ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Workshop on Cold Regions Hydrology 2010

Nordic Snow radar experiment

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Nordic Snow Radar Experiment

Goal: Provide Data for ongoing CoReH20 studies:

(1) CoReH2O geophysical algorithm development

(2) studies of the synergistic use of CoReH2O measurements with other (passive) observational data

Means:

- **Experimental dataset on the backscattering and brightness temperature characteristics of snow**
- **Winter season of 2009-2010 (possible continuation for 2010-2011)**
- **Active X to Ku band microwave observations with ESA SnowScat-system**
- **Passive mw observations at L-, X-, K-, Ka- and W- band radiometers**
- **in situ measurements of snow cover, soil and atmospheric properties**

Measurement site

Intensive Observation Area (IOA)

67°21.712′ N
26°38.270′ E

Site typical boreal coniferous forest on mineral soil

Average permanent snow cover: 6th Nov – 25 Mar (1971-2000)

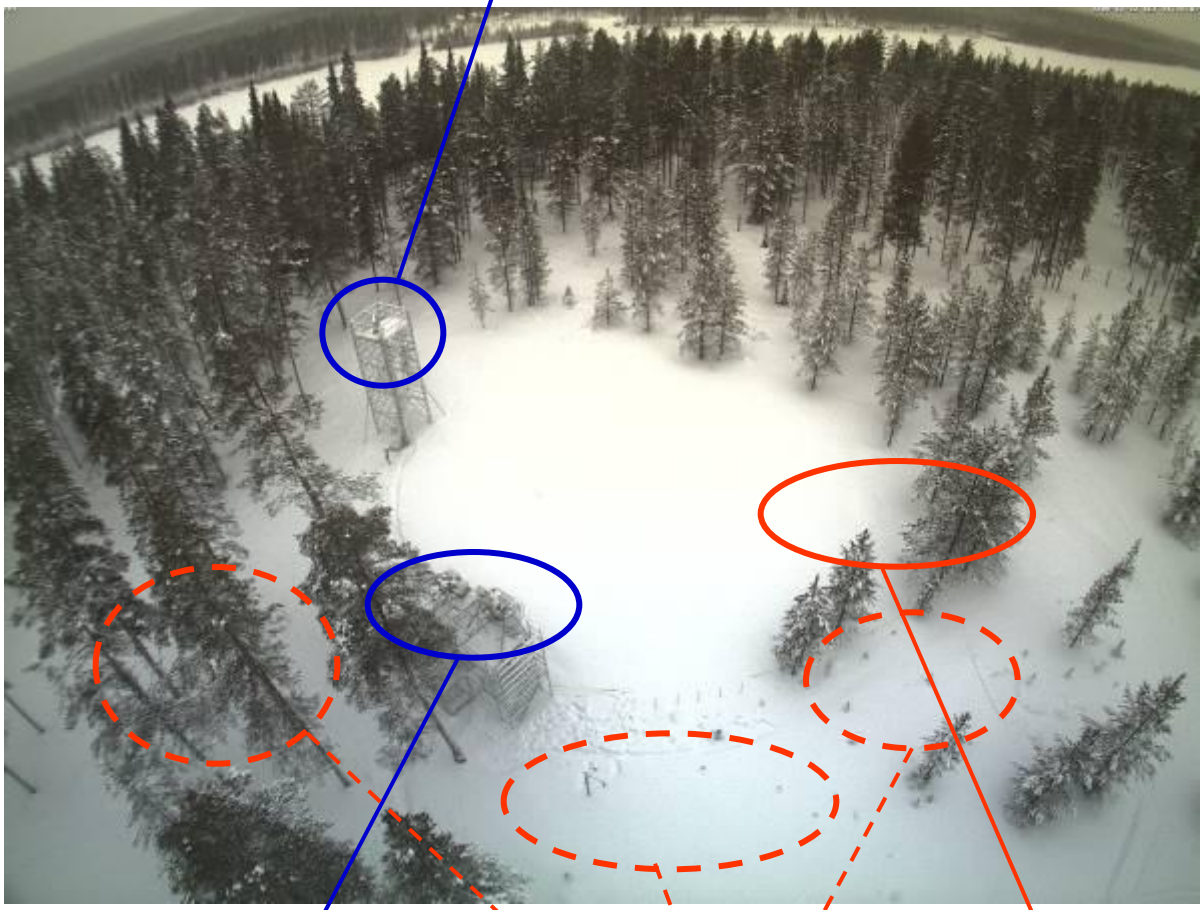
Average maximum snow depth: ~80 cm

Easy access and technical support

FMI Arctic Research Centre, Sodankylä, Finland

X to Ku band scatterometer

Photo: webcam on 30 m tower



L to W band radiometers

Automatic sensors (Temperature, bulk SWE, SD)

bi- weekly snowpits

Intensive Observation Site

Measurement towers for instrument installation (5 m, 8m, 30m)

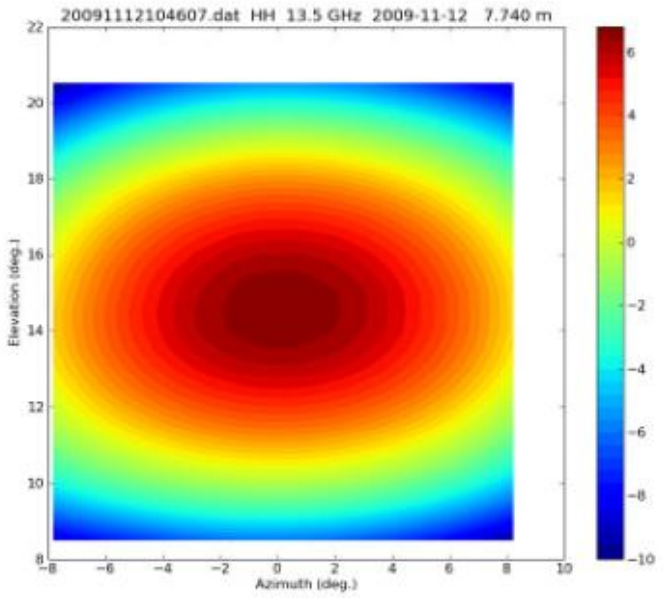
In vicinity of meteorological observations

Manual snow cover measurements on site

Automatic sensors for SWE, snow depth, soil moisture, soil and snow temperature profiles.

SnowScat

- Frequency scanning scatterometer, stepped CW from 9.15 to 17.9 GHz
- measurement every 3 h
- Azimuth scan of 100° (6° steps, 17 looks)
- Elevations 30°, 40°, 50°, 60°
- HH/VV, HV/VH
- Every measurement includes several views of calibration sphere



