



This Presentation has no audio



Using Satellite Data in GIS

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ArcGIS_ArcProv3_Training2023_General_EXERCISE_r1.pptx

Versioning:

2022, Soracco, , ArcGIS Pro 3.0

2022, Soracco, ArcMap 10.8.1

2020, Soracco, ArcMap 10.7



CoastWatch Training, 2023, Virtual Class

This Training

- Component of the *NOAA CoastWatch Satellite Training Course*
- Comprised of 3 modules: Data, Tools, Exercise(s)
- Uses ESRI ArcGIS Pro, but techniques work with QGIS and other GIS software [Spatial Analyst or Image Analyst extension required to access Sample tool]
- Updated from CoastWatch Satellite GIS training originally given in 2000 for avenue-based ArcView 3.1 and in 2022 form ArcMap 10.8.1

A few notes on ArcMap/ArcGIS for NOAA Users



- The version of ArcGIS Pro used in this exercise is v3.0.2
- The Environmental Data Connector (EDC) has been deprecated and removed from this training
- ArcMap 10.8.1 was the final release of ArcMap and all future development is in 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.



Using Satellite Data in GIS: Exercise

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2020, Soracco, ArcMap 10.7

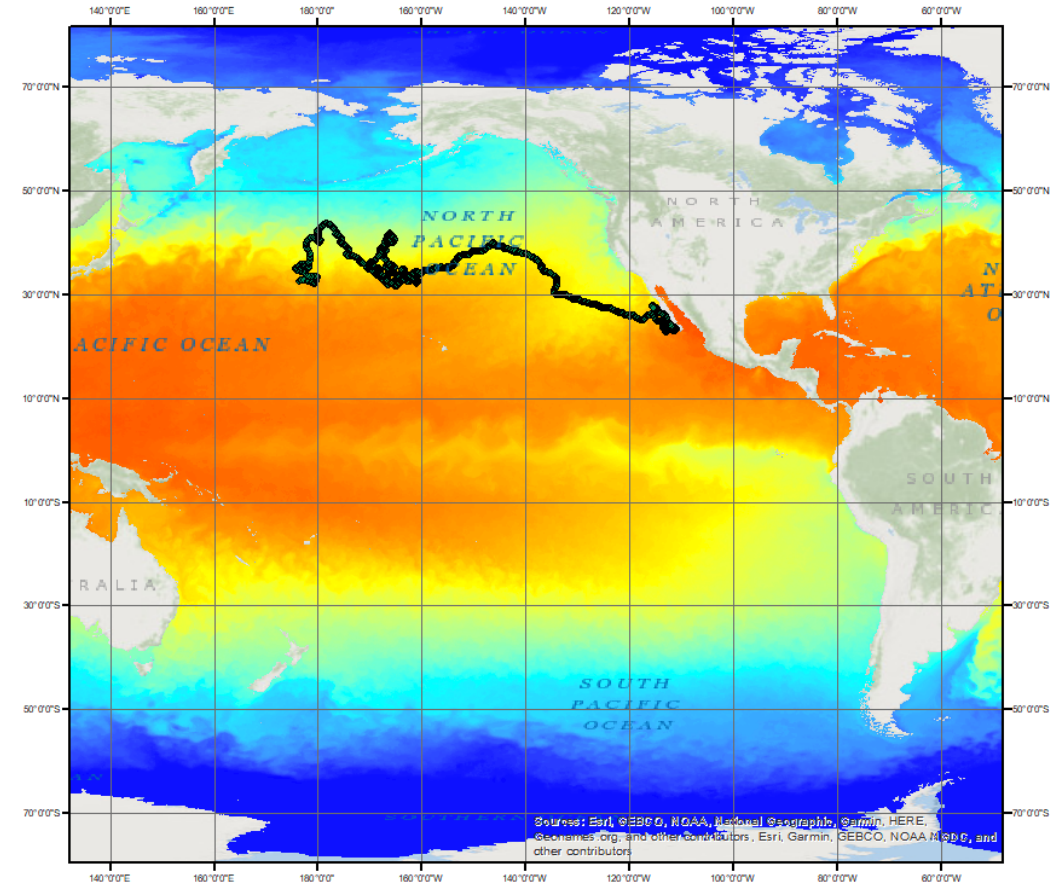


Exercise Background

- 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



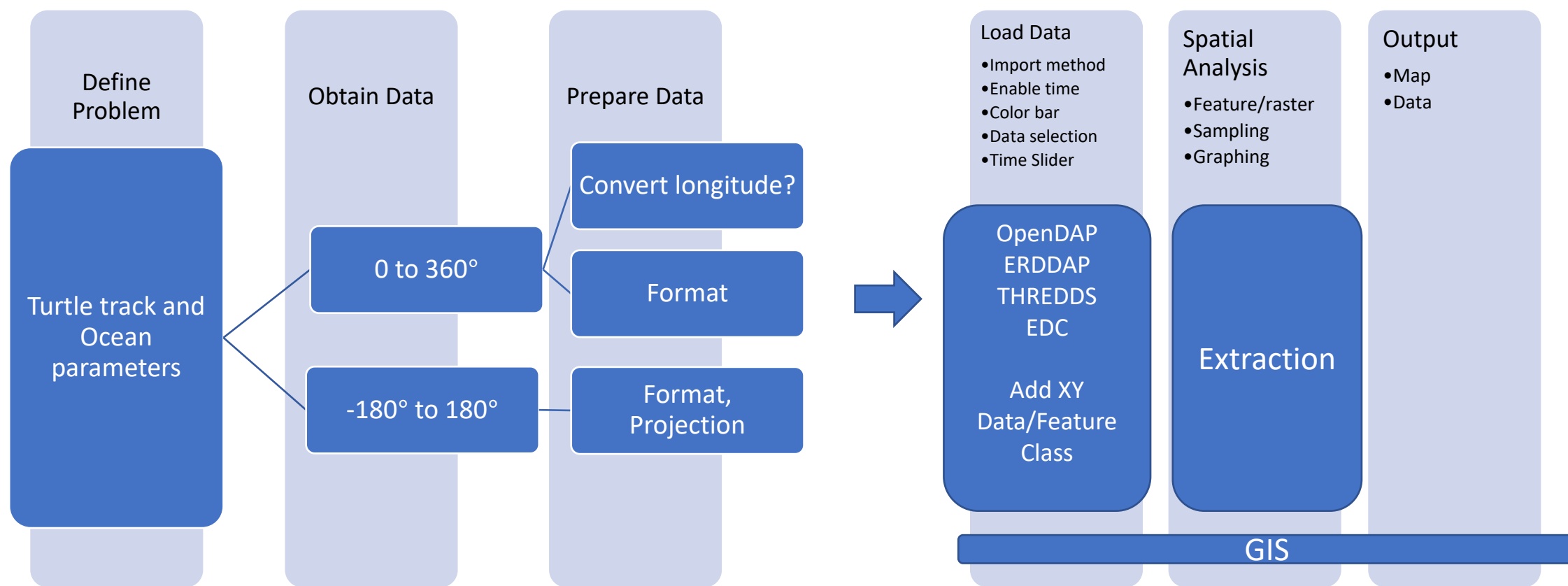
Multi-year turtle track atop single SST image

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

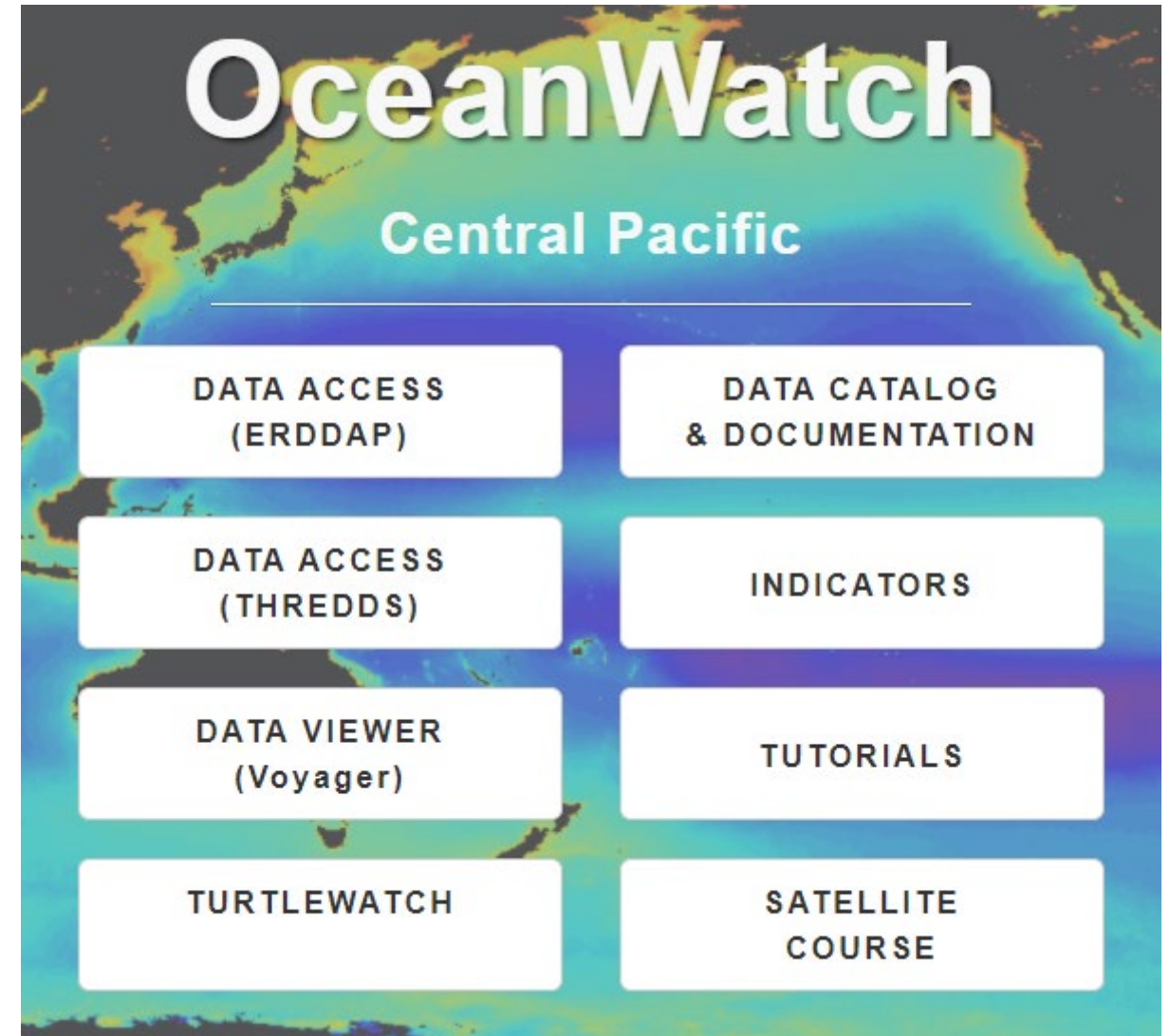
- Perform matchup of turtle locations with parameters
 - Import Turtle CSV:
 - https://oceanwatch.pifsc.noaa.gov/files/25317_05.dat
 - Convert to Feature Layer / Shapefile
- Obtain SST satellite data for geographic coverage and period of study
- Outputs:
 1. Overview map – example day of parameter and 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

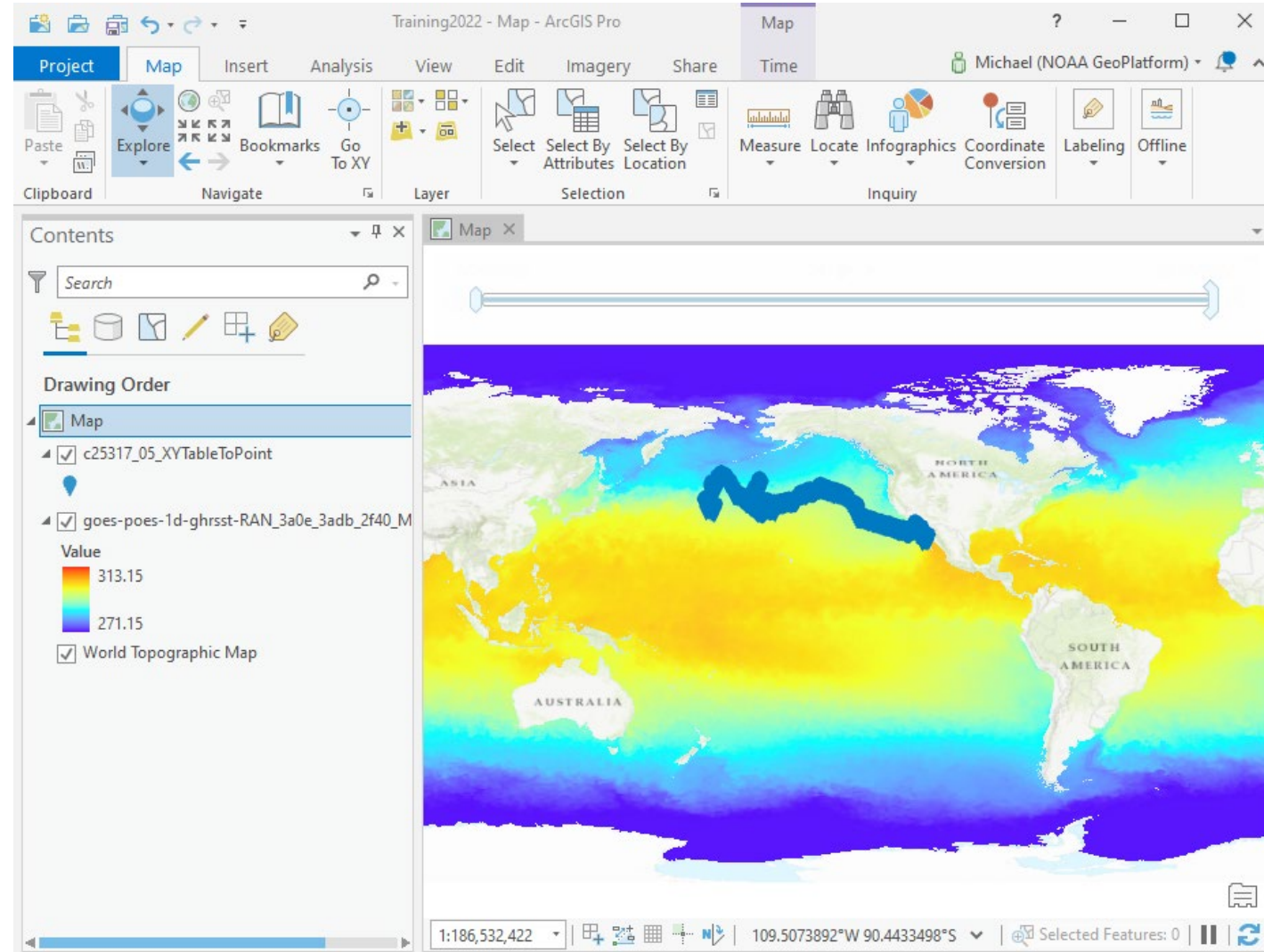
Output 1: Overview Map

- 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
 - NetCDF format
 - ERDDAP [Link](#)



