



Near real-time air quality forecasts using the NASA GEOS model

K. Emma Knowland

USRA/GESTAR

NASA Global Modeling and Assimilation Office (GMAO)

In collaboration with:

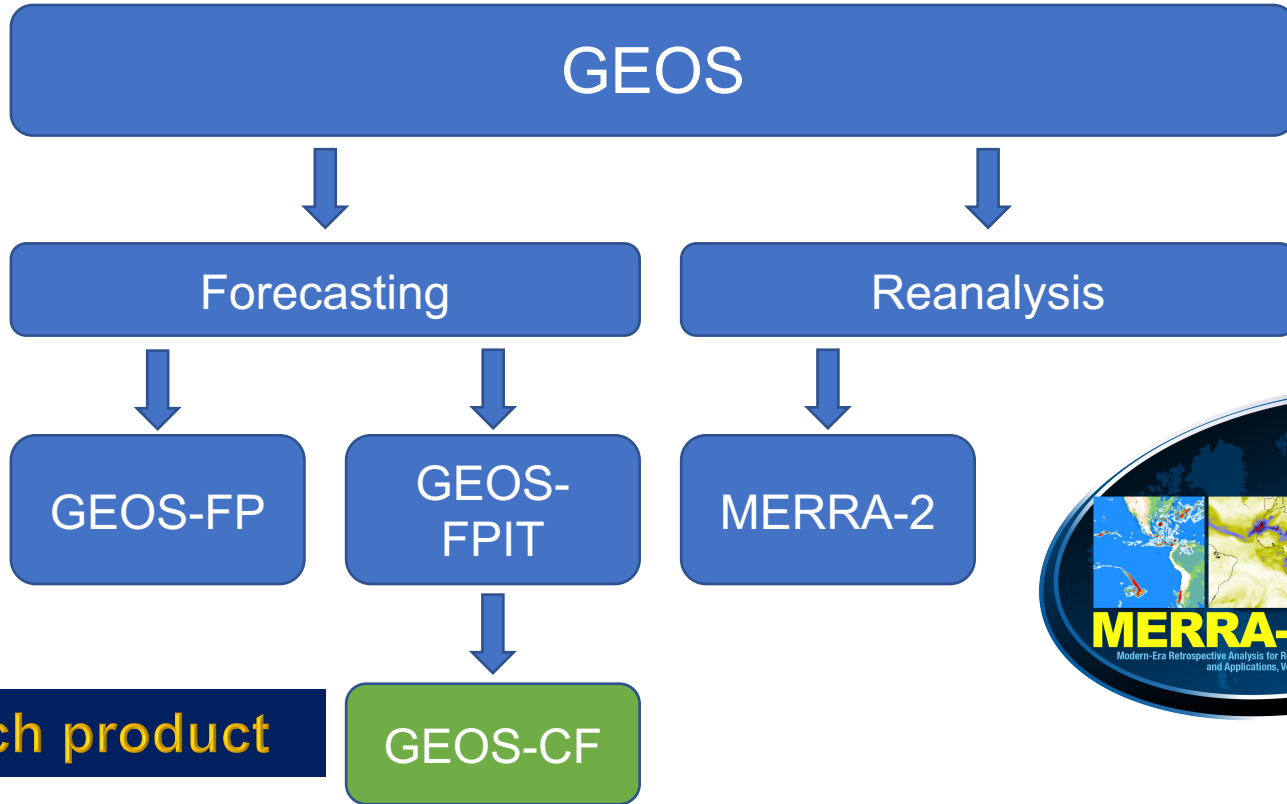
GMAO: Christoph Keller, Lesley Ott, Steven Pawson, Emily Saunders, Pamela Wales

Atmospheric Chemistry and Dynamics Lab: Bryan Duncan, Melanie Follette-Cook, Junhua Liu, Julie Nicely

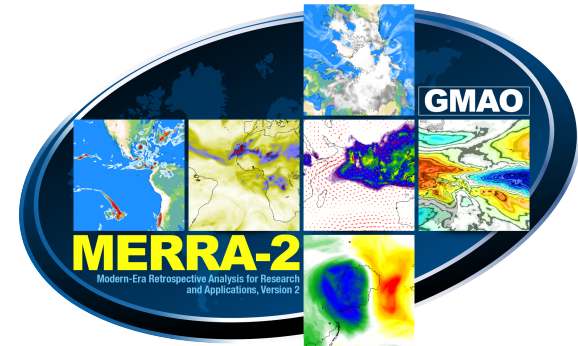




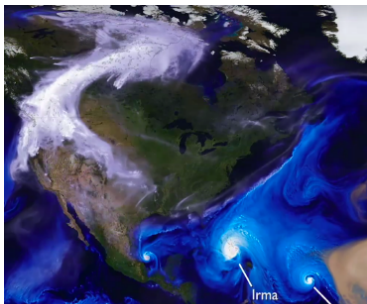
NASA GMAO global meteorology and chemistry products