SnowScat Specifications

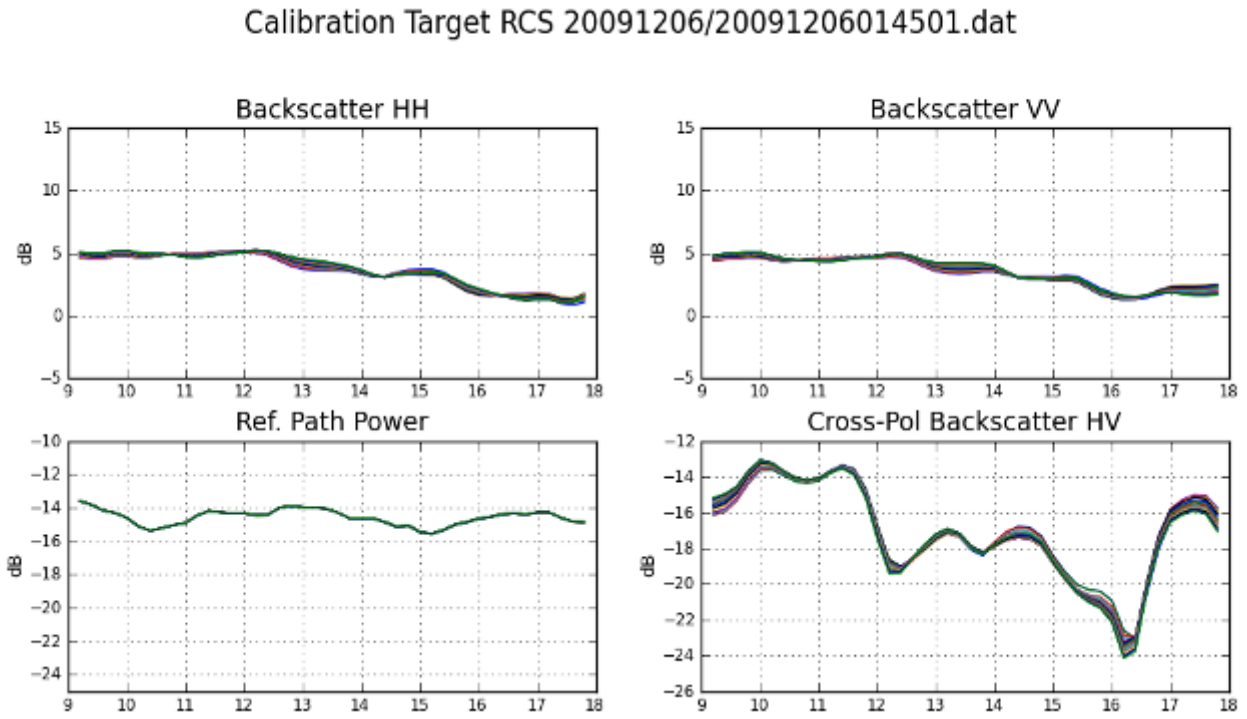
- **Power:** 230V, max ~ 60W
- **Weight:** ~ 40 kg
- **Temperature Range:** -40° C to 40° C (tested & proven at -39 ° C !)
- **Antenna:** dual pol, < 10° (3dB)
- **Antenna cross-pol iso:** < -20 dB
- **Frequency:** Stepped CW from 9.15 to 17.9 GHz
- **Incidence angle:** -40° to 110°
- **Azimuth angle:** -180° to 180°
- **Polarisation:** HH, HV, VV, VH
- **Dynamic range:** Receiver dynamic range > 80 dB with the 16 bit ADC
- **Signal bias:** < 0.5 dB
- **Gain characterisation:** Internal calibration loop, reference target (8'' sphere)
- **Control:** Remote Control through Ethernet; stand alone
- **Data storage:** Internal, external through Ethernet
- **RFI:** Frequency blacklist

SnowScat Calibration

- **Internal Calibration Loop measurements (usually done before each measurement)**
- **Antenna Diagram measured at ESTEC CATR (one time measurement)**
- **Sphere measurement (per campaign, repeated before and after each measurement cycle to have an independent measure of end-to-end system performance)**

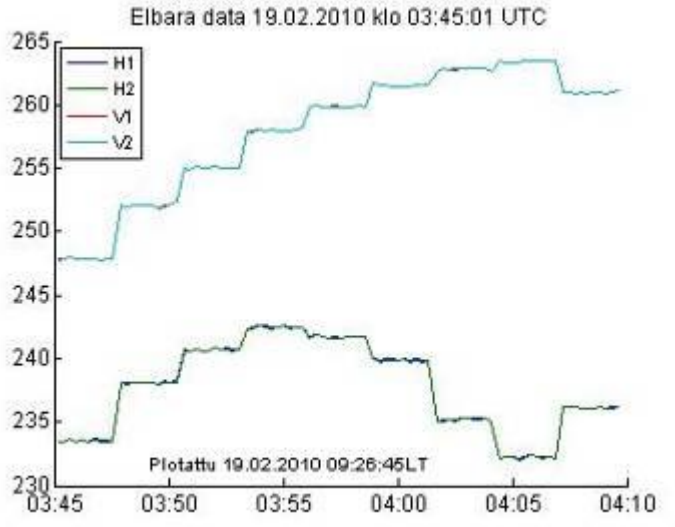
Calibration Target Measurements in Field

- **Once per campaign and repeated for performance monitoring before and after each cycle.**



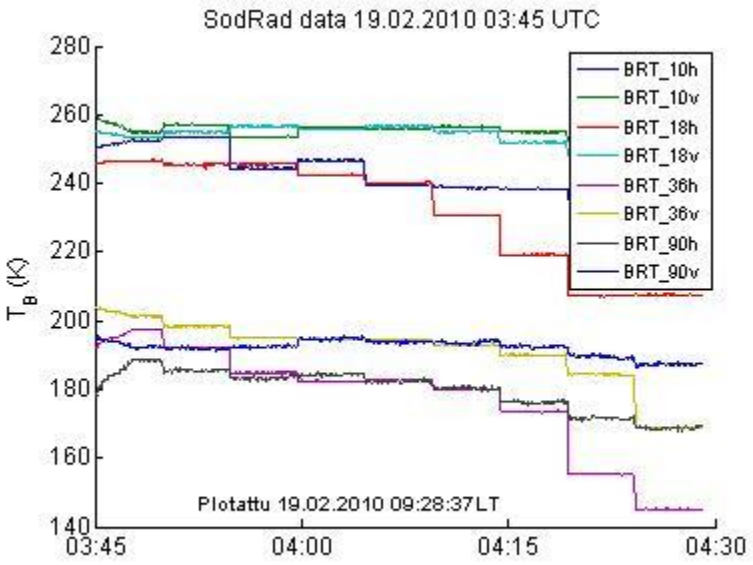
Elbara-II

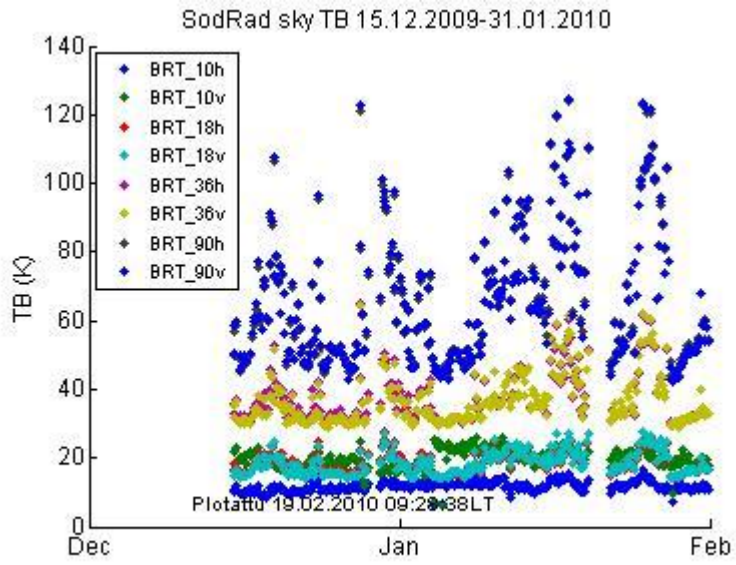
- Dual pol L-band radiometer
- Reference instrument for SMOS cal/val purposes
- 30 min long measurement every 3 h
- Elevation 30 - 70°
- Internal two-point calibration using terminated load and ACL
- Short sky measurement every night to verify receiver stability
  - Longer sky calibration of ACL monthly (if weather conditions permit) gives calibration parameters



SodRad

- X-, K-, Ka- and W- band dual pol radiometers
- 30 min measurement every 3 h
- Elevations 30 – 70 °, azimuth scanning possible
- Sky tip calibration every 12 h
- Sky measurement used to verify stability between snow observations





