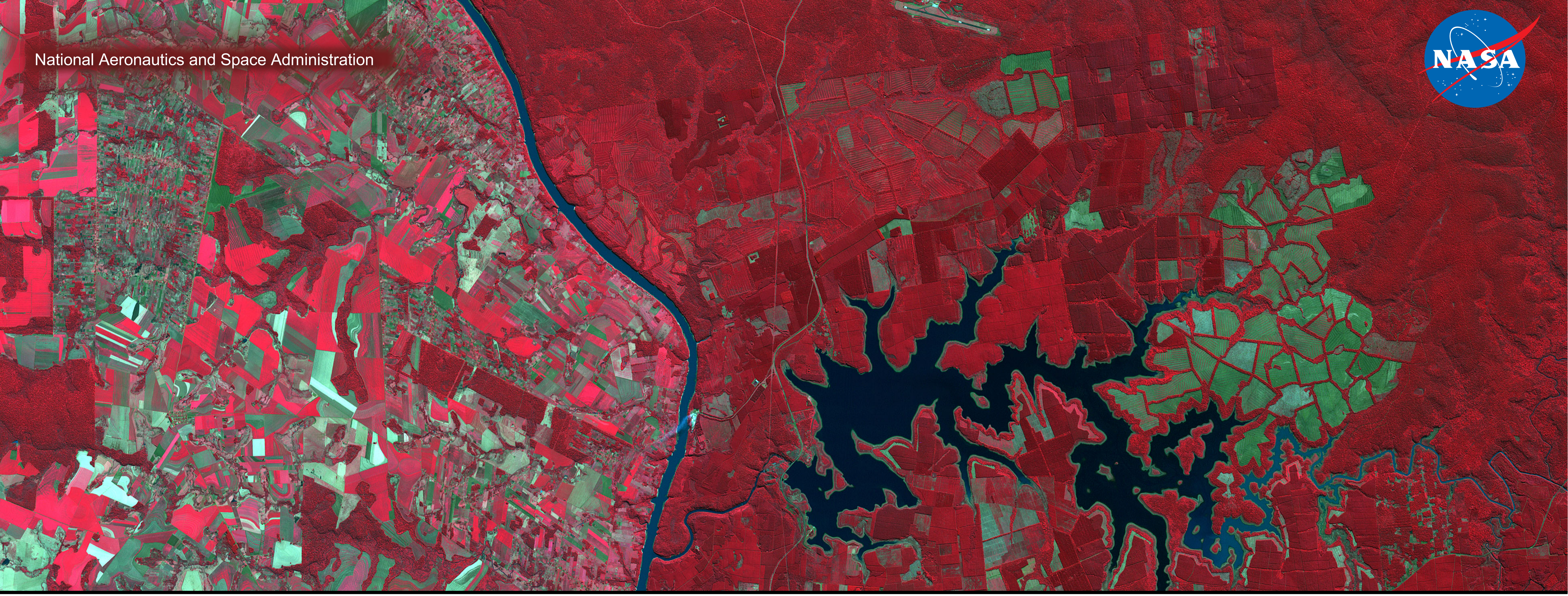
National Aeronautics and Space Administration



