US EPA Remote Sensing Information Gateway: An introduction

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Remote Sensing Information Gateway

- General Overview

- Popular Data Sets

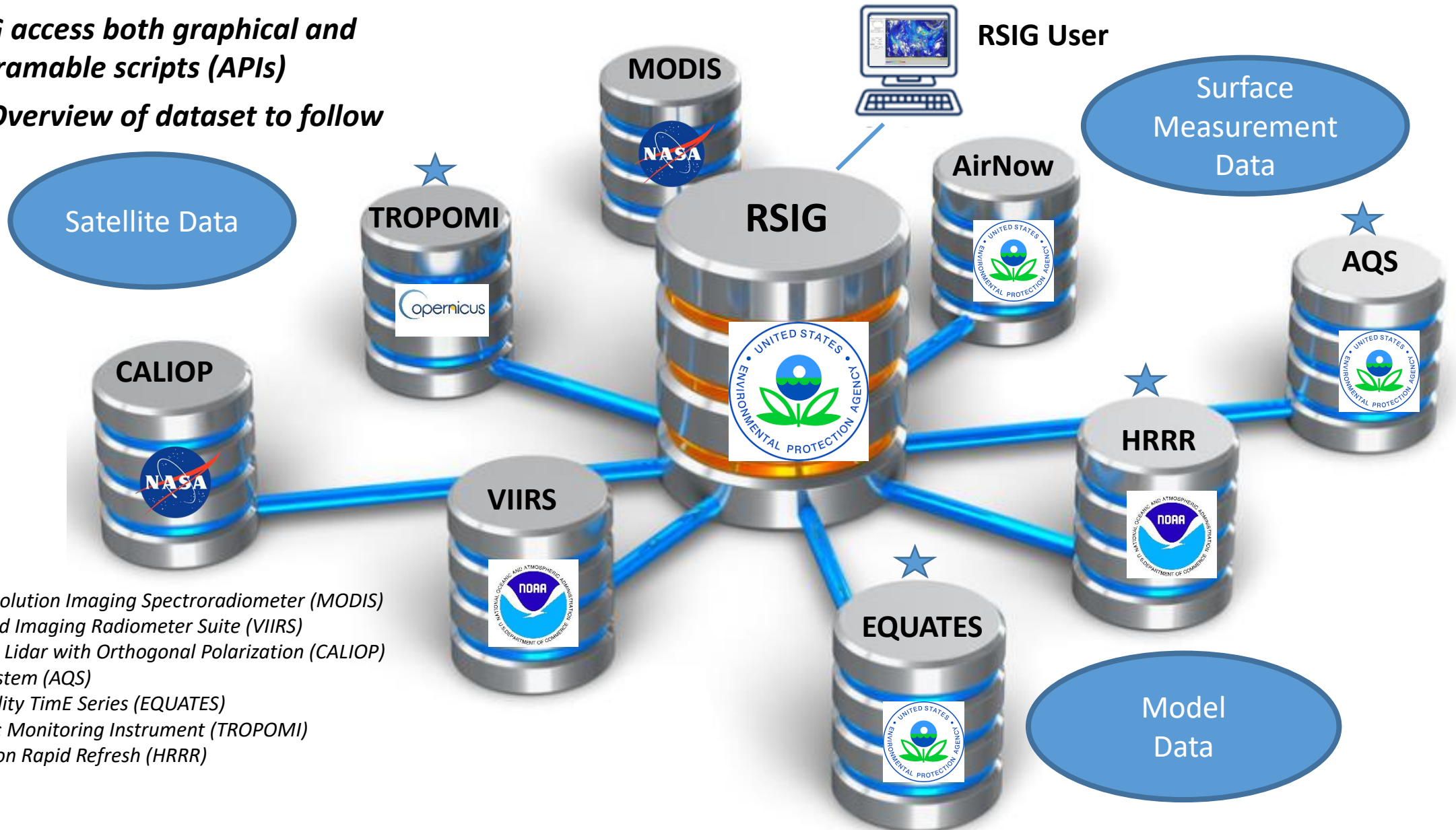- User Interface

- API/Python Case Studies

What is the Remote Sensing Information Gateway?

- Free multi-platform, scriptable software system which creates a consolidated access point to 100's of terabytes (TB) of air quality relevant model, measurement and satellite data sets

- Provides quick and easy ways of retrieving, visualizing and saving subsets of these selected geospatial atmospheric data

- Target users are air quality professionals, modelers, and researchers interested in historic and contemporary air-quality data
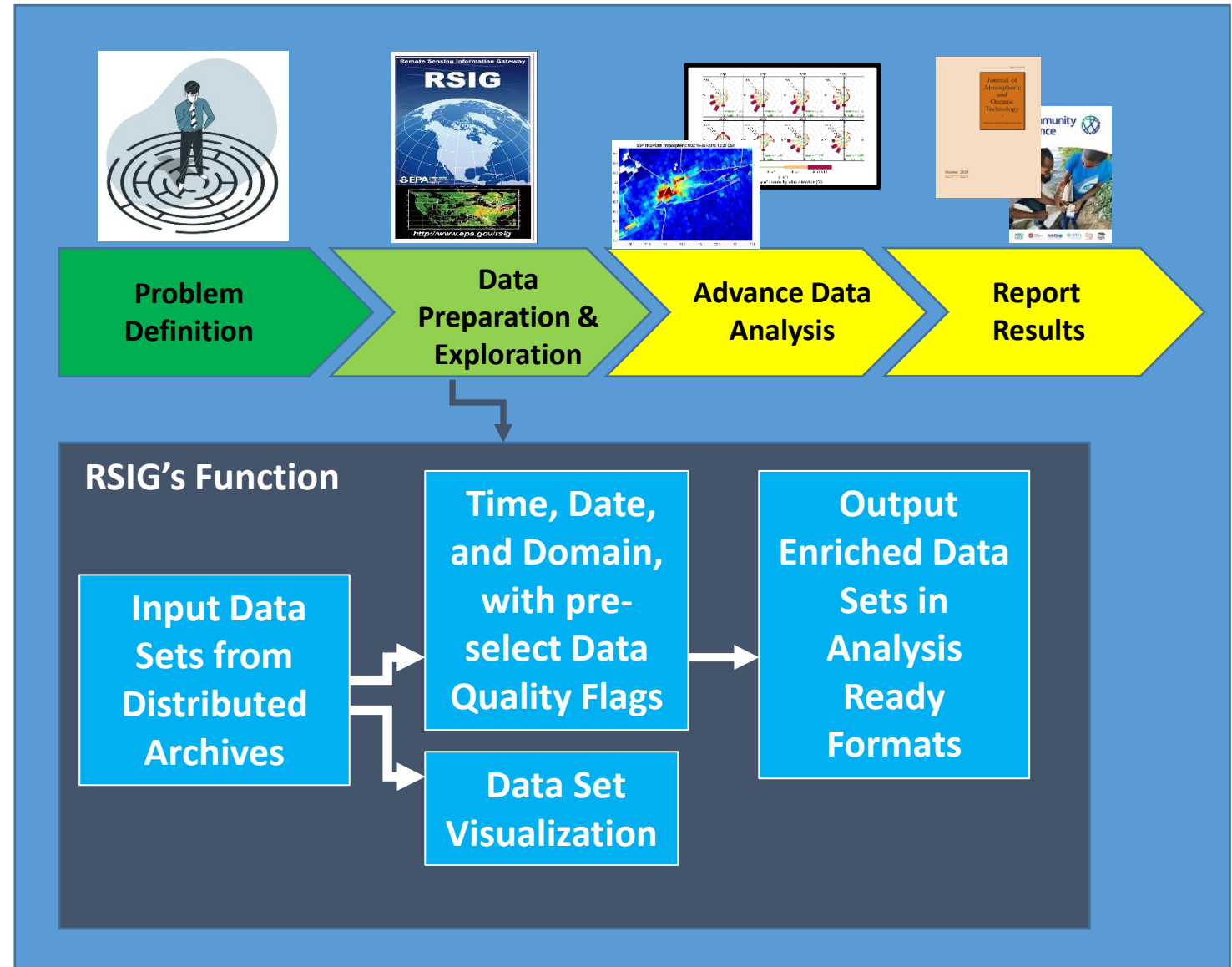
https://www.epa.gov/rsig
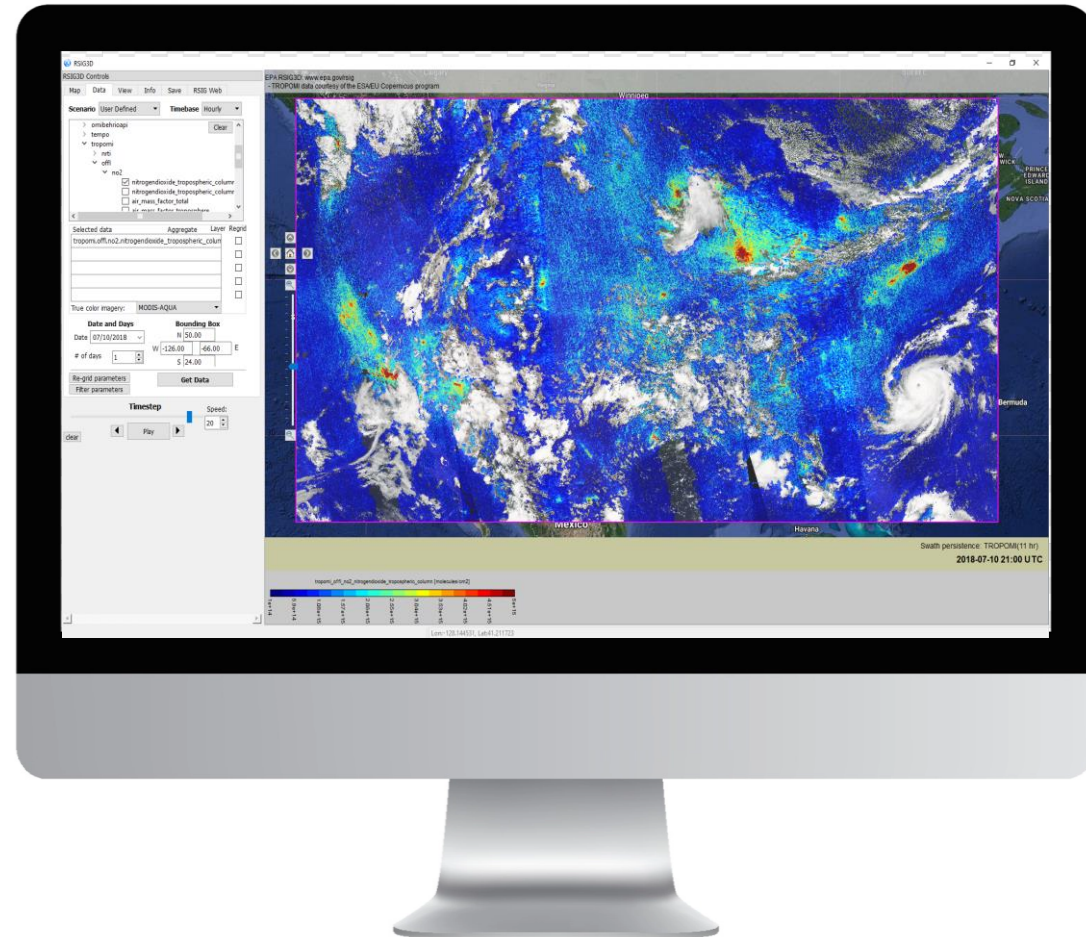
Popular Air Quality Datasets

-RSIG access both graphical and programable scripts (APIs)

-⭐ Overview of dataset to follow

RSIG User

Satellite Data

Surface Measurement Data

Model Data

MODIS

TROPOMI

RSIG

AirNow

AQS

CALIOP

VIIRS

HRRR

EQUATES

Moderate Resolution Imaging Spectroradiometer (MODIS)
Visible Infrared Imaging Radiometer Suite (VIIRS)
Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP)
Air Quality System (AQS)
EPA's Air QUAlity TimE Series (EQUATES)
TROPOspheric Monitoring Instrument (TROPOMI)
High-Resolution Rapid Refresh (HRRR)

Enabling Improved Data Access

- Air quality management decisions required under the Clean Air Act are often informed though analyses of complex data

- RSIG facilitates access to complex data sets through web services and allow users to save data in an analysis-ready-format for further use in their own software, R, python, excel, etc.

