

WELCOME TO NASA APPLIED REMOTE SENSING TRAINING (ARSET) WEBINAR SERIES



Water Resources Management Using NASA Earth Science Data

COURSE DATES: EVERY Tuesday, October 13, 20, 27; November 3, 10
TIME: 10 TO 11 AM AND 2 TO 3 PM Eastern US Time
(UTC-4 Hours for October and UTC-5 Hours for November)



Applied Remote Sensing Training



Webinar Outline

Week 1



NASA Remote Sensing Data and Applications for Water Resources Management

Week 2



Precipitation and Soil Moisture Data Access and Applications

Week 3



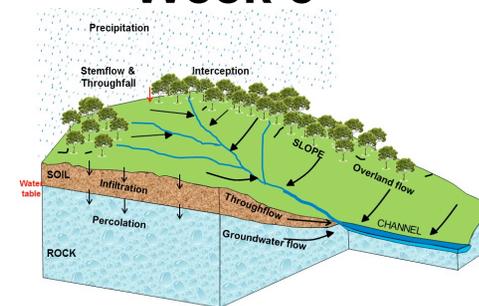
Run off, Streamflow and Reservoir Level Data Access and Applications

Week 4



Evapotranspiration and Ground Water Data Access and Applications

Week 5



Land Data Assimilation for Water Budget Estimation and Case Studies with GIS Applications



Training Team

Instructors:

- Amita Mehta (ARSET): amita.v.mehta@nasa.gov
- Cynthia Schmidt (ARSET): cynthia.l.schmidt@nasa.gov (Week-4)
- Brock Blevins (ARSET): bblevins37@gmail.com

Guest Speakers:

- **Eni Njoku(NASA-JPL):** eni.g.njoku@jpl.nasa.gov **(Week-2)**
- Brian Thomas (NASA-JPL): Brian.F.Thomas@jpl.nasa.gov (Week-4)
- Sujay Kumar (NASA-GSFC): sujay.v.kumar@nasa.gov (Week-5)

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Access to ARSET Trainings

<http://arset.gsfc.nasa.gov>



The screenshot displays the ARSET website interface. At the top, there are navigation tabs for **DISASTERS**, **ECO FORECASTING**, **HEALTH & AIR QUALITY**, and **WATER RESOURCES**. A red circle highlights the **WATER RESOURCES** tab. Below the tabs, the main content area is divided into two columns. The left column contains a sidebar with links: **Webinars**, **Workshops**, **Apply for Training**, **Personnel**, **Links**, and **Upcoming Webinar**. A red circle highlights the **Webinars** link. A red arrow points from this link to the right column, which displays training details. The right column features two training entries under the heading **Webinars**. The first entry is **Water Resources Management Using NASA Earth Science Data**, scheduled for **Tuesday, October 13, 2015 to Tuesday, November 10, 2015**. It includes details on time (10 to 11 AM and 2 to 3 PM Eastern US time), application area (Water Resources), keywords (Flooding, Satellite Imagery, Tools), and instruments/missions (Aqua, GPM, SMAP, Terra, TRMM). A **Read more** button is provided. The second entry is **Satellite Remote Sensing of Particulate Matter Air Quality: Data, Tools, Methods and Applications (Aka AOD-PM)**, scheduled for **Thursday, October 1, 2015 to Thursday, October 29, 2015**. It includes details on time (11:30 AM (EDT)), application area (Airquality), keywords (Aerosols, Air Pollution, PM10, PM2.5), and instruments/missions (MISR, MODIS, VIIRS). A **Read more** button is also provided.



Review of Week-1



NASA Satellites and Models for Water Resources Monitoring



Models

GLDAS : Global Land Data Assimilation System

NLDAS : North American Land Data Assimilation System

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

Landsat (07/1972-present)

TRMM (11/1997-04/2015)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

Jason-1&2 (12/2001-present)

NASA Satellites and Earth Systems Models

Provide global scale water cycle quantities on hourly, daily, seasonal, and multi-year time scales useful for water resources management



- Rain
- Temperature
- Humidity
- Winds
- Soil Moisture
- Snow/Ice
- Clouds
- Terrain
- Ground Water
- Vegetation Index
- Evapotranspiration
- Runoff

Water Resources Management:

Rain Amount, Snowmelt Amount
Runoff
Soil Moisture
Evapotranspiration
Ground Water

Hydrology Modeling Inputs:

Rain Amount, Snowmelt Amount
Surface Temperature, Wind, Humidity
Terrain, Land Cover
Solar and Terrestrial Radiation at the Surface

All other quantities are available from satellite observations as well as from models
Quantities in green are derived from satellite observations
Quantities in red are from atmosphere-land models in which satellite observations are assimilated

Agenda for Week-2



Overview of Precipitation and Soil Moisture Data

- ❑ Precipitation Data Products from GPM and TRMM
- ❑ Snow Cover Data from Terra and Aqua MODIS
- ❑ Overview of Soil Moisture Data from SMAP



Precipitation Data Products from GPM and TRMM

For detailed information about GPM please review the following ARSET webinar

<http://arset.gsfc.nasa.gov/disasters/webinars/global-precipitation>

NASA Remote Sensing Data for Rain and Snow

Satellite	Sensors	Quantities
GPM 2/2014-Present	Dual Frequency Precipitation Radar (DPR) GPM Microwave Imager (GMI)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain
TRMM 11/1997-4/2015	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain
Terra and Aqua 12/1999-Present 5/2002-Present	MODerate Resolution Imaging Spectroradiometer (MODIS)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover

Rain Rate is measured in mm/hour

Accumulated Rain is measured in mm (over a day or a month)

Snow Cover is the fractional area covered by snow

GPM

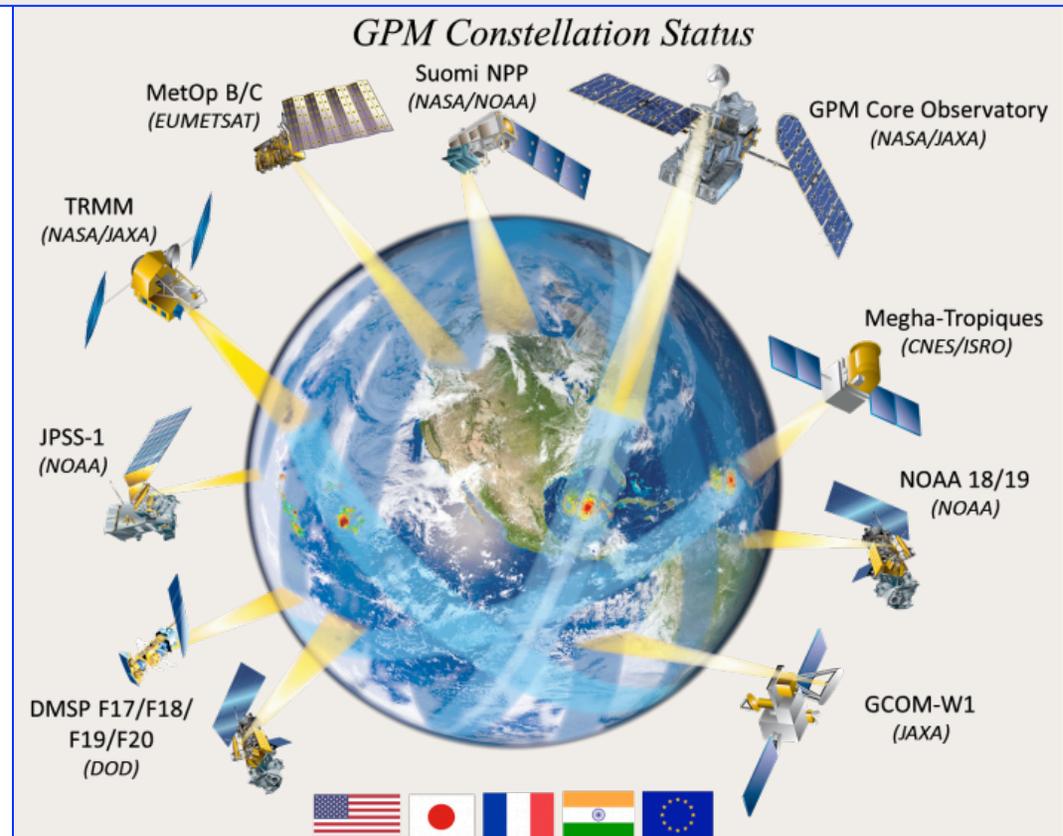
Global Precipitation Measurement Mission



<http://pmm.nasa.gov/GPM>

- ❑ An international network of satellites with a GPM Core satellite designed to provide global observations of rain and snow
- ❑ Initiated by NASA and the JAXA as a successor to TRMM

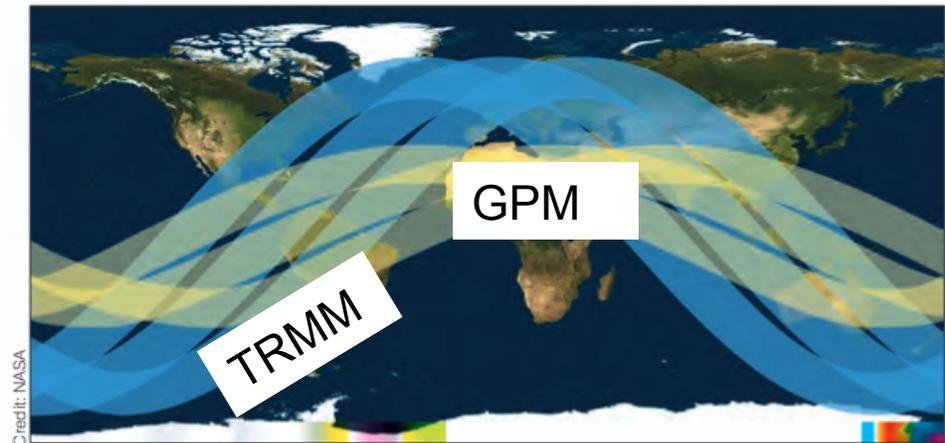
**GPM Core satellite was launched on
February 27th, 2014**



GPM Orbits and Spatial Coverage



- GPM is in non-polar, low inclination orbit with 16 orbits per day
- GPM observes global regions between 65° S to 65° N latitudes
- TRMM was in non-polar, low inclination orbit with 16 orbits per day **but provides observation** between 35° S to 35° N latitudes



the area covered by three TRMM orbits [yellow] versus orbits of the GPM Core Observatory [blue]

GPM measurements span middle and high latitudes

TRMM and GPM Measurements



<http://pmm.nasa.gov/>

TRMM Microwave Imager (TMI)
(Passive Sensor)

Frequencies: 10.7, 19.4, 21.3, 37, 85.5 GHz
Swath: 760 km (870* km)
Resolution: 5 to 45 km (channel-dependent)

Precipitation Radar (PR)
(Active Sensor)

Frequencies: 13.6 GHz (Ku band)
Swath: 220 km (247* km)
Resolution: 5 km

GPM Microwave Imager (GMI)
(Passive Sensor)

Frequencies: 10.6, 18.7, 23.8, 36.5, 89, 166 & 183 GHz
Swath width: 885 km
Resolution: ~4 to 32 km ((channel-dependent))

Dual-frequency Precipitation
Radar (DPR)
(Active Sensor)

Frequencies: 13.6 GHz (Ku), 35.5 GHz (Ka)
Swath: 245 km, 120 km
Resolution: 5.2 km

TRMM and GPM Measurements



<http://pmm.nasa.gov/>

Compared to TRMM, GPM has:

- Higher sensitivity to light rain and snow
- Better accuracy of measurements
- Improved light rain and snow detection
- Extended Spatial Coverage

- ◆ TRMM measurements provide long-term precipitation that is very useful for monitoring climate variability and trends
- ◆ TRMM and GPM data will be inter-calibrated to provide a combined, long-term, record in the near future



TMPA: TRMM Multi-satellite Precipitation Analysis

IMERG: Integrated Multi-satellitE Retrievals for GPM

IMERG and TMPA are produced by combining GMI/DPR and TMI/PR data with global constellation of satellites to yield improved spatial/temporal precipitation estimates:

	IMERG	TMPA
Temporal Resolution :	30-minutes	3 hours
Spatial Resolution:	0.1°x0.1°	0.25°x0.25°
Spatial Coverage:	Global 60°S to 60°N	Global 50°S to 50°N

TMPA, available from 1998-present, is widely used in water resources applications and IMERG with its improved spatial resolution and coverage will replace TMPA in many applications

GPM IMERG Data Products

2. IMERG Data Sets

Multiple runs accommodate different user requirements for latency and accuracy

- “Early” – 4 hours (flash flooding)
- “Late” – 12 hours (crop forecasting)
- “Final” – 3 months (research data)

Time intervals are half-hourly and monthly (Final only)

0.1° global CED grid

- PPS will provide subsetting by parameter and location
- initial release covers 60°N-S

User-oriented services

- interactive analysis (GIOVANNI)
- alternate formats (KMZ, KML, TIFF WRF files, ...)
- area averages

Half-hourly data file (Early, Late, Final)	
1	<i>[multi-sat.] precipitationCal</i>
2	<i>[multi-sat.] precipitationUncal</i>
3	<i>[multi-sat. precip] randomError</i> ←
4	<i>[PMW] HQprecipitation</i>
5	<i>[PMW] HQprecipSource [identifier]</i>
6	<i>[PMW] HQobservationTime</i>
7	<i>IRprecipitation</i>
8	<i>IRkalmanFilterWeight</i>
9	<i>probabilityLiquidPrecipitation [phase]</i>
Monthly data file (Final)	
1	<i>[sat.-gauge] precipitation</i>
2	<i>[sat.-gauge precip] randomError</i> ←
3	<i>GaugeRelativeWeighting</i>
4	<i>probabilityLiquidPrecipitation [phase]</i>

GPM and TRMM Data Access Tools



Tools	Data Products and Formats	Analysis and/or Visualization	Data Download
Mirador http://mirador.gsfc.nasa.gov	L1B, L2, and L3 from TMI and GMI, PR and DPR Data, Combined TMI-PR and GMI-DPR TPMA 3-hourly, Monthly IMERG Half-hourly, Monthly Orbital and Gridded Daily, Monthly HDF5, OPenDAP (can be converted to ASCII, Binary, NetCDF)	N/A	Batch Download
 Giovanni http://giovanni.gsfc.nasa.gov/giovanni/	TPMA (3B42) 3-hourly, (3B43) Monthly IMERG Half-hourly, Monthly NetCDF, GeoTIFF, PNG	Visualization: Map, Time Series, Scatter Plot, Histogram Analysis: Time-averaged Maps, Time Series, Scatter Plot, Map Correlations, Vertical Profiles, Time-averaged Differences	Download by Select and Click on Data Files
PPS/STORM https://storm.pps.eosdis.nasa.gov/storm	L1B and 1C, L2, L3 TMI, PR, GMI, DPR TMI-PR and GMI-DPR Combined Data Orbital and Gridded Daily, Monthly TPMA 3-hourly, Monthly and IMERG Half-hourly, Monthly HDF5, PNG	Map Visualization, Interactive Latitude/Longitude Point Data Value Display	FTP



Mirador: Data Search and Access

<http://mirador.gsfc.nasa.gov/>

The screenshot shows the Mirador web interface with several callout boxes highlighting key features:

- Analyze Data with Giovanni**: A menu option in the top left.
- Search Data using Keyword**: A yellow box pointing to the **Keyword** search field.
- Temporal Selection**: A yellow box pointing to the **Time Span** and **To** date selection fields.
- Spatial Selection by latitude-longitude**: A yellow box pointing to the **Location** input field.
- Spatial Selection from Map**: A yellow box pointing to the map interface.
- Search**: A blue box pointing to the **Search GES-DISC** button.

Additional features listed in the left sidebar include: OVERVIEW, HELP CENTER, DATA HOLDINGS, VIEW CART, News, Restricted Data, Feedback, and FAQ.

