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Microwave Model Comparison of Snow Slab Measurements

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Introduction

Snow is an incredibly important component of the water cycle; as over 1 billion people rely on it for their water supply [1]. However, estimates of snow mass from passive microwave observations can have large errors associated with them, due to incorrect assumptions about the snow microstructure.

The Arctic Snow Microstructure Experiment (ASMEx) took place in Sodankylä, Finland, over the winter months of 2014 and 2015. ASMEx involved taking snow slabs from the natural snowpack, and observing their microwave emissions with ground based radiometers, as well as using modern high resolution techniques for measuring the microstructure of the slab. ASMEx aims to use this data to improve the current understanding and modelling of internal scattering processes.

Snow Emission Models

The HUT (Helsinki University of Technology) snow emission model [2] and MEMLS (Microwave Emission Model of Layered Snowpacks) [3] are two semi-empirical microwave emission models, capable of simulating the microwave brightness temperature of snow. The main difference between the two models is the way in which scattering and absorption (collectively known as extinction) is treated.

The primary assumption of HUT is that scattering is concentrated in the forward direction, in the form of a single extinction coefficient. MEMLS uses a two flux sandwich model, derived from a six flux model, to calculate the upwelling and downwelling radiation.

HUT and MEMLS schematics

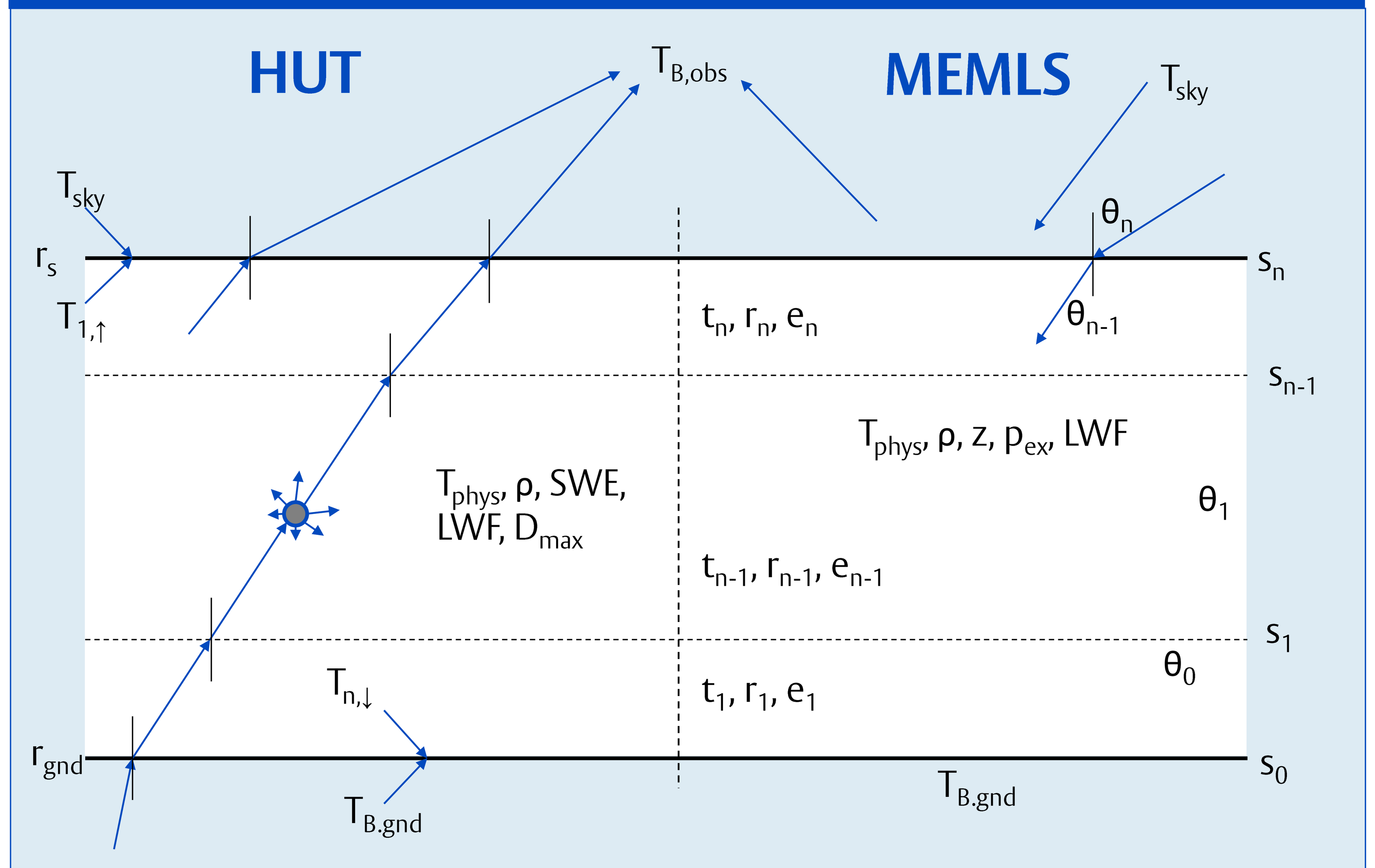

Figure 1: Schematic of HUT (left, adapted from [2]), and MEMLS (right, adapted from [3]).

Arctic Snow Microstructure Experiment

ASMEx consists of radiometric and physical measurements of 14 snow slabs extracted from the natural snowpack. The measurements included:

- **5 different frequencies (18.7, 21.0, 36.5, 89.0, and 150 GHz).**
- **Two separate bases (assumed perfect black body and perfect reflector).**
- **Profiles of temperature, density, observed grain size, and Specific Surface Area (measured with an IceCube machine) [4].**
- **Stratigraphic measurements with a SnowMicroPen and Micro Computer Tomography.**