Problem Definition → Data Preparation & Exploration → Advance Data Analysis → Report Results

RSIG's Function

Input Data Sets from Distributed Archives → Time, Date, and Domain, with pre-select Data Quality Flags → Output Enriched Data Sets in Analysis Ready Formats

Data Set Visualization

Select Data Sets Overview
EPA's Air QUAlity TimE Series (EQUATES) Project

- Data Set Type: Modeled datasets for the Conterminous U.S. (CONUS) at a 12km horizontal grid spacing and the Northern Hemisphere at a 108km grid spacing

- Dates: 2002-2017+ (future data to be added as model runs completed)

- Based on Weather Research and Forecasting (WRF) model v.4.1.1 for simulating weather conditions and EPA's Community Multiscale Air Quality (CMAQ) model v.5.3.2 for air quality modeling

- Types of variables: surface and upper model level gas and aerosol concentration, total column, deposition, metrological

- Typical Application Uses: air quality trends, epidemiological studies, critical loads analyses

Metadata: https://www.epa.gov/cmaq/equates
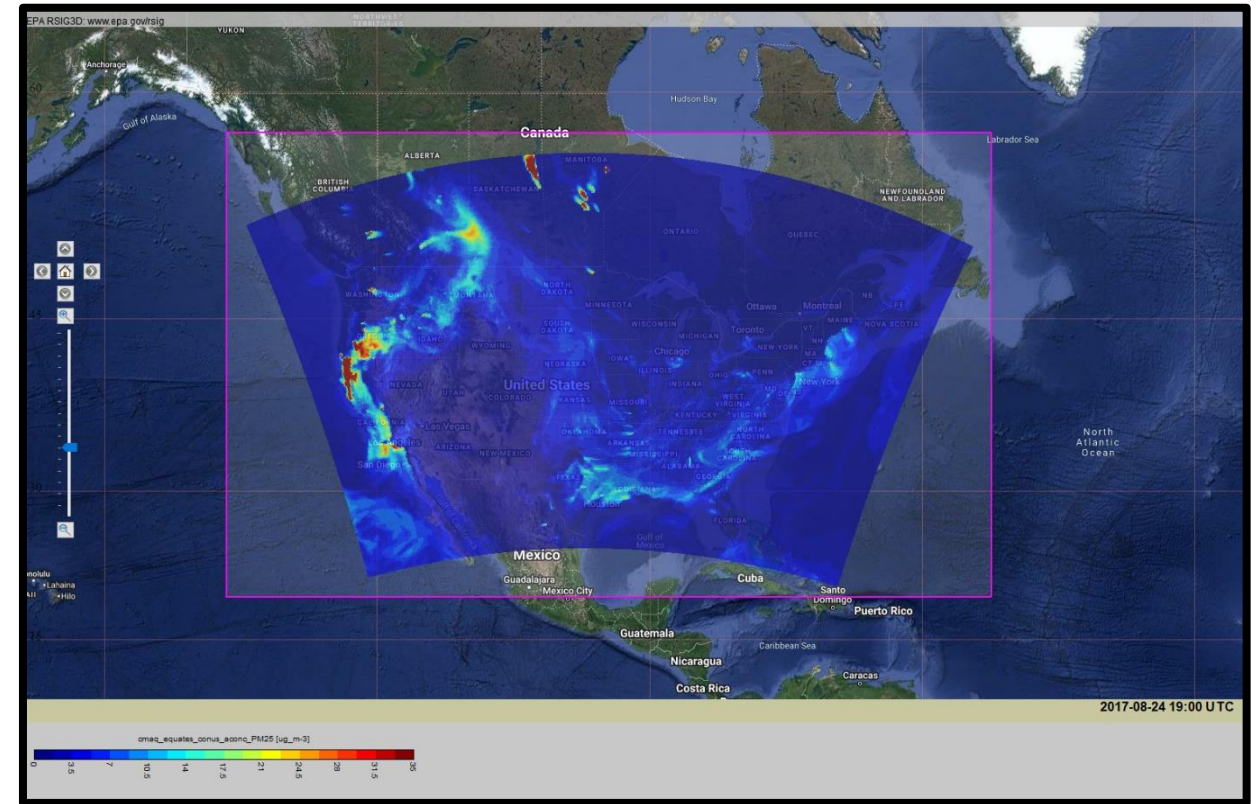
Select Data Sets Overview
Copernicus (ESA) TROPOspheric Monitoring Instrument (TROPOMI)

- Data Set Type: Satellite dataset from Copernicus Sentinel-5 Precursor satellite with daily global cover at various grid spacing

- Dates: June 2018-present

- Types of variables: Tropospheric Column Abundances of nitrogen dioxide, methane, carbon monoxide and formaldehyde with predetermined QA metrics

- Typical Application Uses: model evaluation, air quality event and trends analysis, pollutant emissions research, air pollutant exposure studies

- Typical Data Latency: Near-Real Time (NRT) vs Offline (OFFL) ~1 day to 2 weeks

Metadata: http://www.tropomi.eu/data-products/level-2-products
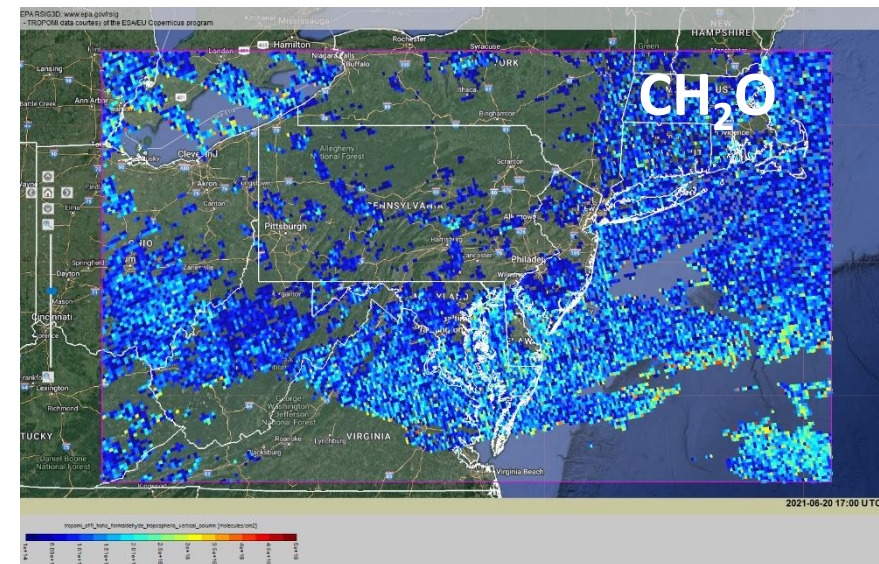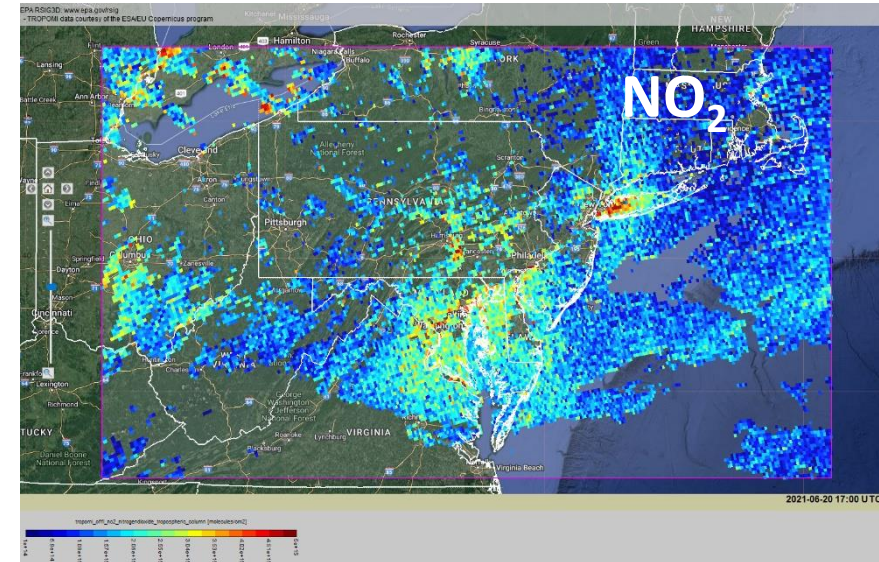
NOAA High-Resolution Rapid Refresh (HRRR)

- Data Set Type: Modeled datasets for the Conterminous U.S. (CONUS) at a 3km horizontal grid spacing

- Dates: 2014-present (future data to be added as model runs completed)

- Types of variables: surface winds (in the process of adding additional meteorological variables and altitudes)

- Typical Application Uses: assess frontal passages, sea or land breezes formation.

- Typical Data Latency: less than 4 hours

Metadata: https://hive.utah.edu/concern/datasets/47429912h
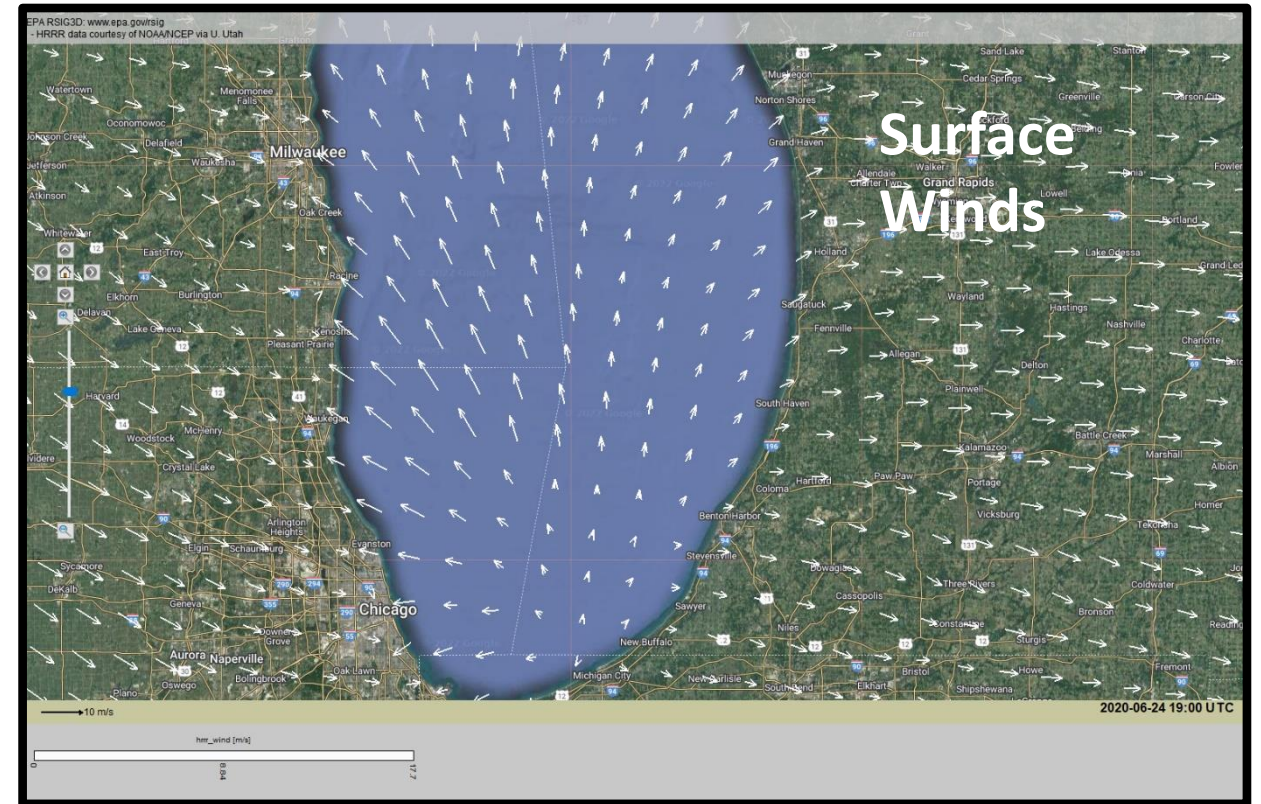
Select Data Sets Overview
EPA's Air Quality System (AQS) Database

- Data Set Type: Measurement - ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from over thousands of monitors

- Dates: 1998 - present

- Types of variables: Major pollutants and meteorology (O_3, $PM_{2.5}$, NO_2, SO_2, T, RH, WS, WD)

- Typical Application Uses: assist in attainment/non-attainment designations, model evaluation, air quality event and trends analysis, pollutant emissions research, air pollutant exposure studies

- Typical Data Latency: 6 months – use AirNow for more recent data

8 hr. daily max O_3

Metadata: https://www.epa.gov/aqs
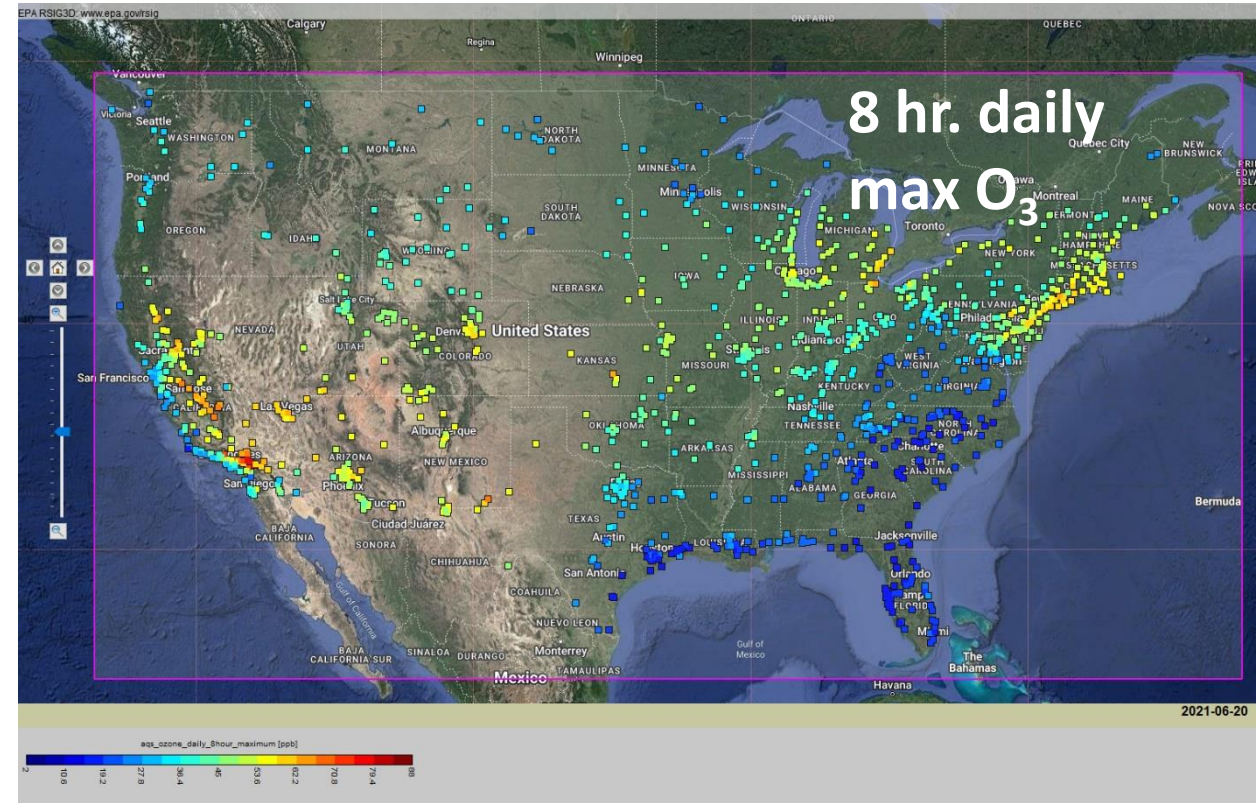
Future Data Sets

Tropospheric Emissions: Monitoring of Pollution –TEMPO

- The first space-based instrument to monitor major air pollutants across the North American continent every daylight hour at high spatial resolution

- Launch – Early 2023

- Public Release of Data Anticipated Late 2023

Unified Ceilometer Network–UCN

- The first operational ceilometer network focused on aerosol profiles and planetary boundary layer heights

- Developed by EPA, University of Maryland, Baltimore County (UMBC), NASA, state & local agencies