Access & Analysis of GLDAS Runoff Over the Sao Francisco Verdadeiro Watershed

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Objectives

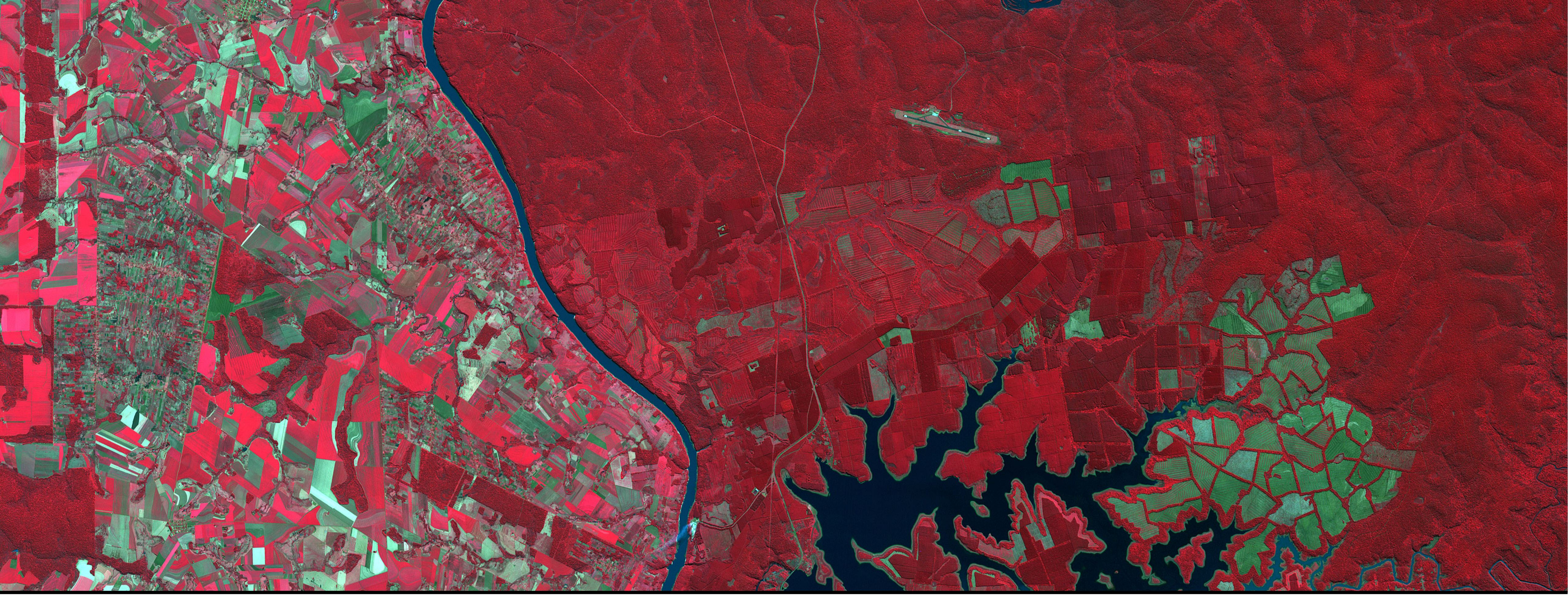
By the end of this exercise, you will be able to download and analyze NDVI (Normalized Difference Vegetation Index) over the SFV watershed and examine inter-annual differences

Requirements

- QGIS installed on your computer
  - https://arset.gsfc.nasa.gov/sites/default/files/water/drought/Introduction%20to%20QGIS.pdf
- A shapefile for the Sao Francisco Verdadeiro watershed saved on your computer
  - http://arset.gsfc.nasa.gov/
- NASA Earthdata Account

Outline

- Part 1: Subset GLDAS Runoff Data and Make Monthly Time Series
- Part 2: Make and Download Monthly Runoff Maps
- Part 3: Runoff Analysis in QGIS
  – Convert NetCDF Runoff data into GeoTIFF
  – Interpolate and Clip Runoff Data to SFW
  – Calculate Monthly Accumulated Runoff over the SFV Watershed



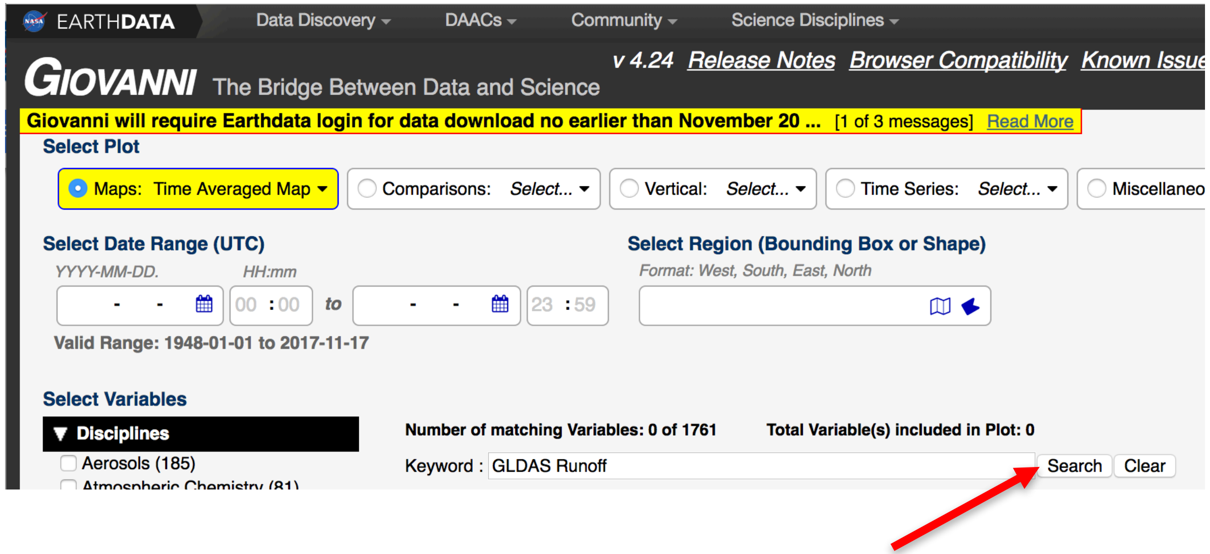
Subset GLDAS Runoff Data and Make Monthly Time Series

