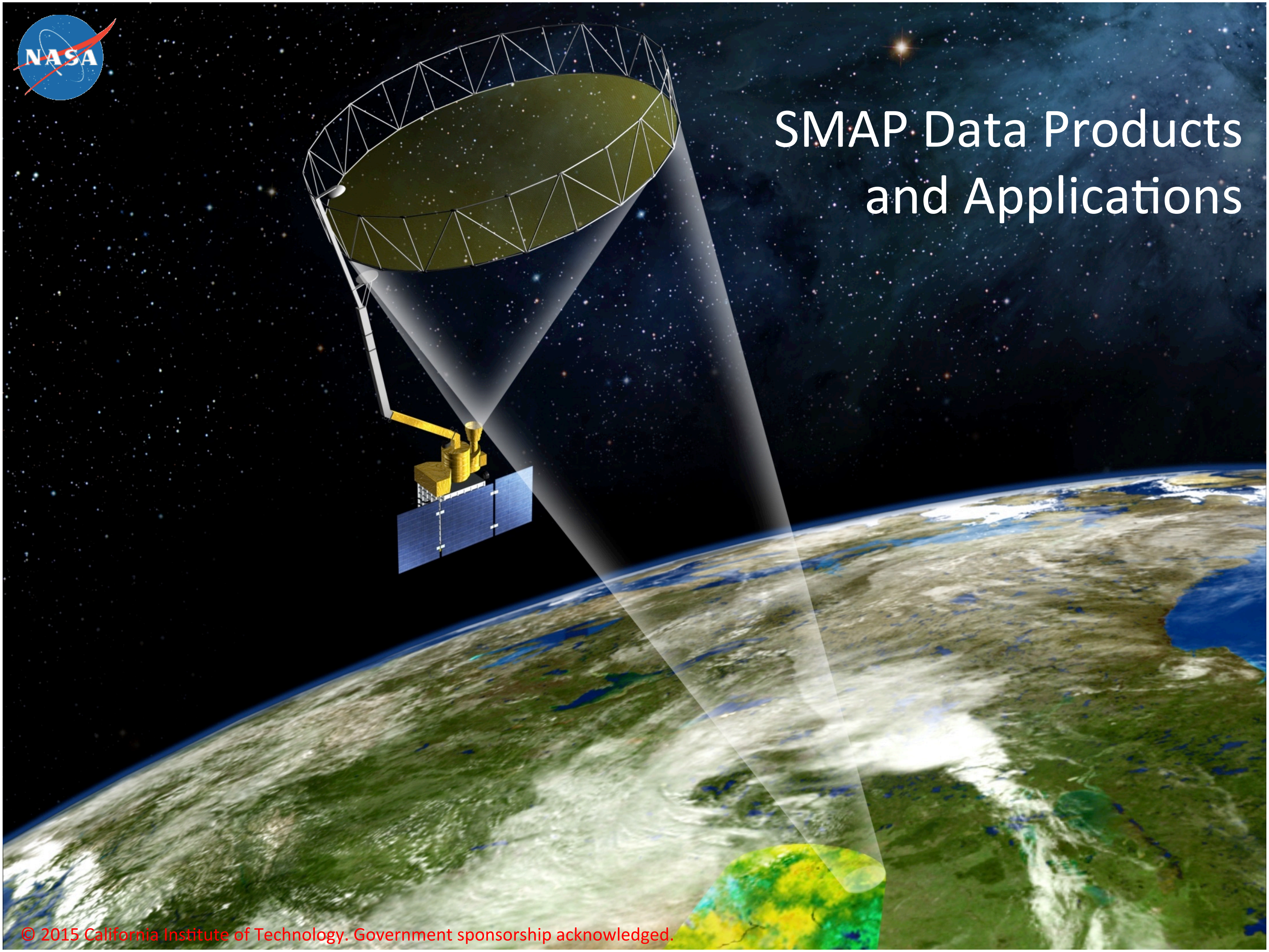
SMAP Data Products and Applications



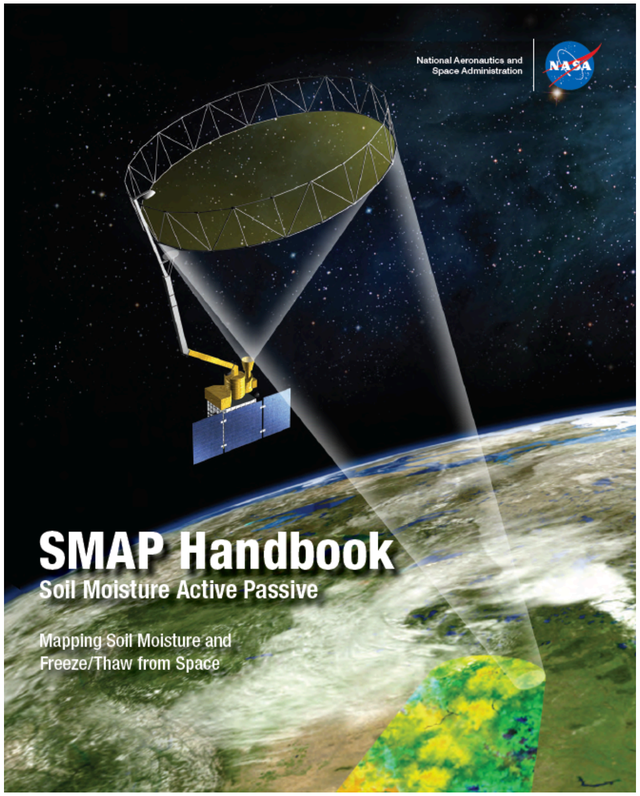
Outline

Contents:

1. Overview and Mission Objectives
2. Instruments (radar and radiometer)
3. Retrieval Algorithms
4. Data Products
5. Calibration/Validation
6. Applications

- Details provided in SMAP Handbook

- Credits: *SMAP Project Team*
  SMAP Science Team



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

Entekhabi, D. et al., "SMAP Handbook," *JPL Publication JPL 400-1567*, Jet Propulsion Laboratory, Pasadena, California, 182 pages, July 2014.

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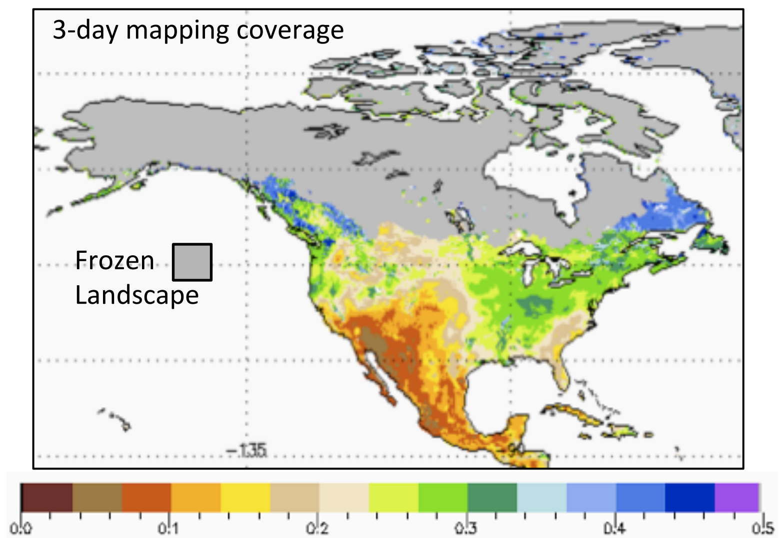
What Is SMAP?

- SMAP is the Soil Moisture Active Passive mission, a NASA Earth science mission
- SMAP's science objective is to provide high-resolution, frequent-revisit, global observations of soil moisture and 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

__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 soil and vegetation



Surface soil moisture [cm^3/cm^3]

SMAP was initiated in 2008 in response to recommendations of the NRC Earth Science Decadal Survey (2007) and was launched in January 31, 2015

NASA Earth Observing Satellite Fleet

Courtesy of the NASA Goddard Visualization Lab

ID_004

Why Soil Moisture?

Enhanced weather & climate forecasting

Improved agricultural productivity and crop yield predictions

Drought monitoring and early warning

Flood monitoring and prediction

Human health and vector borne diseases

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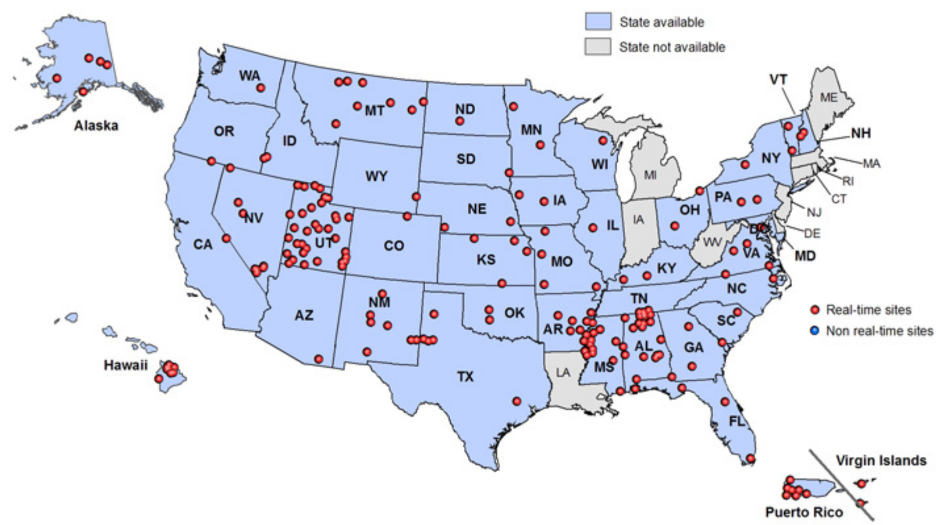
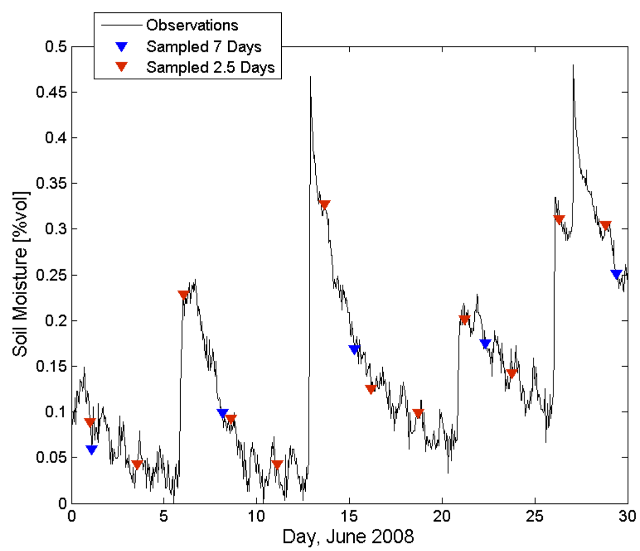
Why Measure from Space?

SMAP provides a capability for global observations of soil moisture and its frozen or thawed state with high spatial resolution and frequent temporal revisit

- Current ground measurements of soil moisture are sparse and have limited global coverage
- Previous space missions have relatively low soil moisture accuracy, resolution, and coverage
- **SMAP provides 10-40 km spatial resolution, 3-day global revisit, accuracy of 0.04 m^3/m^3**



