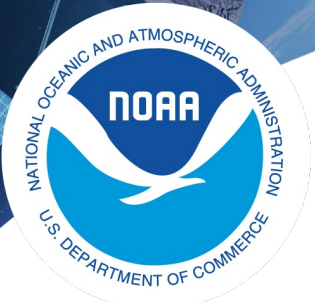




Using Satellite Data in GIS

Michael Soracco
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College Park, MD

<https://coastwatch.noaa.gov>
coastwatch.info@noaa.gov

Versioning:

20210429, Soracco
20210401, Soracco
2020, Soracco
2019, Soracco



This Training

- Component of the *NOAA CoastWatch Satellite Training Course*
- Comprised of 3 modules: Data, Tools, Exercise(s)
- Uses ESRI ArcMap, but techniques work with QGIS and other GIS software
- Updated from CoastWatch Satellite GIS training originally given in 2000 for avenue-based ArcView 3.1



A few notes on ArcMap for NOAA Users



- The exercises and screenshots were created using ArcGIS 10.7
- The current version of ArcMap is 10.8.1
- The EDC has been updated and will install with any version of ArcMap 10.4+
- ArcMap 10.8.1 is the final release of ArcMap and all future development will go into ArcGIS Pro. ArcMap 10.8.1 will continue to be supported until 2026 via the normal Esri support cycle. If you are unsure of which product to choose, consider ArcGIS Pro.
- ESRI support for ArcMap 10.8.1

ESRI support for ArcMap 10.8.1

Product Life Cycle

Product Lifecycle Policy

Product: ArcGIS Desktop 10.8.1

Release Date: July 28, 2020

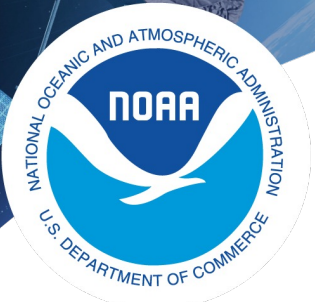
Support status: **General Availability**

		General Availability Jul 2020 - Feb 2022	Extended Support Mar 2022 - Feb 2024	Mature Support Mar 2024 - Feb 2026	Retired March 01, 2026
Technical Support	Request Case	✓	✓	✓	
	Phone and Chat	✓	✓	✓	
	Online support resources	✓	✓	✓	✓
Software Support	Software updates and patches	✓	✓		
	Software hotfixes	✓	✓		
	New environment certification	✓			

Note for Software Hotfixes: For details about hotfix policies, please refer to the Developer Technologies section in the [Esri Product Lifecycle Support Policy](#) document.

This slide has no audio





Using Satellite Data in GIS: Tools

Michael Soracco
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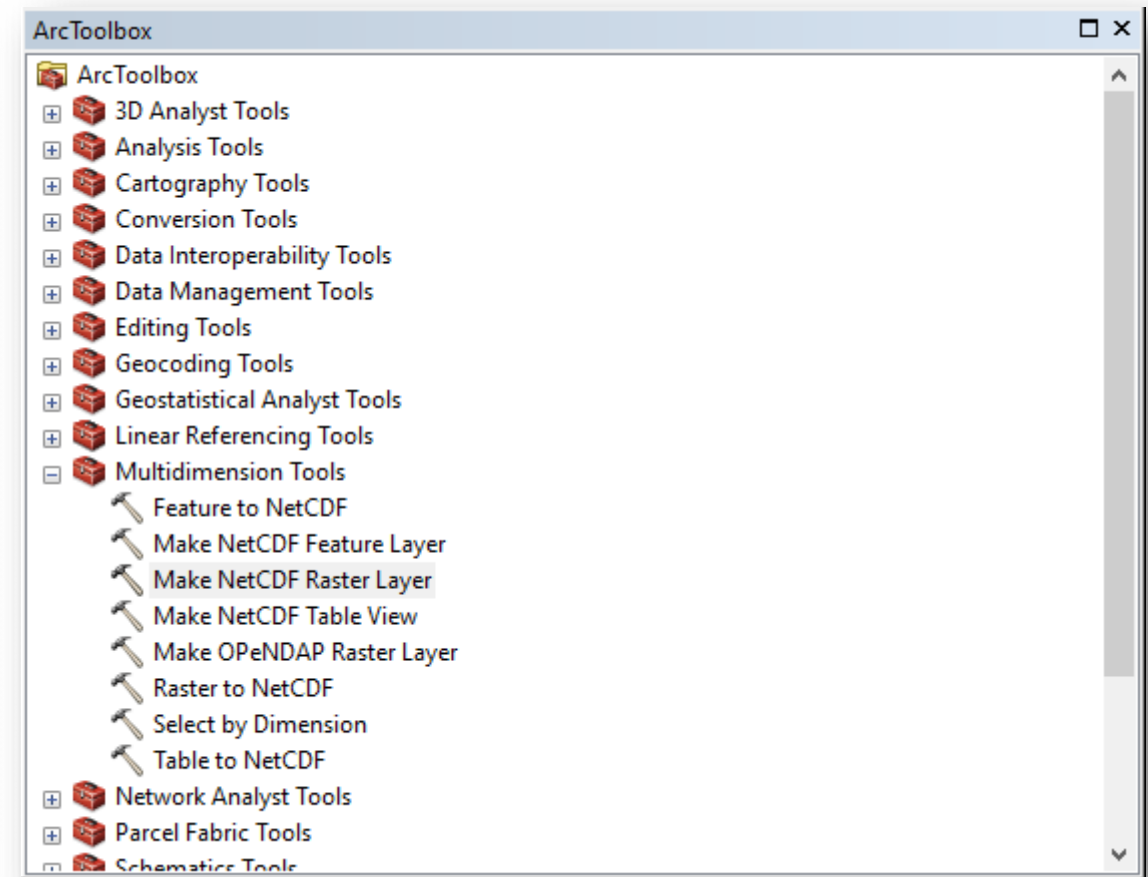
<https://coastwatch.noaa.gov>
coastwatch.info@noaa.gov

Versioning:
2020, Soracco



Overview: Tools/Methods

- ArcGIS built-ins
- ArcGIS add-ons
- External



ArcMap's Toolbox



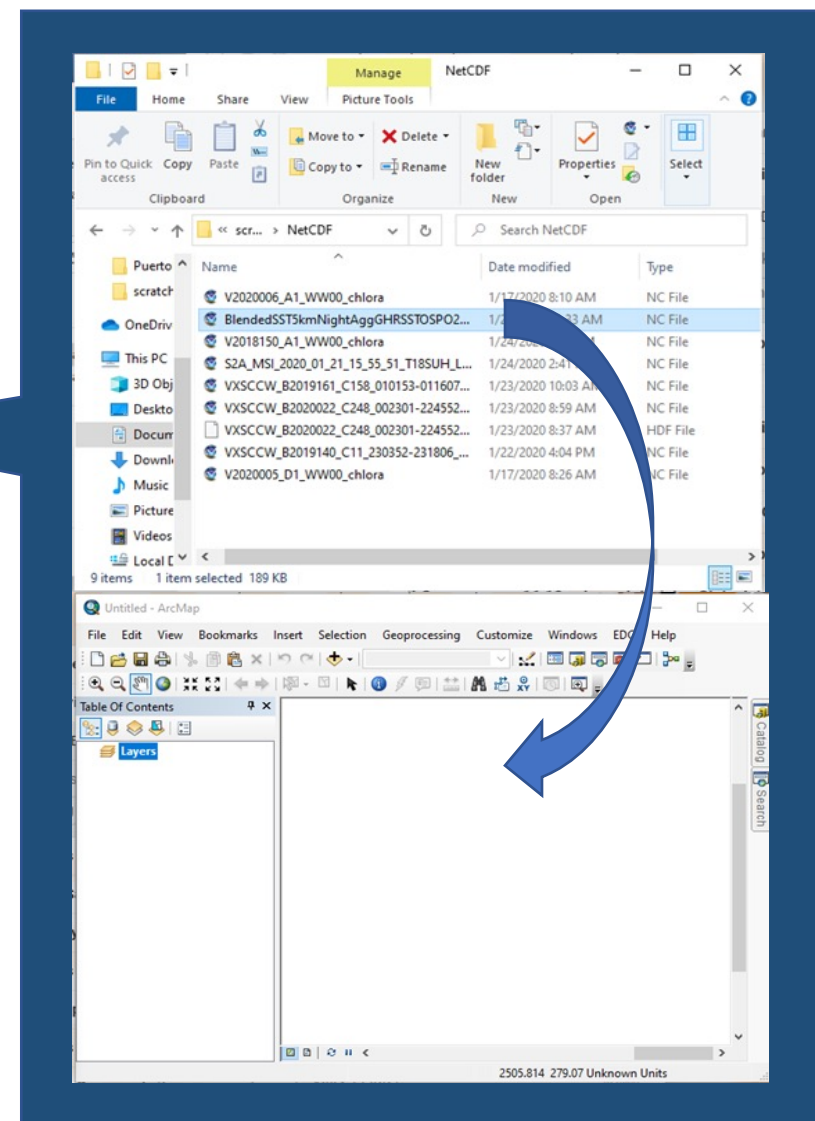
Useful Extensions / Add-ons

- ArcGIS Spatial Analyst (license) – ESRI
 - Raster tools
- Environmental Data Connector (EDC v1.3.7.1)
 - Helper tool to obtain multidimensional data (space-time-+)
 - Run from ArcMap or as standalone
 - Graphical-user-interface to ERDDAP / THREDDS services
 - <https://www.pfeg.noaa.gov/products/EDC/EDCdownloads.html>
- CoastWatch Utilities:
 - Command line tools: cwexport, cwsample, cwrender
 - <https://coastwatch.noaa.gov/cw/user-resources/coastwatch-utilities.html>



