



Accessibility of NASA GEOS Composition Forecasts for the Health and Air Quality Communities

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¹ USRA/GESTAR

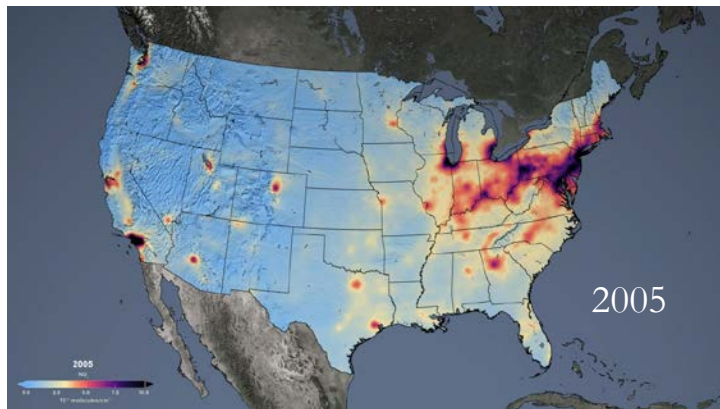
² NASA GSFC Global Modeling and Assimilation Office (GMAO)

13 December 2019



Unique Advantages of Satellite Data

Spatial Coverage & Changes over Time



OMI Nitrogen Dioxide:
 NO_2
(gridded to $\sim 10 \times 10 \text{ km}^2$)

Satellite data are validated with independent observations (e.g., AQS, NASA field campaigns) and emissions (e.g., CEMS)



July 13, 2019 Can you see the mountains?!



National Parks/Monuments Tribal Boundaries
The tribal boundaries shown here are provided by the Bureau of Indian Affairs as a general spatial reference only. They are not a formal determination of tribal boundaries or jurisdictional authority, including the right to regulate on- or off-reservation conduct.

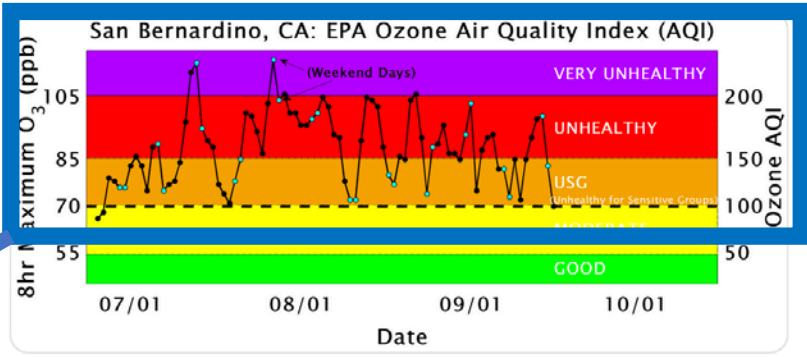


twitter.com/rms5539/status/1173951085876326401



Ryan Stauffer @rms5539 · Sep 17

This streak included 5 Code Purple ozone days, as well as 18 consecutive Code Red days from July 22nd to August 8th



1 7



Ryan Stauffer @rms5539 · Sep 17

After doing some digging, the last time I can reliably say a single monitor recorded this many Code Orange ozone days in a row was in 1994, 25 years ago, a bit north of here in Crestline, CA

1 1



Ryan Stauffer @rms5539 · Sep 17

Code Purple ozone was a lot more common back then, but clearly ozone pollution remains a critical health problem for residents near Los Angeles

1

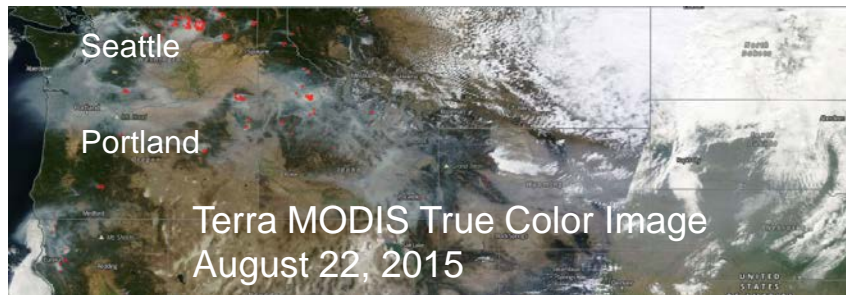


Ryan Stauffer @rms5539 · Sep 17

It's worth noting that the streak ended because the 8-hour average rounded down to 70 ppb instead of up to 71. So it technically wasn't a Code Orange...barely

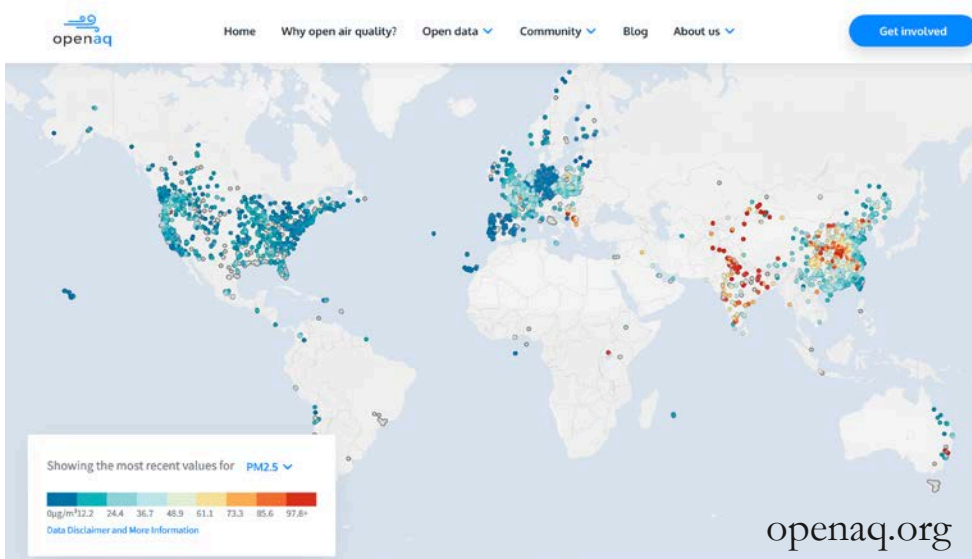
GMAO

Wildfires are part of the problem



Sparse Surface AQ Monitors

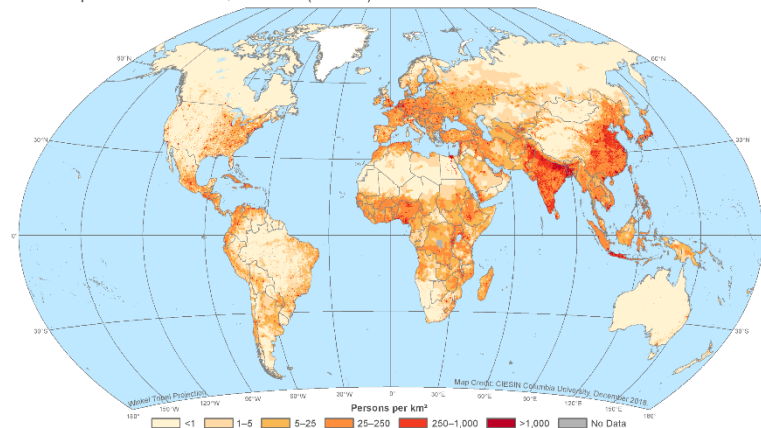
OpenAQ Surface Monitor Locations



Population Density

Population Density, v4.11, 2015

Gridded Population of the World, Version 4 (GPWv4)



Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11 consists of estimates of human population density based on counts consistent with national censuses and population registers for the years 2000, 2005, 2010, 2015, and 2020. A proportional allocation gridding algorithm, utilizing approximately 13.5 million national and sub-national administrative units, is used to assign population counts to 30 arc-second (approximately 1 km at the equator) pixels. The population count rasters are divided by the land area raster to produce population density rasters with pixel values representing persons per square kilometer.

