



Monitoring Pre-fire Conditions: Bolivia

In this exercise, we will analyze pre-wildfire conditions for major wildfire outbreaks using web-based tools including: Climate Engine and the Global Wildfire Information System (GWIS). We will focus on our case-study example of the Bolivian Fires of 2020.

Objectives:

- Analyze pre-fire climate and landscape conditions for the Bolivian Fires of 2020

Overview of Topics:

- Introduction
- Part 1: Pre-fire Climatology in Climate Engine
- Part 2: Pre-fire Landscape Characteristics in Climate Engine
- Part 3: The Global Wildfire Information System (GWIS)
- Conclusion

Tools needed:

- Chrome web browser

Introduction

In this exercise, we will explore the climatic and landscape conditions in northern Bolivia in the months, weeks, and days leading up to a large wildfire outbreak in 2020.

In October 2020 the usually small fires that are routinely used as a tool to maintain pastures and for crop clearing expanded into several large ecosystems in Bolivia. These ecosystems included the Pantanal wetlands to the east, the Chiquitano forest in the south, and the Beni savanna and the Amazon rainforest in the north. This fire season followed another large fire outbreak in 2019, indicating prolonged dry conditions and potential connections to the effects of large-scale climate variability such as the Atlantic multidecadal Oscillation (AMO) which has led to a prolonged drought in the region.

During these 2020 fires, nearly 1.3 million acres have been reported as burned, affecting many small towns and agricultural and livestock management.

In this exercise, we will explore the pre-fire climate conditions using Climate Engine and the Global Wildfire Information System (GWIS).

Part 1: Pre-fire Climatology

1. Open Google Chrome
2. Navigate to the website: <https://climateengine.com/>
3. Along the top right, click on **Research App**
4. Scroll down the webpage and click on **Go to App**

When you first arrive on the Climate Engine App website you will be given the option to take a tour. This is recommended if you have never used the interface. For now, we will skip the tour and get directly to our analysis.

5. In the bottom of the map, where it says **Enter Place or Location**, type: **Bolivia** and click on **Center Map**.
 - a. Zoom in to view the northern half of the country in the map

The screenshot displays the Climate Engine web application interface. On the left, there is a control panel with the following sections:

- GET MAP LAYER** (green button)
- Variable** section: Type: Climate & Hydrology; Dataset: gridMET - Daily; Variable: Precipitation (PPT); Units: millimeters; Computation Resolution (Scale): 4000 m (1/24-deg).
- Processing** section: Statistic (over day range): Total; Calculation: Values.
- Time Period** section: Period of Record: 1979-01-01 to 2021-12-14; Last 60 Days of Data.
- Start Date: 2021-10-16; End Date: 2021-12-14.
- GET MAP LAYER** (green button)

The main map area shows a satellite-style view of Bolivia. At the top of the map, there are navigation options: Colors, Map, Layers, Masking, Download, Link, and Reset. A search bar at the bottom of the map contains the text "Bolivia" and a "Center Map" button. The map shows various geographical features, including rivers, lakes, and national parks. The word "Bolivia" is prominently displayed in the center of the map.

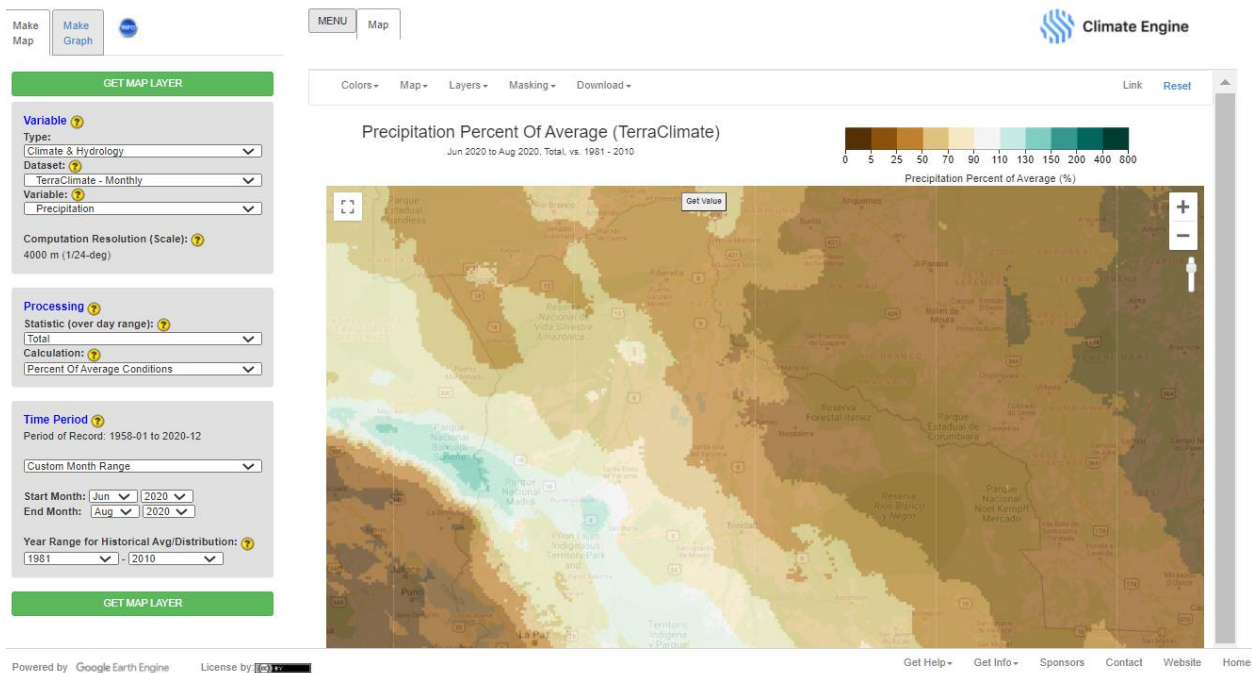
At the bottom of the page, there is a footer with the following text: "Powered by Google Earth Engine License by [Creative Commons] Get Help - Get Info - Sponsors Contact Website Home".

6. Along the top, click on the **Map** dropdown menu, then under **Base Map**, select **Road Map**. Close the Map Options menu.

Precipitation and Drought

7. Along the left-hand side, use the **Make Map** panel to select your visualization options.
 - a. Keep the **Variable Type** as **Climate and Hydrology**
 - b. Change the **Dataset** to **TerraClimate- Monthly**
 - c. Under **Variable** select **Precipitation**
 - d. Under **Processing**, keep the **Statistic (over day range)** as **Total** and change the **Calculation** to **Percent of Average Conditions**
 - e. Under **Time Period**, select **Custom Month Range**
 - i. **Start Month: Jun 2020**
 - ii. **End Month: Aug 2020**
 - f. The **Year Range for Historical Avg/Distribution** will be left as the default range for this exercise
 - g. Click on **Get Map Layer** along the bottom and wait for the map to load

During this step, and for many of the steps in this exercise, there is a large computational lift, and therefore it can take a few minutes for your map to load. Please be patient. If the map does not load you can always use the Reset button along the top and repeat the steps above. Additionally, if many users are conducting analysis on Climate Engine, the time for maps to load can be delayed.



8. Along the top of the map, click on **Get Value**. Move the geomarker to a region of interest. Click on **Show Value** and wait for the data to load.
 - a. Here you can see a wide range of precipitation anomalies, from nearly average to extremely below average. On my map I selected a region that had nearly 24% of average rainfall.

