THE NASA SOIL MOISTURE ACTIVE PASSIVE (SMAP) MISSION: OVERVIEW

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INTRODUCTION

The National Research Council's (NRC) Decadal Survey, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*, was released in 2007 after a two-year study commissioned by NASA, NOAA, and USGS to provide consensus recommendations to guide the agencies' space-based Earth observation programs in the coming decade [1]. Many factors involving engineering maturity, scientific advances, and societal benefits of potential missions were considered as part of the NRC evaluation process. Five of the six NRC Earth science discipline panels (water resources & the hydrologic cycle; climate; weather; human health & security; and land use, ecosystems, & biodiversity) cited numerous science and applications needs that could be wholly or partially met by a mission devoted to measuring surface soil moisture and its freeze/thaw state. Based on the NRC recommendations and on its own evaluation of technical readiness, NASA selected the Soil Moisture Active Passive (SMAP) mission to be the first of the Decadal Survey missions to be developed, with a launch date now in the 2014-2015 time frame. This mission will be a joint effort of NASA's Jet Propulsion Laboratory (JPL) and Goddard Space Flight Center (GSFC), with project management responsibilities at JPL.

SMAP SCIENCE

Soil moisture and its freeze/thaw state are key variables which help to control the water, energy, and carbon fluxes at the land-atmosphere interface. This interface is highly complex, and new data are required at finer space-time scales to advance understanding of the processes driving the Earth's water, energy, and carbon cycles. The primary science objectives of the SMAP mission are to provide high-resolution global mapping of soil moisture and its freeze/thaw state in order to: (1) estimate global water and energy fluxes at the Earth's surface, (2) improve weather and climate forecast skill, (3) develop more accurate flood and drought predictions, (4) quantify carbon fluxes in boreal landscapes, and (5) help link together terrestrial water, energy, and carbon cycle processes. SMAP also enables a large number of other science research areas and applications of benefit to society, including the potential to provide NPOESS-era soil moisture measurements, vegetation growth and agricultural productivity estimates, and information relevant to heat stress and human health, and national security.

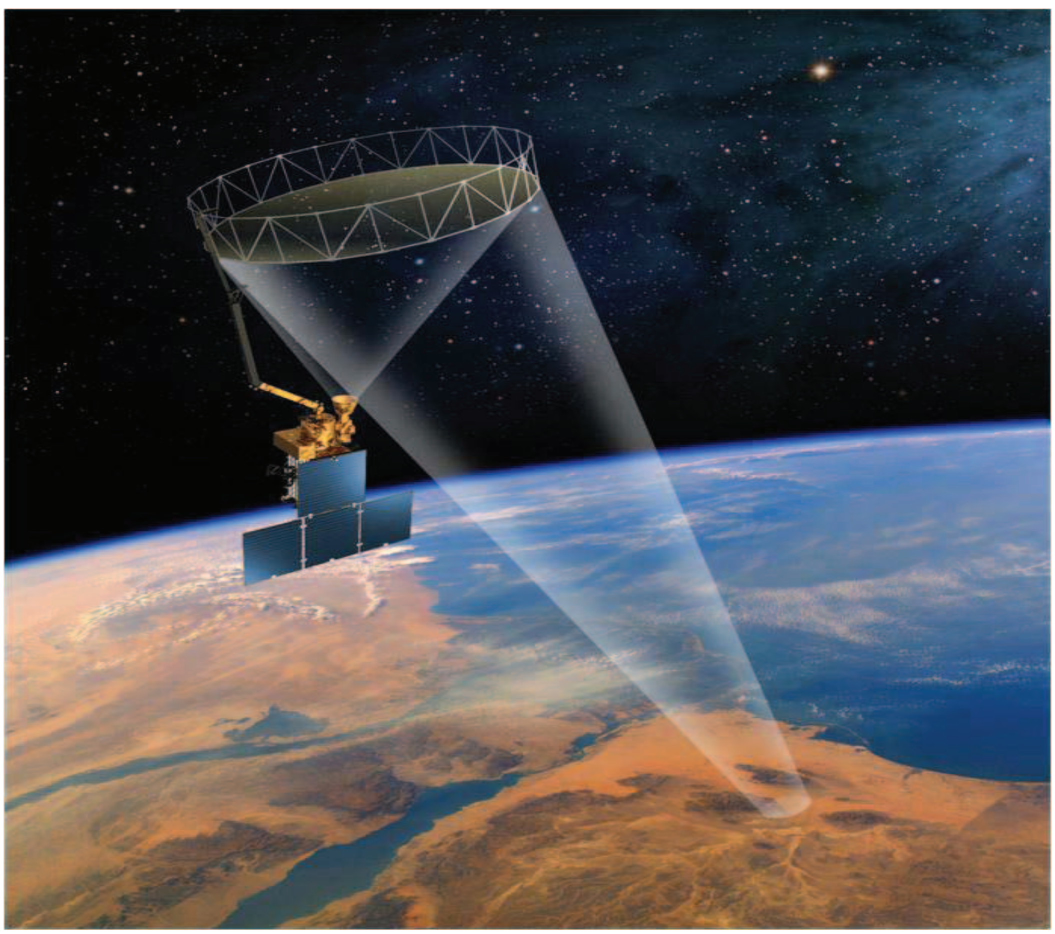

Figure 1. The SMAP mission concept consists of an L-band radar and radiometer sharing a single spinning 6-m mesh antenna in a sun-synchronous dawn/dusk orbit.

