



NASA GEOS Composition Forecast System: “GEOS-CF”

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USRA/GESTAR

NASA Global Modeling and Assimilation Office (GMAO)

In collaboration with:

GMAO: Christoph Keller, Lesley Ott, Steven Pawson, Pamela Wales

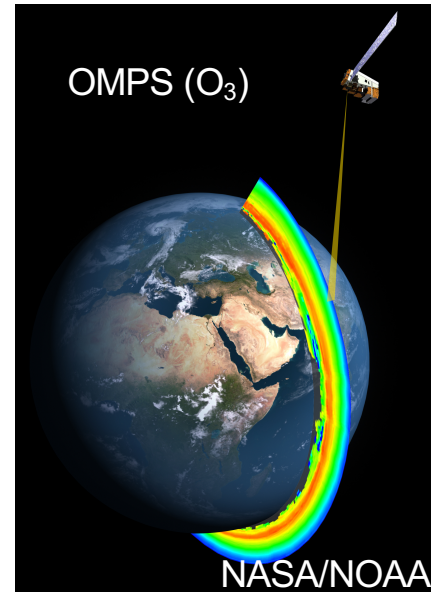
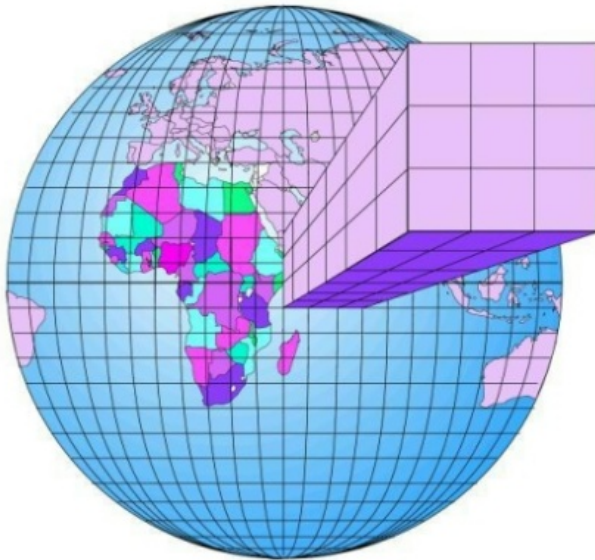
Atmospheric Chemistry and Dynamics Lab: Bryan Duncan

4 June 2020



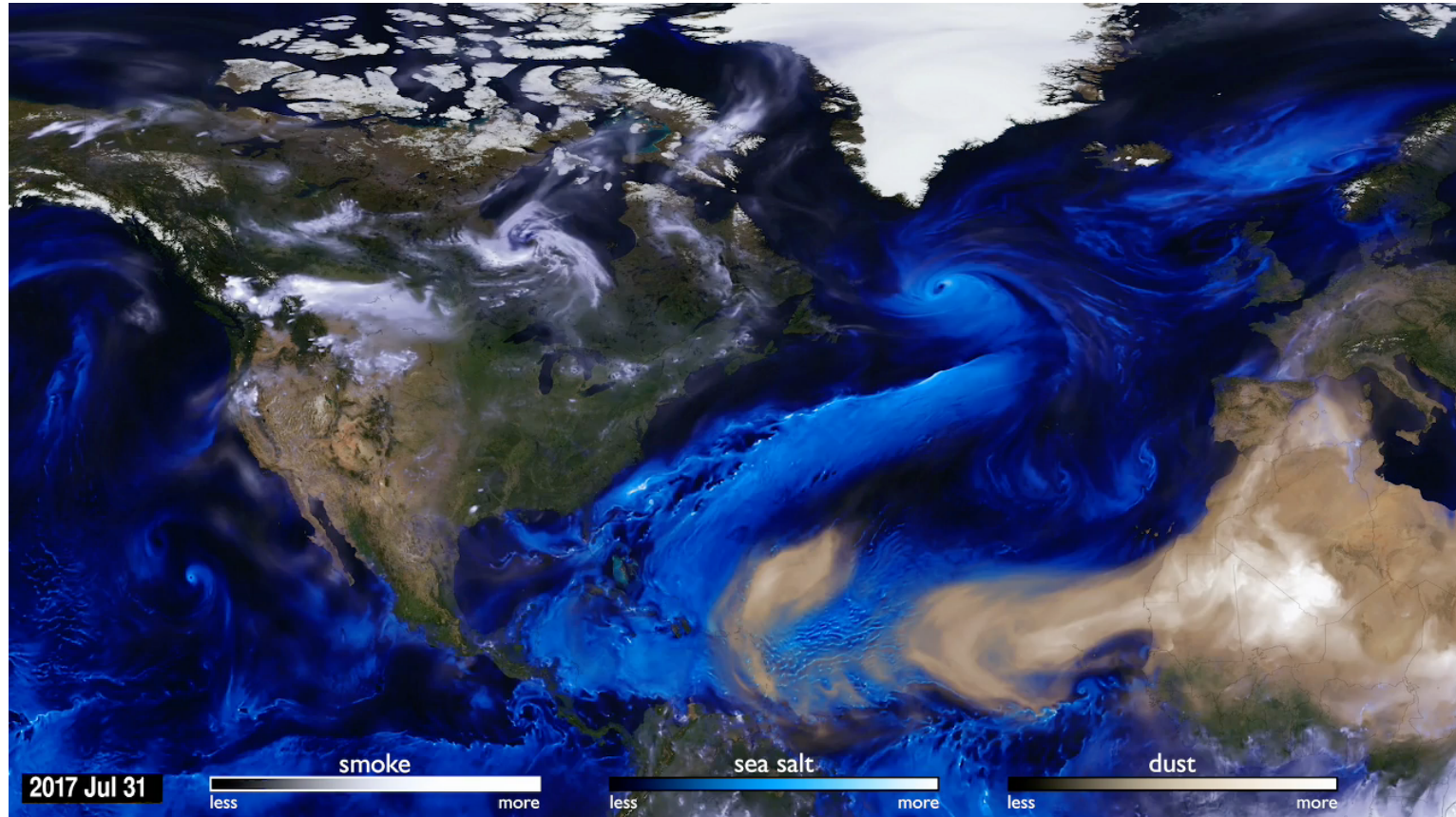
NASA GMAO global meteorology and chemistry products

