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

Bryan Duncan

Atmospheric Chemistry and Dynamics Lab

NASA Goddard Space Flight Center (GSFC)

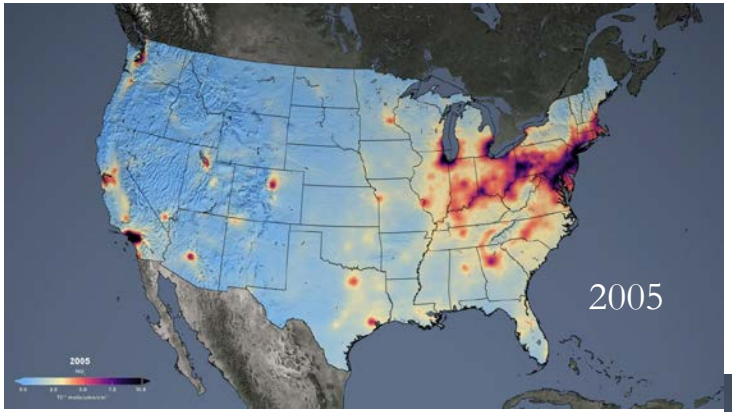
K. Emma Knowland[1,2], Christoph Keller[1,2], Steven Pawson[2]

[1] USRA/GESTAR

[2] NASA GSFC Global Modeling and Assimilation Office (GMAO)

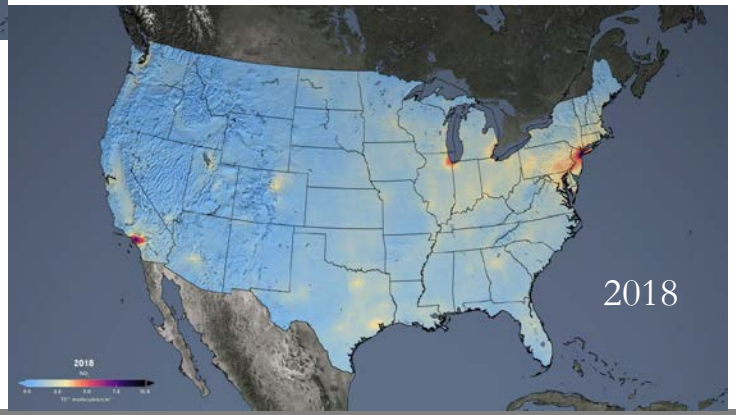
13 December 2019

Unique Advantages of Satellite Data
Spatial Coverage & Changes over Time



OMI Nitrogen Dioxide:
NO_2
(gridded to ~10x10 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?!

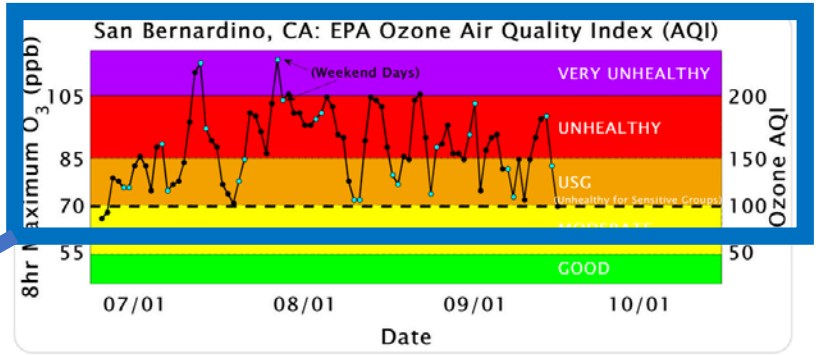
GMAO

witter.com/rms5539/status/1173951085876326401

Search

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

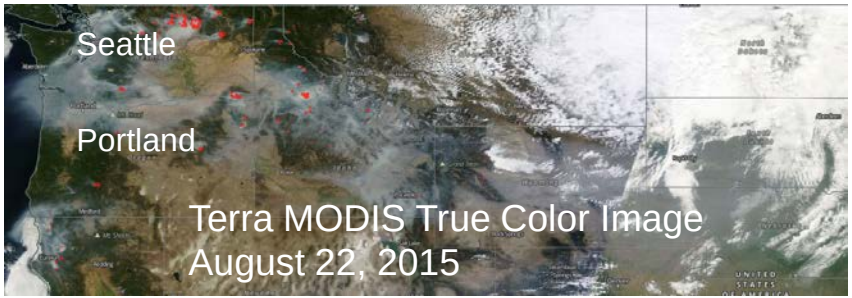
Code Purple ozone was a lot more common back then, but clearly ozone pollution remains a critical health problem for residents near Los Angeles

1

Ryan Stauffer @rms5539 · Sep 17

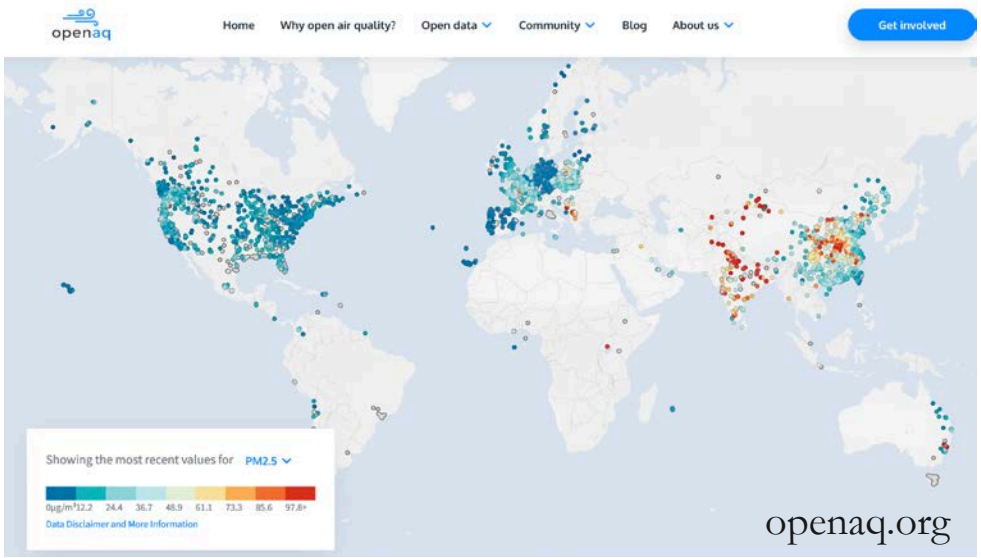
It's worth noting that the streak ended because the 8-hour average rounded down to 70 ppb instead of up to 71. So it technically wasn't a Code Orange...barely

Wildfires are part of the problem

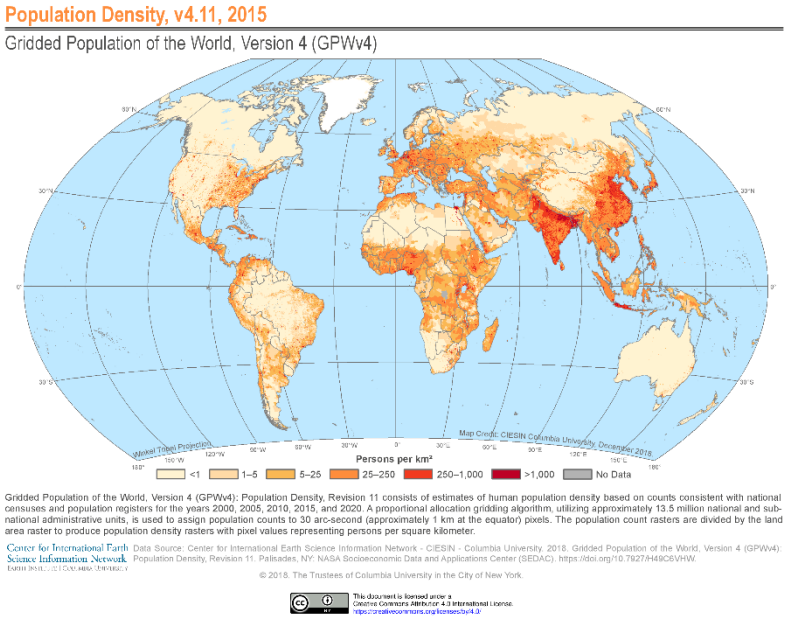


Sparse Surface AQ Monitors

OpenAQ Surface Monitor Locations



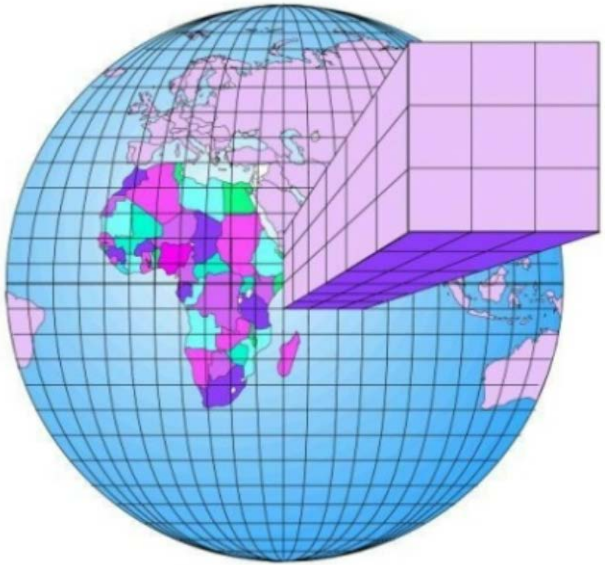
Population Density

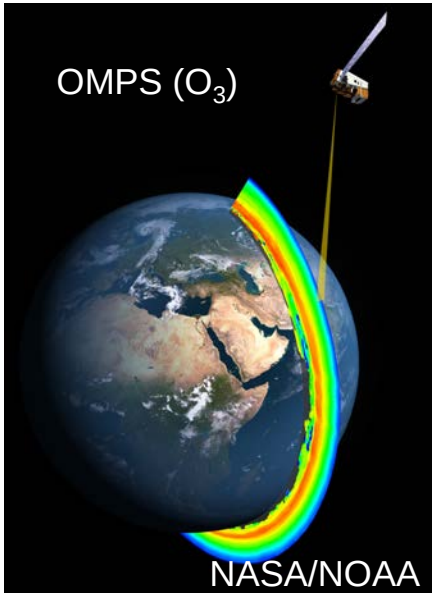


Most global citizens have little or no access to air quality information, but most have access to the internet and, therefore, could have access if the information is made available.