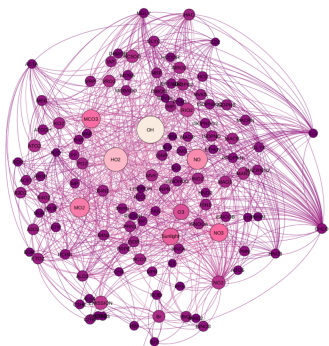
Research product



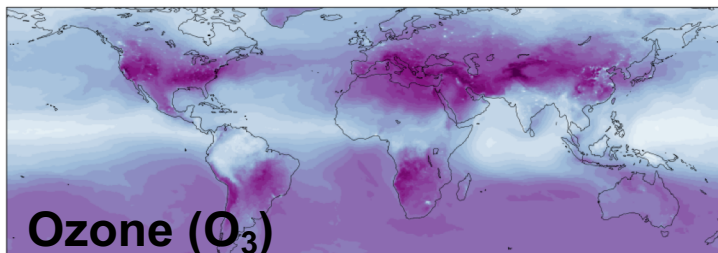
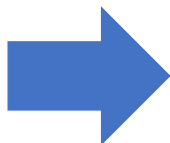
NASA's composition forecast (GEOS-CF)



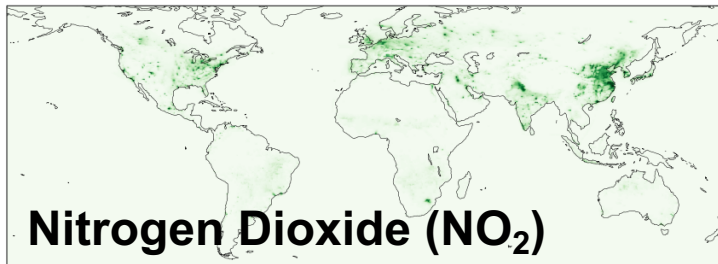
GEOS FPIT



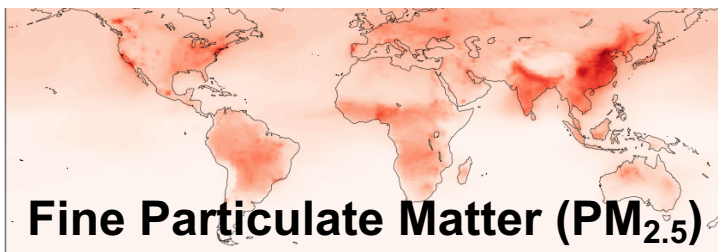
GEOS - Chem



Ozone (O_3)

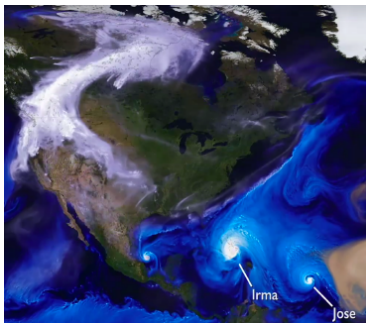


Nitrogen Dioxide (NO_2)

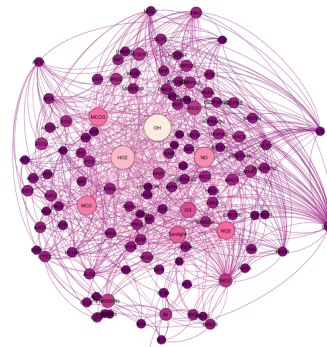


Fine Particulate Matter ($PM_{2.5}$)

NASA GMAO's Composition Forecast



GEOS NWP



GEOS - Chem

Research product

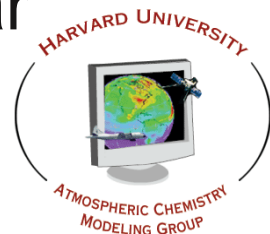


GEOS-Chem is a state-of-the science chemistry transport model

Tropospheric and Stratospheric full chemistry

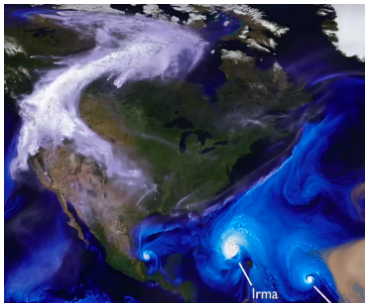
- 250 reactive species, 725 reactions
- 100+ user/developer groups worldwide
- Updated version is released about every year

