BOREAS Experiment Plan

Appendices A – H

Miscellaneous Project Information

May 1996 Version 2.0

BOREAS Executive Summary

This document is the Experiment Plan (EXPLAN-96) for BOREAS field operations to be conducted in 1996 (BOREAS-96). This work will consist primarily of a set of extended eddy correlation (H, LE CO_2) measurements at a number of tower flux sites from March through November 1996, supported by ecophysiological, hydrological, and biogeochemical observations. There will be a small winter campaign (FFC-W) to explore the physics of remote sensing over snow-covered forests, and three growing season field campaigns (thaw, midsummer, fall) in which the bulk of the in situ measurements and aircraft operations (airborne remote sensing and flux measurements will be concentrated.

Chapter 1 reviews the science issues and objectives of BOREAS; the overall design of the field observation component of BOREAS; the field operations and some preliminary results from BOREAS-94; and the shortcomings of the BOREAS-94 data set. The last item provides the motivation for the return to the field; i.e. for BOREAS-96.

Chapter 2 reviews the analyses and planning activities that took place in the period 1994-1995. These resulted in three white papers which are summarized in the text.

Chapter 3 describes the field operations planned for BOREAS-96. These are based directly on the requirements from the white papers summarized in Chapter 2. Chapter 3 is divided into six sections: overview; monitoring; NSA growing season studies; SSA growing season studies; and AFM and RSS growing season activities.

Chapter 4 describes operations procedures; the facilities to be made available by the project; and the schedules for site support.

Chapter 5 describes the aircraft operations. Complete summaries of all the mission plans for all the BOREAS-96 aircraft are included.

Chapter 6 provides a "quick look" summary of field campaign objectives, including tables showing which teams and aircraft will be present during IFC's.

Chapter 7 describes emergency procedures in case of accidents in the field.

Appendices A-H contain further details on investigator contact information; shipping and customs; data documentation; references; satellite overpass schedules; team activity write-ups; directions to BOREAS auxiliary sites, and an acronym list.

BOREAS Experiment Plan 1996

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AFM
TF
TE
TGB
HYD
RSS

Appendix G BOREAS Auxiliary Site Directions

Appendix H Acronyms List

Suraiya Ahmad
NASA/Goddard Space Flight Center
Biospheric Sciences Branch
Code 923
Greenbelt, MD 20771

Phone: (301) 286-5437
FAX: (301) 286-0239
E-Mail: sahmad@ltpmail.gsfc.nasa.gov
Notes: RSS-1

Michael Apps
Forestry Canada
5320-122 Street
Edmonton, Alberta
T6H 3S5
Canada
Phone: (403) 435-7305
FAX: (403) 435-7359
E-Mail: mapps@nofc.forestry.ca
Notes: TE-13

Robert Banta
NOAA/ERL Wave Propagation Laboratory
NOAA/ERL - R/E/WP2
325 Broadway
Boulder, CO 80303-3328
Phone: (303) 497-5535
FAX: (303) 497-5318
E-Mail: rbanta@etl.noaa.gov
Notes: AFM-6

George M. Alger
NASA/Ames Research Center
MS N-211-12
Moffett Field, CA 94035

Phone: (415) 604-5338
FAX: (415) 604-3885
E-Mail: galger@msmail.arc.nasa.gov
Notes: NASA C130, DC-8

Tim Arkebauer
University of Nebraska
Department of Agronomy
106 KCR
Lincoln, NE 68583-0817

Phone: (402) 472-2847
FAX: (402) 472-3654
E-Mail: tja@unlinfo.unl.edu
Notes: TF-11, TE-12

Alan Barr
Atmospheric Environmental Service
National Hydrology Research Center
11 Innovation Boulevard
Saskatoon, SK, Canada S7N 3H5

Phone: (306) 975-4324
FAX: (306) 975-6516
E-Mail: barra@nhrisv.nhrc.sk.doe.ca
Notes: AFM-5

Michael Allen
National Science Foundation
Ecological Studies Program
4201 Wilson Blvd., Room 640
Arlington, VA 22230

Phone: (703) 306-1479
FAX: (703) 306-0367
E-Mail: mallen@nsf.gov
Notes: BCC

John Arveson
NASA/Ames Research Center
Mail Stop 240-6
Moffett Field, CA 94035

Phone: (415) 604-5376
FAX: (415) 604-4987
E-Mail: jarvesen@msmail.arc.nasa.gov
Notes: NASA ER-2

Amar Bazzaz
Harvard University
Engineering Sciences Laboratory
40 Oxford Street
Cambridge, MA 02168

Phone: (617)496-4571
FAX: (617)495-4902
E-Mail: amb@io.harvard.edu
Notes: TF-3

Dean E. Anderson
USGS MS 413
Box 25046
Rm H2910 Bldg 53
Federal Center
Denver, CO 80225-0046
Phone: (303) 236-5691
FAX: (303) 236-5034
E-Mail: deander@pawspaws.cr.usgs.gov
Notes: TF-4

Richard Asselin
1049 Promenade Moffatt
Cumberland, Ontario
K4C 1B7 Canada

Phone: (613) 833-0180
FAX: (613) 995-7283
E-Mail: asselinj@hookup.net
Notes:

Joe Berry
Carnegie Institution
Department of Plant Biology
290 Panama Street
Stanford, CA 94305

Phone: (415) 325-1521 x221
FAX: (415) 325-6857
E-Mail: joeberry@biosphere.stanford.edu
Notes: TE-4

Darwin W. Anderson
Dept of Soil Science
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0
Canada
Phone: (306) 966-6827
FAX: (306) 966-6881
E-Mail: darwin_anderson@agric.usask.ca
Notes: TE-1

Dennis Baldocchi
NOAA/ARL
Atmos. Turbulence & Diffusion
456 S. Illinois Ave
P.O. Box 2456
Oak Ridge, TN 37831-2456
Phone: (423) 576-1243
FAX: (423) 576-1327
E-Mail: baldocchi@atdd.noaa.gov
Notes: TF-5, AFM-1

Pierre Bessemoulin
CNRM /GMEI
Meteo-France
42 Av. Gustave Coriolis
31057 Toulouse Cedex
France
Phone: 33-61-07-93-64
FAX: 33-61-07-96-27
E-Mail: bessemoulin@meteo.fr
Notes: TF-6

Gary Angelici
Sterling Software
NASA Ames Research Center
Mail Stop 242-4
Moffett Field, CA 94035

Phone: (415) 604-5947
FAX: (415) 604-4680
E-Mail: gary@pldsa1.arc.nasa.gov
Notes:

Lawrence E. Band
University of Toronto
Dept of Geography
100 St. George st.
Toronto, ON
M5S 1A1 Canada
Phone: (416)978-3375
FAX: (416)978-6729
E-Mail: lband@eos.geog.utoronto.ca
Notes: HYD-8

Alan K. Betts
Atmospheric Research
R.R. 3, Box 3125
Pittsford, VT 05763-9405

Phone: (802) 483-2087
FAX: (802) 483-6167
E-Mail: akbetts@aol.com
Notes: AFM-8

David Billesbach
201N WSEC
University of Nebraska
Lincoln, NE 68588-0511
Phone: 402/472-7961
FAX:
E-Mail: dbillesbach@crcvms.unl.edu
Notes: TF-11

Robert P. Bukata
Canada Centre for Inland Waters
National Water Research Institute
867 Lakeshore Road, P.O. Box 5050
Burlington, Ontario
L7R 4A6 Canada
Phone: (416)336-4670
FAX: (416)336-4972
E-Mail: u109@cs.cciw.ca
Notes: TE-15

Al Chang
Code 974
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
Phone: (301) 286-8997
FAX: (301) 286-1758
E-Mail: achang@rainfall.gsfc.nasa.gov
Notes: HYD-2

Andrew Black
University of British Columbia
Dept of Soil Science
139 - 2357 Main Mall
Vancouver, British Columbia
V6T1Z4 Canada
Phone: (604) 822-2730
FAX: (604) 822-8639
E-Mail: andrew_black@mtsg.ubc.ca
Notes: TF-1

Roger Burke
USEPA-Research Lab
960 College Station Road
Athens, GA 30605-2720
Phone: (706)546-3174
FAX: (706)546-3636
E-Mail: burke@athens.ath.epa.gov
Notes: TGB-5

Terry Chapin
Dept of Integrative Biology
University of California
Berkeley, CA 94720
Phone: (510) 642-1003
FAX: (510) 643-6264
E-Mail:
Notes:

Gordon Bonan
NCAR
P.O. Box 3000
Boulder, CO 80307-3000
Phone: (303) 497-1613
FAX: (303) 497-1324
E-Mail: bonan@ncar.ucar.edu
Notes: TE-14, AFM-9, RSS-17

Jim Buttle
Dept of Geography
Trent University
Peterborough, Ontario
Canada K9J 7B8
Phone: (705) 748-1475
FAX: (705) 748-1205
E-Mail: jbuttle@trentu.ca
Notes: TF-10

Ms. Carmen Charette
Nat. Sciences & Eng. Research Council
Constitution Square, Tower II
350 Albert Street, 14th Floor
Ottawa, Ontario
K1A 1H5 Canada
Phone: (613)995-5695
FAX: (613) 992-5337
E-Mail: clc@nserc.ca
Notes: BCC

Richard A. Bourbonniere
National Water Research Inst.
Environment Canada
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario L7R 4A6 Canada
Phone: (905) 336-4547
FAX: (905) 336-4972
E-Mail: rick.bourbon@cciw.ca
Notes: TGB-5

Ian Campbell
Forestry Canada
Northwest Region
5320 122 Street
Edmonton, Alberta
T6H 3S5 Canada
Phone: (403) 435-7300
FAX: (403) 435-7359
E-Mail: icampbell@nofc.forestry.ca
Notes: TE-7

Narinder Chauhan
NASA/GSFC
Code 923
Greenbelt, Maryland 20771
Phone: (301) 286-4840
FAX: (301) 286-1758
E-Mail: nsc@fire.gsfc.nasa.gov
Notes: RSS-15

Francois-Marie Breon
LMCE Batiment 709
L'Orme des Merisiers
F-91191 GIF sur YVETTE
France
Phone: 33 01 69 08 77 15
FAX: 33 01 69 08 77 16
E-Mail: breon@asterix.saclay.cea.fr
Notes: TF-6, RSS-20

Tom Carroll
NRSHP
Office of Hydrology
NWS, NOAA
6301, 34 Avenue S., Room 112
Minneapolis, MN 55450
Phone: (612) 725-3039
FAX: (612) 725-3338
E-Mail: tc@nohrsc.nws.gov
Notes: HYD-6

Jing M. Chen
Canada Centre for Remote Sensing
Energy Mines & Resources
588 Booth Street, 4th floor
Ottawa, Ontario
Canada K1A OY7
Phone: (613)947-1266
FAX: (613)947-1406
E-Mail: chen@ccrs.emr.ca
Notes: RSS-7, TE-16

Jill Bubier
Complex Systems Research Center
Institute for Study of Earth, Oceans & Space
University of New Hampshire
Durham, NH 03824-3525
Phone: (603)862-0297
FAX: (603)862-0188
E-Mail: jbubier@kaos.unh.edu
Notes: TGB-3

Stephen Chan
NASA/Goddard Space Flight Center
Code 925
Greenbelt, MD 20771
Phone: (301) 286-2386
FAX: (301) 286-2717
E-Mail: sailun@ltpmail.gsfc.nasa.gov
Notes: TE-10

Chris Chovit
AVIRIS Experiment Coordinator
JPL M/S 306-336
4800 Oak Grove Dr
Pasadena, CA 91109
Phone: (818)354-8077
FAX: (818)393-4406
E-Mail: avec@gomez.jpl.nasa.gov
Notes: AVIRIS RSS-18

Josef Cihlar
Canada Center for Remote Sensing
Energy Mines & Resources Canada
588 Booth Street, 4th floor
Ottawa, Ontario
K1A 0Y7 Canada
Phone: (613) 947-1265
FAX: (613) 947-1406
E-Mail: cihlar@ccrs.nrcan.gc.ca
Notes: TE-16, RSS-7

Jim Collatz
NASA/GSFC
Code 923
Greenbelt, MD 20771
Phone: (301) 286-1425
FAX: (301) 286-0239
E-Mail: jcollatz@biome.gsfc.nasa.gov
Notes: TE-4

Harry Cooper
Florida State University
Department of Meteorology
306 Love Building
Box 3034
Tallahassee, Florida 32306-3034
Phone: (904) 644-6716
FAX: (904) 644-9639
E-Mail: cooper@met.fsu.edu
Notes: RSS-14

Valerie K. Corey
NASA/GSFC
Code 923
Greenbelt, MD 20771
Phone: (301) 286-3720
FAX: (301) 286-0239
E-Mail: valerie@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Joseph Coughlan
NASA Ames NRC
MS 242-4
Moffett Fleld, CA 94035-1000
Phone: (415) 604-5689
FAX: (415) 604-4680
E-Mail: josco@vessna.arc.nasa.gov
Notes: TE-21, HYD-8

Marie R. Coyea
Centre de Recherch en Biologie
Forestiere
Faculte de Foresterie et Geomatique
Universite Laval
Ste-Foy Quebec
Phone: (418) 656-2131 x6546
FAX: (418) 656-3551
E-Mail: marie.coyea@sbf.ulaval.ca
Notes: TE-8

Timothy L. Crawford
NOAA-Atmospheric Turbulence
& Diffusion Division
456 S. Illinois Ave
PO Box 2456
Oakridge, TN 37831-2456
Phone: (615) 576-0452
FAX: (615) 576-1327
E-Mail: t29@stc10.ctd.ornl.gov
Notes: AFM-1,TF-5

Patrick M. Crill
Complex Systems
University of New Hampshire
EOS/MORSE
Durham, NH 03824-3525
Phone: (603) 862-3519
FAX: (603) 862-0188
E-Mail: patrick.crill@unh.edu
Notes: TGB-1

William L. Crosson
NASA/MSFC
Code ES42
Huntsville, Alabama 35812
Phone: (205) 544-8300
FAX: (205) 544-5760
E-Mail: bill.crosson@msfc.nasa.gov
Notes: RSS-14

Richard Cuenca
Bioresource Engineering Department
Oregon State University
Gilmore Hall 116
Corvallis, Oregon 97331-3906
Phone: (541) 737-6307
FAX: (541) 737-2082
E-Mail: cuencarh@pandora.bre.orst.edu
Notes: HYD-1

Shelaine L. Curd
NASA/GSFC
Code 923
Greenbelt, Maryland 20771
Phone: (301)286-2447
FAX: (301)286-0239
E-Mail: shelaine@ltpmail.gsfc.nasa.gov
Notes: US Staff

Paul Curran
Department of Geography
University of Southampton
Highfield
Southampton SO9 5NH
United Kingdom
Phone: (0703) 592259
FAX: (44) 0703 593295
E-Mail: ggcurran@uk.ac.southampton
Notes: RSS-4

Phillip Dabney
NASA/GSFC, Code 925
Greenbelt, Maryland 20771
Phone: (301) 286-9153
FAX: (301) 286-0239
E-Mail: pdabney@asas.gsfc.nasa.gov
Notes: RSS-2

Richard Dame
National Science Foundation
Ecosystem Studies
4201 Wilson Blvd
Arlington, VA 22230
Phone: (703) 306-1479
FAX: (703) 306-0367
E-Mail: rdame@nsf.gov
Notes: BCC

Qinglai Dang
NASA/GSFC
Code 923
Greenbelt, MD 20771
Phone: (301)286-0780
FAX: (301)286-0239
E-Mail: qdang@ltpmail.gsfc.nasa.gov
Notes:

Patricia F. Daugherty
Oak Ridge National Laboratory
PO Box 2008, Bldg. 0907
Mail Stop 6490
Oak Ridge, TN 37831
Phone: (615) 574-7817
FAX: (615) 574-4665
E-Mail: pvd@ornl.gov
Notes: ORNL/DAC

Eric A. Davidson
The Woods Hole Research Center
19 Church St.
Woods Hole, MA 02543
Phone: (508) 540-9900
FAX: (508) 540-9700
E-Mail: eadwhrc@mcimail.com
Notes: TGB-12

Robert (Bert) Davis
US Army Corps of Engineers
CRREL
72 Lyme Road
Hanover, NH 03755-1290
Phone: (603)646-4219
FAX: (603)646-4278
E-Mail: bert@hanover-crrel.army.mil
Notes: HYD-3

Bruce L. Deck
Scripps Institute of Ocean.
University of California, San Diego
La Jolla, CA 92093-0220

Phone: (619) 534-6248
FAX: (619) 534-0967
E-Mail: bdeck@ucsd.edu
Notes: TGB-6

Donald W. Deering
Code 923, Biospheric Sciences
NASA/GSFC
Greenbelt, MD. 20771

Phone: (301) 286-9186
FAX: (301) 286-0239
E-Mail: ddeering@ltpmail.gsfc.nasa.gov
Notes: RSS-1

Pierre-Yves Deschamps
Laboratoire d'Optique Atmospherique
Unversite de Lille 1
F-59655 Villeneuve d'Ascq,
FRANCE

Phone: 33 320 436 697
FAX: 33 320 434 342
E-Mail: deschamps@loa.univ-lillel.fr
Notes: TF-6

Raymond Desjardins
Centre for Land & Biological
Resource Research
Agriculture Canada, Bldg. 74
Ottawa, Ontario
K1A 0C6 Canada

Phone: (613) 759-1522
FAX: (613) 996-0646
E-Mail: ottres7.desjardinsr@em.agr.ca
Notes: TF-7, AFM-4, TE-16,AFM-13

Robert E. Dickinson
University of Arizona
Dept of Atmospheric Sciences
PAS Bldg. #81, Room 542
Tucson, AZ 85721

Phone: (602)621-2810
FAX: (602)621-6833
E-Mail: robted@air.atmo.arizona.edu
Notes: AFM-9

Ralph Dubayah
Department of Geography
1113 LeFrak Hall
University of Maryland
College Park, MD 20742

Phone: (301) 405-4069
FAX: (301) 314-9299
E-Mail: ralph_dubayah@umail.umd.edu
Notes: TE-17

Doug Dunlap
Earth observation Lab
Institute for Space & Terrestrial
Sciences
4850 Keele St., 2nd Floor
North York, Ontario

Phone: (416) 665-5411
FAX: (416) 665-2032
E-Mail: dunlop@ists.ists.ca
Notes: RSS-19

Laura L. East
U.S. BOREAS Office
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-3720
FAX: (301) 286-0239
E-Mail: lblasingame@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Tom Eck
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-6559
FAX: (301) 286-0239
E-Mail: teck@ltpmail.gsfc.nasa.gov
Notes: RSS-1, RSS-11

Grant Edwards
University of Guelph
School of Engineering
Guelph, Ontario
Canada N1G 2W1

Phone: (519) 824-3665
FAX: (519) 836-0227
E-Mail: gedwards@net2.eos.uoguelph.ca
Notes: TF-1

Geoffrey Edwards
Universite Laval
Sciences geodiques et teledetection
Ste.-Foy, Quebec
G1K 7P4
Canada

Phone: (418) 656-2553
FAX: (418) 656-7411
E-Mail: geoffrey.edwards@scg.ulaval.ca
Notes: TE-9

James Ehleringer
University of Utah
Department of Biology
Salt Lake City, UT 84112

Phone: (801) 581-7623
FAX: (801) 581-4665
E-Mail: ehleringer@bioscience.utah.edu
Notes: TE-5

Ted Engman
NASA/Goddard Space Flight Center
Code 974
Hydrological Sciences Branch
Greenbelt, MD 20771

Phone: (301) 286-5355
FAX: (301) 286-1758
E-Mail: tengman@neptune.gsfc..nasa.gov
Notes: HYD-9, RSS-16

Gunar Fedosejevs
CCRS
588 Booth Street
Ottawa, Ontario
K1A 0Y7 Canada

Phone: (613)947-1232
FAX: (613)947-1383
E-Mail: fedosejevs@ccrs.emr.ca
Notes: RSS-19

Motte Feldman
Centre for Land & Biological Research
Cental Experimental Farm
Agirculture and Agri-food Canada
Otawa, Ontario Canada K1A 0C6

Phone: (613)759-1847
FAX: (613)759-1924
E-Mail: feldmanmf@em.agr.ca
Notes:

Mike Fitzgerald
NASA/Ames Research Center
MS 240-6, Bldg. 240, Room 219
Moffett Field, CA 94035-1000

Phone: (415) 604-6252
FAX: (415) 604-4987
E-Mail: mfitz@msmail.arc.nasa.gov
Notes: MAS on ER-2

David Fitzjarrald
Atmospheric Sciences Res. Centre
S.U.N.Y.
100 Fuller Road
Albany, NY 12205

Phone: (518)442-3838
FAX: (518)442-3867
E-Mail: fitz@boojum.asrc.albany.edu
Notes: TF-8

Michael Fitzsimmons
Canadian Parks Service
P.O. Box 100
Waskesiu Lake, SK
20J 2Y0
Canada

Phone: (306)663-5322
FAX: (306)663-5424
E-Mail: none
Notes: PANP Manager

Larry Flanagan
Carleton University
Dept of Biology
1125 Colonel By Drive
Ottawa, Ontario
K1S 5B6 Canada
Phone: (613) 788-2600 ext 7549
FAX: (613) 788-4497
E-Mail: lflana@ccs.carleton.ca
Notes: TE-5

James L. Foster
NASA/GSFC
Code 974
Greenbelt, MD 20771
Phone: (301)286-7096
FAX: (301)286-1758
E-Mail: jfoster@glacier.gsfc.nasa.gov
Notes: RSS-8

Richard Fournier
Canadian Forest Service
Laurentian Forestry Centre
1055 rue du PEPS
Sainte-Foy, Quebec
Canada G1V 4C7
Phone: (418)648-4492
FAX: (418)648-5849
E-Mail: rfournier@cfl.forestry.ca
Notes: RSS-19

Jim Freemantle
Earth Observation Laboratory
Institute for Space and Terrestrial Science
4850 Keele Street
North York
Phone: (416) 665-5405
FAX: (416) 665-2032
E-Mail: freemant@eol.ists.ca
Notes: RSS-19

Steve Frolking
Complex Systems Research Center
Morse Hall
University of New Hampshire
Durham, NH 03824-3525
Phone: (603) 862-0244
FAX: (603) 862-0188
E-Mail: steve.frolking@unh.edu
Notes: TE-19

John A. Gamon
California State University, Los Angelos
Dept of Biology & Microbiology
5151 State University Drive
Los Angelos, CA 90032
Phone: (213)343-2066
FAX: (213)343-2670
E-Mail: jgamon@bio10sun.calstatela.edu
Notes: TE-4

Charles Garten
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6038
Phone: (615) 574-7355
FAX: (615) 576-8646
E-Mail: ctg@stc10.ctd.ornl.gov
Notes: ORNL/DAAC

Merilyn J. Gentry
417 South Chamberlain Avenue
Rockwood, TN 378854-2215
Phone: (423)376-2655
FAX:
E-Mail: mjg@ornl.gov
Notes: ORNL/DAAC

Marty Gibson
Keewatin Air
P.O. Box 1018
Thompson, MB
Canada R8N 1N7
Phone: (204) 677-3333
FAX: (204) 778-8572
E-Mail: none
Notes: NSA Contact

Narendra S. Goel
Wayne State University
Dept of Computer Science
431 State Hall
Detroit, MI 48202
Phone: (313) 577-6779
FAX: (313) 577-6868
E-Mail: ngoel@cs.wayne.edu
Notes: RSS-5

Prasad Gogineni
University of Kansas
Remote Sensing Laboratory
2291 Irving Hill Drive
Lawrence, KS 66045
Phone: (913) 864-7734
FAX: (913) 864-7789
E-Mail: gogineni@rsl.ukans.edu
Notes: RSS-13

Sara Kathrine Golightley
NASA Goddard Space Flight Center
Code 923
Greenbelt, MD 20771
Phone:
FAX: (301)286-0239
E-Mail: sgolight@pop900.gsfc.nasa.gov
Notes: TGB

Barry Goodison
Canadian Climate Centre
Atmosp. Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4 Canada
Phone: (416) 739-4345
FAX: (416) 739-5700
E-Mail: barry.goodison@ec.gc.ca
Notes: HYD-4

James Gosz
National Science Foundation
Div of Environmental Biology
4201 Wilson Blvd
Arlington, VA 22230
Phone: (703) 306-1480
FAX: (703) 306-0367
E-Mail: jgosz@nsf.gov
Notes: BCC

Michael Goulden
Harvard University
Engineering Sciences Laboratory
40 Oxford Street
Cambridge, MA 02138
Phone: (617) 496-4571
FAX: (617) 495-4902
E-Mail: mlg@io.harvard.edu
Notes: TF-3

Samuel N. Goward
University of Maryland
Department of Geography
1113 Le Frak Hall
College Park, MD 20742
Phone: (301) 405-4055
FAX: (301) 314-9299
E-Mail: SG21@umail.umd.edu
Notes: TE-17

Stith Tom Gower
Department of Forestry
University of Wisconsin
1630 Linden Drive
Madison, WI 53706
Phone: (608) 262-0532
FAX: (608) 262-9922
E-Mail: gower@calshp.cals.wisc.edu
Notes: TE-6

Patrick Grant
NASA/Ames Research Center
MS N-211-12
Moffett Field, CA 94035
Phone: (415) 604-5338
FAX: (415) 604-3885
E-Mail: pgrant@msmail.arc.nasa.gov
Notes: ER-2/MAS

Robert O. Green
JPL MS 11-116
4800 Oak Grove Drive
Pasadena, CA 91109

Phone: (818) 354-9136
FAX: (818) 393-4406
E-Mail: rog@gomez.jpl.nasa.gov
Notes: RSS-18

Dr. Florian E. Guertin
Director, Applications Division
CCRS
588 Booth Street, 3rd Floor
Ottawa, Ontario
K1A 0Y7 Canada

Phone: (613) 947-1356
FAX: (613) 947-1385
E-Mail: guertin@ccrs.nrcan.gc.ca
Notes:

Sophie Hale
Institute of Ecology & Resource Mgmt.
University of Edinburgh
Darwin Bldg., The King's Bldgs.
Edinburgh EH9 3JU
United Kingdom

Phone: 44 131 650 5398
FAX: 44 131 662 0478
E-Mail: s.hale@ed.ac.uk
Notes: TF-9

Peter J. Hall
Canadian Forest Service
Natural Resources Canada
351 St. Joseph Boulevard
Hull, Quebec
K1A 1G5 Canada

Phone: (819) 997-1107 ext.2006
FAX: (819) 994-3389
E-Mail: phall@am.ncr.forestry.ca
Notes: BCC

Dorothy K. Hall
NASA/Goddard Space Flight Center
Code 974
Greenbelt, MD 20771

Phone: (301) 286-6892
FAX: (301) 286-1758
E-Mail: dhall@glacier.nasa.gov
Notes: RSS-8

Forrest G. Hall
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-2974
FAX: (301) 286-0239
E-Mail: fghall@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff/TE-18

David Halliwell
Forestry Canada
5320-122 Street
Edmonton, Alberta
T6H 3S5 Canada

Phone: (403) 435-7267
FAX: (403) 435-7359
E-Mail: dhalliwe@nofc.forestry.ca
Notes: TE-13

Jennifer Harden
US Geological Survey
345 Middlefield Road
Mail Stop 962
Menlo Park, CA 94025

Phone: (415)329-4949
FAX: (415)329-4920
E-Mail: jharden@isdmnl.wr.usgs.gov
Notes: TGB-12

Richard Harding
Institute of Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford Oxfordshire
OX10 8BB United Kingdom

Phone: 44 1491 838800
FAX: 44 1491 832256
E-Mail: r.harding@ua.nwl.ac.uk
Notes: HYD-5

David J. Harding
NASA/GSFC
Code 921
Greenbelt, MD 20771

Phone: (301)286-4849
FAX:
E-Mail: harding@denali.gsfc.nasa.gov
Notes:

Janet P. Hardy
Geophysical Science Division
CRREL
72 Lyme Road
Hanover, NH 03755-1290

Phone: (603)646-4306
FAX: (603)646-4397
E-Mail: jhardy@crrel.usace.army.mil
Notes: HYD-3

Robert Harriss
NASA Headquarters
Code YS
300 E Street, N.W.
Washington, D. C. 20546

Phone: (202)358-2559
FAX: (202)358-2770
E-Mail: rharriss@mtpe.hq.nasa.gov
Notes: TE-19

D. R. Hastie
York University
Dept of Chemistry
4700 Keele Street
North York, Ontario
M3J 1P3 Canada

Phone: (416) 736-5388
FAX: (416) 736-5411
E-Mail: fs300071@sol.yorku.ca
Notes: TGB-9

Robert Hawkins
Canada Centre for Remote Sensing
Energy Mines & Resources Canada
3484 Lime Bank
Ottawa, Ontario
K1A OY7 Canada

Phone: (613) 998-9060
FAX: (613) 993-5022
E-Mail: hawkins@ccrs.emr.ca
Notes: Canadian Staff/RSS-7

David Henderson
CGCP
Royal Society of Canada
225 Metcalfe Street, #308
Ottawa, Onatario
Canada K2P 1P9

Phone: (613)991-5639
FAX: (613)991-6996
E-Mail: dhenders@rsc.ca
Notes:

Jean-Claude Henein
Canada Centre for Remote Sensing
Energy, Mines & Resources
588 Booth Street, 3rd Floor
Ottawa, Ontario
K1A 0Y7 Canada

Phone: (613) 947-1274
FAX: (613) 947-1385
E-Mail: henein@ccrs.emr.ca
Notes: BCC alternate

David D. Herring
NASA/Goddard Space Flight Center
Code 920.2
Greenbelt, MD 20771

Phone: (301)286-9515
FAX: (301)286-1757
E-Mail: herring@ltpmail.gsfc.nasa.gov
Notes:

Nick Hewitt
Institute of Environmental and
Biological Sciences
Lancaster University
Lancaster LA1 4YQ UK

Phone: 44 1524 593931
FAX: 44 1524 843854
E-Mail: n.hewitt@lancaster.ac.uk
Notes: TGB-10

Bruce B. Hicks
NOAA-Air Resources Laboratory
R/E/AR, SSMC3, Room 3151
1325 East West Highway
Silver Spring, MD 20910

Phone: (301) 713-0684
FAX: (301)713-0119
E-Mail: hicks@arlrisc.ssmc.noaa.gov
Notes: BCC

Anthony Hollingsworth
ECMWF
Shinfield Park
Reading RG2 9AX
England

Phone: 44 1734 499005
FAX: 44 1734 869450
E-Mail: anthony.hollingsworth@ecmwf.co.u
Notes: AFM-8

Andrea Jackson
Lancaster University
Institute of Env & Biological Sciences
Lancaster, United Kingdom
LA1 4YQ

Phone:
FAX:
E-Mail: a.jackson@lancaster.ac.uk
Notes: TGB-10

Stewart Hill
c/o MKO Natural Resources
Secretariat
23 Station Road
Thompson, Manitoba
R8N ON6 Canada

Phone: (204)778-4435
FAX: (204)778-7655
E-Mail:
Notes: MKO Contact

K. Fred Huemmrich
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: (301) 286-4862
FAX: (301) 286-0239
E-Mail: fred@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Anthony C. Janetos
NASA Headquarters
Code SEP03
300 E Street, SW
Washington, DC 20546

Phone: (202) 358-0272
FAX: (202) 358-3098
E-Mail: tjanetos@mtpe.hq.nasa.gov
Notes: NASA HQ

Gary B. Hodges
Florida State University
404 Love Bldg
Tallahassee, FL 32306-3034

Phone: (904) 644-2575
FAX: (904) 644-9639
E-Mail: hodges@met.fsu.edu
Notes: RSS-14

Alfredo Huete
University of Arizona
Dept of Soil and Water Sci.
429 Shantz, #38
Tucson, AZ 85721

Phone: (602) 621-3228
FAX: (602) 621-1647
E-Mail: swshuete@ccit.arizona.edu
Notes: RSS-8

Paul G. Jarvis
University of Edinburgh
Darwin Building, King's Bldgs.
Mayfield Road
Edinburgh, ST EH9 3JU
United Kingdom

Phone: 44 131 650 5426
FAX: 44 131 662 0478
E-Mail: SWilson@srv0.bio.edinburgh.ac.uk
Notes: TF-9

Dan J. Hodkinson
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: (301) 286-3621
FAX: (301) 286-0239
E-Mail: danhod@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Fred M. Irani
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-4545
FAX: (301) 286-0239
E-Mail: irani@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Michael Jasinski
Code 974
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: (301) 286-7099
FAX: (301) 286-1758
E-Mail: mike@hydromet.gsfc.nasa.gov
Notes: HYD-9

E.H. (Ted) Hogg
Forestry Canada
Northwest Region
5320 122 Street
Edmonton, Alberta
T6H 3S5 Canada

Phone: (403) 435-7225
FAX: (403) 435-7359
E-Mail: thogg@nofc.forestry.ca
Notes: TE-7

James R. Irons
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-8978
FAX: (301) 286-0239
E-Mail: jim_irons@gsfc.nasa.gov
Notes: RSS-2

Dennis E. Jelinski
Department of Forestry, Fish &
Wildlife
101 Plant Industry
Univ. of Nebraska-Lincoln
Lincoln, NE 68583-0814

Phone: (402) 472-9684
FAX: (402) 472-2964
E-Mail: jelinski@unlinfo.unl.edu
Notes: TF-10

Brent Holben
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-2975
FAX: (301) 286-0239
E-Mail: brent@kratmos.gsfc.nasa.gov
Notes: RSS-10, RSS-11

David Irvine
5060 Blacksmith Drive
Columbia, MD 21044-1304

Phone: (410)730-4655
FAX:
E-Mail: dirvine@erols.com
Notes:

John H. Jerome
Canada Centre for Inland Water
National Water Research Institute
867 Lakeshore Road, PO Box 50
Burlington, Ontario
CANADA L7R 4A6

Phone: (416) 336-4922
FAX: (416) 336-4972
E-Mail: john.jerome@cciw.ca
Notes: TE-15

Christopher O. Justice
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-7372
FAX: (301) 286-1775
E-Mail: justice@kratmos.gsfc.nasa.gov
Notes: RSS-8

Slava Kharuk
Sukachev Forest Institute
Russian Academy of Sciences
Acdemgorodok
Krasnoyarsk-36, 660036
Russia
Phone: 7 39 12 49 59 78
FAX: 7 39 12 27 15 78
E-Mail: morf@ifor.krasnoyarsk.su
Notes: TE-8

Robert G. Knox
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: (301) 286-4837
FAX: (301) 286-0239
E-Mail: knox@spruce.gsfc.nasa.gov
Notes: TE-20

Eugenia Kalnay
Development Division
NOAA/NWS/NMC
W/NMC2, WWB, Room 204
Washington, DC 20233

Phone: (301) 763-8005
FAX: (301) 763-8545
E-Mail: wd23ek@sun1.wwb.noaa.gov
Notes: AFM-11

Ken M. King
Dept of Land Resource Science
Ontario Agricultural College
University of Guelph
Guelph, Ontario
N1G 2W1 Canada
Phone: (519) 824-4120
FAX: (519) 824-5730
E-Mail: kking@lrs.uoguelph.ca
Notes: TF-1

