

ARSET

Applied Remote Sensing Training

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

 @NASAARSET

Applications of Remote Sensing to Soil Moisture and Evapotranspiration

Speakers:

Erika Podest

Amita Mehta

Guest Speaker:

Christopher Hain, NOAA, chris.hain@noaa.gov

Homework and Certificate

- **Homework**

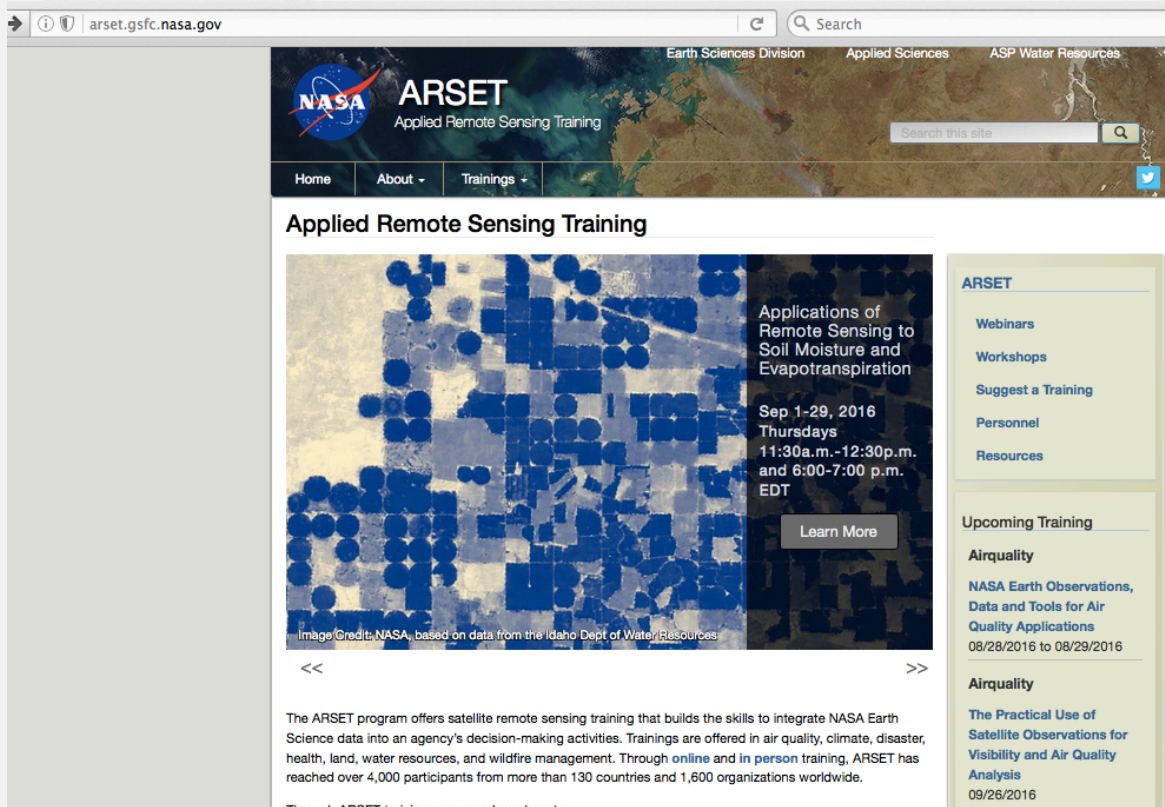
- Answers to homework questions via Google form
- will be Available at <http://arset.gsfc.nasa.gov/water/webinars/apps-et-smap>

- **Certificate of Completion**

- Attend all 5 webinar sessions
- Complete both homework assignments
- Certificates will be emailed approx. 2 months after the course finishes by Marines Martins (marines.martins@ssaihq.com)

Course Material

<http://arset.gsfc.nasa.gov/water/webinars/apps-et-smap>



The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo and the text 'ARSET Applied Remote Sensing Training'. Navigation links for 'Home', 'About', and 'Trainings' are visible. The main content area features a large image of a satellite map with blue circular markers, titled 'Applications of Remote Sensing to Soil Moisture and Evapotranspiration'. The text next to the image states: 'Sep 1-29, 2016 Thursdays 11:30a.m.-12:30p.m. and 6:00-7:00 p.m. EDT'. A 'Learn More' button is present. Below the image, a paragraph describes the ARSET program: 'The ARSET program offers satellite remote sensing training that builds the skills to integrate NASA Earth Science data into an agency's decision-making activities. Trainings are offered in air quality, climate, disaster, health, land, water resources, and wildfire management. Through online and in person training, ARSET has reached over 4,000 participants from more than 130 countries and 1,600 organizations worldwide.' A sidebar on the right lists various resources and upcoming training, including 'Airquality' and 'The Practical Use of Satellite Observations for Visibility and Air Quality Analysis'.

Course Agenda:

[Agenda.pdf](#)

Session One: Introduction to Soil Moisture, Evapotranspiration, and an Overview of the Soil Moisture Active Passive (SMAP) Satellite Mission

September 1, 2016

Session Two: Applications of SMAP Data

September 8, 2016

Session Three: Accessing SMAP Data

September 15, 2016

Session Four: Landsat-based Evapotranspiration Estimates (METRIC) and Google Earth Engine Evapotranspiration Flux (EEFlux) Portal

September 22, 2016

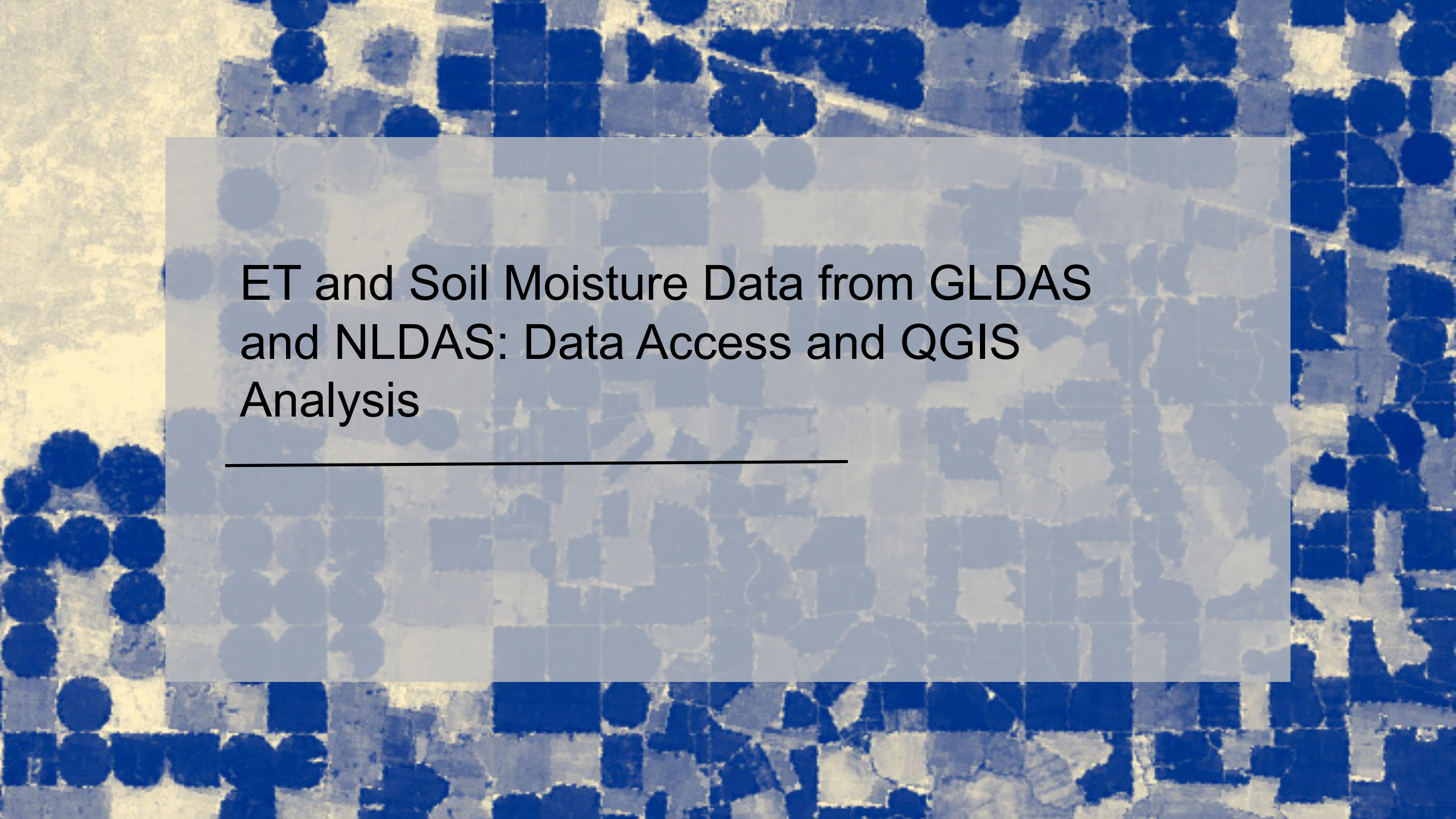
Session Five: MODIS-based Evapotranspiration (ALEXI) and Soil Moisture and Evapotranspiration data from GLDAS/NLDAS