Search criteria shown: **Keyword:** IMERG, **Time Span:** 2014-07-15, **To:** 2014-07-16, **Location:** (14.07,-138.50),(53.84,-48.50).

gazetteer locations such as Kansas or Ice Shelf; OR
a bounding box: (minLat,minLon),(maxLat,maxLon)
(LL),(UR) (Mirador will choose smallest area)
OR 80N 20s 120east 20wes OR
a partial Lat/Lon: of 22n is equivalent to (22,180),(-90,-180)

Bulk data download by using scripts

Mirador: Data Search and Access



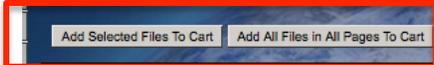
<http://mirador.gsfc.nasa.gov/>

IMERG Half-hourly Data Files List

GPM Level 3 IMERG Half Hourly 0.1 x 0.1 degree Info		
<input type="checkbox"/> Add Selected Files To Cart <input type="checkbox"/> Add All Files in All Pages To Cart		
<input checked="" type="checkbox"/> Select All in Page	File Names/Descriptive File Names	Start Time
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S233000-E235959.1410.V03D.HDF5 (2.53 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 23:30:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S233000-E232959.1380.V03D.HDF5 (2.43 MB)	2014-07-16 23:00:00
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S233000-E235959.1410.V03D.HDF5 (2.53 MB)	
One Click Download: HDF5 (FTP) OPeNDAP		
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S210000-E212959.1260.V03D.HDF5 (2.56 MB) One Click Download: HDF5 (FTP) OPeNDAP	
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S203000-E205959.1230.V03D.HDF5 (2.49 MB) One Click Download: HDF5 (FTP) OPeNDAP	
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S200000-E202959.1200.V03D.HDF5 (2.42 MB) One Click Download: HDF5 (FTP) OPeNDAP	
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S193000-E195959.1170.V03D.HDF5 (2.49 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 19:30:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S190000-E192959.1140.V03D.HDF5 (2.52 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 19:00:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S183000-E185959.1110.V03D.HDF5 (2.52 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 18:30:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S180000-E182959.1080.V03D.HDF5 (2.48 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 18:00:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S173000-E175959.1050.V03D.HDF5 (2.44 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 17:30:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S170000-E172959.1020.V03D.HDF5 (2.41 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 17:00:00 Metadata
<input checked="" type="checkbox"/>	3B-HHR.MS.MRG.3IMERG.20140716-S163000-E165959.0990.V03D.HDF5 (2.50 MB) One Click Download: HDF5 (FTP) OPeNDAP	2014-07-16 16:30:00 Metadata

Download each file by clicking on HDF5 or OPeNDAP
OR Select Multiple files and add to cart

Select File(s) by checking the box



Mirador: Data Search and Access



<http://mirador.gsfc.nasa.gov/>

Data Checkout

Mirador 1.55
Data Access Made Simple

Keyword: IMERG
More Search Options
Search GES-DISC

Shopping Cart
Sort by: Data Set
Continue Searching

Your cart contains 96 items (239.51 MB)

Checkout

Delete GPM Level 3 IMERG Half Hourly 0.1 x 0.1 degree (GPM_3IMERGHH v.03): 96 Items
Empty Entire Cart

Page: 1

Additional Features
+ News
+ Restricted Data
+ Feedback

Keyword: IMERG
More Search Options
Search GES-DISC

Basic Download More Download Options

Your cart will automatically be emptied when you select any download option unless you choose to keep the items.
 Keep items in the cart after selecting a download option

DOWNLOAD DATA (WITH WGET, CURL, ETC.)

URL List (Data) URL List (Metadata) URL List (Data and Metadata)

Instructions:

wget:
Save the list of URLs in one of the above links to your local workstation as myfile.dat
On your command line:
wget -i myfile.dat

a UNIX curl example:
Save the list of URLs in one of the above links to your local workstation as myfile.dat
On your command line:
xargs -n 1 curl -O -u anonymous:curl@example.com < myfile.dat

+ NASA Privacy Policy and Important Notices
+ Contact Us
NASA Official: Steve Kempner

Giovanni Version 4



<http://giovanni.gsfc.nasa.gov/giovanni/>

Select Plot

Maps: **Time-Averaged** Comparisons: *Select...* Time Series: *Select...* Vertical: *Select...* Miscellaneous: *Select...*

Analysis/Plot Options

Select Date Range (UTC) **Select Region (Bounding Box or Shapefile)**

YYYY-MM-DD. HH:mm *Format: West, South, East, North*

- - - 00 : 00 to - - - 23 : 59 -180, -90, 180, 90

Valid Range: 1979-01-01 to 2015-03-10

Temporal and Spatial Search
Map and Shapefile Selection for various countries or US States

Select Variables

Number of matching Variables: 0 of 327 Total Variable(s) included in Plot: 0

Disciplines

- Aerosols (117)
- Atmospheric Chemistry (18)
- Atmospheric Dynamics (64)
- Hydrology (110)
- Water and Energy Cycle (120)

Measurements

- Aerosol Index (1)
- Air Pressure (6)
- Air Temperature (15)
- Albedo (8)
- Altitude (4)
- Angstrom Exponent (16)
- Atmospheric Moisture (23)
- CH4 (4)
- CO (4)
- Cloud Fraction (4)

Keyword :

Search data by keyword

Plot Data

Giovanni Version 4



<http://giovanni.gsfc.nasa.gov/giovanni/>

Search GPM data and Select Spatial, Temporal, Plot Options

Select Plot

Maps: Time-Averaged Comparisons: Select... Time Series: Select... Vertical: Select... Miscellaneous: Select...

Select Date Range (UTC) to

Valid Range: 2014-03-12 to 2014-10-31

Select Region (Bounding Box or Shapefile)

Select Variables

Number of matching Variables: 9 of 327

Keyword : GPM

	Variable Name	Source	Temp. Res.	Spat. Res.	Begin Date	End Date	Vert. Slice
<input checked="" type="checkbox"/>	Gauge relative weighting (GPM_3IMERGM v03)	GPM	Monthly	0.1 °	2014-03-12	2014-10-31	-
<input type="checkbox"/>	Probability of liquid precipitation phase (GPM_3IMERGM v03)	GPM	Monthly	0.1 °	2014-03-12	2014-10-31	-
<input type="checkbox"/>	Satellite-precipitation random error (GPM_3IMERGM v03)	GPM	Monthly	0.1 °	2014-03-12	2014-10-31	-
<input type="checkbox"/>	Satellite and gauge precipitation (GPM_3IMERGM v03)	GPM	Monthly	0.1 °	2014-03-12	2014-10-31	-
<input type="checkbox"/>	Instantaneous Precipitation - High Quality (GPM_3IMERGHH v03)	GPM	Half-Hourly	0.1 °	2014-03-12	2014-10-31	-
<input type="checkbox"/>	Passive microwave source	GPM	Half-Hourly	0.1 °	2014-03-12	2014-10-31	-

July, 2014 Monthly IMERG over the US



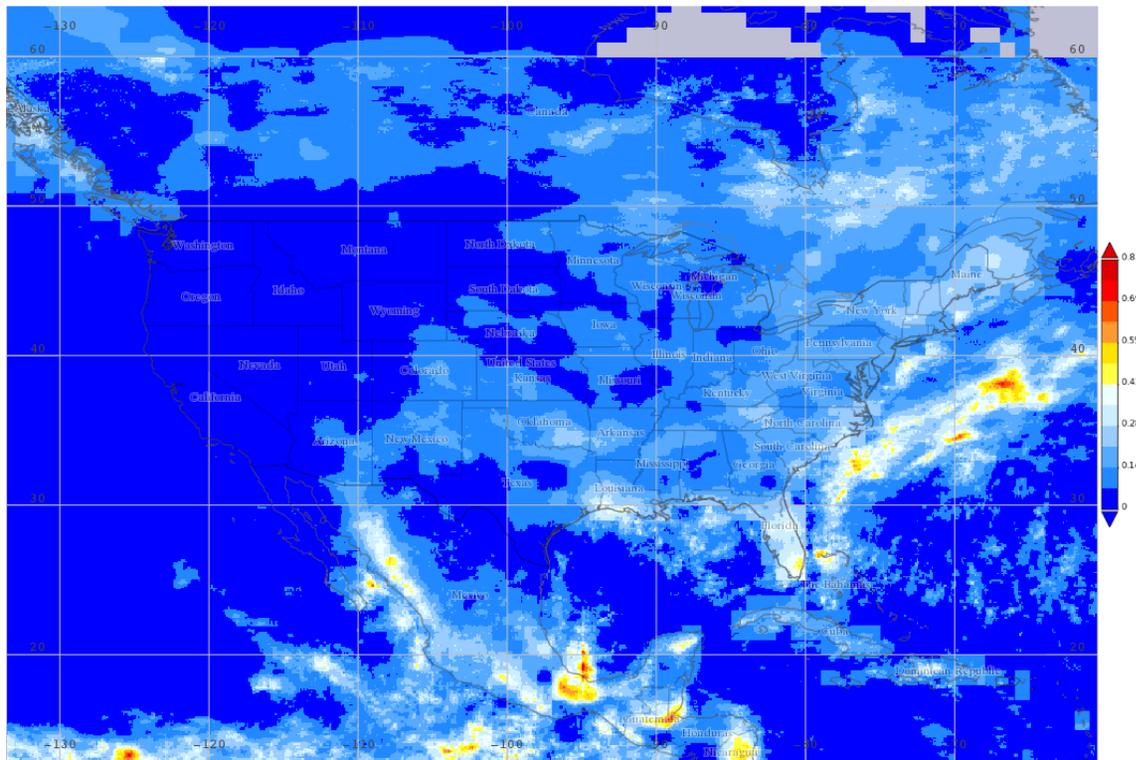
Giovanni Version 4



<http://giovanni.gsfc.nasa.gov/giovanni/>

Search and Plot Result: IMERG Rain Rate for July 2014 over the US

Time Averaged Map of Satellite and gauge precipitation monthly 0.1 deg. [GPM GPM_3IMERGM v03] mm/hr
over 2014-Jul - 2014-Jul, Region 133.5937W, 12.7734N, 60.4687W, 63.3984N



- Selected date range was 2014-07-01 04:00Z - 2014-07-31 04:00Z. Title reflects the date range of the granules that went into making this result.

- **1. Time Averaged Map**
 - [User Input](#)
 - [Plots](#)
 - [Plot Options](#)
 - [Downloads](#)
 - [Lineage](#)

Data and Image
Download Options

Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)



<https://storm-pps.gsfc.nasa.gov/storm/>

NASA National Aeronautics and Space Administration

+ PPS Contacts
+ Related Links

STORM

- HOME + DATA ACCESS + TOOLS + PRODUCT INFORMATION + REGISTRATION

Home

PPS Data Access - to search for GPM and TRMM data, order custom subsets and set up subscriptions.

PPS Public Archive - to access GPM and TRMM standard products via online ftp.

These are the products available to the public. To retrieve data go to [PPS Data Access](#) or [PPS Public Archive](#).

Data Type	Algorithm	Satellite	Instrument	Primary Content
1A	1A01	TRMM	VIRS	Counts
1A	1A11	TRMM	TMI	Counts
1A	1A21	TRMM	PR	Counts
1A	1A21	TRMM	PR	Counts
1A	1AGMI	GPM	GMI	Counts
1B	1B01	TRMM	VIRS	Radiance
1B	1B11	TRMM	TMI	Brightness Temperature
1B	1B21	TRMM	PR	Radar Power
1B	1B21	TRMM	PR	Radar Power
1B	1BGMI	GPM	GMI	Brightness Temperature
1B	1BKa	GPM	DPF, KA	Radar Power

Need Help?

- STORM User Guide
- helpdesk@pps-mail.nascom.nasa.gov

News

2/18/2015 - TRMM/PR data distribution during experimental operation period

1/15/2015 - PPS is releasing the first public version IMERG products

PPS Precipitation Processing System (PPS)

Global Precipitation Measurement Mission (GPM)

Tropical Rainfall Measuring Mission (TRMM)

STORM is specifically designed for GPM and TRMM Precipitation data search, selection, download, and visualization

Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)



<https://storm-pps.gsfc.nasa.gov/storm/>

Requires User Registration

The screenshot shows the STORM web interface. At the top left is the NASA logo and 'National Aeronautics and Space Administration'. On the right are links for '+ PPS Contacts' and '+ Related Links'. The main header features the 'STORM' logo and a 'Precipitation Radar' visualization. Below this are four navigation tabs: '+ DATA ACCESS', '+ TOOLS', '+ PRODUCT INFORMATION', and '+ REGISTRATION'. A red box highlights the '+ REGISTRATION' tab with the text 'Requires User Registration'. The main content area includes a 'Need Help?' section with links to the 'STORM User Guide' and 'helpdesk@pps-mail.nascom.nasa.gov'. Below this is a 'News' section with two entries: '2/18/2015 - TRMM/PR data distribution during experimental operation period' and '1/15/2015 - PPS is releasing the first public version IMERG products'. The central part of the page features a 'PPS Data Access' section with a description: 'to search for GPM and TRMM data, order custom subsets and set up subscriptions.' Below this is the 'PPS Public Archive' section: 'to access GPM and TRMM standard products via online ftp.' A note states: 'These are the products available to the public. To retrieve data go to PPS Data Access or PPS Public Archive.' To the right of these sections are three promotional boxes for 'PPS Precipitation Processing System (PPS)', 'Global Precipitation Measurement Mission (GPM)', and 'Tropical Rainfall Measuring Mission (TRMM)'. At the bottom, a table is highlighted with a red box and labeled 'Data Product Search'. The table has five columns: 'Data Type', 'Algorithm', 'Satellite', 'Instrument', and 'Primary Content'. The table lists various data products such as 1A, 1B, 1A01, 1A11, 1A21, 1A21, 1A21, 1AGMI, 1B01, 1B11, 1B21, 1B21, 1BGM1, and 1BKa, along with their respective algorithms, satellites (TRMM, GPM), instruments (VIRS, TMI, PR, GMI, DPR, KA), and primary content (Counts, Radiance, Brightness Temperature, Radar Power).

Data Type	Algorithm	Satellite	Instrument	Primary Content
1A	1A01	TRMM	VIRS	Counts
1A	1A11	TRMM	TMI	Counts
1A	1A21	TRMM	PR	Counts
1A	1A21	TRMM	PR	Counts
1A	1A21	TRMM	PR	Counts
1A	1AGMI	GPM	GMI	Counts
1B	1B01	TRMM	VIRS	Radiance
1B	1B11	TRMM	TMI	Brightness Temperature
1B	1B21	TRMM	PR	Radar Power
1B	1B21	TRMM	PR	Radar Power
1B	1BGM1	GPM	GMI	Brightness Temperature
1B	1BKa	GPM	DPR, KA	Radar Power

Data Product Search

STORM is specifically designed for GPM and TRMM Precipitation data search, selection, download, and visualization

Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)



<https://storm-pps.gsfc.nasa.gov/storm/>

Product Type

Required

Product Selection

Left click on the header to sort rows. Right click to show/hide columns

Select	Data Type	Algorithm	Start Time	Frequency	Satellite or Ground Validation Site	Instrument	Primary Content	Spatial Extent
<input type="checkbox"/>	3B				GPM			
<input type="checkbox"/>	3B	3CMB	2014-03-01 00:00:00	MONTH	GPM	DPR, GMI	Precipitation	[70.0,-70.0,180.0,-180.0], [67.0,-67.0,180.0,-180.0]
<input type="checkbox"/>	3B	3CMB	2014-12-02 00:00:00	DAY	GPM	DPR, GMI	Precipitation	[70.0,-70.0,180.0,-180.0], [67.0,-67.0,180.0,-180.0]
<input type="checkbox"/>	3B	3IMERGHH	2014-03-12 00:00:00	30_MINUTE	GPM	DPR	Precipitation	[90.0,-90.0,180.0,-180.0]
<input type="checkbox"/>	3B	3IMERGM	2014-03-12 00:00:00	MONTH	GPM	DPR	Precipitation	[90.0,-90.0,180.0,-180.0]

Total Product Types selected: 0

Note: Some selected Product Types might not be visible if filters are used

Temporal Criteria

Date Range Orbit Numbers

Valid range is between 20140312 and 20150310

YYYYMMDD [HH:MM]
[] = optional fields

Start Date/Time 20150130 00:00

Stop Date/Time 20150130 23:59

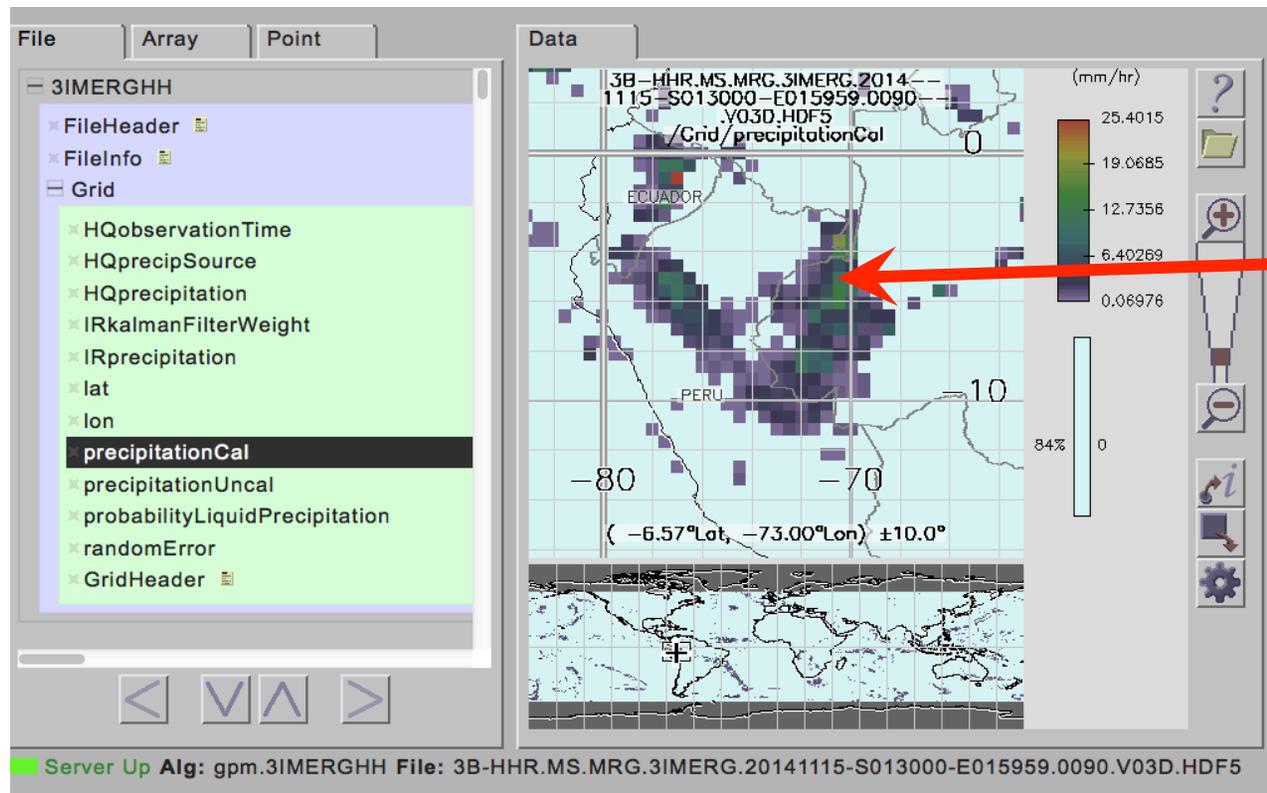
Temporal Selection

Precipitation Processing System (PPS) Science Team On-Line Request Module (STORM)

<https://storm-pps.gsfc.nasa.gov/storm/>



Product Selection, Download, and Visualization by using
Tool for High-resolution Observation Review (THOR)



Precipitation on
November 15,
2014

Ground Validation and Field Data Information

<http://pmm.nasa.gov/science/ground-validation>

Home GPM TRMM Science Applications Meetings Data Access Resources Education

Science

- ▶ Research Topics
- ▶ Precipitation Algorithms
- ▼ **Ground Validation**
 - Direct Statistical Validation
 - Physical Validation
 - Integrated Hydrological Validation
 - ▶ Field Campaigns
 - ▶ Ground and Airborne Instruments
 - GV Documents

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- View Frequently Asked Questions
- View the PMM Glossary
- Contact Us

Ground Validation

Looking ahead it is becoming apparent that the future of precipitation research is probably not one in which satellite data are used in isolation. Instead, integration of satellite precipitation measurements with ground observations, cloud resolving models (CRMs) and land surface data assimilation systems (LDAS) is likely to replace satellite-only precipitation products, particularly for forecasting and hydrological applications that require precipitation as input. This is already apparent in the analyzed precipitation products over the continental US and similar activities in Japan. Hence within this context, GPM validation activities should consider not only the satellite products, but the merged precipitation products based upon GPM data that embrace cloud resolving models and coupled land surface/cloud resolving models used in hydrologic applications. Such modeling components are also needed to improve the physical formulation of the radiometer algorithm over land and thus serve a dual role in the efforts described here.

