Can-CSI - Campaign Update

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with support from CFI, CSA, EC, and NSERC
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Interdisciplinary Centre on Climate Change

UNIVERSITY OF Waterloo

CoReH2O MAGS Meeting
No. 11
Innsbruck, Austria
27 April 2010

CANADIAN PHASE-A FIELD ACTIVITIES

The Canadian CoReH2O Snow and Ice Experiment 2009-2010

Experiment duration:

- November 2009 – April 2010

Experiment location

- Churchill, Manitoba

Remote sensing equipment deployment

- X- and Ku-band scatterometers (University of Waterloo): near continuous measurements during intensive and extensive observing periods;
- passive microwave radiometers (EC): discrete samples during intensive observing periods

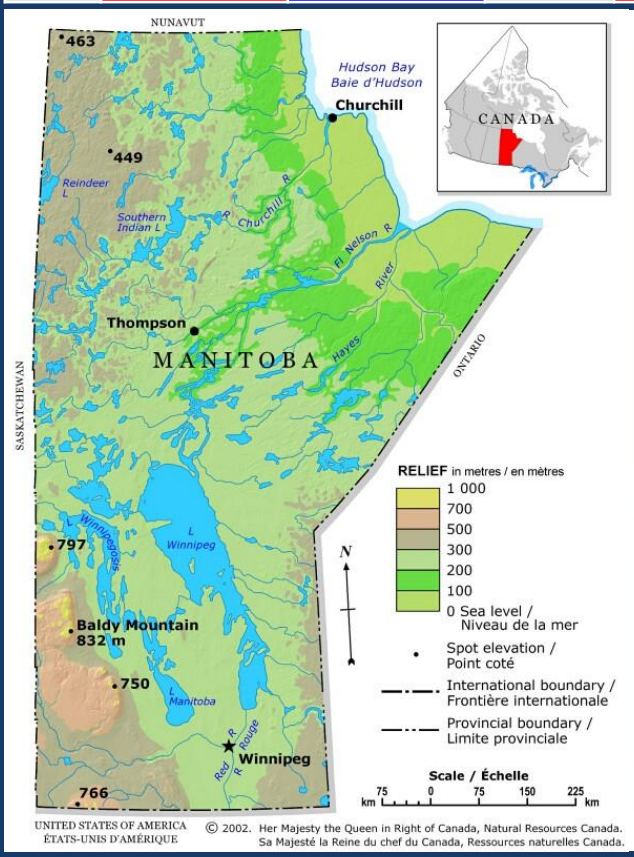
Field *in situ* measurements (UW, EC, CARTEL, NU)

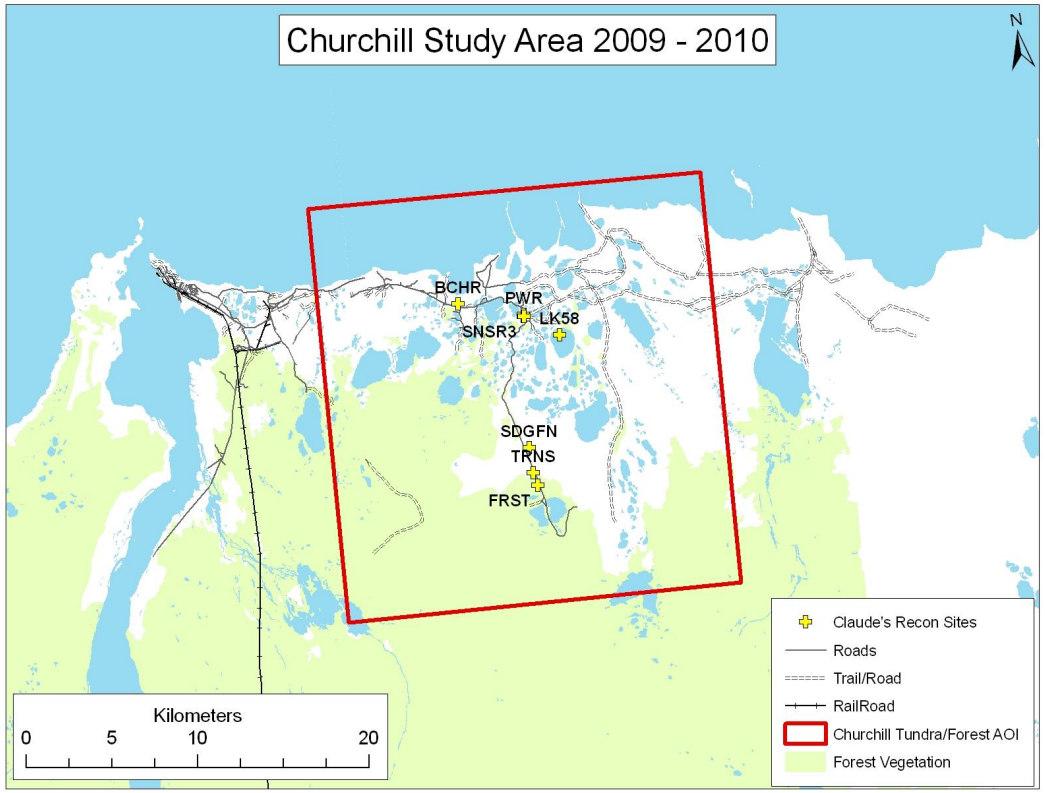
CAN-CSI Experiment 2009-2010

Intensive Observing Periods (IOPs)

Extended Observing Periods (EOPs)

Nov 2009	Dec 2009	Jan 2010	Feb 2010	Mar 2010	Apr 2010
IOP1	EOP1	IOP2	EOP2	IOP3	EOP3	IOP4	EOP4	IOP5





