

# EPA Tools and Resources Webinar: Web-Based Data Visualization of Air Sensor Data with RETIGO Version 4

**Andrea Clements, PhD**

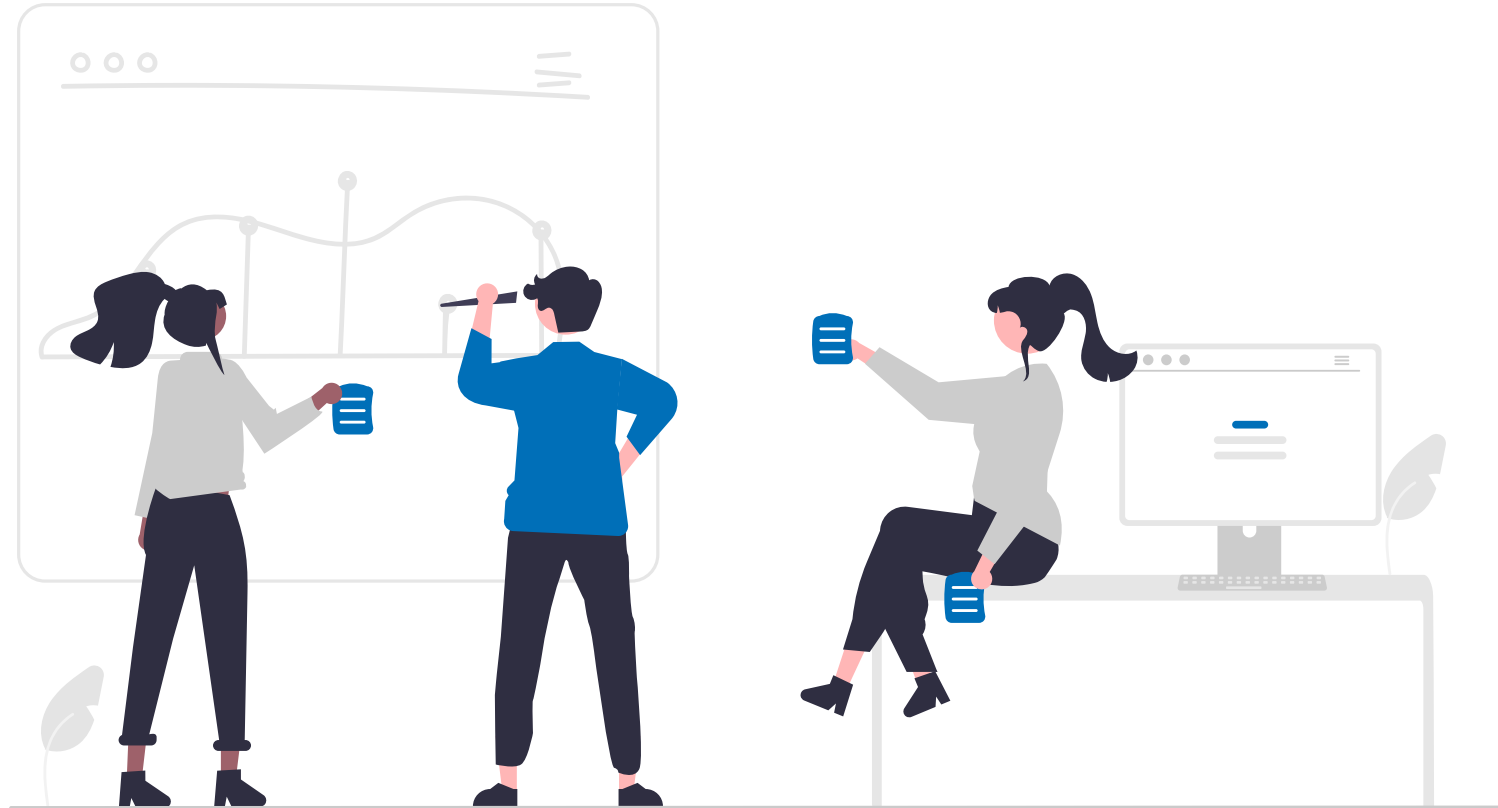
*Center for Environmental Measurement and Modeling  
US EPA Office of Research and Development (ORD)*

**June 5, 2024**



# Presentation Outline

- Problem
- Approach
- Introduction to RETIGO
  - Preparing data files
  - User controls
  - Key visualizations
  - Export options
  - Next steps
- Use Case Examples
- Impact
- Anticipated Outcomes
- Take Home Messages
- Resources
- Acknowledgements and Contacts



# Problem: Data Visualization

- **Use of air sensors continues to grow**
  - Sensors are used by a variety of people and organizations
  - Applications can be stationary or mobile
- **Users have a variety of goals in collecting air sensor data**
  - Goals span a range (e.g.; education -> supplemental monitoring)
  - Goals can influence the number or sensors and the amount of data collected
- **Data visualization can help people learn from and interpret data**
  - Project goals can influence the types of visualizations needed
  - Users and stakeholders have a variety of backgrounds and levels of expertise and thus have different needs when it comes to data visualization