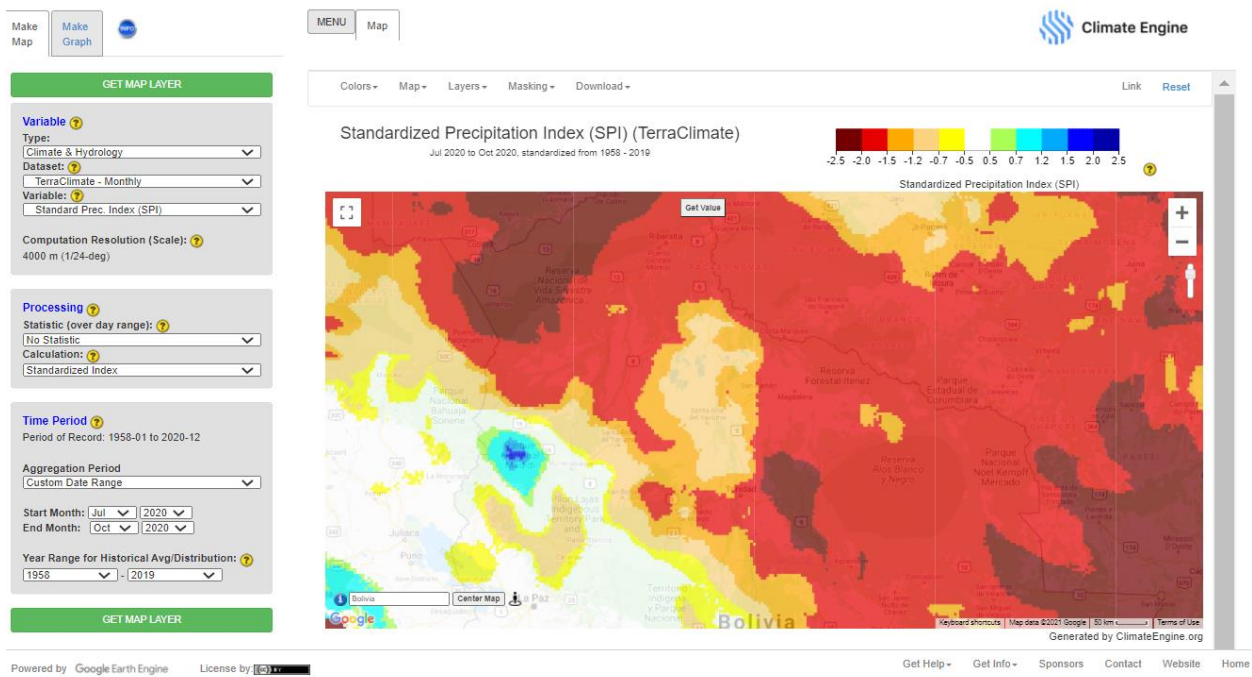
9. **Optional Step:** Change the date range to **Start Month: Sept 2020, End Month: Nov 2020** and see how your map compares.
10. **Optional Step:** Zoom out and examine the larger-scale regional precipitation patterns for different date ranges around the time of the fire outbreak. What are the regional patterns?

We can also compare various drought indices that are a reflection of the precipitation (and other climate variables like evapotranspiration) anomalies.


11. In the **Make Map** panel, change the **Variable** to the Standardized Precipitation Index (SPI)
12. Under **Time Period**, select **Custom Date Range**
 - a. Start Month: Jul 2020
 - b. End Month: Oct 2020

This will generate a map of the 3-month SPI leading up to the fire outbreak.

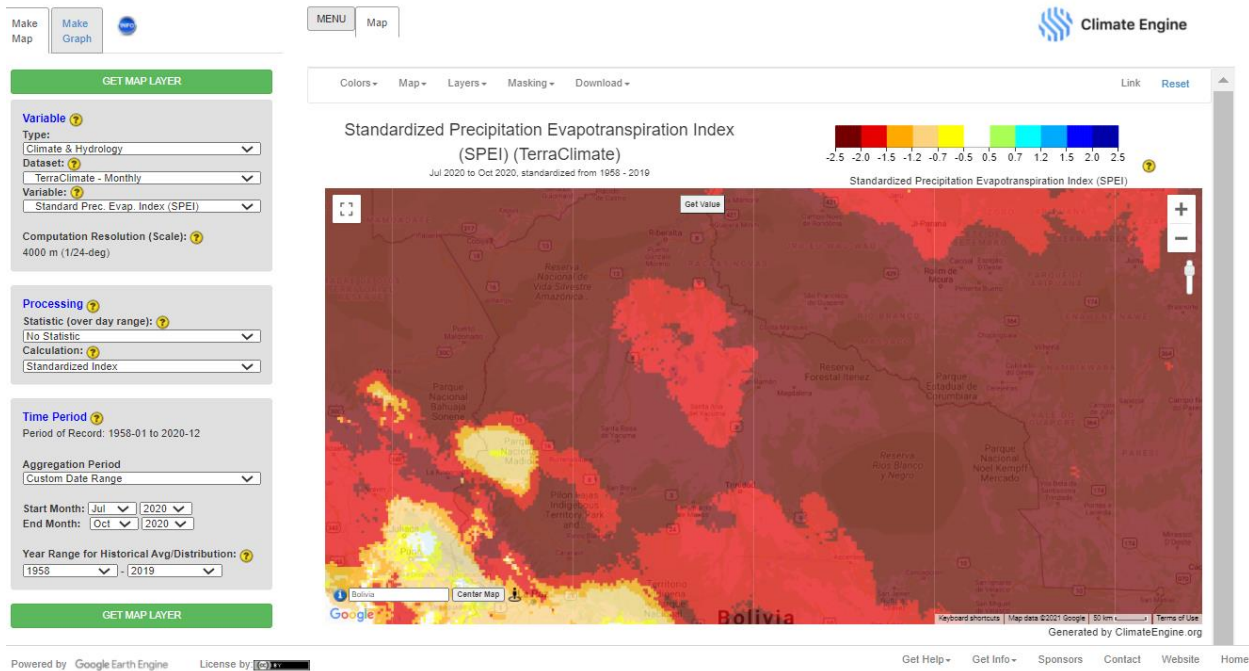
13. Click on **Get Map Layer** and wait for the map to load



Here you can see that the 3-month SPI value is quite low for much of the region.

14. Click on the yellow question mark icon  next to the SPI legend along the top of the map.
 - a. Here you can view the US Drought Monitor categories alongside the color scheme on the map.

15. Along the **Make Map** panel, change the **Variable** to the **Standardized Precipitation Evap. Index (SPEI)**
16. Keep all other settings the same as the previous steps. Click on **Get Map Layer** and wait for the map to load.
 - a. Notice that the drought designation for the SPEI is displaying more extreme drought conditions for the region with the incorporation of evapotranspiration anomalies.



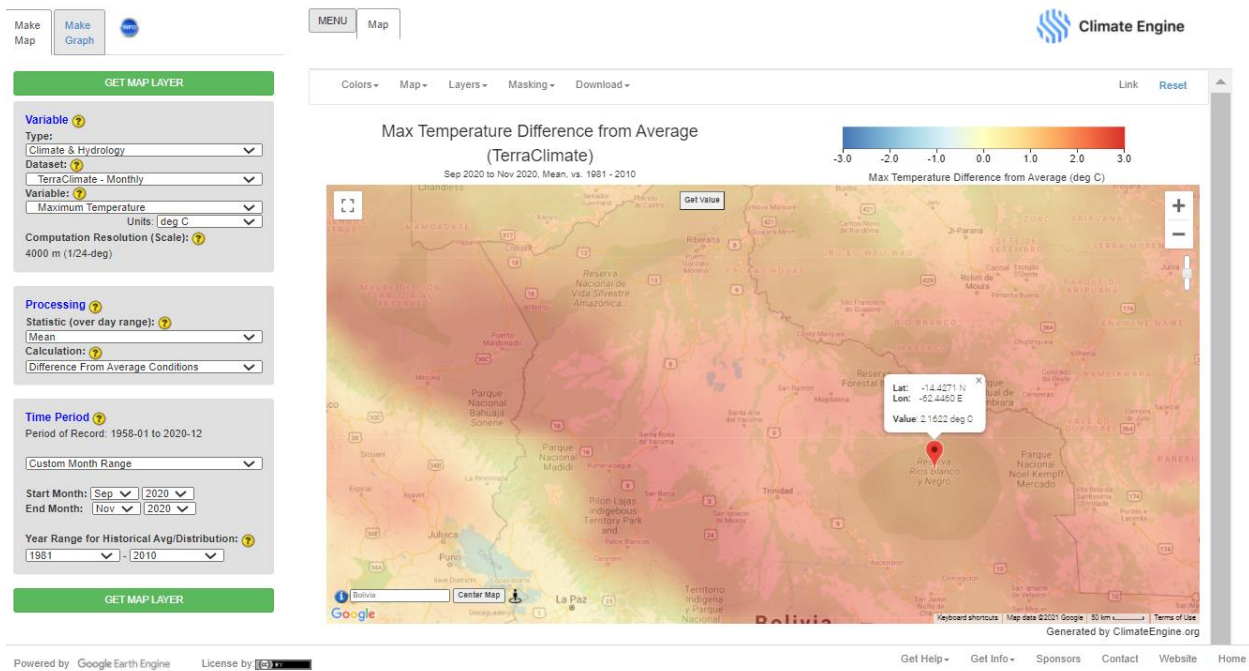
Note that if the data have loaded on your map, and the **Processing Request** window is still up, you can click on **Cancel Request** to view and interact with the data.