SMAP MISSION DESIGN

The SMAP mission design is driven by the temporal and spatial resolution requirements of the hydrometeorology, hydroclimatology, and carbon cycle communities [2]. SMAP will consist of a 1.4 GHz (H, V, U pol) radiometer and a 1.26 GHz (HH, VV, HV pol) radar sharing a single L-band feed and a 6-meter spinning deployable mesh reflector antenna. The antenna rotates about the nadir axis at 14.6 rpm, producing a conically scanned antenna beam with a surface incidence angle of ~ 40° (Figure 1). SMAP will be launched into a sun-synchronous dawn-dusk orbit, and its wide swath of 1000 km will enable global mapping of surface soil moisture and freeze/thaw every 2-3 days. The SMAP radiometer will produce calibrated brightness temperatures at a coarse spatial resolution of 40 km, while the SMAP radar will produce calibrated backscatter at 1-3 km resolution over the outer 70% of the swath (radar resolution degrades to 30 km at center of swath). By combining the high soil moisture retrieval accuracy but coarse resolution radiometer data with the high resolution but lower accuracy radar data, a 10 km soil moisture product will be generated. Baseline mission duration is three years in order to capture positive and negative seasonal anomalies in the water, energy, and carbon cycles across environmentally diverse regions of the globe.

SMAP GEOPHYSICAL DATA PRODUCTS

The planned SMAP data products are listed in Table 1. Level 1B and 1C data products are calibrated and geolocated instrument measurements of radar backscatter and brightness temperature. Level 2 products are geophysical retrievals of soil moisture on a fixed Earth grid based on Level 1 products and ancillary information; the Level 2 products are output on a half-orbit basis. Level 3 products are daily composites of Level 2 surface soil moisture and freeze/thaw state. Retrieval algorithms for these geophysical products are currently being refined and tested, and vetted in open community workshops [3]. The SMAP project is also generating two model-derived value-added Level 4 data products (root zone soil moisture and net ecosystem exchange of carbon) that support key SMAP applications and more directly address driving science questions. The baseline mission requirements are to provide estimates of soil moisture in the top 5 cm of soil with an error no greater than 4% volumetric (excluding regions of snow and ice, frozen ground, mountainous topography, open water, urban areas, and vegetation with water content greater than 5 kg m^{-2}), and a freeze/thaw classification accuracy of 80%. These levels of performance will enable SMAP to meet the needs of the hydroclimatology and hydrometeorology applications identified in the NRC report [1], and to provide the new global data sets necessary to tackle hydrologically-relevant societal issues.

Table 1. SMAP DATA PRODUCTS

Product Name	Short Description	Spatial Resolution
L1A_S0	Radar raw data in time order	–
L1A_TB	Radiometer raw data in time order	–
L1B_S0_LoRes	Low resolution radar σ_o in time order	5x30 km
L1B_TB	Radiometer T_B in time order	36x47 km
L1C_S0_HiRes	High resolution radar σ_o (half orbit, gridded)	1-3 km
L1C_TB	Radiometer T_B (half orbit, gridded)	36 km
L2_SM_P	Soil moisture (radiometer, half orbit)	36 km
L2_SM_A/P	Soil moisture (radar/radiometer, half orbit)	9 km
L3_F/T_A	Freeze/thaw state (radar, daily composite)	3 km
L3_SM_P	Soil moisture (radiometer, daily composite)	36 km
L3_SM_A/P	Soil moisture (radar/radiometer, daily composite)	9 km
L4_SM	Soil moisture (surface & root zone)	9 km
L4_C	Carbon net ecosystem exchange (NEE)	9 km

REFERENCES

[1] National Research Council, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond," pp. 400, 2007.

[2] Entekhabi, D., E, Njoku, P. O'Neill, K. Kellogg, plus 19 others, "The Soil Moisture Active Passive (SMAP) Mission," Proceedings of the IEEE, 2009, in review.

[3] O'Neill, P., M. Moghaddam, and T. Jackson, "SMAP Algorithms and Calibration/Validation Workshop," *The Earth Observer*, NASA, 21 (5), October, 2009, pp. 40-43, 49.