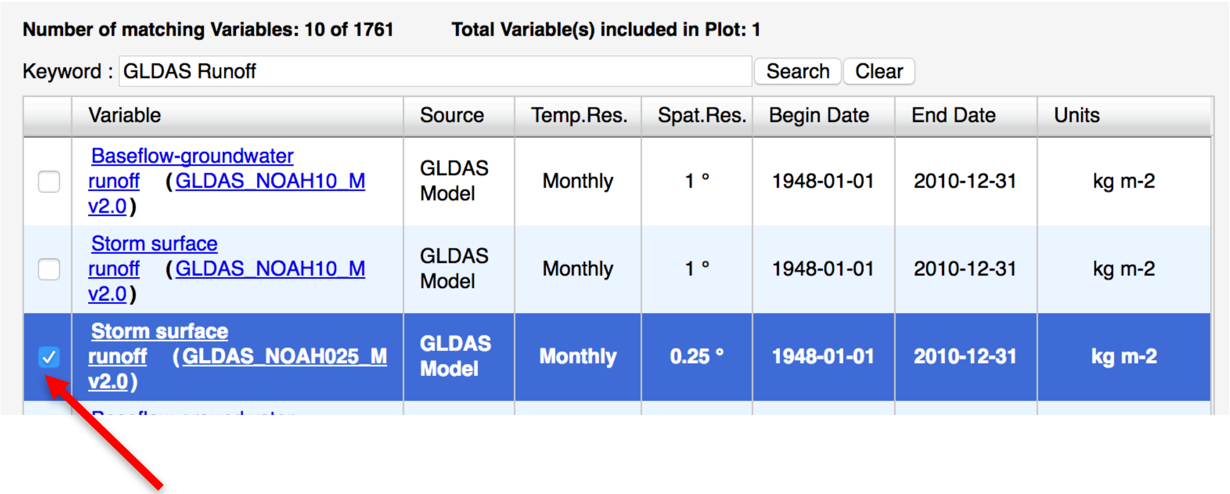
Subset Data and Make Monthly Runoff Time Series

1. Go to Giovanni: http://giovanni.gsfc.nasa.gov/giovanni
2. On the Giovanni page you will see the following options:
   - **Select Plot:** allows selection of analysis options
   - **Select Data Range:** allows selection of a time period
   - **Select Region (Bounding Box or Shapefile):** allows selection of a geographic region by latitude-longitude, map, or shapefile
   - **Keyword:** allows search of data parameters by keyword
   - **Plot Data:** (located on the bottom right of the page) begins the action to make a desired plot

Subset Data and Make Monthly Runoff Time Series

3. Enter the following options:
4. For **Keyword**, enter **GLDAS Runoff**. Click **Search**
5. Select **Storm surface runoff (GLDAS_NOAH025_Mv2.1)** Monthly data



