GREAT AUSTRALIAN BIGHT
RESEARCH PROGRAM

RESEARCH REPORT SERIES

Accessing IMOS Satellite Data and Converting into CSV Format

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This a working document and we would appreciate any feedback from researchers and industry (please contact info@aodn.org.au).

IMOS Integrated Marine Observing System

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GREAT AUSTRALIAN BIGHT RESEARCH PROGRAM

The Great Australian Bight Research Program is a collaboration between BP, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the South Australian Research and Development Institute (SARDI), the University of Adelaide, and Flinders University. The Program aims to provide a whole-of-system understanding of the environmental, economic and social values of the region; providing an information source for all to use.

CONTENTS

OVERVIEW

Several satellite datasets are available from the Integrated Marine Observing System (IMOS) portal (http://imos.aodn.org.au). Data include sea surface temperature, chlorophyll-*a* concentration and sea surface height and derived geostrophic currents and can be downloaded from the IMOS portal in the form of NetCDF files. The available satellite datasets and how to access them is detailed below.

NetCDF (network Common Data Form) is a file format for storing multidimensional scientific data (variables) such as temperature and current speed, and direction, and each of these variables can be displayed through a dimension (such as time). This format is commonly used in oceanography and meteorology and widely used in MATLAB applications.

Panoply (http://www.giss.nasa.gov/tools/panoply/) is a JAVA application developed by NASA that can be used for viewing NetCDF files (allows plotting) and exporting data into a csv or txt file.

In this document:

AVAILABLE IMOS SATELLITE DATA

A number of satellite data are currently available through the IMOS portal: (1) sea surface temperature, (2) chlorophyll-*a* concentration and (3) sea surface height and geostrophic currents. A summary of the products and characteristics is given below. Note that additional new products, including a number of ocean colour parameters and temporal averages might become available with future upgrades of the IMOS portal.

1. Sea surface temperature (SST)

Several satellite-derived SST products are accessible from the IMOS portal:

a. Derived from the Advanced Very High Resolution Radiometer (AVHRR) sensors on board multiple NOAA satellites (L3S data):
   i. Gridded daily composites
      night-time
      day-time
      day and night time
   ii. Gridded 3-day composites (running mean)
      Night-time
      Day-time
      Day and night time
b. Derived from the AVHRR sensor on board the NOAA -19 satellite only:
   i. Gridded daily composites (L3C data)
      Night-time
      Day-time
   ii. Single swaths (L3U data)
c. Derived from the MODIS sensor on board the NASA Aqua satellite (OC MODIS data)
   i. Gridded daily composite
      Day-time

The selection of the SST product is dependent on the purpose of the study as each type of data has different characteristics: daily SST products usually show poor coverage (high number of unavailable data) because the sensors are unable to get data though clouds. Day-time data may be affected by the "warm layer effect" -satellites measure SST from the skin layer of the ocean (<1mm depth), which may differ from the bulk surface temperature, especially under weak winds and high amounts of incoming sunlight. For most applications, a 3-day night time or day+night time SST composite is preferred, being a good compromise between data availability and resolution. A list of available SST products and their main characteristics is given below.

a. SST derived from the AVHRR sensors onboard multiple NOAA satellites
   i. **-> IMOS - SRS Satellite- SST L3S- 01 day composite- night time**
      -> IMOS - SRS Satellite- SST L3S- 01 day composite- day time
      -> IMOS - SRS Satellite- SST L3S- 01 day composite- day and night time composite
   ii. **-> IMOS - SRS Satellite- SST L3S- 03 day composite- night time**

-> IMOS - SRS Satellite- SST L3S- 03 day composite- day time
-> IMOS - SRS Satellite- SST L3S- 03 day composite- day and night time composite

Temporal extent: 1992 to present
Parameter name: Skin temperature of the water body
Units: degrees Kelvin
Region: 70°E to 170°W, 20°N to 70°S
References: Beggs *et al*. (2013)

b. SST derived from the AVHRR sensor onboard the NOAA -19 satellite only
   i. **-> IMOS - SRS Satellite- SST L3C- 01 day composite- NOAA-19- night time**
   -> IMOS - SRS Satellite- SST L3C- 01 day composite - NOAA-19- day time

   Temporal extent: 1992 to present
   Parameter name: Skin temperature of the water body
   Units: degrees Kelvin
   Region: 70°E to 170°W, 20°N to 70°S
   References: Beggs *et al*. (2013)

   ii. **-> IMOS - SRS Satellite- SST L3U- NOAA-19**
   [single swaths]