Current network of USDA/SCAN in situ soil moisture sensors

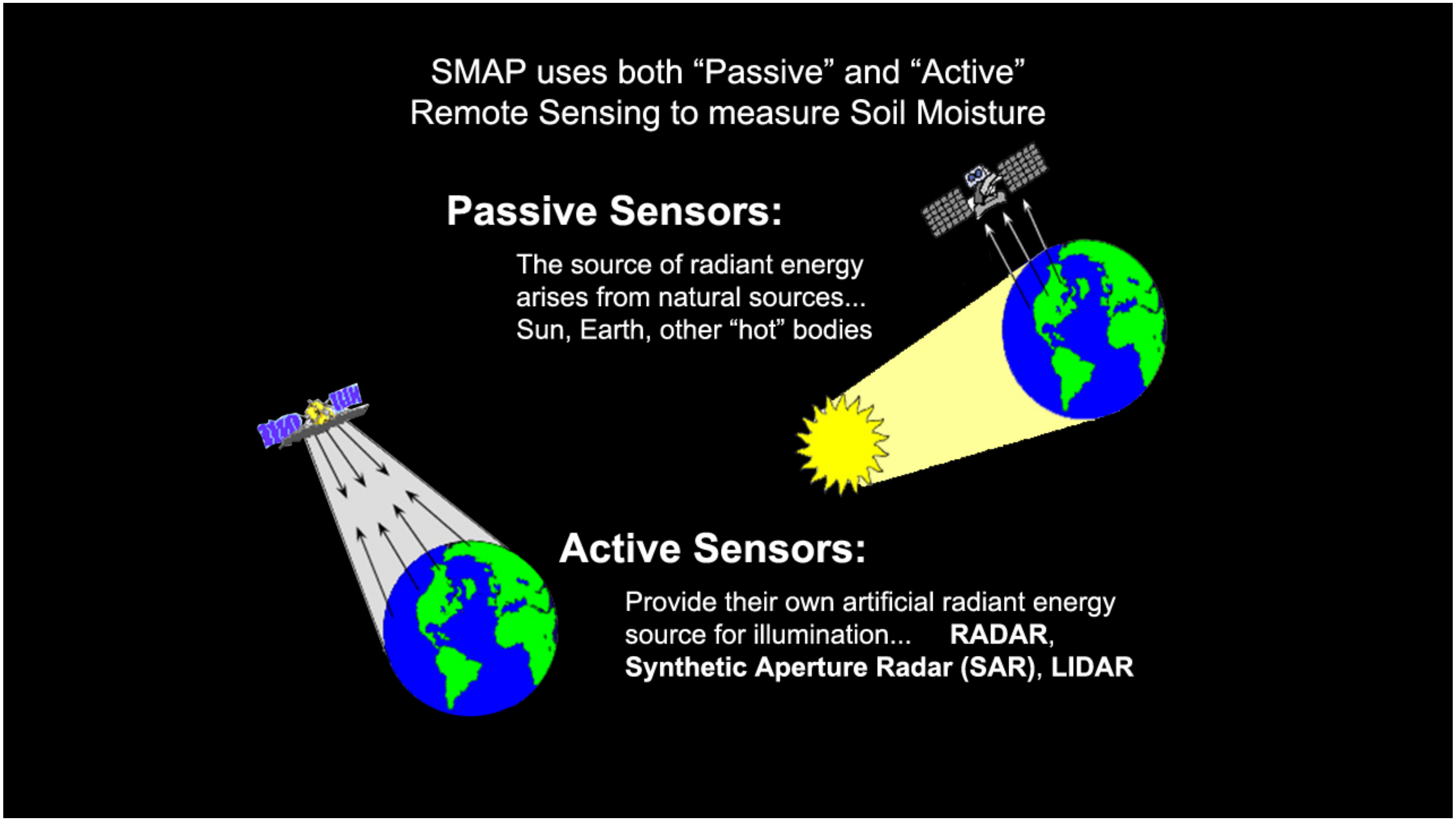


Inter-storm soil moisture dry-down

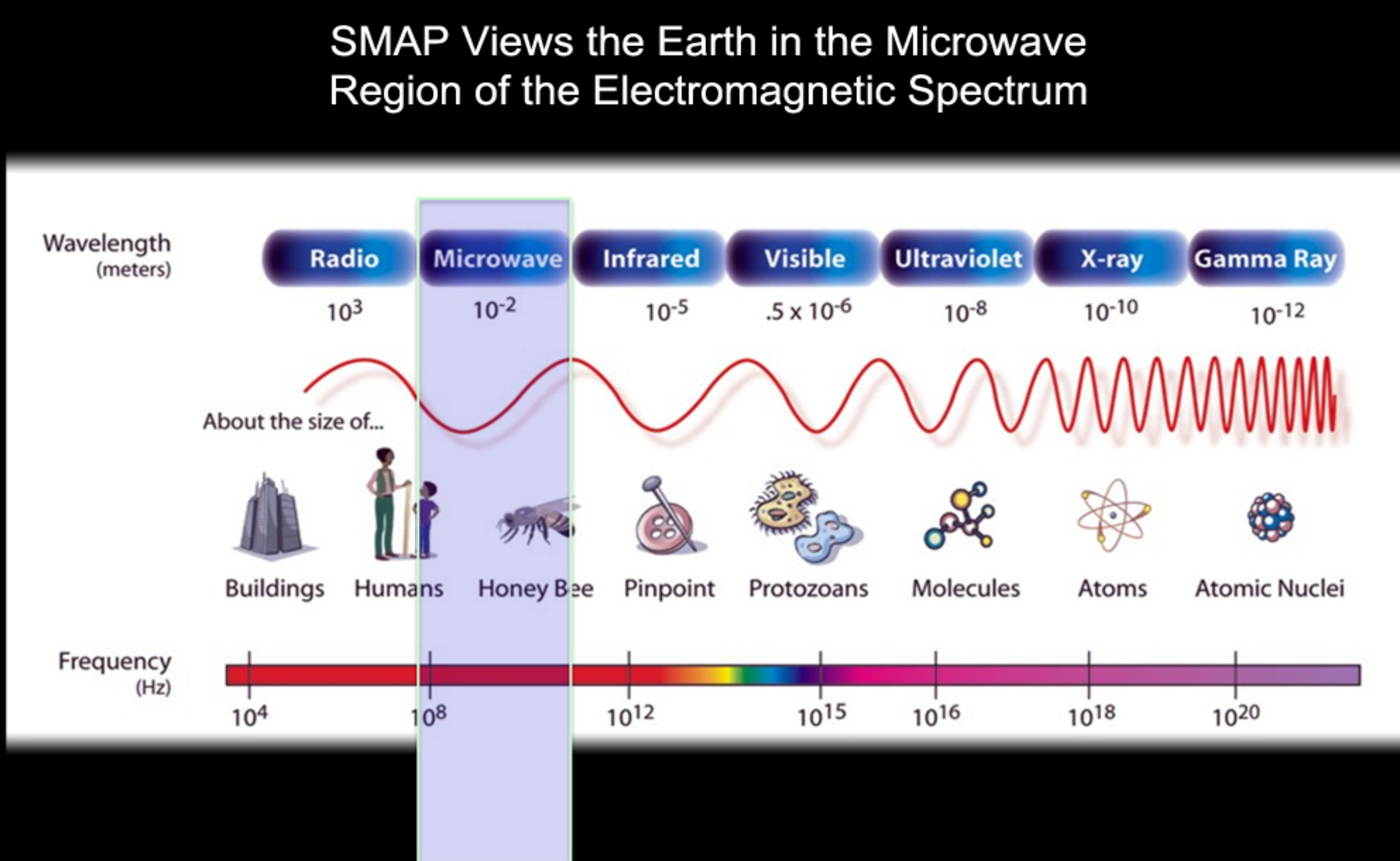
[Sun et al. (2006): How often does it rain?, *J. Climate, **19***]

- Average inter-storm period implies 3-day sampling or better is required to resolve soil moisture variability

Why Active and Passive?



Measurement Frequency



- With optical and infrared wavelength sensors the soil is masked by clouds and vegetation
  Also, optical sensors operate by measuring scattered sunlight and are “daytime only”
- Microwaves can penetrate through clouds and vegetation, operate day and night, and are highly sensitive to the water in the soil due to the change in the soil microwave dielectric properties

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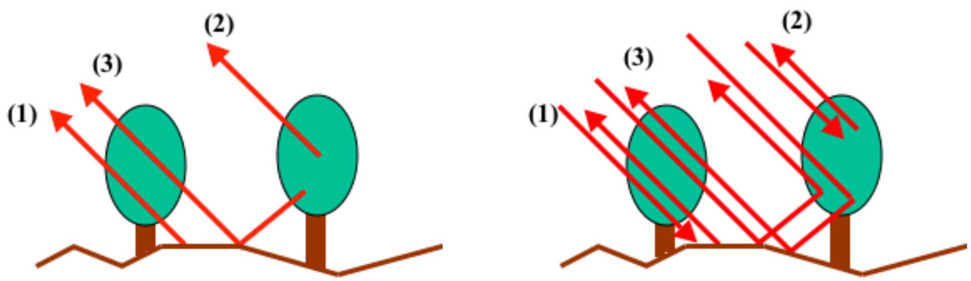
Retrieval of Soil Moisture

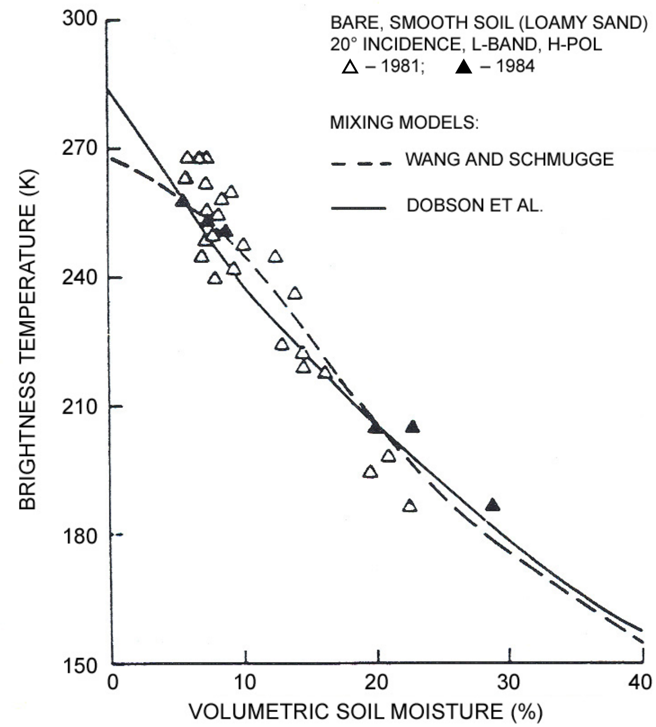


Emission (Radiometer)   *Backscatter (Radar)*

$$T^{t}_{Bp} = T^{s}_{Bp} L_p + T^{v}_{Bp} + T^{sv}_{Bp} \qquad \text{(Emission)}$$

$$\sigma^{t}_{pq} = \sigma^{s}_{pq} L^{2}_{pq} + \sigma^{v}_{pq} + \sigma^{sv}_{pq} \qquad \text{(Backscatter)}$$

- Radiometers measure "brightness temperature", T_B (K)
  Radars measure "backscatter cross-section", σ_o (dB)
- Contributions to emission and backscatter include three terms: soil, vegetation, and soil-vegetation interaction
- Soil moisture is the dominant contributor to the signal
- L is the vegetation attenuation factor, $\exp(-\tau_o / \cos\theta)$



Experimental data showing brightness temperature sensitivity to soil moisture for bare, smooth soil

Retrievals invert these equations to obtain soil moisture, with corrections for vegetation, roughness and surface temperature

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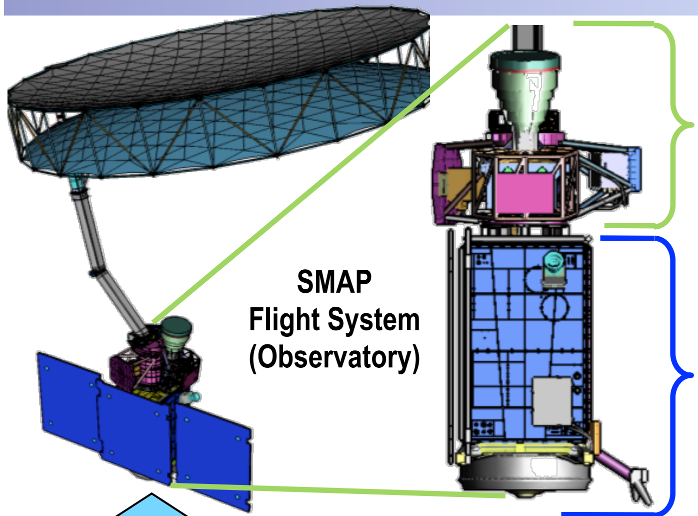
SMAP Mission Design



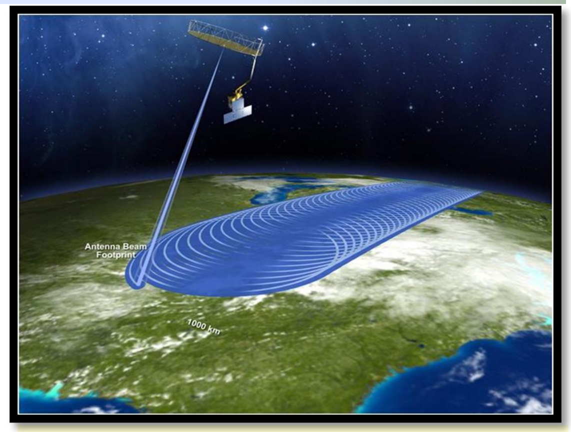
SMAP Flight System (Observatory)

INSTRUMENT

- L-band (1.2-GHz) radar (JPL)
- L-band (1.4-GHz) radiometer (GSFC)
- Shared antenna (6-m diameter)
- Conical scan: 13–14.6 rpm; 40° incidence
- Contiguous 1,000-km swath width

SPACECRAFT (& RADAR ELECTRONICS)

- JPL developed & built
- JPL's MSAP/MSL avionics, power assys with a small number of new mission-unique card designs
- 951-kg wet mass (Observatory-level)
- 1450-W capacity (Observatory-level)
- 80-kg propellant capacity
- Commercial space electronics elsewhere



- 685-km polar orbit (Sun-sync)
- 8-day repeat ground track
- Continuous instrument operation
- 2- to 3-day global coverage
- 3-year mission duration

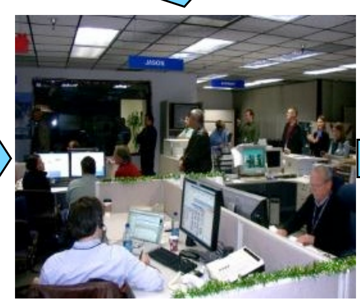
Delta II 7320-10C

Launch:
January 31, 2015
6:22 AM pacific

Vandenberg Air Force Base

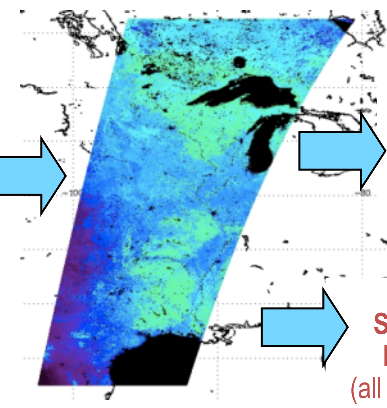
Near-Earth Network

Surface Validation



SMAP Mission Operations & Data Processing
(JPL, GSFC)

SCIENCE DATA PRODUCTS
Soil Moisture & Freeze/Thaw State Data Products



Alaska Satellite Facility Data Center
(radar L1 products)

National Snow and Ice Data Center
(all other products)

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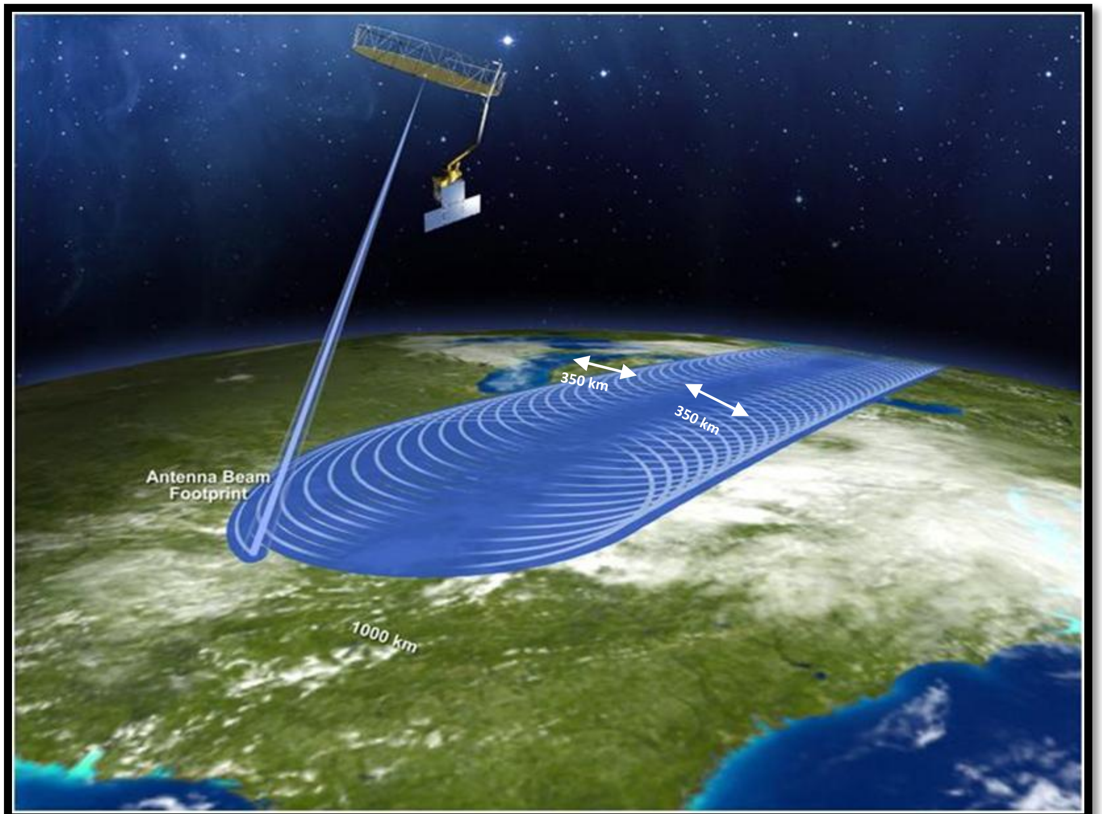
SMAP Instrument and Operating Characteristics

SMAP's objective is to provide high-resolution and frequent-revisit global mapping of soil moisture and landscape freeze/thaw state



Instrument Configuration

<u>Radar</u>
Frequency: 1.26 GHz
Polarizations: VV, HH, HV
Resolution: 1-3 km
Relative Accuracy: 1.0 dB (HH, VV); 1.5 dB (HV)

<u>Radiometer</u>
Frequency: 1.41 GHz
Polarizations: H, V, 3rd & 4th Stokes
Resolution: 40 km
Relative Accuracy: 1.3 K

<u>Shared Antenna</u>
6-m diameter deployable mesh antenna
Conical scan at 14.6 rpm
Constant incidence angle: 40 degrees
1000 km-wide swath
Swath and orbit enable 2-3 day global revisit

