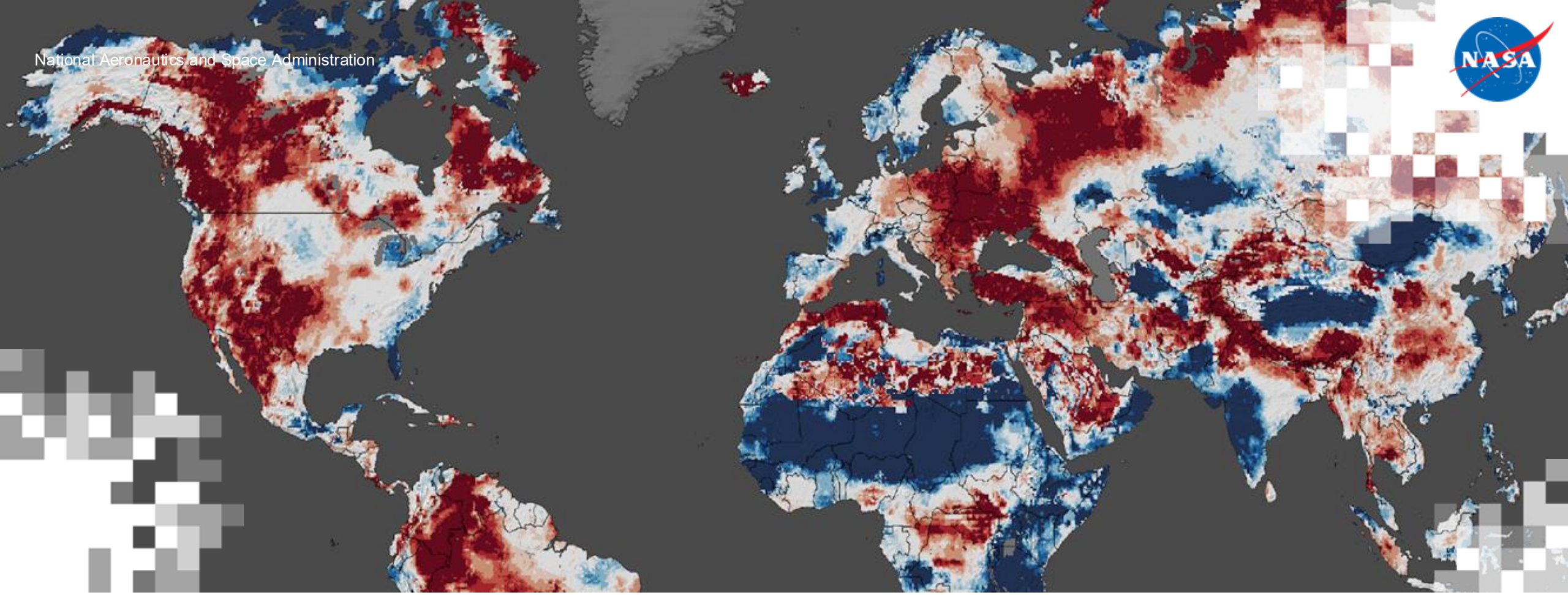


Monitoring Groundwater Changes for Water Resources Management

Exercise 2: GLDAS Groundwater Data Analysis Tool using Giovanni Webtool

April 28, 2026

Exercise 2

In this exercise you will:

- Examine multi-year average maps of groundwater storage in the Colorado watershed from GRACE-assimilated GLDAS V2.2 data using NASA Giovanni Webtool and QGIS.

- Examine time series (2003 to 2025) of daily groundwater storage data from the GLDAS data for the Colorado watershed.

Note: You will save maps and time series to your computer. Your homework will include questions based on this exercise.

Prepare for the Exercise

- You need to work on a computer for this exercise. It will not work on a mobile device.
- Register on NASA Earthdata for using Giovanni (you will be prompted to make a free EarthData account if you haven't already)
- Follow ARSET tutorial to install QGIS (you will be prompted to make a free Moodle account if you haven't already)

