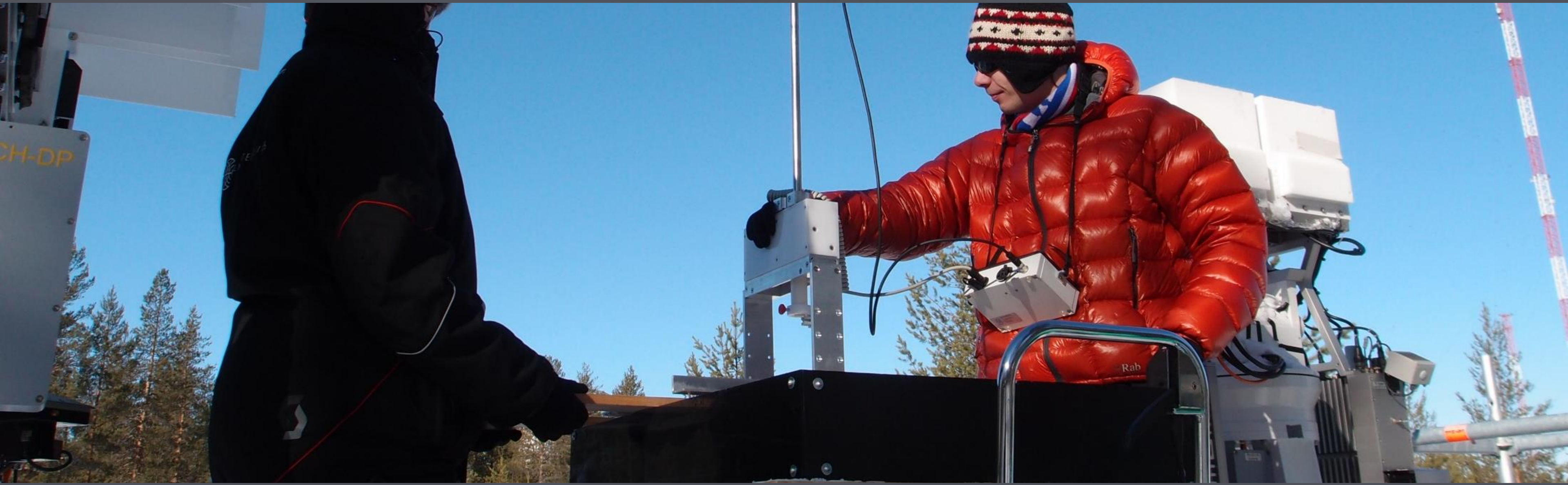
MICROSNOW 2015

FINNISH METEOROLOGICAL INSTITUTE

University of Reading

COMPARISON OF GROUND-BASED OBSERVATIONS OF SNOW SLABS WITH EMISSION MODELS



William Maslanka

Mel Sandells, Robert Gurney (University of Reading)

Juha Lemmetyinen, Leena Leppänen (Finnish Meteorological Institute)

OUTLINE

Motivation

Two semi-empirical snow emission models

- MEMLS
- HUT Snow Emission Model

Arctic Snow Microstructure Experiment

- Setup
- Preliminary Results

Future Work

MOTIVATION

Observations of snow by Microwaves are essential in polar regions

- Polar Nights, Clouds

Remote sensing methods are favoured over traditional methods for snow observations, as traditional methods:

- Are limited by resolution
- Are limited by time
- Have difficulties with polar conditions
- Can be subjective (due to the observer)

In order to extract information from remote sensing techniques, emission models can be used

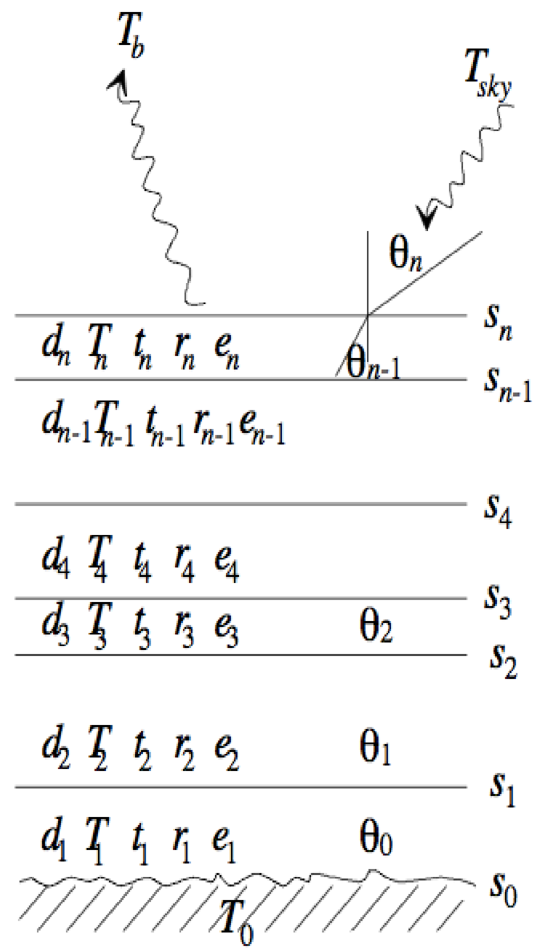
MEMLS

Wiesmann and Mätzler 1999.

