

# Modeling and forecasting for WINTER

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*Mission planning*  
*Mission execution*  
*Post-mission data analysis*

GEOS-5 chemical forecasts

GEOS-Chem chemical transport simulations

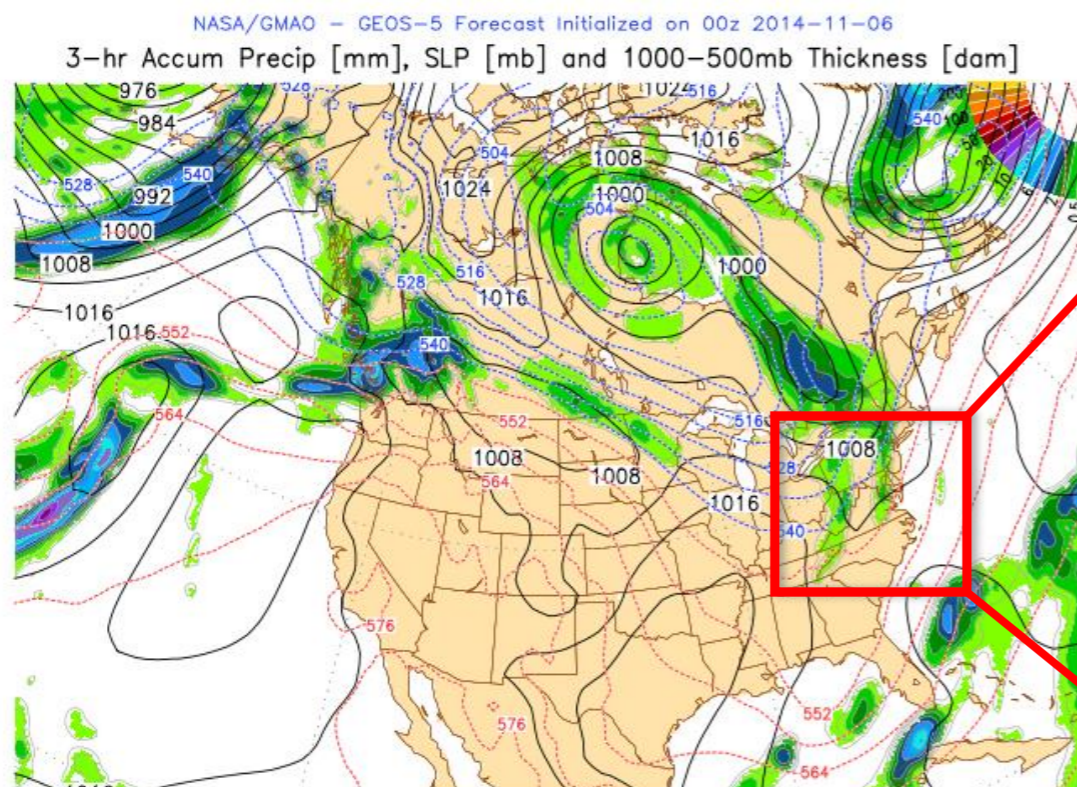
# GEOS-5 chemical forecasts

NASA GSFC Code 614 and GMAO forecasts with GEOS-5 model:

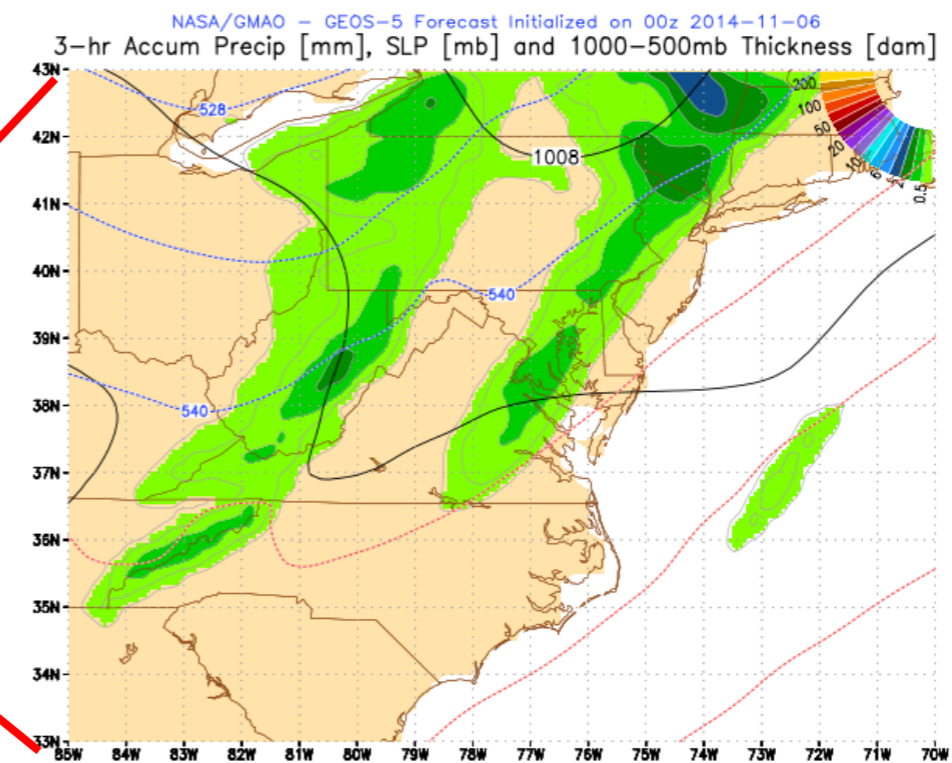
- 10-day global forecasts every 12 hours.  $1/4^\circ$  resolution.
- Meteorology: GEOS-5 Atmospheric Data Assimilation System & GEOS-5 GCM. Winds, precip, RH, cloud cover, temp, radiation, etc...
- Assimilation of aerosol optical thickness based on MODIS
- GEOS-5 online Aerosol/Chemistry: 20 tracers

Forecast for Sunday initialized yesterday:  
Precipitation, SLP

Zoom on Mid-Atlantic region



81-hr forecast valid Sun 09z 2014-11-09



81-hr forecast valid Sun 09z 2014-11-09

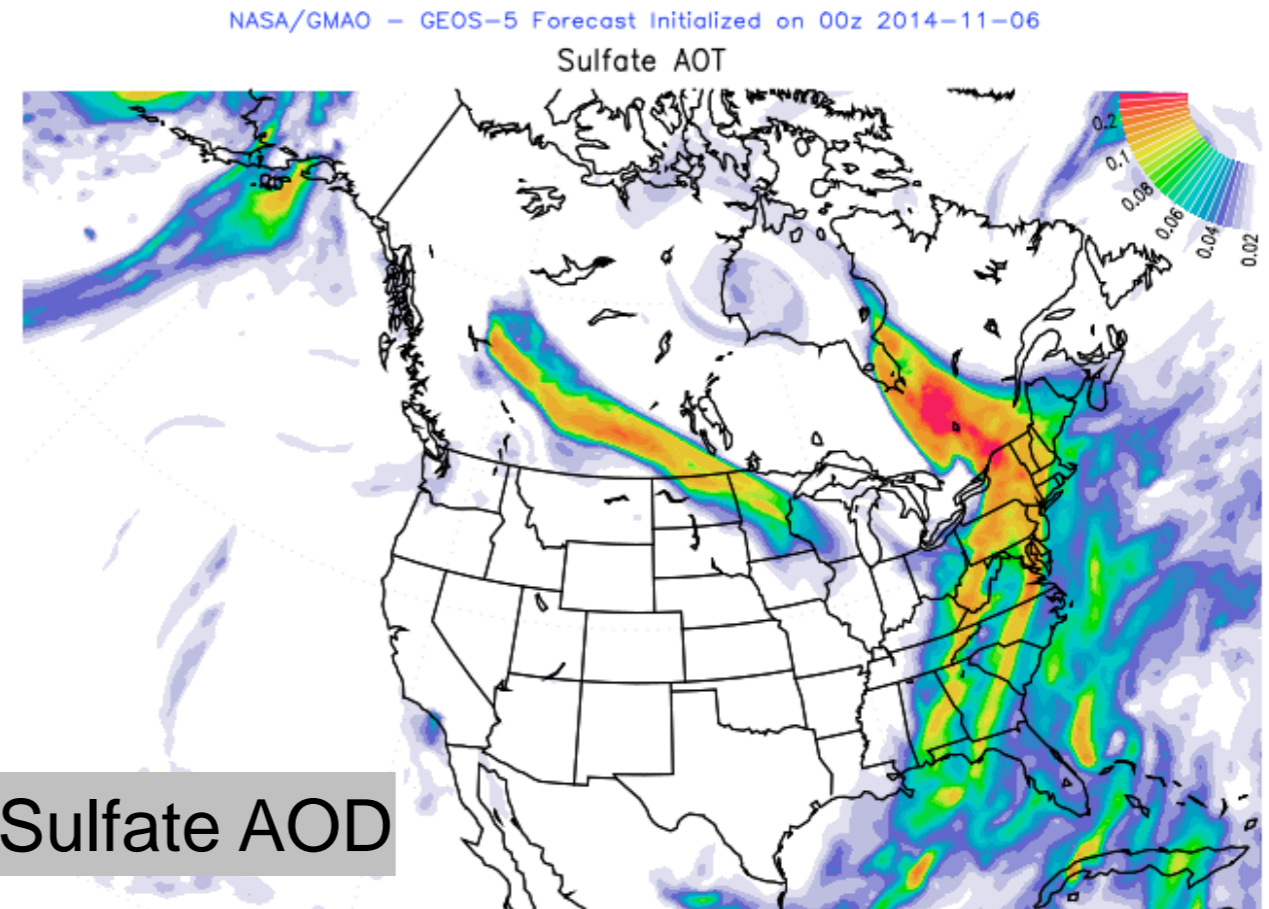


# GEOS-5 forecasts

<http://gmao.gsfc.nasa.gov/forecasts/>

## 20 Tracers

- Global CO and CO<sub>2</sub> tracers
- 9 tagged CO tracers (N. America FF tracer)
- GOCART aerosols (SO<sub>2</sub>, DMS, sulfate, BC, OC, sea salt, dust)
- CFC-12 (trop and strat origin)



