

# OBJECTIVE CHARACTERIZATION OF SNOW MICROSTRUCTURE FOR MICROWAVE EMISSION MODELING

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## 1. INTRODUCTION

Passive microwave (PM) measurements are sensitive to the presence and quantity of snow, a fact that has long been used to monitor snowcover from space [1]. In order to estimate total snow water equivalent (SWE) within PM footprints (on the order of  $\sim 100 \text{ km}^2$ ), it is prerequisite to understand snow microwave emission at the point scale and how microwave radiation integrates spatially; the former is the topic of this paper. Snow microstructure is one of the fundamental controls on the propagation of microwave radiation through snow. Our goal in this study is to evaluate the prospects for driving a the Microwave Emission Model of Layered Snowpacks [2,3] with objective measurements of snow specific surface area to reproduce measured brightness temperatures when forced with objective measurements of snow specific surface area ( $S$ ). This eliminates the need to treat the grain size as a free-fit parameter.

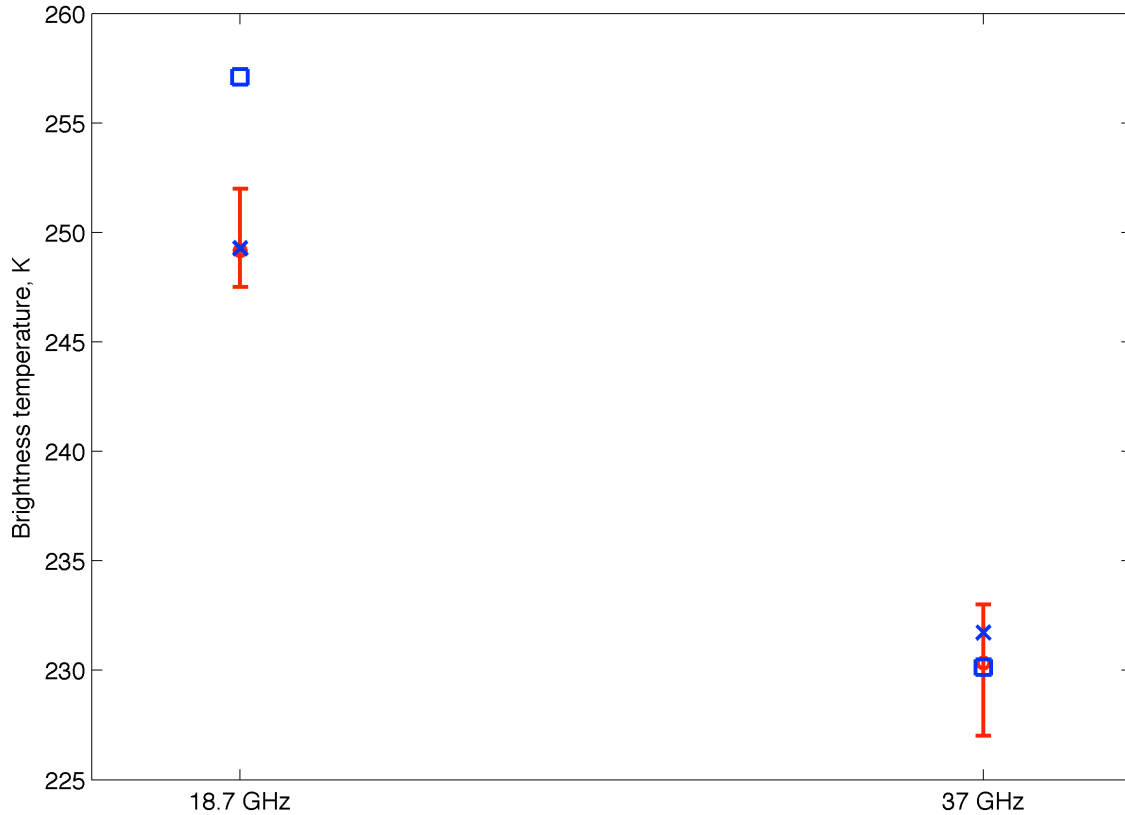
## 2. METHODS

MEMLS utilizes the exponential correlation length ( $L_e$ ) to characterize microstructure. Relating  $S$  to  $L_e$  is crucial, and can be done using a theoretical relationship. To evaluate MEMLS, we made measurements of microwave brightness temperature ( $T_b$ ) via a ground-based radiometer at 19 GHz and 37 GHz, v-pol

for three days in an alpine region in Colorado, USA. We made snowpit measurements, including snow casts from each major stratigraphic layer, and estimated  $S$  and  $L_e$  independently from the samples.

### 3. RESULTS AND CONCLUSIONS

When MEMLS is forced with  $L_e$  estimated directly, it successfully simulates the microwave brightness temperatures with a mean absolute error (MAE) of 5.3 K (see Figure 1). However, the theoretical relationship between  $S$  and  $L_e$  did not hold. Consistent with previous studies, an empirical factor was needed to modify the theoretical relationship between  $S$  and  $L_e$ . When this empirical factor was incorporated, MEMLS can be driven by  $S$  accurately: MEMLS predicted observed  $T_b$  with a MAE of 3.8 K. In order to best utilize field and model based estimates of  $S$  with MEMLS, future work is needed to refine the empirical and theoretical relationships between  $S$  and  $L_e$ .



**Figure 1.** Observed (circles and error bars) and modeled  $T_b$  for 22 February (crosses) and 23 February (squares) are shown. For the observations, the circles indicate the average  $T_b$  from 21-23 February, and the minimum and maximum points on the error bars indicate the minimum and maximum  $T_b$  values, respectively, from 21-23 February. MEMLS simulations are via direct estimation of  $L_e$ .

#### 4. REFERENCES

- [1] A. T. C. Chang, J. L. Foster and D. K. Hall, "Nimbus-7 SMMR derived global snow cover parameters," *Annals of Glaciology*, 9(9), 39-44.
- [2] A. Wiesmann and C. Mätzler, "Microwave emission model of layered snowpacks," *Remote Sens. Environ.*, vol. 70, no. 3, pp. 307–316, Dec. 1999.
- [3] C. Mätzler and A. Wiesmann, "Extension of the microwave emission model of layered snowpacks to coarse-grained snow," *Remote Sens. Environ.*, vol. 70, no. 3, pp. 317–325, Dec. 1999.