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Snow monitoring at FMI Arctic Research Centre

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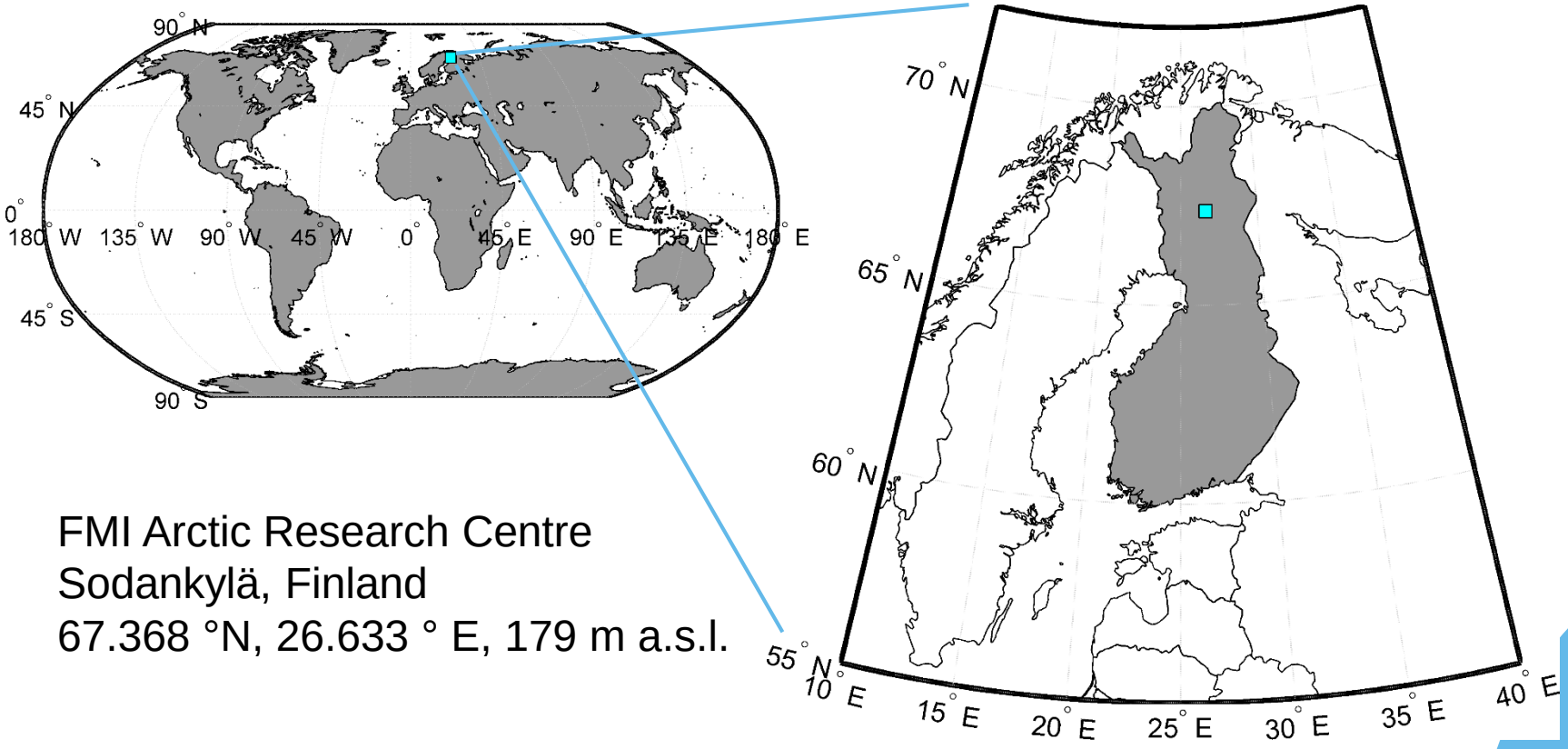
FMI Arctic Research

