NASA’s Soil Moisture Active Passive (SMAP) Mission

The Applications Program Pre Launch Efforts

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WHAT IS SMAP?

Mission Facts:

- SMAP stands for **Soil Moisture Active Passive**.
- The SMAP satellite will launch October 31, 2014.
- SMAP will incorporate an L-Band radar (the active sensor) and an L-band Radiometer (the passive sensor) to take observations.
  - L-band is the optimal frequency for measuring soil moisture.
  - The radar and radiometer share the same mesh antennae.
  - SMAP will cross the equator at 6pm and 6am daily.
  - SMAP will provide complete Global coverage once every 3 days.

http://smap.jpl.nasa.gov/
Primary Science Objectives:

- Link terrestrial water, energy and carbon cycle processes
- Estimate global water and energy fluxes at the land surface
- Quantify net carbon flux in boreal landscapes
- Extend weather and climate forecast skill
- Develop improved flood and drought prediction capability

The proposed SMAP mission was in the first tier recommended by the 2007 National Research Council (NRC) Earth Science Decadal Survey.

Incorporating applications into mission plans is not optional, but rather

1) Mandated from Congress with the NASA authorization act,
2) Recommended as a requirement from the National Research Council.
3) Critical component of the SMAP Applied Sciences activities AND
4) Quickly become a measure for mission’s success

SMAP will launch 31 October 2014

http://smap.jpl.nasa.gov/
SMAP MEASUREMENT APPROACH

**Instruments:**

- **Radar: L-band (1.26 GHz)**
  - High resolution, moderate accuracy soil moisture
  - Freeze/thaw state detection
  - SAR mode: 3 km resolution
  - Real-aperture mode: 30 x 6 km resolution

- **Radiometer: L-band (1.4 GHz)**
  - Moderate resolution, high accuracy soil moisture
  - 40 km resolution

- **Shared Antenna**
  - 6-m diameter deployable mesh antenna
  - Conical scan at 13-14 rpm
  - Constant incidence angle: 40 degrees
    - 1000 km-wide swath

**Orbit:**

- Sun-synchronous orbit
- 6 am local time descending
- 6 pm local time ascending
- 685 km altitude
- Global coverage once every three days

**Mission Operations:**

- 3-year baseline mission

http://smap.jpl.nasa.gov/
## Proposed SMAP Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Gridding (Resolution)</th>
<th>Latency*</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1A_TB</td>
<td>Radiometer Data in Time-Order</td>
<td>-</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1A_S0</td>
<td>Radar Data in Time-Order</td>
<td>-</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1B_TB</td>
<td>Radiometer $T_B$ in Time-Order</td>
<td>(36x47 km)</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1B_S0_LoRes</td>
<td>Low Resolution Radar $\sigma_o$ in Time-Order</td>
<td>(5x30 km)</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1C_S0_HiRes</td>
<td>High Resolution Radar $\sigma_o$ in Half-Orbits</td>
<td>1 km</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L1C_TB</td>
<td>Radiometer $T_B$ in Half-Orbits</td>
<td>36 km</td>
<td>12 hrs</td>
</tr>
<tr>
<td>L2_SM_A**</td>
<td>Soil Moisture (Radar)</td>
<td>3 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L2_SM_P</td>
<td>Soil Moisture (Radiometer)</td>
<td>36 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L2_SM_AP</td>
<td>Soil Moisture (Radar + Radiometer)</td>
<td>9 km</td>
<td>24 hrs</td>
</tr>
<tr>
<td>L3_FT_A</td>
<td>Freeze/Thaw State (Radar)</td>
<td>3 km</td>
<td>50 hrs</td>
</tr>
<tr>
<td>L3_SM_A**</td>
<td>Soil Moisture (Radar)</td>
<td>3 km</td>
<td>50 hrs</td>
</tr>
<tr>
<td>L3_SM_P</td>
<td>Soil Moisture (Radiometer)</td>
<td>36 km</td>
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</tr>
<tr>
<td>L3_SM_AP</td>
<td>Soil Moisture (Radar + Radiometer)</td>
<td>9 km</td>
<td>50 hrs</td>
</tr>
<tr>
<td>L4_SM</td>
<td>Soil Moisture (Surface and Root Zone)</td>
<td>9 km</td>
<td>7 days</td>
</tr>
<tr>
<td>L4_C</td>
<td>Carbon Net Ecosystem Exchange (NEE)</td>
<td>9 km</td>
<td>14 days</td>
</tr>
</tbody>
</table>