Temperature

17. Click on **Reset** along the top right of the webpage and wait for the map to reset.
18. In the **Enter Place or Location** box, type: **Bolivia** and click on **Center Map**.
 - a. Zoom in to view the northern half of the country in the map
19. Under **Map** along the top, change the **Base Map** to **Road Map**
20. Along the left-hand side, use the **Make Map** panel to select your visualization options.
 - a. Keep the **Variable Type** as **Climate and Hydrology**
 - b. Change the **Dataset** to **TerraClimate- Monthly**
 - c. Under **Variable** select **Max Temperature**
 - d. Under **Processing**, keep the **Statistic (over day range)** as **Mean** and change the **Calculation** to **Difference From Average Conditions**

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- e. Under **Time Period**, select **Custom Month Range**
 - i. Start Month: Sep 2020
 - ii. End Month: Nov 2020
- f. Click on **Get Map Layer** along the bottom and wait for the map to load
21. Use the Transparency slider along the right hand side (under the zoom buttons) to make the map 50% opaque
22. Click on **Get Value** and center a geomarker on Reserva Rios blanco y Negro. You may need to zoom in to see the label. Click on **Show Value** and wait for the data to load.
 - g. Here you can see that the maximum temperature difference from average was 2.2 degrees Celsius hotter than normal

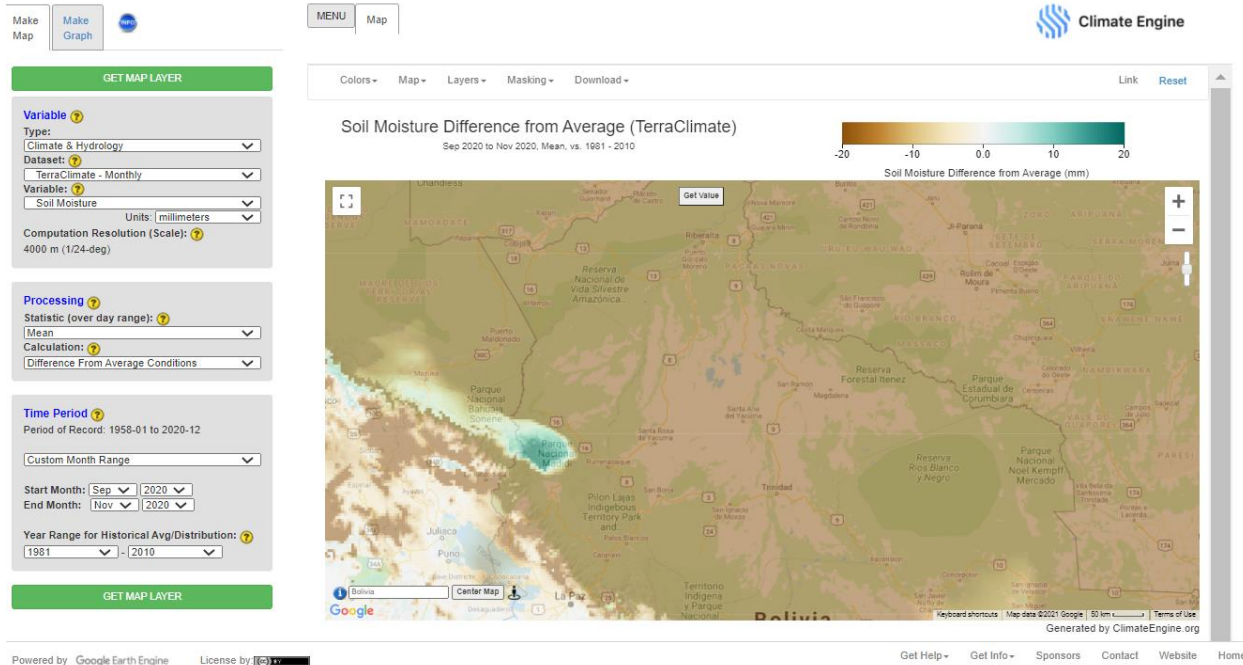


23. **Optional Steps:** Check out the temperature anomalies from a few other dates in 2020.

Soil Moisture

24. Ensure your map is centered on northern Bolivia
25. Along the left-hand side, use the **Make Map** panel to select your visualization options.
 - a. Keep the **Variable Type** as **Climate and Hydrology**
 - b. Keep the **Dataset** as **TerraClimate – Monthly**
 - c. Under **Variable** select **Soil Moisture**
 - d. Under **Processing**, keep the **Statistic (over day range)** as **Mean** and the **Calculation** to **Difference From Average Conditions**

26. Under **Time Period**, keep the date as **Custom Month Range**
 - a. **Start Month: Sep 2020**
 - b. **End Month: Nov 2020**
27. Click on **Get Map Layer** along the bottom and wait for the map to load



Here you can see that much of the region is also experiencing below average soil moisture conditions of around -10mm.

28. **Optional Step:** Take a look at some of the other climate model products under **Datasets** to see if there are other soil moisture metrics to analyze. Run the analysis for the same time period or test out the MAM or JJA time periods.

Climate Water Deficit

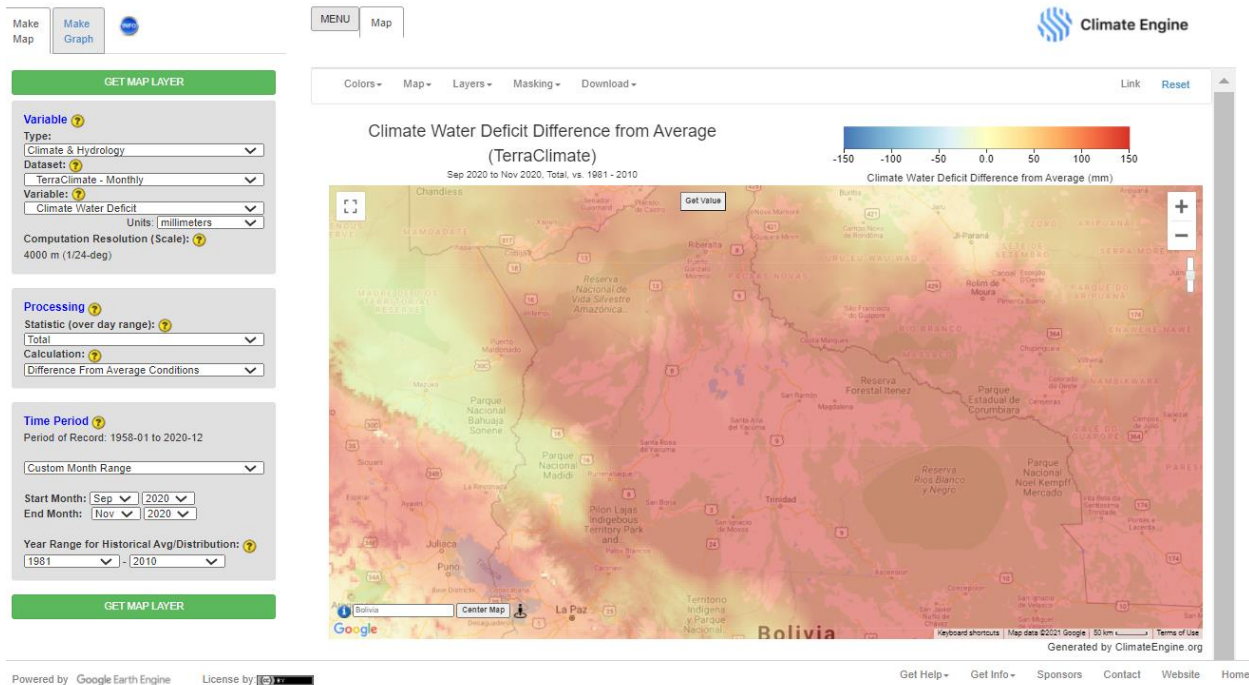
The term climatic water deficit defined by Stephenson (1998) is quantified as the amount of water by which potential evapotranspiration (PET) exceeds actual evapotranspiration (AET). This calculation is an estimate of drought stress on soils and plants.