Center for International Earth Science Information Network - CIESIN - Columbia University 2016. Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 11. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). <https://doi.org/10.7927/H49C6VHW>. Earth Institute of Columbia University

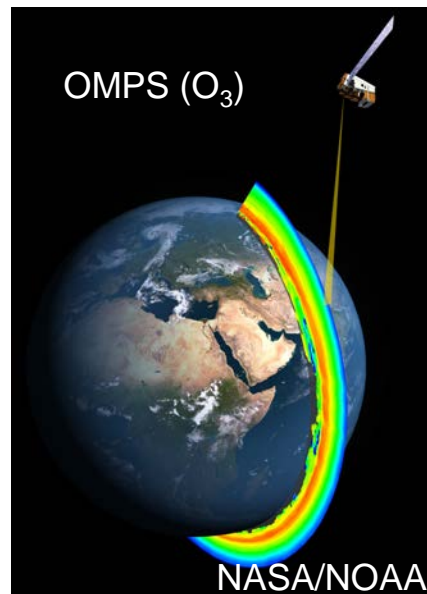
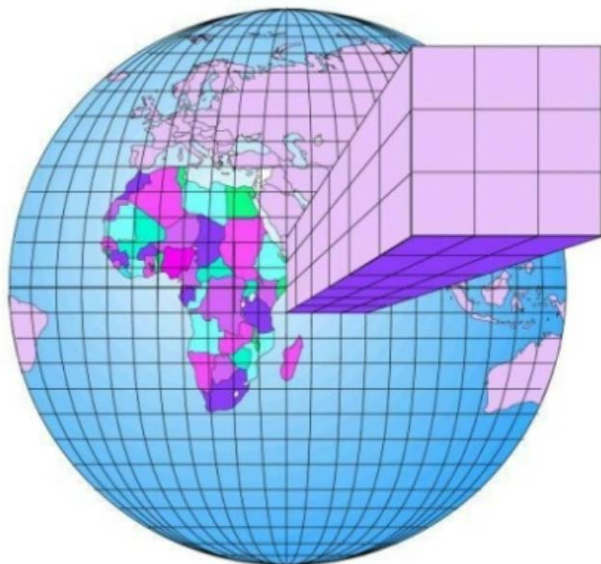
© 2016, The Trustees of Columbia University in the City of New York

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Most global citizens have little or no access to air quality information, but most have access to the internet and, therefore, could have access if the information is made available.

NASA GMAO global meteorology and chemistry products

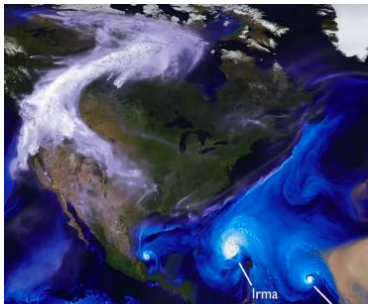
GEOS



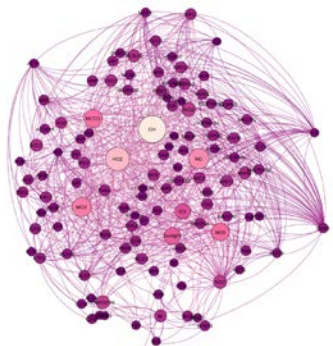
www.nasa.gov



NASA's composition forecast (GEOS-CF)

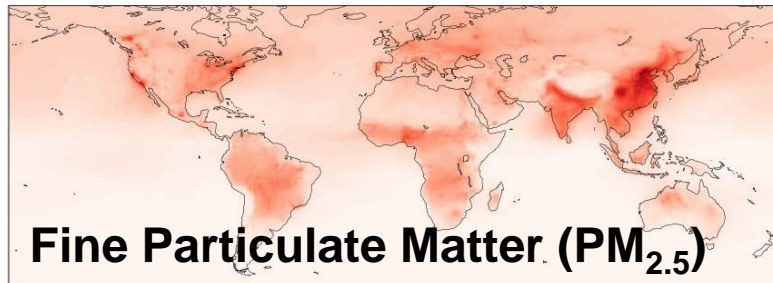
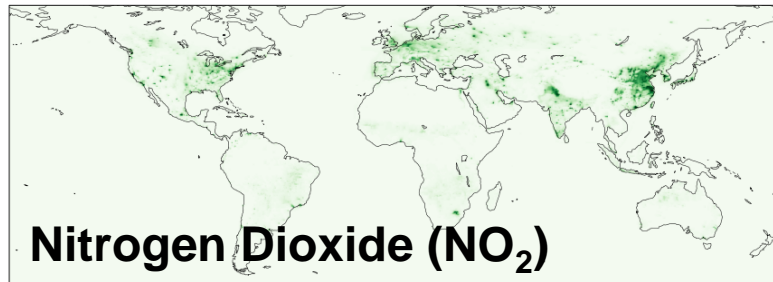
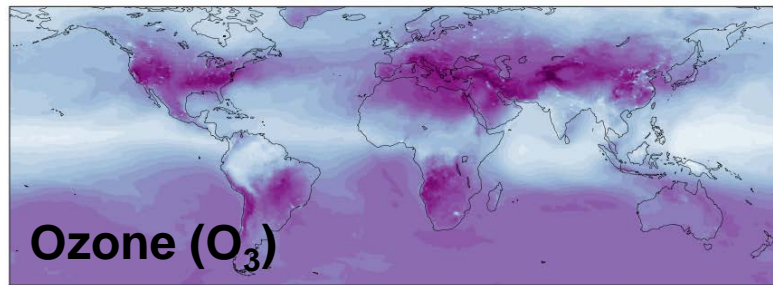


GEOS NWP



GEOS - Chem

- ❖ 250 Chemical Species
- ❖ 725 Chemical Reactions





High-Resolution Global Simulation





Big Data

Every afternoon a **5-day forecast** is produced

➤ **25x25 km²**

➤ **72 levels**

= 75 Million data points per time step!

Output:

➤ **Chemistry and Meteorology fields**

➤ **15 minute “surface”**

➤ **1-hour average and instantaneous 2D & 3D**



Where to find GEOS-CF

GEOS-CF 3D and 2D data since 1 January 2018:

1) Download from the NASA Data Portal

<https://portal.nccs.nasa.gov/datashare/gmao/geos-cf/>

2) Remote access through OPeNDAP

<https://opendap.nccs.nasa.gov/dods/gmao/geos-cf>



Where to find GEOS-CF

Maps available at fluid.nccs.nasa.gov/cf a mobile-friendly website

GMAO

Composition Forecast
CF Datagrams

NATIONAL
San Francisco

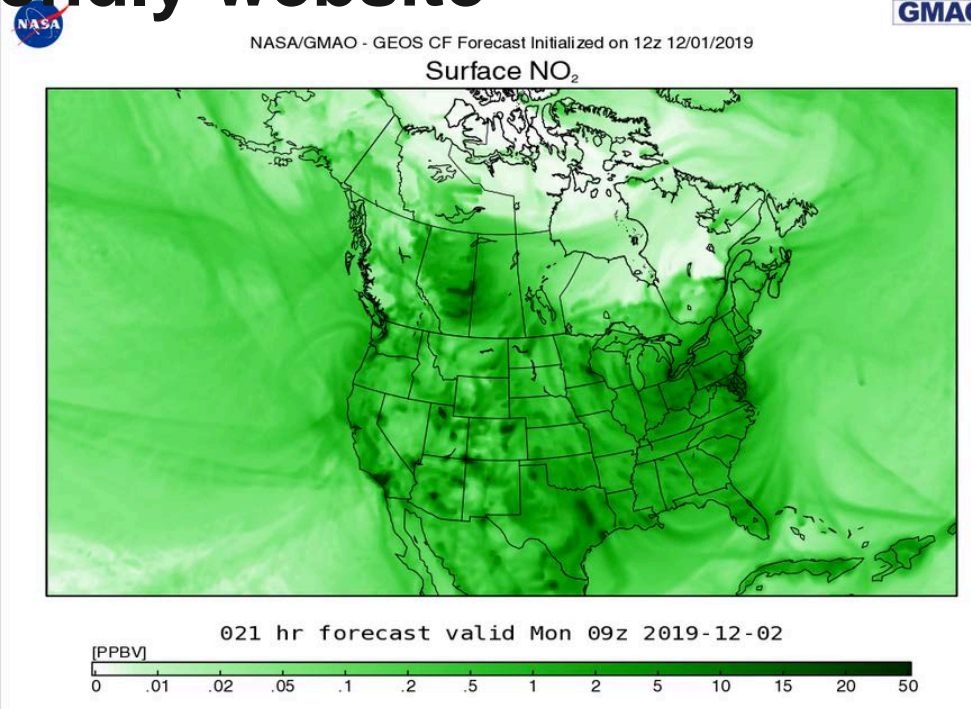
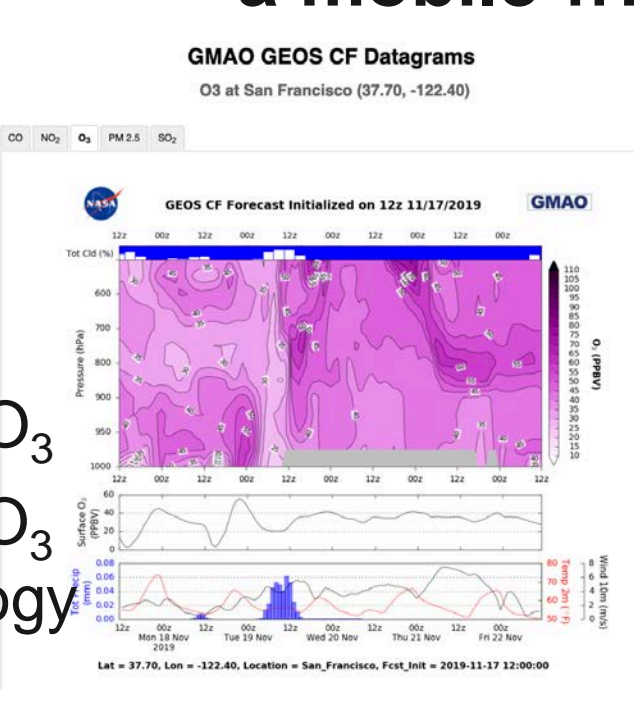
WORLD
Select a Station

