BOREAS
Experiment Plan

Chapter 5
Experiment Execution

May 1994 Version 3.0

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BOREAS EXPERIMENT PLAN

APPENDICES

5.0 EXPERIMENT EXECUTION

This chapter reviews the activities planned for the monitoring program and field campaigns over the period August 1993 through October 1994. The procedures for making decisions and carrying them out are set out in the next section; outlines of mission plans and experiment operations are in subsequent sections.

5.1 Management of Experiment Operations

5.1.1 Overview

During field campaigns, experiment operations will be managed from two Study Area Headquarters (SAHQ); one in the Snodrifters Lodge in Candle Lake (SSA) and one at Keewatin Air in Thompson Airport (NSA). Contact telephone numbers and radio frequencies are given in Section 5.1.6.3. Each SAHQ will be manned during most of the day by a Study Area Manager (SAM), who will coordinate activities among investigators and staff, work logistics problems and receive and transmit reports on the status of activities within the study area. The SAM will be assisted by a secretary and/or van driver/helper, will be in radio contact with the TF site captains and others within the study area and in telephone contact with the other SAHQ.

At any one time, one study area will be the focus of more aircraft and/or specialized ground-based activities than the other. The Mission Manager (MM) will be based at this 'hot' study area, and will coordinate all BOREAS aircraft activities from the 'hot' SAHQ, including those at the 'cool' study area. (The MM may choose to delegate oversight of some local flight activities at the cool study area (SA) to the SAM there). During each IFC, it is planned that after most of the aircraft measurement goals have been completed for one study area, a core group of aircraft (C-130, Kingair, Twin Otter and helicopter) will move with the MM to the other study area, which then becomes 'hot'.

A proposed schedule for these moves is set out in Tables 5.3.x.b (see MM location), but the final decision on the date is to be coordinated by the MM.
The MM will hold nightly meetings of the BOREAS Operations Group (BOG) to organize the next day's activities in detail and follow-on activities (two or three days) in broad strokes, see Section 5.1.4.

The next few subsections cover:

- Decision Making 5.1.2
- Operations management roles and responsibilities 5.1.3
- Meeting schedules and formats 5.1.4
- Aircraft operations protocols 5.1.5
- Communications 5.1.6
- Emergency procedures 5.1.7

5.1.2 Decision Making

There are three principal authorities for making decisions that affect BOREAS field operations and prioritization of follow-on analyses by staff. These are:

(i) The Experiment Plan: This document sets out the strategic framework for the experiment and will be taken as the basis for decision making by the BOREAS Operations Group (BOG = BEX + SSG) and mission managers. Procedures documented in Chapter 5 have precedence over procedures documented elsewhere.

(ii) BOREAS Meetings: BOREAS workshops, science team meetings and workshops, and BOG meetings will be tasked with refining the experiment design and modifying and ratifying the experiment plan. In general, the outcome of any of these meetings should be a written brief to be transmitted to the BOG. This is absolutely essential if the Experiment Plan is to be modified. Any scientist wishing to modify some aspect of the plan is strongly encouraged to air the proposal with his or her group, if time allows, or at least with the group chair prior to bringing it to BOG.

During IFC's and FFC's, there will be a nightly BOG meeting to which all participating scientists and staff are encouraged to attend. This meeting will be chaired by the next days mission manager who will solicit reports from those managing equipment essential to the mission, e.g. team chairs, TF site captains, aircraft managers, etc. These reports and a weather briefing will follow a set format, along the lines of the FIFE SSG meetings, and will include a presentation of proposed aircraft mission options and fallbacks for the next day and an outline of possible missions for the next three days. This proposal will be discussed and modified by those present and the coordination of ground activities will be subsequently arranged.

The final schedule of aircraft missions and planned ground activities will be posted at each SAHQ and at the laboratory of each study area. Additionally, the proposed flight schedules will be faxed to the BOREAS 'outpost' at Prince Albert Airport (in the Athabaska Airways Building) and elsewhere on request. Aircraft Managers should either be present or be represented at the BOG meetings, or make arrangements to otherwise receive the flight planning information.

(iii) Mission Manager: The Mission Manager (MM) will be on duty from the beginning of one BOG meeting to the next, i.e. a 24-hour cycle. The MM will be a BEX member with some experience of coordinating field and aircraft operations. Roles and responsibilities of the MM and other operations staff are laid out in Section 5.1.3.

The MM will use the experiment plan and the missions plus fallbacks proposed by the BOG meeting to guide the management of experiment operations over the next 24-hour duty cycle. All decisions to launch, cancel or modify airborne missions must be routed through the MM who will be located near the most active Study Area with communication links to the aircraft, key investigators and staff. If, because of changing conditions, the MM thinks it is necessary to drastically diverge from the BOG plan, he/she will attempt to consult with the BOG or the affected investigator or, if time or communications do not allow for this, he/she will go ahead and implement the action. The action will be discussed with the BOG and affected scientists as soon as possible thereafter.

5.1.3 Operations Management Roles and Responsibilities

5.1.3.1 BOREAS Mission Manager (MM)

The MM will be a BEX member who has overall responsibility for coordinating all BOREAS activities during a 24 duty cycle within the FFC or IFC. Specifically, the MM is responsible for:

- Chairing the nightly BOG meeting and allocating subsequent action items;
- Oversight of aircraft mission planning, coordination and execution, see Figure 5.1.4.b;
- Resolution of disagreements among investigators beyond what cannot be handled by the SAM (see below).
- At the end of the duty cycle, the MM must modify the mission plans prepared for that day to record the missions and activities actually completed. These records (see Figures 5.1.4.b and c) must be filed at the SAHQ and returned to the BOREAS US Project Office at NASA/GSFC at the end of the IFC/FFC.
- Oversight of the decision to move the hot 'SAHQ' from one study area to the other study area.
- Turning on and turning off the intensive Upper Air Sounding Program.
  Approving significant expenditures of project reserve funds.

Generally, an MM will be on duty continuously for a 24-hour cycle, from the beginning of one BOG meeting to the next. Handover to the next MM must be accompanied by a briefing. The MM will work out of (or be in direct contact with) the SAHQ alongside or in place of the SAM.

5.1.3.2 Study Area Manager (SAM)

The SAM will be a BOREAS staff member who will manage day-to-day ground operations at a study area. He/she will be assisted by a secretary and a driver/helper. The responsibilities of the SAM are:

- Maintain communications between investigators and with the MM and the other SAM.
- Elicit reports from site captains, team representatives and staff in the study area. These reports are to summarize the status of activities within the study area and state special requests, e.g. specific aircraft missions. These reports are to be documented in the team chart (see Figure 5.1.4.c) and passed on to the MM and the other SAM by 2300Z (1700 local in SSA and 1800 in NSA (summer).
- Document events in the mission log. The events should be logged as a separate file for each day with exact local times; e.g.,

  '1300 : DC-8 calls site entry into SSA.
  Ground team informed by radio.
  1303 : DC-8 calls start on first flight line'

  Aircraft take-off, site entry, site exit and landing times must be logged.
- Follow the progress and supervision of tasks handled by local labor liaising with the site manager as necessary.
- Participate in the nightly BOG meetings, either in person, if at the hot SA, or by speaker phone, if at the cool SA. The SAM at the cool SA is encouraged to have other key BOREAS people participate in these meetings.
- The SAM at the cool SA is encouraged to convene meetings or otherwise communicate with the investigators to plan future activities or to discuss the requests to be sent to the MM in more detail. If investigator teams or other groups wish to hold meetings, the SAM should be informed and provide assistance as necessary.
- Inform investigators and staff of the next days plan as finalized by the BOG. This plan, and associated action items, may be broadcast over the radio net when the SAHQ opens for business the next day.
- Ensure that the required sun photometry measurements are being made on clear days.
- Maintain a file on investigator movements and plans. Before setting out for the field, investigators should contact the SAHQ with their intentions for the day -- sites to be visited, activities planned, and expected time of return. The SAM will maintain a file in the format provided, see Figure 5.1.4.c.

  If the investigator is more than three hours late, the SAM will initiate a search. The SAM may initiate a search before this time on his/her own initiative.

The provisional schedule for SAMs and MMs is shown in Table 5.1.3.2.

Table 5.1.3.2: SAM and MM Schedule

	NSA-SAM	SSA-SAM	MM
FFC-W	Atkinson	Goodison/Walker	Goodison
FFW-T	Terroux/Irani	Evans	Sellers
IFC-1	Newcomer/Cihlar	Evans	Sellers/Hall
IFC-2	Newcomer/Hodkinson	Mitchell/Huemmrich	Sellers/Hall
IFC-3	Irani/Huemmrich	Evans/Dalman	Sellers/Hall

5.1.3.3 Team Chairs/Representatives

Each study area will have a set of nominated science team representatives to represent each of the science teams working there. The people listed in Table 5.1.3.3 will ensure that a team representative is present or will show up themselves. The exception is the AFM team who only need report to the MM or the SAM at the hot site. At the cool site, representatives are responsible for giving team reports for that SA to the SAM by 2100Z. This report and associated requests should be brief and may be given to the SAM verbally over the radio net. At the hot site, the team representative should show up to the BOG meeting.

	SSA			NSA		
Group	**IFC-1**	**IFC-2**	**IFC-3**	**IFC-1**	**IFC-2**	**IFC-3**
AFM	MacPherson Crawford	MacPherson Crawford	MacPherson Crawford	Kelly MacPherson	Kelly MacPherson	Kelly MacPherson
TF	den Hartog	den Hartog	den Hartog	McCaughey	McCaughey	McCaughey
TE	Rich	Saugier	Collatz	Gower	Margolis	Ryan
HYD	Kouwen	Kouwen	Kouwen	Cuenca	Cuenca	Cuenca
TGB	Striegl	Striegl	Striegl	Crill	Crill	Crill
RSS	Miller	Ranson	Miller	Walthall	Walthall	Walthall

Table 5.1.3.3 team representatives who should be present or who will ensure the presence of a substitute at BOG meetings.

The team representatives' report should cover the following:

- Team activities carried out that day, particularly changes from the scheduled activities discussed at the previous nights BOG meeting.
- Team activities planned for the next day.
- Needs or requests, particularly any requests for special aircraft flights for the next day.

Team representatives may be given action items by the MM following the BOG.

5.1.3.4 TF and TE Site Captains

The TF principal investigators at each TF site or their nominees are the TF site captains. Also, each TE canopy access tower will have a captain assigned to it. These site captains are responsible for maintaining the quality of their sites, for overseeing the use of resources and for overseeing safety-related procedures on-site. Specifically, the site captains are responsible for:

- Delineating go- or no-go areas around each site. Normally, the TF site WABs will be no-go areas.
- Approving the use of site power for other investigators, likewise the use of huts and other facilities.
- Ensuring continuous radio contact between the TF site and SAHQ.
- Checking the presence and servicability of essential equipment on site: medical kits, fire extinguishers, radio gear, tower climbing gear.
- Reporting on the status of the TF site to SAHQ by 2100Z each day.
- Ensuring that investigators who wish to ascend the tower are properly equipped, trained and briefed.
- Ensuring that investigators working near the tower are wearing hard hats.
- Maintaining the site log. All the TF sites and the autonomous TE sites (i.e. TE sites located nowhere near a TF site) must keep a site log. This is a log book plus a chart with experiment site locations marked in degrees/distance from a reference point (generally the tower base). The aim is to (i) document investigator experiment locations and (ii) prevent interference between experiments. Logs and formats are available from BORIS (Dave Knapp).

Any investigator who wishes to work on or close to a TF or TE site must first consult with the site captain or his/her representative. The site captain may deny access to certain parts of the site. If necessary, a potentially aggrieved investigator or site captain should appeal to the SAM or MM if there is a conflict that cannot be easily resolved.

Table 5.1.3.4 TF and TE site Captains

Northern Study Area			
TF Sites	**TF Captains**	**TE Sites**	**TE Captains**
OBS	Wofsy	OBS	Ryan/Hubbard
OJP	Fitzjarrald	OJP	Ryan/Hubbard
YJP	McCaughey	OA (TE)	Margolis
Fen	Jelinski		

Southern Study Area			
TF Sites	**TF Captains**	**TE Sites**	**TE Captains**
OBS	Moncrieff	OBS	Walter-Shea
OJP	Baldocchi	OJP	Flanagan
YJP	Anderson	OA1	Middleton
Fen	Verma	OA2	Hogg
OA	den Hartog	Mixed	Collatz
YA	Bessemoulin	YA	Arkebauer

5.1.3.5 Field Liaison and Site Managers/Contacts

Dan Hodkinson (US) and David Terroux (Canada) are the first points of contact for investigators who wish to get some significant infrastructure task completed. These two will work with Mary Dalman (SSA), Carl Spence (NSA) and others, as necessary, to get approved work done.

5.1.3.6 Laboratory Chiefs

Betsy Middleton (SSA) and Patrick Crill (NSA) will oversee the allocation of space and other resources at the Paddockwood School (SSA), and 192 Hayes Road facility (NSA), respectively.

5.1.3.7 Aircraft Managers

Proposed aircraft missions must be approved by the MM. Aircraft managers are responsible for maintaining and executing the flight operations planned by their PI's or requested by the BOG through the MM. The aircraft manager or the associated aircraft PI should report to the MM by 2100Z each day with the following information.

- Intentions/requests for the next day's operation, including details of flight plans and statement of necessary decision times (e.g. aircraft prep times, etc).
- Remaining research hours
- Status of aircraft and crew readiness; e.g. '30 hours remaining for the IFC; 10 hours before inspection; two days before a mandatory crew rest day.'

The aircraft management/PI should attend the BOG if based near the hot site, sit in on the BOG by speakerphone with the SAM at the cool site or arrange immediate contact with the AFM representative or MM after the BOG. It is essential that the aircraft manager be aware of the BOG plans during or immediately after the BOG: he/she should get hold of a copy of the next days mission schedule by fax if all else fails. The aircraft manager/PI is then responsible for:

- Scheduling the aircraft preparation and launch.
- Briefing the aircrew on the plans, including the flight activities of other BOREAS aircraft.
- Contacting (or ensuring that the pilot contact) the MM at the target SAHQ by telephone or radio at the following times/events:

  -- prior to setting out to the airport to prepare the aircraft
  -- prior to engine start
  -- 'wheels up' (if in radio range)
  -- 'site approach', when within radio range of the SAHQ, giving aircraft position, altitude, intentions and ETA on-site. (The MM or SAM will respond with information on relevant aircraft and surface activities).
  -- 'start of work' in the study area
  -- movement from one surface target to another (if helicopter)
  -- 'site exit'
  -- 'down safe'
- The 'down safe' call should also include information on
  -- flight take-off time, landing time
  -- mission type
  -- accomplishments/problems

5.1.3.8 Investigators

All investigators must:

(i) Check in by telephone or in person with the SAHQ when arriving in a study area for an IFC and when leaving for home. On arrival, field investigators will get an update briefing, radios, contact materials, etc. Please read Appendices C and D for details.
(ii) Tell their group representative their plans for the next day, also special needs or requests, by noon of each day. Be sure to notify SSA-SAHQ the day before you intend to visit sites in PANP.
(iii) Be familiar with the emergency procedures, see Appendix B and Section 5.1.7.
(iv) When entering the field, notify the SAHQ; keep the radio ON all day; and when leaving the field notify the SAHQ.
(v) Contact the TF or TE site captain when visiting a TF or TE site, especially if you intend to set up an experiment nearby or want to use the tower.

5.1.3.9 Meteorological Forecaster/Briefer

The meteorological forecaster or briefer will provide reports to the MM on request or at agreed-upon times. These forecasts are to include a 24-prog for the MM to take to the BOG and an outlook for the next two or three days. The forecaster/briefer should be readily accessible by telephone during the day. If possible, the forecaster should give the meteorological briefing in person to the BOG meeting.

The forecast will be in a form similar to an avaiation forecast (FT). Current and 24-hour forecast conditions will be provided for points:

WIN	55° 40'N,	98° 40'W (Center of NSA)
WIP	53° 40'N,	106° 15'W (PANP in SSA)

5.1.4 Meeting Schedules and Formats

The BOG meetings will start at 0200Z (2000-SSA; 2100-NSA) chaired by the MM from the hot study area. All BOREAS team members are encouraged to attend, but the following must be represented:

Mission Manager (chair)
Outgoing Mission Manager
Forecaster or representative
Study Area Managers (in person or by speaker phone)
Team representatives
Key aircraft representatives

The steps leading up to the BOG meeting are shown in Figure 5.1.4.a.

The format of the meeting will be as follows:

- Weather forecast: 24-hour prog, 3-day outlook (5 minutes)
- Outgoing mission manager report (5 minutes)
  - Aircraft missions completed
  - Other significant events
- Study area manager reports/updates (2) (2 minutes each)
- Team representative reports/requests (6) (2 minutes each)
- Aircraft status and plans (5 minutes)
- Incoming mission manager mission proposals (5 minutes)
- Discussion (5 minutes)

Figure 5.1.4 Preparations for nightly BOG meeting. Note that the BOG meeting is held at 0200 zulu time in the hot site (in example here, the NSA is the hot site)

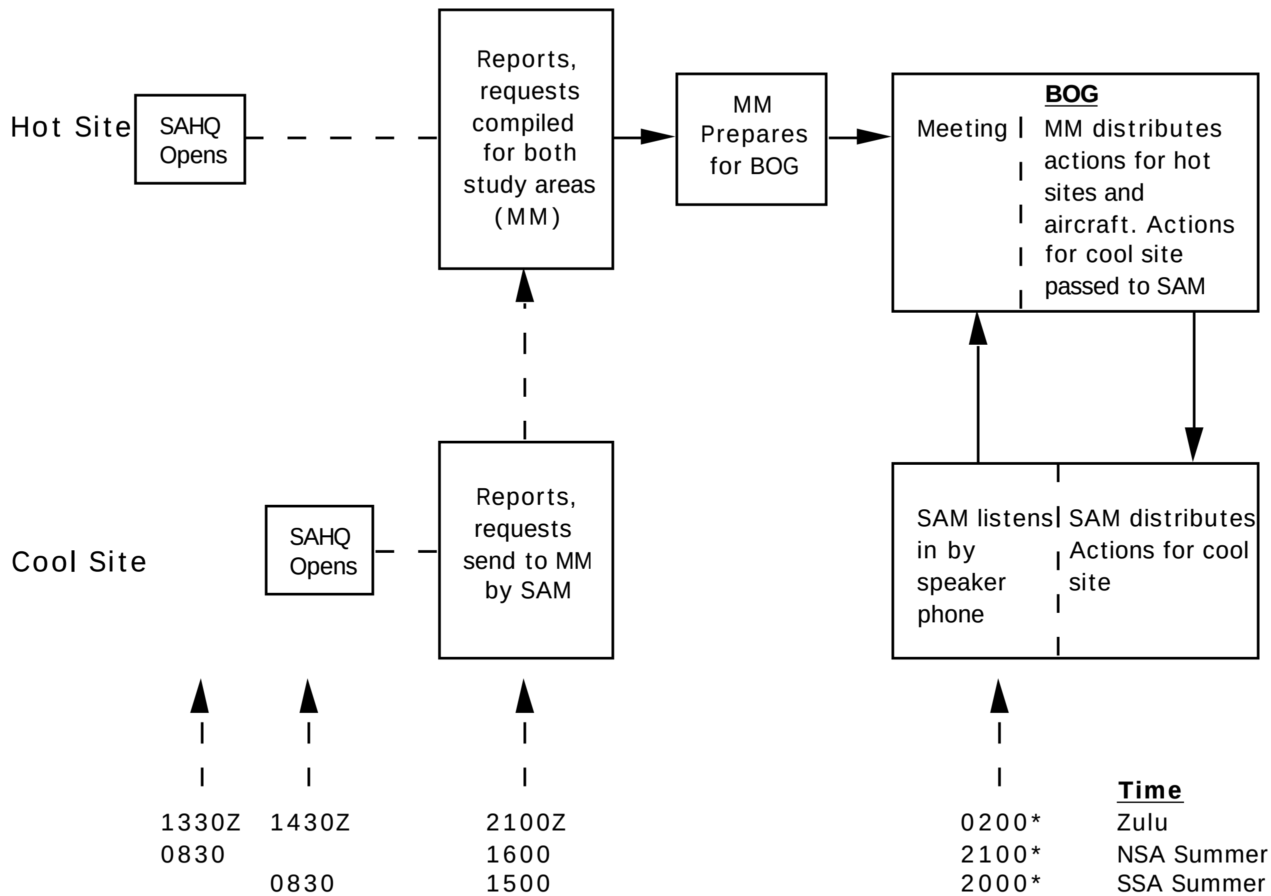


Figure 5.1.4a Steps leading up to the BOG meeting showing flow of reports from SAHQ's to the MM.

BOREAS Aircraft/Satellite Schedule																
Date: 8/13/93				Mission Manager: Sellers Hot Site: NSA					NSA SAM: Evans SSA SAM: Newcomer							
GMT	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	100	200	300	400
NSA	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SSA	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200
SAT		N-12 ∇ 41, 64							N-11 ∇ 44, 48							
AC		DC-8	YXE			RD-MN			YXE	26000'						

Satellite Legend

N = NOAA AVHRR

L = Landsat

S = Spot

N-12 ....Satellite type - number

∇

41,45 ....Satellite views zenith, solar zenith angles

Symbol '∇' at top of row denotes NSA, near base denotes SSA.

Aircraft Legend

DC-8
↑
Aircraft Type

RD-MN
>------ └-------- └----<

YXE
↓
Takeoff time,
Airport
(see Table 5.2.3)

↑
Mission type
see Table 5.2.1.

YXE
↓
Landing time,
Airport

26000
↑
Altitude

Figure 5.1.4b Aircraft/Satellite mission summary chart. Legend explains abbreviations. These charts will be prepared and presented at the BOG meeting to brief BOREAS participants on the next day's activities. At the next BOG, a version of the chart reflecting the actual activities completed for that day will be finalized and filed.

BOREAS Daily Team Participation Form

Mission Manager: Sellers NSA SAM: Evans

DATE: 08-13-93 Hot Site: NSA SSA SAM: Newcomer

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM					P P none *																		
TF								* W OJP AD		* W YJP Fen AD	P Fen AD *												
TE		P OA AD *			P PW AD *			W OA OBS AD *	* P BS AD	P FW AD *		P FW AD *											
TGB					* W leaf rapid AD																		
HYD									nbrj AD *														
RSS				P YJP AD *			* W OJP OBS AD				* ? flin flon	W CL visit AD *				W YA OBS AD *	W OA YJP PM *		W ?WX AD *				

* (top of box) ....NSA site

* (bottom of box) ....SSA Site

Location ....e.g. SSA - OA

Activity ....W = working, P = preparation

Time ....am = morning, AD = all day

Figure 5.1.4c Investigator activity summary. Legend explains abbreviations. These will be prepared and presented at the BOG meeting to brief BOREAS participants on the next day's activities. At the next BOG, a version of the chart reflecting the actual activities completed for that day will be finalized and filed.

- Finalization of plans for next day, distribution of of action items (5 minutes)

TOTAL 46 minutes

These BOG meetings will start promptly at 0200Z at:

2000 LT:	Snodrifters Lodge, Candle Lake	(SSA)
2100 LT:	Inco Training Center	(NSA)

The formal BOG business may be followed by a variety of follow-up science or operations meetings.

Figures 5.1.4b and c show examples of mission summary charts.

The people listed at the beginning of this section must be represented at BOG meetings unless specific arrangements have been made with the MM or SAM otherwise. While all investigators are encouraged to attend any BOG meeting, every two or three days there will be a call for investigators to show up and participate on a particular evening. These bigger meetings are intended to open up communication between investigators working in the same study area: refreshments (beer, snacks, etc.) will be available.

5.1.5 Aircraft Operations Protocols

The following procedures for the submission and approval of aircraft mission plans, monitoring of flight operations and communications have been set up to ensure flight safety and efficient coordination in BOREAS.

Proposed aircraft missions must be communicated to the MM in time for their incorporation into the evening BOG briefing held the day before the mission is executed. It is preferred that each aircraft have a representative (P.I., aircraft manager or pilot) at the BOG meeting. Any changes to the missions as described in section 5.2 must be communicated to the MM as soon as practicable.

The MM will formally approve proposed mission plans at the BOG meeting in which the schedule for the next days missions will be set out in the Ops chart (Satellite/Aircraft) as shown in figure 5.1.4.b; copies will be made available and/or faxed to aircrews on request. For safety reasons, the following protocols have been established:

- Aircraft missions will be separated by time and/or altitude. The exceptions will be some combined flux missions and helicopter mission in which case aircrews will confer with each other beforehand. The Aircraft Ops chart will show aircraft missions by altitude from top to bottom.

- Any departure from mission profiles (take-off times, site-entry times, altitudes, etc.) must be communicated to the MM as soon as possible.

- The SSA flux aircraft low-level routes are one-way only at any given time. The direction and clearance to enter these routes will be handled by BOREAS Ops, see Figure 5.2.1.10.9.

- All BOREAS aircraft will communicate with BOREAS-Ops and each other on 122.7. Some calls are mandatory, see below.

- Flight plans must be filed for each flight.

- Significant BOREAS/aircraft activity will be NOTAM'd by the MM.

If, for some reason, an aircraft team wishes to execute an unscheduled mission at short notice (i.e., not advertised at the previous BOG meeting) they must first contact the MM or his/her representative for approval. At this time, the MM will bring the team up to date with respect to other aircraft operations.

Most aircraft operations will be coordinated by the MM from the hot SAHQ by telephone and the aircraft radio net. Occasionally, operations over a study area may be coordinated by an MM or designee of the MM from an aircraft holding above the study area. The call-sign of this aircraft is 'EYEBALL'.

Each aircraft pilot is responsible for keeping the aircraft manager/PI informed as to the state of the aircraft readiness, hours remaining and significant scheduling considerations, e.g. time remaining to inspection, crew rest requirements, etc. The pilot and/or aircraft manager shall also ensure that the following radio contacts are made with the SAHQ.

-- 'wheels up', if within radio range
-- 'site approach', when within radio range giving position, altitude, intentions and ETA on-site.
-- 'east/west route entry/exit'. When a flux aircraft enters or exits a low level route, the route and direction must be pre-announced.
-- 'start of work' in the study area
-- movement from one surface target to another (helicopter)
-- 'site exit'

Within the study areas, aircraft should call out their positions relative to either the YPA or YTH VOR/DME NAVAIDS as required or on request, see figures 5.1.5. Low-flying aircraft out of range of the VOR/DME should use LORAN or GPS to provide the same information, i.e. 'virtual' VOR/DME positions. This information will also be used by BOREAS-Ops to give advisories to non-BOREAS traffic transiting the study areas.

Figures 3.5.4.2 and 2.1.1.2 show the layout of the BOREAS Operational Grid which is used to locate and name sites within and ouside the study areas. Instructions from BOREAS-Ops to aircraft to proceed to a particular site will use these identifiers - the exceptions will be the TF sites which are well-known landmarks and will be referred to by their 'popular names'; for example, 'TF-Old-Jack Pine', to avoid confusion. If an aircraft, particularly the helicopter, needs to identify its position with respect to the BOREAS Operational grid, it should call out the site's latitude identifier followed by the site's longitude identifier, e.g., 'Charlie-Echo' or 'Charlie-North, Echo-East', which translates to grid square CD with C-vertical axis, E-horizontal axis. If in doubt, the position will be passed across as VOR/DME coordinates.

Figures 5.1.5 show the BOREAS TF and auxiliary sites by Category for each study area, with the VOR/DME grids overlaid; note that DME arcs are shown in conventional nautical miles. Site categories define the priority of a site as a remote sensing target; see Section 3.2.4.4.

Clean copies of figures 2.1.1.2, 3.5.4.2 and 5.1.5 can be obtained from BORIS.

5.1.6 Communications

5.1.6.1 Aircraft Radio Net

In both the NSA and SSA, the BOREAS frequency is 122.7. In the NSA, low-flying aircraft should also monitor Thompson (YTH) tower on 118.8; in the SSA, low-flying aircraft should monitor Prince Albert (YPA) radio on 122.3.

Aircraft approaching the BOREAS study area should contact the SAHQs as per the calls specified in section 5.1.5. The call signs for the SAHQs are 'BOREAS Ops'.

The SAHQs (Operations Centers) and/or EYEBALL will be the only radio links between BOREAS-Ops and all surface operations to the BOREAS aircraft.

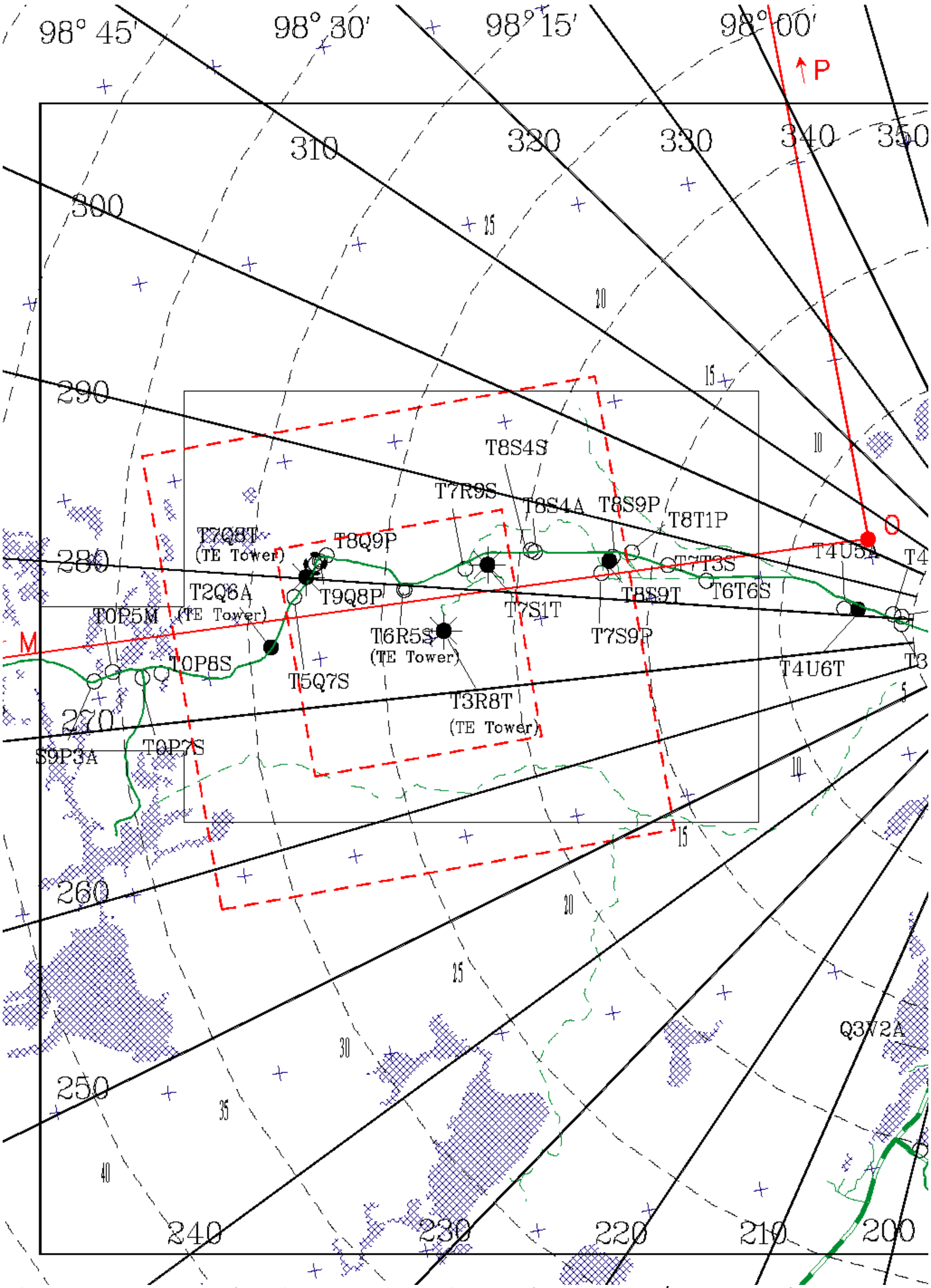


Figure 5.1.5a NSA showing BOREAS sites and YTH VOR/DME overlay.

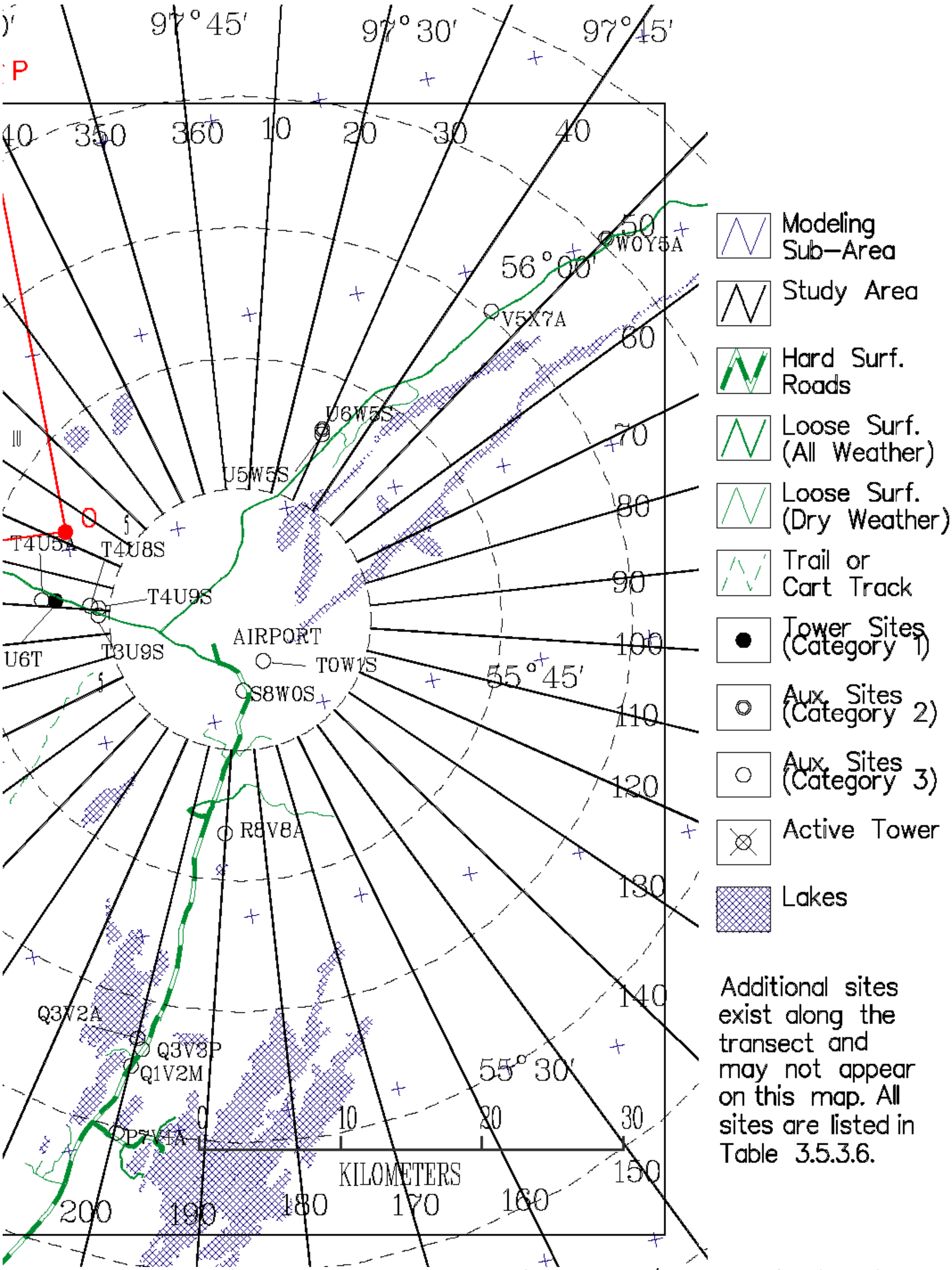


Figure 5.1.5a NSA showing BOREAS sites and YTH VOR/DME overlay (cont.)

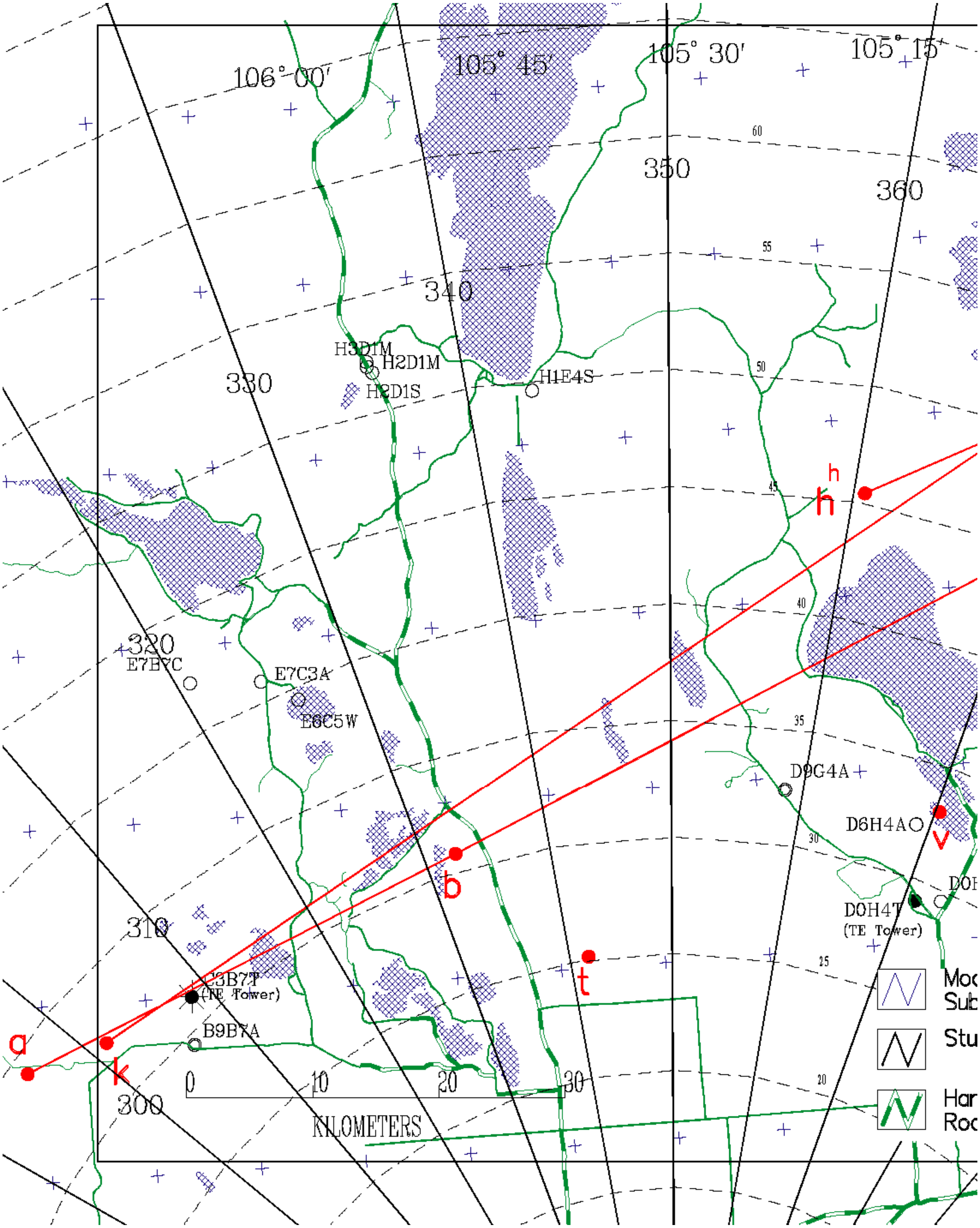


Figure 5.1.5b SSA showing BOREAS sites and YPA VOR/DME overlay.