GEOS-Chem

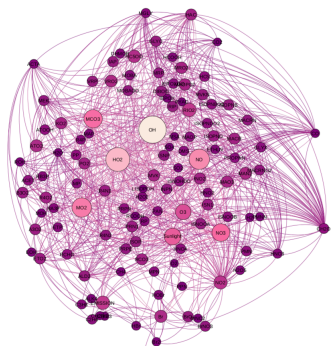




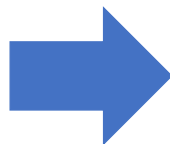
Daily composition forecast



GEOS NWP



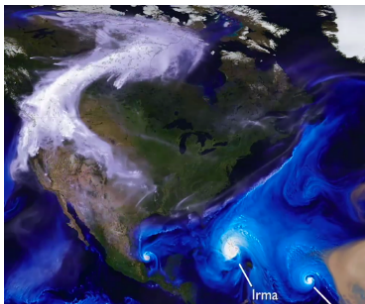
GEOS - Chem



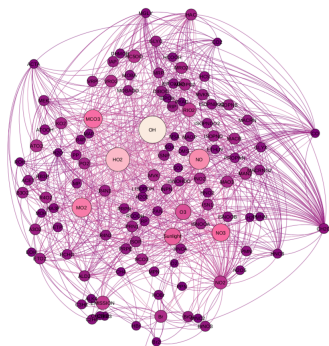
GEOS - CF

One **5-day forecast** per day

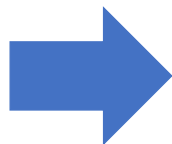
Daily composition forecast



GEOS NWP



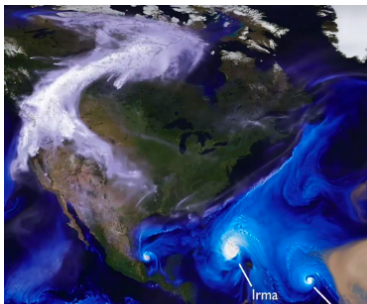
GEOS - Chem



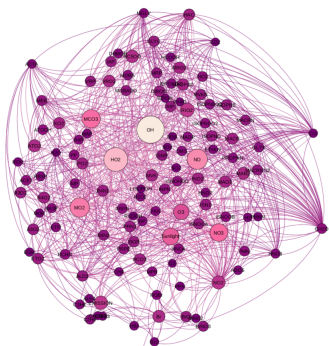
GEOS - CF

- One **5-day forecast** per day
- 1-day hindcast “analysis”
 - 5-day forecast

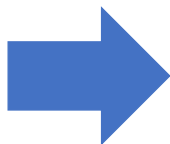
Daily composition forecast



GEOS NWP



GEOS - Chem

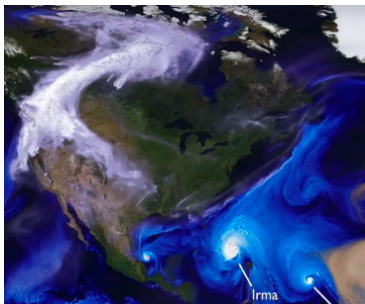


GEOS - CF

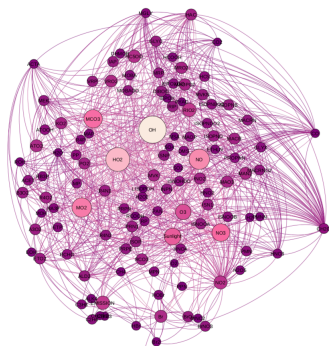
One **5-day forecast** per day

- 1-day hindcast
- 5-day forecast
- c360 (0.25° , $\sim 25 \times 25 \text{ km}^2$) resolution, 72 model layers

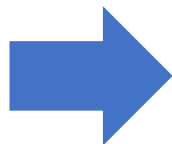
Daily composition forecast



GEOS NWP



GEOS - Chem

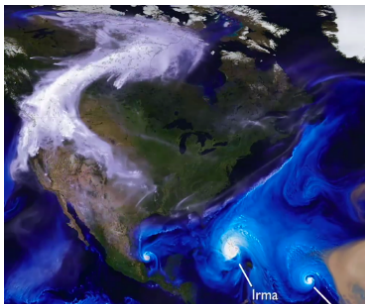


GEOS - CF

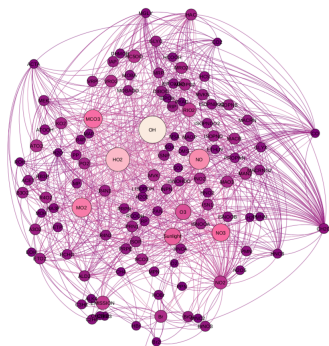
One **5-day forecast** per day

- 1-day hindcast
- 5-day forecast
- c360 (0.25° , $\sim 25 \times 25 \text{ km}^2$) resolution, 72 model layers
- O_3 , NO_x , VOCs, PM ...