Output 1: Overview Map

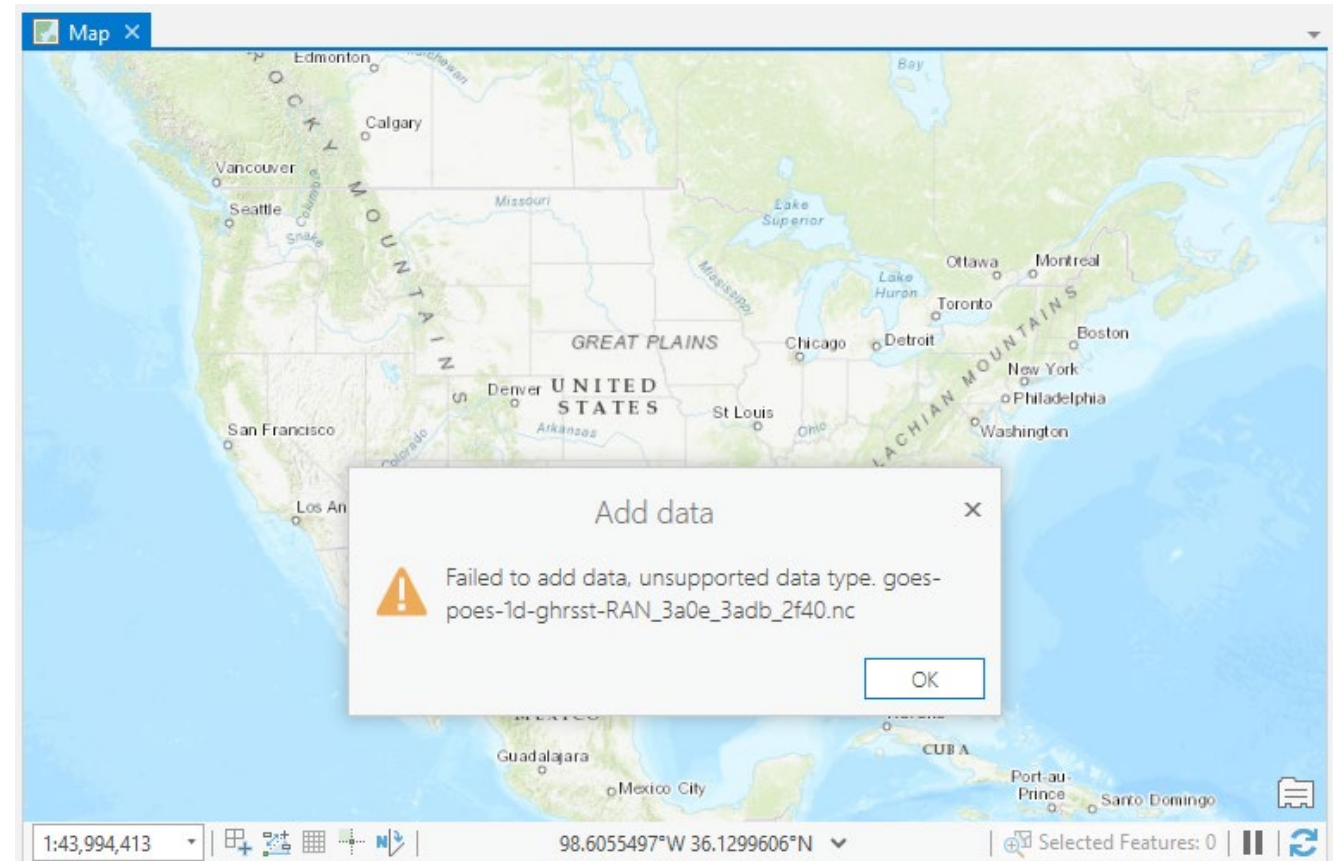
- Obtain Turtle Track
 - Data [Link](#)
 - Save As: 25317_05.dat.csv



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

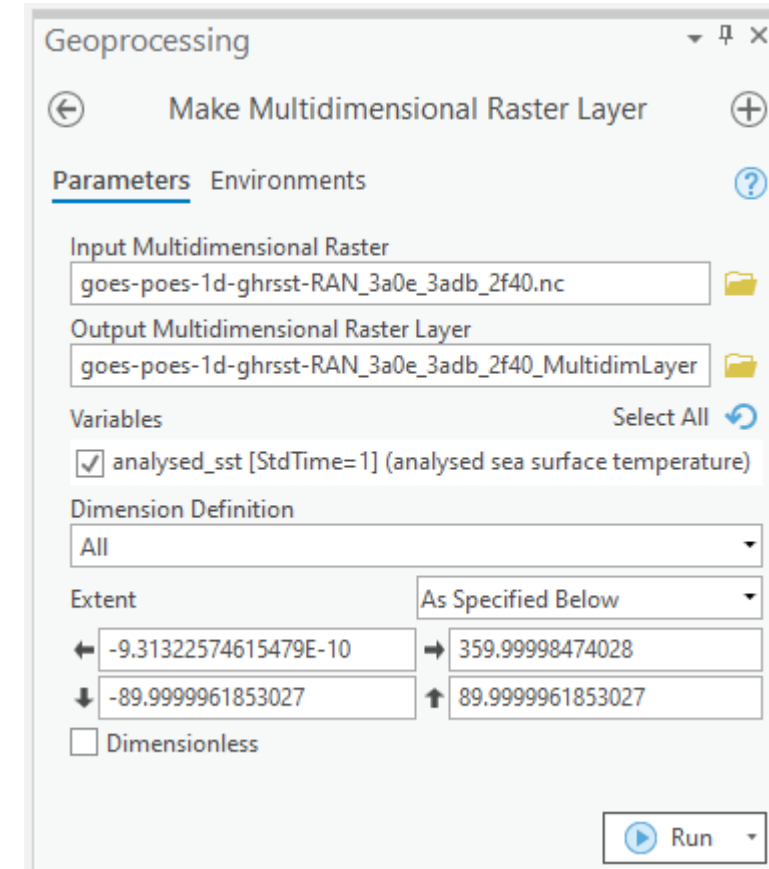
Output 1: Overview Map

- Open ArcGIS Pro to Blank Map
- Drag-and-Drop the NetCDF file onto the View
- Data may not load



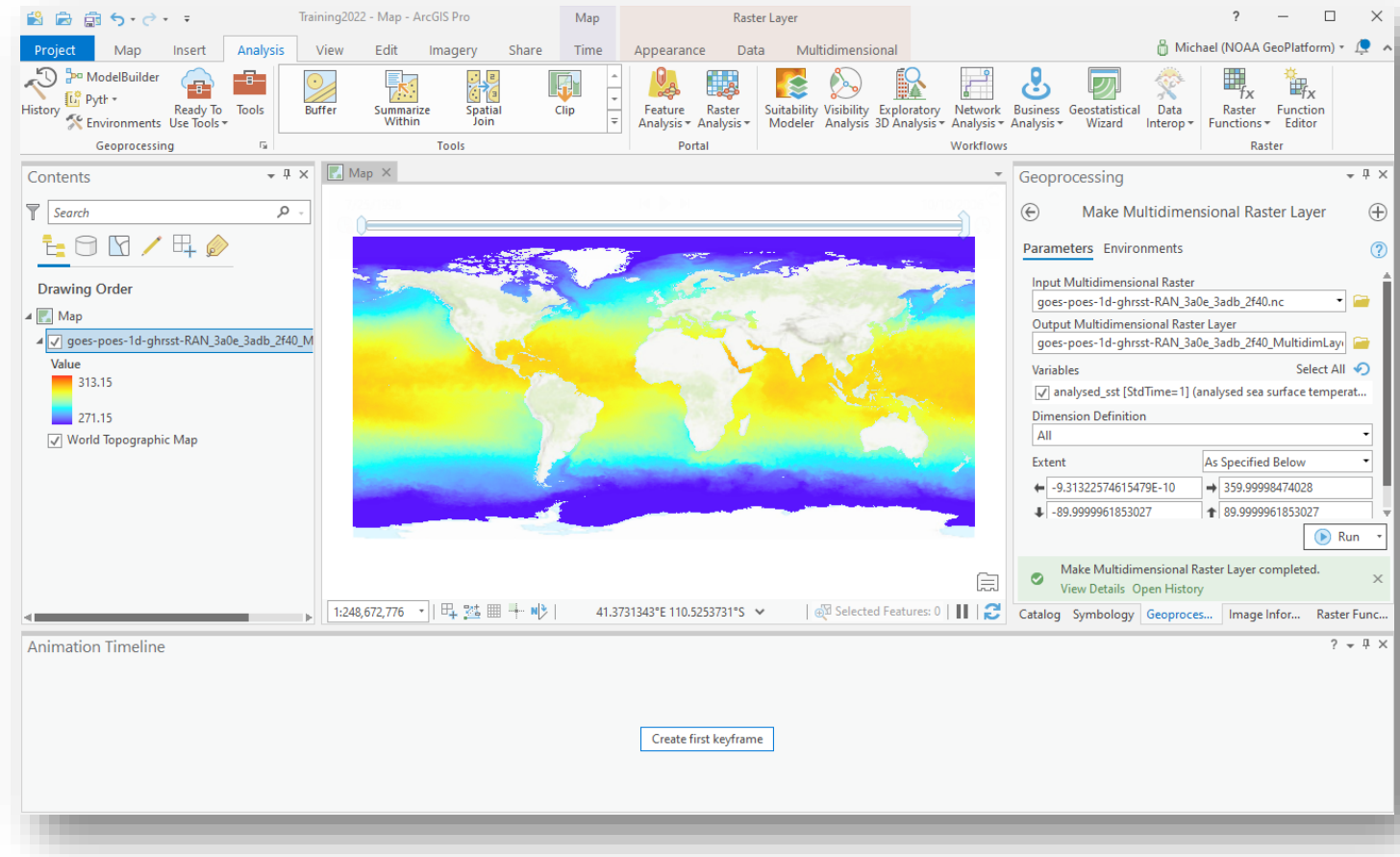
Output 1: Overview Map

- Use Tools (tool via Add Data or Toolbox)
- “Make Multidimensional Raster Layer”
- Click ‘Run’



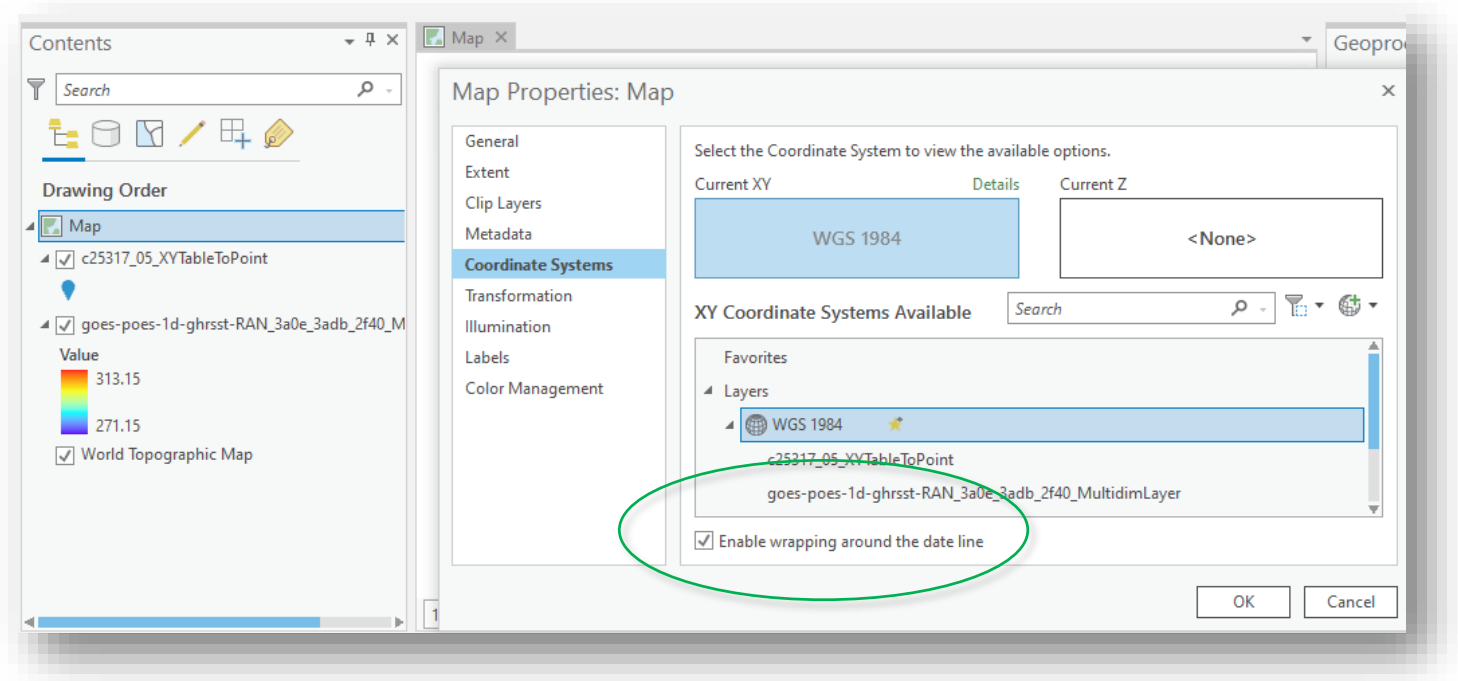
Output 1: Overview Map

- Data displays
- Does not appear 0-360



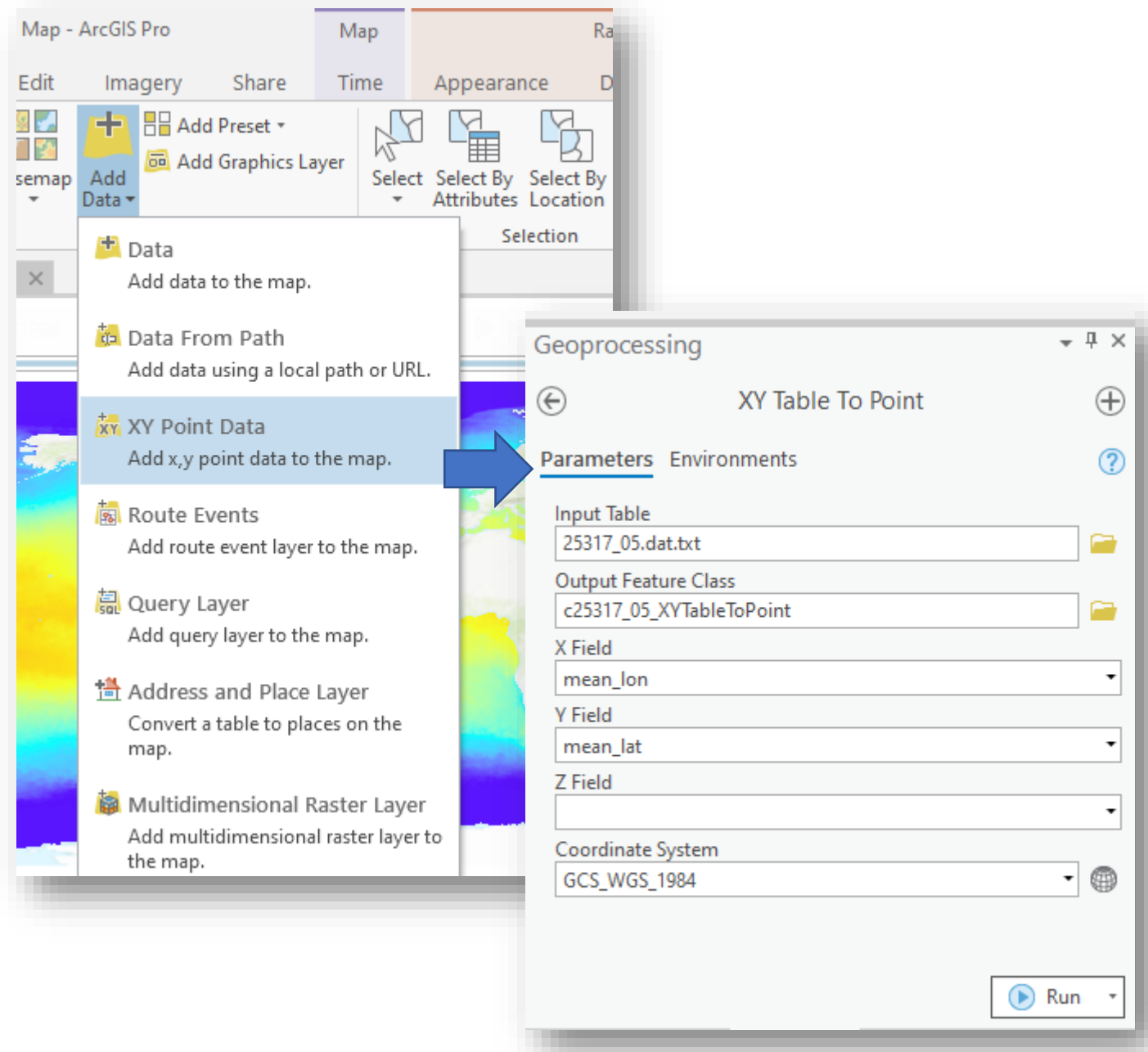
Output 1: Overview Map

- Modify “Map Properties”
 - <right click>
- Set Coordinate Systems to “Enable wrapping around the date line”
- Click ‘Ok’