Orbit

Sun-synchronous, 6 am/pm, 685 km altitude

Mission Operations

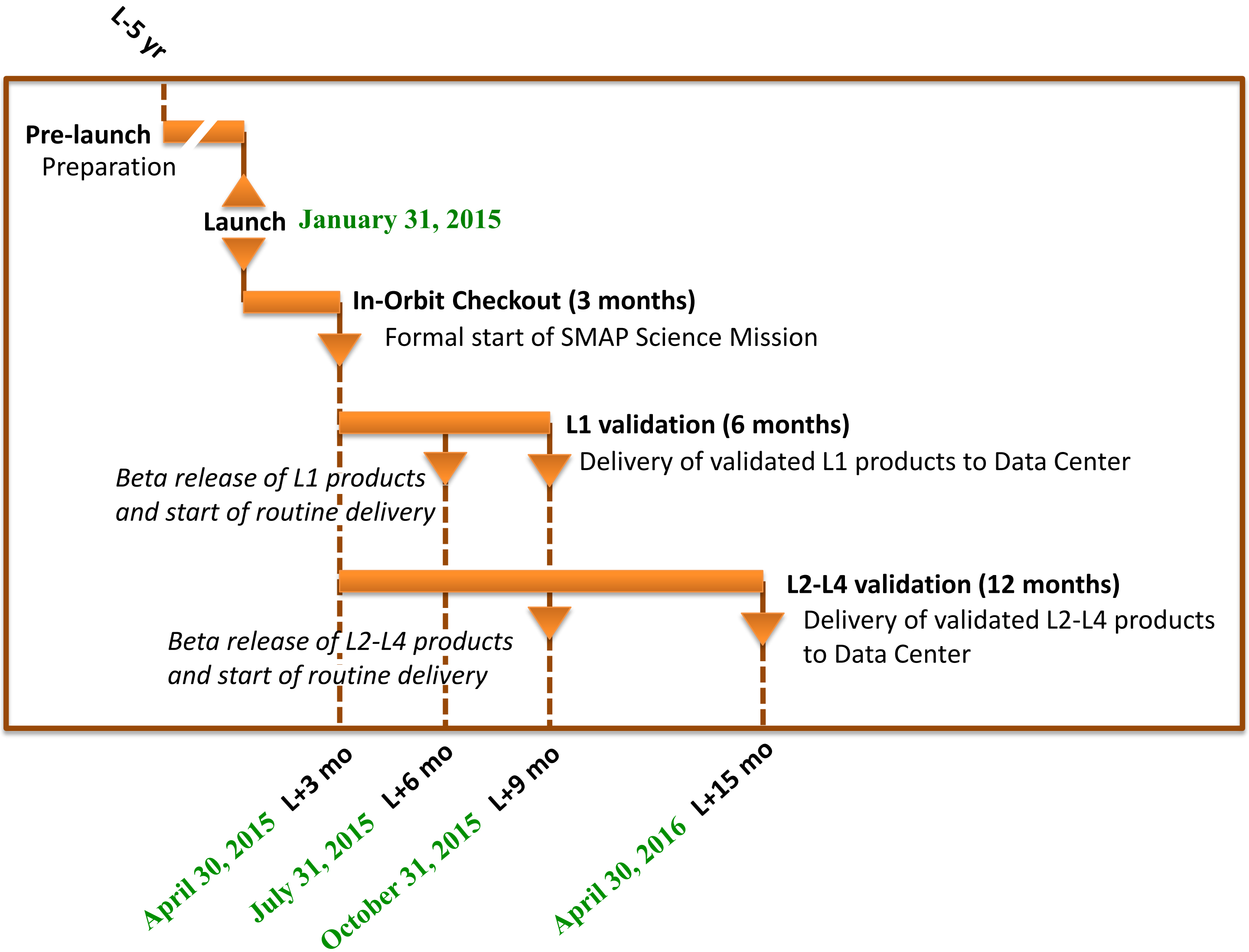
3-year baseline mission

- ***Radar*** - High spatial resolution (1-3 km) but more influenced by surface roughness and vegetation
- ***Radiometer*** - High accuracy (less influenced by roughness and vegetation) but coarser spatial resolution (40 km)
- ***Combined Radar-Radiometer –*** Soil moisture product (9 km) provides optimal blend of resolution and accuracy

SMAP Data Products

Data Product Short Name	Description	Grid (Resolution)	Granule Extent
L1A_Radar	Parsed Radar Instrument Telemetry		Half Orbit
L1A_Radiometer	Parsed Radiometer Instrument Telemetry		Half Orbit
L1B_S0_LoRes	Low Resolution Radar σ_o in Time Order	(5x30 km) (slices)	Half Orbit
L1C_S0_HiRes	High Resolution Radar σ_o on Swath Grid	1 km	Half Orbit
L1B_TB	Radiometer T_B in Time Order	(39x47 km)	Half Orbit
L1C_TB	Radiometer T_B	36 km	Half Orbit
L2_SM_A	Radar Soil Moisture (includes Freeze-Thaw)	3 km	Half Orbit
L2_SM_P	Radiometer Soil Moisture	36 km	Half Orbit
L2_SM_AP	Active-Passive Soil Moisture	9 km	Half Orbit
L3_FT_A	Daily Global Composite Freeze/Thaw State	3 km	North of 45° N
L3_SM_A	Daily Global Composite Radar Soil Moisture	3 km	Global
L3_SM_P	Daily Global Composite Radiometer Soil Moisture	36 km	Global
L3_SM_AP	Daily Global Composite Active-Passive Soil Moisture	9 km	Global
L4_SM	Surface & Root Zone Soil Moisture	9 km	Global
L4_C	Carbon Net Ecosystem Exchange	9 km	Global

Data Delivery Schedule



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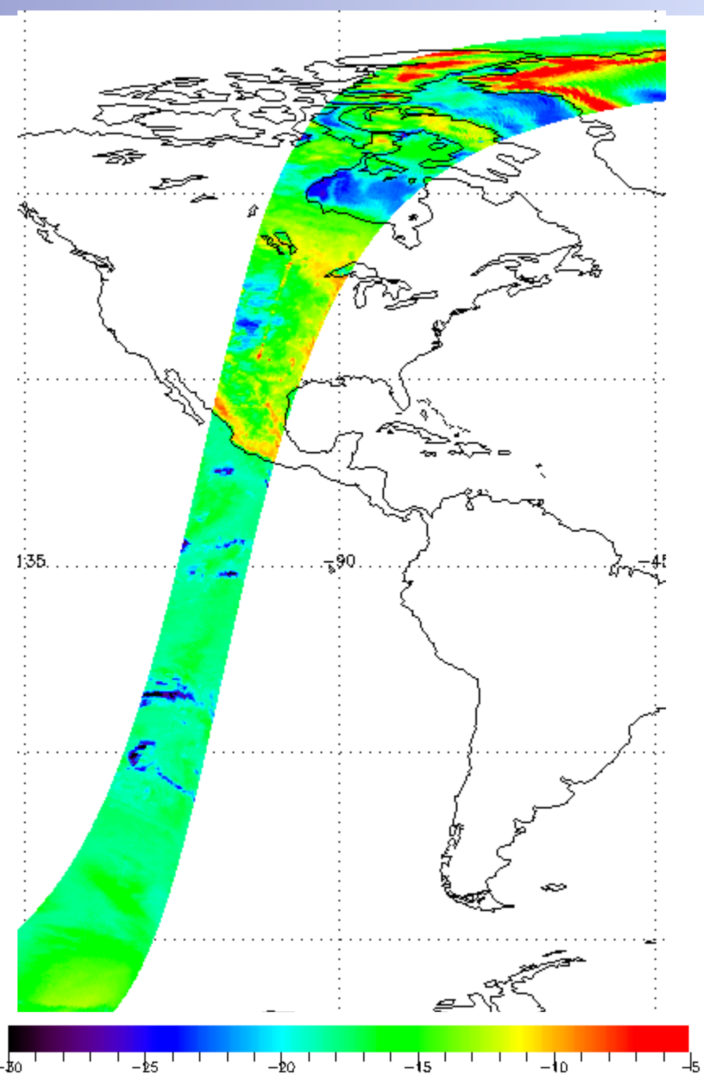
Current Status

Date	Milestone
January 31, 2015	SMAP launch
February 24	Antenna reflector deployed
March 26	Antenna spin-up to 14.6 RPM
March 31	Radiometer begins routine science operation
April 13	Radar begins routine science operation
July 7	Radar stops transmitting (traced to low-voltage power supply of radar amplifier) Radiometer continues to operate normally
July 31	Beta data for L1 Radiometer and Radar released to public
September 2	NASA official announcement that all efforts to restart the radar are unsuccessful
September 9	Beta data for L2/3 Soil Moisture Passive (radiometer) released to public
Early November	Validated data for L1 Radiometer and Radar released to public
Early November	Beta data for L2-L3 Soil Moisture and Freeze/Thaw , L4 Soil Moisture and L4 Carbon released to public
Through April 2018 (nominal mission)	Science data available through data centers are used to demonstrate SMAP science and applications

Data Product Descriptions

- The following slides describe the SMAP data products
- The slides will be updated with browse images from the data center portals (ASF and NSIDC) once these are available

Level 1B Radar Product



Sigma0 HH (dB)

- Each granule contains time ordered data that covers one spacecraft half orbit
- Coverage is continuous over all surface types
- Contains Earth-located, calibrated radar backscatter measurements for co-pol and cross-pol data
- Estimated Kp errors are assigned to each measurement
- Includes spacecraft orbit and attitude information and instrument pointing geometry
- Includes short term and external calibration data used to generate product output
- Provides calibrated backscatter measurements for approximately ten range-resolved "slices" of the full radar FOV footprint (~30 km by 5 km)

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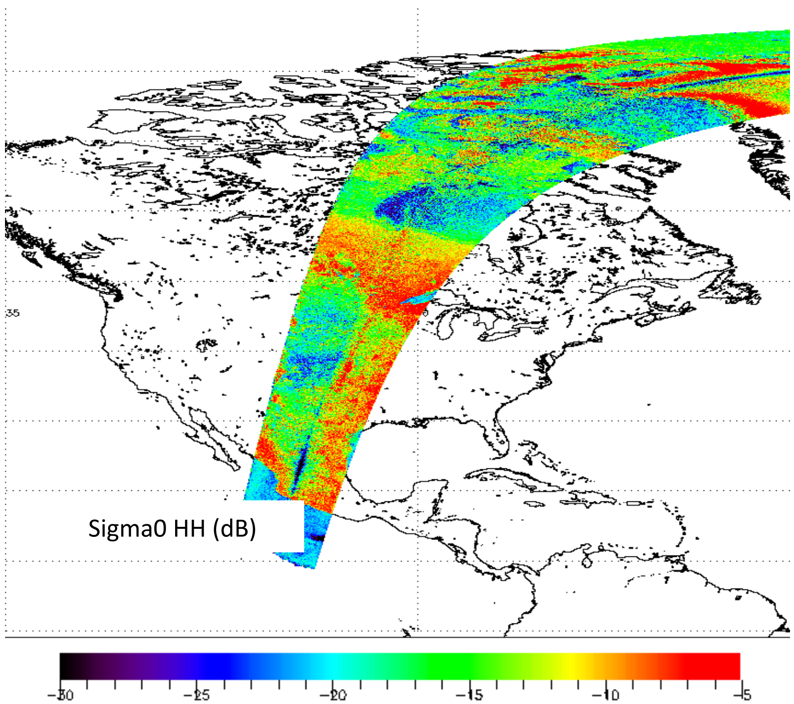
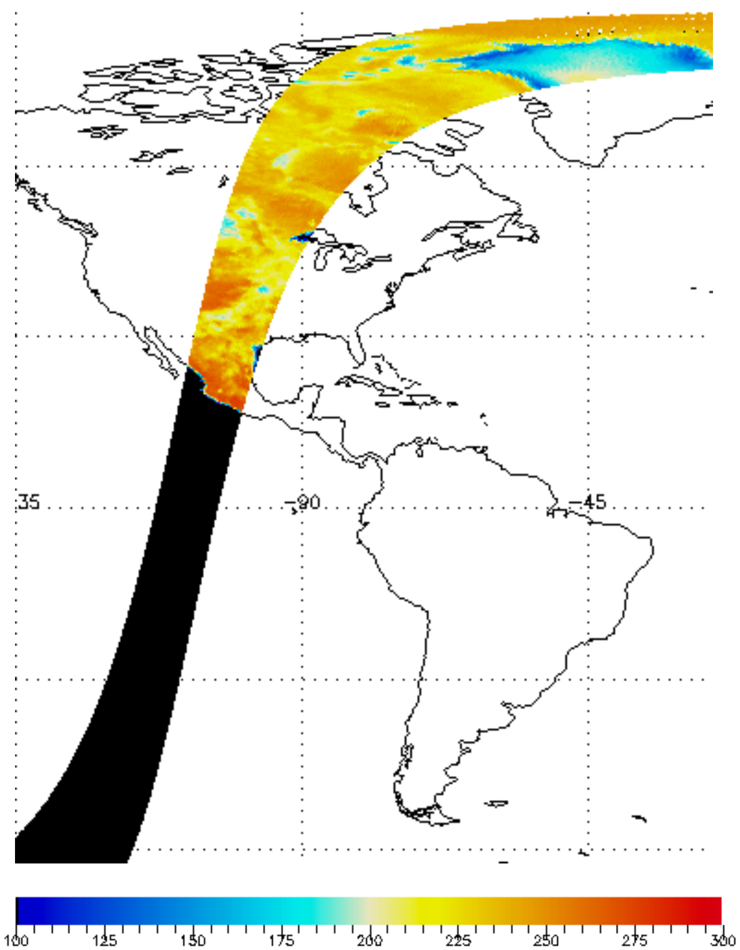
Level 1C Radar Product



- Each granule contains geographically ordered data in 1 km grid cells in an along track/cross track swath grid
- Coverage is restricted to land and coastal water over one spacecraft half orbit
- SAR provides high-resolution single-look measurements. Resolution varies from ~400 m at the swath edge to about 1.2 km at 150 km from the nadir sub-track. Nadir looks are thin slices as wide as the beam footprint
- Contains Earth located and calibrated h-pol, v-pol and cross-pol backscatter measurements, each separately multilooked

- Radar measurements achieve approximately 1 km resolution over the outer 70% of the swath Resolution degrades in the nadir region (middle 30% of swath)
- Forward looking and aft looking measurements are stored separately
- Includes spacecraft orbit and attitude information and instrument pointing geometry
- Includes short term and external calibration data used to generate product output
- Provides reference to global and polar 1-km EASE grid coordinates