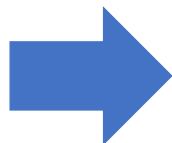
Daily composition forecast



GEOS NWP



GEOS - Chem

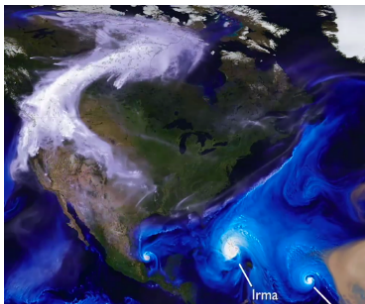


GEOS - CF

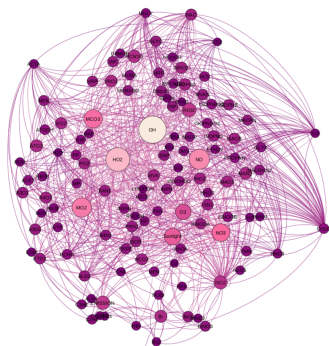
One **5-day forecast** per day

- 1-day hindcast
- 5-day forecast
- c360 (0.25° , $\sim 25 \times 25 \text{ km}^2$)
- **15 minute** “surface”
- **1-hour** average and instantaneous 2D & 3D

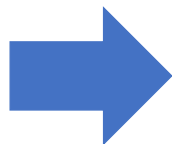
Daily composition forecast



GEOS NWP



GEOS - Chem



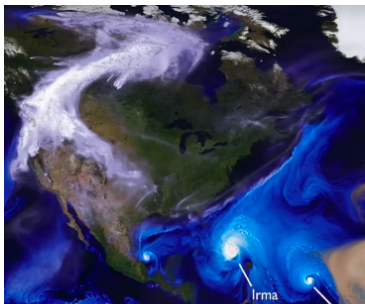
GEOS - CF

One **5-day forecast** per day

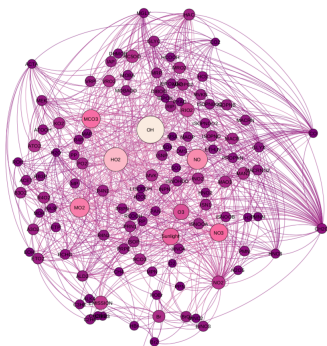
- 1-day hindcast
- 5-day forecast
- c360 (0.25° , $\sim 25 \times 25 \text{ km}^2$)

➤ **1 January 2018 - NRT**

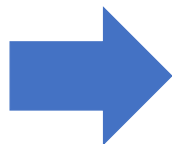
Chemistry is not cheap!



GEOS NWP



GEOS - Chem



GEOS - CF

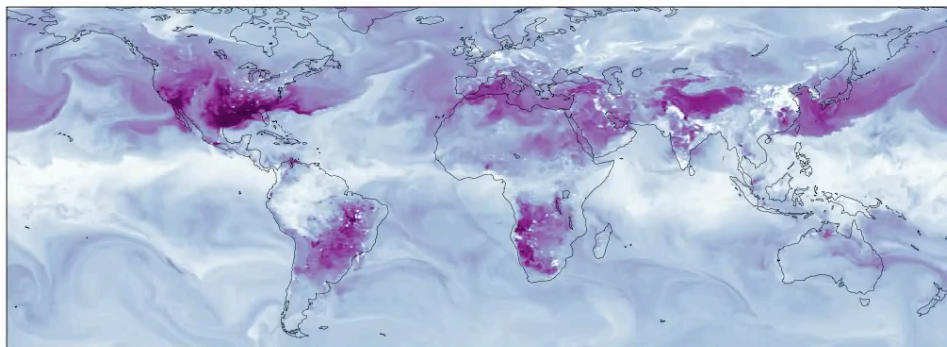
Run on **NASA's** Center for Climate Simulation **supercomputer**

- using the computing power equivalent to **3500** personal computers.

