NASA's High-Resolution GEOS Forecasting and Reanalysis Products: Support for TOLNet

K. Emma Knowland

USRA/GESTAR

NASA Global Modeling and Assimilation Office (GMAO)

In collaboration with:

NASA GMAO: Christoph Keller, Lesley Ott, Steven Pawson, Brent Smith, Callum Wayman

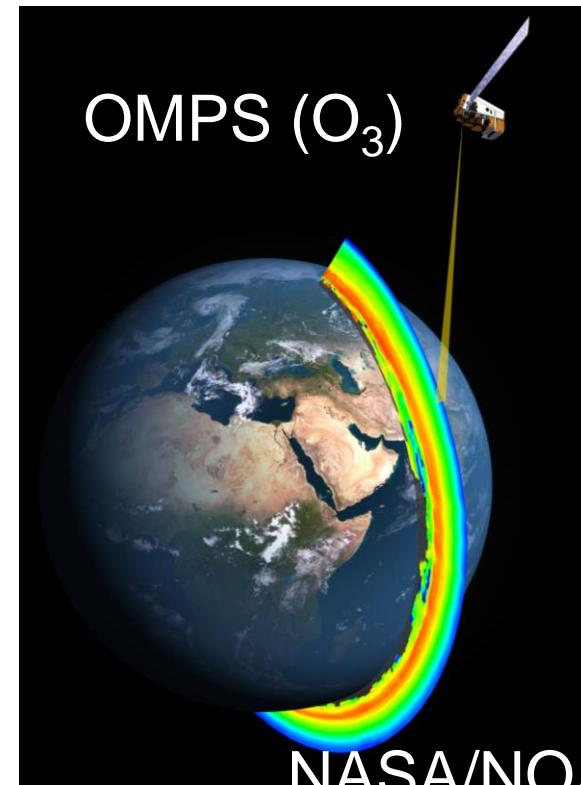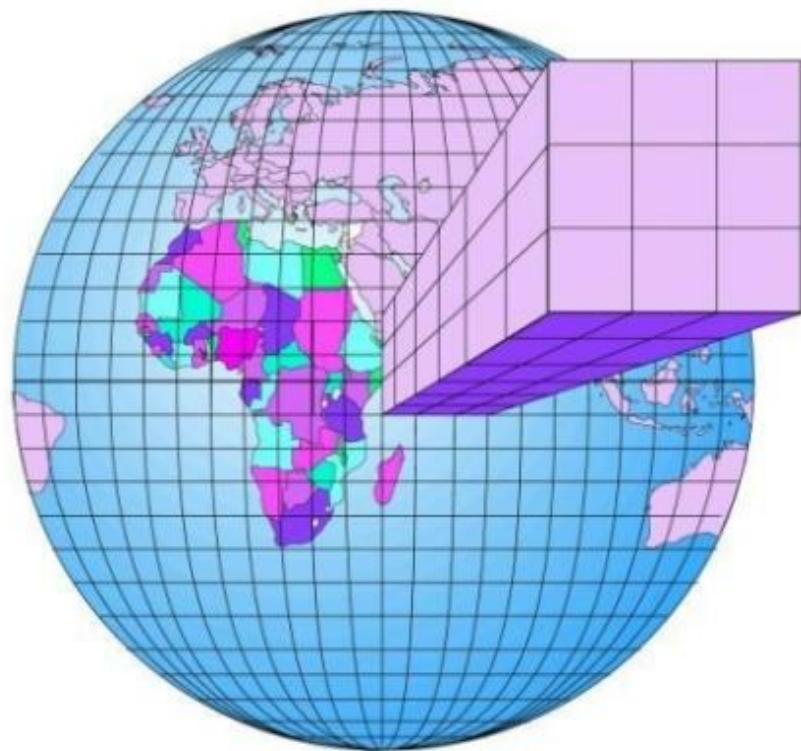NASA Atmospheric Chemistry and Dynamics Lab: Bryan Duncan, John Sullivan

NASA LaRC: Tim Berkoff, Guillaume Gronoff

12 March 2020
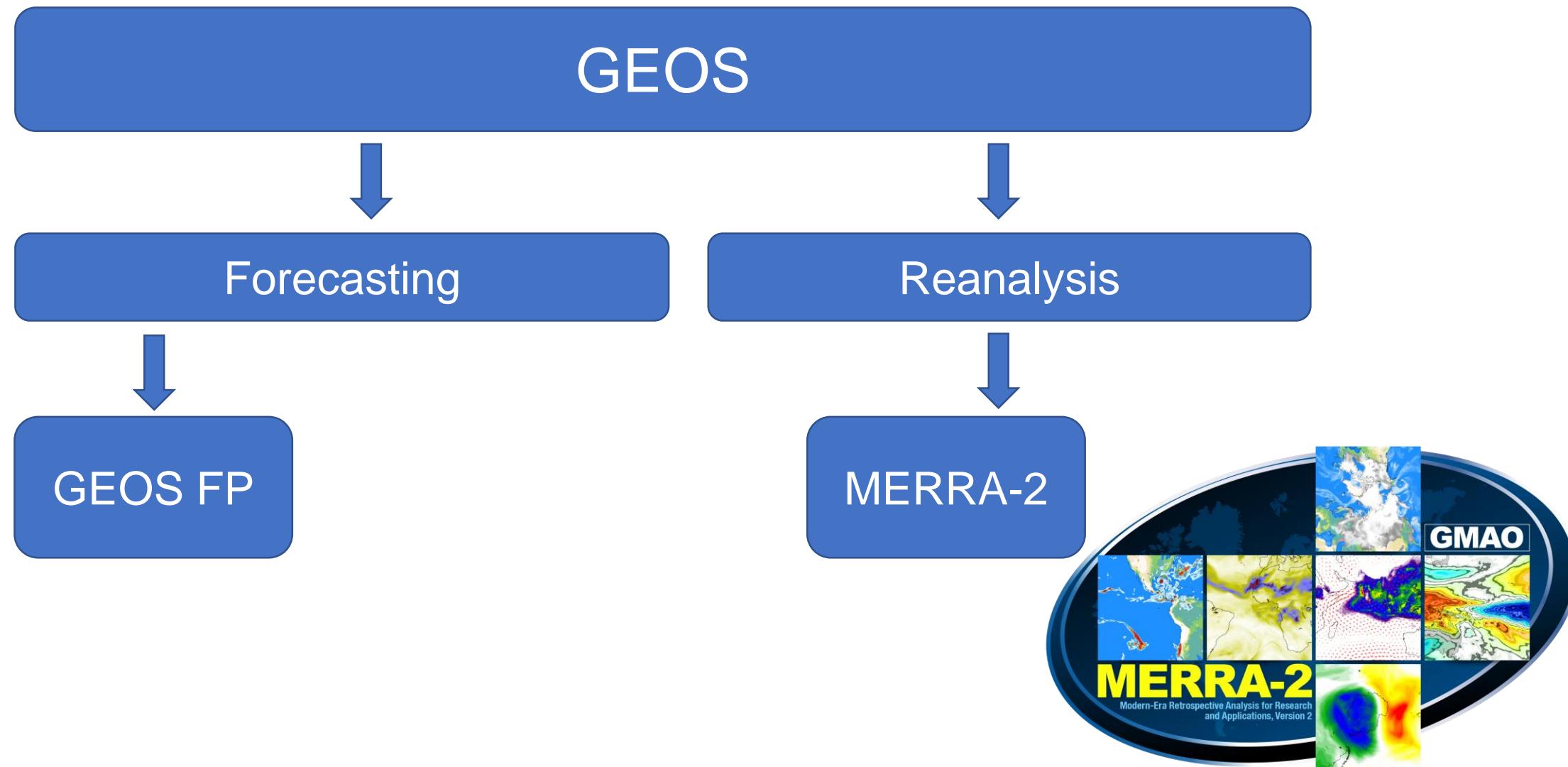
NASA GMAO global meteorology and chemistry products

GEOS

OMPS (O$_3$)

NASA/NOA

www.nasa.gov

NASA GMAO global meteorology and chemistry products

GEOS

Forecasting

Reanalysis

NASA GMAO global meteorology and chemistry products

GEOS

Forecasting

Reanalysis

GEOS FP

MERRA-2

NASA GMAO global meteorology and chemistry products

GEOS

Forecasting

Reanalysis

GEOS FP

MERRA-2

GEOS 5.17   11/01/2017 - 7/11/2018
5.21   7/11/2018 - 3/13/2019
5.22   3/13/2019 - 1/30/2020
5.25   1/30/2020 - on-going

GEOS 5.12.4

MERRA-2
Modern-Era Retrospective Analysis for Research
and Applications, Version 2

NASA's MERRA-2 Reanalysis

- High resolution global data set
  - ➢ 50 km horizontal
    0.5⁰ latitude x 0.625⁰ longitude
  - ➢ 72 levels up to 0.01 hPa

- Product of GEOS data assimilation system
  - Assimilates conventional meteorological observations, aerosols and ozone

- Available since 1980 to a few weeks behind present
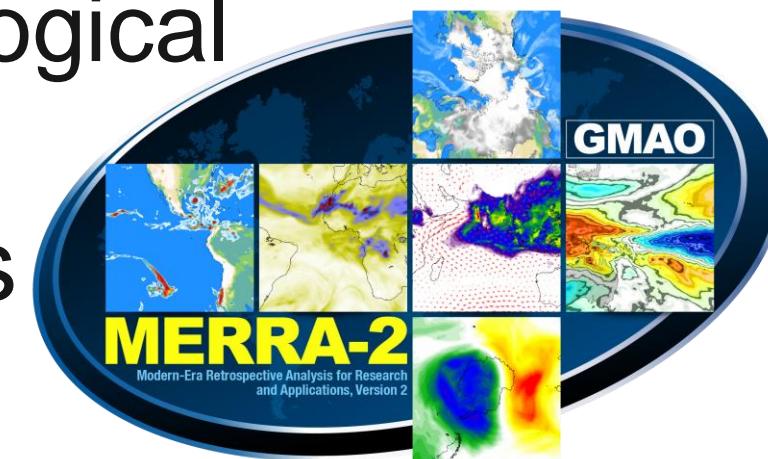
Question 1

Can MERRA-2 capture the dynamical features of a stratospheric intrusion?
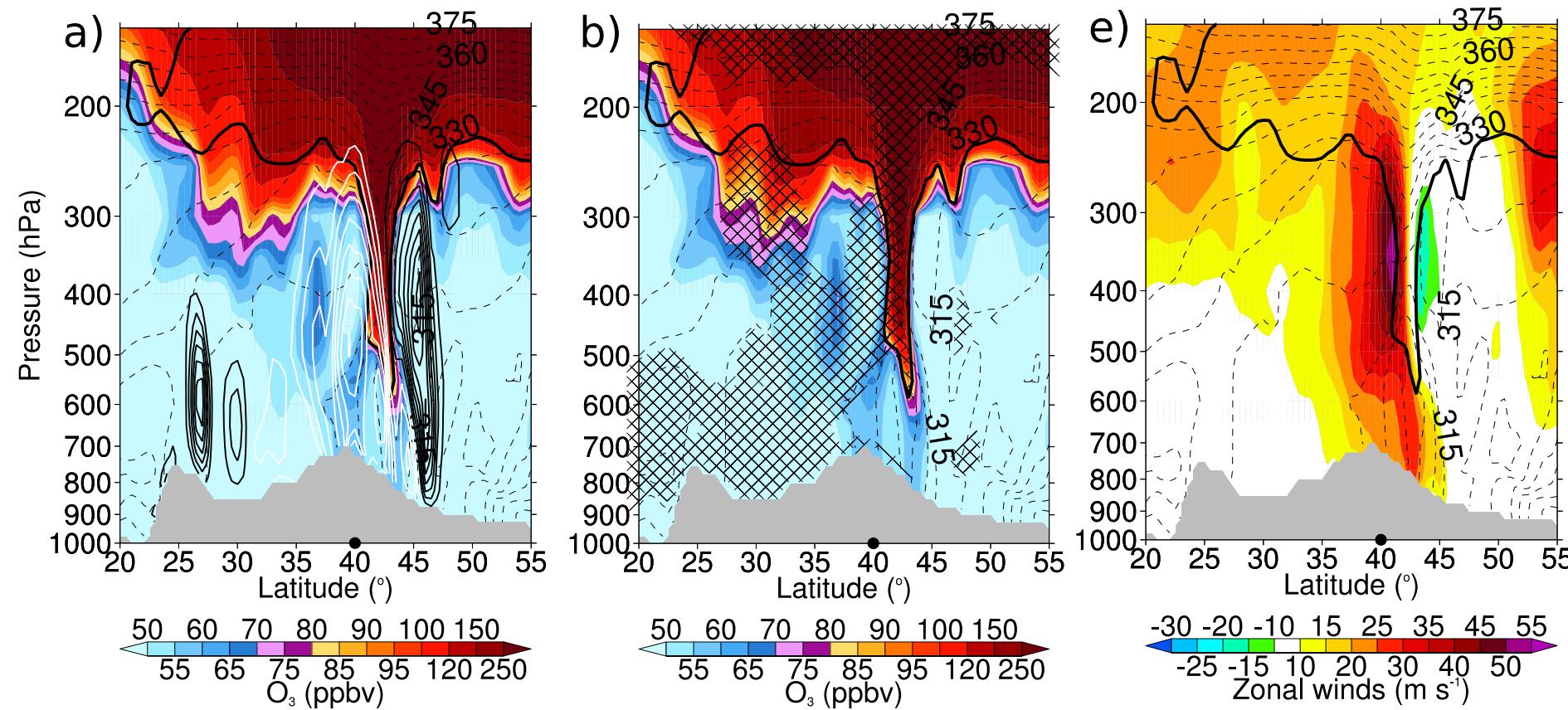
March 27, 2012 0UTC

Atmospheric dynamics
✓ Tropopause descends to ~600 hPa
✓ Wrapped around jet core
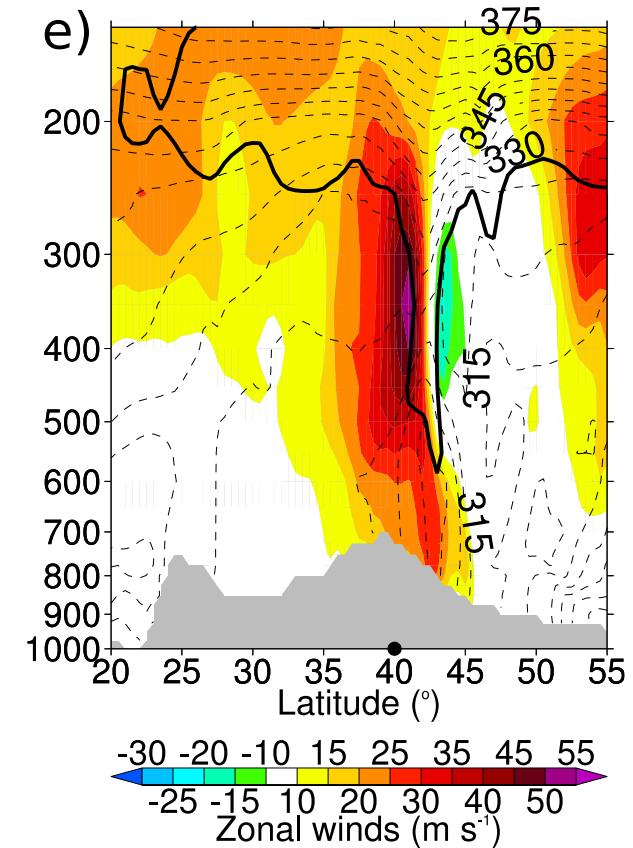
Knowland et al., 2017, GRL

March 27, 2012 0UTC

- Tropopause folds are associated with:
  - High O$_3$, PV (2PVU thick line)
  - Low RH (hatching), CO (not shown)

Knowland et al., 2017, GRL

March 27, 2012 0UTC
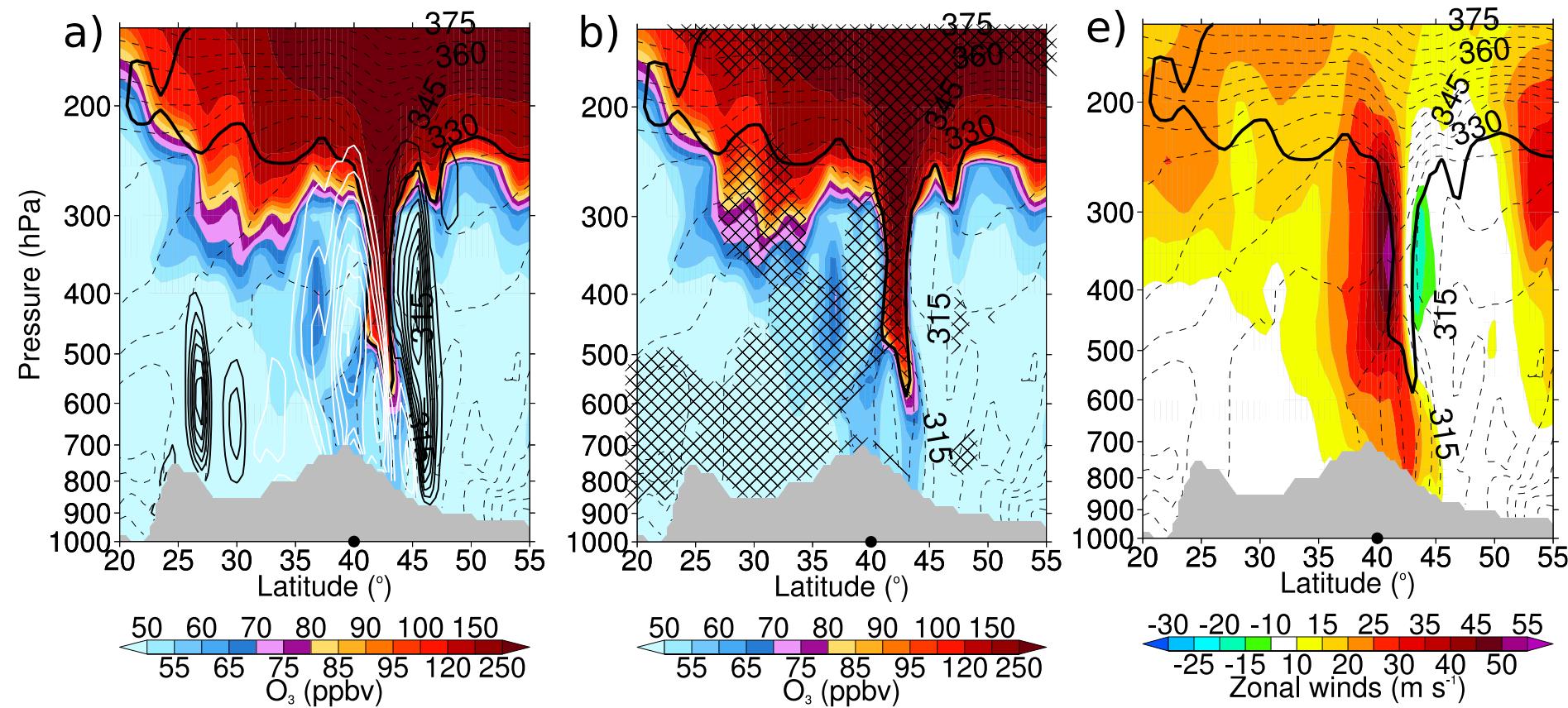
> Since assimilated O_3 is mainly stratospheric, MERRA-2 O_3 is realistic within the SIs, however biased elsewhere in the troposphere.