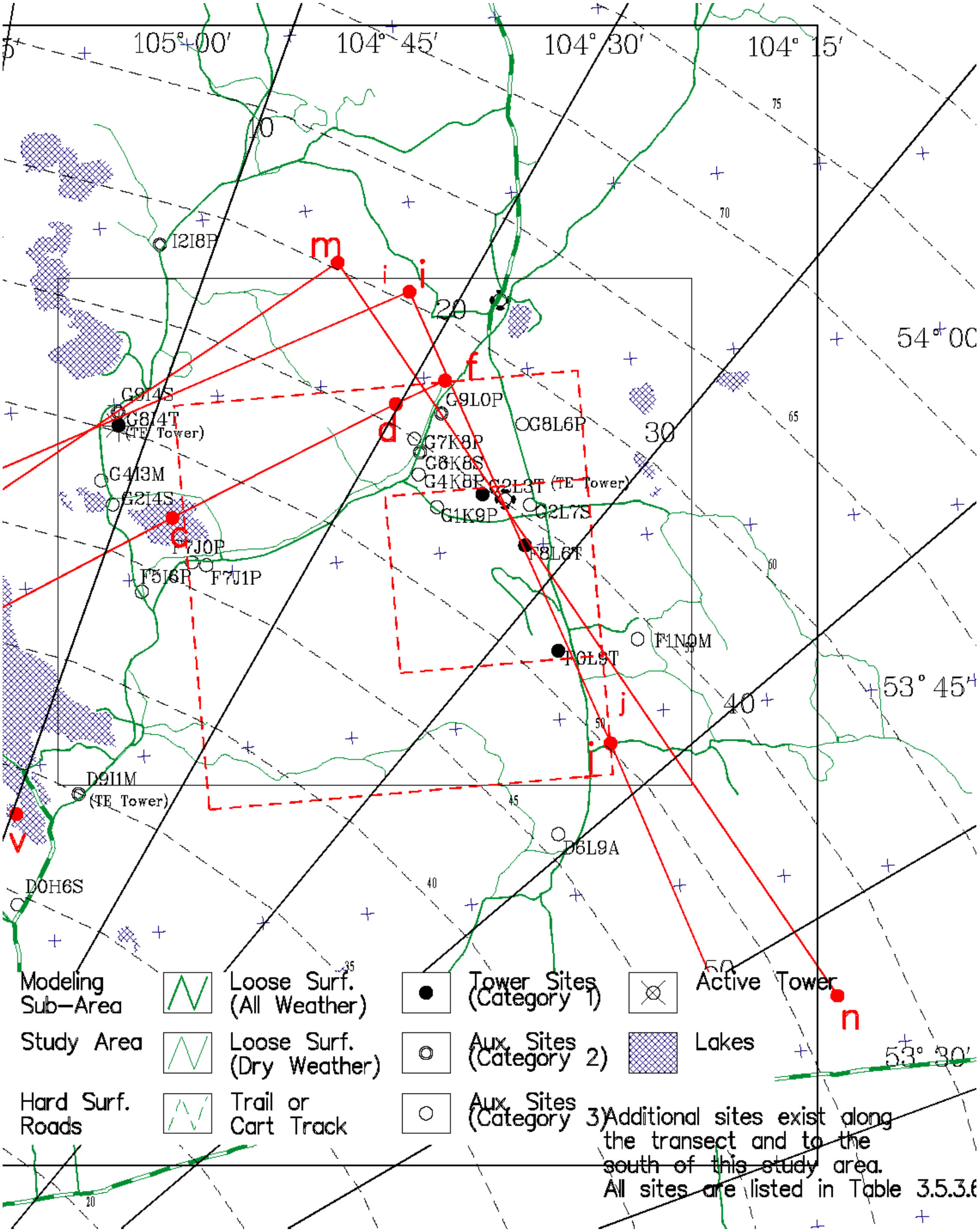


Figure 5.1.5b SSA showing BOREAS sites and YPA VOR/DME overlay (cont.)

5.1.6.2 Ground Radio Net

Ground radio nets will be in place in both the NSA and SSA. These will allow conversations between the SAHQ, TF Site Captains, TE Site Captains and other key investigators. It is desirable that radio communication follow these rules:

- On the first transmission/contact, say:
  -- Person or place to be contacted
  -- Name of person, team number and position of person transmitting

  e.g. 'BOREAS Ops; this is Joe Bloggs, TF-20 at the Young palm-tree site.'

- Keep transmissions as short as possible, i.e. no rambling, no long lists or monologues.

- At the end of the conversation say:
  -- Name of person transmitting - clear

  e.g. 'Joe Bloggs, clear'.

- At the end of transmission, ensure that the radio is not still transmitting; i.e. no stuck button. Otherwise, no one can hear anything anywhere.

- Site captains in particular, but everyone in general, keep your radios ON. Site Captains perform a radio check with the SAHQ when turning the radio on in the morning and prior to turning off in the evening.

- Radios can be drawn from the SAM in each study area; these sets must be returned when the investigator leaves the study area (even if he/she is moving to the other study area). Investigators can rent their own radios for the season from the supplier; contact David Terroux for details.

- Investigators should get a briefing on channels to use, etc., when picking up their sets. They should also be familiar with the emergency procedures listed in Appendix B and in section 5.1.7.

The FM radios issued to BOREAS participants have channel selectors. In the NSA, channel 10 is used on-site while channel 09 can be used to contact BOREAS Operations or the Lab from town or on the stretch of Route 391 leading out to the study area from the airport. In the SSA, users should select the

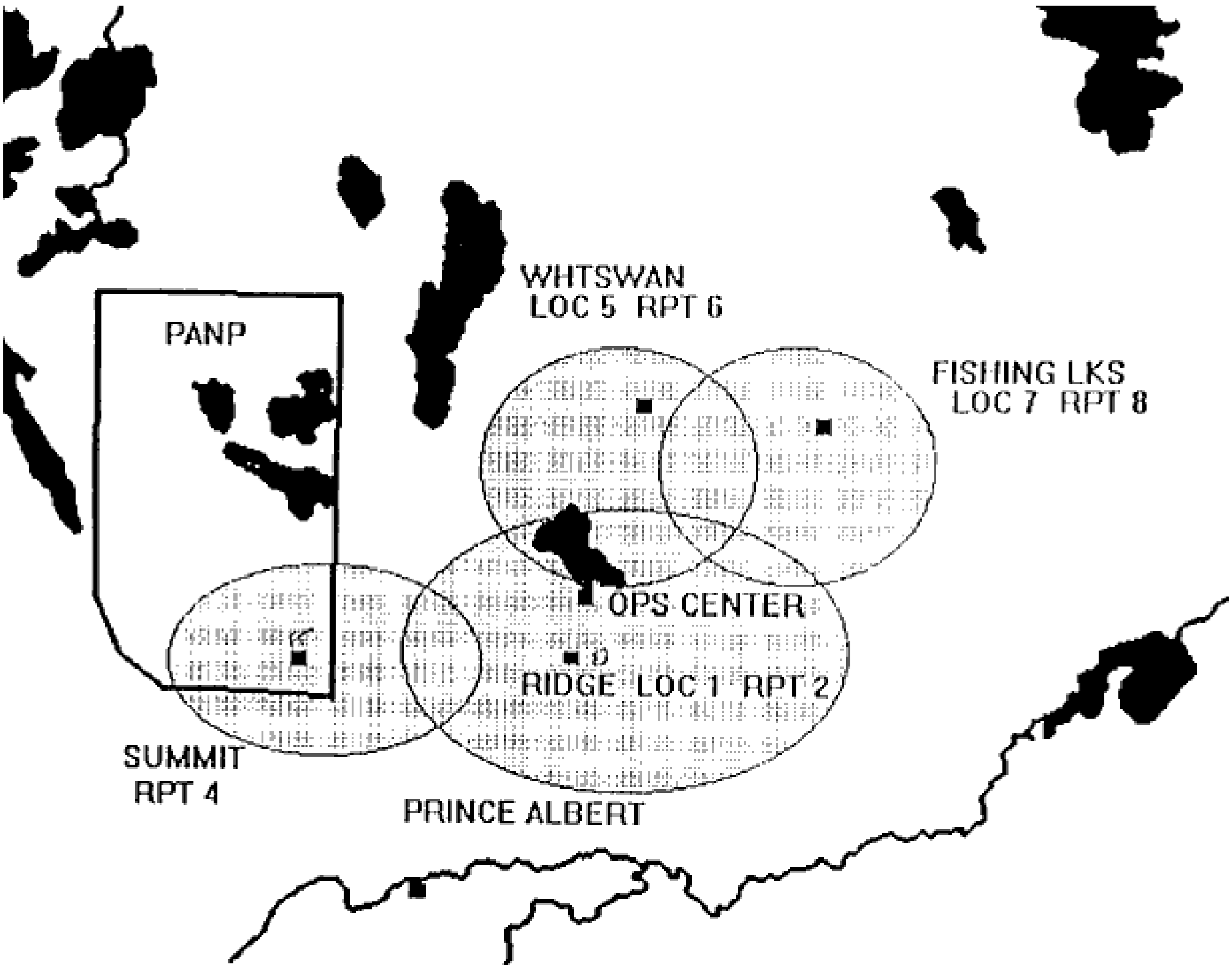


Figure 5.1.6.2 Ground radio net repeater coverage in SSA. Users should select channels denoted by RPT.

channel denoted by the repeater number (e.g. RPT 4 for the PANP area) as shown in Figure 5.1.6.2. The radios can be used to contact BOREAS Operations from Prince Albert Airport from the Athabaska tower (Channel 02).

5.1.6.3 Telephone/Faxes

The following telephone numbers are useful.

Southern Study Area		
SAHQ - Snowdrifters Lodge, Candle Lake	(Voice)	306-929-2669
		306-929-2668
	(FAX)	306-929-2322
Snocastle Lodge, Candle Lake	(Voice)	306-929-2174
Ships Lantern, Candle Lake	(Voice)	306-929-4555
PANP Park HQ (also sunphotometer)	(Voice)	306-663-5322
SRC (AMS Network)	(Voice)	306-933-5437
Paddockwood School		306-989-2011
	(Speaker)	306-989-4412
	(FAX)	306-989-4413
Prince Albert Airport,Weather Services		306-953-8640
Prince Albert Weather Office (taped message)		306-953-2114
Prince Albert Airport, Flight Service Station	(Voice)	306-953-8625
Prince Albert Airport, Athabaska briefing room	(Voice)	306-953-8828
	(FAX)	306-953-8829
Prince Albert Airport Old Tower (LongEZ Ops)	(Voice)	306-953-8806
Prince Albert Airport Fuel Room (C-130/Ops)	(Voice)	306-953-8808
Prince Albert Airport, Athabaska Airways	(Voice)	306-764-1404
Prince Albert Airport, Athabaska Airways	(FAX)	306-763-1313
Prince Albert Inn	(Voice)	306-922-5000
Marlboro Inn	(Voice)	306-763-2643
	(FAX)	306-763-6336
Delta Bessborough (Saskatoon) (DC-8)	(Voice)	306-244-5521
	(FAX)	306-653-2458

Northern Study Area

SAHQ - Keewatin Hangar, Thompson Airport	(Voice)	204-677-7070
	(Speaker)	204-677-7071
	(FAX)	204-677-7072
Inco Training Center	(Voice)	204-677-7073
	(Speaker)	204-677-7074
	(FAX)	204-677-7075
Inco Plant Laboratory	(Voice)	204-677-6450
Thompson Airport Flight Services	(Voice)	204-677-4043
Thompson Airport Weather Office	(taped message)	204-677-6900
Keewatin Community College	(Voice)	204-677-6450
	(Payphone)	204-778-6119
Hayes Road Laboratory	(Voice)	204-677-2277
	(Speaker)	204-677-7079
Jo Lutley (Sunphotometer)	(Voice)	204-778-7669
Burntwood Hotel	(Voice)	204-677-4551
Meridian Hotel	(Voice)	204-778-8387
Country Inn	(Voice)	204-778-8879
Mystery Lake Hotel	(Voice)	204-778-8331
AES Radiosonde Network-Thompson Zoo	(Voice)	204-677-7078
(AES Observer)	(Voice)	204-677-7982

5.1.7 Emergency Procedures and Safety

5.1.7.1 Emergency Procedures

Fire: There are fire extinguishers at each TF hut. Additionally, in the NSA, there will be fire extinguishers at each generator hut. Call for assistance by radio. If you see a fire out in the bush, call in its location immediately - you may be the first to see it.

Accident: There are first aid kits in each TF site hut. Call SAHQ to arrange medevac, if necessary. The ground net radio can also be used to place an emergency phone call (see last section in this volume, Appendix B). All TF sites are close to potential medevac helicopter landing sites. (In the case of the OA-SSA, the two clearings back down the trail are adequate for this). More details on procedures can be found in the last section in Appendix B; all investigators should read this prior to entering the field for the first time.

5.1.7.2 Safety

Investigator plans for the day: Investigators are strongly encouraged to tell SAHQ where they will be on any given day. This is especially important for 'roving' investigators in TE, TGB and HYD teams. On leaving for the field, call in to SAHQ with a brief message of where you are going and expected time of return (ETR). The SAM will maintain a file on your plans. This information should also be given to your team representative. If you do not report back in (by radio, phone or in person), the SAM will initiate a search no later than three hours after your ETR. TF teams should contact the SAHQ by radio each morning upon entering their site and also prior to leaving. Investigator teams are also advised to have a copy of the latest EXPLAN with them in the field: it provides a great deal of information on site locations/attributes and operations procedures. It can also be used to start a pretty good campfire in a pinch.

Tower climbing: All tower climbing must be cleared by the TF or TE site captains or his/her representative. Caution should be used when climbing the scaffold towers - under some conditions the steps and walkways can be slippery. The Rohn Towers should not be climbed without safety harness and at least one other person present on the ground. If only one other person is present, he/she must have a radio. If two or more others are there, a radio is still strongly advisable. Tower climbers and backups should be familiar with the basics of climbing and rescue techniques, i.e., lowering an injured person from the top of the towers. Hard hats must be worn in the vicinity of the TE and TF towers.

1. TF towers (scaffold and Rohn): Site Captains control access and work on their towers. They are responsible for the placement of safety equipment, and (especially in case of Rohn towers) for ensuring that people who are to climb the tower have received the necessary training.

2. TE Canopy Access towers: Site Captains control access and work on their towers. They are responsible for the availability of safety equipment and for checking that people who are to climb the tower have received the necessary training. There will be training seminars held close to the beginning of IFC-1 which will be arranged by Mike Ryan (TE Chair 303-498-1012) and Dan Hodkinson (US Staff 301-286-3621). Dan Hodkinson will arrange subsequent training as necessary. Anyone wishing to use a TE tower should contact Mike Ryan or Dan Hodkinson.

3. SRC (AFM-7) Meteorological towers: Only SRC personnel or their nominees are to climb these towers.

Insurance: Investigators are responsible for their own insurance while working on the project. This should cover medical expenses, third party injury, etc.

5.2 Mission Plans

This section summarizes individual mission plans by aircraft (Section 5.2.1) mission strategies (5.2.2), flight hours and basing (5.2.3) and the satellite schedule (5.2.4).

Aircraft representatives are referred to sections 5.1.4, 5.1.5, and 5.1.6 for further information on mission plan submission/approval, aircraft operations protocols and communications.

5.2.1 Individual Aircraft Mission Plans

Each aircraft mission in BOREAS is assigned a four letter identifier which includes information on:

First Letter:	The type of mission (remote sensing or flux measurement)
Second Letter:	Aircraft type/identification (see Table 5.2.1.a)
Third Letter:	Specific mission objective (see Table 5.2.1.b)
Fourth Letter:	Mission target area

The mission identifiers are listed by aircraft type in Table 5.2.1.b. Table 5.2.1.c provides a quick reference for decoding mission identifiers. For example, 'RC-MN' translates to:

R: Remote sensing aircraft
C: C-130
M: Mapping mission
N: NSA

The missions for each aircraft are covered in the subsections 5.2.1.x. The cognizant investigator for each aircraft (see Table 5.2.1a) is responsible for informing BOREAS about any changes in aircraft status or proposed mission profiles.

Table 5.2.1a Aircraft in BOREAS

Aircraft/ Mission Identifier	Aircraft Type	Tail Number	Instruments	Cognizant Investigator	Team
Remote Sensing Aircraft					
RC	C-130	NASA-707	TMS,ASAS, MAS, POLDER, ATSP, Photo	Irons	RSS-2
RD	DC-8	NASA-717	AIRSAR	Ranson	RSS-15
RV	CV-580	C-GRSC	CCRS-SAR	Cihlar	TE-16
RT	Twin Otter (DH-6)	C-FPOK	Microwave radiometers	Chang	HYD-2
RE	ER-2	NASA-706	AVIRIS, MAS	Green/Ranson	RSS-18
RP	Chieftain	C-GCJX	CASI	Miller	RSS-19
RF	DC-3	C-GRSA	MEIS	Chen/Gauthier	RSS-7
RH	Helicopter	NASA-415	SE-590, IRT, MMR, Scatt, POLDER, ATSP	Walthall	RSS-3
RA	Aerocommander	N-5IRF	Gamma-ray	Peck	HYD-6
Flux Aircraft					
FL	LongEZ	N3R	Flux; H,LE,CO_2,τ	Crawford	AFM-1
FK	Kingair	N2UW	Flux; H,LE,CO_2,τ	Kelly	AFM-2
FE	Electra	N308D	Flux/Chemistry	Lenschow	AFM-3
FT	Twin Otter (DH-6)	C-FPOK	Flux; H,LE,CO_2,τ	McPherson	AFM-4

Table 5.2.1b Mission Summaries for BOREAS Aircraft

I. Remote Sensing Aircraft

Aircraft	Mission Identifier	Duration (hours)	Mission Summary
C-130	RC-SN	3.5	NSA TF sites during FFC-T(snow)/ASAS
	RC-SS	3.5	SSA TF sites during FFC-T(snow)/ASAS
	RC-TN	3.5	NSA TF sites (IFCs)/ASAS, MAS, (IFC-2), POLDER,TMS
	RC-TS	4.5	SSA TF sites (IFCs)/ASAS, MAS, (IFC-2), POLDER,TMS
	RC-MN	2.0	NSA Mapping; TMS, POLDER, MAS, (IFC-2)
	RC-MS	3.0	SSA Mapping; TMS, POLDER, MAS, (IFC-2)
	RC-RT	2.0	Transect between SSA & NSA aligned with AFM Regional transect; TMS, MAS, (IFC-2),
DC-8	RD-MS	3.0	AIRSAR SSA Modeling Grid Mosaic
	RD-MN	2 .0	AIRSAR NSA Modeling Grid Mosaic
	RD-RT	1 .0	AIRSAR SSA to NSA AFM Transect
	RD-BS	1.7	AIRSAR SSA Baseline
	RD-BN	1 .0	AIRSAR NSA Baseline with 43° angle
	RD-IS	1.0	AIRSAR SSA Baseline with 25° angle
	RD-DS	1.7	AIRSAR SSA Baseline pre-dawn
CV-580	RV-BS	3.0	SAR over SSA
	RV-RT	3.0	SAR SSA to NSA AFM transect
	RV-BN	2.0	SAR over NSA
DH-6 (Twin Otter)	RT-SN	3.0	Snow microwave, NSA (FFC-W)
	RT-SS	3.0	Snow microwave, SSA (FFC-W)
	RT-ST	3.0	Snow microwave, transect (FFC-W)
ER-2	RE-MS	6.0	Mapping of SSA, AVIRIS
	RE-MN	8.0	Mapping of NSA, transect, AVIRIS
	RE-US	6.0	Snow Survey, SSA, MAS (FFC-W)
	RE-SS	6.0	Snow lines, SSA, AVIRIS (FFC-T)
	RE-SN	6.0	Snow lines, NSA, AVIRIS (FFC-T)
Chieftain	RP-TS	2.0	Mapping of SSA TF and aux sites
	RP-TN	2.0	Mapping of NSA TF and aux sites
	RP-SS	2.0	Snow lines SSA
	RP-SN	2.0	Snow lines NSA
	RP-RT	3.5	Regional transect, line segments
DC-3	RF-TS	5.0	Mapping of SSA TF sites
	RF-TN	3.0	Mapping of NSA TF sites
Helicopter	RH-TS	2.3	TF, aux site optical mission, SSA
	RH-BS	2.3	Microwave scatterometer mission, SSA
	RH-TN	2.3	TF, aux site optical mission, NSA
	RH-BN	2.3	Scatterometer mission, NSA
Aerocommander	RA-SS	4.0	Gamma snow survey, SSA
	RT- ST	4.0	Gamma snow survey, transect
	RA-SN	4.0	Gamma snow survey, NSA
	RA-WS	4.0	Gamma soil moisture survey, SSA
	RA-WT	4.0	Gamma soil moisture survey, transect

II. Flux Aircraft

Table 5.2.1b Mission Summaries for BOREAS Aircraft (times are approximate)

Aircraft	Mission Identifier	Duration	Mission Summary
LongEZ	FL-CS	2.0	Candle Lake runs (SSA)
	FL-TS	1.0-1.5	Site specific (TF site) (SSA)
	FL-LS	3.0	Mini, meso transect (SSA)
	FL-GS	3.0	Grids and stacks (SSA)
	FL-FS	0.5-1	Flights of two (SSA)
	FL-ZS	0.3	Low level routes (SSA)
DH-6	FT-CS	2.0	Candle Lake runs
(Twin Otter)	FT-TS,N	1.0-1.5	Site specific (TF site)
	FT-LS,N	1.5-2.5	Mini, meso transect (SSA, NSA)
	FT-GS,N	2.5-3.0	Grids and stacks (SSA, NSA)
	FT-PS,N	2.5-3.0	Budget box pattern(SSA, NSA)
	FT-HS,N	2.5-3.0	Stacks and Tees (SSA, NSA)
	FT-FS,N	0.5-1.0	Flights of two (SSA, NSA)
	FT-ZS	0.2	Low level routes (SSA)
King Air	FK-CS	1.5	Candle Lake runs
	FK-LS,N	1.0-2.0	Mini, meso transect (SSA, NSA)
	FK-GS,N	1.0-2.0	Grids and stacks (SSA, NSA)
	FK-PS,N	2.0-3.0	Budget box pattern(SSA, NSA)
	FK-HS,N	2.0-3.0	Stacks and Tees (SSA, NSA)
	FK-FS,N	2.0-3.0	Flights of two (SSA, NSA)
	FK-ZS	0.2	Low level routes (SSA)
Electra	FE-CS	1.5	Candle Lake runs
	FE-RT	6.0	Regional transect
	FE-LS,N	1.0-2.0	Mini, meso transect (SSA, NSA)
	FE-FS,N	0.5-1.0	Flights of two (SSA, NSA)

Table 5.2.1.c Reference table for decoding BOREAS aircraft mission identifiers (e.g. RC-MN = R: remote sensing aircraft; C: C-130 - M: Mapping mission; N: - NSA)

First Letter Mission Type	**Second Letter Aircraft Type**	**Third Letter Mission Objective**	**Location**
R: Remote Sensing	A: Aerocommander C: C-130 D: DC-8 E: ER-2 F: DC-3 H: Helicopter P: Chieftain T: Twin Otter V: CV-580	B: Radar or microwave baseline D: Like B, predawn I: Like B, 25 degree incidence M: Mapping R: Regional S: Snow survey T: Tower or aux site (optical) U: Special snow survey (ER-2) W: Soil moisture survey	N: NSA S: SSA T: Transect
F: Flux Measurement	L: LongEZ K: Kingair E: Electra T: Twin Otter	C: Candle Lake Run F: flights of two G: Grids/stacks H: Stacks/tees L: Regional/mini transect P: Budget box pattern R: Regional transect T: TF site specific run Z: Low-level routes	N: NSA S: SSA T: Transect

5.2.1.1 C-130 (RC)

The major objectives are to obtain (1) multiangle TMS (or MAS), and POLDER large area coverage mapping of the Modeling Sub-Areas, (2) multiangle ASAS and POLDER data over Tower Flux sites, and (3) TMS (or MAS) data on a regional transect between study areas. The priorities of these different missions will vary depending on the specific field campaign. All C-130 missions are dependent on clear-sky conditions (no more than 5-10 % cloud cover). During the FFC-T, the C-130 will be based in Prince Albert; for IFCs 1 and 2, the C-130 will fly first to Prince Albert and base in the SSA for 10 days, then fly to Thompson and stay for 10 days there. If the C-130 participates in IFC-3, it will fly first to Thompson, stay 10 days there, then fly to Prince Albert and stay 10 days there.

Flight schedules will be determined during the evening BOG meetings by onsite Team members, air crews, and relevant ground teams. Weather forecasts and morning weather conditions will be used to make daily go or no-go decisions. If skies are sufficiently clear in the morning, all ASAS missions will take off as early as possible in the morning, determined by any solar zenith angle limitations. Flightline orientations for ASAS lines will depend on solar azimuth at the time of acquisition, while a mission-averaged solar azimuth will be used for positioning of the large area coverage grids. Targets of opportunity and simultaneous overflights with other platforms will also be discussed and finalized at the evening BOG meetings.

Details of the C-130 missions are given below in Sections 5.2.1.1.1 - 5.2.1.1.4

5.2.1.1.1 RC-SN and RC-SS: Snow Mission in FFC-T

The C-130 plans to arrive in Prince Albert, Saskatchewan on or before April 11, 1994. It will base at Prince Albert for the entire duration of FFC-T. The C-130 will fly ASAS missions at an altitude of about 17,500 feet above ground level (AGL) over several Tower Flux sites in both the SSA and NSA. In addition, ASAS will acquire several targets for calibration. The prioritized list of sites and flightline orientations relative to the solar principal plane (SPP) are as follows:

SSA: RC-SS

(1)	Old Black Spruce	Parallel, oblique, and perpendicular to SPP
(2)	Old Jack Pine	" " "
(3)	Old Aspen	" " "
(4)	White Gull Lake	Parallel, and oblique to SPP

ASAS missions in the SSA will coordinate with HYD-3, RSS-1 (PARABOLA), and RSS-19 (CASI).

NSA: RC-SN

(1)	Old Black Spruce	Parallel, oblique, and perpendicular to SPP
(2)	Fen	" " "
(3)	Old Jack Pine	" " "
(4)	Young Jack Pine	" " "
(5)	Birch Tree Lake	Parallel, and oblique to SPP

ASAS missions in the NSA will coordinate with HYD-3, and RSS-19 (CASI).

These snow missions depend on snow conditions at each site, with a minimum threshold requirement of 25mm SWE (snow water equivalent) over most of a 1 sq. km patch. If snow conditions at either one of the study areas are not favorable for collection of ASAS data, then a contingency large area coverage mapping mission (RC-MN or RC-MS) may be flown. These mapping missions will acquire TMS (or MAS) data over the Modeling Sub-Areas on flightlines parallel to the SPP at time of mid-mission (sometime around 10:30 or 11:00 local time) at an altitude of 25,000 feet AGL. The spacing between flightlines will be 5 km. Lastly, during transit between the study areas, a regional transect (RC-RT) aligned with the AFM (FE-RT) regional transect may be executed if time permits. Note: A go/no-go decision based on snow conditions will be made on April 6, 1994. If minimum snow requirements are not met, the C-130 will not fly to Canada. The C-130 will go if conditions for at least one study area are favorable.

See figures 5.2.1.1.1a and 5.2.1.1.1b for the RC-SN and RC-SS snow missions. Figures for the other missions will follow their respective sections.

5.2.1.1.2 RC-TN and RC-TS: ASAS, POLDER, TMS Mission Over TF Sites

Multiangle, multispectral ASAS images will be acquired over all five permanent Tower Flux sites in the SSA, and all four Tower Flux sites in the NSA, at an altitude of 17,500 feet AGL. Auxiliary sites will not be acquired. ASAS flightlines will consist of up to three different flightlines (each about 35-40 km long) oriented parallel to the solar principal plane, oblique to the solar principal plane, and perpendicular to the solar principal plane. ASAS also plans to collect data over targets of opportunity such as the AVIRIS calibration site (north of the Prince Albert Airport) and water (White Gull Lake in the SSA and Birch Tree Lake in the NSA). In the SSA, highest priority will be given to the Tower Flux sites where PARABOLA data (RSS-1) are being acquired, i.e. SSA-OA, SSA-OBS, SSA-OJP. ASAS will coordinate with other flight missions where possible. POLDER and TMS may acquire data on these flightlines. RC-TN and RC-TS will be priority 1 during IFC-1, and priority 2 during IFC-2.

See figures 5.2.1.1.2 a for RC-TN and RC-TS missions.

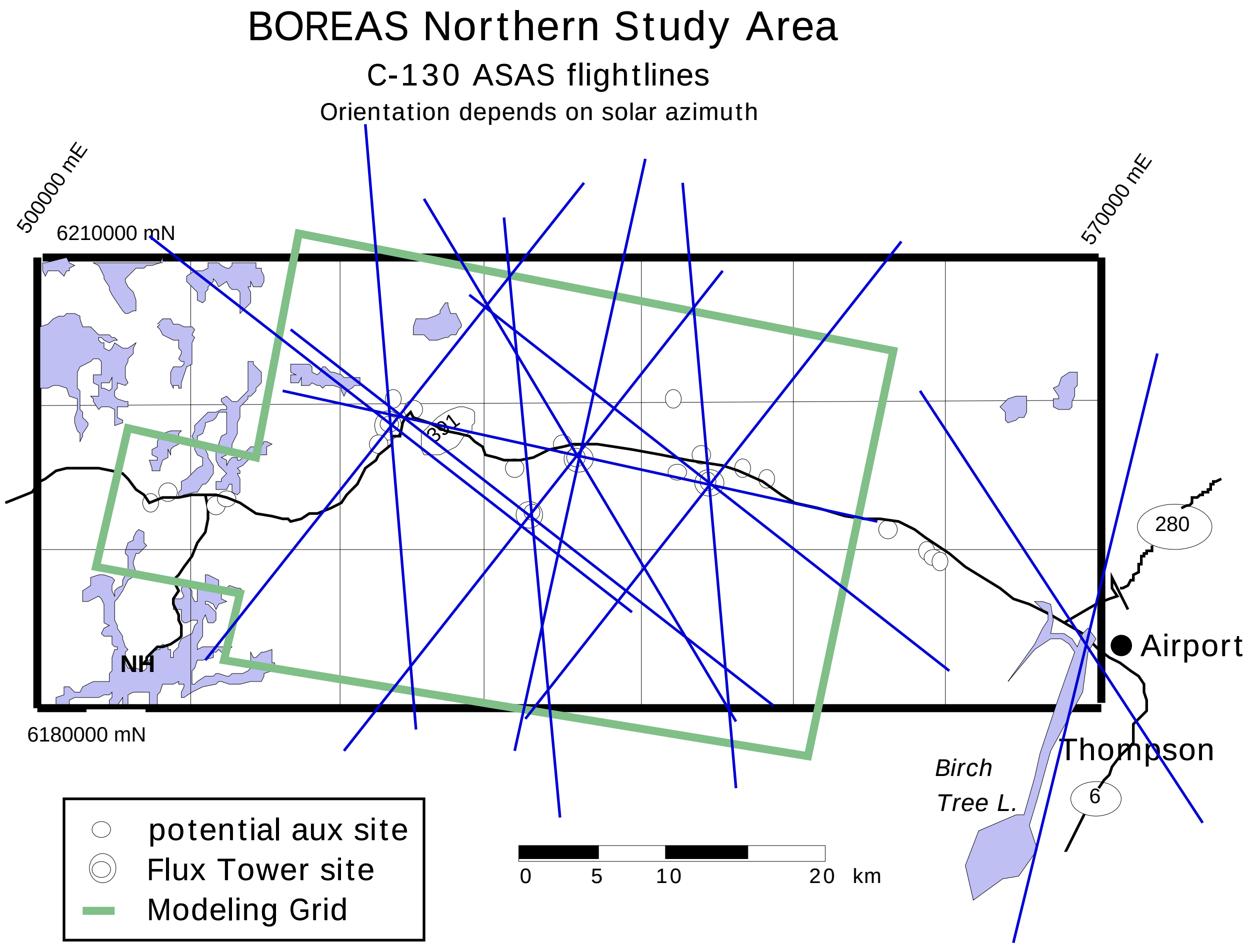


Figure 5.2.1.1.1a RC-SN: C-130 Snow Mission in FFC-T for NSA.

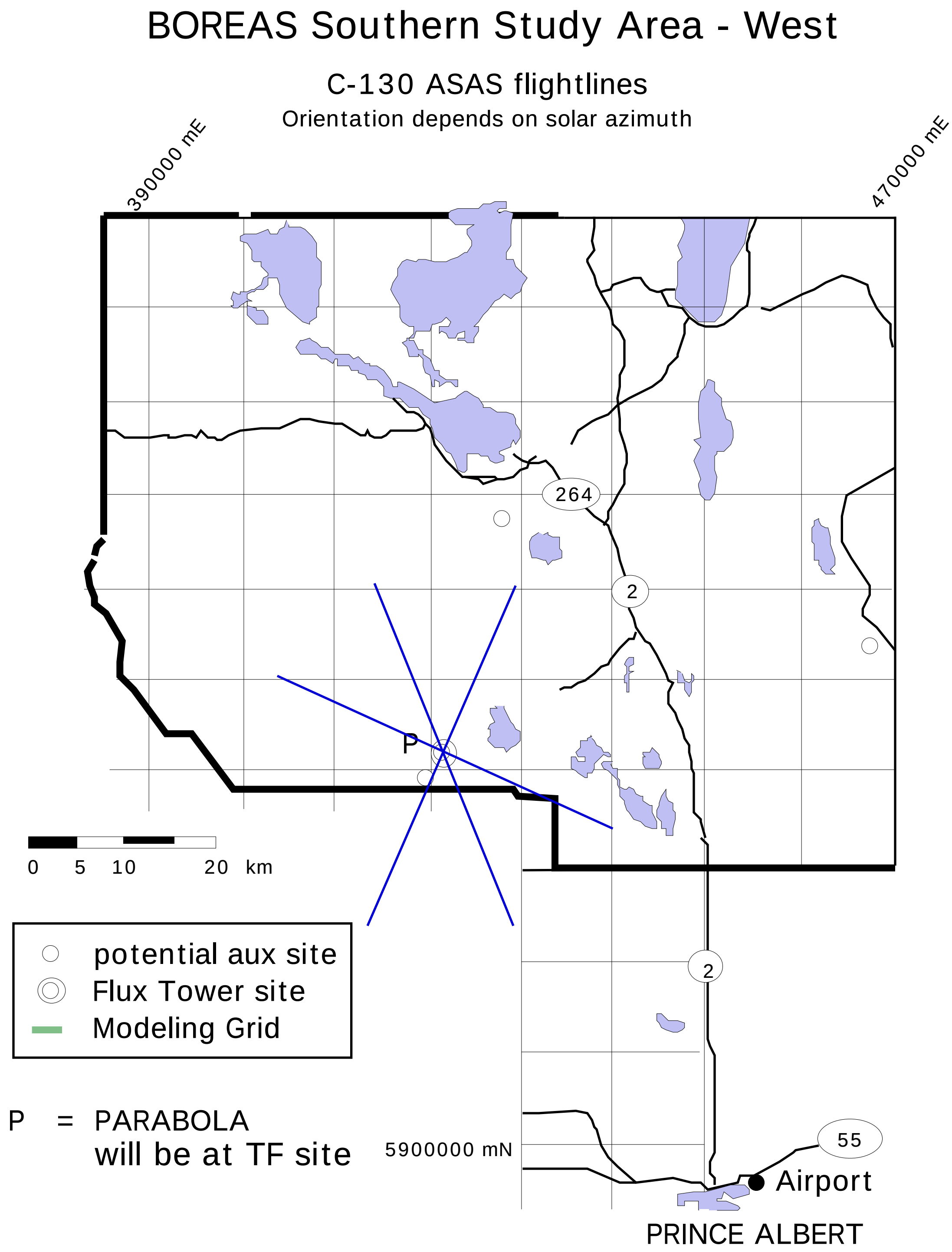


Figure 5.2.1.1.1b RC-SS: C-130 Snow Mission in FFC-T for SSA.

