Subsurface Temperature Sensing Satellite (STemSS)

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Concept: Spaceborne and airborne remote sensing instruments characterize most of the important variables necessary to understand current ice sheet behavior and to predict future changes in ice sheet volume. At present, internal ice sheet temperature is absent from the parameters list, yet temperature is a primary factor in determining the ease at which ice deforms internally and also the rate at which the ice flows across the base. We outline a multi-frequency radiometry concept that, for the first time, enables this critical temperature-measurement remotely.

Measurement Technique: We envision using ultra high frequency (UHF) radio emission to probe the subsurface physical temperature of the polar ice sheets. Thus far, we have completed several modeling studies which suggest that relative changes in average ice sheet internal temperature can be gleaned from single frequency emission data (Jezek and others, 2012). We also showed that brightness temperature anomalies observed in ESA’s 1.4 GHz Soil Moisture and Ocean Salinity (SMOS) satellite (SMOS) data over subglacial Lake Vostok Antarctica are correlated with the lake location. We attribute the correlation to subglacial emission that is extinguished at the lake-surface ice-bottom interface. Although we have yet to complete our full analysis, we suspect that additional information about the details of ice sheet temperature with depth can be determined using multi-frequency data. Our conjecture is based on the frequency dependence of UHF emission once the infra-red dispersion of ice is included in our models.

Based on our models and our work with SMOS we think there is value in developing a multi-frequency radiometer operating from P- to S-band. The system would rely on increased radiometric accuracy (better than 0.25\(^{\circ}\) K) and wide swath (500 km). Similar to SMAP, our concept also includes an L-band, low-resolution, synthetic aperture radar. The SAR is used primarily to support the radiometric observations by measuring relative changes in near surface scattering.

Application benefits: Numerous applications in cryospheric science are possible; our research to date has focused on ice sheet applications. We anticipate there could be additional research applications for permafrost, boreal forests, soil moisture, and seasonal snow cover.

Multi-Process Integration: Temperature information leading to improved prediction of ice-sheet dynamics would contribute greatly to an improved cryospheric monitoring network. Polar change is one of the key Earth Science issues in the coming decade.