Microwave Emission Model of Layered Snowpacks

Semi-empirical model, based on Radiative Transfer Theory

- Empirical scattering / absorption coefficients
- Uses two flux framework ($T_{b\text{-}up}$ / $T_{b\text{-}down}$) to model radiation intensity, via coupled differential equations



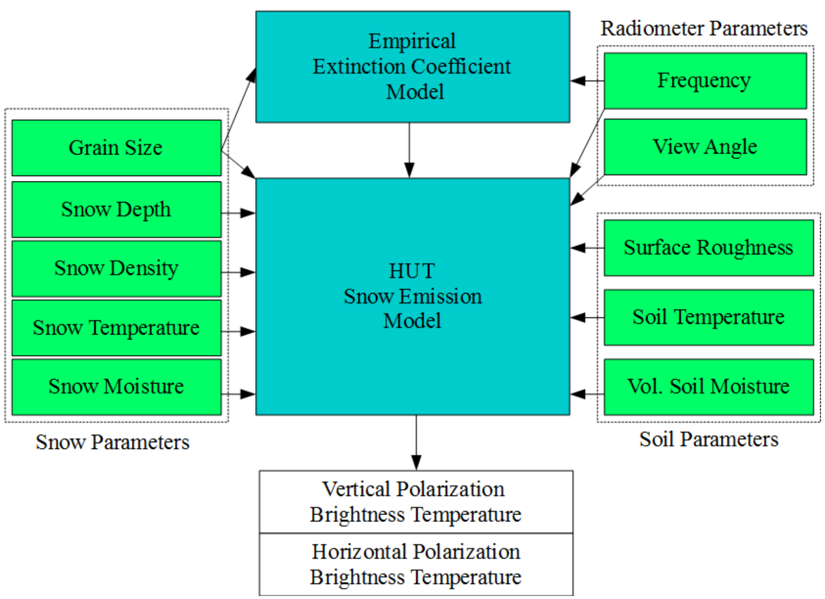
Wiesmann and Mätzler 1999

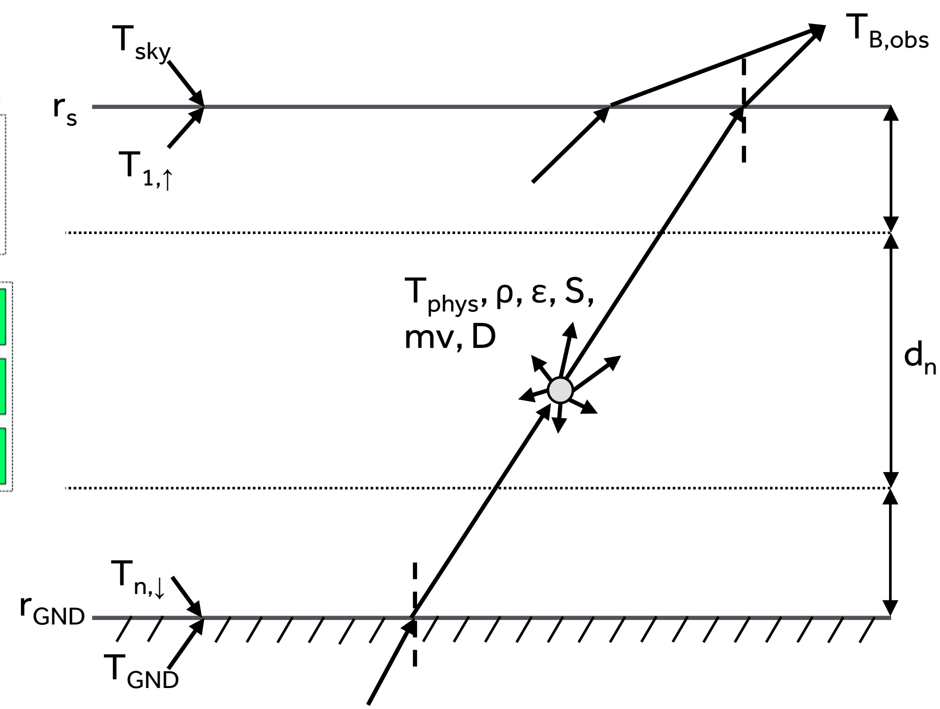
HUT SNOW EMISSION MODEL

Pulliainen et al 1999

Semi-empirical model based on Radiative Transfer Theory

- Primary assumption is that scattering is predominantly in the forward direction (q=0.96)