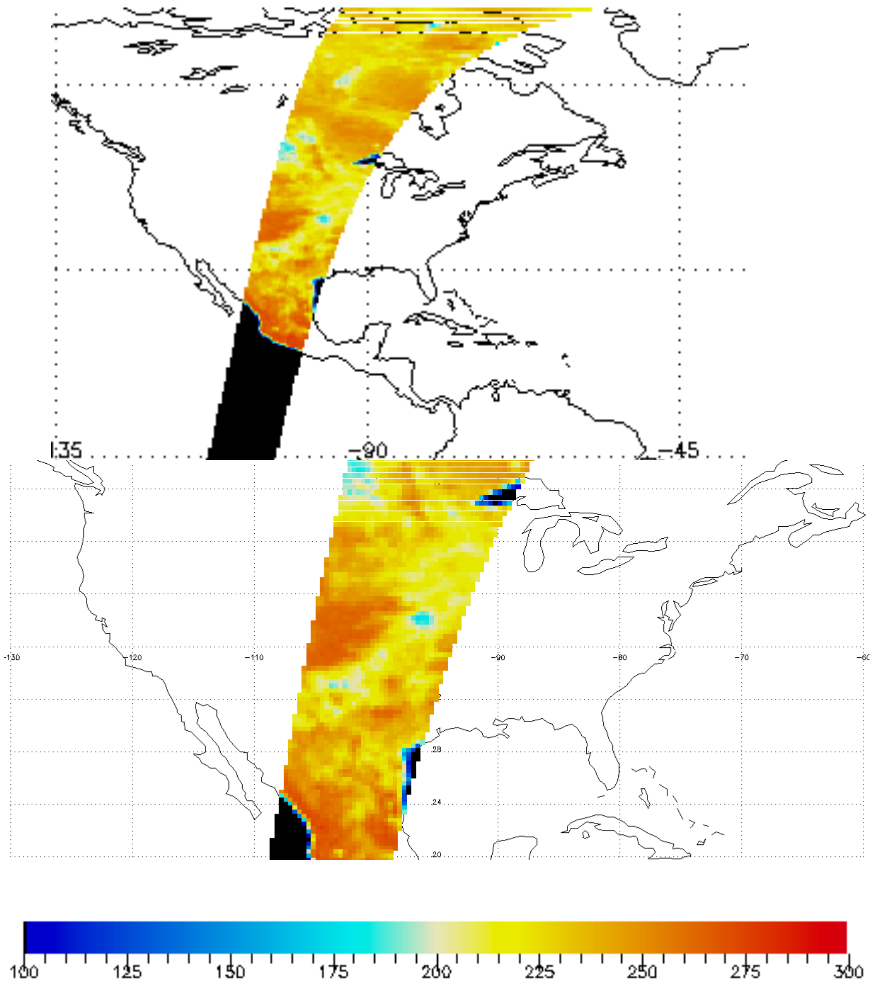
Level 1B Radiometer Product



L1B Time-ordered H-pol TB (K)

- Each granule contains time ordered data that covers one spacecraft half orbit
- Effective field of view footprint is a 39 km by 47 km ellipse
- Coverage continuous over all surface types.
- Earth-located calibrated data for each EFOV
  - Surface-referenced brightness temperatures
  - Antenna temperatures included
  - Corrections for galactic, solar, lunar, ionospheric, atmospheric, and antenna pattern effects
- All four modified Stokes parameters (V, H, T_3 & T_4)
  - 3rd Stokes used for Faraday rotation correction
- Time-frequency-polarization diversity used for RFI detection and removal
- Forward looking and aft looking measurements stored separately
- Includes spacecraft orbit and attitude information and instrument pointing geometry

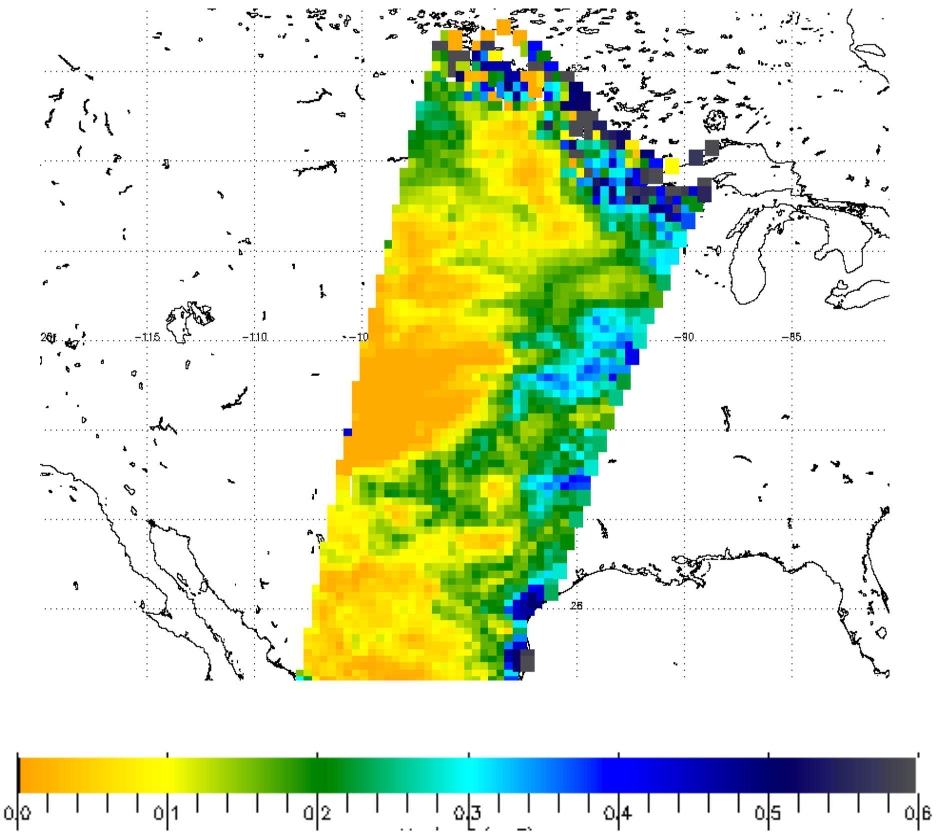
Level 1C Radiometer Product



L1C Earth-fixed H-pol TB (K)

- Consists of level 1B Radiometer data gridded on a 36 km Earth-fixed grid
- Data appear in three projections
  - Global cylindrical grid
  - North polar grid
  - South polar grid
- Forward looking and aft looking observations are stored separately
- Direct input to level 2 passive soil moisture product (36 km) and level 2 active-passive soil moisture and level 4 soil moisture products (9 km)

Level 2 Passive (Radiometer) 36 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Each granule contains one half orbit of data posted on 36 km cylindrical EASE grid cells
- Data are represented in a one dimensional array
- Product lists only those EASE grid cells within the half orbit swath
- Provides retrieved soil moisture over land with 0.04 m^3/m^3 estimated accuracy for low-to-moderately vegetated areas
  - Low to moderate vegetation defined as vegetation water content <= 5 kg/m^2
- Uses water body and freeze-thaw state information generated from the high resolution radar data
- Estimates soil moisture based on 6 am (descending pass) observations
- Includes quality masks for urban areas, mountainous terrain, dense vegetation, precipitation, snow and ice

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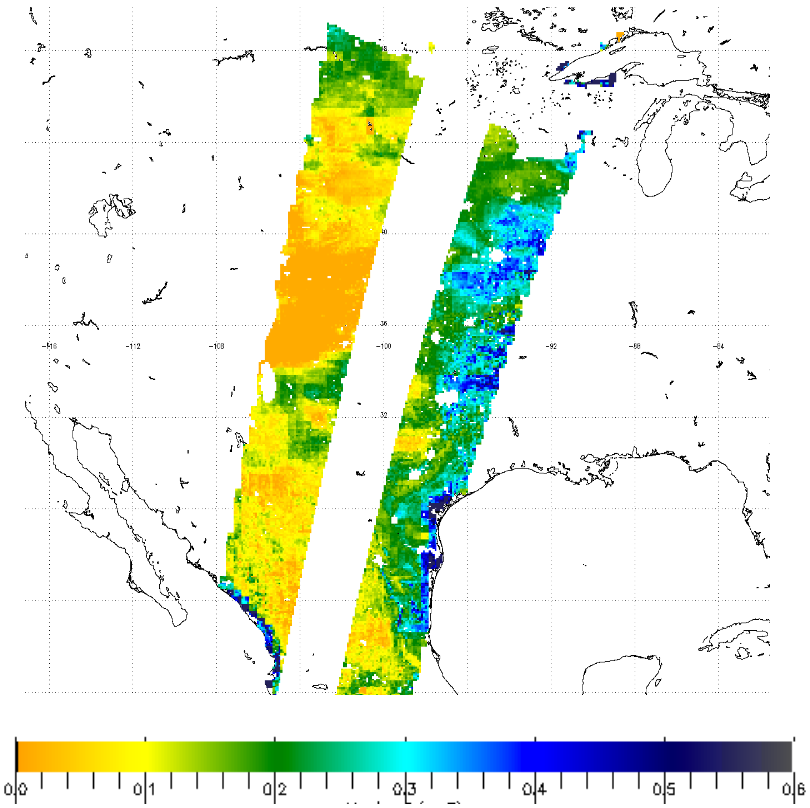
Level 2 Active (Radar) 3 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Each granule contains one half orbit of data posted on a 3-km cylindrical EASE grid cell
- Data are represented in a one dimensional array
- AM Product covers entire Earth land mass, PM product restricted to land north of 45 North longitude
- PM data acquired specifically for freeze-thaw retrievals
- Employs 1 km high resolution radar L1C data averaged over 3 km EASE grid cells to reduce Kp noise
- Soil moisture retrievals use snapshot and/or time-series algorithms
- Provides freeze-thaw state and transient water body information that the other Level 2 soil moisture processes require
- Includes quality masks for urban areas, mountainous terrain, dense vegetation, snow and ice

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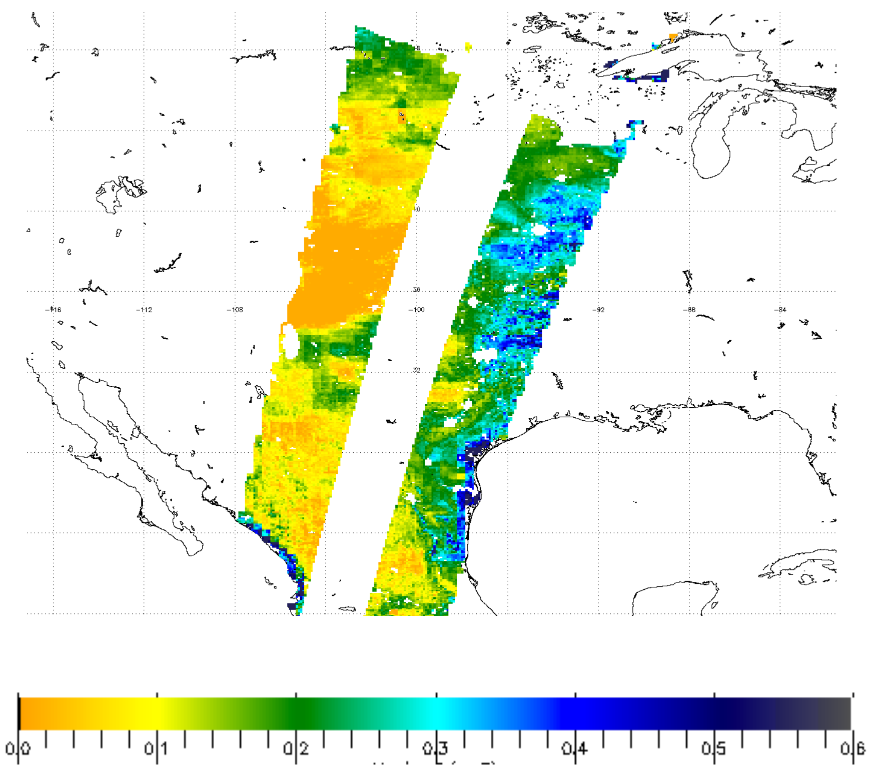
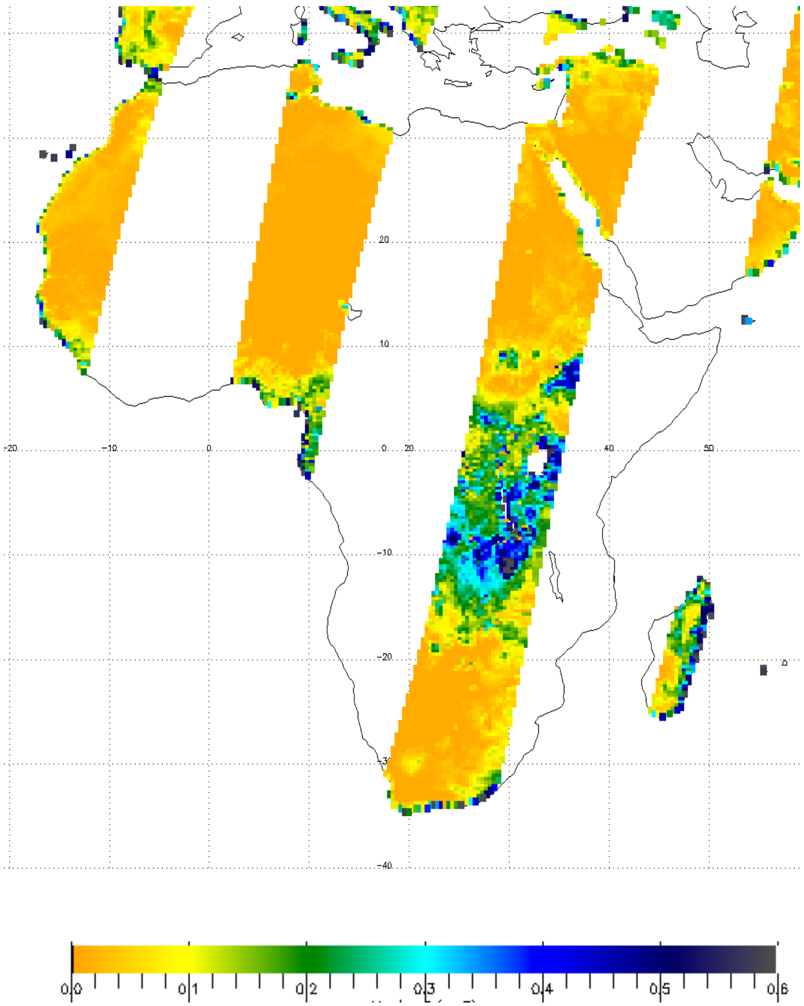
Level 2 Active-Passive 9 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Each granule contains one half orbit of data posted on 9 km cylindrical EASE grid cells
- Data are represented in a one dimensional array
- Product lists only those EASE grid cells within the half orbit swath.
- Merges radar and radiometer data using a time series algorithm
- Provides disaggregated brightness temperatures at 9 km resolution
- Provides retrieved soil moisture over land with 0.04 m^3/m^3 estimated accuracy for low-to-moderately vegetated areas
  - Low to moderate vegetation defined as vegetation water content <= 5 kg/m^2
- Uses water body and freeze-thaw state information from high resolution radar data
- Includes masks for urban areas, mountainous terrain, dense vegetation, precip, snow and ice

Level 3 Passive (Radiometer) 36 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Composite of all Radiometer Level 2 half orbit products where local acquisition time is the same UTC day
- Multiple measurements may overlap at high latitudes. Algorithm selects measurements acquired closest to 6 AM local solar time
- Posted on a 36 km cylindrical EASE grid using a two dimensional array
- Product lists all EASE grid cells, regardless of whether data are available
- Provides retrieved soil moisture over land with 0.04 m^3/m^3 accuracy for low-to-moderately vegetated areas
  - Low to moderate vegetation defined as vegetation water content <= 5 kg/m^2
- Based exclusively on AM data