NASA GMAO global meteorology and chemistry products

GEOS

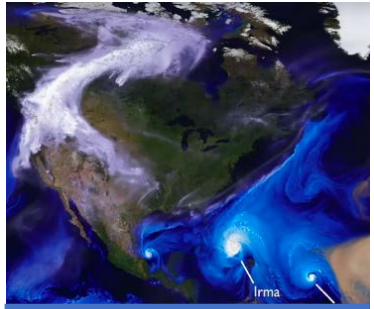




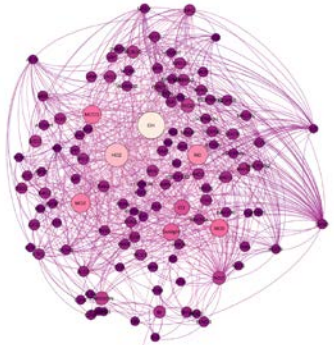
www.nasa.gov

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

NASA's composition forecast (GEOS-CF)

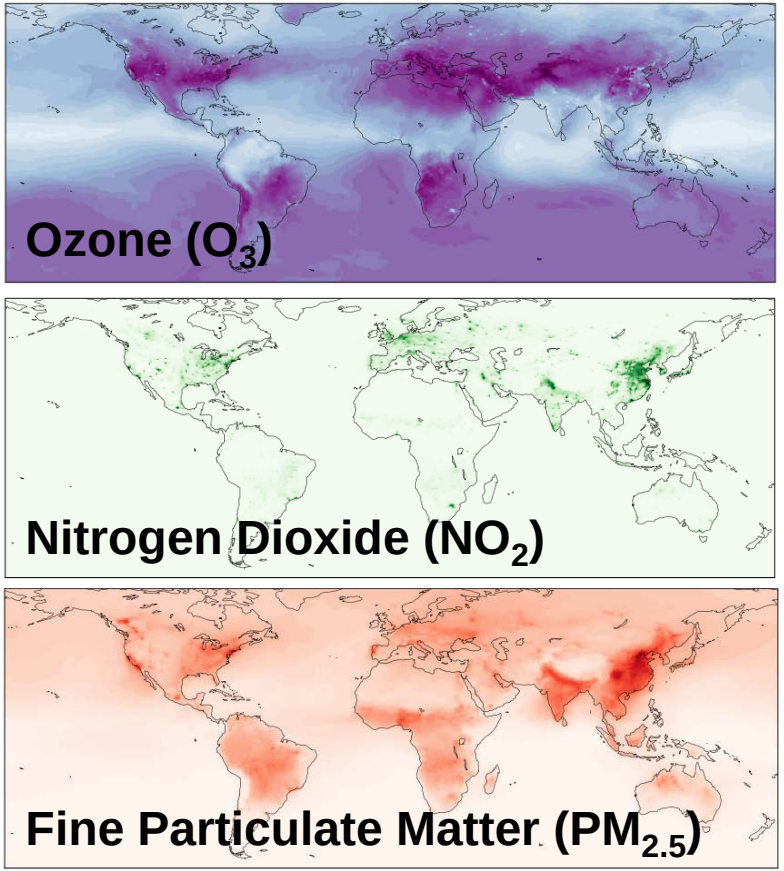


GEOS NWP

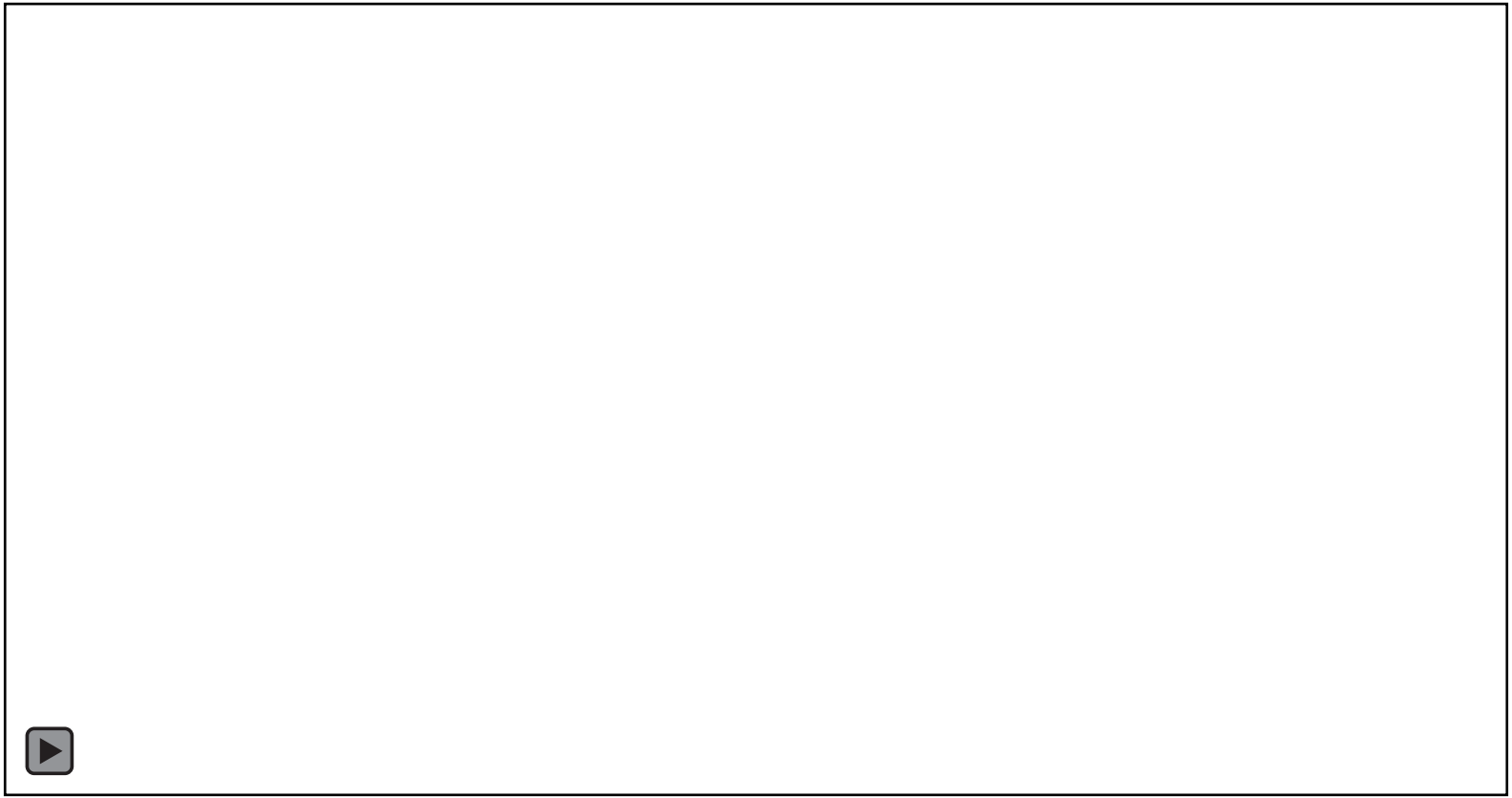


GEOS - Chem

- 250 Chemical Species
- 725 Chemical Reactions



High-Resolution Global Simulation



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