   Temporal extent: 2009 to present
   Parameter name: Skin temperature of the water body
   Units: degrees Kelvin
   Region: 70°E to 170°W, 20°N to 70°S
   References: Beggs *et al*. (2013)

c. SST Derived from the MODIS sensor onboard the NASA Aqua satellite
   i. **-> IMOS - SRS Satellite- OC MODIS- 01 day – Ocean Colour - SST**

   Temporal extent: 2002 to present
   Parameter name: Skin temperature of the water body
   Units: °C
   Region: 80°E to 180°E, 10°N to 60°S
   References: oceancolor.gsfc.nasa.gov
   Remarks: Day-time only
   Dates and times coincident with MODIS Aqua chlorophyll product (see below)

2. Chlorophyll-*a* concentration

Two chlorophyll-*a* concentration products - derived from the MODIS instrument onboard the NASA Aqua satellite - are available through the IMOS portal:

a. Daily images of chlorophyll-*a* concentration based on the standard OC3M algorithm

b. Daily images of chlorophyll-*a* concentration based on the Garver-Siegel-Maritorena (GSM) algorithm

In addition, chlorophyll-*a* concentration products developed and available for the southern Ocean only (south of 30°S) are also available from the IMOS portal. These include:

c. Southern ocean products:
   i. Chlorophyll-*a* derived from MODIS (modified OC3M and OC4 algorithms)
      Weekly composites
      Monthly composites
   ii. Chlorophyll-*a* derived from SeaWIFS (modified OC3M and OC4 algorithms)
      Weekly composites
      Monthly composites

The standard OC3M (O'Reilly *et al*. 2000) is an empirical algorithm developed for global applications. It is reliable in open waters but may be inaccurate in shallow or coastal waters due to bottom reflectance and interaction with colored dissolved organic matter (CDOM). The GSM algorithm (Maritorena *et al.* 2002) is a semi-analytical algorithm that takes into account other parameters such as CDOM but it is more sensitive to errors of atmosphere corrections. The standard OC3M product is more consistent and recommended within the Great Australian Bight area, although the limitations for applications in shallow waters must be taken into account. A list of available chlorophyll products and their main characteristics is given below:

a. Daily images of MODIS Aqua chlorophyll-*a* concentration based on the standard OC3M algorithm
   -> IMOS - SRS Satellite- OC MODIS – 01 day- Chlorophyll a concentration algorithm (OC3)
   Temporal extent: 2002 to present
   Parameter name: Concentration of chlorophyll per unit volume of the water body
   Units: mg/m^3
   Region: 75°E to 180°E, 10°N to 70°S
   References: O'Reilly JE *et al.* (2000)
   Remarks: Dates and times coincident with MODIS Aqua SST product

b. Daily images of MODIS Aqua chlorophyll-*a* concentration based on the semi-analytical GSM algorithm
   -> IMOS - SRS SATELLITE - OC MODIS – 01 day - Chlorophyll a concentration algorithm (GSM)
   Temporal extent: 2002 to present
   Parameter name: Concentration of chlorophyll per unit volume of the water body
   Units: mg/m^3
   Region: 75°E to 180°E, 10°N to 70°S

References: Maritorena *et al.* (2002)
Remarks: Dates and times coincident with MODIS Aqua SST product

c. Southern Ocean products:
   i. **-> SRS Satellite Contributed Ocean Colour - MODIS - Aqua Chlorophyll concentration in the Southern Ocean: Weekly, Johnson et al 2013**
   -> SRS Satellite Contributed Ocean Colour - MODIS - Aqua Chlorophyll concentration in the Southern Ocean: Monthly, Johnson et al 2013
      Temporal extent: 2002 to 2012
      Parameter name: Concentration of chlorophyll per unit volume of the water body
      Units: mg/m^3
      Region: Southern Ocean (south of 30°S)
      References: Johnson *et al.* (2013)
      Remarks: Concentration determined by use of OC3 and OC4 Algorithms, subsequently adjusted for in-situ conditions as described in Johnson et.al. 2013
   ii. **-> SRS Satellite Contributed Ocean Colour - SeaWIFS Chlorophyll concentration in the Southern Ocean: Weekly, Johnson et al 2013**
   -> SRS Satellite Contributed Ocean Colour - SeaWIFS Chlorophyll concentration in the Southern Ocean: Monthly, Johnson et al 2013
      Temporal extent: 1997 to 2010
      Parameter name: Concentration of chlorophyll per unit volume of the water body
      Units: mg/m^3
      Region: Southern Ocean (south of 30°S)
      References: Johnson *et al.* (2013)
      Remarks: Concentration determined by use of OC3 and OC4 Algorithms, subsequently adjusted for in-situ conditions as described in Johnson et.al. 2013