MICROWAVE EMISSION FROM SNOW

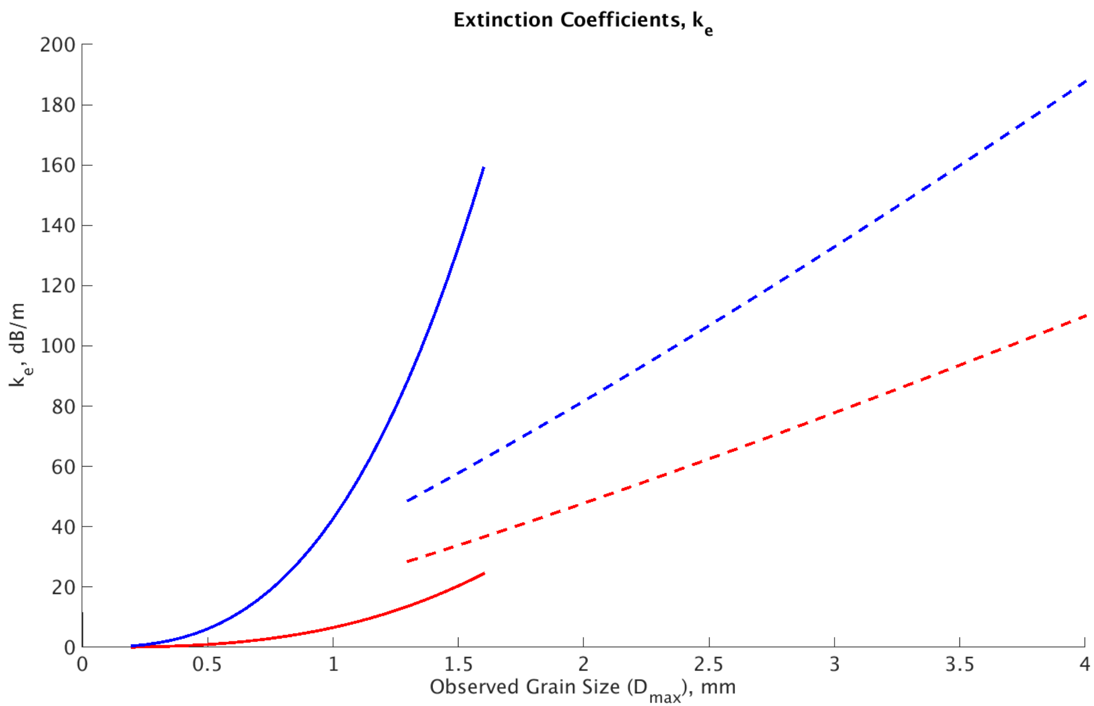
Both models simulate microwave emission from two separate contributions:

- Emission from the snowpack
- Emission from the underlying ground

Snow crystals act as scattering centres for radiation:

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

EXTINCTION OF MICROWAVES IN SNOW



36.5 GHz
18.7 GHz

Solid: Hallikainen et al 1998, $k_e = 0.0018 f^{2.8} d^2$

Dashed: Roy et al 2004, $k_e = \gamma (f^4 d^6)^\delta$

WHAT DO I PLAN TO DO?

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 the snowpack
- Use the revised extinction model with the HUT snow emission model to improve its accuracy

WHAT DO I PLAN TO DO?

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 the snowpack
- Use the revised extinction model with the HUT snow emission model to improve its accuracy