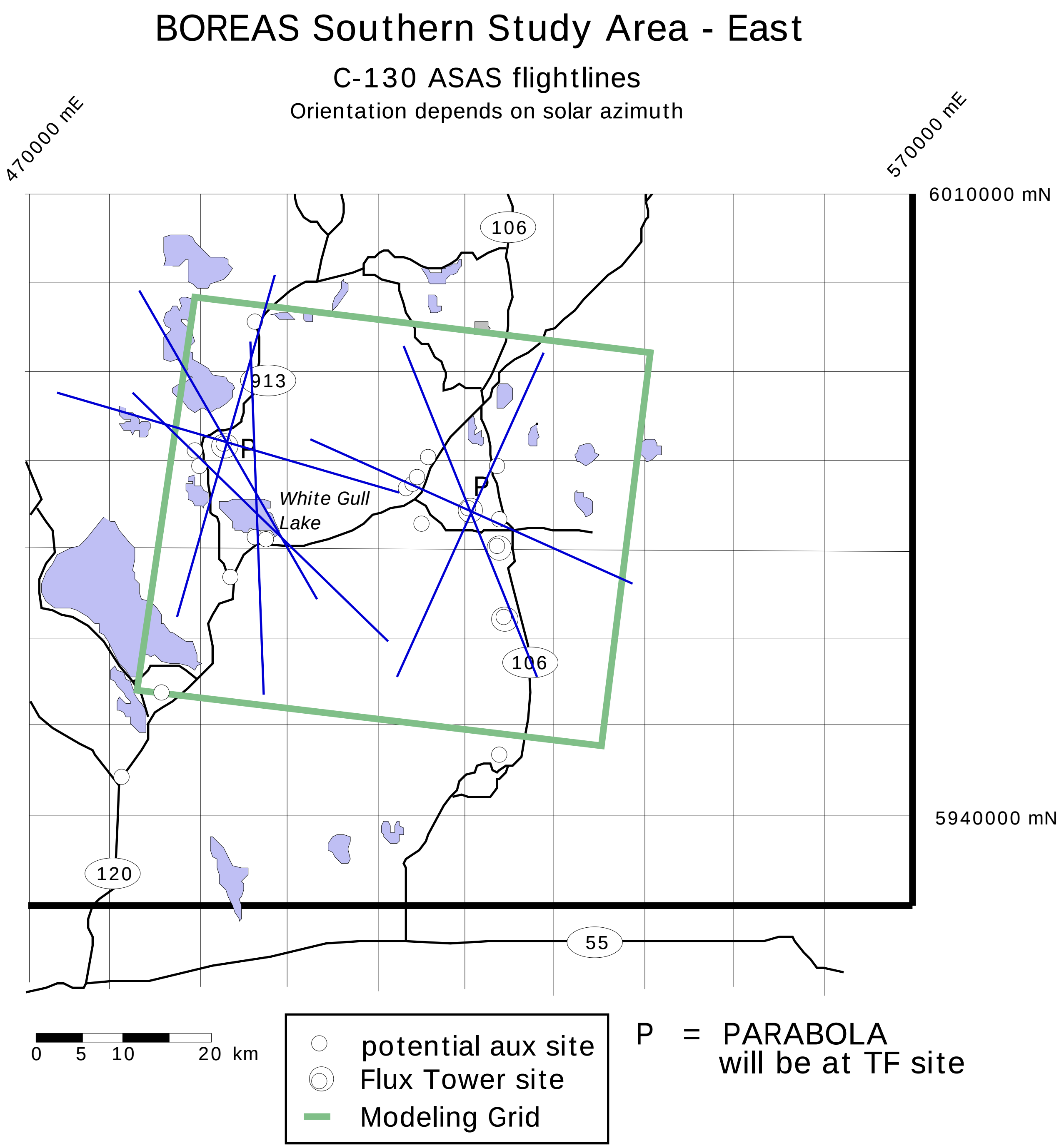


Figure 5.2.1.1.1b RC-SS (Continued)

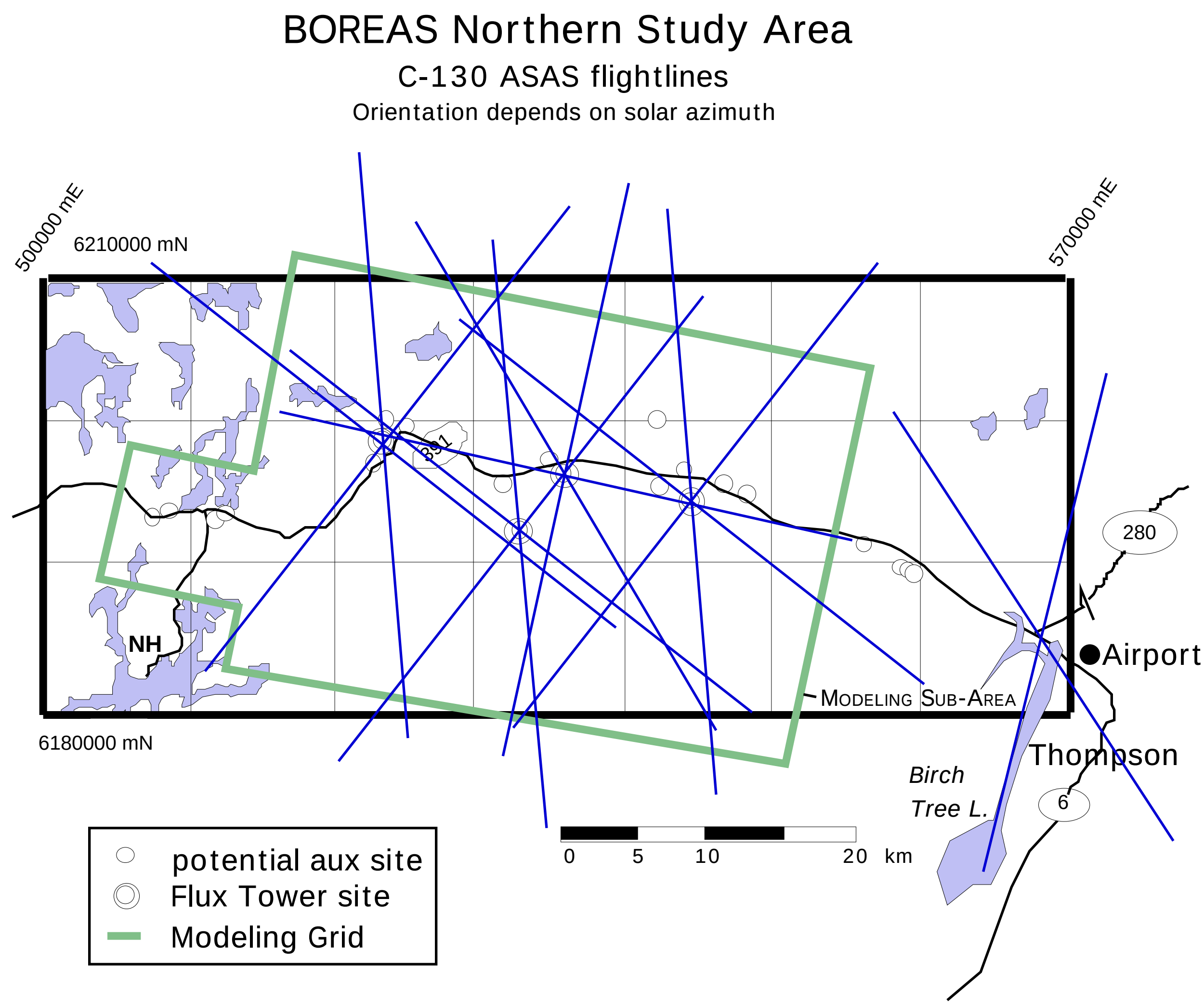


Figure 5.2.1.1.2a RC-TN: C-130 Missions over TF sites in NSA.

5.2.1.1.3 RC-MN and RC-MS: NSA and SSA Mapping; TMS, POLDER, MAS

Multiangle TMS (or MAS) large area coverage data will be acquired over the Modeling Sub-Areas in both the NSA and the SSA, at an altitude of approximately 25,000 feet AGL. POLDER will also acquire data on these flightlines. In the SSA the area covers four Tower Flux sites (Black Spruce, Old Jack Pine, Young Jack Pine and Fen). In the NSA, the area covers all four Tower Flux sites . Most auxiliary sites will be covered in these areas as well. Flightlines will be oriented parallel to the solar principal plane at time of mid-mission (approx. 10:30 am local), with a spacing of 5 km between flightlines. RC-MN and RC-MS will be priority 2 during IFC-1, and priority 1 during IFC-2.

See figures 5.2.1.1.3a and 5.2.1.1.3b for RC-MN and RC-MS missions.

5.2.1.1.4 RC-RT: Regional transect; TMS, MAS

TMS or MAS data will be acquired at an altitude of approximately 24,000 feet AGL along a regional transect between the two study areas. The transect is aligned with the AFM (FE-RT) regional transect but is displaced 2 km to the west to provide better coverage of the WAB contributing to Fx-RT (assuming westerly winds)..

See figure 5.2.1.1.4 for the RC-RT mission.

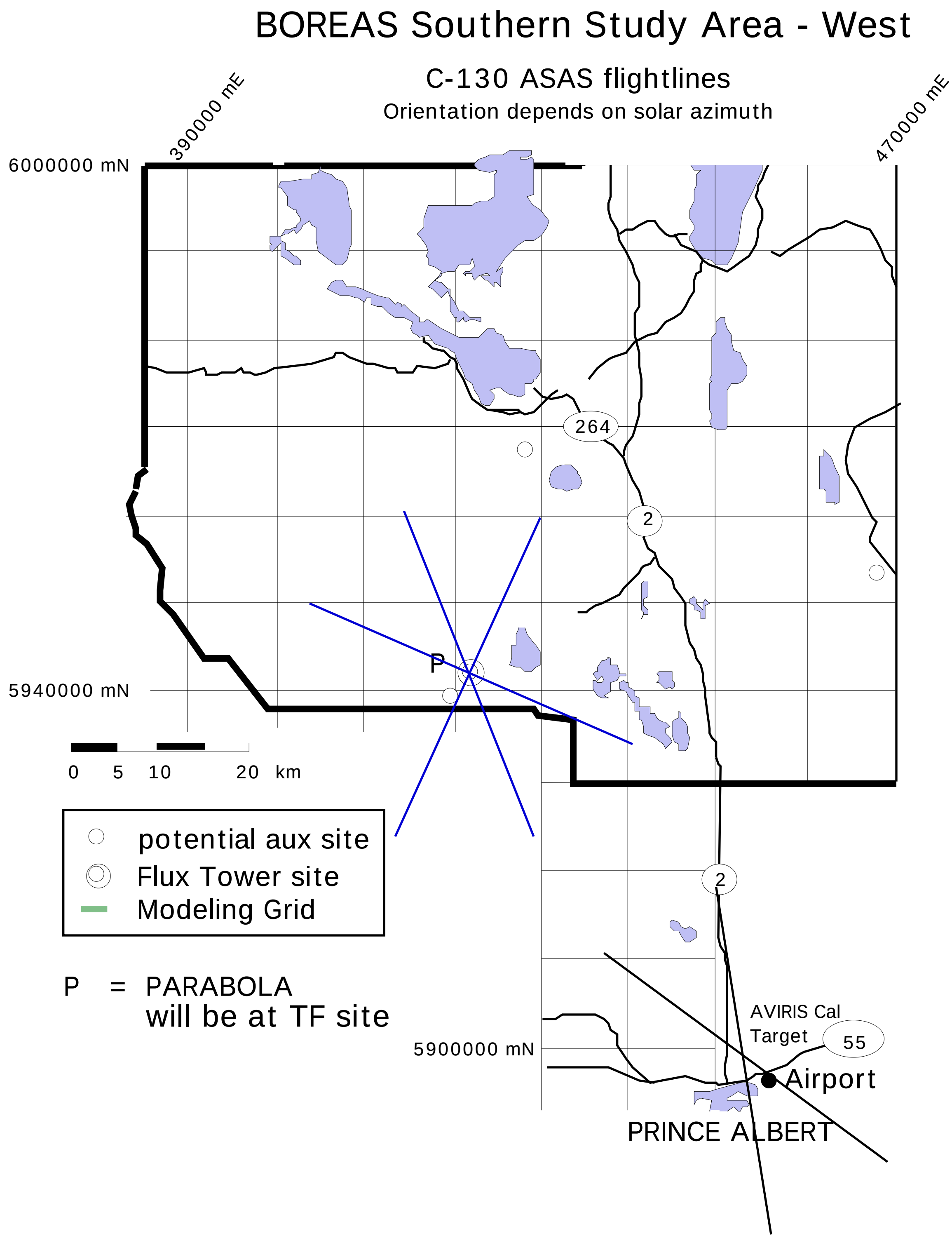


Figure 5.2.1.1.2b RC-TS: C-130 Mission over TF sites in SSA.

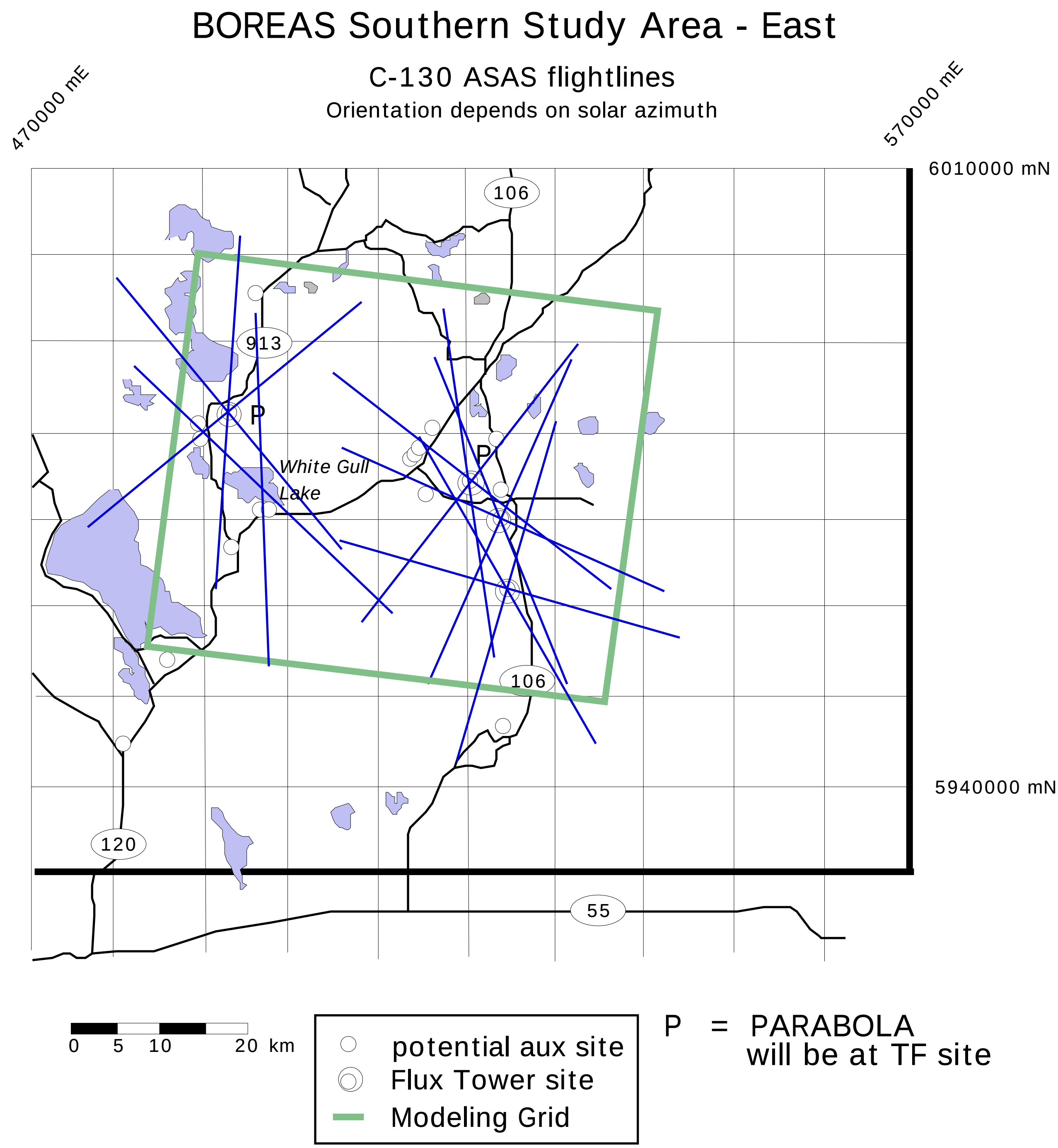


Figure 5.2.1.1.2b RC-TS: C-130 Mission over TF sites in SSA (continued).

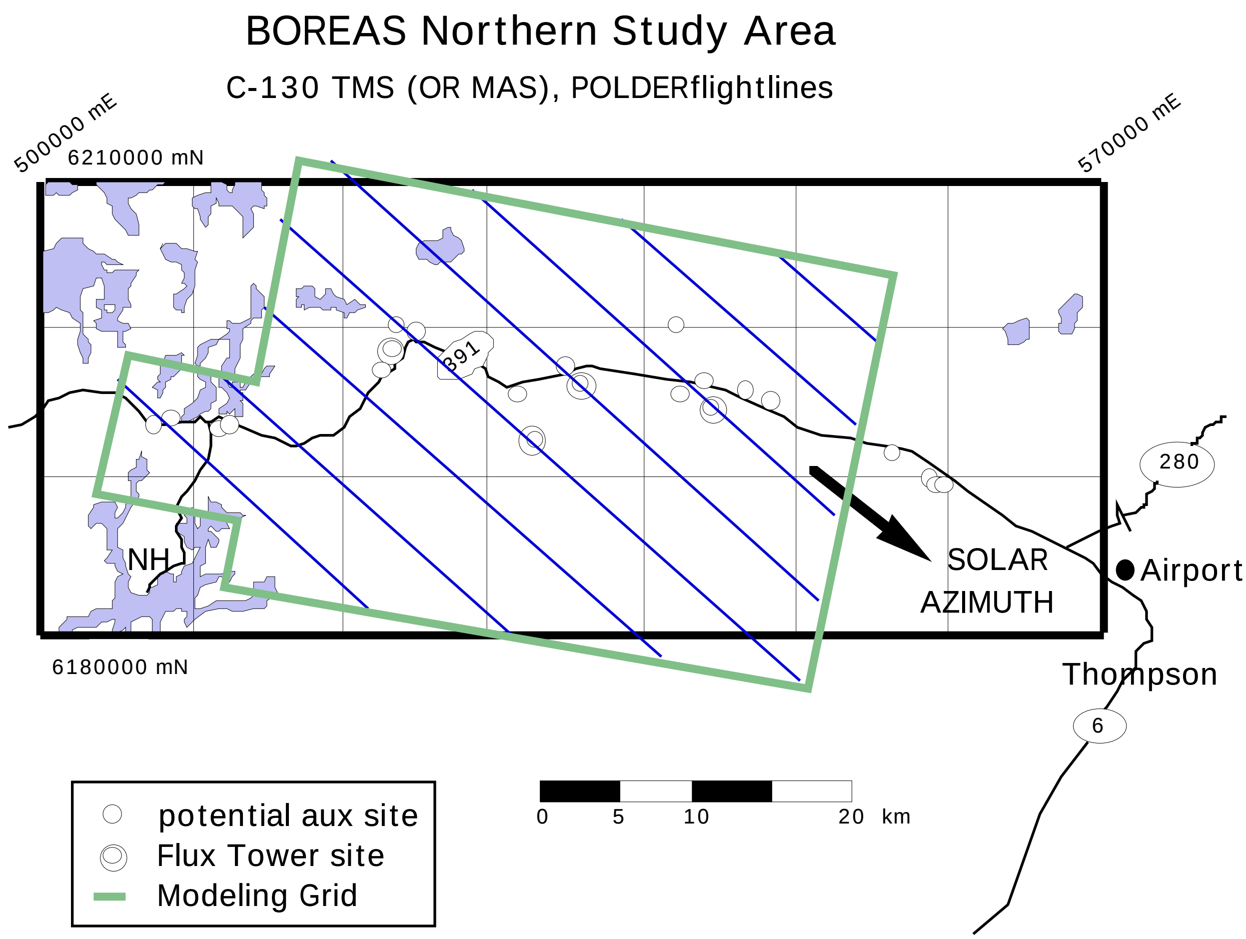


Figure 5.2.1.1.3a RC-MN: C-130 Mapping Mission over the NSA.

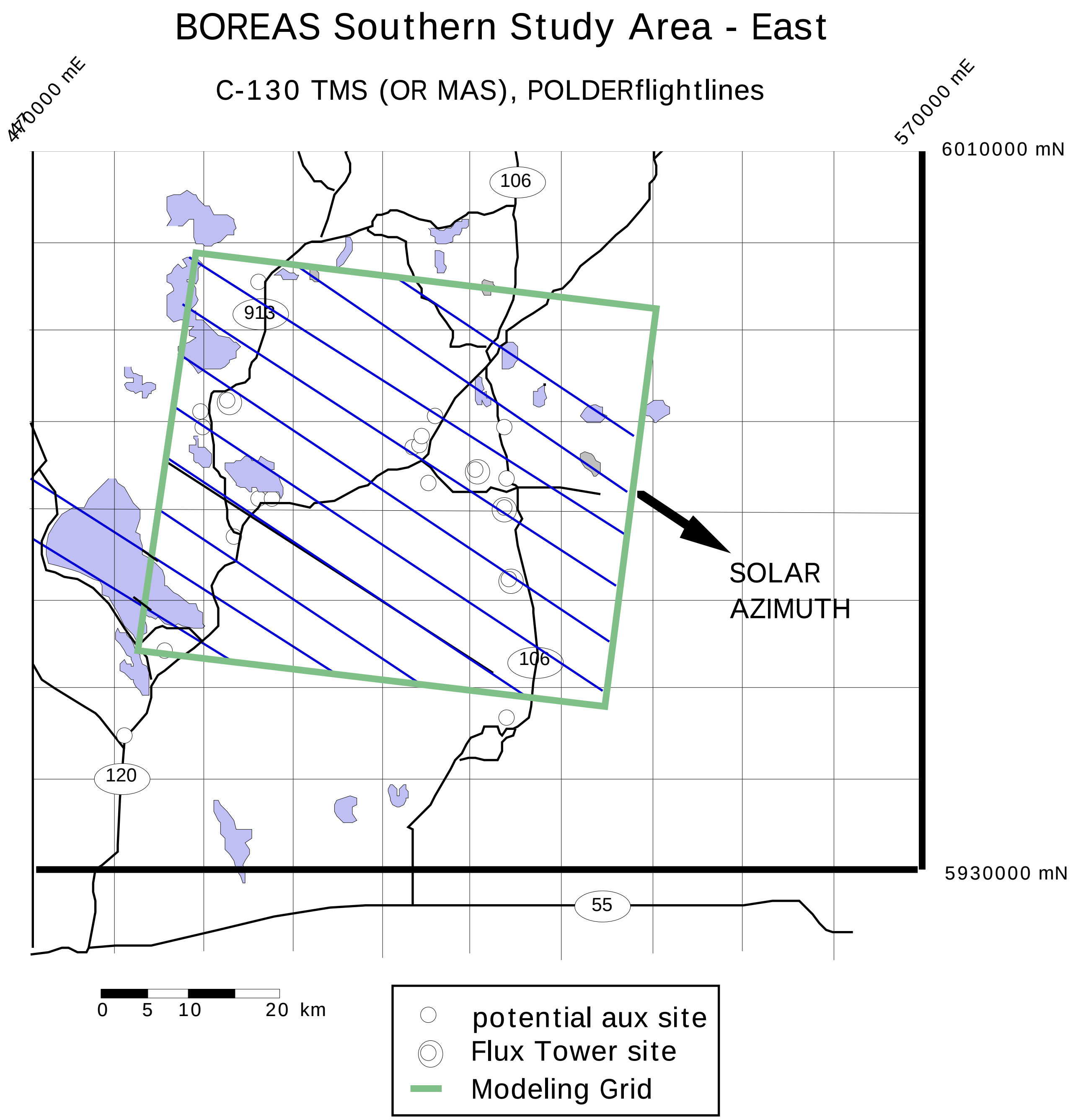


Figure 5.2.1.1.3b RC-MS; C-130 Mapping Mission over the SSA.

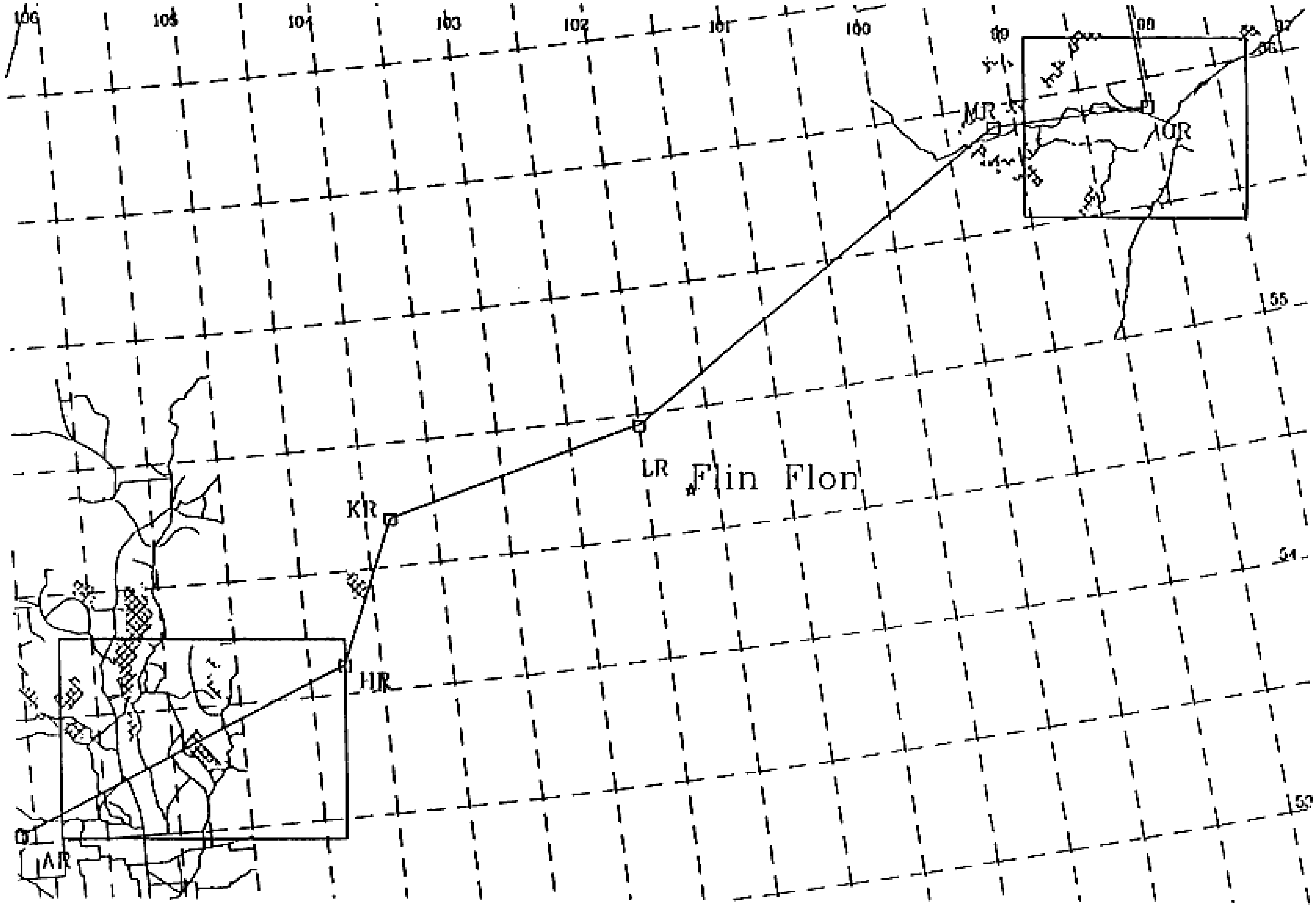


Figure 5.2.1.1.4 RC-RT: C-130 Regional Transect

Table 5.2.1.1.4

Waypoints for all remote sensing regional transect missions (Rx-RT).
These points are displaced 2 km to the west of equivalent FE-RT transect waypoints to place the center of the remotely sensed footpring upwind of the flux transect, see figure 5.2.1.1.4, table 5.2.1.10c and figure 5.2.1.10.3a.

Waypoint	Latitude	Longitude
AR	53° 32.0'	-106° 35.8'
HR	54° 07.0'	-104° 15.3'
KR	54° 41.7'	-103° 49.4'
LR	54° 57.3'	-101° 59.9'
MR	55° 54.8'	-99° 09.4'
OR	55° 53.2'	-98° 01.9'
PR	60° 30.0'	-98° 02.2'
QR	60° 30.0'	-95° 32.2'
RR	59° 00.0'	-95° 32.1'

5.2.1.2 DC-8 (RD)

Objectives: Primary objectives of DC-8 AIRSAR data acquisitions are to provide multifrequency, multipolarization SAR data for mapping above ground woody biomass, component biomass estimation (RSS-15), estimation of soil and canopy moisture (RSS-16) and phenologic event determination including freeze/thaw and leaf on/off (RSS-17).

Instruments: JPL AIRSAR - Three frequency (0.44GHz, 1.25GHz, 5.6GHz) quadpolarized synthetic aperture radar.

Mission Planning: Flights will be planned in advance with modifications required due to weather (e.g., heavy rain) coordinated between on-site investigators and air crews. The FFC-T flights may be augmented by possible SIR-C/XSAR supported AIRSAR coverage around April 15. This corresponds to mission day eight. See proposed SIR-C/XSAR transect in Figure 5.2.1.2.c

During IFC-93, the NASA/JPL AIRSAR collected data over both BOREAS sites and the transect in between. Full area coverage was obtained and synoptic mosaics were developed by JPL. SSA and NSA data were acquired on separate days, August 12 and August 13, respectively. The 1994 missions are planned differently with emphasis on the tower flux sites and modeling grid areas. In addition, extra flightlines have been added to acquire data at one additional illumination angle over the OA, OJP, YJP, and OBS sites in SSA. Pre-dawn/early-afternoon acquisitions are also planned for FFC-T and IFC-2. Table 5.2.1.2.a summarizes the AIRSAR mission scenarios.

Table 5.2.1.2.a
DC-8 (RD) Mission objectives for BOREAS

Field Campaign	**Duration**	**Activities**
IFC-93	6 days	Mosaic supersites Image transect along the SIR-C/X-SAR tracks
FFC-T	12 days	Image SSA, NSA, transect 1-3 frozen days 1-2 thawed days One predawn/midday pair Coordinate with SIR-C /XSAR, CV-580
IFC-1	1 day	Image SSA, NSA, transect
IFC-2	10 days	Image SSA, NSA and transect Multiangle, multiday coverage 3 predawn/midday pairs
IFC-3	1 day	Similar flights as IFC-1 if funds are available

Mission Scenarios: All local flights leave Saskatoon (YXE) and fly to 26000 feet altitude allowing AIRSAR minimum of 20 minutes to warm up. Centerpoint or target illumination angles to be fixed at 43º, except for separate lines flown at incidence angle of 25º. Generate sufficient on-board quicklook products to assure data quality. Flights from Moffett Field will use the same lines as local flights. See Figures 5.2.1.2.a-b for flight line maps.

RD-MS: SSA Modeling Grid Mosaic. Fly SSA modeling grid site as north-parallel lines with headings of 124˚ or 304˚ with sufficient overlap that each strip is imaged with incidence angles between 30˚ and 60˚. (See flight lines SSA 124-n and SSA 304-n on Figure 5.2.1.2.a).

RD-MN: NSA Modeling Grid Mosaic. Fly NSA modeling grid as three parallel east-west or west passes with sufficient overlap that each strip is imaged with incidence angles between 30˚ and 60˚ (See flight lines NSA 117-n, 297-n on Figure 5.2.1.2.b).

RD-RT. Fly remote sensing, transect parallel to AFM transect, acquire data between Old Aspen Site in SSA and Young Jack Pine in NSA. Be sure to acquire data over auxiliary sites near Flin Flon. (See section 5.2.1.1.4 for details).

RD-BS: Baseline Radar Mapping, SSA Coordinate with CV-580 during FFC-T and CV-580 and Helicopter during IFC-2 prior to takeoff. Fly two passes each over OBS, OA and YJP sites. (See flight lines,SSA-OA 268-1, SSA-OBS 92-1, SSA-OBS 271-1, SSA-Fen/SSA-OJP 161-1 andSSA-Fen/SSA-OJP 341-1 on Figure 5.2.1.2a).

RD-BN: Baseline Radar Mapping, NSA Coordinate with CV-580 during FFC-T and CV-580 and Helicopter during IFC-2 prior to takeoff. Fly two passes each over OBS , OJP and YJP sites. (See flight lines Tower Flux 101-1 and Tower Flux 284-1 on Figure 5.2.1.2b).

RD-IS: Multiangle radar passes, SSA. Coordinate with CV-580 during FFC-T and CV-580 and Helicopter prior to takeoff. Fly parallel passes over SSA TF sites (use baseline flight patterns) to acquire additional illumination angle of 25^{o}.

RD-DS : Predawn radar mapping, SSA. Fly two passes each over OBS, OA, OJP and YJP sites at illumination angle of 43^{o}. These flights to precede RD-BS or RD-MS flight in afternoon of same day.

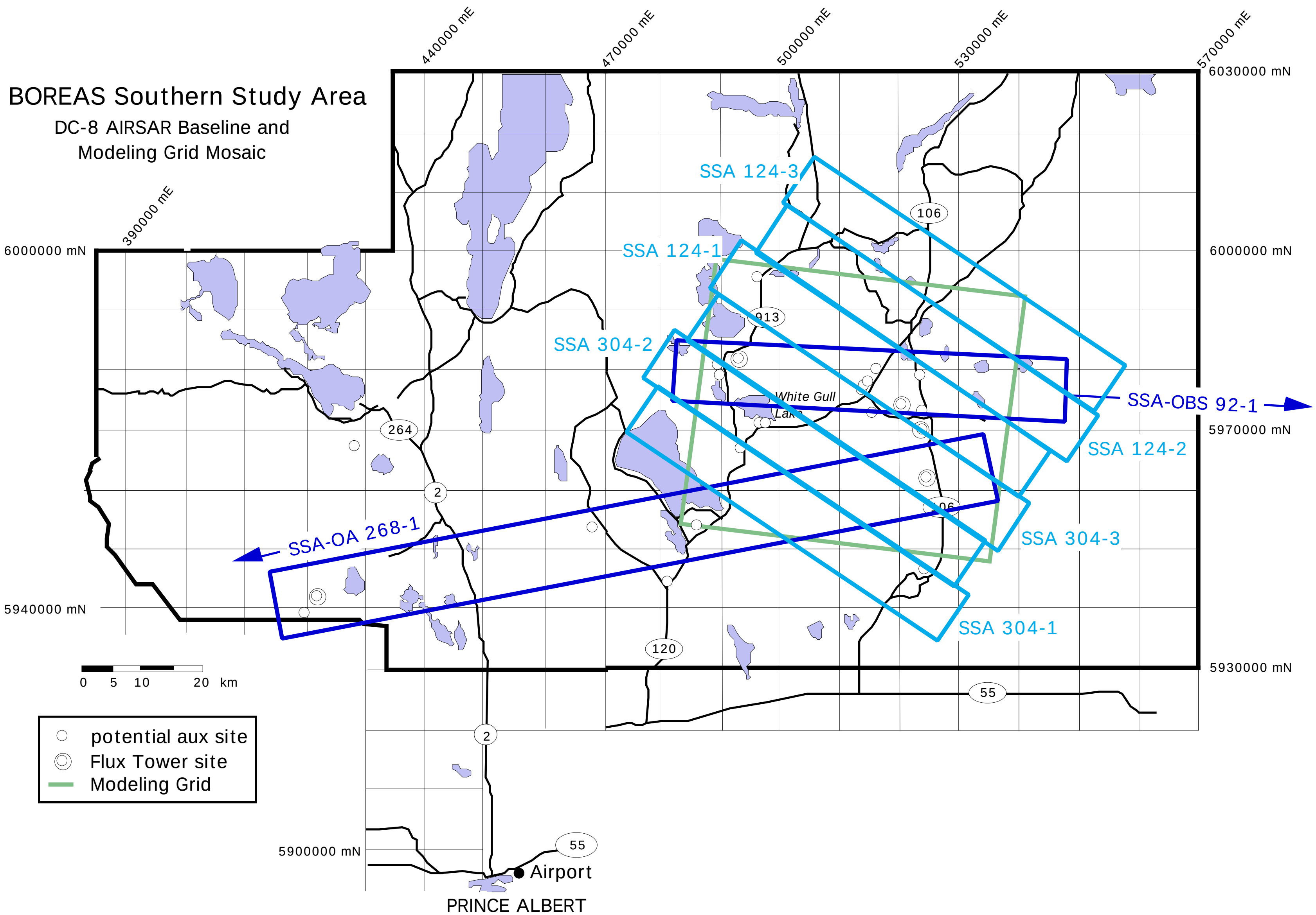


Figure 5.2.1.2.a DC-8 SSA, Modeling Grid Mosaic (RD-MS) and Baseline (RD-BS) Flight Lines

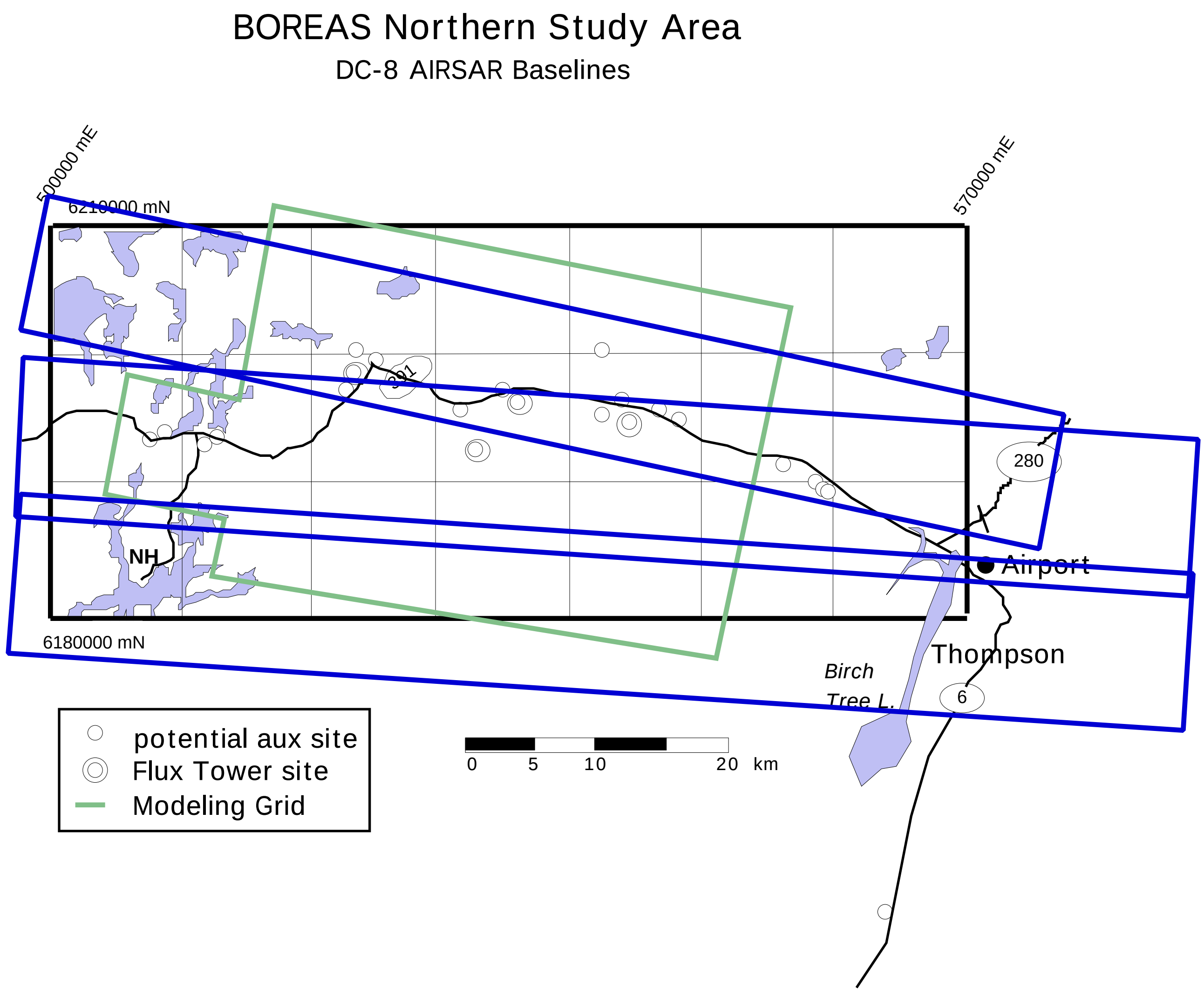


Figure 5.2.1.2.b DC-8 NSA, Modeling and Grid Mosaic (RD-MN) and Baseline (RD-BS) Flight Lines

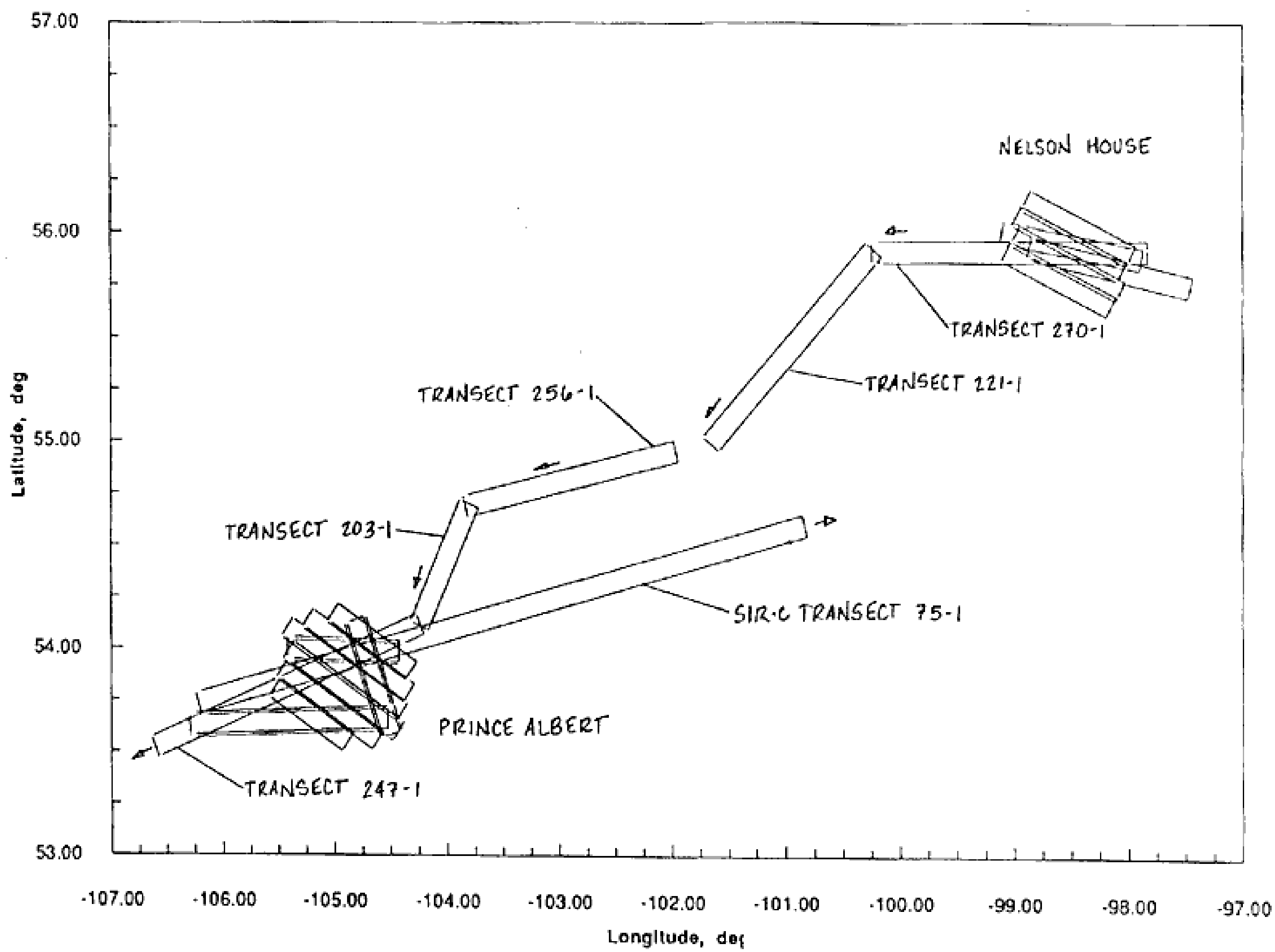


Figure 5.2.1.2.c Diagram of DC-8 flightlines including RD-RT and SIR-C/XSAR transect.