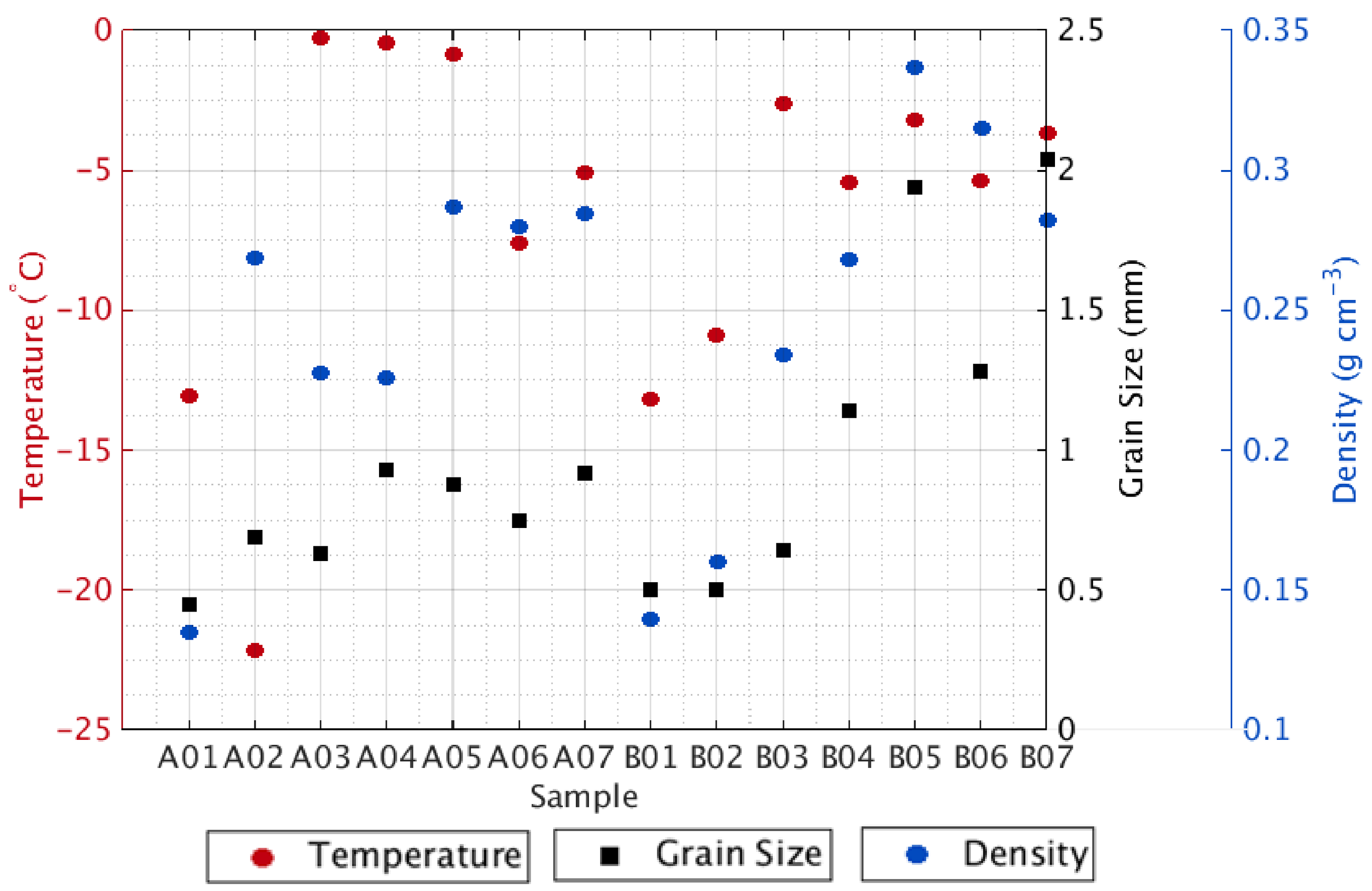

Figure 2: Key physical properties of the snow slabs, taken from traditional snow pit techniques.

Figure 3: Traditional density measurements, using density cutters and scales.

