m @ 40° to pt. 2; 221m @ 360° to pt. 3.
T3U9S	Black Spruce	Intermediate	Low	From int. of Rt.391 and Gillam Road go 4.7 km to tie-in-pt @ Hwy 391 clearance opp. where drainage ditch intersects N side of road; 173.8m @ 169° to pt. 1; 126.4m @ 121° to pt. 2; 126.4m @ 121° to pt. 3.
T4U5A	Aspen	Intermediate	Low	From int. of Rt.391 and Gillam Road go 8.0 km to tie-in-pt @ NE crnr of beehive-shaped clearing on S side of rd, go 458m @ 223° to pt. 1; 173.8m @ 190° to pt. 2.
T4U9S-1	Black Spruce	Intermediate	Medium	From int. of Rt.391 and Gillam Road go 4.7 km to tie-in-pt @ bottleneck of clearing on N side of 391; 442m @ 80° to pt. 1; 95m @ 68° to pt. 2; 158m @ 30° to pt. 3.
T4U9S-2	Black Spruce	Intermediate	Low	From int. of Rt.391 and Gillam Road go 4.7 km to tie-in-pt @ E lobe of clearing on N side of 391; 146m @ 60° to pt. 1; 223m @ 112° to pt. 2; 158m @ 117° to pt. 3; 56m @ 117° to pt. 4.
V5X7A	Aspen	Intermediate	Low	From int. of Rt.391 and Gillam Road go 33.3 km NE on Gillam Rd to tie-in-pt; 63m @ 324° to pt. 1; 95m @ 40° to pt. 3; From pt. 2 - 87m @ 252° to pt. 1.
W0Y5A	Aspen	Intermediate	Low	From int. of Rt.391 and Gillam Road go 42.7 km NE on Gillam Rd (Odei River bridge @40.9km) to tie-in-pt @ NE edge of ditch; 237m @ 313° to pt. 1; 110.6m @ 21° to pt. 2; 94.8m @ 21° to pt.3
Q3V3P	Jack Pine	Mature	High	From int. of Rt.391 and Rt.375 go 27 km S on 375 to tie-in-pt;
P7V1A	Aspen	Mature	??	From int. of Rt.391 and Rt.375 go 33.3 km S on 375 to tie-in-pt;
R8V8A	Aspen	Mature	??	From int. of Rt.391 and Rt.375 go 27 km S on 375 to tie-in-pt;
S8W0P	Jack Pine	Mature	Medium	From int. of Rt.391 and Gillam Road go 7.7 km E on 391 to tie-in-pt;
T8S4A	Aspen	Young	??	From int. of Rt.391 and Gillam Road go W 30.6 km to tie-in-pt;
O9P	Jack Pine	??	??	From int. of Rt.391 and Nelson House access road go W 14.9 km to tie-in-pt;

Southern Study Area (SSA) Auxillary Sites

Site ID	Species	Age Class	Productivity Class	Directions (road distances are imprecise - see text)
B9B7A	Aspen	Intermediate	??	From intersection of Rt.2 and Rt.263, west 21.5 km to intersection of Rt.240 (@Buffalo Paddock), then west on 240 for 9.4 km to tie-in point on north side of road. From tie-in, due E 250m to site 1; 500m @ 126° to site 2; Due E 500m to site 3.
D9G4A	Aspen	Mature	High	From int Rt.120 and Rt.926 (to Snowcastle Lodge), 16.4 km to tie-in-pt on the top of a very large berm; 50m @ 65° from tie-in-pt to site 1; 312m @ 58° to sites 2 & 3.
D0H6S	Black Spruce	Mature	High	From int Rt.120 and Rt.926 (to Snowcastle Lodge), 1.4 km to tie-in-pt. 125m @ 343° from edge of clearing to site (intersection of two cutlines); 187.5m @ 342° from bend in cutline, 325m @ 360° over or around fen.
D9I1A	Aspen	Intermediate	Medium	From int. Rt.120 and Rt.265 (to Candle Lake), 2.8 km NE to tie-in-pt; 112.5m @ 28° to site 1; 325m @ 339° to pts 2 & 3.
D6H4T	Aspen	Young	High	From int. Rt.120 and Rt.926 go N 5.6 km to access road to Snowcastle Lodge, follow access to end at the Lodge, then return W to 1st line cut on S of road. Follow to tower.
D6L9A	Aspen	Disturbed	Medium	From int. of Harding Rd and Rt.106 go S 25.6 km on Rt.106 to tie-in-pt (alt 21.8 km N of int Rt.106 and Rt.55); from S loop of trail fork directly W of stand 722; 124m @ 254° to site 1; 313m @ 254° to site 2; 375m @ 254° to site 3.
E7C3A	Aspen	Mature	High	From intersection of Rt.2 and Rt.263, west 21.5 km to intersection of Rt.240 (@Buffalo Paddock), then north 30.9 km to intersection of Nanekus Lake Rd w/rd (scenic rte) to Washesia; thru park; go 290m @ 270° to pt. 1; 250m W to pt. 2; 250m W to pt. 3.
F5I6P	Jack Pine	Intermediate	Low	From int. of Rt.120 and Rt.913, 1.7 km N to tie-in-pt where trail intersects Rt 913; 183m @ 80° to beg. of transect, then 600m @340° to pt. 2; 600m @ 340° to pt. 3.
F7J0P	Jack Pine	Mature	High	From int. of Rt.120 and Rt.913, 5.3 km to tie-in-pt where trail intersects Rt.120 clearance, go 225m @ 90° to pt. 1; 187.5m @ 94° to pt. 2; and 187.5m @ 94° to pt. 3.
F7J1P	Jack Pine	Mature	Medium	From int. of Rt.120 and Rt.913, 6.9 km to tie-in-pt on S side of Rd; 62m @ 220° to pt. 1; 125m @ 220° to pt. 2; 100m @312° to pt. 3; 87.5m @ 306° to pt. 4.
G2I4S	Black Spruce	Intermediate	High	From int. of Rt.120 and Rt.913, 9.6 km N on Rt.193 to tie-in-pt; 187.5m @ 69° to site 1; 187.5m @ 74° to site 2; 187.5m @ 74° to site 3.
G4I3M	Mixed	??	Medium-High	From int. of Rt.120 and Rt.913, 11.7 km N on Rt.193 to tie-in-pt; 298° for 250m to site 1; 280° for 250m to site 2; 149° for 250m for site 3.
G1K9P	Jack Pine	Mature	Medium	From int. Harding Rd and Rt.120 go 2.9km E on Harding to tie-in-pt @ SW crnr of "house-shaped" cut block, N of road; 400m @ 80° to pt 1; 375m @ 160° to pt 2; 375m @ 160° to pt 3.

Southern Study Area (SSA) Auxillary Sites

Site ID	Species	Age Class	Productivity Class	Directions (road distances are imprecise - see text)
G6K8S	Black Spruce	Mature	High	From int. Harding Rd and Rt.120 go 2.7 km N on Rt.120 to tie-in-pt; 375m @ 93° to site 1; 250m @ 73° to site 2; 250m @ 73° to site 3.
G7K8P	Jack Pine	Mature	Low	From int. Harding Rd and Rt.120 go 3.5 km N on Rt.120 to tie-in-pt; 600m @ 353° to sample pt.; sample pt. 2 is 337.5m @ 304°; sample pt. 3 is 337.5m @ 304° (past logging road).
G8K8P	Jack Pine	Mature	Low	From int. Harding Rd and Rt.120 go 4.4 km N on Rt.120 to tie-in-pt; 325m @ 312° from tie-in-pt (25m from SW corner of stand 99 on rd); 375m @ 347° to site 2; 375m @ 347° to site 3.
G2L7S	Black Spruce	??	Low	From int. Harding Rd and Rt.120 go 10.6 km E on Harding to tie-in-pt @ trail intersect w/ old Hwy 106 clearance @ 541-362 E boundary; 288m @232° to pt.1; 188m @236° to pt. 2; and 187m @ 236° to pt. 3.
G8L6P	Jack Pine	Disturbed	Medium	From int. Harding Rd and Rt.106 go 7.6 km N on Rt.106 to tie-in-pt (283° from fork in rd); 363m to site 1; 375m @ 163° to site 2; 375m @ 163° to site 3.
G9L0P	Jack Pine	Mature	Medium	From int. Harding Rd and Rt.120 go 6.2 km N on Rt.120 to tie-in-pt; 500m @ 194° to site 1; 375m @ 118°to site 2; 375m @ 118° to site 3.
I2I8P	Jack Pine	Intermediate	Low	From int. Rt.120 and Rt.913 go 23.7km N on 913 to tie-in-pt on N side of rd; 125m @ 0° to pt. 1; 125m @ 0° to pt. 2; 125m @ 0° to pt. 3;
H3D1M	Mixed	??	??	From int. Rt.2 and Rt.264 (Waskesiu access) go N 24.7 km on Rt.2 to tie-in-pt;
H2D1M	Mixed	??	??	From int. Rt.2 and Rt.264 (Waskesiu access) go N 24.3 km on Rt.2 to tie-in-pt;
H2D1S	Black Spruce	??	??	From int. Rt.2 and Rt.264 (Waskesiu access) go N 23.7 km on Rt.2 to tie-in-pt;
H1E4S	Black Spruce	??	??	From int. Rt.2 and Rt.264 (Waskesiu access) go N 13.3 km on Rt.2 to int Rt.169, then NE 14 km to Montreal Lake, then E 2.9 km to tie-in-pt;

Appendix J BOREAS Modeling Contributions

BOREAS Model Intercomparisons Plan
April 10th 1994
Joseph C. Coughlan and Steven W. Running

1. Background: At the February '94 Modeler's Meeting in Missoula, the BOREAS modelers agreed to run their models with data for five community types representing the tower flux sites at the NSA (North Study Area) and SSA. The plan is to run all models with identical initial values and boundary conditions and drive them with identical climate data. Both archived climate data and a set of prescribed site conditions likely to be measured at the tower flux sites will be provided to the BOREAS modelers. Site parameters, their values and selected output data for model comparisons are tabulated in this document. The climate data for the SSA and NSA is recorded at a hourly time resolution (from the airports) and the data will be arithmetically averaged into daily and monthly sets and made available in April. The quality of the climate data is still unknown but the list of data fields and their units are posted in this document. The site conditions are estimated from literature and field expeditions to the tower sites.

The objectives of the intercomparison exercise are: 1) compare simulation results of participating terrestrial, hydrological, and atmospheric models over selected time frames; 2) learn about model behavior and sensitivity to estimated boreal site and vegetation definitions; 3) prioritize BOREAS field data collection efforts supporting modeling studies; 4) identify individual model deficiencies as early as possible; 5) present the model comparison results at the BOREAS modelers meeting near IFC-2 and a final report to the BOREAS modelers meeting during the November '94 meeting.

2. For the modeling workshop in Missoula (Feb. '94) the following group representatives presented their modeling plans for BOREAS.

2.1 Terrestrial: Running, Frolkin, Coughlan, Knox, Ojima, Nikolov, Collatz, Prince and Price

2.2 Hydrology: Band, Lettenmaier, and Ek,

2.3 Atmospheric: Pielke, Lee, and Dickenson

2.4 Additional modelers, R. Cuenca, D. Baldocchi and D. Verseghy are participating.

3. For organizing and planning purposes, each group identified in section 2 (above) should submit the following items to Steve Running and Joseph Coughlan:

3.1 Model name, brief model description, (with citation if one is not in the modeling compendium) and a person of contact. This individual might be the person generating the model output.
3.2 Temporal resolution that the model will be run in the exercise: both time frame and step (see Table 1).
3.3 Required climatic variables for running the model.
3.4 Community type parameters needed for the model (see Table 2).
3.5 Output your group will submit for comparison to other models (see Table 1). Both time frame (i.e. annual) and time resolution (i.e. daily, or monthly).

The context for all the information requested is defined by the model intercomparison exercise. Model information extraneous to the exercise is not necessary. If there is any missing site parameter, unacceptable parameter value (Table 2), or unacceptable algorithm generating a data value then please mail an addition / correction to Steve Running & Joseph Coughlan as soon as possible.

4. Table 1. Model comparison matrix

Model Comparisons will be made with the data in Table 1. for the selected time frames listed in the Table. No model is expected to fill all the data in this table. The comparison data also coincides with field measurements collected during the IFC's for model validation. The modelers will provide the data in Table 1 for the time frames of interest. Data should be submitted in the appropriate time resolution and units.

The categories for data comparisons in Table 1. are energy / power, water, and carbon. The time categories are "golden" or selected days (hours, daily total) monthly (daily, monthly total), annual (daily or monthly and annual total). For now, year totals are defined by calendar and not water years.

Table 1. Model comparison matrix

	Annual	**Monthly**	**Selected Days#**	**Other**
Energy	Latent and Sensible	Latent and Sensible	Diurnal Cycle	Diurnal Cycle
Water	E, T Runoff	E, T delta theta	E, T, R, Theta, Snowmelt Groundthaw theta Avg.	
Carbon	NPP Soil Resp	NPP Respiration	Net CO_2 exchange	

The units for data in Table 1 are: Energy Jm^{-2} and Power Wm^{-2}. Water (with snow in SWE) mm for 1-D and m^3ha^{-1} for volume; hydrologic budget in 1-D units. Carbon flux (gas) mmole CO_2 m^{-2} (methane flux?), mg ha^{-1} of C for biomass. Mass of Carbon (leaf, stem, root, litter, and etc.) is C only, not wet or dry weight biomass - dry weight is carbohydrate and convert to C with molecular weight. See comparison time frames/steps in Table 1 for reporting measurements: hour, day, month or year. Label respiration: maintenance, growth, autotrophic and/or etc. Identify productivity as canopy net after maintenance respiration costs are deducted and/or d_growth after allocation and growth respiration costs are deducted. Transpiration should represent a complete vegetation-soil surface (over and understory).

5. Table 2. Model Parameter Value Matrix

The follow parameter list should be used by all modelers. Not all model parameters will be in this list and not all models will use all the data. If there is a critical variable missing which is common to a class of model then please define and mail in the parameter and its initial value(s). Again, if there are suspect or inconsistent values/assumptions then contact Running and Coughlan. Fen and Peat soils still need data values.

Table 2. Model Parameter Value Matrix.

Class	Cwet	Cdry	Dec	Fen	Disturbed
Parameter					
Emissivities	1	1	1	1	1
Albedo					
Veg	0.1	0.1	0.17	0.15	0.2
Snow	0.6	0.6	0.6	0.6	0.6
Zo/h ratio	0.1	0.05	0.	0.1	0.1
SLA($m^2 kg\ C^{-1}$)	27	27	55	40	40
Amax(mmol $m^{-2} s^{-1}$)	10	13	15	15	13
gmax(mol $m^{-2} s^{-1}$)	0.15	0.20	0.25	0.25	0.20
Soil					
Class(Table 3)	peat	sand	clay	FEN	sand
Damping depth	1m	2m	2m	1m	2m
Rooting depth	1m	2m	2m	0.5m	2m
Understory	moss- -sphag.	lichen +50% evgrn	shrub	n/a	50% evgrn +50% soil
Litter layer	needles & peat	needles	BrdLfs	n/a	sparse
(stand conditions)					
NSA (north)	**Cwet**	**Cdry**	**Dec**	**Fen**	**Disturbed**
Can ht north	10m	10m	15m	1m	3m
Veg C tot (Mg/ha)	42	26	71	10	7
Stem C (Mg/ha)	30	20	50	3	5
Root C (Mg/ha)	10	5	20	4	1.5
foliage C (Mg/ha)	2	1	1	3	0.5
Soil/Peat (Mg/ha)	150	50	75	1300	30
Foliage C (kg C/m^{-2})	0.2	0.1	0.1	0.3	0.05
SLA (m^2/kg C/m^{-2})	12.5	12.5	22.5	15	12.5
LAI (projected)	2.5	1.25	2.25	4.5	0.625
(stand conditions)					
SSA (south)	**Cwet**	**Cdry**	**Dec**	**Fen**	**Disturbed**
Can ht south	12m	13m	20m	1m	3m
Veg C tot (Mg/ha)	89	59	100	12	11
Stem C (Mg/ha)	65	45	70	3	8
Root C (Mg/ha)	20	12	28	5	2
Foliage C (Mg/ha)	4	2	2	4	0.6
Soil/Peat (Mg/ha)	60	60	110	1200	30
Foliage C($KgCm^{-2}$)	0.4	0.2	0.2	0.4	0.06
SLA ($m^2 kg\ C^{-1}$)	12.5	12.5	22.5	15	12.5
LAI (projected)	5	2.5	4.5	6	0.75

5.1 Table 3. Soil Properties for soils classes in Table 2

Table 3. Thermal properties of soils and snow (Wijk and Vries 1963; as by Hillel, 1982).

	porosity Void frac	volu. wetness O	thermal k J(cm sec C)$^{-1}$	heat capacity J cm^{-3}C^{-1}	damping depth (diurnal) cm
Sand	0.4	0.0	0.0029	1.3	8.0
	0.4	0.2	0.0176	2.1	15.2
	0.4	0.4	0.0218	2.9	14.3
Clay	0.4	0.0	0.0025	1.3	7.4
	0.4	0.2	0.0117	2.1	12.4
	0.4	0.4	0.0159	2.9	12.2
Peat	0.8	0.0	0.0006	1.5	3.3
	0.8	0.4	0.0029	3.1	5.1
	0.8	0.8	0.0050	4.8	5.4
Snow	0.95	0.05	0.0006	0.2	9.1
	0.8	0.2	0.0013	0.8	6.6
	0.5	0.5	0.0071	2.1	9.7

5.2 Additional soil properties: hydrologic.

Sand:

$\Psi_S = 12$

$K_S = 0.002$ cm s^{-1} (k_S=hydrolic conductivity at saturation)

porosity=40% void

b= 4 (constant from Clapp and Hornberger 1978)

Clay (sandy clay):

$K_S = 2.17*10^{-4}$ cm s^{-1}

porosity = 40% void

$\Psi_S = 15$

b = 10

Peat

K_S = n/a

Porosity=80% void

Ψ_S = n/a

b = n/a

Peat deeper clay-sand-loam (20cm):

$K_S = 0.00063$ cm s^{-1}

Porosity = 40% void

$\Psi_S = 8.5$

b = 7

FEN use peat soil and see below

Soil Equations:

$\Psi(W) = \Psi s * (W^{-b})$

where:

W = soil water content = vol/vol total

b = constant from Clapp and Hornberger 1978

$K(W) = K_s * Wc$

where:

c = 2b + 3

5.3 Operational methods for Soil / Hydrology Model Initialization: Start the model on September 1st with initial data. Assume that the soils are at 50% field capacity (with an even distribution of water) on September 1 and the soil temperature at the surface layer is the average air temperature for the month of September and the temperature at the damping depth is the average air temperature for the year. By January, snow will accumulate and soil moisture may begin to differ, however, these differences are due to the models and not to different data.

Soil Temp (see Table 5a for climate data summaries)

at surface	Mean monthly temp. for initial month
at damping depth	Mean annual temp.

Fens will have saturated soils. For computing the Fen soil's thermal properties and assumptions refer to LaFleur and Rouse (1990, Ag. For. Met. 135-153) Pages 141 and 142. Also refer to Table 3 in this document.

Wet conifer will have a 20 cm peat layer beneath the moss. Below that peat layer is a clay-sand-loam soil. For models with a single soil layer use a clay-sand-loam definition.

6. Climate Data Description

We have a year's worth of hourly data starting Jan 2 (1989) from Thompson and Prince Albert airports.

Table 4a. Parial list of climate data fields and units form both Thompson (th) and Prince Albert (pa) Airports.

Hourly data.

Mo - Month,
Da - Day of Month,
Hr - hour
Psea - sea level pressure (mb)
Td - dew point (degrees C)
Vs - Wind speed (Km/h)
P - Station pressure (mb)

T - Temperature (degrees C)
Cloud - Cloud cover in tenths
DD - wind direction (10 degree intervals)
U - wind component
V - wind component
q - mixing ration (g water / kg dry air)
LW - Total Longwave (W m^{-2} hr^{-1},computed)
SW - Total Shortwave (MJ m^{-2} hr^{-1}, computed)

Table 4b Daily data.

Mo - Month
DOM - Day of month
SAM - Station acronym month
D - Day
Tmax - Daily maximum temp, (degrees C)
Tmin - Daily minimum temp, (degrees C)
Rain - Total rainfall (mm)
Snow - Total snowfall (cm)
Precip - Total precip (mm)
Grnd.Snow - Snow on ground (cm)
Trange - temperature range
X - cumulative 10 day intervals)
LW - Total Longwave (W m^{-2} day^{-1},computed)
SW - Total Shortwave (MJ m^{-2} day^{-1}, computed)

Shortwave is estimated using an hourly time step results summed for the day (Running et al. 1987). Daily atmospheric transmissivity is computed with the air temperature amplitude method from Bristol and Campbell (1984). The specifics are too long to include in this document.

Longwave is estimated with the method in Heitor et. al (1991) Agric. and For. Met. 54:29-48. The daily LW estimate is made with 24 hour average inputs (from the hourly data). Hourly LW were computed with the hourly data.

$Lw = e * 5.67*10^{-8} * Tak^4$
where
Lw - incoming thermal radiation (W/m^2)
5.67e-8 - S-B constant (W m^{-2} K^{-4})
e - atmospheric emissivity (dimensionless)

$e = (0.6 + 0.048 * Ea^{0.5}) * (1 + 0.23 * N)$
where
0.6 - Clear-sky atmos. emissivity in the absence of water-vapor, at screen height

(non-dimensional)
0.048 - coefficient ($hPa^{-0.5}$)
0.23 - coeff. (dimensionless)
N - fractional cloud cover (dimensionless)
Ea - atmos. water vapor pressure (hPa).

All climate data will be placed on anonymous FTP on BORIS in the raw form, corrected, and temporally aggregated along with aggregation methods. Some summary climatic and simple moisture balance information is below in Tables 5a and 5b.

Table 5a. Physical and long term climatic data from the airport meteorological stations.

	elev. meters	Lat. deg..	long deg.	annual tmp.(c)	annual. ppt.(mm)	PET (mm)	July max.	July min.
P.A.:	428	53.2	105.7	0.1	398	446	24.2	10.6
Thmpsn:	212	55.8	97.9	- 3.9	544	299	22.6	8.7

Table 5b. PPT-PET (mm) by month (-value is a moisture deficit)

	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	12mo.
P.A.:	-6	-32	-22	-44	-36	-3	5	-48
Thmpsn:	34	2	-14	5	7	40	42	245

7. Time Table for the comparison exercise.

March 1	Model summaries due to Steve Running and Joseph Coughlan
April 1	A status report to modelers with final site definitions.
April 15	Climate data available on anonymous FTP
June 1	Table 1. Results to Joseph Coughlan
July 23-27	Report to modelers at PA Meeting.

Thanks to:
R. Knox, J. Collatz, D. Price, L. Band, N. Nikolov, T. Hogg, R. Hurdle, J. Coughlan

Appendix K: Measurement Methodologies

Hemi-Surface Area Definition

The most desirable foliage area to use in reporting results from conifer shoots and broad leaves is to use one-half the total surface area, which we shall refer to as Half the Area of the Surface of the Leaf (HASL). For flat leaves the hemi-surface area is the same as the projected area, but for conifer needles or shoots "projected area" is not even well defined and generally not used consistently. Hemi- surface area is not easy to misinterpret for any object.

Hemi-Surface Area Measurement

Surface area for conifer shoots can be measured by several methods, but the two most common are volume displacement and projected area of detached needles using an optical planimeter.

Using the optical planimeter is tedious because needles have to be carefully aligned so as to present their maximum area to the planimeter. Given the measured needle projected area of all the needles that have been detached from the shoot and a known cross sectional shape for the needles, the surface area can be calculated and divided by two to get HSA.

A faster method that is as reliable as the planimeter method and does not require an expensive optical planimeter is the VOLUME DISPLACEMENT METHOD. This method requires a reasonably good, top-loading electronic balance; something common to any lab. The procedure is as follows:

1) A container that is large enough for an intact shoot to be submerged in is filled with water and about 3-5% detergent mixed in with the water. The detergent is necessary because it prevents small air bubbles and films from accumulating on the surface of the shoot. The container has to be large enough for the shoot to be submerged without touching the walls of the container. If shoots are too large, needles can be detached and submerged in the container using a fine wire.

2) The container and liquid are placed on a top loading electronic balance and tared to provide a zero reading. An intact shoot (or a group of needles from a shoot) is submerged in the liquid with out touching the walls of the container and the weight recorded. To push the shoot into the water a force equal to thebuoyant force must be applied. The buoyant force is related to the mass of the volume of water displaced by the shoot. Thus, the volume of the intact shoot (V) in cubic centimeters is numerically equal to the weight increase indicated on the balance.

3) The number of needles on the shoot (n) are counted and their averaged length (L) determined from a subsample of 10 to 20 needles spaced over the length of the shoot.

4) For precise work, the needles can be removed from the shoot and the volume of the woody portion of the shoot measured by submerging it in the liquid-filled container on the balance. The needle volume is the difference between the total volume and the woody volume. The volume of the woody portion is generally 5 to 15% of the total volume.

5) The shape of the cross sectional area is determined from observations under a microscope. This shape is usually fixed for all needles of a given species and so has to be determined only once for a given species. This shape determines the coefficients in an equation that relates the above measurements to surface area (SA).

The total surface area (SA) of a group of conifer needles is given by:

1) $SA = nLP$

where n is the number of needles, L is their mean length and P is the length of the perimeter of the needle cross section. The volume of the needles is:

2) $V = nLA$

where A is the needle cross section. Solving for A gives:

3) $A = V/(nL)$.

We can define a dimensionless "shape factor" X:

4) $X = P/\mathrm{sqrt}(A)$

thus

5) $P = X\ \mathrm{sqrt}(A)$.

Substituting this into 1) gives:

6) $SA = nLX\ \mathrm{sqrt}(A)$

and from 3):

7) $SA = nLX\ \mathrm{sqrt}[V/(nL)] = X\ \mathrm{sqrt}(VnL)$.

This equation is valid for any arbitrary cross-sectional needle shape. Moreover, the factor will remain constant even if the needle tapers at its end, provided its shape remains the same.

Shape	**Equation**	**Species**
Square	SA = 4.00 sqrt(V n L)	Spruce
Ellipse (1:3 ratio of axes	SA = 4.17 sqrt(V n L)	Douglas-Fir
Cylinder	SA = 3.54 sqrt(V n L)	
Hemi-Cylinder	SA = 4.10 sqrt(V n L)	Black Pine
Rectangle (width=length/10) (width=length/4) (width=length/3) (width=length/2)	 SA = 6.96 sqrt(V n L) SA= 5.00 sqrt(V n L) SA = 4.62 sqrt(V n L) SA= 4.24 sqrt(V n L)	

Note: sqrt means square root of the quantity in ( ).

Careful measurements of total surface area were done on several species by both the volume displacement method and optical planimeter method.

Species	**Optical Planimeter (mm^2)**	**Volume Displacement (mm^2)**
Blue Spruce	3276	3216
Douglas-Fir	9990	9705
Black Pine	4084	3900

With Douglas Fir, if detergent was not added to the water, the Volume displacement method overestimated the surface area by 35% in one case and 39% in a second case because of entrapped air.

HSA is just one half the total surface area.

Proposal: Investigators using the volume displacement method should report total and half surface area (SA and HSA, respectively) along with the shape factor (X). A description of the method used to calculate the shape factor should also be provided.

Appendix L: AES Surface Weather Stations

ENVIRONMENT CANADA **Active Stations Operating Between the years 1991 and September, 1993**
Between Latitudes 51°N and 60°N and Longitudes 94°W and 111°W
ALL PROGRAMS

Station Name	Stn. No.	Lat	Long	Elv m	Year	Month last program change	Program SyH T P I W SoE SuR O U SnT A N
ALBERTA							
ACADIA VALLEY	3020018	5111	11014	732	1988	5	- - - X - - - - - - - - - - - -
ACADIA VALLEY MACTAVISH	3020025	5112	11010	744	1988	5	- - X X - - - - - - - - - - - -
ACADIA VALLEY VANDYNE	3020031	5102	11018	709	1988	5	- - X X - - - - - - - - - - - -
CADOGAN	3010991	5215	11032	665	1989	11	- - - X - - - - - - - - - - - -
CAMBRIA LO	3071150	5915	11048	327	1987	5	- - X X - - - - - - - - - - - -
CHAUVIN	3011479	5243	11010	640	1988	10	- - X X - - - - - - - - - - - -
COLD LAKE A	3081680	5425	11017	541	1986	4	X X X X X - - - S - - - V - - N
COWPAR LO	3061930	5550	11023	563	1965	5	- - X X - - - - - - - - - - - -
DEWBERRY	3012072	5339	11036	616	1987	5	- - - X - - - - - - - - - - - -
ESTHER	3012459	5140	11012	707	1986	12	- - - - - - - - - - - - - - A -
ESTHER	3022460	5136	11014	747	1980	8	- - - X - - - - - - - - - - - -
ESTHER 1	301B460	5140	11012	707	1988	9	- H - - - - - - - - - - - - - -
FABYAN	3012515	5258	11100	698	1981	7	- - X X - - - - - - - - - - - -
GOLDEN VALLEY	301B8LR	5312	11009	640	1988	6	- - X X - - - - - - - - - - - -
GORDON LAKE LO	3062889	5537	11030	488	1964	4	- - X X - - - - - - - - - - - -
JOHNSON LAKE LO	3063563	5735	11020	549	1965	5	- - X X - - - - - - - - - - - -
KEANE LO	3063630	5819	11017	457	1964	5	- - X X - - - - - - - - - - - -
LLOYDMINSTER A	3013961	5319	11004	665	1982	4	X X X X - - - - - - - - - - - N
MONITOR	3014600	5201	11033	732	1983	4	- - - X - - - - - - - - - - - -
MUSKEG LO	3064740	5708	11054	652	1965	8	- - X X - - - - - - - - - - - -
NEUTRAL VALLEY	3014783	5208	11053	758	1989	12	- - X X - - - - - - - - - - - -
NEW BRIGDEN EAST	3014788	5141	11016	695	1985	6	- - X X - - - - - - - - - - - -
OYEN CAPPON	3024961	5110	11031	793	1974	1	- - X X - - - - - - - - - - - -
OYEN CARA	3024962	5121	11028	770	1990	5	- - X X - - - A - - - - - - - -
PARADISE VALLEY	3014995	5307	11021	658	1982	10	- - X X - - - - - - - - - - - -
POPLAR GLEN	3015287	5252	11054	686	1990	6	- - X X - - - - - - - - - - - -
PRIMROSE LAKE DND	3065304	5445	11003	702	1987	1	- J - - - - - - - - - X - X - -
PRIMROSE LAKE 2	306E304	5447	11003	606	1991	9	H H - - - - - - - - - - - - - -
PRIMROSE LO	3065305	5445	11003	678	1967	6	- - X X - - - - - - - - - - - -
RICHARDSON LO	3065492	5755	11058	305	1983	4	- - X X - - - - - - - - - - - -
SAND RIVER LO	3065710	5439	11059	732	1964	4	- - X X - - - - - - - - - - - -
SEDALIA EAST	3015799	5139	11033	762	1982	4	- - X X - - - - - - - - - - - -
SIBBALD	3025920	5128	11015	716	1956	1	- - X X - - - - - - - - - - - -
SIBBALD WESTGARD	3025928	5125	11009	724	1988	8	- - - X - - - - - - - - - - - -
TULLIBY LAKE	3016590	5340	11008	574	1989	3	- - X X - - - - - - - - - - - -
TULLIBY LAKE EAST	3016591	5341	11007	584	1990	5	- - - X - - - - - - - - - - - -
VETERAN	3016817	5200	11100	785	1988	6	- - X X - - - - - - - - - - - -
WAINWRIGHT A	301FRLJ	5248	11053	662	1990	5	- D - - - - - - - - - X - - - -
WINEFRED LO	3067590	5520	11012	744	1965	5	- - X X - - - - - - - - - - - -

Station Name	Stn. No.	Lat	Long	Elv m	Year	Month last program change	Program SyH T P I W SoE SuR O U SnT A N
SASKATCHEWAN							
ALSASK HARDENE	4020130	5120	10951	658	1973	12	- - X X - - - - - - - - - - - -
ARMIT	4080250	5250	10147	308	1990	5	- - X X - - - - - - - - - - - -
ARRAN 23N	4080262	5212	10138	450	1970	6	- - X X - - - - - - - - - - - -
ARTLAND	4040267	5247	10954	640	1983	1	- - X X - - - - - - - - - - - -
AYLSHAM	4070365	5312	10348	362	1979	10	- - X X - - - - - - - - - - - -
BEACON HILL	4060452	5420	10937	533	1983	2	- - X X - - - - - - - - - - - -
BEARTOOTH ISLAND	4060468	5913	10942	238	1990	8	- H - - - - - - - - - - - - - -
BICKLEIGH	4040587	5118	10824	671	1988	12	- - X X - - - - - - - - - - - N
BIGGAR	4040600	5204	10759	671	1974	7	- - X X - - - - - - - - - - - -
BIG RIVER	4060620	5350	10702	503	1983	5	- - X X - - - - - - - - - - - -
BUFFALO NARROWS A	4060982	5550	10826	434	1986	4	- D X X X U - - - - - - - - - N
BUFFALO NARROWS (AUT)	4060983	5550	10826	434	1988	1	H H - - - - - - - - - - - - - -
BUTTE ST PIERRE	4041000	5327	10912	572	1964	9	- - X X - - - - - - - - - - - -
CAMEO	4051080	5317	10633	488	1991	8	- - X X - - - - - - - - - - - -
CANDO	4041088	5224	10816	710	1984	7	- - X X - - - - - - - - - - - -
CARLTON	4051147	5248	10634	521	1987	6	- - X X - - - - - - - - - - - -
CEN RGN RSB SASKATOON	4051435	5208	10637	502	1989	1	- - - - - - - - - - - - - - - -
CHOICELAND	4071560	5330	10429	442	1948	12	- - X X - - - - - - - - - - - -
CIGAR LAKE	4061570	5805	10429	467	1987	9	- - X X - - - A - - - - - - - -
CLUFF LAKE	4061590	5822	10931	330	1981	9	- - X X X B - A - - - - V - - N
CODETTE ELKHORN	4071612	5315	10410	398	1977	5	- - - X - - - - - - - - - - - -
COLLINS BAY	4061629	5811	10342	492	1990	6	- H - - - - - - - - - - - - - -
COLONSAY	4051636	5156	10546	543	1971	12	- - X X - - - - - - - - - - - -
COTE	4011846	5131	10148	457	1970	6	- - X X - - - - - - - - - - - -
CREE LAKE	4061861	5721	10708	497	1986	4	X E X X X U D A S - - - V - - N
CREE LAKE	406JQ60	5721	10708	497	1983	8	- - - - - - - - - - - - - A - -
DAVIDSON 17NE	4012125	5122	10548	626	1991	10	- - - - - - - - - - - - - - - -
DINSMORE	4052210	5119	10720	648	1976	11	- - X X - - - - - - - - - - - -
DUVAL	4012300	5110	10451	591	1963	7	- - X X - - - - - - - - - - - -
EDAM	4042338	5311	10846	549	1990	5	- - X X - - - - - - - - - - - -
ELBOW (AUT)	4022359	5108	10635	593	1990	10	H H - - - - - - - - - - - - - -
ELBOW RADAR	4022L62	5108	10635		1983	11	- - - - - - - - - - - - - - - -
ELBOW 2 NE	4022363	5110	10633	605	1990	5	- - X X - - - - - - - - - - - -
ELROSE	4022368	5108	10802	610	1976	5	- - X X - - - - - - - - - - - -
ESK	4012381	5148	10451	542	1984	7	- - - X - - - - - - - - - - - -
ESTON	4022440	5109	10846	680	1989	4	- - X X - - - - - - - - - - - -
ETHELTON	4052448	5246	10454	466	1985	7	- - X X - - - - - - - - - - - -
FENWOOD	4012483	5109	10304	625	1973	6	- - X X - - - - - - - - - - - -
GEIKIE RIVER	4062825	5742	10357	412	1985	7	- - X X - - - - - - - - - - - -
GLENSIDE	4052933	5128	10650	568	1971	2	- - - X - - - - - - - - - - - -
GOOD SPIRIT LAKE	4012943	5130	10240	484	1986	6	- - X X - - - - - - - - - - - -
GRASSWOOD	4052956	5204	10638	503	1982	6	- - - X - - - - - - - - - - - -

Station Name	Stn. No.	Lat	Long	Elv m	Year Month last program change		Program SyH T P I W SoE SuR O U SnT A N
SASKATCHEWAN continued							
GUERNSEY	4013038	5147	10517	526	1990	12	- - X X - - - - - - - - - - - -
HAFFORD	4053080	5243	10722	587	1966	1	- - X X - - - - - - - - - - - -
HARRIS	4053120	5144	10735	578	1923	5	- - X X - - - - - - - - - - - -
HILLMOND	4043246	5326	10943	587	1991	6	- - X X - - - - - - - - - - - -
HOEY	4053264	5251	10547	473	1990	4	- - - X - - - - - - - - - - - -
HOLDFAST	4013270	5100	10531	544	1988	8	- - X X - - - - - - - - - - - -
HUDSON BAY	4083322	5249	10219	357	1992	7	H H - - - - - - - - - - - - - -
HUDSON BAY A	4083321	5249	10219	357	1992	7	- D X X X - D A S - - - V - - N
HUMBOLDT	4013401	5216	10507	549	1981	9	- - X X - - - - - - - - - - - -
ISLAND FALLS	4063560	5532	10221	299	1986	1	- - X X X B - - - - - - - - - N
JIMMY LAKE	4063621	5454	10958	636	1986	4	- J - - - - - - - - - - - - - -
KELLIHER	4013660	5115	10345	671	1981	1	- - X X - - - - - - - - - - - -
KERROBERT	4043750	5158	10907	673	1977	6	- - X X - - - - - - - - - - - -
KEY LAKE	4063755	5715	10537	509	1985	8	- - X X - B - A - - - - - - - N
KINDERSLEY A	4043900	5131	10910	694	1992	5	X X X X X - D A S - - - - - - N
KUROKI	4014115	5200	10327	585	1961	6	- - X X - - - - - - - - - - - -
LANGHAM 2W	405DJDN	5222	10701	503	1990	6	- - X X - - - - - - - - - - - -
LA RONGE A	4064150	5509	10516	375	1985	2	X X X X X - D A - - - - - - - N
LAST MOUNTAIN WILDLIFE	4014156	5125	10514	496	1975	5	- - X X - - - - - - - - - - - -
LENEY	4054306	5153	10731	556	1961	11	- - X X - - - - - - - - - - - -
LEROY	4014322	5200	10438	533	1980	6	- - X X - - - - - - - - - - - -
LIPTON 2	4014481	5105	10354	646	1979	10	- - X X - - - - - - - - - - - -
LLOYDMINSTER 12E	4044562	5317	10940	648	1976	5	- - X X - - - - - - - - - - - -
LOON LAKE CDA EPF	4064600	5403	10906	543	1962	1	- - X X - - - - - - - - - - - -
LOST RIVER	4074640	5317	10420	375	1947	6	- - X X - - - - - - - - - - - -
MACDOWALL	4054795	5301	10601	477	1985	11	- - X X - - - - - - - - - - - -
MARCELIN	4055010	5255	10648	523	1986	11	- - X X - - - - - - - - - - - -
MARGO	4015020	5150	10320	544	1986	4	- - - X - - - - - - - - - - - -
MARTENSVILLE	4055043	5220	10640	520	1981	4	- - X X - - - - - - - - - - - -
MCKAGUE	4085050	5234	10350	539	1985	2	- - - X - - - - - - - - - - - -
MCKAGUE 2	4085052	5235	10350	543	1985	7	- - X X - - - - - - - - - - - -
MEADOW LAKE	406N0NM	5408	10831	480	1988	6	- G - - - - - - - - - - - - - -
MEADOW LAKE A	4065058	5408	10831	480	1977	8	X F X X X U - - S - - - - - - N
MEDSTEAD	4045070	5321	10802	700	1990	9	- - X X - - - - - - - - - - - -
MELFORT	4055079	5249	10436	490	1990	11	H H - - - - - - - - - - - - - -
MELFORT CDA	4055085	5249	10436	480	1976	7	- - X X X B - A S - - - - - - N
MILDEN	4055165	5126	10730	578	1984	10	- - X X - - - - - - - - - - - -
MILDRED	4065172	5320	10715	617	1984	5	- - - X - - - - - - - - - - - -
MUENSTER	4015440	5211	10500	579	1960	10	- - X X - - - - - - - - - - - -
NEILBURG	4045487	5248	10936	668	1987	4	- - - X - - - - - - - - - - - -
NIPAWIN	407N51G	5320	10400	373	1988	1	- G - - - - - - - - - - - - - -
NIPAWIN A	4075518	5320	10400	372	1987	4	X F X X X U D A S - - - V - - N

Station Name	Stn. No.	Lat	Long	Elv m	Year Month last program change		Program SyH T P I W SoE SuR O U SnT A N
SASKATCHEWAN continued							
NOKOMIS	4015560	5131	10500	526	1929	1	- - X X - - - - - - - - - - - -
NORTH BATTLEFORD A	4045600	5246	10815	548	1979	1	X X X X X - - - - - - - - - - N
OUTLOOK PFRA	4055736	5129	10703	541	1988	4	- - X X X B - A S K - - - - - N
PARKERVIEW	4015870	5124	10316	637	1984	5	- - X X - - - - - - - - - - - -
PASWEGIN	4015960	5159	10355	533	1963	9	- - X X - - - - - - - - - - - -
PAYNTON	4045975	5301	10857	561	1970	6	- - X X - - - - - - - - - - - -
PELLY	4086000	5205	10152	509	1973	6	- - X X - - - - - - - - - - - -
PELLY 2	4086001	5144	10154	499	1978	7	- - - X - - - - - - - - - - - -
PILGER	4056120	5225	10509	552	1944	10	- - X X - - - - - - - - - - - -
PORCUPINE PLAIN	4086160	5239	10309	465	1986	9	- - X X - - - - - - - - - - - -
PREECEVILLE	4016185	5157	10239	518	1970	5	- - X X - - - - - - - - - - - -
PRINCE ALBERT A	4056240	5313	10541	428	1986	4	X X X X X - - - S - - - V - - N
QUINTON	4016335	5121	10425	623	1986	4	- - - X - - - - - - - - - - - -
RADISSON 1	4056381	5224	10725	520	1977	6	- - X X - - - - - - - - - - - -
ROCK POINT	4026847	5109	10716	725	1974	10	- - X X - - - - - - - - - - - -
ROSETOWN	4046879	5137	10801	586	1981	4	- - X X - - - - - - - - - - - -
ROSETOWN EAST	4046884	5134	10755	586	1991	6	H H - - - - - - - - - - - - - -
RUDDELL	4046977	5235	10751	538	1985	6	- - X X - - - - - - - - - - - -
ST DONATUS	4047050	5159	10954	745	1979	5	- - X X - - - - - - - - - - - -
ST WALBURG	4047081	5343	10909	663	1983	2	- - X X - - - - - - - - - - - -
SASKATOON A	4057120	5210	10641	501	1992	5	X X X X B - - - - - - X - - - N
SASKATOON SRC	4057180	5209	10636	497	1981	4	- - X X X - D A S - - - X - - N
SASKATOON WATER TP	4057202	5207	10641	483	1985	6	- - X X X - - - - - - - - - - -
SCOTSTOWN	4047238	5223	10924	685	1967	1	- - X X - - - - - - - - - - - -
SCOTT CDA	4047240	5222	10850	660	1990	9	- - X X X B - - S - - - - - - N
SEMANS	4017320	5125	10444	562	1987	4	- - X X - - - - - - - - - - - -
SERATH	4017370	5110	10424	622	1980	11	- - X X - - - - - - - - - - - -
SMOKY BURN	4077557	5322	10310	319	1983	12	- - X X - - - - - - - - - - - -
SMOOTH STONE RIVER	4067576	5509	10616	434	1989	6	- - X X - - - - - - - - - - - -
SONNINGDALE	4047644	5219	10746	716	1984	11	- - X X - - - - - - - - - - - -
SOUTHEND	4067655	5620	10317	344	1989	4	- H - - - - - - - - - - - - - -
SOVEREIGN	4047681	5131	10743	587	1984	10	- - - X - - - - - - - - - - - -
SPALDING	4017704	5222	10422	578	1990	7	- - X X - - - - - - - - - - - -
SPIRITWOOD	4067720	5322	10732	589	1991	5	- - X X - - - - - - - - - - - -
SPIRITWOOD WEST	4067723	5322	10733	584	1991	12	H H - - - - - - - - - - - - - -
STAR CITY	4057757	5252	10420	465	1985	7	- - - X - - - - - - - - - - - -
STONY RAPIDS A	4067PR5	5915	10550	250	1986	10	X X X X X - - - - - - - - - - N
STRANRAER	4047798	5142	10831	641	1990	5	- - X X - - - - - - - - - - - -
STRONGFIELD	4027880	5120	10636	614	1980	1	- - X X - - - - - - - - - - - -
THEODORE	4018074	5130	10258	526	1991	6	- - X X - - - - - - - - - - - -
UNITY SOUTH	4048326	5214	10912	655	1986	10	- - X X - - - - - - - - - - - -
URANIUM CITY (AUT)	406QLD0	5934	10829	318	1986	6	H H - - - - - - - - - - - - - -

Station Name	Stn. No.	Lat	Long	Elv m	Year Month last program change		Program SyH T P I W SoE SuR O U SnT A N
SASKATCHEWAN continued							
VANSCOY COMINCO	4058425	5201	10706	505	1976	10	- - X X - - - - - - - - - - - -
VANSCOY UA	4058420	5201	10702	510	1990	5	- - - - - - - - - - - X - - - -
VISCOUNT	4058492	5157	10538	547	1981	6	- - X X - - - - - - - - - - - -
WASECA	4048520	5308	10924	650	1951	12	- - X X - - - - - - - - - - - -
WASKESIU LAKE	4068559	5355	10604	569	1991	1	H H - - - - - - - - - - - - - -
WASKESIU LAKE	4068560	5355	10605	532	1989	1	- - X X - - - - - - - - V - - -
WATHAMAN RIVER (AUT)	4068600	5705	10343	360	1984	10	- - - - S - - - - - - - - - - -
WATROUS	4018640	5140	10528	541	1953	2	- - X X - - - - - - - - - - - -
WATROUS EAST	4018642	5140	10524	525	1991	7	H H - - - - - - - - - - - - - -
WEIRDALE	4058728	5327	10515	474	1985	10	- - X X - - - - - - - - - - - -
WHITESAND DAM	4068840	5614	10309	344	1986	1	- - X X - - - - - - - - - - - -
WISHART	4019007	5134	10407	648	1989	5	- - X X - - - - - - - - - - - -
WYNYARD	4019035	5146	10412	561	1991	4	- - X X B - D A S - - - - - T N
WYNYARD (AUT)	40190LN	5146	10412	561	1991	4	H H - - - - - - - - - - - - - -
YORKTON A	4019080	5116	10228	498	1991	10	X X X X X - - - S - - - - - - N
YORKTON 1	4019099	5115	10227	497	1989	5	- - - - - - - A - - - - - - - -
MANITOBA							
ASHERN NW	5040JK0	5112	9823	267	1989	10	- - - X - - - - - - - - - - - -
BACHELORS ISLAND MARINE	5040131	5145	9954	256	1992	6	H H - - - - - - - - - - - - - -
BERENS RIVER A	5030203	5221	9702	222	1992	9	X X X X X - - - S - - - - - - N
BIRCH RIVER	5040218	5228	10100	281	1970	6	- - X X - - - - - - - - - - - -
BISSETT	5030282	5102	9541	268	1985	4	- - X X - - - - - - - - - - - -
BOGGY CREEK	5010310	5132	10123	643	1991	3	- - - X - - - - - - - - - - - -
BROCHET A	5060520	5753	10141	346	1987	11	- - X X - - - - - - - - - - - -
CHURCHILL A	5060600	5844	9404	28	1990	12	X X X X X - - A S - - - - - - N
CHURCHILL UA	5060606	5844	9405	27	1991	1	- - - - - - - - - H O X X X - -
COWAN	5040FJ3	5202	10039	366	1984	7	- - X X - - - - - - - - - - - -
CROSS LAKE A	5060621	5437	9746	216	1987	11	- - X X - - - - - - - - - - - -
CROSS LAKE JENPEG	5060623	5432	9802	219	1979	6	- - X X - - - - - - - - - - - -
DAUPHIN A	5040680	5106	10003	305	1986	4	X X X X X - - - S - - - V - - N
DUCK BAY	5040789	5207	10012	254	1991	6	- - X X - - - - - - - - - - - -
ETHELBERT	5040899	5132	10023	343	1983	12	- - - X - - - - - - - - - - - -
FISHER BRANCH	5030916	5106	9733	247	1970	6	- - - X - - - - - - - - - - - -
FISHER BRANCH (AUT)	50309J6	5105	9733	252	1985	9	H H - - - - - - - - - - - - - -
FISHER BRANCH SOUTH	5030917	5103	9731	259	1979	7	- - X X - - - - - - - - - - - -
FLIN FLON	5050919	5441	10141	303	1988	7	- G - - - - - - - - - - - - - -
FLIN FLON	5050920	5446	10151	335	1927	1	- - X X - - - - - - - - - - - -
FLIN FLON A	5050960	5441	10141	304	1978	12	- D X X X U - - - - - - - - - N
FORK RIVER	5040973	5131	10001	267	1987	4	- - - X - - - - - - - - - - - -
FORK RIVER NORTH	5040R73	5134	9959	260	1982	7	- - - X - - - - - - - - - - - -
GEORGE ISLAND (AUT)	5030984	5248	9737	223	1984	8	H H - - - - - - - - - - - - - -

Station Name	Stn. No.	Lat	Long	Elv m	Year program change	Month last program change	Program SyH T P I W SoE SuR O U SnT A N
MANITOBA continued							
GILBERT PLAINS	5040985	5106	10028	404	1969	8	- - X X - - - - - - - - - - - -
GILLAM	5060999	5622	9442	145	1988	8	- G - - - - - - - - - - - - - -
GILLAM A	5061001	5621	9442	145	1990	1	X F X X X U - - - - - - V - - N
GODS LAKE NARROWS A	5061067	5433	9429	189	1985	10	- - X X - - - - - - - - - - - -
GRAND RAPIDS (AUT)	5031A10	5311	9916	223	1982	11	H H - - - - - - - - - - - - - -
GRAND RAPIDS HYDRO	5031111	5309	9917	223	1980	2	- - X X - B - - - - - - - - - N
GRANDVIEW	5041116	5107	10042	442	1977	7	- - - X - - - - - - - - - - - -
HODGSON 2	5031301	5111	9727	232	1969	11	- - X X - - - - - - - - - - - -
HUNTERS POINT	5051311	5302	10056	256	1992	7	H H - - - - - - - - - - - - - -
ISLAND LAKE A	5061376	5351	9439	237	1986	4	X X X X X - - A - - - - V - A N
KELSEY HYDRO	5061423	5602	9632	183	1983	12	- - X X - - - - - - - - - - - -
LEAF RAPIDS	5061550	5628	10001	282	1991	9	- - X X - - - - - - - - - - - -
LIMESTONE GS	5061567	5630	9411	88	1985	10	- - X X - - - - - - - - - - - -
LYNN LAKE A	5061646	5652	10105	357	1986	2	X X X X X - - - S - - - - - - N
MAFEKING	5041685	5241	10106	325	1989	10	- - X X - - - - - - - - - - - -
MAGNET	5041686	5119	9929	264	1989	11	- - X X - - - - - - - - - - - -
MOOSEHORN COOK	5041804	5117	9825	265	1984	7	- - X X - - - - - - - - - - - -
NORWAY HOUSE A	506B047	5358	9750	223	1987	11	X X X X X - - - - - - - - - - N
NORWAY HOUSE FORESTRY	506B0M7	5400	9748	217	1986	8	- - X X X - - A - - - - - - - N
OCHRE RIVER	50420E5	5104	9947	280	1970	6	- - X X - - - - - - - - - - - -
OVERFLOWING RIVER	5042058	5309	10106	258	1990	12	- - X X - - - - - - - - - - - -
PASQUIA PROJECT	5052060	5343	10132	262	1985	6	- - X X - - D - - - - - - - - -
PIKWITONEI A	5062111	5535	9710	192	1987	11	- - X X - - - - - - - - - - - -
PINE DOCK	5032163	5138	9648	222	1976	10	- - X X - - - - - - - - - - - -
PINE RIVER SNOW RANCH	5042169	5148	10034	378	1981	11	- - X X - - - - - - - - - - - -
ROBLIN	5012472	5114	10123	556	1986	4	- - X X - - - - - - - - - - - -
ROBLIN FRIESEN 3NW	501B4G2	5116	10124	589	1991	3	- - - X - - - - - - - - - - - -
RORKETON WEST	5042485	5126	9944	266	1987	11	- - X X - - - - - - - - - - - -
STE ROSE	5042610	5102	9923	274	1975	8	- - - X - - - - - - - - - - - -
SNOW LAKE	5062706	5452	9959	274	1987	5	- - X X - - - - - - - - - - - -
SOUTH INDIAN LAKE 'A'	5062736	5648	9854	289	1989	6	- - X X - - - - - - - - - - - -
STEEP ROCK	5042774	5127	9848	250	1987	5	- - X X - - - - - - - - - - - -
SWAN RIVER	5042800	5207	10116	336	1969	7	- - X X - - - - - - - - - - - -
SWAN RIVER (AUT)	504K80K	5207	10114	335	1987	10	H H - - - - - - - - - - - - - -
SWAN RIVER 2	5042805	5159	10111	412	1967	9	- - - X - - - - - - - - - - - -
THE PAS A	5052880	5358	10106	271	1990	12	X X X X X - - - S A - - X - - N
THE PAS UA	505KR20	5358	10106	273	1991	1	- - - - - - - - - A - X X - - -
THOMPSON A	5062922	5548	9752	215	1991	3	X X X X X - D - S - - - - - - N
THOMPSON I W B	506BRBK	5545	9751	182	1980	10	- - - - - - - - - - - - - - - -
THOMPSON ZOO	5062926	5545	9752	206	1991	8	- - X X - - D A - - - - V - - -
WABOWDEN	5063041	5455	9839	232	1982	8	- - X X - - - - - - - - - - - -
WANLESS	5053080	5411	10122	271	1991	8	- - X X - - - - - - - - - - - -
WINNIPEGOSIS SOUTH EAST	5043226	5136	9953	256	1987	6	- - X X - - - - - - - - - - - -

EXPLANATION OF PROGRAM CODES

Sy Synoptic observations
X - surface weather observations in a numerical code based on WMO regulations, and exchange worldwide.
H - observations as above taken by an automatic station.