81 hr forecast valid Sun 09z 2014-11-09

<http://coco.atmos.washington.edu/cgi-bin/ion-p?page=winter.ion>

Web-based interactive visualization for WINTER:

- server at UW (used for NOMADSS, ARCTAS, INTEX, ITCT2K2)
- maps, cross section, animations for specific regions and tracers
- sample forecasts along planned aircraft flight track

WINTER: GEOS-5 chemical forecasts and GEOS-Chem hindcast/NRT simulations

University of Washington  
Lyatt Jaeglé, Viral Shah

GEOS-5 forecasts and GEOS-Chem hindcast/near real time simulations

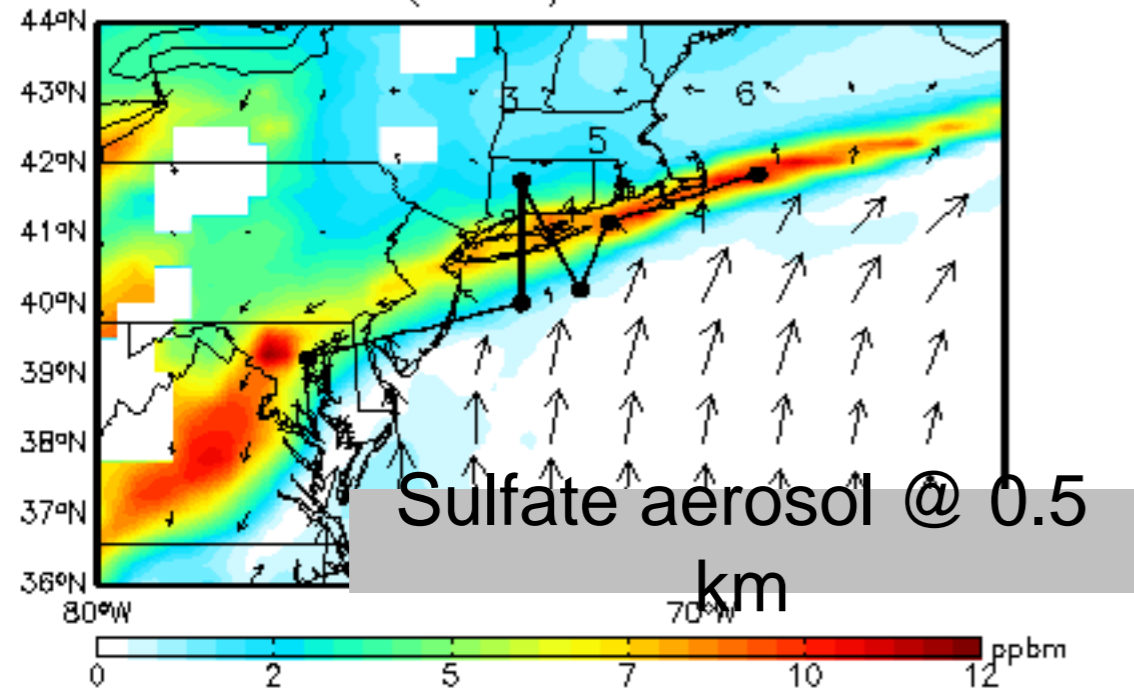
|                                     |                      |                                   |
|-------------------------------------|----------------------|-----------------------------------|
| GEOS-5 1/4 degree forecast browser: | 20141008_12 (latest) | Start 1/4 degree forecast browser |
| GEOS-5 1/2 degree hindcast browser: |                      | Start hindcast browser            |
| GEOS-Chem Near Real Time browser:   | Available soon       | Start NRT browser                 |

WINTER  
The Wintertime Investigation of Transport, Emissions, and Reactivity (WINTER) field campaign will use the C-130 aircraft and will be based in Hampton, Virginia for a 6 week period: February 1 - March 15 2015. For more information, please see the UCAR web site.

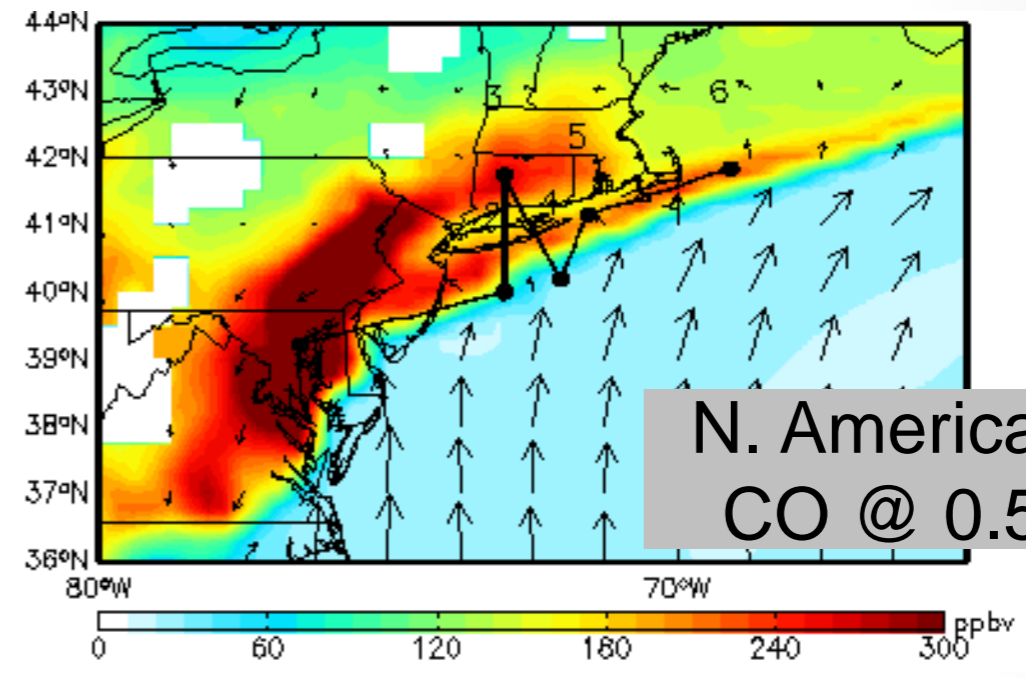
# Sample forecasts along flight track

GEOS-5 forecast: Initialized 20140327\_00

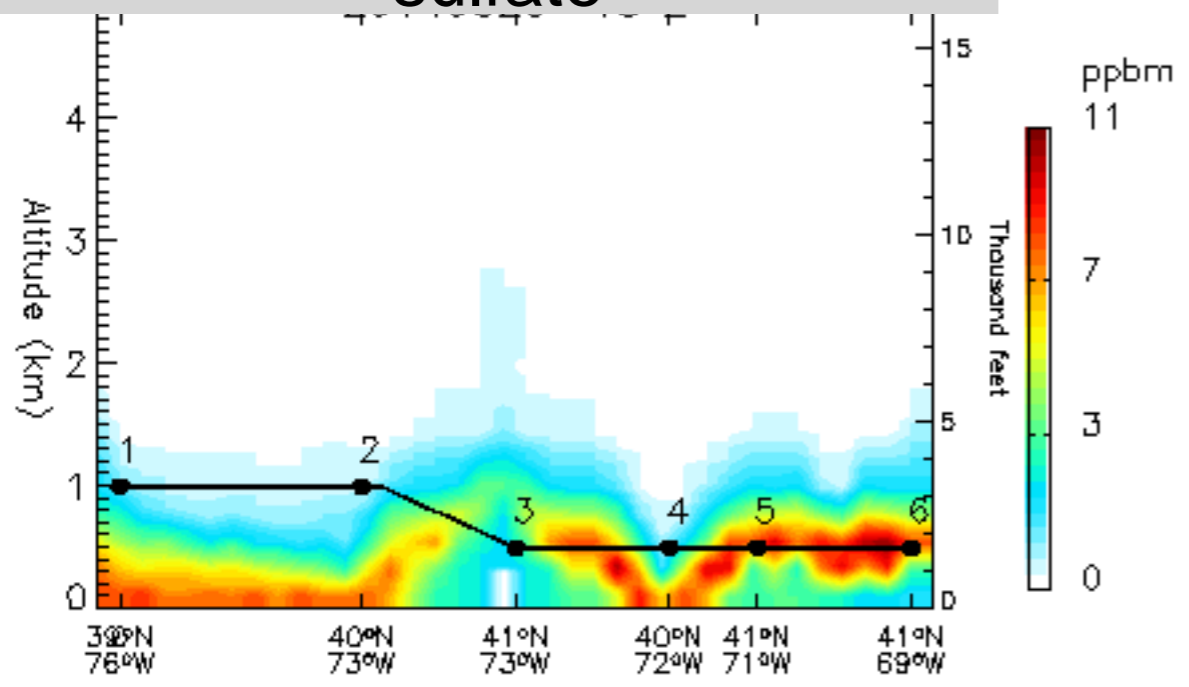
SULPHATE AEROSOL MIXING RATIO  
950 hPa ( 0.5 km) 20140329 18 Z