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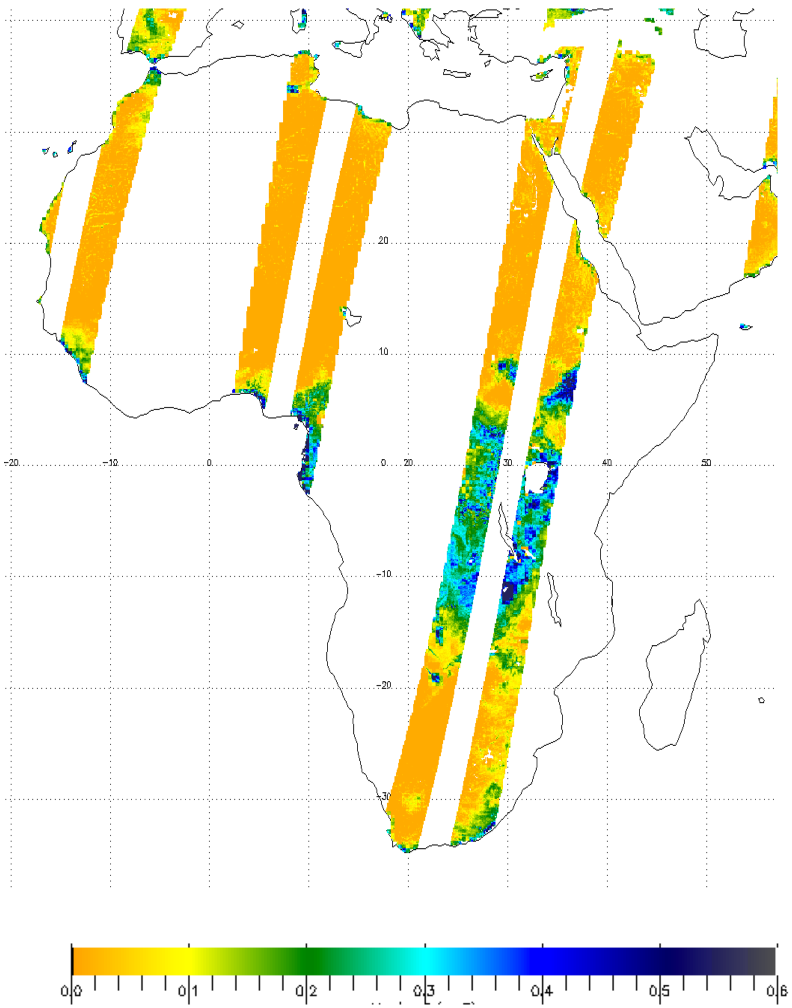
Level 3 Active (Radar) 3 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Composite of all Radar Level 2 half orbit products where the local acquisition time is the same UTC day
- Multiple measurements may overlap at high latitudes. Algorithm selects those measurements acquired closest to 6 AM local solar time
- Posted on a 3 km cylindrical EASE grid using a two dimensional array
- Product lists all EASE grid cells, regardless of whether data are available
- Soil moisture retrievals use snapshot and/or time-series algorithms
- Depending on the terrain classification, multiple optional models/algorithms may be employed for retrieval
- Based exclusively on AM data

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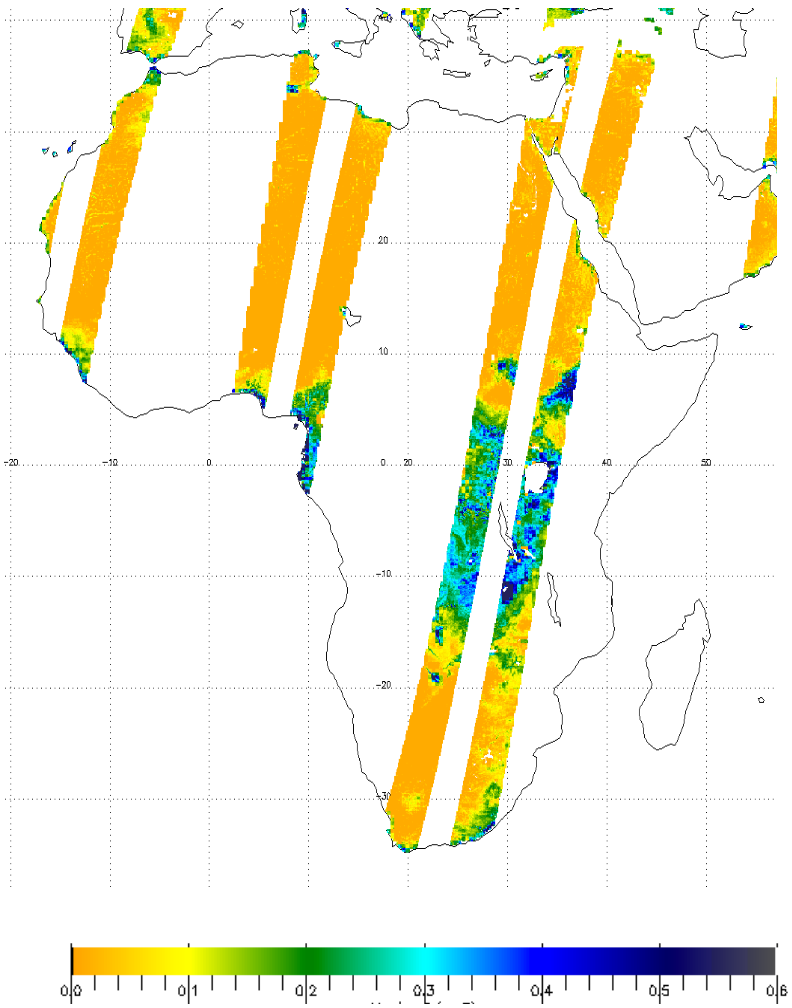
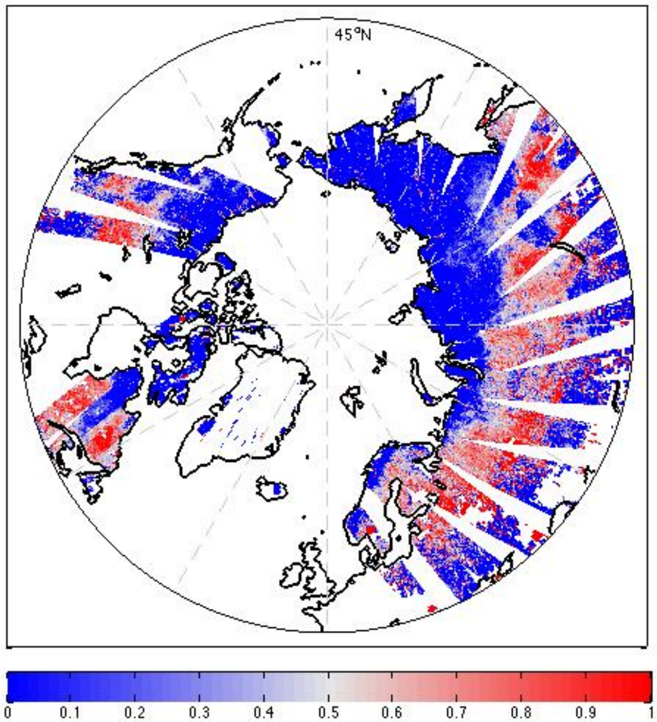
Level 3 Active/Passive 9 km Soil Moisture Product



Volumetric Soil Moisture (m^3/m^3)

- Composite of all Active/Passive Level 2 half orbit products where local acquisition time is the same UTC day
- Multiple measurements may overlap at high latitudes. Algorithm selects measurements acquired closest to 6 AM local solar time
- Posted on a 9 km cylindrical EASE grid using a two dimensional array
- Product lists all EASE grid cells, regardless of whether data are available
- Provides retrieved soil moisture over land with 0.04 m^3/m^3 accuracy for low-to-moderately vegetated areas
    - Low to moderate vegetation defined as vegetation water content <= 5 kg/m^2
- Based exclusively on AM data

Level 3 Freeze/Thaw 3 km Product



Red: Thawed, Blue: Frozen

Daily Freeze/Thaw State

- Uses the 1 km Level 1C high resolution radar data and a time-series change detection algorithm to infer freeze/thaw state
- Quantifies daily freeze/thaw state as a binary condition for land surface
- Includes both AM and PM data, with intra-day state transition flags
- Posted on a 3 km polar EASE grid using a two dimensional array
- Each product represents a single calendar day UTC
- Target is to achieve 80% freeze/thaw state classification accuracy

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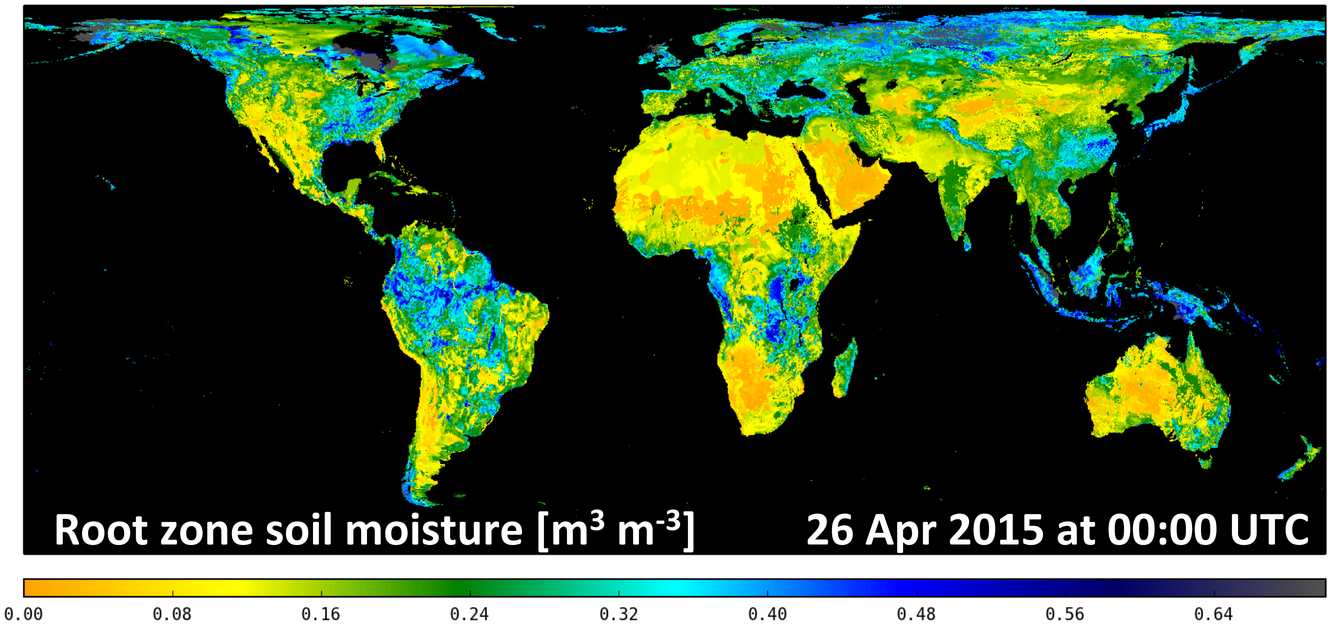
Level 4 Surface and Root-Zone 9 km Soil Moisture Product



- Global product, presented in two collections
- Based on assimilation of SMAP brightness temperatures from the L1C_TB and L2_SM_AP products into a state-of-the-art land surface model

Geophysical Data ("gph" Collection)	Analysis Update Data ("aup" Collection)
3-hour time averages	*3-hour instantaneous (snapshots)*
Surface and **root zone** soil moisture, soil temperature, snow, land surface fluxes, surface meteorological forcing data	Brightness temperatures (observed and modeled), soil moisture and soil temperature (model forecast and analysis), **uncertainty estimates**

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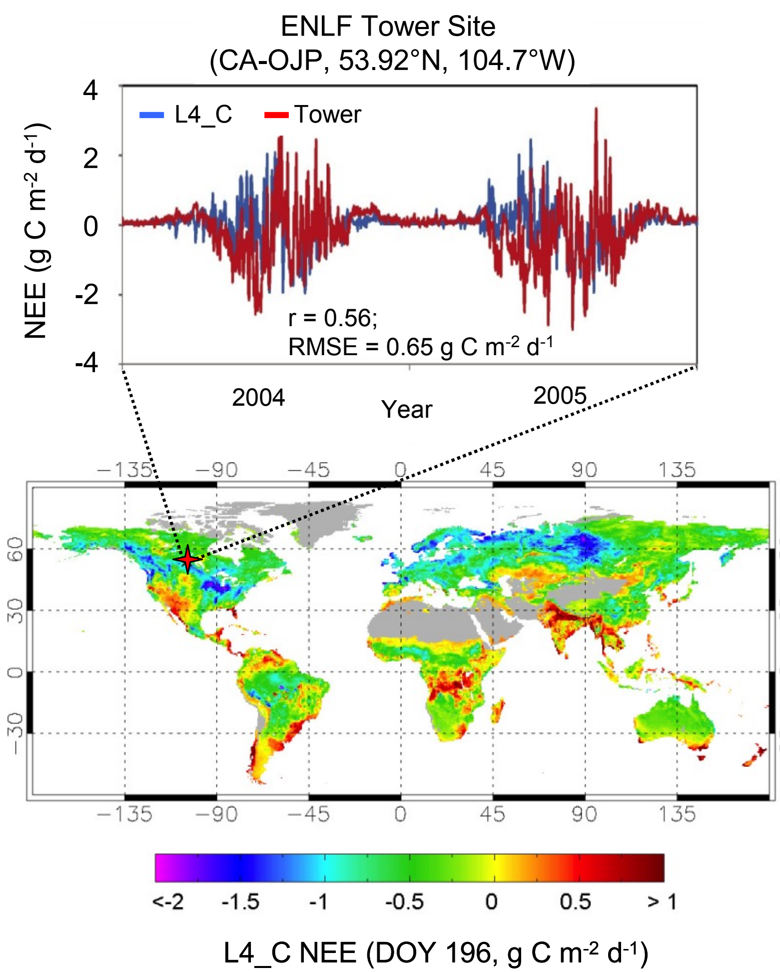
Level 4 Carbon Product (9 km)

Mean Daily net CO_2 Exchange



- Daily global maps of net ecosystem CO_2 exchange (NEE) at 9 km resolution with 14-day latency
- Quantifies the net carbon flux in boreal landscapes
- Reduces uncertainty with regard to existing carbon sinks on land
- Applies a soil decomposition algorithm driven by SMAP L4_SM and Gross Primary Production (GPP) inputs to compute net land-atmosphere CO_2 exchange (NEE)
- Accuracy commensurate with tower based CO_2 observations (RMSE ≤ 30 g C m^{-2} yr^{-1} or 1.6 g C m^{-2} d^{-1})

SMAP Resources at the ASF DAAC

The ASF DAAC archives and supports user services for SMAP radar level 1 products

1. ASF SMAP web interface at https://www.asf.alaska.edu/smap

2. ASF Data Access and Distribution
   a. ASF API at https://portal.asf.alaska.edu/get-data/api
   b. Vertex at https://vertex.daac.asf.alaska.edu

3. ASF User Services and Points of Contacts
   a. User Services Representative (uso@asf.alaska.edu)
   b. Project Manager – Scott Arko (saarko@alaska.edu)
   c. Product Owner – Angela R. Allen **(**arallen@alaska.edu**)**

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SMAP Resources at the NSIDC DAAC

The NSIDC DAAC archives and provides user support for level 1 radiometer products as well as all SMAP level 2, level 3 and level 4 products

- SMAP Web site
  - http://nsidc.org/data/smap/
- NSIDC Data Search
  - http://nsidc.org/data/search/
- SMAP Data Tools
  - Will be released with data products
  - Subsetting and reformatting on-demand services
  - HDF utilities. Matlab and IDL readers
- User Support
  - http://nsidc.org/forms/contact.html
  - nsidc@nsidc.org

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SMAP Portal at the ASF DAAC

UAF ALASKA SATELLITE FACILITY
Making remote-sensing data accessible since 1991

Home | Get Data | Datasets | Data Tools | About SAR | News | About ASF | Search...