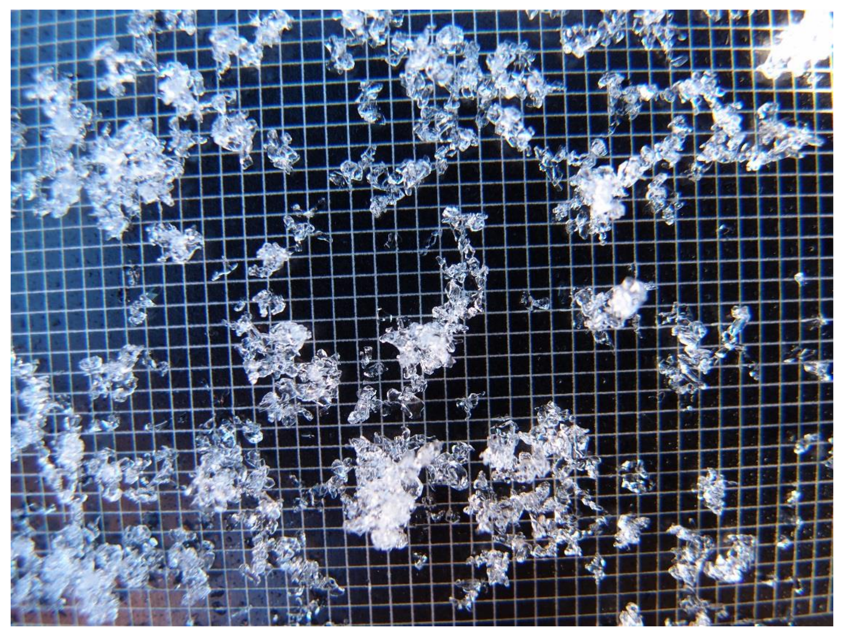

Figure 4: Macrophotography of snow grains on a millimetre grid, for observed grain size observations.

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Model Comparison with observations