CAN-CSI Experiment 2009-2010

Platform site

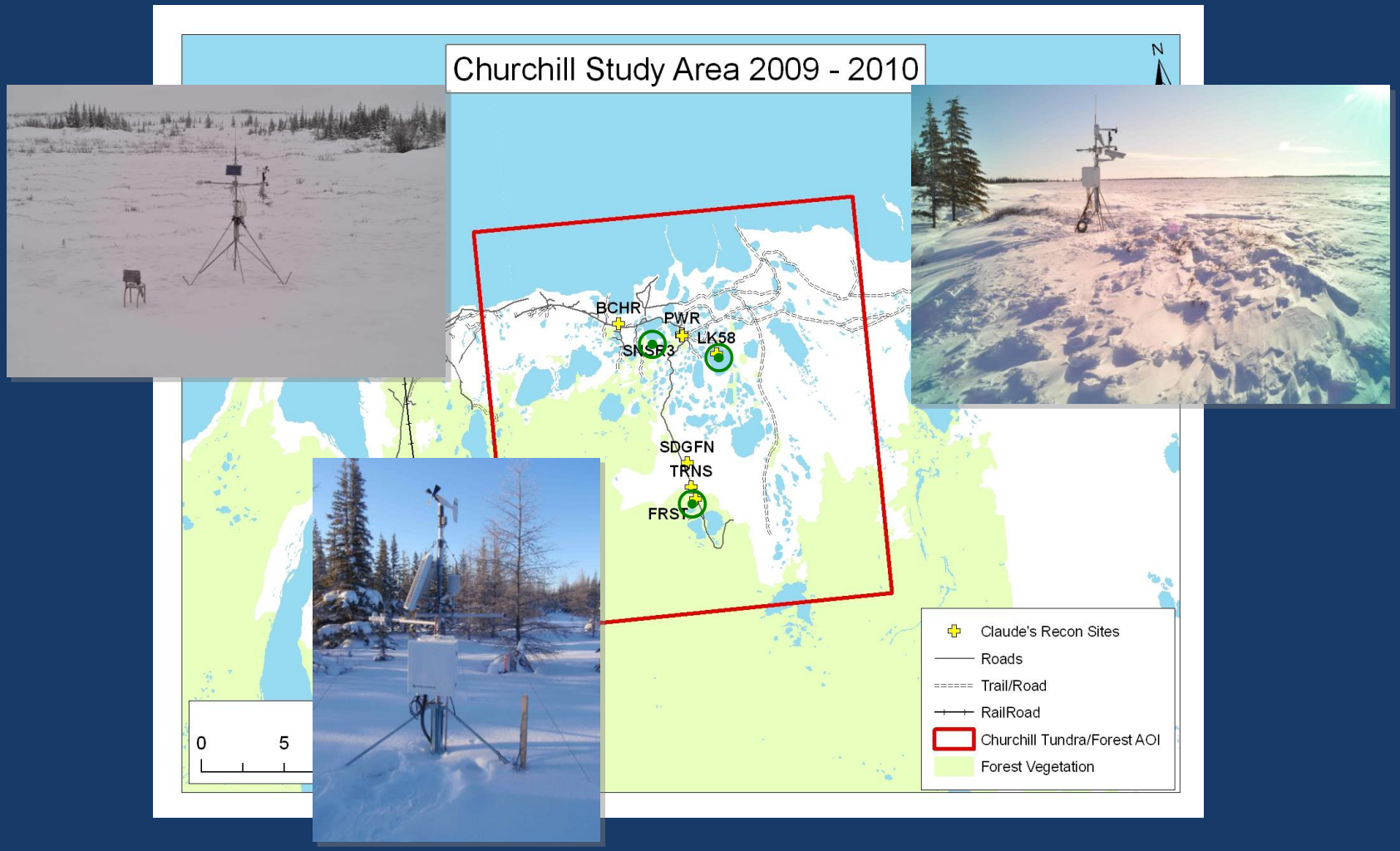
Wet & Dry Fen site

Lake58 site

Forest site

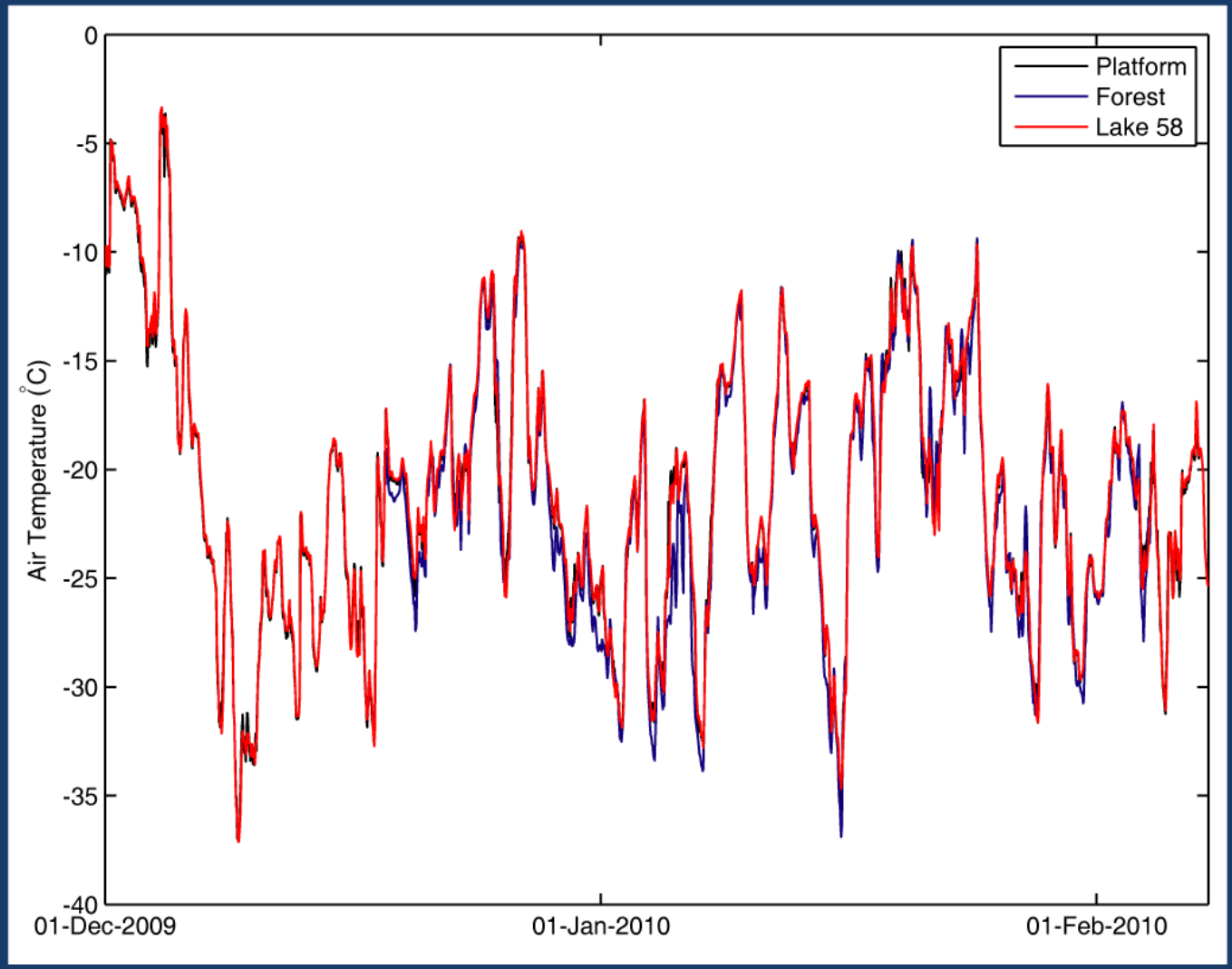
CAN-CSI :: Weather

Meteorological measurements at 3 sites (⊙)