- Data Anticipated Late 2022
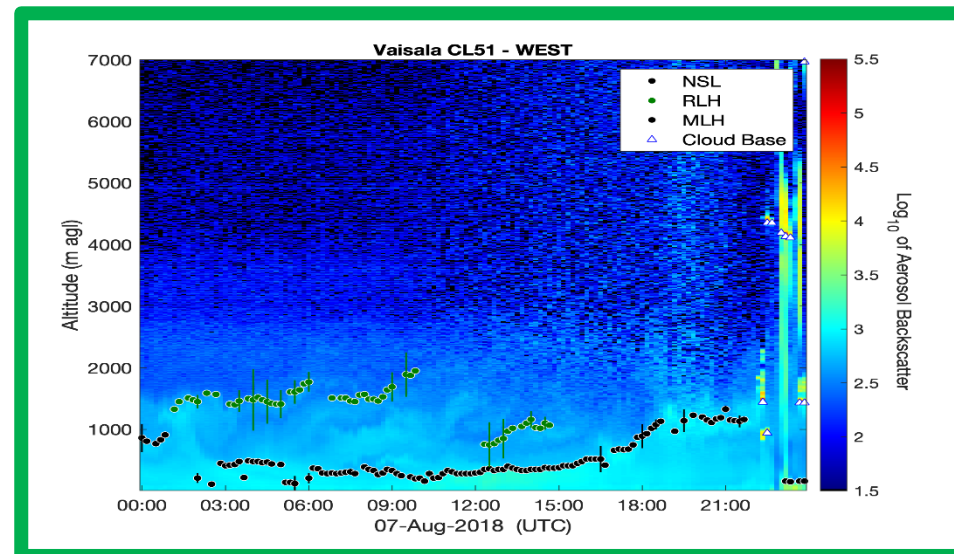
RSIG3D User Interface Orientation

www.epa.gov/rsig

"Getting started" video tutorials

Web access to RSIG data

Standalone/remote CMAQ* file reader tutorial

How RSIG regrids data

RSIG3D application download
- Windows
- Mac
- Linux (RHEL7)

*Community Multiscale Air Quality Modeling System

RSIG3D User Interface Orientation

Control tabs

Tab specific controls

Animation controls

Useful info including full WCS string
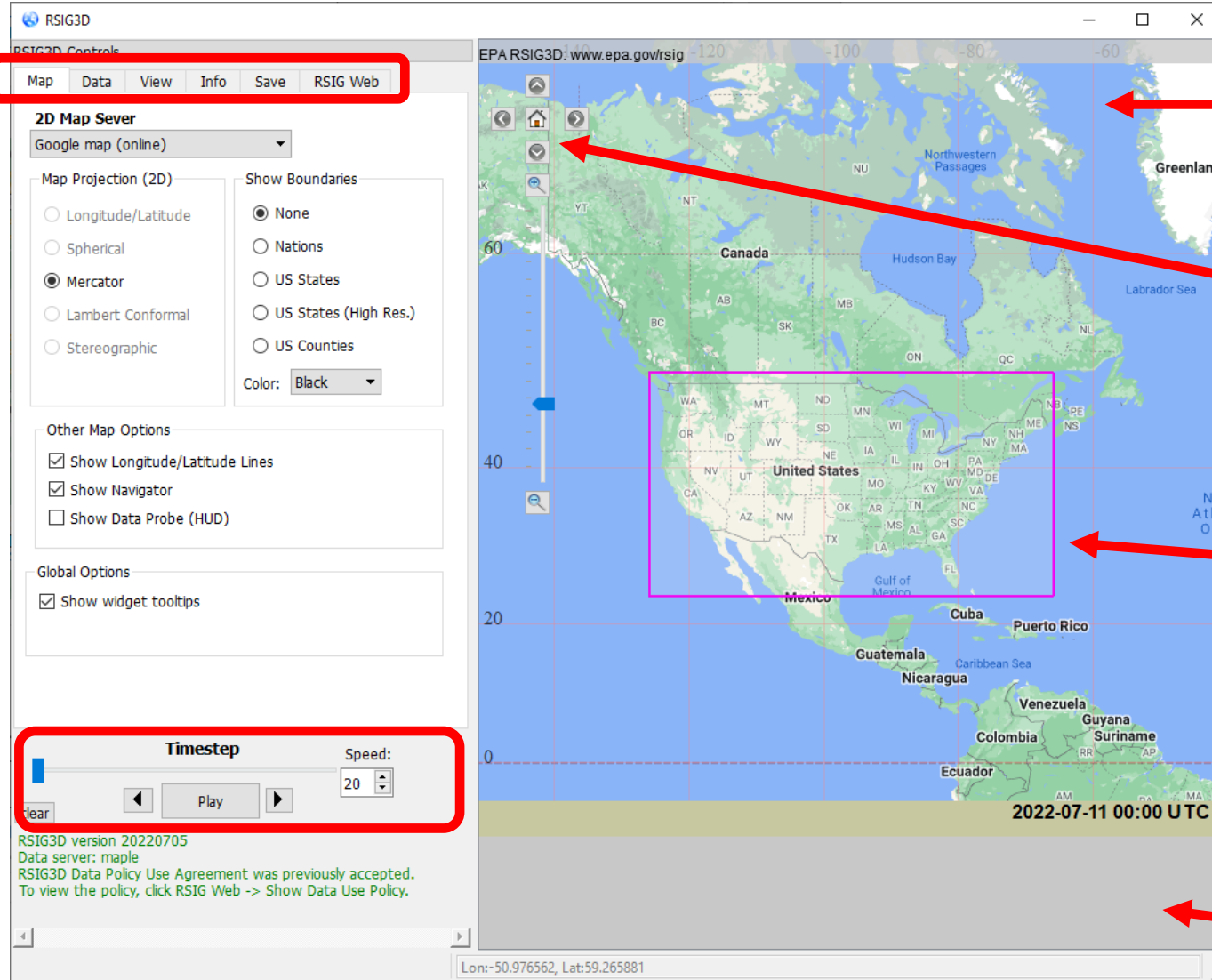
Map / data display

Map Controls

Bounding box for data retrievals

Time and date

Colorbar area

RSIG3D User Interface – Map Tab
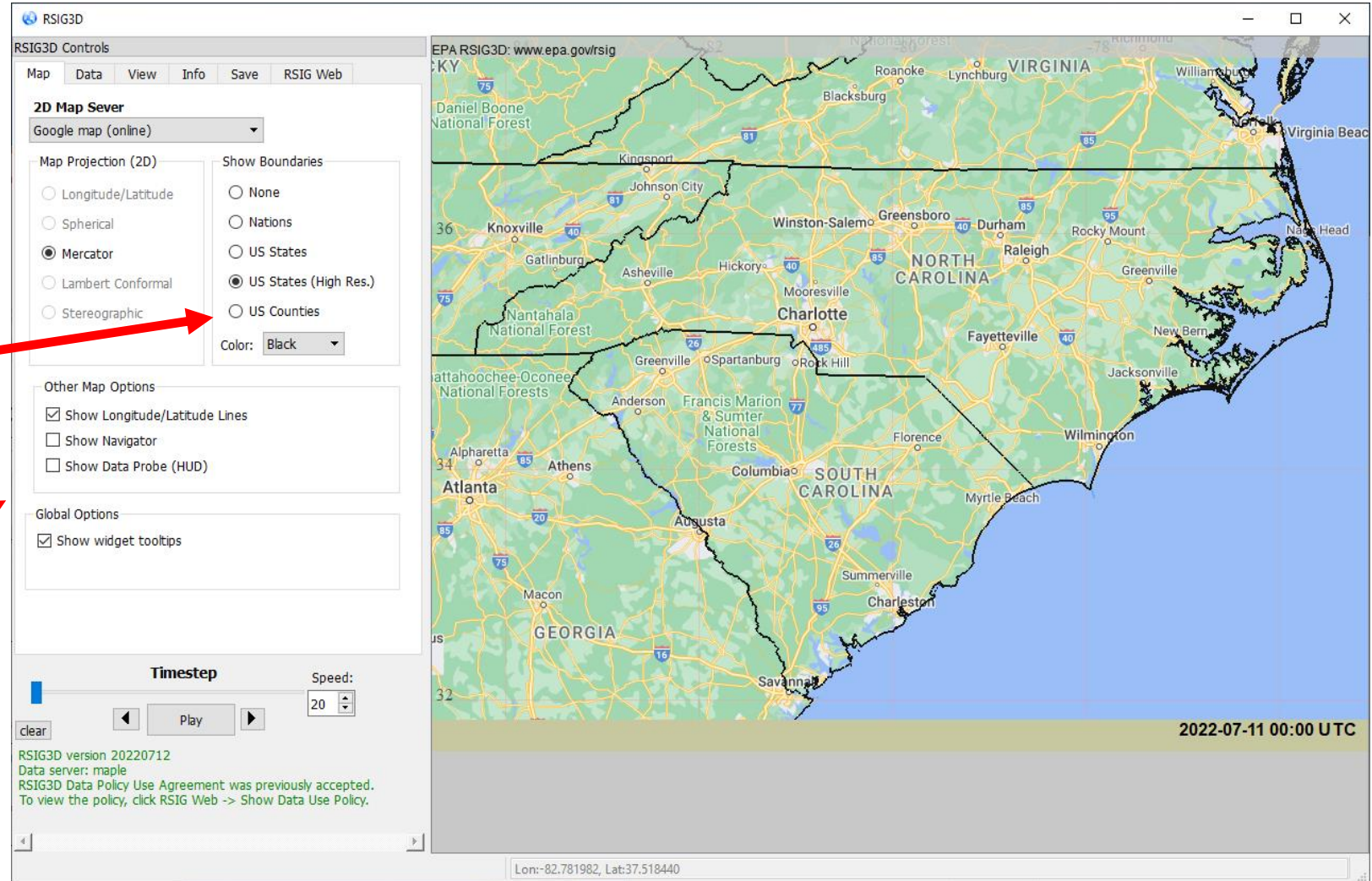
Basemap

Map projection

Political boundaries

Other options
- Grid lines
- Map navigator
- Data probe
- Tooltips

RSIG3D User Interface – Data Tab

Time base (hourly, daily, or monthly)

Data selection tree
- 27 sources
- 4148 variables
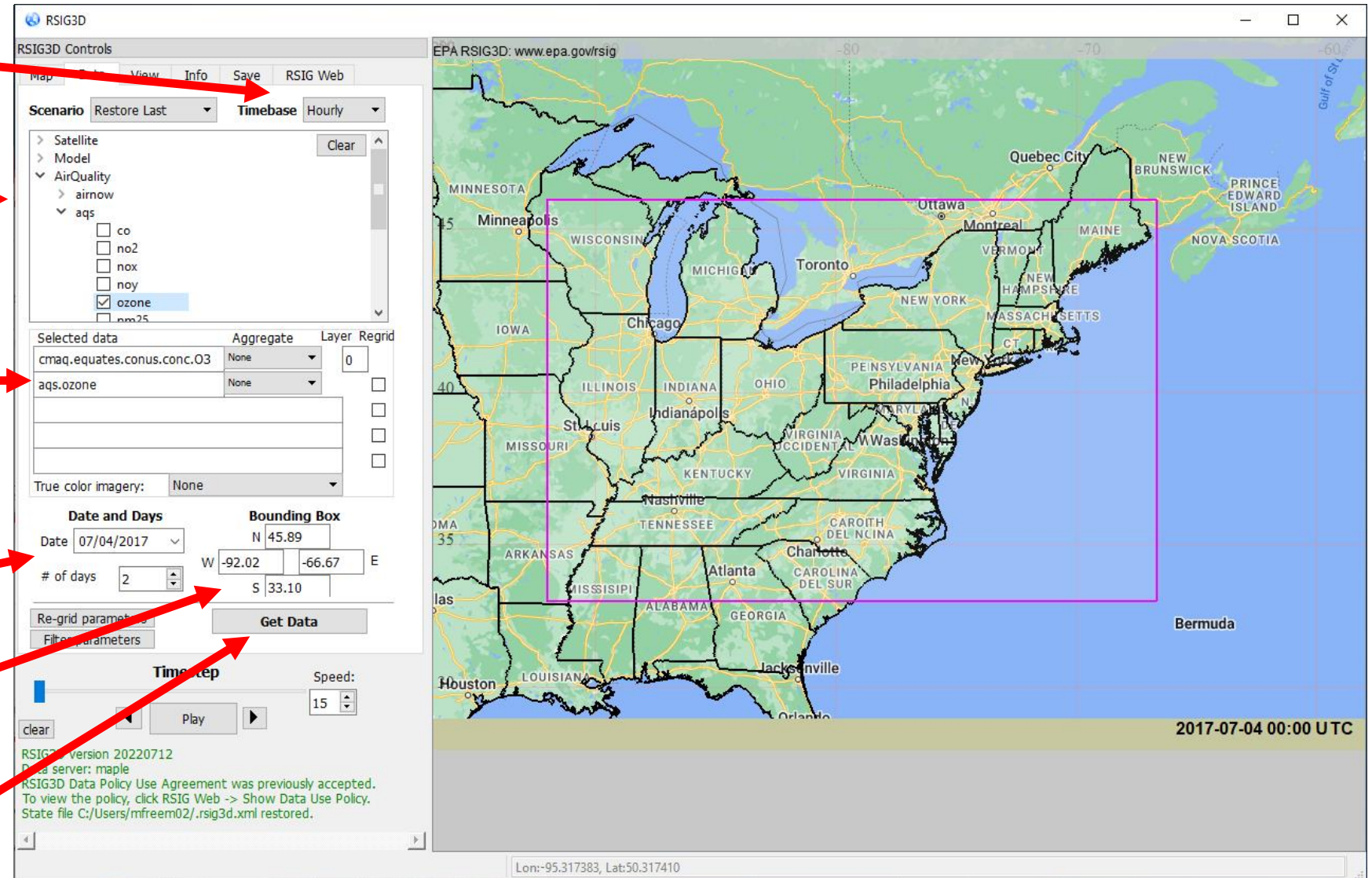
Selected variables appear here (up to five)

Date and number of days to process

Bounding box
(or draw with mouse)

