AN INTRODUCTION TO SNOW OBSERVATIONS

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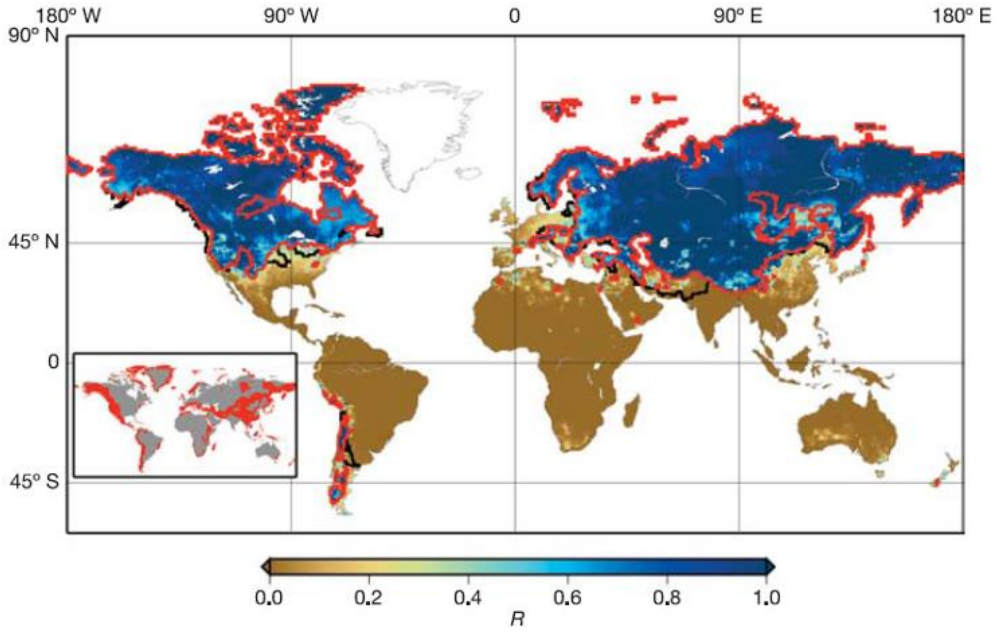
CONTENTS

- Importance of Snow
- Two forms of snow observation techniques
- Snow Emission Model
  - Helsinki University of Technology (HUT) Snow Emission Model
- Arctic Snow Microstructure Experiment (ASMEX)

WHY IS SNOW IMPORTANT?

Snow plays an important role in numerous global cycles and interactions.

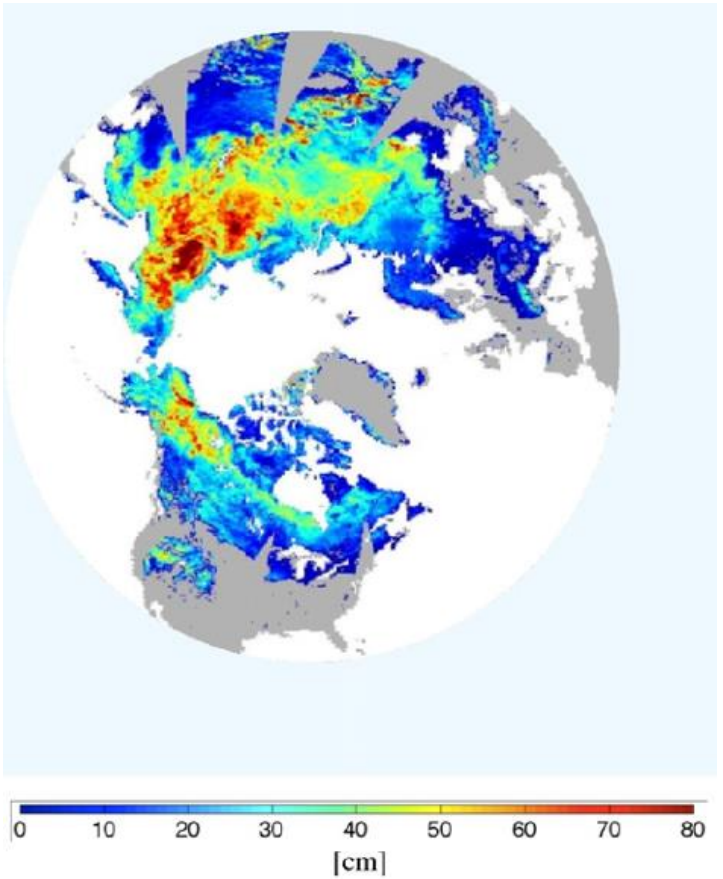
- Hydrological, Meteorological, and Climatological
- Hydropower production
- Freshwater and flood forecasting



>1 billion people rely on snowmelt for their fresh water supply (Barnett et al, 2005)