Introduction to Giovanni

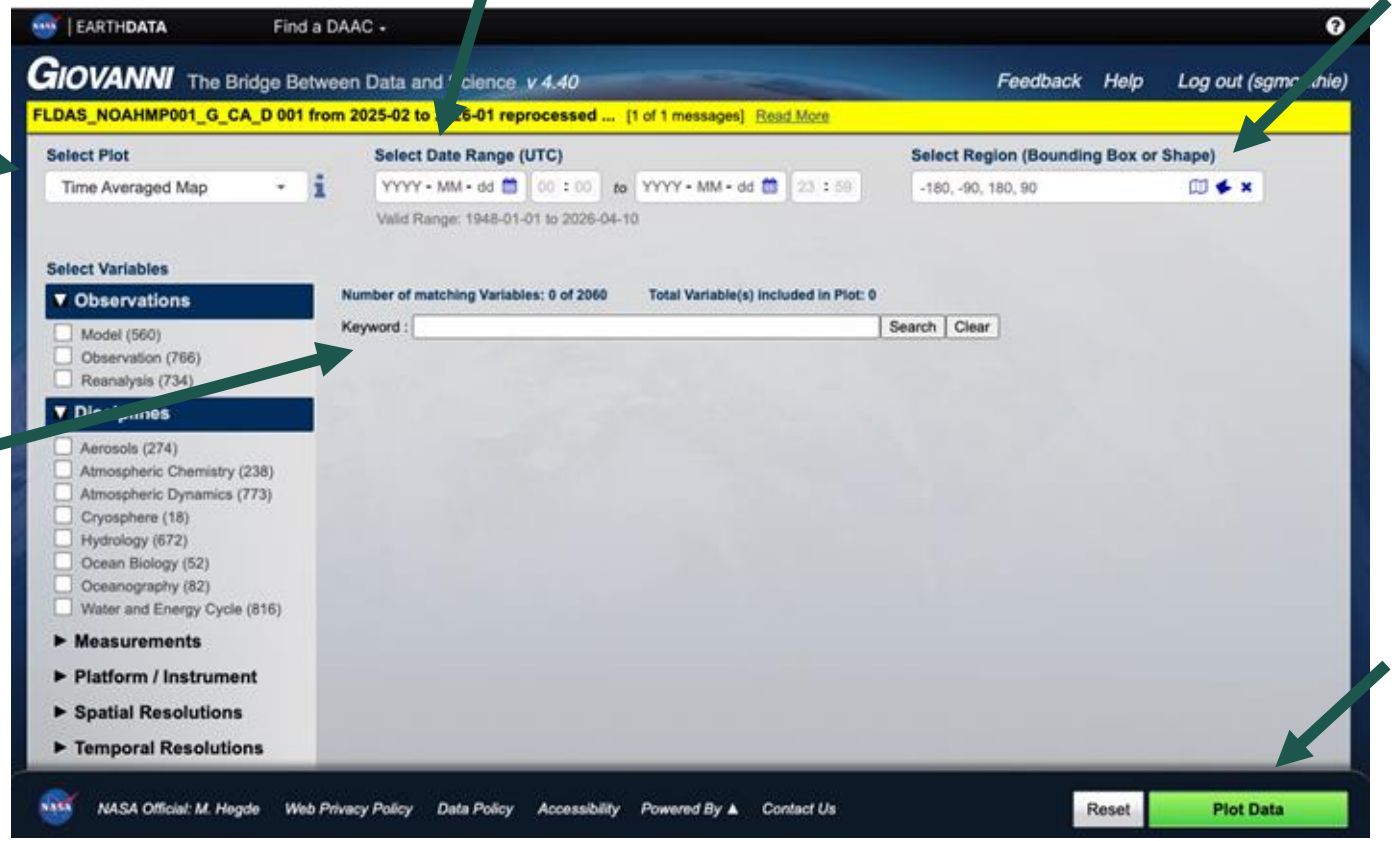
1. Login to Giovanni with your Earthdata account

If this is your first time using Giovanni, you will be asked to sign the End User License Agreement.

Select Date Range (UTC)
select a time period

Select Plot
select analysis options

Select Region (Bounding Box or Shape)
select a geographic region by map, shapefile, or latitude-longitude

