UNSTABLE

The UNderstanding Severe Thunderstorms and Alberta Boundary Layers Experiment

2008 Pilot Experiment Operations Plan

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List of Abbreviations

AERI	Atmospheric Emitted Radiance Interferometer
AHP	Alberta Hail Project
AIMMS	Aircraft Integrated Meteorological Measurement System
AIRMET	Airman's Meteorological Information
ALHAS	Alberta Hail Studies
AMDAR	Aircraft Meteorological Data Reporting
AMMOS	Automated Mobile Meteorological Observation System
ATMOS	Automated Transportable Meteorological Observation System
BAQS-Met	Border Air Quality Study – Meteorological Measurements
CaPE	Convection and Precipitation/Electrification Experiment
CAPE	Convective Available Potential Energy
CBL	Convective Boundary Layer
CEOS	Centre for Earth Observation Science
CI	convective initiation
CIN	Convective Inhibition
CINDE	Convection Initiation and Downburst Experiment
CLASS	Canadian Land Surface Scheme
CLDN	Canadian Lightning Detection Network
CMAC-W	Canadian Meteorological Aviation Centre – West
CMOS	Canadian Meteorological and Oceanographic Society
CPSWRS	Cloud Physics and Severe Weather Research Section
CRD	Climate Research Division
EC	Environment Canada
ELBOW	Effects of Lake Breezes on Weather
ET	Evapotranspiration
FCA	Foothills Climate Array
FOPEX	Foothills Orographic Precipitation Experiment
GEM	Global Environmental Multiscale
GPS	Global Positioning System
HAL	Hydrometeorology and Arctic Lab
IHOP	International H_2O Project
IOD	Intensive Observation Day
IOP	Intensive Observation Period
LAM	Limited Area Model
LCL	Lifted Condensation Level
LFC	Level of free convection
LIMEX	Limestone Mountain Experiment
MARS	Mobile Atmospheric Research System
MOCISE	Mesoscale Observations of Convective Initiation and Supercell Experiment
MPC	Mountain-Plain Circulation
MRD	Meteorological Research Division
NALDN	North American Lightning Detection Network
NRC	National Research Council
NWP	Numerical Weather Prediction
OPP	Outcome Project Plan
PASPC	Prairie and Arctic Storm Prediction Centre
PI	Principal Investigator
PW	Precipitable Water
QC	Quality Control
RSD	Research Support Desk
SIGMET	Significant Meteorological Information
STEPS	Severe Thunderstorm Electrification and Precipitation Study
UAV	Unmanned Aerial Vehicle
UNSTABLE	Understanding Severe Thunderstorms and Alberta Boundary Layers Experiment
UTC	Coordinated Universal Time
VORTEX	Verification of the Origins of Rotation in Tornadoes Experiment
WMI	Weather Modification Incorporated

1: Introduction

The Understanding Severe Thunderstorms and Alberta Boundary Layers Experiment (UNSTABLE) is a field study designed to improve understanding of processes leading to convective initiation (CI) and severe thunderstorm development over the Alberta foothills. Details on the rationale and science objectives of UNSTABLE are available in the scientific overview document (Taylor et al. 2007). The field component of UNSTABLE is designed in two parts, a pilot field study in 2008 (described in this document) and the full-scale experiment in 2011. The purpose of the pilot project is to test critical instrumentation and measurement strategies to answer the UNSTABLE science questions outlined in the scientific overview document. Results from the pilot project will be used to refine the science overview and operations plan for the full-scale project in 2011.

This document outlines the operational details of the UNSTABLE 2008 pilot experiment and includes information on instrumentation used, measurement strategies to be tested, field coordination of mobile teams, forecast / nowcast support to the field campaign, and plans for daily operations.

1.1: Summary of UNSTABLE Science Objectives

Through UNSTABLE we ultimately aim to improve the accuracy and timeliness of summertime severe weather watches and warnings, assess the ability of the GEM LAM to resolve relevant processes and provide useful numerical guidance, and refine existing conceptual models for CI and severe thunderstorm development over Alberta and the western Canadian prairies. UNSTABLE has been designed to address three main science questions and a number of sub-questions associated with convective initiation and severe storm development. The science questions fall under three research areas with leads identified for each. The main science questions and associated sub-questions are included here. Additional questions to be considered are found in the UNSTABLE scientific overview document (Taylor et al. 2007).

<u>Atmospheric Boundary Layer (ABL) Processes</u> *(Neil Taylor and David Sills)*
Science Question 1: What are the contributions of ABL processes to the initiation of deep moist convection and the development of severe thunderstorms in the Alberta Foothills region?

a. What is the 4-dimensional characterization of ABL water vapour through the diurnal mixing process and prior to / during CI?
b. What role do mesoscale boundaries and circulations (e.g., mountain-plain circulation, dryline or other convergence boundaries, horizontal convective rolls) play in CI, the development of severe thunderstorms, and their evolution?
c. What is the 4-dimensional characterization of the dryline, and how often is it a key factor in the development / evolution of severe thunderstorms?
d. What synoptic / mesoscale processes act to inhibit CI in the region?
e. Are existing conceptual models for CI and severe thunderstorm development / evolution in this region adequate?

<u>Land Surface Interactions</u> *(John Hanesiak)*
Science Question 2: What are the contributions of surface processes to the initiation of deep moist convection and the development of severe thunderstorms in the Alberta Foothills region?

a. Are there detectable gradients of surface (and ABL) water vapour across the major wet/dry areas over the cropped region (as quantified by root-zone soil moisture)?
b. Are there detectable gradients of water vapour between cropped land and forested areas?
c. Is there a noticeable difference in the location and timing of CI with respect to wet and dry areas over the cropped region?

d. Are mesoscale circulations detectable between areas of contrasting root-zone soil moisture or vegetation type?
e. Under what conditions are mesoscale circulations (land breezes) observed to trigger deep convection?

Numerical Weather Prediction *(Jason Milbrandt)*
Science Question 3: To what extent can high-resolution numerical weather prediction models contribute to forecasting the initiation and development of severe convective storms that originate in the Alberta foothills?

a. What defines a "success" for a high-resolution simulation in terms providing useful numerical guidance from the current GEM-LAM configuration?
b. Can the atmospheric state be classified a priori as "predictable" or "non-predictable" in terms of recommended use of the GEM-LAM run to guide the forecast?
c. How realistic are the simulated storm structures and microphysical fields?
d. How realistic is the evolution of the boundary layer and surface processes in the foothills region for the high-resolution model simulations?
e. What would be the effect of performing a subsequent nest to a higher-resolution grid, driven from the 2.5-km GEM-LAM run?
f. Can an ensemble of high-resolution runs improve the prediction of convection?

2: Operations Overview

The UNSTABLE 2008 pilot study is smaller in scope than the full-scale experiment described in the scientific overview document. The pilot will be used as a means to test numerous aspects of UNSTABLE experimental design and will include nearly all the instrument platforms planned for use in 2011. The main reductions to the field program in 2008 consist of a shorter intensive observation period (IOP), the installation of only 5 ATMOS[1] mesonet stations, only two mobile radiosonde systems, and a limited aircraft campaign using only the Weather Modification Inc. (WMI) instrumented Cheyenne II for pre-storm flights. Details of UNSTABLE 2008 operations are provided in the remaining sections of this document.

2.1: UNSTABLE Domains

The experimental domains for UNSTABLE 2008 remain unchanged from those discussed in the scientific overview. Figure 1 shows a general map of the primary and secondary UNSTABLE domains, the field operations coordination center located at Olds-Didsbury airport, and towns in the area. The domains were selected to coincide with climatologically active areas of severe thunderstorm development, suitable road networks, and to make use of existing surface station and radar networks (Taylor et al. 2007).

[1] Automated Transportable Meteorological Observation System

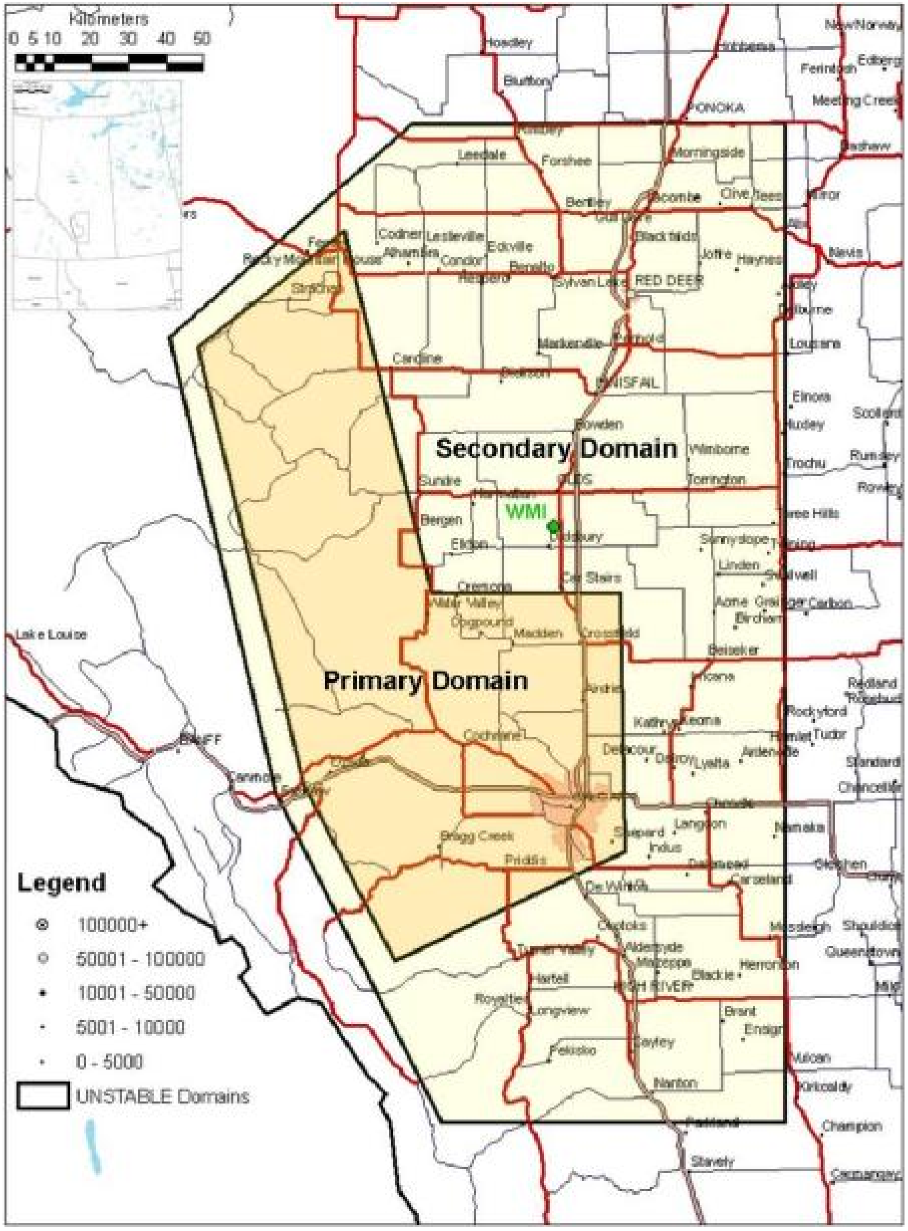

Figure 1: General map showing the primary and secondary UNSTABLE domains and field coordination headquarters at the Weather Modification Incorporated (WMI) facility located at Olds-Didsbury airport.

2.2: Field Schedule

The UNSTABLE 2008 study period will run from 15 June to 15 August. For this two month duration, special surface observations taken from fixed ATMOS stations (see Figure 5) will be integrated with existing observation networks. A 15-day Intensive Observation Period (IOP) will run from 9-23 July during which time targeted mobile surface and upper-air observations will augment the surface observations. During the second half of June 2008 testing of fixed and mobile instrumentation and communications will occur prior to the start of the IOP. Forecast and nowcast support from the Prairie and Arctic Storm Prediction Center – Edmonton (PASPC-Edm) is expected to commence on 7 July and continue until the end of the IOP. Eight intensive observation days (IODs) will be planned during the 15-day IOP. To satisfy the objectives of the UNSTABLE 2008 pilot multiple sampling strategies will be tested for each mission. Plans have been made for aircraft missions on only a subset (four) of these IODs best satisfying the IOD criteria and the interests of the principal investigators. Field personnel will be on standby for the duration of the 15-day IOP.

2.3: Instrumentation Overview

Instrumentation to be deployed for the UNSTABLE 2008 field campaign will consist of a variety of fixed and mobile surface and upper-air date collection platforms as listed in Table 1. Details on instrumentation and measurement strategies for the UNSTABLE 2008 IOP are given in chapters 3 and 4.

Table 1: List of special instrumentation to be used in the UNSTABLE 2008 field campaign.

Parameter(s)	Mobility	Instrument	Owner	Comments
Surface Measurements				
T, T_d, Wind, P, PCPN, RAD, ΔT (9.5 m-0.5 m)	Fixed	5 x ATMOS	EC - CPSWRS	
1m T, T_d, P, PCPN 2m wind	Fixed	3 FOPEX Station	EC - CRD	No pressure at one FOPEX station
T, T_d, PCPN	Fixed	~200 FCA	U of C	FCA stations within study area
T, T_d, Wind, P, PCPN	Fixed	3 FCA	U of C	
T, T_d, Wind, P	Mobile	Airmar Wx Sensor (MARS)	U of M - CEOS	
T, T_d, Wind, P, lightning	Mobile	AMMOS	EC - CPSWRS	
T, T_d, P	Mobile	Mobile Wx Station	G. Strong	No wind data
T, T_d, Wind, P	Mobile	Wx Station – Mobile Radiosonde	EC - CRD	
Upper Air / Profiles				
T, T_d, Wind, P	Fixed	Radiosonde	WMI	
T, T_d, Wind, P	Fixed	Radiosonde	EC – Tech Svcs	
T, T_d, Wind, P	Mobile	2 Radiosonde	EC - CRD	
3km T, RH	Mobile	AERI (MARS)	U of M - CEOS	
1.3km Wind, VV, Mixing Depth, Turb.	Mobile	SODAR (MARS)	U of M - CEOS	
Convective cloud-base temperature	Mobile	IR Pyrometer (MARS)	U of M - CEOS	
10 km RH, liquid H_2O, integrated water	Fixed	Profiling Microwave Radiometer	U of C	
1.5 km T, T_d, Wind, P	Fixed	Tethersonde	EC - MRD	
Total Column Water				
PW	Fixed	15 x GPS PW	U of C	
Water Vapour, Liquid H_2O	Fixed	Water Vapour Radiometer	U of C	
Water Vapour, Liquid H_2O	Mobile	Water Vapour Radiometer	U of M - CEOS	
Airborne				
T, T_d, P, Wind, VV, microphysics	Mobile	Aventech AIMMS-20 and Lyle Lilie microphysics	WMI Inc.	
Radar				
Doppler / Reflectivity	Fixed	Strathmore (XSM)	EC	
Doppler / Reflectivity	Fixed	Carvel (WHK)	EC	
Doppler / Reflectivity	Fixed	WMI	WMI Inc.	

2.4: Field Participation

Field and support personnel during UNSTABLE 2008 will be composed largely of Environment Canada staff and students along with university and WMI participants. Field coordination duties will be shared by N. Taylor and D. Sills operating from Olds-Didsbury airport. A team of PASPC forecast leads, based in Edmonton, will provide daily forecast and nowcast support during UNSTABLE 2008 operations. They will also act as a conduit between PASPC forecast operations and the UNSTABLE Field Coordinator (FC) relaying critical information to each. Field teams for UNSTABLE 2008 will consist of an instrumentation lead and assistant. At least one member of each team will hold valid first aid certification at all times and be aware of task-hazard analyses for their duties. Field personnel and associated roles are given in section 3.2.

2.5: Funding and In-Kind Support for UNSTABLE 2008

The UNSTABLE 2008 field campaign is being funded largely from within Environment Canada. This includes providing field personnel, ATMOS stations, the AMMOS, tethersonde system, 3 of 4 radiosonde systems and expendables, forecast / nowcast support, and most of the costs associated with travel, instrumentation deployment, and communications.

In-kind support is a significant component of the UNSTABLE field campaign. Major contributors in this regard include:

- ***Dr. Terry Krauss, Weather Modification Incorporated***: Use of facilities for field coordination headquarters, personnel and radiosonde system for one fixed upper-air site, chartering of WMI aircraft for airborne measurements, access to WMI radar data
- ***Dr. John Hanesiak, University of Manitoba, Centre for Earth Observation Science***: MARS observation system, field personnel
- ***Dr. Susan Skone, University of Calgary, Department of Geomatics Engineering***: GPS PWV sensors and data, water vapour radiometers
- ***Dr. Shawn Marshall, Dr. Manda Adams, University of Calgary, Department of Geography***: Foothills Climate Array station data
- ***Dr. Geoff Strong, University of Alberta*** (Adjunct): Mobile surface data collection platform
- ***Dr. Gerhard Reuter, University of Alberta***: Field personnel, possible photogrammetry observations

3: UNSTABLE 2008 Observations

In this chapter the existing and special instrumentation networks for UNSTABLE observations are described.