3. Sea surface height and geostrophic currents

Two sea surface height (SSH) and geostrophic currents products are available through the IMOS portal. Both include sea surface height anomaly, sea surface height above the geoid and northward and eastward geostrophic current velocity as (a) delayed mode and (b) near real time. Their name and characteristics are:

a. Delayed mode product:
   -> IMOS - OceanCurrent - Gridded sea level anomaly - Delayed mode
      Temporal extent: 1992 to present
      Parameters name: Eastward geostrophic current velocity in the water body

Northward geostrophic current velocity in the water body
Sea surface height anomaly
Sea surface height above geoid

Region: Australasian
References: http://imos.aodn.org.au/oceancurrent

b. Near real time product:

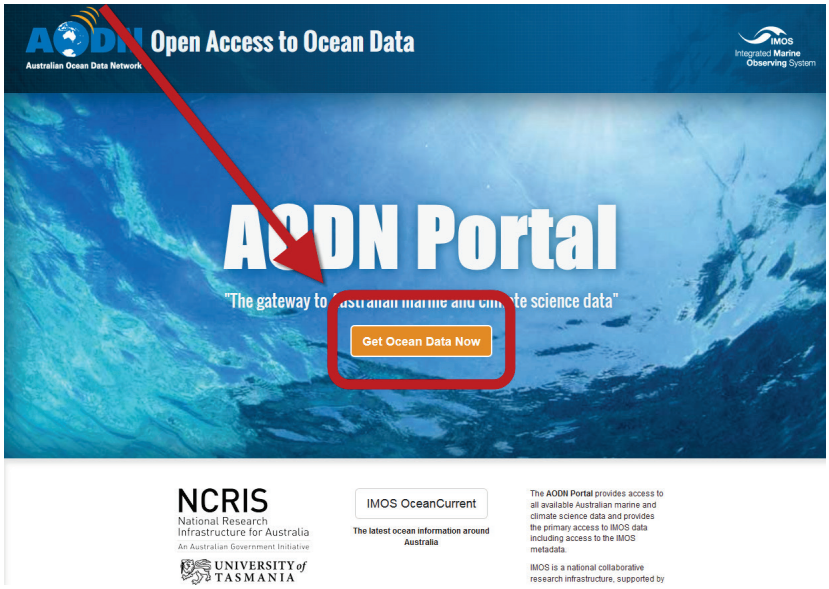
-> IMOS - OceanCurrent - Gridded sea level anomaly - Near real time

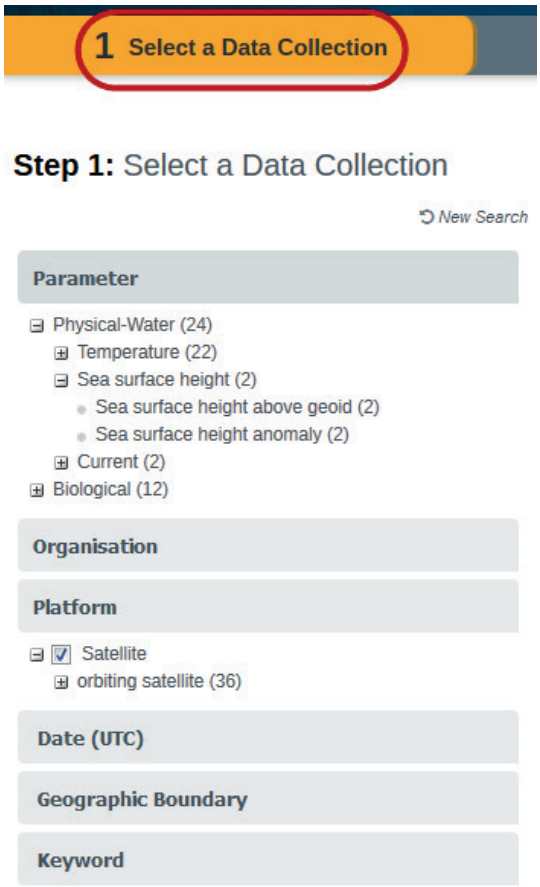
Temporal extent: 2011 to present
Parameters name: Eastward geostrophic current velocity in the water body
Northward geostrophic current velocity in the water body
Sea surface height anomaly
Sea surface height above geoid