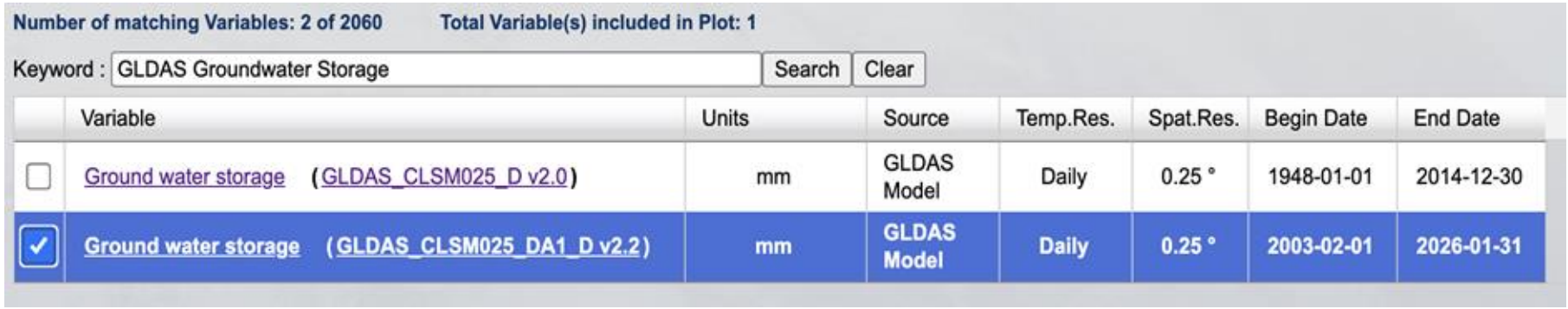


Keyword
search for data parameters

Plot Data
create a plot with selected settings

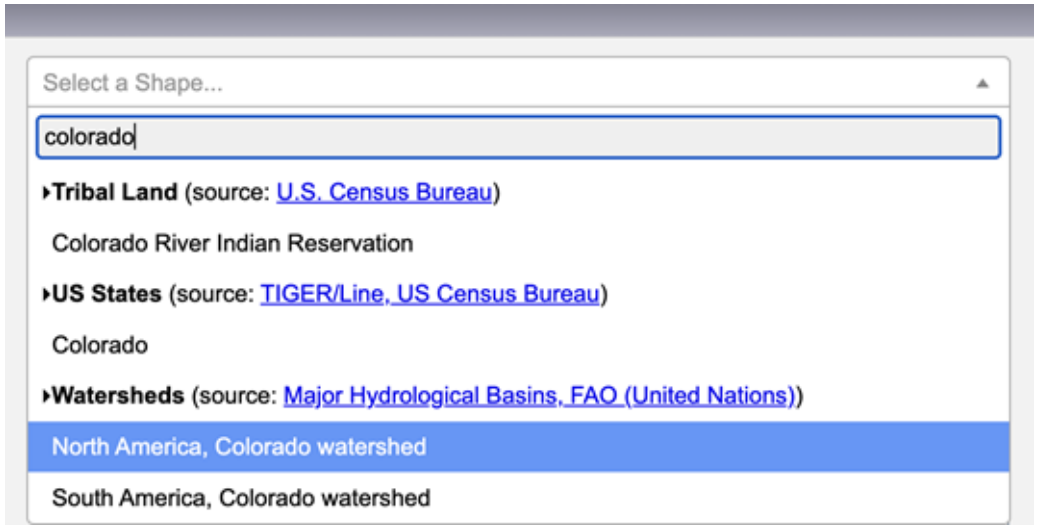
Giovanni: Search and Select Dataset

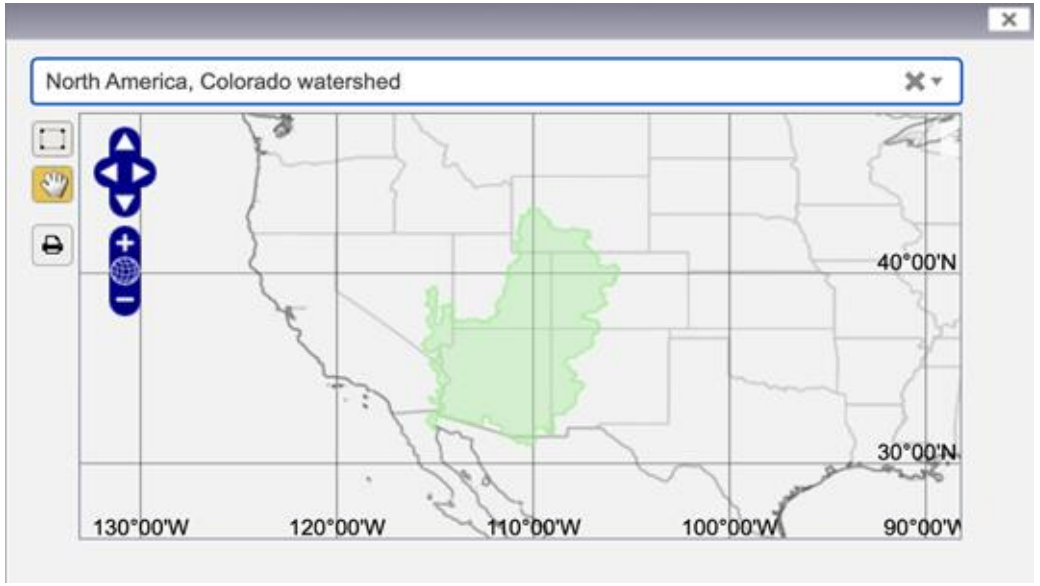
2. In the **Keyword** box, search for **GLDAS Groundwater Storage**
   - From the drop-down list of variables, select the checkbox for **Groundwater Storage (GLDAS_CLSM025_DA1_D v2.2)**
   - Note the values for **Units, Temporal Resolution**, **Spatial Resolution, Begin Date, End Date**



Giovanni: Select Analysis Options

3. Select Plot type and region of interest (North America, Colorado watershed)
   - **Select Plot** (top left of screen)**:** use drop-down menu to choose **Time Averaged Map**
   - **Select Region (Bounding Box or Shape):**
   - Click **Select a Shape**
     - In the Shape search window, enter **Colorado**
     - From the list of options, select **North America, Colorado watershed**
   - The Colorado watershed map displays in a window