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

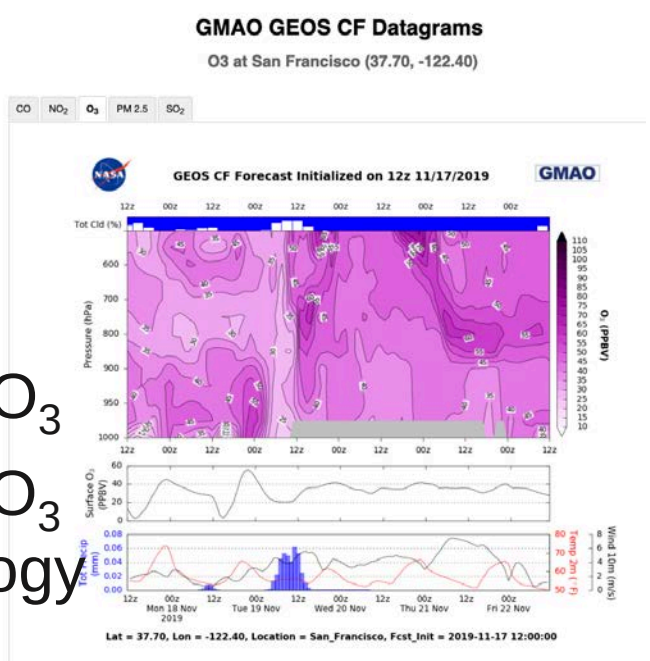
Where to find GEOS-CF

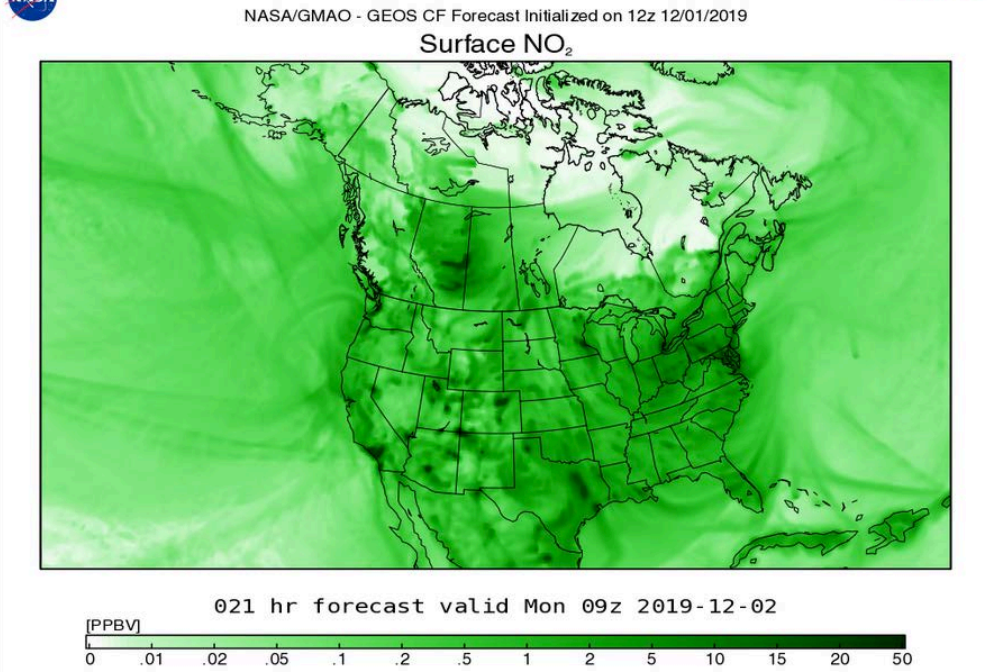
Maps available at fluid.nccs.nasa.gov/cf
a mobile-friendly website

Vertical O_3

Surface O_3

Meteorology



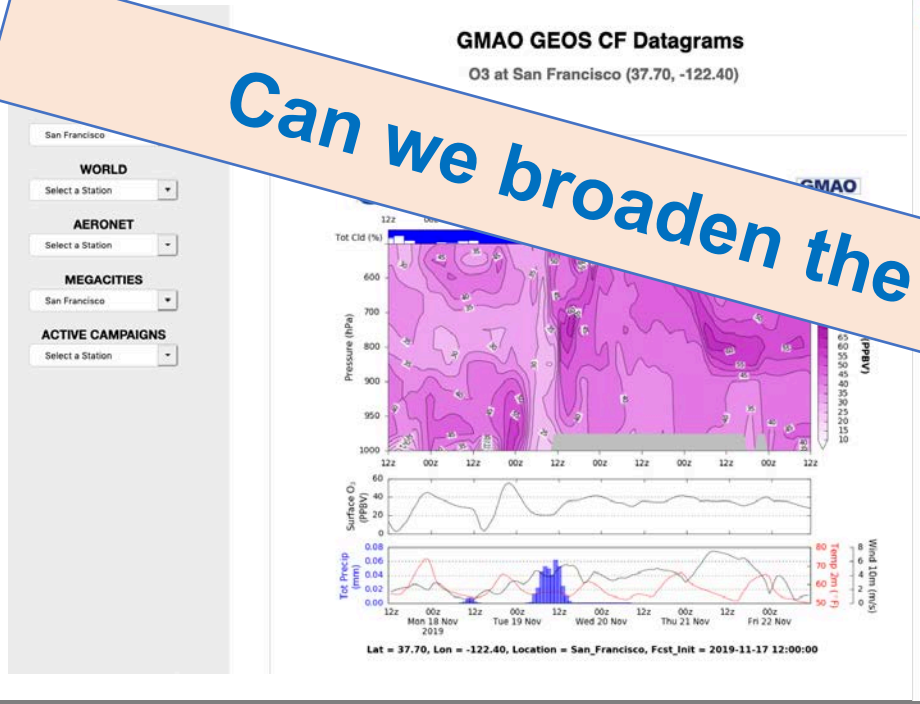


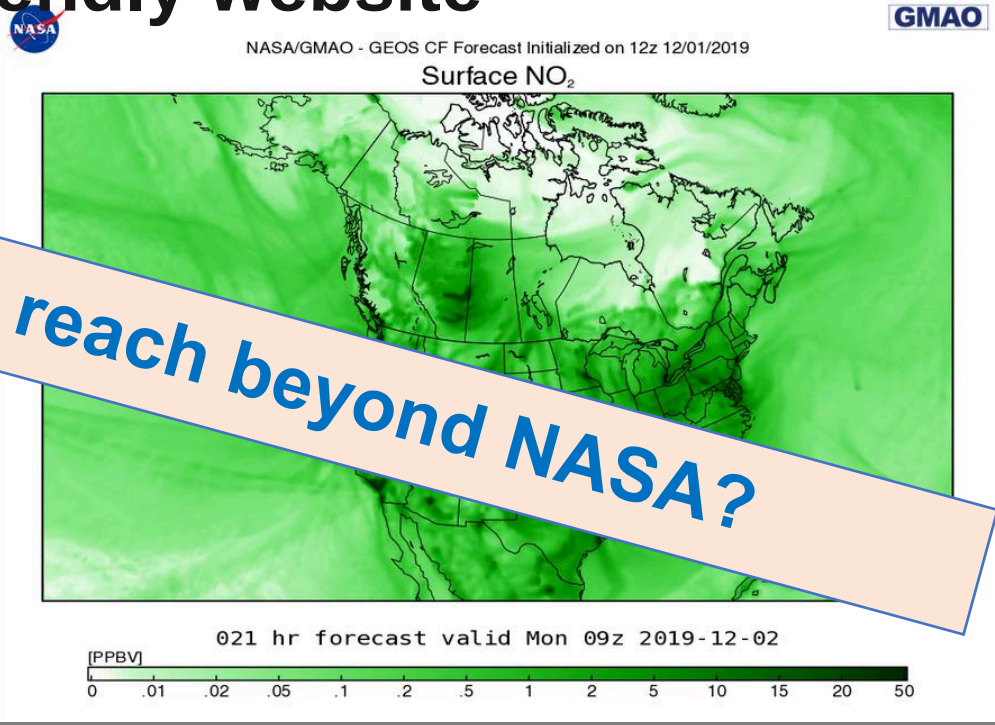
Where to find GEOS-CF

Maps available at fluid.nccs.nasa.gov/cf

a mobile-friendly website

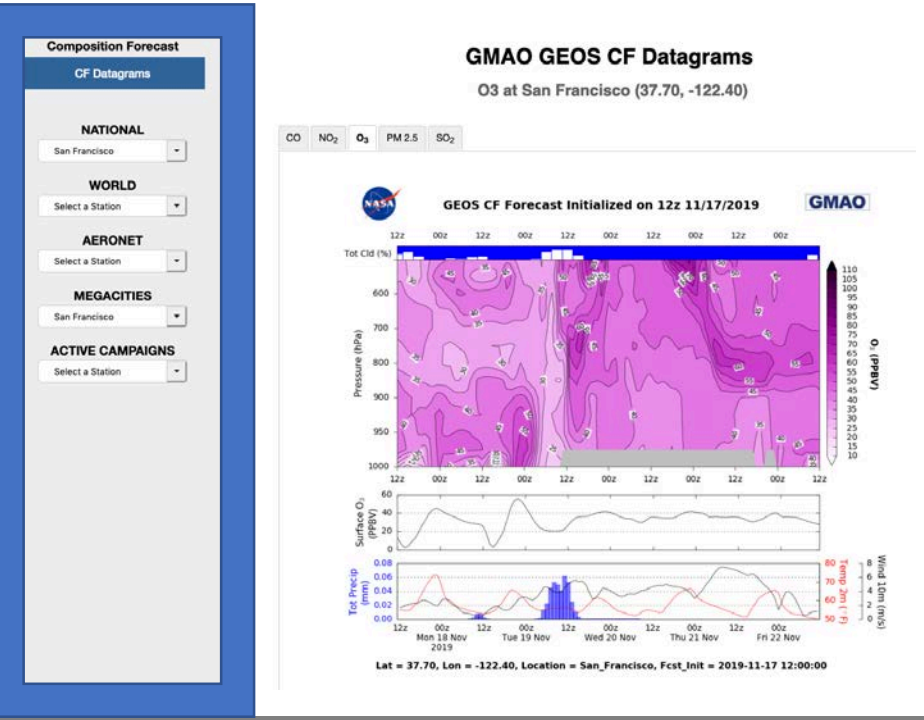
Can we broaden the reach beyond NASA?



