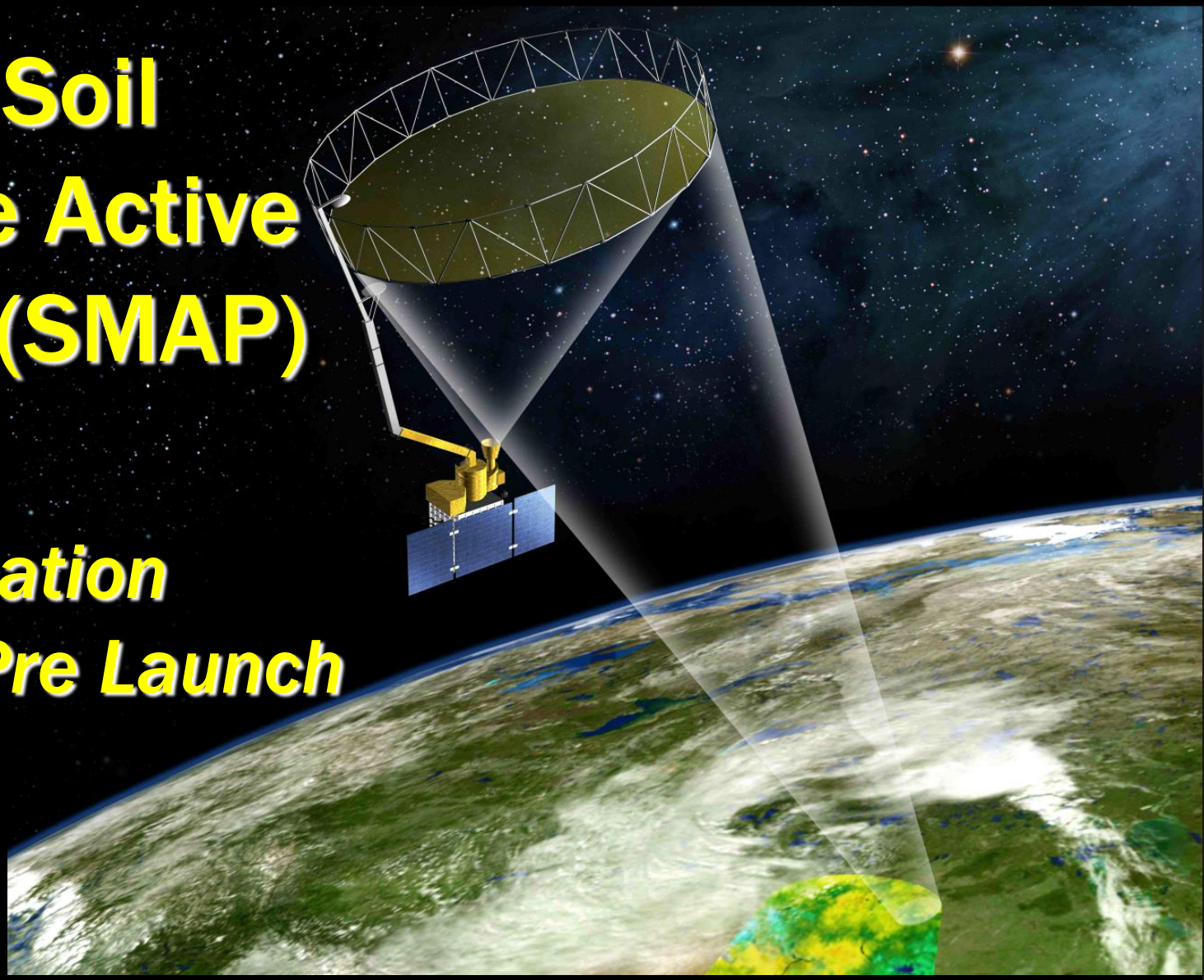
NASA's Soil Moisture Active Passive (SMAP) Mission

The Application Program Pre Launch Efforts



Vanessa M. Escobar
NASA GSFC/Sigma Space
vanessa.escobar@nasa.gov

What is SMAP?

Mission Facts:

- SMAP stands for Soil Moisture Active Passive.
- The SMAP satellite will launch November 5, 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

SMAP Mission Overview

Primary Science Objectives :

Global, high-resolution mapping of soil moisture and its freeze/thaw state to:

- **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

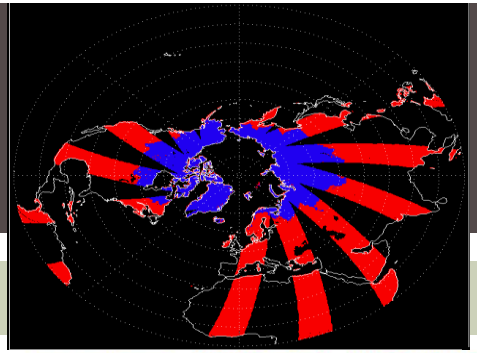
1)Mandated from Congress with the NASA authorization act,

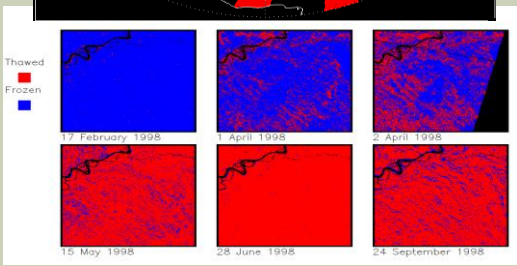
2)Recommended as a requirement from the National Research Council.