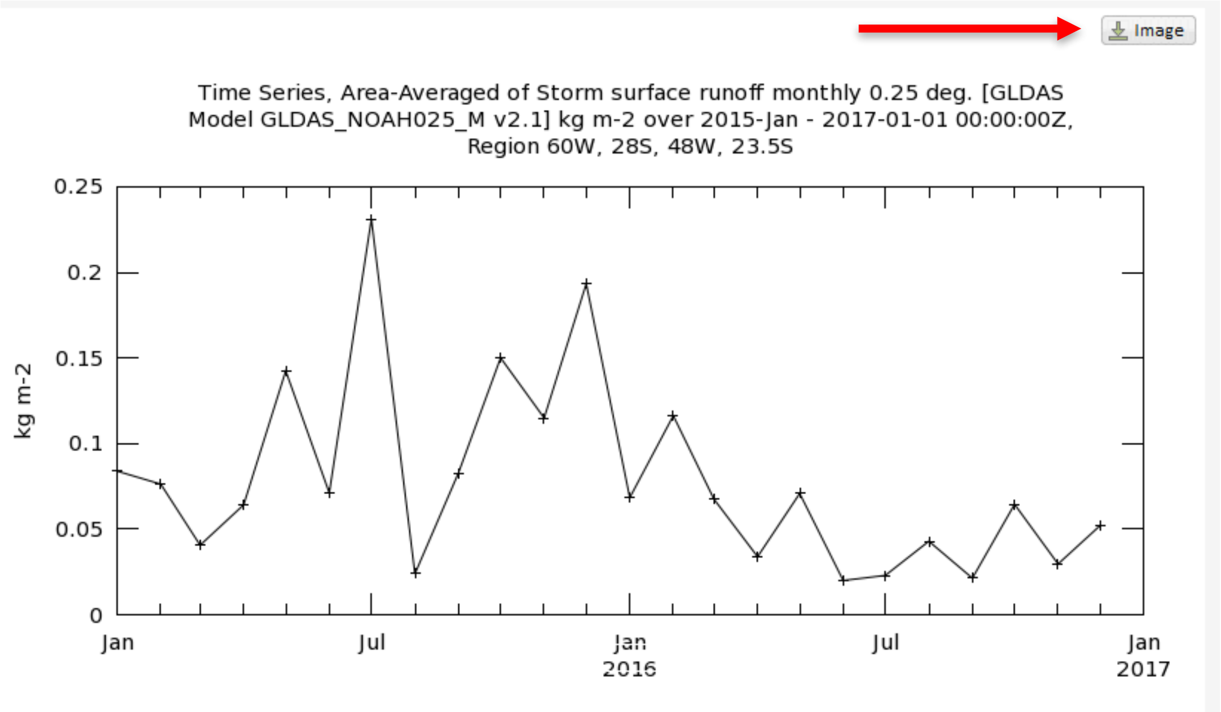


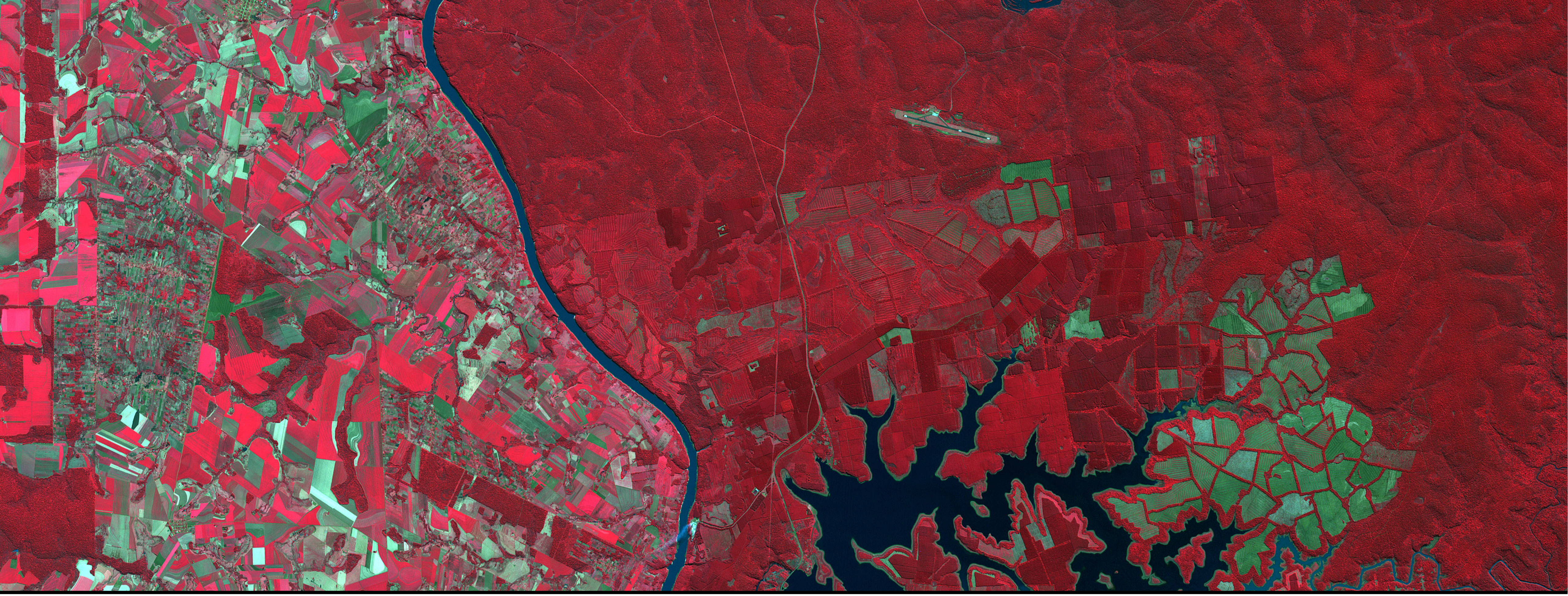
Subset Data and Make Monthly Runoff Time Series

6. Under **Select Plot**, the default selection is **Maps: Time Averaged Map**. Select **Time Series**, and then select **Area Averaged** from the drop-down menu
6. Under **Select Region (Bounding Box or Shape)**, enter the longitude-latitude around Parana: -60.0, -28.0, -48.0, -23.5
   - Note: west longitudes and south latitudes are negative, whereas east longitudes and north latitudes are positive
   - Click on the map icon to see the region

