




# ARSET

Applied Remote Sensing Training

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

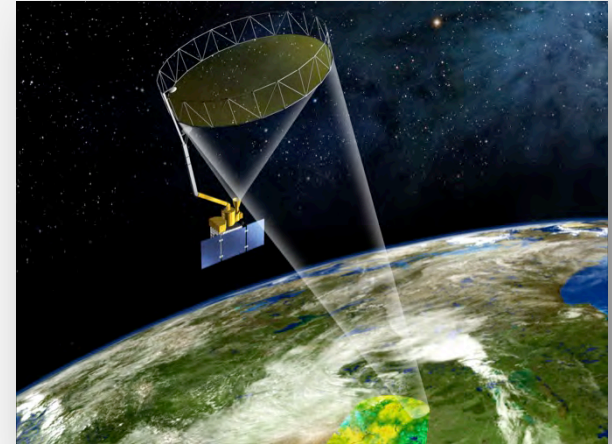
 @NASAARSET

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# SMAP Hands-On

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Jul. 20, 2016



# Outline

1. Data products overview
2. Discovering and downloading the data
3. Visualizing the data
4. Analyzing the data

A satellite dish antenna is shown in space, pointing towards the Earth. The dish is a large, white, parabolic structure with a metal frame. It is mounted on a satellite platform. The Earth is visible in the background, showing a mix of green land, blue oceans, and white clouds. A semi-transparent white box is overlaid on the image, containing the text "Data Products Overview" and a horizontal line below it.

## Data Products Overview

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Data Set ID	Data Set Description	Gridding Resolution	Temporal Coverage	DAAC
SPL1AA	L1A Radar Time-Ordered Parsed Telemetry	—	4/13/15 – 7/7/15	ASF
SPL1BS0	L1B Radar Half-Orbit Time-Ordered Low-Resolution $\sigma_0$ Data	5x30 km	4/13/15 – 7/7/15	ASF
SPL1CS0	L1C Radar Half-Orbit High-Resolution Radar $\sigma_0$ Data	1 km	4/13/15 – 7/7/15	ASF
SPL1AP	L1A Radiometer Time-Ordered Parsed Telemetry	—	3/31/15 – present	NSIDC
SPL1BTB	L1B Radiometer Half-Orbit Time-Ordered TB	36x47 km	3/31/15 – present	NSIDC
SPL1CTB	L1C Radiometer Half-Orbit EASE-Grid TB	36 km	3/31/15 – present	NSIDC
SPL2SMA	L2 Radar Half-Orbit EASE-Grid Soil Moisture	3 km	4/13/15 – 7/7/15	NSIDC
SPL2SMP	L2 Radiometer Half-Orbit EASE-Grid Soil Moisture	36 km	3/31/15 – present	NSIDC
SPL2SMAP	L2 Radar/Radiometer Half-Orbit EASE-Grid Soil Moisture	9 km	4/13/15 – 7/7/15	NSIDC
SPL3FTA	L3 Radar N. Hemisphere Daily EASE-Grid Freeze/Thaw State	3 km	4/13/15 – 7/7/15	NSIDC
SPL3SMA	L3 Radar Global Daily EASE-Grid Soil Moisture	3 km	4/13/15 – 7/7/15	NSIDC
SPL3SMP	L3 Radiometer Global Daily EASE-Grid Soil	36 km	3/31/15 – present	NSIDC
SPL3SMAP	L3 Radar/Radiometer Global Daily EASE-Grid Soil Moisture	9 km	4/13/15 – 7/7/15	NSIDC
SPL4SMAU	L4 Global Surface & Root Zone Soil Moisture Analysis Update	9 km	3/31/15 – present	NSIDC
SPL4SMGP	L4 Global Surface & Root Zone Soil Moisture Geophysical Data	9 km	3/31/15 – present	NSIDC
SPL4CMDL	L4 Global Daily Carbon Net Ecosystem Exchange (NEE)	9 km	4/13/15 – present	NSIDC

# Product Configuration

- **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  $\text{cm}^3/\text{cm}^3$
  - Freeze/thaw is a binary measurement, either frozen or thawed
  - Net ecosystem exchange is in grams of carbon/square meter per day

# Product Configuration

- Values
  - The radiometer data (brightness temperature) are in Kelvin
  - The radar data are in sigma naught
  - Soil moisture is volumetric and expressed as  $\text{cm}^3/\text{cm}^3$
  - Surface freeze/thaw state is a binary measurement
  - Net carbon ecosystem exchange is in grams per square meter per day

A satellite dish antenna is shown in space, pointing towards Earth. The dish is a large, white, parabolic structure with a metal frame. The Earth is visible in the background, showing a mix of green land, blue oceans, and white clouds. A semi-transparent white rectangular box is overlaid on the image, containing the text "Discovering and Downloading the Data". Below the text is a horizontal line. The background is a starry space scene.

## Discovering and Downloading the Data

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# Data Access: NSIDC

NSIDC DAAC: <http://nsidc.org/data/smap>

- Access to the L1 radiometer data and all L2, L3, and L4 radiometer and radar products.
- Data access, data set user guide documents, tools, news, published research, quality information, FAQs, and many other resources.

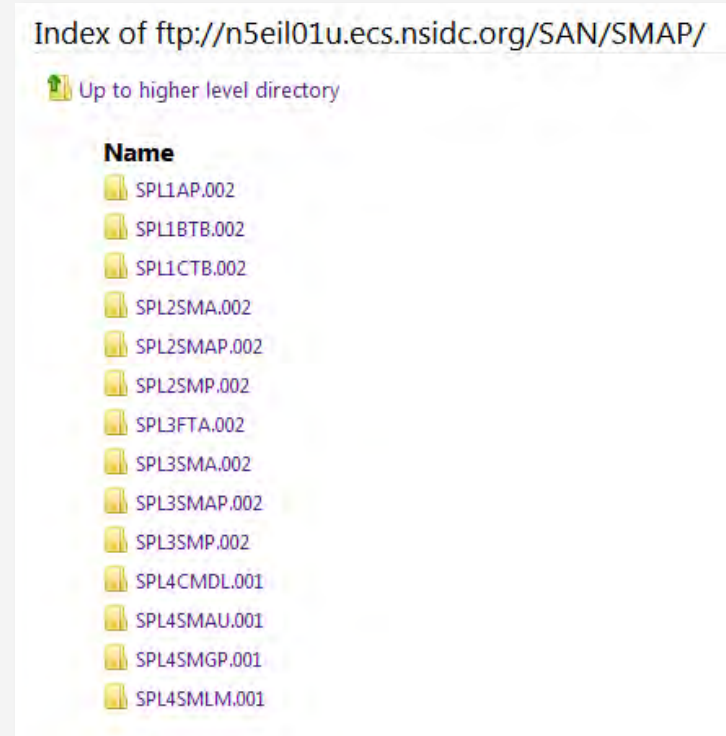
The screenshot shows the NSIDC website for SMAP Data. The navigation bar includes 'DATA', 'RESEARCH', 'NEWS', and 'ABOUT'. The main header identifies the site as the 'NASA Distributed Active Archive Center (DAAC) at NSIDC' for 'SMAP Data'. A sidebar on the left provides a menu of options including 'Overview', 'Data Sets', 'Data Versions', 'Tools', 'FAQs', 'How Tos', 'Data Announcements', 'Published Research', and 'Validation Data'. The main content area features an 'Overview' section describing the SMAP mission and a 'Mapping Moisture' section with a global soil moisture map. A 'RELATED RESOURCES' section on the right lists links to the SMAP Handbook, SMAP Radar Data at the ASF DAAC, SMAP information at NASA and JPL, HDF5 Tools, EASE-Grid Data, and NSIDC User Services.