Knowland et al., 2017, GRL

Question 2

Can we forecast SI events in GEOS forecasting products?

NASA GMAO global meteorology and chemistry products
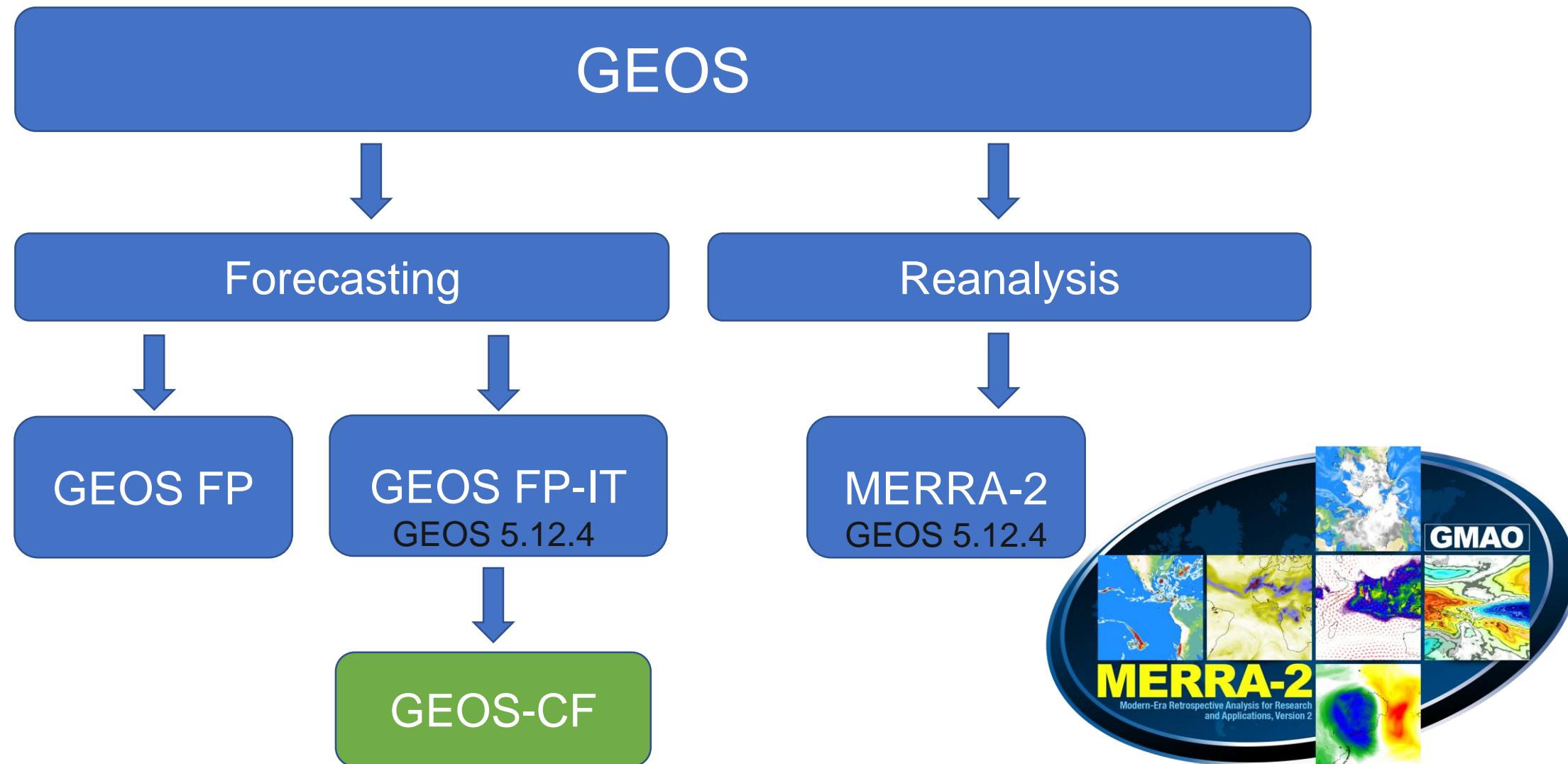
NASA's composition forecast (GEOS-CF)
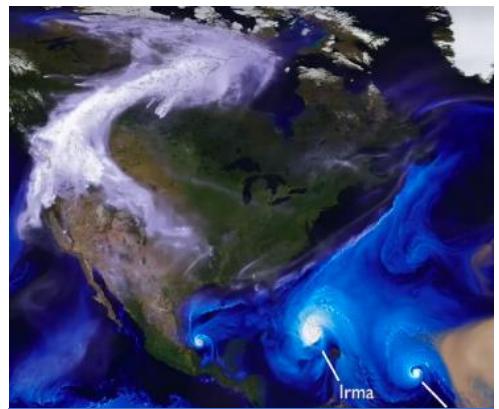
GEOS FP-IT
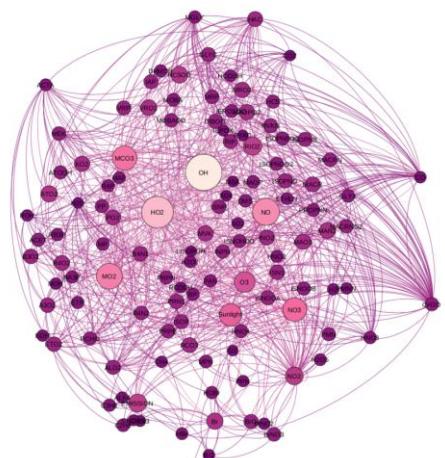
GEOS - Chem

❖ 250 Chemical Species
❖ 725 Chemical Reactions

GE🌐S-Chem
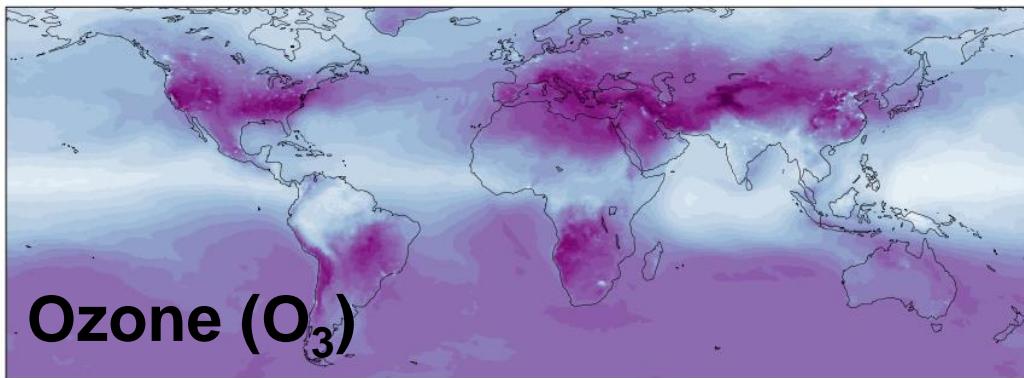
Ozone (O$_3$)
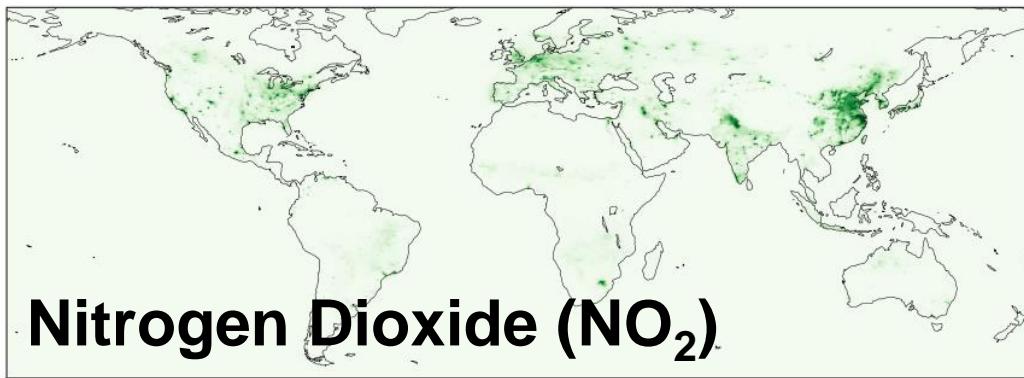
Nitrogen Dioxide (NO$_2$)
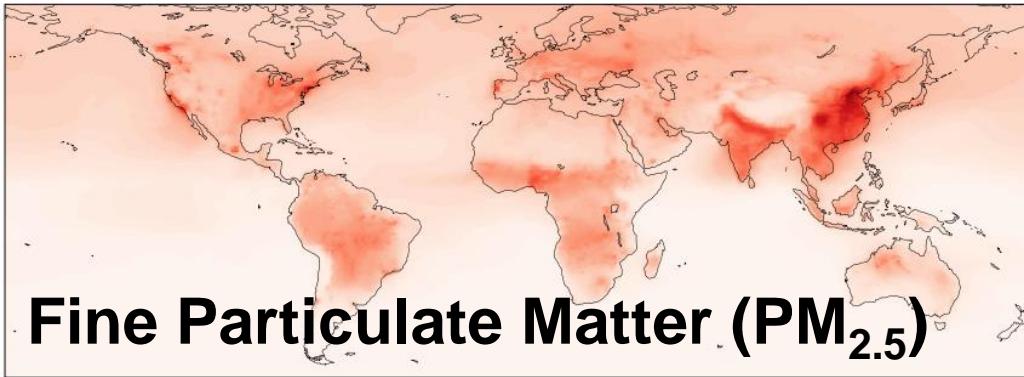
Fine Particulate Matter (PM$_{2.5}$)

Incorporation of satellite observations
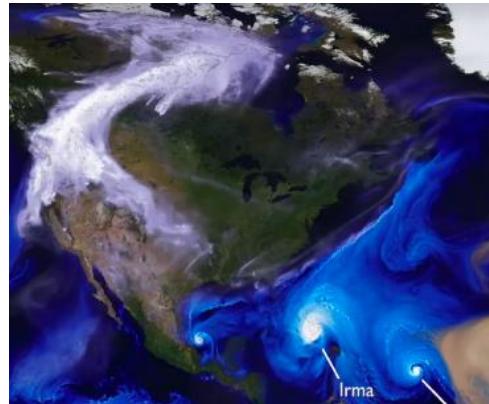
GEOS NWP
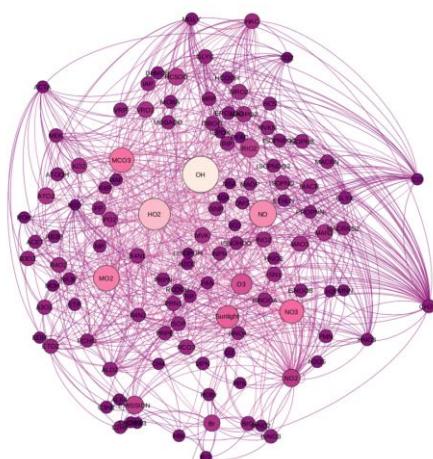
GEOS - Chem
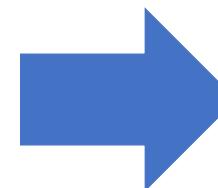
GEOS - CF

➢ Currently no direct data assimilation of constituents

➢ Real-time fire emissions from QFED

➢ Anthropogenic emissions scaled using satellite data (previous year)

➢ Stratospheric O_3 nudged to GEOS assimilated O_3

Forecasting and validating SI events
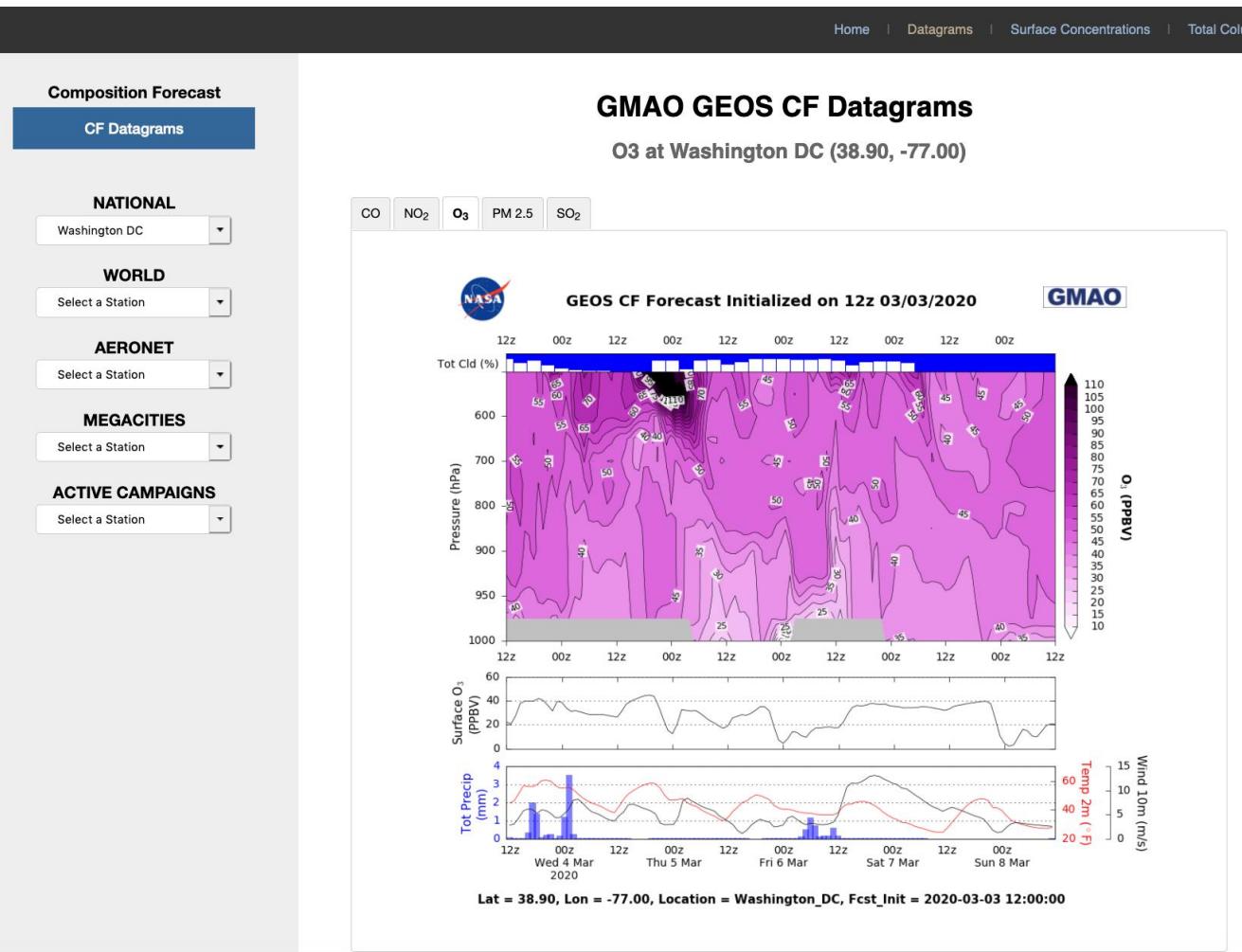
GEOS - CF