3.1: Existing Observational Networks

The UNSTABLE domains were selected, in part, to take advantage of existing observation networks. Data from the following sources will be used to augment special observations taken during the UNSTABLE 2008 IOP.

3.1.1: Surface Stations

Environment Canada and Province of Alberta Surface ‘Full’ Observation Stations

A total of 16 full observation (i.e., station pressure, 1.5 m temperature, dewpoint, 10 m wind speed and direction, tipping bucket rainfall accumulation) surface stations will already be in place within the UNSTABLE domains prior to the beginning of the 2008 field campaign. These stations are part of the network of surface observations available to Environment Canada forecasters and include stations operated by Alberta Environment and Alberta Agriculture (AGDM – Agriculture Drought Monitoring stations). These stations will be used as part of the UNSTABLE surface station network and where possible their sampling frequency will be increased to once per minute for the duration of the UNSTABLE IOP. Two of these stations, operated by Alberta Agriculture, include soil moisture measurements at depths of 0.05, 0.20, 0.50, 1.00 m.

FOPEX Surface Observation Stations

Three remaining stations from the Foothills Orographic Precipitation EXperiment (FOPEX – Smith 2005) will comprise part of the UNSTABLE surface network. Measurements from these stations will be one-minute averages of 1 m temperature and relative-humidity, station pressure, 2 m wind speed and direction, and tipping bucket rainfall accumulation. FOPEX stations are shown in Figure 2.

University of Calgary Foothills Climate Array (FCA)

The University of Calgary operates some 285 surface stations over the southern Alberta foothills region. The stations are classified as either 'farm' or 'mountain' depending on their location. The farm stations record 1.5 m temperature / humidity and 2.0 m tipping bucket precipitation while the mountain stations record 2.0 m temperature / humidity and 2.5 m tipping bucket precipitation (to account for deeper snow cover over the higher terrain). There are also currently 3 full observation stations (including 10 m wind speed and direction) within the FCA network. A set of 20 FCA stations will be converted to record 1-min. average data to be consistent with the ATMOS stations. These stations are located along the medium density line of ATMOS stations from near P4 to the station at Neir in Figure 5. The locations of the FCA stations in general are indicated in Figures 2 and 5.

Alberta Agriculture AGCM Stations

Alberta Agriculture operates a class of stations in agricultural areas known as AGCM stations. These stations record 2.0 m temperature, humidity, wind speed (no direction) and accumulated precipitation and are also shown in Figure 2.

Weather Bug Surface Station Network

Contingent on weather station site inspections, data from a number of Weather Bug weather stations may be included. These are high-end home weather stations. Data from these stations are quality controlled through the Meteorological Assimilation Data Ingest System (MADIS) through NOAA's Earth System Research Laboratory (ESRL) Global Systems Division (GSD). Information on MADIS can be found at: http://madis.noaa.gov/. More information on Weather Bug can be found at: www.**WeatherBug**.com. Weather Bug stations are not shown in Figure 2.

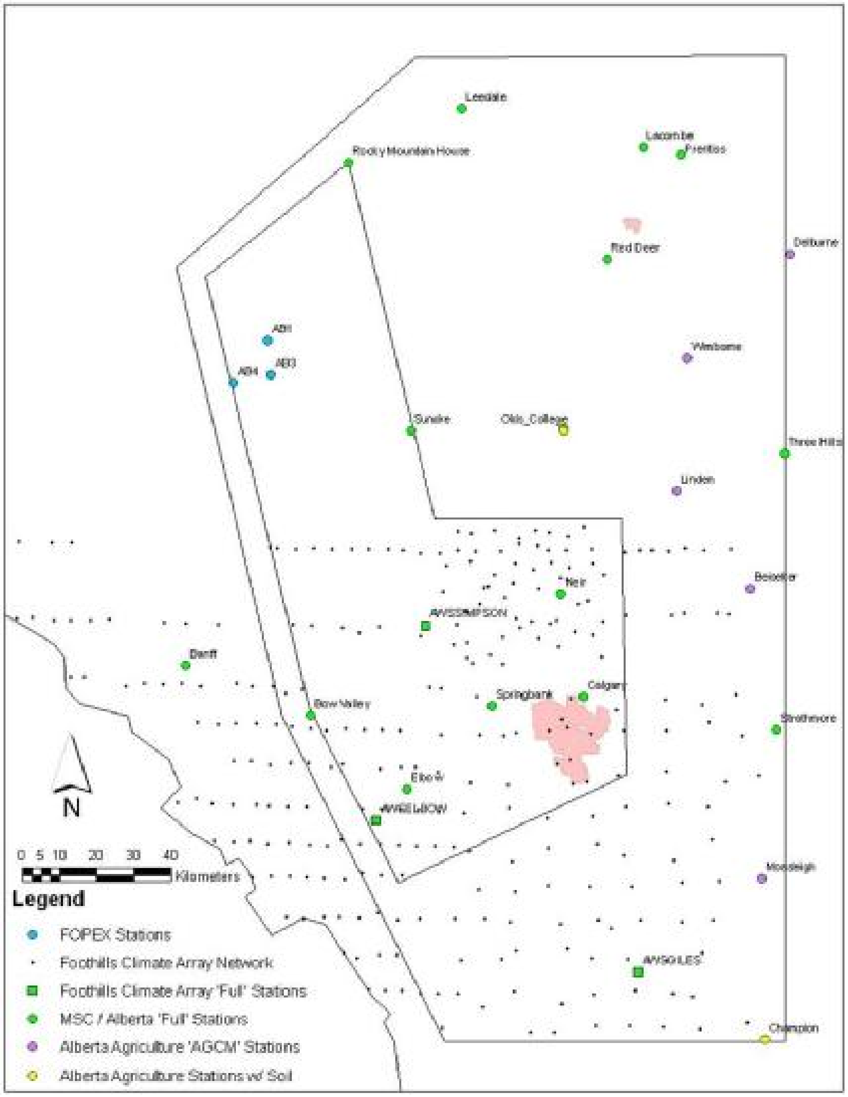

Figure 2: Existing surface stations to be used as part of the UNSTABLE 2008 surface network. More stations may be available by the time the IOP commences.

3.1.2: Environment Canada (and other) Satellite Imagery

UNSTABLE will utilize standard satellite imagery available to operational forecasters at the Prairie and Arctic Storm Prediction Centre. These will include 15-minute temporal resolution imagery of visible, infrared (11 µm) and water vapour (7 µm) imagery from GOES satellites. These images will be archived for later studies. Polar Orbiting NOAA satellite and other imagery sources available on the internet will also be incorporated and archived.

3.1.3: Environment Canada Radar

Two Environment Canada Radars are in relatively close proximity to the UNSTABLE study area. These are Carvel (53.56 ˚N, 114.14 ˚W) and Strathmore (51.21 ˚N, 113.40 ˚W). Both radars are C-Band (~5 cm wavelength) and offer Doppler capability within a range of 120 km. Some details of the radars are included in Table 2 below.

Table 2: Some specifications of Environment Canada radars to be used during UNSTABLE.

	Carvel	Strathmore
Ground Elevation (MSL)	748 m	968 m
Wavelength	5.32 cm	5.32 cm
Dish Size	3.6 m	6.1 m
Beam Width	1.10˚	0.63˚
Frequency	5625 MHz	5628 MHz

3.1.4: Weather Modification Incorporated Radar

A C-Band (5.4 cm) radar is operated by Weather Modification Inc. at the Olds-Didsbury Airport (51.71˚N, 114.11 ˚W). This radar has a beamwidth of 1.65˚ Following the field campaign, it may be possible to ingest WMI radar data into Environment Canada's URP2 radar software for analysis.

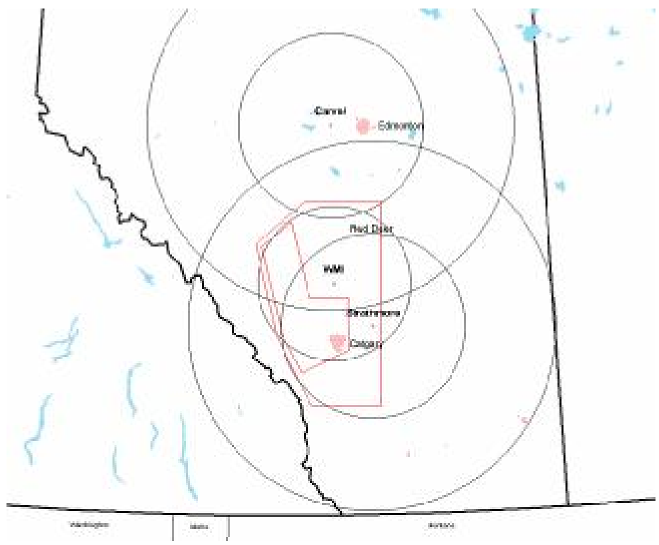

Figure 3: Radar coverage for UNSTABLE showing 120 km (Doppler range) and 240 km (detectable range) range rings for Carvel and Strathmore radars and 100 km (range for detection of 0 dBZ) range ring for the WMI radar. The primary (inner) and secondary (outer) UNSTABLE domains are outlined in red. The primary domain lies almost entirely within 100 km of the WMI radar and partially within the 120 km domain of the Strathmore radar. Carvel utility for UNSTABLE will be limited.

3.1.5: Canadian Lightning Detection Network (CLDN)

Environment Canada meteorologists utilize real-time lightning data via the Canadian Lightning Detection Network (CLDN). The CLDN (Part of the North American Lightning Detection Network – NALDN) includes 83 sites using either Time of Arrival (TOA) or Magnetic Direction Finder (MDF) sensors providing accurate location and timing of cloud-to-ground (CG) lightning within the network domain (cloud-to-cloud lightning detection efficiency is much lower than for CG lightning). The UNSTABLE project area lies within the highest resolution area of the network providing 90% detection efficiency and location within 500 m (see Figure 4).

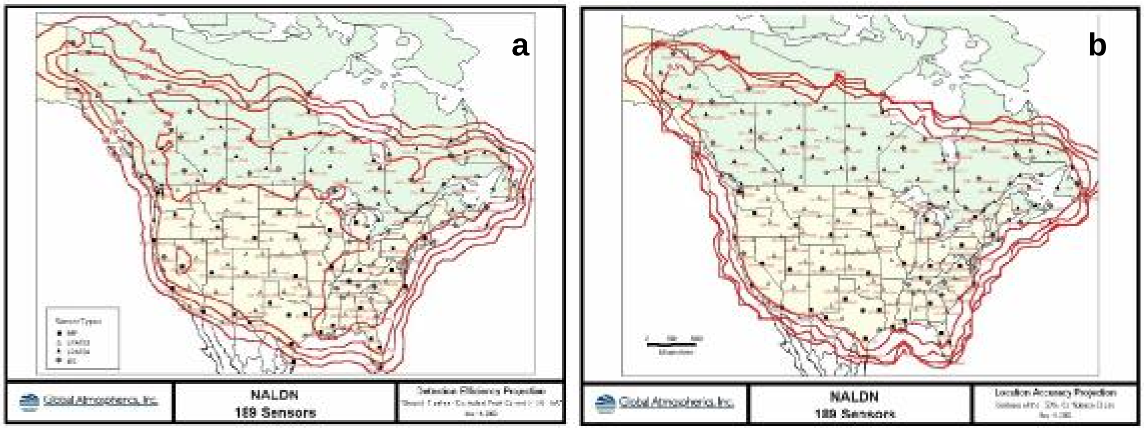

Figure 4: NALDN detection efficiency for cloud-to-ground flashes (a) and location accuracy (b).

Though lightning studies are not currently identified as a primary focus for UNSTABLE, the data are useful for storm initiation and storm track information and will be archived along with the other data sets for future study.

3.1.6: Environment Canada Soundings

There are no existing sounding locations within the UNSTABLE project area. The nearest sounding to the project area is at Stony Plain, AB (53.55 ˚N, 114.10 ˚W) a distance of ~225 km to the center of the primary UNSTABLE domain. While some information regarding environmental characteristics may be available from these soundings, their representativeness of ABL and pre-storm environments over the Alberta foothills is in question (see for example, Golden et al. 1986, Brooks et al. 1994, and Thompson et al. 2003 regarding sounding representativeness). For upstream, upper-level conditions (i.e., west of the Rocky Mountain Divide) the sounding at Kelowna (49.97 ˚N, 119.38 ˚W) is useful, especially with respect to winds passing over the mountains into the UNSTABLE project area. These and other sounding locations surrounding the UNSTABLE project area will be analysed and included in the data archive.

3.2: Special UNSTABLE 2008 IOP Instrumentation

A number of special data collection platforms will be utilized for the UNSTABLE 2008 IOP (see list in Table 1). These will consist of both fixed and mobile surface and upper-air instrumentation as detailed below. Teams are assigned to each type of instrumentation to be used during the UNSTABLE IOP consisting of the team lead and additional members as required. The team lead holds expertise and experience with the instrumentation and will be responsible for instrument operation and data collection / back-up. The instrumentation teams are listed in Table 3.

Table 3: UNSTABLE special instrumentation and field teams.

Instrumentation	Instrumentation Lead	Field Team Members (role)
ATMOS Stations	***Sills***	***Taylor**, **Sowiak** (installation/removal)* ***Other** (inspection and data collection)*
AMMOS	***Sills***	***Sills/Taylor** (operations lead)* ***Giles** (driver/assistant)* ***Burrows** (driver/assistant)*
2nd Mobile Surface Observations	***Strong***	***Strong** (operations lead)* ***Kochtubajda** (driver/assistant)* ***Toth** (driver/assistant)*
3rd Mobile Surface Observations	***Sills***	***Sirvatka** (operations lead)* ***TBD** (assistant)*
MARS	***Hanesiak***	***Brimelow** (operations lead)* ***Hanesiak** (operations lead)* ***Anderson** + **Moodie** (assistants)*
Tethersonde System	***Froude, Smith***	***Sheppard** (operations lead)* ***Other** (assistant)*
Mobile Radiosonde (MARS)	***Hanesiak***	***Brimelow** (operations lead)*
Mobile Radiosonde (CRD)	***Smith***	***Smith** (operations lead)* ***Cole** (Upper-air technical lead)*
Fixed Radiosonde (WMI)	***Krauss***	***WMI Staff***
Fixed Radiosonde (Water Valley or other location)	***Smith***	***Thompson** (operations lead)* ***Misfeldt** (assistant)*
WMI Aircraft	***Krauss***	***King** (flight system operator)*
Atmospheric Microwave Radiometers (Radiometrics WVR-1100 & WVP-1500)	***Skone***	***Skone, Smith** (operations leads)*
GPS Integrated Precipitable Water Vapour	***Skone***	***Skone, Smith** (operations leads)*

3.2.1: Automated Transportable Meteorological Observation System (ATMOS) Stations (Sills, Taylor, Sowiak)

The primary source of supplemental surface observations for UNSTABLE will be from the deployment of 5 Environment Canada ATMOS stations. These stations are solar powered, have communications capability via cell phone modem, and will record measurements as one-minute averages of the following:

- 10 m Wind Speed and Direction (RM Young 05103-10 wind monitor)
- 1.5 m Temperature and Humidity (HMP 45C T/H sensor + shield)
- 1.5 m 'Fast Response' Temperature (44212 T sensor + shield)
- Precipitation (liquid) (TE 525 tipping bucket rain gauge)
- Difference in Temperature between 0.5 m and 9.5 m (thermocouple + shields)
- Station Pressure (Vaisala PTB210 pressure sensor + SPH10 static pressure head)
- Incoming Solar Radiation (SP-Lite radiation sensor (1 component - downwelling solar))

The ATMOS stations will be placed in close proximity to existing stations to form a high-density (~ 10 km spacing) and a medium-density (~ 15-25 km spacing) line of stations. These lines will be oriented approximately perpendicular to the axis of the Rocky Mountain Barrier to obtain surface measurements normal to the frequent orientation of convergence boundaries. While significantly less dense than the originally proposed UNSTABLE mesonet, these lines of stations will test what spatial resolution may be appropriate to sample surface boundaries in the foothills region. The ATMOS stations will be installed (at sites already selected) in June 2008 and remain in operation until mid- August.