Nicholas Kouwen
University of Waterloo
Dept of Civil Engineering
Waterloo, Ontario
N2L 3G1
Canada
Phone:
FAX: (519) 888-6197
E-Mail: kouwen@sunburn.uwaterloo.ca
Notes: HYD-9

Keith Kaminsky
NASA/GSFC
Code 923
Greenbelt, MD 20771

Phone: (301)286-3134
FAX: (301)286-0239
E-Mail: kaminsky@ltpmail.gsfc.nasa.gov
Notes: US Staff/TE-18

Clark King
National Oceanic & Atmospheric Admin.
Wave Propagation Laboratory
325 Broadway
Boulder, CO 80303
Phone: (303) 497-6381
FAX: (303) 497-6978
E-Mail: cwk@wpl.erl.gov
Notes: AFM-6

Terry Krauss
National Hydrology Research Centre
Saskatoon, Saskatchewan
S7N 3H5 Canada

Phone: (306)975-4215
FAX: (306) 975-5143
E-Mail: krausst@nhrisv.nhrc.sk.doe.ca
Notes: HYD-9

Yoram Kaufman
NASA/Goddard Space Flight Center
Code 913
Greenbelt, MD 20771

Phone: (301) 286-4866
FAX: (301) 286-1759
E-Mail: kaufman@climate.gsfc.nasa.gov
Notes: RSS-8, RSS-11

Timothy Kittel
Climate System Modeling Program
UCAR
Box 3000
1850 Table Mesa Drive
Boulder, CO 80307-3000
Phone: (303) 497-1606
FAX: (303) 497-1695
E-Mail: kittel@ncar.ucar.edu
Notes: AFM-12

Peter Lafleur
Dept of Geography
Trent University
Peterborough, Ontario
K9J 7B8
Canada
Phone: (705) 748-1487
FAX: (705) 748-1205
E-Mail: plafleur@trentu.ca
Notes: TF-10

Robert D. Kelly
University of Wyoming
Dept of Atmsopheric Science
P.O. Box 3038, Univ. Station
Laramie, WY 82071-3038

Phone: (307) 766-4955
FAX: (307) 766-2635
E-Mail: rkelly@coati.Uwyo.EDU
Notes: AFM-2,3, 11 BEX/BOG

David E. Knapp
NASA/GSFC
Code 923
Building 22, Room 222
Greenbelt, MD 20770

Phone: (301) 286-1424
FAX: (301) 286-0239
E-Mail: knapp@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

David R. Landis
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Phone: (301) 286-3349
FAX: (301) 286-0239
E-Mail: landis@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Yann Kerr
LERTS BPI 2801
18 Avenue E. Belin
Toulouse Cedex 31055
France

Phone: 33 61 55 85 22
FAX: 33 61 55 85 00
E-Mail: Yann.Kerr@cesbio.cnes.fr
Notes: TF-6

Roger Knowles
Dept of Microbiology
MacDonald College, McGill University
21111 Lakeshore Rd.
Ste. Anne de Bellevue, Quebec
H9X 3V9 Canada
Phone: (514) 398-7751
FAX: (514) 398-7990
E-Mail: eh13@musica.mcgill.ca
Notes: TGB-3

Robert Landry
CCRS
588 Booth Street, Room 459
Ottawa, Ontario
K1A 0Y7 Canada

Phone: (613) 947-1241
FAX: (613) 947-1385
E-Mail: landry@ccrs.emr.ca
Notes: RSS-19

Joe Landsberg
CSIRO Center for Environmental Mechanics
Black Mountain Laboratories
Canberra Act 2601
Australia
Phone: (616) 246-5604
FAX: (616) 246-5560
E-Mail: joe@python.enmech.csiro.au
Notes: SAG

Claude Lefrancois
Coordinator, Canadian Global Change Program c/o The Royal Society of Canada
PO Box 9734
Ottawa, Ontario, Canada K1G 5J4
Phone: (613)991-5641 or 5639
FAX: (613)991-6996
E-Mail: wcsrsc@carleton.ca
Notes: CBCC advisor

Zhanqing Li
Canada Centre for Remote Sensing
Energy Mines & Resources Canada
4th Floor, 588 Booth Street
Ottawa, Ontario
K1A OY7 Canada
Phone: (613) 947-1311
FAX: (613) 947-1406
E-Mail: li@ccrs.emr.ca
Notes: TE-16

Roger H. Lang
George Washington University
Dept of Elec. Engineering & Computer Science
Academic Center
Washington, DC 20052
Phone: (202) 994-6199
FAX: (202) 994-0227
E-Mail: lang@seas.gwu.edu
Notes: RSS-15, SAG

Don Lenschow
NCAR
1850 Table Mesa Drive
Boulder, CO 80307
Phone: (303) 497-8903
FAX: (303) 497-8181
E-Mail: lenschow@ncar.ucar.edu
Notes: AFM-3, AFM-11, AFM-2

Glenn Liston
NASA/GSFC
Hydrological Sciences Branch
Code 974
Greenbelt, MD 20771
Phone: (301) 286-3314
FAX: (301) 286-1758
E-Mail: yfgel@rootboy.gsfc.nasa.gov
Notes: HYD-2

Michael Lavigne
Forestry Canada, Maritimes Region
P.O. Box 4000
Fredericton, New Brunswick E3B 5P7
Canada
Phone: (506) 452-3384
FAX: (506) 452-3525
E-Mail: mlavigne@fcmr.forestry.ca
Notes: TE-7

Dennis P. Lettenmaier
University of Washington
Dept of Civil Engineering
164 Wilcox Hall, FX-10
Seattle, WA 98915
Phone: (206) 543-2532
FAX: (206) 685-3836
E-Mail: dennisl@u.washington.edu
Notes: HYD-9

Gerald P. Livingston
NASA/Ames Research Center
SGE 239.20
Moffett Field, CA 94035-1000
Phone: (415) 604-3232
FAX: (415) 604-4680
E-Mail: glivingston@qaia.arc.nasa.gov
Notes: RSS-12

Monique Leclerc
University of Georgia
Laboratory for Environmental Physics
Georgia Station
1109 Experiment Street
Griffin, GA 30123-7279
Phone: (770) 228-7279
FAX: (770)229-3215
E-Mail: mleclerc@gold.griffin.peachnet.edu
Notes: AFM-13

Don Letters
Environment Canada
10th Floor, Room 1000
266 Graham Avenue
Winnipeg, Manitoba
R3C 3V4 Canada
Phone: (204)983-4411
FAX:
E-Mail: lettersd@rpm2.mb.doe.ca
Notes: Canadian Staff

Lance Lockhart
University of Kansas
Remoste Sensing Laboratory
2291 Irving Hill Drive
Lawrence, KS 66045
Phone: 913/864-7734
FAX: (913) 864-7789
E-Mail: lockhart@rsl.ukans.edu
Notes: RSS-15

Robert Leconte
Universite du Quebec
Ecole de technologie superieure
4750 Avenue Henri-Julien
Montreal, Quebec
H2T 2C8 Canada
Phone: (514)289-899
FAX: (514) 289-1997
E-Mail: rleconte@ctn.etsmtl.ca
Notes: HYD-9

Joel S. Levine
NASA Langley Research Center
Hampton, VA 23665-5225
Phone: (804) 864-5692
FAX: (804) 864-6326
E-Mail: j.s.levine@larc.nasa.gov
Notes: TGB-5

Tom Loveland
EROS Data Center/USGS
Sioux Falls, SD 57198
Phone: (605) 594-6111
FAX: (605) 594-6589
E-Mail: loveland@edcsnw19.cr.usgs.gov
Notes: AFM-12

Ellsworth LeDrew
University of Waterloo
Earth-Observations Lab
Isaiah Bowman Building
Waterloo, Ontario
N2L 3G1 Canada
Phone: (519) 885-1211 x 2783
FAX: (519) 888-6768
E-Mail: ledrew@watdcs.uwaterloo.ca
Notes: RSS-19

Elissa R. Levine
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771
Phone: (301) 286-5100
FAX: (301) 286-0239
E-Mail: Elissa@lichen.gsfc.nasa.gov
Notes: TE-20

Ian MacPherson
NRC
Uplands Bldg. U-61
Ottawa, Ontario
K1A 0R6
Canada
Phone: (613) 998-3014
FAX: (613) 952-1704
E-Mail: ian.macpherson@nrc.ca
Notes: AFM-4, AFM-11, AFM-13,

Larry Mahrt
Oregon State University
Dept of Atmospheric Sciences
Corvallis, OR 97331-2209

Phone: (503) 737-5691
FAX: (503) 737-2540
E-Mail: mahrt@ats.orst.edu
Notes: AFM-11

Jonathan M. Massheder
Institute of Ecology & Resource Management
University of Edinburgh
Darwin Bldg., The King's Bldg.
Edinburgh EH9 3JU UK

Phone: 44 131 650 8746
FAX: 44 131 662 0478
E-Mail: j.massheder@ed.ac.uk
Notes: TF-9

Jeffrey McQueen
NOAA-Air Resources Lab (R/E/AR)
1325 East West Highway
Silver Spring, MD 20910

Phone: (301) 713-0295
FAX: (301) 713-0119
E-Mail: jeff@arlrise.ssmc.noaa.gov
Notes: BCC alternate

Hank Margolis
Centre de recherche en biologie forestiere
Pavillon Abitibi-Price
Universite Laval
Sainte-Foy, Quebec Canada G1K 7P4

Phone: (418) 656-2131 poste 7120
FAX: (418) 656-3551
E-Mail: Hank.Margolis@sbf.ulaval.ca
Notes: TE-9, TE-2, BCC, BEX/BOG

Pamela A. Matson
ESPM: Soil Science
108 Hilgard Hall
University of California, Berkeley
Berkeley, CA 94720

Phone: (510)643-9880
FAX: (510)643-5098
E-Mail: pamatson@nature.berkeley.edu
Notes: SAG

Mark Mesarch
University of Nebraska
107 L W Chase
Lincoln, NE 68583-0728

Phone: (402) 472-5904
FAX: (402) 472-6338
E-Mail: mmesarch@unlinfo.unl.edu
Notes: TE-12

Brian L. Markham
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-5240
FAX: (301) 286-0239
E-Mail: markham@highwire.gsfc.nasa.gov
Notes: RSS-11

Bonita B. Maxfield
NASA/GSFC/WFF
Flight Vehicles and Systems Section
Code 841.2
Wallops Island, VA 23337

Phone: (804)824-1082
FAX: (804)824-2415
E-Mail: bonnie_maxfield@ccmail.gsfc.nasa.g
Notes: NASA C130

Elizabeth Middleton
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-8344
FAX: (301) 286-0239
E-Mail: betsym@ltpmail.gsfc.nasa.gov
Notes: TE-10, RSS-1

Danny G. Marks
US Geological Survey
USEPA Environmental Research Laboratory
200 S.W. 35th Street
Corvallis, OR 97333

Phone: (503) 754-4484
FAX: (503) 754-4338
E-Mail: danny@heart.cor.epa.gov
Notes: HYD-9

J. Harry McCaughey
Queen's University
Dept of Geography
Kingston, Ontario
K7L 3N6
Canada

Phone: (613) 545-6035
FAX: (613) 545-6122
E-Mail: mccaughe@qucdn.queensu.ca
Notes: TF-10

John R. Miller
York University
Earth Observations Lab
4700 Keele Street
North York, Ontario
M3J 1P3 Canada

Phone: (416)665-5407
FAX: (416)665-2032
E-Mail: miller@eol.ists.ca
Notes: RSS-19, TE-15

Gerry F. Marsters
National Research Council
Bldg M13-A
Montreal Road Campus
Ottawa, Ontario
K1A 0R6 Canada

Phone: (613) 993-0141
FAX: (613) 952-7214
E-Mail: gerry.marsters@nrc.ca
Notes: BCC

Beth McCowan
NASA/GSFC
Code 923
Greenbelt, MD 20771

Phone: (301) 286-4005
FAX: (301) 286-0239
E-Mail: beth@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Karen D. Mitchell
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-3240
FAX: (301) 286-0239
E-Mail: karen@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Brooks Martner
NOAA/WPL
325 Broadway
Boulder, C 80303

Phone: (303) 497-6375
FAX: (303) 497-6978
E-Mail: bmartner@etl.noaa.gov
Notes: AFM-6

Kyle C. McDonald
Terrestrial Science Research Element
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109

Phone: (818) 354-3263
FAX: (818) 354-9476
E-Mail: kyle.mcdonald@jpl.nasa.gov
Notes: RSS-17

Mahta Moghaddam
MS 300-235
Jet Propulsion Lab
4800 Oak Grove Drive
Pasadena, California 91109

Phone: (818) 354-1591
FAX: (818) 393-6943
E-Mail: mahta@venice.jpl.nasa.gov
Notes: RSS-16

John B. Moncrieff
Institute of Ecology & Resource Mgmt.
University of Edinburgh
Darwin Building, Mayfield Road
Edinburgh, EH9 3JU
United Kingdom
Phone: 44 131 650 5402
FAX: 44 131 662 0478
E-Mail: j.moncrieff@ed.ac.uk
Notes: TF-9

Andrew Morse
Institute of Ecology & Resource Mgmt.
University of Edinburgh
Darwin Bldg., The King's Bldgs.
Edinburgh EH9 3JU
United Kingdom
Phone: 44 151 794 2879
FAX: 44 151 794 2866
E-Mail: apmorse@liverpool.ac.uk
Notes: TF-9

Tim A. Nerbas
Dept of Soil Science
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0 Canada
Phone: (306)966-4292
FAX: (306) 966-6881
E-Mail: nerbas@digger.usask.ca
Notes: TE-1

Russell Monson
Department of Environmental,
Population & Organismic Biology
University of Colorado
Campus Box 334
Boulder, CO 80309-0334
Phone: (303) 492-6319
FAX: (303) 492-8699
E-Mail: monsonr@colorado.edu
Notes: TGB-8

Jarvis Moyers
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
Phone: (703) 306-1522
FAX: (703) 306-0377
E-Mail: jmoyers@nsf.gov
Notes: BCC

Harold Neumann
Air Quality Processes Research
Division Atmospheric Env't Science
4905 Dufferin Street
Downsview, Ontario
M3H 5T4 Canada
Phone: (416) 739-4858
FAX: (416) 739-4224
E-Mail: hneumann@cid.aes.doe.ca
Notes: TF-2

Kathleen Moore
Atmospheric Science Research Center
SUNY
100 Fuller Road
Albany, NY 12205
Phone: (518) 442-3823
FAX: (518) 442-3867
E-Mail: moore@halfog.asrc.albany.edu
Notes: TF-8

Jan-Peter Muller
Department of Photogrammetry
and Surveying
University College London
Gower Street
London, England WC1E 6BT
Phone: 44 171 380 7227
FAX: 44 171 380 0453
E-Mail: jpmuller@ps.ucl.ac.uk
Notes: RSS-8

Jeffrey A. Newcomer
Hughes STX Corporation
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
Phone: (301) 286-7858
FAX: (301) 286-0239
E-Mail: newcomer@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Timothy R. Moore
McGill University
Dept of Geography Rm 513
805 Sherbrooke Street West
Montreal, Quebec
H3A 2K6 Canada
Phone: (514) 398-4112
FAX: (514) 398-7437
E-Mail: moore@felix.geog.mcgill.ca
Notes: TGB-3

J. William Munger
Harvard University
401 ESL; 40 Oxford Street
Cambridge, MA 02138
Phone: (617) 495-5361
FAX: (617) 495-9837
E-Mail: jwm@io.harvard.edu
Notes: TF-3

Jaime E. Nickeson
Code 923
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
Phone: (301) 286-3373
FAX: (301) 286-0239
E-Mail: jaime@ltpmail.gsfc.nasa.gov
Notes: U.S. Staff

Andy Moris
University of Liverpool
Department of Geography
P.O. Box 147
Liverpool L69 3BX
United Kingdom
Phone: 44 151 794 2879
FAX: 44 151 794 2866
E-Mail:
Notes:

Jeff Myers
Aircraft Data Facility
MS240-6
NASA Ames Research Center
Moffett Field, CA 94035-1000
Phone: (415)604-6252
FAX: (415)604-4987
E-Mail: jmyers@msmail.arc.nasa.gov
Notes:

Carey E. Noll
NASA/GSFC
Code 902.2
Greenbelt, MD 20771
Phone: (301) 286-9283
FAX: (301) 286-4943
E-Mail: NOLL@CDDIS.GSFC.NASA.GOV
Notes: BORIS/US Staff

Amy L. Morrell
Hughes/STX
NASA/GSFC
Code 923
Greenbelt, MD 20771
Phone: (301) 286-7544
FAX: (301) 286-0239
E-Mail: amy@ltpmail.gsfc.nasa.gov
Notes: BORIS, US Staff

Ranga B. Myneni
Department of Geography
Boston University
675 Commonwealth Avenue
Boston, MA 02215
Phone: (617) 353-5742
FAX: (617) 353-8399
E-Mail: rmyneni@crsa.bu.edu
Notes: RSS-6

John M. Norman
University of Wisconsin
Dept of Soil Science
1525 Observatory Drive
Madison, WI 53706-1299
Phone: (608) 262-4576
FAX: (608) 262-2658
E-Mail: norman@calshp.cals.wisc.edu
Notes: TE-6

Norman O'Neill
Cartel Universite de Sherbrooke
Sherbrooke, Quebec
J1K 2R1 Canada

Phone: (819)821-7956
FAX: (819)821-7944
E-Mail: noneill@magellan.geo.usherb.ca
Notes: RSS-19

Paula Pacholek
Prince Albert National Park
Box 100
Waskesiu Lake, SK
S0J 2Y0

Phone: (306)663-4529
FAX: (306)663-5424
E-Mail: tamarack@sk.sympatico.ca
Notes: Canadian Staff, BEX/BOG

David L. Peterson
NASA Ames Research Center
Mail Code 242-4
Moffett Field, CA 94035-1000

Phone: (415)604-5899
FAX: (415)604-4680
E-Mail: dpeterson@gaia.arc.nasa.gov
Notes: HYD-8, TE-21

Dennis S. Ojima
Natural Resource Ecology Laboratory
Colorado State University
Ft. Collins, CO 80523

Phone: (303) 491-1976
FAX: (303) 491-1965
E-Mail: dennis@saccharum.nrel.colostate.e
Notes: TGB-5

William Parton
Colorado State University
Natural Resource Ecology Lab.
Fort Collins, CO 80523

Phone: (303) 491-1987
FAX: (303) 491-1965
E-Mail: billp@nrel.colostate.edu
Notes: TF-11, TGB-5

Roger A. Pielke
Colorado State University
Dept of Atmospheric Science
Fort Collins, CO 80523

Phone: (303) 491-8293
FAX: (303) 491-8449
E-Mail: dallas@europa.atmos.colostate.edu
Notes: AFM-12

Keith Oleson
University of Colorado at Boulder
Campus 431
Boulder, CO 80309

Phone: (303)492-8868
FAX: (303)492-2825
E-Mail: oleson@frodo.colorado.edu
Notes: RSS-8

Elizabeth Pattey
Centre for Land & Biological Resource Research
Agriculture Canada, CEF, Bldg. 74
Ottawa, Ontario
Canada K1A 0C6

Phone: (613) 957-4347
FAX: (613) 996-0646
E-Mail: patteye@em.agr.ca
Notes: TF-7

Stephen Plummer
British National Space Centre
Remote Sensing Applications Develop. Unit
Monks Wood, Abbots Ripton
Cambridgeshire, England PE17 2LS

Phone: 44 1487 773381 x103
FAX: 44 1487 773277
E-Mail: s.plummer@nss.nerc.ac.uk
Notes: RSS-4

Steven Oncley
NCAR/ATD
P.O. Box 3000
Boulder, CO 80307-3000

Phone: (303) 497-8757
FAX: (303) 497-8770
E-Mail: oncley@ncar.ucar.edu
Notes: AFM-3,AFM-11

Eugene L. Peck
Hydex Corporation
2203 Lydia Place
Vienna, VA 22181

Phone: (703) 281-6284
FAX: (703) 281-6284
E-Mail: genepeck@aol.com.
Notes: HYD-6

Donald J. Pluth
University of Alberta
Dept Soil Science
Edmonton, Alberta
T6G 2E3
Canada

Phone: (403) 492-3417
FAX: (403) 492-1767
E-Mail: dpluth@gpu.srv.ualberta.ca
Notes: TE-1

Heather Osborne
SRC
15 Innovation Boulevard
Saskatoon, SK
Canada S7N 2X8

Phone: (306) 933-6759
FAX: (306) 933-7446
E-Mail: osborne@src.sk.ca
Notes: AFM-7

Derek R. Peddle
Earth-Observations Laboratory
Dept of Geography
University of Waterloo
Waterloo, Ontario
N2L 3G1 Canada

Phone: (519) 888-4567 x2689
FAX: (519) 888-6768
E-Mail: drp@wateol.uwaterloo.ca
Notes: RSS-19

Anthony Price
University of Toronto
Dept of Geography
100 St. George st.
Toronto, Ontario
M5S 1A1 Canada

Phone: (416)287-7327
FAX: (416)287-7283
E-Mail:
Notes: TE-21, HYD-8

Kristen Overturf-Mitchell
EPA-JSB
200 S.W. 35th Street
Corvallis, OR 97330

Phone: (503) 754-4480
FAX: (503) 754-4338
E-Mail: kristi@crystal.cor.epa.gov
Notes: HYD-9

Earl V. Petersen
NASA/Ames Research Center
Mail Stop 240-2
Moffett Field, CA 94035-1000

Phone: (415)604-6099
FAX: (415)604-4251
E-Mail: earlvpetersen@arc.nasa.gov
Notes: NASA DC-8, ER-2, C130

Stephen Prince
University of Maryland
Department of Geography
1113 LeFrak Hall
College Park, MD 20742-8225

Phone: (301) 405-4062
FAX: (301) 314-9299
E-Mail: sp43@umail.umd.edu
Notes: TE-17

Jeff Privette
University of Colorado
CB 431, Univ. of Colorado
Boulder, CO 80309

Phone: (303) 492-8868
FAX: (303) 492-2825
E-Mail: privette@frodo.colorado.edu
Notes: RSS-6

K. Jon Ranson
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-4041
FAX: (301) 286-0239
E-Mail: jon@taiga.gsfc.nasa.gov
Notes: RSS-15, RSS-2, TE-20

Gloria Rapalee
Woods Hole Research Center
P.O. Box 296
Woods Hole, MA 02543

Phone: (508)540-9900
FAX: (508)540-9700
E-Mail: grapalee@whrc.org
Notes: TGB-12

Mark Rayment
Institute of Ecology & Resource Mgmt.
University of Edinburgh
Rm. 313, Darwin Bldg., King's Bldgs.
West Mains Rd.
Edinburgh, UK EH9 3JU

Phone: 44 131 650 5423
FAX: 44 131 662 0478
E-Mail: m.rayment@ed.ac.uk
Notes: TF-9

Paul Rich
Biological Sciences - Haworth Hall
University of Kansas
Lawrence, KS 66045

Phone: (913) 864-7769
FAX: (913) 864-7789
E-Mail: prich@oz.kbs.ukans.edu
Notes: TE-23

Terry Ridgway
University of Waterloo
Dept. of Civil Engineering
Water Resources Group
Waterloo, Ontario, Canada N2L 3G1

Phone: (519) 885-1211 x3042
FAX: (519) 888-6197
E-Mail: terry@sunburn.uwaterloo.ca
Notes: HYD-9

Paul Ringold
EPA
RD-682
8401 M Street SW
Washington, DC 20460

Phone: (202) 260-5609
FAX: (202) 260-6370
E-Mail: none
Notes: BCC

Donald K. Rinker
NASA/GSFC
Code 923
Greenbelt, MD 20771

Phone: (301)286-0544
FAX: (301)286-0239
E-Mail: drinker@pop900.gsfc.nasa.gov
Notes: AFM

James Ritchie
Pebbledash Cottage
Corfe, Taunton
Somerset TA3 7AJ
England

Phone: 44 1823 421 434
FAX: 44 1823 421 434
E-Mail: jcr@aberystwyth.ac.uk
Notes:

Andy Roberts
NASA Ames Research Center
High Altitude Aircraft Branch
MS-240-6
Moffett Field, CA 94305

Phone: (415)604-5344
FAX: (405) 604-4987
E-Mail:
Notes: NASA Aircraft

B. N. Rock
University of New Hampshire
Complex Systems Research Center
Inst. for the Study of Earth
Durham, NH 03824

Phone: (603) 862-2949
FAX: (603) 862-1915
E-Mail: barryr@pyramid.unh.edu
Notes: TE-8

Jean-Louis Roujean
CNRM/METEO-FRANCE
42, Avenue Gustave Coriolis
31057 Toulouse Cedex
France

Phone: 33 61 07 93 43
FAX: 33 61 07 96 26
E-Mail: roujean@meteo.fr
Notes: TF-6

Nigel T. Roulet
Dept of Geography
McGill University
805 Sherbrooke St., West
Montreal, Quebec H3A 2K6 Canada

Phone: (514)398-4945
FAX: (514)398-7437
E-Mail: roulet@felix.geog.mcgill.ca
Notes: TGB-4

Alain Royer
CARTEL
Universite de Sherbrooke
Sherbrooke, Quebec
J1K 2R1
Canada

Phone: (819) 821-7961
FAX: (819) 821-7944
E-Mail: aroyer@courrier.usherb.ca
Notes: RSS-19

Steven W. Running
University of Montana
School of Forestry
Missoula, MT 59812

Phone: (406) 243-6311
FAX: (406) 243-4510
E-Mail: swr@ntsg.umt.edu
Notes: RSS-8; TE-21

Craig Russell
University of Guelph
Dept. of Land Resource Science
Guelph, Ontario, Canada N1G 2W1

Phone: (519)824-4120 x2452
FAX: (519) 824-5730
E-Mail: crussell@lrs.uoguelph.ca
Notes: TF-1

Carol A. Russell
Code 923, USRA
NASA/GSFC
Greenbelt, MD 20771

Phone: (301) 286-9416
FAX: (301) 286-0239
E-Mail: car@quartz.gsfc.nasa.gov
Notes: RSS-2

Philip B. Russell
NASA/Ames Research Center
Mail Stop 245-5
Moffett Field, CA 94035

Phone: (415) 694-5405
FAX: (415) 604-3625
E-Mail: philip_russell@qmgate.arc.nasa.gov
Notes: RSS-12

Michael G. Ryan
U.S. Department of Agriculture
Rocky Mountain Experiment Station
240 W. Prospect Rd.
Ft. Collins, CO 80526-2098

Phone: (303) 498-1012
FAX: (303) 498-1010
E-Mail: mryan@lamar.colostate.edu
Notes: TE-2

Steve Scott
Institute of Ecology & Resource Mgmt.
University of Edinburgh
Darwin Bldg., The King's Bldgs.
Edinburgh EH9 3JU
United Kingdom
Phone: 44 131 650 5398
FAX: 44 131 662 0478
E-Mail: s.scott@srv0.bio.ed.ac.uk
Notes: TF-9

Mac Sinclair
National Research Council Canada
Flight Research Laboratory
Uplands Bldg. (U-61)
Ottawa, Ontario
Canada K1A 0R6
Phone: (613) 998-3071
FAX: (613) 952-1704
E-Mail: mac.sinclair@nrc.ca
Notes: BCC alternate

Sasan S. Saatchi
JPL/California Institute of Technology
4800 Oak Grove Dr.
Mail Stop 300-243
Pasadena, CA 91109

Phone: (818) 354-1051
FAX: (818) 393-6943
E-Mail: saatchi@bacchus.jpl.nasa.gov
Notes: RSS-16

David Seburn
Northern Forestry Centre
5320 122 Street
Edmonton, AB
T6H 3S5 Canada

Phone: (403) 435-7296
FAX: (403) 435-7359
E-Mail: dseburn@nofc.forestry.ca
Notes: Canadian Staff

Robert E. Slye
NASA/Ames Research Center
MS 242-4
Moffett Field, CA 94035-1000

Phone: (415) 604-6031
FAX: (415) 604-4680
E-Mail: buzz@meadow.arc.nasa.gov
Notes: RSS-12

Bernard Saugier
Laboratoire d'Ecologie Vegetale
Universite Paris-Sud
Orsay Cedex
France

Phone: 33 1 69 41 79 61
FAX: 33 1 69 41 72 38
E-Mail: saugier@psisun.u-psud.fr
Notes: TE-11

Piers J. Sellers
NASA/Johnson Space Center
Mail Code CB
Houston, TX 77058

Phone: (713) 244-8855/8821
FAX: (713) 244-8873
E-Mail: psellers@ems.jsc.nasa.gov
Notes: AFM-14, TE-18

Lowell Smith
8401
U.S. EPA
401 M Street SW
Washington, DC 20460

Phone: (202) 260-5717
FAX: (202) 260-6370
E-Mail: smith.lowell@epamail.epa.gov
Notes: BCC

Jeff Schoenau
University of Saskatchewan
Dept of Soil Science
Saskatoon, Saskatchewan
S7N 0W0
Canada
Phone: (306) 966-6844
FAX: (306) 966-6881
E-Mail: none
Notes: TE-1

Gary Shelton
NASA/Ames Research Center
Mail Stop 240-6
Moffett Field, CA 94035

Phone: (415) 604-5344
FAX: (415) 604-4987
E-Mail: gashelton@nasamail.nasa.gov
Notes: NASA ER-2

Eric A. Smith
Florida State University
Department of Meteorology
306 Love Building
Tallahassee, FL 32306-3034

Phone: (904) 644-4253
FAX: (904) 644-9639
E-Mail: esmith@metsat.met.fsu.edu
Notes: RSS-14

Peter Schuepp
Dept of Renewable Resources
McGill University
2111 Lakeshore Road
Ste Anne de Bellevue, Quebec
H9X 1C0 Canada
Phone: (514) 398-7935
FAX: (514) 398-7983
E-Mail: pschuepp@nrs.mcgill.ca
Notes: AFM-13, TF-7

Stanley R. Shewchuk
Atmospheric Sciences Section
Sask. Research Council
15 Innovation Blvd.
Saskatoon, Saskatchewan
Canada S7N 2X8
Phone: (306) 933-5437
FAX: (306) 933-7817
E-Mail: shewchuk@src.sk.ca
Notes: AFM-7

Richard Snell
Natural Sciences and Engineering
Research Council of Canada
350 Albert St., Tower 2
Ottawa, Ontario
K1A 1H5 Canada
Phone: (613) 996-4148
FAX: (613) 992-5337
E-Mail: rrs@nserc.ca
Notes: BCC Observer

Christi Scofield
NASA/Ames Research Center
Mail Stop 211-12
Moffett Field, CA 94035-1000

Phone: (415)604-4599
FAX: (415) 604-3885
E-Mail: scofield@msmail.arc.nasa.gov
Notes: NASA DC8, C130

Herman H. Shugart
University of Virginia
Clark Hall
Dept of Environmental Sciences
Charlottesville, VA 22903

Phone: (804) 924-7761
FAX: (804) 982-2137
E-Mail: hhs@virginia.edu
Notes: TE-22

Ric Soulis
University of Waterloo
Dept of Civil Engineering
Waterloo, Ontario
N2L 3G1
Canada
Phone: (519) 885-4567 x 2175
FAX: (519) 888-6197
E-Mail: ric@sunburn.uwaterloo.ca
Notes: HYD-9

Michael Spanner
Johnson Controls
NASA/Ames Research Center
M/S 242-4
Moffett Field, CA 94035

Phone: (415) 604-3620
FAX: (415) 604-4680
E-Mail: mike_spanner@sggate.arc.nasa.gov
Notes: RSS-12

Karl Spence
Nelson House First Nation
Nelson House, Manitoba
R0B 1A0
Canada

Phone: (204) 484-2332
FAX: (204) 484-2392
E-Mail:
Notes: NSA Contact

Shannon Spencer
University of New Hampshire
Morris Hall
CSRC
Durham, New Hampshire 03824

Phone: (603)862-4311
FAX: (603)862-0188
E-Mail: shannon@garnet.unh.edu
Notes: TE-8

Gerald St-Amour
Centre for Food & Animal Research
Agricutlure Canada, CEF, Bldg. 94
Ottawa, Ontario
Canada K1A 0C6

Phone: (613) 957-4347
FAX: (613) 995-3845
E-Mail: none
Notes: TF-7

Jean-Claude St-Pierre
Central Experimental Farm
930 Carling Ave., Rm. 715
Sir John Carling Building
Ottawa, Ontario
K1A 0C5 Canada

Phone: (613) 995-7084 X 7146
FAX: (613) 943-0440
E-Mail:
Notes: BCC

Karl Staenz
Canada Centre for Remote Sensing
Energy, Mines & Resources
588 Booth Street
Ottawa, Ontario
K1A 0Y7 Canada

Phone: (613) 947-1250
FAX: (613) 947-1383
E-Mail: staenz@ccrs.emr.ca
Notes: RSS-19

Pam Stephens
Large Scale Meteorology
National Science Foundation
Atmospheric Sciences Division
4201 Wilson Boulevard
Arlington, VA 22230

Phone: (703) 306-1522
FAX: (703) 306-0377
E-Mail: pstephen@nsf.gov
Notes: BCC alternate

Robert B. Stewart
Canadian Forest Service
Natural Resources Canada
580 Booth Street, 7th Floor
Ottawa, Ontario
Canada K1A 0Y7

Phone: (613)947-9014
FAX: (613)947-9035
E-Mail: rstewart@am.ncr.forestry.ca
Notes: BCC alternate

Louis T. Steyaert
NASA/Goddard Space Flight Center
Code 923, Room 315X
Greenbelt, MD 20771

Phone: (301) 286-2111
FAX: (301) 286-0239
E-Mail: steyaert@ltpmail.gsfc.nasa.gov
Notes: AFM-12

Brian J. Stocks
Canadian Forest Service-Ontario Region
Great Lakes Forestry Centre
1219 Queen St. East
Sault Ste Marie, Ontario, Canada P6A

Phone: (705) 949-9461
FAX: (705) 759-5700
E-Mail: stocks@fcor.glfc.forestry.ca
Notes: TGB-5

John Stone
Climate Research Branch
Atmopsheric & Environ. Service
Le Terrases de la Chaudiere
10 Wellington St., 5th Floor
Hull, Quebec Canada K1A 0H3

Phone: (819) 997-3805
FAX: (819) 994-8854
E-Mail: stonej@ncrsv2.am.doe.ca
Notes: BCC

Alan Strahler
Boston University
Center for Remote Sensing
725 Commonwealth Avenue
Boston, MA 02215

Phone: (617) 353-5984
FAX: (617) 353-3200
E-Mail: alan@bu.edu
Notes: RSS-8

Robert Striegl
US Geological Survey
PO Box 25046 MS 413
Denver, CO 80225

Phone: (303) 236-4993
FAX: (303) 236-5034
E-Mail: rstriegl@swampgas.cr.usgs.gov
Notes: TF-4

Murray Strome
Natural Resources Canada
Canadian Forest Service
Victoria, British Columbia
V8Z 1M5 Canada