September 29, 2016

Application Area: [Water](#)

Agenda: Week 5

- ALEXI ET and Applications
- ET and Soil Moisture Data from Global and North American Land Data Assimilation Systems (GLDAS and NLDAS): Data Access and QGIS Analysis

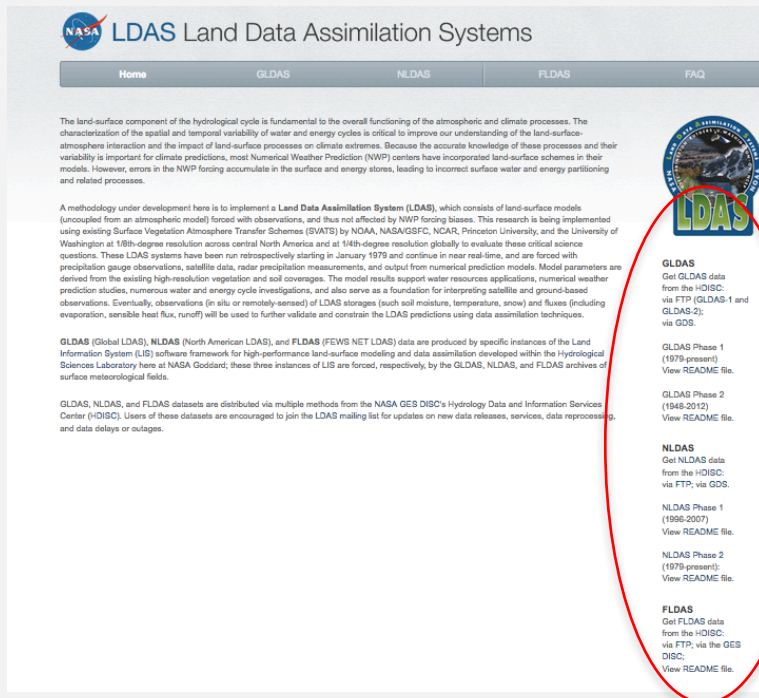


ET and Soil Moisture Data from GLDAS
and NLDAS: Data Access and QGIS
Analysis

ET and Soil Moisture from Land Surface Models

Land Data Assimilation System (LDAS): <http://ldas.gsfc.nasa.gov>

- Integrate satellite and ground observations within sophisticated numerical models with water and energy balance



GLDAS

Get **GLDAS** data from the **HDISC**:
via **FTP (GLDAS-1 and GLDAS-2)**;
via **GDS**.

GLDAS Phase 1
(1979-present)
View **README** file.

GLDAS Phase 2
(1948-2012)
View **README** file.

NLDAS

Get **NLDAS** data from the **HDISC**:
via **FTP**; via **GDS**.

NLDAS Phase 1
(1996-2007)
View **README** file.

NLDAS Phase 2
(1979-present):
View **README** file.

FLDAS

Get **FLDAS** data from the **HDISC**:
via **FTP**; via the **GES DISC**;
View **README** file.

North American Land Data Assimilation System-2 (NLDAS-2)

<http://ldas.gsfc.nasa.gov/nldas>

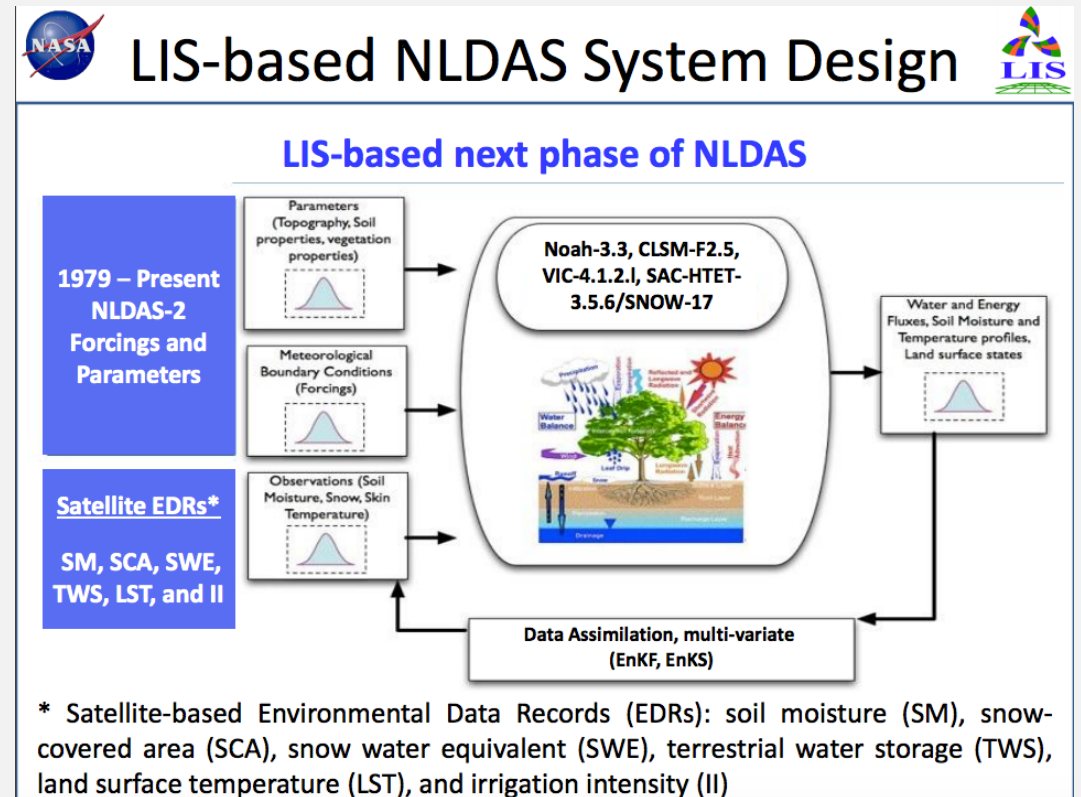
Four Land Surface Model Versions: NLDAS-2 Mosaic, Noah, SAC, and VIC