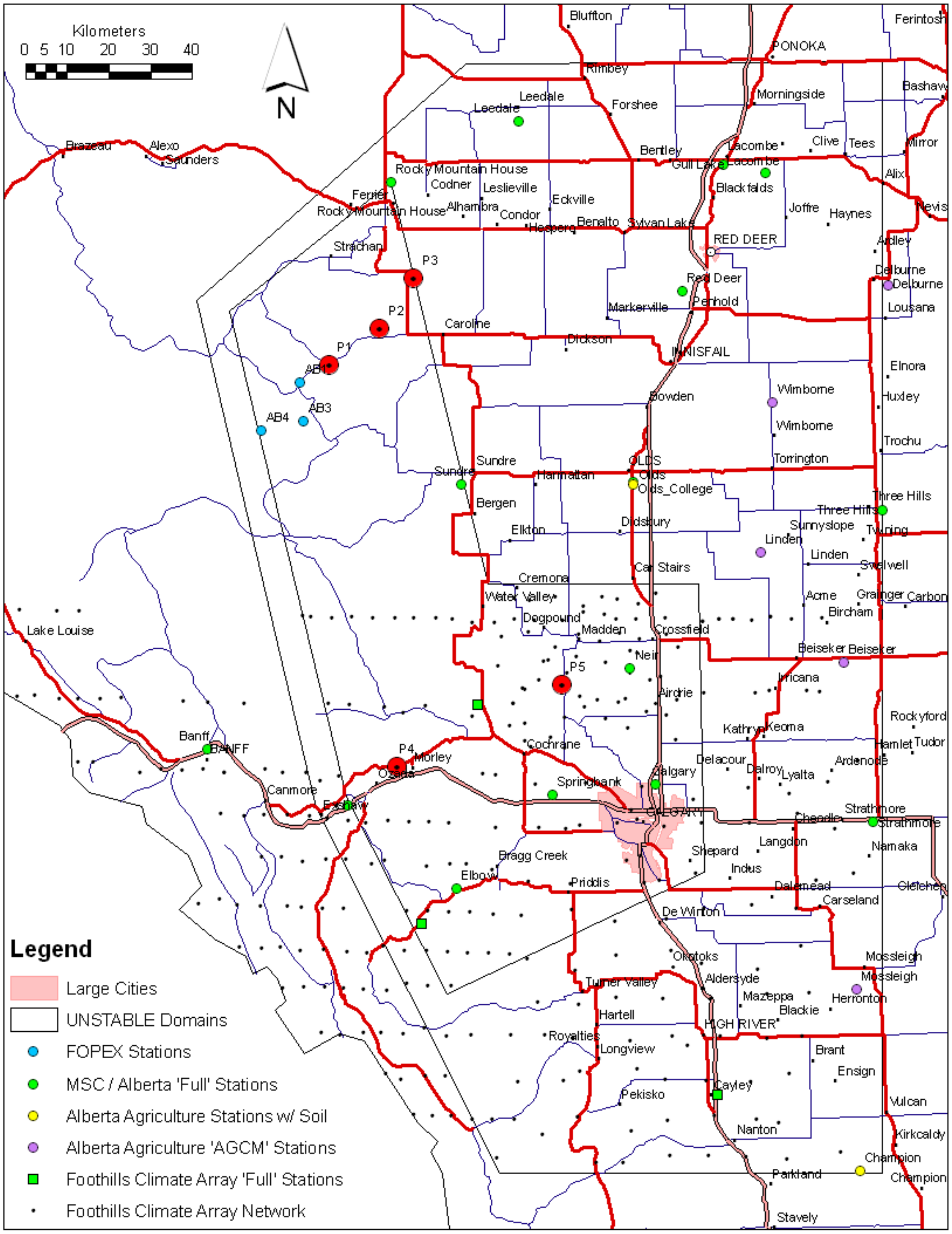

Figure 5: Locations of five ATMOS stations to be used in the UNSTABLE 2008 field campaign (indicated as large red circles labelled P1 – P5). The stations will be installed to create two lines approximately perpendicular to the regional terrain barrier, one of high density (including P1 to P3 at ~ 10 km spacing) and one of medium density (including P4 and P5 at ~15-25 km spacing).

Figure 6: Photo of the ATMOS station. Photo by Dave Sills.

3.2.2: Automated Mobile Meteorological Observation System (AMMOS – Sills)

The AMMOS will record 1 second samples of the following parameters:

- Wind Speed and Direction (RM Young 05103-10 wind monitor and 32500 compass)
- Temperature and Humidity (HMP 45C T/H sensor + shield)
- 'Fast Response' Temperature (44212 T sensor + shield)
- Station Pressure (Vaisala PTB210 pressure sensor + SPH10 static pressure head)

Lightning flashes (total lightning) and their proximity to the vehicle will also be recorded using a Boltek LD-250 with a flux gate compass.

Figure 7: The Environment Canada Automated Mobile Meteorological Observation System (AMMOS). Photo by Dave Sills.

A second mobile data collection platform (recording temperature, humidity, and pressure only) will be operated in conjunction with the AMMOS by Dr. Geoff Strong, adjunct professor at the University of Alberta. Tentative plans are for a third unit (same observations as the second system) to be included and operated by Dr. Paul Sirvatka, College of Du Page, Illinois. Mobile teams will be dispatched on each IOD during the 2008 field campaign. Mobile teams (excepting 3rd mobile surface team) will be equipped with Garmin 250W GPS Navigation systems loaded with fixed station locations and other points of interest for use in navigation during operations.

3.2.3: Mobile Atmospheric Research System (MARS – Hanesiak)

The Centre for Earth Observation Science (CEOS) at the University of Manitoba operates a mobile trailer consisting of multiple data collection platforms providing upper-air and vertical profiles of ABL characteristics. The MARS will also act as a platform for radiosonde observations using a system on loan from Environment Canada. The MARS will be deployed on IODs during the UNSTABLE IOP in tandem with the AMMOS, the 2nd mobile surface team, and a second mobile radiosonde system. Instrumentation consists of:

*Atmospheric Emitted Radiance Interferometer (AERI MR100)***:** The AERI system provides profiles of temperature and water vapour in the lowest 3km of the atmosphere. Vertical resolution is <100 m to 1 km AGL and near 200 m at 3 km AGL. Profiles can be obtained at 10-minute intervals.
http://cimss.ssec.wisc.edu/aeri/

*Doppler Sodar (Ramtech PA1-NT)***:** The PA1-NT Doppler Sodar provides continuous profiles of wind speed and direction, vertical motion, mixing depth, and turbulence from 20 m to 1300 m (maximum 2000 m).
http://www.remtechinc.com/sodidx.htm

Atmospheric Microwave Radiometer (Radiometrics WVR-1100): Provides total column integrated water vapour and liquid water at intervals of up to 30 seconds.

IR Pyrometer (Heitronics KT 19 II): Used to measure convective cloud base temperatures to determine cloud base heights when compared with sounding data.

Airmar PB-100: Designed for marine applications, the Airmar instrument system supplies information on surface temperature, humidity, pressure, and wind speed and direction while stationary or in motion.
http://www.airmartechnology.com/uploads/brochures/weatherstation.pdf

Figure 8: Photo of the MARS trailer. Photo by John Hanesiak.

3.2.4: Tethersonde (Froude, Smith)

A Vaisala tethersonde system will be used to obtain ABL upper-air measurements. The system is equipped with 6 meteorological sondes and 3 km of line (see Figure 9) and will be operated from the same site as the P3 ATMOS station for the duration of the IOP. On non-IODs 3 ozone sondes may be utilized along with 3 meteorological sondes. Both longer-term (~ 6 h) balloon deployment and ascending/descending profile strategies will be tested in 2008. The system will be operated daily during the IOP from ~ 14 UTC until CI or precipitation is observed in the vicinity.

Figure 9: The Environment Canada tethersonde balloon (left) and close-up of a sonde.

3.2.5: Fixed Radiosondes (Smith, Krauss)

Two fixed-location radiosonde systems will be operated during the UNSTABLE IOP. One of these sites will be at the Olds-Disdbury airport (co-located with the UNSTABLE field coordination center) while the other will be located in the Water Valley area (final site to be confirmed). These will be designated as Forecast Radiosonde (FR) sites as daily operations will include 12 UTC[2] soundings in support of UNSTABLE IOD decisions.

[2] During UNSTABLE soundings will be released 15 min. prior to the sounding valid time so that the valid time coincides with the sonde being near the top of a typical, well-mixed, convective boundary layer.

3.2.6: Mobile Radiosondes (Smith)

Two mobile radiosonde teams (one also being the MARS team) will be dispatched on each IOD. These will be designated as Intensive Radiosondes (IR). The IR teams will release simultaneous soundings from the field on either side of interesting mesoscale boundaries. Radiosondes released within 30 nm of Calgary International (YYC) will have to be launched from sites designated ahead of time in coordination with NAV Canada[3]. On IODs, the FR sites will act as fixed IR sites releasing balloons in time with the mobile teams. In total, 220 radiosondes are planned to be released during UNSTABLE 2008 operations.

3.2.7: Instrumented Aircraft (Krauss)

Aircraft measurements will be taken during UNSTABLE 2008 using an instrumented Cheyenne II aircraft operated by WMI for hail mitigation flights in the region. Estimating 4 flying days during the IOP and one, three-hour flight on each of those days will result in 12 h of flight time for a cost of ~ $ 6000. This aircraft will be affixed with the Aircraft Integrated Meteorological Measurement System (AIMMS) instrumentation package developed by Aventech Research Inc and a Lyle Lilie microphysics package. The AIMMS package provides in-situ measurements of temperature, relative humidity, 3-axis wind, and turbulence. Information on the AIMMS package can be found at: http://www.aventech.com/index.php?content=application&site=atmospheric

Figure 10: Instrumented Cheyenne II aircraft operated by WMI.

3.2.8: Atmospheric Microwave Radiometers (Skone)

Two microwave radiometers operated by the University of Calgary will be deployed within the primary UNSTABLE domain. The Radiometrics WVP-1500 provides profiles of water vapour to 10 km AGL and total column integrated liquid water at intervals of 10 seconds. The Radiometrics WVR-1100 was already described as part of the MARS trailer.
WVP-1500: http://www.etl.noaa.gov/technology/radiometers/pdfs/1500.pdf

3.2.9: GPS-Derived Integrated Precipitable Water Vapour (PWV)

The University of Calgary, Department of Geomatics Engineering operates a network of Global Positioning System (GPS) sensors as a remote sensing tool for PWV. This network has been used to obtain PWV estimates associated with thunderstorms over the Alberta foothills (Smith et al. 2008). Data from an existing network of GPS sensors will be made available to UNSTABLE and a few sensors will be loaned for temporary installation within the primary UNSTABLE domain.

[3] Smith and Taylor will scout potential mobile radiosonde sites within the 30 nm no-fly zone on 29-30 May, 2008.

3.2.10: Photogrammetry and In-Situ Photography

In-situ photography will be an important source of observations from field teams on IODs. Each team will be equipped with a camera and will be required to log metadata for each photo (i.e., GPS position, time, direction of photo, comments). Stand-by volunteers for storm interception photography are being investigated and imagery from available web cams (e.g., AMA highway cameras) will also be archived when they capture interesting events.

3.2.11: Observation Strategies and Metadata

It is important for data collection and recording to be conducted in a consistent manner among the field teams. Standardized templates for data collection and associated metadata will be drafted for each field team prior to the IOP. This will ensure critical information (e.g., GPS location, time, direction of view in photos, comments, etc.) is recorded for use in future data analysis.

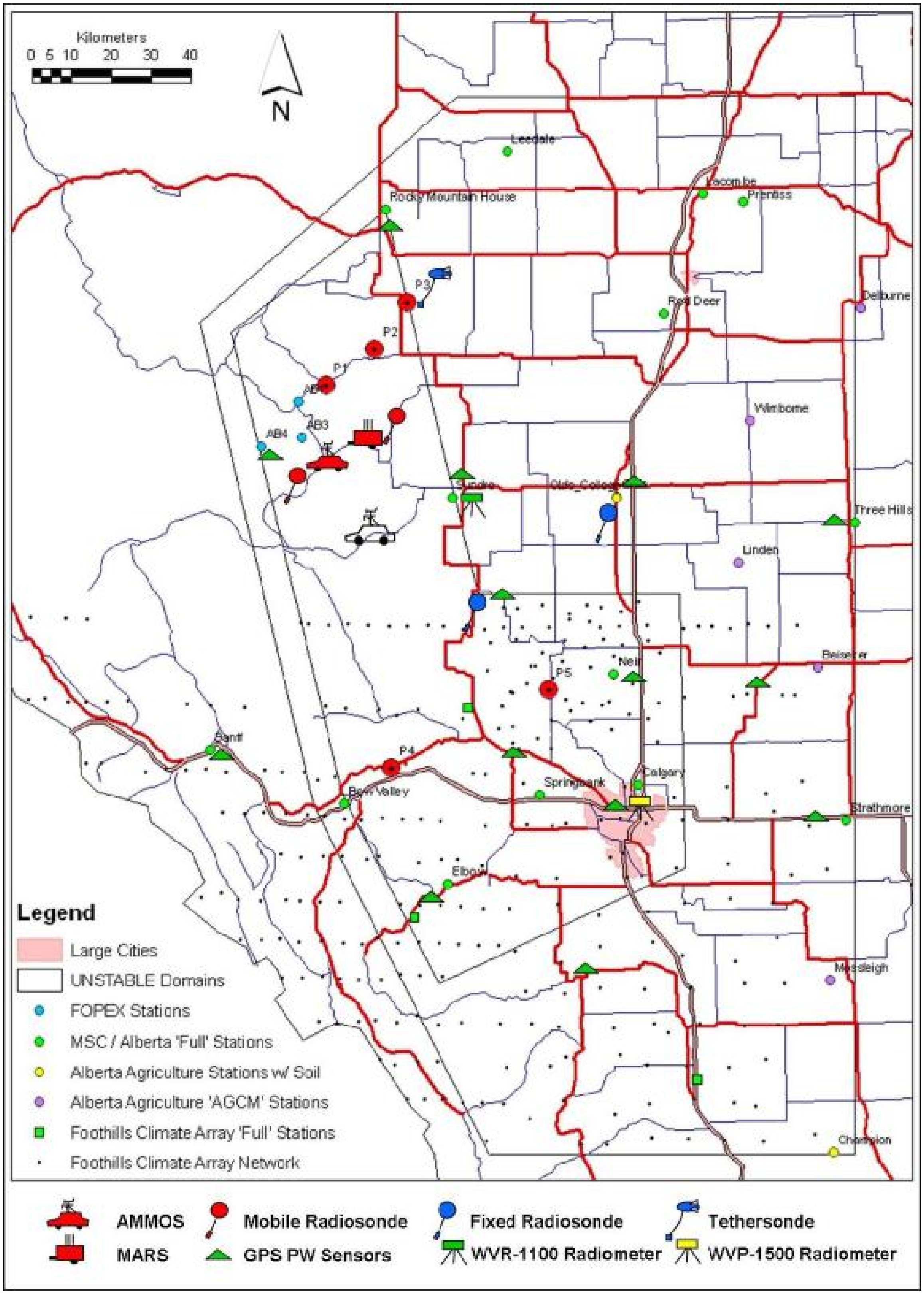

Figure 11: Map showing the domains, mesonet stations and fixed and mobile (surface-based) instrumentation for UNSTABLE 2008 operations. The transparent 'AMMOS' symbol represents the 2nd mobile surface team. The UNSTABLE 2008 ATMOS mesonet station locations are large red circles with the black dot in the middle and are labelled P1 through P5. Locations of some instrumentation (e.g., GPS PW sensors and radiometers) are still to be finalized.

4: UNSTABLE Intensive Observation Days (IODs)

On IODs UNSTABLE instrumentation teams will conduct field measurements to address the science questions posed for the experiment (section 1.1). Eight intensive observation days are planned for during the UNSTABLE 2008 15-day IOP. Since UNSTABLE 2008 operations will only occur on eight days, IODs and associated observation missions will need to be carefully selected. Five observation missions have been designed to address the science questions and are listed in Table 4. Preliminary selection of IODs will occur during evening briefings for the following day. Following a morning briefing, IOD status (GO, STANDBY, or NO-GO) will be confirmed and targeted measurement areas refined as appropriate.

For each IOD mission general measurement strategies will be pre-defined with variations tested in the field. This will include pre-defined surface and aircraft transects that can be modified on a case-by-case basis as required. Results from the pilot project will be used to refine measurement strategies for UNSTABLE 2011. In general, operations for the fixed radiosonde and tethersonde sites will remain the same regardless of which IOD mission is selected. For the tethersonde this will consist of deployment in the morning with continuous operations and/or ascent/descent profile strategies being tested on each day of the IOP. For the fixed radiosondes this will consist of a 12 UTC sounding on each day during the IOP and two-hourly soundings thereafter on IODs. Details on fixed upper-air operations are included in section 4.2.

It is necessary to document the structure and severity of storms that develop within the UNSTABLE domains. Mobile data collection and storm observations by surface mobile teams are therefore an integral component of IOD missions. These activities are specifically related to science questions 1b, c, e, 3c (and the additional questions to consider defined in the scientific overview document). To document storm evolution and characterize intensity, especially following storm-boundary interactions, photographic evidence and quantitative observations of severe weather elements (e.g., wind speeds, hail size) are required. These observations will complement those obtained through remote sensing networks (e.g., radar, satellite, and lightning detection). Instrumented mobile surface platforms are best suited for these activities. For UNSTABLE, the AMMOS is the preferred storm observation vehicle due to the inclusion of wind measurements in its instrumentation suite. Protocols have been designed to allow selected mobile teams to terminate IOD mission sampling in favour of storm interception activities, these may be altered while in the field with agreement among UNSTABLE investigators. Where appropriate, these protocols are outlined for each IOD mission.