GEOS

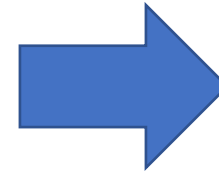
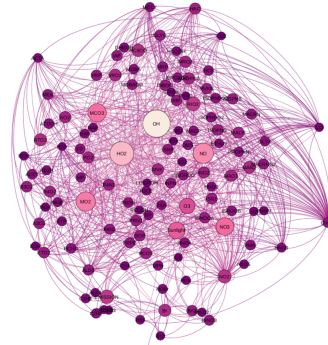
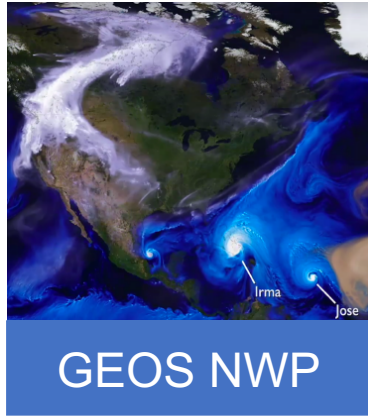


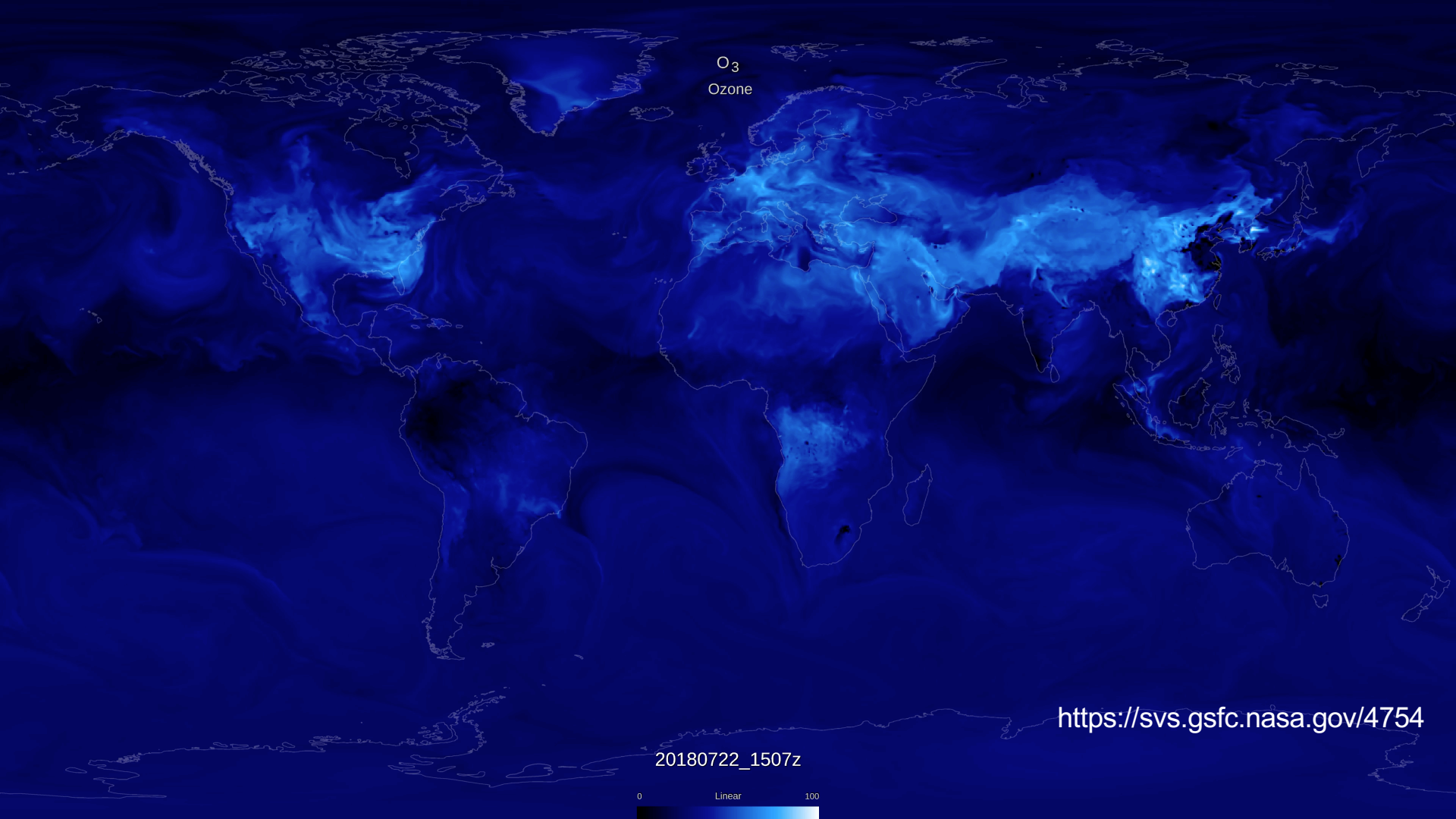
www.nasa.gov

The GMAO's role is to support NASA's Earth observations



NASA GMAO's Composition Forecast





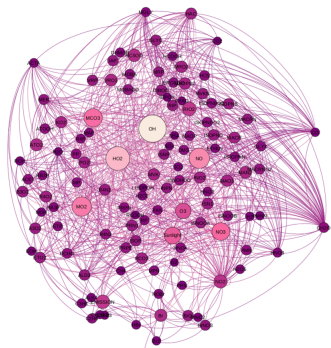
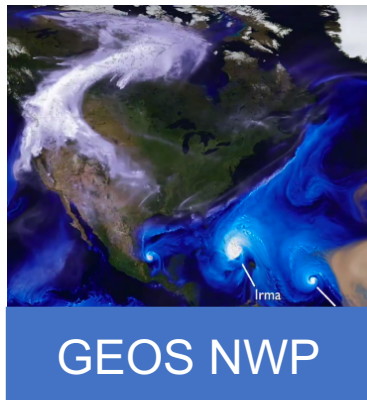
O₃
Ozone