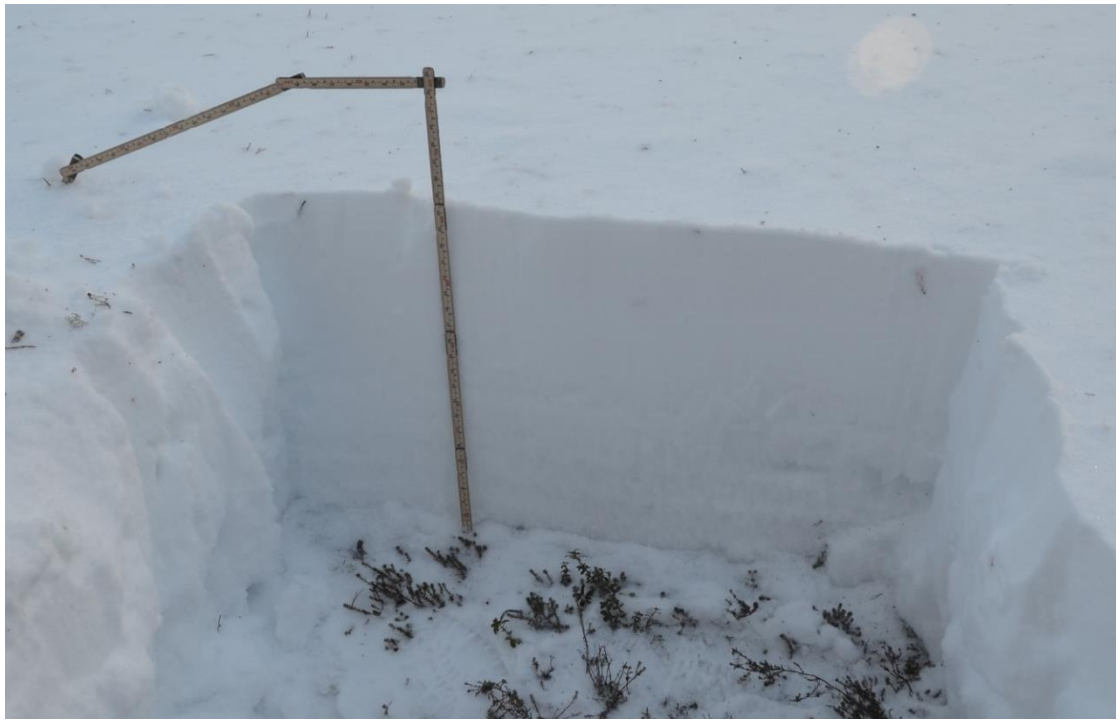
HOW DO WE MEASURE SNOW?

- Point measurements
- Remote Sensing Techniques



Frei et al 2012

SNOWPITS

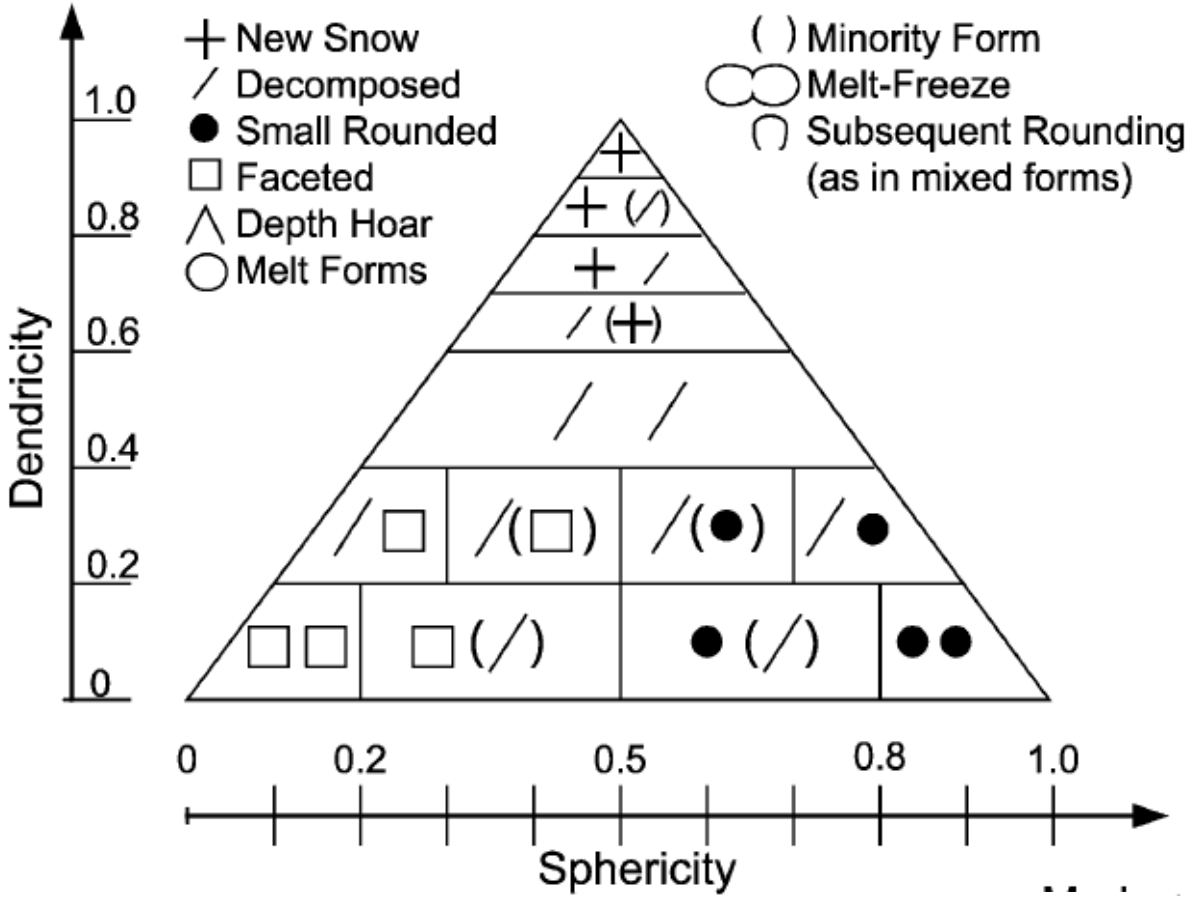


SNOWPITS

Various different measurements

- Bulk measurements
  - Depth
  - Snow Water Equivalent (SWE)
- Profiles
  - Temperature
  - Density
- Layers
  - Grain Size / Type
  - Hardness
  - Wetness