*Instrument Data

*Science Data (Half-Orbit)*

*Science Data (Daily Composite)*

*Science Value-Added*

The SMAP Project will make a best effort to reduce the data latencies beyond those shown in this table.

* Research product with possible reduced accuracy

** Over Outer 70% of Swath

http://smap.jpl.nasa.gov/
A primary goal of the SMAP Mission is to engage SMAP end users and build broad support for SMAP applications through a transparent and inclusive process. Toward that goal, the SMAP Mission:

- Formed the SMAP Applications Working Group (AppWG)
  - Currently over 300 members
- Produced a Formal SMAP Applications Plan (A living document)
- The Objectives of the SMAP Application Working Group:
  - Communicate with user community and leverage relationships
  - Facilitate between Users and SMAP SDT
  - *Societal needs and information are addressed to maximize mission product design at inception*
  - Demonstrate added value through feedback loops and workshops that engage all users (science, business and policy)
  - Coordination with other international programs and missions (ESA, SMOS, Aquarius) to improve the outcome of mission products.
The SMAP Applications Plan is a living document.

“This plan provides an implementation strategy for promoting applications research and engaging a broad community of users in SMAP applications.”

- **Implementation Strategy**
  1) Engagement with Early Adopters
  2) Promotion of Community of Potential
  3) SMAP Applications Research, possibly funded by ROSES call
  4) Coordination with SMAP data calibration
  5) Coordination with other NASA Missions

- **SMAP Applications are led by:**
  - Molly Brown, SMAP Applications Coordinator
  - Vanessa Escobar, SMAP Applications Deputy Coordinator
  - Susan Moran, Chair, SMAP Applications Working Group

https://smap.jpl.nasa.gov/science/wgroups/applicWG/AppsPlan/
Applications are defined as innovative uses of mission data products in decision-making activities for societal benefit.

Applications research will provide fundamental knowledge of how mission data products can be scaled and integrated into users’ policy, business and management activities to improve decision-making efforts.

User Community includes
- individuals or groups
- public or private sectors
- national or international organizations
- local to global scales of decision making

http://smap.jpl.nasa.gov/
ASSESSING THE SMAP COMMUNITY
Results revealed that the SMAP user community had:

- Gap between research and policy applications
- High perceived value of soil moisture
- Uncertainty as to how ground observations will scale to remotely sensed data
- Where to access SMAP-like data

Applications will focus on bridging a gap

- Results show most users associated with SMAP are research/science users.
- Operational users were under represented. *Our goal is to address this gap*

![Bar chart showing the distribution of users by category.](http://smap.jpl.nasa.gov/)

- Water Resources: 46%
- Agriculture and Forestry: 40%
- Weather and Climate: 54%
- Disasters/Floods: 21%
- Hazards: 16%
- Other: 19%

*Figure from Brown, Escobar, 2012, JSTARS, in press*
Move science into action

- A clear need to facilitate the movement of research into policy.

Respondents

http://smap.jpl.nasa.gov/

Figure from Brown, Escobar, 2012, JSTARS, in press
Advancing SMAP Applications with Early Adopters
Engagement with Early Adopters

**What is an Early Adopter?**

Early Adopters are defined as those groups or individuals who have a clearly defined need for SMAP-like soil moisture or freeze/thaw data and who have sufficient interest and personnel to demonstrate the utility of SMAP data for their particular application.

Recall that applications are defined as innovative uses of SMAP data products in *decision-making activities for societal benefit*.

**Why are we engaging Early Adopters?**

To conduct *pre-launch applications research* to accelerate the use of SMAP products after the launch of SMAP.