Region: Australasian
References: http://imos.aodn.org.au/oceancurrent

DOWNLOADING DATA FROM THE IMOS PORTAL

1. Go to https://portal.aodn.org.au/ and click '*Get Ocean Data Now*'





2. Select a data collection from the left menu:

Measured parameter

For SST select:
+Physical-Water
+Temperature
Skin temperature of the water body

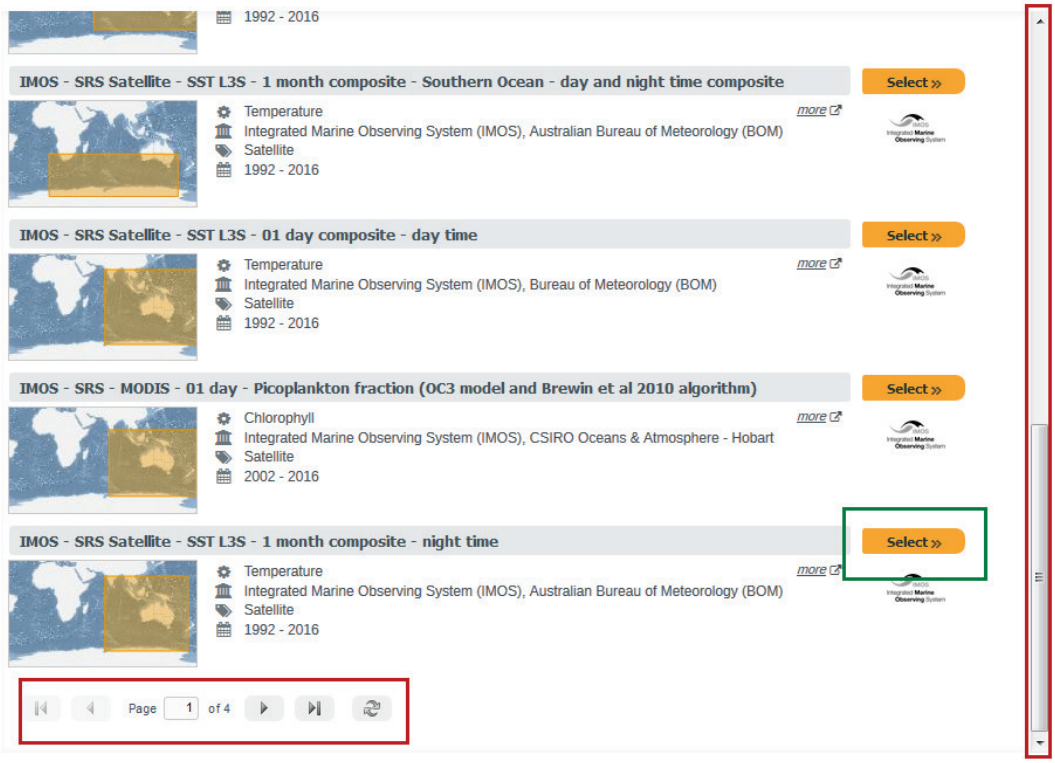
For Chlorophyll-*a* select:
+Biological
+Chlorophyll
Concentration of chlorophyll per unit volume of the water body

For SSH select:
+Physical-Water
Sea surface height

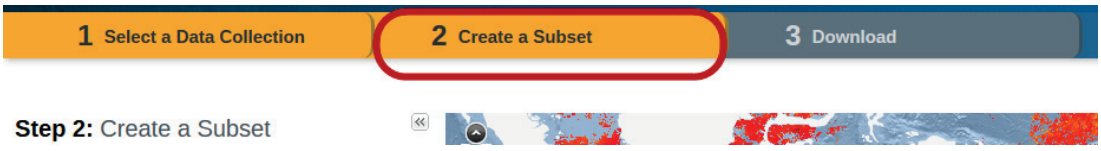
Platform:

For all satellite products select:
+Satellite
Orbiting satellite

3. Find and select the desired product from the list on the right (check list of names and description of data from previous section)