## ○ Example: pollution outflow



## Curtain plot along flight track: sulfate



**WINTER: GMAO GEOS-5 chemical forecasts**  
Interactive visualization  
Forecast Day: 20141106\_00

**GENERAL OPTIONS**

Plot 1: Level/Type: 850 hPa ( 1.5 km) | Day (or start day for animation): 20141106 | Hour: 00 Z | Species: so2 mixing ratio

Plot 2: Level/Type: 850 hPa ( 1.5 km) | Day (or end day for animation): 20141112 | Hour: 00 Z | Species: CO North America FF

**REGION SELECTION**

|                         | Minimum | Maximum |   |
|-------------------------|---------|---------|---|
| Plot 1 Latitude range:  | 25      | 50      |   |
| Plot 1 Longitude range: | -100    | -60     |   |
| Plot 2 Latitude range:  | 25      | 50      | <input checked="" type="checkbox"/> same as plot 1                    |
| Plot 2 Longitude range: | -100    | -60     |   |
| Plot 1 value range:     | 0       | 3       | <input type="checkbox"/> Automatic <input type="checkbox"/> Log scale |
| Plot 2 value range:     | 0       | 150     | <input type="checkbox"/> Automatic <input type="checkbox"/> Log scale |

**DISPLAY AND MAP OPTIONS**

Colortable:  DIAL  WhGrYIRd | Gridlines:  | Orthographic Projection:  Plot 1  Plot 2

Overplot winds:  Plot 1  Plot 2 | Coarse pixels:  | Polar Projection:  Plot 1  Plot 2

**CURTAIN PLOT OPTIONS**

Plot 1  Plot 2 | Choose a flight track by pattern:

Or select "None" in the above and enter latitudes, longitudes, altitudes separated by commas.  
For a curtain plot, select 'Curtain Plot' in Plot:Level/Type menu.

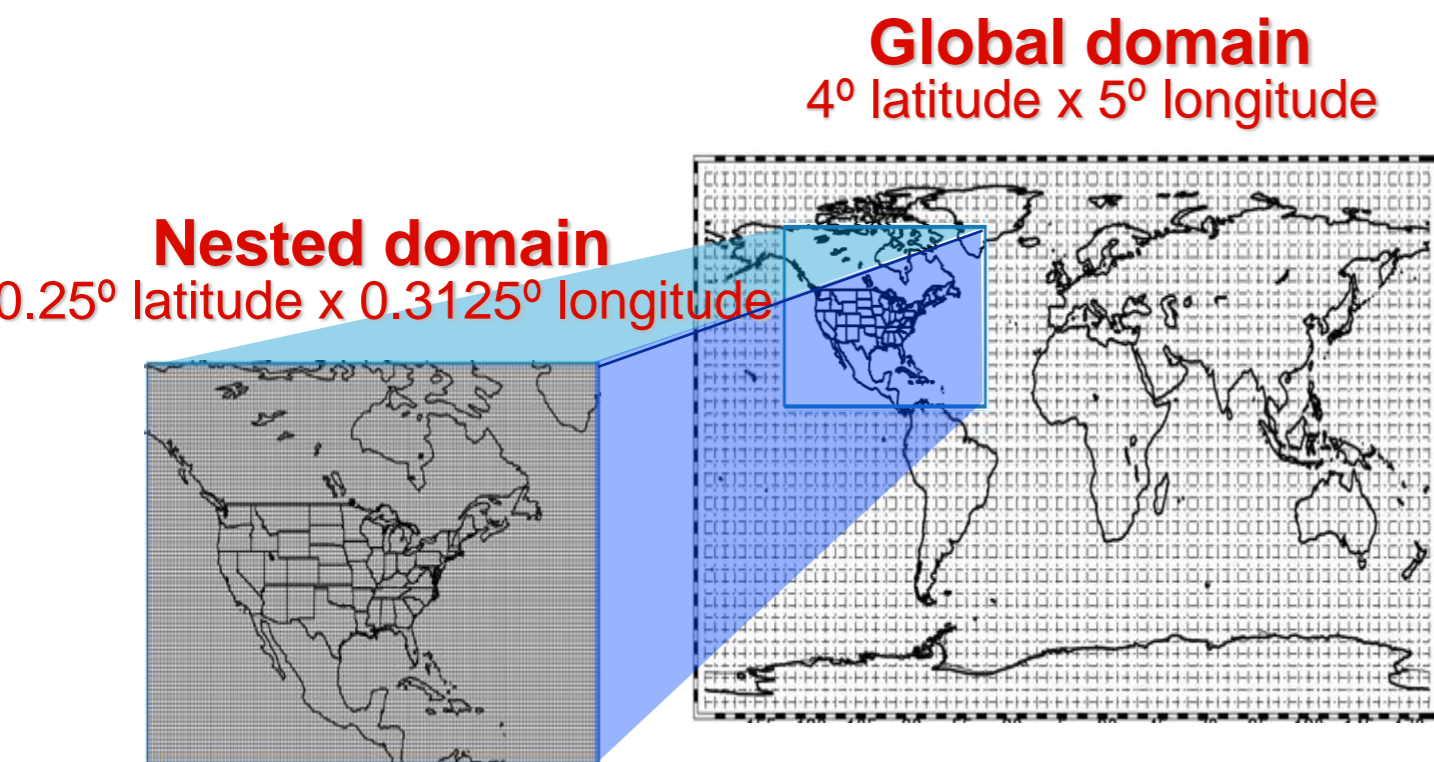
Latitudes (N):   
Longitudes (E):   
Altitudes (km):

PLOT Animation Save as postscript EXIT



# GEOS-Chem chemical transport model

- Global 3D model  $4^\circ \times 5^\circ$  resolution, 47 vertical levels
- Nested grid simulation  $0.25^\circ \times 0.3125^\circ$  (~25 km) over N. America
- GEOS-5 assimilated meteorology NASA GMAO
- Aerosol-oxidant simulation
  - Oxidant chemistry:  $\text{HO}_x$ - $\text{NO}_x$ - $\text{O}_3$ - VOC- $\text{BrO}_x$
  - Simple  $\text{ClNO}_2$  scheme from  $\text{N}_2\text{O}_5$  hydrolysis
  - Aerosols:  $\text{SO}_4^{2-}$ - $\text{NH}_4^+$ - $\text{NO}_3^-$ , organic carbon (Hodzic & Jimenez, 2011: primary and secondary OA from FF, BB, + SOA from isoprene, monoterpenes), BC, dust, sea salt
  - Emissions: Anthropogenic (NEI2008), vegetation, soils, fires, lightning



- Before mission: run multi-winter simulation
- During mission: Near-Real-Time (NRT) simulations 2-3 days after flights → quick comparison to obs
- After mission: data analysis

# Hindcast simulations with GEOS-Chem

Hindcast simulations for Feb 1-Mar 15: 2009, 2010, 2011, 2012, 2013

Animations posted on web site, interactive access

<http://www.atmos.washington.edu/~jaegle/WINTER/planning.html>

tml

home GEOS-5 forecasts NRT Planning About this interface

WINTER: GEOS-5 chemical forecasts and GEOS-Chem hindcast/NRT simulations

Planning animations for WINTER

You can access here GEOS-Chem simulations of wintertime chemical composition for flight planning. These simulations were conducted for the winters of 2009-2013 using the GEOS-5 meteorological fields at a horizontal resolution of 0.5°x0.667° over N. America, with boundary conditions provided by a global 4°x5° resolution simulation. We used the GEOS-Chem model version v9-02. Results are archived between Jan 30 and March 16 of each year, 4 times daily (0 GMT = 7 pm EST; 6 GMT = 1 am EST; 12 GMT = 7 am EST; 18 GMT = 1 pm EST).

Below are animations for each year. You can also generate your own plots by using our interactive interface.

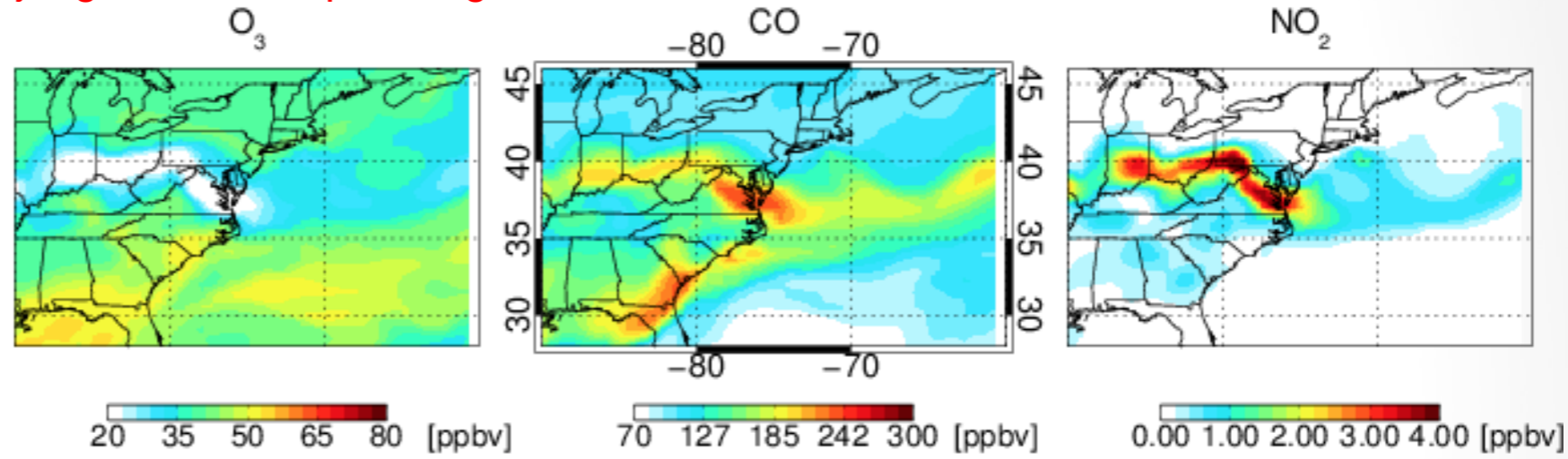
Questions? Requests? Please contact Lyatt Jaegle ([jaegle@uw.edu](mailto:jaegle@uw.edu))