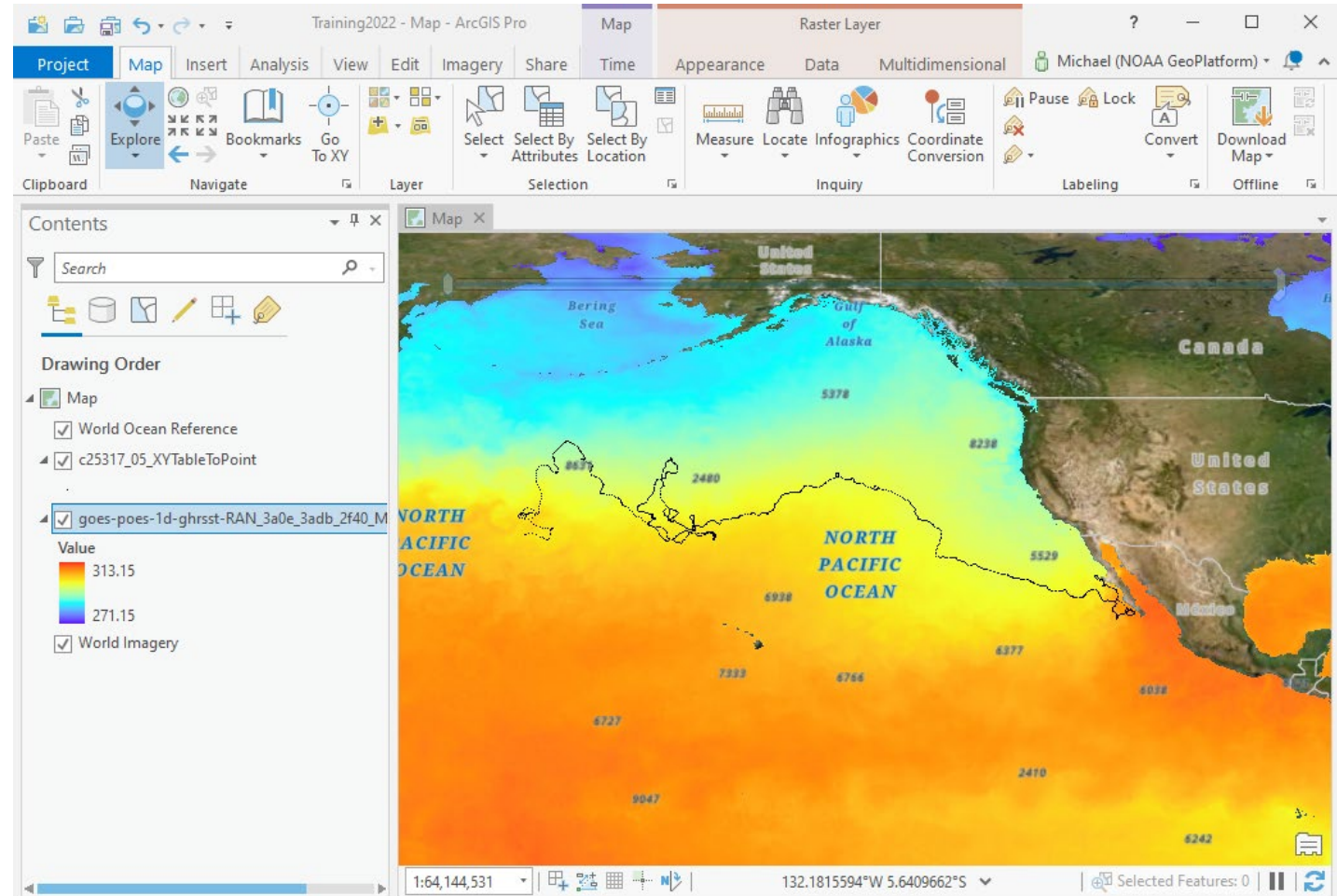
Output 1: Overview Map

- Add XY Point Data to import Turtle Track
- Confirm the X and Y Fields



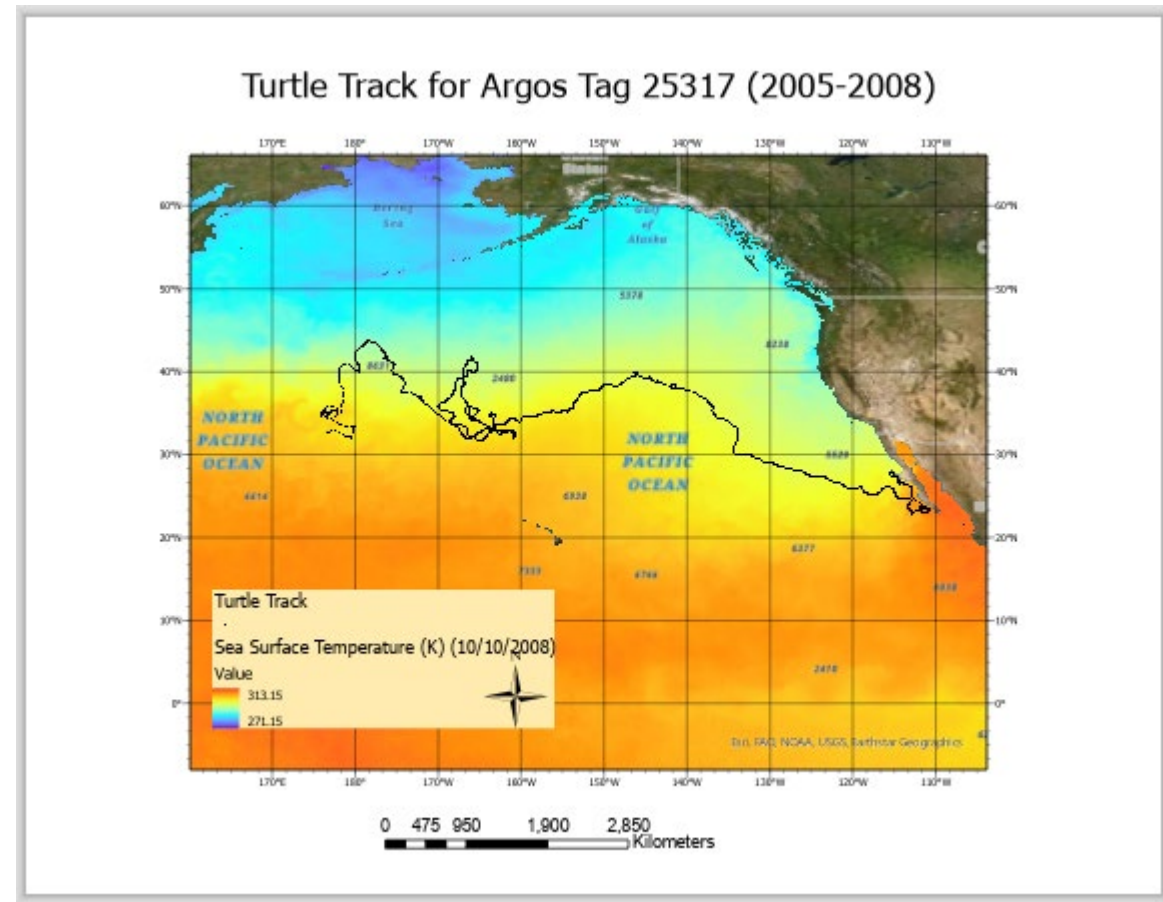
Output 1: Overview Map

- 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

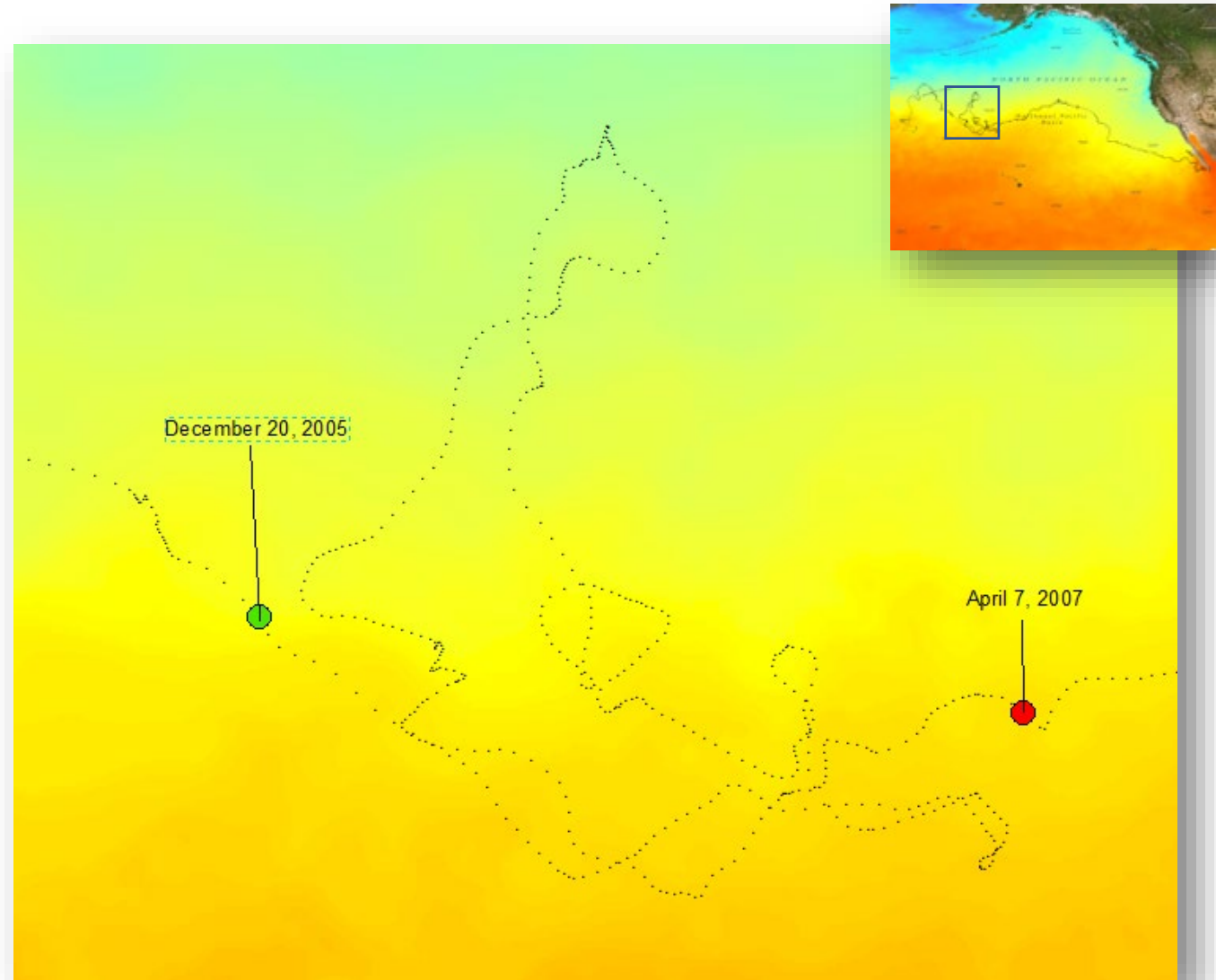


Overview Map -- Observations

- Data is displayed across the Dateline when 'Enable wrapping' is checked
- Loading X-Y Data created a table for display only (not queryable/selectable)
- Drag-and-drop may not work
- 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.)

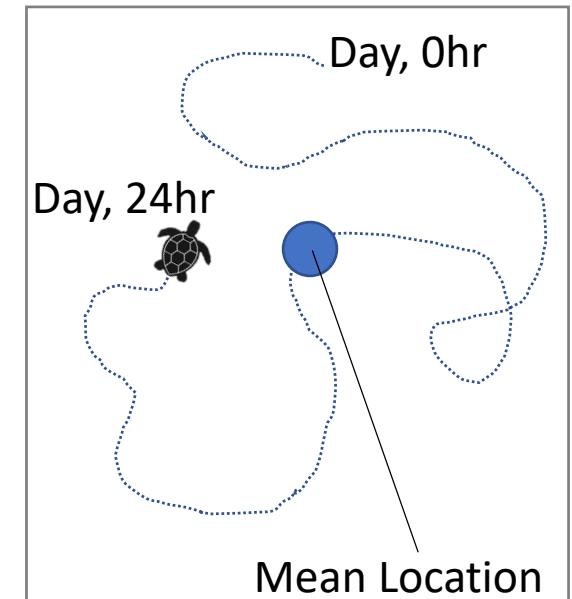
- Headers: "mean_lon", "mean_lat", "year", "month", "day"

- 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 **'=A2-360'**
- 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/BlendedSST5kmNightAggGHRSTSTARLoM?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 east -160

south
31

☒ 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)

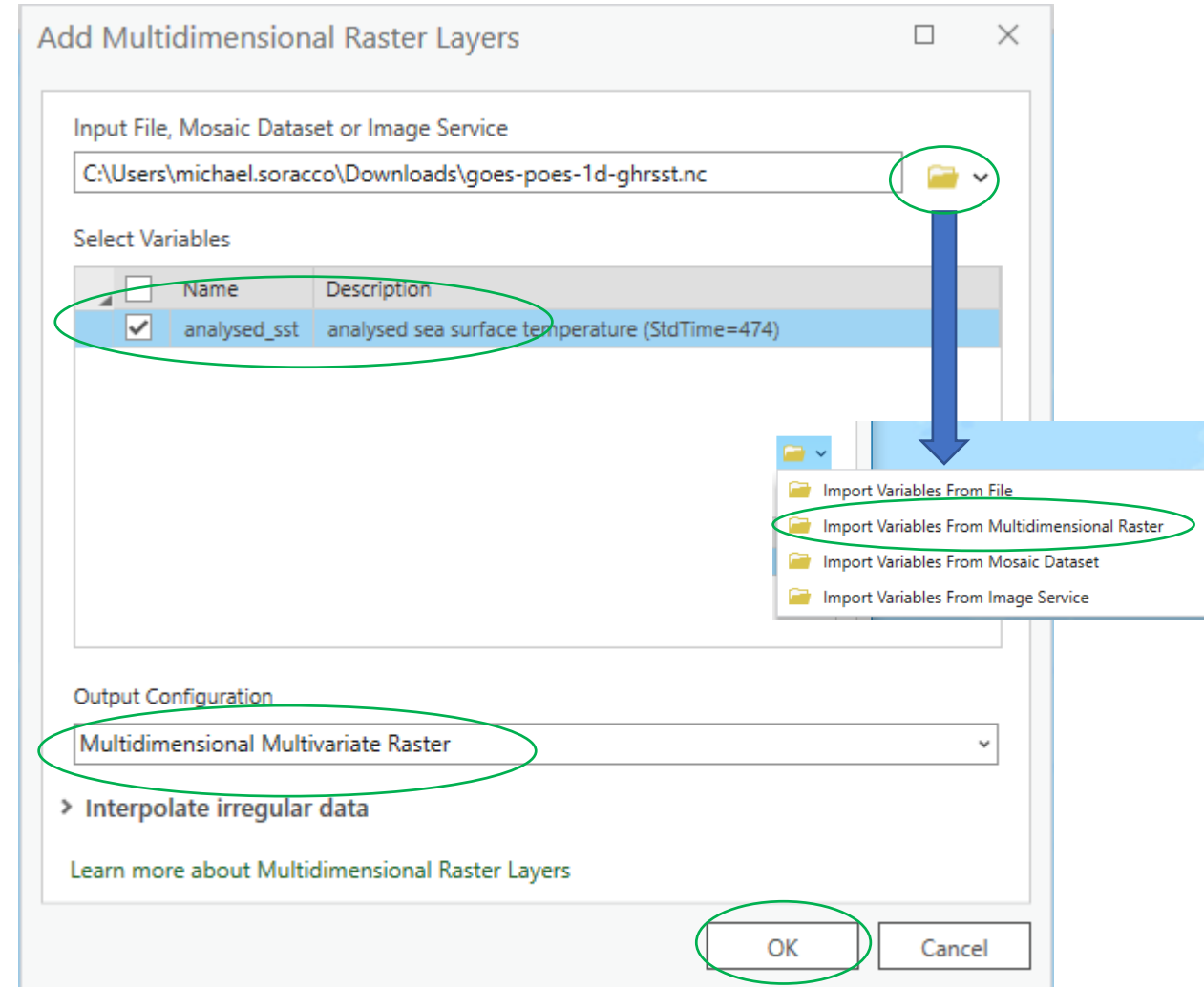
☒ Add Lat/Lon variables

Choose Output Format:

Format: netcdf ▼

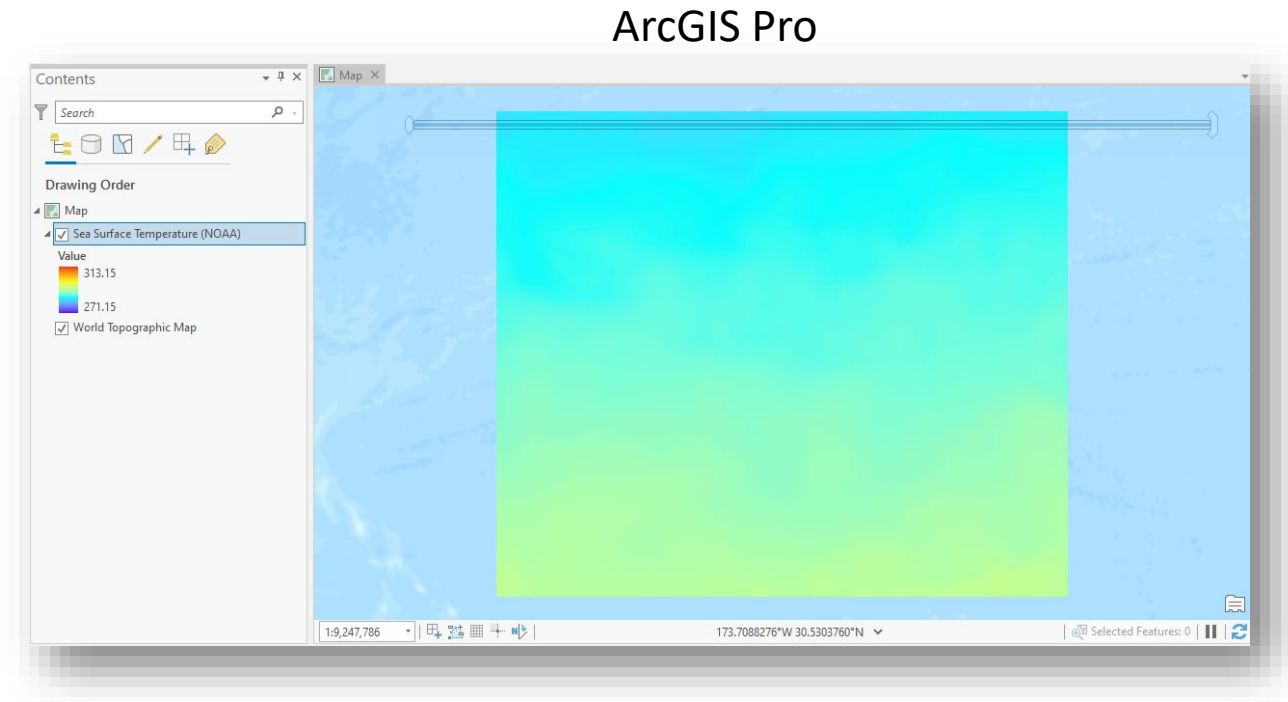
Loading Satellite Data

- Open ArcGIS to Blank Map
- ArcGIS Pro: Add Data
 - Add Multidimensional Raster Layers
- Set the Input netCDF file
- Select Variable: analysed_sst
- Set Output Configuration to:
 - ArcPro 3.0+: Multidimensional Multivariate Raster
 - ArcPro < 3.0: Classic NetCDF Raster
 - This allows the time dimension to be keyed to the data variable so when 'Time' is enabled for the layer, it is synced to the time slider



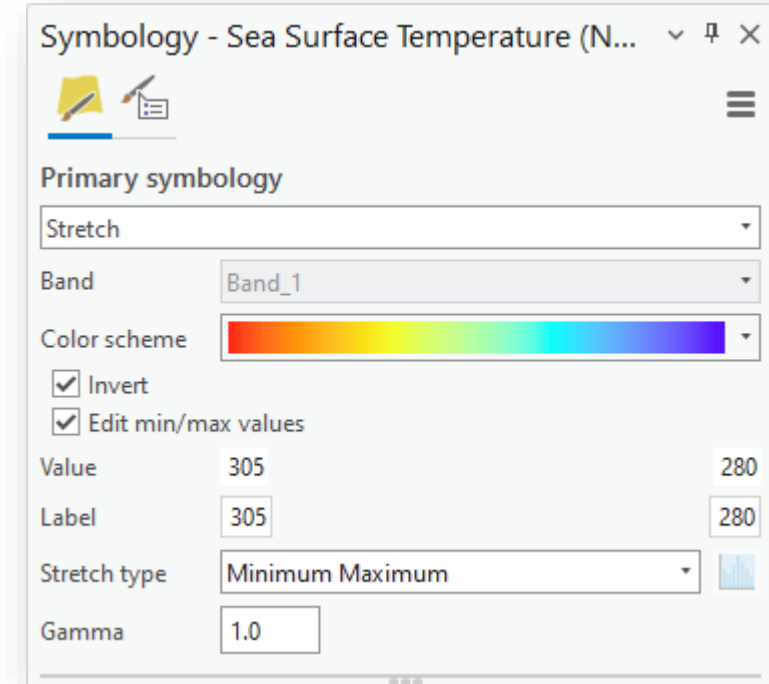
Loading Satellite Data -- Layer Properties – General / Extent

- **Rename:** <right-click, Properties>
 - Layer:
 - Sea Surface Temperature (NOAA)
 - Description
 - Credit
- **Confirm Extent**



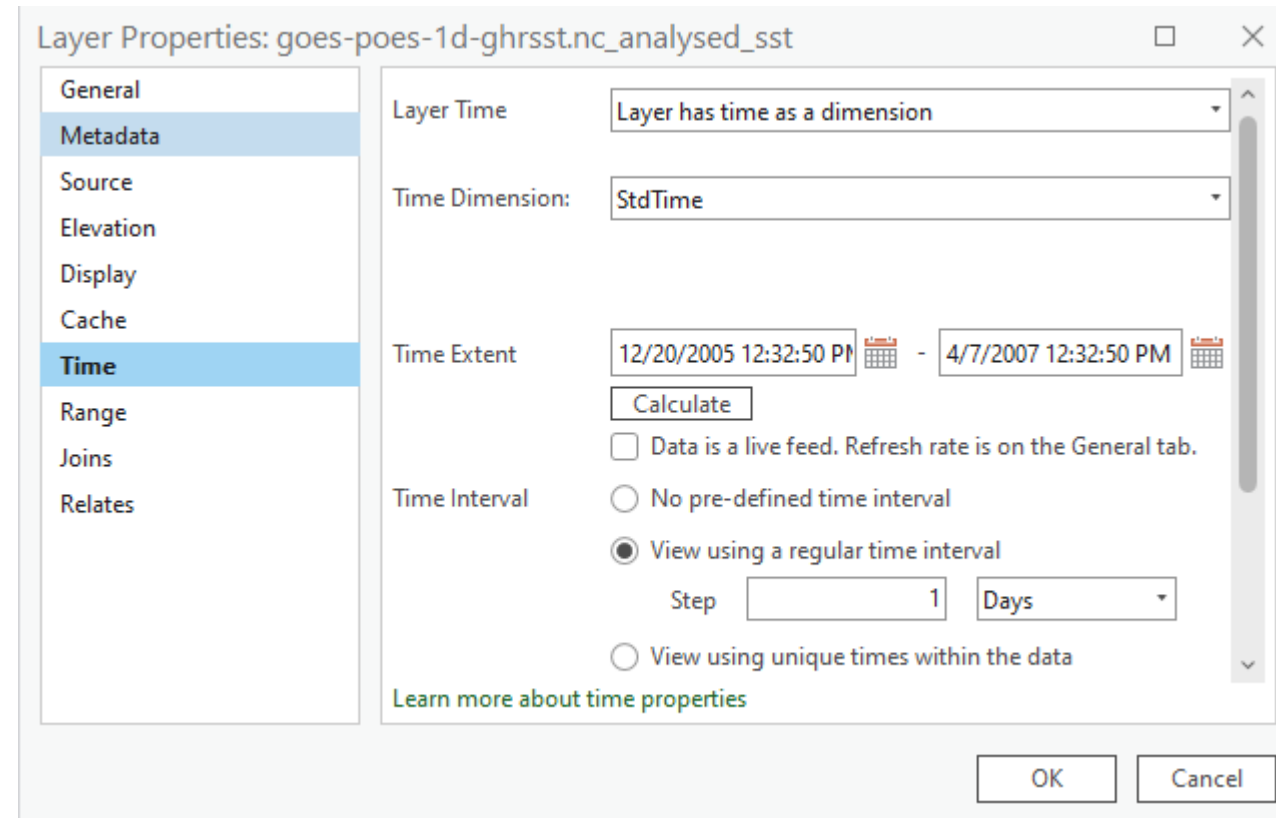
Loading Satellite Data -- Layer Properties -- Symbolology

- *<double-click on raster legend>*
- *Reset* the Stretch type to Minimum-Maximum
- *Reset* the High/Low Values to 280-305
- *Select* a color scheme/palette of choice



Loading Satellite Data -- Layer Properties – Time – ArcGIS Pro

- <right-click, Properties>
- *Confirm* Time on the Layer
- *Set* the Time Dimension to 'stdtime'
- *Set* the Step Interval to '1' Day
- *Set* the Time Zone to UTC
- *Click* 'OK'



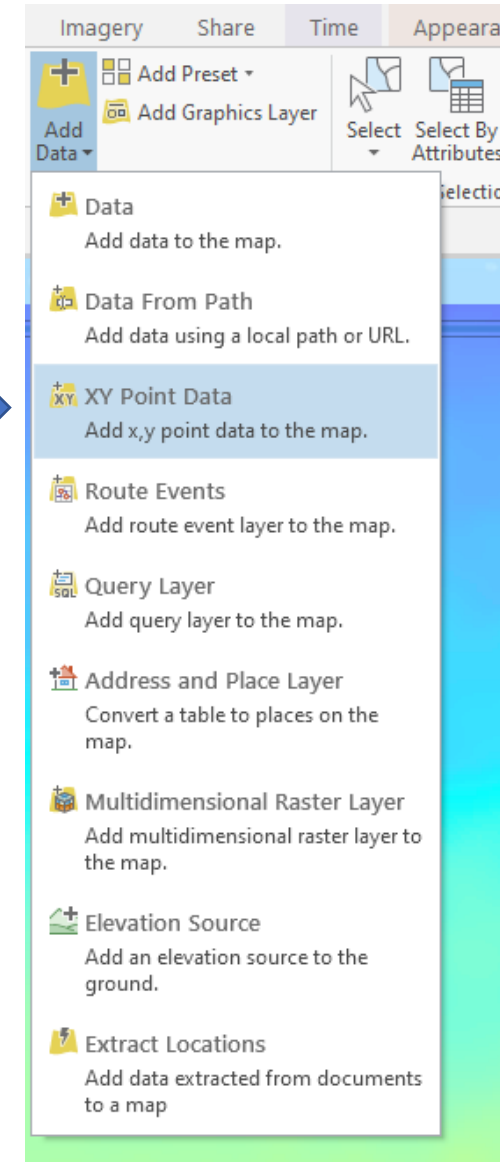
ArcGIS Pro

Loading Data: CSV file

Add XY Data

1. Within ArcGIS Pro

2. *Add Data -> XY Point Data*



Loading Data: CSV file

Add XY Data

1. Set the table to your CSV file
2. Set the X,Y Fields
 1. Longitude and Latitude, where the field names may vary from the diagram
3. Edit and Set the Coordinate System [Global Coordinate System -> WGS1984]
4. Click OK
5. Data are automatically subset to match the NOAA SST extent

lon180 may be your X Field

Geoprocessing

XY Table To Point

Parameters Environments

Input Table
25317_05_modified180.csv

Output Feature Class
c25317_05_modified180/XYTableToPoint

X Field
mean_lon180

Y Field
mean_lat180

Z Field

Coordinate System
GCS_WGS_1984

Run

Geoprocessing

XY Table To Point

Parameters Environments

Output Coordinates
Output Coordinate System
GCS_WGS_1984

Processing Extent

Extent
-172.000006103516
30.9999996141954

As Specified Below

Default
Union of Inputs
Intersection of Inputs
Current Display Extent
As Specified Below
Browse....
Same As layer:
Sea Surface Temperature (NOAA)

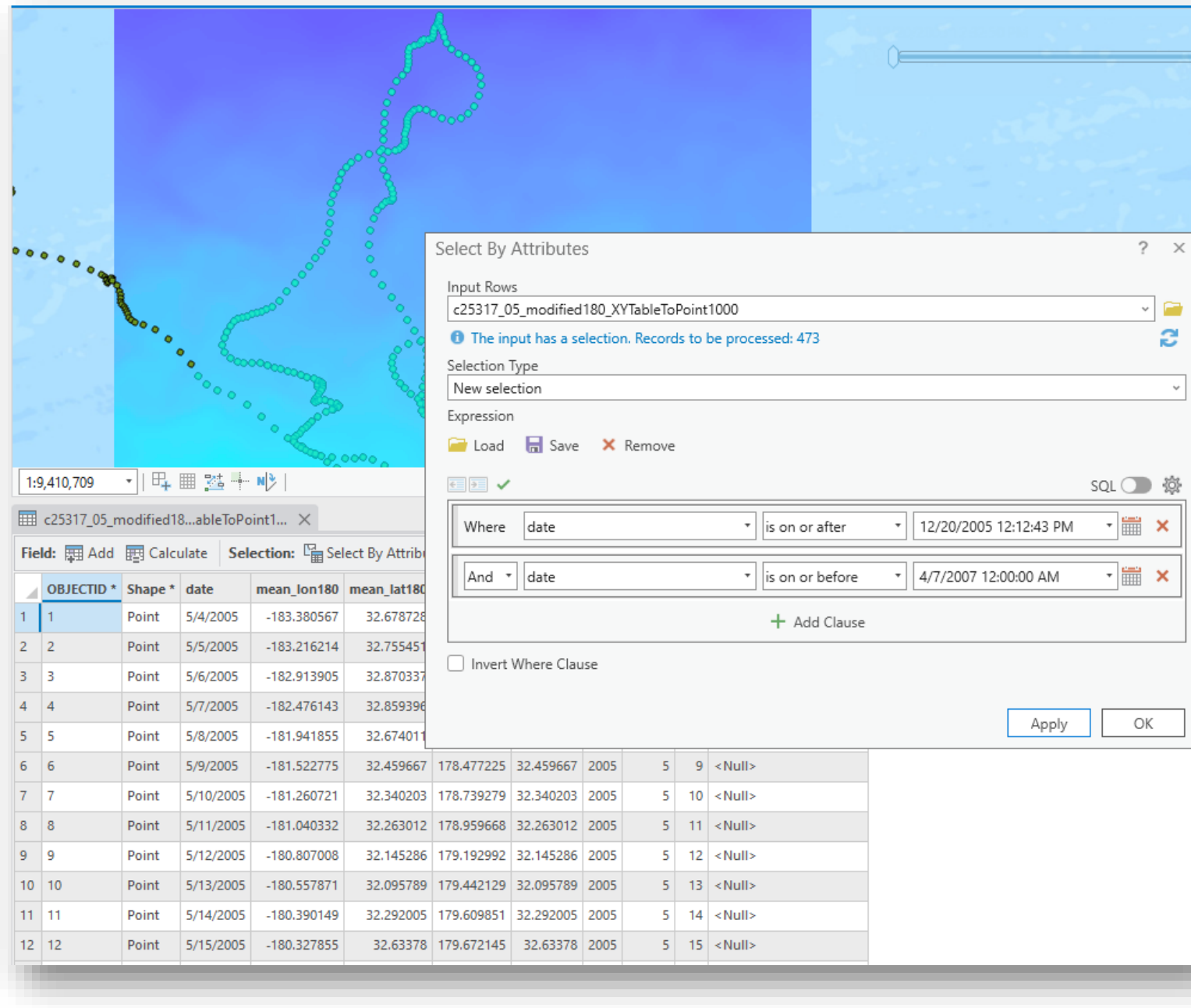
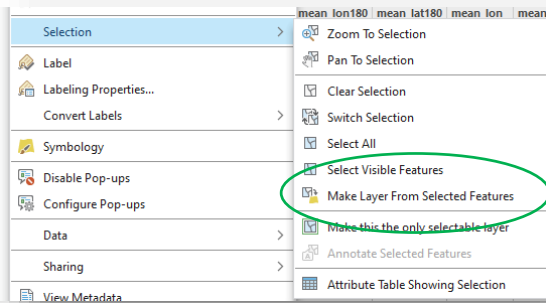
Run

Feature Layer Workflow

- The entire Turtle Track may be loaded (Loading by extent of Raster or Intersection may not always work – are points in 0-360 and raster - 180?)
- 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
- Export data, Add as layer
- Proceed

Loading Data: CSV file

1. Create a selection of only the data matching the SST layer
2. Open Attribute Table for the Feature Layer
3. Select by Attributes
4. Save as Feature Layer



Loading Data: CSV file

Add XY Data

1. Adjust the Track Properties to set Time
2. Setting the clipping extent may or may not work depending on your ArcGIS Pro version.