# Data Access: NSIDC

NSIDC DAAC: <http://nsidc.org/data/smap>

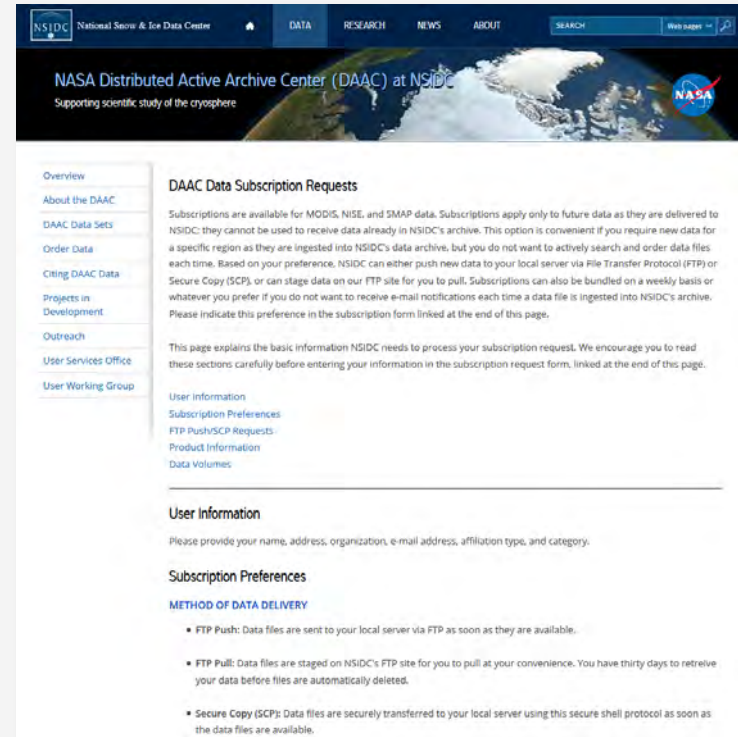
- HTTPS
  - <https://n5eil01u.ecs.nsidc.org/SMAP/>
- FTP
  - <ftp://n5eil01u.ecs.nsidc.org/SAN/SMAP>
- Direct access to the SMAP data



# Data Access: NSIDC

Subscription: <http://nsidc.org/daac/subscriptions.html>

Automatic delivery of data as it becomes available.



The screenshot shows the NSIDC (National Snow & Ice Data Center) website. The header includes the NSIDC logo, the text "National Snow & Ice Data Center", and navigation links for "DATA", "RESEARCH", "NEWS", and "ABOUT". A search bar and a "Web page" link are also visible. The main content area features a banner for the "NASA Distributed Active Archive Center (DAAC) at NSIDC" with the tagline "Supporting scientific study of the cryosphere" and a NASA logo. Below the banner is a sidebar with a navigation menu containing links for "Overview", "About the DAAC", "DAAC Data Sets", "Order Data", "Citing DAAC Data", "Projects in Development", "Outreach", "User Services Office", and "User Working Group". The main content area is titled "DAAC Data Subscription Requests" and contains the following text:

Subscriptions are available for MODIS, NISE, and SMAP data. Subscriptions apply only to future data as they are delivered to NSIDC; they cannot be used to receive data already in NSIDC's archive. This option is convenient if you require new data for a specific region as they are ingested into NSIDC's data archive, but you do not want to actively search and order data files each time. Based on your preference, NSIDC can either push new data to your local server via File Transfer Protocol (FTP) or Secure Copy (SCP), or can stage data on our FTP site for you to pull. Subscriptions can also be bundled on a weekly basis or whatever you prefer if you do not want to receive e-mail notifications each time a data file is ingested into NSIDC's archive. Please indicate this preference in the subscription form linked at the end of this page.

This page explains the basic information NSIDC needs to process your subscription request. We encourage you to read these sections carefully before entering your information in the subscription request form, linked at the end of this page.

User Information  
Subscription Preferences  
FTP Push/SCP Requests  
Product Information  
Data Volumes

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**User Information**

Please provide your name, address, organization, e-mail address, affiliation type, and category.