Table 4: IOD missions, objectives, and specific science questions addressed. Though not explicitly stated, characterization and evolution of the capping lid is inherent in each mission.

Observation Mission	Objectives	Science Question
CI 1 *(ABL Water Vapour*[4]*)*	*To characterize the evolution of ABL water vapour within areas favourable for CI and the development of thunderstorms in the absence of well-defined mesoscale convergence boundaries.*	1a, 1d, 1e
CI 2 *(Mesoscale Boundary)*	*To sample the environment near and within mesoscale boundaries and associated circulations with the potential to trigger CI.*	1b, 1d, 1e
Dryline	*To resolve and characterize the 4-D dryline environment with and without associated CI and thunderstorm development.*	1c, 1d, 1e
Water Vapour Gradient 1 *(Soil Moisture)*	*To sample horizontal water vapour gradients associated with discontinuities in soil moisture from PAM-II model forecasts and observed areas of recent precipitation.*	2a, 2c, 2d, 2e
Water Vapour Gradient 2 *(Vegetation)*	*To sample horizontal water vapour gradients associated with contrasting areas of vegetation type, specifically forested vs. cropped areas.*	2b, 2d, 2e

Days where field operations will stand down include:

- Overcast or rainy days without sufficient forcing for surface-based CI
- Days with uniform westerly or north-westerly SFC winds where ABL moisture (sufficient for surface-based deep convection) has been advected out of the UNSTABLE domains
- Rapidly moving cold fronts – these would be difficult to sample with mobile instrumentation though some valuable data could result from fixed mesonet data and stationary soundings and profiling platforms. Partial operations may be conducted on these days subject to agreement among UNSTABLE investigators.

4.1: IOD Missions

Following are descriptions of mobile team operations for each of the IOD missions listed in Table 4. Fixed site operations are described in section 4.2 for all IOD missions.

4.1.1: CI 1 (ABL Water Vapour)

Objective: To characterize the evolution of ABL water vapour within areas favourable for CI and the development of thunderstorms in the absence of well-defined mesoscale convergence boundaries.
Required Conditions: Threat area for CI (with priority given to regions favourable for severe thunderstorm development) with no clearly defined mesoscale boundary to provide lift. Situations may include synoptically favoured upslope flow against the foothills and Rocky Mountains, development of a mountain-plain circulation due to differential heating of higher terrain, etc.
Alternate Condition Considered: The sampling strategy for mission CI1 may be employed on a day when thunderstorm development is not anticipated but strong insolation favours evapotranspiration and the development of a mountain-plain circulation.

The CI1 mission will utilize all fixed and mobile instrumentation teams. The AMMOS, MARS, mobile radiosonde and 2nd/3rd mobile surface teams may be dispatched together to a primary threat area for severe storm development or may travel in groups to each of the lines of mesonet

[4] ABL water vapour in association with mesoscale convergence boundaries will be characterized in mission CI 2 (Mesoscale Boundary).

stations for a widespread threat area. In each case the radiosonde team will release two-hourly balloons in time with the fixed radiosonde sites commencing at 16 UTC and continuing until CI is observed within the threat area. The MARS and mobile radiosonde teams may have the option of releasing additional soundings during CI if convective storms are observed to develop in the immediate vicinity[5]. Where possible the teams will be positioned in the vicinity of the mesonet station lines to maximize the density of observations taken. Once the teams are in position the mobile surface teams will proceed 'upslope' in an attempt to reach the westernmost extent of the moist, unstable ABL. If such a boundary is found the mobile team should conduct continuous transects from the dry side of this boundary to the mobile radiosonde team in the moist air until CI is observed. These transects will capture the evolution of near-surface water vapour in the horizontal leading up to CI. The MARS will operate continuously to sample the evolution of water vapour in the vertical. If the area with greatest potential for CI and severe storms changes (determined through coordination with the FC and PASPC support meteorologist) then mobile teams will have an option to redeploy to a new location to continue measurements. Given the variety of meteorological situations that may satisfy the requirements for CI1, additional measurement strategies may be proposed and tested during the IOP. The mobile surface teams will be available to conduct storm observation activities once storms have moved away from the area of CI and there are indications that storms are no longer interacting with mesoscale boundaries associated with CI. Since the focus of the mission is on ABL water vapour, mobile teams will continue conducting transects despite risks of being out of position for storm observations. Following CI-associated soundings, there may be an option for the MARS to proceed ahead of storms to obtain proximity soundings within the storm inflow region.

Aircraft support to the mission, if included, will consist of stepped traverses from the lowest flight level through the lowest few km of the troposphere to capture the larger-scale flow and to resolve the mountain-plain circulation if present. The axis of the traverses should be perpendicular to the axis of the terrain barrier. This will resolve the thermodynamic and kinematic structure of the ABL and near-ABL environment in two-dimensions prior to CI. An additional racetrack flight pattern (Figure 14) may also be conducted if aircraft availability allows. The time of all flights will be coordinated with PASPC and WMI meteorologists to ensure completion of the flight prior to commencement of any anticipated WMI seeding operations.

[5] Additional sounding availability will be contingent on balloon and helium inventories as the experiment progresses.

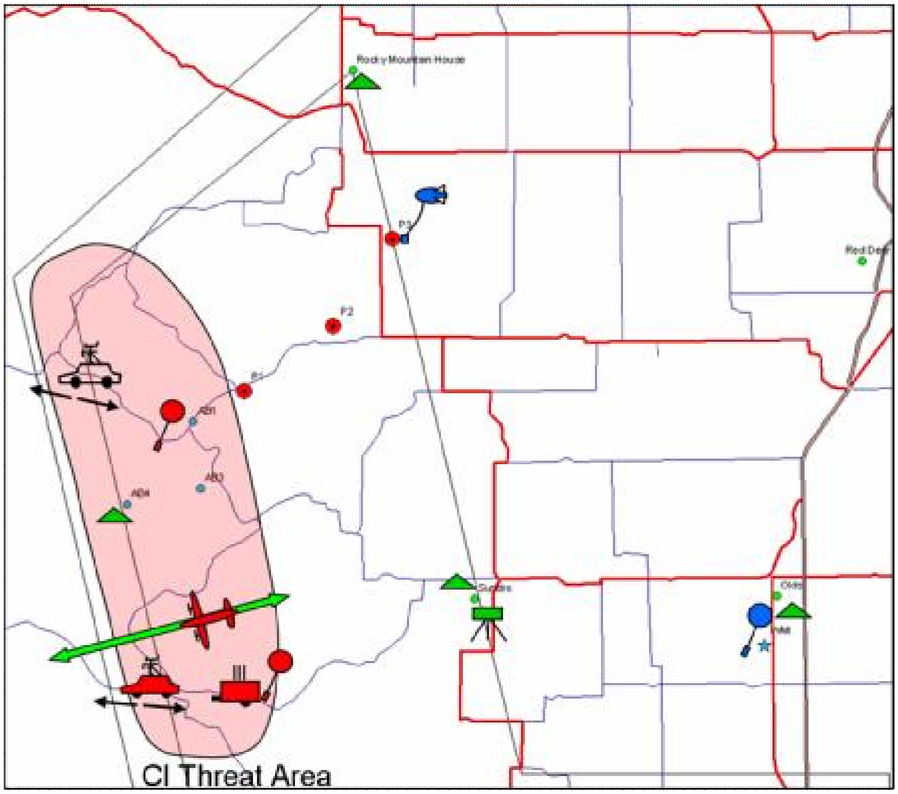

Figure 12: Plan view example of CI1 mobile operations. In this example the mobile teams are in pairs within the identified CI threat area. The AMMOS / 2nd mobile surface team conducts transects between MARS / mobile radiosonde teams and the western extent of the moist unstable ABL. The aircraft conducts upper-air transects along the same area.

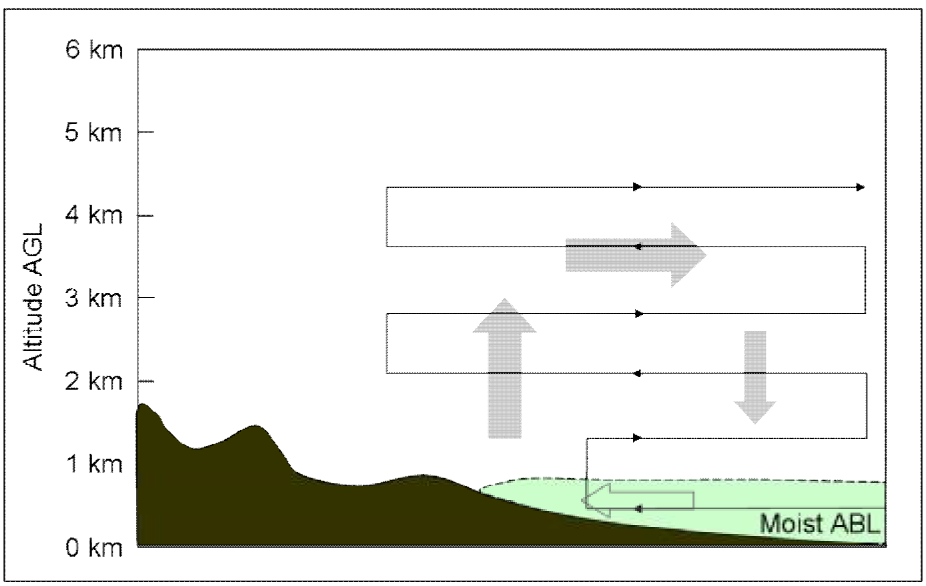

Figure 13: Schematic showing idealized flight track for mission CI1. Gray arrows indicate the possibility of a mountain-plain circulation.

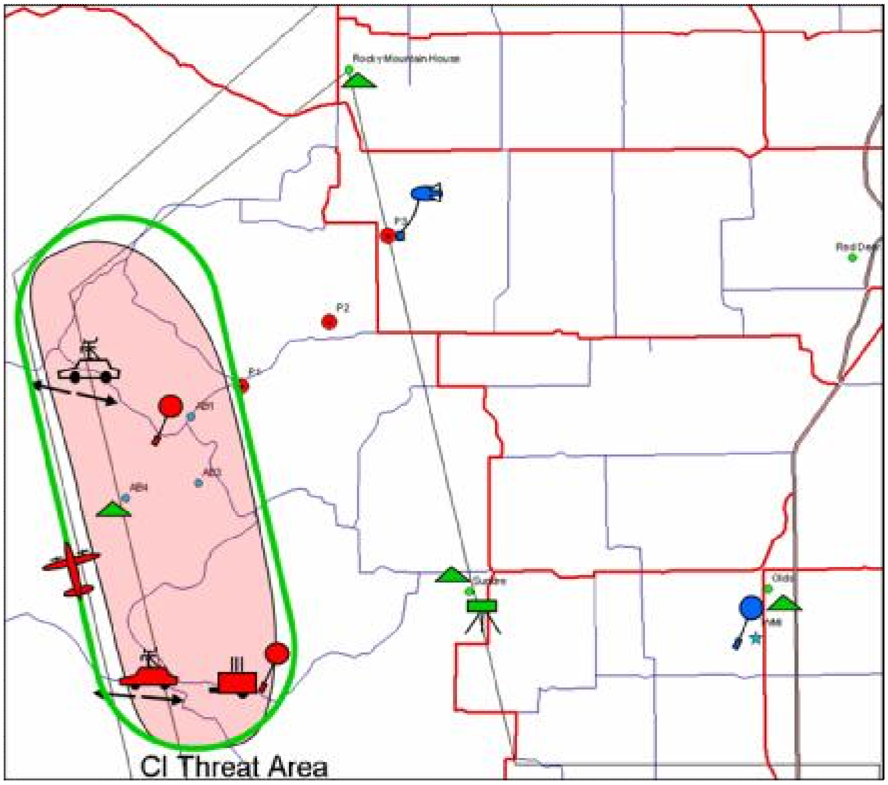

Figure 14: As is Figure 12 but showing a racetrack flight pattern to characterize horizontal variability and divergence in the CI threat area environment. Racetrack patterns at multiple levels may also be tested.

4.1.2: CI 2 (Mesoscale Boundary)

Objective: To sample the pre-storm environment (including ABL water vapour) near and within mesoscale boundaries and associated circulations with the potential to trigger CI.

Required Conditions: Threat area for CI (with priority given to regions favourable for severe thunderstorm development) with a clearly defined mesoscale boundary to provide lift. Boundaries of interest may include a lee trough, QS frontal boundary, or a slow-moving cold pool boundary. The dryline is considered separately. Fast moving (i.e., > ~ 5 ms^{-1}) outflow or frontal boundaries will not be considered for intensive mobile observations.

Surface-based convection is typically initiated along some low-level convergence boundary. Mission CI2 will be selected on days where a threat area is identified for the development of thunderstorms and where a mesoscale boundary will act as a focus for lift. Since the location and orientation of such boundaries will vary on a day-to-day basis, the positioning of mobile teams and aircraft flight tracks will be boundary dependent. In general, the MARS, AMMOS, mobile radiosonde, and other mobile surface teams will be dispatched together to an area along the boundary favourable for CI (i.e., in area of greatest instability and strong low-level convergence). As the teams approach the boundary location the AMMOS should proceed ahead of the group to determine the precise location of the boundary. Once that location is identified the MARS should be positioned near and on the most unstable side of the boundary with the mobile radiosonde team on the more stable side. Distances these teams should be placed from the boundary will not be pre-determined for UNSTABLE 2008 so that different distances can be tested. It is important for the MARS that it be positioned far enough away from the boundary that the likelihood of the boundary passing over the MARS location within a 2-3 h timeframe is small.

The AMMOS and other mobile surface teams will conduct transects across the boundary. One option for this is to have these teams conduct longer transects at higher speeds while the AMMOS conducts slower transects over shorter distances. The speeds of the mobile teams can be varied according to the width of the boundary (see the dryline mission for more detail on this surface transect measurement strategy). A second option will be to have the 2nd/3rd mobile surface teams sample the boundary at other locations of interest. Both approaches will be tested and results compared for best resolution of the boundary both spatially and in time. Where roads allow the mobile surface teams can conduct transects following a 'box' pattern crossing the boundary in multiple locations (this strategy can be experimented in all boundary-related missions). Preliminary transect locations have been identified for areas where roads are limited and are shown in Figure 15. These routes will serve as starting points with transect length adjusted based on boundary locations via fixed and mobile surface observations. Radiosondes should be launched from the mobile teams on either side of the boundary at two-hour intervals beginning at 16 UTC depending on when teams are in position. The MARS and mobile radiosonde teams may have the option of releasing additional soundings during CI if convective storms are observed to develop in the immediate vicinity.

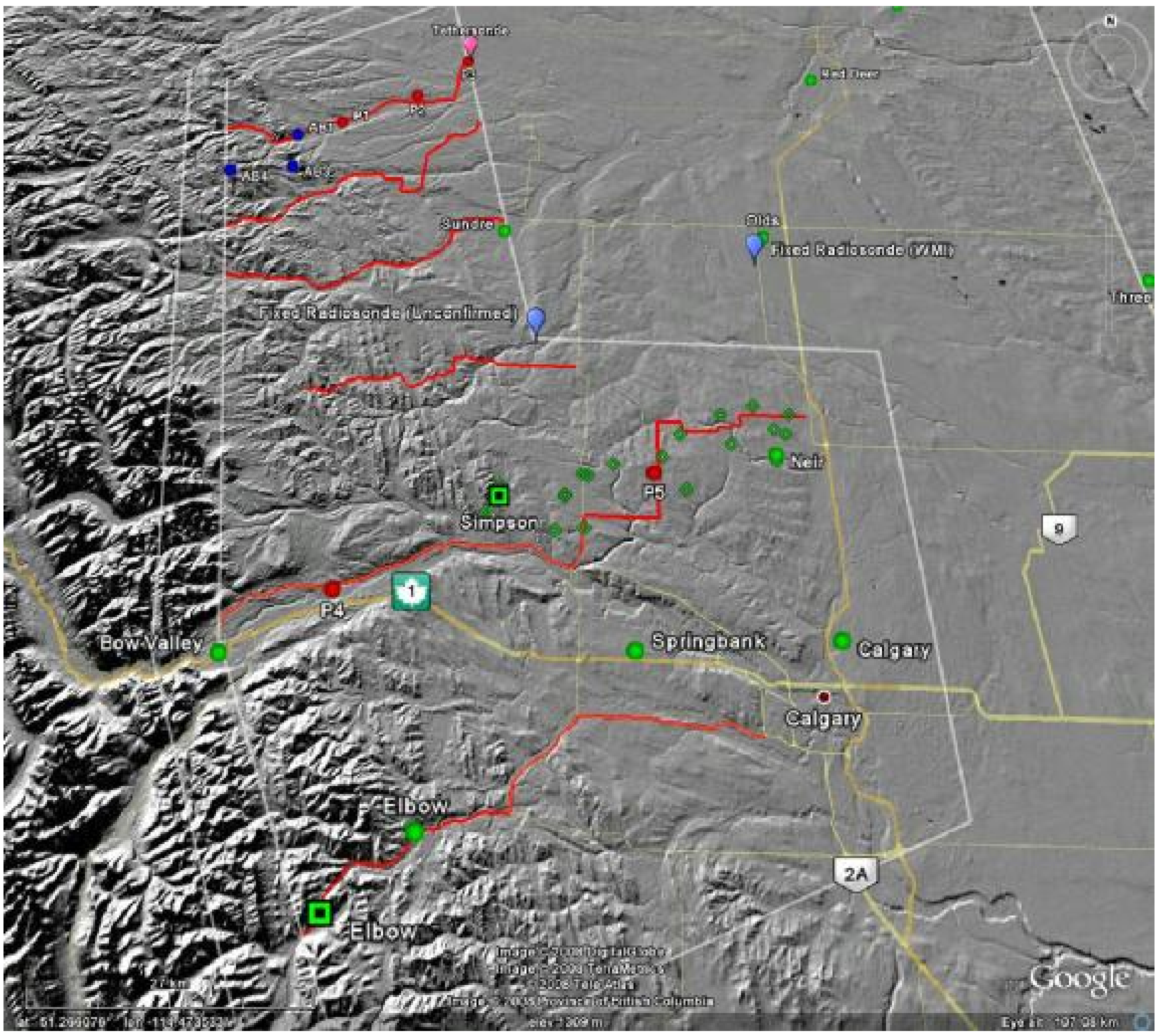

Figure 15: Google Earth image with shaded relief showing preliminary mobile surface transect locations in areas of limited roads. North-South transects will be defined on a mission-by-mission basis. Also shown are fixed surface stations, the tethersonde location, and the locations of fixed radiosonde sites.