One **5-day forecast** per day
- ➤ 1-day replay
- ➤ 5-day forecast
- ➤ c360 (0.25°, **~25x25** km^2)
- ➤ Chemistry and Meteorology fields

www.fluid.nccs.nasa.gov/cf

Forecasting and validating SI events
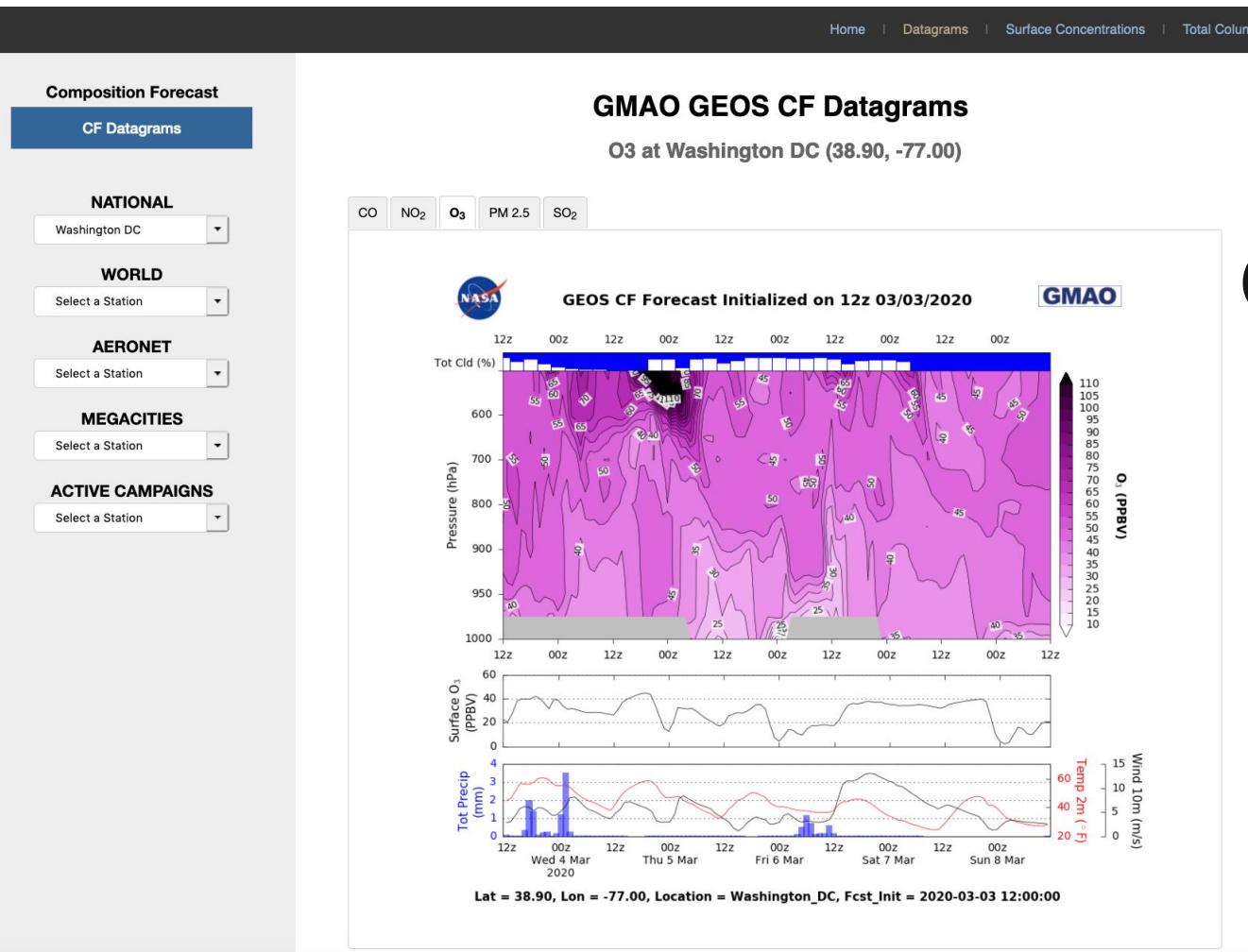
GEOS - CF

One **5-day forecast** per day

➢1-day replay

➢5-day forecast

➢c360 (0.25°, ~25x25 km^2)

➢**15-minute** 2D fields

➢**1-hour** 2D and 3D fields

➢Available since **Jan 2018**

www.fluid.nccs.nasa.gov/cf

GEOS-CF model output available to the public in near real-time

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

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

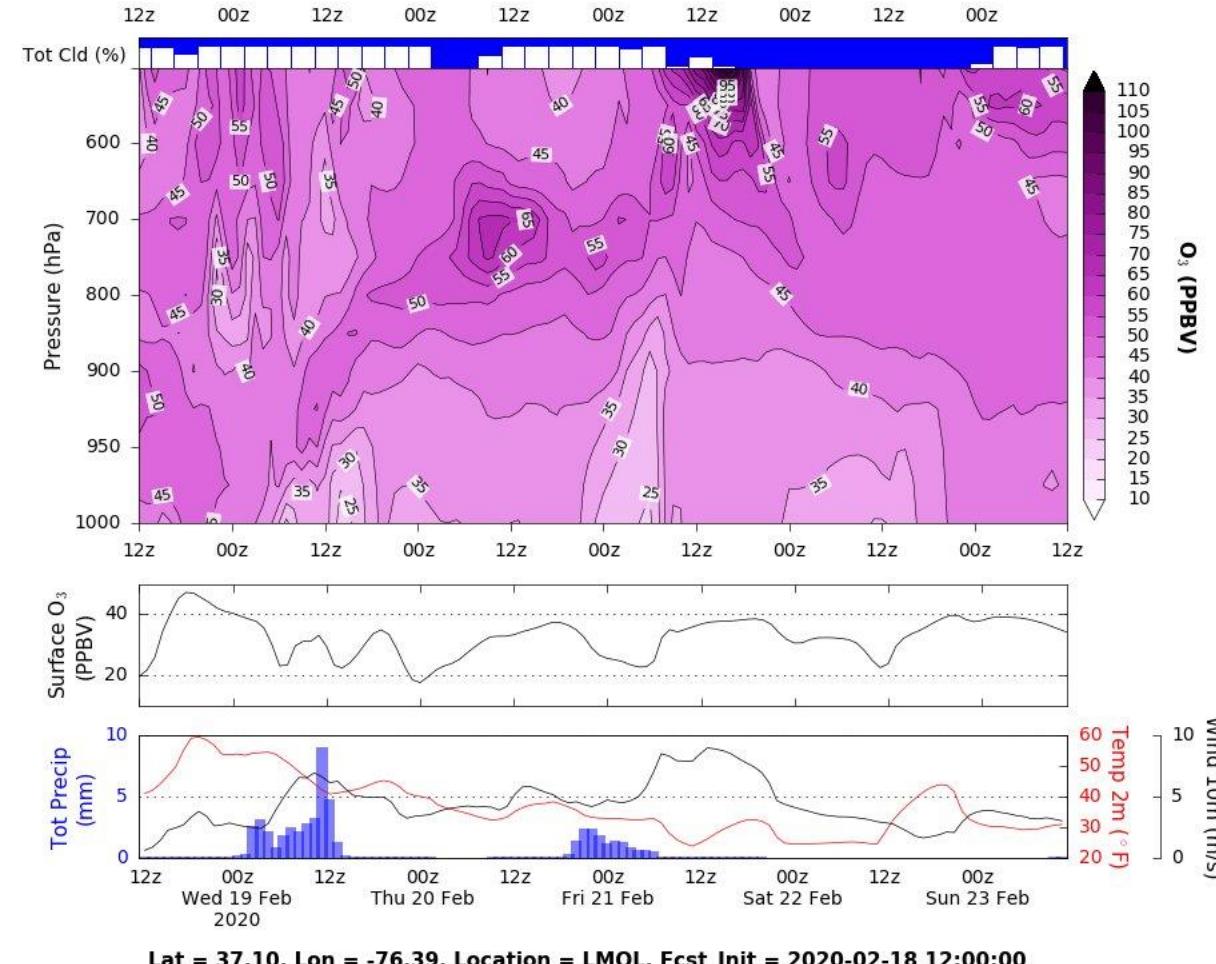https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/

Next step:

Can we provide a flag or alert to indicate to end-users that a stratospheric intrusion is likely in their area?
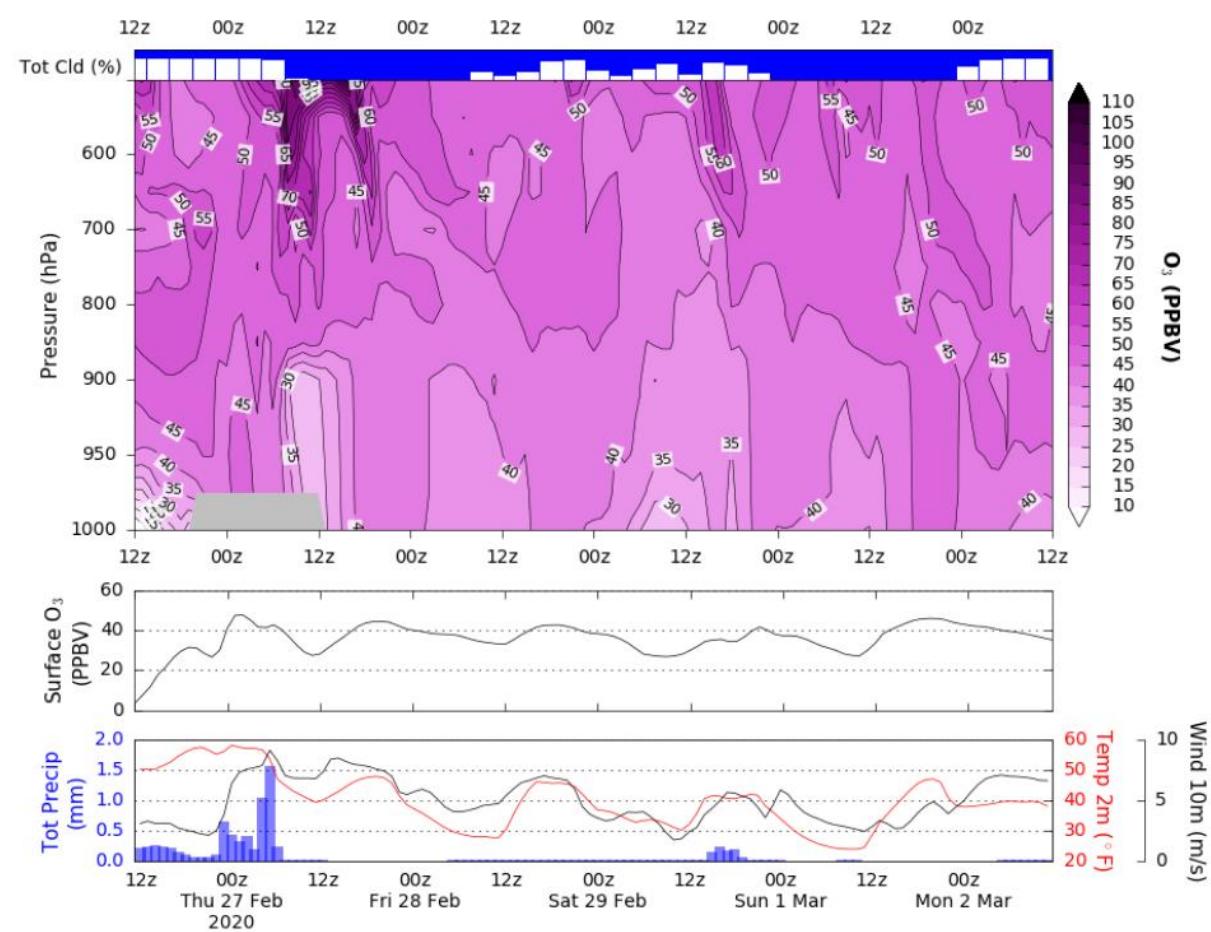
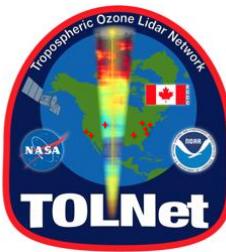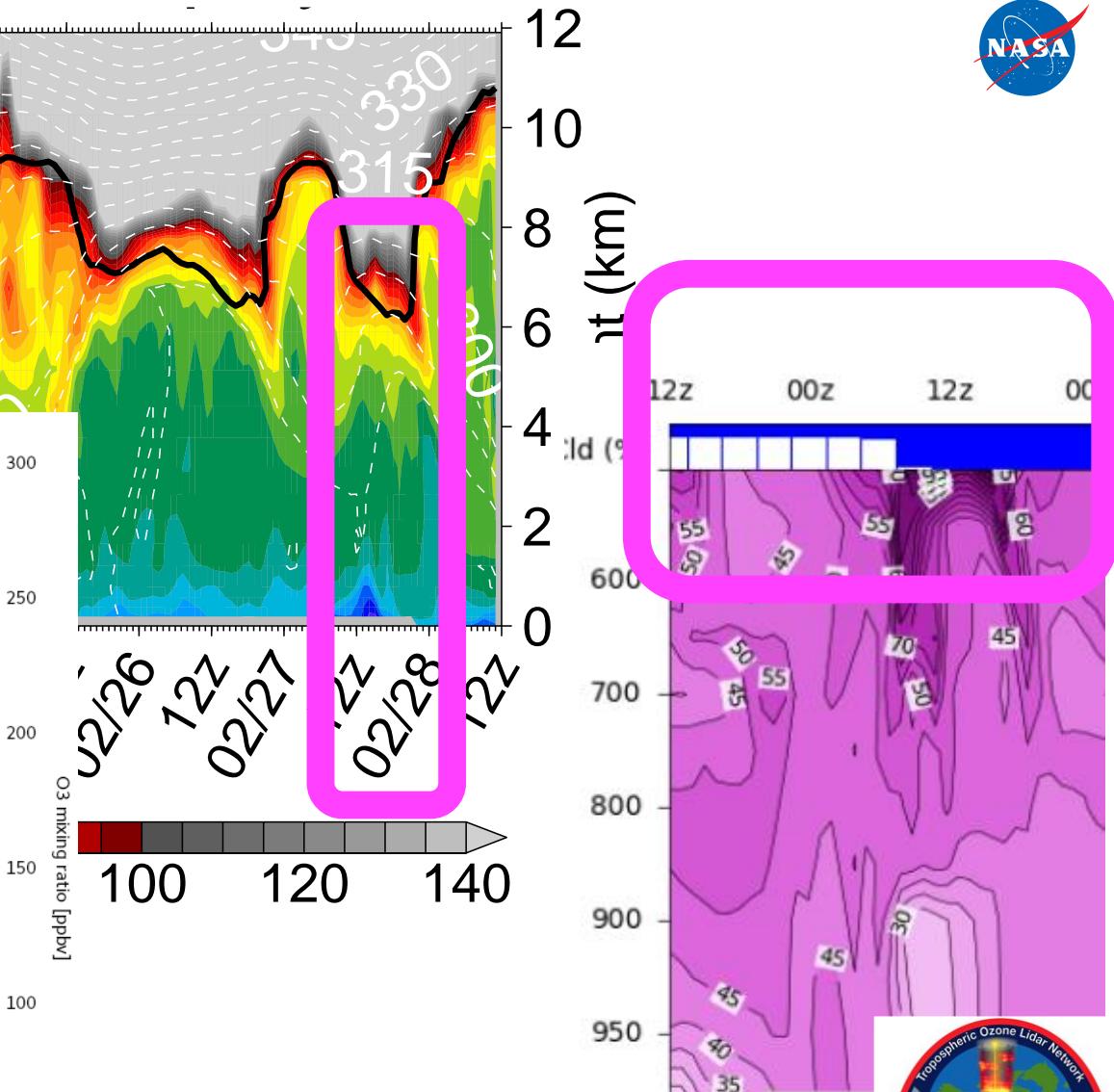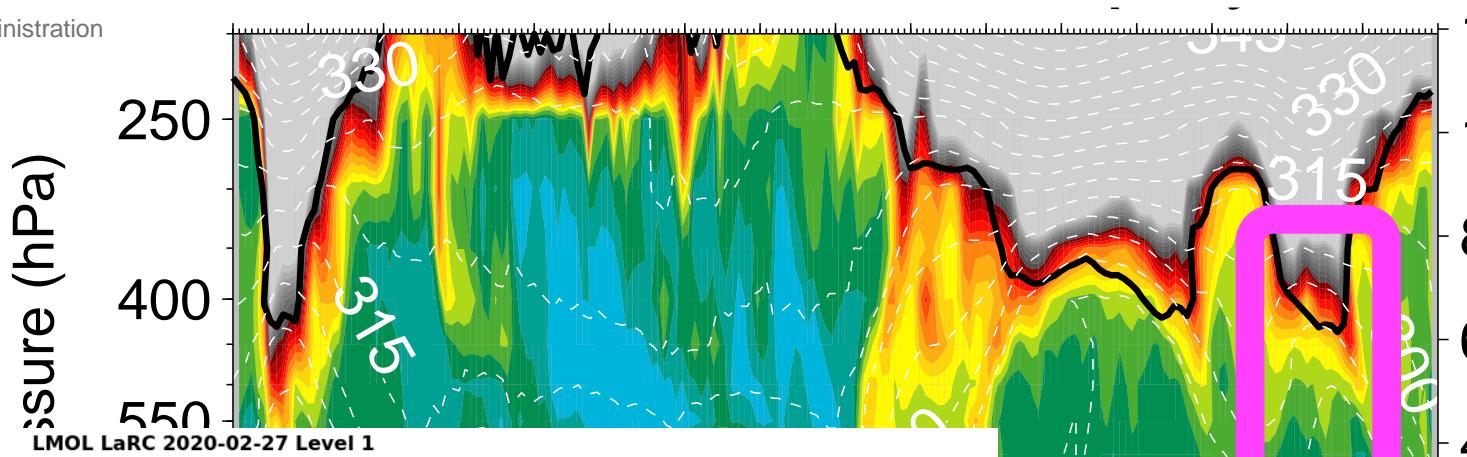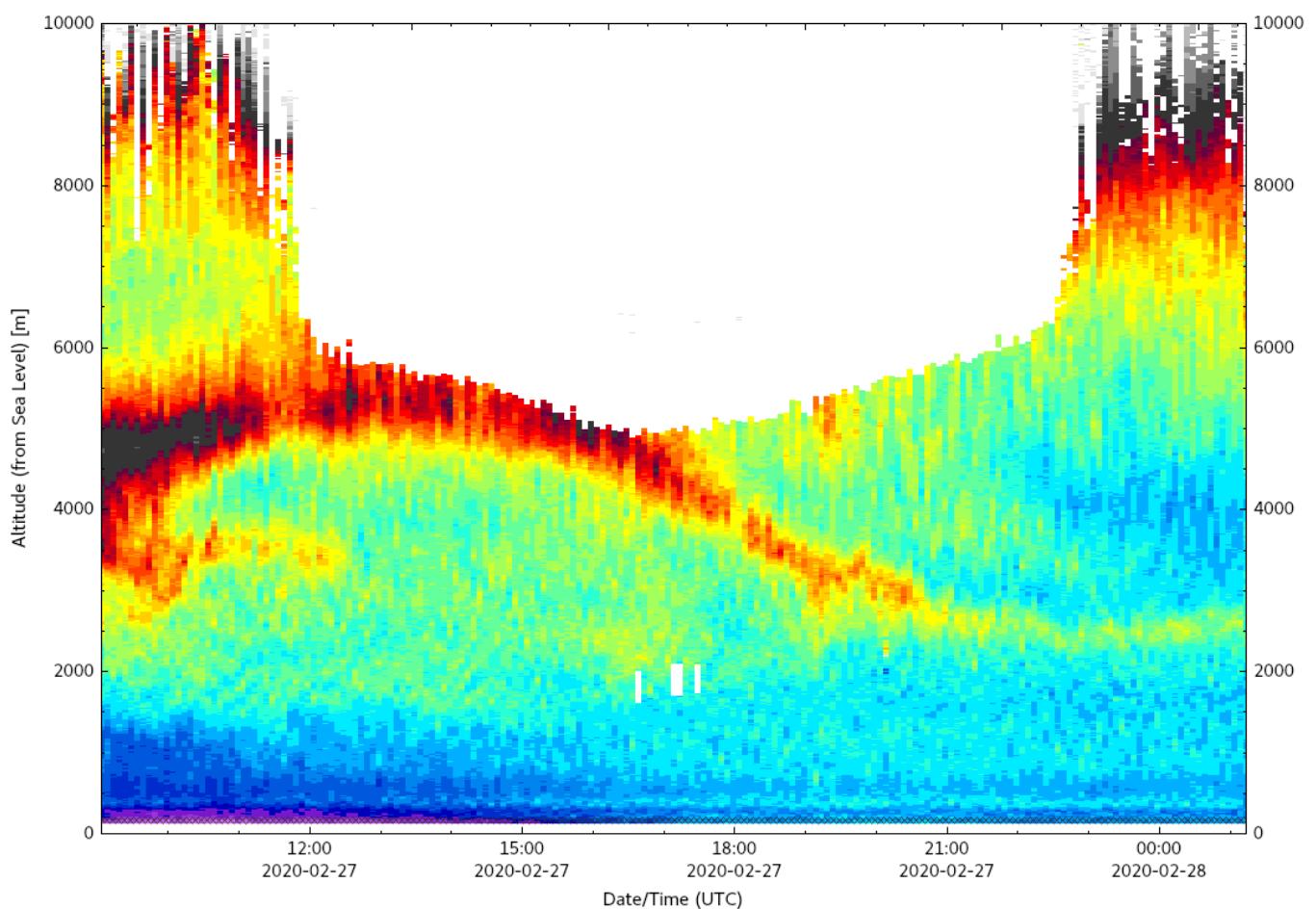# GEOS-CF Forecasts for NASA Langley: "LMOL"
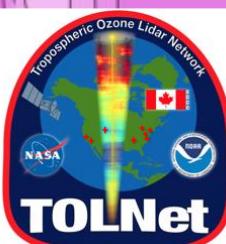
GEOS-CF 'analysis' at Langley (12z Feb 20 – 12z Feb 28, 2020)
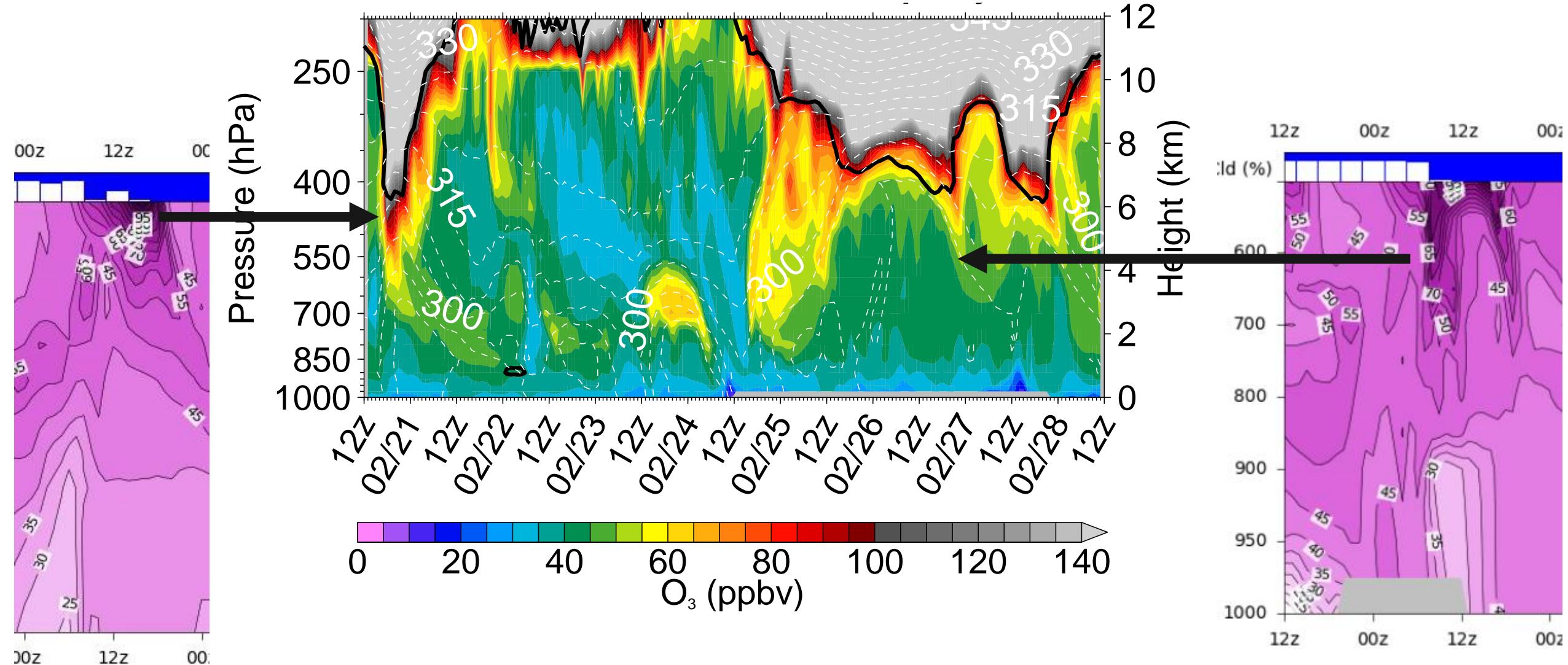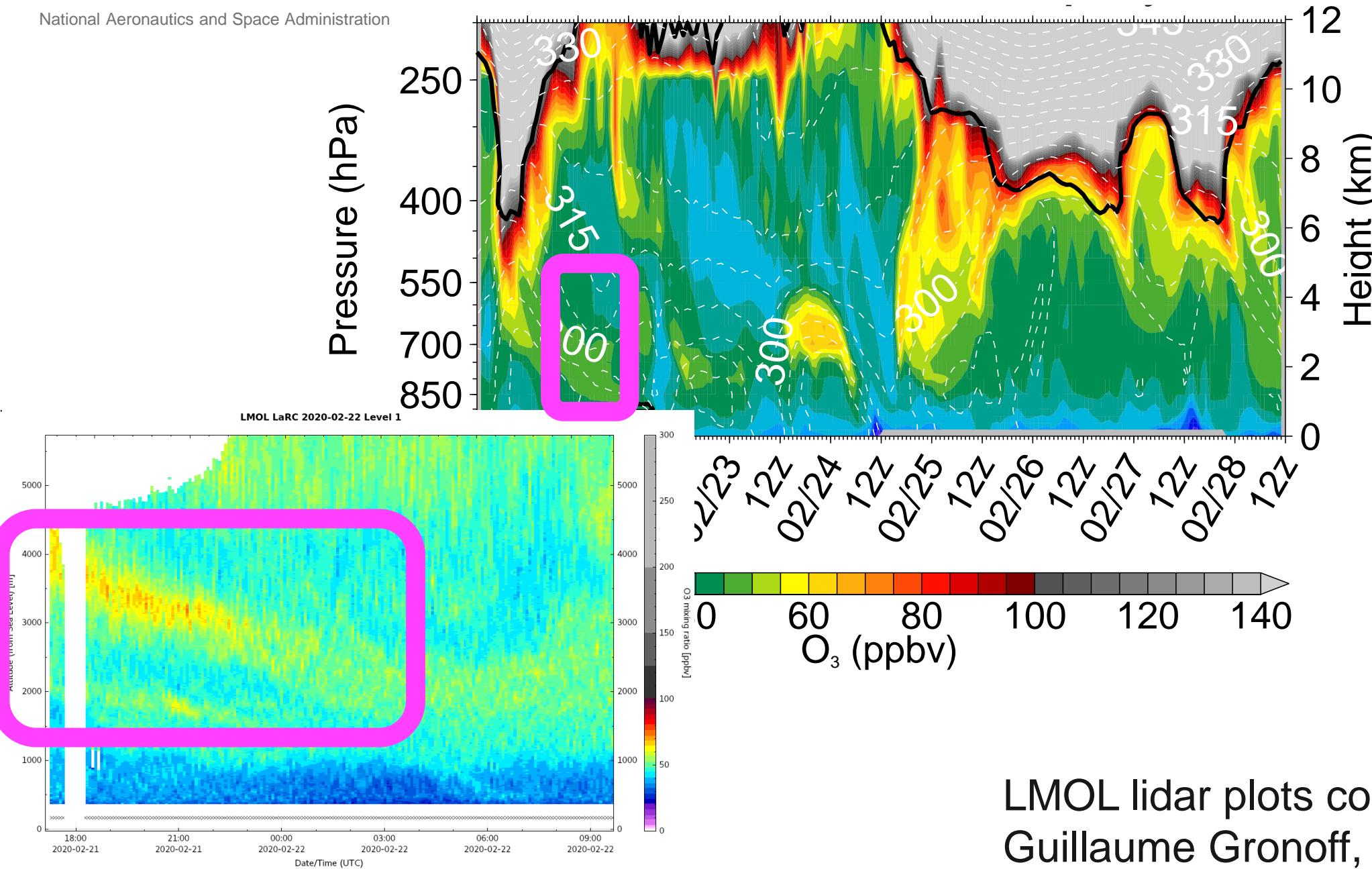
LMOL lidar plots courtesy of
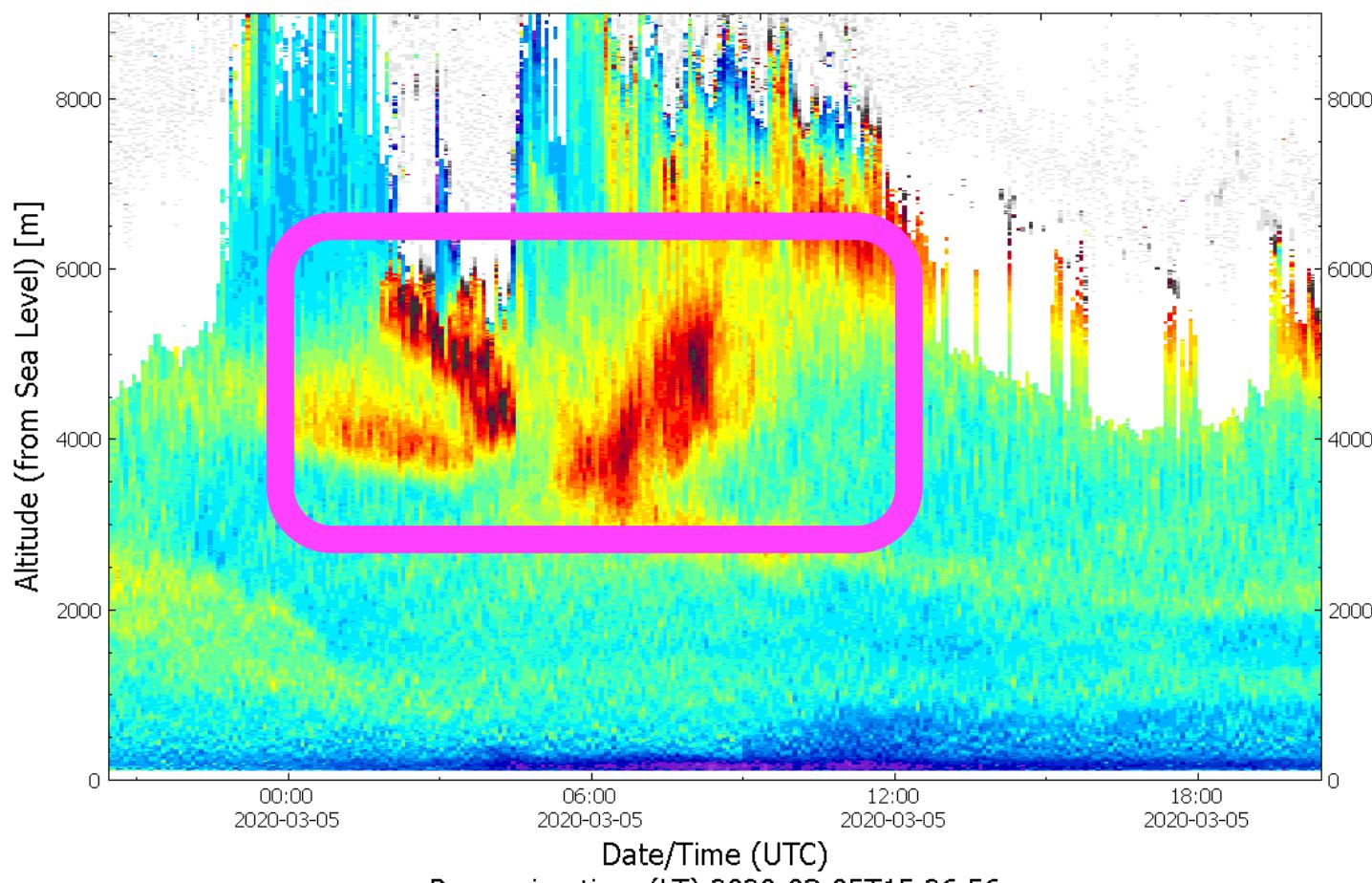Guillaume Gronoff, LaRC