**Subscription Preferences**

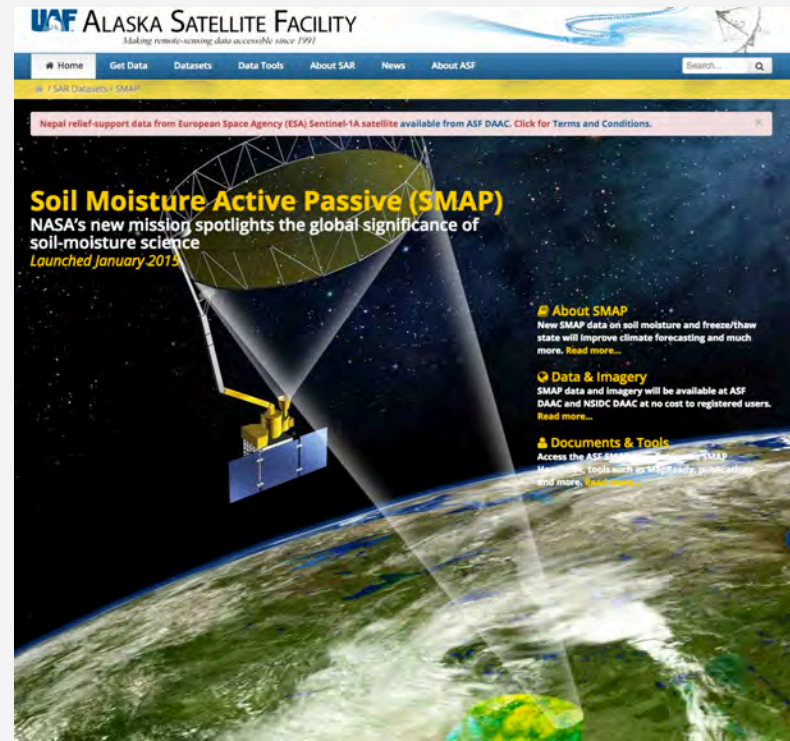
**METHOD OF DATA DELIVERY**

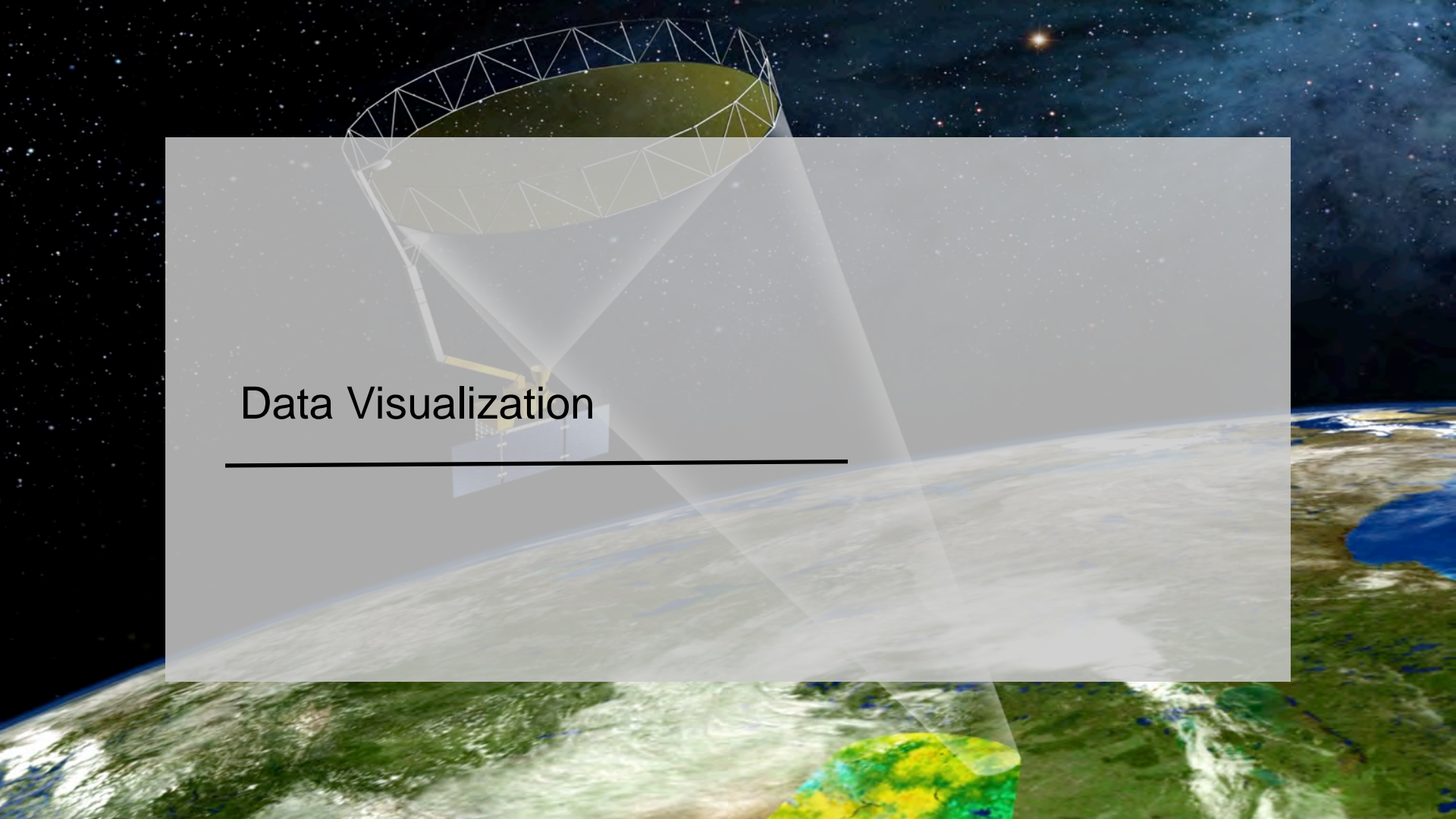
- **FTP Push:** Data files are sent to your local server via FTP as soon as they are available.
- **FTP Pull:** Data files are staged on NSIDC's FTP site for you to pull at your convenience. You have thirty days to retrieve your data before files are automatically deleted.
- **Secure Copy (SCP):** Data files are securely transferred to your local server using this secure shell protocol as soon as the data files are available.

# Data Access: ASF

ASF DAAC: <http://asf.alaska.edu/smap>

- Access to the L1 radar data only.
- Data access, data set user guide documents, tools, news, published research, quality information, FAQs, and many other resources.



A satellite dish antenna is shown in space, pointing towards Earth. The dish is a large, white, parabolic structure with a metal frame. A beam of light or data is projected from the dish onto the Earth's surface. The Earth is shown in a curved perspective, with green landmasses and blue oceans. A semi-transparent white rectangular box is overlaid on the image, containing the text "Data Visualization" and a horizontal line below it. The background is a starry space scene.

