



This Presentation has no audio



Using Satellite Data in GIS

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Versioning:
20210429, Soracco
20210401, Soracco
2020, Soracco
2019, Soracco



CoastWatch Training, 2021, Virtual Class

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.

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Using Satellite Data in GIS: Exercise

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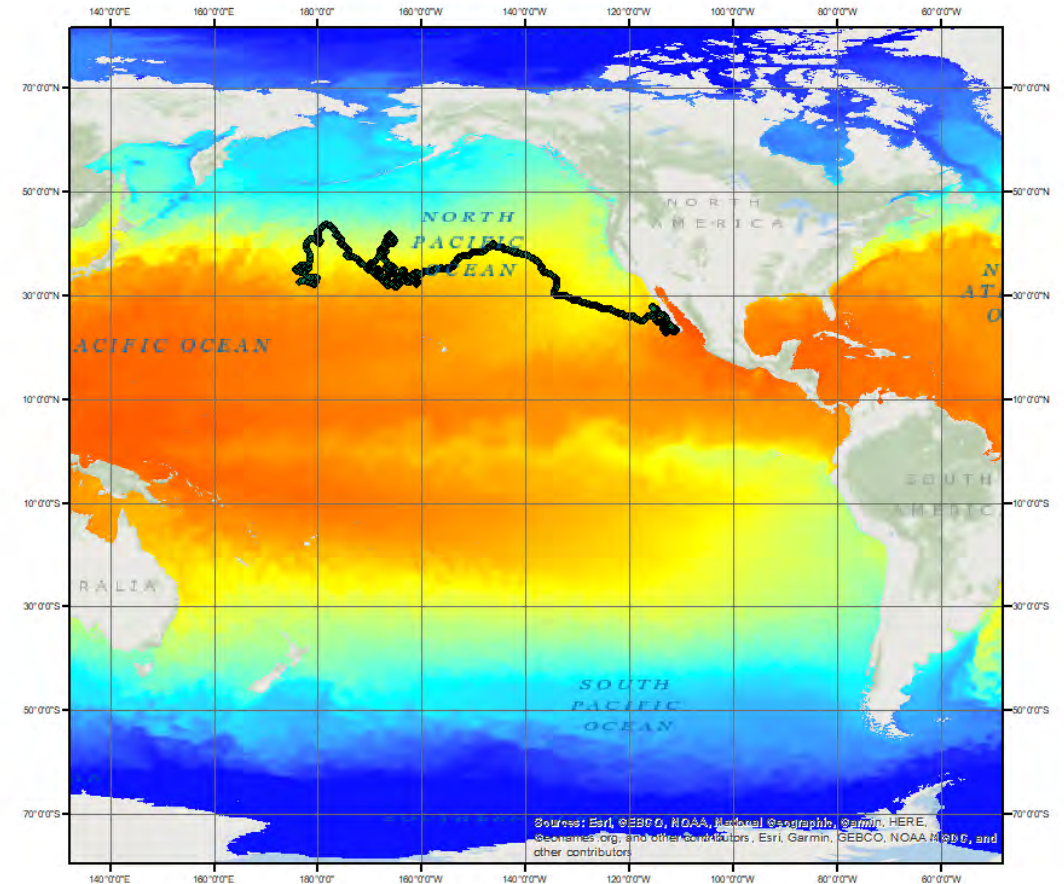
<https://coastwatch.noaa.gov>
coastwatch.info@noaa.gov

Versioning:
2020, Soracco, ArcMap 10.7



Exercise Background

- Patterned after Python Exercise:
“Extract data along turtle track” --
<https://coastwatch.gitbook.io/satellite-course/tutorials/python-tutorial/4.-extract-data-along-a-turtle-track>
- Uses import of NetCDF, CSV
- Builds upon “ArcGIS Tutorial” and TurtleWatch Zone --
<https://coastwatch.gitbook.io/satellite-course/tutorials/arcgis-tutorial>
- Identifies 0 to 360 and
-180 to 180 longitude issues



Multi-year turtle track atop single SST image

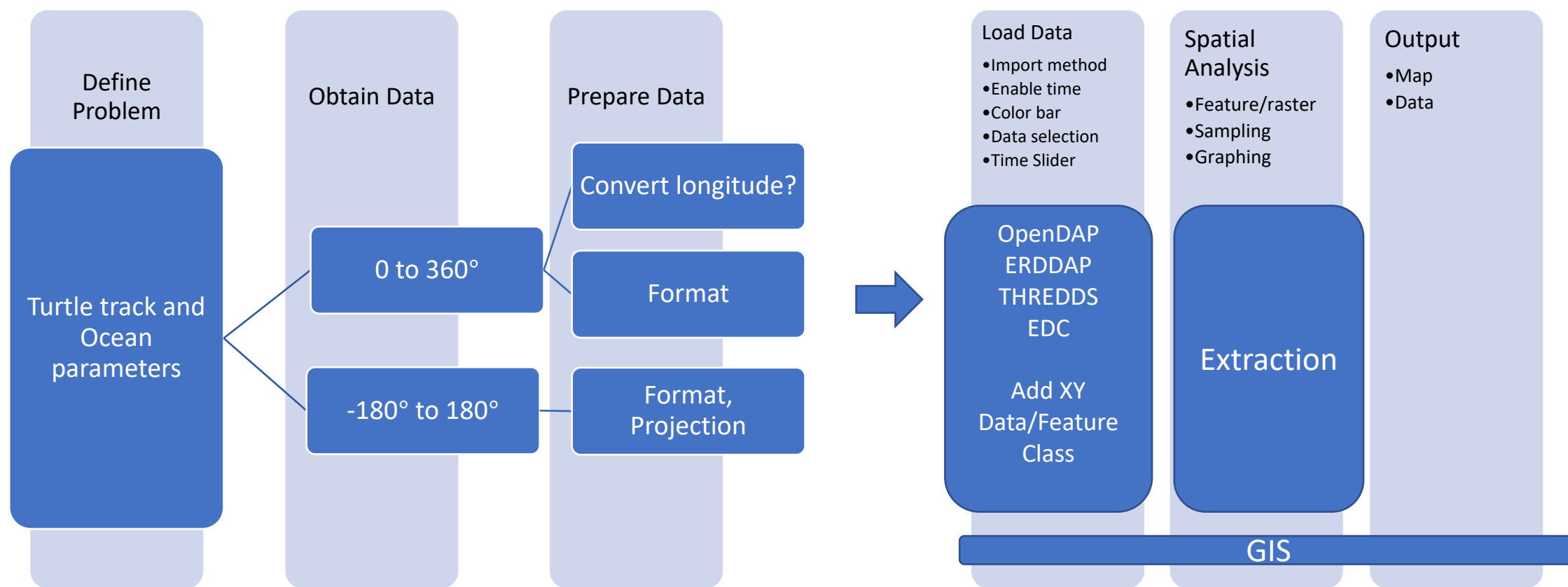
ArcGIS: Extract data along a turtle track

- Scenario: A juvenile loggerhead sea turtle (ARGOS ID 25317) provided positional data over a period of three years
- Research Question: Does this sea turtles' behavior correspond to oceanographic surface parameters such as sea surface temperature? Does the turtle remain within the TurtleWatch Area (17.5° to 18.5°C)?
- Conditions:
 - Date range: May 2005 – 2008 (1232 days)
 - Distance travelled: 19,491 km
 - Tracking Duty Cycle:
 - 6 hours on , 48 hours off



Strategy

There are often several pathways to achieve the same results using GIS.



Strategy

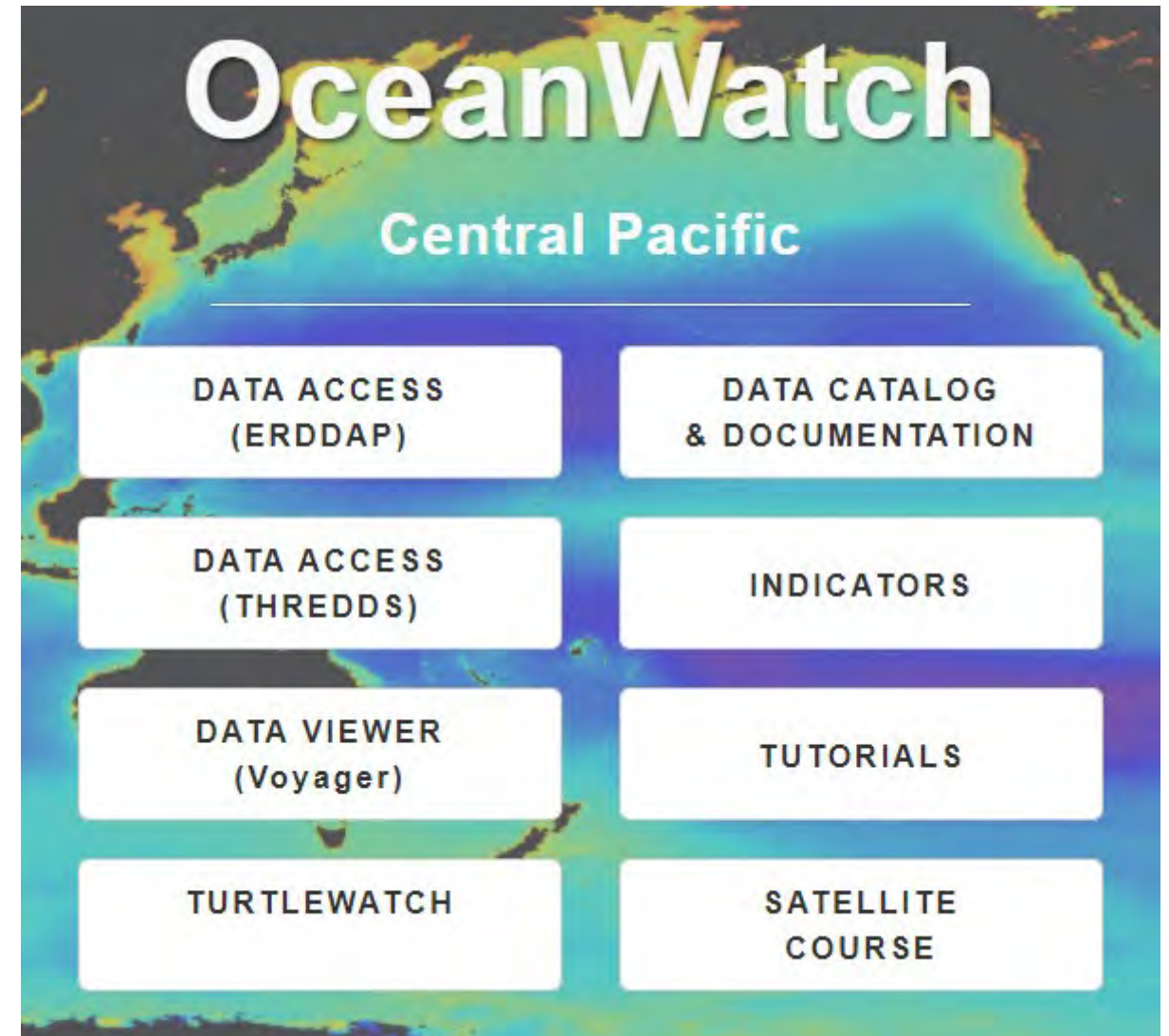
- Perform matchup of turtle locations with parameters
 - Import Turtle CSV:
 - https://oceanwatch.pifsc.noaa.gov/files/25317_05.dat
 - Convert to Feature Layer / Shapefile
- Obtain SST satellite data for geographic coverage and period of study
- Outputs:
 1. Overview map – example day of parameter and turtle tracks
 2. Map output showing turtle locations and parameter values
 3. Graph of parameter value for each turtle location vs Time
 4. Export Movie showing Turtle, Parameter, TurtleWatch Zone

Output 1: Overview Map

- Allows a quick look at the data types and extents we'll be working with
- For the Overview Map, only the turtle track CSV file is required.
- Displaying a parameter (i.e. SST) is optional, but the map should be labeled that the SST data is from a single day.
- Use 0->360 data for this Overview Map
- As a general rule-of-thumb, load raster data first as ArcMap will use the coordinate system of the raster data

Output 1: Overview Map

- Obtain SST data from <https://oceanwatch.pifsc.noaa.gov/>
 - in 0-360
 - a SINGLE date between the start/end of the turtle track – i.e. October 10, 2006
 - ERDDAP [Link](#)



Output 1: Overview Map

- Obtain Turtle Track

- Data [Link](#)

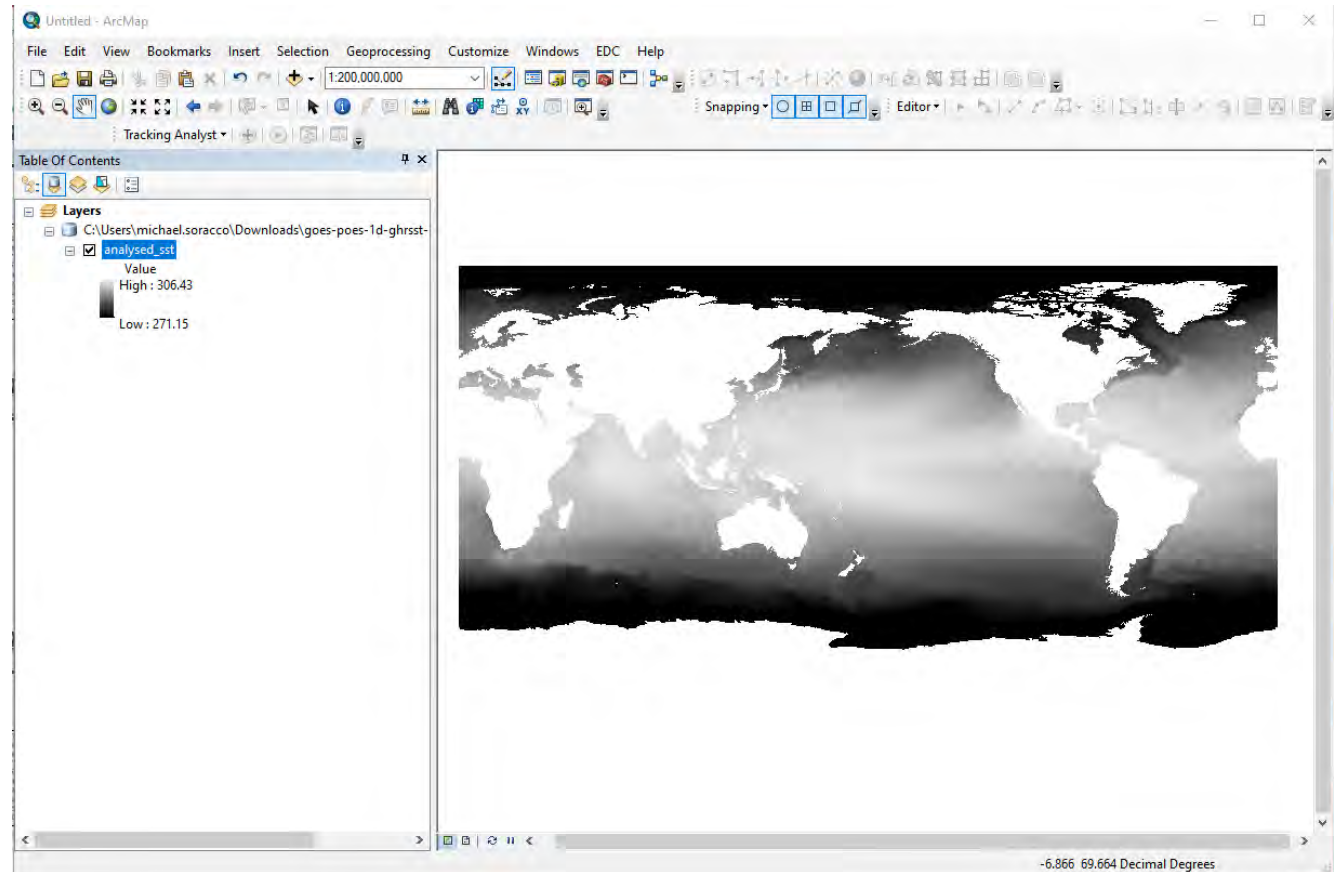
```
"mean_lon","mean_lat","year","month","day"  
176.619432886108,32.6787283689241,2005,5,4  
176.783786497336,32.755450905856,2005,5,5  
177.086094792196,32.8703371644739,2005,5,6  
177.523857440759,32.8593957701299,2005,5,7  
178.058144591188,32.6740108044364,2005,5,8  
178.477225321586,32.4596669014395,2005,5,9  
178.739279086398,32.3402034409515,2005,5,10  
178.959668448728,32.2630123770382,2005,5,11  
179.19299156409,32.1452863228285,2005,5,12
```

https://oceanwatch.pifsc.noaa.gov/files/25317_05.dat



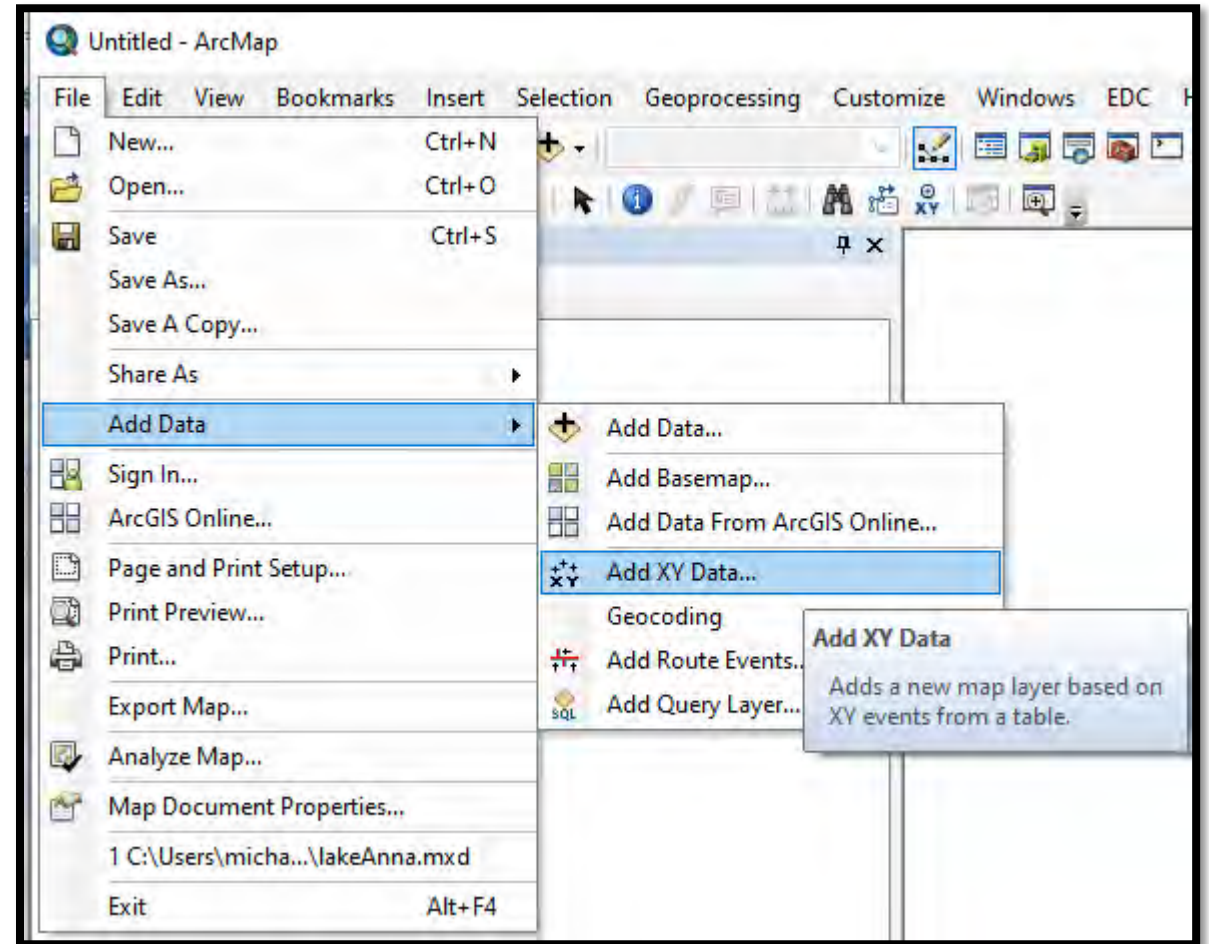
Output 1: Overview Map

- Open ArcMap to Blank Map
- Drag-and-Drop the NetCDF file onto the View
- SST data is 0-360



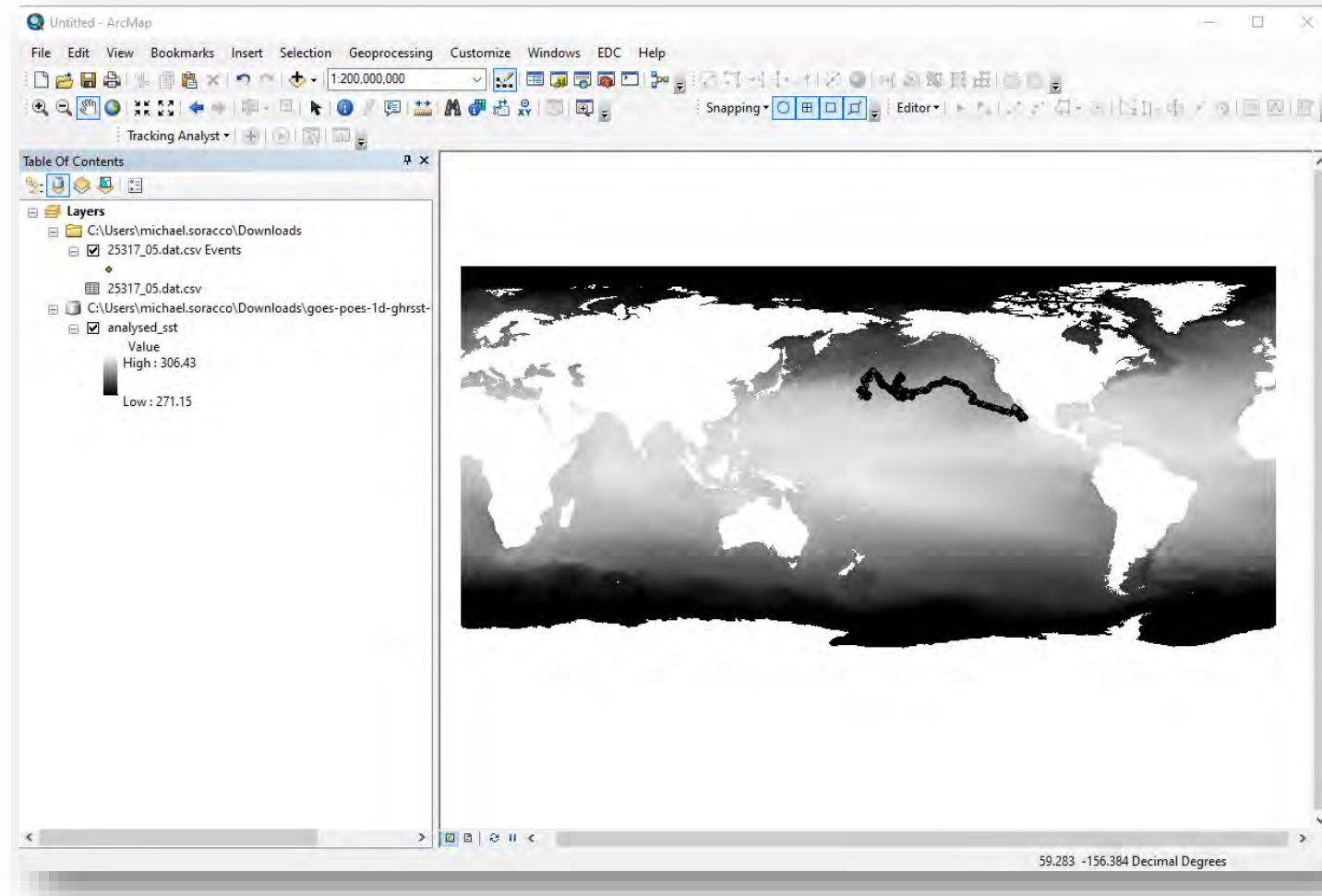
Output 1: Overview Map

- Add XY Data to import Turtle Track using one of these methods
 - Add Data Icon, locate CSV, right-mouse Add X-Y
 - File->Add Data->Display X-Y Data
- Set the X and Y Fields