TYPES OF SNOW GRAINS

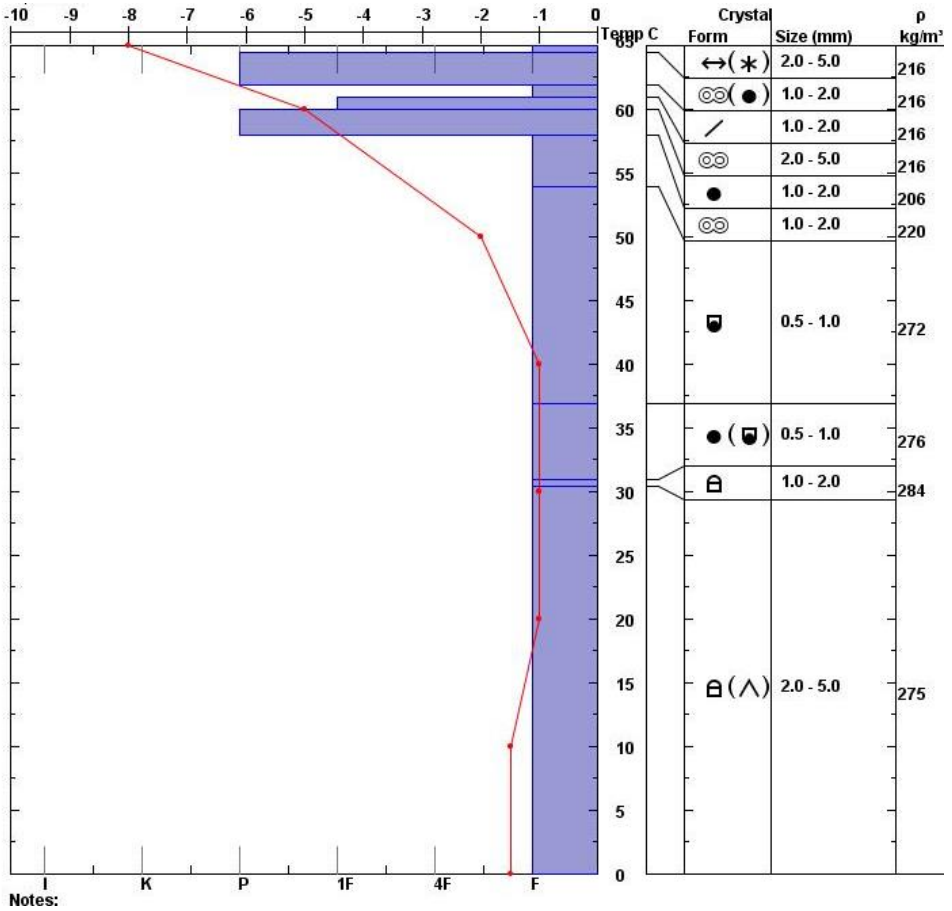


SNOWPIT ADVANTAGES

Collect data on internal layers within the snow pack.

Potential for measurement of different parameters.

Resolution up to you (within reason)



SNOWPIT DISADVANTAGES

Snowpits are time and labour extensive

- A single snow pit: >1 hour.

Exposed to the elements.

- Wind: Wind chill / Drifting and blowing snow
- Temperatures

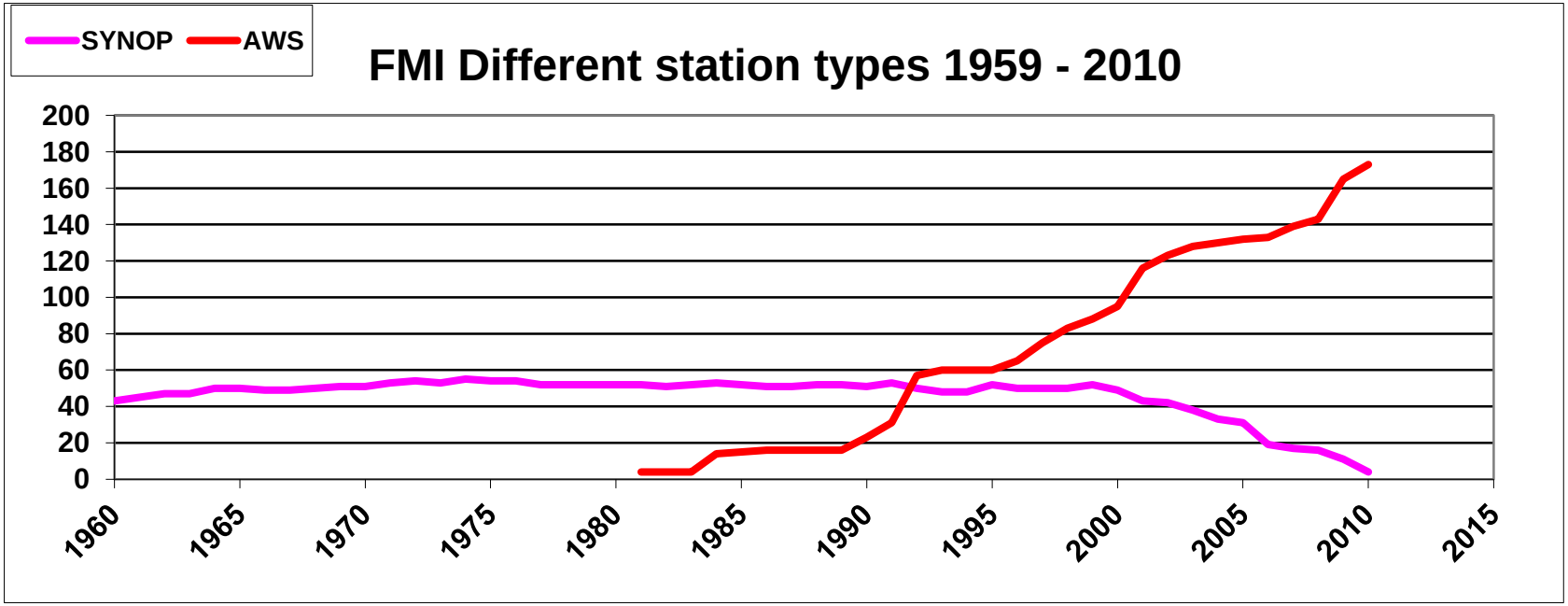
Point measurements, sparcely distributed.