LMOL LaRC 2020-02-27 Level 1

LMOL lidar plots courtesy of
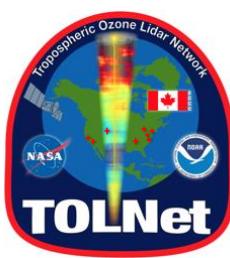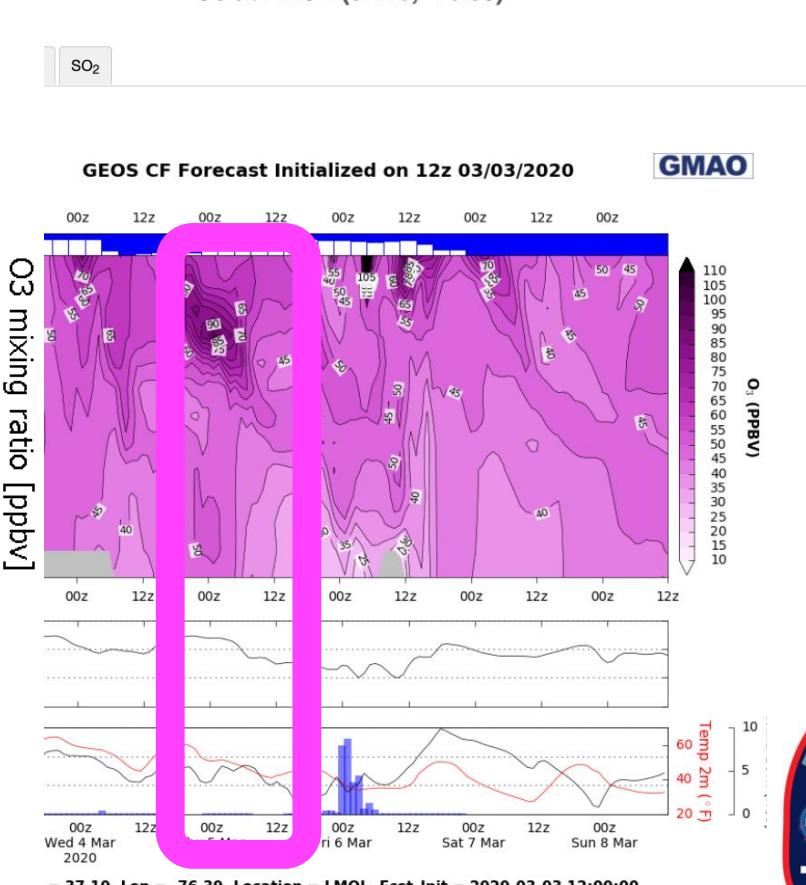Guillaume Gronoff, LaRC

John Sullivan (GSFC) and Guillaume Gronoff (LaRC) captured last week's event ☺

Ozone curtain plot. -- WARNING QUICKLOOK -- Latest data at UTC: 2020-03-05T20:26:39Z
Langley Mobile Ozone Lidar. Location: Hampton Latitude: 37.095 Longitude -76.389

GMAO GEOS CF Datagrams

O3 at LMOL (37.10, -76.39)

GEOS CF Forecast Initialized on 12z 03/03/2020

= 37.10, Lon = -76.39, Location = LMOL, Fcst_Init = 2020-03-03 12:00:00

GMAO Global Modeling and Assimilation Office
gmao.gsfc.nasa.gov
www.fluid.nccs.nasa.gov/cf
k.e.knowland@nasa.gov   23

John Sullivan (GSFC) and Guillaume Gronoff (LaRC) captured last week's event ☺
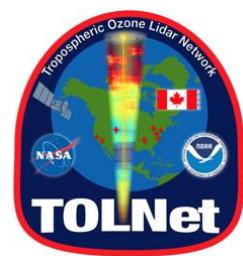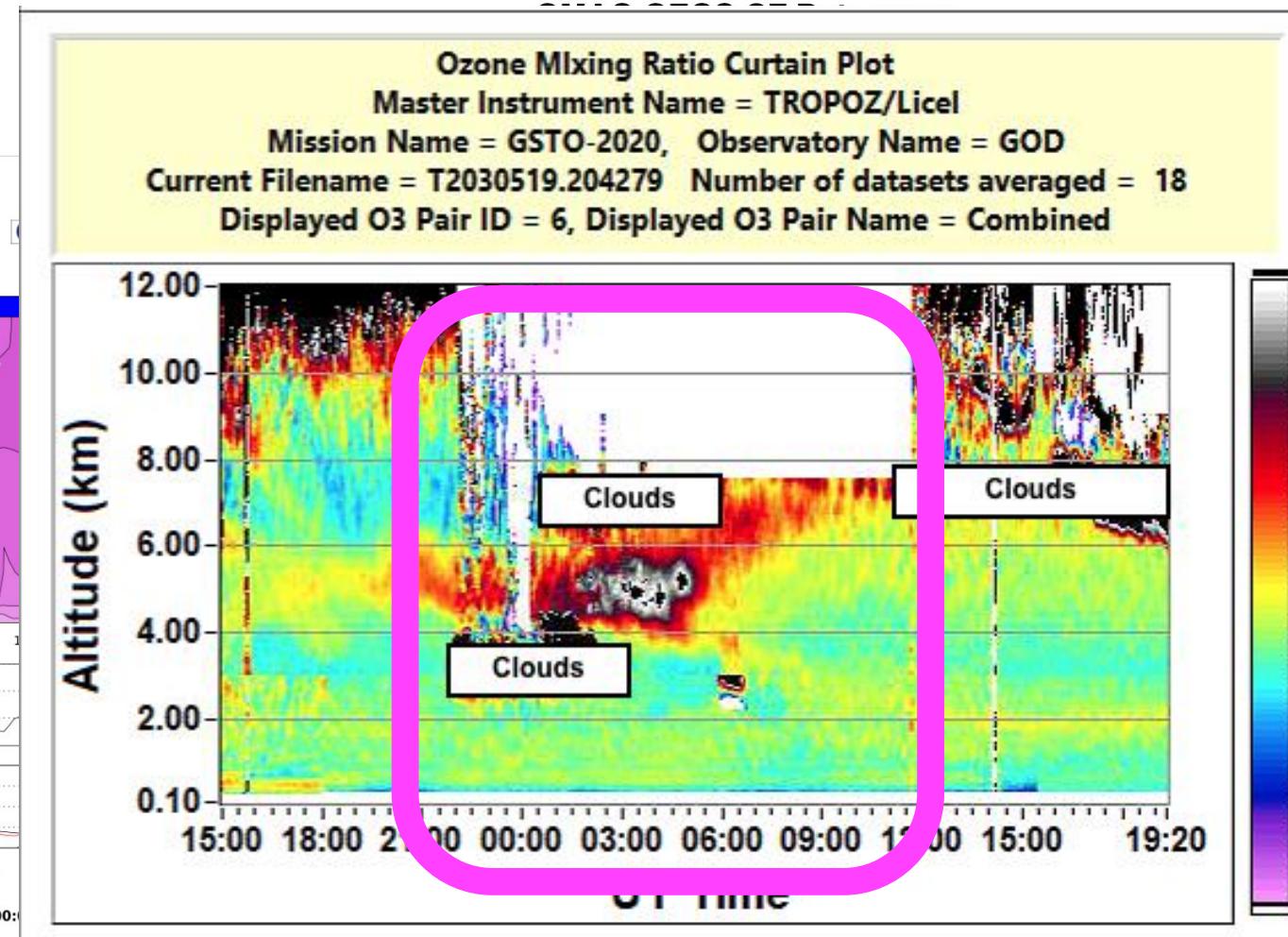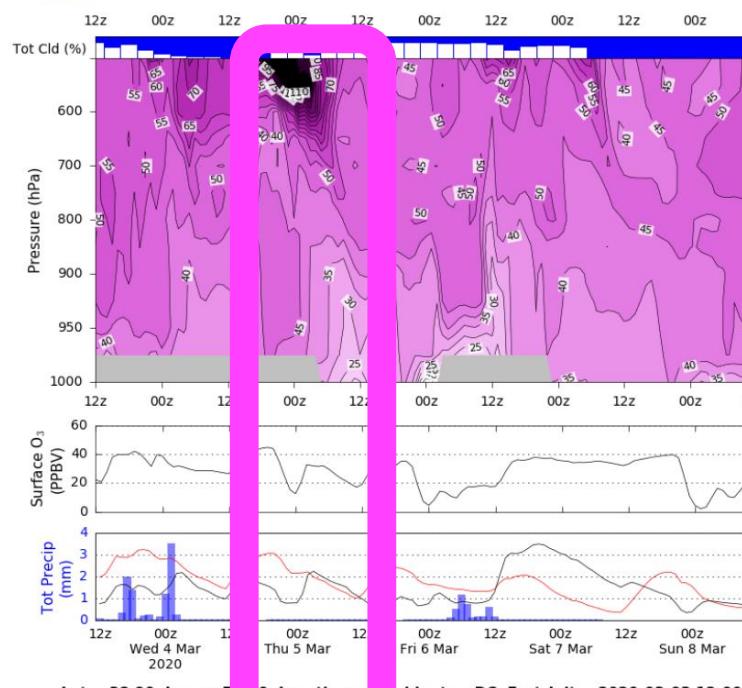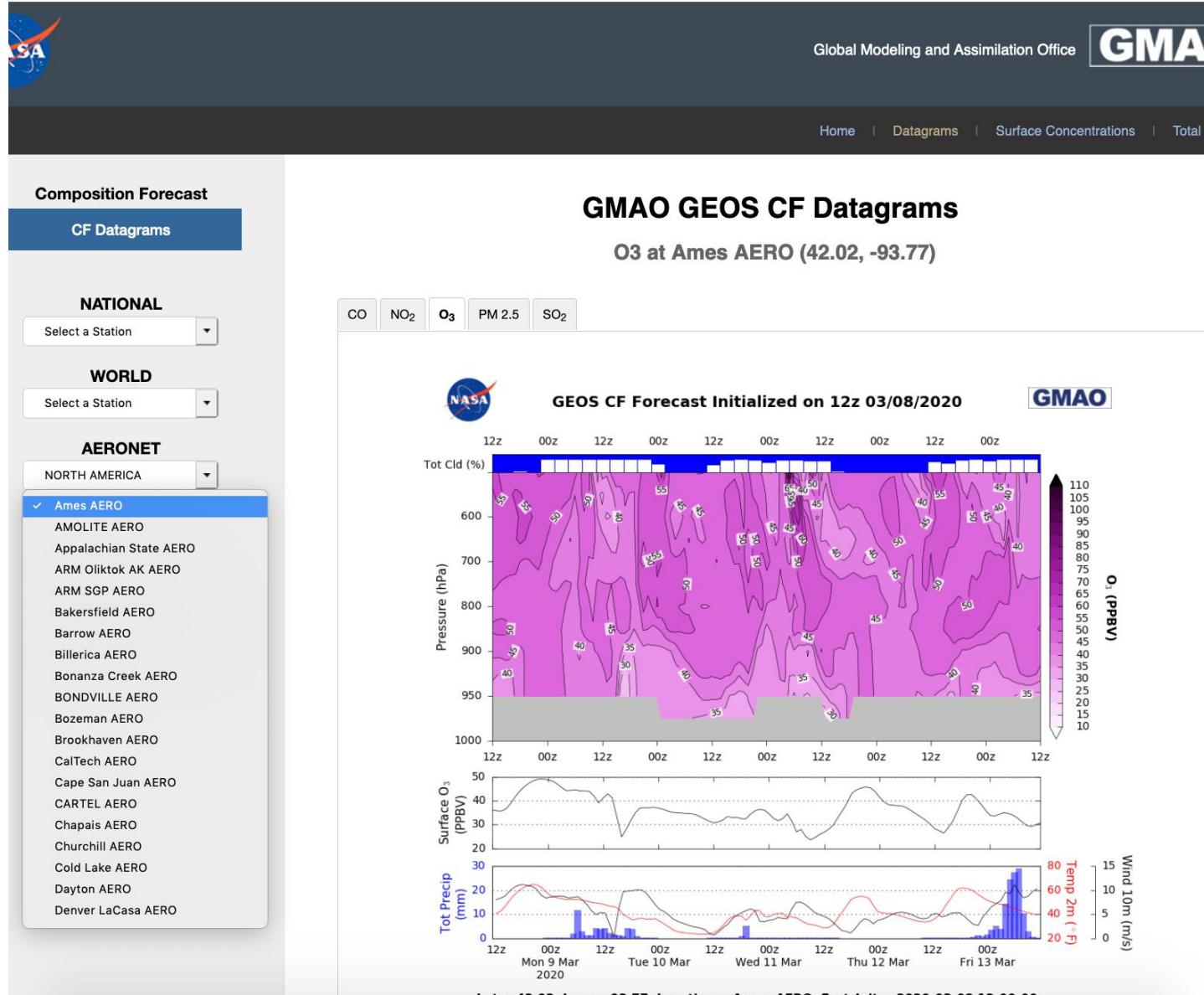
Do we have all the TOLNet locations?

Fluid has 200 preset Datagram locations:

1. National locations

2. World
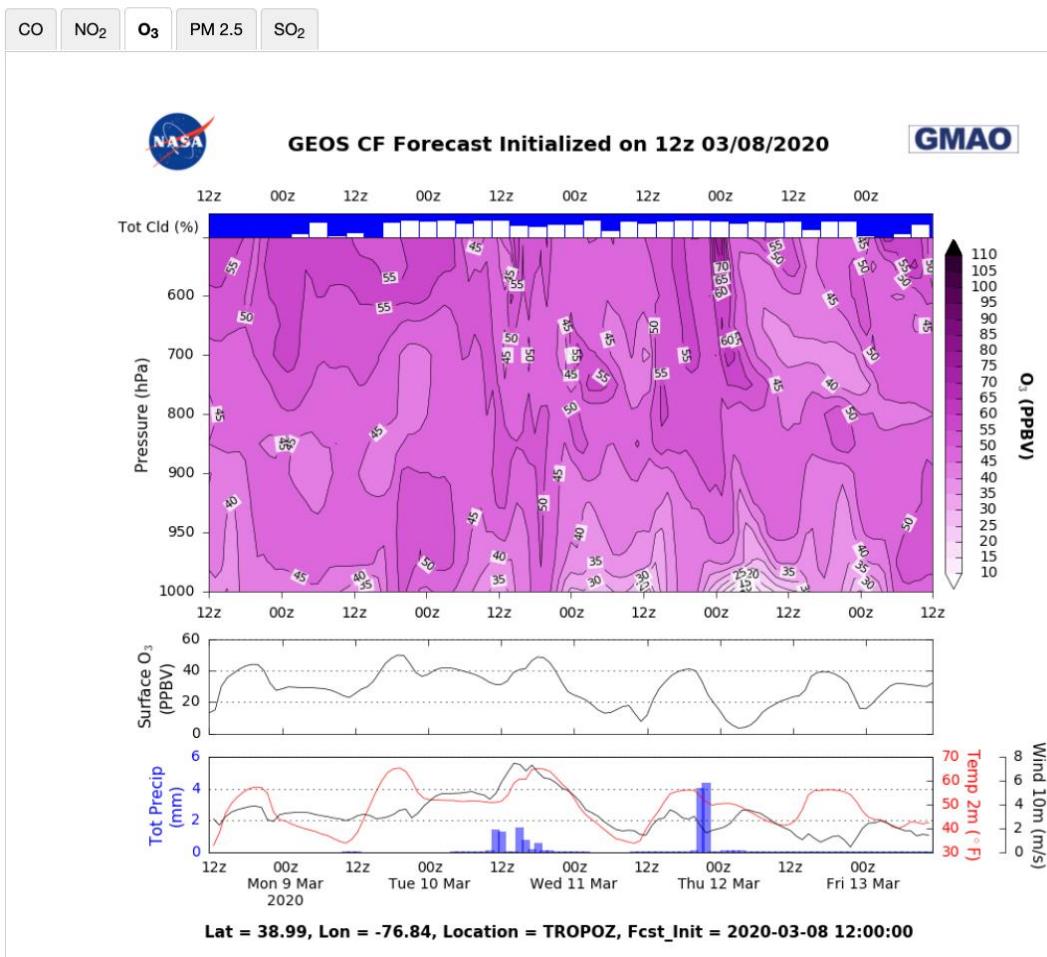
3. **Aeronet (by continent)**
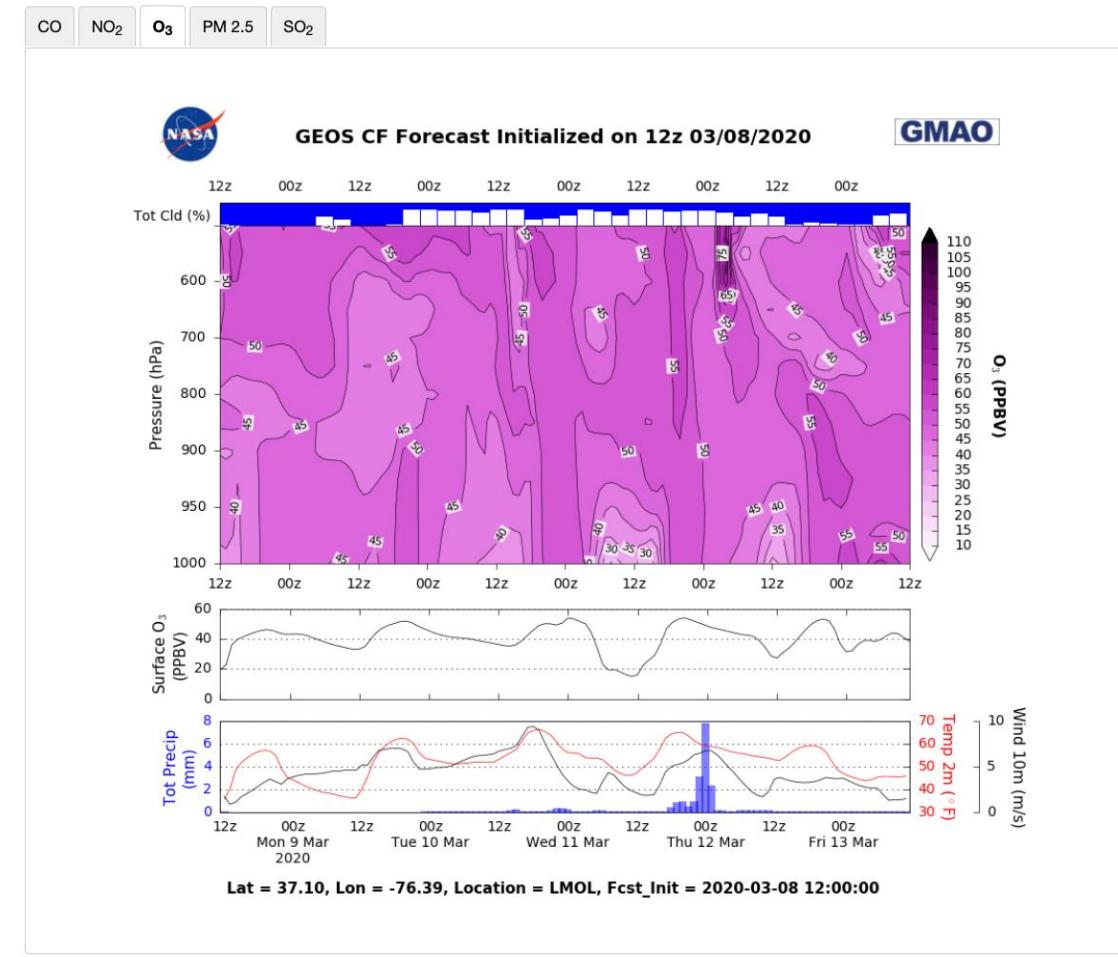
4. Megacities