Output 1: Overview Map

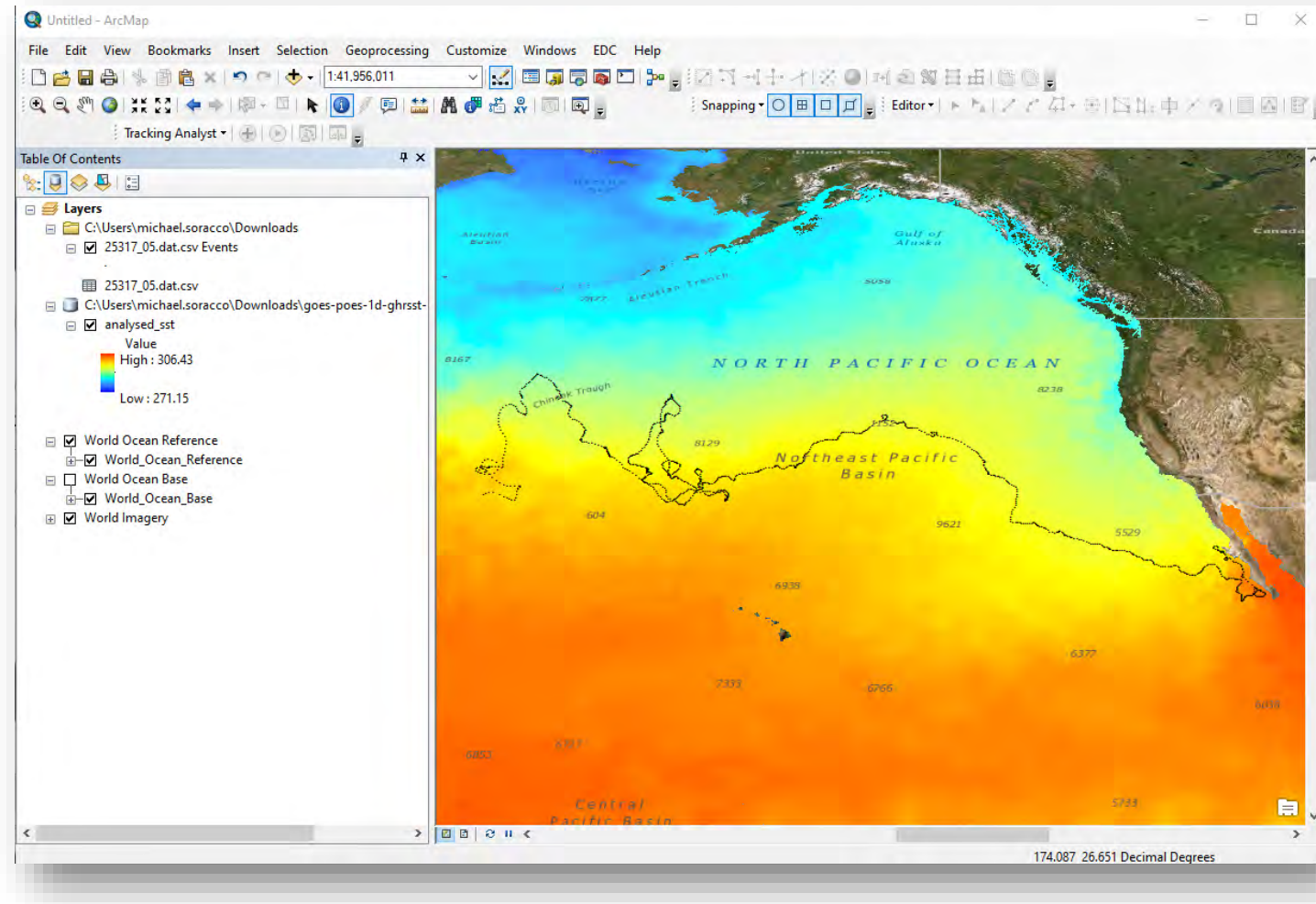
- Obtain Turtle Track
 - Data [Link](#)
 - Save As: 25317_05.dat.csv



https://oceanwatch.pifsc.noaa.gov/files/25317_05.dat

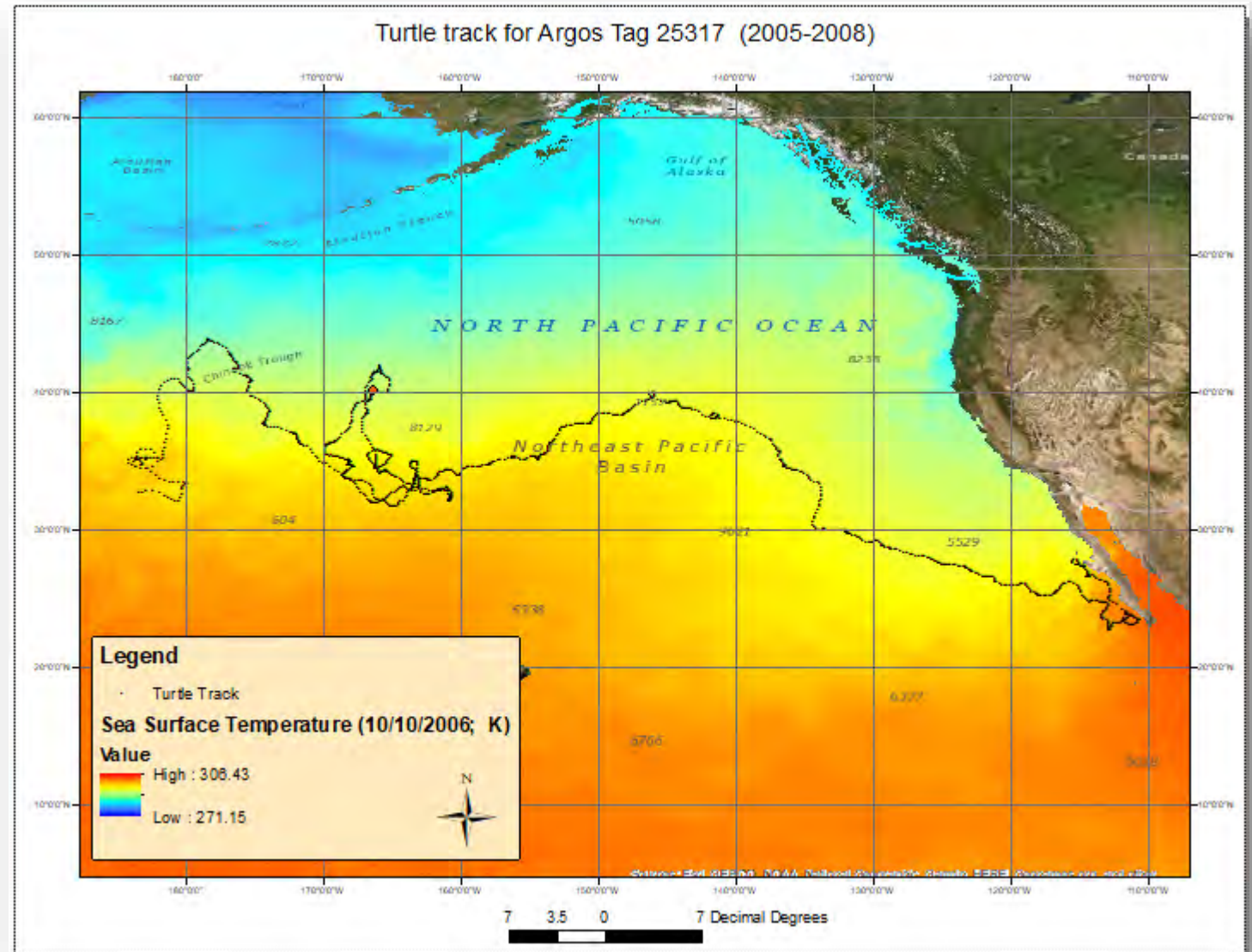
Output 1: Overview Map

- Tailor the Map
- Options:
 - Title
 - Color symbology to SST
 - Turtle track icon/color
 - Basemap / Labels
 - Map properties (Legend, scale, North arrow, graticules)



Output 1: Overview Map

- Label the Layout View
- Save the map as an image file
- We now have an overview of the 3+ year Turtle track

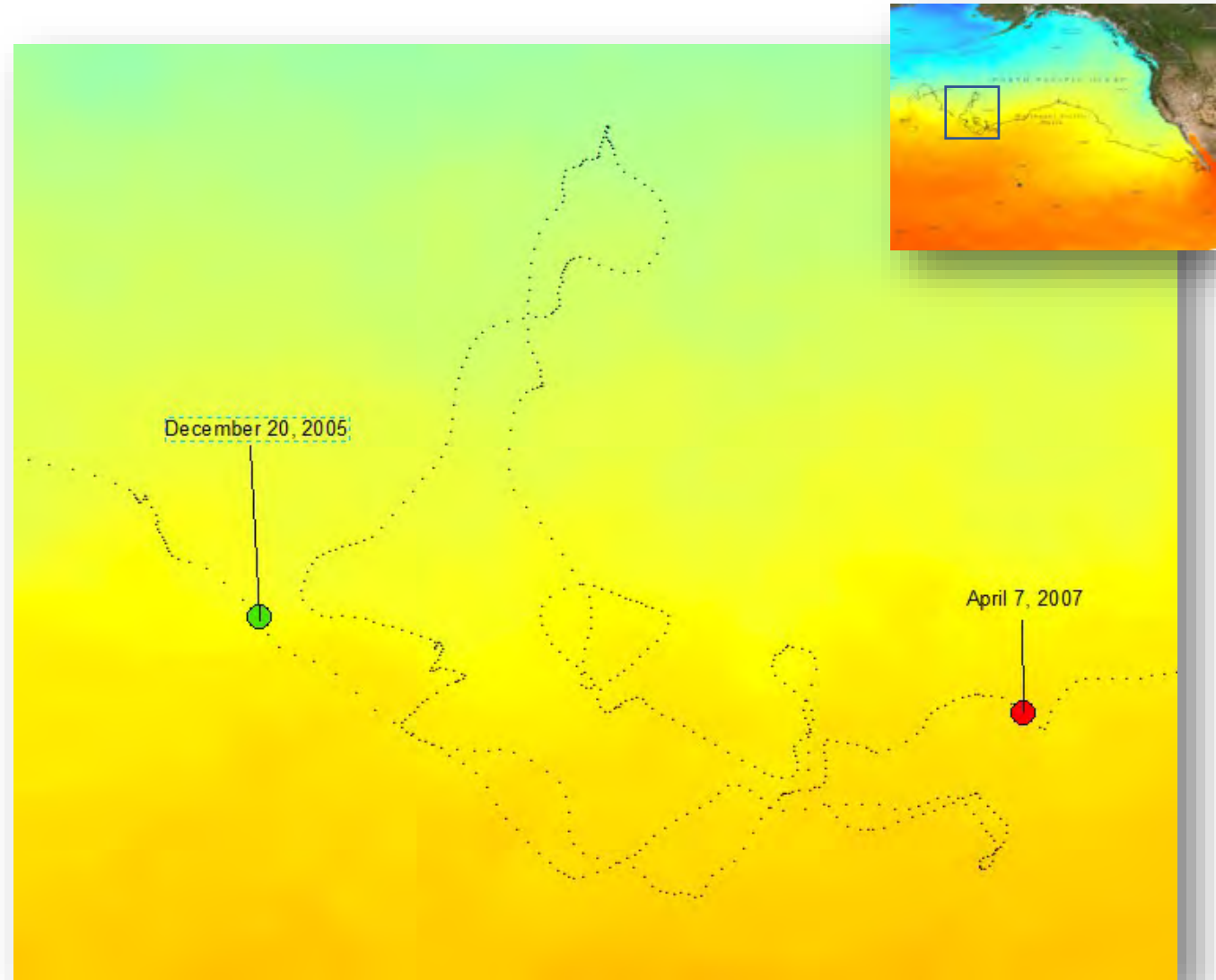


Overview Map -- Observations

- Data is displayed across the Dateline
- Loading X-Y Data created a table for display only (not queryable/selectable)
- Drag-and-drop worked well for the single NetCDF image and subsequent data matched the coordinate system of the raster layer.
- Given the extent of the track spatially and temporally, that could result in a lot of data...

Strategy Adjustments

- Reduce study area to:
 - Feature of interest
 - ~15 months or (37% of total track time)
 - Geographic area
 - Lat: 31-42 deg N
 - Long360: 189 to 200 deg
 - Long180: -171 to -160 deg
- Work in -180 to 180



Data Preparation -- Turtle Data

- Turtle CSV:
https://oceanwatch.pifsc.noaa.gov/files/25317_05.dat
- No metadata
- One X-Y pair per day
- Satellite tracking so we'll assume WGS84 Ellipsoid / Datum

Data Preparation – Turtle Data (cont.)

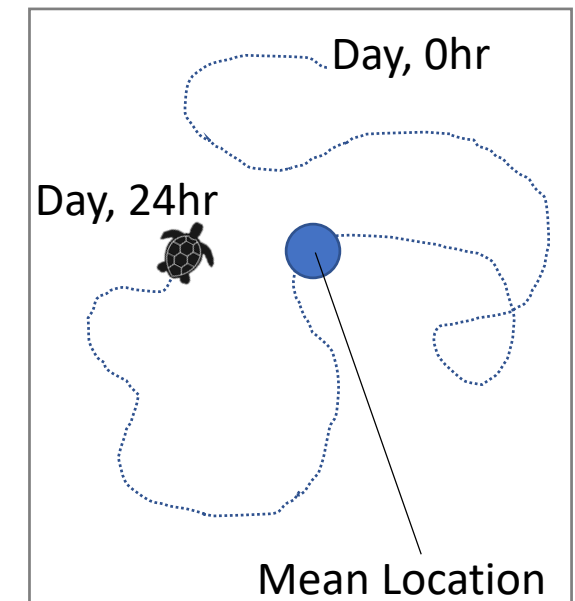
- Headers: "mean_lon", "mean_lat", "year", "month", "day"

- Save As .csv; load into a spreadsheet or use 'more' in Linux to see file contents

mean_lon	mean_lat	year	month	day	mean_lon	mean_lat	year	month	day
176.6194329	32.67873	2005	5	4	247.0782107	22.70993	2008	6	9
176.7837865	32.75545	2005	5	5	247.0520168	22.74948	2008	6	8
177.0860948	32.87034	2005	5	6	247.1459359	22.75972	2008	6	10
177.5238574	32.8594	2005	5	7	247.0483884	22.83755	2008	6	7
					247.2265195	22.85263	2008	6	11

- Other observations about the CSV

- Temporal Range: May 4, 2005 – September 18, 2008
- Spatial Range:
 - Latitude: 22.70 to 43.86;
 - Longitude: 175.86 to 249.28 (175.86E to 110.72W)
- Longitudes 0 to 360 degrees. [Most GIS can handle 0-360 but not with all tools]
- Separate fields for Year, Month, Day. No times.



Data Preparation: Input data modification

- Modify the dat/CSV file. Combine the Year, Month, Day to a single field. For this exercise using ArcMap, the following conventions are preferred:
 - A coverage or shapefile identifies dates in a date field with this format: yyyy-mm-dd.
 - A geodatabase formats the date as datetime yyyy-mm-dd hh:mm:ss AM or PM
- Use a spreadsheet and create a **Date** column with **'=DATE(C2,D2,E2)'** to convert into a date and re-format to custom **yyyy-mm-dd**
- Use a spreadsheet and create a **mean_lon180** column with **'=A1-360'**
- Reorder columns: Date, mean_lon180, mean_lat, etc. Save as CSV

Action: Use a spreadsheet and modify the CSV file:

- Add mean_lon180
- Add Date

	A	B	C	D	E	F	G	H	I	J
1	Date	mean_lon180	mean_lat	mean_lon	mean_lat	year	month	day	Date	mean_lon180
2	2005-05-04	-183.3805671	32.67873	176.6194329	32.67873	2005	5	4	2005-05-04	-183.3805671
3	2005-05-05	-183.2162135	32.75545	176.7837865	32.75545	2005	5	5	2005-05-05	-183.2162135
4	2005-05-06	-182.9139052	32.87034	177.0860948	32.87034	2005	5	6	2005-05-06	-182.9139052
5	2005-05-07	-182.4761426	32.8594	177.5238574	32.8594	2005	5	7	2005-05-07	-182.4761426
6	2005-05-08	-181.9418554	32.67401	178.0581446	32.67401	2005	5	8	2005-05-08	-181.9418554



Obtain Satellite Data

- SST
 - Require values of each parameter
 - Source of turtle data is mean lat/long, can a turtle travel more than 1km or 5km in a day?
 - Temporal period is daily, multiyear
 - NOAA Blended SST a good candidate
- Use either EDC, ERDDAP, THREDDS, OpenDAP to obtain a NetCDF dataset with daily time 'slices'.
- Note if using 0 to 360 or -180 to 180; Choose to match other data
- The following slides show multiple means to obtain the data

ERDDAP > griddap > Data Access Form

Dataset Title: **Sea Surface Temperature, NOAA geopolar blended - Daily, 2002-Present (2017 Reanalysis)** [✉](#) [RSS](#)

Institution: Office of Satellite Products and Operations (Dataset ID: goes-poes-1d-ghrsst-RAN)

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

Dimensions	Start	Stride	Stop	Size	Spacing
<input checked="" type="checkbox"/> time (UTC)	2005-12-20T12:00:00Z	1	2007-04-07T12:00:00Z	6597	1 day 0h 2m 24s (uneven)
<input checked="" type="checkbox"/> latitude (degrees_north)	31	1	42	3600	0.05 (even)
<input checked="" type="checkbox"/> longitude (degrees_east)	188	1	201	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.)

Obtain Satellite Data

- ERDDAP:

- 0-360: goes-poes-1d-ghrsst-RAN_360_turtle2005-2007.nc

- [https://oceanwatch.pifsc.noaa.gov/erddap/griddap/goes-poes-1d-ghrsst-RAN.nc?analysed_sst\[\(2005-12-20T12:00:00Z\):1:\(2007-04-07T12:00:00Z\)\]\[\(31\):1:\(42\)\]\[\(188\):1:\(201\)\]](https://oceanwatch.pifsc.noaa.gov/erddap/griddap/goes-poes-1d-ghrsst-RAN.nc?analysed_sst[(2005-12-20T12:00:00Z):1:(2007-04-07T12:00:00Z)][(31):1:(42)][(188):1:(201)])



- -180 to 180: noaacwBLENDEDsstDaily_180_turtle2005-2007.nc

- [https://coastwatch.noaa.gov/erddap/griddap/noaacwBLENDEDsstDaily.nc?analysed_sst\[\(2005-12-20T12:00:00Z\):1:\(2007-04-07T12:00:00Z\)\]\[\(31\):1:\(42\)\]\[\(-171\):1:\(-160\)\]](https://coastwatch.noaa.gov/erddap/griddap/noaacwBLENDEDsstDaily.nc?analysed_sst[(2005-12-20T12:00:00Z):1:(2007-04-07T12:00:00Z)][(31):1:(42)][(-171):1:(-160)])

- THREDDS (Aggregated View):

- https://coastwatch.noaa.gov/thredds/ncss/BlendedSST5kmNightAggGHRSSSTSTARLoM?var=analysed_sst&north=42&west=-171&east=-160&south=31&disableProjSubset=on&horizStride=1&time_start=2005-12-20T12%3A00%3A00Z&time_end=2007-04-07T12%3A00%3A00Z&timeStride=1&accept=netcdf

Obtain Satellite Data -- THREDDS

- THREDDS (Aggregated View)
 - NCSubsetService
 - Generates URL in addition to fetching data

Select Variable(s):

Variables with Time coordinate time

- ☒ analysed_sst = analysed sea surface temperature
- ☐ analysis_error = estimated error standard deviation of analysed_sst
- ☐ mask = sea/land/ice bit mask
- ☐ sea_ice_fraction = sea ice fraction

https://coastwatch.noaa.gov/thredds/ncss/BlendedSST5kmNightAggGHRSSSTARLOM?var=analysed_sst&north=42&west=-171&east=-160&south=31&disableProjSubset=on&horizStride=1&time_start=2005-12-20T12%3A00%3A00Z&time_end=2007-04-07T12%3A00%3A00Z&timeStride=1&accept=netcdf

Lat/lon subset **Coordinate subset**
Bounding box, in decimal degrees
(initial extents are approximate):

north
42
west -171 -160 east
31
south

☒ Disable horizontal subsetting
[reset to full extension](#)

Horizontal Stride: 1

Choose Time Subset:

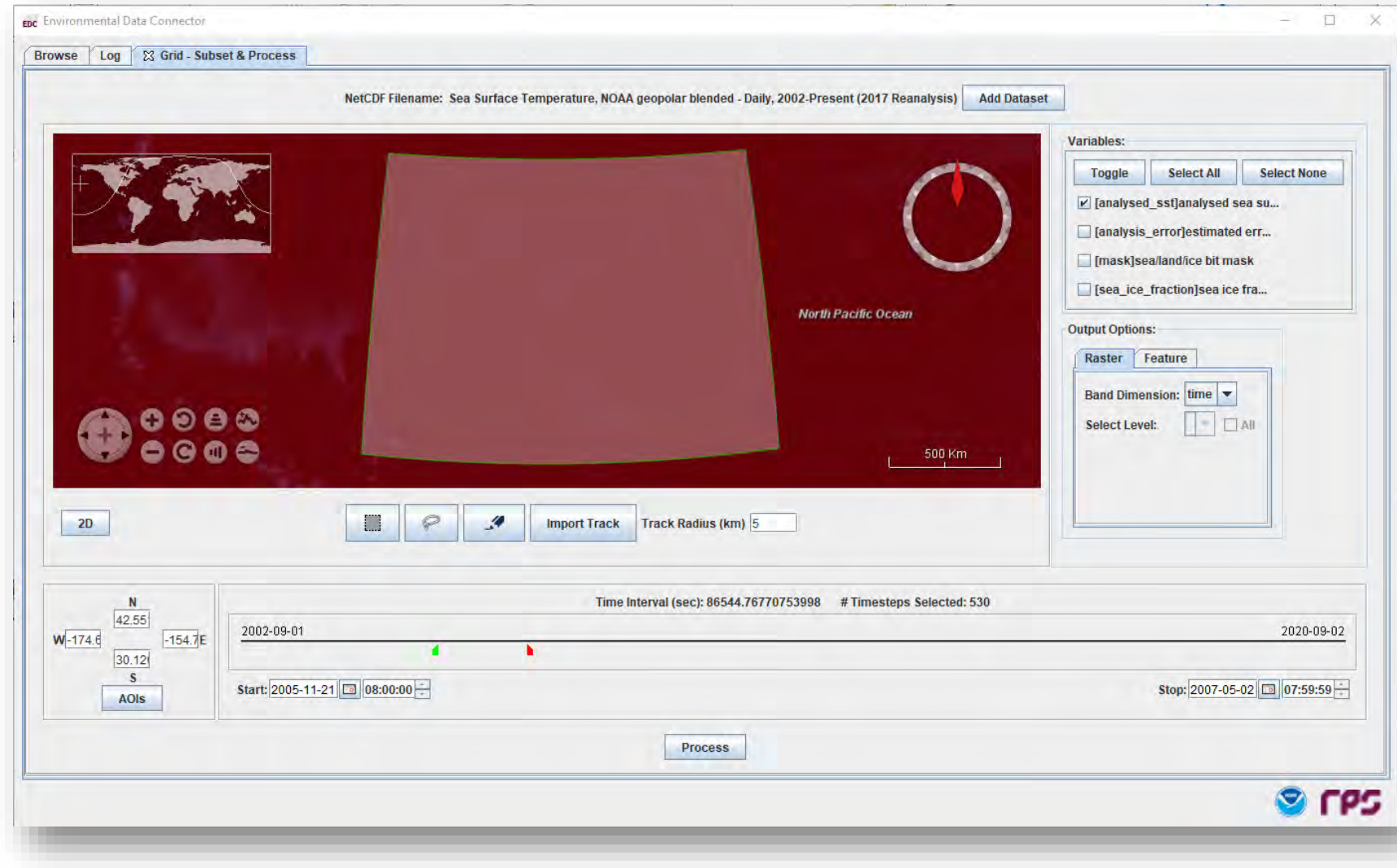
Time range **Single time**
Start: 2005-12-20T12:00:00Z
End: 2007-04-07T12:00:00Z
Stride: 1
[reset to full extension](#)