**2009 (January 30 - March 16):**

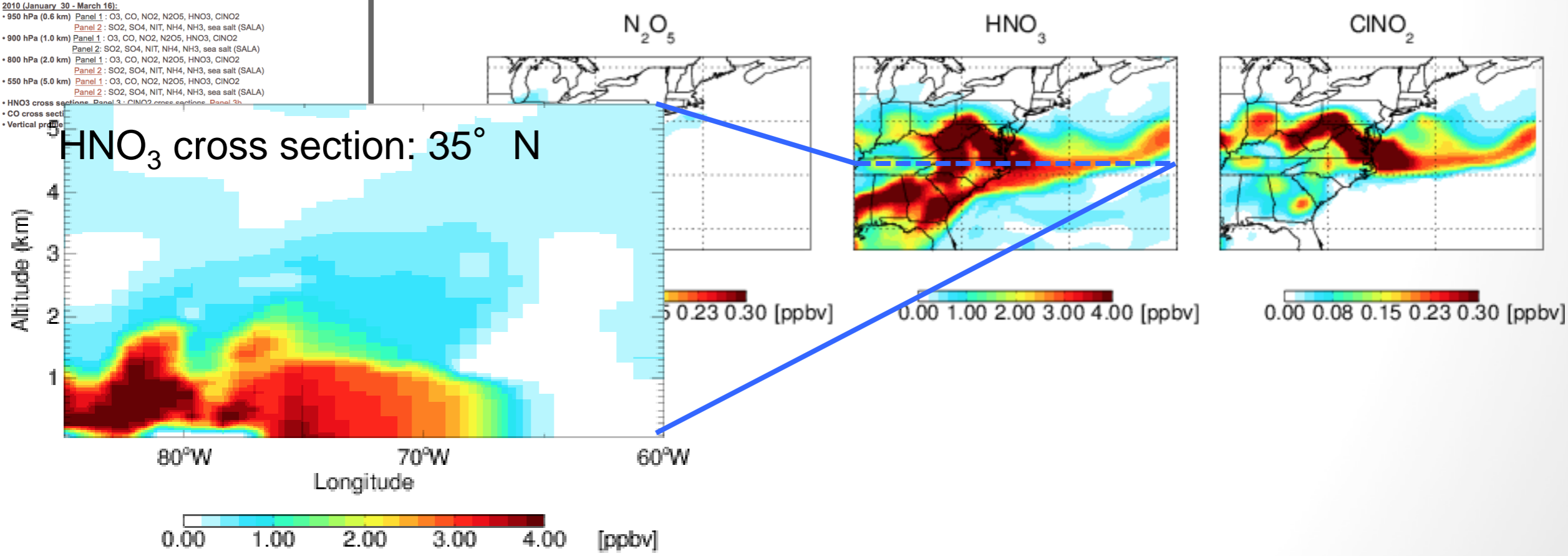
- 950 hPa (0.6 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA); Panel 2b: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 900 hPa (1.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 800 hPa (2.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 550 hPa (5.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- HNO<sub>3</sub> cross sections Panel 3; ClNO<sub>2</sub> cross sections Panel 3b
- CO cross sections Panel 4
- Vertical profiles (35-40N; 74-70W) Panel 5

**2010 (January 30 - March 16):**

- 950 hPa (0.6 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 900 hPa (1.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 800 hPa (2.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- 550 hPa (5.0 km) Panel 1: O<sub>3</sub>, CO, NO<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, HNO<sub>3</sub>, ClNO<sub>2</sub>; Panel 2: SO<sub>2</sub>, SO<sub>4</sub>, NIT, NH<sub>4</sub>, NH<sub>3</sub>, sea salt (SALA)
- HNO<sub>3</sub> cross sections Panel 3; ClNO<sub>2</sub> cross sections Panel 3b
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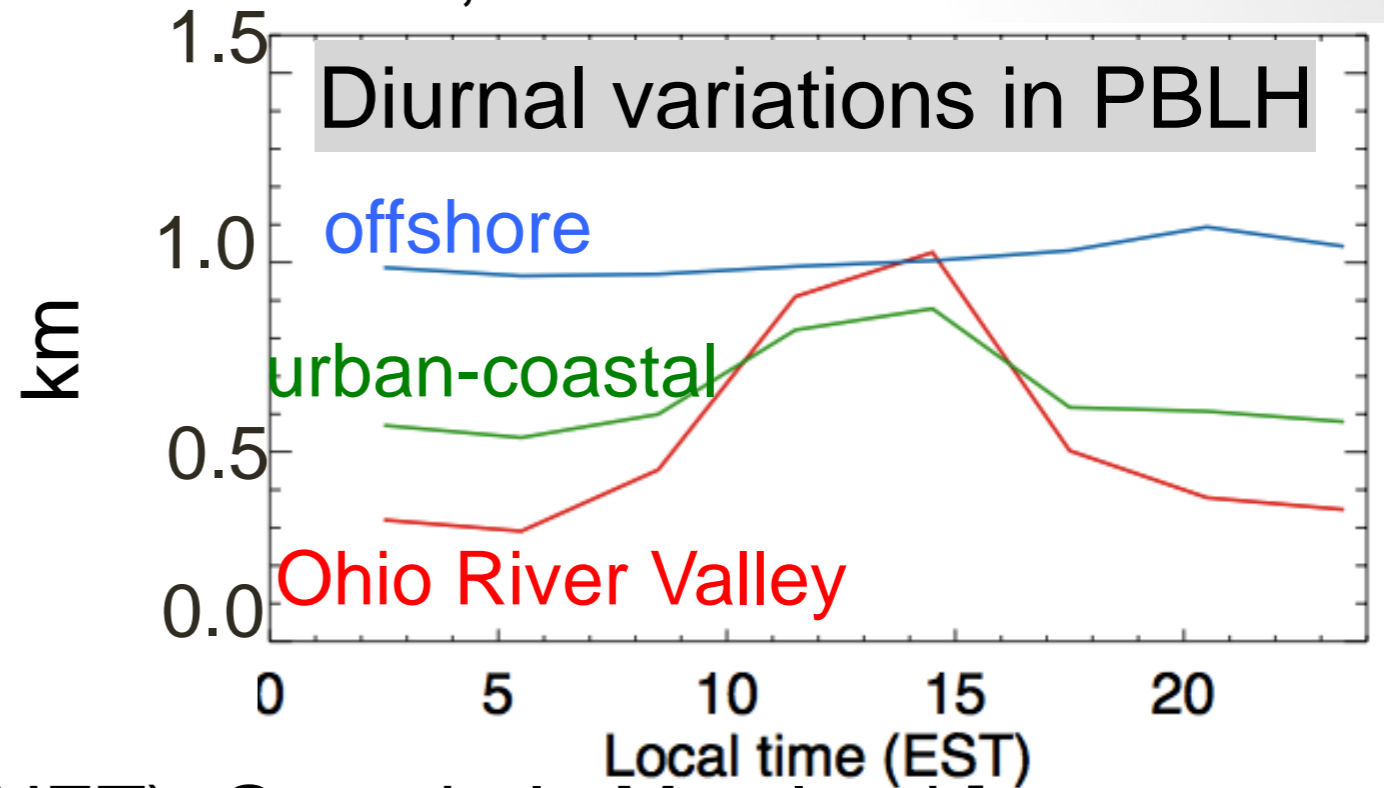
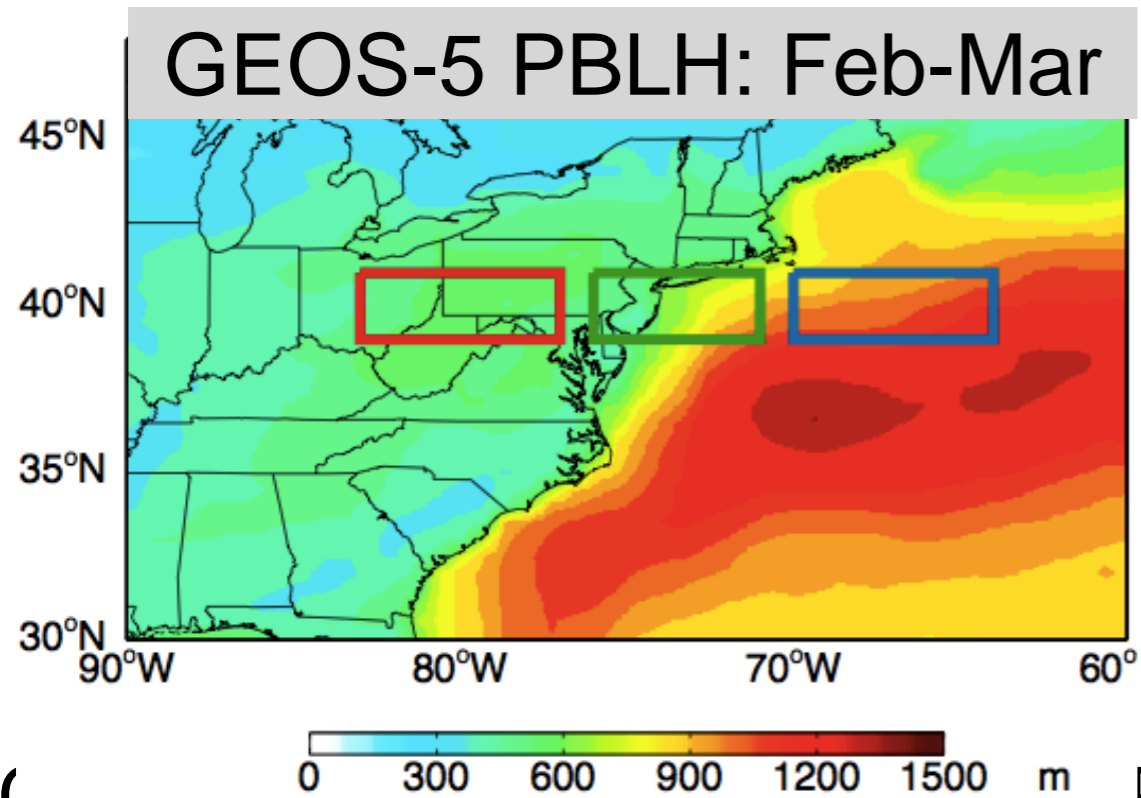