- Correlation between population centres and snowpit locations.
- Negative correlation between latitude and snowpit numbers.

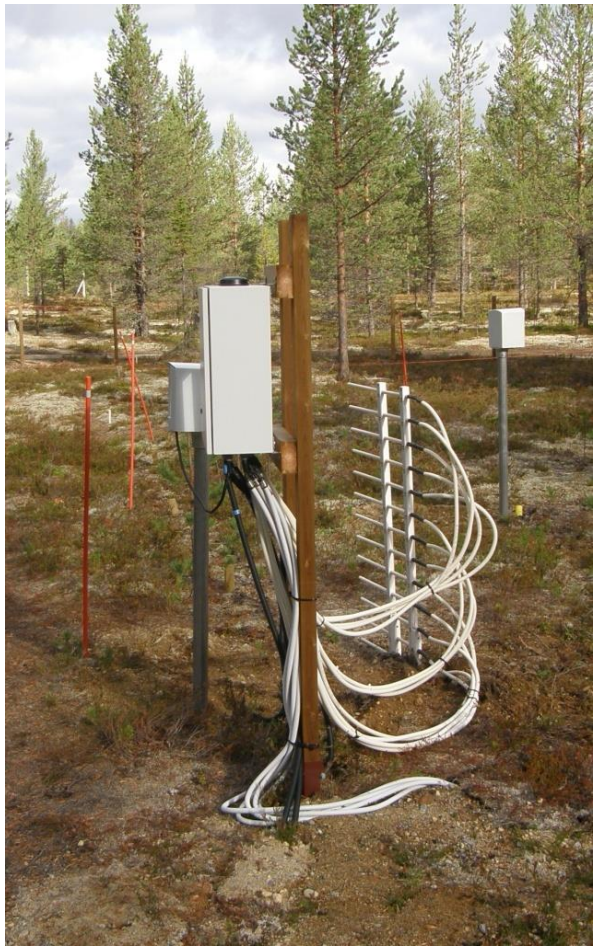
AUTOMATIC STATIONS

Increasing move away from manual measurements to automatic measurements

- Weather Stations (AWS)
- Snow Measurements (ASM)



AUTOMATIC STATIONS



AUTOMATIC STATIONS

REMOTE SENSING OF SNOW

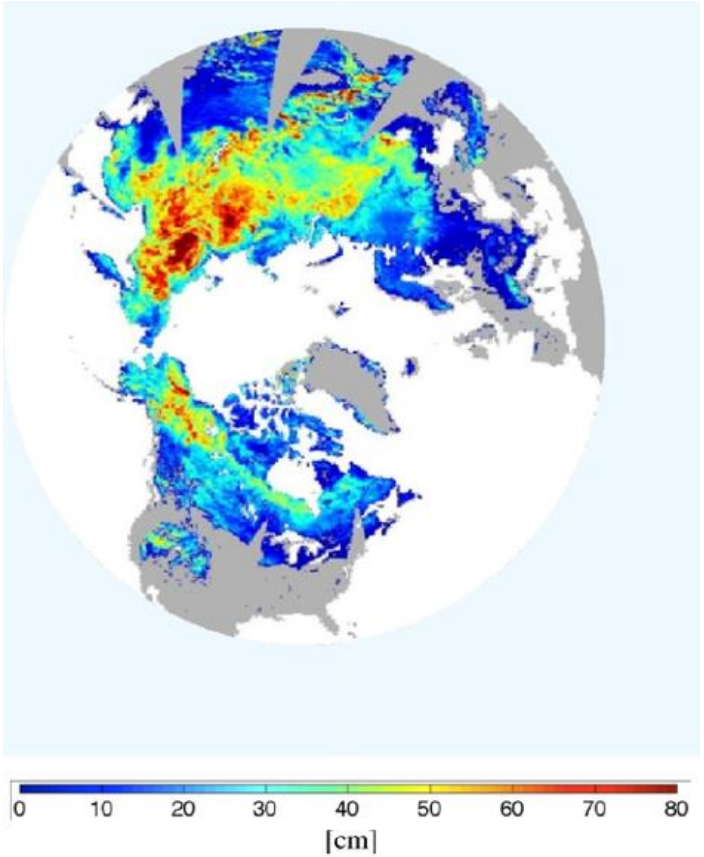
Observing snow from a distance, via electromagnetic radiation.

Active Remote Sensing

- Exposing Earth's surface to a signal, and measuring the return.

Passive Remote Sensing

- Measuring the naturally emitted signal.



Frei et al 2012

REMOTE SENSING OF SNOW

	Visible	Infra-red	Microwaves
Lighting conditions	During daylight hours	Not dependant on lighting	Not dependant on lighting
Cloud conditions	Cannot penetrate through clouds	Cannot penetrate through clouds	Can penetrate through non-precipitating clouds
Information gained	Snow Extent/Cover	Skin temperature	Snow Depth SWE Snow Extent/Cover*

REMOTE SENSING OF SNOW

Microwave emission from snow consists of two separate contributions

- Emission from the snowpack
- Emission from the underlying surface.