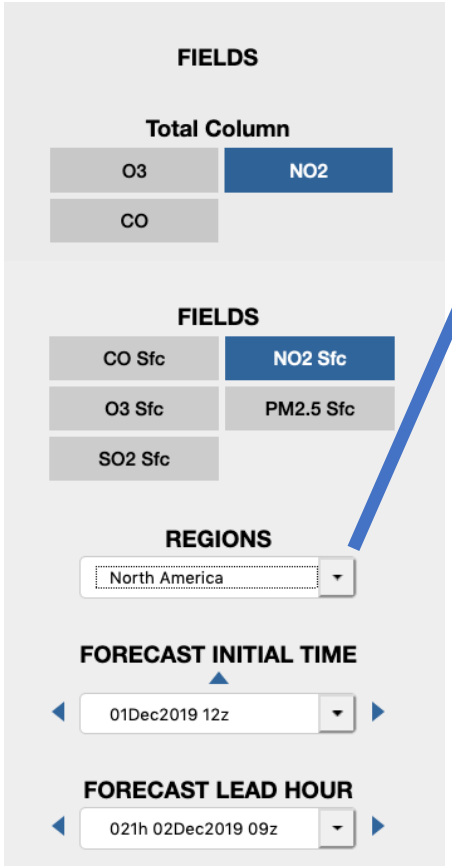


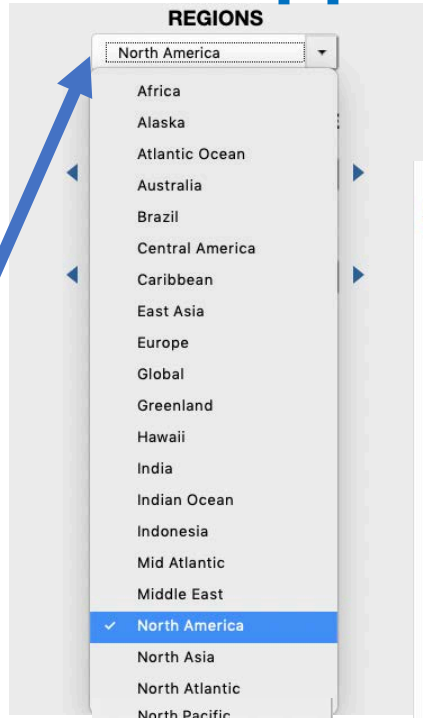
NASA supports NASA science

- Currently FLUID is static, with 200 preset Datagram locations: Focus on
  1. NASA Campaigns
  2. AERONET sites
  3. USA cities – not even all capital cities!
  4. World cities

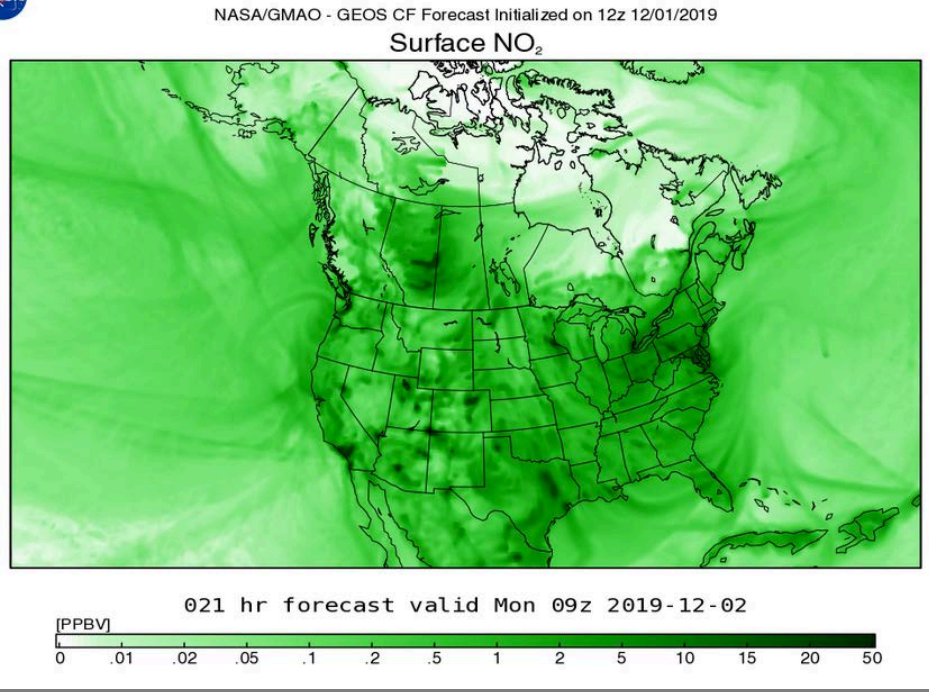


NASA supports NASA science



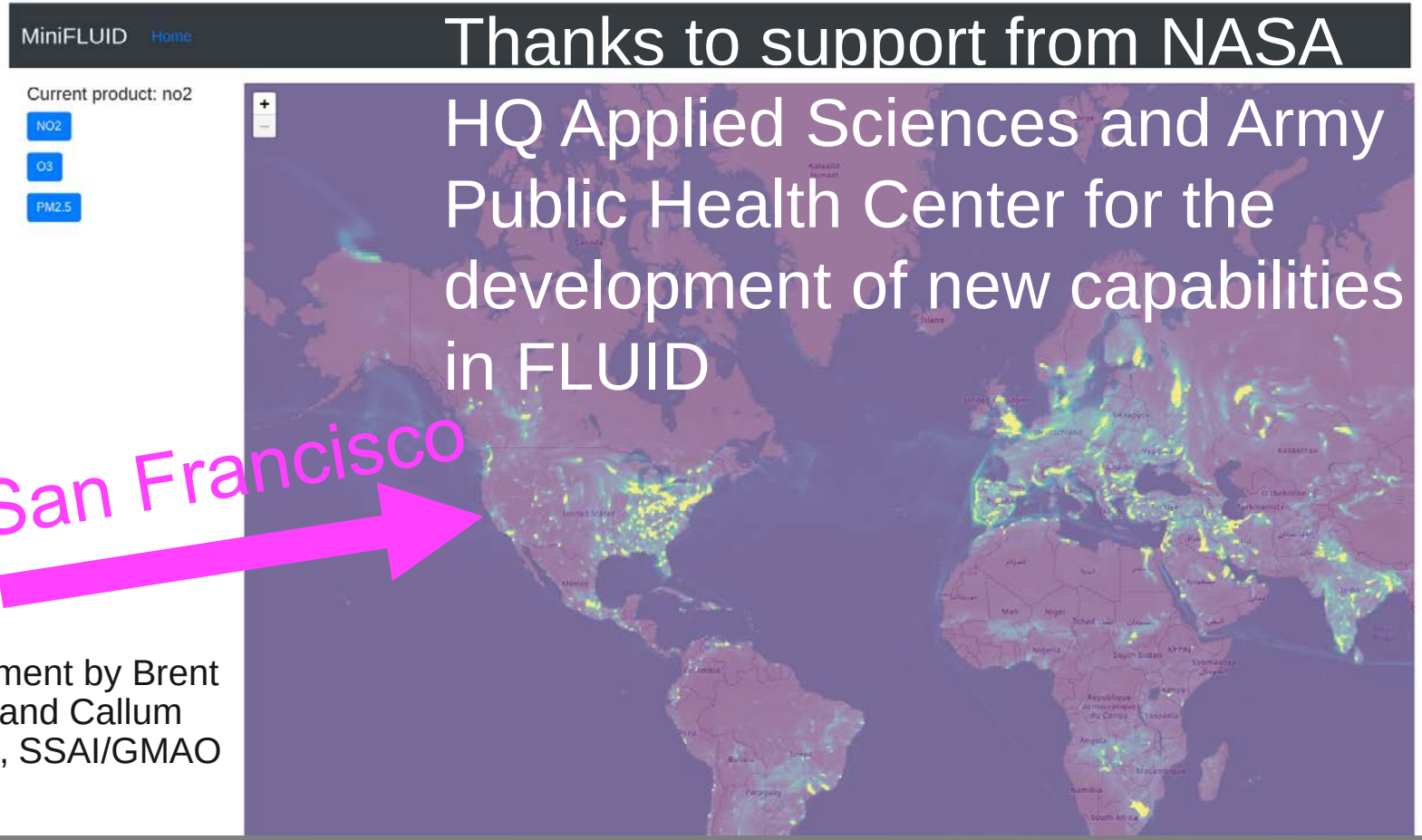


- **8** Chemistry Fields
- **29** pre-determined regions…**20 more** regions than GEOS NWP maps!



