

Forecasting Tools for Stratospheric Ozone Intrusions

Updated November 6, 2018

Note: These slides are intended to summarize publicly available resources that air agencies may find helpful to use when developing analyses to support exceptional events demonstrations for stratospheric ozone intrusions (SOIs). The U.S. Environmental Protection Agency (EPA) is not responsible for the development or ongoing maintenance of the resources referenced in these slides.

For detailed information on developing demonstrations for SOIs, please see EPA's "Guidance on the Preparation of Exceptional Events Demonstrations for Stratospheric Ozone Intrusions," available at <https://www.epa.gov/air-quality-analysis/exceptional-events-implementation-tools-templates-and-links>.

NOAA RAP Chem

(<https://rapidrefresh.noaa.gov/RAPchem/Welcome.cgi>)

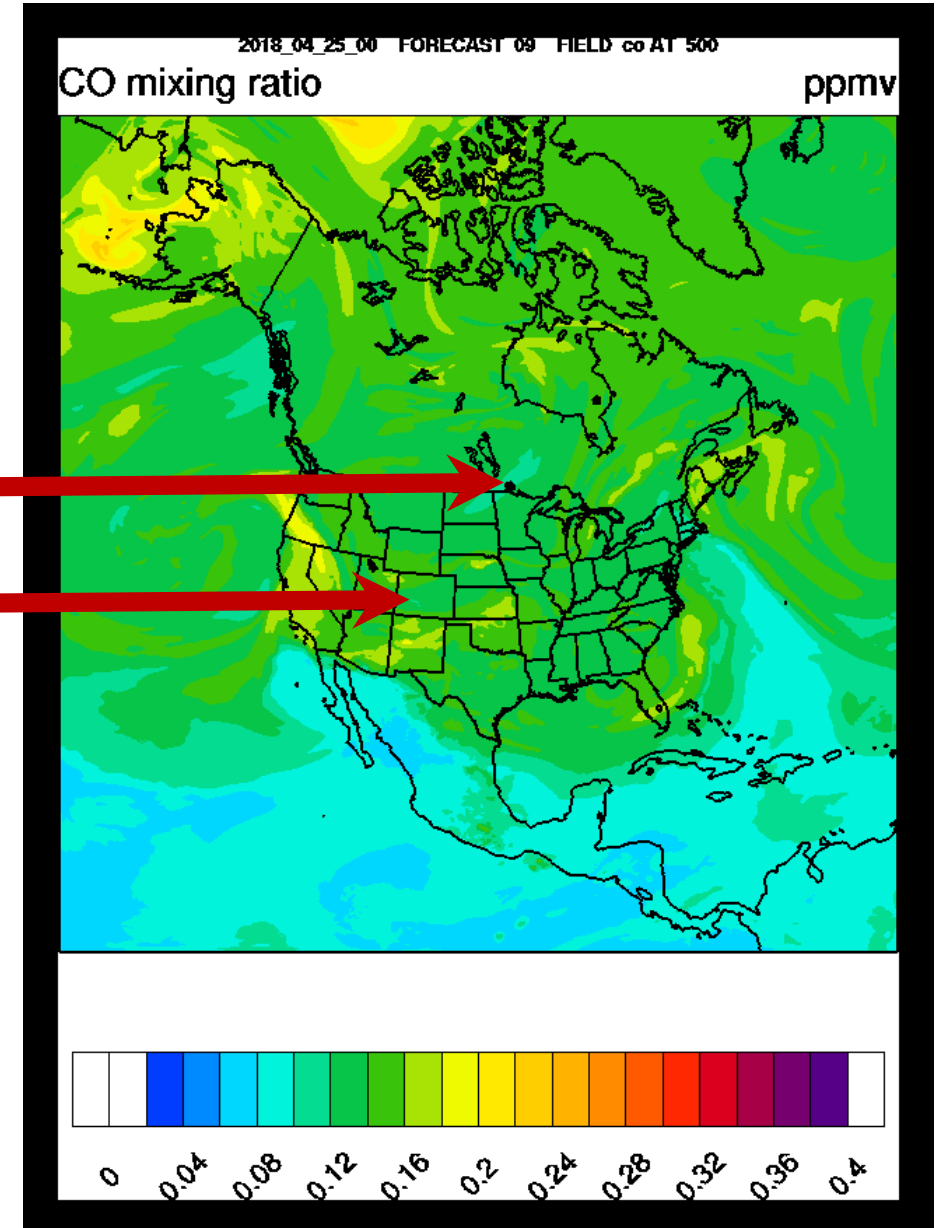
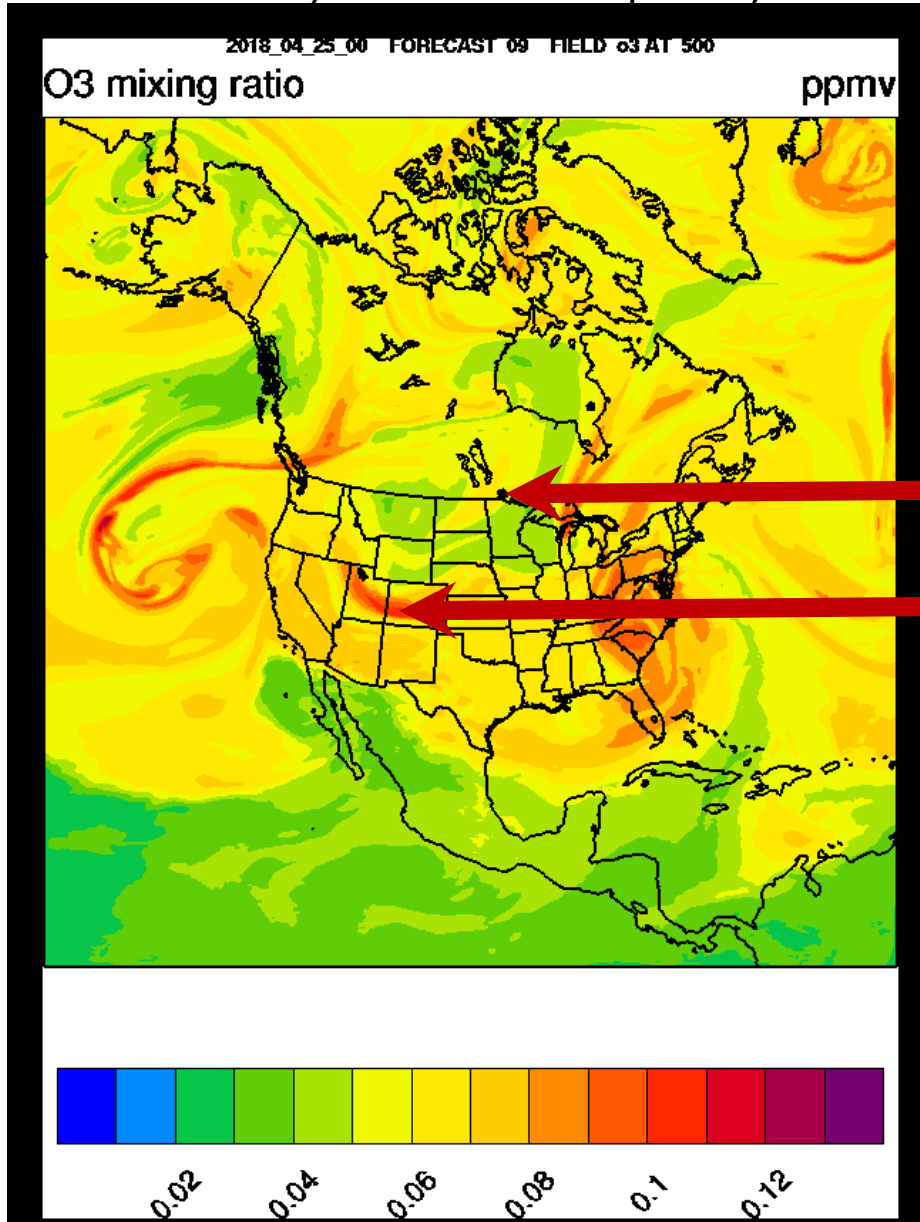
- Capabilities (North America, archived June 27, 2016-Aug. 7, 2018):
 - 4 Domains: North America, Continental US, Central Rockies, and Mid-North Atlantic Coast
 - Static plots, 48 hour forward forecasting of O₃ & CO concentration at surface, 850 mb, 700 mb and 500 mb pressure heights
 - Static plots, 48 hour forward forecasting of 300, 500, 700 and 850 mb pressure heights
 - Looped 48 hour forecast maps
 - Click on check mark in loop column for plot of interest

NOAA RAP Chem Example

For illustration and discussion purposes only

500 mb Ozone, 2:00 am MST April 25, 2018

500 mb CO, 2:00 am MST April 25, 2018



Simultaneous O₃
Enhancement,
CO minima

NCAR Whole Atmosphere Community Climate Model (WACCM)

- Capabilities (Global and North America Domains, archived back to January 1, 2018):
 - Vertical cross sections, maps, and time series plots at location/elevation
 - Plot Interface: <https://www.acom.ucar.edu/waccm/plot.shtml>
 - Global and Regional Map interface: <https://www.acom.ucar.edu/waccm/forecast/>
 - Numerous parameters: CO, O₃, O₃S (stratospheric O₃), but also hydrocarbons, black carbon, SO₂, NO_x and others
- Global/regional netcdf binary file downloads available:
 - MOZART WRF-Chem, January 1, 2007-January 21, 2018: <https://www.acom.ucar.edu/wrf-chem/mozart.shtml>
 - WACCM Chemistry, January 7, 2018-current + 10 day forecast: <https://www.acom.ucar.edu/waccm/download.shtml>

WACCM Interface: <https://www.acom.ucar.edu/waccm/plot.shtml>

The image shows a screenshot of the WACCM plotting interface with several annotations. The interface is titled "Whole Atmosphere Community Climate Model (WACCM)" and "WACCM PLOTTING". It includes a "Create a plot of WACCM data:" section with a "Chemical species" dropdown menu (circled) containing CH4, CO, CO01, CO02, and CO03. Below this are input fields for "Minimum value to plot" (0.01), "Maximum value" (1), "Minimum height to plot" (1000 hPa), and "Maximum height" (10 hPa). A "Date and time" section shows 2018, April, 25, 6:00. The "Plot Type" section has three options: "Map", "Vertical cross-section", and "Time series". The "Map" option is selected and highlighted in cyan, showing a "Model level (0-1000 hPa)" of 500 and a "Select a geographic region" section with radio buttons for Global, Continental U.S., Tropical America, South America, Asia, Africa, Australia, Europe, Pacific, and North America. Below this are input fields for "North latitude", "West longitude", "East longitude", and "South latitude". The "Vertical cross-section" option is also highlighted in cyan, showing "along a single" radio buttons for "latitude" and "longitude" (selected), "at value" 40.1 degrees, and "Range of x-axis" from -124 to -84 degrees. The "Time series" option is also highlighted in cyan, showing "Latitude", "Longitude", "at" "model level" 1000, and "Ending date and time" 2018, April, 28, 0:00. At the bottom, there are "Submit" and "Cancel" buttons. The footer contains copyright information for UCAR and the National Science Foundation.

