

Using NetCDF data within ArcGIS

Objective:

This practical introduces the importing and use of Network Common Data Form (netCDF) data within ArcGIS. The NetCDF format is commonly used in climatology and oceanography as a means of handling spatio-temporal data sets, particularly those in raster format.

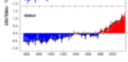
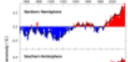
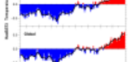

Data:

To access the data for this exercise, go to the University of East Anglia Climate Research Unit's web site at:

<http://www.cru.uea.ac.uk/cru/data/temperature/>

We will download a simple data set here that contains global average monthly temperatures for the period 1961-1990, measured in degrees centigrade. The data are labelled as 'absolute' in the file. There are thus 12 time periods and the data are for grid squares that are 5 degrees of latitude by 5 degrees of longitude.

To access the data, under 'data for downloading' on this page, scroll down to the 'absolute' data set and choose the NetCDF format. Save the file to your computer:

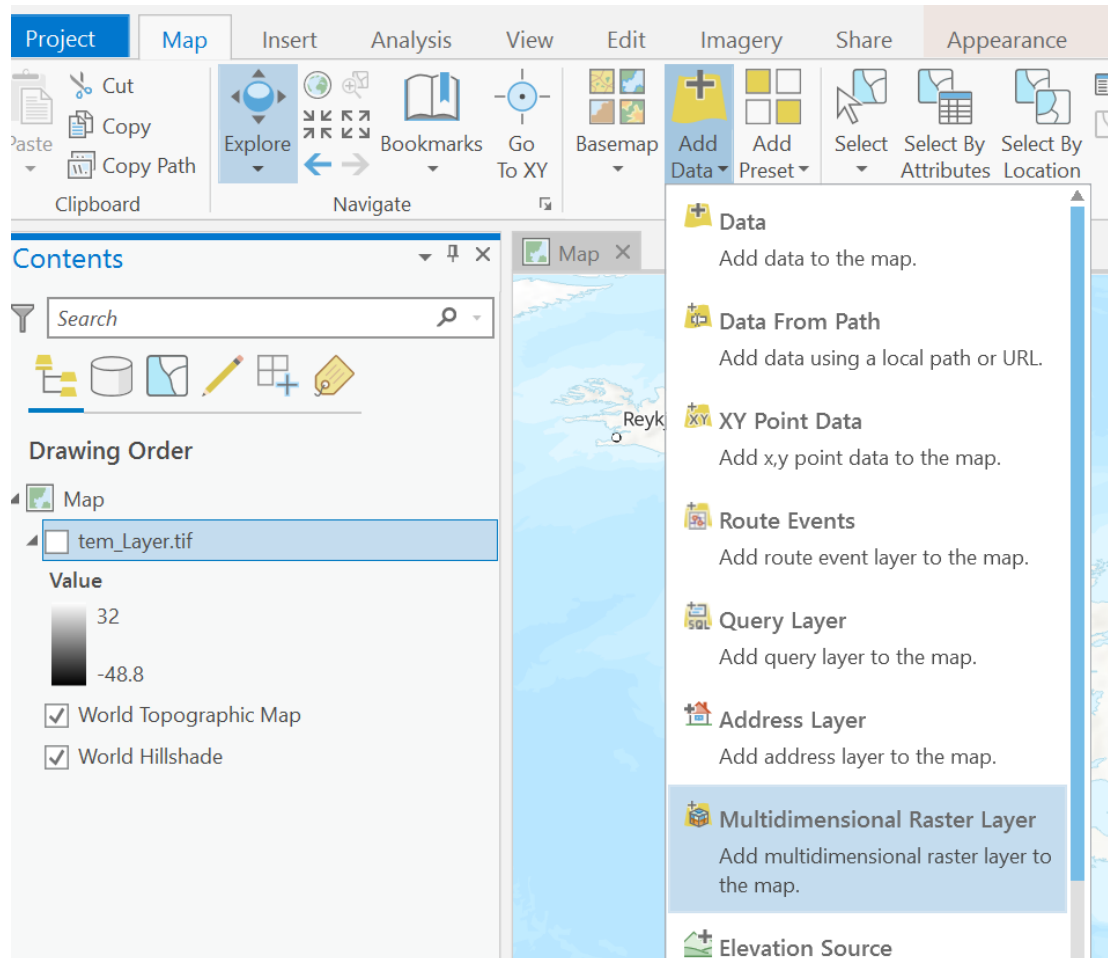
Variance adjusted version of CRUTEM4			GL		
HadSST3	NetCDF (21MB)	2020-09 2020-10-15	NH		HadSST3
Sea surface temperature anomalies on a 5° by 5° grid (Kennedy et al., 2011)			SH		
Absolute	NetCDF (1MB)		GL		
Absolute temperatures for the base period 1961-90 on a 5° by 5° grid (Jones et al., 1999). Note that in this file, latitudes run from North to South.					