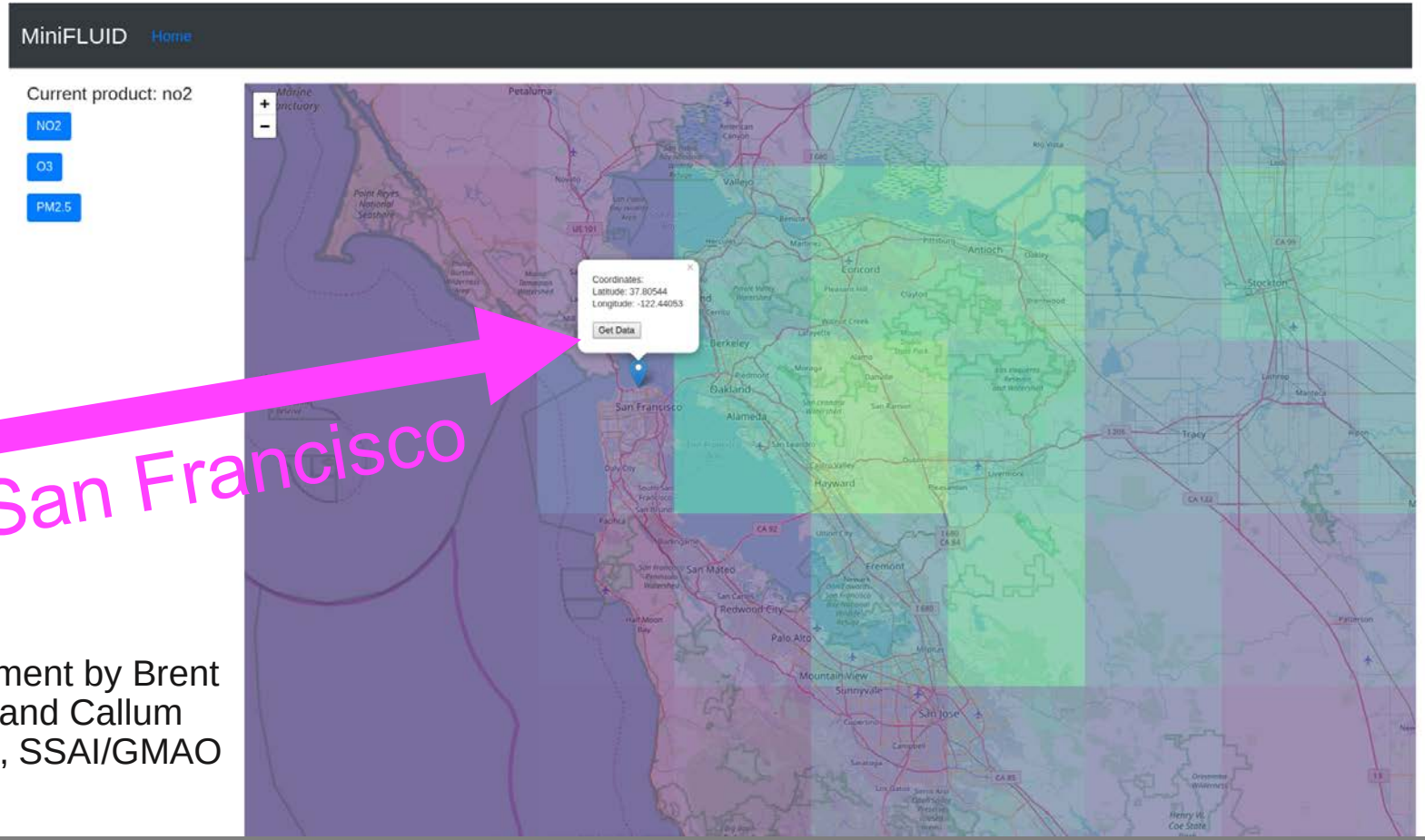
k.e.knowland@nasa.gov
christoph.a.keller@nasa.gov

Added features to FLUID *in Development* ☺



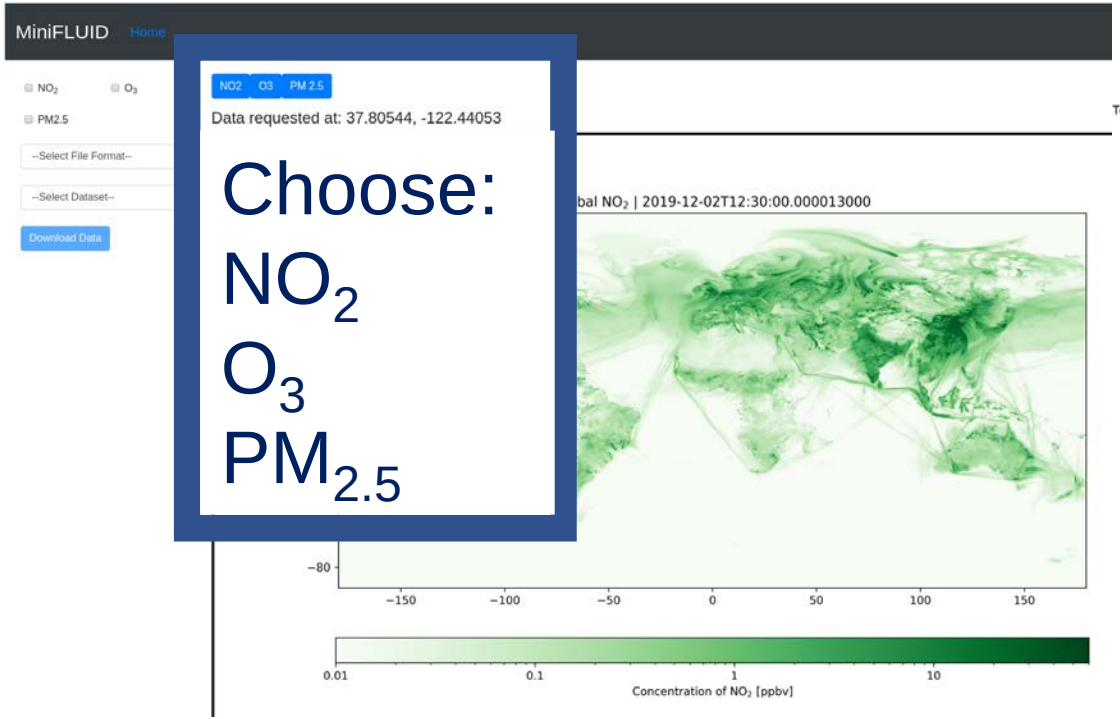
Development by Brent Smith and Callum Wayman, SSAI/GMAO

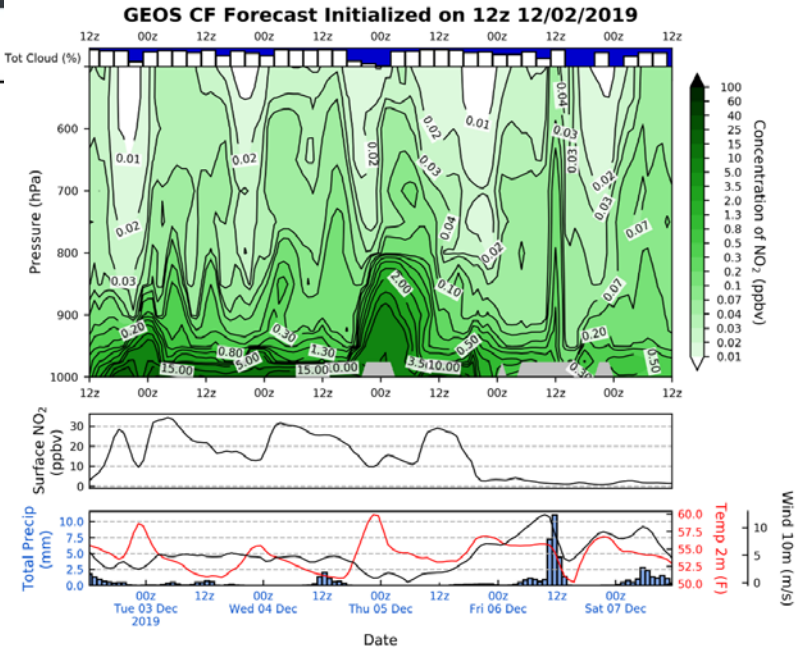
Added features to FLUID *in Development* ☺