Table 5.2.1.2.b
BOREAS 1994 DC-8 AIRSAR Flight Plans

FFC-W		No flights
FFC-T		
Moffett Field to Saskatoon =		2.5 hours
Local Saskatoon flights		
1 Mosaic of NSA SSA modeling grids + transects =		6.20 hours
(RD-MS,RD-BS,RD-RT,RD-MN)		
1 baseline (no transects) =		(SIR-C/XSAR Hours)
(RD-BS,RD-BN)		
1 baseline (no transects)		3.25 hours
(RD-BS)		
1 incidence angle run =		1.75 hours
(RD-IS)		
Saskatoon to Moffett Field =		2.50 hours
1 Diurnal		1.75 hours
(RD-DS)		
	Subtotal	20.15 hours
IFC-1		
Moffett Field to Saskatoon =		2.5 hours
1 baseline with SSA-NSA transect		3.5 hours
(RD-BS,RD-RT,RD-BN)		
Saskatoon to Moffett Field =		2.5 hours
	Subtotal	8.5 hours
IFC-2		
Moffett Field to Saskatoon =		2.5 hours
Local Saskatoon flights		
1 diurnal (SSA baseline)=		1.75 hours
(RD-DS)		
1 Mosaic of NSA SSA modeling grids + transects + baselines =		6.20 hours
(RD-MS, RD-BS, RD-RT, RD-MN,RD-BN)		
1 diurnal (SSA baseline)=		1.75 hours
(RD-DS)		
1 baseline (no transects) =		3.25 hours
(RD-BS,RD-BN)		
1 diurnal (SSA baseline)=		1.75 hours
(RD-DS)		
1 baseline (no transects)		3.25 hours
(RD-BS,RD-BN)		
1 incidence angle run (SSA baseline)=		1.75 hours
(RD-IS)		
Saskatoon to Moffett Field =		2.5 hours
	Subtotal	26.45 hours
IFC-3		
Moffett Field to Saskatoon =		2.5 hours
1 baseline with SSA-NSA transect		3.5 hours
(RD-BS,RD-RT,RD-BN)		
Saskatoon to Moffett Field =		2.5 hours
	Subtotal	8.5 hours
Total BOREAS DC-8 Hours		61.35 hours

5.2.1.3 CV-580 (RV)

Objectives: The objective for the CV-580 is to acquire CCRS SAR radar data over SSA and NSA during FFC-W for snow (RSS-16), frozen tree (RSS-17) and frozen soil studies (RSS-16), FFC-T and IFC-2 data will support studies of radar backscatter from forest biomass components (RSS-15) and soils (RSS-16).

Instruments: CCRS SAR with C and X-band multipolarization capabilities.

Mission Planning: The CCRS SAR will coordinate with AIRSAR missions during FFC-T and IFC-2, and HELOSCAT (RH-BS,N) during IFC-2. Flights during FFC-T and IFC-2 will be planned the previous evening by on-site investigators from RSS-13, RSS-15, RSS-16, and aircrews. See Table 5.2.1.3 for mission summaries.

Table 5.2.1.3 CV-580 Mission Summaries

Field Campaign	Duration	Activity
IFC-93		No flights
FFC-W		No flights
FFC-T	10 days	Single day coverage NSA 2-days SSA frozen and/or thawed conditions concurrent with SIR-C/XSAR mission Coordinate with AIRSAR regional transect (RD-RT)
IFC-1	No flights planned	
IFC-2	10 days	Single day coverage (NSA) Multiday coverage (SSA) Coordinate with AIRSAR and HELOSCAT regional transect (RD-RT)
IFC-3	No flights planned	

RV-BS: CCRS Radar baseline passes over SSA.
Leave Saskatoon and fly to 20000 feet altitude allowing SAR minimum adequate warm-up time. Fly baseline transits of OA, Fen, YJP, OJP and OBS. Fly one pass each along AFM transect within SSA. Return to Saskatoon. Elapsed time 3 hours. (See Figure 5.2.1.3a).

RV-RT: Regional Transect.
Leave Saskatoon and fly to 20000 feet altitude allow SAR adequate warmup time. Fly along regional transect (See section 5.2.1.1.4) acquire limited data at TBD locations including auxiliary sites near Flin Flon).

RV-BN: CCRS Radar baseline pases over NSA.
After traversing regional transect (RV-RT) fly two passes over NSA tower flux sites as shown in Figure 5.2.1.3.1b.

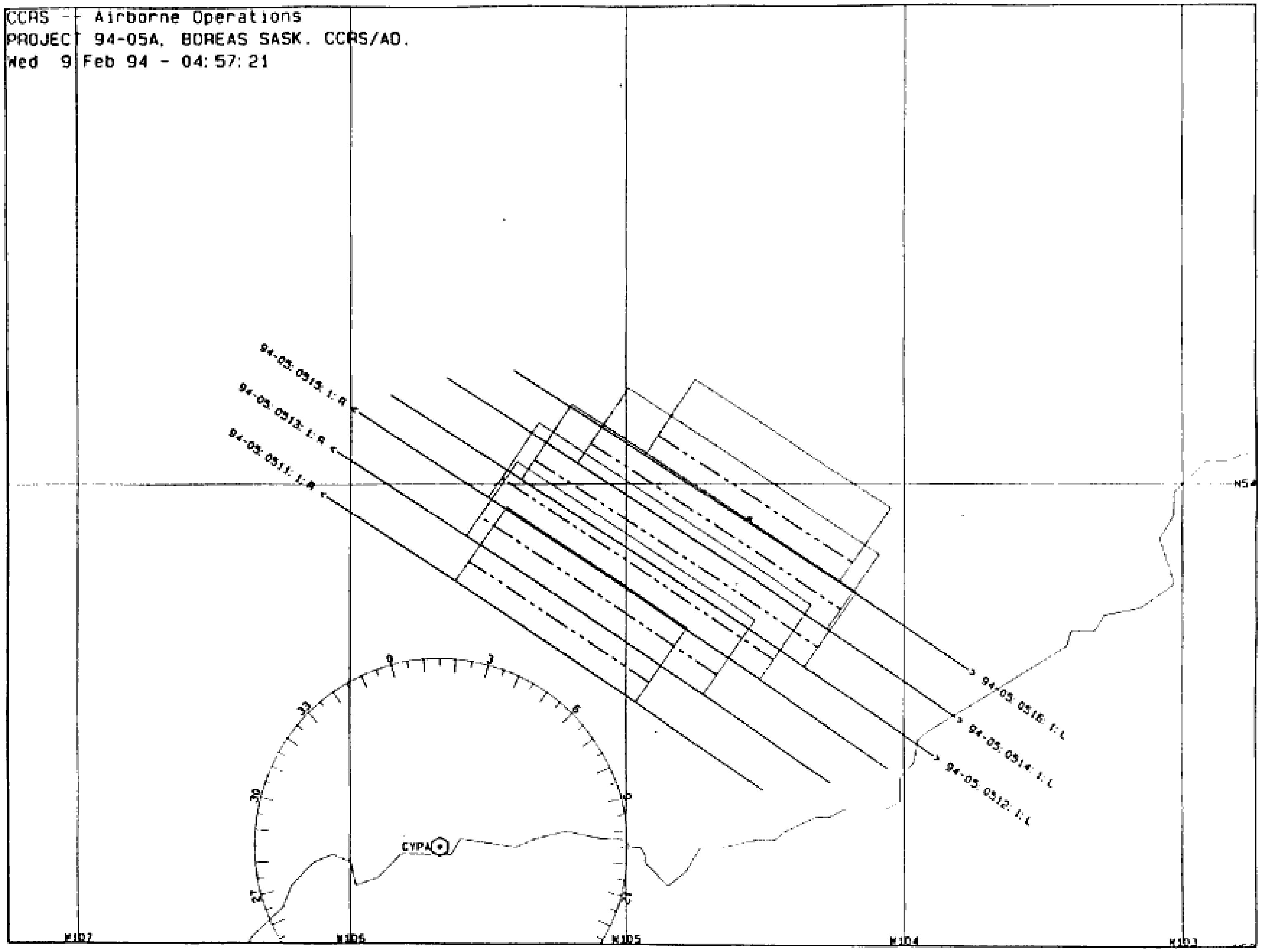


Figure 5.2.1.3.1a CV-580 SSA Baseline (RV-BS) flight lines.

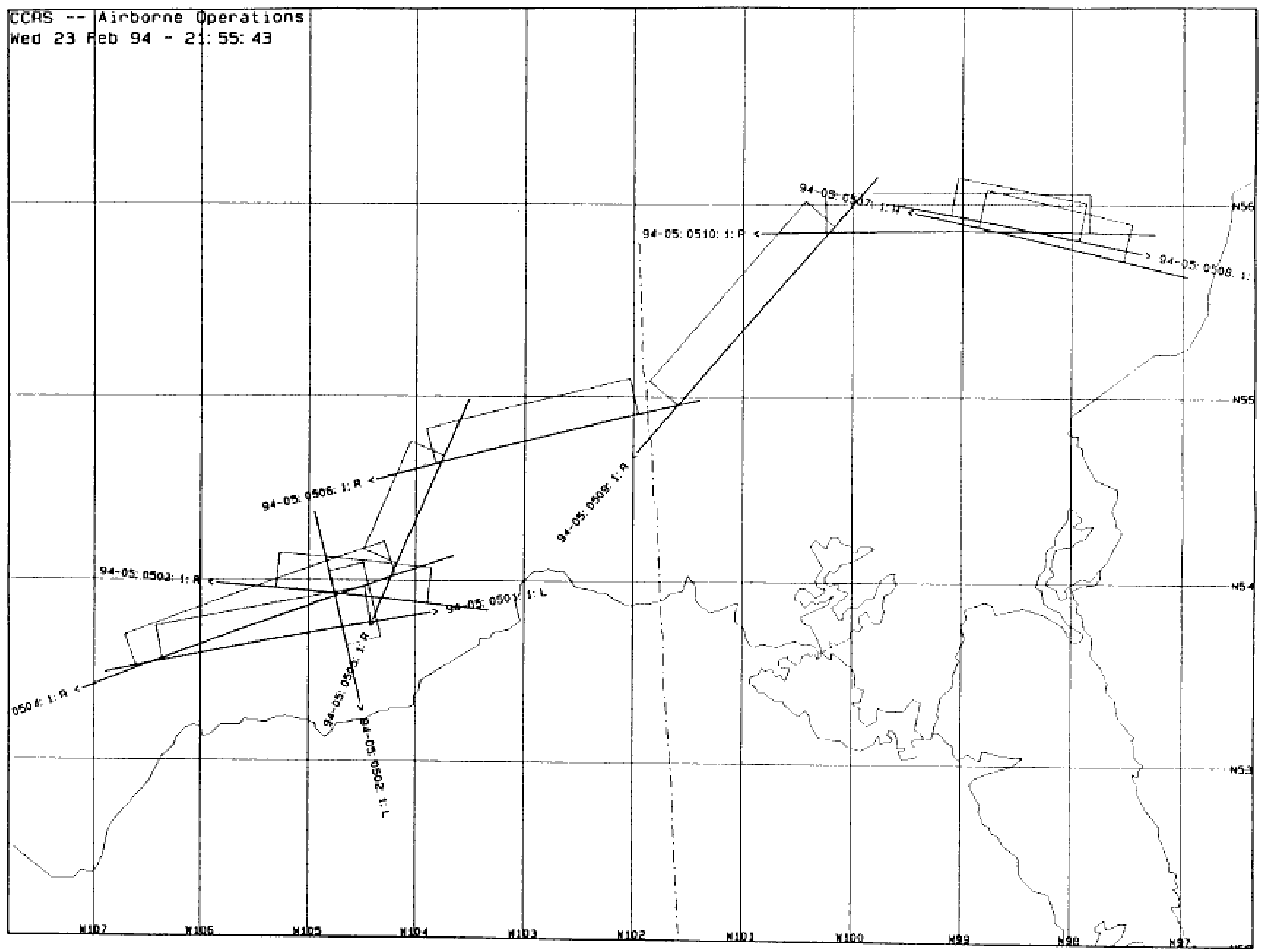


Figure 5.2.1.3.1b CV-580 AFM Transect (RV-RT) flight lines.

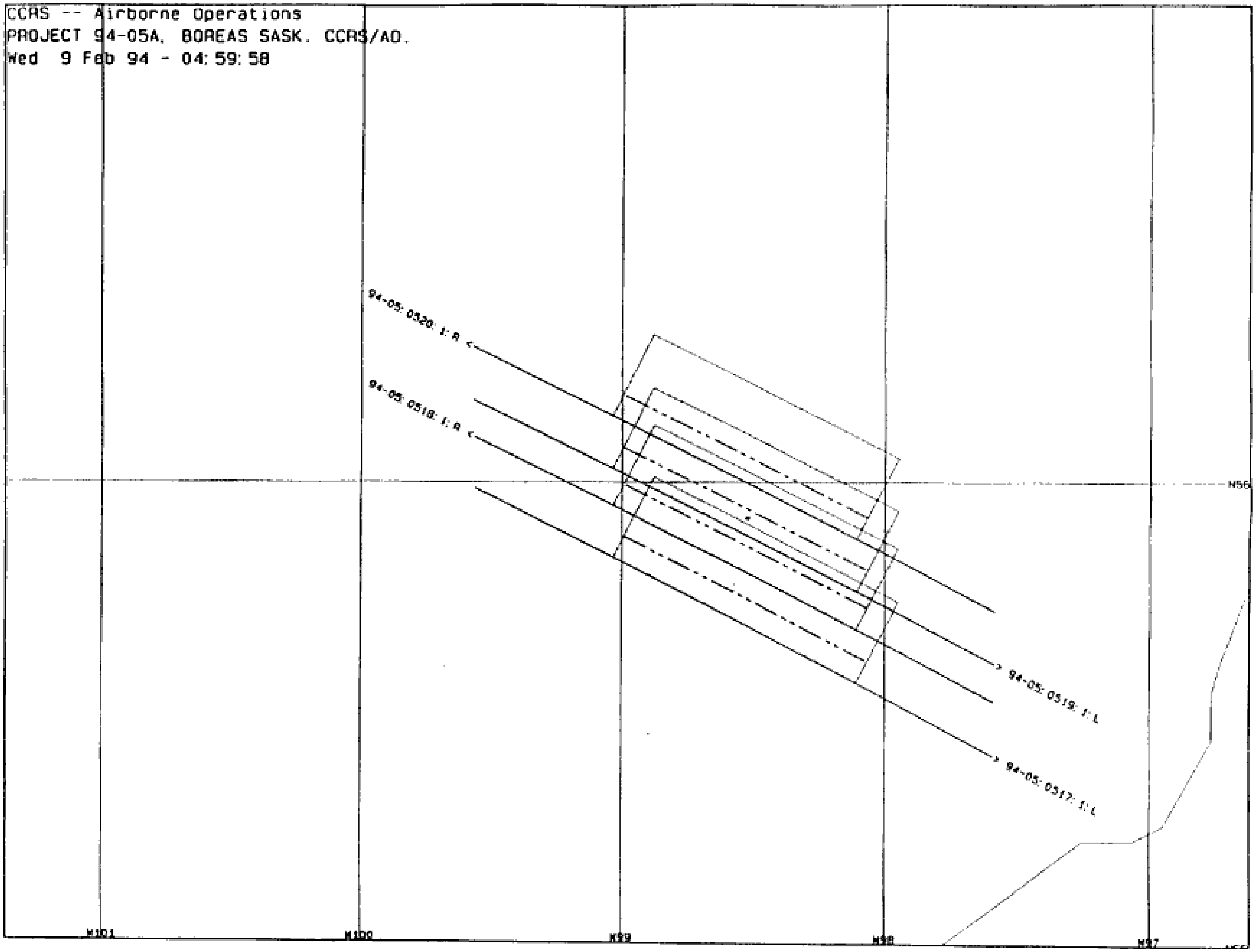


Figure 5.2.1.3.1c CV-580 NSA Baseline (RV-BN) flight lines.

5.2.1.4 DH-6 (RT)

Instruments: Passive microwave dual polarized radiometers at 18, 37 and 92Ghz, video camera, mounted for side viewing at 45º viewing angle. PRT-5 vertical viewing for surface temperature measurement when temperatures are within instrument range.

Mission Planning: Flights during FFC-W will be planned by the on-site Team members and air crews (HYD-4, HYD-2) on a day-to-day basis. Weather conditions and snowpack state in the morning will be used to make a go or no-go decision. Decisions on flying at the northern or southern site and in-between will be made based on weather, transit time and snowpack conditions.

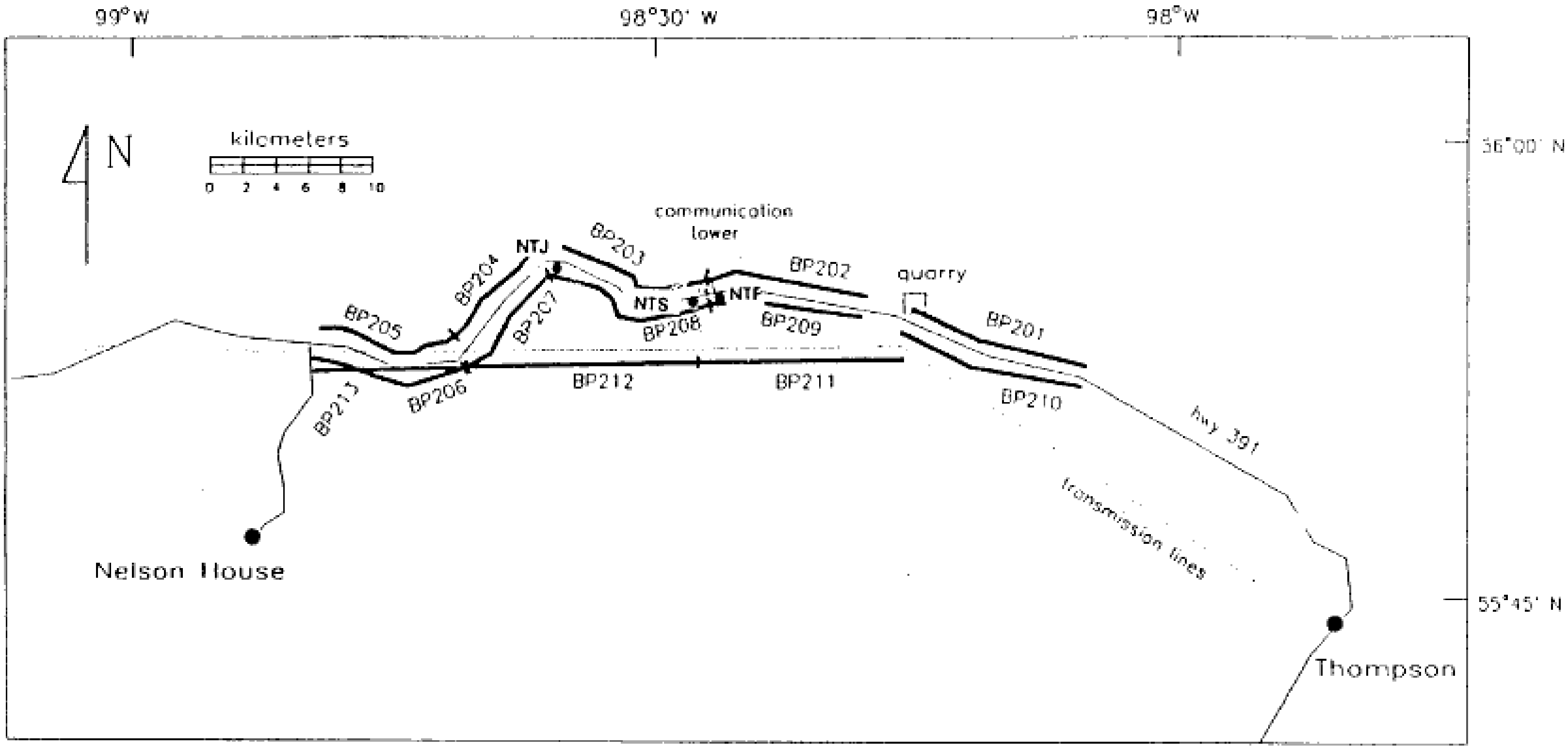
Microwave Radiometer:

1. Flights will be concurrent with Aerocommander (airborne gamma) and Chieftain (CASI); see Figures 5.2.1.4.
2. Flights will be conducted along pre-selected flight lines and some missions may involve flights at different altitudes. NASA's SSM/I Land products Working Team will advise on special experiment configurations.
3. Flights may be scheduled under a variety of sky conditions since all aircraft fly VFR and at low altitudes.
4. Co-ordination with ground crews is critical.

Mission Scenario:

1. Prepare instruments and pre-flight aircraft, check in with BOREAS operations office at Prince Albert airport 1 hour before take-off to finalize daily flight plan schedule in conjunction with Aerocommander and Chieftain..
2. Transit to sites and collect data.
3. Return to airfield to dump data and check-in with BOREAS Operations.

The flight lines on these maps are the same as those for which snow surveys are being collected during the winter using the Aerocommander airborne gamma radiation system and the Twin Otter Microwave System. SM measurements during the summer of 1994 will be collected using the Aerocommander airborne gamma radiation system for the outlined area on Figure 5.2.1.4c for the SSA, the 12 flight lines in the NSA (Figure 5.2.1.4a), and the 5 lines between the SSA and the NSA.



BOREAS - Core Snow Course locations, vicinity of Nelson House
(NTF=Fen, NTJ=mature Jack Pine, NTS=Black Spruce)

Figure 5.2.1.4a RA-SN and RT-SN: Flight Lines for Twin Otter (Microwave) and Aerocommander snow surveys at NSA. Note that the selected sites do not correspond to BOREAS TF sites.

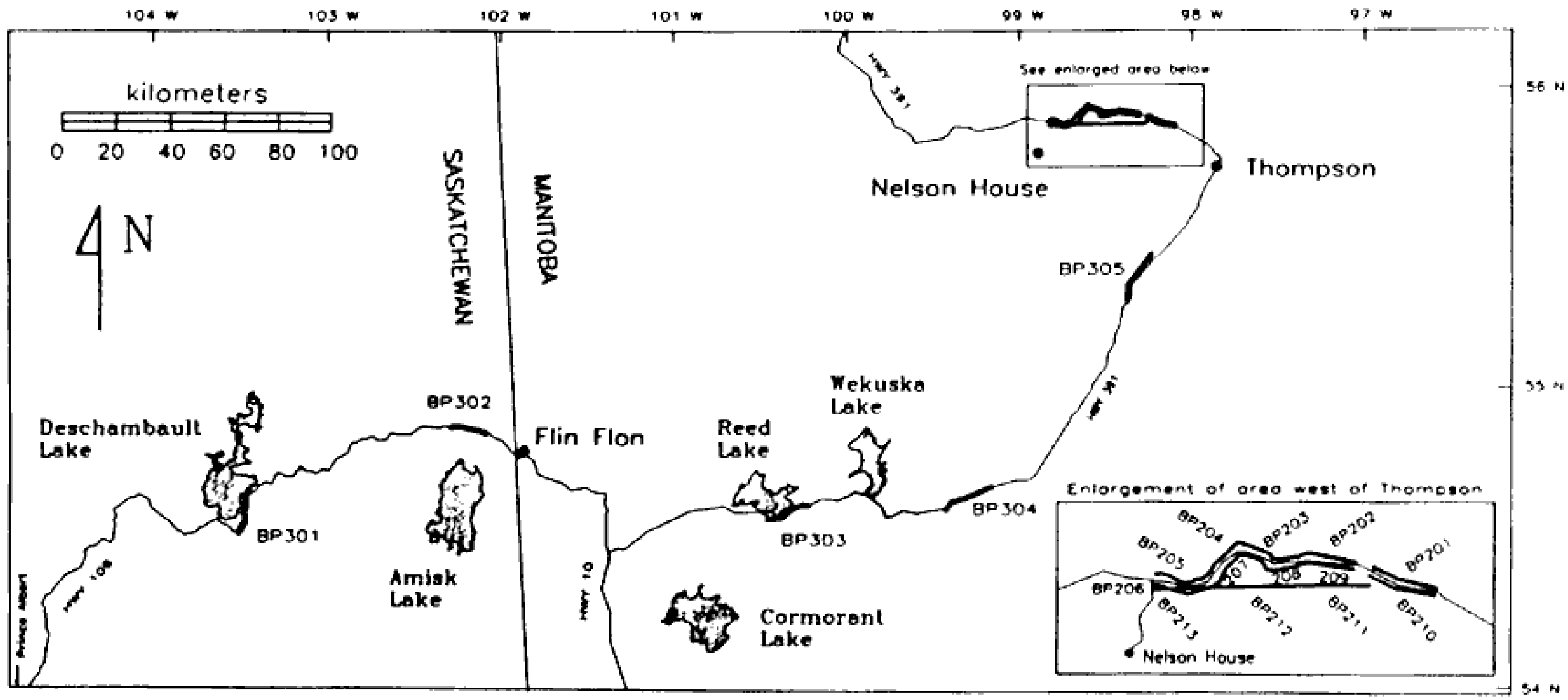
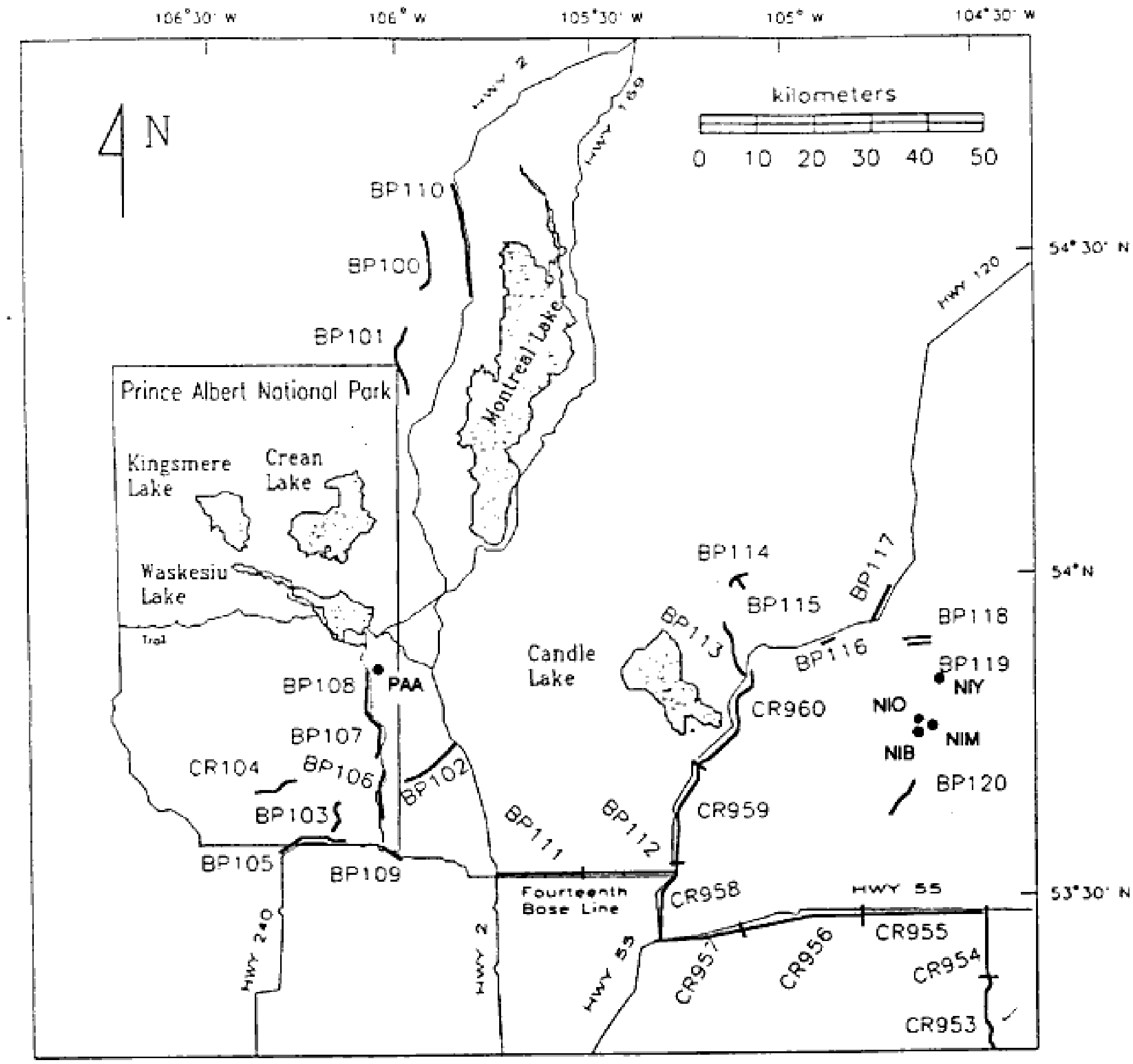


Figure 5.2.1.4b RA-ST, RA-WT and RT-ST: Flight Lines for Twin Otter (Microwave) and Aerocommander snow and soil moisture surveys between NSA and SSA.



BOREAS - Core Snow Course locations, vicinity of Prince Albert National Park
(PAA=Aspen, NIO=open regenerating, NIM=mature Jack Pine, NIY=young Jack Pine, NIB=Black Spruce)

Figure 5.2.1.4c RA-SS and RT-SS: Flight Lines for Twin Otter (Microwave) and Aerocommander Snow Survey at SSA

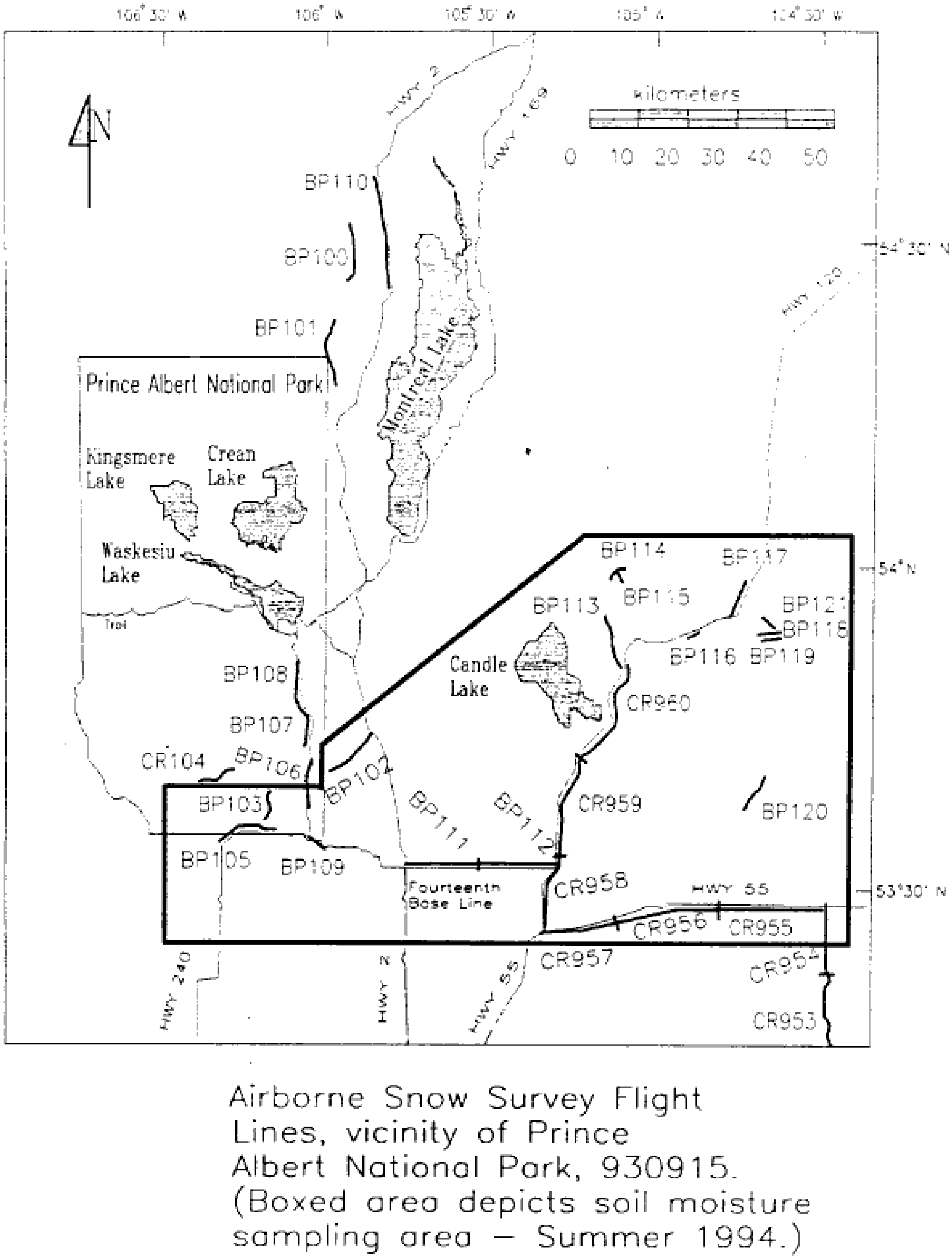


Figure 5.2.1.4d RA-WS: Flight Lines for Aerocommander soil moisture survey in SSA (in boxed area).

5.2.1.4.1 RT-SN: Snow Microwave, NSA
See Figures 5.2.1.4a.

5.2.1.4.2 RT-ST: Snow Microwave, Transect
See Figure 5.2.1.4b.

5.2.1.4.3 RT-SS: Snow Microwave, SSA
See Figure 5.2.1.4c.

5.2.1.5 <u>ER-2 (RE)</u>

<u>Objective:</u> Primary AVIRIS objectives are to provide fine spectral resolution reflectance data for forest cover assessment and canopy chemistry studies (RSS-4, RSS-9, RSS-19,TE-9). MAS data were collected in FFC-W and may also be collected in IFC-3.

<u>Instruments</u>: ER-2 supports the JPL AVIRIS, NASA/Ames AOCI and the GSFC MAS instruments. AOCI data (if available) will be used to investigate lake water quality (TE-15, RSS-12). MAS is a MODIS simulator and includes several optical reflectance thermal channels. These data will be used for energy budget and surface cover studies.

<u>Mission Planning:</u> A mosaic of AVIRIS scenes of both NSA and SSA and the transect in between will be acquired during FFC-T and once during either IFC-1, IFC-2 or IFC-3. The ER-2 crew will be in regular contact with the MM regarding mission scheduling and priorities.

5.2.1.5.1 RE-US: ER-2 MAS Snow Survey, SSA

The NASA ER-2 aircraft flew over Prince Albert National Park on 2/8/94. The flight line covered Glacier National park, Montana, and then PANP with a planned arrival time at approximately noon in order to begin flying the flight lines at the time of maximum sun elevation. A sketch map of the flight lines is shown in Figure 5.2.1.5.

The purpose of this flight was to acquire data in the visible, near-infrared and thermal infrared parts of the spectrum over snow-covered areas in the northern U.S. and in Saskatchewan in support of the MODIS Land Group BOREAS project. This will help us to determine which MODIS bands will be most useful for snow-mapping purposes, in varying terrain and lighting conditions. The snow flight will be of use in the development of a snow-mapping algorithm which will use MODIS data when it is launched in 1998.

DK Hall is planning to use the following MAS bands: 1, 2, 5, 6, 7, 9, 10, 14, 31 and 45.