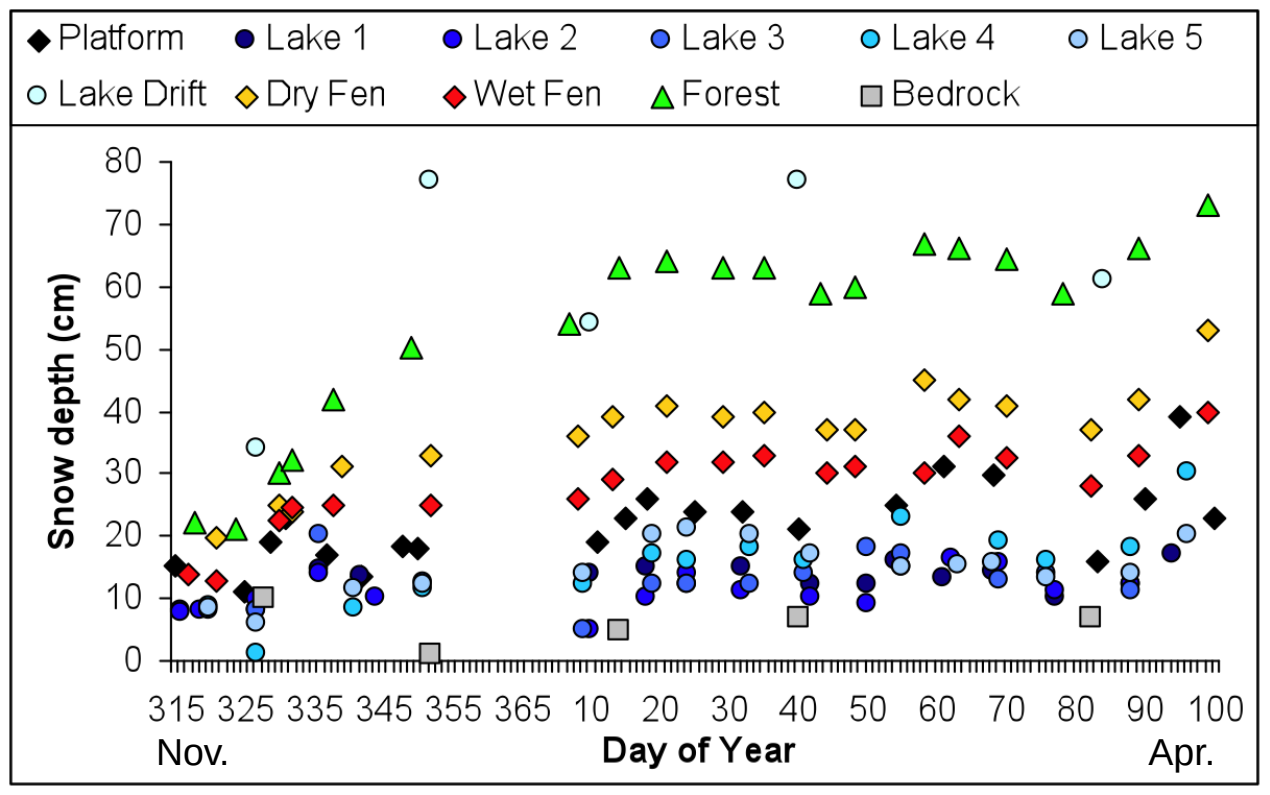
CAN-CSI :: Weather

Meteorological measurements: temperature



CAN-CSI :: Snow Accumulation

- Similar snowfall input across the study area
- Vastly different snow accumulation, redistribution, and metamorphosis due to wind distribution and interactions with vegetation.



CAN-CSI :: Microphysical snow pit

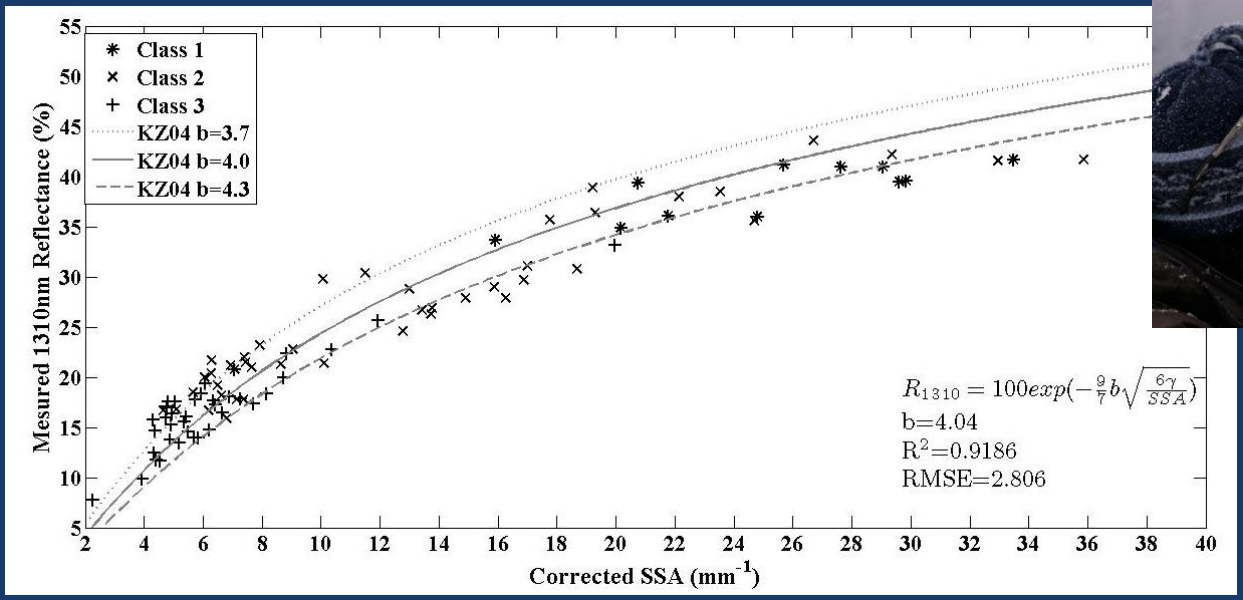
High resolution snow pit characterization to explain backscatter responses

- Optical measurements
  for snow grain size (SSA) measurements
    - Integrating sphere (laser)
    - Near IR photographs
    - Grain shape and type analysis
- Density profile
- Temperature profile
- Water liquid content profile
- Layering