Development by Brent Smith and Callum Wayman, SSAI/GMAO

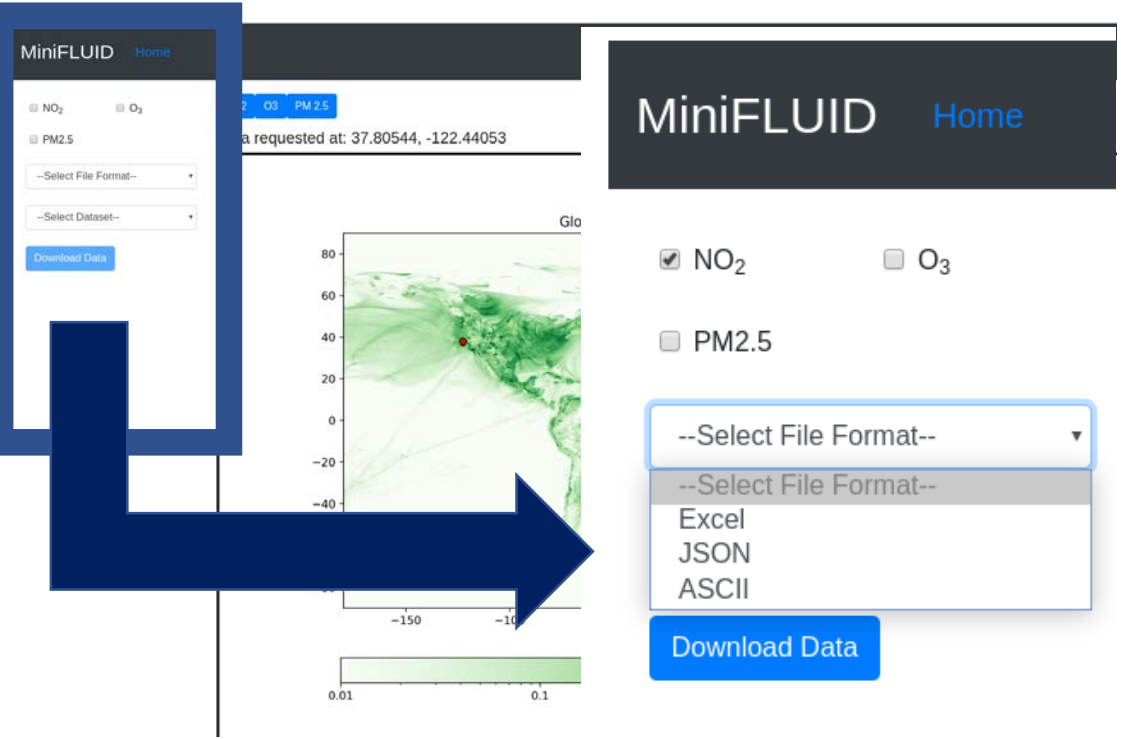
Added features to FLUID *in Development* ☺





Development by Brent Smith and Callum Wayman, SSAI/GMAO

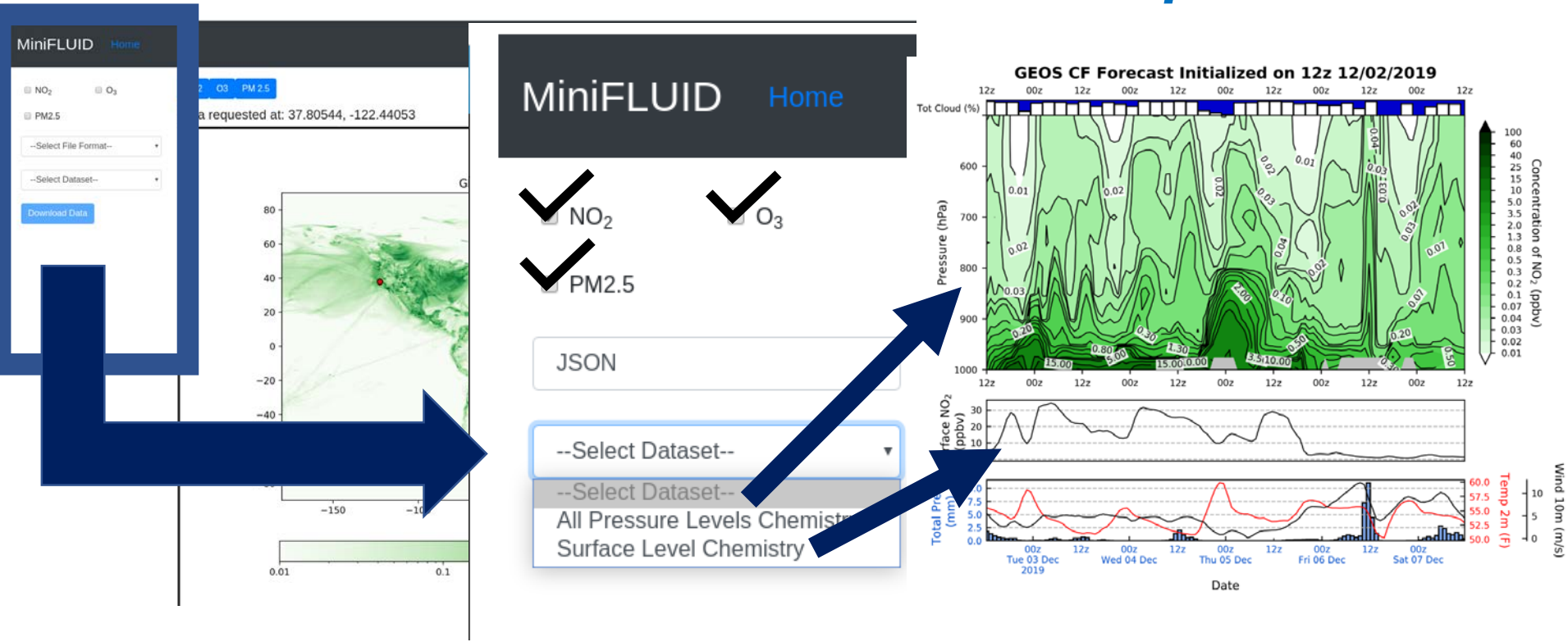
Added features to FLUID *in Development* ☺



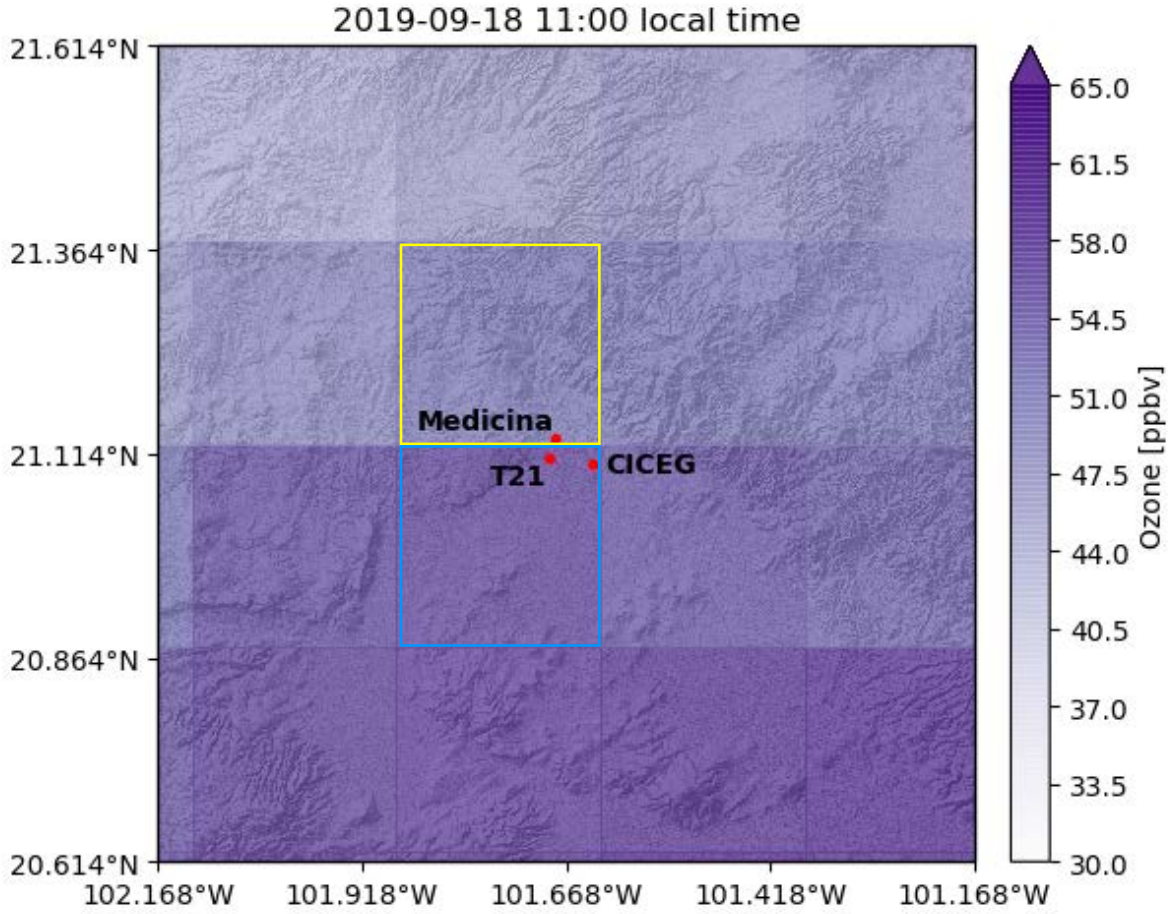
Download Data in 3 user-friendly formats

