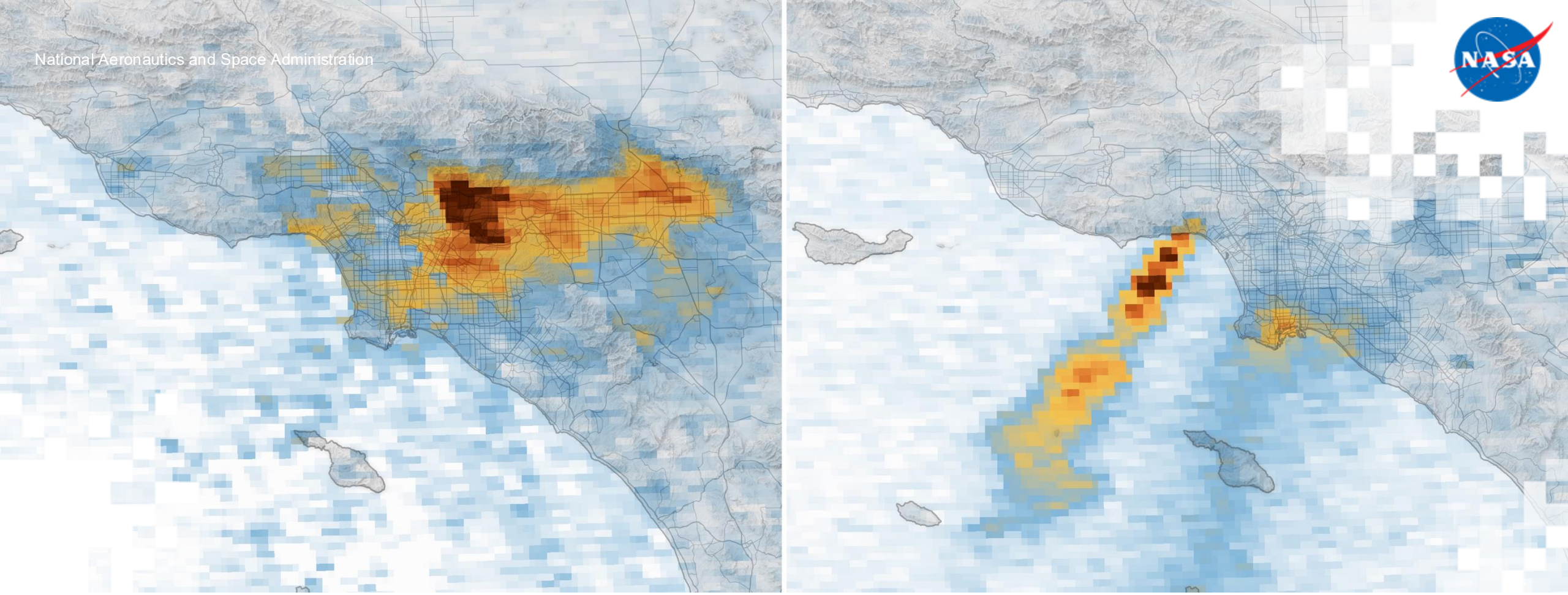
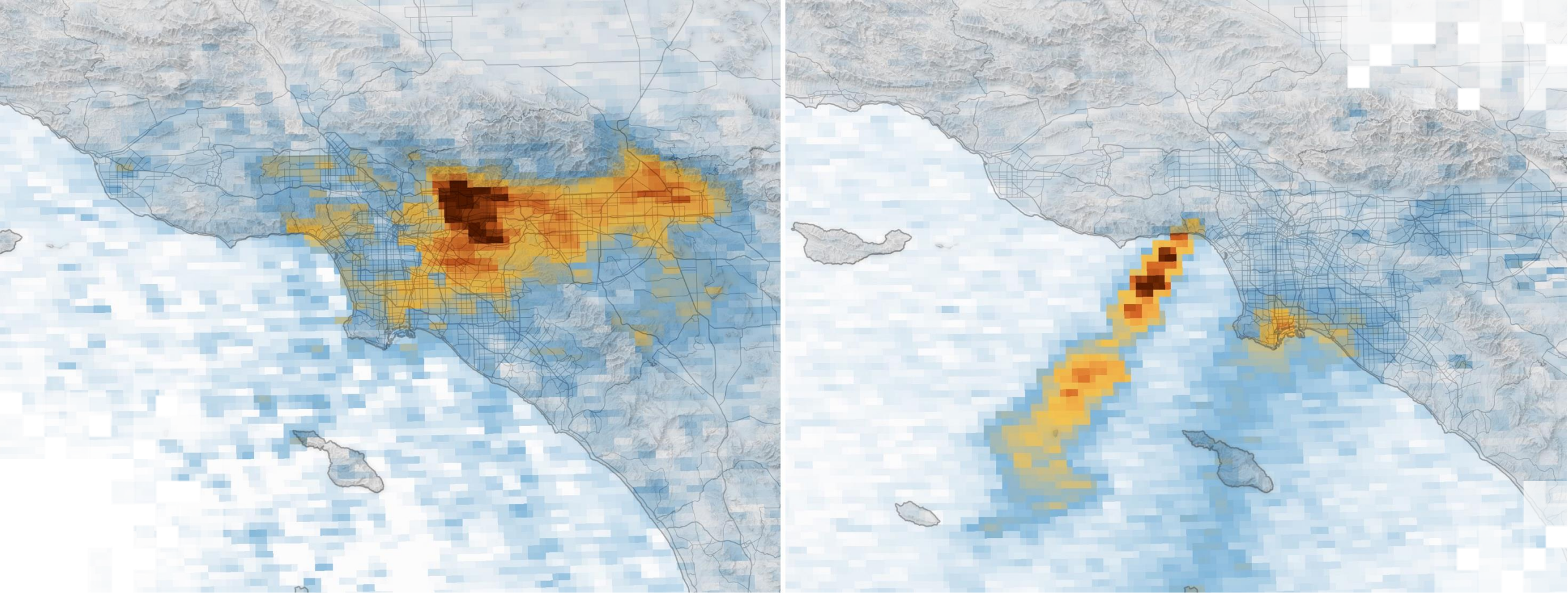


Introduction to Geostationary Observations for Air Quality Applications in the Western US

Day 2, Part 4: TEMPO in Earthdata GIS

Georgina Hayes-Crepps (ASDC)

August 6, 2025



Introduction to Geostationary Observations for Air Quality Applications in the Western US

Day 2, Part 4: TEMPO in Earthdata GIS

ArcGIS Image Services

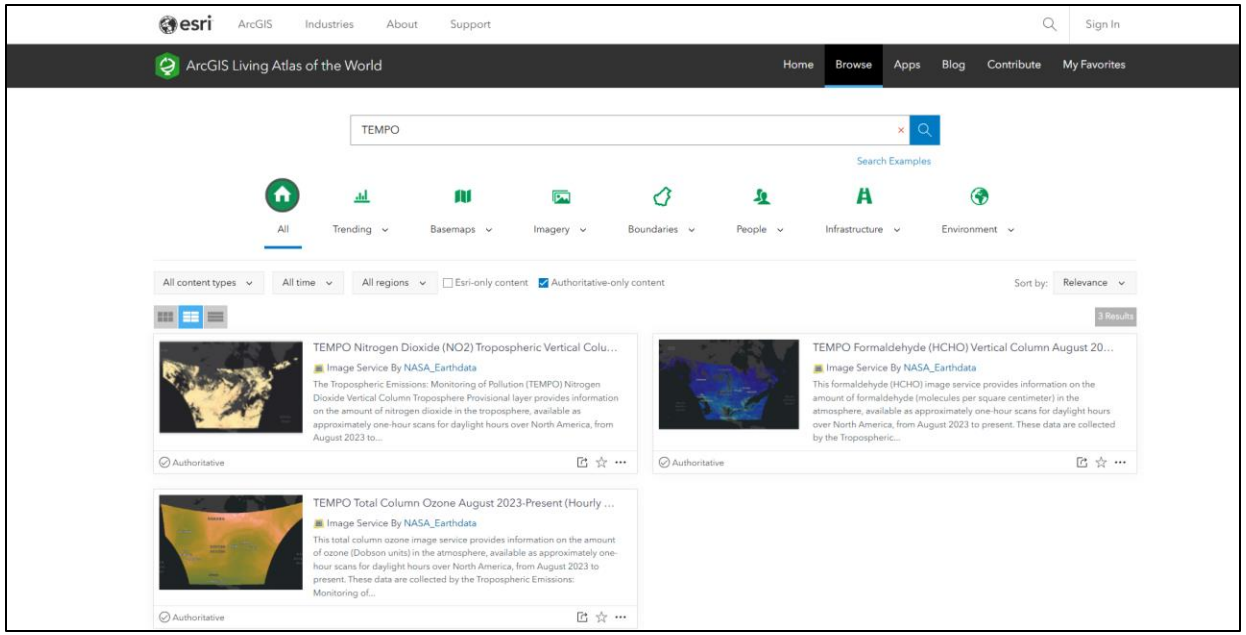
- **Esri Living Atlas of the World**
  - Read service descriptions!
- **Access TEMPO ArcGIS Image Service in ArcGIS Pro (Desktop Software) – License Needed**
  - Search for TEMPO services in Living Atlas Portal
  - Add multiple layers to map
  - Explore data (select dates/times)
  - Temporal Profile
    - Use point or shapefile as area of interest
    - Chart Options (e.g., aggregation, download as CSV)
- **Access TEMPO ArcGIS Image Service Programmatically (Jupyter Notebook) – No License Needed**
  - Choose a TEMPO image service to query
  - Select time period and point (X,Y) of interest
  - View data values for point of interest in a table
  - Chart returned values for point of interest
  - View imagery for the time period of interest in interactive mapper

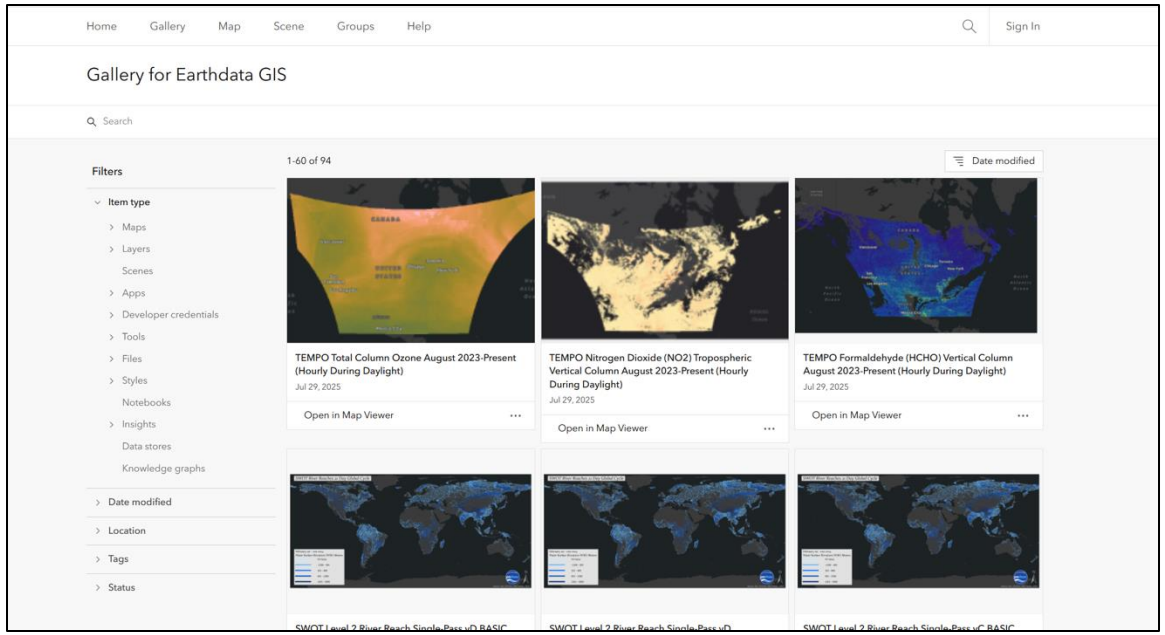
Resources

- Geographic Information System (GIS)
  - Accessing Worldview Imagery in GIS
  - ArcGIS REST API
  - Esri Living Atlas of the World
  - NASA Earthdata GIS Portal
  - TEMPO NO_2 ArcGIS Image Service
  - TEMPO Total Column Ozone ArcGIS Image Service
  - TEMPO Formaldehyde ArcGIS Image Service
  - Temporal Profile Chart (ArcGIS Pro)
- Jupyter Notebook (ASDC GitHub):
  - Accessing, Analyzing, & Visualizing TEMPO Data through ArcGIS Image Services Programmatically **or** "pretty view" as html
- Earthdata GIS GitHub:
  - General Tutorials
  - Accessing, Analyzing, & Visualizing TEMPO Data through ArcGIS Image Services Programmatically (Bounding Box)