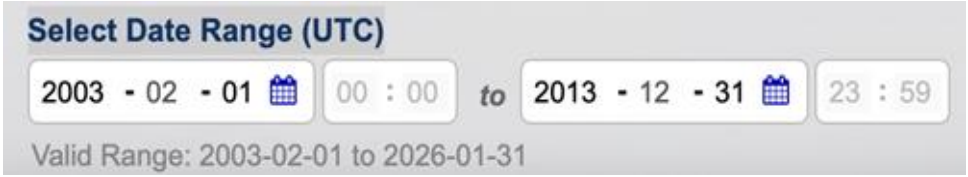


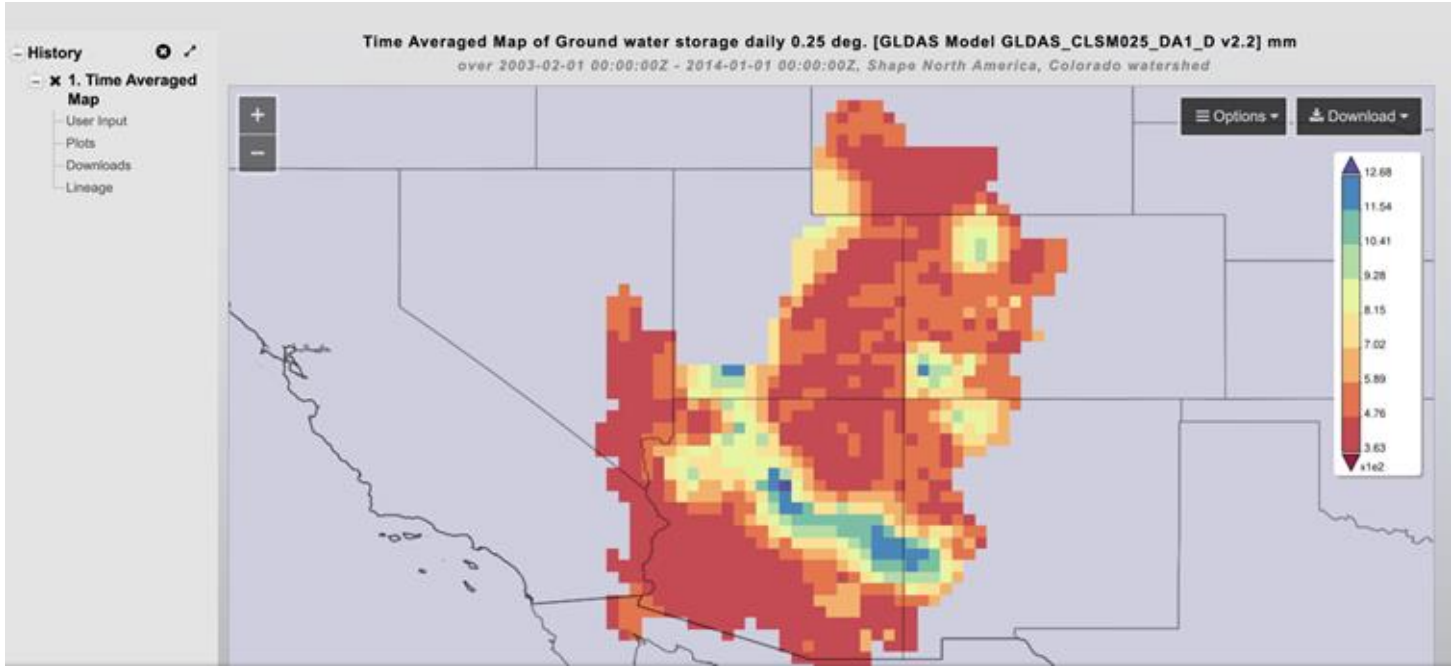


Giovanni: Select Time Periods and Generate Maps

4. Generate Maps for a given time period
   - **Select Date Range (UTC):**
     - Enter **2003-02-01 to 2013-12-31** in the range windows

     - Select the **Plot Data** button (bottom right of screen) to generate the 11-year mean groundwater map for the Colorado watershed. This may take a few minutes.

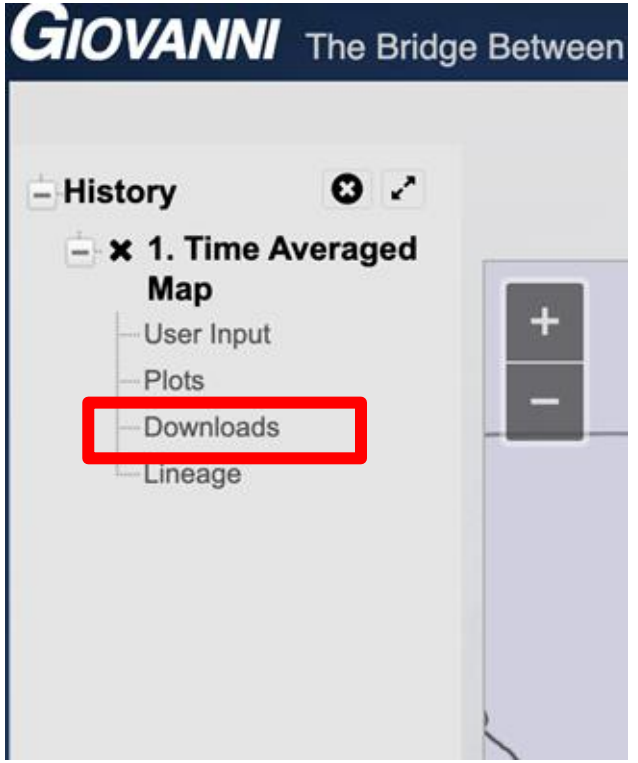




Giovanni: Download Map Data

5. In the left menu, click **Downloads** to save the map
    - Under **File Links**, Select **GeoTIFF** format
        - Note: you must be logged in download data
    - Rename the file to a shorter name for convenience, **GLDAS_GW_Colorado_2003-2013.tif**
    - Select **Back to Data Selection** (bottom right) to be navigated back to the main window

6. Repeat steps 4 and 5 to generate a map and download data with a different time range: **2014-01-01 to 2025-12-31**
    - Rename the file to shorter names for convenience, **GLDAS_GW_Colorado_2014-2025.tif**