5. NASA Campaigns

GSFC and LaRC

GMAO GEOS CF Datagrams

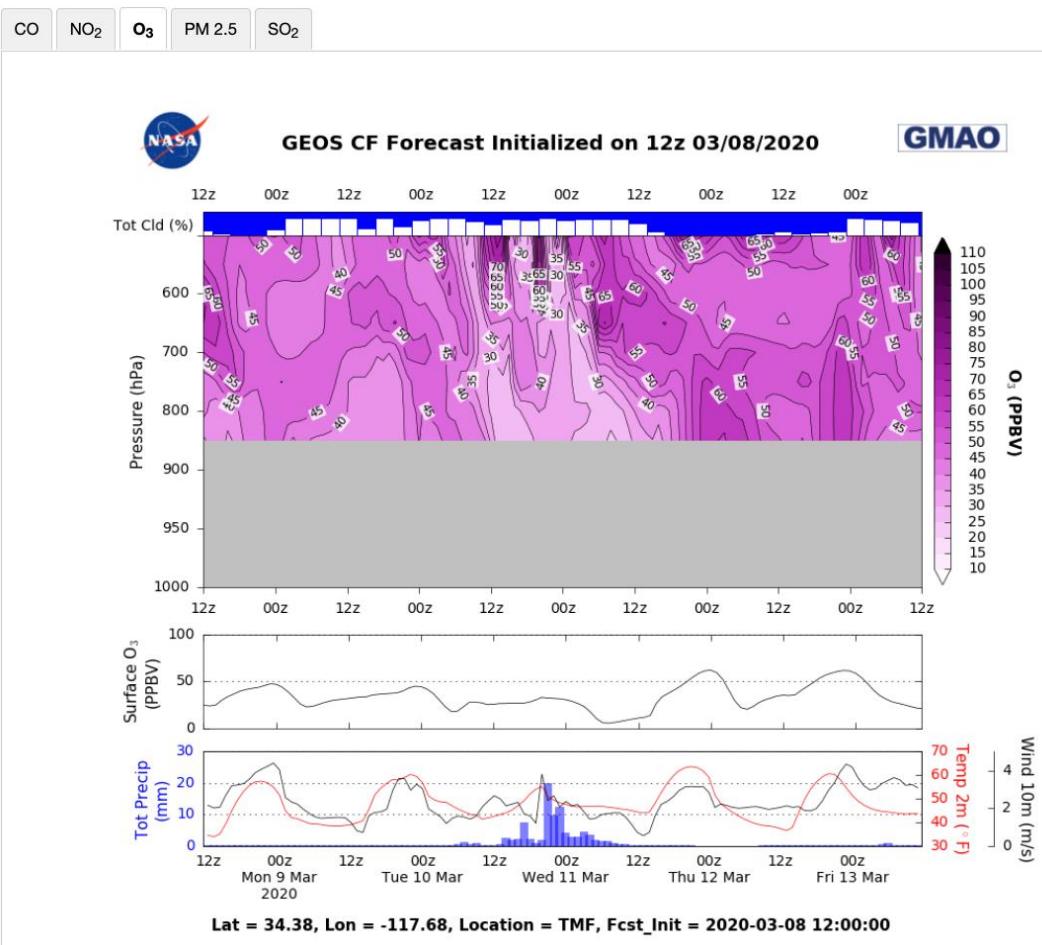O3 at TROPOZ (38.99, -76.84)

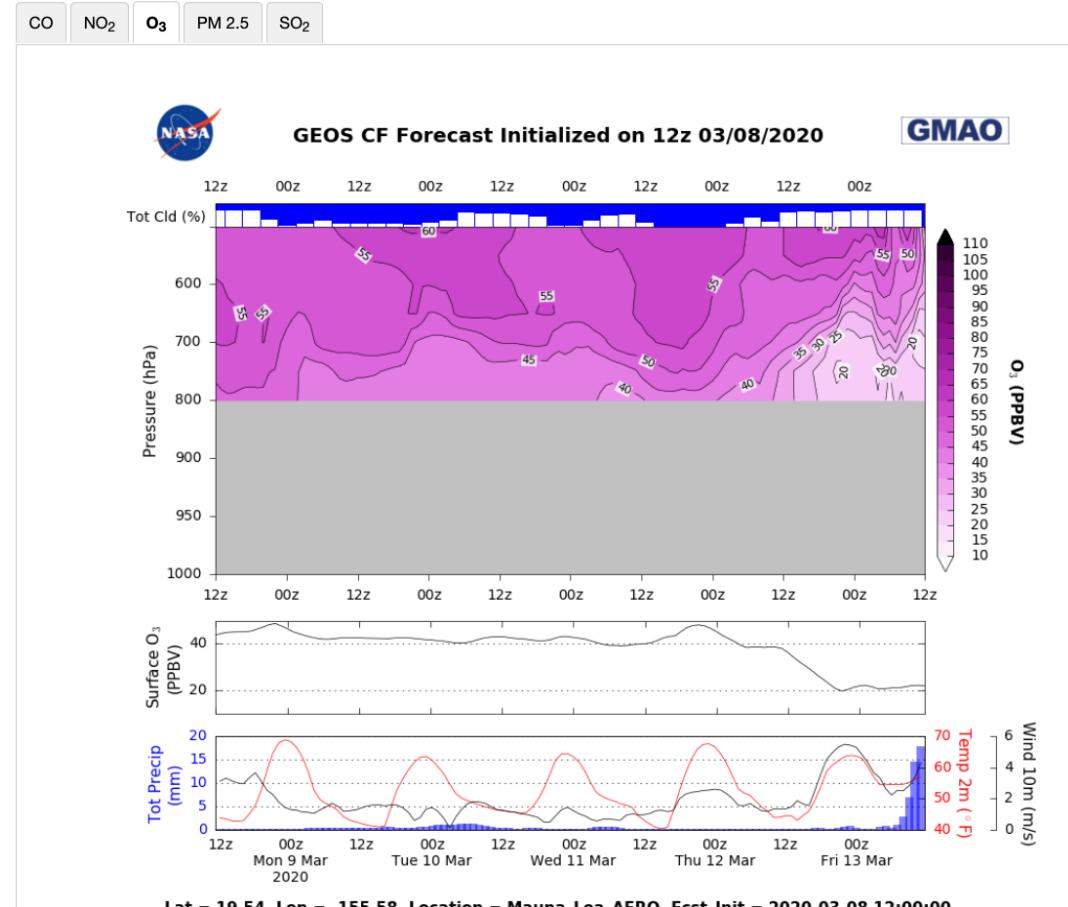**GMAO GEOS CF Datagrams**

O3 at LMOL (37.10, -76.39)

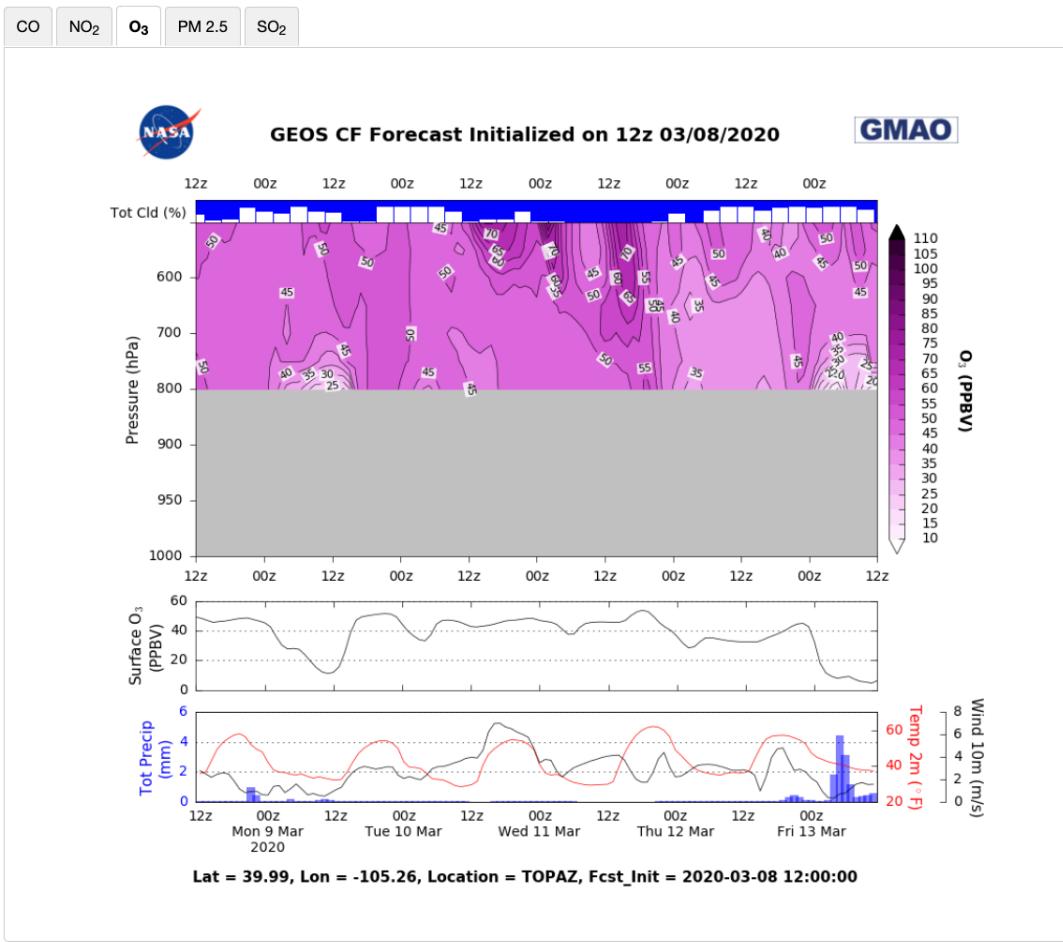# TMF and Mauna Loa
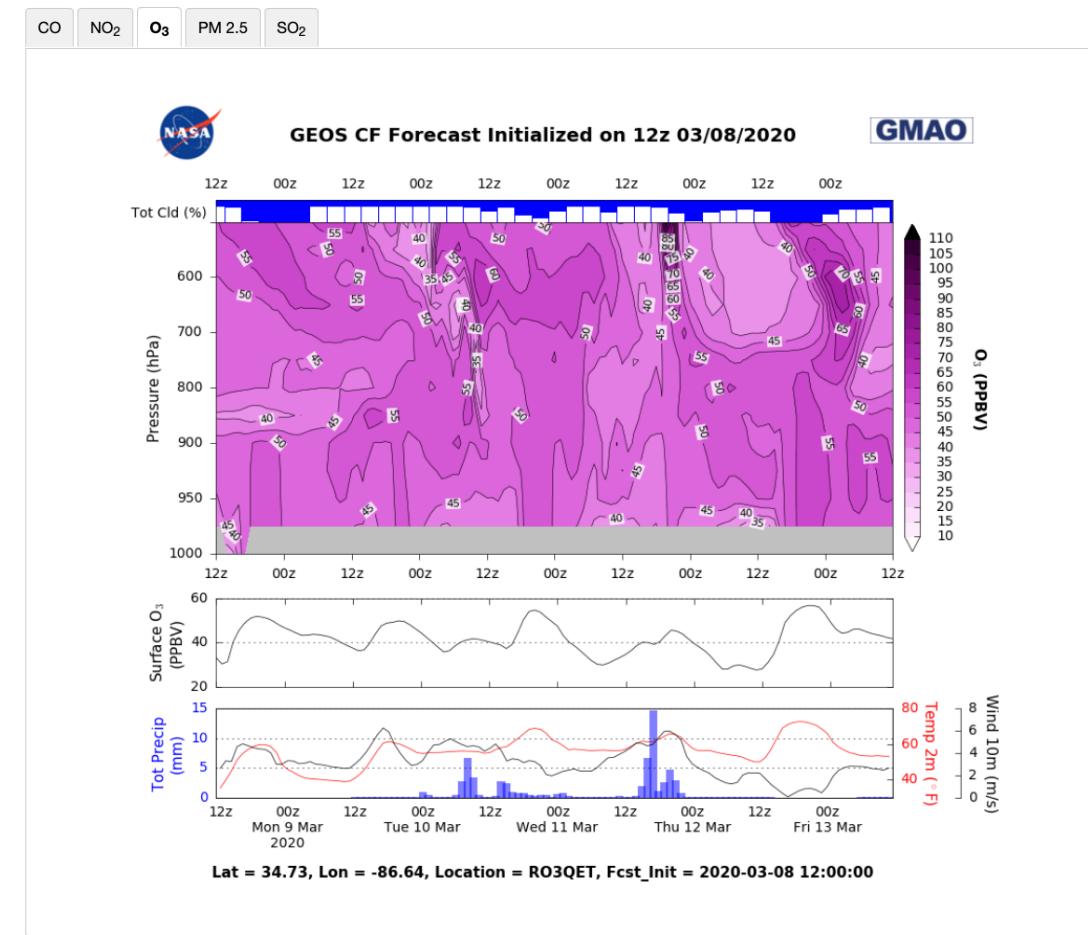
NOAA Boulder and NASA Huntsville