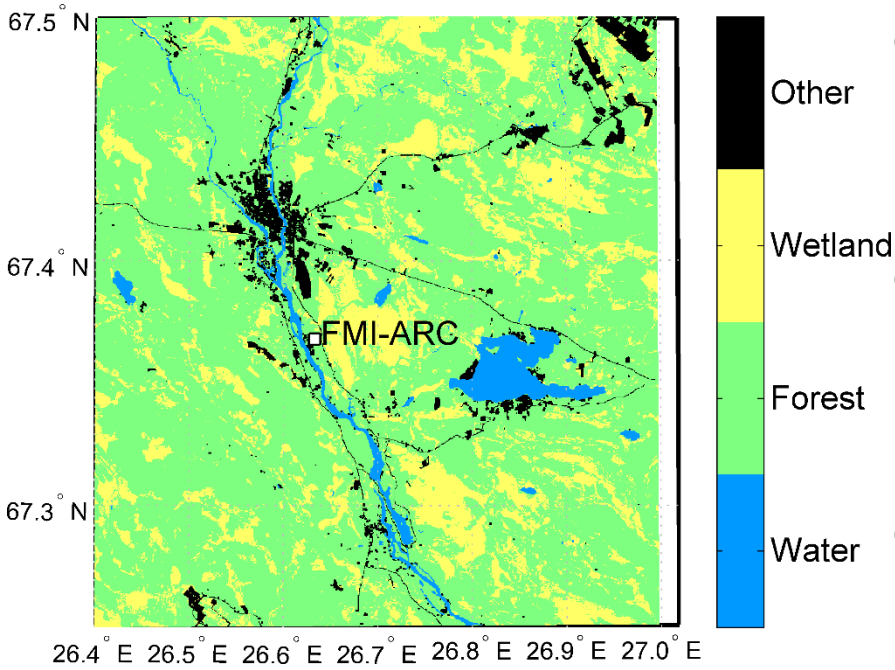
Introduction

Location

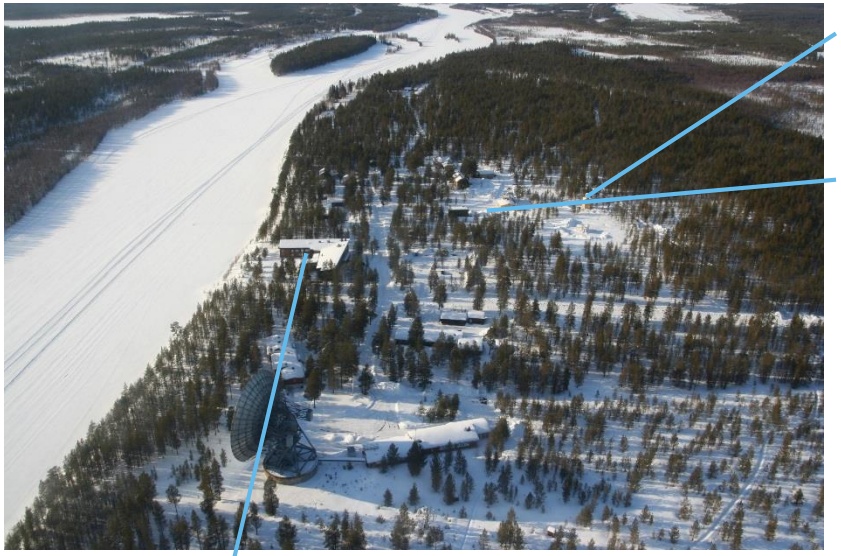


FMI Arctic Research Centre
Sodankylä, Finland
67.368 °N, 26.633 ° E, 179 m a.s.l.

Surroundings



- Institute area:
  - sparse pine forest
  - wetland
  - river
- Other measurement sites:
  - Lake Orajärvi, dist. 10 km
  - Saariselkä tundra, dist. 130 km
- Sodankylä centre, dist. 9 km

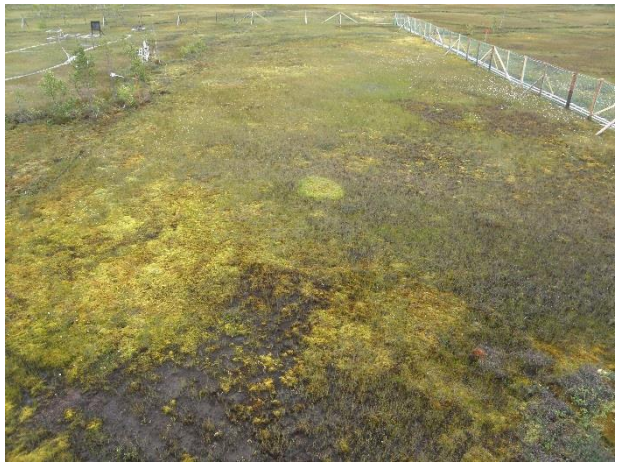


Satellite reception

Sounding station: Weather station, radiation

Main building

Bog site:
Weather station, radiation, soil, CO flux



IOA: Snow measurements, soil, radiation

Micrometeorological mast: CO2 flux, radiation, wind & temperature & humidity profiles