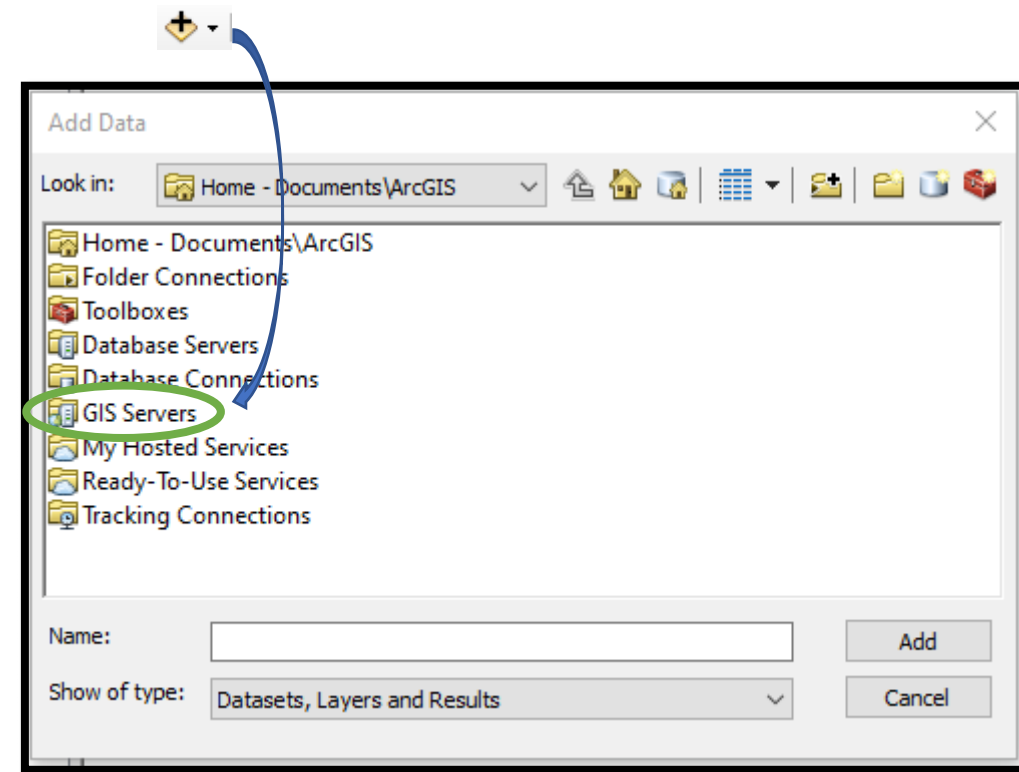
Methods to add Satellite Data

- WMS and WCS
- Drag-n-drop
 - GeoTIFF, HDF, NetCDF, JPEG2000
- Multidimension Toolbox 
 - Make OpenDAP Raster Layer (ArcToolbox->Multidimensional Tools)
 - Make NetCDF Raster Layer (ArcToolbox->Multidimensional Tools)
- EDC (Environmental Data Connector) 
- Programmatically: Python, Jupyter Notebooks



Web Mapping and Coverage Services (WMS and WCS)

- Add Data 
- WMS: image
- WCS: data values
- Comments:
 - Ok for single time/place
 - Can be frustrating on finding the correct URL
 - Each change in PZI results in refresh call...and sometimes errors



And sometimes errors...

The image is a collage of three screenshots from the ArcMap software interface, illustrating common errors when adding a WMS server.

Top Left Screenshot: Add WMS Server dialog box
URL: <https://coastwatch.noaa.gov/thredds/wms/Blended/SST5km/Night/GHRSSTOSPO/2020>
Version: 1.3.0
Custom Parameters: (Empty table)
Server Layers: STAR TDS Installation > STAR TDS Installation > Analysed blended sea surface temperature
Name: analysed_sst
Abstract: analysed sea surface temperature
LatLongBoundingBo: -179.975006, -89.974998
Scale range: Minimum: 0.000000, Maximum: 0.000000
Supported SRS: EPSG:4326, CRS:84, EPSG:27700, EPSG:27701
Account (Optional): User: , Password: , ☒ Save

Top Right Screenshot: Add Data dialog box
Look in: Analysed blended sea surface t
Layers: estimated error standard deviation of analysed_sst, sea_ice_area_fraction, sea_land_ice_bit_mask, sea_surface_foundation_temperature
Buttons: Add, Cancel

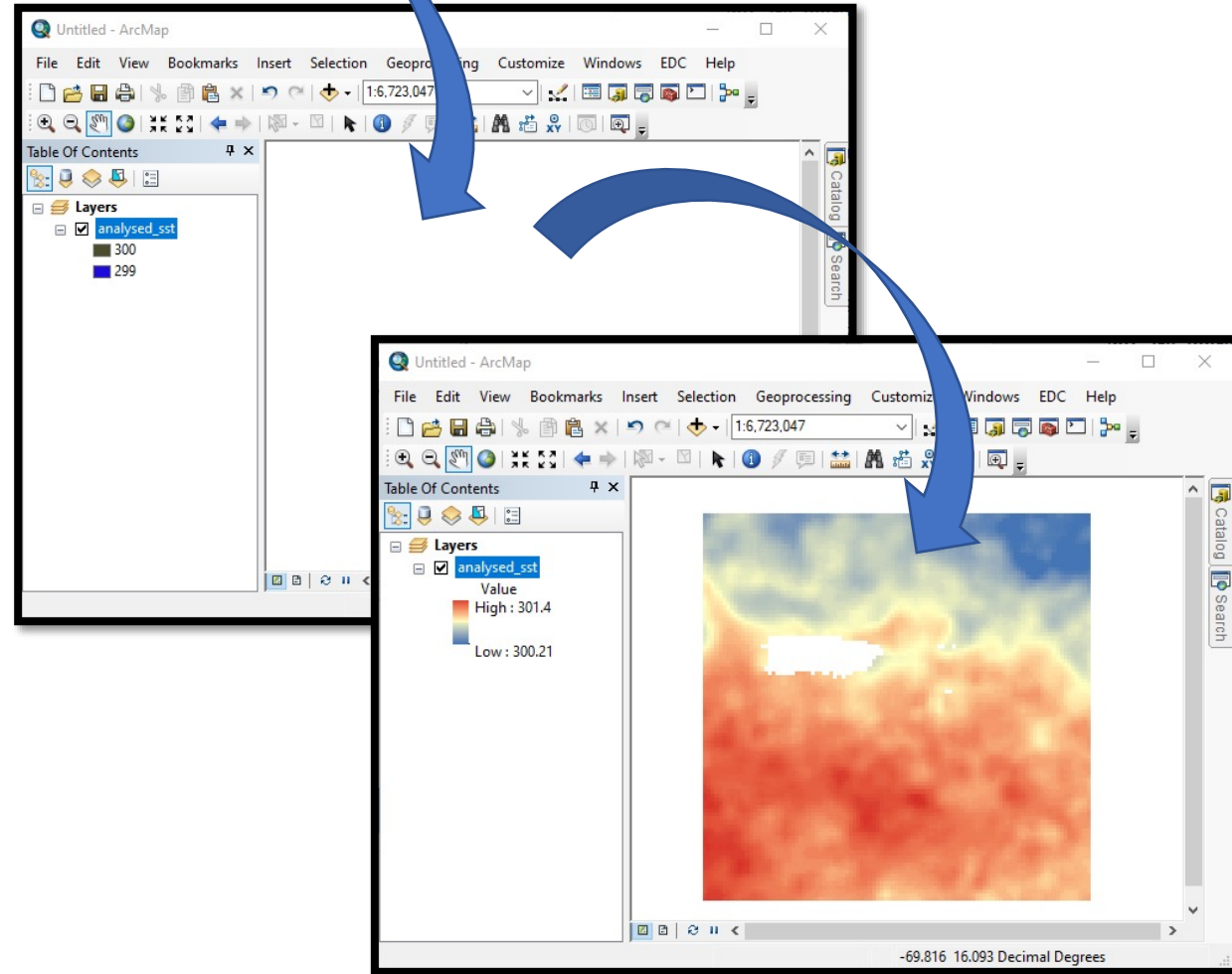
Bottom Left Screenshot: ArcMap Drawing Errors dialog box
Title: ArcMap Drawing Errors
Message: One or more layers failed to draw:
STAR TDS Installation: WMS service exceptions:Service Error
Description: Unexpected error of type java.io.IOException

Bottom Right Screenshot: ArcMap Drawing Errors dialog box
Title: ArcMap Drawing Errors
Message: One or more layers failed to draw:
STAR TDS Installation: This WMS Service has a layer limit of 1 per request. Try to add each WMS sub layer individually to send multiple requests.
STAR TDS Installation: WMS service exceptions:Service Error
Description: You may only create a map from 1 layer(s) at a time

Drag -n- Drop

- Quick and easy
- Requires configuration
[symbology, NetCDF, time, time slider]
- Comments:
 - Defaults to first variable
 - Don't always get what you want