Accessing TEMPO Image Services

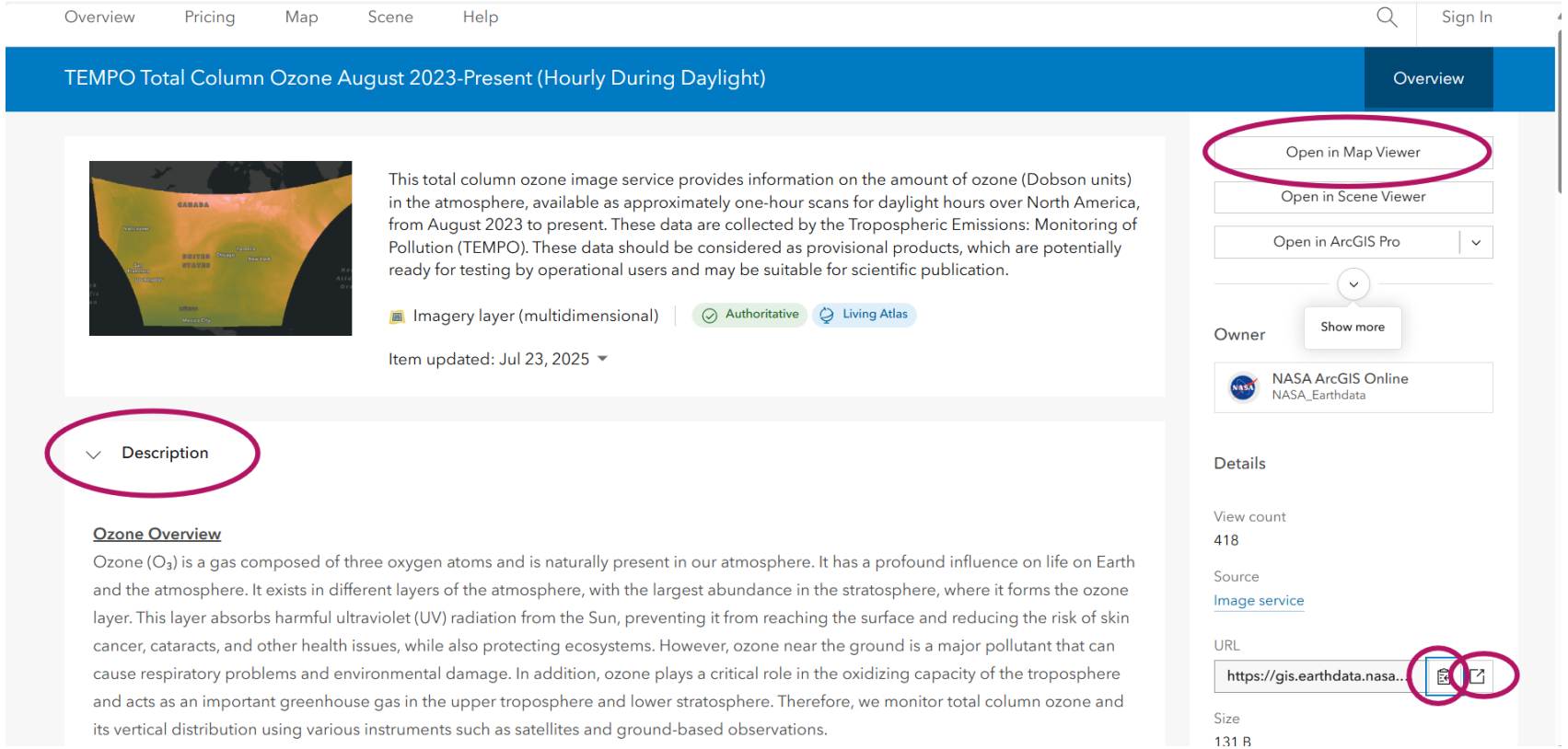
- TEMPO image services can be accessed either through the Esri Living Atlas of the World or the NASA Earthdata GIS Portal.





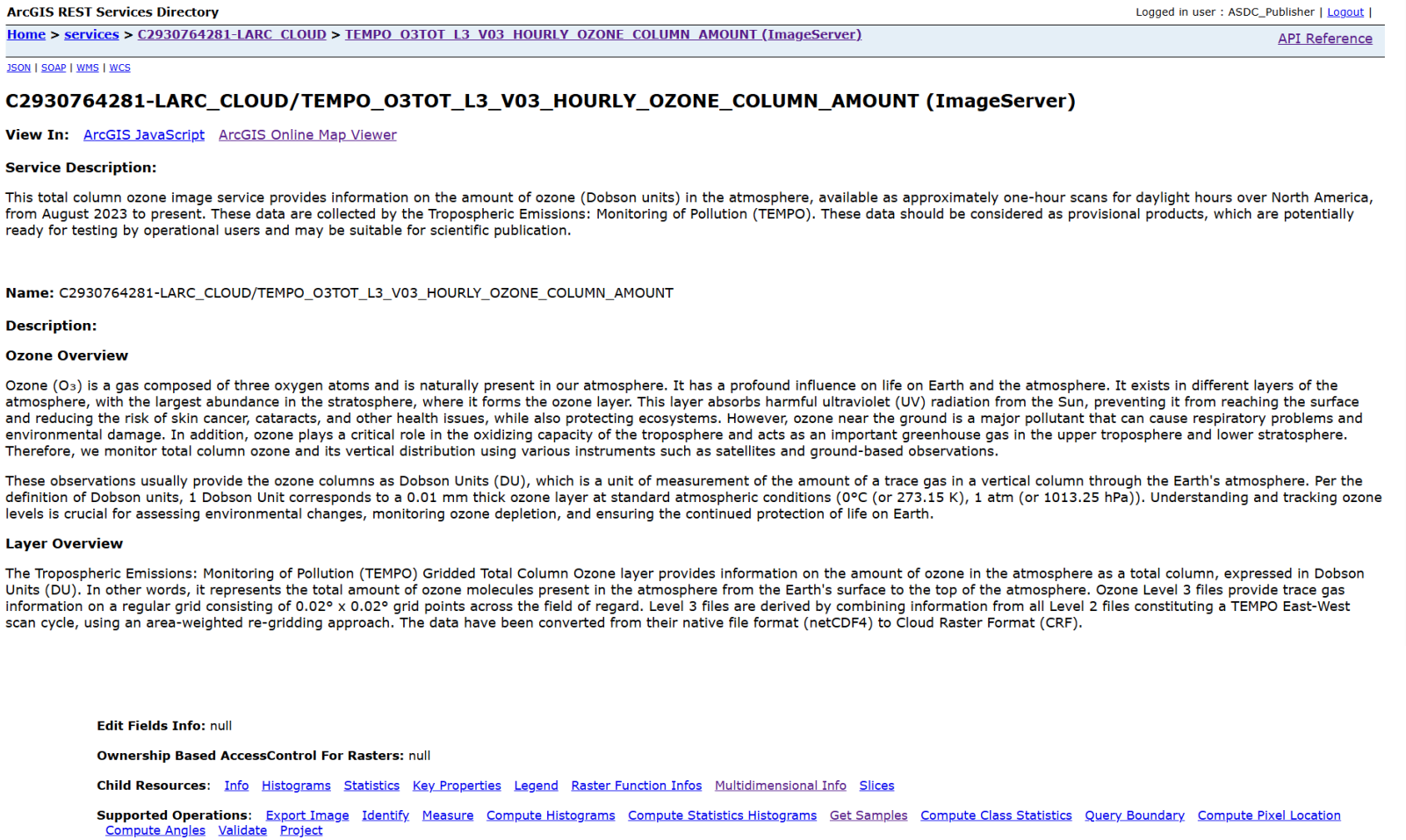
Service Portal Page

- Each service page has important information (e.g., filtering, temporal and spatial coverage) under “Description”.
- Link to view the service in an online mapper (no license required)
- Link to the service URL and API functionality (no license required)



Service URL – REST API Functions

- The service URL is used for both web interface and programmatic access to the image service.
- The service URL page contains the same metadata as on the portal description page, as well as additional technical details about the service.
- Associated functions available through the service REST API are available at the bottom of the page under “Child Resources” and “Supported Operations.
- ArcGIS REST API



ArcGIS REST Services Directory

Logged in user : ASDC_Publisher | Logout |

Home > services > C2930764281-LARC_CLOUD > TEMPO_O3TOT_L3_V03_HOURLY_OZONE_COLUMN_AMOUNT (ImageServer)

API Reference

JSON | SOAP | WMS | WCS

C2930764281-LARC_CLOUD/TEMPO_O3TOT_L3_V03_HOURLY_OZONE_COLUMN_AMOUNT (ImageServer)

View In: ArcGIS JavaScript ArcGIS Online Map Viewer

Service Description:

This total column ozone image service provides information on the amount of ozone (Dobson units) in the atmosphere, available as approximately one-hour scans for daylight hours over North America, from August 2023 to present. These data are collected by the Tropospheric Emissions: Monitoring of Pollution (TEMPO). These data should be considered as provisional products, which are potentially ready for testing by operational users and may be suitable for scientific publication.

Name: C2930764281-LARC_CLOUD/TEMPO_O3TOT_L3_V03_HOURLY_OZONE_COLUMN_AMOUNT

Description:

Ozone Overview

Ozone (O_3) is a gas composed of three oxygen atoms and is naturally present in our atmosphere. It has a profound influence on life on Earth and the atmosphere. It exists in different layers of the atmosphere, with the largest abundance in the stratosphere, where it forms the ozone layer. This layer absorbs harmful ultraviolet (UV) radiation from the Sun, preventing it from reaching the surface and reducing the risk of skin cancer, cataracts, and other health issues, while also protecting ecosystems. However, ozone near the ground is a major pollutant that can cause respiratory problems and environmental damage. In addition, ozone plays a critical role in the oxidizing capacity of the troposphere and acts as an important greenhouse gas in the upper troposphere and lower stratosphere. Therefore, we monitor total column ozone and its vertical distribution using various instruments such as satellites and ground-based observations.

These observations usually provide the ozone columns as Dobson Units (DU), which is a unit of measurement of the amount of a trace gas in a vertical column through the Earth's atmosphere. Per the definition of Dobson units, 1 Dobson Unit corresponds to a 0.01 mm thick ozone layer at standard atmospheric conditions (0°C (or 273.15 K), 1 atm (or 1013.25 hPa)). Understanding and tracking ozone levels is crucial for assessing environmental changes, monitoring ozone depletion, and ensuring the continued protection of life on Earth.

Layer Overview

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) Gridded Total Column Ozone layer provides information on the amount of ozone in the atmosphere as a total column, expressed in Dobson Units (DU). In other words, it represents the total amount of ozone molecules present in the atmosphere from the Earth's surface to the top of the atmosphere. Ozone Level 3 files provide trace gas information on a regular grid consisting of 0.02° x 0.02° grid points across the field of regard. Level 3 files are derived by combining information from all Level 2 files constituting a TEMPO East-West scan cycle, using an area-weighted re-gridding approach. The data have been converted from their native file format (netCDF4) to Cloud Raster Format (CRF).

Edit Fields Info: null

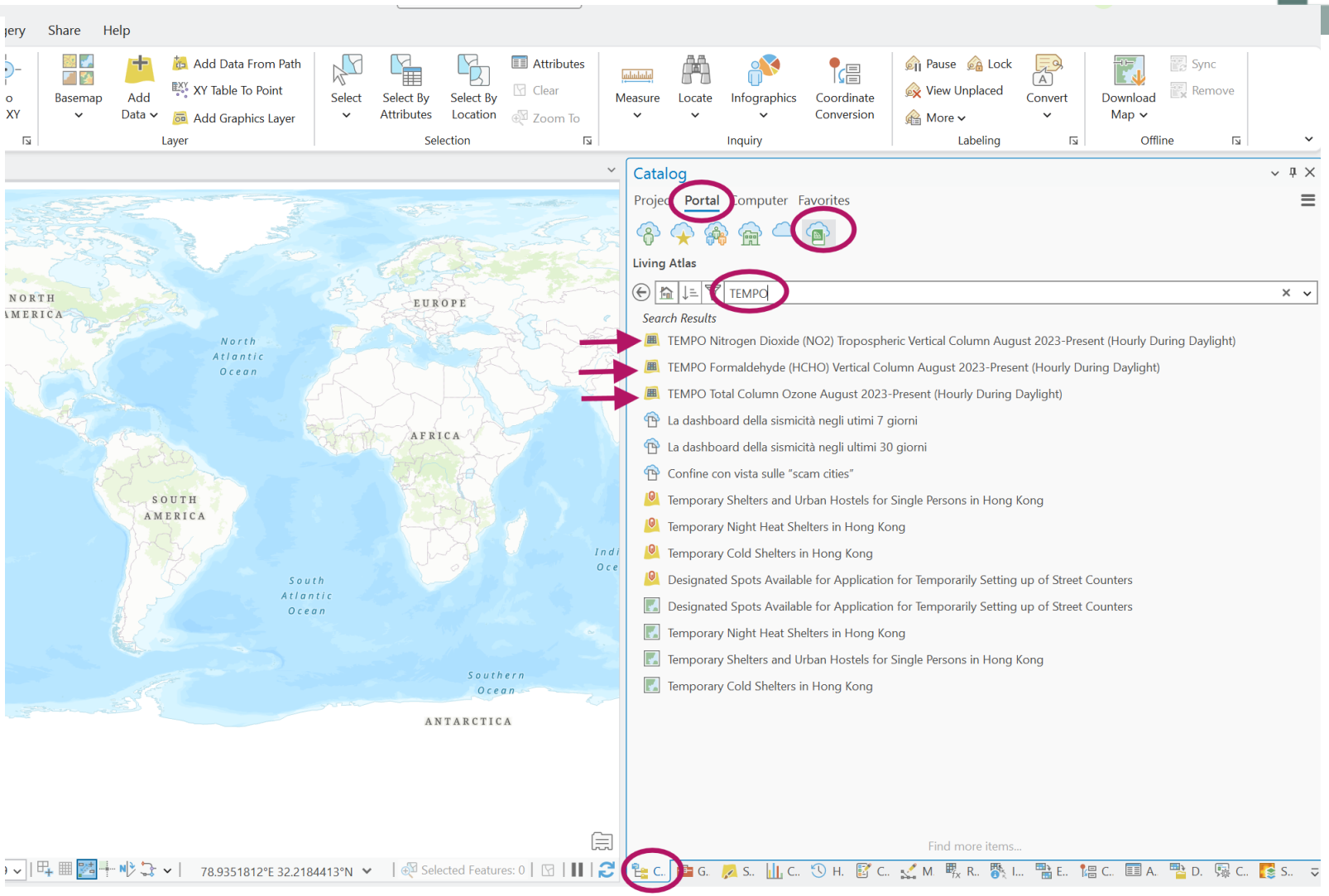
Ownership Based AccessControl For Rasters: null

Child Resources: Info Histograms Statistics Key Properties Legend Raster Function Infos Multidimensional Info Slices