CAN-CSI :: Microphysical snow pit

SSA measurements (IRIS): CARTEL (U. Sherbrooke) instrument

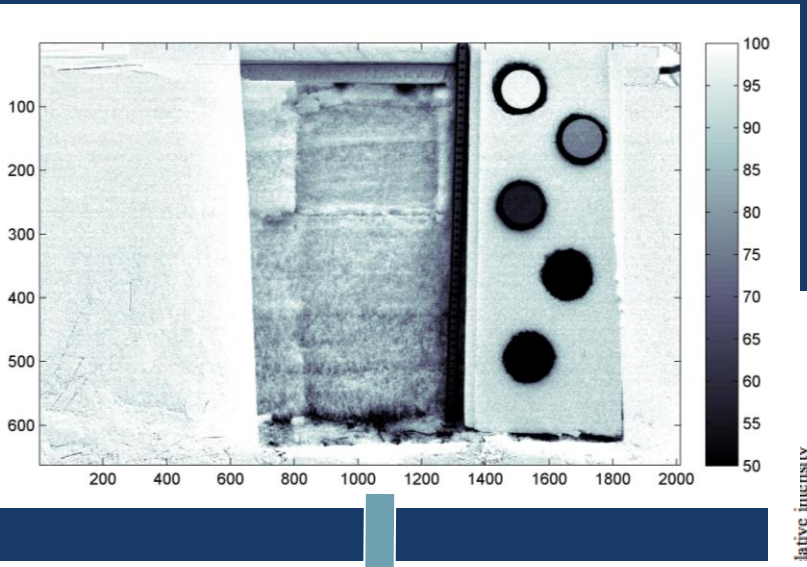
Measurements of hemispheric reflectance at 1300 nm using a mobile integrating sphere



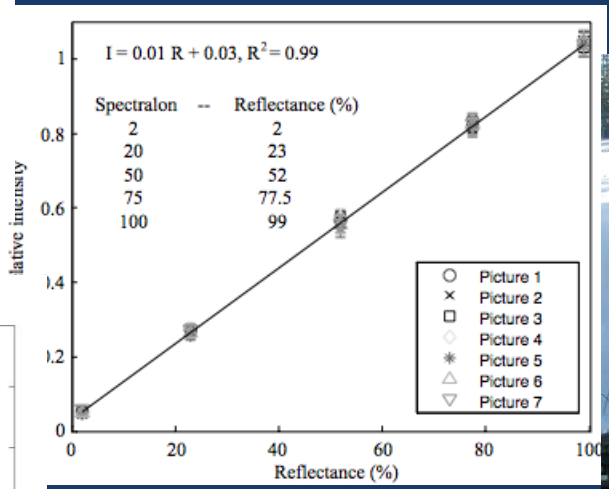
Comparison with the theoretical reflectance model of Kokhanovsky and Zege, 2004. Scattering optics of snow. Applied Optics, 43: 1589-1602 (KZ04)

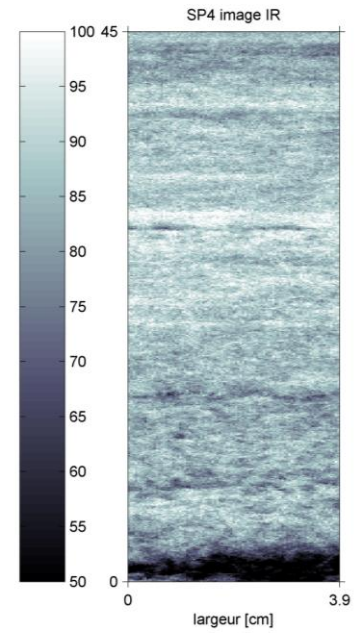
Royer et al., to be submited

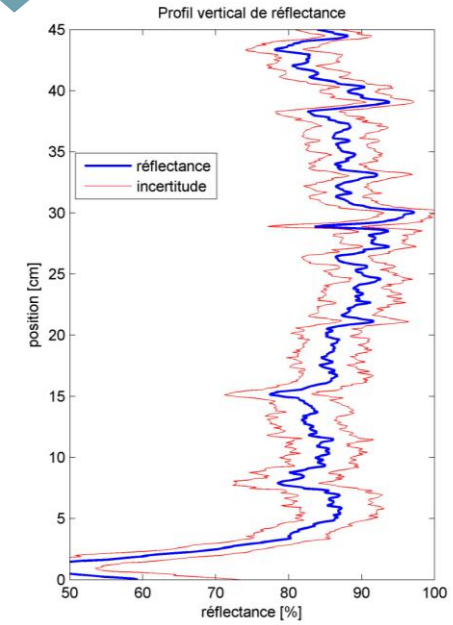
CAN-CSI :: Microphysical snow pit



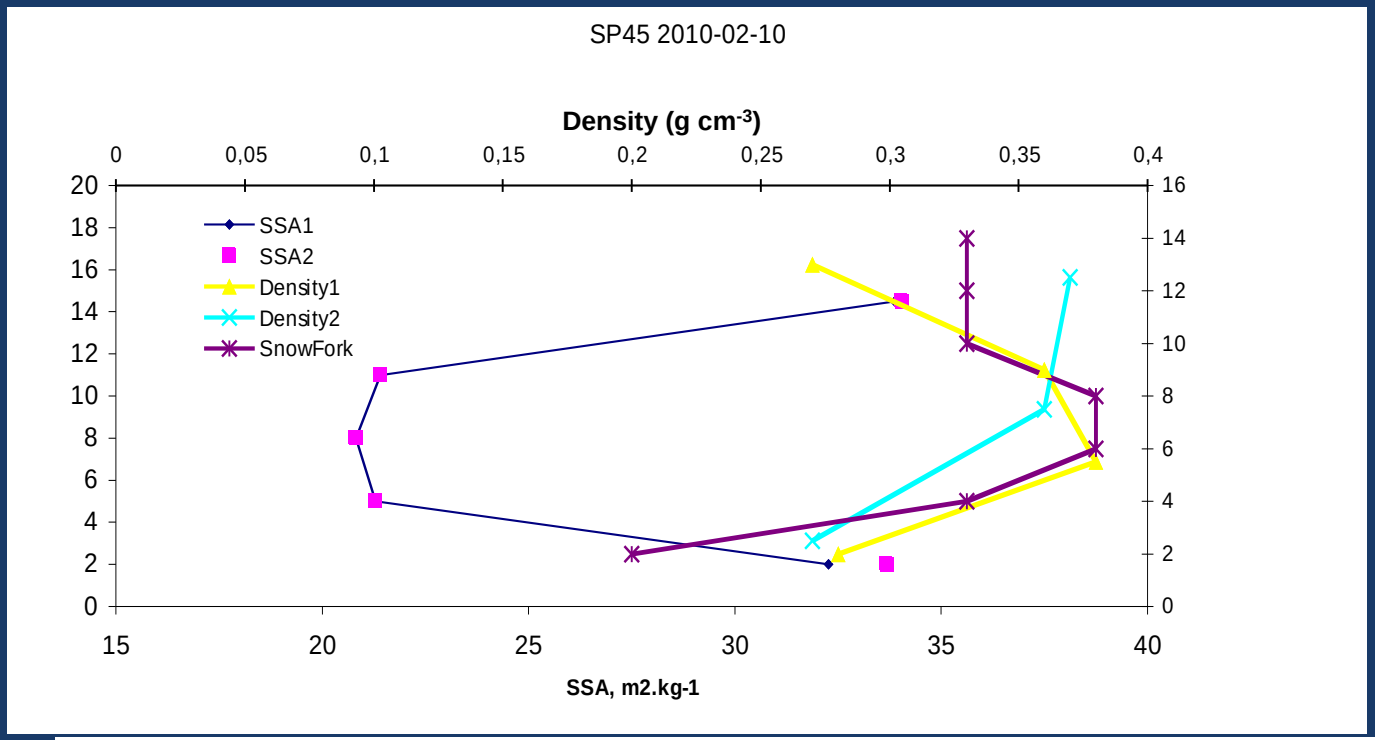
NIR Photographs
Normalized intensity photo (800 nm) calibrated into reflectance