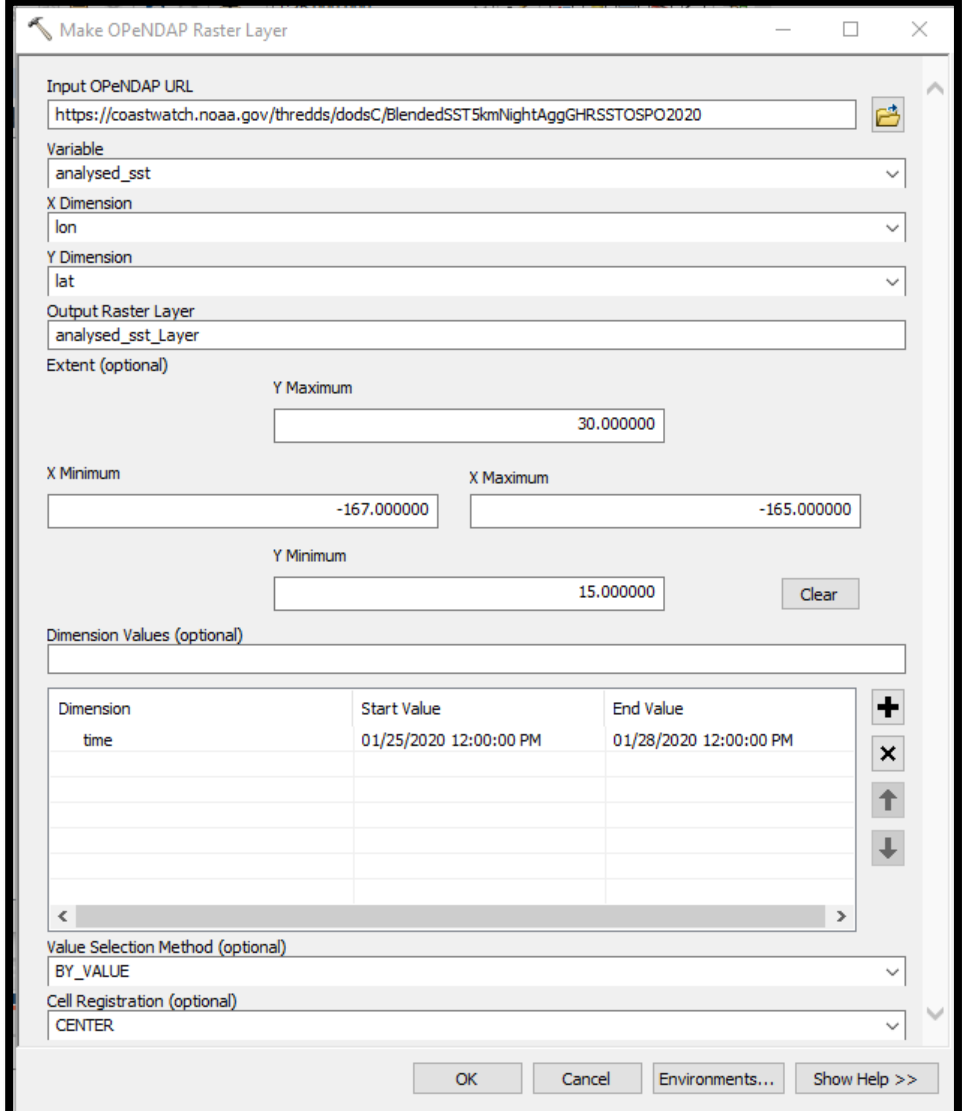
BlendedSST
5kmNightA
ggGHRSSST
OSPO2020



Make OpenDAP Raster Layer

ArcToolbox->Multidimension Tools->Make OpenDAP Raster Layer

- A few clicks 
- Menu-driven configuration to maximize usefulness
- Handles file or aggregates. Enter URL without extension
- Requires additional configuration [time, time slider] to maximize usefulness
- Comments:
 - Unexpected Errors
 - Results may vary



Make OPeNDAP Raster Layer

Input OPeNDAP URL

Variable

X Dimension

Y Dimension

Output Raster Layer

Extent (optional)

Y Maximum

X Minimum

X Maximum

Y Minimum

Clear

Dimension Values (optional)

Dimension	Start Value	End Value
time	01/25/2020 12:00:00 PM	01/28/2020 12:00:00 PM

Value Selection Method (optional)

Cell Registration (optional)

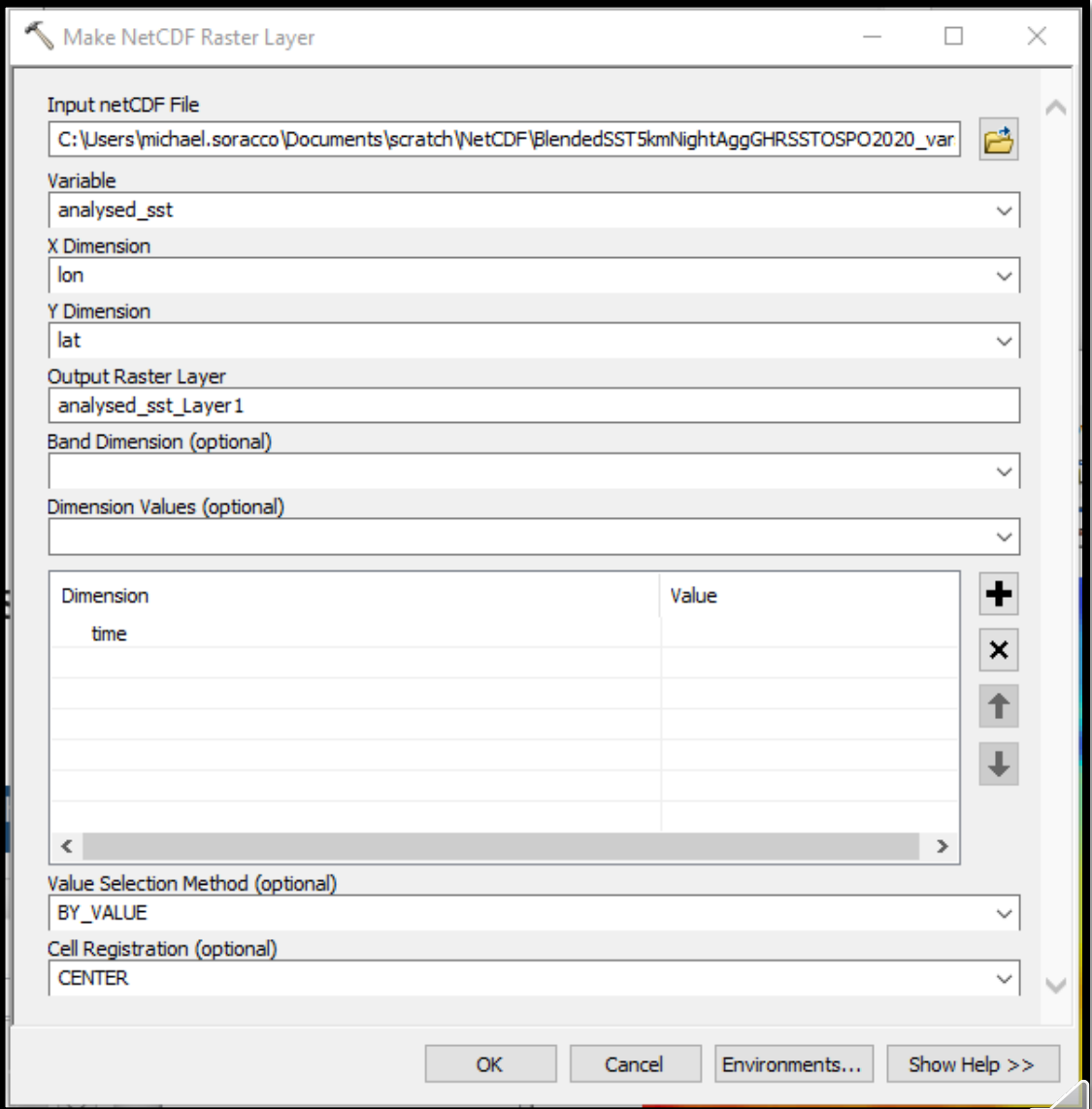
OK Cancel Environments... Show Help >>



Make NetCDF Raster Layer

- A few clicks 
- Menu-driven configuration to maximize usefulness
- Requires configuration [time, time slider]

ArcToolbox->Multidimension Tools->Make NetCDF Raster Layer



Make NetCDF Raster Layer

Input netCDF File
C:\Users\michael.soracco\Documents\scratch\NetCDF\BlendedSST5kmNightAggGHRSTOSPO2020_var

Variable
analysed_sst

X Dimension
lon

Y Dimension
lat

Output Raster Layer
analysed_sst_Layer1

Band Dimension (optional)

Dimension Values (optional)

Dimension	Value
time	

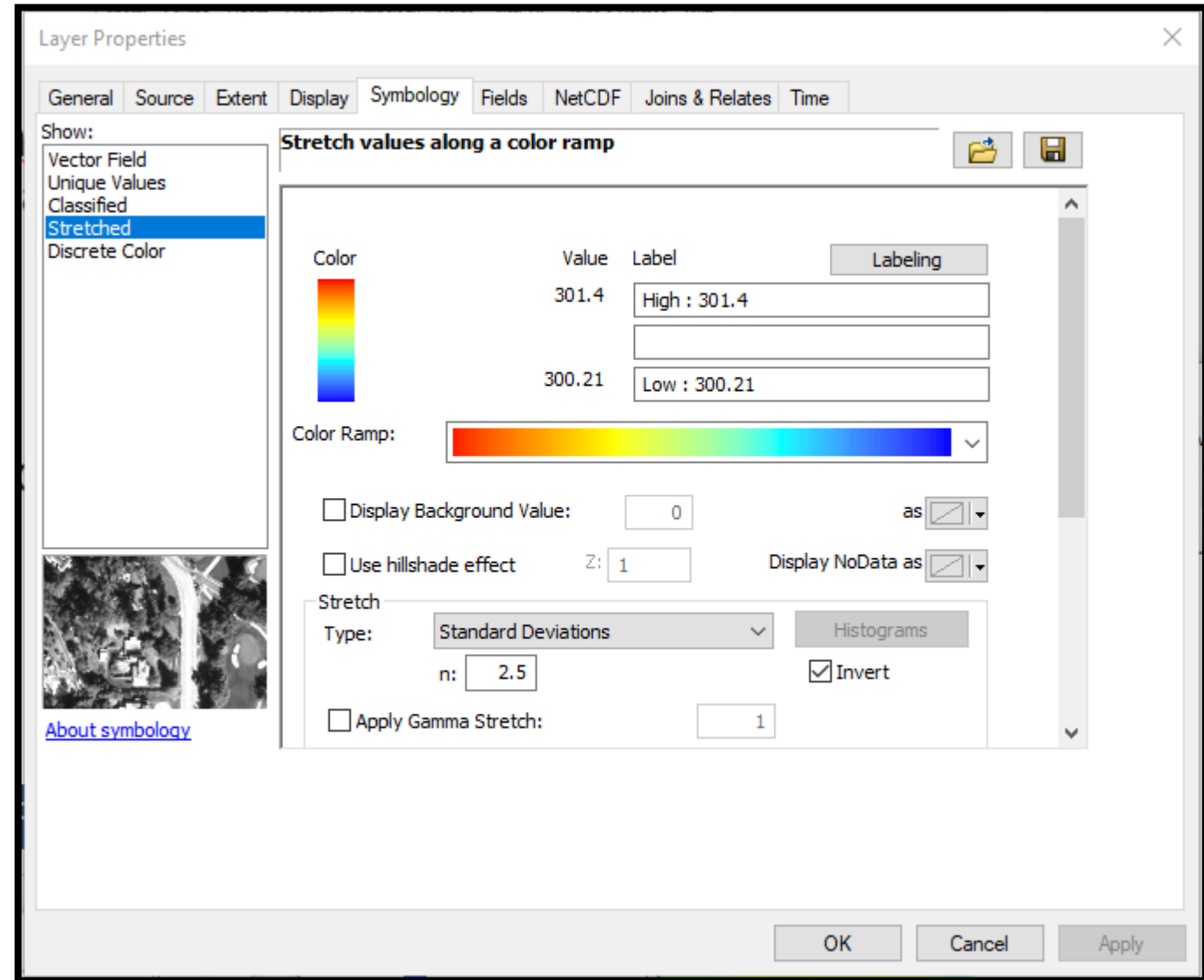
Value Selection Method (optional)
BY_VALUE