Add 2D Lat/Lon to file (if needed for CF compliance)
☒ Add Lat/Lon variables

Choose Output Format:
Format: netcdf

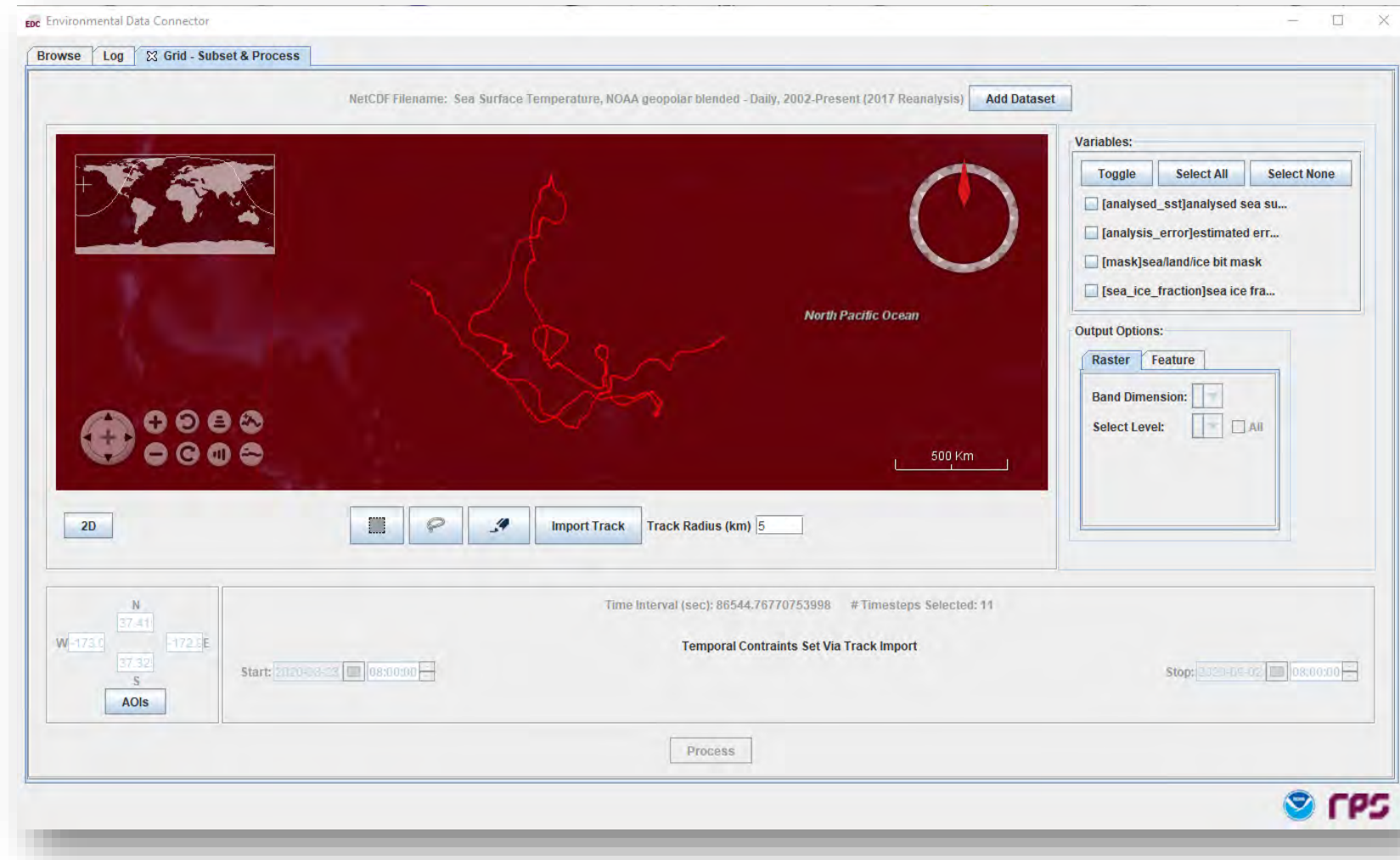
Obtain Satellite Data

- EDC
- Graphical interface to define extent, time, variables
- Automatically loads into GIS




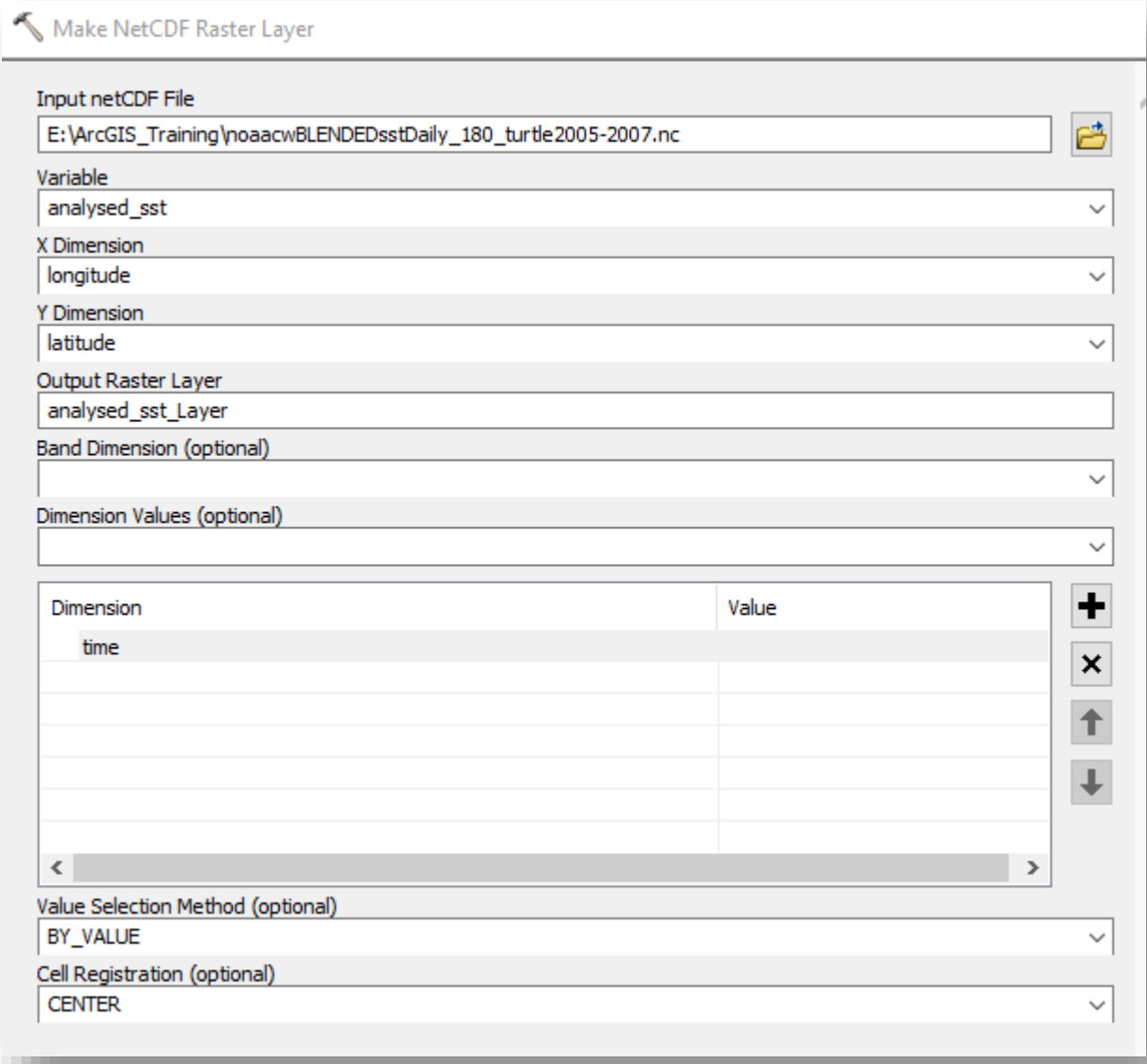
Obtain Satellite Data

- EDC
- Can load the track and only pull the raster values for each point/time



Loading Satellite Data

- Open ArcMap to Blank Map
- Open ArcToolBox 
- Use Multidimension Tools:
 - Make NetCDF Raster Layer
- Set the Input netCDF file
 - noaacwBLENDEDsstDaily_180_turtle2005-2007.nc
- Confirm Variable, X, and Y Dimensions
- Add time as a Dimension Value



Make NetCDF Raster Layer

Input netCDF File
E:\ArcGIS_Training\noaacwBLENDEDsstDaily_180_turtle2005-2007.nc

Variable
analysed_sst

X Dimension
longitude

Y Dimension
latitude

Output Raster Layer
analysed_sst_Layer

Band Dimension (optional)

Dimension Values (optional)

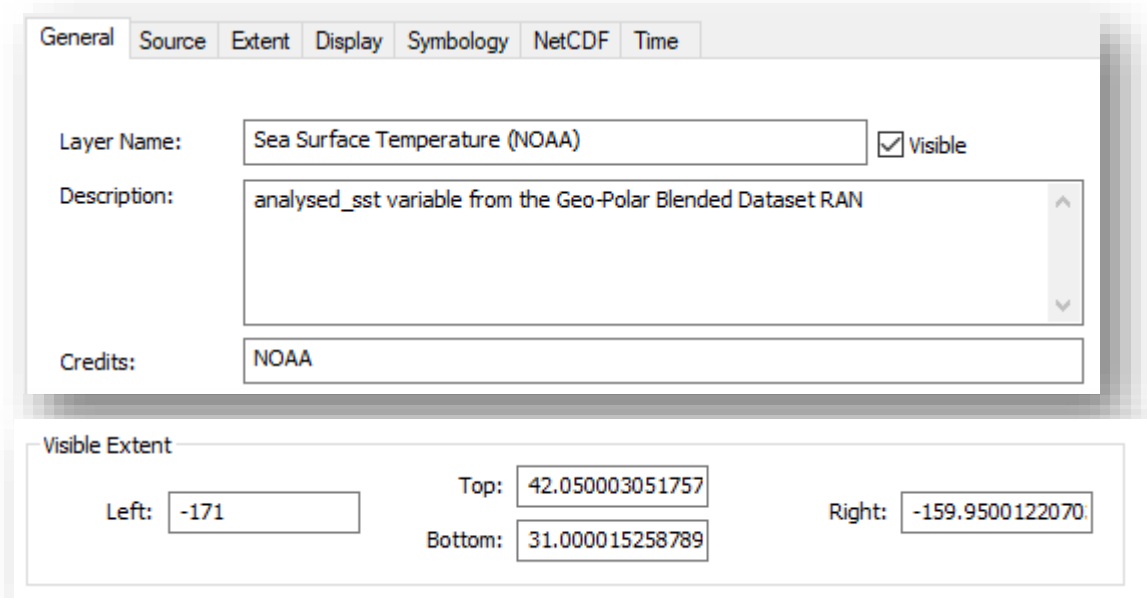
Dimension	Value
time	

Value Selection Method (optional)
BY_VALUE

Cell Registration (optional)
CENTER

Loading Satellite Data -- Layer Properties – General / Extent

- Rename:
 - Layer:
 - Sea Surface Temperature (NOAA)
 - Description
 - Credit
- Confirm Extent

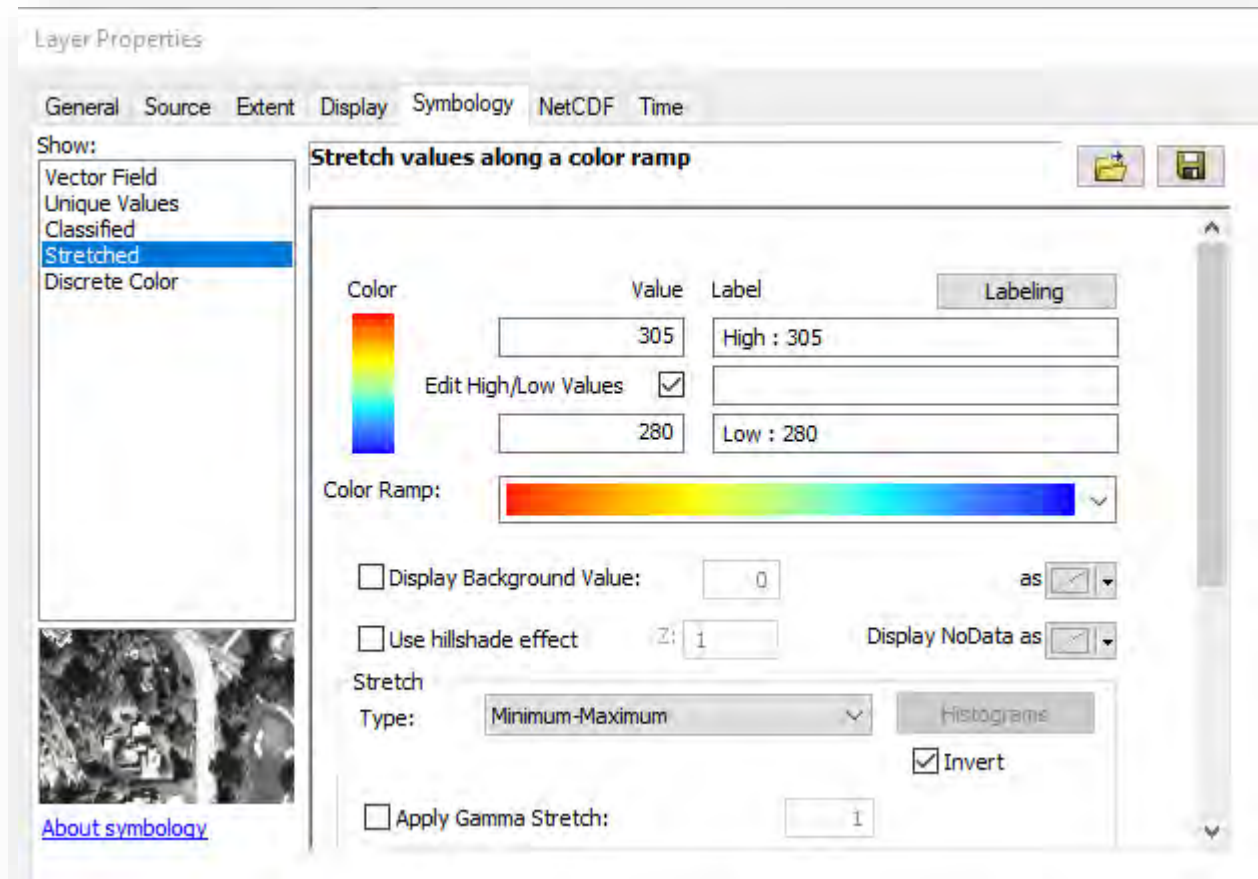


The screenshot shows the 'Layer Properties' dialog box with the 'General' tab selected. The 'Layer Name' is 'Sea Surface Temperature (NOAA)' and the 'Visible' checkbox is checked. The 'Description' is 'analysed_sst variable from the Geo-Polar Blended Dataset RAN'. The 'Credits' are 'NOAA'. The 'Visible Extent' section shows the following coordinates: Left: -171, Top: 42.050003051757, Bottom: 31.000015258789, and Right: -159.9500122070.

Property	Value
Layer Name	Sea Surface Temperature (NOAA)
Visible	<input checked="" type="checkbox"/>
Description	analysed_sst variable from the Geo-Polar Blended Dataset RAN
Credits	NOAA
Visible Extent	
Left	-171
Top	42.050003051757
Bottom	31.000015258789
Right	-159.9500122070

Loading Satellite Data -- Layer Properties -- Symbology

- *Reset* the Stretch type to Minimum-Maximum
- *Reset* the High/Low Values to 280-305
- *Select* a color ramp of choice



Loading Satellite Data -- Layer Properties -- NetCDF

- Verify the NetCDF settings

The screenshot shows the 'NetCDF' tab in the Layer Properties dialog box. The 'NetCDF' tab is selected and circled in red. The 'Variable' is set to 'analysed_sst'. The 'X Dimension' is set to 'longitude'. The 'Y Dimension' is set to 'latitude'. The 'Band Dimension' is empty. The 'Dimension Values' table shows a single row with 'time' as the dimension and '12/20/2005 12:00:00 PM' as the value. The 'Vertical Dimension' is empty.

Dimension	Value
time	12/20/2005 12:00:00 PM


Loading Satellite Data -- Layer Properties -- Time

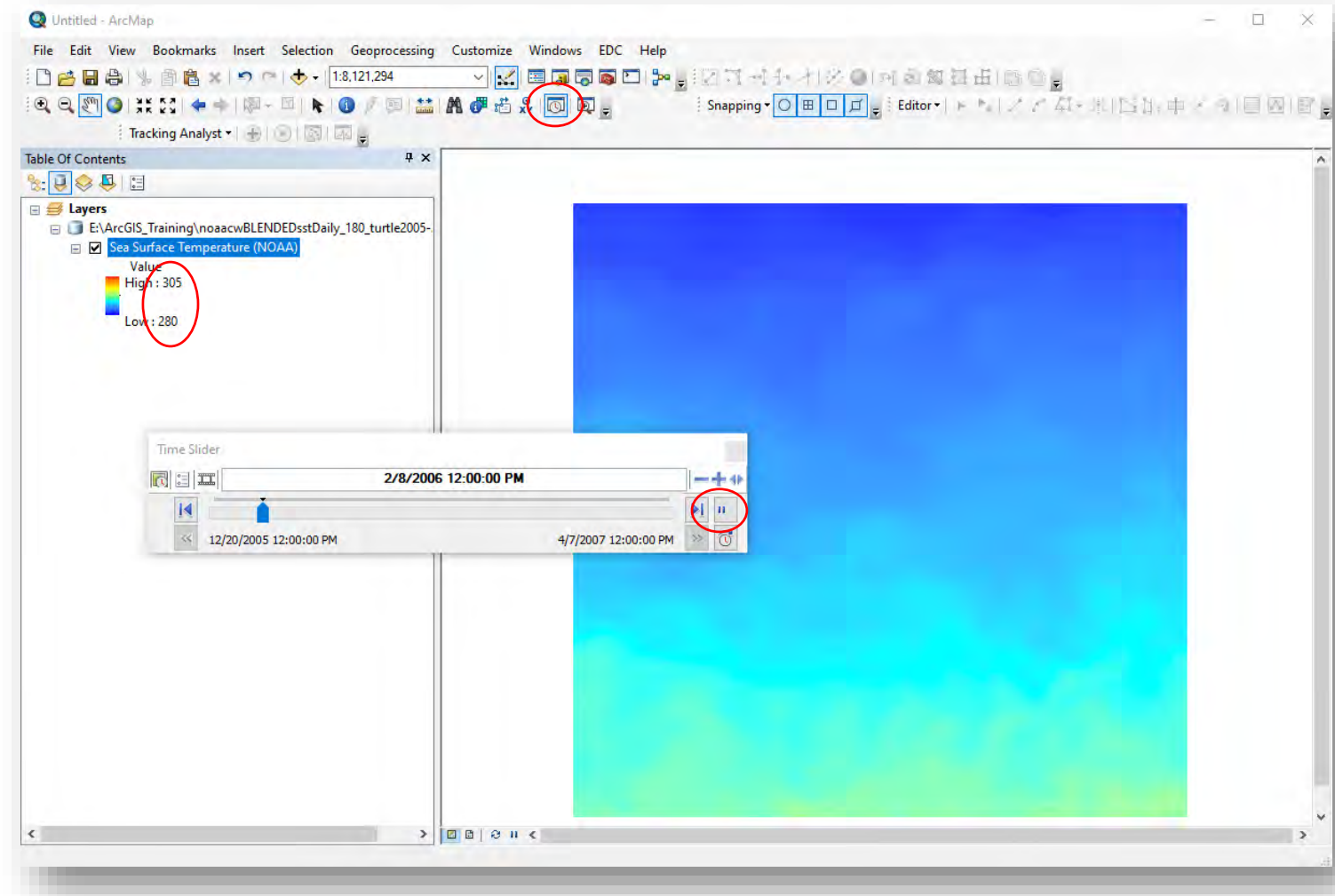
- *Enable* Time on the Layer
- *Set* the Time Dimension to 'time'
- *Set* the Step Interval to '1'
 - You may need to revisit this as ArcMap will reset the value when Calculating range
- *Set* the Time Zone to UTC
- *Click* 'Apply' and verify values
- *Click* 'OK'

The screenshot shows the 'Layer Properties' dialog box with the 'Time' tab selected. The 'General' tab is also visible. The 'Time' tab contains the following settings:

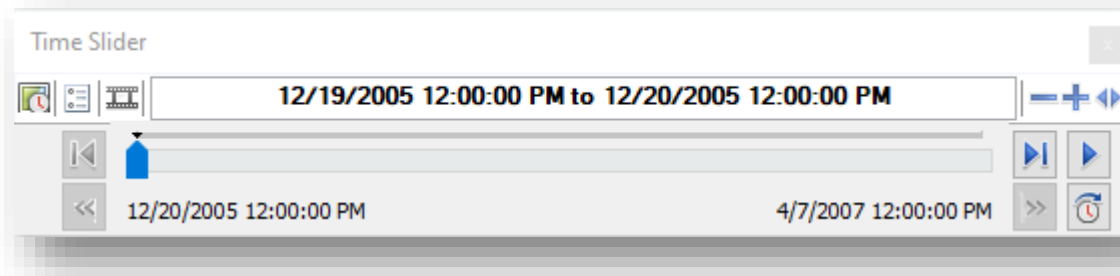
- ☒ Enable time on this layer
- Time properties
 - Layer Time: Layer has time as a dimension.
 - Time dimension: time
 - Field Format: <Date/ Time>
 - Time Step Interval: 1 Days
 - Layer Time Extent: 12/20/2005 12:00:00 PM To: 4/7/2007 12:00:00 PM [Calculate]
 - ☐ Data changes frequently so calculate 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

Display Satellite Data

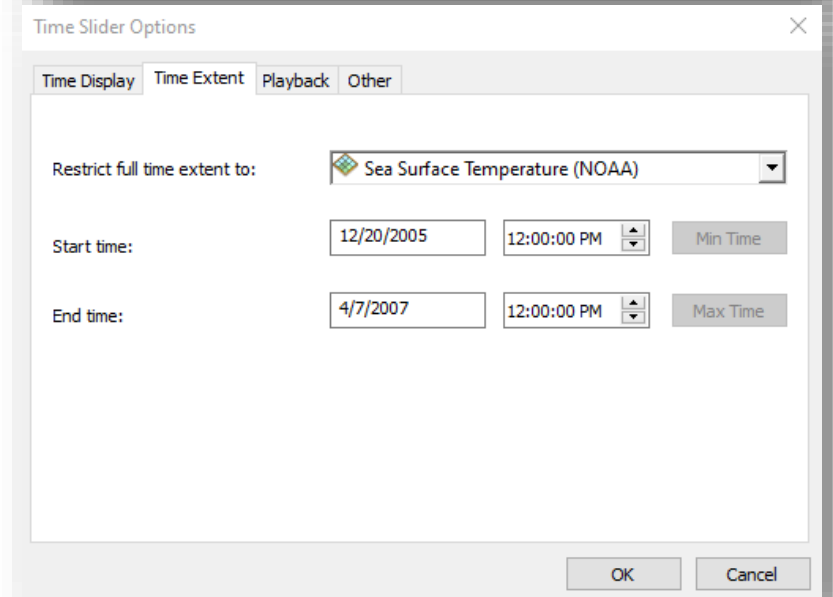
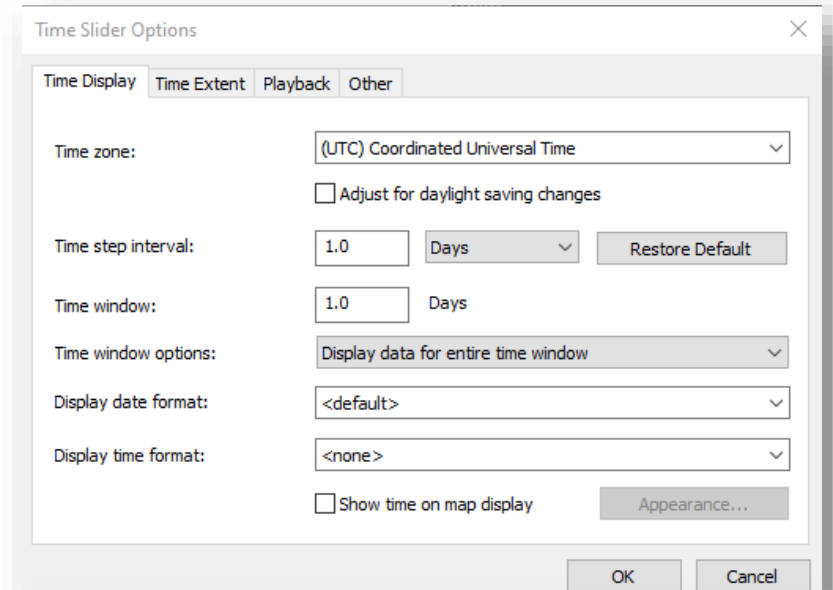
- Enable Time Slider 
- Click the 'Play' Arrow
 - The images should change as the dates advance
 - The color scale range should remain the same for each time step



Time Slider



- Controls time for all layers in map (Enable/Disable) and Tools
- If layers do not display, check:
 - Time Zone
 - Step Interval
 - Time Window
- Exports movie