Layer Properties: Turtle Track

General
Metadata
Source
Elevation
Selection
Display
Cache
Definition Query
Time
Range
Indexes
Joins
Relates
Page Query

Layer Time: Each feature has a single time field

Time Field: date

Time Extent: 5/4/2005 - 9/18/2008
Calculate
☐ Data is a live feed. Refresh rate is on the General tab.

Time Interval:
☐ No pre-defined time interval
☒ View using a regular time interval
Step: 1 Days
☐ View using unique times within the data

Time Zone: (UTC) Coordinated Universal Time
☐ Adjust For Daylight Saving

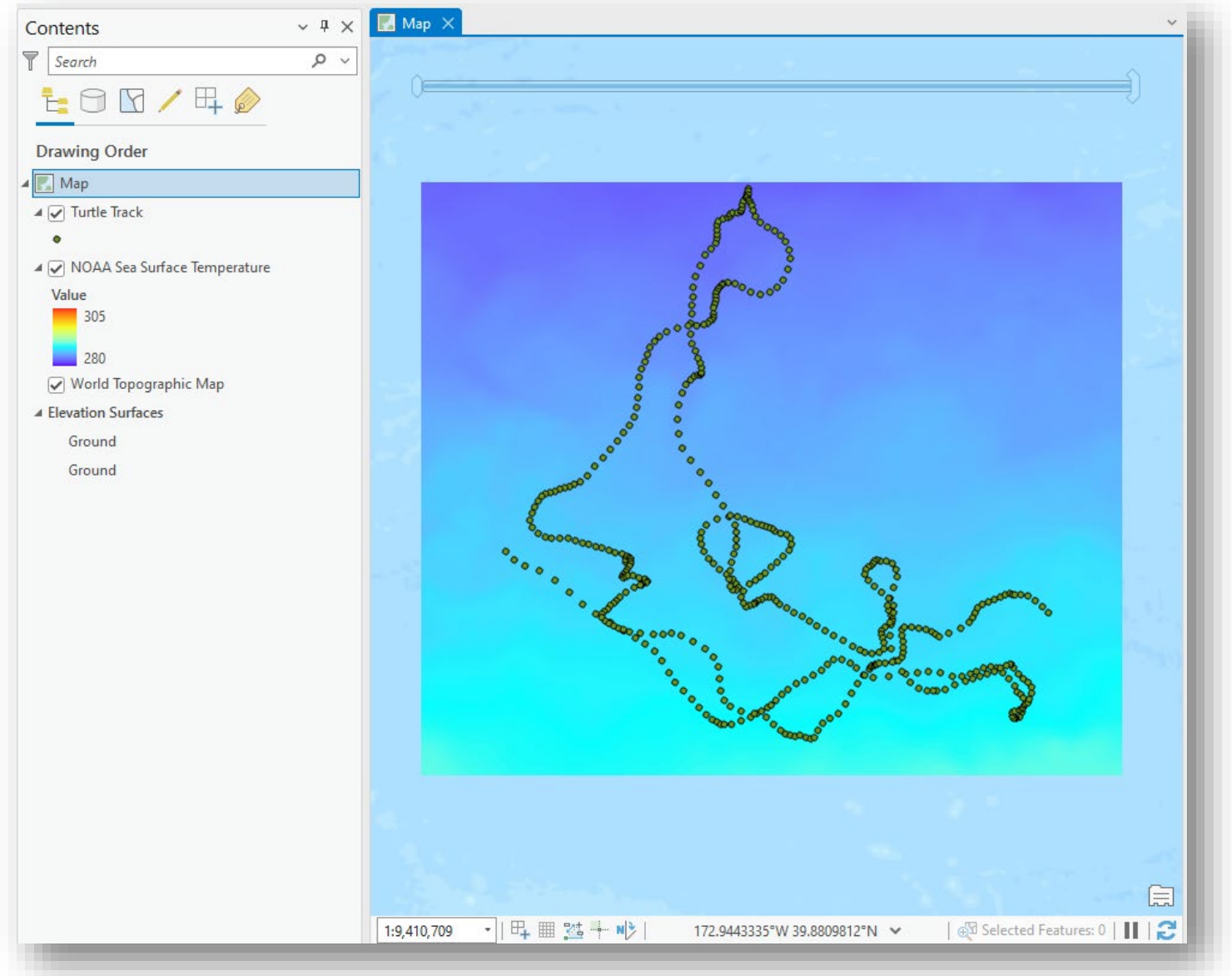
Time Offset: 0 Days

[Learn more about time properties](#)

OK Cancel

XY Data

1. Imported as Feature Class
2. Turtle Tracks in Time Slider
3. When Time Slider is enabled, the corresponding point and satellite data for the selected date will show



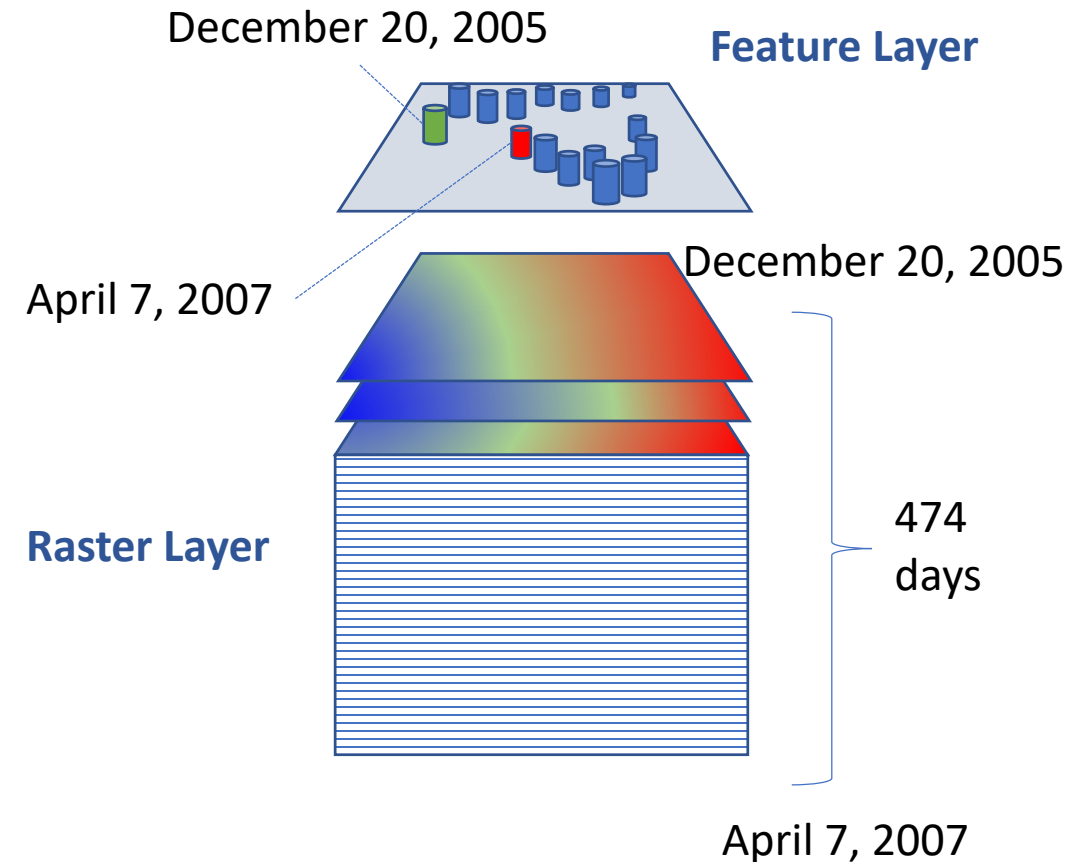
Extracting data from the Raster Layer by using the Feature Layer

- ArcGIS Pro:

- <https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/h-how-sample-works.htm>
- ArcToolbox->Spatial Analyst Tools->Extraction ▶ Sample

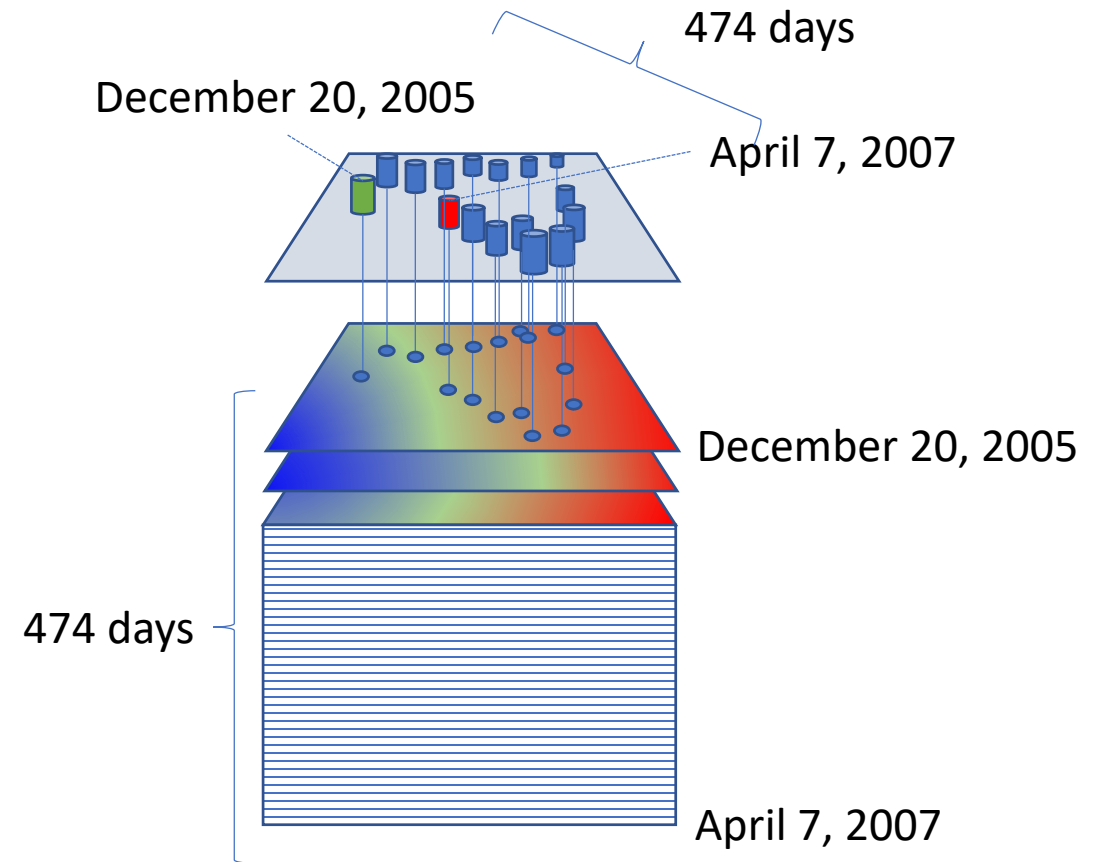
- QGIS:

- 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



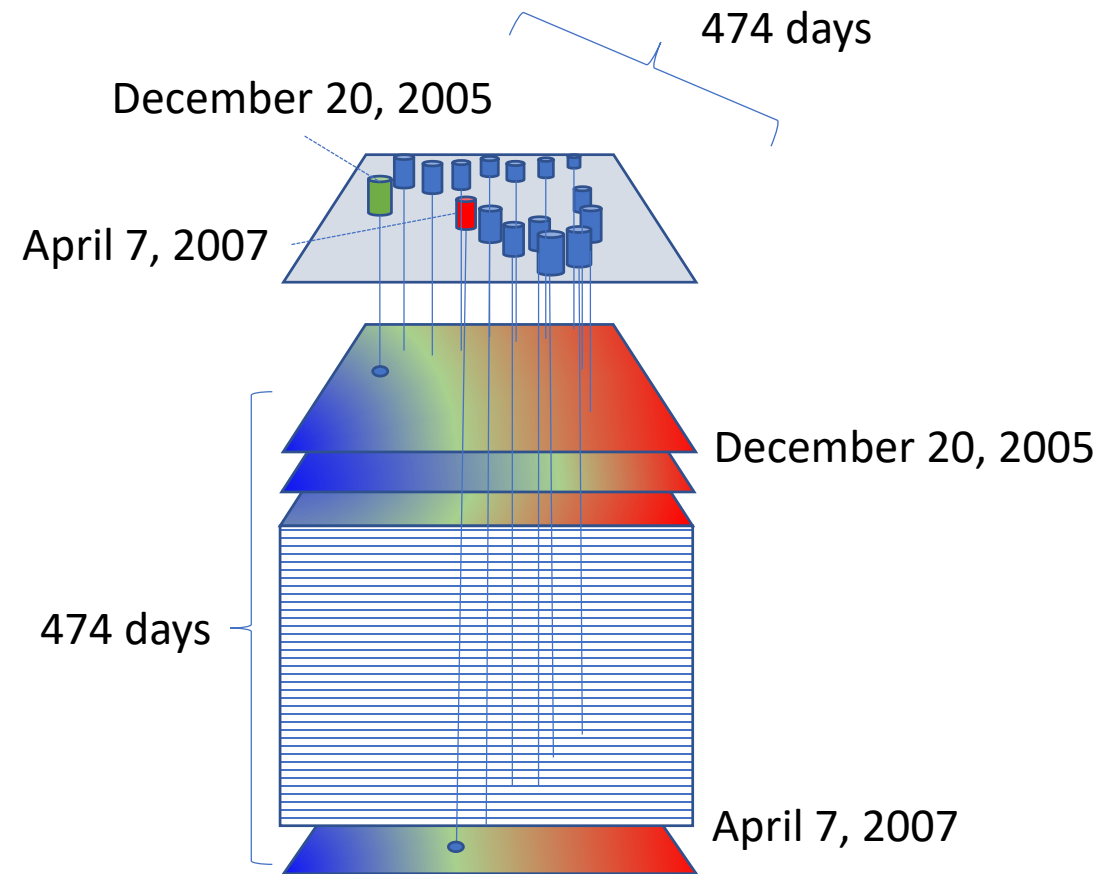
Extracting data using the Sample Tool

- 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).