Cell Registration (optional)
CENTER

OK Cancel Environments... Show Help >>

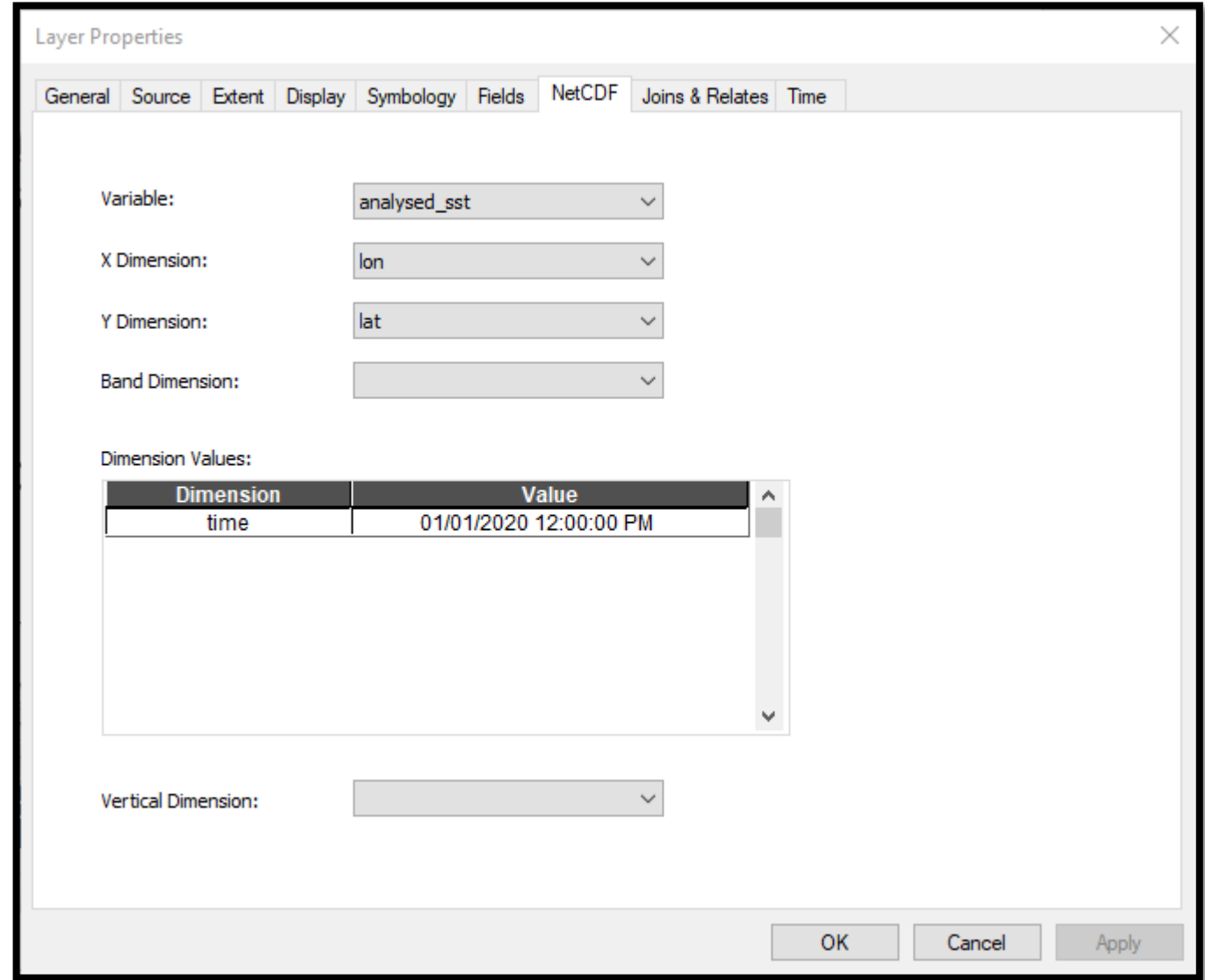
Layer Properties: Symbology

- ArcToolbox-> Multidimension Tools-> Make NetCDF Raster Layer
- Menu-driven configuration to maximize usefulness



Layer Properties: NetCDF

- ArcToolbox-> Multidimension Tools-> Make NetCDF Raster Layer
- Menu-driven configuration to maximize usefulness



The screenshot shows the 'Layer Properties' dialog box with the 'NetCDF' tab selected. The 'Variable' is set to 'analysed_sst'. The 'X Dimension' is 'lon' and the 'Y Dimension' is 'lat'. The 'Band Dimension' is empty. The 'Dimension Values' table shows a single row for 'time' with the value '01/01/2020 12:00:00 PM'. The 'Vertical Dimension' is empty. The 'OK', 'Cancel', and 'Apply' buttons are at the bottom right.

Dimension	Value
time	01/01/2020 12:00:00 PM

Layer Properties: Time

- ArcToolbox->Multidimension Tools->Make NetCDF Raster Layer
- Menu-driven configuration to maximize usefulness

The screenshot shows the 'Layer Properties' dialog box with the 'Time' tab selected. The 'Enable time on this layer' checkbox is checked. Under 'Time properties', 'Layer Time' is set to 'Layer has time as a dimension.', 'Time dimension' is 'time', 'Field Format' is '<Date/ Time >', 'Time Step Interval' is '1' days, and 'Layer Time Extent' is from '1/1/2020 12:00:00 PM' to '1/28/2020 12:00:00 PM'. A 'Calculate' button is next to the extent. The 'Data changes frequently so calculate time extent automatically' checkbox is unchecked. Under 'Advanced settings', 'Time Zone' is '(UTC) Coordinated Universal Time', 'Values are adjusted for daylight savings' is unchecked, 'Time Offset' is '0.00' years, and 'Display data cumulatively' is checked. At the bottom are 'OK', 'Cancel', and 'Apply' buttons.

Layer Properties

General Source Extent Display Symbology Fields NetCDF Joins & Relates Time

☒ Enable time on this layer

Time properties

Layer Time: Layer has time as a dimension.

Time dimension: time

Field Format: <Date/ Time >

Time Step Interval: 1 Days

Layer Time Extent: 1/1/2020 12:00:00 PM To: 1/28/2020 12:00:00 PM Calculate

☐ Data changes frequently so calculate time extent automatically.

Advanced settings

Time Zone: (UTC) Coordinated Universal Time

☐ Values are adjusted for daylight savings

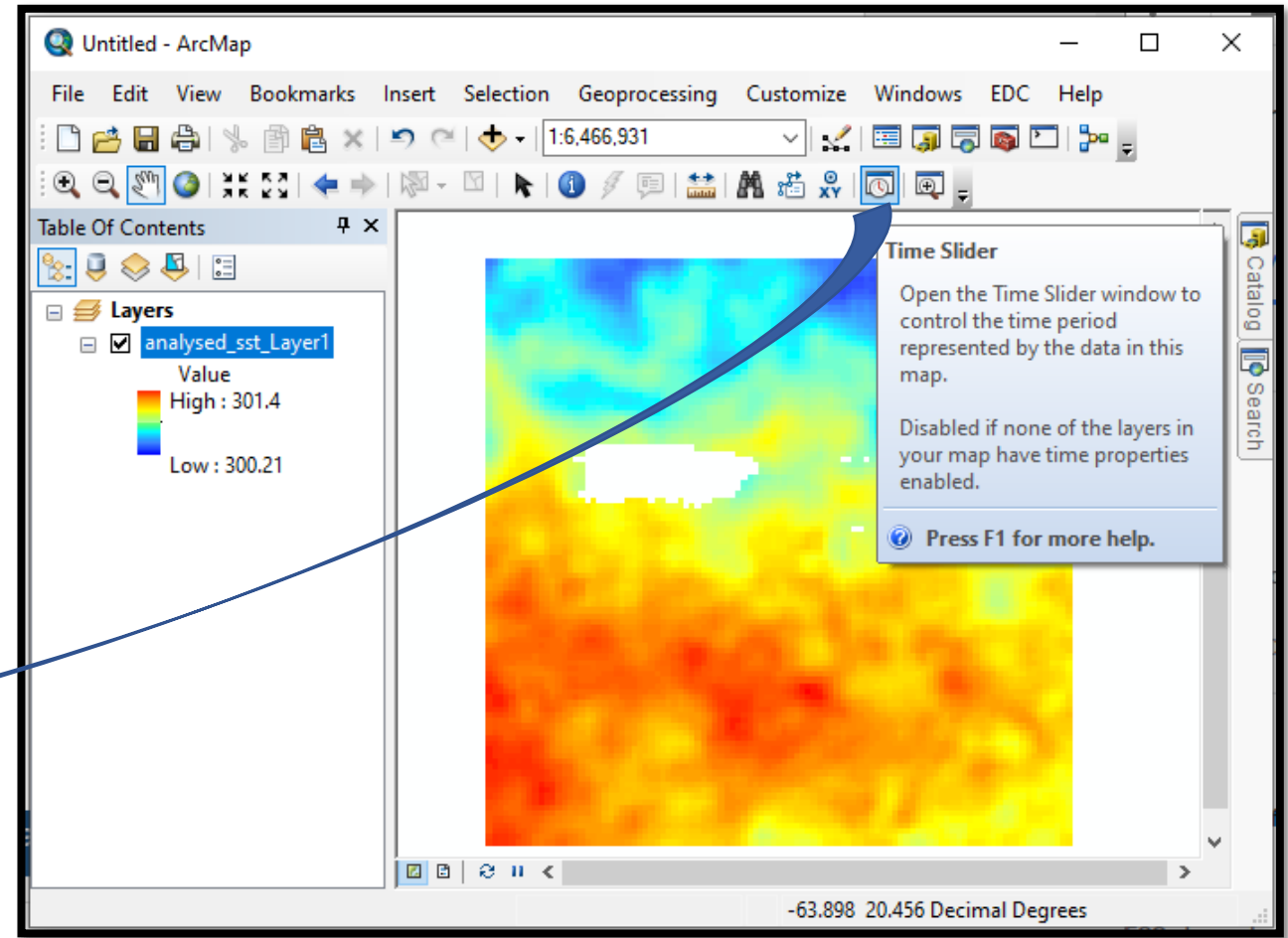
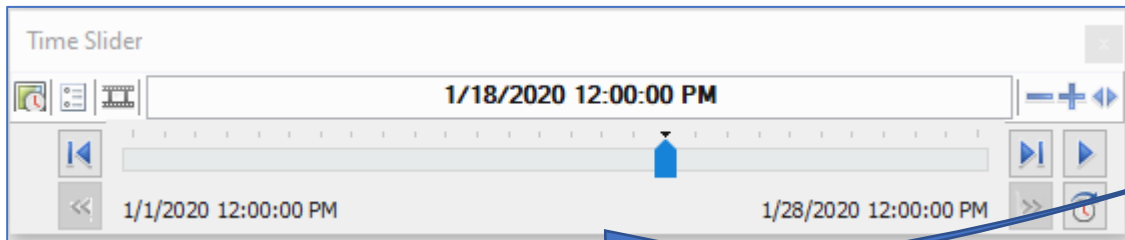
Time Offset: 0.00 Years