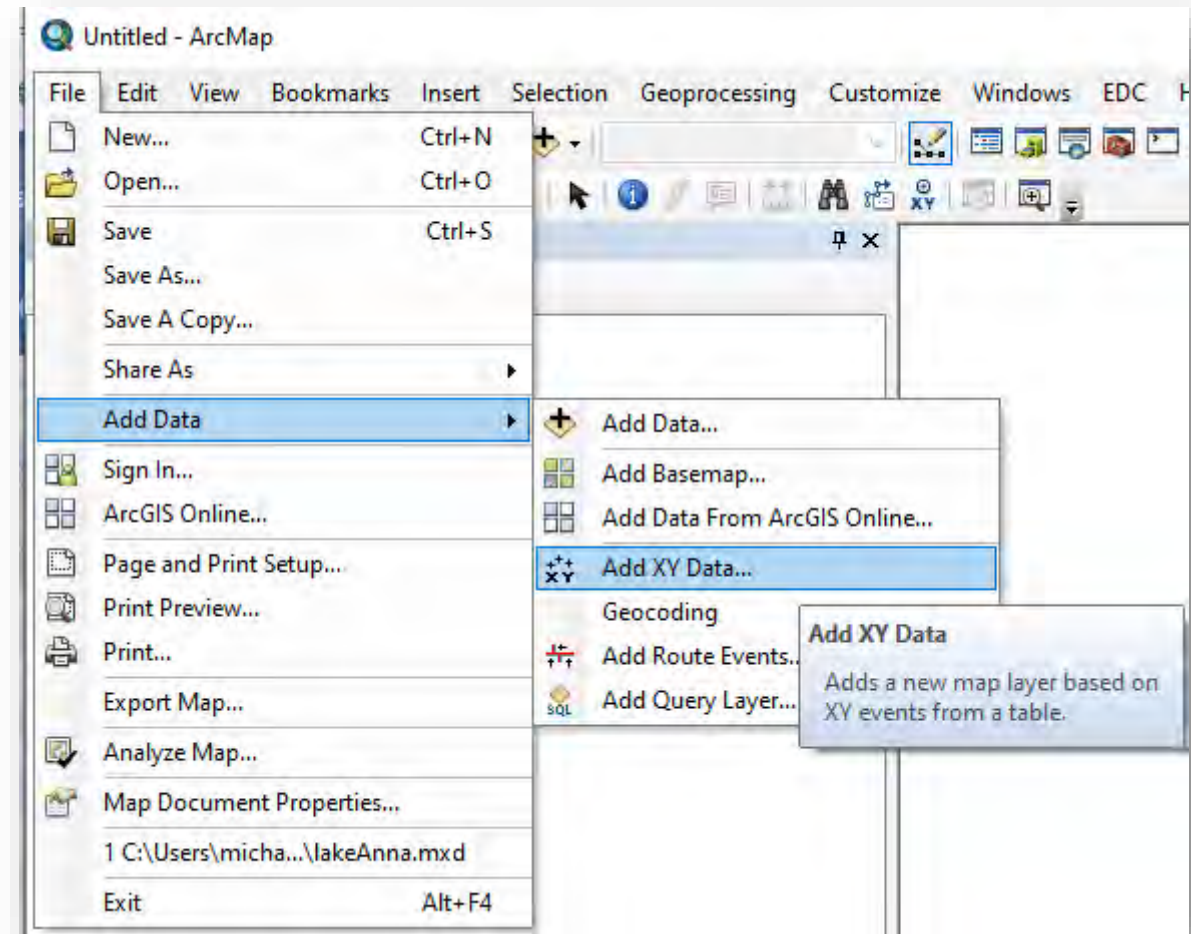
Loading Data: CSV file

- Use the CSV file:
 - 25317_05_dat_DATE_LON180.csv
- Choose a method to import the CSV file
 - Add XY Data, or
 - Create Feature Class from X-Y Table
- Export as Shapefile [Feature Class will do this automatically]

Loading Data: CSV file

Add XY Data

1. Open ArcMap
2. Open a Blank Map
3. *Select file->Add Data->Add XY Data*



Loading Data: CSV file Add XY Data

1. Set the table to your CSV file
2. Set the X,Y Fields
3. Edit and Set the Coordinate System [Global Coordinate System -> WGS1984]
4. Click OK

lon180 may be your X Field

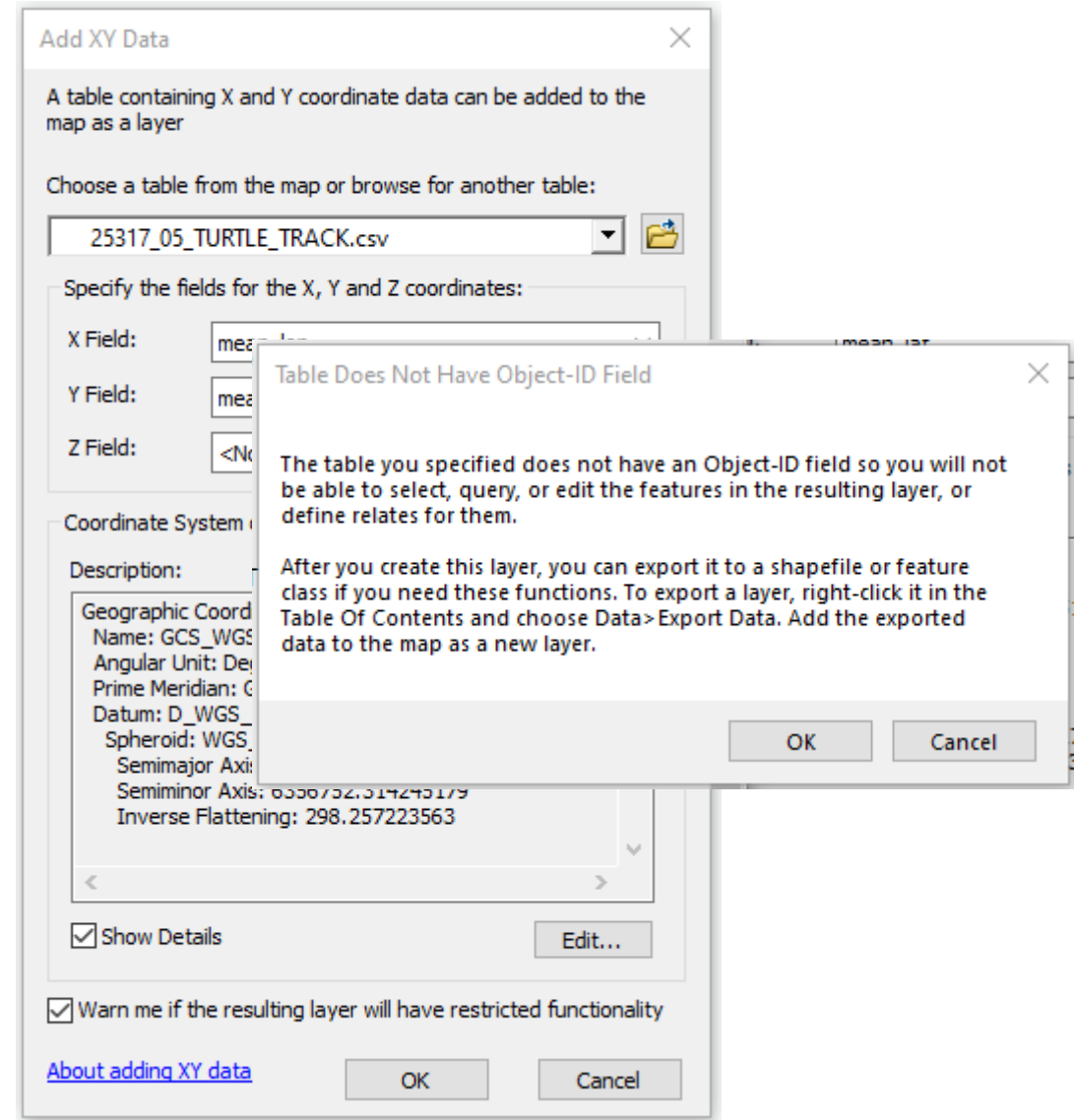
The screenshot shows the 'Add XY Data' dialog box. A red circle highlights the table selection dropdown, which contains '25317_05_TURTLE_TRACK.csv'. Another red circle highlights the 'X Field' dropdown, which contains 'mean_lon'. A third red circle highlights the 'Y Field' dropdown, which contains 'mean_lat'. The 'Z Field' dropdown is set to '<None>'. The 'Coordinate System of Input Coordinates' section shows 'Unknown Coordinate System'. The 'Show Details' checkbox is unchecked. The 'Warn me if the resulting layer will have restricted functionality' checkbox is checked. The 'About adding XY data' link is visible at the bottom left. The 'OK' and 'Cancel' buttons are at the bottom right.

The screenshot shows the 'Add XY Data' dialog box with the same settings as the previous one, but the 'Coordinate System of Input Coordinates' section now shows 'Geographic Coordinate System: Name: GCS_WGS_1984, Angular Unit: Degree (0.0174532925199433), Prime Meridian: Greenwich (0.0), Datum: D_WGS_1984, Spheroid: WGS_1984, Semimajor Axis: 6378137.0, Semiminor Axis: 6356752.314245179, Inverse Flattening: 298.257223563'. The 'Show Details' checkbox is now checked.

Loading Data: CSV file

Add XY Data

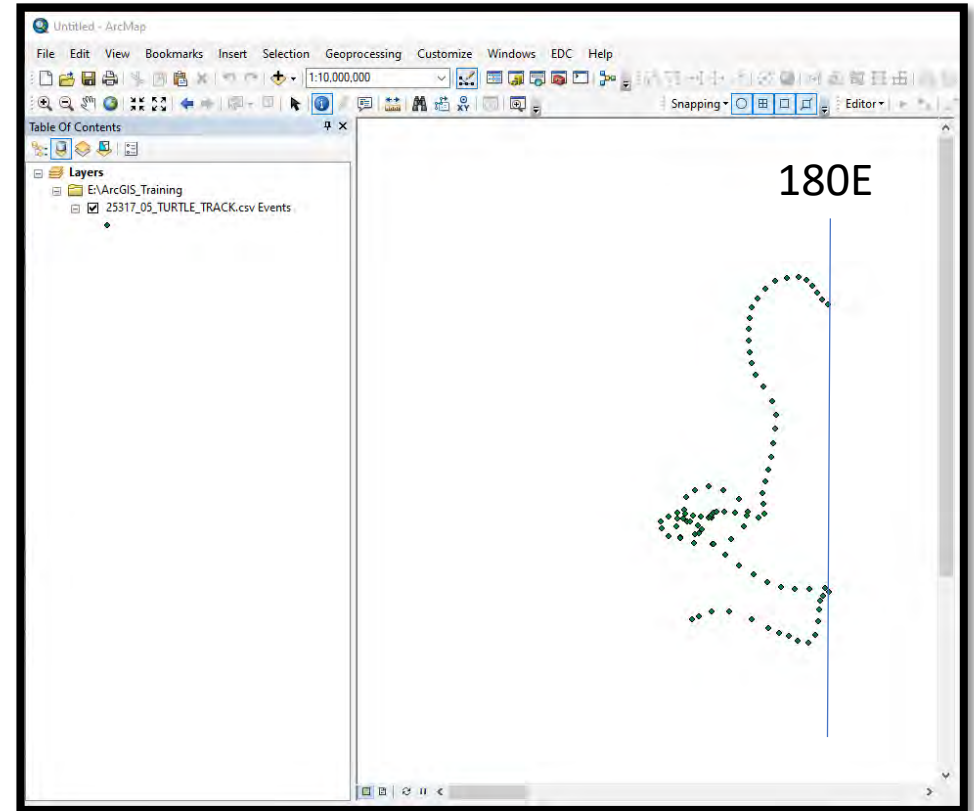
1. An Object-ID warning may appear
2. Click OK
3. If the warning appeared, Export the data and re-add the layer to Map



Loading Data: CSV file

Add XY Data

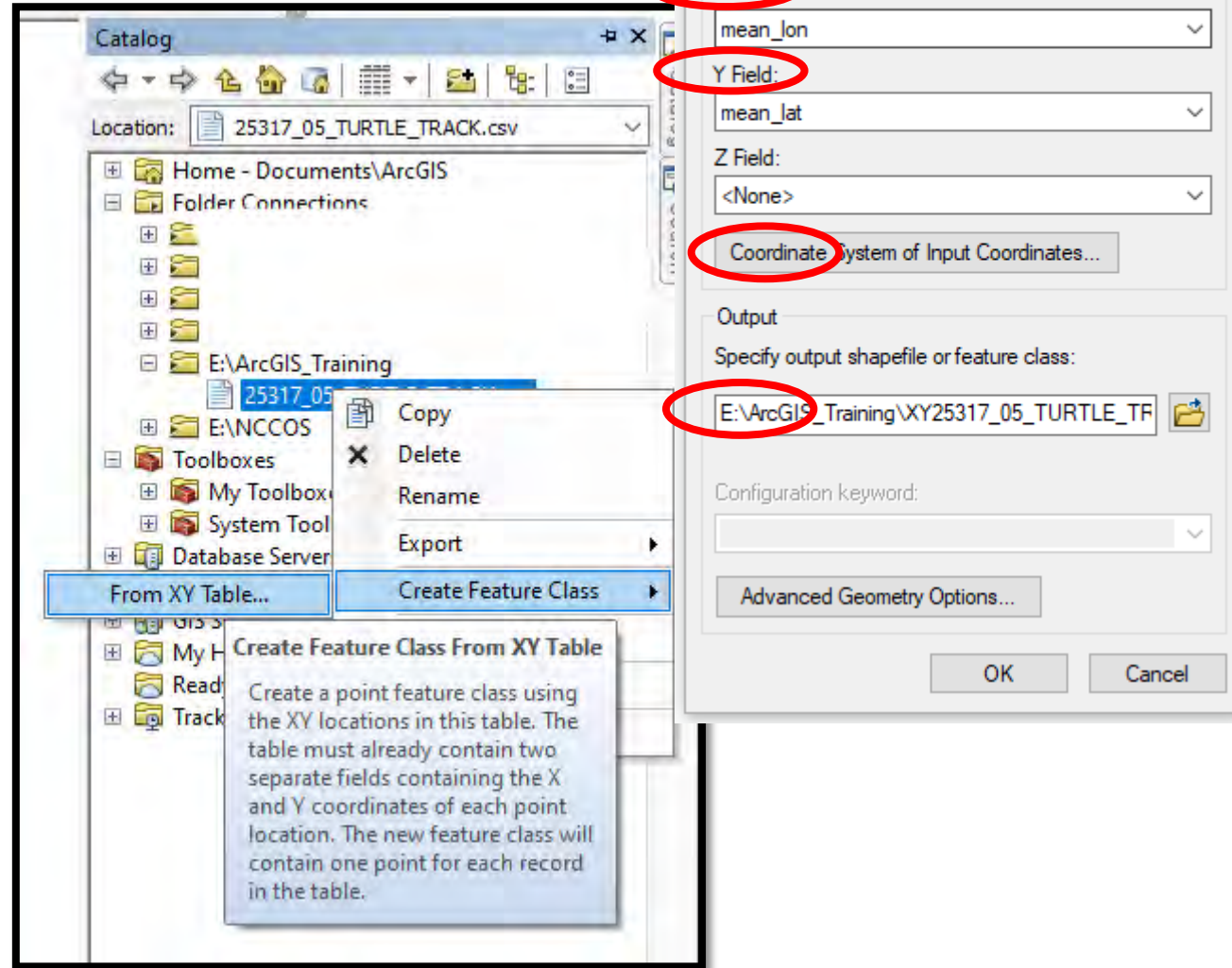
- By default, the View will show -180 to 180, splitting the data at the 'dateline'
- When we adjusted the longitudes (subtracting 360), the East longitudes become 'westernized' as values less than -180. Depending on how the data are loaded and assigned projection, they can display across the dateline.



Loading Data: CSV file

- Open the Catalog
- Navigate to the CSV file and right-click
- Select Create Feature Class
- Populate the Input Fields, Coordinate System, and Output shapefile location
- A notification may suggest adding an ObjectID

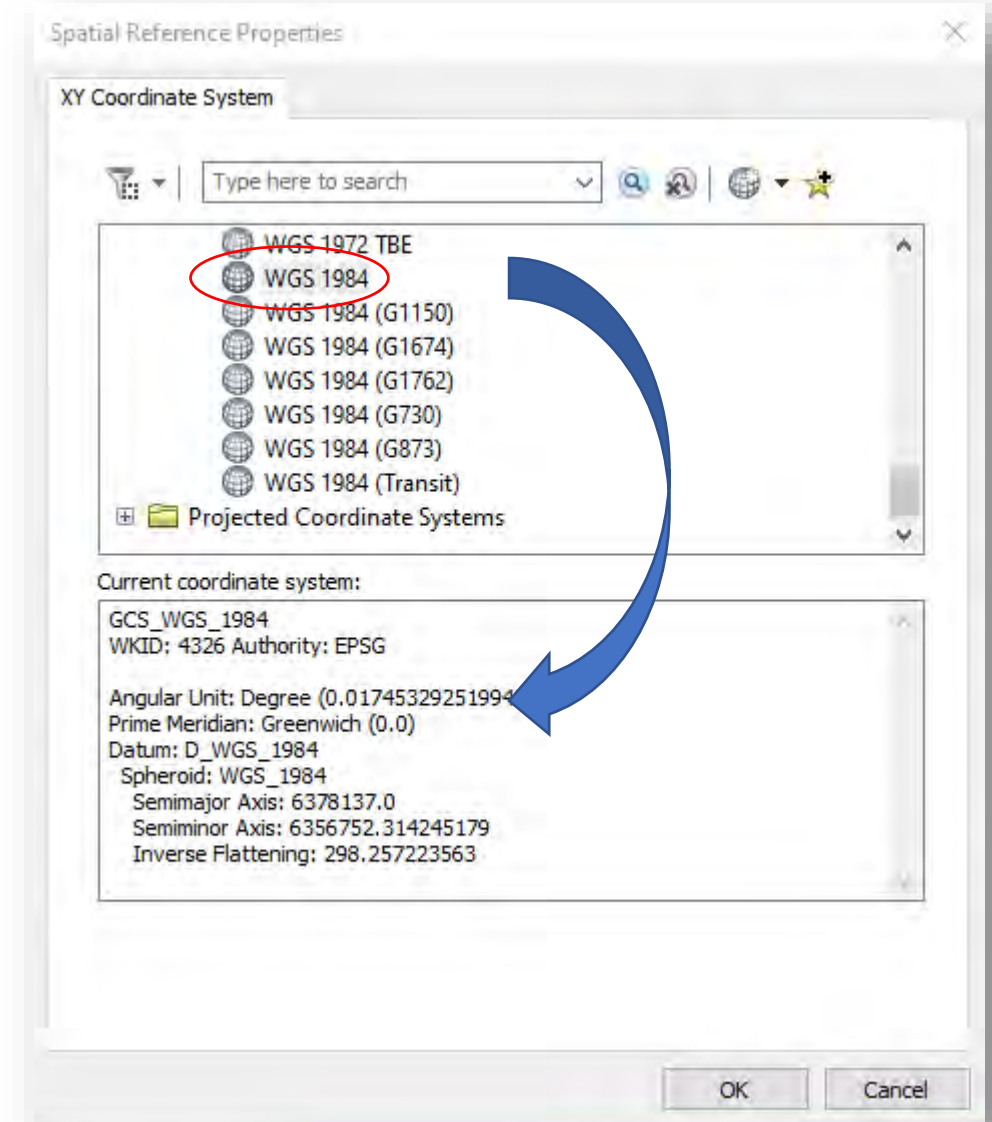
Create Feature Class



Loading Data: CSV file

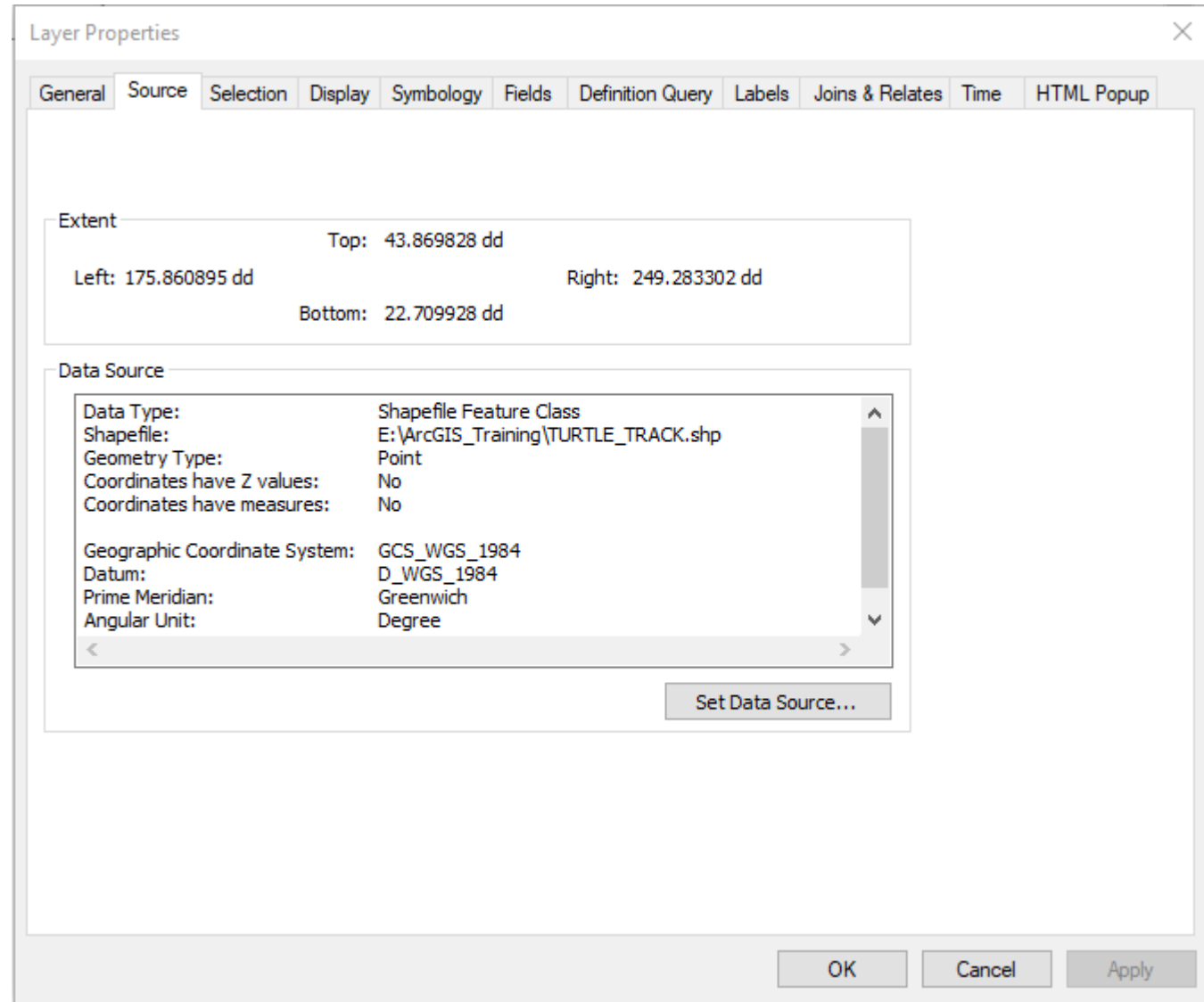
- Set/Confirm the Coordinate system
- *Select* Global Coordinate System
- *Select* WGS1984