If the AMMOS and 2nd/3rd mobile surface team are sampling in the same area the former may terminate boundary sampling and conduct storm observation activities once a storm develops and moves away from the boundary. If the boundary appears to be associated with further CI at least one of the 2nd/3rd mobile surface teams should continue sampling the boundary until no further evidence of CI is observed prior to conducting storm observation activities.

Aircraft measurements for mission CI2, if included, will have flight tracks determined by boundary position and anticipated timing for CI. Flight paths will follow the proposed methodology of the dryline mission (see Figure 18). Mobile surface and aircraft observations will not be conducted within main population centres to avoid traffic congestion and maintain safe field operations.

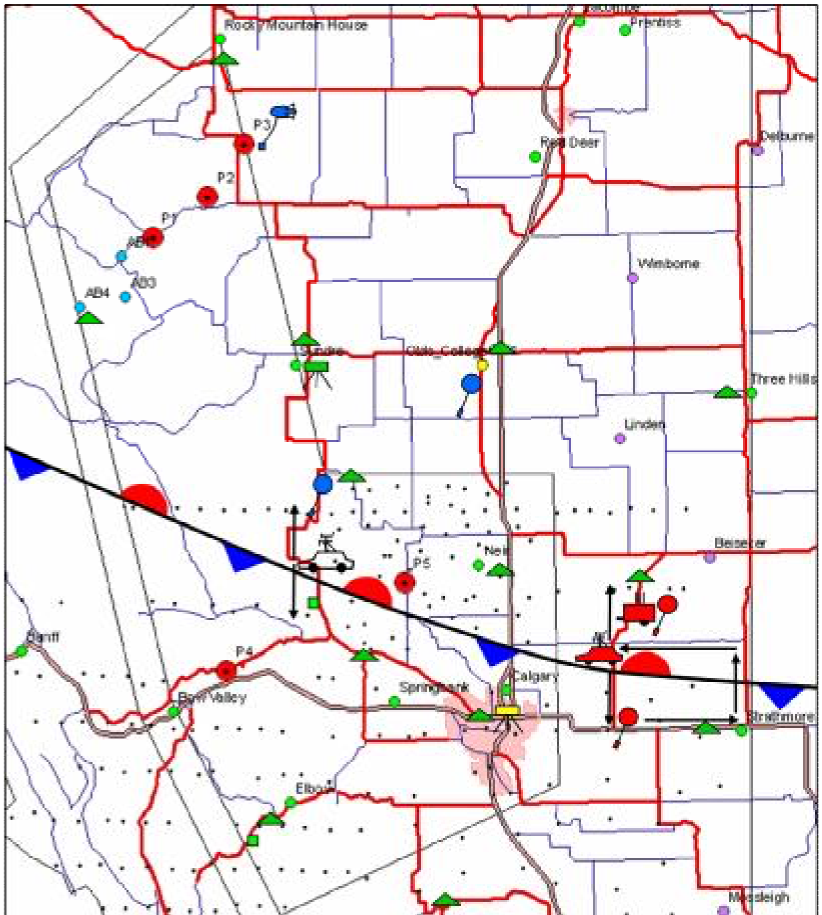

Figure 16: Sample configuration of mobile teams for a QS frontal boundary. Shown here with the 2nd mobile surface team sampling the boundary at a different location than the other teams. Where roads allow, the mobile surface teams may be able to conduct transects following a box pattern.

4.1.3: Dryline

Objective: To resolve and characterize the 4-D dryline environment. Includes situations where CI and thunderstorm development are, and are not, anticipated.
Required Conditions: A dryline that either remains in a QS position along the foothills or that exhibits bulging over the southern region of the UNSTABLE domains. Priority will be given to days on which CI and severe storms are expected.

Previous work in Alberta has shown favourable areas for dryline development lie in the western portions of the UNSTABLE domain(s). Mobile radiosonde, AMMOS, MARS, and mobile surface teams will be dispatched together to sample the dryline on days where its development is expected. As for the CI 2 mission, the AMMOS will proceed ahead to locate the position of the dryline prior to the other mobile teams being positioned. For the purposes of the pilot experiment, the high- and med-density station lines will be used as anchor points for mobile team operations. On a potential dryline day mobile teams will begin measurements in the vicinity of one of the mesonet station lines depending on which line is in a favoured area for development of severe thunderstorms (or if no CI expected, the line that is expected to be in the area of the strongest moisture gradient). The mobile teams should be arranged as indicated in Figure 17 with the AMMOS and 2nd/3rd mobile surface team conducting transects across the boundary. Two strategies will be tested for the 2nd/3rd mobile surface teams, in one scenario these teams will conduct longer transects than the AMMOS, at greater speed along the same route (3rd team likely along another route). In the second scenario the teams can be dispatched to the data-poor region between the mesonet station lines for simultaneous transects along a different portion of the dryline.

Approximate locations for the mobile teams and endpoints for surface transects will be predetermined but distances of the teams from the boundaries will not as part of the purpose of the pilot is to determine the best measurement strategies to be used. Distances will be varied on different IODs or determined as being most suitable given observations of a particular boundary. Following plans outlined for the International H_2O Project 2002 (IHOP_2002), the AMMOS will conduct initial transects at speeds near 10 ms^{-1} (36 km h^{-1}). After the first complete transect the AMMOS lead will subjectively assess the sharpness of the boundary (e.g., abrupt or gradual change in humidity and other parameters) to determine appropriate speeds for further transects. If the boundary is sharp then speeds should be reduced to near 5 ms^{-1} (18 kmh^{-1}) to maximize spatial detail of measurements. The length of the transect should be reduced accordingly to ensure resolution of the width of the boundary while maintaining frequent transects across it. If the boundary appears diffuse then the speed should be increased to 15-20 ms^{-1} (54-72 kmh^{-1}) to reduce the time required to sample the entire boundary. Various speeds across drylines of different widths can be tested with results compared to determine the best strategy for UNSTABLE 2011. If sampling together the AMMOS can conduct storm observations after a storm develops and moves off the dryline while at least one of the other mobile surface teams continues dryline sampling until no further evidence of CI is apparent. If sampling separately, the teams should coordinate so that one of them continues sampling until CI is no longer evident along the boundary.

Aircraft observations will be coordinated with surface teams and will be taken near the lines of mesonet stations. The basic strategy used in ELBOW 2001 (Sills et al. 2002) for lake breezes will be applied to the dryline. Aircraft will perform ascending / descending spirals and stepped traverses through the dryline as illustrated in Figure 18. Pre-defined flight plans will use selected mesonet station locations as endpoints for the transects and locations of the spirals in the moist and dry air. The appropriate line of stations to be used will be selected at the morning briefing. A plan view of the flight plans are shown in Figure 19 with the circular arrows representing locations of ascending/descending spirals and the straight green arrow representing the axis of stepped traverses.

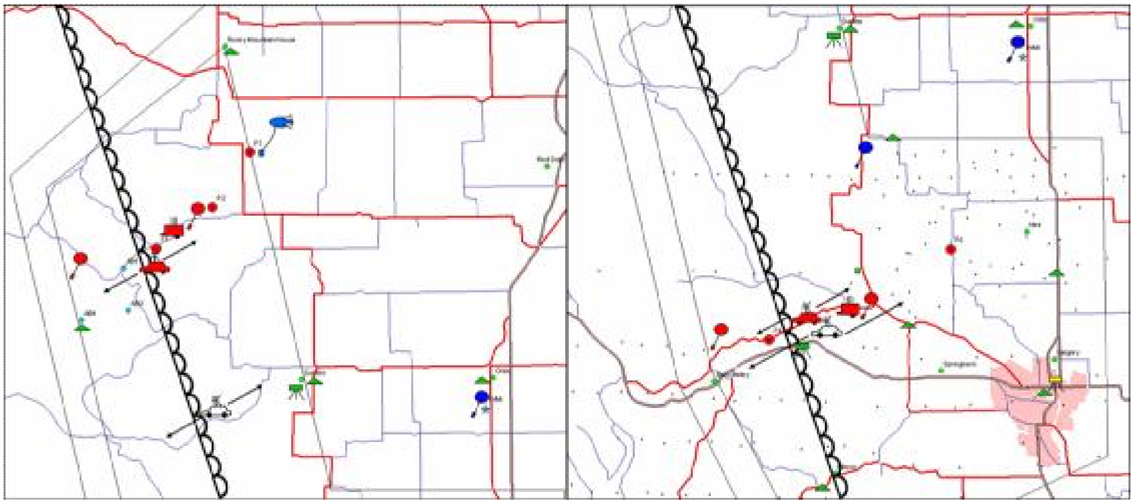

Figure 17: Maps showing instrumentation deployment on a dryline day near the high-density line of stations (left) and medium-density line (right). Mobile teams are coloured red, fixed teams blue. Other instruments are as per the legend in Figure 11. To intercept and sample the dryline one mobile radiosonde team will be positioned on the dry side of the boundary while the MARS/mobile radiosonde team will be on the moist side. Soundings will be launched simultaneously in 2 h intervals until CI is observed. The AMMOS and 2nd mobile surface team will conduct transects across the boundary between the mobile radiosonde teams. On the left the 2nd mobile surface team is shown conducting transects in the data-poor region. On the right the 2nd mobile surface team is conducting longer transects at higher speeds on the same route as the AMMOS.

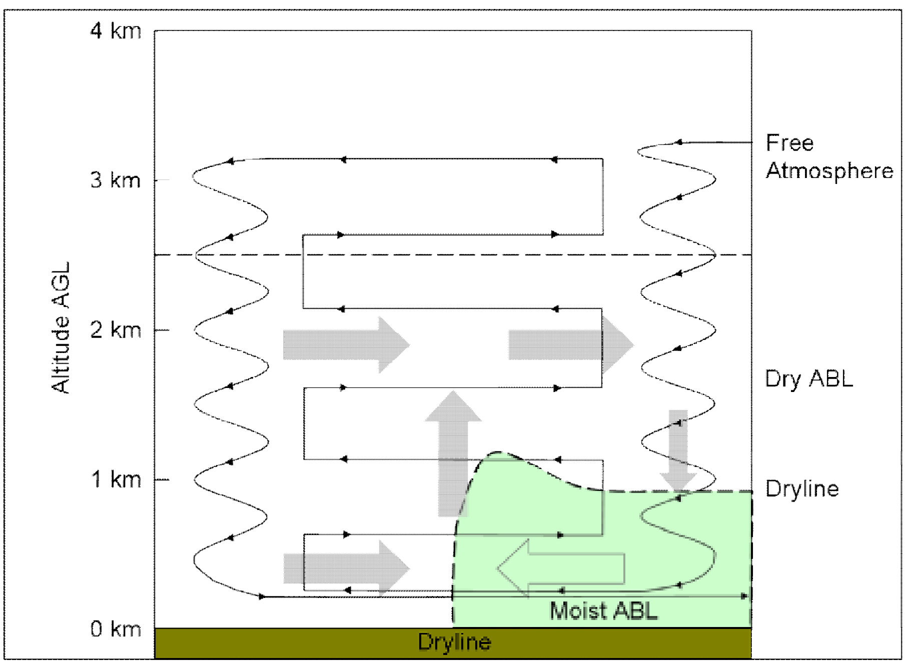

Figure 18: Schematic showing idealized flight path in the vicinity of the dryline (not to scale). Thin arrows delineate the flight path, large gray arrows represent the dryline-associated circulation. Ascending / descending spirals profile the environment on the dry and moist sides of the dryline and well as the top of the dry and moist ABL. Stepped traverses resolve the horizontal (and vertical) characteristics across the dryline and through the depth of the dry ABL.

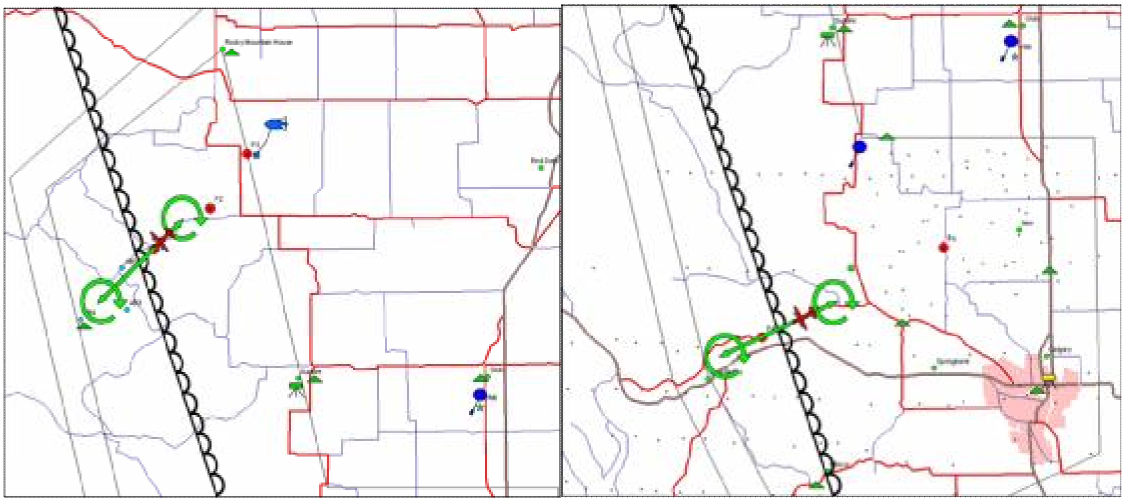

Figure 19: Plan view of flight plans for aircraft dryline sampling. Flight plan end-points will be near the locations of mesonet stations. Circular arrows represent the locations of ascending/descending spirals.

Bulging of the dryline is commonly observed in general and in Alberta has been associated with vertical transport of westerly momentum to the surface in the dry air (e.g., Taylor 2001). On IODs with the potential for dryline bulging, efforts will be made to sample the region of the dryline linking the QS part along the foothills to that bulging to the east (see Figure 20). On these IODs mobile teams will sample the foothills-area dryline prior to and including CI before relocating to sample the bulging dryline. The MARS and mobile radiosonde teams will be deployed on either side of the boundary while the AMMOS and $2^{nd}/3^{rd}$ mobile surface team conduct transects of the boundary. In cases where storms may interact with the bulging dryline, particular efforts will be made to follow these storms and document their evolution. Aircraft support to sampling the bulging dryline will only be available if no WMI seeding operations are anticipated and if aircraft flight time is still available. If available the general flight path in Figure 18 will be implemented across the dryline to coincide with the location of the surface-based mobile teams.