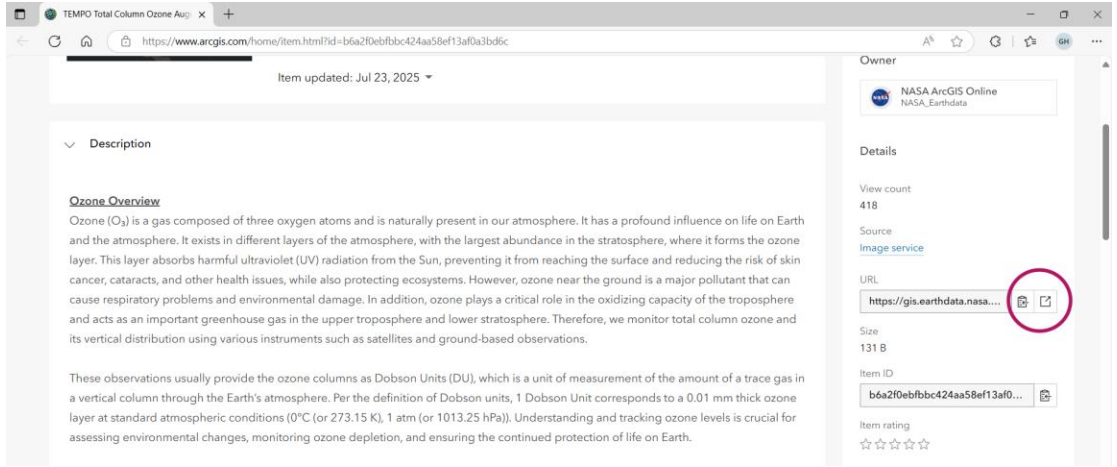
Supported Operations: Export Image Identify Measure Compute Histograms Compute Statistics Histograms Get Samples Compute Class Statistics Query Boundary Compute Pixel Location Compute Angles Validate Project

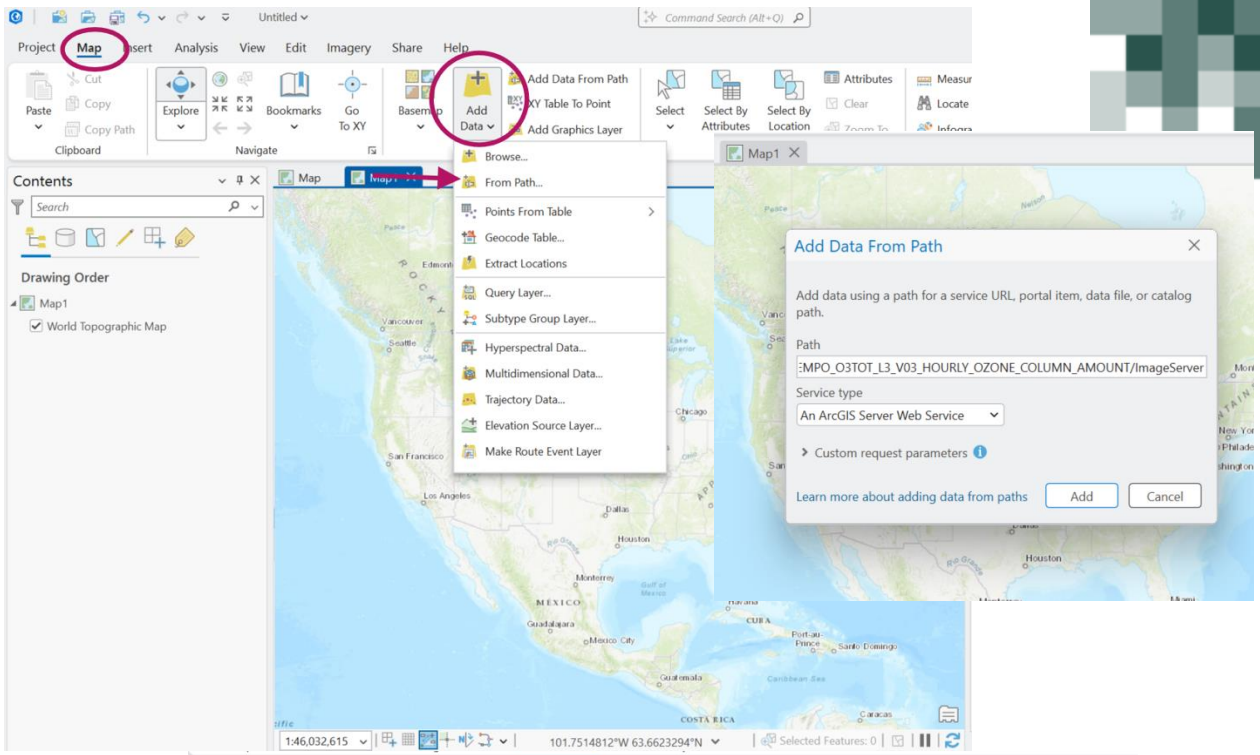
Accessing TEMPO Data in ArcGIS Pro (through Esri Living Atlas Portal)

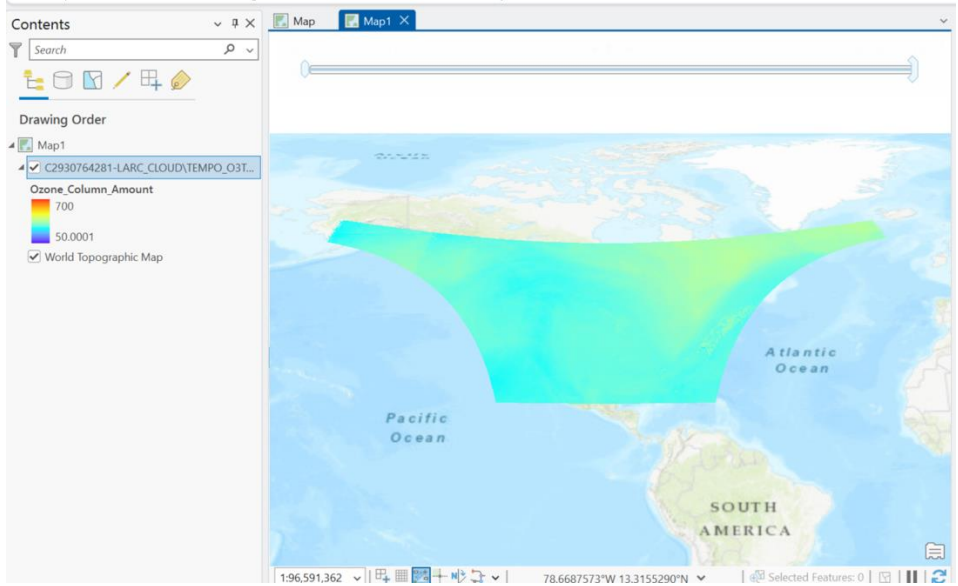
- Open a project in ArcGIS Pro
- Go to "Catalog" pane
- Select "Portal" tab
- Select "Living Atlas"
- In search bar, search for "TEMPO"
- Add TEMPO layer(s) to map (Right click > Add to Current Map OR drag & drop)
- **Note:** If Living Atlas is not an option to select **or** if the TEMPO data do not appear in the search results, it is likely due to how the user is signed in. Users may need to switch the active portal. The service may be accessed in an alternative method.



Accessing TEMPO Data in ArcGIS Pro (through “Add Data”)



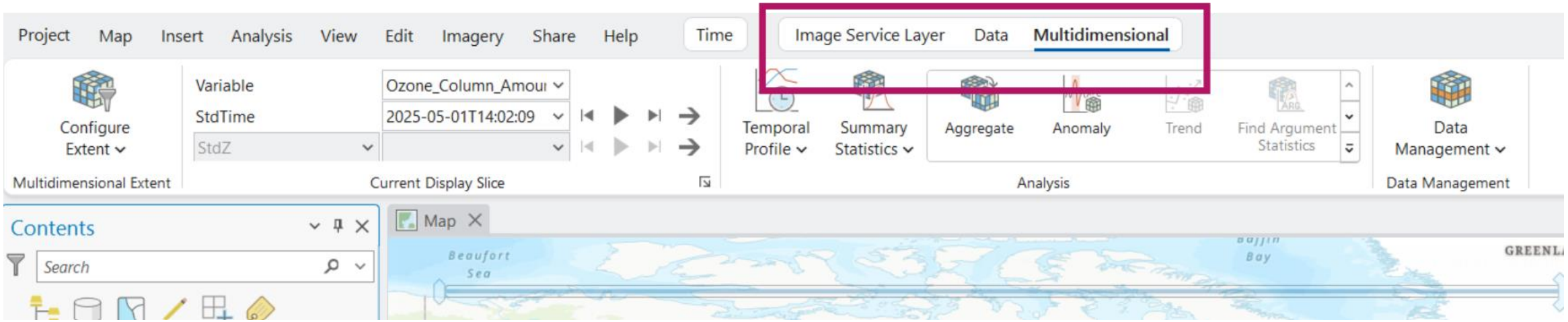




- Users may also utilize the service URL (available on the portal page) to access the service in ArcGIS Pro
- Go to “Map” ribbon
- Select “Add Data” > “From Path…”
- Enter the URL in the “Path” field in the popup and click “Add”
- **Note:** Using this method, the preferred colormap is not applied to the service. Users will have to adjust the symbology as needed.

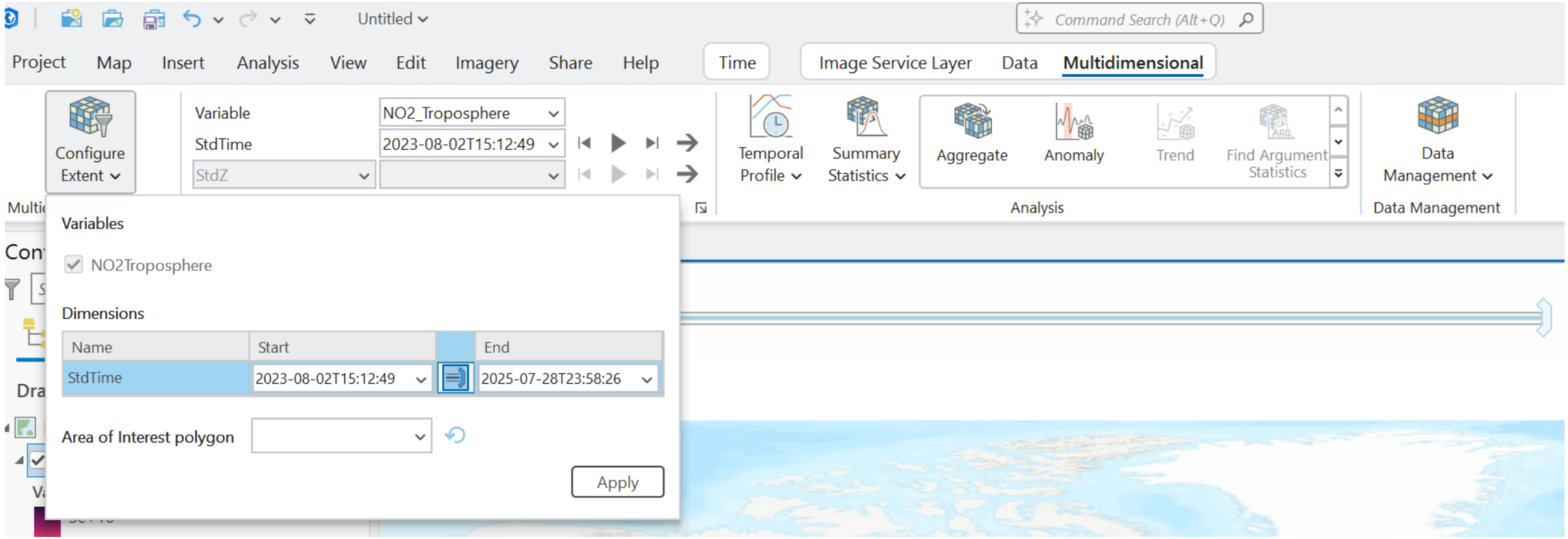
Image Service (Multidimensional) Tabs Appear in Ribbon

- Once the image service is added to the map, a new set of tabs will appear in the ribbon (Image Service Layer, Data, and Multidimensional).
- New Tabs in the Control Ribbon that Appear:
  - **Image Service Layer** – Primarily for visualization options; includes option to set transparency
  - **Data** – Data functions that will likely of less use with the services, but does offer an alternative method of charts
  - **Multidimensional** – Functions to control time extent, select specific time stamps, and analysis tools



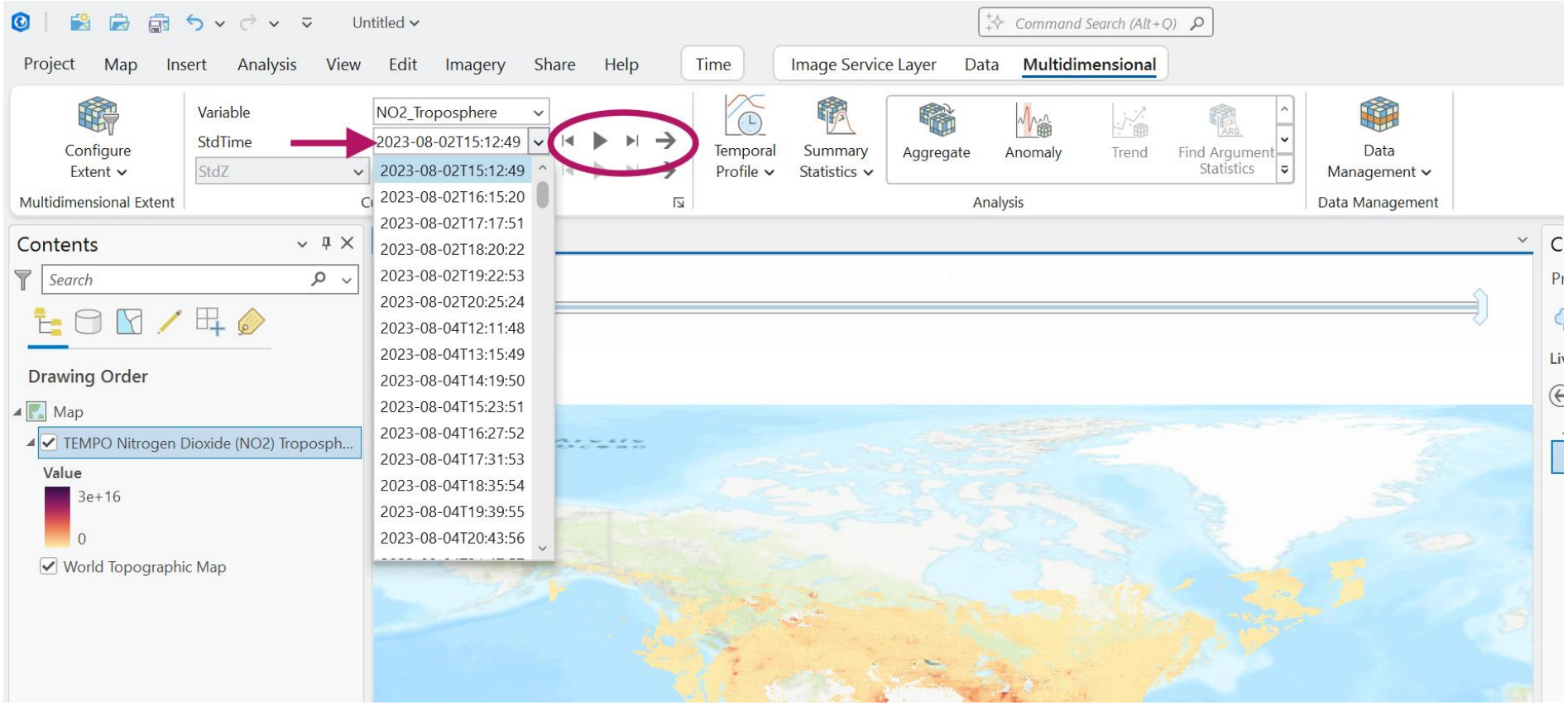
Multidimensional Tab: Configure Extent

- **Configure Extent** – Pick a specific time range for viewing/analysis if user doesn't want the entire TEMPO mission span.