High-Resolution Global Simulation

GEOS - CF

2017-10-01 00:30 UTC



10 20 30 40 50 60

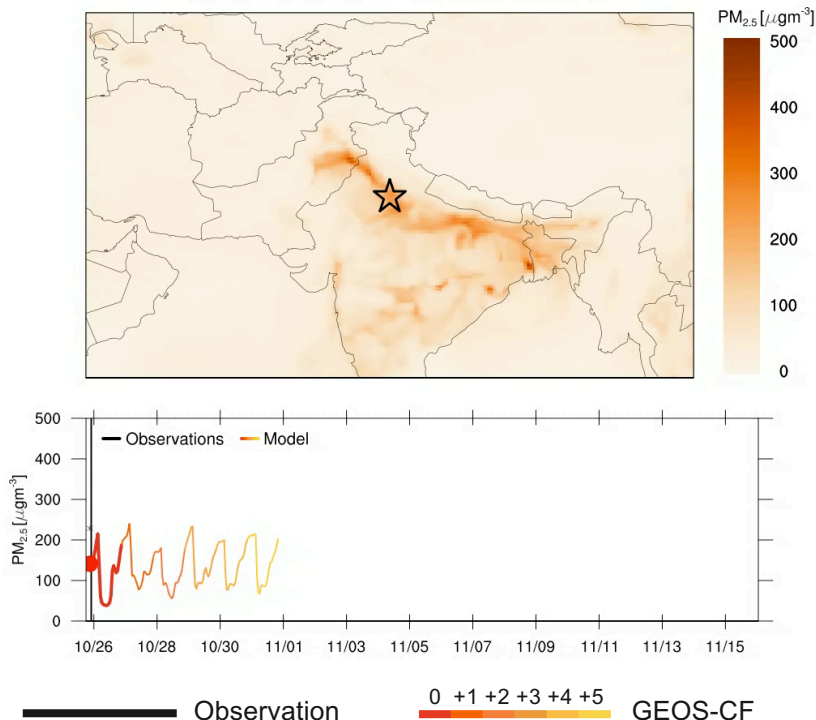
Surface ozone [ppbv]

25 km x 25 km (16 miles)

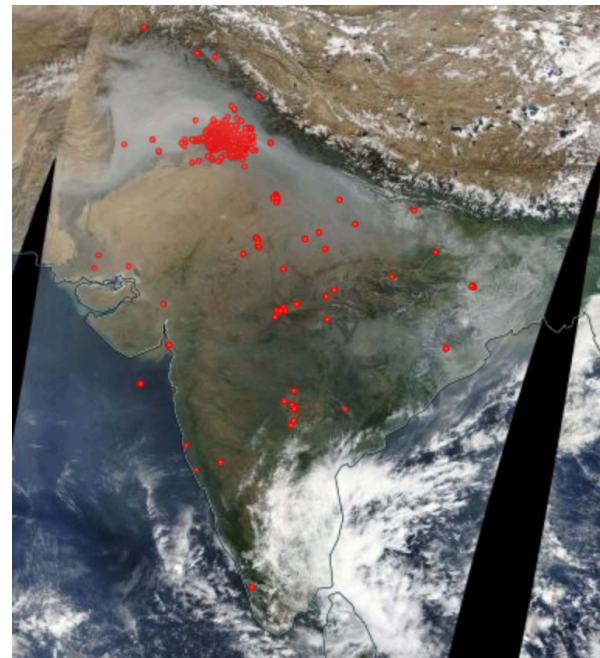
- **Highest** horizontal resolution of a global atmospheric composition forecast
- **10 x higher** than conventional global atmospheric chemistry simulations.

Case study: agricultural fires in India

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

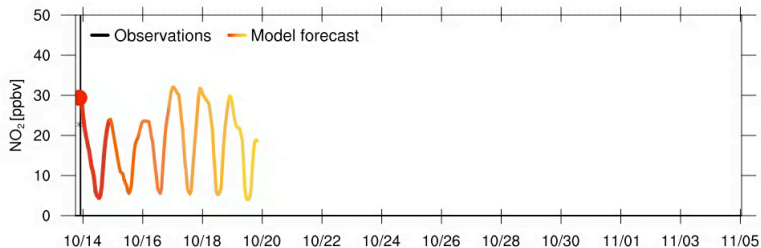
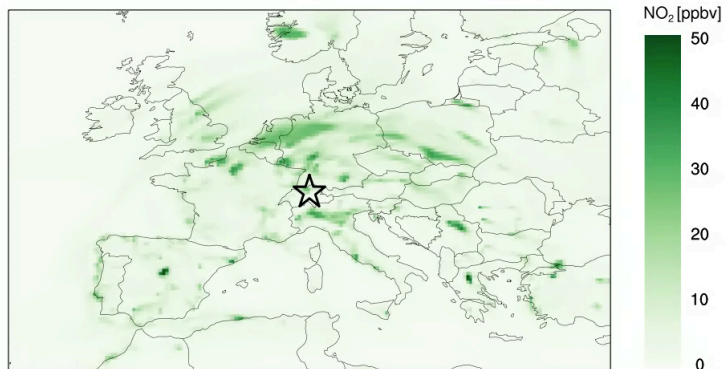