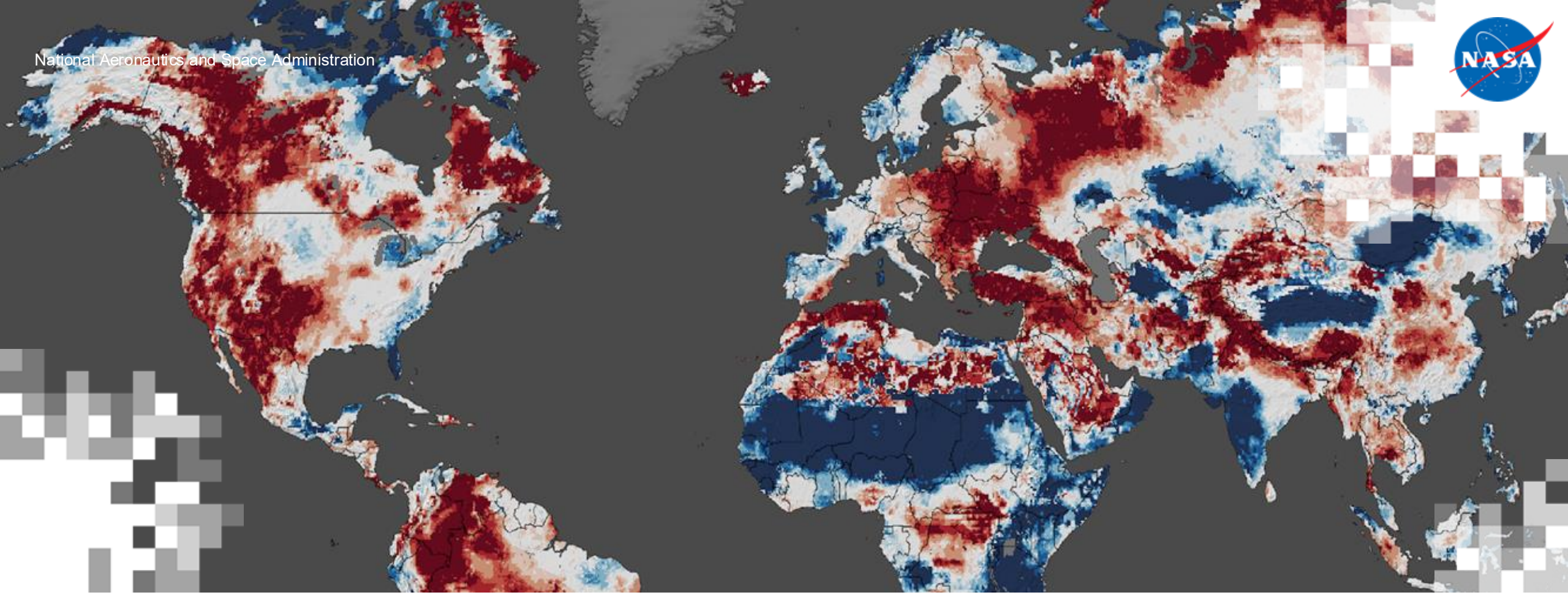


Giovanni: Create a Time Series

7. Create a time series plot and download the data
    - **Select Plot**: from dropdown choose **Time Series: Time Series, Area-Averaged**
    - **Select Date Range (UTC):** 2003-02-01 to 2026-01-31 in the time range windows
    - Select the **Plot Data** button (bottom right of screen) to generate a plot of a time series showing groundwater storage averaged over the Colorado watershed
    - Click **Downloads** (in the left menu bar) and save the time series as both:
        - i) .png image, and
        - ii) .csv file
        - When downloading, rename the files to shorter names for convenience, **GLDAS-GW_TS.png** and **GLDAS-GW_TS.csv**

Note: You will use the .csv file and timeseries you saved for your homework.

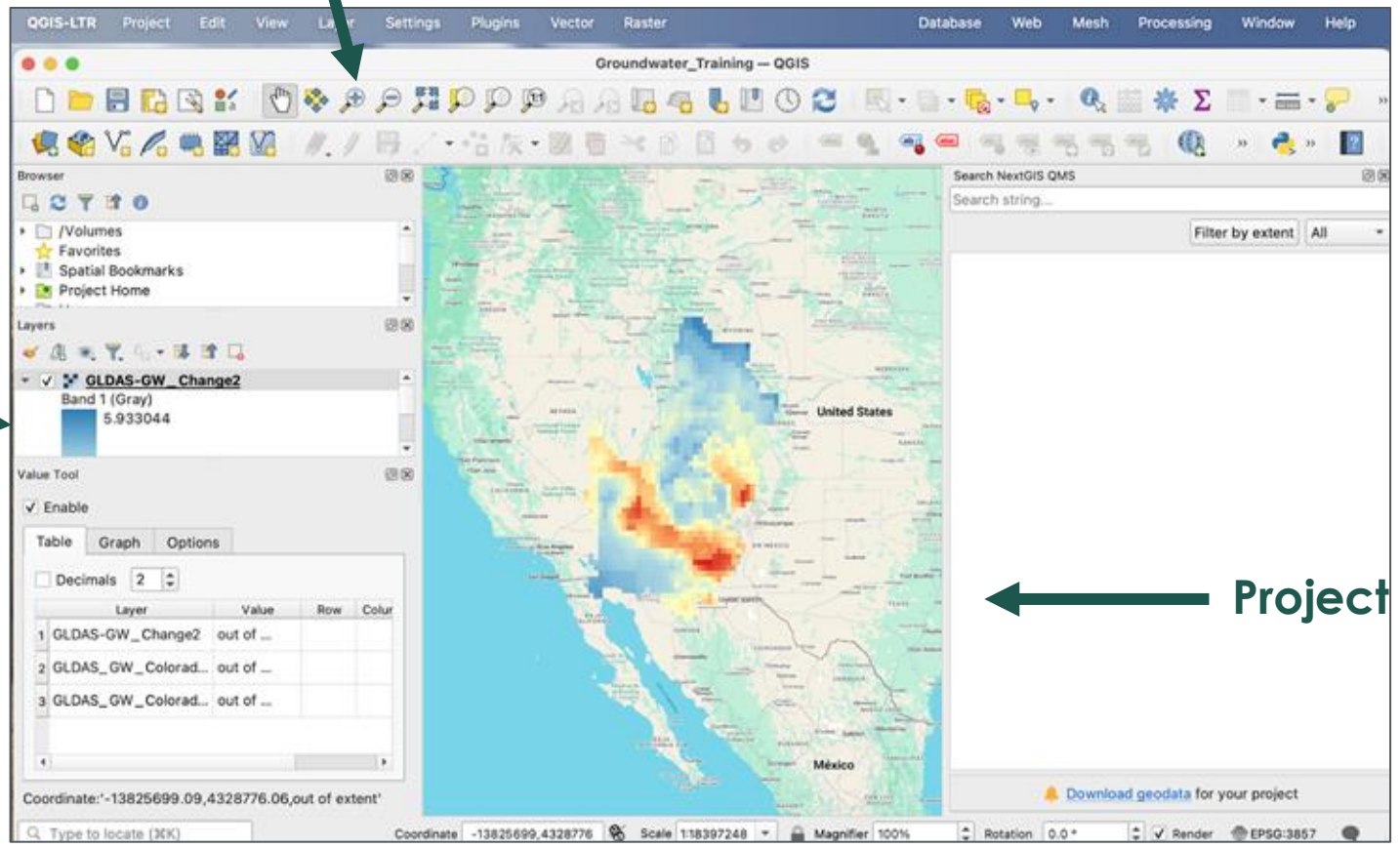
National Aeronautics and Space Administration