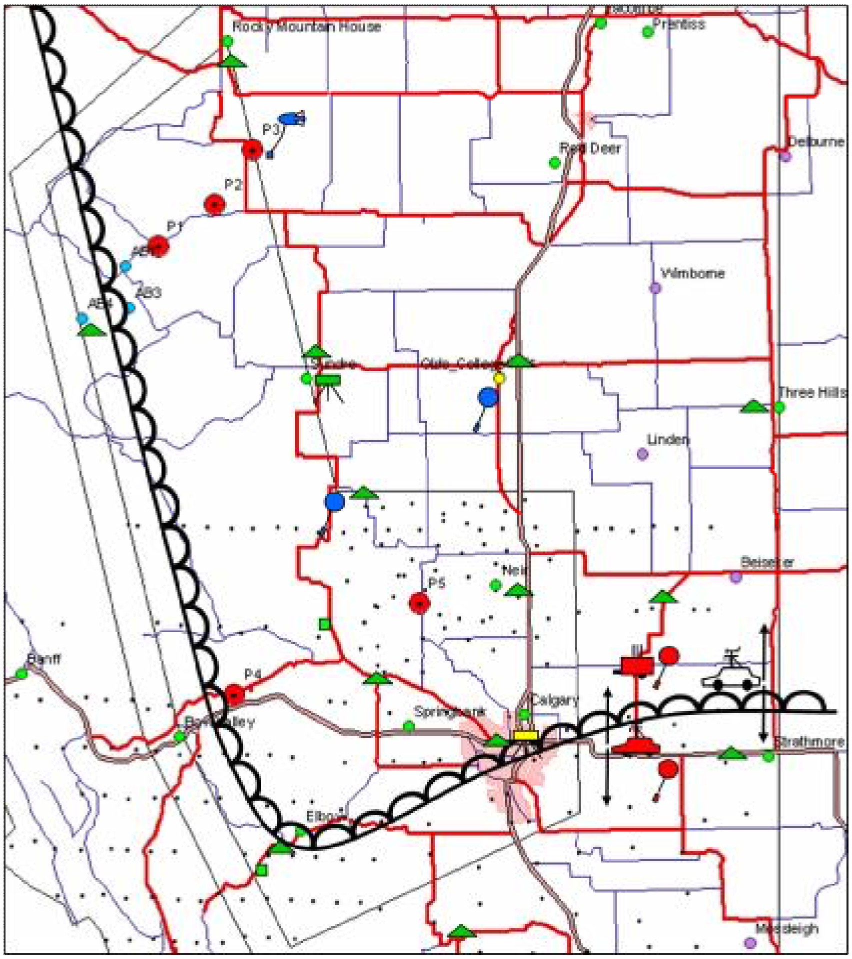

Figure 20: Map showing configuration of surface-based fixed and mobile teams for sampling a bulging dryline. Aircraft measurements will utilize the flight pattern in Figure 18 with end-points specified to capture the bulging dryline.

4.1.4: Water Vapour Gradient 1 (Soil Moisture)

Objective: To sample horizontal water vapour gradients associated with discontinuities in soil moisture as determined from PAM-II model forecasts and observed areas of recent precipitation.
Required Conditions: Quiescent days on which significant insolation is expected and near-surface winds are anticipated to be ~ 5 kt or less. PAM-II forecast of adjacent areas with contrasting soil moisture within the UNSTABLE domains. Alternatively, on days with areas that experienced widespread overnight precipitation, the presence of a region with contrasting soil moisture within the UNSTABLE domains. If present, areas with potential for CI and thunderstorm development will be targeted.

Based on overnight / morning precipitation, PAM-II model output, and / or Normalized Difference Vegetation Index (NDVI) imagery, the mobile teams will be dispatched to a region with anticipated contrasting soil moisture within the UNSTABLE domains. The MARS will be positioned over the moist soil and within a few km of the expected location of the strongest soil moisture gradient. The mobile radiosonde team will be positioned within a few km of the strongest gradient on the dry side. The AMMOS and other mobile surface team can be used to conduct transects between the MARS and mobile radiosonde team following strategies outlined in the previous mission descriptions. Since there will be uncertainty as to the actual location of the strongest moisture gradient (especially if based on model output) the MARS and other teams will consider redeployment once measurements refine the location of the actual gradient. As in the other missions soundings will be launched at two our intervals beginning at 16 UTC.

Aircraft support to the mission, if available, will follow the measurement strategy outlined in section 4.1.3 for the dryline with spirals and stepped traverse paths on either side of the moisture gradient. End-points for the traverses and wet / dry spirals should be located near the positions of the MARS and mobile radiosonde teams.

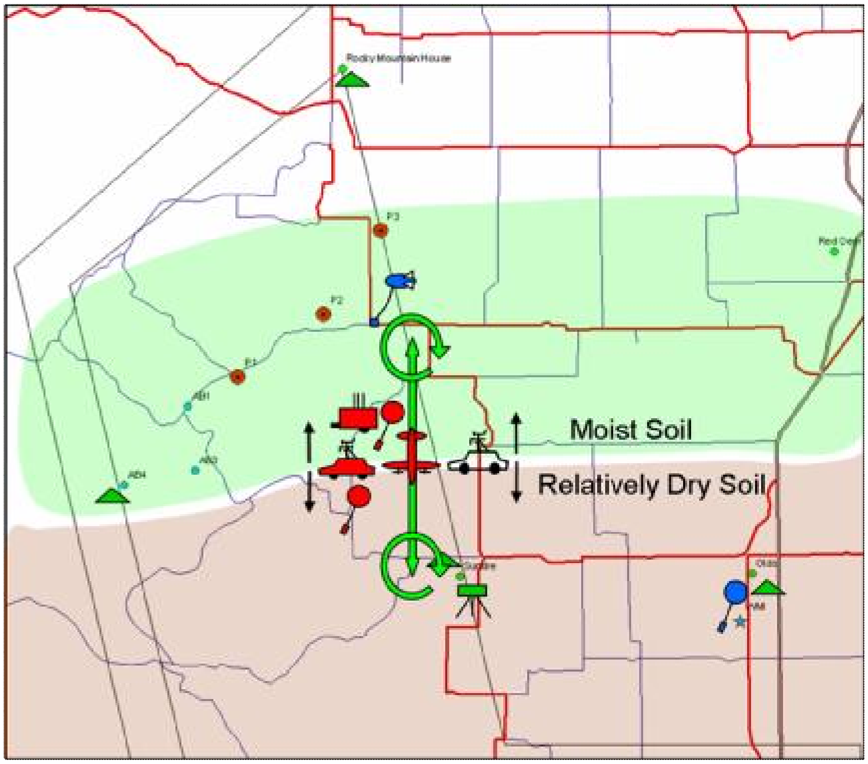

Figure 21: Plan view schematic of operations for the water vapour gradient 1 (soil moisture) mission, actual operations could occur anywhere within the UNSTABLE domains. The green area represents an area forecast by the PAM-II model to have high soil moisture or that recently received widespread precipitation. The brown area represents an area with relatively drier soil moisture. Aircraft measurements if included (not shown) would follow the spiral / traverse pattern as per the dryline mission with flight path end-points approximately near the positions of the MARS and mobile radiosonde teams.

4.1.5: Water Vapour Gradient 2 (Vegetation)

Objective: To sample horizontal water vapour gradients associated with adjacent regions of forest vs. cropped vegetation.

Required Conditions: Quiescent days on which significant insolation is expected and near-surface winds are anticipated to be ~ 5 kt or less. Water vapour gradients in this case should be generated by varying latent heat flux regardless of soil moisture so no precipitation conditions are required. If present, areas with potential for CI and thunderstorm development will be targeted.

Measurement strategies for this mission are essentially the same as for water vapour gradient 1 (soil moisture) with the exception that the boundaries to be targeted are fixed with respect to surface vegetation. The map in Figure 22 shows the (idealized) boundary between the forested and agricultural areas (Soil Landscapes of Canada v.3.0, National Land and Water Information Service, Agriculture and Agri-Food Canada) to the west and east of the heavy green line, respectively. This boundary could be used as a preliminary target area for deployment of the mobile teams, actual suitable areas with a sharp forest – crop transition will be located during IOD operations. Aircraft support to this mission (if available) would follow the spiral / traverse pattern already discussed with the area targeted to coincide with the location of the mobile teams.

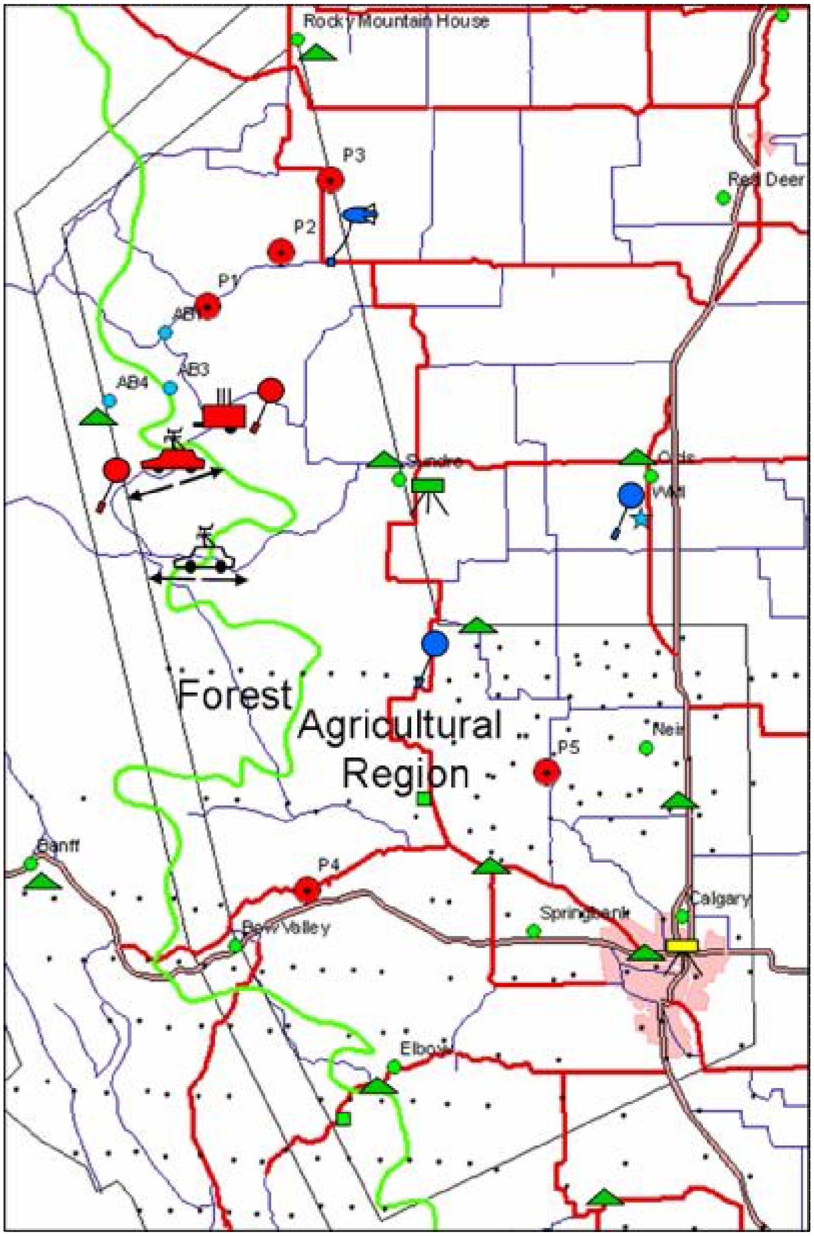

Figure 22: Map showing the idealized boundary between forested and agricultural areas in the UNSTABLE domains as defined by the Canadian Soil Information System, Agriculture and Agri-Food Canada (from 2001 Census). Possible locations for mobile instrumentation teams are shown with actual sampling locations determined while in the field. Aircraft flight paths are not shown.

More detailed information on land cover has been obtained from the Canadian Centre for Remote Sensing in the form of a high resolution map (250 m) of Canadian land cover up to 2005. Using this map three potential transects have been defined to traverse the boundary between agricultural and forested land. The Google Earth image in Figure 23 shows the location of three transects that will be used for this mission. Instrumentation teams will be positioned using the strategy already described. There may also be an opportunity to document water vapour differences across clear-cut vs. forest areas.

Figure 23: Annotated Google Earth image showing the approximate location of the local crop-forest land cover boundary and proposed mobile transects to be used for the Water Vapour Gradient 2 (Vegetation) mission. The three transects are coloured yellow, green, and blue for transect 1-3, respectively. Endpoints of the transects are labelled following CF#_E or CF#_W for the eastern and westernmost points of each transect. Locations of the FOPEX and ATMOS stations (P1 to P3) and proposed tethersonde location are also shown.

4.2: Fixed Instrumentation Daily Operations

Descriptions in section 4.1 focused on mobile instrumentation teams. Details on fixed instrumentation teams are provided in the following sections.

4.2.1: Fixed Radiosondes

Two fixed radiosonde teams will be utilized during the UNSTABLE 2008 IOP. These will be located at WMI operations (Olds-Didsbury airport, 51.71 °N 114.11 °W) and at another location to be confirmed within the primary UNSTABLE domain (likely in the vicinity of Water Valley, 51.50 °N 114.60 °W). Fixed radiosonde teams will provide a dual role in UNSTABLE 2008 operations. Soundings released at 1145 UTC (valid for 12 UTC) from these sites will be used as part of daily UNSTABLE IOD decisions and will be designated Forecast Radiosondes (FR). On UNSTABLE IODs these sites will continue to release additional sondes at two-hourly intervals beginning at 14 UTC. These additional sondes will be designated Intensive Radiosondes (IR) and will continue until CI is observed in the target area or until 00 UTC. Soundings from WMI will be released by WMI staff with the exception of the 12 UTC sounding which will be released by one of the mobile sounding teams (WMI operations do not generally commence until later in the morning). Attempts will be made for both FR and IR soundings to be disseminated to Environment Canada's data network for use in CMC model assimilation and by PASPC / CMAC-W forecasters.

4.2.2: Tethersonde System

The tethersonde system will be operated from the P3 ATMOS site (weather permitting) during the UNSTABLE 2008 IOP. Operations will be conducted from 1500 UTC to 0000 UTC on IODs and from 1500 UTC to 2100 UTC on non-IODs. Unless an IOD, tethersonde operations will stand down on weekends. For 2008 the tethersonde is equipped with 3 km of line, 6 meteorological sondes, and 3 ozone sondes[6]. The system will be operated from ~ 15 UTC until 00 UTC or until precipitation in the area forces earlier termination of operations. Operations will test both continuous deployment (limited by battery lifetime) and profiling using only one sonde. Vertical profiles (ascent and descent) should be conducted within a 1 h timeframe.

4.2.3: WVR-1100 and WVP-1500 Radiometers (University of Calgary)

University of Calgary radiometers will be located at the university (WVP-1500) and Sundre (WVR-1100) to complement the network of fixed GPS PWV systems and radiosondes. The systems are expected to be run continuously throughout the 15-day IOP with data to be quality controlled at the University of Calgary following the IOP. Radiometer data will not be available in real time during UNSTABLE field operations.

4.2.4: GPS Integrated Precipitable Water Vapour Systems

As with the radiometers, the GPS PWV systems are anticipated to be collecting data continuously during the 15-day IOP with data to be quality controlled at the University of Calgary following the IOP. GPS PWV data will not be available in real time during UNSTABLE field operations.

5: Forecast and Nowcast Support[7]

The PASPC will support UNSTABLE mainly through providing forecast / nowcast support. At present three expert summer severe weather forecasters have been identified for this role and will provide operational support from 7-23 July. Support will be provided via a modified Research Support Desk (RSD) utilizing the operational suite of software, Aurora, and web-based information. The UNSTABLE RSD (URSD) meteorologist will focus exclusively on the UNSTABLE study area and surroundings. On days where severe weather threatens this area the URSD meteorologist will coordinate frequently both with the UNSTABLE FC and the PASPC operational forecast team. The URSD shift will be scheduled to run from 0800 to 2000 LT (1400 to 0200 UTC) to leverage their expertise during the pre-storm period through to the evening briefing for DAY-2 UNSTABLE operations. Prior to the morning UNSTABLE planning meeting, the FC will coordinate with the outgoing PASPC shift supervisor on expectations for the day's weather and changes from the previous day's forecast. Details on forecast and nowcast support provided by the URSD are described below.

5.1: Forecast Support

The URSD meteorologist will produce both graphical and textual CI forecast products for the next day's operations (DAY-2: T+24-36) and for an outlook period (DAY 3: T+48-60). The forecast domain will be southern AB in general with specific focus on the UNSTABLE domains. Decisions for current day (DAY-1) operations will be made using the previous day's DAY-2 forecast modified early in the morning by the FC in collaboration with the overnight PASPC supervisor. The URSD will participate in evening meetings to discuss DAY-2 weather and potential UNSTABLE operations.

The DAY-2 and DAY-3 graphic forecasts will be issued before 00 UTC and include:

- Locations of meteorological boundaries that are expected to be significant for CI (e.g., fronts, dryline, decayed cold pool boundaries) at 2100 UTC along with direction of motion and speed.
- Graphical delineation of areas favourable for CI and the development of thunderstorms and expected time of CI.
- Supporting text where required to clarify the forecast or identify specific points of interest.

[6] Ozone sondes will only be deployed on non-IODs during the IOP.

[7] Details on forecast / nowcast support are still being finalized and will be confirmed in a later draft of the operations plan.