Phone: (604) 363-0705
FAX: (604) 363-6004
E-Mail: mstrome@sylvanus.pfc.forestry.ca
Notes: RSS-9

Joseph H. Sullivan
University of Maryland
Department of Botany
College Park, Md 20742

Phone: (301) 405-1626
FAX: (301) 314-9082
E-Mail: botn9@umdd.umd.edu
Notes: TE-10

Guoqing Sun
NASA/GSFC Code 923
Greenbelt, MD 20771

Phone: (301) 286-2485
FAX: (301) 286-0239
E-Mail: guoqing@tundra.gsfc.nasa.gov
Notes: RSS-15

Jielun Sun
PAOS
University of Colorado
Campus Box 311
Boulder, CO 80309-0311

Phone: (303)497-8994
FAX: (303)497-8171
E-Mail: sun@ats.orst.edu
Notes: AFM-11

Eric Sundquist
US Geological Survey
Quissett Camplus
Woods Hole, MA 02543

Phone: (508) 457-2397
FAX: (508) 457-2310
E-Mail: esundqui@nobska.er.usgs.gov
Notes: TGB-12

Doug Sutton
40 Oxford Street, 4th Floor
Harvard University
Cambridge, MA 02138

Phone: (617) 496-4571
FAX: (617)495-5361
E-Mail: djs@io.harvard.edu
Notes: TF-3

Keith Thomson
Universite Laval
Faculte des Sciences Geodesiques
Pavillon CASULT
Ste.-Foy, Quebec
G1K 7P4 Canada
Phone: (418) 656-2645
FAX: (418) 656-7411
E-Mail: keith.thomson@scg.ulaval.ca
Notes: TE-9

George Thurtell
University of Guelph
Dept of Land Resource Science
Guelph, Ontario
N1G 2W1
Canada
Phone: (519) 824-4120
FAX: (519) 824-5730
E-Mail: gthurtel@lrs.uoguelph.ca
Notes: TF-1

Gillian Traynor
Canada Centre for Remote Sensing
Energy, Mines & Resources
588 Booth Street, 4th Floor
Ottawa, Ontario
K1A OY7 Canada
Phone: (613) 947-1292
FAX: (613) 947-1406
E-Mail: traynor@ccrs.emr.ca
Notes: Canadian Staff

Susan Trumbore
University of California, Irvine
Department of Earth System Science
Irvine, CA 92717-3100

Phone: (714) 824-6142
FAX: (714) 824-3256
E-Mail: setrumbo@uci.edu
Notes: TGB-12

Robert Turner
Oak Ridge National Laboratory
Mail Stop 6038
PO Box 2008
Oak Ridge, TN 37831-6038

Phone: (615) 574-4175
FAX: (615) 574-8646
E-Mail: rtt@ornl.gov
Notes: ORNL-DAAC

Frank Ullman
Dept. Electrical Engineering
University of Nebraska
Lincoln, NE 68588-0511

Phone: (402)472-6614
FAX: (402)472-4732
E-Mail: eerdfgu@engvms.unl.edu
Notes: TF-11

Stephen G. Ungar
NASA/GSFC
Code 923
Greenbelt, MD 20771

Phone: (301) 286-4007
FAX: (301) 286-0239
E-Mail: ungar@highwire.gsfc.nasa.gov
Notes: U.S. Staff

Michael Unsworth
Center for Analysis of Env. Change
Oregon State University
Weninger Hall, Room 283
Corvalis, OR 97331-6511

Phone: (503) 737-1744
FAX: (503) 737-3399
E-Mail: unswortm@ucs.orst.edu
Notes: SAG

Vern Vanderbilt
NASA Ames Research Center
Mail Stop 242-2
Moffett Field, CA 94035-1000

Phone: (415) 604-4254
FAX: (415) 604-4680
E-Mail: vern_vanderbilt@qmgate.arc.nasa.g
Notes: RSS-20,TF-6

Thierry Varem-Sanders
Northern Forestry centre
5320-122 Street
Edmonton, Alberta
T6H 3S5 Canada

Phone:
FAX:
E-Mail: tvarem@nofc.forestry.ca
Notes: TE-7

Hugo Veldhuis
Agriculture and Agri-Food Canada
Centre for Land & Biological Res. Research
Rm. 362, Ellis Bldg.
Winnipeg, Manitoba
Phone: (204)474-6124
FAX: (204)275-5817
E-Mail:
Notes: Soils

Shashi B. Verma
University of Nebraska
Dept. of Agric. Meteorology
244 L.W. Chase Hall
P.O. Box 830728
Lincoln, NE 68583-0728
Phone: (402) 472-6702
FAX: (402) 472-6614
E-Mail: agme009@unlvm.unl.edu
Notes: TF-11

Eric Vermote
NASA/Goddard Space Flight Center
Code 923
Greenbelt, MD 20771

Phone: (301) 286-6232
FAX: (301) 286-3221
E-Mail: eric@kialmos.gsfc.nasa.gov
Notes: RSS-11

Diana Verseghy
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario
M3H 5T4
Canada
Phone: (416) 739-4422
FAX: (416) 739-5700
E-Mail: dverseghy@cid.aes.doe.ca
Notes: AFM-15

Alain Viau
Department of Geography
University of Laval
1351 Pavillion Casault
Sainte-Foy, Quebec
J1K 7P4 Canada
Phone: (418) 656-2530
FAX: (418) 656-7411
E-Mail: alain.viau@scg.ulaval.ca
Notes: TE-9, TE-2

Pier Luigi Vidale
Dept. Atmospheric Sciences, Offices 224
Colorado State University
Fort Collins, CO 80523

Phone: (303) 491-8318
FAX: (303) 491-8449
E-Mail: vidale@homebrew.atmos.colostate.
Notes: AFM-12

Pedro Viterbo
ECMWF
Shinfield Park
Reading, Berkshire
RG2 9AX United Kingdom

Phone: 44 1734 499 734
FAX: 44 1734 869 450
E-Mail: p.viterbo@ecmwf.int
Notes: AFM-8

Chris Vogel
NOAA
Turbulence and Diffusion Division
Oak Ridge, TN

Phone: (615) 576-1236
FAX: (615) 576-1327
E-Mail: vc3@stc06.ctd.ornl.gov
Notes: TF-5

Anne Walker
Environmental Scientist
Canadian Climate Centre
4905 Dufferin Street
Downsview, Ontario
M3H 5T4 Canada
Phone: (416) 739-4357
FAX: (416) 739-5700
E-Mail: walkera@aestor.am.doe.ca
Notes: HYD-4

JoBea Way
Jet Propulsion Laboratory
Mail Stop 300-233
4800 Oak Grove Drive
Pasadena, CA 91109

Phone: (818) 354-8225
FAX: (818) 354-9476
E-Mail: way@lor.jpl.nasa.gov
Notes: RSS-17

Jason Vogel
Department of Forestry
1630 Linden Drive
University of Wisconsin
Madison, WI 53706

Phone: (608)262-6369
FAX: (608)262-9922
E-Mail: vogel@calshp.cals.wisc.edu
Notes: TE-6

Elizabeth Walter-Shea
University of Nebraska
Dept of Agricultural Meteorology
246 LWC
Lincoln, NE 68583-0728

Phone: (402) 472-1553
FAX: (402) 472-6614
E-Mail: agme012@unlvm.unl.edu
Notes: TE-12

Hal Westberg
Civil Environment Engineering Dept
Washington State University
Pullman, WA 99164

Phone: (509) 335-1529
FAX: (509) 335-7632
E-Mail: westberg@mail.wsu.edu
Notes: TGB-10

Larry D. Voorhees
Oak Ridge National Laboratory
PO Box 2008, MS 6490
Oak Ridge, TN 37831-6490

Phone: (615)574-7817
FAX: (615)574-4665
E-Mail: ldv@ornl.gov
Notes: ORNL/DAAC

Charles Walthall
USDA/ARS
Remote Sensing Research Laboratory
BARC West
Building 007, Room 116
Belstville, MD 20705
Phone: (301)504-6074
FAX: (301) 314-9299
E-Mail: cwalthal@asrr.arsusda.gov
Notes: RSS-3, RSS-2

Charles Whitlock
NASA/Langley Research Center
Mail Stop 420
Hampton, VA 23681-0001

Phone: (804) 864-5675
FAX: (804) 864-7996
E-Mail: c.h.whitloc@larc.nasa.gov
Notes: RSS-14

Paul Voroney
Dept of Land Resource Science
University of Guelph
Guelph, Ontario
N1G 2W1
Canada
Phone: (519)824-4120 X3057
FAX: (519)824-5730
E-Mail: pvoroney@lrs.uoguelph.ca
Notes: TF-1

Zhengming Wan
Computer System Lab/CRSEO
University of California, Santa
Barbara
Santa Barbara, CA 93106-3060

Phone: (805) 893-4541
FAX: (805) 893-2578
E-Mail: wan@icess.ucsb.edu
Notes: RSS-8

Diane E. Wickland
Terrestrial Ecology Program
NASA Headquarters
Code YSE
300 E Street, SW
Washington, DC 20546
Phone: (202) 358-0272
FAX: (202) 358-2771
E-Mail: Diane.Wickland@hq.nasa.gov
Notes: BCC

Martin Wahlen
University of California, San Diego
Scripps Institution of Oceanography
LaJolla, CA 92093-0220

Phone: (619) 534-0828
FAX: (619) 534-0967
E-Mail: mwahlen@ssurf.ucsd.edu
Notes: TGB-6

James R. Wang
NASA/Goddard Space Flight Center
Code 975
Greenbelt, MD 20771

Phone: (301)286-8949
FAX: (301)286-1761
E-Mail: wang@sensor.gsfc.nasa.gov
Notes: HYD-2

James Wilczak
NOAA/WPL
325 Broadway R/E/WP7
Boulder, CO 80303

Phone: (303) 497-6245
FAX: (303) 497-6978
E-Mail: jmw@wpl.erl.gov
Notes: AFM-6

Don Waite
Environment Canada
Room 300, Park Plaza
2365 Albert Street
Regina, Saskatchewan
S4P 4K1 Canada
Phone: (306) 780-6438
FAX: (306) 780-6466
E-Mail: waited@regina.wxe.sk.doe.ca
Notes: TGB-7

Jeffrey Watson
Director, Canadian Global Change
Program
c/o The Royal Society of Canada
225 Metcalfe St., #308
Ottawa, Ontario, Canada
Phone: (613)991-5641
FAX: (613)991-6996
E-Mail: jwatson@rsc.ca
Notes: CBCC advisor

Darrel Williams
NASA/Goddard Space Flight Center
Biosphric Sci. Brch
Research/EOS Dept
Code 923
Greenbelt, MD 20771
Phone: (301) 286-8860
FAX: (301) 286-0239
E-Mail: darrel@ltpmail.gsfc.nasa.gov
Notes: RSS-6, RSS-3

Greg Winston
US GeologicalSurvey
Quissett Campus
Woods Hole, MA 02543

Phone: (503) 457-2331
FAX: (503) 457-2310
E-Mail: gwinston@nobska.er.usgs.gov
Notes: TE-3

Steven Wofsy
Harvard University
Pierce Hall
29 Oxford Street
Cambridge, MA 02138

Phone: (617) 495-4566
FAX: (617) 495-9837
E-Mail: scw@io.harvard.edu
Notes: TF-3

Eric Wood
Princeton University
Dept of Civil Engineering
E-Quad, Olden St. Rm E-330
Princeton, NJ 08544

Phone: (609) 258-4675
FAX: (609) 258-1270
E-Mail: efwood@pucc.princeton.edu
Notes: HYD-8, TE-21

Valerie L. Young
York University
Centre for Atmospheric Chemistry
006A Steacie Science Library
North York, Ontario
M3J 2Z3 Canada

Phone: (416)736-5410
FAX: (416)736-5411
E-Mail: fs300540@sol.yorku.ca
Notes: TGB-9, TF-7

Anthony Young
Hughes STX
NASA/GSFC
Code 923
Greenbelt, MD 20771

Phone: (301) 286-1272
FAX: (301) 286-0239
E-Mail: young@boreas.gsfc.nasa.gov
Notes: U.S. Staff

Richard G. Zepp
Environmental Protection Agency
Environmental Research Laboratory
College Station Road
Athens, GA 30613

Phone: (706) 355-8117
FAX: (706) 355-8104 (706)
E-Mail: zepp.richard@epamail.epa.gov
Notes: TGB-5

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

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

Please make sure the following is clearly indicated on your packages: the BOREAS project name, the P.I. name, and the team number. See section three of this appendix (B.2) for names and addresses of shipping destinations. **NO** C.O.D. shipments!

If you are originating in the States, 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 may want proof that foreign-made items were with you when you departed. This can be done easily ahead of time by either taking your equipment or proof of ownership to your local customs office . If you do not take the equipment, the papers you take to customs must include the manufacturer's serial number. The form you need is customs form 4455 and is called a certificate of registration. If your equipment is not registered, your shipping document, with serial numbers, may be enough proof to show that you are returning to the U.S. only with equipment you took with you to Canada.

Be prepared to pay duties on equipment purchased in Canada when totals exceed $400.

OPTIONS FOR 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 equipment

  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.

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 0239
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.

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

Goddard Space Flight Center
Greenbelt, Maryland
20771

NASA

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

B.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. **Note** that the depot for field equipment at the NSA is on the north side of the runway, opposite the terminal.

Field Equipment
BOREAS Project
Government Air Services Branch
Thompson Airport
North Hangar Rd.
Thompson, Manitoba
CANADA R8N 1X4
ATTN: Charlie Wilson
(204) 677-6476 or
Jeff Tilling
(204) 677-6475

Lab Equipment
BOREAS Project
Heritage North Museum
162 Princeton Drive
Thompson, Manitoba
CANADA R8N 2A4
ATTN: Linda Garvey
(204) 677-2216

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
ATTN: Bob Stevenson
Home: (306) 989-2142
or... Jim Bruce
Shop: (306) 763-2323
Office: (306) 764-1511
Home: (306) 922-3054

Contact with these people prior to shipping would be advisable and is required for large shipments. Make sure your carrier will off-load such items as directed by Bob or Jim. Please be courteous and take time differences into account when calling these people at home.

Geomantics Canada | Géomantique Canada

Canada Centre for Remote Sensing | Centre canadien de télédétection

588 Booth Street
Ottawa, Canada
K1A QY7

588, rue Booth
Ottawa (Canada)
K1A QY7

To whom it 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, with participants from United Kingdom, France and other countries, 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. Canada Centre for Remote Sensing of Natural Resources Canada is the administering agency for the Canadian Government.

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. Participants are to be documented on employment authorizations and are exemt from the validation process [R20(5)(bb)(i)-B-10]. Immigration documentation fees (i.e., work permits) will be waived for persons working on BOREAS [as per IS 27-Annex 5]. An **Operations Memorandum** (OM PE95-06) has been posted by Citizenship and Immigration. These provisions are to be applied to Dr. Piers J. Sellers'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,

Florian Guertin
Director, Application Division

Canada

The National Surveys, Mapping and Remote Sensing Organization, Natural Resources Canada

L'organisme national des levés, de la cartographie et de la télédétection, Ressources naturelles Canada

B.3 Immigration Formalities

The agreement signed between Canada and the United States for BOREAS is still in place but was not reproduced for this version as it is not necessary that you have the document on your person.

All U.S. PI's should have received a '**letter of invitation**' like the example on the following page. This letter explains how BOREAS participants are exempted from fees for permits, etc. This letter should be shown to the first person you encounter at customs. The customs officer will direct you to the Immigration officer to fill out the required Employment Authorization Permit (also called temporary entry to Canada) which is valid for six months. These are computer-generated and should not take you long to complete. Please note that you **must** fill out the form and there may be a line for processing the information.
An Operations Memorandum from Immigration Canada - Port of Entry Control - was sent out to pertinent points of entry informing them of BOREAS and explaining exemptions for participants.

If you have not received your 'letter of invitation', contact Gill Traynor at the BOREAS Secretariat (613) 947-1292. PI's should copy this letter and attach a personal letter for a persons working under them and traveling to Canada. Such a letter will extend all provisions to the named persons, as stated in the last paragraph of your letter.

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.

<u>All Citrus and Citrus relatives are prohibited.</u>

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)*

*See page 3.

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

(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) (<u>Rubus</u>) 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 <u>Rubus</u> stunt agent based on visual examination and indexing of the parent stock.

(14) (<u>Prunus</u>) 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. <u>Prunus</u> seeds in the subgeneus Cerasus require certification that plum box (Sharka) virus does not occur in the country where the seed was grown.

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

(16) (<u>Allium sativum</u>) Bulbs require a written permit.

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

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 <u>not</u> 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. 1977-720-355/3251

Agriculture Canada

APPLICATION FOR EXPORT INSPECTION AND PHYTOSANITARY CERTIFICATION

DEMANDE D'INSPECTION DES EXPORTATIONS ET DE CERTIFICATION PHYTOSANITAIRE

Food Production and Inspection Branch — Direction générale Production et inspection des aliments

PART I - PARTIE I

Ultimate country of destination - Pays ultime de destination	Required date for inspection - Date requise pour l'inspection
Name and Address of Exporter - Nom et adresse de l'exportateur	Name and Address of Legal Owner (if different from the Exporter) Nom et adresse du propriétaire légal (si différent de l'exportateur)
Name and Address of the importer - Nom et adresse de l'importateur	Inspection site and address - Lieu d'inspection et adresse
Number and description of package - Nombre et nature des colis	Distinguishing marks of packages (where applicable) Marques distinctives des colis (s'il y a lieu)
Area of production - Lieu de production	Declared means of conveyance - Moyen de transport déclaré
Declared Loading Port - Port de chargement	Declared point of entry - Point d'entrée déclaré

Name of produce, quantity declared and botanical name of produce - Nom du produit quantité déclarée et le nom botanique du produit

Declared end use of product - Utilisation ultime du produit

consumption / consommation ☐ propagation / propagation ☐ other / autres ☐ ____________

Applicant's Name (printed) - Nom du requérant (imprimer)	Title - Titre	Telephone - Téléphone
Signature	Date	

Additional Information or Instructions:

B.4 Importation of Plant and Soil Samples

Please note that the USDA Plant Protection and Quarantine Programs Office has moved from the Federal Building in Hyattsville, to the following address:

U.S. Department of Agriculture, APHIS
Plant Protection and Quarantine Programs
4700 River Road, Unit 136
Riverdale, MD 20737-1236
(301) 734-8645

Also included here is a poor copy of a phytosanitary certificate. This Agriculture Canada document may not be necessary, but is mentioned in the USDA circular.
A clean copy may be obtained from:

Bev Muziek
Agriculture Canada
Food Production and Inspection
100 - 350 Third Avenue North
Saskatoon, Saskatchewan
S7K 6Q7

Fax: (306) 975-4339

Appendix C: BOREAS Data Documentation Outline

Version 3.1 of the BOREAS Experiment Plan for the 1994 field acitvities, contained an outline of the original BORIS documentation outline. Based on interactions with the ORNL DAAC, BORIS agreed to accept the ORNL DAAC Guide Document format to help improve the transfer of data from BORIS to the DAAC. Since the Guide Document format meets the overall DAAC requirements, the ORNL DAAC will have much less manual conversion to perform if the BOREAS data set documentation comes to them in the required format. As mentioned at the October 1995 workshop, the Guide Document content is essentially the same as the original BOREAS document outline. The new format reflects a different organization of the information. As you update any existing documentation or supply initial documentation to BORIS, we will require you to submit the documentation in the new Guide Document Format to consider it in our tabulation of 'Delivered Documentation'.

BORIS has prepared a look-up table for use in moving sections from your existing BOREAS documents to the new format along with some overall guidelines that if followed will help the overall documentation effort. The overall guidelines, the new document outline, and the look-up table are described below.

C.1 Overall Documentation Guidelines

1) Left justify all text and section headings.

2) Do not mix graphics in with the text sections. We are working on the details regarding graphics. For now, please submit digital versions in separate files and clear hardcopy versions of any graphics you refer to in the text sections and leave a labeled/designated space for the graphic's inclusion.

3) Do not use tabs for formatting tables. Please use blank spaces to get the desired spacing.

4) Let text lines wrap naturally unless specific line breaks are required for tables and new paragraphs.

5) Set your margins to allow a maximum of 80 characters per line and use a fixed width font rather than proportional ones. We suggest using a 10 pt Courier font with left and right margins of 1.0 and 0.8 inches, respectively.

6) When using acronyms, spell them out first followed by the acronym in parentheses. Please include all acronyms in Section 19 in alphabetic order.

7) Use dates in the form of dd-mon-yyyy (e.g., 10-JAN-1994). Day of Year may be used but also include this standard date format.

8) References in section 17 should be left justfied and allow the text lines to wrap naturally as the other text. Separate references with blank text lines.

C.2 Data Set Guide Document Outline

Note: The text surrounded by square brackets ([..]) is an expanded instruction, or set of instructions, for the outline item which appears directly above it.

Data Set Document Title

Summary:
[Provide an abstract about the data set]

Table of Contents
[This list of sections is required in each document.]

* 1 Data Set Overview
* 2 Investigator(s)
* 3 Theory of Measurements
* 4 Equipment
* 5 Data Acquisition Methods
* 6 Observations
* 7 Data Description
* 8 Data Organization
* 9 Data Manipulations
* 10 Errors
* 11 Notes
* 12 Application of the Data Set
* 13 Future Modifications and Plans
* 14 Software
* 15 Data Access
* 16 Output Products and Availability
* 17 References
* 18 Glossary of Terms
* 19 List of Acronyms
* 20 Document Information

1. Data Set Overview
1.1 Data Set Identification
[Title or name for the data set, generally a short descriptive phrase, e.g. AVHRR LAC1, LEVEL 1 DATA.]
1.2 Data Set Introduction
1.3 Objective/Purpose

[Why the study was undertaken, and what the Principal Investigator hoped to achieve by conducting it. Be as specific as possible here in relating how this data set will help or provide information to the BOREAS effort.]

1.4 Summary of Parameters

[A summary of the phenomena which are being studied, and their parameters. A full description will be given in section 7.]

1.5 Discussion

[A few introductory paragraphs which describe the experiment, the nature of the data, the quality of the data, etc.]

1.6 Related Data Sets

[Note any similar or related data collected by the investigator, other investigators, or other data centers.]

2. Investigator(s)

2.1 Investigator(s) Name and Title

[Identify the Principal Investigator for this data set, including general affiliation, if applicable]

2.2 Title of Investigation

2.3 Contact Information

[Identify those persons most knowledgeable about the actual collection and processing of the data sets. In many cases this will be a person (or persons), other than the Principal Investigator, who prepared the data for submission to BOREAS and is sufficiently knowledgeable about the data to answer technical questions about it. When the Principal Investigator is a primary contact, full address information should also be given here.] (Include name(s), address, telephone number, FAX number, E-mail address)

3. Theory of Measurements

[Theoretical basis for the way in which the measurements were made (e.g. special procedures, characteristics of the instrument, etc.).]

4. Equipment:

4.1 Sensor/Instrument Description

[A listing of the instrumentation and the characteristics of the instrumentation.]

4.1.1 Collection Environment

[Under what environmental conditions were the data collected and the instrumentation operated.]

4.1.2 Source/Platform

[What the instrument is mounted on.]

4.1.3 Source/Platform Mission Objectives

[The reason why the mission was undertaken. (Mission here refers, in general, to the general purpose of operational or research satellites and aircraft. The particular study objectives are in item 1.3.)]

4.1.4 Key Variables

[The primary quantities being measured (e.g. surface radiance).]

4.1.5 Principles of Operation

[Fundamental scientific basis for the way the instrument operates. This is a summary; where a full development is required, it should be placed in item 3.]

4.1.6 Sensor/Instrument Measurement Geometry

[Describe the sensor location, orientation, and any other parameters which affect the collection or analysis of data, e.g. field of view, optical characteristics, height, etc.]

4.1.7 Manufacturer of Sensor/Instrument

[Name, address, and telephone number of the company which produced the instrument. If the measuring device was built by the investigator, or specially customized, please specify.]

4.2 Calibration

[Describe how the measurements made by the device(s) are calibrated with known standards. Specific details should be given in the subsections below.]

4.2.1 Specifications

[Record any specifications which affect the calibration of the device, its operations, or the analysis of the data collected with it.]

4.2.1.1 Tolerance

[Describe the acceptable range of inputs and the precision of the output values.]

4.2.2 Frequency of Calibration

[Indicate how often the instrument is measured against a standard. Also indicate any other routine procedures required to maintain calibration or detect miscalibrations. Describe also the actual practice with this device.]

4.2.3 Other Calibration Information

[Give factory calibration coefficients, information about independent calibrations, history of modifications, etc.]

5. Data Acquisition Methods

[Describe the procedures for acquiring this data in sufficient detail so that someone else with similar equipment could duplicate your measurements.]

6. Observations

[Use this section to record observations made during actual data collection, which could bear on the analysis of the data, e.g. condition of site, peculiar procedures or operations, the presence of U.F.O.'s or bears, oddities in equipment functioning, etc.]

6.1 Data Notes

6.2 Field Notes

7. Data Description

7.1 Spatial Characteristics

[Describe the actual spatial resolution and coverage of the data collected for BOREAS.]

7.1.1 Spatial Coverage

[Indicate the total area covered by each measurement or set of measurements. Give enough information to locate the geo-graphic position of the measurement with suitable precision.]

7.1.2 Spatial Coverage Map

[Include a geographic map or schematic showing the area over which the data were collected.]

7.1.3 Spatial Resolution

[The degree to which the terrain may be resolved into constituent or elementary parts (e.g. The dimensions of each image pixel.).]

7.1.4 Projection

[If applicable, describe the geographic coordinate system or map projection in which the data are referenced/stored.]

7.1.5 Grid Description

[If applicable, describe the grid system in which the data are referenced/stored.]

7.2 Temporal Characteristics

[Describe the actual temporal resolution and coverage of the data collected.]

7.2.1 Temporal Coverage

[The period(s) of time during which data was collected more or less continuously (e.g. an Intensive Field Campaign).]

7.2.2 Temporal Coverage Map

[Include a table listing the dates when the data was collected at the various locations.]

7.2.3 Temporal Resolution

[Describe the optimum and typical intervals between measurements during the periods in 7.2.1 (e.g. hourly, daily).]

7.3 Data Characteristics

[Describe the data submitted, with items 7.3.1 through 7.3.5 (below) being represented as columns in a table]

7.3.1 Parameter/Variable

7.3.2 Variable Description/Definition

7.3.3 Unit of Measurement

7.3.4 Data Source

7.3.5 Data Range

7.4 Sample Data Record

[One or more sample records from a data file]

8. Data Organization

[BORIS and ORNL DAAC to fill in]

8.1 Data Granularity

[BORIS and ORNL DAAC to fill in]

8.2 Data Format(s)

[Specify for this data set, the smallest unit of orderable data. For the point source data sets this will generally be the data collected at a particular site on a given day. For image data, the smallest unit is generally a particular image or flight line. Also, indicate the format specifier for the data (as it will appear on the CD-ROM).]

9. Data Manipulations

9.1 Formulae

[List any formulae required in processing the data.]

9.1.1 Derivation Techniques and Algorithms

[Describe any special techniques or algorithms used.]

9.2 Data Processing Sequence

9.2.1 Processing Steps

[Indicate the sequence of processing steps.]

9.2.2 Processing Changes

[For long term, repetitive, or revised data sets; give a history of changes in the processing sequence.]

9.3 Calculations

9.3.1 Special Corrections/Adjustments

[List any ‘special’ corrections/adjustments made to portions but not all of the data to make it compatible with the data set as a whole.]

9.3.2 Calculated Variables

9.4 Graphs and Plots

10. Errors

10.1 Sources of Error

[Describe what factors of the instrument or environment may introduce errors in the observations.]

10.2 Quality Assessment

10.2.1 Data Validation by Source

[Describe all efforts to validate the data by the submitter.]

10.2.2 Confidence Level/Accuracy Judgement

[Subjective discussion of data quality.]

10.2.3 Measurement Error for Parameters

[Quantitative error estimates.]

10.2.4 Additional Quality Assessments

[May include visual review of plots, etc.]

10.2.5 Data Verification by Data Center

[BORIS and ORNL DAAC to fill in]

11. Notes

11.1 Limitations of the Data

11.2 Known Problems with the Data

[List known problems and discrepancies in the data set.]

11.3 Usage Guidance

[Place any "Truth in Analysis" warnings here.]

11.4 Other Relevant Information

[Use this section for any other information about the study (such as humorous anecdotes, lame excuses, abject apologies, miracles, etc.).]

12. Application of the Data Set
[Provide a description of how the data set may be used.]

13. Future Modifications and Plans
[Describe any planned modifications to the processing or data.]

14. Software
[Describe software that was used and is available for use by someone who may want to perform further processing of the data.]

14.1 Software Description

14.2 Software Access

15. Data Access
[BORIS and ORNL DAAC to fill in]

15.1 Contact Information
[BORIS and ORNL DAAC to fill in]
(Include name(s), address, telephone number, FAX number, E-mail address.)

15.2 Data Center Identification

15.3 Procedures for Obtaining Data

15.4 Data Center Status/Plans

16. Output Products and Availability
[Describe the various data and related products that are available.]

16.1 Tape Products

16.2 Film Products

16.3 Other Products

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation
[List any published documentation relevant to the data collected, such as manufacturer's instruction manuals, government technical manuals, user's guides, etc.]

17.2 Journal Articles and Study Reports
[List technical reports and scientific publications which concern the methods, instruments, or data described in this document. Publications by the Principal Investigator or investigating group which would help a reader understand or analyze the data are particularly important. Be sure to include the standard BOREAS project description articles.]

17.3 Archive/DBMS Usage Documentation

18. Glossary of Terms
[Think of this as a place to define discipline related jargon andthe wealth of scientific notations/symbols that may be used in the text.]

19. List of Acronyms

[Include a list of any acronyms used in the text.]
[The following list should be included.]
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GSFC - Goddard Space Flight Center
NASA - National Aeronautics and Space Administration
ORNL - Oak Ridge National Laboratory
URL - Uniform Resource Locator

20. Document Information

20.1 Document Revision Date

[Use dd-mon-yyyy format]

20.2 Document Review Date(s)

[Use dd-mon-yyyy format]
BORIS Review:
Science Review:

20.3 Document

[BORIS and ORNL DAAC to fill in]

20.4 Citation

[How the Principal Investigator would like to be acknowledged when this data set is referenced or used by another investigator.]

20.5 Document Curator

[BORIS and ORNL DAAC to fill in]

20.6 Document URL

[BORIS and ORNL DAAC to fill in]

[Include a list of appropriate key words to assist in searching for information.]