AERONET
Select a Station

MEGACITIES
San Francisco

ACTIVE CAMPAIGNS
Select a Station

Vertical O₃
Surface O₃
Meteorology



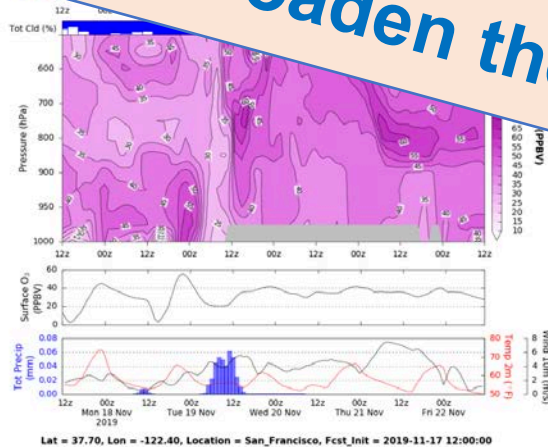
Where to find GEOS-CF

Maps available at fluid.nccs.nasa.gov/cf
a mobile-friendly website

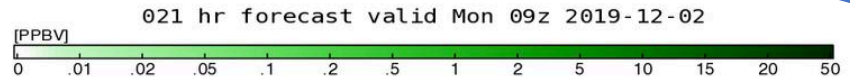
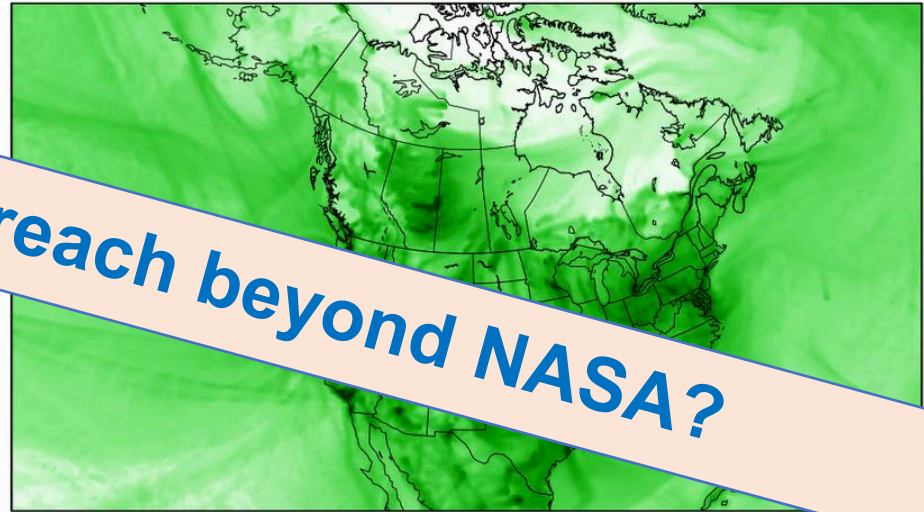
GMAO

Can we broaden the reach beyond NASA?

GMAO GEOS CF Datagrams
O3 at San Francisco (37.70, -122.40)



NASA/GMAO - GEOS CF Forecast Initialized on 12z 12/01/2019
Surface NO₂





➤ Currently FLUID is static, with 200 preset Datagram locations: Focus on

locations: Focus on

1. NASA Campaigns

2. AERONET sites

3. USA cities – not even all capital cities!

4. World cities

Composition Forecast

CF Datagrams

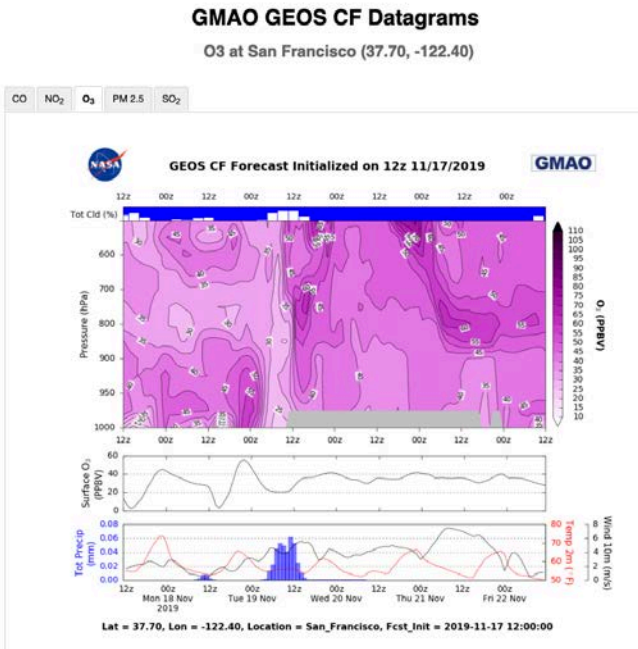
NATIONAL
San Francisco

WORLD
Select a Station

AERONET
Select a Station

MEGACITIES
San Francisco

ACTIVE CAMPAIGNS
Select a Station



NASA supports NASA science



FIELDS

Total Column

| | |
|----|------------|
| O3 | NO2 |
| CO | |

FIELDS

| | |
|---------|----------------|
| CO Sfc | NO2 Sfc |
| O3 Sfc | PM2.5 Sfc |
| SO2 Sfc | |

REGIONS

North America

FORECAST INITIAL TIME

01Dec2019 12z

FORECAST LEAD HOUR

021h 02Dec2019 09z

REGIONS

- North America
- Africa
- Alaska
- Atlantic Ocean
- Australia
- Brazil
- Central America
- Caribbean
- East Asia
- Europe
- Global
- Greenland
- Hawaii
- India
- Indian Ocean
- Indonesia
- Mid Atlantic
- Middle East
- North America**
- North Asia
- North Atlantic
- North Pacific
- N Polar
- Orthographic East
- Pacific Ocean
- South America
- Seven Seas
- Siberia
- S Polar
- United States

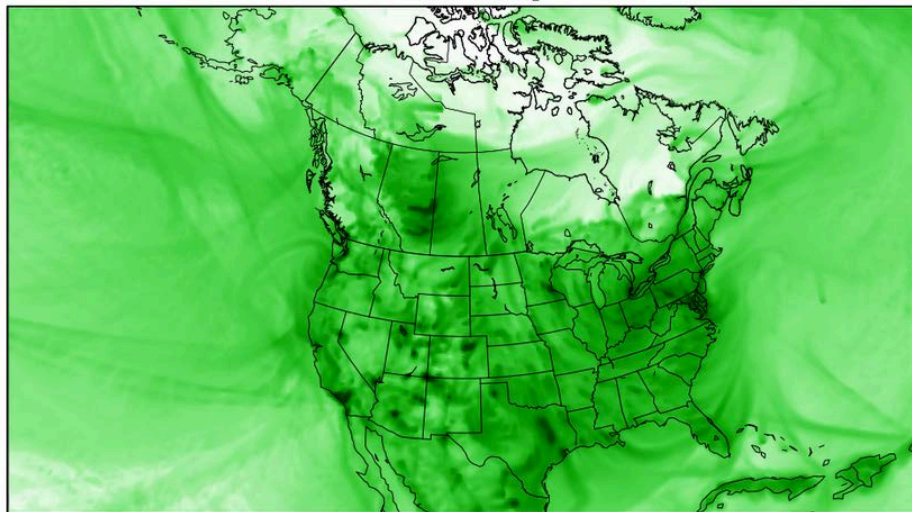
- 8 Chemistry Fields
- 29 pre-determined regions...20 more regions than GEOS NWP maps!