Development by Brent Smith and Callum Wayman, SSAI/GMAO

Added features to FLUID *in Development* ☺



Development by Brent Smith and Callum Wayman, SSAI/GMAO

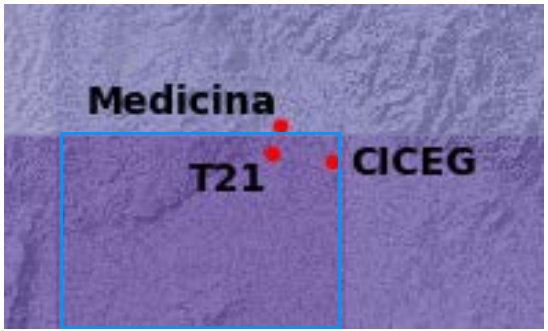


Improve local forecasts using statistical bias correction

3 monitoring stations in Leon, Mexico

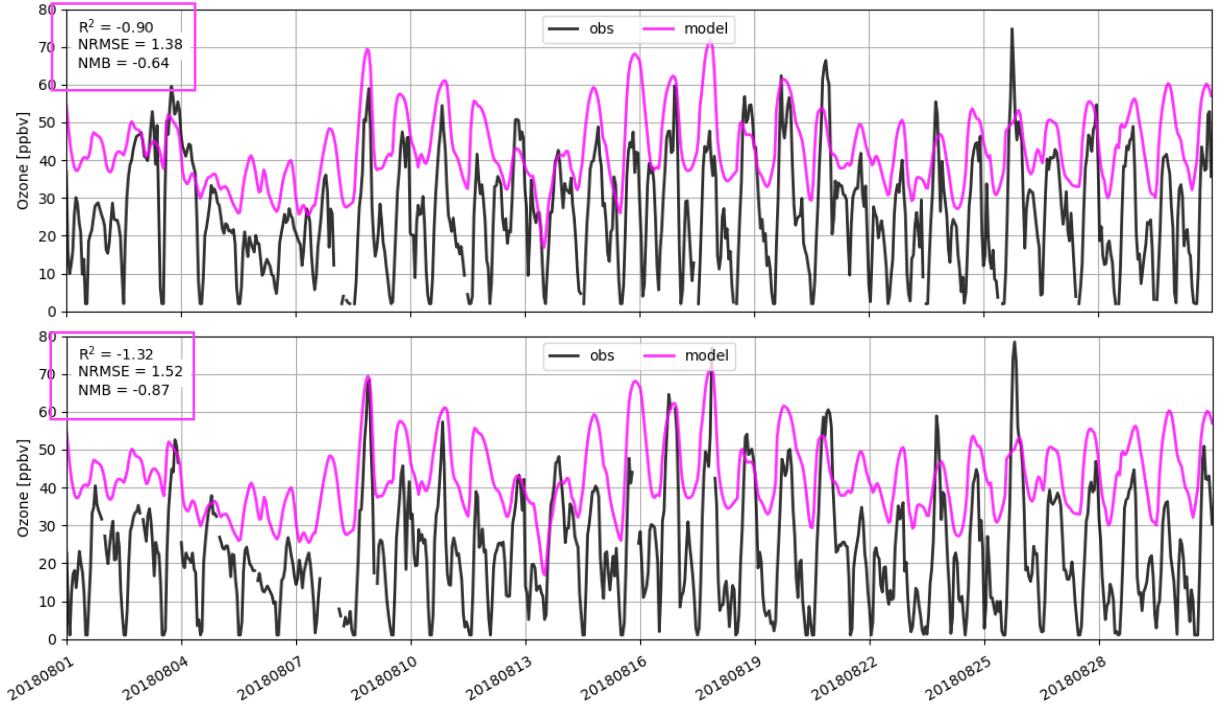
- 1 in one grid box
- 2 share a grid box
- Difficult terrain within each grid box

Improve local forecasts using statistical bias correction



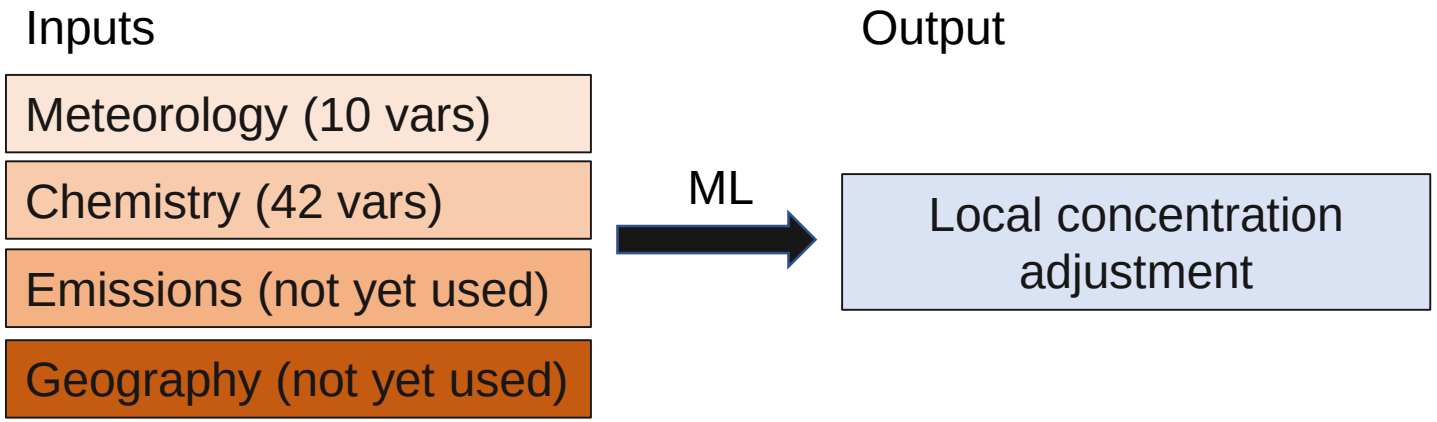
Two observation sites in the same grid box

- GEOS-CF generally over-estimates



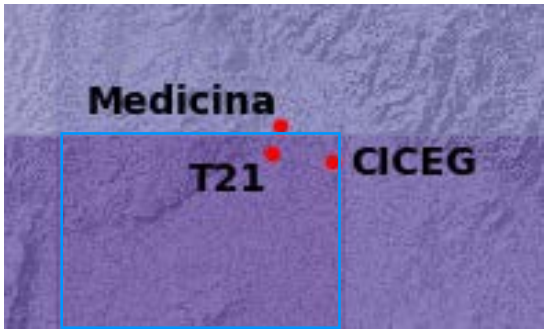
Observations Model

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



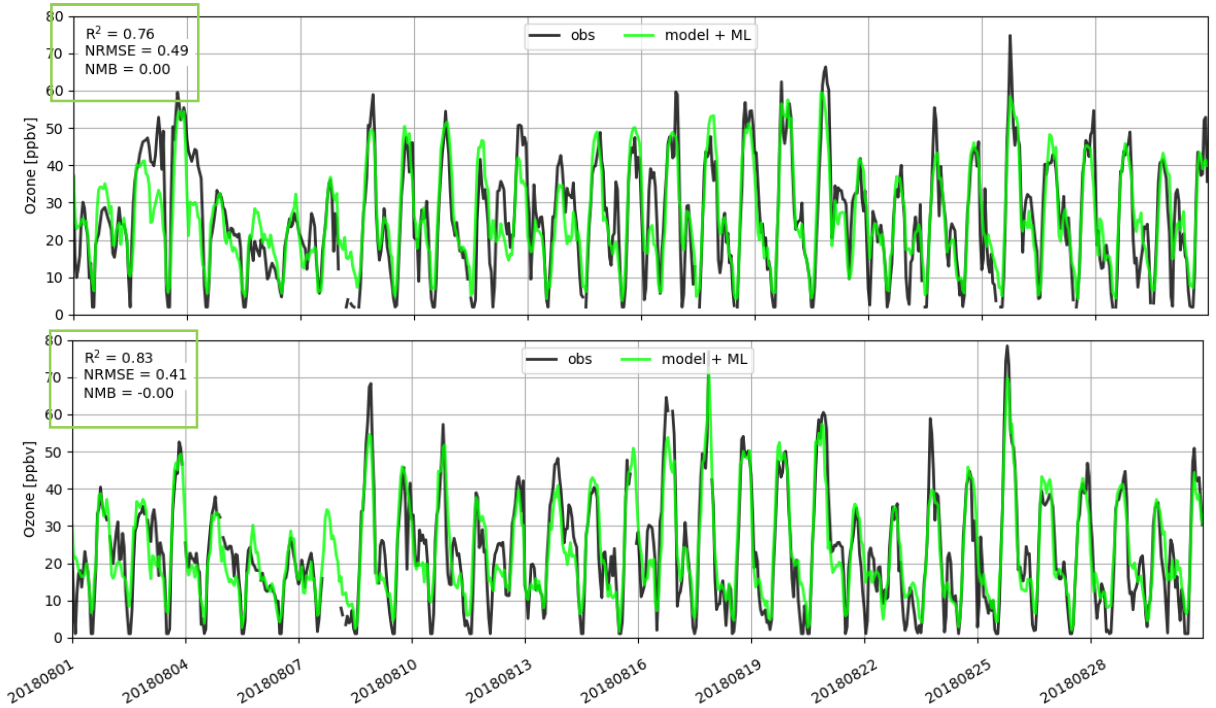
- Algorithm: gradient boosted decision trees (XGBoost)
- Train separate algorithm for each site

Improve local forecasts using statistical bias correction



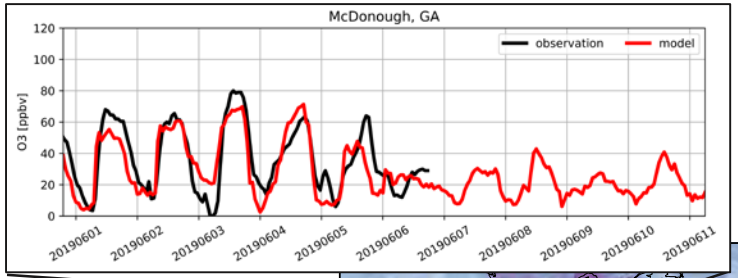
Two observation sites in the same grid box

