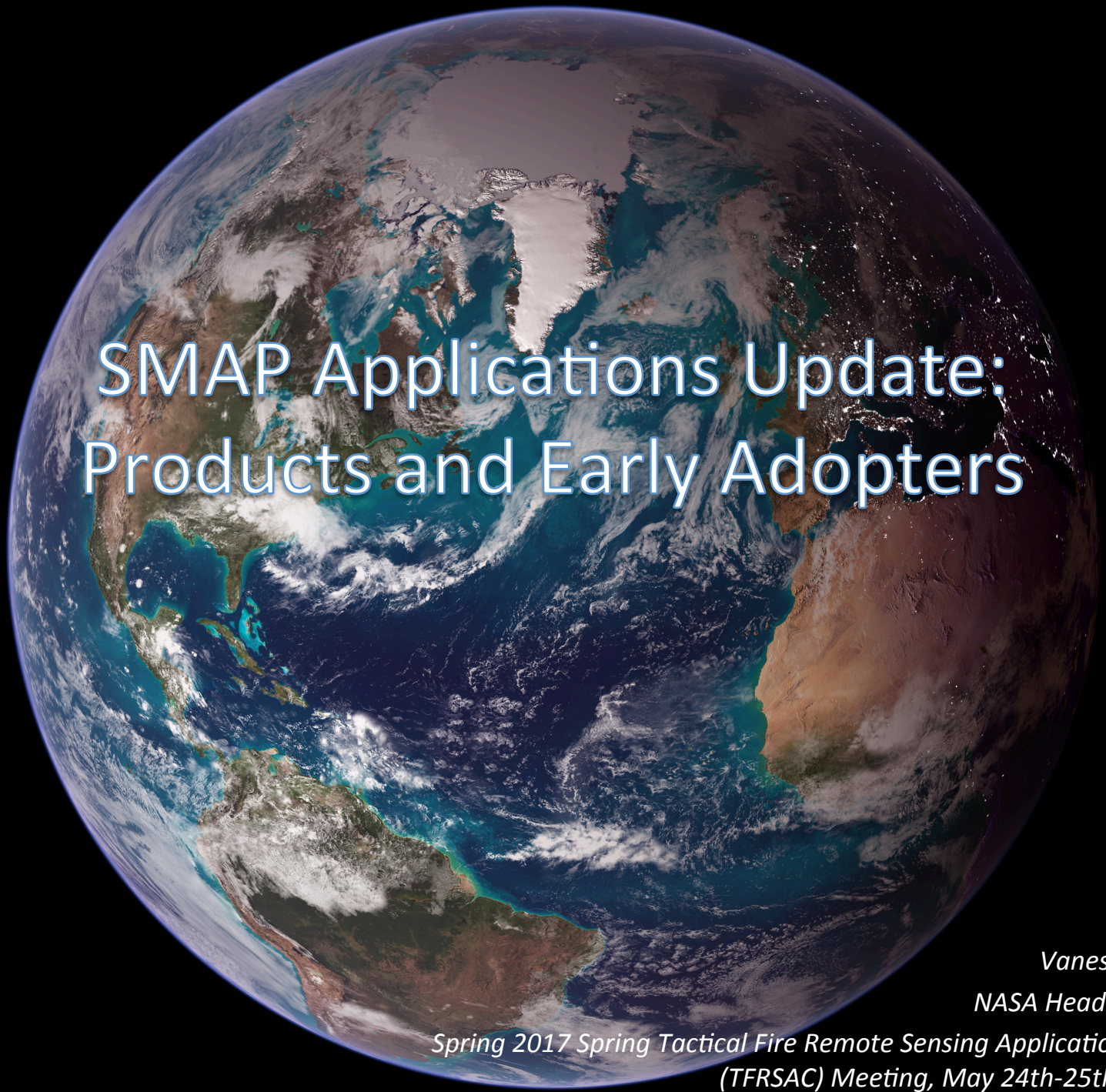


SMAP Applications Update: Products and Early Adopters

Vanessa M. Escobar

NASA Headquarters/ BAH

Spring 2017 Spring Tactical Fire Remote Sensing Applications Committee (TFRSAC) Meeting, May 24th-25th at NASA ARC

Outline

- NASA and the Applied Sciences Program
- Defining Applications
- SMAP Products and Applications

National Research Council Decadal Survey

- Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond

- *However, the compelling need for measurements in support of human health and safety and for documenting, forecasting, and mitigating changes on Earth creates a continuum between science and applications—illustrating again the need for multiple agencies to be intimately involved in the development of Earth science and applications from space.*

- *The declarations call for a renewal of the national commitment to a program of Earth observations in which attention to securing practical benefits for humankind plays an equal role with the quest to acquire new knowledge about the Earth system.*

NASA Applied Sciences Program

9 Areas of Societal Benefit

- Weather forecasting
- Reduce loss of life and property damage from disasters
- Understand assess, predict mitigate and adapt to climate variability
- Support sustainable agriculture and forestry and combat land degradation,
- Understand the effect of environmental factors on human health and well being
- Develop the capacity to make ecological forecasts
- Protect and monitor water resources
- Monitor and manage energy resource

Society

Science Data Developer

- Extended time in implementing products
- Challenges with data (access latency, use, size, format, structure)
- Disconnect with organization's present day goals

What are *applications?*

Applications help hazard mitigation and decision-making in government, private, and civic institutions working to reduce its impact on human wellbeing.

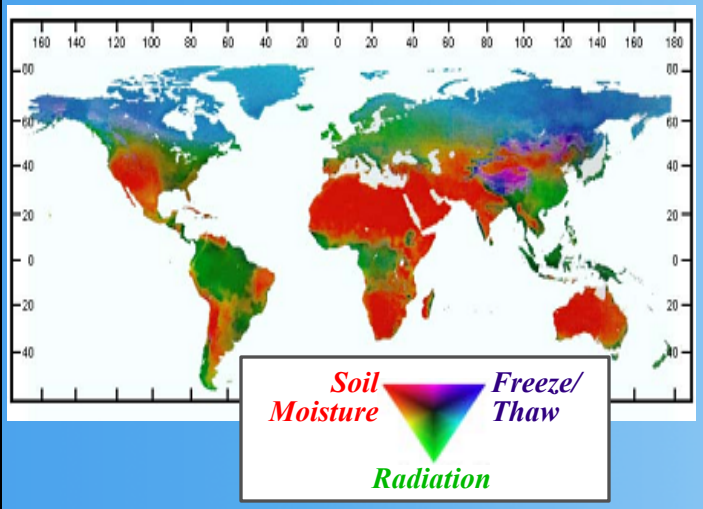
Producing science *is not enough*, products must have a link to societal benefits and demonstrate value to users.

"The high-resolution data gleaned from VIIRS are available in a short time period and significantly enhance the Forest Service's current strategic fire detection and monitoring capabilities." Brad Quayle, U.S. Forest Service

NASA's Soil Moisture Active Passive (SMAP) Mission

Soil Moisture Active Passive (SMAP) Mission

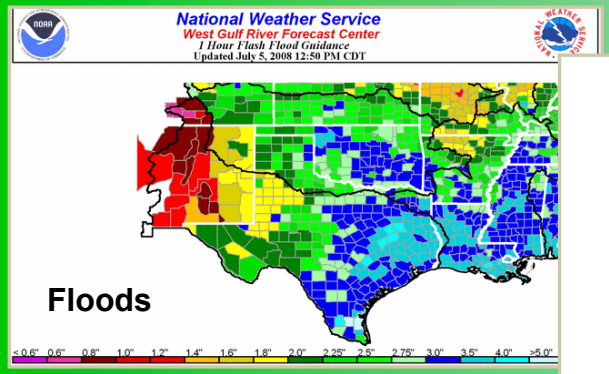
Science Returns

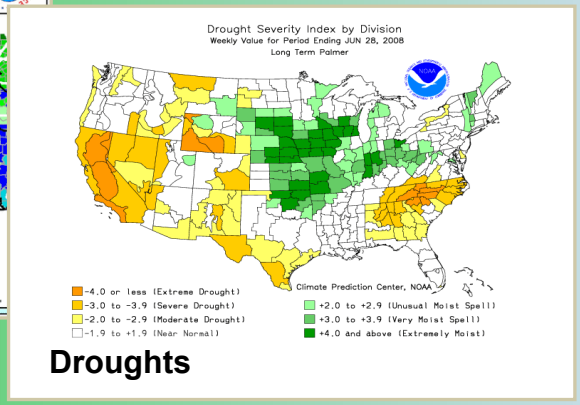


1. Estimating global surface water and energy fluxes
2. Quantifying net carbon flux in boreal landscapes
3. Reduce uncertainty of climate model projections

L-band (~21 cm; All-Weather; Canopy Penetration; Sensing Depth)

Applications Returns





4. Enhancing weather forecasts
5. Improving flood prediction and drought monitoring

6m conically scanning (14 rpm) antenna for 1000 km swath

Global coverage every 2-3 days

All products ARL-9

SMAP Measurement Approach

Instruments:

Only July 7 the SMAP radar stopped transmitting due to a power supply problem.