NASA/GMAO - GEOS CF Forecast Initialized on 12z 12/01/2019



Surface NO₂





Added features to FLUID *in Development* 😊

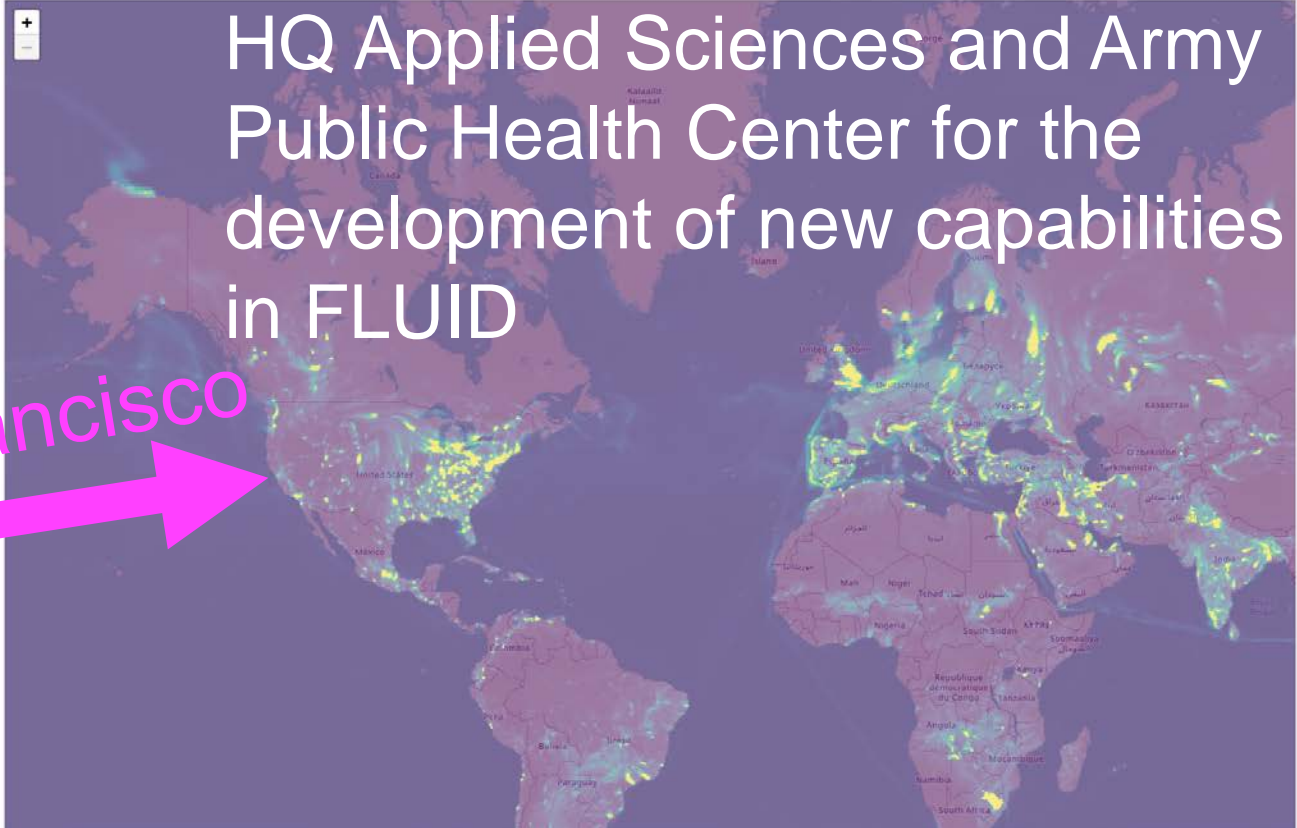
MiniFLUID [Home](#) Thanks to support from NASA

Current product: no2

NO2

O3

PM2.5



HQ Applied Sciences and Army
Public Health Center for the
development of new capabilities
in FLUID

San Francisco

Development by Brent
Smith and Callum
Wayman, SSAI/GMAO





Added features to FLUID *in Development* 😊

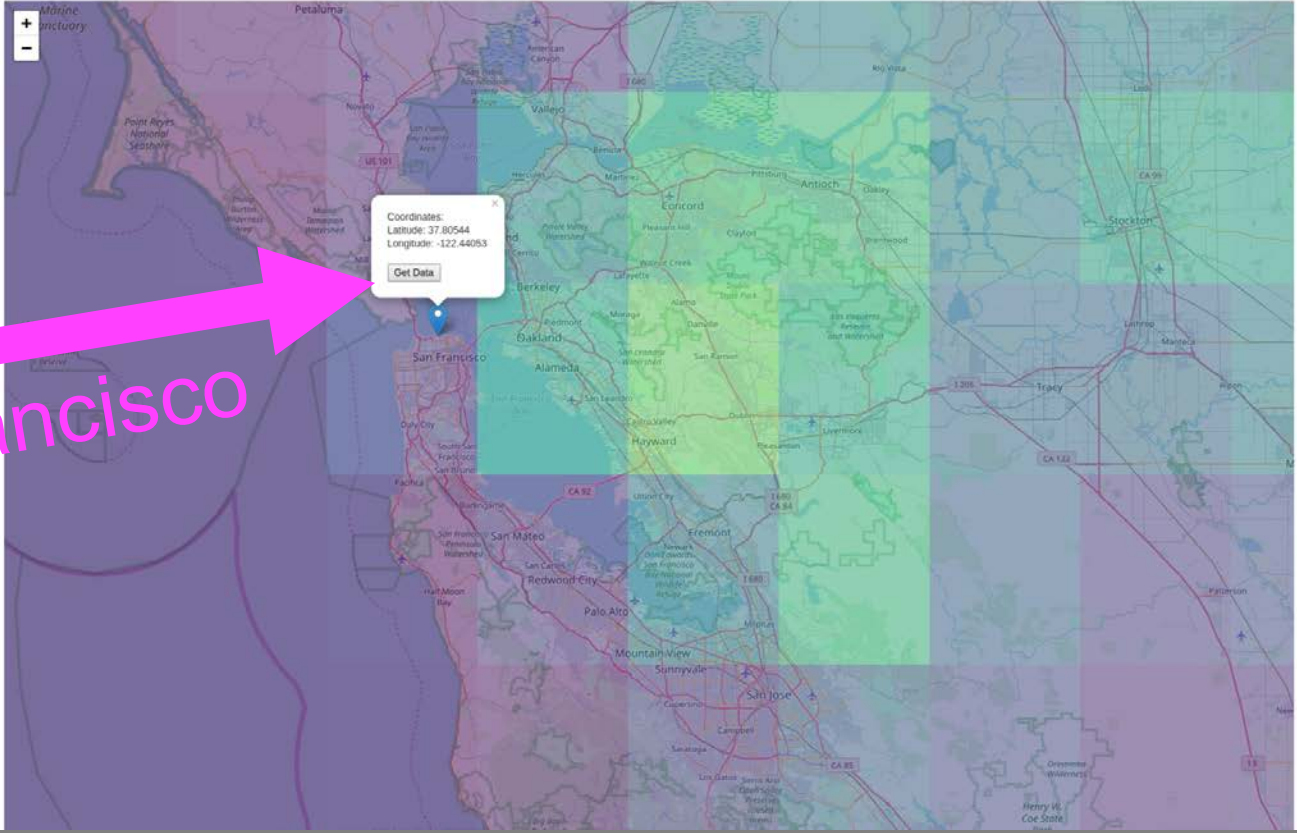
MiniFLUID [Home](#)