Select Parameter → (points to the Chemical species dropdown menu)

Select Date/Time → (points to the Date and time dropdowns)

Specify Concentration Range → (points to the Minimum value to plot and Maximum value input fields)

Specify Altitude Range → (points to the Minimum height to plot and Maximum height input fields)

Map Option Selection and Extent → (points to the Map radio button)

Specify Model Altitude Level → (points to the Model level (0-1000 hPa) input field)

Specify Map Domain or Lat/Long → (points to the North latitude, West longitude, East longitude, and South latitude input fields)

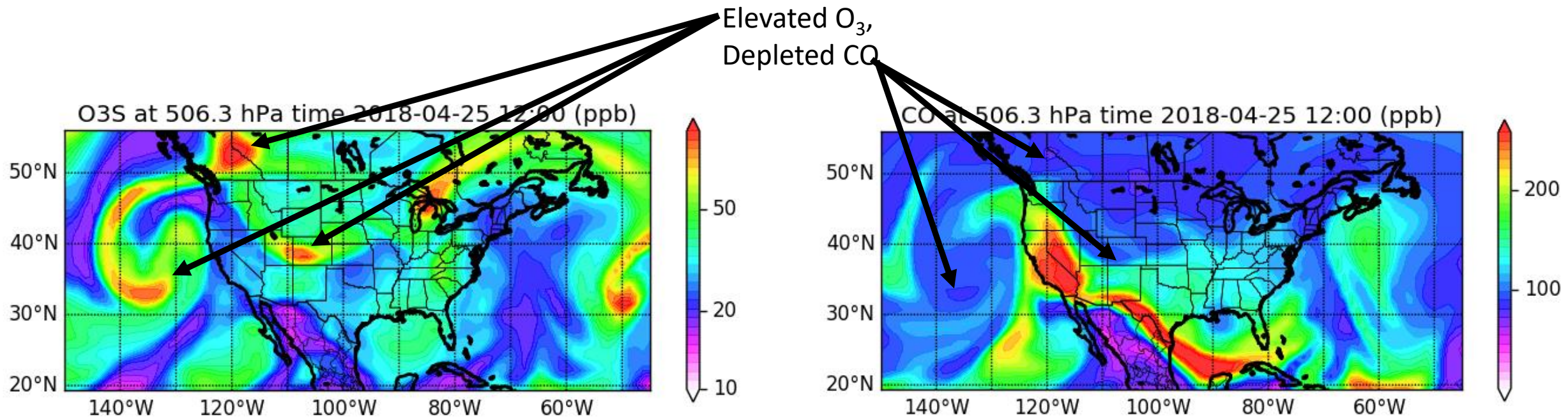
Vertical Profile Option Selection and Extent → (points to the Vertical cross-section radio button)

Time Series Option Selection and Location/Altitude → (points to the Time series radio button)

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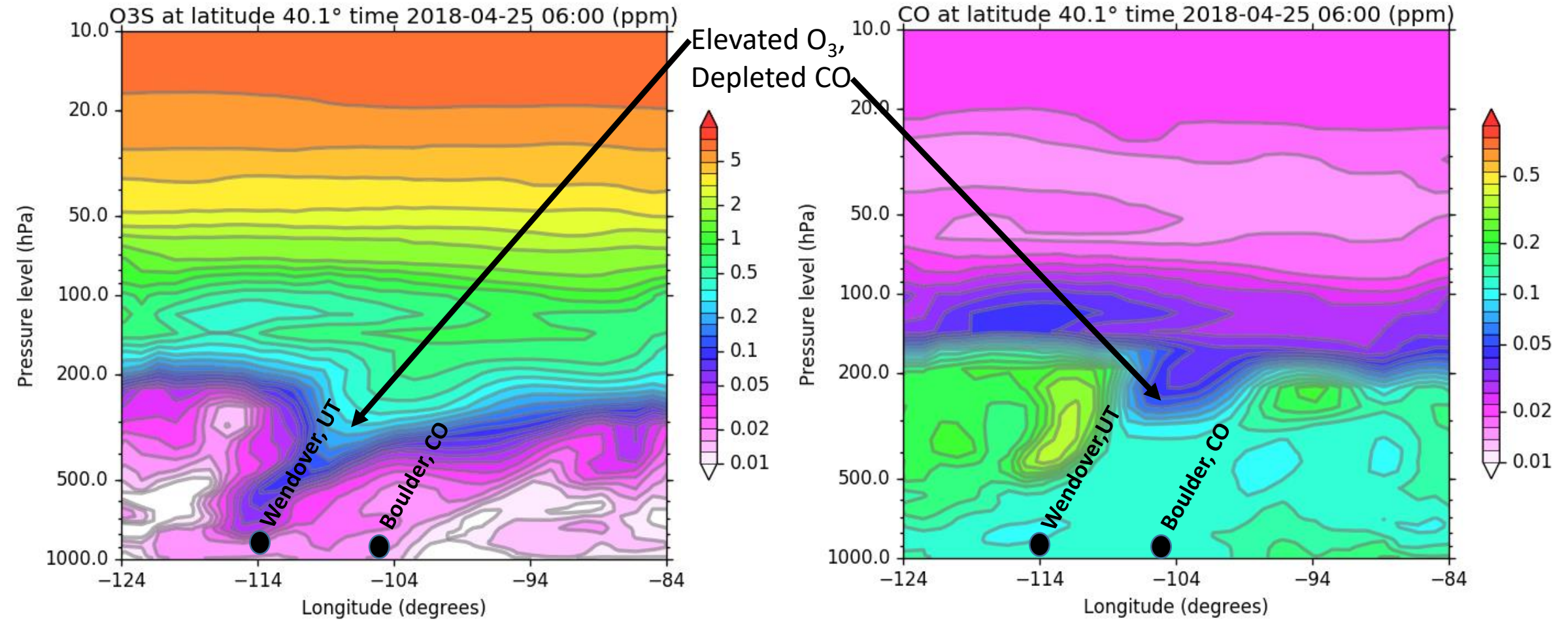
WACCM Maps, O₃ and CO, 506 hPa, April 25, 2018, 12:00 UTC



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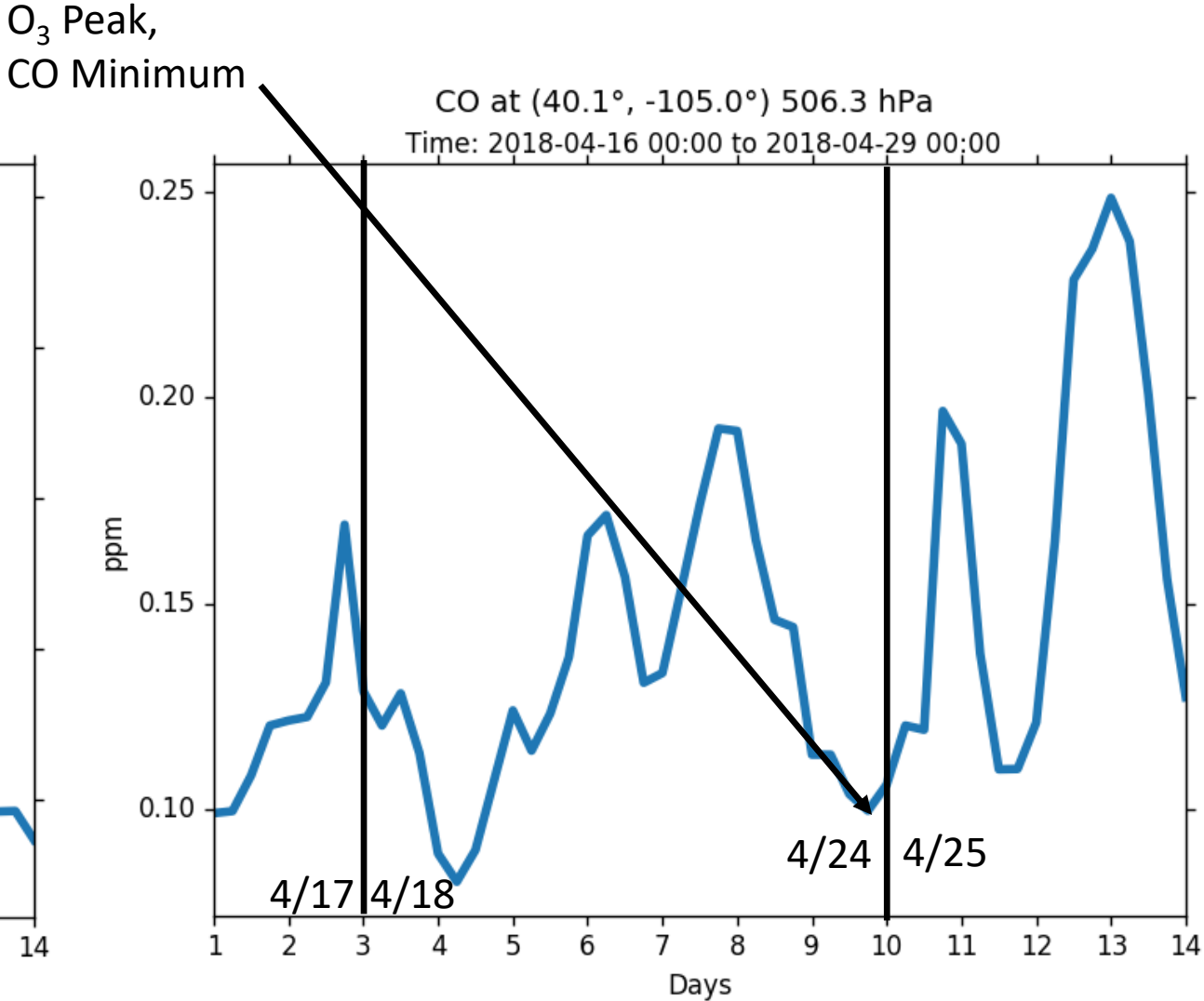
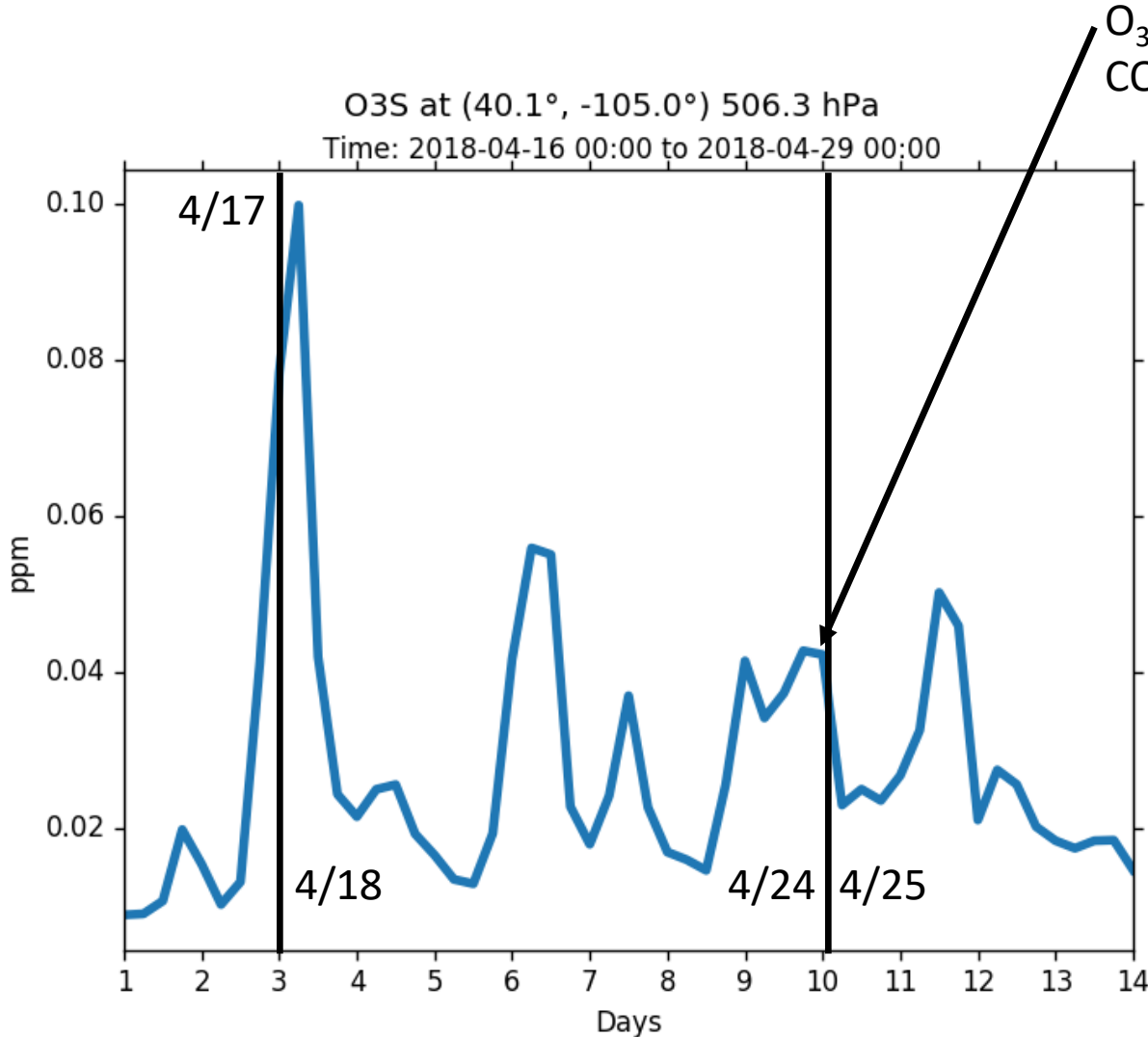
WACCM Vertical Profiles, O₃ and CO, April 25, 2018, 06:00UTC