GMAO GEOS CF Datagrams

O3 at TOPAZ (39.99, -105.26)
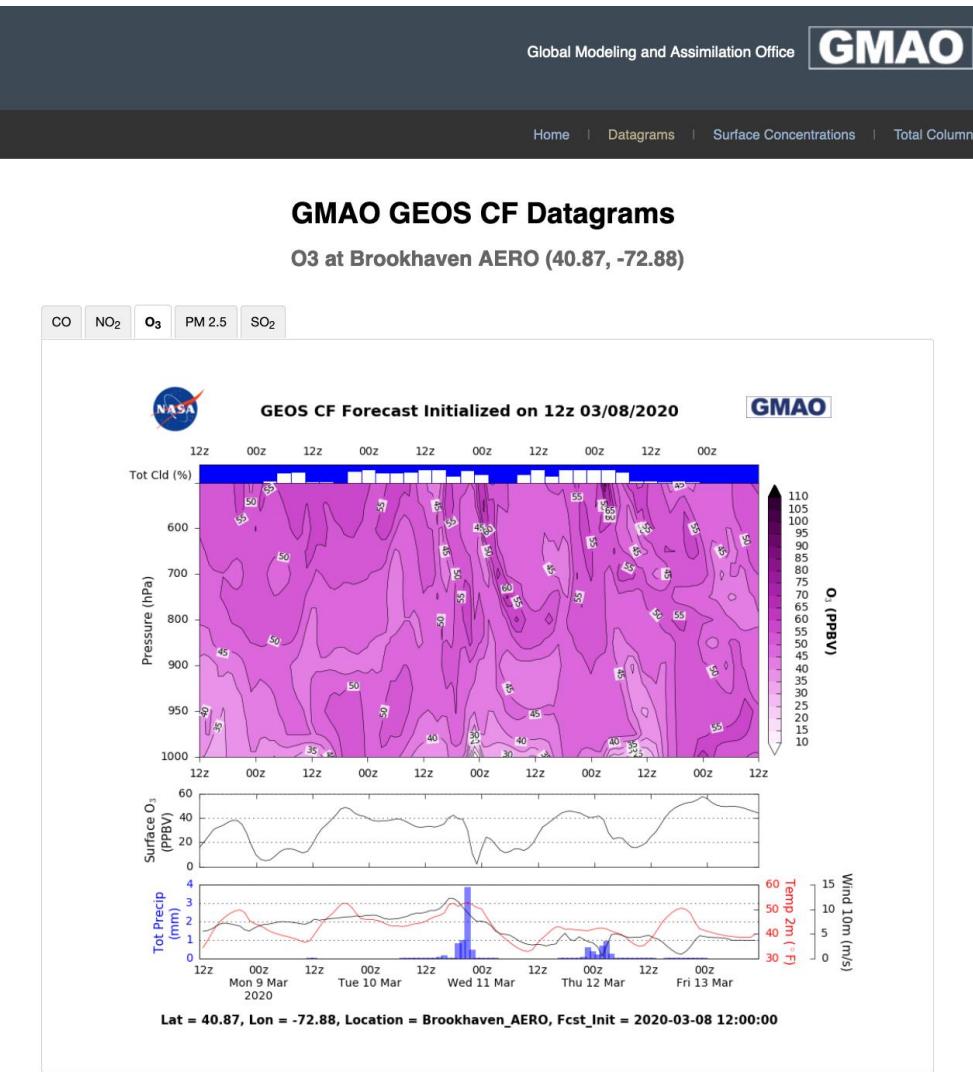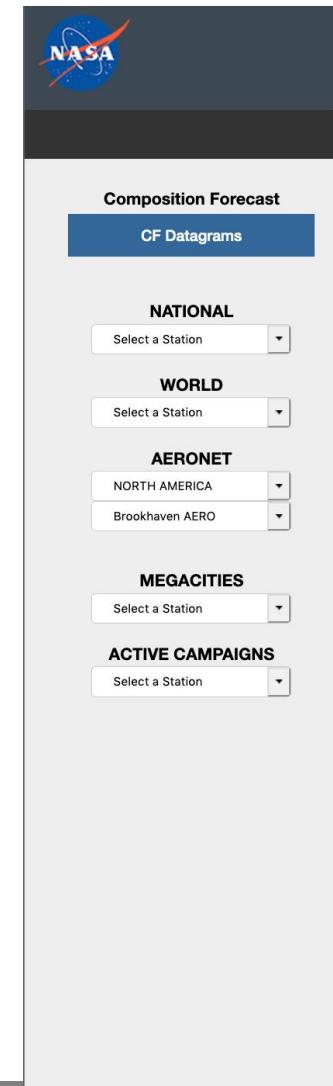
GMAO GEOS CF Datagrams

O3 at RO3QET (34.73, -86.64)

ECCC and CCNY
(approximate locations, the AMOLITE location is in Alberta)
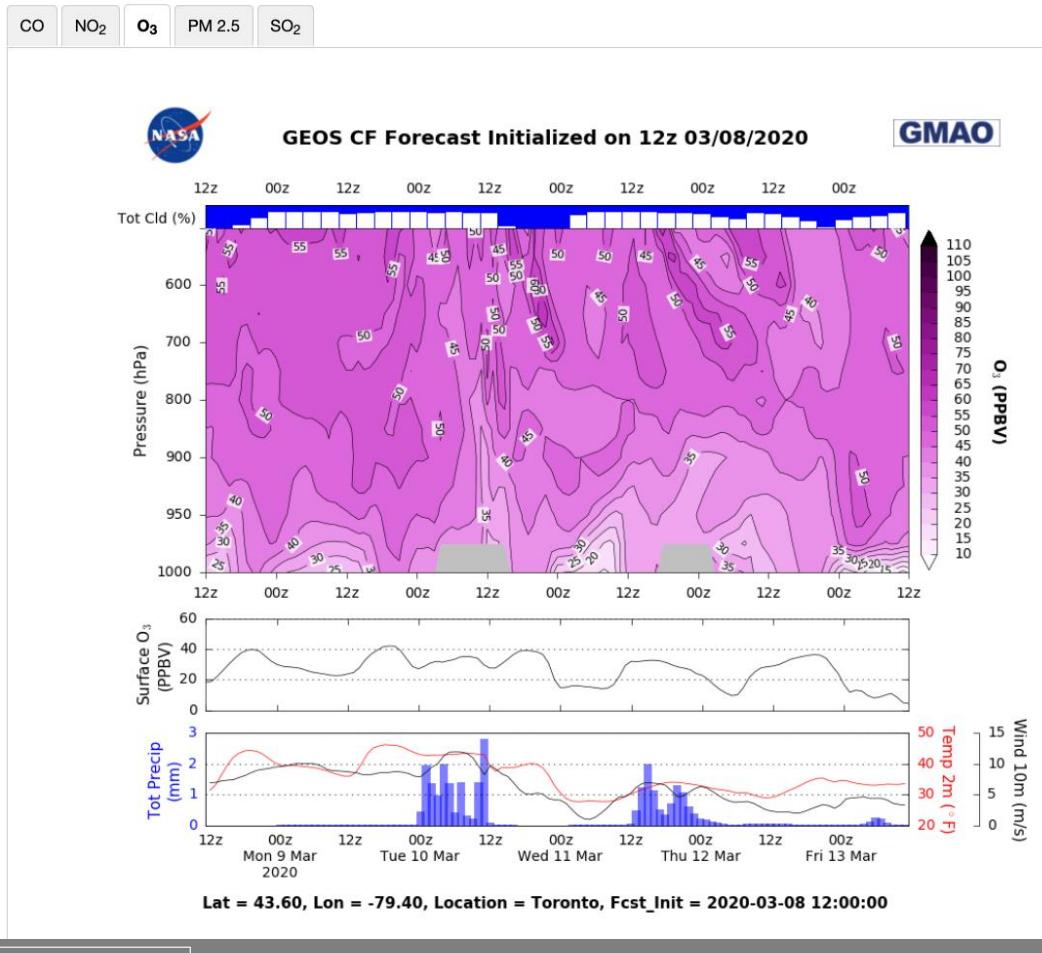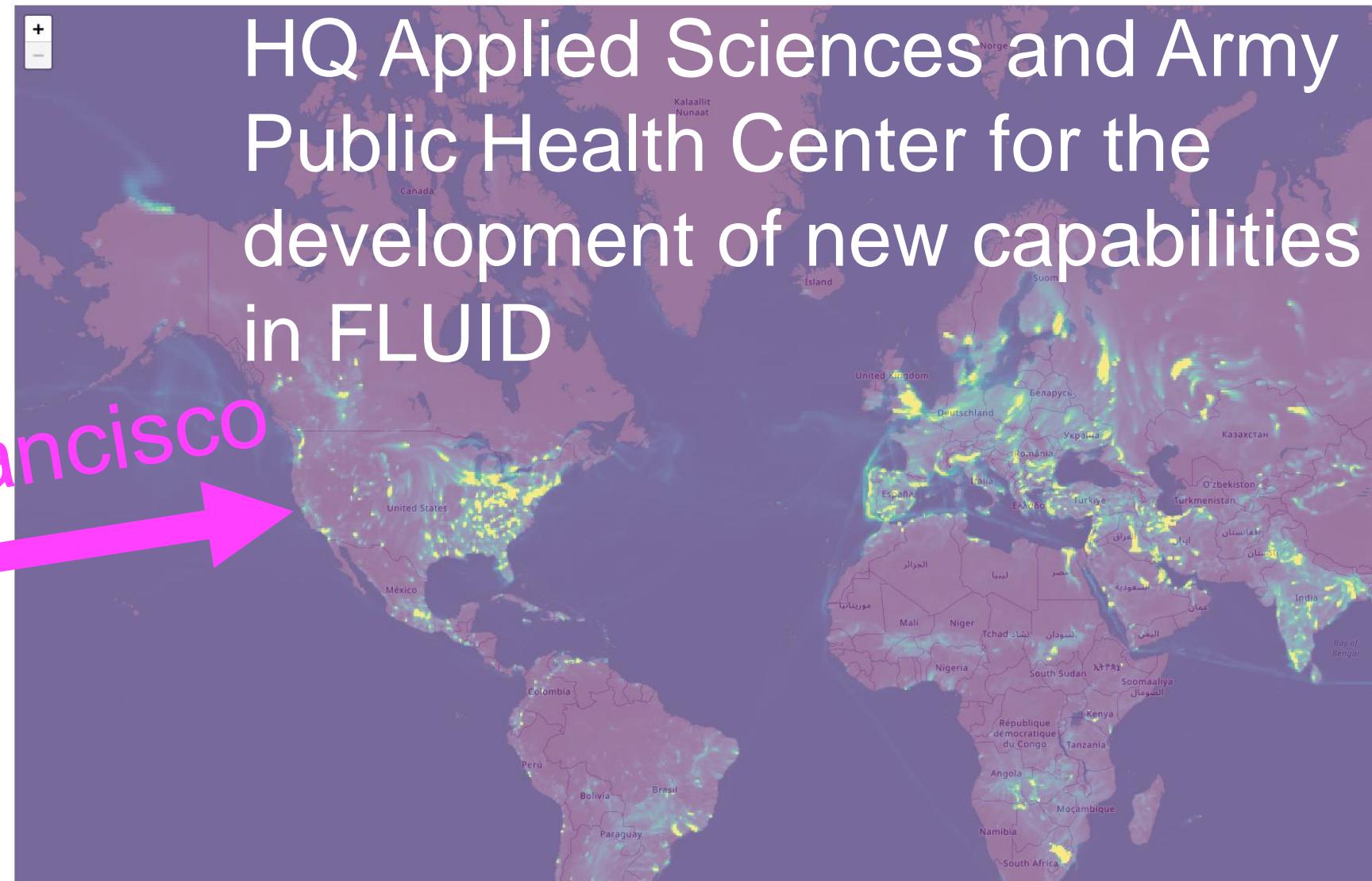
Added features to FLUID *in Development* ☺

Thanks to support from NASA 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
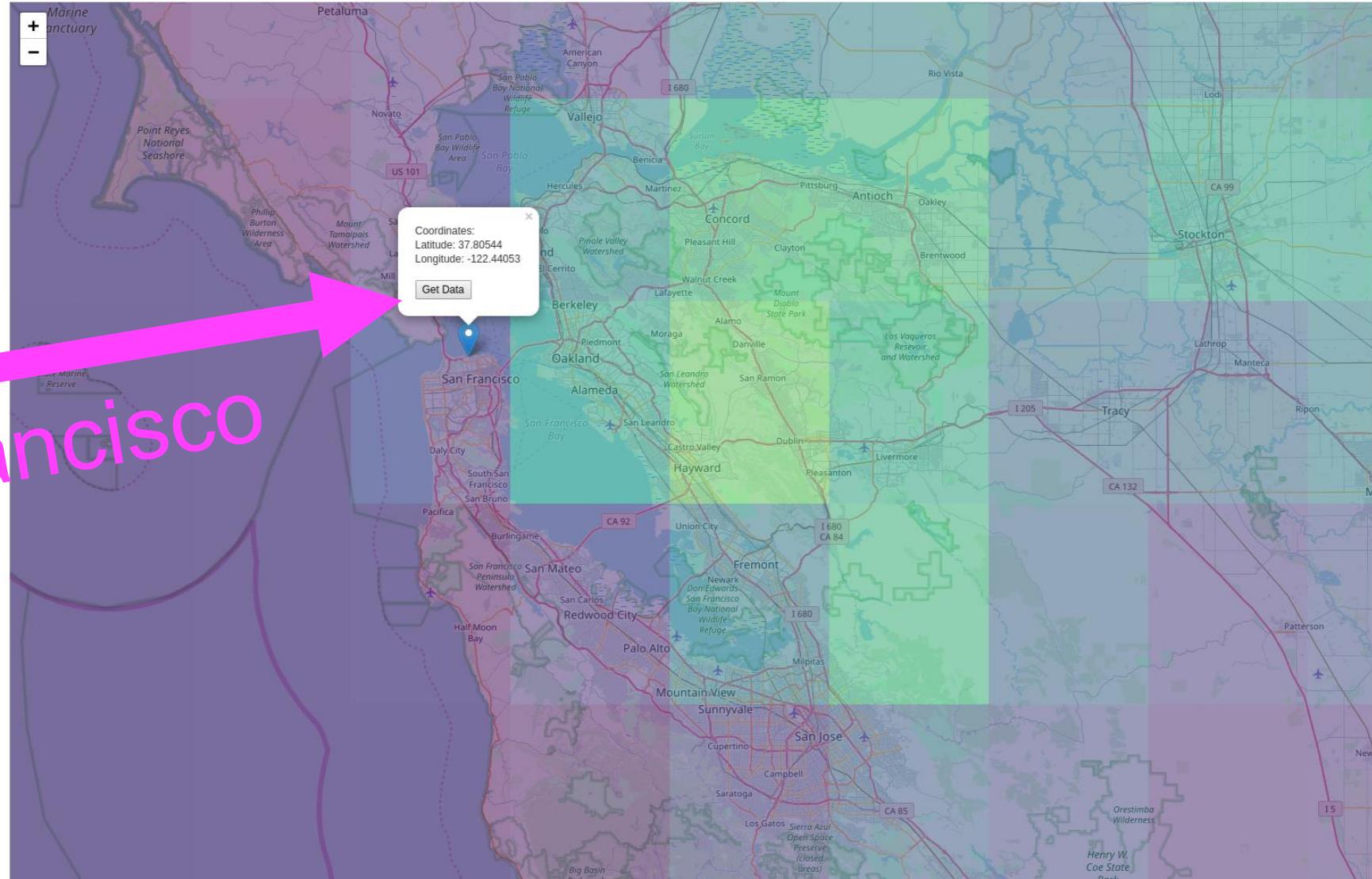
GMAO

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San Francisco

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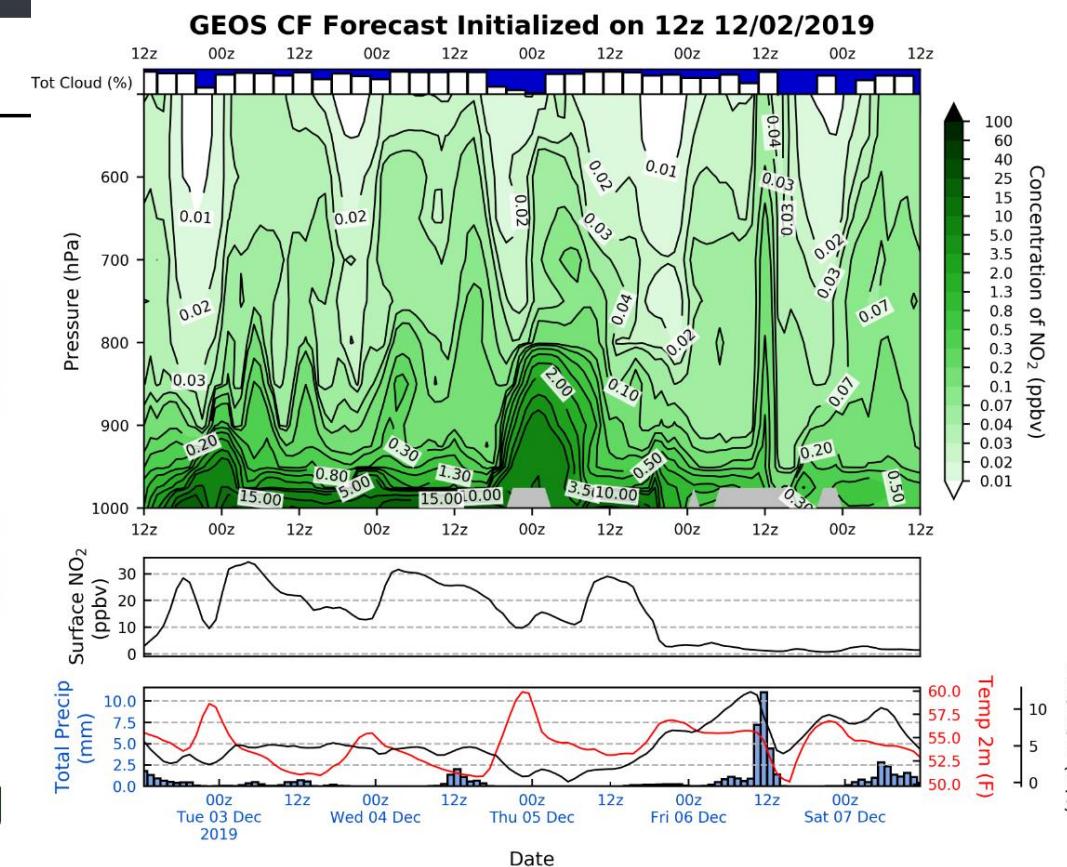
Added features to FLUID *in Development* ☺

