DSET Application Case Study: Drought

Please refer to the primary User Guide document for a general overview of the Navajo Nation Drought Severity Evaluation Tool (DSET) and a complete list of case study examples (including agriculture, wildfire, snowpack, and downloading data). If you are only interested in the drought case-study example, you can use this document.

Introduction

As temperatures rise under a warming climate, drought risk increases, especially in arid to semi-arid regions like the Navajo Nation (N.N.). Drought is experienced when an area faces prolonged shortages of water supply. A lack of precipitation can lead to not only environmental impacts, but social and economic hardships as well. The length and severity of drought can also lead to varied impacts.

The various types of droughts include: meteorological, ecological, hydrological, and agricultural. Meteorological droughts are local events and are characterized by low precipitation (in comparison to long-term averages) in the region affected. Ecological droughts caused by reduced rainfall can have impacts on the ecosystem such as loss of plant growth, increase in fire outbreaks, altered rates of nutrient and water cycling and more leading to local species extinction. Lack of precipitation in Hydrological droughts affect streamflow, soil moisture, reservoir and lake levels, and groundwater recharge. Agricultural droughts occur when available water supplies are not able to meet crop water demands.

Short-term droughts are seasonal, while long-term droughts can last decades. On the N.N. short-term droughts can impact the water supply provided by surface water. The impact on groundwater levels can come as a result of long-term drought. Water resource managers can mitigate issues of drought impacts on water supply thorough measures of temporary water conservation, water transfers, and increased use of groundwater.

The Drought Severity Evaluation Tool (DSET) can help in understanding the extent and severity of drought in order to conduct drought assessments that can be used for mitigation decision-making. The data available on DSET provide opportunities to create place-based and near real-time drought assessments. Understanding these drought risks can help the N.N. prepare responses to water supply impacts on agriculture, availability of water for livestock, rangeland vegetation health, and community access to water.

Components of Analysis

- Datasets: METDATA/gridMET
- Variable: Precipitation (PPT) and the Standardized Precipitation Index (SPI)

Objectives

- Use the DSET to develop a drought assessment by evaluating patterns of precipitation for the Last Northern Water Year (Oct – Sept). In this example the time period for the Last Northern Water Year was from 2018-10-01 to 2019-09-30. Depending on the year this exercise is completed the dates for the Last Northern Water Year will change.
- Map the daily precipitation totals in millimeters and calculate the difference from average for the Last Northern Water Year (Oct – Sept) the Navajo Nation using METDATA/gridMET - Daily calculations.
- Calculate the METDATA/gridMET - Daily precipitation Percent of Average conditions for the Navajo Nation for the Last Northern Water Year (Oct – Sept).
- Evaluate drought across the Navajo Nation using the Standardized Precipitation Index (SPI) for the Last Northern Water Year. This example uses the METDATA/gridMET dataset standardized precipitation index (SPI) calculations for the Custom Date Range start date of 2018-10-01and end date of 2019-09-30, the Last Northern Water Year.
- Calculate the six-month and twelve-month gridMET SPI for the Navajo Nation Nageezi Chapter using the Area Averaged Region for dates from 2018-12-31 to 2020-01-01.

Helpful Tips

- DSET is optimized for Google Chrome, please use Chrome.
- Faster networks are preferred when using DSET.
- Zoom to area of interest before submitting map requests to help with re-computing data.
- Resubmission and reset of DSET can help with fail requests that produce a server error.
- The figures included in this case study will help you navigate the DSET to locate the features associated with each step. It is suggested that you use the figure to ensure your selections are correct prior to completing each major step within the exercise.
- In the case study exercise, a color-coding system is used to help with navigation of the DSET features. For example, the section heading **Visualization Layer**, matches the color of the wording you will find on the DSET webpage.

Estimated Time for Completion for the Drought Case Study: **38 Minutes**

This exercise for Case Study 1: Drought is divided into two sections. The first section is Part 1: Daily Precipitation for the Last Northern Water Year and the second is Part 2: Drought Index for the Navajo Nation.

Part 1: Daily Precipitation for the Last Northern Water Year

- Objective: Find the daily precipitation totals for the last northern water year across the Navajo Nation.