Vertical Cross Section Option Controls: Species O3S and CO, Start date Apr. 25, 2018 6Z, Min Value 0.01, Max value 10 O₃ or 1 CO, Latitude 40.1, x-axis -124 to -84 degrees



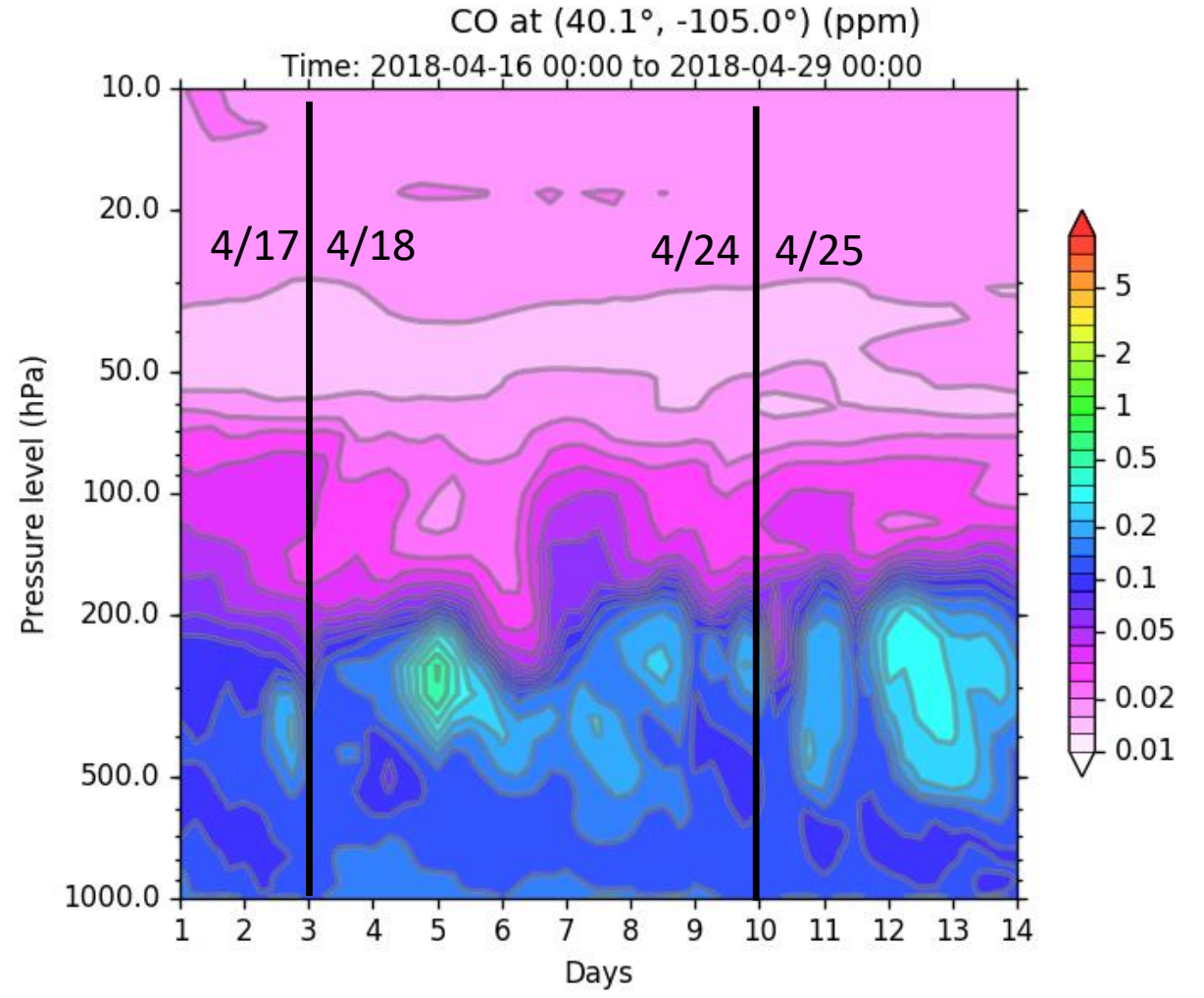
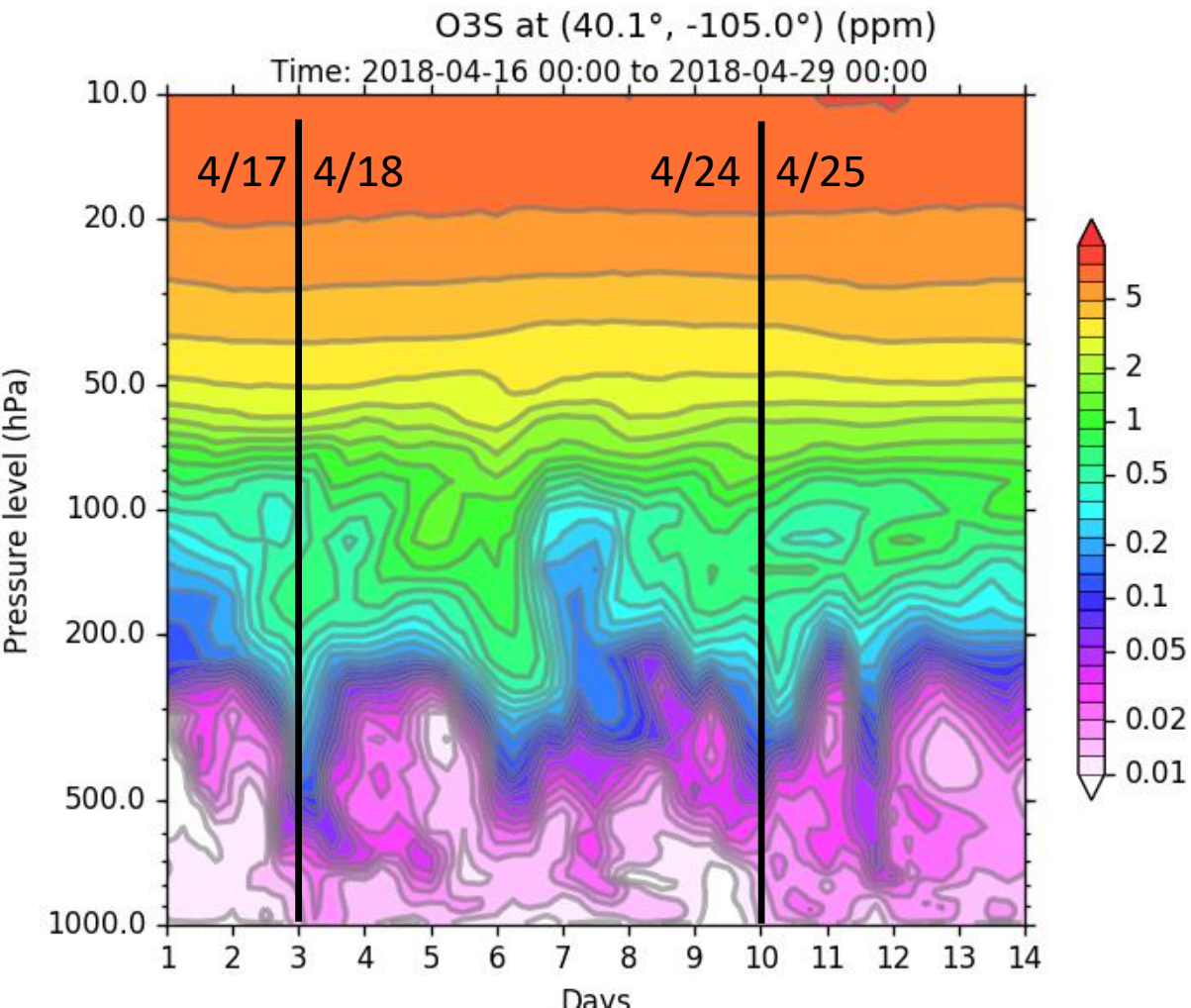
WACCM Time Series

Time Series Option Controls: Species O3S and CO, Start date Apr. 16, 2018 0Z, Latitude 40.1, Longitude -105, model level option at 500 hPa, end date Apr. 29, 2018 0Z.