ASMEX: LOCATION

FMI Arctic Research Centre, Sodankylä

- January – April 2014/2015

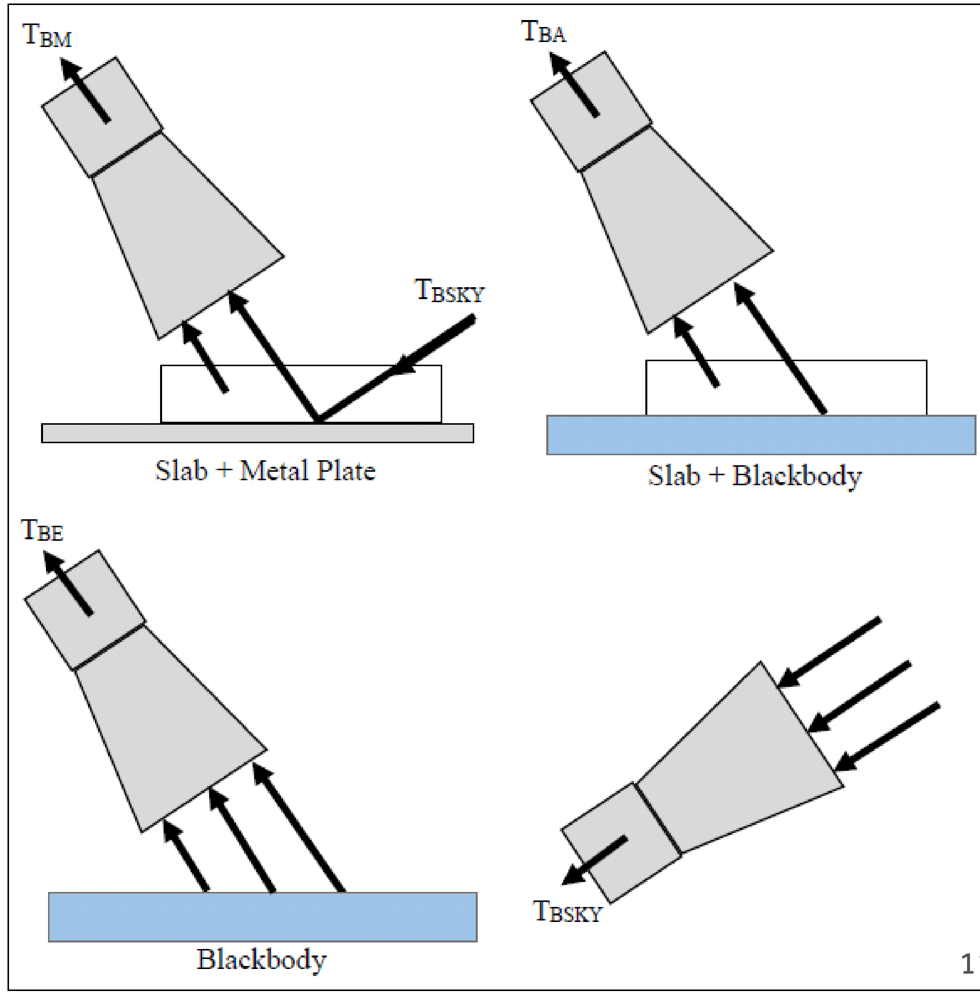
ASMEX: SET UP

Radiometric measurements of extracted snow slabs

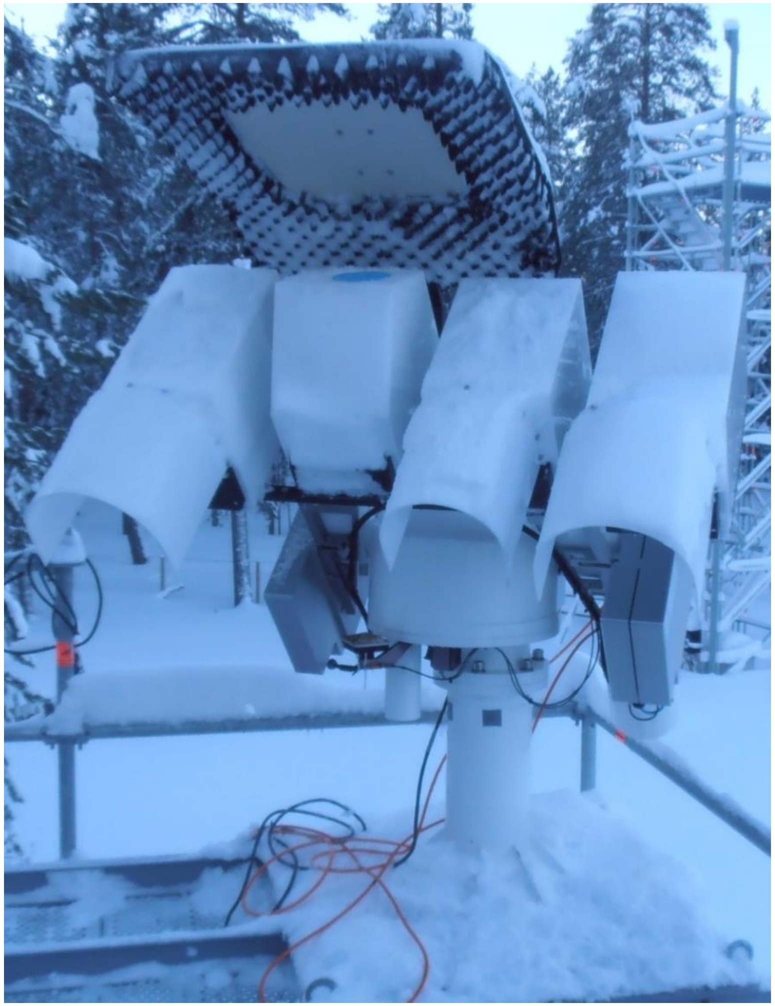
5 Microwave frequenies (H/V Pol)

