Overview of SnowEx 2017 in-situ passive microwave measurements : a context for SWE assimilation

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1. Introduction

Snow is a key hydrological variable, acting as an important freshwater reservoir for human consumption, hydroelectricity production and natural ecosystems. Large uncertainties remain, however with regard to: 1) the amount and distribution of water stored in seasonal snow cover (*snow mass*); 2) the effect of warming temperatures on climatological cooling and heating patterns, including temporal lags and spatial teleconnections (*snow extent*); 3) the initialization of snow cover for operational numerical weather prediction, hydrological simulations, and seasonal forecasts; and 4) the parameterization of snow physics in global circulation models (GCMs) for climate projections. All of these areas would benefit from improved snow products derived from remote sensing. With these potential remote sensing tools available, a multi-scale remote sensing and modeling approach becomes essential, and in-situ validation of airborne and satellite measurements must be conducted over a wide range of snow, vegetation, and climatic conditions.

2. Objectives and methods

Main objective :

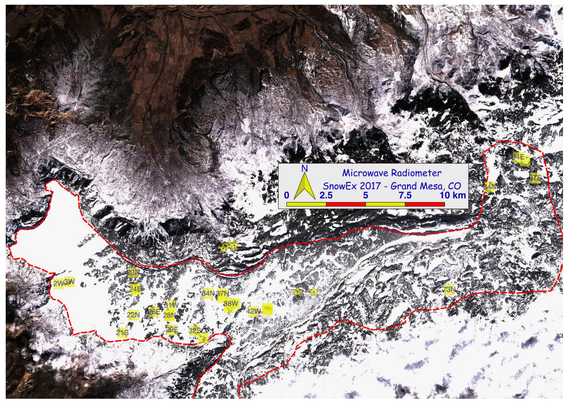
Use multi-sensor, high resolution airborne measurements from SnowEx to enhance observational inputs to a land surface modeling system.

Method

Four surface-based radiometers (SBR : 89, 37, 19, 11 GHz) were deployed into the field during the SnowEx2017 campaign from February 14th to February 18th. The radiometers were mounted on a sled attached to a snowmobile (Figure 1). T_B measurements were acquired at 89, 37, 19 and 10.67 GHz in both vertical (V-pol) and horizontal (H-pol) polarizations at a height of approximately 1.5 m above the ground and at an angle of 55° (hereinafter, the 10.67GHz SBR is noted 11GHz for simplicity). The integrating time of the four radiometers are 6 seconds (one measurement every 6 second is taken). With a beamwidth of 6° for 89, 37 and 19 GHz SBR, the footprint of the measurements at the snow surface was approximately 0.6m x 0.6m. The 11 GHz beamwidth is 8° with a footprint of about 0.8m x 0.8 m. At each site, brightness temperatures (T_B) were measured during 2-4 minutes close (as close as possible) to snowpits done by ground-based teams (pictures were taken at each sites).

Figure 1: Four radiometers mounted on a sled and attached to a snowmobile.

- Feb. 14th: SBR measurements were done at LSOS at 2 different locations : close to the radar (RS) and close to Michigan radiometers site (JC).
- Feb. 15th to Feb. 17th: measurements were done across the Grand Mesa region (GM : 29 sites, see map). During surface melt, continuous measurements (~ 20 minutes) were taken to look at the T_B increase caused by the liquid water in the snow (32S, 97S and 84N).
- Feb. 18th: measurements were done behind the two mega trenches (LSOS_MegaTrenchAspen and LEP_MegaTrenchSpruce). Measurements of the snow surface, and measurement of the forest emission (see Roy et al., 2016) were done. Measurements were also done at the County Line parking on a scissor-lift (2 highs and 3 footprint). At the end of the day, a calibration with LN2 and ambient black body was conducted.



Location	# sites
LSOS	5
Grand Mesa	28 (3 short snowmelt time series) 13 SnowFork
Aspen Trench	5 (snow + veg.)
CountyLine	3 (2 highs)
Spruce Trench	3 (snow + veg.)

3. Preliminary results

During the campaign, several ambient black body (BB) measurements were taken to quantify the radiometers stability. Figure 2 shows that the Mean absolute errors (absolute difference between the radiometers measurements and measured black body physical temperature) of all BB measurements are around 1 K. Note that the biases are under 1 K for all radiometers (Fig. 2).

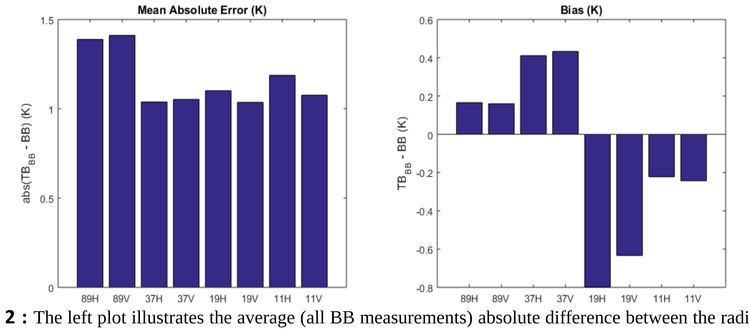


Figure 2 : The left plot illustrates the average (all BB measurements) absolute difference between the radiometers measurements and measured black body physical temperature (BB). The right plot illustrates the bias between the radiometers measurements and measured black body physical temperatures.

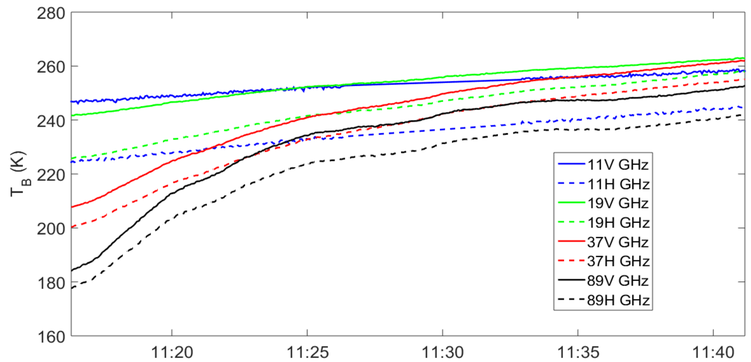


Figure 3 : Continuous measurements at site 97 N (2017-02-17)

- Strong brightness temperature increase related to surface snowmelt
- Stronger sensitivity at high frequencies (37 and 89 GHz) because of lower emission depth
- Signal seems to saturate quickly (20 minutes)

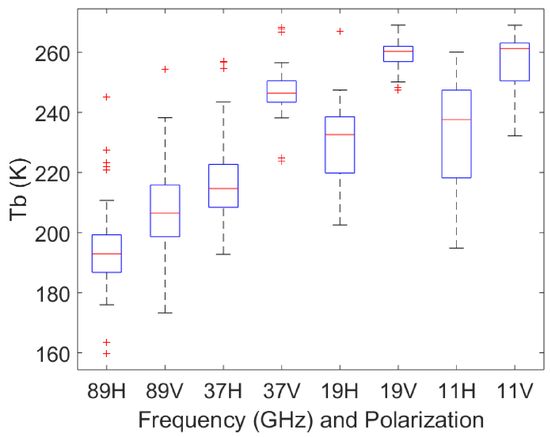


Figure 4 : Boxplot of all Tb measured in open areas at LSOS and Grand Mesa

4. Next steps

- Sensitivity analysis of snow wetness on T_B
- Assimilation of T_B using satellite data (absence of airborne results)
- CaLDAS simulations forced with SnowEx observations

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