20120208 at 12 GMT (7 am EST), 898 hPa( 1.0 km)

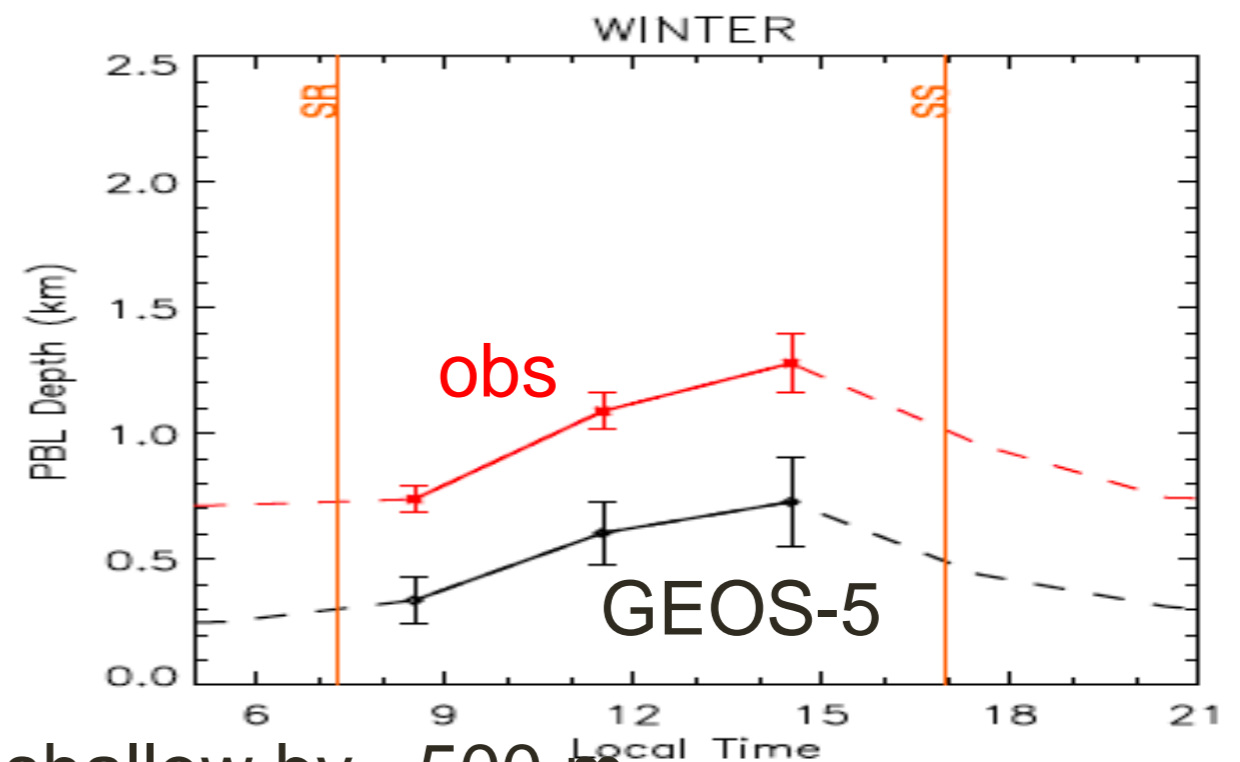
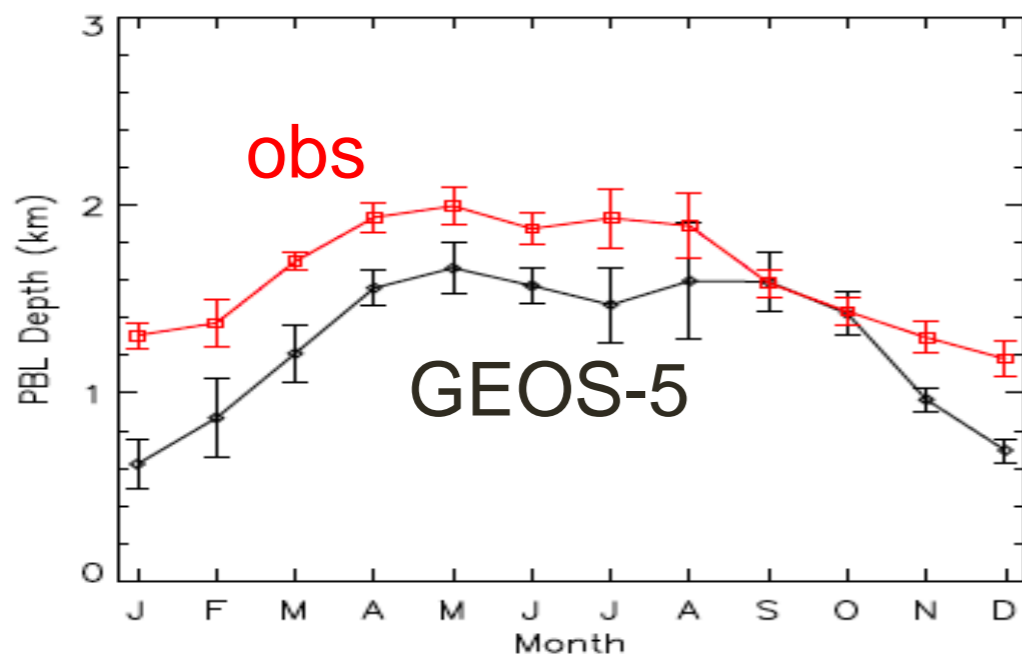