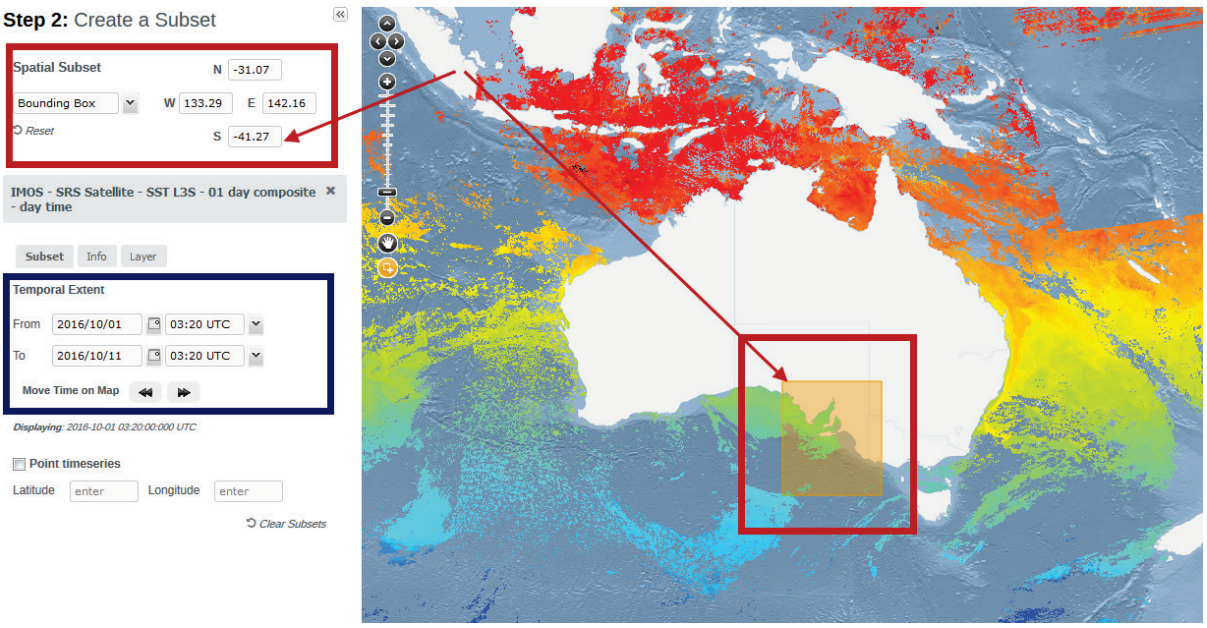


4. Create a subset



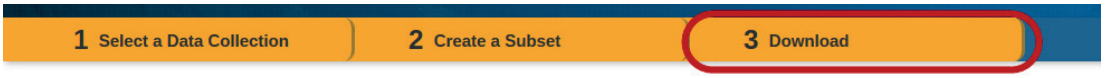
Create a spatial subset using the bounding box or a polygon. You can use the interactive map or enter the desired coordinates (for the bounding box only). Then choose the temporal extent (select the date range, the UTC time cannot be changed as this is related to the time of satellite overpass on a particular day), click interface to save changes (else your values will not be stored) and then click next.

Note: Currently, all satellite data coordinates vary between 0 and 360 degrees. IMOS is also developing a new aggregation method that will also allow the selection of a single point.



Note: if the 'temporal extent' box (i.e. 'From' or 'To') shows a red border, it means that there is no data available for the selected day. Choose the calendar (the little box adjacent) to select another day.

5. Download the data



Download the data (available only as NetCDF format) and/or view the metadata record. The download size is unknown at the time of the request (it depends on the period and region requested) and subsetting the data may take a long time. You will be asked to provide an email address to be notified when your data is ready to download. You will also be provided with a URL address to check on the progress of your download request.

Note: we suggest downloading a few days of data for a small region first to get an idea of the size of the download and time it will take for a bigger data set to download. Currently the limits on download are 2232 files or 2 hours cpu processing time, whichever comes first, and if either of these are reached the request will fail and you will receive an email error message.

Individual satellite images (netCDF files) can be downloaded directly from the THREDDS server; go to http://thredds.aodn.org.au/ and select 'SRS Datasets', 'sst' or 'oc' and navigate to the file of choice, then click on the file name to see the download options:

- OPENDAP – allows examination of the file contents
- HTTPServer – download the file to your desktop
- WMS – gives the XML representation of the file
- NetcdfSubset – allows subsetting of the file contents then download to your desktop.