/ SAR Datasets / SMAP

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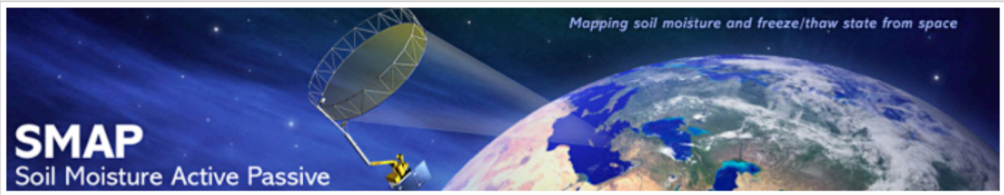
  - Applications
  - Data & Imagery
  - Documents & Tools
  - How to Cite
  - News & Media
- Sentinel-1A
- Seasat
- Wetlands MEaSUREs
- Sea Ice MEaSUREs
- Terrestrial Ecology
- InSAR
- ALOS-1 PALSAR
- RADARSAT-1
- ERS-1
- ERS-2
- JERS-1
- UAVSAR
- AirMOSS
- AIRSAR

SMAP



Get SAR Data

Data & Imagery

SMAP maps the world's soil moisture every three days. Data and imagery will be available at no cost to registered users at ASF DAAC (Level 1 radar) and NSIDC DAAC (Level 1 radiometer and all Levels 2, 3, & 4).

Read more...

Global Significance

SMAP data on soil moisture and freeze/thaw state will aid climate forecasting; flood, landslide, and drought monitoring; agricultural planning; and much more.

Read more...

Documents & Tools

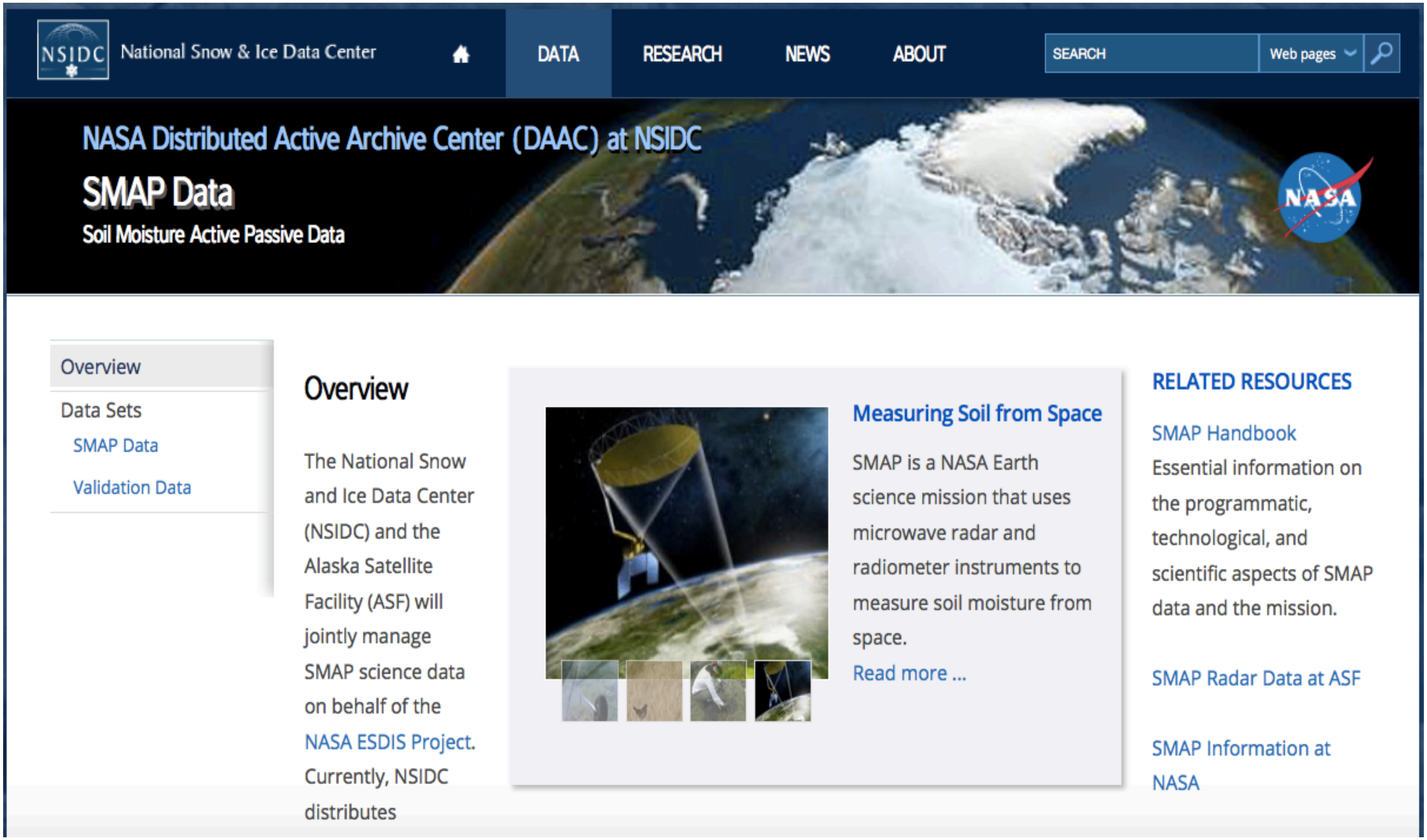
Access the ASF SMAP User Guide, the SMAP Handbook, tools such as MapReady, a table of ancillary-data reports with links to the data they cite, and more.

Read more...

"A rare characteristic of the SMAP Project is its emphasis on serving both basic Earth System science as well as applications in operational and practice-oriented communities.

— SMAP Handbook

SMAP Portal at the NSIDC DAAC



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SMAP on Worldview

EOSDIS Data Visualization, Discovery, and Download Tool for GIBS

- General-purpose, full-resolution satellite imagery browser built to
  - Explore
  - Compare
  - Download
  - Share
  - Educate

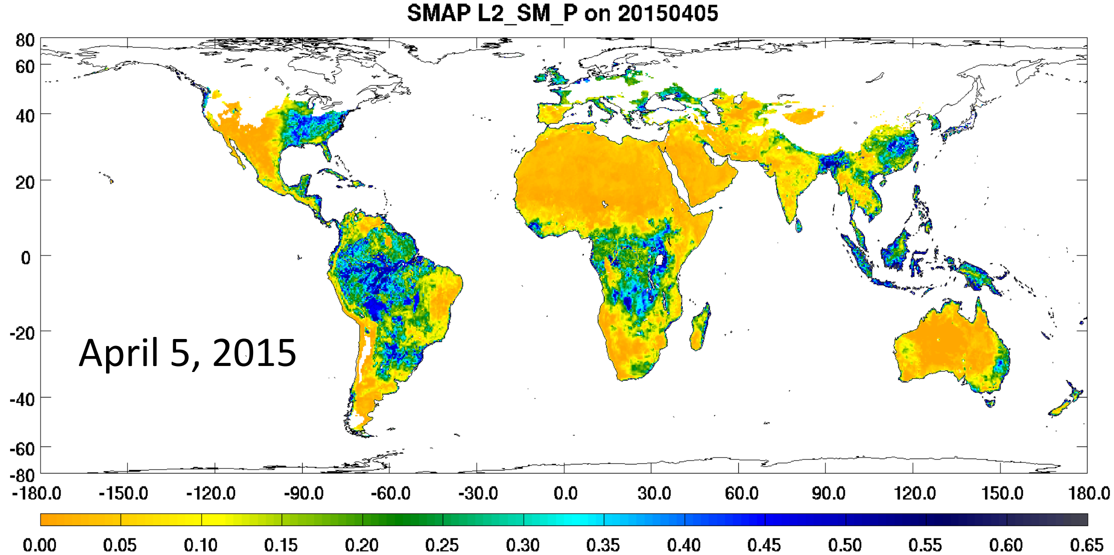
- Web browser-based and open source

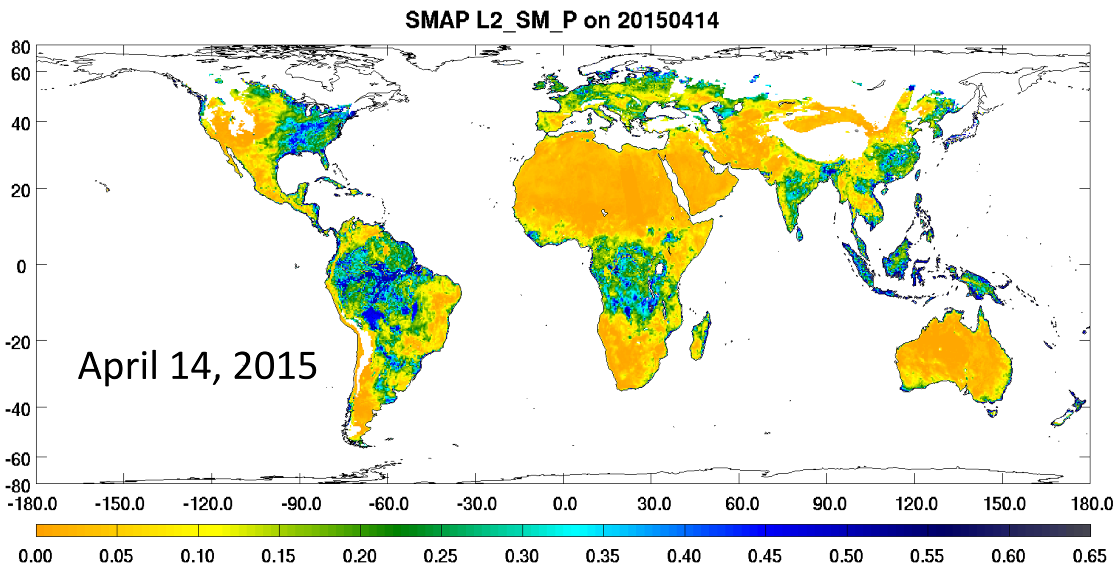
https://earthdata.nasa.gov/worldview

https://github.com/nasa-gibs/worldview

Soil Moisture - Observed Changes

- Passive (36 km) data processed into soil moisture 3-day global images centered on April 5 and 14, 2015
- Soil moisture patterns agree with expected geographical soil moisture distribution

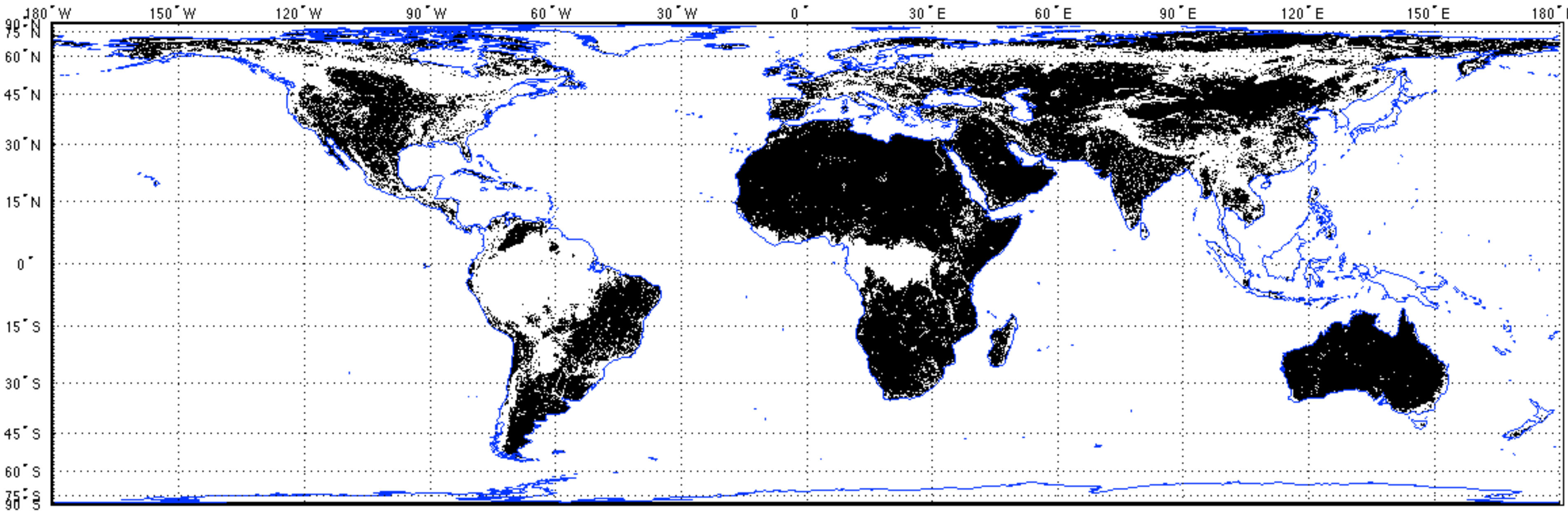




- Soil moisture changes are evident in the time-sequence
- Rainfall in India, Bangladesh, and Vietnam
- Dry-down in eastern Australia and Argentina

Soil Moisture - Expected Accuracy

- Regions where SMAP soil moisture retrievals are expected to meet L1 accuracy requirement of 0.04 m^3/m^3



- Retrieval expected quality mask (black colored pixels indicate good quality) with following specifications:
  - a) Vegetation water content ≤ 5 kg/m^2
  - b) Urban fraction ≤ 0.25
  - c) Water fraction ≤ 0.1
  - d) DEM slope standard deviation ≤ 3 deg

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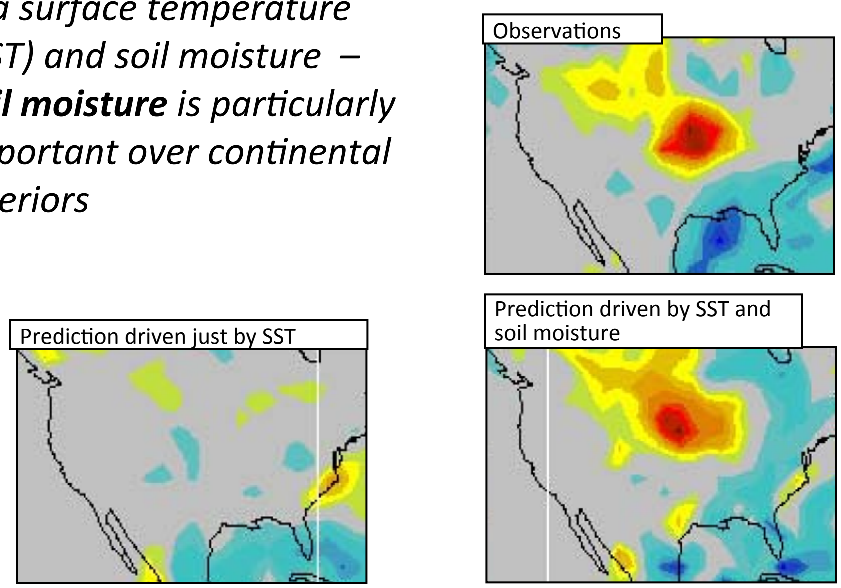
Value of Soil Moisture Data to Weather and Climate

New space-based soil moisture observations and data assimilation modeling can improve forecasts of local storms and seasonal climate anomalies