The graphical forecast products will be generated using Aurora and posted to the UNSTABLE operations web page. The accompanying text discussions will be generated via a text editor, posted to the operations web page, and should include:

- General synopsis of synoptic / mesoscale weather and features of interest for the valid time period. Where appropriate quantitative values of selected parameters should be included.
- Specific discussion of mesoscale features and boundaries that will be important for CI
- Processes that may act to suppress or inhibit CI
- A measure of confidence in the forecast and caveats that could come into play

Both the graphic and text discussion will be posted to an UNSTABLE Operations website (to be developed prior to field operations in 2008) for use in UNSTABLE meetings and for access by participating scientists and other interested parties. The operations site will include direct links to web-based tools for forecast / nowcast information.

Forecasts will be generated using a variety of standard and experimental data sources. These will include:

- Standard suite of observational surface, satellite, and other data
- Standard CMC produced NWP prognoses (deterministic and ensemble) via operational software and web interfaces
- Experimental CI and severe weather model fields (at 15 km / 1 h resolution) developed in the HAL over the prairies and a dedicated UNSTABLE domain via web interface
- HAILCAST model output over the UNSTABLE domain
- SPC/NCEP Short-Range Ensemble Forecasts (SREF) and other NWP data available via the web
- GEM LAM 2.5 km model output over the UNSTABLE domain via operational an experimental websites
- Access to GEM LAM 1 km model output over the UNSTABLE domain

The URSD will be asked to give a general briefing on their forecast products via teleconference during the evening UNSTABLE coordination meeting.

5.2: Nowcast Support

A large amount of the URSD meteorologist’s time will be spent providing nowcast information for UNSTABLE operations. For UNSTABLE purposes, nowcasting refers to 0-3 h forecasts focussing primarily on the position and strength of mesoscale (and synoptic-scale) boundaries and the development / evolution of deep convection. Formal nowcast products will not be produced but nowcast information will be provided through frequent consultations with the FC via telephone.

In addition to standard operational suite of observations (synoptic surface obs., satellite, EC radar, lightning, AMDAR, etc.) the URSD will have access to:

- An UNSTABLE operations website with direct links to various web-based remote sensing and other data sources
- Two-hourly soundings from fixed locations in the UNSTABLE domains.
- Display of EC radar, GOES VIS satellite, lightning, and surface observations from ATMOS / FOPEX stations in Google Earth (under development) for ready coordination with the FC
- Display of EC radar, satellite, lightning, ATMOS/FOPEX observations via Aurora. Screen captures will also be posted to the UNSTABLE operations website
- A dedicated mesoscale analysis window (based on the RUC model) over the UNSTABLE domain produced by the SPC in Norman, OK. This window will be accessed via the

standard web interface at: http://www.spc.noaa.gov/exper/mesoanalysis/. Details on the domain and duration the window will be available are being coordinated with Steve Weiss. An approximate domain relative to other mesoanalysis windows is shown in below.

Figure 24: Sample location of the UNSTABLE domain mesoanalysis window to be provided by the SPC.

As part of nowcast support to UNSTABLE operations, hourly mesoanalyses will be produced using Aurora software beginning at 15 UTC. The first mesoanalysis will be produced using 15 UTC observations and posted to the web by 1530 UTC. Subsequent mesoanalysis will be produced hourly and posted to the web at 30 min. past the hour until 0030 UTC. These products will only be produced on IODs and will also be available for use by the PASPC forecast team via the web.

Hourly mesoanalyses will include positions of all detectable (via surface observations, radar finelines, satellite imagery) mesoscale boundaries within the UNSTABLE domains as well as surface station plots and XSM low-level PPI radar imagery. Mesoscale boundaries will be drawn manually within Aurora and the final image will be automatically posted to the UNSTABLE Operations website. The images and Aurora database will be archived for use in later research.

It will be critical for the USM to monitor areas that may be outside the region selected for IOD operations. For example, while mobile teams are on route a boundary may become diffuse and reform in some other location or the surface wind field may advect the boundary or areas of significant ABL moisture outside the IOD domain. It will be important to have the longest lead time possible to ensure any required redeployment of mobile teams is done in a timely manner.

5.3: UNSTABLE RSD Activities

A preliminary operational schedule for the PASPC URSD is included below. The URSD will start at 0800 LT (1400 UTC) and continue until 2000 LT (0200 UTC). As already described, duties will be split between generation of DAY-2 and DAY-3 forecasts and nowcasting coordination with the UNSTABLE FC (includes coordination with PASPC forecast team). Times in the table below are proposed and may be modified following test operations on the URSD. Consultation with the UNSTABLE FC can occur at any time and is encouraged whenever new information is available or modifications to the original forecast are required. Ongoing informal notes and summaries of weather-related issues would be valuable to UNSTABLE investigators during later research. The URSD meteorologist is asked to keep an ongoing log through their shift, this can be in the form of an online 'BLOG' and can include screen captures of interesting model or analysis figures, severe weather reports, thoughts on the forecast or actual evolution of meteorological situation, etc.

Table 5: PASPC Unstable Support Meteorologist operations schedule. If no UNSTABLE operations then mesoanalyses will be unnecessary and URSD meteorologist will focus on preparation of DAY-2 / DAY-3 forecast and other work.

Time Local	Time UTC	Forecaster Activities
0800	1400	• Briefing from PASPC operational shift and review of previous day's DAY-2 forecast. • Call to FC for IOD decision and mission selection if 'GO' and to discuss DAY-1 weather • Quick spin-up on current synoptic and mesoscale environment (surface analysis, satellite imagery, 00Z NWP output)
0905	1505	• Work on 1500 UTC mesoanalysis to be posted to web by 1530 UTC
0930	1530	• Consultation with UNSTABLE FC as mobile teams will be nearing position for IOD measurements
1005	1605	• Work on 1600 UTC mesoanalysis • Evaluate suitability of IOD target area
1105	1705	• Work on 1700 UTC mesoanalysis
1130	1730	• Lunch
1205	1805	• Work on 18 UTC mesoanalysis • Begin preparations for DAY-2 forecast
1305	1905	• Work on 19 UTC mesoanalysis
1405	2005	• Work on 20 UTC mesoanalysis
1500	2100	• Preliminary DAY-2 forecast graphic and discussion complete and posted to the web site • Begin DAY-3 Forecast as time allows • Continued nowcast support to UNSTABLE operations
1505	2105	• Work on 21 UTC mesoanalysis
1605	2205	• Work on 22 UTC mesoanalysis
1705	2305	• Work on 23 UTC mesoanalysis
1805	0005	• Work on 00 UTC mesoanalysis • Post DAY-3 forecast
1900	0100	• Participate in UNSTABLE DAY-2 planning meeting if no UNSTABLE operations • If operations ongoing meeting will be delayed / cancelled • Work on 0100 UTC mesoanalysis if operations continue
2000	0200	• URSD shuts down for the day

6: Daily Planning and Operations Schedule

UNSTABLE 2008 operations will follow a general schedule throughout the IOP. On IODs this schedule will include a morning planning meeting, aircraft flight planning, regular releases of soundings and mobile observations, consultations with the PASPC URSD, and an evening de-briefing and planning meeting. As a test of planning strategy, the early morning planning meeting could be omitted on selected days to permit early dispatch of mobile teams and mobile soundings valid for 16 UTC. This decision will be made at the previous evening's planning meeting.

6.1: Morning Planning Meeting

The UNSTABLE FC will coordinate with the outgoing PASPC forecast team lead at 0645 LT (1245 UTC) on anticipated convective weather for the day. The previous day's DAY-2 forecast will be reviewed and compared against the most recent observational and NWP data to assess the need for modification. The morning planning meeting will begin at 0715 LT (1315 UTC) involving all mobile field teams (fixed radiosonde and tethersonde teams will be stationed elsewhere). The purpose of this meeting will be for review and discussion of the (modified) previous day's DAY-2 forecast and preliminary operational / mission decisions. The most recent observational and NWP output will be discussed and final decisions reached on operational status and mission selection if applicable. The meeting will wrap-up at 0800 LT (1400 UTC) at which time mobile teams will be dispatched to prepare for 1600 UTC mobile surface and upper-air observations.

6.1.1: Operational Status

The first decision to be made at the morning meeting is whether or not to conduct operations. Where possible this decision will be made by consensus among the UNSTABLE science leads and other principal investigators present. If consensus within the larger group is not possible the decision will rest with the UNSTABLE science leads (or alternate representative, e.g., J. Brimelow in lieu of J. Hanesiak). A day will only be designated an IOD if it is anticipated that measurements will satisfy one of the IOD missions (or some modification thereof). Operational status will be designated as 'GO', 'NO-GO', or 'STANDBY' as follows:

GO
The meteorological situation satisfies requirements for one or more of the IOD missions. Mobile teams will plan to depart WMI by 1400 UTC and fixed teams will commence sounding and tethersonde operations as scheduled.

NO-GO
The meteorological situation does not satisfy any of the IOD missions.

STANDBY
Conditions for IOD missions may be met but uncertainty at the time of the morning planning meeting precludes initiating IOD measurements immediately. If conditions do not satisfy an IOD mission by 1600 UTC no, or only limited, IOD measurements (as determined by the science leads) will occur.

If an operational status of 'GO' or 'STANDBY' is determined, an IOD mission and target area will be selected. This will include utilization of pre-defined mobile transect routes as defined in the IOD missions. Mission selection will come through consensus of the science leads; if consensus is not immediately reached there will be an option for leads to propose a modified mission that may satisfy the group. The IOD target area will be defined using input from field participants and available observational or NWP information. At the conclusion of the planning meeting a status message including the mission selected will be emailed to all field teams and UNSTABLE participants.

6.1.2: IOD Mission Selection

UNSTABLE IOD missions have been designed to address specific science questions and to facilitate UNSTABLE operations on days meeting various meteorological criteria. Since only eight IODs are planned for UNSTABLE 2008 careful selection of IODs and associated missions is required. Missions should be selected according to anticipated meteorological conditions and likelihood that the mission on that IOD will be successful. To aid in mission selection a decision tree was proposed by J. Brimelow and designed by D. Sills (see Figure 25).

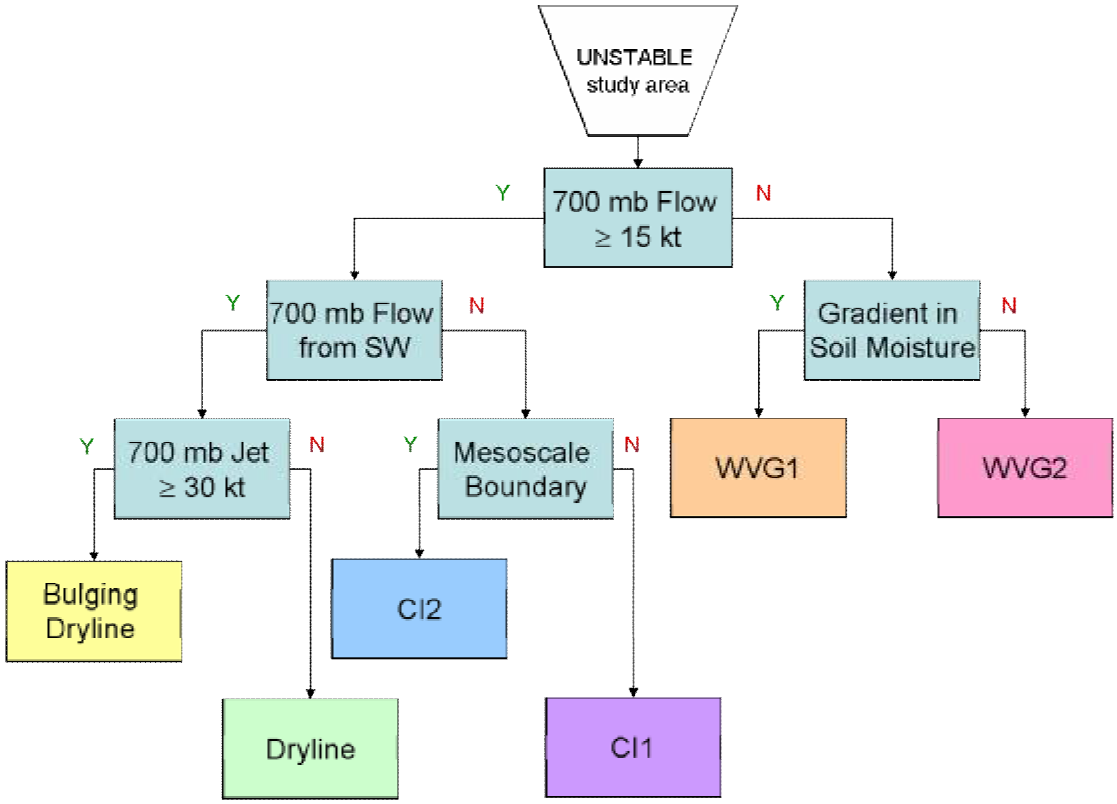

Figure 25: Decision tree to be used for IOD mission selection.

Decisions will be based on criteria applying to the UNSTABLE domains. Initial consideration will be of anticipated afternoon 700 mb flow. Flow in excess of 15 kt will likely result in mixing of momentum to the surface by the afternoon thus negating the requirement for a quiescent day to undertake the WVG1 and WVG2 missions. If flow at 700 mb will be less than 15 kt the dynamic requirements of the conditions for the CI1, CI2 and Dryline missions may not be not be met so that the WVG1 and WVG2 missions would be favoured. Assuming weak 700 mb flow, overnight accumulated precipitation will be considered for the presence of a rain / no-rain boundary within the UNSTABLE domains. If present then WVG1 will be selected. Alternatively, if no precipitation gradient exists but PAM-II model output suggests a gradient in soil moisture in the domains then WVG1 will be selected. In the absence of an anticipated soil moisture gradient, and under quiescent conditions, WVG2 will be selected.

If the flow at 700 mb is anticipated to be in excess of 15 kt the next consideration will be flow direction. If the flow is approximately SW then subsidence in the lee of the mountains and the development of a dryline may be favoured. An embedded jet of 30 kt or more in the 700 mb SW flow may indicate the potential for a bulging dryline so that modification of the dryline mission would be selected. In the absence of an embedded jet a QS dryline may be expected and the dryline mission selected.

If the 700 mb flow is not from the SW then organized subsidence in the lee of the rockies is unlikely and a dryline will not be favoured. Consideration will then be given to the potential for other mesoscale boundaries, e.g., surface trough, front, decayed outflow boundary. If a mesoscale boundary is anticipated to play a role in CI, then mission CI2 will be selected. If it's probably for no boundary to be present mission CI1 will be selected.

During morning discussions the modification of IOD missions to suit the particular mesoscale environment will be considered. The underlying premise will remain to satisfy the science questions through either unmodified or modified IOD missions.

6.2: Aircraft Mission Flight Planning[8]

Once operational status and mission have been determined the science leads must decide whether or not to conduct aircraft observations. Since only 4 aircraft missions are planned for UNSTABLE 2008 careful selection of aircraft days will be required. Flights will not be included on days where there is only a marginal chance of the meteorological situation meeting mission requirements. Decisions on aircraft measurements will rest on the science leads.

Once the science requirements for aircraft support are met, leads (or the FC if mobile teams have already departed) will coordinate with WMI on flight planning. Timing of flights must satisfy WMI operations and on days with hailstorm potential must be concluded prior to WMI estimated times for cloud seeding. Flight times will hinge strongly on expected timing for CI.

6.3: Mobile Team Travel

Mobile teams will generally leave WMI together following the morning planning meeting. It is important for teams to be in position to conduct operations prior to 16 UTC so that soundings can be timed with the fixed radiosonde and tethersonde teams. The AMMOS should take the lead during mobile team travel on boundary missions to identify the actual locations of boundaries. Teams will be in frequent contact with each other and with the FC who will provide updates on meteorology and other logistics information as well as providing navigational information where required.

6.4: Mission Debrief and DAY-2 Planning

On non-IODs a DAY-2 planning meeting will be held at 1900 LT (0100 UTC) at WMI headquarters. All available field teams will participate. The purpose of this meeting is to make preliminary status and IOD mission decisions for the next day. The DAY-2 and DAY-3 forecasts will be presented by the URSD meteorologist via phone along with evaluation of NWP output. Following the briefing and open discussion preliminary status and mission decisions will be made.

On IODs field teams will likely not be available for a 1900 LT meeting. On these days the FC will have a discussion with the URSD meteorologist via phone. Preliminary decisions will be made by the FC who will then wait for the arrival of the field teams. Once the teams are available an informal mission de-brief will be held outlining successes / challenges associated with conducting the day's observations, updates on consumables, and suggestions for improvements to measurement strategies. Mobile instrumentation leads will be asked to upload copies of their observational data to an external hard drive on the FC's computer. The FC will then present the DAY-2 and DAY-3 forecasts and relevant NWP output for discussion among the group. Preliminary status and mission decisions will then be made pending modification at the morning meeting. If time does not allow upload of observational data at the evening meeting then upload will occur on the next non IOD.

