

2 **NASA's Soil Moisture Active Passive (SMAP) Mission and Opportunities For**
4 **Applications Users**

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20 Water in the soil, both its amount (soil moisture) and its state (freeze/thaw), plays
a key role in water and energy cycles, in weather and climate, and in the carbon
22 cycle. Additionally, soil moisture touches upon human lives in a number of ways—
from the ravages of flooding to the needs for monitoring agricultural and hydrologic
24 droughts. Because of their relevance to weather, climate, science, and society,
accurate and timely measurements of soil moisture and freeze/thaw state with
26 global coverage are critically important.

28 To address this need, NASA has initiated the Soil Moisture Active Passive (SMAP)
satellite mission, as recommended by the National Research Council in their 2007
30 report, “Earth Science and Applications from Space: National Imperatives for the
Next Decade and Beyond.” Set to launch in October 2014, SMAP will use a
32 combination of an active radar and a passive radiometer to provide global
measurements of surface soil moisture and soil freeze/thaw state (Figure 1). The
34 synergy of active and passive microwave observations, combined with SMAP’s wide
swath, enables measurements of soil moisture and freeze/thaw state with high
36 resolution, and adequate sensitivity, area coverage, and revisit frequency. This
design will address many scientific problems in hydrology, meteorology, and
38 ecology, as well as provide information to science applications such as flood
forecasting, drought monitoring, and numerical weather prediction.

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The 2007 report tasked NASA with ensuring that "emerging scientific knowledge is
42 actively applied to obtain societal benefits," and emphasized the importance of early

and sustained interaction of the Earth science community with a broad range of
44 organizations and individuals. From its inception, SMAP has been committed to a
strong, integrated program of engagement with potential data users in applied and
46 operational domains, the first NASA mission to have such a program before the
satellite is launched. The SMAP Applications program is designed to first increase
48 and then sustain the interaction between application users and scientists involved
in mission development. The SMAP project has sponsored several applications
50 meetings and workshops. To better reach the applications users, some of these have
been held at user locations such as the U.S. Department of Agriculture (USDA), U.S.
52 Geological Survey (USGS), and NOAA headquarters among others. Feedback from
user communities is formally and actively reported to mission scientists to broaden
54 and facilitate eventual SMAP data access and enhance opportunities to use mission
data to address societal needs. For example, collaboration between the SMAP
56 mission and the USDA's Foreign Agriculture Service (FAS) has elicited the
requirements of yield forecasting and familiarized analysts to soil moisture data.
58 Another example pertains to the Emergency Response and Operational users, who
have worked with the SMAP mission to plan for providing data in friendly formats
60 (kmz and geotiffs) for a more rapid ingestion of soil moisture data into decision-
making environments.

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The SMAP Applications program is ground-breaking and serves as an example for
64 other NASA missions to expand their focus to include user communities' needs in
the early phases of mission development. Through a team that includes an

66 applications lead on the Science Definition Team (SDT), leadership from the
mission, and an applications coordinator, the applications program works to
68 characterize the community of mission data users through workshops and applied
research. We have also initiated a program of Early Adopters to promote
70 application research in the pre-launch stages of the mission, in order to provide a
better understanding of how SMAP data products can be scaled and integrated onto
72 organizations' policy, business, and management activities. These efforts will
expand the use of the data after launch, and increase the societal benefit of the
74 mission.

76 The overall strategy for the SMAP Applications program is to develop a community
of end users and decision makers who are interested in using SMAP products in
78 their applications by providing opportunities to learn about SMAP's unique
capabilities and scientific objectives. The SMAP science objectives are to acquire
80 space-based hydrosphere state measurements to (1) understand processes that link
the terrestrial water, energy, and carbon cycles; (2) estimate global water and
82 energy fluxes at the land surface; (3) quantify net carbon flux in boreal landscapes;
(4) enhance weather and climate forecast abilities; and (5) develop improved flood
84 prediction and drought monitoring capabilities. To meet its scientific goals, SMAP
will fly a dedicated satellite in a near-polar, sun synchronous orbit, crossing the
86 equator at 6 a.m. and 6 p.m. local time. The satellite will carry an L-band (1.26 GHz)
radar and an L-band (1.4 GHz) radiometer that share a deployable light-weight
88 mesh parabolic reflector, which provides a conically scanning antenna beam with a

constant surface incidence angle of approximately 40° and will measure a swath
90 approximately 1000 kilometers wide. The combined observations from the two
sensors will allow accurate estimation of soil moisture and freeze/thaw states at
92 spatial scales valuable for both hydro-meteorological (10 km) and hydro-
climatological (40 km) studies.