Seasonal Climate Predictability

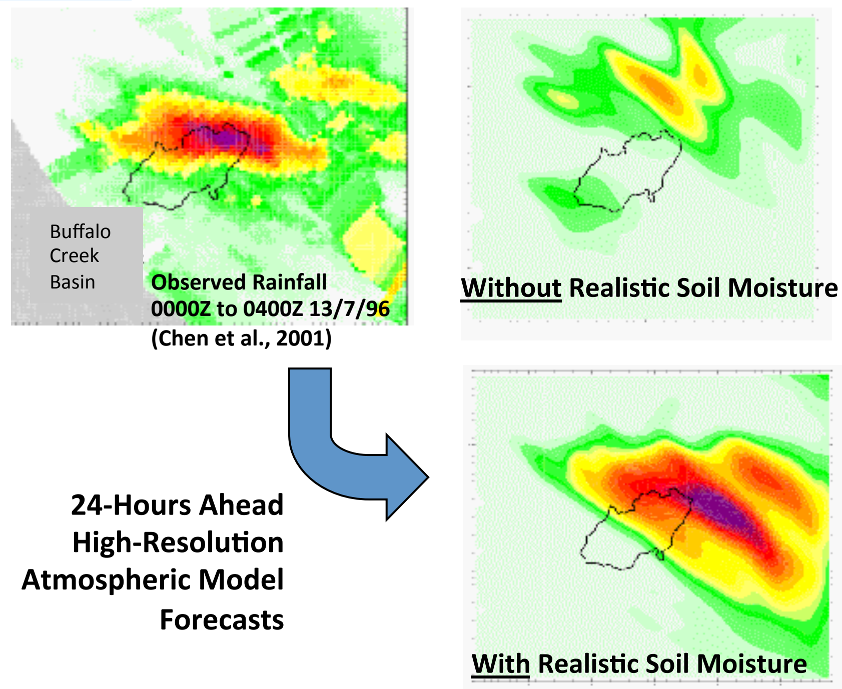
Predictability of ***seasonal climate*** *is dependent on boundary conditions such as sea surface temperature (SST) and soil moisture –* ***soil moisture*** *is particularly important over continental interiors*

Difference in Summer Rainfall: 1993 (flood) minus 1988 (drought) years



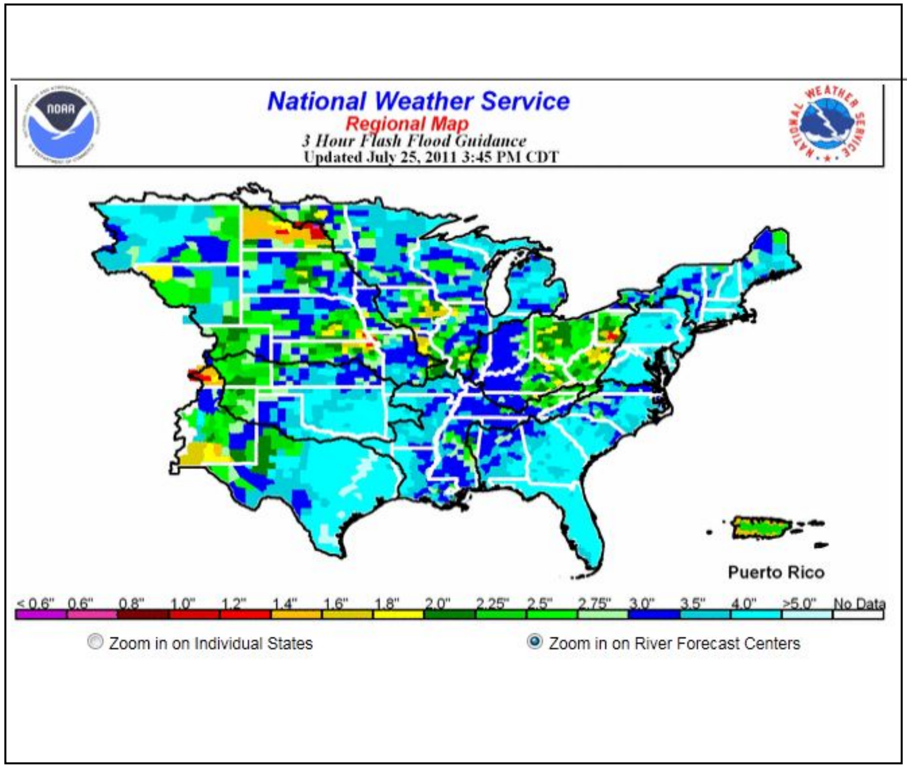
(Schubert et al., 2002)

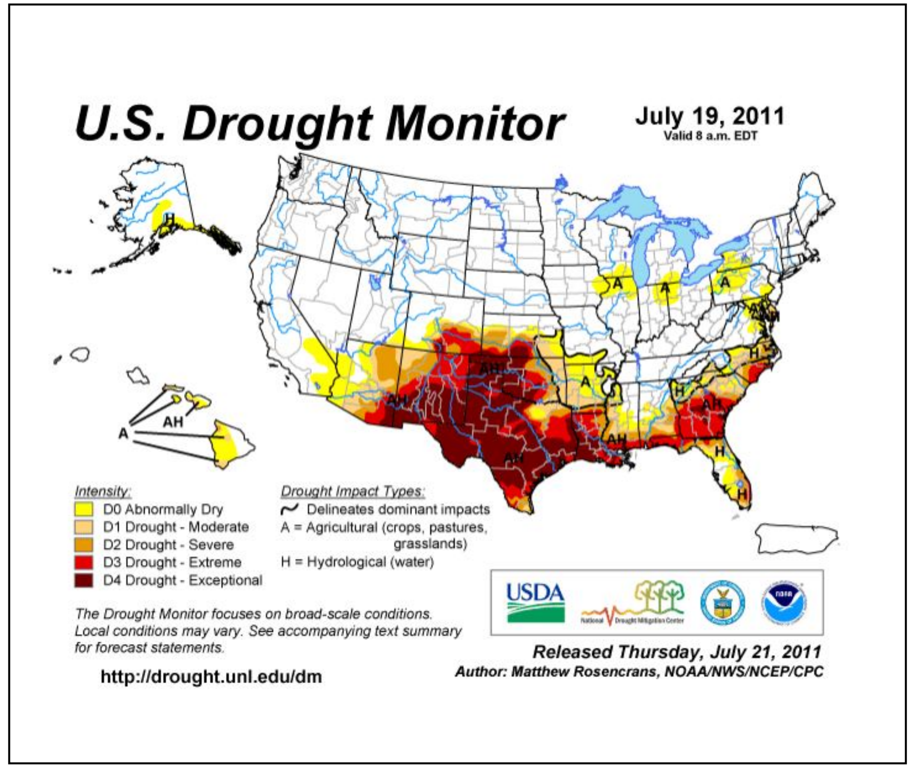
NWP Rainfall Prediction



In weather forecasting, SMAP surface soil moisture, with x10 higher resolution than existing model estimates, will result in enhanced predictions

Flood and Drought Applications





<u>Current</u>: Empirical soil moisture indices based on rainfall and air temperature
(by counties >40 km and climate divisions >55 km)

<u>Future</u>: SMAP soil moisture direct observations of soil moisture at 9 km

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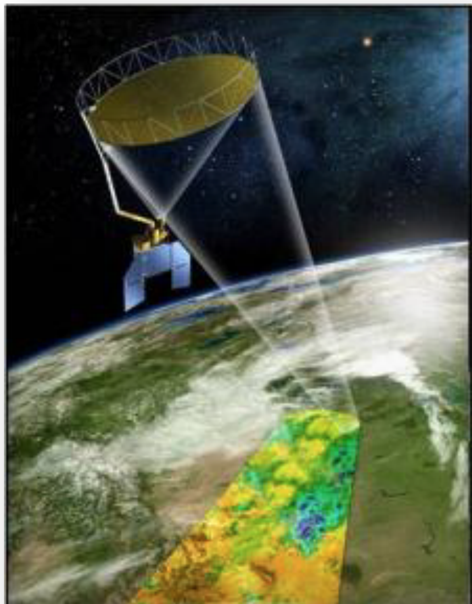
A Flood Example



Application of a SMAP-Based Index for Flood Forecasting in Data-Poor Regions

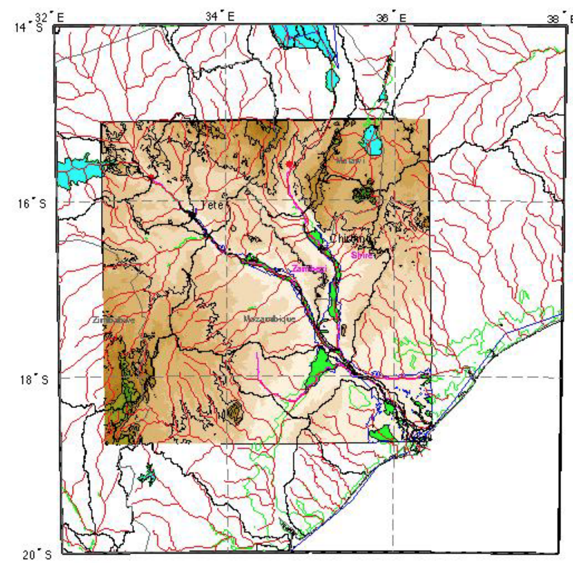
Current Capability: The UN-WFP uses satellite derived flood maps to locate floods and map delivery routes to affected areas.

Enhanced Capability: Use SMAP to expand their current flood database with look-up information that produces flood indices for a given rainfall forecast (ECMWF) and soil moisture condition (SMAP).

Study Area: Zambezi basin and its delta in Mozambique.

Algorithm Structure: VIC output on flow is input into a hydrodynamic model (LISFlOOD-FP), which is complemented with a sub-grid channel formulation to generate flood inundation variables (inundated area, floodplain water volume) for the lower Zambezi basin. ECMWF archived forecast rainfall data is used to compute flows for daily inundation patterns over 10 years.

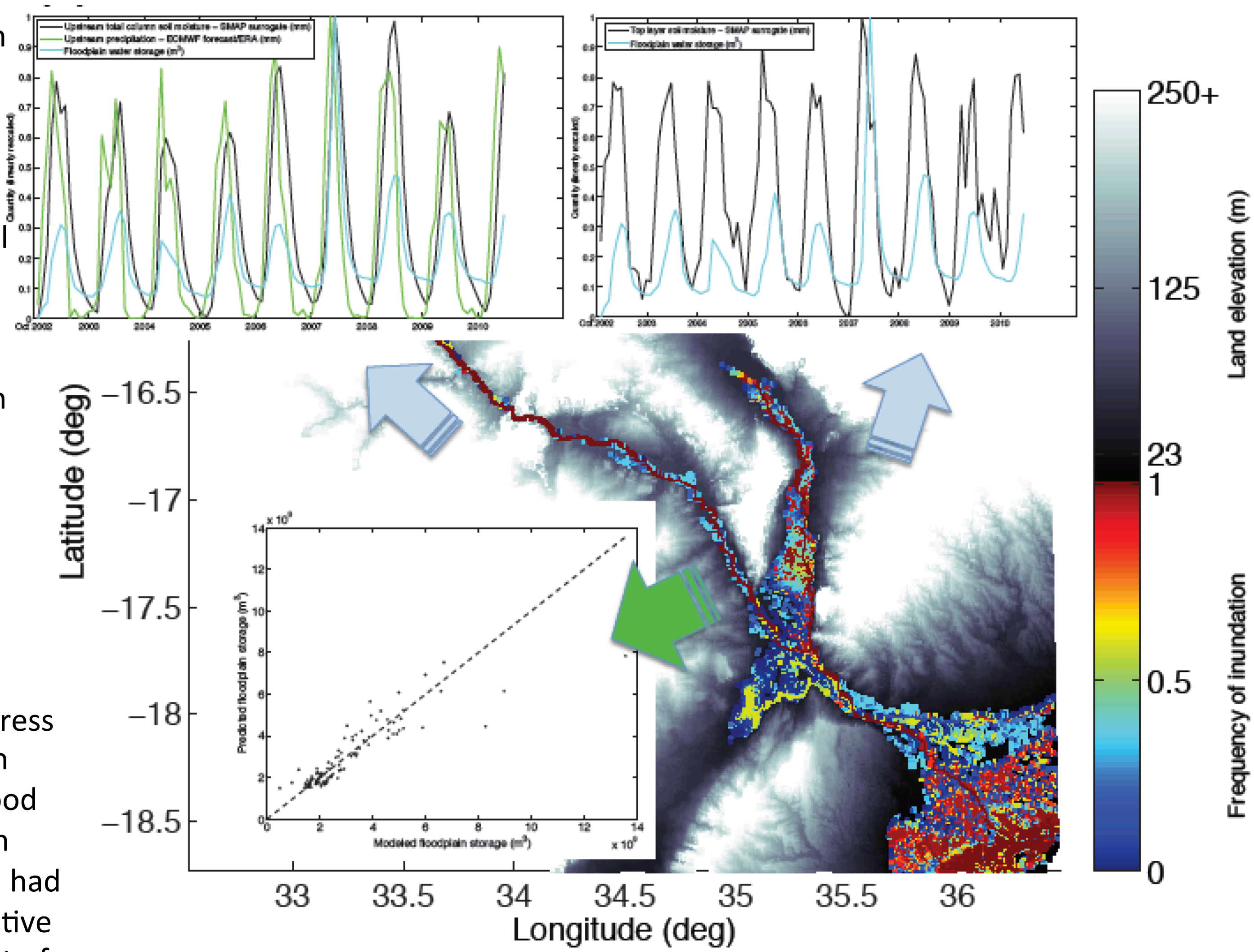
Courtesy of
Guy Schumann
UCLA



A Flood Example - Results

Long-term variations in upstream rainfall and soil moisture column vs. floodplain inundation volume (top left panel) and downstream top layer soil moisture (top right panel). Upstream rainfall plus soil moisture 0.88 and rainfall only 0.49. Downstream top layer soil moisture 0.52. The map depicts long-term variations in floodplain inundation patterns from the LISFLOOD-FP flood model. Regression model results for predicting floodplain inundation volume are shown in the bottom left scatter plot.

These variables were used to regress and predict floodplain inundation volume for the February 2007 flood event, which was taken out when regressing. The regression model had a relative bias of 17%, with a relative error in predicting the 2007 event of 33%.