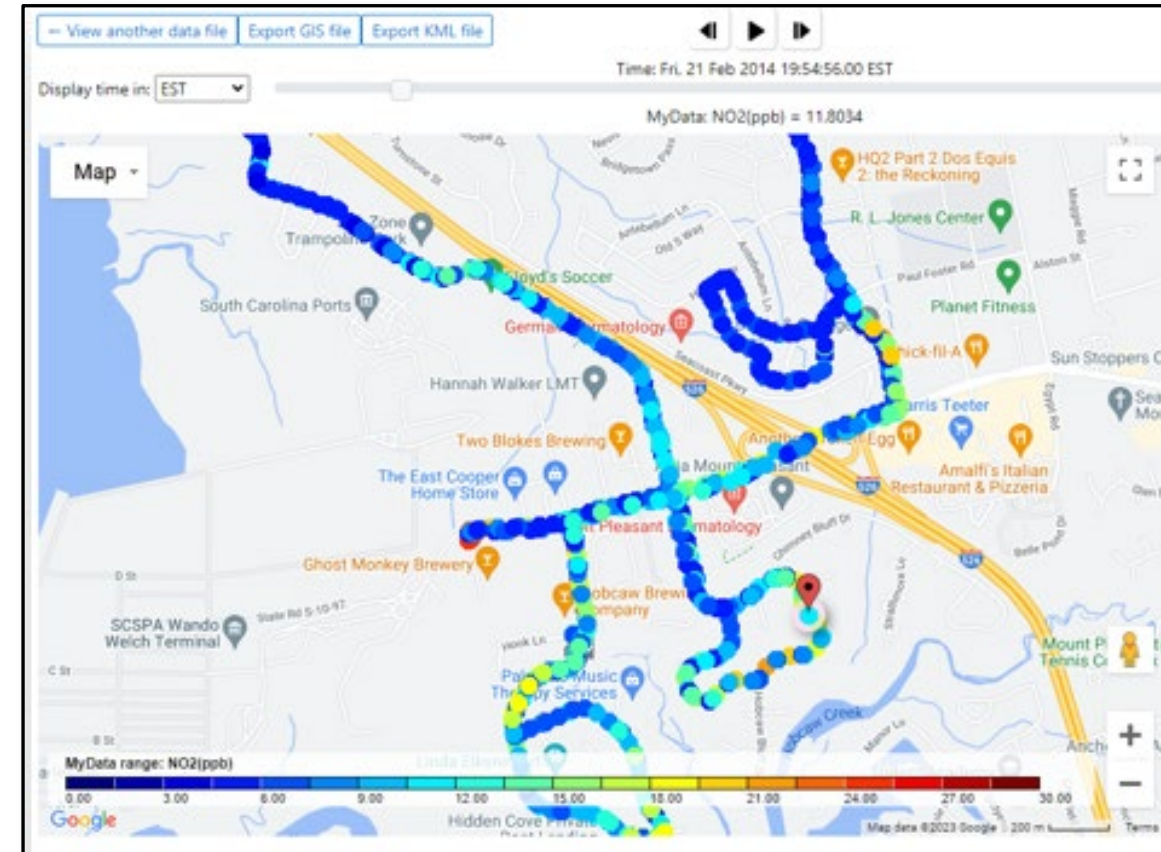
# Problem: Air Sensor Data

- **Air sensors can produce a large volume of data quickly**
  - Familiar tools (e.g., Excel) may no longer be sufficient; new tools or coding skills may be needed
  - Organizing, harmonizing, and visualizing multiple sensors or data sources can be time consuming and tricky; expertise would be helpful
- **Some data visualization tools exist but may not meet user needs**
  - Manufacturers may provide a proprietary data portal but may display only one sensor type, be costly to maintain, or limit sharing
  - Data visualization code packages exist but require coding skill
  - Visualizations may not be customizable

**Solution: Build a tool that reduces the technical barriers associated with data visualization thereby allowing more users to explore their air quality data**

# Approach – Introducing RETIGO

- **RETIGO is the Real-Time Geospatial Data Viewer**
  - It is a FREE web-based data analysis and visualization tool that allows users to quickly display and explore their own data
- **Key Features**
  - NO coding required
  - Users provide their own datasets
  - Data remains local; will NOT be shared with others unless desired\*
  - Data can be compared with several other public data sources



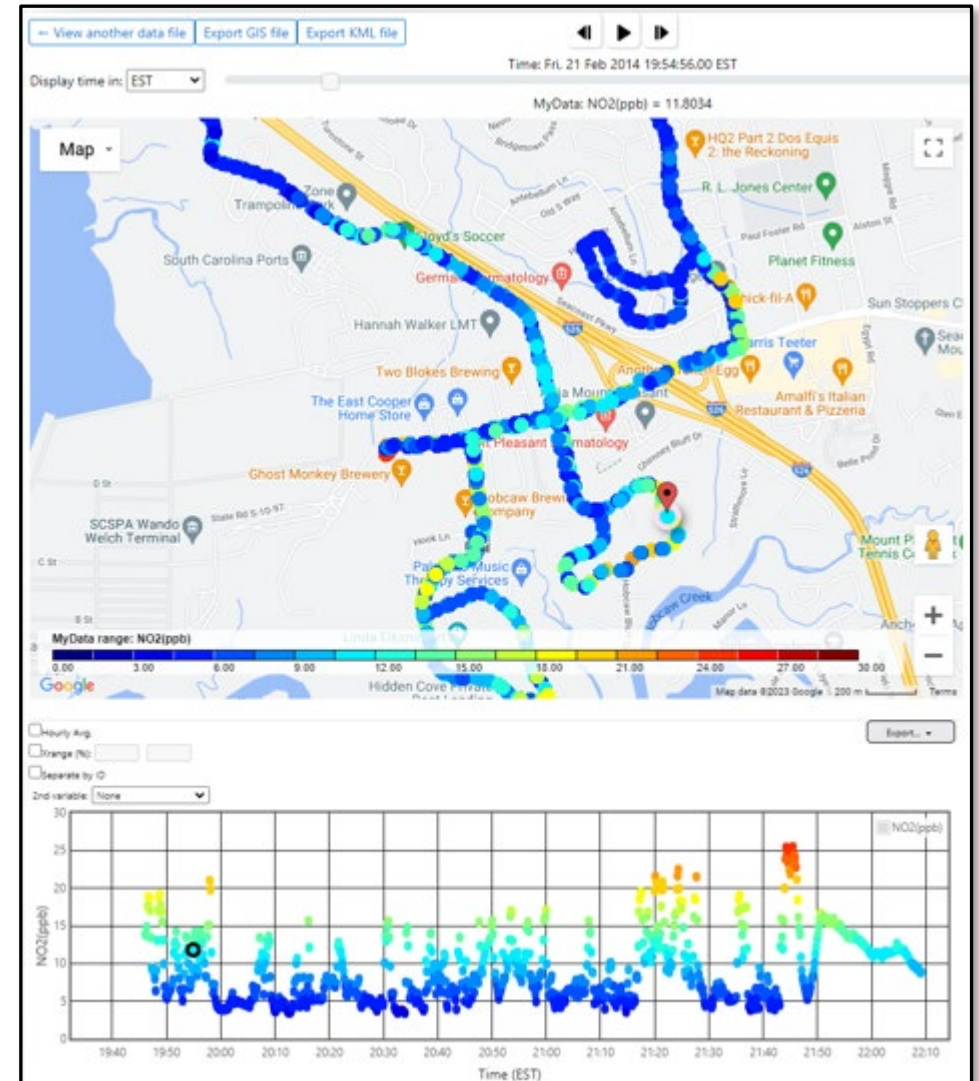
# Preparing Data Files

- **Sensor data files have a variety of formats and likely need to be edited before they can be loaded into RETIGO**
  - Save data files in either a space or comma delimited format (e.g., .csv)
  - Ensure the file contains:
    - Time – ISO 8601 standard format; labeled as “Timestamp(UTC)”
    - Location – 2 columns; labeled as “EAST\_LONGITUDE(deg)” and “NORTH\_LATITUDE(deg)”
    - Sensor ID – labeled “ID(-)”; can contain several sensors
    - Pollutant/environmental variables (with units) – can contain several columns

```
## Operator: Jane Doe
## Location: Raleigh NC
Timestamp(UTC)      EAST_LONGITUDE(deg) NORTH_LATITUDE(deg) ID(-)  ozone(ppb)
2012-07-18T15:44:00-00:00    -78.9979      35.9508      route1  49.0491
2012-07-18T15:44:19-00:00    -78.9947      35.9470      route1  43.2706
2012-07-18T15:44:57-00:00    -78.9896      35.9361      route1  42.3130
2012-07-18T15:45:58-00:00    -78.9846      35.9172      route1  47.7046
2012-07-18T15:46:17-00:00    -78.9733      35.9048      route1  47.7046
```