# Boundary layer height during Feb-Mar

□ Three boxes: **Ohio River Valley**, **urban-coastal**, **offshore**



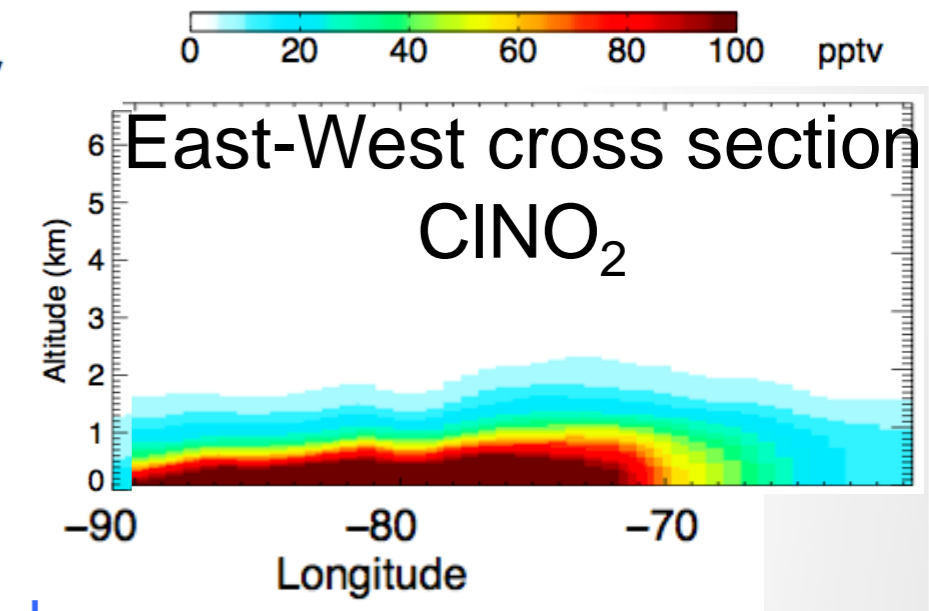
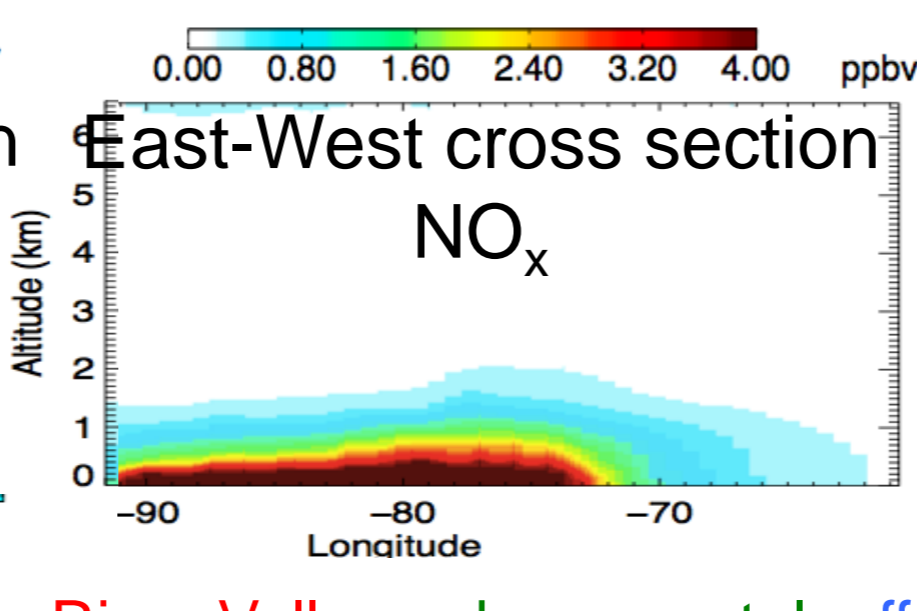
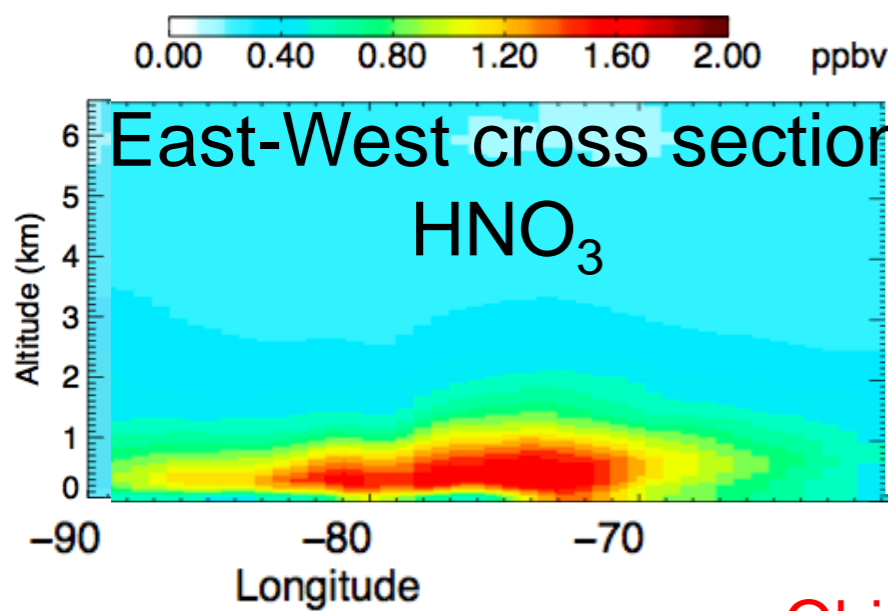
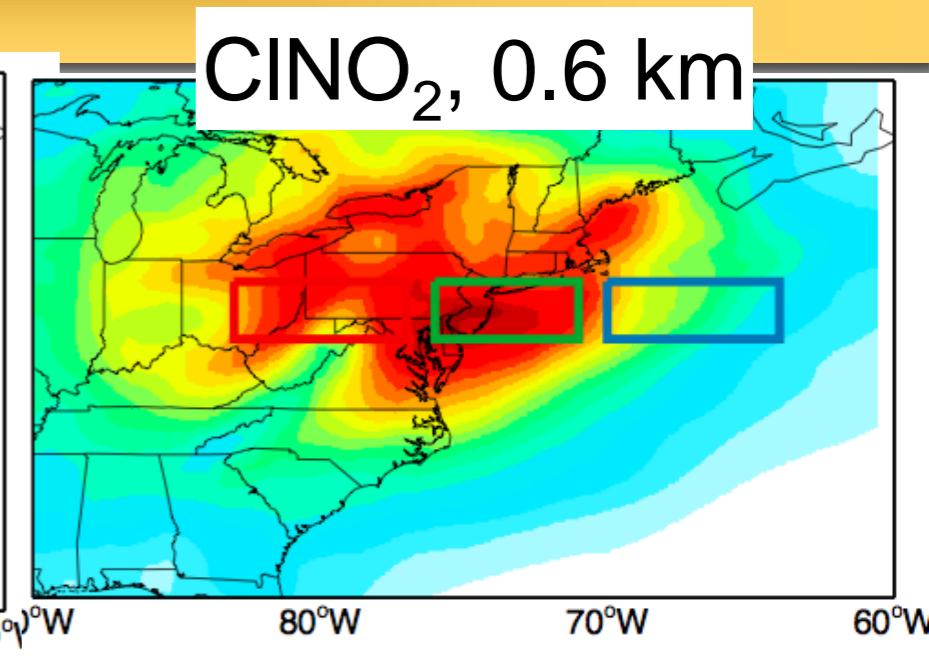
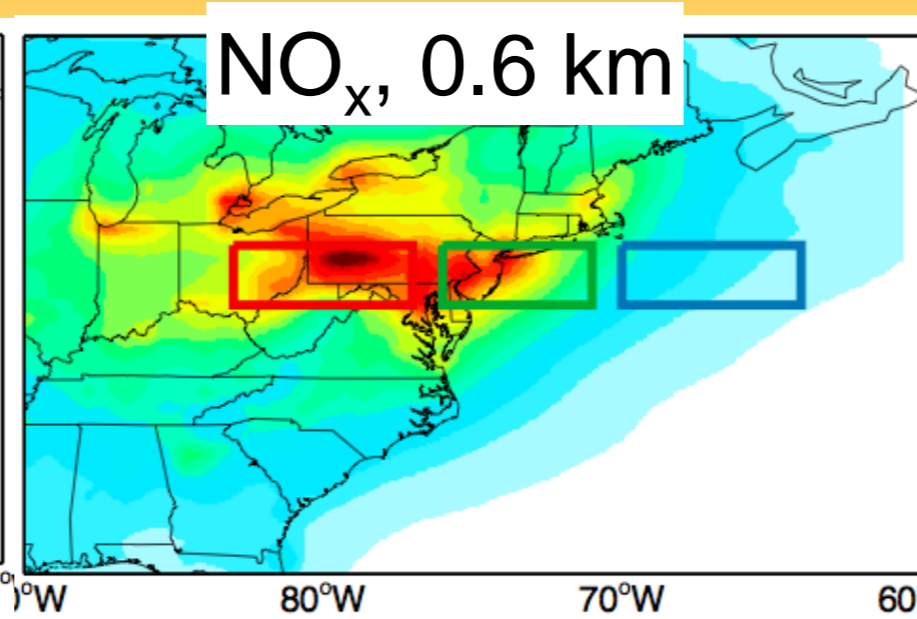
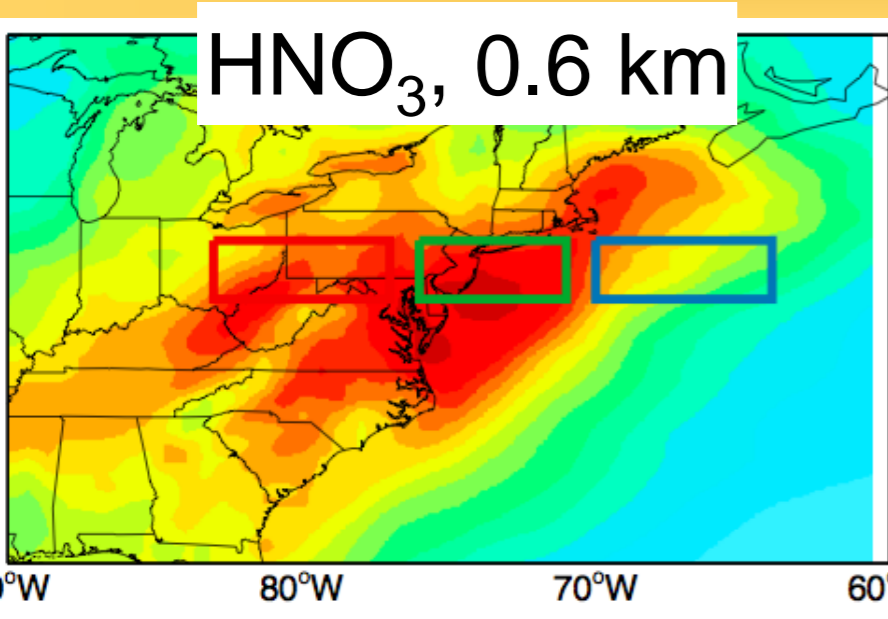
Comparison observed PBLH (MIPLNET): Greenbelt, Maryland [Lewis et al., 2013]