Courtesy of Guy Schumann, UCLA

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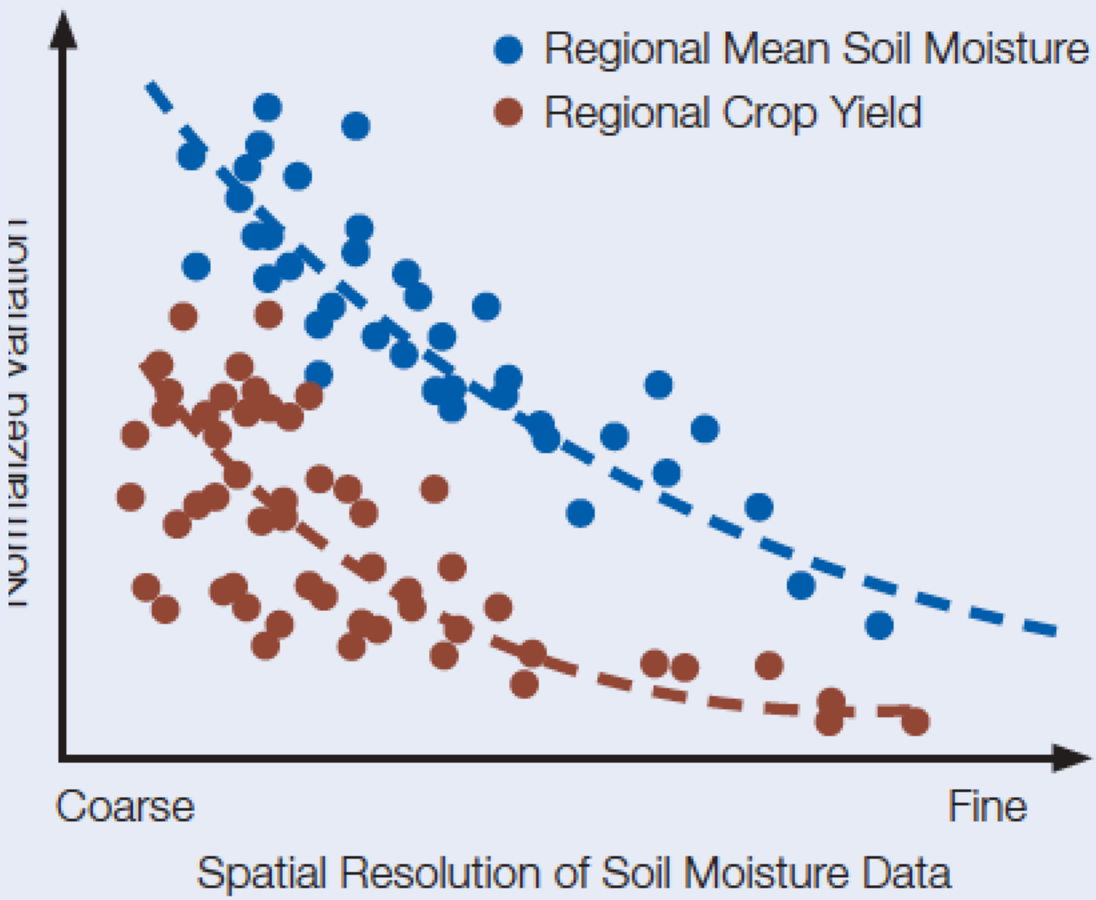
Crop Yield Modeling

Agricultural models have been developed to predict the yield of various crops at field and regional scales. One key input of the agricultural models is soil moisture. The conceptual diagram relates variation in regional domain-averaged soil moisture to variation in total crop yield. Statistical analysis would lead to the development of probability distributions of crop yield as a transformation of the probability distribution of domain averaged soil moisture at the beginning of the growing season.



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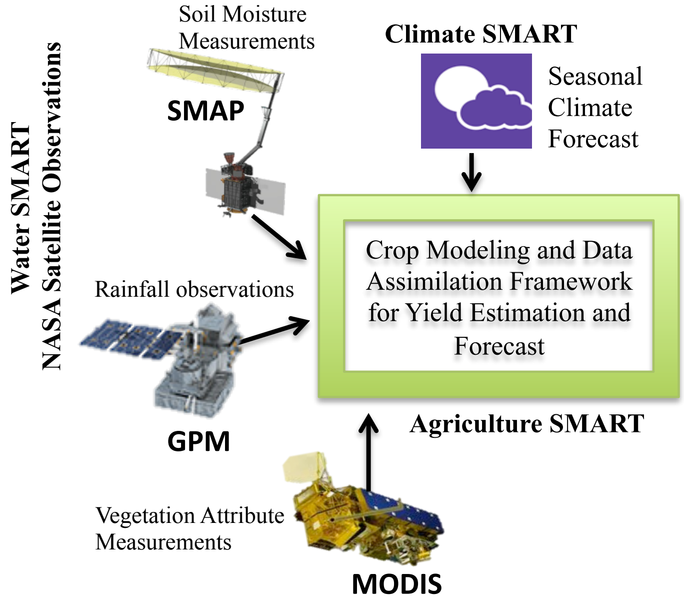
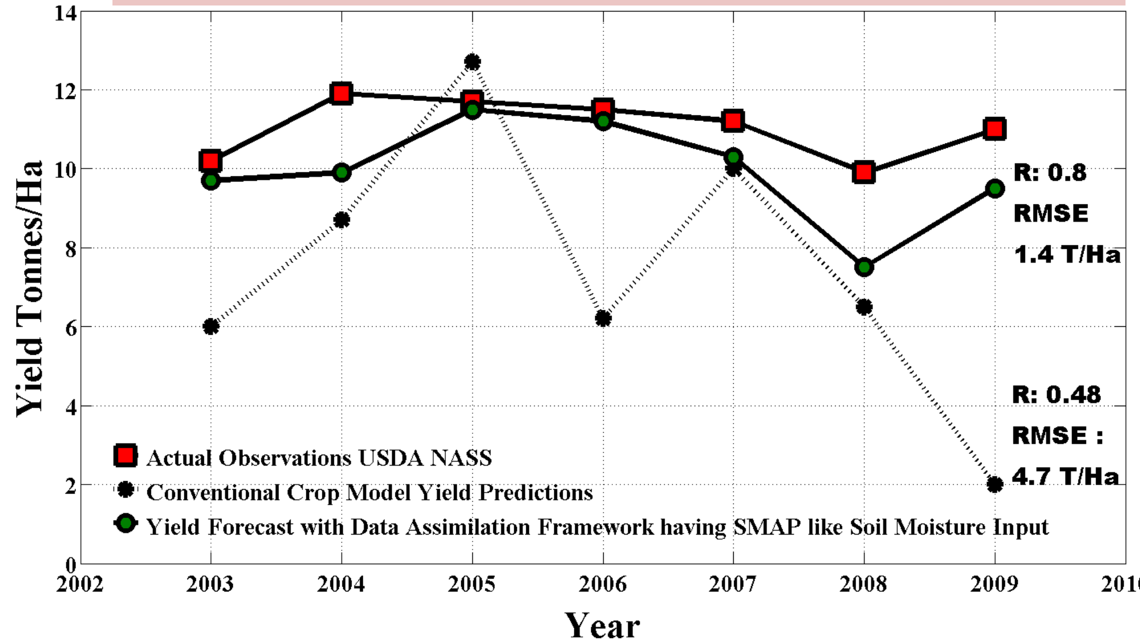
Agricultural Crop Yield and Food Security Applications



- Statement of Problem: The world faces an uphill struggle in feeding a projected nine to ten billion people by 2050

Corn yields with improved estimation and optimal forecasts based on the use of SMAP-like soil moisture estimates



Crop Simulation Model for Maize Yield Prediction. RSE-D-12-00872R2: Remote Sensing of Environment, *In Press*

- Water is the defining link between the climate and agriculture. To improve agricultural drought decision support systems and ensure food security, better quality and better use of soil moisture information is vital.

- This information will increase the lead time and skill of of crop yield forecasts.

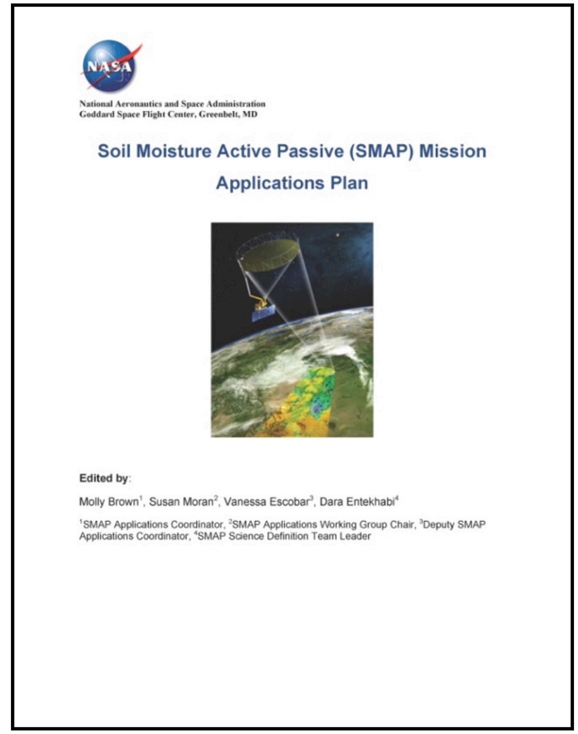
Courtesy of Narendra Das, JPL

SMAP Applications Development Approach

- A primary goal of NASA's SMAP Mission is to engage applications end users and build broad support for SMAP applications through a transparent and inclusive process.

- Toward that goal, the SMAP Mission:

    1. Formed the SMAP Applications Working Group (200+ members)
    2. Supports a SMAP Applications Coordinator
    3. Developed the SMAP Applications Plan (right)
    4. Developed the "Early-Adopter" program (50+ members)
    5. Holds SMAP Applications Workshops at user agencies and institutions (e.g., NOAA, USDA, USGS)
    6. Conducts hands-on tutorials and workshops



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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

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

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SMAP Applications Early Adopters

- Full list available at http://smap.jpl.nasa.gov/science/early-adopters/

SMAP Early Adopters†, SMAP project contacts, and applied research topics. Many Early Adopters cross multiple applications.	
Early Adopter PI and institution **SMAP Contact**	**Applied Research Topic**
Weather and Climate Forecasting	
* **Stephane Bélair**, Meteorological Research Division, Environment Canada (EC); SMAP Contact: **Stephane Bélair**	Assimilation and impact evaluation of observations from the SMAP mission in Environment Canada's Environmental Prediction Systems
* **Lars Isaksen and Patricia de Rosnay**, European Centre for Medium-Range Weather Forecasts (ECMWF); SMAP Contact: **Eni Njoku**	Monitoring SMAP soil moisture and brightness temperature at ECMWF
* **Xiwu Zhan, Michael Ek, John Simko and Weizhong Zheng**, NOAA National Centers for Environmental Prediction (NCEP), NOAA National Environmental Satellite Data and Information Service (NOAA-NESDIS); SMAP Contact: **Randy Koster**	Transition of NASA SMAP research products to NOAA operational numerical weather and seasonal climate predictions and research hydrological forecasts
* **Michael Ek, Marouane Temimi, Xiwu Zhan and Weizhong Zheng**, NOAA National Centers for Environmental Prediction (NCEP), NOAA National Environmental Satellite Data and Information Service (NOAA-NESDIS), City College of New York (CUNY); SMAP Contact: **Chris Derksen**	Integration of SMAP freeze/thaw product line into the NOAA NCEP weather forecast models
* **John Galantowicz**, Atmospheric and Environmental Research, Inc. (AER); SMAP Contact: **John Kimball**	Use of SMAP-derived inundation and soil moisture estimates in the quantification of biogenic greenhouse gas emissions
◊ **Jonathan Case, Clay Blankenship and Bradley Zavodsky**, NASA Short-term Prediction Research and Transition (SPoRT) Center; SMAP Contact: **Molly Brown**	Data assimilation of SMAP observations, and impact on weather forecasts in a coupled simulation environment
Droughts and Wildfires	
* **Jim Reardon and Gary Curcio**, US Forest Service (USFS); SMAP Contact: **Dara Entekhabi**	The use of SMAP soil moisture data to assess the wildfire potential of organic soils on the North Carolina Coastal Plain
* **Chris Funk, Amy McNally and James Verdin**, USGS & UC Santa Barbara; SMAP Contact: **Molly Brown**	Incorporating soil moisture retrievals into the FEWS Land Data Assimilation System (FLDAS)
◊ **Brian Wardlow and Mark Svoboda**, Center for Advanced Land Management Technologies (CALMIT), National Drought Mitigation Center (NDMC); SMAP Contact: **Narendra Das**	Evaluation of SMAP soil moisture products for operational drought monitoring: potential impact on the U.S. Drought Monitor (USDM)
◊ **Uma Shankar**, The University of North Carolina at Chapel Hill – Institute for the Environment; SMAP Contact: **Narendra Das**	Enhancement of a Bottom-up Fire Emissions Inventory Using Earth Observations to Improve Air Quality, Land Management, and Public Health Decision Support
Floods and Landslides	
* **Fiona Shaw**, Willis, Global Analytics; SMAP Contact: **Robert Gurney**	A risk identification and analysis system for insurance; eQUIP suite of custom catastrophe models, risk rating tools and risk indices for insurance and reinsurance purposes

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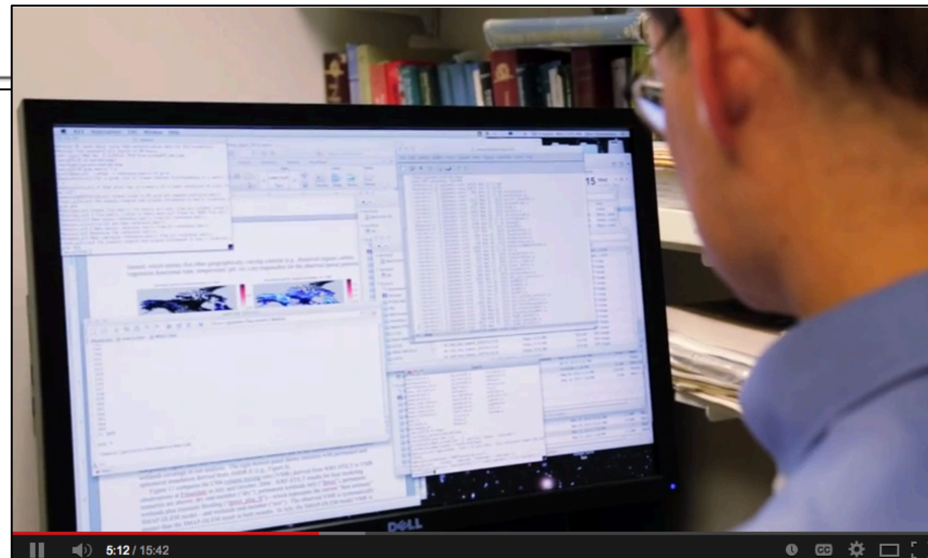
Applications Early Adopters Video

SMAP Early Adopters video

This diverse group represents a cross-section of end-users of SMAP data who collaborate to ensure integration of SMAP data into operations that affect our day-to-day lives. Examples include the U.S. Forest Service, the UN World Food Programme, and the U.S. Department of Agriculture.

VTT files: English (VTT, 18 KB) | Italian (VTT, 18 KB) | Spanish (VTT, 19 KB)

Early Adopters



SMAP Early Adopters

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

SMAP Documents

Document	Location	URL
SMAP Handbook	JPL ASF NSIDC	http://smap.jpl.nasa.gov/mission/description/ https://www.asf.alaska.edu/smap/documents-tools/ https://nsidc.org/data/smap/
Algorithm Theoretical Basis Documents (ATBDs)	JPL ASF NSIDC	http://smap.jpl.nasa.gov/documents/ https://www.asf.alaska.edu/smap/data-imagery/ https://nsidc.org/data/smap/smap-data.html
Ancillary Data Reports	JPL ASF	http://smap.jpl.nasa.gov/documents/ https://www.asf.alaska.edu/smap/data-imagery/ancillary-data/
Calibration and Validation Plan	JPL	http://smap.jpl.nasa.gov/science/validation/
Data Assessment Reports	ASF	https://www.asf.alaska.edu/smap/documents-tools/
User Guides	ASF NSIDC	https://www.asf.alaska.edu/smap/documents-tools/user-guide/ https://nsidc.org/data/smap/smap-data.html
Product Specification Documents	ASF	https://www.asf.alaska.edu/smap/data-imagery/