Create Feature Class



Loading Data: CSV file

- Verify the Coordinate System under the Source tab

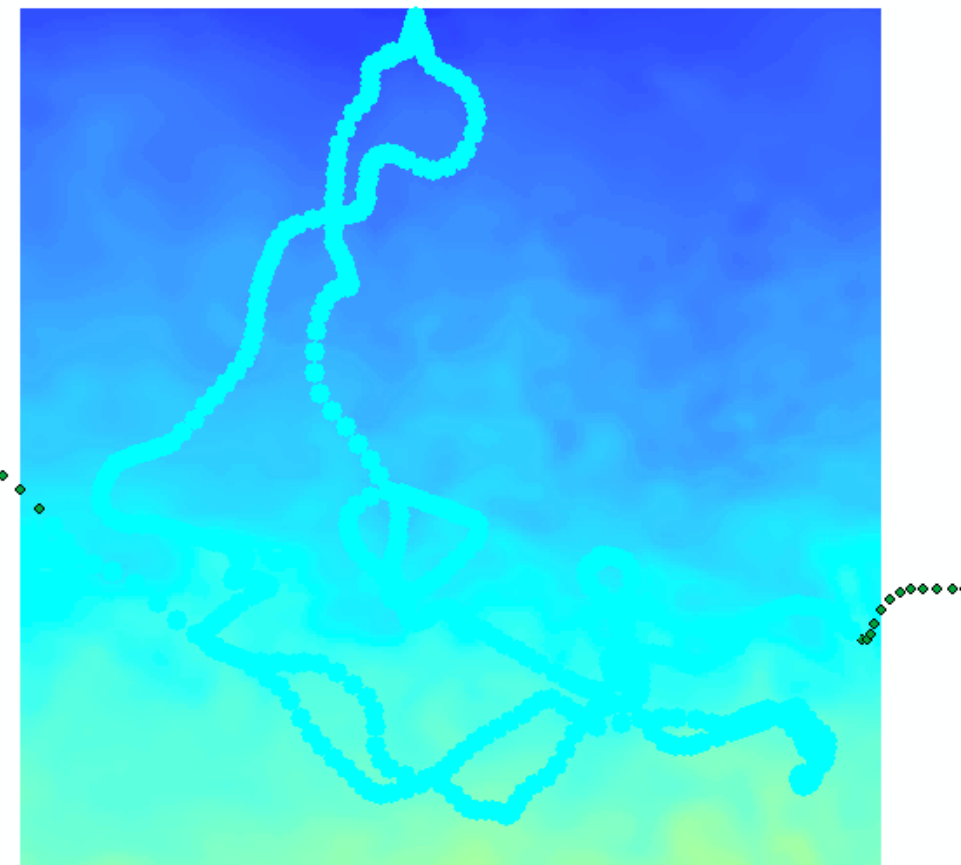
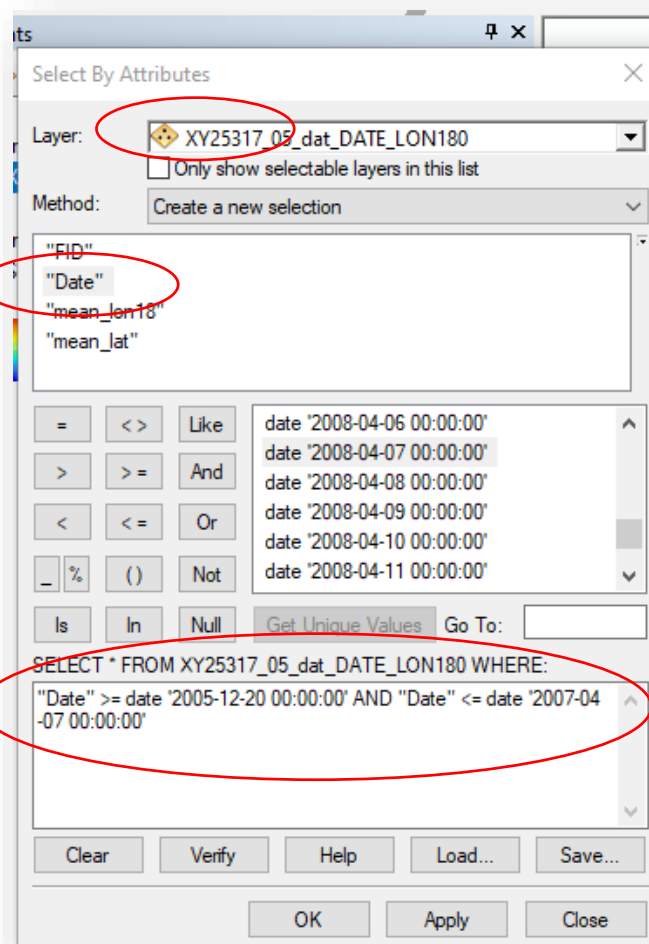


Feature Layer Workflow

- The entire Turtle Track is loaded
- Reduce/filter track to only dates between 12/20/2005 and 4/07/2007
- Perform spatial-temporal sampling with the new Track and SST layer
- Select events from the results to reduce the results to the track points and corresponding SST by date
- Export data, Add as layer
- Proceed

Filter the Feature Layer

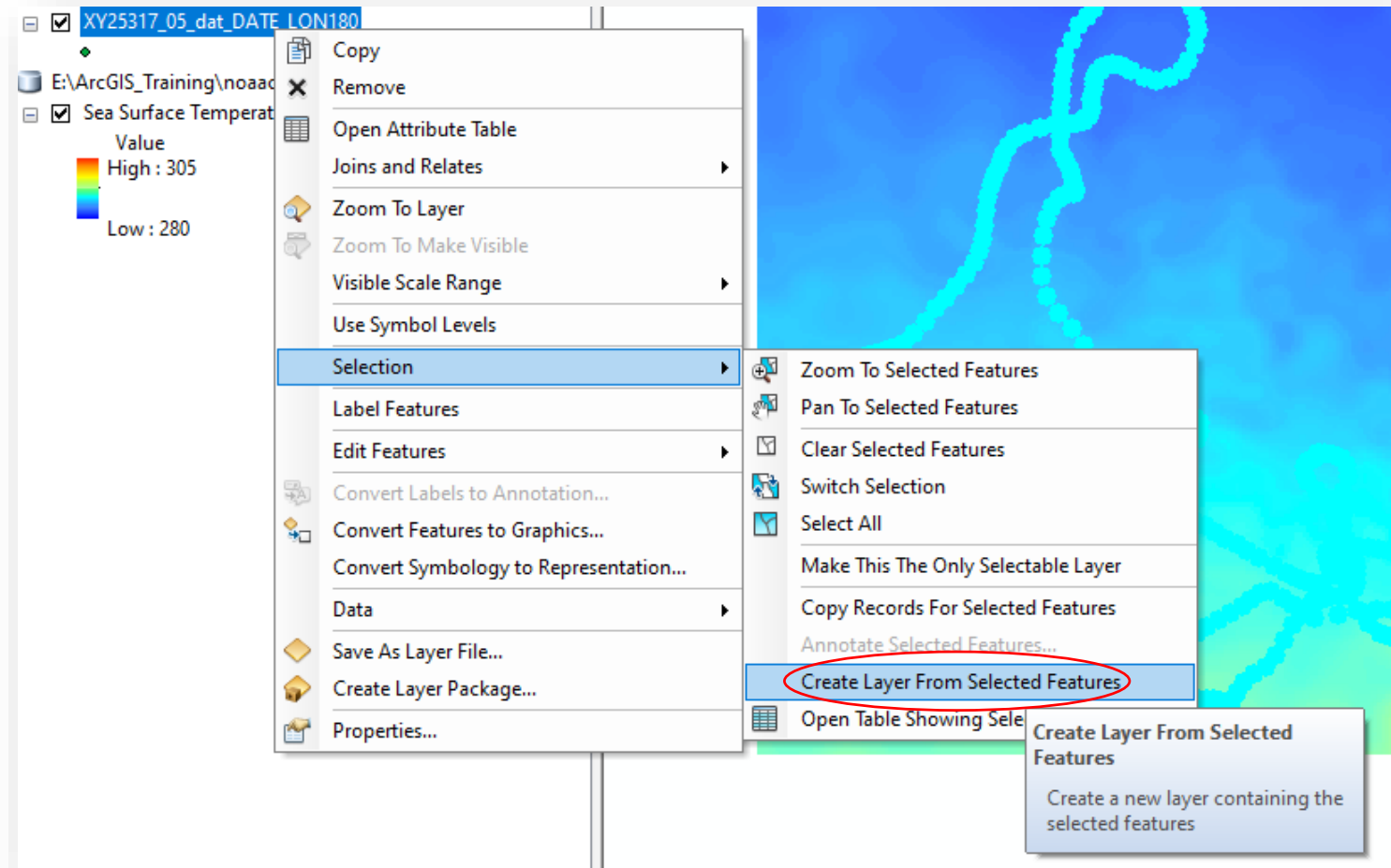
- Open 'Select by Attributes'
- Use Date in the SELECT statement to
- Other selection methods could achieve the same results



"Date" >= date '2005-12-20 00:00:00' AND "Date" <= date '2007-04-07 00:00:00'

Save the Selection as a Layer

- Right-mouse *click* on the feature layer
- Follow the Selection menu to 'Create Layer From Selected Features'
- When prompted, accept 'Add this layer to map'



Enable Time on the Selection Layer

- Open Layer Properties
- *Check* the 'Enable time on this layer' box
- Set Time Step Interval to 1 Days
- Set Time Zone to UTC
- Click *Apply* and *Calculate*
- Reset Time Step Interval to '1' and 'Days'
- *Click* OK

The screenshot shows the 'Layer Properties' dialog box with the 'Time' tab selected. Red circles highlight the following elements:

- ☒ Enable time on this layer
- Time properties section:
 - Layer Time: Each feature has a single time field
 - Time Field: Date
 - Field Format: <Date/ Time>
 - Time Step Interval: 1 Days
 - Layer Time Extent: 12/20/2005 12:00:00 AM To: 4/7/2007 12:00:00 AM
 - Calculate button
- Advanced settings section:
 - Time Zone: (UTC) Coordinated Universal Time
 - Time Offset: 0.00 Years
- Buttons at the bottom: OK, Cancel, and Apply.

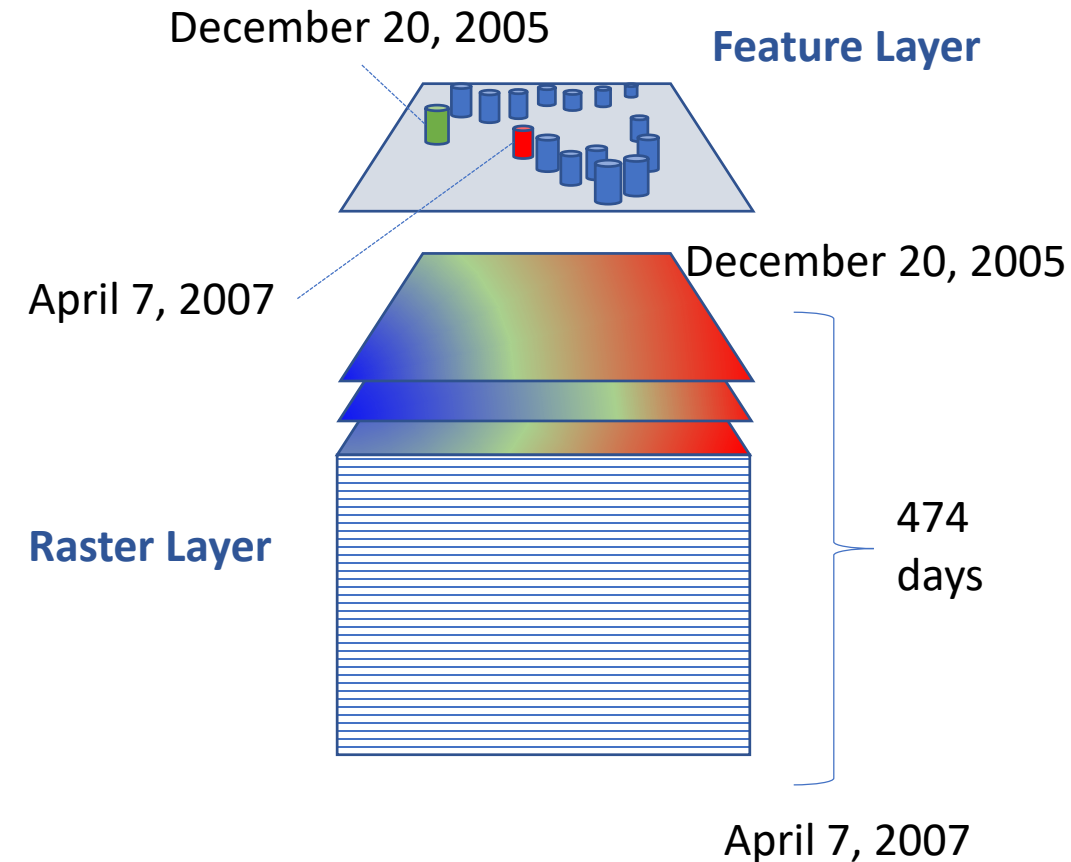
Extracting data from the Raster Layer by using the Feature Layer

- ArcGIS:

- <https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/an-overview-of-the-extraction-tools.htm>
- ArcToolbox->Spatial Analyst Tools->Extraction ▶ Sample

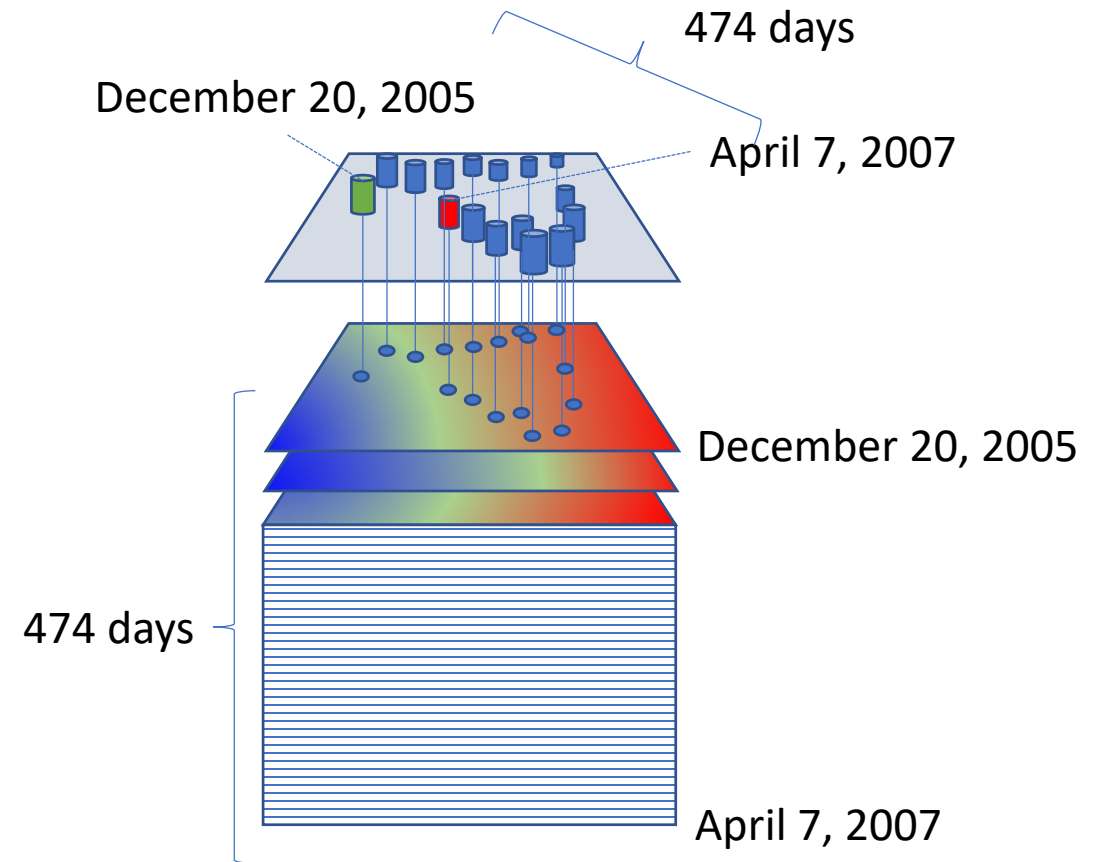
- QGIS:

- https://docs.qgis.org/3.10/en/docs/user_manual/processing_algs/qgis/rasteranalysis.html#sample-raster-values
- Processing->Toolbox-> Raster analysis ▶ Sample raster values algorithm



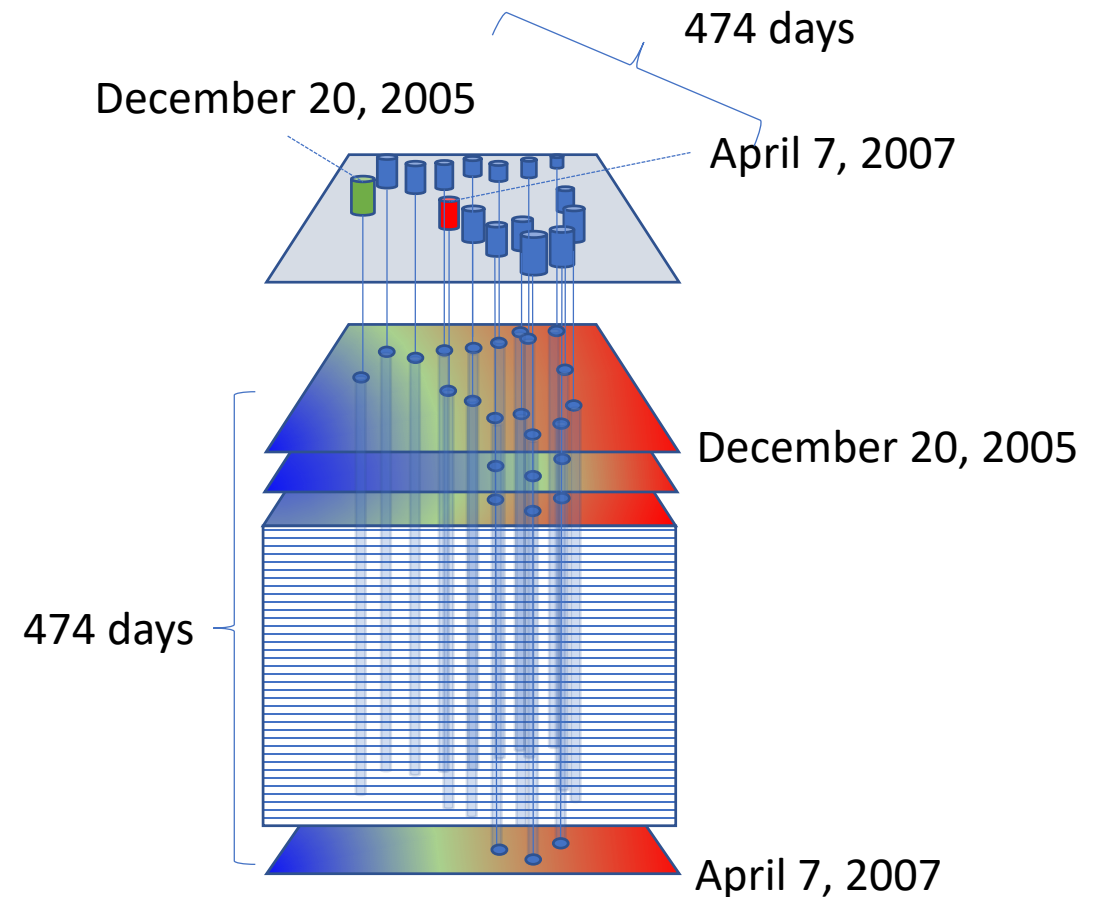
Extracting data using the Sample Tool

- By default, the tool will operate for all points on a single 'slice' of the Raster cube.
- Resulting table is a single layer raster extraction for December 20, 2005 for all points (Dec 2005 to April 2007).



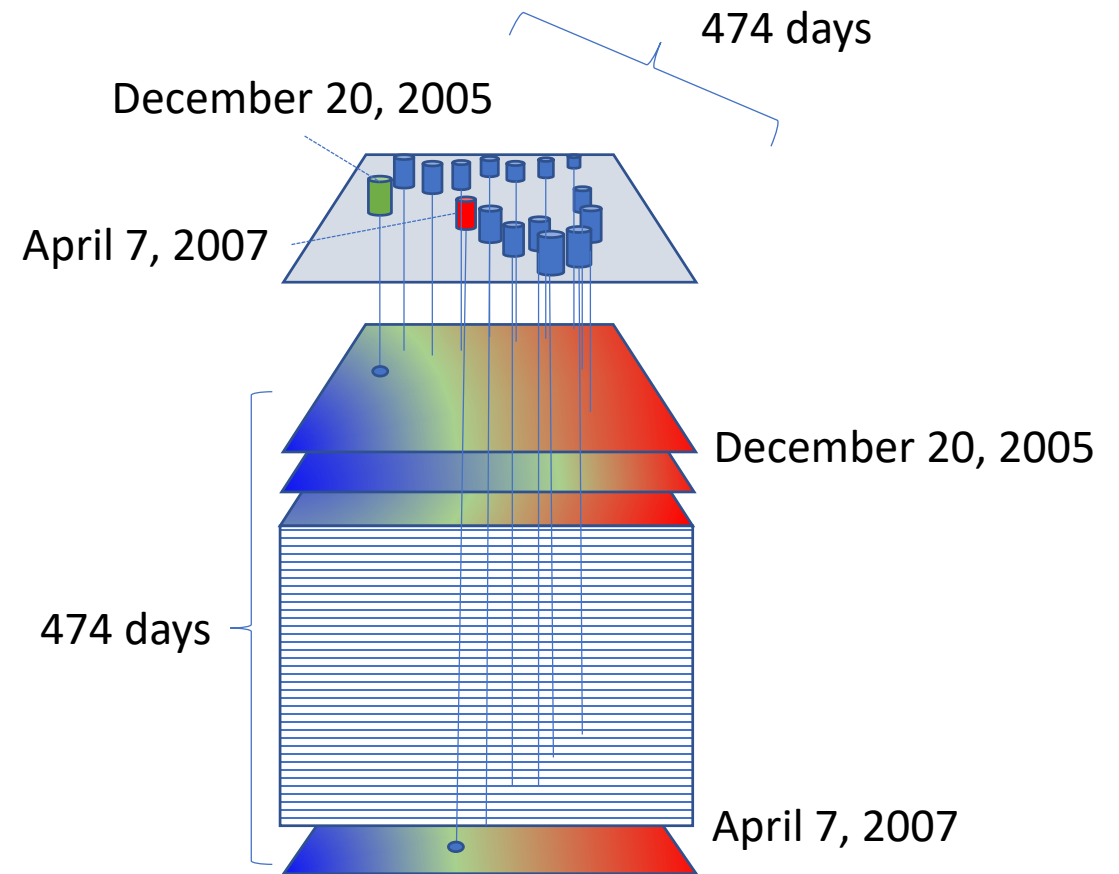
Extracting data using the Sample Tool

- Tool performs multidimensional extraction retrieving values for all slices
- Resulting table has raster values for each point for each time slice



Extracting data using the Sample Tool

- Our result requires selecting the records from the results table to build a layer with the appropriate x,y,t between the point and raster layer

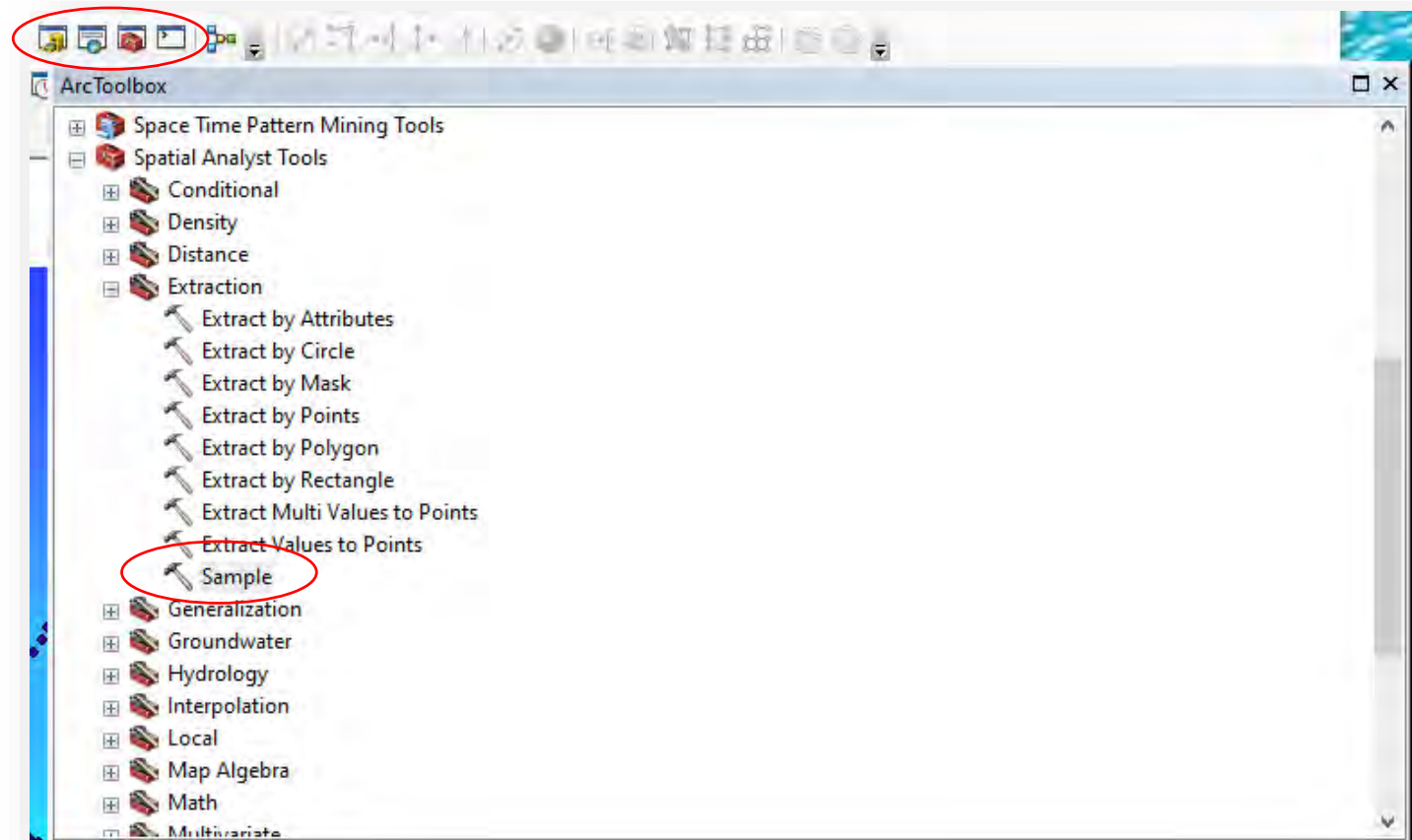


Using the Selected Feature Layer for Sampling

- The selected feature layer contains 474 points.
- The SST layer contains 474 raster layers; one for each day.
- Most geoprocessing tools will work with time (which in ArcMap is managed by the Time Slider), but not always how we would expect.
- The Sample tool will obtain an SST value for each point on each day. [474 points * 474 days = 224676 records]