- 18.7 GHz
- 21.0 GHz
- 36.5 GHz
- 89.0 GHz
- 150.0 GHz

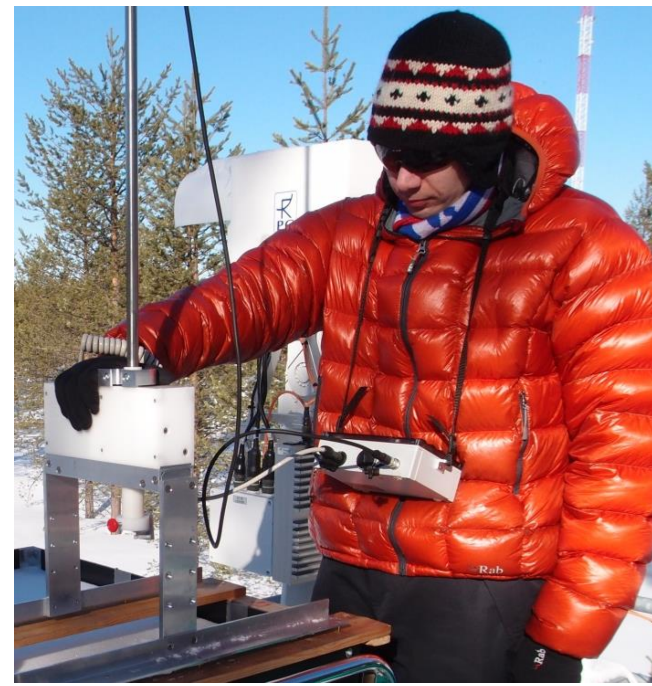
Physical and Stratigraphic measurements



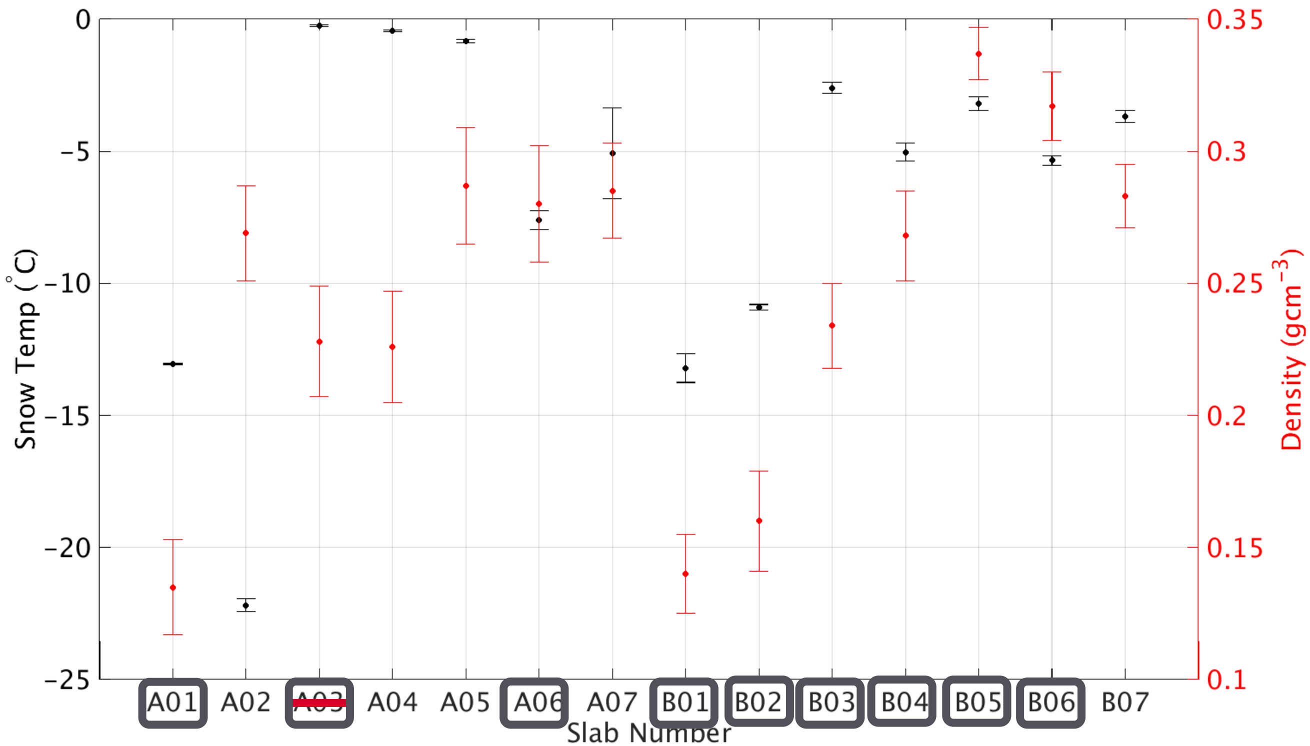
ASMEX



ASMEX



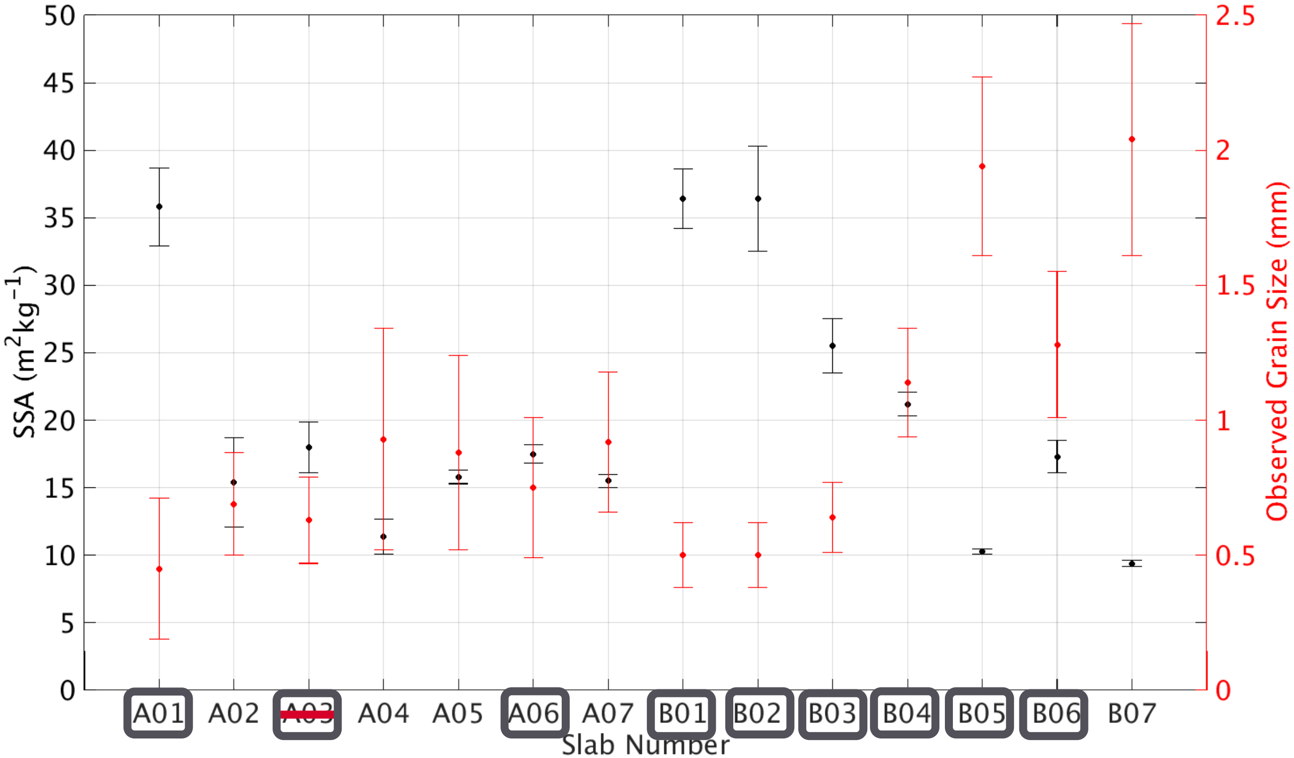