Correction issued 30 March 2016. The HadSST3 NH and SH files have been replaced. The temperature anomalies were correct but the values for the percent coverage was correct, as were all the HadCRUT4 and CRUTEM4 files. If you downloaded the HadSST3 NH or SH files before 30 March 2016, please download them again.

File Formats

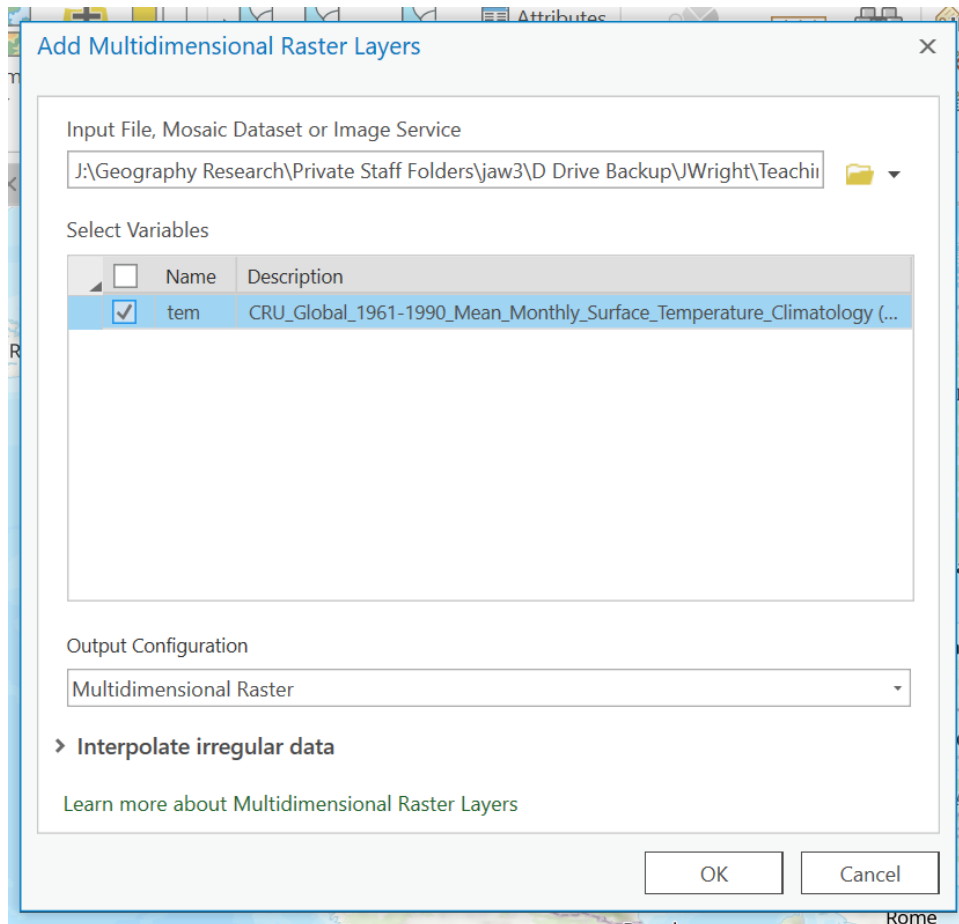
Practical instructions

Start up ArcGIS Pro with the *map* template. On the *map* menu ribbon, click on *add data*, then choose *multidimensional raster layer*:



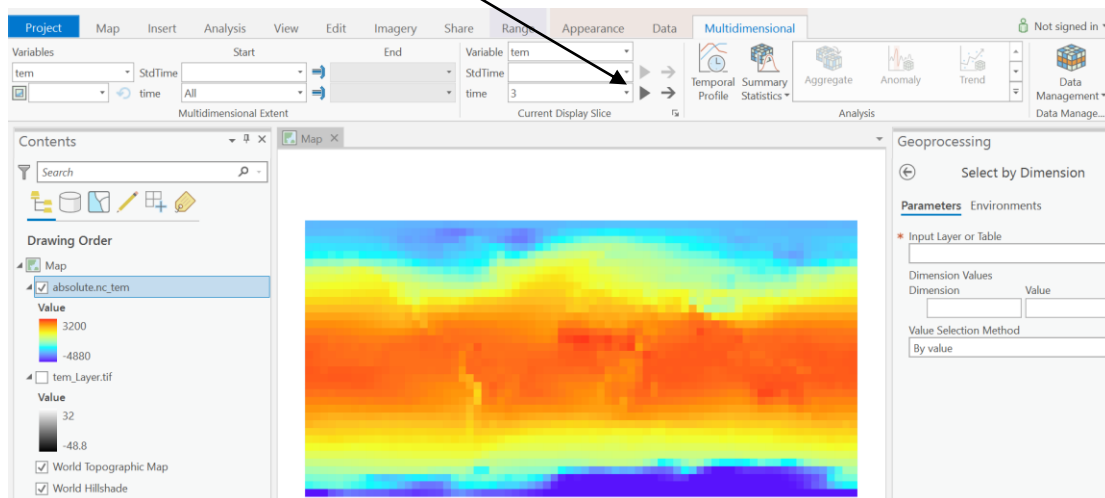
In ArcGIS Pro, formats such as NetCDF are known as multi-dimensional rasters. They differ from multi-band rasters (i.e. rasters where multiple values can be stored in each pixel) since the format is extensible can handle more than one additional dimension. For example, a single file could be used to store temperature and humidity (two variables) in raster format (x and y) for different days (time) at different heights in the atmosphere (z – making four dimensions in total). A multi-band raster would be able to handle one dimension (e.g. time or height), but not all dimensions simultaneously.

Choose the NetCDF file that you just downloaded (with its .nc extension) and you should be able to select **tem** as the variable to work with:



Note that this layer has mean monthly temperature in degrees centigrade, multiplied by 100, so for example 3000 = 30 degrees centigrade. You should see January's temperatures displayed by default. If you highlight the layer in the left-hand table of contents panel, you should be able to click on the *multidimensional* menu.

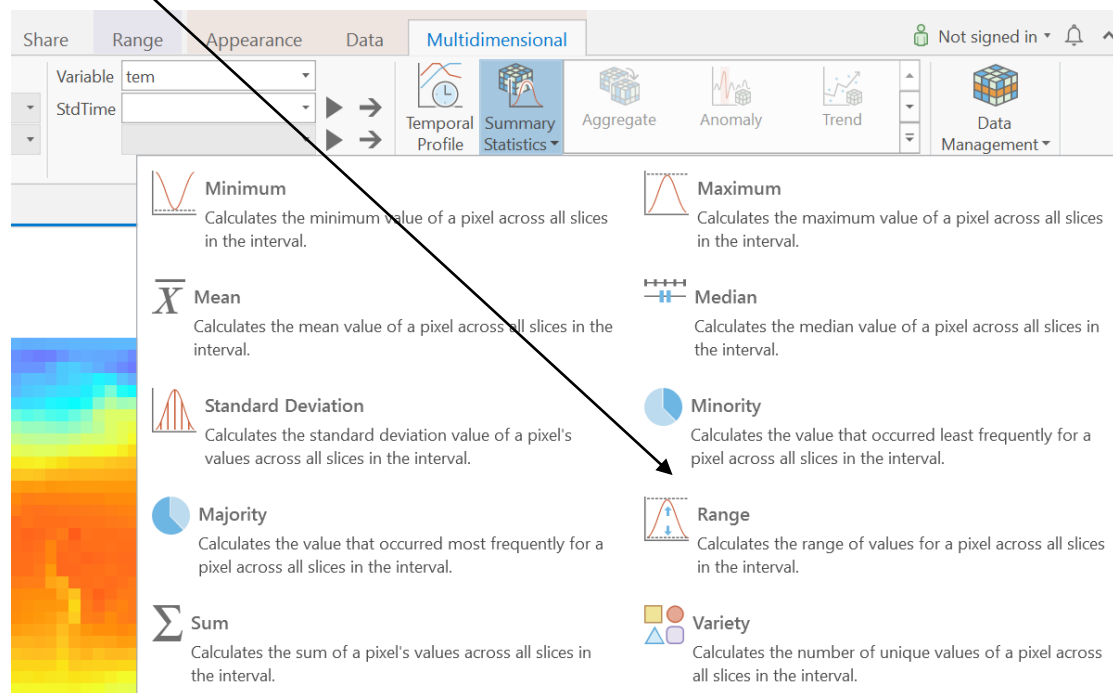
Because the layer consists of multiple rasters depicting temperature, we can animate the layer via this button



When you press this button, you should see ArcGIS Pro cycle through the 12 months of the year, displaying temperatures for each one.