3)Critical component of the SMAP Applied Sciences activities AND

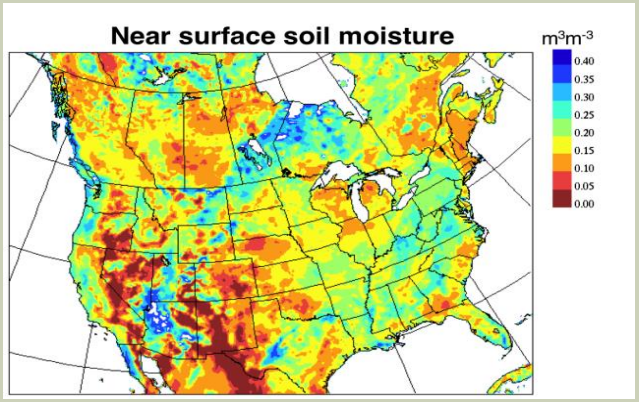
4)Quickly become a measure for mission's success

Freeze/thaw state

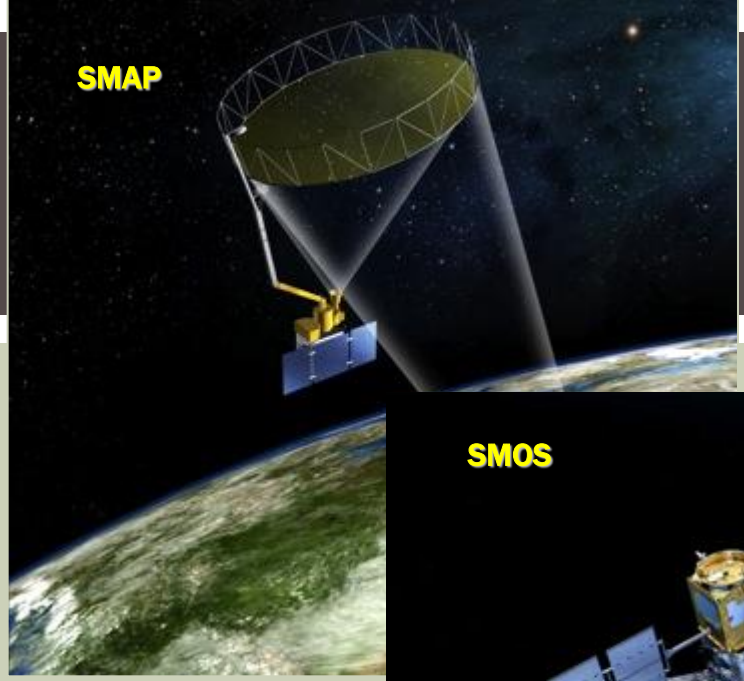


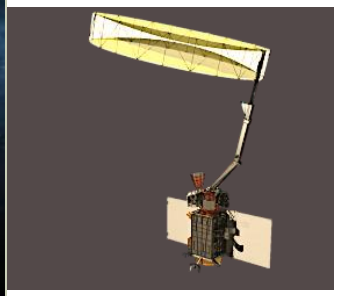


SMAP will launch 31 October 2014



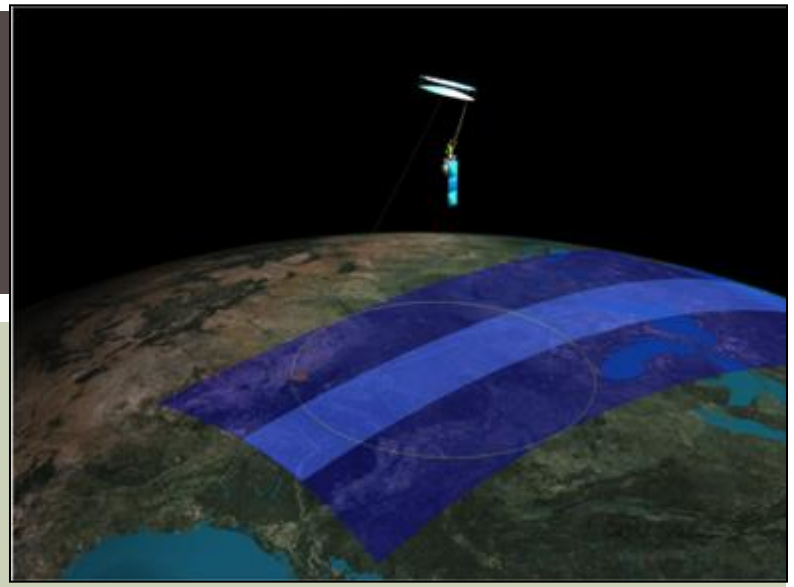
SMAP Lessons Learned





- Improved RFI challenges learned from SMOS (Soil Moisture Ocean Salinity Satellite from ESA)
- High Resolution and High accuracy products because of the combined radar radiometer.
- Using L-band radar
  - Improvement from C-Band instruments (SMMR)
  - Deeper soil penetration (from 1cm to 5 cm)
  - Better sensing over vegetated areas
- Fixed incident angle (40 degrees) for improved sensing over vegetation
- First NASA mission with an Applications Program-Working with SMOS mission for continuity of soil moisture applications