Manual in situ measurements

Three sites

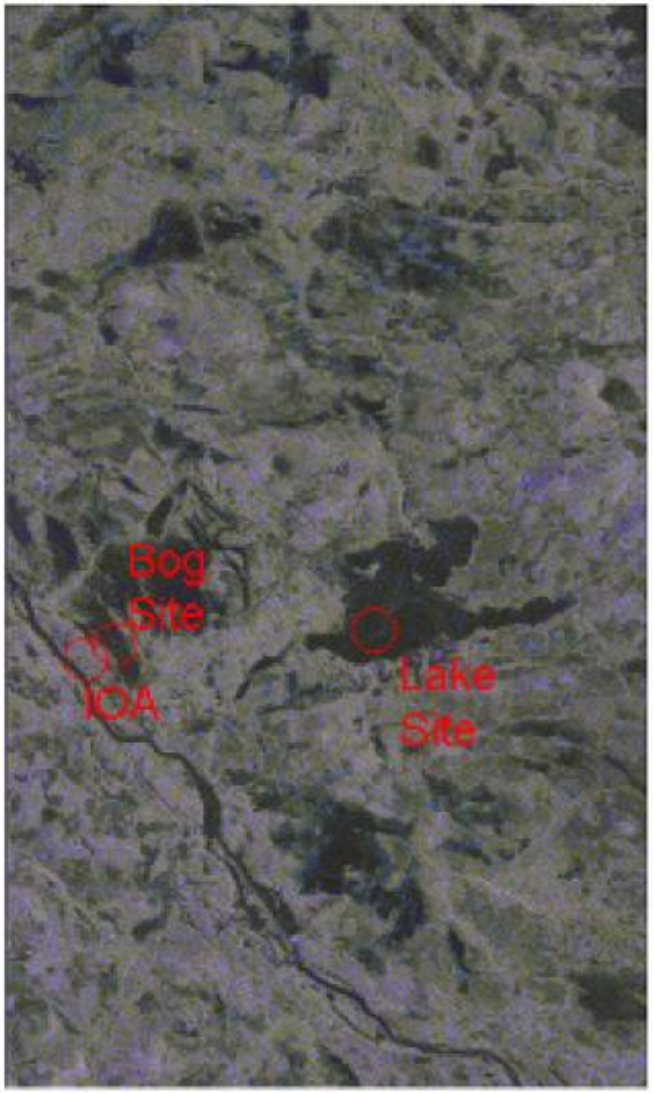
- IOA (bi-weekly)
- Bog (1 km distance, bi-weekly)
- Lake ice (once/month)

Parameters

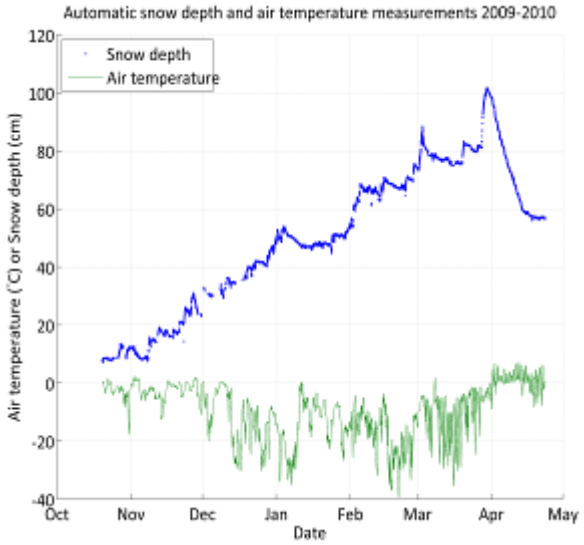
- Stratigraphy
- Density profile (snow fork and snow scale)
- Grain size profile
- Temperature profile
- Snow moisture
- Bulk values for SD, SWE, density

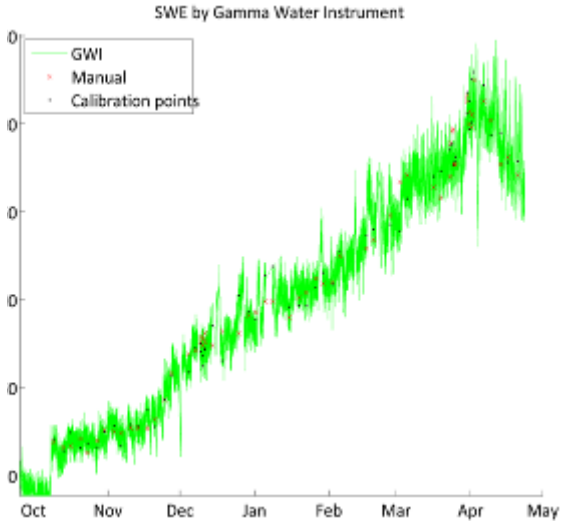
In addition, several periods of detailed activites

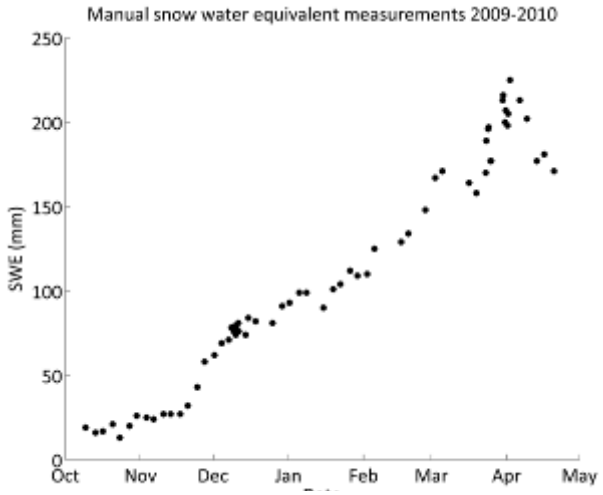
- Snow depth/SWE distribution
- SSA measurements/ NIR photography
- High resolution penetromety
- Daily snow pit measurements
- Instruments in continuous observation mode (diurnal change observation)