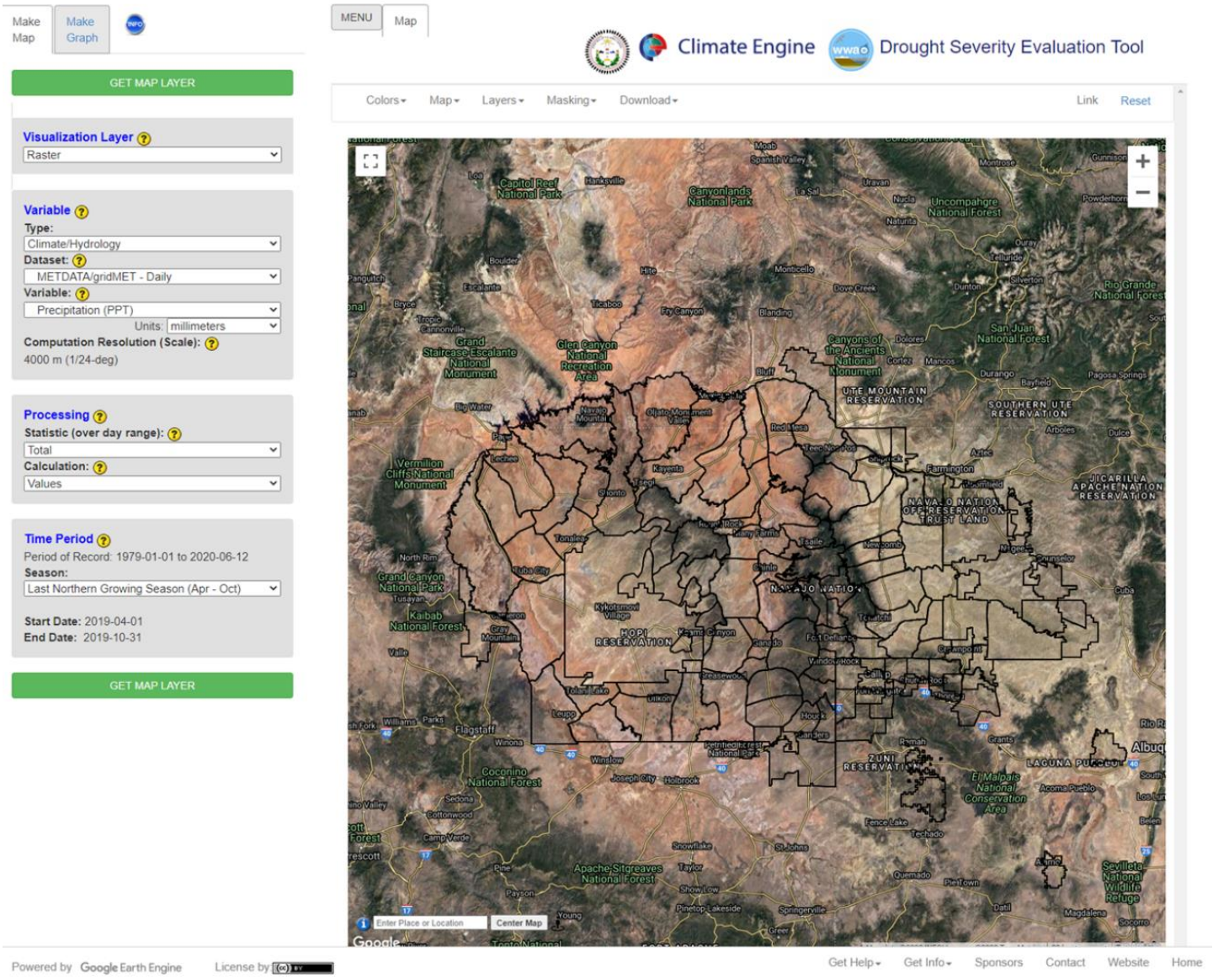

Figure 1. The DSET home screen displaying the entire Navajo Nation.