Proposed SMAP Measurement Approach



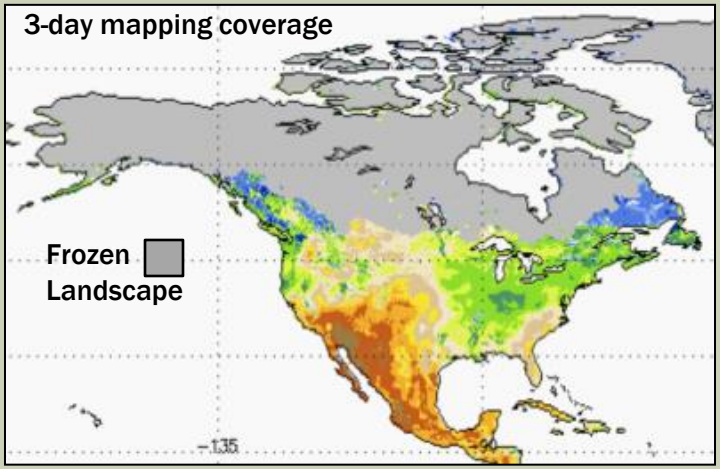
- **Instruments:**
  - **Radar: L-band (1.26 GHz)**
    - High resolution, moderate accuracy soil moisture
    - Freeze/thaw state detection
    - SAR mode: 3 km resolution
    - Real-aperture mode: 30 x 6 km resolution
  - **Radiometer: L-band (1.4 GHz)**
    - Moderate resolution, high accuracy soil 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

SMAP Science Measurements

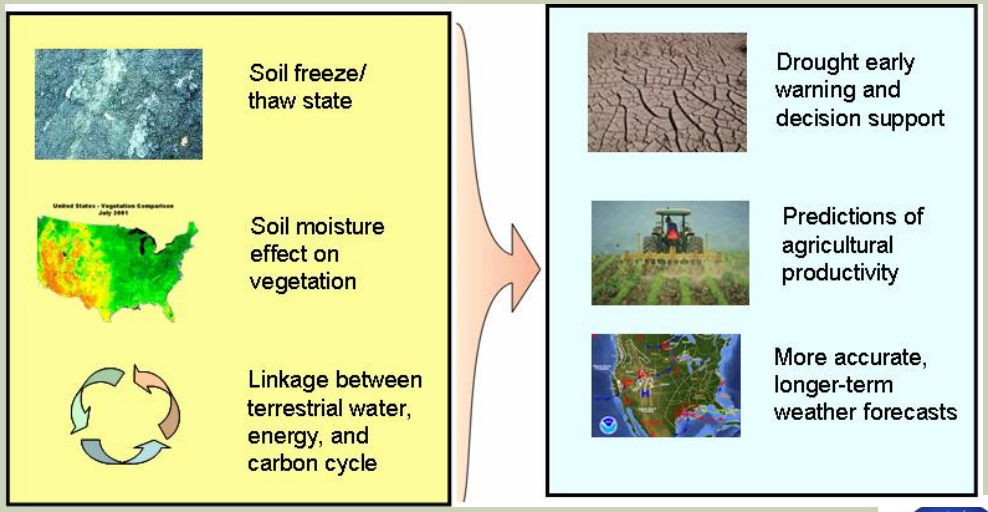
SMAP will provide high resolution and frequent –revisits global observations of soil moisture and freeze thaw state

Soil moisture is defined in terms of volume of water per unit volume of soil

Freeze/thaw state is defined as the phase of the water contained within the landscape including surface soil and vegetation



SMAP measurements of soil moisture and freeze/thaw state address a wide range of Earth science applications



NRC Earth Science Decadal Survey Report, 2007

Proposed SMAP Products

Product	Description	Gridding (Resolution)	Latency*	
L1A_TB	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_S0	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1B_S0_LoRes	Low Resolution Radar σ_o in Time-Order	(5x30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_o in Half-Orbits	1 km (1-3 km)***	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A**	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
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	

* 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

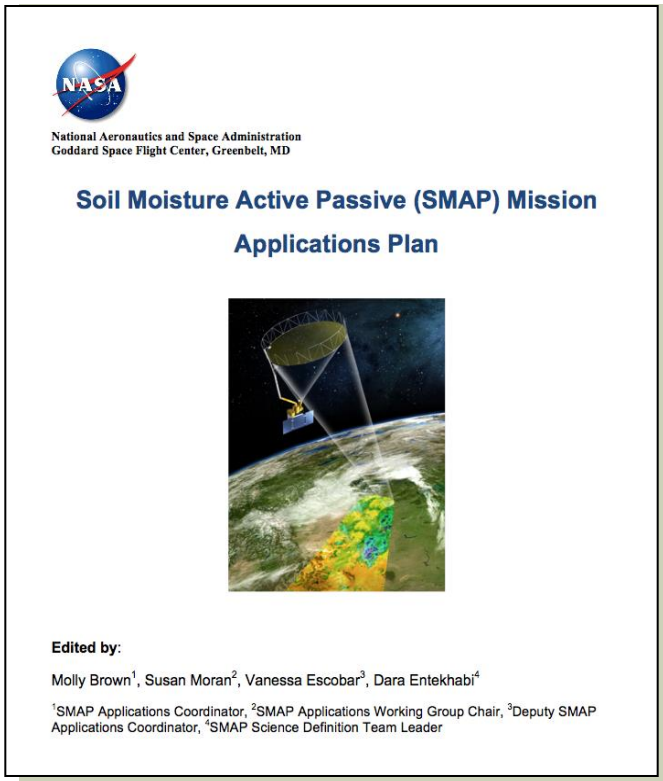
The SMAP Applications Program

- 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.

