REMOTE SENSING EARTH'S CRYOSPHERE WITH 0.5-2.0 GHZ MICROWAVE RADIOMETRY: RECENT UPDATES

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ABSTRACT

Recent updates in the use of 0.5-2 GHz microwave radiometry for remotely sensing Earth's cryosphere are reported. These updates concern measurements and modeling of the spectral properties of brightness temperatures for geophysical regions such as ice sheets, sea ice, ice shelves, and others. The results are intended to support the continued development of 0.5-2 GHz passive microwave mission concepts for future deployment in space.

Index Terms— microwave radiometry, ice sheets, sea ice, cryosphere

1. INTRODUCTION

Recent works have demonstrated the utility of 0.5-2 GHz microwave radiometry for monitoring Earth's ice sheets, ice shelves, and sea ice [1]-[13]. The use of frequencies lower than the traditional 1.4 GHz of the SMOS, Aquarius, and SMAP missions enables the reception of information from deeper within the ice medium. This in turn can enable the sensing of the physical temperature profile within an ice sheet throughout the ice thickness, as well as improve the sensing of sea ice thickness for sea ice of greater than 50 cm thickness. These results have supported the development of the CryoRad and PolarRad mission concepts for future flight in space [5], [14].

A recent work [12] reported results from airborne measurements of near-coastal Antarctic 0.5-2 GHz brightness temperatures acquired by the Ultra-wideband Software-Defined Microwave Radiometer (UWBRAD). The flight campaign performed included observations of coastal sea ice of various types as well as inland ice and glaciers. The results in [12] provided initial examination of the frequency dependence for various geophysical targets and initial interpretations as to the source of these spectra. Among the spectral variations encountered, brightness temperatures that decrease as the frequency increases are typically associated with "ice sheet" type scenes, due to the increase in the ice physical temperature with depth to which the lowest frequencies are the most sensitive. In contrast, brightness temperatures that decrease with frequency tend to indicate "sea ice" type media due to the "cold" appearance of the reflective ice/water boundary whose contributions again become more significant at lower frequencies.

2. RECENT ANALYSES

Continuing studies have extended the results in [12] to include additional investigations for multiple cryospheric targets encountered in the flight campaign. Particular targets of interest have included the Priestley Glacier, the Campbell Ice Tongue, and both "fast" and "dynamic" sea ice regions.

As an example, Figure 1 illustrates the portion of the Priestley glacier overflown during the 2018 UWBRAD flight campaign (red line) and also includes an image mosaic from the RadarSat C-band SAR (left image) as well as from LandSat (right image). The right image further includes

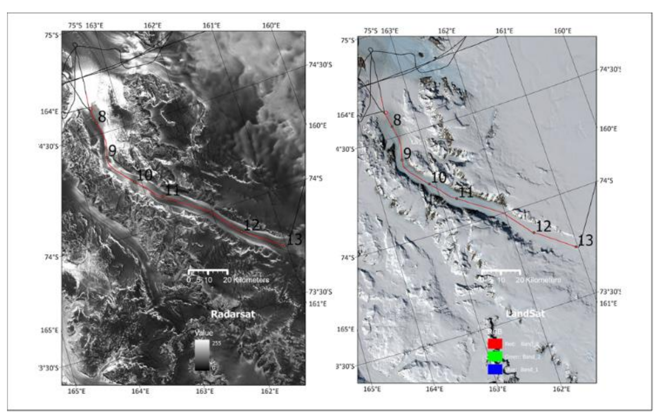

Figure 1: 11/25/2018 UWBRAD flight path from 02:28-03:14 UTC along Priestley Glacier overlaid on RadarSat image mosaic (left) and LandSat image (right). Locations "8" through "13" also labeled in right plot.

labels “8” through “13” marking distinct locations of interest along the glacier. The UWBRAD dataset is available in [13], and the results to be shown were recorded from 02:28-03:14 UTC on 11/25/2018.

Site 8 in Figure 1 is on the seaward ice shelf extending from the glacier. Figure 2 plots UWBRAD observed brightness temperature spectra in this region, which show the expected increasing trend with frequency for a “sea ice” like target. Note that UWBRAD observes at nadir in circular polarization with an antenna pattern of approximately 60 degrees beamwidth. The multiple spectra in Figure 2 arise from UWBRAD measurements over a 100 second interval (a transit of ~5 km) near Site 8.

Figure 3 in contrast illustrates brightness temperature spectra from overflight of the Campbell Glacier Ice Tongue that occurred at 05:24 UTC on the same date. Although this is a similar seaward extension of an inland glacier, the decreasing trend appears more “ice sheet-like” than “sea ice-like”. The reasons for this difference are currently under investigation and will be reported in the presentation.

The measured spectrum from Site 11 is shown in Figure 4; similar results occur at Sites 9 and 10. The increasing trend in frequency again is surprising for this inland glacier case, and suggests the potential presence of water at the glacier base. Glaciological analyses are in process to develop a potential assessment of the likelihood of liquid water’s presence at the glacier base.