This section provides access to ground validation activities supported by NASA's GPM Project and by GPM Partners around the world.

Ground Validation Data Portal

The GPM Ground Validation Data Portal provides access to a wide range of ground validation data collected and managed by the MSFC Disdrometer and Radar Observations of Precipitation (DROP) facility. Instrument descriptions are provided along with useful data analysis tools and points of contact.

- Ground Validation Data General Portal
- Field Campaign Data Archive Hosted at the GHRC DAAC

Validation Network Software and Data Products

The software that runs Data and the Validation Network (VN) is now open source. Validation Network data and end products are available. View documentation that describes the VN data, including the directory structure of the VN data archive:

- Validation Network Data Product User's Guide - Volume 1 (TRMM)
- Validation Network Data Product User's Guide - Volume 2 (GPM)

GPM Ground Validation Web Portal

Quick links

- GPM GV Data
- GPM Precipitation Science Research Facility at Wallops Flight Facility
- GCPEX Science Plan
- D3R Radar
- Validation Network Data
- Validation Network journal article
- Validation Network Software
- Validation Network Data User's Guide - Volume 1 (TRMM)
- Validation Network Data User's Guide - Volume 2 (GPM)
- MC3E Science Plan
- 8th Intl GPM Planning Workshop
- Profiler Data Sets
- Science Implementation Plan
- Access to C3VP data
- Disdrometer results from C3VP
- LPVEX Overview
- LPVEX Science Plan
- LPVEX Data

SHARE THIS ARTICLE



Snow Data Products

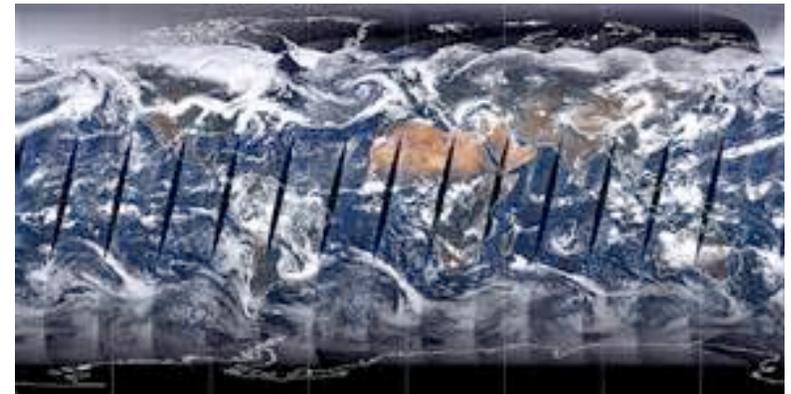
Review of Terra and Aqua

<http://trmm.gsfc.nasa.gov>



Terra

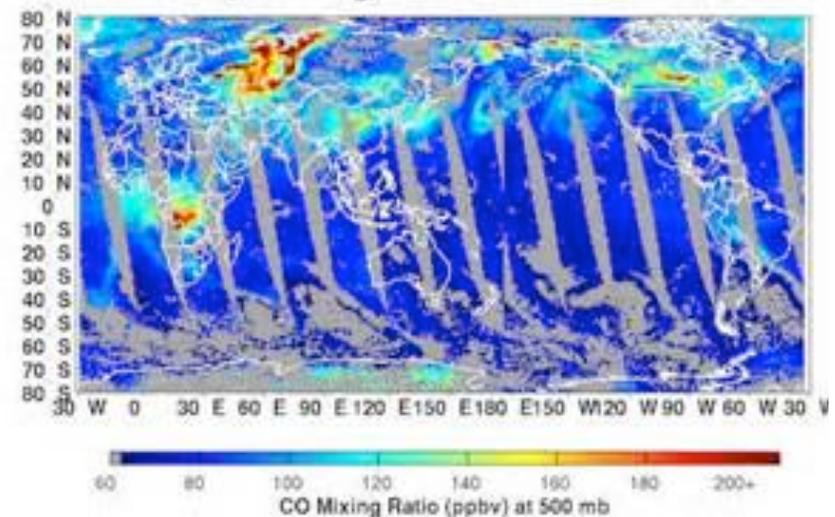
- ❑ Polar, Sun-Synchronous Orbit, Global Coverage
- ❑ Twice-daily Observations 10:30 AM/PM Descending Orbits
- ❑ From 12/1999 – Present



Aqua

- ❑ Polar, Sun-Synchronous Orbit, Global Coverage
- ❑ Twice-daily Observations 1:30 AM/PM Descending Orbits
- ❑ From 5/2002 – Present

Local noon (ascending) AIRS CO at 500 mb on 2010.08.01.

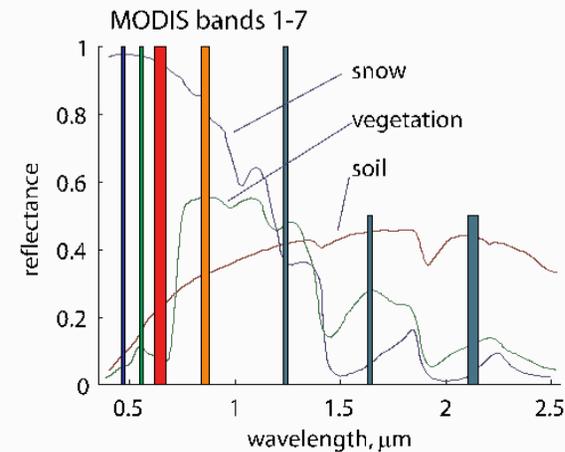


Terra and Aqua MODerate Resolution ImagingSpectroradiometer (MODIS)



<http://modis.gsfc.nasa.gov/>

- A key instrument aboard Terra and Aqua providing 4-times per day observations (1:30 and 10:30 AM/PM) from the two satellites
- 36 spectral bands ranging from 0.41 to 14.385 microns
- Many applications, including **snow/ice**, clouds, vegetation, aerosol
- Available in various resolution (depends on product)



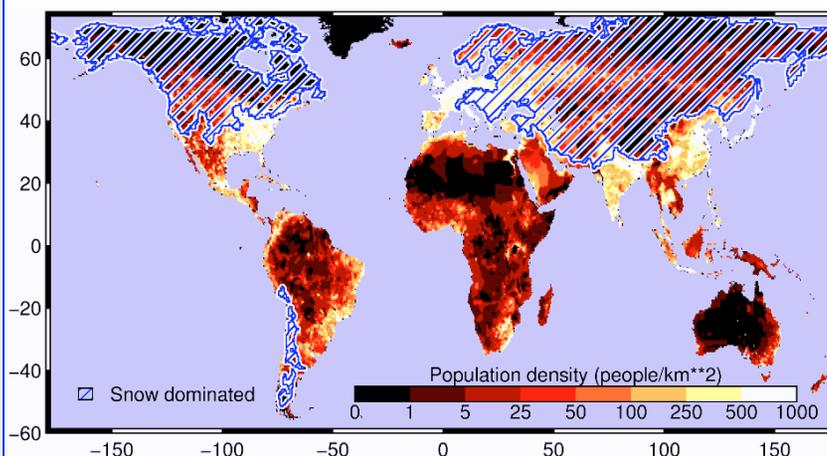
<http://modis-snow-ice.gsfc.nasa.gov/>



There are Two MODIS-based Snow Data Products

- Standard MODIS Product: Fractional Snow Cover
- MODSCAG (MODIS Snow Covered Area and Grain-size)
Product : Fractional Snow Cover, Grain Size, Snow Water Equivalent

Snow-Dominated Regions



MODIS Standard Products: Daily, 8-Day, Monthly Snow Cover available from Terra and Aqua

From Dorothy Hall NASA-GSFC

T
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A
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a

Long Name	Earth Science Data Type (ESDT)	Spatial Resolution
MODIS/Terra Snow Cover 5-Min L2 Swath 500m	MOD10_L2	500-m resolution, swath of MODIS data
MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid (includes daily snow albedo)	MOD10A1	500-m resolution, projected, gridded tile data
MODIS/Terra Snow Cover 8-Day L3 Global 500m SIN Grid	MOD10A2	500-m resolution, projected, gridded tile data
MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG	MOD10C1	0.05° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover 8-Day L3 Global 0.05Deg CMG	MOD10C2	0.05° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover Daily L3 Global 0.25Deg CMG	Not yet a standard product	0.25° resolution, lat/lon climate modeling grid
MODIS/Terra Snow Cover Monthly L3 Global 0.05Deg CMG	MOD10CM	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover 5-Min L2 Swath 500m	MYD10_L2	500-m resolution, swath of MODIS data
MODIS/Aqua Snow Cover Daily L3 Global 500m SIN Grid (includes daily snow albedo)	MYD10A1	500-m resolution, projected, gridded tile data
MODIS/Aqua Snow Cover 8-Day L3 Global 500m SIN Grid	MYD10A2	500-m resolution, projected, gridded tile data
MODIS/Aqua Snow Cover Daily L3 Global 0.05Deg CMG	MYD10C1	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover 8-Day L3 Global 0.05Deg CMG	MYD10C2	0.05° resolution, lat/lon climate modeling grid
MODIS/Aqua Snow Cover Monthly L3 Global 0.05Deg CMG	MYD10CM	0.05° resolution, lat/lon climate modeling grid

MODIS Standard Snow Product Data Access and Visualization

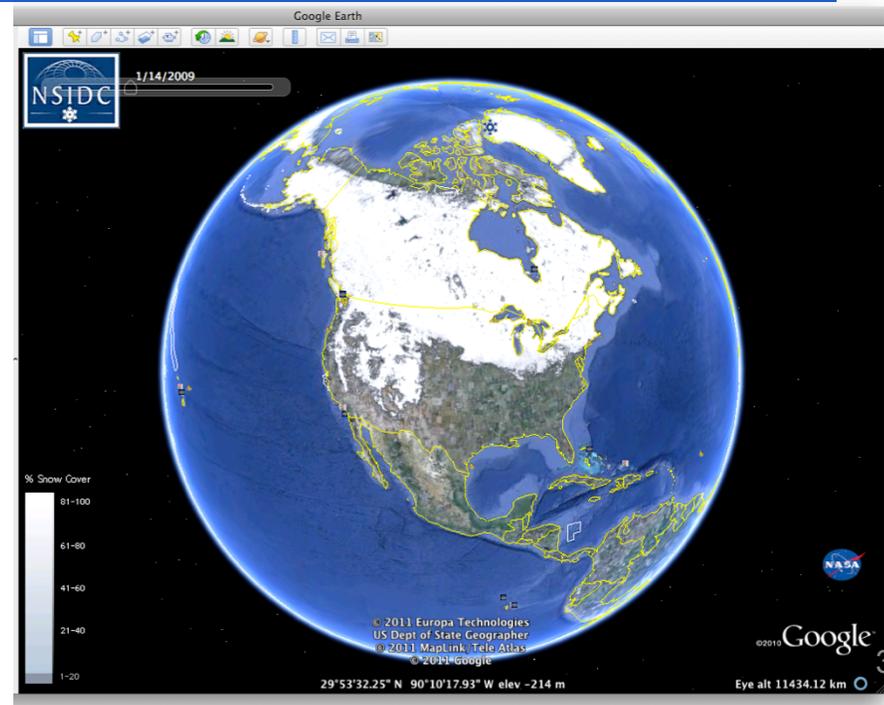
MODIS Snow Products are available from the National Snow and Ice Data Center <http://nsidc.org/>

MODIS monthly snow cover can be visualized on Google Earth maps from http://nsidc.org/data/virtual_globes/index.html

Data Start Date: 2000-02-24
Daily, 8-Day, Monthly

Coverage: Global

Multiple Spatial Resolutions



Selected Aqua-MODIS Snow Product from Reverb/ECHO

<http://reverb.echo.nasa.gov/reverb>

The screenshot displays the Reverb/ECHO web interface. At the top left is the NASA logo and the text "National Aeronautics and Space Administration". Below this is "EOSDIS NASA's Earth Observing System Data and Information System". On the right, it says "Reverb | ECHO The Next Generation Earth Science Discovery Tool". The main interface is divided into several sections: "Spatial Search" with a bounding box input field (containing "e.g. -50.736, 163.477, -11.144, 105.680 (S,E,N,W)"), a "Satellite" dropdown menu, and a map view with navigation controls. To the right is the "Search Terms" section with an input field containing "MYD10CMV5". Below that is the "Temporal Search" section with "START" and "END" date pickers. At the bottom of this section, it says "* all times must be specified in GMT". There are also "Date Range" and "Annual Repeating Dates" buttons.

The screenshot shows the "Step 2: Select Datasets" page. A search result is listed: "MODIS/Aqua Snow Cover Monthly L3 Global 0.05Deg CMG V005". Below this, it says "Archive Center: NSIDC Short Name: MYD10CM Version: 5". This result is circled in red. To the right of the result, a red-bordered box contains the text "Swath, Daily, and Monthly products are available". In the bottom right corner, there are icons for settings, a list, and information, along with the number "35".

Near-real Time Standard MODIS Products

<http://lance-modis.eosdis.nasa.gov/>

NASA GODDARD SPACE FLIGHT CENTER [+ Visit NASA.gov](#)

LANC-MODIS

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LANC-MODIS will operate on a 7x24 hour basis. LANCE-MODIS has two standalone systems that use different network routes. It is expected that this redundancy will reduce the system downtime to less than 1%.

Whereas the standard MODIS forward processing acquires 2-hour L0 files for Aqua and Terra from EDOS within 7-8 hours of real time, LANCE-MODIS acquires session-based L0 files from EDOS and the end of the session is available within 10-30 minutes after real time. LANCE-MODIS uses the Terra attitude and ephemeris data entrained in the L0 data. However, for Aqua the attitude and ephemeris data are acquired from the EDOS rate buffer. All of the MODIS Level 1 (L1), L2, and L3 products generated by LANCE-MODIS have been modified to add "NRT" metadata to the filenames to enable the products to be distinguished from the MODIS standard forward-processed products. LANCE-MODIS acquires all of the ancillary products from the data suppliers. The production rules for some of the science codes have been relaxed with respect to these ancillary data to allow the data products to be generated within 3 hours of real time.

Data products are archived in a rolling archive for 7+ days and are available for distribution by direct access to the [FTP sites](#).