Perform the Sampling

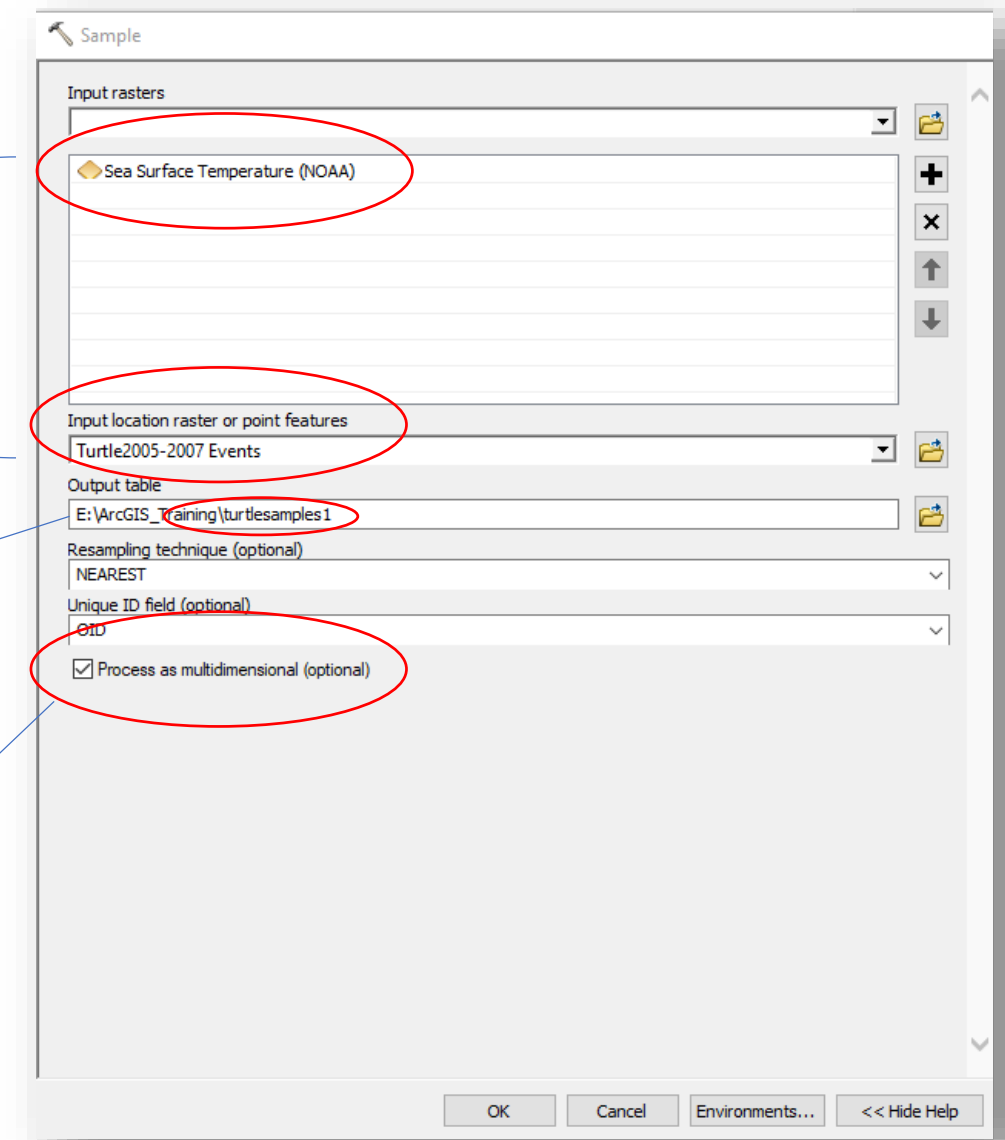
- Open the ArcToolBox
- Find *Spatial Analyst Tools->Extraction->Sample*
- Double-click to activate Sample tool



Perform the Sampling

- Set the input raster and location source fields
- Set a name for the output table
- Sampling tool has a checkbox to enable using multidimensions

By default (multidimensional unchecked), the tool will work on the current date selected in the Time Slider



Perform the Sampling


- Right-mouse and open the data table on the turtlesamples table
- Note the layout of the table
 - Multiple entries per date
 - Analysed_sst column added
 - Rowid prefixed to the table
 - 224,676 records total

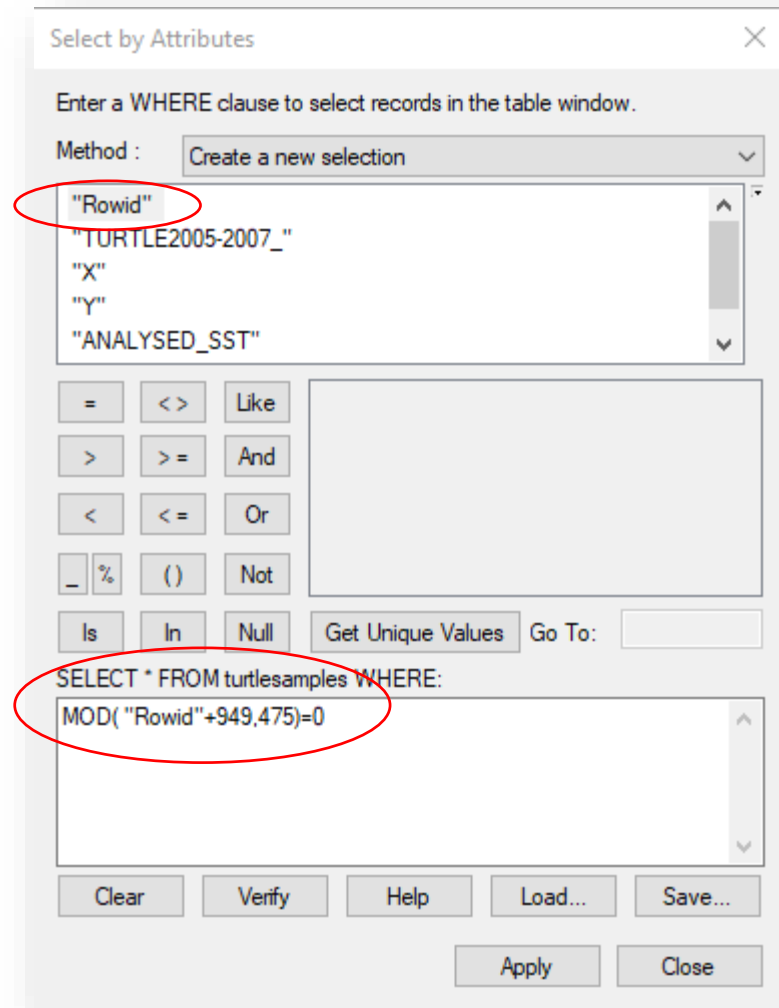
e:\arcgis_training
turtlesamples

Rowid	TURTLE2005-2007	X	Y	ANALYSED_SST	TIME
1	0	-170.563514	35.386402	289.16	12/20/2005
2	1	-170.420929	35.180685	289.39	12/20/2005
3	2	-170.275334	35.005874	289.52	12/20/2005
4	3	-170.065114	34.895738	289.61	12/20/2005
5	4	-169.801612	34.811369	289.76	12/20/2005
6	5	-169.517574	34.6447	290.11	12/20/2005
7	6	-169.240426	34.402489	290.44	12/20/2005
8	7	-168.988636	34.17868	290.63	12/20/2005
9	8	-168.740027	34.006809	290.74	12/20/2005
10	9	-168.484304	33.855427	290.81	12/20/2005
11	10	-168.229963	33.704795	290.98	12/20/2005
12	11	-168.00598	33.567442	291.16	12/20/2005
13	12	-167.827647	33.45093	291.12	12/20/2005
14	13	-167.665197	33.325988	291.03	12/20/2005
15	14	-167.518611	33.14283	291.02	12/20/2005
16	15	-167.393592	32.922825	291.05	12/20/2005
17	16	-167.263742	32.732147	291.16	12/20/2005
18	17	-167.118637	32.573252	291.26	12/20/2005
19	18	-166.968249	32.420312	291.4	12/20/2005
20	19	-166.818379	32.268085	291.5	12/20/2005
21	20	-166.684849	32.137928	291.61	12/20/2005
22	21	-166.581626	32.048744	291.69	12/20/2005
23	22	-166.494297	31.988446	291.69	12/20/2005
24	23	-166.429122	31.956778	291.65	12/20/2005
25	24	-166.367899	31.945366	291.67	12/20/2005
26	25	-166.23245	31.962584	291.56	12/20/2005
27	26	-166.040152	32.020436	291.47	12/20/2005
28	27	-165.874184	32.087047	291.41	12/20/2005

(0 out of 224676 Selected)

Filter the Sampling Results

- Select by Attribute 
- Design an algorithm to grab every 475th row.
 - $\text{MOD}(\text{OBJECTID}+2n-x, n) = 0$
 - n is the every nth record
 - x is the objectid to start from
- $\text{MOD}(\text{"Rowid"}+949,475)=0$
 - Note, Rowid may be OBJECT_ID depending on how data was added



Select by Attributes

Enter a WHERE clause to select records in the table window.

Method : Create a new selection

"Rowid"
"TURTLE2005-2007_"
"X"
"Y"
"ANALYSED_SST"

= <> Like
> >= And
< <= Or
_ % () Not
Is In Null Get Unique Values Go To:

SELECT * FROM turtlesamples WHERE:
MOD("Rowid"+949,475)=0

Clear Verify Help Load... Save...
Apply Close

Filter the Sampling Results

- Our results have 474 records
- The 2nd column shows the sequential order of points in the track
- The Time column matches the Date range we expect.
- This selection must be exported and then displayed to aid in our final outputs.
- Add the new table to the map

Table

turtlesamples

Rowid	TURTLE2005-2007	X	Y	ANALYSED_SST	TIME
1	0	-170.563514	35.386402	289.16	12/20/2005
476	1	-170.420929	35.180685	288.94	12/21/2005
951	2	-170.275334	35.005874	288.78	12/22/2005
1426	3	-170.065114	34.895738	288.83	12/23/2005
1901	4	-169.801612	34.811369	288.93	12/24/2005
2376	5	-169.517574	34.6447	289.13	12/25/2005
2851	6	-169.240426	34.402489	289.13	12/26/2005
3326					
3801					
4276					
4751					
5226					
5701					
6176					
6651					
7126					
7601					
8076					
8551					
9026					
9501					
9976					
10451					
10926					
11401					
11876					
12351					
12826					

turtlesamples

Table

turtlesample

Export Data

Export: Selected records

Use the same coordinate system as:

☐ this layer's source data

☐ the data frame

☐ the feature dataset you export the data into (only applies if you export to a feature dataset in a geodatabase)

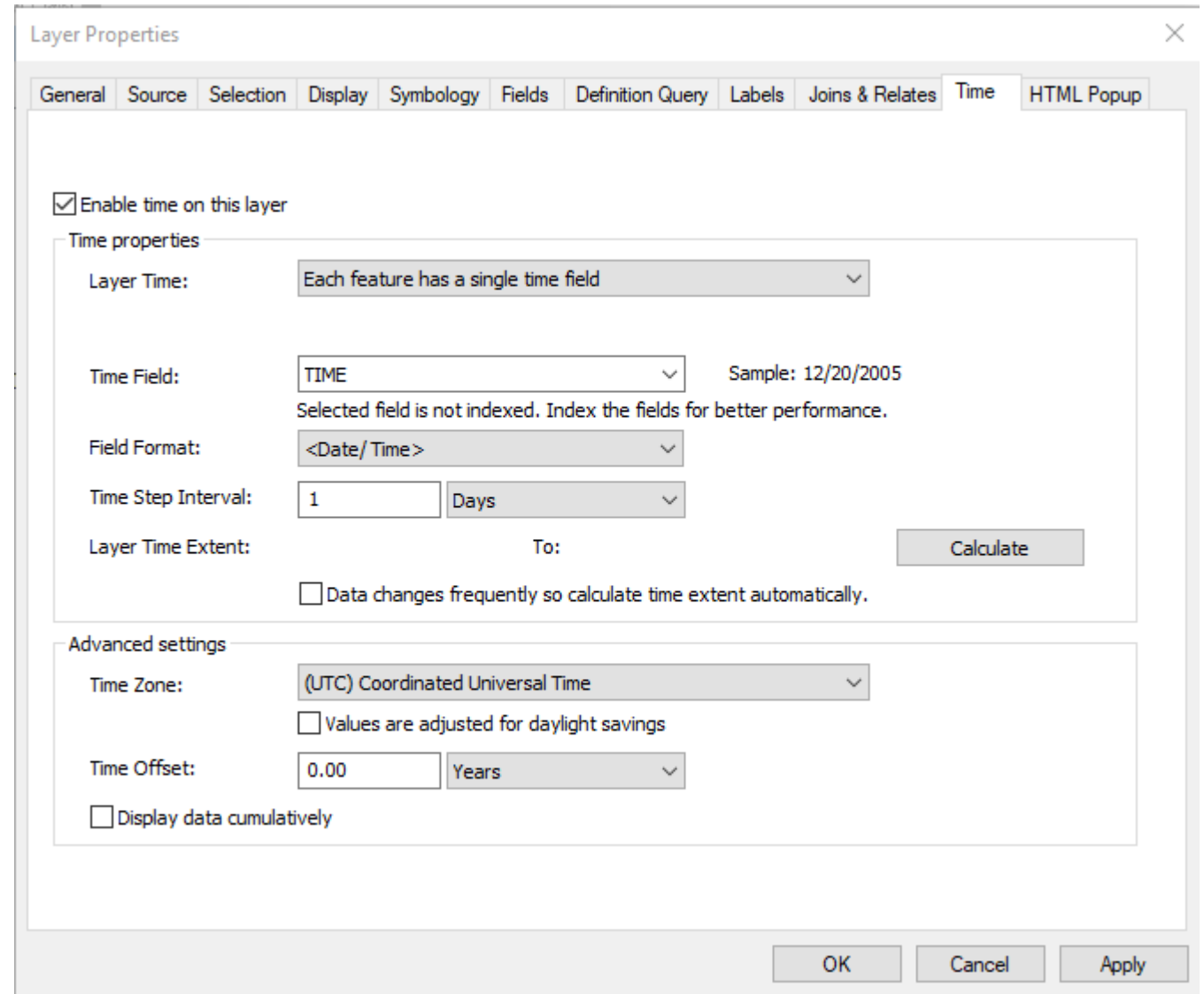
Output table:

E:\ArcGIS_Training\SamplesTurtleTrack.dbf

OK Cancel

Display the Sampling Results

- Display the selected results
- Enable Time (Layer Properties)



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 'Each feature has a single time field'. 'Time Field' is set to 'TIME' with a sample date of '12/20/2005'. A note states 'Selected field is not indexed. Index the fields for better performance.' 'Field Format' is set to '<Date/Time>'. 'Time Step Interval' is set to '1' 'Days'. 'Layer Time Extent' is empty, and 'To:' is empty, with a 'Calculate' button. A checkbox 'Data changes frequently so calculate time extent automatically.' is unchecked. Under 'Advanced settings', 'Time Zone' is set to '(UTC) Coordinated Universal Time'. A checkbox 'Values are adjusted for daylight savings' is unchecked. 'Time Offset' is set to '0.00' 'Years'. A checkbox 'Display data cumulatively' is unchecked. The bottom of the dialog has 'OK', 'Cancel', and 'Apply' buttons.

Layer Properties

General Source Selection Display Symbology Fields Definition Query Labels Joins & Relates Time HTML Popup

☒ Enable time on this layer

Time properties

Layer Time: Each feature has a single time field

Time Field: TIME Sample: 12/20/2005

Selected field is not indexed. Index the fields for better performance.

Field Format: <Date/Time>

Time Step Interval: 1 Days

Layer Time Extent: To: Calculate

☐ Data changes frequently so calculate time extent automatically.

Advanced settings

Time Zone: (UTC) Coordinated Universal Time

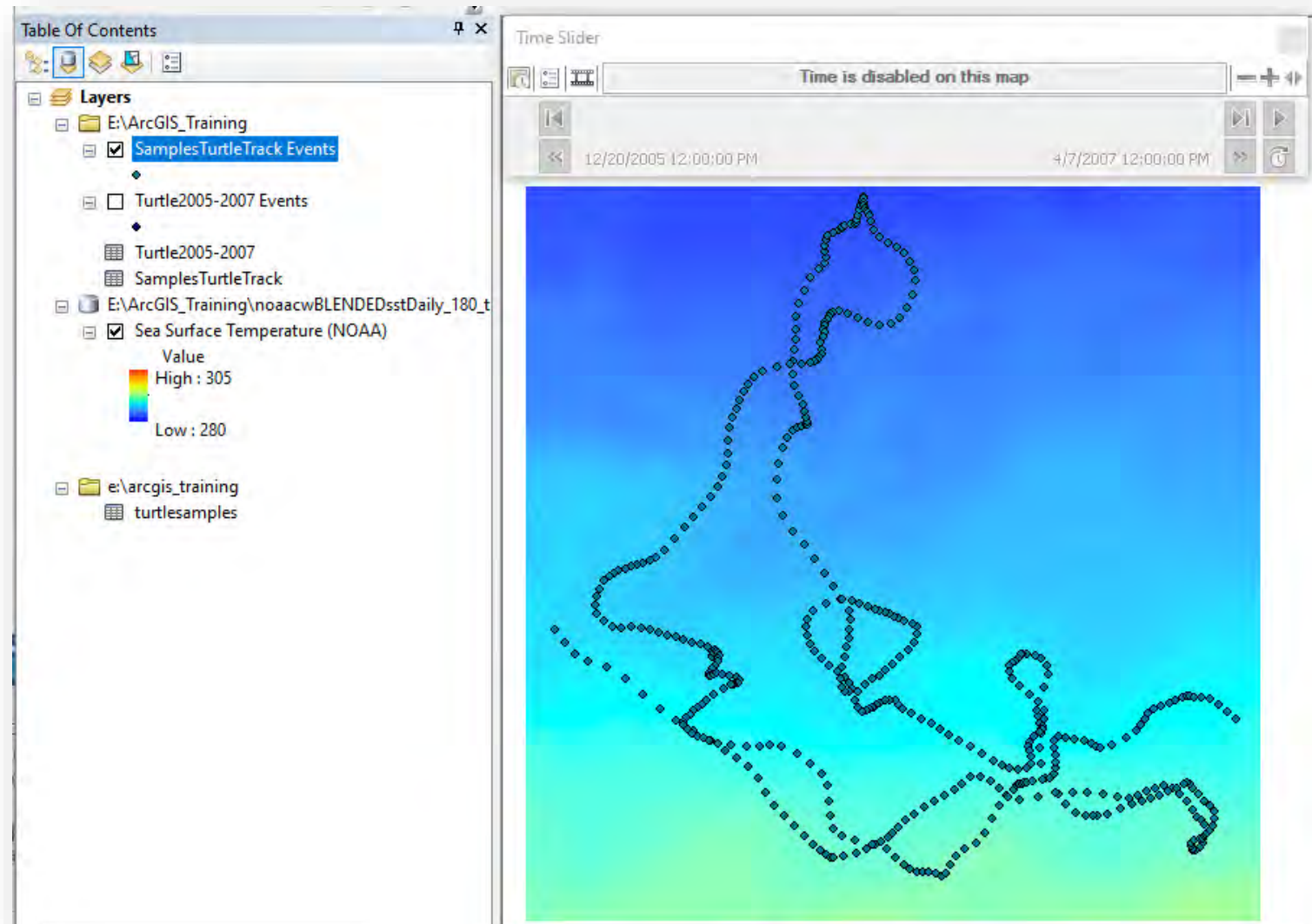
☐ Values are adjusted for daylight savings

Time Offset: 0.00 Years

☐ Display data cumulatively

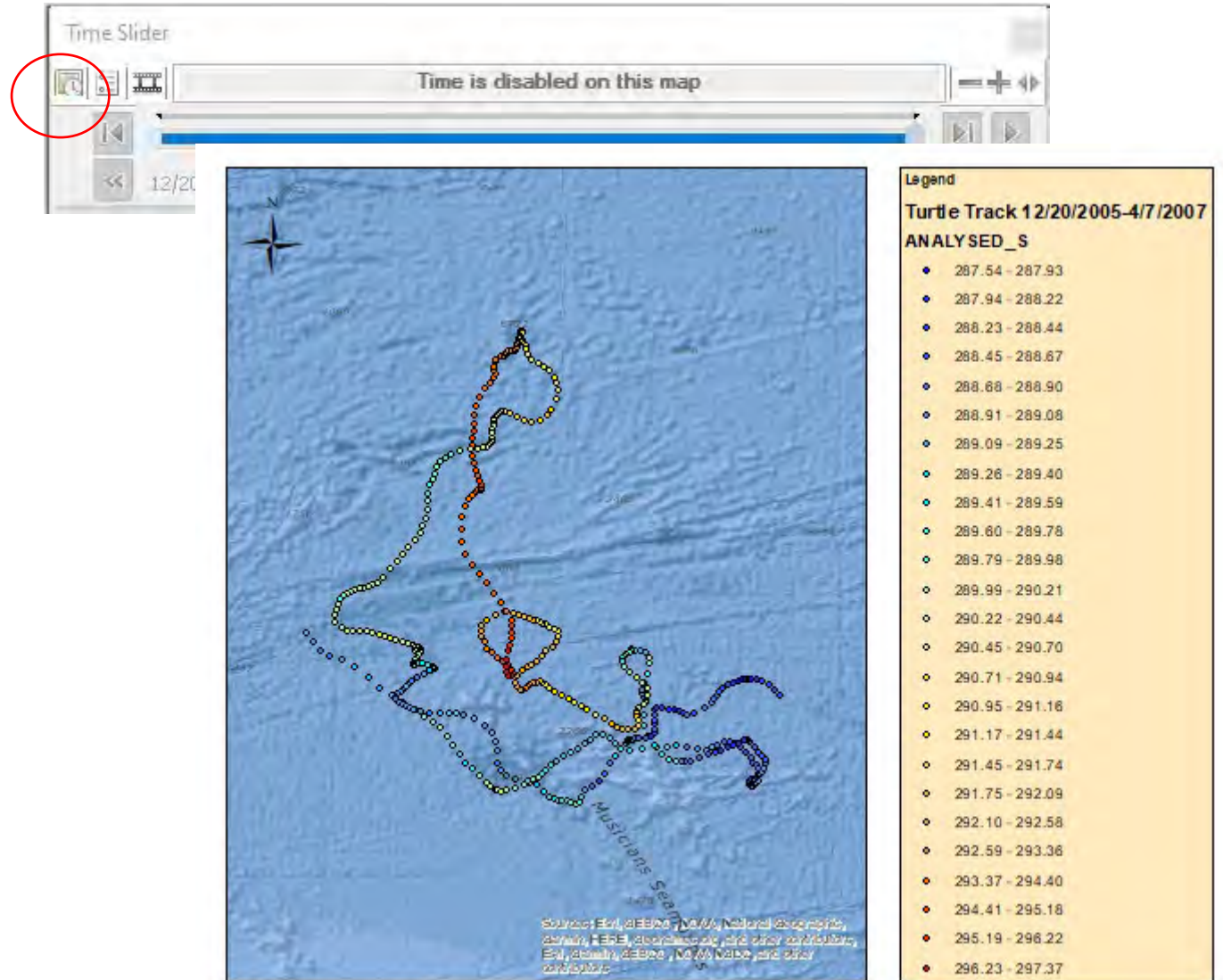
OK Cancel Apply

- Rename samples layer
- Modify Icon
- Remove Turtle2005-2007 layer and table
- Enable Time Slider