Bog
Site
IOA
Lake
Site

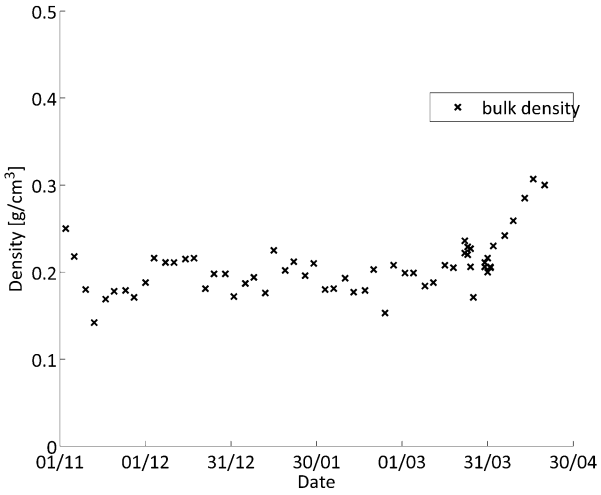
Measurements: in situ observations

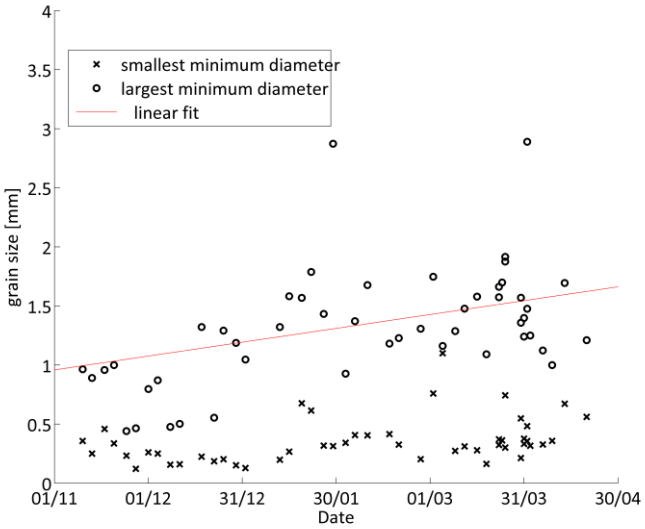


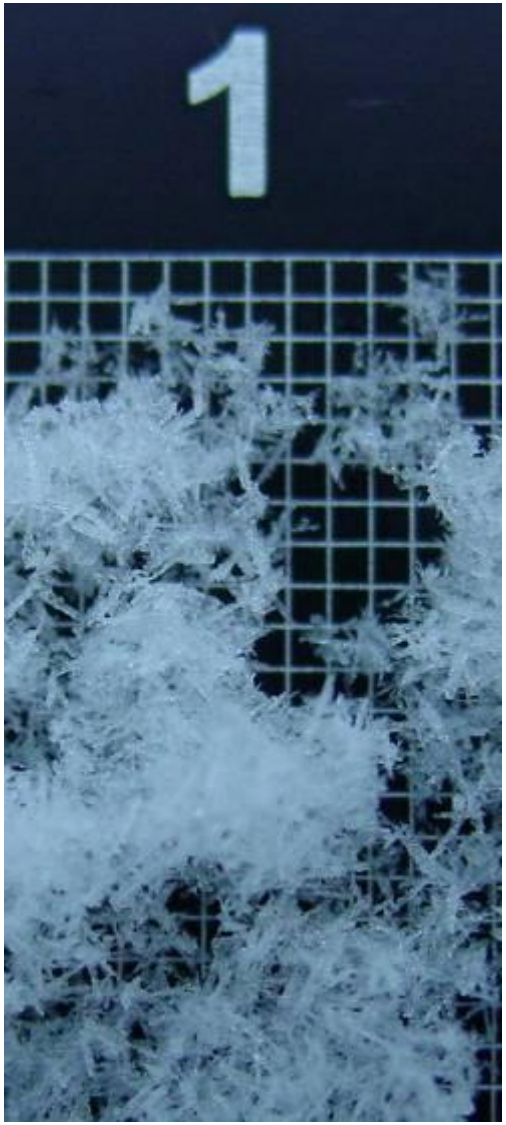




Grain size, weighted average



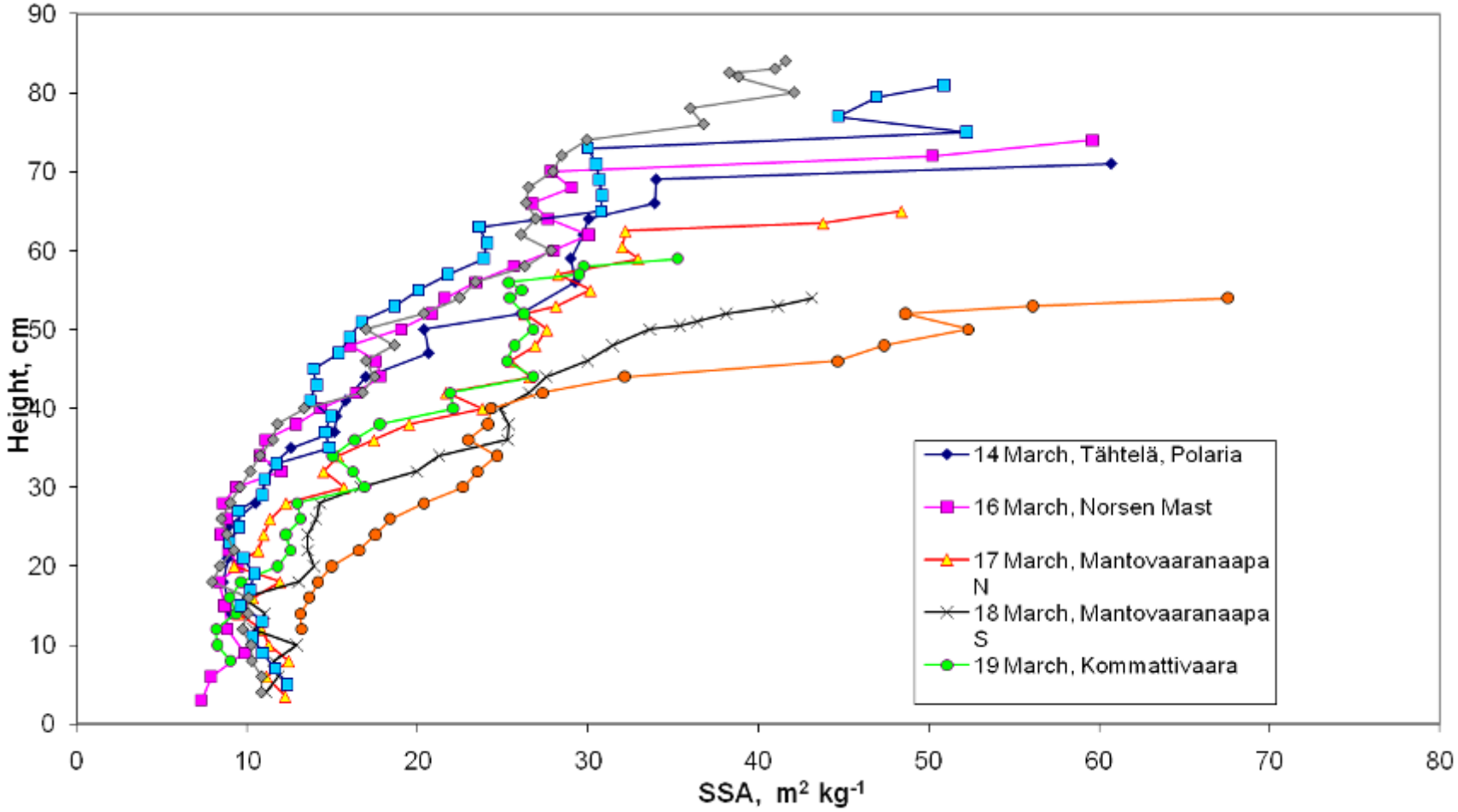



1


1


2

SSA with integrating sphere



Data by Florent and Kati

Strat, density core + Toikka

N: 67°21'47.66"
E: 26°38'8.51"

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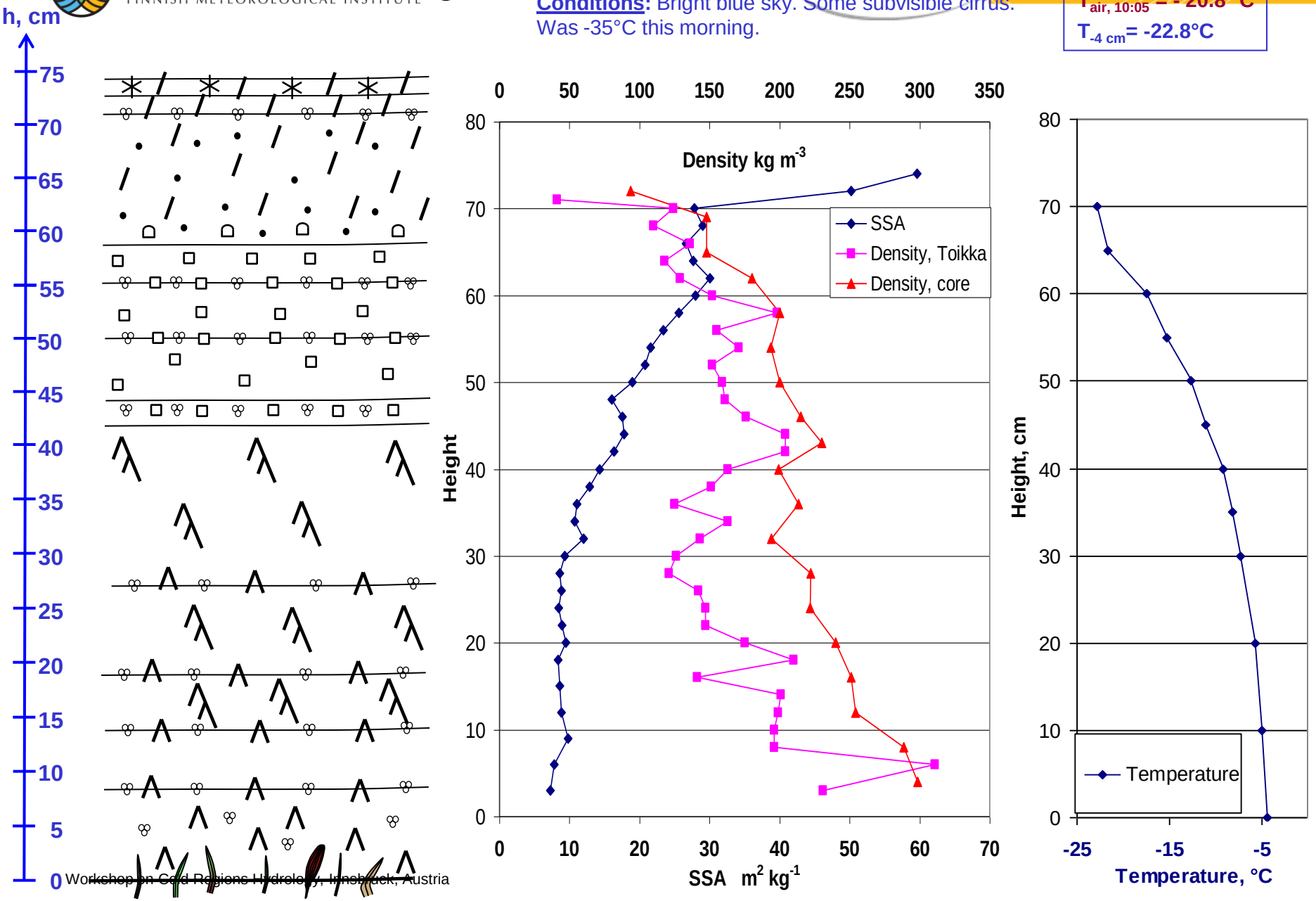
GAMMA REMOTE SENSING

