PIFSC Ocean Satellite Data Course
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NetCDF and Panoply Tutorial

Xkcd.com

NetCDF (Network Common Data Form) is a file format for storing multidimensional scientific data (variables) such as temperature, salinity, chlorophyll concentration, wind speed, ...

Many organizations and scientific groups in different countries have adopted netCDF as a standard way to represent some forms of scientific data.

The NetCDF format has many advantages, the most important of which is that it is **self-describing**, meaning that software packages can directly read the data and determine its structure, the variable names and essential metadata such as the units. This self-describing aspect of netCDF file format means that the information needed to ensure accurate work (reduce the incidence of errors) is available within the data itself (no need for additional files). Secondly, it means that different software can examine a netCDF file and generate the code needed to read it whether it be Matlab, R, Python or ArcGIS (among many others). Thirdly, plotting and analysis packages (e.g. Ferret, R, Matlab, **Panoply**) can directly read the netCDF files for plotting or analysis.

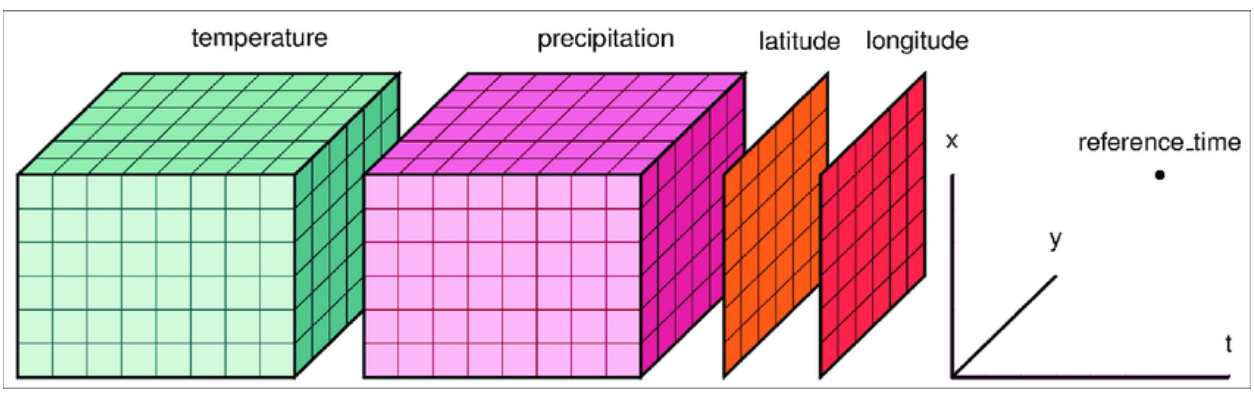
```
netcdf filename {
dimensions:
        lat = 3 ;
        lon = 4 ;
        time = UNLIMITED ; // (2 currently)

variables:
        float lat(lat) ;
                lat:long_name = "Latitude" ;
                lat:units = "degrees_north" ;
        float lon(lon) ;
                lon:long_name = "Longitude" ;
                lon:units = "degrees_east" ;
        int time(time) ;
                time:long_name = "Time" ;
                time:units = "days since 1895-01-01" ;
                time:calendar = "gregorian" ;
        float rainfall(time, lat, lon) ;
                rainfall:long_name = "Precipitation" ;
                rainfall:units = "mm yr-1" ;
                rainfall:missing_value = -9999.f ;

// global attributes:
                :title = "Historical Climate Scenarios" ;
                :Conventions = "CF-1.0" ;

data:
 lat = 48.75, 48.25, 47.75;
 lon = -124.25, -123.75, -123.25, -122.75;
 time = 364, 730;
 rainfall =
   761, 1265, 2184, 1812, 1405, 688, 366, 269, 328, 455, 524, 877,
   1019, 714, 865, 697, 927, 926, 1452, 626, 275, 221, 196, 223;
}
```

Coordinate variable

Variable attribute

Global attribute

Example of embedded metadata within a NetDCF file.



Example structure of a NetCDF file containing temperature and precipitation data across a region for 8 time steps.