29. Ensure your map is centered on northern Bolivia
 - a. Keep the **Variable Type** as **Climate and Hydrology**
 - b. Keep the **Dataset** as TerraClimate - Monthly
 - c. Under **Variable** select **Climate Water Deficit**
 - d. Under **Processing**, set the **Statistic (over day range)** as **Total** and the **Calculation** as **Difference From Average Conditions**
30. Under **Time Period**, keep date to **Custom Month Range**

a. **Start Month: Sep 2020**

b. **End Month: Nov 2020**

31. Click on **Get Map Layer** along the bottom and wait for the map to load



Here you can see the trend of drought continuing with the Climate Water Deficit. Please see the References section for more information about this variable and how it is calculated.

Another great feature of Climate Engine is the ability to make time series figures of many of these variables. For example, you can compare how precipitation varies with drought indices.

32. Click on the **Make Graph** tab on the left

33. Under **Time Series Calculation** leave **Native Time Series** selected and change the second drop-down option to **Two Variable Analysis**

34. Under **Region**, select **Polygon**

- a. When you do this, a pop-up will appear to assist you in creating a custom polygon.
- b. Click on the rectangle on the top left of the map and click on the map to select a rectangular region in northern Bolivia.

Create/Update a Polygon ✕

How to create a polygon:

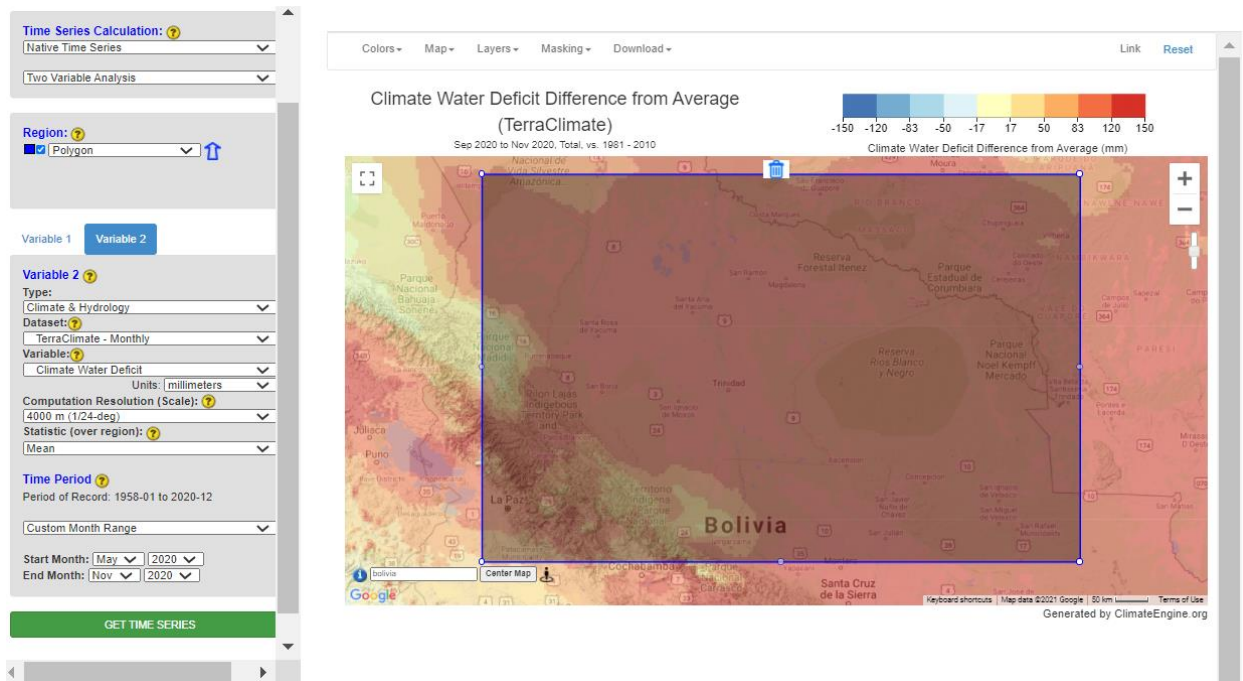
- (1) Click **Rectangle** or **Polygon** on map
- (2) Draw on the map **Polygon**: Click locations on map in order of Polygon vertices. Click initial vertex to close the Polygon.
Rectangle: Click at a corner, hold and drag.

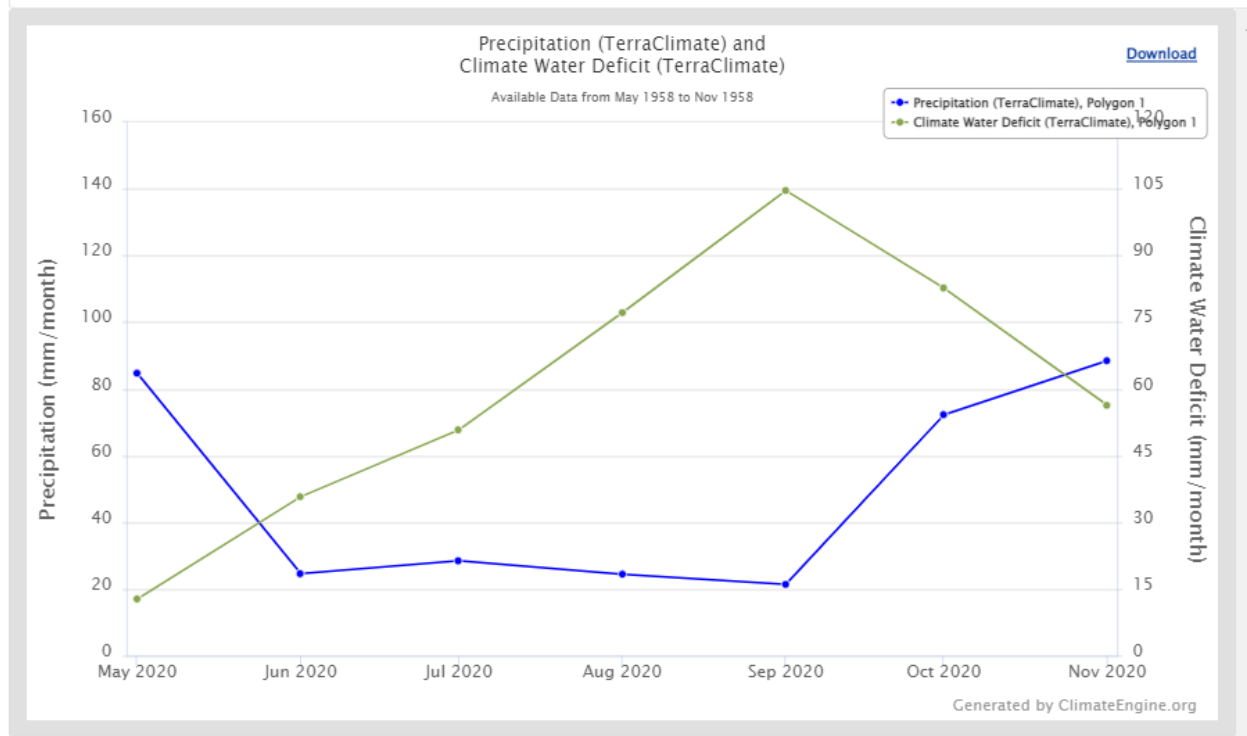
How to delete a polygon: (1) Click on map

How to name a polygon:
 Enter a name for the polygon (to put on graph).
 Click **UPDATE** button.

