National Aeronautics and Space Administration

Soil Moisture for Agricultural Applications

Erika Podest and Amita Mehta

April 21, 2020

APPLIED REMOTE SENSING TRAINING PROGRAM

TRAIN - EMPOWER - ADVANCE

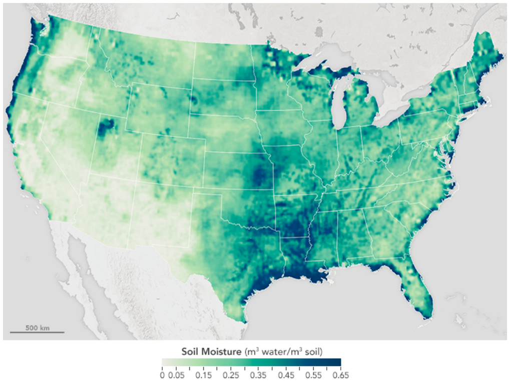
Training Outline

April 14, 2020

Overview of Agricultural Remote Sensing

https://eospso.nasa.gov/content/nasas-earth-observing-system-project-science-office

April 21, 2020



Soil Moisture for Agricultural Applications

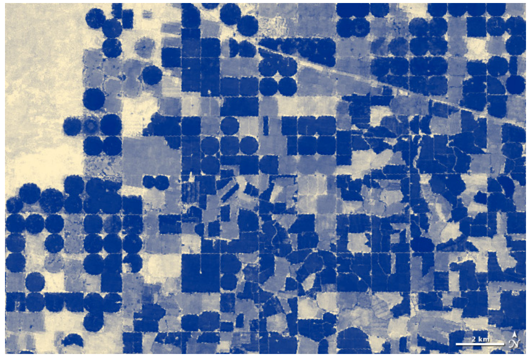
https://earthobservatory.nasa.gov/images/87036/soil-moisture-in-the-united-states

April 28, 2020

Earth Observations for Agricultural Monitoring

https://earthobservatory.nasa.gov/images/90095/satellites-eye-winter-cover-crops

May 5, 2020



Evapotranspiration & Evaporative Stress Index for Agricultural Applications

https://earthobservatory.nasa.gov/images/42428/water-use-on-idahos-snake-river-plain

Training Format, Homework, and Certificate

- Four, 1.5-hour sessions with Q&A
- Homework Assignments will be available after parts 1 & 3 from: https://arset.gsfc.nasa.gov/water/webinars/remote-sensing-for-agriculture-20
  - Answers must be submitted via Google Form
  - Due dates: **April 28** & **May 12**
- Certificate of Completion will be awarded to those who:
  - Attend all webinars
  - Complete all homework assignments
- You will receive a certificate approximately two months after the completion of the course from: marines.martins@ssaihq.com

Soil Moisture for Agricultural Applications

Outline:

- Soil Moisture Active Passive (SMAP)
  - Overview of SMAP
  - Examples of SMAP for agricultural applications
  - SMAP products & data access
- Land Data Assimilation Systems (LDAS)
  - Overview of LDAS
  - Examples of LDAS for agricultural applications
  - LDAS data access
  - Demonstration of GLDAS data access and soil moisture analysis

National Aeronautics and Space Administration

Soil Moisture for Agricultural Applications
The Soil Moisture Active Passive (SMAP) Satellite Mission

Amita Mehta and Erika Podest

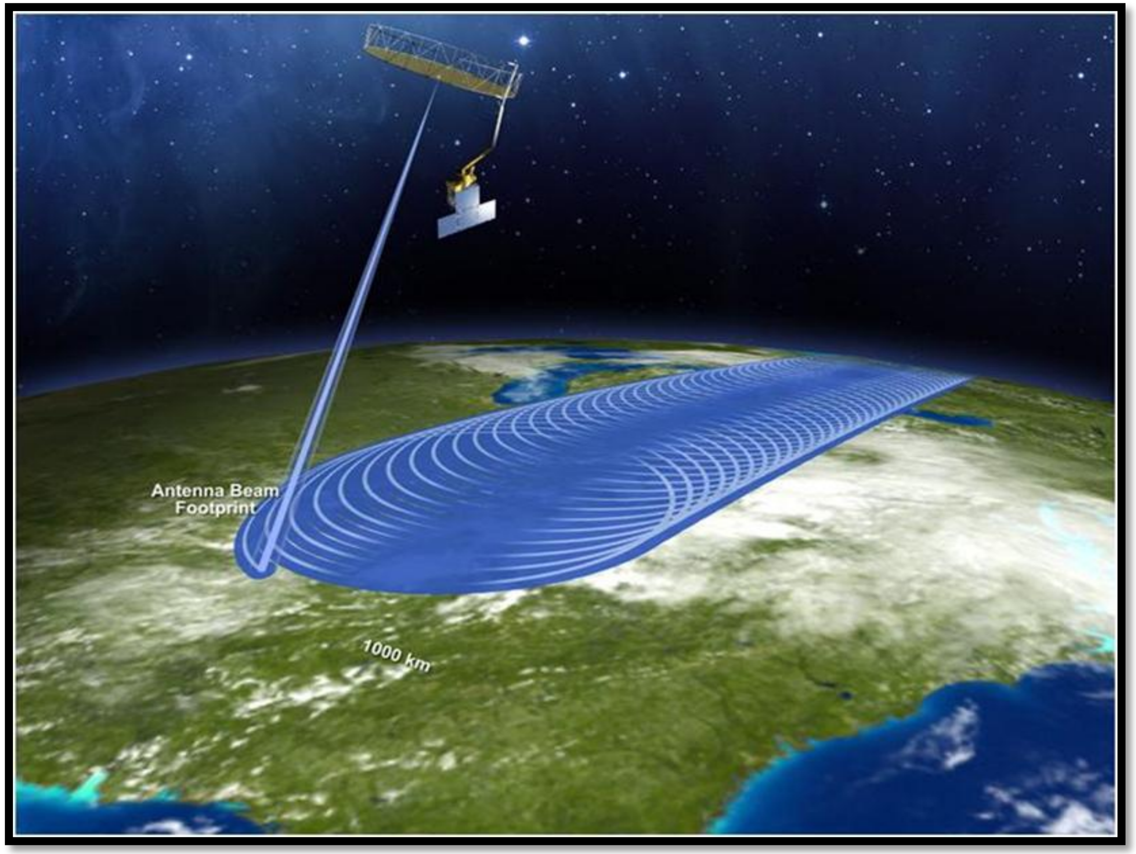
April 21, 2020

Outline

1. Overview of SMAP
2. Examples of SMAP for Agricultural Applications
3. SMAP Products
4. SMAP Data Access

SMAP Overview

SMAP Overview



Launched on Jan. 31, 2015

Orbit: Sun-Synchronous, 6 am/pm orbit
685 km altitude

Radiometer

- Frequency: 1.41 GHz
- Polarization: H, V, 3rd & 4th Stokes
- Resolution: 40km
- Relative Accuracy: 1.3K

Antenna

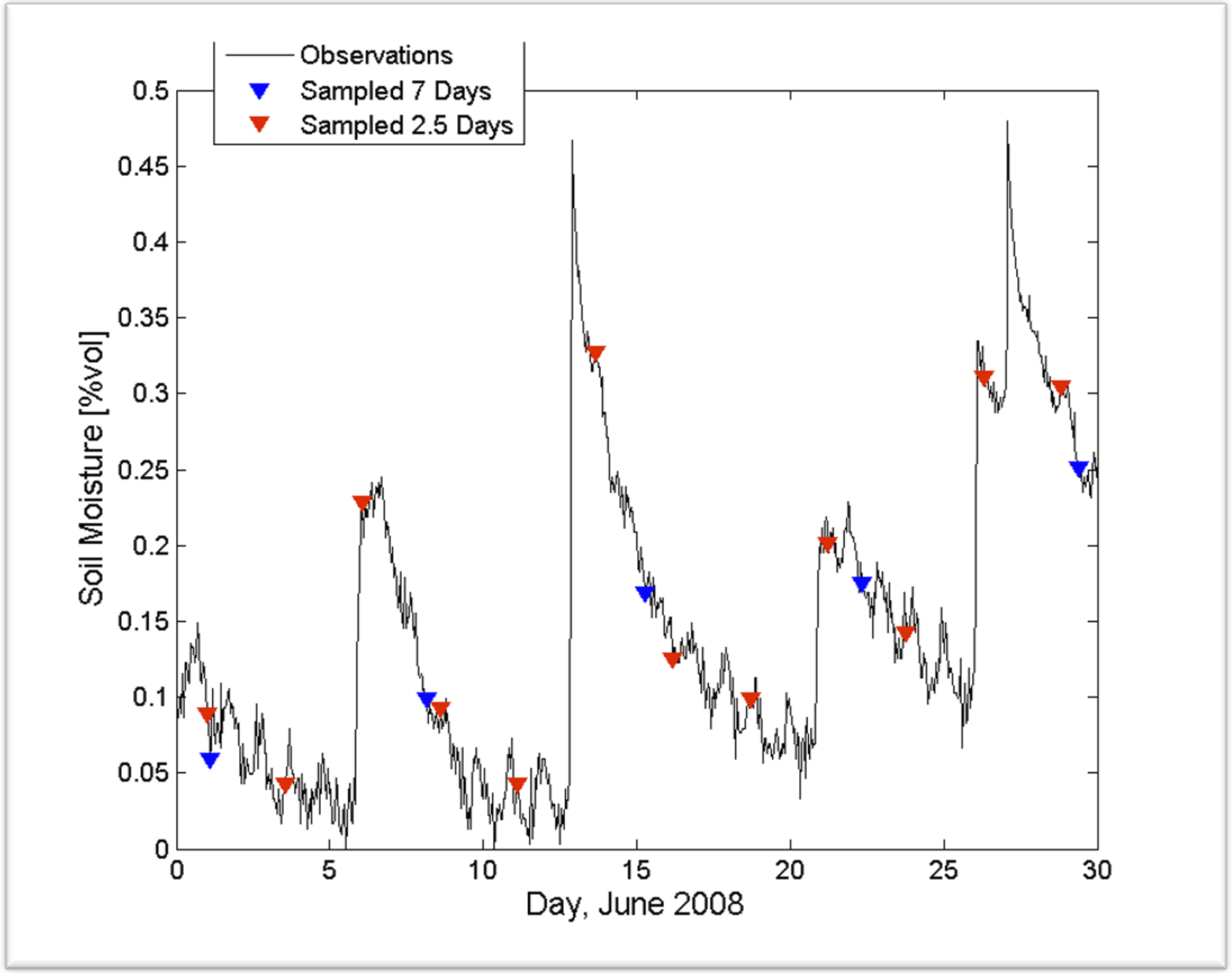
- 6m diameter
- Conical scanning at 14.6 r.p.m.
- Constant Incidence Angle: 40 deg.
- Swath: 1000km wide
- Swath and orbit allow global coverage every 2-3 days

SMAP Soil Moisture Measurements

- Domain: Global
- Spatial Resolution: 9 and 36 km
- Temporal Repeat: Every 3 days
- Sensing Depth: 5 cm
- Measurement: Volumetric Soil Moisture
- Accuracy: **0.04** [cm^3/cm^3]
- Data Access Policy: Freely Available

Justification for Observations Every 3 Days

- Observations are needed every 3 days or less to optimally determine the variability in soil moisture.

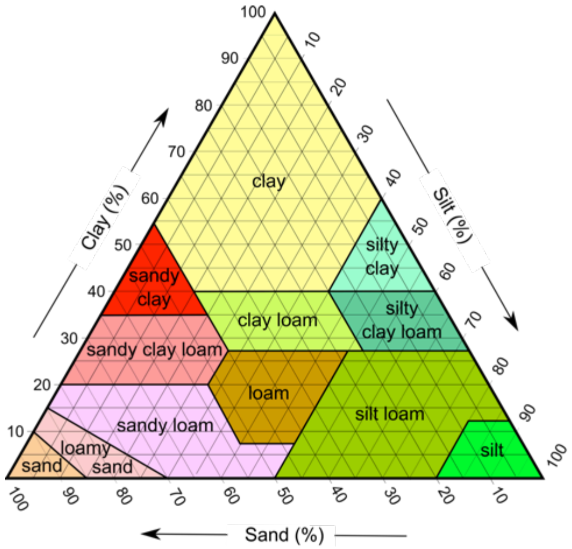


Factors Influencing Soil Moisture

Soil Moisture varies with space and time.
Primary factors that influence the distribution of soil moisture are:

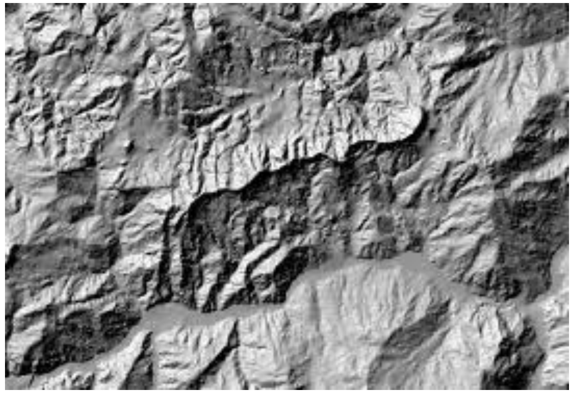
Rainfall

Soil Texture



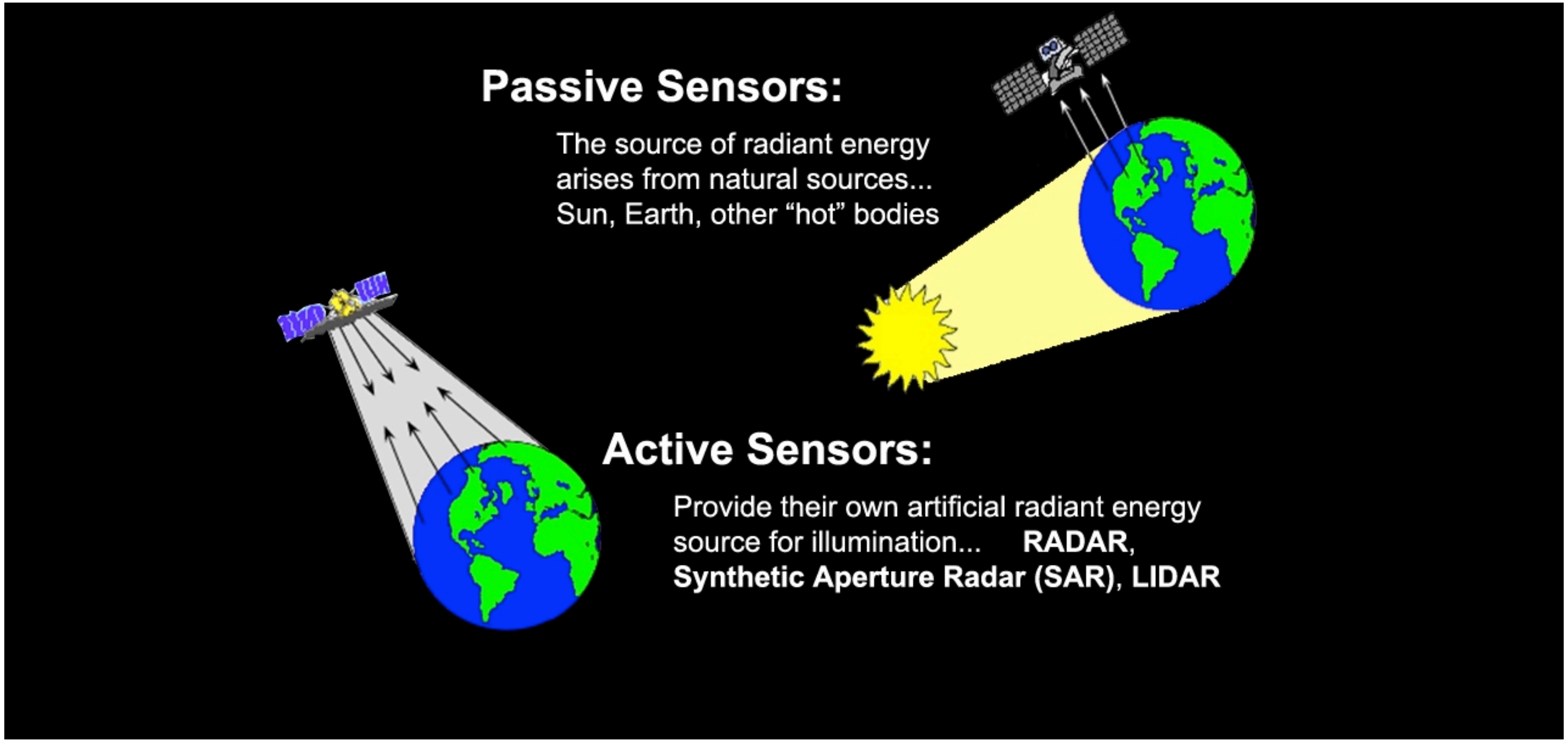
Vegetation

Topography



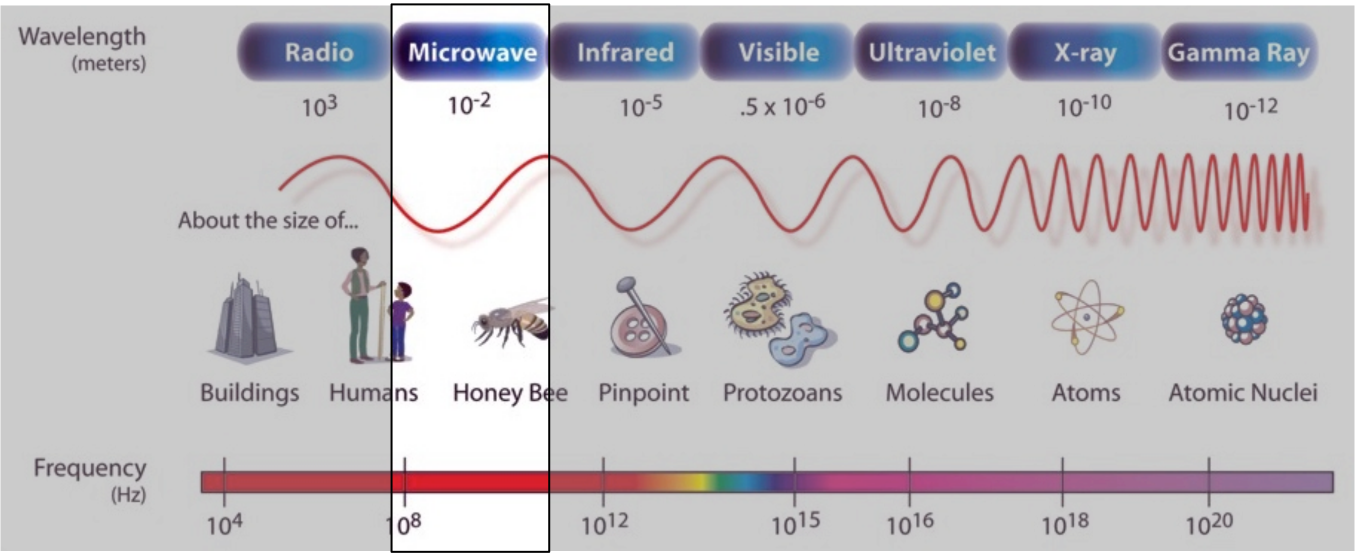
Passive and Active Remote Sensing

SMAP uses active and passive sensors to measure soil moisture.



Microwave Remote Sensing

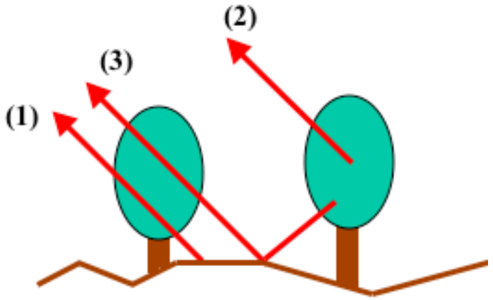
- With Visible and Infrared sensors the soil is masked by clouds and vegetation. Optical sensors operate by measuring scattered sunlight and are “daytime only”.
- Microwaves can penetrate through clouds and vegetation, operate day and night, and are highly sensitive to the water in the soil due to the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



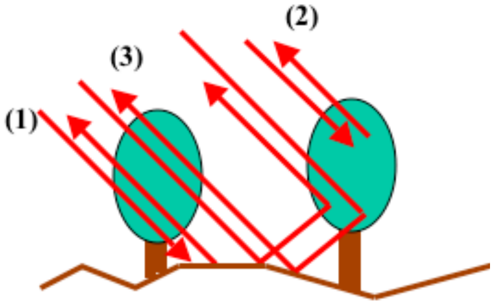
Measurement Approach

- Contributions from the:
  - Soil
  - Vegetation
  - Soil-vegetation interaction
- Soil moisture measurements are corrected for the effects of vegetation, surface roughness, and temperature

Emission



Backscatter



Ancillary Data Sources

Ancillary data are used to estimate the key unknown parameters: surface temperature (≈ surface air temp. at 6 am), vegetation opacity, surface roughness, and soil texture.

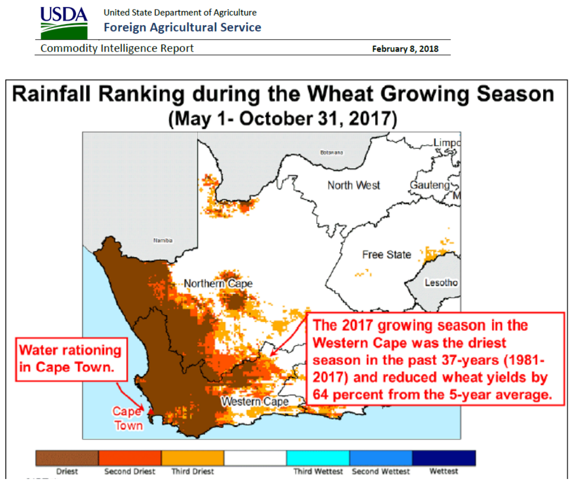
Parameter	Description/Sources
Surface air meteorology	- Data assimilation (GEOS/DAO) - Forecast models (NCEP and ECMWF)
Vegetation opacity	- Vis/IR satellite-derived NDVI, LAI, landcover (MODIS, IGBP-DIS) - Historical phenology (AVHRR)
Surface topography	- Digital elevation models (USGS and SRTM)
Soil texture	- Soils databases (Global, NGDC; US, STATSGO)
Land/water boundaries	- Coastal boundaries and inland water bodies (NGDC)

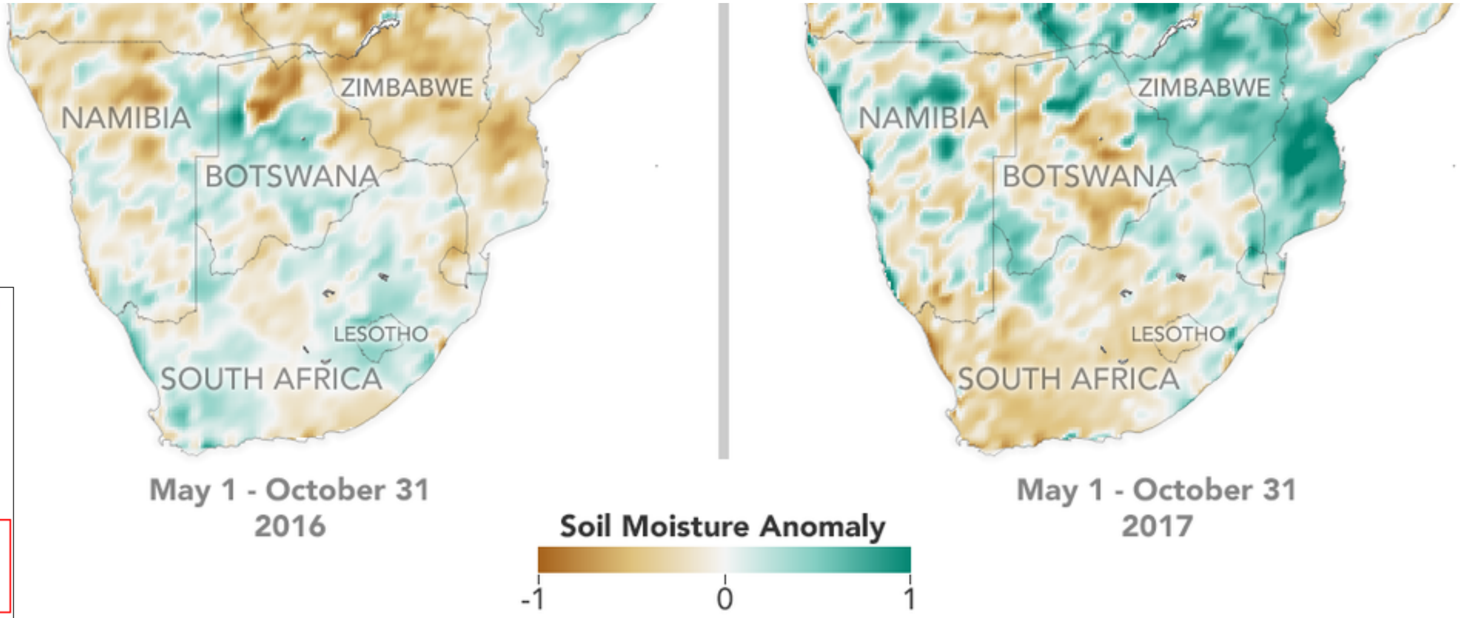
Soil Moisture Products from Different Satellites

- SMAP - L-Band, 40 km, observations every 3 days
  - https://nsidc.org/data/smap/smap-data.html
- SMOS - L-Band, 40 km, observations every 3 days
  - https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos/news/-/article/smos-level-2-soil-moisture-data-now-available-via-eumetcast-in-near-real-time
- ASCAT - C-Band, 12.5 and 25 km, daily observations

SMAP for Agricultural Applications

Improved Global Agricultural Monitoring Through the Integration of SMAP Soil Moisture into the USDA-FAS Crop Forecasting System



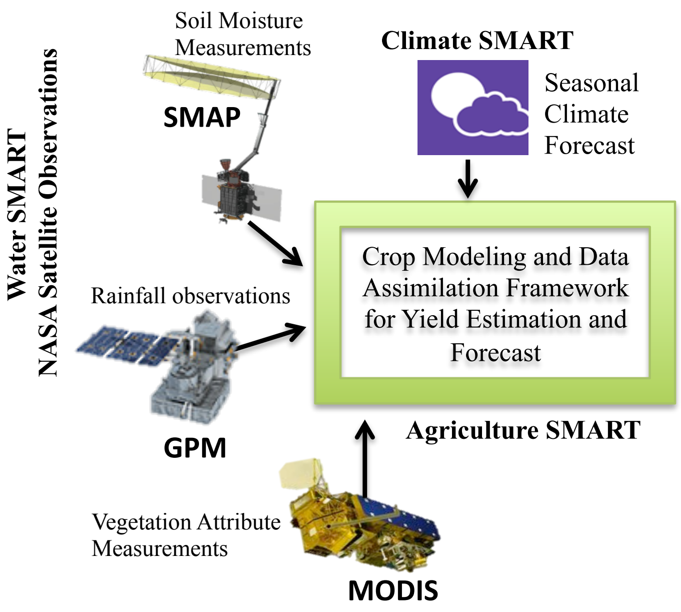


Severe Drought in the Western Cape Reduces South Africa's 2017/18 Wheat Output

Source: Iliana E. Mladenova, John D. Bolten, and Nazmus Sazib, Hydrological Sciences Lab , NASA GSFC

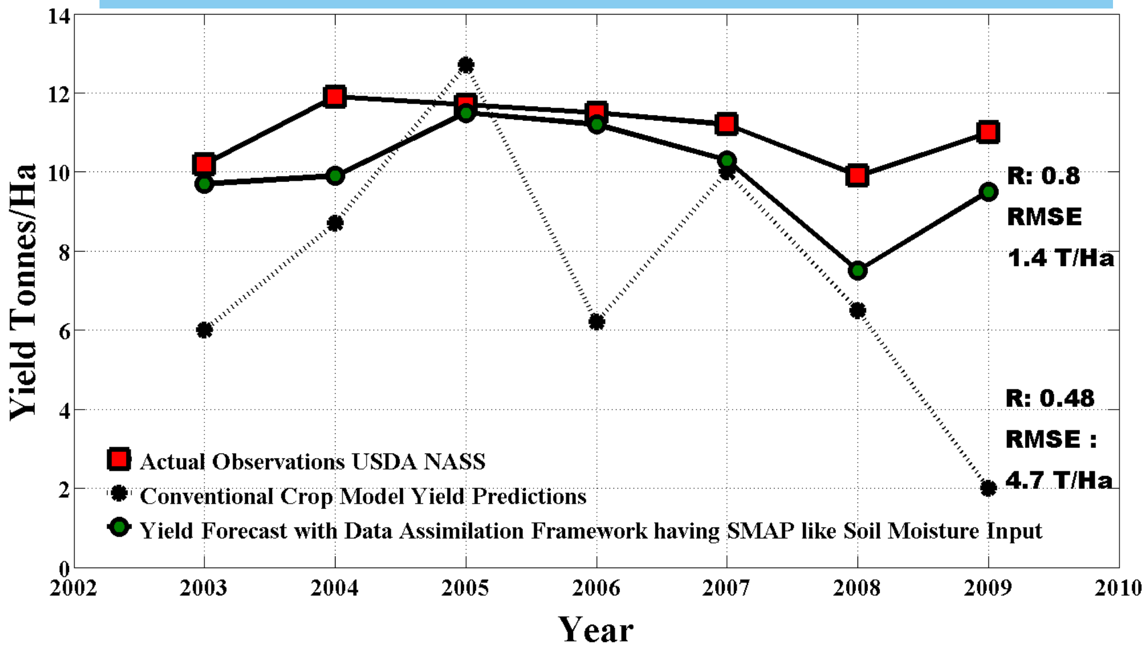
The USDA-FAS Global Crop Decision Support System has been enhanced by the integration of NASA SMAP soil moisture observations. The efforts have led to the generation of improved soil moisture information that is essential for the agency's crop forecasting activities.