Inputs:

- Precipitation: NOAA-CPC rain gauges
- Meteorological: North American Regional Reanalysis (NARR)
- Surface Shortwave Radiation Data: NARR with GOES satellite bias-correction

Integrated Outputs Include:

- **Soil Moisture**
- **Evapotranspiration**
- Surface/Sub-Surface Runoff
- Snow Water Equivalent



Courtesy of David Mocko, NASA GSFC

<http://ldas.gsfc.nasa.gov/nldas/presentations/NLDAS-LIS-status-future> 2015-03-11.pdf

Global Land Data Assimilation System (GLDAS)

<http://ldas.gsfc.nasa.gov/gldas/>

Four Land Surface Model Versions: Noah, CLM2, Mosaic, and VIC

Inputs:

- Rainfall: TRMM and Multi-Satellite Based Data
- Meteorological Data: Global reanalysis and observations-based data from Princeton
- Vegetation Mask, Land/Water Mask, Leaf Area Index: MODIS (GLDAS-2)
- Clouds and Snow (for surface radiation); NOAA and DMSP satellites

Integrated Output Include

- **Soil Moisture**
- **Evapotranspiration**
- Surface/Sub-Surface Runoff
- Snow Water Equivalent

Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, 2004. The Global Land Data Assimilation System. *Bulletin of the American Meteorological Society*, 85(3):381–394.

LDAS Soil Moisture and ET Data Access

Model	Spatial/Temporal Resolutions	Data Source
GLDAS (NOAH)	<ul style="list-style-type: none"> • 1/4th – 1 degree (global) • 3 hour, monthly • 1948 – 2010 	<p>Giovanni: http://giovanni.gsfc.nasa.gov/giovanni</p> <p>Mirador: http://mirador.gsfc.nasa.gov/</p>
NOAH (v 2.1)	<ul style="list-style-type: none"> • 2000 – present 	
VIC	<ul style="list-style-type: none"> • 1979 – present 	
NLDAS (NOAH, VIC)	<ul style="list-style-type: none"> • 1/8th – 1 degree (global) • 1 hour, monthly • 1979 - present 	

Original data files are in GRIB format

Soil Moisture and Evapotranspiration Data Access

- Demonstration
- Examples: Access and Download:
 - 1) GLDAS VIC data using Mirador
 - 2) NLDAS VIC data using Giovanni and import into QGIS

Search, Select, and Download Data from Mirador

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

The screenshot shows the Mirador web interface with several key components highlighted by callout boxes:

- Search data by Keyword:** A callout box pointing to the 'Keyword' input field containing 'GLDAS'.
- Temporal Selection:** A callout box pointing to the 'Time Span' input fields, which are set to '2016-07-01' and '2016-07-31'.
- Spatial selection by latitude-longitude:** A callout box pointing to the 'Location' input field containing the coordinates '(-28.65,-62.57),(3.12,-33.74)' and the 'Update Map' button.
- Spatial Selection from Map:** A callout box pointing to a black rectangular selection box on a world map over South America, with a red arrow indicating the selection.

Other visible interface elements include tabs for 'Keyword', 'Projects', and 'Science Areas'; a 'Search GES-DISC' button; a 'Search' button; a 'Map' dropdown menu; a 'Map' button; a 'Google' logo; 'Map data ©2016 Terms of Use Report a map error' text; and an 'Advanced Search' dropdown menu.

Search, Select, and Download Data from Mirador

GLDAS Noah Land Surface Model L4 monthly 0.25 x 0.25 degree V2.0 (GLDAS_NOAH025_M) ⚙️

[View Files](#) | [Info](#) | [Data Calendar](#)

Approx. 2 files found (Avg Size: 19.38 MB)

Parameters: SURFACE PRESSURE, HEAT FLUX, LONGWAVE RADIATION, SHORTWAVE RADIATION, SURFACE TEMPERATURE, EVAPOTRANSPIRATION, RUNOFF...

Spatial Resolution: 0.25 degree x 0.25 degree

Temporal Resolution: 1 month

GLDAS VIC Land Surface Model L4 3 Hourly 1.0 x 1.0 degree V001 (GLDAS_VIC10_3H) ⚙️

[View Files](#) | [Info](#) | [Data Calendar](#)

Approx. 248 files found (Avg Size: 0.56 MB)

Parameters: EVAPOTRANSPIRATION, HUMIDITY, SURFACE WINDS, SNOW WATER EQUIVALENT, RUNOFF, SOIL MOISTURE/WATER CONTENT, SNOW...

Spatial Resolution: 1 degree x 1 degree

Temporal Resolution: 3 hours

GLDAS VIC Land Surface Model L4 Monthly 1.0 x 1.0 degree V001 (GLDAS_VIC10_M) ⚙️

[View Files](#) | [Info](#) | [Data Calendar](#)

Approx. 2 files found (Avg Size: 0.51 MB)

Parameters: EVAPOTRANSPIRATION, HUMIDITY, SURFACE WINDS, SNOW WATER EQUIVALENT, RUNOFF, SOIL MOISTURE/WATER CONTENT, RAIN...

Spatial Resolution: 1 degree x 1 degree

Temporal Resolution: 1 month

Choose

Search, Select, and Download Data from Mirador

Results 1 - 1 for GLDAS (1 second)

GLDAS VIC Land Surface Model L4 Monthly 1.0 x 1.0 degree V001 [Info](#)

The following services are available for the data set(s). Whenever you add files to the shopping cart, you will be presented with options for selecting any of these services if they are cart-enabled.

[Subset Spatially and/or by Parameter](#) [Convert to NetCDF](#)

<input checked="" type="checkbox"/> Select All in Page <input type="checkbox"/> File Names/Descriptive File Names	Start Time
<input checked="" type="checkbox"/> GLDAS VIC10 M.A201607.001.grb (0.55 MB) One Click Download: NetCDF	2016-07-01 00:00:00 Metadata

[Add Selected Files To Cart](#) [Add All Files in All Pages To Cart](#)

NASA Search Results
Page: 1

Click on the file name to download
Or select and 'Add to Cart' for
multiple file download

Save Data in NetCDF Format

Search, Select, and Download Data from Mirador

Keyword Projects Science Areas

Service Selection

Total Number of Files being added to the Cart is 15

Cancel

Continue to Cart

Instructions for Service Selection

- Data set files added to the cart have their corresponding services, and only one service can be selected per data set.
- To enable a service, select the radio button for any of the available services.
- Selecting a service that has subsetting will take you to a Service Options page and then back to this page.
- To change options for a service you have already selected, click on the "Edit" button.
- After choosing your services, click "Continue to Cart" to proceed, or click "Cancel" to return to your search results.