READING NETCDF DATA USING PANOPLY

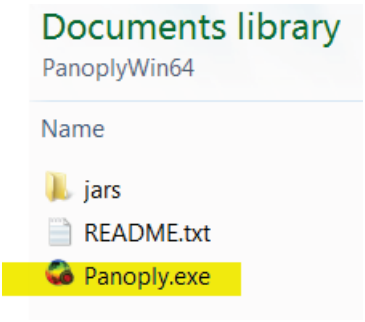
1. Install JAVA and Panoply

   Panoply (http://www.giss.nasa.gov/tools/panoply/) is a JAVA application and it requires Java SE 6 runtime environment -or better- to be installed. To install Java go to http://www.java.com/en/download/manual.jsp and download and install the JAVA file according to your operating system (Mac OS X, Windows 64-bit, Linux, etc). To install Panoply go to http://www.giss.nasa.gov/tools/panoply/ scroll down to the bottom of the page and choose to download Panoply according to your operating system (Mac OS X, Windows 64-bit, Linux, etc.). Note that Panoply package for Windows comes as a Zip archive and you must manually extract this archive prior to the installation. You can place Panoply in any directory but will need to set the PATH to use Panoply anywhere.

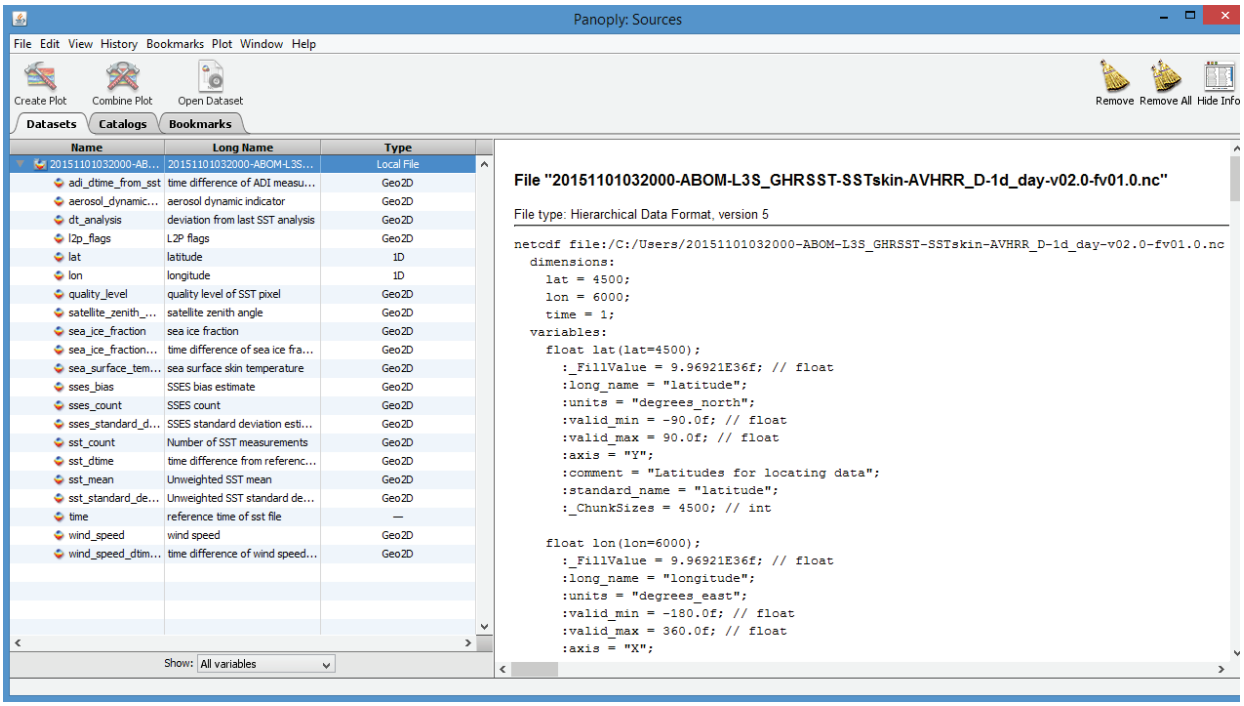
2. Open NetCDF files:

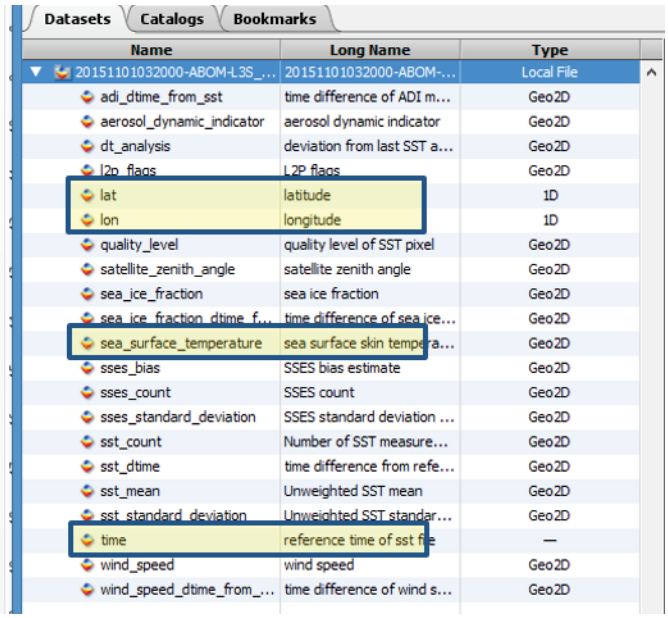
   Double-click on the Panoply.exe application to run the program and then go to file->open and choose the NetCDF file of interest.