6.5: Post-Storm Damage Surveys

Where possible, following severe storm events within the UNSTABLE domains, post-storm damage surveys will be conducted. These may be conducted on non-operational days by

[8] Flight planning details are being coordinated with Terry Krauss, WMI. More information will appear in a later version of the operations plan.

UNSTABLE investigators and may include the participation of PASPC-Edm operational staff and / or regional Warning Preparedness Meteorologists. Alternatively PASPC operational staff and Warning Preparedness Meteorologists may conduct surveys independently.

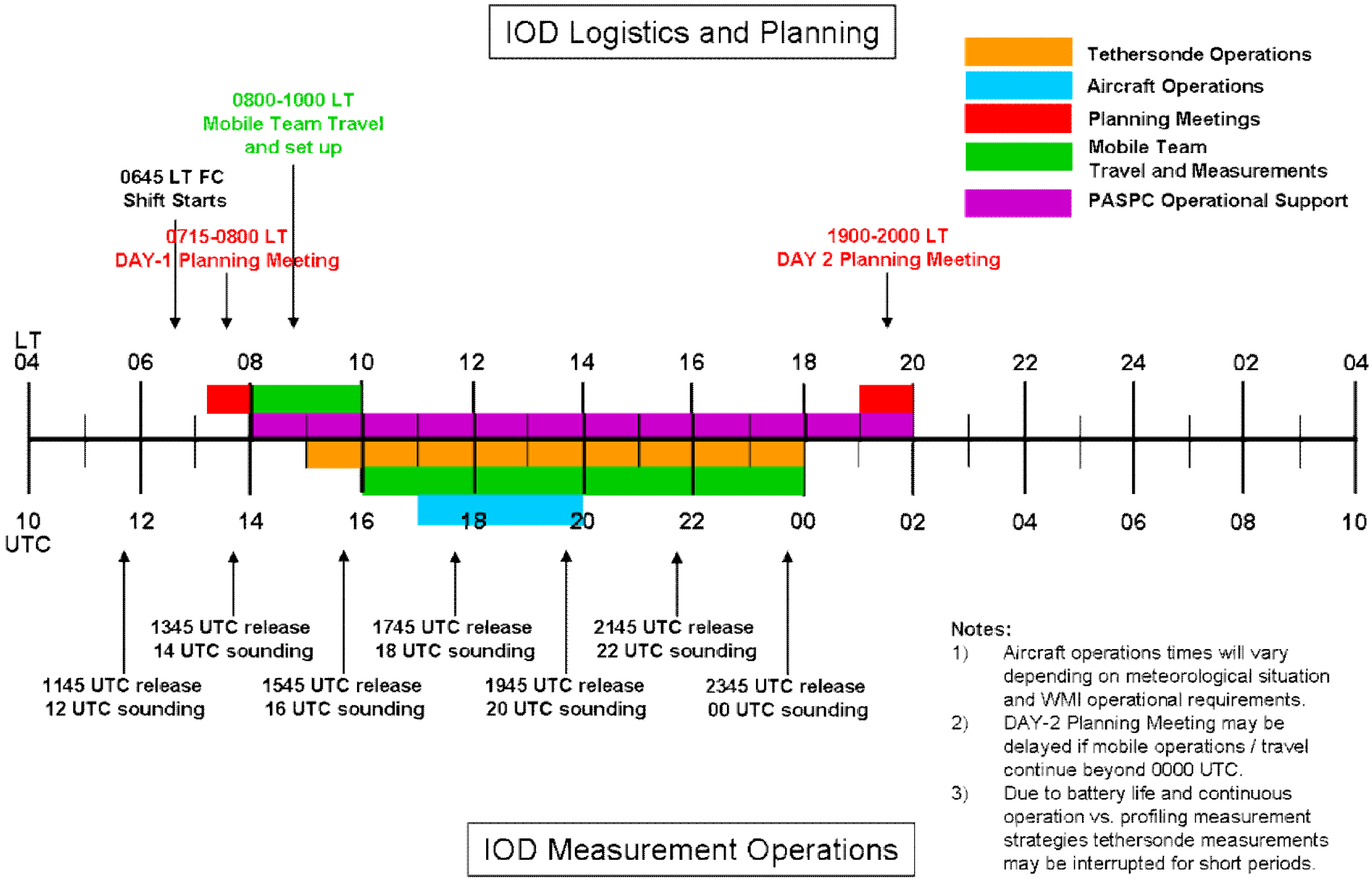

Figure 26: Daily timeline for UNSTABLE IODs. Coloured bars indicate timing and duration of various components of UNSTABLE 2008 operations. Some times are approximate and may be adjusted during field operations as required.

7: Field Coordination and Communications

Coordination of fixed and mobile field operations is critical for the success of the UNSTABLE field campaign. Attempting to conduct detailed coordination activities in 2008 will provide a good test for the approach to be used in 2011. Central field coordination for the instrumentation teams in UNSTABLE 2008 will occur from WMI operations at the Olds-Didsbury airport. The FC will oversee general operations during the field campaign. The primary duties of the FC will be to vector mobile teams to appropriate positions, coordinate with the PASPC and field teams on operational decisions, and to act as the central point of communication for all field personnel for OHS or other issues. The FC will be reachable via cell phone, email, and text messages.

7.1: Coordination of Mobile Instrumentation Teams

By the conclusion of the morning planning meeting IOD status will be confirmed and if operations are 'GO' an IOD mission will have been selected. The mobile teams will depart WMI immediately following the morning meeting (0800 LT) to get in position for sampling operations. Mobile teams (AMMOS, MARS, Mobile Radiosonde, 2nd SFC Mobile) will be equipped with a GPS navigation device (Garmin Nuvi 250W), laptop, Blackberry or cellular phone, and in some cases, aircards for the laptops. This configuration will allow for automatic transmission of GPS position to the FC via purchased software (Franson GPS Gate v2.6) where positions will be viewed in real-time using Google Earth.

Frequent mesoanalyses information will be required to position mobile teams in areas of interest for IOD missions. Google Earth will be used to visualize mobile team positions, current Environment Canada radar data, observations from mesonet stations, and (possibly) objective analyses of meteorological fields simultaneously. Combined with frequent reports from mobile teams the FC will be able to ensure the teams are in the most appropriate position for measurement operations.

7.2: Coordination of Fixed Instrumentation Teams

The FC will also be responsible to ensure coordinated operations occur between the fixed and mobile teams. This would included releasing simultaneous soundings, being kept aware of technical or other problems being encountered in the field, and coordinating assistance from other teams if necessary. Fixed instrumentation teams will be equipped with Blackberry devices or cellular phones that will allow them to remain in frequent contact with the FC, or if necessary, other instrumentation teams.

7.3: Other FC Duties

The FC will be the central source of information for the field teams. This will mean staying apprised of the operational status and position of all teams, recording reports of problems from the field, providing weather and logistical information to field teams on request, etc. The FC will chair the evening and morning IOD planning meetings and provide reports to the group on any issues affecting operations. The FC will be the liaison between WMI and UNSTABLE operations and will coordinate with WMI staff on sounding release times, aircraft operations, WMI radar data, and observations from the field. The FC will be responsible for dissemination of status messages and updates to field teams at regular intervals.

8: Data Management and Access Policy

Data management is an integral component of the success of any field campaign. At this time a formal data manager has not been identified but steps will be taken to ensure data integrity and back-up both during the IOP and immediately following.

During the IOP, instrumentation leads will be responsible for backing up observational data. For mobile teams this should occur after each IOD (or the next day), for radiosonde and other fixed instrumentation teams this should occur each day during the IOP. At the evening planning meeting mobile teams will be asked to copy their most recent observational data to a hard drive connected to the FC computer. This will ensure a central back-up of observational data throughout the IOP.

Data QC will generally be the responsibility of instrumentation leads as shown in the table below.

Table 6: Data collection platforms, associated data, data originators and QC champions.

Platform	Data	Originator	QC
	Special UNSTABLE Datasets		
ATMOS	SFC T, P, T_d, Wind, Pcpn, Rad., ΔT	Sills / Taylor	Sills
FOPEX	SFC T, P, T_d, Wind, Pcpn	Smith	Smith
FCA	SFC T, P, T_d, Wind, Pcpn	Marshall	Marshall
AMMOS	SFC T, P, T_d, Wind	Sills / Taylor	Sills
2nd Mobile	SFC T, P, T_d	Strong	Strong
3rd Mobile	SFC T, P, T_d	Sills	Sills
MARS	SFC T, P, T_d, Wind	Hanesiak	Hanesiak
	AERI – 3km T, RH	Hanesiak	Hanesiak
	SODAR – 1.3km Wind, VV, Mix. Depth, Turb.	Hanesiak	Hanesiak
	IR Pyrometer – Cloud Base Temp.	Hanesiak	Hanesiak
	WVR-1100 – PWV / liquid water	Hanesiak	Hanesiak
Mobile RS (MARS)	P, T, RH, Wind	Smith / Hanesiak	Smith
Mobile RS	P, T, RH, Wind	Smith	Smith
Fixed RS (WMI)	P, T, RH, Wind	Krauss	Smith
Fixed RS (Wat. Valley)	P, T, RH, Wind	Smith	Smith
Tethersonde	Upto 3 km P, T, RH, Wind	Taylor / Sheppard	Sheppard
WVP-1500	10km RH, liquid water, PWV	Skone	Skone
WVR-1100	PWV / liquid water	Skone	Skone
GPS PWV	PWV	Skone	Skone
Aircraft	T, T_d, P, Wind, VV, microphysics	Krauss	Taylor
WMI Radar	All Products	Krauss	Krauss / Patrick (?)
	Operational UNSTABLE Datasets		
GOES Satellite	Visible, IR, Water Vapour, Multispectral	EC	Goodson (?)
EC Radar	All Products from XSM, WHK	EC	Patrick (?)
CLDN	All Data within UNSTABLE domain	EC	Vaisala
RS	WSE and other soundings	EC	EC
SFC EC	Existing Surface Stations within UNSTABLE domain	EC	EC / Taylor (?)
SFC AB	Existing Surface Stations within UNSTABLE domain	Gov't AB	Gov't AB
Weather Bug	SFC T, P, T_d, Wind, Pcpn	Station Owner	?
	Web-Based Data		
World Wide Web	A variety of web-based imagery (e.g., pcpn maps, satellite imagery, etc.) will be archived during the project	Originating Agencies	Taylor

A data access policy has been established and agreed to by all UNSTABLE PIs. In essence the policy limits access to special UNSTABLE datasets as follows:

- UNSTABLE PIs will have unlimited access immediately following the IOP
- UNSTABLE Co-Is will have access to all UNSTABLE data following a QC period of up to one year. They will have access to operational data immediately following the IOP. Co-Is may be granted earlier access to special datasets upon permission from the UNSTABLE science team (consisting of UNSTABLE PIs)
- UNSTABLE partners and other interested parties will have access to operational UNSTABLE data immediately following the IOP. These groups will have access to all UNSTABLE data following a one year period beyond completion of data QC (maximum two year period in total)

Other details on data access, usage, and requirements for acknowledgement / co-authorship are available in the UNSTABLE Data Access Policy (available on request and via the UNSTABLE website).

9: Occupational Health and Safety

The health and safety of UNSTABLE participants while in the field are of the utmost concern. UNSTABLE PIs have worked with EC's OHS Manager for Prairie and Northern to ensure that EC criteria for OHS have been met. EC field participants have undergone First Aid training, and will have read and signed all relevant OHS documentation for fieldwork associated with UNSTABLE. These Task Hazard Analysis (THA) documents outline potential hazards and safe work procedures to be followed while in the field. Non-EC participants in the project will be strongly encouraged to read and sign all relevant THAs prior to participating in the project. As part of OHS considerations, all field teams will consist of at least 2 individuals and communication protocols have been established with the FC. The THAs relevant to UNSTABLE are the following:

- General Field Operations
- Driving
- Ball Hitch Trailers
- Compressed Gas Cylinders
- Balloon Release
- Work in Extreme Temperatures – Hot
- Mobile Meteorological Data Collection and Observations
- Storm Damage Surveys
- Travel in Fixed-Wing Aircraft

All THAs as well as background documentation are available via the UNSTABLE operations website.

10: References

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Appendices

A1 Field Participants and Contact List

The following table contains the most up-to-date information on UNSTABLE Field participants, their roles, and affiliations. A similar table with more detailed contact information will be available to all field participants. A field participation schedule is included in Table 8.

Table 7: General Field Participants and email contact information. Participants may be added as the IOP nears.

Field Participants			
Name	**Affiliation**	**Position**	**Email**
Field Coordination			
Neil Taylor	HAL-EC	Lead	Neil.Taylor@ec.gc.ca
Automated Mobile Meteorological Observation System (AMMOS)			
Dave Sills	CPSWRS-EC	Lead	David.Sills@ec.gc.ca
Andrew Giles	HAL-EC	Asst.	Andrew.Giles@ec.gc.ca
Bill Burrows	HAL-EC	Asst.	William.Burrows@ec.gc.ca
2nd Mobile SFC Team			
Geoff Strong	U of A	Lead	geoff.strong@shaw.ca
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Jay Anderson	U of M	Asst.	
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Tethersonde			
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Name	**Affiliation**	**Position**	**Email**
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Water Vapour Radiometers			
Susan Skone	U of C	Lead	shskone@ucalgary.ca
Precipitation Occurrence Sensor System (POSS)			
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Visitors			
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David Bright	SPC		David.Bright@noaa.gov

Acronyms

AB Env	Alberta Environment
AQS	Air Quality Science
CoD	College of Du Page
CPSWRS	Cloud Physics and Severe Weather Research Section
CRD	Climate Research Division
EC	Environment Canada
HAL	Hydrometeorology and Arctic Lab
OSPC	Ontario Storm Prediction Centre
PASPC	Prairie and Arctic Storm Prediction Centre
SPC	Storm Prediction Center
U of A	University of Alberta
U of C	University of Calgary
U of M	University of Manitoba
WMI	Weather Modification Inc.

Table 8: UNSTABLE field participants, their affiliations, role, and dates of participation. This table will change as positions are finalized.

			S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T
Name	***Role***	***Affiliation***	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Neil Taylor	Field Coordinator	EC		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Dave Sills	AMMOS Lead	EC		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Andrew Giles	AMMOS Asst.	EC				•	•	•	•	•	•	•									
Bill Burrows	AMMOS Asst.	EC											•	•	•	•	•	•	•	•	
Geoff Strong	2nd Mobile Lead	U of A		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Bob Kochtubajda	2nd Mobile Asst.	EC														•	•	•	•	•	
Garry Toth	2nd Mobile Asst.	EC							•	•	•	•	•								
Paul Sirvatka	3rd Mobile Lead	C DuPage			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Danny Brown	3rd Mobile Asst.	U of A			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
John Hanesiak	MARS Lead	U of M	•	•	•	•	•	•	•	•	•	•									
Julian Brimelow	MARS Lead	U of M	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Jay Anderson	MARS Asst.	U of M	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Shannon Moodie	MARS Asst.	U of M	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Craig Smith	Mobile RS Lead	EC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bruce Cole	Mobile RS Asst.	EC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Erin Thompson	Fixed RS Lead	EC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Joe Misfeldt	Fixed RS Asst.	EC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Andrew Sheppard	Tethersonde Lead	EC	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Curtis Mooney	Tethersonde Asst.	EC	•	•	•																
Garry Toth	Tethersonde Asst.	EC			•	•	•	•						•	•	•	•	•	•	•	
Ron Goodson	Tethersonde Asst.	EC							•	•	•	•	•								
Pat King	Aircraft Scientist	EC			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	

A2 Accommodations

Accommodations for mobile field teams will be at Olds College Court Townhouses. These townhouses sleep 4 and on most nights these accommodations will be available at a rate of $35 per person per night (based on 4-person occupancy). The following website contains more information:
http://www.oldscollege.ca/studentresidence/college-court-townhouses.htm

The fixed radiosonde team at Water Valley will stay in Cochrane at the Best Western Country Harvest Inn (403-932-1410). The tethersonde teams will stay in Rocky Mountain House at the Best Western (403-844-3100).

A3 UNSTABLE 2008 Operations Calendar

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
May 18	19	20	21	22	23	24
25	26	27	28	29 Taylor / Smith Site Scouting	30	31
June 1 Cellular Plans Commence	2	3	4 ATMOS Deployment (P1-P3)	5	6	7
8	9	10	11 ATMOS Deployment (P4-P5)	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	July 1	2	3	4	5
6	7 Set-Up & PASPC Support	8 Testing / Cross Calibration	9 **IOP Begins**	10	11	12
13	14	15	16	17	18	19
20	21	22	23 **IOP Ends**	24 Removal	25	26
27	28	29	30	31 Cellular Plans Terminate	August 1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20 ATMOS De-Install (P1-P3)	21	22	23
24	25	26	27	28 ATMOS De-Install (P4-P5)	29	30