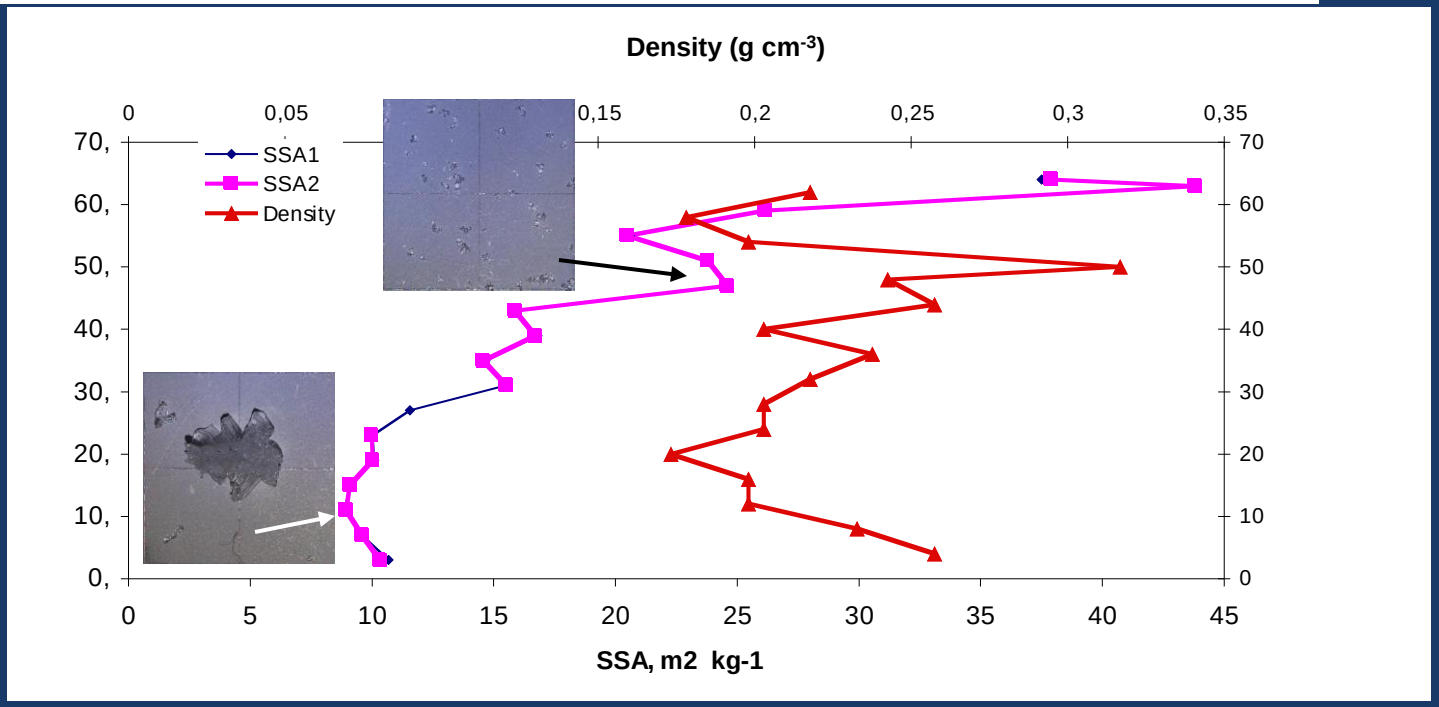




Langlois et al., 2009. On the relationship between measured and modeled snow grain morphology using infrared reflectance. Cold Regions Science and Technology, 2010.



