Imagery Workflows

Multidimensional raster analysis in ArcGIS Pro

Available with Image Analyst license.

In ArcGIS Pro you can visualize and process scientific data for temporal and spatial analysis. In our changing world, it is more and more important to work with and understand scientific data and to incorporate the data into GIS workflows.

You can work with scientific data in ArcGIS Pro using multiple formats: space-time cubes, multidimensional layers, mosaic datasets, or with multidimensional raster datasets in Cloud Raster Format (CRF). In this guided tutorial, you will explore some of the ways you can process and display scientific data using multidimensional raster datasets.

First, you will add a multidimensional raster layer to ArcGIS Pro, depicting sea surface temperature from the National Center for Atmospheric Research's (NCAR) Research Data Archive.

Next, you will use geoprocessing tools and charting to explore sea surface temperature change over time and discover warming anomalies in the ocean.

> **Note:**
>
> ArcGIS Pro 2.4+ and the ArcGIS Image Analyst extension are required to complete this tutorial.

Add multidimensional data to your project

The data packaged for this tutorial comes from the NCAR Research Data Archive. It is a netCDF file included in the Climate System Reanalysis Forecast (CFSR) product. It contains 35 years of monthly sea surface temperature data with a spatial resolution of 0.5 degrees.

1. [Download the tutorial data](#) and save it to C:\SampleData\SST_tutorial.
2. In ArcGIS Pro, create a new project using the **Map** template and sign in to your ArcGIS Online account if necessary.
3. On the **Map** tab, under the **Layer** group, click the **Add Data** drop-down and select **Multidimensional Raster Layer**.
4. In the **Add Multidimensional Raster Layers** dialog, under **Input File, Mosaic Dataset or Image Service**, click the **Import Variables from file** button and browse to C:\SampleData\SST_tutorial or wherever you downloaded the tutorial data. Select the CFSR_sst.nc layer and click **OK**.
5. There is only one variable in this netCDF file. Check the box next to the cfsrsst variable to select the sea surface temperature. Leave the remaining default parameters and click **OK**. Zoom out to the full extent of the dataset.

   This netCDF file contains monthly sea surface temperature data across 36 years from 1980 to 2015.
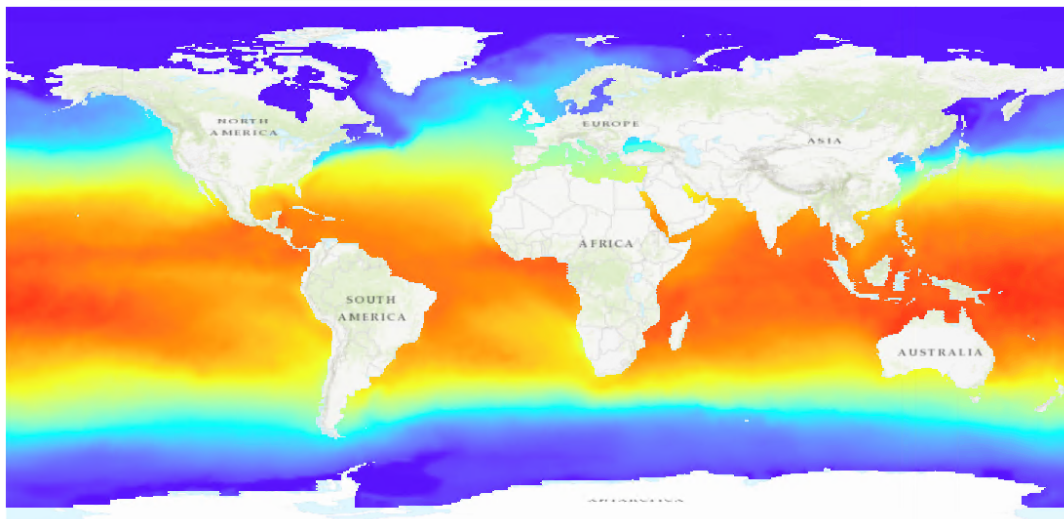
6. Double-click the cfsrsst layer in the **Contents** pane to open the **Layer Properties** dialog. Open the **Source** menu, then expand the **Multidimensional Info** sub-group.