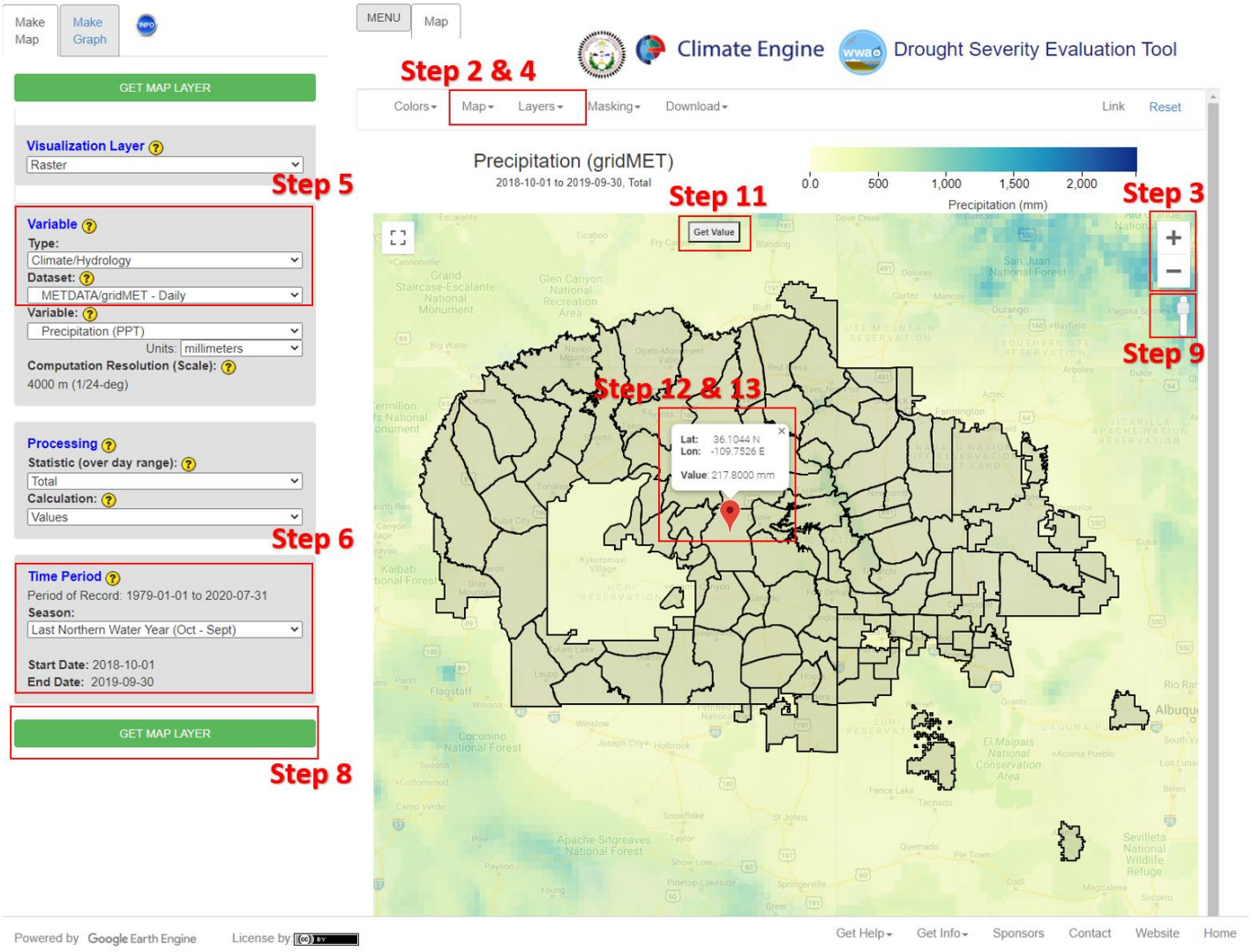

Figure 2. METDATA/gridMET - Daily calculations for the Navajo Nation for the Last Northern Water Year displaying the precipitation (mm). Guidance for steps 2 through 13 are indicated in this figure.

1. Go to the DSET website using this link https://app.climateengine.org/dset.
2. Under the **Layers** tab along the top, ensure that the **Navajo Nation Chapters** boundary is selected and displayed on the map.
    a. Note: The Navajo Nation Chapter boundaries should appear as the default.
3. Zoom into the Navajo Nation reservation boundary using the "+" sign along the top right.
4. Click on the **Map** tab along the top, which hosts the map options, and select the **Road map**.
5. Located on the Make Map panel on the left side of the webpage, under the **Variable** section leave the **Type** parameter as the default (**Climate/Hydrology**), and change the **Dataset** parameter to **METDATA/gridMET-Daily**.
6. Under the **Time Period** section located on the same panel, change the **Season** to **Last Northern Water Year (Oct– Sept)**.
    a. Selecting the Last Northern Water Year (Oct– Sept) will change the start date to **2018-10-01** and end date to **2019-09-30**. Depending on the year of analysis the Water Year (WY) will change. For example, if this exercise is done in the year 2022, the Last Northern Water Year (Oct—Sept) will have a start date of 2020-10-01 and an end date of 2021-09-30.
7. Leave all other options on the panel as default.
8. Click on **Get Map Layer**, wait for the map to load. The loading of the map may take a few minutes for the request to process.
9. Once the processing is complete, the map will automatically display the data. The **transparency** may be decreased or enhanced to better see the results. On the top right of the map, move the opacity slider 

down to 70% Opaque.
10. Your map should look like Figure 2 (above). Notice that the precipitation values are similar except for the higher elevation regions along the Chuska Mountain which has values above 500 mm.
11. Now let's examine the precipitation value at a specific point on the Navajo Nation. Click on the **Get Value** box located on the top center of the map.
12. For this analysis, we are interested in the precipitation for the **Tselani Chapter** area. Click the **Get Value** pop-up box and drag the **red geo marker**  to the Tselani Chapter boundary (see Figure 2 for where the Tselani Chapter is located).
13. Click on the blue **Show Value** box, wait for the request to be processed. The value calculated is the total precipitation for the Last Northern Water Year.

The result of this analysis shows that the Precipitation (PPT) variable in the METDATA/gridMET -Daily data set shows that the entire Navajo Nation for the Last Northern Water Year had less than 500 mm of precipitation (Figure 2), except for the higher elevation regions. Through DSET's layer capabilities N.N. Chapter analysis is available. For this example, in Figure 2 the Tselani N.N. Chapter showed that for the Last Northern Water Year the chapter area had around 217.8 mm of precipitation. Please be mindful that the value of precipitation will vary with latitude and longitude location within a chapter boundary. The 217.8 mm value for this exercise may be different from

the value you calculate. The reason for this variability is the value for the exact location you place the geo marker. To verify if your value is similar to this case study exercise use the precipitation value scale for reference located above the map. The next steps in this drought case study will be to understand the precipitation values more and how they correlate to drought conditions.