H Hourly weather
X - 24 hours per day.
B - 8 observations per day, taken every 3 hours
C - 4 observations per day, taken every 6 hours.
D - irregular observations, daily.
E - 8 observations per day, taken every 3 hours, plus extra hours.
F - 4 observations per day, taken every 6 hours, plus extra hours.
G - automatic station (various types) irregular, daily.
H - automatic station (various types) 24 hours per day.
J - irregular observations, not processed.

T Temperature
X - daily readings of maximum and minimum temperature (°C)

P Precipitation
x - daily values of liquid, freezing or frozen precipitation (mm)

I Rate of Precipitation
X - tipping bucket rain gauge, hourly rainfall values and rate of rainfall (mm)
S - Fisher and Porter precipitation gauge, quarter hourly values and rate of precipitation (mm)
B - both X and S.
W - weighting type precipitation gauge (mm)
V - volumetric precipitation gauge, periodic measurements (mm)

W Wind
B - data processed from 45B autographic record, hourly total wind run in km/h and direction to 8 compass points
U - data processed from U2A autographic record, hourly (short duration mean) wind speed in km/h and direction to tens of degrees.

So Soil Temperature
D - morning values recorded for depths; 5, 10, 20, 50, 100, 150, and 300 cm (°C); and afternoon values for the first three depths only.
G - same as D but from an automatic recorder.

E Evaporation
A - net water loss from pan and calculated lake evaporation (mm), type A pan, daily values.
R - type A pan, daily values using radioactive tracer (for Atomic Energy of Canada).

Su Sunshine
R - hourly values of bright sunshine from an electronic recorder.
S - hourly values of bright sunshine.

R Radiation
radiation values are recorded hourly in Local Apparent Time and the units are expressed in megajoules per square metre, except daylight illumination is in 1000 lumen-hours per square metre.
A - global solar radiation RF1.
B - sky radiation RF2.
C - reflected solar radiation RF3.
D - net radiation RF4.
E - daylight illumination RF7
F - A + B
G - A + C
H - A + D
J - A + B + C
K - A + B + C + D
L - A + C + D
M - A + B + C + D + E
N - A + B + D

O Ozone
T - total ozone and umkehr observations using Dobson spectrophotometer, daily in m-atm-cm and μmb units respectively.
S - ozonesonde on a weekly basis (usually Wednesday) in μmb units.
O - T and S.

U Upper air
X - rawinsonde (temperature, pressure, humidity and wind)
W - wind only.
T - radiosonde (temperature, pressure and humidity)

Sn Snow Survey
V - 5 points, 30 m apart, on the 1st, 8th, 15th and 23rd of the month.
X - 10 points, 30 m apart, taken on the 1st and 15th of the month.

T Tower.

A Air Quality
T - Turbidity, observations of total aerosol content at 09, 12, and 15 LST on cloudless days.
A - Canadian Air and Precipitation Monitoring network (CAPMoN).
C - precipitation chemistry.
B - T + C.
P - particulate sampling.
G - gaseous sampling.
H - T + C + P
J - T + C + P + G

N Nipher - snow water equivalent (mm).

Appendix M: Traditional Land Use Map and Calendar

BOREAS WORKSHOP
Winnipeg, Manitoba
May 26-28, 1993

TRADITIONAL LAND USE MAP AND CALENDER
Nelson House Land and Resource Use Study
The MKO Natural Resources Secretariat

1.0 Background

In 1992, the Natural Resources Secretariat of the Manitoba Keewatinowi Okimakanak, Inc. (MKO) was contracted to document and determine the type and extent of land use by Nelson House First Nation members within the BOREAS study area. The MKO represents the 25 northern-most First Nations in Manitoba which can generally be described as extending north of the 53rd parallel covering some two-thirds of the province. The Nelson House First Nation is a member of the MKO.

The Natural Resources Secretariat conducted the Nelson House First Nation Land and Resource Use Study which documents the spatial and temporal aspects of traditional resource use activities of Nelson House First Nation members in the BOREAS study area. The final report of this study is in the process of being assembled but the land use map and calendar are presented and explained here so it can be utilized as part of the present workshop.

2.0 Traditional Land Use Map

The BOREAS study area is located entirely within the traditional territory and resource area of the Nelson House First National (NHFN). Therefore, the entire area utilized by BOREAS is used, inhabited and occupied by members of the NHFN both historically and presently.

The traditional resource harvest activities of twelve members of the NHFN within the BOREAS study areas were recorded through seven map biography interviews (attached map). The land use information recorded in the map as provided by the informants does not cover the entire area of the supersite. This does not mean that the areas with no land use information are not used for traditional pursuits but rather, it means that more interviews need to be conducted with other members of the NHFN who use the area.

The land use map depicts the spatial distribution of land use by the informants from the NHFN in relation to the spatial distribution of the BOREAS activities. The information in the map also shows that the BOREAS study area is extensively used by the twelve informants from the NHFN.

The traditional resource harvesting activities and sites depicted by the map include the following:

Yellow lines - Trapping
Blue lines - Hunting
Green lines - Fishing
Red areas - Berry and Plant Gathering
Red triangle - Campsites
Black square - Cabins

The BOREAS study sites (within the supersite) in the form of towers and other manmade features of the area such as the highway and transmission line are also included.

The supersite includes a section of the Sapochi River and numerous creeks which are important to traditional harvesting activity by the NHFN. The supersite and the extra study site also contain trails and sites established and used by members of the NHFN while in pursuit of traditional resources and activities.

The types of resources and the seasons during which they are harvested are presented by the discussion of the land use calender in the next section.

3.0 The Land Use Calender

The land use calender depicts the type of uses which occur throughout the study area during various seasons throughout the year. It also depicts the type of resources which are harvested (attached calender). The resource harvest activities depicted by this land use calender are as follows:

- Trapping
- Hunting
- Fishing
- Berry and Plant Gathering
- Timber Cutting
- Egg Collecting

The land use calender will be described by the activities mentioned above in the order they appear and the resources which are harvested.

3.0.1 Trapping

Trapping for fur bearing animals occur throughout most of the year from about the month of October to May but for different species. The different time periods and the different species of fur bearing animals harvested is presented in the following:

Beaver, Otter and Muskrat

Trapping for beaver and otter occurs from the month of October to the end of May (late fall, winter and spring). From about the month of March to May (spring), the harvest of beaver and otter is combined with the harvest of muskrat.

Mink, Fisher and other Species (ie. Marten, Wolf, Fox, Lynx)

These species are harvested from the month of October to February (late fall and winter). The harvest of lynx is combined with the other species during the months of January and February (winter).

Rabbits snaring occurs throughout the year for food and not for the value of the pelt. This list is not an exhaustive list but is a good representative sample of the time periods and the species harvested as provided by the informants.

3.0.2 Hunting

Hunting for different species of animals and waterfowl occurs throughout the year. The spring and fall seasons are peak seasons for hunting. The following are some of the species of animals and birds hunted throughout the year.

Waterfowl

With the onset of spring and the return of waterfowl from their wintering grounds, ducks and geese are hunted. This period ranges from mid-April to the end of May or mid-June.

The other time when waterfowl are hunted is during the fall season during the southern migration. This period ranges from late August to mid-October.

Moose and Woodland Caribou

The moose hunt in the fall season is a very important annual event because the rutting season makes it favourable to hunt this animal. This period extends from about the month of September to early November. But moose can be hunted year-round, wherever possible.

Woodland caribou are hunted mostly during the fall and winter seasons. The woodland caribou species have not yet been incorporated into the land use calender but are a species which are hunted.

Small game species such as rabbits and grouse or spruce hens are hunted year-round. The periods mentioned here are the favourable times to hunt for all species but if other opportunities exists during the year, then hunting will occur. For example, if a moose is spotted during the winter, then it will be hunted.

3.0.3 Fishing

Fishing with a net under the ice can occur anywhere between the month of November after freeze-up to the end of April. Angling can occur anywhere between the month of May, after the ice thaws, and the end of September. The species harvested by angling include mostly jackfish (northern pike) and walleye. The domestic species (traditional net fishing) also includes whitefish in addition to the previously mentioned species. Suckers and burbot are also caught in the nets but are not eaten.

3.0.4 Berry and Plant Gathering

Both berry and plant gathering occurs during the growing season. Berry picking occurs during the months of July and August after the berries have ripened. Referring to the land use map presented and discussed earlier, the red areas along the highway are berry picking areas. The type of berries include raspberries, cranberries and blueberries, among others.

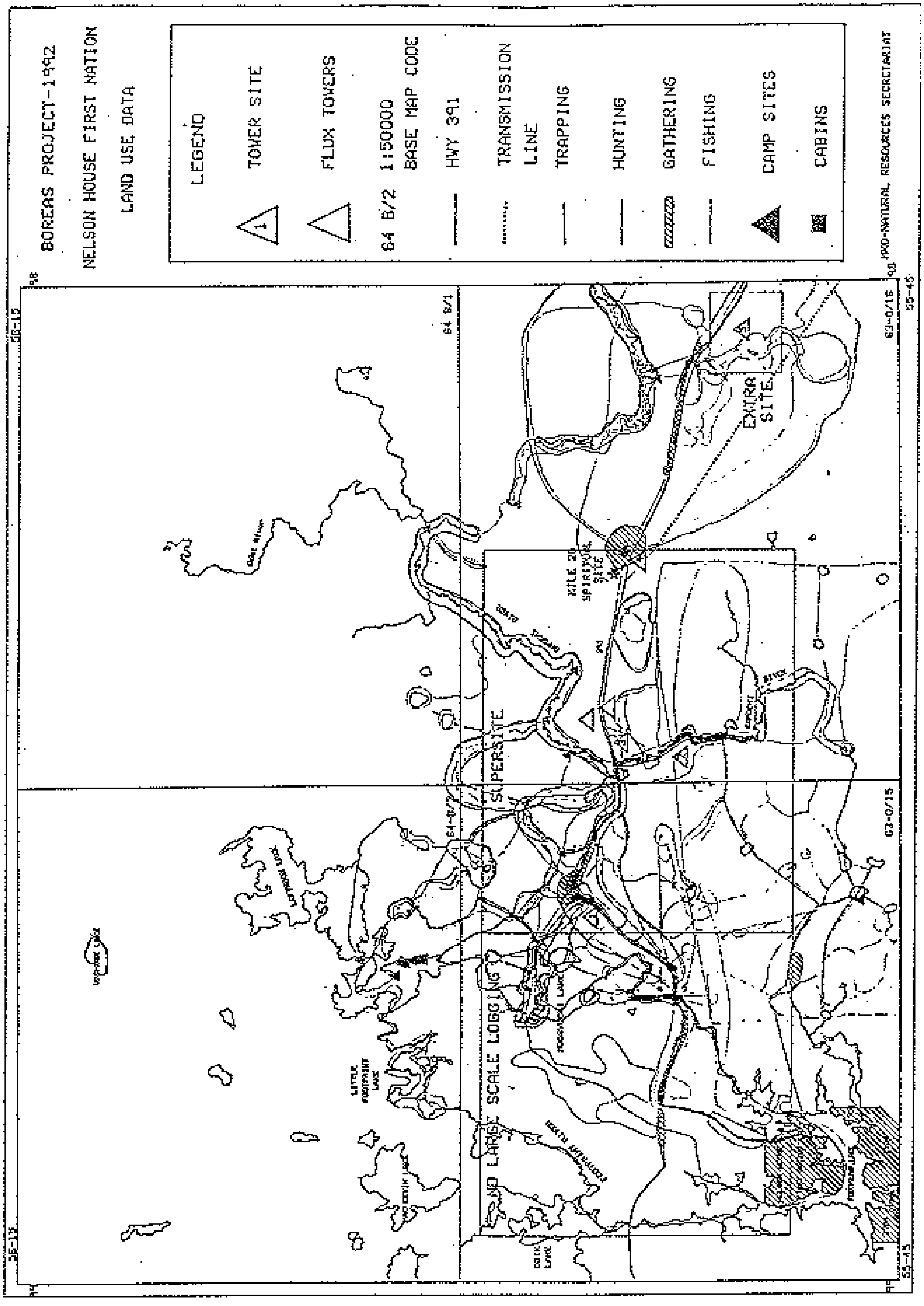
Wild mint and other plants are gathered within the BOREAS study site during the growing season from about the month of June to about the month of august or September.

3.0.5 Timber Cutting

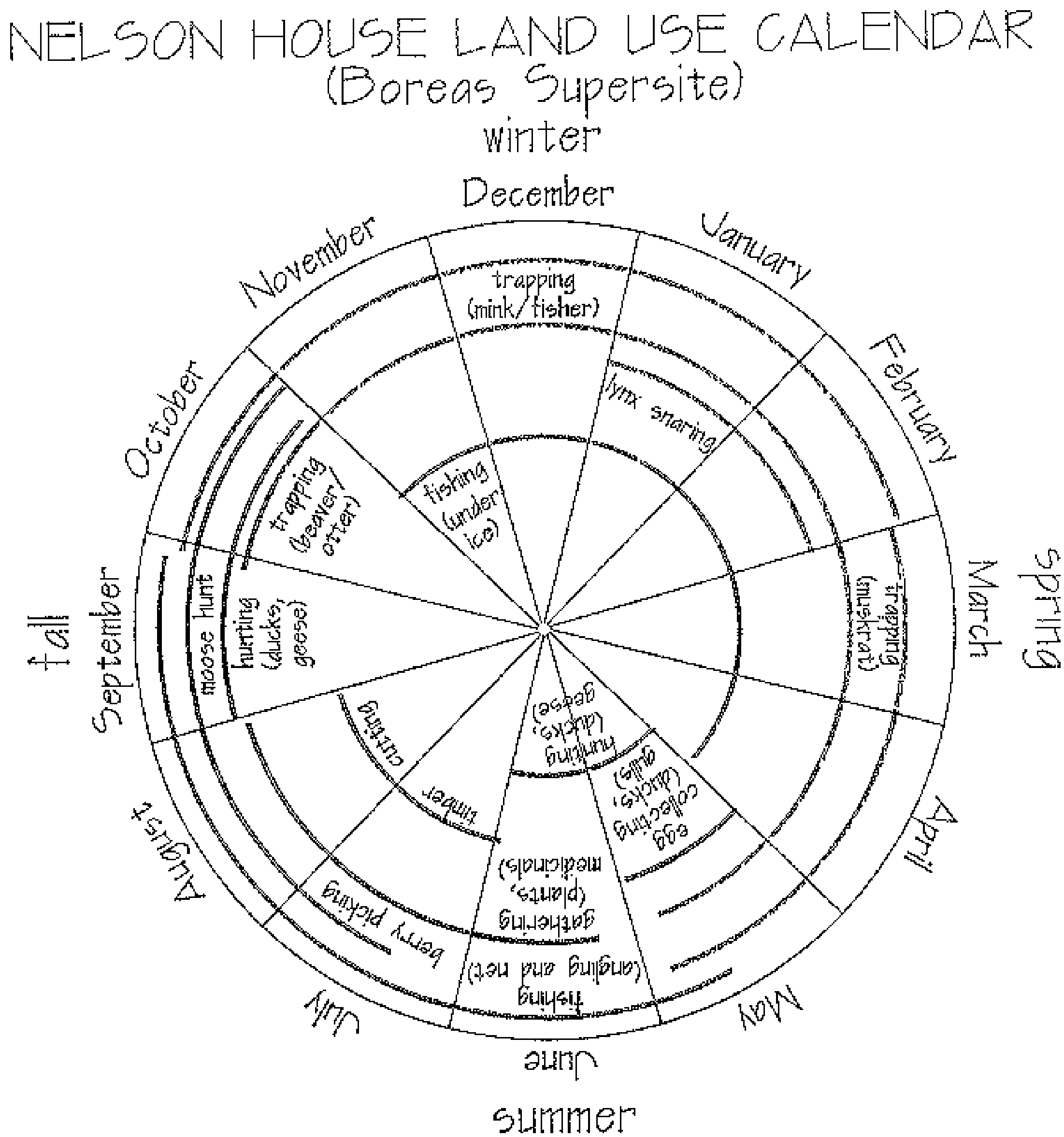
Timber cutting for firewood occurs year-round but the peak period is during the fall season in preparation for the oncoming winter. Timber cutting for cabins occurs during the months of July and August.

3.0.6 Egg Collecting

Egg collecting from duck and seagull nest sites occurs during late May to early June.



Highway 391 and hunting, fishing, and trapping lines cannot be distinguished in black and white. Color copies of this map may be requested through BORIS.



Nelson House Band Land-Use Calendar for the BOREAS Northern Study Area (NSA)

Appendix N: Investigation Profiles

Airborne Flux and Meteorology

Tower Fluxes

Terrestrial Ecosystems

Trace Gas Biogeochemistry

Snow/Hydrology

Remote Sensing Science

Airborne Flux and Meteorology (AFM)

AFM-1	Crawford
AFM-2	Kelly
AFM-3	Lenschow
AFM-4	MacPherson
AFM-5	Atkinson
AFM-6	Banta
AFM-7	Schewchuck
AFM-8	Betts
AFM-9	Dickinson
AFM-11	Mahrt
AFM-12	Pielke
AFM-13	Schuepp
AFM-14	Sellers
AFM-15	Verseghy

Ref. Number AFM-1

P.I.(s):	Crawford, T./NOAA
CO-I(s):	Baldocchi, D., Meyers, T., McMillen, R./ NOAA
Title:	Experimental and Modeling Studies of Water Vapor, Sensible Heat, and CO_2 Exchange Over and Under a Boreal Forest
Objectives and Approach:	We propose to measure and model air-surface exchange rates of water vapor, sensible heat, and CO_2 over a boreal forest, and to study the abiotic and biotic factors that control the fluxes of scalars in this landscape. Scalar flux densities will be measured with aircraft-borne eddy correlation flux measurement systems. Spatial variability of surface fluxes over the boreal forest landscape will be measured with an airplane-mounted eddy flux system. The airplane-mounted flux system will also ascertain the significance of edges and advection on the scaling of mass and energy fluxes from points to regions. Core Measurements include the mass and energy exchange studies just described, as well as measurements of meteorological variables. A hierarchy of single and multi-layer mass and energy (water vapor, heat, and CO_2) exchange models--based on Eulerian and Lagrangian frameworks and on micrometeorology, radiative transfer, plant physiology, and biochemistry theory--will be developed and tested using the data obtained over a boreal forest. Comparing the hierarchy of models will enable us to rank the controlling variables and to develop a simpler surface exchange model that can be used by climate and ecosystem models. Our final goal is to drive the simple model with satellite-derived land-use data and meteorological information to evaluate the spatially-integrated surface fluxes.

Ref. Number AFM-2

P.I(s).:	Kelly, R./Univ of Wyoming, Lenschow, D./NCAR
Title:	Airborne Investigation of Biosphere--Atmosphere Interactions Over the Boreal Forest
Objectives and Approach	We propose to carry out a program of airborne investigations using the University of Wyoming King Air (Kelly) and the NCAR Ellectra (Lenshow), The King Air will be used to measure fluxes of latent and sensible heats, momentum, and CO_2. Other measurements include up- and down-welling radiation, and cloud microphysics (cloud droplet spectra and liquid water content). The Electra and King Air flight patterns will be coordinated with other aircraft and with the surface network, and will be carefully designed to provide adequate sampling statistics and evaluation of horizontal variability. The data will be used to calculate fluxes and other statistical variables, as well as spectral and cospectral variables. Analysis objectives (King Air) -- fluxes, profiles, and budgets for sensible and latent heat and CO_2 -- estimates of surface fluxes -- error analysis -- conditional sampling -- footprint analysis -- effects of clouds on fluxes, profiles, budgets -- spectral and cospectral analysis of variability

Deliverables
-- pass-by-pass compilation of mean, variance, skewness, and horizontal gradients
-- eddy momentum fluxes (x, y, and z)
-- vertical fluxes of momentum, sensible and latent heat, and CO_2
-- extrapolation estimates of surface fluxes of momentum, sensible and latent heat, and CO_2

Needs from other groups
-- all surface and canopy height fluxes
-- all surface radiation measurements

Needs from project staff
-- forecasting
-- cloud-cover documentation (satellite, all-sky cameras)

Ref. Number AFM-3

P.I.(s): Lenschow, D./NCAR, Kelly, R./Univ of Wyoming

Title: Airborne Investigation of Biosphere--Atmosphere Interactions Over the Boreal Forest

Objectives and Approach: We propose to carry out a program of airborne investigations using the NCAR Electra (Lenschow) and the University of Wyoming King Air aircraft (Kelly). The Electra will be used to measure fluxes of latent and sensible heats, momentum, and CO_2, as well as other trace gas species, and mean concentrations of species for which sensors for flux measurements are not available. Other measurements include up- and down-welling radiation, vegetation-sensitive radiation for estimating the NDVI, cloud microphysics (cloud droplet and aerosol spectra and liquid water content), lidar measurements of cloud base and BL depth, and possibly remote Doppler air velocity. The Electra and King Air flight patterns will be coordinated with other aircraft and with the surface network, and will be carefully designed to attempt to provide adequate sampling statistics and evaluation of the effects of horizontal variability of surface variables and cloudiness. The data will be used to calculate fluxes and other statistical variables, as well as spectral and cospectral variables.

Deliverables (focus on transects between NH and PA)
-- pass -by-pass compilation of mean, variance, skewness, and horizontal gradients
-- eddy momentum fluxes (x, y, and z)
-- vertical fluxes of momentum, sensible and latent heat, and CO_2

Needs from other groups
-- all surface and canopy height fluxes
-- all surface radiation measurements
-- model predictions of fluxes

Needs from project staff
-- logistical assistance for basing in Saskatoon and Churchill
-- good communications between Saskatoon and PA and NH sites

-- laboratory/office space at Saskatoon for computer and chemical equipment (possible coordination of Univ, of Saskatoon?)
-- forecasting
-- cloud-cover documentation (satellite, all-sky cameras)

Ref. Number AFM-4

P.I.(s): MacPherson, J.I./NRC, Desjardins, R.L./Agriculture Canada,

CO. P.I.(s): Schuepp, P.H./McGill Univ.

Title: Areal Estimates of Mass and Energy Exchange from a Boreal Forest Biome

Objectives and Approach: Aircraft are the most promising means to bridge the gap between local scale tower measurements and regional scales. The proposed research will focus on developing various techniques to obtain large area flux estimates of mass and energy using the aircraft-tower and spectral data combination. Measurements recorded along a transect between PA and NH sites will be used to characterize the spatial variations of canopy conductance and determine its usefulness for inferring mass and energy exchange of relatively important trace gases (CO_2, O_3, etc.). Covariance analyses will be used to improve relationships between trace gas exchange and spectrally derived surface features. Joint observational methods between aircraft will also be developed to arrive at more accurate estimates of regional fluxes including a program for aircraft intercomparison.

Deliverables
-- evaluation of several techniques to obtain large area flux estimates
-- comparison of coherent structures of mass and energy transfer between aircraft and tower data in order to define better criteria for aircraft sampling
-- development of algorithms relating trace gas measurements by aircraft based sensors to spectrally derived surface features

Needs from other groups
-- comparison of measuring techniques and standards
-- information on sky condition (cloud cover, primarily)

Needs from project staff
-- satellite data

Ref. Number AFM-5

P.I.(s):	Atkinson, B./Env. Canada
Title:	Upper-air Measurement Program.

Objectives and Approach:

To provide sufficient definition of the atmosphere on a broad scale for scientific research, by supplementing the existing Atmospheric Environment Service (AES) aerological network, both temporally and spatially. Sponsor additional flights at existing AES aerological stations Churchill, The Pas, and Saskatoon, to three per day during IFCs. Sponsor additional flights at existing AES aerological station Saskatoon to 2 per day during FFC-T. Sponsor additional flights at existing DND aerological stations Primrose Lake and Shilo to 2 per day during IFCs and FFC-T. Sponsor flights by a co-operating agency (NASA) at Lynn Lake during parts of IFC-2 and IFC-3.

Establish 3 additional aerological stations, with communications, at Thompson MB, Candle Lake SK, and Key Lake SK. Contract people to operate these stations, and train them. Assure that observations are being made according to established procedures. Assure that observations are reaching national and international communications in real time. During FFC-T, these stations will release 2 flights per day. During IFCs, these stations will release 3 flights per day, and Thompson and Candle Lake will, on selected days, release 7 flights per day. Refer to Table 3.2.2.

Assure that data from all flights, regularly scheduled and BOREAS sponsored, reach NHRI (Dr. Barr) to be reprocessed before being sent to BORIS.

Field Measurements:
In the vertical, at fixed and significant levels, to at least 100 mb, using the same makes of radiosondes as AES:
temperature
moisture
wind speed
wind direction
geopotential height.

Supporting measurements: None.

Infrastructure needs:
From BOREAS: telephones for communication of data in real time. Arrangements have been made with AES Central Region to have an experienced upper-air inspector manage this network."

Ref. Number AFM-6

P.I.(s):	Banta, R./NOAA
CO. I(s):	Eberhard, W., Wilczak, J., Martner, B./NOAA
Title:	Outer-Boundary-Layer Effects on Surface Fluxes of Momentum, Heat, Moisture, and Greenhouse Gases from the Boreal Forest

Objectives and Approach:

Properties of the outer atmospheric boundary layer (OABL) and lower troposphere above 100 m will be measured using ground-based remote sensing instrumentation, including a UHF profiler equipped with RASS, a Doppler radar, and a Doppler lidar. The measured properties will include profiles of wind and turbulence quantities and temperature as functions of time from each profile, including gradients from the several stations. Lidar/radar scan data show the vertical structure and horizontal variability of wind, aerosols, and clouds. Scan data also reveal the eddy structure of the OABL. Profiles include mean horizontal wind and such turbulence quantities as turbulent kinetic energy and momentum flux. Aircraft data will complement our data sets very nicely.

With this information we will perform integrated analyses of the surface and OABL. These analyses will enable us to determine appropriate controls on surface fluxes for subgrid parameterizations of these processes and for finding appropriate procedures to extend local estimates on fluxes to larger areal averages, such as satellite footprints. This information will be very useful in interpreting the behavior of surface fluxes from point measurements, especially as they relate to larger-scale fluxes, because of the strong interactions between the surface layer and the OABL.

The profiler will operate near Nipawin tower cluster, if possibile during all three IFCs. The radar and lidar will operate during IFC-2.

Deliverables
--hourly profiles of horizontal winds from profilers
--profiles of virtual temperature (RASS)
--profiles of horizontal wind, TKE, momentum flux
--time series of inversion height from all three instruments
--cloud base heights

Needs from other groups
--comparisons with aircraft
--comparisons with surface and tower measurements

Needs from project staff
--help in site selection preparation, including maps with topography and access roads for PANP, Nipawin PP, La Ronge, NH site; liaison to land owners/managers for access; help in site preparation; help in arranging line power service or generator fuel; advice on security needs; help in locating a vendor for liquid nitrogen (PA), and storage space.

Ref. Number AFM-7

P.I.(s): Shewchuck, S./

Title: Mesonet Meterological Data

Objectives and Approach: The Saskatchawan Research Council, located in Saskatoon, will implement and maintain a meso network of nine (9) or ten (10) automated meteorological stations located in the Prince Albert and Thompson supersites and the intervening transect. Standard meteorological and radiation data will be collected and 30 minutes average values produced for BORIS. Some limited analysis of fields will also be available. This data will be available beginning in the fall of 1993 through the 1994 fall season.

Ref. Number AFM-8

P.I.(s): Betts, A./Atmospheric Research

CO-I.(s): Hollingsworth, T./European Centre for Medium Range Weather Forecasting

Title: Boundary Layer Research for BOREAS

Objectives and Approach: The objective of this research is to understand the diurnal evolution of the convective boundary layer over the boreal forest. The approach will be to analyze surface, boundary layer and cloud data from BOREAS using simplified conceptual models, and prepare compacted data bases for comparison with large-scale models. The key contributions by the PI to BOREAS will be:

1) To assist with the design of the surface and upper air networks, and the aircraft measurement program for BOREAS, and to optimize the boundary layer and mesoscale components of the experiment.

2) To analyze the diurnal cycle of the BOREAS boundary layer, using surface, upper air, aircraft and cloud data using budget methods; paying careful attention to the coupling of surface radiation, evapotranspiration, boundary layer growth and cloud fields during the diurnal cycle, and over the seasonal cycle.

3) To produce reduced data sets for the diurnal evolution of the boundary layer for the testing and improvement of the land surface and boundary layer climatology in both regional and global models.

4) To coordinate with ECMWF, the production of post analysis products to describe the basic meteorological fields and the surface and boundary layer energy budgets on the mesoscale across the BOREAS experiment area.

Needs from other groups
-- time series data sets as input to models

Needs from project staff
-- input of surface and upper air data to the GTS for assimilation at ECMWF and NMC.

Ref. Number AFM-9

P.I.(s): Dickinson, R.,/University of Arizona
Collaborator(s): Shuttleworth, J.; Graumlich, L.; Bonan G.; Henderson-Sellers, A.

Title: Incorporation of Boreal Forest Ecosystem Description into Climate Modeling Framework

Objectives and Approach: An integrative modeling investigation will be conducted that would relate the BOREAS study to land process parameterizations of the Biosphere Atmosphere Transfer (BATS) for application in global climate models. The PI and graduate students will carry out modeling studies to establish the relative sensitivity of surface-atmospheric exchanges of energy, moisture and carbon to various parameters and processes for boreal forests, as defined through the PI and Core measurement programs and their analyses. The investigation will also use the results of BOREAS to improve the representation of boreal forests in the BATS code through better specification of parameters and improved process descriptions. The investigation has as its objective the synthesis of the BOREAS study into an improved understanding of the role of boreal forests in the climate system, both in terms of simple concepts and through implementation of better representations in global climate models.

Ref. Number AFM-10 -- DELETED

Ref. Number AFM-11

P.I.(s): Mahrt, L./Oregon State Univ
Collaborator(s): Scanlan, R./Oregon State Univ, MacPherson, I./NRC Kelly, R./Univ of Wyoming, Lenschow, D./NCAR

Title: Fluxes Over Inhomogeneous Surfaces in BOREAS

Objectives and Approach: Aircraft data from the Wyoming King Air and the Canadian Twin Otter, and the NCAR Electra will be analyzed to compute fluxes of heat, moisture, momentum, CO_2, and other chemical species . It is essential that sampling criteria are satisfied and the impact of surface heterogeneity is assessed before useful comparisons can be made between analyzed for sampling and heterogeneity problems in order to make recommendations for the 1994 field program. Immediately after the 1994 program, analysis of sampling problems and flux errors will be completed to provide estimates for BORIS. More detailed analysis of these errors will be continued.

We will emphasize variations over inhomogeneous surfaces and estimates of spatially averages fluxes over regional scales. Using repeated flight legs over the same terrain and partitioning the flight track according to the greenness index and other indicators of surface conditions, the motion will be divided into turbulence and mesoscale motions. The latter are divided into motions associated with variations of surface conditions and transient mesoscale motions. The direct mesoscale flux and the modulation of the turbulent flux by the mesoscale motion will be computed and their influence on the area-averaged flux will be studied. This analysis will lead to values of fluxes over different types of vegetation. These results can then be compared with surface flux estimates.

Development of BL clouds is expected to have a major influence on the surface energy budget and stomatal conductances in BOREAS. We will also focus on evaluation of models of BL cloud cover and attenuation of solar radiation. This aspect of BL modeling is considered to be one of the most important deficiencies in global climate models.

Deliverables
-- aircraft fluxes
-- flux error estimates
-- turbulence statistics
-- surface energy budget for area-averaged flow

Needs from other groups
-- detailed flight plans for aircraft groups

Ref. Number AFM-12

P.I.(s):	Pielke, R./Colorado State Univ
CO. I(s):	Kittel, T./Colorado State Univ Loveland, T./USGS Steyaert, L./USGS Lee, T.J./Colorado State Univ
Title:	Modeling Biosphere Atmosphere interactions at Various Scales in Support of BOREAS
Objectives and Approach:	The objectives of our participation in BOREAS is to improve our understanding of the interaction between a heterogeneous sub-Arctic landscape and the overlying atmosphere. The Regional Atmospheric Modeling system (RAMS), a state-of-the-art numerical atmospheric model which includes sophisticated parameterization of vegetation and soils will be used for this purpose. Simulations with RAMS will be performed to develop an improved understanding of soil/vegetation/atmospheric interactions and to develop a parameterization of heterogeneous landscapes for use in larger scale models (e.g., general circulation models-GCMs). We also will provide detailed simulations of atmospheric features at various spatial and temporal scales as requested by the BOREAS Science Team. The USGS will develop a land cover characteristic data base derived from the 1-km AVHRR and geographic information system capabilities to support the RAMS work. The USGS will develop a regional land cover characteristics database to support RAMS.

Ref. Number AFM-13

P.I.(s): Schuepp, P./McGill Univ
CO. I(s): MacPherson, J./NRC, Desjardins, R.L./Agric. Canada; Leclerc, M.V./Univ. of Quebec

Title: Analysis and Interpretation of Airborne Flux Observations Over the BOREAS Sites

Objectives and Approach: Much of the BOREAS information is obtained from local observations at or near-the ground whose representativeness for the sites, let alone for the boreal system in this transition zone, must be established. This is particularly true for tower-based flux observations whose "footprint" (area which exerts a significant influence on the flux estimate) represents a vanishing small fraction of the overall area of the site.

We will use Twin Otter flux aircraft observations to provide BOREAS investigators with site-wise and inter-site "mapping" of the exchange of momentum, heat, moisture, CO_2, CH_4, O_3 (and to a more limited extent non-methane hydrocarbon) at specific moments in time. This will permit BOREAS investigators to place their local observations in a site-wide perspective and provide a starting point for the scaling up to truly regional estimates of transfer.

Specifically, our study aims at:

- the definition of a realistic footprint function over the BOREAS sites, so that airborne observations are related to the correct ground surface with its biological and ecological characteristics.

- the statistical and structural analysis of coherent turbulence "events" that dominate transfer between forest canopy and atmosphere, in particular the relationship between transfers of momentum, heat and moisture with those of various trace gases, as a function of forest and boundary-layer characteristics.

- the response of transfer processes to changing radiation conditions induced by intermittent cloudiness.

Ref. Number AFM-14

P.I.(s): Sellers, P.J., Hall, F.G./NASA/GSFC, Nelson, A.K./USRA

Title: Use of Biophysical Models and Satellite Remote Sensing to Quantify the Climate/Land-Surface Interactions Over a Boreal Forest Biome

Objectives: To use the photosynthesis and transpiration models (e.g., SiB of Sellers et al., BGC of Running et al., the model of Bonan et al.), in conjunction with remote sensing inputs of canopy process and biophysical parameters, landscape level disturbance and successional patterns to:

(i) simulate changes in energy and water exchange as a function of climate change scenarios.

(ii) simulate associated changes in growth rates and carbon storage associated with the successional stages in the boreal forest.

We will use the linked stomatal resistance-photosynthesis SiB model in the inverse-mode to calculate canopy photosynthetic capacities, bulk stomatal conductance etc., appropriate to each BOREAS flux site and compare the model predictions to tower measurements. The model will be used to calculate soil evaporation rates to separate the soil and vegetation contributions to the total observed evapotranspiration flux. The resulting isolated vegetation contribution to the flux is limited by vegetation canopy properties, which can then be compared with satellite vegetation indices. In order to make more progress in this area, collaborative links will be maintained with key BOREAS investigators in the Land Surface Climatology and Atmospheric Boundary Layer groups, and other selected BOREAS scientists working in the modeling of canopy photosynthesis.

This work will then be used to calculate fields of fluxes (Latent heat, Carbon dioxide, and heat) and surface state variables (photosynthetic capacity, canopy conductance) over the entire BOREAS sites based on satellite and, where appropriate, aircraft radiometric data. The effect of scale on this approach will be studied to determine the effects of using satellite data at various resolutions (30m to 1km) on the predicted flux fields.

Once we establish confidence in the SiB modeled fields, we will conduct simulation studies over the BOREAS mesoscale region, examining the effects of surface cover change on regional climatology and vice versa. Using this approach we can look at the effects of increased fire frequency on mesoscale albedo, net radiation, evapotranspiration and sensible heat transport.

Ref. Number AFM-15

P.I.(s): Verseghy, D./Canadian Climate Centre

Title: Improvement of Boreal Forest Modelling in the CCC GCM

Objectives and Approach: It is proposed that field data collected during BOREAS be used to place on a firm theoretical footing the modeling of the boreal forest in CLASS (Canadian Land Surface Scheme), a second-generation land surface model which has been developed for the Canadian Climate Centre GCM by the investigator . Currently, because of a lack of data, canopy closure,, albedo, etc.) corresponding to those of temperate coniferous forests. Bulk stomatal resistance, interception of rainfall and snowfall, and the evolution of the snowpack are treated in a very simple fashion, while assumptions about homogeneity or "patchiness" of the land surface are made to simplify the calculation of turbulent fluxes to the atmosphere. Data from BOREAS will enable the testing, refinement, and improvement of CLASS in these areas.

Deliverables

-- application of BOREAS results in an operational GCM framework

Needs from other groups

-- This project is an end user of the field data collected. Data obtained by the RSS groups will be used to improve the calculation of radiative properties of the boreal forest canopy. Information from the TF groups will enable the testing and refinement of the parameterizations of bulk stomatal resistance and surface bulk aerodynamic properties. Measurements made by the HYD groups will be used to validate the algorithms for canopy interception and snowpack growth and ablation. The activities of the TE groups will provide more detailed information on the physical characteristics of boreal vegetation types. Data collected by the BGC groups will be used at a future date, when CO_2 and trace gas fluxes are being incorporated in CLASS.

Input and output variables of CLASS:

Initially specified background grid cell characteristics: Vegetation:

--diurnally-averaged visible albedo

--diurnally-averaged near-IR albedo

--temporal variation of LAI

--standing mass

--rooting depth

Other:

--soil visible albedo, visible saturated albedo, near-IR dry albedo, near-IR saturated albedo, fractional sand and clay contents --fractional grid cell coverage of various land cover types --latitude, longitude, day of year

--initial values of prognostic variables (see below) Micrometeorological forcing data:

--incoming visible, near-IR, direct shortwave, diffuse shortwave, and longwave radiation

--specific humidity, temperature, and wind speed of air above BL

--surface atmospheric pressure

--precipitation rate

Prognostic variables in CLASS:

--soil layer temperatures

--canopy layer temperature

--snow layer temperature

--liquid and frozen moisture content of soil layers --intercepted liquid water, snow, and ice stored on vegetation --snow mass on ground per unit area

--snow visible albedo, near-IR albedo, and density Areally averaged output variables:

--visible and near-IR albedo

--radiative surface temperature

--sensible and latent heat fluxes

--soil drainage

Literature references for CLASS:

Verseghy, D. L., 1991: CLASS--A Canadian land surface scheme for GCMs, I. Soil model." Int. J. Climatol., 11, 111-133. Verseghy et al., 1993: CLASS--A Canadian land surface scheme for GCMs, II. Vegetation model and coupled runs." Int. J. Climatol. (in press)

Tower Fluxes (TF)

TF-1	Black
TF-2	den Hartog
TF-3	Wofsy
TF-4	Anderson
TF-5	Baldocchi
TF-6	Breon
TF-7	Desjardins
TF-8	Fitzjarrald
TF-9	Jarvis
TF-10	Jelinski/McCaughey
TF-11	Verma

Ref. Number TF-1

P.I.(s): Black, T.A./Univ of British Columbia, Thurtell, G.W./Univ of Guelph

CO. I.(s): K.M. King, P.M. Voroney. G.E. Kidd, Univ. of Guelph; M.D. Novak, Univ. of British Columbia

Title: Boreal Forest Atmosphere Interactions: Exchanges of Energy, Water Vapor and Trace Gases

Objectives and Approach: The objectives are to measure the fluxes of sensible (H) and latent heat (E), momentum, CO_2, and trace gases (CH_4, CO, O_3, and NO_2 above, the canopy of an old Aspen stand in Prince Albert Park during the year and to investigate the processes controlling these fluxes. They will be measured using the eddy correlation method with three-dimensional sonic anemometry and closed-path gas analysis (mainly tunable diode lasers (TDL) and open and closed path IRGSs). H and E will also be measured using the Bowen ratio/energy balance method. Below the overstory, H, E and CO_2 fluxes will be measured using the eddy correlation method. Concentration profiles of CO_2,H_2O and the above trace gases will be measured in and above the stand. Soil manipulation experiments will be carried out to determine the response of microbial activity and gas production to changes in soil nitrate and carbohydrate levels. The flow of C and N through the litter/soil system will be measured in situ using ^{13}C and ^{15}N substrates. This project is complementary to TF-2

Deliverables to the project

<u>During Intensives</u>
Eddy Fluxes
--Above Stand
- u*, H, E, CO_2, CH_4, CO, O_3 & N_2O (final decisions on extent of CO & N_2O, TDL measurements will be made at time of experiments)

--Below Overstory
- u*, H, E, & CO_2
- Concentration profiles in and above stand - wind speed, air temperature, H_2O, CO_2, CH_4, O_3, CO, N_2O
- Energy balance components: Rn, incident and reflected shortwave radiation, incident longwave radiation, G, E, H and canopy energy storage
- Water balance components: precipitation, evapotranspiration, soil water storage and drainage
- Soil measurements: soil temperature, water content and potential, carbon and nitrogen pools, microbial activity
- Effective plant areaq index
- General climate (see TF-2)

<u>Between Intensives</u>
Eddy Fluxes
--Above Stand
- u*, H, E, CO_2, CH_4, and N2O
- Stand energy and water balances (as above)
- Soil temperature, water content and potential
- Effective plant area index
- General climate (see TF-2)

Needs from other groups

--soil surface gas exchange measurements (chambers)
--snow surveys across site
--remotely sensed canopy cover and greenness
--remotely sensed radiative surface temperature
--soil texture, bulk density and hydraulic conductivity (saturated and unsaturated) characteristics
precipitation chemistry

Needs from project staff
--120 VAC power (15 k W total for TF-1 and TF-2)
--main scafold tower
--secondary scaffold tower to top of canopy
--boardwalk and huts
--communication including data link
--helicopter transport of heavy fragile equipment prior to intensives

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Ref. Number TF-2

P.I.(s):	den Hartog, G./AES
CO-I(s):	Mickie, R.E., Neumann, H.H., Trivett, N.B.A./AES
Title:	AES Flux Tower Measurements for BOREAS: Exchange or Energy, Water Vapor and Trace Gases Project
Objectives and Approach:	The objectives of this proposal are to quantify and examine the controlling factors for CO_2, O_3, CH_4, N_2O exchange at one Primary, the Old Aspen, Tower Site in PANP and to determine diurnal and seasonal surface energy fluxes at the same site. This study complements TF-1. The broader objectives of the combined proposals include determination of the annual cycle for carbon and nitrogen at the site, with trace gas measurements now also including CO, NO, NO_2, NH_3, and possibly terpenes. Four categories of measurements are proposed - (i) eddy correlation flux measurements of momentum, sensible heat, latent heat, CO_2, O_3, CH_4 and N_2O above the canopy; (ii) within and above canopy profiles of temperature, CO_2 and O_3; (iii) half-hour means of wind speed, wind direction, incoming solar radiation, net radiation, PAR, temperature, relative humidity, wet precipitation, CO_2, O_3, CH_4 and N_2O above the canopy, IR canopy temperature, and soil heat flux and temperature; and (iv) tethersonde profiles including O_3. Four-week measurement periods would coincide with BOREAS intensives. Fluxes and half-hour means would also be measured between intensives in 1994.

Ref. Number TF-3

P.I.(s): Wofsy, S.C./
Co-I(s): Munger, J.W., Daube, B.C., Goulden, M.L., Boering, K.A., Burley J.D./

Title: Eddy Correlation Flux Measurements of CO_2, O_3, and NOy for BOREAS

Objectives and Approach: Eddy-correlation flux measurements for CO_2, and H_2O will be made at the northern black spruce site from the late summer of 1993 through the fall of 1994. Our principle objective is to directly determine the net ecosystem exchange of CO_2, and the surfaceenergy budget, over diurnal, seasonal and annual time scales, and to couple these observations with a comprehensive characterization of the physical environment (PAR, soil temperature, etc.). A low-power automated array will be installed to measure: eddy fluxes and forest column content of CO_2, sensible heat, and water vapor; soil temperatures and moisture, and incident and intercepted PAR. The system will be operated continuously from installation in 9/93 through at least 10/94. Additionally, we will measure the flux of CO_2 from the soil during the summer of 1994 using an array of automated open chambers. Among onther things, these long-term measurements should allow us to assess the importance of winter respiration, and assimilation during transitional periods, tothe annual carbon balance of the boreal forest.

Ref. Number TF-4

P.I.(s): Anderson, D.E. and Striegle, R.G./USGS

CO. I.(s): McConnaughey, E. and Stannard, D.J./USGS

Title: Exchange of Trace Gases, Water and Energy in Disturbed and Undisturbed Boreal Forests

Objectives: We will investigate carbon, water and energy fluxes in boreal forests. through an integrated approach involving flux estimates across the atmosphere-forest and soil-atmosphere boundaries. Eddy correlation measurements of CO_2 latent and sensible heat fluxes, and momentum will be made above a young Jack Pine stand in the Prince Albert area. Concentration profiles of CH_4, $^{12}CO_2$, and $^{13}CO_2$ will be determined within the canopy during one IFC. Soil-atmosphere flux studies will employ soil depth vs.gas concentration measurements, flux chambers and diffusion modelling to determine source and movement of CH_4, $^{12}CO_2$, and $^{13}CO_2$ in the air-soil-water continuum. The distribution and storage of carbon species in the soil profile will also be determined. Long term carbon accumulation will be evaluated by ^{14}C decay of soil carbon.

Net, incoming and PAR radiation, leaf photosynthesis, and certain soil parameters (heat flux, thermal profile) will be measured at the site.

Ref. Number TF-5

P.I.(s):	Baldocchi, D/NOAA
CO-I(s):	Crawford, T., Meyers, T., McMillen, R./NOAA

Title: Experimental and Modeling Studies of Water Vapor, Sensible Heat, and CO_2 Exchange Over and Under a Boreal Forest

Objectives and Approach:

We propose to measure and model air-surface exchange rates of water vapor, sensible heat, and CO_2 over and under a boreal forest and to study the abiotic and biotic factors that control the fluxes of scalars in this landscape. This study is in conjunction with AFM-1. Scalar flux densities will be measured with tower-mounted eddy correlation flux measurement systems over an Old Jack Pine stand in the Prince Albert area. Tower-mounted flux measurement systems will be implemented above and below the canopy. This configuration will allow us to investigate the relative roles of vegetation and the forest floor on the net canopy exchange of mass and energy. We will also use the tower-mounted flux measurement system to study temporal patterns (diurnal and seasonal) of mass and energy exchange at a point in the landscape. Core Measurements include the mass and energy exchange studies just described, as well as measurements of measurements of meteorological variables.

A hierarchy of single and multi-layer mass and energy (water vapor, heat, and CO_2) exchange models - bases on Eulerian and Lagrangian frameworks and on micrometeorology, radiative transfer, plant physiology, and biochemistry theory - will be developed and tested using the data obtained over a boreal forest. Comparing the hierarchy of models will enable us to rank the controlling variables and to develop a simpler surface exchange model that can be used by climate and ecosystem models. Our final goal is to drive the simple model with satellite-derived land-use data and meteorological information to evaluate the spatially-integrated surface fluxes.

Ref. Number TF-6

P.I.(s):	Bessemoulin. P./CNRM
CO-I(s):	Breon, F.M./LMCE, Mahfouf, J.F., Noilhan, J., Roujean, J.L./CNRM Deschamps, P.Y./USTL/LOA,, Kerr, Y./CNES/LERTS, Vanderbilt, V.C./NASA/AMES

Title: Study of the Boreal Forest Effects on Surface/Atmosphere Fluxes

Objectives

Measurements of the fraction of PAR and NIR radiation intercepted by NSA OJP and NSA OBS forest continuously, that is from sunrise to sunset and from May to September (including IFC-1, IFC-2, and IFC-3). Sample within the forest using a large number (around 100) of small optical sensors located at different levels on a vertical 12-meters mast. FPAR and LAI can be estimated as a result.

Our research program includes:

--turbulent (eddy correlation fluxes of sensible and latent heat) and radiactive fluxes measurements at the Young Aspen site in the SSA;

--Modelling of interactions between the surface (soil, vegetation) and the atmosphere at local, meso and large scale (CRNM);
--radiative fluxes (incident and intercepted PAR, directional effects) and atmospheric optics (LOA, LERTS;
--airborne remote sensing measurements with the POLDER instrument (LOA, LMCE, NASA).

Needs from other groups
--surface and airborne fluxes, soil moisture measurements, smeteorological parameters, radiosoundings, remote sensing data
Needs from project staff
--access to TF-6 site (Young Aspen site at Torch Lake) during IFC-2 for turbulent and radiative fluxes measurements, using our own masts;
--Access to SSA OJP and SSA OBS sites for the radiative transfer work during IFC-1,2,3 involving: one dedicated mast for understory measurements, 8 PAR/IR cells at the top of the flux towers at those sites (4 for incoming radiation, 4 for reflected radiation), and a network of cells at the ground;
--Facilities for storage of shipped equipment;
--Topographic, soil and vegetation maps

Ref. Number TF-7

P.I.(s): Desjardins, R.L., Pattey E./Agriculture Canada, MacPherson, J.I./NRC

CO.I.(s): Schuepp, P.H./McGill, Nakane K., Hayashi, M./Japan, St-Amour, G./Agriculture Canada

Title: Areal Estimates of Mass and Energy Exchange from a Boreal Forest Biome

Objectives and Approach: The objective of this study is to develop techniques for studying the contribution of the boreal ecosystem to the greenhouse gas composition of the atmosphere and how this ecosystem responds to environmental conditions. Tower-based flux measurements of heat, momentum, CH_4, CO_2, NMHC, N_2O, and H_2O will be obtained during intensive field campaigns in 1994 over an Old Black Spruce stand in the Prince Albert area. These measurements will be compared with measurements from other research groups in order to verify their accuracy and combined with them to model the boreal forest ecosystem. Techniques will be developed to arrive at a spatial and temporal description of energy, water and carbon fluxes on a large area basis. The Japense section of this team lead by Prof. Nakane will measure CO_2 fluxes in the forest canopy by chamber technique. In addition, soil carbon cycle work will be done in the SSA-OBS and nearby clear-cuts.