Multidimensional Tab: Current Display Slice

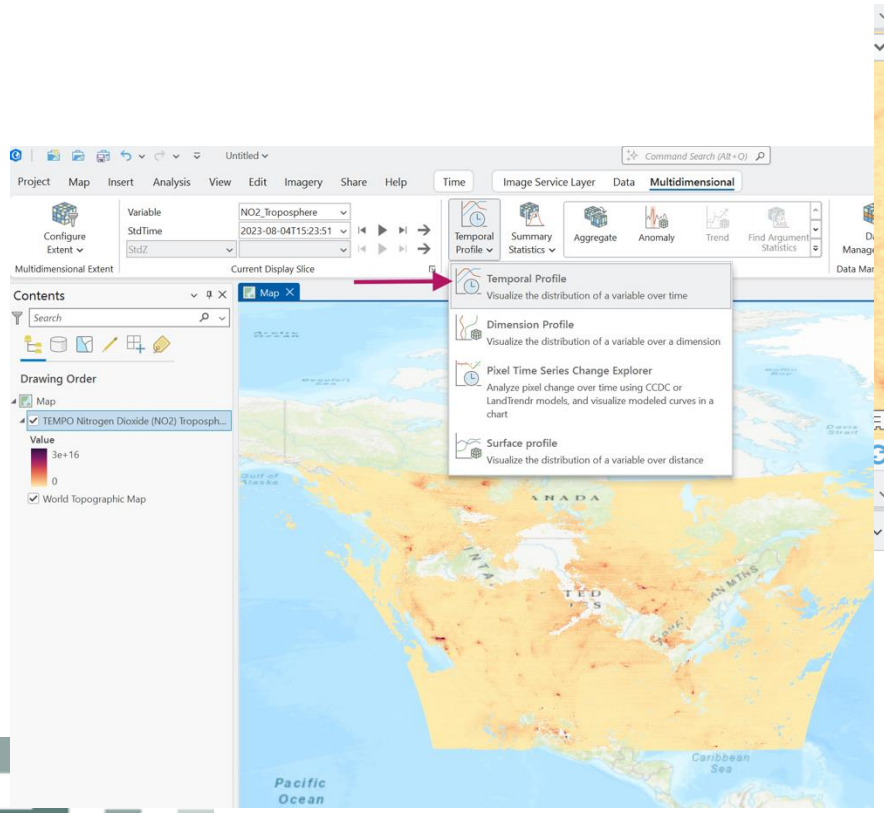
- **Variable** – If a service has more than one variable, then users may select variable of interest. Currently, the TEMPO services have one variable each.
- **StdTime** – Name of time variable (Standard Time). Users can select a specific time slice from the dropdown. Users can use the control arrows to step through the time slices.

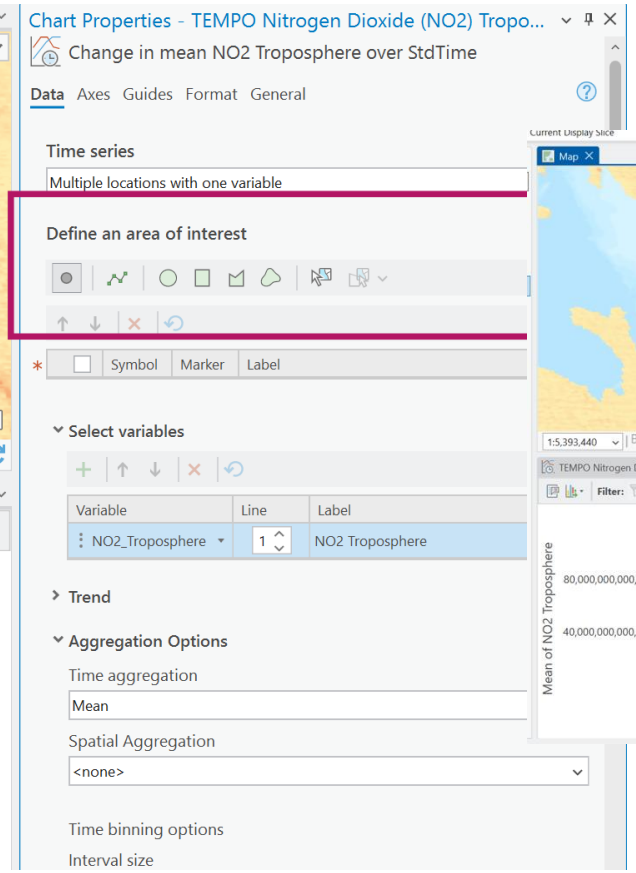


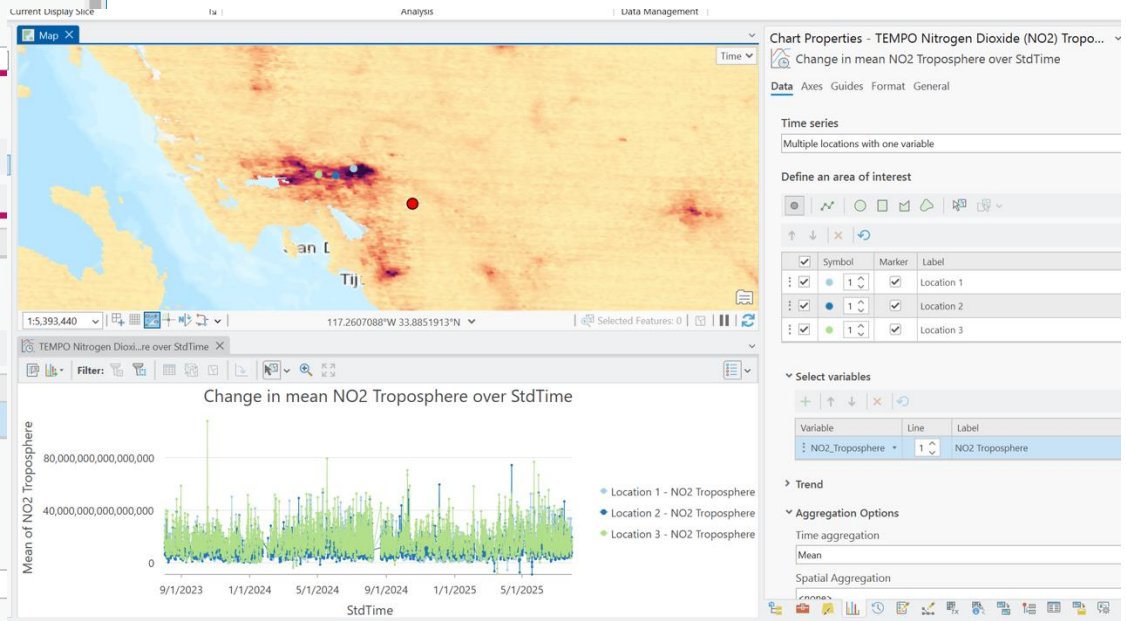
Multidimensional Tab: Analysis

Examples: Nitrogen Dioxide (California)

- The Analysis section provides several functions that can be used for various data analyses and graphical visualizations.
- Temporal Profile (Multidimensional tab > Temporal Profile > Temporal Profile)