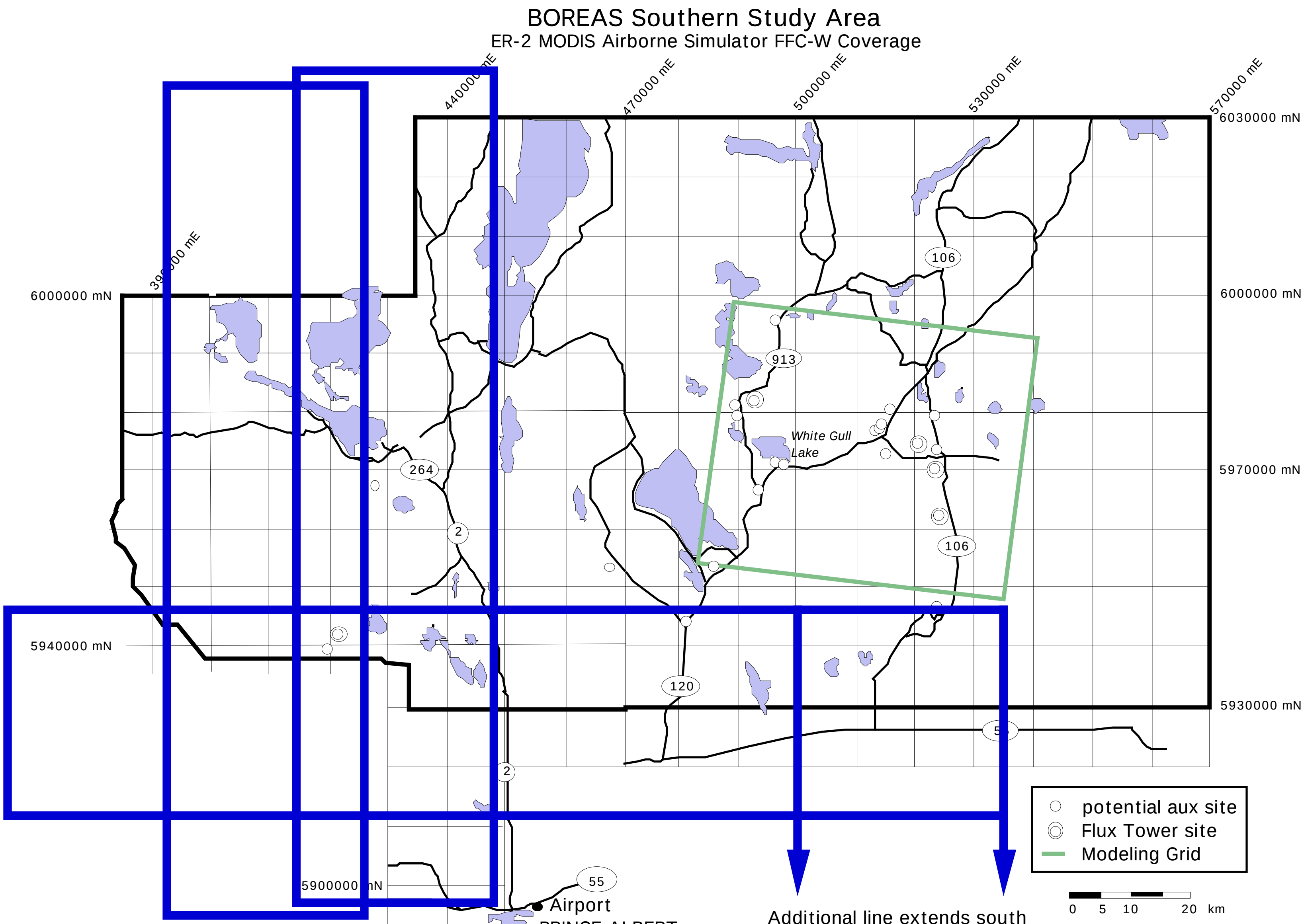


Figure 5.2.1.5.1: RE-US: ER-2 MAS Snow Survey in FFC-W, SSA

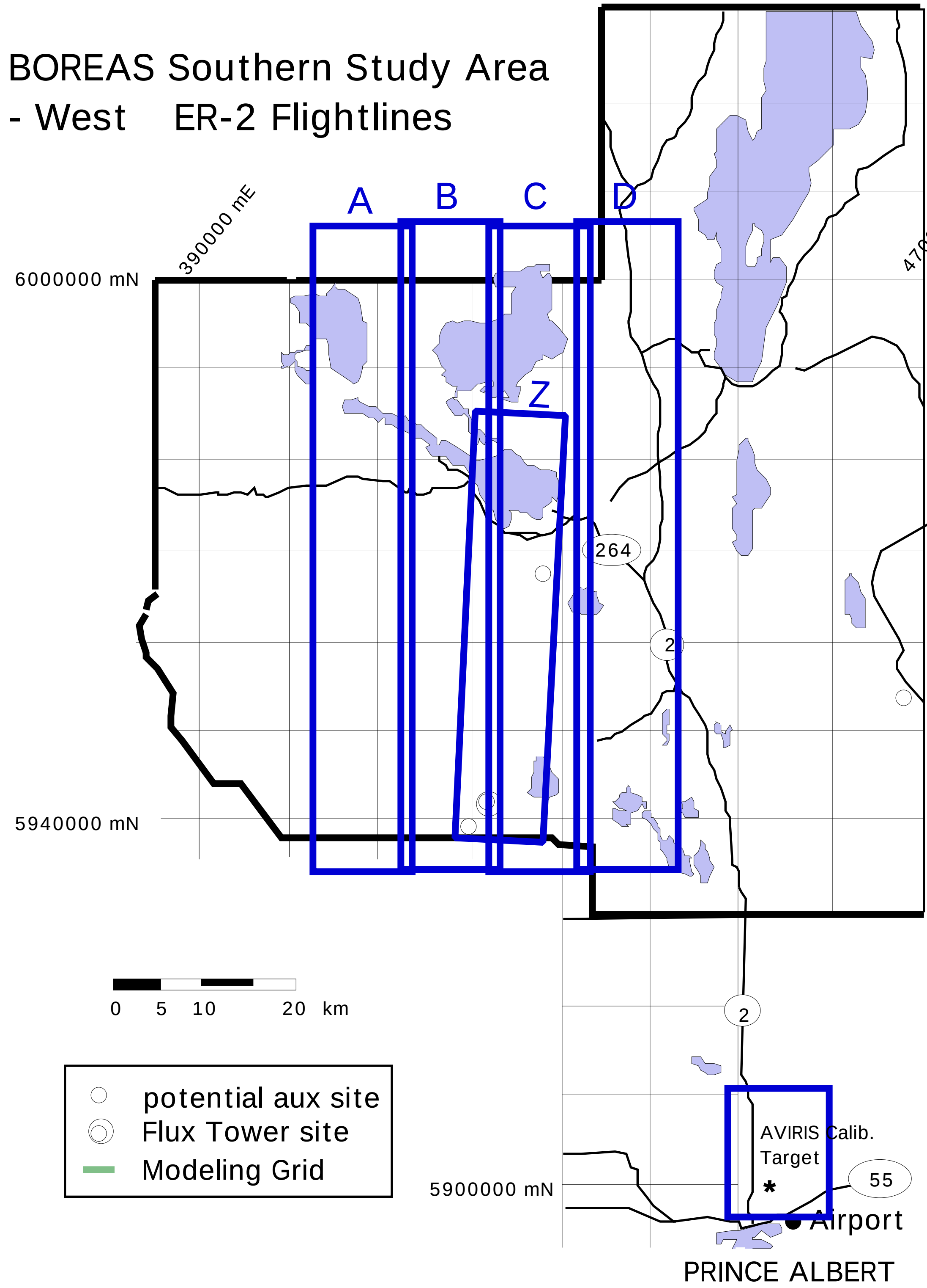


Figure 5.2.1.5.2a West SSA ER-2 AVIRIS flight lines (RE-SS, RE-MS, Davis)

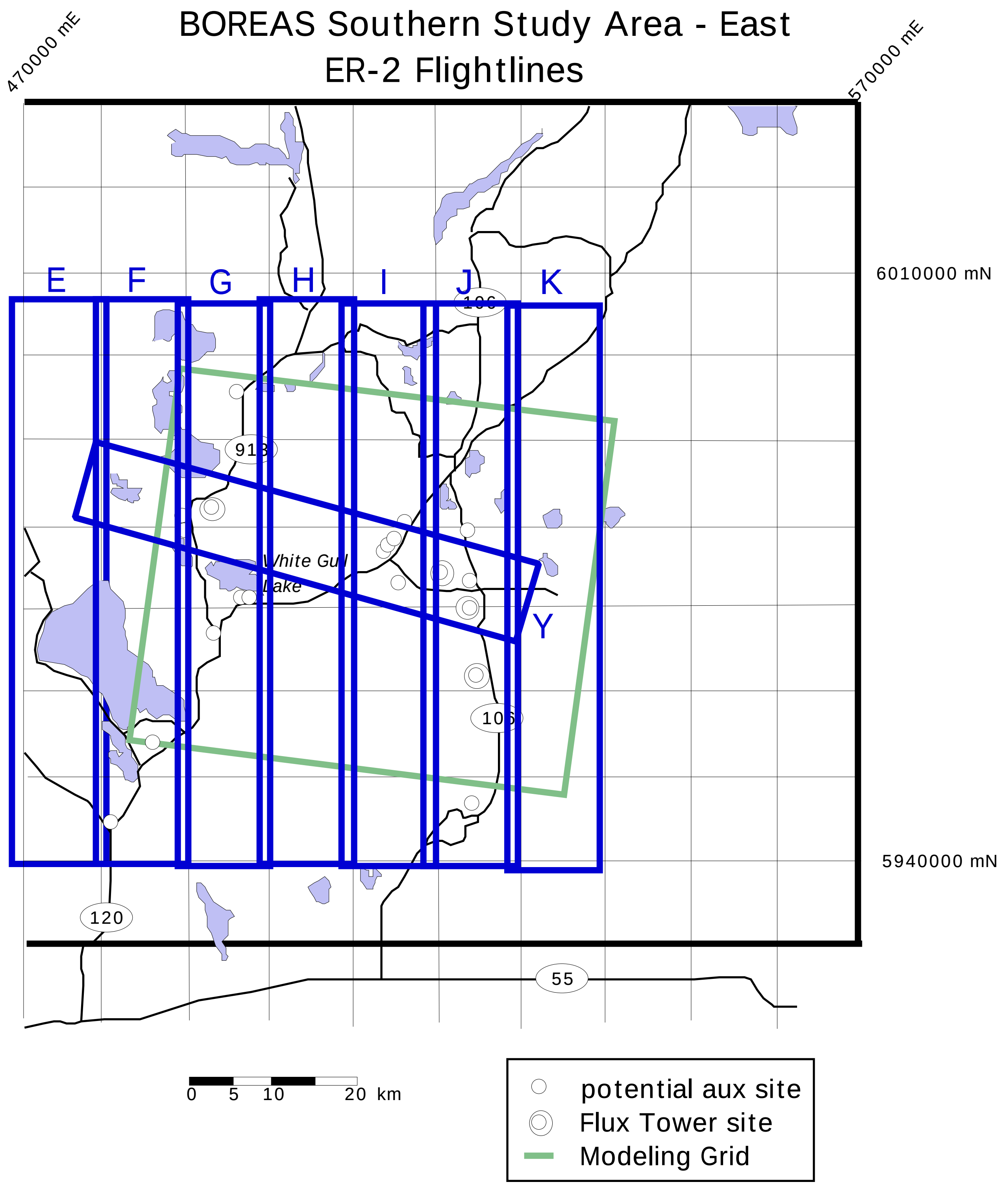


Figure 5.2.1.5.2b East SSA ER-2 AVIRIS flight lines (RE-SS, RE-MS, Davis)

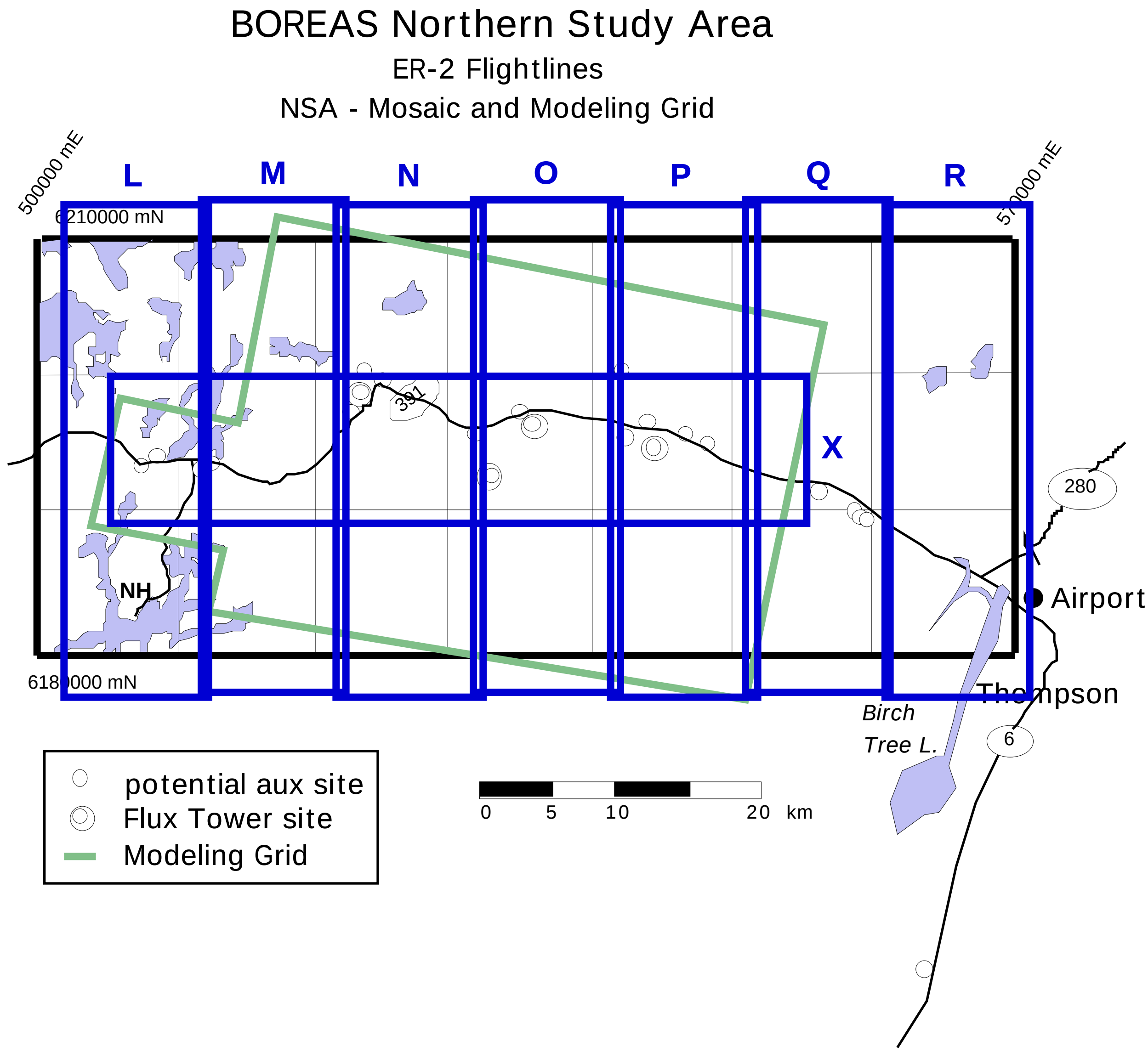


Figure 5.2.1.5.3 NSA ER-2 AVIRIS flight lines for NSA portion of RE-MN and RE-SN (Davis)

5.2.1.5.2 RE-MS: Mapping of SSA

Complete AVIRIS mosaic coverage of the east and west portions of the SSA is planned (See Figures 5.2.1.5.2a and b). At present overflights are planned for FFC-T (IFC-1 as backup) and IFC-2 (IFC-3 as backup). The areas will be flown in north-south strips. Flights are desired with a solar zenith angle of 45º or less.

5.2.1.5.3 RE-MN: Mapping of NSA, Transect

AVIRIS will be flown to get complete coverage of the NSA and portions of the transect (see RC-RT and Figure 5.2.1.5.3).

5.2.1.5.4 RE-SS: Snow over flights of SSA during single pass AVIRIS.
Two flight lines were requested by Bert Davis (HYD-3) to cover snow conditions early in FFC-T. Current scheduling allows coverage no earlier than April 14. A decision to fly these lines will be made prior to ER-2 deployment for FFC-T. The Davis flightlines will be covered under RE-SS.

5.2.1.5.5 RE-SN snow over flights of NSA during FFC-T.
Description similar to RE-SS. Davis flightlines to be covered under RE-SN.

5.2.1.6 Chieftain (RP)

Instruments: Compact Airborne Spectrographic Imager (CASI) equipped with upwelling and downwelling irradiance probes, track recovery monochrome video camera, GPS, pitch and and roll gyro.

Mission Planning: CASI missions flown during FFCs and IFCs will include (i) line image segments up to 20 km in length over auxiliary sites at both NSA and SSA, (ii) line image segments coinciding with snow gamma lines at NSA and SSA, along the transect between study areas, across lakes at SSA, and (iii) multi-altitude and multi-view frame images over flux towers sites, calibration sites, and selected auxiliary sites at both NSA and SSA. Flight planning will be done by designated on-site RSS-19 team leader in conjunction with Chieftain Mission Manager and the air crew. During FFC's, missions will be finalized with BOREAS Operations (evening meetings). During IFCs, plans are to be finalized by BOG, generally the evening before the planned mission. Weather conditions will be used for a go or no-go decisions, with clear sky conditions being the normal requirement but possible missions also under complete cloud cover with no precipitation. Similarily, weather conditions and forcast will be used to determine transect deployment.

Mission Scenario:

1. Pre-flight checks of instruments and aircraft, check-in with SAHQ one hour before scheduled take-off.

2. Transit to sites and collect data along pre-selected mission flight lines, and/or multi-altitude mission over specific study sites (e.g., flux towers and calibration sites). Altitudes will vary from 500 to 10,000 feet agl.

3. Flights may be scheduled under a variety of flight conditions since the aircraft will be flying VFR and will be in radio contact with SAHQ.

4. Return to airfield, check in with SAHQ, and then review airborne imagery and do data tape backups.

5.2.1.6.1 RP-TS: Tower/Auxiliary Sites, SSA

At SSA there will be data collections which focus on (i) Flux Tower Sites, (ii) Auxiliary Sites, (iii) Ground Calibration Sites, and (iv) Aquatic targets. These are described below.

(i) Flux Tower Sites will have data collections as follows:

(a) Multi-view BDRF Data - Hyperspectral mode
Multiview hyperspectral mode inagery (+45°, 30, 13, 0, -15, -30° view angles) over each tower site @ 5500 feet agl at 3 azimuths (i.e. in solar plane, perpendicular and at 45° azimuth to solar plane)
(Swath 800 m; pixels: 2 m x 10.7 m; 72 channels @ spectral resolution 7.8 nm).

(b) Canopy Biogeochemistry - Spectral mode
Hyperspectral model imagery in solar plane
  (i) nadir viewing @ 5500 feet: (Swath 1024 m, pixels: 2 m x 12.7 m).
  (ii) 45° viewing @ 3850 feet to maintain pixel size as above

(c) Site Mapping: LAI, closure, etc - Spatial mode
Spatial mode imagery (15 spectral channels), heading true north, viewing nadir - within 2 hours of solar noon.
  (i) single pass @ 5500 feet agl directly over tower.
  (ii) three passes @ 2000 feet agl: directly over tower, displaced 300 m to east of tower to provide anti-WAB coverage, and displaced 300 m to west of tower to provide WAB coverage (Swath: 370 m; pixels: 0.7 m x 3.1 m).

(d) Direct PAR and Albedo - Hyperspectral mode

Hyperspectral imagery, nadir viewing, directly over tower site in solar plane @ 500 feet. (Swath: 93 m; pixels: 0;18 x 9.5 m)

(ii) Auxiliary sites will be provided with image coverage as follows: as time permits:

(a) Site Mapping - Spatial Mode
-15 channel imagery over each auxiliary site (including Flin Flon sites) @ 5500 feet - Category II Auxiliary sites have first priority (Swath 1024 m; pixels: 2 m x 4.4 m) with Category III sites added as time permits for IFCs.

(b) Limited Multi-view BDRF Data - Hyperspectral mode
For Category II Auxiliary sites hyperspectral mode imagery @ 5500 feet in the solar plane in nadir and at +45˚, -30˚ (Swath 800 m, pixels: 2 m x 11.4 m).

(iii) Ground Calibration Sites selected by mutual agreement by the BOREAS optical sensor investigators which will be characterized through ground measurements, and will be imaged by various optical sensors including CASI. For each such site the following data collection will be carried out:

(a) Site Mapping - Spatial Mode
Spatial mode imagery (15 spectral channels) in solar plane @ 2000 feet agl (Swath: 370 m; pixels: 0.7 m x 3.1 m)

(b) Multi-view BDRF Data - Hyperspectral mode
Multiview hyperspectral mode imagery (+45˚, 30, 15, 0, -15, -30˚ view angles) over each calibration site @ 5500 feet agl at 3 solar azimuths (i.e. in solar plane, perpendicular and at 45˚ azimuth to solar plane) (Swath 800 m; pixels: 2 m x 10.7 m; 72 channels @ spectral resolution 7.8 nm).

(iv) Aquatic Targets at the SSA to be imaged in the hyperspectral mode during all IFCs include two transectrs over Waskesiu Lake (25 to 29 km in length) and two transects of Crean Lake (24 and 27 km).

5.2.1.6.2 RP-TN: Tower/Auxiliary Sites, NSA

The image data collection for NSA follows that described for RP-TS, with the exception of the aquatic targets, which in this case will be instrumented beaver ponds specified by TGB-4.

5.2.1.6.3 RP-SS Snow Lines, SSA

CASI optical spatial mode imagery to be collected over the SSA snow course lines surveyed at ground level by HYD-4 and from the air with the Twin Otter (Microwave HYD-2) and the Aerocommander Gamma sensor. The lines are shown in Figures 5.2.1.4c and d.

5.2.1.6.4 RP-SN Snow Lines, NSA

CASI optical spatial mode imagery to be collected over the NSA snow course lines surveyed at ground level by HYD-4 and from the air with the Twin Otter (Microwave HYD-2) and the Aerocommander Gamma sensor during FFC-W and FFC-T. The lines are shown in Figure 5.2.1.4a.

5.2.1.6.5 RP-RT: Coverage of regional transect

Image data collection on the remote sensing modified Rx-RT transect AR-HR-KR-LR-MR-OR (same as Figure 5.2.1.1.4) will be as follows:
Priority 1: Spatial Model, nadir-viewing @ 8000 feet agl. (Swath 1500 m; pixels: 2.9 m x 5.1 m)
Priority 2: Hyperspectral model nadir imagery @ 8,000 feet (Swath 1160 m; pixels: 2.9 m x 11.7 m).

5.2.1.7 DC-3 (RF)

Instrument: MEIS II (Multi-detector Electro-optical Imaging Scanner).

Mission Period: IFC-2: 4 days at SSA and 3 days at NSA (The exact dates will be coordinated with CASI and ASAS flights). The total on-site flying time is 7-10 hours (exclusive or transect).

Targets: OJP, YJP, OBS and OA tower flux sites at SSA. OJP, YJP and OBS tower flux sites at NSA.

Secondary Targets: Auxiliary sites along flight lines.

Transect: 5 km/target in the southeast direction. The image swath and length are shown in Figure 5.2.1.7.

Flying Heights: 540m and 12000 feet for resolutions of 0.4m and 2.7m, respectively.

Priority Time Window: 0900-1200 Local Time. If weather is not favorable, other time windows will be used.

5.2.1.7.1 RF-TS: TF sites in SSA.

See Figure 5.2.1.7.

5.2.1.7.2 RF-TN: TF sites in NSA.

See Figure 5.2.1.7.

5.2.1.8 Aerocommander (RA)

Instruments: Operational airborne gamma system of NWS including video camera.

Mission Planning: Snow survey flights during FFC-W were planned by the on-site HYD-4 Team members and air crews. Weather conditions and snowpack state in the morning were used to make a go or no-go decision. Decisions on flying at the northern or southern site and in-between were made by the Team and flight crew based on weather, transit time and snowpack conditions.

Soil moisture flights during IFC-2 and IFC-3 will be planned by the on-site Team members and air crews, finalized by BOG the evening before the planned mision. Plans are to conduct flights over the SSA during IFC-2 and IFC-3 and over the NSA during IFC-2. Weather conditions and flight plans for other aircraft will be used to make a go or no-go decision or determining the time the Aercommander flights will be conducted. Decisions on flying at the SSA site and in-between will be made by the Team and air crew, in cooperation with BOG, based on weather, location of the Aerocommander, transit time and requirements for calibration of the flight lines.

Two days of flying, dependent upon the weather, will be scheduled for the NSA. Plan A is to fly in the NSA just before the scheduled start for airborne and ground surveys on 7/27/94 for IFC-2 in the SSA. Plan B would do the NSA flights just before the scheduled flying and ground surveys on 8/30/94 in the SSA for IFC-3, and Plan C will be to do the NSA flight lines immediately following the ending of the IFC-3 surveys on 9/9/94.

Mission Scenario:

1. Prepare instruments and pre-flight aircraft, check in with BOREAS Ops, 1 hour before takeoff, depending on location of Aerocommander and team.
2. Transit to flight lines and collect data.
3. Return to airfield, dump data and check-in with SAHQ .

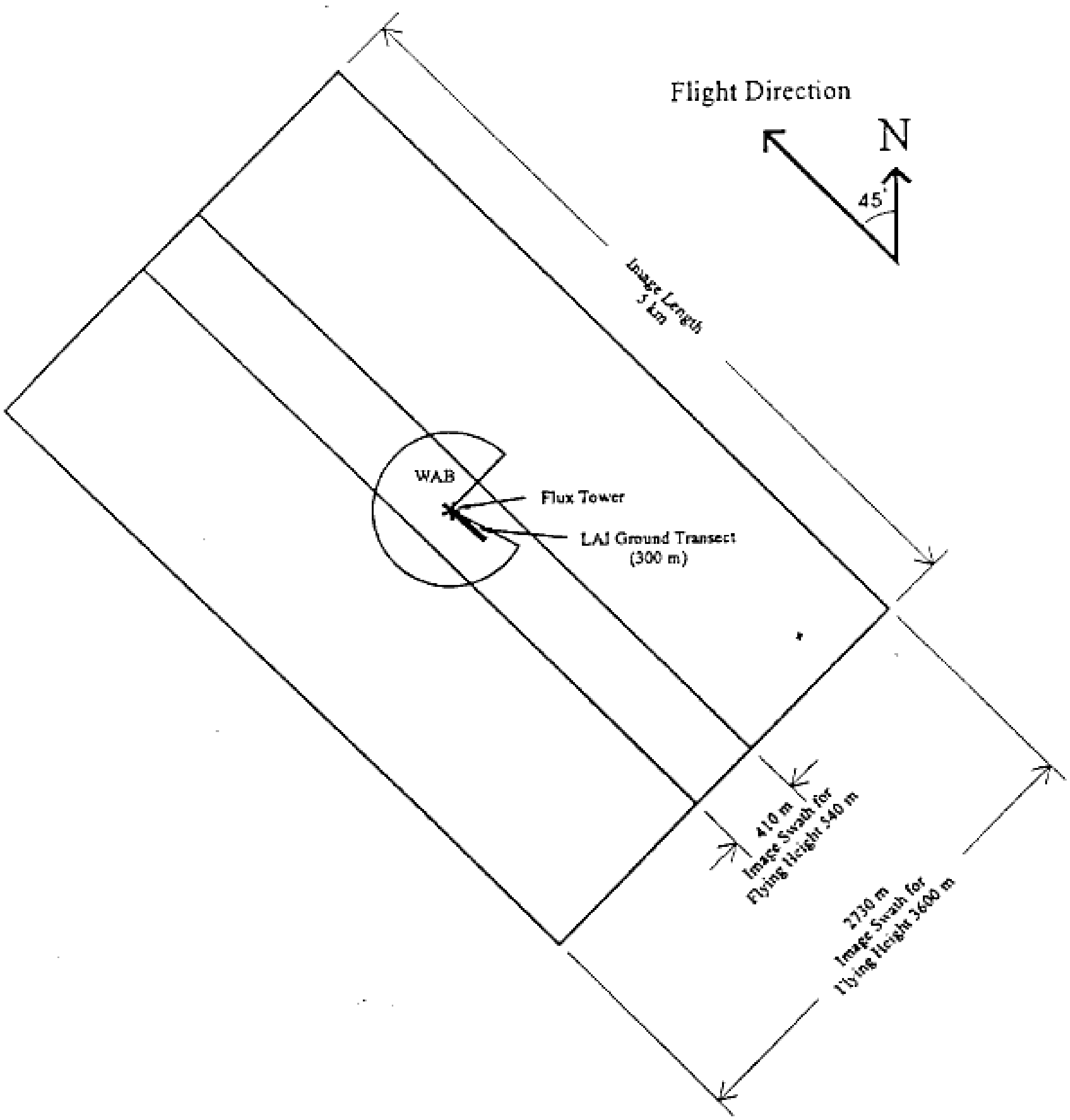


Figure 5.2.1.7 RF-TS, RF-TN: Airborne MEIS II Data Acquisition Flight Plan for Each Tower Flux Site in both the SSA and NSA. Targets: OJP, YJP, OBS and OA tower flux sites at SSA. OJP, YJP and OBS tower flux sites at NSA.

5.2.1.8.1 RA-SN: Snow Survey, NSA

See Figure 5.2.1.4a

5.2.1.8.2 RA-ST: Snow Survey, Transect

See Figure 5.2.1.4b

5.2.1.8.3: RA-SS: Snow Survey, SSA

See Figure 5.2.1.4c

5.2.1.8.4 RA-WT: Soil Moisture Survey, Transect

See Figure 5.2.1.4b

5.2.1.8.5 RA-WS: Soil Moisture Survey, SSA

See Figure 5.2.1.4d

5.2.1.9 NASA Helicopter (RH)

Instruments:

Passive Optical System: SE-590 spectroradiometer with VIS/NIR and SWIR detectors, 8 channel Modular Multiband Radiometer (MMR), IRT, video camera, sun tracking photometer, POLDER, downward-looking PAR sensor, downward-looking pyranometer, 70mm photographic camera loaded with CIR film.

Microwave System: L, C, X bands, video camera

Other: Aircraft radar altimeter, barometric pressure at altitude, outside air temperature, GPS.

Mission Planning and Execution:

Flights will be planned with the SSG the night before based on the weather forecast. The target sites are prioritized as per the scheme described in section 3.2.4.4 and as displayed in figure 5.5.5. Category I sites (mainly TF WABs) are highest priority; Category II sites (intensive ecological studies) are next and Category III sites (RSS targets) are last. Weather updates early in the morning of the flights will be checked with aircrews at the airfield one hour before scheduled take-off. Crews will remain on standby until a general go/no-go decision for the experiment airborne component is reached if the weather is questionable.

Nadir data will be collected by hovering over the WABs (Figure 5.2.1.9a). Off-nadir measurements will be made in the principal plane with all measurements adjusted to the characteristics of each WAB as illlustrated by the figures in Section 4.2.3. Measurements will also be made over the sampling areas out of the WABs. Hovers over tower sites are to take place when flux measurements are not being made and/or to begin just after the hour or half-hour to minimize contamination of surface measurements with engine exhaust and main rotor wash. Note that during a hover the nose of the helicopter is always pointed into the direction of the wind and that this and the solar azimuth angle will determine the location of the helicopter during off-nadir measurements. Secondary sites will also be visited for off-nadir data collection when time allows. Identification of specific sub-sites and auxiliary sites will be by some form of flagging in the upper canopy, or via position relative to easily identifiable landscape features, or by a navigational system such as GPS.

The 70mm camera is to be used to acquire stereo photographic coverage of specific sites. This is to be coordinated with Paul Rich (TE-23). PAR and pyranometer measurements will be made coincident with surface and tower-based remote sensing measurements.

Microwave missions will be flown under sky conditions not suitable for optical missions. Sites to be measured will follow the priority of sites used for optical missions emphasizing Category I and Category II sites. Data will be taken over Category III auxiliary sites where intensive canopy architecture and soil moisture measurements are being made. Some DC-8 flight lines will be used as guides over specific sites. Slow flight transects will be flown for these measurements at five different view zenith angles (Figure 5.2.1.9b). Air speed will be between 20 KPH and 40 KPH. Transect locations will be determined via discussions with site captains and the SSG avoiding WABs and other sensitive areas located on WAB diagrams in section 4.2.3 of the Experiment Plan. Altitude will be determined by the height of the vegetation canopy, atmospheric conditions, the expected magnitude of the impact of main rotor wash on the canopy and surface-based measurements, and safety limits for the aircraft. At the present time an altitude of 30m AGL is considered desirable. We will request a clearance/go-ahead from the surface crews via BOREAS Ops before actually making these measurements.

At the SSA, the helicopter will operate off of a grassy area next to Snodrifters Lodge near Candle Lake. Fuel drums will be delivered to this site as needed. We will transit to Prince Albert Airport for instrument calibration measurements and for possible basing for missions to sites in the southwestern area of the SSA. At the NSA, the helicopter will operate out of Keewatin Air at the Thompson Airport.

Missions are:

RT-TS or RH-TN: Daytime flight using optical systems (SE-590, IRT, video cameras, sun tracking photometer, pyranometer, PAR sensor and photographic camera and POLDER) over tower (TF) sites and/or auxiliary sites (S=SSA, N=NSA)

RH-BS or RH-BN: Daytime flight using Microwave Systems (L,C,X bands, video camera).

These missions are explained in detail in the subsections below.

5.2.1.9.1 RH-TS or RH-TN: Passive Optical Mission (3 hours)

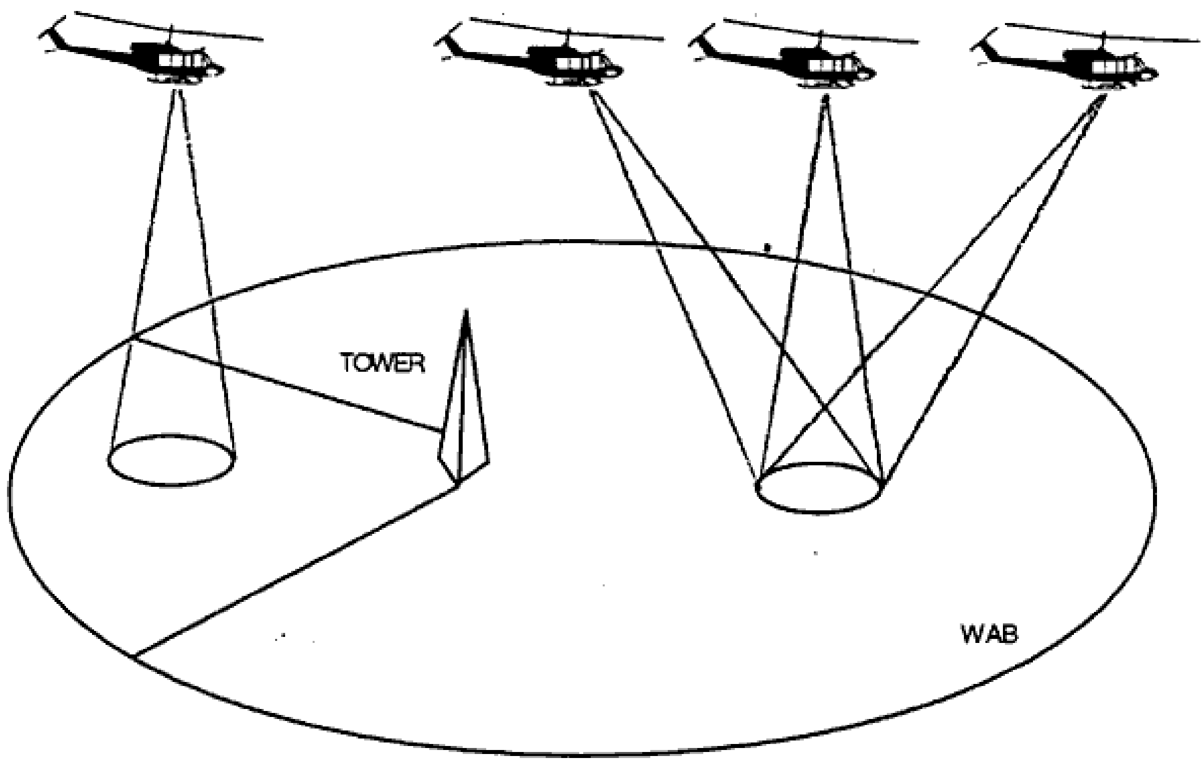


Figure 5.2.1.9a Sampling scheme for optical helo missions (RH-TN, RH-TS). Note that the distance from the tower will be determined by the altitude and the effects of rotor wash. Also note that measurements will be made over the WAB and in areas outside the WAB. Measurements of auxiliary sites will be over areas identified and marked by auxiliary site teams.

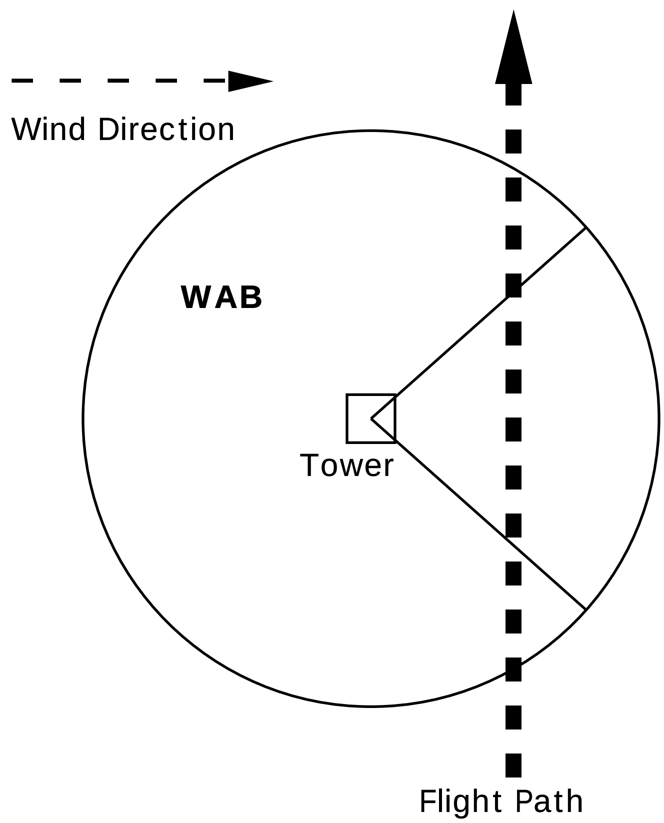


Figure 5.2.1.9b Scatterometer flight path over a tower site (RH-BN, RH-BS). Note that these flights will be flown at very low altitudes and will not require any hovering during data collection.

Objectives:

(i) Collect nadir and off-nadir data over as many sites (Categories I, II, III) as possible. Targets are for specific stands in the WAB.
(ii) Collect multialtitude nadir data over highest priority sites (Category I).
(iii) Coordinate PAR and pyranometer measurements with surface teams.

Mission Planning:

(i) Consult with BOG and surface teams on projected plans at the evening meeting before the mission day. Communicate status of site coverage for the current IFC. Get weather briefing.
(ii) Decide on mission-specific priorities. Coordinate with surface teams and other aircraft. Make sure surface-based sun photometers will be operating.
(iii) Get weather updates early in the morning of the flights for go/no-go decision. Aircrews will be at the airfield one hour before scheduled take-off and will be in contact with SAHQ.

Execution:

(i) Prepare instruments (pre-heat thermal control box) and pre-flight aircraft, check-in with BOREAS operations office before takeoff. (1-Hour)
(ii) While sitting still on the runway or hovering close to the ground, make initial sun photometer readings (5 min.)
(iii) Contact SAHQ for status of other aircraft and status of surface-based researchers
(iv) Fly to transit altitude making sun photometer measurements during ascent.
(v) Transit to sites, notify SAHQ of location prior to data collection. Fly WABs in slow flight transects for nadir data. Hover and collect off-nadir data. Ascend to higher altitudes for multialtitude data collection. Hover for sun photometer measurements if necessary. Total air time for data collection: 2 hours.
(vi) Depending on available fuel and sky conditions, contact BOREAS Ops and return to airfield or land on-site for refueling. Before shutting down the systems, make sun photometer measurements while sitting on the ground or hovering just above the surface. (30+ min. if refueling on-site).
(vii) Following return to airfield, dump all data loggers and contact SAHQ.
(viii) Perform in-field calibration checks on instruments or dismount instruments for transportation to calibration site.