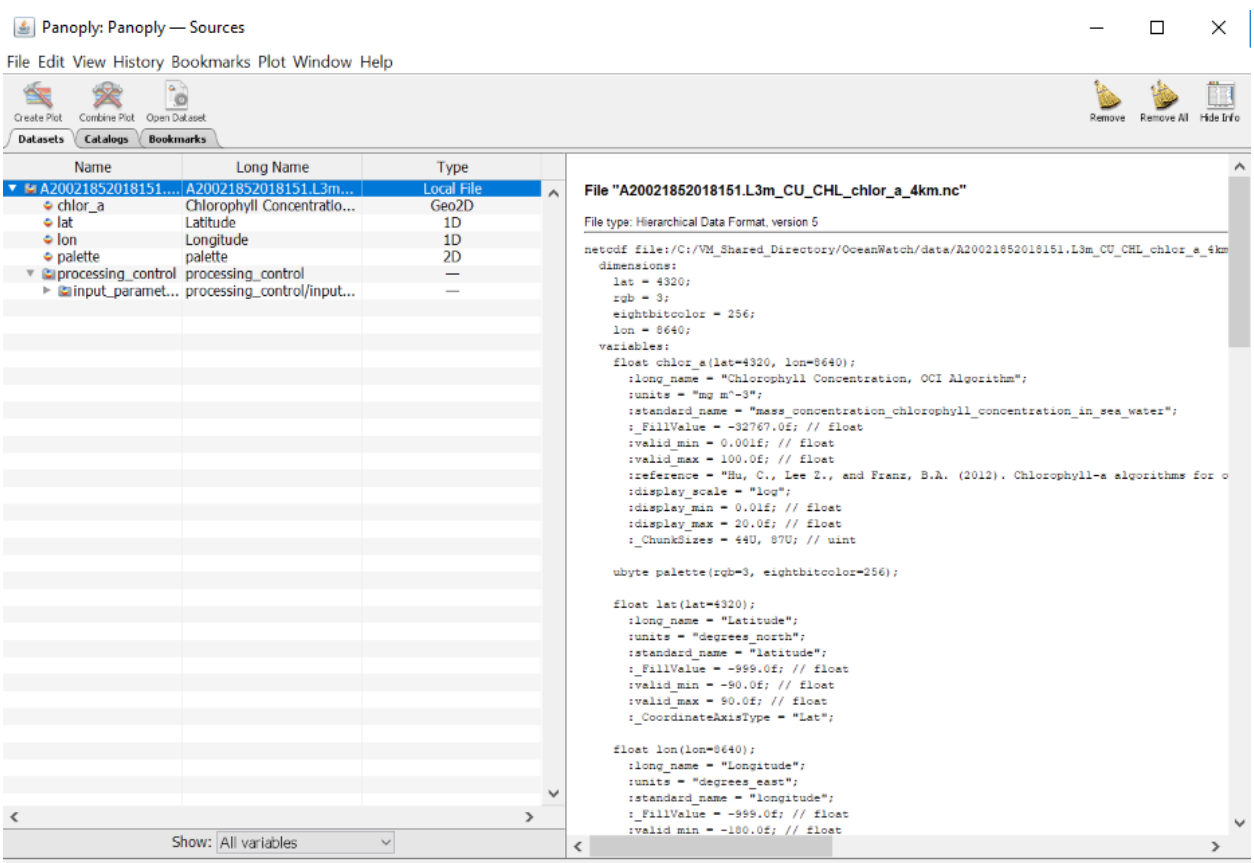
NASA Panoply

NASA developed a viewer that allows users to create images of NetCDF files.
Panoply is available for download at: https://www.giss.nasa.gov/tools/panoply/ and can be run on Windows, Mac and Linux computers.

Panoply walk-through:

We're going to go through a brief overview of Panoply to view the contents of two NetCDF files and make plots.

1. Download the file A20021852018151.L3m_CU_CHL_chlor_a_4km.nc from the Tutorials folder on the Google drive to your computer.
2. Launch Panoply by double clicking on the Panoply.exe file where you downloaded it. It can take a while to launch, be patient.
3. When Panoply opens it prompts you to open a file. Open the file A20021852018151.L3m_CU_CHL_chlor_a_4km.nc