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History

- First thermo-/barometer records in 1856
- Met station during the 1st IPY 1882/83
- Continuous homogenized synoptic weather records from 1908 onwards
- Upper air soundings from 1949
- Solar radiation observations since 1957/58 (1st IGY)
- Radioactivity monitoring since 1963
- Air quality observations since 1970s
- Ozone and UV-observations since 1988
- Stratospheric Aerosol/Humitidy from mid 1990s
- Micrometeorological tower 1999
- Weather radar at Luosto 2000
- Snow in situ measurements 2006
- Microwave radiometers 2009
- Large capacity satellite data reception & archiving 2011
- WMO hosted comparative set of snowing and raining instrumentation 2013

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Infrastructure

Main focus on

- Satellite activities: reception, processing and archiving
- CAL-VAL super-site
- Freeze/thaw measurements
- Snow measurements: in-situ, airborne and spaceborne
- Atmospheric soundings
- Meteorological parameters
- Carbon cycle

On-site facilities

- Accommodation up to 40 persons
- Lecture hall
- Several meeting rooms
- Extensive wifi
- Workshops: metal, wood, electronics
- Biological laboratory
- Dark room
- Several saunas and river-side hut

Campaigns and training schools

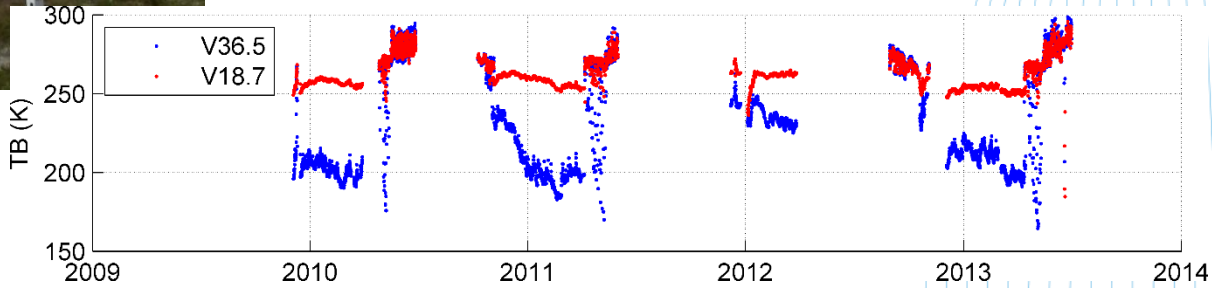
- ESA/NoSREx (2009-2013)
- COST-Pergamon summer school (2013)
- 1st European Snow Science Winter School (2015)

4 cars - 5 snowmobiles - 2 ATVs

Snow and reference measurements

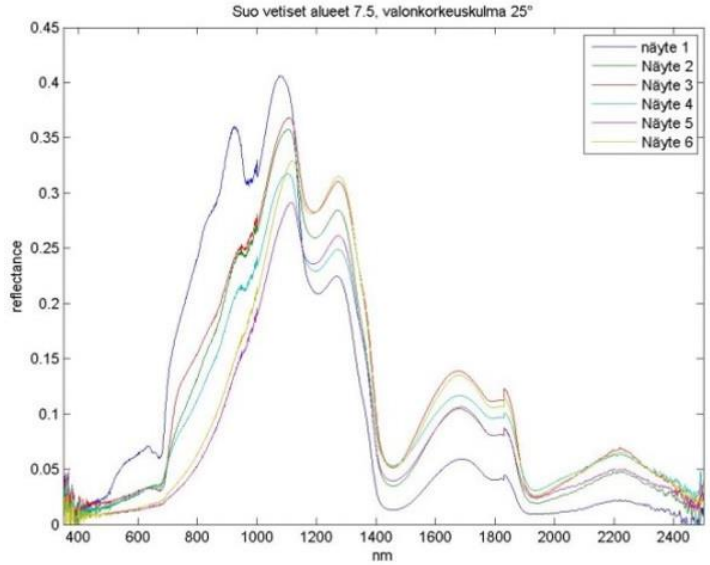
SORAX – Sodankylä Radiometer Experiment

- ELBARA-II: ESA SMOS reference
  - 1.4 GHz
  - At forest site 2009-2012, 2015->
  - At bog site: 2012-2015
  - Elevation scan every hour
- SodRad1 & 2: RPG-DP-XCH
  - 10.7, 18.7, 21, 36.5, 89, 150 GHz
  - Since 2009/2012
  - 2D scan every hour