   The variables and variable properties of the multidimensional dataset are listed. Expand the cfsrsst variable to see the dimension information. In this case, the sea surface temperature data is organized with a time dimension called StdTime (Standard Time), with an interval of 1 month from 1980 to 2015 for a total of 432 rasters.

7. Click **OK** to close the **Layer Properties**.
8. When you added the multidimensional raster layer, the time slider appeared automatically on the map. Click **Play** or use the **Step Forward** button on the slider to see the monthly sea surface temperature changing over
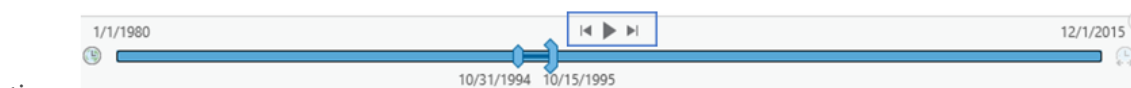
   time.

Process sea surface temperature data

As you saw in the layer properties, the data you are working with is monthly sea surface temperature. As a climate scientist, you might be interested in yearly maximum sea surface temperature, and in temperature anomalies.

> **Note:**
>
> The tools used in this section are in the **Multidimensional Analysis** toolset under the **Image Analyst** toolbox. Alternatively, the **Multidimension Tools** toobox is a separate toolbox containing tools that allow you to work with and create netCDF files.

1. On the **Analysis** tab, under the **Geoprocessing** group, click **Tools** to open the **Geoprocessing** pane.
2. Expand the **Image Analyst Tools** toolbox, then expand the **Multidimensional Analysis** toolset. Open the **Aggregate Multidimensional Raster** geoprocessing tool. This tool combines slices from an existing multidimensional dataset along a dimension to generate a new CRF multidimensional raster.

NOTE: If the ArcGIS Image Analyst extension has not been licensed for ArcGIS Pro, you will not be able to access these tools.
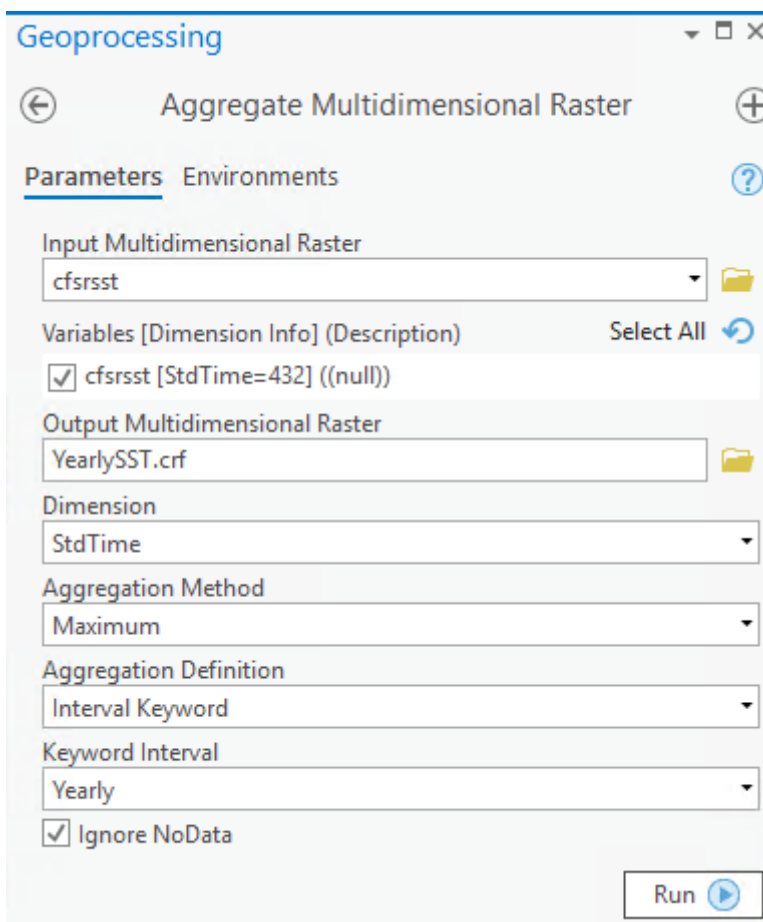
3. Enter the parameters as follows:

- **Input Multidimensional Raster** — cfsrsst
- **Variables** — cfsrsst [StdTime=432] ((null)) checked on
- **Output Multidimensional Raster** — YearlySST.crf
- **Dimension** — StdTime
- **Aggregation Method** — **Maximum**
- **Aggregation Definition** — **Interval Keyword**
- **Keyword Interval** — **Yearly**
- **Ignore NoData** — Checked on

4. Click **Run**.

The result is a multidimensional raster dataset, in .crf format, containing the yearly maximum sea surface temperature value for every pixel and for every year in the dataset.