SMAP for 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 Forecast based on use of SMAP-like Soil Moisture Estimates



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/Water information is vital.

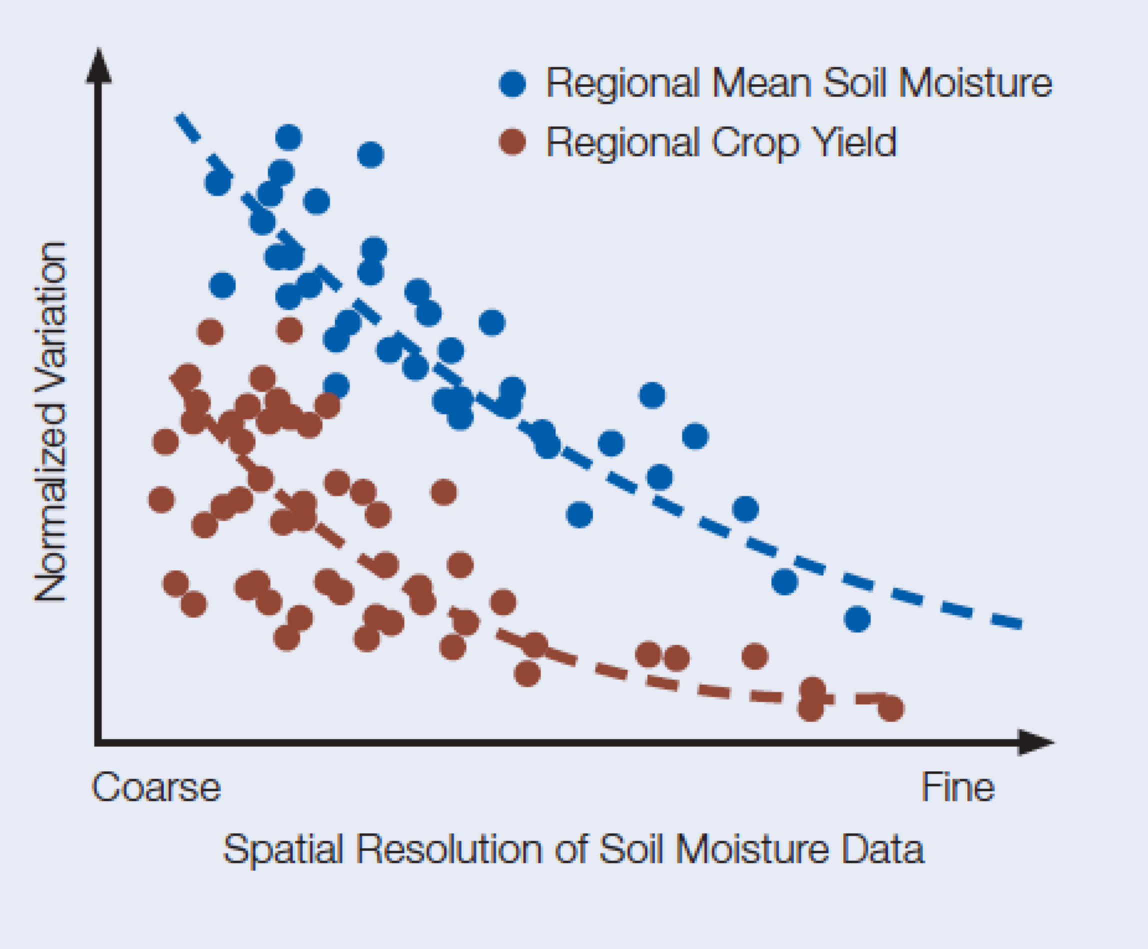
This information will increase the lead time and skill of of crop yield forecasts.

Courtesy of Narendra Das- JPL

Ines, Das et al., 2013. Assimilation of Remotely Sensed Soil Moisture and Vegetation with a Crop Simulation Model for Maize Yield Prediction. RSE-D-12-00872R2: Remote Sensing of Environment.

Crop Yield Modeling

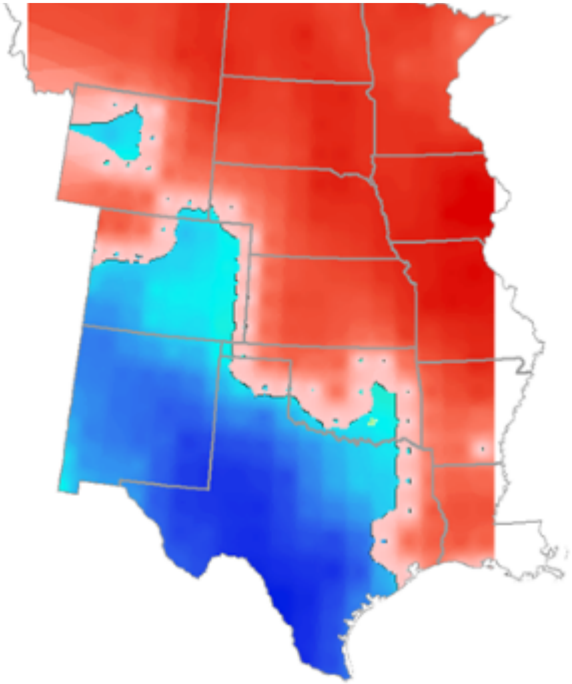
Agricultural models have been developed to predict the yield of various crops at field and regional scales. One key input of the agricultural models is soil moisture. The conceptual diagram relates variation in regional domain-averaged soil moisture to variation in total crop yield. Statistical analysis 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.



Improve Drought/Flood Early Warning

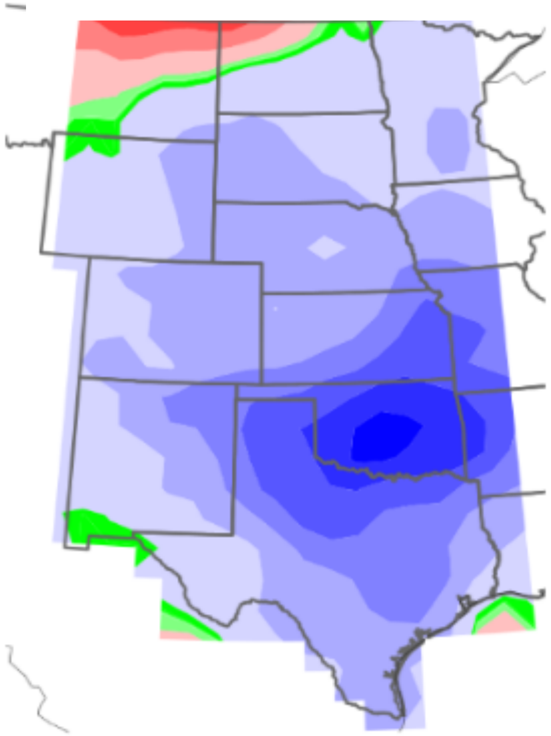
Prediction of 2015 Summer Rainfall Anomalies

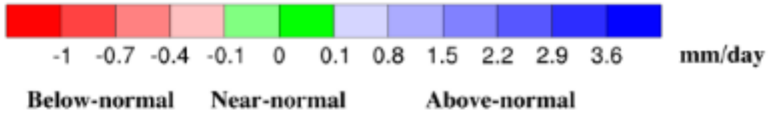
Prediction using Soil Moisture Estimate



Prediction using Soil Moisture from SMAP

Observed Rainfall Anomalies





Texas Water Development Board

UCLA & TWDB, *Rong Fu, Nelun Fernando*

SMAP Products

SMAP Data Products

Product Type	Product description	Gridding (resolution)	Granule Extent
L1A_Radar	Parsed SMAP Radar Telemetry (start-July 7, 2015)		Half Orbit
L1B_S0_LoRes	Low resolution radar sigma0 in time order (start-July 7, 2015)	5x30 km	Half Orbit
L1C_S0_HiRes	High resolution radar sigma0 on Swath Grid (start-July 7, 2015)	1 km	Half Orbit
L1A_Radiometer	Parsed Radiometer Telemetry		Half Orbit
L1B_TB	Geolocated, calibrated brightness temperature in time order	36 km	Half Orbit
L1B_TB_E	Backus-Gilbert interpolated, calibrated brightness temperature in time order	9 km	Half Orbit
L1C_TB	Geolocated, calibrated brightness temperature on EASE2 grid	36 km	Half Orbit
L1C_TB_E	Backus-Gilbert interpolated, calibrated brightness temperature on EASE2 grid	9 km	Half Orbit
L2_SM_A	Radar soil moisture (start-July 7, 2015)	3 km	Half Orbit
L2_SM_P	Radiometer soil moisture	36 km	Half Orbit
L2_SM_P_E	Radiometer soil moisture	9 km	Half Orbit
L2_SM_AP	SMAP active-passive soil moisture	9 km	Half Orbit
L2_SM_SP	SMAP radiometer/Copernicus Sentinel-1 soil moisture	3 km	Sentinel-1
L3_SM_P	Daily global composite radiometer soil moisture	36 km	Daily - Global
L3_SM_P_E	Daily global composite radiometer soil moisture	9 km	Daily - Global
L3_FT_A	Daily global composite radar freeze/thaw state (start-July 7, 2015)	3 km	Daily – North of 45 deg N
L3_SM_A	Daily global composite radar soil moisture (start-July 7, 2015)	3 km	Daily - Global
L3_SM_AP	Daily global composite active passive soil moisture (start-July 7, 2015)	9 km	Daily - Global
L3_FT_P	Daily composite freeze/thaw state	36 km	Daily - Global
L3_FT_P_E	Daily composite freeze/thaw state	9 km	Daily - Global
L4_SM	Surface and Root Zone soil moisture	9 km	3 hours - Global
L4_C	Carbon Net Ecosystem Exchange	9 km	Daily – North of 45 N
L1B_TB_NRT	Near Real Time Geolocated, calibrated brightness temperature in time order	36 km	Half Orbit
L2_SM_P_NRT	Near Real Time Radiometer soil moisture	36 km	Half Orbit

SMAP Data Products

Product Type	Product description	Gridding (resolution)	Granule Extent
L1A_Radar	Parsed SMAP Radar Telemetry (start-July 7, 2015)		Half Orbit
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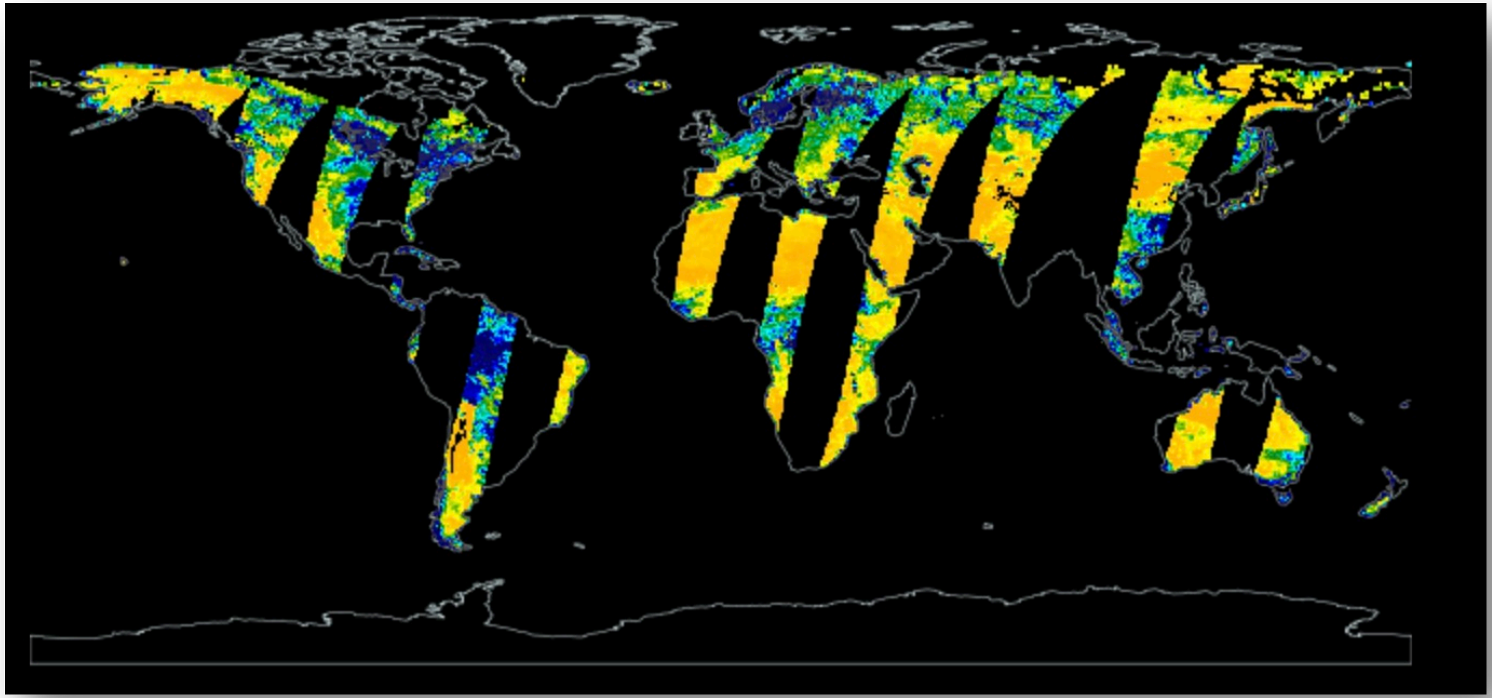
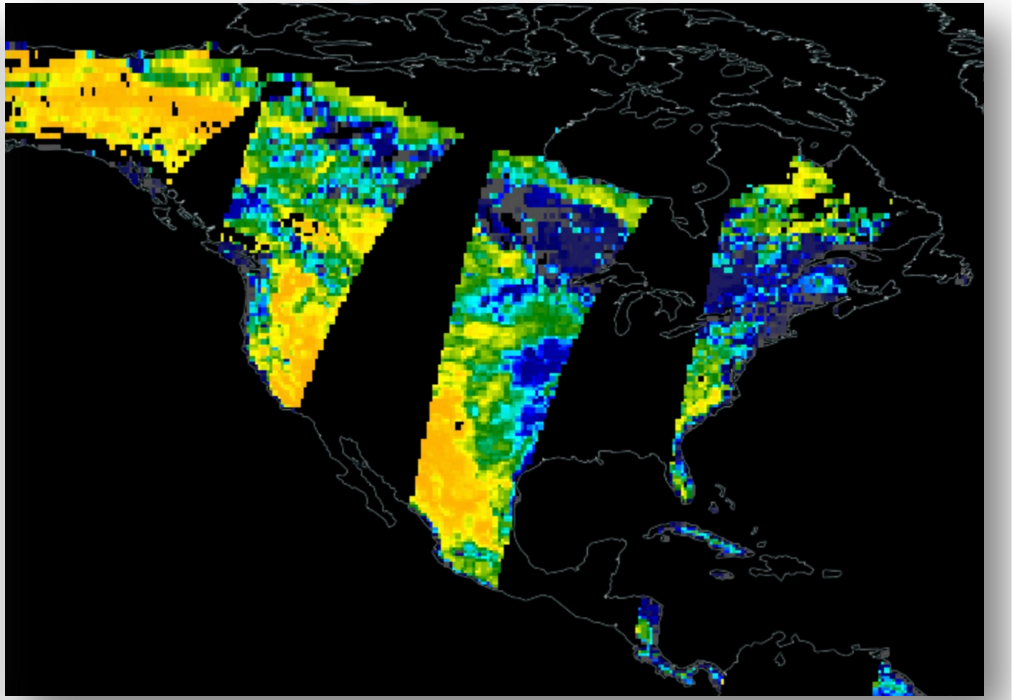
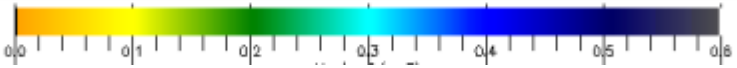
L1A_Radiometer	Parsed Radiometer Telemetry		Half Orbit
L1B_TB	Geolocated, calibrated brightness temperature in time order	36 km	Half Orbit
L1B_TB_E	Backus-Gilbert interpolated, calibrated brightness temperature in time order	9 km	Half Orbit
L1C_TB	Geolocated, calibrated brightness temperature on EASE2 grid	36 km	Half Orbit
L1C_TB_E	Backus-Gilbert interpolated, calibrated brightness temperature on EASE2 grid	9 km	Half Orbit
L2_SM_A	Radar soil moisture (start-July 7, 2015)	3 km	Half Orbit
L2_SM_P	Radiometer soil moisture	36 km	Half Orbit
L2_SM_P_E	Radiometer soil moisture	9 km	Half Orbit
L2_SM_AP	SMAP active-passive soil moisture	9 km	Half Orbit
L2_SM_SP	SMAP radiometer/Copernicus Sentinel-1 soil moisture	3 km	Sentinel-1
L3_SM_P	Daily global composite radiometer soil moisture	36 km	Daily - Global
L3_SM_P_E	Daily global composite radiometer soil moisture	9 km	Daily - Global
L3_FT_A	Daily global composite radar freeze/thaw state (start-July 7, 2015)	3 km	Daily – North of 45 deg N
L3_SM_A	Daily global composite radar soil moisture (start-July 7, 2015)	3 km	Daily - Global
L3_SM_AP	Daily global composite active passive soil moisture (start-July 7, 2015)	9 km	Daily - Global
L3_FT_P	Daily composite freeze/thaw state	36 km	Daily - Global
L3_FT_P_E	Daily composite freeze/thaw state	9 km	Daily - Global
L4_SM	Surface and Root Zone soil moisture	9 km	3 hours - Global
L4_C	Carbon Net Ecosystem Exchange	9 km	Daily – North of 45 N
L1B_TB_NRT	Near Real Time Geolocated, calibrated brightness temperature in time order	36 km	Half Orbit
L2_SM_P_NRT	Near Real Time Radiometer soil moisture	36 km	Half Orbit