Deliverables:

1. Half-hourl fluxes of momentum, CO_2, sensible and latent heat.

2. Fluxes of NMHC, CH_4 and N_2O will also be provided for selected periods.

3. Compositing of aircraft and tower-based measurements of these fluxes to obtain diurnal pattern of regional fluxes.

Ref. Number TF-8

P.I.(s): Fitzjarrald, D.R./Atmospheric Sciences Research Center
CO-I(s): Moore, K.E./Statue Univ of New York, Albany

Title: Surface Exchange Observations in the Canadian Boreal Forest Region

Objectives and Approach: This study will focus on long-term measurements of radiation, heat, moisture, carbon dioxide and momentum budgets from the tower to be constructed at the Nelson House Old Jack Pine site. Turbulent fluxes are to be determined using the eddy correlation technique and radiative fluxes in the short, long, near infrared, and PAR wavelength bands will be acquired as well as soil moisture content. Collaborating with other groups the CO_2 gradient inside and just above the canopy will be acquired. We will also deploy a digital cloud camera to obtain a seasonal record of cloud fraction and, possibly, cloud type. Our plan addresses the following observational components of the BOREAS Science Plan: a) Radiation and cloud observations at a core site; b) Measurement of standard meteorological variables; (c) Seasonal-scale observations of evapotranspiration and sensible heat flux.

Ref. Number TF-9

P.I.(s): Jarvis, P.G.,Moncrieff, J.B.// Univ of Edinburgh
CO-I(s): Massheder, J.M., Hale, S.E., Rayment, M.B., Scott, S.L./Univ. of Edinburgh; Morse, A.P./Univ. of Liverpool

Title: The CO_2 Exchanges of Boreal Black Spruce Forest

Objectives and Approach: The objectives of this study are to measure and model the CO_2 exchanges of boreal black spruce forest and to determine whether the soils and vegetation are significant global sinks for atmospheric CO_2. Stand CO_2 fluxes will be measured using eddy covariance and respiration components will be measured using chamber based techniques. The CO_2concentration profile will also be measured to allow estimation of the atmospheric storage of CO_2 within the canopy. Further measurements of the photosynthetic components and of stand structure and radiation properties will be obtained by collaboration with other groups. These measurements will be used to construct carbon budgets and to test models (especially Maestro) that will be used to scale up the carbon budgets in space and time.

Needs from Other Groups:
Stand Structure
Tree crown structure
Leaf area density distribution
Branch distribution
Soil optical properties
Leaf optical properties (visible and near infra-red)
Leaf biochemistry especially nitrogen content
Leaf physiological parameters - photosynthesis, respiration
Leaf water potential, Leaf temperatures
Air and leaf ^{13}C in the canopy
Net radiation on the tramway
Fish eye photographs

Ref. Number TF-10

P.I.(s):	McCaughey, J.H./Queen's Univ
CO-I(s):	Jelinski, D.E./State Univ of New York at Buffalo, Lafleur, P.M./Trent Univ
Collaborator(s):	Ponce-Hernandez, R/Trent Univ, Price, J.S./Queen's Univ, Buttle, J./Trent Univ.

Title: Surface Energy and Water Balances of Forest and Wetland Subsystems in the Boreal Forest: Surface-Atmosphere Links and Ecological Controls

Objectives and Approach:

We plan to carry out an intensive series of field experiments on the climatological implications of contrasting ecological controls on surface energy and water balances of forest and wetland subsystems of the northern Boreal Forest. The young-dry jack pine site and the fen site at the Thompson super-site have been selected for the work. For both surfaces, a complete suite of microclimatic (energy, radiation, and water balance data) and biophysical measurements will be taken. We propose to measure the flux of CO_2 at both sites.

As part of the study concerning ecological controls on the hydrology and water balance of a wetland subsystem of the northern boreal forest, TF-10 will be conducting field work during the FFC-T at the fen site at Thompson. A spatially-distributed snowmelt model will be developed from measurements of net radiation, temperature, relative humidity and wind speed at both the fen tower and a nearby forested site. A snow survey consisting of a stratified random sample based on terrain types will be conducted and will include depth-stratified (snow pits) and depth integrated measurements of snow density and snow water equivalent. Other supporting measurements will include meltwater chemistry, depth to frost table, snow and soil emperature profiles as well as gap fraction measurements with a LAI-2000 prior to green-up.

We propose to measure the flux of CO_2 at both sites.

Deliverables to the Project:
Continuous for the 1994 experimental period

Data to be collected at both the jack pine and fen sites, except where specified

- Net radiation, global solar and reflected solar radiation, outgoing longwave radiation data
- Temperature, humidity and wind profile data
- Soil heat flux and soil temperature data (0.05, 0.1, 0.25, and 0.5, and 1.0 m depths)
- Leaf area index, age structure, spacing and diversity (periodic samples at both sites and over the basin)
- Water table elevation, groundwater flow, precipitation, stream discharge (fen site only)

Continuous for the IFCs

All of the continuously collected data (see above) plus the following:

- Leaf water vapor conductance and leaf water potential
- Leaf area index (spatial distribution)
- Sensible and latent heat fluxes from eddy correlation and reversing psychrometry
- Daily soil moisture

Needs from Other Science Groups:

- GIS-based physiognomic data
- Various satellite products, including SPOT, TM, and TIMS data
- Soil properties data, including depth, type, mineral and organic matter fractional contents
- Fluxes of sensible and latent heat from other experimental sites and aircraft

Needs from the Project Staff

Jack pine site:

- Tower (approx. 12 m) and power (AC and 12V drops) installed
- Installation of access walkways and roadways to minimize site disturbance
- Instrument shed (3 x 3 m)
- Periodic visits to the sites to check on the integrity of the equipment when experiment operators will be absent

Fen site:

- Boardwalk (approx. 500-700 m) installed
- Instrument platform (2 x 2 m) installed
- Tower (approx. 5 m) and power (AC and 12V drops) installed
- Instrument shed (3 x 3 m)

General:

- Wet lab space (at least one 4-metre lab bench) with AC power
- Drying ovens and balances

Ref. Number TF-11

P.I.(s): Verma, S.B./Univ of Nebraska-Lincoln

CO-I(s): Arkebauer, T.J.. Ullman, F.G./Univ of Nebraska-Lincoln, Parton, W.J., Schimel, D.S., Valentine, D.W./Colorado State University

Title: Field Micrometeorological Measurements, Process-Level Studies and Modeling of Methane and Carbon Dioxide Fluxes in a Boreal Wetland Ecosystem

Objectives and Approach

We propose an integrated program of reasearch on field micrometeorological measurements, process studies and modeling of methane and carbon dioxide fluxes at a boreal wetland site (fen at SSA). The proposed research has the following four components.

1. Quantifications of surface exchange rates of methane and carbon dioxide at a boreal wetland site. The micrometeorological eddy correlation technique will be employed to obtain 'areally integrated' fluxes.

2. Evaluation of soil surface carbon dioxide flux and characterization of its response to controlling variables.

3. Process studies will include field experimental manipulations to quantify the degree of substrate or pH limitations of methane production and oxidation. The

responses of leaf photosynthesis, plant respiration and stomatal conductance of dominant plant species to relevant controlling variables will be quantified experimentally.

4. Integration of the first three components to test and improve a model of decomposition and methane emission responsive to variability in moisture, temperature, and pH in northern wetland ecosystems.

Deliverables to the project:

The Anticipated data outputs are listed below:

1. Micrometeorological Flux Measurements Methane flux, atmospheric carbon dioxide flux, sensible heat flux, latent heat flux, soil heat flux, friction velocity, and supporting meteorological variables.

2. Experimental Manipulations of Factors Controlling Methane Emission Responses of CH_4 production, oxidation and emission to treatments (*e.g.*, additions of N + P, substrate (EtOH), labile C, and acid or base titrants).

3. Leaf Photosynthesis Single leaf photosynthetic parameters for the dominant vascular plant species: Maximum rates (P_{max}), quantum requirement, light and CO_2 compensation points, carboxylation efficiency, maximum rate of carboxylation of rubisco (V_{cmax}), maximum rate of electron transport (J_{max}), CO_2 compensation point, Leaf dark respiration rate (Rd). Maximum value of leaf stomatal conductance.

4. Modeling and Integration Rates of methane production, consumption and emission, rates of decomposition and fermentation, derivative of above rates with temperature, substrate availability, peat chemistry, pH and water table.

Core Measurement Needs:

a. Vegetation and soil classifications
b. Satellite imagery of the wetland research site for analysis of landscape variability
c. Above and below ground biomass--beginning and end of the growing season
d. Regular soil moisture measurements

Terrestrial Ecosystems (TE)

TE-1	Anderson
TE-2	Ryan
TE-3	Deleted See TGB-12
TE-4	Berry
TE-5	Ehleringer/Flanagan
TE-6	Gower
TE-7	Hogg
TE-8	Kharuk
TE-9	Margolis
TE-10	Middleton
TE-11	Saugier
TE-12	Walter-Shea
TE-13	Apps
TE-14	Bonan
TE-15	Bukata
TE-16	Cihlar
TE-17	Goward
TE-18	Hall
TE-19	Harriss
TE-20	Knox
TE-21	Running
TE-22	Shugart
TE-23	Rich

Ref. Number TE-1

P.I.(s): Anderson, D.W./Univ of Saskatchewan
CO-I(s): Schoenau, J.J., Nisbet, E.G./Univ of Saskatchewan, Pluth, D./Univ of Alberta

Title: Stores and Dynamics of Organic Matter in Boreal Ecosystems

Objectives and Approach: The objective of the proposed research is to characterize the various soil-plant systems along a transect in one of the ecosystems selected for study at the southern BOREAS site. Particular emphasis will be on nutrient biochemistry, the stores and transfers of organic carbon and on soil properties and pedogenesis, and how the characteristics are related to measured methane fluxes. The transect in Prince Albert National Park will include the major plant communities and related soils that occur in that section of the boreal forest. Soil physical, chemical and biological measurements along the transect will be used to characterize the static environment, which will then be related to methane fluxes. Chamber techniques will be used to provide a measure of methane production/uptake. Chamber measurements coupled with flask sampling will be used to determine the seasonality of methane fluxes.

Ref. Number TE-2

P.I.(s): Ryan, M.G./USDA
Collaborator(s): Margolis, H./Universite Laval, Chapin, III, F.S./Univ of California, Berkeley

Title: Autotrophic Respiration in Boreal Ecosystems

Objectives and Approach: Because respiration increases exponentially with temperature, and because warming is expected to be the greatest at high latitudes, autotrophic respiration strongly affects dry-matter production and carbon storage in boreal forests. The research will (1) estimate instantaneous and annual fluxes of CO_2 from all respiration for the footprint of tower flux measurements in three ecosystem types (Spruce, Jack Pine, Aspen) at the two BOREAS locations, (2) test the use of tissue content as a general estimator of CO_2 flux from respiration, (3) use paired genotypes, and (4) estimate an annual carbon budget for these sites (in cooperation with other scientists) to determine whether the ratio of respiration to photosynthesis among species and for different climates. Results from these investigations will better models for estimating CO_2flux from autotrophic respiration, and clarify of autotrophic respiration in regulating productivity and carbon storage in ecosystems.

Deliverables to the project:
1) Estimates of autotrophic respiration (instantaneous and annual budgets) ecosystem types (Black Spruce, Jack Pine, Aspen)
2) Verification of a relationship between tissue N content and maintenance respiration

Needs from other science groups
1) Above- and below-ground biomass, NPP, and N and P content (by component for three ecosystem types (Black Spruce, Jack Pine, Aspen)
2) Eddy-flux measurements of C flux for three ecosystem types (Black Spruce, Jack Pine, Aspen)

Needs from project staff

1) Weather data for sites
2) Remote sensing of canopy temperatures and foliar N content, if scientifically possible

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Ref. Number TE-3 -- DELETED, see TGB-12

Ref. Number TE-4

P.I.(s): Berry, J.A./Canegie Institution of Washington
CO-I(s): Collatz, G.J./Carnegie Institution of Washington, Gamon, J./California State University, Los Angeles

Title: Measurement and Prediction of CO_2 and H_2O Exchange from Boreal Forest Tree Species

Objectives and Approach: We propose to measure steady state gas exchange and spectral reflectator responses to temperature, light, CO_2 and humidity in leaves of Aspen, Jack Pine, Black Spruce. Some of these measurements will be made within canopies of these species in the intensive field campaigns of 1994 and some will be made under more controlled laboratory conditions. Effects of leaf age, and conditions (temperature, light, nitrogen, water) will be measured. Specialized chambers and portable fields are being developed for use with broad leaf and conifer tissue. This data will be used to develop algorithms for predicting photosynthesis and transpiration from bidirect reflectance and to parameterize our mechanistic leaf and canopy models of CO_2 and exchange for the boreal forest.

Products: We will report field and laboratory measurements of nitrogen concentration steady state photosynthesis, stomatal conductance and spectral reflectance (res. approx. 15 nm 1/2 band width between 400-1100 nm) under a variety of important atmospheric and soil conditions. This data will be useful for the development and parameterization of leaf based canopy and regional photosynthesis and evaporation models. We will refine our own models and assist in their implementation as compared to larger scale models.

Needs from other science teams: (spatially and temporally matched with our study sites)

1) Minute to hourly meteorological conditions in the mixed layer, surface layer, with the canopy and/or at the leaf surface including temperature, water vapor, radiation, CO_2 and wind speeds levels (TF).
2) Minute to hourly CO_2, water vapor, sensible heat and radiative fluxes at the top canopy (TF).
3) Spectral reflectance of vegetation at scales greater than leaf (RSS and TE).
4) Minute to hourly values for soil respiration, bole respiration, litter moisture and temperature and rooting layer moisture and temperature (TE and HYD).
5) Daily to weekly values of available solid nitrogen, leaf area index, litterfall and above ground herbivore and disease losses (TE).
6) Seasonal above ground productivity (TE).
7) Measurements of leaf gas exchange and spectral reflectance made by other (TE).

Support Requirements
1) 500KW @ 120V from flux tower power source.

2) 14 square feet of bench space with heat and power.
3) 0.05 cubic meters of freezer space.
4) 0.02 cubic meters of drying oven space.
5) Scaffolding to 12m at each of 3 sites.

Ref. Number TE-5

P.I.(s): Ehleringer, J.R./Univ of Utah
CO-I(s): Flanagan, L.B./Carleton Univ

Title: Vegetation-Atmosphere CO_2 and H_2O Exchange Processes: Stable Isotope Analyses

Objectives and Approach

Determine the influence of vegetation on changes in isotopic composition of atomospheric CO_2. Determine major environmental and biolgical controls on CO_2 and H_2O fluxes from dominant boreal types, including site-integrated estimates of stomatal/biochemical controls on CO_2 and H_2O fluxes, scaleable between leaf and canopy, extent of recycling of CO_2 within forest canopies, quantitative measure of water source use by different tree species, reconstruction of past temporal patterns and how they relate to CO_2 and H_2O flux observations during IFC periods, multiple site comparison capacity within two super sites.

Deliverables:
-- Carbon and oxygen isotope analyses and concentrations of atmospheric CO_2 within canopies on a diurnal and seasonal basis.
-- Carbon isotope analyses of leaves of cominant tree species; Jack Pine, Black Spruce, Aspen.
-- Carbon isotope analyses of annual tree rings of dominant tree species over previous 20-year period.
-- Hydrogen and/or oxygen isotope ratio analyses of xylem sap of dominant tree species on seasons basis.
-- Hydrogen and/or oxygen isotope ratio analyses of meteric, soil, and ground waters on a seasonal basis.
-- Photosynthetic measurement on leaves within canopies as related to reconstructing rates of CO_2 recycling.

Needs from Science Groups:
-- Aircraft collection of atmospheric CO_2 samples.
-- Water samples from hydrological groups of isotopic analyses.

Needs from Project Staff:
-- Access to canopy towers at each site for ecophysiological measurements.
-- 10-15 feet of laboratory bench space for vacuum lines.
-- Electrical power (maximum tkW) at lab bench.
-- Access/delivery of liquid nitrogen (150 liter cylinders).
-- Access/delivery of dry ice (20-25 pound) allotments.

Ref. Number TE-6

P.I. (s): Gower, S.T./ Univ. of Wisconsin

Co. P.I.(s) Norman, J.M./Univ. of Wisconsin

Title: Measurement and Scaling of Carbon Budgets for Contrasting Boreal Forest Sites

Objectives and Approach: The objective of this project is to examine the influence of vegetation, climate and their interaction on the major carbon fluxes for aspen, jack pine and black spruce forest ecosystems at the Southern Study Area and Northern Study Area.(Four, 15 x 15 m plots will be established at each site during the fall 1993 IFC. We will measure above- and below ground net primary production and use leaf respiration, autotrophic respiration and soil surface CO_2 flux data from other PI's to construct stand-level carbon budgets. Above-ground net primary production will be calculated annually for a 10-year period (1985-1994) from annual stemwood radial increment cores and site-specific allometric equations which will be developed in conjunction with M. Apps (TE-13). Below-ground net primary production will be estimated using sequential coring and carbon balance methods. Soil surface CO_2 flux will be measured weekly for the northern aspen stand during the IFC's using a LI-COR 6200 and soil respiration chamber. Soil surface CO_2 flux estimates obtained by this method will be compared to estimates obtained by PI's measuring soil surface CO2 flux (using similar or different methods) at all mature forested sites at least once during 1994. We will develop a method to scale leaf-level photosynthesis measurements to the canopy level using measurements of canopy architecture and models of radiative transfer. The scaled canopy-level CO_2 fluxes will be compared to tower fluxes that are based on micrometeorological methods. We will develop and explore the utility of a new multi-band vegetation imager for indirectly determining forest canopy architecture in aspen and jack pine sites.

Deliverables to the Project

1) Carbon distribution in above and below-ground overstory and understory, forest floor and mineral soil for old aspen, jack pine and black spruce in SSA and NSA.
2) Annual net above- and below-ground net primary production and detritus production for overstory and understory for old aspen, jack pine and black spruce in SSA and NSA.
3) Soil surface CO_2 flux measurements for old aspen stand in NSA.
4) Archived plant tissue samples (stem wood, stem bark, branch, and foliage by age class and canopy position) for old aspen, jack pine and black spruce in SSA and NSA.

Ref. Number TE-7

P.I.(s): Hogg. E.H./Forestry Canada

Co P.I.(s): Ian Campbell, P.A. (Rick) Hurdel, Thierry Varem, Harjit Grewal/Forestry Canada

Title: Climate Change Effects on Net Primary Productivity of Productivity of Aspen and Jack Pine at the Southern Limit of the Boreal Forest

Objectives and Approach: Regional climate-vegetation relationships indicate that the southern limit of the boreal forest is presently governed by moisture stress. this investigation aims to use a combination of field studies and modelling to predict how forest communities at the boreal forest's southern limit could respond to future changes in climate. The investigation includes short-term measurements of transpiration, photosynthesis, stem respiration and LAI, plus longer term studies of stand development, growth (tree ring analysis) and regional forest composition (palynology). this work will also form part of an ongoing Canadian study (BFTCS) of climate change effects on he functioning and carbon balance of the Canadian boreal forest.

Deliverables to the project
--An opportunity for an intensive, multidisciplinary study of ecophysiological/forest canopy processes in a jack pine stand near its extreme southern limit of distribution (Nisbet), and the potential for long-term monitoring of these processes at a site most likely to experience the greatest effects of climate change and increased soil dryness.

--An opportunity for comparisons in structure and functioning of aspen in the southern boreal forest (PANP) with that in the more drought-prone aspen parkland (Batoche), where we have already initiated a similar study (Hogg and Hurdel).

--LAI has already been measured at Batoche (Hogg) using a combination of litter fall traps and the Li-Cor LAI-200 and this could provide a non-destructive method of monitoring LAI at the PANP aspen site.

-- Measurements of leaf area index (LAI) and specific leaf are (m^2/kg) destructive samples at several tower sites, along with some biomass and sapwood area measurements (Penner and Campbell).

-- Assistance with clone boundary definition for aspen (Hogg).

-- An opportunity for continuous, seasonal monitoring of transpiration (1993-94) in these most drought-prone sites by the heat pulse velocity method (Hogg and Hurdle).

-- Leaf level photosynthesis/transpiration measurements by Li-Cor 6200, coupled with scholander bomb measurements of leaf water potential (Hogg and Hurdle).

-- Measurements of soil temperature and soil moisture (fiberglass Colman blocks) at Nisbet and/or PANP aspen site (Hogg and Hurdle).

-- Measurements of tree stem respiration in aspen (PANP) and jack pine (Nisbet) during 1994. This will be replicated at the Nelson House supersite, resources permitting (Lavigne).

-- Historical information and modelling of regional forest composition and growth processes which would provide the longer-term, larger-scale context for the 1-2 year, measurement time-frame of BOREAS (Campbell).

Needs from other science groups:

-- We would welcome the opportunity to collaborate with a team investigating decomposition, carbon allocation, nutrient cycling and below-ground processes.

-- Our research needs would best be met by working at a flux tower site in collaboration with a more experienced flux measurement team. A full flux tower at the Nisbet jack pine site is our first choice, but we would consider a more limited involvement with another team at the PANP aspen site, while using Nisbet as a terrestrial ecology/ecophysiology site only during BOREAS.

-- We anticipate that leaf level IRGA measurements will be made at PA aspen site and at Nisbet jack pine site, so that we can focus our IRGA measurements at Batoche (Hogg).

Needs from project staff and For Facilities/Measurements:

-- Penner requires some space to up lab balances and drying ovens. For leaf area measuring equipment, laboratory space at both supersites would be desirable.

-- Lavigne and Hogg wish to work at sites where standard meteorological measurements are being made, including air temperature at screen height, RH, PAR, soil temperature and soil moisture. These can be provided by Hogg at Batoche and Nisbet, but at the the other sites (PA aspen and NH sites), we are relying on these measurements being made by others.

-- An aerial overflight of the Batoche site would be very useful to us and to other investigators working on aspen within BOREAS.

-- We anticipate that leaf level IRGA measurements will be made at PA aspen site and at Nisbet jack pine site, so that we can focus our IRGA measurement at Batoche (Hogg).

NAME	SITES	PARAMETERS	FREQUENCY	SAMPLE LOCATION	IFC'S
Hogg Hurdle	PA pine (Nisbet) PA aspen Batoche aspen	Sap flow velocity (Heat pulse)	4-6 times/day	10 trees (Nisbet) 4 clones x 2/clone x 2 sites (aspen)	IFC93 (testing) IFC94- 1,2,3
Hogg Hurdle	PA pine (Nisbet) PA aspen Batoche aspen	Soil moisture (Colman blocks) Soil temperature	mean/max/ min time of max/min daily (Apr-Oct)	2-4 per site x 2 depths (10, 30 cm)	IFC93 (testing) IFC94- 1,2,3
Hogg Hurdle	Batoche aspen (possible also at Nisbet)	Leaf P/S, Transp. Xylem tension (Li-Cor 6200, Scholander bomb)	bi-hourly dawn-dusk (3 day periods)	4 clones mid-canopy	IFC93 (testing) IFC94- 1,2,3
Hogg Hurdle	Batoche aspen	Canopy level P/S and E /T (eddy flux)	continuous dawn-dusk (3 day periods)	tower	IFC93 (testing) IFC94- 1,2,3
Hogg Hurdle	Batoche aspen Nisbet (if needed)	Air temp (screen and 8 m ht), RH, wind, PAR and solar radiation above canopy	hourly continuous	at tower	IFC93 IFC94- 1,2,3
Hogg	Batoche aspen PA aspen (if needed)	Litter fall (LAI+SLA by tree/ shrub species)	October	20-30 bucket traps	(IFC93, 94-3)
Hogg	Batoche aspen PA aspen (if needed)	Clone boundaries	Once (spring or fall)	near tower	
Penner	PA aspen (1993-4) PA pine (1993-4) NH aspen (1994) NH pine (1994)	Specific Leaf Area of fast- vs. slow-growing stands	Once (destructive)	upper crown 4 trees/stand 4 stands/species/ supersite	IFC93 IFC94- 1,2,3
Penner	PA aspen (1993-4) PA pine (1993-4) NH aspen(1994-5?) NH pine (1994-5?)	Leaf Area Index of area of fast- vs. slow-growing stands (destructive and with LAI-2000)	twice	upper crown 4 trees/stand 4 stands/species/ supersite (funding permitting)	IFC93 IFC94- 1,2,3
Lavigne	PA aspen PA pine NH aspen NH pine	Woody stem respiration (battery-powered IRGA)	3-4 days/site per month, May-October	stem/branch segments 16 trees/site	IFC94- 1,2,3
Campbell	Botoche-Gillam including PA and NH	Palynology Dendrochronology	ongoing		
Campbell Penner	Batoche aspen PA pine (Nisbet) other locations (PA-NH)	Permanent growth plots (Tree maps with hts, dbh, etc.)	1992-97		

Ref. Number TE-8

P.I.(s): Kharuk , V.I. (P.I., TE-8)

Title: Tree Bark Input in Tree-Atmosphere Interactions

Objective and Approach: The principal aim of this investigation is to evaluate the input of tree bark into tree-atmosphere interactions (i.e., the photosynthetic process).

(II) Investigation Summaries

Tree-atmosphere interaction is considered usually as "leaf" interaction with the atmosphere. But the input of tree bark is not negligible, especially during "leafless" periods (e.g., spring, fall, as well as after defoliation caused by insects or pollution), when the bark is the single source of hydrocarbons. The comparative analysis of biophysical properties of bark versus those of leaves must be done.

A. The studies should include:

1. Comparative analysis of optical propertiesm (transmittance, reflectance, polarization) of bark and leaves.
2. Comparative analysis of bark versus leaf pigment content.
3. Estimation of LAI versus "BAI" ("bark area index").
4. Comparative analysis of bark photosynthesis and evapotranspiration versus leaf photosynthesis/evapotranspiration.
5. Comparative analysis of deciduous (Populus tremuloides) versus coniferous species.

B. The choice of Populus tremuloides as the No. 1 objective is based on the following reasons:

1. P. tremuloides is one of the dominant species in the boreal forest biome.
2. P. tremuloides compete effectively with other species.
3. P. tremuloides is one of the leaders in bark chlorophyll content.

C. The studies may be conducted at any one of three levels.

1. "Bare Minimum Study Level" (BMSL). This would include:
   (a) Bark optical properties.
   (b) Bark pigment content.
   (c) "Map" of optical properties and pigment contentfor the tree's stem and branches.
2. Medium Study Level--would include BMSL above, plus:
   (a) Estimation of photosynthesis/evapotranspiration of bark.
   (b)"Map" of functional activity of tree's bark.
3. Optimal Study Level--would include the two previous levels, plus:
   (a) Seasonal aspect.
   (b) Age aspect.
   (c) Data sets should be obtained for all dominant tree species.
   (d) Polarimetric properties of leaves (needles) and bark for all dominant tree species.

(III) Field Measurements

A. Sampling and design.

1. Measurements should include:
   (a)Field measurements ("morphometry", LAI, "BAI", photosynthesis, evapotranspiration);
   (b)Lab-based measurements (bark/leaf optic and pigment content).
2. On test areas, 3 to 5 trees of each species should be chosen.
3. Detailed tree inventory and "morphological" data should be obtained:
   (a) Height;
   (b) Stem diameter at different heights;
   (c) The length and diameter of branches of different age;
   (d) LAI; (e) Total bark surface ("BAI"). 4-7. Pigment content, optical properties, evapotranspiration, rate of photosynthesis versus age of branch and its position in the crown.

B. Parameters.

1. For measuring optical properties, chlorophyll content samples ("disks") should be taken from different heights on the stem and length of branch. Samples should be analyzed in the lab.

C. Frequency.

1. Three data sets (spring-summer-fall) for the whole tree must be obtained. The highest frequency sampling rate (once per every 3 to 7 days) should be in the spring. It seems that in order to obtain reliable data, measurements should be made throughout an entire IFC.

Coordination should be done with TE-4, TE-9, TE-10, TE- 12, RSS-6, RSS-20 (to be specified). The work to be done at tower and auxiliary sites should be specified in May 1993, following site visits.

(IV) Supporting Measurements

Hourly surface weather data will be necessary. Aircraft/satellite data for the beginning-middle-end of growing season.

(V) Infrastructure Needs

Power: 120V AC; 12V DC. Lab space: 2 square meters of bench space.

(VI) Next Steps

A. 1993 IFC priorities:

1. Coordination with colleagues.
2. Checking the equipment and methods.
3. Collection of "bare minimum" data set which is necessary and sufficient for
   (a) Preparing for 1994 IFC's; (b) solving the problem at "zero approximation". It includes:
   (i) Inventory data and "morphological" assessment of a tree;
   (ii) Optical properties of bark; (iii) Bark chlorophyll content;
   (iv) Estimations (first approximation) of photosynthesis and evapotranspiration.

B. 1994 IFC's:

Evaluation of dynamic aspects of tree bark-atmosphere interactions (during the growing season):
1. During the spring: activity of bark versus leaves in "transition period" (i.e., from the opening buds of maturation of leaves).
2. The middle of growing season. 3. The end of growing season.

The timing of the 1994 IFC's/FFC's will be decided after May 1993 site visits and Winnipeg workshop discussions.

Ref. Number TE-9

P.I.(s): Margolis, H.A., Edwards, G., Thomson, K.P.B., Viau, A. (Université Laval)

Title: Relationship Between Measures of Absorbed and Reflected Radiation and the Photosynthetic Capacity of Boreal Forest Canopies and Understories

Objectives and Approach: This project will examine the relationship between net photosynthetic (net Ps) capacity, N concentration and percent photosynthetically active radiation (%PAR) of three major boreal forest cover types (jack pine, black spruce and aspen) as well as their link to remotely-sensed and land-based measures of reflected and absorbed radiation. We will attempt to establish general relationships which can be used to predict the vertical distribution of the net Ps capacity for these cover types, including their understories, when neither water nor temperature is greatly limiting. We will also determine how these relationships will vary over the growing season and among six different stand conditions at the Northern Study Area (NSA). Furthermore, the photosynthetic response surface of foliage from the three main cover types with respect to light, temperature, vapor pressure deficit and internal CO_2 will be determined during each IFC using a laboratory-based photosynthetic system with cut branches. The effects of in situ frost exposures on the photosynthetic characteristics of the three main cover types as well as their patterns of recovery will be determined in order to introduce more realistic algorithms of the effects of frost on carbon flux. PAR measurements taken within the the canopy will be supplemented with geometry measurements of the different canopy constituents and the spatial variability of these measurements within the stand will be examined. Additionally, the BDRF of soil and understory components, the spatial variability of the spectral signatures of soil and understory components, and the spectral distribution of hemispherical downwelling radiation will be characterized in order to drive and validate a forest canopy reflectance model (TRELITE). This model will be used to estimate PAR levels within the various forest canopies and these estimates will then be used as input to the photosynthetic model. Depending on the availability of additional resources, canopy biochemistry (lignin, cellulose, starch, sugars, chlorophyll and terpenes) will be followed over the growing season for six stands.

Deliverables to:

- -- Photosynthetic response surface (i.e., response to light, temperature, vapor pressure deficit and CO_2), nitrogen concentrations and specific leaf area of foliage from a vertical profile of the three main cover types including understory and mosses.
- -- Estimation of canopy photosynthetic capacity for the growing season.
- -- Punctual measurements of PAR levels at different vertical levels.
- -- BDRF and spatial variability of reflectance of soil and understory components spectroradiometer.
- -- Occasional measurements of leaf water potential.
- -- Testing and validation of TRELITE.
- -- Possibly canopy biochemistry (depending on other resources becoming available).

Needs from other Science Groups:
- -- Maintenance respiration (Ryan)
- -- Annual soil respiration (Ryan)
- -- Above- and below-ground carbon accumulation (Gower)

Needs from Project Staff:
- -- Helicopter-based measurement of canopy reflectance of three to four Nelson House flux tower sites and three to four auxiliary sites using Spectron SE-590.
- -- CASI measurements of canopy reflectance for same sites as in 1.
- -- ASAS and Landsat simulator measurements of canopy reflectance from NASA C-130 for same sites as in 1.
- -- AVIRIS measurements of canopy reflectance from ER-2 for same sites as in 1.
- -- Daily climatic data in the vicinity of Nelson House stands for average daily, maximum and minimum air temperatures, vapor pressure deficits, relative humidity, solar radiation (PAR), soil moisture.

Ref. Number TE-10

P.I.: Middleton, E.

Title: CO_2 and Water Fluxes in the Boreal Forest overstory: Relationship to fAPAR and Vegetation Indices for Needles/Leaves

Objectives and Approach: In this study we will correlate physiological processes at the leaf/needle level with optical measurements amenable to remote sensing. Specifically, *in situ* measurements for gas exchange flux rates for CO_2 and water, plant stress as indicated by chlorophyll-a fluorescence, and other supporting measurements will be acquired for dominant species of the boreal forest overstory at the BOREAS Southern sites (mature aspen, mature jack pine, young jack pine, black spruce, and mixed aspen/white spruce). In the laboratory, further measurements of photosynthetic capacity will be made in conjunction with continuous visible/near-infrared spectral optical properties and pigment analyses. Nitrogen will be determined from dry foliar material. This data set will be utilized to estimate the vertical gradients of carbon assimilation, nitrogen use efficiency, and photosynthetic efficiency for different species as a function of phenology and environmental conditions, especially available water, nitrogen, and PAR. These data will be used to examine the relationships between the physiological parameters, especially photosynthesis and conductance rates, and the optical parameters (fAPAR and spectral vegetation indices, or SVIs). They will also be used to parameterize the canopy level radiative transfer and physiological models utilized in landscape in landscape analyses by other investigators.

Ref. Number TE-11

P.I.(s):	Saugier, B./ Universite Paris-Sud
CO-I(s):	Deleens, E./CNRS, Granier, A./INRA, Rambal, S./CNRS
Collaborator(s):	Dedieu, G/LERTS, Ducoudre, N./LMCE

Title: Seasonal Variations of Net Photosynthesis and Transpiration at the Tree Level

Objectives and Approach: The objective is to monitor the net assimilation and transpiration rate of trees throughout the 1994 growing season, at the Prince Albert Old Jack Pine site (and short sapflow measurements in P.A. mixed-stand). For this we propose the following steps using several original methods:

1. Installation of sapflow probes in the trunk of 6 representative trees in PAOJP at the end of FFC94-T, monitoring of sapflow from May to September 1994 (Prince Albert Mixed Site will be equipped with sapflow probes during the IFC92-2 campaign only).. The probes are laboratory made, constant heated needles.
2. Measurements during IFC94-2 of CO_2 and H_2O exchanges of 2 representative branches (PAOJP). Estimation of the water use efficiency (WUE: CO_2 assimilation/transpiration). The gas-exchange is measured in home-made cuvettes operating in a closed system for 5 minutes every half-hour.
3. Modelling of photosynthesis, transpiration and WUE of the branch. WUE varies with VPD and may vary through the season (needle age). This will be chcked by measuring the delta ^{13}C of growing shoot samples collected monthly (collaboration with TF-5).
4. Use of 1., 2. and 3. to predict trees transpiration and carbon uptake during whole season.

Sap flow measurements will be compared with eddy correlation measurements of H_2O and CO_2 fluxes above the forest. Simple models of forest productivity will be tested using data form the site: a "top-down" model of the Monteith type and a mechanistic "bottom-up" model, both developed in the laboratory.

Forest inventories, geostatistic models and remote sensing data will be used to extend the plot measurement to the region.

1, Diameter at breast height inventories will be used to extrapolate single trees transpiration measurements to the stand.
2. Extensive LAI measurements (from other teams will be used for geostatic purposes.
3. Continous and discreete algorithms of radiative transfer will be tested to derive surface parameters (PAR interception and LAI) from remote sensing data, and from cover maps. to extrapolate to the whole BOREAS region.

Tentatively, we'll try to measure CO_2/H_2O exchange of the lichen layer at PAOJP using plastic enclosures, including a T/RH sensor, connected to a portable IRGA (collab. with TE-5).

Deliverables to the Project:

Preliminary 1993 campaign have shown the feasibility of measurmeents during a week (days 239-244). All measurements will be made during the 1994 gowing season. All the resulting data will be processed and quality checked during the winter season of 1994-95, and delivered to BORIS at the beginning of 1995. Results of model and spatial extension will be published by the end of 1995. The following raw data to be delivered to BORIS:

Parameter Measured	**dt**	**Period of Measurement**
sapflow on 6 trees (PAOJP)	30'	5/5-9/10/94
sapflow on 6 trees (PAMS)	30'	IFC94-2 (ext. to 8/15/94)
CO_2 and H_2O exchange on 2 branches	30'	IFC94-2 (ext. to 8/15/94)
$d^{13}C$ of growing shoots	month	5/94-9/94

These data will be used to calculate the following parameters:

Parameter Calculated	**dt**	**Period of Measurement**
transpiration of trees	30'	94 Growing season
net photosynthesis of trees	30'	94 Growing season

Needs from other science groups:
- Other items of the carbon budget in PAOJP; above-and below-ground biomass increments, autotrophic respiration, soil respiration, CO_2 and H_2O fluxes above and under the canopy.
- Data on sapflow, gas exchange (any level), and stable isotopes on all sites.
- Data on water vapor and aerosol content in the atmosphere, for remote sensing correction.
- In-situ measurements of reflectances, albedo, incident global ratiation and intercepted PAR for validation purposes of remote sensing algorithms.
- Data on canopy geometry (trees height, branch angles and length), radiative properties of canopy and substrate (soil, snow, lichens).
- Airborne fluxes of CO_2 and H_2O and airborne radiometric measurements.

Needs from Project Staff:
- Canopy access tower for housing the branch bags
- Manpower to collect samples of shoots at diffeent levels in the canopy (PAOJP) every month during the growing season.

Needs in ancillary data:
- Specific biometric relationships and forests inventories (diameters at breast height to retrieve: sapwood area, leaf area of branches, LAI, biomass per units.
- Climatological data (all available data).
- Aerial photographs of all Prince Albert sites.

Equipment we plan to bring:
- FFC94-T: sapflow probes, a Campbell CR21 data logger and a power supply
- IFC94-2: sapflow probes, two Campbell CR10 data loggers, two IRGAs (CID 301-PS and ADC LCA2 or PP systems EGMI), a pressure chamber (PMS).

Ref. Number TE-12

P.I.(s): Walter-Shea, E.A./Univ of Nebraska
CO-I(s): Arkebauer, T.J./Univ of Nebraska

Title: Radiation and Gas Exchange of Canopy Elements in a Boreal Forest

Objectives and Approach: Coordinated research program emphasizing measurements of radiation and gas exchange characteristic of canopy elements and resulting interactions of radiation and gas exchange within canopy environments in a boreal forest ecosystem with the following components:

1. Characterization of foliage element and substrate optical properties during periods. Leaf, needle, twig, substrate and shoot optical properties will be made and conifer shoot geometry will be characterized. Models will be used to aid understanding of key variables influencing canopy element optical properties.
2. Characterization of gas exchange of canopy elements during critical periods. Responses of CO_2 exchange and stomatal conductance to environmental factors and diurnal courses of photosynthesis, respiration and stomatal conductance of canopy elements will be determined. Models will be used to describe the influence of relevant controlling variables on CO_2 and water vapor fluxes.
3. Integration of foliage optical properties and gas exchange characteristics. Many will be used to couple radiation and gas exchange of canopy elements under and total radiation conditions.

Deliverables to the Project:

Core Measurements

Type	Estimated volume of Data Sampling	Frequency	Submission Medium
Leaf, needle, twig, and substrate optical properties	4 samples x 3 ages x 3 trees x 3 species x 3 weeks x 4 IFC x 252 wave bands	5-6 samples per hour during suitable conditions	Floppy disk and/or network
Substrate optical properties (tripod mounted radiometer)	4 samples x 3 substrates x 3 weeks x 4 IFC x 252 wave bands	periodic, suitable and canopy conditions	Floppy disk and/or network
Shoot bidirectional reflectance (and transmittance)	2 samples x 3 ages x 3 species x (4 IFC + 2 FFC) x 252 wave bands	2-4 samples per day on days when measure-menets are made	Floppy disk and/or network
Gas exchange	5 response curves x 3 ages x 3 canopy heights x 3 species	each IFC	Floppy disk and/or network

Products Derived from Core Measurements

Type	Estimated Volume	Frequency	Submission Medium
Light use efficiency	Same as gas exchange	For each sample from which diurnal gas exchange was measured	Floppy disk and/or network
Modeled spectral bidirectional reflectance and transmittance of shoots	2 samples x 3 ages x 3 species x (4 IFC + 2 FFC) x 252 wavebands	estimated for each illumination-shoot geometry measured	Floppy disk and/or network
Estimated spectral directional and bi-hemispherical reflectance, transmittance and absorbtion of shoots	3 ages x 3 species x (4 IFC + 2 FFC) x 252 wavebands	approximated for each age of each species	Floppy disk and/or network
Shoot and leaf directional and bi-hemispherical fraction of absorbed PAR	3 ages x 3 species x (4 IFC + 2 FFC) x 252 wavebands	approximated for each sample	Floppy disk and/or network

Derived physiological 3 ages x 3 canopy each IFC parameters associated heights x 3 species with photosynthesis, stomatal conductance and dark respiration.

Needs from Other Science Groups:

Coordination with site selection of old black spruce at Prince Albert:

1. Don Deering (RRS-1) PARABOLA measurement
2. Eddy flux measurements (tower)
3. Remote sensing "super site" - N. Goel modeling study - at which detail measurements of canopy structure (LAI, shoot angles, branch area index, tree density and height are made.

It is necessary to locate all these near the sample place (i.e., in the same homestand so the modeling work (canopy bidirectional reflectance, canopy CO_2? would complement the measurement work (shoot bidirectional reflectance and exchange, canopy bidirectional reflectance and eddy flux CO_2 exchange).

- Calibration of spectroradiometer, radiometers (and wavelength characterization) and reference panel.
- Measurements of shoot axis inclination and orientation.
- Chlorophyll, lignin and nitrogen contents of needs from trees in our site preferable coordinated with our measurements.
- Leaf and shoot extension data.
- Meteorological data collected on site.

Needs from Project Staff:
- Scaffolding to provide platform from which to measure canopy component optical properties and shoot photosynthesis.
- Electrical power to power light sources and recharge batteries at the site. Computers and spectroradiometers may need external power at times of extended research hours.

- On-site tent area for optical pressure chamber and shoot geometry measurements.
- Room for shoot bidirectional reflectance measurements near lodging for measurements. The room must be the following minimum requirements (1) dimensions of 13 ft. wide x 13 ft. long x 10 ft. high; (2) ability darken room, electric power for powering light source and computer.
- Collection of branch samples to be packed and shaped to the University of Nebraska, Lincoln for shoot bidirectional reflectance, needle optical property, shoot geometry measurements at various times during 1993 and 1994, par for FFCs.
- Delivery of nitrogen gas for leaf and shoot water potentials and CO_2 standard gases for analyzer calibration for leaf and shoot gas exchange.
- Cool-room storage and accessibility to ice for storing and shipping samples.
- Customs clearance of all vegetation samples from Canada to United States.
- Lab space for sampling drying, access to drying ovens.

Destructive Sampling:

Four small branches with the three age classes represented will be harvested from each tree each day. Three trees will be selected from which samples will be made for optical property measurements.

For each assimilation, stomatal conductance response curve, determined as above, approximately 3 small (<20 cm) shoots will be removed from the can water potential measurements. In addition, the measured shoot (<20 cm) will be removed. Approximately 100 of these shoots will be removed, spread over the canopy height, per IFC.

Equipment:

Li-COR Integrating Sphere and Light Source SE-590 Spectroradiometer
Broad Band Radiometer
Scholander-type pressure chamber
Camera
Computer Image Analysis System
Tripod
Calibrated Standard Reference Panel

Li-COR IRGA 6262

Integrating Sphere with Cuvette
Other Measurement Cuvettes
Li-COR LI-610 Dew Point Generator
Laptop Computers (2)
Data Loggers (5)
Computer Printers (2)
Regulators for Gas Cylinders
Mettler Balance

Ref. Number TE-13

P.I.(s): Apps, M.J/Forestry Canada

Co: P.I.'s: Price, D.T./Forestry Canada
Kurz, W.A./ESSA Environmental and Social Systems Analysts Ltd.

Title: Annual carbon budget and climate induced changes in boreal forest ecosystems at the landscape level.

Objectives: and Approach: The objective of this work is to scale up existing (and emerging) understanding of ecological and climatic controls on annual carbon cycling in boreal forest ecosystems to landscape level. These will be used to provide process-driven linkages to an existing national-scale carbon budget model of the Canadian forest sector (CBM-CFS), to provide prognostic assessments of future carbon budget contributions by Canadian boreal forests under alternative scenarios of climate change and resource management (Apps and Kurz, 1991).

Scaling of the representation of process controls on net ecosystem productivity will be performed both spatially and temporally to match the CBM-CFS, which presently operates with a borad ecological/climatological spatial resolution and on an annual time step. A meta-model (response surface) approach is being developed to link process-orientated sub-models of forest ecosystem productivity to the CBM-CFS. Annual changes in forest ecosystem C pools (soils, litter and biomass), esplicitly accounting for the influence of disturbances, will be simulated to provide estimates of annual carbon fluxes with the atmosphere (and within the terrestrial carbon pools) along a transect through the boreal forest. This transect will extend beyond the Nelson House study area to the subartic woodland (Gillam Manitoba) and south of the PANP study area to the aspen parkland (Batoche, Saskatchewan).

Existing models of stand-level carbon budgets will be tested against detailed observations of biomass, soil and litter carbon pools at representative pure stands of the dominant species, at mixed wood stands at the southern and northern BOREAS study areas, and at sites in the mid-transect. Subject to funding confirmation, biometry and allometry measurement will be made in these stands in conjunction with other BOREAS investigators (TE-6, TE-7) to provide the observational database for these validations. The sites will be selected to reinforce other TE measurements and tower flux measurements and will be part of the Forestry Canada contribution to the core measurement program.

Anticipated BOREAS empirical data and other BOREAS modeling results will be used to perform limited validation checks on the CBM-FS approach. Data compilations as with the CBM-CFS calibration across the boreal transect will be made available to BOREAS researchers.

Proposed Research

The research seeks to estimate (1) the sites of ecosystem carbon, (2) the annual of carbon between ecosystem compartments and with the atmosphere, and ecological and climatic controls on these pools and fluxes. This work will be ?? within the context of Forestry Canada's Boreal Forest Transect Case Study (BFTCS) extends from the aspen parkland (Batoche National Park, south of Prince Albert ?? the BOREAS sites in the boreal forest and into the sub-artic woodland (Gillam, northeast of Thompson). The BFTCS is a key experimental project of Forestry climate change research program and involves a number of parallel Forestry Ca?? collaborative investigations. Some of these are explicitly reflected in the proposal submitted by Dr. E.H. Hogg while other contribute less directly to BOF more to the longer-term, broader scale NBIOME activities. The overall goal of the ?? to develop predictive understanding of the ecological and climatic processes that boreal forest structure and function at the biome level in order to assess the ?? of these forests to potential changes in climate. The modeling activity outlined addresses the carbon cycle feedback aspects of this vulnerability.

The focus of the carbon budget assessment work will be on the net carbon between forest biomass, forest floors and soils at the landscape level and on a ?? basis. Net annual atmospheric fluxes are based on mass conservation estimated changes in these pools and includes direct release by disturbances such as fire. The Budget Model of the Canadian Forest Sector (CBM-CFS, Apps and Kurz, 1991: Kurz 1991) will be used as the modeling framework. This model has been used to ??? first national scale estimates of Canada's forests' contribution to the global carbon (Kurz et al., 1992), finding it to be a weak, but vulnerable sink for atmospheric the reference year 1986.

The CBM-CFS model estimates net ecosystem production at a pseudo-stand level by simulating biomass-ver-age curves for biomass carbon accumulation, stand-age dependent litterfall transfers to the forest floor and transfers between the forest and soil organic matter using a simple 3 compartment model. Forest floor decom?? rates are ecosystem (site) specific and are related to the stage of stand development variable exposure factor to capture the short-term (<100 year) changes in carbon following disturbances.

Structure has been designed to facilitate process simulation. The phase 1 model is strongly data-drive by relationship derived from Canada's national forest ciomass inventory, the Oak Ridge National Laboratory (ORNL) soil and data base, and annual forest disturbance statistics for wildfire, insect damage and harvest records maintained by Forestry Canada and Statistics Canada. These relationships are clearly not appropriate for prognostic analysis but are the best for obtaining results for a benchmark, reference year.

Disturbances, particularly fire in the mid-continent boreal forest, play an ecological role in maintaining both the structure (e.g., forest cover types and distributions) and the function (e.g., growth and decomposition processes) of the forest. The CBM-CFS explicitly simulate three facets of disturbance influences for forest carbon flows: (1) direct release of carbon to the atmosphere, (2) transfers between biomass and the forest floor, (3) determine the age-class-structure subsequent biomass dynamics) of the forested landscape. These last two factors in many assessments, are expected to play increasingly important roles in a climate where disturbance rates are expected to increase (Flannigan and Van 1991) and ecosystem successional processes will be affected (e.g., Overpeck et al.) In the CBM-CFS estimate of carbon flows for 1986, the wildfire effected transfers to the forest floor which exceeded the carbon release to the atmosphere at least a factor of two (Apps and Kurz, 1991).

The CBM-CFS model will be scaled down from a national scale to the regional scale appropriate to the BOREAS sites and the NBFTCS, making use of higher spatial resolution data in the forest biomass inventory, the regionalized CBM-CFS will be used to in?? the estimates of carbon stored in biomass. Below-ground estimates will initially be derived using (limited) regionally specific allometric relationships (and will be subsequently improved suing results from other BOREAS studies and in follow-up ?? research). Parameterization of forest floor and soil dynamics in the model will be direct measurements of forest floor decomposition rates across the boreal transect during and subsequent to BOREAS (Trofymow et al.). Soil carbon data from the ORN database, will be supplemented by data from a Canada-specific forest soil carbon base currently being compiled as part of the CBM-CFS project.

Comparisons of CBM-CFS estimates of annual carbon fluxes at the BOREAS sites empirical resulls and estimates from her, more process-oriented mechanistic

(?? empirical models expected to be proposed for BOREAS (e.g., bonan, Running, Hunt) used to provide limited cross-validation tests. Because the CBM-CFS ioerates at a kevek if aggregation than most mechanistic ecosystem models, this comparison is anticipated to require scaling up of their results to an annual value and to the sp?? scale of the BOREAS supersites.

As stated previously, the objective of the CBM-CFS is to develop a prognostic mo?? assessing the vulnerability of future forest carbon budgets. Process representation CB-CFS is relative simple and climatic controls are currently exercised by pr?? modifiers of site growth rate, carrying capacity, decomposition rates, and change disturbance regimes. Although the BOREAS project is restricted to a single growth season time-slice, it is anticipated that significant advances will be made in the ?? modelling of climatic controls on ecosystem dynamics. A met-model structure is developed (Price and Apps, 1992) to link such process models to the CBM-CFS fra??. This meta-model structure will scale up the intra-annual processes and will empl?? nested set of process-based models of differing resolution to provide analyzed surfaces for biomass and forest floor dynamics under different climatic condition response surfaces will be used to capture predicted changes in ecosystem function productivity. In addition, by incorporating sucession-level models in these response surfaces, they should be able to simulate the potential for flips in ecosystem sta?? trajectories following disturbances, and this is an area of priority research in NBI.

The meta-model development will be initiated during BOREAS by focusing on bior?? dynamics (which is currently the best-understood area of ecosystem function) are continued during the NBIOME project. Initially, FORSKA2 (a boreal forest-specific model variant developed by Prentice, Leemans and co-workers) will be used to si?? forest dynamics across the boreal transect landscape and to develop biomass-over parameterizations for key forest types (hardwood, softwood and mixed woods) under different climatic conditions. In future investigations, other mechanistic models used, with particular attention being given to those incorporating ecophysiological controls which are expected to emerge during the BOREAS project. These models ?? be performed on a Canadian parallel-process supercomputer (MYRIAS) and FORSK/?? has already been modified to make use of this technology. The parallel computing environment is currently being used to explore the meso-scale dynamics of forest disturbances (fires and insects) by prescribing spatially-linked interactions between neighboring forest patches to simulate contagion.

Resources

Forest Canada, Northwest Region has a strong base of computer hardware/software support staff. In addition to VAX computers, a network of dedicated based Pcs and SUN workstations, the climate change modelling group has uni?? (and free) use of the MYRIAS parallel-process supercomputer at the University Alberta Physics Department.

Forestry expertise at the Northern Forest Centre is particularly strong in ecology modelling and the centre has been appointed the lead centre for forestry Canada's Climate Change program. Dr. D. Price is a visiting scientist working with Dr. Apps with proven record in canopy ecophysiology modelling, complements the group's expertise.