5. Double-click the YearlySST.crf layer in the **Contents** pane to open the **Layer Properties**. Open the **Source** menu, then expand the **Multidimensional Info** sub-group. Notice that the number of StdTime values has dropped from 432 (months) to 36 (years). Now let's take a look at some of the anomalies.

6. Click the **Back** arrow on the **Geoprocessing** pane to go back to the menu. Open the **Generate Multidimensional Anomaly** tool from the **Multidimensional Analysis** toolbox. This tool generates a new CRF

multidimensional raster depicting, for each year, the difference in temperature between each pixel and the global average for that year.
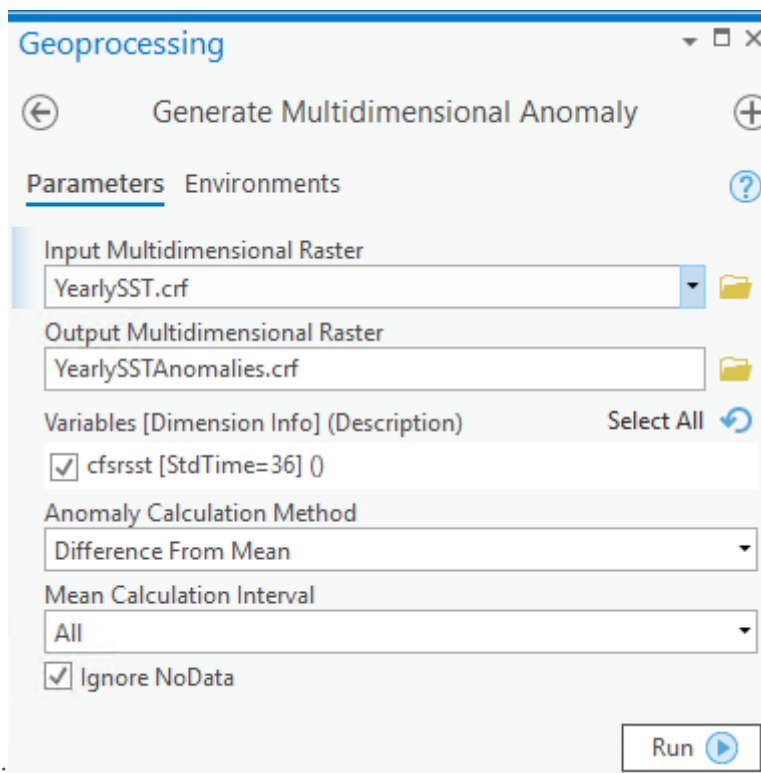

7. Enter the parameters as follows:

  - **Input Multidimensional Raster** — YearlySST.crf
  - **Output Multidimensional Raster** — YearlySSTAnomalies.crf
  - **Variables** — cfsrsst [StdTime=36]() checked on
  - **Anomaly Calculation Method** — **Difference From Mean**
  - **Mean Calculation Interval** — **All**
  - **Ignore NoData** — Checked on

8. Click **Run**. When the tool completes, the new raster layer will appear in your map.

9. With the YearlySSTAnomalies.crf layer selected in the Contents pane, open the **Appearance** tab under the **Raster Layer** contextual tab on the ribbon. In the **Rendering** group, click the **Stretch Type** drop-down and select **Standard Deviation**.