☒ Display data cumulatively

OK Cancel Apply

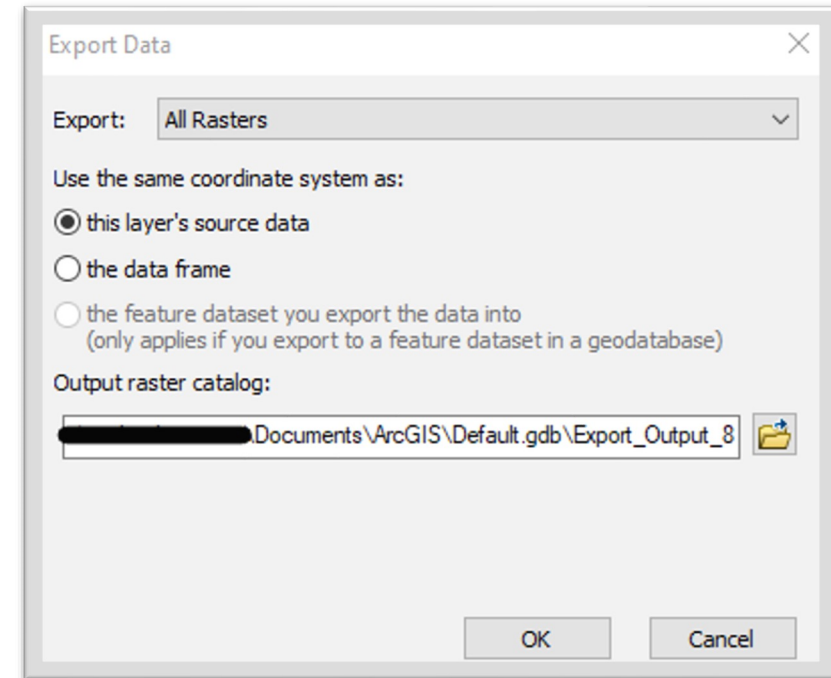
Enable Time Slider for the Map

- Select the 'Time Slider' icon to activate the slider control



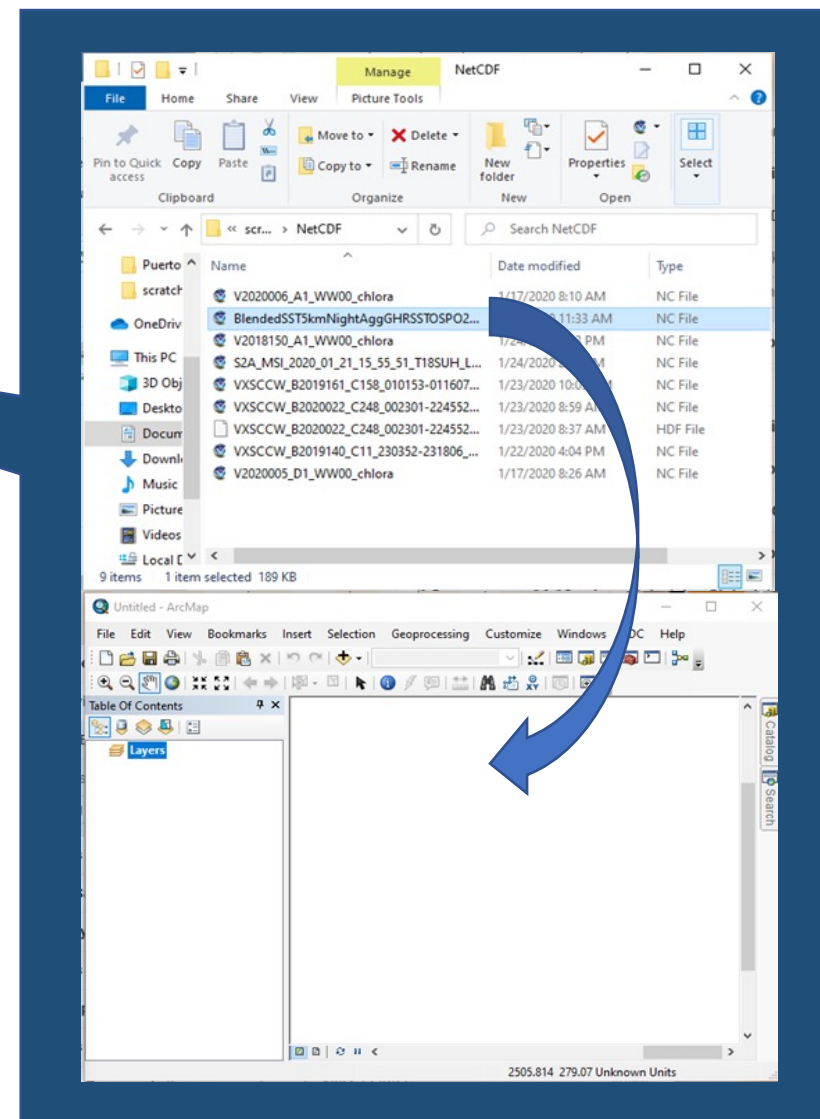
Export Data to Geospatial Database

- Right-mouse-click on layer -> Click Data -> Export Data
- Set the desired GeoDatabase location
- Select Export



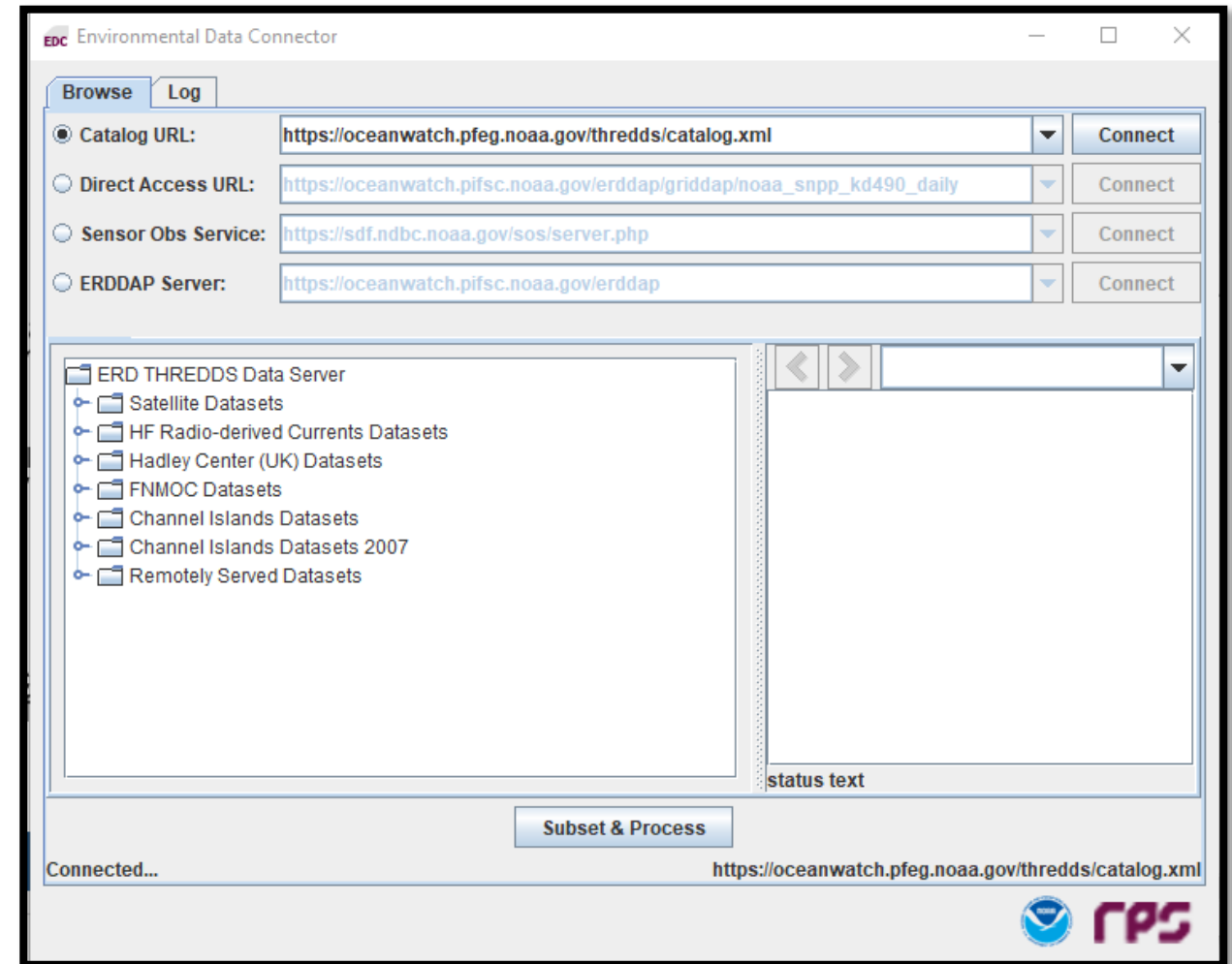
Recap Methods to add Satellite Data

- **Drag-n-drop**
 - GeoTIFF, HDF, NetCDF, JPEG2000
- **Multidimension Toolbox** 
 - Make NetCDF Raster Layer (ArcToolbox->Multidimensional Tools)
- **EDC** (Environmental Data Connector) 
- Programmatically: Python, Jupyter Notebooks
- Multidimension Toolbox
 - Make OpenDAP Raster Layer (ArcToolbox->Multidimensional Tools)
- WMS and WCS



Environmental Data Connector

- Updated for ArcMap 10.8
- Connects to a variety of services
- Provides data listings
- Subsets by space and time to only retrieve data that is needed
- Simplifies import by automating the 'layer properties' steps