Data Set(s) Being Added to Shopping Cart

GLDAS VIC Land Surface Model L4 Monthly 1.0 x 1.0 degree V001 (GLDAS_VIC10_M.001)

Select Service Option: None Convert to NetCDF Subset Spatially and/or by Parameter...

Spatial Subsetting has been pre-selected because you chose the bounding box: (-28.65,-62.57),(3.12,-33.74)

Search, Select, and Download Data from Mirador

[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:

1. Save the list of URLs in one of the above links to your local workstation as myfile.dat
2. [Create a ~/.netrc file pointing to urs.earthdata.nasa.gov and an empty ~/.urs_cookies file](#)
3. On your command line, using wget 1.14 (or higher):

```
wget --content-disposition --load-cookies ~/.urs_cookies --save-cookies ~/.urs_cookies --auth-no-challenge=on --keep-session-cookies -i myfile.dat
```

a UNIX curl example:

1. Save the list of URLs in one of the above links to your local workstation as myfile.dat
2. re-arrange the urls and provide output filenames as described in the curl config file format described below:

```
url = http://host.example.gov/dir/filename.hdf
output = filename.hdf
url = http://host.example.gov/dir/filename2.hdf
output = filename2.hdf
...
```
3. [Create a ~/.netrc file pointing to urs.earthdata.nasa.gov and an empty ~/.urs_cookies file](#)
4. On your command line:

```
curl -b ~/.urs_cookies -c ~/.urs_cookies -K ./myfile.dat
```

Note about pre-authentication downloads
Users who already tried to use wget to download data before authorizing NASA GESDISC Data Access will need to re-create their .urs_cookies file.

[More Options...](#)

Download file(s) using
wget or curl

Search, Select, and Download Data from Giovanni

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

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

- Analysis/Plot Options:** A box pointing to the 'Select Plot' section, which includes options for 'Maps: Time Averaged Map', 'Comparisons', 'Time Series', 'Vertical', and 'Miscellaneous'.
- Temporal & Spatial Search:** A box pointing to the 'Select Date Range (UTC)' and 'Select Region (Bounding Box or Shapefile)' sections. The date range is set to '00 : 00' to '23 : 59' and the region is '-180, -90, 180, 90'.
- Search data by Keyword:** A box pointing to the 'Select Variables' section, which includes a search bar and a 'Search' button. The text 'Number of matching Variables: 0 of 1404 Total Variable(s) included in Plot: 0' is visible.
- Plot Data:** A box pointing to the 'Plot Data' button at the bottom right of the interface.

Search, Select, and Download Data from Giovanni

Select Plot

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

Select Date Range (UTC)

YYYY-MM HH:mm

2016 -07 -01 00 : 00 to 2016 -07 -31 23 : 59

Select Region (Bounding Box or Shapefile)

Format: West, South, East, North

-125, 25, -67, 53

Show Map Show Shapes

Valid Range: 1979-01-02 to 2016-08-31

Number of matching Variables: 33 of 1315 Total Variable(s) included in Plot: 2

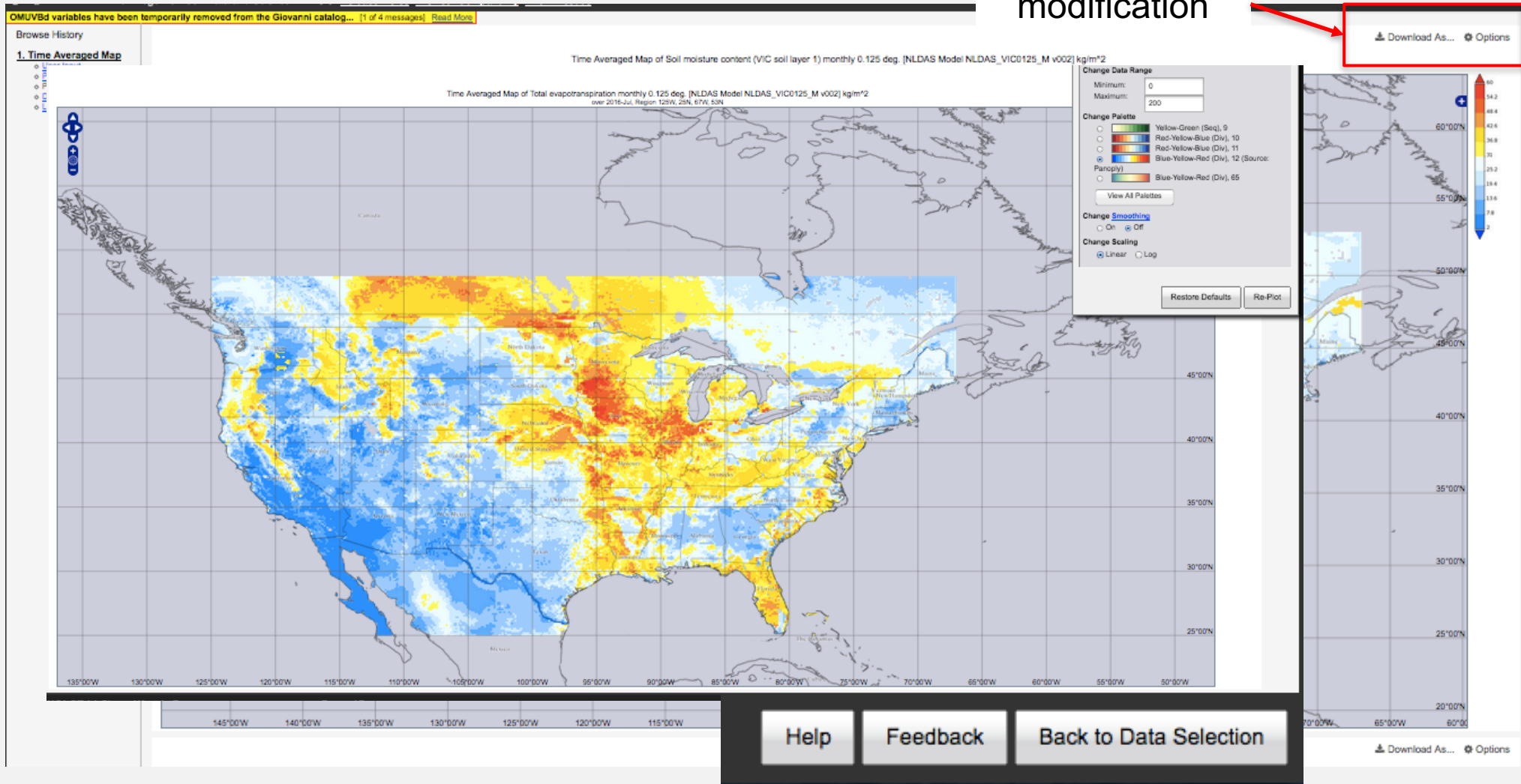
Keyword: NLDAS VIC Search Clear

Variable	Source	Temp.Res.	Spat.Res.	Begin Date	End Date	Units
<input type="checkbox"/> Latent heat flux (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Canopy water evaporation (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Ground heat flux (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Moisture availability (total column) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	%
<input type="checkbox"/> Rainfall (unfrozen precipitation) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input checked="" type="checkbox"/> Root zone soil moisture content (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Sensible heat flux (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Snowfall (frozen precipitation) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Snow water-equivalent (accumulated) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Sublimation (evaporation from snow) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Subsurface runoff (baseflow) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Surface radiative temperature (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	K
<input type="checkbox"/> Surface runoff (non-infiltrating) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Temperature (average surface skin) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	K
<input checked="" type="checkbox"/> Total evapotranspiration (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Transpiration (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	W/m^2
<input type="checkbox"/> Latent heat flux (NLDAS_VIC0125_H.v002)	NLDAS Model	Hourly	0.125 °	1979-01-02	2016-09-17	W/m^2
<input checked="" type="checkbox"/> Soil moisture content (VIC soil layer 1) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2
<input type="checkbox"/> Soil moisture content (VIC soil layer 2) (NLDAS_VIC0125_M.v002)	NLDAS Model	Monthly	0.125 °	1979-01-02	2016-08-31	kg/m^2