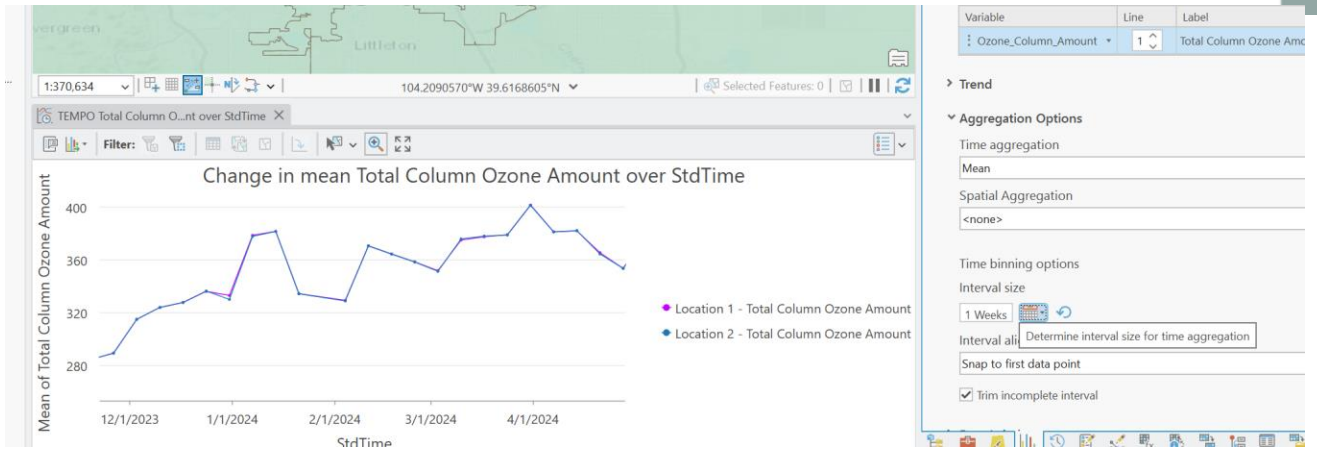


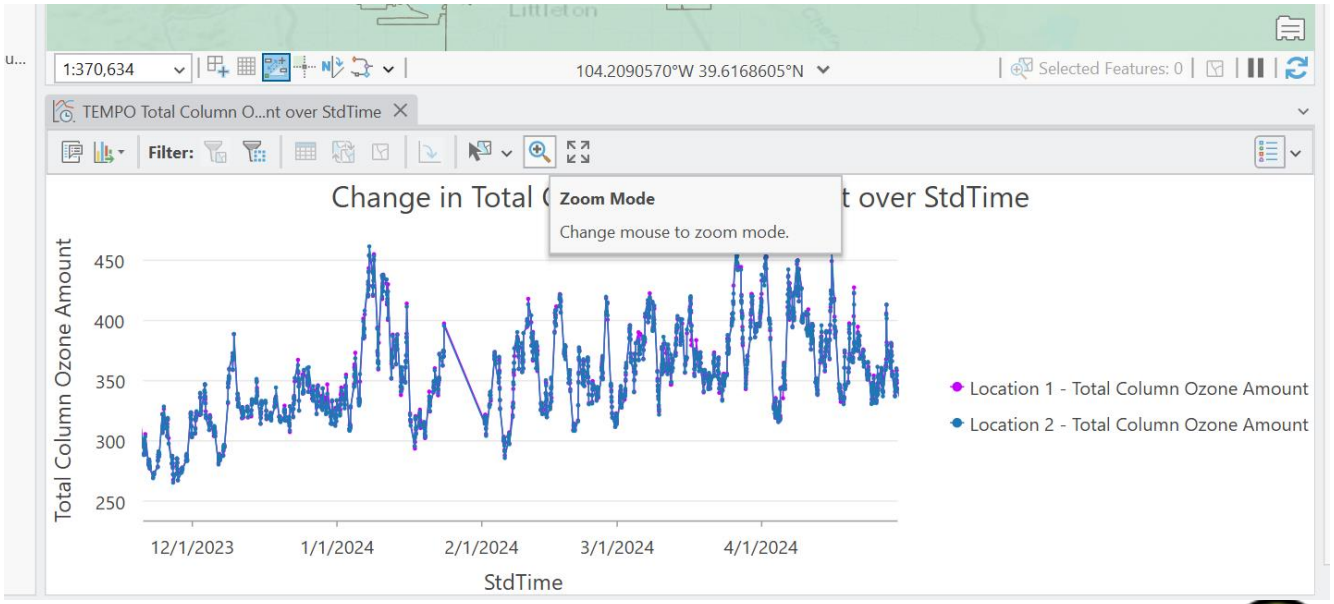




Additional Options in Temporal Profile

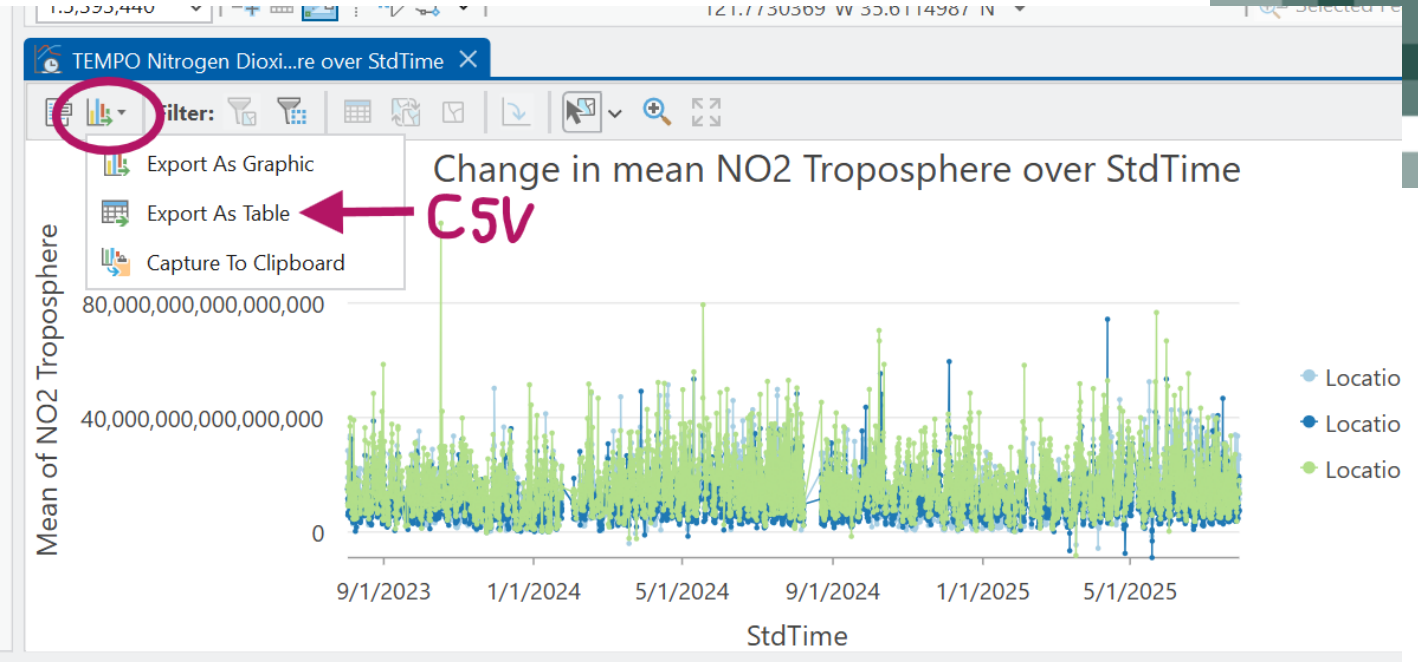
- **Time binning options > Interval size**
  - Users can choose different aggregation intervals when aggregating temporally
  - **Note:** There is a known bug in ArcGIS Pro currently in which the interval size cannot be decreased after selecting data on the map.
  - **Workaround:** Choose interval size before selecting data on map. Interval size can then be made larger, if desired, after data have been added.
- **Charts**
  - Users can zoom in on specific time periods of the chart for clarity.





Export Graph/Data from Temporal Profile

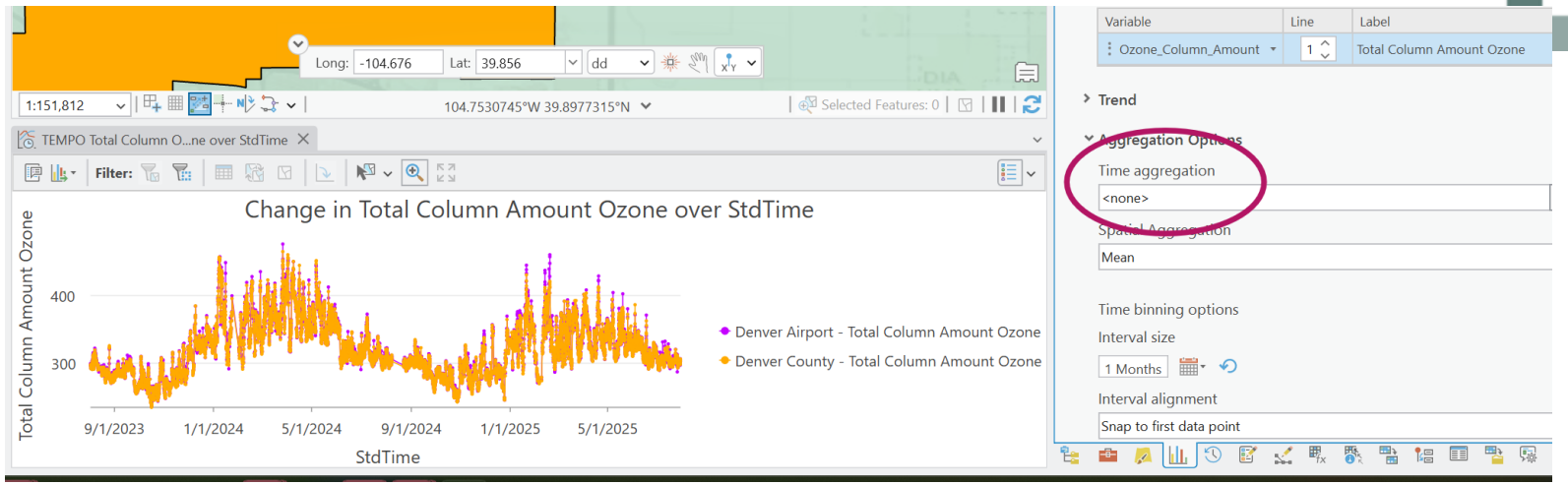
- Users can use the "Export" menu to export the chart as a graphic or export the data points to a CSV.
- **Note:** Variable and areas of interest can be named using the "Label" options in the "Temporal Chart" side menu.
- Data value labels can also be added under "Data Labels".
- **Note:** The CSV export option is limited. It will not allow you to export all data points for the TEMPO time series. This option is best used with the "Configure Extent" option set to a small time period. Depending on how many points are being exported, it may only include the data for the first point of interest.

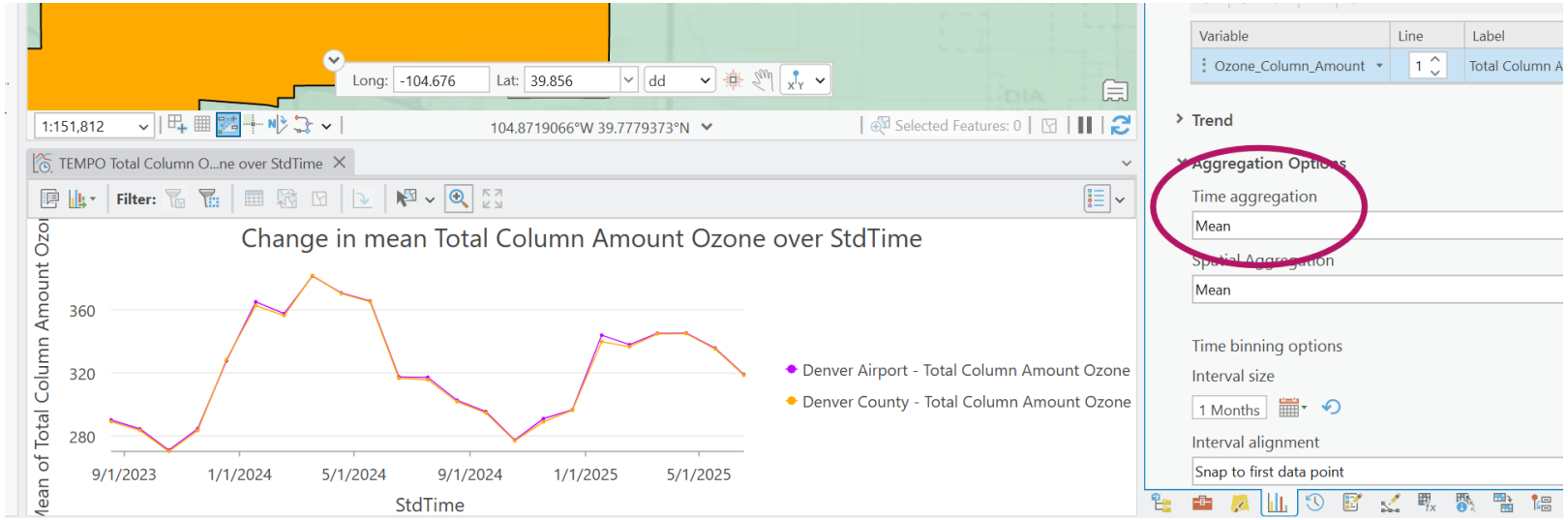


	A	B	C
1	StdTime	Denver Airport - Total Cc	Denver Cc
2	8/2/2023	299.65149	
3	8/2/2023	296.64874	
4	8/2/2023	299.47336	
5	8/2/2023	297.26422	
6	8/2/2023	295.13666	
7	8/2/2023	292.43546	
8	8/4/2023	291.56723	
9	8/4/2023	298.4473	
10	8/4/2023	301.06805	
11	8/4/2023	303.05496	
12	8/4/2023	303.78854	
13	8/4/2023	304.01926	
14	8/4/2023	303.09201	
15	8/4/2023	303.80042	
16	8/4/2023	305.0007	
17	8/4/2023	301.19879	

Important Note on Aggregation Options > Time Aggregation

- If "Time Aggregation" is set to "none," then the graph will include all data points in the time period (i.e., the time bin interval size is used for controlling the graph display).
- If "Time Aggregation" is set to something other than "none" (e.g., "mean"), the selected statistical method will be used, resulting in manipulated data (e.g., if a one-month interval is selected with a time aggregation of mean, then the data will be averaged by month resulting in one data point per month).
- Additional information can be found here: [Temporal Profile Chart](#).

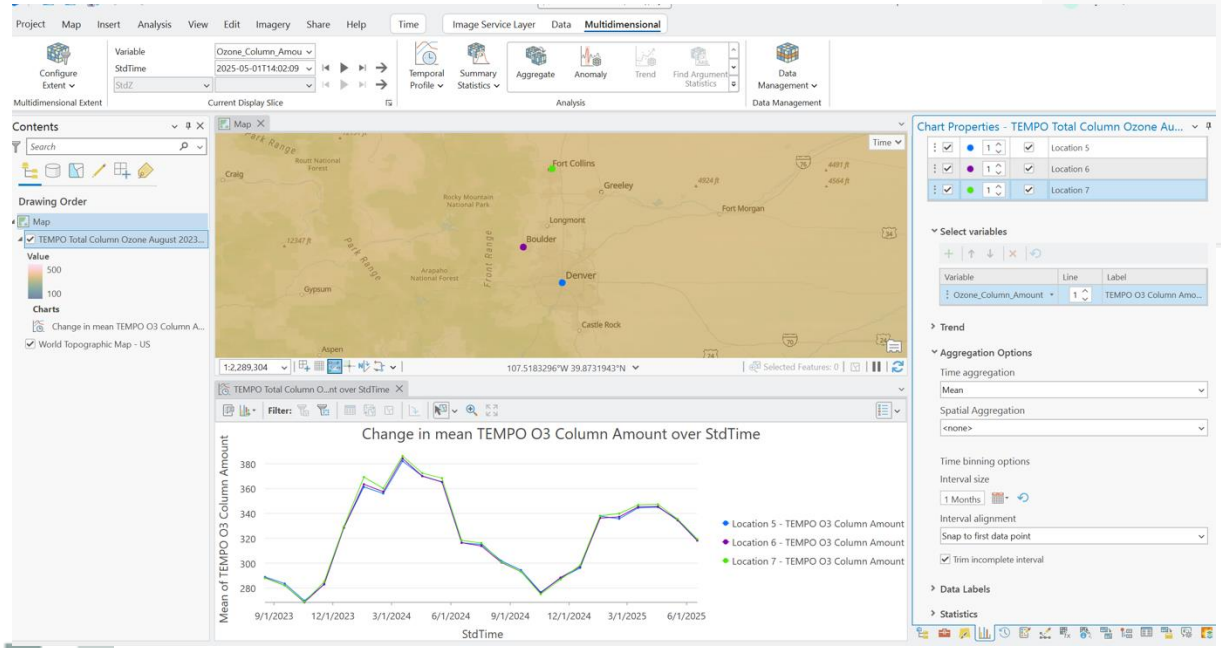


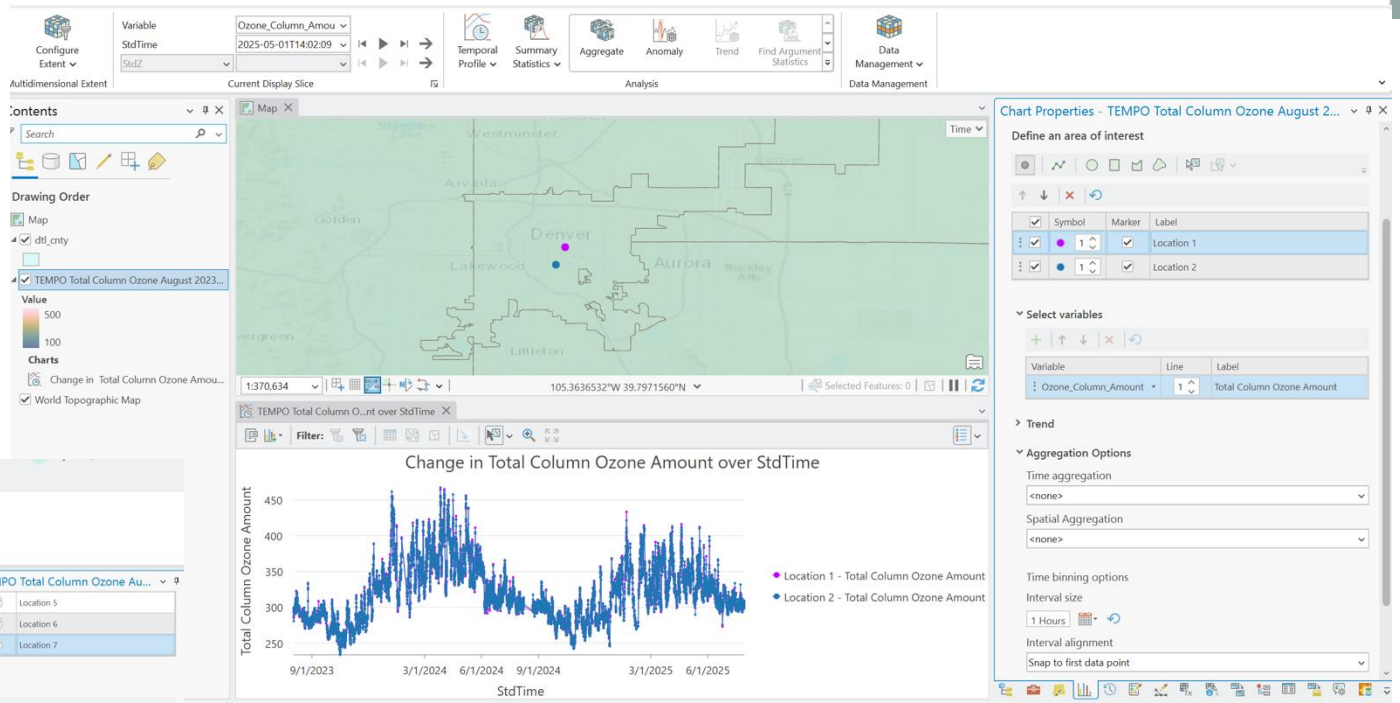


Temporal Profile: Comparing Multiple Points of Interest

Examples: Ozone Total Column (Colorado)

- Users can select multiple point locations to compare, changing the time period, time aggregation interval, and statistic shown.