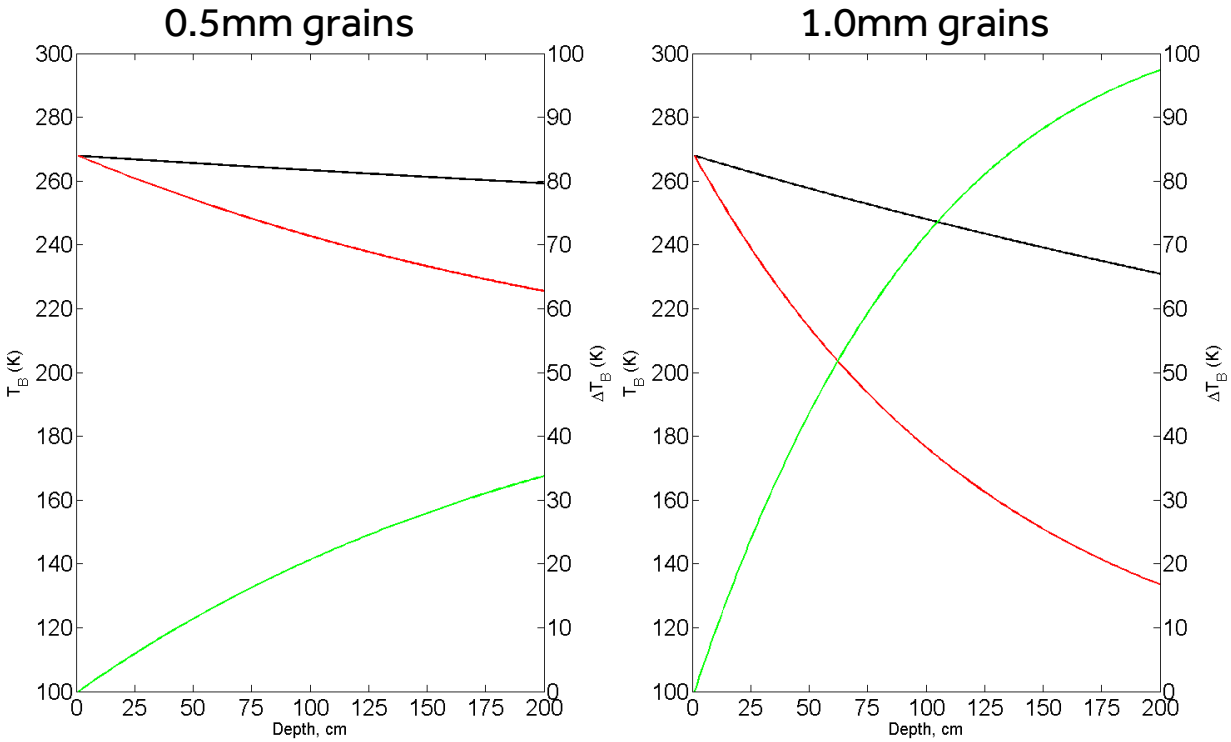
Snow crystals act as scattering centres for upwelling radiation

- Deeper snow leads to more scattering
- Larger grains leads to more scattering
- Higher frequencies leads to more scattering

REMOTE SENSING OF SNOW

Can use different frequencies to infer snow depth or SWE.

Commonly use a two-frequency approach (18/19 GHz and 35/36 GHz)