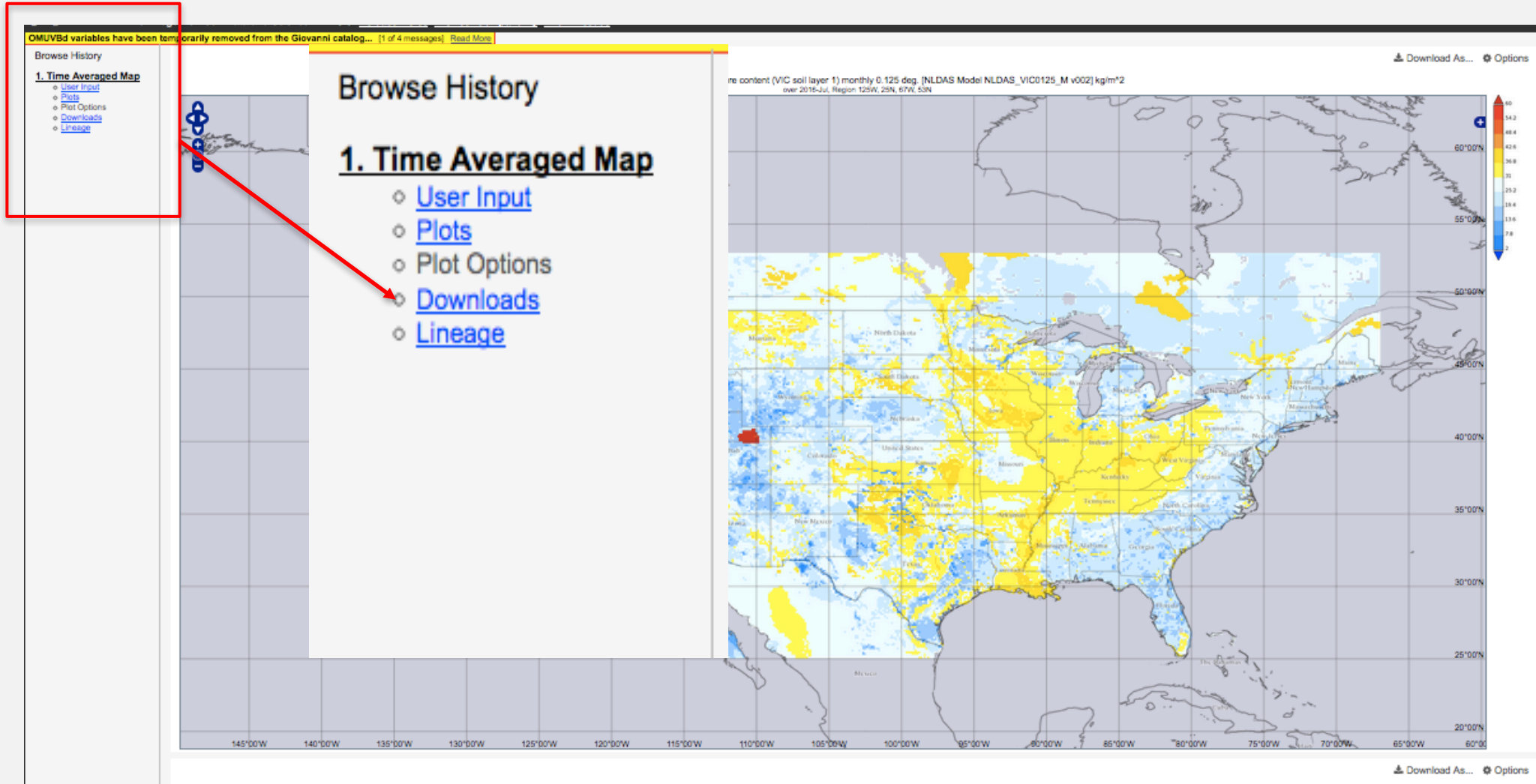
Select Soil Moisture and ET for July 2016

Plot Data in Giovanni

Plot
modification



Plot Data in Giovanni



Download Data Using Giovanni

Browse History

1. Time Averaged Map

- [User Input](#)
- [Plots](#)
- [Plot Options](#)
- **[Downloads](#)**
- [Lineage](#)

Click on file links to download. Files contain data portrayed in the plot images.

NetCDF:

[g4.timeAvgMap.NLDAS VIC0125 M 002 soilmlyr1.20160701-20160731.125W 25N 67W 53N.nc](#)

[g4.timeAvgMap.NLDAS VIC0125 M 002 evpsfc.20160701-20160731.125W 25N 67W 53N.nc](#)

PNG:

[g4.timeAvgMap.NLDAS VIC0125 M 002 soilmlyr1.20160701-20160731.125W 25N 67W 53N.png](#)

[g4.timeAvgMap.NLDAS VIC0125 M 002 evpsfc.20160701-20160731.125W 25N 67W 53N.png](#)

GEOTIFF:

[g4.timeAvgMap.NLDAS VIC0125 M 002 soilmlyr1.20160701-20160731.125W 25N 67W 53N.geotif](#)

[g4.timeAvgMap.NLDAS VIC0125 M 002 evpsfc.20160701-20160731.125W 25N 67W 53N.geotif](#)

KMZ:

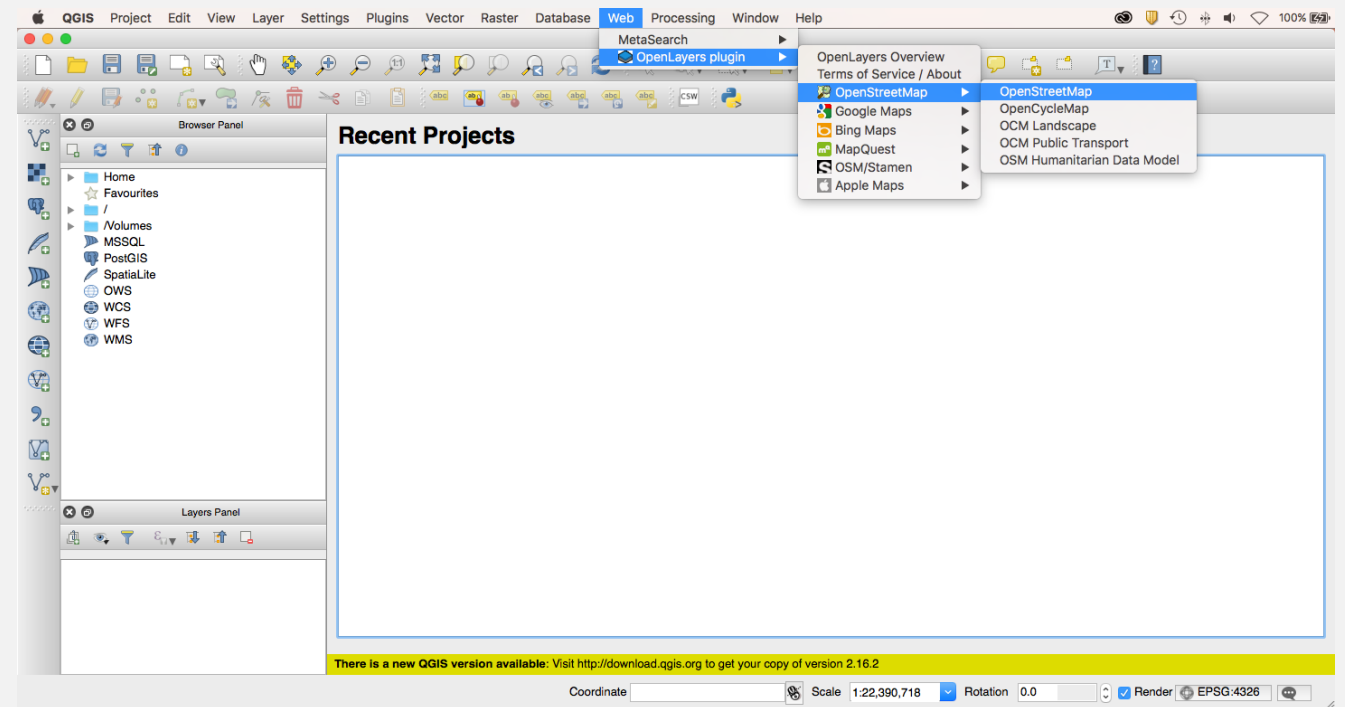
[g4.timeAvgMap.NLDAS VIC0125 M 002 soilmlyr1.20160701-20160731.125W 25N 67W 53N.kmz](#)

[g4.timeAvgMap.NLDAS VIC0125 M 002 evpsfc.20160701-20160731.125W 25N 67W 53N.kmz](#)

NetCDF, Geotiff, kmz, and png files

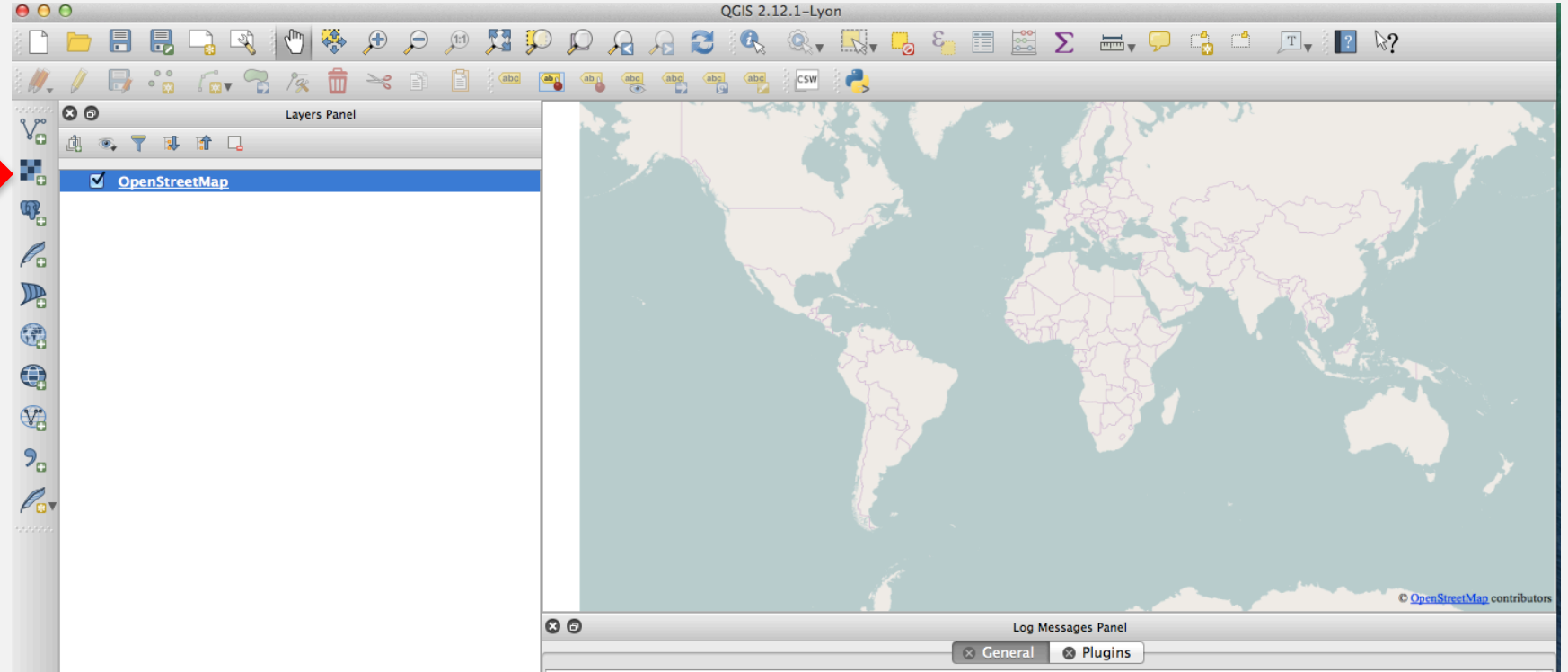
Import NLDAS ET and Soil Moisture NetCDF Files in QGIS

- Install QGIS on your computer:
 - http://bit.ly/ARSET_QGIS_Download_and_Install
- Open QGIS and OpenStreetMap
 - From top bar click on 'Web'
 - Select 'OpenLayers Plugin'
 - Select a background map (our exercise uses 'OpenStreetMap')