Ongoing contract (M. Apps, Scientific Authority) work with the CBM-CFS model is conducted under external funding (Federal Panel on Energy R&D) and these funds were used to support Dr. Kurz' involvement as a consultant to model validation activities.

Scientific staff in other Forestry Canada centres (in Petawawa National Forestry Institute, and Newfoundland) have been identified in Dr. E. H. Hogg's BOREAS proposed 7). These and other participants in the Boreal Forest Transect Case Study Experiments are expected to contribute to the collection of data across the transect (of _______ Pacific Forest Centre will ________________________ rates although all these data will be available during the BOREAS campaign and are not reflected in the budget.

Management

Dr. Apps is the designated team leader for forestry Canada's Climate Change rese?? program. He also leads the development of the CBM-CFS model and is Scientific ?? for contracted model applications at ESSA Ltd. He will be responsible for coordinating model development, collection of transect data required by the model, and comparison data for validation.

Ref. Number TE-14

P.I.(s): Bonan, G. B./NCAR

Title: Estimating Regional Biosphere-Atmosphere Exchange of Carbon Dioxide and Water in Boreal Forests with Ecosystem Models

Objectives and Approach: Models provide a means to extrapolate processes to large spatial and long temporal scales. I will conduct simulation analyses with coupled ecosystem and land surface process model to: (1) identify key physiological processes and ecological variables needed for a general predictive model of biosphere CO_2 and water fluxes; (2) quantify errors produced by parameter uncertainty; (3) derive seasonal and annual CO_2 and water budgets for several BOREAS tower sites and the two regional sites.

Global extrapolation will proceed by coupling the land surface process model to the NCAR Community Climate Model. Regional estimates of CO_2, water, and energy exchange obtained from the off-line modeling will be used to test the representation of sub-grid scale land surface heterogeneity for the land surface process model.

The major deliverables to BOREAS are seasonal and annual CO_2 and water budgets for individual tower sites and the two regional sites. This will require from other groups ground truth data for particular forest types to initialize and validate the models. It will also require from the BOREAS Project Staff meteorological data to force the models (30 minute resolution, collected for one full year); and maps of ecosystem and soil cover for the southern and northern sites.

Ref. Number TE-15

P.I.(s): Bukata, R.P./National Water Research Institute

Title: Utilizing Remotely Sensed Data to Model Limnological Carbon Budgets and Primary Production in Boreal Ecosystems

Objectives and Approach: We propose to use remotely-sensed data to determine the co-existing concentrations of aquatic chlorophyll, dissolved organic matter, and suspended inorganic matter. The chlorophyll estimates will be used to model primary production through transfer coefficients. The dissolved organic matter estimates and the primary productivity will be used to model the carbon budgets of the lakes in the BOREAS test area.

Remotely-sensed data will be acquired by the Airborne Ocean Color Imager (AOCI) from NASA flying on the ER-2 at 20 km with 50 meters resolution and by the Compact Airborne Spectrographic Imager (CASI) from York University. The CASI will fly at lower altitudes to provide higher spatial as well as higher spectral resolution. The AOCI data will be atmospherically corrected using methodology recently developed by NASA investigators. Extension of the atmospheric correction methodology to the CASI data will be performed.

The inherent optical properties of aquatic chlorophyll, dissolved organic matter, and suspended inorganic matter will be determined by direct sampling and in situ mid-lake measurements using surface and underwater spectroradiometers. When used in conjunction with the atmospherically corrected AOCI and CASI data, these inherent optical properties will enable the determination of the concentrations of chlorophyll and dissolved organic matter necessary for modelling primary productivity and the carbon budget.

Ref. Number TE-16

P.I.(s): Cihlar, J./CCRS
CO-I(s): Z. Li, Y.M. Chen/CCRS, R. Desjardins/Agriculture Canada

Title: Land Cover and Primary Productivity in the Boreal Forest

Objectives and Approach: The study is aimed at addressing the use of satellite data in ecological monitoring with emphasis on two parameters, land cover and ecosystem productivity. For land cover, the objective of the research is to determine improvements in land cover type identification with data from future sensors (simulated MODIS, Radarsat SAR), compared to research presently underway which emphasizes AVHRR. For productivity, the principal objective is to assess the feasibility of estimating forest primary productivity and net primary productivity using models that can be realistically applied over large areas yet have high spatial resolution. To be practical, the models should require a minimum of data that (i) can be obtained from satellites or (ii) can be cost-effectively obtained over large areas. Such models have been formulated and tested in recent years, and will be included among those models studied in other BOREAS investigations. The intention in this study is to focus on the contribution of remote sensing data at the landscape and regional levels, and to collaborate with modelers in validating remote sensing inputs and model performance. Specific tasks to be carried out include: improvement in land cover determination and information on seasonal dynamics from simulated MODIS and RADARSAT SAR data; derivation of site and landscape ecosystem parameters (bidirectional surface reflectance, vegetation indices, vegetation density) from optical data in relation to the sensor spatial resolution (10^2m to $> 10^3$m); feasibility of direct APAR estimation from AVHRR and similar data; the relationship of instantaneous gas (CO_2, H_2O) exchange to satellite-derived reflectance and emission quantities; and derivation of the above and related quantities for testing ecosystem productivity models at the regional level.

Ref. Number TE-17

P.I.(s): Goward, S.N./Univ of Maryland
CO.I.(s): Prince, S.D., Dubayah, R., Townshend, J./Univ. of Maryland, Tucker, C.J./NASA/GSFC

Title: Biospheric Dynamics in the Boreal Forest

Objectives and Approach: A study of primary production in the boreal forest ecotone using regional scale models driven by coarse-resolution satellite data. The primary scale of interest is the BOREAS inter-site transect and the entire N. American Boreal Forest biome. Net primary production (NPP) will be modelled using production efficiency models (PEM), parameterized using the detailed field site measurements planned at the Intensive Study site scale (400km2). A multi-scale analysis will be used to address the problem of scaling of information from the ISS to the regional scales.

Ref. Number TE-18

P.I.(s): Hall, F.G., Sellers, P.J./NASA/GSFC, Nelson, A.K./USRA

Title: Regional-Scale Carbon Flux from Modeling and Remote Sensing

Objectives and Approach: To use long-term satellite remote sensing to characterize the successional and disturbance dynamics at a regional scale and to associate, via the use of carbon flux models, these dynamics with carbon flux.

Landsat MSS and TM, SPOT and AVHRR data will be acquired for the BOREAS study area, including both supersites and the intervening transect for the period of record of each satellite (Landsat back to 1972). Key successional stages will be identified using pattern recognition and machine processing. The rates of changes between successional stages will then be quantified using change analyses. These results will be combined with ecophysiological models that relate carbon flux the successional state and climate history to estimate regional carbon flux.

Ref. Number TE-19

P.I.(s): Harriss, R.C./Univ of New Hampshire
CO-I(s): Aber, J., Frolking S.E./Univ of New Hampshire

Title: Modeling Climate-Biosphere Interactions in the Boreal Forest

Objectives and Approach: We propose a research program which integrates and advances two separate models we have recently developed for understanding carbon and nitrogen cycling in soil and vegetation. The primary product of this model integration will be a capability for assessing and understanding the sensitivity of boreal ecosystem carbon and nitrogen pools and fluxes to climate variability. The proposed modeling research program will be coordinated with the BOREAS field measurements program. Field measurement at BOREAS sites will be used to test and validate our model. Our model will provide conceptual framework for testing which components of the boreal ecosystem are especially sensitive to climate change. The results of the combined field and studies will provide a sound rationale for the design and implementation of a ?? measurement program in the boreal forest ecosystem using the Earth Observing System (EOS).

Ref. Number TE-20

P.I.(s):	Knox, R.G./NASA/GSFC
CO-I(s):	Levine, E.R., Ranson, K.J., Goltz, S.M./NASA/GSFC
Title:	Multidiscipline Integrative Models of Forest Ecosystem Dynamics for the Boreal Forest Biome: Modeling Gas and Energy Fluxes from Landscapes

Objectives and Approach:

This effort is collaborative with TE-22 which has as its objective the development of a model-based synthesis of the influence of water and nutrients on forest community composition, and of evaluating the feedback from community composition to surface biophysical characteristics for the BOREAS project. The models involved in this synthesis are:

1. ZELIG, a spatial individual tree model. ZELIG is currently part of the FED model;
2. FED, a model shell allowing the interfacing of several different models of forest ecosystem dynamics and, hence, several different ecosystem processes;
3. HYBRID, a combination model including forest growth; canopy physiology; and soil moisture, carbon and nutrients (see Friend, Shugart, and Running, 1993);
4. Residue, a physical, multilayer soil temperature and moisture model (Bidlake et al. 1992).

The ZELIG and HYBRID models will be parameterized and implemented for the BOREAS test sites, and will be used to project the composition and canopy structure of forests over relatively long time spans for different regions. This will also provide a capability to predict CO_2 and H_2O fluxes from the forests. ZELIG predictions of forest structure will be related to results of remote sensing (in collaboration with RSS-15) and compared with field data from soil and stem maps and auxiliary sites. Simple transport models will be used to relate spatio-temporal variation in flux predictions, from the combination of HYBRID and Residue, to temporal variation in tower flux measurements.

Ref. Number TE-21

P.I.(s):	Running, S/Univ of Montana
CO-I(s):	Nemani, R./Univ of Montana, Peterson, D., Dungan, J., Coughlan, J/NASA Ames Research Center, Harding, D. NASA/GSFC. Wood, E./ Princeton Univ, Scuderi, L./Boston Univ, Price, A.,Carleton, T./Univ of Toronto
Title:	Simulation of Boreal Ecosystem Carbon and Water Budgets: Scaling from Local to Regional Extents

Objectives and Approach:

To simulate boreal landscape/atmosphere exchange processed and the scaling behavior of these processes from local to regional extents. Our emphasis is boreal ecosystem water and carbon flux processes, which will be simulated using a suite of models based on the processes of photosynthesis, respiration, evapotranspiration and surface and subsurface hydrologic flow. The implications of model and data generalization on the agreement between simulated and measured flux rates will be explored by constructing a hierarchy of modeling and surface parameterization methods. Each level in the hierarchy will vary in the degree of complexity of process and surface representation. The set of computed surface flux rates in combination with flux rates measured by other science groups will be used to quantify the impact of process and parameter generalization in terms of model bias at each level of the hierarchy, and the scaling behavior of flux processes computed over the range of parameter resolutions we will sample. We hypothesize that the spatial patterns of surface/atmosphere flux is strongly influenced by the distribution of available soil moisture and inundation areas in the study sites, which, in conjunction with disturbance regime, may provide a key organizing framework for scaling stand to regional simulations. We will develop surface parameter sets for the models with a combination of field measurement of hydrologic processes, remotely sensed canopy information and laser and radar altimetry.

Ref. Number TE-22

P.I.(s):	Shugart, H.H./Univ of Virginia
CO-I(s):	Smith, T.M./Univ of Virginia
Title:	Multidiscipline Integrative Models of Forest Ecosystem Dynamics for the Boreal Forest Biome
Objectives and Approach:	The development of a model-based synthesis of the influence of water and nutrients on forest community composition, and of evaluating the feedback from community composition to surface biophysical characteristics for the BOREAS project. The models involved in this synthesis are: 1. ZELIG, a spatial individual tree model. ZELIG is currently part of the FED model; 2. FED, a model shell allowing the interfacing of several different models of forest ecosystem dynamics and, hence, several different ecosystem processes; 3. HYBRID, a combination model (see appendix C) including ZELIG, a photosynthesis model and a coupling with a canopy biophysical model (GBC, Running and Coughlan 1990); 4. SiB, a canopy water and heat balance model designed for interfacing with larger scale meteorological models. The ZELIG and HYBRID models will be parameterized and implemented for the BOREAS test sites, and will be used to project the composition and canopy structure of forests over relatively long time spans for different regions. This will also provide a capability to predict CO_2 and H_2O fluxes from the forests. Several of the data sets being developed in conjunction with the BOREAS project will be implemented to test these model implementations. An important aspect of the project will be the incorporation of outputs and inputs of the SiB models with the other models to provide an interfacing of the terrestrial forest dynamics with the feedbacks to and from the atmosphere.

Ref. Number TE-23

P.I.(s):	Rich,P.M./Univ of Kansas
Title:	Canopy Architecture of Boreal Forests: Studies of Solar Radiation, Leaf Area Index, and Forest Dynamics
Objectives and Approach:	The primary goal of this project is to characterize canopy architecture as it influences within-canopy solar radiation regimes, with implications for forest ecosystem dynamics and remote sensing. The project will also provide indirect estimates of fPAR and LAI, measurements of canopy surface topography, and detailed maps of stand architecture. Hemispherical (fisheye) photography will be used 1) to measure the angular distribution of canopy openings, 2) to estimate fPAR, and 3) to estimate LAI and leaf inclination for the BOREAS project study sites (tower flux, auxiliary, and mixed boreal forest sites). Acquisition of arrays of hemispherical photographs will permit examination of horizontal variation within each site and vertical variation in the understory and throughout low canopies. Photographs taken from towers will permit examination of complete vertical profiles for Tower Flux and TE Tower Sites. Estimates of fPAR (direct, diffuse, and total) from photographs will be validated using PAR sensor measurements, while LAI and leaf inclination estimates will be validated using both direct and indirect methods. Field measurements, construction of detailed stand maps, and analyses will be coordinated with TE-9, TE-13, TE- 20, RSS-7, RSS-19, BOREAS staff efforts and Canadian contributions to biometric measurements.

TE-23 SCHEDULE

- May 12-15 Southern Study Area (Rich + 2 assistants) set up mapped forest plots at all sites
- May 16-18 Northern Study Area (Rich + 2 assistants) set up mapped forest plots at all sites
- May 19-June 5 Southern Study Area (2 assistants) hemispherical photography at all sites
- June 6-16 Northern Study Area (2 assistants) hemispherical photography at all sites
- June 17-July 11 Auxiliary Sites hemispherical photography, characterize sites
- July 12-14 Northern Study Area (Rich + 2 assistants) characterize mapped plots at all sites
- July 15-18 Southern Study Area (2 assistants) characterize mapped plots at all sites
- July 19-28 Southern Study Area (2 assistants) hemispherical photography at all sites
- July 29-Aug 8 Northern Study Area (2 assistants) hemispherical photography at all sites

Trace Gas Biochemistry (TGB)

TGB-1	Crill
TGB-3	Moore
TGB-4	Roulet
TGB-5	Zepp
TGB-6	Wahlen
TGB-7	Waite
TGB-8	Monson
TGB-9	Niki
TGB-10	Westburg
TGB-12	Trumbore

Ref. Number TGB-1

P.I.(s): Crill, P.M./Univ of New Hampshire

Title: Magnitude and Control of Trace Gas Exchange in Boreal Ecosystems

Objectives and Approach:

We propose to examine the role of boreal soils in trace gas exchange with the atmosphere. There are three objectives to this study:

Objective 1: To quantify the exchange rates of CO, N_2O, CO_2 and especially CH_4 with representative, drained upland soil sites in the boreal forest over an entire biological "active" season.

Objective 2: To quantify the relative contributions of upland soils and lowland beaver ponds and their associated wetlands in the regional CH_4 cycle.

Objective 3: To develop techniques that will allow confident scaling of flux measurements from local to landscape to regional scales.

Deliverables:

Direct measurements of exchange rate of CH_4, N_2O, CO_2 and possible CO using enclosures at three or four upland sites that will be defined principally by soil type and moisture regime. Concentration profiles of these gasses in the soil will also be measured at the same time. Empirical diffusion versus moisture curves will be developed with SF6 uptake in a variety of soil types (with TGB-3, TGB-4 and TE-3). We will also quantify CH_4 effluxes from wet beaver flooded sites in close collaboration with TGB-4 (Roulet). At least one each of the upland and wetland sites will be in very close association with micrometeorology/flux towers where we propose to make very previse, quasi-continuous ambient CH_4 concentration measurements at multiple levels.

Needs from other science groups (incomplete list):

The successful attainment of all of the objectives of this proposal requires soil climate monitoring (temperature, moisture, heat flux, etc. with TGB-4 and TF-8) , soil physical and chemical characteristics (with TE-3), beaver pond tower and momentum transfer coefficients to calculate fluxes from the measured CH_4 gradients at the beaver pond (with TGB-4). For the scale aspects of the study we need remote sensing of surface soil type and its moisture and associated (with enclosure flux studies) micronet tower physical and chemical fluxes.

Needs from project staff (incomplete list):

Housing and transportation (pickup truck) for three, source of chromatography grade fuel, air and carrier gasses for the gc's, at least ten feet of lab bench space, clean power. For the automated systems, we need a maximum of ten amps current (usual draw is about three) and about four feet of a standard 19 in. instrument rack, gasses.

Location: Nelson House
Sites: Old Black Spruce, Old Jack Pine, Beaver pond and Jack Pine-auxiliary
Duration: May-September, 1994
Measurements:
half-hourly - gradients of CH_4 concentration (BP and OJP)

once/4 -6 d- CH_4, CO_2 (dark), CO, N_2O, flux for 20 runs with enclosures at 6 to 8 collar locations/site (OBS,OJP)

episodic-SF6 diffusion experiments with flux measurements during the IFC's we will work with TGB-4 for extensive regional surveys of CH_4 and CO_2fluxes from beaver ponds

Measurements expected from other groups:
- ^{222}Rn profiles - TE-3 - (Trumbore)
-physical and chemical characterization of soils at sites (Harden)
-del ^{13}CH4 and del $^{13}CO_2$from soil flux (TGB-6, TE-3)
-soil moisture and temperature measurements at each site

Ref. Number TGB-2 -- DELETED

Ref. Number TGB-3

P.I.(s): Moore, T.R./McGill Univ, Knowles. R./MacDonald Campus of McGill Univ

Title: Carbon Dioxide and Methane Exchanges Between Wetland and Upland Soils and the Atmosphere, Southern Boreal Forest

Objectives and Approach: At sites representing the range of wetlands in the Nelson House area, we shall measure methane emissions by a static chamber method. Emission rates will respond tochanges in the thermal and hydraulic regimes of the soils, and used to test predictive models based on vegetation, water table or mechanisms. Carbon dioxide and methane fluxes will be measured from upland soils at the major sites, and related to microbial and environmental characteristics, as well as vegetation (e.g. post-fire succession). Samples of peat and upland soils will be incubated under lab conditions to establish the major controls on microbial production or consumption of these gases. Measurements will be made at approximately weekly intervals from late May to September 1994. DOC concentrations in soil water and streams will be measured to provide an estimate of DOC flux within the C cycle.

Deliverables:

Fluxes of methane from wetland soils in the region (using vegetation and remote sensing to scale up or point measurements), as well as sites of methane exchange within the tower footprint.

Fluxes of methane by upland soils, within the tower footprints, as well as major forest types.

Fluxes of carbon dioxide from the forest floor of upland soils, combining decomposition and root respiration, within the tower footprint, as well as different vegetation types.

Relationships between the climatic variables, such as temperature, precipitation, and water table position and gas flux.

Sources and sinks of DOC at selected sites at Thompson and DOC export from small catchments draining different terrain types.

Needs:

Ecological attributes of the upland sites (we can deal ourselves with the wetland sites), as well as thermal and hydrologic regimes. Remote sensing characterization of the sites will be useful in any attempt to scale up, and we may also be able to use some of the more detailed low-level information collected to see if we can recognize some of the smaller-scale variability in vegetation and microtopography which will influence gas flux rates. We may wish to include some of the Prince Albert wetland and upland soils in the incubation studies, to provide a wider comparison and applicability of the results.

From the Project Staff, we expect:

1. Provision of spurs to the measurement sites along the fen boardwalk.

2. Provision of wood and materials to build small boardwalks/platforms at other wetland sites where disturbance will be a problem.

3. Provision of laboratory facilities in Thompson; central GC lab with other TGB members, plus drying oven, balance and other basic laboratory equipment. Accomodation at Thompson needs to be resolved by late summer, 1993. We shall probably have a truck at Thompson for the period, but will need access to ATV for equipment transport occasionally.

Location: Nelson House
Sites: Wetland-fen (tower site), palsa, collapse scars of bog, intermediates fen and rich fen
Upland-Young Jack Pine (tower site), mature spruce-moss forest (2); mature aspen stand; 30 year burn of spruce-moss and aspen stands; possibly more recent burn sites.

Duration: May-September 1994

Measurements:
Weekly - CH_4, flux using enclosures at wet sites; Water table,;temperature profiles; Soil CO_2, and CH_4, exchange using enclosures at dry sites; Soil pore CO_2, and CH_4 profiles

Occasionally - samples of soils from wetland and upland sites for CH_4 production and consumption and CO_2 production studies. (to be collected August 1993).
Soil samples for microbial studies of CH_4 dynamics.
Role of plants in CH_4 and CO_2 flux through experimental manipulations and rhizosphere analyses.

Measurements expected from other groups:
-- Soil characterization at upland sites (???)
-- Soil moisture and soil temperature at upland sites (???)
-- Possible collaboration with PA, CH_4 flux groups (TE-1, TE-11) for methane production/consumption potential of soils.

Ref. Number TGB-4

P.I.(s): Roulet, N.T./York Univ

Title: The Fluxes of Energy and Trace Gases from Beaver Ponds and Dry Upland Forest Floor in the Northern BOREAS Field Site

Objectives and Approach: The primary objective of the proposed research is to quantify the exchange of heat, water, and CH_4 between boreal forest beaver ponds and the atmosphere for the ice free period of BOREAS. The fluxes of heat, water and CO_2 from one beaver pond will be measured continuously using the energy balance Bowen ratio approach. The diffuse and bubble flux CH_4 will be measured several times a week using chambers. The chamber approach will be used to sample CO_2 and CH_4 flux from 4 to 5 additional beaver ponds, once every two weeks, and regional survey of the surface concentrations of CO_2, CH_4, and DOC will be carried out on accessible beaver ponds once during the IFC. The results of this work will be extrapolated from the local to regional scale in collaboration with the remote sensing project of J. Miller (York University - separate proposal). The secondary objective of the proposed research is to study the soil climate and soil characteristics at a forest site in conjunction with the flux studies of P. Crill (UNH). Soil moisture and temperatures will be measured continuously, and soil porosity will be determined.

Deliverables to the project:
1. Continuous record of heat, water and CO_2 flux from one beaver pond; 2. Frequent measurements of CH_4 flux from the same pond, 3. Bi-weekly fluxes of CO_2 and CH_4 from up to five beaver ponds; 4. A spatial survey of surface concentrations of CO_2, CH_4, and DOC from accessible beaver ponds; 5. Continuous record of soil moisture and temperature and water levels from one forest soil site.

Needs from other science groups:
Areal extent of beaver ponds - preferably the frequency and size distribution of; and 2. isotopic composition of CH_4 from beaver ponds .

Needs from project staff:
1. On-site project manager to handle general logistic concerns.
2. Cut trail for ATV into beaver pond site.
3. Platform in beaver pond to support tower.
4. Boardwalk from shore of beaver pond to tower platform.
5. Platform at edge of beaver pond to support a 2500 W generator.
6. Small boat (12") for sampling in beaver pond.
7. List of vehicle rental agencies for trucks and ATVs.
8. List of suppliers for gases in Thompson.
9. Laboratory space in Thompson.
10. Detailed description of how to ship material to Thompson.

Location: Nelson House
Sites: Auxiliary beaver pond site, several other beaver ponds.
Duration: May to September 1994

Measurements:
Half hourly - net radiation, incoming and reflected solar radiation, incoming and emitted longwave, incoming and reflected PAR.
-- Gradients (0.25, 0.5, 1.0, 2.0 m) of temperature, humidity, CO_2, CH_4 (TGB-1) wind speed, open water and sediment temperature
-- Wind direction

-- Water level, atmospheric pressure, pond discharge (possibly)

Twice/week - CH_4 and CO_2 diffuse flux for 20 to 120 minute runs with enclosure (with TGB-1)

-- CH_4 bubble flux from sediments (possibly bubbling rate with some form of sonar?)

-- (DOC)

Once/2 wk - profile of CO_2 and CH_4 in open water and sediments

Once/3 wk on up to four additional ponds

-- Instantaneous measurements of surface (CO_2), (CH_4), water temperature and wind speed (1m), water level, (DOC)

One IFC on as many ponds as are accessible.

-- Instantaneous measurements of surface (CO_2), (CH_4), water temperature and wind speed (1m), water level, (DOC), One IFC on as many ponds as are accewssible; Instanteous measurements of surface (CO_2), (CH_4), water temperature and wind speed (1m), water level, (DOC)

Measurements expected from other groups:

-- UV at Nelson House - Science Staff

-- (DOC) and some fractionation work - TGB-5 (Zepp, et al.)

-- ^{222}Rn flux across sediment/water and water/atmosphere interface - TE-3 (Trumbore)

-- Basic water chemistry on beaver ponds - TGB-5 (Zepp, et al.)

Ref. Number TGB-5

P.I.(s): Zepp, R.G./U.S. EPA

Co.I.(s): Burke, R.A./AERL, Levine, J.S. and Cofer, W.R./NASA Langley, Ojima, D.S. and Parton, W.J./Colorado State, Stocks, B.J./Forestry Canada, Bourbonniere, R.A./Environment Canada, Moran, M.A. and Hodson, R.E./University of Georgia

Title: Trace Gas Exchange in the Boreal Forest Biome: Effects of Fire and Beaver Activity

Objectives and Approach: This proposal describes a three year interdisciplinary effort to examine the effects of fire and beaver activity on trace gas fluxes and biogeochemical processes in burned soils and oxic zones of beaver ponds in the boreal biome. Specifically, the post-burning effects of fires on soil fluxes of trace gases (CH_4, CO, CO_2, N_2O and NO) will be determined in upland black spruce and jack pine ecosystems located in and near the BOREAS Northern Study Area (NSA). A mathematical model (CENTURY), which has been developed to simulate trace gas biogeochemistry in forest soils, will be modified to include the effects of fires. Model predictions of soil fluxes will be evaluated through a chronosequence of fires in these ecosystems.

Other studies will focues on trace gas biogeochemical processes that affect organic matter cycling in the oxic zones of beaver ponds in the NSA. In conjunction with studies proposed to BOREAS by TGB-4 on methane and carbon dioxide fluxes, we propose to obtain a data set of CO flux measurements in selected beaver ponds and other wetlands with ancillary data relevant to process models that describe carbon cycling in these ecosystems (e.g., microbial and organic matter characterization, solar spectral irradiance). Field and laboratory studies will be conducted to develop an understanding of microbial and photochemical processes that produce and consume CO and CO_2 in baver ponds and other wetlands of the boreal biome.

Deliverables:
Soil-atmosphere exhange rates of carbon dioxide, methane, carbon monoxide, nitrous oxide, and nitric oxide will be determined in burned upland black spruce and jack pine forests and in nearby unburned control sites in the NSA. Carbon monoxide fluxes, organic matter characterization, and microbial carbon cycling data will be obtained in active beaver ponds. These data will be submited to BORIS within one year after sample collection on floppy disk in the DAFT format specified by BORIS. Experimental reslts and data interpretation will be presented in annual progress reports and peer-review publications.

Needs from other science groups:
Trace gas flux data from upland forest sites in the NSA that have not recently been burned (TGB-1, TGB-3) are required as control data for ourproject. We will also need meteorological (e.g., windspeed) data and measurements of other physical factors that control air-water gas exchange from TGB-4. We also need ^{222}Rn flux data and soil physical and chemical data.

Needs from Project Staff:
Our project will require the following Core Measurement that we anticipate obtaining from BORIS for model development and experiments.

Climate information: monthly precipitation; monthly averaged maximum daily temperature; monthly averaged minimum daily temperatures; nitrogen deposition estimates (wet and dry), windspeed, barametric pressure solar radiation.

Soil properties: soil texture (% sand, silt, and clay content); soil organic matter content by depth (C, N, and P); pH, cation exchange capacity, base saturation, bulk density of soils; landscape variation in soil properties or regional distribution of soils, nitrogen species.

Plant characteristics: biomass estimates by month of growing season above and below-ground production estimates chemical analysis of plant components (C, N, % lignin). We also request that project staff provide us with logistical support for the IFC's, planning for and managing the operations of the IFC's and organizing BOREAS Science Team meetings and workshops.

Location: NSA
Sites: mostly auxiliary recent burn sites (< 15 yrs) (total of 5; 4 upland black spruce, 1 jack pine); work on 2 beaver pond sites in NSA
Duration: May to September

Measurements:

Weekly - CO_2, CH_4, CO, N_2O, NO fluxes using enclosures (6 collars/site). Vertical profiles of CO_2, CH_4, CO,at selected soil depths at burn sites and at nearby unburned controls.

Weekly - SF_6, exchange studies to determine soil diffusivities at burn sites and nearby unburned controls.

Determination of fire characeristics; nature of fire; age of trees at time of burn, burn frequency at site, extent of organic layer removal; dominant species (trees, moss ground cover) at time of fire and at time of soil flux measurements.

Occasionally
-- water chemistry at the 2 beaver ponds

-- DOM characterization in beaver ponds
-- Process studies on oxic zone in beaver ponds
-- Photochemical CO production studies from pond water

Weekly--Concentrations of CO above pond water surface and at various depths below water surface measured hourly; fluxes of CO measured using floating quartz enclosures.

Measurements expected from other groups:
-- 222Rn concentrations/fluxes at various depths in soils
-- Soil carbon content and above-and below-ground biomass densities at various burn sites and at nearby unburned controls
-- Solar spectral irradiance (including UV-B and UV-A)
-- Physical and chemical characterization of soils at burn sites and nearby unburned controls
-- Input variables for CENTURY model

Ref. Number TGB-6

P.I.(s): Wahlen, M./Scripps Institution of Oceanography

Title: Isotopic Composition of Methane Produced and Consumed in Boreal Ecosystems

Objectives and Approach: We propose to determine the isotopic composition (d$^{13}CH_4$, dD in CH_4 and $^{14}CH_4$) in methane emitted to the atmosphere from the boreal forest ecosystems, so that this source, together with the net flux, can be considered in a global isotopic methane budget. We also intend to study the relative importance of methane production versus methane consumption by oxidation in these ecosystems, using the stable isotopes (d$^{13}CH_4$ and dD in CH_4) as tracers. The isotopic fractionation induced by methane oxidation will be determined. If bacterial methane oxidation is a substantial sink globally (compared to the atmospheric sink) the isotopic consequences of this sink should be determined. Investigations of the dD for methane will allow to determine the split in methane production from acetate fermentation and CO_2 reduction in these ecosystems. Furthermore, we propose to analyze the ^{14}C in the methane emitted from these sites, to investigate the age of the stored carbon, and, to find out if releases of methane highly depleted in ^{14}C could reconcile the discrepancy between statistical estimates for fossil methane releases and those derived from measurements of $^{14}C_4$.

Deliverables:
Measurements of the isotopic composition of methane emitted to the atmosphere and of carbon dioxide exchanged with the atmosphere at 3-6 sites from the norther and southern study areas. Measurements of these quantities in background air.

Cooperation:
Flux determinations will not be made by our group but will be coordinated with those of Crill, Ehleringer, Moore, Roulet, Trumbore and Verma. Samples will be taken using chambers established by these investigators. This will maximize the background data in support of the isotopic determinations.

Needs from Project Staff:
Limited storage space for field sampling equipment and pressurized A1 taks prior to and after deployment.

Location: Nelson House and Prince Albert
Sites: PA Young jack Pine, Old Jack Pine, Fen, NH Young and Old Jack Pine, Old Black Spruce, Fen, Beaver Pond, Jack Pine-Aux, Fire sites.
Duration: IFCs 1994

Measurements:
-- 100 to 150 samples distributed in time and among sites from chambers and dislodged bubbles for analysis of $^{13}CH_4$, D in CH_4, $^{14}CH_4$, $^{13}CO_2$, $C^{18}O_2$ and concentration of CH_4, CO_2, CO, H_2 and N_2O in samples taken, also some samples from ambient air.

Measurements: expected from other groups:
-- Gas fluxes TGB-1(Crill), TGB-3 (Moore), TGB-4 (Roulet), TE-3 (Trumbore), TE-5 (Ehleringer), and TF-11 (Verma).
-- A collection protocol is available for interested parties.

Ref. Number TGB-7

P.I.(s): Waite, D.T./Environment Canada

Title: Atmospheric Transport of Agricultural Pesticides into the Boreal Ecosystem

Objectives and Approach: We propose to measure the deposition in the boreal forest of seven herbicides (2, 4-D, bromoxynil, dicamba, MCPA, triallate, trifluralin and diclop-methyl) known to appear in the atmosphere of the Canadian prairies, three herbicides (atrazine, alaclor and metlaclor) commonly used in the central United States and known to be deposited in precipitation in the forest and three groups of insecticides (toxaphene, lindane and breakdown products and DDT and breakdown products) reported from the literature and from unpublished data to occur in boreal and arctic food chains.

Deposition will be measured in rain and dry fall-out (gases, colloids and particles) using a new sampler designed and built by Environment Canada specifically for pesticide and trace organic work. Ambient air samples will be collected using currently available high volume PUF samplers.

Sampling locations will be; 1 - Regina atmospheric study site (source of herbicides originating in prairie Canada); 2 - BOREAS site in Saskatchewan (southern boreal forest); 3 - Yellowknife NWT Env. Can. site (northern boreal forest); 4 - Inuvik AES meteorological station (northernmost boreal forest site); and, 5 - Iqaluit (a remote site on the eastern arctic).

Sediment core samples will be collected from Great Slave Lake (Yellowknife) in the winter of 1992 and from either Montreal L. or Waskesiu L. (BOREAS) in the winter of 1993. The cores will be sectioned and analyzed for the same pesticides as the atmospheric samples. The result will be a measurement of yearly deposition rate of pesticides.

Ref. Number TGB-8

P.I.(s):	Monson R./Univ of Colorado
Title:	The Relationship Between Non-Methane Hydrocarbon Emission and Leaf Carbon Balance in the Boreal Forest: An Approach for Mechanistic Ecosystem Modelling

Objectives and Approach:

We propose to investigate the mechanistic controls over non-methane hydrocarbon (NMHC) fluxes from boreal forest trees. The studies will be used to modify existing ecosystem models to include NMHC emissions and their response to seasonality and resource variability (primarily water and nitrogen). The proposed research is ordered around three general questions: (1) To what extent are leaf carbon balance and isoprene synthase activity (the enzyme responsible for isoprene emission) predictors of NMHC flux?, (2) How do leaf carbon balance and isoprene synthase activity depend on nitrogen/water availability and carbon source/sink parameters?, and (3) How do we modify the FOREST-BGC ecosystem model based on questions 1 and 2, to predict canopy-level NMHC fluxes? Studies will include seasonal monitoring of NMHC emissions and its relationship to plant phenology, photosynthesis, respiration, isoprene synthase activity, and leaf starch concentrations. Fertilization and irrigation of some plots will be conducted to discern the relationship of NMHC emission and leaf carbon balance to resource availability.

Manipulation of branch source/sink balance will be performed in a bud-removal experiment. The latter experiment aims to unequivocally demonstrate the role of carbon balance in regulating seasonal emissions patterns. Studies will be conducted to examine the relationship between monoterpene production versus emission. This will focus on the potential for emission variation due to differential vapor pressures of the dominant monoterpenes. Finally, algorithms will be produced to modify FOREST-BGC to provide mechanistically-based predictions of ecosystem MNHC emissions as linked to carbon balance.

Deliverables:
Data sets to be contributed to BORIS include seasonal measurements of leaf/needle photosynthesis rate, transpiration rate, stomatal conductance, hydrocarbon emission rate, leaf/needle nitrogen concentrations, leaf/needle starch concentrations (dawn and dusk), needle monoterpene concentrations, and seasonal plant water potential patterns, on aspen and black spruce at the Prince Albert Park site.

Needs from other groups:
Access to sampling towers and possibly daily access to a gas chromatograph for gas sampling from approximately 12 stainless steel containers (access to the latter is flexible -- measurements can be conducted at night).

Needs from Project Staff:
More money.

Location: Prince Albert
Sites: Black Spruce and Aspen
Duration: IFCs 1994

Measurements: (all done on upper canopy - sunlit leaves or needles)

Daily:

-- am/pm photosynthesis rate for aspen and black spruce leaves
-- am/pm/evening starch and nitrogen content in spruce and aspen tissue
-- leave water potentials (pre-dawn and midday) each day during IFC.

Occasionally:
-- Tissue concentration and flux rate of monoterpenes for black spruce.
-- Isoprene emission rate for black spruce and aspen.

Measurements expected from other groups:
None.

Ref. Number TGB-9

P.I.: Niki,H./ Hastie, D./York University

Title: Ambient Measurements of Ozone, Nitrogen Oxides and Non-Methane Hydrocarbons

Objectives and Approach: An intensive ground based measurement campaign of ambient concentrations of biogenic and anthropogenic C_2-C_{10} non-methane hydrocarbons at one of the Intensive Study Sites over the course of the 1994 experiment year, with full participation in the Intensive Field Campaigns (IFC) and possibly in the Focused Field Campaign during the spring thaw. A weekly to twice weekly hydrocarbon sampling schedule is envisioned through the years 1993, 1994 and 1995 to provide season distribution data on these hydrocarbons.

Air samples will be collected in stainless steel canisters, filled and pressurized using a portable battery operated pumping unit, and either returned to York University for analysis or analyzed on site in our mobile laboratory. Analysis methodology has been developed already. A gas chromatography (GC)-based method is being employed involving cryogenic (liq. Ar) sample preconcentration on glass beads, and cryogenic (liq N_2) sample focusing onto the CG column head. Separation of C_3-C_{10} hydrocarbon range is done while C_2-C_6 hydrocarbons are analyzed on an Al_2O_3/KC1 PLOT column.

Air samples will be collected with the intent of itemizing the biogenic hydrocarbon inventory of the boreal forest ecosystem, as well as to determine the relationship between ambient concentrations and factors controlling their emission rates such as temperature and insolation. Spatial distribution will also be investigated in order to better understand the effect of vegetative composition, forest stand age, and plant stress on the hydrocarbon constituency of forest air. Samples collected on a weekly basis throughout the 1993-1995 period will provide a unique continental, chemical climatological record of key trace gases prominent in the global atmosphere such as ethane, propane and benzene. These species are indicative both of the atmosphere's oxidizing potential and pollutant loading due to long range transport.

Deliverables to the Project:
Ambient data of non-methane hydrocarbons during the study period.

Needs from Other Science Groups:
Collection of air samples in stainless steel canisters (3 litre).

Needs from Project Staff:
Collection and shipping of air samples in stainless steel canisters to and from York University in Toronto.

Location: Prince Albert (some Nelson House)
Sites: Young and old aspen, black spruce, pine
Duration: August 1993, mostly IFCs 1994.

Measurements:

Continuous:
-- Hydrocarbon flux at black spruce, aspen, for half of each IFC, 3 1/2 hour periods/day.
-- Gradients on each flux tower including NH, 3/day during IFCs.

Daily:
-- Hydrocarbons C_2 - C_{10}, 6/day, old aspen, IFCs (Westburg, Zimmerman)
-- Hydrocarbons grab sample, IFCs, two daily.
-- Hydrocarbon profiles in lower BL, two daily during IFC.
-- Aldehyes and organic acides, 2 to 6/day

Twice Weekly:
-- Hydrocarbons grab sample, year round, old aspen (Niki)

Occasionally:
-- Hydrocarbon flux, species survey during IFC, pine, spruce, aspen.
-- Aircraft hydrocarbon flux on Twin Otter, 9/flight during IFC for a total of 20 to 30 on specific flights.
-- Aircraft hydrocarbon flux on Electra, 8/flight during IFC for a total of 20 to 30 on specific flights.
-- CH_4 fluxes at tower sites, where needed.

Measurements expected from other groups:
-- O_3, COS, CO, NO_x, CCN concentration in troposphere.

Ref. Number TGB-10

P.I.: Westberg, H./Washington State University

Co.I.: Hewitt, Nick./Lancaster University

Title: Measurement of Biogenic Hydrocarbon Fluxes and Surface Exchange Processes in a Boreal Forest

Objectives and Approach: We will measure 1) biogenic hydrocarbon emission fluxes, 2) oxidant deposition rates (ozone & hydrogen peroxide), 3) boundary layer exchange rates (via concentration gradient measurements and tracer studies), and 4) diurnal ambient concentration patterns of VOC's and oxidants. These data will be used to determine the role of biogenic hydrocarbon emissions with respect to carbon cycles in the boreal forest and to examine the atmospheric chemical fate of boreal biogenic emissions. Measurements of oxidant deposition rates will be used to investigate feedback mechanisms between atmospheric chemical cycles and forest dynamics.

We will measure Hydrogen peroxide and organic peroxides in ambient air at the southern Prince Albert field site during the July 19-August 8, 1994 second field intensive. Our objective is to examine the hypothesis that VOC emissions from the biosphere contribute to peroxide formation in the atmosphere. We will collaborate closely with Dr. Hal Westburg, Washington State University, in this.

Deliverables:
These measurements will be provided to the project in terms of tabulated emission fluxes (by tree species and compound type), emission algorithms, vertical concentration profiles, boundary layer transport properties, oxidant depostion rates, and ambient concentrations of each measured species as functions of time and location. Peripheral environmental data will also be included.

Needs:
Needs from other science groups will include vegetation surveys, biomass surveys, CO_2 exchange rates, boundary layer depth measurements, and associated meteorological parameters.

Needs from the Project Staff:
Assistance with the arrangements of access and logistics.

Location: Prince Albert
Sites: Old aspen, black spruce, old jack pine.
Duration: IFCs 1994.

Measurements:
Daily:
- -- Biogenic hydrocarbon flux at black spruce, old aspen and old jack pine during each IFC three 1/2 hr periods/day
- -- Biogenic hydrocarbon gradients on the three flux towers, 3/day during IFcs
- -- Ozone and H_20_2 gradients at old jack pine site, IFCs
- -- Ambient hydrocarbon (C_2-C_{10}) grab samples, IFCs, 6 daily
- -- Hydrocarbon profiles in lower BL, two daily during IFC
- -- Aldehyde and organic acid sampling, 2 to 6/day
- -- Ambient ozone and H_20_2

Occasionally:

-- Aircraft hydrocarbon flux on Twin Otter, 9/flight during IFC for a total of 20 to 30 on specific flights.

-- Aircraft hydrocarbon flux on Electra, 8/flight during IFC for a total of 20 to 30 on specified flights.

Measurements expected from other groups:

-- CO, NO_x, concentration in troposphere.

Ref. Number TGB-11 -- DELETED

Ref. Number TGB-12

P.I.(s): Trumbore, S.E./Univ of California, Irvine

CO-I(s): Davidson, E.A./Woods Hole Research Center, Harden, J., Sundquist, E./USGS

Title: Input, Accumulation, and Turnover of Carbon in Boreal Forest Soils: Integrating ^{14}C Isotopic Analyses with Ecosystem Dynamics

Objectives and Approach: We will combine measures of carbon inventories of soils, ^{14}C content of soil atmospheres, and rates of soil respiration to estimate the rates of carbon accumulation and turnover in soils of each of the major vegetation types of the boreal forests at Prince Albert and Nelson House. ^{14}C measurements of physically and chemically fractionated soils will be used to partition soil organic matter into pools that turn over on annual, decadal-centennial, and millennial time scales. The understanding of soil carbon dynamics gained from these estimates will be tested against evidence from (1) chronosequence studies which document the accumulation of carbon in physically and chemically defined pools on decadal (time since fire) and millennial (time since soil formation) scales, and (2) estimates of rates of soil respiration and ^{14}C content of respired CO_2. We will explore several of the factors controlling soil carbon accumulation and dynamics, including (1) quality of the detrital substrate, and (2) availability of O_2 as expressed by soil moisture, gas exchange rate, or drainage class. Measurements will be coordinated with those of other investigations to maximize the amount of information gathered at each site.

Data:

1) ^{14}C measurements of fractioned organic matter from archived soil profiles are collected during 1993-4 field seasons.

2) Isotopic composition of CO_2 fluxes and soil atmosphere concentrations

3) Measures of soil gas exchange rate (from 222Rn) at the same site. Sites will be selected to augment information being gathered by other investigators, and will include both primary tower sites and auxiliary sites selected to study processes in trace gas geochemistry.

4) We will also provide C inventory data for sites we measure, including soil bulk density, and organic carbon content.

5) Form data synthesis: Model of carbon cycling including the effect of moisture and litter quality on decomposition rates.

Needs from other groups:

Litterfall and root turnover estimates
--Soil moisture data/ysimeter to sample TDOC DOC
--Soil Characterization (eg. grain size, CEC, etc.) (can be done by our project with more resources

Needs from project staff
--Logistics, as we will be sampling all three BOREAS sites

Snow/Hydrology (HYD)

HYD-1	Cuenca
HYD-2	Chang
HYD-3	Davis
HYD-4	Goodison
HYD-5	Harding
HYD-6	Peck
HYD-7	DELETED
HYD-8	Band
HYD-9	Soulis

Ref. Number HYD-1

P.I.(s): Cuenca, R.H./Oregon State Univ

Title: Coupled Atmosphere-Forest Canopy-Soil Profile Monitoring and simulation

Objectives and Approach: The objective of this project is to design a coordinated program of data collection for soil properties and soil monitoring over the BOREAS sites collaboration with ecosystem, hydrologic and staff scientists. Properties to be specified include texture, particle size distribution, soil water retention function. The resulting data set will be used for initialization, parameterization, and verification of simulation models in the fields of remote sensing, atmospheric modeling, ecological systems modeling, hydrology and simulation of soil physical process. In order to meet the needs of the various research items, the measurement program will be divided into the areas of (1) Core Measurement Program (b) IFC Soil Moisture Content, Water Table and Soil Property Monitoring, (c) Continuous Soil Moisture Content and Temperature Monitoring, (d) Surface Moisture Measurement, (e) Soil Profile Transect and (f) Soils data for Auxiliary sites. The second objective of this project will be simulation of soil physical processes. A finite element model for simulation of soil physical processes will be parameterized using the data described above, and tested and verified using soil monitoring data collected at the BOREAS tower sites. The calibrated simulation models for infiltration, soil moisture redistribution, evapotranspiration, and drainage will then be available for prediction of the soil moisture state at locations of interest to researchers working at sites where only Core Measurement Program data are collected, as well as regionally over the BOREAS experimental domain for the predominant soil textures.

Ref. Number HYD-2

P.I.(s): Chang, A.T.C./NASA/GSFC

Title: Validation of a passive Microwave Snow Water Equivalent Algorithm Using an Energy Balance Model

Objectives and Approach: The surface meteorological data to be collected at the tower and ancillary sites will be used as inputs to an energy balance model to monitor the amount of snow storage in the boreal forest region. SWE derived from an energy balance model and in situ observed SWE will be used to compare the SWE inferred from airborne or spaceborne microwave data and to assess the accuracy of microwave retrieval algorithms. The major external measurements that will be needed are snowpack temperature profiles, and in-situ snow areal extent and snow water equivalent data.

Ref. Number HYD-3

P.I.(s): Davis, R.E./U.S. Army Cold Regions Research & Engineering Lab

Title: Distributed Energy Transfer Modeling in Snow and Soil for Boreal Ecosystems

Objectives and Approach: The goal of this project is to model the spatial and temporal distributions of critical snow pack properties and processes at the scale up to the size of two intensive study sites to develop tools linking the model predictions to remote sensing. The three principal objectives of the project are: (1) to classify the Boreal forest biome based on the spatial distribution of three stands and vegetation, and establish land cover units which have similar attributes in the context of the upper and lower boundary conditions required by the energy and mass transfer model: (2) to extend an energy and mass transfer model of snow and soil to simulate the distributions of insoluable particles, and to incorporate the thermal effects of three wells over a large area: and (3) to identify the capabilities and limitations of remote sensing measurements to monitor the state of the snowpack. The study will focus on the winter and thaw periods, and on the relatively small spatial scale (e.g., plot or hillslope).

Ref. Number HYD-4

P.I.(s): Goodison, B./Canadian Climate Centre

Title: Determination of snow cover variations in the Boreal Forest using passive microwave radiometry.

Objectives: and Approach: This study will investigate snow cover variations within and between the BOREAS study areas using passive microwave radiometry. It will involve algorithm development and validation to derive snow water equivalent and extent from passive microwave radiometer data, incorporating variations in surface land cover. Ground, airborne, and satellite data will facilitate scaling up to the satellite resolution. The effects of forest cover (density, type) on snow cover retrievals will be assessed and incorporated in the determination of snow cover variability. The use of passive microwave data in combination and optical and thermal IR data to improve snow cover retrievals will be explored. Although dry snow conditions are a priority, flights during a melting state are desirable as well.

Ref. Number HYD-5

P.I.(s):	Harding, R.J./Institute of Hydrology
CO-I's:	
Title:	The Regional Representation of the Energy and Moisture Fluxes from Snow Covered Areas in the BOREAS Experiment
Objectives and Approach:	This project will seek to characterize the energy and water vapor fluxes, as well as related properties (density, depth, temperature, melt) for forested and non-forested areas. Equipment will be set up in the winter FFC and run through to the Thaw FFC. Two sites will be operated in or near the Prince Albert Park area. One is above a mixed jack pine and aspen forest stand near Bear Trap Creek (this site is being run in conjunction with the NHRI GEWEX experiment). The second site is near the centre of Namekus Lake (750 m from the western edge). It may be necessary to move the lake site to a clear cut area to the NE of Waskisiu in the Thaw FFC. Eddy correlation and full set of meteorological measurements will be made. An extensive program of meteorological and SVAT modeling is planned to investigate the problems of aggregation of surface fluxes in a snow covered landscape. One and two dimensional boundary layer models will be used to investigate scales from 100m to 10km. A three dimensional mesoscale model will be used to aggregate from 10 km to 1000 km. This latter model will require extensive meteorological and ground cover data from the BOREAS study region. Improved snow parameterisations for GCM's will be one of the important products of this research.

Ref. Number HYD-6

P.I.(s):	Peck, E.L./Hydex Corp
Title:	Remote Sensing of Hydrologic Variables in Boreal Areas
Objectives and Approach:	This project will utilize airborne gamma sensing to measure soil moisture (SM) in areas underlain with permafrost (northern site) and in forested boreal areas, and will cooperate with HYD-4 in the measurement of snow water equivalent (SWE). The airborne estimates of SWE and SM will be used with estimates from other investigators to prepare information about the distributions of SWE and SM for the BOREAS sites and to investigate the relationships of these site measurements to those observed on a regional scale. Intercomparison studies of estimates of SWE and SM by the airborne gamma and other remote sensing techniques will be conducted. Flight lines will be established in the vicinity of the northern and southern sites, and (possibly) along the transect between the two sites. The flight lines, which will be constrained to be along roads due to accessibility constraints for the ground truth data will be located within areas having six surface conditions, defined on the basis of vegetation type and age, soil type, and soil moisture. The airborne estimates of the snow water equivalent will be validated using surface snow surveys. Background flights and in situ soil moisture measurements will be performed during Fall 1993. Airborne snow measurements will be flown during Winter 1994 (probably February), and snow course and soil moisture measurements will be conducted during the thaw and port-thaw periods of Spring 1994. Airborne soil moisture measurements will be collected during the three summer IFCs. The primary needs of this project for external data collection are ground data on vegetation and soil characteristics.

Ref. Number HYD-7 -- DELETED

Ref. Number HYD-8

P.I.(s): Band, L.E./Univ of Toronto

Title: Simulation of Boreal Ecosystem Carbon and Water Budgets: Scaling from Local to Regional Extents

Objectives and Approach: This project is primarily a modeling effort, which will seek to describe the scaling behavior of water and carbon flux processes from local to regional extents. A suite of simulation models will be used to describe photosynthesis, respiration, evapotranspiration and surface and subsurface flow over a range of scales. The underlying hypothesis to be investigated is that the spatial patterns of surface-atmospheric fluxes are strongly influenced by the spatial distribution of soil moisture and inundation areas in the study sites, which, in conjunction with disturbance regime, are thought to provide the key to scaling from stand to regional simulations. The small scales to be modeled will be essentially hillslopes or subcatchments for which the spatial resolution will be 5-10 m; these subcatchments or hillslopes will probably be located in the vicinity of the tower sites to facilitate use of surface flux data to be collected there. The larger scale will be on the order of the size of the NSA or SSA site, with data resolution extending down to that of AVHRR. The primary external data requirements are for high resolution DEM data, particularly for the hillslope sites, and vegetation and soils data at resolutions comparable to that of the DEM.