enveo

Tuesday 16 March 2010, Norsen Mast

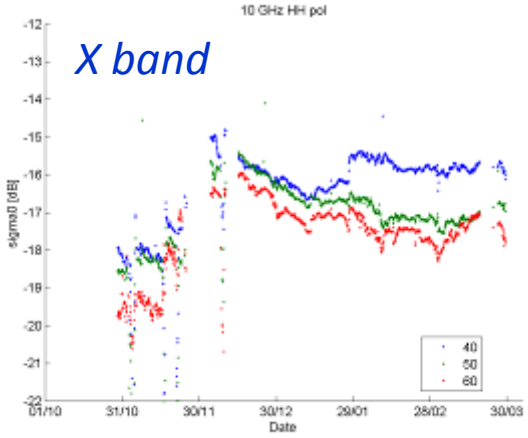
Conditions: Bright blue sky. Some subvisible cirrus. Was -35°C this morning.

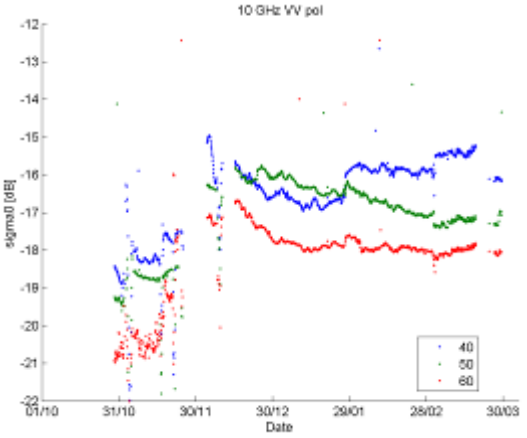
$T_{air,\ 10:05}$ = - 20.8 °C
$T_{-4\ cm}$ = -22.8°C