<https://svs.gsfc.nasa.gov/4754>

20180722_1507z

0 Linear 100

Daily composition forecast



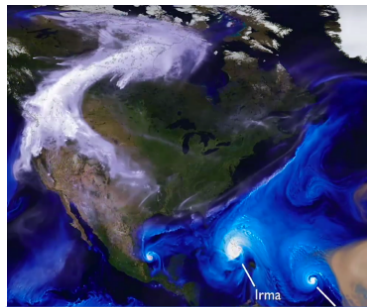
GEOS-Chem

GEOS - CF

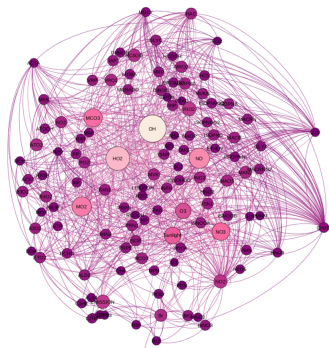
One **5-day forecast** per day

- 1-day meteorological replay (“analysis”)
- 5-day forecast
- 0.25° resolution, ~**25x25 km²**, Global
- 72 model layers, surface to 0.1 hPa
- Chemistry: O₃, NO_x, CO, VOCs, PM, ...
- Meteorology: T, U, V, RH
- **15 minute** “surface”
- **1-hour** average and instantaneous 2D & 3D
- **Available since 1 January 2018**

Daily composition forecast



GEOS NWP



GEOS-Chem

GEOS - CF

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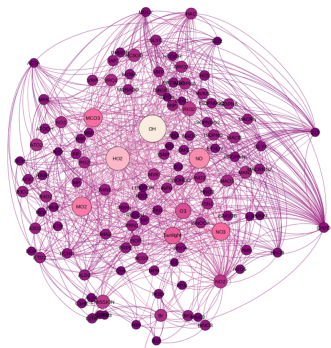
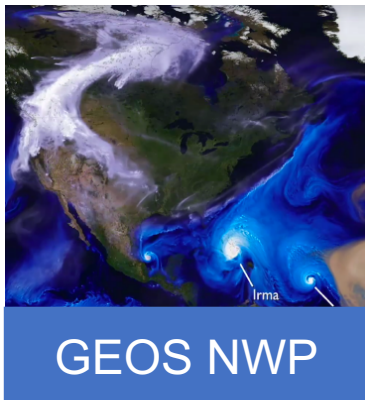
Emissions:

- HTAP (global bottom-up) for anthropogenic
- Near real-time fires (QFED)
- Online dust, sea salt, plant emissions

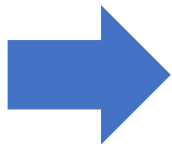
Daily composition forecast

GEOS - CF

Currently **no direct data assimilation of constituents**



GEOS-Chem

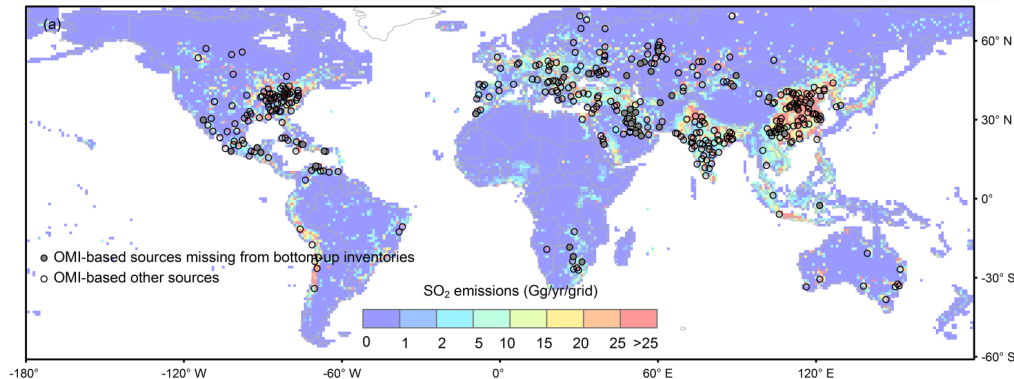


- GOCART aerosols constrained by satellite measurements of AOD
- Biomass burning emissions from QFED
- Stratospheric O_3 (above ~ 75 hPa) nudged to GEOS NWP ($\Rightarrow$ MLS) O_3