Subset Data and Make Monthly Runoff Time Series

7. Under **Select Date Range (UTC)**, in the YY-MM windows, enter 2015-01 for start date and 2016-12 for the end date
8. Click on **Plot Data** (on the bottom right-hand of the screen) to get the time series plot on the right





Make and Download Monthly Runoff Maps

Make and Download Monthly Runoff Maps

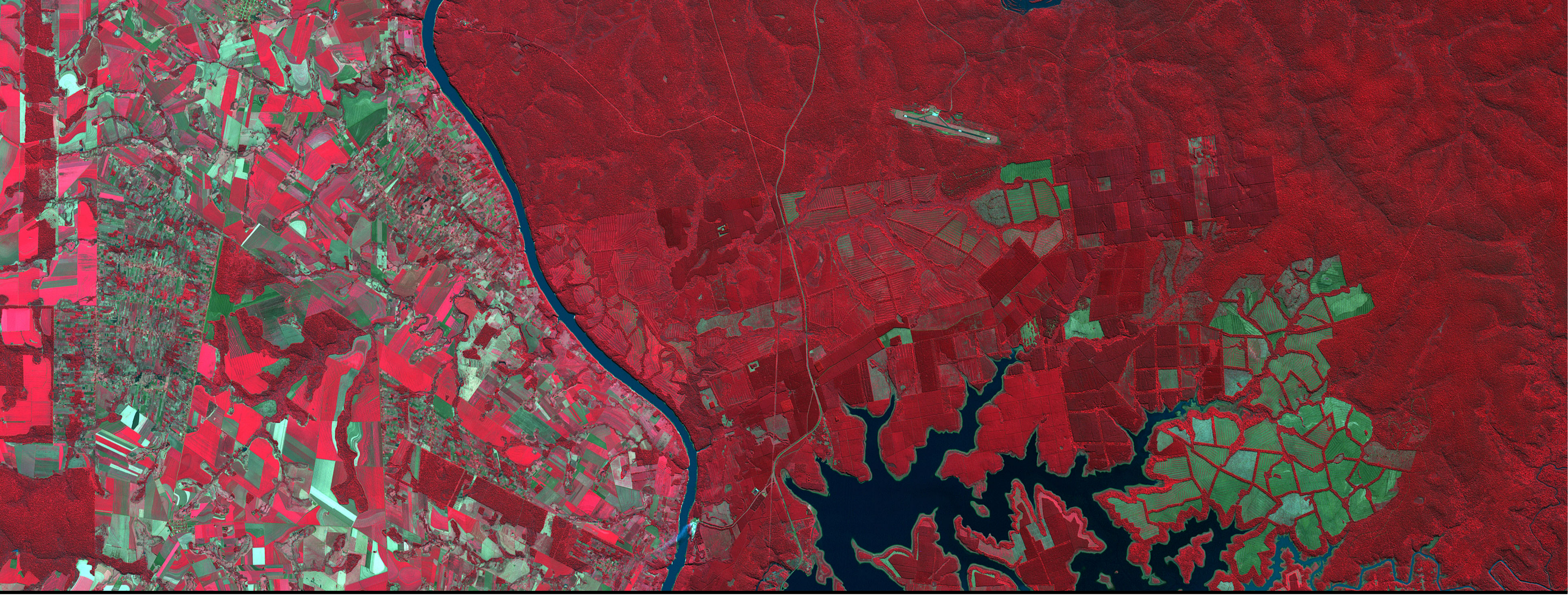
1. Click on **Back to Data Selection** on the lower, right-hand side of the page
2. Enter the following options:
   – Under **Select Plot**, change to **Maps: Monthly and Seasonal**
   – Under **Select Seasonal Dates**, enter December and 2015 to 2015 (just the one month)
   – Click on **Plot Data** (on the bottom right) to get a map of monthly Runoff
3. Click on the **Downloads** link on the left to see multiple file options. Choose the NetCDF file by clicking on the link to save the file to your computer
   – Suggestion: Save the December 2015 monthly files in the folder **Panara-Data** you created for the GPM IMERG data

NetCDF:
g4.timeAvgMap.GLDAS_NOAH025_M_2_1_Qs_acc.20151201-20151231.60W_28S_48W_23S.nc

Make and Download Monthly Runoff Maps

4. Click **Back to Data Selection** on the bottom right part of the screen
5. Repeat **Select Date Range** for December 2016
6. Click on the **Downloads** link on the left and save the NetCDF file on your computer in the same folder as December 2015
   – Suggestion: Rename the NetCDF files to avoid long, Giovanni-generated file names. For example: Runoff-Dec2015.nc and Runoff-Dec2016.nc