Black = 19 GHZ

Red = 36 GHz

Green = Difference

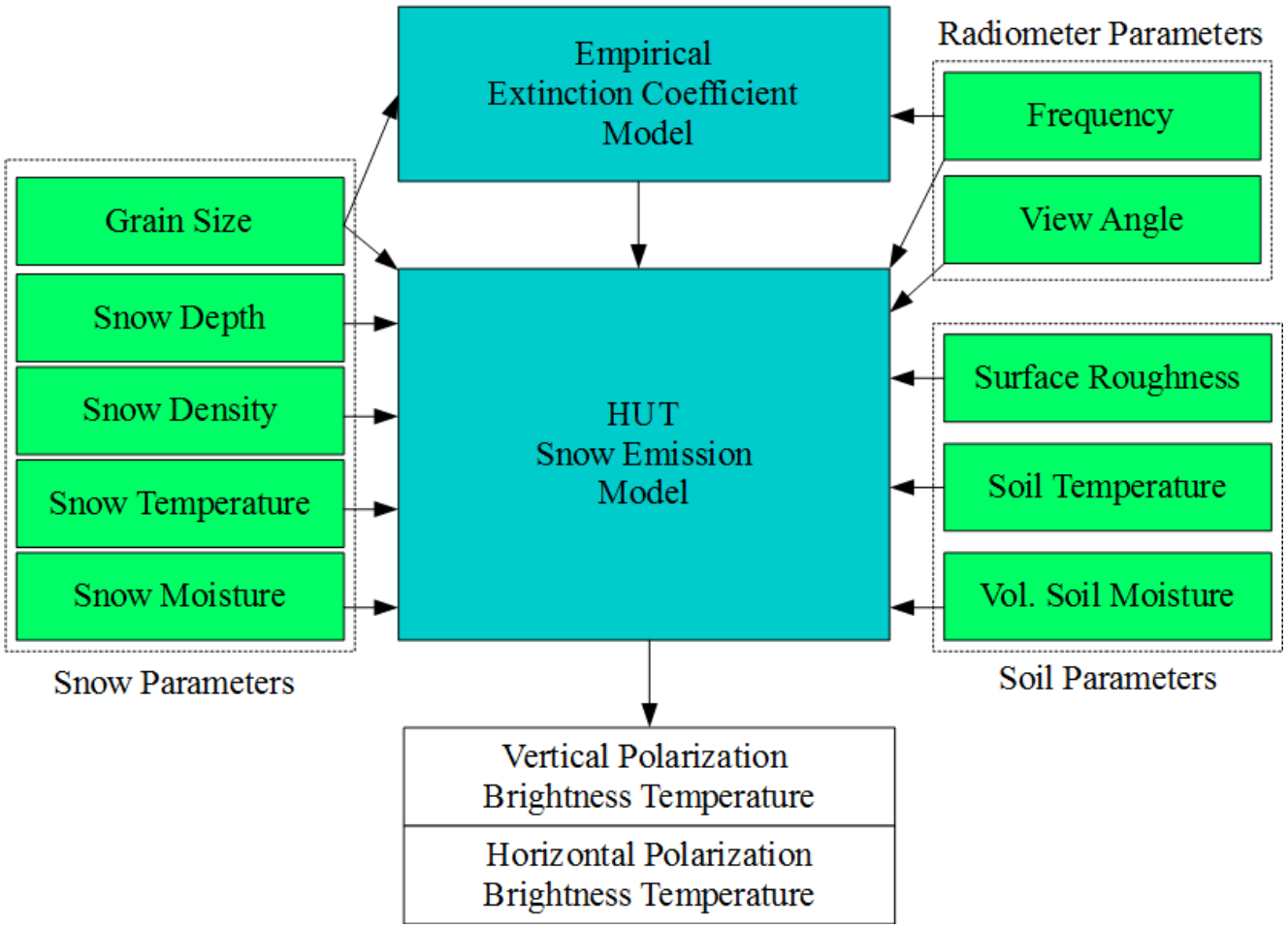
SNOW EMISSION MODELS

Can use snow emission models to simulate the emission from the snowpack.

Reliable models can retrieve snowpack characteristics via inversion of the model.

Much more accurate that using empirical inversion algorithms, however needs some input parameters.

HUT SNOW EMISSION MODEL



Semi-empirical

Radiative Transfer Theory

Scattering is concentrated in the forward direction

PHD AIMS

- The aims of my PhD are:
  - Take natural snow samples over 2 winter periods
    - Arctic Snow Microstructure Experiment (ASMEX)
  - Develop a revised model for the amount of extinction within a natural snowpack.
  - Use the revised model within the HUT snow emission model, to improve its accuracy.