ASMEX: PHYSICAL RESULTS (1)



In total, 14 slabs extracted and measured (7 in 2014, 7 in 2015)

- 13 dry slabs
- 9 homogeneous slabs (SMP)

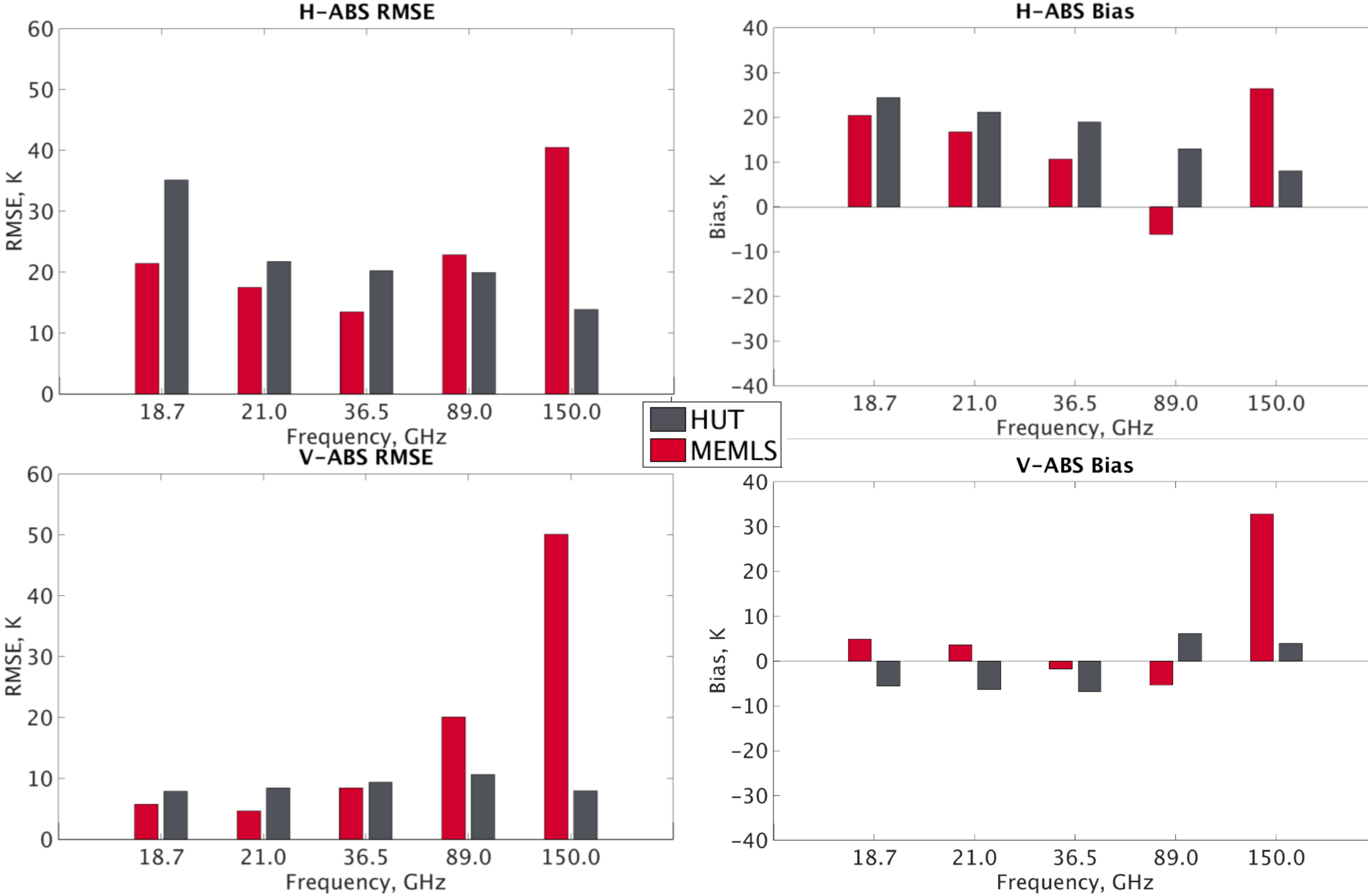
ASMEX: PHYSICAL RESULTS (2)