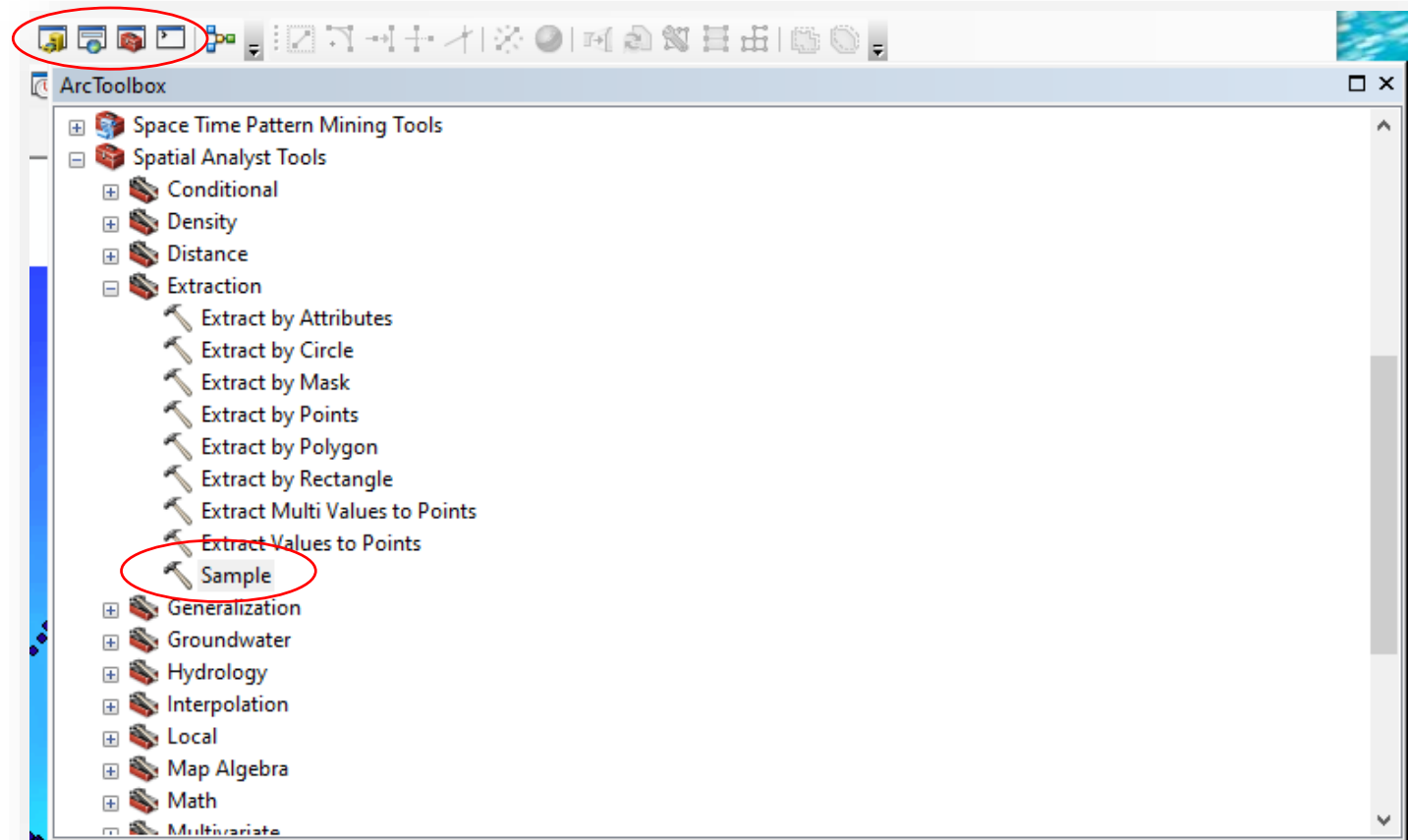
Extracting data using the Sample Tool

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



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
- Generate Feature Class

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

The screenshot shows the 'Sample' tool in the Geoprocessing pane. Blue lines connect the tool's parameters to the list items on the left. A red circle highlights the 'Run' button at the bottom right.

Geoprocessing Sample

Parameters **Environments**

Input rasters ▼

NOAA Sea Surface Temperature ▼

Input location raster or features ▼

?5317_05_modified180_XYTableToPoint2 selection ▼

! The input has a filter. Records to be processed: 0 ↺

Output table or feature class ▼

turtle_samples ▼

Resampling technique ▼

Nearest ▼

Unique ID field ▼

OBJECTID ▼

☒ Process as multidimensional

Acquisition information of location data ▼

Dimension ▼

StdTime ▼

Start field or value ▼

date ▼

End field or value ▼

Relative value or days before ▼

Relative value or days after ▼

+ Add another

Statistics type ▼

Buffer distance field or value ▼

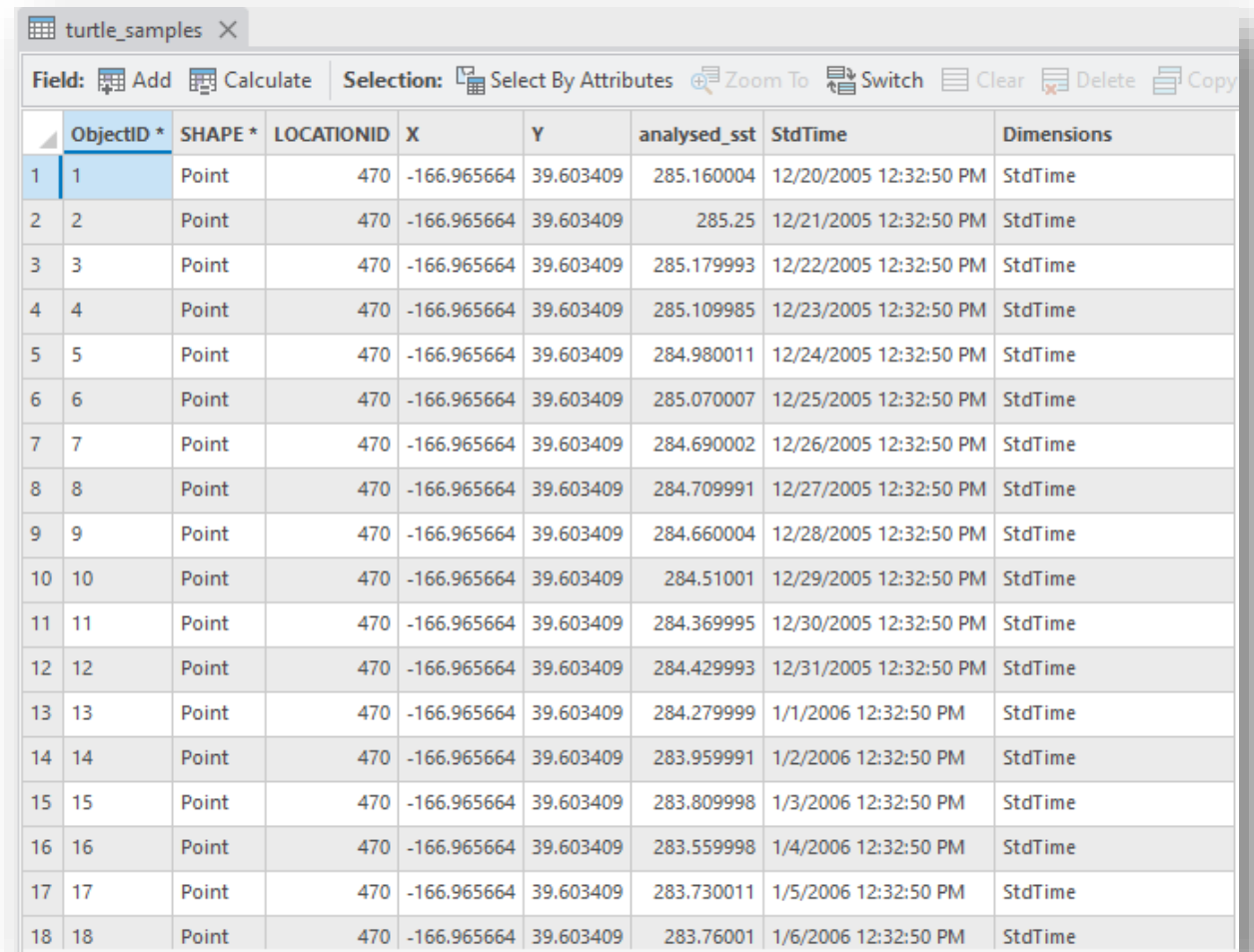
☐ Column-wise layout

☒ Generate feature class

▶ Run ▼

Perform the Sampling

- Rename output to 'turtle_samples'
- Right-mouse and open the data table on the 'turtle_samples' table
- Note the layout of the table
 - Analysed SST column added
 - 474 rows of results (matching time slices of original NetCDF)
 - Double-click StdTime to sort



The screenshot shows a software window titled 'turtle_samples'. It contains a data table with the following columns: ObjectID *, SHAPE *, LOCATIONID, X, Y, analysed_sst, StdTime, and Dimensions. The table displays 18 rows of data, with the first row highlighted. The 'StdTime' column is sorted chronologically, starting from 12/20/2005 and ending on 1/6/2006.

	ObjectID *	SHAPE *	LOCATIONID	X	Y	analysed_sst	StdTime	Dimensions
1	1	Point	470	-166.965664	39.603409	285.160004	12/20/2005 12:32:50 PM	StdTime
2	2	Point	470	-166.965664	39.603409	285.25	12/21/2005 12:32:50 PM	StdTime
3	3	Point	470	-166.965664	39.603409	285.179993	12/22/2005 12:32:50 PM	StdTime
4	4	Point	470	-166.965664	39.603409	285.109985	12/23/2005 12:32:50 PM	StdTime
5	5	Point	470	-166.965664	39.603409	284.980011	12/24/2005 12:32:50 PM	StdTime
6	6	Point	470	-166.965664	39.603409	285.070007	12/25/2005 12:32:50 PM	StdTime
7	7	Point	470	-166.965664	39.603409	284.690002	12/26/2005 12:32:50 PM	StdTime
8	8	Point	470	-166.965664	39.603409	284.709991	12/27/2005 12:32:50 PM	StdTime
9	9	Point	470	-166.965664	39.603409	284.660004	12/28/2005 12:32:50 PM	StdTime
10	10	Point	470	-166.965664	39.603409	284.51001	12/29/2005 12:32:50 PM	StdTime
11	11	Point	470	-166.965664	39.603409	284.369995	12/30/2005 12:32:50 PM	StdTime
12	12	Point	470	-166.965664	39.603409	284.429993	12/31/2005 12:32:50 PM	StdTime
13	13	Point	470	-166.965664	39.603409	284.279999	1/1/2006 12:32:50 PM	StdTime
14	14	Point	470	-166.965664	39.603409	283.959991	1/2/2006 12:32:50 PM	StdTime
15	15	Point	470	-166.965664	39.603409	283.809998	1/3/2006 12:32:50 PM	StdTime
16	16	Point	470	-166.965664	39.603409	283.559998	1/4/2006 12:32:50 PM	StdTime
17	17	Point	470	-166.965664	39.603409	283.730011	1/5/2006 12:32:50 PM	StdTime
18	18	Point	470	-166.965664	39.603409	283.76001	1/6/2006 12:32:50 PM	StdTime

Set Time Properties on Results

- Rename output to 'turtle_samples'
- Right-mouse and open the data table on the 'turtle_samples' table
- Note the layout of the table
 - Analysed SST column added
 - 474 rows of results (matching time slices of original NetCDF)

Layer Properties: turtle_samples

General
Metadata
Source
Elevation
Selection
Display
Cache
Definition Query
Time
Range
Indexes
Joins
Relates
Page Query

Layer Time: Each feature has a single time field

Time Field: StdTime

Time Extent: 12/20/2005 12:32:50 PM - 4/7/2007 12:32:50 PM
Calculate
☐ Data is a live feed. Refresh rate is on the General tab.

Time Interval:
☐ No pre-defined time interval
☒ View using a regular time interval
Step: 1 Days
☐ View using unique times within the data

Time Zone: (UTC) Coordinated Universal Time
☐ Adjust For Daylight Saving

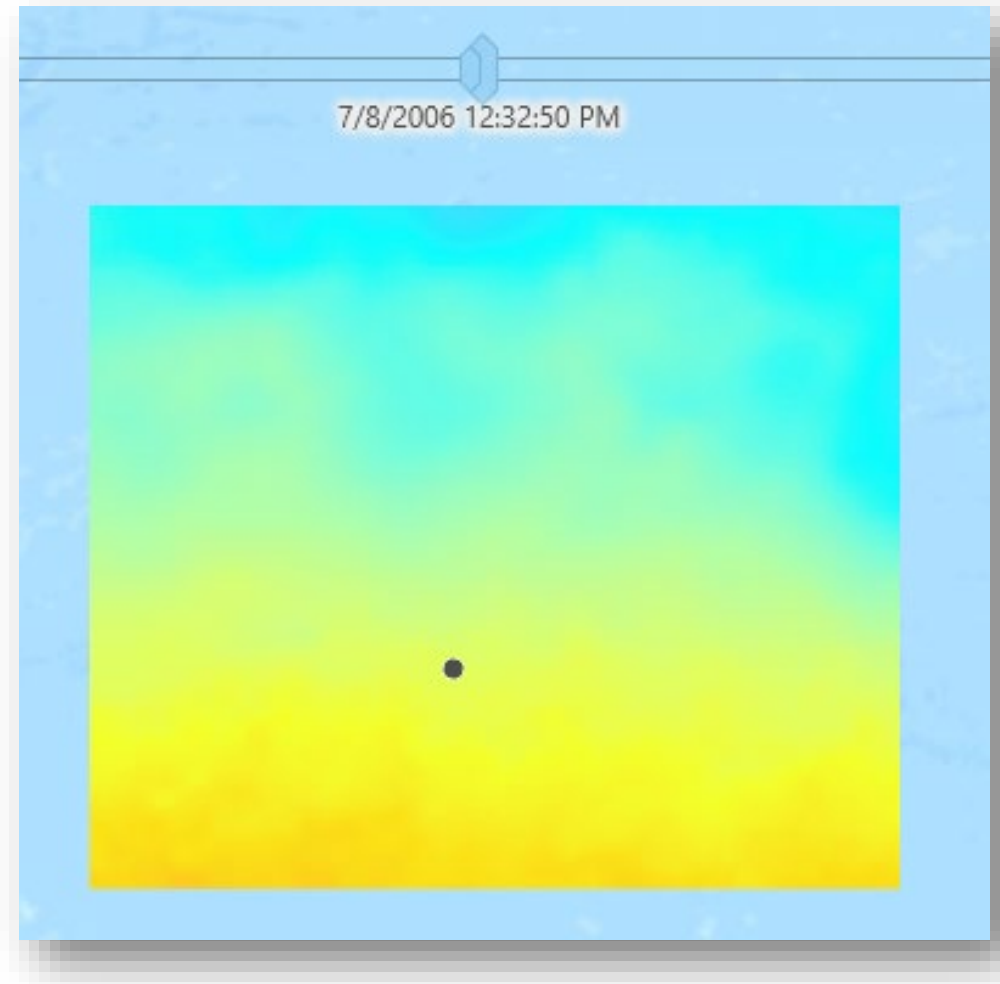
Time Offset: 0 Days

[Learn more about time properties](#)

OK Cancel

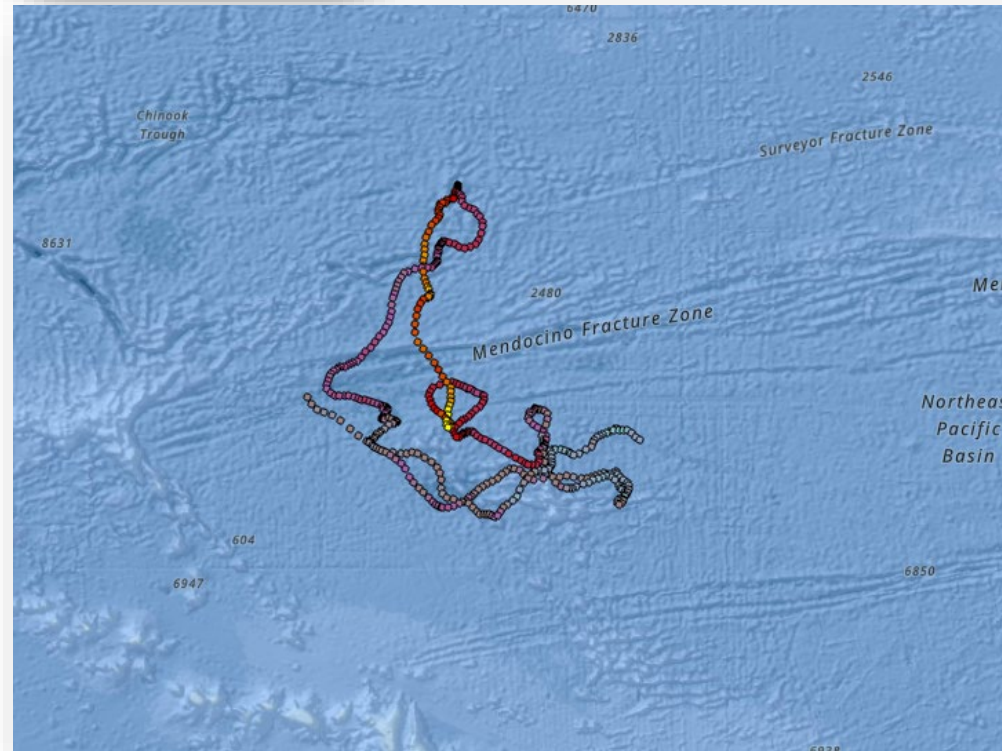
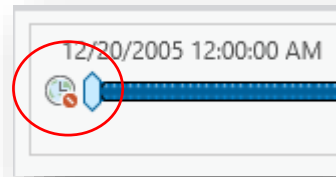
Add Results to the Map

- Check both the Turtle Samples and SST Layers
- Enable Time Slider and click Play
- The Turtle Sample symbol should advance with a change in the daily SST data.