ASMEX LOCATION

FMI Arctic Research Centre, Sodankylä

Range of conditions

- -40°C to +10°C
- 2 – 17 hours of sunlight
- Max snow depth: 95cm

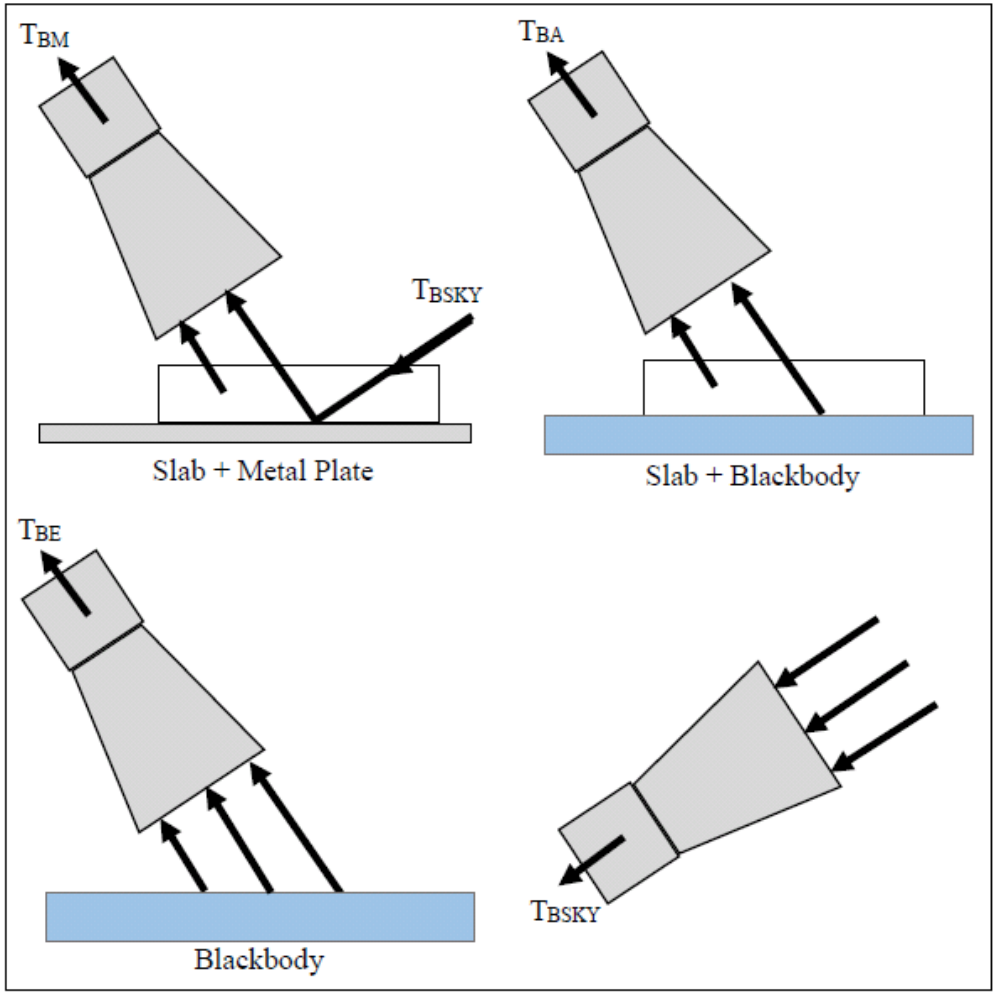
ASMEX SET UP

Radiometric measurements of extracted snow slabs

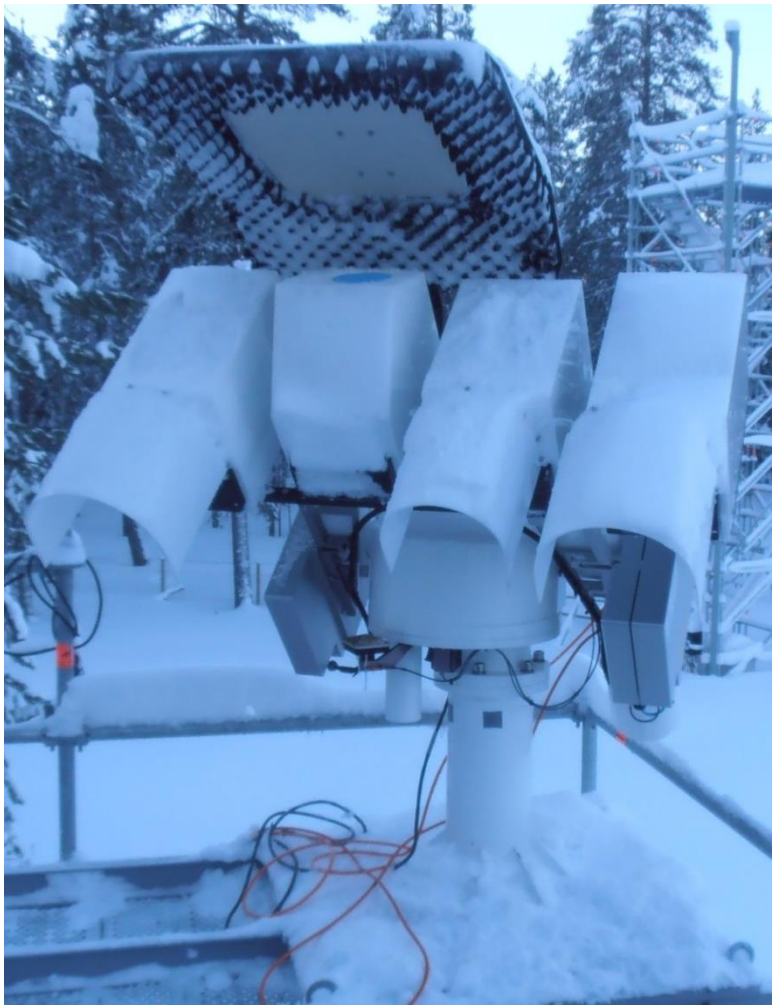
5 Microwave frequenies

- 18.7, 21.0, 36.5, 89.0, and 150 GHz (H/V Pol)

Physical and Stratigraphic measurements



ASMEX



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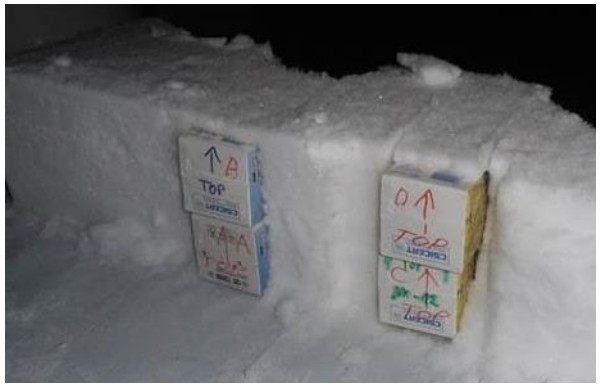
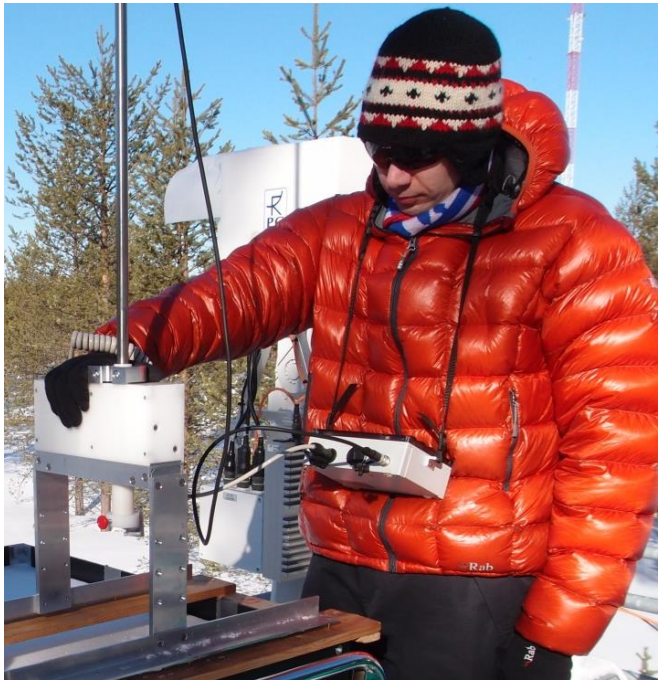