Daily composition forecast

GEOS - CF

SO₂ emissions in the OMI-HTAP inventory



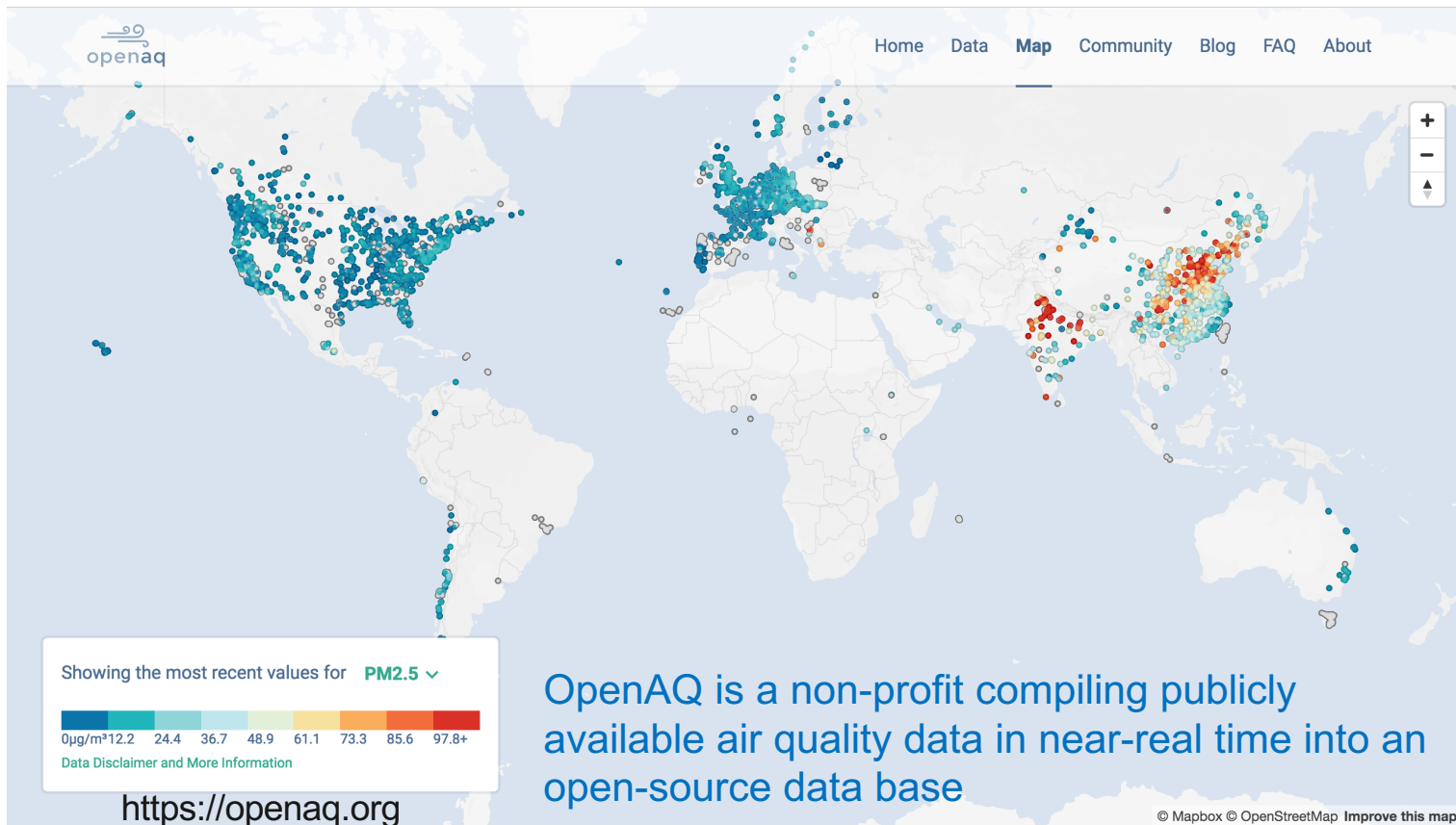
A new emission inventory, OMI-HTAP, combines OMI-based SO₂ emissions for large sources and the bottom-up inventory, HTAP, for smaller sources.

Liu, F., et al., *Atmos. Chem. Phys.*, 18, 2018

➤ Annual gridded scale factors based on satellite data are applied to the emissions of CO (Oda et al., 2017) and SO₂ (Liu et al., 2018).