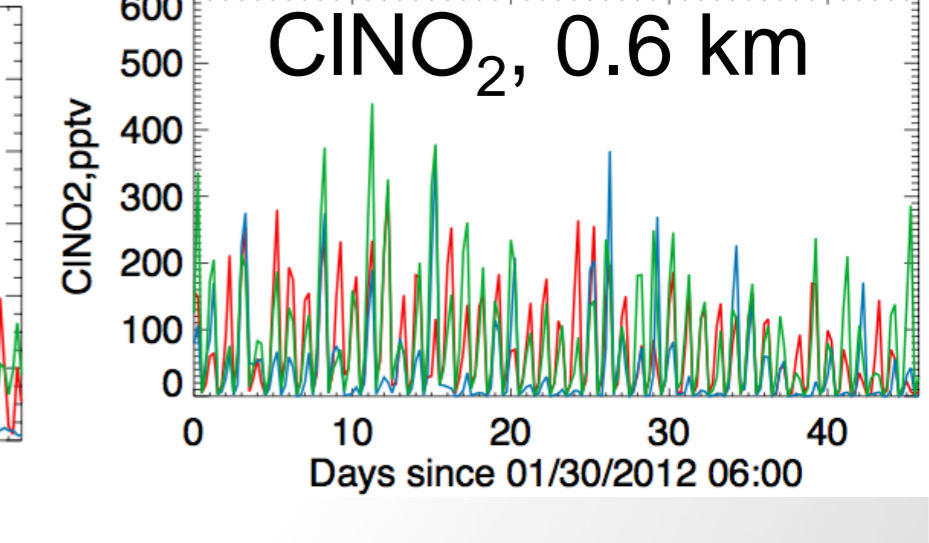
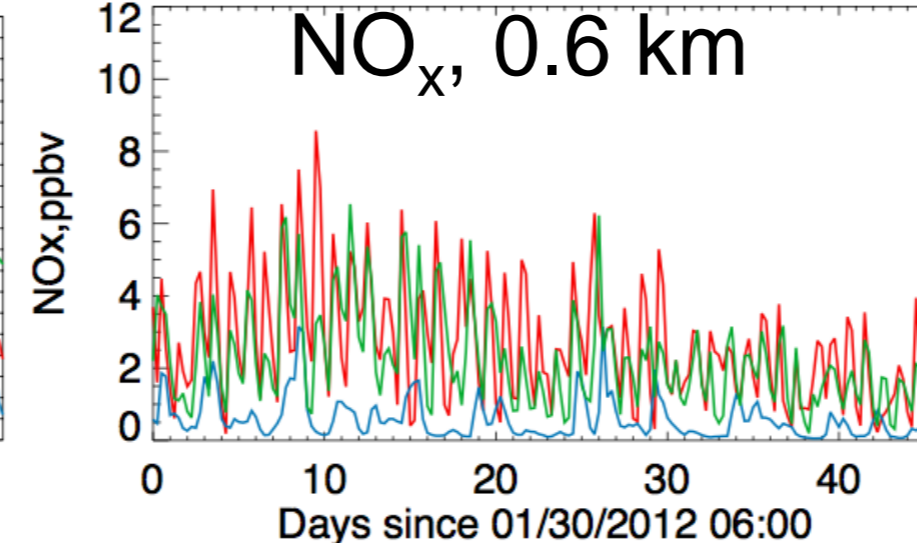
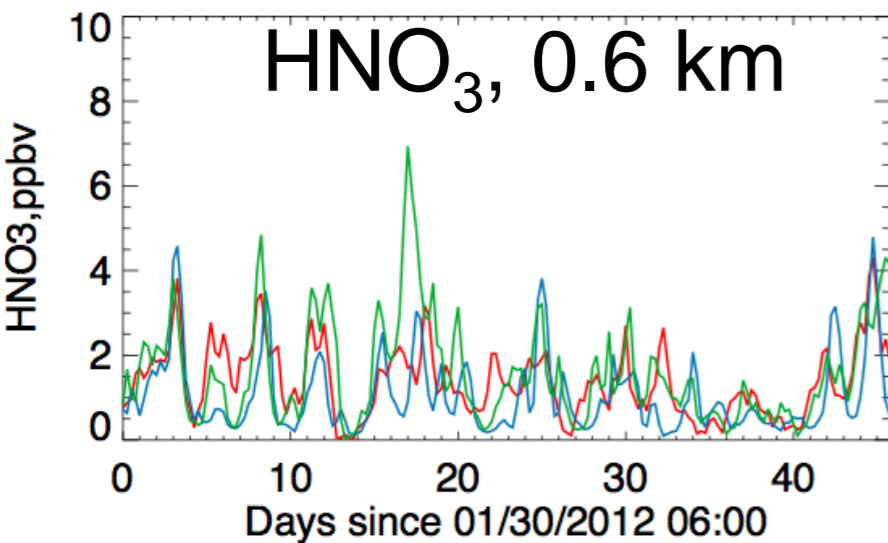
→ GEOS-5 PBL too shallow by ~500 m



# HNO<sub>3</sub>, NO<sub>x</sub>, CINO<sub>2</sub>: Feb-Mar 2012



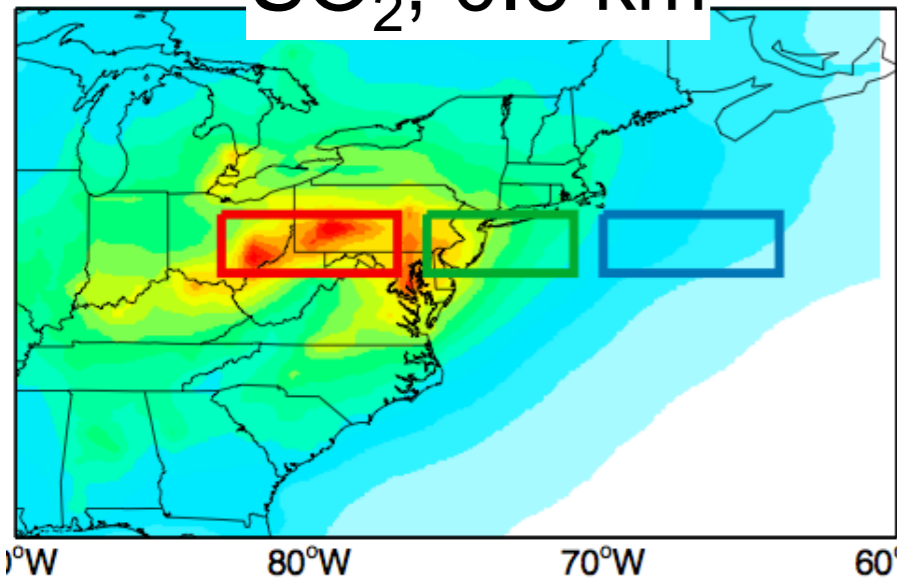
Ohio River Valley, urban-coastal, offshore





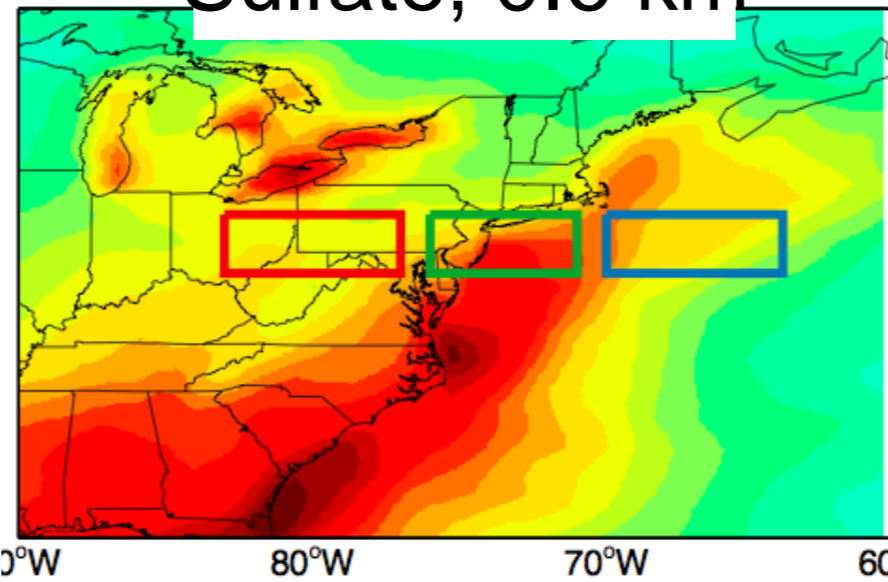
# SO<sub>2</sub>, sulfate and nitrate. Feb-Mar 2012