Output 2: Map output showing turtle locations and values

- Disable Time (on slider)
- Open Symbology
 - <double click symbol>
- Assign color scheme and classification – 25 levels (Field to analysed_sst)
- Turn off raster visibility
- Turn on Basemap



Symbology - turtle_samples

Primary symbology

Graduated Colors

Field: analysed_sst

Normalization: <None>

Method: Equal Interval

Classes: 25

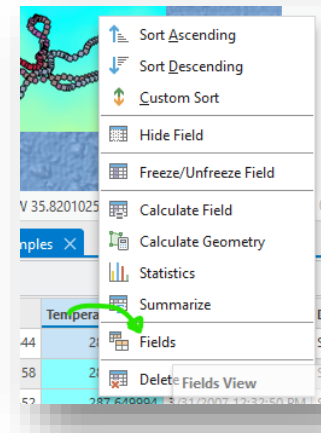
Color scheme: [Color bar]

Classes Histogram Scales

Symbol	Upper value	Label
•	≤ 287.951598	287.559998 - 287.951598
•	≤ 288.343198	287.951599 - 288.343198
•	≤ 288.734799	288.343199 - 288.734799
•	≤ 289.126399	288.734800 - 289.126399
•	≤ 289.517999	289.126400 - 289.517999
•	≤ 289.9096	289.518000 - 289.909600
•	≤ 290.3012	289.909601 - 290.301200
•	≤ 290.6928	290.301201 - 290.692800
•	≤ 291.084401	290.692801 - 291.084401
•	≤ 291.476001	291.084402 - 291.476001
•	≤ 291.867601	291.476002 - 291.867601
•	≤ 292.259202	291.867602 - 292.259202
•	≤ 292.650802	292.259203 - 292.650802
•	≤ 293.042402	292.650803 - 293.042402
•	≤ 293.434003	293.042403 - 293.434003

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

- *Open* the Attribute Table for Turtle Samples layer
- *Modify* the alias for **analysed_sst** to 'Temperature(K)'
- *Create* a new field with a field name of TemperatureC , type of 'Double' , alias of 'Temperature (C)', and Number Format of 'Numeric'



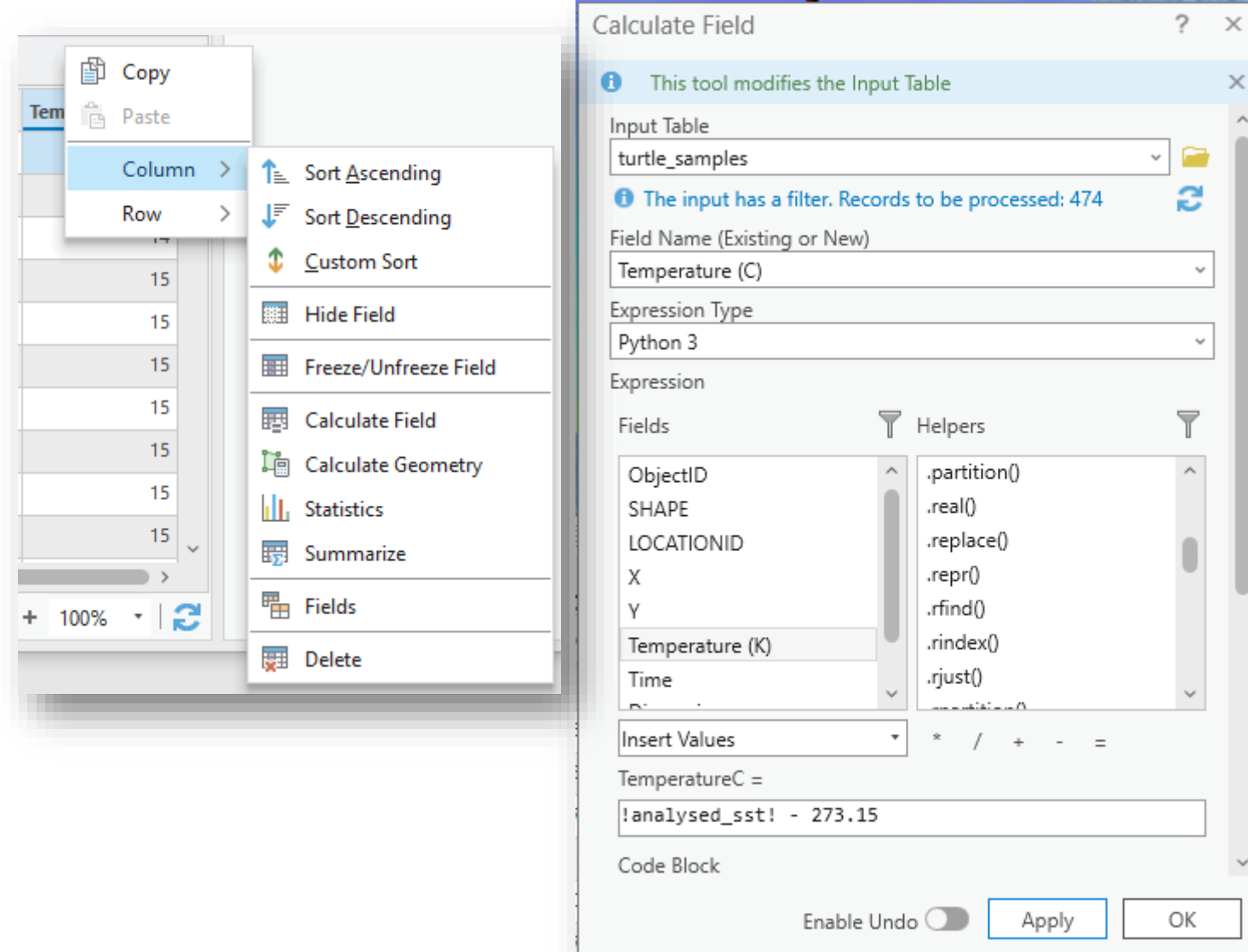
turtle_samples | turtle_samples - Temperature (C) over Time | *Fields: turtle_samples (Map)

Current Layer: turtle_samples (Map)

	Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Domain
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	StdTime	Time	Date	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	X	X	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric	
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Y	Y	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric	
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	analysed_sst	Temperature (K)	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric	
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	SHAPE	SHAPE	Geometry	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	LOCATIONID	LOCATIONID	Long	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric	
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	OBJECTID	ObjectID	Object ID	<input type="checkbox"/>	<input type="checkbox"/>	Numeric	
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Dimensions	Dimensions	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	TemperatureC	Temperature (C)	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric	

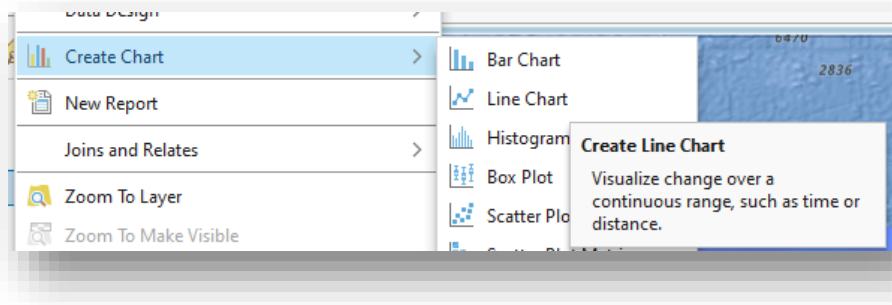
Output 3: Graph of parameter value for each turtle location vs Time

- **Select Calculate Field** for the newly created **Temperature (degrees C)** Column
- Set the conversion for **Kelvin** to **degrees C** and *apply*
- Set Properties to plot analysed_sst versus StdTime

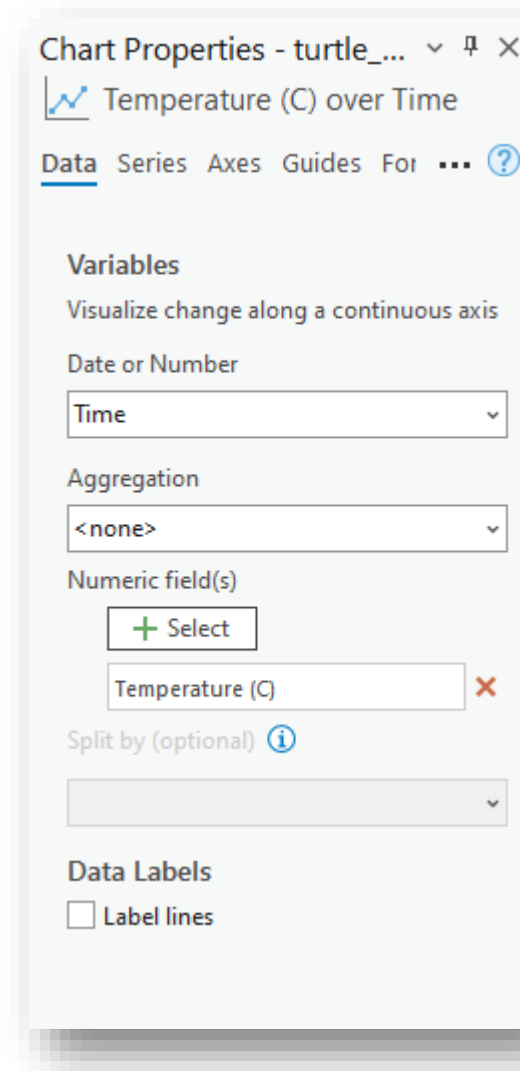


Output 3: Graph of parameter value for each turtle location vs Time

- Select Create Chart->Line Chart from Turtle Samples layer

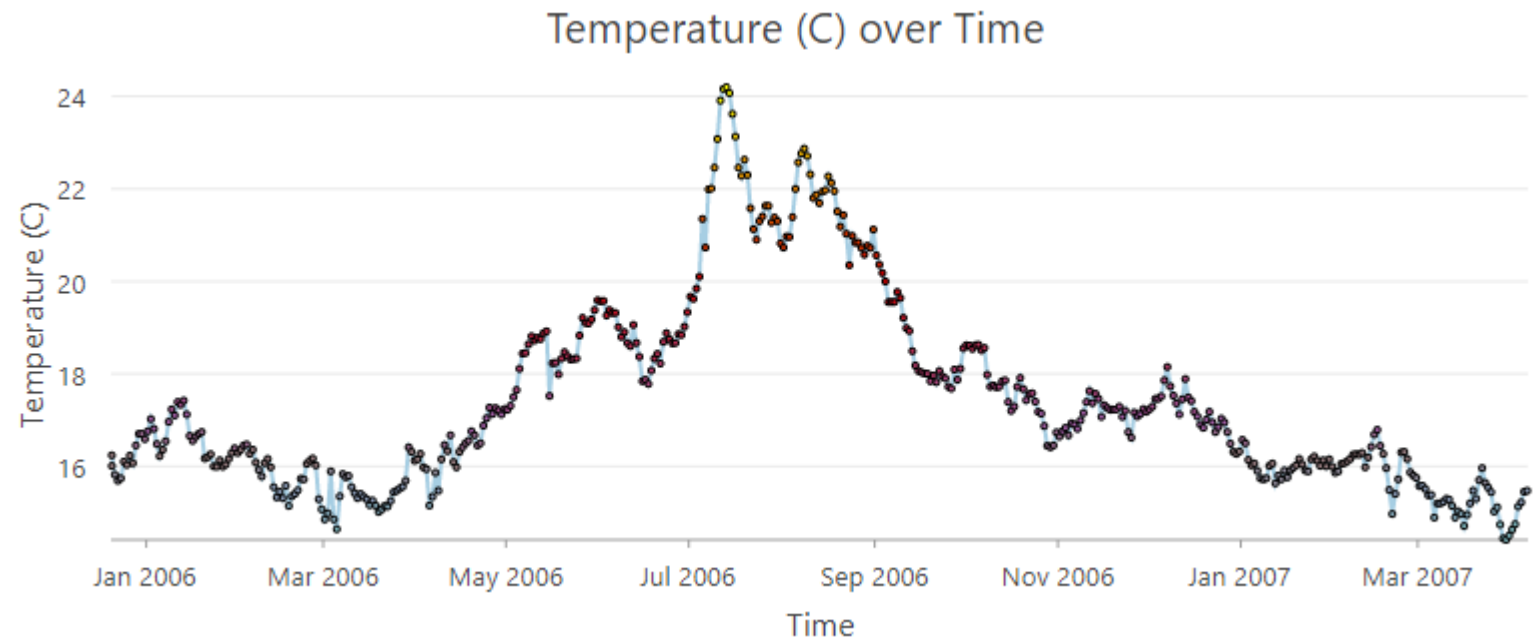


- Set Properties to plot Time and Temperature (C)

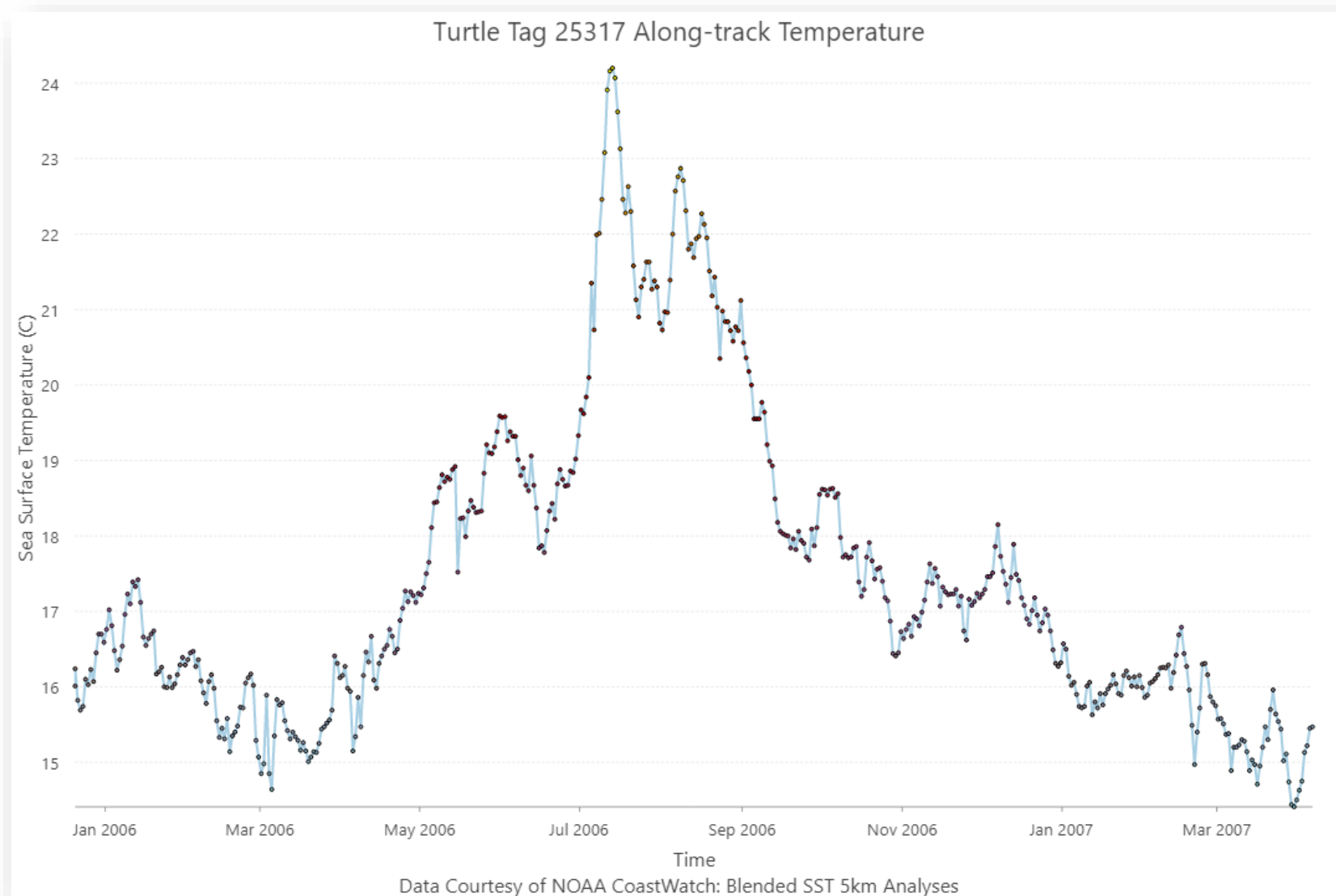


Output 3: Graph of parameter value for each turtle location vs Time

- Continue with the Chart Properties 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>