5.2.1.9.2 RH-BS or RH-BN: Microwave Scatterometer Data Collection (3 hours)

Objectives:

(i) Collect scatterometer data over Category I and II sites where intensive canopy architecture and soil moisture measurements are being made.
(ii) Fly slow flight transects with air speed between 20 KPH and 40 KPH. Five view angles will be flown over each transect. Fly as low as possible.
(iii) Weather permitting, collect coincident passive optical data.

Planning:

(i) Consult with BOG and surface teams on projected plans at the evening meeting before the mission day. Communicate status of site coverage for the current IFC. Get weather briefing.
(ii) Decide on mission-specific priorities. Coordinate with surface teams and other aircraft. Decide on altitude based on the height of the vegetation canopy, atmospheric conditions, Canadian air space regulations, locations of surface-based measurement teams and safety limits for the aircraft. .
(iii) Get weather updates early in the morning of the flights for go/no-go decision. Air crews will be at the airfield one hour before scheduled take-off. Crews will remain on standby until a general go/no-go decision for the experiment airborne component is reached if the weather is questionable.

Execution:

(i) Prepare instruments and pre-flight aircraft, check-in with SAHQ before takeoff. (1 Hour)
(ii) Communicate with SAHQ. Transit to sites and collect data, notifying operations center with each move to a new site. (2+ Hours).
(iii) Communicate with SAHQ. Return to airfield to refuel or land on-site to refuel and continue data collection if necessary (30+ min. if landing on-site).
(iv) Following return to airfield, dump data loggers, contact SAHQ .

5.2.1.10 Flight Plans for Flux Aircraft Operations in 1994 IFCs

The flux aircraft missions for BOREAS have been broken down into several "generic" groups, with one or more specific flight designs per group. The groups and their abbreviations are listed in Table 5.2.1.10a:

Table 5.2.1.10a Abbreviations for Flux Missions

Abbreviation	Mission Summary	Section
CS	Candle Lake runs	5.2.1.10.1
TS,N	Site-specific, multiple passes with relatively short runs, generally over TF sites	5.2.1.10.2
RT	Electra transects (SSA-NSA and beyond)	5.2.1.10.3
LS,N	Mini- or Meso-transects, covering greater variety at surface than TS,N	5.2.1.10.4
GS,N	Grids and stacks, together or separately PS,N - Budget box pattern	5.2.1.10.5
PS,N	Budget Box Pattern	5.2.1.10.6
HS,N	Stacks and Tees	5.2.1.10.7
FS,N	Flights-of-two (formation flights for intercomparisons)	5.2.1.10.8
ZS	Low-level routes (SSA)	5.2.1.10.9

These missions are described in detail in sections 5.2.1.10.1 through 5.2.1.10.9. The following points apply to all the missions.

Mission duration: In the flight plans, the airspeeds shown in Table 5.2.1.10b have been used to estimate the times required for flying each pattern. These times are for the patterns themselves, and do not include the ferry/transit times.

Table 5.2.1.10b Flux aircraft airspeeds

Abbrev.	Aircraft	m/s	km/h
FL	LongEZ	50	180
FT	Twin Otter	60	216
FK	King Air 90	90	324
FE	Electra 100	100	360

Soundings: Soundings by individual aircraft may be added to or included in many of the flight patterns described here. For example, soundings are needed just prior to patterns BB, GS, and ST in order to choose flight levels. The soundings will typically extend from near the surface to above the boundary layer, e.g., from 50 m to 2000+ m agl.

Time-centered patterns: Several of the patterns described (PS,N; GS,N) refer to "time-centered" sequencing. For example, if the pattern includes horizontal passes at three sequential altitudes 1, 2, and 3, then a time-centered flight would be 1-2-3-3-2-1 or 3-2-1-1-2-3. This allows removal of first-order changes with time in post-flight processing, with equal sampling at each level. For application examples, see Betts et al., 1990, Bound. Layer Meteor., 50, 109-137.

Waypoints: In many of the patterns waypoints will be given as letters, rather than with fully listed latitudes and longitudes, to avoid unnecessary repetition and to ease the task of editing and correction as the patterns evolve in the field, see Table 5.2.1.10c.

Table 5.2.1.10c Flux Aircraft Waypoint Menu

Pt.	Lat.	Long.
A	53d32.0'	106d34.0'
C	53d37.8"	-106d11.4' (same as PANP-OA)
G	53d55.6'	-104d59.7'
H	54d07.0'	-104d13.5'
K	54d41.7'	-103d47.5'
L	54d57.3'	-101d58.0'
M	55d54.8'	-99d07.5'
O	55d53.2'	-98d00.0'
P	60d30.0'	98d00.0'
Q	60d30.0'	-95d30.0'
R	59d00.0'	-95d30.0'
CH	58d44.5'	-94d04.0' (Churchill airport)
a	53d34.7'	-106d23.8'
b	53d42.8'	-105d52.0'
c	53d55.0'	-105d04.0'
d	53d59.0'	-104d47.2'
f	53d59.8'	-104d43.5'
g	53d32.0'	-104d27.6'
h	53d56.8'	-105d20.5'
i	54d03.7'	-104d45.5'
j	53d43.8'	-104d34.0'
k	53d35.8'	-106d18.0'
m	54d05.2'	-104d50.5'
n	53d32.2'	-104d19.5'
s	53d17.0'	-105d43.0'
t	53d38.0'	-105d43.0'
u	53d17.0'	-105d32.0'
v	53d43.0'	-105d17.0'

Coordinates used for the TF sites in preparing the aircraft paths and waypoints were:

N/S	Site	Lat.	Long.
N	OJP	55d55.8'	-98d37.2'
N	OBS	55d52.8'	-98d28.8'
N	Fen	55d55.2'	-98d25.2'
N	YJP	55d54.0'	-98d17.4'
S	OA	53d37.8'	-106d11.4'
S	BS	53d59.4'	-105d07.2'
S	Fen	53d48.0'	-104d37.2'
S	OJP	53d55.2'	-104d41.4'
S	YJP	53d52.8'	-104d39.0'

Other locations:

NOAA radar 55d56'02" -98d36'47" (55d56.0', -98d36.8')
NOAA SSA 53d55.2' -104d40.2'
profiler
NOAA lidar 54d00.0' -104d39.5' (very approximate location--(tentative) within 1 km)

5.2.1.10.1 Fx-CS: Candle Lake Runs

Objectives:
The mission profiles are shown in figure 5.2.1.10.1. This path is based on one used by the Twin Otter (FT) in 1993 and has promise as an SSA-scale transect which covers a variety of surface characteristics. Repeating the path at various altitudes and through all three IFCs can then serve as a baseline data set for assessing seasonal changes, diurnal changes, etc. The path is included in several of the specific flight patterns, with the intent that it serve the additional purpose of helping tie the different aircraft platforms and different aircraft flight patterns together for purposes of analysis.

General:
Preferred weather is clear conditions, or at least late morning prior to ABL cloud development. It needs to be covered by the C-130 at least once per IFC. Endpoints for the run could be either b-c, or extended to a-d (to cover a significant portion of aspen and black spruce). Pass a-d goes directly over the SSA-OA TF site.

Time estimates per round trip (hours) are shown in Table 5.2.1.10.1.

Table 5.2.1.10.1 Time Estimates for CS Round Trips

Endpoints	LongEZ	Twin Otter	KingAir
a-d	0.7	0.6	0.4
b-c	1.4	1.2	0.8

Specific patterns:

CS-1:
Single aircraft, probably with repeated passes at one or more altitudes, e.g., FL, FT, FK at 20, 50, and 50-100 m, respectively.

CS-2:
Joint FT+FL mission. Coordinated flight at two pre-selected altitudes, with repeated passes. For example, with FT at 100 m and FL at 20 m.

CS-3:
Joint FL+FT+FK coordinated flight with three aircraft at three preselected altitudes and with repeated passes. For example, with FL, FT, and FK at 20, 100, and 500 m, respectively.

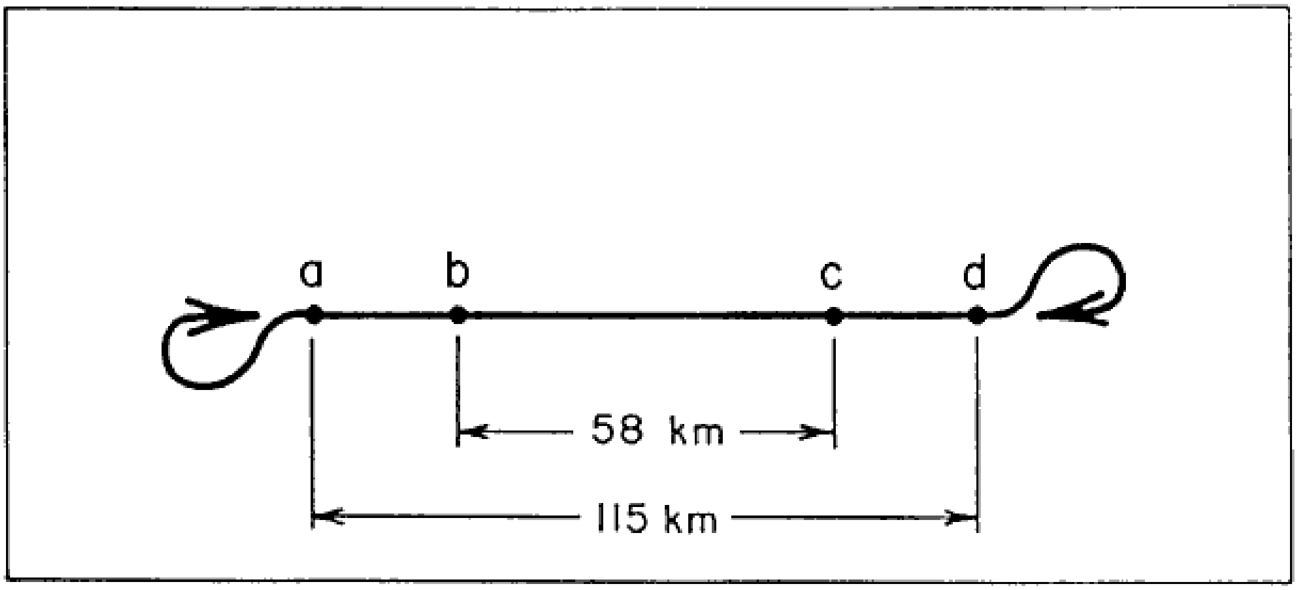


Figure 5.2.1.10.1: Fx-CS: Flux aircraft Candle Lake Runs

5.2.1.10.2 Fx-TS, Fx-TN: Site-Specific, Short Passes

Objectives:
Mission profiles are shown in Figures 5.2.1.10.2a and 5.2.1.10.2b. Compare aircraft and tower measurements, with aircraft coverage limited to homogeneous area surrounding and representative of the TF site. Obviously this may restrict application to a subset of the TF sites. Footprint studies under varying wind directions, varying ground conditions,varying cloud cover, etc. with "ground truth" data near the center of the surface area.

General:
Best suited to the FL and FT, owing to the short flight length required, since they can both fly low enough to be in or near the top of the surface layer and can thus obtain reasonable samples of the dominant flux wavelengths at those levels. Table 5.2.1.10a contains endpoints and comments regarding several flight legs used by the Twin Otter (FT) in 1993.

Times: see patterns.

TS,N-1:
Repeated, straight-line, constant-altitude passes, usually centered on a TF site. The length will depend on the site, as it should be as homogeneous as possible and representative of the environment being sampled by the tower. Lengths of 10 km have been discussed, allowing multiple repeats (reduction of sampling uncertainty) in reasonably short time intervals. The flight leg would typically be oriented cross-wind, if allowed by the surface cover. In some instances other orientations may be dictated by the extent of the surface cover. For 6 passes over a 10 km leg, including turns, approximate times would be 0.43 h for FL, and 0.38 h for FT.

TS,N-2:
Repeated, constant-altitude "+" pattern centered on a specific site (usually a TF site), with the legs oriented along- and cross-wind. Again, lengths of 10 km have been discussed, allowing multiple repeats (reduction of sampling uncertainty) in reasonably short time intervals. For 3 "+"s, with a reverse heading pass on each leg (12 passes total), including turns, approximate times would be 1 h for FL and 0.9 h for FT. Again, the orientation of the flight legs will depend on the wind direction and extent of surface cover.

TS,N-3
Asterisk pattern as illustrated, yielding 12 flight legs @ 12 km, crossing a central point at azimuth intervals of 15 degrees. Flight time about 1.5 hours.

TS,N-4:
Repeat TS,N--3 so that each azimuth is traversed along reversed headings, resulting in 24 flight legs @ 12 km. Flight time about 3 hours.

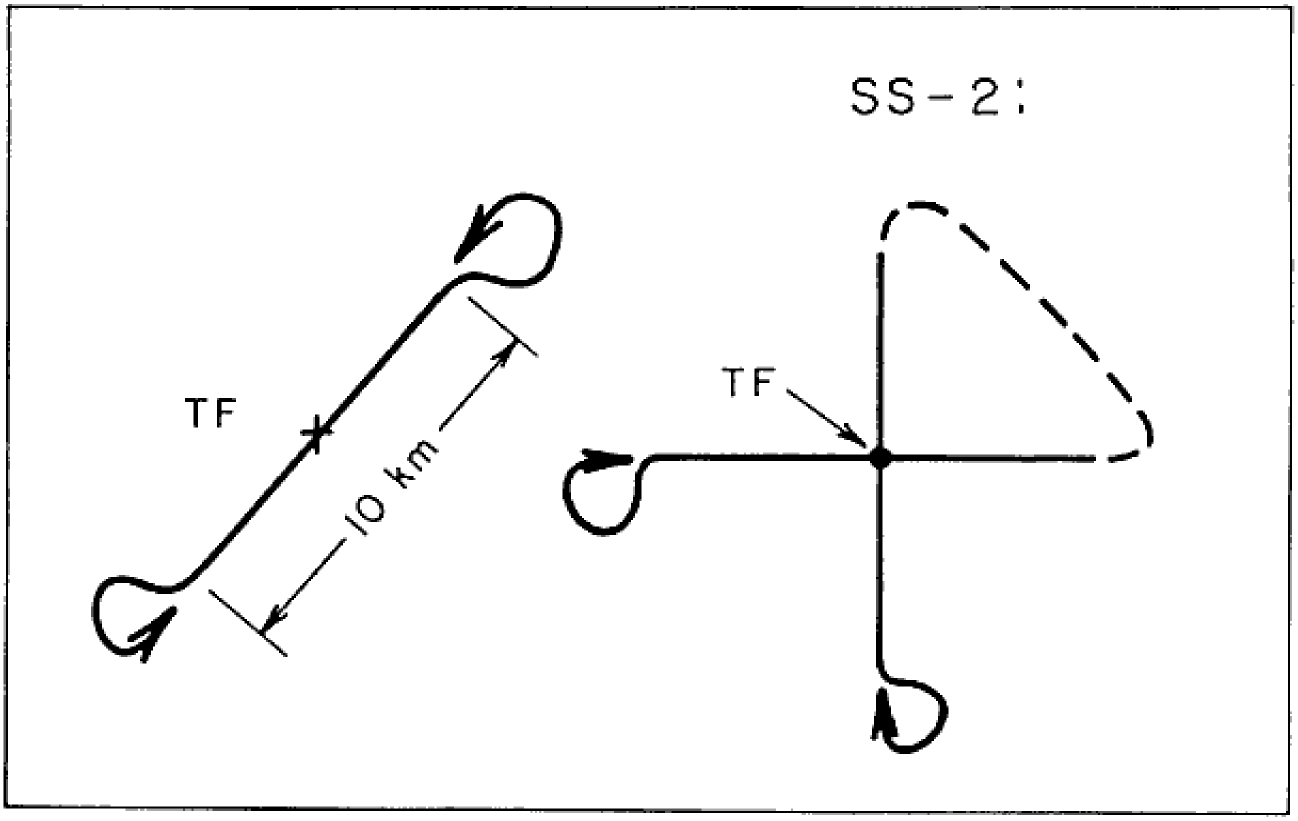


Figure 5.2.1.10.2a: Fx-TS, Fx-TN: Flux Mission, Site Specific (over a TF Site)

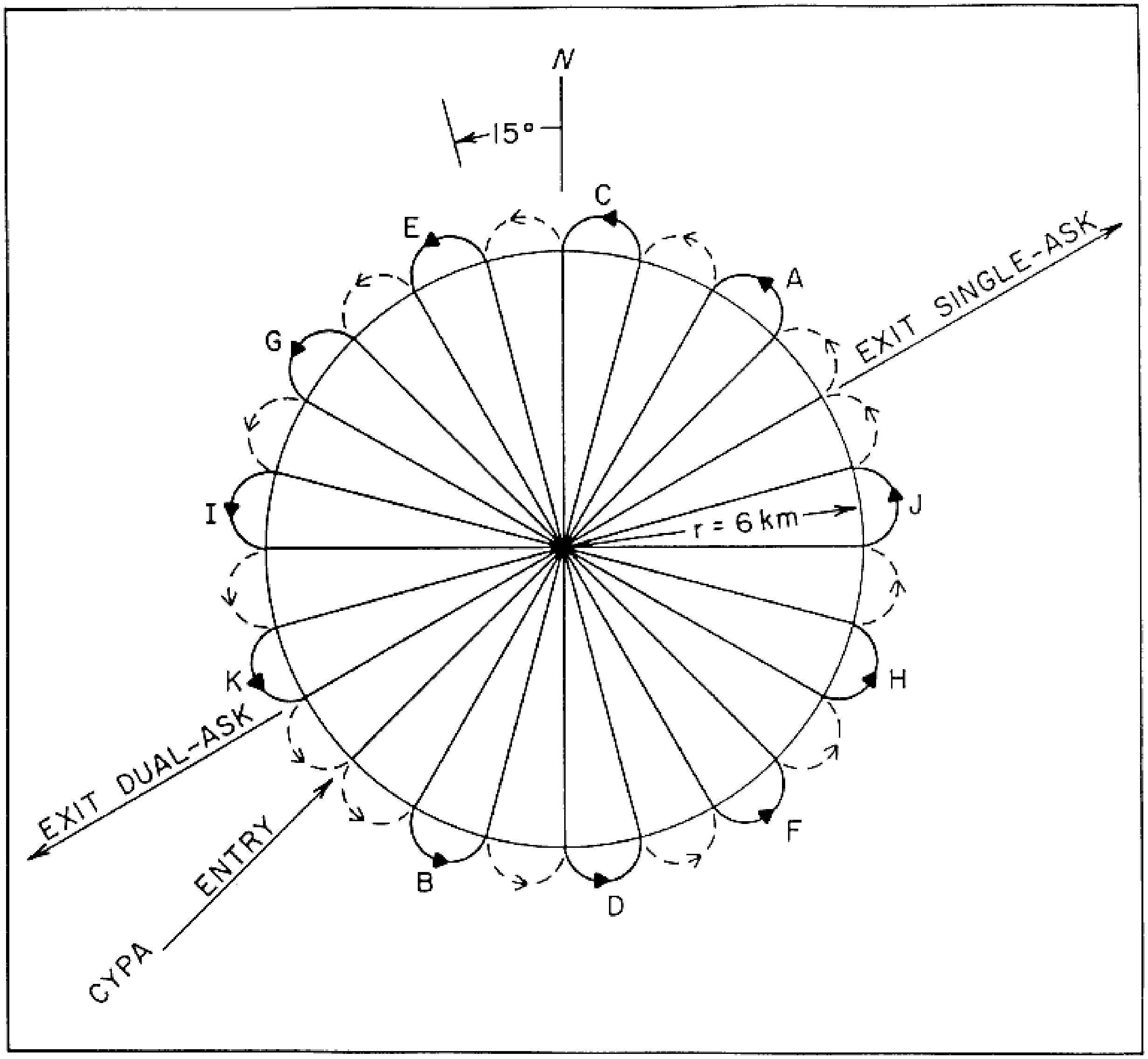


Figure 5.2.1.10.2b: **Fx-TS,N-3 and Tx-TS,N-4: Site-specific asterisk flux mission**

The waypoints used by the Twin Otter (FT) in 1993 for several specific sites and areas are shown in Table 5.2.10.2. They are presented here as examples and/or candidates for TS,N-1 type runs. Note that all were established with LORAN-C and will be refined with GPS and other information before and during the 1994 operations.

Table 5.2.1.10.2 Waypoints for Fx-TS,N Missions

	Waypoint 1		Waypoint 2		
Site	**Lat.**	**Long.**	**Lat.**	**Long.**	**Comments**
OA-SSA	53°35.4'	-106°16.8'	53°38.2'	-106°09.6'	~10 km homogeneous vegetation
OA-SSA	53°34.9'	-106°16.8'	53°38.2'	-106°09.6'	Longer, but still homogeneous vegetation
OBS-SSA	53°59.0'	-105°08.2'	53°58.2'	-105°00.1'	About 9 km homogeneous
OJP-SSA	53°53.6'	-104°44.2'	53°56.0'	-104°39.5'	Only 6 km homog, so marginal for TS
OBS-NSA	55°52.5'	-98°22.5'	55°52.4'	-98°34.0'	~12 km good sfc.
OJP-NSA	55°55.6'	-98°37.7'	55°56.6'	-98°36.2'	~3 km homog. veg.-doubtful for TN
NSA-Burn	55°49.7'	-98°19.4'	55°48.8'	-98°41.0'	~23 km burned with center spot OBS
NSA-Burn	55°49.7'	-98°19.4'	55°51.6'	-98°30.0'	~11 km, all burned

5.2.1.10.3 FE-RT: Electra Transects

Objectives:
Measure trans-boreal gradients. Examine large variety of surface characteristics, stemming from vegetation, land type (dry, bog, lake), land use (primitive, logged, burned), all with application to scaling up and down across the range of scales to be sampled in BOREAS.

General:
Most of the flight time will be in the boundary layer (e.g., at 100 m or above). Some time will be devoted to use of the DIAL laser remote sounding system, which must be flown above the ABL in a down-looking mode.

Times: see patterns.

RT-1:
Waypoints as follows:

Near Sask-A-(SSA-OA)-(abcd)-H-K-L-M-O-tundra

This pattern cuts across SSA along the Candle Lake (CS) path, directly across the SSA-OA TF site, then turns northerly at a point east of the Narrow Hills Park, and passes directly through NSA very close to all four TF sites. The length A-O is over 700 km. A round trip of A-O plus about 170 km on each end is about 6h.

DIAL flight pattern:
Flight patterns to make use of the DIAL system may be added at any point to a transect using the pattern illustrated. Flight level 1 is the transect in progress, 2 is a reverse track at an altitude above the ABL, and 3 is parallel to the transect path but above it. Levels 1 and 3 thus provide "air truth" measurements for the DIAL, which will sample during leg 2.

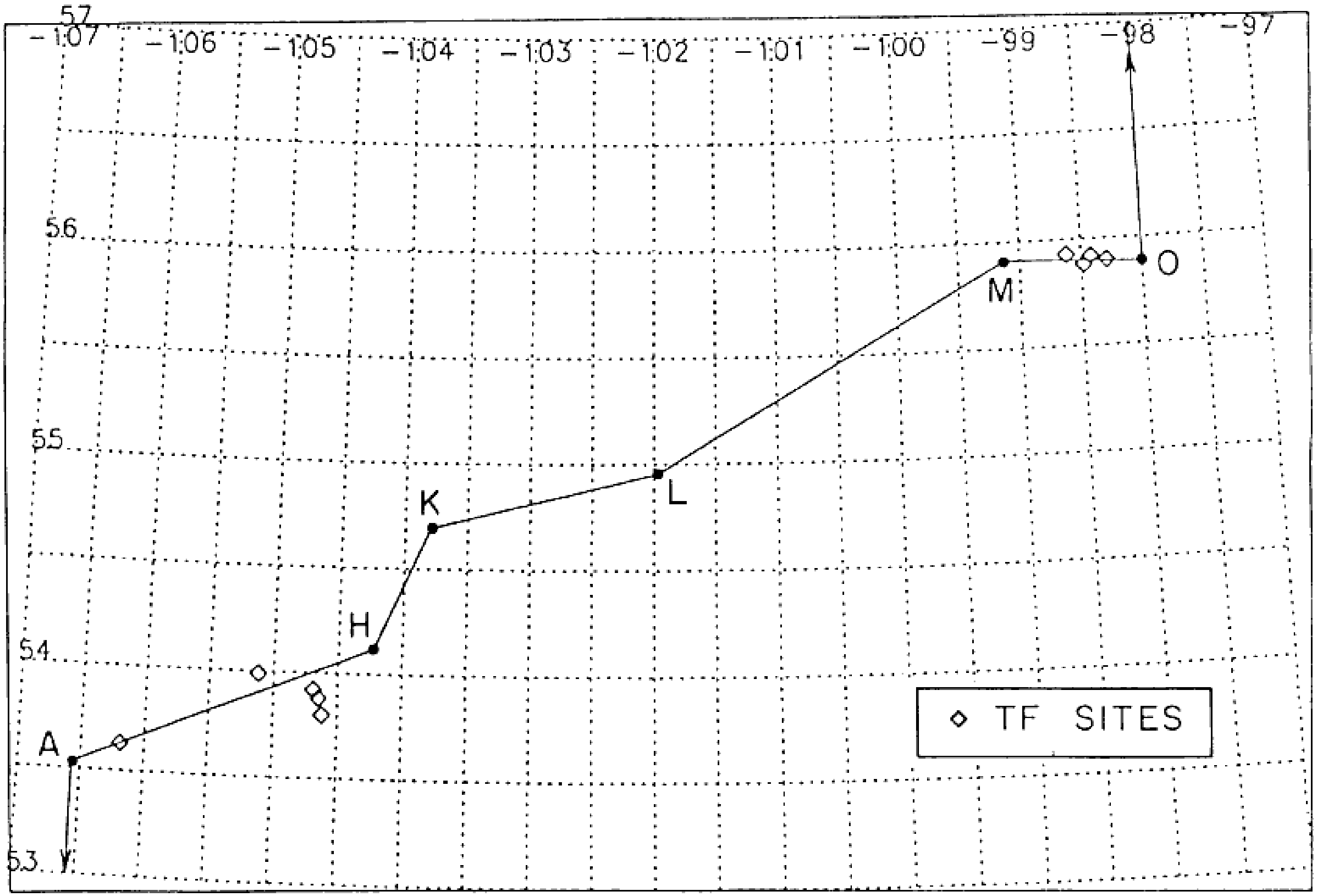


Figure 5.2.1.10.3a: FE-RT: Electra Regional Transect

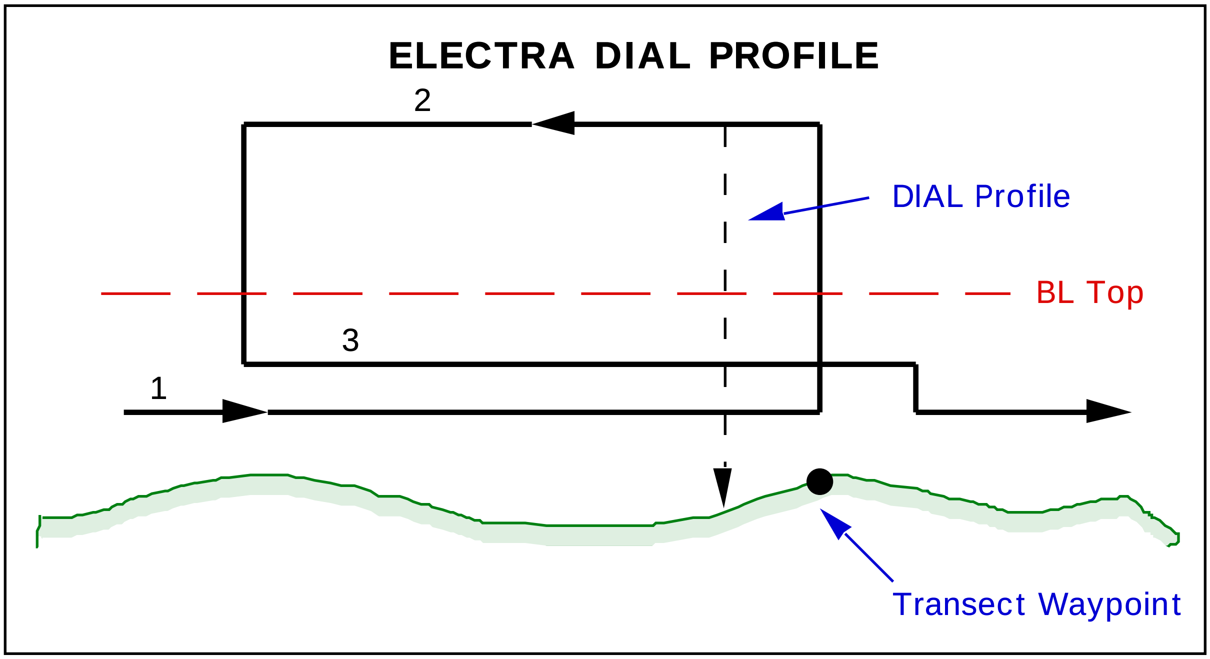


Figure 5.2.1.10.3b: FE-RT: Electra Regional Transect; DIAL profile over transect waypoint.

5.2.1.10.4 Fx-LS, Fx-LN : Mini-/Meso-Scale Transects and L-shaped Patterns

Objectives: Flight plans for some of the LS,N patterns are shown in Fig. 5.2.1.10.4, especially those that pass over or very close to any of the TF sites. These paths need to be long enough to cover a variety of surface characteristics (like the CS run), e.g., over various TFs and along segments covered by other flight plans (like the Electra Transects), but over "short" enough distances to be sampled several times and/or at se as moveable, to take advantage of what we learn about ground cover, land use, seasonal changes, etc. These patterns are ideal for footprint studies, where we examine flight-level vs. surface variability to understand the surface sources and their integration/mixing in the atmosphere. They will also be used to examine flight-level flux variability under changing degrees of cloudiness and changing cloud positions.

General: Flight levels will range from about 50 m to the top of the BL.

Times: See patterns

Note: Waypoints here are given as lower case letters. The corresponding latitude and longitude values are contained in the table at the start of this section.

LS,N-1: This is designed to cover a transect similar to CS and pass close to or over three TF sites (OJP, YJP, Fen) as an "L". Total length is about 180 km. One-way flight times, including turns, are about 1.0 h for FT and 0.7 h for FK.

LS,N-2:
Designed as path h-i-j, which passes over or near four of the SSA TF sites (OBS, OJP, YJP, Fen). Total length is about 80 km. One-way flight times, including turn, are about 0.37 h for FT and 0.25 h for FK.

LS,N-3:
Designed as path k-m-n, which passes over the OA, OBS, OJP, and YJP TF sites in the south, and not too far from the Fen site, as an "L". Total length is about 180 km. One-way flight times, including turn, are about 0.9 h for FT and 0.6 h for FK.

LS,N-4:
Path from near Prince Albert airport to area near the OA TF site, using waypoints s and t (lower case). Intended as a site-entry path into the western part of the SSA, it should provide a good sample of the agriculture/agriculture + forest pattern of the southern boreal forest "boundary." The path length is about 39 km (0.2 h for FL and FT, 0.15 h for FK). This may be superceded by (low-level) Route West, see Section 5.2.1.10.9.

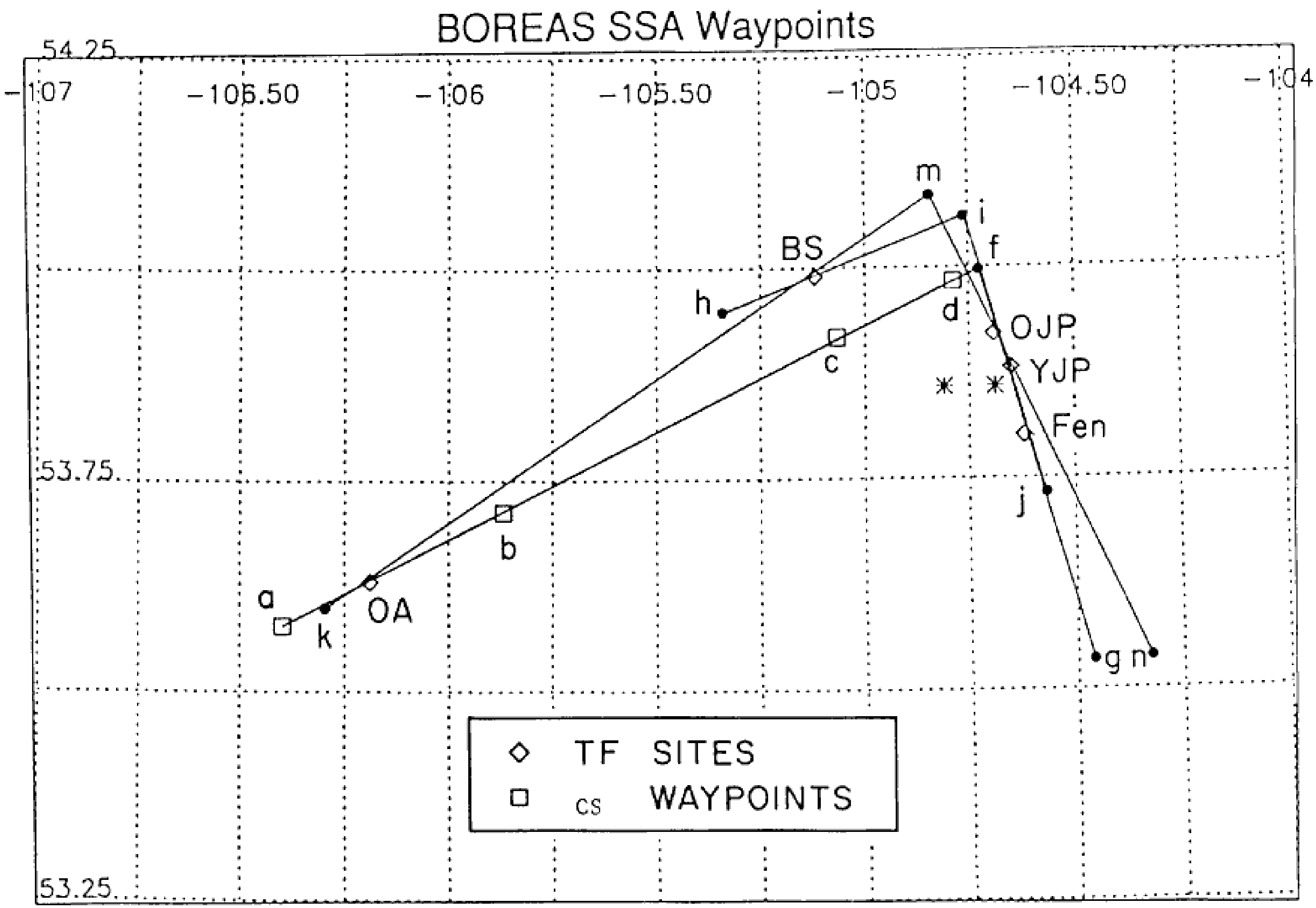


Figure 5.2.1.10.4: Fx-LS, Fx-LN: Mesoscale Transects.

LS,N-5:
Another site entry, from near Prince Albert airport to the center of SSA near Candle Lake, using waypoints u and v (lower case). Again, this is intended to provide a sample of the ag/forest transition. The path length is about 52 km (0.3 h for FL and FT, 0.2 h for FK). This may be superceded by (low-level) Route East, see Section 5.2.1.10.9.

LS,N-6:
Generic "L", with coordinates chosen for desired targets.

LS,N-7:
Generic straight line pass (transect), with coordinates chosen for desired target.

5.2.1.10.5 Fx-GS, Fx-GN: Grid and Stack

Objectives:
Mission plans are shown in Figure 5.2.1.10.5. Measure horizontal and vertical gradients simultaneously, e.g., for ABL budget studies, by using two aircraft. Mapping areal heterogeneities, to examine correlations between flight level and surface variations (re: footprints, modeling, scaling). Good areas for this pattern would be in the SSA covering the Candle Lake area TFs, and all of the NSA. Use tower-released tracer (sampled by aircraft in stack) to examine over-forest diffusion in conditions of different ABL stability. Very relevant to footprint studies.

General:
The patterns will be oriented North South or East-West, parallel or orthogonal to lines of latitude and longitude. The FL and FT grids will be patterns of nine parallel lines flown at 100' alg, 2 km spacing covering an area of 16 x 16 km. This pattern will be embedded within a larger pattern flown by FK of nine parallel lines flown at 200' agl, 5 km spacings, covering an area of 32 x 32 km. The area enclosing the grids (North-South lines shown only) are shown in figures 5.2.1.10.5a for the SSA and 5.2.1.10.5b for the NSA. Grid centerpoints are given in Table 5.2.1.10.5.

Aircraft	Study Area	Latitude	Longitude	Grid Type
FT, FL	SSA NSA	53˚ 51.5' 55˚ 52.5'	104˚ 41.25' 98˚ 31.5'	16x16 km 9 lines 2km spacing 100' agl
FK	SSA NSA	53˚ 51.5 55˚ 52.5	104˚ 48.6' 98˚ 31.5'	32x32 km 9 lines 4 km spacing 200' agl

Table 5.2.1.10.5 Grid locations (center points) and location for flux aircraft in BOREAS. Note that the FK lines should coincide with alternate FT, FL lines (see also figures 5.2.1.10.5a, b).

If flight time allows, a 10th north-south grid line will be added to the SSA pattern for FK, in order to give added coverage to the OBS area. The Easternmost FK lines in the NSA grid will be dropped if the Nelson House First Nation request that the spiritual area be undisturbed.

Figure 5.2.1.10.5c shows a grids and stacks flight pattern. This would be performed using two flux aircraft, one for the grid and one for the stacks.