Examine Interdecadal Change in Groundwater Storage using QGIS

QGIS: Introduction to QGIS

Open QGIS on your computer (refer to the Prepare slide if you have not already installed QGIS)



QGIS: Check for/ Install Plugin

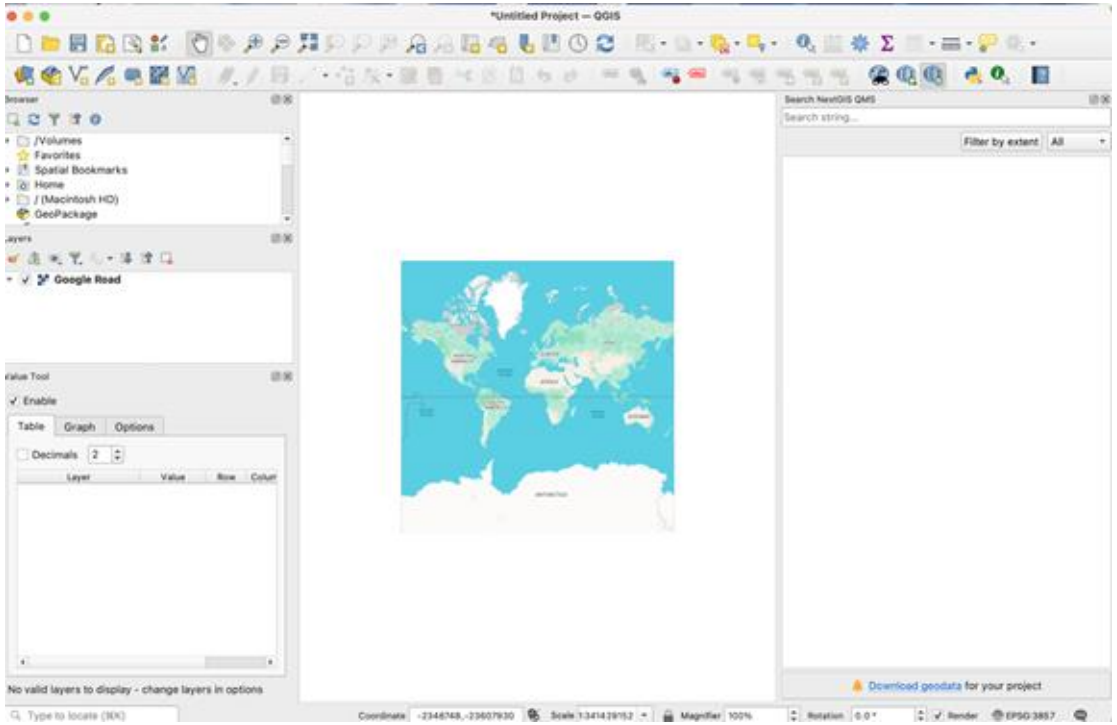
8. Check for **QuickMapServices** plugin

- On the top menu bar, click **Web** to check if you have the **QuickMapServices Plugin** in the drop-down menu.
- If the plugin is not listed, you need to install it.
- From top menu bar, select **Plugins** and from the drop-down list choose **Manage and Install Plugins.**
- In the search window, enter **QuickMapServices.** From the results list below, select **NextGIS QuickMapServices**.
- Click the **Install** button (bottom right).

QGIS: Add Background Map

9. Select and open a background map

- From the top menu bar, click on **Web**, select **QuickMapServices > Google > Google Road** to display the map in the center panel.
- On the top menu bar, click the zoom button then use the tool to zoom into the western United States.
- Note: You may use another map option available in QuickMapServices.