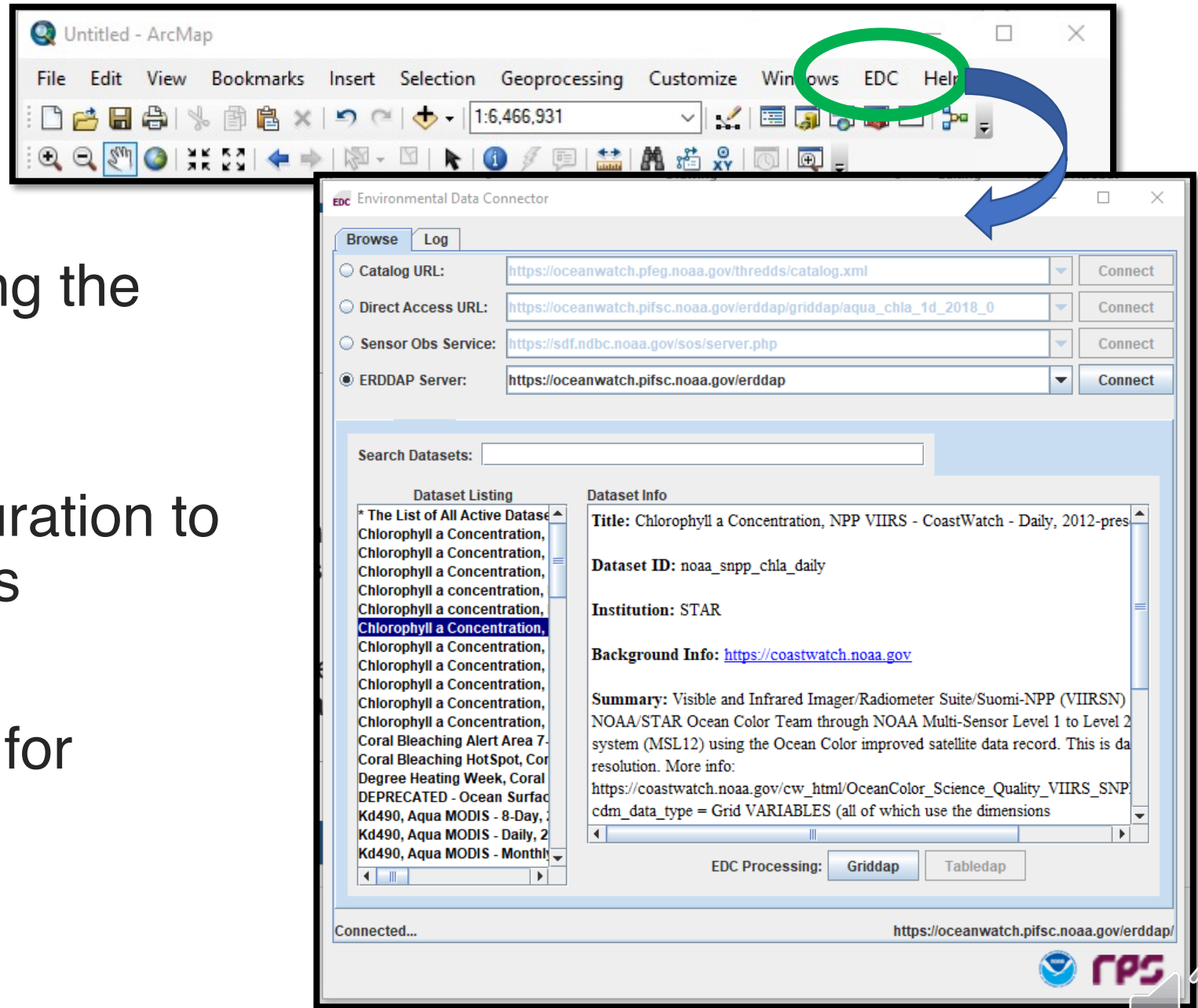
Installing EDC

- Use Java to run the 'setup.jar' file
 - Java -jar <path>\setup.jar
 - Upon execution, it will re-launch under wscript with command-line options
- Installation:
 - Creates directory for EDC standalone programs
 - Integrates with ArcMap
 - Requires advance installation of Java (OpenJDK)
 - Extra steps/permissions if installed within Program Files.

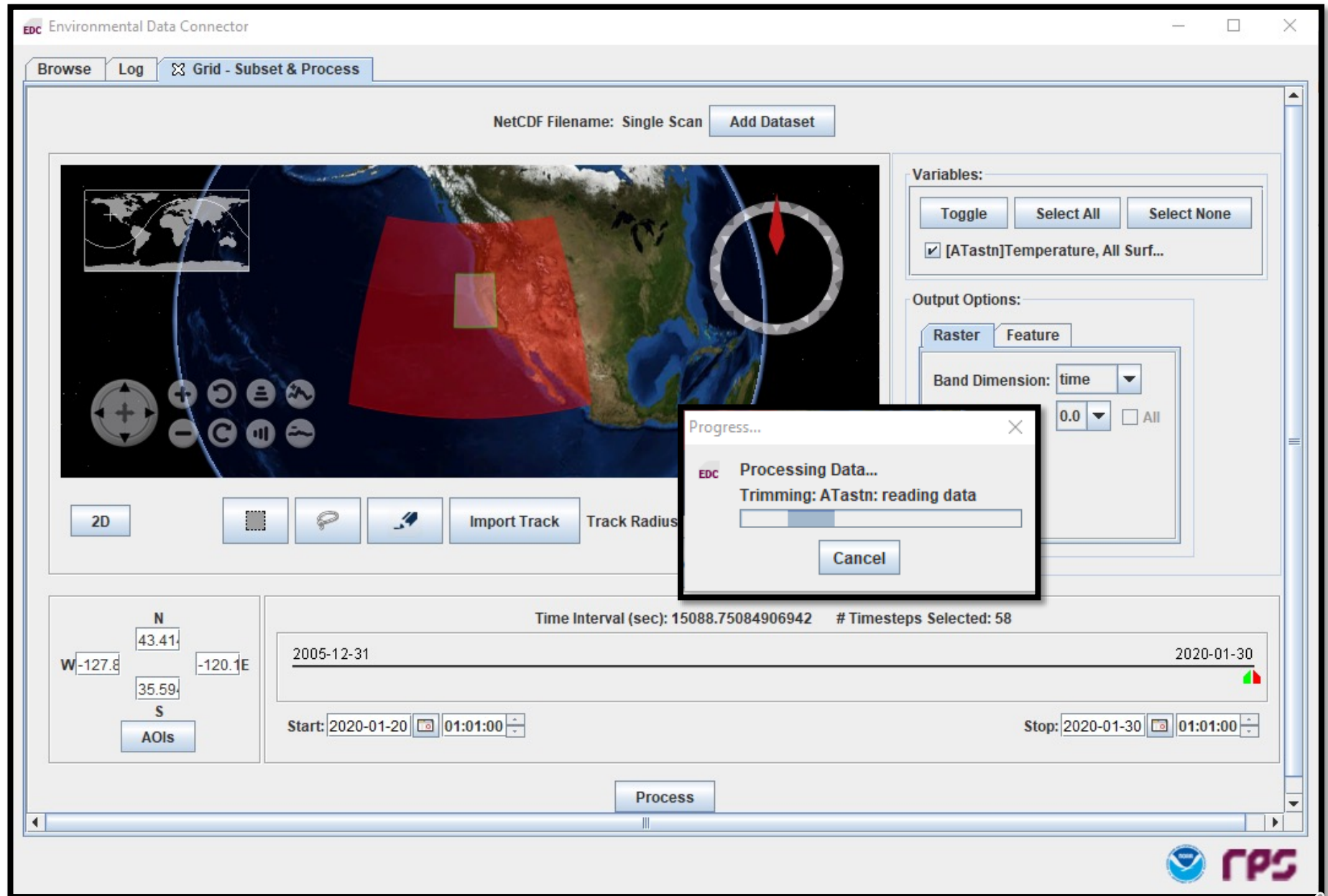


Activating EDC

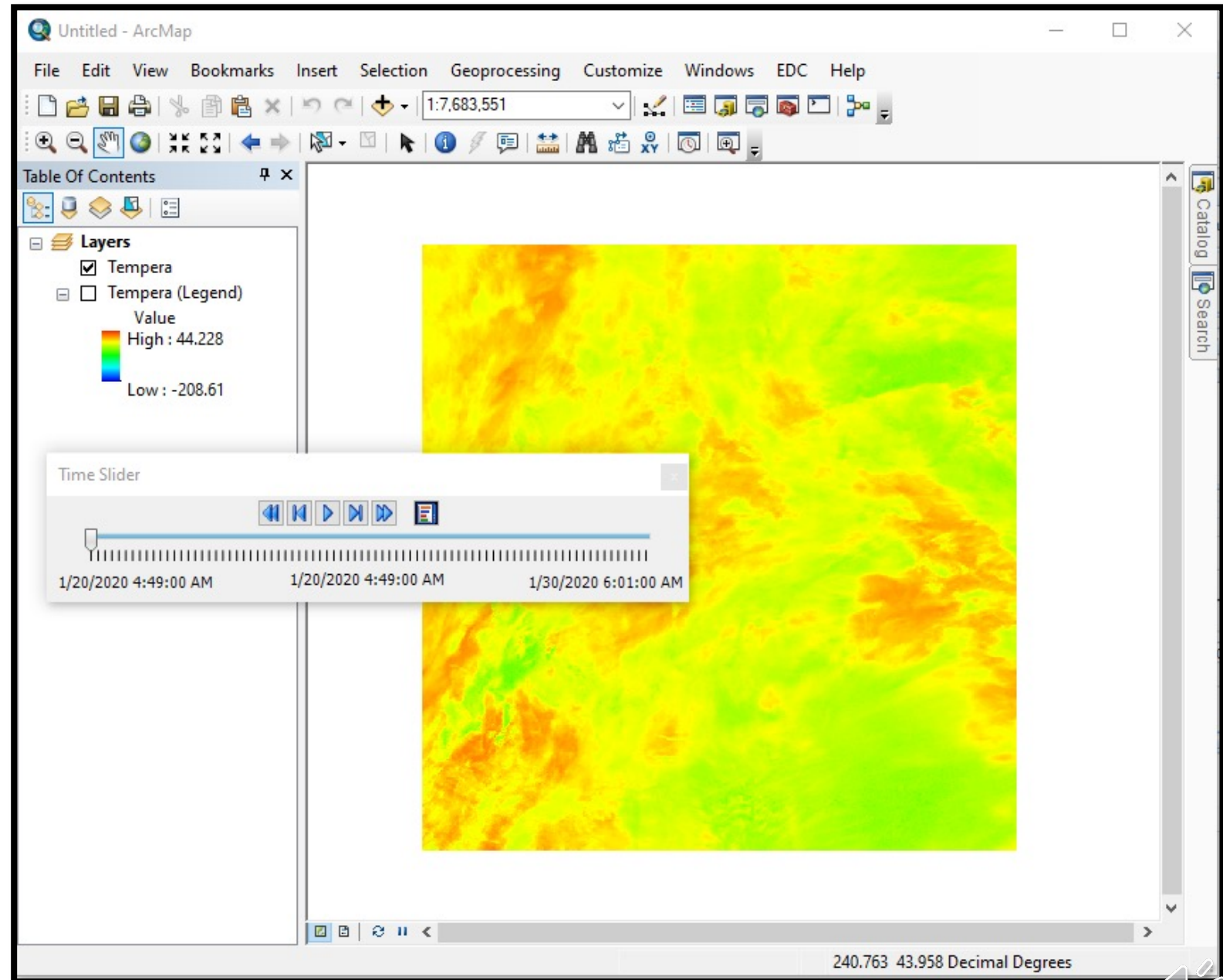
- Activated by selecting the EDC menu
- Menu-driven configuration to maximize usefulness
- Custom Time Slider for syncing data