Mast spectrometer

- ASD FieldSpec Pro Jr
- VIS and NIR spectrum, 350-2500 nm (since 2015 only 350-1000 nm)
- Installed in a 30-m mast, measures forest and open area
- Similar instrument used in field and dark room laboratory measurements
- Since 2006



Long- and shortwave solar radiation

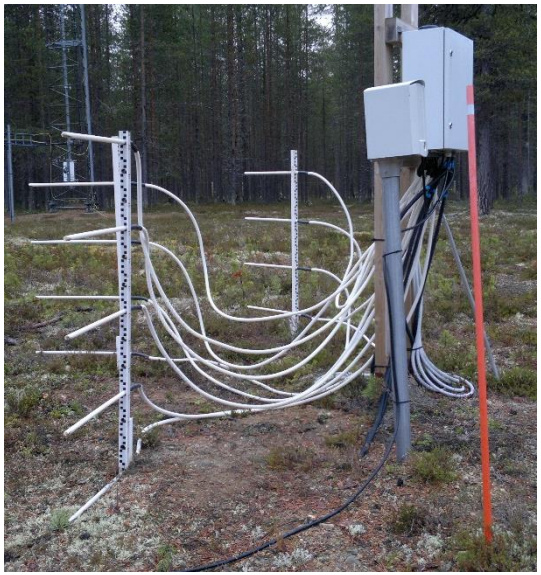
- IOA and bog site:
  - Global and reflected SW
- Met mast and forest:
  - Global and reflected SW+LW
- Sounding station:
  - Global and reflected SW at field and in tower
- Most since 2012

Reference measurements at IOA

Snow depth, air temperature and humidity

Disdrometer (precipitation type and intensity)

Soil permittivity/temperature/moisture + Snow temperature



Snow scale (SWE)

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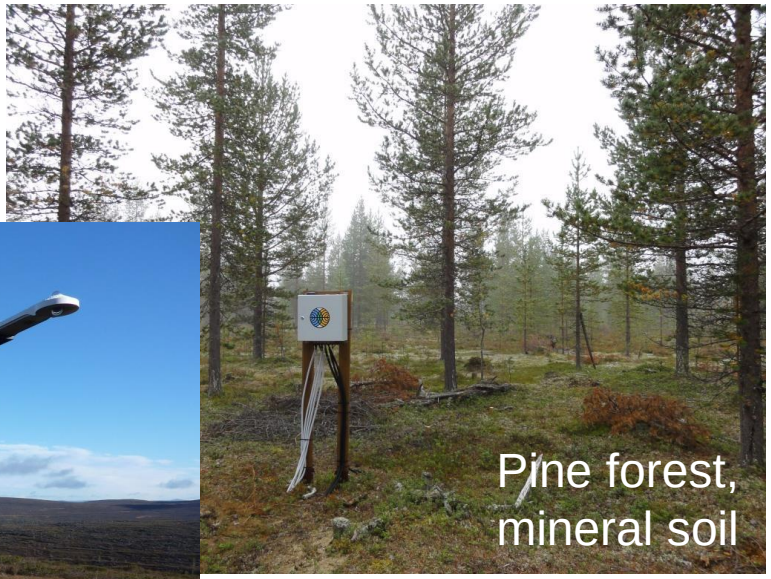
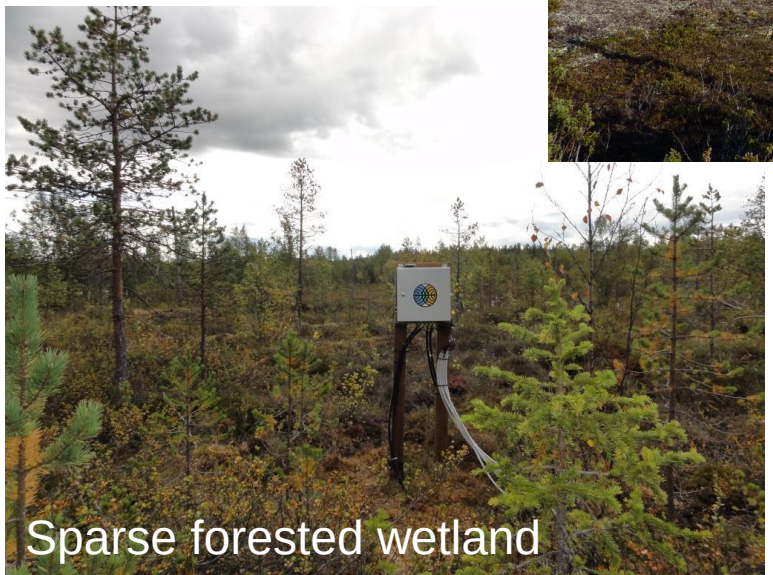
Soil moisture stations