We can also use options on this ribbon to analyse our NetCDF file. However, to do this, first you will need to activate the *Spatial Analyst* and / or *Image Analyst* extensions. To do this, head for the *project* menu, then *licensing* and press the *configure licencing options* button, checking both of these extensions.

Next, select your NetCDF layer once more, then head for the *multidimensional* menu again. If you choose *Summary Statistics*, you should be able to select *Range*:



Running this option should calculate annual temperature ranges (maximum – minimum monthly temperature), with continental and polar areas showing the greatest temperature ranges. This will be added to your display as a new raster layer.

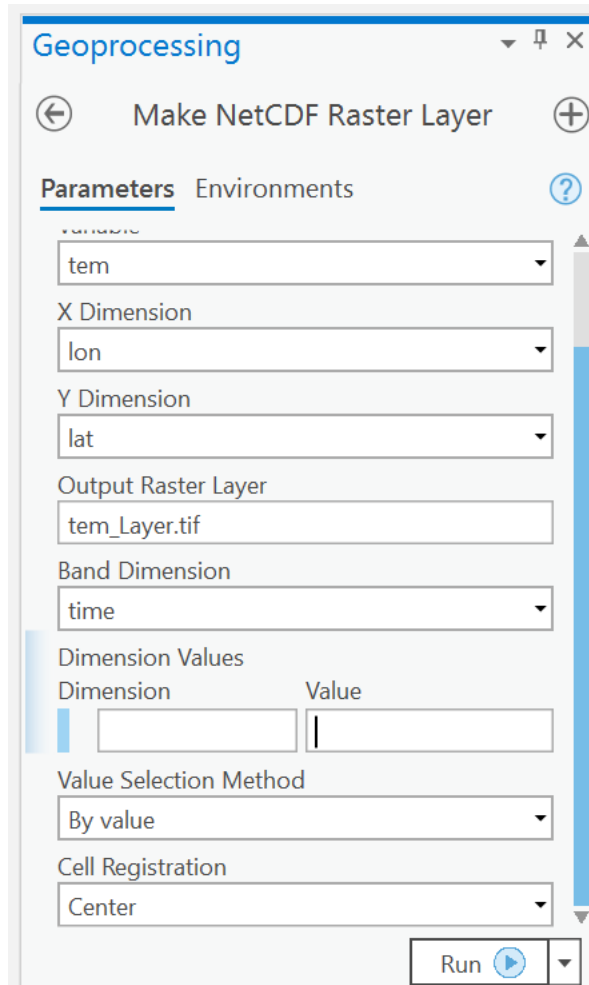
Some other brief notes on functionality on this toolbar are as follows:

- Via the *data management* button on the ribbon, there are also options to *Make multidimensional raster layer* and *subset* the NetCDF file. Subset enables you to save just some of the time slices in our file to a new multidimensional raster (e.g. just October-December's temperature). *Make multi-dimensional raster layer* will save our NetCDF file in ESRI's own multi-dimensional raster format, enabling its subsequent use in various NetCDF tools. Try running this option now with the default settings and saving your NetCDF file in ESRI format.

- To the right of *summary statistics*, there are also options for calculating anomalies (e.g. difference between mean monthly temperature for each month) and trends from our multi-dimensional raster.
- The *temporal profile* button will not work with this particular NetCDF file. This is because the file contains average temperatures, rather than a time series of temperatures for particular months or days (e.g. Jan 1980 to March 2020), so the 'time' dimension is a number (1 to 12) rather than a date. If the time dimension was formatted as a date rather than a number, it would be possible to right-click on our layer, choose *properties* and then *time*, and indicate that it had a time dimension. We could then use *temporal profile* to produce graphs of temperature changes over time by digitising a region of interest or point on top of our multi-dimensional raster.