Ref. Number HYD-9

P.I.(s): Soulis, E.D./University of Waterloo

CO-I(s): Jasinski, J./NASA Hydrological Sciences Branch,;Kite, G./National Hydrology Research Institute; Kouwen, N./University of Waterloo; Leconte, R./University of Quebec a` Monteal; Lettenmaier, D./Univ of Washingont; Marks, D./US Geological Survey

Title: From Micro-Scale to Meso-Scale Snowmelt, Soil Moisture and Evapotranspiration from Distributed Hydrologic Models

Objectives and Approach: This project will seek to identify, through field measurements and computer modeling, the space-time distribution of meltwater supply to the soil during the spring melt period, and the evolution of soil moisture, evaporation, and runoff from the end of the snowmelt period through freeze up. The snow modeling activity, being conducted by Lettenmaier and Marks, will consist of two components: The first will make use of existing "off the-shelf" models, to forecast the onset and spatial extent of snowmelt and meltwater supply to the soil column prior to the 1994 IFCs. The second phase will extend, implement, and verify a physically based energy balance snowmelt model of the two sites and will evaluate approaches to aggregating detailed snowmelt predictions and measurements based on the model to larger scales, up to the size of a rectangle of several hundred km containing the northern and southern sites. The soil moisture modeling being conducted by Soilis and Engman, is based on a grouped response unit method which will allow characterization of soil moisture, evaporation, and runoff for the entire northern and southern sites. The primary external data requirements of the project are for (1) water period surface meteorological and energy flux data, (2) high quality DEM data, (3) vegetation characterization, at the scale of the DEM, (4) supplemental snow-free period precipitation data at the local (hillslope) scale, perhaps along selected transects.

Remote Sensing Science (RSS)

RSS-1	Deering
RSS-2	Irons
RSS-3	Walthall
RSS-4	Curran
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RSS-6	Williams
RSS-7	Chen/Penner/Cihlar
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RSS-13	Gogenini
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RSS-16	Saatchi
RSS-17	Way
RSS-18	Green
RSS-19	Miller
RSS-20	Vanderbilt

Ref. Number RSS-1

P.I.:	Deering, D./NASA
CO-I(s):	Middleton, E./ NASA; Ahmad, S./Hughes/STX Corp.
Title:	Radiative Transfer Characteristics of Boreal Forest Canopies and Algorithms for Energy Balance and PAR Absorption

Objectives and Approach:

The objectives of the proposed study are 1) to characterize the multidirectional interactions of solar energy in various types of boreal forest canopies through intensive measurements and through modeling, and 2) to relate these characteristics to ecologically important biophysical parameters. Emphasis is given to the directionally-dependent absorption of photosynthetically active radiation (PAR) by the forest canopies and the directional reflection of the radiation from them (constituting the albedo). The goal is to develop the necessary understanding and subsequently the algorithms to use measurements from satellites to quantify the radiation regimes above and within the forest canopies to reliably interpret the biophysical state of the boreal forest ecosystem. BOREAS Objectives II and VII are directly addressed through this proposed study. Additional contributions are made to the observational components of Objective III.

Our approach is to acquire comprehensive sets of angular spectral bidirectional radiance and reflectance measurements for boreal forest types under various sky conditions; diurnally and seasonally. These angular radiance distribution measurements will be made both above and at various levels within the canopies, including the forest floor, to characterize the complete radiative transfer within the forest canopy types. A suite of unique field radiometers, which are significantly enhanced, but patterned after the original Portable Apparatus for Rapid Acquisitions of Bidirectional Observations of Land and Atmosphere, or PARABOLA, multidirectional field radiometer, will be deployed on trams to simultaneously traverse and measure the directional radiance distributions at the multiple levels within and above the forest canopies, while suspended between towers approximately 30 - 40 m apart.

The measurements will be used in the proposed study and other proposed BOREAS investigators to validate physically-based models. Using detailed 3D models, we will simulate bidirectional reflectance and transmittance measurements for different forest types (foliage density, crown shape and crown spacing) under different illumination conditions. These simulated measurements will be used in the Ahmad-Deering model to parameterize the coefficient of the scattering phase function, thus extending its applicability to non-homogenous scenes and heterogeneous canopies. The extended Ahmad-Deering model will then be validated using field observations. Particular emphasis will be given to assessments of the fraction of photosynthetically active radiation absorbed and related biophysical variables and forest albedo. The model will be provided to BOREAS investigators for accurate interpretation of satellite data. Furthermore, we will test an hypothesis from Sellers *et al.* (1992) that the bidirectional reflectances for PAR obtained at a solar zenith angle of 60^{o} provide a good estimate of the time-weighted mean fraction of absorbed PAR.

Ref. Number RSS-2

P.I.:	Irons, J./NASA
Title:	Dynamics of Canopy Photosynthesis and Stomatal Conductance in the Boreal Forest: A Study Using Airborne, Multi-Angle, Imaging Spectroradiometer Data
Objectives and Approach:	To obtain multi-angle, high spectral resolution reflectance data of important forestal components of a boreal landscape and relate these data to biophysical states (albedo, FPAR, leaf area index). The Advanced Solid State Array (ASAS) system will be flown over representative sites in BOREAS to acquire the data. Radiative transfer models will be used in combination with the multi-angle data to develop algorithms for biophysical parameter estimation.

Ref. Number RSS-3

P.I.:	Walthall, C./University of Maryland
Title:	Biophysical Significance of Spectral Vegetation Indices in the Boreal Forest
Objectives and Approach:	The primary objective of this study is to test alternate hypotheses concerning the biophysical significance of Spectral Vegetation Index (SVI) variations in the boreal forest region. It is proposed to investigate if current approaches for spectral estimates of APAR are suitable for the boreal forest, and what biophysical attributes of the boreal forest vegetation gradient are revealed by spectral vegetation index measurements. Two alternate radiative transfer models are to be employed which realistically represent the end points between "turbid media" canopies and "geometric" canopies. These models provide estimates of both observed spectral reflectance and canopy APAR. Intensive laboratory, ground and helicopter field measurements will be acquired to provide accurate parameter specifications for the radiative transfer models as well as measurements which can be compared to the model calculations. Measurements will be carried out at both the Prince Albert and Nelson House study sites to evaluate variance in model parameters and radiance properties at each end of the gradient. SVI analysis using the normalized difference vegetation index (NDVI) and simple ratio indices will be investigated, as will alternative approaches using second derivative analysis of the spectral reflectance function. Satellite observations from Landsat will be evaluated to establish the SVI gradient present in the BOREAS region and consider the question of landscape heterogeneity in producing the observed SVI gradient. Measurements will be coordinated with other BOREAS investigators and BOREAS Staff Science Teams.

Ref. Number RSS-4

P.I.: Curran, P./University of Swansea

Title: Coupling Remotely Sensed Data to Ecosystem Simulation Models

Objectives and Approach: The proposed research will consist of four phases. (i) Collection of i*n situ* forest biophysical/biochemical data at pre-selected plots within one of the prime study sites. A four week data collection program will be planned, the timing of which will coincide with the pilot intensive field campaign programmed for the summer of 1993. Destructive and non destructive measurements at all plots will include leaf nitrogen and chlorophyll concentrations, leaf area index, tree diameter at breast height and percentage canopy cover. (ii) Derivation and validation of relationships between remotely sensed data and forest attribute data. (iii) Use of these relationships to estimate those forest variables required to drive and validate Forest BGC over the 400-600 km^2 study area. (iv) Reporting of results.

Ref. Number RSS-5

P.I.: Goel, N./Wayne State University

Title: Boreal Forest Community Composition and Structure, Photosynthesis, Remote Sensing, Scaling and Net Carbon Flux

Objectives and Approach: The overall objectives of this proposal are to address the following questions related to two quantities--photosynthesis and soil radiation absorption--for boreal forest: (1) How important is the detailed architecture and species distribution in boreal forest canopy in determining these quantities and how do they vary as a function of season when canopy architecture undergoes changes? (2) Can we estimate them using a simpler equivalent model using surrogate parameters for canopy architecture? (3) Are these parameters correlated to each other under different canopy architectural conditions, and can one estimate photosynthesis using measurement of radiation absorbed by the soil? (4) Can one estimate photosynthesis using radiation leaving a canopy? In particular, how does the relationship between FPAR (fraction of photosynthetically active radiation) and NDVI (normalized difference vegetation index) depend upon the complex forest community and architecture? (5) How can one scale up their estimation for a large collection of heterogeneous canopies such as those found in boreal forest? (6) To what degree different forest stands can be differentiated by using remotely sensed data? and (7) Can one estimate the net carbon flux over the area covered by the BOREAS site by using a combination of vegetation models, scaling strategies, ground observations, and satellite images.

Ref. Number RSS-6

P.I.: Williams, D./NASA

Title: Modeling and Remote Sensing of Radiant Energy Interactions and Physiological Functioning in a Boreal Ecosystem

Objectives and Approach:

The Objectives of our research program are twofold :

- to develop and validate a three-dimensional boreal forest canopy/atmosphere radiation model capable of simulating canopy reflectance, absorbance and atmospheric effects:

- to develop and validate algorithms for estimating surface albedo, solar and photosynthetically active radiation absorbed by boreal forest canopies, solar radiation absorbed by the background and, boreal forest canopy photosynthetic and bulk conductance efficiencies from spectral, spatial and temporal patterns of surface radiance fields.

The physical problem is posed as a 3D radiative transfer equation (RTE), describing the interaction of photons in the atmosphere/vegetation medium, the solution of which is the remote spectral measurement. We propose to develop models of boreal forest community at the BOREAS experimental sites suing fractals and computer graphics. These scenes will be digitized to parameterize the 3D RTE together with canopy and atmospheric optical data. The resulting within-canopy radiation regime and bidirectional reflectance factor (BRF) distribution above the canopy and atmosphere will be compared with experimental and satellite data (II.A). We propose to use the shoot as the fundamental element for needle canopies. The validated radiation model will be coupled to a leaf/shoot physiology model to estimate canopy photosynthesis and bulk stomatal conductance, and compared with field data. Algorithms for estimating surface albedo, solar and photosynthetically active radiation absorbed by the canopy and background, canopy photosynthetic and conductance efficiencies from spectral indices will be developed using the 3D model and validated with experimental data. The model will also be used to investigate several fundamental problems in remote sensing science with special reference to boreal forest canopies (effects of architecture, optics, atmosphere, wavelength, adjacency, spatial heterogeneity, stand mixture, scaling, etc.

Ref. Number RSS-7

P.I.: Chen, J.M./Canada Centre for Remote Sensing
Co. P.I(s): Penner, M./ PNFI; Cihlar, J./CCRS

Title: Retrieval of Boreal Forest Leaf Area Index From Multiple Scale Remotely Sensed Vegetation Indices

Objectives and Approach:

We propose to develop and validate an algorithm that will allow the retrieval of the spatial distribution of LAI from remotely sensed vegetation indices. Field measurements of LAI and FPAR (fraction of Absorbed Photosynthetically Active Radiation) will be undertaken for major boreal forest species (jack pine, quaking aspen, black spruce) and stand types. For each species, stands with different percentages of forest cover will be studies. FPAR will be measured but for smaller spatial areas than LAI due to logistical constraints. Field measurements of effective LAI will be taken both along transects and on a regularly spaced grid with the LAI-2000 sensor. For selected stands (YJP,OJP and OBS tower sites in both SSA and NSA), high frequency data (1 sample/cm) will be obtained from a LI-COR quantum sensor carried by a person walking along transects beneath the overstory to improve LAI calculations and to characterize the architecture of the canopy. The measurements of the moving quantum sensor will be used to calculate FPARThese field measurements will allow us to establish relationships between LAI, FPAR and remotely sensed radiances and their transformations including vegetation indices. These relationships will then be used to test the performance of spatial mapping of LAI by extrapolation.

An airborne CCD scanner MEIS (Multi-detector Electro-optical imaging scann) will be used to remotely sense the forest in areas that coincide with LAI-2000 measurements. The airborne instrument will be flown at different altitudes producing images with pixel sizes of 0.5m, 2 m and 7 m. Lower resolution images will be obtained from LANDSAT and/or SPOT and possibly from other remote sensing instruments available through other BOREAS studies. Techniques to analyze the image content at different scales (e.g. image degradation, texture and contextual analysis) will be used to study the relationship between LAI and transformed satellite radiances at various scales. We will also study the the influence of variable forest cover and the influence of variable understory and soil reflectances on these relationships. By using land cover classification techniques combined with image degradation techniques, we will investigate the possibility of extrapolating to the NOAA-AVHRR scales the relations obtained between vegetation indices from LANDSAT data and LAI from indirect field measurements. These techniques will allow us to address the scaling-up process of LAI from local to regional area measurement.

Ref. Number RSS-8

P.I.(s): Running,S.W./Univ of Montana

Title: MODIS Land Team (Moland) Alborithm Development for Boreal Forests: Participation in BOREAS

Objectives and Approach: We plan two phases to our BOREAS participation. First, during the IFCs we plan to participate in ground validation measurements of: 1) land cover mapping of the northern and southern sites, using both TM data and MODIS airborne simulator (MAS) data with ground derived mapping. 2) mapping and satellite monitoring of the seasonal snowcover and snowmelt on both sites using MAS and ASAS sensors. 3) development of advanced spectral vegetation indices, predominantly using MAS and ground BRDF measurements. 4) surface temperatures, as monitored by the meteorological tower network planned for each site, and related to both aircraft and satellite measured thermal emmittances.

We then plan to use carbon and water flux measurements taken from cuvette, tower and aircraft levels by other investigators to validate our hierarchichal modeling of ecosystem water and carbon balances done with FOREST-BGC and our current ΔNDVI modeling. We will integrate these core products into new spatially scalable estimates of daily photosynthesis-respiration balances, evapotranspiration, and soil decomposition and CO_2 production.

Our second phase of work will be to take these MODLAND products, tested and validated during the IFCs, and extrapolate them to the global boreal forest biome.

Ref. Number RSS-9

P.I.(s): Strome, M.

Title: High Spatial and Spectral Resolution Image Analysis Techniques for Ecological and Biophysical Data (HIGH SPIRITED)

Objectives: and Approach:

A major objective will be to attempt to develop techniques and algorithms to enable us to monitor changes in the test sites and to relate the remotely sensed data to forest models. The multi-temporal data will be used to attempt to monitor changes resulting from phenologic events, especially those related to vegetative stress where possible.

The majority of past efforts to analyze high spectral resolution data have focused upon relatively simple signal processing techniques, such as selection of optimum bands to dinstinguish features of interest such as species identification, vegetative stress and defoliationdue to insect damage. Some techniques, used principally for giological applications, have looked at thepositions of peaks and valleys in the spectral signature. We intend to apply several other signal processing techniques to identify and extract features from the shape of the spectral signature. Some of these include the use of expert systems fromthe DEIDAM project, neural networks, and signal processing/information extraction techniques similar to those used in acoustics, magnetic anomaly detection and radar signal processing.

Data required to conduct the research will include that collected on the ground by other scientists. We will also require complete AVIRIS data coverage of the test sites from three data as acquired for RSS-18. We wish to obtain raw data as well as radiometrically and geometrically corrected (preferably geocoded) data, as well as processed Global Positioning System (GPS) reference data. It would also be desirable to obtain CASI data in both high spectral and spatial mode if it is available from RSS-19.

Ref. Number RSS-10

P.I.(s): Holben, B./NASA
CO-I,: Bhartia, P./NASA

Title: Satellite Estimation of PAR and UV-B Irradiances and LONG TERM ESTIMATES OF TRENDS OF UV-B from Ozone Depletion and Cloud Variability at the BOREAS Sites

Objectives and Approach: We Propose to investigate from ground and satellite observations the observations the magnitude of daily, seasonal and yearly variations of UV-B irradiance during the course of the BOREAS field experiment and to examine the 14 year record of Total Ozone Mapping Spectrometer data over the BOREAS sites for ozone and cloud reflectance variability. We also propose to estimate the incident Photosynthetically Active Radiation by refining our existing model which utilizes TOMS reflectivity data to account for cloud attenuation. In addition, we will extend the results of our algorithm development for application to the entire circumpolar boreal forest biome.

Ref. Number RSS-11

P.I.(s): Markham, B.L., Holben, B.N./NASA/GSFC

Title: Characterization of Atmospheric Optical Properties for BOREAS

Objectives and Approach: We propose to characterize the physical and optical properties of the atmospheric aerosol and the atmospheric column abundances of water vapor and ozone over the BOREAS study area. a network of five fully automatic sunphotometers/radiometers will be established on a transect connecting the northern and southern BOREAS sites. These sites will provide year-round hourly direct solar and diffuse sky radiance measurements in the solar almucantar in the visible to near-infrared. During the intensive field campaigns the measurements will be supplemented by additional moveable stations and sampling of the aerosol particles. Aerosol physical properties of size distribution/concentration and composition, and aerosol optical properties of optical depth, phase function and albedo of single scattering will be determined. The annual cycle of the concentration and properties of the atmospheric aerosol particles in the Boreal region and the relation between the aerosol properties and the meteorological conditions, in particular the air trajectory and origin, will be assessed. The measured atmospheric properties will be used to validate retrieval algorithms of atmospheric parameters (e.g., water vapor, aerosol optical depths) from remotely sensed data. For selected remotely sensed data, atmospheric corrections will be performed using a radiative transfer code that accounts for the non-Lambertaian forest canopy reflectance. The retrieved reflectances will be compared to those measured at the surface and to those obtained using the atmospheric correction methodology used operationally by the BOREAS project.

Ref. Number RSS-12

P.I.(s):	Wrigley, R.C./NASA/Ames
Title:	Aerosol determinations and Atmospheric Correction for BOREAS Imagery
Objectives and Approach:	First, we propose to acquire Sun photometer data using ground-based instruments as well as using the Airborne Tracking Sun Photometer mounted on NASA's C-130 aircraft coincident with much of the remotely sensed data to be acquired for BOREAS; we will process this data to derive aerosol optical depths as a function of wavelength and make these data available as Core Measurements. Second, we propose to use the spectral aerosol optical depths to derive aerosol size distributions coincident with important BOREAS remote sensing data sets and use the size distributions to calculate aerosol optical properties such as phase functions and single scattering albedoes necessary for our atmospheric correction model. Third, we propose to incorporate a model of contribution of skylight into our atmospheric correction model to enable calculation of surface reflectances from our surface radiances. Fourth, we propose to extend our atmospheric correction model to data collected by the Advanced Solid-state Array Spectroradiometer (ASAS), incorporate an approximate Rayleigh multiple scattering correction, and provide a detailed evaluation of the results. Finally we will process the important remote sensing data sets for BOREAS from the Thematic Mapper (TM), the TM Simulator, System Probatoire de la Terre (SPOT), and ASAS. In sum, our proposed effort will provide critical atmospheric optical measurements and derive the aerosol optical properties necessary for atmospheric correction of BOREAS data, extend our atmospheric correction model, and provide atmospherically corrected data for BOREAS.

Ref. Number RSS-13

P.I.:	S. P. Gogineni/The University of Kansas
GSRP Student:	G. Lance Lockhart/The University of Kansas
Title:	Helicopter-Based Measurements of Microwave Scattering Over the Boreal Forest
Objectives and Approach:	The objectives of the microwave measurement project are (1) to acquire the quantitative backscatter data required to understand better the physics of scattering from vegetative components and (2) to develop a neutral-network-based algorithm for estimating soil moisture and biomass of the boreal forest. The second objective is being supported by a GSRP fellowship from NASA-GSFC. Ultimately, we will develop a scattering model and model-based inversion algorithm to estimate soil moisture and biomass from satellite remote sensing data over the boreal forest, in particular by ERS-1, JERS-1 and SIR-C Synthethic-Aperture Radar (SAR). To accomplish these objectives, we will use a helicopter-based FM scatterometer operating at 10, 5.3 and 1.5 GHz with all four linear polarizations over incidence angles of 0^{o} to 50^{o}. This system will measure backscatter as a function of angle and frequency over the sites. Also, we will collect fine-resolution data at selected sites in an effort to determine the relative contributions of individual forest components to the total backscatter. All data will be reduced to backscatter coefficients using vector-correction techniques. After reducing the data, it will be used to train and test a feed-forward artificial

neutral netwock (ANN). The accuracy of the ANN will be evaluated using ground-truth data collected with help from Dr. jon Ranson and Dr. Roger Lang. Upon completion, we will provide data related to the interpretation of SAR data to other investigators via BORIS.

Ref. Number RSS-14

P.I.(s): Smith, E.A., Cooper, P.J., Gielisse, P.J./F.S.U., Gautier, Catherine/UCSB

Title: Quality Assurance of BOREAS Net Radiation Measurement

Objectives and Approach: Because surface net radiation is generally a main determinant of how the hydrometeorological system operates and how the phenology of a canopy functions, it is a fundamental observable for BOREAS. this project is designed to ensure the highest possible accuracy and precision of the net radiation measurements taken throughout and between the BOREAS sites, and is further designed to help resolve past discrepancies in net radiation measurements based on engineering design and material properties differences in various makes of net radiometers. This project will also assess how well current geosynchronous satellite algorithms, based on 2-channel GOES VIS-IR radiance inputs, can retrieve surface net radiation at a hierarchy of space and time scales. The main deliverables of this project will be a time sequence of inter-calibrated and objectively analyzed gridded net radiation fields throughout the BOREAS IFCs, and a set of scientific papgers onL (1) the measured BOREAS surface net radiation field; (2) the radiometer inter-calibration issue and engineering design study; and (3) the measurement-satellite retrieval intercomparison study. The spatial resolution of the grids will be consistent with the separation distance between the radiometer sites; the time step will match that of the radiometer sampling time recommended by the BOREAS Science Team. All net radiation measurements incorporated in the objective analysis from the multiple sites will be inter-calibrated to an Eppley 4-way directional radiometer system, for which the calibrations of the directional devices would be traceable to the primary radiometer standard maintained at the Davos, Switzerland World Radiation Centre, which is calibrated on the World Radiometric Reference (WRR) scale. All radiometers used in the field will be cross calibrated at a common site prior to the onset of the 1994 BOREAS summer field phase. All net radiometer stations at and between the northern and southern study areas will then be visited at least once in the course of the summer IFCs with a copy of the standard field model deployed on a portable data station to check on residual sensitivty differences. This radiometer will have been cross-calibrated to the similar device, mounted along side the reference 4-way directional system at the calibration site. The satellite measurements needed for this research will be acquired here at FSU

Ref. Number RSS-15

P.I.(s): Ranson, K.J./NASA/GSFC

Title: Distribution and Structure of Biomass in Boreal Forest Ecosystems

Objectives and Approach: The overall objective of this research is to determine the amount and distribution of above ground biomass for ecologically distinct areas of the boreal forest. Specifically, we will 1) Improve and develop algorithms for mapping standing biomass in boreal forests; 2) Develop model inversion strategies for partitioning forest biomass into foliage, branch and bole components; 3) Determine the appropriate radar wavelength, resolution and incidence angle for detection of forest gaps, and to evaluate the ability of multifrequency polarimetric SAR data for extraction of information on forest spatial structure. To ensure success for the above objectives we will investigate the effects of forest structure, i.e., forest floor, understory, boles, branches and leaves on radar backscattering through field measurements, image data analysis, and backscatter modeling.

Our results will consist of biomass estimates over regional areas and through our efforts to invert radar backscatter models, stand level partitioning of biomass into bole, branch and leaf components will be accomplished. These data will be made available to ecosystem modelers to aid in improved estimates of net primary productivity and carbon balance.

Ref. Number RSS-16

P.I.(s): Saatchi, S./Jet Propulsion Laboratory

Title: Estimation of Hydrological Parameters in Boreal Forest Using SAR Data

Objectives and Approach: The objectives of this proposal are to evaluate the spatial and temporal variations of soil and vegetation characteristics in the boreal forest. The main focus of the following study will be on the application of multi-polarization, multi-frequency and multi-look angle SAR data to extract those parameters which have direct application in hydrology and boreal forest ecosystem models. Specifically, we intend

(i) To acquire SAR images over a variety of soil and vegetation conditions during the intensive field campaigns of BOREAS. In particular, for the hydrology aspect of the experiment we will focus on successional stages, thawing and freezing cycles, snow cover and melting periods. In addition, we intend to process and calibrate all SAR images obtained during the field campaigns so that there will be a uniform data set available to investigators and to the BOREAS Information System (BORIS).

(ii) To improve and implement a classification algorithm to identify various scattering mechanisms in SAR data, classify vegetation cover and species, and generate images or maps of clusters of various trees and gaps in boreal forest test sites.

(iii) To develop and implement inversion algorithms for estimating vegetation characteristics such as water content of the top layer, and tree density and height. We will extend the applicability of the current physically based invertible forward model used in agricultural areas to forest canopies in order to correlate the above surface canopy water content with the type of species, density and height.

(iv) To estimate the surface characteristics such as soil moisture at various stages of freezing, thawing, snow, permafrost and dry conditions, surface roughness parameter, and digital elevation data. We will combine the inversion algorithm with the result of the classification program to identify open soil surfaces and double bounce scattering mechanisms to extract surface information. The accuracy of the SAR derived parameters will be verified with the *in situ* measurements.

v) To upscale the soil and vegetation characteristics derived from the SAR data to the scales needed for local, mesoscale, and regional hydrological modeling.

The main focus of this proposal will be the hydrological parameter estimation from SAR data by developing inversion algorithms with reasonable accuracy. To verify, develop, and test the algorithms proposed in this research we will make use of other remote sensing data such as passive microwave data and the visible/infrared imaging spectometer (AVIRIS) data for identifying surface features not visible in SAR images.

Ref. Number RSS-17

P.I.(s): Way, J./Jet Propulsion Laboratory

Title: Monitoring Environmental and Phenologic State and Duration of State with SAR as Input to Improved CO_2 Flux Models

Objectives and Approach: We propose to monitor the environmental and phenologic state using AIRSAR and SIR-C/X-SAR data, and the duration of state with ERS-1 and RADARSAT data.

To quantitatively assess the importance of monitoring the environmental and phenologic state of the boreal forests, we propose to provide directly measured values of physiological state and duration of state to existing CO_2 models to asses the improvement in annual CO_2 flux estimates relative to measured values provided by BOREAS. In addition, the circumpolar boreal forest is divided into two classes: taiga and northern taiga for estimating total carbon uptake. We propose to provide regional maps of functional groups using SAR and winter optical (Landsat or SPOT) data.

Ref. Number RSS-18

P.I.(s):	Green, R. O./Jet Propulsion Laboratory
Title:	Surface and Atmosphere Measurements and Radiative Transfer Modeling for the Calibration and Validation of the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS) for Quantitative Data Analysis at BOREAS
Objectives and Approach:	Spectral and radiometric calibration of radiance-measuring sensors and for quantitative comparison of data acquired from different sites, times and instruments to meet calibration and validation requirements for AVIRIS during the BOREAS experiment. Ground based surface and atmospheric measurements with rigorously calibrated field instruments will be acquired simultaneously with the AVIRIS overflights. With assessments of surface and atmospheric characteristic derived from these ground based measurements a radiative transfer code will be used to predict the total radiance incident at AVIRIS. Analysis using this predicted radiance and the AVIRIS reported radiance will allow validation and calibration of the in-flight spectral and radiometric properties of AVIRIS. Rigorous error analysis of the field measurements, derived parameters, radiative transfer models and sensor characteristics will be implemented to constrain fully the results of this experiment.

Ref. Number RSS-19

P.I.(s):	Miller, J.R./York University
Title:	Variation in Radiometric Properties of the Boreal Forest Landscape as a Function of the Ecosystem Dynamics
Objectives and Approach:	Data collection is proposed with a Compact Airborne Spectrographic Imager (CASI) in the February to September 1994 period, at all 5 intensive and focused field campaigns. The CASI is being fitted with a calibrated downwelling irradiance fiber-optic link permitting direct acquisition of scene reflectances (also allowing under-cloud image acquisition) to generate a full seasonal database of temporal change in the spatial distribution of landscape components and the corresponding spectral reflectance changes in the boreal forest landscape. This dataset of high spectral/spatial resolution reflectance observations will provide a measure of the boreal forest ecosystem dynamics through changes in the physical parameters that describe the BOREAS landscape components [including overstory vegetation and understory -- moss/lichens or snow, water (bogs, ponds and lakes)]. The airborne data collections are intended to contribute to collaborative projects with other BOREAS co-investigators and collaborators. Analysis of these high spatial/spectral reflectance data in conjunction with requested AVIRIS data are intended to determine: (i) site albedos of the wintering boreal forest landscapes and the relationship of reflectance changes prior to and during snow melt to physical snow properties, (ii) the relationship to trace gas emissions and aquatic dissolved organic carbon content, (iii) the role of understory components and phenologic change in overall canopy reflectance for open canopies, and (iv) the seasonal/temporal variation in closed canopy reflectance as a function of (a) phenologic development of foliar components, (b) canopy architecture, (c) species composition, (d) canopy biophysical parameters of LAI and biomass, (e) foliar chemistry.

To address the question of scaling results from a site-specific level to a broader boreal region using remote sensing, we will examine: (i) seasonal change in reflectance/parameter gradients along a 500 km transect between the primary sites, (ii) remote sensing methods to relate high altitude radiance information to reflectance of landscape components, and (iii) methods for classification of the boreal region on a forest ecosystem/landscape unit basis.

Ref. Number RSS-20

P.I.(s):	Vanderbilt, V.C./Ames Research Center
Title:	Estimation of Photosynthetic Capacity using Polder Polarization
Objectives and Approach	The overall hypothesis of this proposal is that the ecosystem-dependent variability in the various vegetation indices is in part attributable to the effects of specular reflection. The polarization channels on the French sensor POLDER provide the potential to estimate this specularly reflected light and allow the modification of the vegetation indices to better measure the photosynthetic process in plant canopies. In addition these polarization channels potentially provide additional ecologically important information about the plant canopy. The expected result from this research is a series of map products providing seasonal estimates of 'minus specular' vegetation indices for flightlines at the two BOREAS test sites. This is a companion effort to TF-6.

Appendix O: Satellite Overpass Schedule

The data from the Landsat-5, NOAA-9, and NOAA-11 overpasses listed on the pages of this appendix WILL BE ACQUIRED by CCRS. Subsequent processing and inclusion of these scenes into BORIS and their availability to BOREAS investigators will depend on prevailing cloud cover conditions.

At the time of printing this document, a firm plan for acquiring actual SPOT data has not been reached. The SPOT overpasses listed on the pages of this appendix include all those scenes that could occur. The information about actual SPOT acquisitions will be updated and distributed at a later date.