C.3 BORIS to DAAC Documentation Look-up table

BORIS Section Number	BOREAS Section Title	Guide Document Section Number	Guide Document Section Title
NA	(For BORIS/ORNL Use)	10.2.5	Data Verification by Data Center
NA	(For BORIS/ORNL Use)	13	Future Modifications and Plans
NA	(For BORIS/ORNL Use)	20.3	Document ID
NA	(For BORIS/ORNL Use)	20.5	Document Curator
NA	(For BORIS/ORNL Use)	20.6	Document URL
1	Title	1	Data Set Overview
1.1	Data Set identification	1.1	Data Set Identification
1.2	BORIS Data Base Table Name	NA	For BORIS and ORNL DAAC Use
1.3	CD-ROM File Name	NA	For BORIS and ORNL DAAC Use
1.4	Document History	20.1	Document Revision Date
1.4	Document History	20.2	Document Review Date
2	Investigator	2	Investigator(s)
2.1	Investigator(s) Name And Title	2.1	Investigator(s) Name And Title
2.2	Title Of Investigation	2.2	Title Of Investigation
2.3	Contacts	2.3	Contact Information
2.4	RequestedForm of Acknowledgment	20.4	Citation
3	Introduction	1.2	Data Set Introduction
3.1	Objective/Purpose	1.3	Objective/Purpose
3.2	Summary of Parameters	1.4	Summary of Parameters
3.3	Discussion	1.5	Discussion
4	Theory of Measurements	3	Theory of Measurements
5	Equipment	4	Equipment
5.1	Instrument Description	4.1	Sensor/Instrument Description
5.1.1	Platform	4.1.2	Source/Platform
5.1.2	Mission Objectives	4.1.3	Source/Platform Mission Objectives
5.1.3	Key Variables	4.1.4	Key Variables
5.1.4	Principles of Operation	4.1.5	Principles of Operation
5.1.5	Instrument Measurement Geometry	4.1.6	Sensor/Instrument Measurement Geometry
5.1.6	Manufacturer of Instrument	4.1.7	Manufacturer of Instrument
5.2	Calibration	4.2	Calibration
5.2.1	Specifications	4.2.1	Specifications
5.2.1.	Tolerance	4.2.1.1	Tolerance
5.2.2	Frequency of Calibration	4.2.2	Frequency of Calibration
5.2.3	Calibration Information	4.2.3	Other Calibration Information
6	Procedure	5	Data Acquisition Methods
6.1	Data Acquisition Methods	5	Data Acquisition Methods
6.1	Data Acquisition Methods	4.1.1	Collection Environment
6.2	Spatial Characteristics	7.1	Spatial Characteristics
6.2	Spatial Characteristics	7.1.2	Spatial Coverage Map
6.2	Spatial Characteristics	7.1.4	Projection
6.2	Spatial Characteristics	7.1.5	Grid Description
6.2.1	Spatial Coverage	7.1.1	Spatial Coverage
6.2.2	Spatial Resolution	7.1.3	Spatial Resolution
6.3	Temporal Characteristics	7.2	Temporal Characteristics
6.3.1	Temporal Coverage	7.2.1	Temporal Coverage
6.3.1	Temporal Coverage	7.2.2	Temporal Coverage Map
6.3.2	Temporal Resolution	7.2.3	Temporal Resolution

7	Observations	6	Observations
7	Observations	6.1	Data Notes
7.1	Field Notes	6.2	Field Notes
8	Data Description	7	Data Description
8	Data Description	7.3	Data Characteristics
8.1	Table Definition With Comments	NA	(For BORIS/ORNL Use)
8.2	Type of Data	NA	(For BORIS/ORNL Use)
8.2.1	Parameter/Variable Name	7.3.1	Parameter/Variable
8.2.2	Parameter/Variable Description	7.3.2	Variable Description/ Definition
8.2.3	Data Range	7.3.5	Data Range
8.2.4	Units of Measurement	7.3.3	Unit of Measurement
8.2.5	Data Source	7.3.4	Data Source
8.3	Sample Data Record	7.4	Sample Data Record
8.4	Data Format(s)	8	Data Organization
8.4	Data Format(s)	8.1	Data Granularity
8.4	Data Format(s)	8.2	Data Format(s)
8.5	Related Data Set	1.6	Related Data Sets
9	Data Manipulations	9	Data Manipulations
9.1	Formulae	9.1	Formulae
9.1.1	Derivation Techniques/Algorithms	9.1.1	Derivation Techniques and Algorithms
9.2	Data Processing Sequence	9.2	Data Processing Sequence
9.2.1	Processing Steps	9.2.1	Processing Steps
9.2.2	Processing Changes	9.2.2	Processing Changes
9.3	Calculations	9.3	Calculations
9.3	Calculations	9.3.2	Calculated variables
9.3.1	Special Corrections/ Adjustments	9.3.1	Special Corrections/ Adjustments
9.4	Graphs and Plots	9.4	Graphs and Plots
9.5	Related Processing Software	14	Related Software
9.5	Related Processing Software	14.1	Software Description
9.5	Related Processing Software	14.2	Software Access
10	Errors	10	Errors
10.1	Sources of Error	10.1	Sources of Error
10.2	Quality Assessment	10.2	Quality Assessment
10.2.1	Data Validation by Source	10.2.1	Data Validation by Source
10.2.2	Confidence Level/Accuracy Judgment	10.2.2	Confidence Level/Accuracy Judgement
10.2.3	Measurement Error for Parameters	10.2.3	Measurement Error for Parameters
10.2.4	Additional Quality Assessments	10.2.4	Additional Quality Assessments
11	Notes	11	Notes
11.1	Known Problems With The Data	11.1	Limitations of the Data
11.1	Known Problems With The Data	11.2	Known Problems With The Data
11.2	Usage Guidance	11.3	Usage Guidance
11.2	Usage Guidance	12	Application of the Data Set
11.3	Other Relevant Information	11.4	Other Relevant Information
12	References	17	References
12.1	Satellite/Instrument/Data	17.1	Platform/Sensor/Instrument/ Data Processing Documentation
12.2	Journal Articles and Study Reports	17.2	Journal Articles and Study Reports
12.3	Archive/DBMS Usage Documentation	17.3	Archive/DBMS Usage Documentation

13	Data Access	15	Data Access
13.1	Contacts for Archive/Data	15.1	Contact Information Access Information
13.2	Archive Identification	15.2	Data Center Identification
13.3	Procedures for Obtaining Data	15.3	Procedures for Obtaining Data
13.4	Archive/PLDS Status/Plans	15.4	Data Center Status/Plans
14	Output products and availability	16	Output products and availability
14.1	Tape Products	16.1	Tape Products
14.2	Film Products	16.2	Film Products
14.3	Other Products	16.3	Other Products
15	Glossary of Acronyms	18	Glossary of Terms
15	Glossary of Acronyms	19	Glossary of Acronyms
16	Key Words	At end. No given section number	

Appendix D: References

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Appendix E — Sattelite Operpass Schedule

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
25-Feb-96	1507	SSA	NOAA-12	53.83	-104.83	27.8	81.3	118.8
25-Feb-96	1510	NSA	NOAA-12	55.92	-99.47	40.6	79.4	124.4
25-Feb-96	1921	NSA	NOAA-14	55.92	-99.47	15.5	65.3	188.1
25-Feb-96	1921	SSA	NOAA-14	53.83	-104.83	40.2	63.0	182.3
26-Feb-96	1445	NSA	NOAA-12	55.92	-99.47	21.6	82.1	118.7
26-Feb-96	1445	SSA	NOAA-12	53.83	-104.83	4.8	83.9	114.0
26-Feb-96	1910	NSA	NOAA-14	55.92	-99.47	26.2	64.8	185.2
27-Feb-96	1422	NSA	NOAA-12	55.92	-99.47	3.4	84.6	113.8
27-Feb-96	1423	SSA	NOAA-12	53.83	-104.83	23.6	86.5	109.4
27-Feb-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	65.7	162.8
27-Feb-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	65.5	164.1
27-Feb-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	64.1	158.9
27-Feb-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	64.1	158.9
27-Feb-96	1859	NSA	NOAA-14	55.92	-99.47	35.4	64.3	182.3
27-Feb-96	2039	SSA	NOAA-14	53.83	-104.83	40.8	64.8	203.9
28-Feb-96	1401	NSA	NOAA-12	55.92	-99.47	27.2	87.0	109.1
28-Feb-96	1401	SSA	NOAA-12	53.83	-104.83	43.7	89.3	104.7
28-Feb-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	66.5	148.2
28-Feb-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	65.3	162.8
28-Feb-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	65.1	164.1
28-Feb-96	1848	NSA	NOAA-14	55.92	-99.47	43.1	63.9	179.4
28-Feb-96	2028	SSA	NOAA-14	53.83	-104.83	31.2	63.9	201.2
29-Feb-96	1519	SSA	NOAA-12	53.83	-104.83	39.5	78.4	120.8
29-Feb-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	63.3	158.8
29-Feb-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	63.3	158.8
29-Feb-96	2017	SSA	NOAA-14	53.83	-104.83	20.1	63.0	198.4
29-Feb-96	2018	NSA	NOAA-14	55.92	-99.47	42.1	66.1	204.0
1-Mar-96	1457	NSA	NOAA-12	55.92	-99.47	33.8	79.2	120.8
1-Mar-96	1458	SSA	NOAA-12	53.83	-104.83	18.8	80.8	116.0
1-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	64.5	162.8
1-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	64.3	164.0
1-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	63.0	158.7
1-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	62.9	158.8
1-Mar-96	2007	NSA	NOAA-14	55.92	-99.47	33.5	65.1	201.2
1-Mar-96	2007	SSA	NOAA-14	53.83	-104.83	8.4	62.1	195.6

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
2-Mar-96	1436	NSA	NOAA-12	55.92	-99.47	13.0	81.5	116.0
2-Mar-96	1436	SSA	NOAA-12	53.83	-104.83	7.7	83.4	111.3
2-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	64.1	162.7
2-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	63.9	164.0
2-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	62.6	158.7
2-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	62.6	158.8
2-Mar-96	1956	NSA	NOAA-14	55.92	-99.47	23.4	64.2	198.3
2-Mar-96	1956	SSA	NOAA-14	53.83	-104.83	7.3	61.4	192.7
3-Mar-96	1413	NSA	NOAA-12	55.92	-99.47	13.2	84.0	111.1
3-Mar-96	1414	SSA	NOAA-12	53.83	-104.83	32.2	86.2	106.5
3-Mar-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	66.3	150.1
3-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	63.7	162.7
3-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	63.6	164.0
3-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	62.2	158.7
3-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	62.2	158.7
3-Mar-96	1945	NSA	NOAA-14	55.92	-99.47	11.7	63.4	195.5
3-Mar-96	1945	SSA	NOAA-14	53.83	-104.83	18.2	60.7	189.7
4-Mar-96	1352	NSA	NOAA-12	55.92	-99.47	35.3	86.5	106.4
4-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	63.4	162.7
4-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	63.2	164.0
4-Mar-96	1934	NSA	NOAA-14	55.92	-99.47	0.7	62.7	192.6
4-Mar-96	1934	SSA	NOAA-14	53.83	-104.83	29.0	60.1	186.6
5-Mar-96	1510	NSA	NOAA-12	55.92	-99.47	43.7	76.2	123.1
5-Mar-96	1510	SSA	NOAA-12	53.83	-104.83	32.1	77.7	118.1
5-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	61.4	158.6
5-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	61.4	158.6
5-Mar-96	1923	NSA	NOAA-14	55.92	-99.47	12.8	62.0	189.7
5-Mar-96	1923	SSA	NOAA-14	53.83	-104.83	38.2	59.6	183.6
6-Mar-96	1448	NSA	NOAA-12	55.92	-99.47	26.0	78.5	118.1
6-Mar-96	1449	SSA	NOAA-12	53.83	-104.83	9.8	80.3	113.3
6-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	62.6	162.7
6-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	62.4	164.0
6-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	61.0	158.6
6-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	61.0	158.6
6-Mar-96	1913	NSA	NOAA-14	55.92	-99.47	23.9	61.4	186.8
7-Mar-96	1426	NSA	NOAA-12	55.92	-99.47	3.9	80.9	113.1
7-Mar-96	1427	SSA	NOAA-12	53.83	-104.83	18.5	82.9	108.6
7-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	62.2	162.7
7-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	62.0	164.0
7-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	60.6	158.5
7-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	60.6	158.6
7-Mar-96	1902	NSA	NOAA-14	55.92	-99.47	33.4	60.9	183.8
7-Mar-96	2042	SSA	NOAA-14	53.83	-104.83	43.0	61.8	206.2

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
8-Mar-96	1404	NSA	NOAA-12	55.92	-99.47	23.1	83.4	108.4
8-Mar-96	1406	SSA	NOAA-12	53.83	-104.83	40.3	85.6	104.0
8-Mar-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	63.1	147.3
8-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	61.8	162.7
8-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	61.6	164.0
8-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	60.2	158.5
8-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	60.2	158.6
8-Mar-96	1851	NSA	NOAA-14	55.92	-99.47	41.5	60.4	180.8
8-Mar-96	2031	SSA	NOAA-14	53.83	-104.83	33.7	60.8	203.4
9-Mar-96	1342	NSA	NOAA-12	55.92	-99.47	42.5	86.0	103.5
9-Mar-96	1523	SSA	NOAA-12	53.83	-104.83	42.9	74.6	120.3
9-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	61.4	162.7
9-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	61.2	164.0
9-Mar-96	2021	NSA	NOAA-14	55.92	-99.47	44.1	63.0	206.2
9-Mar-96	2021	SSA	NOAA-14	53.83	-104.83	23.0	59.8	200.6
10-Mar-96	1501	NSA	NOAA-12	55.92	-99.47	37.4	75.4	120.4
10-Mar-96	1502	SSA	NOAA-12	53.83	-104.83	23.6	77.0	115.4
10-Mar-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	62.9	152.2
10-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	59.4	158.4
10-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	59.4	158.5
10-Mar-96	2010	NSA	NOAA-14	55.92	-99.47	35.7	62.0	203.4
10-Mar-96	2010	SSA	NOAA-14	53.83	-104.83	11.4	58.9	197.7
11-Mar-96	1439	NSA	NOAA-12	55.92	-99.47	17.4	77.7	115.4
11-Mar-96	1440	SSA	NOAA-12	53.83	-104.83	2.7	79.7	110.5
11-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	60.6	162.7
11-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	60.4	164.0
11-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	59.0	158.4
11-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	59.0	158.5
11-Mar-96	1958	SSA	NOAA-14	53.83	-104.83	4.7	58.1	194.5
11-Mar-96	1959	NSA	NOAA-14	55.92	-99.47	26.0	61.0	200.4
12-Mar-96	1418	NSA	NOAA-12	55.92	-99.47	8.1	80.2	110.6
12-Mar-96	1418	SSA	NOAA-12	53.83	-104.83	28.0	82.4	105.9
12-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	60.2	162.7
12-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	60.0	164.0
12-Mar-96	1947	SSA	NOAA-14	53.83	-104.83	15.3	57.3	191.5
12-Mar-96	1948	NSA	NOAA-14	55.92	-99.47	14.6	60.1	197.6
13-Mar-96	1355	NSA	NOAA-12	55.92	-99.47	31.5	82.8	105.7
13-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	58.2	158.4
13-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	58.2	158.4
13-Mar-96	1937	NSA	NOAA-14	55.92	-99.47	2.2	59.3	194.6
13-Mar-96	1937	SSA	NOAA-14	53.83	-104.83	26.5	56.7	188.4

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
14-Mar-96	1515	SSA	NOAA-12	53.83	-104.83	36.0	73.9	117.6
14-Mar-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	59.4	162.7
14-Mar-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	59.2	164.0
14-Mar-96	1926	SSA	NOAA-14	53.83	-104.83	36.2	56.1	185.3
14-Mar-96	1927	NSA	NOAA-14	55.92	-99.47	10.1	58.6	191.6
15-Mar-96	1452	NSA	NOAA-12	55.92	-99.47	30.1	74.7	117.7
15-Mar-96	1453	SSA	NOAA-12	53.83	-104.83	14.6	76.4	112.7
15-Mar-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	60.3	147.0
15-Mar-96	1915	SSA	NOAA-14	53.83	-104.83	44.3	55.6	182.2
15-Mar-96	1916	NSA	NOAA-14	55.92	-99.47	21.5	58.0	188.6
16-Mar-96	1430	NSA	NOAA-12	55.92	-99.47	8.2	77.0	112.7
16-Mar-96	1431	SSA	NOAA-12	53.83	-104.83	13.4	79.1	107.8
16-Mar-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	57.0	158.3
16-Mar-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	57.0	158.4
16-Mar-96	1905	NSA	NOAA-14	55.92	-99.47	31.4	57.4	185.5
16-Mar-96	2045	SSA	NOAA-14	53.83	-104.83	45.0	58.8	208.8
IFC-1 '96								
1-Apr-96	1341	NSA	NOAA-12	55.92	-99.47	42.8	77.7	99.7
1-Apr-96	1522	SSA	NOAA-12	53.83	-104.83	42.9	66.1	116.7
1-Apr-96	1932	NSA	NOAA-14	55.92	-99.47	6.0	52.0	196.3
1-Apr-96	1932	SSA	NOAA-14	53.83	-104.83	32.0	49.3	189.6
2-Apr-96	1500	NSA	NOAA-12	55.92	-99.47	37.5	66.9	117.0
2-Apr-96	1500	SSA	NOAA-12	53.83	-104.83	23.8	68.8	111.5
2-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	51.8	162.9
2-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	51.6	164.4
2-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	50.3	158.1
2-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	50.3	158.2
2-Apr-96	1921	NSA	NOAA-14	55.92	-99.47	16.8	51.3	192.9
2-Apr-96	1921	SSA	NOAA-14	53.83	-104.83	40.8	48.7	186.2
3-Apr-96	1437	NSA	NOAA-12	55.92	-99.47	17.3	69.3	111.8
3-Apr-96	1438	SSA	NOAA-12	53.83	-104.83	4.6	71.4	106.6
3-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	51.4	163.0
3-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	51.2	164.4
3-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	49.9	158.1
3-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	49.9	158.2
3-Apr-96	1910	NSA	NOAA-14	55.92	-99.47	27.1	50.6	189.6
4-Apr-96	1416	NSA	NOAA-12	55.92	-99.47	9.8	71.8	106.9
4-Apr-96	1417	SSA	NOAA-12	53.83	-104.83	28.4	74.2	101.8
4-Apr-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	53.6	148.5
4-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	51.0	163.0
4-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	50.8	164.5
4-Apr-96	1900	NSA	NOAA-14	55.92	-99.47	36.2	50.0	186.2
4-Apr-96	2040	SSA	NOAA-14	53.83	-104.83	40.6	51.8	211.9

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
5-Apr-96	1354	NSA	NOAA-12	55.92	-99.47	32.0	74.4	101.9
5-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	49.1	158.1
5-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	49.1	158.1
5-Apr-96	1849	NSA	NOAA-14	55.92	-99.47	43.8	49.5	182.9
5-Apr-96	2029	SSA	NOAA-14	53.83	-104.83	31.1	50.6	208.6
6-Apr-96	1513	SSA	NOAA-12	53.83	-104.83	36.2	65.5	113.8
6-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	50.3	163.0
6-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	50.1	164.5
6-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	48.7	158.1
6-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	48.7	158.1
6-Apr-96	2018	SSA	NOAA-14	53.83	-104.83	19.6	49.5	205.5
6-Apr-96	2019	NSA	NOAA-14	55.92	-99.47	42.1	52.9	211.4
7-Apr-96	1451	NSA	NOAA-12	55.92	-99.47	30.0	66.2	114.2
7-Apr-96	1451	SSA	NOAA-12	53.83	-104.83	13.4	68.2	108.7
7-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	49.9	163.0
7-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	49.7	164.5
7-Apr-96	2007	SSA	NOAA-14	53.83	-104.83	7.0	48.5	202.3
7-Apr-96	2008	NSA	NOAA-14	55.92	-99.47	33.1	51.8	208.4
8-Apr-96	1429	NSA	NOAA-12	55.92	-99.47	6.9	68.7	109.1
8-Apr-96	1430	SSA	NOAA-12	53.83	-104.83	14.1	70.9	103.8
8-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	48.0	158.0
8-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	47.9	158.1
8-Apr-96	1957	NSA	NOAA-14	55.92	-99.47	22.8	50.8	205.3
8-Apr-96	1957	SSA	NOAA-14	53.83	-104.83	6.9	47.6	198.9
9-Apr-96	1407	NSA	NOAA-12	55.92	-99.47	18.7	71.3	104.1
9-Apr-96	1407	SSA	NOAA-12	53.83	-104.83	37.1	73.8	99.0
9-Apr-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	50.6	145.2
9-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	49.1	163.1
9-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	48.9	164.6
9-Apr-96	1946	NSA	NOAA-14	55.92	-99.47	11.8	49.8	202.1
9-Apr-96	1946	SSA	NOAA-14	53.83	-104.83	19.1	46.8	195.5
9-Apr-96	2357	NSA	NOAA-12	55.92	-99.47	42.8	77.5	265.8
10-Apr-96	1345	NSA	NOAA-12	55.92	-99.47	39.6	73.9	99.3
10-Apr-96	1935	NSA	NOAA-14	55.92	-99.47	4.1	48.9	198.7
10-Apr-96	1935	SSA	NOAA-14	53.83	-104.83	30.0	46.1	192.0
11-Apr-96	1503	NSA	NOAA-12	55.92	-99.47	40.5	63.2	116.6
11-Apr-96	1504	SSA	NOAA-12	53.83	-104.83	27.9	65.1	110.8
11-Apr-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	50.3	151.1
11-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	46.8	158.0
11-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	46.8	158.0
11-Apr-96	1924	NSA	NOAA-14	55.92	-99.47	13.7	48.1	195.3
11-Apr-96	1924	SSA	NOAA-14	53.83	-104.83	39.1	45.4	188.5

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
12-Apr-96	1441	NSA	NOAA-12	55.92	-99.47	21.6	65.6	111.4
12-Apr-96	1443	SSA	NOAA-12	53.83	-104.83	4.4	67.7	106.0
12-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	48.0	163.1
12-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	47.8	164.6
12-Apr-96	1913	NSA	NOAA-14	55.92	-99.47	24.6	47.4	191.9
13-Apr-96	1420	NSA	NOAA-12	55.92	-99.47	5.4	68.1	106.4
13-Apr-96	1421	SSA	NOAA-12	53.83	-104.83	24.0	70.6	101.1
13-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	46.1	157.9
13-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	46.1	158.0
13-Apr-96	1902	NSA	NOAA-14	55.92	-99.47	34.1	46.8	188.4
13-Apr-96	2043	SSA	NOAA-14	53.83	-104.83	42.7	49.1	215.0
14-Apr-96	1358	NSA	NOAA-12	55.92	-99.47	28.0	70.8	101.4
14-Apr-96	1359	SSA	NOAA-12	53.83	-104.83	44.3	73.4	96.4
14-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	47.3	163.1
14-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	47.1	164.6
14-Apr-96	1852	NSA	NOAA-14	55.92	-99.47	42.1	46.3	184.9
14-Apr-96	2032	SSA	NOAA-14	53.83	-104.83	33.4	47.8	211.7
15-Apr-96	1517	SSA	NOAA-12	53.83	-104.83	39.5	61.9	113.2
15-Apr-96	2021	SSA	NOAA-14	53.83	-104.83	22.4	46.7	208.4
15-Apr-96	2022	NSA	NOAA-14	55.92	-99.47	43.9	50.2	214.4
16-Apr-96	1455	NSA	NOAA-12	55.92	-99.47	33.8	62.5	113.9
16-Apr-96	1455	SSA	NOAA-12	53.83	-104.83	18.3	64.6	108.1
16-Apr-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	48.0	144.8
16-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	45.0	157.8
16-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	45.0	157.9
16-Apr-96	2010	SSA	NOAA-14	53.83	-104.83	10.7	45.7	205.1
16-Apr-96	2011	NSA	NOAA-14	55.92	-99.47	35.1	49.0	211.3
17-Apr-96	1433	NSA	NOAA-12	55.92	-99.47	11.9	65.1	108.6
17-Apr-96	1433	SSA	NOAA-12	53.83	-104.83	8.6	67.4	103.1
17-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	46.2	163.1
17-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	46.0	164.7
17-Apr-96	2000	NSA	NOAA-14	55.92	-99.47	25.1	48.0	208.1
17-Apr-96	2000	SSA	NOAA-14	53.83	-104.83	5.5	44.7	201.7
18-Apr-96	1411	NSA	NOAA-12	55.92	-99.47	13.8	67.7	103.6
18-Apr-96	1411	SSA	NOAA-12	53.83	-104.83	33.0	70.3	98.3
18-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	44.3	157.8
18-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	44.3	157.8
18-Apr-96	1949	NSA	NOAA-14	55.92	-99.47	14.4	47.0	204.8
18-Apr-96	1949	SSA	NOAA-14	53.83	-104.83	16.7	43.9	198.1

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
19-Apr-96	1349	NSA	NOAA-12	55.92	-99.47	36.0	70.4	98.6
19-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	45.5	163.1
19-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	45.3	164.7
19-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	44.0	157.7
19-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	44.0	157.8
19-Apr-96	1938	NSA	NOAA-14	55.92	-99.47	3.3	46.0	201.2
19-Apr-96	1938	SSA	NOAA-14	53.83	-104.83	27.7	43.1	194.5
20-Apr-96	1507	NSA	NOAA-12	55.92	-99.47	43.5	59.6	116.3
20-Apr-96	1508	SSA	NOAA-12	53.83	-104.83	31.8	61.6	110.3
20-Apr-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	47.8	147.5
20-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	45.2	163.1
20-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	45.0	164.7
20-Apr-96	1927	NSA	NOAA-14	55.92	-99.47	11.1	45.2	197.8
20-Apr-96	1927	SSA	NOAA-14	53.83	-104.83	37.2	42.4	190.8
21-Apr-96	1445	NSA	NOAA-12	55.92	-99.47	25.6	62.2	110.9
21-Apr-96	1446	SSA	NOAA-12	53.83	-104.83	9.5	64.3	105.3
21-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	43.3	157.7
21-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	43.3	157.7
21-Apr-96	1916	NSA	NOAA-14	55.92	-99.47	22.4	44.5	194.2
22-Apr-96	1423	NSA	NOAA-12	55.92	-99.47	5.0	64.8	105.8
22-Apr-96	1424	SSA	NOAA-12	53.83	-104.83	19.3	67.2	100.3
22-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	44.5	163.1
22-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	44.3	164.7
22-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	42.9	157.6
22-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	42.9	157.7
22-Apr-96	1906	NSA	NOAA-14	55.92	-99.47	32.2	43.8	190.6
22-Apr-96	2046	SSA	NOAA-14	53.83	-104.83	44.5	46.6	217.9
23-Apr-96	1402	NSA	NOAA-12	55.92	-99.47	23.8	67.4	100.9
23-Apr-96	1403	SSA	NOAA-12	53.83	-104.83	40.9	70.1	95.6
23-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	44.1	163.1
23-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	44.0	164.7
23-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	42.6	157.6
23-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	42.6	157.6
23-Apr-96	1855	NSA	NOAA-14	55.92	-99.47	40.6	43.2	186.9
23-Apr-96	2035	SSA	NOAA-14	53.83	-104.83	35.4	45.3	214.7
24-Apr-96	1340	NSA	NOAA-12	55.92	-99.47	43.2	70.2	95.9
24-Apr-96	1521	SSA	NOAA-12	53.83	-104.83	42.6	58.6	112.6
24-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	43.8	163.1
24-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	43.6	164.7
24-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	42.3	157.5
24-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	42.3	157.6
24-Apr-96	2024	SSA	NOAA-14	53.83	-104.83	24.9	44.2	211.4

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
25-Apr-96	1458	NSA	NOAA-12	55.92	-99.47	37.1	59.3	113.3
25-Apr-96	1459	SSA	NOAA-12	53.83	-104.83	23.0	61.3	107.4
25-Apr-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	45.1	143.7
25-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	43.5	163.0
25-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	43.3	164.7
25-Apr-96	2013	SSA	NOAA-14	53.83	-104.83	13.4	43.1	207.9
25-Apr-96	2014	NSA	NOAA-14	55.92	-99.47	37.2	46.5	214.1
26-Apr-96	1436	NSA	NOAA-12	55.92	-99.47	16.7	61.9	108.0
26-Apr-96	1437	SSA	NOAA-12	53.83	-104.83	3.1	64.1	102.5
26-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	41.6	157.4
26-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	41.6	157.5
26-Apr-96	2002	SSA	NOAA-14	53.83	-104.83	2.5	42.1	204.4
26-Apr-96	2003	NSA	NOAA-14	55.92	-99.47	27.8	45.4	210.8
27-Apr-96	1415	NSA	NOAA-12	55.92	-99.47	8.8	64.5	103.0
27-Apr-96	1415	SSA	NOAA-12	53.83	-104.83	28.6	67.1	97.5
27-Apr-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	44.8	150.1
27-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.8	163.0
27-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.7	164.6
27-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	41.3	157.4
27-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	41.3	157.4
27-Apr-96	1952	NSA	NOAA-14	55.92	-99.47	16.4	44.3	207.2
27-Apr-96	1952	SSA	NOAA-14	53.83	-104.83	13.3	41.2	200.7
28-Apr-96	1352	NSA	NOAA-12	55.92	-99.47	32.1	67.3	98.0
28-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.5	163.0
28-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.3	164.6
28-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	41.0	157.3
28-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	41.0	157.4
28-Apr-96	1941	NSA	NOAA-14	55.92	-99.47	4.1	43.4	203.7
28-Apr-96	1941	SSA	NOAA-14	53.83	-104.83	25.0	40.4	196.9
29-Apr-96	1511	SSA	NOAA-12	53.83	-104.83	35.5	58.5	109.6
29-Apr-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.2	162.9
29-Apr-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.0	164.6
29-Apr-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	40.7	157.3
29-Apr-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	40.7	157.3
29-Apr-96	1930	NSA	NOAA-14	55.92	-99.47	8.5	42.5	200.1
29-Apr-96	1930	SSA	NOAA-14	53.83	-104.83	35.0	39.6	192.8
IFC-2 '96								
8-Jul-96	1444	NSA	NOAA-12	55.92	-99.47	28.4	54.7	102.3
8-Jul-96	1445	SSA	NOAA-12	53.83	-104.83	12.4	57.3	96.3
8-Jul-96	2014	NSA	NOAA-14	55.92	-99.47	35.4	37.5	216.1
8-Jul-96	2014	SSA	NOAA-14	53.83	-104.83	10.3	34.1	209.7

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
9-Jul-96	1422	NSA	NOAA-12	55.92	-99.47	6.8	57.8	97.5
9-Jul-96	1423	SSA	NOAA-12	53.83	-104.83	15.8	60.6	91.9
9-Jul-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	38.5	140.0
9-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	35.2	157.5
9-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.0	159.3
9-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.0	150.8
9-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	33.9	150.8
9-Jul-96	2003	NSA	NOAA-14	55.92	-99.47	25.6	36.8	212.1
9-Jul-96	2003	SSA	NOAA-14	53.83	-104.83	3.0	33.5	205.3
10-Jul-96	1400	NSA	NOAA-12	55.92	-99.47	20.6	61.0	92.8
10-Jul-96	1401	SSA	NOAA-12	53.83	-104.83	38.2	64.0	87.4
10-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	35.3	157.5
10-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.1	159.3
10-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.1	150.8
10-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	34.1	150.9
10-Jul-96	1952	NSA	NOAA-14	55.92	-99.47	14.5	36.2	208.0
10-Jul-96	1952	SSA	NOAA-14	53.83	-104.83	15.6	33.0	200.8
10-Jul-96	2350	NSA	NOAA-12	55.92	-99.47	43.6	64.5	272.3
11-Jul-96	1338	NSA	NOAA-12	55.92	-99.47	40.6	64.2	88.4
11-Jul-96	1519	SSA	NOAA-12	53.83	-104.83	44.6	52.6	104.2
11-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	35.5	157.5
11-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.2	159.3
11-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.2	150.8
11-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	34.2	150.9
11-Jul-96	1942	NSA	NOAA-14	55.92	-99.47	2.2	35.6	203.8
11-Jul-96	1942	SSA	NOAA-14	53.83	-104.83	27.0	32.6	196.1
12-Jul-96	1456	NSA	NOAA-12	55.92	-99.47	39.3	53.5	105.4
12-Jul-96	1457	SSA	NOAA-12	53.83	-104.83	26.5	56.0	99.3
12-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	35.6	157.5
12-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.4	159.3
12-Jul-96	1930	SSA	NOAA-14	53.83	-104.83	36.6	32.3	191.2
12-Jul-96	1931	NSA	NOAA-14	55.92	-99.47	10.4	35.2	199.4
13-Jul-96	1435	NSA	NOAA-12	55.92	-99.47	20.2	56.6	100.6
13-Jul-96	1436	SSA	NOAA-12	53.83	-104.83	2.9	59.2	94.9
13-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.5	150.9
13-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	34.5	150.9
13-Jul-96	1919	SSA	NOAA-14	53.83	-104.83	44.5	32.2	186.4
13-Jul-96	1920	NSA	NOAA-14	55.92	-99.47	21.8	34.9	195.1

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
14-Jul-96	1413	NSA	NOAA-12	55.92	-99.47	5.9	59.7	95.9
14-Jul-96	1414	SSA	NOAA-12	53.83	-104.83	25.4	62.6	90.4
14-Jul-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	38.4	136.1
14-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	35.9	157.5
14-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.7	159.3
14-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.7	150.9
14-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	34.7	151.0
14-Jul-96	1909	NSA	NOAA-14	55.92	-99.47	31.7	34.7	190.6
14-Jul-96	2049	SSA	NOAA-14	53.83	-104.83	44.6	37.9	221.9
15-Jul-96	1351	NSA	NOAA-12	55.92	-99.47	29.2	63.0	91.3
15-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	36.1	157.5
15-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	35.8	159.3
15-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	34.8	150.9
15-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	34.8	151.0
15-Jul-96	1858	NSA	NOAA-14	55.92	-99.47	40.1	34.6	186.1
15-Jul-96	2038	SSA	NOAA-14	53.83	-104.83	35.7	37.0	218.0
16-Jul-96	1510	SSA	NOAA-12	53.83	-104.83	38.2	54.6	102.6
16-Jul-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	38.7	143.7
16-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	36.3	157.5
16-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	36.0	159.4
16-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	35.0	151.0
16-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	35.0	151.1
16-Jul-96	2028	SSA	NOAA-14	53.83	-104.83	25.3	36.2	213.9
17-Jul-96	1448	NSA	NOAA-12	55.92	-99.47	32.5	55.4	103.8
17-Jul-96	1449	SSA	NOAA-12	53.83	-104.83	16.6	57.9	97.9
17-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	36.4	157.6
17-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	36.2	159.4
17-Jul-96	2016	SSA	NOAA-14	53.83	-104.83	14.0	35.5	209.5
17-Jul-96	2017	NSA	NOAA-14	55.92	-99.47	37.6	38.9	216.0
18-Jul-96	1426	NSA	NOAA-12	55.92	-99.47	10.2	58.6	99.0
18-Jul-96	1426	SSA	NOAA-12	53.83	-104.83	10.3	61.3	93.4
18-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	35.4	151.1
18-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	35.3	151.2
18-Jul-96	2006	NSA	NOAA-14	55.92	-99.47	27.8	38.3	212.1
18-Jul-96	2006	SSA	NOAA-14	53.83	-104.83	2.4	34.9	205.2

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
19-Jul-96	1404	NSA	NOAA-12	55.92	-99.47	15.5	61.8	94.3
19-Jul-96	1405	SSA	NOAA-12	53.83	-104.83	34.4	64.6	89.1
19-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	36.8	157.6
19-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	36.5	159.4
19-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	35.5	151.2
19-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	35.5	151.3
19-Jul-96	1955	NSA	NOAA-14	55.92	-99.47	16.9	37.7	208.1
19-Jul-96	1955	SSA	NOAA-14	53.83	-104.83	12.7	34.5	200.8
19-Jul-96	2353	NSA	NOAA-12	55.92	-99.47	40.7	66.0	271.8
20-Jul-96	1342	NSA	NOAA-12	55.92	-99.47	37.3	65.0	89.9
20-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	37.0	157.7
20-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	36.7	159.5
20-Jul-96	1944	NSA	NOAA-14	55.92	-99.47	6.6	37.2	203.7
20-Jul-96	1944	SSA	NOAA-14	53.83	-104.83	24.4	34.1	196.3
21-Jul-96	1500	NSA	NOAA-12	55.92	-99.47	42.5	54.4	107.2
21-Jul-96	1501	SSA	NOAA-12	53.83	-104.83	30.3	56.7	101.2
21-Jul-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	39.5	137.0
21-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	35.9	151.3
21-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	35.9	151.4
21-Jul-96	1933	NSA	NOAA-14	55.92	-99.47	8.1	36.8	199.5
21-Jul-96	1933	SSA	NOAA-14	53.83	-104.83	34.5	33.9	191.7
22-Jul-96	1438	NSA	NOAA-12	55.92	-99.47	24.0	57.5	102.3
22-Jul-96	1439	SSA	NOAA-12	53.83	-104.83	6.0	60.1	96.5
22-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	37.4	157.7
22-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	37.1	159.6
22-Jul-96	1922	NSA	NOAA-14	55.92	-99.47	19.3	36.5	195.3
22-Jul-96	1922	SSA	NOAA-14	53.83	-104.83	42.9	33.9	187.2
23-Jul-96	1417	NSA	NOAA-12	55.92	-99.47	1.4	60.6	97.7
23-Jul-96	1418	SSA	NOAA-12	53.83	-104.83	20.9	63.4	92.2
23-Jul-96	1912	NSA	NOAA-14	55.92	-99.47	29.6	36.4	191.0
24-Jul-96	1355	NSA	NOAA-12	55.92	-99.47	25.2	63.9	93.0
24-Jul-96	1355	SSA	NOAA-12	53.83	-104.83	42.2	66.9	87.8
24-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	36.5	151.6
24-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	36.5	151.7
24-Jul-96	1901	NSA	NOAA-14	55.92	-99.47	38.4	36.4	186.7
24-Jul-96	2041	SSA	NOAA-14	53.83	-104.83	38.0	38.7	217.5
25-Jul-96	1333	NSA	NOAA-12	55.92	-99.47	44.3	67.1	88.7
25-Jul-96	1514	SSA	NOAA-12	53.83	-104.83	41.4	55.6	104.6
25-Jul-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	41.2	141.2
25-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	38.0	157.8
25-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	37.8	159.8
25-Jul-96	2030	SSA	NOAA-14	53.83	-104.83	27.7	38.0	213.6