# Key Visualizations

- **A map displays user data**
  - Users can adjust the base map, color scale, and the color scale range to customize the visualization
- **A time series plot appears below map**
  - Users can select the pollutant or environmental variable to visualize
  - The cursor can be used to zoom into a more specific time frame
  - The graph can be exported and saved
- **Buttons along the top control an animation and markers move within both images**



# User Control Menus – MyData and Merge

- A series of menus on the right allow users to control the displays

“MyData” lets you control how your data is displayed

Plot selection and options

Filter by the IDs in your data file

Time range selector

Variable selection, color map, and data range

“Merge” lets you import air quality or weather data

PurpleAir read key

Add your own stationary monitoring data files (up to five)

Add web available sensor and/or satellite data layers to the map

Opacity for satellite layers

Global data ranges for imported data

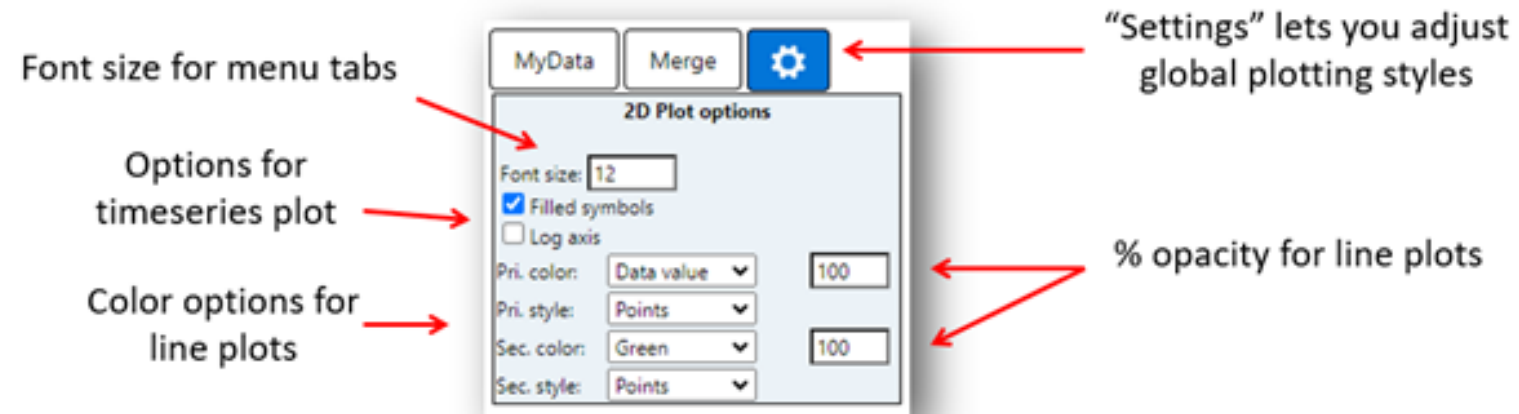
Add web available sensor data to the timeseries plot

	Global range	min	max
AirNow O <sub>3</sub>	0	120	
AirNow PM <sub>2.5</sub>	0	60	
AirNow CO	0	1	
AirNow NO <sub>2</sub>	0	60	
AirNow SO <sub>2</sub>	0	20	
METAR temp.		-10	40
METAR pressure		1000	1200
METAR wind spd.		0	20
PurpleAir PM <sub>2.5</sub>		0	100