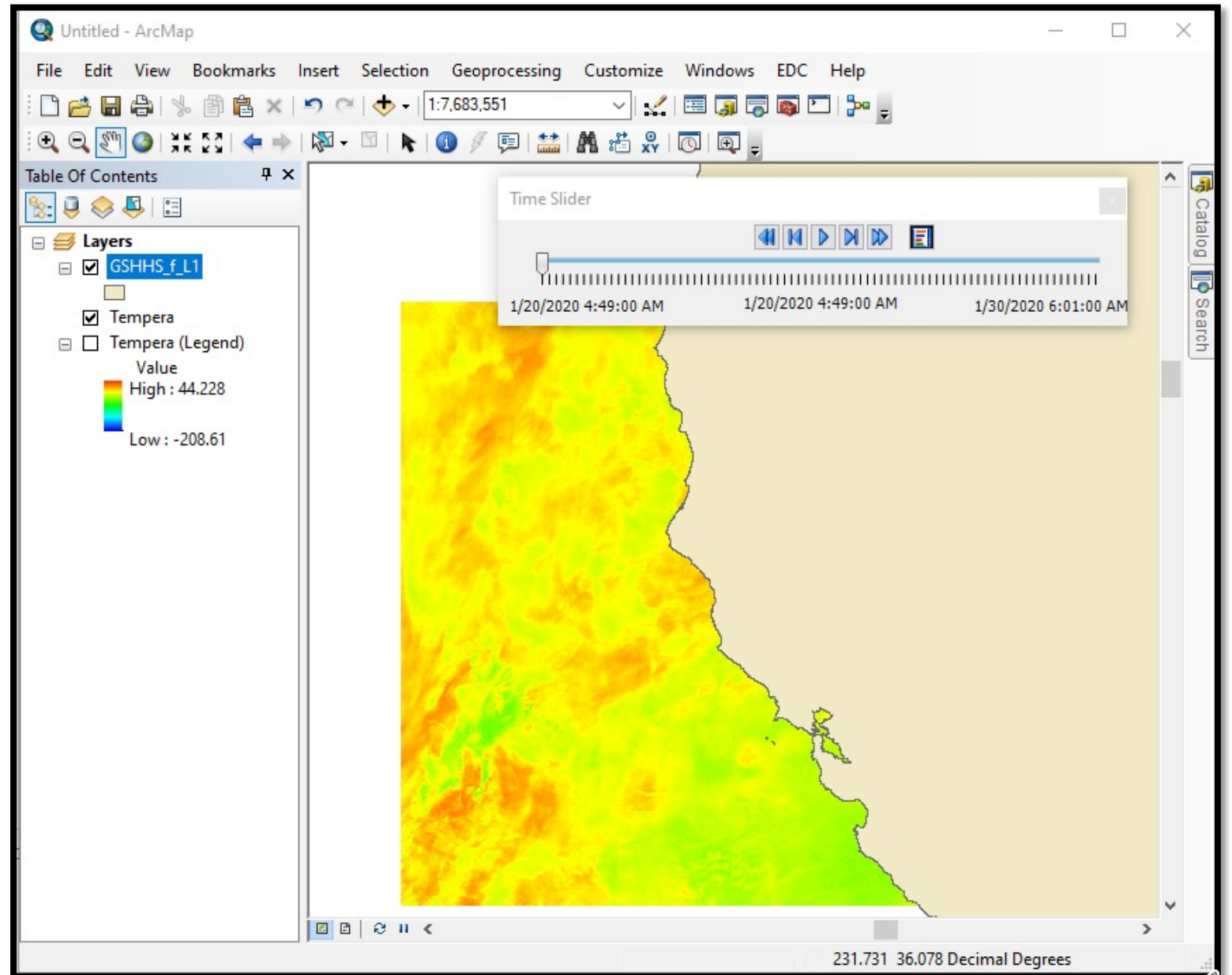
- Activated by selecting the EDC menu
- Menu-driven configuration to maximize usefulness
- Custom Time Slider for syncing data



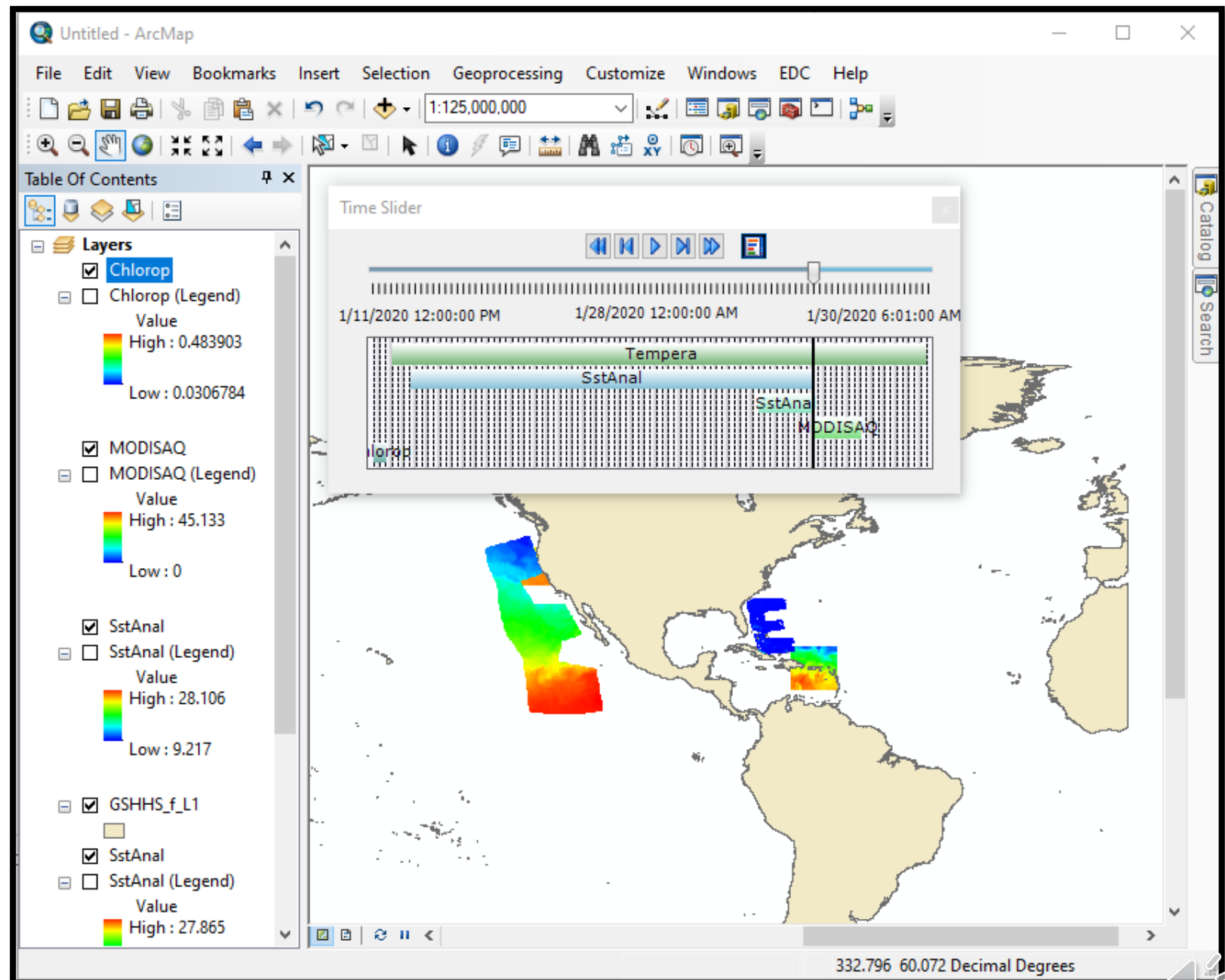
- Layer and Layer's Legend are loaded time-enabled with default scaling and color bar applied.