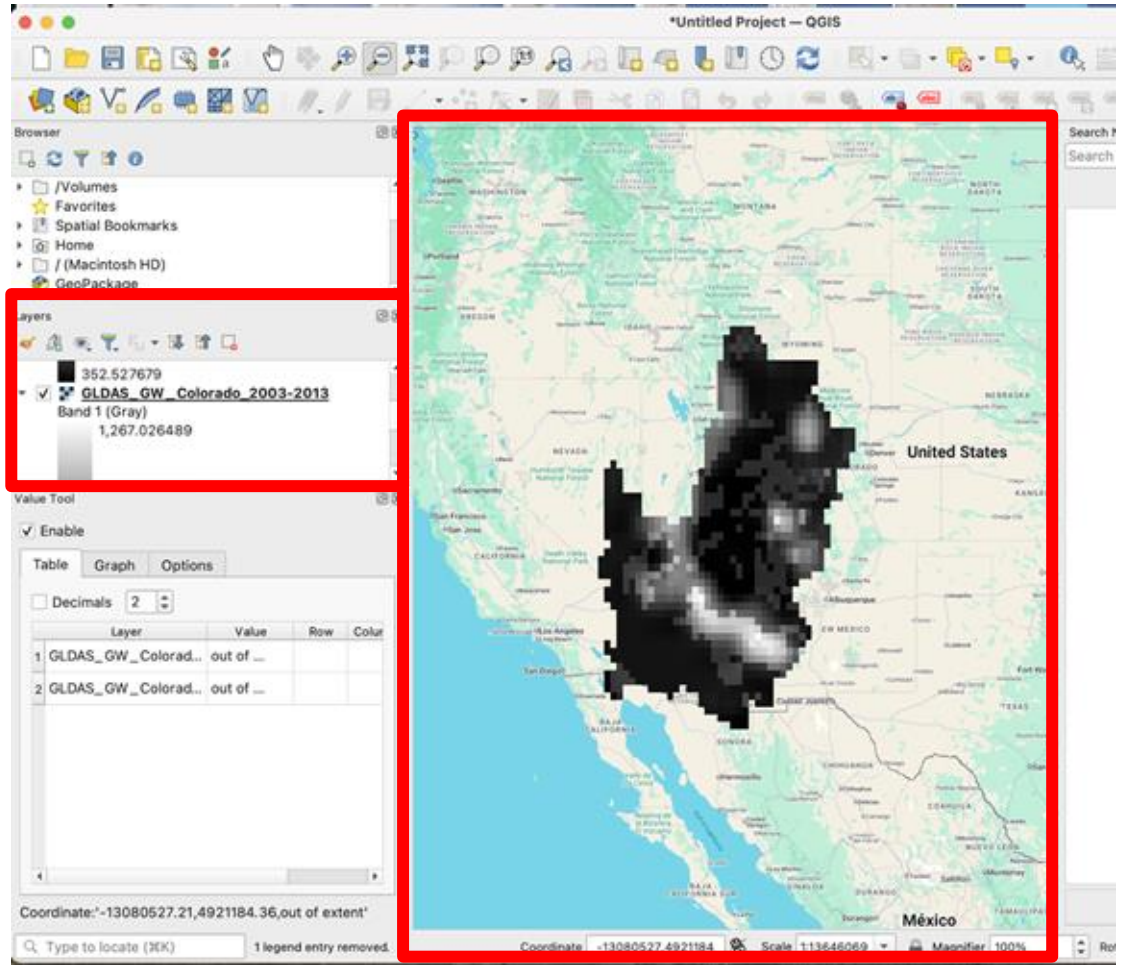


QGIS: Add Raster Layers from Data Files

10. From top menu bar, click **Layer** (top menu bar) **> Add Layer > Add Raster Layer** to open the window, **Data Source Manager | Raster**.

- **Source, Raster Dataset(s):** Click the browse button (..., right of text entry box) to open the file navigation window.
- Navigate to files saved on your computer from Giovanni and upload **GLDAS-GW_Colorado_2003-2013.tif**. Repeat to upload **GLDAS-GW_Colorado_2014-2025.tif**
- Select **Add** (bottom right) and then **Close**.

  Both the raster maps will be listed in the **Layers panel** and visible in the **Project panel**.



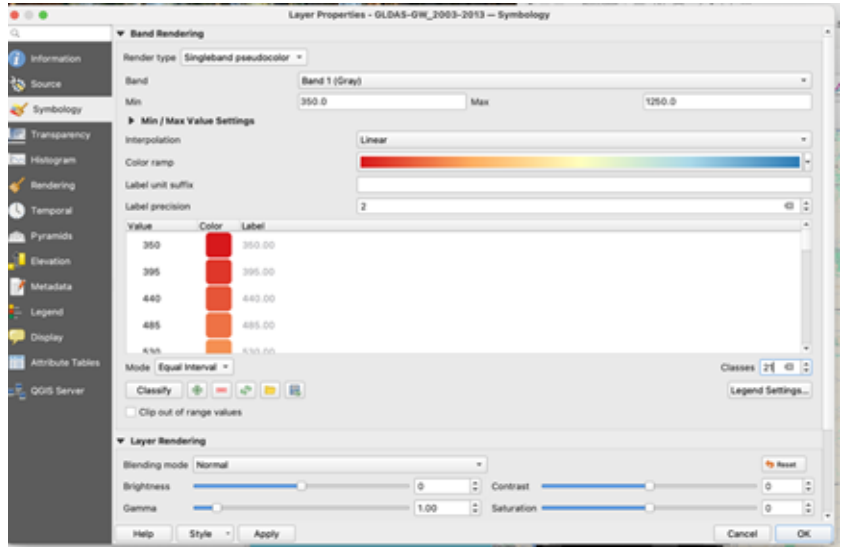
Layers Panel

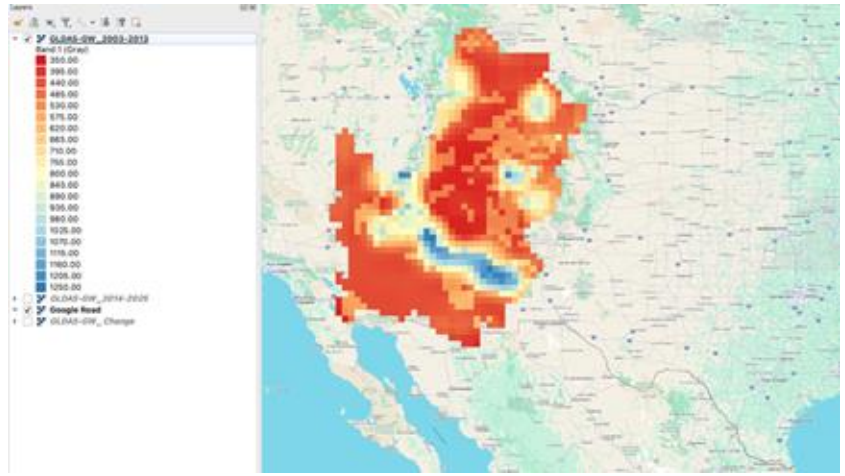
Map Panel

Add Symbology to the Groundwater Raster Maps

11. Change the colors used in the raster maps
    - In the **Layer panel**, right click on the layer **GLDAS-GW_2003-2013** and from the drop-down menu select **Properties > Symbology.**
    - Select the **Render Type** as **Singleband pseudocolor**
    - **Color ramp:** click drop-down arrow, select **All Color Ramps > (RdYlBu)** Red-Yellow-Blue color palette.
    - Set **Label precision t**o **2**
    - Change the **Min** and **Max** values to **350** and **1250** respectively
    - Below the color display, change the **Mode** to **Equal Interval** and **Classes** to 21. Click **OK** to save.