NetCDF:
g4.timeAvgMap.GLDAS_NOAH025_M_2_1_Qs_acc.20161201-20161231.60W_28S_48W_23S.nc



Runoff Analysis in QGIS

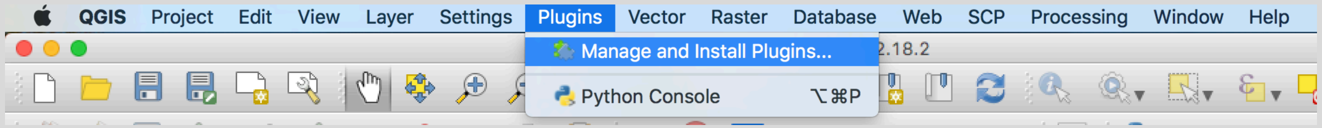
Runoff Analysis in QGIS

- Note: You will need the latest version of QGIS (Preferably 2.18.9 or higher) to work with the NetCDF files. **It is always a good idea to save your QGIS project often so that your work is not lost.**

1. Open QGIS and start a new project
2. On the top menu bar, click on **Web** to check if you have **OpenLayers Plugin**

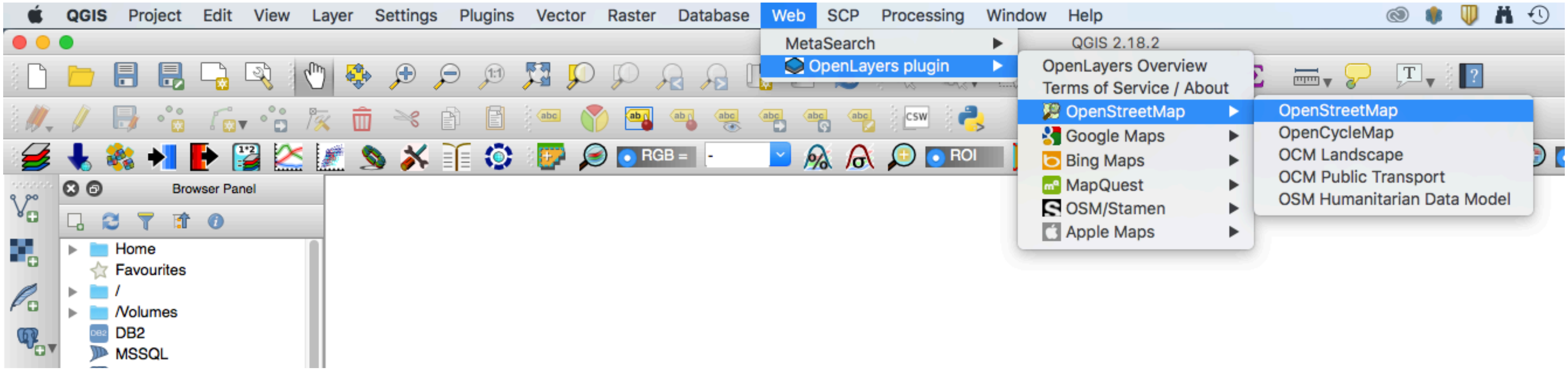
If you do not have the OpenLayers Plugin

- Select **Plugins** from the top menu, and choose **Manage and Install Plugins**
- You will get a window with options for Plugins
- Enter OpenLayers in the search window
- Clicking on the **OpenLayers Plugin** and press **Install** in the bottom right



Runoff Analysis in QGIS

3. From the top menu bar, click on **Web**, select **Open Layer Plugin** and select a background map
4. This exercise uses the plugin **OpenStreetMap**