Lake 58



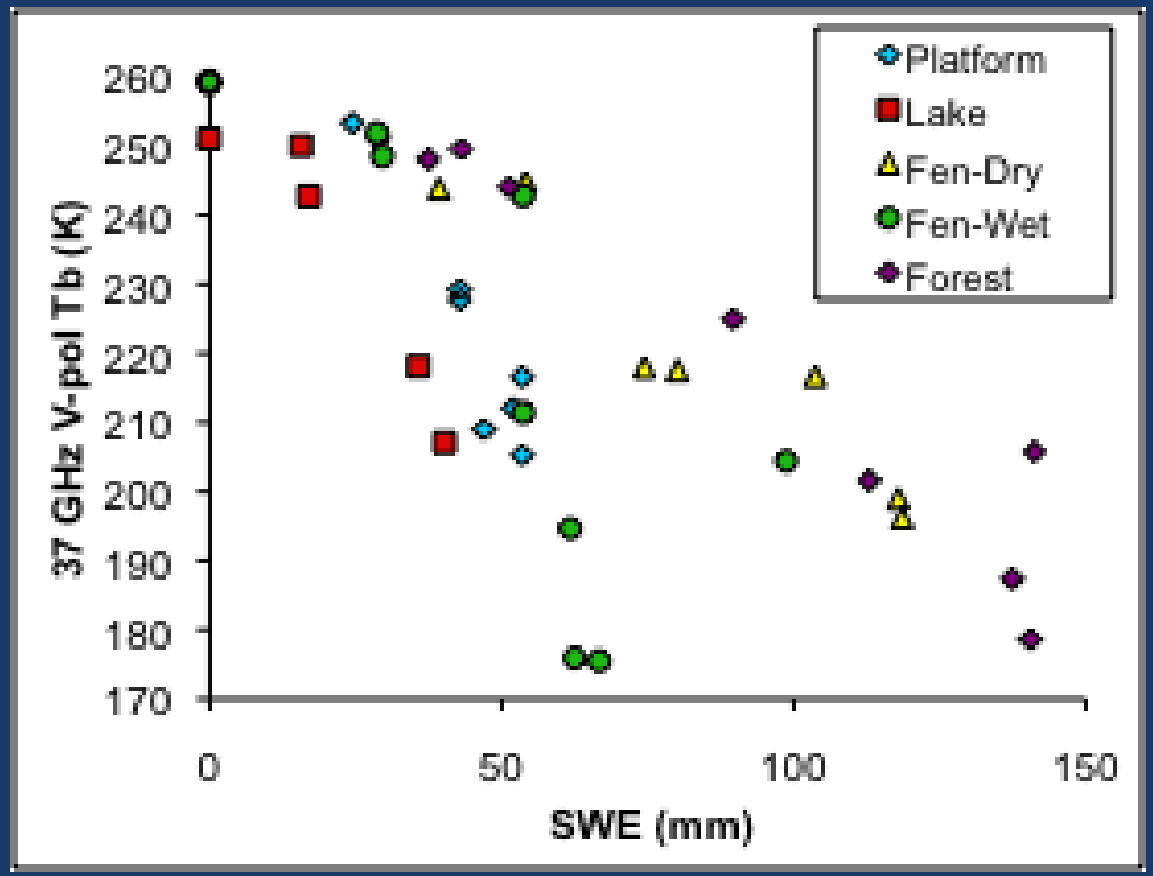
Forest

CAN-CSI :: Radiometer

Coincident radiometer and scatterometer measurements from mobile sleds (89, 37, 19, 6 GHz, at 53˚)

CAN-CSI :: Radiometer

Coincident radiometer and scatterometer measurements from mobile sleds (89, 37, 19 GHz, at 53˚) – IOP1 to IOP3 (Nov.-Feb.)



CAN-CSI :: Scatterometer

Scatterometer Characteristics: Ku and X band system

Pedestal deployment with Kipp and Zonen 2AP sun tracker

Scans possible from -90˚ to +90˚ azimuth and 0˚ to 180˚ elevation

Deployed at the platform site during EOPs and at the Lake58 and Fen sites during the IOPs

Scatterometer Specifications

Radar Parameter	Value
RF output frequency	9.35-9.85 GHz
Transmit power	9.5 dBm flood beam mode -11.8 dBm narrow beam mode
Transmit bandwidth	500 MHz
Range resolution	0.3 meters
Antenna beamwidth	4.3 degrees, single antenna narrow beam mode 5.8 degrees, dual antenna flood beam mode
Cross-polarization isolation	>30 dB, measured at the peak of the beam
Transmit/receive polarizations	Linear, Vertical and Horizontal
Sensitivity, minimum NRCS at 15 m range	-50 dB m^2/m^2
Chirp length	0.975 ms
2 channel digitizer	16 bits, 1.25 MS/

Radar Parameter	Value
RF output frequency	16.95-17.45 GHz
Transmit power	3.5 dBm flood beam mode -8 dBm narrow beam mode
Transmit bandwidth	500 MHz
Range resolution	0.3 meters
Antenna beamwidth	5.6 degrees, single antenna narrow beam 7.5 degrees, dual antenna flood beam
Cross-polarization isolation	>30 dB, measured at the peak of the beam
Transmit/receive polarizations	Linear, Vertical and Horizontal
Sensitivity, minimum NRCS at 15 m range	-50 dB m^2/m^2
Chirp length	Variable, 0.1-15 ms
2 channel digitizer	16 bits, 1.25 MS/s

CAN-CSI :: Scatterometer

Scatterometer deployment modes

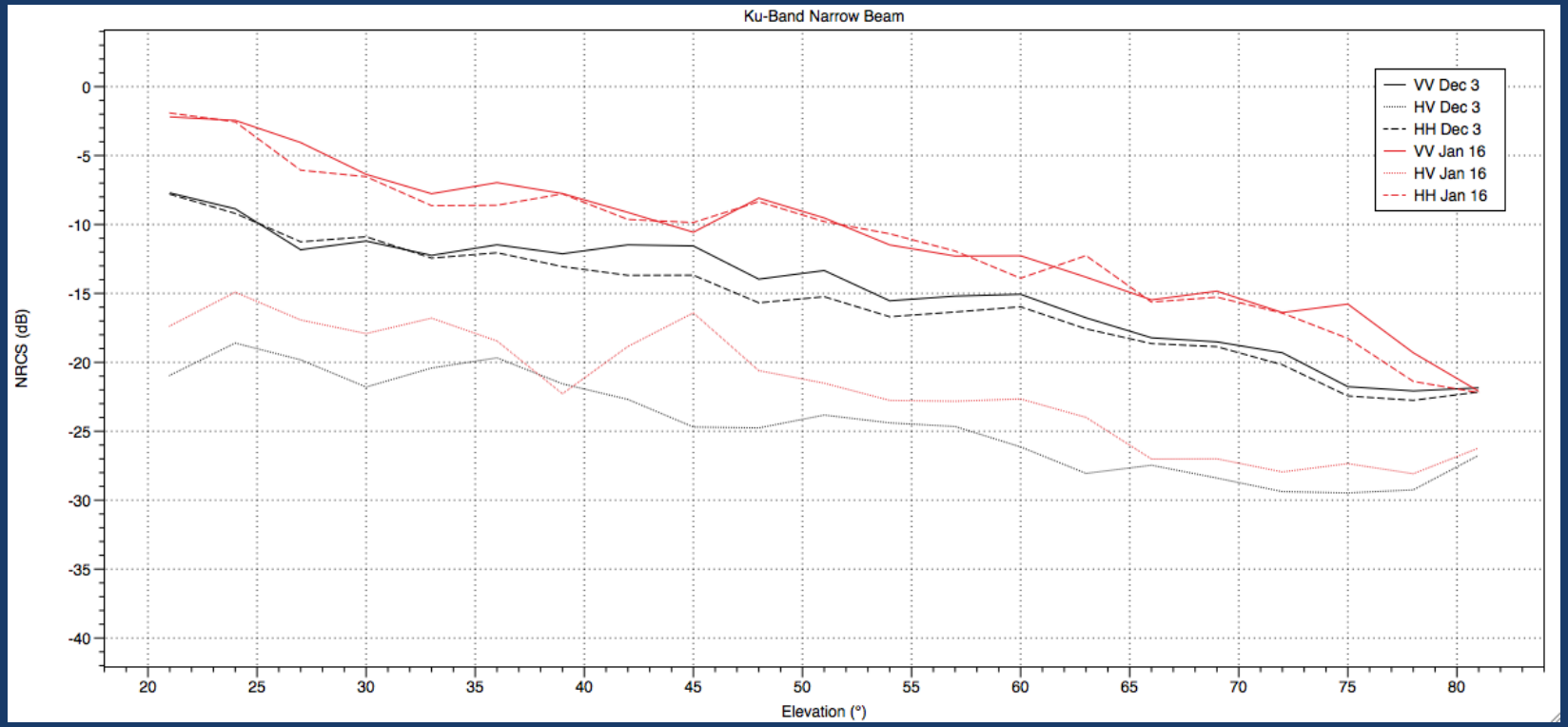
Nov 2009		Dec 2009		Jan 2010		Feb 2010		Mar 2010		Apr 2010	
	IOP1	EOP1		IOP2	EOP2	IOP3	EOP3	IOP4	EOP4		IOP5