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
26-Jul-96	1451	NSA	NOAA-12	55.92	-99.47	35.7	56.5	105.8
26-Jul-96	1452	SSA	NOAA-12	53.83	-104.83	21.2	58.9	99.9
26-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	36.9	151.8
26-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	36.9	151.9
26-Jul-96	2019	SSA	NOAA-14	53.83	-104.83	16.1	37.4	209.5
26-Jul-96	2020	NSA	NOAA-14	55.92	-99.47	39.5	40.9	215.9
27-Jul-96	1430	NSA	NOAA-12	55.92	-99.47	14.8	59.6	101.0
27-Jul-96	1430	SSA	NOAA-12	53.83	-104.83	6.3	62.3	95.4
27-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	38.4	158.0
27-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	38.2	159.9
27-Jul-96	2008	NSA	NOAA-14	55.92	-99.47	30.3	40.2	211.9
27-Jul-96	2008	SSA	NOAA-14	53.83	-104.83	5.9	36.9	205.4
28-Jul-96	1407	NSA	NOAA-12	55.92	-99.47	11.4	62.9	96.3
28-Jul-96	1408	SSA	NOAA-12	53.83	-104.83	30.6	65.6	91.1
28-Jul-96	1957	SSA	NOAA-14	53.83	-104.83	10.4	36.4	200.9
28-Jul-96	1958	NSA	NOAA-14	55.92	-99.47	19.3	39.6	208.0
28-Jul-96	2357	NSA	NOAA-12	55.92	-99.47	37.9	68.0	271.3
29-Jul-96	1346	NSA	NOAA-12	55.92	-99.47	33.9	66.1	91.9
29-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	37.6	152.2
29-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	37.6	152.2
29-Jul-96	1946	SSA	NOAA-14	53.83	-104.83	22.1	36.2	196.6
29-Jul-96	1947	NSA	NOAA-14	55.92	-99.47	7.6	39.2	204.0
30-Jul-96	1505	SSA	NOAA-12	53.83	-104.83	34.1	57.8	103.4
30-Jul-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	41.4	138.1
30-Jul-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	39.1	158.2
30-Jul-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	38.9	160.2
30-Jul-96	1936	NSA	NOAA-14	55.92	-99.47	6.9	38.9	200.0
30-Jul-96	1936	SSA	NOAA-14	53.83	-104.83	32.5	36.0	192.2
31-Jul-96	1442	NSA	NOAA-12	55.92	-99.47	28.0	58.7	104.5
31-Jul-96	1443	SSA	NOAA-12	53.83	-104.83	11.7	61.2	98.7
31-Jul-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	38.1	152.4
31-Jul-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	38.0	152.5
31-Jul-96	1925	NSA	NOAA-14	55.92	-99.47	17.3	38.6	195.7
31-Jul-96	1925	SSA	NOAA-14	53.83	-104.83	41.3	36.0	187.9
1-Aug-96	1420	NSA	NOAA-12	55.92	-99.47	6.5	61.9	99.7
1-Aug-96	1421	SSA	NOAA-12	53.83	-104.83	16.9	64.5	94.4
1-Aug-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	42.0	145.4
1-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	39.6	158.5
1-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	39.4	160.4
1-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	38.3	152.6
1-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	38.3	152.6
1-Aug-96	1914	NSA	NOAA-14	55.92	-99.47	27.6	38.5	191.6

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
2-Aug-96	1358	NSA	NOAA-12	55.92	-99.47	21.4	65.1	95.2
2-Aug-96	1359	SSA	NOAA-12	53.83	-104.83	39.0	68.0	90.0
2-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	39.9	158.7
2-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	39.6	160.5
2-Aug-96	1903	NSA	NOAA-14	55.92	-99.47	36.7	38.5	187.4
2-Aug-96	2044	SSA	NOAA-14	53.83	-104.83	39.9	41.0	217.3
2-Aug-96	2348	NSA	NOAA-12	55.92	-99.47	44.2	67.8	268.7
3-Aug-96	1336	NSA	NOAA-12	55.92	-99.47	41.4	68.4	90.8
3-Aug-96	1518	SSA	NOAA-12	53.83	-104.83	44.3	56.8	107.0
3-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	38.8	152.9
3-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	38.8	152.9
3-Aug-96	1852	NSA	NOAA-14	55.92	-99.47	44.2	38.7	183.3
3-Aug-96	2033	SSA	NOAA-14	53.83	-104.83	30.2	40.3	213.5
4-Aug-96	1455	NSA	NOAA-12	55.92	-99.47	38.9	57.8	108.2
4-Aug-96	1455	SSA	NOAA-12	53.83	-104.83	25.8	60.1	102.2
4-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	40.4	158.8
4-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	40.1	160.7
4-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	39.0	153.0
4-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	39.0	153.1
4-Aug-96	2022	NSA	NOAA-14	55.92	-99.47	41.3	43.2	215.7
4-Aug-96	2022	SSA	NOAA-14	53.83	-104.83	18.6	39.8	209.6
5-Aug-96	1433	NSA	NOAA-12	55.92	-99.47	19.7	60.9	103.4
5-Aug-96	1434	SSA	NOAA-12	53.83	-104.83	4.0	63.5	97.8
5-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	40.6	159.1
5-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	40.4	160.8
5-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	39.3	153.2
5-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	39.3	153.2
5-Aug-96	2011	SSA	NOAA-14	53.83	-104.83	6.6	39.3	205.4
5-Aug-96	2012	NSA	NOAA-14	55.92	-99.47	32.4	42.6	212.0
6-Aug-96	1411	NSA	NOAA-12	55.92	-99.47	7.0	64.1	98.9
6-Aug-96	1412	SSA	NOAA-12	53.83	-104.83	26.4	66.8	93.5
6-Aug-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	43.0	139.6
6-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	40.9	159.3
6-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	40.7	160.9
6-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	39.6	153.3
6-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	39.5	153.4
6-Aug-96	2000	NSA	NOAA-14	55.92	-99.47	22.0	42.1	208.1
6-Aug-96	2000	SSA	NOAA-14	53.83	-104.83	8.6	38.9	201.4
7-Aug-96	1349	NSA	NOAA-12	55.92	-99.47	30.2	67.4	94.3
7-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	41.2	159.4
7-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	40.9	161.1
7-Aug-96	1949	NSA	NOAA-14	55.92	-99.47	10.0	41.7	204.2
7-Aug-96	1949	SSA	NOAA-14	53.83	-104.83	19.8	38.6	197.3

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Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
8-Aug-96	1508	SSA	NOAA-12	53.83	-104.83	37.7	59.2	105.9
8-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	40.1	153.7
8-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	40.1	153.7
8-Aug-96	1938	NSA	NOAA-14	55.92	-99.47	3.4	41.4	200.4
8-Aug-96	1938	SSA	NOAA-14	53.83	-104.83	30.5	38.5	193.2
9-Aug-96	1446	NSA	NOAA-12	55.92	-99.47	31.7	60.1	107.2
9-Aug-96	1447	SSA	NOAA-12	53.83	-104.83	15.6	62.4	101.5
9-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	41.7	159.7
9-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	41.5	161.3
9-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	40.4	153.8
9-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	40.3	153.9
9-Aug-96	1928	NSA	NOAA-14	55.92	-99.47	15.2	41.2	196.5
9-Aug-96	1928	SSA	NOAA-14	53.83	-104.83	39.6	38.5	189.0
10-Aug-96	1424	NSA	NOAA-12	55.92	-99.47	9.1	63.2	102.5
10-Aug-96	1425	SSA	NOAA-12	53.83	-104.83	11.5	65.8	97.0
10-Aug-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	45.0	143.8
10-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.0	159.8
10-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	41.8	161.4
10-Aug-96	1917	NSA	NOAA-14	55.92	-99.47	25.7	41.1	192.5
11-Aug-96	1402	NSA	NOAA-12	55.92	-99.47	16.6	66.5	97.8
11-Aug-96	1403	SSA	NOAA-12	53.83	-104.83	35.4	69.2	92.7
11-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.3	159.9
11-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.1	161.6
11-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	40.9	154.2
11-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	40.9	154.3
11-Aug-96	1906	NSA	NOAA-14	55.92	-99.47	35.0	41.1	188.6
11-Aug-96	2046	SSA	NOAA-14	53.83	-104.83	41.8	43.7	217.1
11-Aug-96	2352	NSA	NOAA-12	55.92	-99.47	41.5	70.5	268.1
12-Aug-96	1340	NSA	NOAA-12	55.92	-99.47	38.2	69.7	93.5
12-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	42.6	160.1
12-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.4	161.7
12-Aug-96	1855	NSA	NOAA-14	55.92	-99.47	42.8	41.3	184.7
12-Aug-96	2036	SSA	NOAA-14	53.83	-104.83	32.6	43.1	213.4
13-Aug-96	1458	NSA	NOAA-12	55.92	-99.47	41.9	59.3	111.0
13-Aug-96	1500	SSA	NOAA-12	53.83	-104.83	29.5	61.4	105.2
13-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	41.5	154.5
13-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	41.5	154.6
13-Aug-96	2025	NSA	NOAA-14	55.92	-99.47	43.2	45.9	215.6
13-Aug-96	2025	SSA	NOAA-14	53.83	-104.83	21.3	42.5	209.7

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
14-Aug-96	1437	NSA	NOAA-12	55.92	-99.47	23.1	62.4	106.2
14-Aug-96	1437	SSA	NOAA-12	53.83	-104.83	4.7	64.9	100.6
14-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	43.2	160.4
14-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	42.9	162.0
14-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	41.8	154.7
14-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	41.7	154.8
14-Aug-96	2014	NSA	NOAA-14	55.92	-99.47	34.4	45.4	212.1
14-Aug-96	2014	SSA	NOAA-14	53.83	-104.83	8.7	42.1	205.9
15-Aug-96	1415	NSA	NOAA-12	55.92	-99.47	1.9	65.7	101.5
15-Aug-96	1416	SSA	NOAA-12	53.83	-104.83	22.0	68.2	96.3
15-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	43.5	160.6
15-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	43.2	162.2
15-Aug-96	2003	NSA	NOAA-14	55.92	-99.47	24.5	45.0	208.5
15-Aug-96	2003	SSA	NOAA-14	53.83	-104.83	5.7	41.8	202.1
16-Aug-96	1353	NSA	NOAA-12	55.92	-99.47	26.2	68.9	97.1
16-Aug-96	1353	SSA	NOAA-12	53.83	-104.83	43.0	71.7	92.0
16-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	42.3	155.1
16-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	42.3	155.2
16-Aug-96	1952	NSA	NOAA-14	55.92	-99.47	12.8	44.6	204.8
16-Aug-96	1952	SSA	NOAA-14	53.83	-104.83	17.7	41.5	198.0
17-Aug-96	1512	SSA	NOAA-12	53.83	-104.83	40.7	60.6	109.1
17-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	44.1	160.9
17-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	43.9	162.5
17-Aug-96	1941	SSA	NOAA-14	53.83	-104.83	28.4	41.4	194.1
17-Aug-96	1942	NSA	NOAA-14	55.92	-99.47	0.4	44.3	201.2
18-Aug-96	1449	NSA	NOAA-12	55.92	-99.47	35.0	61.7	110.1
18-Aug-96	1450	SSA	NOAA-12	53.83	-104.83	20.1	63.9	104.4
18-Aug-96	1930	SSA	NOAA-14	53.83	-104.83	37.8	41.4	190.1
18-Aug-96	1931	NSA	NOAA-14	55.92	-99.47	12.3	44.1	197.4
19-Aug-96	1428	NSA	NOAA-12	55.92	-99.47	13.6	64.8	105.4
19-Aug-96	1428	SSA	NOAA-12	53.83	-104.83	6.7	67.3	100.0
19-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	43.2	155.7
19-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	43.2	155.8
19-Aug-96	1920	NSA	NOAA-14	55.92	-99.47	23.6	44.1	193.7
20-Aug-96	1406	NSA	NOAA-12	55.92	-99.47	12.2	68.1	100.8
20-Aug-96	1406	SSA	NOAA-12	53.83	-104.83	31.5	70.8	95.6
20-Aug-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	45.0	161.4
20-Aug-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	44.8	163.0
20-Aug-96	1908	NSA	NOAA-14	55.92	-99.47	33.2	44.1	189.8
20-Aug-96	2049	SSA	NOAA-14	53.83	-104.83	43.7	46.8	217.2
20-Aug-96	2355	NSA	NOAA-12	55.92	-99.47	38.6	73.6	267.4

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
21-Aug-96	1344	NSA	NOAA-12	55.92	-99.47	34.7	71.3	96.4
21-Aug-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	43.8	156.1
21-Aug-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	43.8	156.2
21-Aug-96	1858	NSA	NOAA-14	55.92	-99.47	41.5	44.2	186.2
21-Aug-96	2038	SSA	NOAA-14	53.83	-104.83	34.6	46.2	213.7
IFC-3 '96								
30-Sep-96	1410	NSA	NOAA-12	55.92	-99.47	3.6	78.4	113.5
30-Sep-96	1411	SSA	NOAA-12	53.83	-104.83	23.7	80.4	108.8
30-Sep-96	2006	NSA	NOAA-14	55.92	-99.47	24.4	62.4	208.1
30-Sep-96	2006	SSA	NOAA-14	53.83	-104.83	5.1	59.2	202.6
1-Oct-96	1349	NSA	NOAA-12	55.92	-99.47	27.6	81.5	109.1
1-Oct-96	1349	SSA	NOAA-12	53.83	-104.83	44.0	83.8	104.5
1-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	60.0	168.7
1-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	59.9	170.1
1-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	58.2	164.6
1-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	58.2	164.6
1-Oct-96	1954	SSA	NOAA-14	53.83	-104.83	17.2	59.0	199.4
1-Oct-96	1955	NSA	NOAA-14	55.92	-99.47	13.4	62.1	205.1
2-Oct-96	1507	SSA	NOAA-12	53.83	-104.83	38.9	73.5	121.5
2-Oct-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	60.8	153.1
2-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	60.3	168.9
2-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	60.2	170.2
2-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	58.5	164.7
2-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	58.5	164.8
2-Oct-96	1943	NSA	NOAA-14	55.92	-99.47	3.2	61.9	202.0
2-Oct-96	1943	SSA	NOAA-14	53.83	-104.83	27.9	58.9	196.3
3-Oct-96	1445	NSA	NOAA-12	55.92	-99.47	33.1	75.0	122.1
3-Oct-96	1446	SSA	NOAA-12	53.83	-104.83	18.0	76.6	117.0
3-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	60.7	169.0
3-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	60.6	170.3
3-Oct-96	1932	NSA	NOAA-14	55.92	-99.47	11.6	61.7	199.0
3-Oct-96	1932	SSA	NOAA-14	53.83	-104.83	37.3	58.9	193.2
4-Oct-96	1423	NSA	NOAA-12	55.92	-99.47	11.4	77.9	117.5
4-Oct-96	1424	SSA	NOAA-12	53.83	-104.83	8.6	79.8	112.6
4-Oct-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	62.4	158.6
4-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	59.3	165.0
4-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	59.3	165.1
4-Oct-96	1922	NSA	NOAA-14	55.92	-99.47	22.8	61.7	196.0

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
5-Oct-96	1401	NSA	NOAA-12	55.92	-99.47	13.9	81.0	112.9
5-Oct-96	1403	SSA	NOAA-12	53.83	-104.83	32.8	83.0	108.3
5-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	61.5	169.3
5-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	61.4	170.6
5-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	59.6	165.2
5-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	59.6	165.2
5-Oct-96	1911	NSA	NOAA-14	55.92	-99.47	32.6	61.7	193.0
5-Oct-96	2052	SSA	NOAA-14	53.83	-104.83	43.6	64.5	215.0
5-Oct-96	2351	NSA	NOAA-12	55.92	-99.47	39.9	89.5	260.1
6-Oct-96	1340	NSA	NOAA-12	55.92	-99.47	35.8	84.1	108.5
6-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	61.8	169.4
6-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	61.7	170.7
6-Oct-96	1900	NSA	NOAA-14	55.92	-99.47	40.8	61.8	190.0
6-Oct-96	2041	SSA	NOAA-14	53.83	-104.83	34.7	64.0	212.1
7-Oct-96	1458	NSA	NOAA-12	55.92	-99.47	42.9	74.8	125.9
7-Oct-96	1459	SSA	NOAA-12	53.83	-104.83	31.2	76.1	120.9
7-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	60.4	165.5
7-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	60.4	165.5
7-Oct-96	2030	NSA	NOAA-14	55.92	-99.47	44.7	66.9	214.3
7-Oct-96	2030	SSA	NOAA-14	53.83	-104.83	24.0	63.5	209.0
8-Oct-96	1436	NSA	NOAA-12	55.92	-99.47	24.9	77.6	121.3
8-Oct-96	1437	SSA	NOAA-12	53.83	-104.83	7.5	79.2	116.4
8-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	62.6	169.6
8-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	62.5	171.0
8-Oct-96	2019	NSA	NOAA-14	55.92	-99.47	36.5	66.4	211.3
8-Oct-96	2019	SSA	NOAA-14	53.83	-104.83	11.7	63.1	206.1
9-Oct-96	1414	NSA	NOAA-12	55.92	-99.47	1.6	80.6	116.7
9-Oct-96	1415	SSA	NOAA-12	53.83	-104.83	19.1	82.4	112.1
9-Oct-96	1716	SSA	LANDSAT 5	53.80	-105.20	0.0	63.3	154.7
9-Oct-96	2008	NSA	NOAA-14	55.92	-99.47	26.5	66.1	208.4
9-Oct-96	2008	SSA	NOAA-14	53.83	-104.83	4.1	62.9	203.1
10-Oct-96	1352	NSA	NOAA-12	55.92	-99.47	23.3	83.6	112.3
10-Oct-96	1353	SSA	NOAA-12	53.83	-104.83	40.7	85.8	107.7
10-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	61.5	165.9
10-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	61.5	166.0
10-Oct-96	1957	NSA	NOAA-14	55.92	-99.47	15.6	65.8	205.5
10-Oct-96	1957	SSA	NOAA-14	53.83	-104.83	14.5	62.6	200.0
11-Oct-96	1330	NSA	NOAA-12	55.92	-99.47	42.8	86.9	107.8
11-Oct-96	1511	SSA	NOAA-12	53.83	-104.83	41.9	75.8	124.6
11-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	63.7	170.0
11-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	63.6	171.3
11-Oct-96	1946	NSA	NOAA-14	55.92	-99.47	4.8	65.5	202.7
11-Oct-96	1946	SSA	NOAA-14	53.83	-104.83	25.6	62.5	197.0

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
12-Oct-96	1449	NSA	NOAA-12	55.92	-99.47	36.6	77.3	125.1
12-Oct-96	1449	SSA	NOAA-12	53.83	-104.83	22.7	78.7	120.1
12-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	62.2	166.2
12-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	62.2	166.2
12-Oct-96	1935	SSA	NOAA-14	53.83	-104.83	35.4	62.4	194.0
12-Oct-96	1936	NSA	NOAA-14	55.92	-99.47	9.2	65.4	199.8
13-Oct-96	1426	NSA	NOAA-12	55.92	-99.47	16.0	80.2	120.4
13-Oct-96	1428	SSA	NOAA-12	53.83	-104.83	4.3	81.8	115.7
13-Oct-96	1653	NSA	LANDSAT 5	55.83	-97.82	0.0	66.1	157.5
13-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	64.4	170.2
13-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	64.3	171.5
13-Oct-96	1924	SSA	NOAA-14	53.83	-104.83	43.6	62.5	191.1
13-Oct-96	1925	NSA	NOAA-14	55.92	-99.47	20.6	65.3	196.8
14-Oct-96	1405	NSA	NOAA-12	55.92	-99.47	9.1	83.2	115.9
14-Oct-96	1406	SSA	NOAA-12	53.83	-104.83	28.7	85.1	111.4
14-Oct-96	1914	NSA	NOAA-14	55.92	-99.47	30.7	65.2	193.9
14-Oct-96	2354	NSA	NOAA-12	55.92	-99.47	36.8	93.1	259.3
15-Oct-96	1343	NSA	NOAA-12	55.92	-99.47	32.1	86.3	111.5
15-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	63.3	166.5
15-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	63.3	166.6
15-Oct-96	1903	NSA	NOAA-14	55.92	-99.47	39.2	65.3	191.0
15-Oct-96	2043	SSA	NOAA-14	53.83	-104.83	36.6	67.5	212.1
16-Oct-96	1502	SSA	NOAA-12	53.83	-104.83	35.0	78.3	123.8
16-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	65.5	170.5
16-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	65.4	171.7
16-Oct-96	2032	SSA	NOAA-14	53.83	-104.83	26.2	67.1	209.3
17-Oct-96	1440	NSA	NOAA-12	55.92	-99.47	28.9	79.9	124.2
17-Oct-96	1440	SSA	NOAA-12	53.83	-104.83	12.8	81.3	119.4
17-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	64.0	166.7
17-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	64.0	166.8
17-Oct-96	2021	SSA	NOAA-14	53.83	-104.83	14.4	66.7	206.3
17-Oct-96	2022	NSA	NOAA-14	55.92	-99.47	38.3	70.0	211.5
18-Oct-96	1418	NSA	NOAA-12	55.92	-99.47	6.0	82.8	119.6
18-Oct-96	1418	SSA	NOAA-12	53.83	-104.83	14.5	84.5	114.9
18-Oct-96	1710	TRANS-W	LANDSAT 5	53.80	-103.62	0.0	66.4	155.9
18-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	66.3	170.7
18-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	66.2	171.9
18-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	64.4	166.8
18-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	64.4	166.9
18-Oct-96	2010	SSA	NOAA-14	53.83	-104.83	5.0	66.4	203.4
18-Oct-96	2011	NSA	NOAA-14	55.92	-99.47	28.6	69.6	208.7

Satellite Overpass Times

Date	Time (GMT)	Site	Platform	Lat	Long	View Zenith	Solar Zenith	Solar Azimuth
19-Oct-96	1356	NSA	NOAA-12	55.92	-99.47	19.1	85.8	115.2
19-Oct-96	1356	SSA	NOAA-12	53.83	-104.83	37.3	87.8	110.7
19-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	66.6	170.7
19-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	66.5	172.0
19-Oct-96	2000	NSA	NOAA-14	55.92	-99.47	18.0	69.3	205.9
19-Oct-96	2000	SSA	NOAA-14	53.83	-104.83	11.8	66.1	200.5
19-Oct-96	2345	NSA	NOAA-12	55.92	-99.47	43.2	93.5	256.6
20-Oct-96	1710	TRANS-E	LANDSAT 5	55.83	-99.42	0.0	68.1	160.9
20-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	65.1	167.0
20-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	65.1	167.1
21-Oct-96	1745	NSA-WEST	SPOT	55.96	-98.75	?	67.3	170.9
21-Oct-96	1746	NSA-EAST	SPOT	55.97	-98.08	?	67.2	172.1
21-Oct-96	1758	SSA-EAST	SPOT	53.65	-105.35	?	65.4	167.1
21-Oct-96	1800	SSA-WEST	SPOT	53.65	-105.80	?	65.4	167.2

Appendix F: Team Science Activities for BOREAS-1996

Team Summaries were submitted in early 1996.
They may not contain up to date information.

AFM-3; Lenschow/Kelly

Proposed activities

(a) Ongoing work (i.e. if no 1996 field activities)

Analysis of 1994 field data described in our FY96 Work Plan (submitted to BOREAS Headquarters 12 Oct. 1995, and appended below).

In addition, we propose to extend our analyses in FY96 to begin to address two further scientific goals:

1) What is the role of planetary boundary-layer (PBL) growth in the forcing of plant stomatal activity? It has been proposed (e.g., Sellers et al, BAMS, vol. 76, 1549-1577) that deep growth and drying of the PBL over the boreal forest caused stomates to close early in the day during BOREAS94, shifting the surface energy balance from latent tosensible heat release and causing even greater deepening of the PBL.

   Marr and Davis, however (unpublished manuscript) saw no obvious relation between vapor pressure deficit and photosynthetic CO_2 flux when examining three tower sites (SOJP, NOJP, NOBS). CO_2 flux should be tied to stomatal activity. The NCAR Electra measured vertical profiles of heat, CO_2 and H_2O fluxes over the southern and northern study areas during BOREAS-94 which, combined with PBL height, can be used to derive a water vapor budget in the PBL to see if this PBL drying due to entrainment was taking place and how it affected the vapor pressure deficit over time. The Electra flights spanned midday, when stomatal closure was said to be taking place.

   This analysis of aircraft data will be coupled with data concerning the timing of stomatal closure at the study areas, drawing on the observations made by Joe Berry and other, and probably simulations of SiB2, possibly with the addition of a 1-D PBL model to simulate the entire plant-PBL system (Scott Denning, CSU). A more definitive characterization of this proposed feedback is necessary to gain an accurate picture of net carbon and water exchange between the boreal ecosystem and the atmosphere. Just as the start and end of the growing season have a strong influence on the total exchange of CO_2 between forest and atmosphere, so does the length of time available each day for photosynthesis. If stomatal closure due to PBL growth and drying is an important forcing of photosynthesis, it must be confirmed and carefully described in order to accurately model the carbon and water budgets of the boreal forest.

2) Second, we would like to investigate further means of extrapolating observed fluxes over the entire boreal forest region. Our goals are i) to

obtain, from tower flux data which are continuous in time, but limitedin space and from aircraft flux data which span the whole boreal region but are very limited in temporal coverage, a robust estimate of the net exchange of carbon dioxide (and perhaps water and heat) over the entire BOREAS region during the time-span of the 1994 field campaign, and ii) to create the simplest possible semi-empirical model of the factors controlling these fluxes.

The NCAR Electra flux data from BOREAS-94 covers the entire BOREAS region, from the Saskatoon to the southern boundary of the Northwest Territories. The Electra data set includes observations of temperature, PAR and NDVI. Marr and Davis (unpublished manuscript), working with flux data from three tower sites, found that a semi-empirical model using temperature and PAR captured the vast majority of the diurnal and seasonal (May to October) variability in CO_2 exchange at these sites. We would propose to use similar simple scaling of both the tower and aircraft data, combined with satellite derivation of the area vegetation cover (Lou Steyaert) and satellite NDVI to estimate May to October 1994 net fluxes of CO_2 over the entire study area. Such a large-area estimate could then be used to test scaled-up models of CO_2 flux which properly capture the detailedphysiology of CO_2 exchange.

(b) Proposed work for 1996 field activities.

None.

FY96 Work Plan for NASA Grant PO S-12857-F; NCAR Proposal No. 92-23

Biosphere-Atmosphere Interactions over Boreal Forest

Dr. Donald Lenschow, Principal Investigator
Mesoscale and Microscale Meteorology Division, NCAR

The major activities for the coming year are:

We plan to continue processing and analyzing the Electra aircraft data and prepare several papers for publication. The preprints listed in the FY95 Progress Report will provide the basis for some of these papers. Much of this work will involve collaboration with other BOREAS investigators and others interested in the Electra data set. We will address a subset of the following topics depending on time available:

(1) a general analysis of all the low-level flux data categorized according to, for example, surface type, season, and time of day for use in regional andlarge-scale carbon and water budget studies;

(2) studies of the effect of a nonuniform surface (e.g., intermingled lakes, bogs, burned areas, and multiple forest types) and varying cloudiness (particularly fair-weather cumulus) on, for example, mean and turbulence statistics, integral length scales or eddy sizes, blending height, and mesoscale circulations;

(3) studies of boundary-layer evolution and characteristics in a region of small-scale surface heterogeneity and slowly varying solar input including the feedback between the boundary-layer water vapor budgets and photosynthetic activity;

(4) estimation of ozone deposition over the boreal forest and subarctic tundra;

(5) studies of the similarity between the turbulent transport of the various measured scalars, including temperature, water vapor, carbon dioxide and ozone;

(6) studies of the boundary-layer top, gravity-wave production and entrainment;

(7) application of the DLR lidar measurements of aerosol backscatter and water vapor distribution to studying boundary-layer structure;

(8) comparisons of Electra measurements with other flux aircraft and tower measurements, as well as with NOAA radar measurements of reflectivity and radial velocity; and

(9) extension of aircraft measurements to scales resolvable by global-scale models, and comparison of these results with model predictions.

The activities described above are all consistent with our original NASA proposal.

AFM-4 MacPherson/Schuepp/Mahrt/Leaitch/Wang

1. Field Program

It is planned that the Twin Otter atmospheric research aircraft will participate in IFC-2 of the 1996 field program, making areal estimates of the fluxes of mass and energy over the bvarious sites in both the SSA and the NSA. The aircraft will arrive at Prince Albert on sunday, July 7 and operate in the SSA for approximatey half of IFC-2, before flying the transect to Thompson somewhere in the period Augut 9. The number of flying hours to be devoted to the campaign is 92 (22 transit, 70 project). there will aslo be a number of test flight hours flown in the Ottawa area during May.

The principal objective of the Twin Otter's 1996 campaign is similar to that of 1994 - to provide airborne flux data to be used in scaling up energy/mass exchange estimates from tower scales to the landscape scales observed by satellites. It is expected that the flight tracks flown will be identical to those of 1994 in order to allow direct comparison of the fluxes, radiometric data, etc., to help answer questions about interannual variability. The flight plans are detailed in Section 5.2.5. The focus will likely be the grid flights, the sie specific (tower fly-by), the agricultural line, the Candle Lake run and soundings. In all probablity the SSA/NSA transect will be flown only once. TF-7 will be utilizing a tethersonde to investigate mixing layer depth and night-time respiration. It has been proposed that the Twin Otter perform a coordinated night-time flight in the area of TF-7, consisting primarily of soundings to characterize the top of the mixed layer and the free atmosphere above it.

As was the case in 1994, a complete data playback system will be set up in the field to provide post-flight analyses and flux estimates. A review of these data by collaborating scientists can provide feedback to the experimental design, for example, a change in the priorities of the mission types, adjustment to flight tracks or altitudes, etc.

Instrumentation:

Some significant changes and additions to the aircraft instrumentation are being made for the 1996 campaign. first, the airborne computer system in the Twin Otter has been changed to a VME-based system, and the data recording rate has been increased from 16 to 32 Hz, improving the short wavelength resolution of the flux data. This computer system was changed in 1995 and has been used in two major research programs to date. A new, stiffer carbon-fibre noseboom is being fitted to the aircraft during March 1996. Airborne estimates of the fluxes will continue to be computed in real-time and displayed to both the cockpit and cabin crew.

Original plans for BOREAS-96 called for the Tuneable Diode Laser Methane Analyzer to be flown in the Twin Otter to make estimates of the vetical flux of CH_4. Flight testing of this instrument has not been completed and, furthermoe, it was decided that its 350 lb weight would place an unwelcome restriction on the fuel load, and hence endurance, of the aircraft. Rather than flying this instrument, CH_4, (and perhaps VOC) flux estimates will be attempted using the relaxed eddy accumulation technique. The focus of this work will likely be the site-specific run past the SSA Old Black Spruce site, where TF-7 proposes to make tower-based estimates of the methane flux. Isoprene flux measurements will be atempted on the SSA Old Aspen track.

Plans are for several additional instruments flown on the Twin Otter in BOREAS-96. Depending on aircraft weight, these instruments fall into the: (a) almost certain and (b) probable categories:

a) Laser altimeter: This instrument will give fast-response absolute height above the terrain, for use in studies of surface roughness, and will be easier to interpret than current radio-altimeter measurements.

   Upgraded Licor CO_2/H_2O) analyzer, replacing Licor 6262 flown in 1994. (The AgCanada ESRI infrared analyzer will also be flown, and has undergone significant maintenance and adjustment since 1994).

   An NO/NoX analyzer to provide measurements used in interpreting the ozone chemistry.

b) Aerosol probe: This PC-ASP particle probe measures the concentration and the spectrum of aerosol particles in 15 size ranges between approximately 0.1 and 2 microns. An attempt will be made to measure the vetical flux of aerosol particles over the boreal forest. Data will be rcorded on either the NRC dat aacquisition system resident on the aircraft, or an additional system provided by AES.

2. Analyses

Analysis of the 1994 data is continuing by the team of Pis, CO PIs, and collaborators. Much of this work will be reported in the JGR Special Issue, but will continue throughout FY 96/97. The data from the 1996 field program will be archived in the identical format used for the 1994 data. If particle concentrations and fluxes are computed, these data can be appended to the archive files.

AFM-5 Barr

BOREAS 1996 Radiosonde Field Program.

Radiosondes will be released from Candle Lake and Thompson during the summer and fall IFCs. On fair-weather days, we will release six soundings, at 1115, 1515, 1715, 1915, 2115 and 2315 UTC. On other days, at the discretion of the mission manager, we will release three soundings, at 1115, 1715 and 2315 UTC. The current plan allows for 24 days in the summer IFC and 10 days in the fall IFC with six soundings per day. We will also collect and process the full resolution soundings from Saskatoon, The Pas and Churchill during the summer and fall IFCs. All soundings will be quality assured at full resolution and also interpolated to regular 5 mb levels.

Ongoing Analyses: Boundary-Layer Climatology of Boreal Forest.

I will continue to analyze the 1994 and 1996 BOREAS radiosonde data and prepare several papers for publication. The analyses will be done in collaboration with AFM-8 (Alan Betts). The objectives will include some but probably not all of the following:

1) To prepare a surface and BL climatology of the boreal forest, with special attention to: the diurnal and seasonal cycles; the coupling of surface forcings, surface climate, BL evolution and entrainment; and the contrast between the climates of the boreal forest and the crop/grassland to the south.

2) To extend the boundary-layer (BL) heat and moisture budget analysis of 1994 BOREAS sondes to 1996. To develop budget methodology to include sites with three soundings per day.

3) To evaluate the diurnal BL cycle in large-scale meteorological models, using the observed soundings.

4) To analyze the large-scale atmospheric heat and moisture budget above boreal forest, based on the best available large-scale model analyses and forecasts.

AFM-7

All of the 10 AMS sites will continue in operation through at least November of 1996; after that, they may be reduced to a subset which will likely include the sites at SSA-OA, SSA-OJP, NSA-OJP/Fen, NSA-YTH (Airport). The measurements taken at the sites are summarized in table 3.2.1, and the distribution of sites is shown in figure 3.2.1a. A schematic of an AMS site is shown in figure 3.2.1b.

AFM-8 Betts/Hollingsworth

Ongoing work.

The analysis of the BOREAS sonde data using budget methods (with the TwinOtter data as ground truth) will be submitted. I am working on climatological studies with the BOREAS surface data from both the AES and BOREAS surface met. stations. I am intercomparing the BOREAS met. and surface flux data with the ECMWF model timeseries data for BOREAS, the NCEP Eta model for 1994 and the 1994 NCEP reanalysis for the NSA and SSA. These are based on similar studies using FIFE timeseries data, which will also be finished this year. I shall then intercompare the FIFE and BOREAS regions.

1996 Field campaigns.

ECMWF will support the 1996 IFCs with forecasts, and will continue to archive model timeseries data for selected points and areas in the BOREAS region. I will not be able to attend the 1996 summer IFC, as I will be at ECMWF part of that time.

This work will continue regardless of the 1996 IFC's. If the 1996 field campaigns take place as planned, I will ask ECMWF and NMC to provide us again with forecast support. I have some conflicts in summer 1996 (a NATO conference in Europe and a planned visit to ECMWF), so I do not know how much time I will be spending in Canada at either SSA or NSA. My presence is less needed than in 1994 anyway. I will absorb any IFC travel costs in my budget, which follows.

Alan Betts and Alan Barr designed the growing season radiosonde program. Sondes will be released six times a day from Candle Lake (SSA-HQ) and Thompson Zoo (NSA) during IFC-2 and IFC-3. The data will be posted onto GTS for the numerical forcast centers, and Alan Barr will further analyze them for submission to BORIS, see also AFM-5.