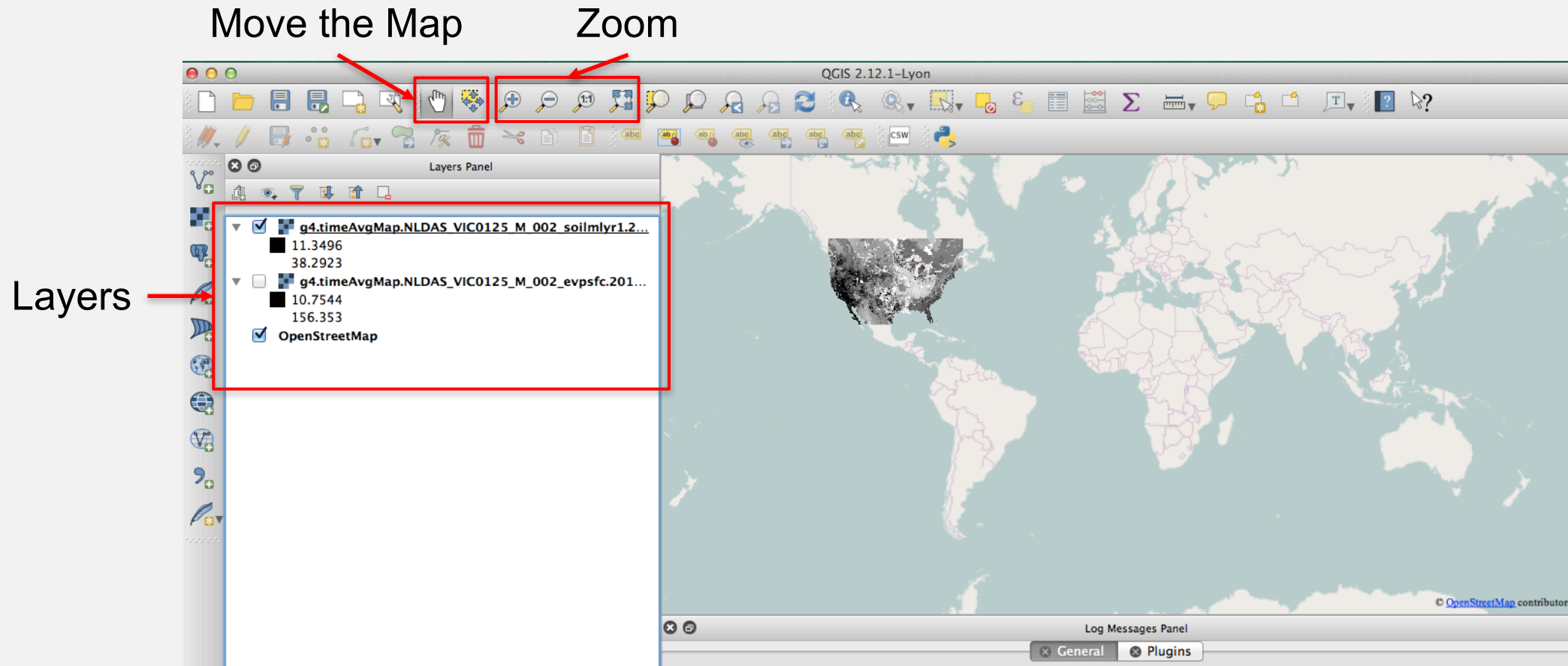
Import NLDAS ET and Soil Moisture NetCDF Files in QGIS

- Select 'Add Raster'
- Load the NLDAS ET and soil moisture NetCDF data files one by one



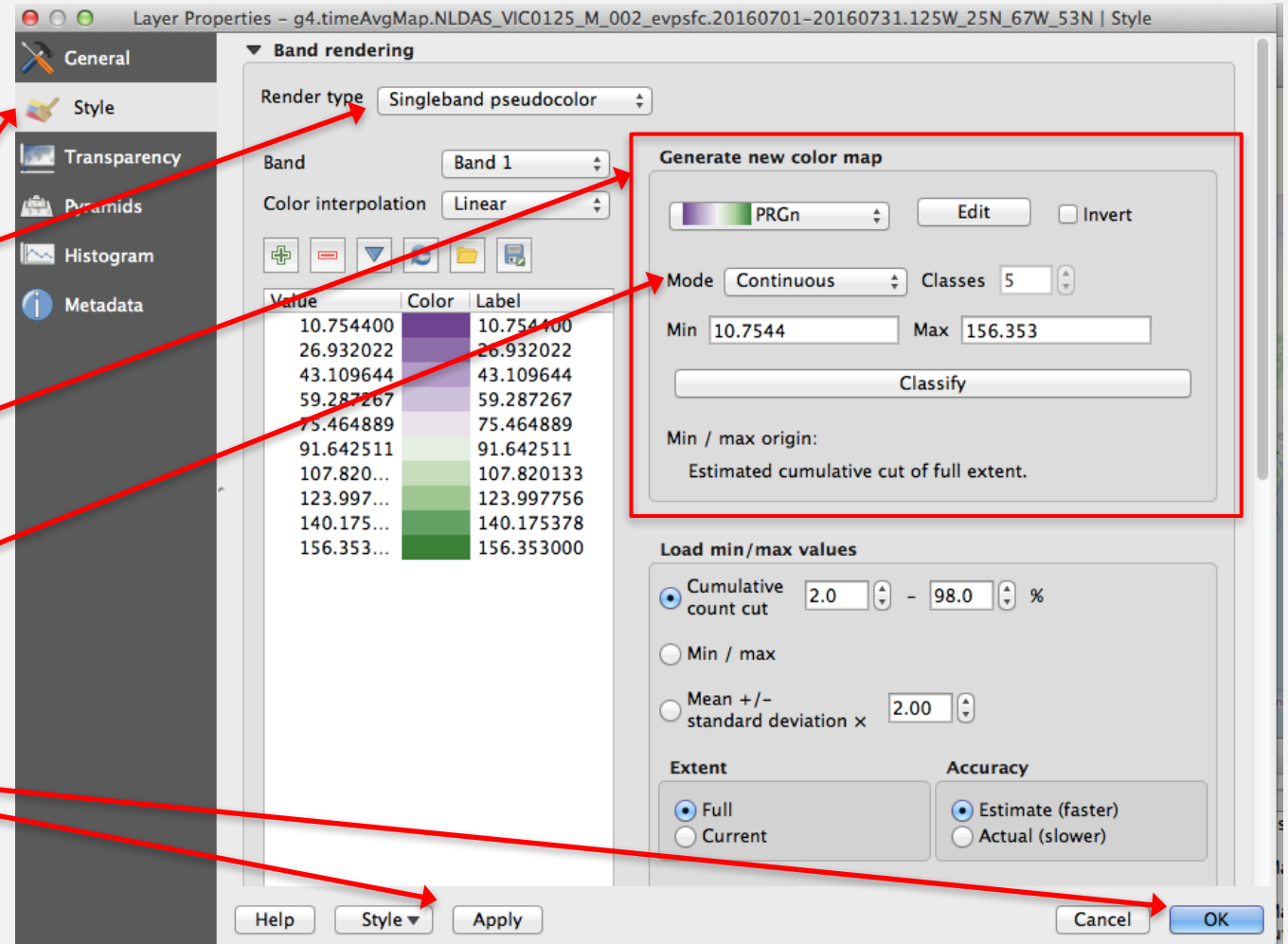
Import NLDAS ET and Soil Moisture NetCDF Files in QGIS