Get Data!
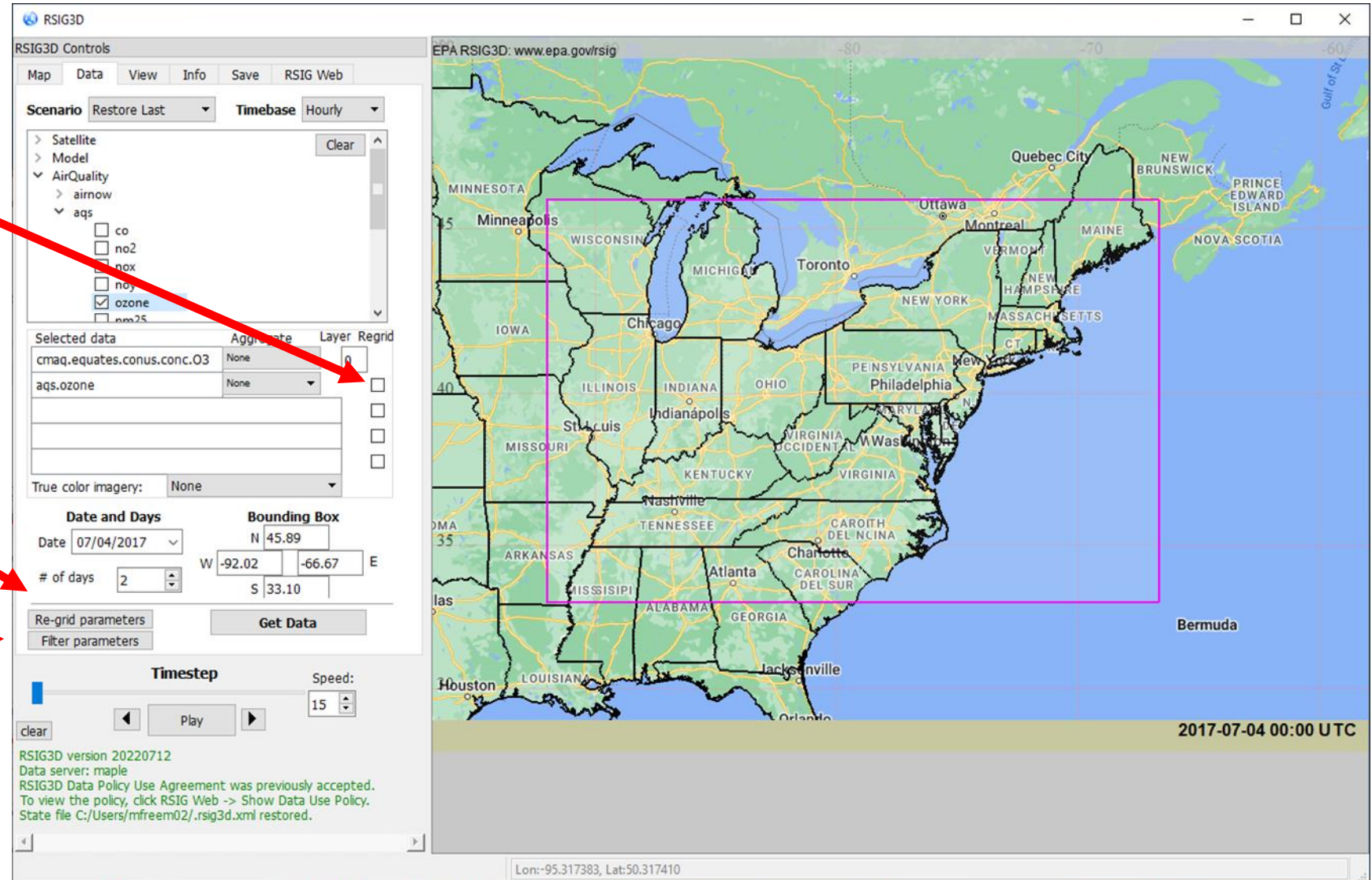
RSIG3D User Interface – Data Tab

Advanced options

Each data type can optionally be interpolated (regridded) to CMAQ or other grids

Regridding parameters can be specified here

Some data sources have filter or quality control parameters that can be specified here

Regridding parameters

TROPOMI NO$_2$, native resolution
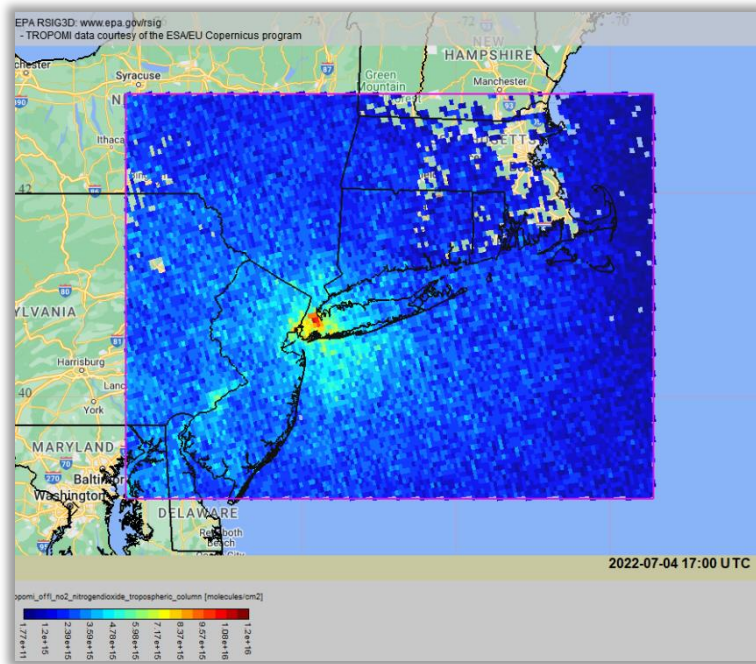
TROPOMI NO$_2$, regridded to CMAQ EQUATES 12km CONUS grid
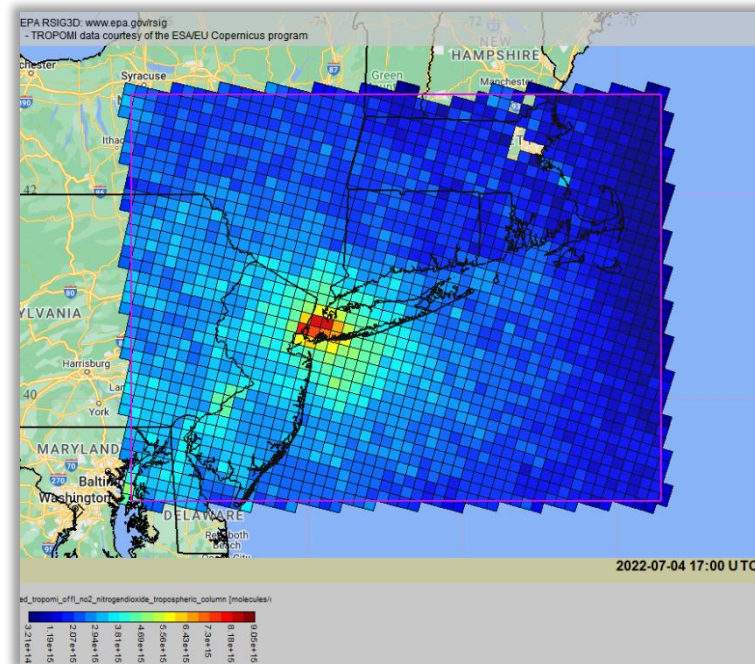
RSIG3D User Interface – View Tab

Select the variable on which to operate

Visibility toggle
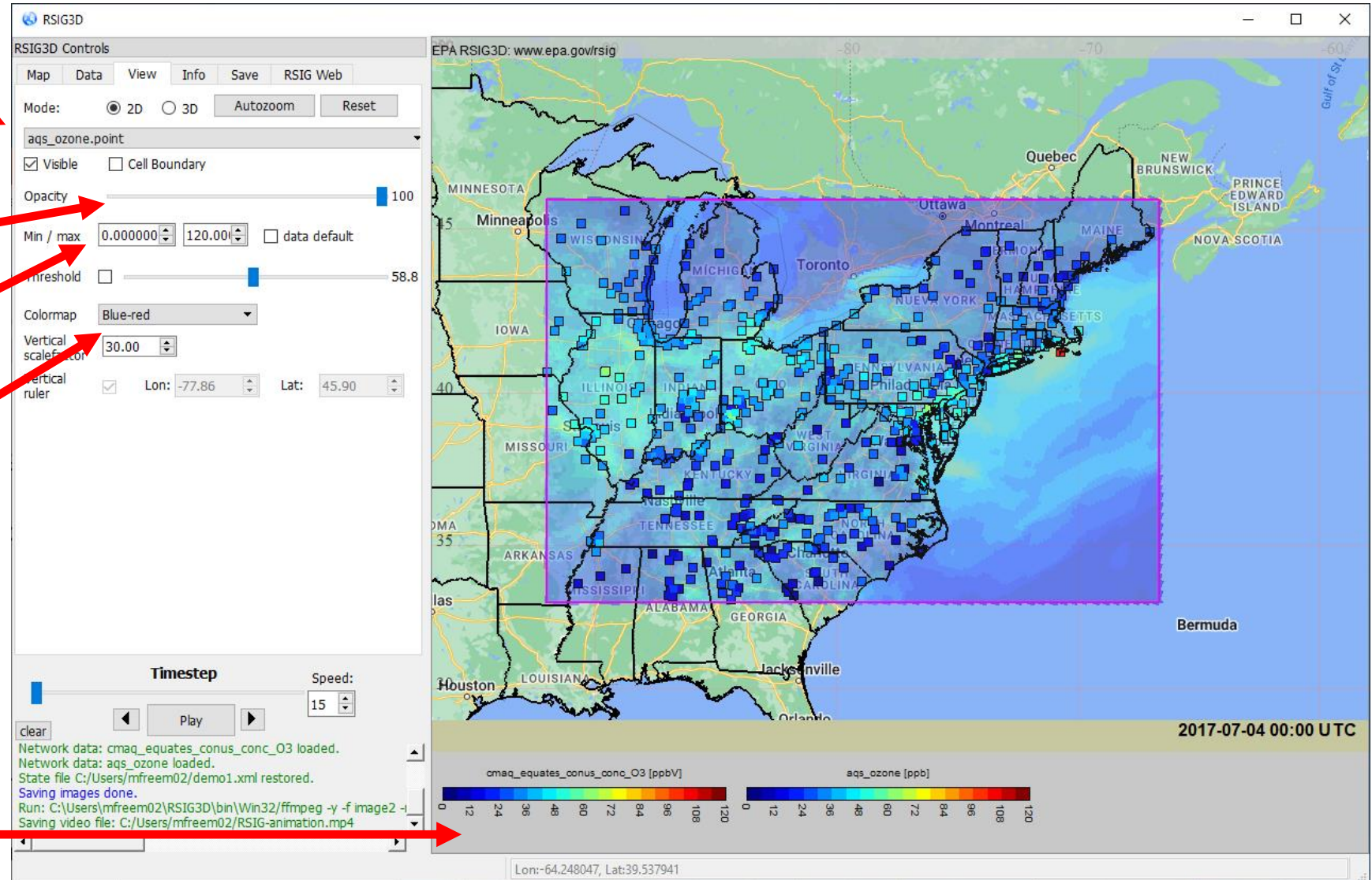
Opacity

Data range to display

Color map

Animation controls

Color bars for each variable shown here

Advanced options

Visualization mode
(2D or 3D)