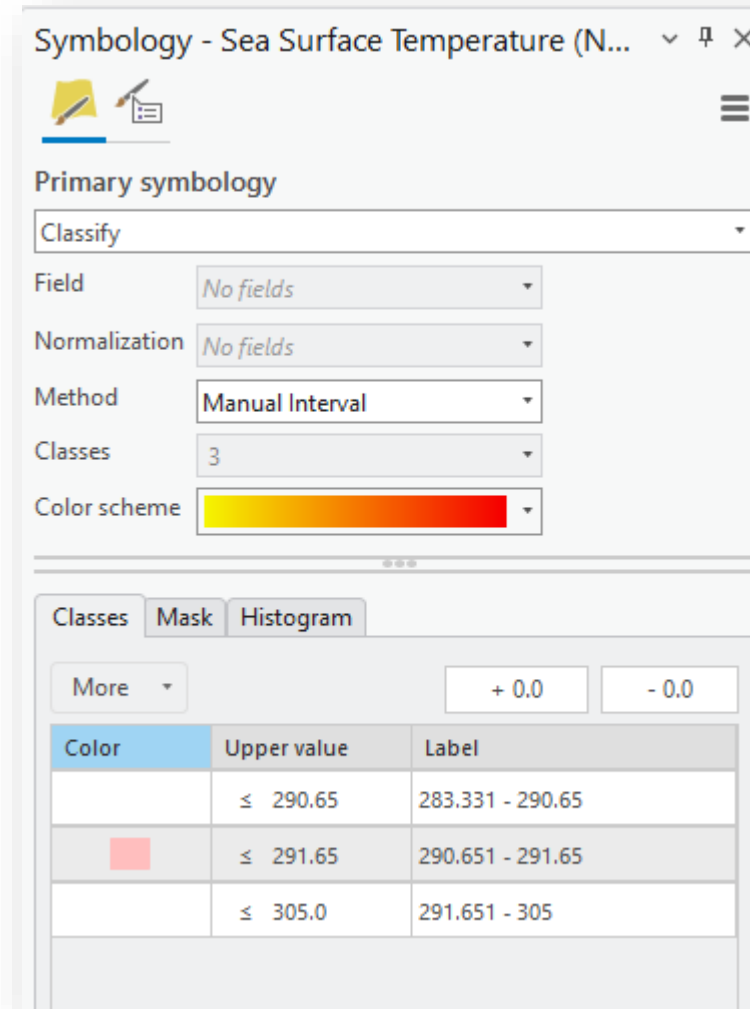
- TurtleWatch Zone:
 - Most loggerhead turtles stay in water colder than 65.5°F (about 18.5°C). When the 65.5°F temperature contour is drawn on a map of the current sea surface temperature conditions, it delineates the current southern boundary of the loggerhead's preferred habitat. Over 50% of recorded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

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

- What is the behavior of this turtle?
- After completing this exercise, could you calculate the percentage of time the turtle is within/outside the zone?

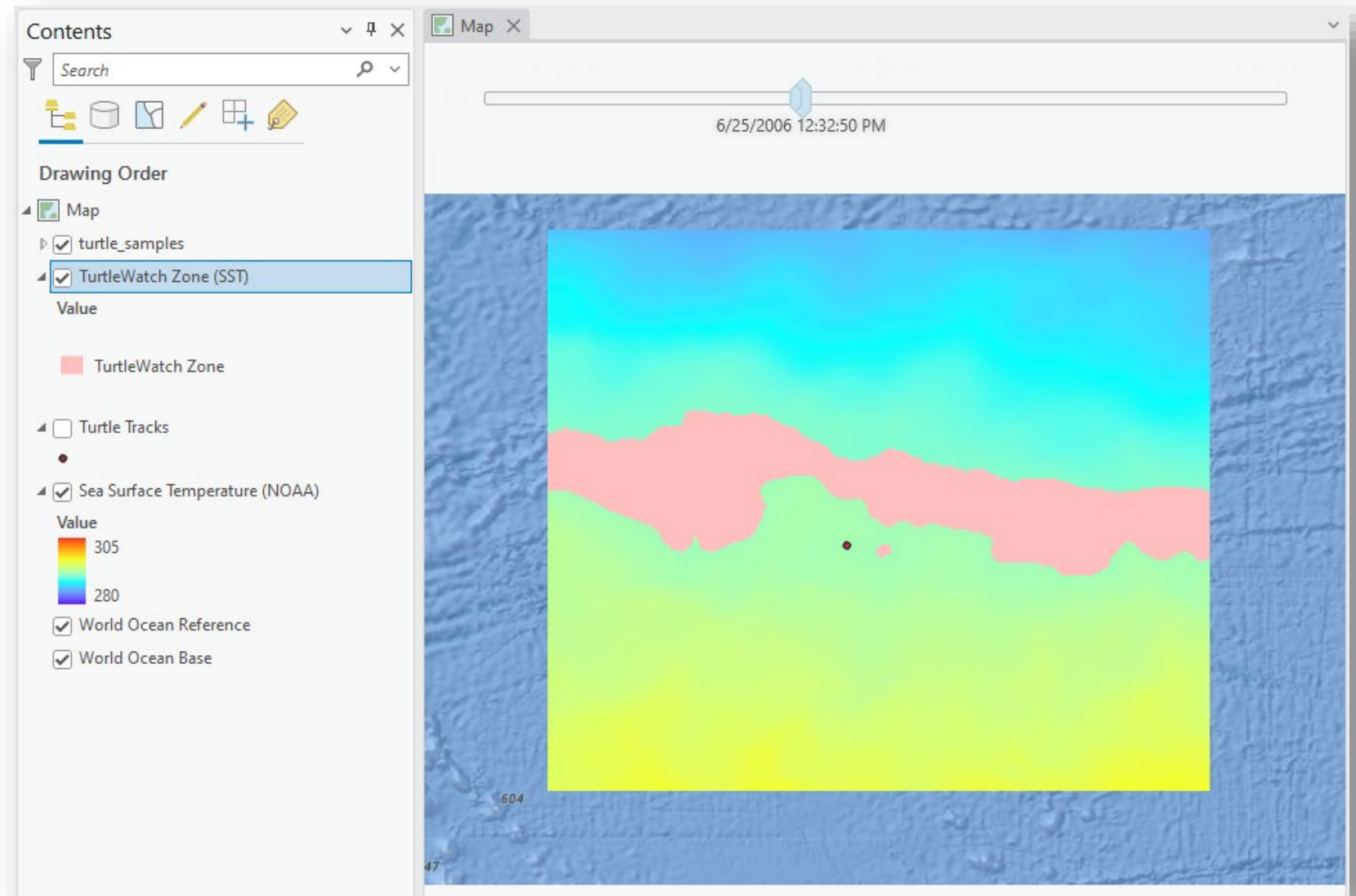
Output 4: Export Movie showing Turtle, Parameter, TurtleWatch Zone

- Copy and Paste SST raster layer
- Rename Layer
- Open Symbology for this new layer
 - Set classes so the 'zone' is a single color and 'no color' is applied to values outside the zone



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

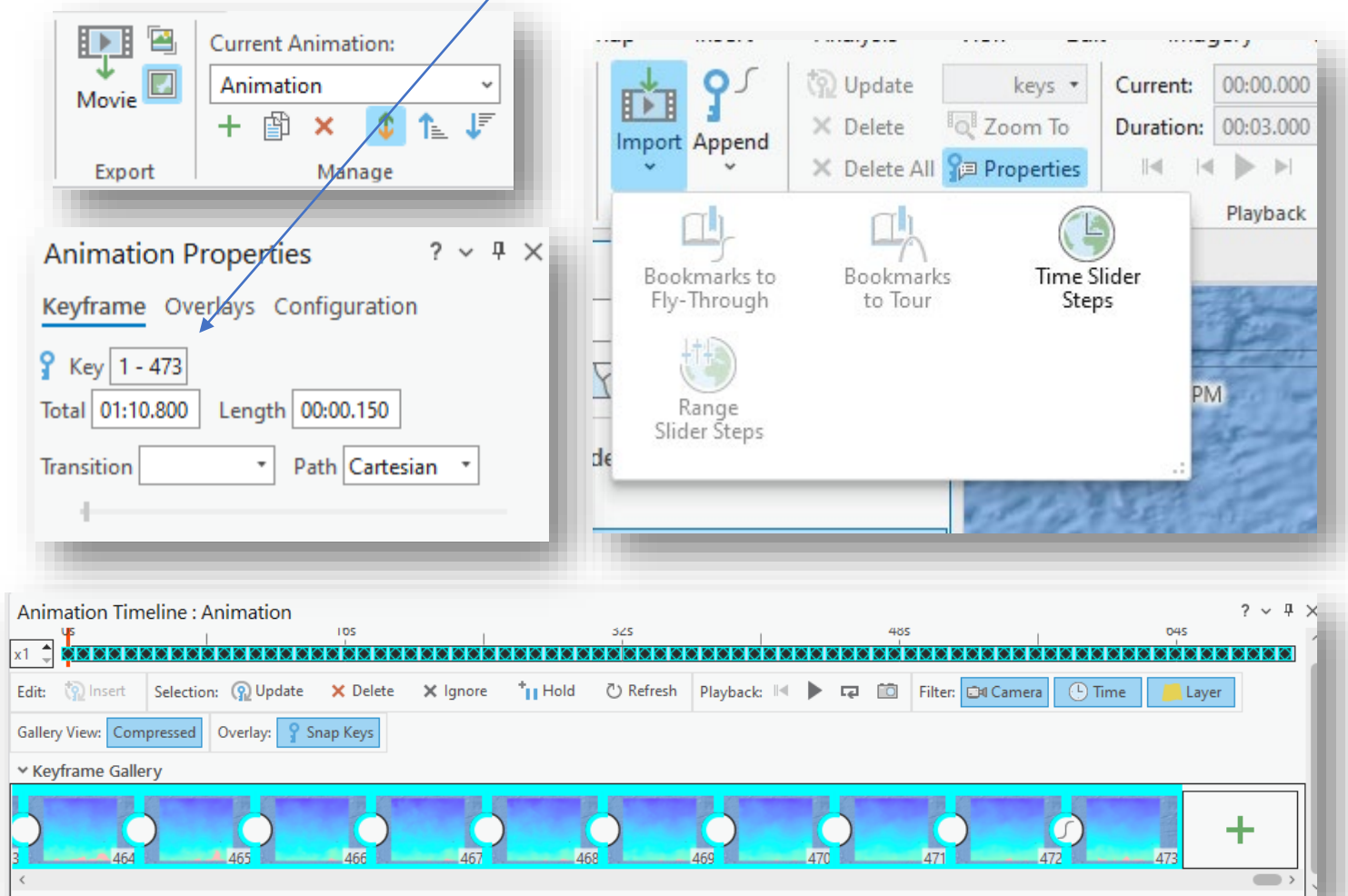
- Save your work!
- Use the 'Animation' tab to configure and save the movie



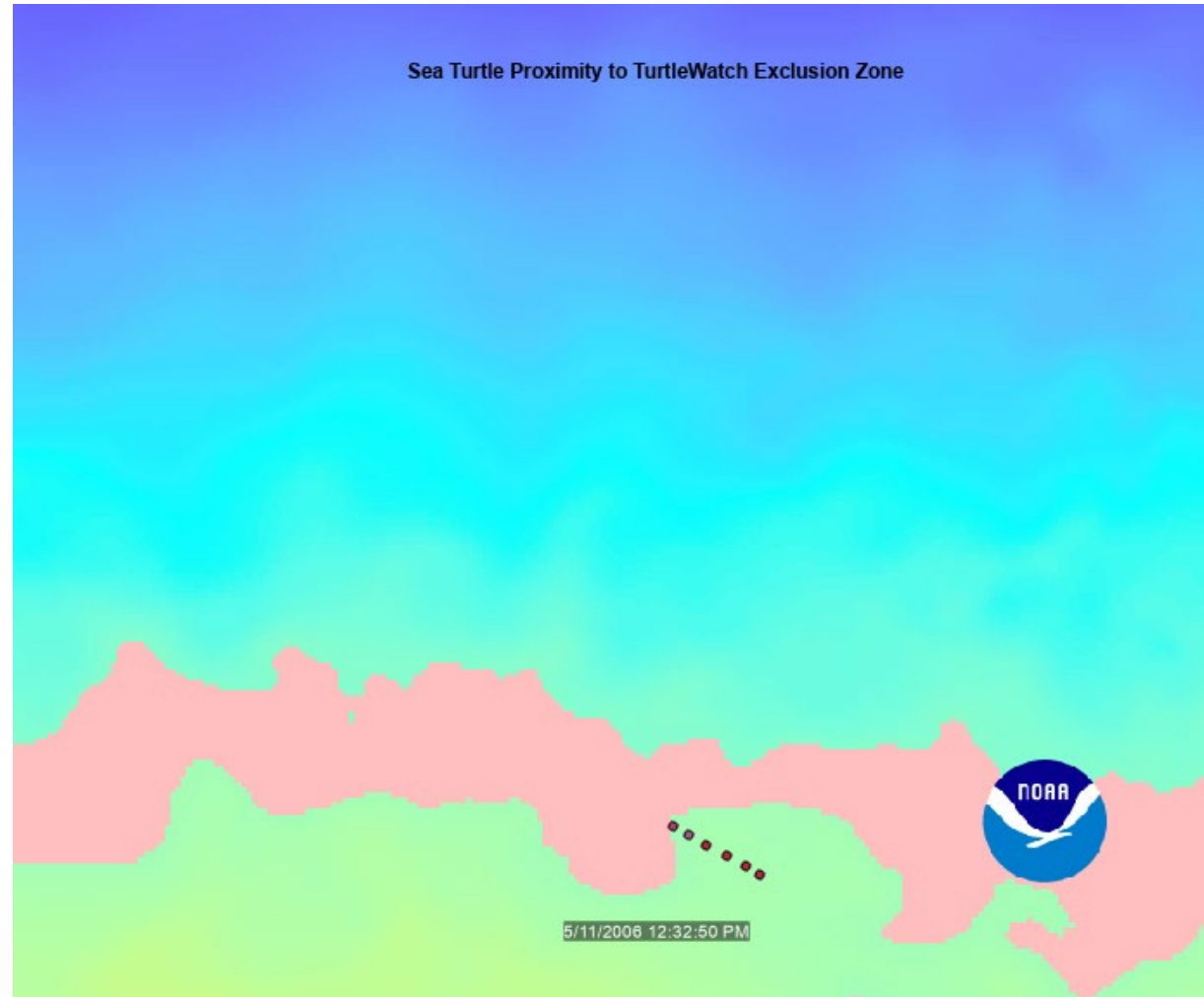
Output 4: Animation

- *Import* the Time Slider images to create the animation timeline
- *Adjust* the Frames per second and duration of each frame
- *Set* any titles / overlays / legends

This value (473) will be dependent on how many images are in your time slider



Output 4: Animation (screenshot from video)



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.
- Animation: The export of movies sometimes seems trial and error in getting all layers to draw properly.

End of Exercise

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