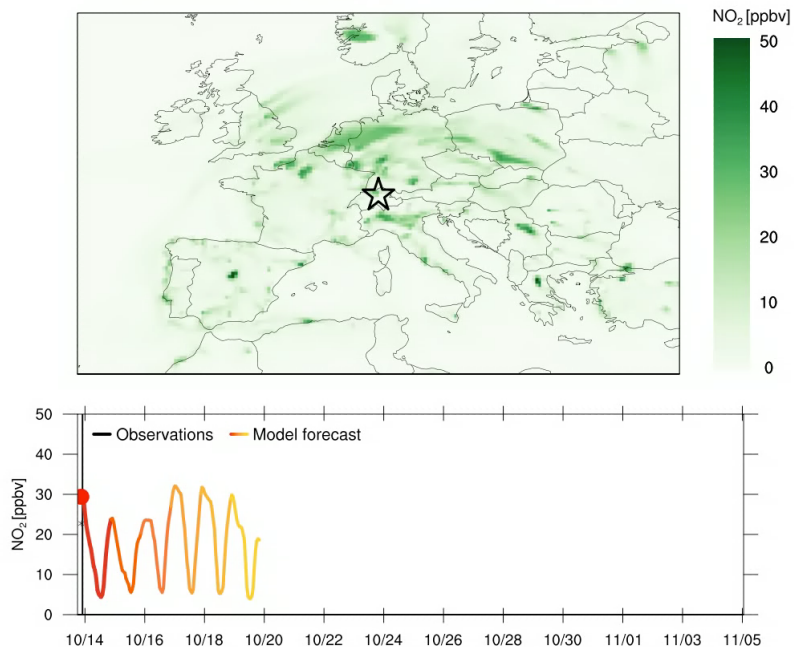
“Business-as-usual”
assumed for 2020

OpenAQ surface observation data base



Daily composition forecast

Zurich, Switzerland, 2017-10-14 00:00 UTC



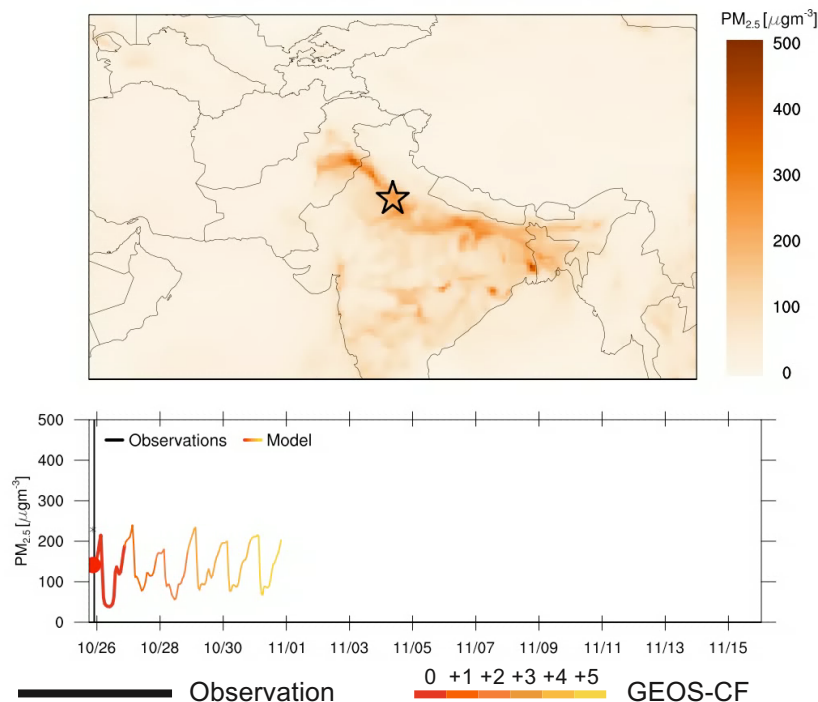
GEOS - CF

- Scale factors applied to emissions for diurnal and weekly variations

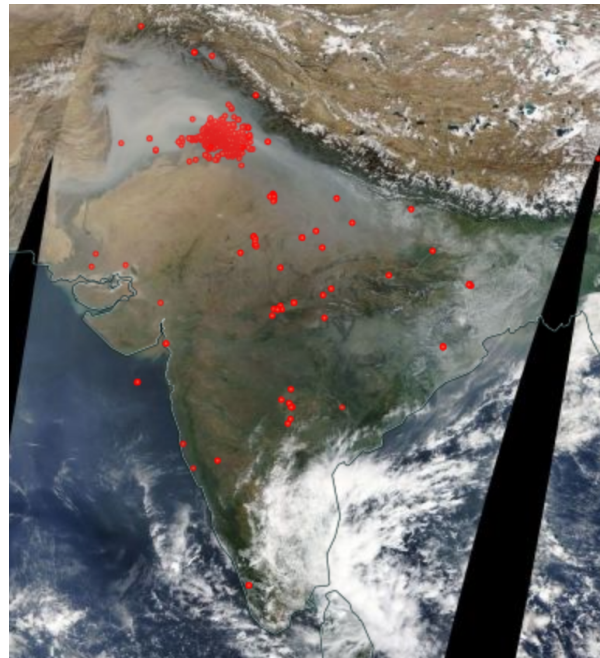
Model evaluation with surface observations