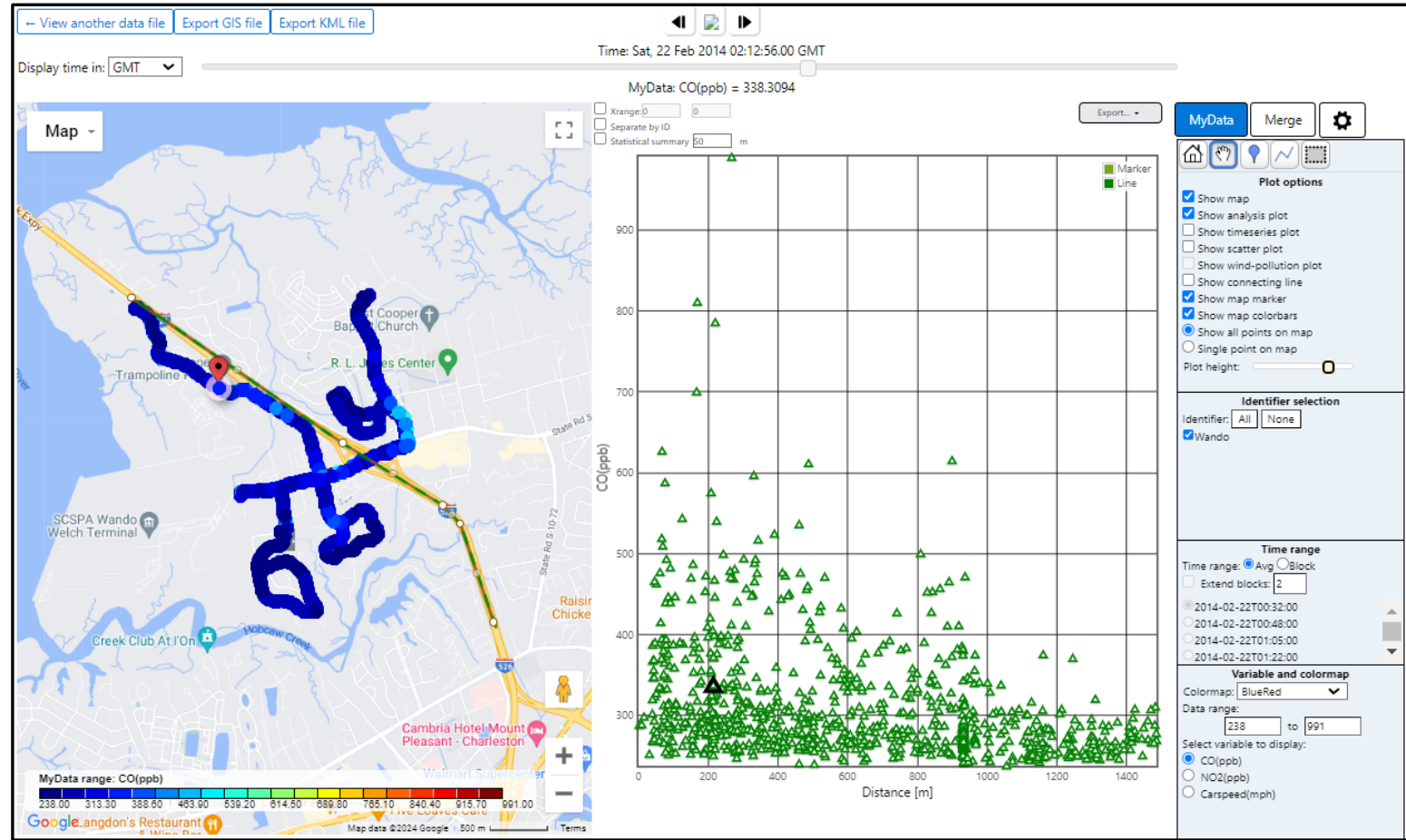
# User Controls Menus - Settings

- A series of menus on the right allow users to control the displays



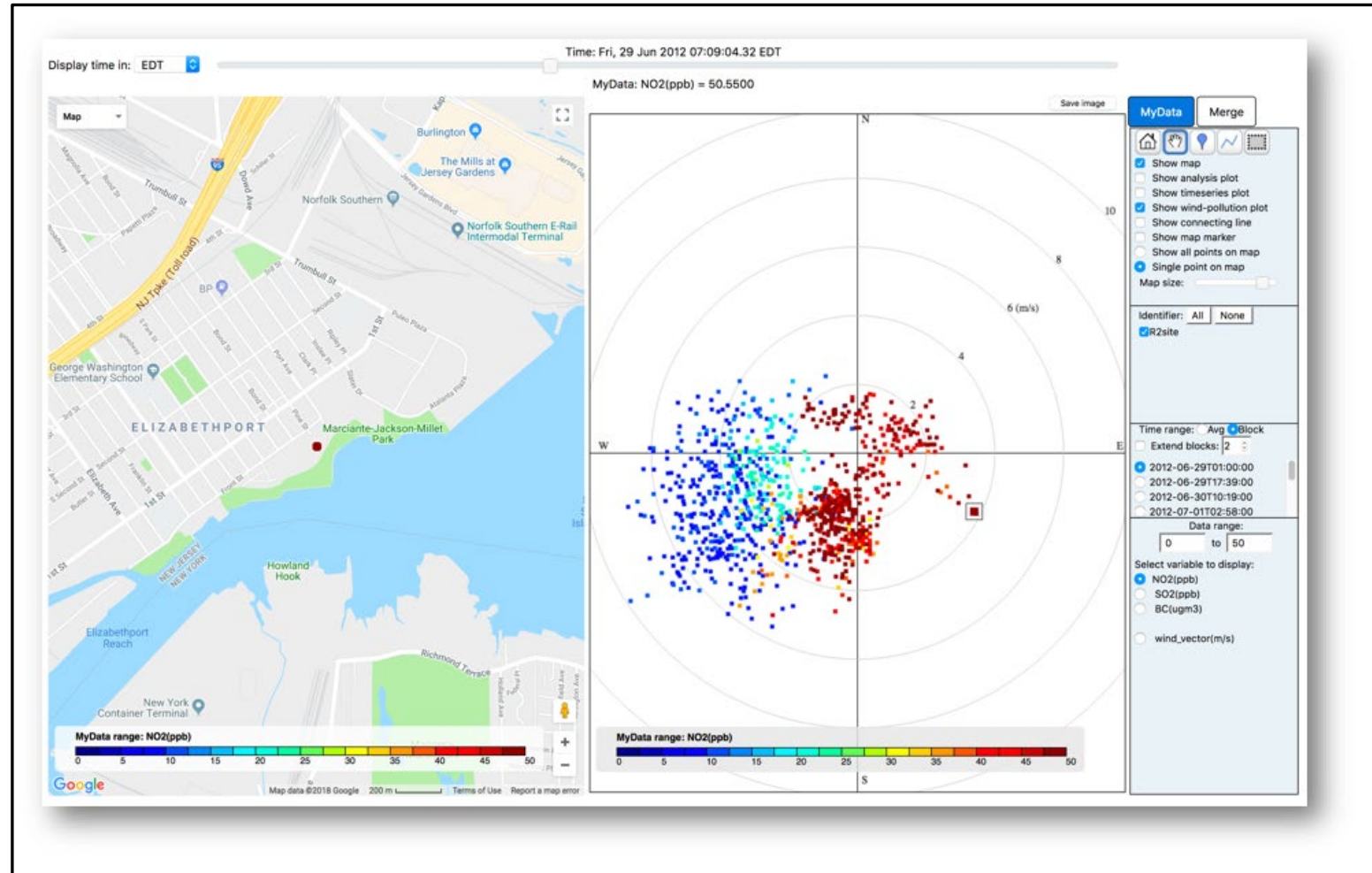
# Investigative Visuals – Distance from Potential Sources

- **Several options help investigate user data**
  - Data vs. distance from a point
  - Data vs. minimum distance from a line