MODIS fires Nov 01, 2017



Daily composition forecast

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

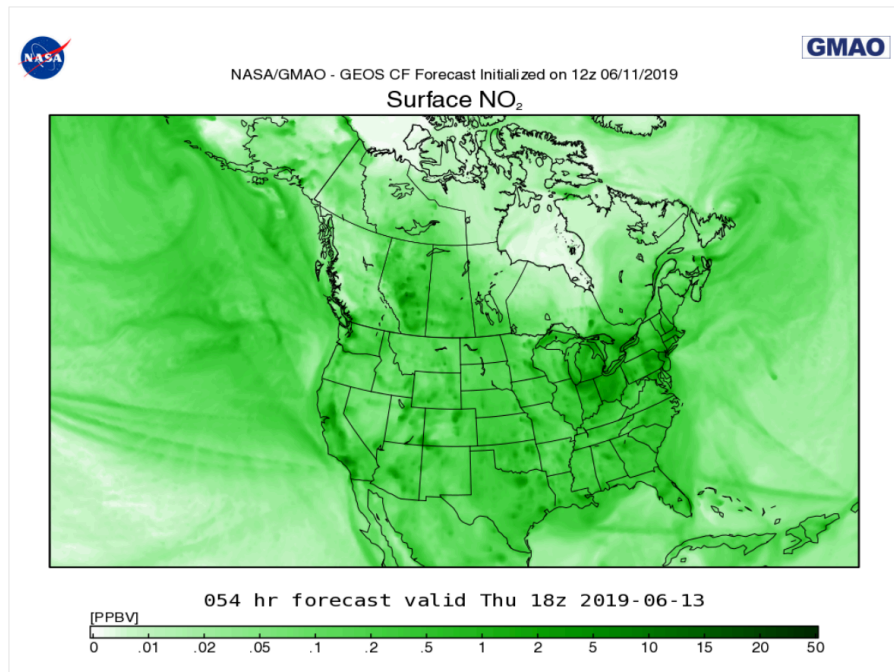


GEOS - CF

- Annual emission scale factors based on satellite
- Scale factors applied to emissions for diurnal and weekly variations