Ways to update a

35. Under Variable 1 modify these settings:
 - a. **Type:** Climate and Hydrology
 - b. **Dataset:** TerraClimate – Monthly
 - c. **Variable:** Precipitation, keep the units as mm
 - d. Keep the **Computational Resolution** and the **Statistic** as the default
 - e. **Time Period:** Custom Month Range
 - i. Start Month: May 2020
 - ii. End Month: Nov 2020
36. Under the Variable 2 tab modify these settings:
 - a. **Type:** Climate and Hydrology
 - b. **Dataset:** TerraClimate – Monthly
 - c. **Variable:** Climate Water Deficit
 - d. Keep the **Computational Resolution** and the **Statistic** as the default
 - e. **Time Period:** Custom Month Range
 - i. Start Month: May 2020
 - ii. End Month: Nov 2020
37. Click on Get Time Series and wait for the figure to load





Now you can see that as precipitation decreases in the region, the climate water deficit increases, as to be expected.

38. **Optional Step:** Take a look at some of the other products and make additional figures for comparisons.

Note that the monthly wind speed in this region was not anomalous, and therefore we will not investigate it as a factor in the fire ignition or spread in this example. However, you may investigate this using the Wind Speed variable in the TerraClimate – Monthly dataset.

Part 2: Pre-fire Landscape Characteristics

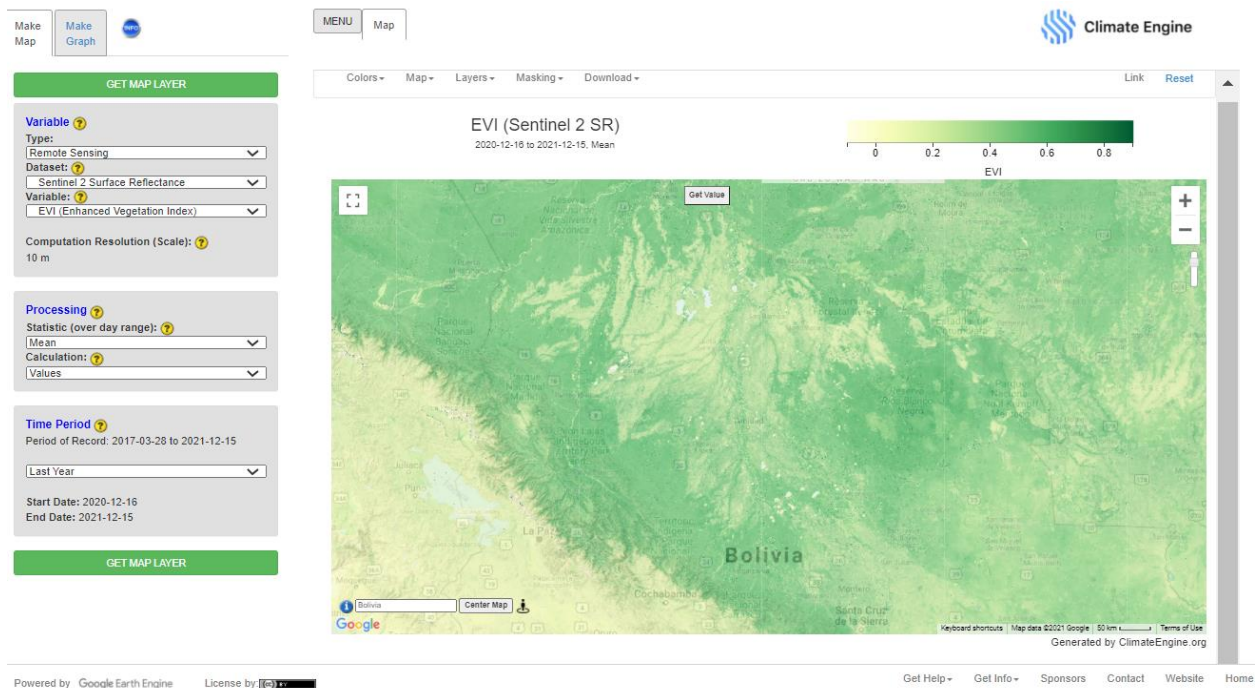
Topography

1. Click on **Reset** along the top right of the webpage.
2. Under **Enter Place or Location**, type: **Bolivia** and click on **Center Map**. Then zoom into the region of northern Bolivia.
3. Under **Map** along the top, change the **Base Map** to **Terrain**
 - a. Unlike our Lytton, BC example the terrain in the regions where the fires occurred is less mountainous and includes many low-lying wetlands and forested regions. You can however, see the higher elevation regions to the west around La Paz.

Vegetation Health

4. Ensure your map is centered on northern Bolivia
5. Along the left-hand side, use the **Make Map** panel to select your visualization options.
 - a. Change the **Variable Type** to **Remote Sensing**
 - b. Change the **Dataset** to **Sentinel 2 Surface Reflectance**
 - c. Ensure the **Variable** is **NDVI (Vegetation Index)**
 - d. Under **Processing**, ensure the **Statistic (over day range)** is **Mean**
 - e. Ensure the **Calculation** is **Values**
6. Under **Time Period**, select **Last Year**
7. Click on **Get Map Layer** along the bottom and wait for the map to load.
8. **Optional Steps:** Take a look at the EVI and/or the NDVI using Landsat. How do the values compare?

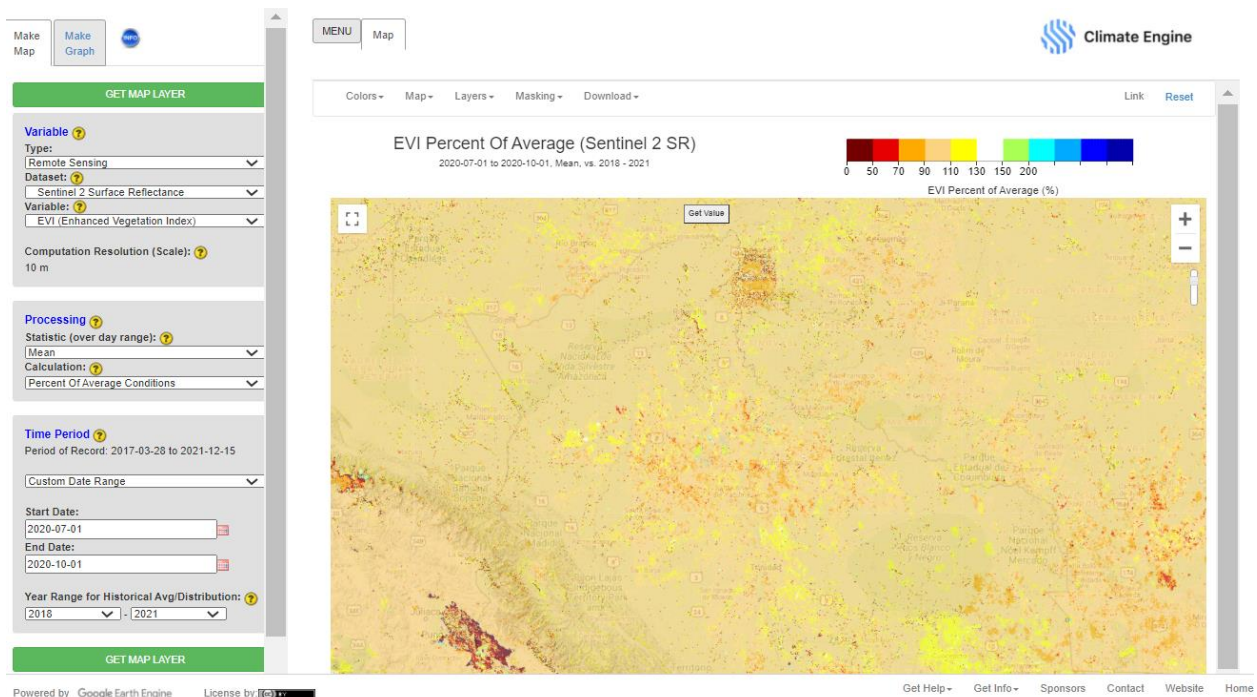
Here you can see that much of the region has dense vegetation, with lower vegetation in the mountainous regions to the west. Note that for this example, we used the Enhanced Vegetation Index (EVI), which can be more useful in dense vegetated regions like the Amazon rainforest. Now let's take a look at how healthy the vegetation is in this region in the months prior to the fires and during the fires.



9. Ensure your map is centered on northern Bolivia
10. Along the left-hand side, use the **Make Map** panel to select your visualization options.