Level 3 Radiometer 36 km Soil Moisture Product

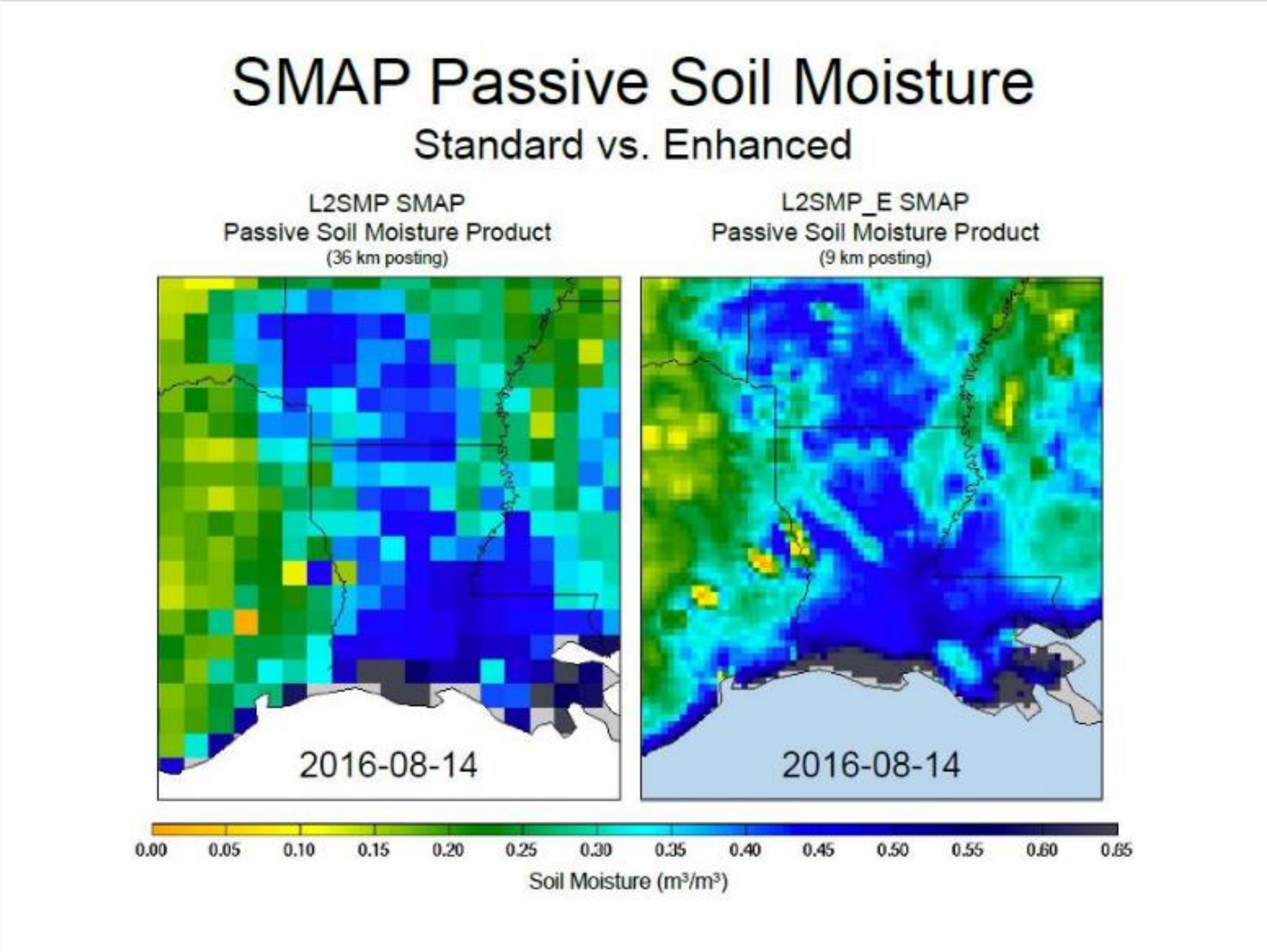




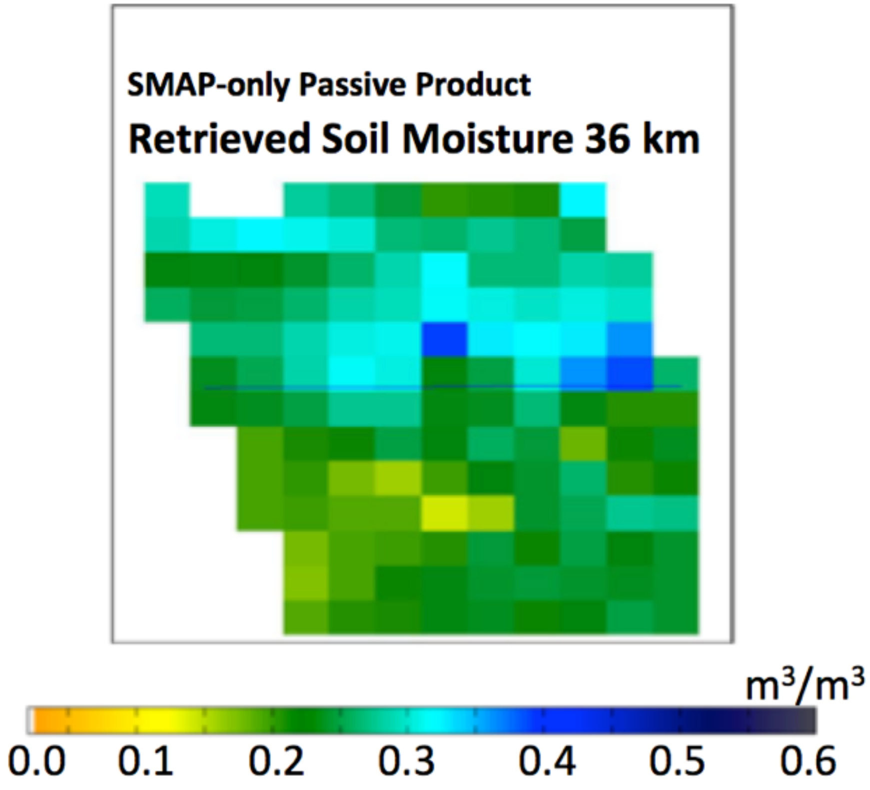


Volumetric Soil Moisture (cm^3/cm^3)

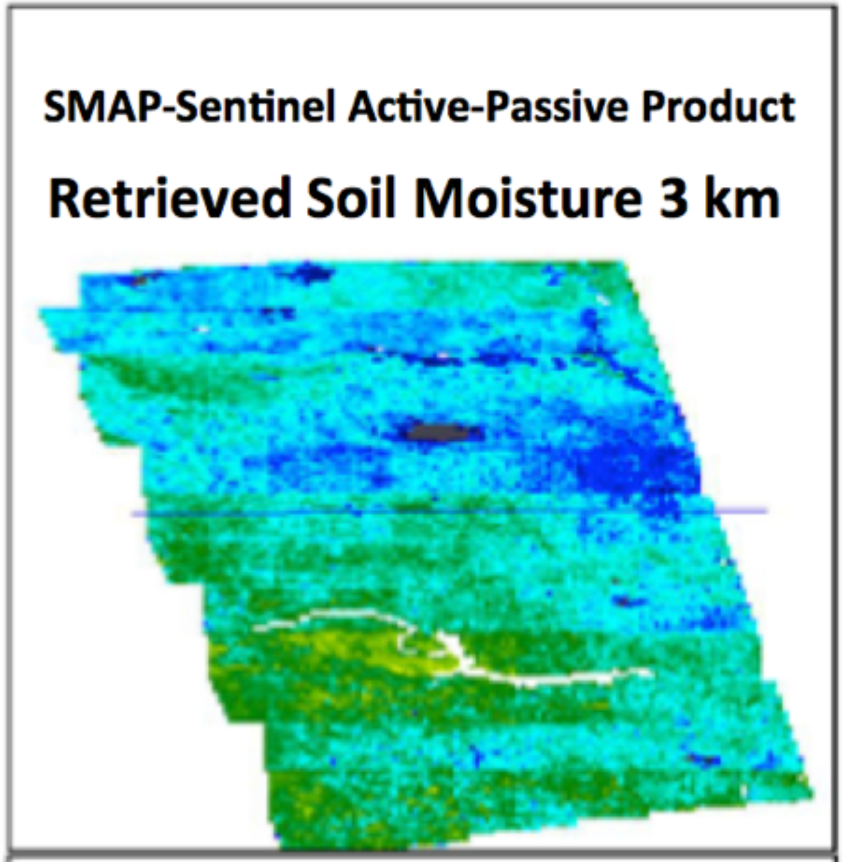
SMAP Soil Moisture - Enhanced Product



SMAP Enhanced Active-Passive Product Using Sentinel-1

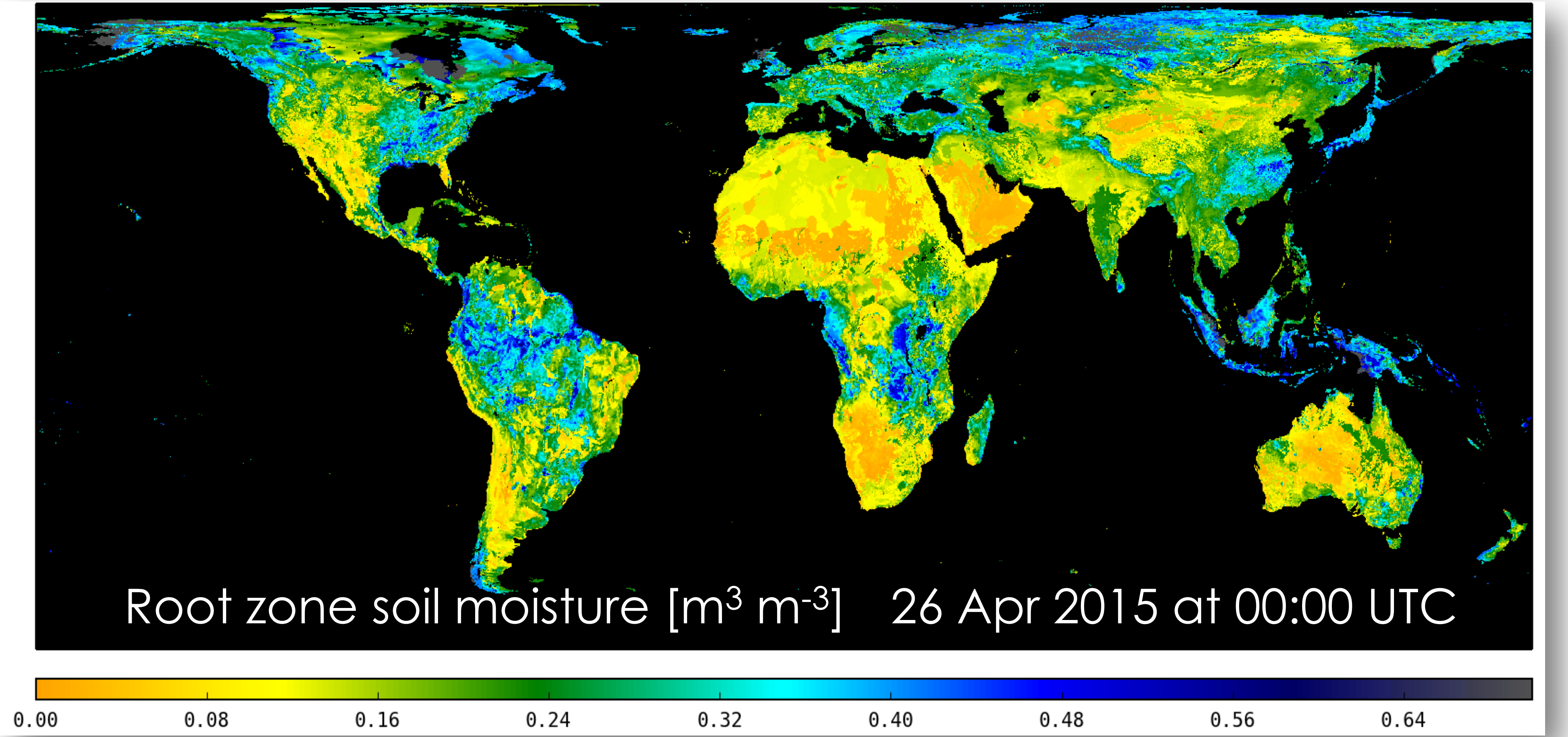


Soil Moisture at Different Resolutions
Retrieved for May 17th, 2015
Over Manitoba region Canada