WACCM Curtain Plot Time Series

Time Series Option Controls: Species O3S and CO, Start date Apr. 16, 2018 OZ, Min Value 0.01, Max 10, Height 1000 hPa to 10 hPa, Latitude 40.1, Longitude -105, model level option off, end date April 29, 2018 OZ



NOAA NCEP/GFS Forecasts

- http://www.cpc.ncep.noaa.gov/products/stratosphere/strat_int/
- Maps of 120 hour GFS forecast:
 - Ozone at 400 hPa to 100 hPa
 - Tropopause height
 - PV on the 320K surface
 - Height of the 2 PVU surface
- 12 hour time steps
- No archiving at present

GFS Ozone at 400 hPa and 200 hPa, Apr. 26, 2018, 0Z

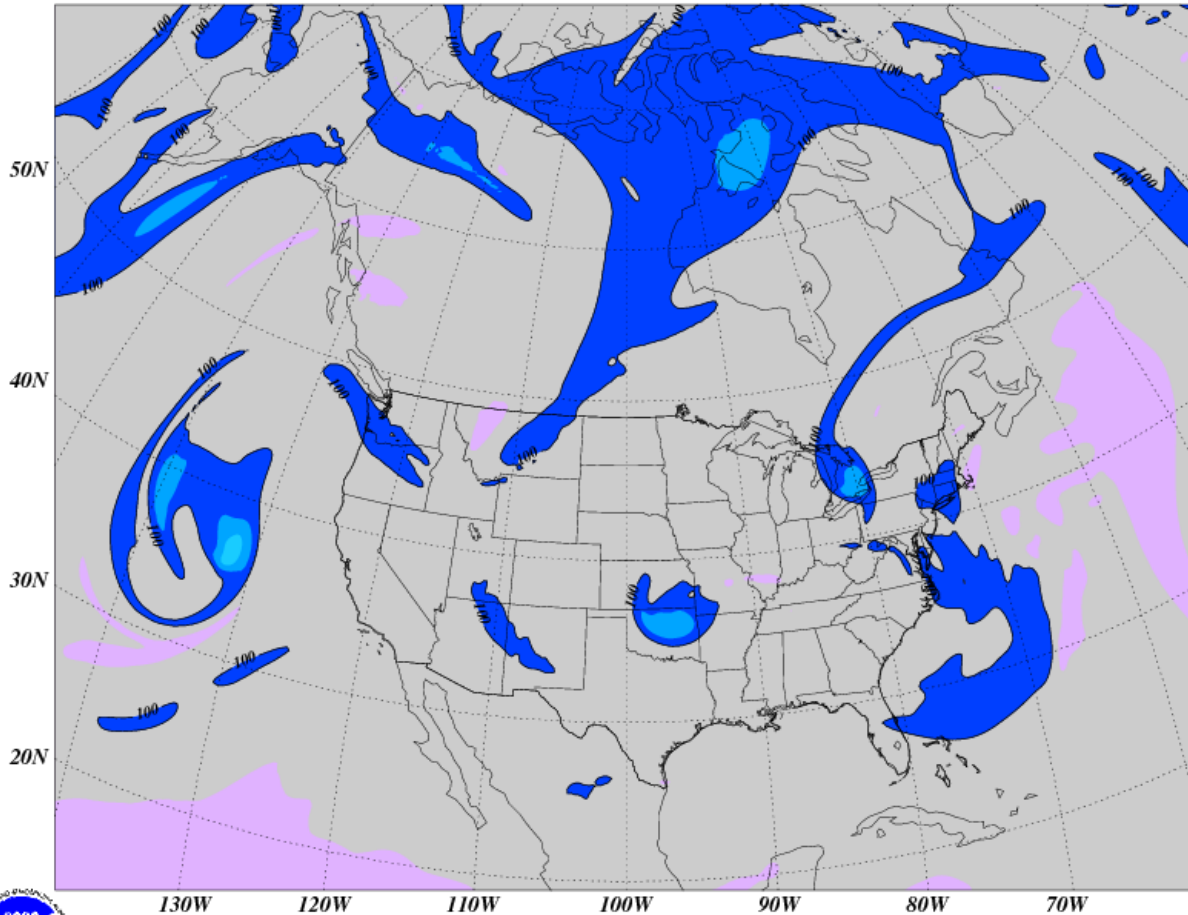
(approximately 23,000 and 39,000 feet)

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GFS Ozone Mixing Ratio - 400 hPa

Min value = 26.6, Max value = 271.6

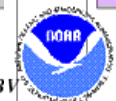
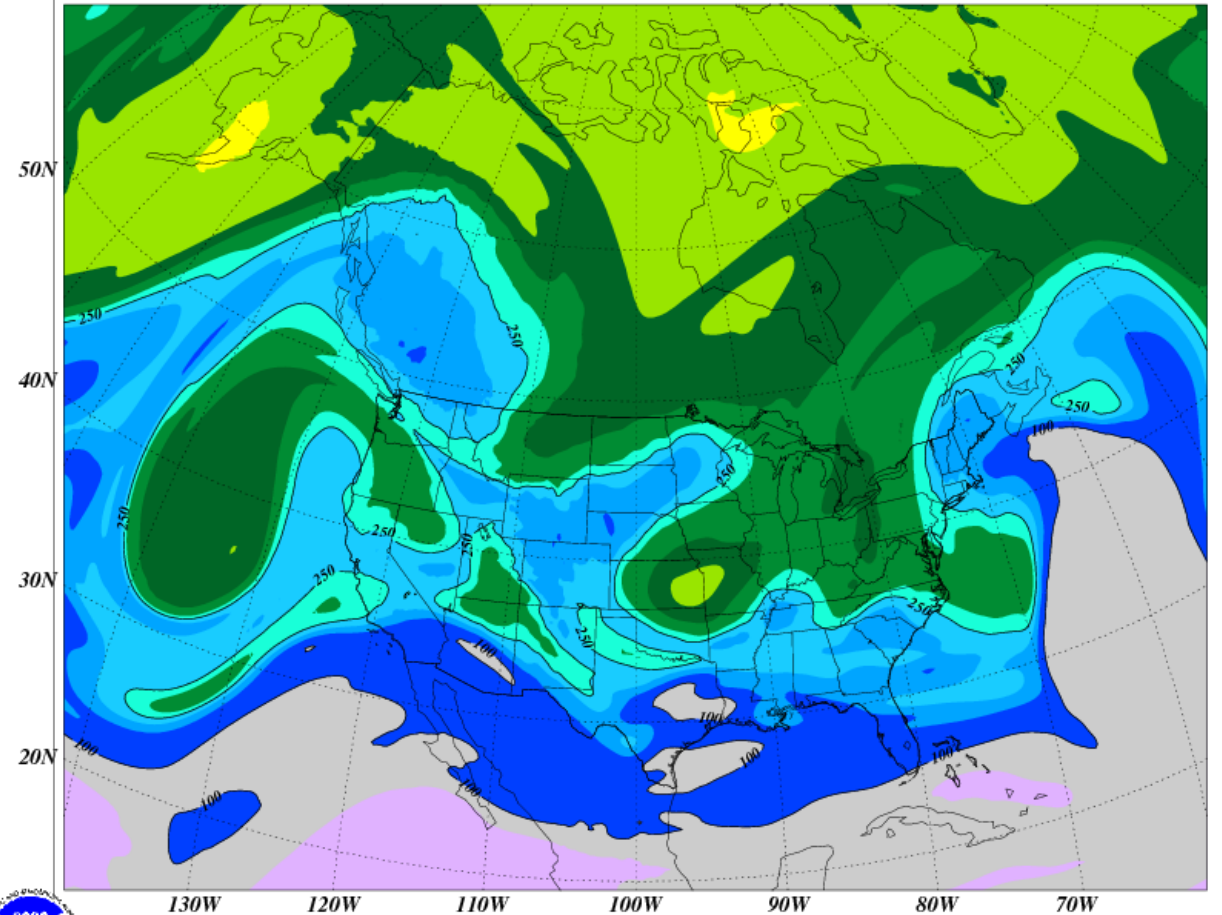
20180426 : 00Z : f00