SMAP Applications Plan



National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, MD

Soil Moisture Active Passive (SMAP) Mission

Applications Plan

Edited by:

Molly Brown[1], Susan Moran[2], Vanessa Escobar[3], Dara Entekhabi[4]

[1]SMAP Applications Coordinator, [2]SMAP Applications Working Group Chair, [3]Deputy SMAP Applications Coordinator, [4]SMAP Science Definition Team Leader

https://smap.jpl.nasa.gov/science/wgroups/applicWG/AppsPlan/

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

What is an Application?

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

ASSESSING THE SMAP COMMUNITY

SMAP Survey conducted in 2012

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

Brown, Escobar (2012). Assessment of soil moisture data requirements by the potential SMAP data user community. Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTAR), in press.

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***

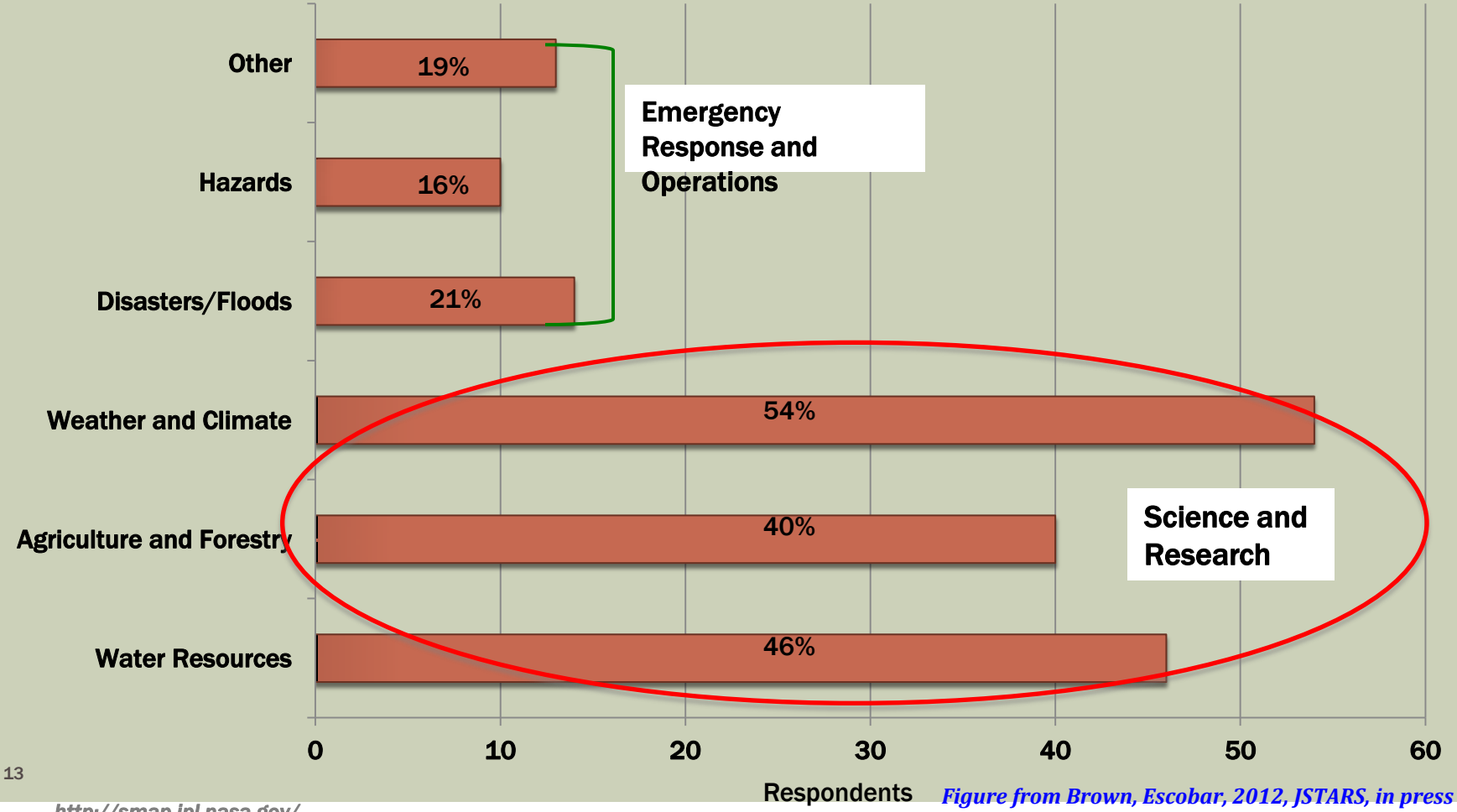


Figure from Brown, Escobar, 2012, JSTARS, in press

Move science into action

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

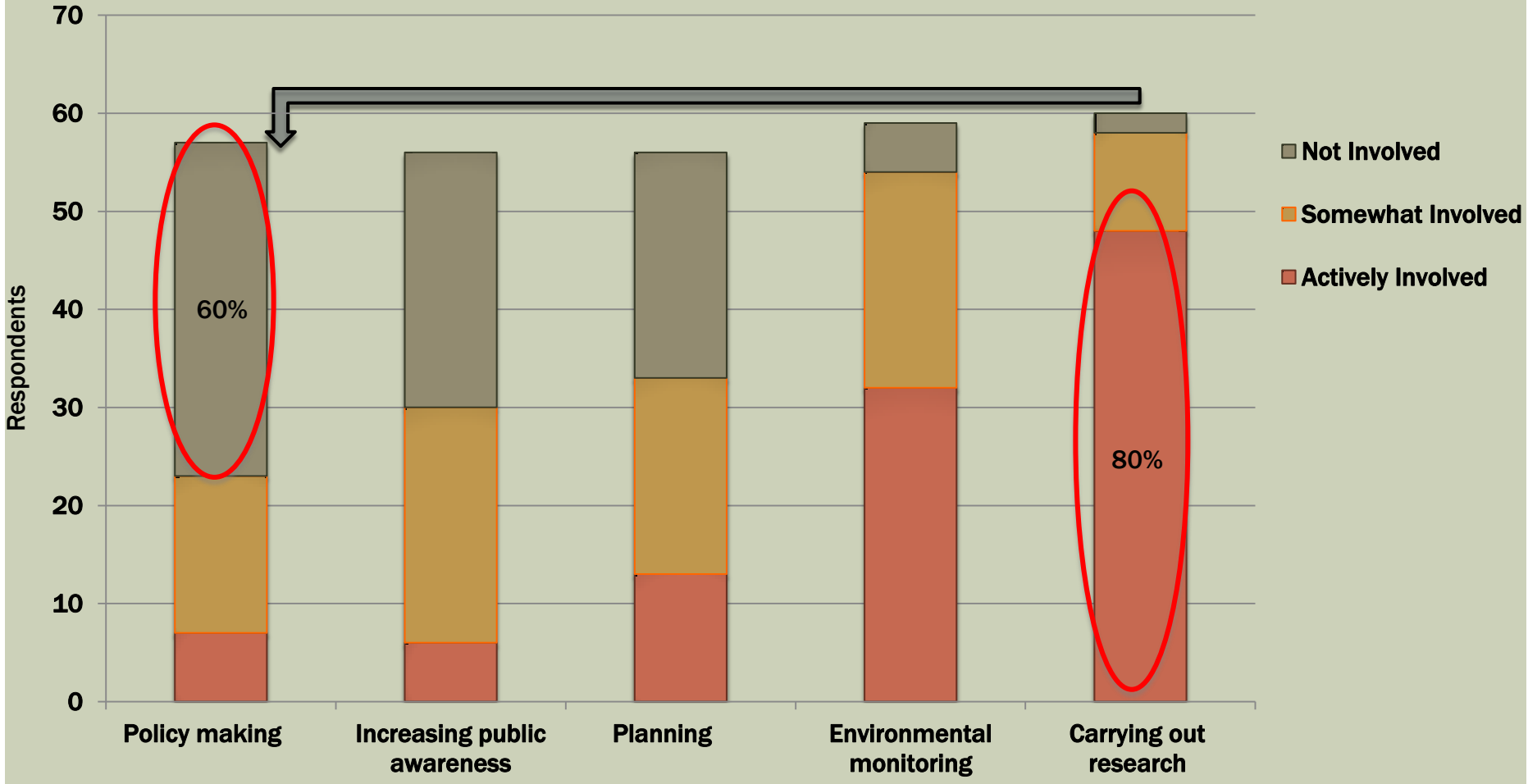


Figure from Brown, Escobar, 2012, JSTARS, in press

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)