- You will get a black & white image of the data













Change Data Layer Properties

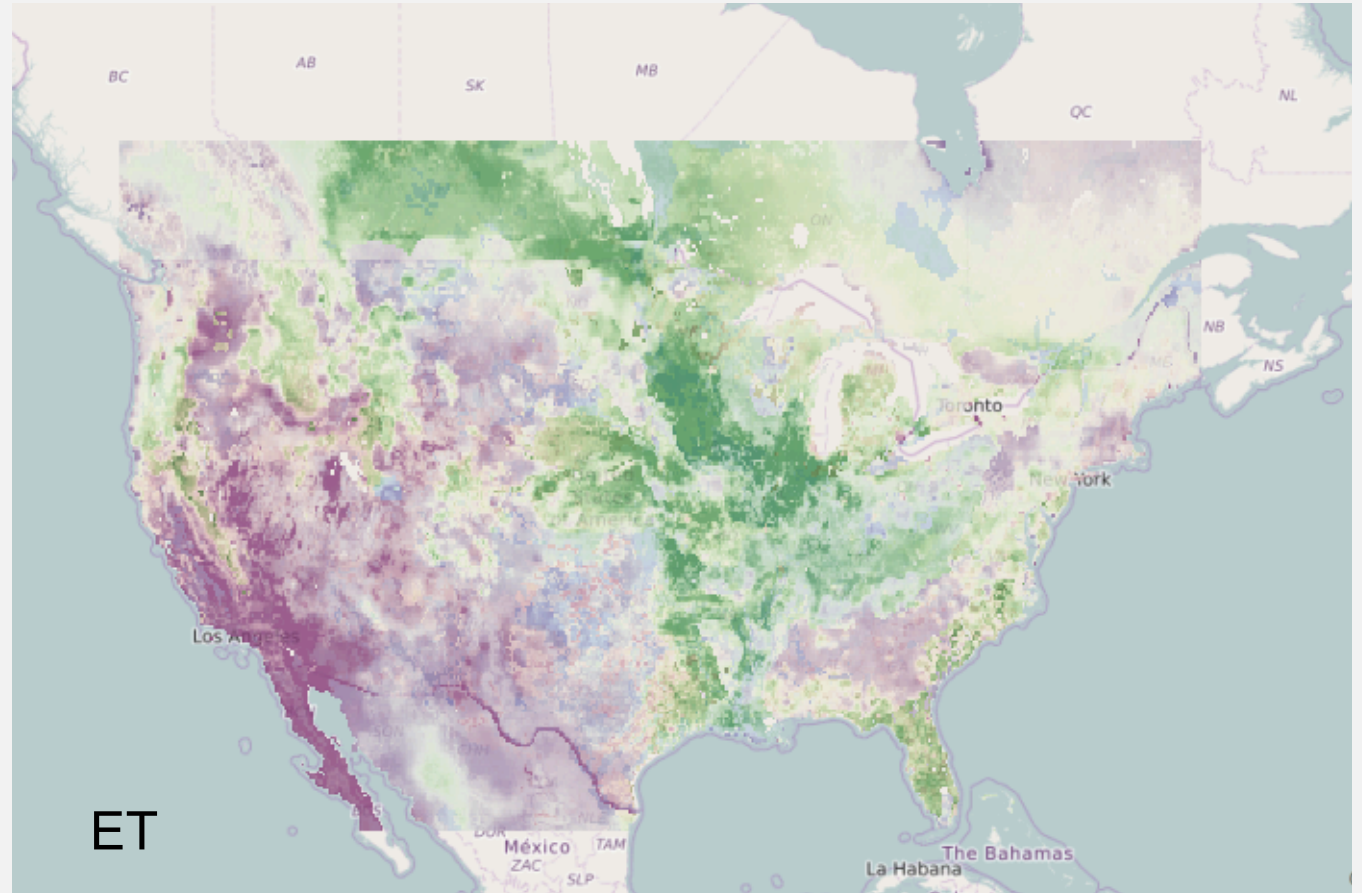
- Click on 'layer' on the top bar and select 'properties' to edit the map visualization & analysis
- Select 'Style' in 'Render Type' and select 'Singleband pseudocolor'
- Choose color table from 'Generate new color map'
- Choose 'mode' as continuous or 'Equal Interval'
- Click on 'Apply' and 'OK'



Change Data Layer Properties

Value	Color	Label
10.754400		10.754400
26.932022		26.932022
43.109644		43.109644
59.287267		59.287267
75.464889		75.464889
91.642511		91.642511
107.820...		107.820133
123.997...		123.997756
140.175...		140.175378
156.353...		156.353000

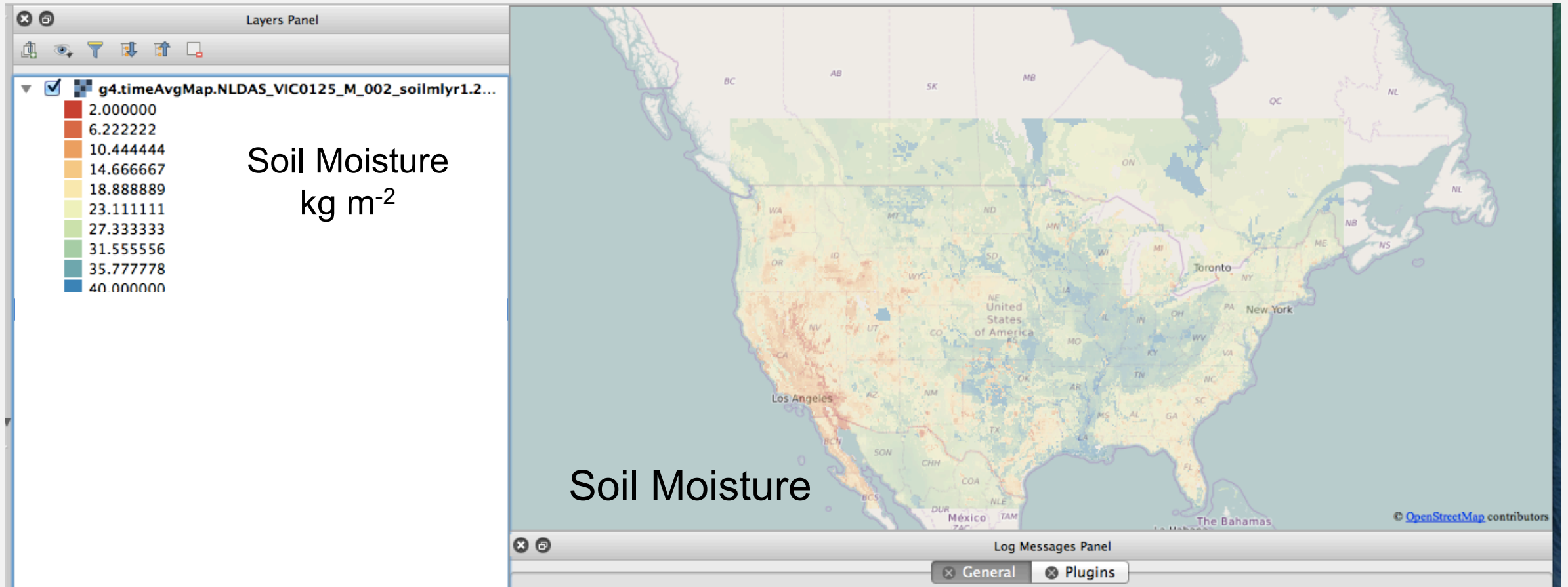
ET
kg m⁻²



- From 'Layer' in the top bar, select 'properties'
- From the left side menu, select 'Transparency'
- Choose the appropriate % value to see the OpenStreetMap under the ET layer

ET and Soil Moisture Layers

- Repeat for the 'Layer,' 'Properties' steps for the soil moisture layer



Course Summary

This course provided information about:

- NASA's Soil Moisture Active Passive (SMAP) mission, soil moisture data from SPAM and its applications in the fields of agriculture, flood and drought monitoring, weather and climate forecasting, and human health
- SMAP data access from NASA's National Snow & Ice Data Center (NSIDC): <http://nsidc.org>
- Evapotranspiration estimates based on Landsat (METRIC) and its access from EEFLUX: <http://eeflux-level1.appspot.com>
- Evapotranspiration estimates from MODIS/GOES (ALEXI) and its access from NOAA: <http://www.ospo.noaa.gov/Products/land/getd>
- Evapotranspiration estimates based on Land Data Assimilation Models and its access from:
 - Mirador: <http://mirador.gsfc.nasa.gov>
 - Giovanni: <http://giovanni.gsfc.nasa.gov/giovanni>

Thank You

Sign up to receive updates on future ARSET trainings:
<http://lists.nasa.gov/mailman/listinfo/arset>