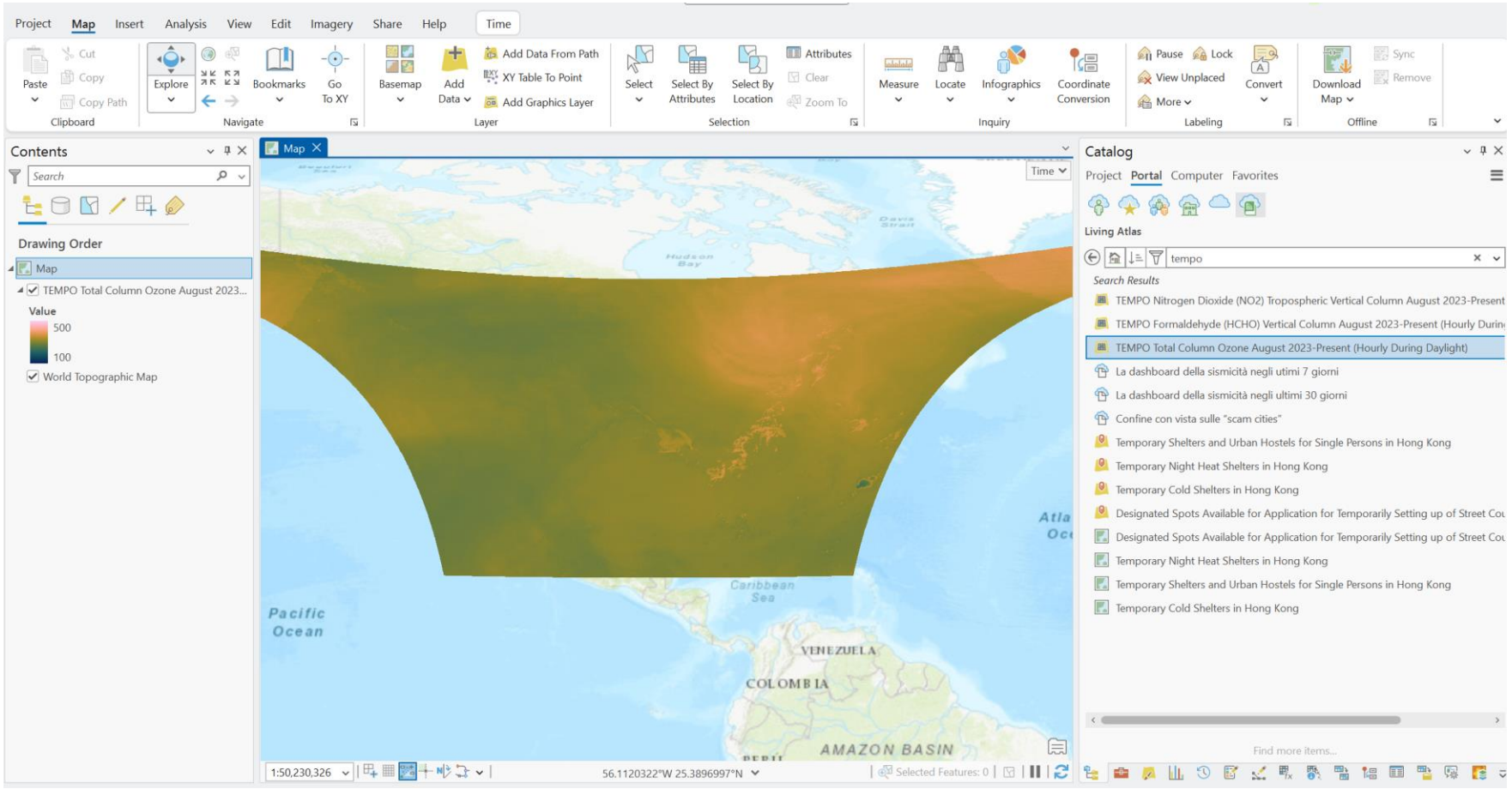




Demo: Temporal Analysis of Total Ozone Column Amount in Colorado

Step 1: Add TEMPO Data from Esri Living Atlas Portal

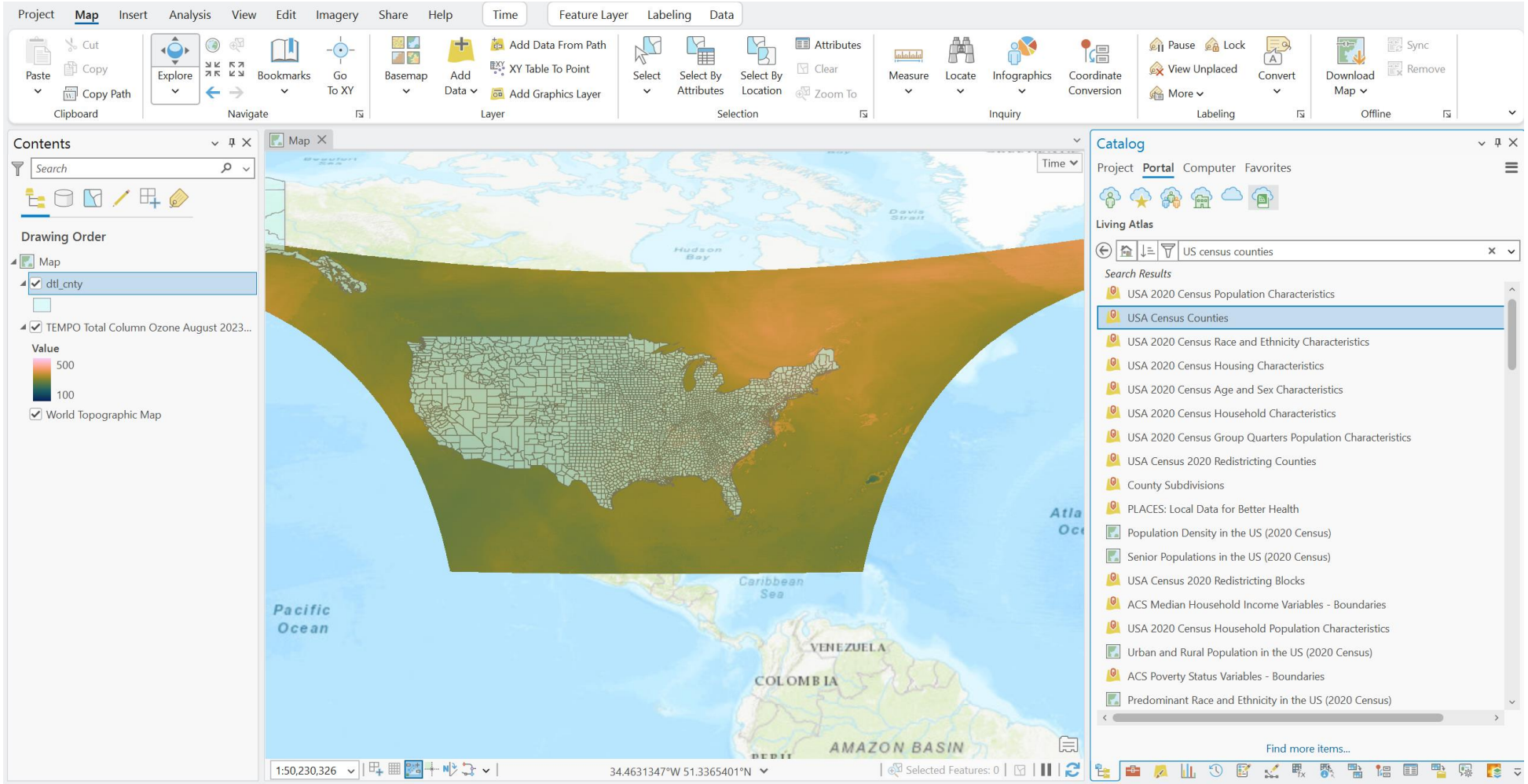
- Go to Esri Living Atlas Portal
- Search and add TEMPO Total Column Ozone image service to map



Add Data for Comparison

Step 2: Add US County Data from Esri Living Atlas Portal

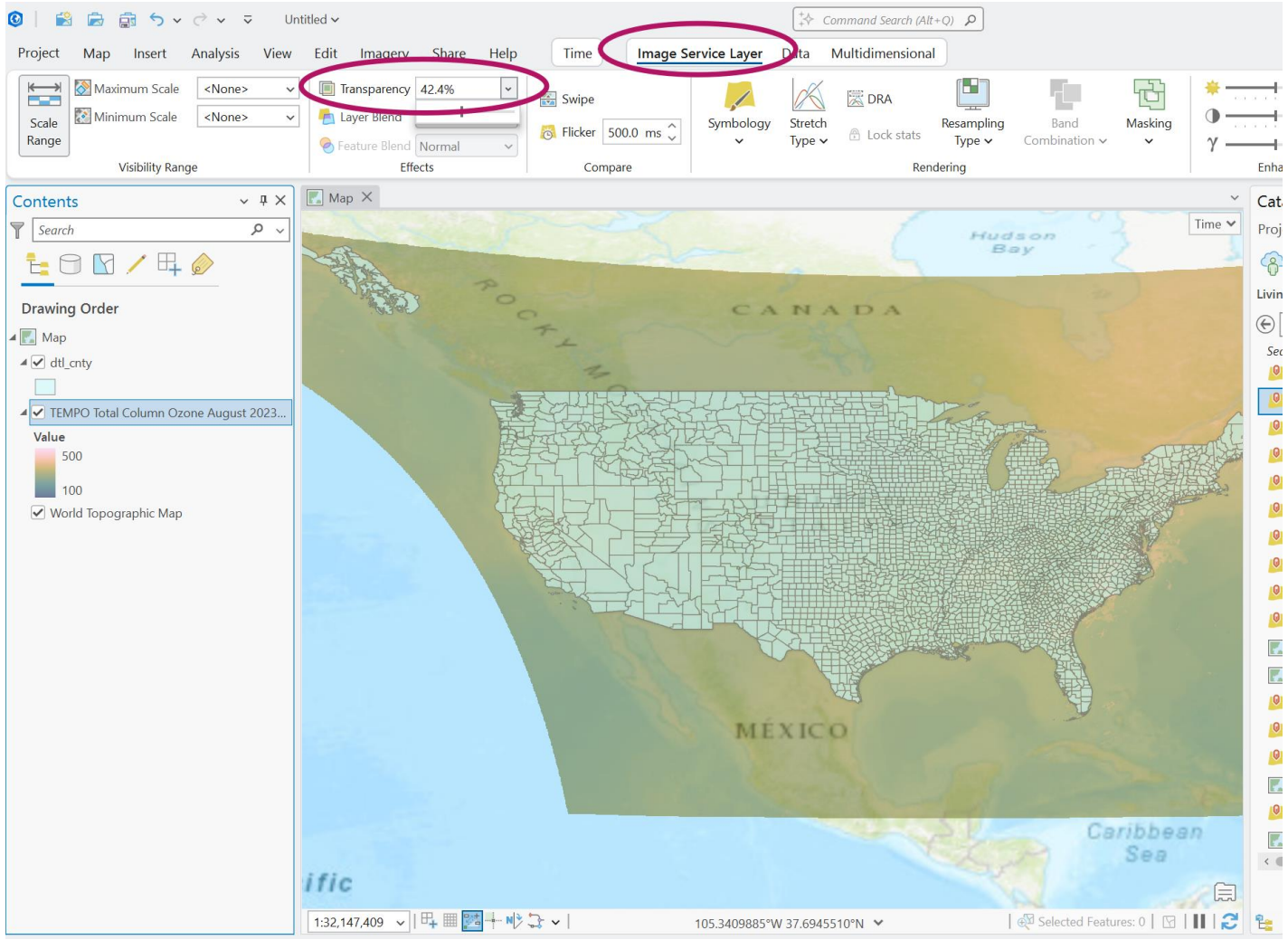
- Search and add "USA Census Counties" service to map