12. Right click on the **GLDAS-GW_2003-2013** raster and go to **Styles > Copy Style > Symbology**
    - Right click on **GLDAS-GW_2014-2025**, then select **Styles > Paste Style > Symbology** to use the same color scheme for this raster.





QGIS: Create Map of Interdecadal Change

13. Open **Raster > Raster Calculator** (menu bar)

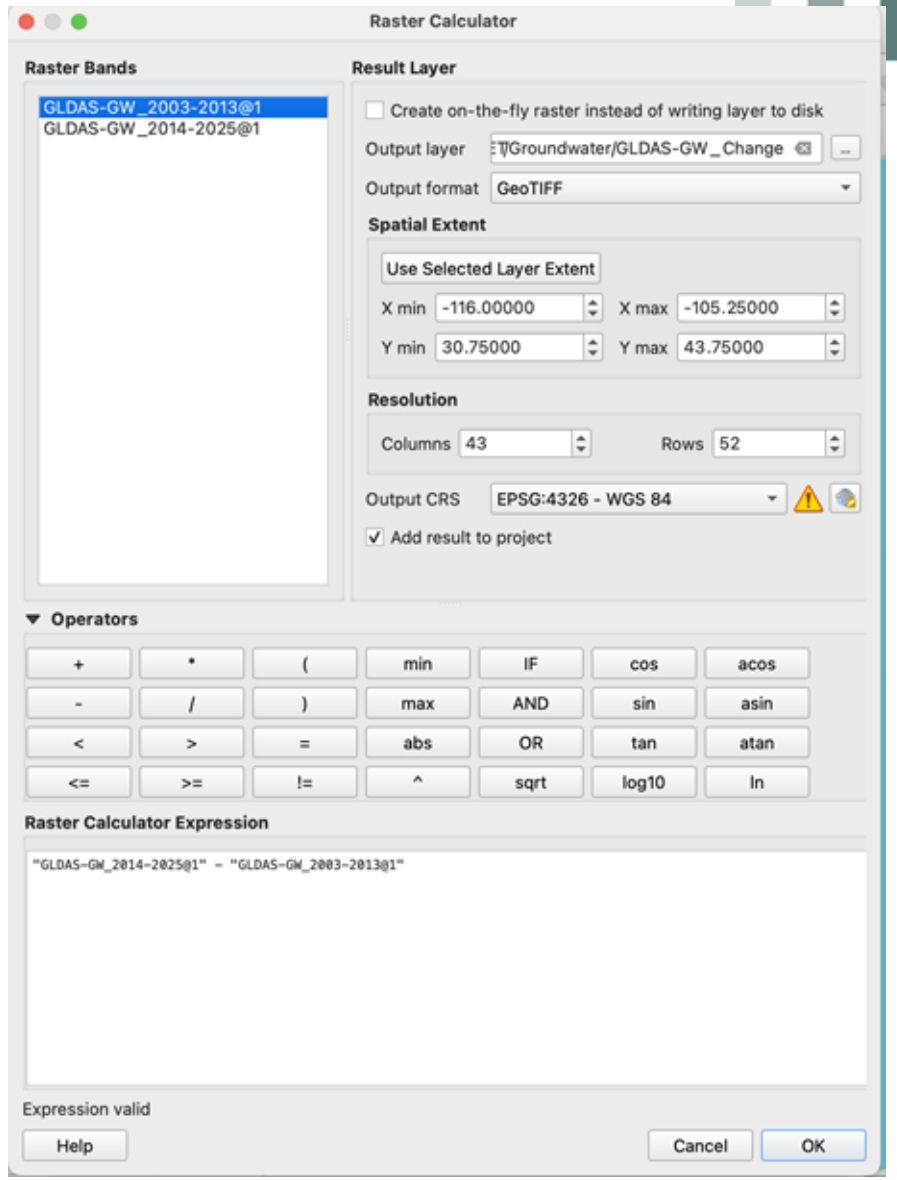
- **Output layer:** Click on the browse button (...) and save the file as **GLDAS-GW_Change** to your working directory.
- **Output format:** Set to GeoTIFF.
- In Raster Bands, double click the layer name **GLDAS-GW_2014–2025.** Note the layer is added in the **Raster Calculator Expression** window below.
- In Operators, click the **minus (-)** sign. Then double click on **GLDAS-GW_2003–2013**.

The Raster Calculator Expression window contains:

"GLDAS_GW_Colorado_2014-2025.@1" -

"GLDAS_GW_Colorado_2003-2013@1"

- Click **OK** to create and save the map.



QGIS: Examine Interdecadal Groundwater Storage Change

14. Repeat Step 11 to add the color scheme to **GLDAS-GW_Change** but do not change min and max values of the layer.

- Right click the Layer name, select **Properties > Symbology.**
  - Set **Render Type** as **Singleband pseudocolor.**
  - **Color ramp:** drop-down arrow to select **All Color Ramps > (RdYlBu)** color palette.
  - Set **Label precision t**o **2**
- Set **Mode** to **Equal Interval** and **Classes** to **11** and click **OK**.
- Click **Legend Settings** and uncheck **Use continuous legend.** Click **OK** and **OK** to save.

15. Export and save the project.

- In the Layer panel, click **GLDAS-GW_Change**.
- From the top menu bar, click on **Project > Import/Export > Export Map to Image** and save the map as an image to your computer as filename **GLDAS-GW_Change_Export.**
- Save this Project before quitting QGIS.

Note: You will use this map for your homework. Some questions will be based on the difference map.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Thank You!