Platform

Roving

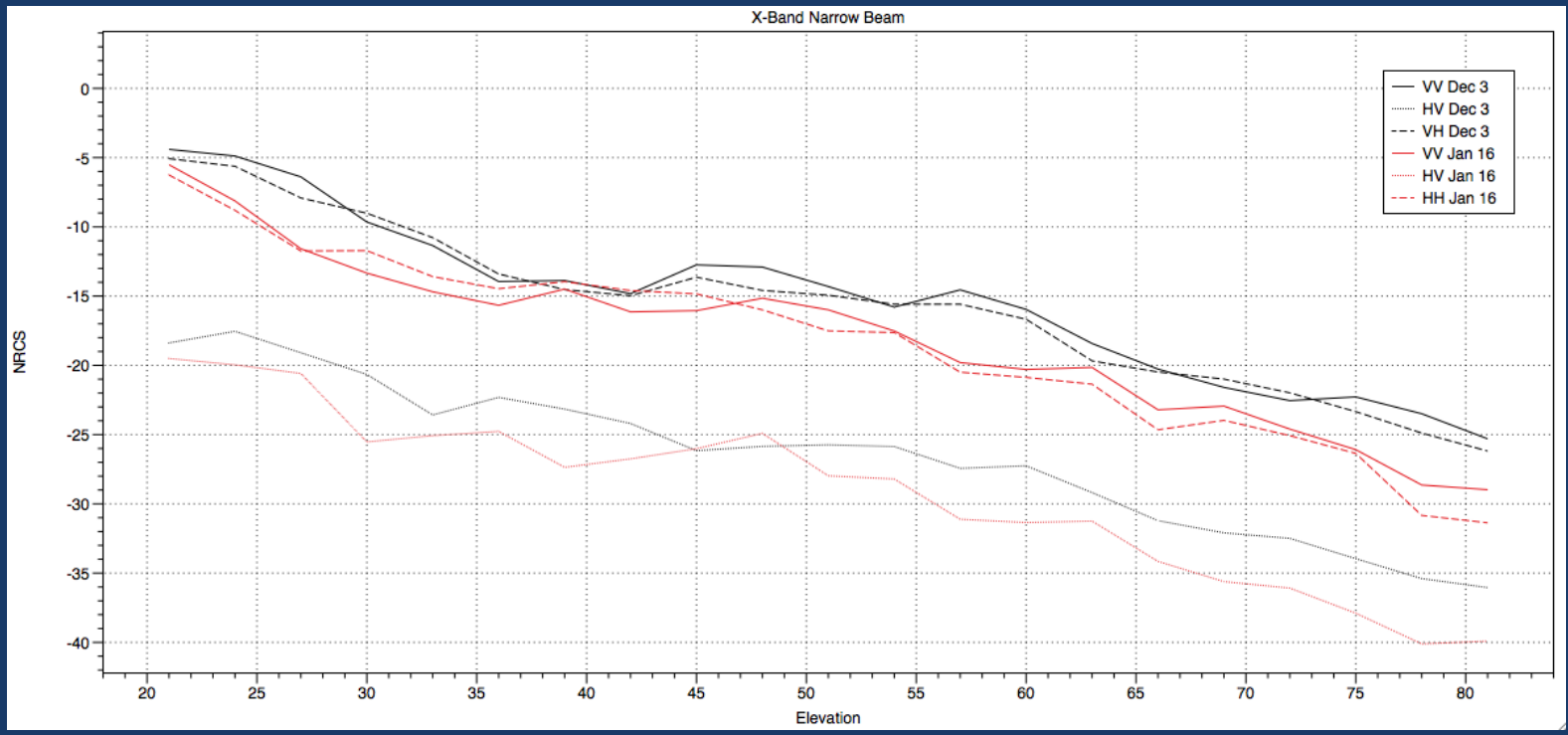
CAN-CSI :: Scatterometer

Scatterometer: angular responses at Ku band, narrow beam mode at platform site. Increased backscattering from snow with time (early winter)



CAN-CSI :: Scatterometer

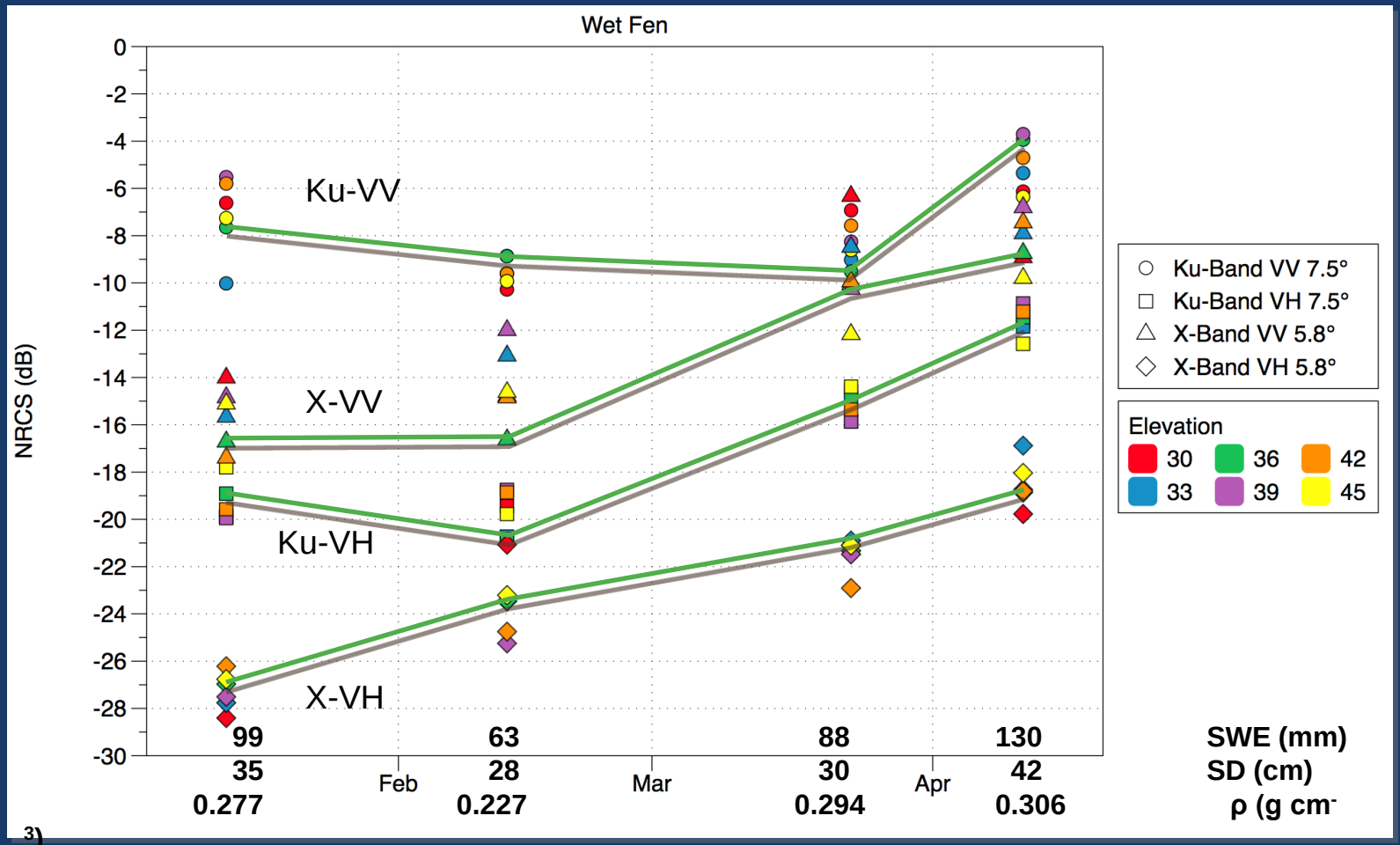
Scatterometer: angular responses at X band, narrow beam mode at platform site: decreased sub-nivean backscattering with time (early winter)