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	01-Feb-94	01:44:42	64	37	271	112	716.88	606.96
SSA	NOAA9	01-Feb-94	01:44:42	57	55	266	109	405.10	333.18
SSA	NOAA9	01-Feb-94	03:25:12	265	39	287	123	405.10	333.18
NSA	NOAA9	01-Feb-94	03:25:33	264	54	294	125	716.88	606.96
NSA	NOAA11	01-Feb-94	11:47:24	109	13	87	113	716.88	606.96
SSA	NOAA11	01-Feb-94	11:48:08	99	33	83	117	405.10	333.18
NSA	NOAA9	01-Feb-94	15:38:39	104	35	134	83	716.88	606.96
SSA	NOAA9	01-Feb-94	15:39:20	98	49	130	84	405.10	333.18
NSA	NOAA12	01-Feb-94	15:57:28	305	53	138	82	716.88	606.96
SSA	NOAA12	01-Feb-94	15:58:42	291	45	134	82	405.10	333.18
NSA	NOAA9	01-Feb-94	17:19:09	300	54	157	76	716.88	606.96
SSA	NOAA9	01-Feb-94	17:19:50	303	48	152	75	405.10	333.18
NSA West	SPOT1	01-Feb-94	17:44:54	114	11	165	74	771.02	615.45
NSA East	SPOT1	01-Feb-94	17:44:56	132	8	165	74	820.96	618.22
SSA East	SPOT2	01-Feb-94	18:39:57	295	26	172	71	394.69	335.04
SSA West	SPOT2	01-Feb-94	18:39:58	299	23	171	71	334.84	324.67
SSA	NOAA11	01-Feb-94	21:40:35	63	51	216	77	405.10	333.18
NSA	NOAA11	01-Feb-94	21:40:53	60	30	221	81	716.88	606.96
SSA	NOAA11	01-Feb-94	23:21:08	256	45	238	88	405.10	333.18
NSA	NOAA9	02-Feb-94	01:31:51	63	46	269	110	716.88	606.96
SSA	NOAA9	02-Feb-94	03:12:01	249	27	284	121	405.10	333.18
NSA	NOAA9	02-Feb-94	03:12:41	265	46	291	123	716.88	606.96
NSA	NOAA11	02-Feb-94	11:35:13	111	26	84	115	716.88	606.96
SSA	NOAA11	02-Feb-94	11:35:56	101	44	81	118	405.10	333.18
SSA	NOAA11	02-Feb-94	13:16:28	299	52	101	103	405.10	333.18
NSA	NOAA12	02-Feb-94	13:55:58	95	54	113	95	716.88	606.96
NSA	NOAA9	02-Feb-94	15:25:48	103	45	131	85	716.88	606.96
NSA	NOAA12	02-Feb-94	15:36:11	297	39	134	83	716.88	606.96
SSA	NOAA12	02-Feb-94	15:37:05	292	26	129	84	405.10	333.18
NSA	NOAA9	02-Feb-94	17:06:18	299	48	154	76	716.88	606.96
SSA	NOAA9	02-Feb-94	17:07:21	289	39	149	76	405.10	333.18
NSA East	SPOT1	02-Feb-94	17:25:37	111	28	161	74	820.96	618.22
NSA West	SPOT2	02-Feb-94	18:19:53	290	27	173	73	771.02	615.45
SSA East	SPOT2	02-Feb-94	18:20:36	323	6	167	72	394.69	335.04
SSA West	SPOT2	02-Feb-94	18:20:37	9	5	166	72	334.84	324.67
NSA	NOAA11	02-Feb-94	21:28:42	59	39	218	80	716.88	606.96
SSA	NOAA11	02-Feb-94	23:08:55	256	35	235	86	405.10	333.18
NSA	NOAA11	02-Feb-94	23:09:35	268	53	240	90	716.88	606.96
NSA	NOAA9	03-Feb-94	01:19:00	60	53	266	108	716.88	606.96
SSA	NOAA9	03-Feb-94	02:59:12	249	12	282	119	405.10	333.18
NSA	NOAA9	03-Feb-94	02:59:29	254	37	288	121	716.88	606.96
NSA	NOAA11	03-Feb-94	11:22:41	96	37	81	116	716.88	606.96
SSA	NOAA11	03-Feb-94	11:23:23	93	52	78	120	405.10	333.18
NSA	NOAA11	03-Feb-94	13:03:13	305	53	102	102	716.88	606.96
SSA	NOAA11	03-Feb-94	13:04:16	298	45	98	105	405.10	333.18
NSA	NOAA9	03-Feb-94	15:12:36	94	53	128	86	716.88	606.96
NSA	NOAA12	03-Feb-94	15:14:34	305	21	129	86	716.88	606.96
SSA	NOAA12	03-Feb-94	15:15:29	342	3	124	87	405.10	333.18
NSA	NOAA9	03-Feb-94	16:53:26	299	40	151	77	716.88	606.96
SSA	NOAA9	03-Feb-94	16:54:32	283	28	146	76	405.10	333.18
NSA East	SPOT2	03-Feb-94	18:00:31	287	11	169	73	820.96	618.22
NSA West	SPOT2	03-Feb-94	18:00:32	289	7	168	73	771.02	615.45
SSA East	SPOT2	03-Feb-94	18:01:17	96	19	162	72	394.69	335.04
SSA West	SPOT2	03-Feb-94	18:01:18	94	23	161	72	334.84	324.67
SSA West	SPOT1	03-Feb-94	18:47:30	285	29	172	71	334.84	324.67
NSA	NOAA11	03-Feb-94	21:16:28	59	47	215	79	716.88	606.96
SSA	NOAA11	03-Feb-94	22:56:43	258	23	233	85	405.10	333.18
NSA	NOAA11	03-Feb-94	22:57:01	259	46	237	89	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	04-Feb-94	02:46:23	35	4	279	117	405.10	333.18
NSA	NOAA9	04-Feb-94	02:46:39	258	25	285	119	716.88	606.96
NSA	NOAA11	04-Feb-94	11:10:27	97	46	78	118	716.88	606.96
NSA	NOAA11	04-Feb-94	12:51:20	295	47	99	103	716.88	606.96
SSA	NOAA11	04-Feb-94	12:52:05	296	36	96	106	405.10	333.18
NSA	NOAA12	04-Feb-94	14:53:19	150	6	124	88	716.88	606.96
SSA	NOAA12	04-Feb-94	14:53:53	97	24	120	89	405.10	333.18
NSA	NOAA9	04-Feb-94	16:40:37	297	29	148	77	716.88	606.96
SSA	NOAA9	04-Feb-94	16:41:22	308	15	143	77	405.10	333.18
NSA East	SPOT2	04-Feb-94	17:41:11	107	11	164	73	820.96	618.22
NSA West	SPOT2	04-Feb-94	17:41:12	105	15	163	73	771.02	615.45
SSA East	SPOT1	04-Feb-94	18:28:08	272	14	168	71	394.69	335.04
SSA West	SPOT1	04-Feb-94	18:28:10	272	8	168	71	334.84	324.67
NSA	NOAA11	04-Feb-94	21:04:15	58	54	213	77	716.88	606.96
SSA	NOAA11	04-Feb-94	22:44:32	274	9	230	83	405.10	333.18
NSA	NOAA11	04-Feb-94	22:44:47	260	36	235	87	716.88	606.96
SSA	NOAA9	05-Feb-94	02:33:34	59	18	276	115	405.10	333.18
NSA	NOAA9	05-Feb-94	02:33:50	269	12	282	117	716.88	606.96
NSA	NOAA11	05-Feb-94	10:58:14	98	54	75	119	716.88	606.96
NSA	NOAA11	05-Feb-94	12:39:07	293	39	97	105	716.88	606.96
SSA	NOAA11	05-Feb-94	12:39:53	294	25	93	108	405.10	333.18
NSA	NOAA12	05-Feb-94	14:31:42	110	28	119	90	716.88	606.96
SSA	NOAA12	05-Feb-94	14:32:16	97	44	115	92	405.10	333.18
SSA	NOAA12	05-Feb-94	16:12:09	302	53	136	80	405.10	333.18
NSA	NOAA9	05-Feb-94	16:27:48	294	17	145	78	716.88	606.96
SSA	NOAA9	05-Feb-94	16:28:33	39	4	140	78	405.10	333.18
NSA West	SPOT1	05-Feb-94	18:07:42	304	16	170	72	771.02	615.45
NSA East	SPOT1	05-Feb-94	18:07:44	297	19	171	72	820.96	618.22
SSA East	SPOT1	05-Feb-94	18:08:48	125	11	163	71	394.69	335.04
SSA West	SPOT1	05-Feb-94	18:08:51	113	16	163	71	334.84	324.67
SSA	NOAA11	05-Feb-94	22:32:21	31	8	228	81	405.10	333.18
NSA	NOAA11	05-Feb-94	22:32:35	264	25	232	85	716.88	606.96
SSA	NOAA9	06-Feb-94	02:20:44	60	31	274	113	405.10	333.18
NSA	NOAA9	06-Feb-94	02:21:00	12	6	280	115	716.88	606.96
NSA	NOAA11	06-Feb-94	12:26:56	288	29	94	106	716.88	606.96
SSA	NOAA11	06-Feb-94	12:27:42	288	11	90	110	405.10	333.18
NSA	NOAA12	06-Feb-94	14:09:45	93	46	115	92	716.88	606.96
NSA	NOAA12	06-Feb-94	15:49:58	299	48	136	81	716.88	606.96
SSA	NOAA12	06-Feb-94	15:50:53	294	39	131	82	405.10	333.18
NSA	NOAA9	06-Feb-94	16:14:58	277	3	142	79	716.88	606.96
SSA	NOAA9	06-Feb-94	16:15:44	101	17	137	79	405.10	333.18
SSA	Landsat5	06-Feb-94	17:20:00	217	5	152	74	405.1	333.18
NSA West	SPOT1	06-Feb-94	17:48:22	72	8	165	73	771.02	615.45
NSA East	SPOT1	06-Feb-94	17:48:24	58	4	166	72	820.96	618.22
SSA West	SPOT2	06-Feb-94	18:43:43	289	27	171	70	334.84	324.67
SSA	NOAA11	06-Feb-94	22:19:49	80	20	225	80	405.10	333.18
NSA	NOAA11	06-Feb-94	22:20:04	234	12	230	84	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	07-Feb-94	02:07:51	81	18	277	113	716.88	606.96
SSA	NOAA9	07-Feb-94	02:07:55	60	41	272	110	405.10	333.18
SSA	NOAA9	07-Feb-94	03:48:25	261	54	294	125	405.10	333.18
NSA	NOAA11	07-Feb-94	12:14:44	278	17	91	108	716.88	606.96
SSA	NOAA11	07-Feb-94	12:15:31	134	4	88	111	405.10	333.18
NSA	NOAA12	07-Feb-94	15:28:22	301	34	131	83	716.88	606.96
SSA	NOAA12	07-Feb-94	15:29:17	299	19	126	84	405.10	333.18
NSA	NOAA9	07-Feb-94	16:02:09	118	12	139	80	716.88	606.96
SSA	NOAA9	07-Feb-94	16:02:53	104	30	134	80	405.10	333.18
NSA West	SPOT1	07-Feb-94	17:29:03	96	28	160	73	771.02	615.45
NSA East	SPOT1	07-Feb-94	17:29:04	98	24	161	73	820.96	618.22
SSA East	SPOT2	07-Feb-94	18:24:23	276	9	167	70	394.69	335.04
SSA West	SPOT2	07-Feb-94	18:24:23	287	5	166	70	334.84	324.67
SSA	NOAA11	07-Feb-94	22:07:38	72	32	223	78	405.10	333.18
NSA	NOAA11	07-Feb-94	22:07:53	114	3	227	82	716.88	606.96
NSA	NOAA9	08-Feb-94	01:55:02	72	30	274	111	716.88	606.96
SSA	NOAA9	08-Feb-94	01:55:05	59	50	269	108	405.10	333.18
SSA	NOAA9	08-Feb-94	03:35:34	261	46	291	123	405.10	333.18
NSA	NOAA11	08-Feb-94	12:02:13	344	6	88	109	716.88	606.96
SSA	NOAA11	08-Feb-94	12:03:20	117	19	85	113	405.10	333.18
NSA	NOAA12	08-Feb-94	15:07:06	276	12	126	85	716.88	606.96
SSA	NOAA12	08-Feb-94	15:07:40	75	9	122	86	405.10	333.18
NSA	NOAA9	08-Feb-94	15:49:00	93	26	136	81	716.88	606.96
SSA	NOAA9	08-Feb-94	15:50:03	104	42	131	81	405.10	333.18
Tran East	Landsat5	08-Feb-94	17:07:00	209	8	152	74	632.4	514.82
SSA	NOAA9	08-Feb-94	17:30:33	297	53	154	72	405.10	333.18
NSA East	SPOT2	08-Feb-94	18:03:57	308	16	170	71	820.96	618.22
NSA West	SPOT2	08-Feb-94	18:04:18	267	12	169	71	771.02	615.45
SSA East	SPOT2	08-Feb-94	18:05:03	113	15	162	70	394.69	335.04
SSA West	SPOT2	08-Feb-94	18:05:03	106	18	161	70	334.84	324.67
SSA	NOAA11	08-Feb-94	21:55:27	68	42	220	77	405.10	333.18
NSA	NOAA11	08-Feb-94	21:55:42	71	16	225	81	716.88	606.96
SSA	NOAA11	08-Feb-94	23:36:20	263	54	242	88	405.10	333.18
NSA	NOAA9	09-Feb-94	01:42:12	67	40	272	109	716.88	606.96
SSA	NOAA9	09-Feb-94	03:22:44	263	36	288	121	405.10	333.18
NSA	NOAA9	09-Feb-94	03:23:02	262	52	294	123	716.88	606.96
NSA	NOAA11	09-Feb-94	11:50:02	94	11	86	111	716.88	606.96
SSA	NOAA11	09-Feb-94	11:50:48	96	32	82	114	405.10	333.18
NSA	NOAA12	09-Feb-94	14:45:30	113	13	122	87	716.88	606.96
SSA	NOAA12	09-Feb-94	14:46:03	94	32	117	89	405.10	333.18
NSA	NOAA9	09-Feb-94	15:36:09	98	37	132	82	716.88	606.96
SSA	NOAA9	09-Feb-94	15:36:52	95	51	128	83	405.10	333.18
NSA	NOAA9	09-Feb-94	17:16:39	303	53	156	73	716.88	606.96
SSA	NOAA9	09-Feb-94	17:17:42	295	46	151	73	405.10	333.18
NSA East	SPOT2	09-Feb-94	17:44:57	141	9	165	72	820.96	618.22
NSA West	SPOT2	09-Feb-94	17:44:57	128	12	164	72	771.02	615.45
SSA East	SPOT1	09-Feb-94	18:31:36	294	18	169	69	394.69	335.04
SSA West	SPOT1	09-Feb-94	18:31:39	303	12	168	69	334.84	324.67
SSA	NOAA11	09-Feb-94	21:43:15	65	50	217	75	405.10	333.18
NSA	NOAA11	09-Feb-94	21:43:30	66	28	222	79	716.88	606.96
SSA	NOAA11	09-Feb-94	23:24:08	264	46	239	86	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	10-Feb-94	01:29:41	56	48	269	107	716.88	606.96
SSA	NOAA9	10-Feb-94	03:09:33	245	24	285	119	405.10	333.18
NSA	NOAA9	10-Feb-94	03:10:11	263	44	291	121	716.88	606.96
NSA	NOAA11	10-Feb-94	11:37:51	105	24	83	112	716.88	606.96
SSA	NOAA11	10-Feb-94	11:38:35	97	43	79	116	405.10	333.18
SSA	NOAA11	10-Feb-94	13:19:08	301	53	100	101	405.10	333.18
NSA	NOAA12	10-Feb-94	14:23:53	104	35	117	90	716.88	606.96
SSA	NOAA12	10-Feb-94	14:24:27	95	50	113	92	405.10	333.18
NSA	NOAA9	10-Feb-94	15:23:18	99	47	130	83	716.88	606.96
SSA	NOAA12	10-Feb-94	16:04:40	295	49	134	79	405.10	333.18
NSA	Landsat5	10-Feb-94	17:00:00	28	7	152	74	716.88	606.96
NSA	NOAA9	10-Feb-94	17:03:47	303	46	153	74	716.88	606.96
SSA	NOAA9	10-Feb-94	17:04:53	293	36	147	73	405.10	333.18
NSA East	SPOT2	10-Feb-94	17:25:17	95	28	160	72	820.96	618.22
NSA West	SPOT1	10-Feb-94	18:11:31	288	19	171	71	771.02	615.45
NSA East	SPOT1	10-Feb-94	18:11:32	286	23	172	70	820.96	618.22
SSA East	SPOT1	10-Feb-94	18:12:16	84	6	164	69	394.69	335.04
SSA West	SPOT1	10-Feb-94	18:12:19	89	12	163	70	334.84	324.67
NSA	NOAA11	10-Feb-94	21:31:19	63	38	219	78	716.88	606.96
SSA	NOAA11	10-Feb-94	23:11:35	253	37	237	85	405.10	333.18
NSA	NOAA11	10-Feb-94	23:12:12	265	54	241	89	716.88	606.96
NSA	NOAA9	11-Feb-94	01:16:50	56	54	267	105	716.88	606.96
SSA	NOAA9	11-Feb-94	02:56:44	236	9	283	117	405.10	333.18
NSA	NOAA9	11-Feb-94	02:57:19	265	34	289	119	716.88	606.96
NSA	NOAA11	11-Feb-94	11:25:39	103	36	80	114	716.88	606.96
SSA	NOAA11	11-Feb-94	11:26:23	98	51	76	117	405.10	333.18
NSA	NOAA11	11-Feb-94	13:06:11	299	54	101	100	716.88	606.96
SSA	NOAA11	11-Feb-94	13:06:55	300	46	97	103	405.10	333.18
NSA	NOAA12	11-Feb-94	14:02:16	101	51	112	92	716.88	606.96
NSA	NOAA9	11-Feb-94	15:10:26	99	55	127	84	716.88	606.96
NSA	NOAA12	11-Feb-94	15:42:09	301	44	134	80	716.88	606.96
SSA	NOAA12	11-Feb-94	15:43:04	297	33	129	81	405.10	333.18
NSA	NOAA9	11-Feb-94	16:51:16	290	38	150	74	716.88	606.96
SSA	NOAA9	11-Feb-94	16:52:04	288	24	144	74	405.10	333.18
NSA West	SPOT1	11-Feb-94	17:52:11	108	2	166	71	771.02	615.45
NSA East	SPOT1	11-Feb-94	17:52:12	252	2	167	71	820.96	618.22
SSA East	SPOT1	11-Feb-94	17:52:57	100	28	159	70	394.69	335.04
NSA	NOAA11	11-Feb-94	21:19:06	62	46	217	76	716.88	606.96
SSA	NOAA11	11-Feb-94	22:59:23	253	25	235	83	405.10	333.18
NSA	NOAA11	11-Feb-94	22:59:59	266	47	239	87	716.88	606.96
SSA	NOAA9	12-Feb-94	02:43:55	79	7	280	114	405.10	333.18
NSA	NOAA9	12-Feb-94	02:44:09	247	22	286	117	716.88	606.96
NSA	NOAA11	12-Feb-94	11:13:25	103	46	77	115	716.88	606.96
NSA	NOAA11	12-Feb-94	12:53:57	299	48	98	101	716.88	606.96
SSA	NOAA11	12-Feb-94	12:54:44	301	37	95	104	405.10	333.18
NSA	NOAA12	12-Feb-94	15:20:53	287	27	129	82	716.88	606.96
SSA	NOAA12	12-Feb-94	15:21:48	260	11	124	83	405.10	333.18
NSA	NOAA9	12-Feb-94	16:38:27	284	27	146	75	716.88	606.96
SSA	NOAA9	12-Feb-94	16:39:14	275	11	141	75	405.10	333.18
NSA West	SPOT1	12-Feb-94	17:32:51	105	24	161	71	771.02	615.45
NSA East	SPOT1	12-Feb-94	17:32:52	109	20	162	71	820.96	618.22
SSA East	SPOT2	12-Feb-94	18:27:49	301	14	168	68	394.69	335.04
SSA West	SPOT2	12-Feb-94	18:27:49	316	11	167	68	334.84	324.67
NSA	NOAA11	12-Feb-94	21:06:53	61	53	214	75	716.88	606.96
SSA	NOAA11	12-Feb-94	22:47:12	260	11	232	81	405.10	333.18
NSA	NOAA11	12-Feb-94	22:47:25	255	38	237	85	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	13-Feb-94	02:31:06	68	22	278	112	405.10	333.18
NSA	NOAA9	13-Feb-94	02:31:19	246	8	283	115	716.88	606.96
NSA	NOAA11	13-Feb-94	11:00:51	94	53	74	117	716.88	606.96
NSA	NOAA11	13-Feb-94	12:41:44	299	40	96	103	716.88	606.96
SSA	NOAA11	13-Feb-94	12:42:33	301	26	92	106	405.10	333.18
NSA	NOAA12	13-Feb-94	14:59:17	282	3	124	84	716.88	606.96
SSA	NOAA12	13-Feb-94	15:00:12	118	18	119	86	405.10	333.18
NSA	NOAA9	13-Feb-94	16:25:18	310	14	143	76	716.88	606.96
SSA	NOAA9	13-Feb-94	16:26:25	146	7	138	76	405.10	333.18
NSA East	SPOT2	13-Feb-94	18:07:42	291	19	170	70	820.96	618.22
NSA West	SPOT2	13-Feb-94	18:07:43	292	15	170	70	771.02	615.45
SSA East	SPOT2	13-Feb-94	18:08:29	87	11	163	69	394.69	335.04
SSA West	SPOT2	13-Feb-94	18:08:30	86	15	162	69	334.84	324.67
SSA	NOAA11	13-Feb-94	22:35:01	34	5	230	79	405.10	333.18
NSA	NOAA11	13-Feb-94	22:35:13	257	27	234	83	716.88	606.96
SSA	NOAA9	14-Feb-94	02:18:16	65	34	275	110	405.10	333.18
NSA	NOAA9	14-Feb-94	02:18:30	64	7	281	113	716.88	606.96
NSA	NOAA11	14-Feb-94	12:29:33	296	30	93	104	716.88	606.96
SSA	NOAA11	14-Feb-94	12:30:22	304	13	89	107	405.10	333.18
NSA	NOAA12	14-Feb-94	14:37:40	104	21	119	87	716.88	606.96
SSA	NOAA12	14-Feb-94	14:38:35	106	39	115	88	405.10	333.18
NSA	NOAA9	14-Feb-94	16:12:28	36	3	140	77	716.88	606.96
SSA	NOAA9	14-Feb-94	16:13:16	95	21	135	77	405.10	333.18
NSA East	SPOT2	14-Feb-94	17:48:22	93	3	165	70	820.96	618.22
NSA West	SPOT2	14-Feb-94	17:48:23	98	7	165	70	771.02	615.45
SSA East	SPOT1	14-Feb-94	18:35:24	283	22	170	67	394.69	335.04
SSA West	SPOT1	14-Feb-94	18:35:27	283	16	169	67	334.84	324.67
SSA	NOAA11	14-Feb-94	22:22:50	56	19	227	78	405.10	333.18
NSA	NOAA11	14-Feb-94	22:23:02	266	14	232	82	716.88	606.96
SSA	NOAA9	15-Feb-94	02:05:27	63	44	273	108	405.10	333.18
NSA	NOAA9	15-Feb-94	02:05:41	63	21	278	111	716.88	606.96
SSA	NOAA9	15-Feb-94	03:46:17	266	52	295	122	405.10	333.18
NSA	NOAA11	15-Feb-94	12:17:22	292	18	90	105	716.88	606.96
SSA	NOAA11	15-Feb-94	12:18:11	75	3	87	109	405.10	333.18
NSA	NOAA12	15-Feb-94	14:16:03	101	41	114	89	716.88	606.96
SSA	NOAA12	15-Feb-94	14:16:39	94	54	110	91	405.10	333.18
NSA	NOAA12	15-Feb-94	15:55:56	301	52	136	78	716.88	606.96
SSA	NOAA12	15-Feb-94	15:56:52	297	44	131	78	405.10	333.18
NSA	NOAA9	15-Feb-94	15:59:39	102	16	137	77	716.88	606.96
SSA	NOAA9	15-Feb-94	16:00:25	100	34	132	78	405.10	333.18
Tran West	Landsat5	15-Feb-94	17:13:00	119	2	151	71	498.12	419.01
NSA East	SPOT2	15-Feb-94	17:29:02	104	24	160	70	820.96	618.22
NSA West	SPOT2	15-Feb-94	17:29:03	103	28	160	70	771.02	615.45
NSA West	SPOT1	15-Feb-94	18:14:58	303	24	171	69	771.02	615.45
NSA East	SPOT1	15-Feb-94	18:14:59	299	27	172	69	820.96	618.22
SSA East	SPOT1	15-Feb-94	18:16:04	173	2	165	68	394.69	335.04
SSA West	SPOT1	15-Feb-94	18:16:08	116	7	164	68	334.84	324.67
SSA	NOAA11	15-Feb-94	22:10:18	75	31	224	76	405.10	333.18
NSA	NOAA11	15-Feb-94	22:10:30	156	5	229	80	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	16-Feb-94	01:52:37	62	52	270	106	405.10	333.18
NSA	NOAA9	16-Feb-94	01:52:52	61	32	275	109	716.88	606.96
SSA	NOAA9	16-Feb-94	03:33:07	258	44	292	120	405.10	333.18
NSA	NOAA11	16-Feb-94	12:05:11	274	5	87	107	716.88	606.96
SSA	NOAA11	16-Feb-94	12:06:00	108	17	84	110	405.10	333.18
NSA	NOAA12	16-Feb-94	15:34:40	291	39	131	80	716.88	606.96
SSA	NOAA12	16-Feb-94	15:35:15	302	25	126	81	405.10	333.18
NSA	NOAA9	16-Feb-94	15:46:50	107	29	134	78	716.88	606.96
SSA	NOAA9	16-Feb-94	15:47:35	101	45	129	79	405.10	333.18
SSA	NOAA9	16-Feb-94	17:28:05	299	51	152	70	405.10	333.18
NSA East	SPOT1	16-Feb-94	17:55:39	326	8	167	69	820.96	618.22
NSA West	SPOT1	16-Feb-94	17:55:59	221	5	166	69	771.02	615.45
SSA East	SPOT1	16-Feb-94	17:56:45	110	24	160	68	394.69	335.04
SSA West	SPOT1	16-Feb-94	17:56:49	107	29	159	68	334.84	324.67
SSA	NOAA11	16-Feb-94	21:58:07	70	41	222	75	405.10	333.18
NSA	NOAA11	16-Feb-94	21:58:19	82	15	226	78	716.88	606.96
NSA	NOAA9	17-Feb-94	01:40:03	60	42	273	107	716.88	606.96
SSA	NOAA9	17-Feb-94	03:20:16	259	33	289	118	405.10	333.18
NSA	NOAA9	17-Feb-94	03:20:32	259	51	295	120	716.88	606.96
NSA	NOAA11	17-Feb-94	11:53:00	127	10	85	108	716.88	606.96
SSA	NOAA11	17-Feb-94	11:53:49	109	30	81	112	405.10	333.18
NSA	NOAA12	17-Feb-94	15:13:04	290	19	126	82	716.88	606.96
SSA	NOAA12	17-Feb-94	15:13:59	196	3	122	83	405.10	333.18
NSA	NOAA9	17-Feb-94	15:34:00	107	40	131	79	716.88	606.96
SSA	NOAA9	17-Feb-94	15:34:24	93	53	126	80	405.10	333.18
NSA	NOAA9	17-Feb-94	17:14:29	298	51	155	71	716.88	606.96
SSA	NOAA9	17-Feb-94	17:15:14	298	44	149	70	405.10	333.18
NSA East	SPOT1	17-Feb-94	17:36:19	89	17	162	69	820.96	618.22
NSA West	SPOT1	17-Feb-94	17:36:39	117	21	161	69	771.02	615.45
SSA East	SPOT2	17-Feb-94	18:31:35	282	18	169	66	394.69	335.04
SSA West	SPOT2	17-Feb-94	18:31:36	286	14	168	66	334.84	324.67
NSA	NOAA11	17-Feb-94	21:46:08	71	27	224	77	716.88	606.96
SSA	NOAA11	17-Feb-94	21:46:16	57	49	219	73	405.10	333.18
SSA	NOAA11	17-Feb-94	23:26:49	263	48	241	84	405.10	333.18
NSA	NOAA9	18-Feb-94	01:27:11	59	50	270	105	716.88	606.96
SSA	NOAA9	18-Feb-94	03:07:26	263	20	287	116	405.10	333.18
NSA	NOAA9	18-Feb-94	03:07:41	258	42	293	118	716.88	606.96
NSA	NOAA11	18-Feb-94	11:40:28	94	23	82	110	716.88	606.96
SSA	NOAA11	18-Feb-94	11:41:16	96	41	78	113	405.10	333.18
SSA	NOAA11	18-Feb-94	13:21:49	303	54	99	98	405.10	333.18
NSA	NOAA12	18-Feb-94	14:51:28	94	6	121	84	716.88	606.96
SSA	NOAA12	18-Feb-94	14:52:23	109	26	117	85	405.10	333.18
NSA	NOAA9	18-Feb-94	15:20:48	96	49	128	80	716.88	606.96
NSA	NOAA9	18-Feb-94	17:01:38	296	44	151	71	716.88	606.96
SSA	NOAA9	18-Feb-94	17:02:25	296	34	146	71	405.10	333.18
NSA East	SPOT2	18-Feb-94	18:11:08	303	23	171	68	820.96	618.22
NSA West	SPOT2	18-Feb-94	18:11:29	277	20	170	68	771.02	615.45
SSA East	SPOT2	18-Feb-94	18:12:15	122	6	163	67	394.69	335.04
SSA West	SPOT2	18-Feb-94	18:12:15	107	10	163	67	334.84	324.67
NSA	NOAA11	18-Feb-94	21:33:57	67	37	221	75	716.88	606.96
SSA	NOAA11	18-Feb-94	23:14:36	266	38	239	83	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	19-Feb-94	02:54:37	300	7	284	114	405.10	333.18
NSA	NOAA9	19-Feb-94	02:54:50	260	31	290	116	716.88	606.96
NSA	NOAA11	19-Feb-94	11:28:17	100	35	79	111	716.88	606.96
SSA	NOAA11	19-Feb-94	11:29:04	98	50	75	115	405.10	333.18
NSA	NOAA11	19-Feb-94	13:08:49	302	55	100	97	716.88	606.96
SSA	NOAA11	19-Feb-94	13:09:36	303	47	96	100	405.10	333.18
NSA	NOAA12	19-Feb-94	14:29:52	101	29	117	86	716.88	606.96
SSA	NOAA12	19-Feb-94	14:30:46	103	45	112	88	405.10	333.18
SSA	NOAA12	19-Feb-94	16:10:39	297	52	134	76	405.10	333.18
NSA	NOAA9	19-Feb-94	16:48:48	293	35	148	72	716.88	606.96
SSA	NOAA9	19-Feb-94	16:49:36	294	21	143	72	405.10	333.18
NSA East	SPOT2	19-Feb-94	17:52:08	218	5	166	68	820.96	618.22
NSA West	SPOT2	19-Feb-94	17:52:09	164	5	165	68	771.02	615.45
SSA East	SPOT2	19-Feb-94	17:52:55	108	28	158	67	394.69	335.04
SSA East	SPOT1	19-Feb-94	18:38:52	296	26	170	65	394.69	335.04
SSA West	SPOT1	19-Feb-94	18:38:55	300	21	170	66	334.84	324.67
NSA	NOAA11	19-Feb-94	21:21:45	64	46	218	74	716.88	606.96
SSA	NOAA11	19-Feb-94	23:02:04	252	27	237	81	405.10	333.18
NSA	NOAA11	19-Feb-94	23:02:37	264	48	241	85	716.88	606.96
SSA	NOAA9	20-Feb-94	02:41:27	90	12	281	112	405.10	333.18
NSA	NOAA9	20-Feb-94	02:42:01	268	19	287	114	716.88	606.96
NSA	NOAA11	20-Feb-94	11:16:04	101	44	76	112	716.88	606.96
NSA	NOAA11	20-Feb-94	12:56:36	301	49	97	98	716.88	606.96
SSA	NOAA11	20-Feb-94	12:57:25	302	38	93	101	405.10	333.18
NSA	NOAA12	20-Feb-94	14:08:15	99	47	112	89	716.88	606.96
NSA	NOAA12	20-Feb-94	15:48:07	303	48	134	77	716.88	606.96
SSA	NOAA12	20-Feb-94	15:49:03	299	38	129	78	405.10	333.18
NSA	NOAA9	20-Feb-94	16:35:59	288	24	145	73	716.88	606.96
SSA	NOAA9	20-Feb-94	16:36:47	285	6	140	73	405.10	333.18
NSA East	SPOT2	20-Feb-94	17:32:47	117	21	161	68	820.96	618.22
NSA West	SPOT2	20-Feb-94	17:32:48	114	25	160	69	771.02	615.45
NSA West	SPOT1	20-Feb-94	18:18:46	293	27	172	67	771.02	615.45
SSA East	SPOT1	20-Feb-94	18:19:32	330	5	165	66	394.69	335.04
SSA West	SPOT1	20-Feb-94	18:19:35	46	5	164	66	334.84	324.67
NSA	NOAA11	20-Feb-94	21:09:31	63	52	216	73	716.88	606.96
SSA	NOAA11	20-Feb-94	22:49:53	256	13	234	79	405.10	333.18
NSA	NOAA11	20-Feb-94	22:50:03	253	39	239	83	716.88	606.96
SSA	NOAA9	21-Feb-94	02:28:38	74	25	279	110	405.10	333.18
NSA	NOAA9	21-Feb-94	02:28:52	211	5	284	112	716.88	606.96
NSA	NOAA11	21-Feb-94	11:03:30	92	52	73	114	716.88	606.96
NSA	NOAA11	21-Feb-94	12:44:23	301	41	95	100	716.88	606.96
SSA	NOAA11	21-Feb-94	12:45:14	302	28	91	103	405.10	333.18
NSA	NOAA12	21-Feb-94	15:26:52	292	32	129	79	716.88	606.96
SSA	NOAA12	21-Feb-94	15:27:47	279	17	124	80	405.10	333.18
NSA	NOAA9	21-Feb-94	16:23:10	272	10	142	73	716.88	606.96
SSA	NOAA9	21-Feb-94	16:23:57	120	10	136	74	405.10	333.18
NSA West	SPOT1	21-Feb-94	17:59:26	301	6	167	67	771.02	615.45
NSA East	SPOT1	21-Feb-94	17:59:28	286	10	168	67	820.96	618.22
SSA East	SPOT1	21-Feb-94	18:00:13	96	20	160	66	394.69	335.04
SSA West	SPOT1	21-Feb-94	18:00:16	95	26	159	66	334.84	324.67
SSA	NOAA11	21-Feb-94	22:37:41	25	3	232	77	405.10	333.18
NSA	NOAA11	21-Feb-94	22:37:51	253	28	236	81	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	22-Feb-94	02:15:49	69	37	276	108	405.10	333.18
NSA	NOAA9	22-Feb-94	02:16:02	80	11	282	110	716.88	606.96
NSA	NOAA11	22-Feb-94	12:32:12	299	31	92	101	716.88	606.96
SSA	NOAA11	22-Feb-94	12:33:03	305	15	88	104	405.10	333.18
NSA	NOAA12	22-Feb-94	15:05:15	298	11	124	81	716.88	606.96
SSA	NOAA12	22-Feb-94	15:06:11	117	10	119	82	405.10	333.18
NSA	NOAA9	22-Feb-94	16:10:21	154	7	139	74	716.88	606.96
SSA	NOAA9	22-Feb-94	16:11:08	115	25	133	75	405.10	333.18
SSA	Landsat5	22-Feb-94	17:20:00	3	8	150	68	405.1	333.18
NSA West	SPOT1	22-Feb-94	17:40:06	101	16	162	67	771.02	615.45
NSA East	SPOT1	22-Feb-94	17:40:08	107	12	163	67	820.96	618.22
SSA East	SPOT2	22-Feb-94	18:35:00	298	22	169	64	394.69	335.04
SSA West	SPOT2	22-Feb-94	18:35:01	303	19	168	65	334.84	324.67
SSA	NOAA11	22-Feb-94	22:25:30	57	17	229	76	405.10	333.18
NSA	NOAA11	22-Feb-94	22:25:40	258	15	234	79	716.88	606.96
SSA	NOAA9	23-Feb-94	02:02:59	66	46	274	105	405.10	333.18
NSA	NOAA9	23-Feb-94	02:03:13	69	24	279	108	716.88	606.96
SSA	NOAA9	23-Feb-94	03:43:49	264	50	296	120	405.10	333.18
NSA	NOAA11	23-Feb-94	12:20:00	297	20	89	103	716.88	606.96
SSA	NOAA11	23-Feb-94	12:20:52	26	2	85	106	405.10	333.18
NSA	NOAA12	23-Feb-94	14:43:39	96	15	119	83	716.88	606.96
SSA	NOAA12	23-Feb-94	14:44:34	105	34	114	85	405.10	333.18
NSA	NOAA9	23-Feb-94	15:57:11	97	20	135	75	716.88	606.96
SSA	NOAA9	23-Feb-94	15:57:57	97	37	130	76	405.10	333.18
NSA East	SPOT2	23-Feb-94	18:14:53	292	26	172	66	820.96	618.22
NSA West	SPOT2	23-Feb-94	18:14:54	293	23	171	66	771.02	615.45
SSA East	SPOT2	23-Feb-94	18:15:39	34	4	164	65	394.69	335.04
SSA West	SPOT2	23-Feb-94	18:15:41	62	7	163	65	334.84	324.67
SSA	NOAA11	23-Feb-94	22:13:19	58	30	227	74	405.10	333.18
NSA	NOAA11	23-Feb-94	22:13:29	320	4	231	78	716.88	606.96
NSA	NOAA9	12-Apr-94	01:48:41	63	41	289	93	716.88	606.96
SSA	NOAA9	12-Apr-94	03:29:04	262	35	306	103	405.10	333.18
NSA	NOAA9	12-Apr-94	03:29:31	265	52	311	105	716.88	606.96
NSA	NOAA11	12-Apr-94	12:36:15	286	29	85	83	716.88	606.96
SSA	NOAA11	12-Apr-94	12:36:51	310	11	80	87	405.10	333.18
NSA	NOAA12	12-Apr-94	14:08:38	97	46	104	70	716.88	606.96
NSA	NOAA9	12-Apr-94	15:42:38	106	39	126	58	716.88	606.96
SSA	NOAA9	12-Apr-94	15:43:12	97	52	120	60	405.10	333.18
NSA	NOAA12	12-Apr-94	15:48:51	295	49	128	58	716.88	606.96
SSA	NOAA12	12-Apr-94	15:49:33	297	39	122	59	405.10	333.18
NSA	NOAA9	12-Apr-94	17:23:07	298	52	155	49	716.88	606.96
SSA	NOAA9	12-Apr-94	17:24:02	293	45	148	49	405.10	333.18
NSA West	SPOT2	12-Apr-94	17:48:39	67	8	164	48	771.02	615.45
NSA East	SPOT2	12-Apr-94	17:48:40	46	4	165	48	820.96	618.22
SSA	NOAA11	12-Apr-94	22:29:19	58	21	243	61	405.10	333.18
NSA	NOAA11	12-Apr-94	22:29:23	247	12	247	65	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	13-Apr-94	01:35:49	61	49	287	91	716.88	606.96
SSA	NOAA9	13-Apr-94	03:15:54	244	22	303	102	405.10	333.18
NSA	NOAA9	13-Apr-94	03:16:19	256	44	308	103	716.88	606.96
NSA	NOAA11	13-Apr-94	12:23:43	308	17	82	85	716.88	606.96
SSA	NOAA11	13-Apr-94	12:24:40	79	5	78	88	405.10	333.18
NSA	NOAA12	13-Apr-94	15:27:15	294	33	122	60	716.88	606.96
SSA	NOAA12	13-Apr-94	15:27:57	305	19	116	61	405.10	333.18
NSA	NOAA9	13-Apr-94	15:29:26	95	48	123	60	716.88	606.96
Tran East	Landsat5	13-Apr-94	17:07:00	245	5	148	50	632.4	514.82
NSA	NOAA9	13-Apr-94	17:10:16	297	45	151	50	716.88	606.96
SSA	NOAA9	13-Apr-94	17:11:13	289	35	144	50	405.10	333.18
NSA East	SPOT2	13-Apr-94	17:29:20	97	24	159	48	820.96	618.22
NSA West	SPOT2	13-Apr-94	17:29:20	97	27	158	49	771.02	615.45
SSA East	SPOT3	13-Apr-94	18:34:41	291	20	171	45	394.69	335.04
SSA West	SPOT3	13-Apr-94	18:34:42	296	16	170	45	334.84	324.67
SSA	NOAA11	13-Apr-94	22:17:08	58	33	240	59	405.10	333.18
NSA	NOAA11	13-Apr-94	22:17:12	51	3	245	63	716.88	606.96
SSA	NOAA9	14-Apr-94	03:03:04	237	7	301	100	405.10	333.18
NSA	NOAA9	14-Apr-94	03:03:28	257	33	306	101	716.88	606.96
NSA	NOAA11	14-Apr-94	12:11:32	336	4	79	86	716.88	606.96
SSA	NOAA11	14-Apr-94	12:12:29	106	18	75	90	405.10	333.18
NSA	NOAA12	14-Apr-94	15:05:39	300	12	117	62	716.88	606.96
SSA	NOAA12	14-Apr-94	15:06:41	136	10	111	64	405.10	333.18
NSA	NOAA9	14-Apr-94	16:57:26	293	36	147	50	716.88	606.96
SSA	NOAA9	14-Apr-94	16:58:24	281	23	140	51	405.10	333.18
NSA East	SPOT3	14-Apr-94	18:14:22	301	24	174	47	820.96	618.22
NSA West	SPOT3	14-Apr-94	18:14:23	304	21	173	47	771.02	615.45
SSA East	SPOT3	14-Apr-94	18:15:21	83	4	164	45	394.69	335.04
SSA West	SPOT3	14-Apr-94	18:15:22	86	8	163	45	334.84	324.67
SSA	NOAA11	14-Apr-94	22:04:57	58	42	238	57	405.10	333.18
NSA	NOAA11	14-Apr-94	22:05:01	59	16	242	61	716.88	606.96
SSA	NOAA11	14-Apr-94	23:45:29	262	54	261	71	405.10	333.18
SSA	NOAA9	15-Apr-94	02:50:15	69	9	298	98	405.10	333.18
NSA	NOAA9	15-Apr-94	02:50:39	264	21	303	99	716.88	606.96
NSA	NOAA11	15-Apr-94	11:59:21	102	11	77	87	716.88	606.96
SSA	NOAA11	15-Apr-94	12:00:17	110	31	72	91	405.10	333.18
NSA	NOAA12	15-Apr-94	14:44:03	95	14	112	65	716.88	606.96
SSA	NOAA12	15-Apr-94	14:44:44	93	33	106	67	405.10	333.18
NSA	NOAA9	15-Apr-94	16:44:37	287	25	143	51	716.88	606.96
SSA	NOAA9	15-Apr-94	16:45:14	317	9	136	52	405.10	333.18
NSA	Landsat5	15-Apr-94	17:00:00	72	7	148	50	716.88	606.96
NSA East	SPOT3	15-Apr-94	17:55:23	225	6	168	47	820.96	618.22
NSA West	SPOT3	15-Apr-94	17:55:24	181	5	167	47	771.02	615.45
SSA East	SPOT3	15-Apr-94	17:56:02	101	26	158	46	394.69	335.04
SSA West	SPOT3	15-Apr-94	17:56:03	99	30	156	46	334.84	324.67
SSA East	SPOT2	15-Apr-94	18:31:48	295	19	170	44	394.69	335.04
SSA West	SPOT2	15-Apr-94	18:31:48	305	15	169	45	334.84	324.67
SSA	NOAA11	15-Apr-94	21:52:44	57	50	235	56	405.10	333.18
NSA	NOAA11	15-Apr-94	21:52:50	59	28	239	60	716.88	606.96
SSA	NOAA11	15-Apr-94	23:33:17	263	46	258	69	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	16-Apr-94	02:37:26	64	24	296	96	405.10	333.18
NSA	NOAA9	16-Apr-94	02:37:30	219	8	300	98	716.88	606.96
NSA	NOAA11	16-Apr-94	11:47:10	113	24	74	89	716.88	606.96
SSA	NOAA11	16-Apr-94	11:47:44	97	42	70	92	405.10	333.18
SSA	NOAA11	16-Apr-94	13:28:17	304	53	90	78	405.10	333.18
NSA	NOAA12	16-Apr-94	14:22:27	100	36	107	67	716.88	606.96
SSA	NOAA12	16-Apr-94	14:23:08	95	50	101	70	405.10	333.18
SSA	NOAA12	16-Apr-94	16:03:21	295	49	124	56	405.10	333.18
NSA	NOAA9	16-Apr-94	16:31:48	272	13	139	52	716.88	606.96
SSA	NOAA9	16-Apr-94	16:32:25	89	8	132	53	405.10	333.18
NSA East	SPOT3	16-Apr-94	17:36:03	118	20	161	47	820.96	618.22
NSA West	SPOT3	16-Apr-94	17:36:04	115	24	160	47	771.02	615.45
NSA East	SPOT2	16-Apr-94	18:11:45	283	24	173	46	820.96	618.22
NSA West	SPOT2	16-Apr-94	18:11:45	283	20	172	46	771.02	615.45
SSA East	SPOT2	16-Apr-94	18:12:28	77	4	163	45	394.69	335.04
SSA West	SPOT2	16-Apr-94	18:12:28	81	10	162	45	334.84	324.67
NSA	NOAA11	16-Apr-94	21:40:38	58	38	236	58	716.88	606.96
SSA	NOAA11	16-Apr-94	23:20:44	252	36	256	67	405.10	333.18
NSA	NOAA11	16-Apr-94	23:21:11	260	54	260	71	716.88	606.96
SSA	NOAA9	17-Apr-94	02:24:37	62	36	293	94	405.10	333.18
NSA	NOAA9	17-Apr-94	02:24:40	83	9	298	96	716.88	606.96
NSA	NOAA11	17-Apr-94	11:34:37	97	35	71	90	716.88	606.96
SSA	NOAA11	17-Apr-94	11:35:32	99	50	67	94	405.10	333.18
NSA	NOAA11	17-Apr-94	13:15:10	305	54	92	76	716.88	606.96
SSA	NOAA11	17-Apr-94	13:16:04	301	46	87	79	405.10	333.18
NSA	NOAA12	17-Apr-94	14:00:50	98	51	102	70	716.88	606.96
NSA	NOAA12	17-Apr-94	15:41:03	293	44	125	57	716.88	606.96
SSA	NOAA12	17-Apr-94	15:41:45	296	32	119	58	405.10	333.18
NSA	NOAA9	17-Apr-94	16:18:38	52	5	135	53	716.88	606.96
SSA	NOAA9	17-Apr-94	16:19:36	106	22	129	54	405.10	333.18
NSA East	SPOT2	17-Apr-94	17:52:25	230	4	167	46	820.96	618.22
NSA West	SPOT2	17-Apr-94	17:52:25	164	3	166	46	771.02	615.45
SSA East	SPOT2	17-Apr-94	17:53:08	102	26	157	45	394.69	335.04
NSA	NOAA11	17-Apr-94	21:28:25	58	46	233	56	716.88	606.96
SSA	NOAA11	17-Apr-94	23:08:32	252	24	253	65	405.10	333.18
NSA	NOAA11	17-Apr-94	23:08:57	260	46	257	69	716.88	606.96
SSA	NOAA9	18-Apr-94	02:11:47	60	45	291	92	405.10	333.18
NSA	NOAA9	18-Apr-94	02:11:51	68	22	295	94	716.88	606.96
SSA	NOAA9	18-Apr-94	03:52:17	260	52	312	104	405.10	333.18
NSA	NOAA11	18-Apr-94	11:22:24	99	45	69	91	716.88	606.96
NSA	NOAA11	18-Apr-94	13:02:56	303	47	89	77	716.88	606.96
SSA	NOAA11	18-Apr-94	13:03:53	300	37	85	81	405.10	333.18
NSA	NOAA12	18-Apr-94	15:19:26	292	26	120	59	716.88	606.96
SSA	NOAA12	18-Apr-94	15:20:08	312	10	114	61	405.10	333.18
NSA	NOAA9	18-Apr-94	16:05:49	101	17	132	54	716.88	606.96
SSA	NOAA9	18-Apr-94	16:06:46	107	35	125	55	405.10	333.18
NSA East	SPOT2	18-Apr-94	17:33:05	116	20	160	46	820.96	618.22
NSA West	SPOT2	18-Apr-94	17:33:05	112	24	159	47	771.02	615.45
SSA East	SPOT3	18-Apr-94	18:38:29	284	24	173	43	394.69	335.04
SSA West	SPOT3	18-Apr-94	18:38:30	286	20	171	43	334.84	324.67
NSA	NOAA11	18-Apr-94	21:16:12	57	53	230	55	716.88	606.96
SSA	NOAA11	18-Apr-94	22:56:21	259	10	251	63	405.10	333.18
NSA	NOAA11	18-Apr-94	22:56:44	262	37	255	67	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	19-Apr-94	01:58:57	59	53	289	90	405.10	333.18
NSA	NOAA9	19-Apr-94	01:59:02	64	34	293	92	716.88	606.96
SSA	NOAA9	19-Apr-94	03:39:27	261	43	310	103	405.10	333.18
NSA	NOAA11	19-Apr-94	11:10:10	99	53	66	93	716.88	606.96
NSA	NOAA11	19-Apr-94	12:50:43	303	40	87	79	716.88	606.96
SSA	NOAA11	19-Apr-94	12:51:42	299	26	82	82	405.10	333.18
NSA	NOAA12	19-Apr-94	14:57:50	309	3	114	61	716.88	606.96
SSA	NOAA12	19-Apr-94	14:58:32	91	18	108	64	405.10	333.18
NSA	NOAA9	19-Apr-94	15:53:00	106	30	128	55	716.88	606.96
SSA	NOAA9	19-Apr-94	15:53:35	96	46	122	56	405.10	333.18
SSA	NOAA9	19-Apr-94	17:34:25	295	51	151	46	405.10	333.18
NSA East	SPOT3	19-Apr-94	18:18:10	294	27	176	45	820.96	618.22
NSA West	SPOT3	19-Apr-94	18:18:11	295	24	175	45	771.02	615.45
SSA East	SPOT3	19-Apr-94	18:19:09	232	2	166	43	394.69	335.04
SSA West	SPOT3	19-Apr-94	18:19:10	113	3	164	44	334.84	324.67
SSA	NOAA11	19-Apr-94	22:44:10	36	6	248	61	405.10	333.18
NSA	NOAA11	19-Apr-94	22:44:11	246	26	252	65	716.88	606.96
NSA	NOAA9	20-Apr-94	01:46:13	61	44	291	90	716.88	606.96
SSA	NOAA9	20-Apr-94	03:26:36	265	32	307	101	405.10	333.18
NSA	NOAA9	20-Apr-94	03:27:03	267	50	312	102	716.88	606.96
NSA	NOAA11	20-Apr-94	12:38:32	303	30	84	80	716.88	606.96
SSA	NOAA11	20-Apr-94	12:39:31	298	13	79	84	405.10	333.18
NSA	NOAA12	20-Apr-94	14:36:14	102	22	109	64	716.88	606.96
SSA	NOAA12	20-Apr-94	14:36:55	96	40	103	66	405.10	333.18
NSA	NOAA9	20-Apr-94	15:39:49	94	41	125	56	716.88	606.96
SSA	NOAA9	20-Apr-94	15:40:44	97	54	118	57	405.10	333.18
Tran West	Landsat5	20-Apr-94	17:13:00	115	6	146	47	498.12	419.01
NSA	NOAA9	20-Apr-94	17:20:39	297	51	154	47	716.88	606.96
SSA	NOAA9	20-Apr-94	17:21:34	292	42	146	46	405.10	333.18
NSA East	SPOT3	20-Apr-94	17:58:50	308	7	169	45	820.96	618.22
NSA West	SPOT3	20-Apr-94	17:58:51	330	4	168	45	771.02	615.45
SSA East	SPOT3	20-Apr-94	17:59:50	109	22	159	44	394.69	335.04
SSA West	SPOT3	20-Apr-94	17:59:51	105	26	158	44	334.84	324.67
SSA East	SPOT2	20-Apr-94	18:35:13	302	24	172	43	394.69	335.04
SSA West	SPOT2	20-Apr-94	18:35:34	279	19	170	43	334.84	324.67
SSA	NOAA11	20-Apr-94	22:31:59	55	19	246	59	405.10	333.18
NSA	NOAA11	20-Apr-94	22:32:00	246	13	250	63	716.88	606.96
NSA	NOAA9	21-Apr-94	01:33:21	60	51	288	88	716.88	606.96
SSA	NOAA9	21-Apr-94	03:13:26	246	18	304	99	405.10	333.18
NSA	NOAA9	21-Apr-94	03:13:51	258	41	310	100	716.88	606.96
NSA	NOAA11	21-Apr-94	12:26:21	303	18	81	82	716.88	606.96
SSA	NOAA11	21-Apr-94	12:27:20	111	2	77	85	405.10	333.18
NSA	NOAA12	21-Apr-94	14:14:37	101	42	104	67	716.88	606.96
SSA	NOAA12	21-Apr-94	14:15:19	96	55	99	69	405.10	333.18
NSA	NOAA9	21-Apr-94	15:26:58	96	50	121	57	716.88	606.96
NSA	NOAA12	21-Apr-94	15:54:30	302	52	128	54	716.88	606.96
SSA	NOAA12	21-Apr-94	15:55:32	293	43	122	55	405.10	333.18
NSA	NOAA9	21-Apr-94	17:07:48	295	43	150	47	716.88	606.96
SSA	NOAA9	21-Apr-94	17:08:45	287	32	142	47	405.10	333.18
NSA East	SPOT3	21-Apr-94	17:39:30	96	16	163	45	820.96	618.22
NSA West	SPOT3	21-Apr-94	17:39:31	97	19	161	45	771.02	615.45
NSA East	SPOT2	21-Apr-94	18:15:10	290	27	175	44	820.96	618.22
NSA West	SPOT2	21-Apr-94	18:15:10	292	24	174	44	771.02	615.45
SSA East	SPOT2	21-Apr-94	18:16:12	205	5	165	43	394.69	335.04
SSA West	SPOT2	21-Apr-94	18:16:13	143	6	163	43	334.84	324.67
SSA	NOAA11	21-Apr-94	22:19:27	74	31	243	57	405.10	333.18
NSA	NOAA11	21-Apr-94	22:19:49	40	1	247	61	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	22-Apr-94	03:00:36	246	3	302	97	405.10	333.18
NSA	NOAA9	22-Apr-94	03:01:01	260	30	307	99	716.88	606.96
NSA	NOAA11	22-Apr-94	12:14:10	311	5	79	83	716.88	606.96
SSA	NOAA11	22-Apr-94	12:15:09	114	17	74	87	405.10	333.18
NSA	NOAA12	22-Apr-94	15:33:14	290	38	123	56	716.88	606.96
SSA	NOAA12	22-Apr-94	15:33:56	294	25	116	58	405.10	333.18
NSA	NOAA9	22-Apr-94	16:54:59	291	33	146	48	716.88	606.96
SSA	NOAA9	22-Apr-94	16:55:36	305	20	138	48	405.10	333.18
NSA East	SPOT2	22-Apr-94	17:55:50	286	6	168	44	820.96	618.22
NSA West	SPOT2	22-Apr-94	17:55:50	298	3	167	44	771.02	615.45
SSA East	SPOT2	22-Apr-94	17:56:33	94	23	158	43	394.69	335.04
SSA West	SPOT2	22-Apr-94	17:56:33	92	28	156	44	334.84	324.67
SSA	NOAA11	22-Apr-94	22:07:16	69	41	240	56	405.10	333.18
NSA	NOAA11	22-Apr-94	22:07:38	60	15	245	60	716.88	606.96
SSA	NOAA11	22-Apr-94	23:48:09	263	55	263	70	405.10	333.18
SSA	NOAA9	23-Apr-94	02:47:47	63	13	299	95	405.10	333.18
NSA	NOAA9	23-Apr-94	02:48:11	271	18	304	97	716.88	606.96
NSA	NOAA11	23-Apr-94	12:01:58	109	9	76	84	716.88	606.96
SSA	NOAA11	23-Apr-94	12:02:36	94	30	72	88	405.10	333.18
NSA	NOAA12	23-Apr-94	15:11:38	287	18	117	58	716.88	606.96
SSA	NOAA12	23-Apr-94	15:12:20	33	3	111	60	405.10	333.18
NSA	NOAA9	23-Apr-94	16:42:09	284	22	142	49	716.88	606.96
SSA	NOAA9	23-Apr-94	16:42:46	327	5	134	49	405.10	333.18
NSA East	SPOT2	23-Apr-94	17:36:29	108	16	161	45	820.96	618.22
NSA West	SPOT2	23-Apr-94	17:36:29	106	20	160	45	771.02	615.45
SSA East	SPOT3	23-Apr-94	18:41:57	298	27	174	41	394.69	335.04
SSA West	SPOT3	23-Apr-94	18:41:57	303	24	173	41	334.84	324.67
SSA	NOAA11	23-Apr-94	21:55:04	66	49	237	54	405.10	333.18
NSA	NOAA11	23-Apr-94	21:55:27	59	27	242	58	716.88	606.96
SSA	NOAA11	23-Apr-94	23:35:56	264	47	261	68	405.10	333.18
SSA	NOAA9	24-Apr-94	02:34:58	61	27	297	93	405.10	333.18
NSA	NOAA9	24-Apr-94	02:35:02	204	3	302	95	716.88	606.96
NSA	NOAA11	24-Apr-94	11:49:47	112	23	73	86	716.88	606.96
SSA	NOAA11	24-Apr-94	11:50:24	98	41	69	90	405.10	333.18
SSA	NOAA11	24-Apr-94	13:30:56	301	53	89	75	405.10	333.18
NSA	NOAA12	24-Apr-94	14:50:02	111	6	112	61	716.88	606.96
SSA	NOAA12	24-Apr-94	14:50:43	98	26	106	63	405.10	333.18
NSA	NOAA9	24-Apr-94	16:29:00	322	9	138	50	716.88	606.96
SSA	NOAA9	24-Apr-94	16:29:57	101	11	130	50	405.10	333.18
NSA West	SPOT3	24-Apr-94	18:21:59	288	28	176	43	771.02	615.45
SSA East	SPOT3	24-Apr-94	18:22:38	328	7	167	42	394.69	335.04
SSA West	SPOT3	24-Apr-94	18:22:58	217	4	166	42	334.84	324.67
NSA	NOAA11	24-Apr-94	21:43:16	58	37	239	56	716.88	606.96
SSA	NOAA11	24-Apr-94	23:23:24	254	38	259	65	405.10	333.18
NSA	NOAA11	24-Apr-94	23:24:09	268	55	262	69	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	25-Apr-94	02:22:09	60	38	295	91	405.10	333.18
NSA	NOAA9	25-Apr-94	02:22:12	71	13	299	93	716.88	606.96
NSA	NOAA11	25-Apr-94	11:37:15	96	34	71	87	716.88	606.96
SSA	NOAA11	25-Apr-94	11:38:12	100	50	66	91	405.10	333.18
NSA	NOAA11	25-Apr-94	13:17:47	304	54	91	73	716.88	606.96
SSA	NOAA11	25-Apr-94	13:18:44	300	47	86	77	405.10	333.18
NSA	NOAA12	25-Apr-94	14:28:25	105	30	106	64	716.88	606.96
SSA	NOAA12	25-Apr-94	14:29:06	98	46	101	66	405.10	333.18
SSA	NOAA12	25-Apr-94	16:08:59	301	52	125	52	405.10	333.18
NSA	NOAA9	25-Apr-94	16:16:11	84	7	134	50	716.88	606.96
SSA	NOAA9	25-Apr-94	16:17:08	108	26	127	51	405.10	333.18
NSA East	SPOT3	25-Apr-94	18:02:39	280	11	170	43	820.96	618.22
NSA West	SPOT3	25-Apr-94	18:02:39	281	7	169	43	771.02	615.45
SSA East	SPOT3	25-Apr-94	18:03:19	90	18	160	42	394.69	335.04
SSA West	SPOT3	25-Apr-94	18:03:39	114	22	159	42	334.84	324.67
SSA East	SPOT2	25-Apr-94	18:38:58	284	27	173	41	394.69	335.04
SSA West	SPOT2	25-Apr-94	18:38:58	288	22	172	41	334.84	324.67
NSA	NOAA11	25-Apr-94	21:31:03	58	45	236	54	716.88	606.96
SSA	NOAA11	25-Apr-94	23:11:12	254	26	256	63	405.10	333.18
NSA	NOAA11	25-Apr-94	23:11:35	260	47	260	67	716.88	606.96
SSA	NOAA9	26-Apr-94	02:09:20	59	47	292	90	405.10	333.18
NSA	NOAA9	26-Apr-94	02:09:23	64	26	297	91	716.88	606.96
SSA	NOAA9	26-Apr-94	03:49:49	261	50	313	102	405.10	333.18
NSA	NOAA11	26-Apr-94	11:25:01	98	44	68	88	716.88	606.96
NSA	NOAA11	26-Apr-94	13:05:34	304	48	89	75	716.88	606.96
SSA	NOAA11	26-Apr-94	13:06:33	299	38	84	78	405.10	333.18
NSA	NOAA12	26-Apr-94	14:06:48	102	47	101	66	716.88	606.96
NSA	NOAA12	26-Apr-94	15:46:41	300	47	126	53	716.88	606.96
SSA	NOAA12	26-Apr-94	15:47:43	291	37	119	55	405.10	333.18
NSA	NOAA9	26-Apr-94	16:03:21	105	21	130	51	716.88	606.96
SSA	NOAA9	26-Apr-94	16:03:57	94	38	123	53	405.10	333.18
NSA East	SPOT3	26-Apr-94	17:43:19	113	12	164	43	820.96	618.22
NSA West	SPOT3	26-Apr-94	17:43:19	108	15	163	43	771.02	615.45
NSA West	SPOT2	26-Apr-94	18:18:34	298	27	175	43	771.02	615.45
SSA East	SPOT2	26-Apr-94	18:19:38	259	6	166	41	394.69	335.04
SSA West	SPOT2	26-Apr-94	18:19:38	165	1	165	41	334.84	324.67
NSA	NOAA11	26-Apr-94	21:18:49	57	52	233	53	716.88	606.96
SSA	NOAA11	26-Apr-94	22:59:01	263	12	254	62	405.10	333.18
NSA	NOAA11	26-Apr-94	22:59:21	261	38	258	65	716.88	606.96
SSA	NOAA9	27-Apr-94	01:56:29	58	55	290	87	405.10	333.18
NSA	NOAA9	27-Apr-94	01:56:34	61	37	294	90	716.88	606.96
SSA	NOAA9	27-Apr-94	03:36:59	264	40	311	100	405.10	333.18
NSA	NOAA11	27-Apr-94	11:12:48	99	52	65	90	716.88	606.96
NSA	NOAA11	27-Apr-94	12:53:41	291	41	86	76	716.88	606.96
SSA	NOAA11	27-Apr-94	12:54:22	297	27	81	80	405.10	333.18
NSA	NOAA12	27-Apr-94	15:25:25	286	32	120	56	716.88	606.96
SSA	NOAA12	27-Apr-94	15:26:07	291	16	113	57	405.10	333.18
NSA	NOAA9	27-Apr-94	15:50:32	108	34	126	53	716.88	606.96
SSA	NOAA9	27-Apr-94	15:51:07	97	48	120	54	405.10	333.18
SSA	Landsat5	27-Apr-94	17:20:00	34	6	145	44	405.1	333.18
NSA	NOAA9	27-Apr-94	17:30:41	306	55	157	44	716.88	606.96
SSA	NOAA9	27-Apr-94	17:31:37	303	48	149	43	405.10	333.18
NSA West	SPOT2	27-Apr-94	17:59:14	315	7	168	43	771.02	615.45
NSA East	SPOT2	27-Apr-94	17:59:15	300	11	169	42	820.96	618.22
SSA East	SPOT2	27-Apr-94	18:00:18	116	19	159	42	394.69	335.04
SSA West	SPOT2	27-Apr-94	18:00:18	108	24	158	42	334.84	324.67
SSA	NOAA11	27-Apr-94	22:46:49	14	5	251	60	405.10	333.18
NSA	NOAA11	27-Apr-94	22:47:09	266	28	255	63	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	28-Apr-94	01:43:44	60	46	292	88	716.88	606.96
SSA	NOAA9	28-Apr-94	03:23:48	250	28	308	98	405.10	333.18
NSA	NOAA9	28-Apr-94	03:24:13	258	48	313	99	716.88	606.96
NSA	NOAA11	28-Apr-94	12:41:09	303	31	83	78	716.88	606.96
SSA	NOAA11	28-Apr-94	12:42:11	294	14	79	81	405.10	333.18
NSA	NOAA12	28-Apr-94	15:03:49	275	10	114	58	716.88	606.96
SSA	NOAA12	28-Apr-94	15:04:31	100	10	108	60	405.10	333.18
NSA	NOAA9	28-Apr-94	15:37:20	96	44	123	54	716.88	606.96
NSA	NOAA9	28-Apr-94	17:18:10	296	49	153	44	716.88	606.96
SSA	NOAA9	28-Apr-94	17:18:47	302	40	145	44	405.10	333.18
NSA West	SPOT2	28-Apr-94	17:39:54	96	16	162	43	771.02	615.45
NSA East	SPOT2	28-Apr-94	17:39:55	98	12	163	43	820.96	618.22
SSA West	SPOT3	28-Apr-94	18:45:46	293	28	174	40	334.84	324.67
SSA	NOAA11	28-Apr-94	22:34:18	83	17	248	58	405.10	333.18
NSA	NOAA11	28-Apr-94	22:34:38	246	15	252	62	716.88	606.96
NSA	NOAA9	29-Apr-94	01:30:52	59	53	289	86	716.88	606.96
SSA	NOAA9	29-Apr-94	03:10:59	253	14	306	97	405.10	333.18
NSA	NOAA9	29-Apr-94	03:11:22	259	38	311	98	716.88	606.96
NSA	NOAA11	29-Apr-94	12:28:58	303	20	81	79	716.88	606.96
SSA	NOAA11	29-Apr-94	12:30:00	191	1	76	83	405.10	333.18
NSA	NOAA12	29-Apr-94	14:42:13	114	16	109	61	716.88	606.96
SSA	NOAA12	29-Apr-94	14:42:54	101	34	103	63	405.10	333.18
NSA	NOAA9	29-Apr-94	15:24:29	97	52	119	55	716.88	606.96
NSA	NOAA9	29-Apr-94	17:05:19	294	40	148	45	716.88	606.96
SSA	NOAA9	29-Apr-94	17:05:58	301	29	141	45	405.10	333.18
Tran East	Landsat5	29-Apr-94	17:07:00	68	5	147	45	632.4	514.82
SSA West	SPOT3	29-Apr-94	18:26:26	309	6	167	40	334.84	324.67
SSA East	SPOT3	29-Apr-94	18:26:27	288	10	168	40	394.69	335.04
SSA	NOAA11	29-Apr-94	22:22:07	73	30	246	56	405.10	333.18
NSA	NOAA11	29-Apr-94	22:22:27	274	1	250	60	716.88	606.96
SSA	NOAA9	30-Apr-94	02:58:10	20	3	303	95	405.10	333.18
NSA	NOAA9	30-Apr-94	02:58:32	263	27	308	96	716.88	606.96
NSA	NOAA11	30-Apr-94	12:16:47	308	7	78	80	716.88	606.96
SSA	NOAA11	30-Apr-94	12:17:49	118	15	74	84	405.10	333.18
NSA	NOAA12	30-Apr-94	14:20:36	106	37	104	63	716.88	606.96
SSA	NOAA12	30-Apr-94	14:21:18	100	51	98	66	405.10	333.18
NSA	NOAA12	30-Apr-94	16:00:29	299	55	129	51	716.88	606.96
SSA	NOAA12	30-Apr-94	16:01:11	300	47	122	52	405.10	333.18
NSA	NOAA9	30-Apr-94	16:52:30	289	30	144	46	716.88	606.96
SSA	NOAA9	30-Apr-94	16:53:09	303	16	136	46	405.10	333.18
NSA East	SPOT3	30-Apr-94	18:06:07	306	15	172	41	820.96	618.22
NSA West	SPOT3	30-Apr-94	18:06:07	313	12	171	41	771.02	615.45
SSA East	SPOT3	30-Apr-94	18:07:07	104	14	161	40	394.69	335.04
SSA West	SPOT3	30-Apr-94	18:07:07	98	18	160	40	334.84	324.67
SSA West	SPOT2	30-Apr-94	18:42:24	293	26	173	39	334.84	324.67
SSA	NOAA11	30-Apr-94	22:09:56	68	40	243	54	405.10	333.18
NSA	NOAA11	30-Apr-94	22:10:16	59	13	247	58	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	01-May-94	02:45:20	56	17	301	93	405.10	333.18
NSA	NOAA9	01-May-94	02:45:22	238	14	305	94	716.88	606.96
NSA	NOAA11	01-May-94	12:04:36	108	7	75	82	716.88	606.96
SSA	NOAA11	01-May-94	12:05:17	96	28	71	85	405.10	333.18
NSA	NOAA12	01-May-94	13:58:38	93	52	99	66	716.88	606.96
NSA	NOAA12	01-May-94	15:38:51	300	42	123	53	716.88	606.96
SSA	NOAA12	01-May-94	15:39:55	287	31	116	54	405.10	333.18
NSA	NOAA9	01-May-94	16:39:40	280	19	140	46	716.88	606.96
SSA	NOAA9	01-May-94	16:40:20	14	2	132	47	405.10	333.18
NSA	Landsat5	01-May-94	17:00:00	246	1	147	45	716.88	606.96
NSA East	SPOT3	01-May-94	17:46:48	73	9	165	42	820.96	618.22
NSA West	SPOT3	01-May-94	17:47:08	130	12	164	42	771.02	615.45
SSA West	SPOT2	01-May-94	18:23:03	309	4	166	39	334.84	324.67
SSA East	SPOT2	01-May-94	18:23:04	282	9	167	39	394.69	335.04
SSA	NOAA11	01-May-94	21:57:45	65	48	240	52	405.10	333.18
NSA	NOAA11	01-May-94	21:58:04	59	25	244	56	716.88	606.96
SSA	NOAA11	01-May-94	23:38:37	265	48	263	66	405.10	333.18
SSA	NOAA9	02-May-94	02:32:11	76	30	298	91	405.10	333.18
NSA	NOAA9	02-May-94	02:32:33	102	2	303	93	716.88	606.96
NSA	NOAA11	02-May-94	11:52:25	112	21	73	83	716.88	606.96
SSA	NOAA11	02-May-94	11:53:05	100	39	68	87	405.10	333.18
SSA	NOAA11	02-May-94	13:33:37	300	54	88	72	405.10	333.18
NSA	NOAA12	02-May-94	15:17:35	282	25	117	55	716.88	606.96
SSA	NOAA12	02-May-94	15:18:18	279	7	111	57	405.10	333.18
NSA	NOAA9	02-May-94	16:26:31	336	6	136	47	716.88	606.96
SSA	NOAA9	02-May-94	16:27:30	109	15	129	48	405.10	333.18
NSA East	SPOT3	02-May-94	17:27:29	96	28	158	42	820.96	618.22
NSA East	SPOT2	02-May-94	18:02:40	306	15	171	41	820.96	618.22
NSA West	SPOT2	02-May-94	18:03:00	264	12	170	41	771.02	615.45
SSA West	SPOT2	02-May-94	18:03:44	103	20	158	40	334.84	324.67
SSA East	SPOT2	02-May-94	18:03:45	113	14	160	40	394.69	335.04
SSA	NOAA11	02-May-94	21:45:31	63	55	237	50	405.10	333.18
NSA	NOAA11	02-May-94	21:45:53	58	36	242	54	716.88	606.96
SSA	NOAA11	02-May-94	23:26:04	255	39	261	64	405.10	333.18
SSA	NOAA9	24-May-94	02:50:27	73	14	305	89	405.10	333.18
NSA	NOAA9	24-May-94	02:50:45	254	16	309	90	716.88	606.96
NSA	NOAA11	24-May-94	12:24:46	273	12	76	74	716.88	606.96
SSA	NOAA11	24-May-94	12:25:29	104	10	72	78	405.10	333.18
NSA	NOAA12	24-May-94	14:02:25	93	50	96	61	716.88	606.96
NSA	NOAA12	24-May-94	15:42:38	300	45	120	47	716.88	606.96
SSA	NOAA12	24-May-94	15:43:44	286	34	113	49	405.10	333.18
NSA	NOAA9	24-May-94	16:44:43	297	21	139	41	716.88	606.96
SSA	NOAA9	24-May-94	16:45:46	235	6	130	41	405.10	333.18
NSA East	SPOT2	24-May-94	17:38:00	106	14	160	36	820.96	618.22
NSA West	SPOT2	24-May-94	17:38:00	103	18	159	37	771.02	615.45
SSA East	SPOT3	24-May-94	18:44:49	284	30	175	33	394.69	335.04
SSA West	SPOT3	24-May-94	18:44:49	287	26	174	33	334.84	324.67
SSA	NOAA11	24-May-94	22:17:36	72	36	249	50	405.10	333.18
NSA	NOAA11	24-May-94	22:17:54	77	8	253	54	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	25-May-94	02:37:38	66	28	302	87	405.10	333.18
NSA	NOAA9	25-May-94	02:37:56	321	3	307	88	716.88	606.96
NSA	NOAA11	25-May-94	12:12:15	48	5	74	76	716.88	606.96
SSA	NOAA11	25-May-94	12:13:18	110	24	69	80	405.10	333.18
NSA	NOAA12	25-May-94	15:21:02	303	29	114	50	716.88	606.96
SSA	NOAA12	25-May-94	15:22:08	269	13	108	52	405.10	333.18
NSA	NOAA9	25-May-94	16:31:54	288	7	134	42	716.88	606.96
SSA	NOAA9	25-May-94	16:32:37	92	13	126	43	405.10	333.18
NSA West	SPOT3	25-May-94	18:24:28	295	30	177	35	771.02	615.45
SSA East	SPOT3	25-May-94	18:25:29	268	9	167	33	394.69	335.04
SSA West	SPOT3	25-May-94	18:25:29	271	4	165	34	334.84	324.67
SSA	NOAA11	25-May-94	22:05:25	68	45	246	48	405.10	333.18
NSA	NOAA11	25-May-94	22:05:43	66	21	250	52	716.88	606.96
SSA	NOAA11	25-May-94	23:46:17	263	51	269	63	405.10	333.18
SSA	NOAA9	26-May-94	02:24:48	63	39	300	85	405.10	333.18
NSA	NOAA9	26-May-94	02:25:07	50	14	304	87	716.88	606.96
NSA	NOAA11	26-May-94	12:00:04	101	16	71	77	716.88	606.96
SSA	NOAA11	26-May-94	12:00:45	95	36	67	81	405.10	333.18
NSA	NOAA12	26-May-94	14:59:26	329	8	109	53	716.88	606.96
SSA	NOAA12	26-May-94	15:00:32	121	15	102	55	405.10	333.18
NSA	NOAA9	26-May-94	16:19:05	126	8	130	43	716.88	606.96
SSA	NOAA9	26-May-94	16:19:48	103	26	122	44	405.10	333.18
NSA West	SPOT3	26-May-94	18:05:08	304	10	170	35	771.02	615.45
NSA East	SPOT3	26-May-94	18:05:09	295	13	171	35	820.96	618.22
SSA East	SPOT3	26-May-94	18:06:10	118	16	159	34	394.69	335.04
SSA West	SPOT3	26-May-94	18:06:10	110	19	157	34	334.84	324.67
SSA West	SPOT2	26-May-94	18:40:30	288	24	172	33	334.84	324.67
SSA East	SPOT2	26-May-94	18:40:31	283	29	173	33	394.69	335.04
NSA	NOAA11	26-May-94	21:53:32	62	32	247	50	716.88	606.96
SSA	NOAA11	26-May-94	21:53:33	56	52	243	46	405.10	333.18
SSA	NOAA11	26-May-94	23:34:05	265	43	267	61	405.10	333.18
NSA	NOAA9	27-May-94	02:11:57	74	27	301	85	716.88	606.96
SSA	NOAA9	27-May-94	02:11:59	61	48	297	83	405.10	333.18
SSA	NOAA9	27-May-94	03:52:29	260	49	318	95	405.10	333.18
NSA	NOAA11	27-May-94	11:47:53	107	29	69	79	716.88	606.96
SSA	NOAA11	27-May-94	11:48:33	98	46	64	83	405.10	333.18
SSA	NOAA11	27-May-94	13:29:05	302	50	83	69	405.10	333.18
NSA	NOAA12	27-May-94	14:37:49	91	19	103	55	716.88	606.96
SSA	NOAA12	27-May-94	14:38:34	94	37	98	58	405.10	333.18
NSA	NOAA9	27-May-94	16:05:55	93	22	126	44	716.88	606.96
SSA	NOAA9	27-May-94	16:06:57	105	39	119	46	405.10	333.18
NSA West	SPOT3	27-May-94	17:45:48	95	13	162	36	771.02	615.45
NSA East	SPOT3	27-May-94	17:45:49	97	9	163	35	820.96	618.22
SSA	NOAA9	27-May-94	17:47:06	305	55	151	35	405.10	333.18
NSA West	SPOT2	27-May-94	18:20:05	297	29	175	35	771.02	615.45
SSA West	SPOT2	27-May-94	18:21:09	257	2	163	33	334.84	324.67
SSA East	SPOT2	27-May-94	18:21:11	259	9	165	33	394.69	335.04
NSA	NOAA11	27-May-94	21:41:21	60	41	244	49	716.88	606.96
SSA	NOAA11	27-May-94	23:21:32	254	32	264	59	405.10	333.18
NSA	NOAA11	27-May-94	23:21:53	259	51	268	62	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	28-May-94	01:59:08	68	37	299	83	716.88	606.96
SSA	NOAA9	28-May-94	01:59:08	60	55	295	82	405.10	333.18
SSA	NOAA9	28-May-94	03:39:37	261	39	315	94	405.10	333.18
NSA	NOAA9	28-May-94	03:39:58	262	54	320	94	716.88	606.96
NSA	NOAA11	28-May-94	11:35:20	95	40	66	80	716.88	606.96
SSA	NOAA11	28-May-94	11:36:21	100	54	62	84	405.10	333.18
NSA	NOAA11	28-May-94	13:15:52	306	52	86	67	716.88	606.96
SSA	NOAA11	28-May-94	13:16:53	301	43	81	70	405.10	333.18
NSA	NOAA12	28-May-94	14:16:12	97	40	98	58	716.88	606.96
SSA	NOAA12	28-May-94	14:16:58	95	53	93	61	405.10	333.18
NSA	NOAA9	28-May-94	15:53:05	100	34	122	46	716.88	606.96
SSA	NOAA9	28-May-94	15:53:45	95	48	115	47	405.10	333.18
NSA	NOAA12	28-May-94	15:56:05	304	53	123	45	716.88	606.96
SSA	NOAA12	28-May-94	15:57:11	295	45	116	47	405.10	333.18
NSA East	SPOT3	28-May-94	17:26:30	103	30	155	36	820.96	618.22
NSA	NOAA9	28-May-94	17:33:35	302	54	155	36	716.88	606.96
SSA	NOAA9	28-May-94	17:34:35	295	48	146	36	405.10	333.18
NSA West	SPOT2	28-May-94	18:00:45	307	9	167	35	771.02	615.45
NSA East	SPOT2	28-May-94	18:00:46	297	13	169	35	820.96	618.22
SSA West	SPOT2	28-May-94	18:01:50	106	22	155	34	334.84	324.67
SSA East	SPOT2	28-May-94	18:01:51	116	17	157	34	394.69	335.04
NSA	NOAA11	28-May-94	21:29:08	59	49	241	47	716.88	606.96
SSA	NOAA11	28-May-94	23:09:20	256	19	262	57	405.10	333.18
NSA	NOAA11	28-May-94	23:09:40	259	43	265	60	716.88	606.96
NSA	NOAA9	29-May-94	01:46:17	65	46	296	82	716.88	606.96
SSA	NOAA9	29-May-94	03:26:47	266	27	312	92	405.10	333.18
NSA	NOAA9	29-May-94	03:27:07	263	47	317	93	716.88	606.96
NSA	NOAA11	29-May-94	11:23:06	97	49	63	82	716.88	606.96
NSA	NOAA11	29-May-94	13:03:59	295	45	83	68	716.88	606.96
SSA	NOAA11	29-May-94	13:04:42	299	33	78	72	405.10	333.18
NSA	NOAA12	29-May-94	13:54:35	96	54	94	61	716.88	606.96
NSA	NOAA12	29-May-94	15:34:48	295	40	117	48	716.88	606.96
SSA	NOAA12	29-May-94	15:35:35	296	27	110	50	405.10	333.18
NSA	NOAA9	29-May-94	15:40:13	102	44	119	47	716.88	606.96
SSA	Landsat5	29-May-94	17:20:00	165	8	141	37	405.1	333.18
NSA	NOAA9	29-May-94	17:20:43	301	48	151	37	716.88	606.96
SSA	NOAA9	29-May-94	17:21:46	291	39	142	37	405.10	333.18
NSA West	SPOT2	29-May-94	17:41:24	90	14	160	36	771.02	615.45
NSA East	SPOT2	29-May-94	17:41:25	90	11	161	35	820.96	618.22
SSA West	SPOT3	29-May-94	18:48:18	295	30	175	32	334.84	324.67
NSA	NOAA11	29-May-94	21:16:54	58	55	238	45	716.88	606.96
SSA	NOAA11	29-May-94	22:57:09	287	6	259	55	405.10	333.18
NSA	NOAA11	29-May-94	22:57:27	261	33	263	59	716.88	606.96
NSA	NOAA9	30-May-94	01:33:45	54	53	294	80	716.88	606.96
SSA	NOAA9	30-May-94	03:13:37	243	13	310	91	405.10	333.18
NSA	NOAA9	30-May-94	03:13:55	252	37	314	92	716.88	606.96
NSA	NOAA11	30-May-94	12:51:47	291	36	81	70	716.88	606.96
SSA	NOAA11	30-May-94	12:52:31	296	21	76	74	405.10	333.18
NSA	NOAA12	30-May-94	15:13:12	297	21	111	50	716.88	606.96
SSA	NOAA12	30-May-94	15:13:59	342	4	105	53	405.10	333.18
NSA	NOAA9	30-May-94	15:27:02	93	52	115	49	716.88	606.96
NSA	NOAA9	30-May-94	17:07:52	300	40	146	38	716.88	606.96
SSA	NOAA9	30-May-94	17:08:57	285	28	137	38	405.10	333.18
SSA West	SPOT3	30-May-94	18:28:58	307	9	166	33	334.84	324.67
SSA East	SPOT3	30-May-94	18:28:59	291	13	168	33	394.69	335.04
SSA	NOAA11	30-May-94	22:44:38	96	11	256	53	405.10	333.18
NSA	NOAA11	30-May-94	22:44:55	244	22	260	57	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	31-May-94	03:00:48	69	3	307	89	405.10	333.18
NSA	NOAA9	31-May-94	03:01:04	253	25	312	90	716.88	606.96
NSA	NOAA11	31-May-94	12:39:36	284	26	78	71	716.88	606.96
SSA	NOAA11	31-May-94	12:40:20	288	7	74	75	405.10	333.18
NSA	NOAA12	31-May-94	14:51:35	66	4	106	53	716.88	606.96
SSA	NOAA12	31-May-94	14:52:23	96	24	100	56	405.10	333.18
NSA	NOAA9	31-May-94	16:55:02	297	30	141	39	716.88	606.96
SSA	NOAA9	31-May-94	16:55:47	309	15	132	39	405.10	333.18
Tran East	Landsat5	31-May-94	17:07:00	98	8	143	38	632.4	514.82
NSA East	SPOT3	31-May-94	18:08:37	307	18	172	34	820.96	618.22
NSA West	SPOT3	31-May-94	18:08:57	274	14	171	34	771.02	615.45
SSA East	SPOT3	31-May-94	18:09:39	102	11	159	33	394.69	335.04
SSA West	SPOT3	31-May-94	18:09:39	96	15	158	33	334.84	324.67
SSA West	SPOT2	31-May-94	18:43:55	294	28	172	32	334.84	324.67
SSA	NOAA11	31-May-94	22:32:27	75	24	254	51	405.10	333.18
NSA	NOAA11	31-May-94	22:32:44	242	8	257	55	716.88	606.96
SSA	NOAA9	01-Jun-94	02:47:59	63	18	305	87	405.10	333.18
NSA	NOAA9	01-Jun-94	02:48:15	263	12	309	89	716.88	606.96
NSA	NOAA11	01-Jun-94	12:27:04	308	14	76	73	716.88	606.96
SSA	NOAA11	01-Jun-94	12:28:08	124	8	71	77	405.10	333.18
NSA	NOAA12	01-Jun-94	14:29:59	99	27	101	56	716.88	606.96
SSA	NOAA12	01-Jun-94	14:30:46	98	44	95	59	405.10	333.18
SSA	NOAA12	01-Jun-94	16:10:38	302	53	119	45	405.10	333.18
NSA	NOAA9	01-Jun-94	16:42:13	292	17	137	40	716.88	606.96
SSA	NOAA9	01-Jun-94	16:42:58	35	3	128	41	405.10	333.18
NSA West	SPOT3	01-Jun-94	17:49:37	131	9	163	35	771.02	615.45
NSA East	SPOT3	01-Jun-94	17:49:38	153	7	164	35	820.96	618.22
SSA West	SPOT2	01-Jun-94	18:24:35	302	6	164	33	334.84	324.67
SSA East	SPOT2	01-Jun-94	18:24:37	279	12	166	32	394.69	335.04
SSA	NOAA11	01-Jun-94	22:20:15	69	35	251	49	405.10	333.18
NSA	NOAA11	01-Jun-94	22:20:33	62	6	254	53	716.88	606.96
SSA	NOAA9	02-Jun-94	02:35:10	61	31	302	86	405.10	333.18
NSA	NOAA9	02-Jun-94	02:35:26	15	5	307	87	716.88	606.96
NSA	NOAA11	02-Jun-94	12:14:53	43	2	73	75	716.88	606.96
SSA	NOAA11	02-Jun-94	12:15:37	93	23	69	78	405.10	333.18
NSA	NOAA12	02-Jun-94	14:08:22	99	45	96	59	716.88	606.96
NSA	NOAA12	02-Jun-94	15:48:15	303	49	120	46	716.88	606.96
SSA	NOAA12	02-Jun-94	15:49:22	291	39	113	47	405.10	333.18
NSA	NOAA9	02-Jun-94	16:29:24	257	4	132	41	716.88	606.96
SSA	NOAA9	02-Jun-94	16:30:09	105	16	124	42	405.10	333.18
NSA	Landsat5	02-Jun-94	17:00:00	313	7	143	38	716.88	606.96
NSA West	SPOT3	02-Jun-94	17:29:57	94	30	155	36	771.02	615.45
NSA East	SPOT3	02-Jun-94	17:29:58	95	26	156	35	820.96	618.22
NSA East	SPOT2	02-Jun-94	18:04:11	305	17	170	34	820.96	618.22
NSA West	SPOT2	02-Jun-94	18:04:30	268	13	169	34	771.02	615.45
SSA West	SPOT2	02-Jun-94	18:05:15	104	18	156	33	334.84	324.67
SSA East	SPOT2	02-Jun-94	18:05:17	117	13	158	33	394.69	335.04
SSA	NOAA11	02-Jun-94	22:08:04	65	44	248	47	405.10	333.18
NSA	NOAA11	02-Jun-94	22:08:22	60	20	252	51	716.88	606.96
SSA	NOAA11	02-Jun-94	23:48:57	265	52	270	62	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	03-Jun-94	02:22:16	80	17	304	85	716.88	606.96
SSA	NOAA9	03-Jun-94	02:22:20	59	41	300	84	405.10	333.18
SSA	NOAA9	03-Jun-94	04:02:50	261	54	320	95	405.10	333.18
NSA	NOAA11	03-Jun-94	12:02:42	110	15	71	76	716.88	606.96
SSA	NOAA11	03-Jun-94	12:03:25	99	35	66	80	405.10	333.18
NSA	NOAA12	03-Jun-94	15:26:59	291	34	114	48	716.88	606.96
SSA	NOAA12	03-Jun-94	15:27:46	290	19	108	50	405.10	333.18
NSA	NOAA9	03-Jun-94	16:16:35	128	12	128	42	716.88	606.96
SSA	NOAA9	03-Jun-94	16:17:19	108	30	120	44	405.10	333.18
NSA West	SPOT2	03-Jun-94	17:44:50	80	11	161	35	771.02	615.45
NSA East	SPOT2	03-Jun-94	17:44:51	75	7	162	35	820.96	618.22
SSA	NOAA11	03-Jun-94	21:55:52	63	52	245	46	405.10	333.18
NSA	NOAA11	03-Jun-94	21:56:11	58	31	249	50	716.88	606.96
SSA	NOAA11	03-Jun-94	23:36:24	257	44	268	60	405.10	333.18
NSA	NOAA9	04-Jun-94	02:09:27	70	30	301	84	716.88	606.96
SSA	NOAA9	04-Jun-94	02:09:30	58	50	297	82	405.10	333.18
SSA	NOAA9	04-Jun-94	03:50:00	262	46	317	94	405.10	333.18
NSA	NOAA11	04-Jun-94	11:50:31	112	28	68	78	716.88	606.96
SSA	NOAA11	04-Jun-94	11:51:12	102	45	64	82	405.10	333.18
SSA	NOAA11	04-Jun-94	13:31:45	299	51	83	67	405.10	333.18
NSA	NOAA12	04-Jun-94	15:05:23	288	13	109	51	716.88	606.96
SSA	NOAA12	04-Jun-94	15:06:10	102	7	102	53	405.10	333.18
NSA	NOAA9	04-Jun-94	16:03:25	99	25	124	44	716.88	606.96
SSA	NOAA9	04-Jun-94	16:04:08	96	42	117	45	405.10	333.18
NSA East	SPOT2	04-Jun-94	17:25:31	100	27	154	35	820.96	618.22
SSA	NOAA9	04-Jun-94	17:44:37	303	53	149	34	405.10	333.18
SSA East	SPOT3	04-Jun-94	18:32:27	303	17	169	32	394.69	335.04
SSA West	SPOT3	04-Jun-94	18:32:47	270	14	167	32	334.84	324.67
NSA	NOAA11	04-Jun-94	21:44:00	57	41	246	48	716.88	606.96
SSA	NOAA11	04-Jun-94	23:24:12	258	33	265	58	405.10	333.18
NSA	NOAA11	04-Jun-94	23:24:32	261	52	269	62	716.88	606.96
NSA	NOAA9	05-Jun-94	01:56:38	65	40	299	82	716.88	606.96
SSA	NOAA9	05-Jun-94	03:37:09	265	36	315	92	405.10	333.18
NSA	NOAA9	05-Jun-94	03:37:28	264	52	319	93	716.88	606.96
NSA	NOAA11	05-Jun-94	11:37:58	98	39	66	79	716.88	606.96
SSA	NOAA11	05-Jun-94	11:38:40	94	53	61	83	405.10	333.18
NSA	NOAA11	05-Jun-94	13:18:31	303	52	85	66	716.88	606.96
SSA	NOAA11	05-Jun-94	13:19:33	297	44	80	69	405.10	333.18
NSA	NOAA12	05-Jun-94	14:43:47	107	12	104	54	716.88	606.96
SSA	NOAA12	05-Jun-94	14:44:33	102	32	98	56	405.10	333.18
NSA	NOAA9	05-Jun-94	15:50:35	103	37	120	45	716.88	606.96
SSA	NOAA9	05-Jun-94	15:51:17	98	51	113	47	405.10	333.18
NSA	NOAA9	05-Jun-94	17:31:04	300	53	154	36	716.88	606.96
SSA	NOAA9	05-Jun-94	17:31:47	302	46	144	35	405.10	333.18
NSA West	SPOT3	05-Jun-94	18:12:25	289	18	172	34	771.02	615.45
NSA East	SPOT3	05-Jun-94	18:12:26	287	21	173	33	820.96	618.22
SSA East	SPOT3	05-Jun-94	18:13:07	72	8	160	32	394.69	335.04
SSA West	SPOT3	05-Jun-94	18:13:27	127	12	159	33	334.84	324.67
NSA	NOAA11	05-Jun-94	21:31:46	57	48	242	46	716.88	606.96
SSA	NOAA11	05-Jun-94	23:12:00	264	21	263	56	405.10	333.18
NSA	NOAA11	05-Jun-94	23:12:19	262	44	266	60	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	06-Jun-94	01:43:46	63	48	296	80	716.88	606.96
SSA	NOAA9	06-Jun-94	03:23:59	251	23	312	91	405.10	333.18
NSA	NOAA9	06-Jun-94	03:24:36	266	44	317	92	716.88	606.96
NSA	NOAA11	06-Jun-94	11:25:45	100	48	63	81	716.88	606.96
NSA	NOAA11	06-Jun-94	13:06:17	303	46	83	67	716.88	606.96
SSA	NOAA11	06-Jun-94	13:07:21	293	34	78	71	405.10	333.18
NSA	NOAA12	06-Jun-94	14:22:11	104	35	99	57	716.88	606.96
SSA	NOAA12	06-Jun-94	14:22:57	101	49	93	59	405.10	333.18
NSA	NOAA9	06-Jun-94	15:37:43	103	47	117	47	716.88	606.96
SSA	NOAA12	06-Jun-94	16:02:50	299	49	116	45	405.10	333.18
NSA	NOAA9	06-Jun-94	17:18:13	299	46	149	36	716.88	606.96
SSA	NOAA9	06-Jun-94	17:18:58	301	36	139	36	405.10	333.18
NSA West	SPOT3	06-Jun-94	17:53:05	109	4	163	34	771.02	615.45
NSA East	SPOT3	06-Jun-94	17:53:06	173	1	165	34	820.96	618.22
SSA East	SPOT3	06-Jun-94	17:53:48	97	29	152	33	394.69	335.04
SSA West	SPOT2	06-Jun-94	18:28:01	298	10	165	32	334.84	324.67
SSA East	SPOT2	06-Jun-94	18:28:03	284	16	167	32	394.69	335.04
NSA	NOAA11	06-Jun-94	21:19:33	56	54	239	45	716.88	606.96
SSA	NOAA11	06-Jun-94	22:59:29	220	8	260	54	405.10	333.18
NSA	NOAA11	06-Jun-94	23:00:05	264	35	264	58	716.88	606.96
NSA	NOAA9	07-Jun-94	01:30:55	61	54	294	79	716.88	606.96
SSA	NOAA9	07-Jun-94	03:11:09	259	8	310	89	405.10	333.18
NSA	NOAA9	07-Jun-94	03:11:25	255	34	314	90	716.88	606.96
NSA	NOAA11	07-Jun-94	11:13:11	92	55	61	82	716.88	606.96
NSA	NOAA11	07-Jun-94	12:54:04	302	37	80	69	716.88	606.96
SSA	NOAA11	07-Jun-94	12:55:10	288	23	76	73	405.10	333.18
NSA	NOAA12	07-Jun-94	14:00:13	92	51	94	60	716.88	606.96
NSA	NOAA9	07-Jun-94	15:24:31	95	54	113	48	716.88	606.96
NSA	NOAA12	07-Jun-94	15:40:26	300	44	117	46	716.88	606.96
SSA	NOAA12	07-Jun-94	15:41:34	285	33	110	48	405.10	333.18
NSA	NOAA9	07-Jun-94	17:05:22	297	37	144	37	716.88	606.96
SSA	NOAA9	07-Jun-94	17:06:09	300	25	135	38	405.10	333.18
Tran West	Landsat5	07-Jun-94	17:13:00	230	6	140	37	498.12	419.01
NSA East	SPOT3	07-Jun-94	17:33:46	109	23	157	35	820.96	618.22
NSA West	SPOT3	07-Jun-94	17:33:46	107	26	156	35	771.02	615.45
NSA East	SPOT2	07-Jun-94	18:07:36	304	20	171	33	820.96	618.22
NSA West	SPOT2	07-Jun-94	18:07:57	274	17	169	33	771.02	615.45
SSA West	SPOT2	07-Jun-94	18:08:41	101	14	157	33	334.84	324.67
SSA East	SPOT2	07-Jun-94	18:08:42	119	8	158	32	394.69	335.04
SSA	NOAA11	07-Jun-94	22:47:17	83	9	257	52	405.10	333.18
NSA	NOAA11	07-Jun-94	22:47:33	249	23	261	56	716.88	606.96
SSA	NOAA9	08-Jun-94	02:58:20	47	8	307	88	405.10	333.18
NSA	NOAA9	08-Jun-94	02:58:34	258	22	311	89	716.88	606.96
NSA	NOAA11	08-Jun-94	12:41:53	300	27	78	71	716.88	606.96
SSA	NOAA11	08-Jun-94	12:42:59	267	9	73	74	405.10	333.18
NSA	NOAA12	08-Jun-94	15:19:10	283	27	112	49	716.88	606.96
SSA	NOAA12	08-Jun-94	15:19:58	272	10	105	51	405.10	333.18
NSA	NOAA9	08-Jun-94	16:52:32	293	27	139	38	716.88	606.96
SSA	NOAA9	08-Jun-94	16:53:19	299	11	130	39	405.10	333.18
NSA East	SPOT2	08-Jun-94	17:48:16	42	5	163	34	820.96	618.22
NSA West	SPOT2	08-Jun-94	17:48:16	65	8	161	34	771.02	615.45
SSA	NOAA11	08-Jun-94	22:35:06	69	22	255	51	405.10	333.18
NSA	NOAA11	08-Jun-94	22:35:21	255	9	258	54	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	09-Jun-94	02:45:31	56	22	305	86	405.10	333.18
NSA	NOAA9	09-Jun-94	02:45:45	281	9	309	87	716.88	606.96
NSA	NOAA11	09-Jun-94	12:29:42	297	15	75	72	716.88	606.96
SSA	NOAA11	09-Jun-94	12:30:28	73	8	71	76	405.10	333.18
NSA	NOAA12	09-Jun-94	14:57:34	245	5	106	52	716.88	606.96
SSA	NOAA12	09-Jun-94	14:58:21	114	17	100	54	405.10	333.18
NSA	NOAA9	09-Jun-94	16:39:43	282	14	135	39	716.88	606.96
SSA	NOAA9	09-Jun-94	16:40:30	115	5	126	40	405.10	333.18
NSA East	SPOT2	09-Jun-94	17:28:56	97	24	155	35	820.96	618.22
NSA West	SPOT2	09-Jun-94	17:28:56	97	27	154	35	771.02	615.45
SSA East	SPOT3	09-Jun-94	18:36:15	283	21	170	31	394.69	335.04
SSA West	SPOT3	09-Jun-94	18:36:16	286	17	168	31	334.84	324.67
SSA	NOAA11	09-Jun-94	22:22:55	64	34	252	49	405.10	333.18
NSA	NOAA11	09-Jun-94	22:23:10	39	6	255	53	716.88	606.96
SSA	NOAA9	10-Jun-94	02:32:21	72	34	302	84	405.10	333.18
NSA	NOAA9	10-Jun-94	02:32:35	97	8	306	86	716.88	606.96
NSA	NOAA11	10-Jun-94	12:17:31	250	1	73	74	716.88	606.96
SSA	NOAA11	10-Jun-94	12:18:17	101	21	68	78	405.10	333.18
NSA	NOAA12	10-Jun-94	14:35:58	115	21	101	55	716.88	606.96
SSA	NOAA12	10-Jun-94	14:36:44	106	39	95	57	405.10	333.18
NSA	NOAA9	10-Jun-94	16:26:54	187	4	131	41	716.88	606.96
SSA	NOAA9	10-Jun-94	16:27:41	115	21	122	42	405.10	333.18
NSA East	SPOT3	10-Jun-94	18:15:53	296	25	174	33	820.96	618.22
NSA West	SPOT3	10-Jun-94	18:15:53	298	21	172	33	771.02	615.45
SSA East	SPOT3	10-Jun-94	18:16:55	152	3	161	32	394.69	335.04
SSA West	SPOT3	10-Jun-94	18:16:56	113	7	160	32	334.84	324.67
SSA	NOAA11	10-Jun-94	22:10:44	62	43	249	47	405.10	333.18
NSA	NOAA11	10-Jun-94	22:10:59	53	19	252	51	716.88	606.96
SSA	NOAA11	10-Jun-94	23:51:37	268	53	271	62	405.10	333.18
SSA	NOAA9	11-Jun-94	02:19:32	65	44	299	83	405.10	333.18
NSA	NOAA9	11-Jun-94	02:19:46	67	20	304	84	716.88	606.96
SSA	NOAA9	11-Jun-94	04:00:22	263	52	320	94	405.10	333.18
NSA	NOAA11	11-Jun-94	12:05:20	121	14	70	75	716.88	606.96
SSA	NOAA11	11-Jun-94	12:06:04	105	34	66	79	405.10	333.18
NSA	NOAA12	11-Jun-94	14:14:01	95	41	96	58	716.88	606.96
SSA	NOAA12	11-Jun-94	14:14:48	94	54	91	61	405.10	333.18
NSA	NOAA12	11-Jun-94	15:54:14	297	52	121	44	716.88	606.96
SSA	NOAA12	11-Jun-94	15:55:01	296	44	113	46	405.10	333.18
NSA	NOAA9	11-Jun-94	16:13:44	95	16	126	42	716.88	606.96
SSA	NOAA9	11-Jun-94	16:14:30	97	34	119	44	405.10	333.18
NSA East	SPOT3	11-Jun-94	17:56:34	323	4	166	33	820.96	618.22
NSA West	SPOT3	11-Jun-94	17:56:34	22	3	164	34	771.02	615.45
SSA East	SPOT3	11-Jun-94	17:57:36	111	25	153	33	394.69	335.04
SSA West	SPOT3	11-Jun-94	17:57:37	107	29	152	33	334.84	324.67
SSA West	SPOT2	11-Jun-94	18:31:26	297	15	166	31	334.84	324.67
SSA East	SPOT2	11-Jun-94	18:31:28	287	19	167	31	394.69	335.04
NSA	NOAA11	11-Jun-94	21:58:28	73	30	249	49	716.88	606.96
SSA	NOAA11	11-Jun-94	21:58:32	60	51	246	45	405.10	333.18
SSA	NOAA11	11-Jun-94	23:39:04	260	45	269	60	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	12-Jun-94	02:06:42	63	51	297	81	405.10	333.18
NSA	NOAA9	12-Jun-94	02:06:57	63	32	301	83	716.88	606.96
SSA	NOAA9	12-Jun-94	03:47:32	266	44	317	93	405.10	333.18
NSA	NOAA11	12-Jun-94	11:52:48	97	27	68	77	716.88	606.96
SSA	NOAA11	12-Jun-94	11:53:32	95	44	63	81	405.10	333.18
SSA	NOAA11	12-Jun-94	13:34:25	296	52	83	67	405.10	333.18
NSA	NOAA12	12-Jun-94	15:32:38	296	38	115	47	716.88	606.96
SSA	NOAA12	12-Jun-94	15:33:25	298	25	108	49	405.10	333.18
NSA	NOAA9	12-Jun-94	16:00:55	104	29	123	44	716.88	606.96
SSA	NOAA9	12-Jun-94	16:01:40	100	44	115	45	405.10	333.18
NSA East	SPOT3	12-Jun-94	17:37:14	99	19	158	34	820.96	618.22
NSA West	SPOT3	12-Jun-94	17:37:14	98	22	157	34	771.02	615.45
SSA	NOAA9	12-Jun-94	17:42:10	300	51	147	34	405.10	333.18
NSA East	SPOT2	12-Jun-94	18:11:01	304	24	172	33	820.96	618.22
NSA West	SPOT2	12-Jun-94	18:11:22	278	21	170	33	771.02	615.45
SSA West	SPOT2	12-Jun-94	18:12:06	96	9	157	32	334.84	324.67
SSA East	SPOT2	12-Jun-94	18:12:08	126	4	159	32	394.69	335.04
NSA	NOAA11	12-Jun-94	21:46:17	67	40	246	47	716.88	606.96
SSA	NOAA11	12-Jun-94	23:26:52	263	35	266	58	405.10	333.18
NSA	NOAA11	12-Jun-94	23:27:09	262	53	269	61	716.88	606.96
NSA	NOAA9	13-Jun-94	01:54:08	60	42	298	81	716.88	606.96
SSA	NOAA9	13-Jun-94	03:34:21	258	33	314	91	405.10	333.18
NSA	NOAA9	13-Jun-94	03:34:58	267	51	319	92	716.88	606.96
NSA	NOAA11	13-Jun-94	11:40:36	101	38	65	79	716.88	606.96
SSA	NOAA11	13-Jun-94	11:41:20	97	52	61	82	405.10	333.18
NSA	NOAA11	13-Jun-94	13:21:08	301	53	85	65	716.88	606.96
SSA	NOAA11	13-Jun-94	13:22:12	293	45	80	68	405.10	333.18
NSA	NOAA12	13-Jun-94	15:11:01	300	19	109	50	716.88	606.96
SSA	NOAA12	13-Jun-94	15:11:49	15	4	103	52	405.10	333.18
NSA	NOAA9	13-Jun-94	15:48:05	106	40	119	45	716.88	606.96
SSA	NOAA9	13-Jun-94	15:48:29	93	53	111	47	405.10	333.18
NSA	NOAA9	13-Jun-94	17:28:34	298	51	152	35	716.88	606.96
SSA	NOAA9	13-Jun-94	17:29:19	298	43	142	35	405.10	333.18
NSA East	SPOT2	13-Jun-94	17:52:01	220	6	164	33	820.96	618.22
NSA West	SPOT2	13-Jun-94	17:52:02	178	5	162	34	771.02	615.45
SSA East	SPOT2	13-Jun-94	17:52:48	110	27	151	33	394.69	335.04
NSA	NOAA11	13-Jun-94	21:34:03	64	48	243	46	716.88	606.96
SSA	NOAA11	13-Jun-94	23:14:19	246	23	263	56	405.10	333.18
NSA	NOAA11	13-Jun-94	23:14:56	264	45	267	59	716.88	606.96
NSA	NOAA9	14-Jun-94	01:41:16	59	50	296	79	716.88	606.96
SSA	NOAA9	14-Jun-94	03:21:31	265	20	312	90	405.10	333.18
NSA	NOAA9	14-Jun-94	03:21:46	259	42	316	91	716.88	606.96
NSA	NOAA11	14-Jun-94	11:28:23	102	47	63	80	716.88	606.96
NSA	NOAA11	14-Jun-94	13:08:55	300	47	83	67	716.88	606.96
SSA	NOAA11	14-Jun-94	13:10:01	288	36	78	70	405.10	333.18
NSA	NOAA12	14-Jun-94	14:49:25	75	7	104	53	716.88	606.96
SSA	NOAA12	14-Jun-94	14:50:12	96	26	98	55	405.10	333.18
NSA	NOAA9	14-Jun-94	15:34:53	96	49	115	47	716.88	606.96
NSA	NOAA9	14-Jun-94	17:15:43	296	44	147	36	716.88	606.96
SSA	NOAA9	14-Jun-94	17:16:30	296	33	138	36	405.10	333.18
SSA	Landsat5	14-Jun-94	17:20:00	283	7	139	36	405.1	333.18
NSA East	SPOT2	14-Jun-94	17:32:20	93	20	156	34	820.96	618.22
NSA West	SPOT2	14-Jun-94	17:32:21	94	24	154	35	771.02	615.45
SSA East	SPOT3	14-Jun-94	18:39:43	292	25	171	31	394.69	335.04
SSA West	SPOT3	14-Jun-94	18:39:43	296	21	169	31	334.84	324.67
NSA	NOAA11	14-Jun-94	21:22:10	54	54	240	44	716.88	606.96
SSA	NOAA11	14-Jun-94	23:02:08	247	8	261	54	405.10	333.18
NSA	NOAA11	14-Jun-94	23:02:22	253	36	264	58	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	15-Jun-94	03:08:21	211	6	309	88	405.10	333.18
NSA	NOAA9	15-Jun-94	03:08:56	262	31	313	89	716.88	606.96
NSA	NOAA11	15-Jun-94	11:15:49	94	54	60	82	716.88	606.96
NSA	NOAA11	15-Jun-94	12:56:41	298	38	80	68	716.88	606.96
SSA	NOAA11	15-Jun-94	12:57:30	302	24	75	72	405.10	333.18
NSA	NOAA12	15-Jun-94	14:27:49	99	29	99	56	716.88	606.96
SSA	NOAA12	15-Jun-94	14:28:35	98	45	93	58	405.10	333.18
SSA	NOAA12	15-Jun-94	16:08:28	302	52	117	44	405.10	333.18
NSA	NOAA9	15-Jun-94	17:02:54	291	35	142	37	716.88	606.96
SSA	NOAA9	15-Jun-94	17:03:41	291	21	133	38	405.10	333.18
NSA East	SPOT3	15-Jun-94	18:19:21	302	28	175	33	820.96	618.22
NSA West	SPOT3	15-Jun-94	18:19:41	282	25	174	33	771.02	615.45
SSA East	SPOT3	15-Jun-94	18:20:23	310	3	162	31	394.69	335.04
SSA West	SPOT3	15-Jun-94	18:20:23	54	4	161	32	334.84	324.67
SSA	NOAA11	15-Jun-94	22:49:57	58	7	258	52	405.10	333.18
NSA	NOAA11	15-Jun-94	22:50:10	254	24	261	56	716.88	606.96
Tran East	Landsat5	16-Jun-94	17:07:00	331	3	141	37	632.4	514.82
NSA East	SPOT3	16-Jun-94	18:00:21	259	9	167	33	820.96	618.22
NSA West	SPOT3	16-Jun-94	18:00:21	245	6	166	33	771.02	615.45
SSA East	SPOT3	16-Jun-94	18:01:04	104	21	154	32	394.69	335.04
SSA West	SPOT3	16-Jun-94	18:01:04	100	25	153	33	334.84	324.67
SSA West	SPOT2	16-Jun-94	18:34:52	296	18	167	31	334.84	324.67
SSA East	SPOT2	16-Jun-94	18:34:53	289	23	169	31	394.69	335.04
SSA	NOAA9	19-Jul-94	02:32:13	66	38	299	85	405.10	333.18
NSA	NOAA9	19-Jul-94	02:32:22	78	12	304	87	716.88	606.96
NSA	NOAA11	19-Jul-94	12:42:12	304	22	78	73	716.88	606.96
SSA	NOAA11	19-Jul-94	12:43:07	349	4	73	77	405.10	333.18
NSA	NOAA12	19-Jul-94	13:53:38	98	55	92	63	716.88	606.96
NSA	NOAA12	19-Jul-94	15:33:51	293	40	115	50	716.88	606.96
SSA	NOAA12	19-Jul-94	15:34:44	287	27	108	52	405.10	333.18
NSA	NOAA9	19-Jul-94	16:26:20	82	7	130	43	716.88	606.96
SSA	NOAA9	19-Jul-94	16:27:12	101	26	122	45	405.10	333.18
NSA East	SPOT2	19-Jul-94	17:56:15	305	8	163	36	820.96	618.22
NSA West	SPOT2	19-Jul-94	17:56:16	321	5	162	36	771.02	615.45
SSA East	SPOT2	19-Jul-94	17:57:04	95	21	151	36	394.69	335.04
SSA West	SPOT2	19-Jul-94	17:57:23	112	26	150	36	334.84	324.67
SSA	NOAA11	19-Jul-94	22:35:34	62	28	251	51	405.10	333.18
NSA	NOAA11	19-Jul-94	22:35:40	240	3	255	55	716.88	606.96
SSA	NOAA9	20-Jul-94	02:19:23	62	47	297	84	405.10	333.18
NSA	NOAA9	20-Jul-94	02:19:33	66	26	301	85	716.88	606.96
SSA	NOAA9	20-Jul-94	03:59:53	258	50	317	95	405.10	333.18
NSA	NOAA11	20-Jul-94	12:30:01	307	9	75	75	716.88	606.96
SSA	NOAA11	20-Jul-94	12:30:56	105	13	71	79	405.10	333.18
NSA	NOAA12	20-Jul-94	15:12:15	290	21	110	53	716.88	606.96
SSA	NOAA12	20-Jul-94	15:13:07	249	3	103	55	405.10	333.18
NSA	NOAA9	20-Jul-94	16:13:31	106	21	126	45	716.88	606.96
SSA	NOAA9	20-Jul-94	16:14:22	102	39	118	46	405.10	333.18
NSA	Landsat5	20-Jul-94	17:00:00	337	0	140	40	716.88	606.96
NSA East	SPOT2	20-Jul-94	17:36:55	102	15	156	37	820.96	618.22
NSA West	SPOT2	20-Jul-94	17:36:56	102	18	155	37	771.02	615.45
SSA East	SPOT3	20-Jul-94	18:45:02	295	30	171	33	394.69	335.04
SSA West	SPOT3	20-Jul-94	18:45:02	300	27	169	33	334.84	324.67
SSA	NOAA11	20-Jul-94	22:23:23	59	39	248	50	405.10	333.18
NSA	NOAA11	20-Jul-94	22:23:29	59	11	252	54	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	21-Jul-94	02:06:33	60	54	294	82	405.10	333.18
NSA	NOAA9	21-Jul-94	02:06:44	62	37	298	84	716.88	606.96
SSA	NOAA9	21-Jul-94	03:47:03	260	40	314	94	405.10	333.18
NSA	NOAA11	21-Jul-94	12:17:49	109	6	73	77	716.88	606.96
SSA	NOAA11	21-Jul-94	12:18:45	110	27	69	81	405.10	333.18
NSA	NOAA12	21-Jul-94	14:50:39	112	4	105	56	716.88	606.96
SSA	NOAA12	21-Jul-94	14:51:31	110	24	99	58	405.10	333.18
NSA	NOAA9	21-Jul-94	16:00:42	107	34	122	47	716.88	606.96
SSA	NOAA9	21-Jul-94	16:01:11	94	49	115	48	405.10	333.18
SSA	NOAA9	21-Jul-94	17:42:01	297	49	146	37	405.10	333.18
NSA West	SPOT3	21-Jul-94	18:24:58	289	30	174	36	771.02	615.45
SSA West	SPOT3	21-Jul-94	18:25:42	318	5	161	34	334.84	324.67
SSA East	SPOT3	21-Jul-94	18:25:43	291	9	163	34	394.69	335.04
SSA	NOAA11	21-Jul-94	22:11:12	58	47	245	48	405.10	333.18
NSA	NOAA11	21-Jul-94	22:11:18	58	24	249	52	716.88	606.96
SSA	NOAA11	21-Jul-94	23:51:44	262	50	268	63	405.10	333.18
NSA	NOAA9	22-Jul-94	01:53:55	59	46	296	83	716.88	606.96
SSA	NOAA9	22-Jul-94	03:34:12	264	29	312	93	405.10	333.18
NSA	NOAA9	22-Jul-94	03:34:24	259	48	316	94	716.88	606.96
NSA	NOAA11	22-Jul-94	12:05:38	115	20	71	79	716.88	606.96
SSA	NOAA11	22-Jul-94	12:06:12	96	38	66	82	405.10	333.18
NSA	NOAA12	22-Jul-94	14:29:03	107	28	100	59	716.88	606.96
SSA	NOAA12	22-Jul-94	14:29:34	94	44	94	62	405.10	333.18
NSA	NOAA9	22-Jul-94	15:47:31	96	44	119	48	716.88	606.96
SSA	NOAA12	22-Jul-94	16:09:47	296	54	118	47	405.10	333.18
NSA	NOAA9	22-Jul-94	17:28:21	296	49	151	38	716.88	606.96
SSA	NOAA9	22-Jul-94	17:29:12	293	40	142	38	405.10	333.18
NSA East	SPOT3	22-Jul-94	18:05:38	273	15	167	36	820.96	618.22
NSA West	SPOT3	22-Jul-94	18:05:38	271	11	166	36	771.02	615.45
SSA West	SPOT3	22-Jul-94	18:06:23	100	19	154	36	334.84	324.67
SSA East	SPOT3	22-Jul-94	18:06:24	108	15	155	35	394.69	335.04
SSA East	SPOT2	22-Jul-94	18:39:10	299	28	168	34	394.69	335.04
SSA West	SPOT2	22-Jul-94	18:39:28	285	24	167	34	334.84	324.67
NSA	NOAA11	22-Jul-94	21:58:47	72	35	246	51	716.88	606.96
SSA	NOAA11	22-Jul-94	21:59:00	56	54	242	47	405.10	333.18
SSA	NOAA11	22-Jul-94	23:39:32	265	41	265	61	405.10	333.18
NSA	NOAA9	23-Jul-94	01:41:03	58	53	293	81	716.88	606.96
SSA	NOAA9	23-Jul-94	03:21:03	244	14	309	92	405.10	333.18
NSA	NOAA9	23-Jul-94	03:21:33	261	38	313	93	716.88	606.96
NSA	NOAA11	23-Jul-94	11:53:07	98	32	68	80	716.88	606.96
SSA	NOAA11	23-Jul-94	11:54:00	99	48	64	84	405.10	333.18
SSA	NOAA11	23-Jul-94	13:34:32	301	49	83	70	405.10	333.18
NSA	NOAA12	23-Jul-94	14:07:05	93	46	95	62	716.88	606.96
NSA	NOAA9	23-Jul-94	15:34:40	98	53	116	50	716.88	606.96
NSA	NOAA12	23-Jul-94	15:47:19	299	49	119	49	716.88	606.96
SSA	NOAA12	23-Jul-94	15:48:11	295	40	112	50	405.10	333.18
NSA	NOAA9	23-Jul-94	17:15:30	293	41	146	40	716.88	606.96
SSA	NOAA9	23-Jul-94	17:16:22	286	29	137	40	405.10	333.18
NSA East	SPOT3	23-Jul-94	17:46:18	136	10	160	37	820.96	618.22
NSA West	SPOT3	23-Jul-94	17:46:18	125	13	158	37	771.02	615.45
NSA West	SPOT2	23-Jul-94	18:19:01	296	28	171	36	771.02	615.45
SSA East	SPOT2	23-Jul-94	18:19:49	320	8	161	35	394.69	335.04
SSA West	SPOT2	23-Jul-94	18:20:07	218	3	159	35	334.84	324.67
NSA	NOAA11	23-Jul-94	21:46:35	66	44	242	49	716.88	606.96
SSA	NOAA11	23-Jul-94	23:27:00	254	29	262	59	405.10	333.18
NSA	NOAA11	23-Jul-94	23:27:28	262	50	266	63	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	24-Jul-94	03:08:14	52	2	306	90	405.10	333.18
NSA	NOAA9	24-Jul-94	03:08:22	246	27	311	92	716.88	606.96
NSA	NOAA11	24-Jul-94	11:40:55	101	42	66	82	716.88	606.96
NSA	NOAA11	24-Jul-94	13:21:27	301	50	86	69	716.88	606.96
SSA	NOAA11	24-Jul-94	13:22:21	299	40	81	72	405.10	333.18
NSA	NOAA12	24-Jul-94	15:25:42	299	34	114	52	716.88	606.96
SSA	NOAA12	24-Jul-94	15:26:35	298	19	107	54	405.10	333.18
NSA	NOAA9	24-Jul-94	17:02:40	286	31	142	41	716.88	606.96
SSA	NOAA9	24-Jul-94	17:03:13	308	16	133	41	405.10	333.18
NSA East	SPOT3	24-Jul-94	17:26:39	97	29	152	38	820.96	618.22
NSA East	SPOT2	24-Jul-94	17:59:41	293	12	165	37	820.96	618.22
NSA West	SPOT2	24-Jul-94	17:59:41	300	8	164	37	771.02	615.45
SSA East	SPOT2	24-Jul-94	18:00:30	97	17	153	36	394.69	335.04
SSA West	SPOT2	24-Jul-94	18:00:48	116	23	152	36	334.84	324.67
NSA	NOAA11	24-Jul-94	21:34:22	64	51	239	48	716.88	606.96
SSA	NOAA11	24-Jul-94	23:14:48	261	16	260	58	405.10	333.18
NSA	NOAA11	24-Jul-94	23:15:15	265	41	263	61	716.88	606.96
SSA	NOAA9	25-Jul-94	02:55:24	59	17	303	89	405.10	333.18
NSA	NOAA9	25-Jul-94	02:55:33	249	13	308	90	716.88	606.96
NSA	NOAA11	25-Jul-94	11:28:21	93	50	64	84	716.88	606.96
NSA	NOAA11	25-Jul-94	13:09:14	300	43	84	70	716.88	606.96
SSA	NOAA11	25-Jul-94	13:10:10	295	30	79	74	405.10	333.18
NSA	NOAA12	25-Jul-94	15:04:06	310	13	108	55	716.88	606.96
SSA	NOAA12	25-Jul-94	15:04:58	86	8	102	57	405.10	333.18
NSA	NOAA9	25-Jul-94	16:49:31	303	18	138	42	716.88	606.96
SSA	NOAA9	25-Jul-94	16:50:24	23	2	129	43	405.10	333.18
Tran West	Landsat5	25-Jul-94	17:13:00	105	7	139	40	498.12	419.01
NSA East	SPOT2	25-Jul-94	17:40:20	108	11	158	38	820.96	618.22
NSA West	SPOT2	25-Jul-94	17:40:20	104	15	156	38	771.02	615.45
SSA West	SPOT3	25-Jul-94	18:48:30	296	30	171	34	334.84	324.67
SSA	NOAA11	25-Jul-94	23:02:37	329	5	257	56	405.10	333.18
NSA	NOAA11	25-Jul-94	23:02:42	254	31	260	60	716.88	606.96
SSA	NOAA9	26-Jul-94	02:42:35	58	30	301	88	405.10	333.18
NSA	NOAA9	26-Jul-94	02:42:44	21	3	305	89	716.88	606.96
NSA	NOAA11	26-Jul-94	12:57:03	296	34	81	72	716.88	606.96
SSA	NOAA11	26-Jul-94	12:57:59	289	18	77	76	405.10	333.18
NSA	NOAA12	26-Jul-94	14:42:30	88	13	104	58	716.88	606.96
SSA	NOAA12	26-Jul-94	14:43:22	97	32	98	60	405.10	333.18
NSA	NOAA9	26-Jul-94	16:36:42	304	4	134	44	716.88	606.96
SSA	NOAA9	26-Jul-94	16:37:34	109	16	126	45	405.10	333.18
SSA West	SPOT3	26-Jul-94	18:29:10	307	9	163	35	334.84	324.67
SSA East	SPOT3	26-Jul-94	18:29:12	290	13	165	35	394.69	335.04
SSA	NOAA11	26-Jul-94	22:50:06	81	14	254	54	405.10	333.18
NSA	NOAA11	26-Jul-94	22:50:31	260	18	257	58	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	27-Jul-94	02:29:26	69	41	298	86	405.10	333.18
NSA	NOAA9	27-Jul-94	02:29:54	53	17	302	88	716.88	606.96
NSA	NOAA11	27-Jul-94	12:44:51	291	23	79	74	716.88	606.96
SSA	NOAA11	27-Jul-94	12:45:48	250	4	74	78	405.10	333.18
NSA	NOAA12	27-Jul-94	14:20:54	96	35	99	61	716.88	606.96
SSA	NOAA12	27-Jul-94	14:21:46	98	50	93	64	405.10	333.18
SSA	NOAA12	27-Jul-94	16:01:39	302	49	116	49	405.10	333.18
NSA	NOAA9	27-Jul-94	16:23:52	118	11	130	45	716.88	606.96
SSA	NOAA9	27-Jul-94	16:24:45	112	30	122	46	405.10	333.18
NSA East	SPOT3	27-Jul-94	18:09:06	278	18	169	37	820.96	618.22
NSA West	SPOT3	27-Jul-94	18:09:06	277	14	167	37	771.02	615.45
SSA West	SPOT3	27-Jul-94	18:09:51	98	15	155	36	334.84	324.67
SSA East	SPOT3	27-Jul-94	18:09:52	107	11	157	36	394.69	335.04
SSA West	SPOT2	27-Jul-94	18:42:53	283	27	169	35	334.84	324.67
SSA	NOAA11	27-Jul-94	22:37:55	69	27	251	53	405.10	333.18
NSA	NOAA11	27-Jul-94	22:38:20	301	7	254	57	716.88	606.96
SSA	NOAA9	28-Jul-94	02:16:36	65	50	295	85	405.10	333.18
NSA	NOAA9	28-Jul-94	02:16:45	73	29	299	86	716.88	606.96
SSA	NOAA9	28-Jul-94	03:57:26	265	47	316	97	405.10	333.18
NSA	NOAA11	28-Jul-94	12:32:40	275	10	77	76	716.88	606.96
SSA	NOAA11	28-Jul-94	12:33:16	84	12	72	80	405.10	333.18
NSA	NOAA12	28-Jul-94	13:59:17	97	51	94	64	716.88	606.96
NSA	NOAA12	28-Jul-94	15:39:30	294	44	118	51	716.88	606.96
SSA	NOAA12	28-Jul-94	15:40:23	288	33	111	52	405.10	333.18
NSA	NOAA9	28-Jul-94	16:10:43	95	25	126	47	716.88	606.96
SSA	NOAA9	28-Jul-94	16:11:34	99	42	119	48	405.10	333.18
NSA East	SPOT3	28-Jul-94	17:49:47	152	6	161	38	820.96	618.22
NSA West	SPOT3	28-Jul-94	17:49:47	131	9	160	38	771.02	615.45
SSA	NOAA9	28-Jul-94	17:52:04	301	54	151	38	405.10	333.18
SSA East	SPOT2	28-Jul-94	18:23:16	299	11	162	36	394.69	335.04
SSA West	SPOT2	28-Jul-94	18:23:33	248	7	161	36	334.84	324.67
SSA	NOAA11	28-Jul-94	22:25:44	64	38	248	51	405.10	333.18
NSA	NOAA11	28-Jul-94	22:25:48	84	10	251	55	716.88	606.96
NSA	NOAA9	29-Jul-94	02:03:55	66	39	297	85	716.88	606.96
SSA	NOAA9	29-Jul-94	03:44:16	256	37	313	96	405.10	333.18
NSA	NOAA9	29-Jul-94	03:44:46	263	54	318	96	716.88	606.96
NSA	NOAA11	29-Jul-94	12:20:09	59	6	74	78	716.88	606.96
SSA	NOAA11	29-Jul-94	12:21:05	101	25	70	82	405.10	333.18
NSA	NOAA12	29-Jul-94	15:17:54	292	27	112	54	716.88	606.96
SSA	NOAA12	29-Jul-94	15:18:47	279	9	106	56	405.10	333.18
NSA	NOAA9	29-Jul-94	15:57:52	101	37	123	49	716.88	606.96
SSA	NOAA9	29-Jul-94	15:58:44	101	51	116	50	405.10	333.18
NSA East	SPOT3	29-Jul-94	17:30:07	95	26	154	39	820.96	618.22
NSA West	SPOT3	29-Jul-94	17:30:07	95	29	153	39	771.02	615.45
NSA	NOAA9	29-Jul-94	17:38:22	302	54	155	39	716.88	606.96
SSA	NOAA9	29-Jul-94	17:39:14	299	46	146	39	405.10	333.18
NSA East	SPOT2	29-Jul-94	18:03:06	287	16	166	38	820.96	618.22
NSA West	SPOT2	29-Jul-94	18:03:06	289	12	165	38	771.02	615.45
SSA West	SPOT2	29-Jul-94	18:03:53	92	19	153	37	334.84	324.67
SSA East	SPOT2	29-Jul-94	18:03:55	101	13	155	37	394.69	335.04
SSA	NOAA11	29-Jul-94	22:13:33	61	47	244	50	405.10	333.18
NSA	NOAA11	29-Jul-94	22:13:37	68	23	248	54	716.88	606.96
SSA	NOAA11	29-Jul-94	23:54:05	259	51	267	64	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	30-Jul-94	01:51:04	63	48	294	84	716.88	606.96
SSA	NOAA9	30-Jul-94	03:31:25	260	25	310	94	405.10	333.18
NSA	NOAA9	30-Jul-94	03:31:54	265	46	315	95	716.88	606.96
NSA	NOAA11	30-Jul-94	12:07:58	100	18	72	80	716.88	606.96
SSA	NOAA11	30-Jul-94	12:08:53	104	37	68	83	405.10	333.18
NSA	NOAA12	30-Jul-94	14:56:17	298	3	107	57	716.88	606.96
SSA	NOAA12	30-Jul-94	14:57:10	112	18	101	59	405.10	333.18
NSA	NOAA9	30-Jul-94	15:45:01	103	47	119	50	716.88	606.96
NSA	NOAA9	30-Jul-94	17:25:31	300	47	150	40	716.88	606.96
SSA	NOAA9	30-Jul-94	17:26:25	296	37	142	40	405.10	333.18
NSA East	SPOT2	30-Jul-94	17:43:46	136	8	159	39	820.96	618.22
NSA West	SPOT2	30-Jul-94	17:43:46	123	11	158	39	771.02	615.45
SSA	NOAA11	30-Jul-94	22:01:20	59	54	241	49	405.10	333.18
NSA	NOAA11	30-Jul-94	22:01:26	63	34	245	53	716.88	606.96
SSA	NOAA11	30-Jul-94	23:41:53	261	42	264	63	405.10	333.18
NSA	NOAA9	31-Jul-94	01:38:13	61	55	291	82	716.88	606.96
SSA	NOAA9	31-Jul-94	03:18:16	226	11	307	93	405.10	333.18
NSA	NOAA9	31-Jul-94	03:18:42	255	36	312	94	716.88	606.96
NSA	NOAA11	31-Jul-94	11:55:47	107	30	70	82	716.88	606.96
SSA	NOAA11	31-Jul-94	11:56:20	95	47	65	85	405.10	333.18
SSA	NOAA11	31-Jul-94	13:37:13	295	49	85	71	405.10	333.18
NSA	NOAA12	31-Jul-94	14:34:41	106	22	103	60	716.88	606.96
SSA	NOAA12	31-Jul-94	14:35:34	106	40	97	62	405.10	333.18
NSA	NOAA9	31-Jul-94	15:31:49	95	55	116	52	716.88	606.96
NSA	NOAA9	31-Jul-94	17:12:39	298	38	146	42	716.88	606.96
SSA	NOAA9	31-Jul-94	17:13:35	291	25	138	42	405.10	333.18
NSA East	SPOT2	31-Jul-94	17:24:06	95	28	152	40	820.96	618.22
SSA West	SPOT3	31-Jul-94	18:32:39	300	13	165	36	334.84	324.67
SSA East	SPOT3	31-Jul-94	18:32:40	290	17	166	36	394.69	335.04
NSA	NOAA11	31-Jul-94	21:49:15	60	43	242	51	716.88	606.96
SSA	NOAA11	31-Jul-94	23:29:40	265	31	262	61	405.10	333.18
NSA	NOAA11	31-Jul-94	23:29:48	259	51	265	65	716.88	606.96
SSA	NOAA9	01-Aug-94	03:05:26	90	6	305	92	405.10	333.18
NSA	NOAA9	01-Aug-94	03:05:52	259	23	309	93	716.88	606.96
NSA	NOAA11	01-Aug-94	11:43:14	95	41	67	83	716.88	606.96
SSA	NOAA11	01-Aug-94	11:44:08	97	54	63	87	405.10	333.18
NSA	NOAA11	01-Aug-94	13:23:46	305	51	88	70	716.88	606.96
SSA	NOAA11	01-Aug-94	13:25:01	292	41	83	73	405.10	333.18
NSA	NOAA12	01-Aug-94	14:13:04	104	42	98	63	716.88	606.96
SSA	NOAA12	01-Aug-94	14:13:37	95	55	93	66	405.10	333.18
NSA	NOAA12	01-Aug-94	15:52:57	299	52	122	50	716.88	606.96
SSA	NOAA12	01-Aug-94	15:53:50	296	44	115	51	405.10	333.18
NSA	NOAA9	01-Aug-94	16:59:50	293	27	142	43	716.88	606.96
SSA	NOAA9	01-Aug-94	17:00:46	275	11	134	43	405.10	333.18
SSA	Landsat5	01-Aug-94	17:20:00	236	5	140	41	405.1	333.18
NSA East	SPOT3	01-Aug-94	18:12:35	280	22	170	38	820.96	618.22
NSA West	SPOT3	01-Aug-94	18:12:35	280	18	169	38	771.02	615.45
SSA West	SPOT3	01-Aug-94	18:13:20	95	11	157	37	334.84	324.67
SSA East	SPOT3	01-Aug-94	18:13:21	108	6	159	37	394.69	335.04
NSA	NOAA11	01-Aug-94	21:37:02	58	50	238	50	716.88	606.96
SSA	NOAA11	01-Aug-94	23:17:08	247	18	259	60	405.10	333.18
NSA	NOAA11	01-Aug-94	23:17:34	260	42	262	63	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	02-Aug-94	02:52:37	68	21	302	90	405.10	333.18
NSA	NOAA9	02-Aug-94	02:53:03	282	10	306	92	716.88	606.96
NSA	NOAA11	02-Aug-94	11:31:01	98	49	65	85	716.88	606.96
NSA	NOAA11	02-Aug-94	13:11:53	294	44	85	72	716.88	606.96
SSA	NOAA11	02-Aug-94	13:12:50	286	31	81	75	405.10	333.18
NSA	NOAA12	02-Aug-94	15:31:21	299	39	116	53	716.88	606.96
SSA	NOAA12	02-Aug-94	15:32:14	297	25	110	54	405.10	333.18
NSA	NOAA9	02-Aug-94	16:47:01	281	14	138	44	716.88	606.96
SSA	NOAA9	02-Aug-94	16:47:36	62	7	130	45	405.10	333.18
NSA East	SPOT3	02-Aug-94	17:53:15	193	5	163	39	820.96	618.22
NSA West	SPOT3	02-Aug-94	17:53:15	149	6	162	39	771.02	615.45
SSA East	SPOT3	02-Aug-94	17:54:02	107	29	152	39	394.69	335.04
SSA West	SPOT2	02-Aug-94	18:26:39	299	10	163	37	334.84	324.67
SSA East	SPOT2	02-Aug-94	18:26:41	283	15	164	37	394.69	335.04
SSA	NOAA11	02-Aug-94	23:04:57	266	3	256	58	405.10	333.18
NSA	NOAA11	02-Aug-94	23:05:22	264	32	260	62	716.88	606.96
SSA	NOAA9	03-Aug-94	02:39:48	63	34	299	89	405.10	333.18
NSA	NOAA9	03-Aug-94	02:39:53	90	6	304	91	716.88	606.96
NSA	NOAA11	03-Aug-94	12:59:42	288	35	83	73	716.88	606.96
SSA	NOAA11	03-Aug-94	13:00:18	303	19	78	77	405.10	333.18
NSA	NOAA12	03-Aug-94	15:09:45	305	19	111	56	716.88	606.96
SSA	NOAA12	03-Aug-94	15:10:38	28	3	105	58	405.10	333.18
NSA	NOAA9	03-Aug-94	16:33:51	23	5	134	46	716.88	606.96
SSA	NOAA9	03-Aug-94	16:34:47	102	20	126	47	405.10	333.18
Tran East	Landsat5	03-Aug-94	17:07:00	68	5	142	42	632.4	514.82
NSA East	SPOT3	03-Aug-94	17:33:35	93	23	156	40	820.96	618.22
NSA West	SPOT3	03-Aug-94	17:33:36	94	26	155	40	771.02	615.45
NSA East	SPOT2	03-Aug-94	18:06:32	277	20	168	39	820.96	618.22
NSA West	SPOT2	03-Aug-94	18:06:32	276	16	167	39	771.02	615.45
SSA West	SPOT2	03-Aug-94	18:07:19	104	14	155	38	334.84	324.67
SSA East	SPOT2	03-Aug-94	18:07:21	123	9	157	38	394.69	335.04
SSA	NOAA11	03-Aug-94	22:52:46	55	12	253	56	405.10	333.18
NSA	NOAA11	03-Aug-94	22:52:50	248	20	257	60	716.88	606.96
SSA	NOAA9	04-Aug-94	02:26:59	60	44	296	88	405.10	333.18
NSA	NOAA9	04-Aug-94	02:27:04	67	20	301	89	716.88	606.96
SSA	NOAA9	04-Aug-94	04:07:28	260	53	317	99	405.10	333.18
NSA	NOAA11	04-Aug-94	12:47:11	302	24	81	75	716.88	606.96
SSA	NOAA11	04-Aug-94	12:48:07	311	5	76	79	405.10	333.18
NSA	NOAA12	04-Aug-94	14:48:08	70	8	106	59	716.88	606.96
SSA	NOAA12	04-Aug-94	14:49:02	100	26	101	61	405.10	333.18
NSA	NOAA9	04-Aug-94	16:21:02	100	15	130	47	716.88	606.96
SSA	NOAA9	04-Aug-94	16:21:57	106	34	123	48	405.10	333.18
NSA East	SPOT2	04-Aug-94	17:46:51	45	6	161	40	820.96	618.22
NSA West	SPOT2	04-Aug-94	17:47:11	144	8	160	40	771.02	615.45
SSA	NOAA11	04-Aug-94	22:40:14	78	26	250	55	405.10	333.18
NSA	NOAA11	04-Aug-94	22:40:39	260	6	254	59	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	05-Aug-94	02:14:08	58	52	294	86	405.10	333.18
NSA	NOAA9	05-Aug-94	02:14:15	62	32	298	88	716.88	606.96
SSA	NOAA9	05-Aug-94	03:54:38	262	45	314	98	405.10	333.18
NSA	NOAA11	05-Aug-94	12:35:00	300	11	78	77	716.88	606.96
SSA	NOAA11	05-Aug-94	12:35:56	111	10	74	81	405.10	333.18
NSA	NOAA12	05-Aug-94	14:26:32	98	30	102	62	716.88	606.96
SSA	NOAA12	05-Aug-94	14:27:25	100	46	96	64	405.10	333.18
SSA	NOAA12	05-Aug-94	16:07:17	300	52	119	50	405.10	333.18
NSA	NOAA9	05-Aug-94	16:08:13	108	29	127	49	716.88	606.96
SSA	NOAA9	05-Aug-94	16:08:46	96	44	120	50	405.10	333.18
NSA	Landsat5	05-Aug-94	17:00:00	113	6	143	44	716.88	606.96
NSA East	SPOT2	05-Aug-94	17:27:31	98	24	154	41	820.96	618.22
NSA West	SPOT2	05-Aug-94	17:27:31	97	28	153	41	771.02	615.45
SSA	NOAA9	05-Aug-94	17:49:16	304	52	151	40	405.10	333.18
SSA East	SPOT3	05-Aug-94	18:36:08	291	21	168	37	394.69	335.04
SSA West	SPOT3	05-Aug-94	18:36:08	297	17	167	37	334.84	324.67
SSA	NOAA11	05-Aug-94	22:28:03	70	37	247	54	405.10	333.18
NSA	NOAA11	05-Aug-94	22:28:28	46	9	251	57	716.88	606.96
NSA	NOAA9	06-Aug-94	02:01:25	59	42	295	87	716.88	606.96
SSA	NOAA9	06-Aug-94	03:41:27	251	34	311	97	405.10	333.18
NSA	NOAA9	06-Aug-94	03:41:55	259	52	316	98	716.88	606.96
NSA	NOAA11	06-Aug-94	12:22:49	123	3	76	79	716.88	606.96
SSA	NOAA11	06-Aug-94	12:23:45	113	24	72	83	405.10	333.18
NSA	NOAA12	06-Aug-94	14:04:55	99	48	97	65	716.88	606.96
NSA	NOAA12	06-Aug-94	15:44:48	303	48	121	52	716.88	606.96
SSA	NOAA12	06-Aug-94	15:46:01	287	38	114	53	405.10	333.18
NSA	NOAA9	06-Aug-94	15:55:02	96	40	123	51	716.88	606.96
SSA	NOAA9	06-Aug-94	15:55:56	98	53	117	52	405.10	333.18
NSA	NOAA9	06-Aug-94	17:35:32	305	52	155	41	716.88	606.96
SSA	NOAA9	06-Aug-94	17:36:25	302	44	146	41	405.10	333.18
NSA East	SPOT3	06-Aug-94	18:16:02	282	25	172	39	820.96	618.22
NSA West	SPOT3	06-Aug-94	18:16:03	281	22	171	39	771.02	615.45
SSA East	SPOT3	06-Aug-94	18:16:48	108	2	161	38	394.69	335.04
SSA West	SPOT3	06-Aug-94	18:16:48	91	7	159	38	334.84	324.67
SSA	NOAA11	06-Aug-94	22:15:52	66	46	244	52	405.10	333.18
NSA	NOAA11	06-Aug-94	22:15:57	79	22	248	56	716.88	606.96
SSA	NOAA11	06-Aug-94	23:56:45	264	51	266	66	405.10	333.18
NSA	NOAA9	07-Aug-94	01:48:34	57	50	293	85	716.88	606.96
SSA	NOAA9	07-Aug-94	03:28:37	253	21	309	96	405.10	333.18
NSA	NOAA9	07-Aug-94	03:29:04	261	43	314	97	716.88	606.96
NSA	NOAA11	07-Aug-94	12:10:37	119	17	74	81	716.88	606.96
SSA	NOAA11	07-Aug-94	12:11:12	98	36	69	85	405.10	333.18
NSA	NOAA12	07-Aug-94	15:23:32	290	32	115	55	716.88	606.96
SSA	NOAA12	07-Aug-94	15:24:25	278	17	109	57	405.10	333.18
NSA	NOAA9	07-Aug-94	15:42:10	99	49	120	52	716.88	606.96
NSA	NOAA9	07-Aug-94	17:22:40	304	45	150	43	716.88	606.96
SSA	NOAA9	07-Aug-94	17:23:36	300	34	142	42	405.10	333.18
NSA East	SPOT3	07-Aug-94	17:56:43	238	6	165	40	820.96	618.22
NSA West	SPOT3	07-Aug-94	17:56:43	195	4	164	40	771.02	615.45
SSA East	SPOT3	07-Aug-94	17:57:29	108	25	154	40	394.69	335.04
SSA West	SPOT3	07-Aug-94	17:57:29	104	29	152	40	334.84	324.67
SSA West	SPOT2	07-Aug-94	18:30:05	286	14	165	38	334.84	324.67
SSA East	SPOT2	07-Aug-94	18:30:06	278	19	166	38	394.69	335.04
SSA	NOAA11	07-Aug-94	22:03:40	63	53	240	51	405.10	333.18
NSA	NOAA11	07-Aug-94	22:03:46	70	33	244	55	716.88	606.96
SSA	NOAA11	07-Aug-94	23:44:12	256	43	264	65	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	08-Aug-94	03:15:48	279	6	306	95	405.10	333.18
NSA	NOAA9	08-Aug-94	03:16:13	266	33	311	96	716.88	606.96
NSA	NOAA11	08-Aug-94	11:58:06	98	29	72	83	716.88	606.96
SSA	NOAA11	08-Aug-94	11:59:00	101	46	67	87	405.10	333.18
SSA	NOAA11	08-Aug-94	13:39:32	300	50	87	72	405.10	333.18
NSA	NOAA12	08-Aug-94	15:01:56	281	10	110	58	716.88	606.96
SSA	NOAA12	08-Aug-94	15:02:49	125	11	104	60	405.10	333.18
NSA	NOAA9	08-Aug-94	17:09:51	302	35	146	44	716.88	606.96
SSA	NOAA9	08-Aug-94	17:10:47	297	22	138	44	405.10	333.18
NSA East	SPOT3	08-Aug-94	17:37:03	91	19	158	41	820.96	618.22
NSA West	SPOT3	08-Aug-94	17:37:03	92	23	157	41	771.02	615.45
NSA East	SPOT2	08-Aug-94	18:09:37	300	23	170	40	820.96	618.22
NSA West	SPOT2	08-Aug-94	18:09:37	303	20	169	40	771.02	615.45
SSA West	SPOT2	08-Aug-94	18:10:44	115	10	157	39	334.84	324.67
SSA East	SPOT2	08-Aug-94	18:10:46	153	6	159	39	394.69	335.04
NSA	NOAA11	08-Aug-94	21:51:35	65	42	241	54	716.88	606.96
SSA	NOAA11	08-Aug-94	23:32:00	258	32	261	63	405.10	333.18
NSA	NOAA11	08-Aug-94	23:32:27	264	51	265	67	716.88	606.96
NSA	NOAA9	30-Aug-94	01:53:16	58	49	291	93	716.88	606.96
SSA	NOAA9	30-Aug-94	03:33:23	254	22	307	104	405.10	333.18
NSA	NOAA9	30-Aug-94	03:33:46	259	44	313	105	716.88	606.96
NSA	NOAA11	30-Aug-94	12:30:02	333	3	83	84	716.88	606.96
SSA	NOAA11	30-Aug-94	12:31:03	114	19	79	87	405.10	333.18
NSA	NOAA12	30-Aug-94	15:26:37	290	35	122	60	716.88	606.96
SSA	NOAA12	30-Aug-94	15:27:14	303	20	116	62	405.10	333.18
NSA	NOAA9	30-Aug-94	15:46:53	98	48	127	58	716.88	606.96
NSA	NOAA9	30-Aug-94	17:27:43	294	45	156	49	716.88	606.96
SSA	NOAA9	30-Aug-94	17:28:22	298	35	149	49	405.10	333.18
NSA West	SPOT2	30-Aug-94	17:44:15	86	10	163	48	771.02	615.45
NSA East	SPOT2	30-Aug-94	17:44:17	87	6	164	48	820.96	618.22
SSA	NOAA11	30-Aug-94	22:23:10	67	43	242	60	405.10	333.18
NSA	NOAA11	30-Aug-94	22:23:31	60	17	246	64	716.88	606.96
SSA	NOAA11	31-Aug-94	00:04:03	263	53	264	74	405.10	333.18
SSA	NOAA9	31-Aug-94	03:20:34	277	8	304	102	405.10	333.18
NSA	NOAA9	31-Aug-94	03:20:56	264	34	310	104	716.88	606.96
NSA	NOAA11	31-Aug-94	12:17:51	111	12	81	86	716.88	606.96
SSA	NOAA11	31-Aug-94	12:18:31	97	32	76	89	405.10	333.18
NSA	NOAA12	31-Aug-94	15:05:01	281	14	117	63	716.88	606.96
SSA	NOAA12	31-Aug-94	15:05:38	71	8	111	65	405.10	333.18
NSA	NOAA9	31-Aug-94	17:14:33	302	37	153	50	716.88	606.96
SSA	NOAA9	31-Aug-94	17:15:33	294	23	145	50	405.10	333.18
NSA West	SPOT2	31-Aug-94	17:24:55	102	30	157	49	771.02	615.45
NSA East	SPOT2	31-Aug-94	17:24:57	105	27	158	49	820.96	618.22
SSA East	SPOT3	31-Aug-94	18:33:50	300	19	171	45	394.69	335.04
SSA West	SPOT3	31-Aug-94	18:34:09	271	15	170	45	334.84	324.67
SSA	NOAA11	31-Aug-94	22:10:58	64	50	239	59	405.10	333.18
NSA	NOAA11	31-Aug-94	22:11:20	58	29	243	63	716.88	606.96
SSA	NOAA11	31-Aug-94	23:51:51	266	45	261	73	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	01-Sep-94	03:07:24	96	9	301	101	405.10	333.18
NSA	NOAA9	01-Sep-94	03:07:46	250	21	306	103	716.88	606.96
NSA	NOAA11	01-Sep-94	12:05:40	114	25	79	88	716.88	606.96
SSA	NOAA11	01-Sep-94	12:06:19	100	43	74	91	405.10	333.18
SSA	NOAA11	01-Sep-94	13:46:51	300	52	95	77	405.10	333.18
NSA	NOAA12	01-Sep-94	14:43:25	119	12	112	66	716.88	606.96
SSA	NOAA12	01-Sep-94	14:44:01	98	31	107	68	405.10	333.18
NSA	NOAA9	01-Sep-94	17:01:44	299	25	149	51	716.88	606.96
SSA	NOAA9	01-Sep-94	17:02:44	280	9	142	51	405.10	333.18
NSA East	SPOT3	01-Sep-94	18:13:43	289	22	174	48	820.96	618.22
NSA West	SPOT3	01-Sep-94	18:13:43	290	19	173	48	771.02	615.45
SSA West	SPOT3	01-Sep-94	18:14:29	78	10	163	47	334.84	324.67
SSA East	SPOT3	01-Sep-94	18:14:30	78	6	164	46	394.69	335.04
NSA	NOAA11	01-Sep-94	21:58:48	69	39	240	62	716.88	606.96
SSA	NOAA11	01-Sep-94	23:39:18	257	35	259	72	405.10	333.18
NSA	NOAA11	01-Sep-94	23:39:41	261	53	263	75	716.88	606.96
SSA	NOAA9	02-Sep-94	02:54:35	72	23	298	100	405.10	333.18
NSA	NOAA9	02-Sep-94	02:54:57	267	7	304	101	716.88	606.96
NSA	NOAA11	02-Sep-94	11:53:08	99	36	76	90	716.88	606.96
SSA	NOAA11	02-Sep-94	11:53:46	93	51	72	93	405.10	333.18
NSA	NOAA11	02-Sep-94	13:33:40	303	53	97	76	716.88	606.96
SSA	NOAA11	02-Sep-94	13:34:39	298	45	92	79	405.10	333.18
NSA	NOAA12	02-Sep-94	14:21:28	94	34	107	69	716.88	606.96
SSA	NOAA12	02-Sep-94	14:22:25	99	49	102	71	405.10	333.18
SSA	NOAA12	02-Sep-94	16:02:18	301	50	125	58	405.10	333.18
NSA	NOAA9	02-Sep-94	16:48:55	293	12	145	53	716.88	606.96
SSA	NOAA9	02-Sep-94	16:49:55	140	8	138	53	405.10	333.18
SSA	Landsat5	02-Sep-94	17:20:00	273	3	147	50	405.1	333.18
NSA East	SPOT3	02-Sep-94	17:54:24	228	2	168	48	820.96	618.22
NSA West	SPOT3	02-Sep-94	17:54:24	125	3	167	49	771.02	615.45
SSA East	SPOT3	02-Sep-94	17:55:11	103	27	158	48	394.69	335.04
SSA East	SPOT2	02-Sep-94	18:27:13	298	16	169	46	394.69	335.04
SSA West	SPOT2	02-Sep-94	18:27:30	268	12	168	46	334.84	324.67
NSA	NOAA11	02-Sep-94	21:46:55	56	47	237	61	716.88	606.96
SSA	NOAA11	02-Sep-94	23:27:06	261	23	256	70	405.10	333.18
NSA	NOAA11	02-Sep-94	23:27:28	263	46	260	74	716.88	606.96
SSA	NOAA9	03-Sep-94	02:41:46	65	35	296	98	405.10	333.18
NSA	NOAA9	03-Sep-94	02:42:08	39	10	301	100	716.88	606.96
NSA	NOAA11	03-Sep-94	11:40:54	101	46	74	92	716.88	606.96
NSA	NOAA11	03-Sep-94	13:21:27	301	47	95	78	716.88	606.96
SSA	NOAA11	03-Sep-94	13:22:27	294	36	90	81	405.10	333.18
NSA	NOAA12	03-Sep-94	13:59:51	96	50	103	72	716.88	606.96
NSA	NOAA12	03-Sep-94	15:40:04	296	45	126	60	716.88	606.96
SSA	NOAA12	03-Sep-94	15:41:02	287	34	120	61	405.10	333.18
NSA	NOAA9	03-Sep-94	16:36:06	154	3	142	54	716.88	606.96
SSA	NOAA9	03-Sep-94	16:36:45	99	22	135	54	405.10	333.18
NSA East	SPOT3	03-Sep-94	17:35:04	113	21	162	49	820.96	618.22
NSA West	SPOT3	03-Sep-94	17:35:04	110	25	161	50	771.02	615.45
NSA West	SPOT2	03-Sep-94	18:07:01	295	17	171	49	771.02	615.45
NSA East	SPOT2	03-Sep-94	18:07:02	290	20	172	48	820.96	618.22
SSA West	SPOT2	03-Sep-94	18:07:50	85	14	161	48	334.84	324.67
SSA East	SPOT2	03-Sep-94	18:07:52	94	8	162	47	394.69	335.04
NSA	NOAA11	03-Sep-94	21:34:42	55	53	233	60	716.88	606.96
SSA	NOAA11	03-Sep-94	23:14:35	228	10	253	69	405.10	333.18
NSA	NOAA11	03-Sep-94	23:14:54	252	36	257	73	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	04-Sep-94	02:28:56	62	45	293	97	405.10	333.18
NSA	NOAA9	04-Sep-94	02:28:58	74	22	298	99	716.88	606.96
SSA	NOAA9	04-Sep-94	04:09:26	259	52	315	109	405.10	333.18
NSA	NOAA11	04-Sep-94	11:28:20	93	53	72	94	716.88	606.96
NSA	NOAA11	04-Sep-94	13:09:13	300	39	93	80	716.88	606.96
SSA	NOAA11	04-Sep-94	13:10:16	288	25	88	83	405.10	333.18
NSA	NOAA12	04-Sep-94	15:18:28	294	28	121	62	716.88	606.96
SSA	NOAA12	04-Sep-94	15:19:26	274	11	116	64	405.10	333.18
NSA	NOAA9	04-Sep-94	16:22:56	92	17	138	56	716.88	606.96
SSA	NOAA9	04-Sep-94	16:23:55	104	35	132	56	405.10	333.18
Tran East	Landsat5	04-Sep-94	17:07:00	98	7	149	52	632.4	514.82
NSA West	SPOT2	04-Sep-94	17:47:40	103	5	165	49	771.02	615.45
NSA East	SPOT2	04-Sep-94	17:47:42	149	2	166	49	820.96	618.22
SSA East	SPOT2	04-Sep-94	17:48:33	105	29	156	49	394.69	335.04
SSA	NOAA11	04-Sep-94	23:02:23	86	6	250	67	405.10	333.18
NSA	NOAA11	04-Sep-94	23:02:42	254	25	254	71	716.88	606.96
SSA	NOAA9	05-Sep-94	02:16:06	59	53	290	96	405.10	333.18
NSA	NOAA9	05-Sep-94	02:16:09	66	34	295	98	716.88	606.96
SSA	NOAA9	05-Sep-94	03:56:36	261	43	312	108	405.10	333.18
NSA	NOAA11	05-Sep-94	12:57:02	296	29	90	82	716.88	606.96
SSA	NOAA11	05-Sep-94	12:58:05	270	12	86	85	405.10	333.18
NSA	NOAA12	05-Sep-94	14:56:52	303	5	116	65	716.88	606.96
SSA	NOAA12	05-Sep-94	14:57:50	118	16	111	67	405.10	333.18
NSA	NOAA9	05-Sep-94	16:10:07	103	30	135	57	716.88	606.96
SSA	NOAA9	05-Sep-94	16:10:44	95	45	128	58	405.10	333.18
NSA West	SPOT2	05-Sep-94	17:28:21	108	27	159	51	771.02	615.45
NSA East	SPOT2	05-Sep-94	17:28:22	112	23	160	50	820.96	618.22
SSA	NOAA9	05-Sep-94	17:51:34	295	51	158	49	405.10	333.18
SSA East	SPOT3	05-Sep-94	18:37:17	294	22	173	47	394.69	335.04
SSA West	SPOT3	05-Sep-94	18:37:17	300	18	171	47	334.84	324.67
SSA	NOAA11	05-Sep-94	22:50:12	67	20	247	66	405.10	333.18
NSA	NOAA11	05-Sep-94	22:50:31	265	12	251	70	716.88	606.96
NSA	NOAA9	06-Sep-94	02:03:20	62	43	292	96	716.88	606.96
SSA	NOAA9	06-Sep-94	03:43:45	266	32	309	107	405.10	333.18
NSA	NOAA9	06-Sep-94	03:44:10	266	50	314	108	716.88	606.96
NSA	NOAA11	06-Sep-94	12:44:51	288	17	88	84	716.88	606.96
SSA	NOAA11	06-Sep-94	12:45:34	61	5	84	87	405.10	333.18
NSA	NOAA12	06-Sep-94	14:35:16	105	20	112	68	716.88	606.96
SSA	NOAA12	06-Sep-94	14:35:52	95	38	106	71	405.10	333.18
NSA	NOAA9	06-Sep-94	15:57:17	106	41	132	59	716.88	606.96
SSA	NOAA9	06-Sep-94	15:57:53	98	54	125	60	405.10	333.18
NSA	Landsat5	06-Sep-94	17:00:00	131	7	149	53	716.88	606.96
NSA	NOAA9	06-Sep-94	17:37:46	298	50	161	51	716.88	606.96
SSA	NOAA9	06-Sep-94	17:38:44	292	42	154	50	405.10	333.18
NSA East	SPOT3	06-Sep-94	18:17:11	285	26	176	49	820.96	618.22
NSA West	SPOT3	06-Sep-94	18:17:11	286	23	175	49	771.02	615.45
SSA East	SPOT3	06-Sep-94	18:17:58	62	1	166	48	394.69	335.04
SSA West	SPOT3	06-Sep-94	18:17:58	80	6	165	48	334.84	324.67
NSA	NOAA11	06-Sep-94	22:37:59	136	5	248	69	716.88	606.96
SSA	NOAA11	06-Sep-94	22:38:01	62	32	244	65	405.10	333.18