The radar subsystem is no longer operable.
The radiometer continues to produce science data.

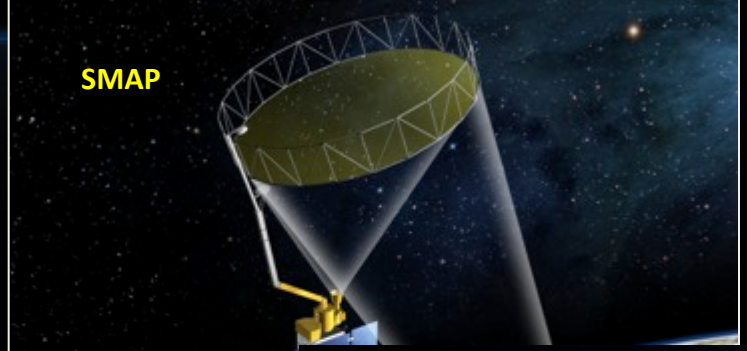
- **Radiometer: L-band (1.4 GHz)**
  - Moderate resolution, high accuracy soil moisture
  - 40 km resolution (3dB) resolution

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

- 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 (enough fuel for 5 year)

SMAP Lessons Learned



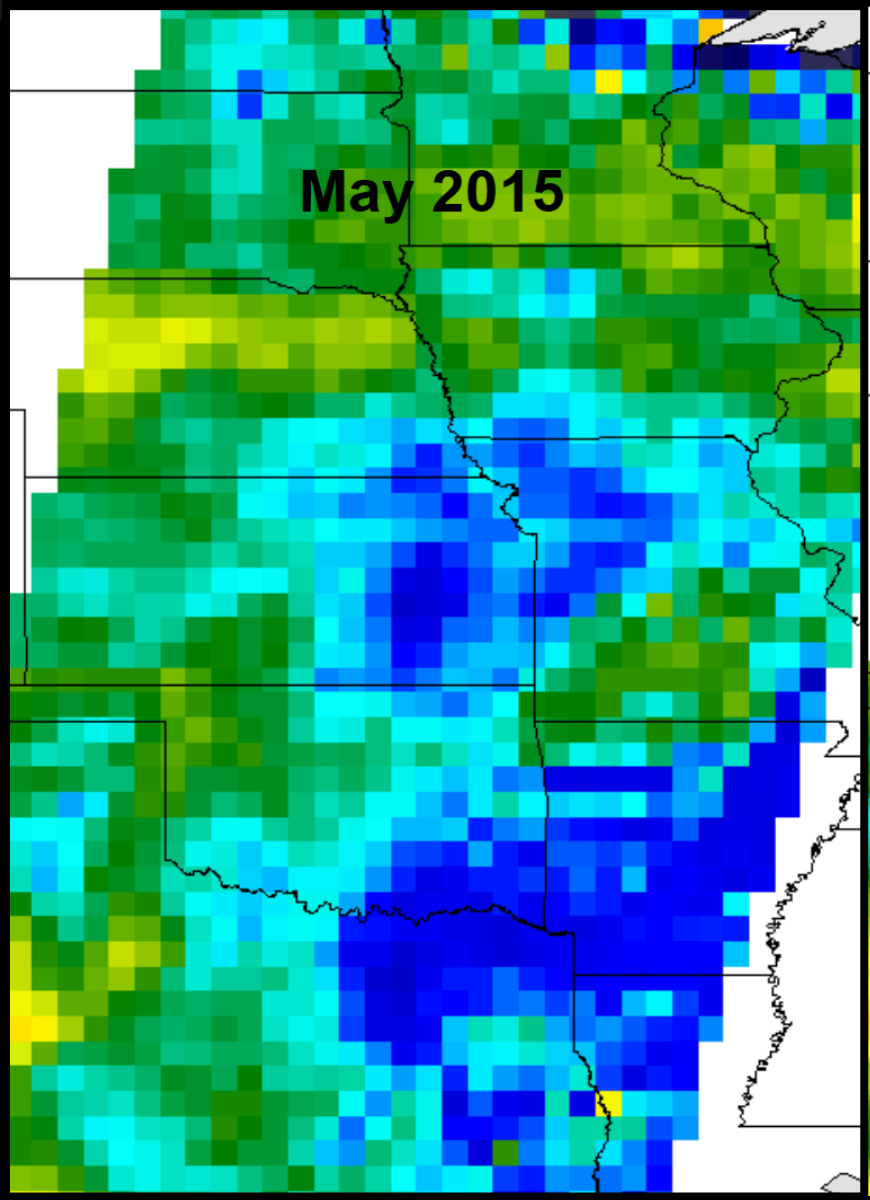
- Improved RFI challenges learned from SMOS (Soil Moisture Ocean Salinity Satellite from ESA)
- High Resolution and High accuracy products because of the combined radar radiometer
- Using L-band
  - Improvement from C-Band instruments (SMMR)
  - Deeper soil penetration (from 1cm to 5 cm)
  - Better sensing over vegetated areas

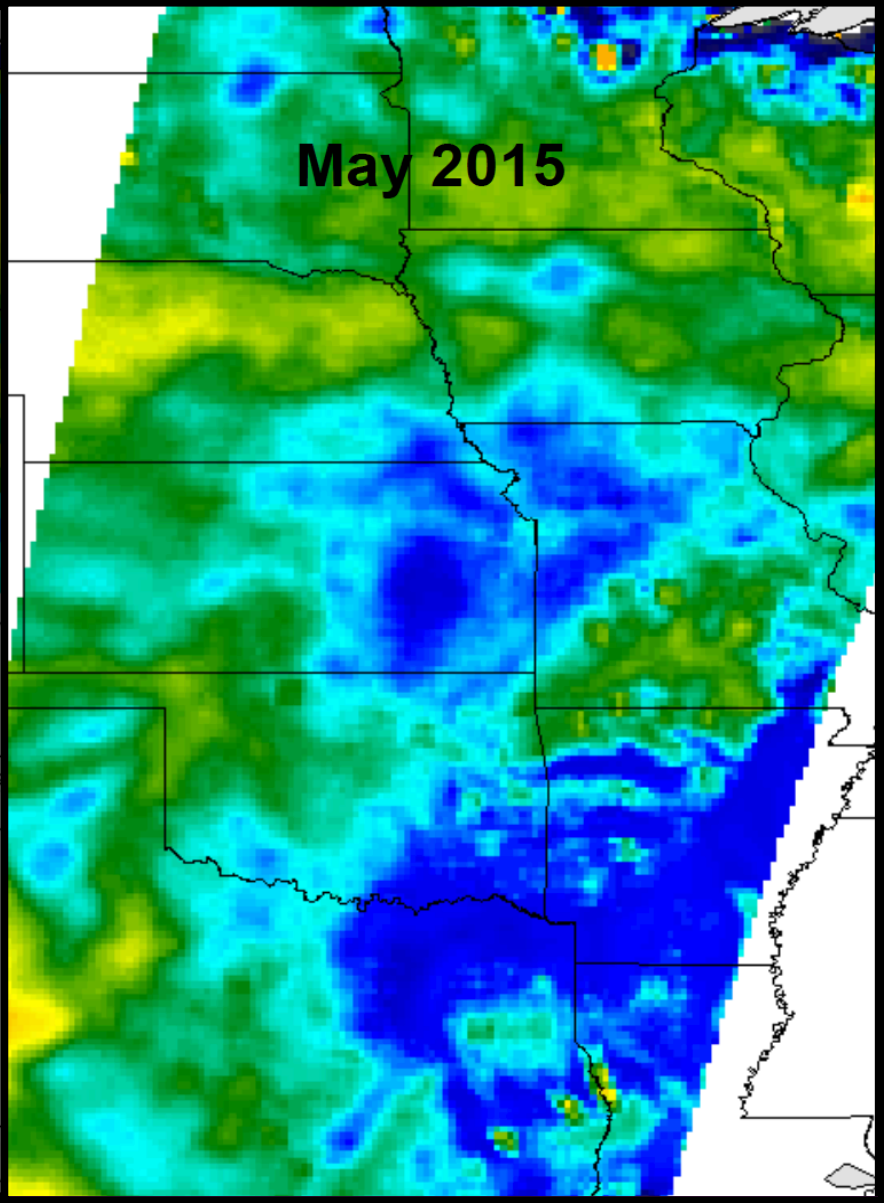
- Fixed incident angle (40 degrees) for improved sensing over vegetation.
- Conical scan, Contiguous 1000 km swath 2-3 days revisit
- Working with SMOS mission for continuity of soil moisture applications