The result is a multidimensional raster dataset, in .crf format, where pixels in red indicate maximum yearly temperatures that were higher than the global mean sea surface temperature in that year. Pixels in blue

indicate temperatures lower than the global mean.
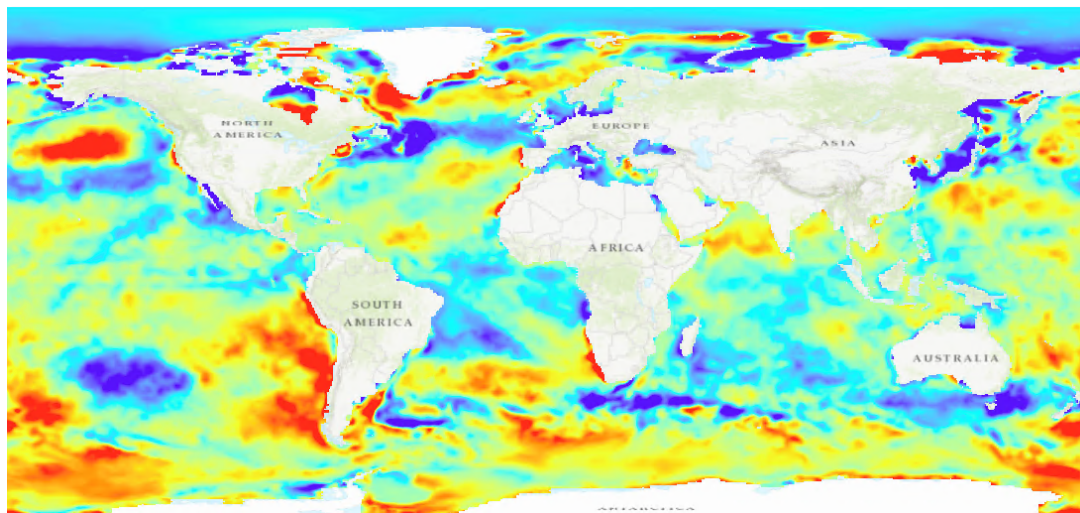
Explore sea surface temperature change and anomalies

Now that you have anomaly data for maximum yearly temperatures, it's time to visualize and explore it. You can use the time slider and temporal profile charts to dig deeper into your data, identify areas experiencing change, and see trends.

1. Make sure the YearlySSTAnomalies.crf layer is selected in the **Contents** pane and open the **Time** tab from the ribbon.

2. Configure the **Current Time** and **Step** groups as follows:

   - **Start** — 1/16/1979 11:59:59 PM
   - **Span** — 349.5 Days
   - **End** — 1/1/1980 11:59:59 PM
   - **Step Interval** — 349.5 Days

3. Click **Play** or use the **Step Forward** button on the time slider to scroll through the slices of anomaly data.

   The map will update with each slice, and the Time Slider will show you the time span being displayed.

4. Use the **Step Forward** or **Step Back** buttons on the slider until you reach the 1998-1999 time span, and look at the slice being displayed in the map.
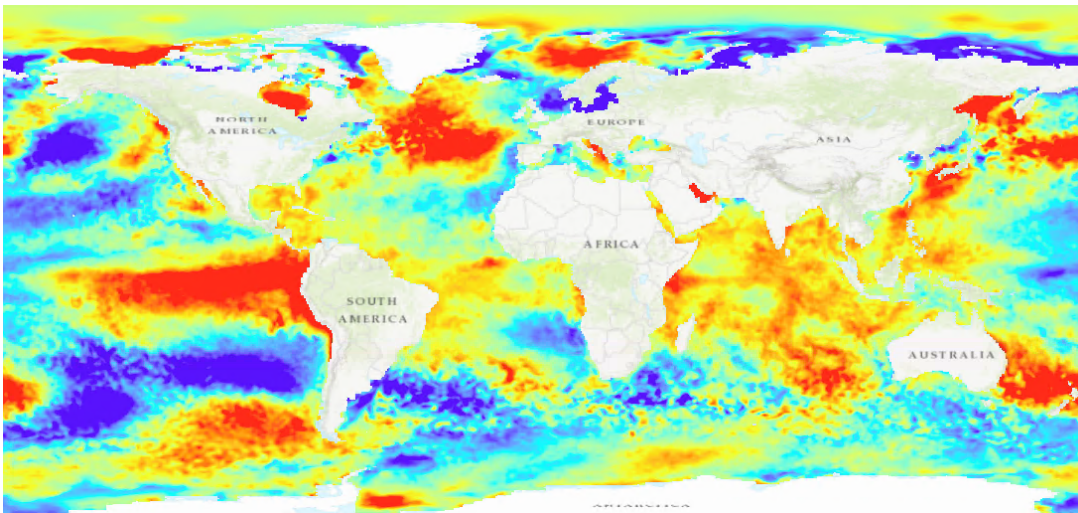
You will notice a large red region off the west coast of South America. The anomaly stretches across the Pacific Ocean, showing a massive area where the maximum temperatures were much higher than the global ocean temperature.