- f. Change the **Variable Type** to **Remote Sensing**
 - g. Change the **Dataset** to **Sentinel 2 Surface Reflectance**
 - h. Ensure the **Variable** is **EVI (Vegetation Index)**
 - i. Under **Processing**, ensure the **Statistic (over day range)** is **Mean**
 - j. Change the **Calculation** to **Percent of Average Conditions**
11. Under **Time Period**, select **Custom Date Range**
 - a. **Start Date: 2020-07-01**
 - b. **End Date: 2020-10-01**
 12. Click on **Get Map Layer** along the bottom and wait for the map to load

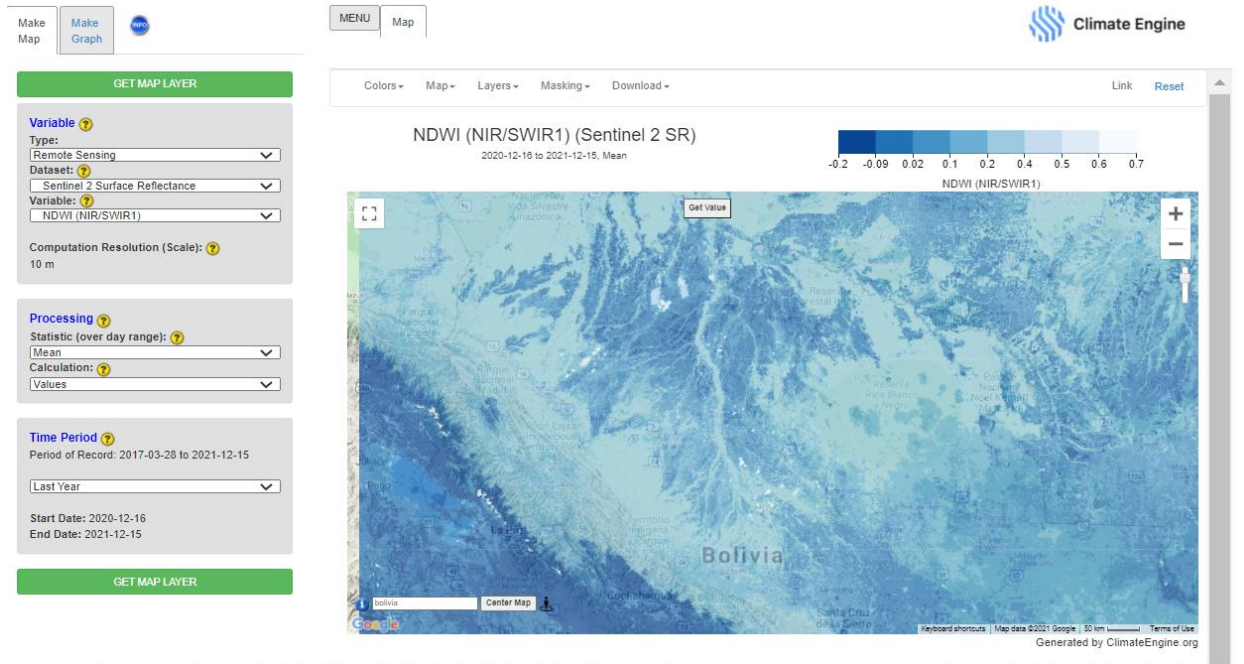
In the months preceding the wildfire outbreak, relatively normal EVI values. This is to be expected, as the tropical and sub-tropical vegetation vigor does not fluctuate as much as we see in the northern latitudes alongside temperature and precipitation variability.



Now let's take a look at the NDWI to identify variations in the moisture content of the vegetation. First, we will view the typical NDWI values in the region, then we will examine the difference from average.

13. In the **Make Map** panel change the **Variable** to **NDWI (NIR/SWIR1)**
 - k. Under **Processing**, ensure the **Statistic (over day range)** is **Mean**
 - l. Change the **Calculation** to **Values**
14. Under **Time Period**, select the **Last Year**
15. Click on **Get Map Layer** along the bottom and wait for the map to load

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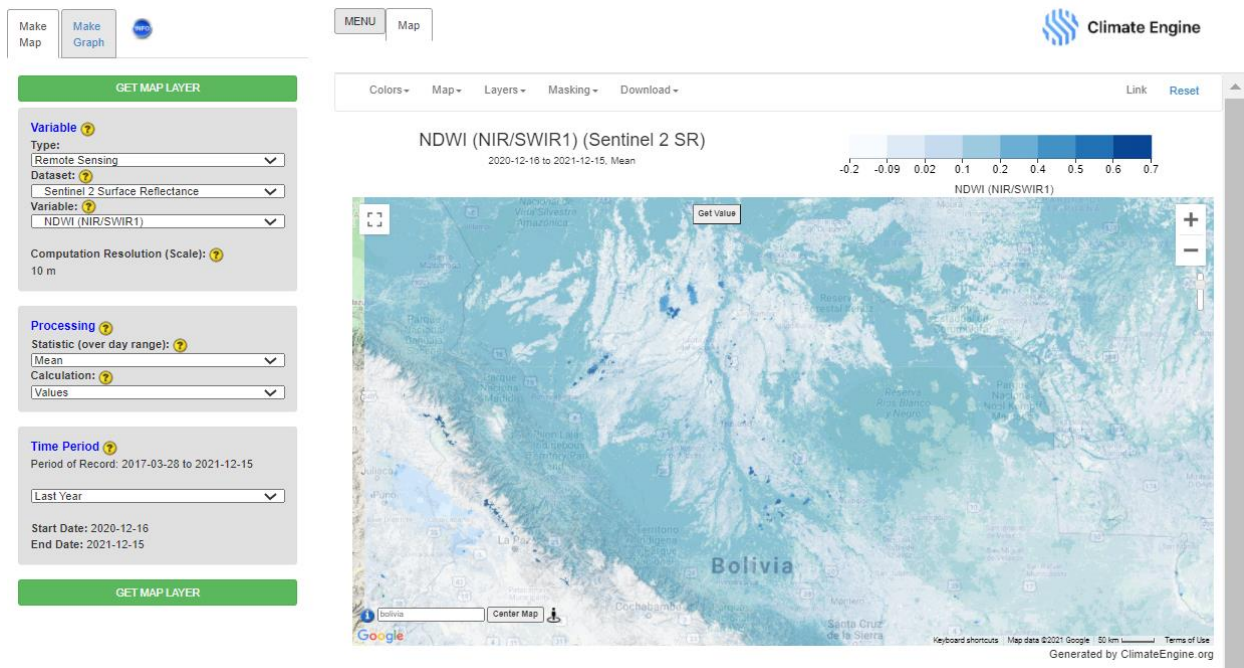


Here you can see that the NDWI values range from about 0.02 to 0.7 and vary based on the topography. Another nice feature of Climate Engine is the ability to modify the legend colors, as you can see in this example, the darker blue indicates less vegetation moisture, which is a little counterintuitive.