# Data Visualization

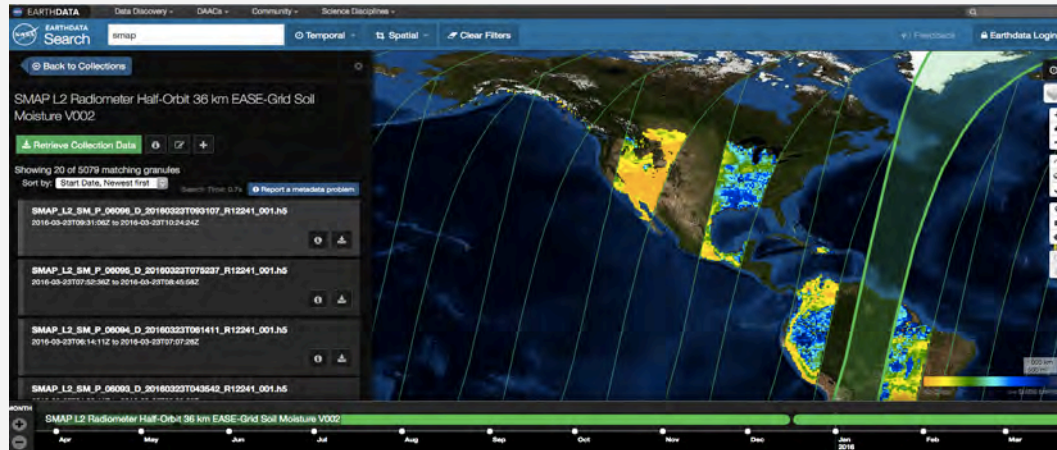
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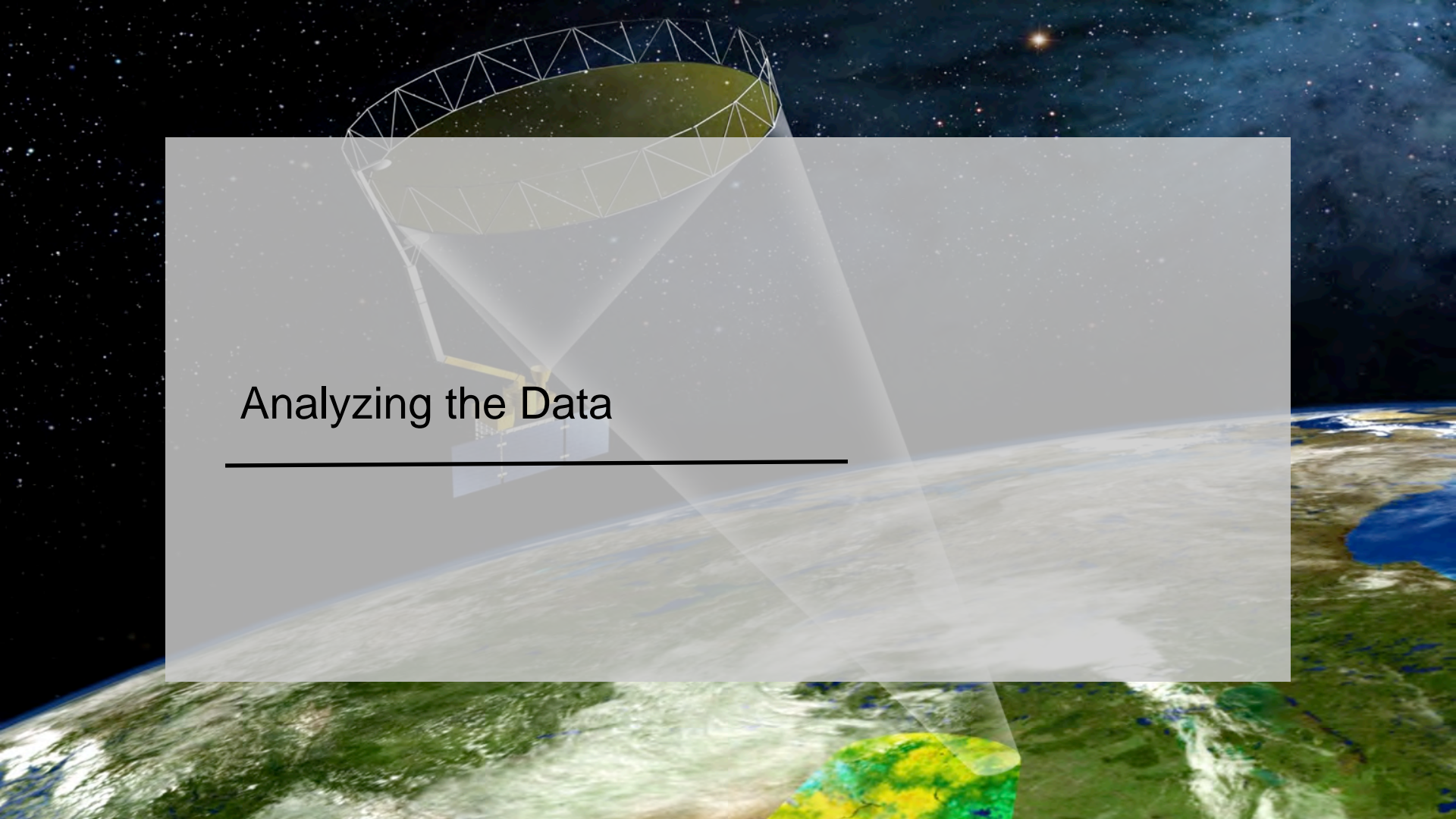
# Visualizing the Data with Worldview

<https://earthdata.nasa.gov/worldview>

**Earthdata Search:** <http://search.earthdata.nasa.gov/>

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



A satellite dish antenna is shown in space, pointing towards Earth. The dish is a large, white, parabolic structure with a metal frame. A beam of light or data is projected from the dish onto the Earth's surface. The Earth is shown in a curved perspective, with a green and yellow data visualization overlay on the landmasses. The background is a starry space with a bright star. A semi-transparent white box is overlaid on the image, containing the text "Analyzing the Data" and a horizontal line.

## Analyzing the Data

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# Tools for Reading SMAP Data

- HDF5

- [http://www.hdfgroup.org/products/hdf5\\_tools/index.html](http://www.hdfgroup.org/products/hdf5_tools/index.html)

- Code in: Python, MATLAB, IDL, y NCL

- [http://hdfeos.org/zoo/index\\_openNSIDC\\_Examples.php#SMAP](http://hdfeos.org/zoo/index_openNSIDC_Examples.php#SMAP)

- Panoply

SMAP	Swath	<a href="#">SMAP_L1A_RADIOMETER_03721_D_20151013T000528_R11920_001.h5</a>	Python	NCL	MATLAB	IDL
		<a href="#">SMAP_L1B_TB_01367_A_20150505T001706_R11850_001.h5</a>	Python	NCL	MATLAB	IDL
		<a href="#">SMAP_L1C_TB_03721_D_20151013T000528_R11920_001.h5</a>	Python	NCL	MATLAB	IDL
		<a href="#">SMAP_L2_SM_P_03721_D_20151013T000528_R11920_001.h5</a>	Python	NCL	MATLAB	IDL
	Grid	<a href="#">SMAP_L3_SM_P_20151012_R11920_001.h5</a>	Python	NCL	MATLAB	IDL

SOFTWARE USING HDF5

CONTENTS:

- [HDF5 Tools and Software](#)
- [HDF5 Tools by Category](#) (view, edit, export, convert, import)
- [Table \(Summary\) of Software Using HDF5](#)
- [HDF5 Command-line Tools](#)
- [Archived](#)

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HDF5 Tools and Software:

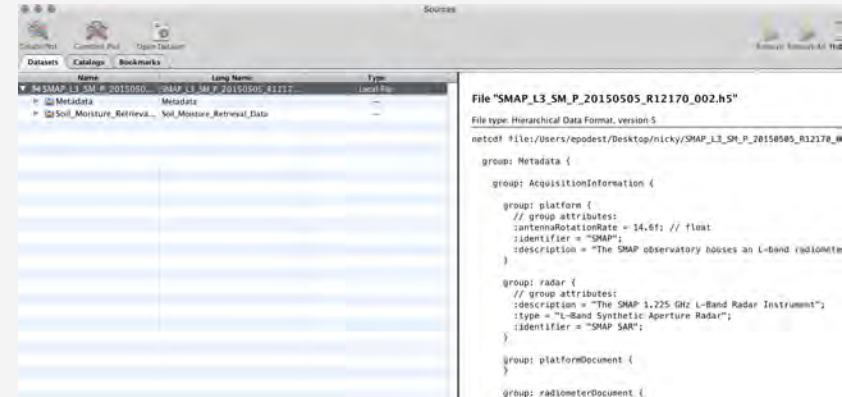
- [HDF-Java Products and HDFView](#): HDFView Java browser for HDF4 and HDF5 and HDF Java wrappers
- [HDF5 Command-line Tools](#): Tools included with the HDF5 distribution
- [HDF5 and .NET](#)
- [H4toH5 Conversion Library and Tools](#): A library and tools for converting to and from HDF4 and HDF5.
- [h5check](#): A tool to check the validity of an HDF5 file.
- [h5edit](#): A tool for editing an HDF5 file. The current (first) release only supports commands for the creation and deletion of attributes of datasets and groups. More commands will be implemented in the future. This software is sponsored by the JPSS project. **NEW**
- [HDF5 XML Information Page](#): DTD and tools for using HDF5 with XML.

See the [Downloads](#) page to access this tool:

- h5fix\_obj\_nmgs: Corrects corrupt object header (rare problem prior to 1.6.6). Search on *Miscouted* [here](#).

# Opening a SMAP File with Panoply: L3 SM\_P

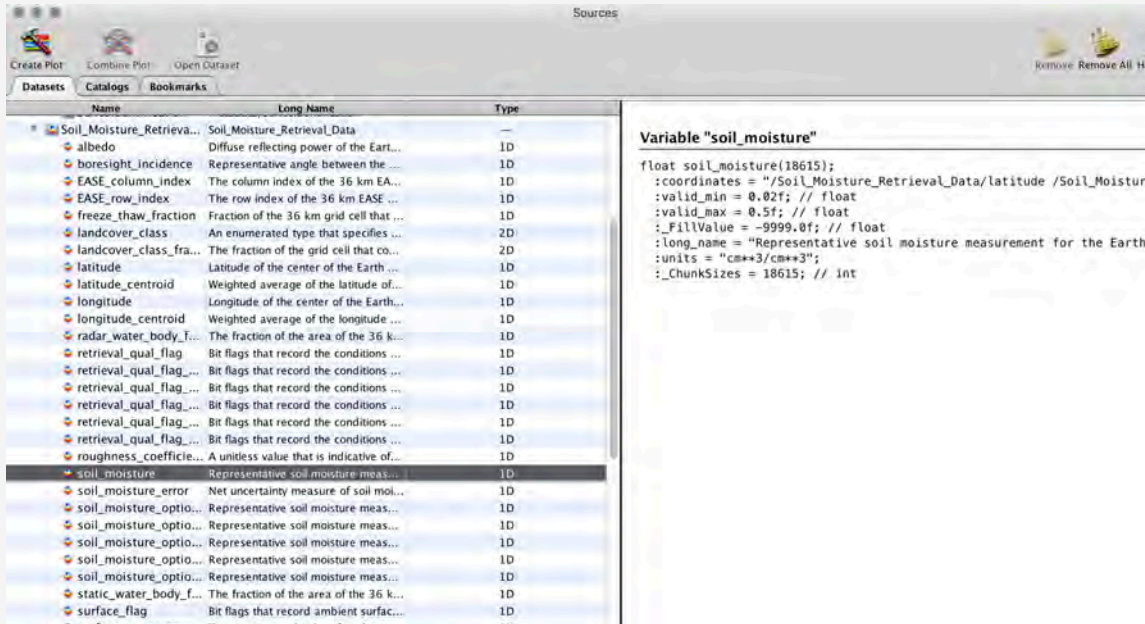
1. Open Panoply
2. Go to File-Open and open your file
3. “SMAP\_L3\_SM\_P\_20150505\_R12170\_002.h5” The left window shows the archive structure, which has two folders: Metadata and Soil Moisture
4. Double click on an archive to see the files within it.





# Opening a SMAP File with Panoply: L3 SM\_P

5. Click on soil moisture to see the characteristics or metadata of the file in the right window.



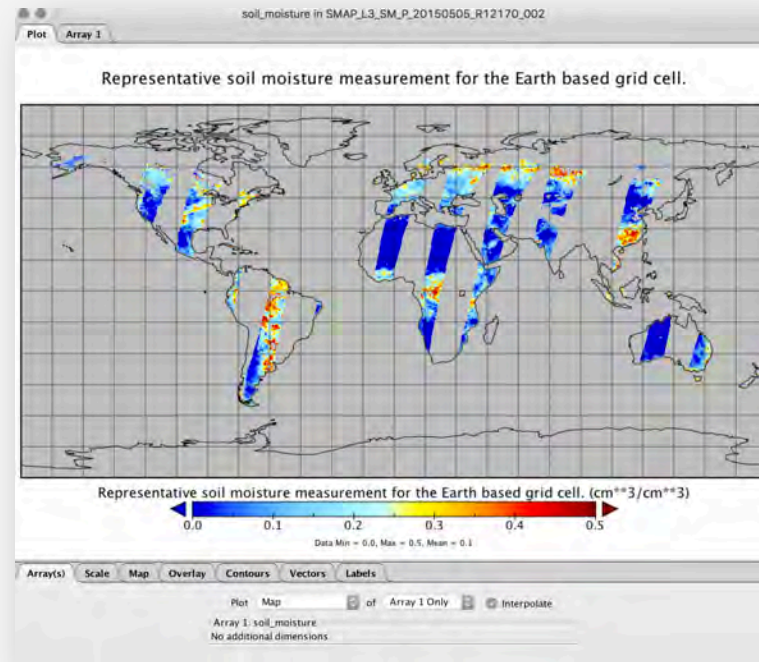
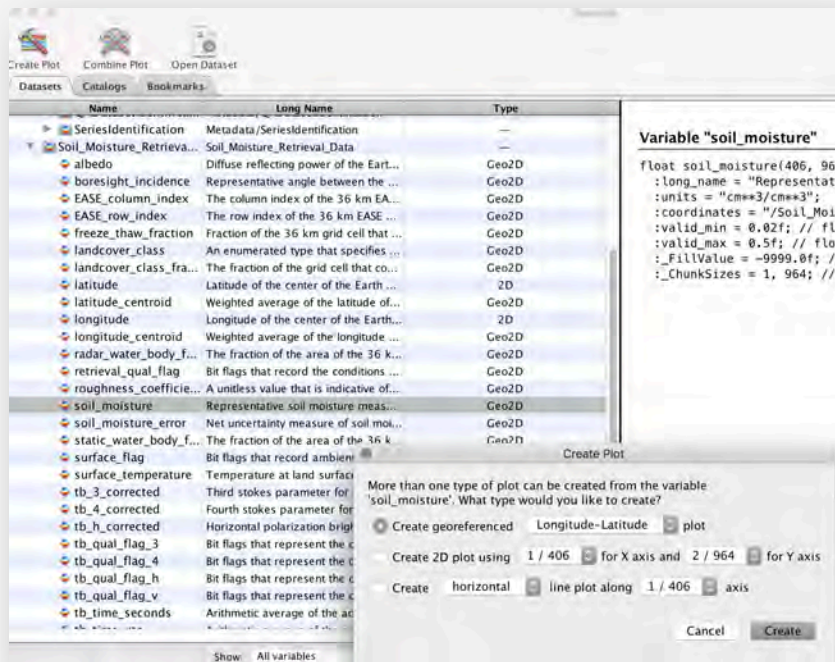
The screenshot shows the Panoply software interface. On the left, a tree view lists various datasets under the 'Soil\_Moisture\_Retrieval...' category. The 'soil\_moisture' dataset is selected and highlighted. On the right, the 'Variable "soil\_moisture"' metadata is displayed, including its data type, coordinates, valid range, fill value, long name, units, and chunk size.

