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Global High Resolution Mapping and Assimilation of Soil Moisture Observations from the SMAP Radar and Radiometer

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The Soil Moisture Active and Passive (SMAP) mission is being developed by NASA for launch in 2015. 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, SMAP high-resolution soil moisture mapping has practical applications in weather and seasonal climate prediction, agriculture, human health, drought and flood decision support. In this paper we provide a brief overview of the SMAP science objectives, instruments, and data products, with a special focus on the Level 4 Surface and Root-Zone Soil Moisture (L4_SM) product.

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 wide swath (1000 km) 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, however, is very sensitive to surface roughness and vegetation structure. The combination of the two measurements allows blending the advantages of each instrument, enabling SMAP to provide global retrievals of surface soil moisture with a horizontal resolution of about 10 km and a refresh rate of 2 to 3 days. Additionally, a radar-based soil-vegetation freeze/thaw product in boreal latitudes will be provided at 3 km resolution with 1-2 day revisit.

SMAP directly observes 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 ($\sim$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 high spatial resolution ($\sim$10 km) of the combined radar-radiometer SMAP soil moisture data products will allow the scientific community to address some of the grand challenges regarding the role of water cycle in the climate system and to further our understanding of climate variability and climate change impacts. The SMAP soil moisture data products will be particularly valuable where water is often a limiting resource.