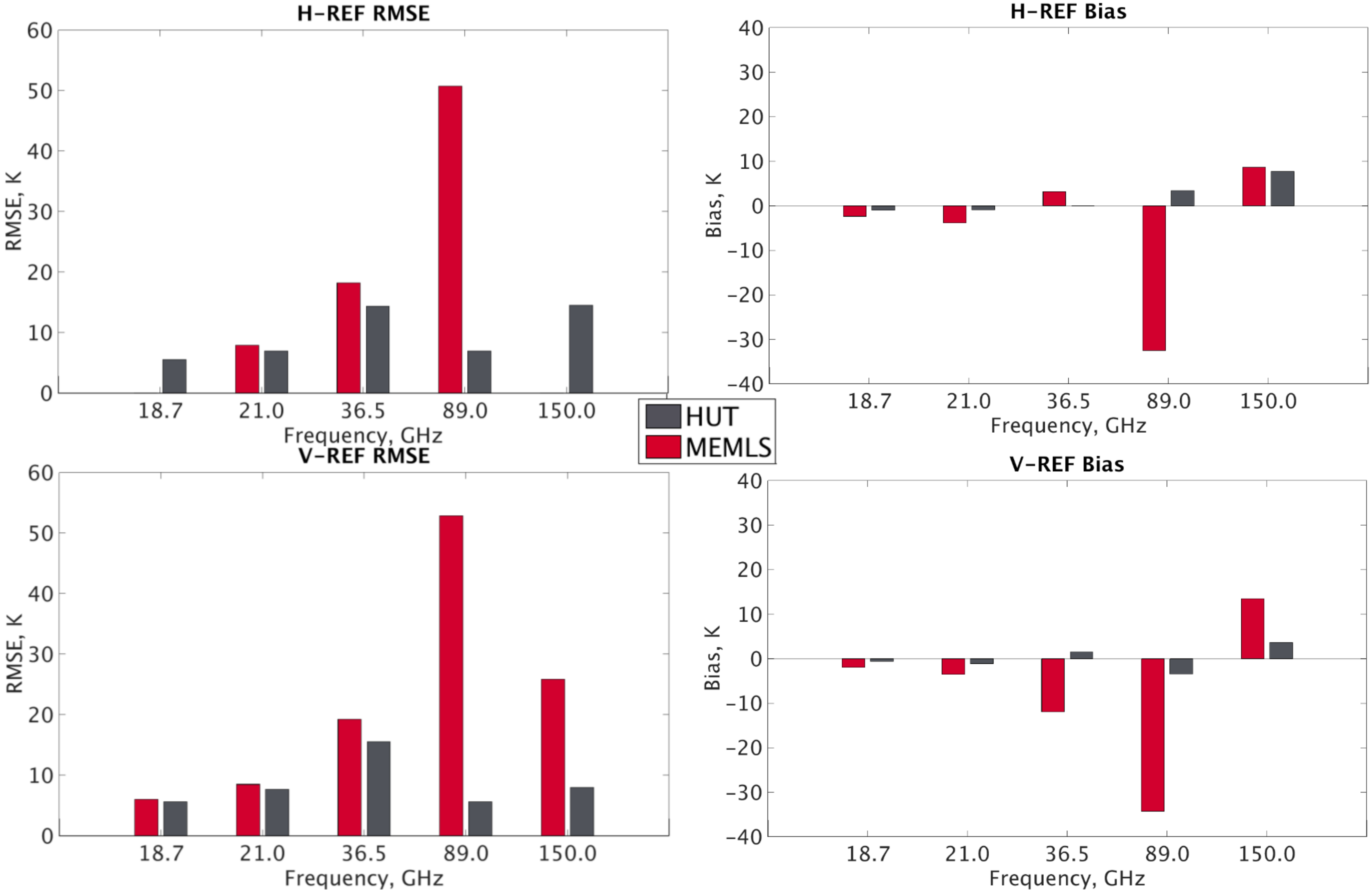
In total, 14 slabs extracted and measured (7 in 2014, 7 in 2015)

- 13 dry slabs
- 9 homogeneous slabs (SMP)

ASMEX: HOMOGENEOUS SLABS (ABS)



ASMEX: HOMOGENEOUS SLABS (REF)