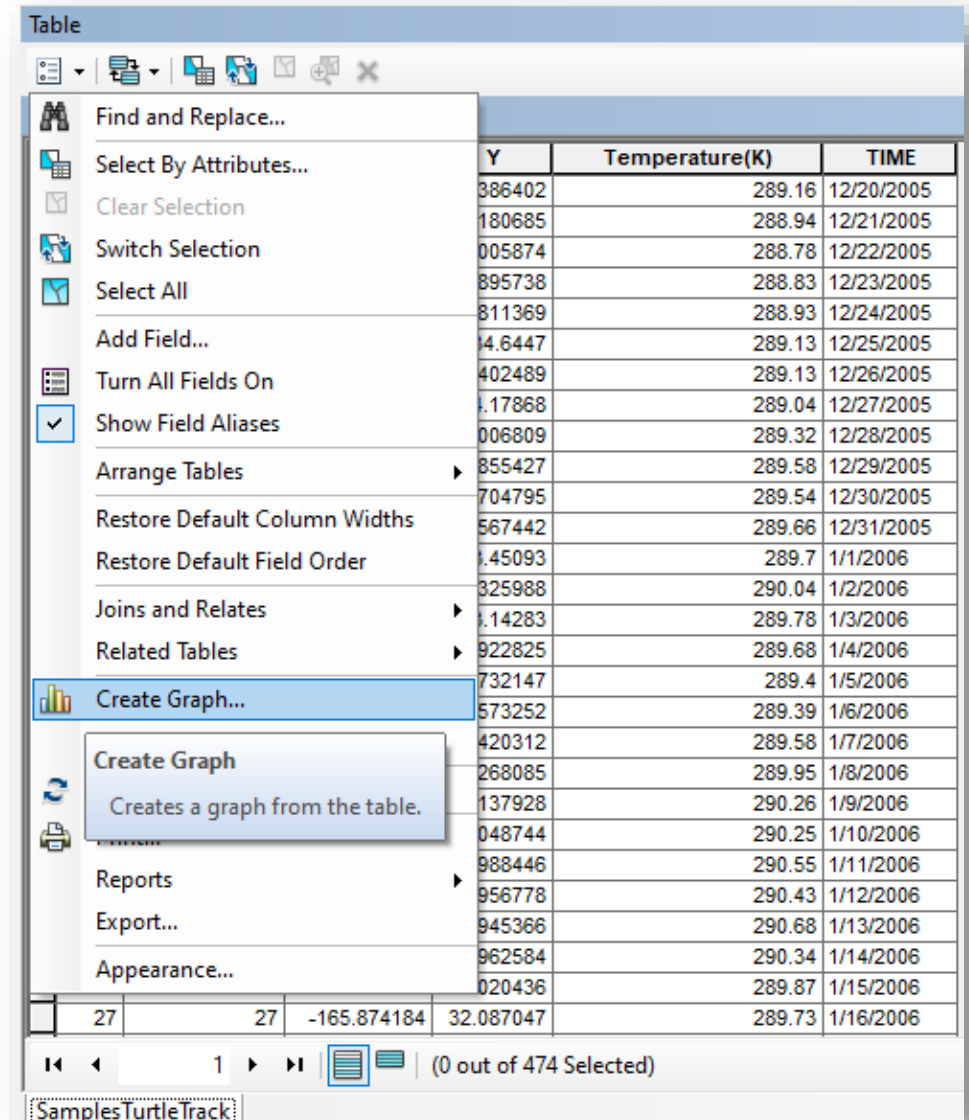
Output 2: Map output showing turtle locations and parameter values

- Disable Time (on slider)
- Open Layer Properties on Turtle layer
- Assign color ramp and classification – 25 levels (Quantities to analysed_sst)
- Turn off raster visibility
- Turn on Basemap



Output 3: Graph of parameter value for each turtle location vs Time

- Open the SamplesTurtleTrackTable
- Rename the ANALYSED_S column to Temperature(K)
- Select 'Create Graph'

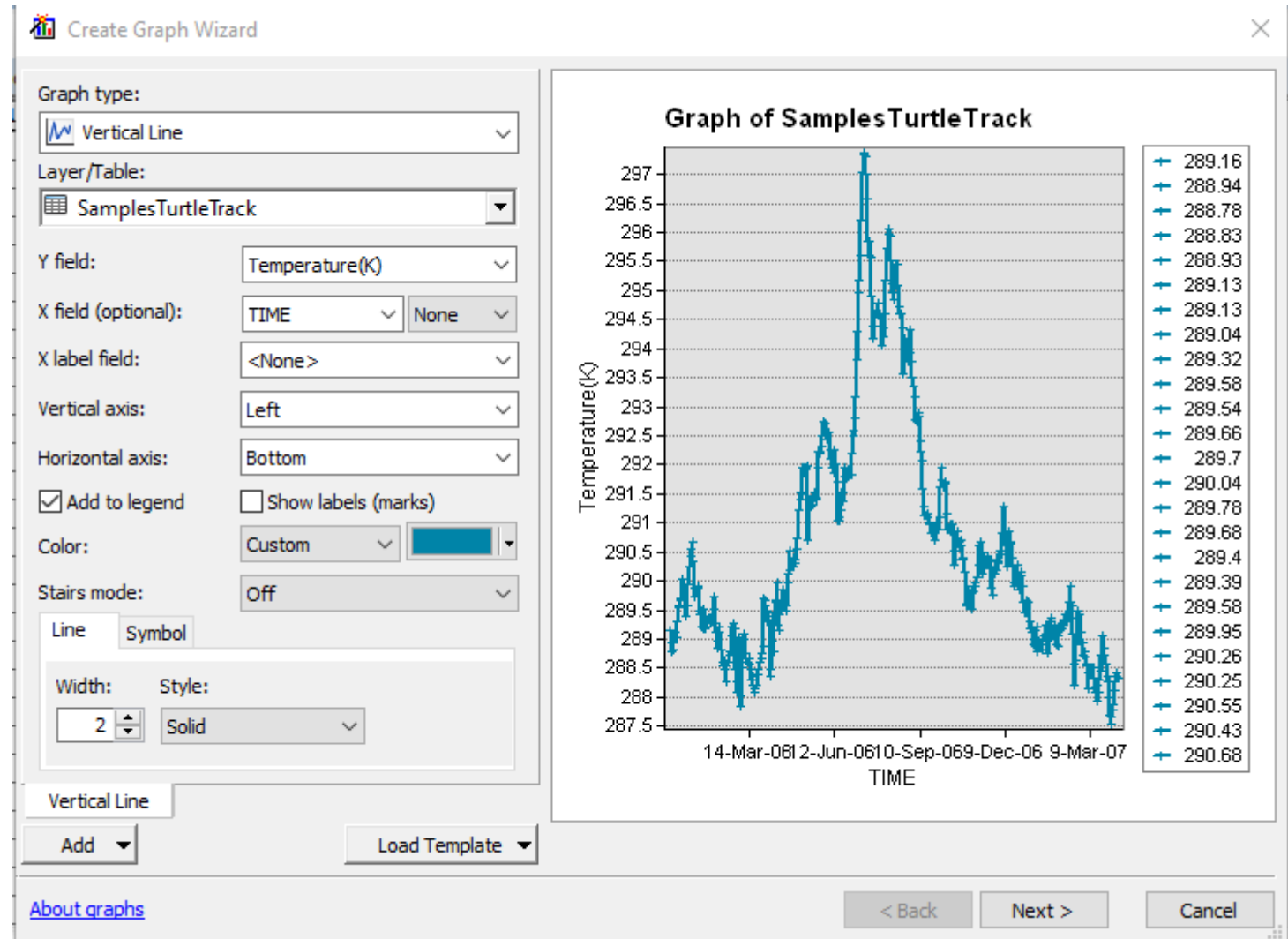


The screenshot shows a software window titled 'Table' containing a data table. A context menu is open over the table, with the 'Create Graph...' option highlighted. The table has three columns: 'Y' (representing latitude), 'Temperature(K)' (representing sea surface temperature), and 'TIME' (representing the date). The data rows show a sequence of turtle locations and temperatures from December 20, 2005, to January 16, 2006. The status bar at the bottom indicates '(0 out of 474 Selected)' and the table name 'SamplesTurtleTrack'.

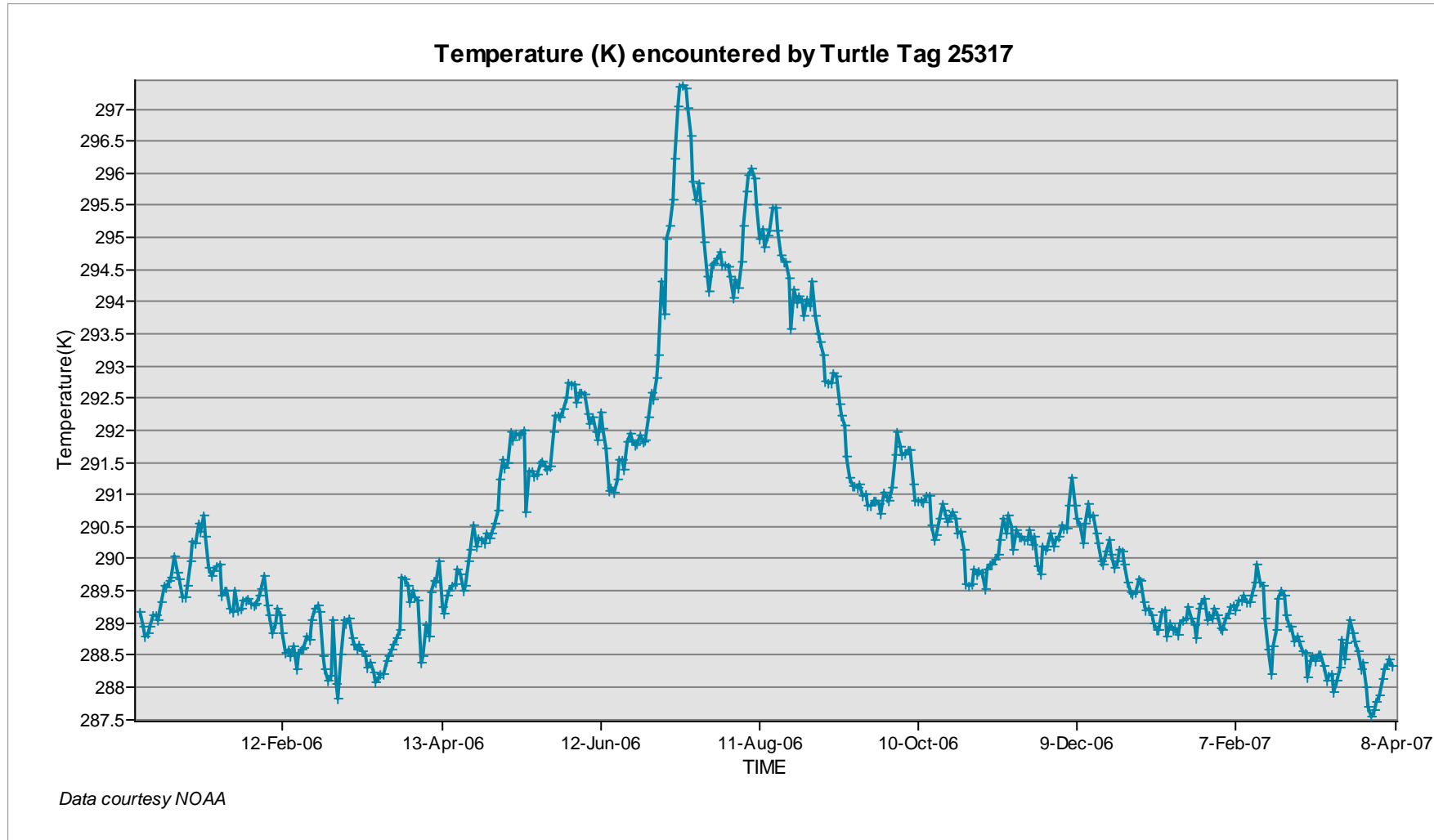
Y	Temperature(K)	TIME
386402	289.16	12/20/2005
180685	288.94	12/21/2005
005874	288.78	12/22/2005
895738	288.83	12/23/2005
811369	288.93	12/24/2005
4.6447	289.13	12/25/2005
402489	289.13	12/26/2005
1.17868	289.04	12/27/2005
006809	289.32	12/28/2005
855427	289.58	12/29/2005
704795	289.54	12/30/2005
567442	289.66	12/31/2005
1.45093	289.7	1/1/2006
325988	290.04	1/2/2006
1.14283	289.78	1/3/2006
922825	289.68	1/4/2006
732147	289.4	1/5/2006
573252	289.39	1/6/2006
420312	289.58	1/7/2006
268085	289.95	1/8/2006
137928	290.26	1/9/2006
048744	290.25	1/10/2006
988446	290.55	1/11/2006
956778	290.43	1/12/2006
945366	290.68	1/13/2006
962584	290.34	1/14/2006
020436	289.87	1/15/2006
27	289.73	1/16/2006

Output 3: Graph of parameter value for each turtle location vs Time

- Select the Graph type: Vertical Line
- Set the Y and X axes
 - Temperature(K) vs Time
- Continue with the Wizard to finalize your chart.



Output 3: Graph of parameter value for each turtle location vs Time



Output 4: Export Movie showing Turtle, Parameter, TurtleWatch Zone

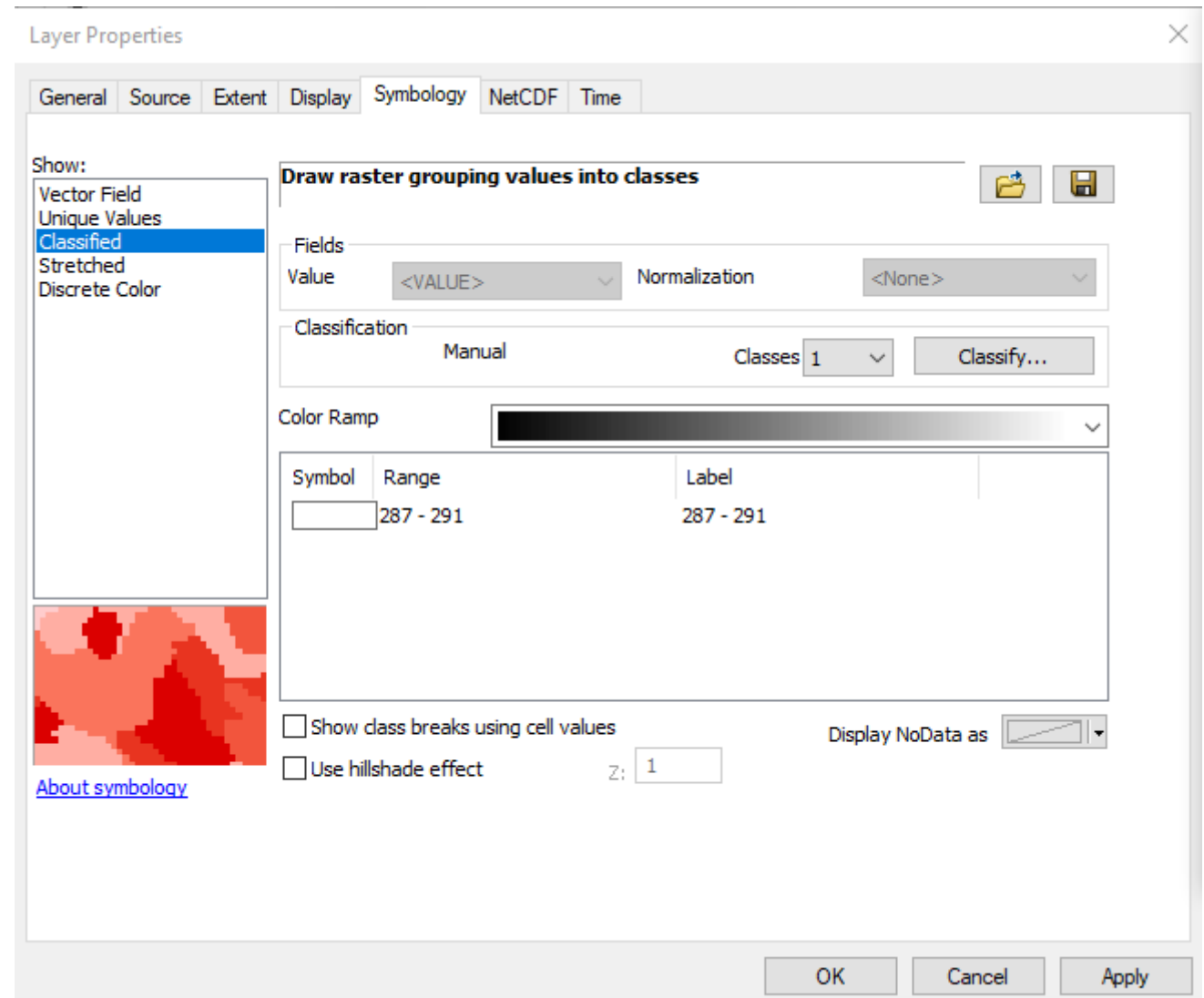
<https://www.fisheries.noaa.gov/resource/map/turtlewatch>

- TurtleWatch Zone:

1. Most loggerhead turtles stay in water colder than 65.5°F (about 18.5°C). When the 65.5°F temperature contour is drawn on a map of the current sea surface temperature conditions, it delineates the current southern boundary of the loggerhead's preferred habitat. Over 50% of recorded loggerhead interactions occurred in waters between this southern 65.5°F boundary and the 63.5°F temperature contour to the north.
2. Converting F to K: 290.65 – 291.65 K

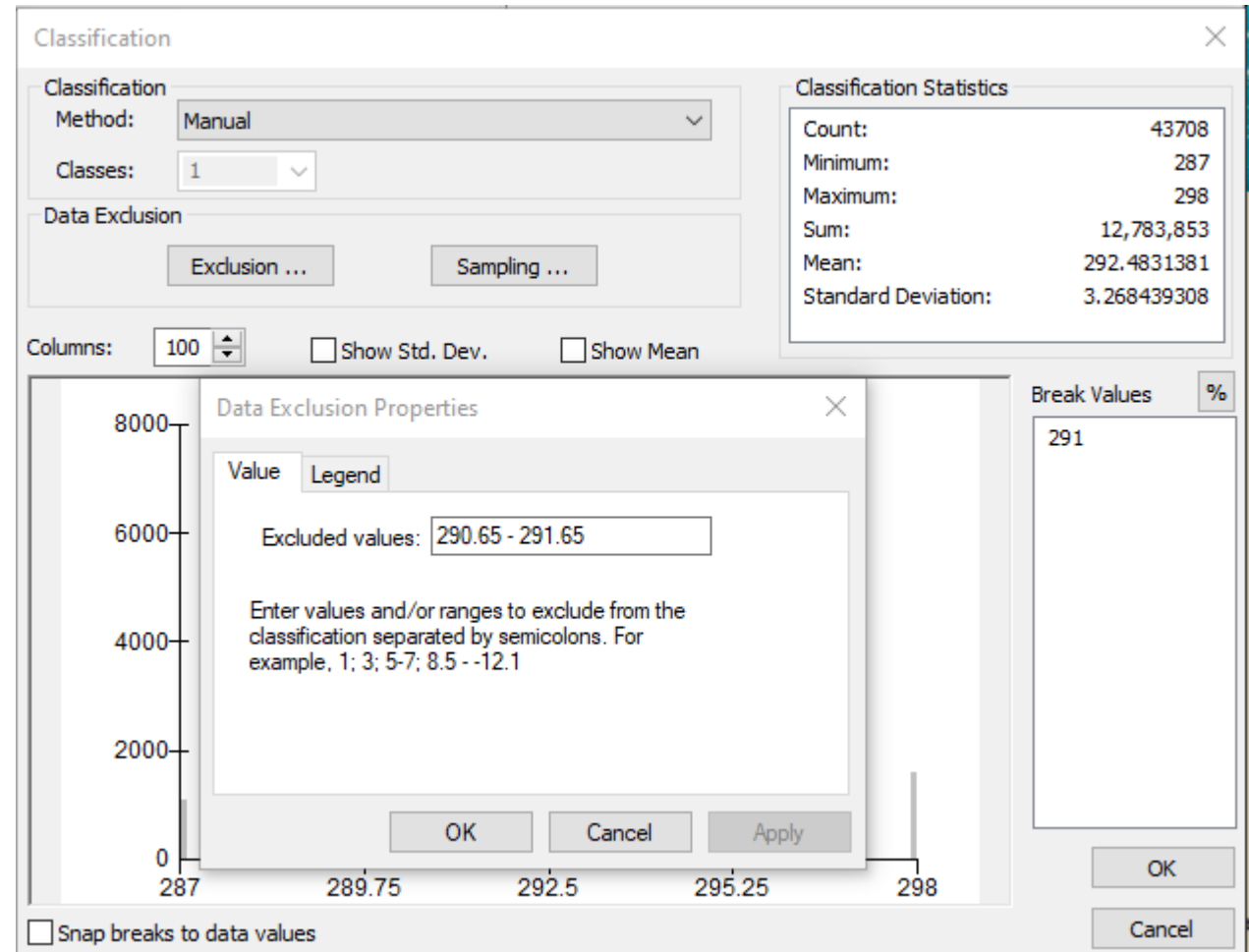
Output 4: Export Movie showing Turtle, Parameter, TurtleWatch Zone

- Copy and Paste SST raster layer
- Rename and Open SST raster Layer Properties

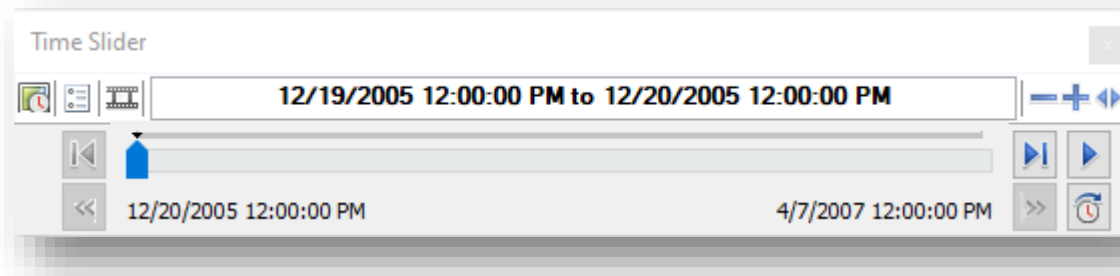


Output 4: Export Movie showing Turtle, Parameter, TurtleWatch Zone

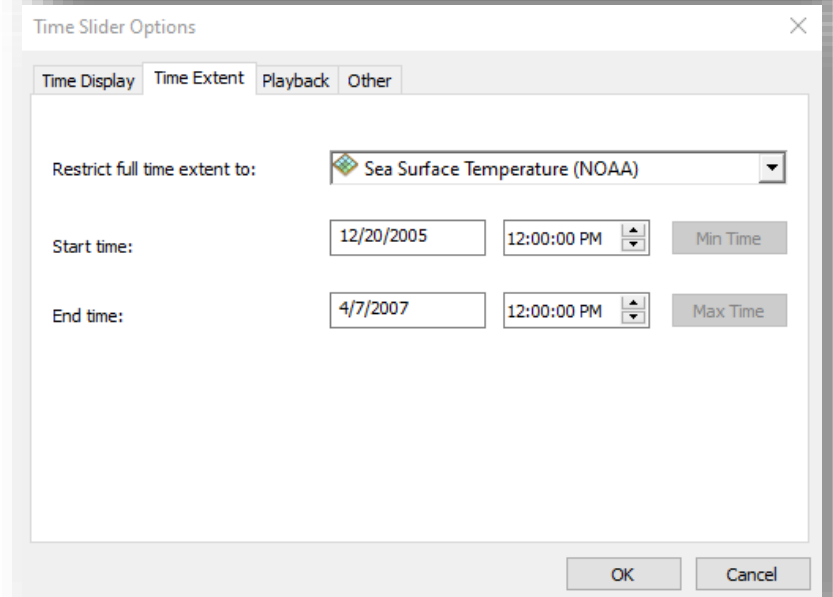
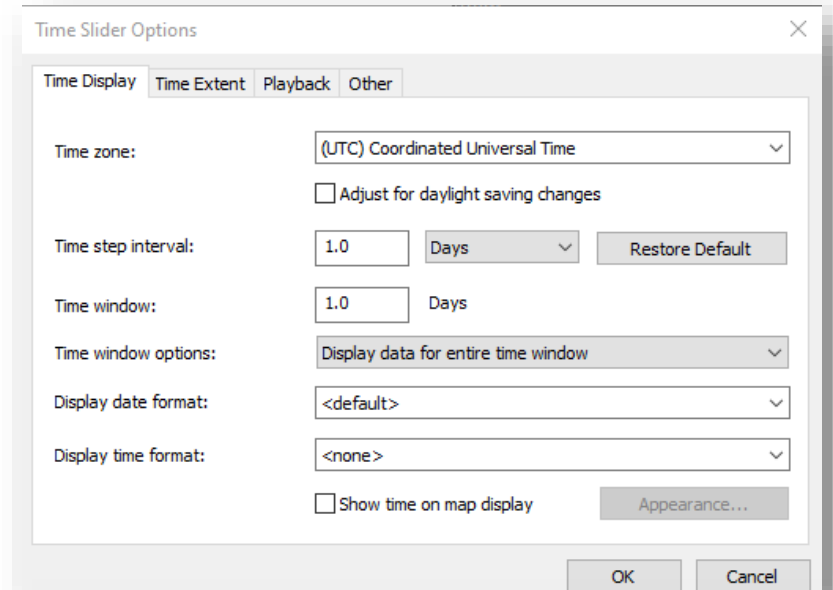
- Steps:
 1. Add TurtleWatch Zone
 2. Export Movie