GFS Ozone Mixing Ratio - 200 hPa

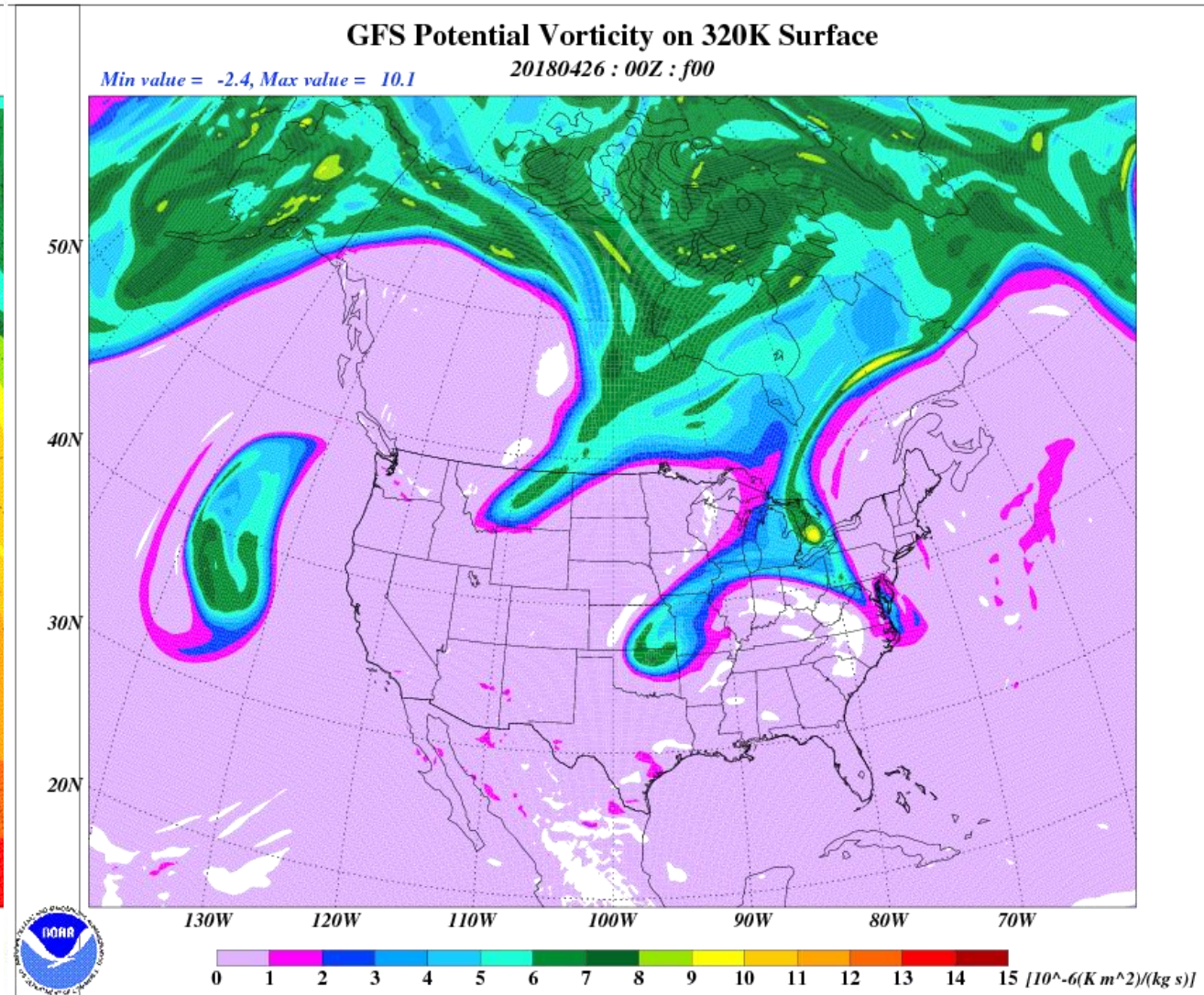
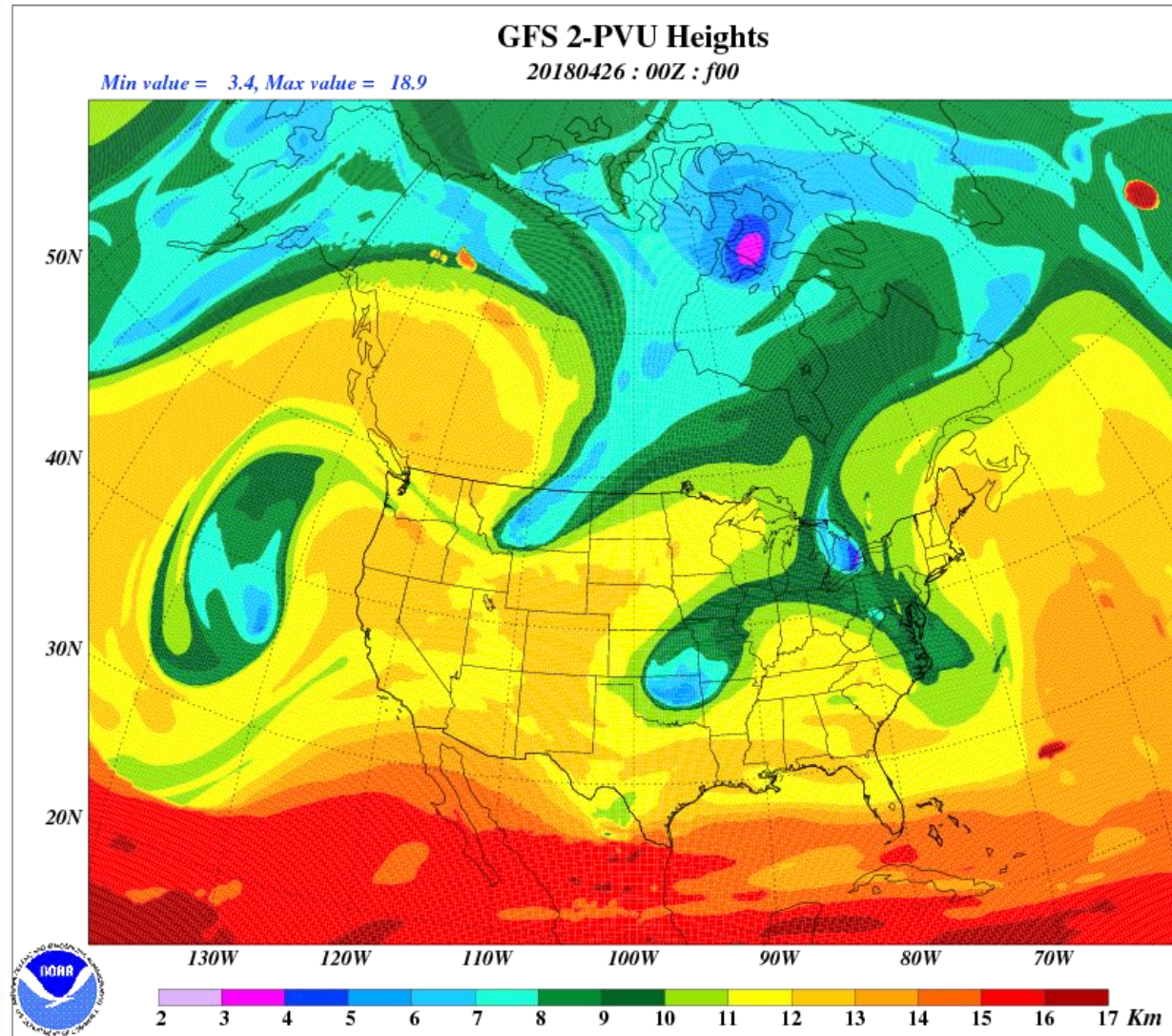
Min value = 28.1, Max value = 881.7

20180426 : 00Z : f00



GFS 2-PVU Ht. (km) and 320k PV, Apr. 26, 2018 0Z

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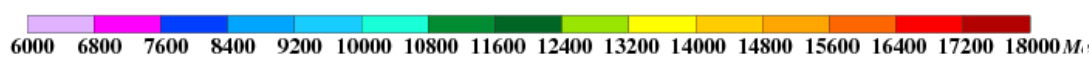
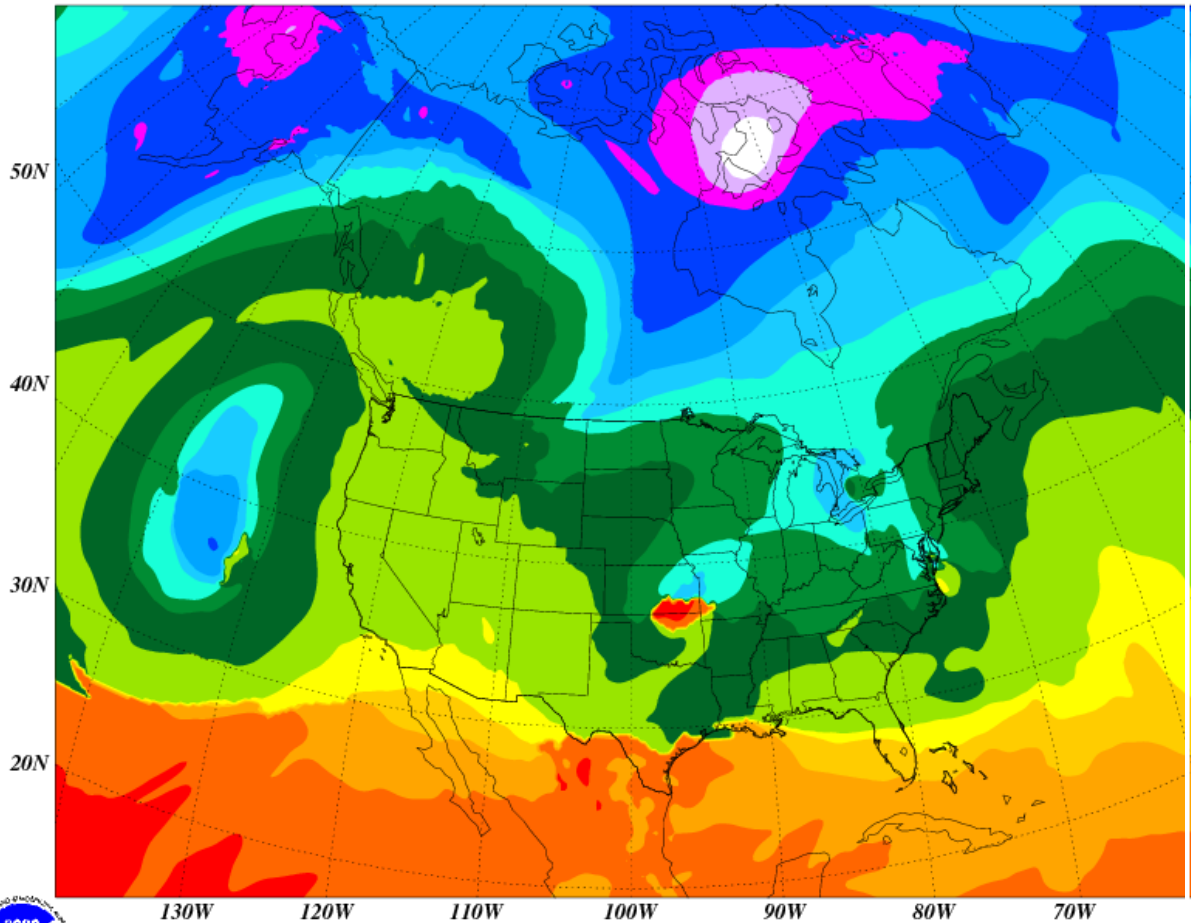
GFS Tropopause Ht. (m) and Total Column O₃, Apr. 26, 2018 0Z