Current product: no2

NO2

O3

PM2.5



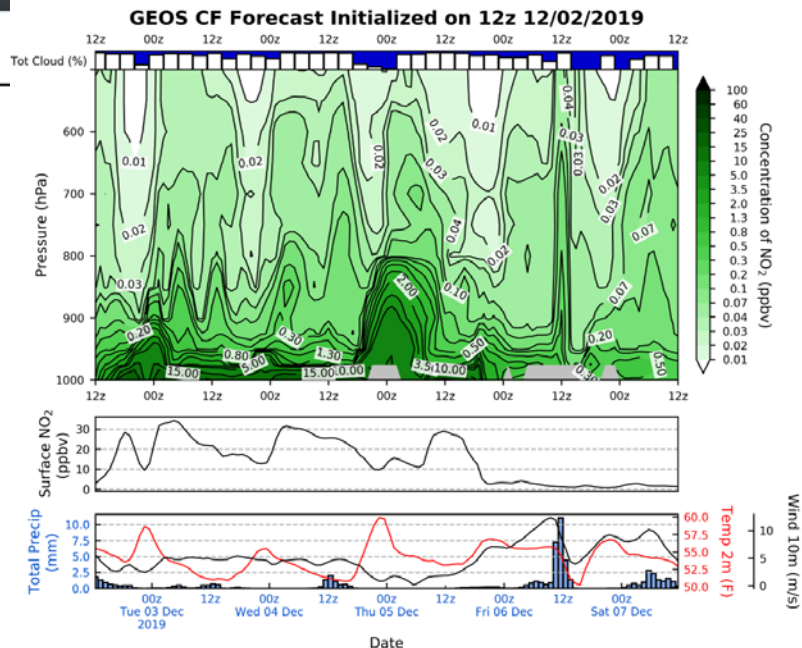
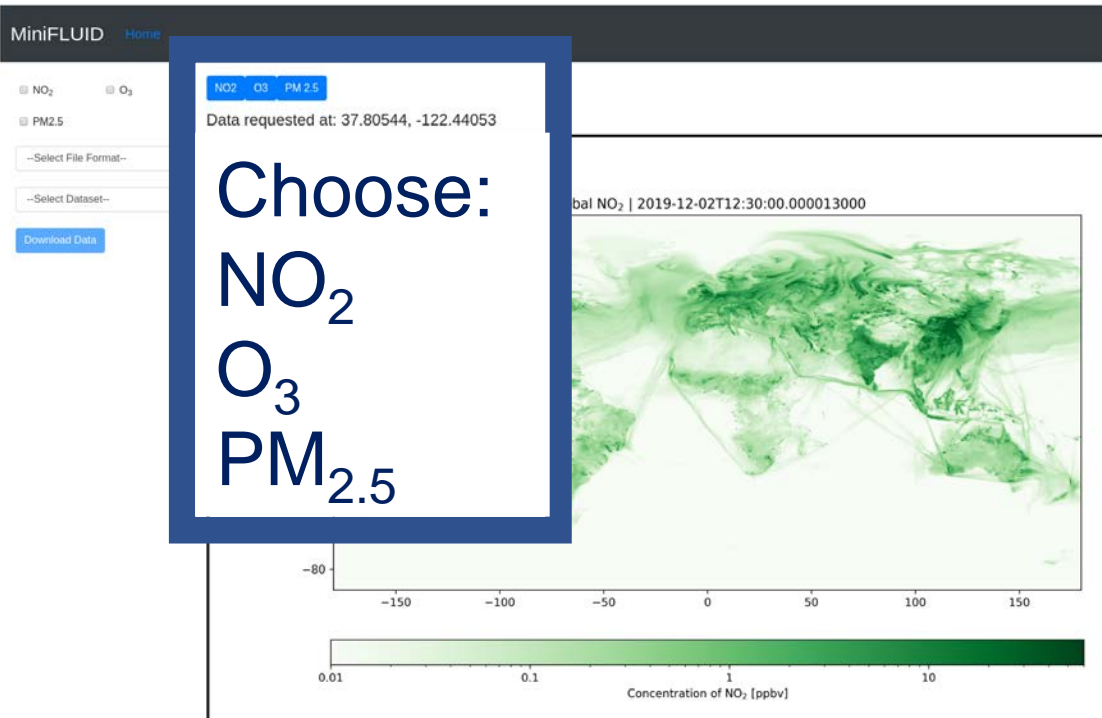
San Francisco