**How are we engaging Early Adopters?**

- Application for Access to Pre-launch SMAP Simulated and Cal/Val Data (unfunded, immediate) - please contact Vanessa or Molly
- ROSES RFP (funded in late 2012)

http://smap.jpl.nasa.gov/
Application for Access to Pre-Launch simulated and CAL/VAL data

- Request for nominations/recommendations through the SMAP AppWG
- Nomination process is submission of 1-page application
  - Description, Approach, Requirements
  - We reviewed the proposals and selected those qualified
- SMAP commitment
  - Provide simulated SMAP data products
  - Provide access to cal/val data
- Early Adopter (EA) commitment
  - Conduct applications research
  - Join the SMAP Applications Team
  - Attend SMAP Applications Workshops to report results

Total of 21 selected. Continuing EA selections through launch
**SMAP Early Adopters 2011-2013**

### Current Early Adopters

Currently 23 Early Adopters working with SMAP

**ECMWF, NOAA, Georgia Tech conducting research in weather applications**

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**SMAP Early Adopters**

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Institution/Project</th>
<th>Application Research Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stephane Belair</td>
<td>Meteorological Research Division, Environment Canada</td>
<td>Assimilation and impact evaluation of observations from the SMAP mission in Environment Canada's Environmental Prediction Systems</td>
</tr>
<tr>
<td>2</td>
<td>Hosni Ghedira</td>
<td>Masdar Institute, UAE</td>
<td>Estimating and mapping the extent of Saharan dust emissions using SMAP-derived soil moisture data</td>
</tr>
<tr>
<td>3</td>
<td>Zhengwei Yang and Rick Mueller</td>
<td>USDA National Agricultural Statistical Service (NASS)</td>
<td>U.S. National cropland soil moisture monitoring using SMAP</td>
</tr>
<tr>
<td>4</td>
<td>Catherine Champagne</td>
<td>Agriculture and Agri-Food Canada (AAFC)</td>
<td>Soil moisture monitoring in Canada</td>
</tr>
<tr>
<td>5</td>
<td>Amor Ines and Stephen Zebiak</td>
<td>International Research Institute for Climate and Society (IRI) Columbia University</td>
<td>Seasonal climate forecasts with dynamic crop simulation, crop forecasting and food security early warning system</td>
</tr>
<tr>
<td>6</td>
<td>Lars Isaksen and Patricia de Rosnay</td>
<td>European Centre for Medium-Range Weather Forecasts (ECMWF)</td>
<td>Monitoring SMAP soil moisture and brightness at ECMWF</td>
</tr>
<tr>
<td>7</td>
<td>Xiwu Zhan, Michael Ek and John Simko</td>
<td>NOAA National Environmental Satellite Data and Information Service, Center for Satellite Applications and Research (NOAA-NESDIS-STAR)</td>
<td>Transition of NASA SMAP research products to numerical weather and seasonal climate prediction, hydrological forecasts</td>
</tr>
<tr>
<td>8</td>
<td>Curt Reynolds</td>
<td>USDA Foreign Agricultural Service (FAS)</td>
<td>Enhancing USDA’s global crop production monitoring system using SMAP soil moisture products</td>
</tr>
<tr>
<td>9</td>
<td>John Eylander</td>
<td>U.S. Army Engineer Research and Development Center (ERDC) Cold Regions Research and Engineering Laboratory (CERREL)</td>
<td>U.S. Army Engineer Research and Development Center (ERDC) SMAP adoption for USACE civil and military tactical support</td>
</tr>
<tr>
<td>10</td>
<td>Jim Reardon and Gary Curcio</td>
<td>US Forest Service (USFS)</td>
<td>Wildfire danger and estimated smoldering potential in the organic soils of the North Carolina coastal plain</td>
</tr>
<tr>
<td>11</td>
<td>Gary McWilliams, Li Li, Andrew Jones and George Mason</td>
<td>Dept. of Defense - Soil Moisture Applications Consortium (SMAC)</td>
<td>Exploitation of SMAP data for Army and Marine Corps mobility assessment</td>
</tr>
<tr>
<td>12</td>
<td>Michael Ek, Marouane Temimi, Xiwu Zhan, NOAA National Centers for Environmental Prediction (NCEP)</td>
<td>NOAA National Centers for Environmental Prediction (NCEP)</td>
<td>Integration of SMAP freeze/thaw product into the NOAA NCEP weather forecast models</td>
</tr>
<tr>
<td>13</td>
<td>John Galantowicz</td>
<td>Atmospheric and Environmental Research, Inc. (AER)</td>
<td>Use of SMAP-derived inundation and soil moisture estimates in the quantification of biogenic greenhouse gas emissions</td>
</tr>
<tr>
<td>14</td>
<td>Jingfeng Wang, Rafael Bras and Aris Georgakakos</td>
<td>Georgia Institute of Technology (GIT)</td>
<td>Application of SMAP observations in modeling energy/water/carbon cycles and its impact on weather and climatic predictions</td>
</tr>
<tr>
<td>15</td>
<td>Kyle McDonald</td>
<td>City College of New York (CUNY) and CREST Institute, and Don Pierson, New York City Dept. of Environmental Protection</td>
<td>Application of SMAP freeze/thaw and soil moisture products for supporting management of New York City’s potable water supply</td>
</tr>
<tr>
<td>16</td>
<td>Chris Funk, Amy McNally and James Verdin</td>
<td>US Geological Survey &amp; UC Santa Barbara</td>
<td>Incorporating soil moisture retrievals into the Famine Early Warning System (FEWS) Land Data Assimilation System (FLDAS)</td>
</tr>
<tr>
<td>17</td>
<td>Fiona Shaw</td>
<td>Willis, Global Analytics</td>
<td>eNCOMPASS – A risk identification and analysis system for insurance; Multiple catastrophe risk models, risk rating tools and risk indices for insurance and reinsurance purposes including a Global Flood Model</td>
</tr>
<tr>
<td>18</td>
<td>Rafael Ameller</td>
<td>StormCenter Communications, Inc.</td>
<td>SMAP for enhanced decision making (emergency management)</td>
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<tr>
<td>20</td>
<td>Barbara S. Minske</td>
<td>University of Illinois and sponsored by John Deere Inc.</td>
<td>Comprehensive, Large-Scale Agriculture and Hydrologic data synthesis</td>
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<tr>
<td>21</td>
<td>Thomas Harris</td>
<td>Exelis Visual Information Solutions</td>
<td>Utilization of SMAP Products in ENVI, IDL and SARscape-Products L1 to L4</td>
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</tbody>
</table>