LANC-MODIS Details:

- [Hardware Configuration](#)
- [Data Flows for MODIS](#)
- [Distribution and Latency Metrics](#)

[+ Privacy Policy and Important Notices](#) NASA Webmaster: [Shriram Ilavajhala](#)
NASA Official: [Ed Masuoka](#)

Near-real Time Standard MODIS Products

<http://lance-modis.eosdis.nasa.gov/>

Level-2 Swath data (500) m and 5 Km resolution Snow Cover available from Terra and Aqua MODIS

Terra

			Fraction Browse					
L2 Snow Cover, 5-Min Swath 500m	MOD10_L2	0.26	L2 Snow Cover Browse	N/A	07	0:46	1:32 (8)	3:14
L2 Coarse Snow Cover, 5-Min Swath 5km	MOD10L2C	0.17				0:46	1:32 (8)	3:14
L2 Sea Ice Extent							1:30	

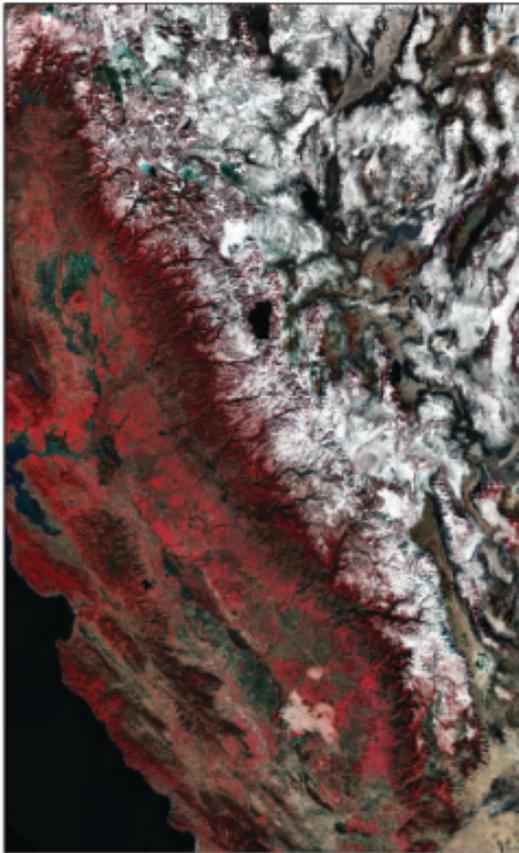
Aqua

			Browse					
L2 Snow Cover, 5-Min Swath 500m	MYD10_L2	0.26	L2 Snow Cover Browse	N/A	07	1:00	1:47 (25)	3:30
L2 Coarse Snow Cover, 5-Min Swath 5km	MYD10L2C	0.17				1:00	1:47 (25)	3:30

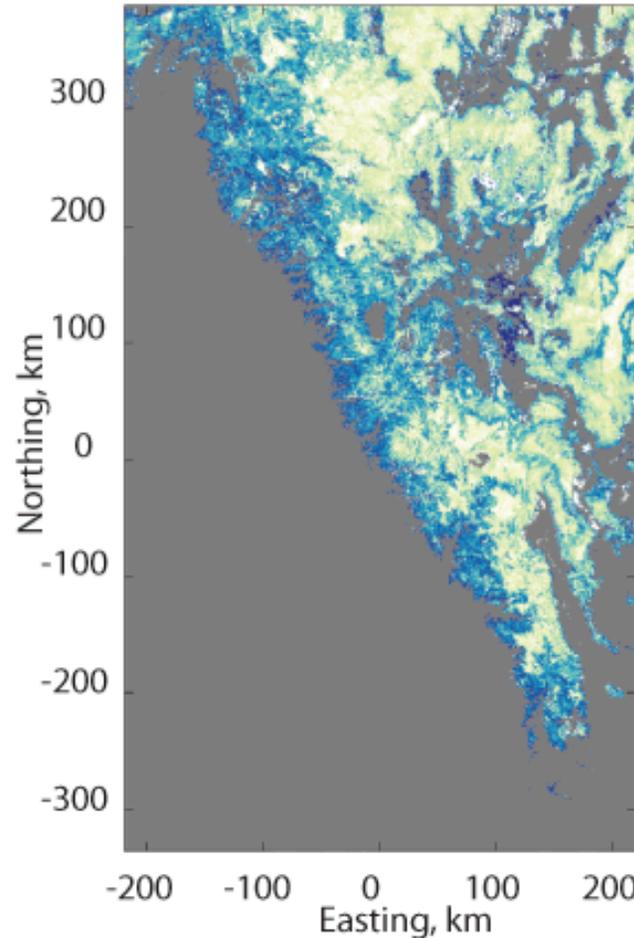
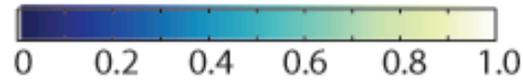
MODSCAG Snow Products

From: Thomas H. Painter and Chris Mattmann (NASA JPL)

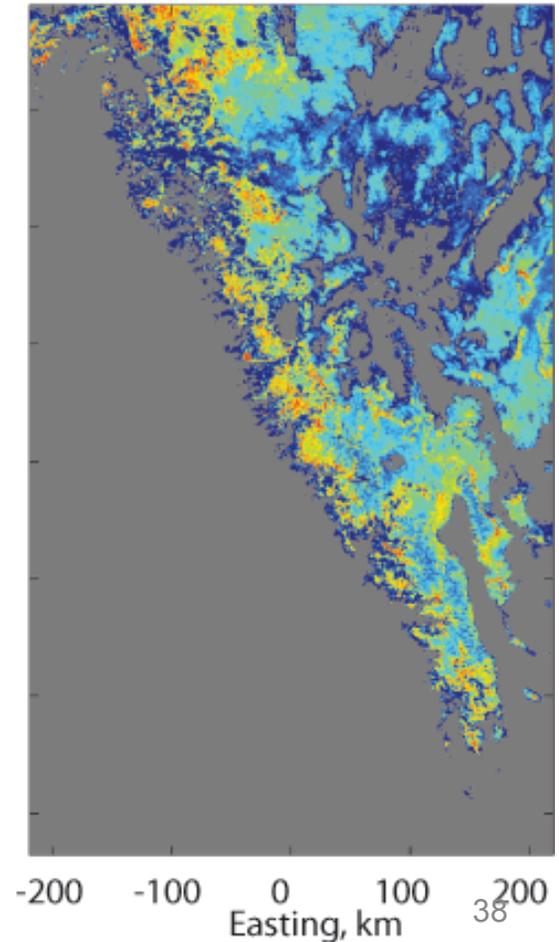
Bands 2,4,3 (RGB)



Fractional snow-covered area



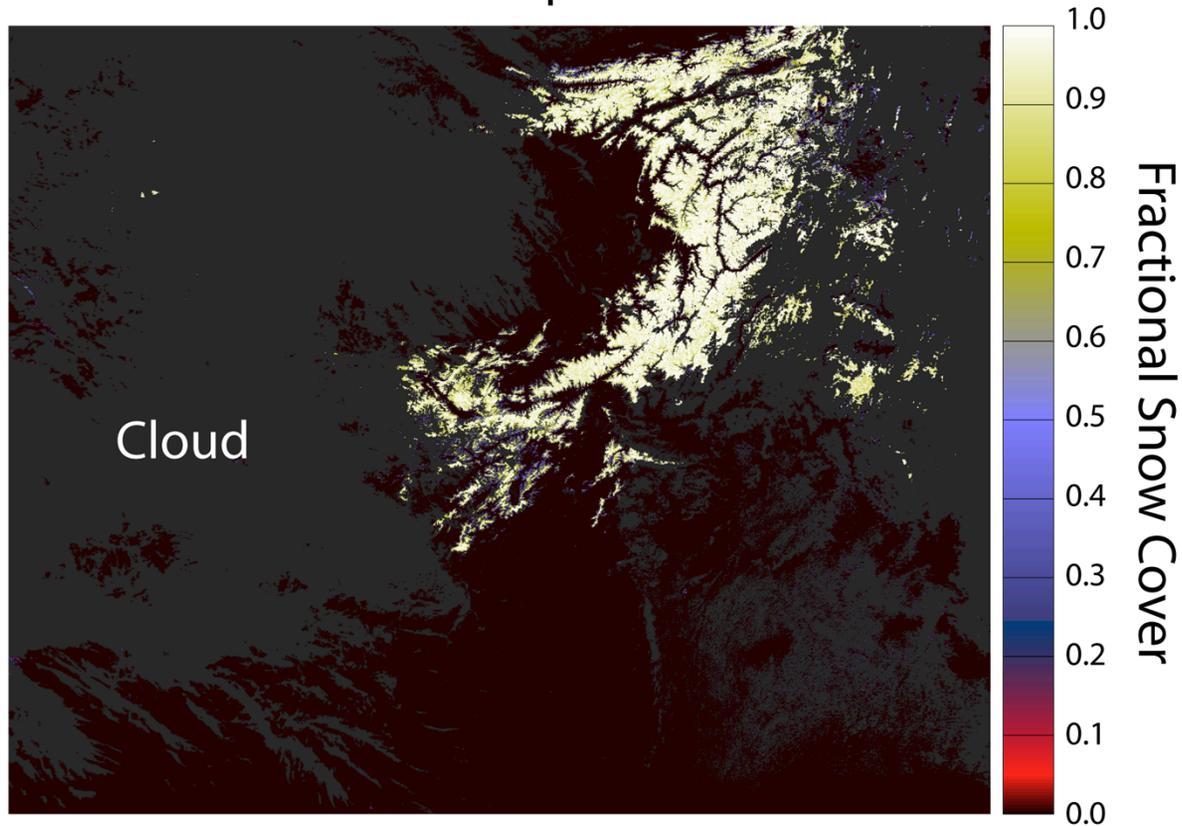
grain size, mm



MODSCAG

<http://snow.jpl.nasa.gov/portal/browse/dataset/urn:snow:MODSCAG>

Hindu Kush April 9/2009



Limitation of MODIS Data : No Snow Mapping Under Clouds

<http://snow.jpl.nasa.gov/portal/browse/dataset/urn:snow:MODSCAG>

The screenshot displays the NASA Jet Propulsion Laboratory website interface. At the top, the NASA logo and the text "Jet Propulsion Laboratory California Institute of Technology" are visible. A navigation menu includes "JPL HOME", "EARTH", "SOLAR SYSTEM", "STARS & GALAXIES", and "SCIENCE & TECHNOLOGY". Below this, there are links for "BRING THE UNIVERSE TO YOU: JPL Email News | RSS | Mobile | Video".

The main content area shows a breadcrumb trail: "Snow Data System : Home → Data → Snow Map". A navigation bar contains "Home", "Data", "Publications", "Media", "People", and "Links". The "Data" link is circled in yellow. Below the navigation bar, there is a date selector set to "Fri Oct 18 2013" and a horizontal slider. Below these are checkboxes for "Snow Cover", "Grain Size", "Dust Forcing", "Clouds", and "RGB". The "Clouds" checkbox is checked. To the right, there are "Regions:" dropdowns for "United States" and "High Asia".

The main content area features a satellite-style map of a mountainous region with snow cover. On the left side of the map, there are three icons: a plus sign, a square, and a camera icon.

MODSACG Data Access and Mapping



Integration of Precision NASA Snow Products with the Operations of the Colorado Basin River Forecast Center (CBRFC) to Improve Decision Making Under Drought Conditions

Principle Investigator: Thomas Painter, Jet Propulsion Laboratory

Abstract

The Colorado Basin River Forecast Center (CBRFC) is responsible for the entire Colorado Basin (CRB) and the eastern Great Basin (GB). From a water management perspective, the commitment of water to various users most often occurs in the spring, and is almost entirely based on estimates of the western USA snowpack. Improving seasonal drought predictions requires use of models that provide physically realistic simulations of fundamental hydrologic processes. Among these, for the western USA, representation of snow is perhaps most critical.

As drought frequency increases in the CRB and GB, it is critical that the CBRFC and the dependent water managers have more comprehensive real-time knowledge of the snow cover and its properties for more precise runoff forecasting and stakeholder decision support. The primary objective of this proposal is to integrate real-time high precision MODIS Snow Covered Area and Grain size (MODSCAG) fractional snow covered area (SCA) into CBRFC modeling and analysis systems and into stakeholder oriented data products, drastically reducing SCA uncertainties that have hampered forecasting operations for decades. A secondary objective is to ingest and study MODIS Dust Radiative Forcing in Snow (MODDRFS) radiative forcing imagery, to better understand its value as an input to modeling and forecasting approaches.

This collaboration directly addresses drought prediction, assessment, adaptation, and mitigation in support of energy security/efficiency; natural resource conservation; and household, municipal, industrial, and in-stream demands for water. It will also improve access and availability of actionable water monitoring, hence drought information. The Snow Cover and Dust Forcing products will be generated and distributed in near real-time by the JPL Snow Server for access by CBRFC. CBRFC will offer a direct connection to stakeholders (End Users) and together with other linked NWS operational centers provides an institutional home to maintain the advances of this effort beyond the project's end.

[top](#)

MODSCAG, Snow and Dust Radiative Forcing Information, along with CBRFC Modeling Analysis is used in **Decision Making for River Basin management**



Soil Moisture Data



SMAP Data Products and Applications

Eni Njoku
Erika Podest
Vanessa Escobar

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA



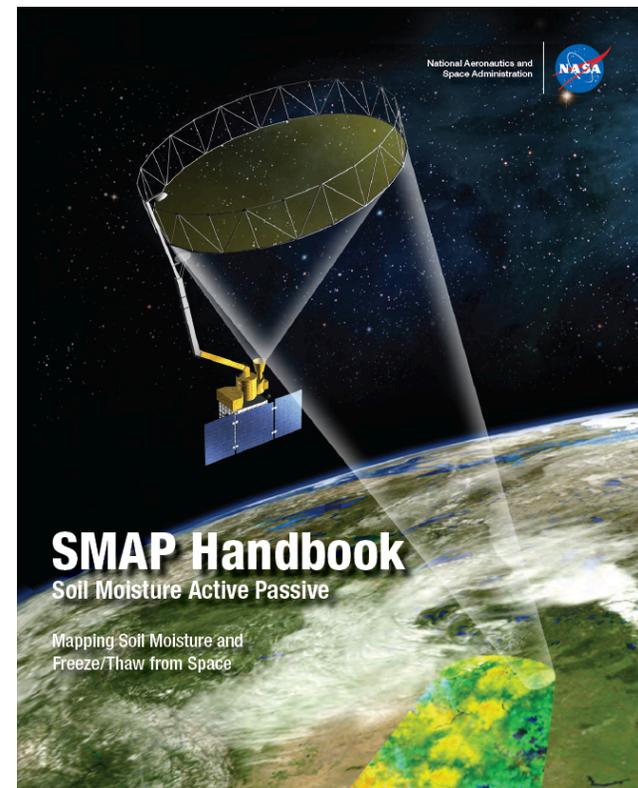
National Aeronautics and
Space Administration
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Outline

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

Details provided in SMAP Handbook

Credits: *SMAP Project Team*
SMAP Science Team



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



Why Soil Moisture?



Enhanced weather & climate forecasting



Improved agricultural productivity and crop
yield predictions



Drought monitoring and early warning



Flood monitoring and prediction



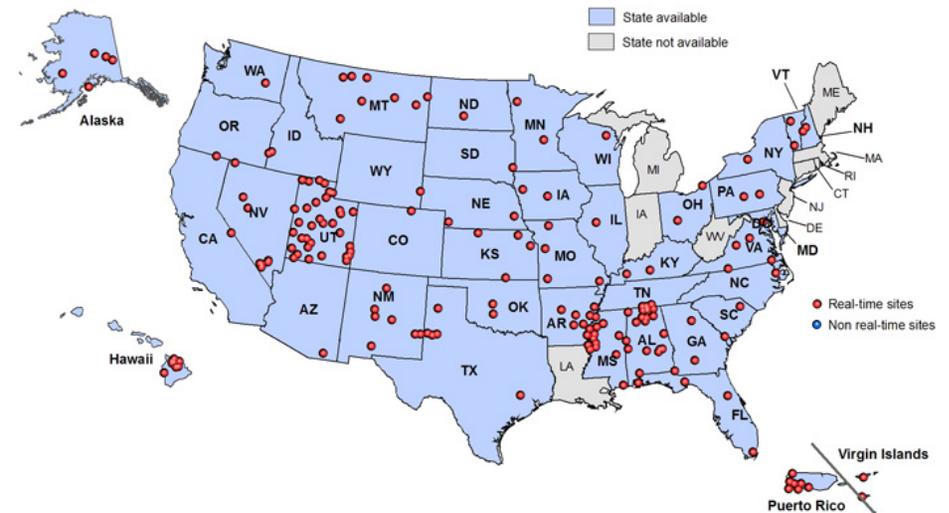
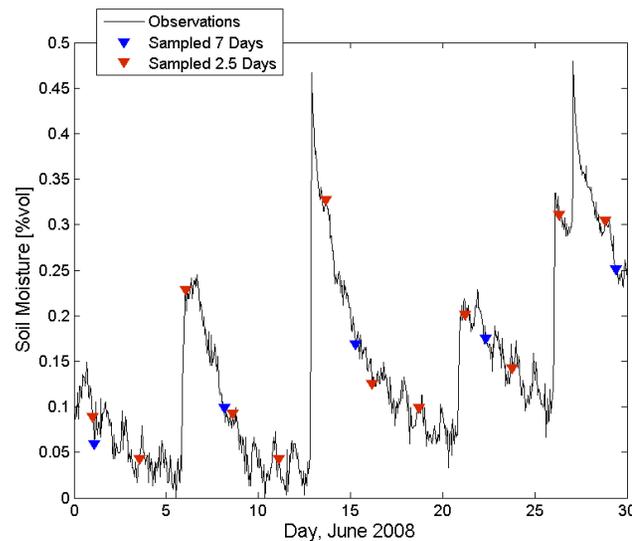
Human health and vector borne diseases



Why Measure from Space?