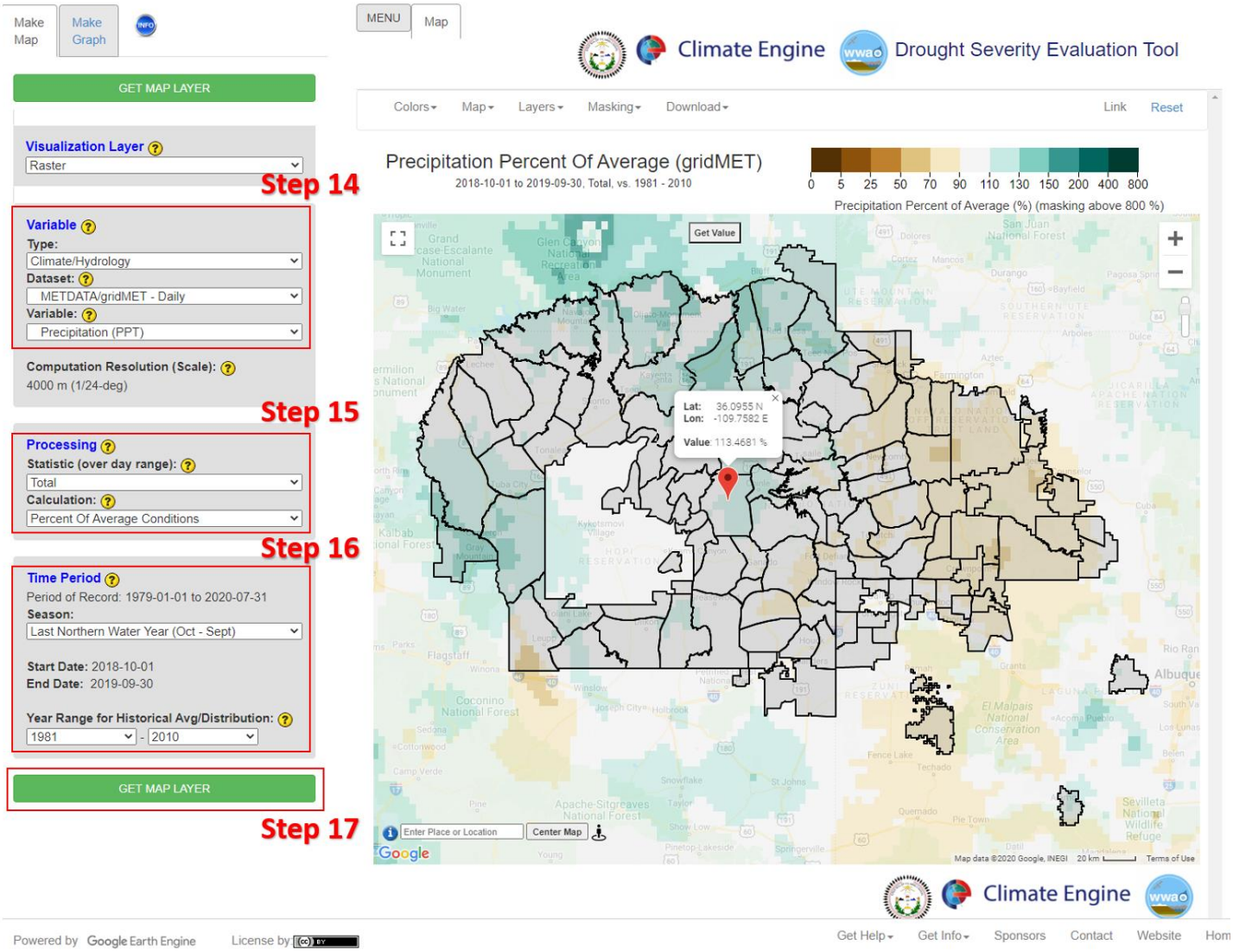

Figure 3. METDATA/gridMET -Daily precipitation percent of average conditions for the Navajo Nation for the Last Northern Water Year. Guidance for steps 14 through 17 are indicated in this figure.

14. Leave the **Variable** dataset as **METDATA/gridMET** and the **Variable** a **Precipitation (PPT).**
15. On the Make Map panel to the left under the **Processing** section and click on the drop-down arrow next to **Calculation** and select **Percent of Average Conditions**.
16. Keep the **Time Period** **Season** as the **Last Northern Water Year (Oct– Sept).**
    a. Note that by selecting the **Percent of Average Conditions**, the **Time Period** section now includes the **Year Range for Historical Avg/Distribution**. The

default years for the historical average range is from **1981 to 2010**, this is the standard climatology. Leave the default years in place for this case study analysis.