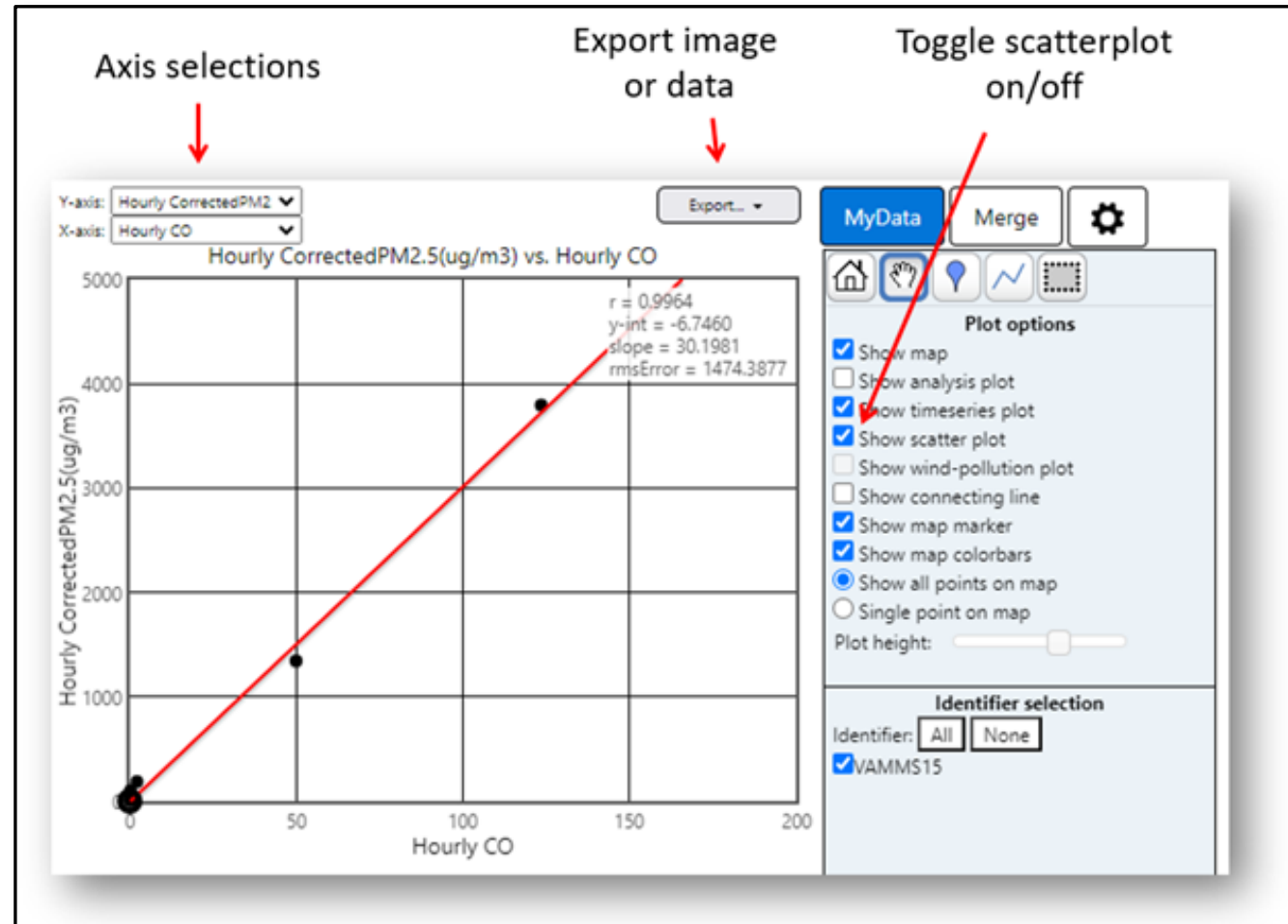
# Investigative Visuals – Wind

- **Several options help investigate user data**
  - Data vs. distance from a point
  - Data vs. minimum distance from a line
  - Data in a polar wind-pollution format



# Investigative Visuals – Variable Comparison

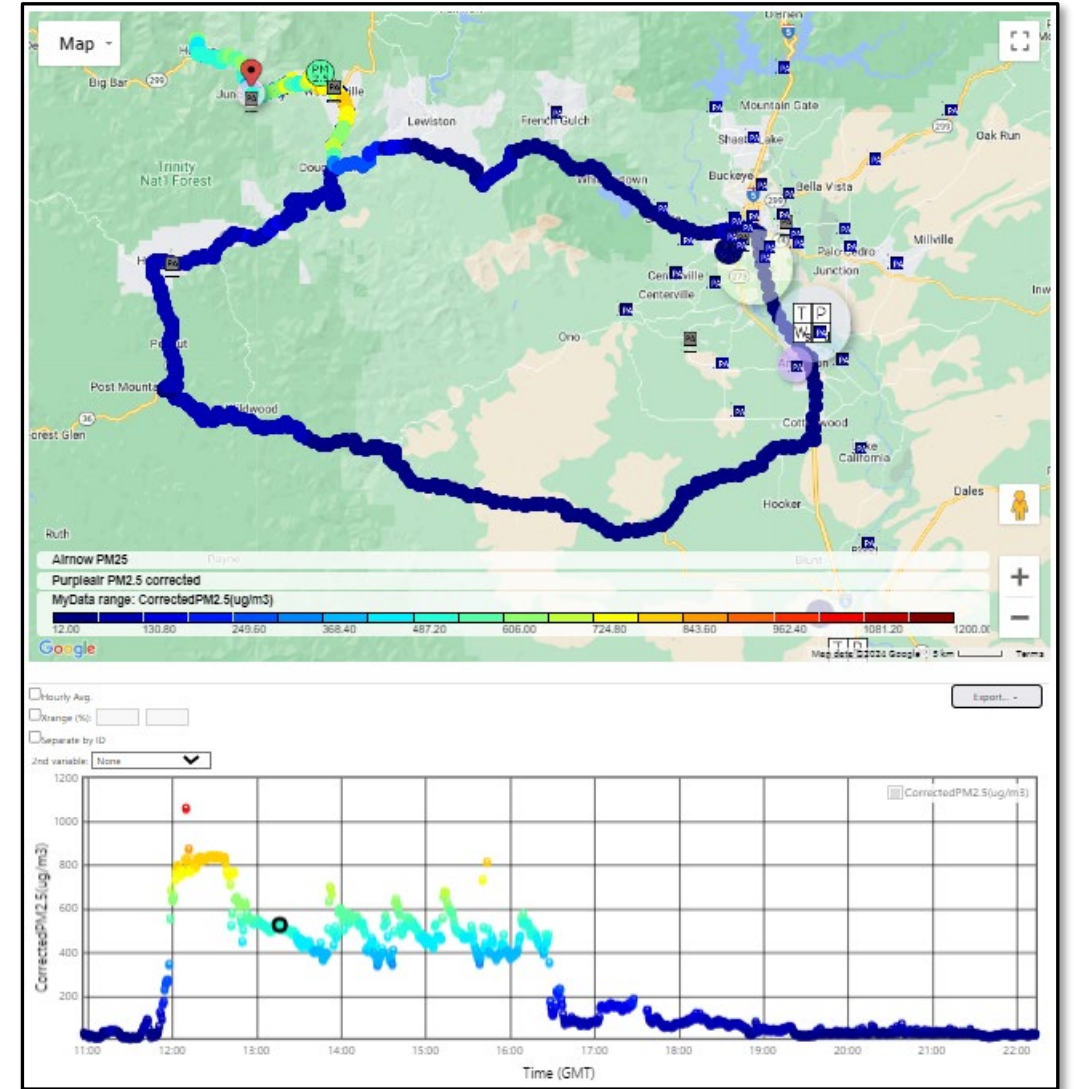
- **Several options help investigate user data**
  - Data vs. distance from a point
  - Data vs. minimum distance from a line
  - Data in a polar wind-pollution format
  - Scatterplot of one variable versus another