Mixed / spruce forest, thicker organic layer


Saariselkä tundra site


Pine forest, mineral soil


Sparse forested wetland


Open wetland

Automatic weather station

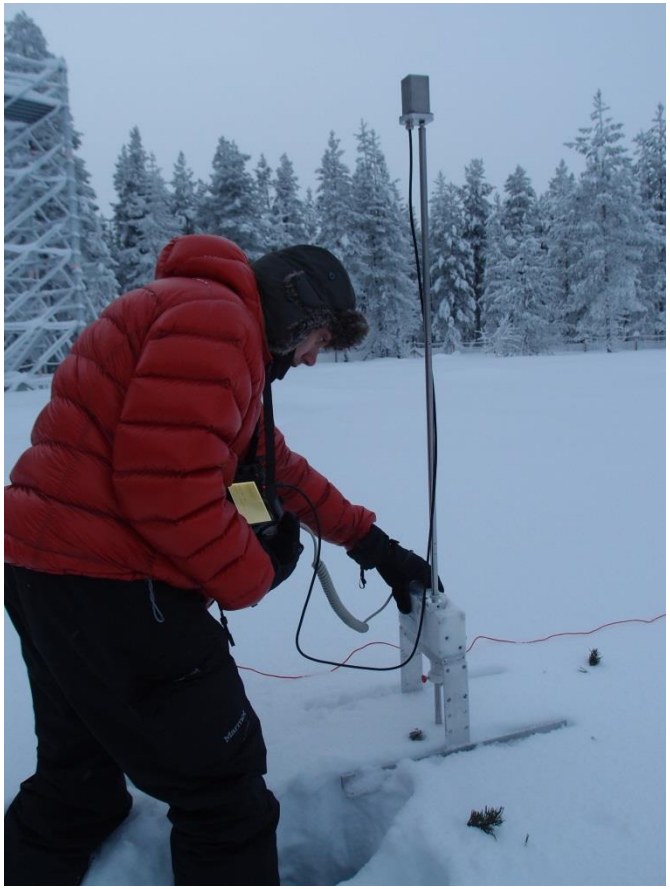
- Main weather station at sounding station
  - Temperature, dew point temperature
  - Relative humidity
  - Air pressure
  - Snow depth
  - Visibility
  - Wind speed and direction
  - Cloud height and cloudiness
- Smaller (SD, Tair) at IOA and bog site
- Continuous homogenized synoptic weather records since 1908
- Main parameters automatic since 2008