17. Click on **Get Map Layer**, wait for the map to load. The loading of the map may take a few minutes for the request. If you should get a **Sever Error or Time Error**, click **Cancel Processing** and click on **Get Map Layer** again. If the error persists, try to **Reset** DSET and run the analysis again (Steps 14 through 16).
18. Follow **Steps 11 through 13**, to get the value for the Tselani Chapter Percent of Average Conditions calculation.

Using the Percent of Average Conditions calculation takes the total precipitation in the Last 60 days and divides it by the "Average Conditions" that is multiplied by 100%. For the Tselani Chapter area selected previously the percent was found to be 113.47% (Figure 3). The Percent of Average Conditions are indicators of drought conditions. Although in this example some areas of the N.N. were found to be above 100% other areas were not. Over a longer time period these values could differ to show long-term drought. Keep in mind the percentage value in this case study exercise may be different from the exact percentage you calculate. Use the precipitation percent of average value scale to see if your percentage calculated correlates to this case study exercise.

Part 2: Drought Indices for the Navajo Nation

- Objective: Develop a map displaying drought severity on the Navajo Nation using the SPI index.

The SPI is a drought index that provides more comprehensive understanding of meteorological drought, or precipitation deficits, on the Navajo Nation.

1. Go to the DSET website using this link https://app.climateengine.org/dset or click on **Reset** to start over if you are already on the website.
2. Under the **Layers** tab along the top, ensure that the **Navajo Nation Chapters** boundary is selected and displayed on the map.
    a. Note: The Navajo Nation Chapter boundaries should appear as the default.
3. Zoom into the Navajo Nation reservation boundary using the "+" sign along the top right.
4. Click on the **Map** tab along the top, which hosts the map options, and select the **Road map**.