16. In the tabs above the map, click on **Colors**

17. Open the drop-down next to **Color Palette**, and click on **Blues**

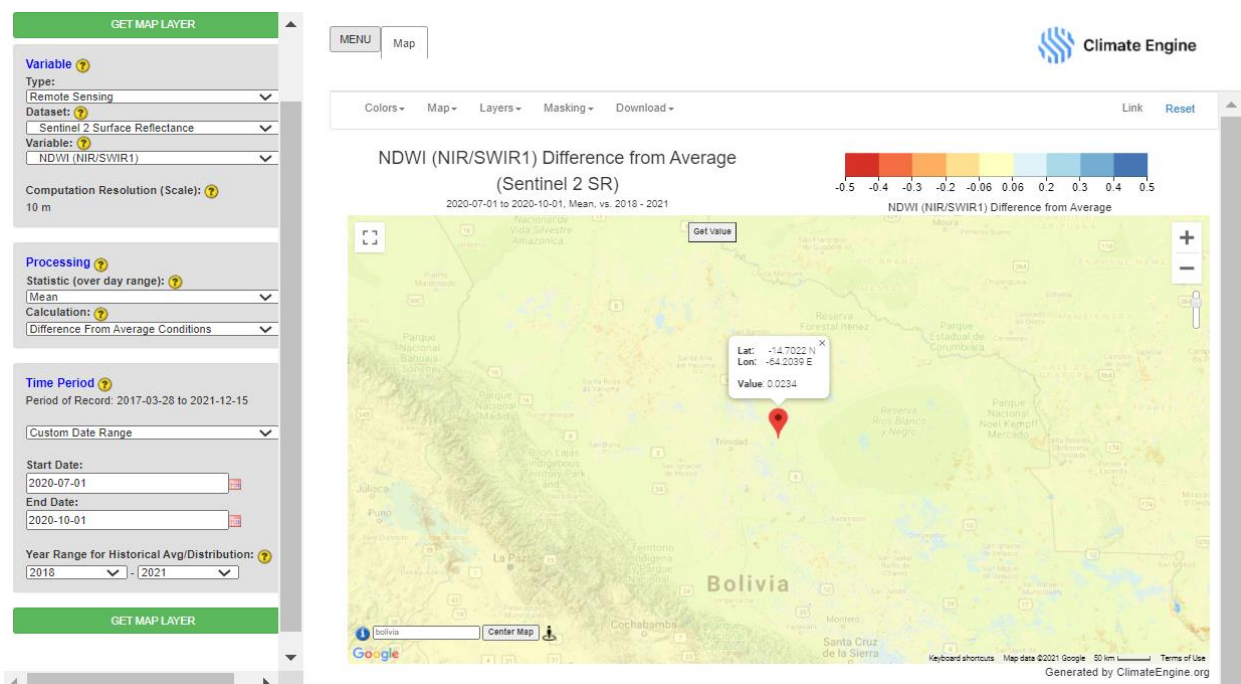
18. Click on **Update Map Layer** and wait for the map to load



Here you can see the darker blues representing more vegetation moisture. Now let's see how the time period during the fires deviated from those average vegetation moisture conditions.

19. In the **Make Map** panel change the **Calculation** to **Difference From Average Conditions**
20. Under **Time Period**, select Custom Date Range
 - a. **Start Date: 2020-07-01**
 - b. **End Date: 2020-10-01**
21. Click on **Get Map Layer** along the bottom and wait for the map to load

As with the EVI calculation, it appears that the vegetation moisture is also close to normal in the region.



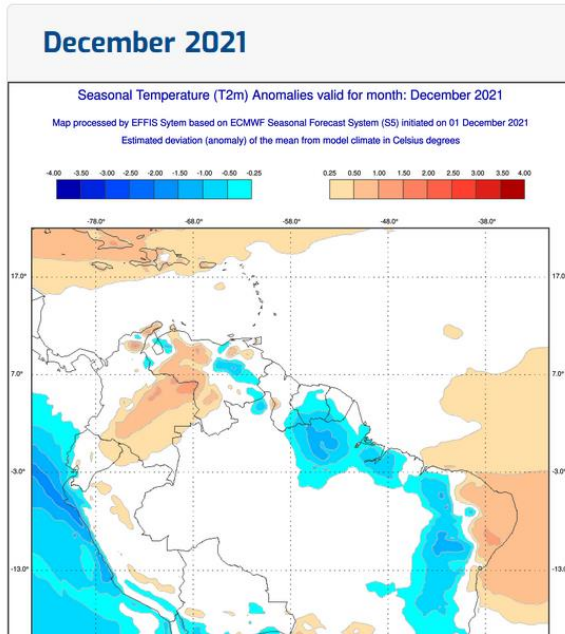
Part 3: The Global Wildfire Information System (GWIS)

In the final portion of this exercise, we will explore the Global Wildfire Information System (GWIS).

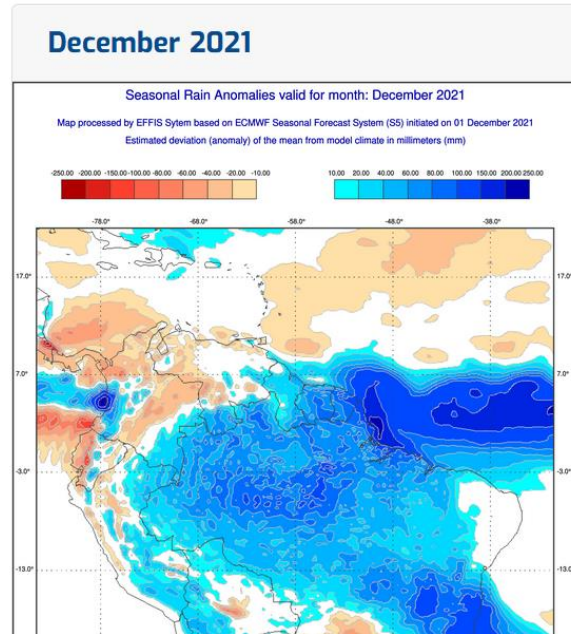
1. Navigate to the GWIS website: <https://gwis.jrc.ec.europa.eu/>
 - a. Read about the program and global work
2. Scroll to the bottom of the webpage and click on **Long-term fire weather forecast**
3. Along the left side, click on **South America**

- a. Take a look at the **monthly** and **seasonal** maps of temperature and rainfall anomalies.

Temperature anomalies



Rain anomalies



We can also look retrospectively at various fire danger data layers using the Current Situation Viewer.

4. Along the top of the webpage, click on **Apps**
5. Click on **Current Situation Viewer**

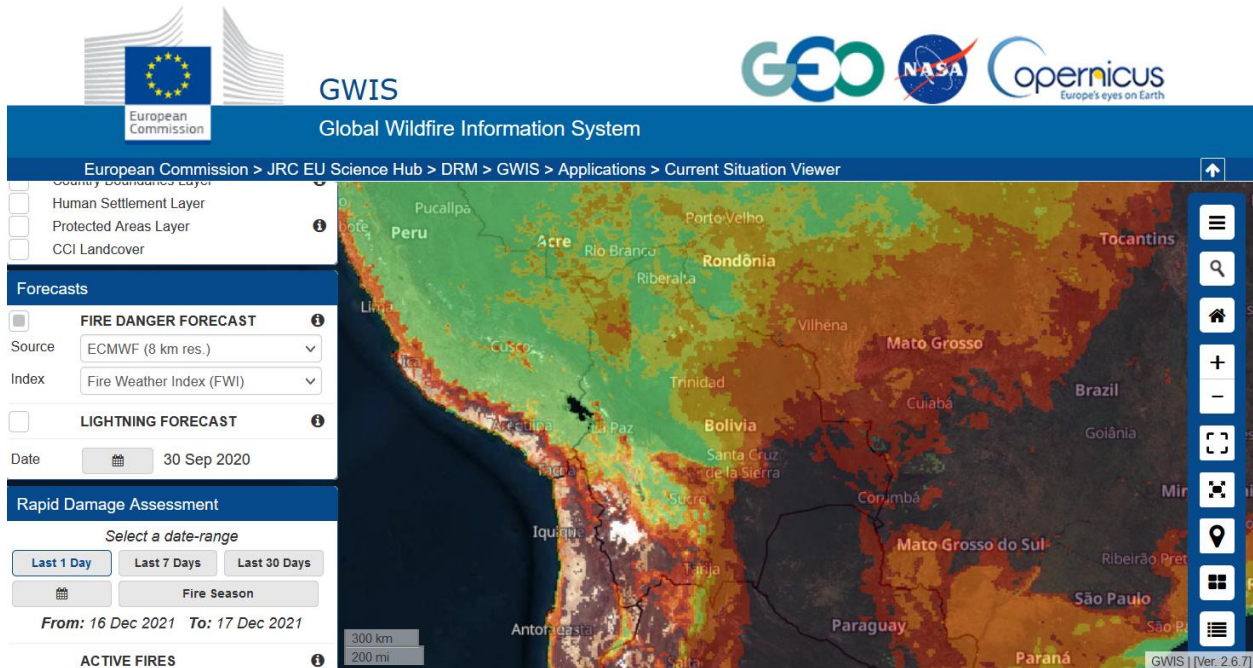
Within the **Current Situation Viewer**, you can add various **Map Options** and **Forecasts** layers along the left side. Along the right side you can modify and navigate around the map.

6. Move the map view to our study region in Bolivia
7. Under the **Forecasts** tab, change the Date to **September 30, 2020** by clicking on



the **Calendar** icon

8. Turn on the Fire Danger Forecast Layer by checking the box in the **Forecasts** tab. This will automatically display the Fire Weather Index (FWI) that we have viewed before.