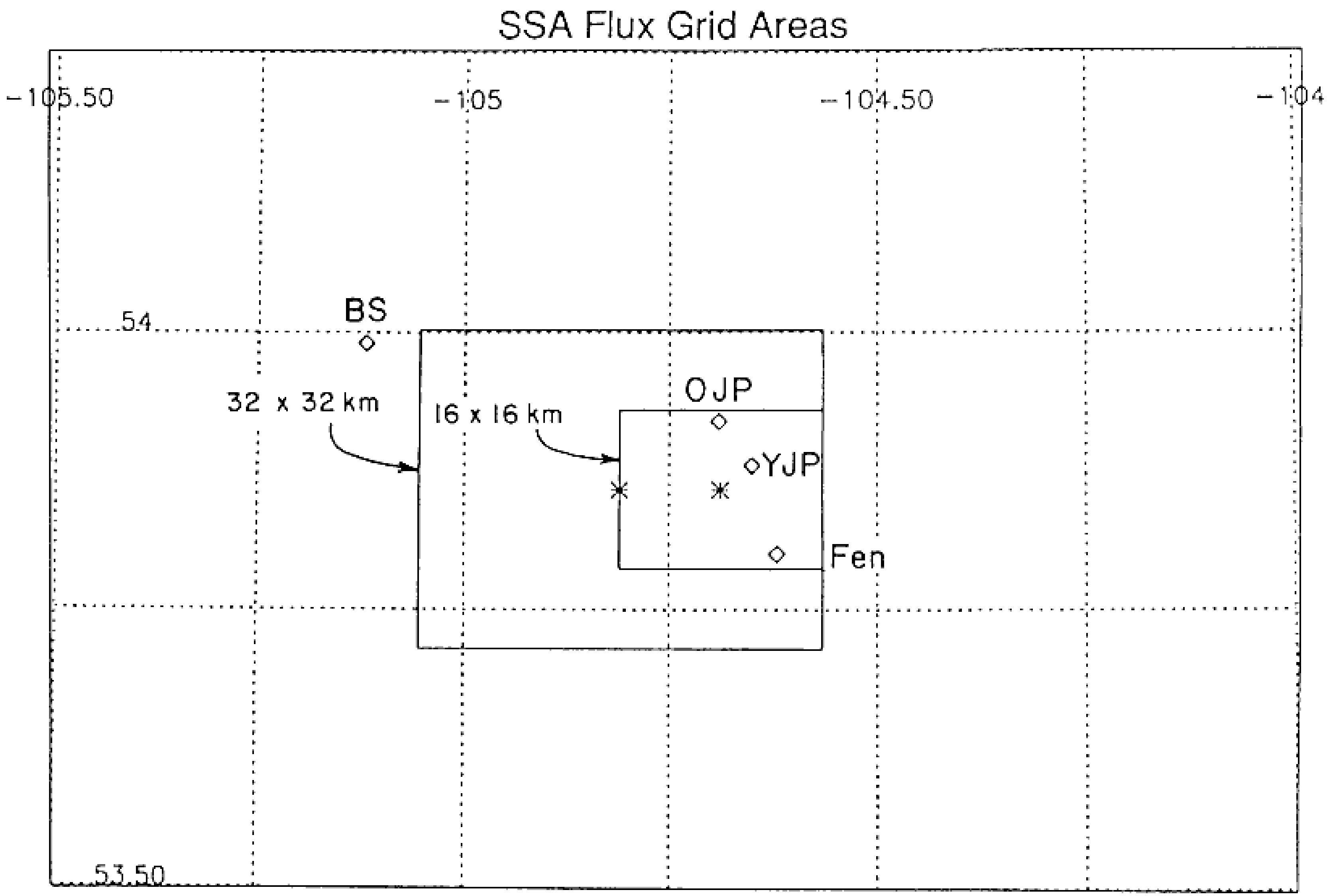


Figure 5.2.1.10.5a: Fx-GS: Grid patterns flown by FT, FL (small pattern) and FK (large pattern) in the SSA.

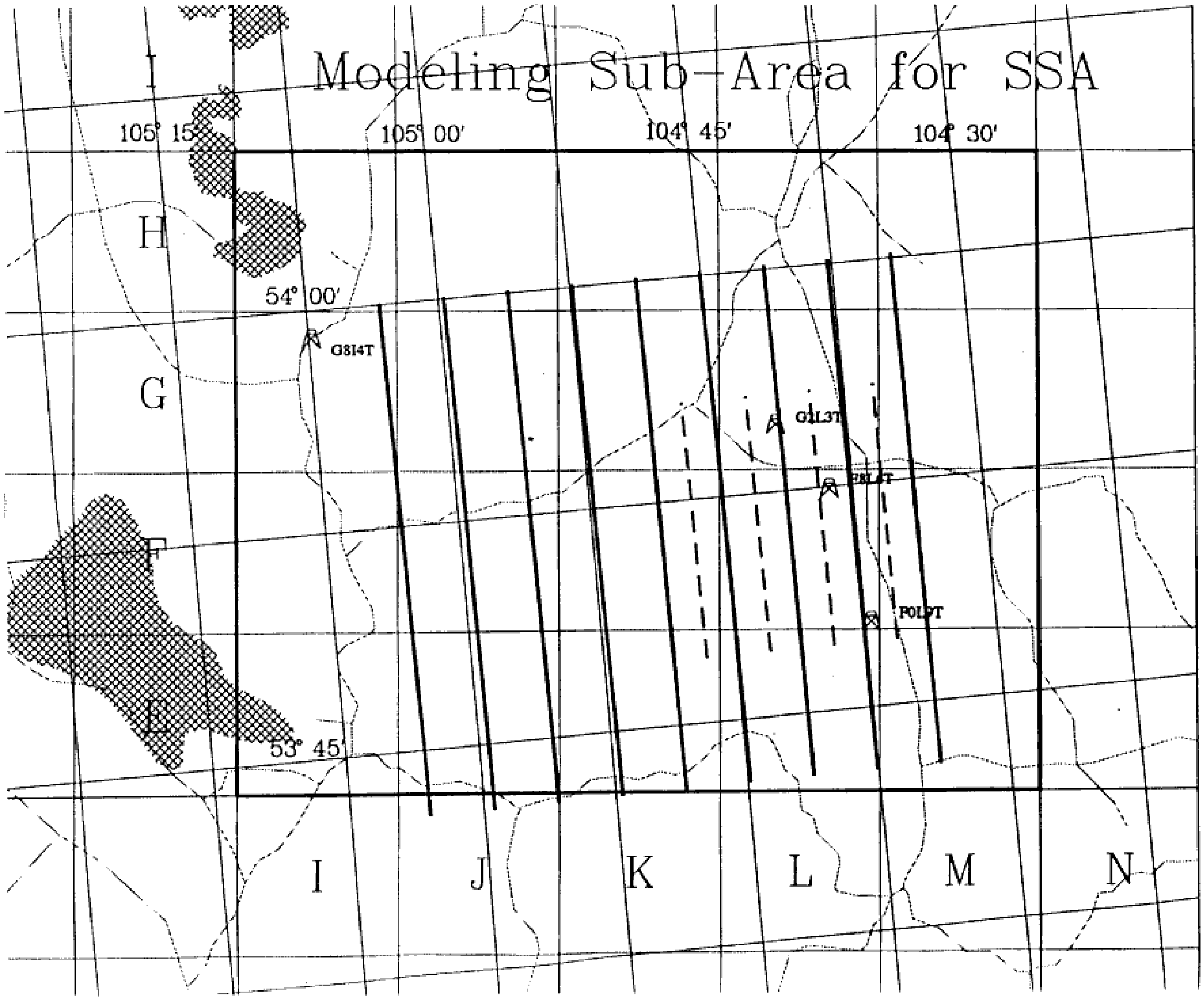


Figure 5.2.1.10.5a: Fx-GN: Grid patterns flown by FT, FL (small pattern) and FK (large pattern) in the SSA (cont.).

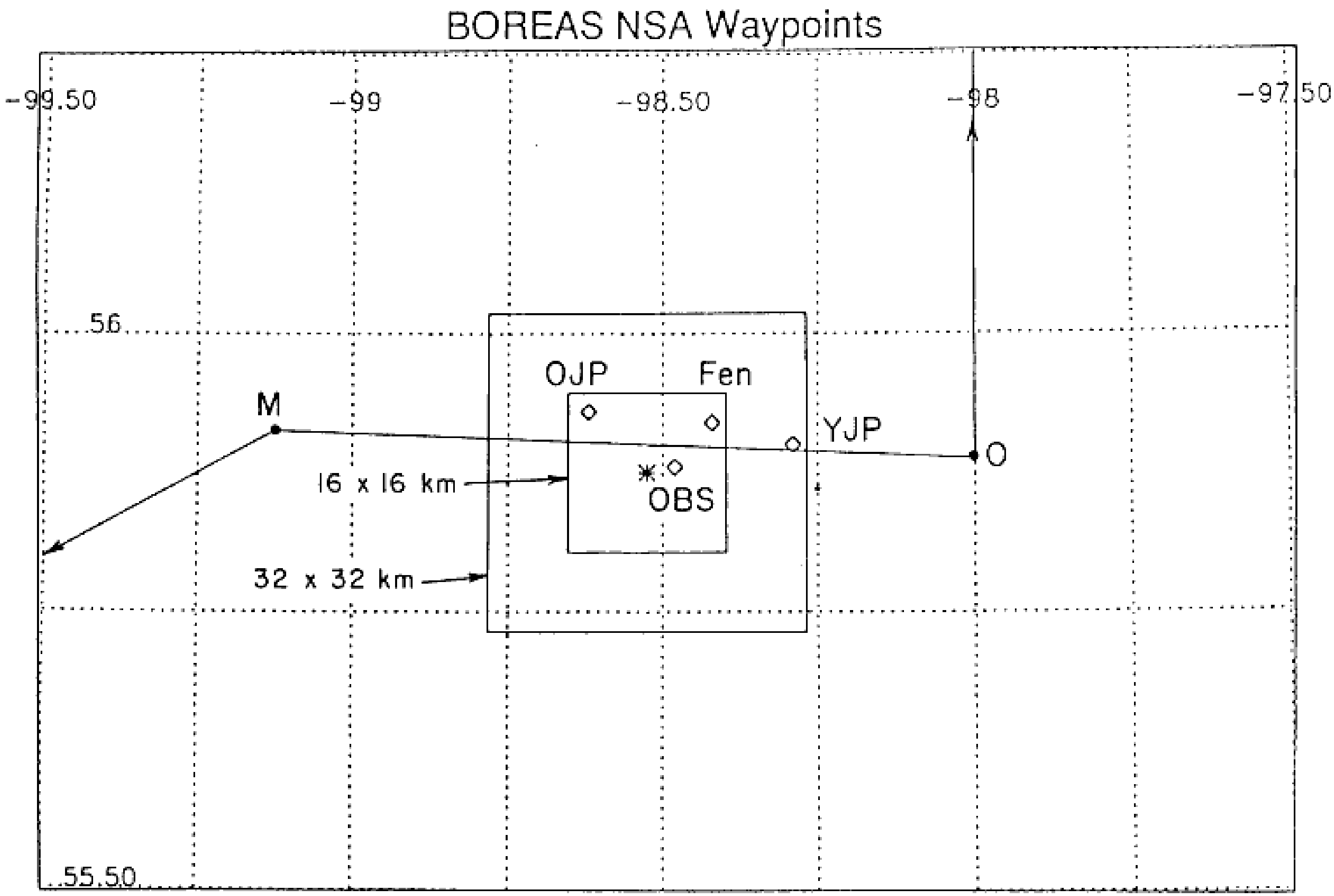


Figure 5.2.1.10.5b: Fx-GN: Grid patterns flown by FT, FL (small patterns) and FK (large patterns) in the NSA.

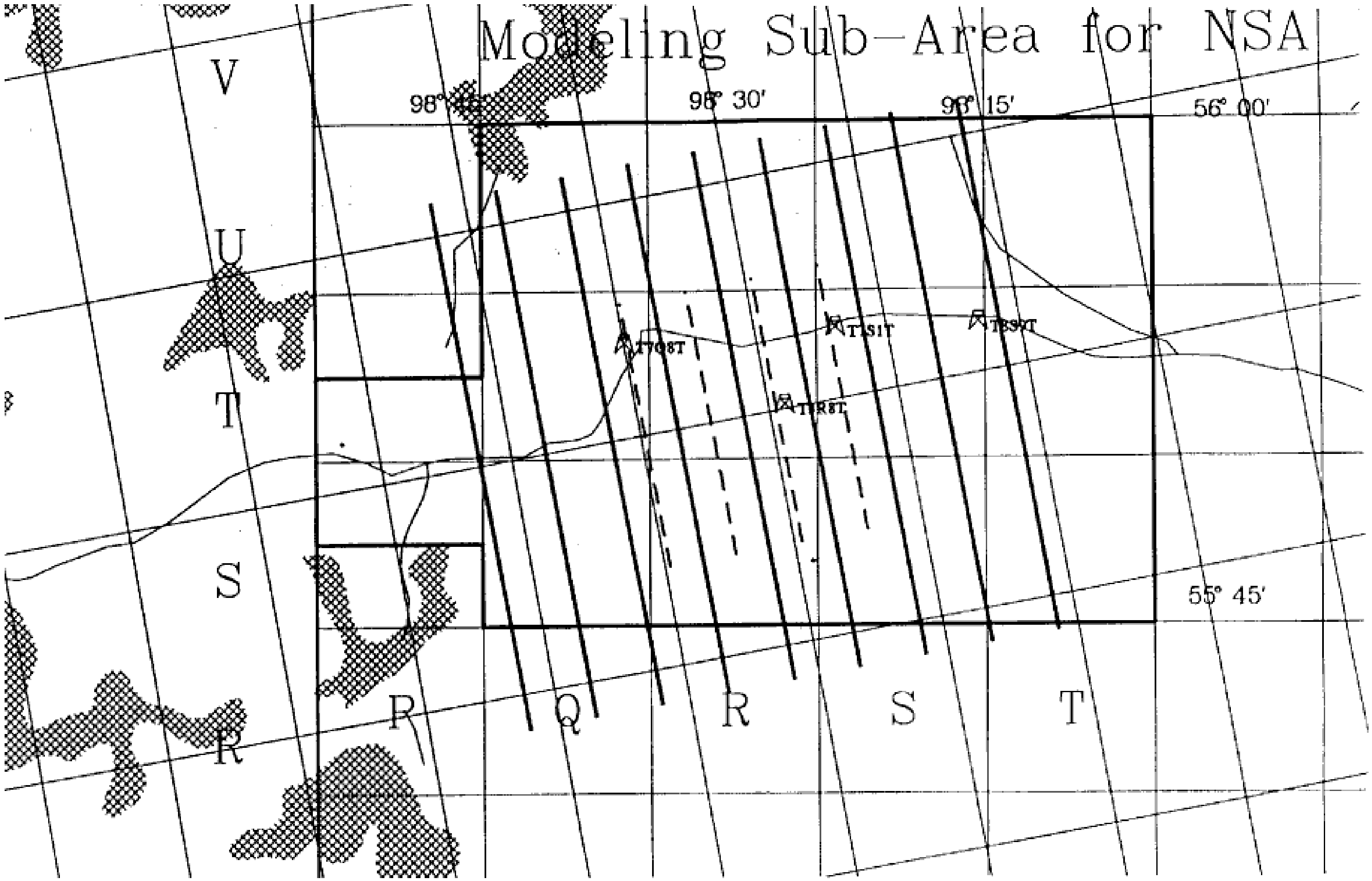


Figure 5.2.1.10.5b: Fx-GS: Grid patterns flown by FT, FL (small patterns) and FK (large patterns) in the NSA (cont.)

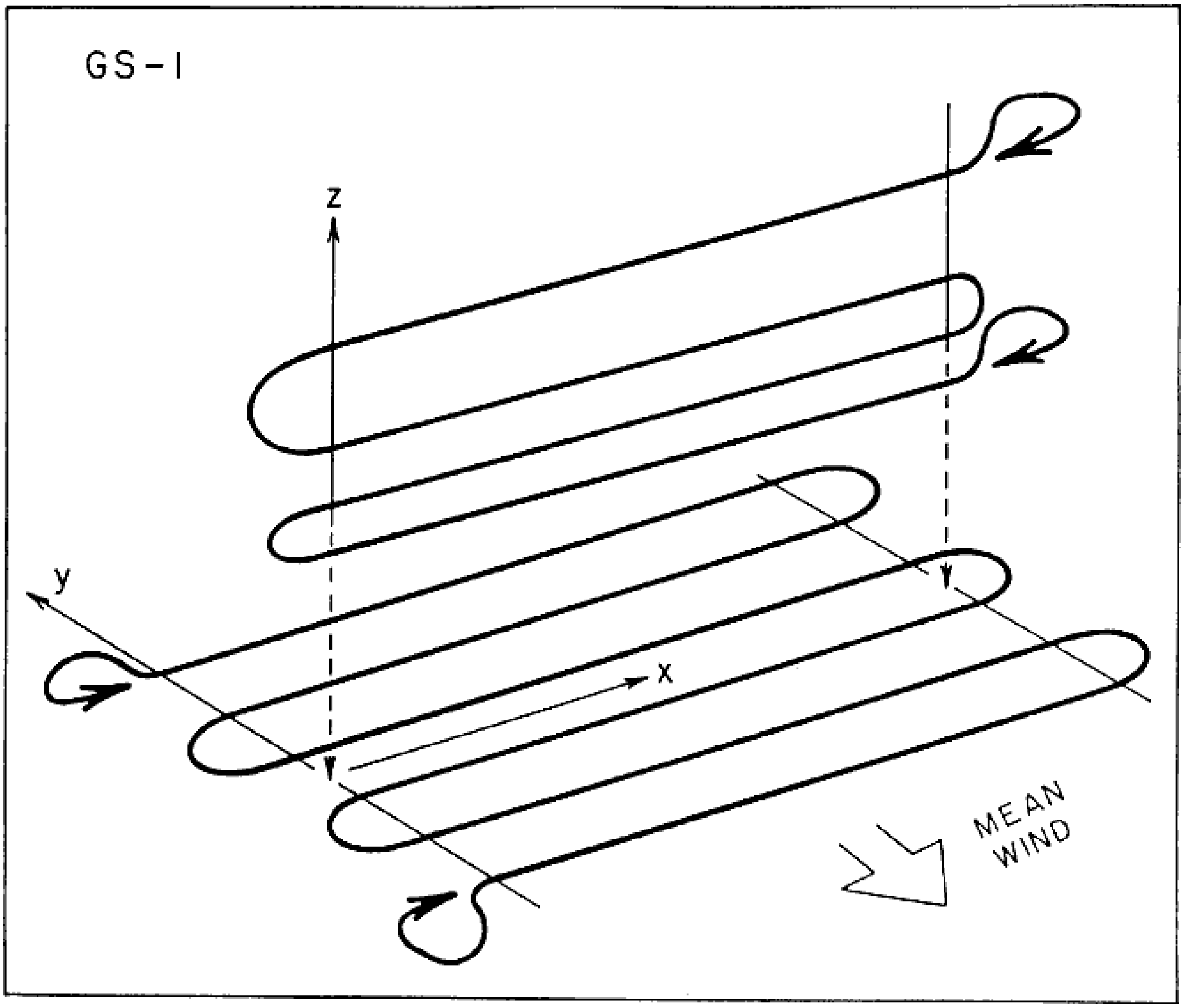


Figure 5.2.1.10.5c: Fx-GS and Fx-GN: Flux Aircraft Missions; Grids and Stacks

5.2.1.10.6 Fx-PS, Fx-PN: Budget Box Patterns

Objectives:
Mission profile is shown in Figure 5.2.1.10.6. Gain estimates of all dominant terms in the ABL budget equations for scalar quantities, to examine degree of closure, degree of error, and relative importance of advective and flux-divergence processes.

General:
Best flown with stack lines on box sides normal to mean wind. Covers flight levels from 50+ m to 1000+m. Operational conditions that should be met for this pattern include: clear skies, or at least radiationally uniform steady winds (speed < 10 m/s, steady direction), no fronts or thunderstorms near the project area, TF sites fully operational.

Times:
If box is 30 km on each horizontal side, and the pattern is flown with 4 levels in complete time centered fashion (up, across, down, up, back, down), the total distance is about 540 km plus turns. Estimated times are 3+h for the FT and 2+h for the FK.

5.2.1.10.7 Fx-HS, Fx-HN: Stacks and Tees

Objectives:
Mission profiles are shown in Figures 5.2.1.10.7. Gain estimates of all dominant terms in the ABL budget equations, to examine degree of closure, degree of error, and relative importance of advective and flux-divergence processes.

General:
Best flown with stack lines on box sides normal and parallel to mean wind. Covers flight levels from 50+ m to 1000+m

Times:
If pattern is 30 km on each horizontal side, and is flown at 3 levels in time centered fashion (up "L"s then down "L"s), the total distance is about 360 km plus turns. Estimated times are 2.4 h for the FT and 1.8 h for the FK.

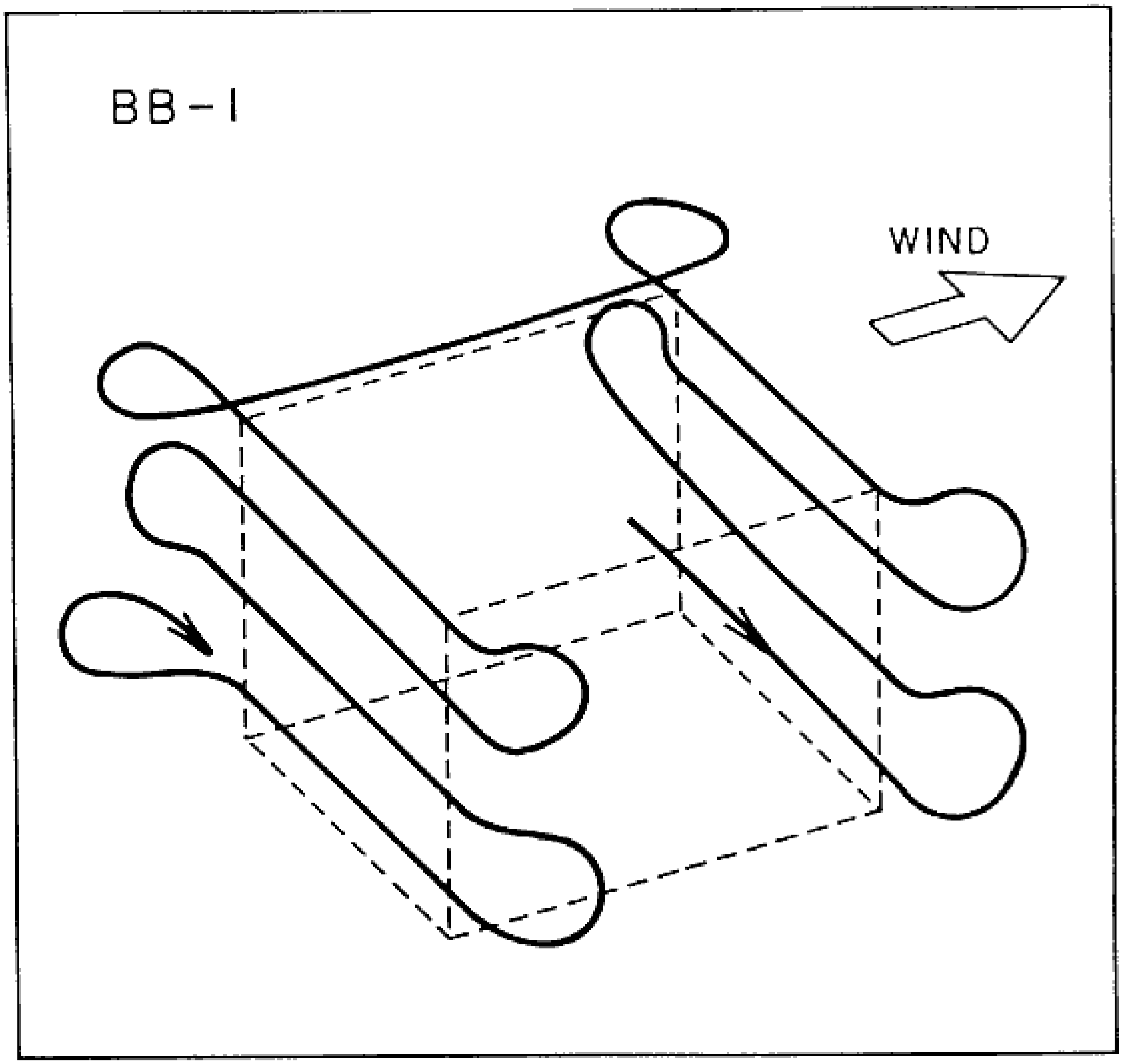


Figure 5.2.1.10.6: Fx-PS, Fx-PN: Flux Aircraft Mission, 'Budget Box Patterns'

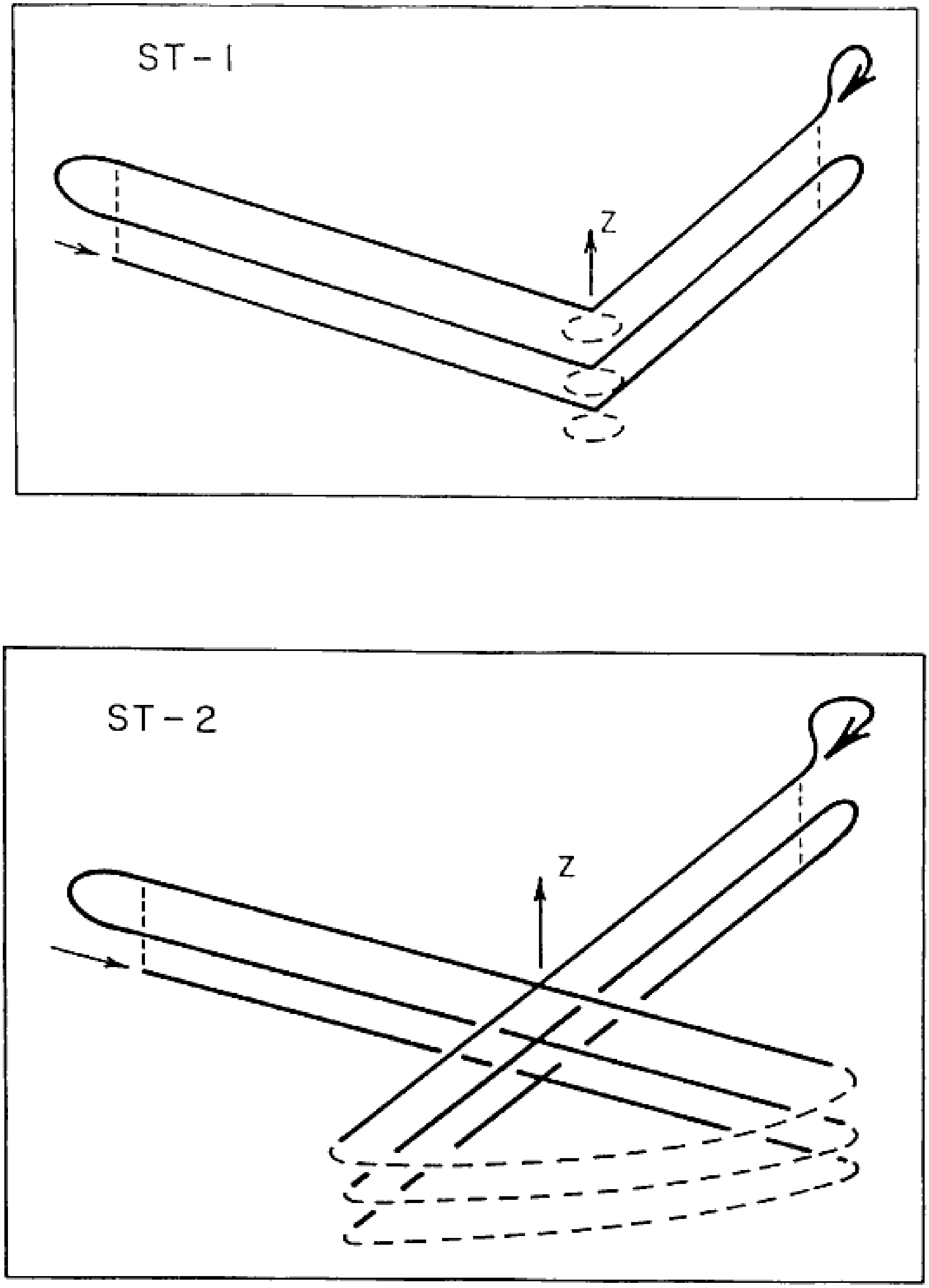


Figure 5.2.1.10.7: Fx-HS, Fx-HN: Flux Aircraft Mission, 'Stacks and Tees'

HS,N-1:
A stack of "L"s, flown time-centered, as illustrated.

HS,N-2:
A stack of "+"s or "T"s, flown time-centered, as illustrated. One disadvantage to this pattern is the extra time spent traversing between the points of the "+".

5.2.1.10.8 Fx-FS, Fx-FN: Flights-of-Two

Objectives:
Valuable wing-to-wing intercomparisons between the flux aircraft. Vital for quality control and error assessment.

General:
Sites, altitudes, patterns flexible, but chosen whenever possible to coincide with patterns already defined and in use.

FS,N-1:
Wing-to-wing, preferably along paths parallel to then normal to mean wind, with reverse-heading passes in each case. Also desirable to have more than one altitude. The only practical combinations for this pattern, due to the wide range of airspeeds, are FL+FT, FT+FK and FK+FE.

FS,N-2
Successive runs by two aircraft down the same flight path(s),in quick succession. This may be demanded by flight safety for cases of low altitudes, speed mismatches and turbulent conditions.

5.2.1.10.9: Fx-LS: SSA Low-Level Route

A low-level route have been laid out between the Prince Albert area and the southern part of the SSA, see Figure 5.2.1.10.9. This route is designed to provide a long run over agriculture, ending in a forested area. The route avoids settlements and heavy livestock-raising areas and was flown many times in IFC-1 at low altitude (FT). Letters have been sent to over 100 landowners living under or near the route; aircrews will be notified immediately if any complaints filter back to BOREAS.

Flux aircraft teams must be careful about using this route. Please use the following precautions:

- Specify which direction you intend to use in time to place it on the BOG Aircraft chart: e.g. Kingair FK-LS (SSA entry); FK-PS; FK-LS (SSA exit).

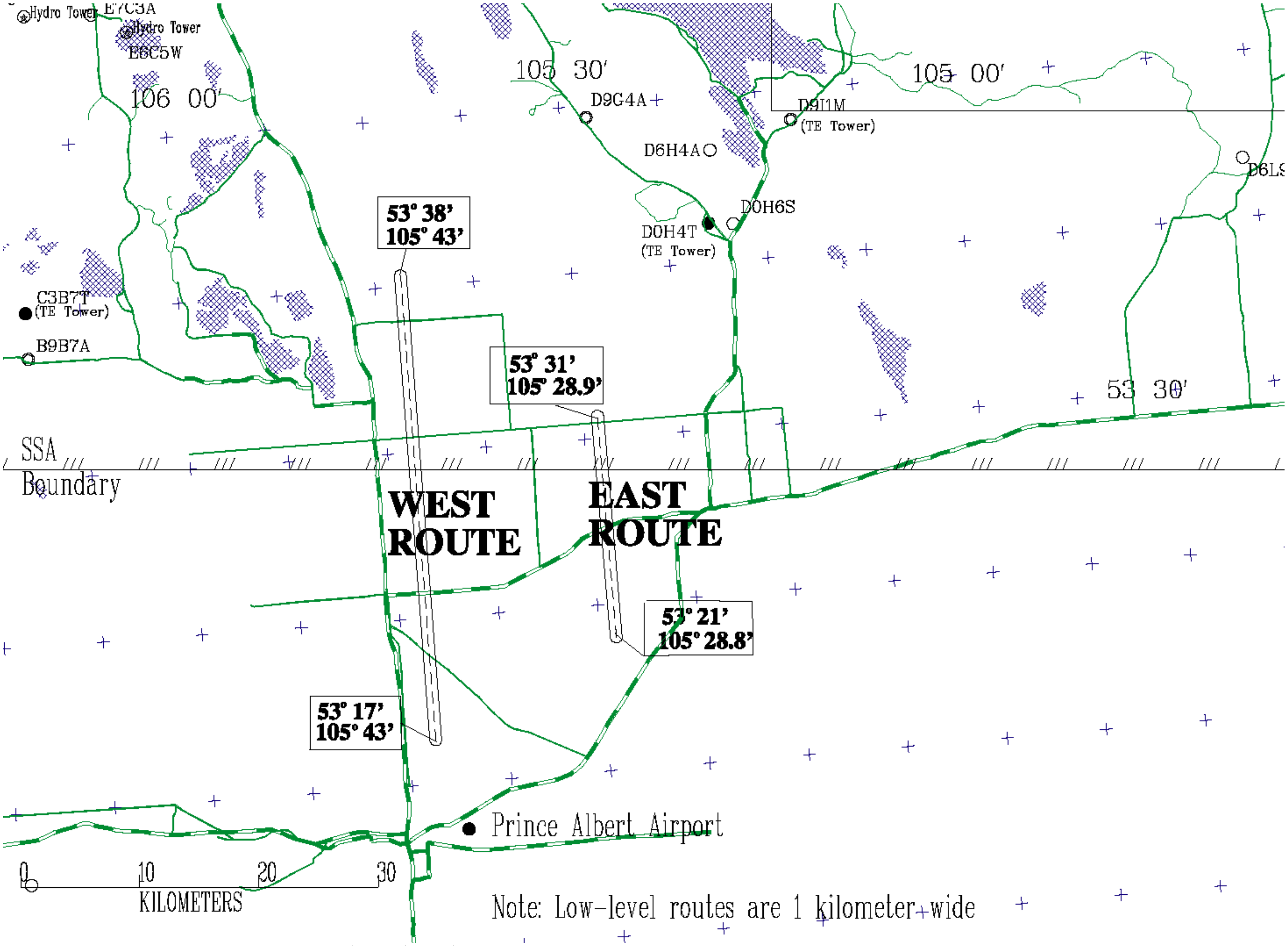


Figure 5.2.1.10.9: Fx-ZS: SSA low-level

- Announce route entry and exit.
- One-way traffic in a route at any given time.
- Notify Ops of any new obstructions or areas of dense livestock near the route.

5.2.2 Mission Strategies

Section 5.2.1 summarizes the individual missions (see Tables 5.2.1) and Section 5.2.3 summarizes the hours available for each aircraft for each IFC. The RSS and AFM team members in conjunction with the BOG and MM must try to make best use of the available flight hours while fulfilling the range of objectives specific to each team.

Table 5.2.2 is an attempt to summarize the percentage of total flight hours that should be dedicated to particular mission types for each aircraft.

Aircraft	**Mission Type**								
	Snow		**TF/Aux. Sites**		**Mapping**		**Special**		**Transect**
RC	SN 15	SS 15	TN 20	TS 20	MN 10	MS 10	-- --	-- --	RT 10
RD	-- --	-- --	BN 15	BS 20	MN 15	MS 20	IS 10	DS 10	RT 10
RV	-- --	-- --	BN 35	BS 45	-- --	-- --	-- --	-- --	RT 20
RT	SN 30	SS 50	-- --	-- --	-- --	-- --	-- --	-- --	ST 20
RE	SN 10	SS 10	-- --	-- --	MN 30	MS 30	US 20	-- --	-- --
RP	SN 15	SS 25	TN 15	TS 35	-- --	-- --	-- --	-- --	RT 10
RF	-- --	-- --	TN 40	TS 60	-- --	-- --	-- --	-- --	-- --
RH	-- --	-- --	TN 15	TS 35	BN 15	BS 35	-- --	-- --	-- --
RA	SN 20	SS 30	-- --	-- --	-- --	-- --	WS 30	WT 10	ST 10

Table 5.2.2a Percentage of site hours to be allocated to different mission types by each remote sensing aircraft.

Aircraft	Missions					
	CS,N	TS,N	RT	LS,N	GS,N	Other
FE	30	--	40	10	--	20
FT	20	25	5	10	40	--
FK	20	--	10	20	40	10
FL	40	30	--	--	30	--

Table 5.2.2b Percentage of site aircraft hours to be allocated to each flux aircraft mission type.

5.2.3 Flight Hours and Basing

Table 5.2.3a shows the flight hours available to each aircraft by field campaign. Table 5.2.3b lists the deployment airports to be used by each aircraft; transit times between the deployment airports and the hot area must be allocated against 'site hours' shows in Table 5.2.3a.

5.2.4 Satellite Schedule

A full tabulation of satellite overpasses and geometry is given in Appendix O with summaries for SPOT, Landsat and ERS-1 shown in Tables 5.3.1a through 5.3.6a. These tables show the theoretical maximum number of scenes. The actual number received is subject to satellite performance as well as ground station constraints and, in the case of SPOT-HRV, constraints due to scheduling off-radio takes for non-BOREAS users. There are limited opportunities for acquiring imagery for these three instruments because of orbital and instrument configurations. Figure 5.2.4 shows the locations of image frames for Landsat and SPOT over the SAs and the transect.

Landsat: Four Landsat scenes are located within the BOREAS region; Southern Study Area (SSA), Transect West (TW), Transect East (TE) and Northern Study Area (NSA). Two of these scenes require that the scene center be shifted for a good transect coverage.

SPOT: In 1993 there are two SPOT satellites in operation, each equipped with two pointable instruments. However, the instruments cannot acquire one site (say SSA) and then slew round to acquire the other (NSA) on the same orbit. It also requires two SPOT scenes to cover the SSA. Sometimes, images may be acquired for both sites on the same day when both SPOT satellites are in range.

ERS-1: The ERS-1 C-VV SAR which operates at a fixed incidence angle of 23°. The ERS-1 orbit is periodically changed by ESA which results in varying coverage of the BOREAS region. For example, complete coverage is provided by a 35-day repeat until December 15, 1993, a 3-day repeat until March 15, 1994 and a 176-day repeat from then on. During the 35- and 176- day repeat, the 1000 x 1000 km site is mapped every 17-days, and therefore collects data on weekly intervals, day and night, at the 5-6 BOREAS latitudes.

Table 5.2.3a Flight Hours Available to BOREAS by Field Campaign

Ferry hours refer to transits from the aircraft home base to and from the deployment airport. Site hours refer to research flight hours and transits from the deployment airports to and from the study areas.

	IFC-93		FFC-W		FFC-T		IFC-1		IFC-2		IFC-3	
Aircraft	**Ferry**	**Site**	**Ferry**	**Site**	**Ferry**	**Site**	**Ferry**	**Site**	**Ferry**	**Site**	**Ferry**	**Site**
C-130					10	13	10	10	10	10	10?	10?
DC-8	6	7			6	21	6	4	6	18	6	9
CV-580					12	10			12	10		
Twin Otter (M)			24	30								
ER-2			3	4	6	8	3	4	3	4	6?	4?
Chieftain			10	30	10	20	10	30	10	30	10	30
DC-3									6	14		
Aerocommander			12	23					16	30	16	30
Helicopter							25	20	--	20	25	20
Electra							10	49	10	48	10	48
Twin Otter (F)							22	55	22	55	22	55
King Air							8	30	8	30	8	30
Long EZ	12	50					12	60	12	60	12	60

( ) denotes hours held as backup if mission from preceeding IFC/FFC does not go.