Data specific controls
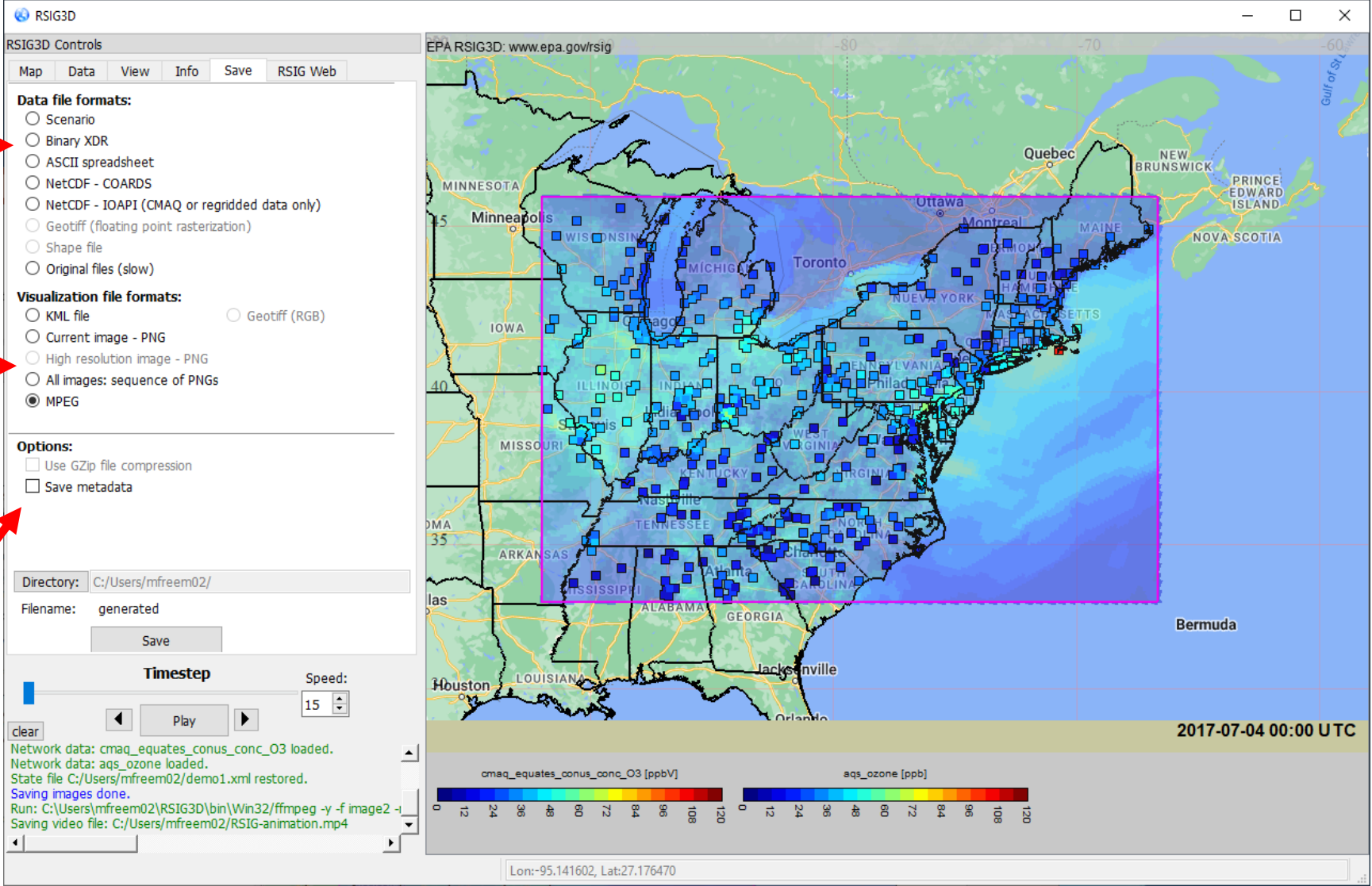(here to manipulate
CMAQ "slice planes")
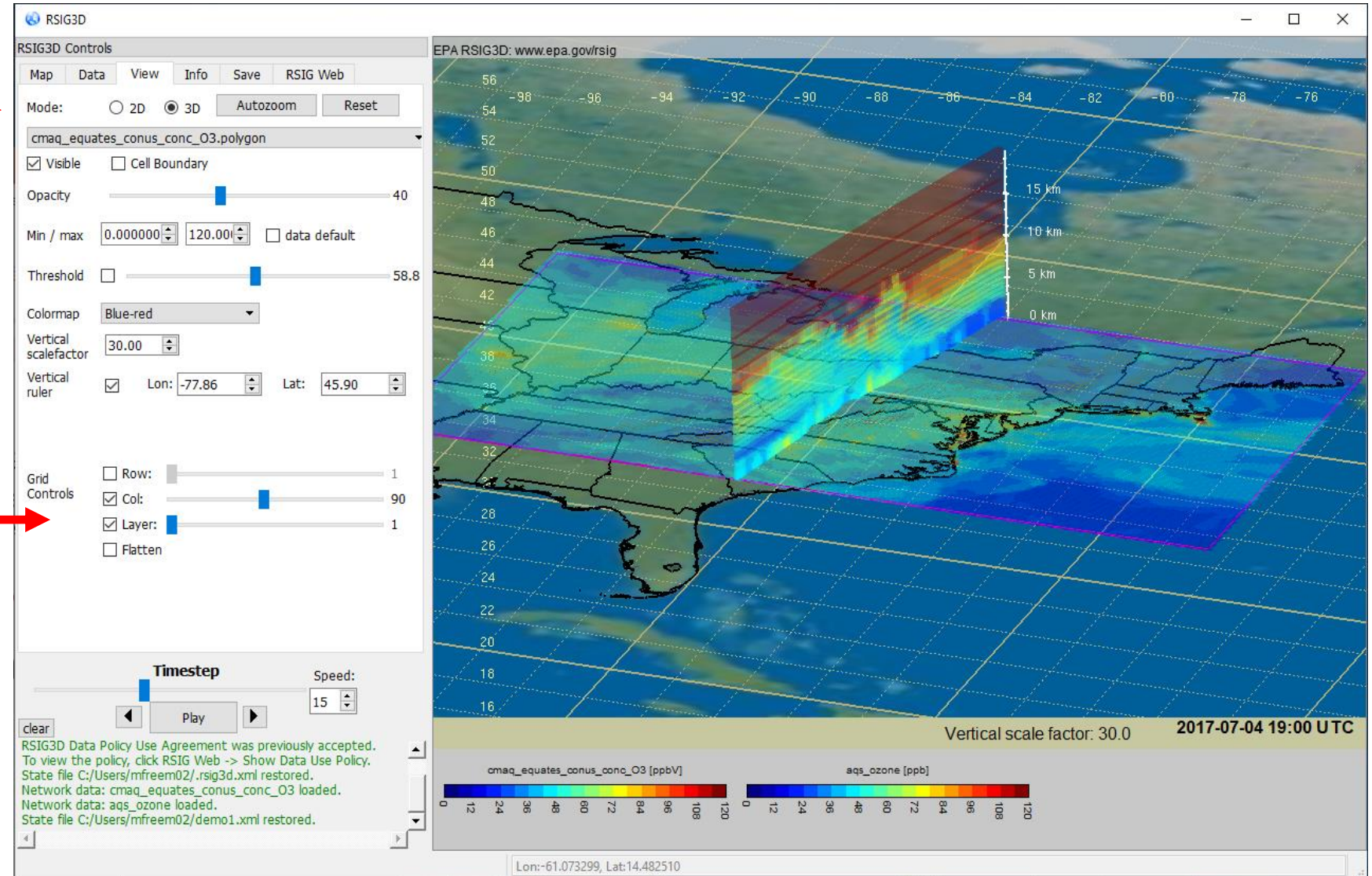
RSIG3D User Interface – Save Tab

Data formats
- Scenario
- Binary or ASCII
- NetCDF (2 kinds)

Visualization formats
- KML
- PNG
- Sequence on PNGs
- MP4

Options
- File compression
- Metadata

Overall Takeaways

- Designed to assist users in obtaining complex datasets relevant to the air quality research and application community.

- The RSIG application significantly reduces data processing time associated with air quality relevant high value data sets.

- Data can be downloaded using the RSIG user interface or users can issue cURL (client URL) scripts.

- RSIG visualization capabilities can be used to explore episodes of interest (case studies) and provide high quality graphics for re-use in reports and presentations.

Contents

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Remote Sensing Information Gateway: https://www.epa.gov/rsig

Thank You!

Extra Slides

Case Studies

- Case Study 1: Overview of datasets related to wildland fires

- Case Study 2: State agency use to help assess differences in air quality forecast

Bootleg Fire, July-August 2021

- Third largest fire in Oregon's history (since 1900)
- Second largest wildfire in the U.S. in 2021
- Over 400,000 acres burned
- Fastest growth: 1,000 acres per hour
- Over 2,200 personnel involved in containing the fire
- 408 buildings and 342 vehicles destroyed
- Affected ground level air quality across northern U.S. and Canada, including in NY, NC and Washington, DC

Photo credit: Freemont-Winema National Forest

Bootleg Fire, July 2021

- Satellite fire detections
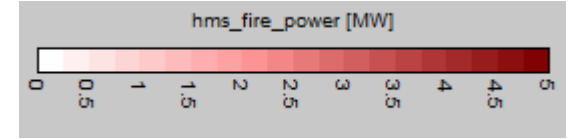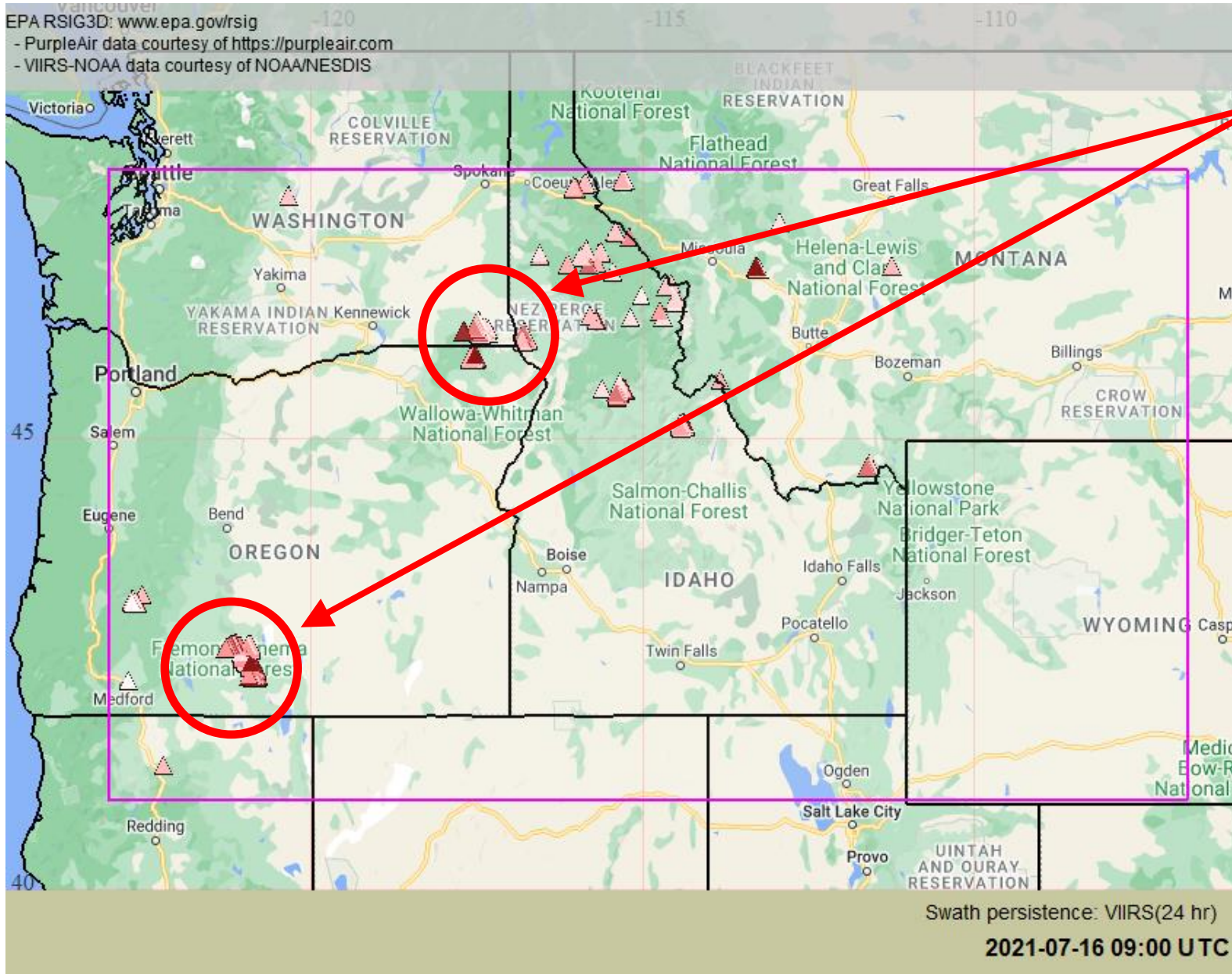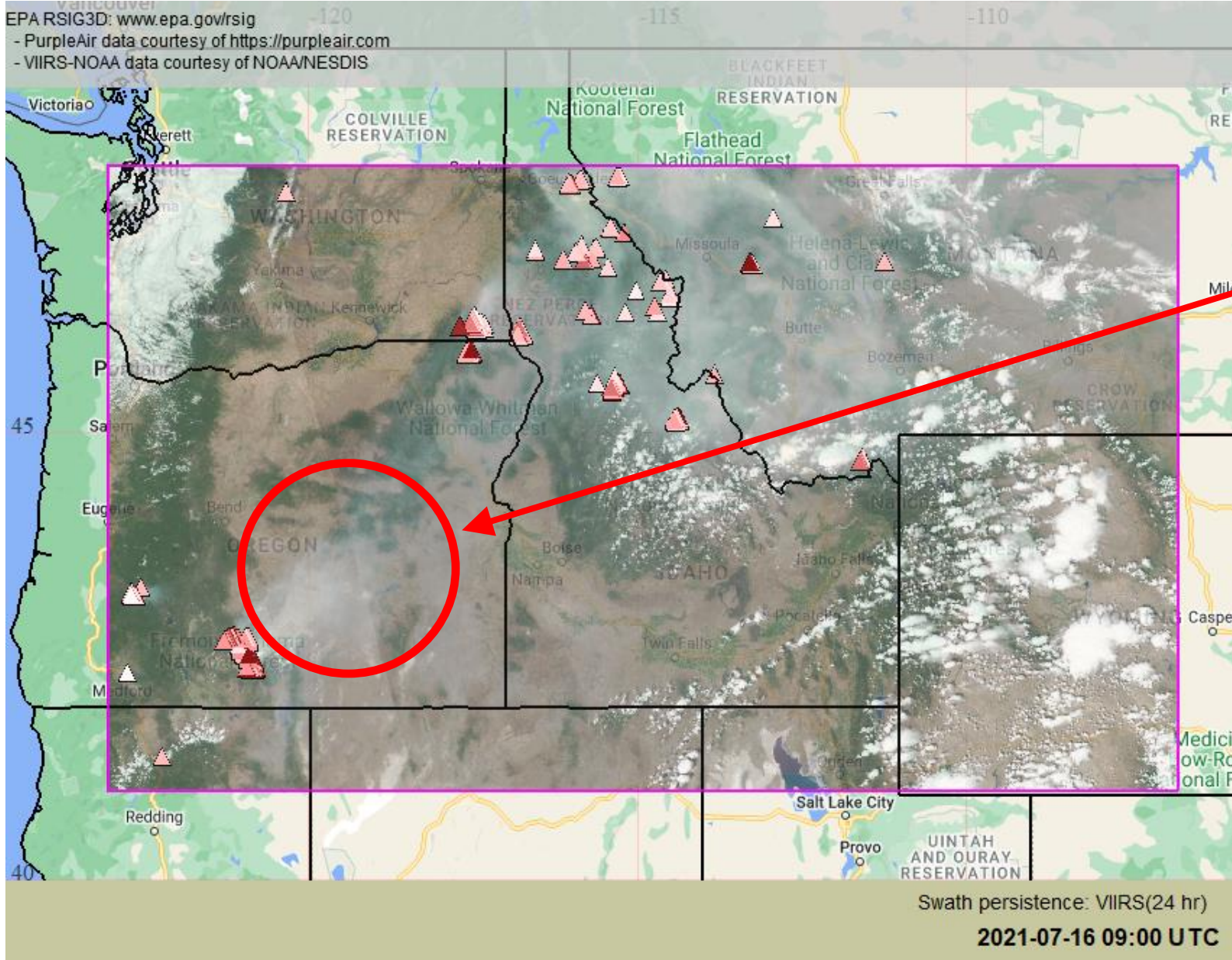
Bootleg Fire, July 2021