   In this example we have loaded an L3S 1-day day-time composite.



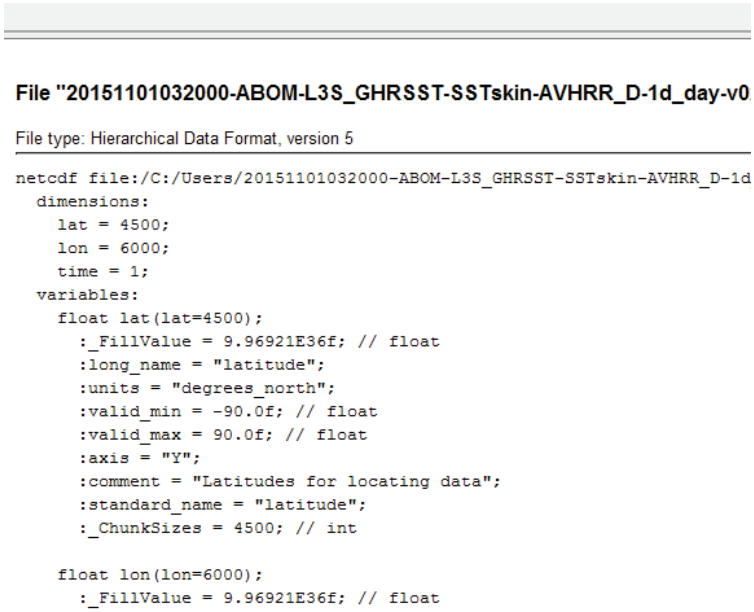
The loaded file looks like this:





The left panel displays the variables within the file, e.g. of interest in the example are lat, lon, sea_surface_temperature and time.

The right panel displays the metadata (info on what who and when about the data).



Clicking on each of the variables on the left will display the attributes of the selected variable on the right panel. It is important to **check the attributes** to get critical information such as the units.

3. Export data

To export the data, load the NetCDF file as shown before and select (click on) the variable (For example. sea_surface_temperature), then go to '*file->export data-> Export data as labelled text',* which will create a txt file with four columns: time, longitudes, latitudes and data values.

Note: the time will be saved as a code number in the units specified in the attributes:
For MODIS data , the time units are `"days since 1800-01-01 00:00:00.0" (Gregorian calendar)`. For example:

01 Jan 1800 will = 1
02 Jan 1800 = 2
03 Jan 1800 = 3
(…)
01 Jan 2014= 78162
02 Jan 2014=78163

Excel can convert dates to code numbers and vice versa, but it uses "`days since 01-01-1900`" as units, hence:
to convert the number to a calendar date using excel:

a. Create a new column subtracting 36522[1] from the code numbers,
   e.g. for the 01 Jan 2014 =>78162 – 36522=41640
b. Select the new column and right click to change the format cells to date ('*home->format->format cells'*)

For AVHRR data (SST), time units are `" seconds since 1981-01-01 00:00:00"`.

[1] Where 36522 is the number of days from 1/1/1800 to 1/1/1900

For example:

01 Jan 1981 00:00:00 will = 1
02 Jan 1981 00:00:00= 86400 (=24h * 60' * 60'')
03 Jan 1981 00:00:00=172800
(…)
01 Jan 2014 15:20:00=1041434400
02 Jan 2014 15:20:00=1041520800

Excel can convert dates to code numbers and vice versa, but it uses "`days since 01-01-1900`" as units, hence:

to convert the number to a calendar date using excel:

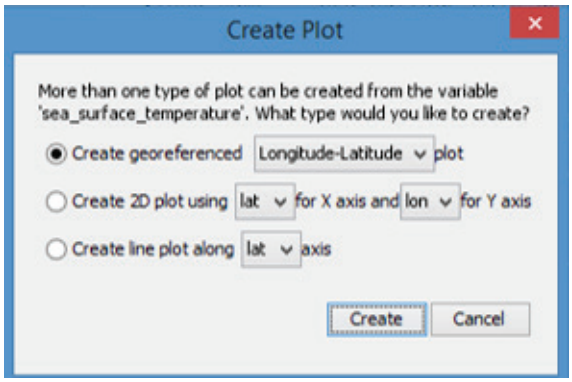
a. Create a new column adding 29587 or "1 Jan 1981" (number of days between 1/1/1900 and 1/1/1981) to the code numbers divided by 86400 (=24h * 60' * 60'') to convert seconds to days (since 1981).
   E.g. for the 01 Jan2014=> = "1 Jan 1981" + 1041434400/86400 = 41640.64
   OR = 29587 + 1041434400/86400 = 41640.64
b. Select the new column and right click to change the format cells to date ('*home->format->format cells'*)

Note: SST data from NOAA is stored as Kelvin rather than degrees Celsius so use the conversion (1°C = 1°K - 273.15) in another column of your csv file.

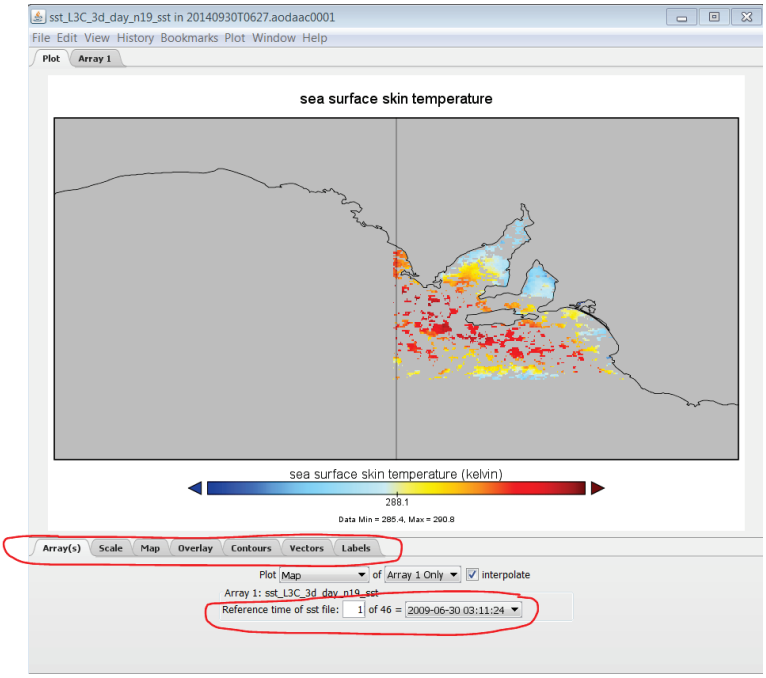
Note: "NaN" stands for "*not a number*" and it is the value assigned to missing data within the satellite image (eg., due to cloud cover etc)

4. Plot data (map)

To display the data on a map, load the netcdf file as shown before and double click on the desired variable (i.e. sea_surface_temperature), then choose '*Create geogridded plot'*



Panoply will display a lat/lon map with your selected parameter for the first of the time references. You can change the displayed dates under the '*Array(s)* ' tab located below the image. By the default, the map uses an '*equirectangular*' projection (global), to zoom into your area of interest, you can select: '*equirectangular (regional)*' by clicking the '*map*' tab located below the image.



you can further personalize the displayed map (color scale, map projection, land overlay, labels, etc…) using the rest of the tabs (‘*scale’*, ‘*overlay’*, …) and save the displayed map in a number of formats (*file->save image as*), including png, pdf and ps.

5. Considerations when using AVHRR SST products:
   For each SST value the AVHRR SST files contain other useful information such as quality level flags (*quality_level)* and bias error estimates (*sses_bias*) among others that can be used to improve the quality and/or spatial coverage of the SST data, i.e.:

   Bias error estimates can be applied to the SST values to reduce the effect from short-term changes in the atmospere and the sensor (De-biased SST=SST-bias).

   Quality level flags can be used to reduce the probabality of cloud contamination within the pixel. For example, SST values with quality_level flag of 5 will have the lowest probability of cloud contamination, while selecting SST values for quality_level > 3 will produce greater spatial coverage and still generally cloud-free pixels.

   A complete description of the different variables and how to use them can be found in: http://imos.org.au/sstproducts.html. We recommend to check the available information prior to using the SST data from AVHRR.

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