Measurements: Active

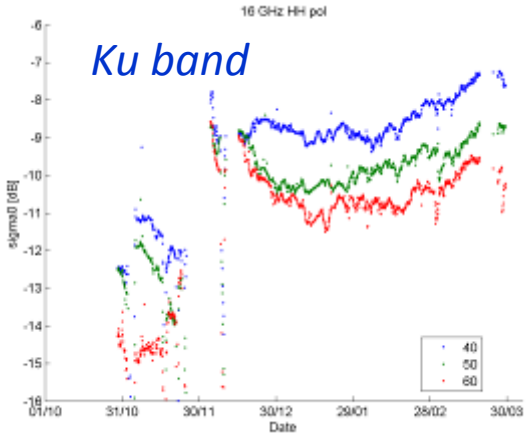
X band

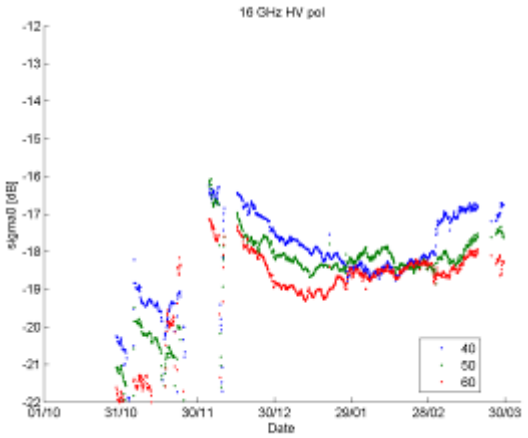


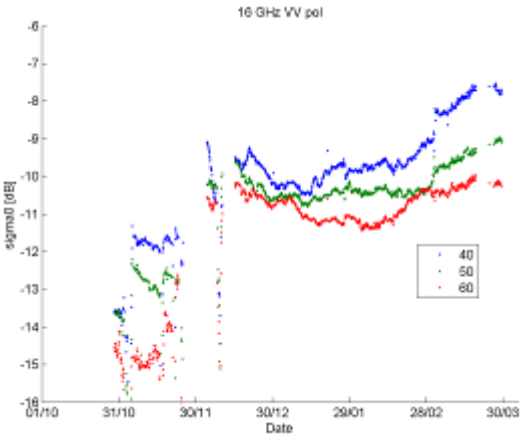


HH - pol *HV pol* *VV - pol*

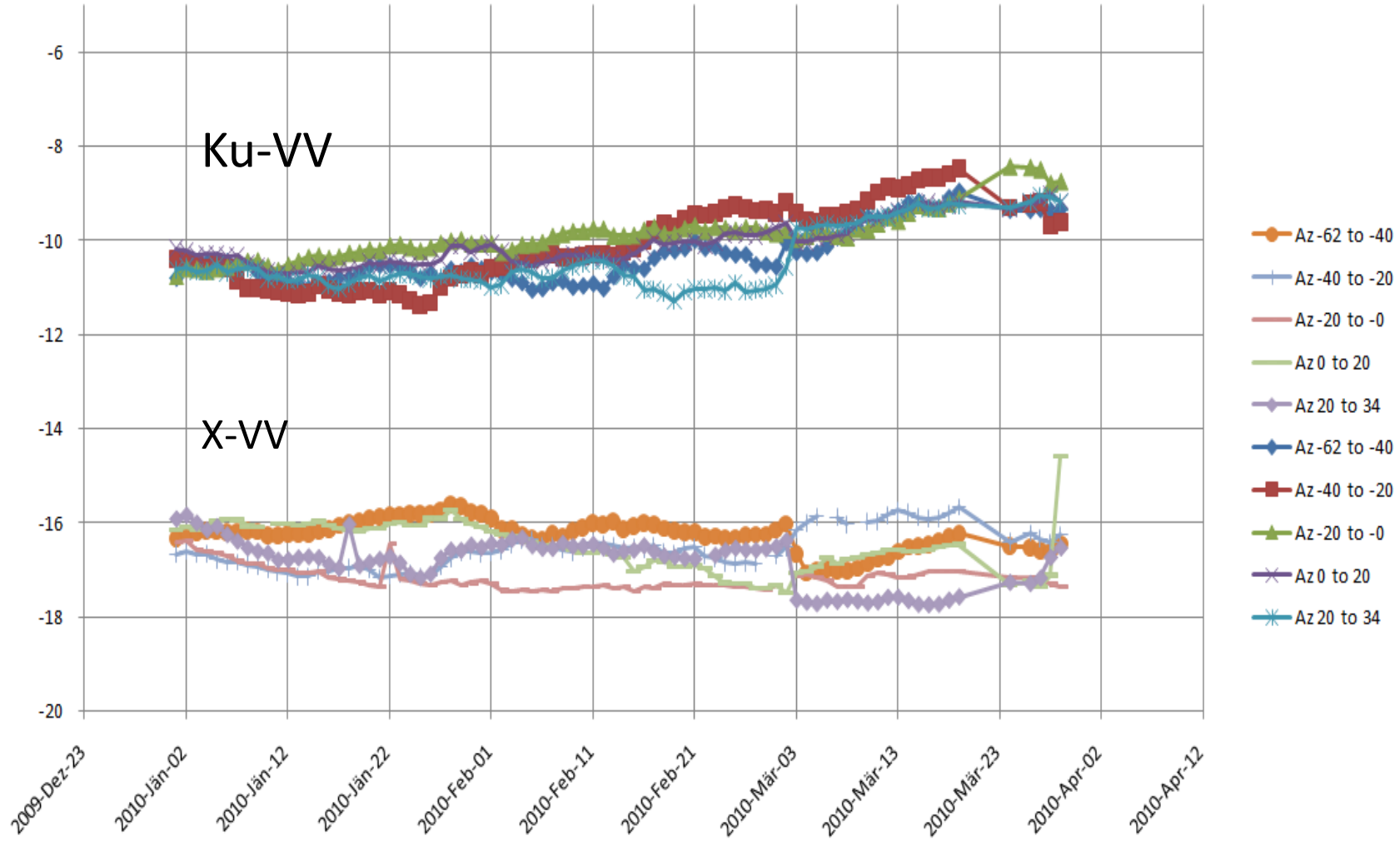
Ku band



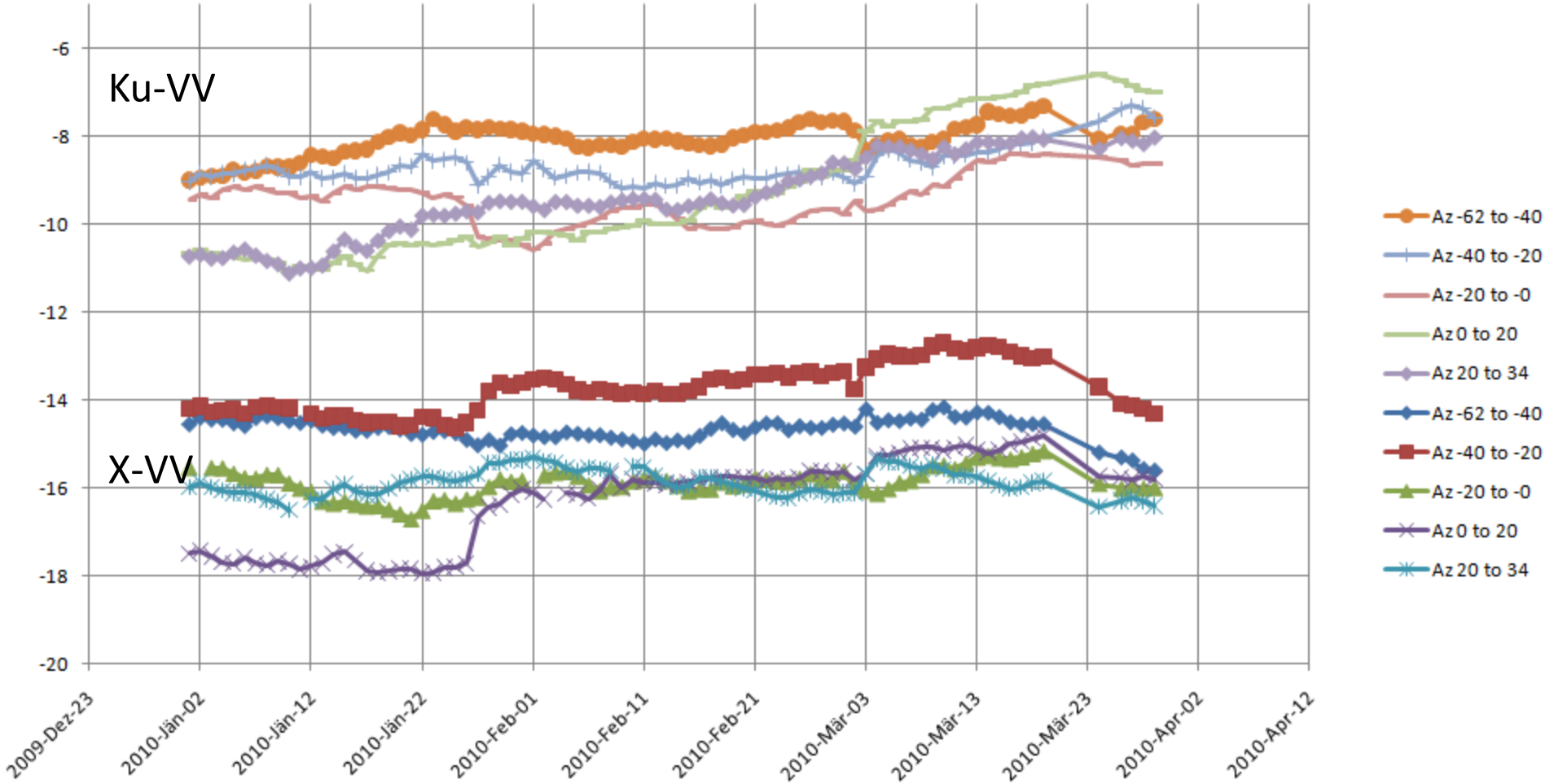




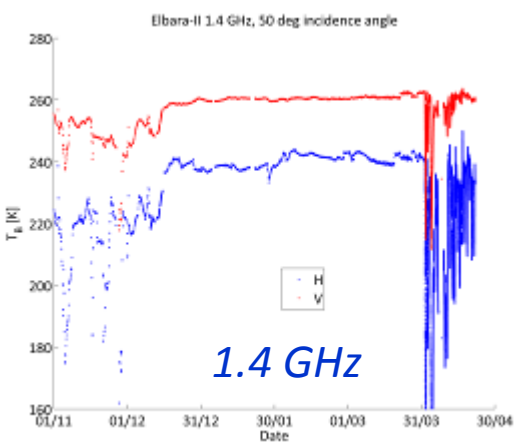
NoSREX – VV - INCANG=50°

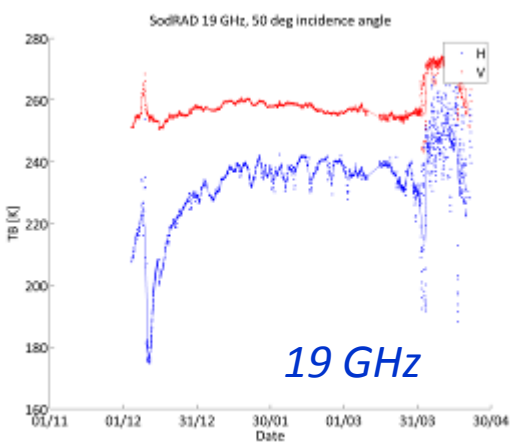


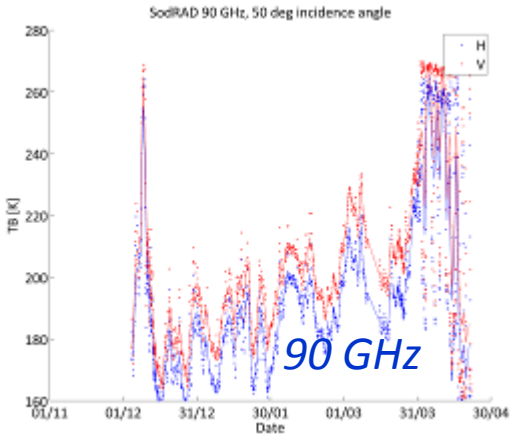
NoSREX – VV - INCANG=40°

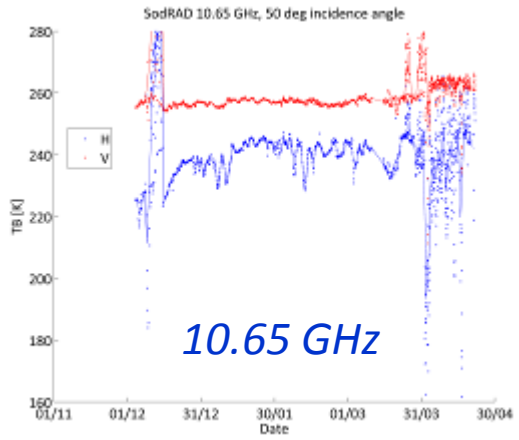


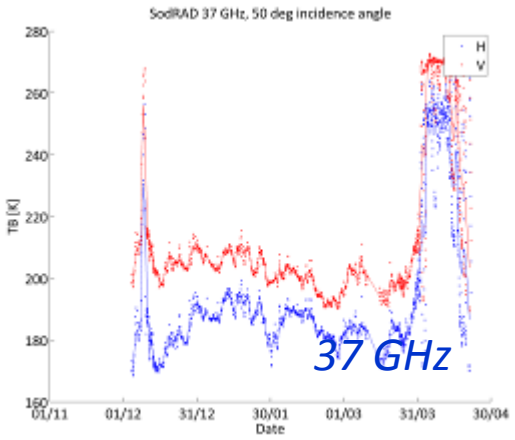
Measurements: Passive (50 deg incidence angle)