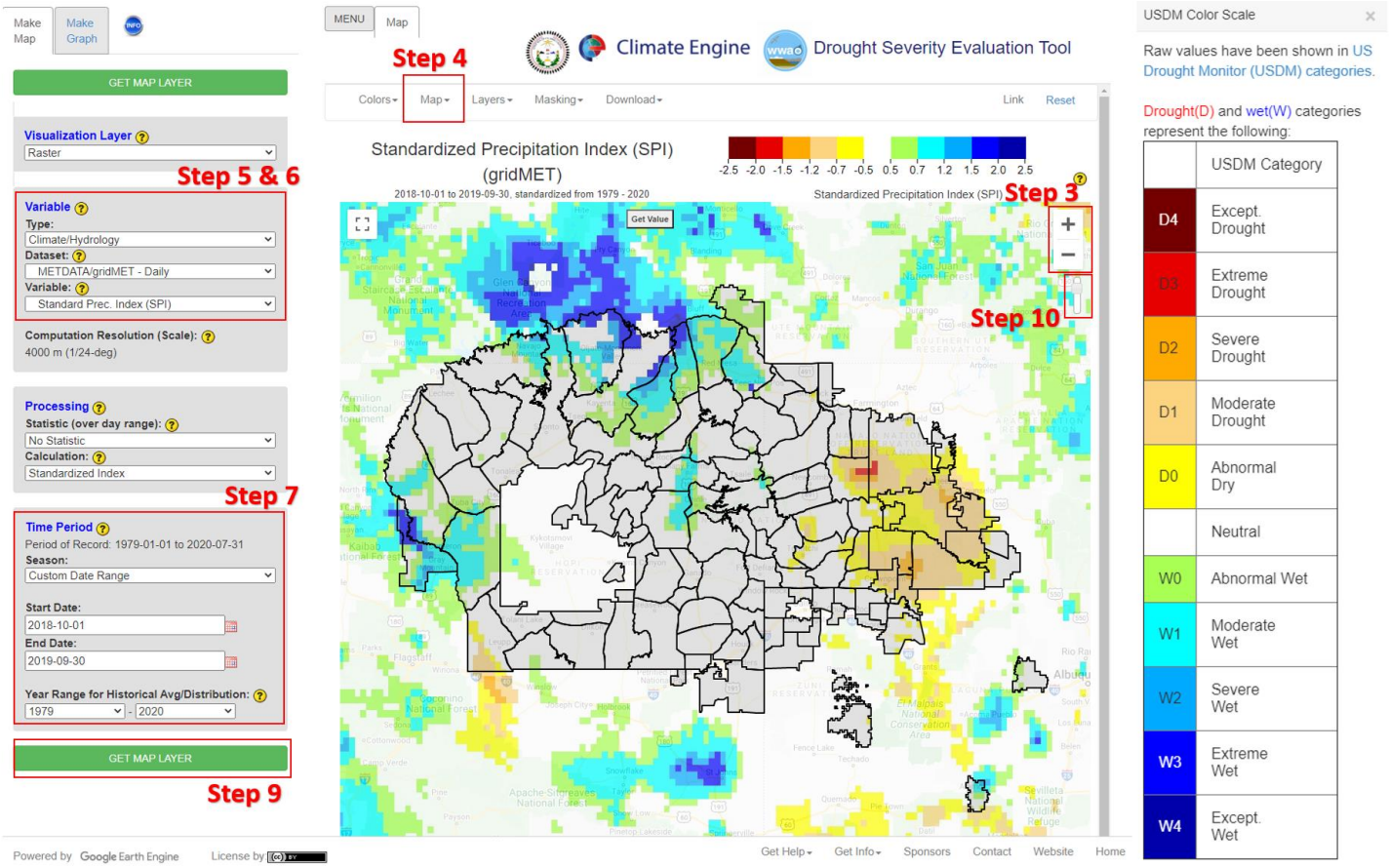

Figure 4. METDATA/gridMET standardized precipitation index (SPI) calculations for the Custom Date Range start date of 2018-10-01and end date of 2019-09-30, the Last Northern Water Year. The SPI is scaled according to the U.S. Drought Monitor Classification that categorizes the drought conditions. Guidance for steps 3 through 10 are indicated in this figure.

5. Located on the Make Map panel to the left of the screen, change the **Variable Dataset** to **METDATA/gridMET**.
6. In the **Variable** drop-down, select the **Standard Prec. Index (SPI)**.
    a. Click on the yellow question mark for a description of the SPI. You can also view the details on all the other available data layers here. The Navajo Nation uses a 6-month SPI value of ≤**-1.5** to declare a drought emergency.
7. In the **Time Period** section use the **Season** drop-down to select the **Custom Date Range**. Change the **Start Date** to **2018-10-01** and the **End Date** to **2019-09-30**. These dates will provide the map display for the Last Northern Water Year.
8. Leave all other parameters as default.
9. Click on **Get Map Layer**, wait for the map to load. Again, give the DSET a moment to process your request.
10. As in Part 1, you can change the opacity slider to help you visualize the data better.
    a. Once the processing is complete, the map will automatically display the data. The **transparency** may be decreased or enhanced to better see the

results. On the top right of the map, move the opacity slider 

down to 70% Opaque.

The SPI indicates that the majority of the N.N. was in a drought for the Last Northern Water Year. The western region of the reservation was experiencing severe/extreme drought. The SPI is scaled according to the U.S. Drought Monitor Classification (USDM) that categorizes the drought conditions as identified in Figure 4. The deep red colors of USDM represent exceptional and extreme drought. The cool deep blue colors in USDM represent exceptional and extreme wet areas. DSET has the ability to also calculate the SPI for area-averages for the Chapters across the reservation as well as the Agency level. The N.N. Chapters Burnham and Huerfano were the only two chapters during this time period that had extreme drought. After becoming familiar with SPI calculations setting up your parameters let's **Reset** the tool to run this analysis. For this analysis let's calculate the SPI area-average for a Chapter.