SMAP Mission Products

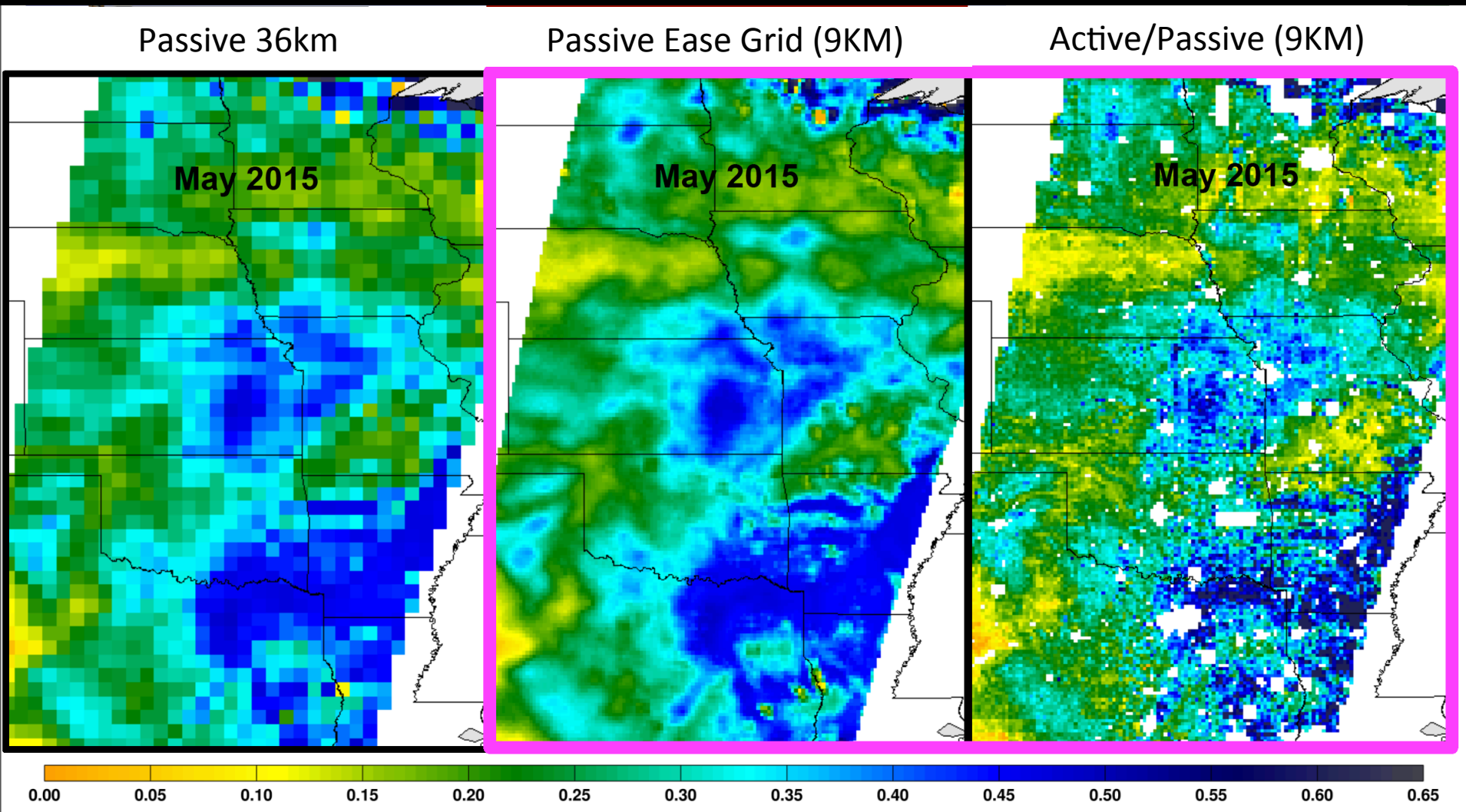
Product	Description	Gridding (Resolution)	Latency**	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1B_TB	Radiometer T_B in Time-Order	(36x47 km)	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_P	Soil Moisture (Radiometer)	36 km	24 hrs	Science Data (Half-Orbit)
L3_SM_P	Soil Moisture (Radiometer)	36 km	50 hrs	Science Data (Daily Composite)
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	