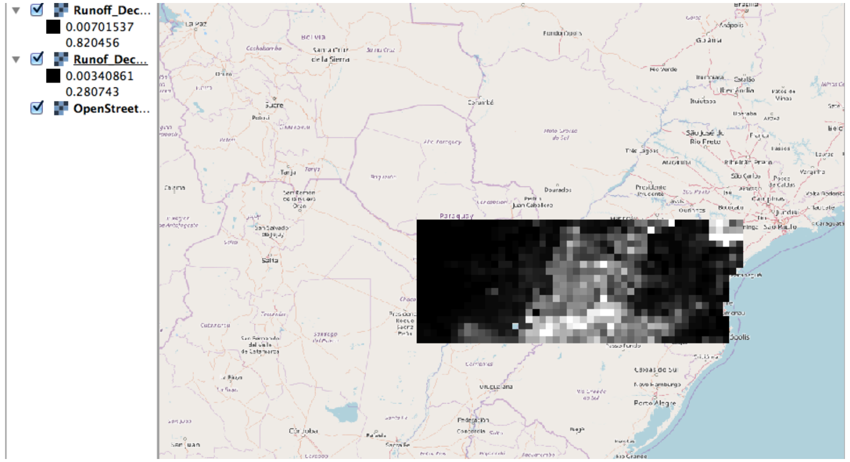


Add the SFV Shapefile

5. Click on the menu on the left bar and click **Add Vector** to add the SFV shapefile: sfv_4326.shp
6. To make the shapefile transparent with only the border left, right click on the layer file and go to **Properties** > **Style**
7. Click on the down arrow in the Fill window and select **Transparent fill**
8. Click on the down arrow in the **Outline** window and choose a color of the shapefile boundary (This example uses black)
9. Set the **outline width** to be 2.0
10. Click **OK** to get the following result in the QGIS window

Convert NetCDF Runoff Data to GeoTiff

11. In your QGIS map, click on the **Add Raster**  function on the left
12. Navigate to your saved Monthly Runoff Files and click on **Open** to add the monthly data files for December 2015 and December 2016. You can do this all at once by highlighting both files.
    - A **Coordinate Reference System Selector** box may pop up. Select WGS84, EPSG 4326
    - From the top Menu Bar, you can zoom in and out on the layer



These NetCDF images have to be converted to GeoTIFF images for you to perform raster calculations on the data.

Convert NetCDF Runoff Data to GeoTiff

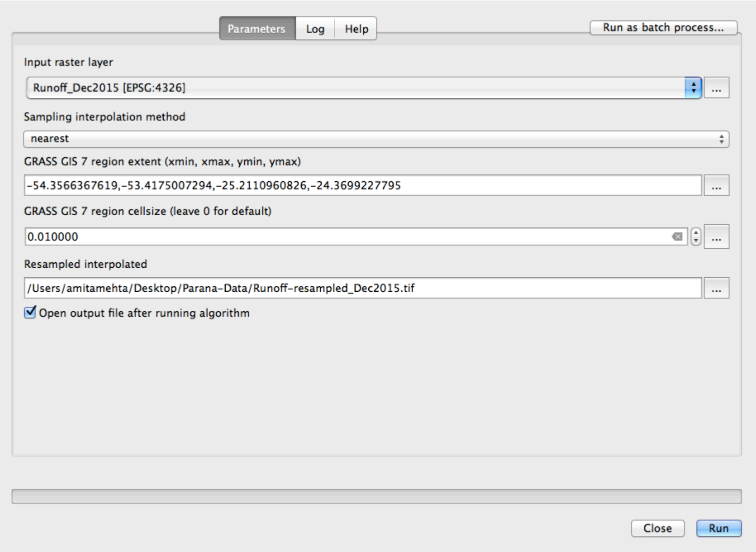
13. Right-Click (or Control-Click on Mac) on the raster layer Runoff-Dec2015
14. From the drop-down menu select **Save As** – this will open a window
    - Note that **Format** in the window is **Gtiff**
    - Make sure the **Add save file to map** option is checked.
    - Click on **Browse** and enter the folder name where all the data are and enter a file name (Suggestion: Runoff-Dec2015) and click on **Save**
    - You will see the GeoTiff layer displayed on the map and the file will be saved to the data folder
15. Repeat steps 13-14 to save the 2016 Runoff layer as a GeoTIFF
16. Now you can remove the NetCDF raster layers by right-clicking on each layer and choosing **Remove**

Resample the Runoff Data

17. In the top menu, select **Processing** > **Toolbox.** A search window will appear to the right of the map. Enter interp.
    – You should see **r.resamp.interp** from the list
18. Double click on **r.resamp.interp –** this will open a window
19. In the **Input Raster Layer** window use the dropdown menu arrow to select Runoff_Dec2015 raster
    – In the **Sampling interpolation method** window, chose **nearest**
    – In the **GRASS GIS 7 region extern (xmin,xmax,ymin,ymax)** window choose **Layer/canvas extent** from the dropdown menu
    – In the **GRASS GIS 7 region cellsize (leave 0 for default)** window enter the factor 0.01 [Note: the resolution of the Runoff data is 0.25 degree, we are resampling the data to1 km by specifying 0.01 cell size) without changing values