Time Slider – Check Settings

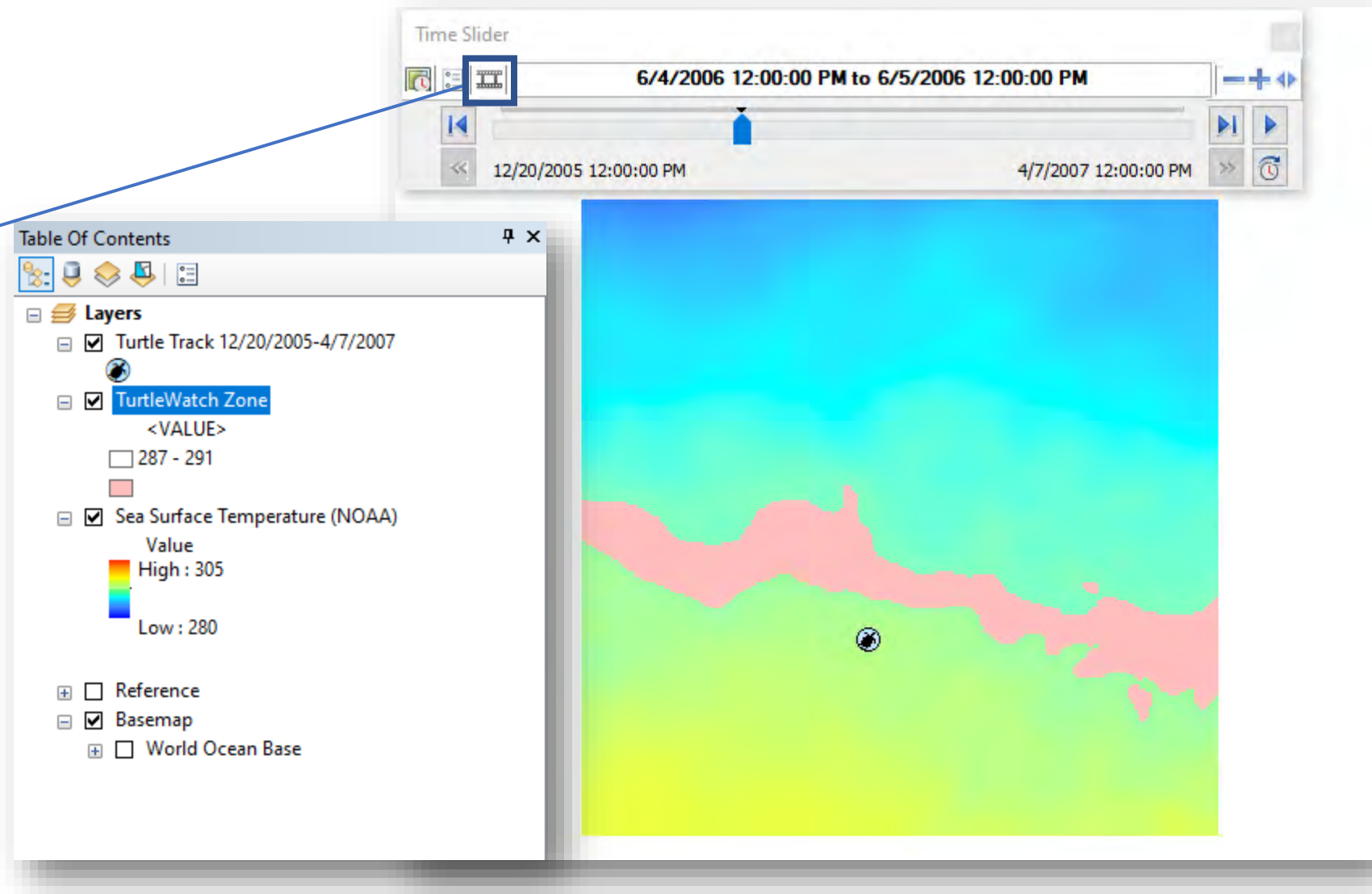


- If layers do not display, check:
 - Time Zone
 - Step Interval
 - Time Window
- When the Feature data were added, the time defaulted to MM/DD/YYYY **00:00 AM**, so the *time window* must be set to allow display of both the Raster and Points Layers



Output 4: Export Movie showing Turtle, Parameter, TurtleWatch Zone

- Save your work!
- Use the Time Slider to save the movie
- Select a codec



Other considerations

- Time: Consider adding a default time to the Turtle Points
- Units: Kelvin is not usually easily related to when communicating temperature. Use the appropriate units to communicate your results. The *Map Algebra->Raster Calculator* or *Math->Minus* tools can be used to convert the Raster data to either degrees Celsius or Fahrenheit.
- Sampling: Often, tools can accept multiple raster layers to sample. If you have a few raster datasets, try loading each time slice as a separate layer. You could also do this with multiple parameters.

End of Exercise

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



Extra Slides on the EDC Tool



EDC Environmental Data Connector

Browse Log

☐ Catalog URL: https://coastwatch.noaa.gov/thredds/socd/coastwatch/catalog_olci_s3b_hires_sector_chlora_daily.xml Connect

☐ Direct Access URL: <https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdQMwind1day> Connect

☐ Sensor Obs Service: <https://sdf.ndbc.noaa.gov/sos/server.php> Connect

☒ ERDDAP Server: <https://oceanwatch.pifsc.noaa.gov/erddap/> Connect

Search Datasets:

Dataset Listing

- Sea Surface Salinity, Aquarius - Weekly, 2011-2015
- Sea Surface Salinity, Miras SMOS - 3-Day, 2010-present
- Sea Surface Salinity, Miras SMOS - Daily, 2010-present
- Sea Surface Salinity, SMAP - Daily, 2015-present
- Sea Surface Temperature Anomaly, Coral Reef Watch, CoralTemp - Daily, 1985-present
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - 8-day, 1985-present
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Cumulative Mean 1985-2018
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Cumulative Mean 1985-2018
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Cumulative Mean 2009-2018
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Cumulative Mean 2019
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Daily, 1985-present
- Sea Surface Temperature, Coral Reef Watch, CoralTemp - Monthly, 1985-present
- Sea Surface Temperature, NOAA geopolar blended - 8-day, 2002-Present (2017 Reanalysis)
- Sea Surface Temperature, NOAA geopolar blended - Cumulative mean 2003-2017 (2017 Reanalysis)
- Sea Surface Temperature, NOAA geopolar blended - Daily, 2002-Present (2017 Reanalysis)**
- Sea Surface Temperature, NOAA geopolar blended - Monthly, 2002-Present (2017 Reanalysis)
- Sea Surface Temperature, Pathfinder Ver 5.3, Night - 8-Day, 1981-2018
- Sea Surface Temperature, Pathfinder Ver 5.3, Night - Monthly, 1981-2018
- Sea Surface Temperature, Pathfinder Ver 5.3, Night, Cumulative Mean, 1982-2017
- Sea Surface Temperature, Pathfinder Ver 5.3, Night, Cumulative Mean, 2018
- ZZZ - DEPRECATED - Chlorophyll a concentration, ESA OC CCI - 8-day, 1997-2018, v3
- ZZZ - DEPRECATED - Chlorophyll a concentration, ESA OC CCI - 8-Day, 1997-2018, v4
- ZZZ - DEPRECATED - Chlorophyll a concentration, ESA OC CCI - Cumulative Mean, 1997-2018, v3
- ZZZ - DEPRECATED - Chlorophyll a concentration, ESA OC CCI - Cumulative Mean, 2018, v3
- ZZZ - DEPRECATED - Chlorophyll a concentration, ESA OC CCI - Cumulative Mean, 2018, v4

Dataset Info

Title: Sea Surface Temperature, NOAA geopolar blended - Daily, 2002-Present (2017 Reanalysis)

Dataset ID: goes-poes-1d-ghrsst-RAN

Institution: Office of Satellite Products and Operations

Background Info: https://podaac.jpl.nasa.gov/dataset/Geo_Polar_Blended_Night-OSPO-L4-GLOB-v1.0

Summary: Analyzed blended sea surface temperature over the global ocean using night only input data. An SST estimation scheme which combines multi-satellite retrievals of sea surface temperature datasets available from polar orbiters, geostationary InfraRed (IR) and microwave sensors into a single global analysis. This global SST analysis provides a daily gap-free map of the foundation sea surface temperature at 0.05° spatial resolution. cdm_data_type = Grid VARIABLES (all of which use the dimensions [time][latitude][longitude]): 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)

ERDDAP Provided Web Services:



WMS GetCapabilities: <https://oceanwatch.pifsc.noaa.gov/erddap/wms/goes-poes-1d-ghrsst-RAN/request>

DataAccess Web Form: <https://oceanwatch.pifsc.noaa.gov/erddap/griddap/goes-poes-1d-ghrsst-RAN.html>

Graphing Web Form: <https://oceanwatch.pifsc.noaa.gov/erddap/griddap/goes-poes-1d-ghrsst-RAN.graph>

EDC Processing: Griddap Tabledap

Connected... <https://oceanwatch.pifsc.noaa.gov/erddap/>



EDC Track Line Format

- **Track Line Format**

- A track line file must be a comma-separated text file. Each line in the text file contains a new point along the track line. Each point can have its own time extent. Each line can have the following fields, in this order:

- 1. Latitude – in decimal degrees
- 2. Longitude – in decimal degrees
- 3. Altitude – in meters (can be 0 if not using altitude)
- 4. Start Time – the beginning of the time range for data to be selected (**optional**)
- 5. Stop Time – the end of the time range for data to be selected (**optional**)

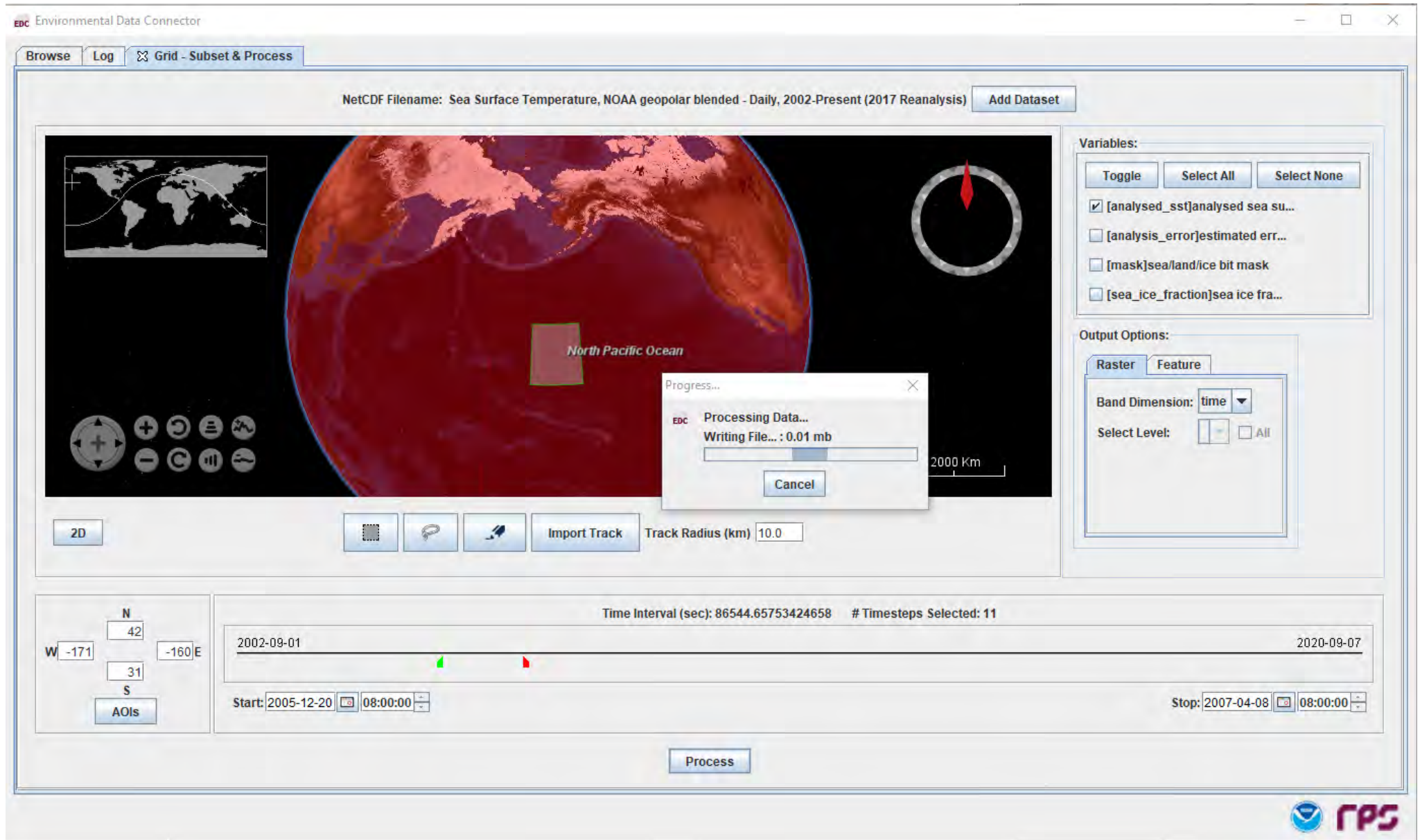
- Here is an example of a track line file:

```
27.8036,-119.8914,0,2013-03-15T14:40Z,2013-13-15T14:40Z
28.7866,-117.9850,0,2012-03-15T14:40Z,2012-13-15T14:40Z
36.3951,-123.6461,0,2011-03-15T14:40Z,2011-13-15T14:40Z
35.2628,-125.9477,0,2010-03-15T14:40Z,2010-13-15T14:40Z
33.2628,-124.3501,0,2009-03-15T14:40Z,2009-13-15T14:40Z
```

- Spreadsheet

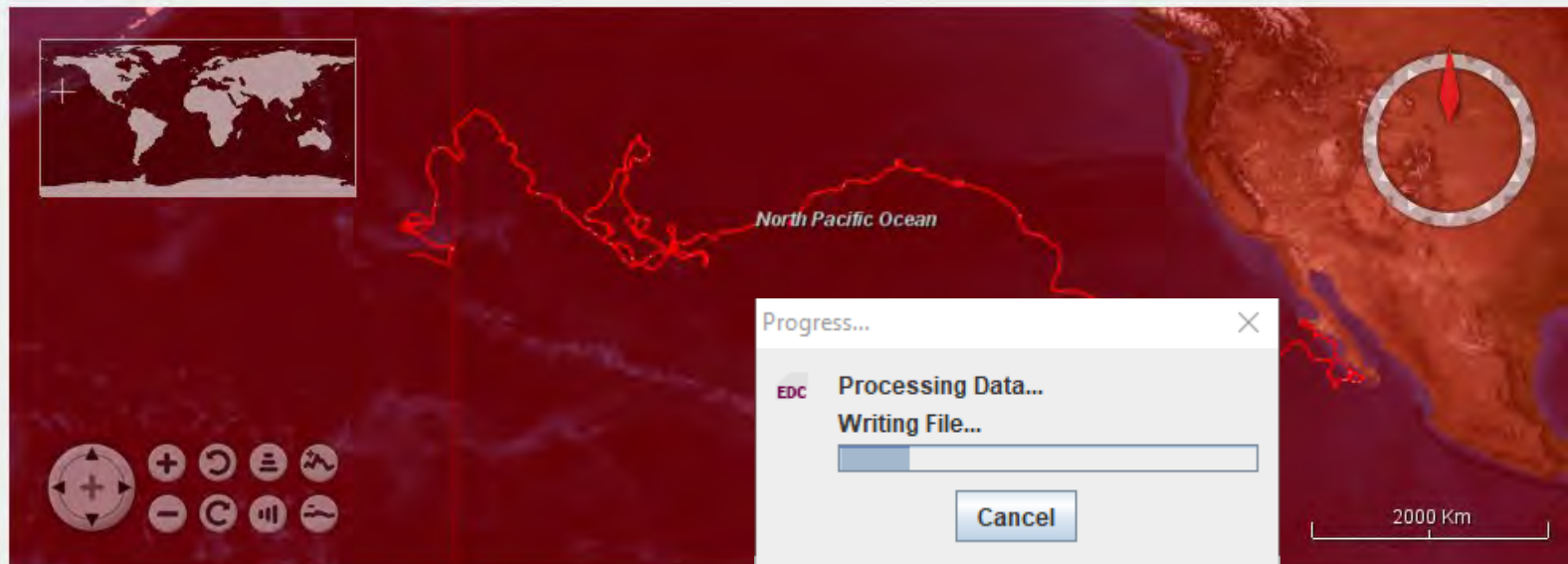
- Convert 0-360 to -180 to 180 (=if(B2>=180,B2-360,B2))
- Convert Year,Month,Day columns to single date (=Date(B3,B4,B5))
- Set Date format to custom (yyyy-mm-ddT12:00Z) (=TEXT(A1,"mm/dd/yyyy")
=CONCATENATE(F2,\$J\$2)





NetCDF Filename: Sea Surface Temperature, NOAA geopolar blended - Daily, 2002-Present (2017 Reanalysis)

Add Dataset



Variables:

Toggle

Select All

Select None

☒ [analysed_sst]analysed sea su...☐ [analysis_error]estimated err...☐ [mask]sea/land/ice bit mask☐ [sea_ice_fraction]sea ice fra...

Output Options:

Raster

Feature

Band Dimension: time

Select Level: ☐ All

3D

Import Track

Track Radius (km)

5

N
32.70
W 175.5 175.6 E
32.65
S
AOIs

Time Interval (sec): 86544.83389210606 # Timesteps Selected: 11

Temporal Constraints Set Via Track Import

Start: 2020-08-20 08:00:00

Stop: 2020-08-30 08:00:00

Process

<https://oceanwatch.pifsc.noaa.gov/erddap/griddap/goes-poes-1d-ghrsst-RAN.html>

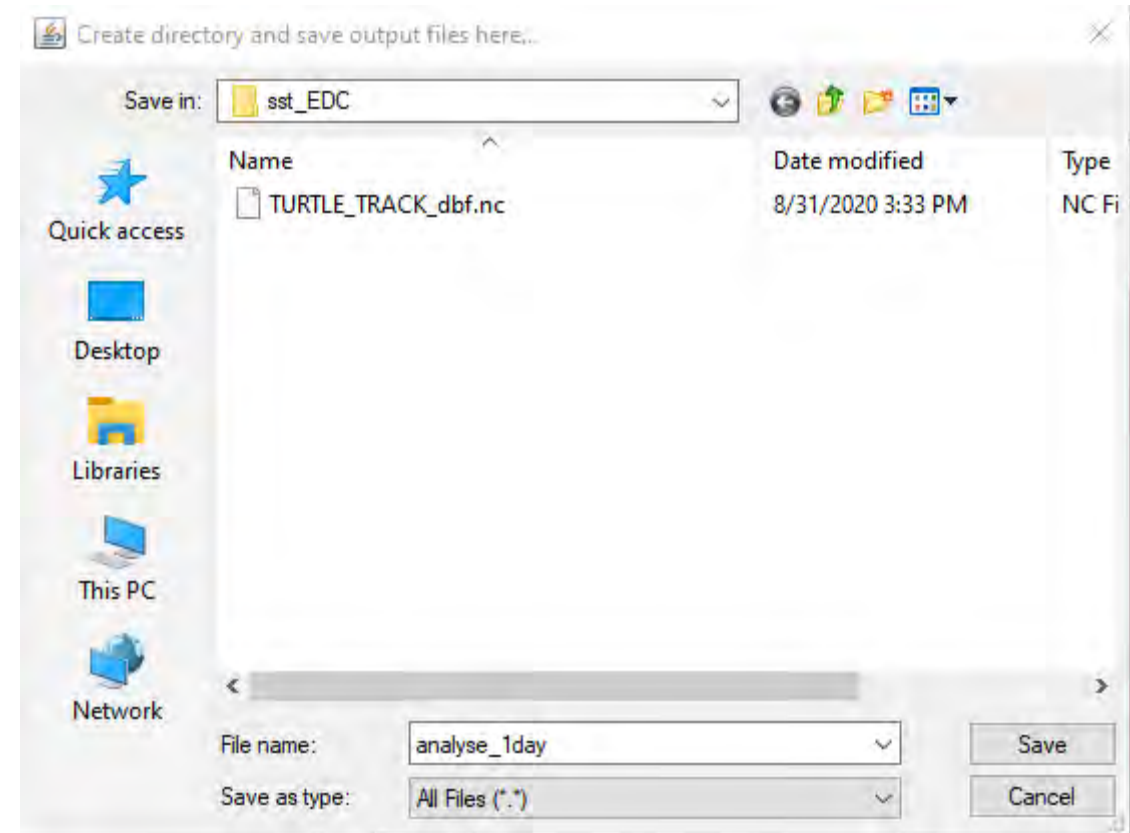


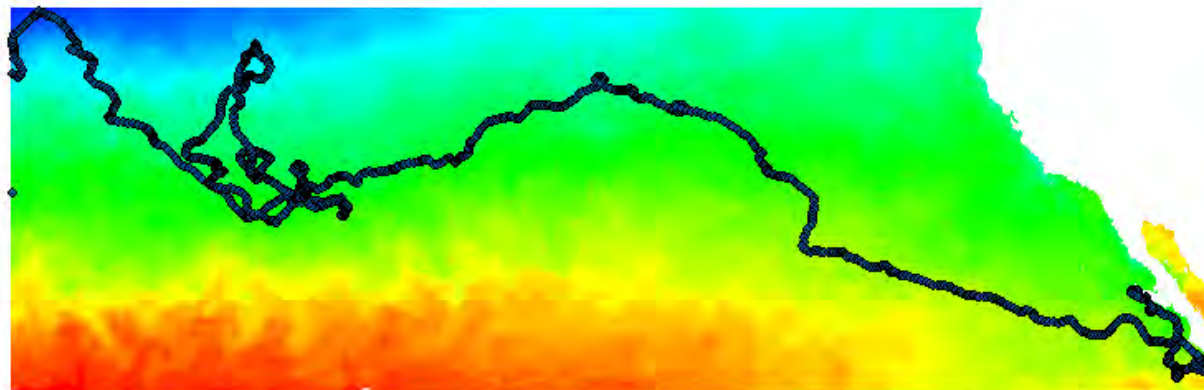
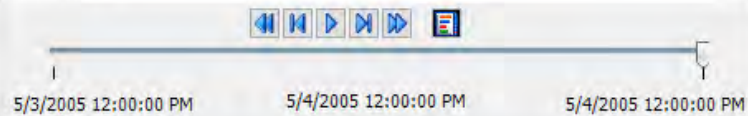
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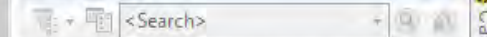
Layers

- ☒ XY25317_05_TURTLE_TRACK_2
 - ☒ analyse_1d
 - ☐ analyse_1d (Legend)
 - Value
 - High : 299.47
 - Low : 278.34
- ☐ 25317_05_TURTLE_TRACK.csv Events

Time Slider



Create Features



There are no templates to show.

Construction Tools

Select a template.