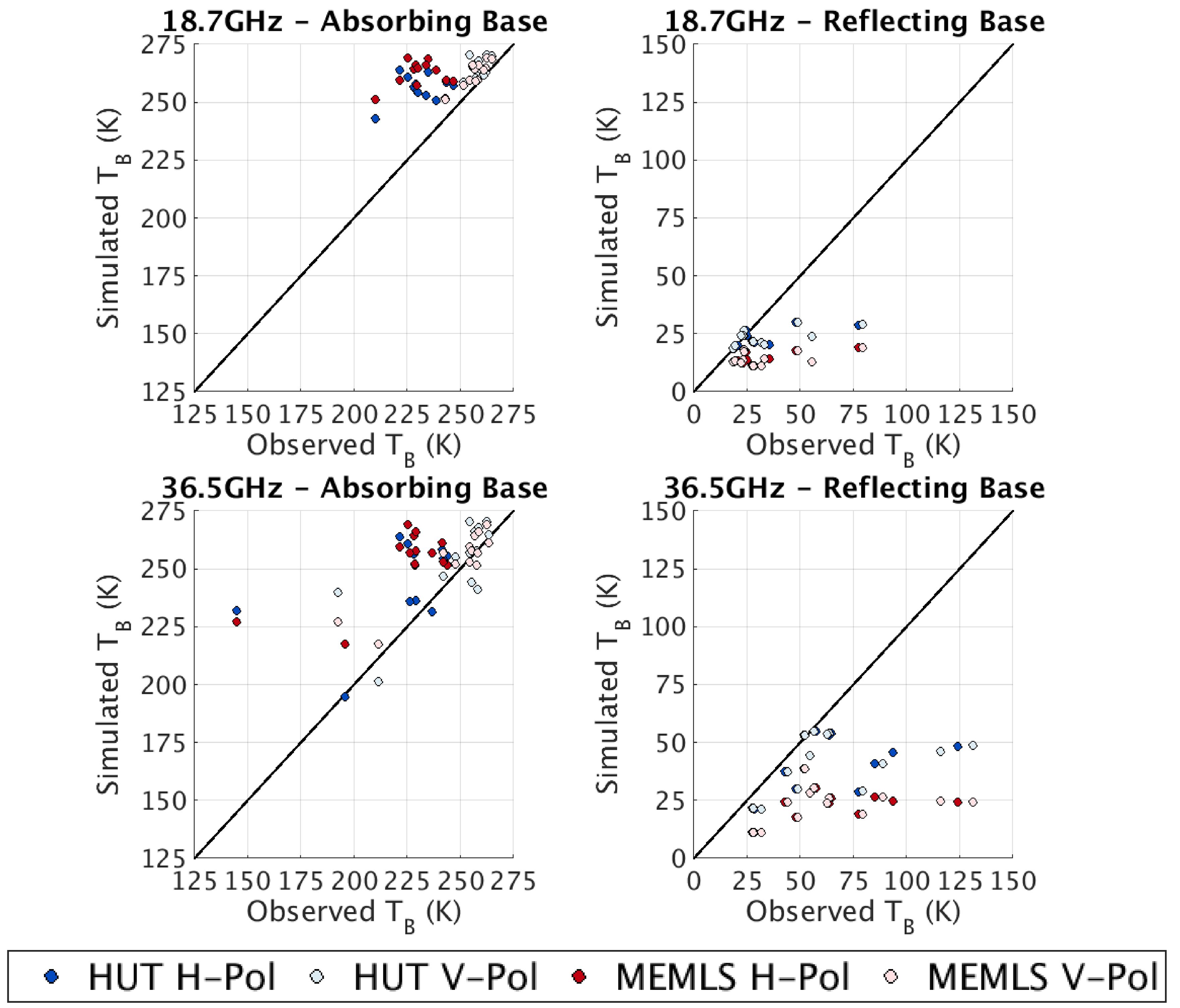

Figure 5: Simulated brightness temperature at H-Pol and V-Pol by HUT and MEMLS compared to observed brightness temperatures. Observations at 18.7 (top) and 36.5 GHz (bottom), on absorbing (left) and reflecting (right) bases.

Future Work

- A new revised extinction coefficient will be modelled from the ASMEx data, using the high resolution techniques.
- The revised extinction coefficient will be applied to HUT simulations of the natural snowpack, resulting in a reduction of simulation error.

References

1. T. P. Barrent, J. C. Adam, D. P. Lettenmaier, "Potential impacts of a warming climate on water availability in snow-dominated regions", *Nature*, vol. 438, 303-309, 2005
2. J. Pulliainen, J. Grandell and M. Hallikainen, "HUT snow emission model and its applicability to snow water equivalent retrieval", *IEEE Trans. Geosci. Remote Senc.*, vol 37, no. 3, 1378-1390, 1999
3. A. Wiesmann, and C. Matzler, "Microwave emission model of layered snowpacks", *Remote Sens. Environ.*, vol. 70, no3, 307-316, 1999
4. J. Gallet, F. Domine, C. Zender, and G. Picard, "Measurements of specific surface area of snow using infrared reflectance in an integrating sphere at 1310 and 1550 nm", *Cryosph*, vol 3, no. 2, 167-182, 2009

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