Set Visualizations of Layers

Step 3: Set Transparency of TEMPO Ozone Layer

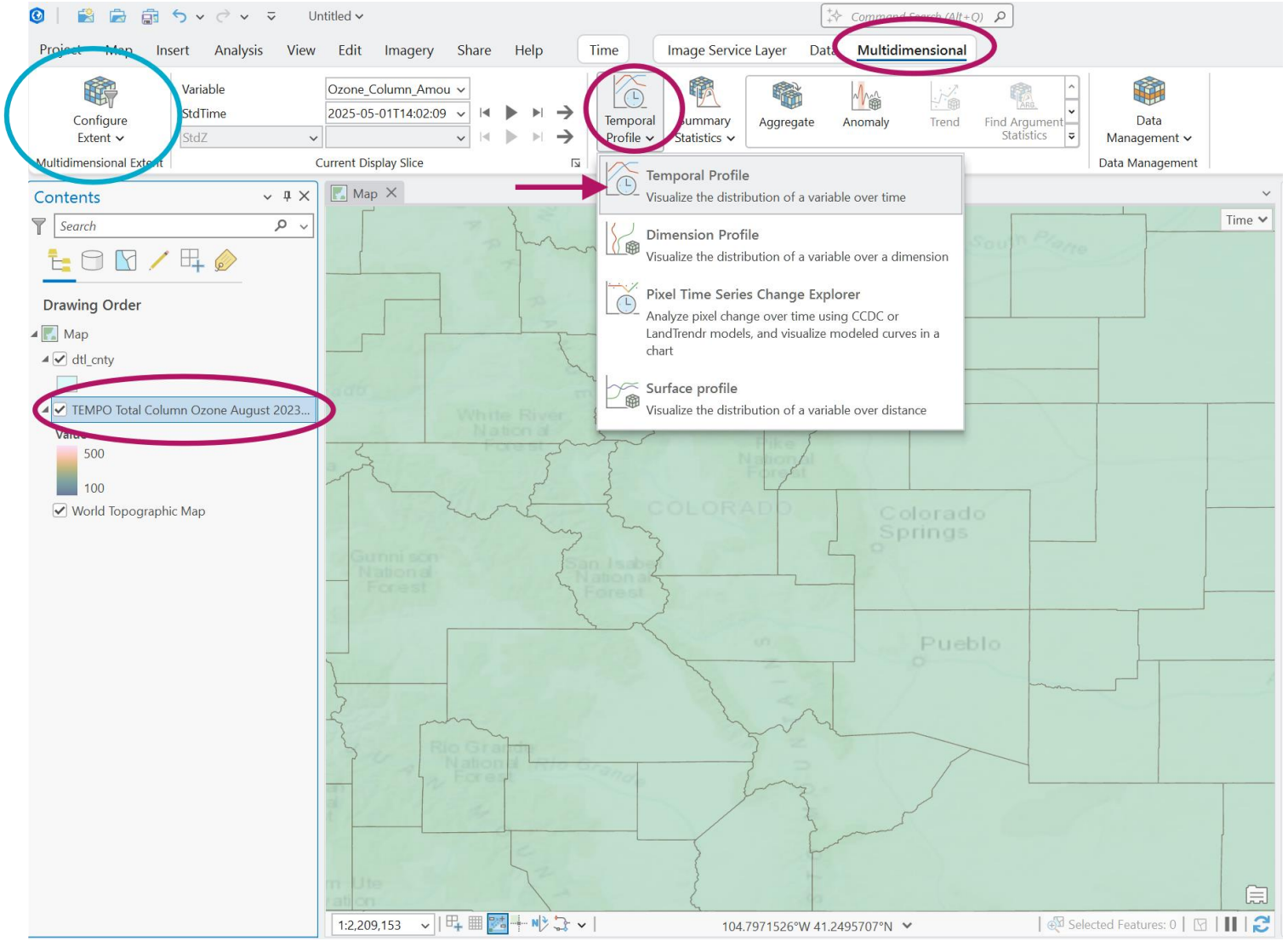
- Go to Image Service Layer tab in ribbon
- Set transparency of TEMPO ozone layer to desired amount (e.g., helpful to see basemap beneath data layer)



Temporal Profile

Step 4: Set Up Temporal Profile

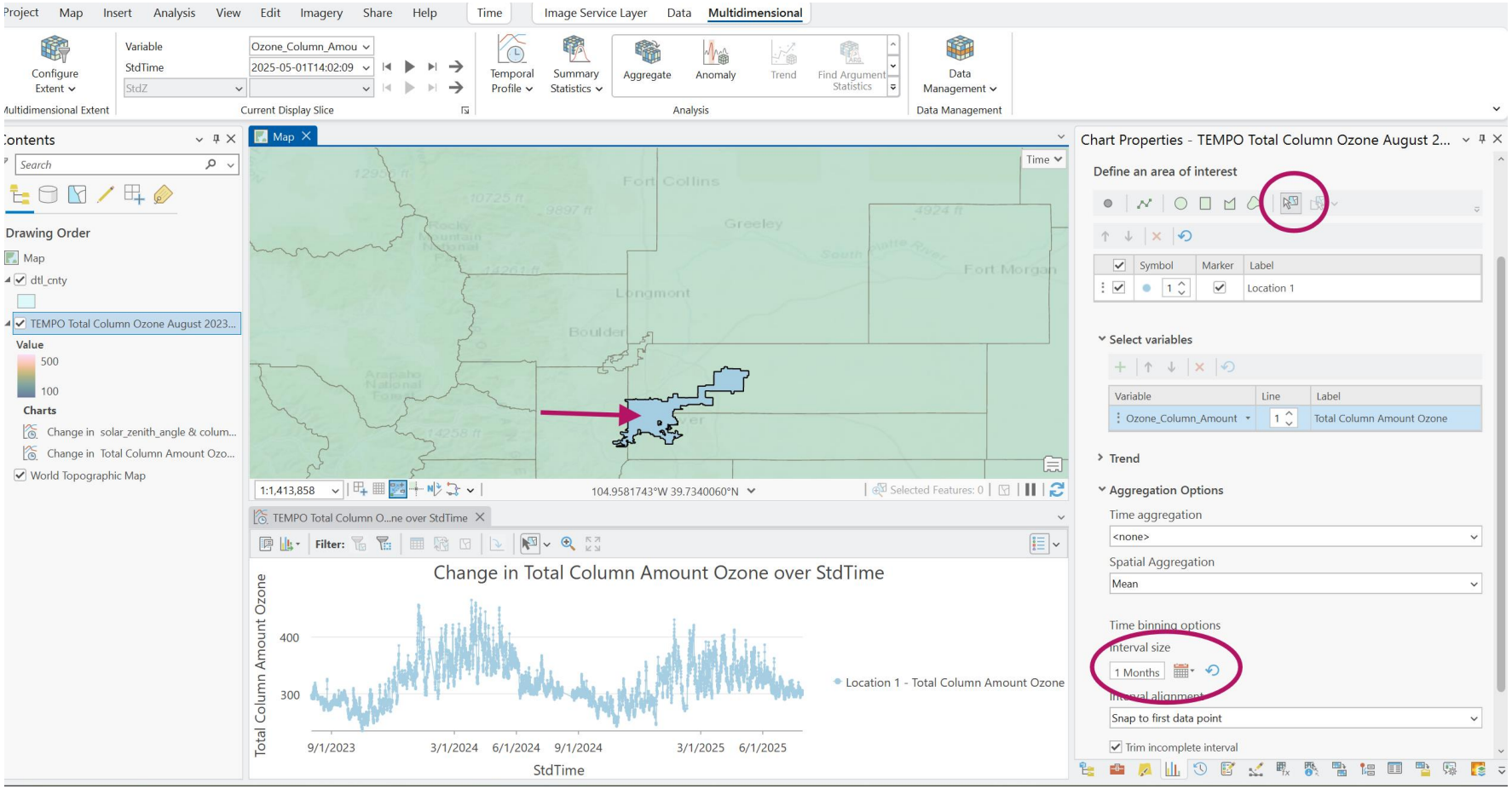
- Go to “Multidimensional” tab in ribbon
- Select “Temporal Profile”
- **Note:** Make sure that the TEMPO ozone layer is active/highlighted in the Contents pane
- **Note:** Can optionally select “Configure Extent” to choose a smaller time period to use



Temporal Profile: Compare Two Counties

Step 5: Add County of Interest to Temporal Profile

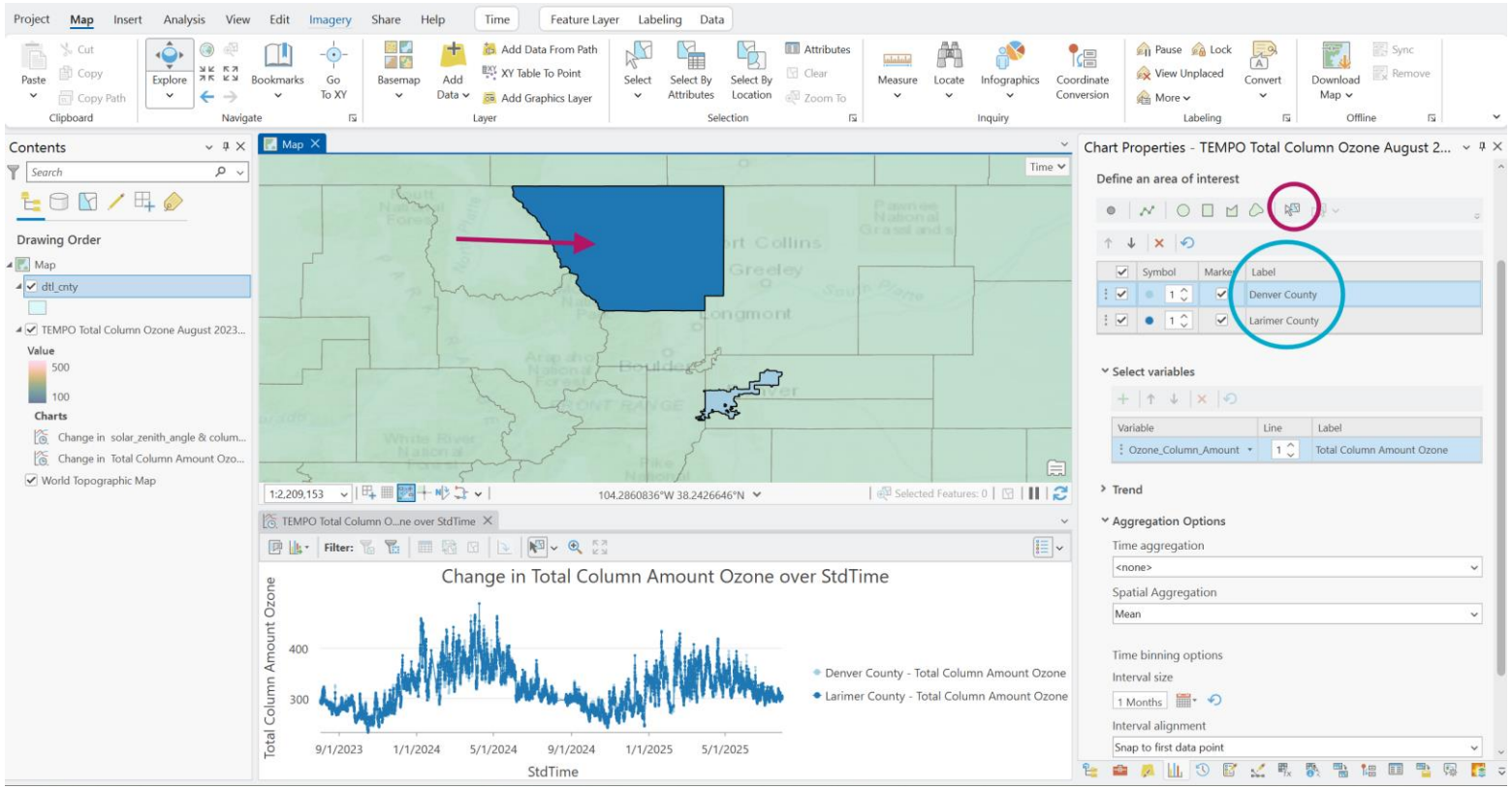
- Under "Define an area of interest," select the "Feature Selector" option
- Click on county of interest in the map
- Shown: Denver County, CO
- Time aggregation: None
- Spatial aggregation: Mean
- Interval size: 1 month



Temporal Profile: Compare Two Counties

Step 6: Add a Second County of Interest to Temporal Profile for Comparison

- Under "Define an area of interest," select the "Feature Selector" option
- Click on county of interest in the map
- Shown: Larimer County, CO
- Time aggregation: None
- Spatial aggregation: Mean
- Interval size: 1 month
- **Note:** Labels can be changed in the "Define an area of interest." Changes are shown in the labels used in the temporal profile chart.