AFM-9 Dickinson

I. Workplan

The objectives of our BOREAS program have been to:

(1) Establish the relative sensitivity of surface-atmospheric exchanges of energy, moisture and carbon to various parameters and processes for boreal forests;

(2) Improve the representation of boreal forests in the BATS code through better specification of parameters and improved process descriptions;

(3) Increase understanding of the role of boreal forests in the climate system; and,

(4) Provide ISCPP cloud data for the BOREAS study areas, initially for 1993 and, when available, for 1994.

Under (1) and (2) above, the moss and plant chemistry algorithms will be validated and further refined if needed using the data obtained during the mid-summer IFC. Additional modeling of the moss physiology (e.g. when it starts and stops photosynthesizing) will be done using the data obtained during the spring thaw IFC and the fall shut-down IFC. The seasonal effects on the plant spectral signatures will also be studied using these two IFCs. This work will be started after the mid-summer IFC.

Jean Morrill, a graduate student, has been running BATS under tasks (1) and (3) above using cleaned-up 1989 observed data and has forwarded these results for the model-intercomparison. These tasks will be repeated for 1994 when they become available.

Tasks (3) and (4) are beginning with the preparation of high resolution (30 km and 3 hours) satellite cloud radiances (visible and infrared). Prof. Rong Fu and a graduate student will produce these from rawinsondes and the ISCCP B3 data set for the summer of 1994 when the ISCCP B3 data for 1994 become available.

AFM-11 Mahrt

Jielun Sun and Larry Mahrt plan to take measurements of the ground distribution of surface radiation temperature toward the goal of predicting the heat flux from multiple surface temperatures, as in the mathematical format of a simple canopy model. The intention is to operate radiometers from a tower (nominally, OBS, SSA) as well as ground surveys to estimate typical differences between the canopy vs the understory and sunny surfaces vs shaded surfaces. In 96, surface radiation measurements will also be made from different angles to accomodate the model of Norman et al. Several Everest radiometers will be brought in addition to the Canadian NRC radiometer used in 94. Improved post field calibration will augment the usual in-field calibration by using the calibration facility at NCAR-FOF.

AFM-13 Schuepp/MacPherson/Desjardins

Analysis and Interpretation of Airborne Flux Observations over the BOREAS Sites.

Objectives and Approach: Twin Otter (TO) airborne observations (surface temperature, greenness, fluxes of sensible heat, latent heat and CO_2) obtained from repeated flights over the 16 km x 16 km TO grid areas at the SSA and NSA will be mapped and compared to maps of surface characteristics obtained from other remote sensing platforms. The analysis of these maps will focus on the persistence in surface characteristics vs. the persistence in flux distributions between the 1994 and 1996 data sets. The relationships between airborne flux estimates and remotely sensed surface characteristics within the flux footprint of the flight trajectories, deduced from the 1994 airborne observations, will be tested on the 1996 grid and line-trajectory data to determine to what degree observations of regional energy and gas exchange over the BOREAS ecosystem can be generalized across time and space. Optional components of our project include deployment of a portable sodar (M. Leclerc) to document the boundary layer structure near the OBS site at the SSA.

AFM-14 Sellers/Desjardins/Berry

The Eyeball (FB) aircraft, a PA-34 (Piper Seneca I), has been fitted with a nose-mounted tube which draws external air into a LiCor-logger system in the cabin. This system is also hooked up to calibration gases (a pure N_2, and a N_2 + 365ppm CO_2 mix) which allows for inflight calibration. The aircraft flies a series of vertical soundings (up to 12000', but more usually up to 10000') and some low passes near TF towers. The mission profile is described in 5.2.5.10 (Fx-VS). Six FB-VS were flown in FFC-W in BOREAS-96; it is planned to repeat a similar number in all the IFC's. The goal is to acquire CO_2 concentration profiles and transects for comparisons with the results of GCM tracer models, see for example Denning et al (1995). The LiCor system was put together by Ray Desjardins and Dave Dow of Agriculture Canada with some resources arranged by Joe Berry. (Carnegie Institute).

TF-1 Black

Carbon dioxide and water vapor exchange between the forest and atmosphere at the Old Aspen Site in the SSA Andy Black, Mike Novak (UBC) and Paul Voroney (U. of Guelph)

Background

Our work in 1996 will address several gaps identified in the White Papers:

1. There was a lack of measurements at the beginning and end of the growing season. At the Old Aspen (OA) site, this was true only for mid-September to mid-October. How much carbon is lost to the atmosphere during this period when there is no photosynthesis and ecosystem respiration is high because the soil is still relatively warm?

2. The 1994 data set was atypical. At the OA site from May 1 to September 30, 1994, air temperature was about 1.5 C above average and precipitation was about 15% above average. To what extent did these conditions result in unrepresentative values of annual evapotranspiration (E) and net ecosystem productivity (NEP)?

3. There was a lack of concurrent tower flux and chamber (leaf and soil) measurements. Can we scale up H_2O and CO_2 fluxes at the leaf and soil level to the stand level?

4. Nighttime CO_2 flux measurements were often erratic at low wind speeds. Are there alternative methods of obtaining CO_2 fluxes under these conditions?

Objectives

1. To measure the fluxes of sensible heat, H_2O and CO_2 above the aspen stand from early spring to late fall.

2. To determine the effects of environmental factors on stand E and NEP.

3. To take part in the development of procedures for scaling up component fluxes to the stand level.

4. To study the processes controlling turbulent transfer of H_2O and CO_2 within the stand.

5. To take part in the evaluation of methods of estimating nocturnal CO_2 fluxes in and above the stand.

Field Measurements

Half-hourly fluxes of sensible heat, H_2O and CO_2 above (39-m height) the aspen stand will be measured continuously from April 15 to November 15, 1996 using the first of two eddy correlation (EC) systems. The same measurements will be made above (4-m height) the hazelnut un-derstory using the second system during the Summer IFC (July 9-August 9, 1996). Both EC systems consist of a Gill Instruments (Solent) 3-dimensional sonic anemometer-thermometer (SAT), a Campbell Scientific Inc. (CSI) K20 open-path krypton hygrometer, and a closed-path CO_2/H_2O infra-red gas analysis unit. This unit is a temperature-controlled LI-COR 6262 analyzer operated in differential mode with a pump drawing air at 8.5 L/min through the analyzer and a 3-m long heated sampling tube. The Solent in the second system will be provided by Alan Barr, AES (AFM-8). An Applied Technologies Inc. 3-dimensional SAT will serve as a back-up unit. Signals will be processed at 20 Hz using two parallel-connected computers with serial inputs from both EC systems. Half-hourly fluxes will be calculated on-line and raw data will be automatically backed up daily on tape.

Half-hourly mean CO_2 and H_2O concentrations will be measured at the 0.5, 4, 10, 17, 20, 24, 29 and 39-m heights in order to calculate changes in storage below the upper measurement height. Air will be coninuously pumped from the eight levels through heated tubing and sampled using a secondary diaphragm pump, solenoid valves, a LI-COR 6262 analyzer and a computer.

We will collaborate with Bernard Saugier, UniversitÈ Paris-Sud (TE-11) and Ted Hogg, Canadian Forest Service (TE-7) in measuring photosynthesis and transpiration at the leaf level using two branch bags (one in the aspen canopy and one in the hazelnut canopy). These will run throughout the growing season. We will measure the stomatal conductance (LI-COR LI-1600 steady state porometer) of leaves adjacent to the branch bags during the Summer IFC to confirm the values measured by the branch bags.We will collaborate with Joe Berry and Jim Collatz (TE-4) in test ing SiB2 at the site using real-time data.

We will make chamber measurements of soil CO_2 flux during the Summer IFC as in 1994. We will estimate the contribution of root respiration to soil CO_2 flux by using micro-plots with root barriers (Paul Voroney). This will complement the work of Mike Lavigne, Canadian Forest Service (TE-7), who will be making chamber measurements of soil CO_2 flux throughout the growing season.

During the Summer IFC an experiment will be carried out to determine whether the rate of change in CO_2 storage in the nocturnal boundary layer provides a good estimate of the CO_2 flux under low wind speed conditions. Harold Neumann and Ralf Staebler, AES (TF-2)) will make tethersonde measurements of nighttime CO_2 concentration profiles above the forest.

Fluxes calculated from these measurements will be compared with our eddy correlation and soil chamber measurements of CO_2 flux. Signals from net radiometers, quantum sensors, a tipping-bucket rain gauge, leaf wetness sensors, soil and bole thermocouples, soil heat flux plates, etc. will be recorded using CSI 21X or CR10 data loggers. Soil moisture content will be measured by Richard Cuenca (HYD-1) using time-domain reflectometry. Leaf area index (LAI) will be measured using a LI-COR LAI-2000 plant canopy analyzer as in 1994.

Analysis

Forest canopy conductances for the single-source Penman-Monteith evaporation model and Priestley-Taylor alpha coefficients will be calculated and related to environmental variables. These relationships will be compared with those obtained in 1994. To test the feasibility of scaling from leaf to canopy fluxes, forest transpiration rates measured by eddy correlation will be compared with those calculated from (i) branch bag transpiration measurements and (ii) aspen sap-flow measurements (Ted Hogg, TE-7) combined with eddy-correlation measurements of the H_2O flux from the understory. Evapotranspiration data will be used together with rainfall and root zone soil moisture data to analyze the site water balance. The data will also be used by Diana Verseghy, AES (AFM-15) in the evaluation and development of the AES land surface model CLASS.

Growing season NEP will be compared with that measured in 1994. The amount of carbon lost during the fall while the soil is still warm will be compared with that sequestered during the growing season. Nighttime CO_2 fluxes obtained by soil chambers, eddy correlation and the tethersonde CO_2 concentration profiles will be compared and related to soil temperature and water content to provide a practical means of estimating ecosystem respiration rate.

TF-2 Neumann/Mickle/Staebler

CO_2 Profiles: Exchange of Energy, Water Vapour and Trace Gases Project (SSA-OA)

Profile measurements of air temperature, relative humidity, wind speed and direction, carbon dioxide conentration, and water vapour pressure will be made from the surface up to 100-300 m using a tethered balloon during the mid-summer intensive only.

The first four measurements will be made with a standard airsonde package and the latter two will be made using a sample line attached to the tethered balloon and a LiCor 6262 infrared gas analyser on the ground. Measurements will be mostly made at night as a means of determining night-time respiration and evaporation.

Past experience in BOREAS 1994 has shown night-time measurements of these fluxes by conventional eddy correlation techiques frequently to be unreliable.The intent here is to improve these measurements by examining concentration profiles and to investigate ways of adjusting or correcting the eddy correlation measurements.

TF-3 Goulden/Wofsy/Daube/Munger

Eddy Covariance Measurements of CO_2 and Water Vapor Flux for BOREAS

We will continue monitoring the physical environment and the turbulent exchanges of carbon dioxide, sensible heat and water vapor above the Northern Old Black Spruce site (NSA-OBS) throughout 1996. Our goals are: 1) to determine the short-term (hourly) response of exchange to the physical environment, 2) to characterize the seasonal courses of CO_2 and energy exchange, 3) to measure the annual CO_2 balance of the site, 4) to determine the effects of interannual climate variability on exchange, and 5) to use this information to assess the sensitivity of carbon and water balance to hypothetical climate change.

The measurements at NSA-OBS have run continuously since April 1994, with reliable observations through March 1996 during 12,000 of 17,000 hours. Whole forest net exchange at 30 m height is calculated for 30-minute intervals using the eddy covariance technique. Turbulent fluctuations in wind and temperature are measured with a 3-axis sonic anemometer, and in CO_2 and H_2O with a closed-path infrared gas analyzer (IRGA). The change in CO_2 and H_2O stored from 0 to 30 m height is determined by sequentially passing air from 6 altitudes through an IRGA. Incident and reflected photosynthetically-active radiation (PAR) are measured with horizontal silicon quantum sensors. Net radiation is measured with a thermopile net radiometer. Moss-surface PAR is measured with quantum sensors at 8 locations along a transect. Air temperature at 2, 10, and 30 m height is measured with precision thermistors in ventilated radiation shields. Soil temperature at 2 sites is measured at 5, 10, 20, 50 and 100 cm beneath the moss surface. Precipitation is measured with a heated tipping-bucket gauge. The turbulent data are archived at 4 Hz and the meteorological data at 1 to 0.125 Hz. The meteorological observations are delivered to BORIS for 30-minute intervals, but higher time resolution can be made available.

Additionally, we will make continuos measurements of moss surface CO_2 exchange using an automated gas exchange system (in collaboration with TGB-1). The system sequentially samples 10 closed-type chambers, completing a circuit every 3 hours. The chambers are clear with a pneumatically-actuated lid that remains open 94% of the time. Soil temperature, air temperature and PAR are measured continuously at each chamber. The system was installed in September 1995, and operated for six weeks prior to a hard freeze. We expect to run the system from snow melt (April or May 1996) though November 1996. The eddy-covariance and chamber measurement systems are fully automated, allowing extended periods of unattended operation. We anticipate twice-weekly site visits by a local employee for data collection. Regularly scheduled visits by science personnel will occur at least once every 5 weeks throughout the summer.

TF-5 and AFM-1 Baldocchi/Crawford/Dobosy

Title: Modelling and Assessing Fluxes of Water, Heat and CO_2 over a Complex Landscape

Work to be Done

Two key issues are associated with the parameterization of surface fluxes are of particular interest to the GEWEX/GCIP programs. One issue concerns the fidelity of the submodels to calculate scalar flux densities to and from a given patch of land. The second issue concerns the spatial variability of surface fluxes within and among constituent patches of a landscape and the integration of these fluxes to the scale of the model grid.

We plan to use existing BOREAS data (obtained from our previous NOAA Global Change funding) and to evaluate several land/atmosphere modelling issues. We plan to assess a hierarchy of carbon and water flux models and we plan to use these models and aircraft meteorological and flux measurements to evaluate landscape variability of water, carbon and energy fluxes. Lessons learned from this exercise will be directly applicable to assessing land-atmosphere fluxes in the GCIP domain.

Specific research tasks being proposed include:

1) develop and update a hierarchy of canopy-scale and PBL-scale water, energy and carbon flux models; the proposed models include a big-leaf, a two-layer and a multi-layer scheme.

2) test these models against available (and in-house) tower-based flux data.

3) apply the validated models along landscape transects (using aircraft meteorological and satellite-derived surface data) and test them with available aircraft flux data.

Subtasks include: a) complete quality control and preparation of Long-EZ data set from the 1993 and1994 summer campaigns;

b) evaluate empirical variability of surface fluxes and the inpact of different land surface features on surface fluxes; c) evaluate the scales on which surface heterogeneity effects (eg. advection) can be ignored or must be treated explicitly; d) quantify feedbacks and forcings between surface fluxes and PBL growth and development.

The ultimate product will be an estimate regional-scale mass and energy fluxes over a heterogenous landscape.

TF-7 Desjardins/Pattey/Sellers/Mahrt/Berry/Cihlar/MacPherson

Estimation of Fluxes from Changes in Concentration

Proposal Activities

1. <u>Field program (nocturnal boundary layer study)</u>

We plan to quantify the nighttime carbon exchange at the old black spruce site in the SSA by measuring the change of CO_2 and CH_4 within the nocturnal boundary. Profiles of CO_2 will be obtained using a small portable CO_2 analyzer or a LICOR 6262. Profiles of methane will be obtained using a tunable diode laser analyzer. Profiles will be measured up to 300m with the portable analyzer and up to 100m using long sampling tubes. Simultaneous measurements of temperature, humidity, pressure, wind speed and direction will also be made using a tethersonde. Profiles of CO_2, H_2O and CH_4 will be obtained simultaneously within the canopy from the TE tower(see AFM-14). All these measurements will be primarily carried out under light wind conditions (0-2 m/s) between July 8 to July 24. Some of these measurements will be done in conjunction with one or two Twin Otter flights in order to characterize advection and mass and energy exchange at the top of the thin nocturnal boundary layer. The tethersonde measurements will be extended vertically using aircraft soundings.

2. <u>Field program (boundary layer budget for retinal estimates of CO_2 flux)</u>

A small portable CO_2 analyzer system was assembled to measure the profiles of CO_2, H_2O, temperature and pressure up to 12,000'. Such profiles will be collected throughout 1996 by P. Sellers to quantify the change in CO_2 in the mixed layer. This is expected to give us a measure of the change in NPP over a large area from hour to hour and from day to day. The first set of flights were done in later March, a second set is scheduled during mid April. Such flights will continue through the growing season in 1996. Such measurements will also be occasionally carried out over agricultural areas for comparison purposes.

3. <u>Analysis</u>

Analysis of TF-7 1994 data showed that considerable underestimation of nighttime respiration by eddy flux measurements was a problem. This is the main reason to complement the eddy flux measurements of TF-9 by the change in CO_2 in the whole boundary layer.

Both layer-integrated budget and eddy correlation methods will be used to estimate the nocturnal fluxes. Because the fluxes are intermittent, it will be necessary to formally estimate flux sampling errors. It will also be necessary to recognize unusual vertical structure in the weak wind nocturnal boundary layer, including cases where the turbulence is generated mainly in elevated layers shear layers well above the canopy. In such cases, flux from the canopy occurs only in intermittent episodes when the elevated turbulence bursts to the surface.

TF-8 Fitzjarrald

1. Overview.

Several data gaps were identified in the TF/TE White Paper on surface measurements. Primarily, we lack C flux, ET, and canopy physiological measurements during the spring thaw and autumn freeze-up transition seasons. We also lack information about the controls over fluxes from the moss layer--critically needed because of the large role of moss in the C and water fluxes, and in water storage. Analysis of observations from the continuously operating flux system at OBS has shown that respiration in autumn may counter a significant fraction of summer C uptake. Therefore, the focus for the autumn measurements is to quantify soil/moss fluxes in the transition period, and determine what triggers overstory shutdown and controls soil/moss C fluxes. Model studies have pointed to the need for more "component" based observations of the contributors to the carbon budget, particularly separating the components of moss/soil C fluxes. To better test models, the modeling groups expressed a desire for a longer, continuous time series of data. Finally, interesting atmosphere-vegetation feedbacks (humidity-transpiration) were observed in 1994, but were not fully explored. Proposed research tasks are written up in section 3.2. NSA-OJP proposes to conduct a program of limited above-canopy flux measurements from April 15 to November 15 at the three NSA tower sites that operated only during the summer 1994 campaign (OJP, YJP, FEN). This will complement the ongoing work at OBS. It is critical to know at what stage in a draw-down cycle that physiological measurements are made. A concurrent program of continuous soil moisture observations (probably using TDR techniques) at the NSA forest tower sites is proposed to support these observations. At OJP, this may be done using the system from McGill operated in 1994 (subject to funding), or by using a new system as proposed by HYD-1. At the fen, continuous measurement of water level is proposed by TF-10.

TF-9 Jarvis/Massheder et al

The OBS (TF 9) flux site will operate continuously from the thaw in the spring through to the freeze up in the fall. Proposed start date is March 15, respectively, and measurements will continue until the end of November approximately.

There will be:

- eddy covariance measurements of fluxes of momentum, sensible heat, H_2O and CO_2 above the canopy (top priority for continuous operation)

- similar eddy covariance flux measurements in the trunk space

- a fully instrumented weather station above the canopy and in the trunk space, and some additional measurements at and close to the soil/moss surface (air and surface temperature, wetness, PAR, humidity, windspeed) especially at OBS

- profiles of atmospheric CO_2 concentration and air temperature

- profiles of soil temperature (to start as soon as possible to run through the winter)

- sap flow estimates of tree transpiration for comparison with eddy flux (TE 7 at OA throughout the entire period. Other details may be found in section 3.3.

TF-9; P.G.Jarvis, J.B.Moncrieff, M.B.Rayment, S.Scott et al.

Proposed activities in 1996

(a) Analysis and paper writing

(b) CO_2 and H_2O flux measurements at SSA OBS 15 March to 30 November above and below the tree crowns, supplemented with soil CO_2 efflux measurements using soil chambers and tree foliage gas exchange with branch bags and cuvettes. Also, weather stations above and below the tree canopy, soil temperature and canopy FPAR.

TF-10 McCaughey/Lafleur/Buttle

Background

This proposal with an estimated budget is submitted on behalf of the Canadian component of the TF-10 group for work at the Fen and Young Jack Pine (YJP) sites at Thompson in 1996.

The work discussed in this document follows the suggestions proposed in the BOREAS white paper (August, 1995), "Fluxes and Processes at the Stand Level", as well as the decisions taken at the Patuxent Science Meeting held in October, 1995. An estimated budget is included. The total estimated financial requirement is $67,250. A contribution to this sum has been received from the AES/NSERC Subvention in spring 1995, with awards to J.H. McCaughey and P. Lafleur of $6,000 each. Another member of the TF-10 group, J. Buttle (Hydrology, Trent University), was also supported by the AES/NSERC Subvention in the sum of $8,000. The latter funds have already been spent on field research conducted during the spring melt from March to June 1995 because of a commitment to the Ph.D. studies of R. Metcalfe. J. Buttle does not plan to conduct field research during 1996. The net amount requested is $55,250. In the preliminary budget estimate previously submitted, the net amount requested was $64,000, which was split evenly between H. McCaughey and P. Lafleur. The new budget proposed here has reduced that request by approximately $9,000.

Proposed Activities

a) Ongoing work

We will complete the analysis of the data sets from both sites from the 1993 and 1994 field experiments. This aspect of the work is already budgeted from the NSERC CSP Collaborative Grant. The fourth year of this support starts on December 1, 1995.

b) Proposed Work for 1996 Field Activities

We propose operating the flux towers at the two sites for the period April 15 to November 15. The data collected will include above-canopy net ecosystem flux of CO_2, as well as convective fluxes of heat and water vapour. We will also provide net radiation, air temperature, relative humidity, and three levels of soil temperature. This has been described as a minimalist suite of flux data whose continuous recording will provide the essential data to resolve the annual carbon budgets for the sites.

I support the collective view of the NSA tower flux groups that it is more important to collect a limited set of data from the maximum number of flux towers rather than to focus intensive data collection at a reduced number of towers.

We will participate in the proposed IFC-2 at the YJP site and run the tower in a more intensive mode during this period. Other tower data added in the IFC will include temperature, humidity, and wind profile information in the canopy and the lower atmosphere. In addition, we will participate in the intensified focused studies on both the Old and Young Jack Pine sites when in-canopy fluxes of heat and moisture will be measured with portable eddy correlation systems. These systems will consist of the Campbell Scientific single-axis sonics, currently owned by both TF-8 and TF-10. These portable systems have been termed Mobile Focused Flux Units (MFFU's). During the intensive in-canopy work, supporting chamber and sap flow measurements will be collected by TE teams. We propose adding to the TE data collection by measuring stomatal conductance. This will allow us to extend our existing 1994 stomatal conductance data set for the Young Jack Pine stand to investigate further the proposed positive feedback between the boundary layer and the canopy in terms of the relationship between boundary layer drying, surface water stress, and stomatal closure.

Our proposal is predicated on obtaining robust sonic anemometry for both the Fen and YJP sites. This was agreed on as a strategy at the Patuxent meeting. Such hardware will not only make our data series more continuous, it will also facilitate the automation of the data collection, allowing us to operate for the required extended peroid of data collection with fewer personnel, and thereby saving both travel and accommodation monies. Also, the personnel complement will be shared between both Jack Pine sites and the Fen. Furthermore, with the same measurement hardware operating at all northern sites, we will increase the potential to exchange hardware with other groups and so avoid down time as a result of instrument failures. I have not included the sonic anemometry and associated ancillary equipment as a budget item. Dave Fitzjarrald is handling the negotiations to obtain the financial support to purchase this new equipment.

It is proposed that the Fen site will be a secondary focus of intensified data collection activity for 2 weeks in the period of April 15 to May 30 (NSA Patuxent summary). This period overlaps the proposed IFC-1. At this time, the majority of the work on the site would involve chamber meaurements by TGB groups to investigate the different dynamics of the carbon and methane fluxes from vegetation groupings on the Fen surface. Data from the 1994 experiment have indicated strong vegetation control of the switch-over from an effluxing condition to one of net uptake at this site in the spring. Different parts of the Fen complex turn on at different times, a condition that is likely connected to the spatially variable thawing that occurs. As the responsible TF team for the Fen, we would attempt to fulfill the necessary tower flux data collection to validate the spatially distributed chamber measurements. However, the first priority at this time remains the OBS site, where moss CO_2 exchange will be the focus. A similar argument is advanced for the autumn shut-down on the Fen. Presumably, there is a similar spatial complexity in the shut-down of different vegetation groupings. We do not know any details of carbon cycling at this site in the autumn, and thus, it would be beneficial to the overall study to gain baseline data of carbon exchange from this ecosystem. Intensive flux tower data collection for 3 weeks would be conducted to support the chamber measurements.

It was proposed at Patuxent that continuous soil moisture measurements be taken with TDR at each flux tower. R. Cuenca (HYD-1) is already running such a system at NSA-OBS. I have been informed that for this to occur at other flux towers, the relevant TF group must obtain the necessary support (est. $15,000 US). I have included one such system in my budget. The first priority of this system would be the YJP site where the soils are suitable for such measurements. The Fen is a secondary priority for TDR continuous data collection because the nature of the bog soil makes it less than ideal for TDR measurements. As well, Queen's University has a Troxler TDR system that we would propose bringing to the experiment. This system uses "pencil probes", which is older technology than the system proposed by R. Cuenca. However, with suitable care, very useful data on soil moisture behaviour would be obtained on a regular sample basis as opposed to a continuous basis. Furthermore, if funding for continuous TDR is not available, the Queen's TDR could be used as a roving instrument to sample at both the Fen and YJP sites whenever personnel are available.

TF-10 for BOREAS 1996

Description

It is understood that the priority periods are

1) Spring to autumn, April 15 to November 15 (214 days), minimalist flux measurement

2) Summer: IFC-2 July 8 to August 11 (35 days); focus at Old and Young Jack Pine sites

3) Spring and autumn intensive measurement periods; focus at Fen site (assumed 2 weeks in spring and 3 weeks in autumn)

It is assumed that TF-10 will operate the flux towers at the Young Jack Pine and Fen sites in the NSA.

The new equipment needs (robust eddy correlation systems) are not included as a budget item. Dave Fitzjarrald is negotiating the purchase of this equipment.

For safety reasons, a minimum of 2 persons must be present on site during data collection periods. At present, the proposed participants will be P. Lafleur (Trent University), J.H. McCaughey (Queen's University), D. Joiner (Ph.D. student, Queen's U.), P. Bartlett (Ph.D. student, Queen's U.), and one unnamed undergraduate research assistant. All persons, except the undergraduate assistant, participated in the 1994 field experiments.

TE-2 Ryan

Problem: Along with assessing fluxes in the spring and autumn, two unresolved problems exist in the current BOREAS data: (1) what is the cause of the large differences between fluxes at OJP and YJP? and (2) Does gas exchange of conifers (OBS, OJP, YJP) shut down in response to atmospheric humidity deficits or hydraulic restrictions on transpiration? If the latter, do hydraulic restrictions differ by species and tree size or age? In addition to gathering data in support of the flux missions, my research proposes to answer these two questions.

Proposed Measurements:

1) Sapflow of trees at NSA-OJP, NSA-YJP, and NSA-OBS from end of April-October 96. These measurements are very useful for comparing with TF energy budgets and model scaling, and allow estimation of whole-tree transpiration and conductance. Whole-tree transpiration and conductance can be compared with meteorological data to derive species-specific canopy-level response functions. We hypothesize that transpiration per unit leaf area will be lower on the spruce than the pine and lower on the older pine than the younger pine.

2) Diurnal leaf CO_2, transpiration, and stomatal conductance profiles through the canopy at NSA-OJP, NSA-YJP, NSA-OBS once in spring, summer, and autumn. Done to compare with tree-level sapflow measurements, compare with 1994 measurements and provide basic information to BOREAS. We will also make an effort to collect more leaf gas exchange during cloudyconditions, because these data are poorly represented in the 94 data set (we were all looking for sunny days!).

3) Experiments to distinguish between transpiration-limited and humidity-limited stomatal response. These involve leaf gas exchange on branches with altered leaf-specific hydraulic conductivity and/or altered humidity.

<u>Other Issues:</u>

TE towers will need to be set up at NSA-OJP, NSA-YJP, NSA-OBS, SSA-OA, andSSA-OBS. I recommend that gravel pads 1.5' thick are installed at the OBS sites because the bases may move during melt. Locating the towers in dense canopy is very important! If Joe Berry is to sample leaf gas exchange in early March, then the towers need to be up then!

TE-4: Berry/Collatz/Gamon/Fu

Proposed activities:

(a) Ongoing work:

We are now working with SiB2 at the BOREAS tower sites. So far, we have completed our first full year simulations using data from the Old Jack Pine tower in the south (TF-5). We are very pleased wit these results. We have received flux data from the old black spruce in the north (TF-3), and we are in the process of putting together a file of meteorological driving data. Our next goal will be the old aspen in the south (TF-2). We plan to do full year simulations at each of these sites. With this, we will have calibrated versions of SiB2 for each of the major tree species. We will test these using data from other TF sites.

(b) Proposed work for 1996 field activities:

Our first priority in 1996 will be to conduct work to examine the recovery of photosynthesis by conifers moss and lichens in the spring. Similar work will examine the loss of photosynthesis in the fall. This work will use chlorophyll fluorescence and leaf gas exchange to probe the activity of shoots at different levels in the canopy. A fiberoptic probe will be constructed to examine the physiological state of moss and lichens beneath the snow. One trip is planned to establish the winter baseline on approximately 15 March. At least one more trip will be made in April when the thaw sets in. Several things are still unclear: (1) we still have not identified someone to make these measurements in the northern study area. It is possible that I will need to cover both areas or that we will have to assume that the plants will respond similarly to temperature in the two areas. (2) it is possible that follow-on measurements could be done by the TF crews when they arrive, meaning fewer trips for me, but would require that equipment be left for them to use. I only have enough to equip one crew (TF-9). (3) It will be important to separate the moss/lichen contribution from that of the overstory trees. It is likely that the lower plants contribute a major portion of late and early season photosynthesis.

During the main season, three activities are planned: (1) we will contribute to the measurement of understory photosynthesis at the OBS site (TF-9). It is my understanding that TE-12 (Tim Arkebauer) will take the lead on this. (2) we will set-up transects for measurement of fluorescence of moss. In 1994 we found very large changes in the fluorescence parameters of moss depending on whether it was wet (photosynthetically active) or dry (dormant), and this varied greatly with location (presumably because of non-uniform drying). We propose that measurements along a set course could be used to assess the proportion of the moss that was wet enough to be photosynthetic at any time. Repeating these measurements on some interval could be used to quantify seasonal changes in moss photosynthesis. This will contribute to work proposed by TE-5 and TE-6. (3) We have discussed setting SiB2 up to run concurrent with flux measurements at both the OBS and OAS tower sites. This will permit comparison of simulations with measurements during the field campaign. This may help to identify problems with the model or measurements that can be addressed at the time. This will require an additional person in the field to get this started.

In 1994 Dennis Baldocchi used a track to obtain spatially integrated radiation measurements below the canopy at OJP. During the recent workshop we discussed that such a track would be very useful at the OBS site to obtain a better idea of the radiation regime above the moss layer for the 1996 campaign. Dennis' equipment is committed. We (CIW) have shop facilities and could fabricate a similar track and robot for this purpose. I estimate that this would cost about 2,500 to construct the track and robot and to purchase tripods to support it. In addition, a data logger and radiation sensors, will be needed. I assume that these can be borrowed from somewhere.

TE-5 Flanagan/Ehleringer

Field Work will be conducted at the Old Black Spruce in the SSA during 3 IFC's in 1996

IFC-1 mid April - early May
IFC-2 July 9 - Aug 9
IFC-3 Oct 2 - Oct 23

GAS EXCHANGE

1) Field measurement of CO_2 and H_2O flux from the moss/soil surface using a LiCor 6200 system and a large clear chamber attached to permanent collars installed in the moss/soil. Sampling for spatial, diurnal, and seasonal variation in fluxes under natural conditions. We will also conduct experiments to determine changes in fluxes associated with experimental wetting of the moss. We also plan to compare the gas exchange in the two major moss types (Sphagnum and Pleurozium). In association with this gas exchange program we would like to quantify the abundance of the two major moss types by sampling the moss vegetation along transects away from the flux tower. Relevant meterological data (soil temperature, moss temperature, PAR, air temperature, RH, moss water content) will be made in association with the gas exchange measurements.

2) The concentration of CO_2 in the soil/moss system at five depths will be measured at 3 different locations (2 in Pleurozium and 1 in Sphagnum) on probes that were installed last fall.

3) To complement the field gas exchange measurements on the moss/soil system, we intend to collect samples of moss at regular intervals and immediately measure its photosynthetic characteristics in an open, steady-state gas exchange system located in the hut at the flux tower site. Moss collections will be from locations near the site of field gas exchange sampling. At a minimum these measurements will also us to document temporal changes in moss photosynthetic capacity. We hope that the measurements will allow calculation of important biochemical parameters, Jmax and Vcmax.

4) We will attempt eddy covariance measurements in the trunk space of the black spruce forest during the summer IFC only. Our sonic anemometer will be installed for all 3 IFCs and we will therefore get measurements of friction velocity so that aerodynamic conductance in the understory can be calculated. This value may be useful for calculating water flux from the forest floor in conjunction with conductance measurements of the moss from our chamber measurements and VPD measurements.

STABLE ISOTOPES

See the Explan for some of the detail on the rationale for our isotope sampling program. In short, we expect that our stable isotope measurements will help us to determine: a) What proportion of ecosystem respiratory CO_2 flux is contributed by the moss. b) The disequilibrium between CO_2 released during ecosystem respiration and atmospheric CO_2. (This is an important parameter that can influence the outcome of global studies of CO_2 partitioning using C^{13}.) c) How temporal changes in moss activity and water content influences the O^{18} content of CO_2 respired from black spruce ecosystems.

1) Measurement of the concentration and stable isotope composition of CO_2 in flask samples of air collected on a diurnal basis from 2 heights on the flux tower (26 m and 3 m). Analysis of these samples will allow us to determine the isotope ratio of CO_2 respired from the entire ecosystem. In addition, if we are able to obtain measurements of the one-way flux of CO_2 into the forest and the one-way flux of CO_2 out of the forest (from the sonic anemometer on top of the flux tower) during the time periods of our flask sampling, we will be able to construct an isotope mass balance and calculate the apparent isotope discrimination by the entire forest. This value could be compared to calculations of forest discrimination from the eddy covariance measurements and model calculations of the forest "big leaf" assimilation, conductance and chloroplast CO_2 concentration. We will likely be able to collect only 2 or 3 sets of diurnal cycles during an IFC period.

2) The contribution of the moss/soil to the isotopic composition of respired CO_2 will be determined by collecting a series of air samples from the head space of chambers placed over the moss/soil surface.

3) Values for the isotope ratio of CO_2 collected from within the moss/soil will be done on samples of air collected from probes installed at different depths within the moss/soil. In conjunction with Sue Trumbore, we also hope to have C^{14} values measured on the soil CO_2 and on different age fractions of moss/soil organic matter.

4) The specific contribution of the moss alone to moss/soil respired CO_2 will be determined in laboratory studies where only the moss will be placed in a gas exchange chamber and respired CO_2 will be collected for later isotopic analysis.