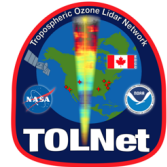
Case study: agricultural fires in India

Delhi, India, 2017-10-26 00:00 UTC



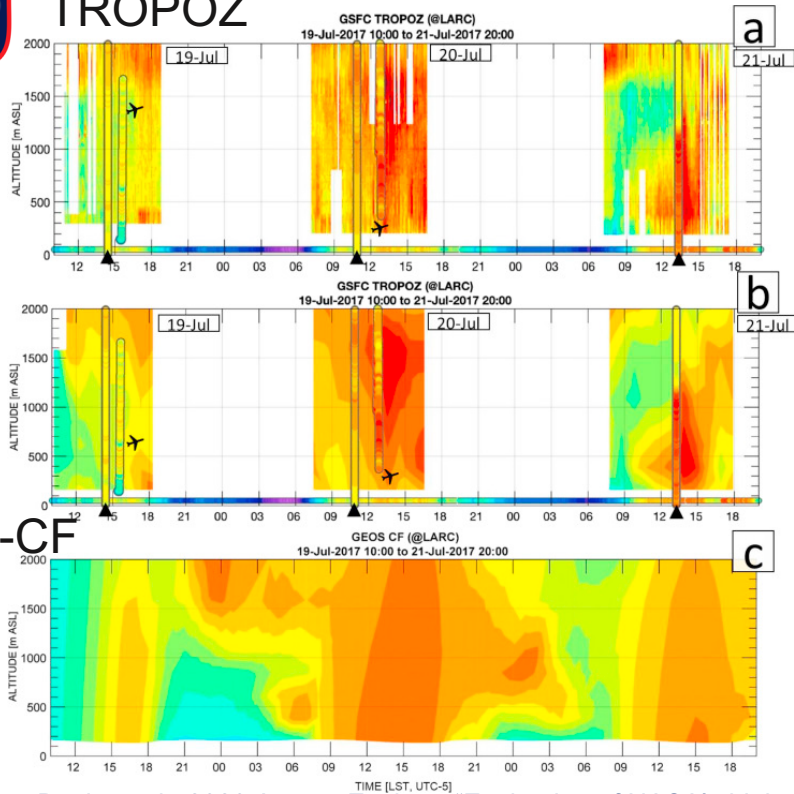
MODIS fires Nov 01, 2017



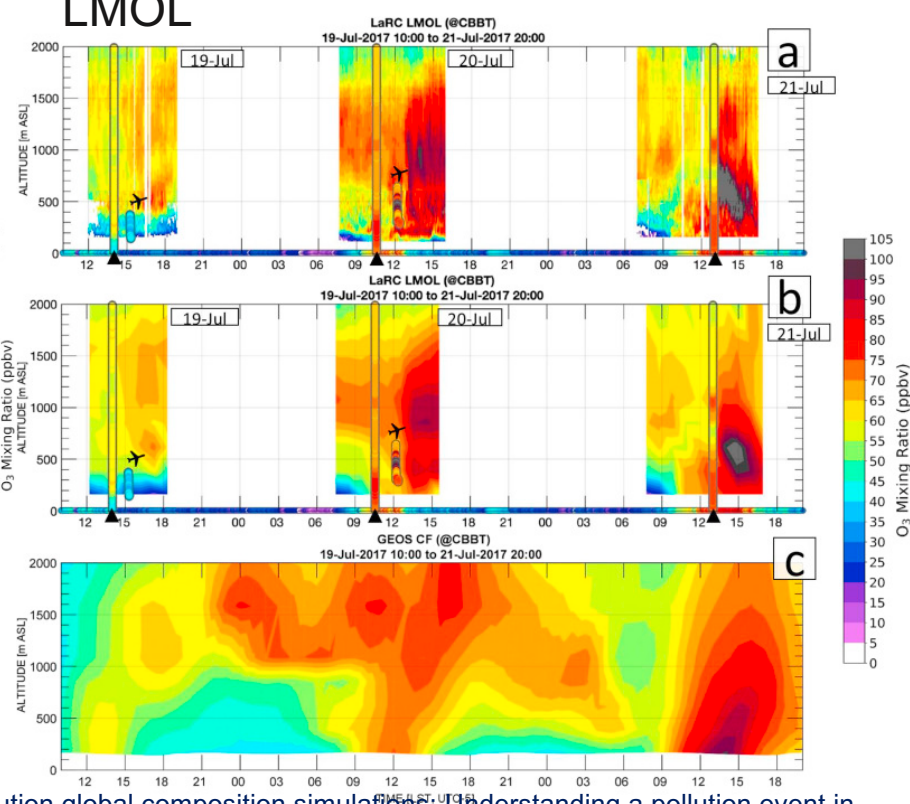


Model evaluation using TOLNet lidars: OWLETS-1

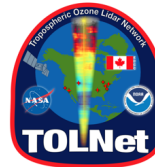
TROPOZ



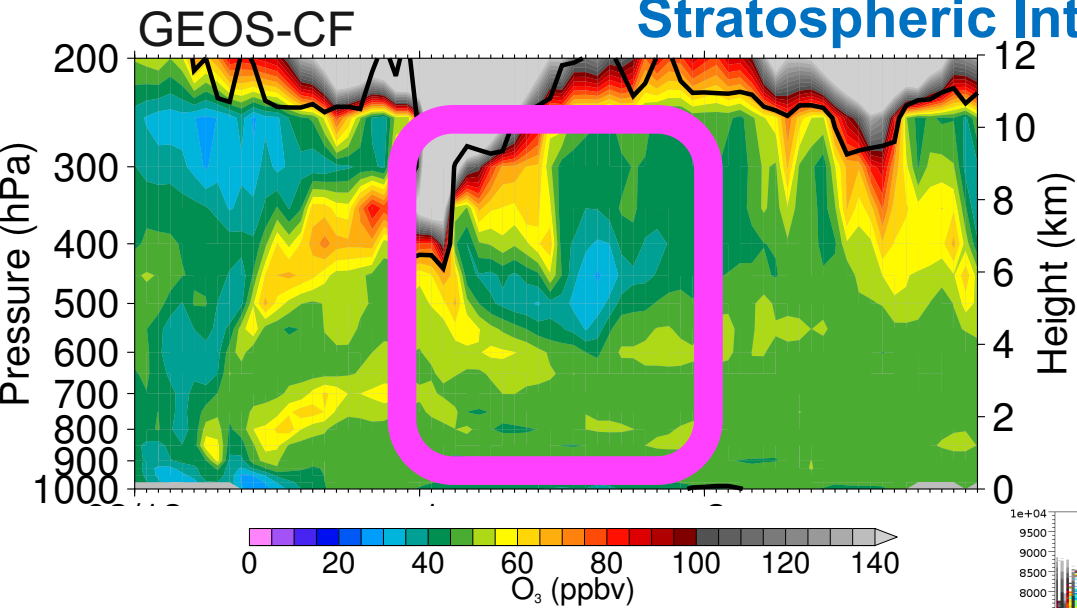
LMOL



Dacic et al., 2020 Atmos. Environ. "Evaluation of NASA's high-resolution global composition simulations: Understanding a pollution event in the Chesapeake Bay during the summer 2017 OWLETS campaign"



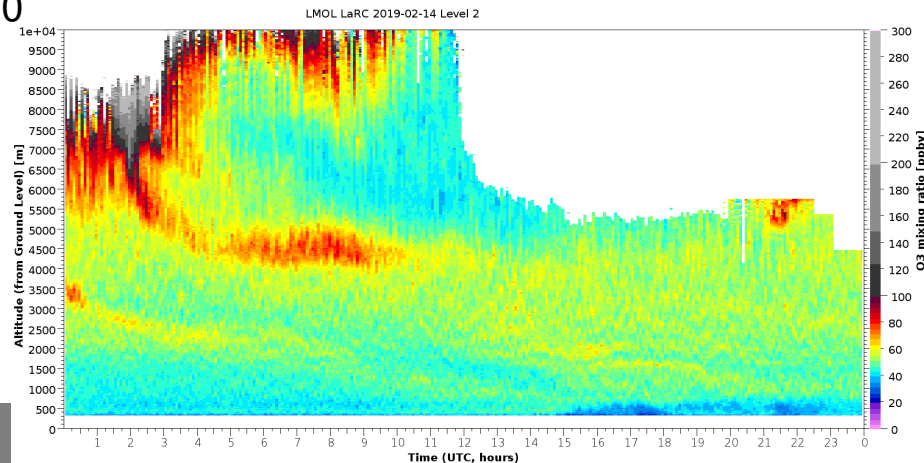
Possible Model Evaluation with TOLNet lidars: Stratospheric Intrusions

