Visualizing Air Quality: How to Use NASA’s Giovanni to Plot Satellite Tropospheric NO$_2$ Columns

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HAQAST2020 WEBINAR SERIES
Outline

• Introduction to NASA’s Giovanni online visualization tool

• Overview of guidance documents from a HAQAST Tiger Team (“Supporting the use of Satellite Data in SIPs”)

• Q&A
Giovanni: The bridge between data and science

Go to: https://giovanni.gsfc.nasa.gov/giovanni/
First step: Register for an account on NASA EarthData

• You can use Giovanni as a guest, but limited to 4 time steps.
• Register your account at: https://urs.earthdata.nasa.gov/users/new
• Go to Giovanni website (https://giovanni.gsfc.nasa.gov/giovanni/), click on Login at the upper right corner.
What can you do with Giovanni?

• Make time-averaged maps (e.g. monthly, seasonal, annual average, or select your own time range).

• Make an animation.

• Make time series.

• Compare two variables: map of correlation, scatter plots.

• Make vertical profiles.

• Zonal mean maps.

• Histograms.

• Multiple measurements: NO₂, SO₂, HCHO, CO, aerosol optical depth (AOD).

• Multiple instruments: OMI, MISR, MOPPIT, AIRS, MODIS.
Limitations of Giovanni

• Cannot define data selection criteria.
• Map/graph customization is limited.
• Not easy to automate the jobs.
• Sometimes it can be slow, especially for large calculation (e.g. multiple years).
• Cannot compare between two time periods.
• Only Level-3 data are supported.
• Some species (e.g. NH$_3$) are not supported.
• TROPOMI data are still not included.
• You can only download the results, not the original data. (To download original data, click on the product landing page or data lineage).
Make a plot in five steps!
Select variables

**Observations**
- Model (16)
- Observation (81)

**Disciplines**
- Aerosols (194)
- Atmospheric Chemistry (77)
  - Atmospheric Dynamics (423)
  - Cryosphere (12)
  - Hydrology (837)
- Ocean Biology (58)
- Oceanography (82)
- Water and Energy Cycle (709)

**Measurements**
- Aerosol Index (2)
- Aerosol Optical Depth (7)
- Air Temperature (1)
- Angstrom Exponent (2)
- CH4 (8)
- CO (22)
- CO2 (2)
- Emissivity (1)
- HCHO (1)
- NO2 (2)
- Ozone (30)
- SO2 (4)
- Total Aerosol Optical Depth (2)

**Platform / Instrument**
- AIRS (35)
- MERRA Model (2)
- MERRA-2 Model (14)
- MODIS-Aqua (5)
- MODIS-Terra (2)
- MOPITT (3)
- OMI (7)
- TOMS EP (1)
- TOMS Meteor-3 (1)
- TOMS Nimbus-7 (1)

**Spatial Resolutions**
- 0.1° (1)
- 0.25° (5)
- 0.5 x 0.625° (14)
- 1° (39)
- 1.0° (9)
- 1.0 x 1.25° (3)
- 1.25° (2)
- 2 x 2.5° (2)
- 4 km (2)

**Temporal Resolutions**
- 3-hourly (2)
- 8-daily (2)
- daily (26)
- hourly (2)
- monthly (42)

**Wavelengths**
- 550.0 (5)
- 869.0 (1)
Options for selecting regions

Option 1: Type in the Latitude/Longitude Range

Option 2: Use the cursor to select a region on map

Working with time averaged maps
Annual average OMI NO$_2$ tropospheric column
How to customize maps?
How to customize maps: More options
Customized map
Four options to save results

- **NetCDF**: for further analysis in other tools (e.g. Panoply, programming).
- **PNG**: Ready to present!
- **GEOTIFF**: tiff with geographic information (e.g. use in ArcGIS).
- **KMZ**: plot in Google Earth.

Click on file links to download. Files contain data portrayed in the plot images.

**NetCDF**:  
g4.timeAvgMap_OMNO2d_003_ColumnAmountNO2TropCloudScreened_201101-20111231.180W_90S_180E_90N.netcdf

**PNG**:  
OMNO2d_003_ColumnAmountNO2TropCloudScreened_201101-20111231.180W_90S_180E_90N.png

**GEOTIFF**:  
OMNO2d_003_ColumnAmountNO2TropCloudScreened_201101-20111231.180W_90S_180E_90N.tif

**KMZ**:  
OMNO2d_003_ColumnAmountNO2TropCloudScreened_201101-20111231.180W_90S_180E_90N.kmz
Working with time series

1. Select the time series you want to work with.
2. Choose the date range for your time series.
3. Select the region for your time series.
4. Choose the variables to include in your analysis.
5. Review and adjust your selections before plotting.
NO$_2$ tropospheric column density over LA region

Time Series, Area-Averaged of NO2 Tropospheric Column (30% Cloud Screened) daily 0.25 deg.