SMAP Early Adopter Concept

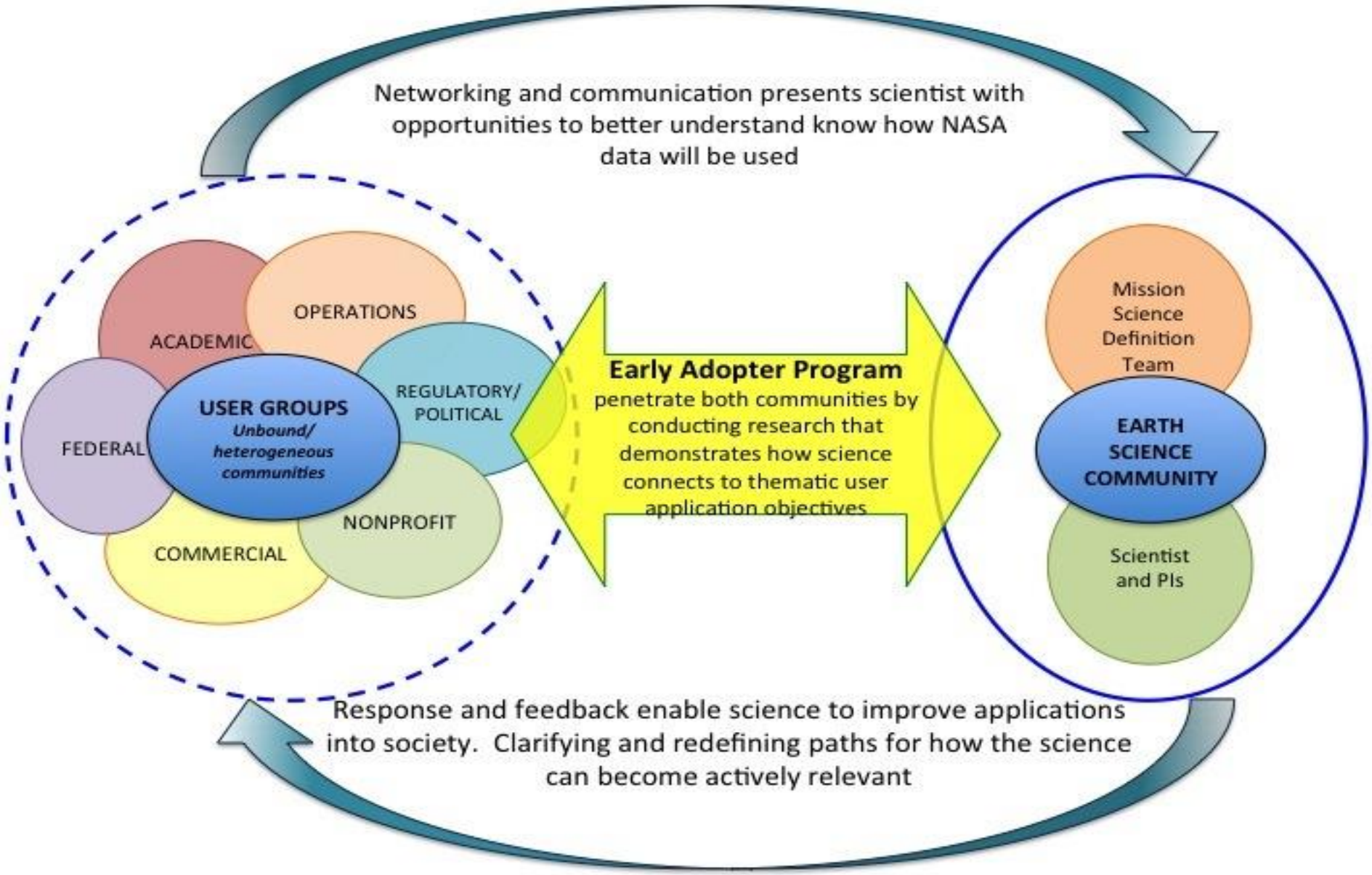
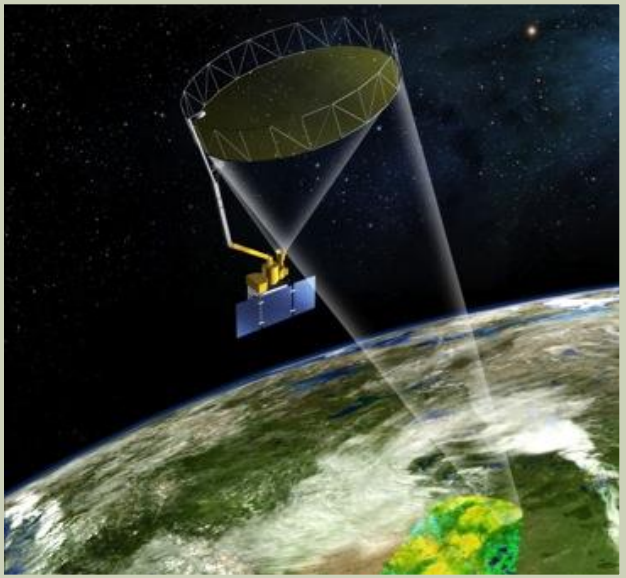


Diagram by V.M. Escobar, 2012

SMAP Early Adopters		
	Investigator and Institution	**Applications Research Topic**
Selected in 2011		
1	**Stephane Belair**, Meteorological Research Division, Environment Canada (EC)	*Assimilation and impact evaluation of observations from the SMAP mission in Environment Canada's Environmental Prediction Systems*
2	**Hosni Ghedira**, Masdar Institute, UAE	*Estimating and mapping the extent of Saharan dust emissions using SMAP-derived soil moisture data*
3	**Zhengwei Yang and Rick Mueller**, USDA National Agricultural Statistical Service (NASS)	*U.S. National cropland soil moisture monitoring using SMAP*
4	**Catherine Champagne**, Agriculture and Agri-Food Canada (AAFC)	*Soil moisture monitoring in Canada*
5	**Amor Ines and Stephen Zebiak,** International Research Institute for Climate and Society (IRI) Columbia University	*Seasonal climate forecasts with dynamic crop simulation models for crop forecasting and food security early warning applications*
6	**Lars Isaksen and Patricia de Rosnay**, European Centre for Medium-Range Weather Forecasts (ECMWF)	*Monitoring SMAP soil moisture and brightness temperature at ECMWF*
7	**Xiwu Zhan, Michael Ek and John Simko**, NOAA National Environmental Satellite Data and Information Service, Center for Satellite Applications and Research (NOAA-NESDIS-STAR)	*Transition of NASA SMAP research products to NOAA operational numerical weather and seasonal climate predictions and research hydrological forecasts*
Selected in 2012		
8	**Curt Reynolds**, USDA Foreign Agricultural Service (FAS)	*Enhancing USDA's global crop production moni SMAP soil moisture products*
9	**John Eylander**, U.S. Army Engineer Research and Development Center (ERDC) Cold Regions Research and Engineering Laboratory (CRREL)	*U.S. Army Engineer Research and Development adoption for USACE civil and military tactical s*
10	**Jim Reardon and Gary Curcio**, US Forest Service (USFS)	*Wildfire danger and estimated smoldering pote soils of the North Carolina coastal plain*