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After launch, the satellite's instruments will be calibrated, (an expected time period
96 of 3 months). Once calibrated, the SMAP mission will deliver estimates of soil
moisture in the top 5 cm of soil with an accuracy of 0.04 cm³/cm³ volumetric soil
98 moisture, at 10 km resolution, with 3-day average intervals (Table 1). Global maps
will also be available of landscape freeze/thaw state derived from L-band radar at 3
100 km spatial resolution with a 2-day refresh rate for the high northern latitudes (i.e.,
latitudes above 45 degrees north). Measurements will be made over the global land
102 area, excluding regions of snow and ice, mountainous topography, open water, and
areas of extremely dense vegetation such as tropical forests (See smap.jpl.nasa.gov
104 for latency, resolution, and other details).

106 In addition to the instrument measurements and derived products for the surface
layer, SMAP will also provide Level 4 data assimilation products by ingesting active
108 and passive observations into land surface models to provide root zone soil
moisture (to a depth of ~100 cm). A net ecosystem exchange product will also be
110 developed that integrates freeze/thaw measurements into a carbon model to
provide ecosystem exchange at 9km resolution. As these two products are intended

112 to serve a broad community, there is an opportunity for user engagement now to
optimize the design of these products so that they can ultimately satisfy user
114 requirements.

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The SMAP Applications program facilitates applied research to provide a
118 fundamental understanding of how SMAP data products can be scaled and
integrated into a user's decision-making process to improve policy, business, and
120 management activities. By working with relevant users and early adopters before
the satellite is launched, SMAP hopes to improve the pace of incorporation of the
122 new measurements in decision making during the life of the mission, which is
expected to be at least 3 years. To join the SMAP Applications Working Group, which
124 is dedicated to enabling scientists and others interested in SMAP to engage with the
SMAP Science Definition Team, readers are encouraged to go to the following
126 website: (<http://smap.jpl.nasa.gov/science/wgroups/applicWG/>).

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ACKNOWLEDGMENTS

130 This research was carried out in part at the Jet Propulsion Laboratory, California Institute
of Technology, under contract with NASA.

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FOR FURTHER READING

134 National Research Council , 2007, Earth Science and Applications from Space:
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136 Press.

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138 Entin, J.K.; Goodman, S.D.; Jackson, T.J.; Johnson, J.; Kimball, J.; Piepmeier, J.R.; Koster,
R.D.; Martin, N.; McDonald, K.C.; Moghaddam, M.; Moran, S.; Reichle, R.; Shi, J.C.;
140 Spencer, M.W.; Thurman, S.W.; Leung Tsang; Van Zyl, J., 2010: The Soil Moisture
Active Passive (SMAP) Mission, Proceedings of the IEEE, Volume: 98 , Issue: 5, Pages
142 704-716. 10.1109/JPROC.2010.2043918

144 “SMAP Applications Plan” document available at smap.jpl.nasa.gov

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Table 1. Anticipated SMAP Mission products

Product	Description	Gridding (Resolution)	Latency *	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer TB in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_0 in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_0 in Half-Orbits	1 km (1-3 km)**	12 hrs	
L1C_TB	Radiometer TB in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	

L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

152 * Mean latency under normal operating conditions. Latency is defined as the time from
154 data acquisition by the instrument to its availability in a designated data archive. The
SMAP project will make a best effort to reduce these latencies.