Table 5.2.3b Deployment Airports for the BOREAS Aircraft

Aircraft	**IFC-93**	**FFC-W**	**FFC-T**	**IFC-1**	**IFC-2**	**IFC-3**
C-130			YPA	YPA,YTH	YPA,YTH	YTH,YPA
DC-8	YXE		YXE	NUQ	YXE	NUQ
CV-580		YXE	YXE		YXE	
Twin Otter (M)		YPA, YTH				
ER-2		Houston, TX		GEG	GEG, NUQ	NUQ
Chieftain		YPA, YTH	YPA, YTH	YPA, YTH	YPA, YTH	YTH, YPA
DC-3				YTH,YPA		
Aerocommander		YPA, YTH			YPA	YPA
Helicopter				YPA*, YTH	YPA*,YTH	YTH,YPA*
Electra				YXE, YQQ	YXE, YQQ	YXE, YQQ
Twin Otter (F)				YPA,YTH	YPA,YTH	YTH, YPA
King Air				YPA,YTH	YPA,YTH	YTH, YPA
Long EZ	YPA			YPA	YPA	YPA

YPA = Prince Albert
YPA*= Prince Albert and Candle Lake
YTH = Thompson
YXE = Saskatoon
YQQ = Churchill
NUQ = Moffett Field
GEG = Spokane

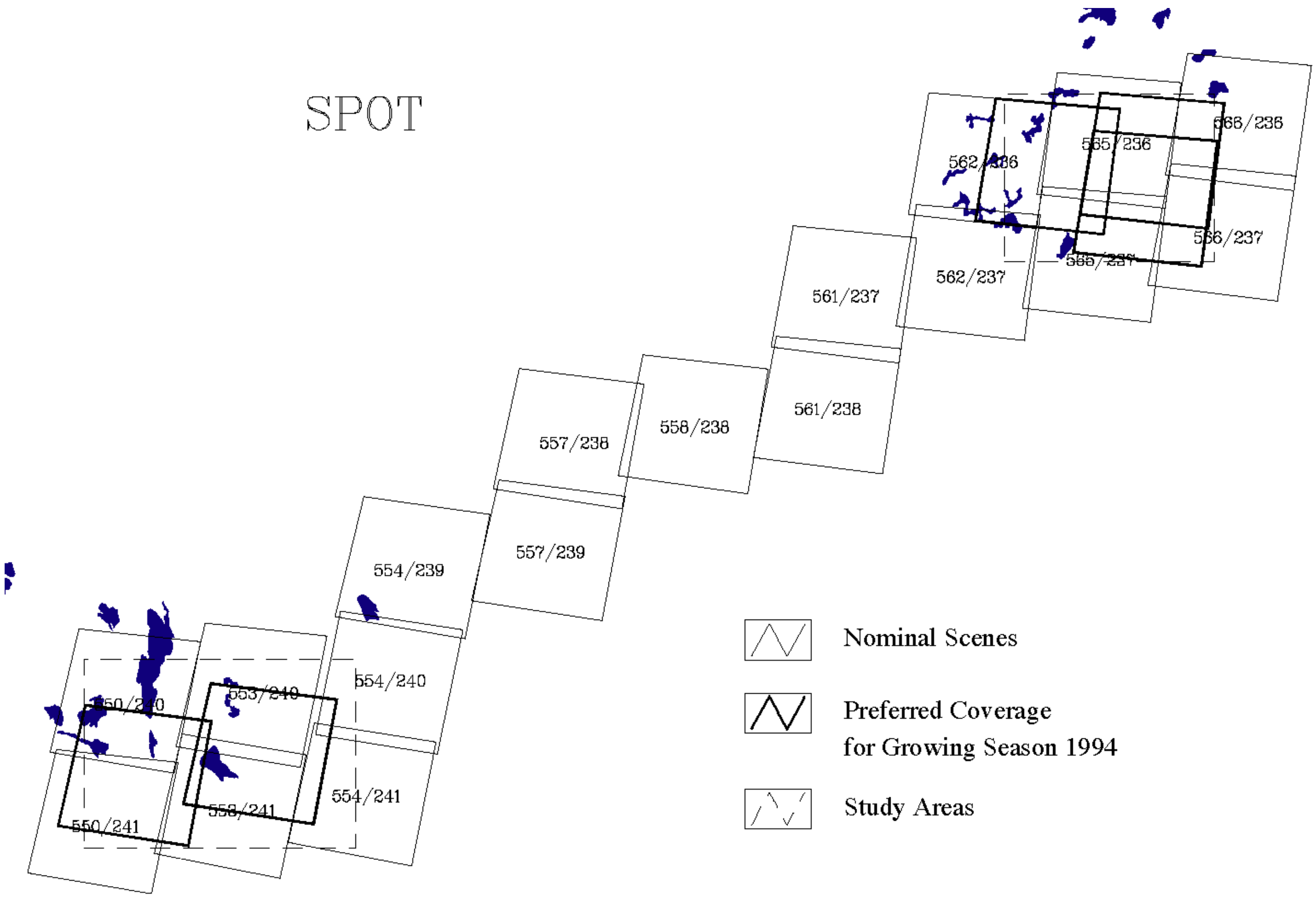


Figure 5.2.4: Arrangement of Landsat and SPOT scenes in the BOREAS Region

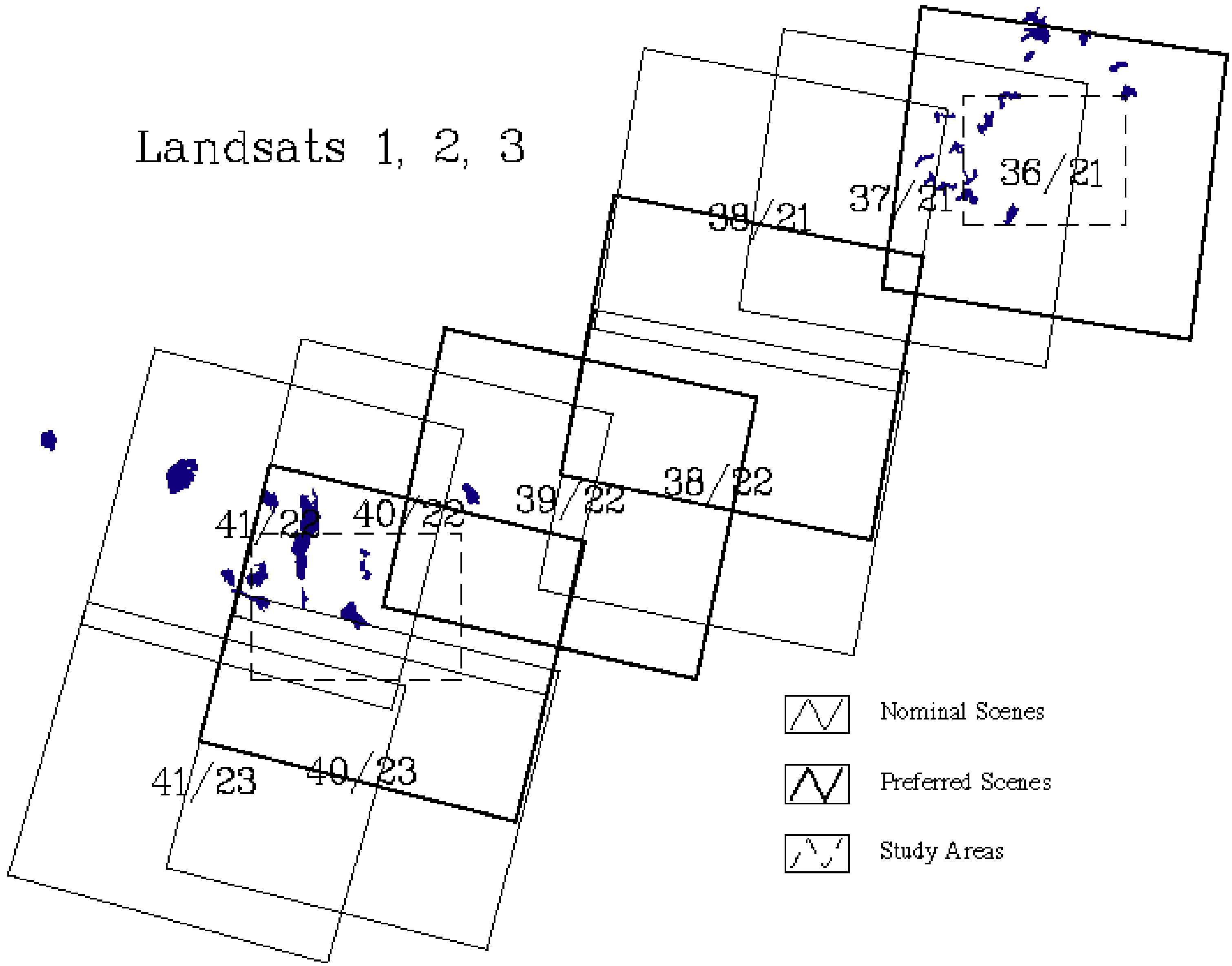


Figure 5.2.4: Arrangement of Landsat and SPOT scenes in the BOREAS Region (cont)

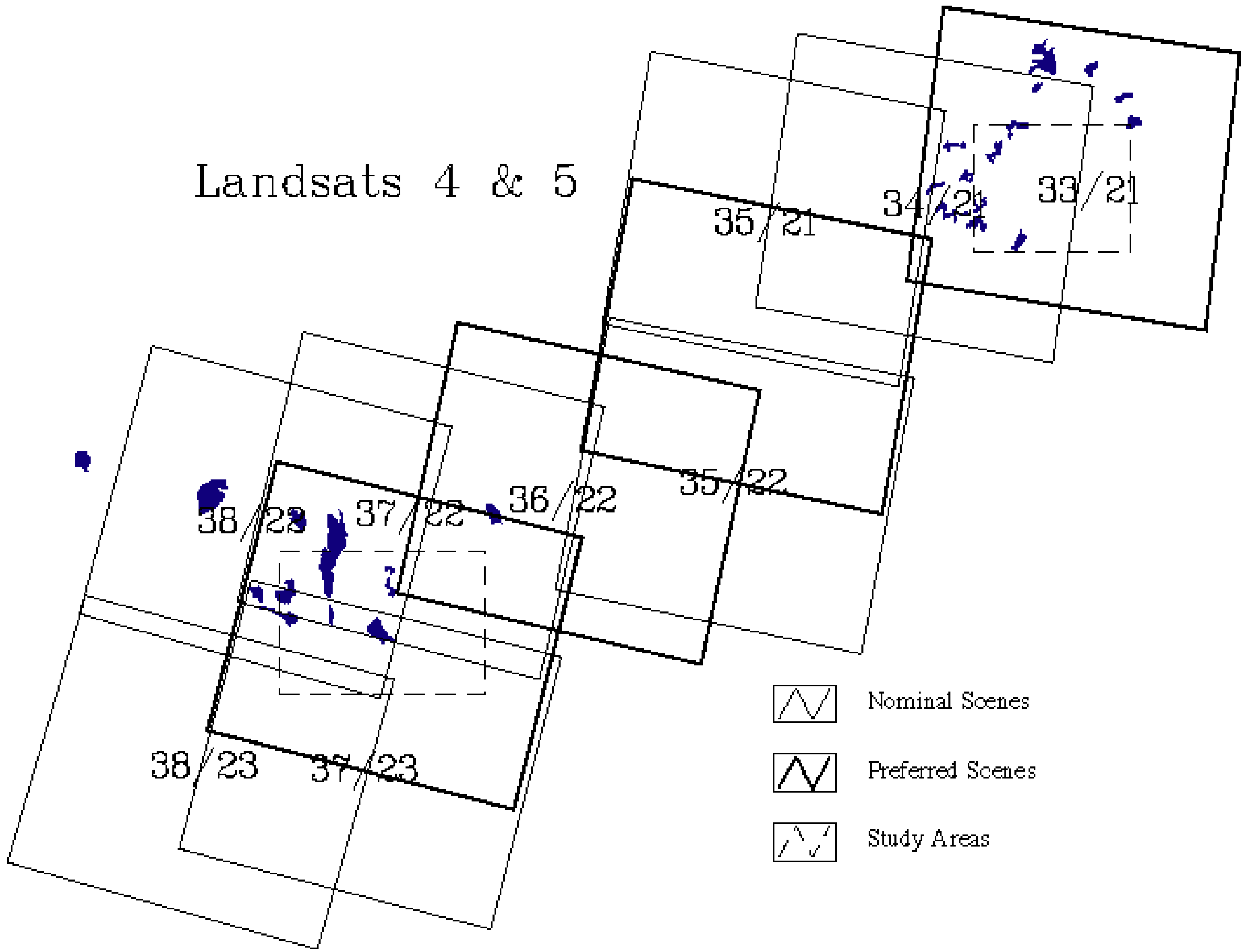


Figure 5.2.4: Arrangement of Landsat and SPOT scenes in the BOREAS Region (cont)

5.3 Experiment Operations

Table 2.2 is reproduced here as Table 5.3 for an easy reference to the timing and scope of the field campaigns. Each of the field campaigns is addressed in turn in the following sections.

Table 5.3
Dates, durations, activities and aircraft associated with BOREAS field campaigns.

	Start Date	End Date	Duration (days)	Activities	Aircraft
IFC -93	8/9/93 221	8/29/93 241	21	Shakedown	DC-8, LongEZ
FFC-W	2/1/94 32	2/18/94 49	18	Snow hydrology and remote sensing ~ 10 teams.	ER-2, Chieftain, Aerocommander, Twin Otter (M)
FFC -T	4/12/94 102	5/2/94 122	21	Thaw hydrology and remote sensing ~25 teams.	DC-8,ER-2, C-130, CV-580 Chieftain
IFC-1	5/24/94 144	6/16/94 167	24	Maximum effort. All field teams.	DC-8, ER-2, C-130, Helo, Chieftain Flux Aircraft (4)
IFC-2	7/19/94 200	8/8/94 220	21	Maximum effort. All field teams.	DC-8, ER-2, C-130, Helo, Chieftain, CV-580, DC-3 Flux Aircraft (4) Aerocommander.
IFC-3	8/30/94 242	9/19/94 262	21	Maximum effort Most field teams.	DC-8, ER-2, C-130, Helo, Chieftain Flux Aircraft (4) Aerocommander

5.3.1 IFC-93

Dates/Duration: 8/9/93-8/29/93 (21 days)

This IFC was used to shakedown experiment equipment, communications, infrastructure and operational procedures. The participating teams and staff are shown in Table 5.3.1a. Aircraft availability is shown in Table 5.3.1b together with significant satellite overpass opportunities and mission manager basing (hot site).

Table 5.3.1a Teams Participating in IFC-93

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM	XX			E	XX	PR	PA			D													
TF	O	O	XX	XX	XX			XX	XX	XX	XX												
TE	XX	XX	T		VI	XX	XX	XX	VI	XX	XX	XX	XX		XX	VI		VI		XX			XX
TGB	SE	D	SE	SE	SE	PR			XX	XX	D	PR											
HYD	XX		VI	VI			D	XX	XX														
RSS	XX		VI	XX	VI		XX				PR	PR			XX	XX	SE	XX					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Key

XX Full Participation
D Deleted
E Performed test work in May 1993
O Experiment started up in October 1993
PA Experiment partly running
PR Preliminary run
SE Experiment being set up
T TE-3 transfered to TGB-12
VI Team visits site

Table 5.3.1b: Overview of IFC '93 (August 1993)

Date (Aug 93) **Day of Year**	9 221	10 222	11 223	12 224	13 225	14 226	15 227	16 228	17 229	18 230	19 231	20 232	21 233	22 234	23 235	24 236	25 237	26 238	27 239	28 240	29 241
Landsat																					
SSA					X							X	X								
TW						X															X
TE														X	X						
NSA	X						X	X								X	X				
SPOT																					
SSA	X	X				X	X				X	X	X	X		X	X	X			X
NSA	X	X	X	X		X	X	X	X			X	X	X			X	X	X		
Choice																					
RS Aircraft																					
C-130																					
DC-8	•	•	•	•	•	•															
CV-580																					
Twin Otter (M)																					
ER-2																					
Aerocommander																					
Helicopter																					
Flux Aircraft																					
Electra																					
Twin Otter (F)																					
King Air																					
Long-EZ																					
Mission Manager																					
SSA								-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSA	-	-	-	-	-	-	-	-	-	-	-	-	-								

5.3.2 FFC-W

Dates/Duration: 2/1/94 - 2/18/94 (18 days)

This FFC was focused on snow hydrology and the remote sensing of snow. A series of airborne remote sensing missions was executed with coordinated sampling of snow depths and properties in these areas. Table 5.3.2a shows the participating teams and staff. Table 5.3.2b shows the schedule for the FFC.

Operations were based at:

SSA	2/1-18/94	Prince Albert Inn
NSA	2/6-16/94	Thompson Inn

Meetings were to be held at these places every evening at around 2000, to organize the next days ground and flight activities. These meetings were also used to complete the days log of activities and perform the final 'check-in' from the field for teams that had been out on ground sample work.

The FFC-W began in the south, and ended up in the north, in an attempt to catch cold, dry snow at both sites.

Snow Measurement Coordination: On Thursday and Friday, Feb. 3-4, there was a meeting in the SSA of all groups involved in measurement of snow properties (e.g. depth, density, SWE, temperature, grain structure, size, and shape, reflectance, and liquid water content), to compare methods, discuss techniques, and calibrate different instruments. This was to ensure that snow measurements made by different groups are comparable.

Equipment Coordination: John Metcalfe (416-739-4354) was the contact for information regarding rental of snow-mobiles at both the SSA and NSA. John suggests possibly hiring a local as a guide for snowmobile transportation, as most of the locals have time on their hands during winter.

Contact Terry Ridgeway (519-885-1211) for information regarding rental of skis, snow shoes, etc., at either SSA or NSA.

No "extra" snow sampling equipment, such as tubes, cutters, scales, etc. is available for the FFC-W for groups to use, so they should make arrangements to bring their own.

Tower Data:

Meteorological and other data collected at the TF sites will be very important during FFC-W. These data are considered a priority and should be collected at at least one tower site in both the NSA and SSA during FFC-W.

Sample site coordination around the TF sites is very important. You must contact the tower captain before you sample near a TF site during FFC-W, even if that tower is not being operated at the time. Disturbing the snowcover will impact TF activities later in the year, and must be accounted for.

Table 5.3.2a Teams Participating in FFC-W

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM				XX			XX			D													
TF	XX	XX	XX																				
TE																							
TGB		D									D	1W											
HYD		XX	XX	XX	XX	XX	D		XX														
RSS														A	1W	XX	XX	XX	XX				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Key

XX Full Participation
D Deleted
E Performed test work in May 1993
O Experiment started up in October 1993
PA Experiment partly running
PR Preliminary run
SE Experiment being set up
T TE-3 transfered to TGB-12
VI Team visits site

Table 5.3.2b: Overview of FCC-W (February 1994)

Date (Feb 94) **Day of Year**	1 32	2 33	3 34	4 35	5 36	6 37	7 38	8 39	9 40	10 41	11 42	12 43	13 44	14 45	15 46	16 47
Landsat																
SSA						X										
TW															X	
TE								X								
NSA										X						
SPOT																
SSA	X					X			X		X	X		X		X
NSA	X		X			X		X	X		X	X	X	X		X
Choice		X		X	X		X			X					X	
RS Aircraft																
C-130																
DC-8																
CV-580																
Twin Otter (M)		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
ER-2																
Chieftain	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-3																
Aerocommander					•	•	•	•	•	•	•	•				
Helicopter																
Flux Aircraft																
Electra																
Twin Otter (F)																
King Air																
Long-EZ																
Mission Manager																
SSA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSA							-	-	-	-	-	-	-	-	-	-

5.3.3 FFC-T

Dates/Duration: 4/12/94 - 5/2/94 (21 days)

FFC-T

The FFC-T will concentrate on two scientific issues:

(i) Remote sensing of snow-covered forest areas and thawed areas within the SSA, the NSA and along a transect aligned with the AFM (FE-ET) regional transect. (This remote sensing transect is covered under RX-RT in C-130 flight plans, section 5.2.1.1.4) The aircraft operations involved are covered below. Some correlative ground measurements will be made; see TE, HYD and RSS sections below.

(ii) Measurement of energy and trace gas exchange over thawing and thawed areas. Most activities will start up toward the end of the FFC although some work will run through the entire campaign.

Mission management will start at the SSA where the aircraft (DC-8, C-130, CV-580 and Chieftain) will be based to start with, moving to the NSA toward the end of the FFC. The following operations priorities have been set:

(i) If on 4/6/94, there is little or no snow at the NSA or SSA, the C-130 and Chieftain deployments will be cancelled.

(ii) The first priority for the optical aircraft (C-130, Chieftan) are the Category I sites (TF and carbon flux sites) in the SSA. (Category I sites in the SSA where RSS-1 is working (Deering PARABOLA) are highest priority). Second priority for both aircraft are the Category I sites in the NSA. Third priority (for the C-130) is a mapping survey of either study area. Third priority for the Chieftain is coverage of Category II sites.

(iii) The first BOG meeting will take place on 4/11/94, at:
2000 LT - SSA (Candle Lake Snodrifters Lodge);
2100 LT - NSA (Thompson INCO Training Center)

(iv) Both Study Area HQs (SAHQ's); that is, Snodrifters Lodge-SSA and Keewatin Air-NSA will be open for business during the FFC-T. Both labs (Paddockwood-SSA; 192, Hayes Road-NSA) will be available.

Group activities are summarized below followed by aircraft mission outlines.

AFM

AFM-5: Radiosondes will be released according to the schedule in Table 3.2.2. Over the 21 days of the FFC, there will be 420 regularly scheduled and 252 BOREAS sponsored supplemental launches. Standard data messages will be passed to AES's NCCS and to the GTS. Data will be post-processed by NHRI (Barr) and delivered to BORIS in 1995.

AFM-7: Mesonet Surface Network. This will be operating and delivering data as set out in Section 3.2.1. Data will be passed to GTS every six hours.

TF

TF-1,TF-2: SSA-OA Tower will be operating. Radiation measurements on tramway installed by RSS-1.

TF-3: NSA-OBS Tower will be operating. Some Chamber measurements may also be made.

TE

The TE group will:

(i) Measure fluxes of CO_2, CH_4 from freshly thawed soils after snowmelt in the SSA.
(ii) Take canopy samples for canopy chemistry assays of conifers in the NSA.
(iii) Erect canopy access towers.

TE-1	CO_2, CH_4 flux from soil in SSA (variable timing)
TE-2	Canopy access towers (4/24-29/94)
TE-6	CO2, CH4 flux from soil in SSA (variable timing)
TE-9	Take samples for canopy chemistry (variable timing)
TE-10	CO_2, CH_4 flux from soil in SSA (variable timing)

Flux data will be in mg m^{-2} h^{-1} and will be sent to BORIS by 5/31/94.

TGB

The TGB group participants in FFC-T will measure early season low temperature exchange rates of CO_2, CH_4, N_2O and CO. Concentrations in the soil profile will also be measured.

TGB-l: Set up in NSA lab 5/1/94. Beaver Pond tower and flux measurements of CH_4, CO_2, CO, N_2O, R_n and SF_6 at TF sites and across soil/biological gradients.

TGB-3: Set up in NSA lab 5/1/94. Beaver Pond tower and flux measurements of CH_4, CO_2, CO, N_2O, R_n and SF_6 at TF sites and across soil/biological gradients.

TGB-4: Set up in NSA lab 5/1/94. Beaver Pond tower and flux measurements of CH_4, CO_2, CO, N_2O, R_n and SF_6 at TF sites and across soil/biological gradients.

TGB-5: Arrive 4/20/94, set up DOC lab at KCC, sample water for chemistry and characterize DOC throughout melt/thaw period at NSA beaver pond sites (Tower, Gillam Rd, and OBS).

TGB-8 Set up of measurements rigs.

TGB-12: Continuation of winter exchange program

TE-1, TE-4 and TE-6: CO_2, CH_4 flux measurements at SSA-OJP, SSA-OBS, SSA-Fen, SSA-OA

HYD

The objective of the hydrology group participation in FFC-T is to characterize the state of the hydrologic system at the onset of snowmelt, which will be the initial condition for modeling of the system through the spring/summer IFCs. The large scale modeling activities of HYD-8 and 9, in particular, are dependent on estimates of snow water storage at or near the onset of melt. These estimates will be based on a combination of the surface and remote sensing measurements made during FFC-W and FFC-T, and modeling predictions driven by ongoing surface meteorology measurements.

HYD-3: Measurement of frozen liquid water (snow/ice) in the Moss layer at TF sites. RSS-16 will measure dielectric constants at the same site. Will start in SSA if snow is present and then move to NSA. Point and stand snow depth, water equivalent, and profiles of density grain size and temperature for selected areas in SSA and NSA (to be delivered by 7/94). Snow extinction and reflectance coefficients for airborne remote sensing. Spectral reflectance measurements with ASD-PS II at selected sites. Subcanopy radiance fields at TF sites in NSA and SSA (depending on snow status). Also, spatially distributed/ nterpolated snow characteristic maps to be produced by 12/94. Coordinate with RSS-1 at PARABOLA sites: SSA-OBS, SSA-OJP. Coordinate with RSS-19 at as many sites as possible.

HYD-5: Measurement of surface energy and CO_2 fluxes at two sites (lake and black spruce) near south boundary of SSA. Energy, moisture, and

CO_2 fluxes at hourly time steps for selected days Data delivery date unknown.

HYD-9: Installation of stream gauges and precipitation gauges in SSA and NSA. Will start on 4/15/94 in SSA and move to NSA on 4/15/94. Thereafter, one member of team (Kouwen) will remain in NSA through mid-summer, another team member (Ridgeway) will stay in SSA. Hourly precipitation at 22 gauges in SSA and NSA, and hourly streamflow for 6 gauges in NSA and SSA. Target for delivery of precipitation data is around 2 months from date of collection.

RSS

The RSS participation will be strongly driven by the aircraft remote sensing work planned for FFC-T, see next section. The goal is to obtain:

(i) Optical multiangle, multispectral data over the Category I sites in the SSA and NSA with additional measurements over Category II sites (CASI) or mapping surveys (C-130).
(ii) SAR data over the Category I sites and surrounding areas.
(iii) Supporting ground measurements of surface/canopy/snow dielectric properties.

RSS-1: PARABOLA measurements in SSA. Priorities are SSA-OBS and SSA-OJP. TF-1 and TF-2 will conduct radiation tramway measurements at SSA-OA.

RSS-2: C-130 (RC) ASAS and NS001 measurements coordinated with RSS-1 and HYD-3. Obtain BRDF measurements over forest with snow-covered ground. Ten hours of flight time have been budgeted.

RSS-11: Handheld sunphotometer measurements at SSA: Mary Dalman/Paula Pacholek; NSA: Jo Lutley. Automated instruments to be outfitted and calibrated at NASA/GSFC for later deployment.

RSS-15: Support DC-8 (RD) and CV-580 (RV) overflights. Take field measurements of canopy properties to validate biomass mapping algorithms near SSA-YJP. DBH, height, surface roughness, soil moisture, moss/lichen characteristics. Establish transects for helicopter scatterometer missions.

RSS-16: Support DC-8 flights, deploy corner reflectors in SSA. Sample soil moisture, canopy water content.

RSS-17: Support DC-8 and SIR-C flights. Measure soil dielectrics, temperature, 26-hour canopy water potential.

RSS-18: ER-2 (RE) overflights scheduled over SSA, NSA and AFM transect.

RSS-19: Support Chieftain (RP) flights at NSA and SSA and on selected transect lines. Ground measurements of understory spectral characteristics using an SE-590 following RSS-7 LAI sample lines. Snow physical properties.

Aircraft Operations

The aircraft participating in FFC-T are:

C-130 (RC): Equipped with NS001 and ASAS optical scanners
Chieftain (RP): Equipped with CASI optical imager
DC-8 (RD): Equipped with SAR
CV-580 (RV): Equipped with SAR

Operations to be conducted by each aircraft are reviewed below.

C-130 (RC)

Basing: Prince Albert (YPA) or Saskatoon (YXE)

SSA Missions: Altitude 17,500' AGL

RC-SS If snow: Old Black Spruce ASAS SPP, OBL, PERP BRDF
Old Jack Pine ASAS SPP, OBL, PERP BRDF
Old AspenASAS SPP, OBL, PERP BRDF
White Gull Lake ASAS SPP, OBL
NS001 may acquire data on these lines.

ASAS to Coordinate with RSS-1 (PARABOLA) and HYD-3 (CASI)

Contingency RC-MS (If conditions in NSA are not favorable)
NS001 coverage within modeling sub-area - flightlines parallel to SPP (at time of mid-mission)
Spacing between flightlines = 5 km
Altitude: 25,000' AGL

NSA Missions: Altitude 17,500' AGL

RC-SN (if snow) Old Black Spruce ASAS SPP, OBL, PERP BRDF
Fen ASAS SPP, OBL, PERP BRDF
Old Jack Pine ASAS SPP, OBL, PERP BRDF

Young Jack Pine ASAS SPP, OBL, PERP BRDF
Birch Tree Lake just west of Thompson Air strip SPP, OBL BRDF
NS001 may acquire data on these lines.

Contingency RC-MN (If conditions in SSA are not favorable)
NS001 coverage within modeling sub-area - flightlines parallel to SPP (at time of mid-mission)
Spacing between flightlines = 5 km
Altitude: 25,000' AGL

<u>Chieftain (RP)</u>

Basing: 4/11-20/94 at YPA; transect flight to YTH;
4/20-?/94 base at YTH

Flight Plans: Altitude: 5500' agl., 2000'agl., 500'agl

(i) RP-TS Tower/Aux Sites - multi view and nadir imagery
Priority (Hi-to-Low): OBS, OJP, OA, White Gull Cal. Site, YJP, Fen, priority aux sites
Coordination with Deering (PARABOLA) once with ASAS on one tower site and on White Gull Lake calibration site

(ii) RP-TN - Tower Aux Sites. multi-view and nadir imagery
Priority (Hi-to-Low): OBS, OJP, OA, small lake just west or airstrip, YJP, Fen, priority aux sites

(iii) RP-RT: Spatial Mode Nadir Imagery.
RSS Transect .(Modified AFM Transect) AR-HR-KR-LR-MR-OR to be flown at 10,000 ft AGL to give 2 km swath.
Add Flin Flon aux sites on transect

<u>DC-8 (RD) and CV-580 (RV)</u>:

Basing: DC-8 at YXE;
CV-580 at YXE

Aircraft Instruments:
- DC-8 JPL AIRSAR C-, L-, P- band quadpolarization synthetic aperture radar
CV-580 CCRS SAR X- or C- band HH, VV, HV polarization
X-band HH, VV for BOREAS

Flightlines:

DC-8	1 RD-MS Modeling Grid South
	1 RD-MN Modeling Grid North
	1 RD-RT AFM-Transect and Aux Sites
	2 RD-BS Baseline South
	2 RD-BN Baseline North
	1 RD-DS Diurnal South
	1 RD-IS Incidence Angle South (25°)
CV-580	1 RV-BS Baseline South
	1 RV-BN Baseline North
	1 RV-RT AFM Transect and Aux sites

Coordination: DC-8 and CV-580 to fly similar flight lines for BS, BN and RT flights. TF sites to be illuminated at 43° by both radars. RT flights will be flown parallel to AFM transect (Fig. 5.2.1.10.4a) with 2 km offset to west (see figure 5.2.1.1.4).

FFC-T overlaps with SIR-C/XSAR shuttle mission. Current plans call for DC-8 overflight of SSA, NSA on 4/15/94 and/or 4/16-17/94 to underfly SIR-C/XSAR. DC-8 to return for BOREAS deployment on 4/20/94 and stay through 4/29/94. CV-580 will begin flights on 4/15/94 and continue through 4/22/94, if possible.

Table 5.3.3a shows the participating scientists and staff. Table 5.3.3b shows the schedule for the FFC.

Table 5.3.3a Teams Participating in FFC-T

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM					XX		XX			D													
TF	XX	XX	XX																				
TE	LW	LW	T			LW			LW	LW	LW											LW	
TGB	LW	D	LW	LW	XX			SE			D	XX											
HYD			XX		XX		D		XX														
RSS	XX	XX									XX			A	XX	XX	XX	XX	XX				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

	Key
XX	Full Participation
D	Deleted
A	Aquired GOES data
SE	Experiment being set up
T	TE-3 transfered to TGB-12
VI	Team visits site

Table 5.3.3b: Overview of FFC-T (provisional) (April-May 1994)

Date (Apr 94) Day of Year	12 103	13 104	14 105	15 106	16 107	17 108	18 109	19 110	20 111	21 112	22 113	23 114	24 115	25 116	26 117	27 118	28 119	29 120	30 121	1 122	2 123
Landsat																					
SSA																X					
TW									X												
TE		X																X			
NSA				X																X	
SPOT																					
SSA	X		X		X	X		X		X	X		X		X	X		X		X	X
NSA	X		X		X	X		X		X	X		X		X	X		X		X	X
Choice		X		X			X		X			X		X			X		X		
RS Aircraft																					
C-130	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-8						•			•	•	•	•	•	•	•	•	•	•	•		
CV-580				•	•	•	•	•	•												
Twin Otter (M)																					
ER-2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Chieftain	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
DC-3																					
Aerocommander																					
Helicopter																					
Flux Aircraft																					
Electra																					
Twin Otter (F)																					
King Air																					
Long-EZ																					
Mission Manager																					
SSA	-	-	-	-	-	-	-	-	-	-	-	-	-								
NSA								-	-	-	-	-	-	-	-	-	-	-	-	-	-

5.3.4 IFC-1

Dates/Duration: 5/24/94 - 6/16/94 (24 days)

This IFC is the first of the full-up IFCs with the larger part of BOREAS investigators and aircraft participating. It will be focused on the 'green-up' of the deciduous foliage and the increase in photosynthesis and respiration of the late spring. Full details may be found in Chapters 3 and 4.

Table 5.3.4a lists the participants. Table 5.3.4b shows the schedule for the IFC

Table 5.3.4a Teams Participating in IFC-1 94

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM	XX	XX	XX	XX	XX	PR	XX	XX		D			XX										
TF	XX	XX	XX	XX	XX		XX	XX	XX	XX	XX												
TE	XX	XX	T	XX	XX	XX	XX	XX	XX	XX		XX	XX		XX								XX
TGB	XX	D	XX	XX	XX	XX		XX	XX	XX	D	XX											
HYD	XX						D	XX	XX														
RSS	XX	XX	XX			XX	XX			XX	XX	XX	XX	A	PA	XX	XX	XX	XX	XX			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Key

XX	Full Participation
D	Deleted
E	Performed test work in May 1993
O	Experiment started up in October 1993
PA	Experiment partly running
PR	Preliminary run
SE	Experiment being set up
T	TE-3 transfered to TGB-12
VI	Team visits site

Table 5.3.4b: Overview of IFC-1 (provisional) (May-June 1994)

Date (May 94) **Day of Year**	24 144	25 145	26 146	27 147	28 148	29 149	30 150	31 151	1 152	2 153	3 154	4 155	5 156	6 157	7 158	8 159	9 160	10 161	11 162	12 163	13 164	14 165	15 166	16 167
Landsat																								
SSA						X																X		
TW															X									
TE								X																X
NSA										X														
SPOT																								
SSA	X	X		X	X		X		X	X		X		X	X			X	X	X	X	X	X	X
NSA	X	X		X	X	X	X		X	X		X		X	X		X		X	X	X	X		X
Choice			X					X			X		X			X								
RS Aircraft																								
C-130	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-8															•	•	•	•	•	•	•	•	•	•
CV-580																								
Twin Otter (M)																								
ER-2	b	b•	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Chieftain	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-3																								
Aerocommander																								
Helicopter	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Flux Aircraft																								
Electra	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Twin Otter (F)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
King Air	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Long-EZ	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Mission Manager																								
SSA	-	-	-	-	-	-	-	-	-	-	-	-	-	-										
NSA									-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

b = ER-2 backup flight from FFC-T
NOTE: DC-8 will fly one day in period 6/6-16/94 from NUQ

5.3.5 IFC-2

Dates/Duration: 7/19/94 - 8/8/94 (21 days)

This IFC is focused on the peak photosynthesis and respiration rates of mid-summer. Full details may be found in Chapters 3 and 4. Table 5.3.5a lists the participants. Table 5.3.5b shows the schedule for the IFC.

Table 5.3.5a Teams Participating in IFC-2 94

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM	XX	XX	XX	XX	XX	PR	XX	XX		D			XX										
TF	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX												
TE	XX	XX	T	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX		XX				XX	XX	XX	XX	
TGB	XX	D	XX	XX	XX	XX		XX	XX	XX	D	XX											
HYD	XX					XX	D	XX															
RSS	XX	XX	XX				XX			XX	XX	XX	XX	A	XX	XX	XX	XX	XX	XX			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Key

XX	Full Participation
D	Deleted
E	Performed test work in May 1993
O	Experiment started up in October 1993
PA	Experiment partly running
PR	Preliminary run
SE	Experiment being set up
T	TE-3 transfered to TGB-12
VI	Team visits site

Table 5.3.5b: Overview of IFC-2 (provisional) (July-August 1994)

Date (Jul 94) **Day of Year**	19 200	20 201	21 202	22 203	23 204	24 205	25 206	26 207	27 208	28 209	29 210	30 211	31 212	1 213	2 214	3 215	4 216	5 217	6 218	7 219	8 220
Landsat																					
SSA														X							
TW							X														
TE																X					
NSA		X																X			
SPOT																					
SSA			X	X	X			X	X	X	X		X	X	X	X		X	X	X	X
NSA	X	X		X	X	X	X		X	X	X	X		X	X	X	X		X	X	X
Choice																					
RS Aircraft																					
C-130	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-8						•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CV-580							•	•	•	•											
Twin Otter (M)																					
ER-2	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Chieftain	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
DC-3	•	•	•	•	•	•	•	•	•	•											
Aerocommander									•	•	•	•	•	•	•	•	•	•	•	•	•
Helicopter	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Flux Aircraft																					
Electra	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Twin Otter (F)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
King Air	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Long-EZ	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Mission Manager																					
SSA	-	-	-	-	-	-	-	-	-	-	-	-	-								
NSA									-	-	-	-	-	-	-	-	-	-	-	-	-

5.3.6 IFC-3

Dates/Duration: 8/30/94 - 9/19/94 (21 days)

This IFC is focused on the decrease in photosynthesis and changes in respiration of the late summer. Full details may be foundin Chapters 3 and 4. Table 5.3.6a lists the participants. Table 5.3.6.b shows the schedule for the IFC.

Table 5.3.3a Teams Participating in IFC-3 94

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM	XX	XX		XX	XX	PR	XX	XX		D			XX										
TF	XX	XX	XX	XX	XX			XX	XX	XX	XX												
TE	XX	XX	T	XX	XX	XX	XX	XX	XX	XX	VI	XX	XX		XX								
TGB	XX	D	XX	XX	XX	XX		XX	XX	XX	D	XX											
HYD	XX					XX	D	XX	XX														
RSS	XX	XX	XX				XX			XX	??	XX	XX	XX		XX	XX	XX	XX	XX			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Key

XX	Full Participation
D	Deleted
E	Performed test work in May 1993
O	Experiment started up in October 1993
PA	Experiment partly running
PR	Preliminary run
SE	Experiment being set up
T	TE-3 transfered to TGB-12
VI	Team visits site

Table 5.3.6b: Overview of IFC-3 (provisional) (August-September 1994)

Date (Aug 94) **Day of Year**	30 144	31 104	1 105	2 106	3 107	4 108	5 109	6 110	7 111	8 112	9 113	10 114	11 115	12 116	13 117	14 118	15 119	16 120	17 121	18 122	19 123
Landsat																					
SSA				X																X	
TW													X								
TE						X															
NSA								X													
SPOT																					
SSA			X	X	X		X	X	X			X	X	X				X	X		
NSA			X	X	X			X		X			X	X	X	X			X	X	X
Choice																					
RS Aircraft																					
C-130	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-8	•	•	•	•	•	•	•														
CV-580																					
Twin Otter (M)																					
ER-2	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Chieftain		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
DC-3																					
Aerocommander	•	•	•	•	•	•	•	•	•	•	•	•	•								
Helicopter	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Flux Aircraft																					
Electra	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Twin Otter (F)	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
King Air	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Long-EZ	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Mission Manager																					
SSA									-	-	-	-	-	-	-	-	-	-	-	-	-
NSA	-	-	-	-	-	-	-	-	-	-	-	-	-								

b = ER-2 back-up flight from IFC-2
Note: DC-8 will fly one day during period 8/30-9/6 /94 from NUQ

Notes

Notes