FUTURE WORK

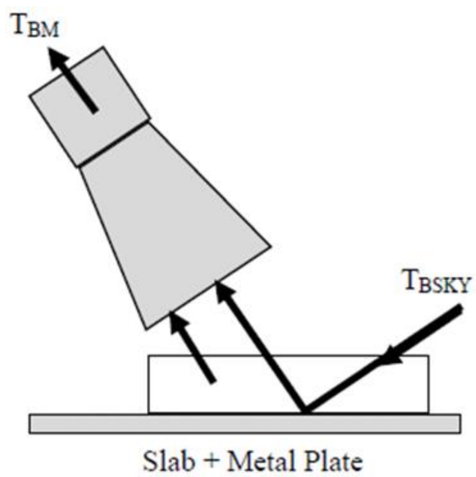
The aims of my PhD are:

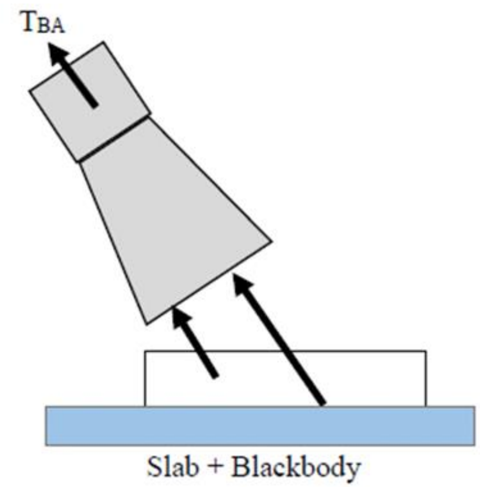
- Take natural snow samples over 2 winter periods
  - Arctic Snow Microstructure Experiment (ASMEx)
- **Develop a revised model for the amount of extinction within the snowpack**
- Use the revised extinction model with the HUT snow emission model to improve its accuracy

FUTURE WORK: EXTINCTION

Currently aiming to calculate the scattering and absorption coefficients via method laid out by Wiesmann et al. 1998

- Calculating the reflectivities of the slab upon an absorbing and reflecting base





$$r_{met} = \frac{T_{BM} - T_{phys}}{T_{BSKY} - T_{phys}}$$

$$r_{abs} = \frac{T_{BA} - T_{phys}}{T_{BSKY} - T_{phys}}$$

FUTURE WORK: EXTINCTION

Currently aiming to calculate the scattering and absorption coefficients via method laid out by Wiesmann et al. 1998

- Simplified two-flux method (radiation up and down)

$$\frac{dT_{up}}{dz} = \boxed{\gamma_a'}(T_{phys} - T_{up}) + \boxed{\gamma_b{}'}(T_{down} - T_{up})$$

$$\frac{-dT_{down}}{dz} = \boxed{\gamma_a'}(T_{phys} - T_{down}) + \boxed{\gamma_b{}'}(T_{up} - T_{down})$$

Where $\gamma_a{}'$ is the 2 flux absorption coefficient, and $\gamma_b{}'$ is the 2 flux scattering coefficient

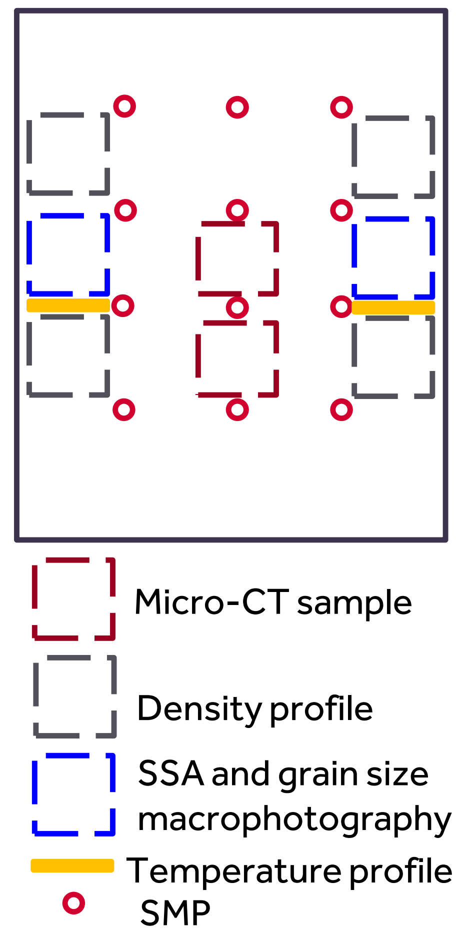
FUTURE WORK: SMP /MICRO CT

Stratigraphy Analysis from each slab:

- 12 SMP Profiles
- 2-4 Micro-CT samples

Use stratigraphic data within HUT and MEMLS to repeat comparison of slab data

Use SMP/Micro-CT data within coefficient calculations



FINNISH METEOROLOGICAL INSTITUTE University of Reading

SUMMARY

- Observations at microwave frequencies vital for snow remote sensing
- Semi-empirical models: HUT and MEMLS
- Introduced ASMEx: Set-up and Physical results
- Preliminary results
- Future work
    - Scattering and Absorption coefficients
    - SMP/Micro CT data