** Over outer 70% of swath.

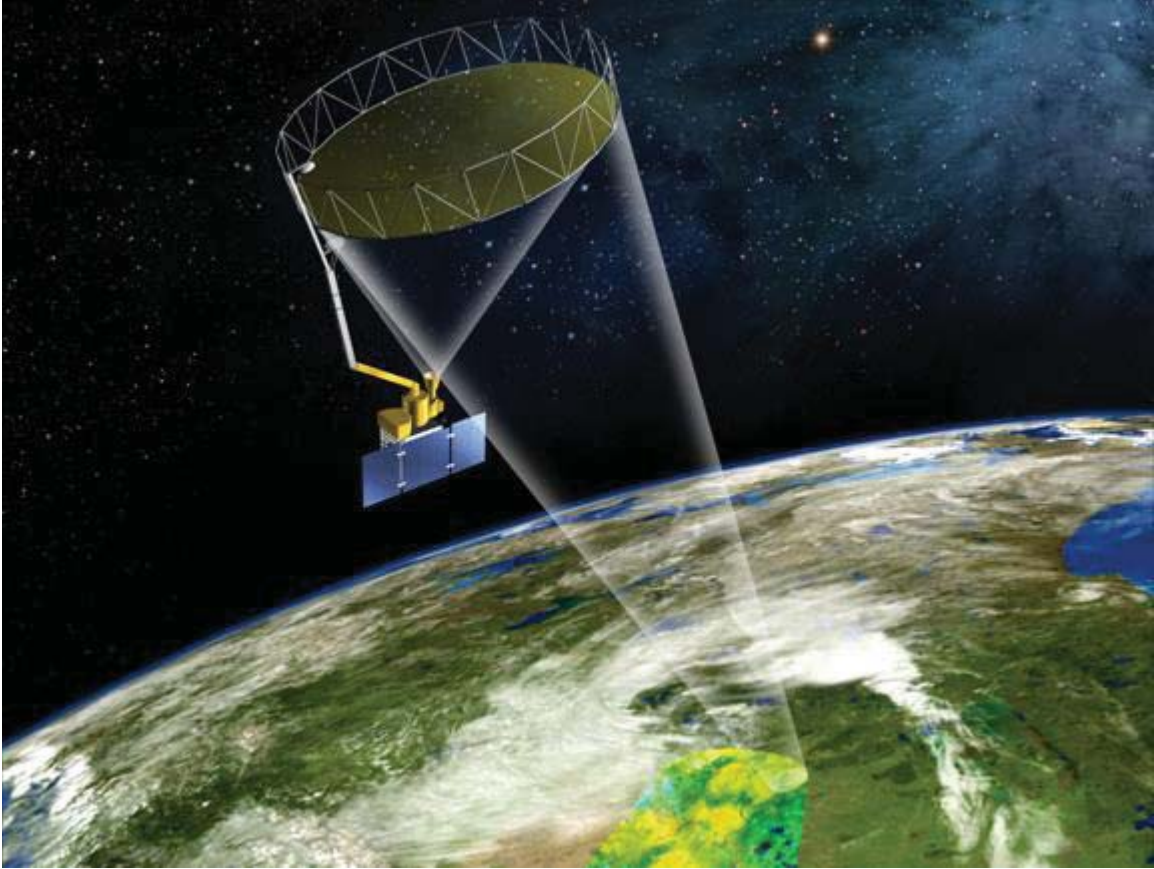
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160 **Figure Caption:**

162 **Figure 1.** The SMAP L-band radar and radiometer share a common feed and reflector
antenna system. The instruments conically scan across a wide swath allowing global
164 mapping with frequent revisit.

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Reviewer/Editor Comments included in this letter (all those pertinent to your revision have either been made in the edited article or have been embedded in comments in the edited article):

Reviewer #1: BAMS 11-00049.

General:

This is a short synopsis on NASA's soil moisture sensor. Given the importance of the parameter and the upcoming launch, this is appropriate for a nowcast article.

Specific:

(there are no line numbers to reference)

Page 1.

"NASA has funded" sounds like NASA funded this out-of-hide. I would think the taxpayers funded it. Suggest verbs such as: started/procured/launched.

If it's launched in October of 2014 - when we users get calibrated data to use? This is date should be included.

"enables measurements of soil moisture and freeze/thaw state with high resolution" Need to state that this is referred to spatial resolution; even better, state the value (10-40 km). Meanings of the words like 'high resolution' vary greatly over sensor, instrument, field, etc.

WE HAVE MADE BOTH THESE CHANGES.

Page 2.

"of its data" is wordy.

WE HAVE AMENDED THIS SENTENCE.

Page 3.

"Following launch" is wordy.

WE HAVE AMENDED THIS SENTENCE.

Page 4.

What format is the exchange product?

How long is the missing lifetime?

WE HAVE ADDED BOTH THESE PIECES OF INFORMATION.

Page 5. <http://smap.jpl.nasa.gov/science/> might be a better link for the BAMS reader, rather than jumping into the Working Group level. [EDITOR'S NOTE: I disagree with this recommendation -- the link you have here is the proper one.]

WE HAVE LEFT THE URL AS STATED.

Reviewer #2: SMAP information will reach an excellent audience within BAMS and will benefit many readers.

THANK YOU.

Authors should add appropriate references and websites that explain more details about the SMAP mission and sensor attributes. [EDITOR'S NOTE: the short Nowcast article format does not allow the inclusion of citations; you are welcome to add any material readers might be interested in to the section at the end of the article labeled FOR FURTHER READING.] In the process, they should add details on product data latency since the draft currently is unclear on age of data, though it does address what products will be made and at what resolution.

WE HAVE ADDED LATENCY INFORMATION, AND HAVE AMENDED THE 'FOR FURTHER READING' SECTION.

Figure 1

[Click here to download Non-Rendered Figure: SMAP_BeautyShot4_Landscape\(3\).jpg](#)