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GFS Tropopause Height

Min value = 5375.1, Max value = 17432.3

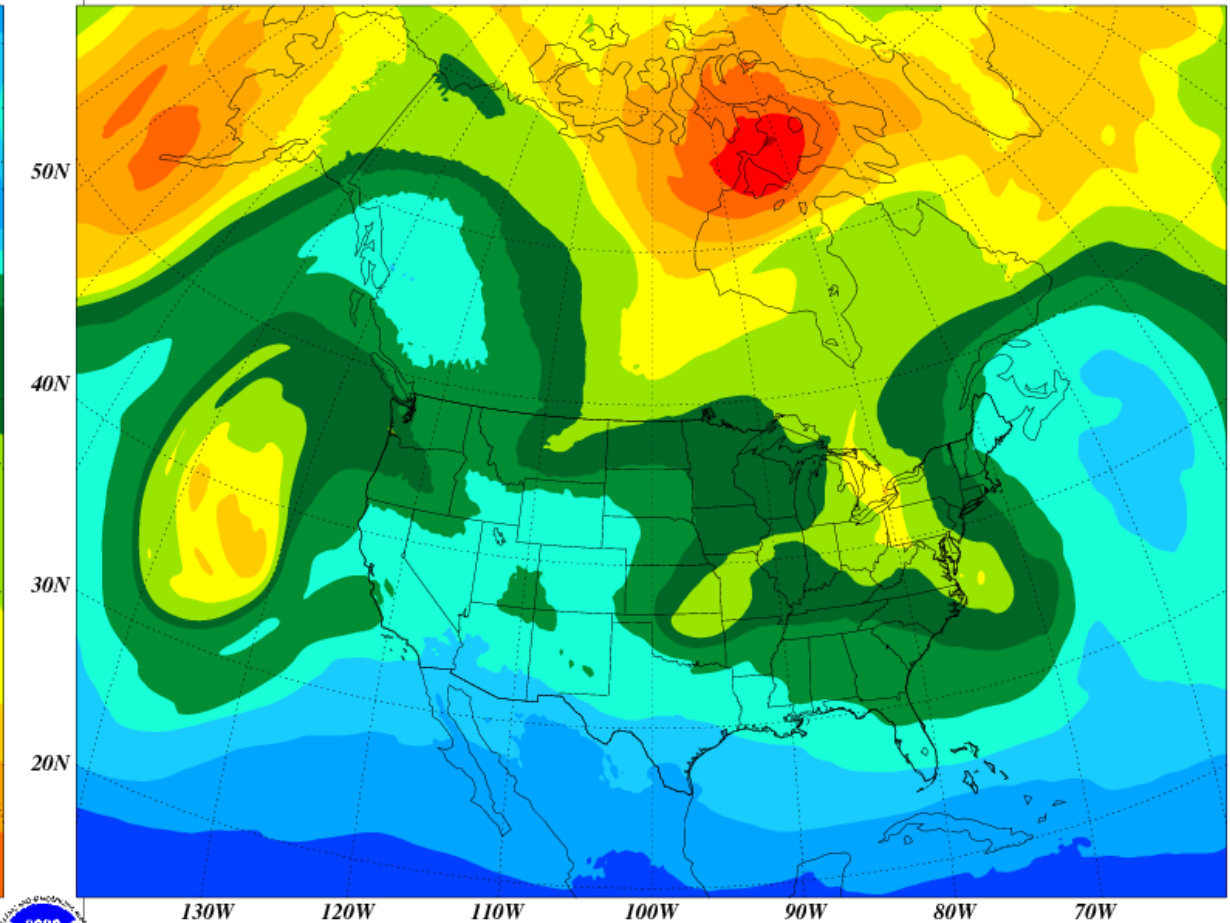
20180426 : 00Z : f00



GFS Total Columnn Ozone

Min value = 252.7, Max value = 501.1

20180426 : 00Z : f00



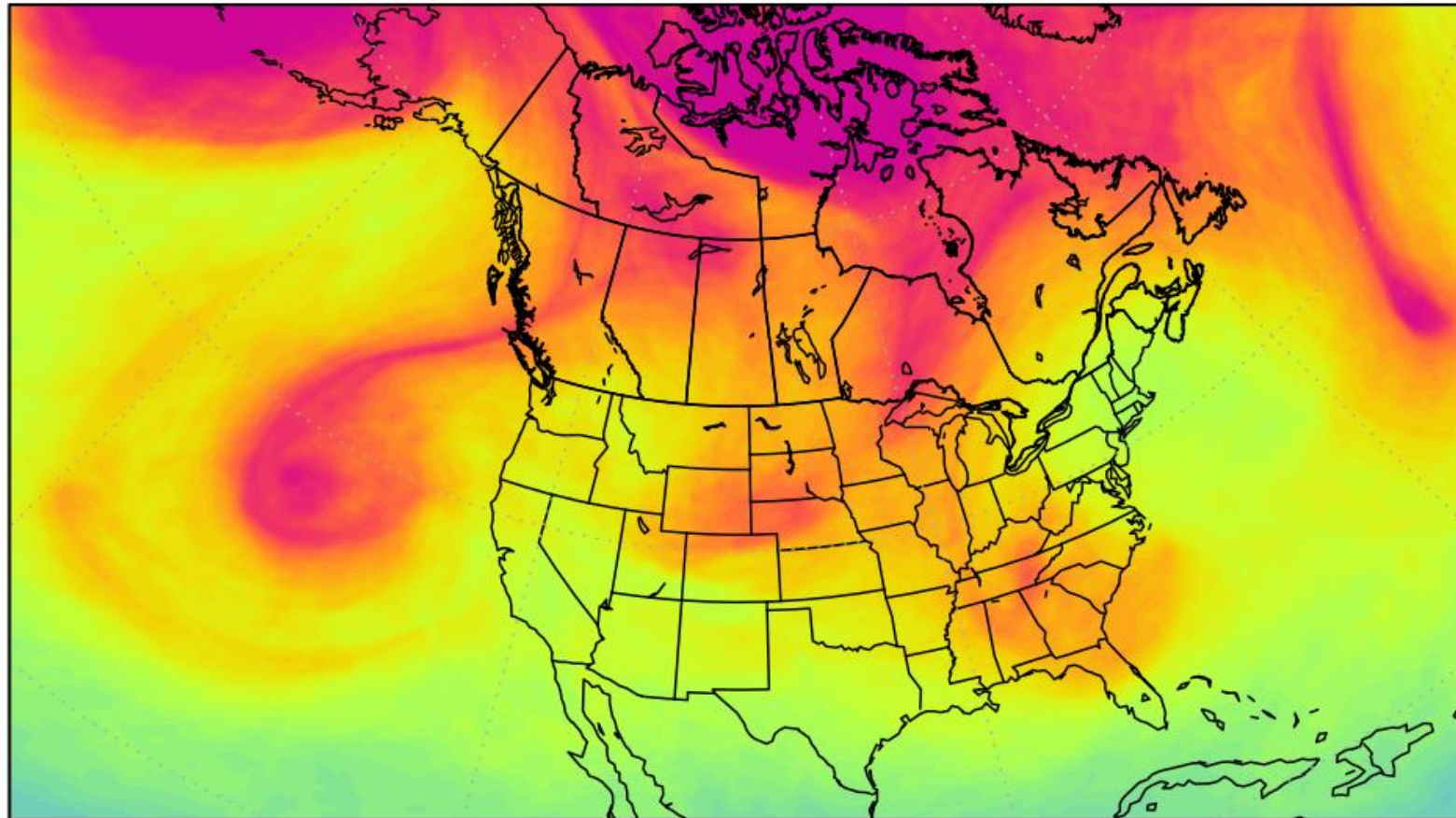
NASA GMAO Atmospheric Composition

- Currently, maps total column ozone in several domains
 - North America, Mid-Atlantic States, Global, Polar, etc.
- 3-D chemistry plots currently being developed off-line
 - May be public in the future
- <https://fluid.nccs.nasa.gov/wxmaps/chem2d/>

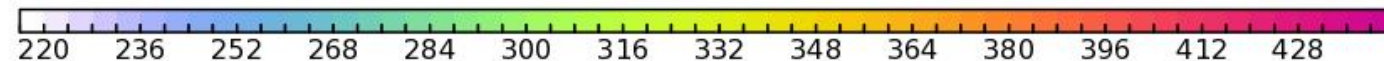
NASA GMAO Total Column Ozone, Apr. 25, 2018 0Z

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GEOS Forecast
NASA - Global Modeling and Assimilation Office (GMAO)
Initial: 04/25/2018 00Z Hour: 000 Valid: 04/25/2018 00Z



Total Ozone [Dobson Units]



NASA/NOAA RAQMS

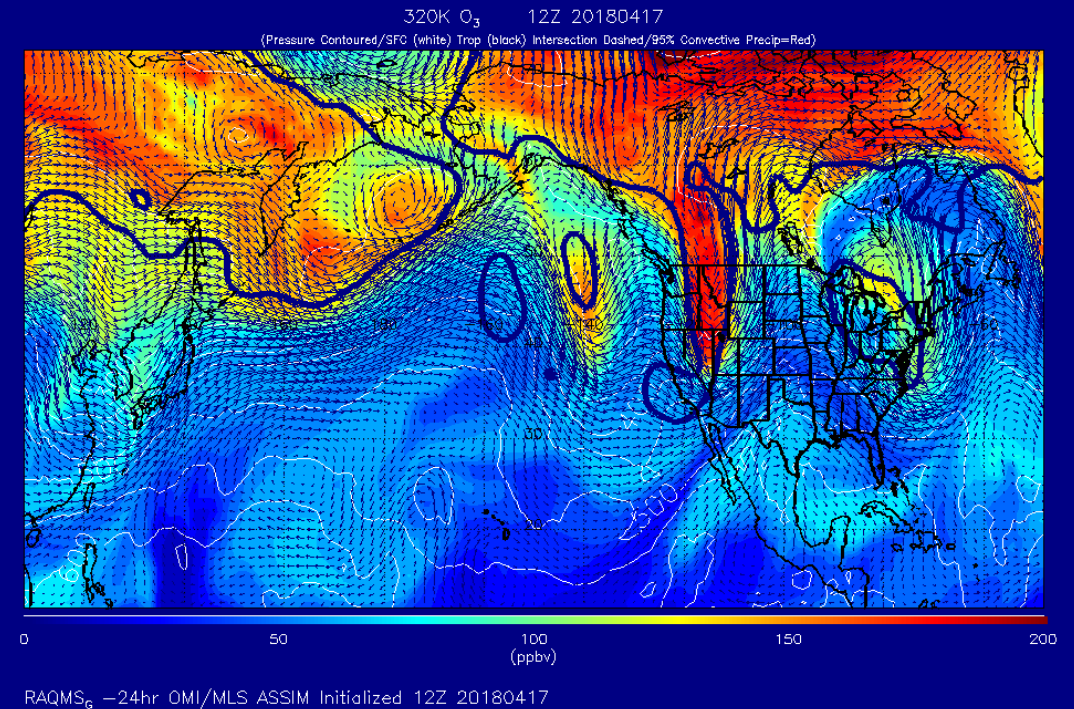
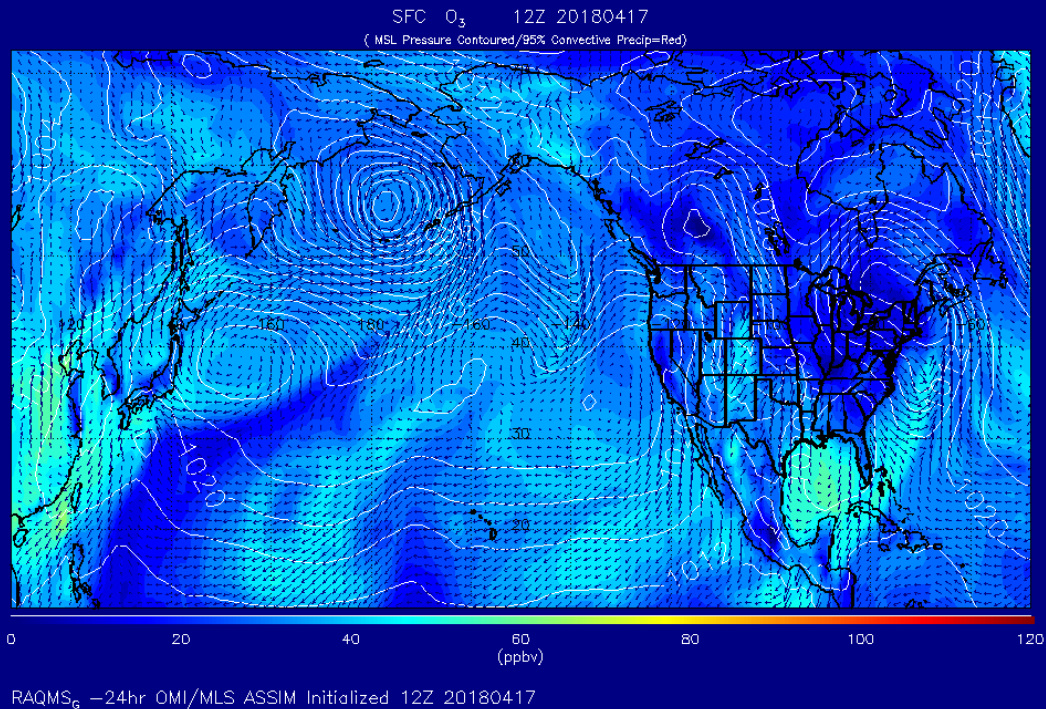
- <http://raqms-ops.ssec.wisc.edu/>
- Animated forecast maps of CO, O₃, carbon, sulfate at surface and elevation
- Tropospheric and total column animated maps
- Animated meridional cross sections at fixed longitudes
- Animated longitudinal cross section at 40° N, central Asia east to the Atlantic
- Model/Monitor correlation and time series plots
- Archived back to January 2010
 - (http://raqms-ops.ssec.wisc.edu/previous_products/)
- Other RAQMS Current Year Chemistry Plots and Animations at:
 - <http://raqms.ssec.wisc.edu/forecast/calendar/>