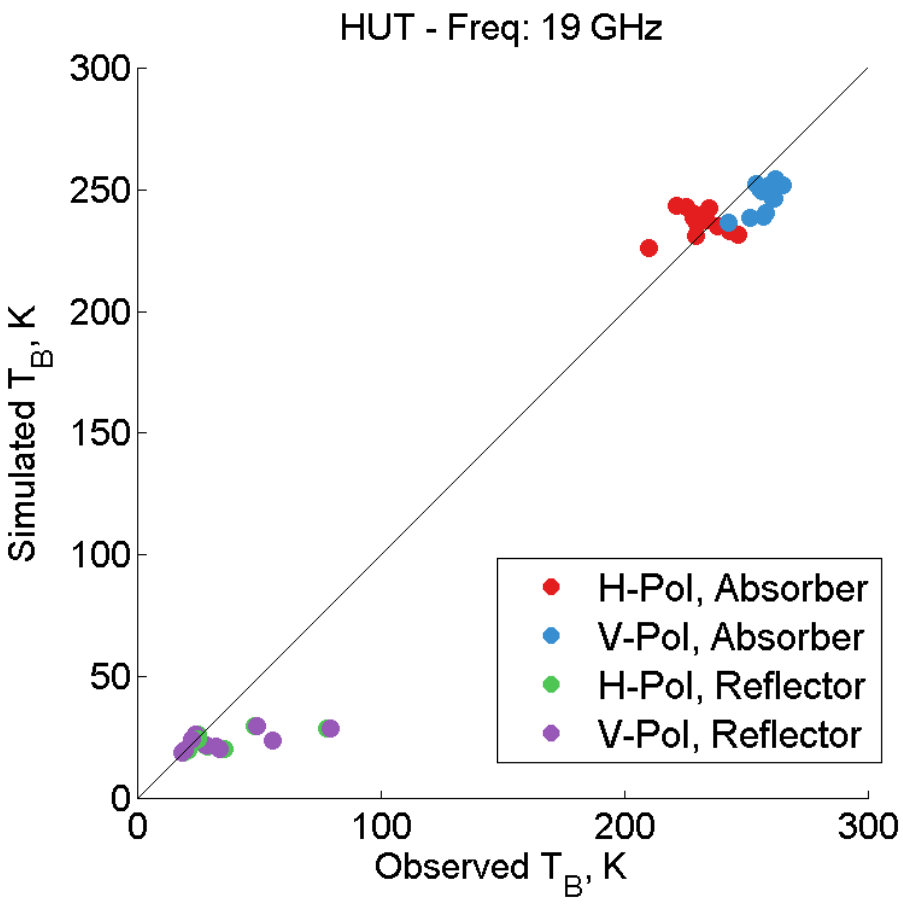
ASMEX PRELIMINARY RESULTS

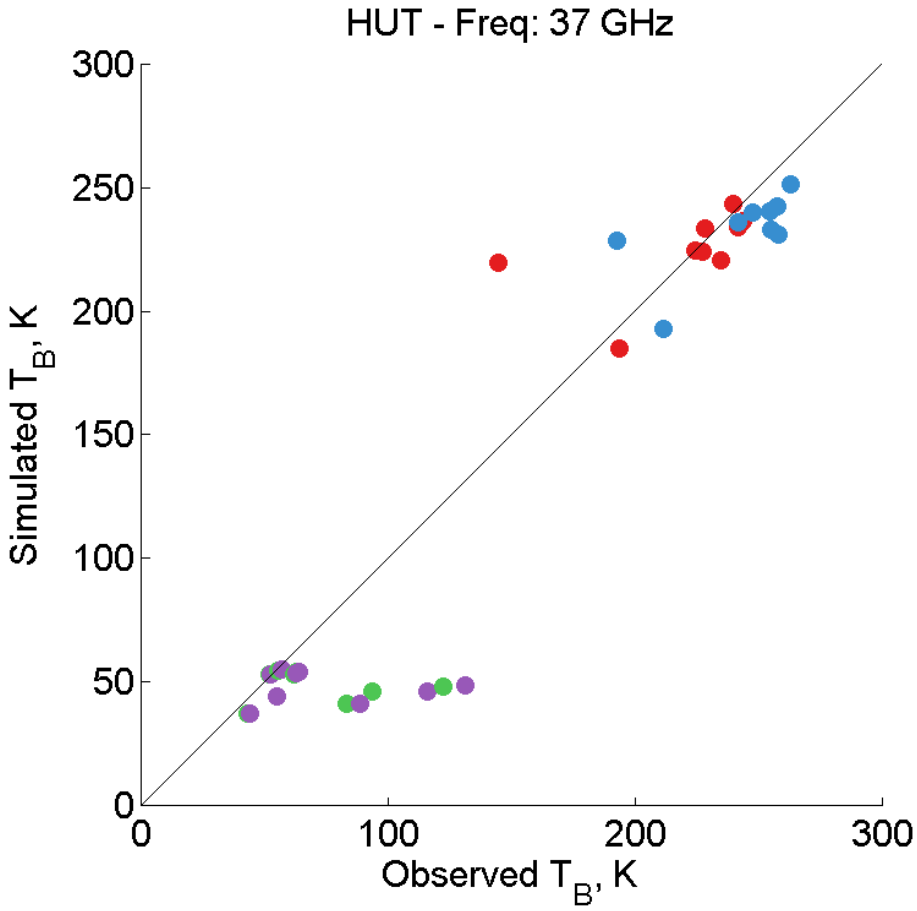
14 slab samples were extracted and measured.

13 considered “dry” slab samples.

- 6 in 2014, 7 in 2015
- Range of grain sizes (0.5mm to 2.0mm)
- Range of typical densities (125 – 325 kgm^{-3})
- Range of snow types (Fresh snow – Depth Hoar)

ASMEX PRELIMINARY RESULTS





PHD FUTURE WORK

Analysis of fieldwork data

- Comparison between different parameters
- Stratigraphy analysis

Model natural snowpack data with HUT snow emission model

- Comparison between simulated and observed brightness temperatures

Begin work on the revised extinction model

- Look into dielectric properties of the snow
- Look into scattering coefficients calculation