SMAP provides a capability for global observations of soil moisture and its frozen or thawed state at 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 $0.04 \text{ m}^3/\text{m}^3$**



Current network of USDA/SCAN in situ soil moisture sensors

Inter-storm soil moisture dry-down

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

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

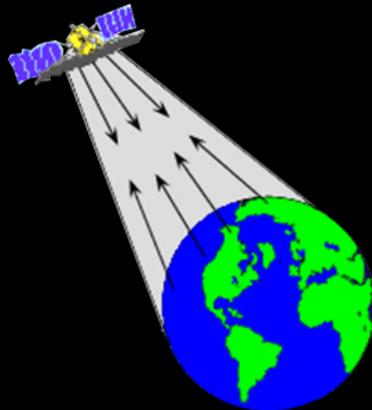
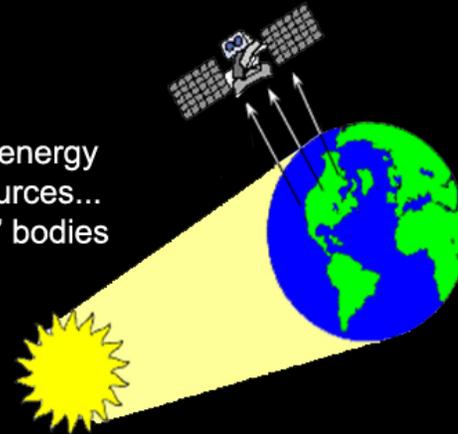


Measurement Approach

SMAP uses both “Passive” and “Active”
Remote Sensing to measure Soil Moisture

Passive Sensors:

The source of radiant energy
arises from natural sources...
Sun, Earth, other “hot” bodies



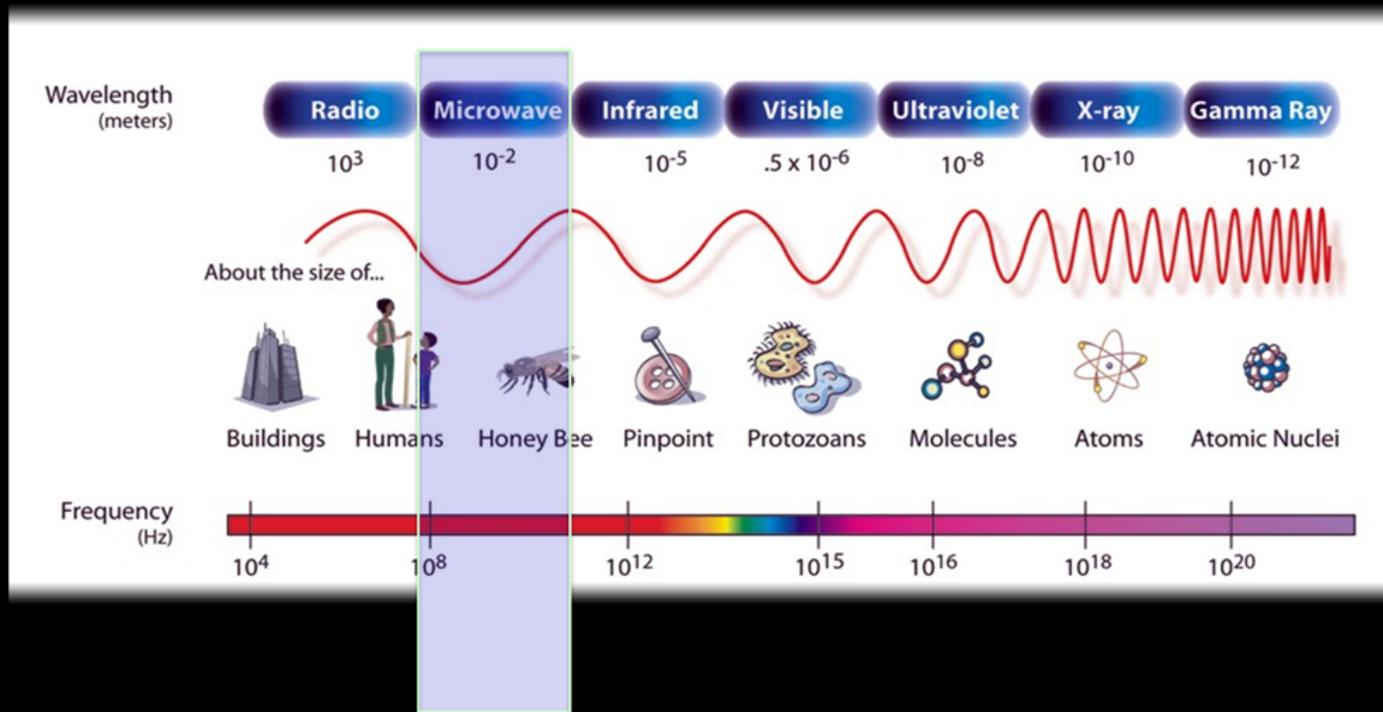
Active Sensors:

Provide their own artificial radiant energy
source for illumination... **RADAR,**
Synthetic Aperture Radar (SAR), LIDAR



Measurement Approach (2)

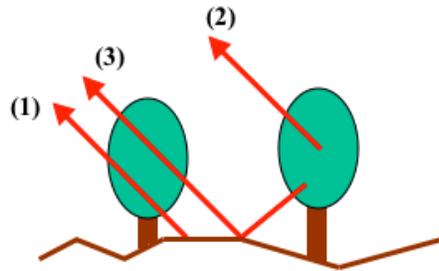
SMAP Views the Earth in the Microwave Region of the Electromagnetic Spectrum



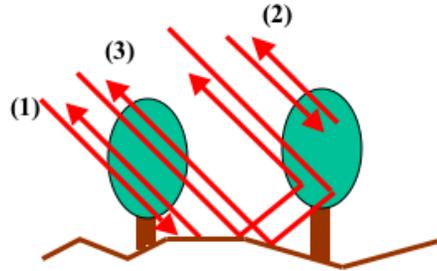
- With optical and infrared wavelength sensors the soil is masked by clouds and vegetation
Also, optical sensors operate by measuring scattered sunlight and are “daytime only”
- Microwaves can penetrate through clouds and vegetation, operate day and night, and are highly sensitive to the water in the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



Measurement Approach (3)



Emission (Radiometer)

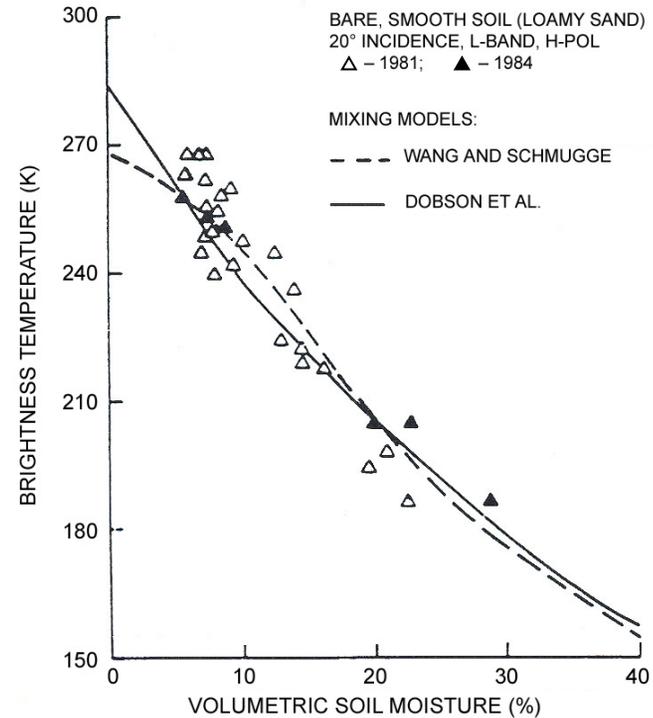


Backscatter (Radar)

$$T_{Bp}^t = T_{Bp}^s L_p + T_{Bp}^v + T_{Bp}^{sv} \quad \text{(Emission)}$$

$$\sigma_{pq}^t = \sigma_{pq}^s L_{pq}^2 + \sigma_{pq}^v + \sigma_{pq}^{sv} \quad \text{(Backscatter)}$$

- 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, $\exp(-\tau_o / \cos\theta)$



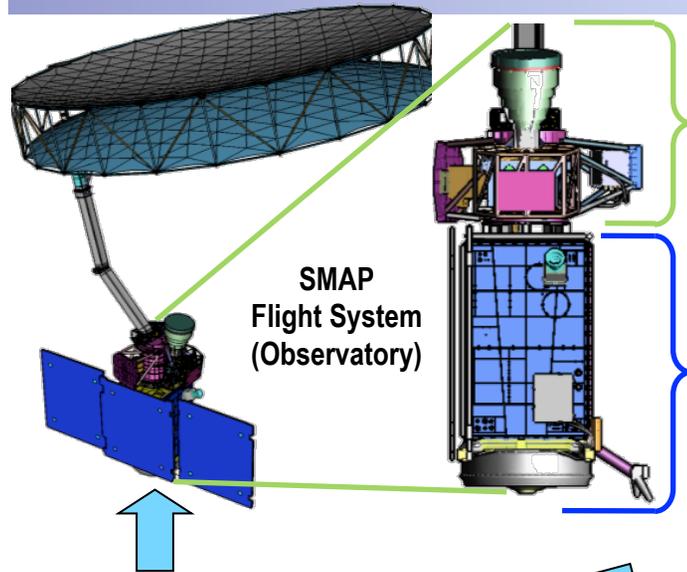
Experimental data showing brightness temperature sensitivity to soil moisture for bare, smooth soil

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



National Aeronautics and Space Administration
Jet Propulsion Laboratory
 California Institute of Technology
 Pasadena, California

SMAP Mission Design

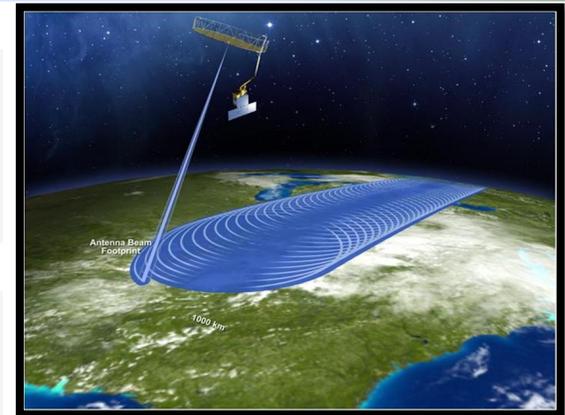


INSTRUMENT

- 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



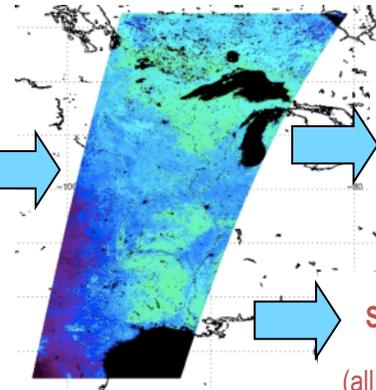
Surface Validation



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)



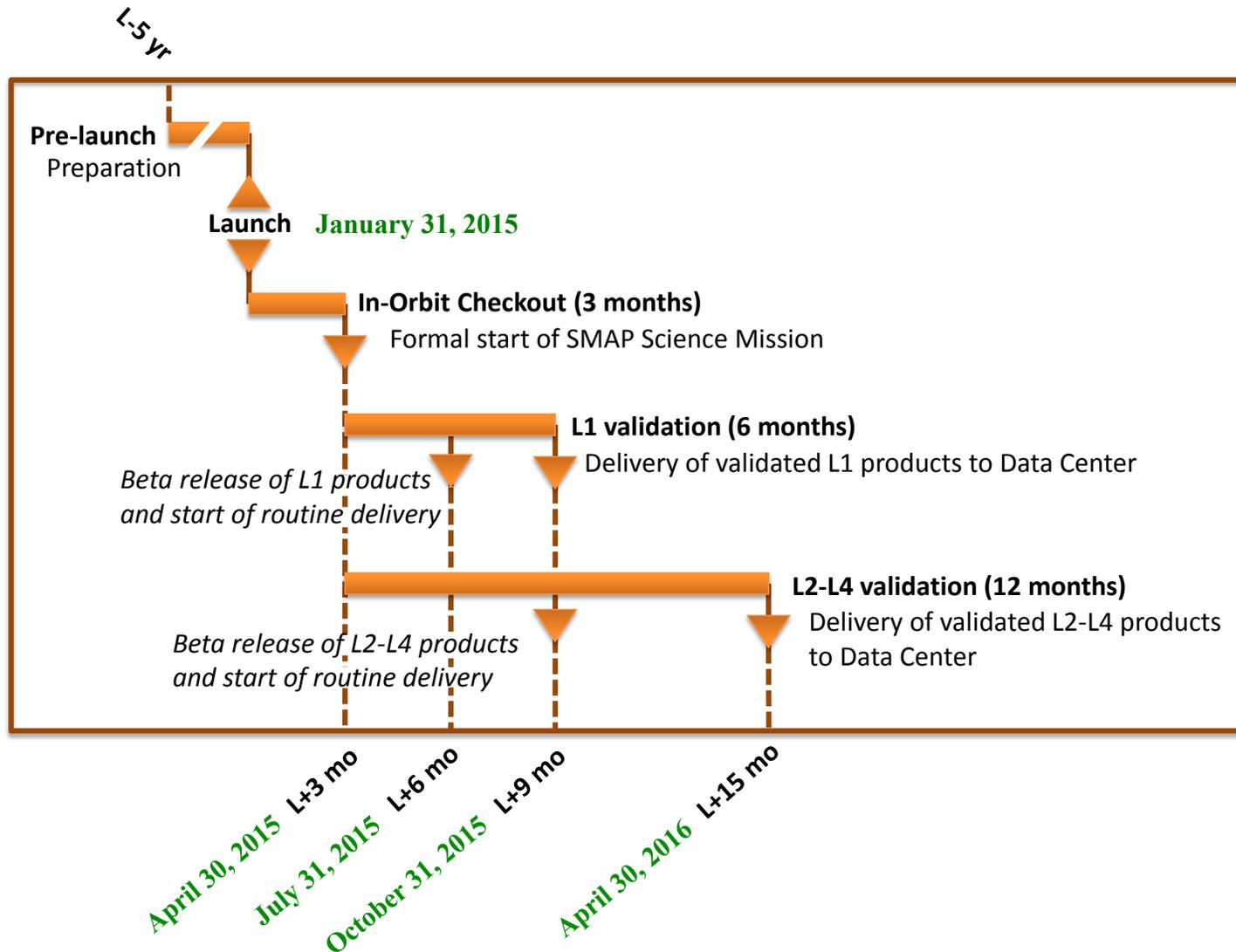
SMAP Data Products

- Datasets in **Green Text** are publicly available in “beta” version via the ASF and NSIDC data centers

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 (10 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



Planned Data Delivery Schedule





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 DAACs
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 DAAC
Early November	Validated data for L1 Radiometer and Radar will be released
Early November	Beta data for L2/3 Soil Moisture Active/Passive, L4 Soil Moisture and L4 Carbon will be released
Through April 2018 (nominal mission)	Science data available through data centers will be used to demonstrate SMAP applications

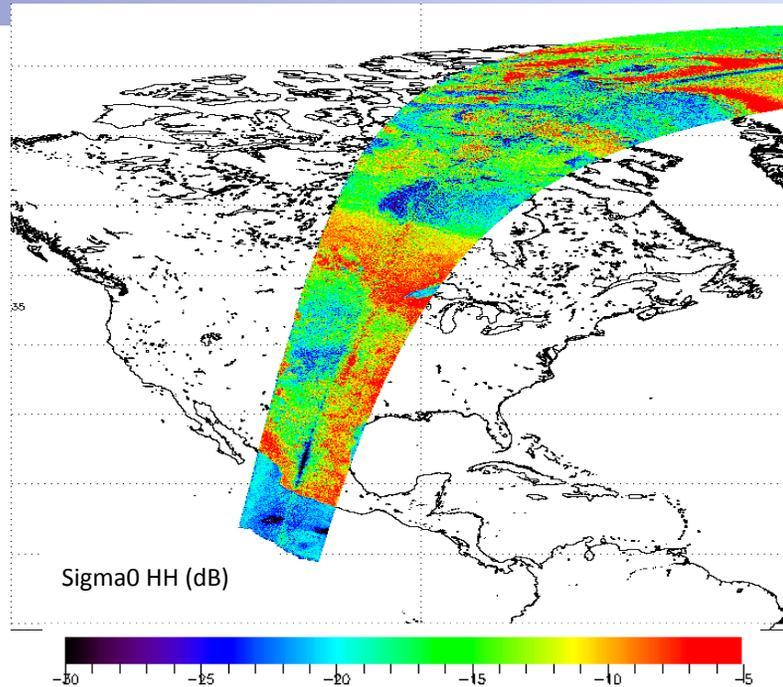


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Radar Level 1C Product

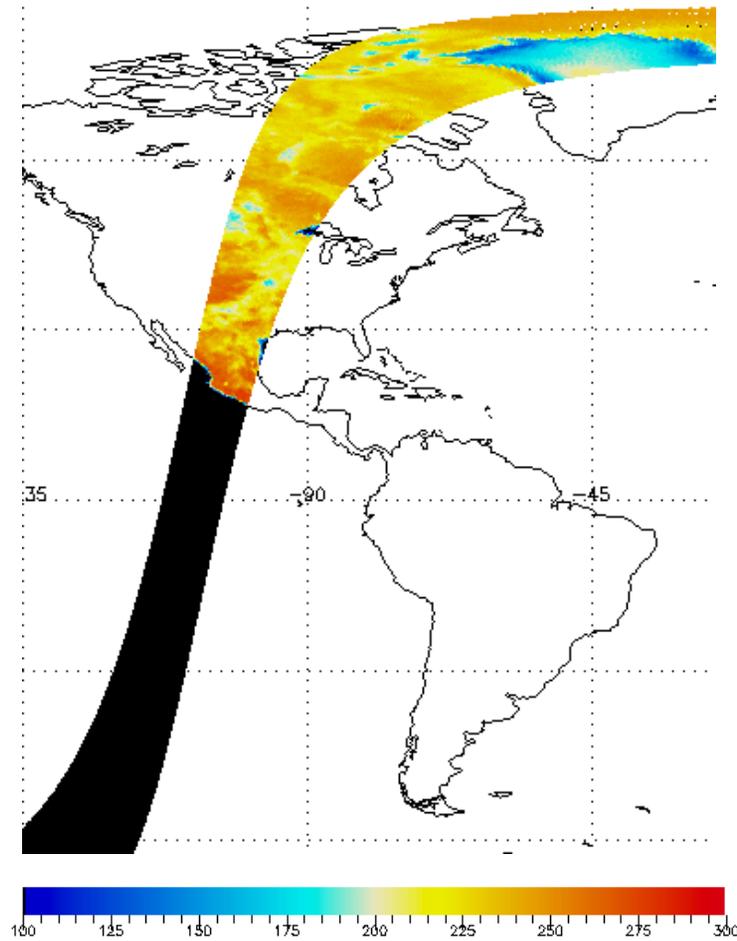
[Data available April 13-July 7, 2015]



- 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 1 km resolution over 70% of the swath. Resolution degrades in the nadir region.
- Forward looking and aft looking measurements 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.