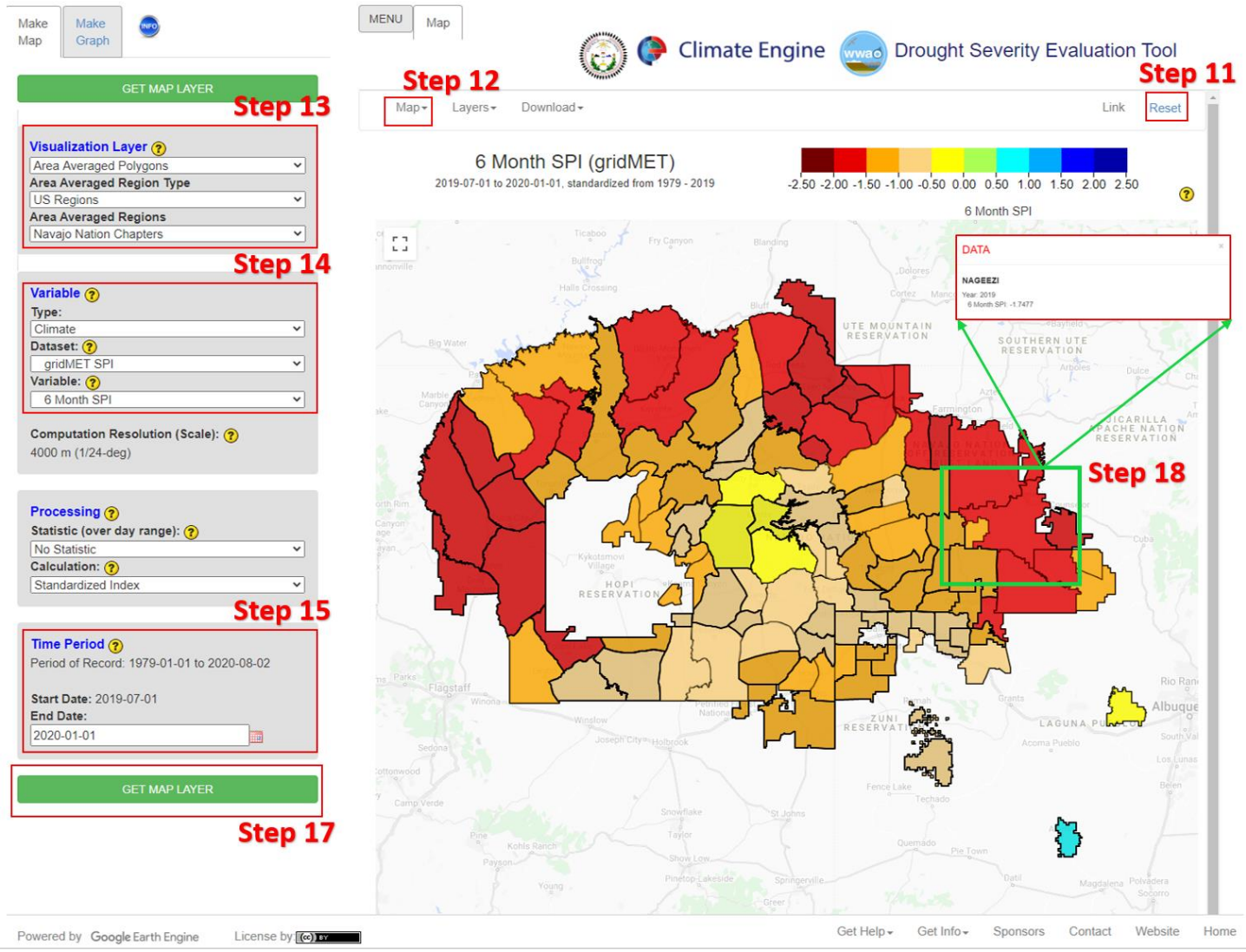

Figure 5. Navajo Nation Chapter six-month gridMET SPI values with a start date of 2019-07-01 and an end date of 2020-01-01. Through the use of the gridMET SPI dataset and Area Averaged Regions specific six-month values are calculated for each N.N. Chapter. In this example, Nageezi was found to have a drought emergency value for the six-month SPI of -1.7477. Guidance for steps 11 through 18 are indicated in this figure.

11. At the top right corner of the map, click **Reset**.
12. To visualize the polygons better for this analysis you have the option of changing the base map. Click on the **Map** tab along the top, and select the **Light Political Style**.
13. In the Make Map panel on the left, in the **Visualization Layer** drop-down select the **Area Averaged Polygons**. Then, ensure that the **Navajo Nation Chapters** are listed under **Area Averaged Regions** (this should be the default).
14. Under the **Variable** section, in the **Dataset** drop-down, select the **gridMET SPI - Daily**. The **6 Month SPI** should then be displayed as the default under **Variable**.
15. In the **Time Period** section, change the **End Date** to be **2020-01-01**. This will automatically change the **Start Date** to six-months prior (2019-07-01).
16. Leave all other parameters as the default.

17. Click on **Get Map Layer** and allow the DSET a few minutes to process your request.
18. Your map should now look similar to Figure 5 above. You now have the option to click on any Chapter boundary and get the 6-month SPI value. Click on any Chapter on the Navajo Nation to display the 6-month SPI value. For example, **Nageezi Chapter** has a 6 Month SPI value of -1.7477, as shown in Figure 5. As mentioned previously, a SPI value below -1.5 would trigger a drought emergency on the Navajo Nation.
    a. If your SPI value for the chapter of your interest does not display, you may have to **Reset** DSET again and run the analysis again by repeating steps 12-19 from this section (Part 2).