- Satellite fire detections
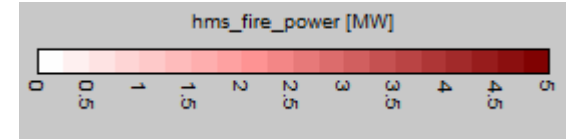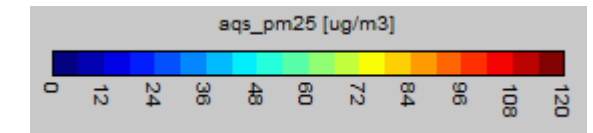
- VIIRS true color imagery showing smoke
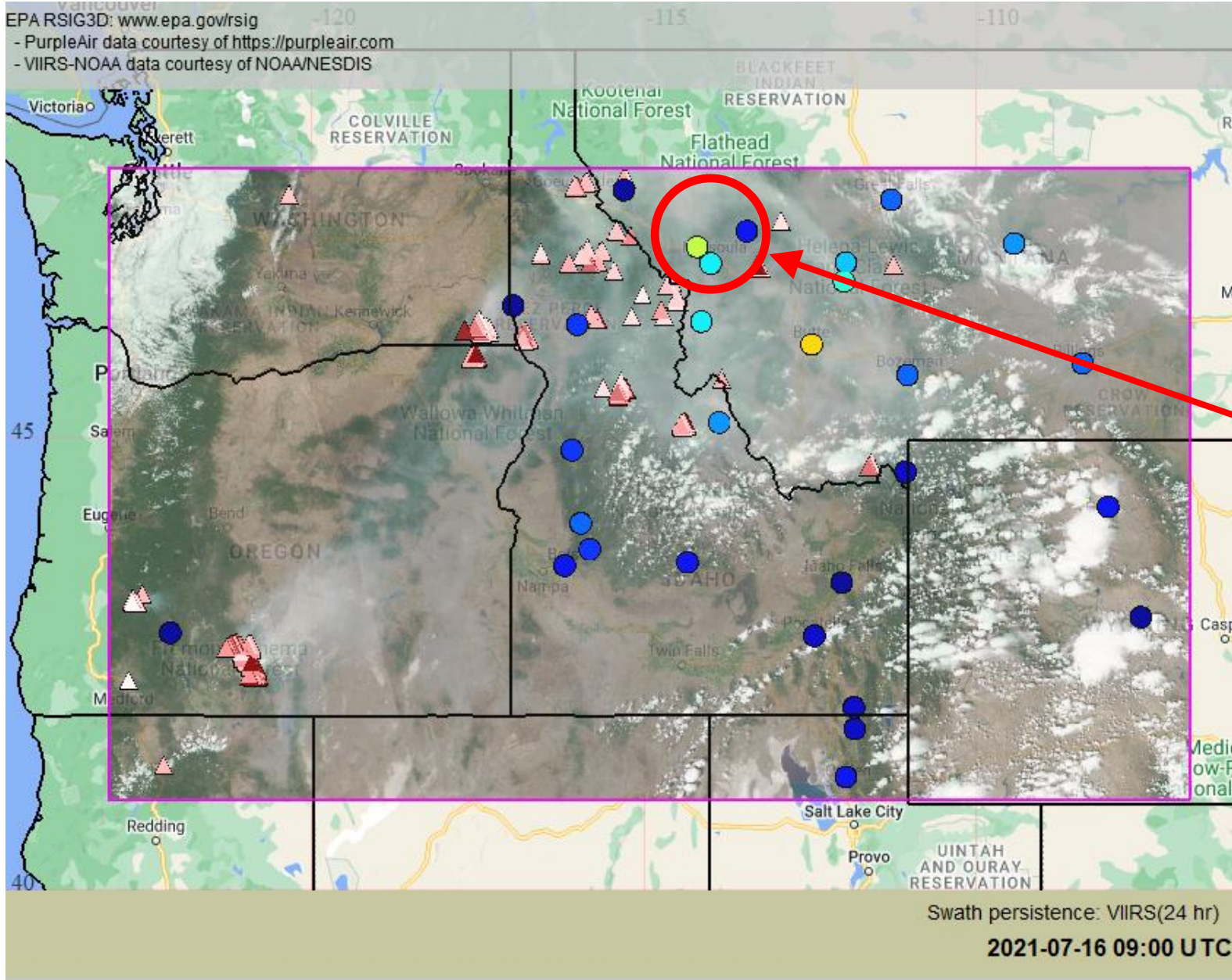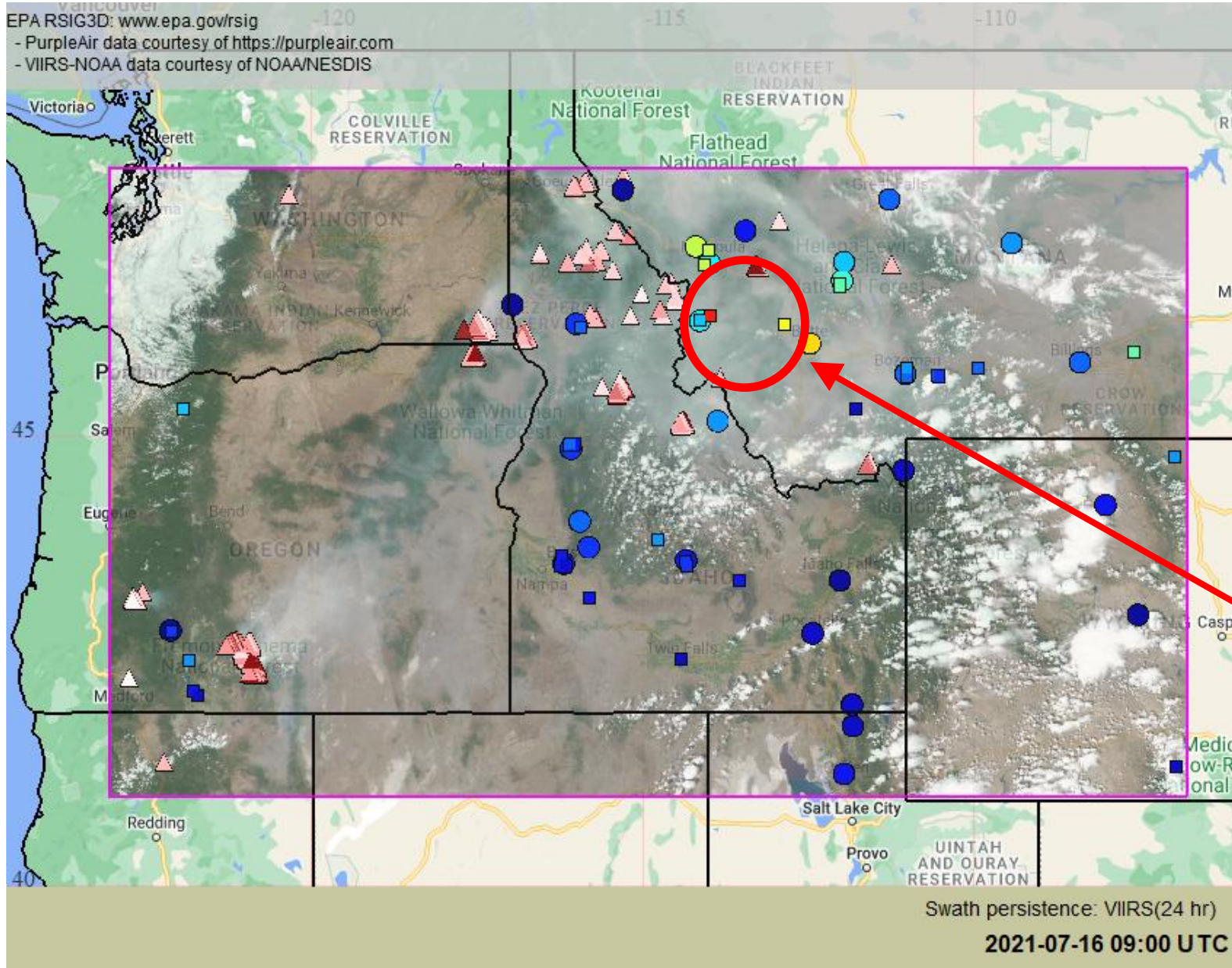
Bootleg Fire, July 2021

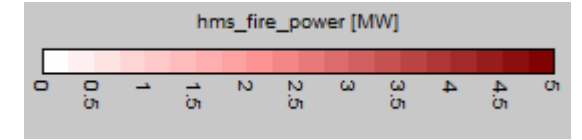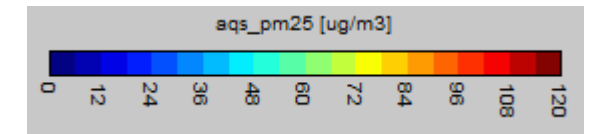- Satellite fire detections
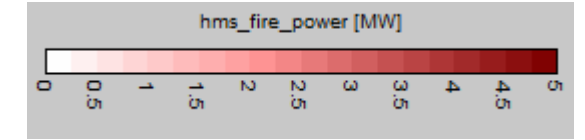
- VIIRS true color imagery showing smoke

- AQS PM$_{2.5}$ monitors
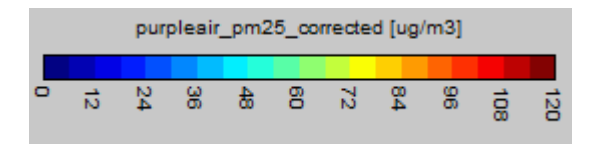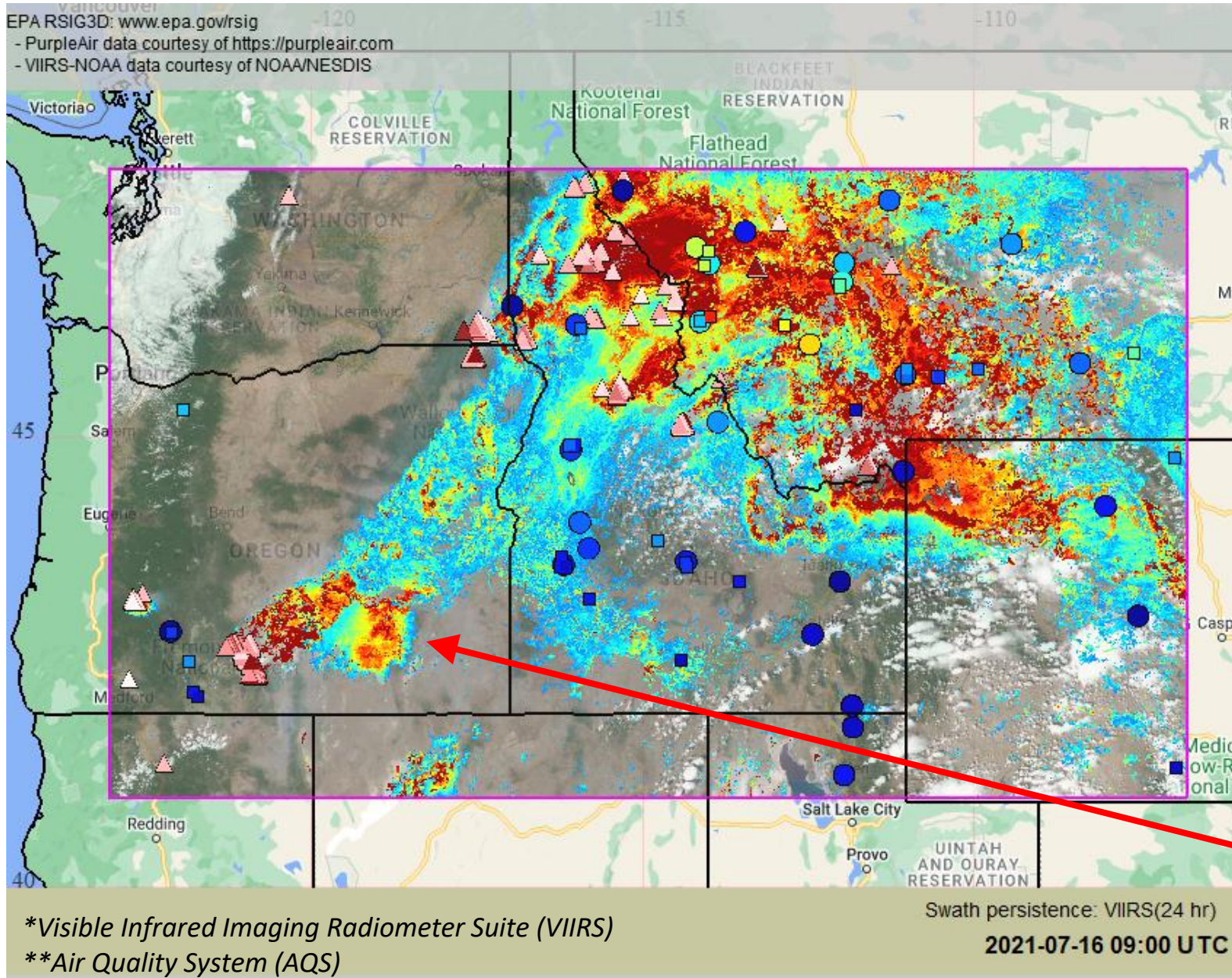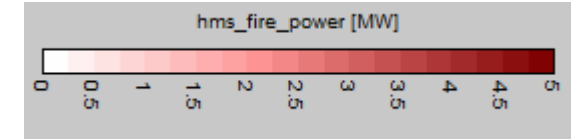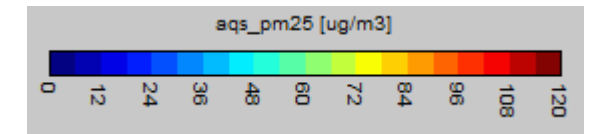
Bootleg Fire, July 2021

- Satellite fire detections

  hms_fire_power [MW]

- VIIRS true color imagery showing smoke

- AQS PM$_{2.5}$ monitors

  aqs_pm25 [ug/m3]

- PurpleAir PM$_{2.5}$ sensors

  purpleair_pm25_corrected [ug/m3]

EPA RSIG3D: www.epa.gov/rsig
- PurpleAir data courtesy of https://purpleair.com
- VIIRS-NOAA data courtesy of NOAA/NESDIS

Swath persistence: VIIRS(24 hr)

