THE SMAP LEVEL 4 SURFACE AND ROOT-ZONE SOIL MOISTURE PRODUCT

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1. INTRODUCTION

The Soil Moisture Active and Passive (SMAP) mission is being developed by NASA for launch in 2015 as one of four first-tier missions recommended by the U.S. National Research Council Committee on Earth Science and Applications from Space in 2007 [1]. The primary science objectives of SMAP are to enhance understanding of land surface controls on the water, energy and carbon cycles, and to determine their linkages. Moreover, the high-resolution soil moisture mapping provided by SMAP has practical applications in weather and seasonal climate prediction, agriculture, human health, drought and flood decision support. In this paper we describe the assimilation of SMAP observations for the generation of the planned SMAP Level 4 Surface and Root-zone Soil Moisture (L4_SM) product.

2. SMAP INSTRUMENTS

The SMAP mission makes simultaneous active (radar) and passive (radiometer) measurements in the 1.26-1.43 GHz range (L-band) from a sun-synchronous low-earth orbit. Measurements will be obtained across a 1000 km wide swath using conical scanning at a constant incidence angle (40°). The radar resolution varies from 1-3 km over the outer 70% of the swath to about 30 km near the center of the swath. The radiometer resolution is 40 km across the entire swath. The radiometer measurements will allow high-accuracy but coarse resolution (40 km) measurements. The radar measurements will add significantly higher resolution information. The radar is however very sensitive to surface roughness and vegetation structure. The combination of the two measurements allows optimal blending of the advantages of each instrument.

3. SMAP L4_SM PRODUCT

SMAP directly observes only surface soil moisture (in the top 5 cm of the soil column). Several of the key applications targeted by SMAP, however, require knowledge of root zone soil moisture (~top 1 m of the soil column), which is not directly measured by SMAP. The foremost objective of the SMAP L4_SM product is to fill this gap and provide estimates of root zone soil moisture that are informed by and consistent with SMAP observations. Such estimates are obtained by merging SMAP observations with estimates from a land surface model in a soil moisture data assimilation system.

The land surface model component of the assimilation system is driven with observations-based surface meteorological forcing data, including precipitation, which is the most important driver for soil moisture. The model also encapsulates knowledge of key land surface processes, including the vertical transfer of soil moisture between the surface and root zone reservoirs. Finally, the model interpolates and extrapolates SMAP observations in time and in space. The L4_SM product thus provides a comprehensive and consistent picture of land surface hydrological conditions based on SMAP observations and complementary information from a variety of sources. The assimilation algorithm considers the respective uncertainties of each component and yields a product that is superior to satellite or model data alone. Error estimates for the L4_SM product are generated as a by-product of the data assimilation system.

The present paper will focus in particular on an error budget for the L4_SM product that is derived from two existing research projects. The first project is the assimilation of surface soil moisture retrievals from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E). This project yielded skill estimates based on the assimilation of actual satellite observations [2]. The second project is an Observing System Simulation Experiment (OSSE). The OSSE results provide skill estimates based on synthetic soil moisture retrievals for a range of modeling and observational errors [3]. By combining the results from the two projects with projected accuracy levels for SMAP observations, we can derive skill estimates for the SMAP L4_SM product. Preliminary results are shown in Table 1. It is expected that the assimilation of SMAP observations improves the anomaly RMSE of surface soil moisture by 0.01 m^3/m^3 over estimates derived from the land model alone. The corresponding expected anomaly RMSE reduction is 0.005 m^3/m^3 for root zone soil moisture estimates.

	Model	L4_SM
Surface soil moisture	0.046	0.035
Root zone soil moisture	0.036	0.031

Table 1: Expected anomaly RMSE [m^3/m^3] of model and L4_SM estimates. Anomalies are computed by removing the mean seasonal cycle from the data.

4. CONCLUSIONS

SMAP will observe only surface soil moisture (in the top 5 cm of the soil column) directly. The SMAP L4_SM product is designed to provide estimates of root zone soil moisture (~top 1 m of the soil column) that are informed by and consistent with SMAP observations. Such estimates are important for several applications targeted by SMAP. The L4_SM product is generated by merging SMAP observations with estimates from a land surface model in a soil moisture data assimilation system. It is expected that the assimilation of SMAP observations improves the anomaly RMSE over model estimates by 0.01 m^3/m^3 for surface soil moisture and by 0.005 m^3/m^3 for root zone soil moisture estimates.

REFERENCES

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