# Data Comparison Visuals – Point Sources

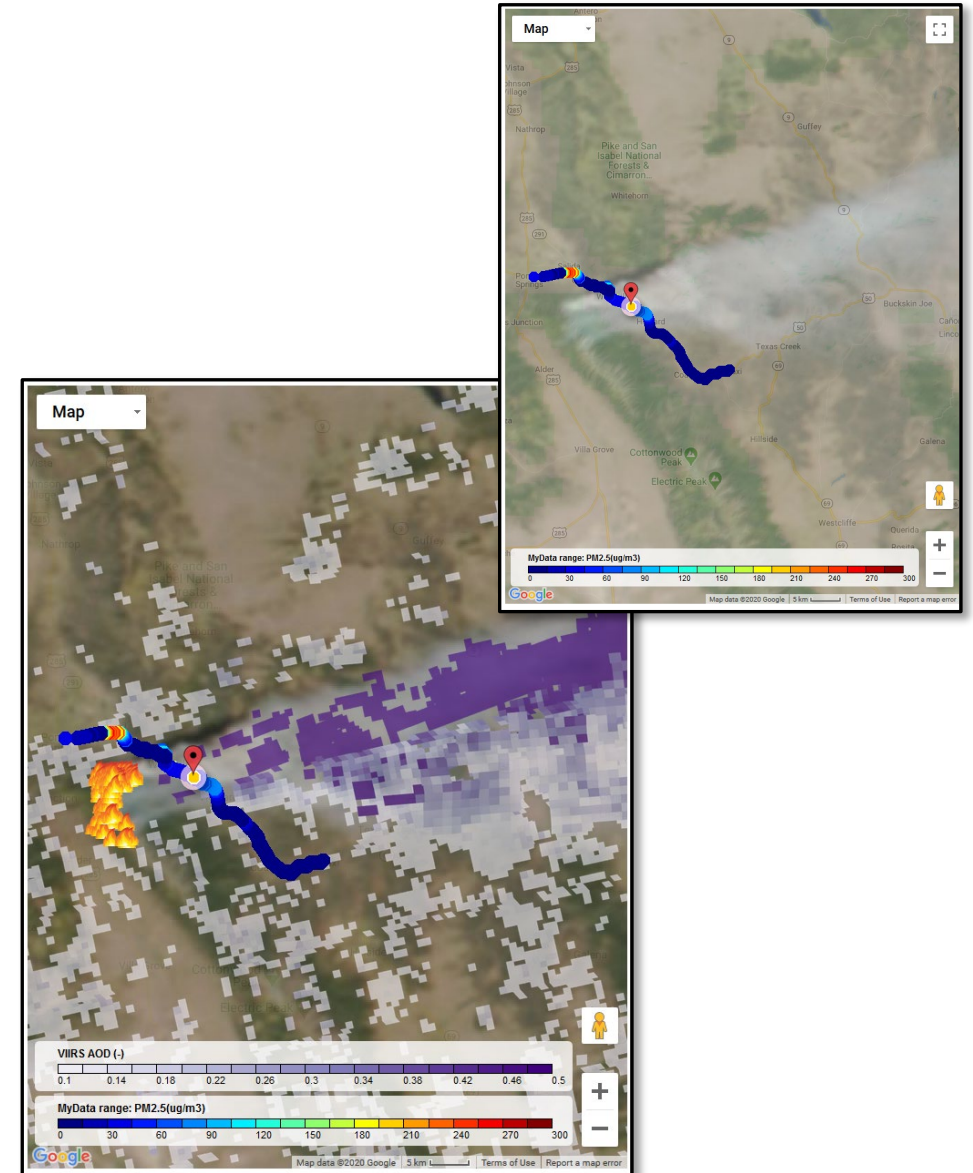
- User data can also be compared to several other publicly available data sources
- Data for the same location and time period will automatically be loaded
- Point data sources include
  - AirNow monitoring sites
  - METAR weather reporting stations
  - PM<sub>2.5</sub> from PurpleAir sensors\*

\*To access PurpleAir data, users must supply their own PurpleAir API read key.