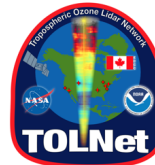


Stratospheric Intrusion on
February 14, 2019

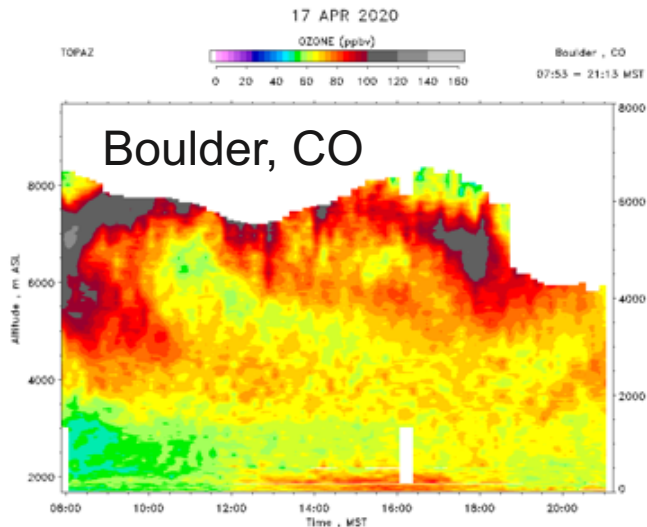
Gronoff et al., 2020, in prep

GEOS-CF able to confirm
high O_3 likely stratospheric
origin



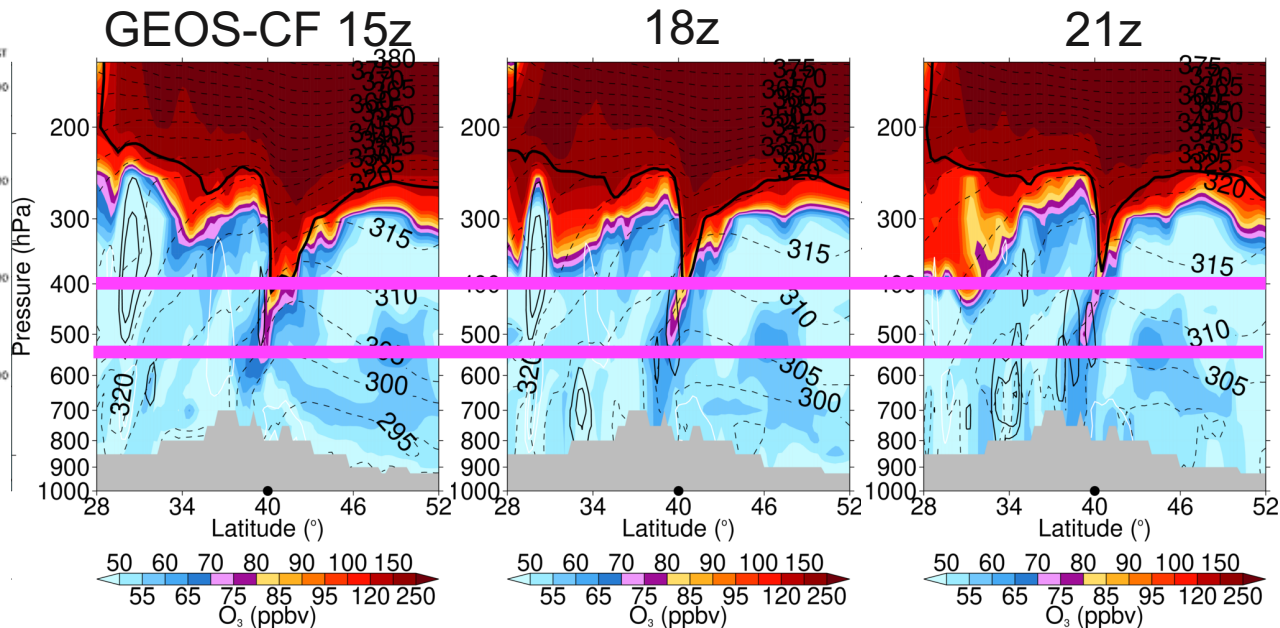


Possible Model Evaluation with TOLNet lidars: Stratospheric Intrusions



15z 18z 21z

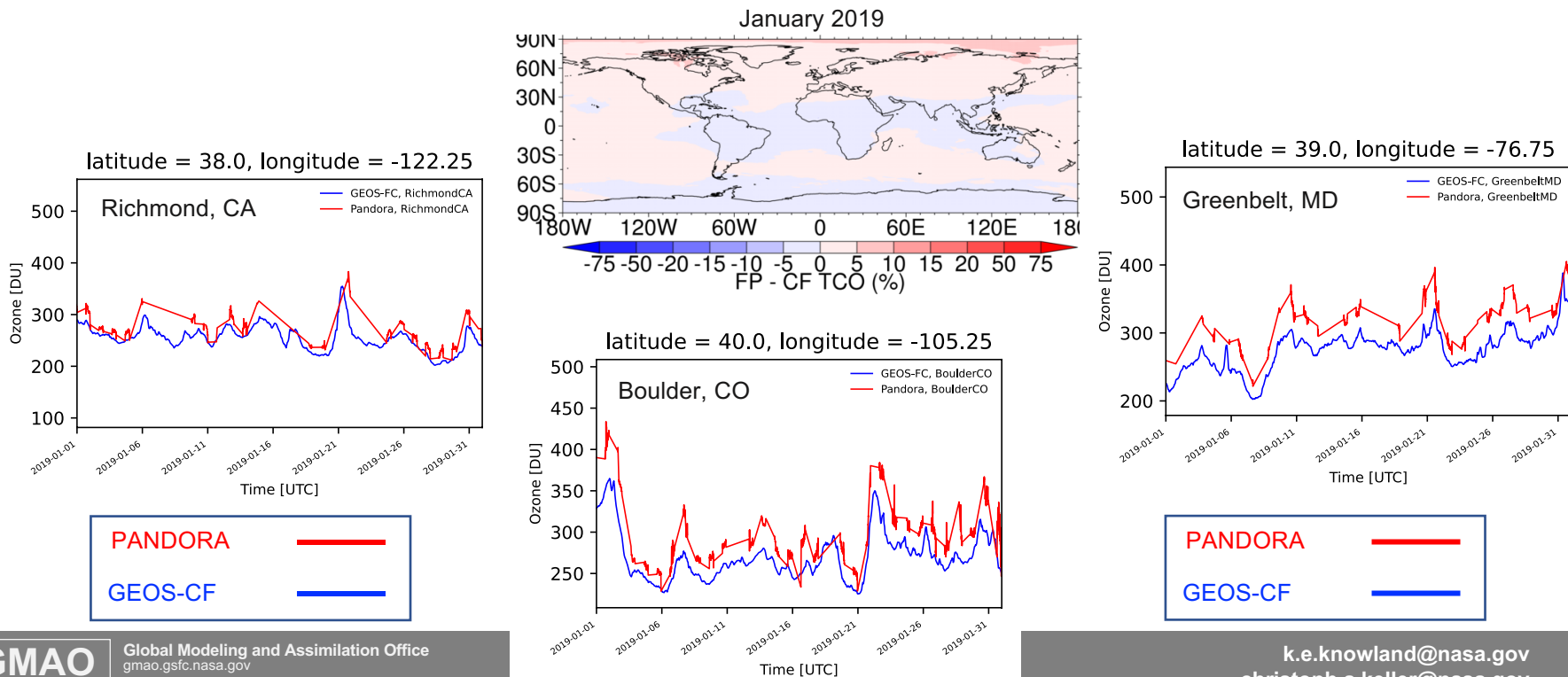
TOPAZ lidar image courtesy of
Raul Alvarez, S. Baider, A.O.
Langford, C.J. Senff
*Plot is preliminary and may include
artifacts near surface and clouds*