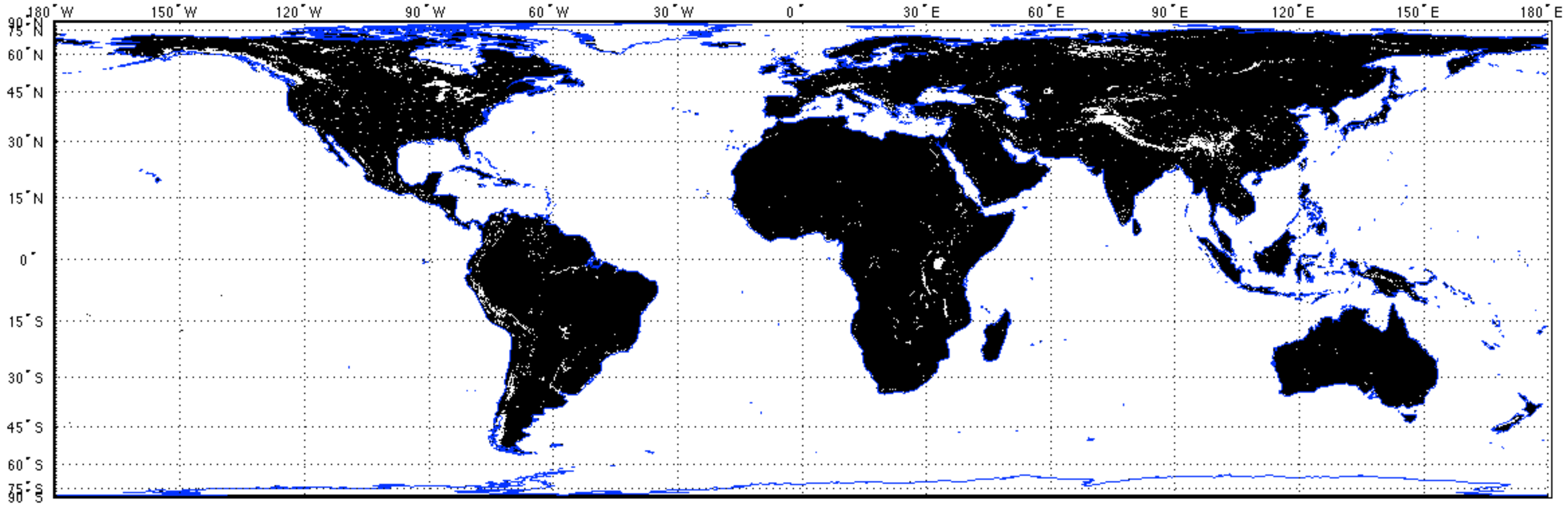


Source: Narendra Das

Surface and Root Zone Soil Moisture- Level 4



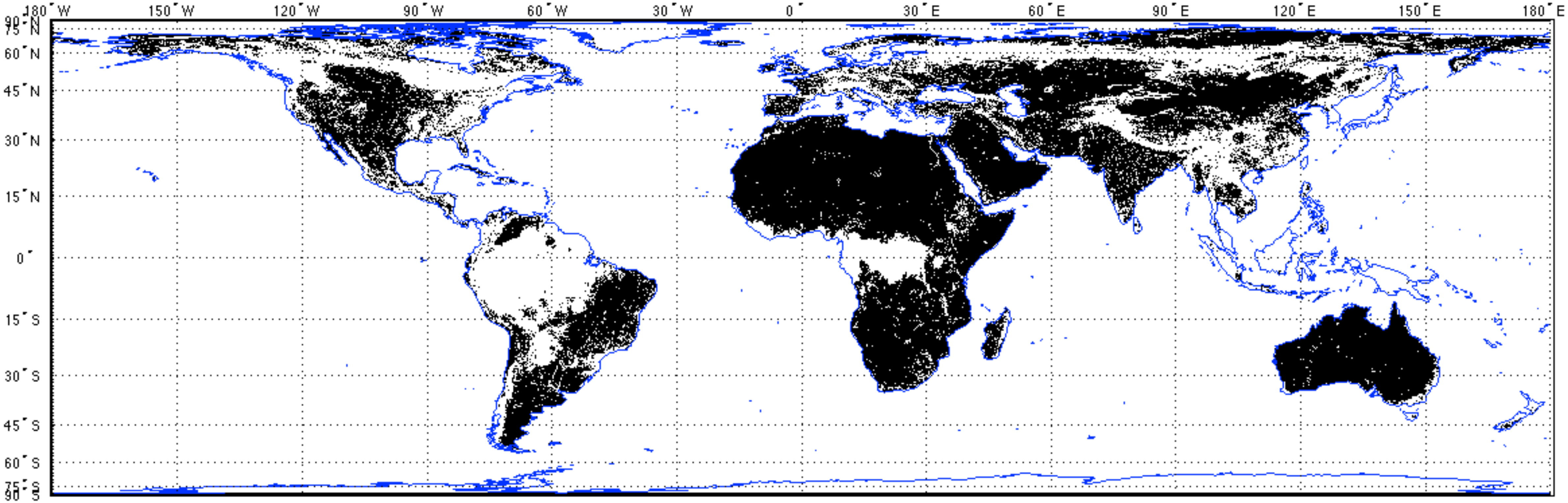
Soil Moisture Retrieval Map



Retrievable mask (black colored pixels) with the following specifications:

a) Urban Fraction < 1
b) Water Fraction < 0.5
c) DEM Slope Standard Deviation < 5 deg

Soil Moisture Expected Accuracy



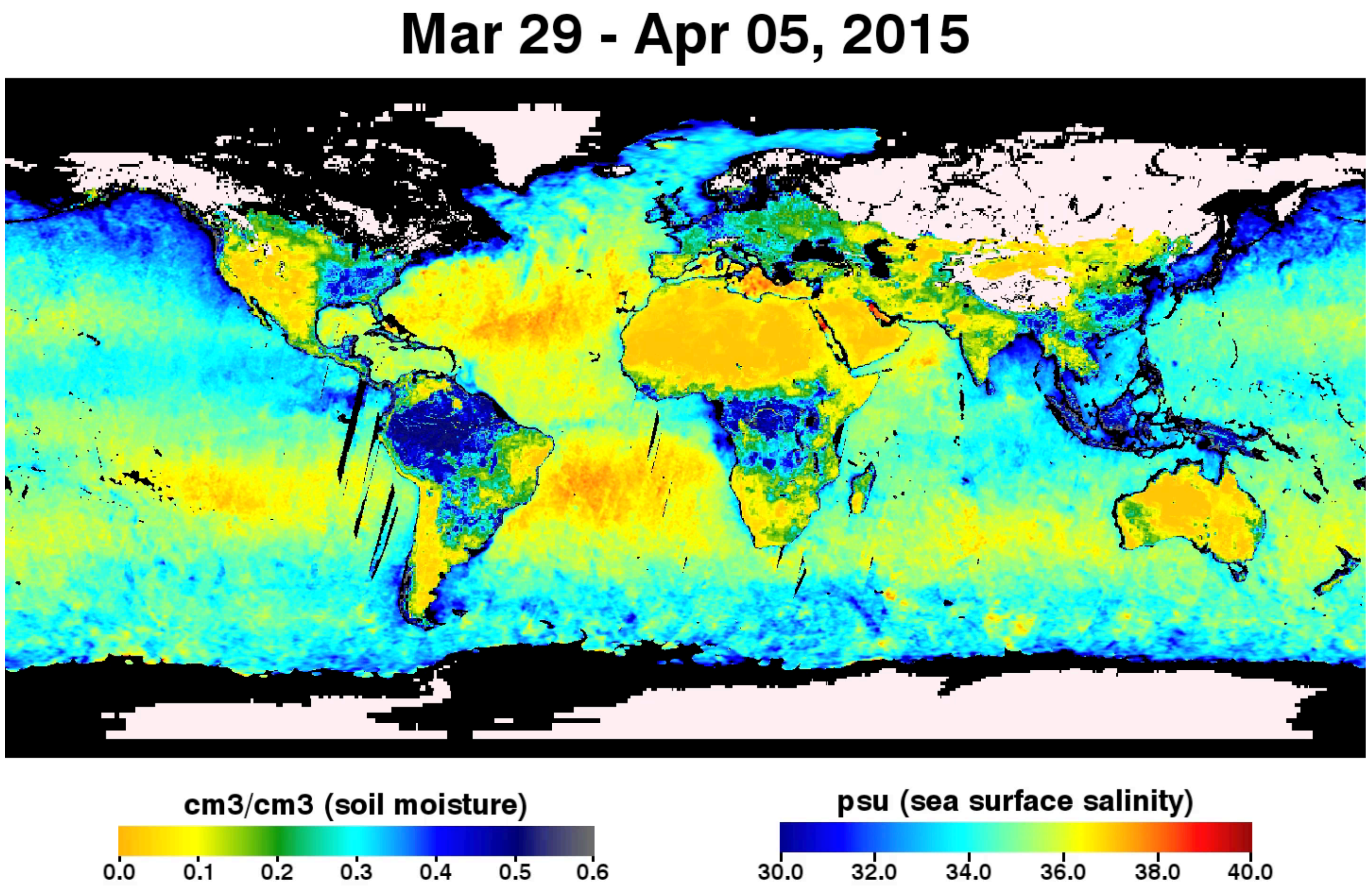
Retrieval expected quality mask (black colored pixels indicate good quality) with following specifications:

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

Global Soil Moisture Animation

SMAP: Soil Moisture + Sea Surface Salinity



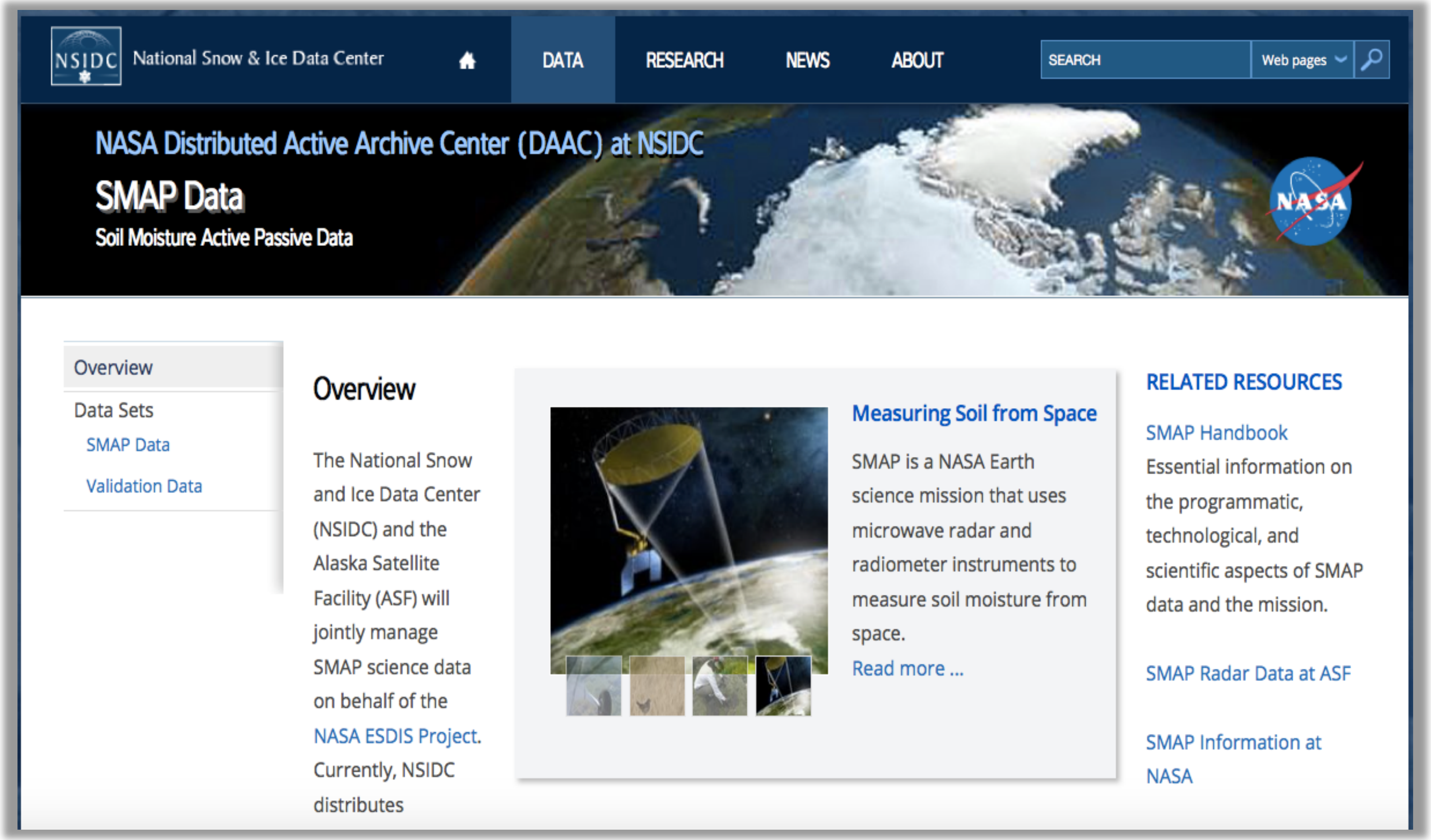
SMAP Data Access

Data Product Design

- **All products are in HDF5 format**
  - Each SMAP HDF5 file contains the primary data parameters (e.g., soil moisture, freeze/thaw, sensor data) and all data used in the production of those primary parameters. These files also include metadata, geolocation information, quality flags, etc.
- **Projection: EASE-Grid 2.0**
  - Equal-area projection
  - Level 2, 3, 4, and radiometer L1C are in this projection
- **Values**
  - Radiometer data (brightness temperature) is in Kelvin
  - Radar data is in sigma naught
  - Soil moisture is a volumetric measurement expressed as cm^3/cm^3
  - Freeze/thaw is a binary measurement, either frozen or thawed
  - Net ecosystem exchange is in grams of carbon per square meter per day