If graphics do not animate within this file, you may view them with animation at the web links provided.

RAQMS Surface and 320K Ozone Animated GIF, Apr. 17-22, 2018

Surface Ozone (ppbv)

320K Elevation Ozone (ppbv)



http://raqms-ops.ssec.wisc.edu/previous_products/20180417/O3_calnex_SFC_180417.gif

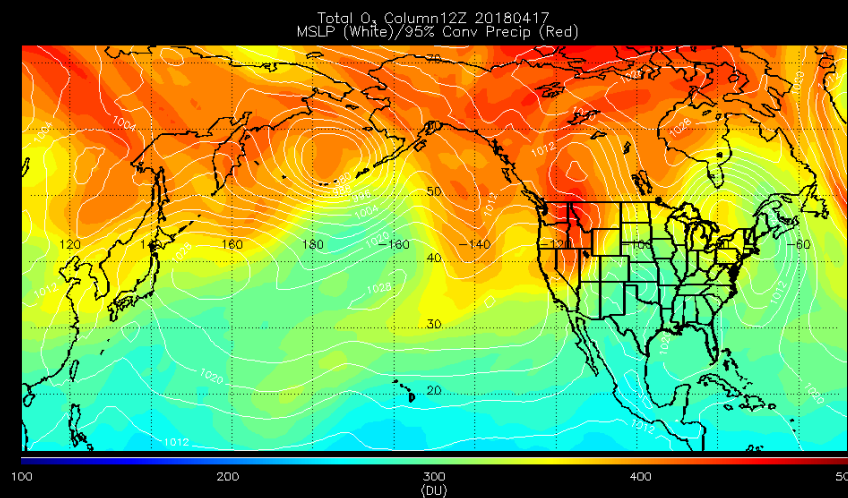
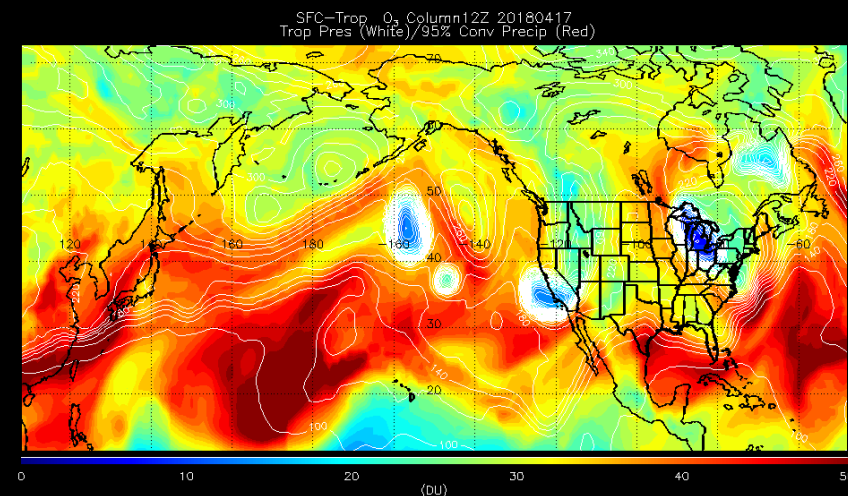
http://raqms-ops.ssec.wisc.edu/previous_products/20180417/O3_calnex_320K_180417.gif

For illustration and discussion purposes only

If graphics do not animate within this file, you may view them with animation at the web link provided.

RAQMS Tropospheric (top) and Total Column O₃ (bottom) Animated GIF, Apr. 17-22, 2018 (Dobson Units)

http://raqms-ops.ssec.wisc.edu/previous_products/20180417/O3_columns_180417.gif



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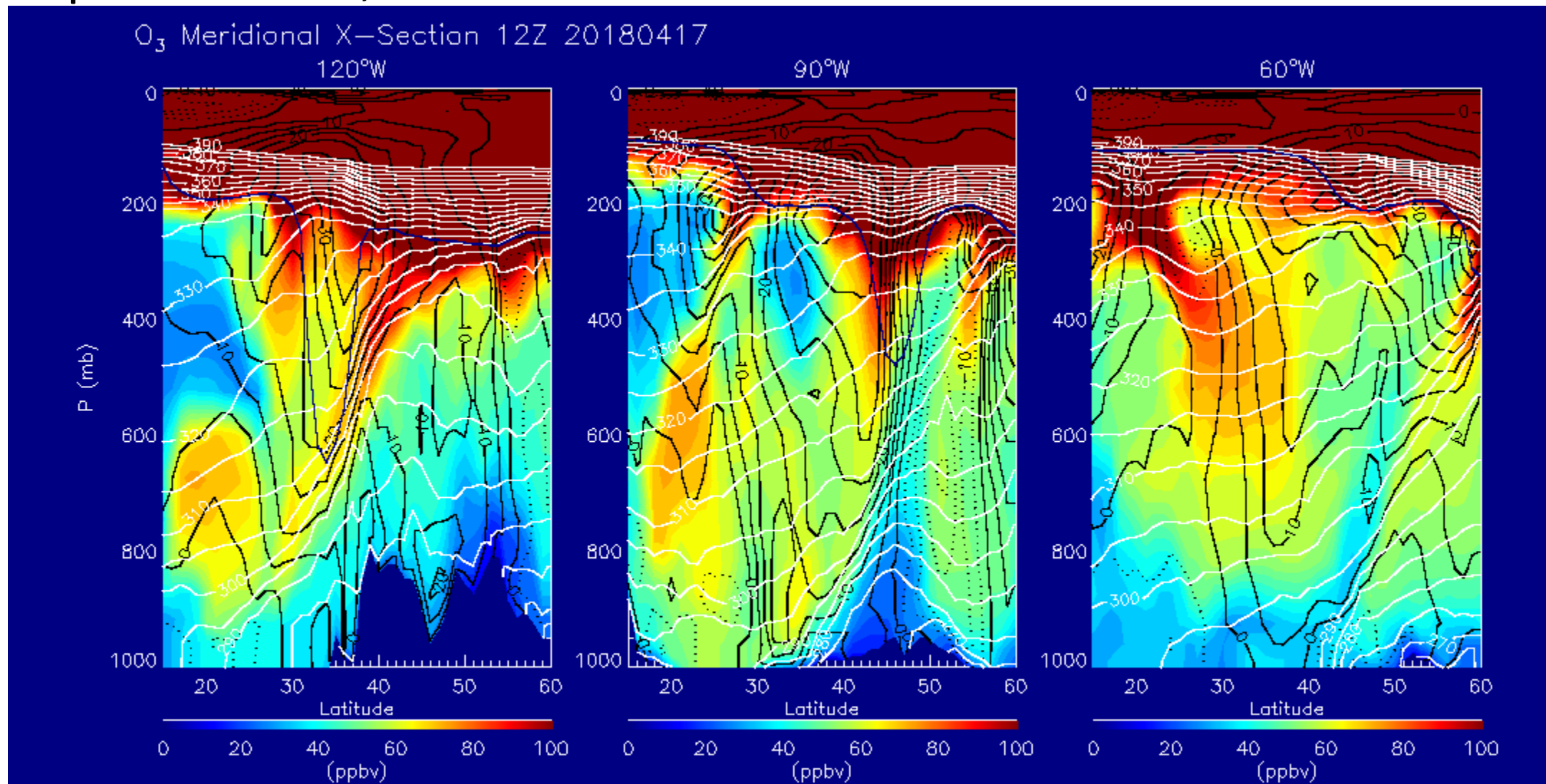
If graphics do not animate within this file, you may view them with animation at the web link provided.