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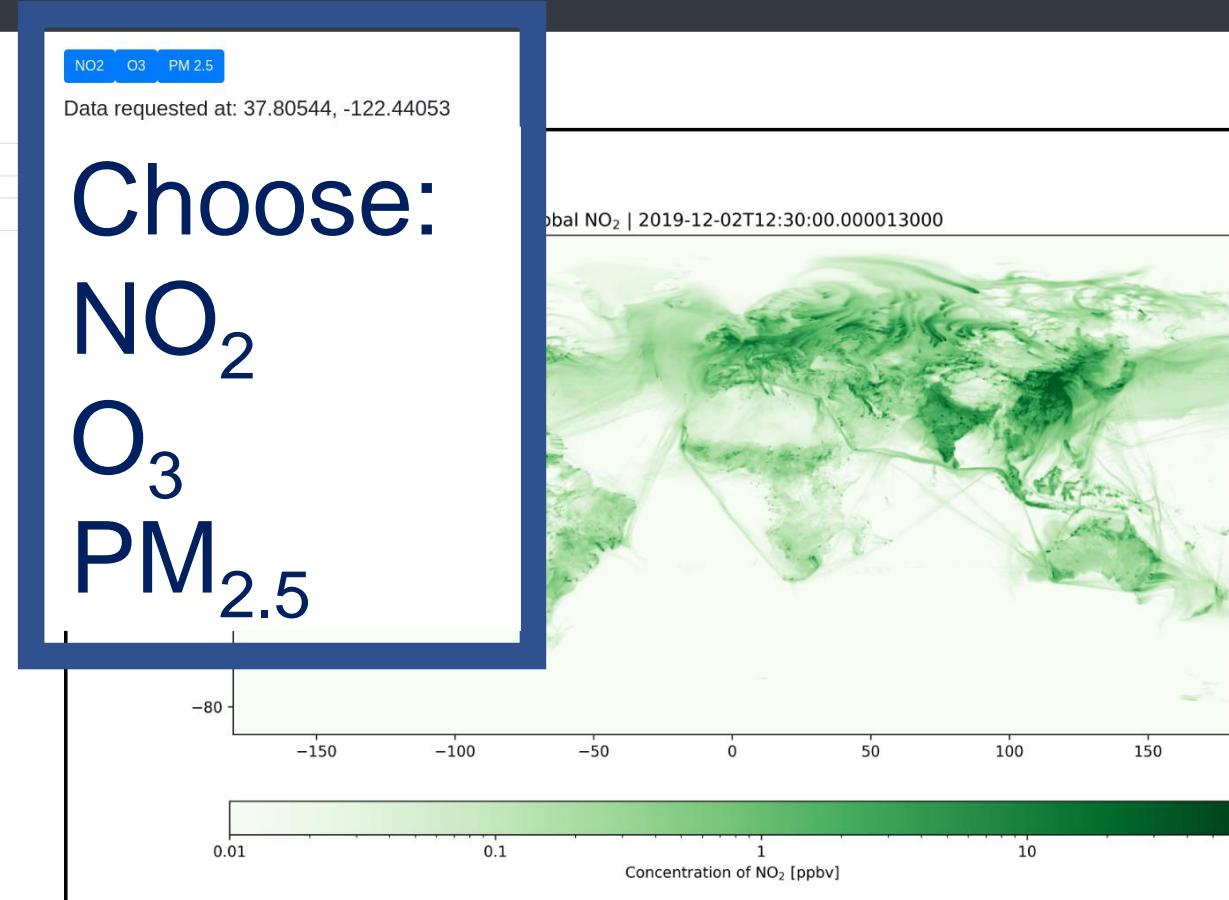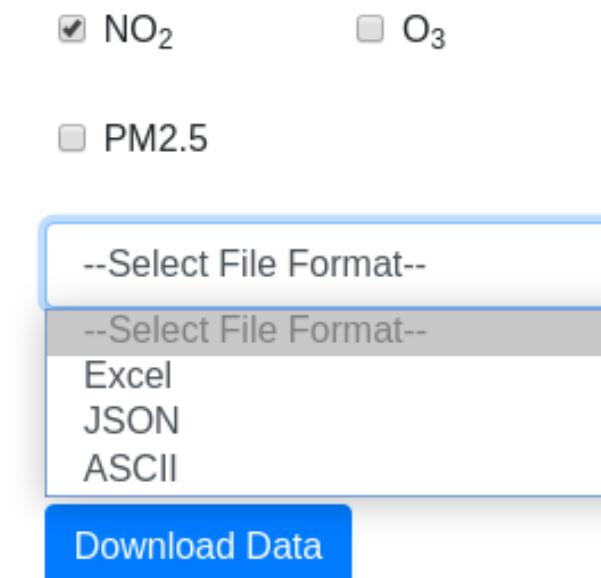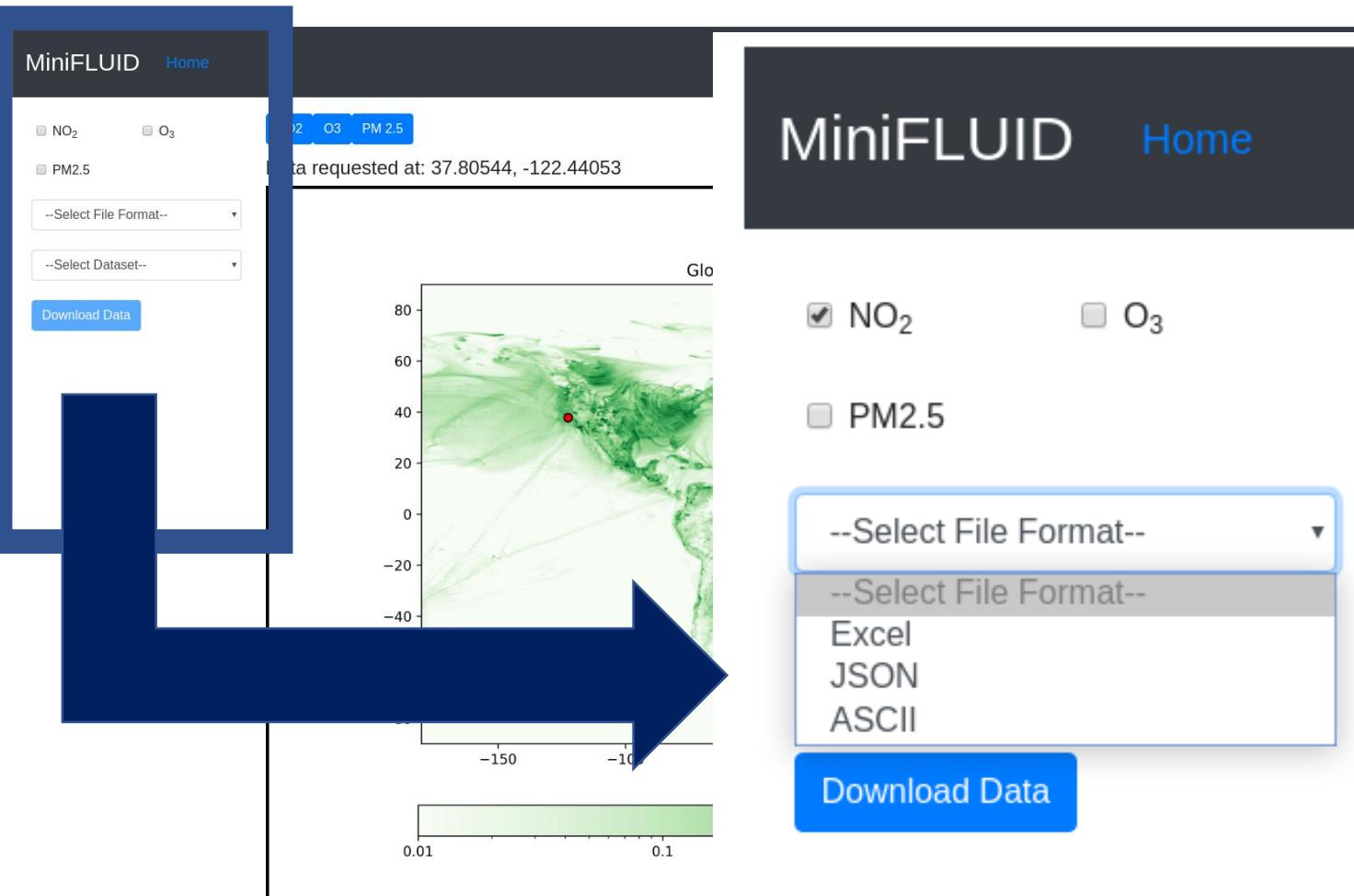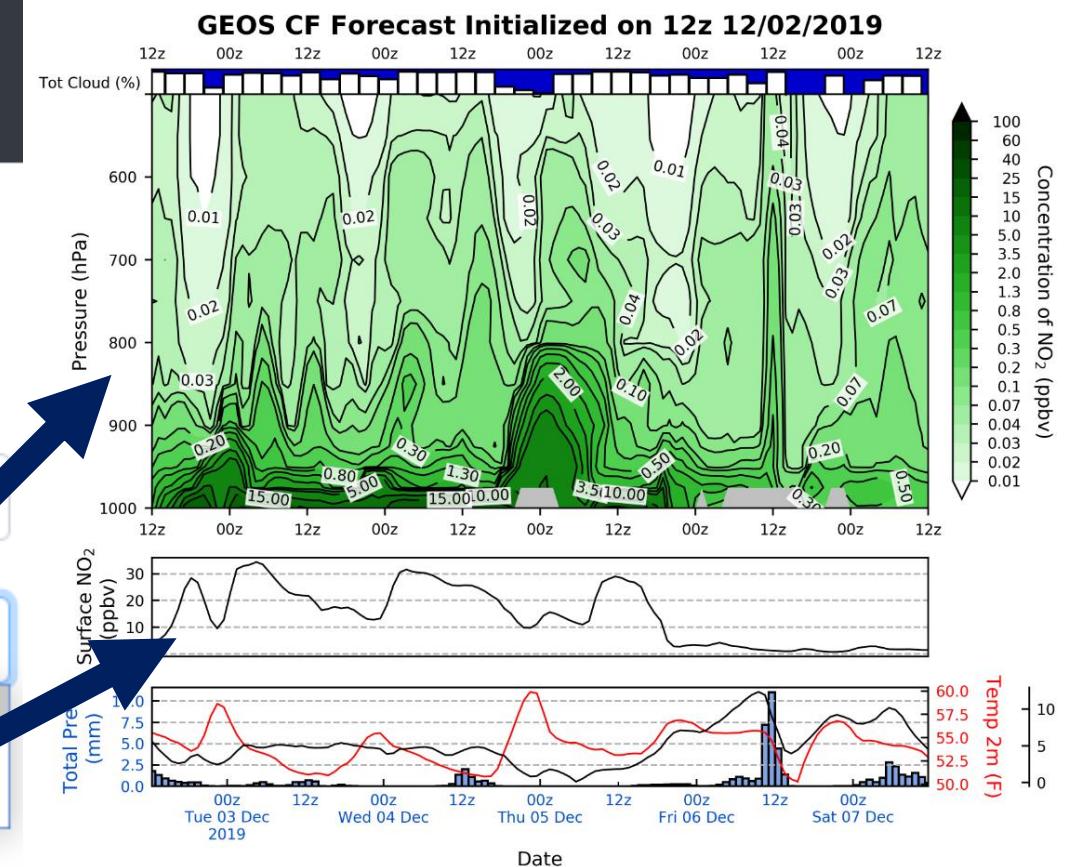# Added features to FLUID *in Development* ☺

Download Data in 3 user-friendly formats

Development by Brent Smith and Callum Wayman, SSAI/GMAO

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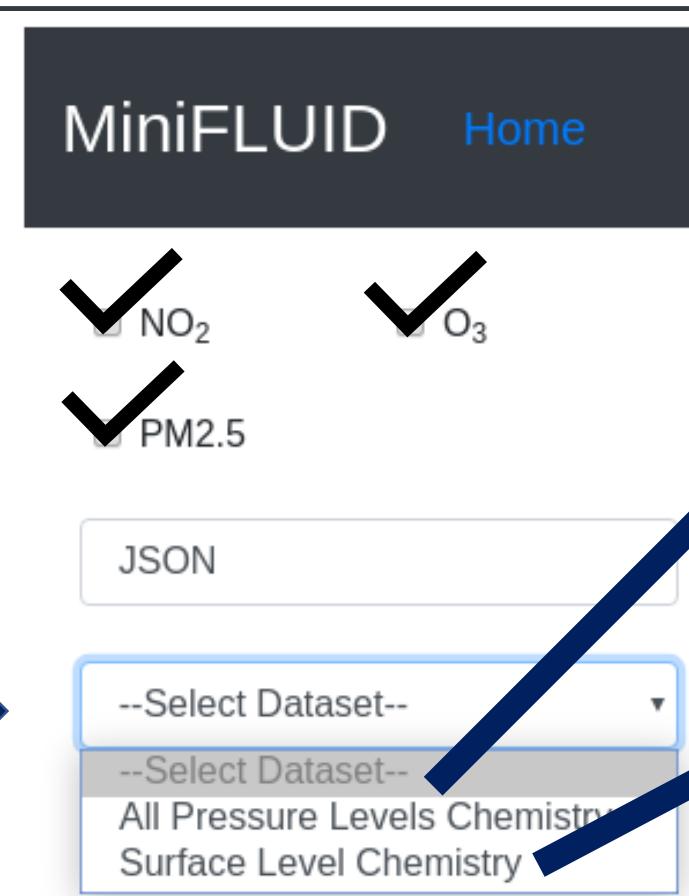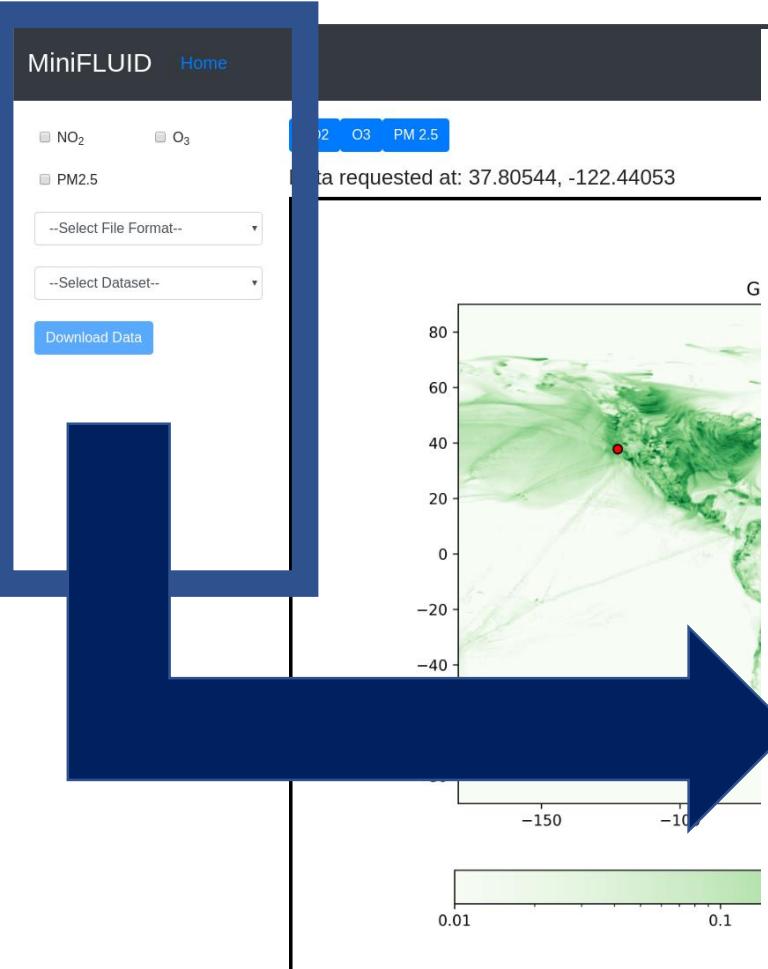
Development by Brent Smith and Callum Wayman, SSAI/GMAO

What type of model output would be useful?

- Pressure or Height z-axis coordinate system
- Meteorological output: U, V, OMEGA, T, Q, Theta, Theta_e ??
- Chemistry output: Ozone, NO2, aerosols?

Summary

✓ MERRA-2 is a high-resolution global reanalysis which can be used in scientific studies to identify SIs by both atmospheric dynamics and O_3

✓ GEOS-CF is suitable tool to support instrument teams measuring tropospheric and lower stratosphere composition

➢ Working on best approach to communicate SI potential to interested end-user groups.

Knowland, et al (2017). Stratospheric intrusion-influenced ozone air quality exceedances investigated in the NASA MERRA-2 reanalysis. GRL https://doi.org/10.1002/2017GL074532