Name	Long Name	Type
Soil_Moisture_Retrieval...	Soil_Moisture_Retrieval_Data	—
albedo	Diffuse reflecting power of the Earth...	1D
boresight_incidence	Representative angle between the ...	1D
EASE_column_index	The column index of the 36 km EA...	1D
EASE_row_index	The row index of the 36 km EASE ...	1D
freeze_thaw_fraction	Fraction of the 36 km grid cell that ...	1D
landcover_class	An enumerated type that specifies ...	2D
landcover_class_fra...	The fraction of the grid cell that co...	2D
latitude	Latitude of the center of the Earth ...	1D
latitude_centroid	Weighted average of the latitude of...	1D
longitude	Longitude of the center of the Earth...	1D
longitude_centroid	Weighted average of the longitude ...	1D
radar_water_body_f...	The fraction of the area of the 36 k...	1D
retrieval_qual_flag	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
retrieval_qual_flag_...	Bit flags that record the conditions ...	1D
roughness_coefficie...	A unitless value that is indicative of...	1D
soil_moisture	Representative soil moisture meas...	1D
soil_moisture_error	Net uncertainty measure of soil moi...	1D
soil_moisture_optio...	Representative soil moisture meas...	1D
soil_moisture_optio...	Representative soil moisture meas...	1D
soil_moisture_optio...	Representative soil moisture meas...	1D
soil_moisture_optio...	Representative soil moisture meas...	1D
soil_moisture_optio...	Representative soil moisture meas...	1D
static_water_body_f...	The fraction of the area of the 36 k...	1D
surface_flag	Bit flags that record ambient surfac...	1D

```
Variable "soil_moisture"
float soil_moisture(18615);
:coordinates = "/Soil_Moisture_Retrieval_Data/latitude /Soil_Moisture_
:valid_min = 0.02f; // float
:valid_max = 0.5f; // float
:_FillValue = -9999.0f; // float
:long_name = "Representative soil moisture measurement for the Earth t
:units = "cm**3/cm**3";
:_ChunkSizes = 18615; // int
```

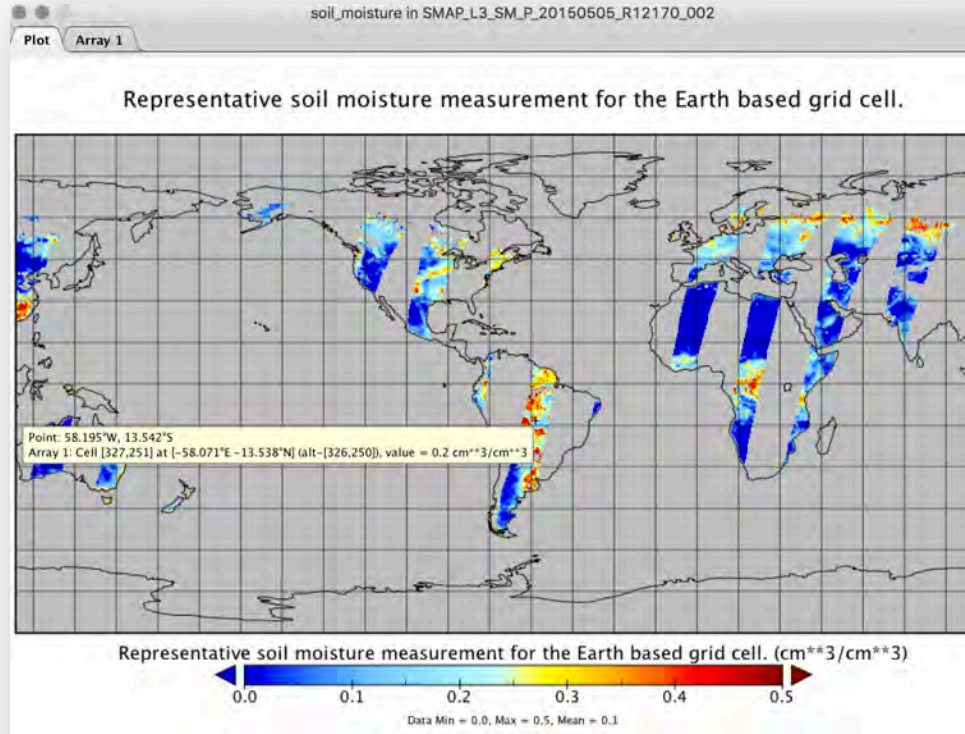
# Opening a SMAP File with Panoply: L3 SM\_P