   Other necessary stable isotope measurements include: a) oxygen isotope ratio of water in: moss, tree leaves, tree stem, soil, atmospheric water vapour. b) carbon isotope ratio of: tree leaves, moss and soil organic matter at the OBS site in the SSA.

OTHER POSSIBLE MEASUREMENTS

We could provide heat balance sap flow gauges to be used in conjunction with branch bag gas exchange sampling, if there was interest.

We may initiate a study of the isotope ratio of methane and N_2O in air samples collected from our soil probes and flask samples in the canopy air space.

TE-6: Norman/Gower

Measurement and modeling of soil surface CO_2 flux for a boreal black spruce forest ecosystem. By Tom Gower

Background

One of the primary goals of BOREAS is to understand the interaction of CO_2 between the atmosphere and terrestrial ecosystems. The 1994 field campaigns elucidated several key factors related to the C cycle of lowland boreal conifer forests. First, the C cycle of black spruce forests is detrital-dominated -- that is to say only a small fraction of the C assimilated is stored in permanent tissues. Thus, it is imperative to accurately estimate the annual transfer of C from the annual turnover of leaf and fine roots, which TE-6 is doing. Second, soil surface CO_2 flux is large relative to other CO_2 losses from the terrestrial ecosystem to the atmosphere and can be positive or negative depending upon the water content and light conditions of the moss/sphagnum layer. Third, preliminary results suggest that moss/sphagnum net primary production equals or exceeds that of overstory trees. Thus, to simulate the net soil surface CO_2 flux from the black spruce forests, it is imperative that an mechanistic model for CO_2 exchange by mosses and soil microbes be developed.

To simulate soil surface CO_2exchange, it is necessry to understand how environmental factors such as temperature, solar radiation and moisture content independently affect moss photosynthesis and microbial soil respiration. Unlike temperate terrestrial ecosystems, the vegetation at the soil surface is decoupled from the soil. For example, in the spring the moss surface is warm while the organic/mineral soil is still frozen resulting in a net CO_2 flux downward. Conversely, in late fall, the moss surface is cool or frozen while the soil is still warm resulting in a net CO_2 flux to the atmosphere (Figure 1). During the summer the moss and soil collectively reach maximum temperature and the direction of CO_2 flux is strongly dependent upon the water status of the feathermoss layer (Figure 2). I made good progress towards understanding the effect of temperature, solar radiation and their interaction on soil surface CO_2 exchange for several sphagnum species at the northern fen (see Figure 1). However, due to numerous other committments and the large amount of time to get to the northern old black spruce forest, I did not make as much progress on feathermoss -- the dominant cover in both the southern and northern old black spruce sites. However, several important lessons were learned. First, it takes several hours for the photosynthetic machinery of feathermosses to recover from dessication. Second, immediately after rewetting of the feathermoss layer there is a large pulse of CO_2 released to the atmosphere (Figure 2). Therefore, wet-down experiments, followed by continuous soil surface CO_2 flux measurements are required to understand the influence of moisture content, temperature and solar radiation on each component contributing to the net flux of CO_2 from the soil surface.

Approach

I propose to work exclusively at one of the old black spruce sites (probably in the SSA because Crill is planning to work at the NSA). I will expand an automated four chamber soil respiration system to 8-chambers and make continuous measurements CO_2 flux three times (spring thaw, summer and late fall) during the year. The current system consists of a Li-Cor 6262 water and CO_2 analyzer manifold system and four 35.5 cm diameter chambers equipped with small fans to ensure adequate air circulation in the chambers. Each chamber is raised and lowered using a linear actuator and programmed to make two sets of measurements per hour.Three measurement periods are required because the moss and soil are decoupled. During each measurement period, we will saturate a 3 x 3 m area and place 4 chambers in the wet-down area. The remaining four chambers will be located in a nearby control area. I will measure soil surface CO_2 flux continuosly as the moss surfaces dries out. Depending upon the time required for the moss to dry out, I hope to repeat the experiment twice during each field campaign. In addition, I will use the moss photosynthesis chamber equipped with the LED light head that I tested in the 1994 field campaign to develop light response curves for feathermoss of varying moisture content.

Analyses

Dark chamber measurements will provide estimates of microbial respiration while the clear chambers or chamber equipped with the light source provide the net soil surface CO_2 flux (i.e. soil respiration - moss photosynthesis). Using soil surface CO_2 flux data and measured environmental parameters I will develop a mechanistic model to simulate net CO_2 flux from the soil surface of a black spruce forest ecosystem. The model will be used to simulate annual net CO_2 flux from the soil surafce of the black spruce forests. I will compare my daily and annual estimates to net ecosystem estimates (obtained from the eddy correlation system) to elucidate the contribution of the moss/soil system to net ecosystem CO_2 exchange. Also, the proposed measurements, in conjunction with the natural isotope abundance measurments proposed by Ehleringer's group, will increase our understanding of the importance CO_2 recycling near the forest floor surface.

I have purchased over $20,000 worth of equipment to build a 4 chamber system. However, to have suitable replication for the proposed wet down experiment I will need to construct an additional 4 chambers and purchase miscellaneous manifolds, flow controllers etc. to complete the system.

Figure 1. Light response curves for Sphagnum fuscum at three different dates or surface temperature. CO_2 flux at 0 PAR represents soil respiration and the difference in CO_2 flux between 0 and maximum PAR equals photosynthesis

by S. fuscum. A positive CO_2 flux simulates a net movement of CO_2 from the atmosphere to S. fuscum cover.

Figure 2. CO_2 flux in relation to moisture content of the feathermoss layer. Measurements conducted at the UW Biotron and similar responses were observed in situ at the NSA black spruce site.

(2) Understory Dynamics in Relation to Hydrology of Black Spruce Forests

Understory biomass and net primary production efforts revealed that understory dynamics are highly variable in black spruce forests ranging from solid feathermosss mats in wet areas to a species-rich, tall statured understory dominated by ericaceous shrubs, sedges, and assorted forbs in drier areas. Net primary production of the understory has greater importance in these forest communities because woody biomass increment is so small compared to temperate forests. In addition, the leaf area of the understory needs to be quantified because it is likely to contribute to the overall reflectance of the forest canopy given the open nature of these forest canopies. The objective of this study is to quantify the understory dynamics biomass, net primary production and leaf area) along the perceived hydrologic gradient in the SSA black spruce forest. Replicated 200 m transects will be established along a gradient originating

From the flux tower and extending in a northwest direction (following the NPP plots established by Gower et al.). A 2 m x 2m plot will be established on each side of the transect at every 5 m and understory biomass will be identified by species, harvested, separated into current tissues (foliage and twig) and older tissue (foliage, branch and stem). Foliage will be sub-sampled for specific leaf area and used to calculate leaf area from foliage mass. Percent cover by sphagnum, feathermoss and lichen will be quantified in each plot. At each 5 m sampling location the depth of organic matter (i.e. sphagnum mat) and water table depth will be determined. During the middle of the growing season, we will use a 35 mm lens equipped with a fish-eye lens to quantify leaf area index and APAR. Canopy images will be processed using software developed by Dr. Paul Rich, University of Kansas.

(3) Soil C and Coarse Woody Detritus at Auxillary Sites

Jason has developed complete organic matter budgets for the aboveground vegetation at all the auxillary sites; however, to my knowledge estimates of carbon content of mineral soil, forest floor (surface detritus) and coarse woody detritus are lacking. Forestry Canada collected forest floor depth but I have no clue how this value could be converted into forest floor mass. A substantial amount of carbon is contained in downed woody biomass in many boreal forests, especially aspen stands. The carbon content of CWD probably exceeds forest floor carbon content. In most forests, mineral soil carbon content exceeds carbon content of vegetation. In addition, while sampling the soil at the tower flux sites, we have frequently encountered charcoal layers. The carbon contained in this fraction has a significantly lower turnover time than carbon contained in other organic fractions.

A field assistant working for one growing season in the field and the balance of the year in the laboratory should be able to collect, analyze, and prepare a report summarizing C content of mineral soil, forest floor and coarse woody detritus for all auxillary sites. Forest floor and mineral soil will be collected at each of the five biometry plots and one 50 m transect will be used to quantify coarse woody detritus. These data will prove valuable in validating regional C model simulations and determining if boreal soils are accumulating C.

(4) Tamarack Allometry

Tamarack, a deciduous conifer, is an important boreal tree species and has unique carbon and nutrient cycling characteristics compared to evergreen conifers. Tamarack occurs in pure stands only infrequently in the NSA and SSA, but it is a common tree species in many of the poorly drained forests and fens. However, we do not have any allometry data for this species. The objective of this study would be to harvest tamarack from the SSA and NSA to develop allometric equations for estimation of biomass and area of major tissues (stem, branch, foliage).

TE-7 Hogg/Hurdle

Ongoing work: Analysis of 1994 and 1995 results, and preparation of publications, including paper with Black, Den Hartog and others comparing latent flux (transpiration) measurements at SSA-OA by eddy flux and sap flow.

Proposed work for 1996 (BOREAS, within context of CFS Boreal Forest Transect Case Study):

SSA-OA: Hourly sap flow of aspen from April to early November 1996
Mid-day leaf water potential of aspen during summer IFC
Litter traps to estimate leaf area and biomass by species
Increment cores for dendrochronology and stand sapwood area
Pilot study of low cost eddy-flux system for latent/sensible flux
Possible collaboration with TE-11 (Saugier) to measure P/S and conductance continuously for several weeks using branch bag

SSA-OBS:
(tentative, subject to budgets and discussions with collaborators)
Hourly sap flow of Black Spruce

TE-10 Middleton

Our TE-10 “spring” effort will complement the early spring measurements to be acquired by Joe Berry, and will take place during a later time 10 day period (e.g., 4/20 - 5/19). 2 University of MD participants (Co-I, J. Sullivan and technician) will partially set-up our field lab at Paddockwood for the 1996 season and acquire photosynthesis and related measurements of photosynthetic function (pigments, fluorescence) at the 2 black spruce sites (SSA and NSA). For the NSA, these 2 persons require air transport from Prince Albert to Thompson provided by P. Sellers, and ground transport provided by BOREAS staff. For the SSA, a vehicle will be rented.

An early summer effort during the new needle emergence time period is needed to fill a 1994 gap in spectral optical properties. The PI (myself) and an SSAI contractor (Stephen Chan) will visit SSA (OBS, OJP, and YJP) for 10 days ~6/5 -15.

For the summer campaign, 3 persons will participate: the PI (myself), an SSAI contractor (S. Chan), and a UMD technician. We plan ~21 days (within the period, 7/9-8/9) at SSA, and will require accomodations in Prince Albert to coordinate schedules and manpower with RSS-1 (canopy BRDF measurements). During this campaign we will make photosynthesis, optical property and pigment measurements on the 3 SSA supersites (OA, OBS, and OJP, with emphasis on the first 2).

The “fall effort” is the most tenuous part of our plan, due to uncertainties in availability of funds and personnel. If conducted for 10 days during October (10/1-10/21), we would coordinate our schedule to complement (rather than duplicate) that of Joe Berry at the 2 OBS sites (SSA and NSA). Transportation the same as in the spring measurement period.

These 1996 data acquisitions will generate data that will require 6 months of technician support to organize, process, analyze and prepare for BORIS. Leaf material will be obtained for the SSA-OA, SSA-OBS sites for analyses of L, N and H. Joe Berry (TE-4) will supply leaf material from NSA-OBS for the same analyses.

TE-12 Walter-Shea/Arkebauer

Proposed activities:

Proposed work for 1996 field activities. Our goal is to gain an understanding of radiation and gas exchange of two dominant understory species at the SSA OBS site. Two scientific objectives have been identified to achieve this goal:

(1) Characterize the PAR environment of two dominant understory species

(2) Characterize the gas exchange of two dominant understory species

Research Procedures. Characterization will be conducted on plants from two dominant species at the SSA OBS site. Incoming PAR and outgoing and transmitted PAR from representative plants will be measured periodically throughout a course of a day for selected days during the field campaign. Direct and diffuse conditions will be quantified as well. Also, leaf optical properties of leaves from the plants will be measured. Diurnal courses of leaf CO2 assimilation, stomatal conductance, air and leaf temperature, PPFD and VPD will be quantified. The measurement of the diurnal courses will be coordinated with the PAR environment characterization. Response curves will be characterized as a step toward modelling leaf diurnal patterns. The canopy overstory will be photographed to document the overstory condition over the selected plants. Also, plants will be removed from the area after completion of measurements for leaf area and biomass measurements.

Ongoing work. We wish to continue our research regarding the bidirectional scattering from conifer shoots. Our presence in BOREAS 1996 will allow us to send conifer samples to Lincoln for detailed measurements of the bidirectional scattering, shoot geometry and needle optical properties.

TE-19 `Frolking

Proposed activities:

(a) Ongoing work:

Model development and applications.

(b) Proposed work for 1996 field activities.

Assist TGB-1 and others in field in north for 2-3 weeks.

TE-23 Rich

I. Proposed Activities:

A. Ongoing Work, FY96

Ongoing work during FY96 will focus in four areas:

1) performing additional analyses of hemispherical photographs to examine a) vertical patterns of foliage distribution and b) the relation between calculated indices and sensor FPAR values;

2) checking and finalizing the hemispherical photography analyses and associated data submitted to BORIS;

3) answering inquiries and meeting the needs of other BOREAS PIs who require the use of our data; and

4) completion of a series of publications, in particular a) an LAI intercomparison paper (with Chen, Gower, and Norman), b) an FPAR intercomparison paper (with Chen, Fournier, and Roujean), and c) a BRDF paper (with Fournier).

B. Field Activities, FY96

The primary goal of field work to be conducted during the summer field season of 1996 will be on acquiring sets of hemispherical photographs to enable better integration of remote sensing and gas flux measurements. In particular, our effort will focus on acquiring hemiphotos from five key categories of locations:

1) at tower flux sites where questions have arisen about data quality or unique circumstances that have not yet been explained;

2) in additional vertical profiles at TF tower and TE tower sites where hemiphotos were not acquired in 1994 (SSA-OA and all NSA towers);

3) above PAR sensors operating in the understory and within the canopy, to examine relations between canopy geometry and temporal variation in PAR;

4) at specific locations where gas exchange measurements have been made, to relate these ecophysiology measures to canopy geometry; and

5) along the new SSA-OBS understory transect to relate allometric measures to estimates of LAI and FPAR.

In addition to acquiring these sets of hemispherical photographs, we will fill in a gap in our data concerning three-dimensional structure of individual mature aspen tree crowns by collecting additional geometric data (for use in fine scale geometric models of BRDF and radiative tranport).

C. Final Analyses, FY97

Final analyses during FY97 will focus on three areas: 1) completion of analysis and archiving of additional hemiphotos acquired during the summer of 1996; 2) testing fine scale geometric models of stand structure to examine temporal variation of FPAR and how this relates to gas exchange; and 3) examining interactions between understory and overstory gas exchange as mediated by temporal variation in FPAR.

TGB-1 Crill

TGB 1 BOREAS activities in 1996, Spring/Fall/IFC,

We plan to continue our program of direct measurement of surface/ atmosphere trace gas exchange at sites in the NSA in 1996. We will focus our attention on methane and carbon dioxide because (1.) 1994 measurements by Zepp (TGB-5) and preliminary observations by ourselves indicate that CO and N2O exchange rates are weak from upland soils and are directly associated with fire history and (2.) CO_2 and CH_4 soil fluxes are quantitatively important in considerations of the regional C balance. We have reconsidered our field program in the light of the 1994 datasets, modelling considerations and the programatic needs as identified in the recent BOREAS "white papers." As a result we have expanded our multi-disciplinary collaborations in our particular projects.

Our principal focus will be the magnitudes and the community level controls on the soil surface exchange of CO_2 and CH_4. We plan to measure net ecosystem exchange of CO_2 (NEE) and CH_4 fluxes across temporal and environmental gradients of moisture, temperature, pH and species composition (primarily bryophytes) during spring thaw, fall freeze up and the IFC using a humidity and temperature controlled chamber and a LICOR infrared gas analyzer and clear auto mmated chambers in order to determine the magnitudes and controls on carbon exchange rates.

In the NSA, results from chamber measurements of NEE and CH_4 flux in 1994 showed a large range in carbon exchange rates among the different plant communities within the NSA. NPP measurements of Sphagnum moss in the NSA-fen showed that most of the season's growth occurred before or during the first IFC. Moss growth also dominated the total ecosystem productivity during the early spring period. These data indicate that the early and late season are critical times for carbon exchange in the fen. There are indications that this is also the case in the feather mosses found at the better drained OBS site as well. We will measure NEE in a greater range of moisture conditions and plant communities from the spring thaw through fall freeze up at different light levels using a humidity and temperature controlled chamber and a LICOR infrared gas analyzer. PAR will be measured at the same time in order to extrapolate short term measurements of carbon exchange to longer term carbon fixation. We also propose to measure NPP of mosses and vascular plant species to determine the relative contribution of different plant lifeforms.

The integrated methane flux from a larger area of the fen can be measured by combining concentration gradients with transfer coeeficients. If the tower of the fen is operational, we would maintain an automated g.c. to measure CH_4 gradients.

Temporal variability in the C flux and seasonal contributions of the moss layers to the net C flux at the OBS will be measured by auto chambers. We (Goulden TF3, Crill TGB1) have designed, built, tested and deployed an automatic chamber system to make direct CO_2 measurements from the moss layer in the OBS-NSA. We tested the chambers in Harvard Forest in August and we moved the chambers to Thompson in September. They will continue operation until freeze up or as late as we can get good measurements. We will then redeploy the system in mid April and continue through the thaw period. The chamber system is designed to measure the CO_2 flux from each of 10 clear chambers every three hours. The chambers are clear lexan to measure NEE and use the nighttime measurements to quantify respiration.

Beaver ponds play an important role in the carbon budget of the boreal landscape. Observations in 1994 (TGB-4, TGB1) indicate that beaver ponds are always a source of atmospheric CO_2. The ponds from the regional survey will be revisited and surface water concentrations of CO_2 and CH_4 will be determined. 1994 data showed that plant communities can be used to extrapolate CH4 flux from the chamber to the entire peatland complex because they are surrogates for the primary controls on CH_4 flux (TGB3). We are currently using the CASI image of the fen (J. Miller) and vegetation maps (Jelinski et al.) to extrapolate 1994 chamber measurements to the regional scale. With methane on the tower and aircraft in 1996, we will be able to test or regional spatial extrapolations more accurately than we can now with only chamber data. We propose to use the same approach with the NEE measurements. With a more complete range of plant communities and seasonal CO_2 measurements, we propose to use vegetation maps, tower flux data and NEE chamber measurements to scale CO_2 exchange across the range of plant community, moisture, nutrient and temperature gradients.

The following table outlines TGB-1's proposed 1996 BOREAS activities.

Site	What	Where	When	Notes	Who
OBS	Autochambers, CO_2 fluxes,T, PAR,10 chambers	Feather moss (6),Sphagnum (3), Lichen (1)	Sept-freeze 1995; Thaw-May, IFC, Sept-freeze 1996	Go until it breaks	Goulden, Crill
OBS	NEE/CH4 fluxes, moisture and plant species gradients	Thaw-May, IFC, Sept-freeze 1996	total of about 3 months of fieldwork		Bubier, Crill, Moore
Fen	NEE/CH_4 fluxes, moisture and plant species gradients	Thaw-May, IFC, Sept-freeze 1996	total of about 3 months of fieldwork		Bubier, Moore, Crill
Fen	Auto-g.c. for CH_4 integrated flux by gradient method	Thaw-May, IFC, Sept-freeze 1996	depends on whether the tower is running		Crill, LaFleur/ Jellinski/ McCaughy, Bubier
Beaver Ponds	CO_2/CH_4 in surface water; revisit regional b.p. survey sites, variability	haw-May, IFC, Sept-freeze 1996	at least twice during each study period		Roulet, Crill

TGB-1 Wahlen

Proposed activities:

a) Analysis of the remaining samples collected in 1994 will continue into the spring of 1996. Correlation and synthesis of the BOREAS results and comparison with data from other studies (with publication) will be performed.

b) Methane consumption in soils is known to be dependent on temperature. In our original proposal sampling at all IFC's in 1994 was planned. The funding cut we had in 94 and the fact that certain sets of samples were not taken for us prevented any analysis of the time/soil temperature effect on methane isotope fractionation during the 1994 season. In conjunction with Sue Trumbore and others we would plan to get a minimal number (24) of soil gas samples during 1995 IFC-2 and 3 at the NSA, OJP and YJP sites. This will span the seasonal soil temperature range around the late August sample set we presently have.

TGB-3 Moore/Knowles

Ongoing work:

We are continuing to analyze the data collected in 1994: one paper has already appeared in Global Biogeochemical Cycles), two theses are to be submitted in November, 1995, and several other papers are in preparation. A significant effort is being made to link the CASI and LANDSAT images with CH_4 flux data from the field (TGB-1, TGB-3, TGB-4, TGB-5 etc,.) to produce a landscape-scale assessment of CH_4 flux from the NSA in 1994. This, hopefully, will be one contribution to the JGR Special Issue.

Proposed work, field 1996:

In collaboration with TGB1 (Crill), I propose to measure CO_2 and CH_4 exchanges from wetlands in the Tower fen complex in the NSA. For CO_2, we intend to extend the sampling season into the spring and the fall (previous results indicating the importance of these two shoulders to the C budget) and across a wider range of sites, especially the dry end of the wetland sites. For CH_4, we shall compare fluxes to data collected from sites in 1994, which was abnormally dry.

The LANDSAT analysis can be conducted with existing funds (carry over of NSERC grant). The 1996 field work will require about $20000 (depends on scale of collaboration with TGB1) and it is proposed that an application to the AES Science Subvention program, as part of a larger BOREAS proposal.

TGB-4 Roulet

Determination of CO_2 flux from beaver ponds in the NSA

To determine the representativeness of the carbon dioxide flux that was observed during the 1994 BOREAS from the NSA tower beaver pond.

During the last two weeks in July and the first week in August (Summer IFC 96?), we will measure the instantaneous CO_2 flux from the 12 beaver ponds that were used in the regional methane study in 1994. We have selected this time period since it was the period we observed the maximum flux, and the maximum interdaily variability in CO_2 flux. Earlier in the year the sediments are to cold to support heterotrophic respiration, and later in the summer the pond can sometimes become very anoxic. The CO_2 flux will be determined by two methods. First we will deploy enclosures and determine the gas flux by the rate of change in CO_2 concentration in the enclosure. These runs will take between 5 and 10 minutes and we can do many runs on a single pond in a given day. The second approach will use the surface water concentration of CO_2 and the thin film boundary layer model to compute the gas flux. To do this we require wind speed over the ponds. Therefore, on a subset of our regional survey ponds we will install and floating wind velocity sensor. On a few occasions we will do diel runs. The final aspect of this project will be to determine the mineral and organic composition of the sediments of the beaver pond. Our working hypothesis is that the high CO_2 flux occurs from beaver pond that have flooded riparian wetlands and, therefore contain a large amount of organic material to support the large amount of heterotrophic respiration needed to sustain the high CO_2. Our pond survey is stratified so that both mineral sediment and organic sediment ponds are in the survey.

This work will be conducted by a survey team of two. No direct logistic requirements from BOREAS are needed for this component except for safety provisions already established - i.e.radio contact at times. Our analysis our the gas samples will be done in the NSA laboratory. These arrangements are being made through TGB-1.

TGB-5

Zepp/Burke/Levine/Ojima/Parton/Stocks,/Bourbonniere/Moran /Hodson,

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

PROPOSED ACTIVITIES

(a) Ongoing work

Both fire and beaver activity are natural disturbances in boreal forests. This project is examining the effects of these disturbances on trace gas fluxes and biogeochemical processes in the BOREAS Northern Study Area (NSA) near Thompson, Manitoba. Post-burning effects on soil fluxes of trace gases (CH_4, CO, CO_2, N_2O, and NO) are being determined in upland jack pine and black spruce sites located in this area. The results of the fire-related field studies are being used to refine and validate the CENTURY model. In addition to the fire studies, we also obtained a set of CO flux measurements and other data (e.g., chemical characterization, ammonification, and microbial degradability of DOM) in beaver ponds and other wetlands for input into process models that describe carbon cycling in these systems.

(b) Proposed work for 1996

Field studies will focus on four burned upland black spruce sites located in close proximity on the Gillam Road, including an intense 40000 hectare fire that occurred during July, 1995. The 1996 studies, which are proposed to take place during the 3 IFCs planned for 1996 BOREAS activities, will focus on carbon gas fluxes and soil carbon characterization. Additional field studies of nitrogen fluxes, with emphasis on NO, are proposed. In addition to new studies during colder periods (April, October), we further propose to examine the postburn changes in persistent soil carbon at these sites and the influence of fire-dependent mosses (e.g. Ceratodon purpureas) on net carbon exchange. Other studies will involve sampling of organic carbon leached from the burn sites using piezometers that have already been placed at the sites and subsequent fractionation and characterization of the organic matter. New analyses of fire frequencies, extent and distribution in boreal forests are proposed.

TGB-12 Harden/Trumbore/Sundquist/Davidson

Proposed activities:

(a) Ongoing work (i.e. if no 1996 field activities)

Harden and Trumbore will core the SSA fen and collect sphagnum moss from OBS site in SSA for comparison with NSA fen and OBS data. We planned to do this in Sept-Oct 1995, but because of possible government furloughs, etc., we delayed the trip unitl next spring. 1995 budgets cover this cost.

(b) Proposed work for 1996 field activities.

We will augment our measurements of $^{14}CO_2$ of soil and moss respired carbon. Results obtained so far hint that net decomposition of old C may be a significant component of fall soil respiration in NSA sites. We will make seasonal measurements of depth profiles of CO_2, $^{14}CO_2$, radon (to parameterize gas exchange), temperature and moisture, as well as surface fluxes of CO_2 and $^{14}CO_2$ using chambers. Timing will be determined by coordination with TGB-1 and TGB-3. We anticipate 6 sampling trips to cover all seasons, with sampling at OBS, OJP and YJP sites.

HYD-1 Cuenca

Project Objectives - Monitoring

Soil Moisture Monitoring - Hydrologic Balance

The HYD-1 team will monitor soil water content over the active root zone at each of the active flux tower sites in the Northern and Southern Study Areas. Based on the October 1995 BOREAS Workshop it is assumed the active towers will be OBS, OJP and YJP in NSA and OBS and OA in SSA. It is proposed to install automated TDR at each site to be monitored. This system has been successfully employed in NSA-OBS and HYD-1 is playing a leading role in application of this technology by present plans to incorporate radio transmission of data from the NSA-OBS site. All of the above mentioned tower sites can be accessed remotely by either radio or cellular phone for data transmission and micrologger program modification. The present automated TDR monitoring procedure includes 8 sites in a transect in the vicinity of the tower, 5 depth segments per site at increments of 15, 15, 30, 30 and 30 cm to a total depth of 1.2 m. The volumetric soil water data are collected on a 4-hour frequency. This frequency can be reduced to 1-hour for special studies and to capture the infiltration front of precipitation in the well-drained sandy sites (i.e. OJP and YJP). Coupled with the TDR soil moisture are below canopy precipitation measurements which are required to quantify the throughfall as well as moss layer interception at the OBS sites. The design for recorded precipitation calls for areal integration over a 5 m diameter circular area at two locations along the TDR transect. This is the only system currently planned in BOREAS for capture of below canopy precipitation, a key component of the hydrologic balance. Current data from the recording precipitation gauge at NSA-OBS coupled with the 1995 TDR data clearly indicate the utility of this technique.

The proposed budget includes the installation of one additional automated TDR system. In order to diversify canopy cover and study area coverage, it is recommended that the highest priority location is SSA-OA. The next priority site should be one of the better drained Jack Pine sites. Each additional site to be monitored on a continuous basis will require additional equipment at a cost of 15 K per site. This includes all of the required equipment, including radio transmission or cell phone system and recording precipitation gauges. This equipment will be installed in March, 1996 and maintained until tower take-down anticipated for November, 1996. There are no additional costs for travel or per diem for the additional automated sites. The travel and per diem costs currently listed in the budget for non-automated monitoring of the tower sites would be shifted from use during the mid-July to mid-August IFC to early and late season to accommodate installation and take-down of the automated TDR systems.

Project Objectives - Science

Soil Water Properties

The HYD-1 team will determine the soil water properties needed for physical simulation modeling of soil-vegetation-atmosphere-transfer (SVAT) based on *in situ* measurements at the flux tower sites. The parameters to be determined include saturated hydraulic conductivity (*Ksat*), soil hydraulic conductivity function [*K(h)* or *K(()* where *h* is soil water tension and *(* is volumetric soil water content] soil water retention function [also referred to as the soil water characteristic curve, *h(()* or *((h)*], and fitting parameters for various expressions of these functions including the van Genuchten (1980), Brooks and Corey (1964), Clapp and Hornberger (1978), and Cosby et al. (1984) functions. *In situ* determination of these properties will be made by analysis of tension infiltrometer tests and the novel method of flux-gradient analysis of soil water content data which has recently been applied to BOREAS data from the 1994 IFCs (Cuenca et al., 1995).

Spatial Variability of Soil Water Properties

The HYD-1 team has collected a data base for soil water property determination which will be applied for analysis of the spatial variability of these properties at the scale of the flux tower. Additional tension infiltrometer tests and flux gradient analyses from the 1996 IFC will augment the data base to the point that the statistical variation of these properties can be determined. The spatial variation over the domain of the flux tower site will be evaluated by determination of the scaling factors that reduce the observed field test data to the underlying theoretical function (Desbarats, 1995 building on the classic work of Miller and Miller, 1956). The spatial variability at the field scale is quantified by the distribution of the scale factors. This procedure has been successfully used in a number of other experiments when an adequate data base existed for evaluation of the scale factor distribution. Both the hydraulic conductivity and soil water retention functions will be scaled.

Simulation Modeling of Soil Moisture Fields

The HYD-1 team is currently working on calibration of the USDA Salinity Lab SWMS-2D finite element model of soil water movement for the BOREAS tower sites. Initial calibration of this physics-based model has been made to the tension infiltrometer data collected by HYD-1 at each site. The next step will be calibration of the model root sink function (Feddes et al., 1978) using the soil water transect data collected during the 1994 IFCs and the time series collected at NSA-OBS beginning in mid-July 1995 using automated TDR. Model verification will be made using soil moisture data collected during 1996 field operations. The calibrated model will be coupled to data bases from BORIS detailing soil texture and plant canopy distribution and density at each tower site. The calibrated SWMS-2D model will be run in a distributed mode to simulate the variation of soil moisture content in depth and time over the flux tower sites. The results will be submitted to BORIS as the simulated field of soil water content for application in other simulation models and verification of remote sensing data analysis. The final results of simulation of the distributed soil water field at the tower sites will serve as the starting point for a follow-on project to scale up the simulation to the study areas and complete BOREAS experimental domain. New funding will be sought for the follow-on project.

HYD-2 Chang

Proposed activities:

(1) FY 96 ongoing research

Continue the analysis of microwave/snow water equivalent over the BOREAS region.

(2) 1996 Winter Field Activity

We will analyze the airborne ASAS and AVIRIS data from the winter experiment.

HYD-3 Davis/Hardy

Project Completion

Overall, our current status is that we need to revisit the field in 1996 to gather measurements to address specific issues. These include validation of GORT in black spruce, testing for the effects on snow cover of interception at the stand scale and validating our canopy closure product from Landsat TM with fisheye photography. To complete all data analysis and modeling work we plan to roll over $20-30K into FY 1997. Therefore, all 1996 field work, data analysis from previous campaigns and modeling must fit within this fiscal constraint. Two plans are proposed, depending on whether the 1996 SSA winter-thaw "snow-canopy albedo" campaigns are carried out, or not.

1996 Field Plan - Current Funding

We plan a limited field excursion to the NSA during thaw, 1996. This campaign is tentatively planned for mid- late- April for a period of up to two weeks. Activities will include, but are not limited to:

Deployment of multi-sensor radiation array near old black spruce tower flux site. We intend to gather measurements under a range of canopy closures to validate GORT.

Fisheye (hemispheric) photography. Measurements under black spruce to support validation of GORT will inlude randomly located measurements as well as a systematic study of a single tree. Additional rolls of film will be shot near the old jack pine, young jack pine, fen andauxilliary sites.

Snow surveys of water equivalence. These measurements will be spatially stratified, rather than purely random as in previous campaigns. We will incoporate these into a spatial data set to compare with model runs.

1996 Field Plan - Extended Funding

We will plan two field campaigns if funded. The first will take place in the SSA to support the proposed "FFC-WT Albedo Campaign":

Deployment of multi-sensor radiation array at SSA OJP, OBS and OA. Our system will be run concurrently with PARABOLA II and ASAS overflights. Measurements of spatially averaged, forest-floor incident, hemispheric solar and thermal radiation will be collected, as well as canopy radiant temperatures. Wind speed, air temperature and relative humidity are also collected at 2 m.

Data analysis, modeling support and validation. We will test GORT and also run predictions of snow BRDF over the spectral range of silicon detectors

(PARABOLA and ASAS). All measurements will be compiled, QC'd and submitted to BORIS, along with model comparisons.

Canopy Properties. Fisheye photographs will be taken, distributedin the canopy during the measurement period. In addition, canopy shape and other variables relating to radiative properties will be measured.

Snow property measurements. We will measure snow properties controlling extinction in the visible/near IR spectral range, incuding and grain size density. We will also measure the spatially distributed snow water equivalence and other properties to support flux work.

The focus of the thaw campaign in the north will be modified:

Fisheye (hemispheric) photography. The primary emphasis will be shifted to validation of remote sensing products, canopy closure and species specific variables. This will be a more spatially diffuse effort, attempting to capture a broad range of properties.

Snow surveys of water equivalence. These measurements will be spatially stratified, rather than purely random as in previous campaigns. We will incoporate these into a spatial data set to compare with model runs. Here emphasis will also be placed on supporting any flux work, as necessary. For example, the presence of snow with impermeable ice crusts over large areas may affect flux measurements and timing.

HYD-5 Harding

Regional representation of fluxes from snow

We plan to investigate further the interaction between between forested and open areas during snow covered periods. This will involve operating eddy correlation devices over a snow covered lake (probably Namekus) and nearby forest areas. In addition measurements will be made of surface meteorology over the forest and at two positions on the lake (centre and near edge). We also plan to deploy a tethered balloon system over the lake to investigate the internal boundary layer developing over the lake.

The experimental programme will be undertaken in collaboration with NHRI (Saskatoon). A period of intensive measurements will take place during March 1996.

In the meantime SVAT modelling is being developed in collaboration with NHRI (Saskatoon) and Hadley Centre (Bracknell). 3D mesoscale modelling is being undertaken in collaboration with Roger Pielke's group in Colorado - this will continue in 1996.

The experimental effort is primarily self contained but the modelling would benefit greatly from the operation of the meteorological towers and the radiosondes. We would very much appreciate it if radiosondes were lauched from Candle Lake during March.

Remote sensing and flux aircraft would also be very useful.