Development by Brent Smith and Callum Wayman, SSAI/GMAO

GMAO

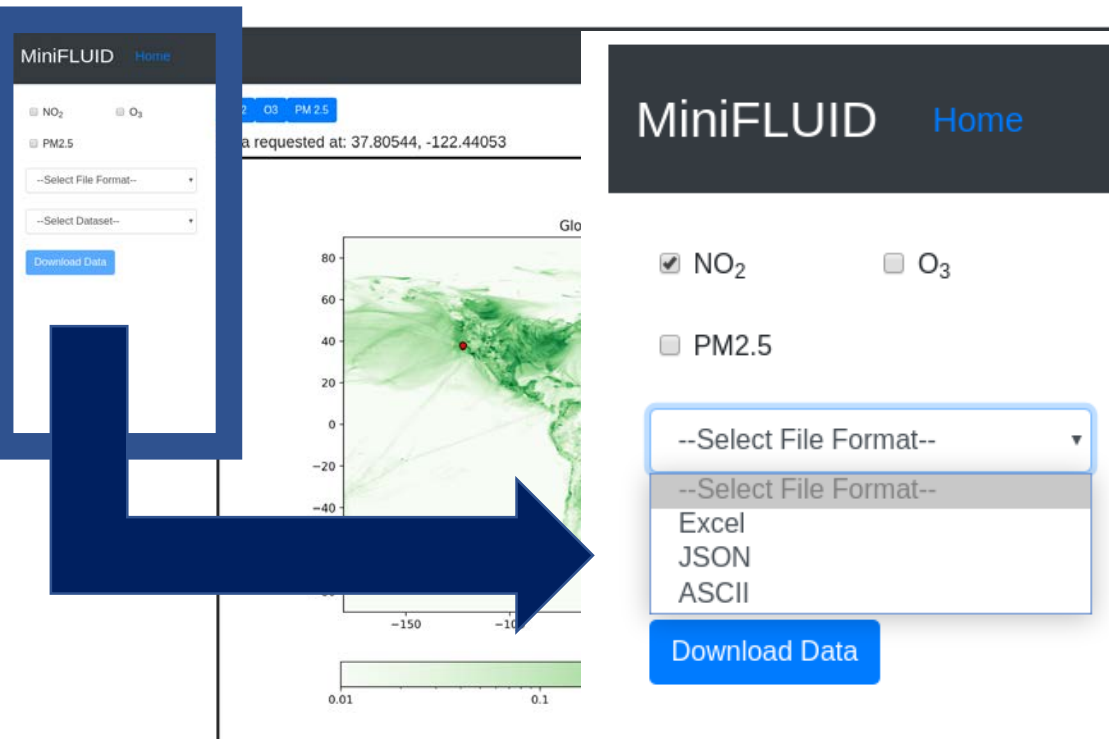


Added features to FLUID *in Development* 😊



Development by Brent Smith and Callum Wayman, SSAI/GMAO

Added features to FLUID *in Development* 😊



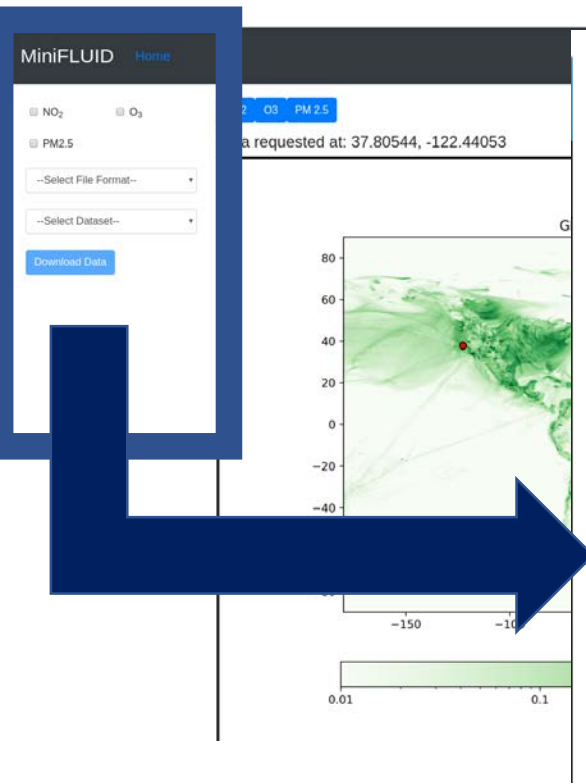
The image shows a screenshot of the MiniFLUID web interface. On the left, a sidebar contains navigation links for NO₂, O₃, and PM2.5, along with dropdown menus for file format and dataset selection, and a 'Download Data' button. The main area displays a map of the United States with a red dot indicating a location. Below the map is a color scale legend ranging from 0.01 to 0.1. On the right, a larger view of the interface shows the same sidebar and a 'Download Data' button, with a dropdown menu open showing options for Excel, JSON, and ASCII.