SMAP Enhanced Products



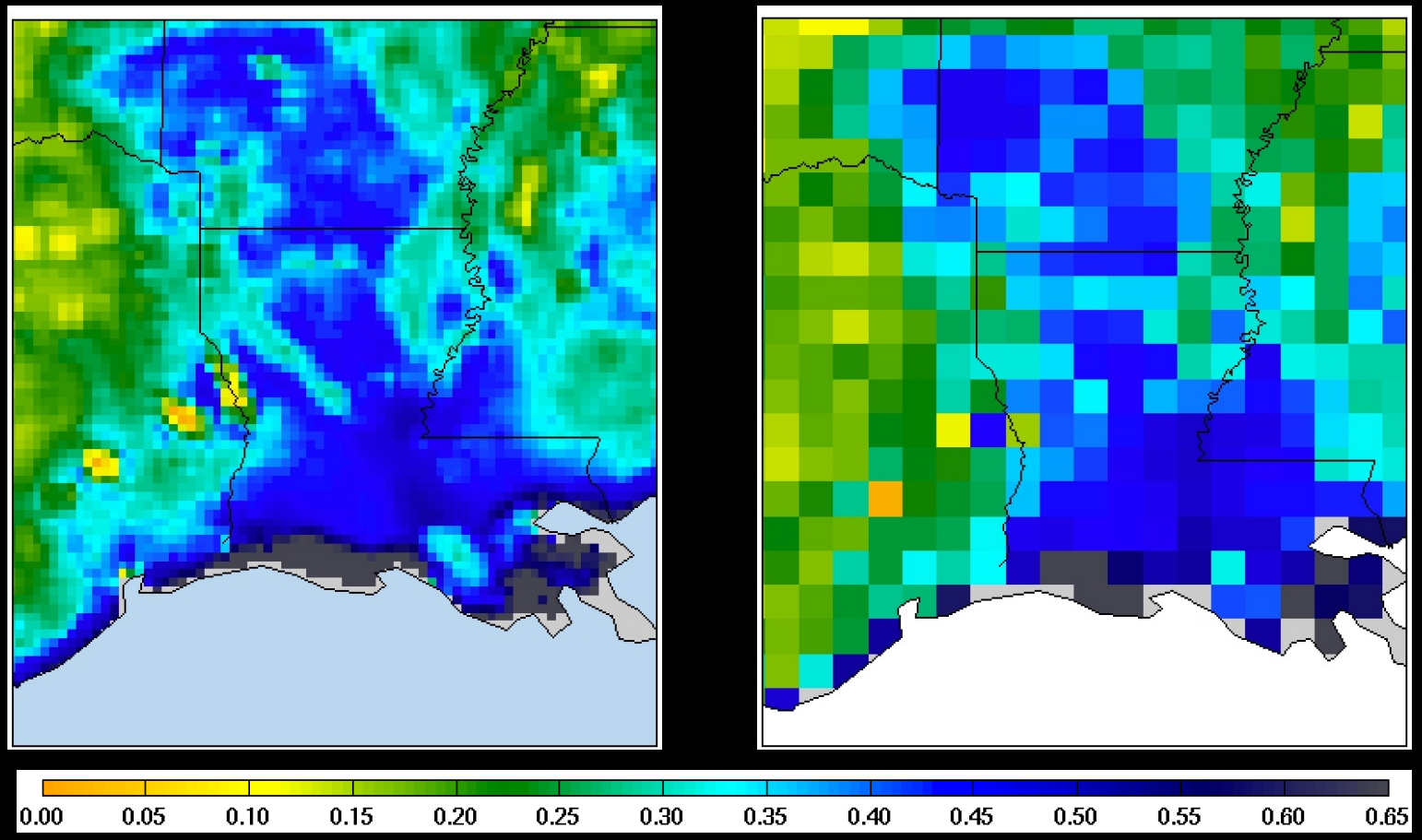


1. SMAP Enhanced Processing For Radiometer



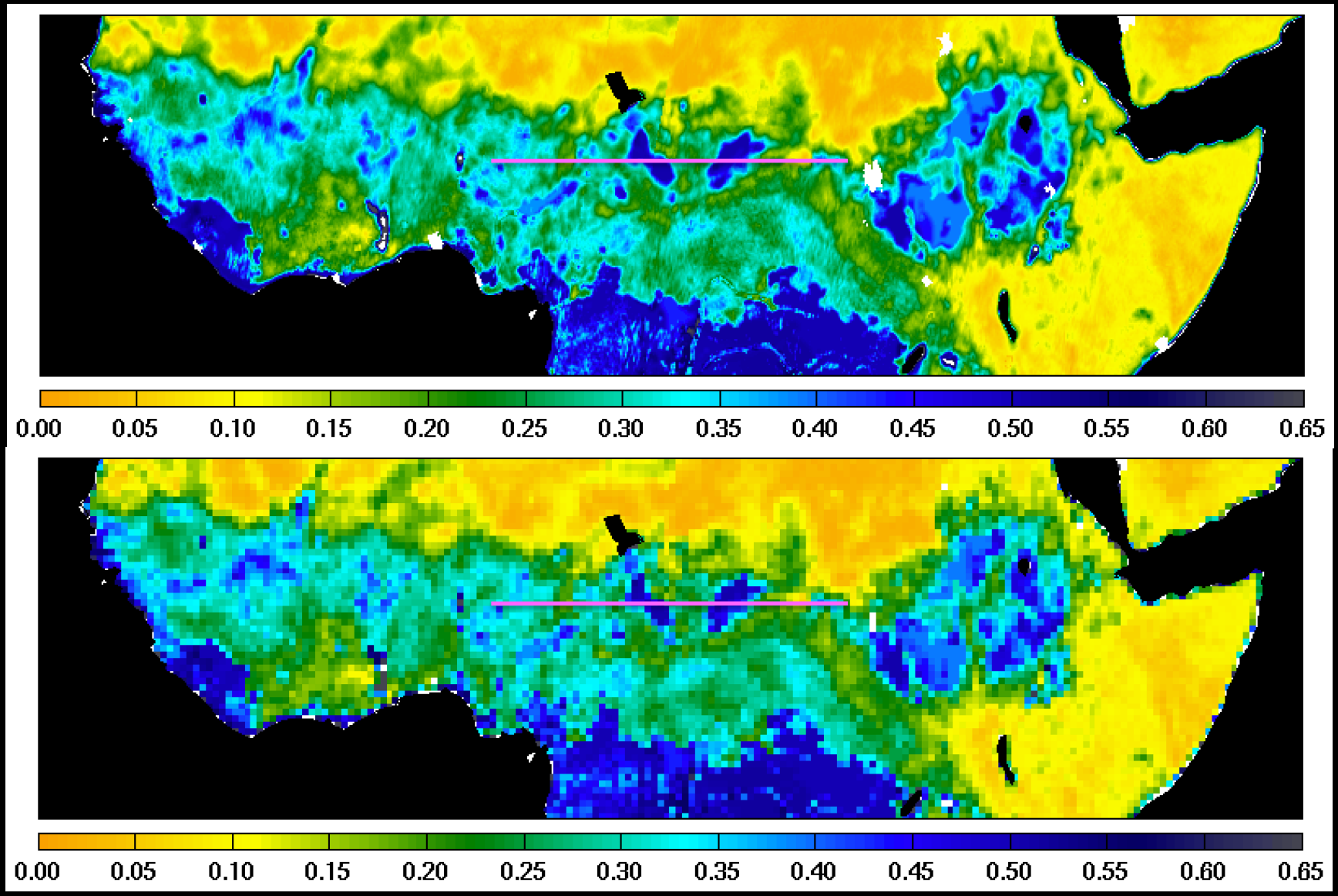
Passive retrieval on FG (middle) reveals spatial features not apparent in the current standard product (left); these features are nonetheless consistent with what the A/P product (right) demonstrated prior to radar failure

1. SMAP Enhanced Processing For Radiometer



1. SMAP Enhanced Processing For Radiometer

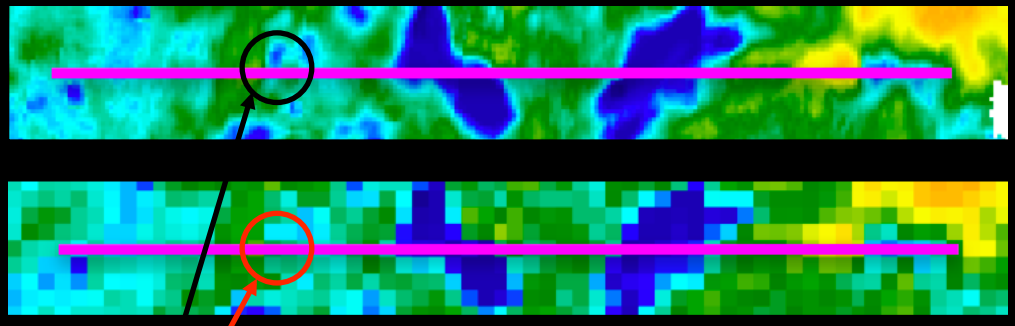
soil moisture variability along transect

