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SMAP Measurements of Frozen and Thawed Soil

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Extended Abstract

NASA's Soil Moisture Active Passive (SMAP) Mission was launched in January 2015. The objective of the mission is global mapping of soil moisture and landscape freeze/thaw state with a 2-3 day revisit cycle. SMAP utilizes a rotating 6-meter mesh reflector antenna to make measurements with its L-band radiometer [1]. The mission included an L-band radar that experienced a failure in July 2015. Currently, the mission is generating soil moisture and freeze/thaw data products from the radiometer measurements. The measured L-band brightness temperature (TB) retrievals provide a resource for investigating and monitoring parameters beyond soil moisture and freeze/thaw and over various kinds of biomes including the challenging environment of the terrestrial cryosphere.

The radiometer-based freeze/thaw state product is based on the signature observed in the normalized difference ratio of vertical and horizontal TB polarizations. Seasonal extremes are searched for thawed and frozen conditions and applied to find the seasonal freeze/thaw transitions [2]. Confounding factors include dry soil conditions during the freezing cycle, melting snow layer during the thawing cycle and rapid freezing and thawing events during the transition seasons. In the validation the central issue is establishing the relationship between the in situ measurements of different landscape elements (soil, air, vegetation) and sensitivity of microwave emission to phase changes in these elements. The current version of the algorithm shows meaningful performance over several landscape types and efforts are ongoing to extend the applicability of the product to a wider range of conditions.

L-band brightness temperature has been shown to be sensitive to bottom layer snow density and ground permittivity under snow; the SMAP measurements can be used to derive these parameters. The snow density and ground permittivity can be further included in Snow Water Equivalent algorithms to improve the spatial and temporal representation of these parameters. Accounting for the ground permittivity under snow can also expand the spatial domain of soil moisture retrieval during the fall season when dry snow may be covering ground that is still thawed [3].

The algorithm of the current SMAP soil moisture data product is designed under several assumptions regarding the soil and vegetation conditions. This version of the algorithm does not allow precise determination of soil moisture over large parts of the terrestrial cryosphere. The soil and vegetation of tundra and taiga with their special features including forest cover, organic soil layer and abundance of small water bodies and bogs require refinements in algorithm assumptions and parameterizations. Applying a regionally refined model using SMAP TB retrievals over a tundra permafrost area shows significant improvement in soil moisture retrieval performance with respect to the current operational SMAP soil moisture product [4]. Future work will include identification of modeling parameters to extend the enhanced soil moisture retrievals to all northern tundra areas.

This presentation will include overview of the SMAP mission and instrument, results of retrieving landscape freeze/thaw state, snow density and ground permittivity parameters and soil moisture in permafrost tundra using SMAP measurements.

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References

[1] Entekhabi, D., et al., "The Soil Moisture Active Passive (SMAP) Mission," *Proc. IEEE*, **98**, 5, pp. 704-716, 2010.

[2] Derksen C., et al, "Retrieving landscape freeze/thaw state from Soil Moisture Active Passive (SMAP) radar and radiometer measurements," *Rem. Sens. Env.*, Under Review.

[3] Lemmetyinen J., et al., "Snow density and ground permittivity retrieved from L-band radiometry: Application to experimental data," *Rem. Sens. Env.*, **180**, pp. 377-391, 2016.

[4] Wrona, E., et al., "Validation of the Soil Moisture Active Passive (SMAP) Satellite Soil Moisture Retrieval in an Arctic Tundra Environment," *Geophys. Res. Letters*, Submission.