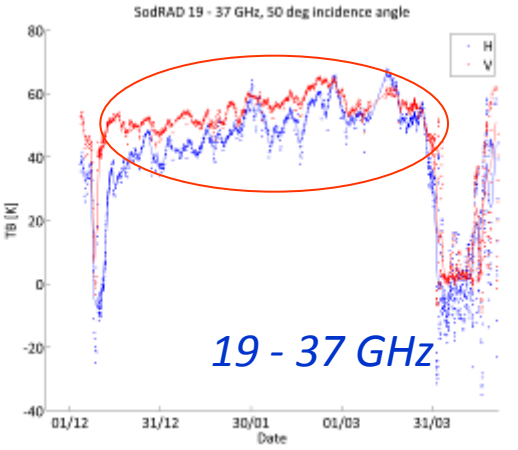












Typical Input Parameters for models

Backscatter models

Snow layer(s)

- Stratigraphy (layering)
- Snow surface roughness/correlation length
- Depth
- Density
- Scattering particle size

Ground interface

- Ground dielectricity
- Ground roughness

  → Surface reflectivity

Emission models

Snow layer(s)

- Stratigraphy (layering)
- Depth
- Density
- Scattering particle size/correlation length (MEMLS: shape)
- Temperature
- Moisture content

  → Snow volume scattering, absorption and emission

Ground interface

- Ground dielectricity
- Temperature
- Ground roughness

  → Surface reflectivity and upwelling emission

Atmospheric effects

- Up- & downwelling brightness temperature
- Snow surface reflectivity

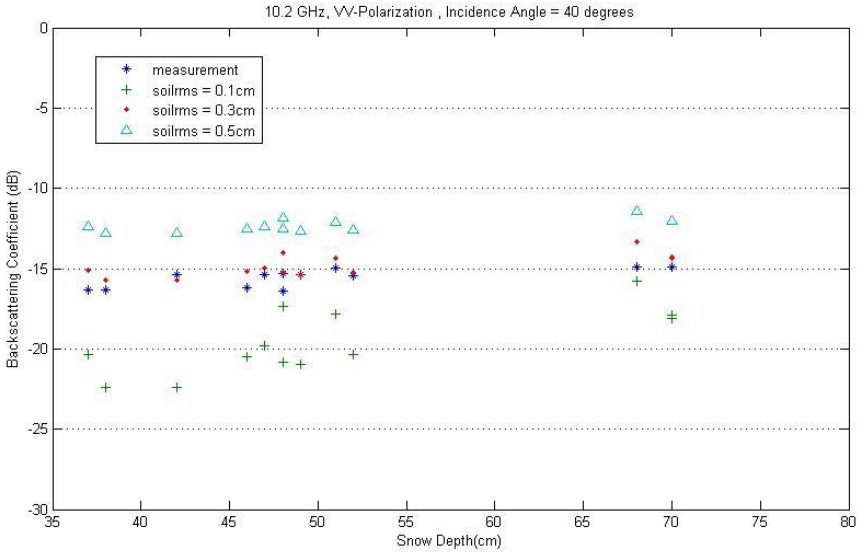
  → Atmospheric contribution to detected emission

Comparisons with models: Active

Dates (13 different dates)

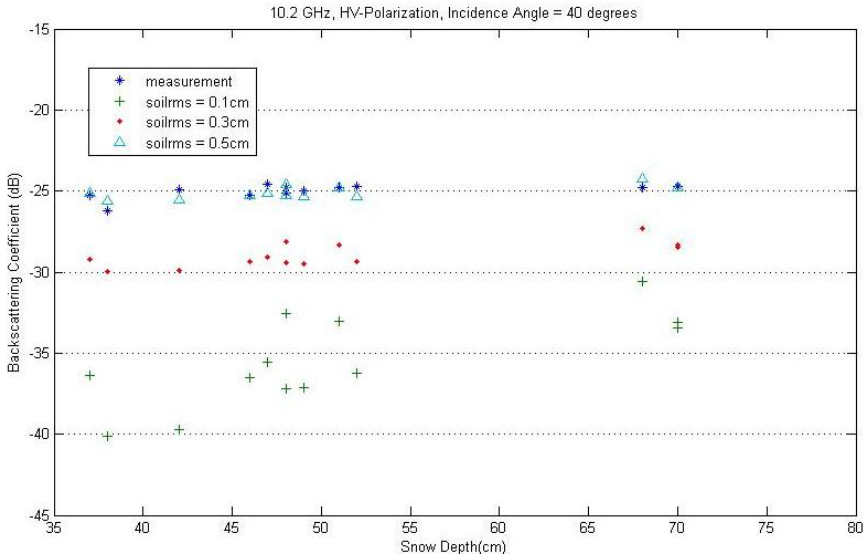
- Snow Ground Data
  - number of layers
  - layer temperature
  - liquid water content
  - snow density
  - thickness
  - grain size
  - snow type

Snowscat sigma0 Data;
incidence Angle = 40 deg
frequencies= 10.2 GHz, 13.3 GHz and 16.7 GHz
polarizations= HH, HV,VH and VV