Resample the Runoff Data

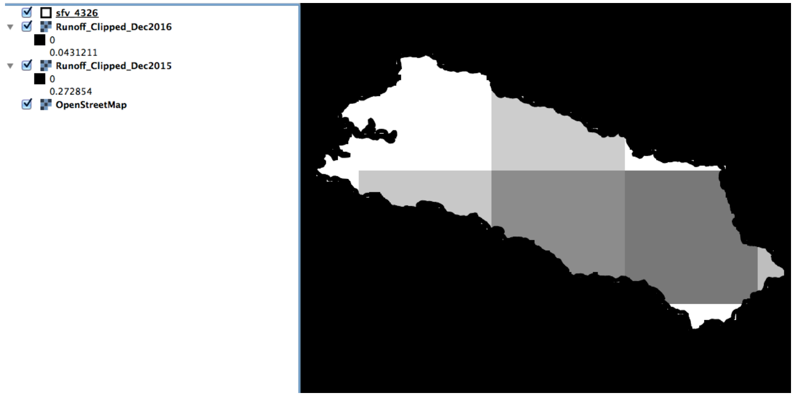
– In the **Resampled Interpolated** window specify the folder and filename where the interpolated data will be saved.
– Make sure that **Open output file after running algorithm** is selected
– Click on **Run** at the bottom right
– You will get a resampled interpolated data layer on the map (in grey colors)
– By right clicking on the resampled layer > **Rename** layer:
(suggest Runoff_resampled_Dec2015)



20. Repeat the above steps and resample the 2016 Runoff data
21. You may uncheck or remove Runoff layers which are not resampled

Clip the Runoff Data to the SFV Watershed

22. Now Clip the interpolated Runoff layers to the SFV shapefile. On the top bar go to **Raster** > **Extraction** > **Clipper** to open the Clipper options window
23. In the Input File (raster) window select layer Runoff_resampled_Dec2015
24. In the Output file window select output folder and enter file name (suggest Runoff_Clipped-Dec2015).
25. Check the **Mask Layer** and in the **Mask Layer** window select the shapefile name sfv_4326.
26. Click **OK** on at the bottom right. You will see the data clipped by the shapefile boundary



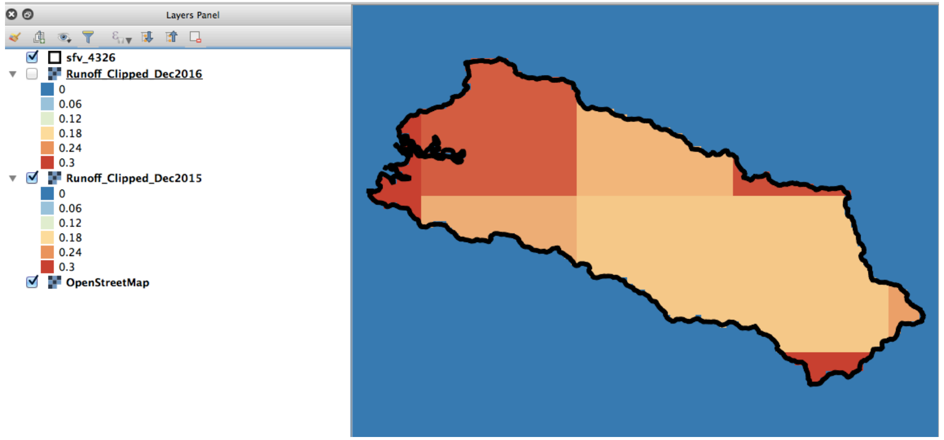
Note

- The original Runoff data from GLDAS is at 0.25° resolution
- We resampled the data because spatial interpolation of Runoff will result in unrealistic distribution of Runoff (Runoff depends on factors such as slope, land cover type, soil moisture, and soil type)
- The GLDAS Runoff only provides large-scale Runoff pattern (~ 25 km x25 km)
- The monthly Runoff value in GLDAS is given as an average of 3-hourly data over the month
- Therefore, in order to estimate total monthly runoff we have to multiple the monthly average value as:

$$(\text{Runoff } (\text{Kg/m}^2)/3 \text{ hr}) * (8 \text{ (3-hr times) /day})*(31 \text{ day/month})$$

- In the next exercise we will use the Raster Calculator to get total monthly Runoff

Add Color to GeoTIFF Runoff Data



27. Right click on the layer file for December 2015 and go to **Properties** > **Style**
28. Select the Render Type as **Singleband Pseudocolor**
29. Next to Color, make sure the Red-Yellow-Blue (**RdYlBu**) color palette is selected
30. Select **Invert** so that low Runoff values are shown in blue and high in red
31. Set **Min** value to 0 Kg/m^2 and **Max** value to 0.3 Kg/m^2
32. Below the color display, change the **Mode** to **Equal Interval** and **Classes** to **6**
33. Click **Classify**, then click **Apply**
34. Repeat the above steps for December 2016 layer

Discussion

1. Over the SFV watershed, which year had more runoff in December?

2. Recall the GPM precipitation analysis conducted on Day-4. Explain the inter-annual differences in runoff with respect to the precipitation differences.

3. How can you get high resolution runoff data?