RAQMS Meridional Cross Section Animated GIF,

April 17-22, 2018

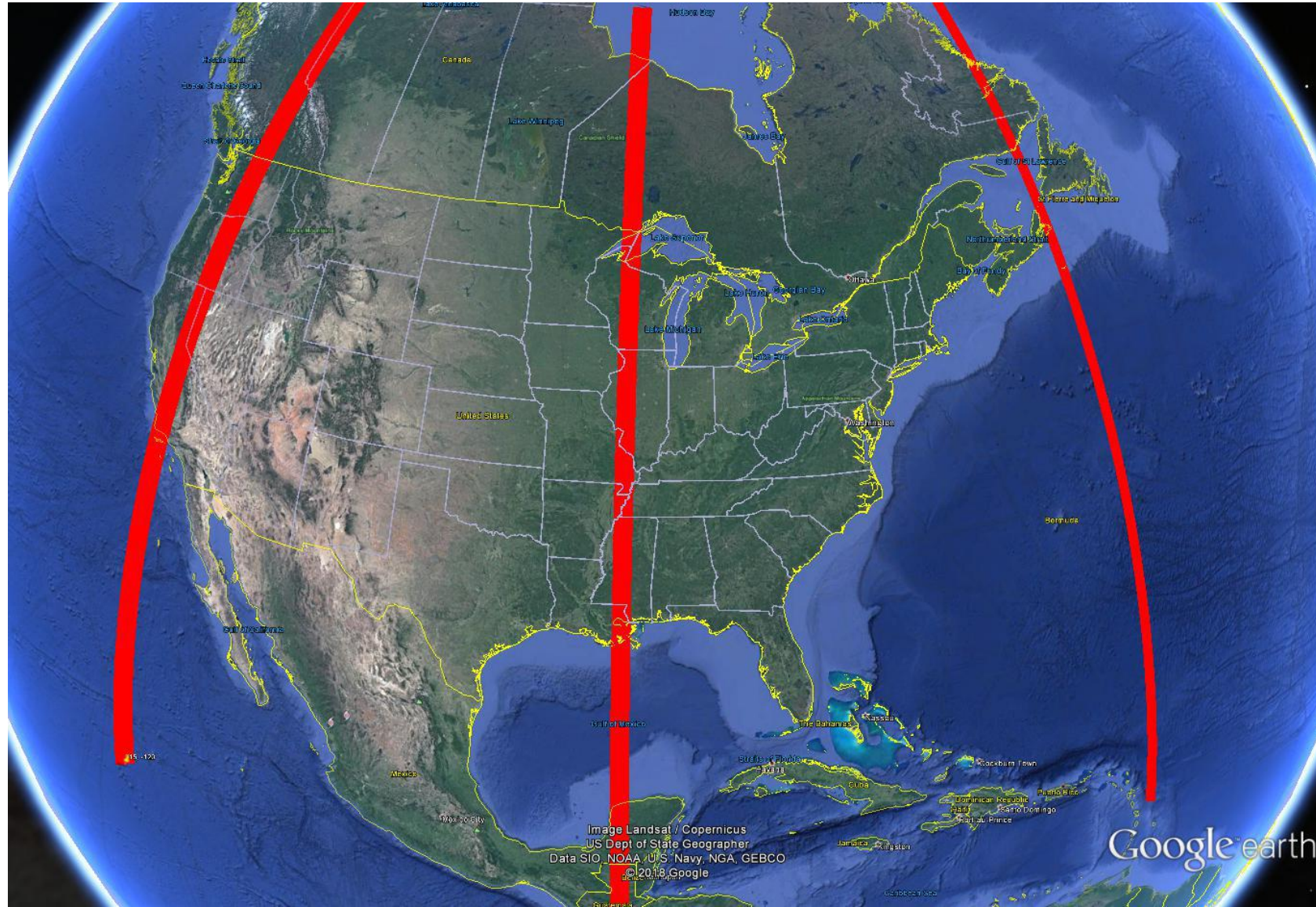
For illustration and discussion purposes only

http://raqms-ops.ssec.wisc.edu/previous_products/20180417/O3_xsection_180417.gif



RAQMS₆ -24hr OMI/MLS ASSIM Initialized 12Z 20180417

RAQMS -60°, -90° and -120° Cross Section Locations



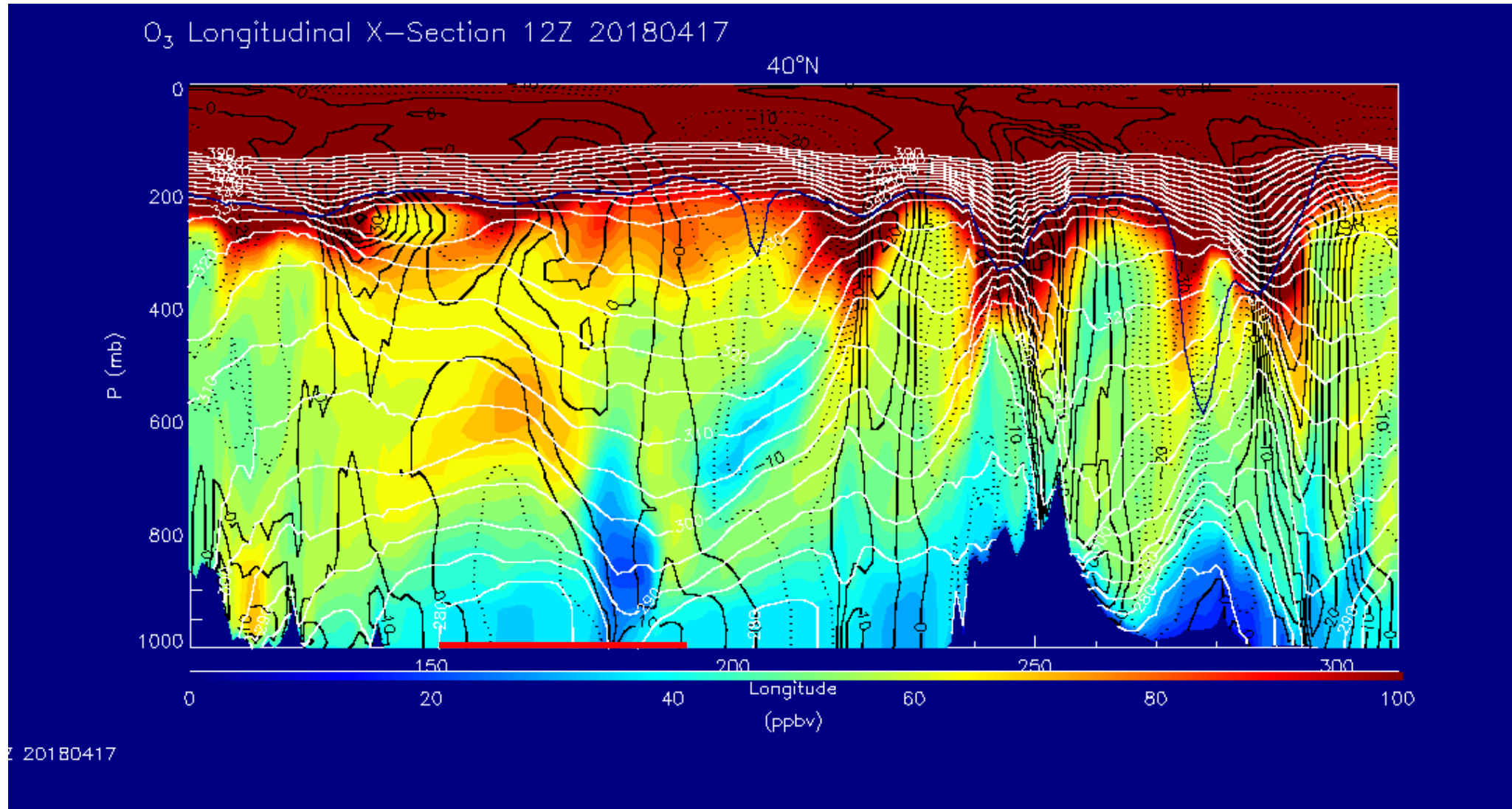
If graphic does not animate within this file, you may view it with animation at the web link provided.

RAQMS Longitudinal Cross Section Animated

GIF, April 17-22, 2018

For illustration and discussion purposes only

http://raqms-ops.ssec.wisc.edu/previous_products/20180417/O3_ysection_180417.gif

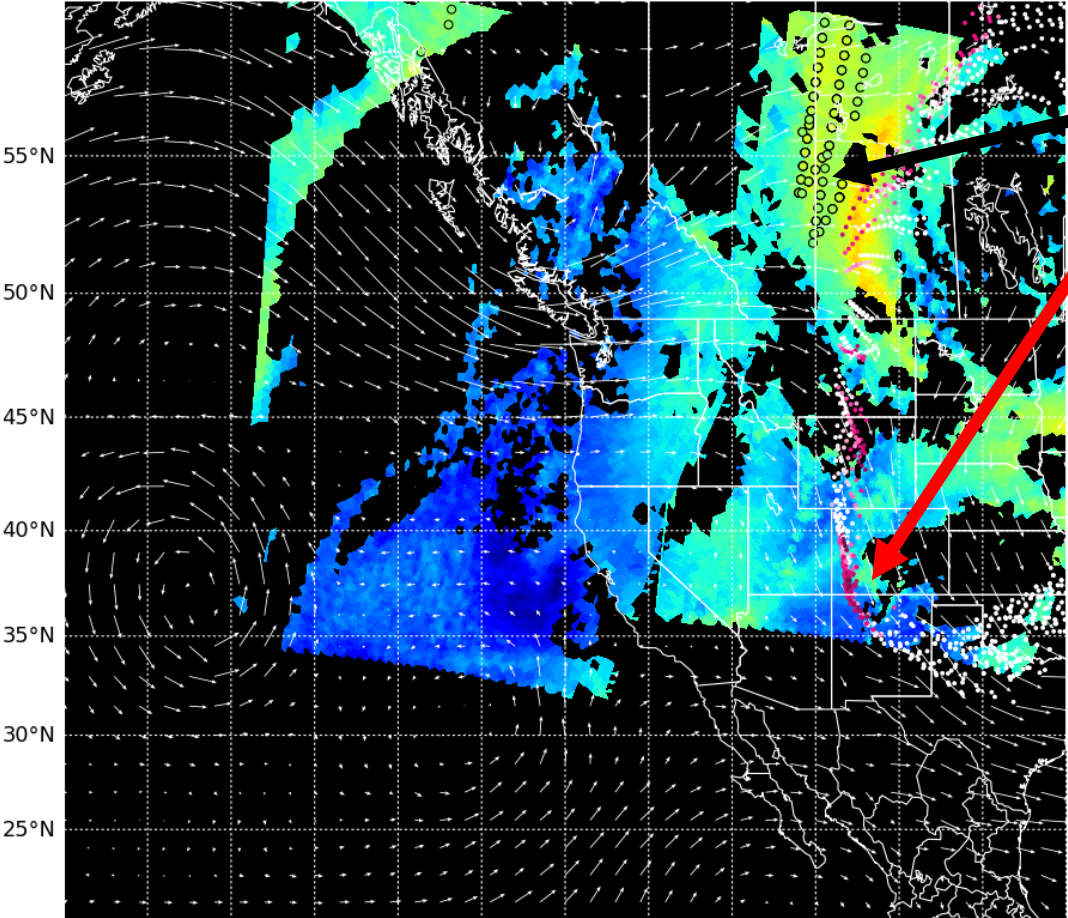


IDEA-I Satellite Ozone Trajectory Forecasts

- <http://smoke.ssec.wisc.edu/idea-i-ozone-live-test/index.php>
- Real-time forward projection of 516 mb satellite detected intrusion ozone using atmospheric trajectory models
 - 2-day forward trajectory animations
- Archived back to August 23, 2016
- Satellite ozone retrievals from both EOS Atmospheric Infrared Sounder (AIRS) and JPSS Cross Track Infrared Sounder (CrIS)

IDEA-I Trajectory Forecast, May 22, 2017

CrIS Ozone & Ozone Trajectories on 2017-05-24 00Z
CrIS swath start times: 709Z 850Z 850Z 1031Z



- CrIS 516mb ozone retrieval 09z, May 22, 2017
- 80 – 100 ppb ozone over Central Alberta
- Forward trajectories descend to below about 600 mb (surface – trajectory pressure < 200 mb) over SW Colorado at 00Z May 24 (39 hours in future)

Pressure altitude units for trajectory:
Surface pressure minus trajectory pressure