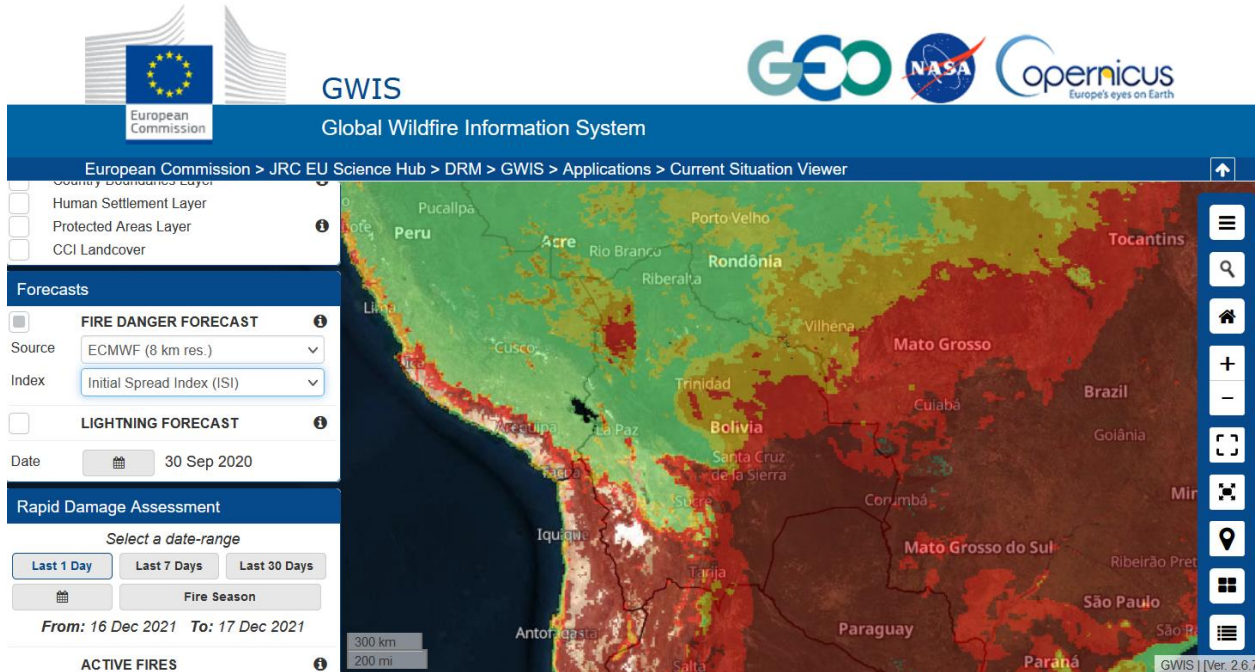


The GWIS has many other layers that were not available in Climate Engine, such as the Initial Spread Index, the Duff Moisture Code, etc.

9. Click on the information icon next to **FIRE DANGER FORECAST** on the left panel.
 - a. Read through the technical information about each of these data layers. As mentioned in the lecture, there are many different fire danger methods and calculations and can be simple or complex.
 - b. Review the **Fire Danger** classes on the table shown here.
 - c. In the **Current Situation Viewer**, the colors corresponding to these ranges are:
 - i. Very low: white
 - ii. Low: Green
 - iii. Moderate: Yellow
 - iv. High: Orange
 - v. Very High: Red
 - vi. Extreme: Purple
10. Go back to the **Current Situation Viewer**
11. Under the **Forecasts** tab, change the **Index** to **Initial Spread Index (ISI)**

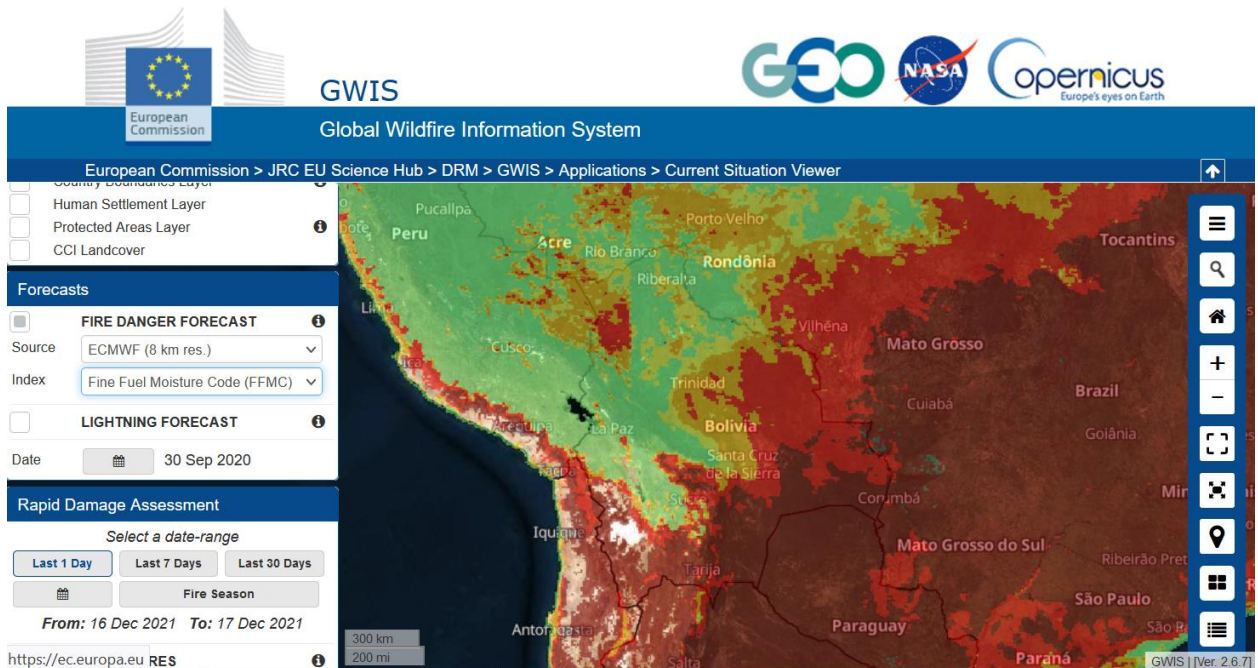
Fire Danger Classes	FWI ranges (upper bound excluded)
Very low	< 5.2
Low	5.2 - 11.2
Moderate	11.2 - 21.3
High	21.3 - 38.0
Very high	38.0 - 50.0
Extreme	>= 50.0

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Similarly, you can see that the ISI indicated that much of the region is experiencing high or extreme ISI values.

12. Under the **Forecasts** tab, change the Index to **Fine Fuel Moisture Code**



Here you can see that the fuels in this region are very dry, confirming what we have seen from previous analysis and increasing the possibility for large fire outbreaks and fire spread.

13. **Optional Steps:** Explore the different Fire Danger Forecast Options on the Current Situation Viewer. Explore different regions and time periods of areas or specific fire conditions you are interested in. We will come back to the GWIS Current Situation Viewer for our Bolivian Fires examples in the next exercise.

Conclusion

That concludes this exercise on pre-fire monitoring for the 2020 Bolivian fire outbreak. We used various online webtools for exploring the pre-fire climate conditions and the landscape conditions. In part two of our training series, we will explore post-fire conditions such as burned area and burn severity using Google Earth Engine.

Resources

- Climate Engine: <https://climateengine.com/>
- TerraClimate Paper: <https://www.nature.com/articles/sdata2017191>
- Climate Water Deficit Paper: <http://climate.calcommons.org/bib/actual-evapotranspiration-and-deficit-biologically-meaningful-correlates-vegetation-distribution>
- SERVIR Amazon Dashboard: <https://globalfiredata.org/pages/amazon-dashboard/>
- Global Wildfire Information System (GWIS): <https://gwis.jrc.ec.europa.eu/>
- NASA Global Fire Weather Database: <https://data.giss.nasa.gov/impacts/gfwed/>
- Earth Observatory Article about the Bolivian Fire outbreak: <https://earthobservatory.nasa.gov/images/147408/fierce-fires-in-bolivia>