11	**Gary McWilliams, Li Li, Andrew Jones and George Mason**, Dept. of Defense - Soil Moisture Applications Consortium (SMAC)	*Exploitation of SMAP data for Army and Marine assessment*
12	**Michael Ek, Marouane Temimi, Xiwu Zhan**, NOAA National Centers for Environmental Prediction (NCEP)	*Integration of SMAP freeze/thaw product into the NOAA NCEP weather forecast models*
13	**John Galantowicz**, Atmospheric and Environmental Research, Inc. (AER)	*Use of SMAP-derived inundation and soil moisture estimates in the quantification of biogenic greenhouse gas emissions*
14	**Jingfeng Wang, Rafael Bras and Aris Georgakakos**, Georgia Institute of Technology (GIT)	*Application of SMAP observations in modeling energy/water/carbon cycles and its impact on weather and climatic predictions*
15	**Kyle McDonald**, City College of New York (CUNY) and CREST Institute, and **Don Pierson**, New York City Dept. of Environmental Protection	*Application of SMAP freeze/thaw and soil moisture products for supporting management of New York City's potable water supply*
16	**Chris Funk, Amy McNally and James Verdin**, US Geological Survey & UC Santa Barbara	*Incorporating soil moisture retrievals into the Famine Early Warning System (FEWS) Land Data Assimilation System (FLDAS)*
17	**Fiona Shaw**, Willis, Global Analytics	*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*
18	**Rafael Ameller**, StormCenter Communications, Inc.	*SMAP for enhanced decision making (emergency management)*
Selected in 2013		
19	**Jonathan Case and Clay Blankenship,** Marshall Space Flight Center and Universites Space Flight Center	*Application of Next-Generation Satellite Data to a High-Resolution, Real-Time Land Surface Model with SMAP.*
20	**Barbara S. Minske**, University of Illinois and sponsored by John Deere Inc.	*Comprehensive, Large-Scale Agriculture and Hydrologic data Synthesis*
21	**Thomas Harris,** Exelis Visual Information Solutions	*Utilization of SMAP Products in ENVI, IDL and SARscape-Products L1 to L4*