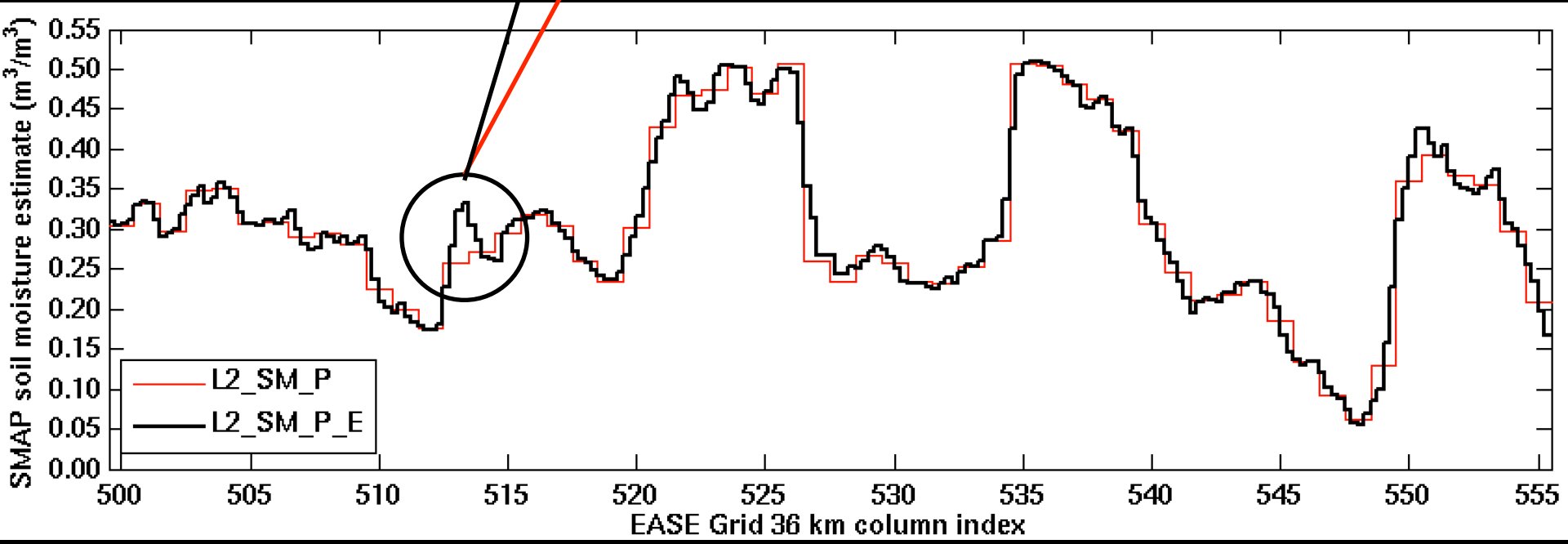


1. SMAP Enhanced Processing For Radiometer

soil moisture variability along transect

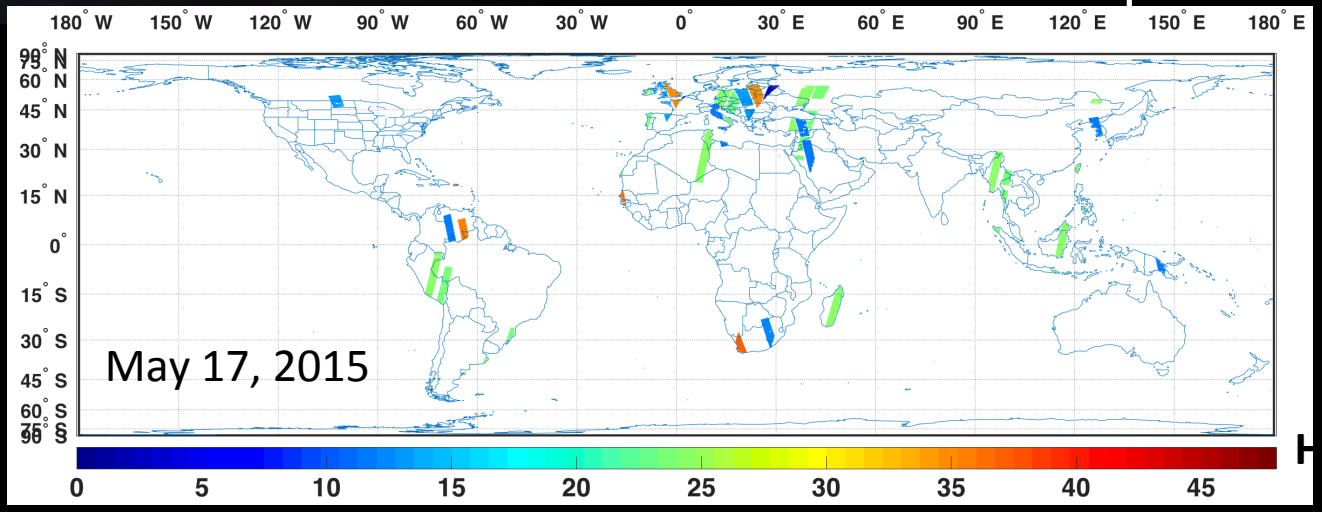
The enhanced product displays more visible spatial features than the standard product.
An example is shown in the highlighted area where the enhanced product captures a peak but the standard product doesn't.



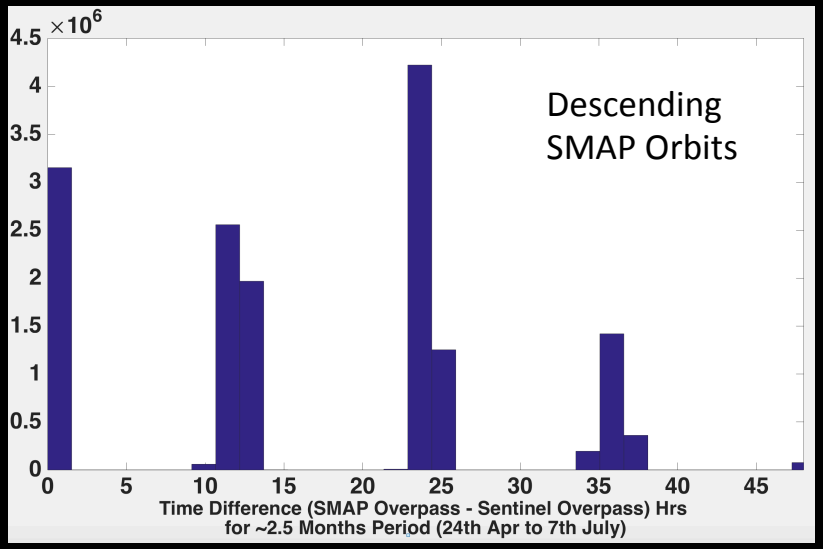


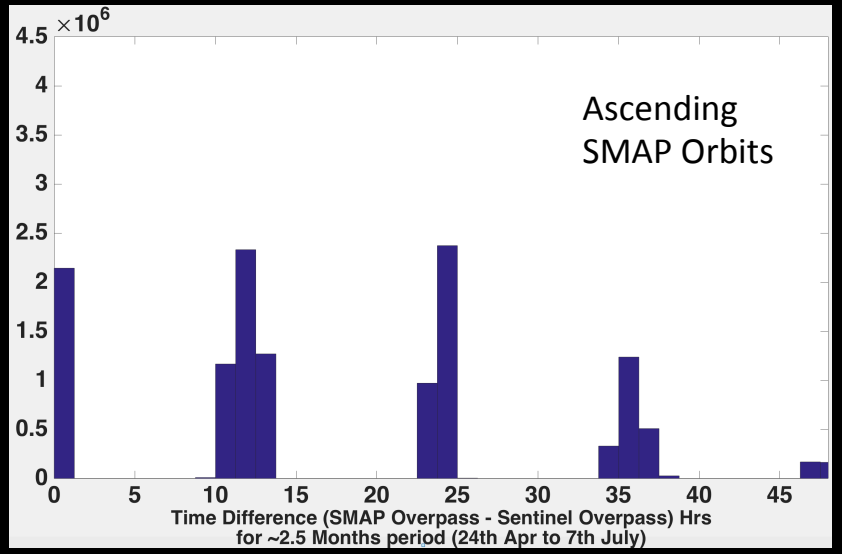
2. SMAP-Sentinel Active-Passive Product

SMAP and Sentinel Global Overlap



With the current orbits characteristics of SMAP and Sentinel the average time difference is ~18 hours that includes the Sentinel Asc. and Des. Overpasses for any given SMAP swath.





2. SMAP-Sentinel Active-Passive Product

Why Sentinel for AP Algorithm

Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Agency	Canadian Space Program (CSP)	European Space Agency (ESA)	Indian Space Research Organization (ISRO)
Instrument	C-band SAR (5.4 GHz)	C-band SAR (5.4 GHz)	C-band SAR (5.35 GHz)
Incidence Angle	Side-looking, 15-45° off-nadir	Side-looking, 15-45° off-nadir	36.85 deg.
Polarization	HH, HV, VV and VH	(VV and VH) or (HH and HV)	HH an HV
Sensor Height at Equator	798 km	693 km	542 km
Orbit	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)	Sun Synchronous (dusk/dawn)
Revisit time (Orbit Repeat cycle)	24 days	12days	25 days
Resolution	100 m	5 m X 20 m	~25 meters
Swath Width	500 km (ScanSAR mode)	250 km (IWS mode)	115 km (MRS)
Mean local time	6:00 AM Descending	6:00 AM Descending	6:00 AM
Launch	Dec 14th, 2007	April 3rd, 2014	April 26th, 2012
Planned Lifetime	7 years minimum	7 years	5 years

2. SMAP-Sentinel Active-Passive Product

Why Sentinel for AP Algorithm

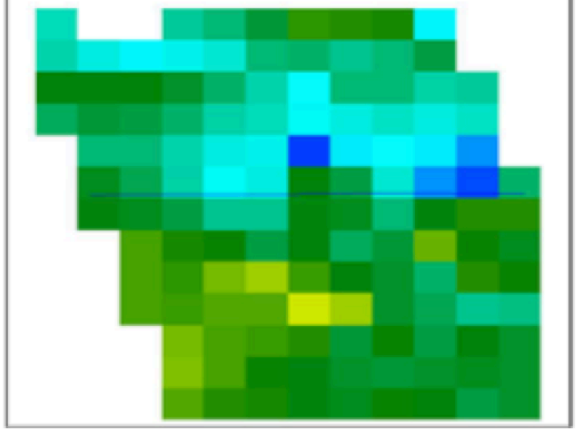
Sensor Name	RADARSAT-2	Sentinel-1A	RISAT-1
Current Data Access	Cost $$$	**Free**	Cost $$$
Future addition to mission	No	Yes-Launched April 2016	No

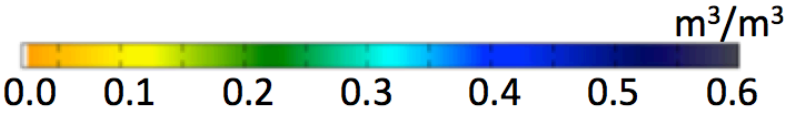
Recommendation is to use Sentinel data because:

- *it is free*
- *has better revisit interval*
- *has the required co-pol and x-pol measurements.*
- *With Sentinel-1B, the revisit interval will improve and have global coverage every 6 days.*