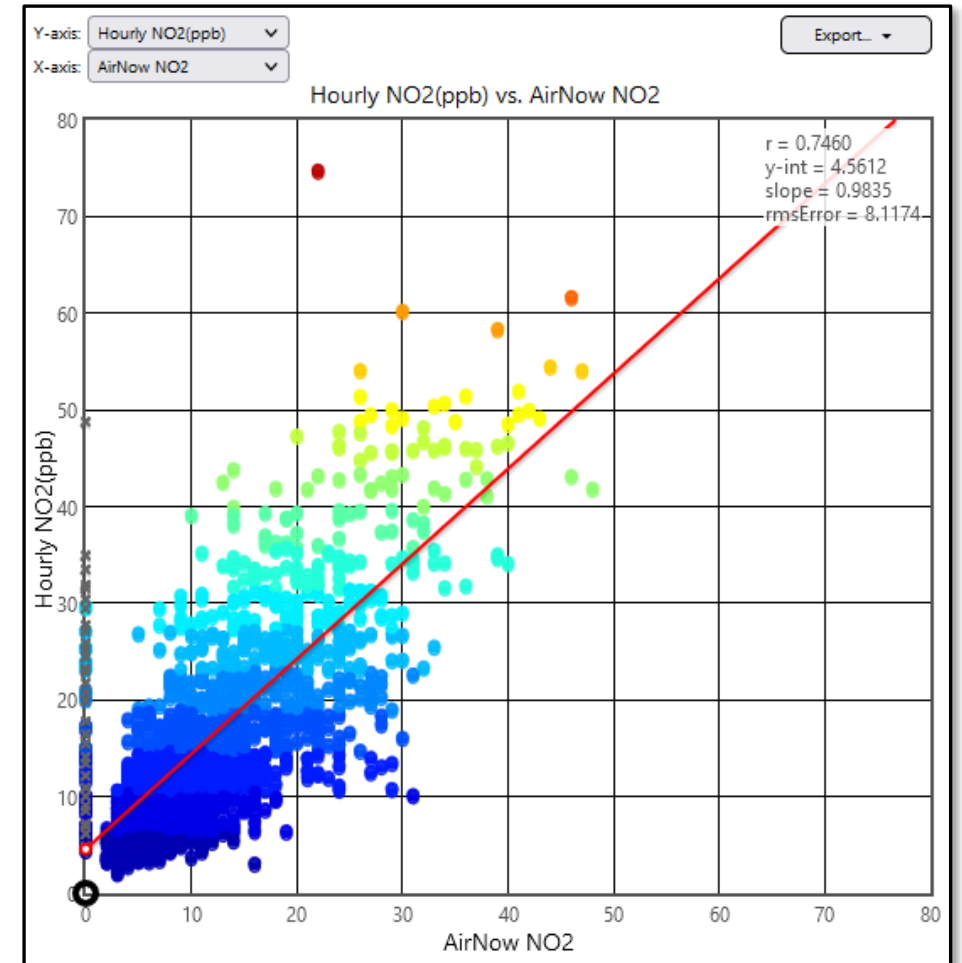
# Data Comparison Visuals – Satellite

- **Several satellite data products are also available including**
  - Fire detections from the Hazard Mapping System (HMS), shown as fire icons
  - True color imagery from NASA's Visible Infrared Imaging Radiometer Suite (VIIRS)
  - VIIRS aerosol optical depth (AOD) providing integrated vertical column aerosol estimates
  - Column integrated nitrogen dioxide ( $\text{NO}_2$ ) from the European Space Agency's TROPospheric Monitoring Instrument (TROPOMI)



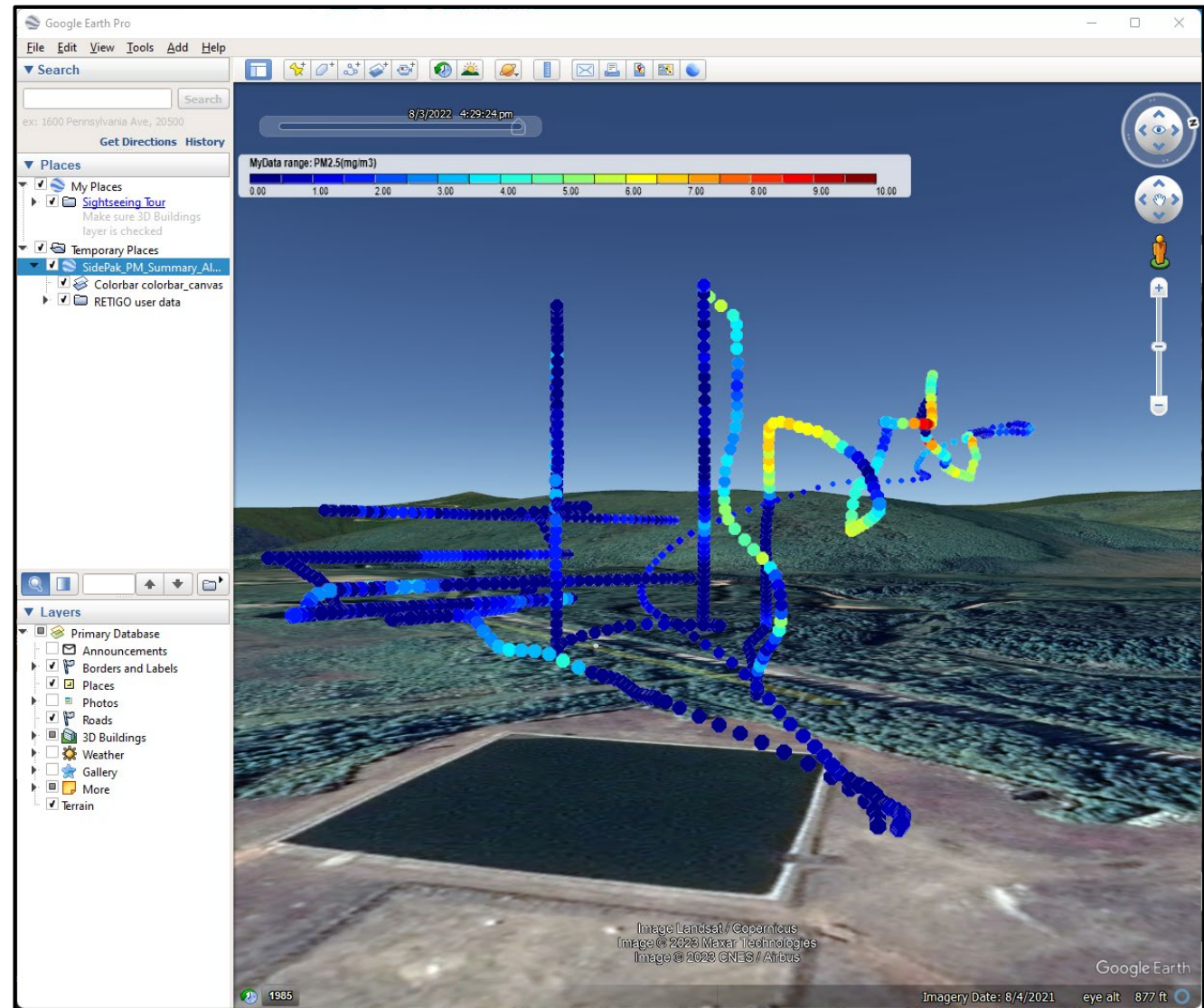
# Export Features

- Many of the graphs created within RETIGO can be exported as images and saved to the user's computer
- Data from the analysis or scatterplots can also be saved as new data files
- The scatterplot function can export
  - Scatterplot data – file containing the data and comparison statistics (e.g., slope, intercept, r)
  - Corrected file – file containing y-axis data adjusted using the linear regression



# 3-Dimensional (3-D) Visualization

- **RETIGO offers a 2-D display but some users collect data above ground level and want 3-D visuals**
  - Data can be exported from RETIGO for visualization in other platforms (e.g., Google Earth)
  - During export, users specify how height was measured (e.g., height above ground level, height above sea level)