SMAP Early Adopters through mid 2013

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

Example of SMAP Early Adopter Research: ENVIRONMENT CANADA

- 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: UAE

EFFECT OF THE SOIL MOISTURE ON DUST EMISSION

HOSNI GHEDIRA, MASDAR INSTITUTE, UAE

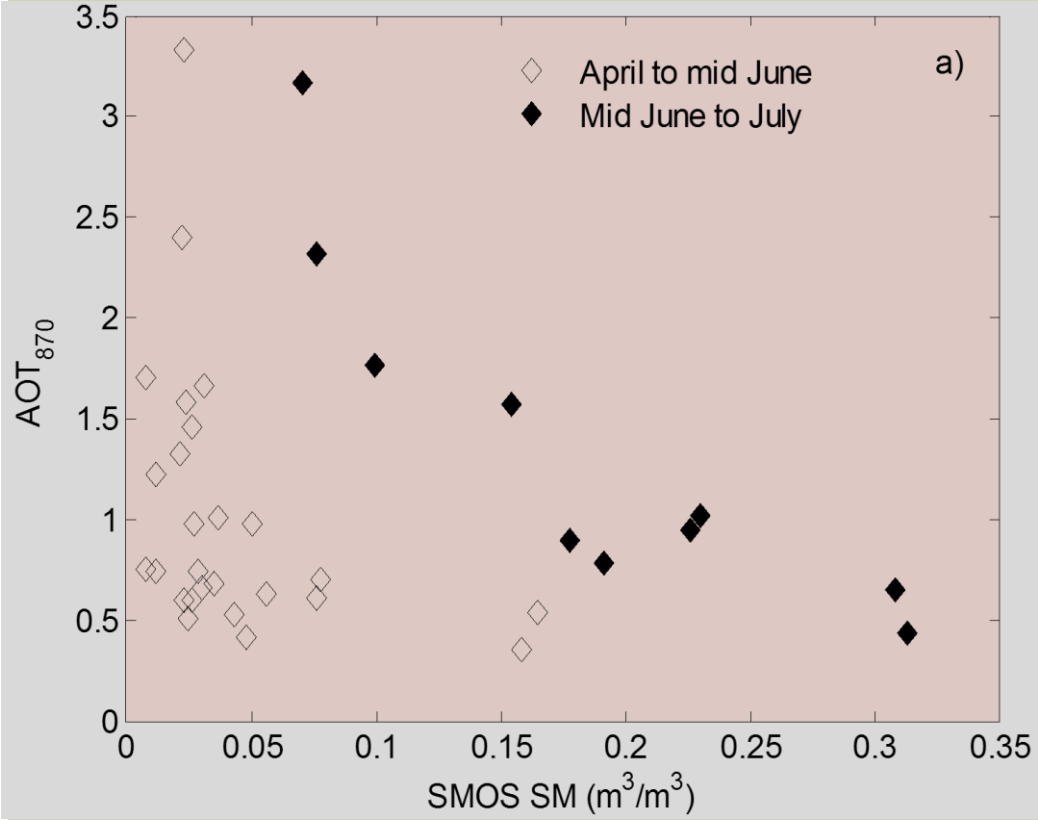
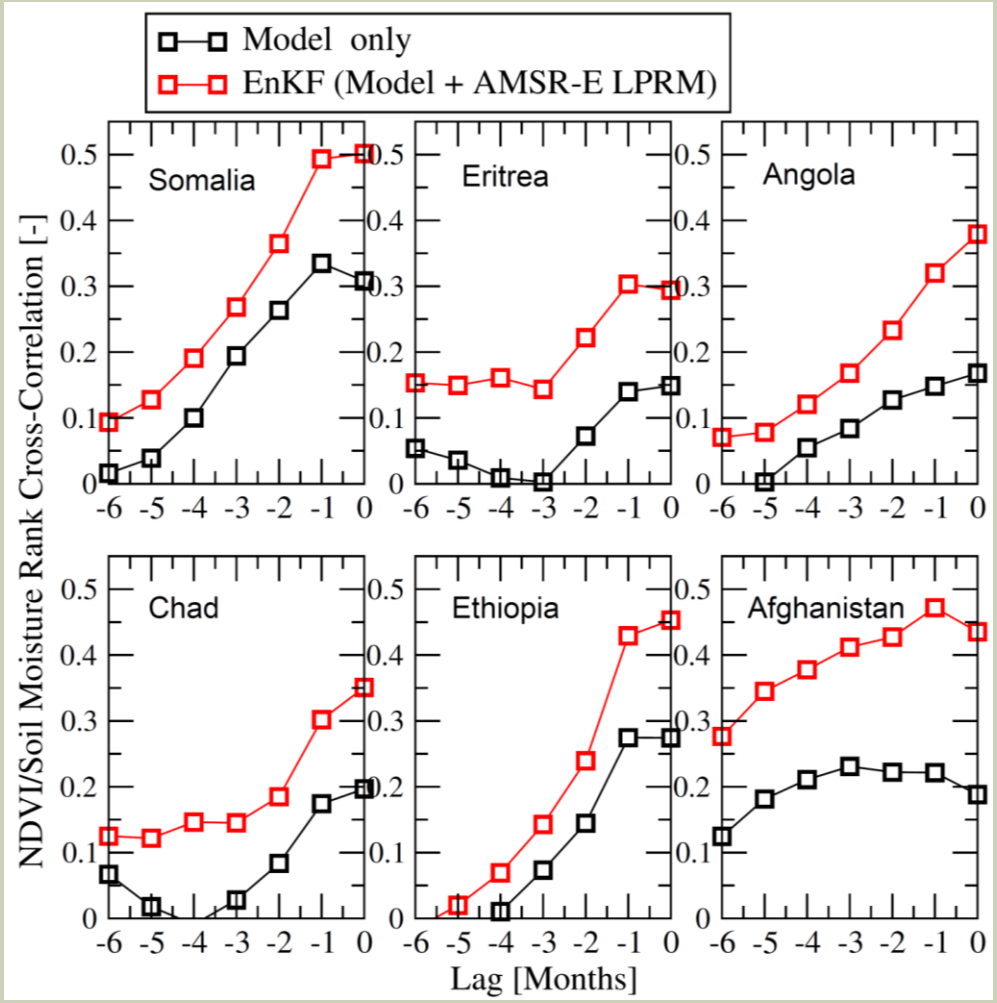