Download Data
in 3 user-friendly
formats

Development by Brent Smith and Callum Wayman, SSAI/GMAO



Added features to FLUID *in Development* 😊



MiniFLUID Home

NO₂ O₃

PM2.5

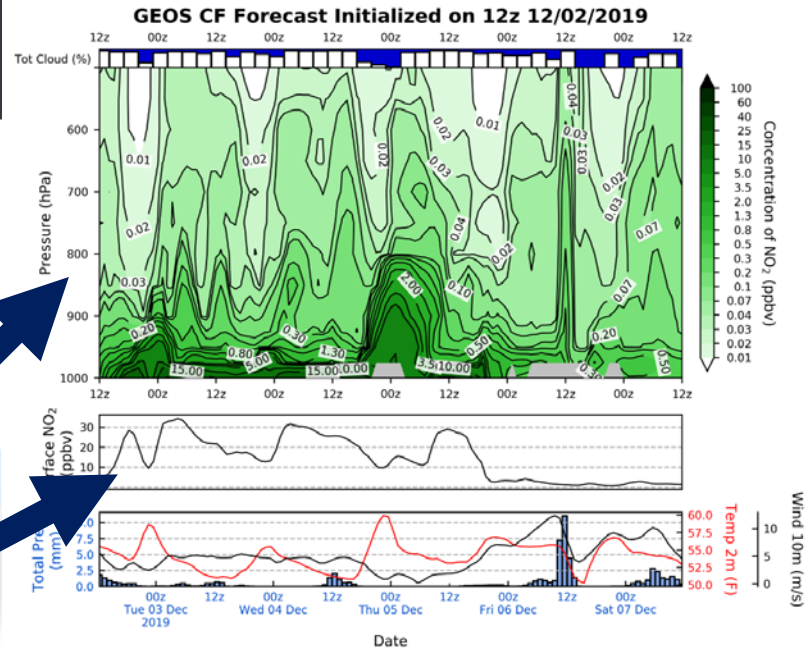
JSON

--Select Dataset--

--Select Dataset--

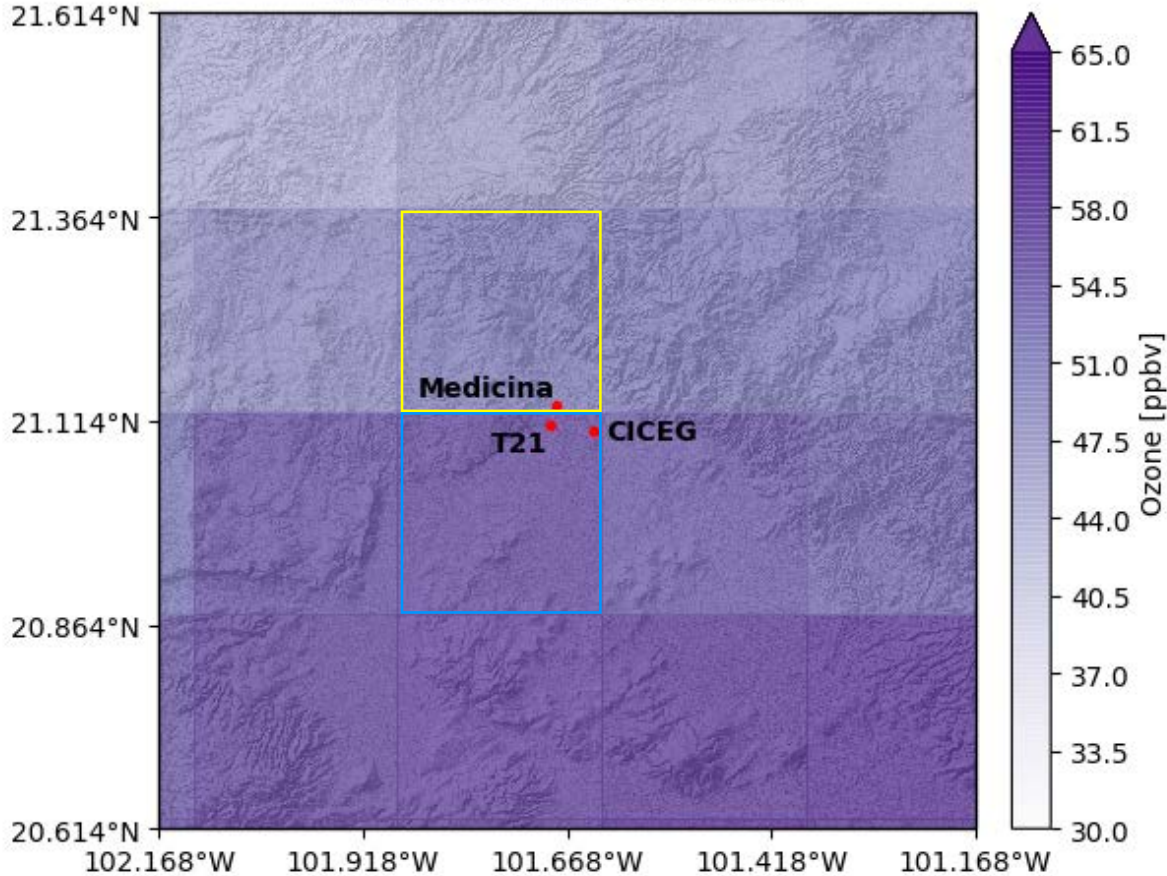
All Pressure Levels Chemistry

Surface Level Chemistry



Development by Brent Smith and Callum Wayman, SSAI/GMAO

2019-09-18 11:00 local time

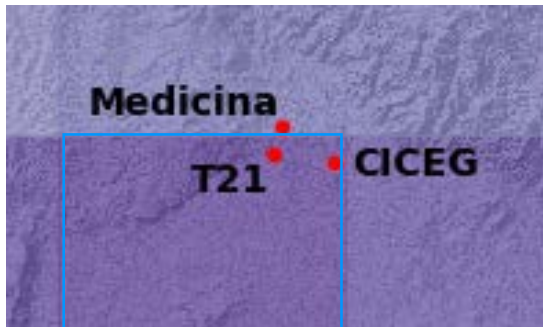


Improve local forecasts using statistical bias correction

3 monitoring stations in Leon, Mexico

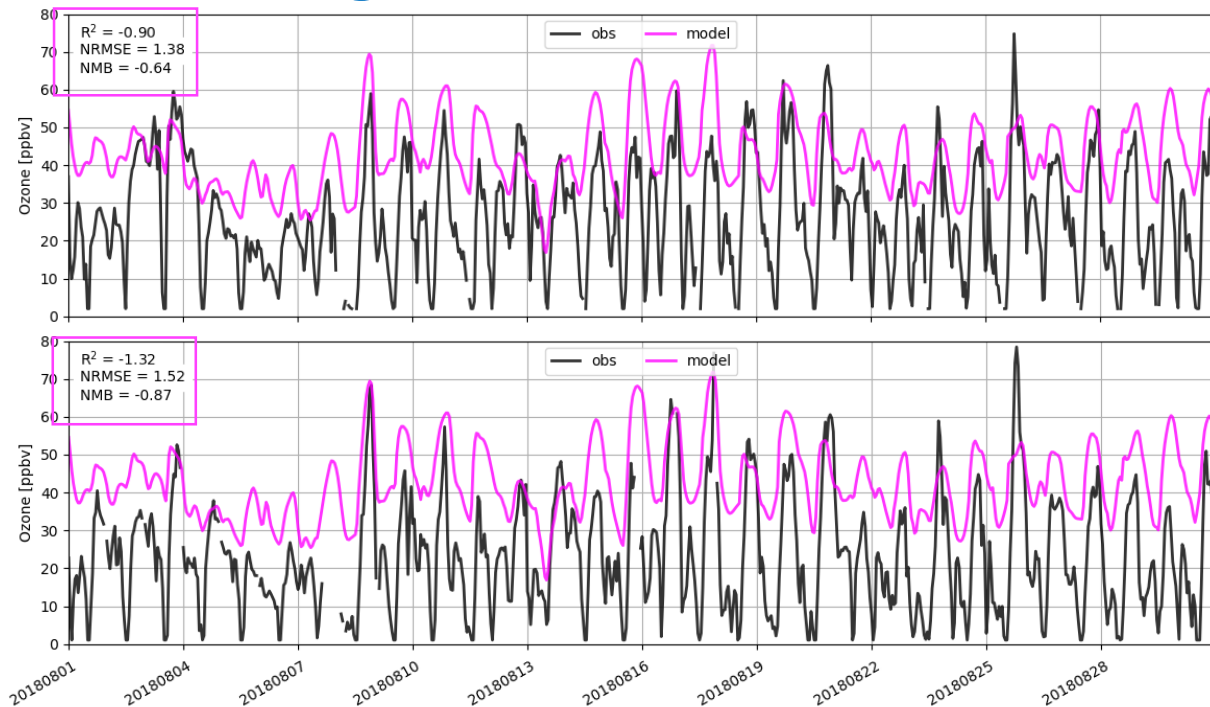
- 1 in one grid box
- 2 share a grid box
- Difficult terrain within each grid box

Improve local forecasts using statistical bias correction



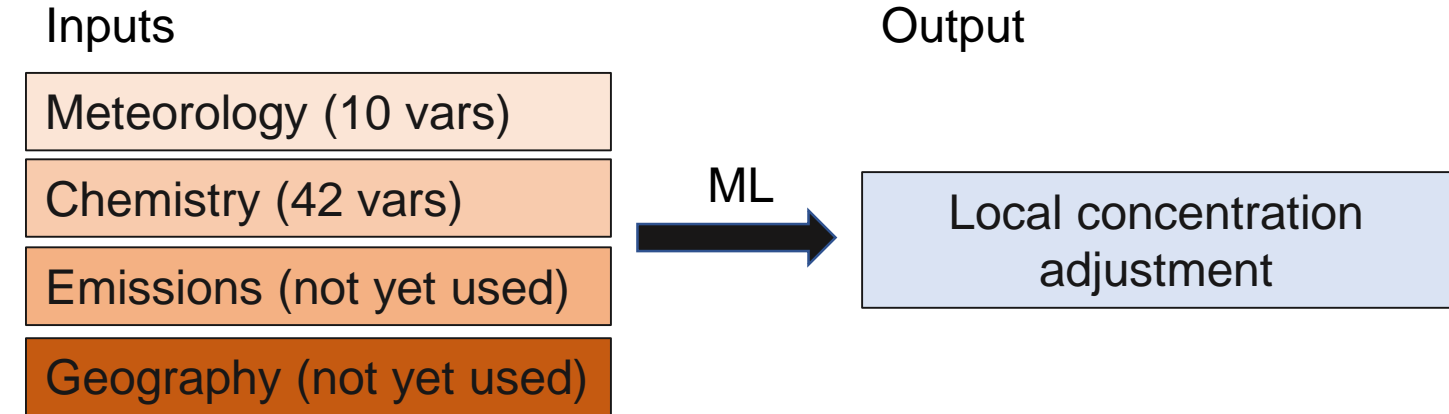
Two observation sites in the same grid box

- GEOS-CF generally over-estimates



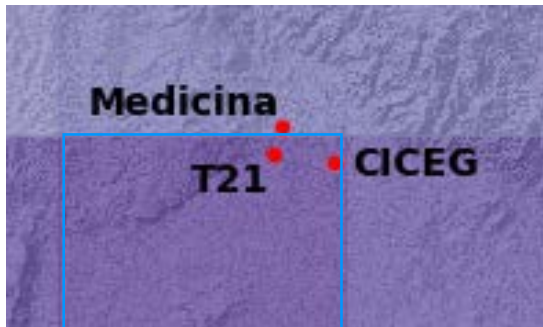
Observations Model

Use machine learning to correct for small scale variability and/or model biases



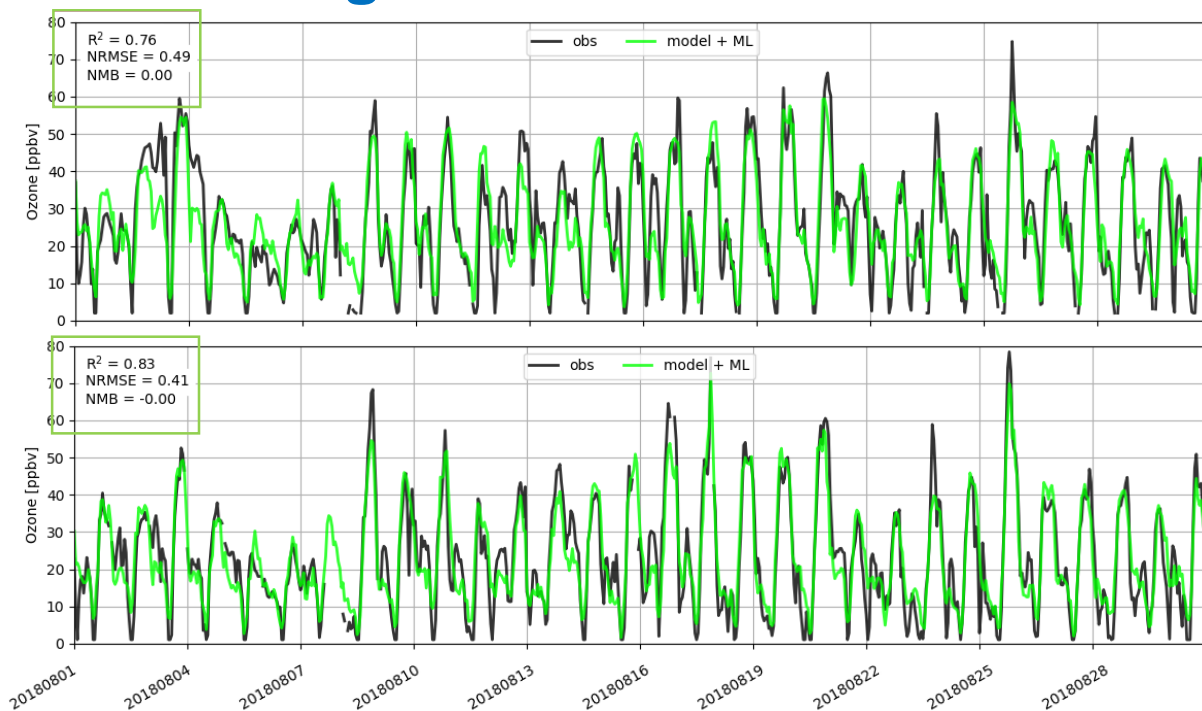
- Algorithm: gradient boosted decision trees (XGBoost)
- Train separate algorithm for each site