Radiometer Level 1B Product

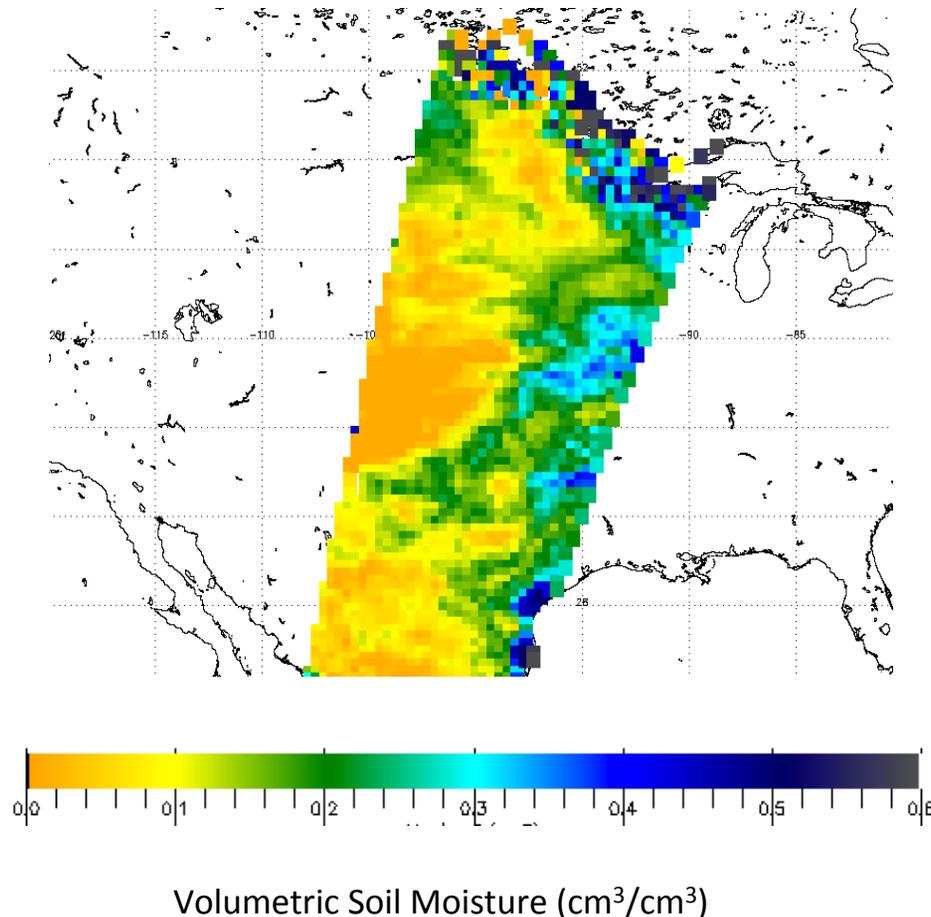


L1B Time-ordered H-pol TB (K)

- 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
- Earth-located calibrated data for each EFOV
 - Apparent aperture (antenna) temperatures
 - Top-of-ionosphere (TOI) brightness temperature
 - Surface-referenced brightness temperatures
- Coverage continuous over all surface types.
- All four modified Stokes parameters (V, H, 3 & 4)
 - 3rd Stokes used for Faraday rotation correction
 - Brightness temperature third Stokes is always zero
- 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



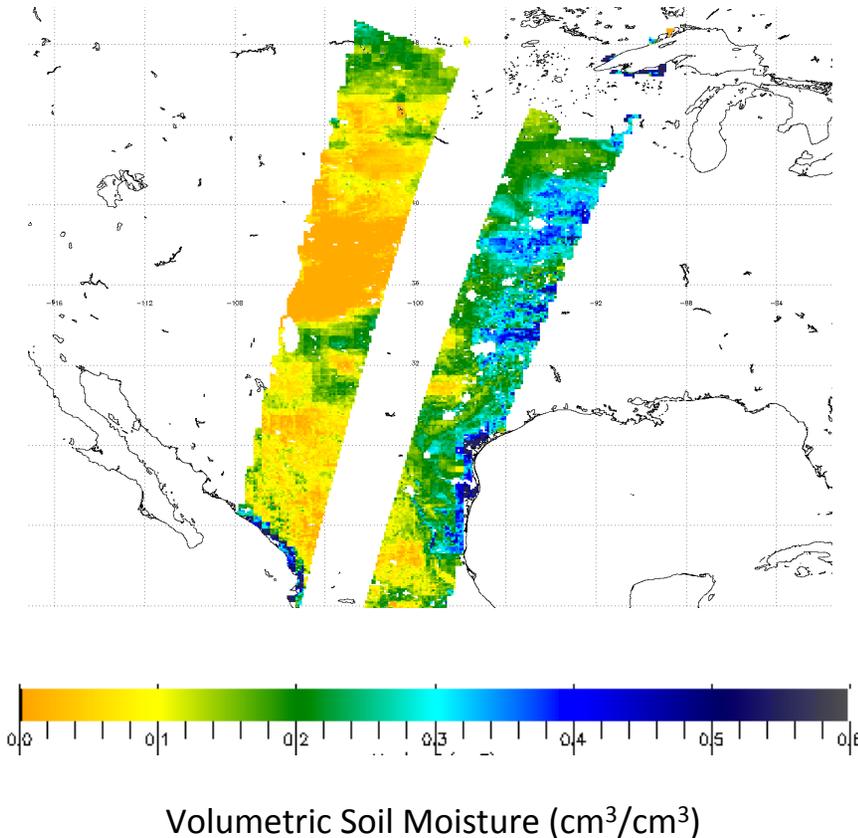
L2 Radiometer 36 km Soil Moisture Product



- 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 4% accuracy for low-to-moderately vegetated areas
 - Low to moderate vegetation defined as vegetation water content $\leq 5 \text{ kg/m}^2$
- Applies water body correction and freeze-thaw state detection that were generated with high resolution radar retrievals
- Estimates soil moisture based on AM observations
- Includes quality masks for urban areas, mountainous terrain, dense vegetation, precipitation, snow and ice



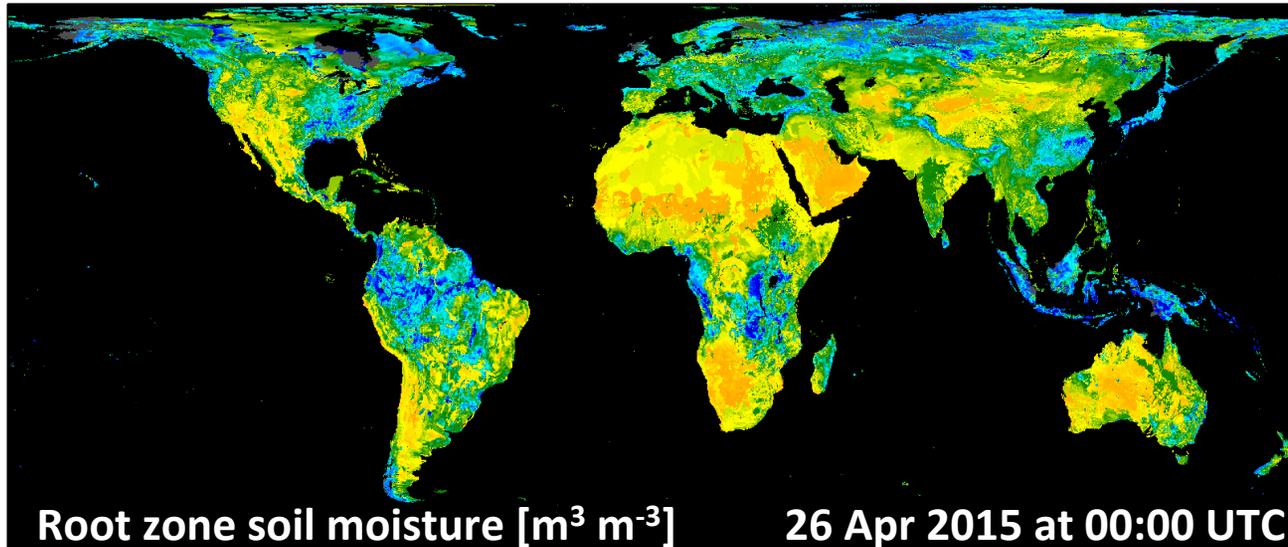
L2 Active/Passive 9 km Soil Moisture Product



- 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 channels using a time series algorithm and spatial heterogeneity of L1C radar product
- Provides dis-aggregated brightness temperatures at 9 km resolution
- Provides retrieved soil moisture over land with 4% accuracy for low-to-moderately vegetated areas
 - Low to moderate vegetation defined as vegetation water content $\leq 5 \text{ kg/m}^2$
- Employs transient water body and freeze-thaw state generated with high resolution radar retrievals
- Include quality masks for urban areas, mountainous terrain, dense vegetation, precipitation, snow and ice



L4 Surface and Root-Zone Soil Moisture Product



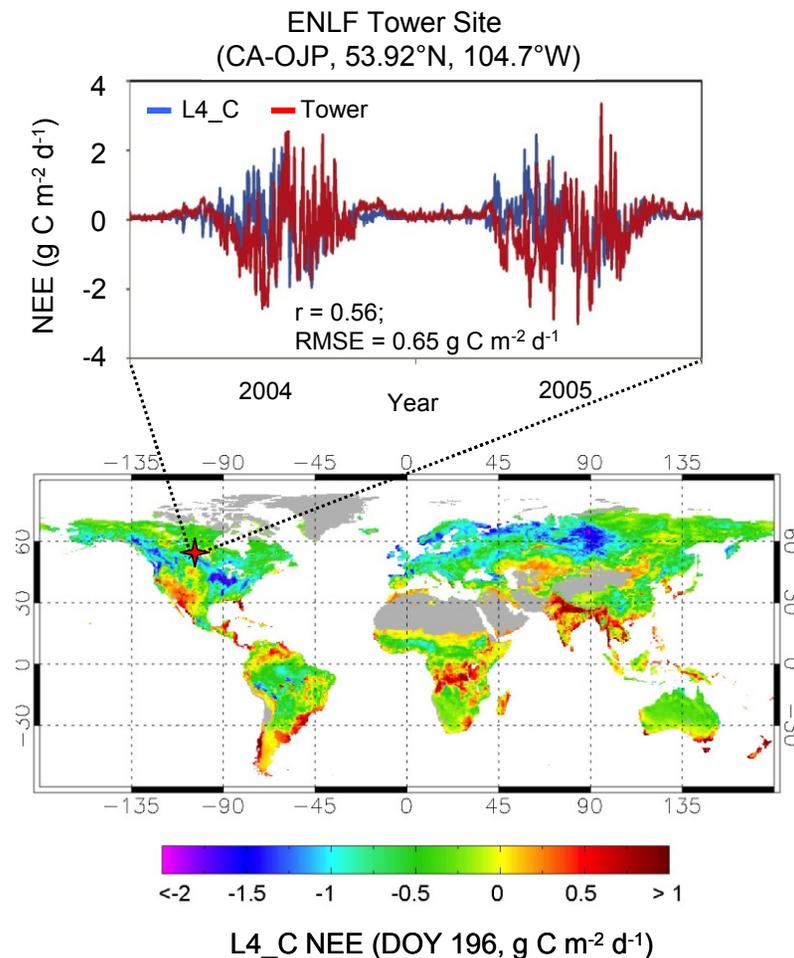
- Global product, presented in two collections
- Based on assimilation of SMAP brightness temperatures from the L1C_TB and L2_SM_AP products into a state-of-the-art land surface model

Geophysical Data (“gph” Collection)	Analysis Update Data (“aup” Collection)
<i>3-hour time averages</i>	<i>3-hour instantaneous (snapshots)</i>
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



L4 Carbon Product

Mean Daily net CO₂ Exchange



- Daily global maps of net ecosystem CO₂ 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 CO₂ exchange (NEE)
- **Accuracy** commensurate with tower based CO₂ observations (RMSE ≤ 30 g C m⁻² yr⁻¹ or 1.6 g C m⁻² d⁻¹)



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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 Website at NSIDC DAAC



National Snow & Ice Data Center



DATA

RESEARCH

NEWS

ABOUT

SEARCH

Web pages



NASA Distributed Active Archive Center (DAAC) at NSIDC

SMAP Data

Soil Moisture Active Passive Data



Overview

Data Sets

[SMAP Data](#)

[Validation Data](#)

Overview

The National Snow and Ice Data Center (NSIDC) and the Alaska Satellite Facility (ASF) will jointly manage SMAP science data on behalf of the [NASA ESDIS Project](#). Currently, NSIDC distributes



Measuring Soil from Space

SMAP is a NASA Earth science mission that uses microwave radar and radiometer instruments to measure soil moisture from space.

[Read more ...](#)

RELATED RESOURCES

[SMAP Handbook](#)

Essential information on the programmatic, technological, and scientific aspects of SMAP data and the mission.