SMAP-only Passive Product

Retrieved Soil Moisture 36 km

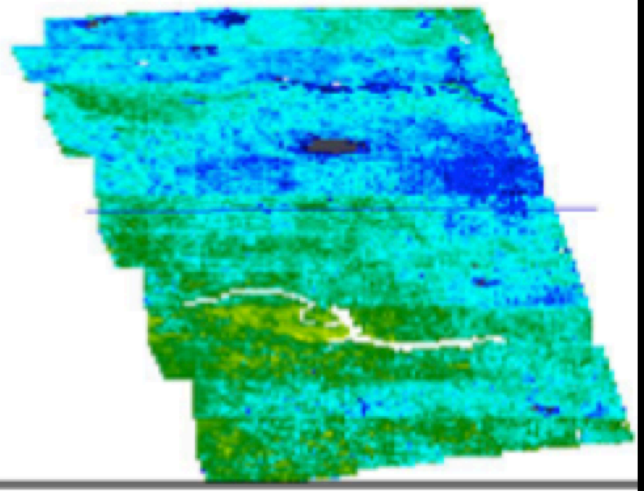




Soil Moisture at Different Resolutions
Retrieved for May 17th, 2015
Over Manitoba region Canada

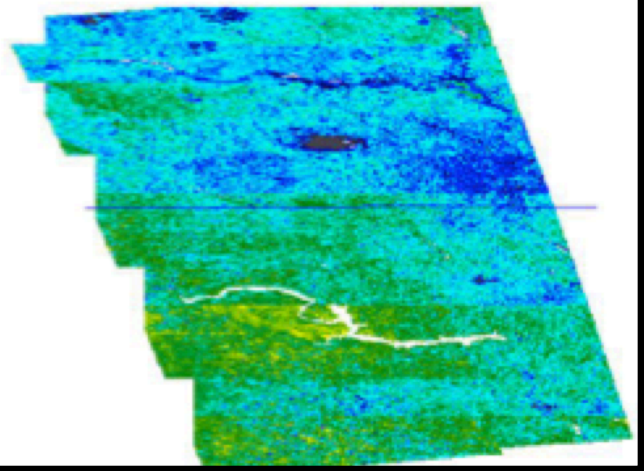
SMAP-Sentinel Active-Passive Product

Retrieved Soil Moisture 3 km



SMAP-Sentinel Active-Passive Product

Retrieved Soil Moisture 1 km



Enhanced Product Suite

Product	Description	Gridding (Resolution)	Latency	Data Type
L1A_Radiometer	**Radiometer Data in Time Order**	**-**	**12 hrs**	Instrument Data
L1A_Radar	Radar Data in Time Order	-	12 hrs	
L1B_TB	**Radiometer T_B in Time Order**	**(36 x 47 km)**	**12 hrs**	
L1B_S0_LoRes	Low Resolution Radar σ_0 in Time Order	(5 x 30 km)	12 hrs	
L1C_S0_HiRes	High Resolution Radar σ_0 on EASE Grid 2.0	1 km (1 – 3 km)	12 hrs	
L1C_TB	**Radiometer T_B on EASE Grid 2.0**	**36 km**	**12 hrs**	
L1C_TB_E (★)	**Radiometer T_B on EASE Grid 2.0 (Enhanced)**	**9 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_P_E (★)	**Soil Moisture (Radiometer, Enhanced)**	**9 km**	**24 hrs**	
L2_SM_AP	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L2_SM_SP (★★)	**Soil Moisture (Sentinel Radar + Radiometer)**	**3 km**	**Best effort**	
L3_FT_A	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_FT_P	**Freeze/Thaw State (Radiometer)**	**36 km**	**50 hrs**	
L3_FT_P_E (★)	**Freeze/Thaw State (Radiometer, Enhanced)**	**9 km**	**50 hrs**	
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P	**Soil Moisture (Radiometer)**	**36 km**	**50 hrs**	
L3_SM_P_E (★)	**Soil Moisture (Radiometer, Enhanced)**	**9 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**	

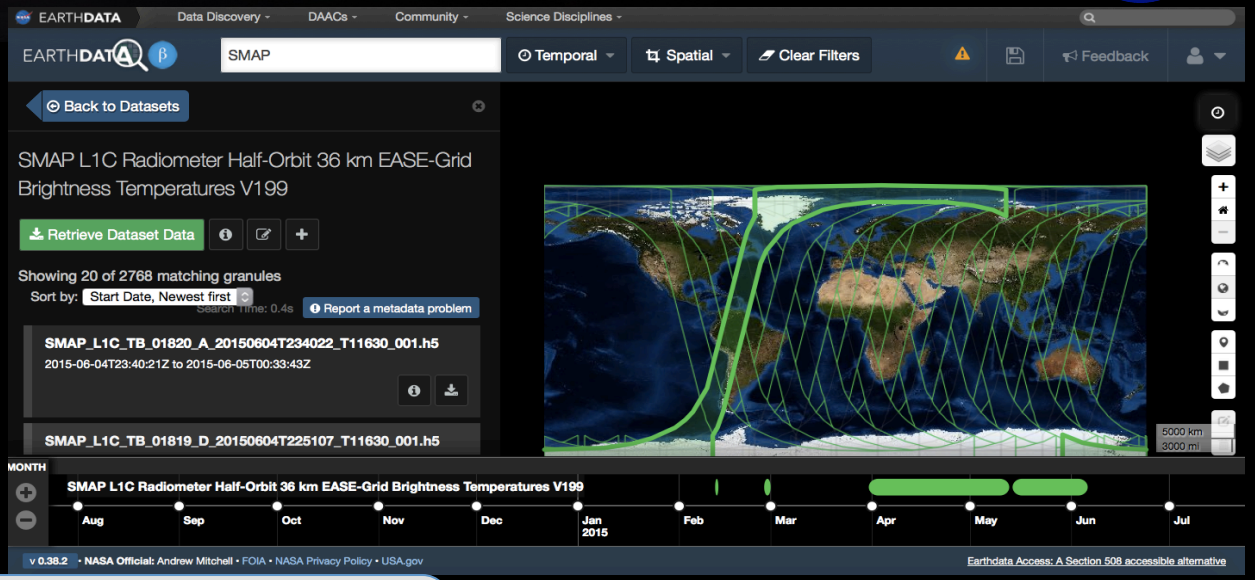
★ Radiometer-based enhanced products were released in Dec 2016
★★ SMAP/Sentinel product to be released in mid-2017

Where to get the data?

Accessing SMAP Data

NSIDC.org/data/smap

ASF.alaska.edu/smap/



Direct Data Access

HTTPS

- Requires login with a NASA Earthdata username
- https://n5eil01u.ecs.nsidc.org/SMAP/

OPeNDAP

- Provides subsetting and reformatting
- Access to data files using Matlab and ArcGIS
- http://n5eil01u.ecs.nsidc.org/opendap/SMAP/