Access to SMAP Data: NSIDC

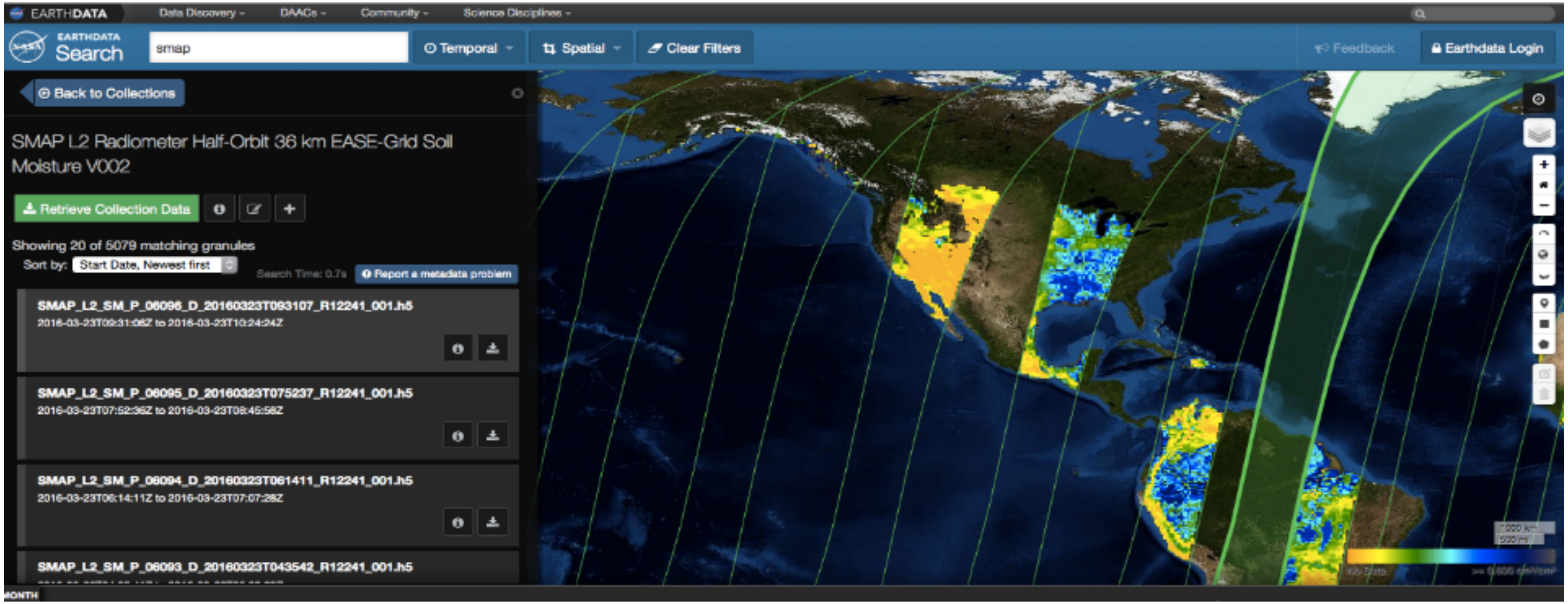
http://nsidc.org/data/smap/



Data Access: Earth Data Search

Earthdata Search: https://search.earthdata.nasa.gov/

- Search and order all SMAP data
- Keyword, spatial, and/or temporal search
- Reformat, reproject, and subset services for most products



Soil Moisture for Agricultural Applications

Erika Podest and Amita Mehta

April 21, 2020

Land Data Assimilation System for Soil Moisture

Outline:

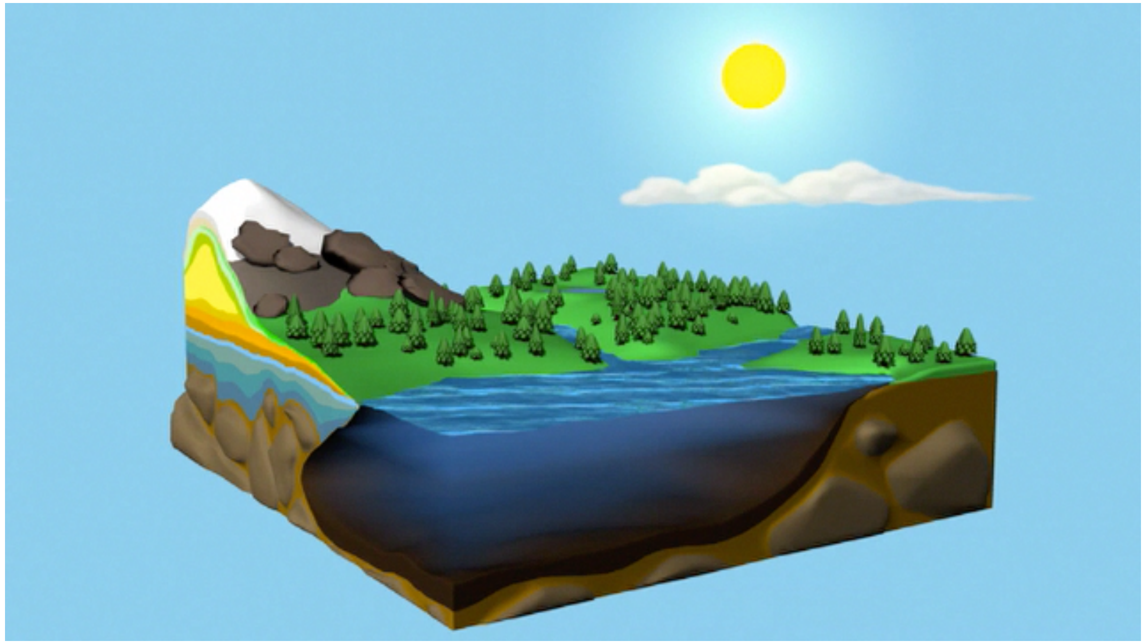
- Overview of Land Data Assimilation Systems (LDAS)
- Examples of LDAS for agricultural applications
- LDAS data access
- Demonstration of GLDAS data access and soil moisture analysis

Overview of Land Data Assimilation Systems

Need for LDAS for Water and Land Management

Proper characterization of spatial and temporal variations in water and energy states (**e.g. soil moisture and temperature**) and fluxes (**e.g. evaporation and runoff**) is critical for many applications:

- Weather prediction
- Agricultural forecasting
- Drought and flood risk assessments
- Improving understanding of land-atmosphere interactions
- Climate change impacts
- https://ldas.gsfc.nasa.gov/

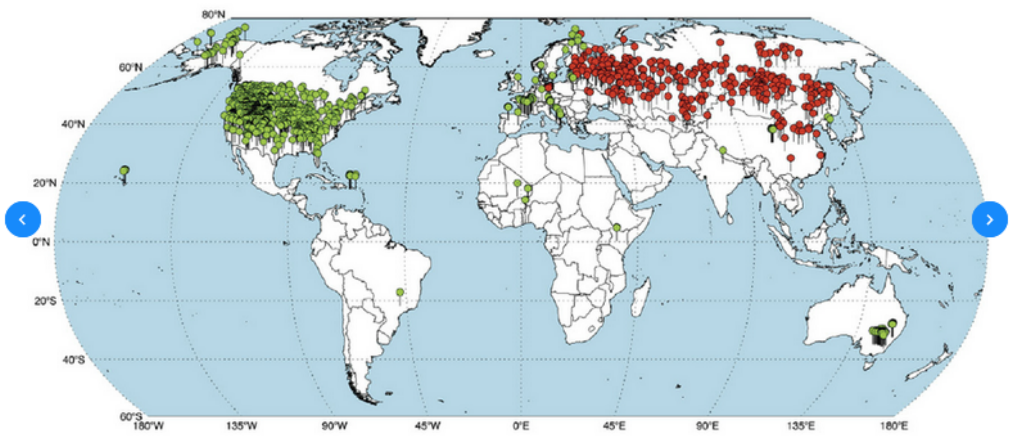


Source: NASA LDAS

Need for LDAS for Water and Land Management

- Various ground- and space-based land and hydrology observations are available, but they have spatial and temporal gaps.
- LDAS integrates surface-based and remote sensing observations, providing uniformly gridded, frequent information of water and energy components.
- LDAS provides quantities that are not directly observed by satellites (e.g. runoff, evapotranspiration, snow water equivalence).
- https://ldas.gsfc.nasa.gov/

Surface-Based Observations
Soil Moisture

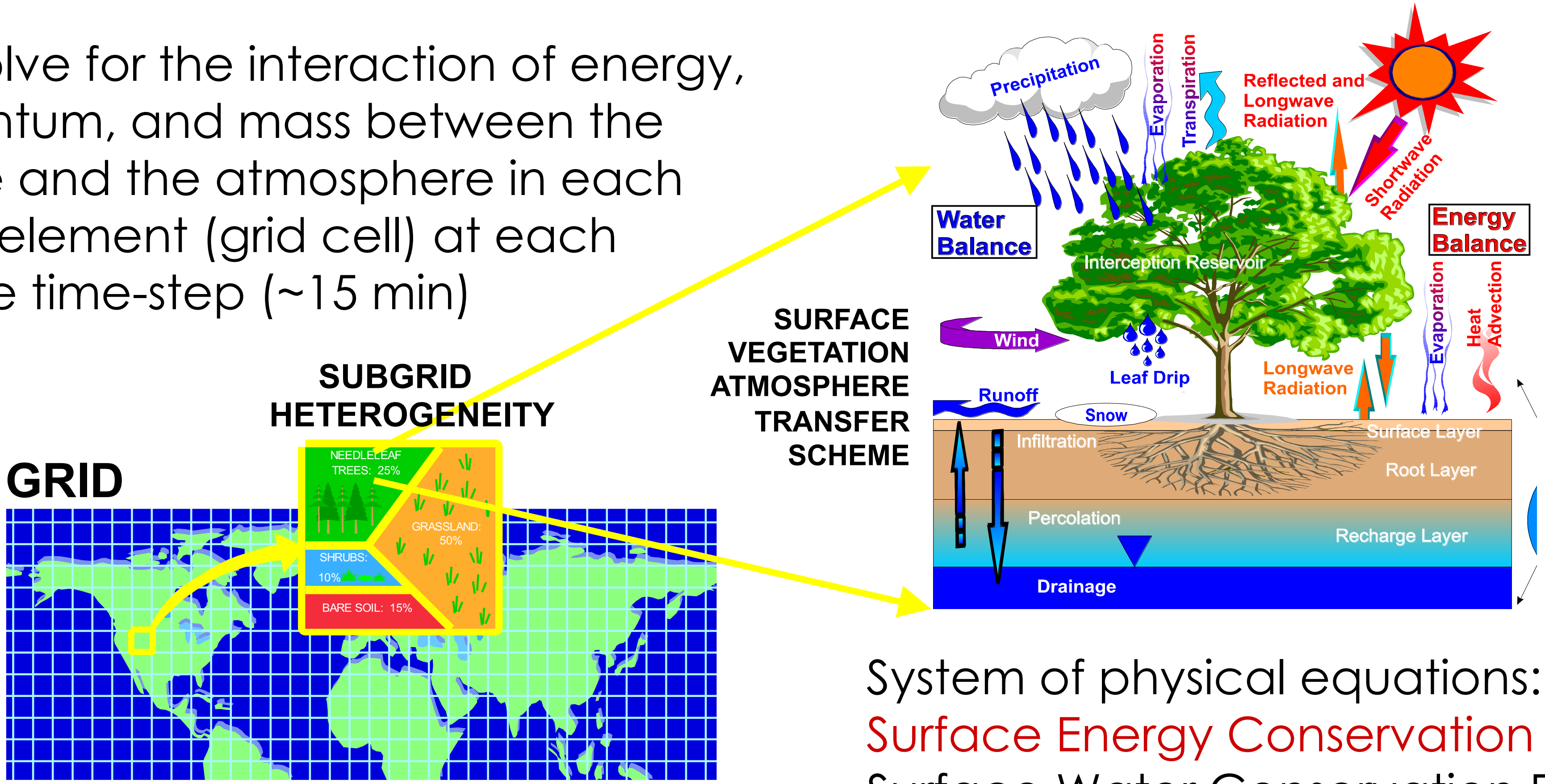


Overview of soil moisture stations currently contained in the International Soil Moisture Network (ISMN). Green dots show the stations that are still measuring soil moisture, red dots the stations that were imported from the Global Soil Moisture Data Bank.

https://www.geo.tuwien.ac.at/insitu/data_viewer/

Land Surface Model (LSM) Structure

LSMs solve for the interaction of energy, momentum, and mass between the surface and the atmosphere in each model element (grid cell) at each discrete time-step (~15 min)



System of physical equations:

Surface Energy Conservation Equation

Surface Water Conservation Equation

Soil Water Flow: Richards Equation

Evaporation: Penman-Monteith Equation

etc.

Source: Matthew Rodell, NASA-GSFC. Email: Matthew.Rodell@nasa.gov

LSM Input and Output Fields

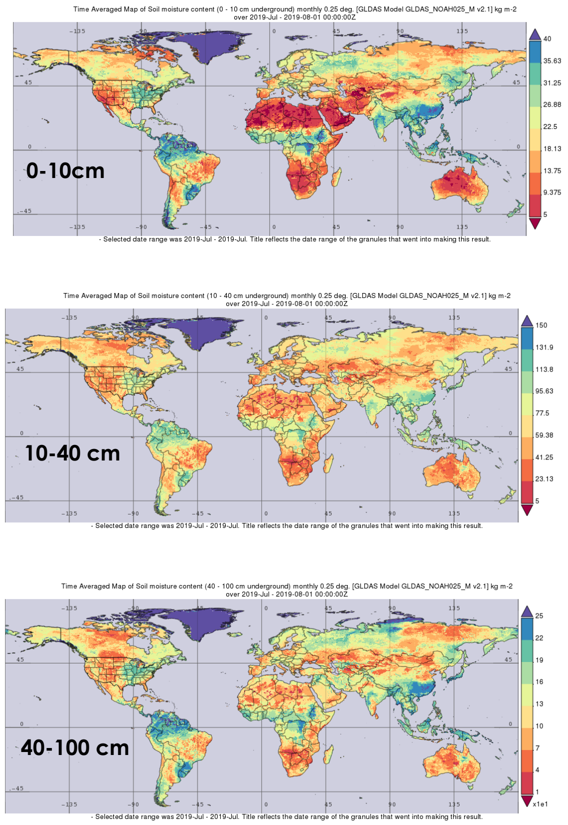
Input Parameters:

vegetation greenness/LAI
vegetation class
soil type
elevation

Required Forcing Fields:

near surface wind speed *(U & V)*
downward shortwave radiation
downward longwave radiation
near surface specific humidity
near surface air temperature
surface pressure
precipitation

Soil Moisture



Summary of Output Fields:

soil moisture in multiple layers
latent, sensible, and ground heat fluxes
net shortwave and longwave radiation
surface and subsurface runoff
soil temperature in each layer
snow water equivalent
snowfall and rainfall
evaporation
transpiration
snowmelt