## 6. Open the file as a map by double clicking on the soil moisture file



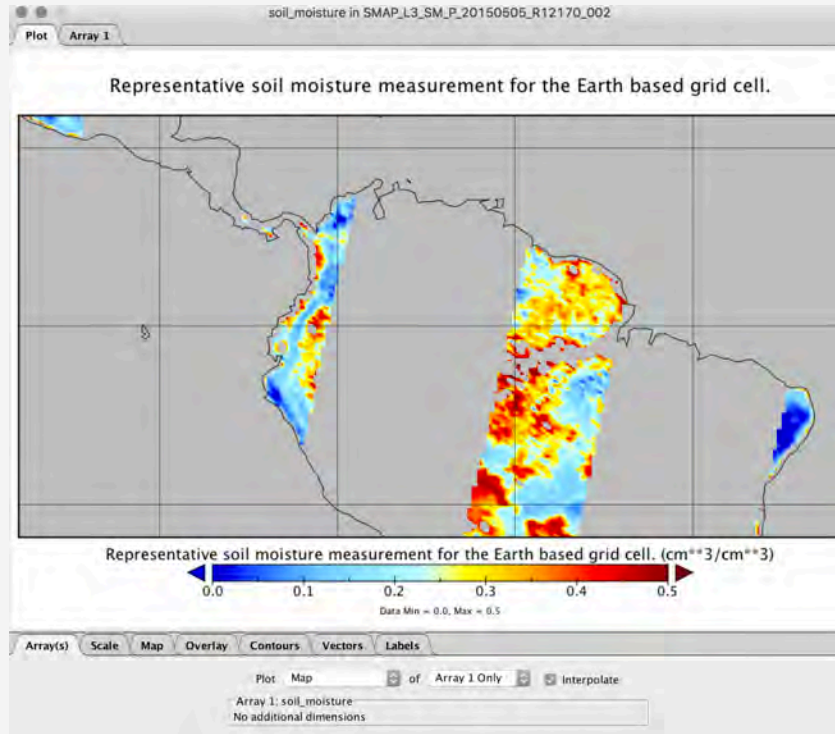
# Displaying the Pixel Value on the Map: L3 SM\_P