Image from EA Research, Hosni Ghedira, Masdar Institute, UAE

Finding: as SMOS soil moisture increases, the AERONET aerosol optical thickness (AOT) decreases up to a threshold moisture content above which no dust emission takes place

Research uses data from:
Aerosol data from Cinzana AERONET
AOT870 measurements vs. soil moisture from SMOS (the Soil Moisture Ocean Satellite from the Europeans)

Example of SMAP Early Adopter Research: USDA FAS

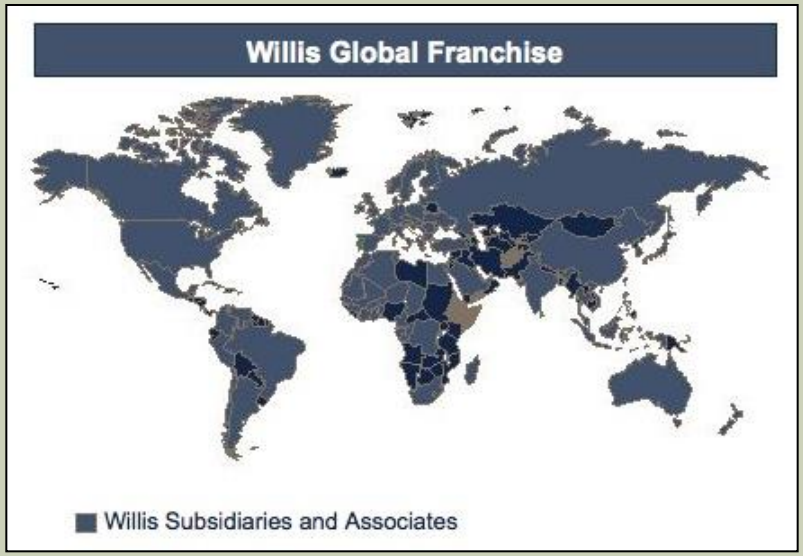


Global Agricultural Drought Monitoring 2002-2010 Performance in Data-Poor Regions

GOAL: Prepare USDA FAS modeling system for the ingestion of SMAP L2/3 and/or L4 products

- Ingest SMOS and ASCAT surface soil moisture products.
- Test accuracy of a data assimilation system using 2002-2011 AMSR-E surface soil moisture data.
- Conducted in 6 of the 10 most "food insecure" countries in 2011

Example of SMAP Early Adopter Research: Willis Global Analytics



Look at the trade offs for using soil moisture for different scale risk analysis

- Sensitivity analysis at the city/state scale
- Scenarios to evaluate value of soil moisture data
- Assess accuracy vs. timeliness

Summary

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

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!

Thank you for your attention

Questions?