- Spatial alignment

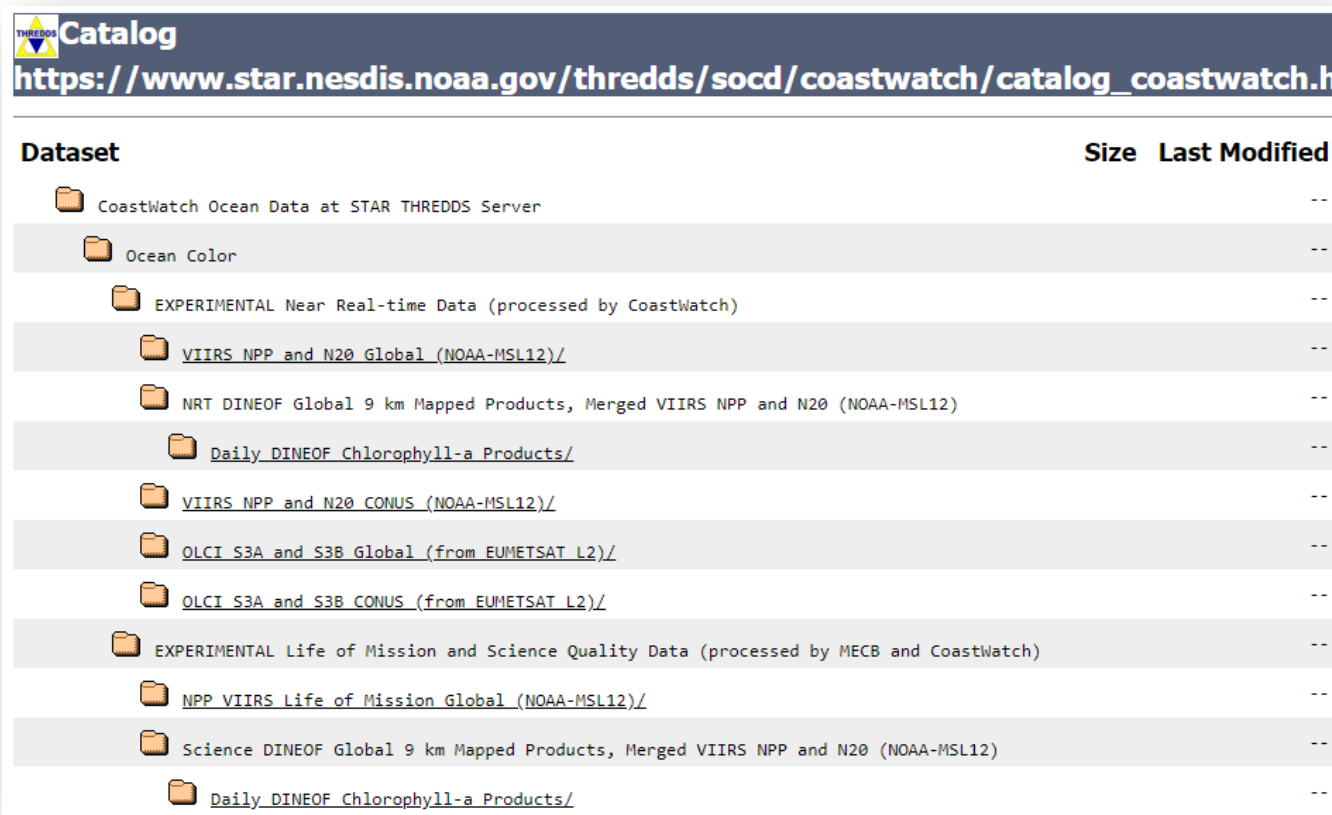


- Time Slider shows alignment/range of temporal data



Additional Services to Obtain Data

- OpenDAP
- THREDDS
- ERDDAP



The screenshot shows the THREDDS Catalog interface. At the top, there is a header with the THREDDS logo and the text "Catalog". Below the header, the URL https://www.star.nesdis.noaa.gov/thredds/socd/coastwatch/catalog_coastwatch.h is displayed. The main content area is a table with three columns: "Dataset", "Size", and "Last Modified". The table lists several datasets, including "CoastWatch Ocean Data at STAR THREDDS Server", "Ocean Color", "EXPERIMENTAL Near Real-time Data (processed by CoastWatch)", "VIIRS NPP and N20 Global (NOAA-MSL12)/", "NRT DINEOF Global 9 km Mapped Products, Merged VIIRS NPP and N20 (NOAA-MSL12)", "Daily DINEOF Chlorophyll-a Products/", "VIIRS NPP and N20 CONUS (NOAA-MSL12)/", "OLCI S3A and S3B Global (from EUMETSAT L2)/", "OLCI S3A and S3B CONUS (from EUMETSAT L2)/", "EXPERIMENTAL Life of Mission and Science Quality Data (processed by MECB and CoastWatch)", "NPP VIIRS Life of Mission Global (NOAA-MSL12)/", "Science DINEOF Global 9 km Mapped Products, Merged VIIRS NPP and N20 (NOAA-MSL12)", and "Daily DINEOF Chlorophyll-a Products/". The "Size" and "Last Modified" columns for all datasets are currently empty, indicated by "--".

Dataset	Size	Last Modified
CoastWatch Ocean Data at STAR THREDDS Server	--	--
Ocean Color	--	--
EXPERIMENTAL Near Real-time Data (processed by CoastWatch)	--	--
VIIRS NPP and N20 Global (NOAA-MSL12)/	--	--
NRT DINEOF Global 9 km Mapped Products, Merged VIIRS NPP and N20 (NOAA-MSL12)	--	--
Daily DINEOF Chlorophyll-a Products/	--	--
VIIRS NPP and N20 CONUS (NOAA-MSL12)/	--	--
OLCI S3A and S3B Global (from EUMETSAT L2)/	--	--
OLCI S3A and S3B CONUS (from EUMETSAT L2)/	--	--
EXPERIMENTAL Life of Mission and Science Quality Data (processed by MECB and CoastWatch)	--	--
NPP VIIRS Life of Mission Global (NOAA-MSL12)/	--	--
Science DINEOF Global 9 km Mapped Products, Merged VIIRS NPP and N20 (NOAA-MSL12)	--	--
Daily DINEOF Chlorophyll-a Products/	--	--

Example of THREDDS Catalog

OpenDAP (Open Data Access Protocol)

- Data model
- Application Program Interface (API)
- Dataset Descriptor Structure (DDS)
 - <https://coastwatch.noaa.gov/erddap/griddap/noaawcBLENDEDsstDaily.dds>
- Dataset Attribute Structure (DAS)
 - <https://coastwatch.noaa.gov/erddap/griddap/noaawcBLENDEDsstDaily.das>
- Used within THREDDS / ERDDAP

```
Dataset {
  Float64 time[time = 6575];
  Float32 latitude[latitude = 3600];
  Float32 longitude[longitude = 7200];
  GRID {
    ARRAY:
      Float32 analysed_sst[time = 6575][latitude = 3600][longitude = 7200];
    MAPS:
      Float64 time[time = 6575];
      Float32 latitude[latitude = 3600];
      Float32 longitude[longitude = 7200];
  } analysed_sst;
  GRID {
    ARRAY:
      Float32 analysis_error[time = 6575][latitude = 3600][longitude = 7200];
    MAPS:
      Float64 time[time = 6575];
      Float32 latitude[latitude = 3600];
      Float32 longitude[longitude = 7200];
  } analysis_error;
  GRID {
    ARRAY:
      Byte mask[time = 6575][latitude = 3600][longitude = 7200];
    MAPS:
      Float64 time[time = 6575];
      Float32 latitude[latitude = 3600];
      Float32 longitude[longitude = 7200];
  } mask;
  GRID {
    ARRAY:
      Float32 sea_ice_fraction[time = 6575][latitude = 3600][longitude = 7200];
    MAPS:
      Float64 time[time = 6575];
      Float32 latitude[latitude = 3600];
      Float32 longitude[longitude = 7200];
  } sea_ice_fraction;
} noaawcBLENDEDsstDaily;
```

Example of Dataset Descriptor Structure

THREDDS and ERDDAP

- Provide additional means to obtain data
- Temporal and Spatial Subsetting
- Useful services:
 - OpenDAP (THREDDS)
 - NetCDF Subset Service (THREDDS)
 - GRIDDAP (ERDDAP)
 - TableDAP (ERDDAP)

The screenshot shows the ERDDAP interface for NOAA CoastWatch. The header includes the NOAA logo and the text 'ERDDAP at NOAA CoastWatch' and 'Easier access to scientific data'. The main title is 'ERDDAP > griddap > Data Access Form'. The dataset title is 'Sea-Surface Temperature, NOAA Geo-polar Blended Analysis, GHRST, Near Real-Time, Global 5km, 2002-Present, Daily'. The institution is 'NOAA NESDIS STAR (Dataset ID: noaacwBLENDEDsstDaily)'. The dimensions section shows 'time (UTC)' with a start of '2020-09-06T12:00:00Z' and a stop of '2020-09-06T12:00:00Z', 'latitude (degrees_north)' with a range from -89.975 to 89.975, and 'longitude (degrees_east)' with a range from -179.975 to 179.975. The grid variables section includes 'analysed_sst', 'analysis_error', 'mask', and 'sea_ice_fraction'. The file type is set to '.htmlTable'. The submit button is labeled 'Submit' with a note '(Please be patient. It may take a while to get the data.)'.

ERDDAP at NOAA CoastWatch
Easier access to scientific data

NOAA CoastWatch
Central Operations

ERDDAP > griddap > Data Access Form

Dataset Title: **Sea-Surface Temperature, NOAA Geo-polar Blended Analysis, GHRST, Near Real-Time, Global 5km, 2002-Present, Daily**

Institution: NOAA NESDIS STAR (Dataset ID: noaacwBLENDEDsstDaily)

Information: [Summary](#) | [License](#) | [FGDC](#) | [ISO 19115](#) | [Metadata](#) | [Background](#) | [Make a graph](#)

Dimensions	Start	Stride	Stop	Size	Spacing
☒ time (UTC)	2020-09-06T12:00:00Z	1	2020-09-06T12:00:00Z	6575	1 day 0h 1m 19s (uneven)
☒ latitude (degrees_north)	-89.975	1	89.975	3600	0.05 (even)
☒ longitude (degrees_east)	-179.975	1	179.975	7200	0.05 (even)

Grid Variables (which always also download all of the dimension variables)

☒ analysed_sst (analysed sea surface temperature, kelvin)

☒ analysis_error (estimated error standard deviation of analysed_sst, degree_C)

☒ mask (sea/land/ice bit mask)

☒ sea_ice_fraction (1)

File type: [\(more info\)](#)

.htmlTable - View a UTF-8 .html web page with the data in a table. Times are ISO 8601 strings.

Just generate the URL:

[\(Documentation / Bypass this form\)](#)

Submit (Please be patient. It may take a while to get the data.)

ERDDAP GRIDDAP Data Access Form

Things to keep track of

- Data Units:
 - SST may come in Kelvin or degrees Celsius (rarely Fahrenheit)
 - Chl comes in several units that do not necessarily change the values
- Time: Check the time zones for data – likely UTC
- Dateline: Most satellite data on services are composited daily products and may span 180W-180E
 - May introduce a mismatch in actual data collection time across the dateline
- Projection / Map Units:
 - Note units within ArcMap – usually the first data loaded sets projection and units
 - Ellipsoids/Datum – satellite data is most likely WGS84, land/coastal data may be NAD83



Additional Resources

- Environmental Data Connector
 - Download: <https://www.pfeg.noaa.gov/products/EDC/EDCdownloads.html>
 - User Guide: https://www.pfeg.noaa.gov/products/PFELData/EDC/EDC-1.3.7-ReleaseNotes_UserGuide.pdf
- ArcGIS [w/EDC] Satellite Data Tutorials/Examples
 - Tutorial for EDC and Make NetCDF Raster
 - ArcGIS_EDC_Training_PFEG.pdf
 - <https://coastwatch.pfeg.noaa.gov/projects/arcgis/>



Using Satellite Data in GIS

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- Versioning:
2020, Soracco
- 2019, Soracco