[SMAP Radar Data at ASF](#)

[SMAP Information at NASA](#)

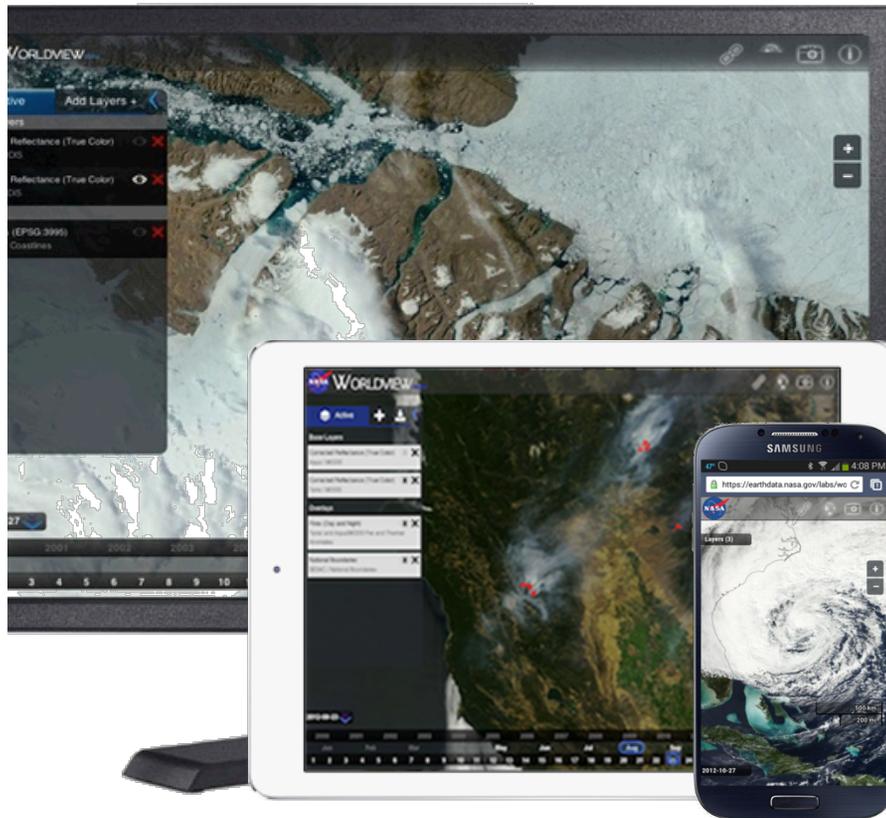


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Worldview

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>

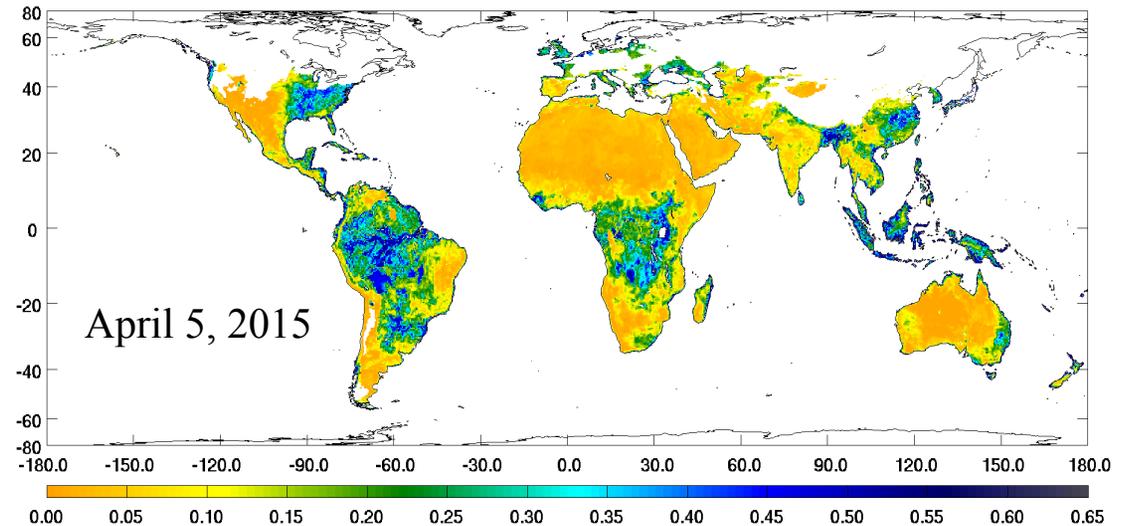
<https://github.com/nasa-gibs/worldview>



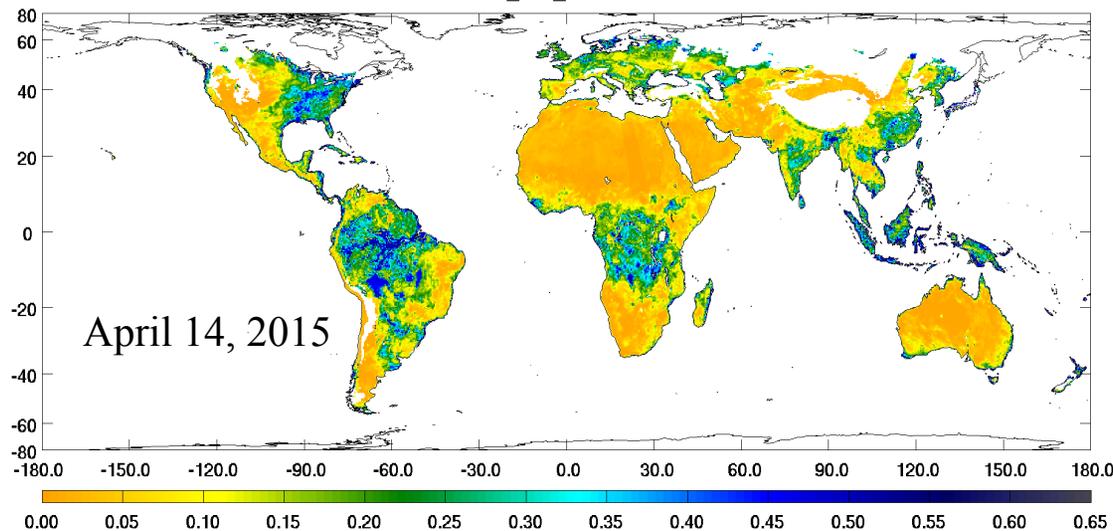
Soil Moisture Product (36 km) Observed Changes

- Passive data successfully processed into soil moisture
- Soil moisture patterns agree with expected geographical soil moisture distribution

SMAP L2_SM_P on 20150405



SMAP L2_SM_P on 20150414



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

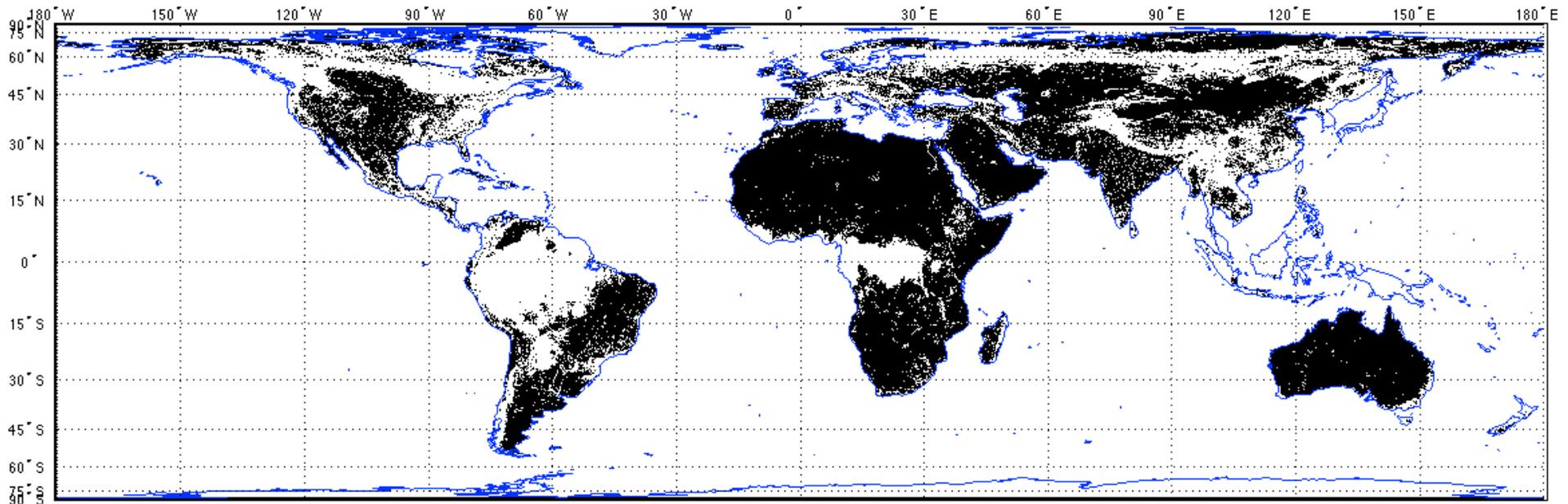


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Soil Moisture Product Expected Accuracy

Regions where SMAP soil moisture retrievals are expected to meet accuracy requirement of $0.04 \text{ m}^3/\text{m}^3$



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

- a) Vegetation water content $\leq 5 \text{ kg}/\text{m}^2$
- b) Urban fraction ≤ 0.25
- c) Water fraction ≤ 0.1
- d) DEM slope standard deviation $\leq 3 \text{ deg}$



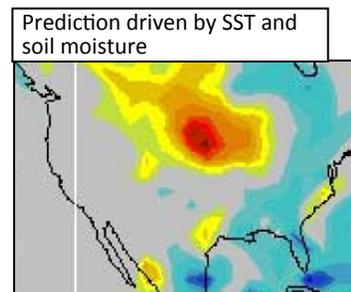
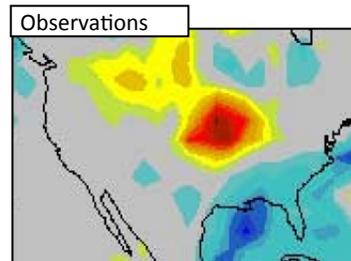
Value of Soil Moisture Data to Weather and Climate

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

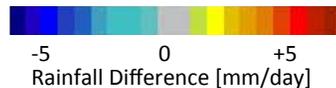
Seasonal Climate Predictability

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.

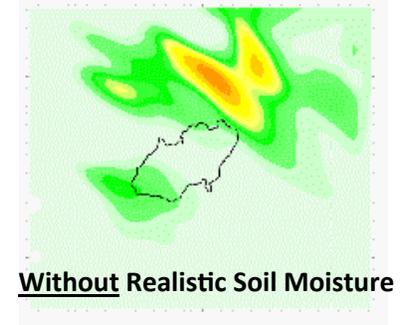
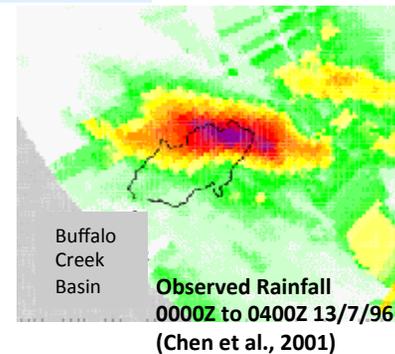
Difference in Summer Rainfall: 1993 (flood) minus 1988 (drought) years



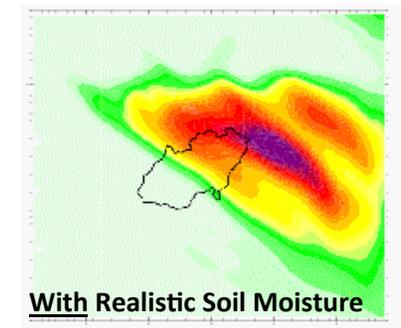
(Schubert et al., 2002)



NWP Rainfall Prediction



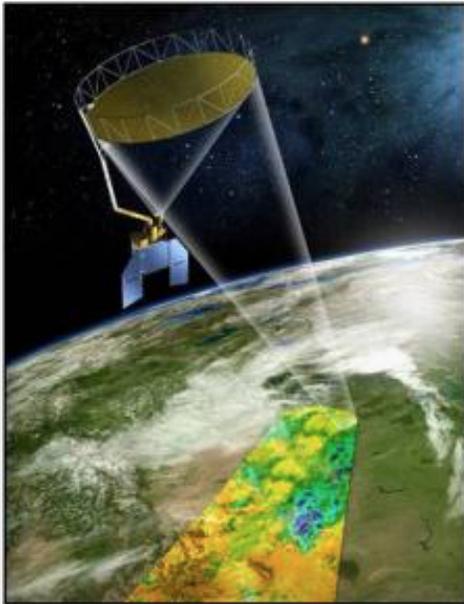
24-Hours Ahead High-Resolution Atmospheric Model Forecasts



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



A Flood Example



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

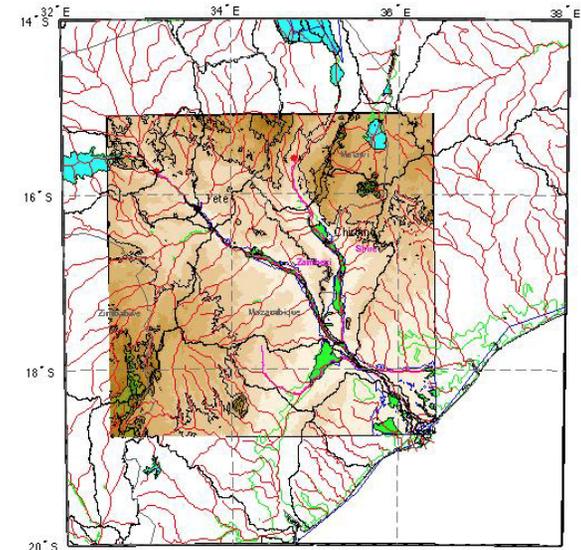
Current Capability: The UN-WFP uses satellite derived flood maps to locate floods and map delivery routes to affected areas.

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

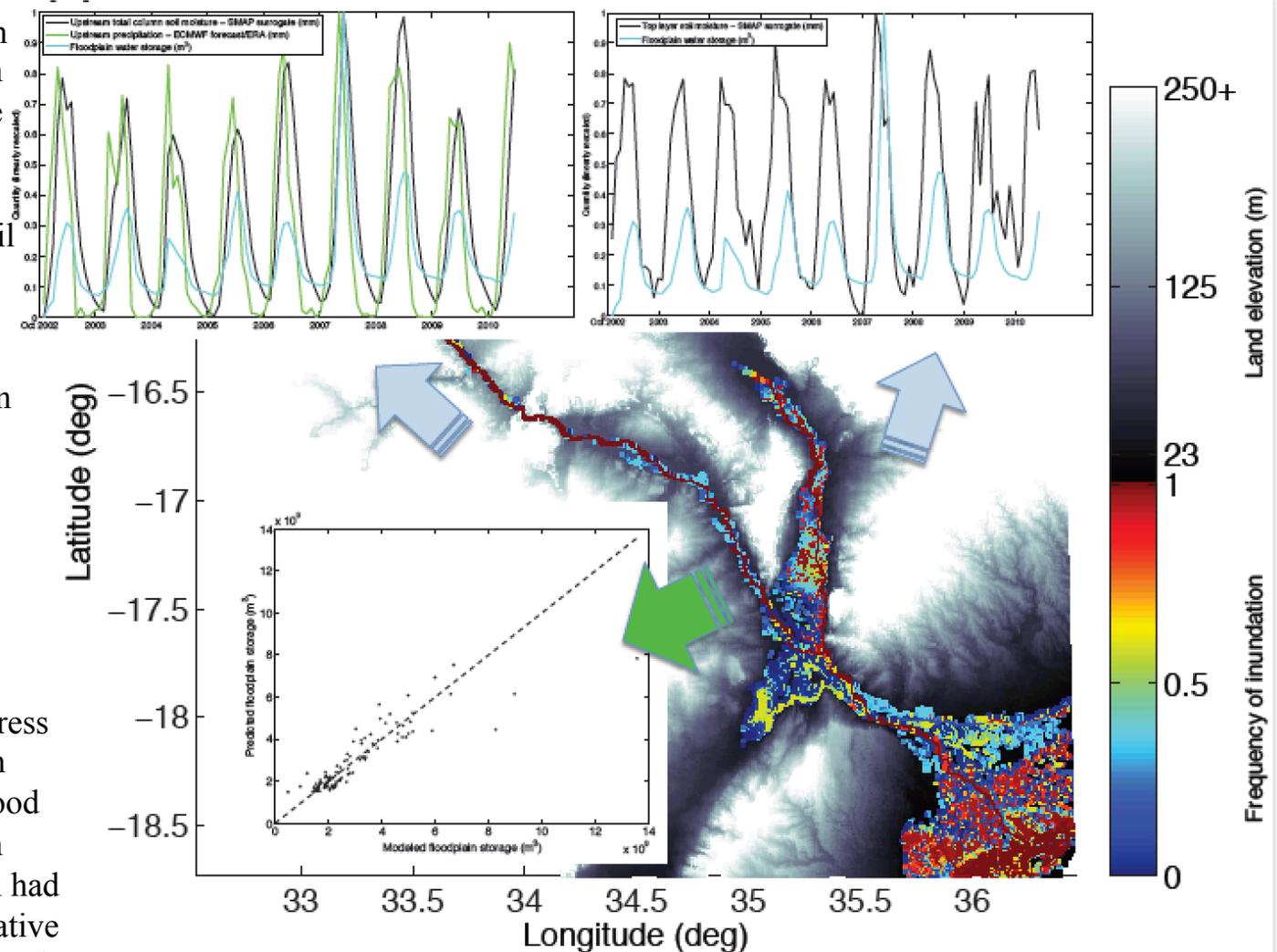




A Flood Example: Results

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%.