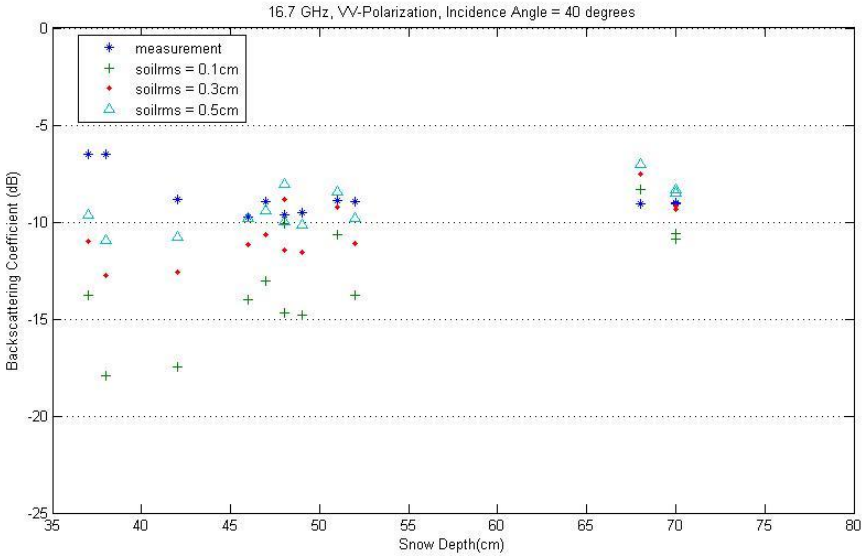
X band

co - pol



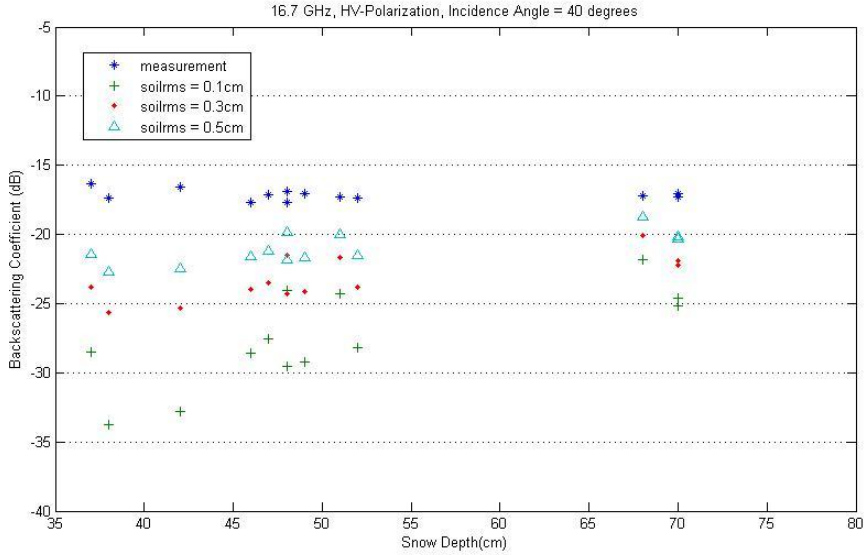
X band

cross - pol



Ku band

VV

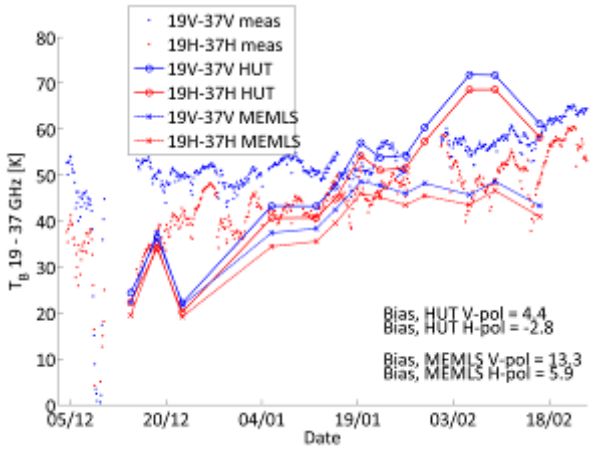


Ku band

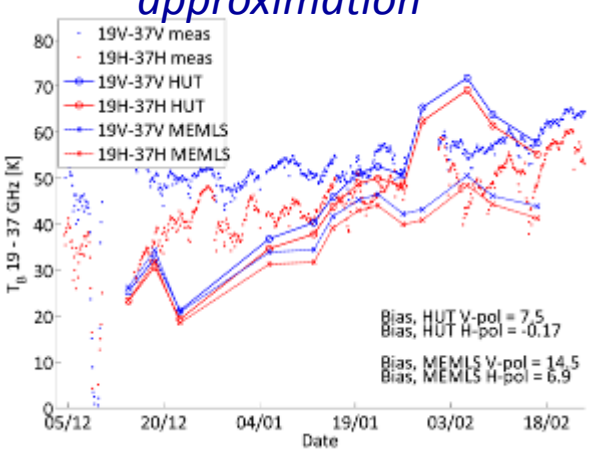
HV

Comparisons with models: Passive

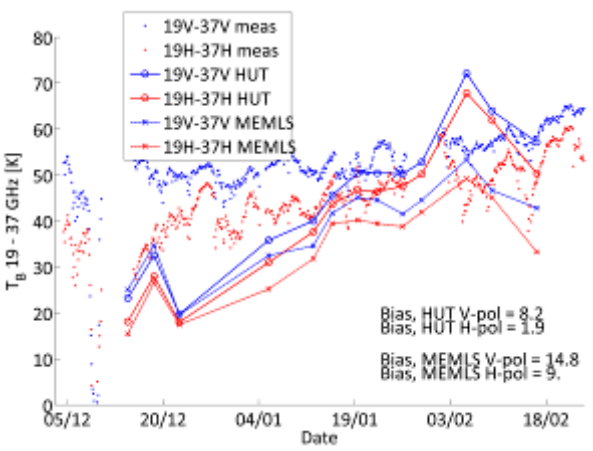
Effective values



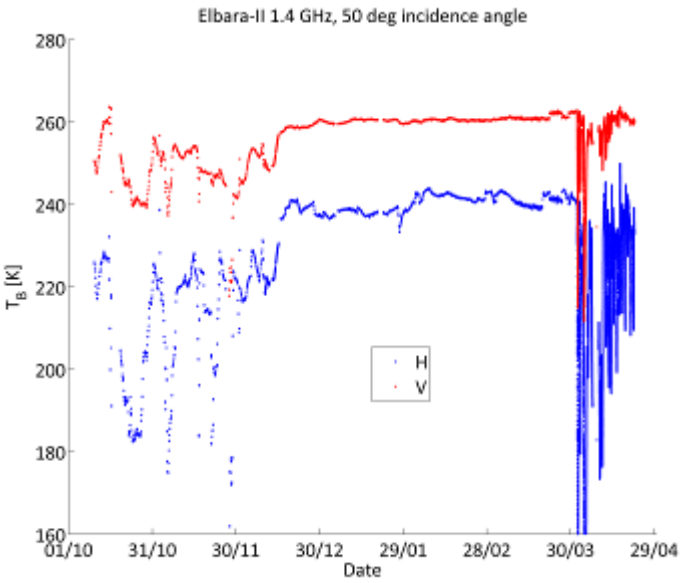
Two layer approximation

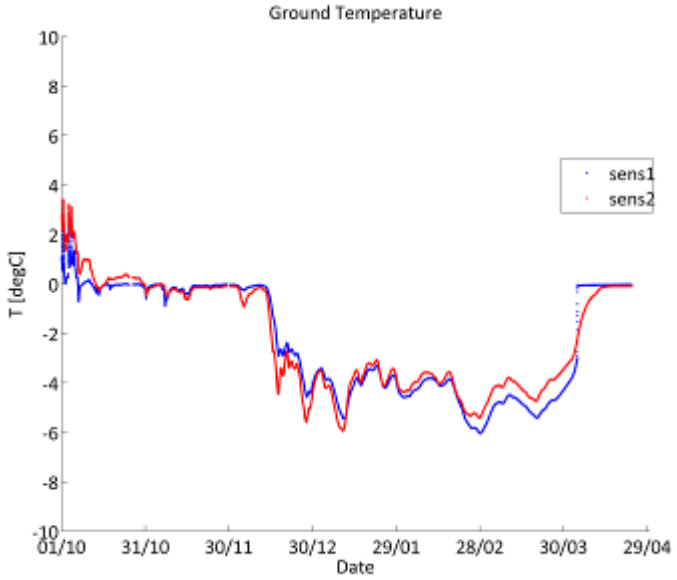


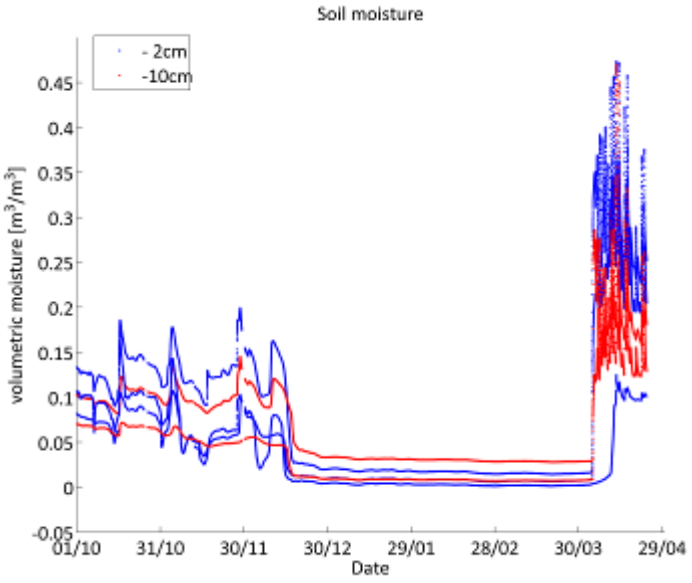
All layers



L-Band response: effect of soil freezing

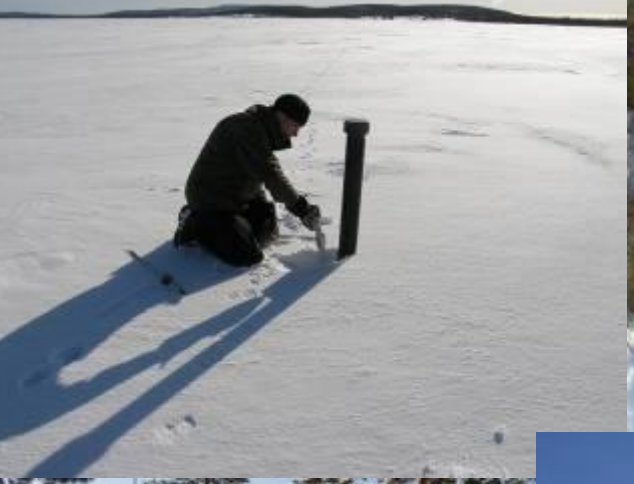






Summary

- The NoSREx campaign is conducted in support of several CoReH20 phase A studies
- The campaign aims at providing a unique dataset spanning an entire winter season (2009/2010) with combined active/passive MW measurements
  - SnowScat scatterometer, X to Ku Band
  - Radiometer systems from L to W band
- Microwave observations are complemented by comprehensive in situ measurements
  - Regular snowpit measurements at three sites
  - Automatic sensors (meteorological, snow depth, SWE, ground properties)
  - Several intensive campaigns
- Data currently undergoing verification




Thank you