Manual observations

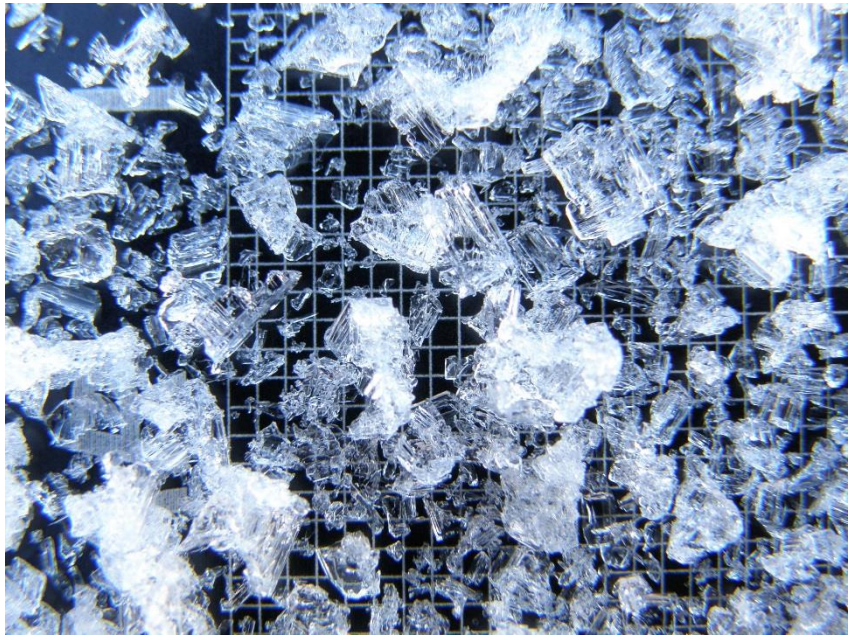
Snow pit

- Profiles of
  - Snow stratification (visual, SMP)
  - Grain size (visual, macrophotos)
  - SSA (IceCube)
  - Density and SWE (Snowfork, scale)
  - Temperature
  - Wetness (Snowfork)
- Operationally 1/week at IOA
  - Previously operationally at bog and lake
  - During campaigns even several pits/day at each site