Converting NetCDF to other formats

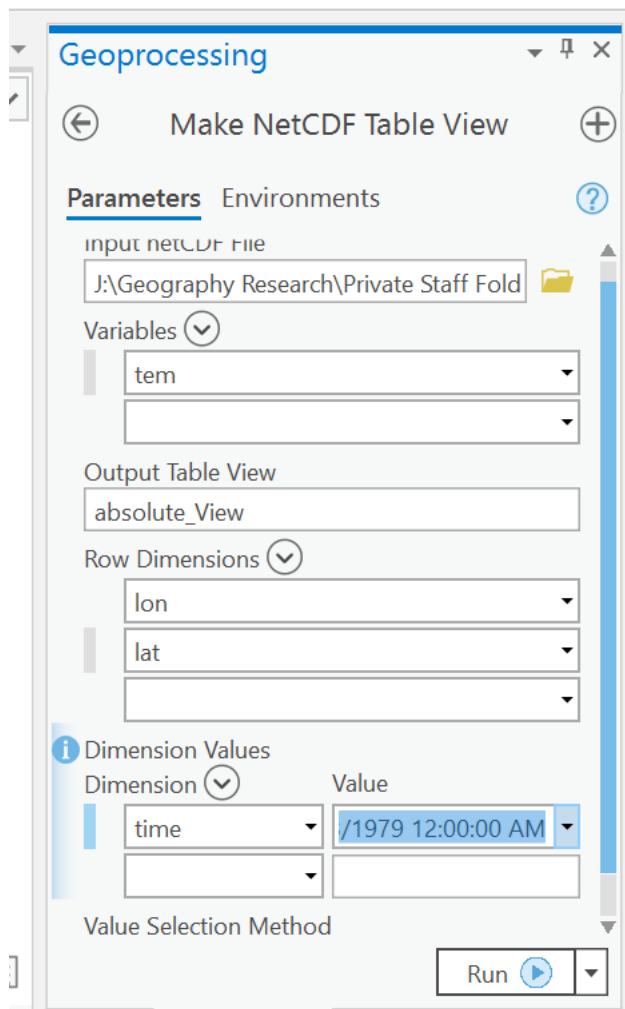
It is also possible to extract data from the NetCDF layer for other forms of analysis. For example, if you head for the *analysis* menu and choose *tools*, you should be able to search in the *geoprocessing panel* for 'NetCDF'. We can use the tool '*Make NetCDF raster layer*' to extract one month's data from our multi-dimensional raster and convert it to an ordinary raster:



Select the file that you just downloaded. Note that ArcGIS will automatically choose **tem** (temperature) as the variable to be contained in this data set, **lon** (longitude) as the X dimension, and **Lat** (latitude) as the Y dimension. Under 'dimension values', select **time** to have time (month of the year) loaded as the third dimension for this data set. Note that in the grid at the foot of this dialog box, you can optionally select a value between 1 and 12 (i.e. January through December) to indicate the month's temperature data that will be displayed by default in map format within ArcGIS. If you leave this blank, by default January's data will be displayed as the first in the series. You can also enter in the name of an *output raster layer* to contain the output. Press OK, and ArcGIS will generate a multi-dimensional raster based on the HDF data.

- We can also use a feature known as 'table views' to extract particular values from our space-time grid in tabular format. What the table view provides is a 'slice' through our large array of temperature values in a tabular format that could be downloaded to a spreadsheet, for example. To do this:
 - In the geoprocessing panel, search for 'NetCDF' and then select 'Make NetCDF Table View' and select your netCDF file that you downloaded under 'Input netCDF file'.

- Under 'variables', select 'tem' (temperature).
- Under 'row dimensions', select 'lat' (latitude) and 'lon' (longitude).
- Under 'dimension values', select 'time'. In the grid beneath this option, you can pick out particular time periods that you want to look at in more detail.
- You can also choose a name for the 'output table view' that will be generated.
- Click on OK and ArcGIS Pro will generate a new table view which has data for temperature for your chosen period, with each row representing the temperature values for a given pixel.
- Note that in order to see the output, head for the bottom left of your screen to find your table view, you can right-click on it and choose open to view the result.



Having created this table, we could use a tool like *Table to Excel* to send these data out to an Excel file for analysis, should we wish.

Summary:

This practical has summarised some of the ways of manipulating data stored in NetCDF format, a format for handling spatio-temporal data. The tools enable us to view 'slices' of information from such files, either visually on-screen in the form of maps or in tabular format, and to extract subsets of the information within the file for further analysis. There are other tools available for analysing files, such as mechanisms for animating the data for different time periods.

In this case, the file is very small – the grid resolution is very coarse, there are few time periods, and there is only a single attribute. The power of this format and the tools for slicing through it comes where the file has many attributes (e.g. abundance data for many different species, with each species held as a separate attribute), and finer spatial and temporal resolution.