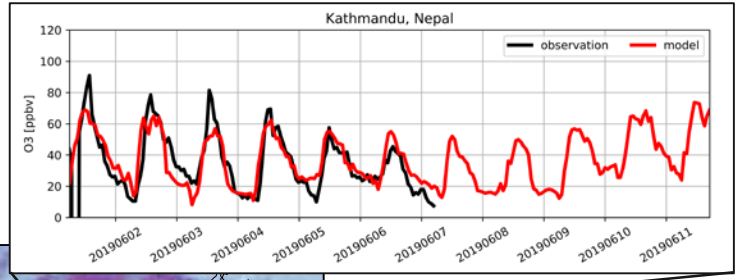
- GEOS-CF+ML captures diurnal variability at sub-grid scale

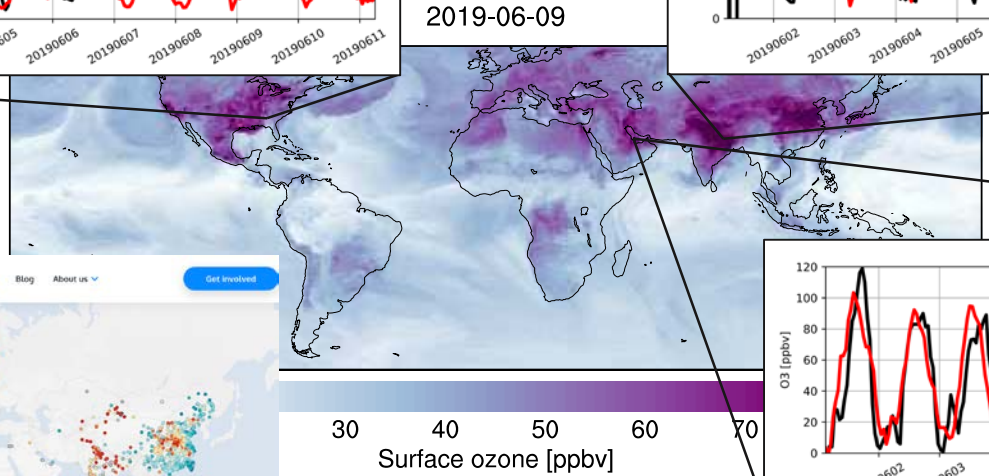


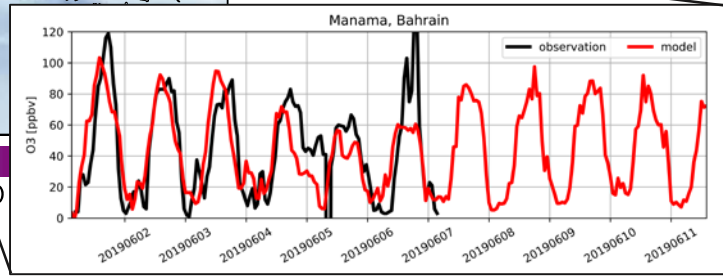
Observations Model + ML

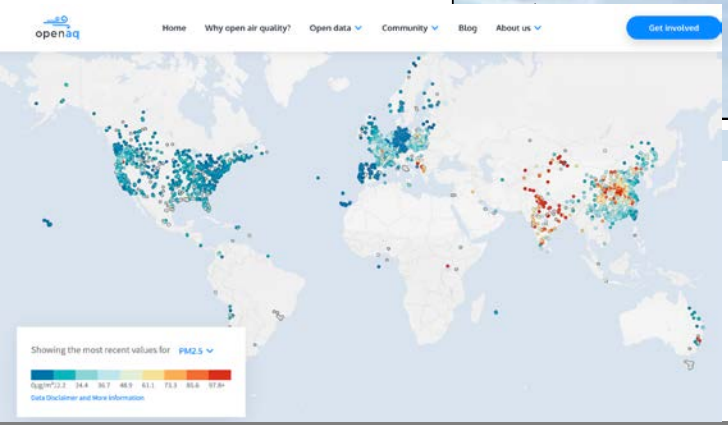
Observe ozone levels around the world











Some Stakeholders

AQ Forecasts

Distribute Forecasts

Handle Messaging

Broaden ML application

WORLD RESOURCES INSTITUTE

City Partners

- Rio de Janeiro
- Jakarta
- Quito
- Others?

Other Partners

IBM, APHC, UNICEF, etc.


UNIVERSITY
of York


ACT
America


IIEC
International Institute for Energy Conservation


HAQAST


developmentSEED


NASA


NYU


Airlabs


UNIVERSITAS DALHOUSIANA
HALIFAXIÆ N.S. MDCCCXVIII


VE RI TAS
HARVARD


FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE


openaq


unicef


QUITO
ALCALDÍA


NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION


JAYA RAYA


BMKG


C40
CITIES
CLIMATE LEADERSHIP GROUP


NASA
ATom
ATMOSPHERIC TOMOGRAPHY MISSION


CLIMATE &
CLEAN AIR
COALITION
TO REDUCE SHORT-LIVED
CLIMATE POLLUTANTS


HawaDawa


APHC
ARMY PUBLIC HEALTH CENTER


BOEM & NASA
SATELLITE COASTAL AND OCEANIC ATMOSPHERIC POLLUTION EXPERIMENT
SCOAPE


KNMI


JOHNS HOPKINS
BLOOMBERG SCHOOL
of PUBLIC HEALTH


ECMWF


UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY


GOVERNO DO
Rio de
Janeiro


IBM


Swiss Re


DEPARTMENT OF STATE
UNITED STATES OF AMERICA


WORLD
RESOURCES
INSTITUTE

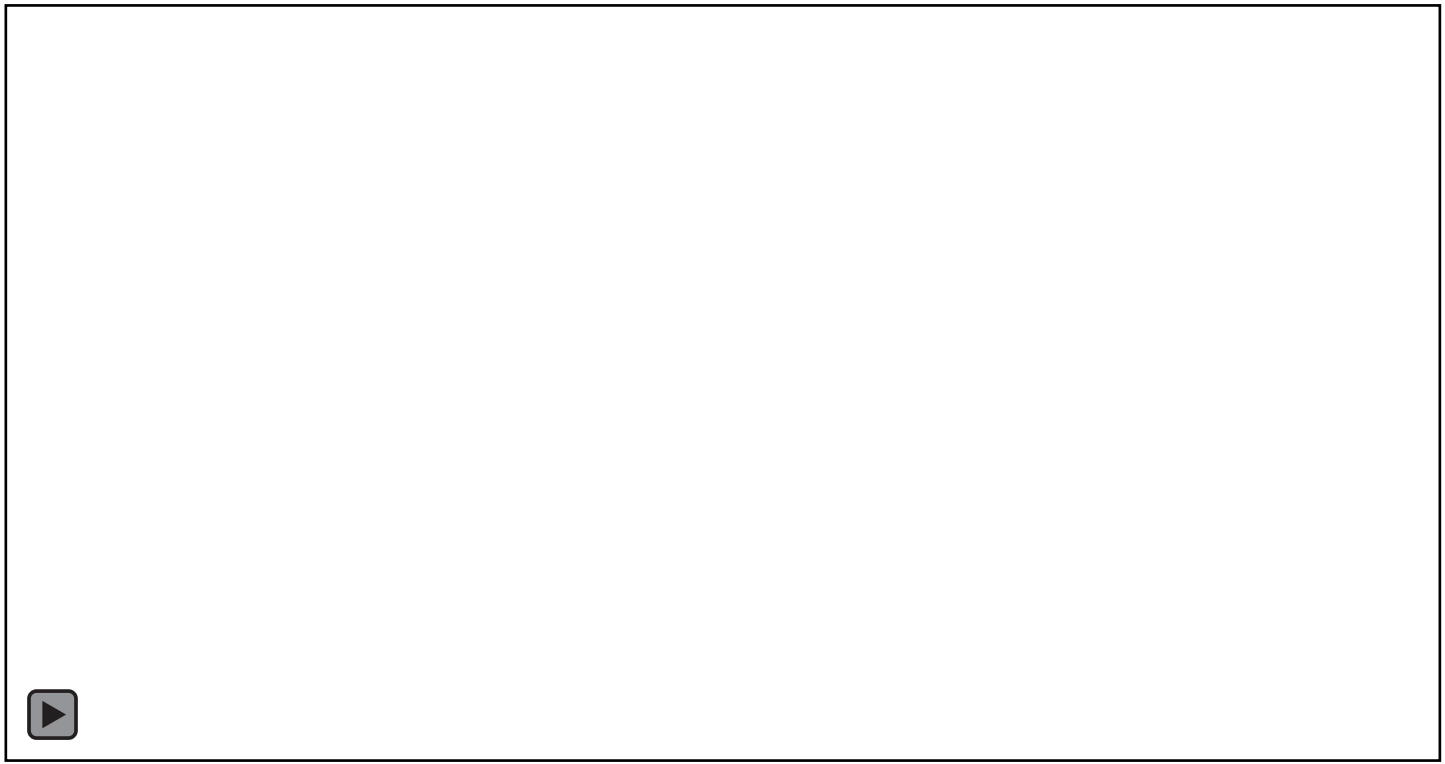
Summary

- 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