Snow stratification

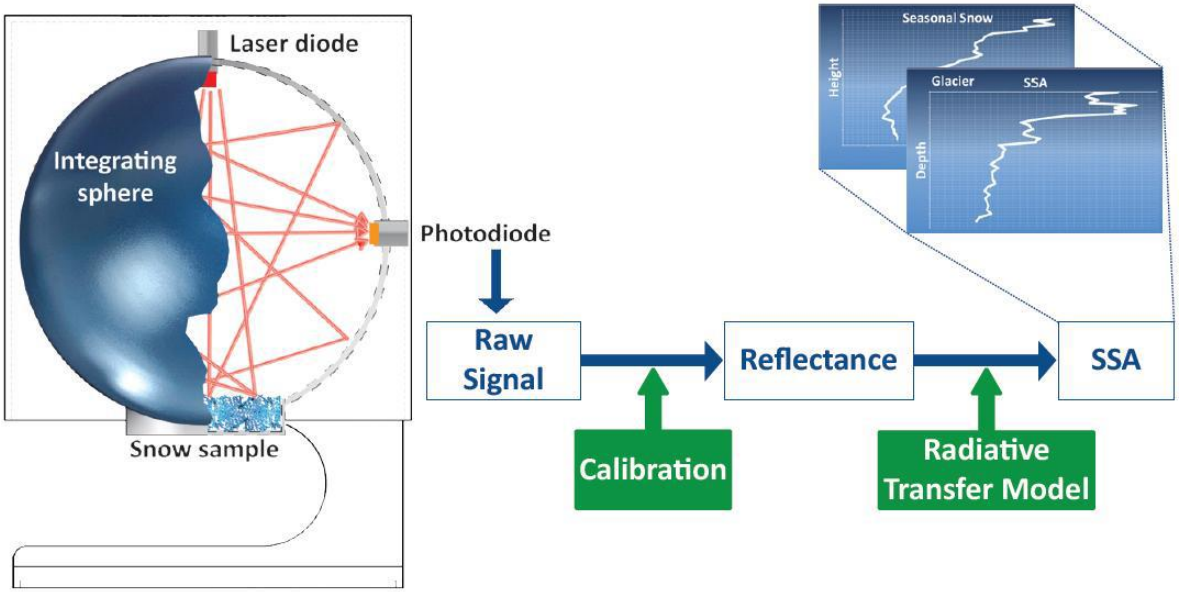


Grain size



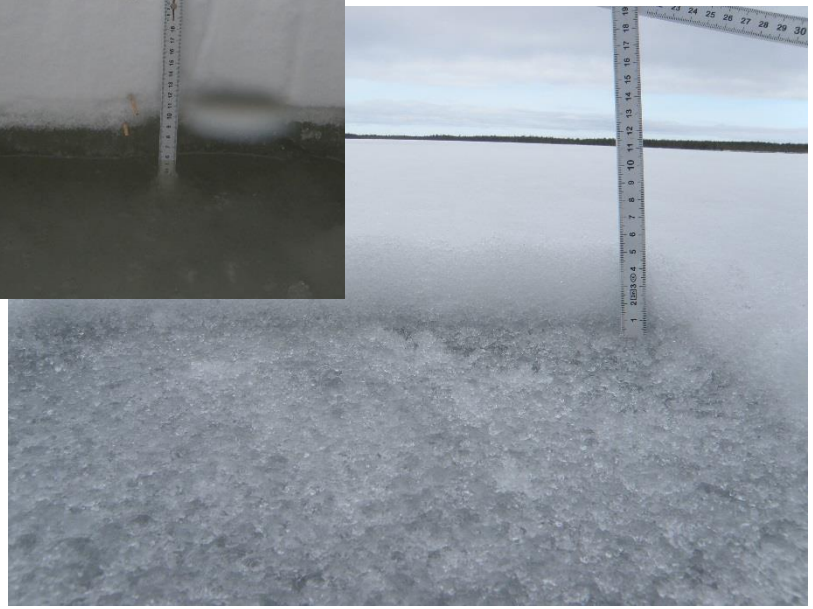
SSA

- SSA profile with 3 cm resolution
- Measures hemispherical reflectance of infrared laser (1310 nm) from snow sample surface
- Results are converted to reflectance and forward SSA with software



Density

Lake ice and snow



Examples of past campaigns and training schools

WMO SPICE

Solid Precipitation Intercomparison Experiment

- Intercomparison of precipitation detectors, precipitation gauges, snow depth sensors, SWE instruments
- 20 sites around the world
- Our interest: snow on ground
- Measurements 2012-2015, now data analysis

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ESA NoSREx
Nordic Snow Radar Experiment

- Goal: Provide data for proposed EE7 *CoReH$_2$O* Phase A studies:
  - Seasonal signatures of snow covered terrain (scatterometer + radiometer measurements at fixed site)
  - Spatial variability of backscatter signal (airborne measurements) → *CoReH$_2$O* retrieval algorithm development and mission concept demonstration
- Data from four full winter seasons
  - NosREx I: 2009-2010
  - NoSREx II: 2010-2011 (airborne test)
  - NoSREx III: 2011-2012 (airborne concept demo)
  - NoSREx IV: 2012-2013
- Continuous measurements with ESA SnowScat (X to Ku band scatterometer) and radiometers (L to W band)
- Weekly/daily observations of snow micro- and macrophysical properties
- Airborne campaigns with ESA SnowSAR system

NoSREx setup

Photo: webcam on 30 m tower

Test field

Snow pit

Automatic sensors (Temperature, bulk SWE, SD)

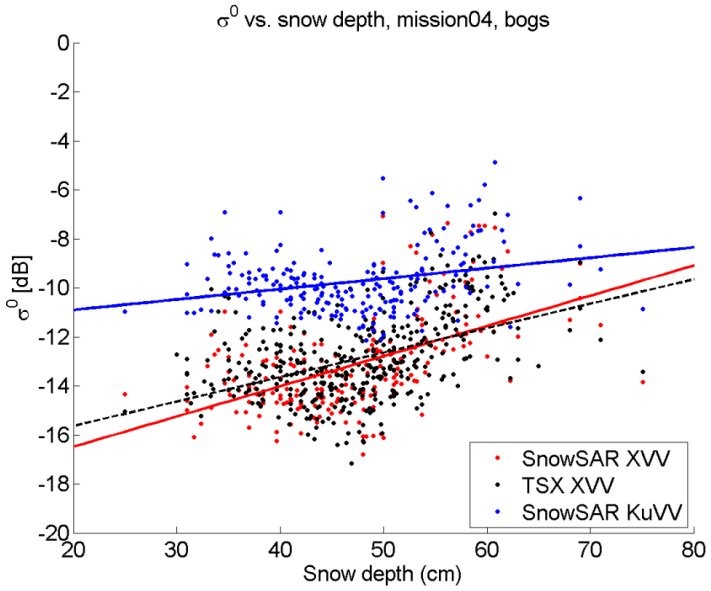
SnowScat (X to Ku freq. scan)