Assess impact on numerical weather prediction systems, hydrological systems and air quality systems done by Stephane Belair.

Progress:
- Completed sensitivity tests where brightness temps were assimilated within CaLDAS.
- SMOS brightness temps were assimilated over the warm season in 2010
  - Positive impact on surface soil moisture correlations
  - Results in the root zone were more neutral
- SMAPVEX12 data now available and used to verify soil moisture analysis at different scales.

Example of SMAP Early Adopter Research: ENVIRONMENT CANADA

http://smap.jpl.nasa.gov/
Assimilating SMOS in NCEP GFS

Findings:

☑ Improved GFS deep layer soil moisture estimates compared with in situ measurements

☑ Reduced GFS temperature forecast biases

☑ Increased latent heat and decreased sensible heat fluxes for most CONUS regions

☑ Had significant impact on precipitation forecasts
SMAP Applications is redefining how NASA integrates data into society

- Weather and climate applications are a critical thematic concentration for the SMAP mission.

- SMAP mission impact can continue to expand by:
  - Gaining a better understanding of the methodologies used by weather and climate communities ingesting SMAP data
  - Lessons learned from EAs and early mission applications
  - Collaboration on applied research and applications

http://smap.jpl.nasa.gov/
Successfully achieving our goals for applications requires bridging scientific research and thematic user communities’ operational decision making priorities and requirements.

Feedback is valuable and we want to hear from you!