Measured spectra from the more inland locations (Sites 12 and 13) are shown in Figure 5. The most inland location, Site 13, shows brightness temperatures that decrease with frequency as expected for “ice-sheet-like” targets, although in this case the increase is limited to only approximately 8 K. Site 12 in contrast is a more “flat” spectrum that appears to be transitional between the decreasing trend of Site 13 and the increasing trends observed at sites 9-11.

Additional results from these measurements and those from other scenes in the region will be reported in the presentation along with the use of forward models to provide insights into the physical mechanisms at work. Additional discussions will also be provided of the potential sensing performance that could be achieved for these media in future spaceborne 0.5-2 GHz measurements.

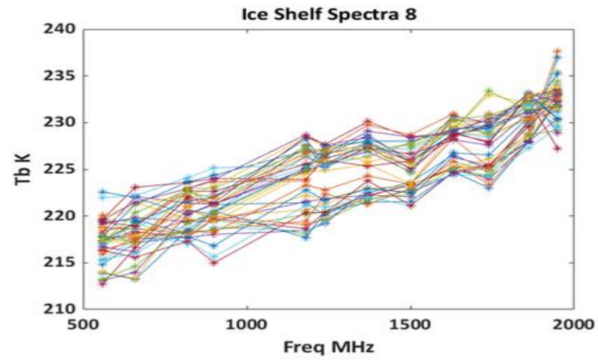

Figure 2: UWBRAD measured brightness temperature versus frequency for Site 8 (seaward extending ice shelf) on the Priestley Glacier

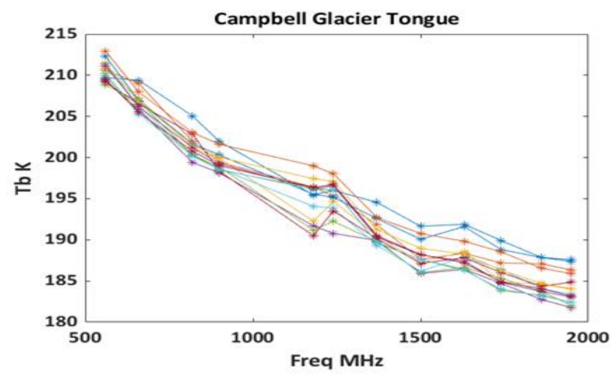

Figure 3: UWBRAD measured brightness temperature versus frequency for Campbell Glacier Ice Tongue observations

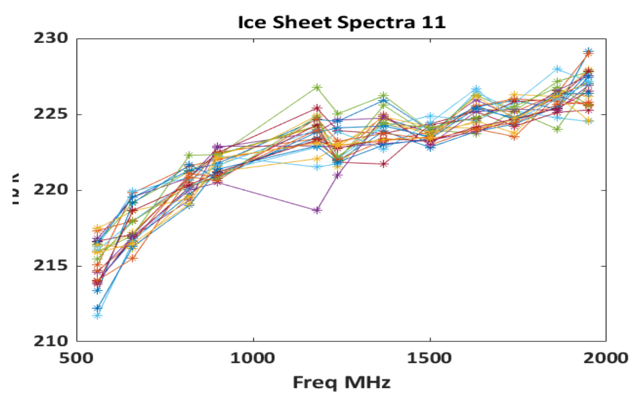

Figure 4: UWBRAD measured brightness temperature versus frequency for Site 11 on the Priestley Glacier

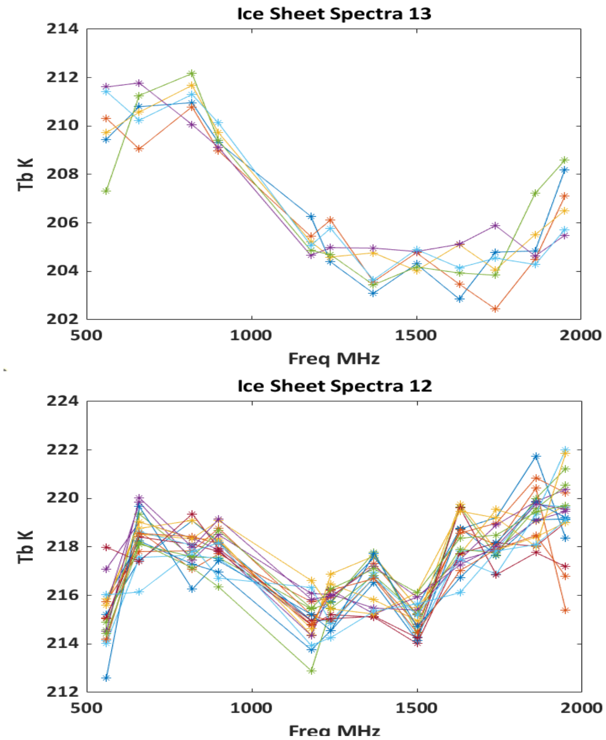

Figure 5: UWBRAD measured brightness temperature versus frequency for Sites 12 and 13 on the Priestley Glacier

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