This stratospheric intrusion on April 17, 2020 over
Boulder was observed by the TROPOZ lidar on April 18th

Possible Model Evaluation with Pandora Instruments: Is the ozone nudging working?

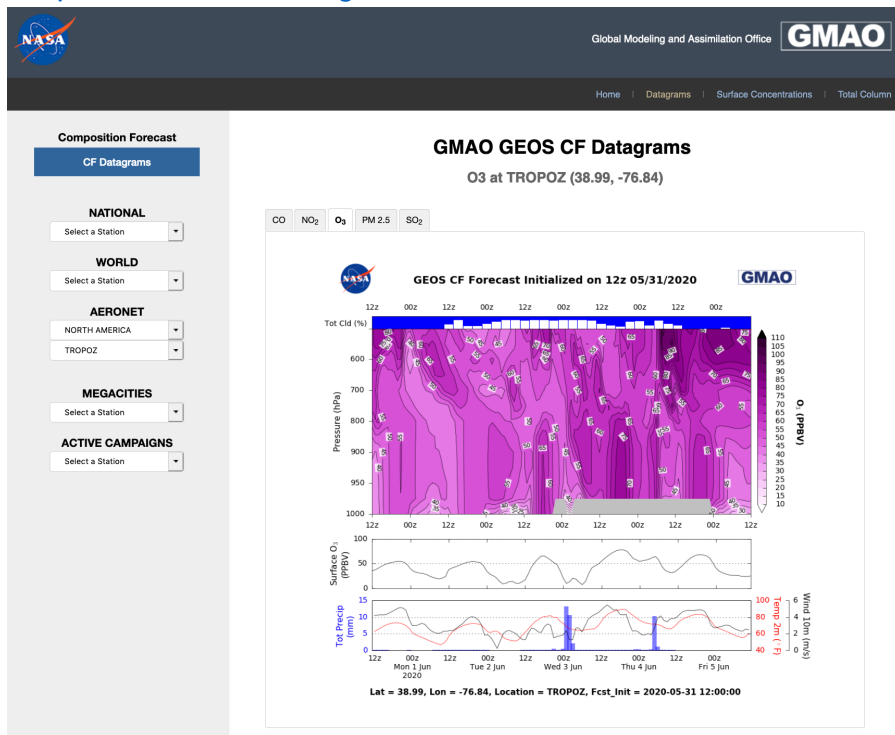
GEOS-CF Total Column Ozone biased low compared to Pandora instruments January 2019
Santos et al., 2020, in prep.



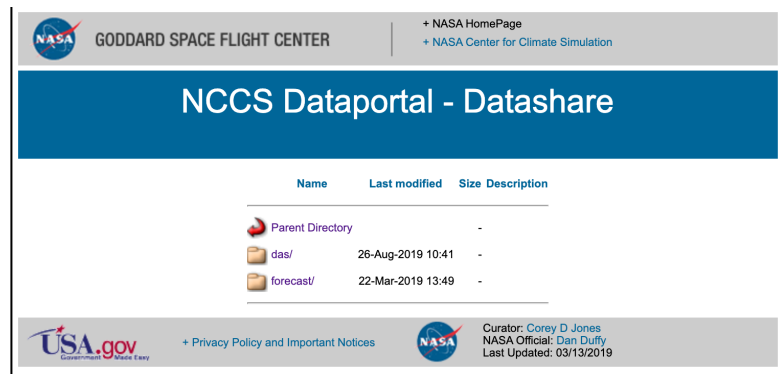
GEOS-CF are available online in near real-time

FLUID is a mobile-friendly website

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



<https://portal.nccs.nasa.gov/datashare/gmao/geos-cf/v1/>



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

GrADS Data Server - info for /gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1 : [dds](#) [das](#)

OPeNDAP/DODS Data URL: https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1

Description: GEOS CF (Composition Forecast)
Documentation: (none provided)
Longitude: -180.000000000000°E to 179.750000000000°E (1440 points, avg. res. 0.25°)
Latitude: -90.000000000000°N to 90.000000000000°N (721 points, avg. res. 0.25°)
Altitude: 72.000000000000 to 72.000000000000 (1 points)
Time: 00:30Z01JAN2018 to 11:30Z31OCT2019 (16044 points, avg. res. 0.042 days)
Variables: (total of 52)
xyle xylene (c8h10, mw = 106.16 g mol⁻¹) volume mixing ratio dry air
dst2 dust aerosol, reff = 1.4 microns (mw = 29.00 g mol⁻¹) volume mixing ratio dry air
hno4 peroxyntitric acid (hno4, mw = 79.00 g mol⁻¹) volume mixing ratio dry air
pm25su_rh35_gcc sulfate_particulate_matter_with_diameter_below_2.5_um_rh_35



Summary

- GEOS-CF produces daily global composition forecasts at 25km (16 miles) horizontal resolution in near-real time
- Model output is available at high temporal resolution for 2D and 3D fields
- Forecast visualizations and links to data available at fluid.nccs.nasa.gov/cf
- Working with instrument teams is a two-way street. The modelers can benefit from the evaluation against observations and the instrument teams have access to forecasts and model data for a priori profiles or post-processing -> Next **Community Discussion** topic.