Source: Matthew Rodell, NASA-GSFC. Email: Matthew.Rodell@nasa.gov

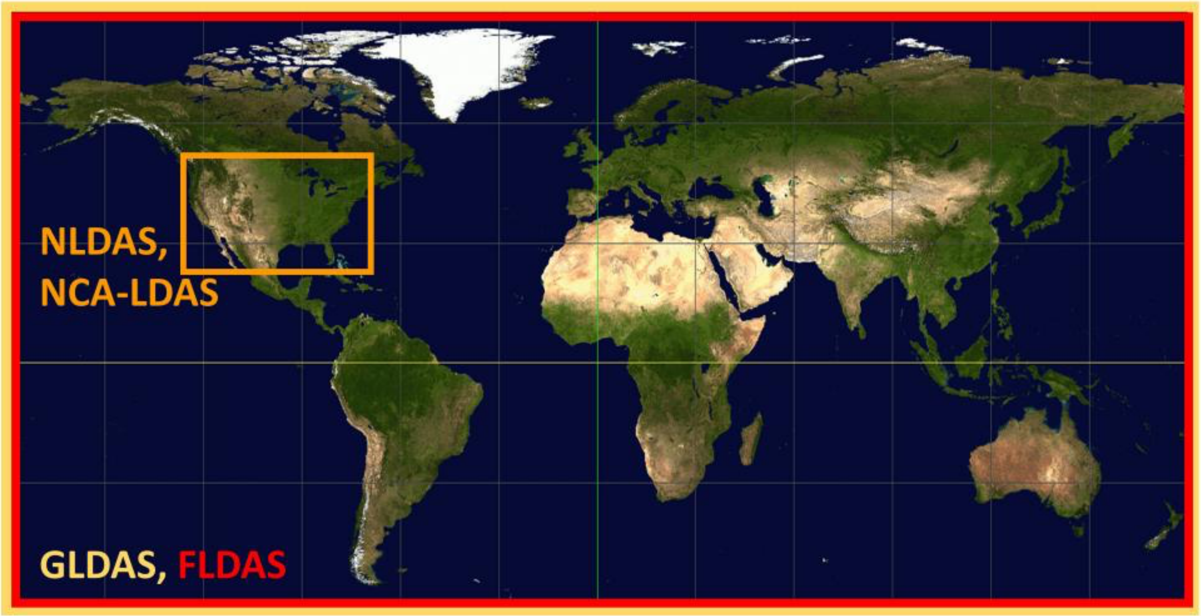
Global and Regional LDAS

GLDAS: Global Land Data Assimilation System

NLDAS: North American Land Data Assimilation System

FLDAS: Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System

NCA-LDAS: The National Climate Assessment - Land Data Assimilation System



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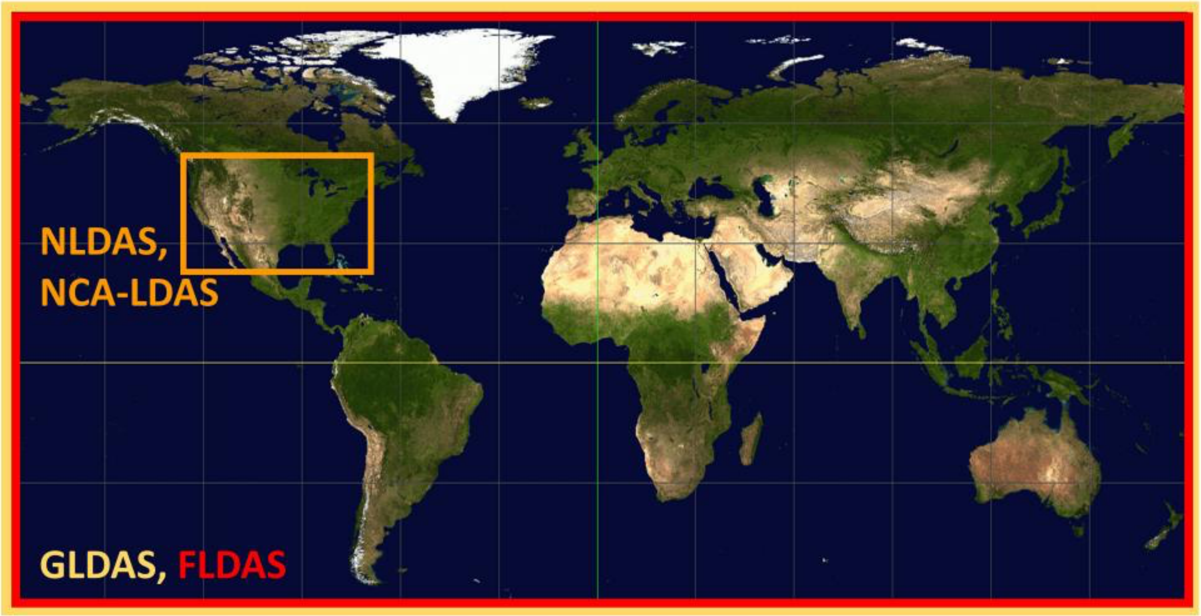

GLDAS and NLDAS

Model	Land Surface Models	Temporal Information	Spatial Resolution
NLDAS	Noah2.8, Mosaic, [1]VIC4.0.3, [2]SAC-Snow-17	Hourly, Monthly 1979-Present (4-day latency)	0.125° x 0.125°
GLDAS V2.0	Noah3.3, Catchment-F2.5	3-Hourly, Daily, Monthly 1948-2014	0.25° x 0.25° 1.0° x 1.0°
GLDAS V2.1	Noah3.3	3-Hourly, Monthly 2000-Present (1-2-month latency)	0.25° x 0.25° 1.0° x 1.0°

[1]Variable Infiltration Capacity [2]Sacramento Snow Model [3]Community Land Model (CLM)

Rodell, et al., 2004: The Global Land Data Assimilation System, Bull. Amer. Meteor. Soc., 85(3), 381-394.
Xia, Y., et al., 2012: Continental-scale water and energy flux analysis and validation for the North American Land Data Assimilation System project phase 2 (NLDAS-2): 1. Intercomparison and application of model products, *J. Geophys. Res.*, 117, D03109, doi:10.1029/2011JD016048.

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GLDAS 2.1 and NLDAS Inputs

GLDAS 2.1

Precipitation:
Global Precipitation Climatology Project (based on multi-satellite and gauge data)

Meteorological Data:
[1]NCEP Global Data Assimilation System

Surface Radiation:
Air Force Weather Agency

https://ldas.gsfc.nasa.gov/

NLDAS

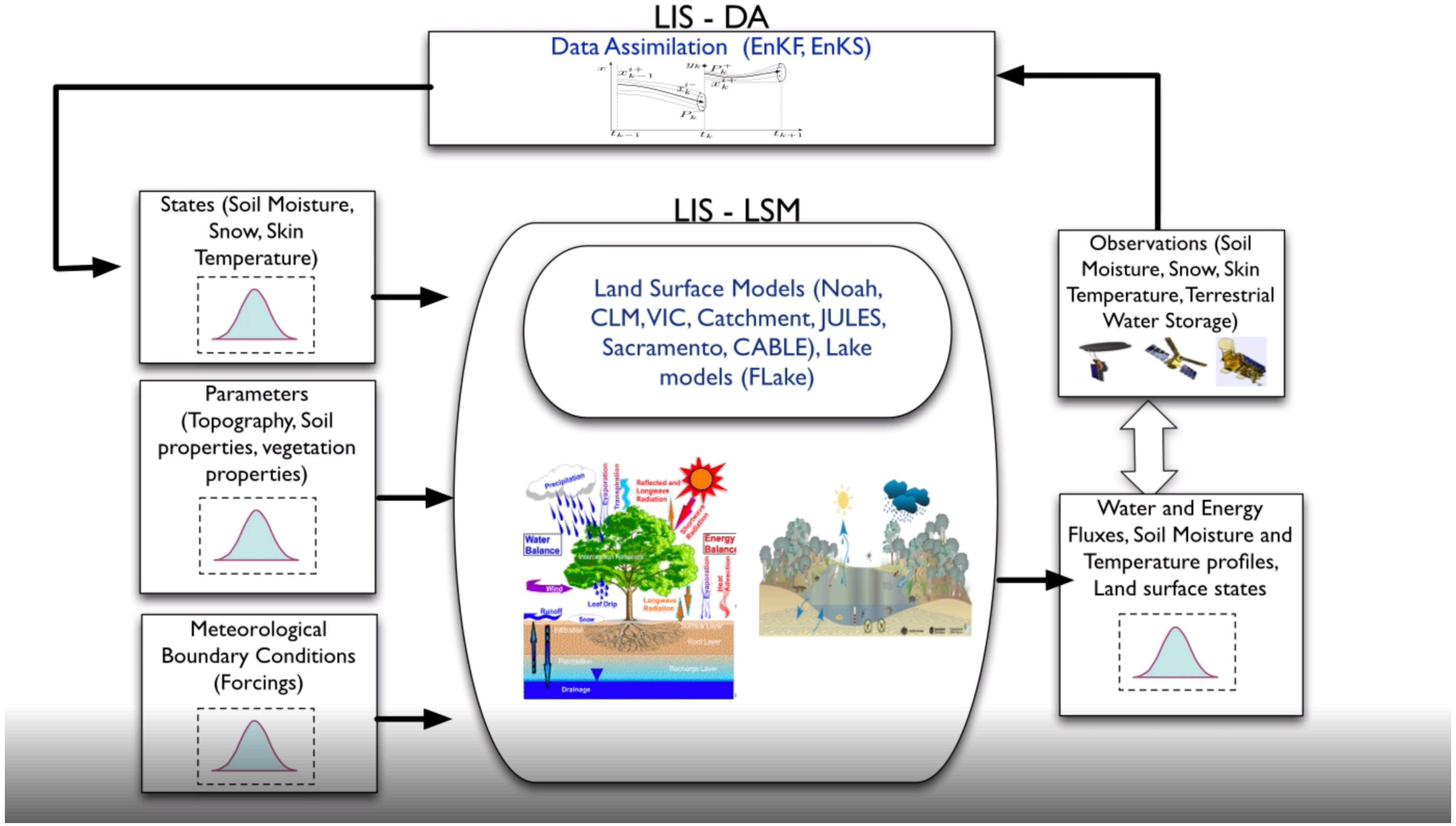
Precipitation:
Climate Prediction Center Gauge Data, Stage II Doppler Radar, [2]CMORPH, [3]NARR

Meteorological Data & Surface Radiation:
NARR

[1]National Center for Environmental Prediction
[2]CPC Morphing Technique
[3]NCEP North American Regional Reanalysis

Land Information System (LIS)

- The Land Information System (LIS) is the software framework used for LDAS.
- LIS allows customized land data assimilation systems to be built, assembled, and reconfigured easily, using shared plugins and standard interfaces.



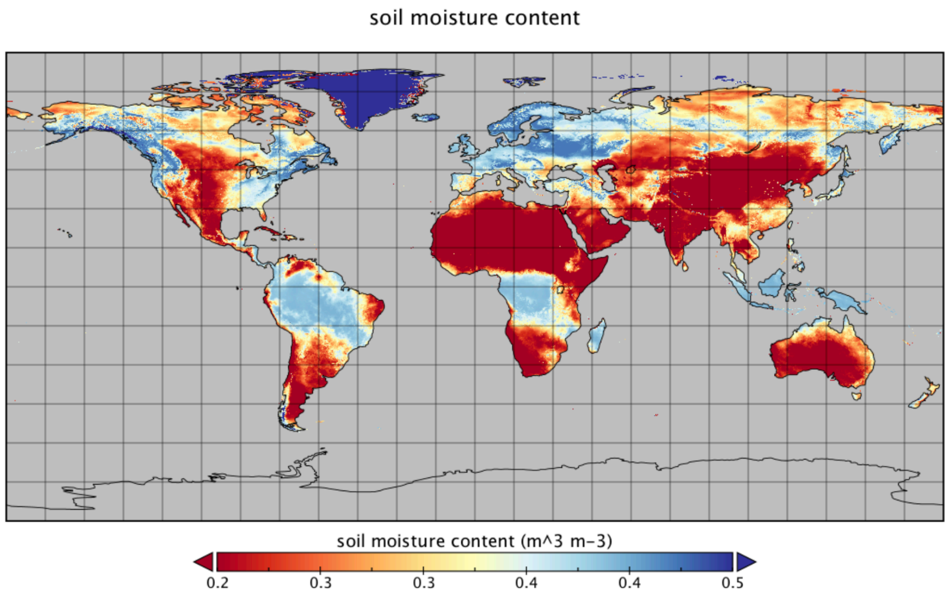
https://lis.gsfc.nasa.gov/

Examples of LDAS for Agricultural Applications

Famine Early Warning

- FLDAS produces global, 10 km resolution soil moisture estimates (1982-present), updated twice a month
- FEWS NET, set up by [1]USAID as leading provider of early warning and evidence-based analysis on food insecurity
- Uses customized LIS to leverage existing land surface models and generate ensembles of soil moisture, ET, and other variables based on multiple meteorological inputs or land surface models
- https://lis.gsfc.nasa.gov/projects/fewsnet

Famine Early Warning System Network (FEWS NET) Land Data Assimilation System (LDAS)



https://agni.geog.umd.edu/project/famine-early-warning-system-network-fews-net-land-data-assimilation-system-ldas

[1]The United States Agency for International Development

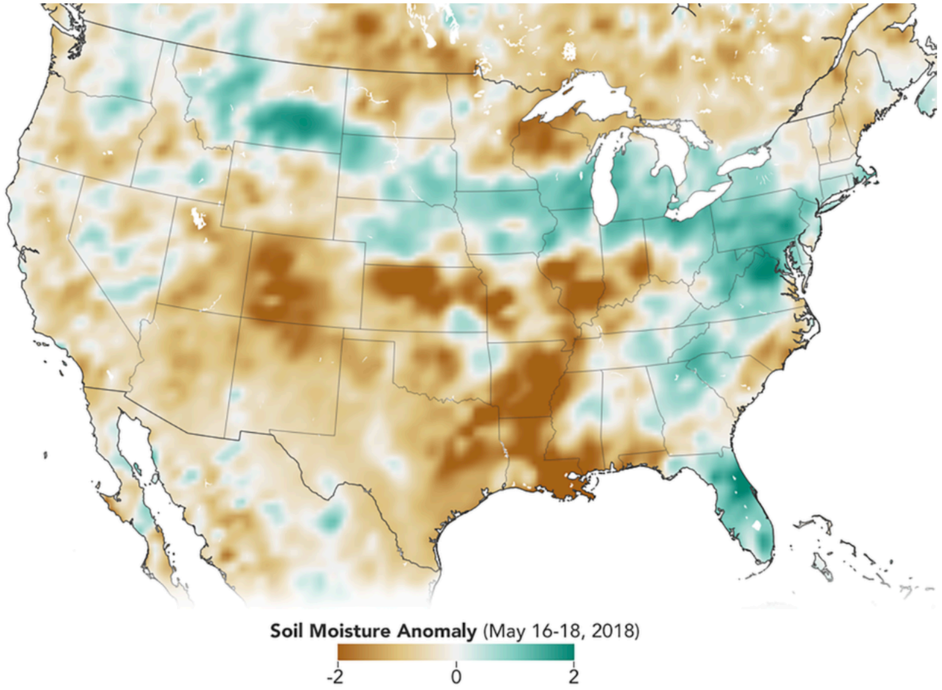
Crop Forecasting

- The United States Department of Agriculture (USDA) uses SMAP soil moisture for crop forecast modeling on a global scale
- https://ipad.fas.usda.gov/cropexplorer/

NASA Soil Moisture Data Advances Global Crop Forecasts

Data from the first NASA satellite mission dedicated to measuring the water content of soils is now being used operationally by the U.S. Department of Agriculture to monitor global croplands and make commodity forecasts.