Improve local forecasts using statistical bias correction



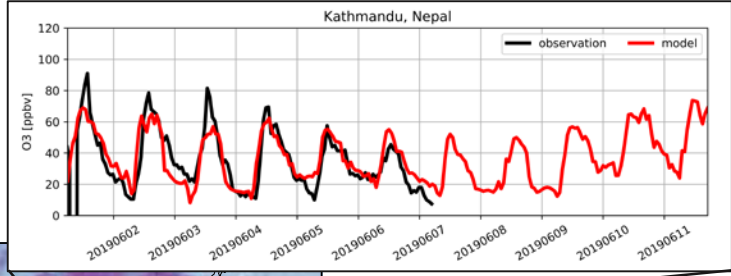
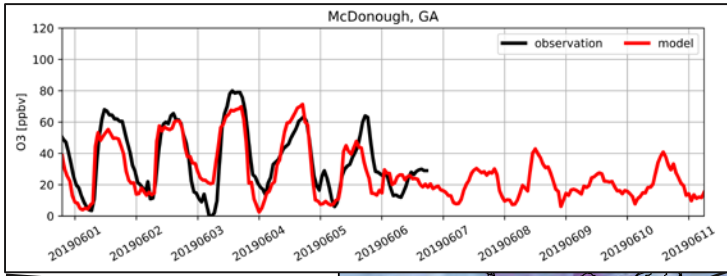
Two observation sites in the same grid box

- GEOS-CF+ML captures diurnal variability at sub-grid scale

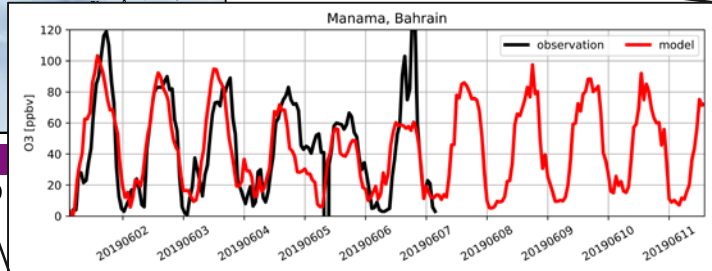
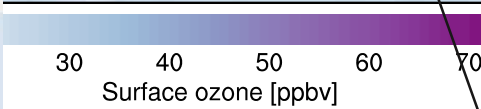
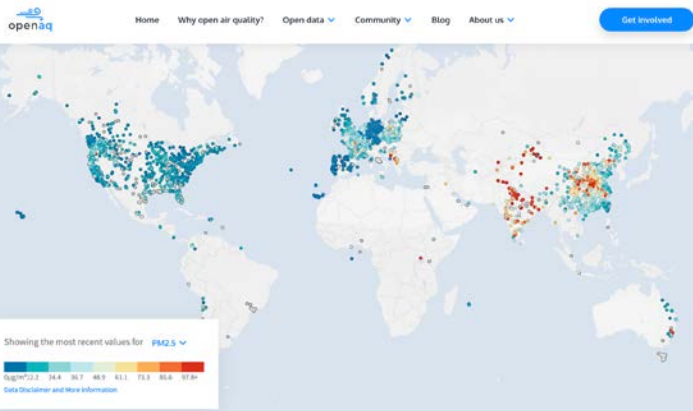
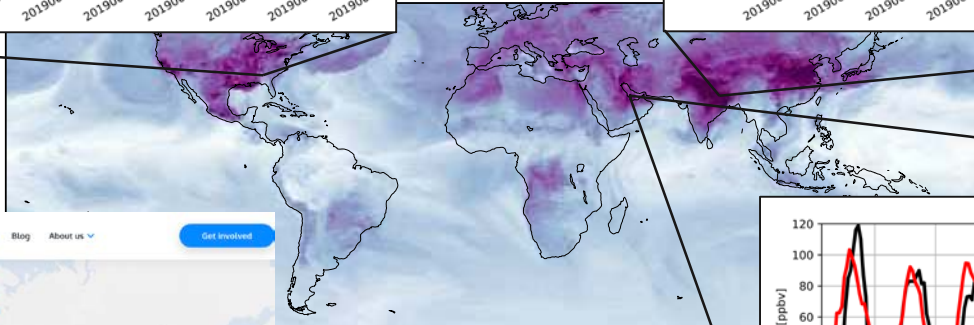


Observations **Model + ML**

Observe ozone levels around the world



2019-06-09





Some Stakeholders

AQ Forecasts

Distribute Forecasts

Handle Messaging

Broaden ML application



WORLD
RESOURCES
INSTITUTE

Other Partners

IBM, APHC, UNICEF, etc.



City Partners

- Rio de Janeiro
- Jakarta
- Quito
- Others?







Summary

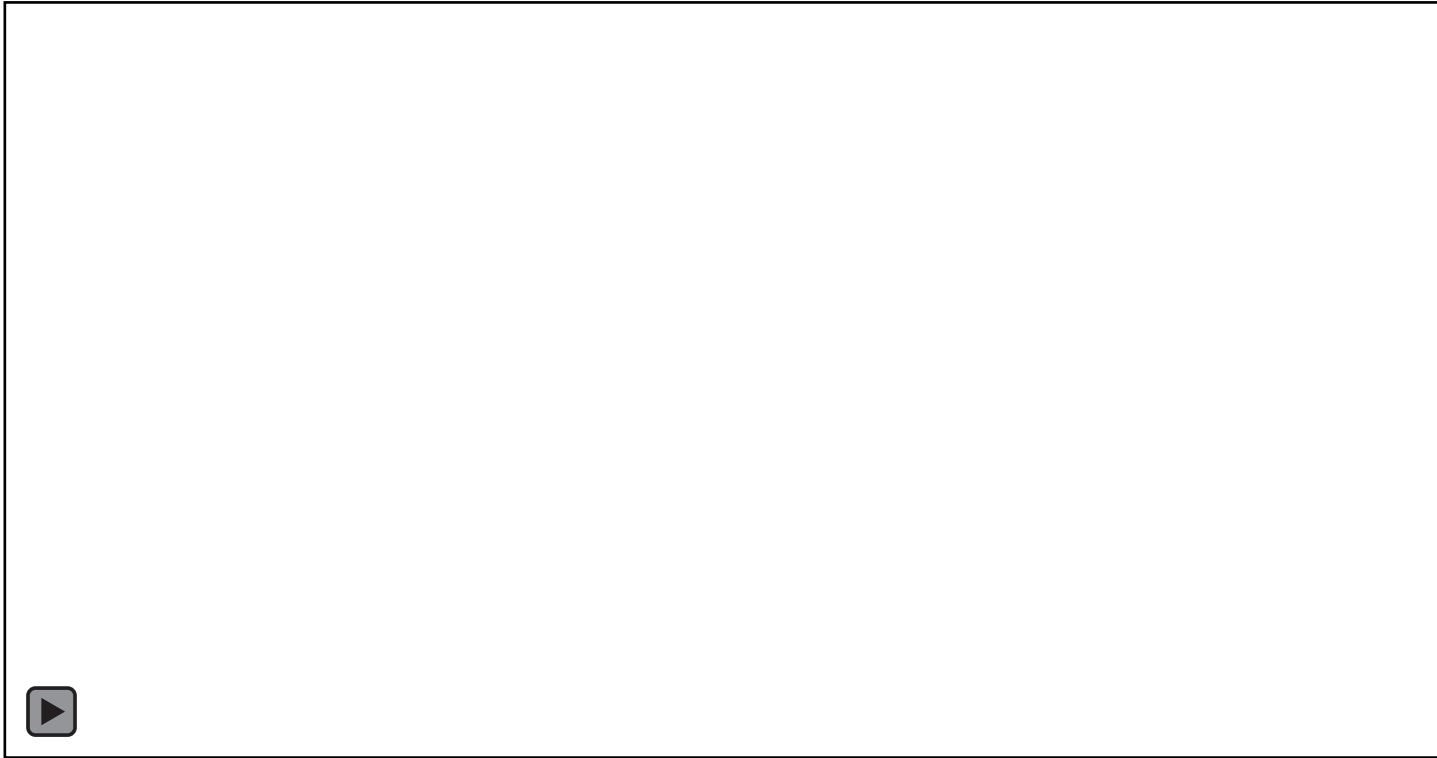
- GEOS-CF produces daily global air quality forecasts at 25km (16 miles) horizontal resolution in near-real time !!
- Data and visualizations available to the public on NASA server and websites
- Exploring internal options as well as outside help to reach the larger health and air quality community

https://gmao.gsfc.nasa.gov/weather_prediction/GEOS-CF/

k.e.knowland@nasa.gov :: christoph.a.keller@nasa.gov



Thank you!



<https://fluid.nccs.nasa.gov/cf>