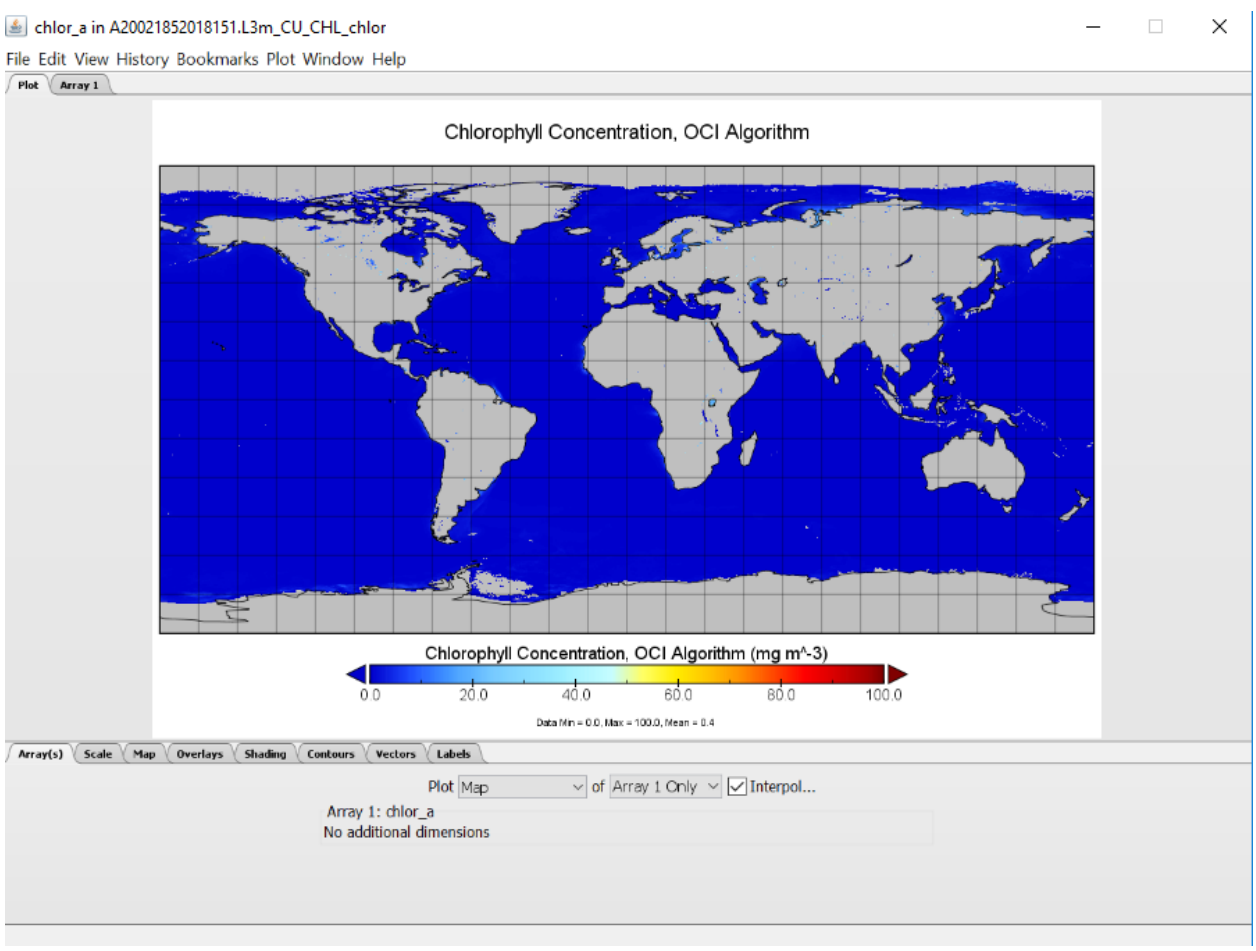


Panoply interface

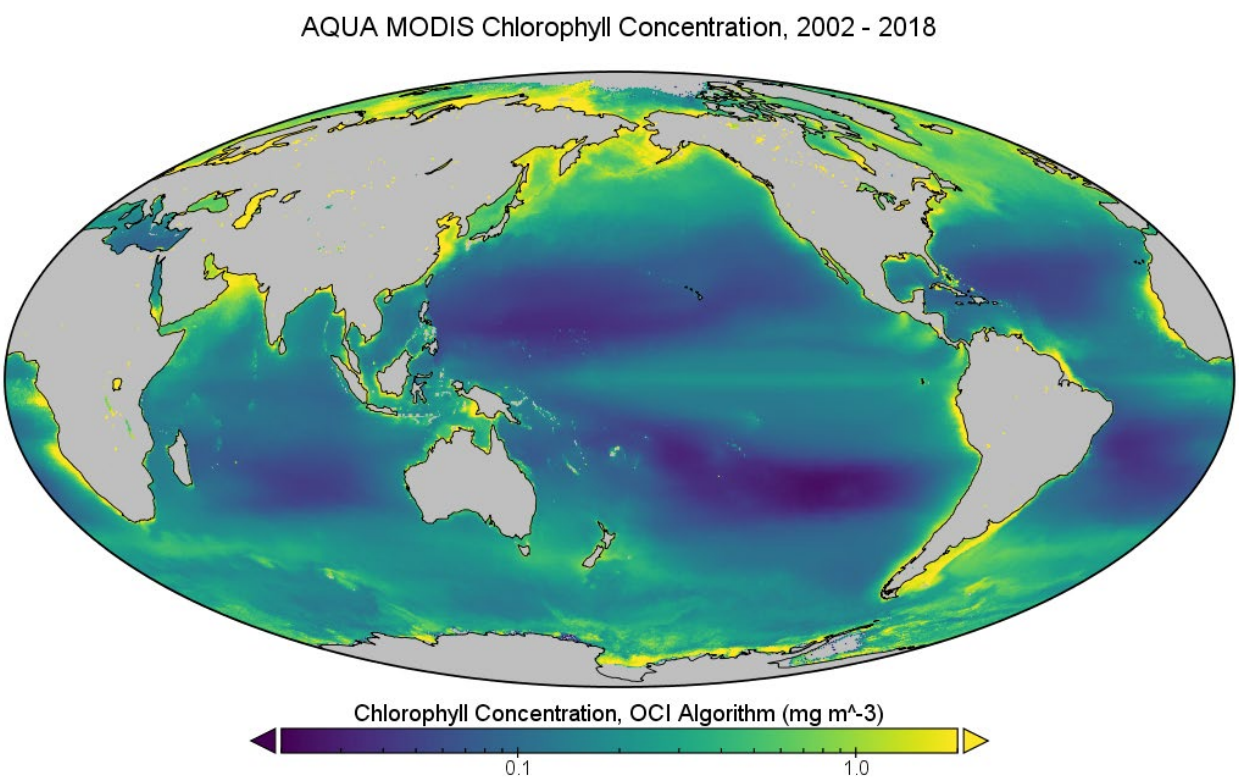
On the left side, Panoply list the variables contained in the file (longitude, latitude, chlorophyll concentration). On the right side, it displays the file's metadata. You can scroll down to get more details. For example, in the global attributes, you will find the platform (This is data from the Aqua satellite), the instrument (MODIS), the processing version (2018.0), the time coverage (2002 to 2018). There is no time variable however, this is a cumulative mean over the time period.

4. Find the `identifier_product_doi_authority` in the list of global attributes. Go to that website.
5. Find the `identifier_product_doi` in the list of global attributes. Copy it in the doi field on the website. This should lead you here: https://oceancolor.gsfc.nasa.gov/data/10.5067/AQUA/MODIS/L3M/CHL/2018/ This page contains extra information about the data if you are interested in reading more about it. Metadata varies from file to file depending on how much information is provided by the data sources.