5. Right-click on the cfsrsst layer and select **Create Chart**, then choose **Temporal Profile**.

   The **Chart Properties** pane opens, and the chart window opens at the bottom of the project.

6. Configure the temporal chart:

   a   Click the point icon under **Define point features to plot on chart**. Place a point in the Pacific Ocean in the large red region described above (near 275°46'4"E 4°23'43"S).

   b   Under the **Time binning options**, change the **Interval size** to 1 Years.

   c   Under **All locations**, use the drop-down menu under the **Variable** column to select cfsrsst.

   The chart updates with the temporal profile for the point location across 36 years of data. You can further configure the chart by using the **Axes**, **Guides**, **Format**, and **General** tabs at the top of the **Chart Properties** pane.
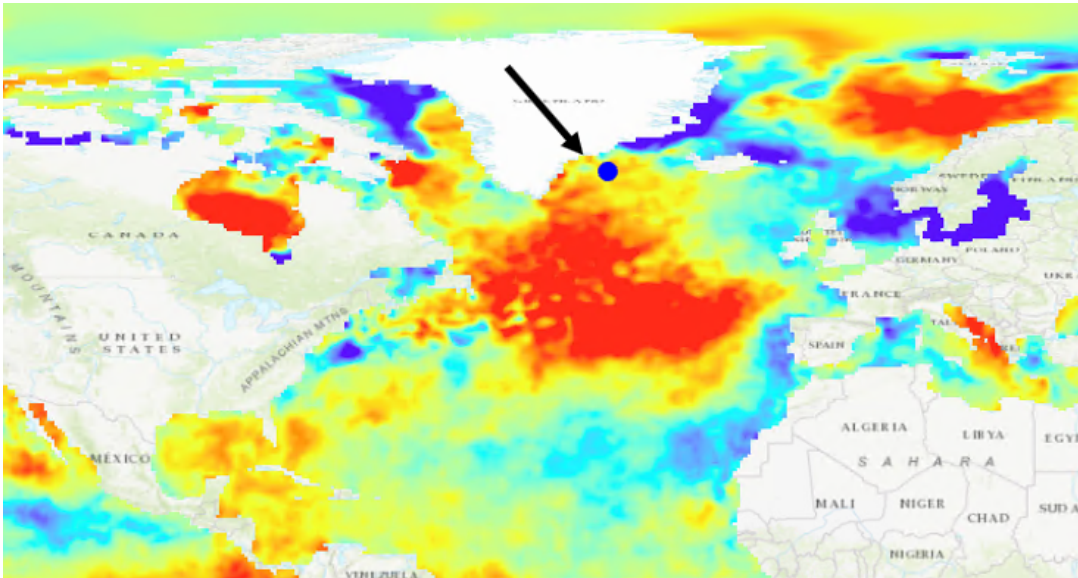
7. Under **Time** format, choose (yyyy) as the **Date Format** and <none> as the **Time Format**.