The Soil Moisture Active Passive mission, or SMAP, launched in 2015 and has helped map the amount of water in soils worldwide. Now, with tools developed by a team at NASA's Goddard Space Flight Center in Greenbelt, Maryland, SMAP soil moisture data is being incorporated into the Crop Explorer website of the USDA's Foreign Agricultural Service, which reports on regional droughts, floods and crop forecasts. Crop Explorer is a clearinghouse for global agricultural growing conditions, such as soil moisture, temperature, precipitation, vegetation health and more.

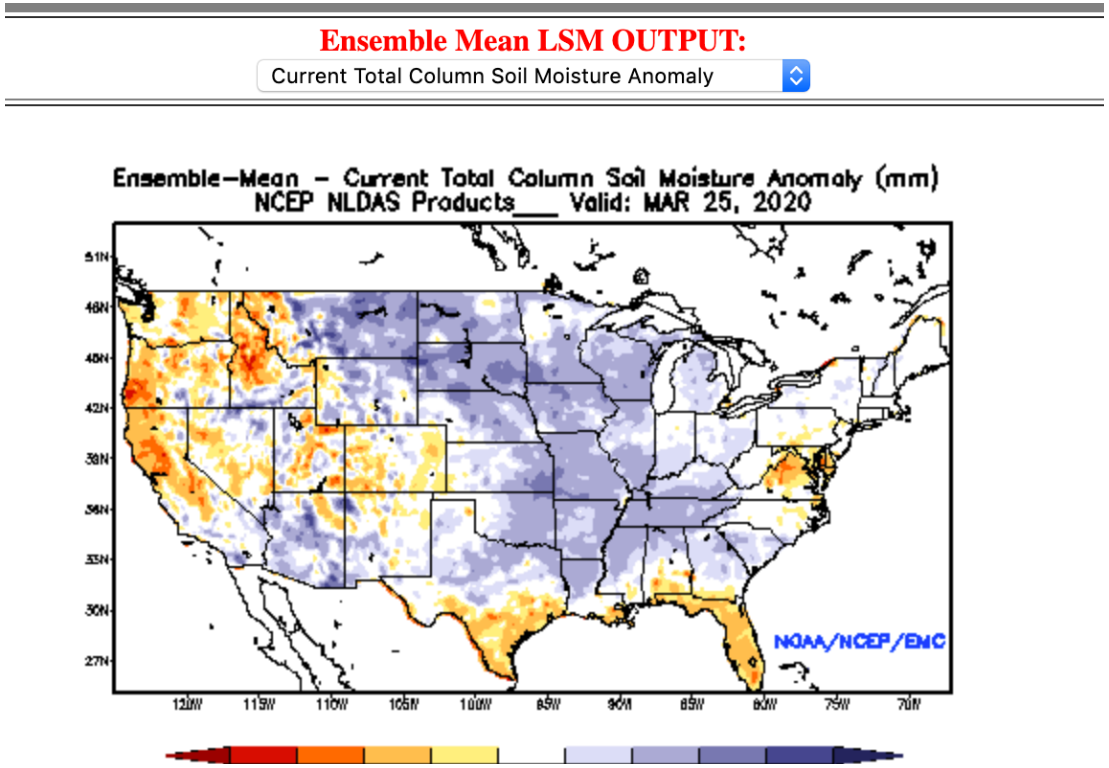


With data from NASA's Soil Moisture Active Passive satellite, researchers can monitor the amount of water in the soils to identify areas prone to droughts or floods. In this map created with SMAP data from May 16- May 18, 2018, soils that are wetter than normal are seen in greens, while those that are drier than normal are seen in browns.
Credits: Joshua Stevens/NASA Earth Observatory

https://www.nasa.gov/feature/2018/goddard/new-nasa-soil-moisture-data-spots-droughts-floods

NLDAS Drought Monitor

- The NLDAS experimental drought monitor is derived from near real-time soil moisture output from both the NASA MOSAIC and NCEP Noah land surface models.
- The soil moisture anomalies and percentiles are derived based on a 28-year climatology (1980-2007).
- https://www.emc.ncep.noaa.gov/mmb/nldas/drought/



LDAS-Morocco Project

- A regional project financed by the Global Environment Facility (GEF), and managed by the World Bank with the support of the USAID and NASA
- Using remote sensing and LDAS, a Composite Drought Indicator (CDI) is derived to monitor agricultural-related drought conditions across Morocco
- https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180001760.pdf

Bijaber et al, 2018: Developing a Remotely Sensed Drought Monitoring Indicator for Morocco, *Geosciences*, *8*(2), 55, https://doi.org/10.3390/geosciences8020055

Composite Drought Index: Morocco

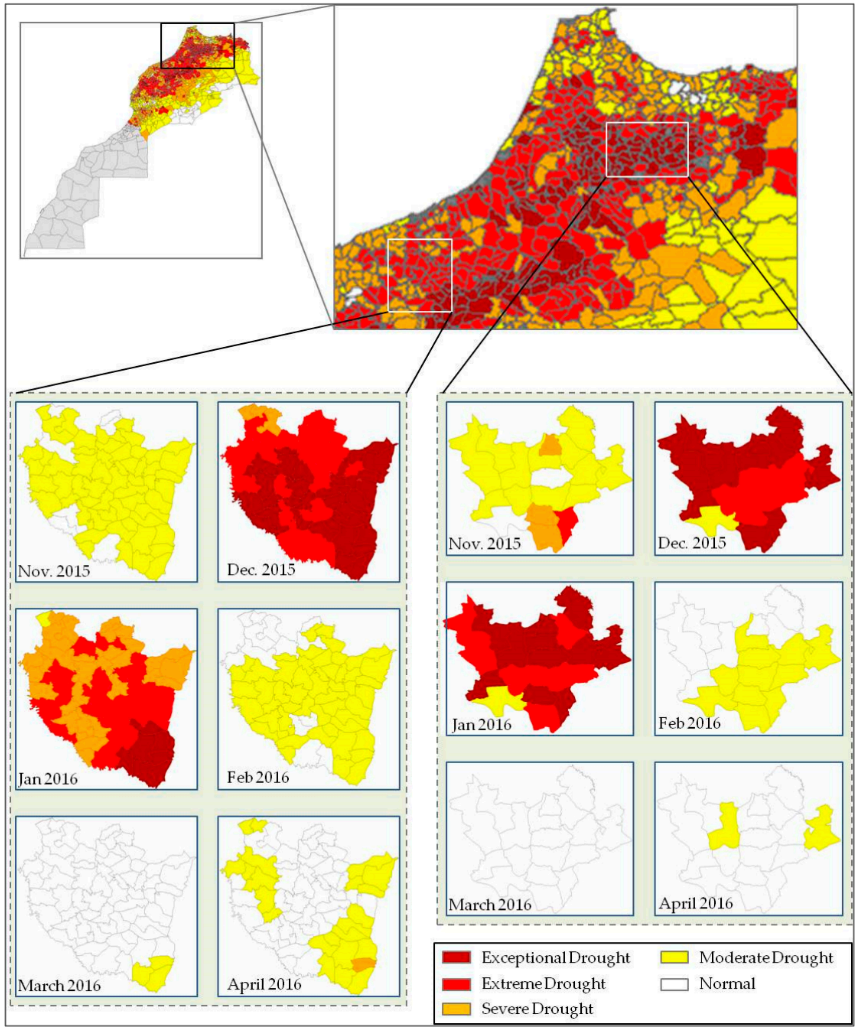
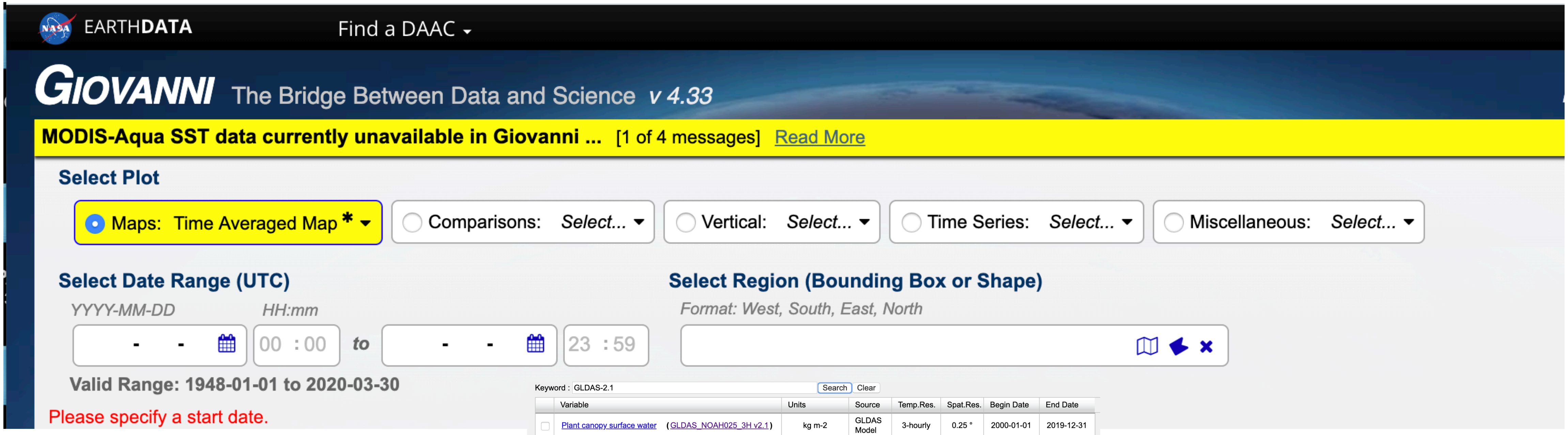


Figure 9. CDI evolution in Settat and Meknes regions (2015–2016).

LDAS Data Access

GLDAS and NLDAS Data Access using Giovanni

https://giovanni.gsfc.nasa.gov/giovanni/



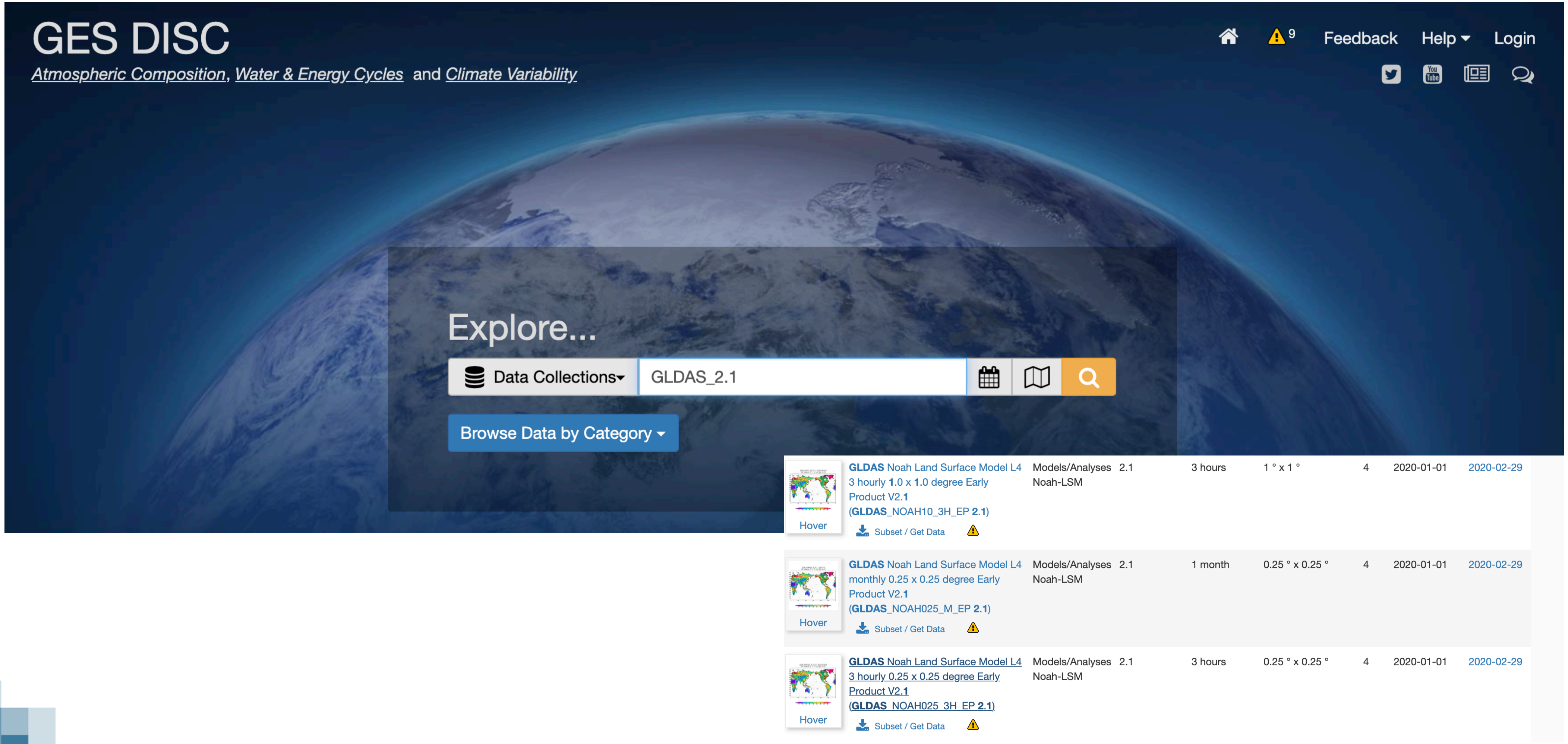
Keyword : GLDAS-2.1 Search Clear

	Variable	Units	Source	Temp.Res.	Spat.Res.	Begin Date	End Date
☐	Plant canopy surface water (GLDAS_NOAH025_3H v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Canopy water evaporation (GLDAS_NOAH025_3H v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Direct evaporation from bare soil (GLDAS_NOAH025_3H v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Rain precipitation rate (GLDAS_NOAH025_3H v2.1)	kg m-2 s-1	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Root zone soil moisture (GLDAS_NOAH025_3H v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Near surface wind speed (GLDAS_NOAH025_3H v2.1)	m s-1	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Soil moisture content (0 - 10 cm underground) (GLDAS_NOAH025_3H v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Latent heat net flux (GLDAS_NOAH025_3H v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Soil temperature (40 - 100 cm underground) (GLDAS_NOAH025_3H v2.1)	K	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Net longwave radiation flux (GLDAS_NOAH025_3H v2.1)	W m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Surface air pressure (GLDAS_NOAH025_3H v2.1)	Pa	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Soil moisture content (10 - 40 cm underground) (GLDAS_NOAH025_3H v2.1)	kg m-2	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31
☐	Snow precipitation rate (GLDAS_NOAH025_3H v2.1)	kg m-2 s-1	GLDAS Model	3-hourly	0.25 °	2000-01-01	2019-12-31

GLDAS and NLDAS Data Access Using GES DISC

https://disc.gsfc.nasa.gov/

Goddard Earth Sciences Data and Information Services Center (**GES DISC)**



Demonstration

Soil Moisture Data Access and Analysis

Thank you!

Next Week: Earth Observations for Agricultural Monitoring

April 28, 2020

Question & Answer Session

- Please enter your questions in the Q&A box
- We will post the questions and answers to the training website following the conclusion of the course:

  https://arset.gsfc.nasa.gov/water/webinars/remote-sensing-for-agriculture-20