HYD-8 Band

The BOREAS project was designed to observe system variables at a variety of resolutions and intensities. This experimental design was constructed to provide a database that could be used to investigate how flux processes observed over small areas will scale to large area system behavior. Specifically, in the CSSM group we are interested in finding methods by which our understanding or simulation (presumably not mutually exclusive) of processes observed for short time periods at the plot and tower levels can be extrapolated over the much larger temporal and spatial scales required to address questions of regional to global carbon budgets. This can be attempted with a range of approaches which include extending similar model structures over larger time and space ranges with a combination of remotely sensed and ground based parameterization, calibrating simpler models that require less detailed input data, or weighting the signal gained from the set of flux observations made over different surface categories with an estimate of the spatial distribution of those categories over increasingly larger areas. In all cases, the methods are heavily dependent on

1. remote sensing and GIS data to characterize surface composition

2. meteorological surfaces either extrapolated from point observations, estimated from atmospheric circulation models, estimated from remote sensing data, or from a combination of these sources

3. the production of a set of observed flux or state variable datasets commensurate with the level of spatial and temporal resolutions of the model output.

Given the range of modeling approaches that will be used in the CSSM group, the specific form of each of these required datasets may vary considerably. However, there is a need to attempt to isolate specific scales at which appropriate data can be made available. Discussions during the October BOREAS meeting indicated the following:

1. tower sites
2. small watershed to study area (NSA, SSA)
3. large watershed (e.g. major tributaries of the Nelson and Saskatchewan
4. full BOREAS transect - encompassing a large portion of central Canada
5. global circumpolar Boreal biome

One approach is to find methods that can scale between each successive step of this hierarchy, using the different observable datasets for model forcing and diagnosis that are available.

1. Tower level:

A major requirement for models acting over large time frames (seasonal to annual rather than just IFC) is to have reliable, continuous meteorologica data. While model diagnosis can be made by testing with IFC measurements, models that require surface state variables including soil moisture and temperature distributions need to spin-up prior to the actual test phase. Extension to our longer time frames also requires year-round meteorological inputs to assess longer term system behavior. A good example of this can be found in simulations of the black spruce sites. Limited measurements indicate the available water capacity for black spruce is limited to the organic layers (negligible root penetration into the mineral soil) of approximately 30mm. The first modeling meeting in Prince Albert in July 1994 showed that all 1-dimensional models required soil capacities an order of magnitude larger than this to avoid major water stress by late summer. Over short time frames this could be achieved, but over longer time scales the slow depletion of the water store may not be sustainable without anaugmentation from another water source (groundwater, lateral flow). The hypothesis that 1-dimensional models are adequate to characterize system behavior in these stands cannot be tested unless long-term continuous data is provided. At present, not all towers have continuous records. Standard, continuous data sets should be synthesized for at least a selected range of towers to reflect the major variations in surface conditions.

It would also be useful if the tower flux measurements that are available could be converted to common physical units at common time steps. This would be required just for an intercomparison of tower results as well as for testing the distribution of flux predictions by the models.

2. Small watershed to study area:

The interpolation of the meteorological records from tower to the study areas is another critical step that must be standardly available to step up from the tower level. This area is below the effective resolution of most atmospheric models, but above the effective scale of surface meteorological observations. Some exceptions include the radar rainfall coverage in the SSA and the small watersheds (NW1 and NW2) in the NSA. Given any interpolation of meteorological records from surface observations are expected to contain significant errors, with the expected error increasing as time step decreases, it will be important to provide surfaces of error estimates to accompany the actual variable surfaces.

Some use of aircraft flux measurements, including the Electra observations, may be used to improve or quantify the estimation errors for the interpolated datasets.

Soil information needs to be made available in as uniform a manner as is consistent with the different forms of models that will be run. Standardly available soil maps may not be particularly useful as the effective resolution is well below the information available for vegetation characteristics from remote sensing data.

The more detailed soil survey recently completed for the NSA may provide more information. The alternative agreed to at the October meeting is to attempt to quantify basic vegetation-soil-landscape relations that are applicable to these environments using the knowledge of soil scientists familiar with the terrain, and to create simple look-up tables for expected soil properties from observed vegetation and terrain characteristics. This is to be pursued at this point as a default option, and the same requirements for expected error of estimates may be required for these fields.

3,4. Large watershed to the full BOREAS transect:

The major advantage of using the large watersheds as an intermediate step between the study areas and the full transect is the continuous river flow datasets that are available for a longer time period. The same issues pertaining to interpolated meteorological data sets for the study areas are applicable here. Meteorological data made available through RFE and ECMWF products require error estimates in order to quantify the error bounds on model output. At this area, estimates of meteorological variables from satellite information will become more important. An assessment of the degree of convergence or bias between different sources of meteorological information that will be used by the range of models is necessary at this stage in order to intercompare model results.

Similar methods for extrapolation of expected soil conditions may be required for these regions. It is recognized that our ability to specify soil conditions, as well as vegetation and meteorological conditions, becomes increasingly limited over these areas, especially at small time and space steps. There may be a transition from mechanistic models more reliant on small time or space steps to calibrated, satellite driven methods somewhere over this range. The degree of overlap and transition between the two methods is of significant interest to the BOREAS project.

Field Work:

Subject: Sampling for moss, litter, and canopy interception in black spruce Characterization of moss spectral reflectance at different water contents

Location: Old Black Spruce site, Southern Study Area

Goals: a. Quantify the processes of interception, evaporation and water retention in black spruce canopy, and understory litter and moss.

b. Measure spectral reflectance changes in moss at different water contents to calibrate CASI data for spectral determination of moss water status.

Methods: We will set up a series of drainage lysimeters in feathermoss in conjunction with a distribution of rain guages under the canopy and in gaps to determine throughfall, litter and feathermoss interception, drainage and water retention. Turves of live moss will be repeatedly weighed to determine water mass gain and loss. Water contents will be determined for a combination of the L layer, the L and F layer and the full L, F, and H layers gravimetrically. The gravimetric water contents will be used to calibrate dew point probes to gain a more extensive distribution of live moss water contents. Plots will be placed along a water availability gradient to attempt to observe a differential dry-down in the surface moss, and characterize both the measured water contents and spectral changes using a field spectrometer.

Expected sample sizes for each of 3-4 plots are

20 drainage lysimeters
10 throughfall guages
2 clearing guages

HYD-9 Kouwen

Objectives

1. To extend the temporal hydrological record

2. To extend the spatial coverage to improve the cover mix diversity.

Science Issues

1. Over the long term, a watershed of sufficient size is essentially a closed system where

Runoff = Precipitation - Evapotranspiration

However, in the short term, that equation should be modified by a change in three components of catchment water storage:

i) Surface storage (snow, ponded water)
ii) Unsaturated soil
(capillary and transient water)
iii) Saturated zone (ground water)

The modified equation that includes storage is:

Runoff = Precipitation - Evapotranspiration + Storage (i, ii, iii)

Much of the effort by other groups is directed to measuring and/or modelling the evapotranspiration via direct measurements at the flux towers sites for short periods and for large areas by flux aircraft but the only possibility for checking the closure of the water balance is to measure streamflow for the determination of runoff.

Catchment water storage varies continually over the year and from year to year. Only the snow component of catchment storage can be measured directly and great difficulties accompany any estimation of the remaining catchment storage. The year-to-year variation is probably a minimum before freeze-up. For hydrological modelling these storages need to be assigned initial values. Usually, the initial conditions are interpreted from antecedent meteorological data, snow course data, snow cover extent from remote sensing and indirectly, from streamflow. However, when hydrological models are applied, the effect of initial errors in estimating initial storages are reduced over time. For this reason, models are usually operated for extended continuous periods.

Usually, the first year of modelling acts as a spin-up (or warm-up) that provides the proper initial conditions for the second year. The continuity of storage is crucial for successfull hydrological modelling. Breaking the record into two segments would require the initial conditions of the three storages to be estimated for both years. This introduces a great deal of uncertainty in a model's parameters because of the interdependence of hydrological parameters. In terms of confidence in the model, a great deal is gained by establishing a continuous hydrological record so initialization problems are reduced.

2. The location of the seven streamflow stations were chosen in May, 1993 to provide a range of watershed sizes and to be located in the vicinity of the tower sites. In addition, it was hoped that there would be a diverse mix of vegetative covers in those watersheds. As it turned out, for the SSA, the mix of covers in the watersheds is similar in each of the four watersheds. This reduces the ability to calibrate the hydrological parameters that are associated with particular vegetative covers.Now that detailed land cover maps are available for the NSA and SSA, a few additional sub-watersheds might be located and gauged in 1996. The incremental cost of installing a few extra gauges is low but the benifits in terms of more robust modelling parameters is substantial.

The additional watersheds will be nested within currently gauged watersheds where possible. This will allow the initial conditions for the new sub-watersheds to be interpolated and/or transposed for 1994/5 and to be carried forward for 1996.

Modelling Involvement

Several models are being applied to the 1994 thaw to freeze-up period. The 1995 data has not yet been processed and submitted to BORIS. Preliminary findings are very encouraging but model initialization is a problem In the short term, the models are calibrated to limited (one season) data sets, using assumed initial conditions. In the long term, the same models will be applied and the results compared to continous data (1994-96), with out the difficulties of having to infer the initial conditions except for the beginning of 1994.

Another very important advantage of having three years of [continous] data is that any one or two year period can be used for calibration with the remaining period used for validation. The ability to switch the years among the two tasks allows an assessment of the robustness of the parameters. In addition, having continuous records allows an assessment of the model's ability to properly predict over-winter catchment storage. This is a necessary component of a continuous hydrological model.

Needs from Staff/Other Teams

NSA

1. Approximately half of the precipitation gauges are in remote areas and require the use of an ARGO vehicle.

2. For safety, radio/telephone coverage for the SSA and NSA should be available SSA

In both study areas, all meteorological data collected as core measurements or as incidental measurements by other groups will be used. It appears that more meteorological data than was originally planned were collected in 1994. Since it is difficult to ascertain what meteorological data are/were collected by other groups until all data are submitted to BORIS, no specific request is made. However, all meteorological data will enhance our model calibration/validation activities.

Land cover maps will also be used but it appears that currently available and planned acquisition is adequate.

Priorities for 1996

Funding levels for 1995 are adequate to repeat most of the 1994 data acquisition activities. In 1994, both the SSA and the NSA were staffed for most of the period from April 15 until the end of September. This intensive monitoring was not repeated in 1995. All sites operated in 1994 and 1995 will be reactivated and visited once every 3-4 weeks by personnel based at the University of Waterloo. During the later part of the summer, the monitoring frequency was reduced, as it was in 1994 and 1995. The water levels in the stand pipes were read at during each visit.

The two streamflow stations operated by Environment Canada were in operation in 1995. The funding for the White Gull gauge @ Hwy. 106 has run out and needs to be renewed.

1996 Work Plan

1. Re-install in April and remove in October, instrumentation for 5 streamflow stations.

2. Conduct streamflow measurements at the gauge locations to form the basis for the stage-discharge curves.

3. Re-install in April and remove in October, approximately 22 precipitation gauges.

4. Conduct regular checks of the precipitation stations

5. Collect accumulated data from the data loggers connected to the stream level recorders and precipitation gauges.

Deliverables

Documented and quality checked streamflow and precipitation data at 15 minute intervals submitted to BORIS.

RSS-1 Deering/Eck

The RSS-1 1996 experiment plan consists of two campaigns. The first will occur in the late winter or FFC-W. The R.S. component of this F.C.-W has been officially defined as the period from Feb. 27 - Mar. 15, 1996. R.S.-1 will require travel a few days prior to the start date in order to prepare the towers and prepare and test the instrumentation in order to be ready for data acquisition on
the start date. Therefore, we will arrive in Prince Albert on Friday, Feb. 23, 1996.

The FFC-W RSS-1 objective is to obtain bidirectional reflectance (and, potentially, emission) measurement data sets above and within the forest canopies at the three SSA primary tower sites, OA, OJP, and OBS, with a snow background. This is the typical condition for approximately one-quarter to one-third of the year in this region and for almost one-half the year in the northern boreal forests and was not acquired during the 1994 campaigns, or since. This RSS-1 activity supports the overall BOREAS RSS tasks of acquiring winter radiation and reflectance measurements, and will be coordinated with the RSS aircraft campaigns (ASAS/AVIRIS/MAS) and ground measurement of the snow hydrology groups. Of special interest is the influence of snow on the albedos of boreal forest canopies. The snow background condition will also allow us to "cleanly" separate the forest canopy (OJP and OBS) from the "contaminating" backgrounds for a unique plant canopy modeling validation.

The second campaign will be undertaken during the central Summer Intensive Field Campaign (Summer IFC) covering the period from approximately July 9 - August 9, 1996 at a fully-developed canopy growing condition in collaboration with other BOREAS SSA investigators, particularly TE-10. A new focus will be on the moss understory contributions to the canopy bidirectional reflectance. The central motivation for RSS-1 is to acquire complete PARABOLA and PARABOLA-III data sets that can be used in validating various algorithms for estimating directional (and hemispherical) PAR from the more limited/constrained data sets obtained in the 1994 IFCs (principally: PARABOLA-I without a specific PAR band; non-coincident upper and lower tram measurements; no direct solar beam radiance; and no directional thermal data). Full analysis of the 1994 PARABOLA-I data awaits the development/validation of the relationships between PARABOLA-I red band data and PARABOLA-III multiple-channel visible and broadband PAR data.

The precise duration of the RSS-1 participation in the 1996 FFC-W campaign will be largely snow cover and sky condition dependent, but is expected to run between two and three weeks long. Our minimum goal is to obtain clear sky data above and beneath the three SSA tower site canopies with good snow background cover. Secondarily, we hope to obtain fresh snow-on-canopy above-canopy BRDF data sets as well, particularly for the OBS site. Additionally, we expect to obtain tripod-based PARABOLA data over a snow covered agricultural site and possibly a "lake site," assuming that the agricultural field does not present a "smooth" snow cover condition (i.e., substantial protruding stubble, large clods from plowing, etc.). These sites will be those being sampled by HYD-3 and RSS-1 measurements will be taken in conjunction with HYD-3's measurements of the snow cover characteristics. These remote sensing opportunities will depend greatly, of course, on the weather and sky conditions during the official FFC-W period.

Our priority site will be the OBS site due to its broader relevance to the global boreal forest types. Second priority will be the OA site, as it is a deciduous canopy and will provide the greatest contrast with the summer condition. The site to measured at the beginning of the FFC-W, however, will be determined by the extant snow conditions at each site. Our BRDF sampling will require one clear sky "full" day for each of the three sites (OA, OJP, OBS) in order to capture the minimum condition of a complete snow background at each site. During the Winter FFC we will have the original PARABOLA and one PARABOLA-III running sequentially on the upper and lower tram systems (OA and OJP; OBS requires tripod undercanopy sampling). The range of solar zenith angles are limited during this winter period. We typically acquire PARABOLA data at 5o increments of solar zenith angle change over the range from 75o to solar noon, which during the summer months reaches approximately 30o. However, during this FFC-W period the solar zenith angles only reach about 60o at solar noon (~65o on Feb. 27 and ~ 55o on March 16). Therefore, we will acquire only about 3 or 4 (up to 5) solar zenith angle sample sets for each site. The local time of data acquisitions will begin at ~10 am (i.e., 75o sza) at the beginning of the FFC-W and at ~9 am by the end of campaign, assuming morning data acquisitions. The last data acquisitions of the day will occur at ~4 pm - ~5pm. Setups and take downs of equipment each day will take an estimated 2 hours; possibly longer if weather conditions are extreme.

In order to fully utilize the PARABOLA instruments, they must be properly calibrated. The principal calibration (optical-reflective spectral regions) will be performed using the GSFC 6' integrating sphere. However, additional calibrations may be performed using the integrating hemisphere at the airport in Prince Albert as is used for the aircraft instruments. However, in the case of the PARABOLA-IIIs, the instruments must be calibrated much like a sun photometer is calibrated for the direct beam radiance. This should be done at Mauna Loa, HI. It is anticipated that the PARABOLA-IIIs will be sun-calibrated during the period almost immediately following the first field or FFC-W and then again either before or after the Summer IFC. Additionally, the thermal channel must be calibrated. This will also be done at GSFC. There is also a requirement for support from RSS-11 for continuous sun photometer data acquisitions relevant to the three SSA tower sites during the FFC-W and Summer IFC from solar zenith angles of 75^{o} to solar noon in the morning and likewise until 75° solar zenith angle in the afternoon if RSS-1 is acquiring data on these sites.

The IFC-2 participation for RSS-1 will be substantially sky condition dependent (with the threat of smoke once again?), but is expected to run a full three+ weeks during the central period between nominally July 9 - Aug. 9. Details of summer sampling will be worked out with TE-10 and other RSS groups (e.g., including ASAS, the helicopter, and Canadian "Chieftain" with the CASI instrument) for precise dates and site priorities for sampling, etc. It is anticipated that two PARABOLA-IIIs will be running concurrently on upper and lower tram systems, for at least one clear sky day (or half-day) for each of the three sites (OA, OJP, OBS). It is hoped that other remote sensing PIs will be participating. The importance of Staff Science and other PI measurements of LAI, leaf optical properties, soil moisture, meteorological conditions, etc. for relating the IFC'96 to the 1994 IFCs is self-evident.

Proposed activities:

(a) On-going work

For the remainder of 1995 and in 1996, ASAS staff will continue processing and analyzing the 1994 datasets.

Current status: the following data have been processed completely to at-sensor digital radiances -IFC-1 SSA_CAL; IFC-2 SSA_OBS, SSA_OA, and SSA_OJP. A sample data tape of the ASAS standard product (at-sensor digital radiance images) has been delivered to BORIS staff; BORIS has now given the go-ahead for delivery of this product and data tapes of the images processed-to-date have been created for BORIS. Data delivery will nowproceed at a rate of one 8 mm data tape per week where each tape contains data from three flights over a particular tower site on a particular day. The data from each flight contains images from a sequence of seven or eight view directions.

Multiangle area-averaged at-surface spectral reflectance factors have been produced for the SSA_CAL site (IFC-1), SSA_OBS & SSA_OA TF sites (IFC-2). These will be delivered to BORIS as site-extracted data tables when complete sets for tower sites for each study area per IFC are ready.

Documentation: Complete documentation for the at-sensor digital radiance data has been delivered to BORIS.

(b) Proposed work for 1996 field activities

In 1996, ASAS would be deployed on the Wallops C130Q for 2 field campaigns - FFC-W and IFC-2. During the FFC-W, ASAS would acquire multiangle data over SSA and NSA TF sites, and over an agricultural target and a lake. For IFC-2, ASAS would acquire multiangle data over SSA and NSA TF sites, and selected auxuliary sites.

RSS-3 Walthall

Proposed Activities

a.) Ongoing Work:

We plan to continue processing the helicopter-based radiometric data. This includes the SE-590 spectroradiometer, eight channel Modular Multiband Radiometer (MMR) data, PAR and pyranometer data. Data quality assessments will be made via simple analyses and collaborations with other BOREAS investigators. We will also test atmospheric corrections possible using only surface-based sun photometer data and using both the surface and helicopter-based sun photometer. Preparation and submittal of documentation and data sets to BORIS will encompass the remaining parts of the work.

b.) Proposed 1996 Field Activities

We do not intend to return to the field.

RSS-7 Chen/Cihlar/Miller

Measurements of Biophysical Parameters in BOREAS Transitional Forests.

Rational: transitional forests occupy about 20% of the BOREAS 1000x 1000 km region, and yet few data are available for deriving the much needed biophysical parameters for this land cover type. We have acquired substantial data in 1993-4 in the study areas, and the techniques and data are found to be reliable. Since interannual variatons in LAI and FPAR are small, we feel that it would be more useful to acquire data in the transitional forests than to repeat measurements in the study areas.

Location: sites along the road from Thompson to Gillam and futher north till the tree line.

Time: mid-end of July 96.

Type of Measurements: LAI, FPAR, APAR, spectral signature of the background (understory and moss)

Instruments: TRAC, LAI-2000, Spectron (SE590), video-camera/image analysis system, GPS

RSS-8 Running/Kimball

This effort will address data sets needed for BOREAS Modeling Studies. These include:

i) Are the model boundary condition data collected during BOREAS adequate? This includes soils, hydrological, allometric, biophysical, etc., data sets. Do we have satisfactory standard atmospheric forcing data (micrometeorology and radiation)?

- moss studies may require additional sub-canopy micro-met data such as wind speed, surface and air temperature, soil moisture, precipitation, relative humidity and solar radiation.

- need to maintain measurements of air, soil temperature, wind speed, and solar radiation, etc. over the winter at the tower sites.

- Improve the existing data sets

- Work with the BORIS staff to develop 1994 (full-year) data sets of surface met forcing variables (i.e. wind speed, air temperature, precipitation, solar and thermal irradiance) for each of the tower sites.

- re-evaluate the standard site parameter data set (Appendix J in EXPLAN-94 V.3.0), using data collected in 1994.

ii) Are the regional-scale RSS-products adequate? What improvements could be made?

Modeling studies require full year AVHRR coverage for 1994 through 1996. Given the degradation of much of the 1994 AVHRR database due to clouds and smoke, is additional effort needed to develop methods to correct and salvage these data.

This effort will also address local-scale; seasonal to multiannual issues:

i) How well do our tuned models reproduce the seasonal energy, water and carbon fluxes? How about the untuned versions?

Two modeling groups (TE-19 and TE-21) presented results of simulations of 1994 compared to tower flux measurements. Model simulations of net carbon exchange were reasonable for sites tested. Model simulations of snowcover, soil moisture and evapotranspiration also compared favorably with measured results. Some improved component flux data sets will be collected in 1996 (e.g., automated chambers at NSA-OBS and more intensive moss studies).

ii) Do the specialized seasonal models do better or worse than the time-aggregated daily models? Why?

iii) How well do these models cope with the nutrient cycle limitations on ecosystem function?

iv) Are there additional isotopic checks that could be used to refine the soil CO2 flux models?

v) What checks can we make on predicting interannual variables of carbon flux and similar studies (besides the long-term flux measurements)?

vi) Fire dynamics will be covered by the large-scale; seasonal to interannual group; what can this local-scale group contribute in the way of process models (e.g., fire-susceptibility, fuel load, etc.)?

RSS-11 Markham/Holben et al

(a) On going work(i.e. no 1996 field activities)

This work will involve shutting down the sunphotometer network for 1995 in November 1995, entering the remaining 1995 handheld sunphotometer data into the database, calibrating and initial quality control on the 1995 data and submission of the data to BORIS. Subsequently all the sun photometer data acquired from 1993-1995 (handheld and automatic) will be reevaluated, recalibrated if necessary, screened and resubmitted to BORIS. Work will proceed on summarizing the data acquired in terms of seasonal trends in aerosol properties and interannual variation of the properties to develop an initial aerosol climatology for the region. Examination of the within site variation in aerosol properties and its effect on atmospheric correction is planned.
1996 Budget- 90K(NASA)

(b1) proposed work for 1996

Two levels of effort are proposed for 1996 field activities. One assumes satellite remote sensing data collection will continue during 1996, but with no summer RSS IFC. Here the automatic sunphotometer network would be deployed much like in 1995. This effort would defer to 1997 much of the data analysis planned in the absence of a field campaign.
1996 Budget - additional 6K (to cover on site support of sunphotometers)
1997 Budget - 70K

The second level of effort is to support a winter and summer RSS field campaign. For the winter campaign we would provide the instruments, but no field support. For the summer campaign we would provide on site support for the duration of the IFC to ensure the quality of the sunphotometer data, and provide a field radiometric calibration source suitable for ASAS and CASI.
1996 budget -additional 19K (~10K travel; 5K source calibration/shipping; 4K field tech salary) (total 25K additional over existing budget)

RSS-12 Spanner

We intend to complete our analysis of the field and airborne Sun photometer data acquired during the 1994 field seasons of BOREAS. We will complete our addition of water vapor to ImageCor, our atmospheric correction algorithm. finally, we will atmospherically correct SPOT and TM images acquired during BOREAS. These analyses will be documented in a paper for the BOREAS special issue of JGR.

RSS-14 Smith

Our 1996 work plan consists of three parts: (1) GOES-8 10-bit satellite data archiving from Feb 25-Oct 30, 1996; (2) completion of the net radiometer intercomparison and net radiometer engineering study; (3) further development, testing, and processing with the GOES SW-LW SRB retrieval algorithm, including applications with GOES-8 measurements. The detailed monthly plan for the remainder of the year is as follows:

GOES-8	Net Radiometer Archiving Intercomparison & Engineering Studies	GOES SW-LW SRB Retrievals
Mar FFC-W (2/27-3/15) + Inter-IFC	Apply correction procedure to all 1994 net radiation observations.	Derive & test NB to BB surface albedo conversion scheme.
Apr IFC-1 (4/02-4/28) + Inter-IFC	Produce corrected database for all 1994 IFCs. Produce objective analyses of Rn from corrected and uncorrected Rn datasets, and analyze time-space differences.	Revise aerosol optical depth/visibility relationships using RSS-11 observations. Complete LW algorithm (Vers 0).
May Inter-IFC BORIS. coeffs	Compare satellite-based fields of Rn for all 1994 IFCs, to corrected Rn datasets. Produce optimized Rn maps for large scale area.	Produce Version 1 SW products for Feb 5-Sep 20, 1994 and submit to Examine LW vs. soil moisture.
Jun Inter-IFC	Submit gridded Rn fields to BORIS. LW products for Feb 5-Sep 20, 1994 and submit to BORIS.	Complete LW tests. Produce Version 0
Jul IFC-2 (begin 7/9)	Finish paper on intercomparison study. Begin engineering bench tests of net radiometers.	Modify SW and LW algorithms for GOES-8 and test.

Aug IFC-2 (end 8/9) Inter-IFC	Continue engineering bench tests of net radiometers.	Continue GOES-8 tests.
Sep Inter-IFC	Continue engineering bench tests of net radiometers.	Start GOES-8 processing of IFC-W & IFC-1, 1996.
Oct IFC-3 1996 (10/1-10/20)	Conclude engineering bench tests of net radiometers. End archiving on Oct 30.	Continue GOES-8 IFC processing.
Nov Quality Control. 1996	Begin paper on engineering study.	Begin paper on GOES-8 results.
Dec Quality Control.	Continue paper on engineering study.	Continue paper on GOES-8 results.

RSS-15 Ranson

Purpose:

Task 1: Check forest type and biomass classification maps derived from radar images (SSA and maybe NSA).

Task 2: Make additional stand measurements of species, dbh where necessary SSA and maybe NSA).

Task 3: Make measurements necessary to develop stand dbh histograms for selection of canopy geometry measurements (see Task 4). (related to Task 2 above).

Task 4: Sample canopy geometry of black spruce stands (SSA). Selected trees based on size histogram generated in Task 3.

Task 5: Make measurements of tree bole, branch, and foliage dielectirc measurements in SSA.

Dates

Tasks 1,2,and 3 will be performed during July 28-August 3 (OR August 3 - August 10) TBD

Tasks 4 and 5 will be performed during August 11-18

Personnel

Tasks 1-3: Jon Ranson, Guoqing Sun, Steve Fifer, Brian Montgomery and TBD student.

Tasks 4-5: Roger Lang, Narinder Chauhan, 2 GWU grad students

RSS-16 Saatchi

Proposed Activities:

We are continuing to analyze the imaging radar data over SSA and NSA acquired
during 1993 and 1994 field campaigns in order to extract parameters such canopy and surface moisture content. So far We have been able to stratify and map the crown and trunk water content over the southern study area, and to verify the results by using ground data from destructive sampling. For estimating surface moisture we need to characterize the soil surface in terms of its roughness and properties of the organic layer. A major part of this work was performed during previous IFCs and SAR derived surface soil moisture over young and old jack pine sites compared reasonably well with TDR measurements on the ground. However, over black spruce sites, the presence of the moss layer changed the properties of the backscatter signal from the SAR data and caused unacceptable errors in surface moisture estimation. It appears that the moss layer works as an absorber of microwave energy under the forest canopy and causes a lower reflection from the underlying soil surface. Furthermore, surface moisture in the
presence of moss layer has not been defined in the literature and there is no agreement as how this moisture contributes in water and energy fluxes of the forest canopy. BOREAS has developed a new of activities for moss/soil processes for 1996 field campaigns.

In SAR backscatter measurements, the moss layer, depending on its moisture, may behave as either reflecting or diffuse and absorbing surface. Therefore, modeling the moss layer underlying black spruce stands will help us to resolve problems associated with analyzing the radar images and to improve the surface moisture estimation algorithms. In addition, further ground measurements of vertical moisture profiles of the moss layer and its spatial variability on the stand scale will provide us with the more information to characterize the moss layer.

During the summer IFC, two persons from our team plan to spend 10 days (within the period of 7/10-8/1) at the SSA-OBS tower site to measure moss moisture proflies on two 500 m transects. We anticipate only one trip to the southern study area. This work will be performed using our current funding.

During this period, we will also visit areas of recent fire for field survey, tree and soil moisture sampling. In July, 1995, DC-8 AIRSAR system acquired images over a major part of the fire scar, north of the southern study area. After the DC-8 overpass, field survey and tree moisture measurements were performed by Paula Pacholek and a team from the Prince Albert National Park. The field survey and data collection during the summer IFC are intended to complete the 1995 field data activities and to support further analysis of the SAR data.

RSS-17 Way/McDonald/Zimmermann

I) Proposed Task: SAR, freeze-thaw, and xylem sap flow measurements

A) RSS-17 Activity Summary

We will continue to collect spaceborne synthetic aperture radar (SAR) data throughout 1996 with the ERS-1 and ERS-2 SARs. This data collection activity will proceed independent of any 1996 BOREAS field campaign although we will require additional resources in FY 1997 to fully analyze these data. Additionally, we propose to conduct continuous in situ monitoring of xylem sap flow, vegetation temperature, and soil temperature at the Southern Study Area Old Black Spruce site. This measurement series will begin prior to the end of February 1996 and will continue at least until December 1996 thus encompassing the entire time period for which continuous tower flux measurements are proposed.

B) Background

During 1994, we collected in situ data for a full annual cycle at five tower sites. We also obtained spaceborne SAR observations of the BOREAS study area throughout the same annual cycle. Our ground-based and remote sensing data sets are complete for characterization of canopy freeze-thaw state and demonstrate our ability to monitor events relating to both spring soil thaw transition that initiates a period of increased soil respiration and spring canopy thaw that initiates carbon uptake.

Although on our own we obtained the necessary in situ meteorological and vegetation and soil temperature measurements to correlate vegetation freeze-thaw status with the multi-temporal spaceborne SAR remote sensing data, many of our scientific objectives will remain unresolved since, except for NSA OBS, there were no tower flux measurement systems in place in the conifers during the critical seasonal transitions in 1994 (spring thaw and fall freeze-up). The tower flux measurements are critical if we are to tie the remote sensing data to canopy growing season length. Furthermore, since the NSA OBS site is on the extreme edge of the Alaska SAR Facility receiving mask, temporal coverage of the northern site is less complete than coverage of SSA OBS. Without flux measurements from the SSA OBS tower to accompany our measurements, there will be no point to repeating our 1994 in situ data series in 1996.

C) posed 1996 Field Activities

We propose to concentrate our 1996 activities on the SSA OBS site since the year-round tower flux measurements not obtained in 1994 are now planned for that site in 1996. This should allow us to resolve several issues related to the spring thaw and autumn freeze processes as observed by spaceborne radar and that bound the period of photosynthetic activity. This could be accomplished with only a modest augmentation of our existing budget.

We will install xylem sap flow sensors in the boles of nine trees at the SSA OBS site for continuous monitoring of xylem sap flow throughout the 1996 growing season. These measurements will be augmented with continuous vegetation temperature measurements of the trunks and branches of these same trees. We will also monitor temperature of the ground in the moss layer, litter layer, and in the underlying soil layer at depths of 5, 25 and 50 cm. The proposed temperature measurements will provide a direct indication of the vegetation and soil freeze-thaw state and may be correlated directly with the observed radar backscatter. The xylem sap flux measurements will provide direct measurements of the trees' water use diurnally and throughout the growing season.

RSS-19 Miller

Overall Objective: to re-deploy an enhanced Compact Airborne Spectrographic Imager (CASI) airborne sensor (York University) to BOREAS in 1996 to evaluate the robustness of algorithms currently being developed using 1994 BOREAS data.

The CASI sensor will be configured to mimic MODIS bands between 400 and 960 (Bands 1,2,3,4, 8-19) and provide down to 1 metre spatial resolution imagery over target sites, permitting ambiguities related to spatial heterogeneity in model-based algorithm evaluation for interpretation of canopy BRDF and canopy cover to be addressed with actual airborne data. We will attempt to collect CASI spatial image data over all BOREAS flux tower sites (SSA and NSA), and, at a lower priority, obtain coverage over auxiliary sites.

Specific Objectives: The specific research goals emphasize collaborations and data support to other BOREAS investigators in the evaluation of:

(i) algorithms for LAI and FPAR, currently being developed by RSS-7 (Chen). These algorithms will evaluated using data at existing sites, augmented by a new transect at NSA capturing a very wide range of LAI values, supported by field measurements of LAI and canopy understorey reflectance,

(ii) the inter-season validity of specific optical scattering and absorption cross-sections, which are the basis for model-based algorithms for retrieval of boreal lake-water constituents (chlorophyll, DOC, SS) using optical imagery. These algorithms for lake constituents will be examined through collaborations with TE-15 (Bukata) through joint airborne (CASI) and in-situ (WATERS) data collection at Candle Lake and Waskesiu Lake at SSA,

(iii) the spatial distribution vegetation classes over the entire NSA fen, at 1m spatial resolution, as a validation of preliminary classifications achieved with 1994 CASI imagery covered part of the fen. This year's data collection work will complete and evaluate results obtained serendipitously with 1994 CASI data through collaborations with Jelinski/McCaughey (TF-10), Bubier/Moore (TGB- 3) and Crill (TGB-1), in which vegetation classification schemes coupled species-specific methane emission rates will permit integrated fen methane area-emission rates to be determined,

(iv) the moss re-generation characteristics in a collaboration with Harding (HYD-5) at BOREAS NSA by field characterizations and airborne CASI imagery over burn sites.

Through collaborators, who will conduct field measurements of physical parameters, our analysis of the CASI airborne data will facilitate the evaluation of the remote sensing parameter algorithms.

In addition some gaps in the BOREAS optical data set will be filled:

(1) 1994 BOREAS RSS data revealed that higher spatial resolution is very desirable in order to relate to field measurements at specific locations within flux tower sites, coupled with the fact that the towers sites were found to be surprising heterogeneous. Our improved CASI sensor will permit 1996 BOREAS imagery to be collected metre spatial resolution (compared with 1994 with about 3 m imagery) for all flux tower sites.

2) technical problems were identified in the CASI up- and down-welling irradiance sensor, precluding accurate low-altitude determination of site spectral albedo and FPAR needed in the GOES-derived maps of albedo and FPAR for the BOREAS SSA and NSA area. This problem has been rectified and will allow these data to be collected in 1996.

Appendix G : 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 H: BOREAS Acronyms

ES	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
CO_2	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 Biogeochemistry
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)