FTP

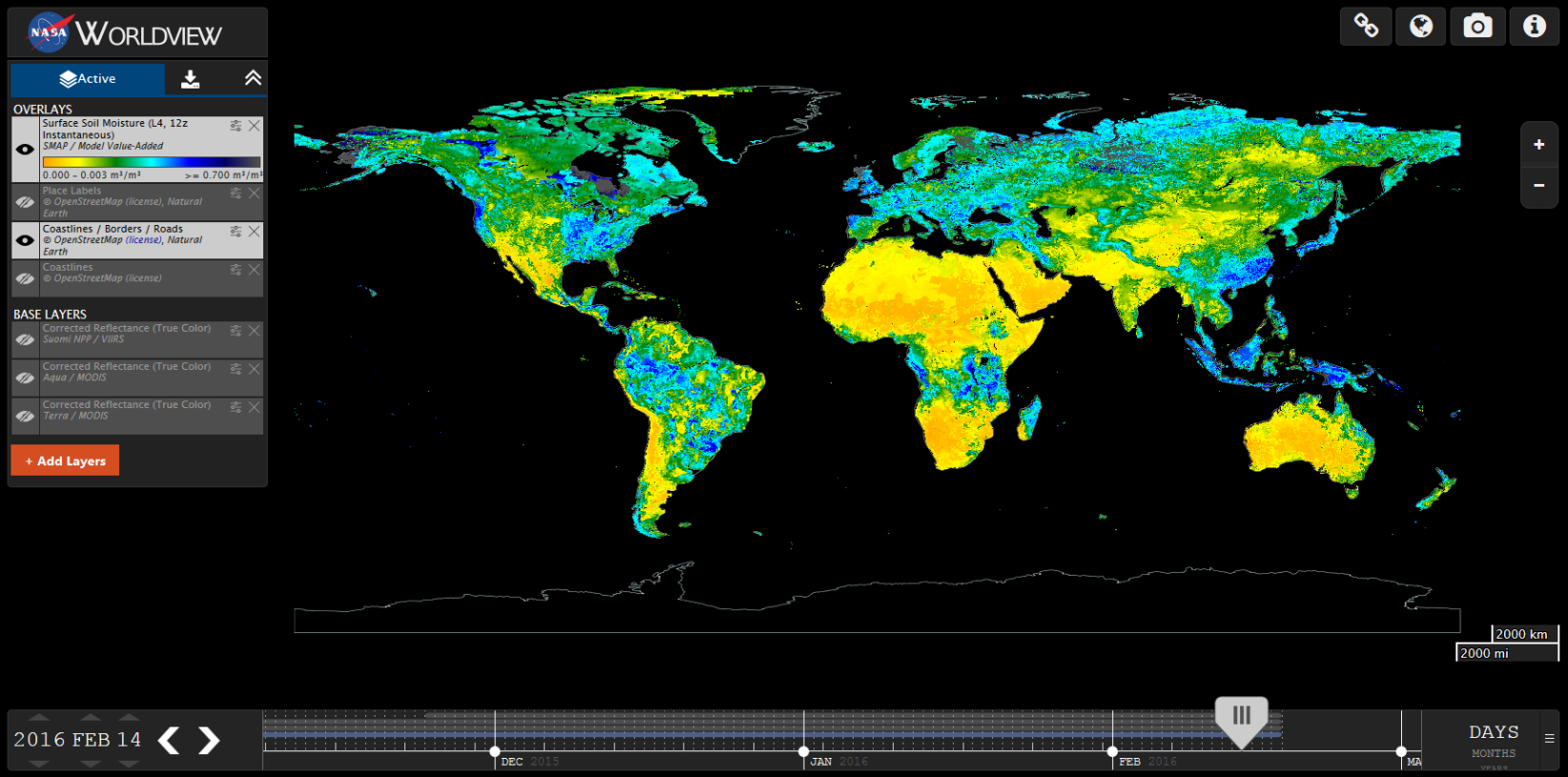
- Likely retired in late 2016
- ftp://n5eil01u.ecs.nsidc.org/SAN/SMAP/

Search & Order

SMAP data distributed by ASF and NSIDC DAACs, as well as all NASA Earth Science data, can be discovered and downloaded in the NASA Reverb and Earthdata Search clients.

http://reverb.echo.nasa.gov
https://search.earthdata.nasa.gov

Visualizing SMAP Data



The NASA Worldview client provides interactive browse and download of full-resolution NASA imagery as well as access to the source data.

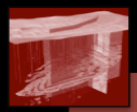
SMAP parameters and quality flags are available as imagery layers in Worldview.

http://earthdata.nasa.gov/labs/worldview

SMAP Data Services

On-Demand Data Services

- Available for Level 1C radiometer, Level 2, 3 and 4 products
- Access through Reverb and Earthdata Search



Subset

- Parameter
- Spatial area

Reformat

- KML
- GeoTIFF
- ASCII
- NetCDF
- HDF-EOS

Reproject

- Geographic
- Lambert
- Polar Stereo
- State Plane
- Transverse Mercator
- UTM

Tools

- Links to HDFView, EASE-Grid tools, and Panoply
- Sample Matlab, Python, IDL, and NCL code from the HDF Group.

User Support

- FAQs & How Tos
- Personalized support for data users with SMAP data and tools.
  - **https://nsidc.org/data/smap**
  - Email: **nsidc@nsidc.org**


UAF
UNIVERSITY OF ALASKA FAIRBANKS
EXELIS
Visual Information Solutions
CUNY The City University of New York
AIR FORCE WEATHER AGENCY
NASS
UNIVERSITE CHOUAIB DOUKKALI
NCEP
TAM
BOISE STATE UNIVERSITY
NCFC
USGS
flire
SPORT
COLUMBIA UNIVERSITY
Dartmouth Flood Observatory
AGRISOLUM LIMITED
CONNECTING FARMERS
NORTH CENTRAL CLIMATE SCIENCE CENTER
UNIVERSITY CONSORTIUM
NATIONAL WEATHER SERVICE
irpi
Agriculture and Agri-Food Canada
PROTEZIONE CIVILE
Willis
YorkshireWater
WFP
World Food Programme
CSIRO
52 SMAP Early Adopters are Spanning Agriculture, Weather, Emergency Response, Human Health, and Military Readiness
UH
ECMWF
aer
Atmospheric and Environmental Research
Universität Bremen
Canadian Ice Service
Service canadien des glaces
NYC Environmental Protection
Google
TOCKLAI
National Drought Mitigation Center
StormCenter COMMUNICATIONS, INC.
NM STATE
IRI
uae
Environment Canada
USDA
FOREIGN AGRICULTURAL SERVICE
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE
HRC
LOCKHEED MARTIN
ALTEC
OHIO STATE
Integra
UNIVERSITY OF MARYLAND
18
56
NH
UNC
INSTITUTE FOR THE ENVIRONMENT
NESDIS
National Environmental Satellite, Data and Information Service
CRREL
Georgia Tech
JOHN DEERE

What is an Early Adopter?

- A subset of volunteers from the mission's Community of Practice
- Given access to pre- and post-launch data streams and conduct applications demonstrations in collaboration with the science team member.
- The selection process may be through a competitive, peer-reviewed NASA announcement of opportunity as was done for the science definition team, or a more informal process.

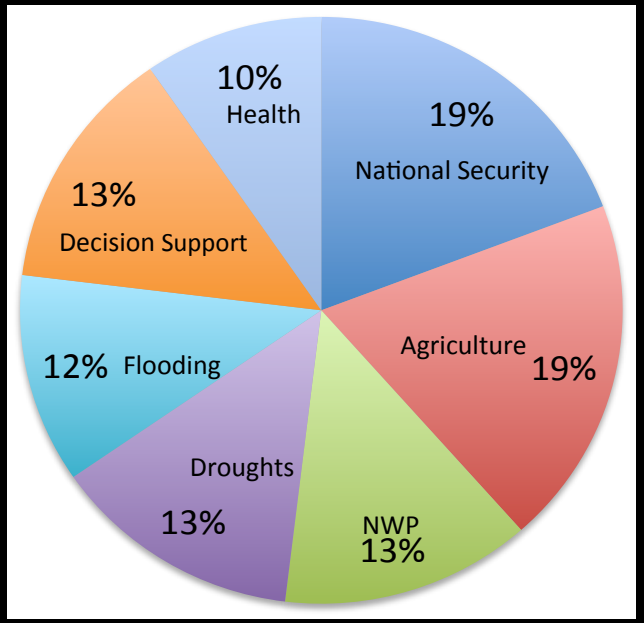
Early Adopters' feedback and engagement provides a link to science development, that helps a product move from a research effort…

…to a user friendly decision support system

SMAP Science and Application Returns

What was Designed

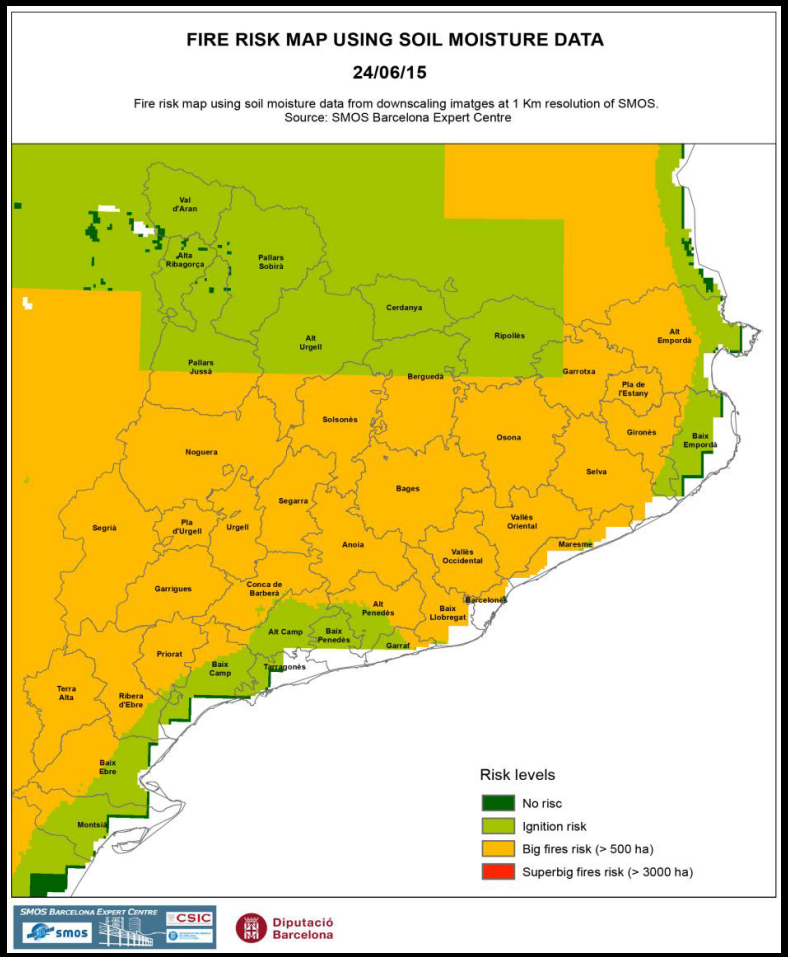
- SMAP Product suite developed to an **ARL-9**
- Intended to satisfy 5 areas of applications (agriculture, weather, drought, flood, health)
- HDF-5 Format