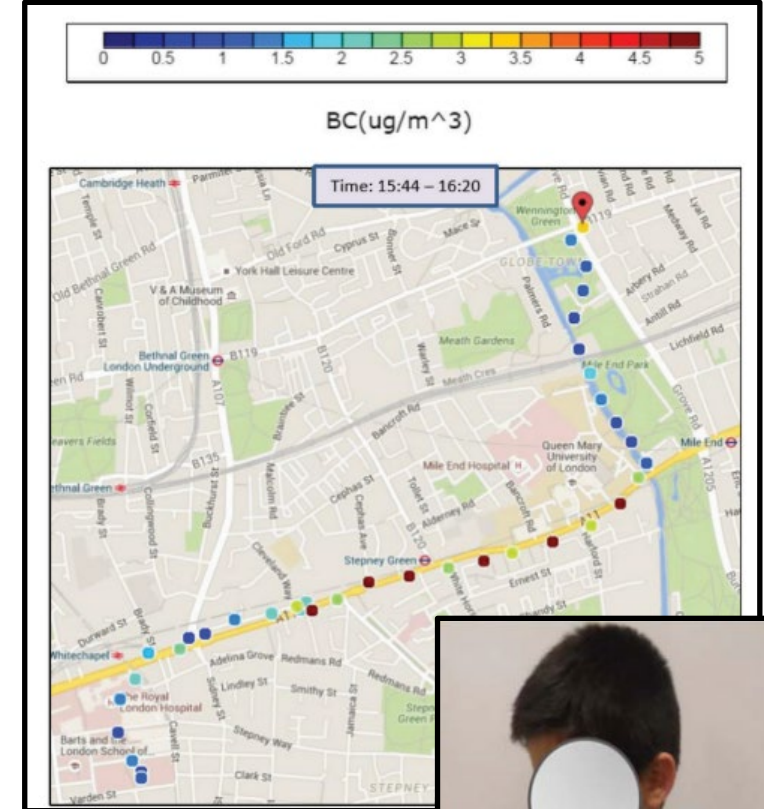
# Next Steps

- **Several of the features highlighted today were added when RETIGO Version 4 was released earlier this year**
- **Development continues on new features**
  - Additional data sources (e.g., AirNow PM<sub>10</sub>, TEMPO satellite products)
  - Data file format checker
  - Sensor agnostic data quality assurance functions
  - Add fire perimeters
- **We encourage user feedback and suggestions**
  - Users help identify bugs (e.g., time conversion)
  - Feature requests are considered for future development proposals



# Use Case Example – Education

- **Researchers engaged school children in monitoring air pollution in London**
  - 400 children learned about air pollution
  - 10 children measured the air pollution while travelling to and from school using sensors
  - Students shared their results with their school
  - Air pollution exposure reduction strategies were discussed with students and parents
- **Results were presented using RETIGO maps**
  - The results were explained to the children who had plenty of questions
  - Children could clearly identify air pollution hotspots and could propose alternative routes



# Use Case Example – Wildfire Smoke Monitoring

- **Air Resource Advisors using Vehicle Add-on Mobile Monitoring System (VAMMS) can easily visualize mobile data in the field**



- The Elkhorn Fire occurred near No Return Wilderness, ID
- There were no monitors along river so the VAMMS was operated on boat to provide air quality information for the rafting community
- VAMMS data is formatted for RETIGO for quick visualization



# Impact

Overall, I love this tool. Thank you for making this product!! I can see many benefits to using it! – *EPA Region 1 Air Monitoring Staff*

This is an amazing tool that will help many of the grantees and small organizations I work with who are taking advantage of using accessible sensors. Early adopters of air sensor technology may not have the resources for intensive data analysis. This tool will help. – *EPA Region 5 Air Monitoring Staff*

I think community groups, State and Local air agencies, and particularly Tribes would really appreciate a tool like this.  
– *EPA Region 10 Air Monitoring Staff*

I use RETIGO extensively to visualize the mobile monitoring data from our wildfire smoke sensor loan program. The Interagency Wildland Fire Air Quality Response Program Air Resource Advisors also use RETIGO to display data from sensors that we loan them. – *EPA ORD WSMART Program Staff*

# Anticipated Outcomes

- New and experienced air sensor users can benefit from a **free, fast, easy-to-use web-based data visualization tool**
- Air sensor **users can put the data they collect into context** by comparing it to other public data collected nearby giving them more confidence in the data collected
- **Downloaded visuals and data files** help describe the monitoring effort and help document data analysis, communicate results
- **Sensor users will be more prepared** to share their results and to have conversations with state/local/federal agencies, researchers or others, thereby building positive relationships or potential collaborations

# Take Home Messages

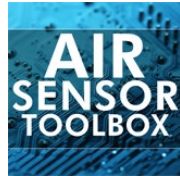
- **RETIGO is a FREE web-based tool, developed by US EPA, which allows users to quickly display and explore their own data**
  - The tool is easy to use, requires no coding skills, and can be used to visualize any type of stationary or mobile sensor data
  - Maps and graphs can be customized with a clickable interface
  - User data can be compared to other public data sources
- **Version 4 was released earlier this year offering new features**
  - Users have more control over display options
  - Additional plot options and public data sources were added
  - Export functions have been enhanced
- **Share it! Feedback and stories are welcome**



Get Started: <https://www.epa.gov/hesc/real-time-geospatial-data-viewer-retigo>

## [Air Sensor Toolbox](#)

Provides the latest science on the performance, operation, and use of air sensors; select resources are now available [in Spanish](#)



## [Enhanced Air Sensor Guidebook](#)

Comprehensive resource providing guidance on the effective use of air sensors for conducting air quality monitoring



# Resources

## [RETIGO](#)

FREE web-based data visualization tool

- [Tutorial Page](#)
  - Using text, visuals, and video, learn about how to format your data file and how to use RETIGO features and controls
- [Timestamp Converter](#)
  - Use this online tool to make your timestamps readable by RETIGO
- [Creating a File from Excel](#)
  - Learn how to take an Excel spreadsheet and convert it into a valid RETIGO file
- [Load Data Page](#)
  - Load your datafile and get started!

# Contact

## Andrea Clements, PhD

Center for Environmental Measurement &  
Modeling

US EPA ORD

[clements.andrea@epa.gov](mailto:clements.andrea@epa.gov)

919-541-1363

## RETIGO

Ask questions, report technical issues,  
provide feedback, etc.

[retigo@epa.gov](mailto:retigo@epa.gov)

**Special Thanks** to members of the development team:  
ORD: Amara Holder, Karoline Barkjohn, Richard Shores  
(retired), Vasu Kilaru, Gayle Hagler; OMS: Heidi Paulsen;  
R2: Jon Gabry; R5: Marta Fuoco; EMVL: Matt Freeman,  
Tony Howard, Yadong Xu, Stephen Beaulieu