2021-07-16 09:00 UTC

Bootleg Fire, July 2021

- Satellite fire detections

  hms_fire_power [MW]
  0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

- VIIRS* true color imagery showing smoke

- AQS** PM$_{2.5}$ monitors

  aqs_pm25 [ug/m3]
  0 12 24 36 48 60 72 84 96 108 120

- PurpleAir PM$_{2.5}$ sensors

  purpleair_pm25_corrected [ug/m3]
  0 12 24 36 48 60 72 84 96 108 120

- VIIRS* satellite AOD

  viirsnoaa_jrraod_AOD550 [-]
  0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

EPA RSIG3D: www.epa.gov/rsig
- PurpleAir data courtesy of https://purpleair.com
- VIIRS-NOAA data courtesy of NOAA/NESDIS

Swath persistence: VIIRS(24 hr)
2021-07-16 09:00 UTC

*Visible Infrared Imaging Radiometer Suite (VIIRS)
**Air Quality System (AQS)

29
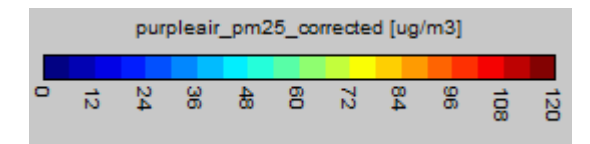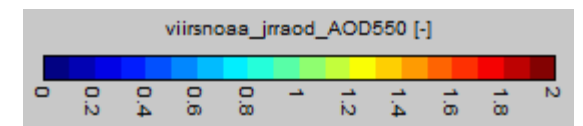
Bootleg Fire, July-August 2021

VIIRS Aerosol Optical Depth (AOD) data saved in ASCII format

Timestamp

Location of polygon centroid

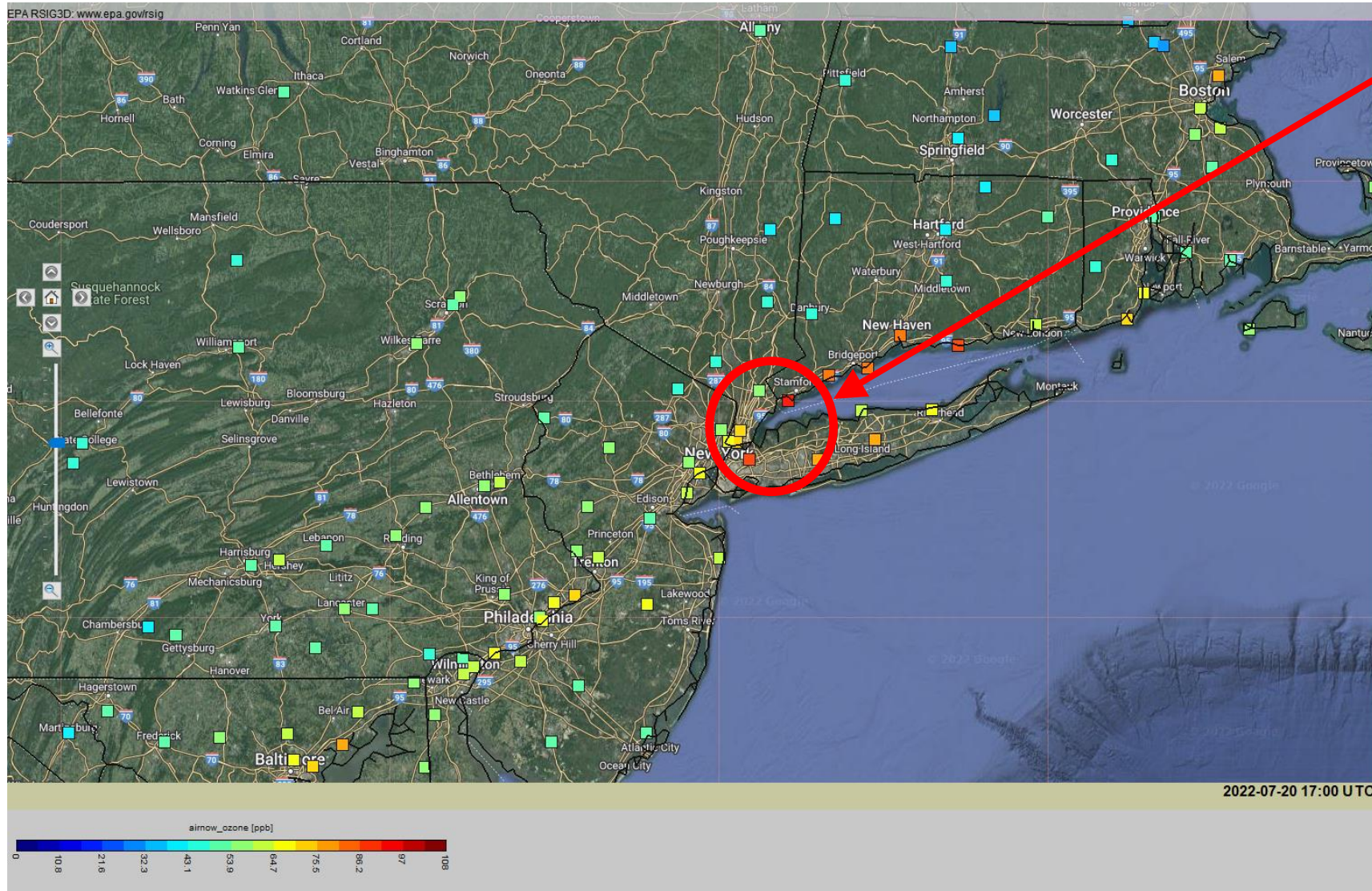Data value

Locations of polygon corners

Retrospective Analysis on Air Quality Forecast July 20, 2022

- Over the Greater NY City Metro area July 20th was the most widespread ozone event of the season, with 2 sites (CT & RI) exceeding 85 ppb for the maximum 8-hr ozone average

- The usually reliable NOAA National Weather Service Bias Correct forecast model, grossly under-estimated the ozone on this day (lower image)

- Use of RSIG data sets help explain evolution of this event to understand the differences between observations and the air quality the NOAA forecast model

Hourly ozone surface concentrations from EPA AirNow

NOAA 8-hour Bias Corrected Modeled Ozone
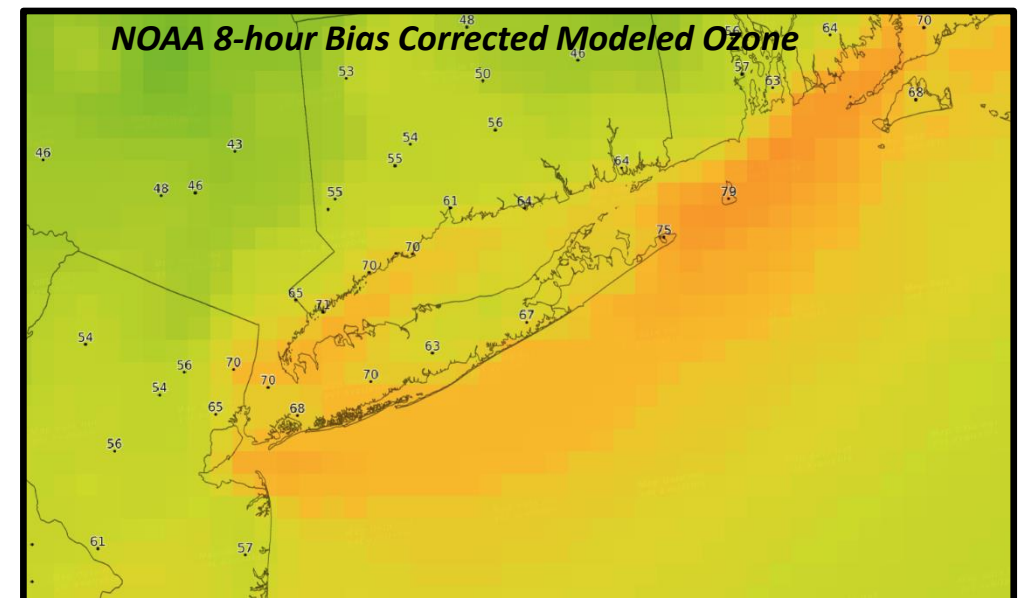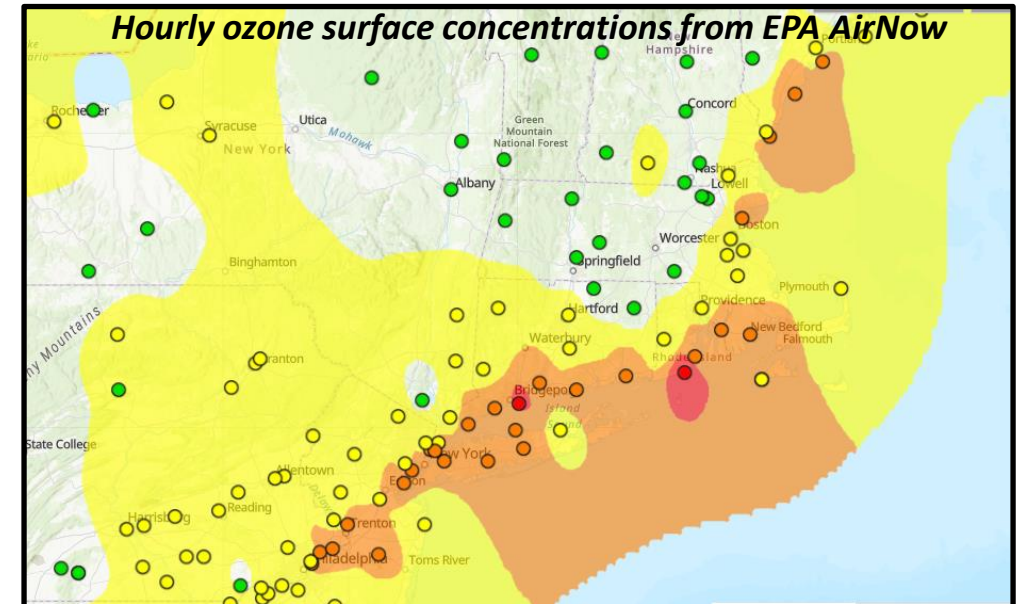
July 20, 2022 - Northeast U.S. Ozone Episode

- AirNow Surface Ozone
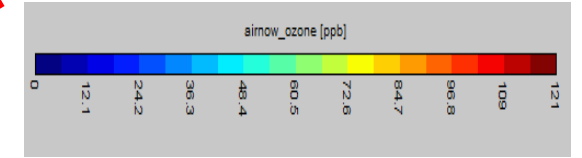
July 20, 2022 - NE U.S. Ozone Episode
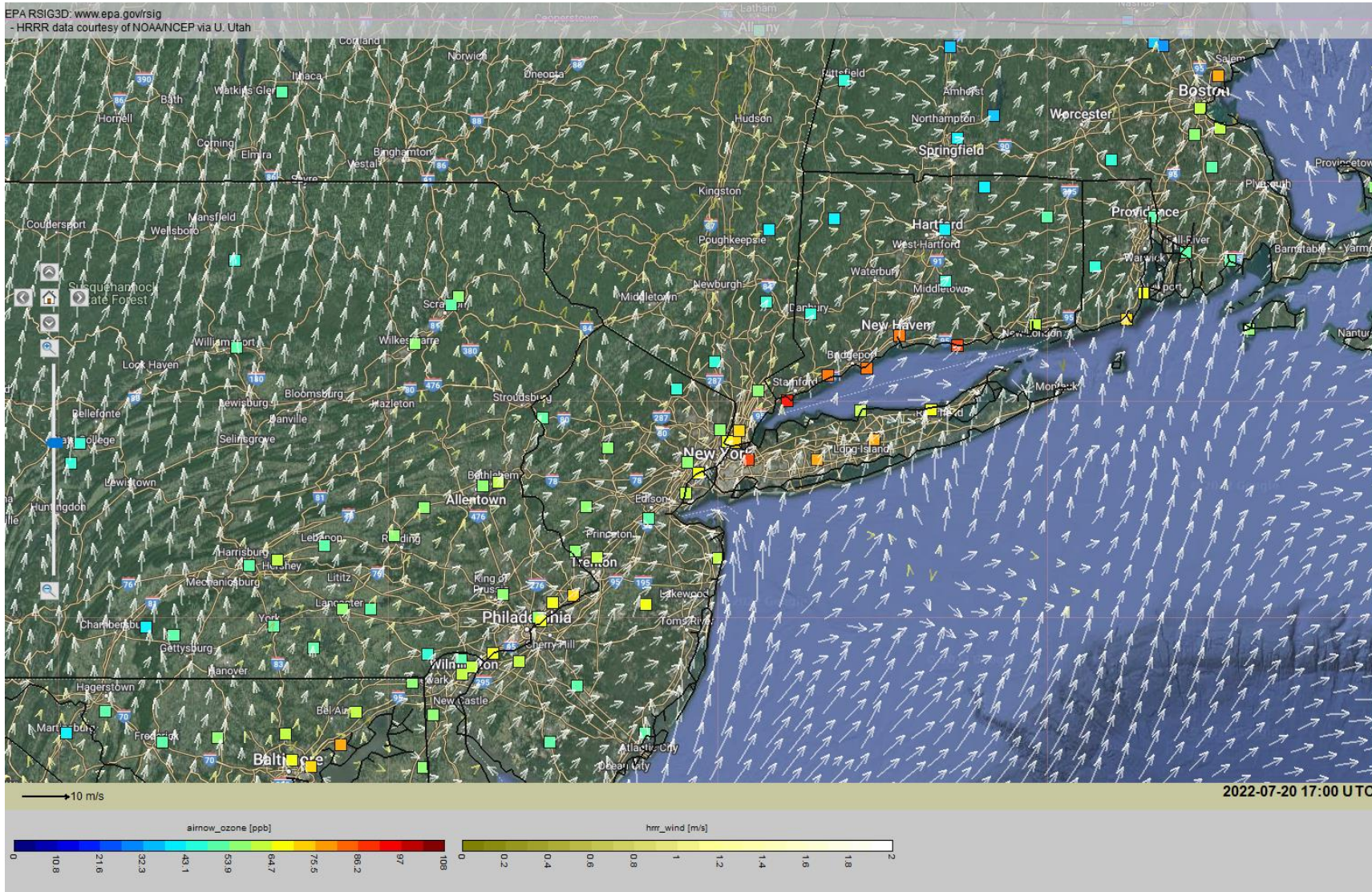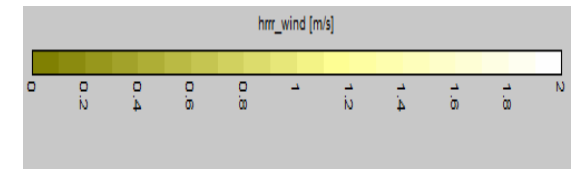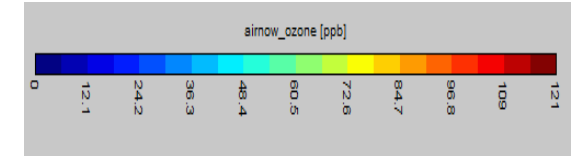