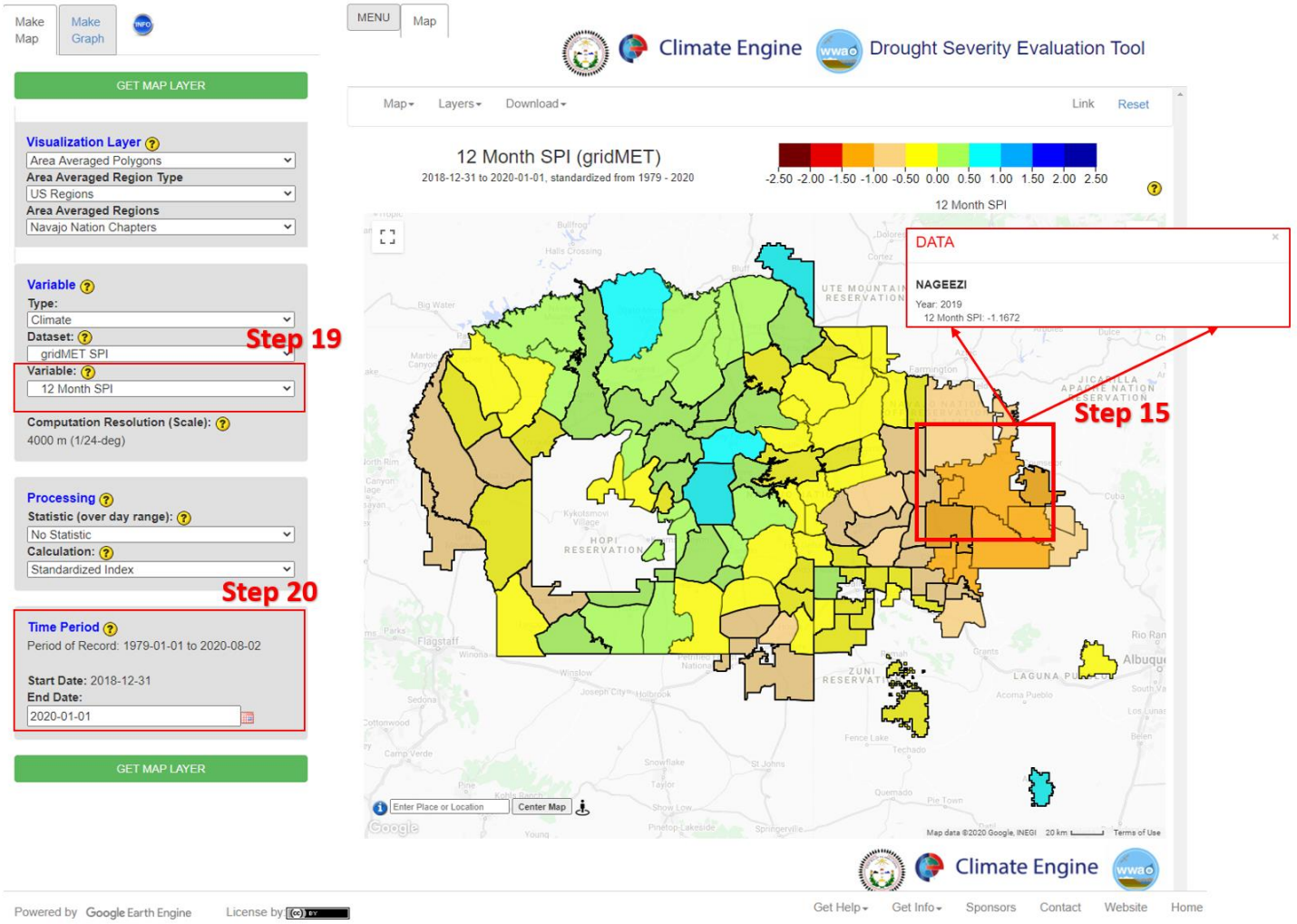

Figure 6. Navajo Nation Chapter 12-month gridMET SPI values. In this example, Nageezi was found not to have a drought emergency (-1.5) value for the six-month SPI of -1.1672. However, Nageezi for the time period of 2018-12-31 to 2020-01-01 was one of the N.N. Chapters with the highest SPI value.

Let's consider the SPI for a year (12-month) compared to the 6-month value for Nageezi Chapter.

19. Change the **Variable** of the **6 Month SPI** to the **12 Month SPI value**.
20. Remember to keep the **End Date** of **2020-01-01**. on **Get Map Layer** and allow the DSET a few minutes to process your request. For this example, the Nageezi Chapter 12-month SPI value was -1.167.
    a. If your SPI value for the chapter of your interest does not display, you may have to **Reset** DSET again and run the analysis again by repeating steps 12-20 from this section (Part 2).

Figures 5 and 6 display the average SPI value for half a year (6-month SPI) and a full year (12-month SPI) for each N.N. Chapter. For the 6-month SPI (Figure 5) there are numerous N.N. Chapters under Extreme Drought. However, when displaying the 12-month SPI values for the N.N. Chapters you will notice a distinct difference in the drought conditions. When displaying the 12-month SPI values there are no Chapters under Extreme Drought conditions, and large portions of the reservation are under Abnormal Wet drought conditions compared to the climatological average (1981-2010). For the Nageezi N.N. Chapter there was a noticeable difference in SPI values from -1.7477 (6-month) to -1.167 (12-month).

Analyzing drought at multiple timescales can help managers understand the differences in short-term (meteorological) vs. and long-term drought (hydrological or ecological). For example, under meteorological drought conditions there is a deficit in precipitation which may impact surface water conditions, but under prolonged droughts, like a hydrological drought, the impacts may be observed on soil moisture and groundwater.

Additional Resources

- The Applied Remote Sensing Training (ARSET) is a program that is designed to build the capacity of decision-makers to use NASA data. ARSET offers online and in-person trainings for beginners and advanced practitioners alike. Trainings cover a range of datasets, web portals, and analysis tools and their application to air quality, agriculture, disaster, land, and water resources management. http://appliedsciences.nasa.gov/arset

- The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information provides public access to climate and weather data. This particular link provides a deeper look at drought as well as provide projections: https://www.drought.gov/drought/data-maps-tools/tools

- DSET is a spin-off of Climate Engine, a web-based platform for conducting on-the-fly climate analysis: http://climateengine.org/data