Where to find GEOS-CF

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



Composition Forecast Maps

FIELDS

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

REGIONS

North America

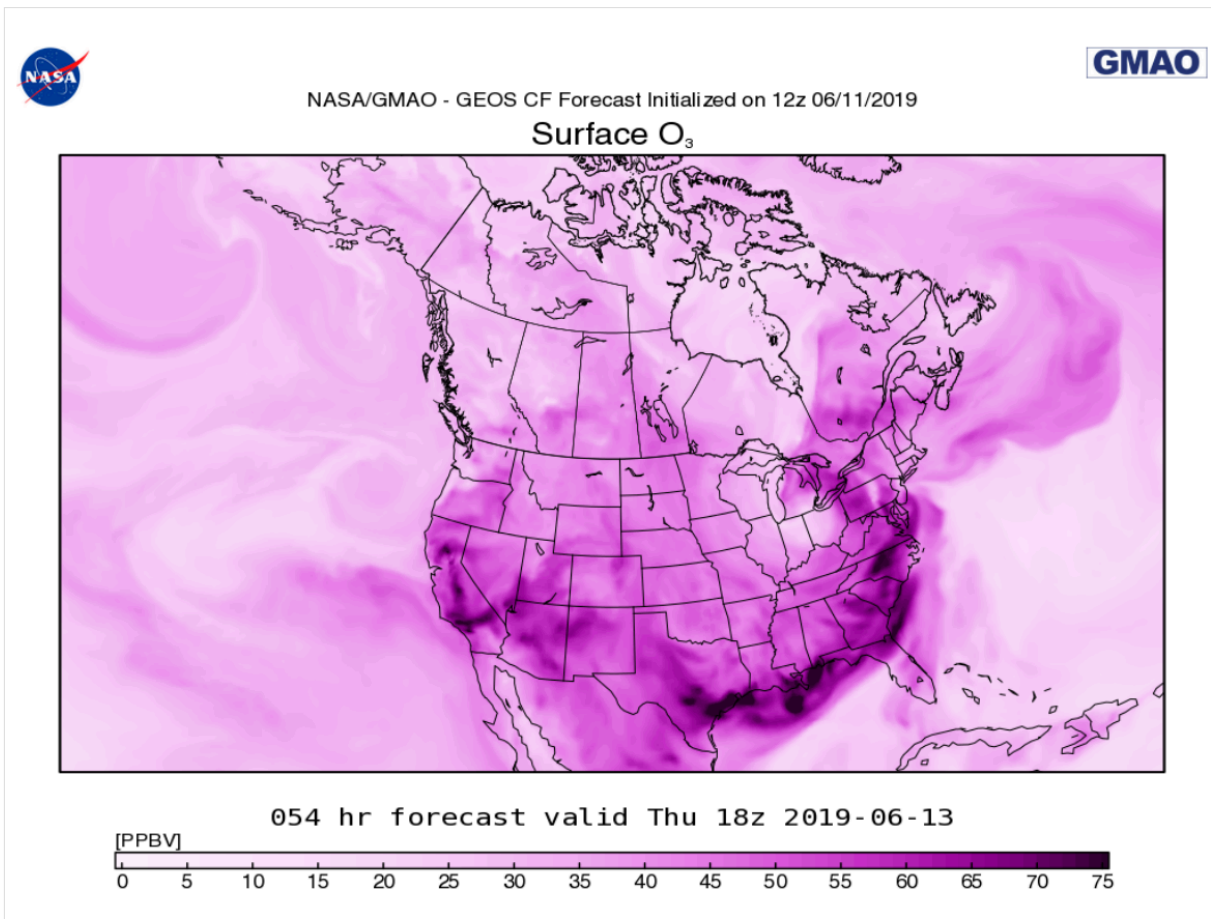
FORECAST INITIAL TIME

11Jun2019 12z

FORECAST LEAD HOUR

054h 13Jun2019 18z

Model forecast O₃



NATIONAL
Raleigh

WORLD
Select a Station

AERONET
Select a Station

MEGACITIES
Select a Station

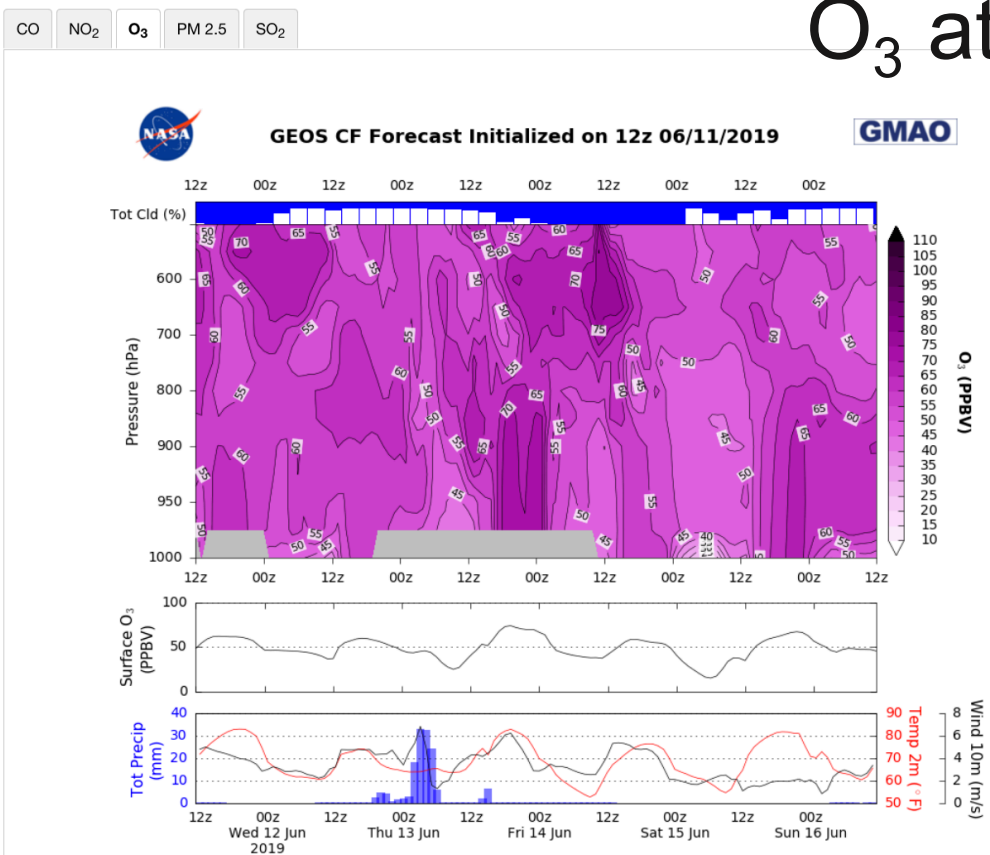
ACTIVE CAMPAIGNS
Select a Station

GMAO GEOS CF Datagrams

O3 at Raleigh (35.80, -78.60)