7. To see the pixel value place the cursor over the point of interest and click “Alt”



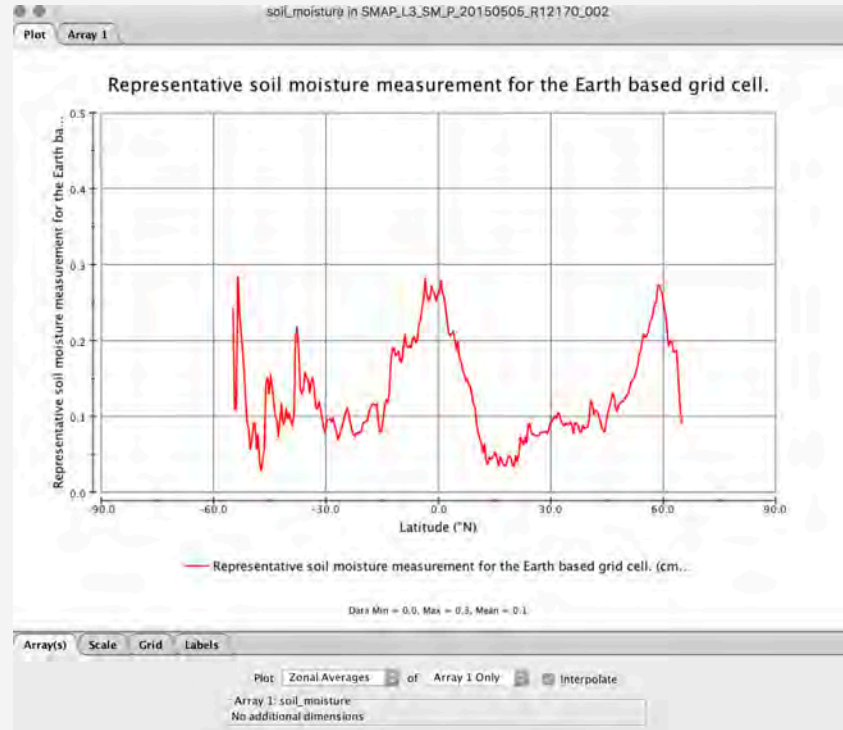
# Zooming into the Image: L3 SM\_P

8. To zoom into an area go to the top menu and select “Plot-Zoom In”



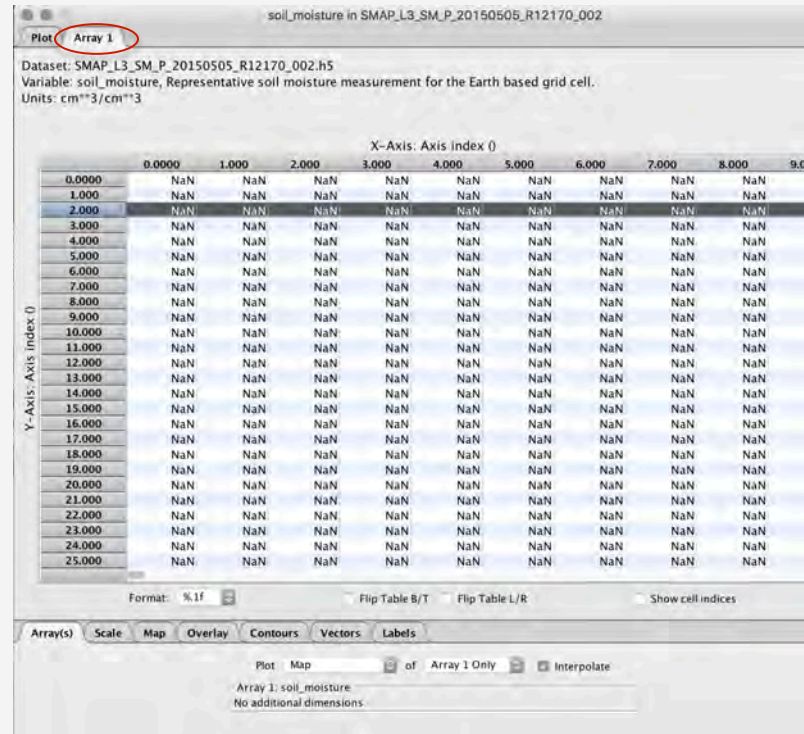
# Plotting the Data: L3 SM\_P

9. In the lower window select “Array-Plot” to create a plot of soil moisture as a function of latitude



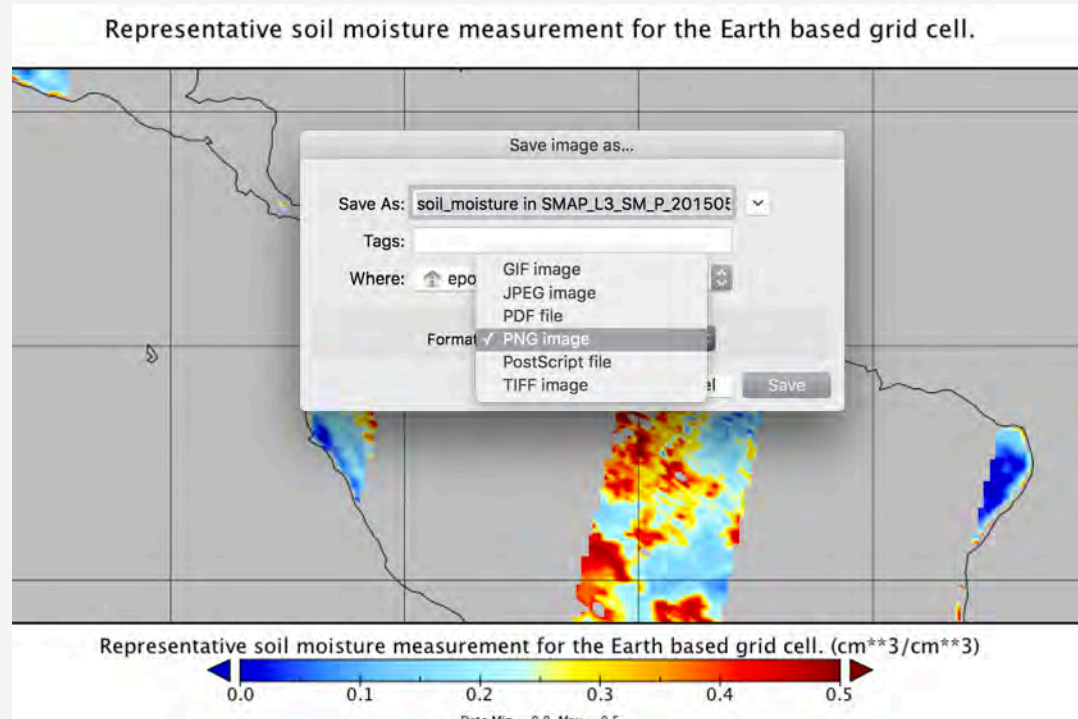
# The File Values: L3 SM\_P

10. Click on the tab option on the top that says “Array” in order to see the values in the file



# Saving a File: L3 SM\_P

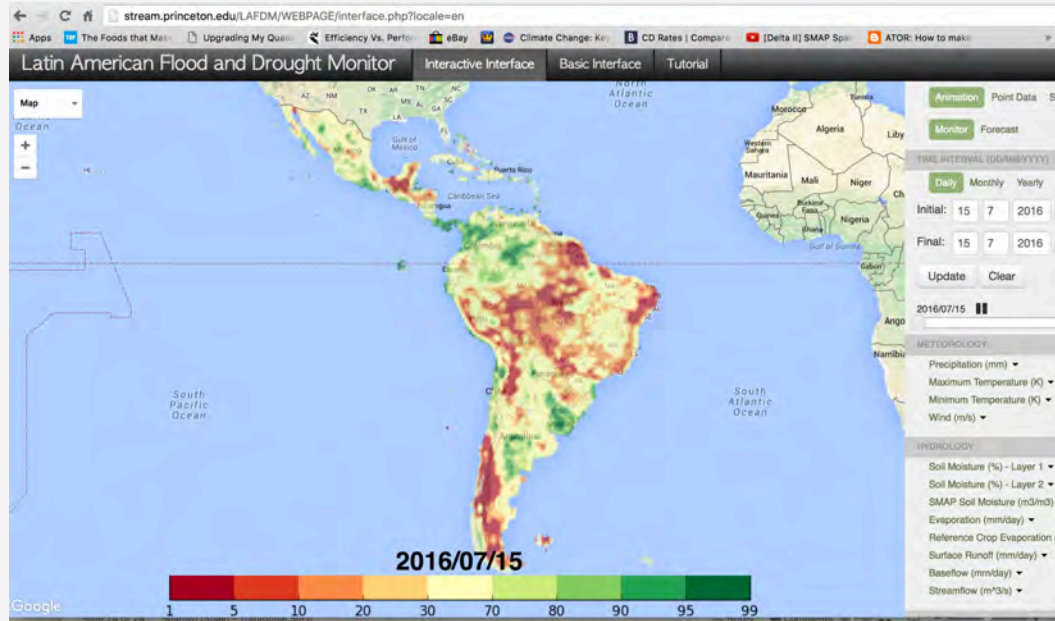
11. To save a file in a different format (e.g. Png, tiff, pdf) select "File-Save Image As" from the main menu



# Extracting SMAP Soil Moisture

12. The most direct way to extract SMAP soil moisture values is using the "Latin American Flood and Drought Monitor" tool from Princeton University:

<http://stream.princeton.edu/LAFDM/WEBPAGE/interface.php?locale=en>





# Extracting SMAP Soil Moisture Values

13. To extract soil moisture values from SMAP:

-in the upper right window select “Point Data”.

-in the next section under “Time Interval” specify the period of interest that you would like soil moisture. Note that SMAP soil moisture data is available as of mid-April 2015.

-in the next section select “SMAP soil moisture” and click on the map over your point of interest or manually specify your lat/lon using the “Manual Entry” option.

-in the last part under “Create Corresponding Data File” select “yes”

-Click on “Download Data” at the very bottom

The screenshot displays the SMAP data extraction interface. At the top, there are three tabs: 'Animation', 'Point Data' (highlighted with a red circle), and 'Spatial Data'. Below the tabs is a 'TIME INTERVAL (DD/MM/YYYY)' section with 'Daily', 'Monthly', and 'Yearly' options. The 'Initial' date is set to 22/6/2016 and the 'Final' date is 22/7/2016. There are 'Update' and 'Clear' buttons. The 'POINT DATA SELECTION' section has 'Map Click' and 'Manual Entry' options. The 'Manual Entry' section shows Latitude: -17.309 and Longitude: -52.910. A list of data types is shown with radio buttons: Indices, Water Balance, Surface Fluxes, Streamflow, Soil Moisture (Layer 1), Soil Moisture (Layer 2), SMAP Soil Moisture (highlighted with a red circle), Reference Crop Evaporation, Vegetation, and Meteorology. Below this is the 'Create Corresponding Data File?' section with 'Yes' (highlighted with a red circle) and 'No' options. At the bottom, there is a 'Download Data' button (highlighted with a red circle) and a note: 'Only the last 1000 timesteps from the selected final date will be displayed'.

# Extracting SMAP Soil Moisture Values

14. The data are downloaded directly to your computer as a text file

```
year,month,day,SMAP Soil Moisture - 1 day composite (m3/m3)
2016,6,22,-999.000
2016,6,23,0.110
2016,6,24,-999.000
2016,6,25,-999.000
2016,6,26,0.119
2016,6,27,-999.000
2016,6,28,-999.000
2016,6,29,0.123
2016,6,30,-999.000
2016,7,1,0.112
2016,7,2,-999.000
2016,7,3,-999.000
2016,7,4,0.120
2016,7,5,-999.000
2016,7,6,-999.000
2016,7,7,0.097
2016,7,8,-999.000
2016,7,9,0.112
2016,7,10,-999.000
2016,7,11,-999.000
2016,7,12,0.111
2016,7,13,-999.000
2016,7,14,-999.000
2016,7,15,-999.000
2016,7,16,-999.000
2016,7,17,-999.000
2016,7,18,-999.000
```

## Exercise

15. From the same page download SMAP soil moisture data as well as vegetation and/or meteorological data for the same point. Plot them and explore correlations.