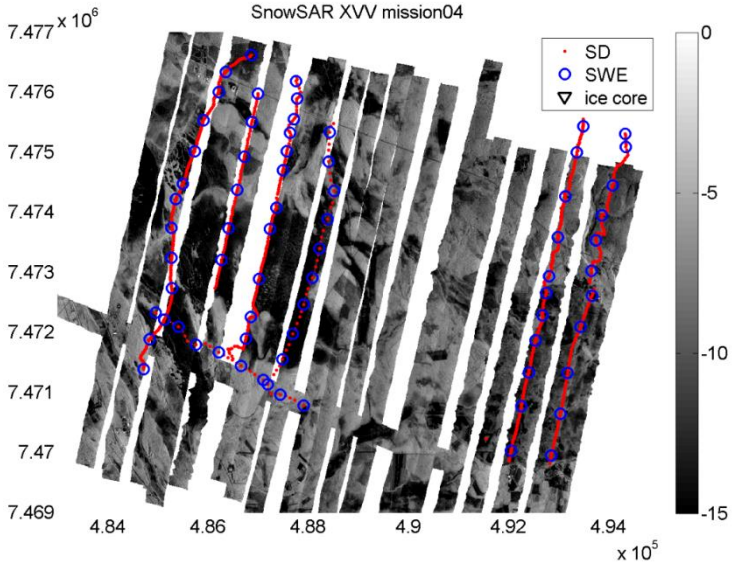
- Azimuth scanning
- incidence angles 30-60°

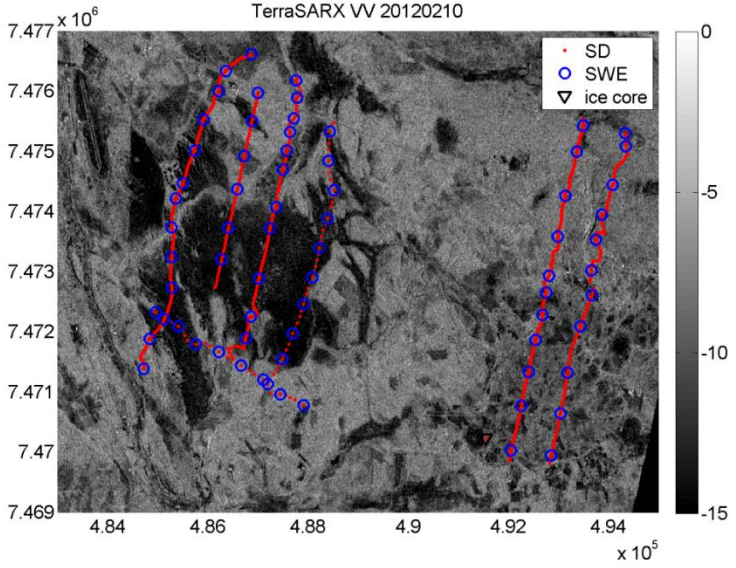
L to W band radiometers

- incidence angles 30-60°

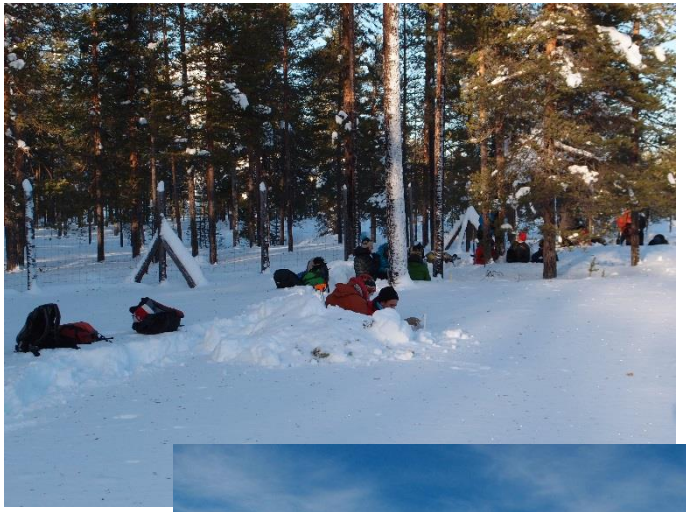
SnowSAR flights







1st European Snow Science Winter School



- Organizers: WSL-SLF and FMI
- February 2015 in Sodankylä, Finland
- 25 students, 8 lecturers from 12 countries in Europe and North America

- Lectures on snow structure, modeling, remote sensing, preparing a field campaign, measurement networks, …
- Focus on field work and techniques, instrumentation

- Different snow: forest, bog, lake, tundra


Thank You for Your Attention!
Photo: Matias Takala