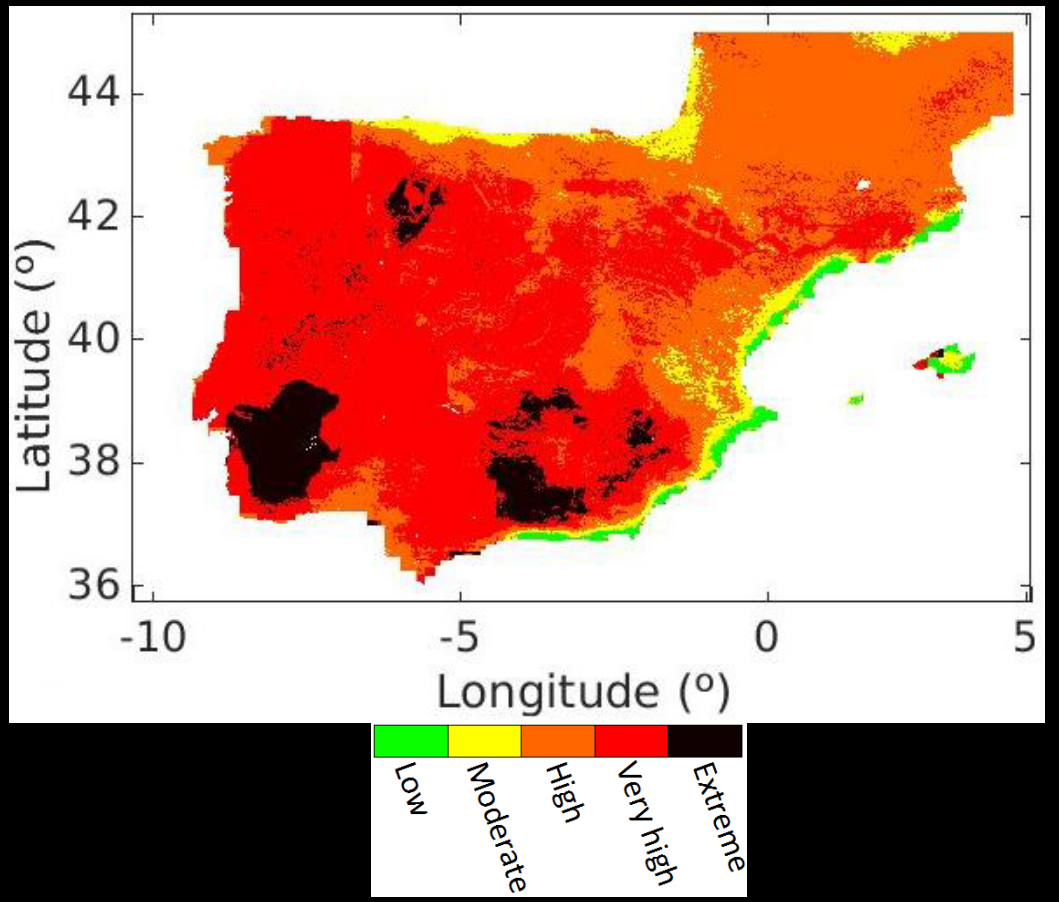


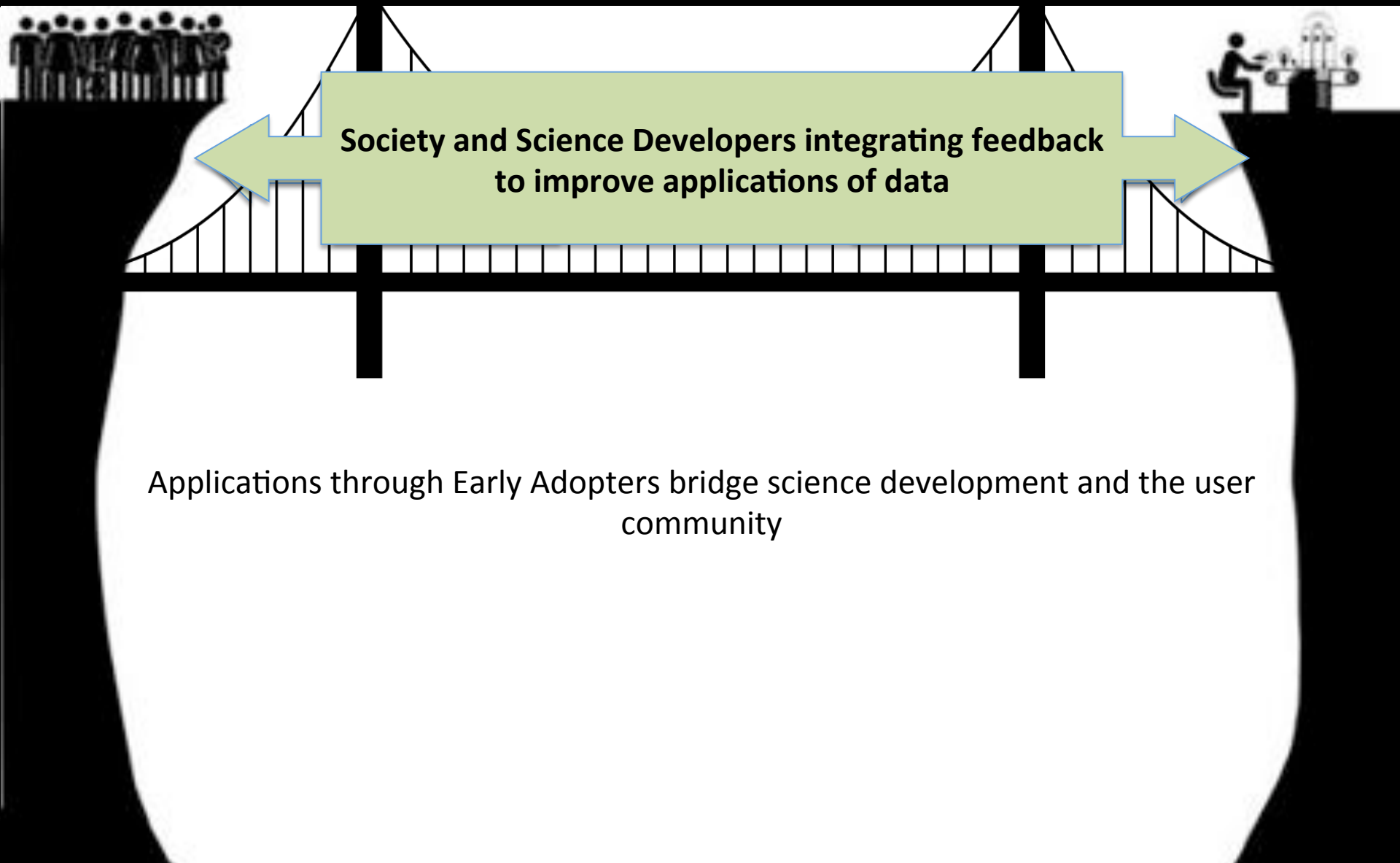
What's actually happening post launch

- Users of SMAP data **average ARL5-6** due to testing SMAP products in through their organizational processes and needs.
- Most demanded Format KMZ and GEOTiffs
- Satisfy over 10 areas of applications

Improving Forest Fire Risk Maps, Maria Piles- Barcelona Expert Center, ICM/CSIC, UPC







Applications through Early Adopters bridge science development and the user community

Upcoming SMAP Applications Event

5th SMAP Applications Workshop hosted by Brad Quayle and the USDA-USFS

May 2018

More details forthcoming!

Thank you for your attention!

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