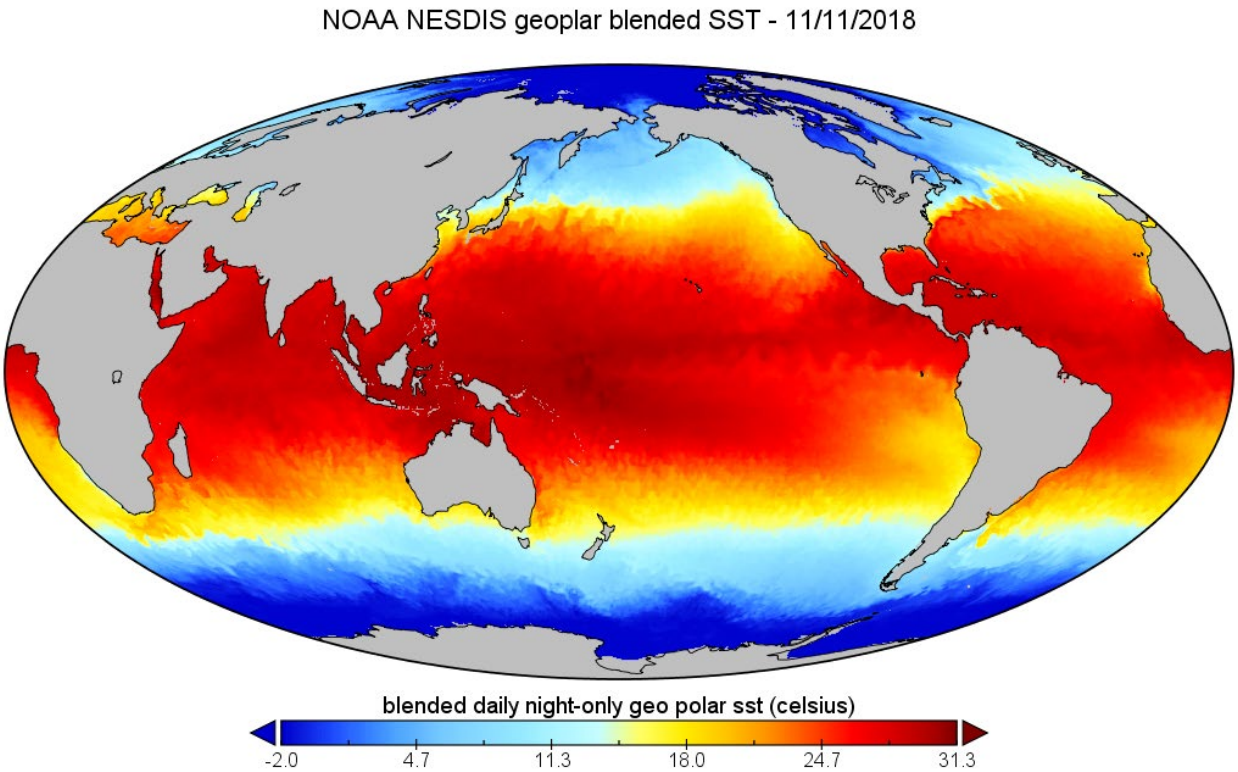
6. Next, on the left side of the screen, double click on the chlor_a variable. Keep the default settings and click Create. (this will take a minute, it's a big file)



7. Panoply generated an image of the chlorophyll data contained in the file. Above the image, click on the "Array 1" submenu. This shows you all the values of chlorophyll concentration contained in the file for each longitude/latitude pixel.
8. We now need to adjust the color scale and tweak some of the image options. Note: There may be lag between clicking or adjusting values, and results. It's a big file.
9. Below the image, click on the "scale" submenu. Change the "Units" from "scalar" to "log10". Adjust the color scale to 0.02 to 2.0.
10. In "Color Table" you have many options of color palettes. I like the "MPL_viridis.rgb" for chlorophyll concentration, but you can choose whichever one you prefer.
11. Next click on the "Map" submenu and change the map projection to "Mollweide Oblique".
12. Change "Center on: Lon." to 180º.
13. Change "Grid: style" to none if you want to remove the longitude/latitude grid.
14. Click on the "Labels" submenu and uncheck the "Center footnote" box.
15. Edit the Title to "AQUA MODIS Chlorophyll Concentration, 2002 – 2018"
16. Finally, save the image to your computer (File > Save image).
17. You can also go to: https://www.giss.nasa.gov/tools/panoply/colorbars/ to download additional color palettes. Download another palette for chlorophyll, open it in Panoply, then change the color palette for your image to this new one. Save the image to your computer.



18. Download the file sst_geo-polar-blended_night_5km_2018315.nc from the google drive and open it in Panoply. Scroll down the list of metadata. You can see it looks different than the metadata for the previous file.
19. Following the same steps as above, create an image of the "sst_analysis" variable with an appropriate color scale. (You do not need to use a log scale for SST though).
20. Find a Julian day calendar to find the file's date (2018315). (Or look through the metadata). Adjust the title with the file's date. Save to your computer.



References:

https://www.unidata.ucar.edu/software/netcdf/docs/netcdf_introduction.html

https://www.unidata.ucar.edu/software/netcdf/docs/faq.html#whatisit

https://www.giss.nasa.gov/tools/panoply/

http://pro.arcgis.com/en/pro-app/help/data/multidimensional/a-quick-tour-of-netcdf-data.htm

https://www.nodc.noaa.gov/woce/woce_v3/wocedata_1/cmdac/primer/why.htm

https://www.researchgate.net/publication/315950787_xarray_N-D_labeled_Arrays_and_Datasets_in_Python

https://xkcd.com/