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	07-Sep-94	01:50:28	60	51	289	95	716.88	606.96
SSA	NOAA9	07-Sep-94	03:30:35	250	18	306	106	405.10	333.18
NSA	NOAA9	07-Sep-94	03:30:58	258	41	311	107	716.88	606.96
NSA	NOAA11	07-Sep-94	12:32:40	245	5	86	85	716.88	606.96
SSA	NOAA11	07-Sep-94	12:33:23	105	18	81	89	405.10	333.18
NSA	NOAA12	07-Sep-94	14:13:39	104	41	107	72	716.88	606.96
SSA	NOAA12	07-Sep-94	14:14:16	96	54	102	74	405.10	333.18
NSA	NOAA9	07-Sep-94	15:44:05	96	50	129	60	716.88	606.96
NSA	NOAA12	07-Sep-94	15:53:32	300	52	131	59	716.88	606.96
SSA	NOAA12	07-Sep-94	15:54:29	293	44	125	60	405.10	333.18
NSA	NOAA9	07-Sep-94	17:24:55	295	43	157	52	716.88	606.96
SSA	NOAA9	07-Sep-94	17:25:34	301	32	150	51	405.10	333.18
NSA East	SPOT3	07-Sep-94	17:57:51	252	6	170	50	820.96	618.22
NSA West	SPOT3	07-Sep-94	17:57:51	218	3	169	50	771.02	615.45
SSA East	SPOT3	07-Sep-94	17:58:39	107	24	160	49	394.69	335.04
SSA West	SPOT3	07-Sep-94	17:58:39	103	28	159	49	334.84	324.67
SSA West	SPOT2	07-Sep-94	18:30:35	300	15	170	48	334.84	324.67
SSA East	SPOT2	07-Sep-94	18:30:37	289	20	171	48	394.69	335.04
NSA	NOAA11	07-Sep-94	22:25:48	76	16	245	67	716.88	606.96
SSA	NOAA11	07-Sep-94	22:25:50	60	42	241	64	405.10	333.18
SSA	NOAA11	08-Sep-94	00:06:22	261	54	263	78	405.10	333.18
SSA	NOAA9	08-Sep-94	03:17:46	290	3	303	105	405.10	333.18
NSA	NOAA9	08-Sep-94	03:18:07	262	30	308	106	716.88	606.96
NSA	NOAA11	08-Sep-94	12:20:08	88	11	83	88	716.88	606.96
SSA	NOAA11	08-Sep-94	12:21:10	108	31	79	91	405.10	333.18
NSA	NOAA12	08-Sep-94	13:51:42	93	55	103	75	716.88	606.96
NSA	NOAA12	08-Sep-94	15:31:55	300	39	126	62	716.88	606.96
SSA	NOAA12	08-Sep-94	15:32:53	291	26	120	63	405.10	333.18
NSA	NOAA9	08-Sep-94	17:12:06	290	34	154	53	716.88	606.96
SSA	NOAA9	08-Sep-94	17:12:45	299	19	147	53	405.10	333.18
NSA East	SPOT3	08-Sep-94	17:38:11	89	18	164	51	820.96	618.22
NSA West	SPOT3	08-Sep-94	17:38:31	117	22	163	51	771.02	615.45
NSA West	SPOT2	08-Sep-94	18:10:26	285	21	173	50	771.02	615.45
NSA East	SPOT2	08-Sep-94	18:10:27	284	24	174	50	820.96	618.22
SSA West	SPOT2	08-Sep-94	18:11:15	96	9	163	49	334.84	324.67
SSA East	SPOT2	08-Sep-94	18:11:17	130	3	165	49	394.69	335.04
NSA	NOAA11	08-Sep-94	22:13:37	66	28	242	66	716.88	606.96
SSA	NOAA11	08-Sep-94	22:13:38	58	50	238	62	405.10	333.18
SSA	NOAA11	08-Sep-94	23:54:10	262	46	261	76	405.10	333.18
SSA	NOAA9	09-Sep-94	03:04:56	49	14	300	104	405.10	333.18
NSA	NOAA9	09-Sep-94	03:04:58	245	17	305	105	716.88	606.96
NSA	NOAA11	09-Sep-94	12:07:57	105	24	81	89	716.88	606.96
SSA	NOAA11	09-Sep-94	12:08:38	97	42	77	93	405.10	333.18
SSA	NOAA11	09-Sep-94	13:49:10	302	53	97	78	405.10	333.18
NSA	NOAA12	09-Sep-94	15:10:19	304	20	121	65	716.88	606.96
SSA	NOAA12	09-Sep-94	15:11:17	304	1	115	66	405.10	333.18
NSA	NOAA9	09-Sep-94	16:58:56	304	22	150	54	716.88	606.96
SSA	NOAA9	09-Sep-94	16:59:55	293	4	143	54	405.10	333.18
NSA East	SPOT2	09-Sep-94	17:51:06	230	5	168	51	820.96	618.22
NSA West	SPOT2	09-Sep-94	17:51:06	176	3	167	51	771.02	615.45
SSA East	SPOT2	09-Sep-94	17:51:57	111	26	159	50	394.69	335.04
NSA	NOAA11	09-Sep-94	22:01:26	62	38	239	65	716.88	606.96
SSA	NOAA11	09-Sep-94	23:41:38	252	37	258	75	405.10	333.18
NSA	NOAA11	09-Sep-94	23:42:19	266	54	262	78	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
SSA	NOAA9	10-Sep-94	02:51:47	73	27	297	102	405.10	333.18
NSA	NOAA9	10-Sep-94	02:52:09	269	3	302	104	716.88	606.96
NSA	NOAA11	10-Sep-94	11:55:45	107	35	79	91	716.88	606.96
SSA	NOAA11	10-Sep-94	11:56:26	99	50	75	95	405.10	333.18
NSA	NOAA11	10-Sep-94	13:35:57	306	54	100	77	716.88	606.96
SSA	NOAA11	10-Sep-94	13:36:58	301	46	95	80	405.10	333.18
NSA	NOAA12	10-Sep-94	14:48:42	64	7	116	68	716.88	606.96
SSA	NOAA12	10-Sep-94	14:49:41	106	25	111	70	405.10	333.18
NSA	NOAA9	10-Sep-94	16:46:07	305	8	146	56	716.88	606.96
SSA	NOAA9	10-Sep-94	16:47:06	120	11	140	56	405.10	333.18
NSA West	SPOT2	10-Sep-94	17:31:25	92	24	161	52	771.02	615.45
NSA East	SPOT2	10-Sep-94	17:31:26	92	20	162	52	820.96	618.22
SSA West	SPOT3	10-Sep-94	18:40:45	293	22	173	49	334.84	324.67
SSA East	SPOT3	10-Sep-94	18:40:46	288	26	175	49	394.69	335.04
NSA	NOAA11	10-Sep-94	21:49:12	60	46	236	64	716.88	606.96
SSA	NOAA11	10-Sep-94	23:29:25	254	24	255	73	405.10	333.18
NSA	NOAA11	10-Sep-94	23:29:45	258	46	259	77	716.88	606.96
SSA	NOAA9	11-Sep-94	02:38:57	67	38	294	101	405.10	333.18
NSA	NOAA9	11-Sep-94	02:39:19	53	13	299	103	716.88	606.96
NSA	NOAA11	11-Sep-94	11:43:11	97	45	77	93	716.88	606.96
NSA	NOAA11	11-Sep-94	13:24:04	295	48	98	79	716.88	606.96
SSA	NOAA11	11-Sep-94	13:24:47	298	37	93	82	405.10	333.18
NSA	NOAA12	11-Sep-94	14:27:06	98	29	111	71	716.88	606.96
SSA	NOAA12	11-Sep-94	14:28:04	103	45	106	73	405.10	333.18
SSA	NOAA12	11-Sep-94	16:07:57	297	53	129	60	405.10	333.18
NSA	NOAA9	11-Sep-94	16:33:18	116	7	143	57	716.88	606.96
SSA	NOAA9	11-Sep-94	16:33:57	96	26	136	57	405.10	333.18
Tran West	Landsat5	11-Sep-94	17:13:00	105	6	150	54	498.12	419.01
NSA East	SPOT3	11-Sep-94	18:20:18	301	29	178	51	820.96	618.22
NSA West	SPOT3	11-Sep-94	18:20:39	282	26	177	51	771.02	615.45
SSA West	SPOT3	11-Sep-94	18:21:25	94	1	167	50	334.84	324.67
SSA East	SPOT3	11-Sep-94	18:21:26	257	4	169	50	394.69	335.04
NSA	NOAA11	11-Sep-94	21:36:59	58	53	233	63	716.88	606.96
SSA	NOAA11	11-Sep-94	23:17:14	267	11	252	72	405.10	333.18
NSA	NOAA11	11-Sep-94	23:17:31	260	37	256	76	716.88	606.96
SSA	NOAA9	12-Sep-94	02:26:08	63	47	291	100	405.10	333.18
NSA	NOAA9	12-Sep-94	02:26:10	75	26	296	102	716.88	606.96
SSA	NOAA9	12-Sep-94	04:06:58	267	50	314	112	405.10	333.18
NSA	NOAA11	12-Sep-94	11:30:58	98	53	74	95	716.88	606.96
NSA	NOAA11	12-Sep-94	13:11:51	292	40	95	81	716.88	606.96
SSA	NOAA11	12-Sep-94	13:12:36	294	26	91	84	405.10	333.18
NSA	NOAA12	12-Sep-94	14:05:29	99	46	107	74	716.88	606.96
NSA	NOAA12	12-Sep-94	15:45:22	303	48	130	62	716.88	606.96
SSA	NOAA12	12-Sep-94	15:46:20	297	38	124	63	405.10	333.18
NSA	NOAA9	12-Sep-94	16:20:28	117	21	140	58	716.88	606.96
SSA	NOAA9	12-Sep-94	16:21:06	102	38	133	59	405.10	333.18
NSA East	SPOT3	12-Sep-94	18:00:59	316	10	172	52	820.96	618.22
NSA West	SPOT3	12-Sep-94	18:00:59	335	7	171	52	771.02	615.45
SSA West	SPOT3	12-Sep-94	18:02:06	108	24	161	51	334.84	324.67
SSA East	SPOT3	12-Sep-94	18:02:07	116	20	163	51	394.69	335.04
SSA West	SPOT2	12-Sep-94	18:34:01	287	19	172	50	334.84	324.67
SSA East	SPOT2	12-Sep-94	18:34:02	282	24	173	50	394.69	335.04
SSA	NOAA11	12-Sep-94	23:04:43	120	6	249	71	405.10	333.18
NSA	NOAA11	12-Sep-94	23:05:19	266	26	254	74	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	13-Sep-94	02:13:21	67	37	293	100	716.88	606.96
NSA	NOAA11	13-Sep-94	12:59:19	303	30	93	83	716.88	606.96
NSA	NOAA12	13-Sep-94	15:24:06	288	33	125	64	716.88	606.96
NSA	NOAA9	13-Sep-94	16:07:19	101	33	136	60	716.88	606.96
NSA East	SPOT3	13-Sep-94	17:41:39	94	14	166	53	820.96	618.22
NSA West	SPOT3	13-Sep-94	17:41:39	94	18	165	53	771.02	615.45
NSA	NOAA9	13-Sep-94	17:47:48	302	55	166	53	716.88	606.96
NSA West	SPOT2	13-Sep-94	18:13:30	303	24	175	52	771.02	615.45
NSA East	SPOT2	13-Sep-94	18:13:31	300	27	176	52	820.96	618.22
SSA West	SPOT2	13-Sep-94	18:14:40	130	5	165	51	334.84	324.67
SSA East	SPOT2	13-Sep-94	18:14:41	210	5	167	51	394.69	335.04
NSA	NOAA11	13-Sep-94	22:52:48	246	13	251	73	716.88	606.96
NSA	NOAA9	14-Sep-94	02:00:30	63	45	290	99	716.88	606.96
NSA	NOAA9	14-Sep-94	03:41:20	265	48	313	111	716.88	606.96
NSA	NOAA11	14-Sep-94	12:47:08	301	19	91	85	716.88	606.96
NSA	NOAA12	14-Sep-94	15:02:30	277	11	120	67	716.88	606.96
NSA	NOAA9	14-Sep-94	15:54:27	103	44	133	61	716.88	606.96
NSA	NOAA9	14-Sep-94	17:34:57	300	48	162	54	716.88	606.96
NSA West	SPOT2	14-Sep-94	17:54:10	346	5	169	53	771.02	615.45
NSA East	SPOT2	14-Sep-94	17:54:11	314	7	170	53	820.96	618.22
SSA East	SPOT2	14-Sep-94	17:55:01	95	22	161	52	394.69	335.04
SSA West	SPOT2	14-Sep-94	17:55:21	112	27	160	52	334.84	324.67
NSA	NOAA11	14-Sep-94	22:40:37	7	2	248	72	716.88	606.96
NSA	NOAA9	15-Sep-94	01:47:39	61	53	287	98	716.88	606.96
NSA	NOAA9	15-Sep-94	03:28:08	256	38	310	110	716.88	606.96
NSA	NOAA11	15-Sep-94	12:34:57	295	5	89	87	716.88	606.96
NSA	NOAA12	15-Sep-94	14:40:54	119	14	116	70	716.88	606.96
NSA	NOAA9	15-Sep-94	15:41:15	95	52	130	63	716.88	606.96
NSA	NOAA9	15-Sep-94	17:22:05	297	40	158	55	716.88	606.96
NSA East	SPOT2	15-Sep-94	17:34:50	101	16	164	54	820.96	618.22
NSA West	SPOT2	15-Sep-94	17:34:50	98	20	163	54	771.02	615.45
SSA West	SPOT3	15-Sep-94	18:44:13	286	26	175	51	334.84	324.67
SSA East	SPOT3	15-Sep-94	18:44:14	283	29	177	51	394.69	335.04
NSA	NOAA11	15-Sep-94	22:28:05	86	15	245	71	716.88	606.96
NSA	NOAA9	16-Sep-94	03:15:18	260	27	307	109	716.88	606.96
NSA	NOAA11	16-Sep-94	12:22:46	123	9	86	89	716.88	606.96
NSA	NOAA12	16-Sep-94	14:18:56	95	36	111	73	716.88	606.96
NSA	NOAA12	16-Sep-94	15:58:49	305	55	135	62	716.88	606.96
NSA	NOAA9	16-Sep-94	17:09:16	292	30	155	56	716.88	606.96
NSA West	SPOT3	16-Sep-94	18:23:46	298	29	178	53	771.02	615.45
SSA West	SPOT3	16-Sep-94	18:24:53	246	4	169	52	334.84	324.67
SSA East	SPOT3	16-Sep-94	18:24:54	254	9	171	51	394.69	335.04
NSA	NOAA11	16-Sep-94	22:15:54	71	26	242	70	716.88	606.96
NSA	NOAA9	17-Sep-94	03:02:09	236	13	304	108	716.88	606.96
NSA	NOAA11	17-Sep-94	12:10:14	95	23	84	91	716.88	606.96
NSA	NOAA12	17-Sep-94	13:57:19	96	51	107	76	716.88	606.96
NSA	NOAA12	17-Sep-94	15:37:32	295	43	130	64	716.88	606.96
NSA	NOAA9	17-Sep-94	16:56:27	281	18	151	57	716.88	606.96
NSA West	SPOT3	17-Sep-94	18:04:26	305	9	172	54	771.02	615.45
NSA East	SPOT3	17-Sep-94	18:04:27	295	13	173	54	820.96	618.22
SSA East	SPOT3	17-Sep-94	18:05:15	93	16	165	52	394.69	335.04
SSA West	SPOT3	17-Sep-94	18:05:35	118	21	163	53	334.84	324.67
SSA East	SPOT2	17-Sep-94	18:37:07	297	27	175	52	394.69	335.04
SSA West	SPOT2	17-Sep-94	18:37:25	280	23	173	52	334.84	324.67
NSA	NOAA11	17-Sep-94	22:03:43	65	37	239	68	716.88	606.96
NSA	NOAA11	17-Sep-94	23:44:36	264	55	261	82	716.88	606.96