- The user-selected region was defined by 122.7832W, 32.7832N, 116.6309W, 36.2109N. The data grid also limits the analyzable region to the following bounding points: 122.625W, 32.875N, 116.875W, 36.125N. This analyzable region indicates the spatial limits of the subsetted granules that went into making this visualization result.
Fit a trend line
Save figure and data

Click on file links to download. Files contain data portrayed in the plot images.

**ASCII CSV:**
- g4.areaAvgTimeSeries.OMNO2d_003_ColumnAmountNO2TropCloudScreened.20050101-20171231.122W_32N_116W_36N.csv

**PNG:**
- g4.areaAvgTimeSeries.OMNO2d_003_ColumnAmountNO2TropCloudScreened.20050101-20171231.122W_32N_116W_36N.png
How to download the original satellite data?

<table>
<thead>
<tr>
<th>Output</th>
<th>Data URL</th>
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<tr>
<td></td>
<td><a href="http://acdisc.project.eosdis.nasa.gov/openmap/HDF-EOS5/ml/Aura_OMI_Level3/OMINO3d_063/2005/Aura_L3-OMINO3d_2005m101_v03-2018m02b144023.h65.nc">http://acdisc.project.eosdis.nasa.gov/openmap/HDF-EOS5/ml/Aura_OMI_Level3/OMINO3d_063/2005/Aura_L3-OMINO3d_2005m101_v03-2018m02b144023.h65.nc</a></td>
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Bookmarking and data sharing

• You can bookmark the analysis by saving the URL of the Giovanni page. In the future you can always reload this analysis by copying and pasting the saved Giovanni URL into a browser.
• If you like the plot and want to share it with other people, you can also save the URL and they will be able to see your selections and figure.
Other figures: Histograms
Other figures: Zonal Mean
Practice:
Linking OMI tropospheric NO$_2$ column with ground-level NO$_2$

Part I: Visualize and analyze OMI tropospheric NO$_2$ data using Giovanni (https://disc-beta.gsfc.nasa.gov/giovanni/)

Part II: Compare OMI NO$_2$ with EPA AQS ground-based measurements of NO$_2$ (https://www.epa.gov/outdoor-air-quality-data) using Excel.

Technical Guidance Documents produced by a HAQAST Tiger Team

A Brief Tutorial on Using the Ozone Monitoring Instrument (OMI) Nitrogen Dioxide (NO₂) Data Product for SIP's Preparation

https://doi.org/10.7916/D80K3S3W

Guide to Using Satellite Images in Support of Exceptional Event Demonstrations

https://doi.org/10.7916/D84B4HT6

Using satellite observed formaldehyde (HCHO) and nitrogen dioxide (NO₂) as an indicator of ozone sensitivity in a SIP

https://doi.org/10.7916/D8M34C7V

Archived at Columbia U Academic Commons Repository
Technical Guidance Document:
Using space-based HCHO/NO\textsubscript{2} as an indicator of O\textsubscript{3} sensitivity

- NASA HAQAST Team
  - Developed the methodology (Jin et al., 2017)

- Air Quality Agency Early Adopters
  - Delivered a technical guidance on using satellite HCHO/NO\textsubscript{2} in SIPs

- Beta Testers
  - Agencies tried the approach outlined in the technical guidance and provided feedback

- Other local, state, regional air quality and health agencies
  - The technical guidance is publicly available on "NASA air quality from Space"

- HAQAST
- Connecticut Department of Energy & Environmental Protection
- Environmental Protection Division
- South Coast AQMD

@nasa_haqast
State Implementation Plans

Publicly available NASA satellite data can help with State Implementation Plans (SIPs)

NASA's Earth science program maintains a large fleet of earth-observing satellites, all of which offer free data products. A number of these can be used to illustrate NOx emissions trends and their relevance to ozone attainment, as well as for weight-of-evidence under the EPA's Exceptional Events Rule. A collaborative team of NASA-funded scientists and public stakeholders has recently developed a suite of easy-to-follow technical guidance documents to support state and local air quality agencies that want to bring the power of NASA's satellites to bear on the documentation of exceptional events. This work is a product of the NASA Health and Air Quality Applied Sciences Team (HAQAST) Year 1 (2017-2018) Tiger Team “Supporting the Use of Satellite Data in State Implementation Plans (SIPs)"

Thanks to Bryan Duncan and his team for hosting these!
Technical Guidance Document

NASA Health and Air Quality Applied Sciences Team
2017–18 Tiger Team Project

Supporting the use of satellite data in State Implementation Plans

Comparison of CMAQ Simulation to Satellite Observations: NO$_2$ Column versus OMI NO$_2$

**Prepared by:**

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Additional documents coming online:

**SHORT TUTORIAL***:

*How do I create a timeseries of NO$_2$ tropospheric columns with Giovanni for my city?*

Daniel Tong (GMU), Jennifer Wei (NASA) & Suhung Shen (GMU)

*includes other links to Giovanni resources*

[https://doi.org/10.7916/d8-cfwm-5x30](https://doi.org/10.7916/d8-cfwm-5x30)
Acknowledgments

Analyses and visualizations used in this presentation were produced with the Giovanni online data system, developed and maintained by the NASA GES DISC
Questions?

Use the question function at the lower right of your screen

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