Model forecast O₃ at Raleigh



Vertical O₃

Surface O₃

Meteorology

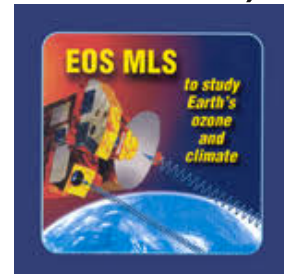
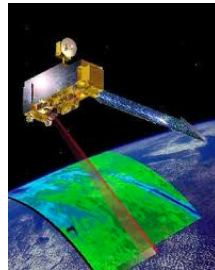
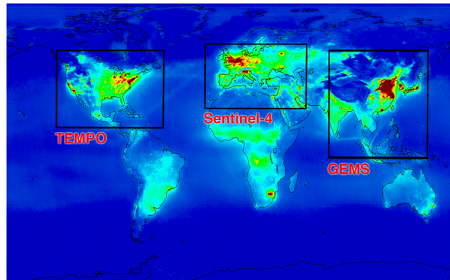
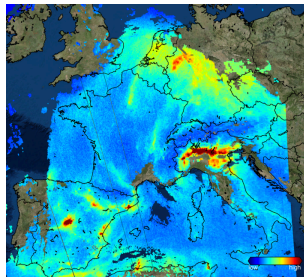
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Summary

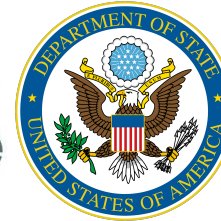
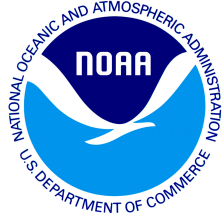
- GEOS-CF produces daily global air quality forecasts at 25km (16 miles) horizontal resolution
- Output available at fluid.nccs.nasa.gov/cf

Under development:

- Assimilation system for trace gases (O_3 , NO_x , CO, & others)

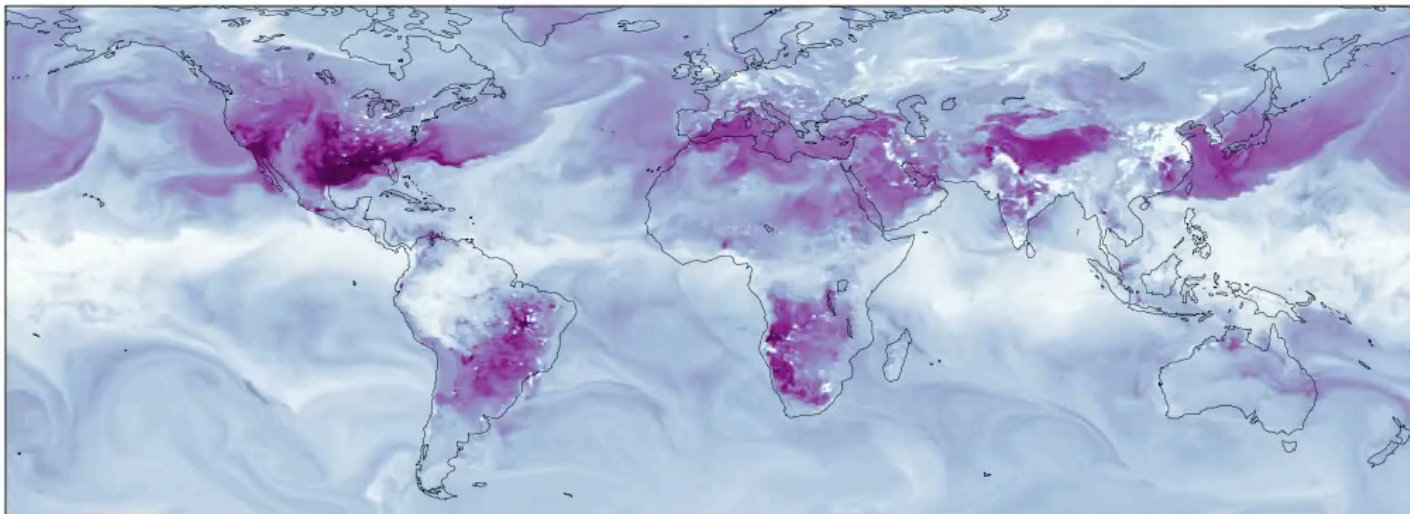


k.e.knowland@nasa.gov



Thank you!

2017-10-01 00:30 UTC



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