CAN-CSI :: Scatterometer

Responses of Ku and X-band, VV and VH (flood beam mode)

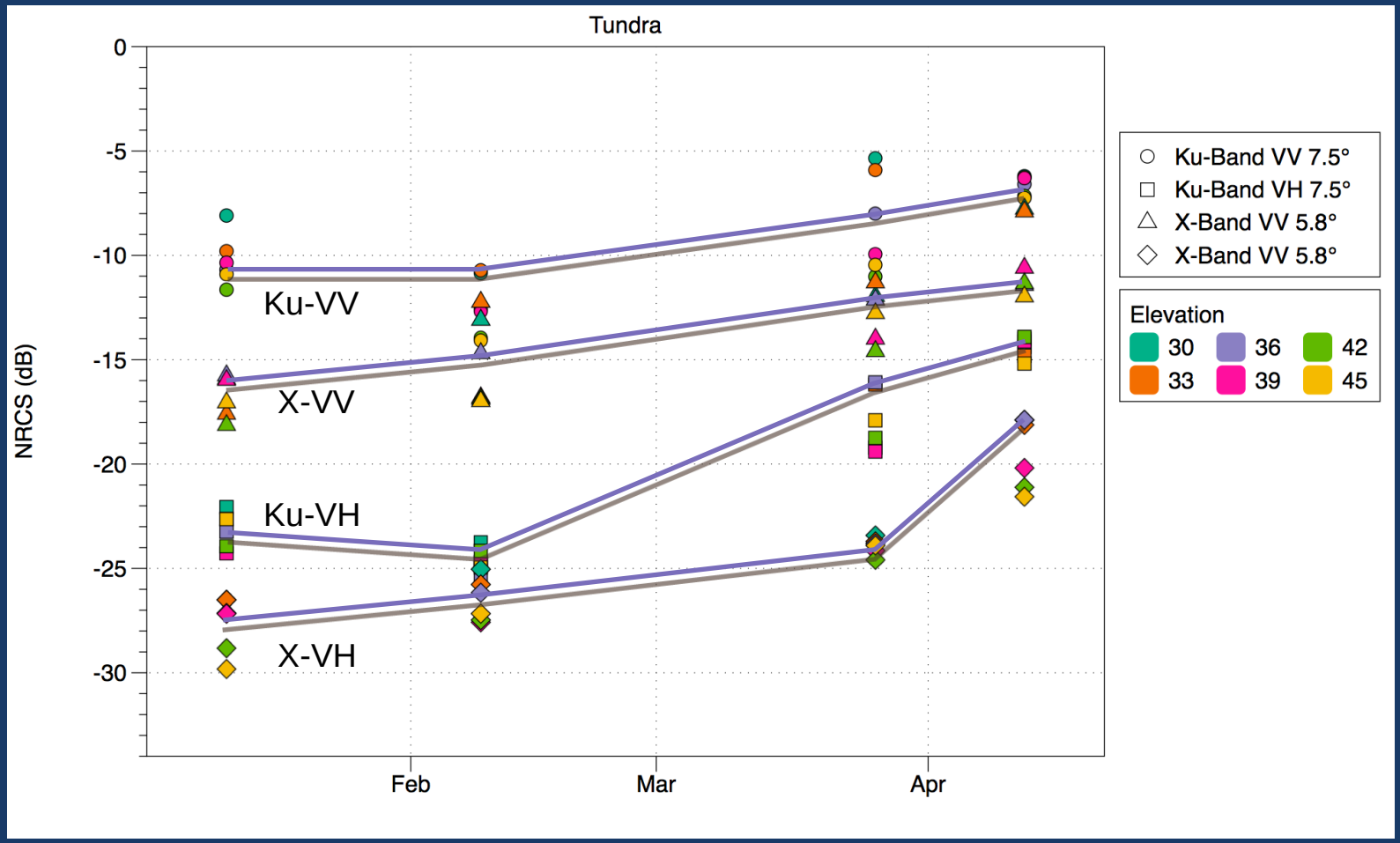
WET FEN SITE (IOP2 - IOP5)



CAN-CSI :: Scatterometer

Responses of Ku and X-band, VV and VH (flood beam mode)

EC PLATFORM SITE (IOP2 - IOP5)



CAN-CSI :: Early results

1. The experiment completed two weeks ago.
2. Sensitivity of snow accumulation to Ku band instrument is behaving as expected: increased backscatter with accumulation.
3. Influence of layering, density and grain size appear to be playing an important role in the backscatter response at Ku.
4. Sub-nivean effects and layering (melt/refreeze events, significant depth hoar) are likely to be influencing the X band response.
5. Coincident radiometer observations is making possible the specific exploration of active-passive microwave relationships over tundra and frozen lake snow accumulation.
6. Snowpack stratigraphy and SSA measurements will provide important clues on the origin of the scattering.
7. Large amount of snowpit measurements and weather data will enable us to accurately characterize the snowpack at fine time resolution through the season.
8. A highly unique experiment that will provide a rich source of data & information to support CoReH2O science.