Daily Satellite Overpasses for IFC's

Location	Platform	Date	TimeUTC	Sat Azm	Sat Zen	Sun Azm	Sun Zen	BOREAS Grid X	BOREAS Grid Y
NSA	NOAA9	18-Sep-94	02:49:19	90	2	301	107	716.88	606.96
NSA	NOAA11	18-Sep-94	11:58:02	102	34	82	93	716.88	606.96
NSA	NOAA11	18-Sep-94	13:38:34	301	55	103	79	716.88	606.96
NSA	NOAA12	18-Sep-94	15:15:56	294	25	125	67	716.88	606.96
NSA	NOAA9	18-Sep-94	16:43:17	335	6	148	58	716.88	606.96
SSA	Landsat5	18-Sep-94	17:20:00	273	3	151	55	405.1	333.18
NSA West	SPOT3	18-Sep-94	17:45:06	102	14	167	55	771.02	615.45
NSA East	SPOT3	18-Sep-94	17:45:07	107	10	168	54	820.96	618.22
NSA West	SPOT2	18-Sep-94	18:16:55	295	27	176	54	771.02	615.45
SSA West	SPOT2	18-Sep-94	18:17:45	21	5	167	52	334.84	324.67
SSA East	SPOT2	18-Sep-94	18:17:46	310	6	169	52	394.69	335.04
NSA	NOAA11	18-Sep-94	21:51:30	62	45	236	67	716.88	606.96
NSA	NOAA11	18-Sep-94	23:32:22	266	47	259	80	716.88	606.96
NSA	NOAA9	19-Sep-94	02:36:30	61	16	298	106	716.88	606.96
NSA	NOAA11	19-Sep-94	11:45:49	104	44	80	95	716.88	606.96
NSA	NOAA11	19-Sep-94	13:26:21	299	48	100	81	716.88	606.96
NSA	NOAA12	19-Sep-94	14:54:19	315	2	120	70	716.88	606.96
NSA	NOAA9	19-Sep-94	16:30:28	103	11	144	60	716.88	606.96
NSA West	SPOT2	19-Sep-94	17:57:34	296	7	171	55	771.02	615.45
NSA East	SPOT2	19-Sep-94	17:57:36	285	10	172	55	820.96	618.22
SSA West	SPOT2	19-Sep-94	17:58:25	97	24	162	54	334.84	324.67
SSA East	SPOT2	19-Sep-94	17:58:27	105	18	163	54	394.69	335.04
NSA	NOAA11	19-Sep-94	21:39:16	60	52	233	66	716.88	606.96
NSA	NOAA11	19-Sep-94	23:19:48	257	38	256	79	716.88	606.96

Appendix P: Acronyms

AES	Atmospheric Environment Service
AFM	Airborne Flux and Meteorology
AGL	Above Ground Level
AMMR	Advanced Multichannel Microwave Radiometer
ANPP	Above-ground net primary production
APAR	Absorbed photosynthetic active radiation
ARC	Ames Research Center
ASL	Above Sea Level
ASAS	Advanced Solid-State Array Spectroradiometer
ATSP	Airborne Tracking Sun Photometer
ATV	All Terrain Vehicle
AVHRR-LAC	Advanced Very High Resolution Radiometer - Local Area Coverage
AVIRIS	Airborne Visible-Infrared Imaging Spectrometer
AWS	Automatic Weather Station
BAI	Bark area index
BRDF	Bidirectional reflectance
BNPP	Below-ground net primary production
BOREAS	Boreal Ecosystem-Atmosphere Study
BORIS	BOREAS Information System
CCC	Canadian Climate Centre
CDROM	Compact Disc - Read Only Memory
CFC	Chloro-Fluoro Carbon
CLASS	Cross Chain Loran Atmospheric Sounding System
CO2	Carbon Dioxide
DOC	Dissolved organic carbon
DBH	Diameter at Breast Height
ECMWF	European Center for Medium Range Weather Forecasting
ERS-1	European Resource Satellite 1
FFC	Focused Field Campaign
FFC-T	Focused Field Campaign-Thaw
FFC-W	Focused Field Campaign-Winter
FIFE	First ISLSCP Field Experiment
FPAR	Fraction of PAR absorbed by the vegetation canopy
GIS	Geographic Information System
GMT	Greenwich Mean Time (Zulu)
GOES	Geostationary Operational Environmental Satellite
GPP	Gross primary production
HRV	High Resolution Visible
HYD	Hydrology
IBM	International Business Machines
IFC	Intensive Field Campaign
IGBP	International Geosphere-Biosphere Project
IPAR	Intercepted photosynthetic action radiation
IRGA	Infrared gas analyzer
ISLSCP	International Satellite Land Surface Climatology Project
JERS-1	Japanese Earth Resources Satellite 1
JPL	Jet Propulsion Laboratory
LAI	Leaf Area Index
Landsat TM	Landsat Thematic Mapper
Landsat MSS	Landsat Multispectral Scanner
LIDAR	Laser Radar
MAS - MODIS	(Moderate Resolution Imaging Spectrometer) Airborne

	Simulator
MKO	Manitoba Keewatinowi Okimakanak, Inc.
MM	Mission Manager
MODIS	Moderate Resolution Imaging Spectrometer
N	Nitrogen
NEP	Net ecosystem productivity
NIR	Near-infrared
NMC	National Meteorological Center
NOAA	National Oceanographic and Atmospheric Administration
NPP	Net primary production
NRC	National Research Council (Canada)
NS001 TMS	NS001 Thematic Mapper Simulator
NDVI	Normalized Difference Vegetation Index
PAR	Photosynthetically Active Radiation
PARABOLA	Portable Aparatus for Rapid Acquisition of Bidirectional Observations of Land and Atmosphere
PEM	Production Efficiency Model
PIR	Precision Infrared Radiometer
PSP	Precision Spectral Pyranometer
RASS	Radio Acoustic Sounding System
RSS	Remote Sensing Science
SAHQ	Site Area Headquarters
SAM	Site Area Manager
SAR	Synthetic Aperature Radar
SIR-C	Shuttle Imaging Radir
SOM	Soil Organic Matter
SPOT	Systeme Probatoire pour l'Observation de la Terre
TE	Terrestrial Ecology
TF	Tower Flux
TGB	Trace Gas
VAX	Virtual Address Extension (minicomputer tradename)
VIS	Visible
WAB	Wind-aligned blob; analogous to footprint
WCRP	World Climate Research Program
WMO	World Meteorological Organization
WUE	Water Use Efficiency
WX	Weather (implies bad weather i.e. scrub)