8. Open the **General** tab in the **Chart Properties** pane. Change the chart title to Sea Surface Temperature 1980 - 2015. Change the X axis title to Date, and the Y axis title to Mean Sea Surface Temperature (C).
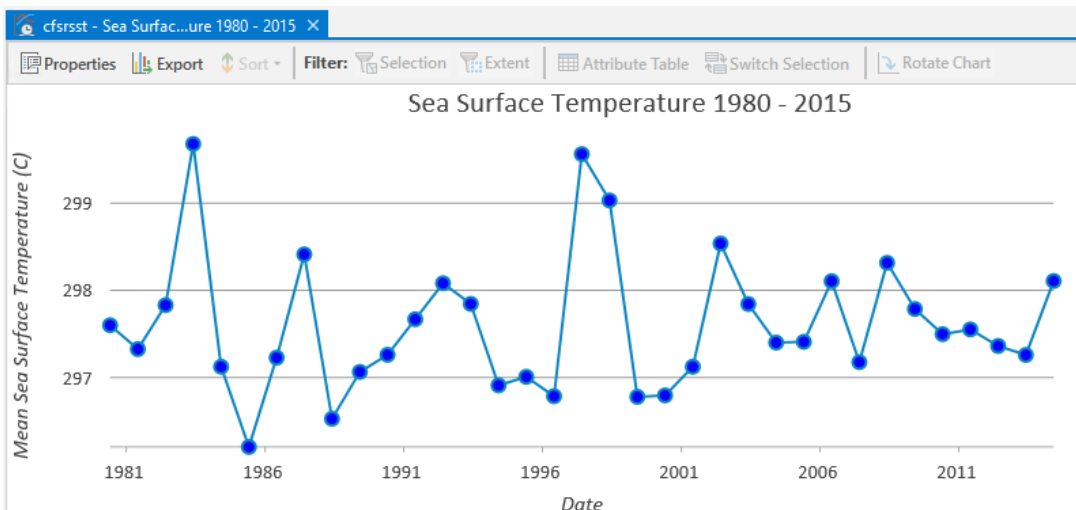
Notice the two years where maximum temperature was much higher than other years. Hover your mouse over the two points to see that 1983 and 1997 were two years with higher-than-average temperatures.
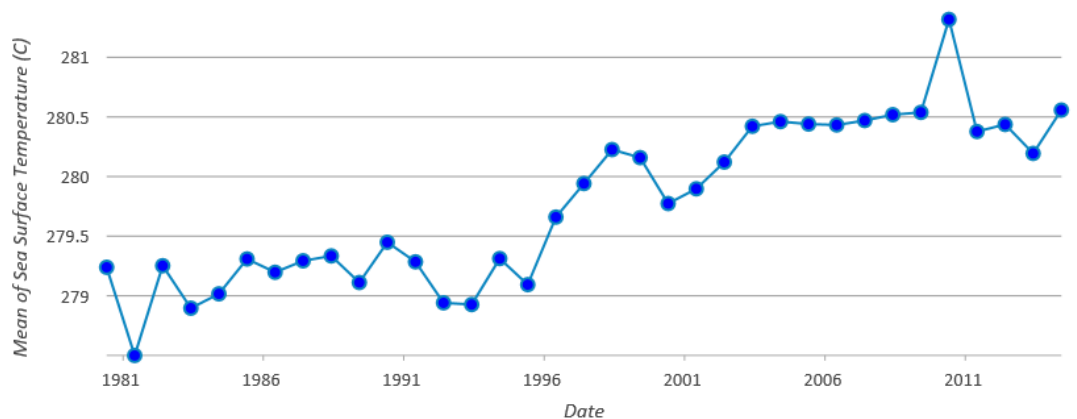
These two years, and the large red region you saw in the anomaly data, correspond to two major El Niño events, in which a band of warm ocean water develops in the central and east-central Pacific region.

9. Click the point feature icon again and this time, add a point in the waters off the southeast coast of Greenland (near 326°59'45"E 64°47'35"N).

10. Uncheck the box next to the first location point under the **Chart Properties** pane to remove the El Niño data from the chart. This way, you can better observe the profile for Greenland.

The temporal profile for this part of the world is very different from the east-central Pacific. Here, you can see a distinct, steady increase in temperature over time - one of the many impacts of global climate change.

What else can you find? Use the anomaly CRF dataset to find other interesting areas. Happy exploring!

Summary

In this tutorial, you added monthly sea surface temperature data to your map, then used geoprocessing tools to aggregate the data into yearly maximum temperature and calculate anomalies. You then explored your data using

temporal profile charts. For more information on these topics, see the resources below:

- [An overview of multidimensional raster data](#)
- [Working with a multidimensional raster layer](#)
- [Multidimensional Analysis toolset](#)
- [Temporal profile chart](#)

The data used in this tutorial is from the NCAR Research Data Archive:

Saha, S., et al. 2010. NCEP Climate Forecast System Reanalysis (CFSR) Monthly Products, January 1979 to December 2010. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6DN438J. Accessed 6/21/19

Related topics

- [Getting Started with Raster Functions in ArcGIS Pro](#)