IMPLEMENTATION OF L-BAND ACTIVE AND PASSIVE ALGORITHMS FOR SMAP FREEZE-THAW AND SOIL MOISTURE RETRIEVALS

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INTRODUCTION

The Soil Moisture Active & Passive (SMAP) mission is one of the first-tier missions identified by the NRC Earth Science Decadal Survey in 2007 [1]. SMAP will combine measurements from two sensors, an L-band synthetic aperture radar (SAR) and an L-band radiometer, to measure land surface soil moisture and freeze-thaw state, providing global coverage every 2-3 days. These measurements will improve our understanding of the processes linking the terrestrial water, energy, and carbon cycles and lead to improved forecasts of weather, flooding, drought, and agricultural productivity.

The geophysical retrievals from SMAP are dependent on three main factors: (1) the quality and resolution of the sensor measurements, (2) the quality of surface ancillary data and the accurate classification of the measurement scene, and (3) the validity of the forward model to be inverted for the given measurement set and surface classification. The SMAP radiometer will produce calibrated brightness temperatures (H, V, and U pol) at a coarse resolution of 40 km. The SMAP high-resolution radar will generate calibrated surface backscatter (HH, VV, and HV pol) at 1-3 km resolution over the outer 70% of the swath. By combining the high soil moisture retrieval accuracy of the radiometer with the high resolution but lower accuracy radar, a 9 km soil moisture product can be generated.

SMAP GEOPHYSICAL ALGORITHM SEQUENCE

We can take advantage of the unique characteristics of the two SMAP sensors together to generate enhanced science data products. The four major algorithm products: freeze-thaw state detection; radar-only and radiometer-only soil moisture retrievals; and combined active/passive soil moisture retrieval;

have data interdependencies that need to be resolved by applying the algorithms in an optimal sequence. In particular, the radar can provide some key preliminary information that can improve the surface classification accuracy in preparation for the soil moisture retrievals.

The presence of standing water in the measurement scene, particularly for the relatively large field of view of the radiometer, is a source of error that must be corrected. High-resolution maps of static water bodies will be a standard element of the ancillary data set used to process SMAP data; however, the occurrence of transient standing water due to flooding also needs to be detected and corrected as far as possible. The radar measurements at 1-3 km resolution can be used to detect open-water sub-elements of the radiometer footprint so that the brightness temperatures may be corrected prior to gridding and geophysical retrievals. The water body detection algorithm under development will use the expected behavior of the backscatter and/or ratios such as the radar vegetation index (RVI) in the presence of open water to flag the radar cells. These high-resolution flags can then be applied to the radiometer FOV to make the appropriate corrections to the brightness temperature measurements prior to the radiometer soil moisture retrievals.

The freeze-thaw state, while of interest in its own right, is another crucial piece of information needed for the soil moisture processing. Neither the radar nor radiometer soil moisture retrieval algorithms work for frozen soil. The baseline freeze-thaw detection algorithm depends heavily on accurate surface terrain and vegetation classification combined with empirically derived thresholds of the radar backscatter for each class. The prior detection of transient water bodies is also required for the freeze-thaw algorithm to produce accurate classifications. For the radar cells, the frozen soil flags generated by the freeze-thaw algorithm will directly determine whether soil moisture retrieval can be performed. For the radiometer, the soil moisture retrieval may be abandoned in the presence of frozen soil beyond some fraction of the footprint area.

Once the transient water and freeze-thaw states have been determined, the radar data are gridded at 3 km resolution and the soil moisture can be retrieved over non-frozen land surfaces. The radiometer soil moisture can be retrieved for non-frozen soil using the water body-corrected brightness temperatures gridded at 36 km resolution. Both the radar-only and radiometer-only soil moisture retrievals depend on a suite of ancillary data including digital elevation maps, surface and soil temperatures, soil texture, permanent and seasonal snow and ice cover, urban masks, permanent water bodies, vegetation class, and vegetation water content (VWC). The ancillary data will be aggregated and gridded at the appropriate resolutions to facilitate matchups. Forward model parameters required for the retrievals will be determined by the surface and vegetation classifications.

The SMAP active/passive retrieval algorithm makes use of the 3 km radar backscatter to provide scene heterogeneity information so that the 36 km brightness temperatures can be disaggregated via a regression algorithm at an intermediate resolution (9 km). The disaggregated brightness temperatures and ancillary data at 9 km are then input to the radiometer retrieval algorithm to estimate the active/passive soil moisture.

CONCLUSION

In this presentation, we describe the functional algorithm sequence we will employ to generate the freeze-thaw and soil moisture science products for SMAP. The optimal sequence makes use of the radar data early in the geophysical processing to provide contemporaneous ancillary information about the presence of transient open water and freeze-thaw state in the measurement scene. This enhances the quality of the surface classification and provides corrected brightness temperatures for the active, passive, and active/passive soil moisture retrievals.

REFERENCE

[1] The National Research Council, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond.*, National Academy Press, Washington, D.C., 2007.