- AirNow Surface Ozone

- HRRR* model surface winds (wind speed and direction)

*High-Resolution Rapid Refresh (HRRR) Model

July 20, 2022 - NE U.S. Ozone Episode
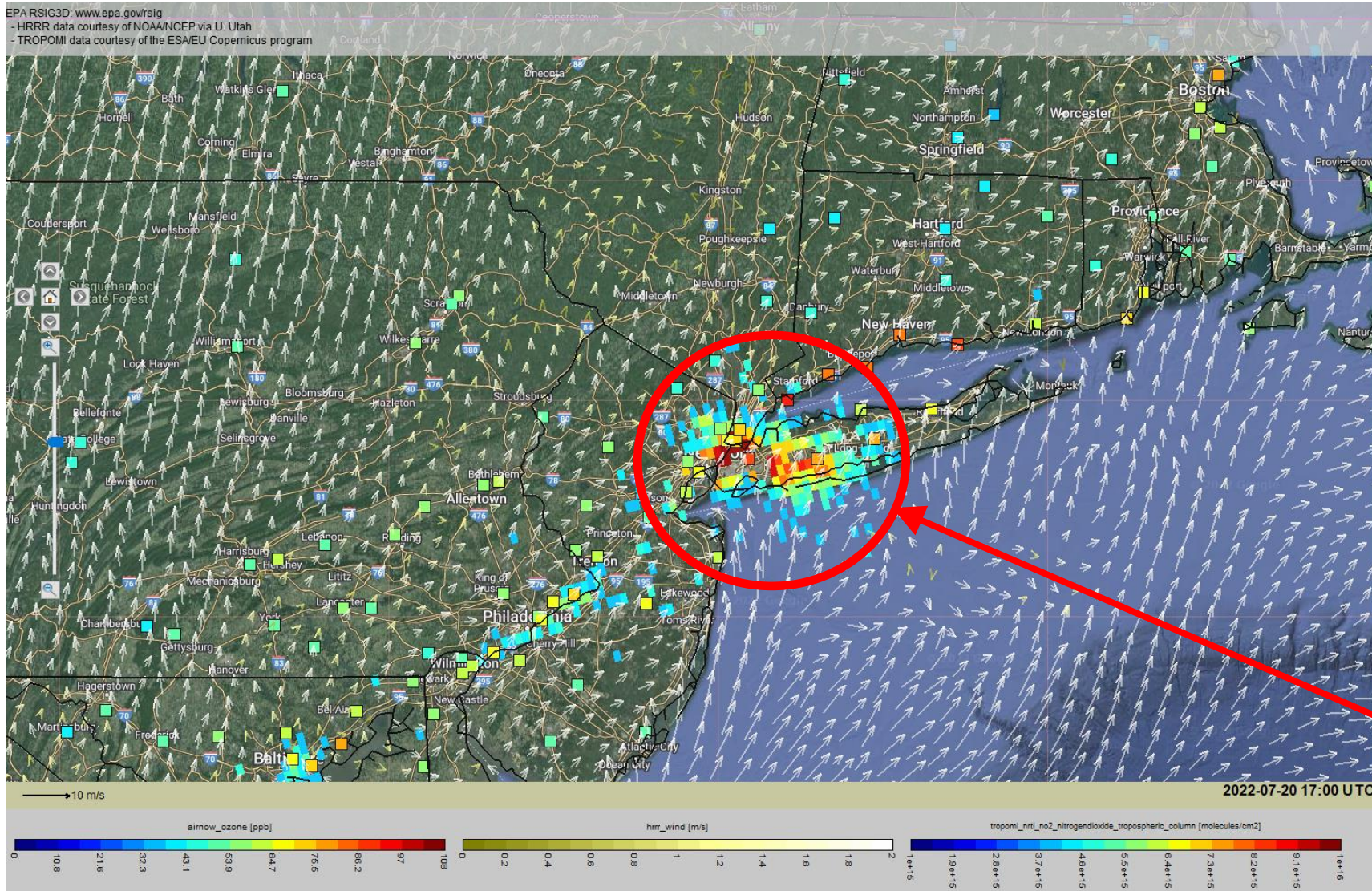
- AirNow Surface Ozone

- HRRR model surface winds (wind speed and direction)
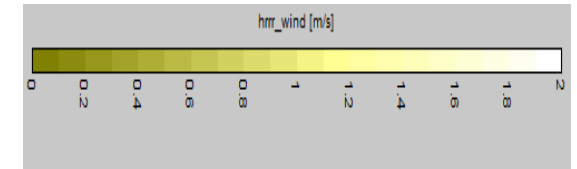
- TROPOMI Tropospheric Column NO_2 abundances
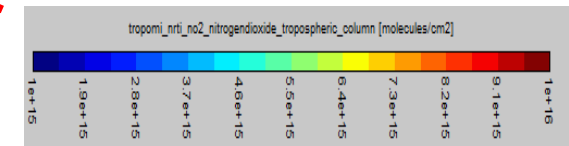
RSIG3D Animation

RSIG Case Study provided by:
Michael Geigert
Air Pollution Control Engineer
Bureau of Air Management

The RSIG3d animation, which layers the HRRR winds, hourly ozone and the afternoon TROPOMI satellite NO2 column, shows the ozone formation occurring further north than modeled

Case Study Takeaways

- Fire Case Study: Not all smoke reaches the surface – routine, accessible visualization of satellite and surface in situ datasets enable air quality managers to gain insights into what factors affect surface-level smoke impacts.
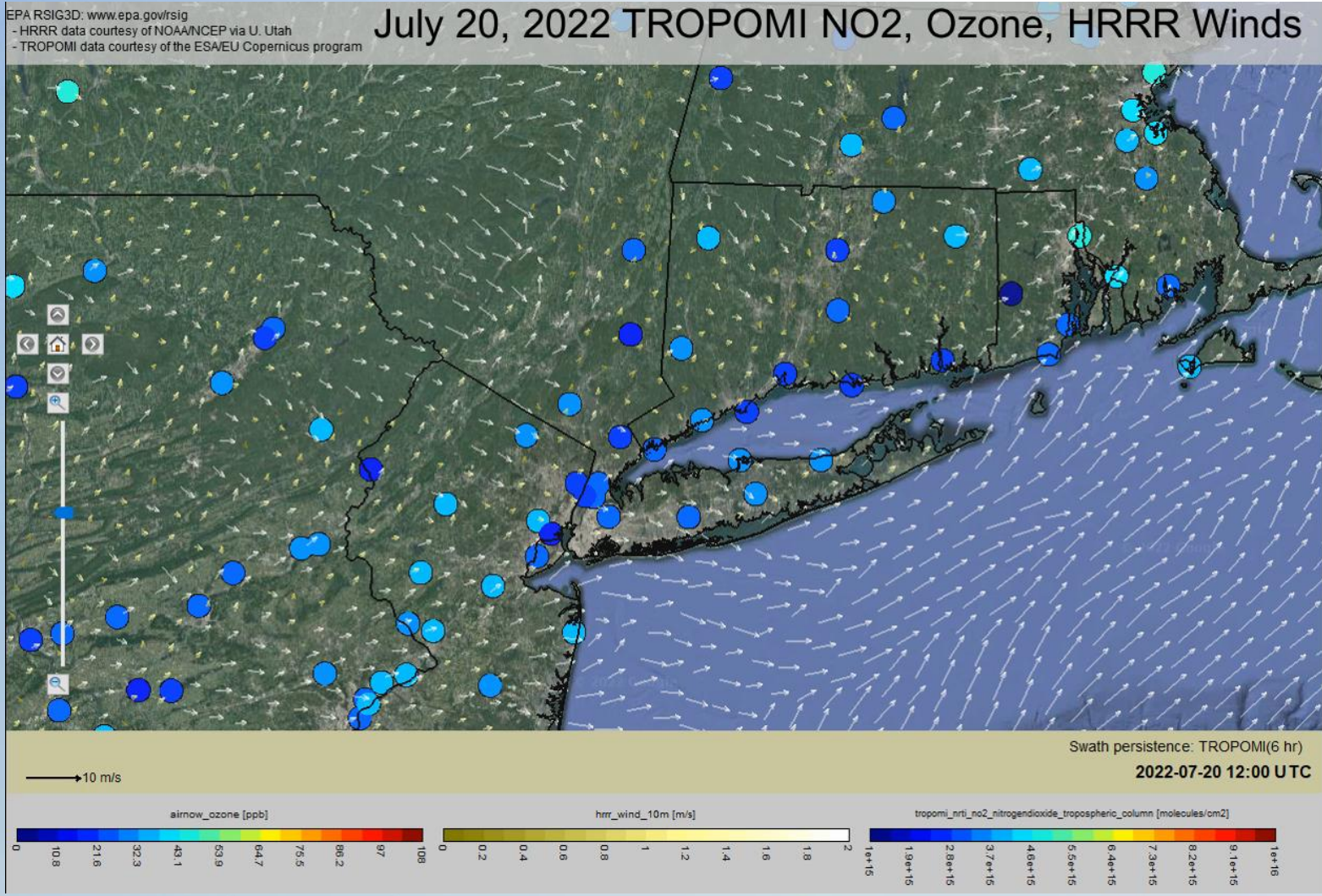
- Air Quality Forecast Case Study: The full spatial coverage of satellite data and higher resolution of NWS meteorological modeling show where 12 km resolution air quality modeling falls short, in this case by not resolving mesoscale features associated with Long Island Sound.

Impact

Process Flow

Problem Definition → Data Preparation & Exploration → Advance Data Analysis → Report Results

RSIG's Function

Input Data Sets from Distributed Archives →

- Time, Date, and Domain, with pre-select Data Quality Flags → Output Enriched Data Sets in Analysis Ready Formats
- Data Set Visualization

End Users
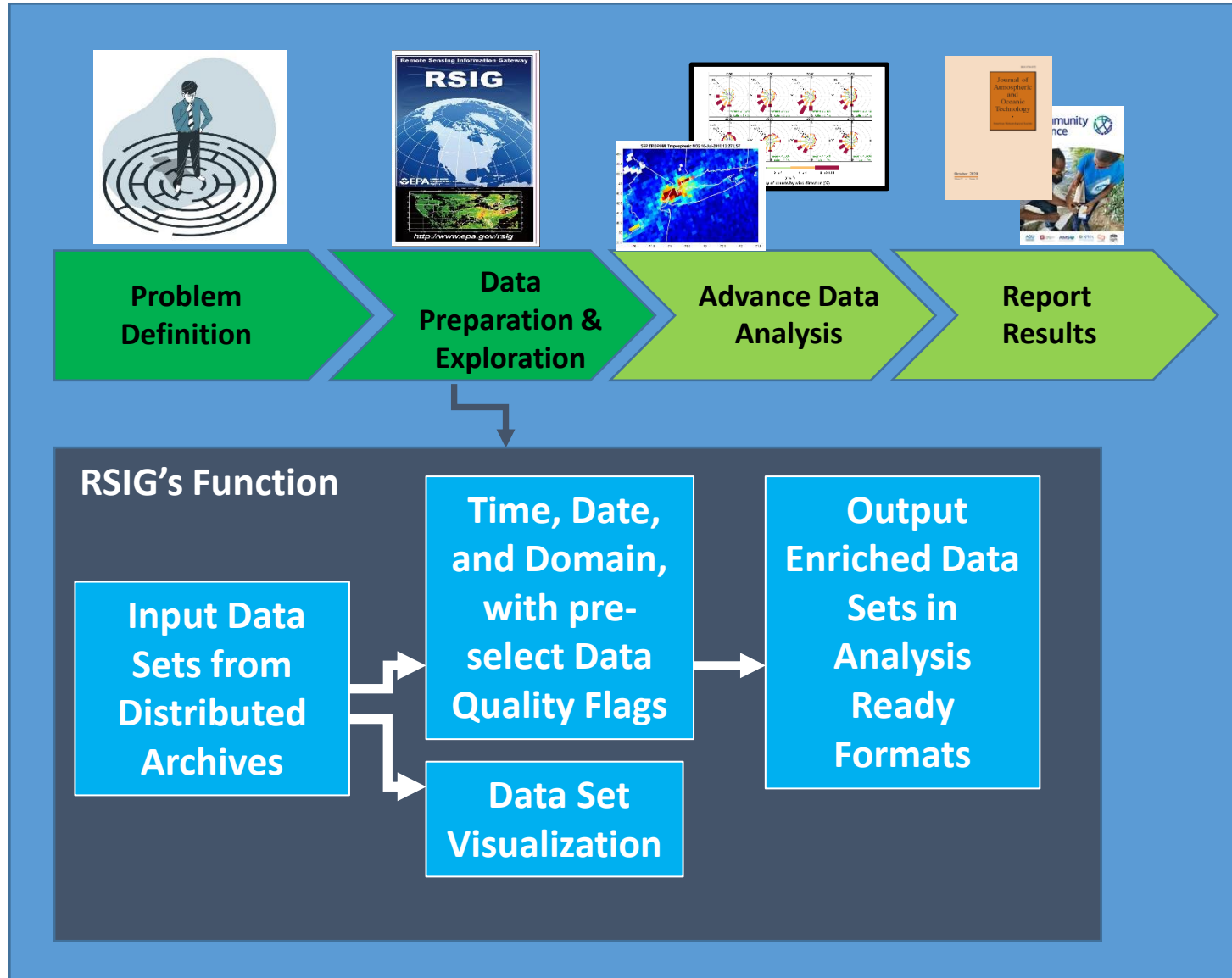
Air Quality Modelers
- Model Evaluation
- Case Study Analysis

Air Quality Forecasters
- Retrospective Analysis

Scientists & Researchers
- Exposure studies
- Inverse modeling studies
- Improving air quality models

Students
- Thesis/Dissertation Research