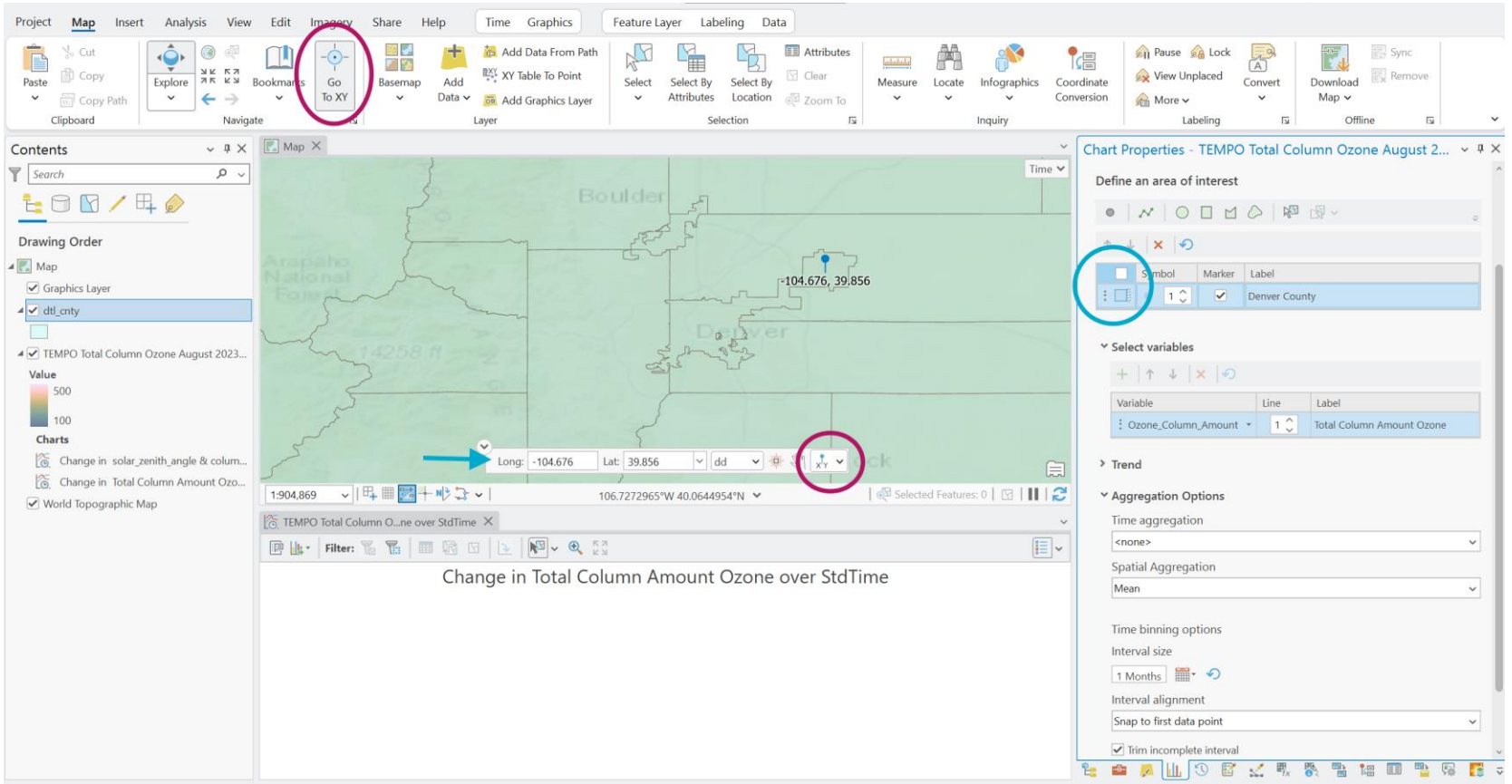


Temporal Profile: Compare Point of Interest with County

Step 7: Add a Pin to Mark Another Point of Interest on the Map

- Go to "Map" tab in ribbon
- Select "Go to XY"
- Type in longitude and longitude of desired point
  - Denver Airport:

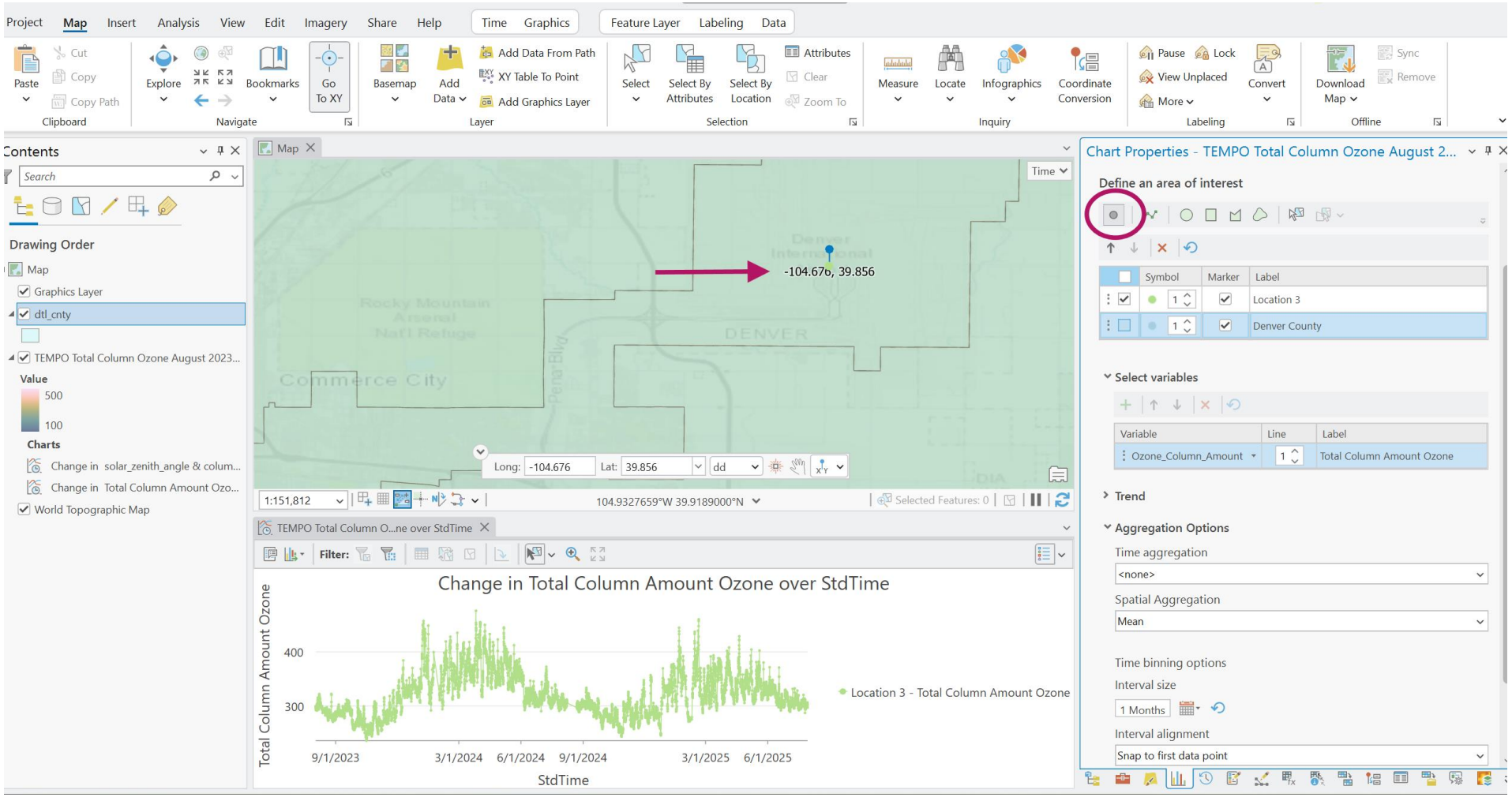
  Lon: -104.676 Lat: 39.856
- Click "Mark Location" and choose an option to drop a pin on desired point
- **Note:** Previously chosen points in Temporal Profile may block view on map. Users can temporarily uncheck the other area of interest, if needed.



Temporal Profile: Compare Point of Interest with County

Step 8: Add Point of Interest to Temporal Profile

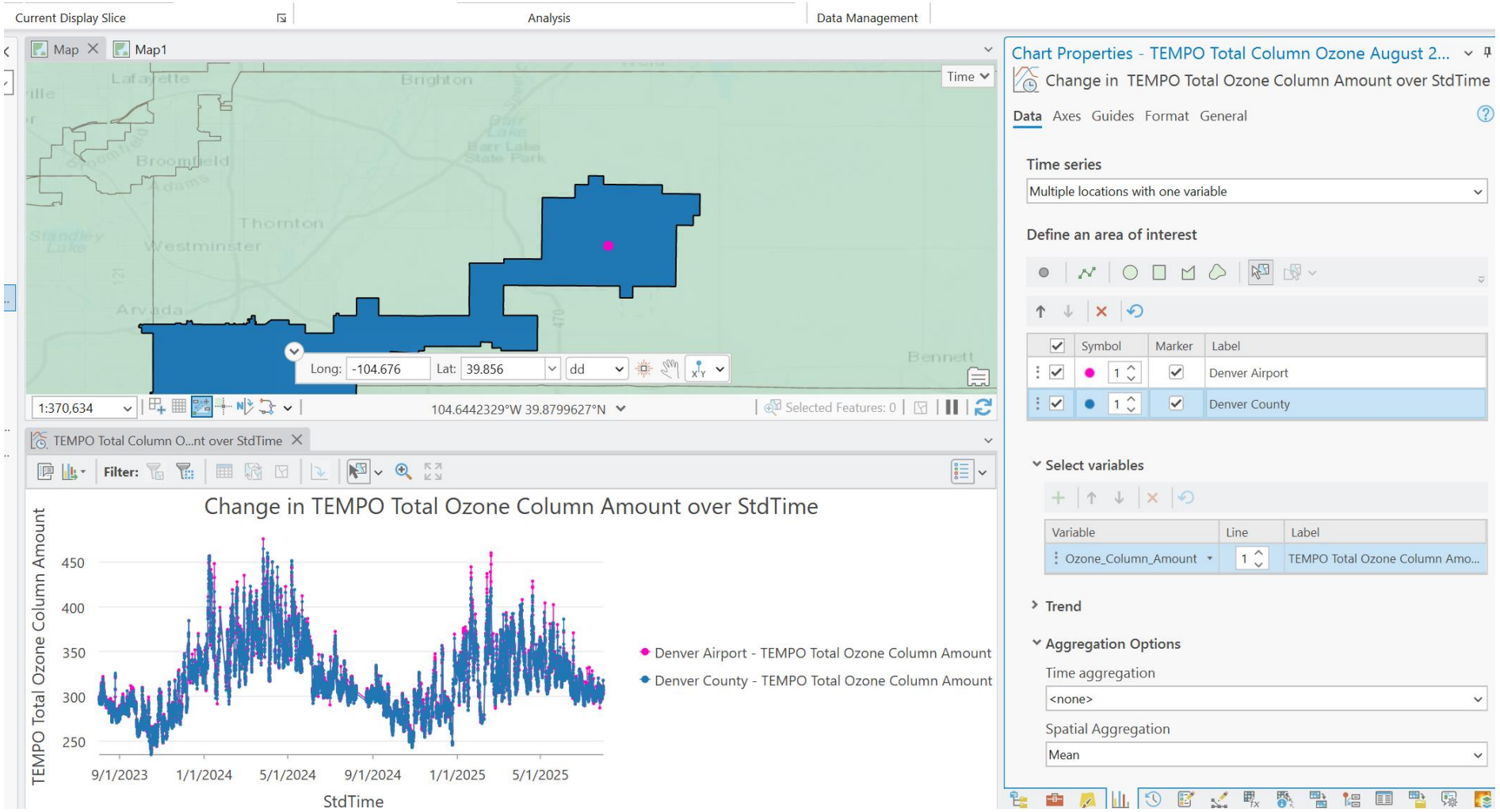
- Under "Define an area of interest," select the Point option
- Click on the map at the base of the dropped pin



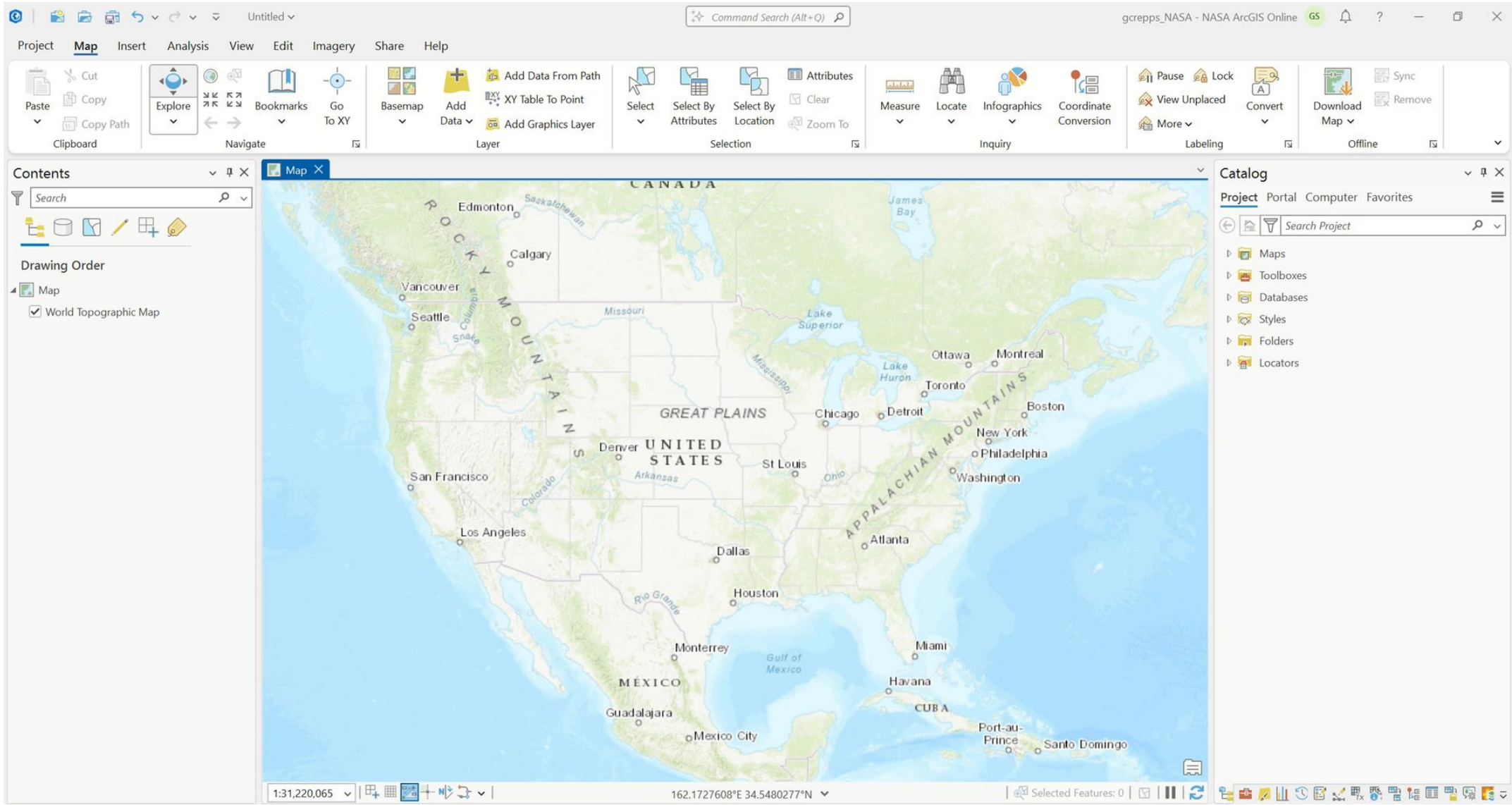
Temporal Profile: Compare Point of Interest with County

Step 9: Review Temporal Profile

- Different time aggregation, time bin intervals, and spatial aggregation options can be selected to explore the data.



Demo: Adding Data, Temporal Profile with Two Counties



Demo: Temporal Profile with Point of Interest and County