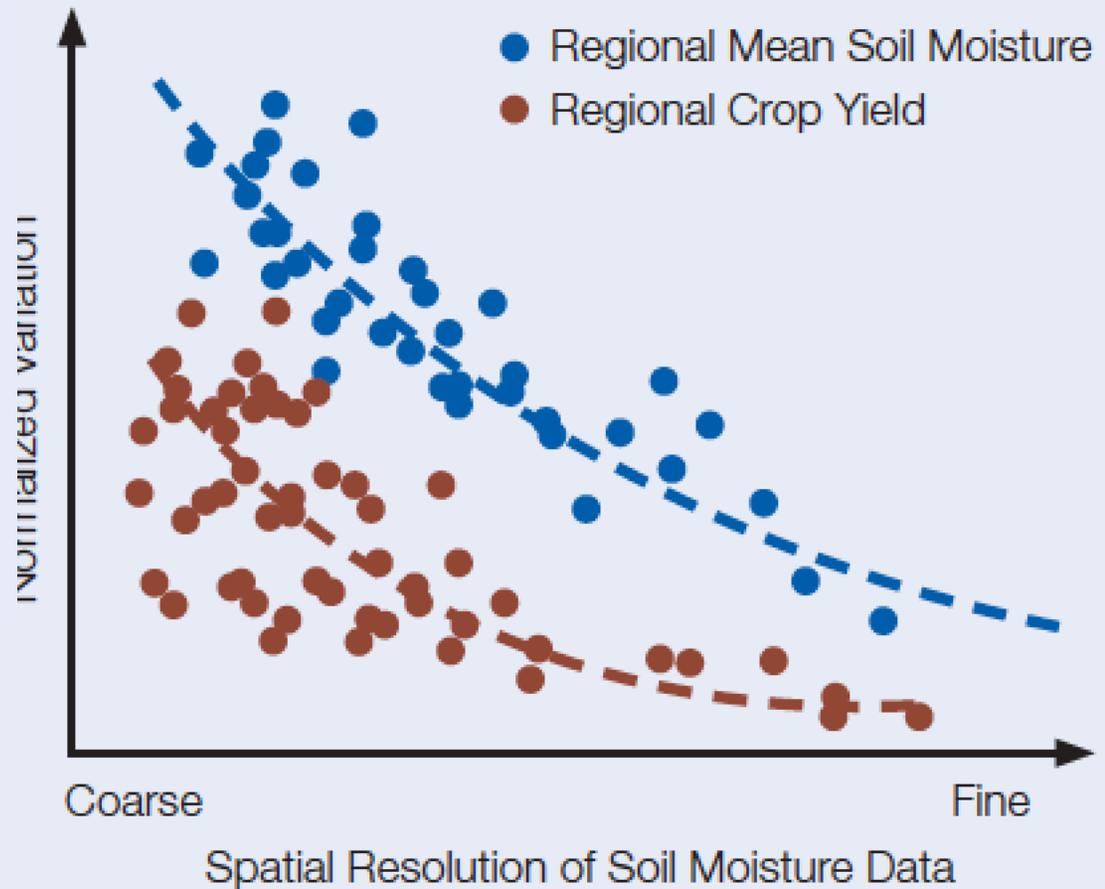


Courtesy of Guy Schumann, UCLA



Crop Yield Modeling

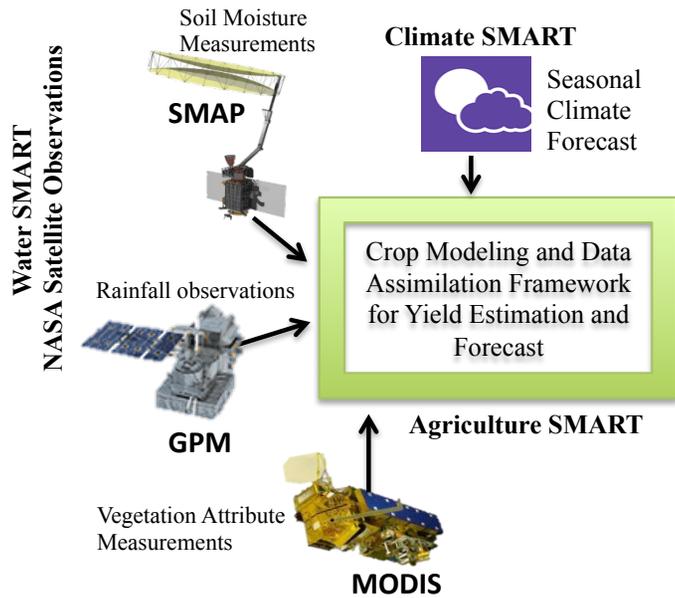
Agricultural models have been developed to predict the yield of various crops at field and regional scales. One key input of the agricultural models is soil moisture. The conceptual diagram relates variation in regional domain-averaged soil moisture to variation in total crop yield. Statistical analysis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





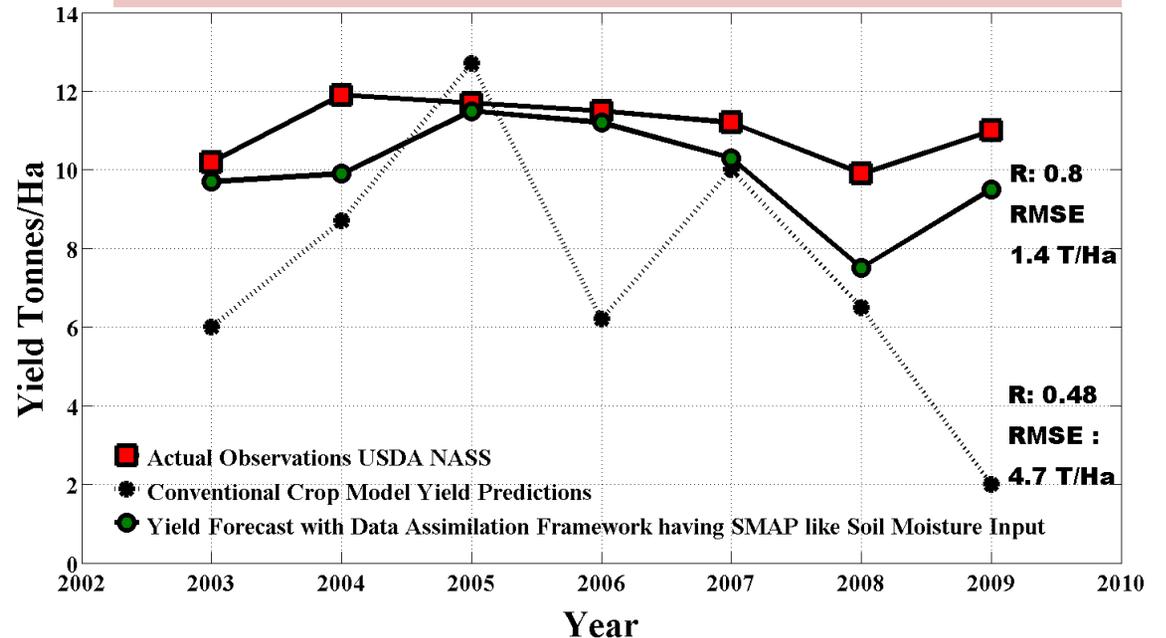
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SMAP for Agricultural Crop Yield and Food Security Applications



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

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



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



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



SMAP Applications 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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SMAP Applications Early Adopters Video



[SMAP Early Adopters video](#)

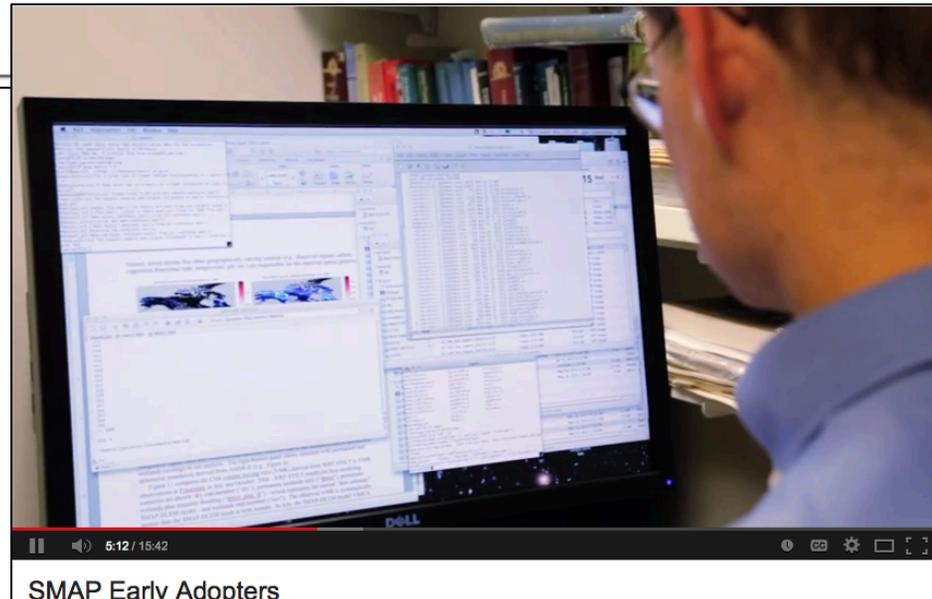
This diverse group represents a cross-section of end-users of SMAP data who collaborate to ensure integration of SMAP data into operations that affect our day-to-day lives. Examples include the U.S. Forest Service, the UN World Food Programme, and the U.S. Department of Agriculture.

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

[Early Adopters](#)

<http://smap.jpl.nasa.gov/early-adopters/>

Thank you
for your attention!





Thank You!

Amita Mehta

email: amita.v.mehta@nasa.gov



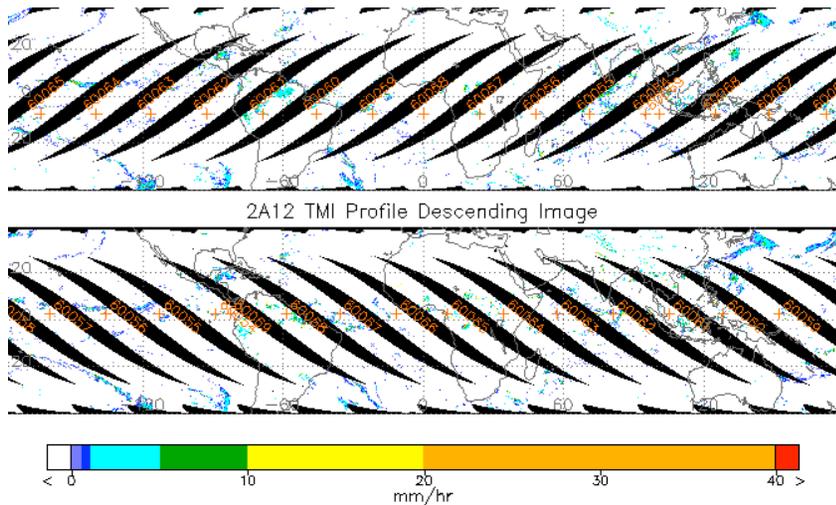
Extra Slides

TRMM Measurements

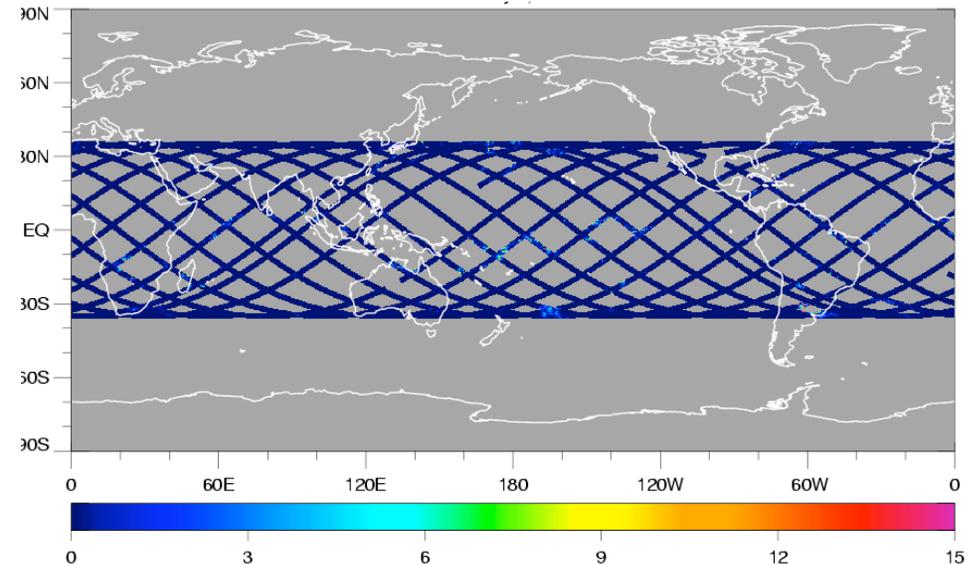


TMI

PR⁺



2008/05/31 image contains 16 orbits, orbit numbers from 60054 to 60069



Frequencies: 10.7, 19.4, 21.3, 37, 85.5 GHz
Swath: 760 km (870* km)
Resolution: 5 to 45 km (channel-dependent)

Frequencies: 13.6 GHz
Swath: 220 km (247* km)
Resolution: 5 km

* After the orbit was raised in August 2001 +Stopped after October 7, 2014

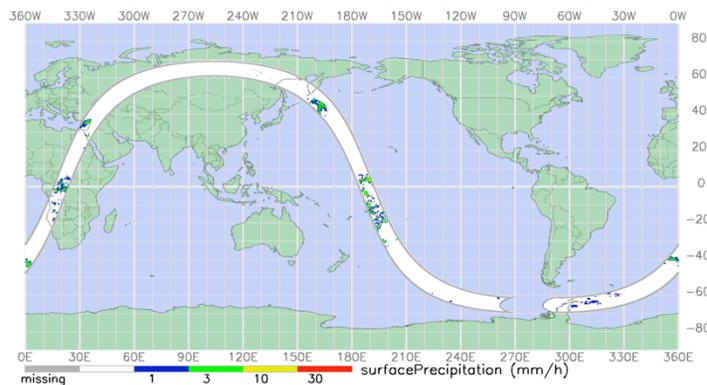
Strength: High pixel resolution, Accurate measurements
Limitation: No global, diurnal coverage on daily basis

GPM Measurements

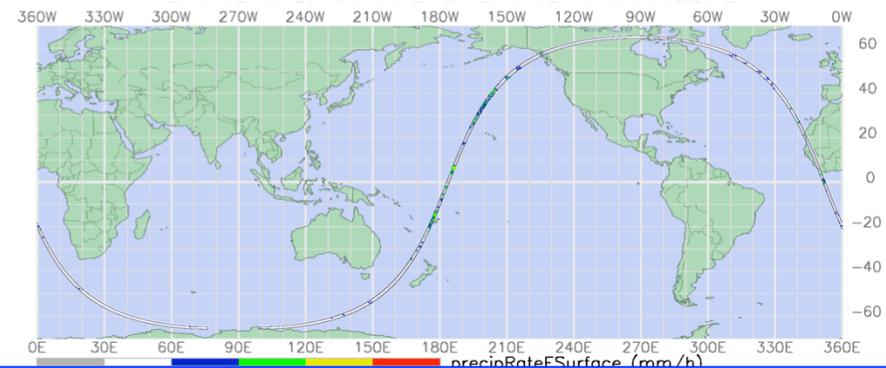


<http://pmm.nasa.gov/GPM>

GMI



DPR



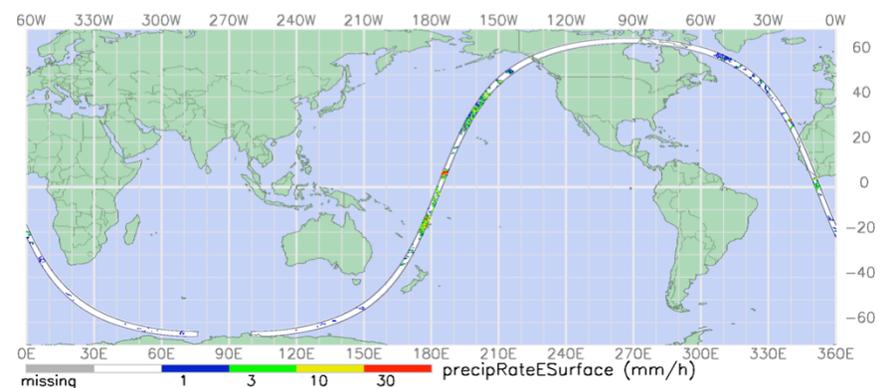
Ka 35.5 GHz, Swath Width 120 km, Resolution 5.2 km

GMI Frequencies:
10.6, 18.7, 23.8, 36.5, 89, 166 & 183 GHz

Swath width 885 km

Resolution: 19.4km x 32.2km (10 GHz)
to 4.4km x 7.3km (183 GHz)

Higher spatial resolutions than TMI
High frequencies help measure snow



Ku 13.6 GHz, Swath Width 245 km, Resolution 5.2 km

Summary of GPM Level-2 Precipitation Products



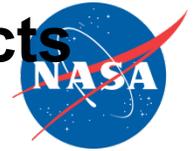
*Surface Rainfall Rate in mm/hour

GPM data are available from March 2014 to present

Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
DPR Ku-only/ 2A-Ku DPR Ka-only/2A-Ka DPR KU & Ka/ 2A-DPR	5.2 km x125 m Single Orbit and 16 orbits per day (70°S-70°N)	20-120 minutes 24 hours	HDF5 and OPenDAP
GMI/2A-GPROF	4 km x 4 km Orbital and 16 orbits per day (70°S-70°N)	2 – 40 hours	
Combined GMI and DPR/2A-CMB	Orbital (70°S-70°N) 5 km x 5 km, Coincident Ku-Ka-GMI footprints	3 – 40 hours	

*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products

Summary of GPM Level-3 Precipitation Products



*Surface Rainfall Rate in mm/hour

GPM data are available from March 2014 to present

Sensor/Product Name	Spatial Resolution and Coverage	Temporal Resolution	Data Format
IMERG	0.1°x0.1° (90°S-90°N)	30-minutes(Near Real Time) with 4-hour latency, 12-hour latency and 4-months latency	HDF4, NetCDF, OPenDAP, ASCII GIF, PNG Images KML for Google Earth
3-CMB Combined GMI + DPR rainfall Averages	0.1°x0.1° (70°S-70°N)	Monthly	
3-DPR rainfall Averages	0.25°x0.25° 5.0°x5.0° (67°S-67°N) for Daily (70°S-70°N) for Monthly	Daily and Monthly Daily and Monthly	
3-GPROF GMI rainfall Averages	0.25°x0.25° (90°S-90°N)	Daily and Monthly	

*In addition to surface rainfall rate in mm//hour, vertical precipitation profiles and latent heating are available in these data products