## SO<sub>2</sub>, 0.6 km



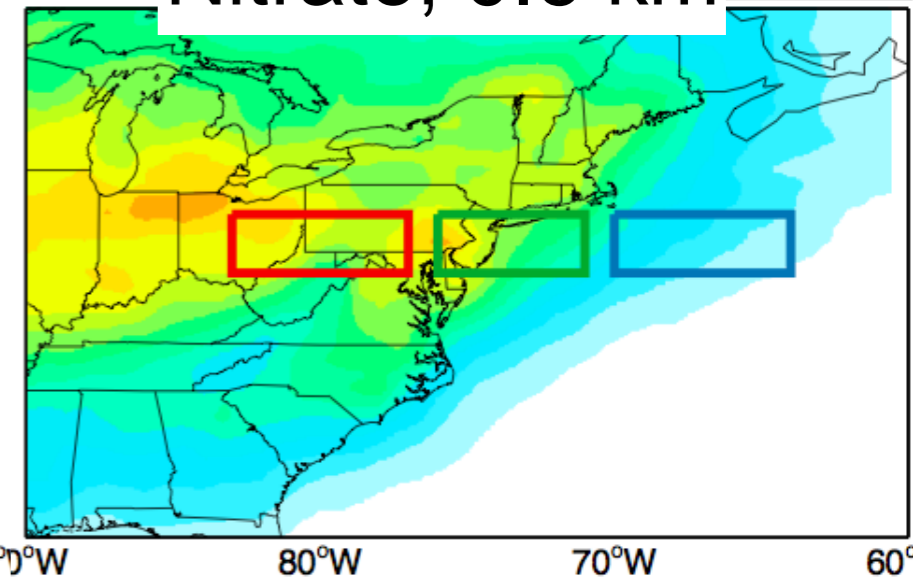
0.00 0.80 1.60 2.40 3.20 4.00 ppbv

## Sulfate, 0.6 km



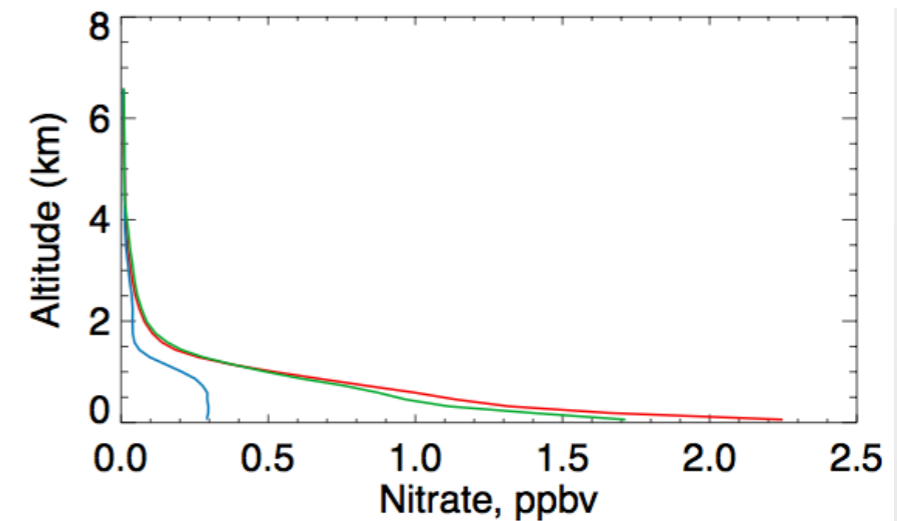
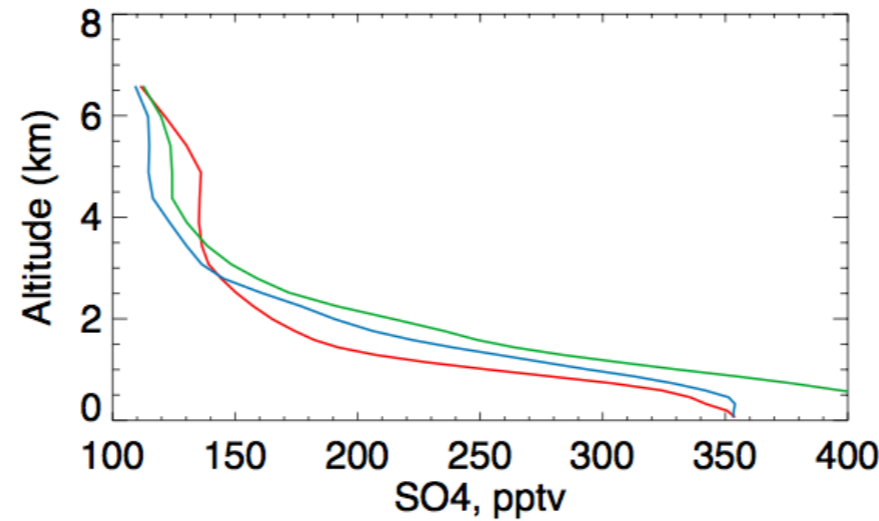
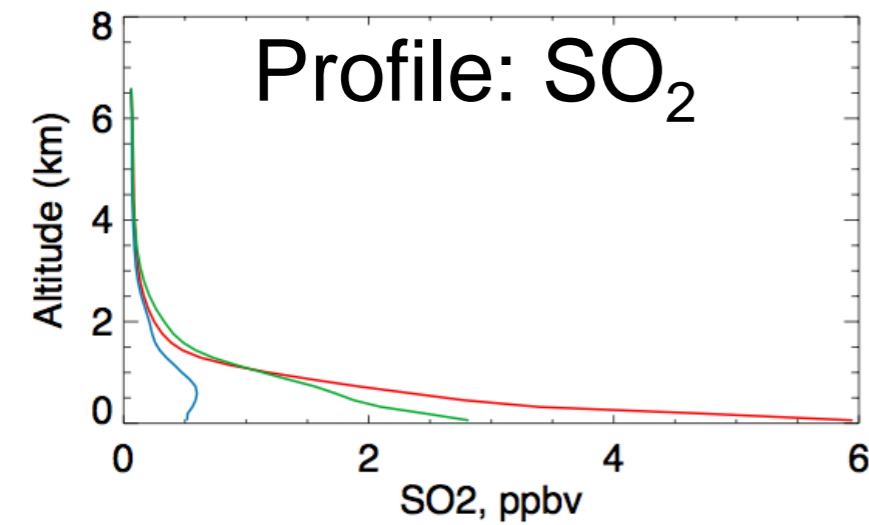
0 120 240 360 480 600 pptv

## Nitrate, 0.6 km

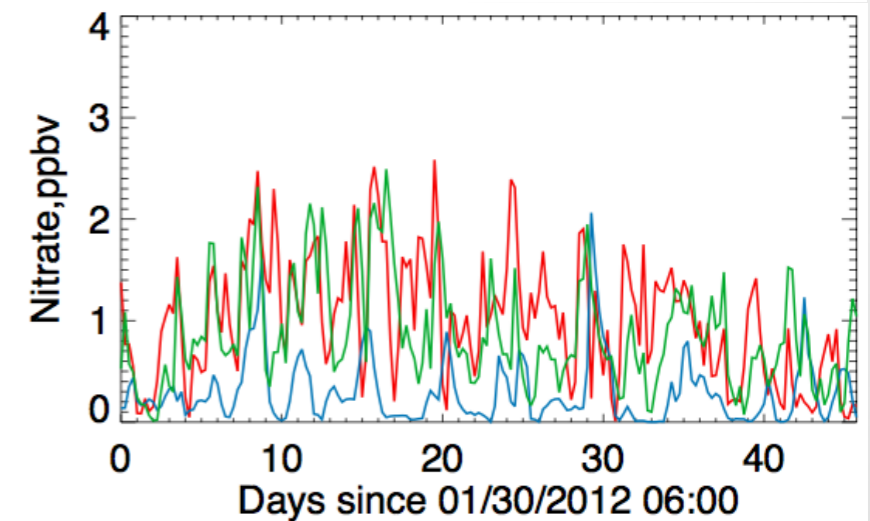
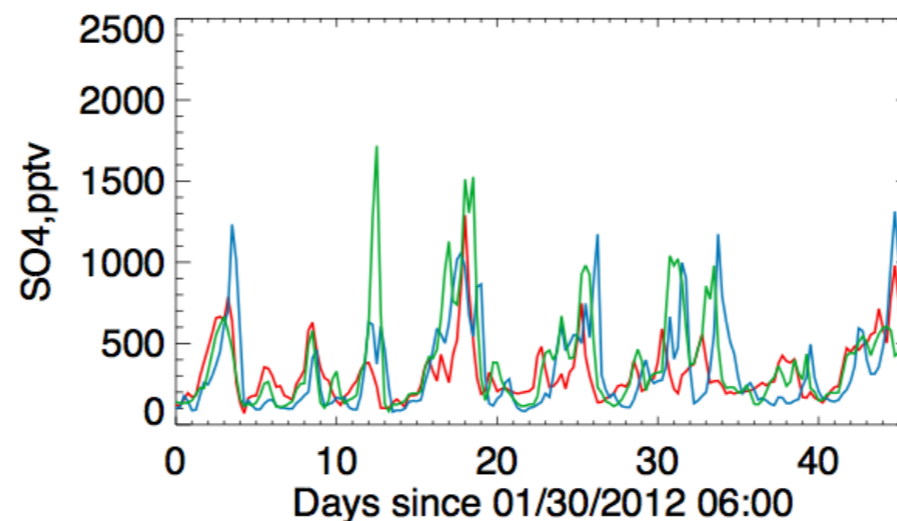
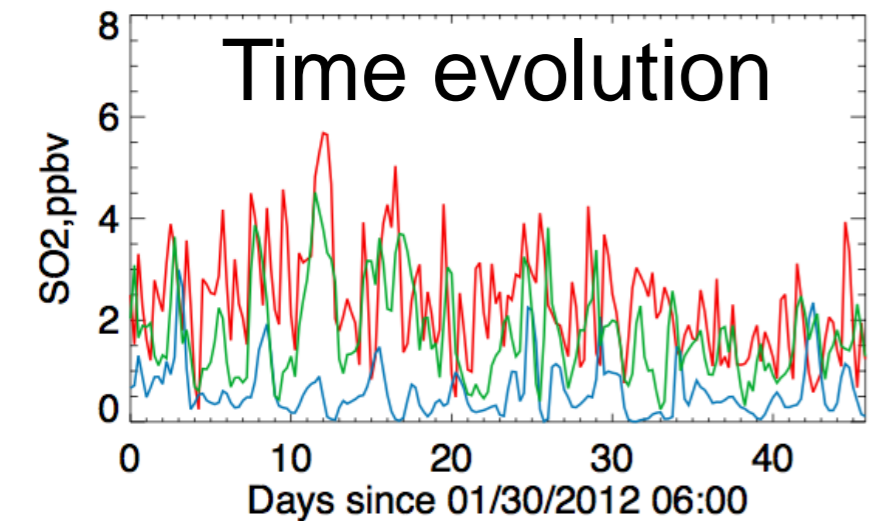


0.00 0.40 0.80 1.20 1.60 2.00 ppbv

## Profile: SO<sub>2</sub>

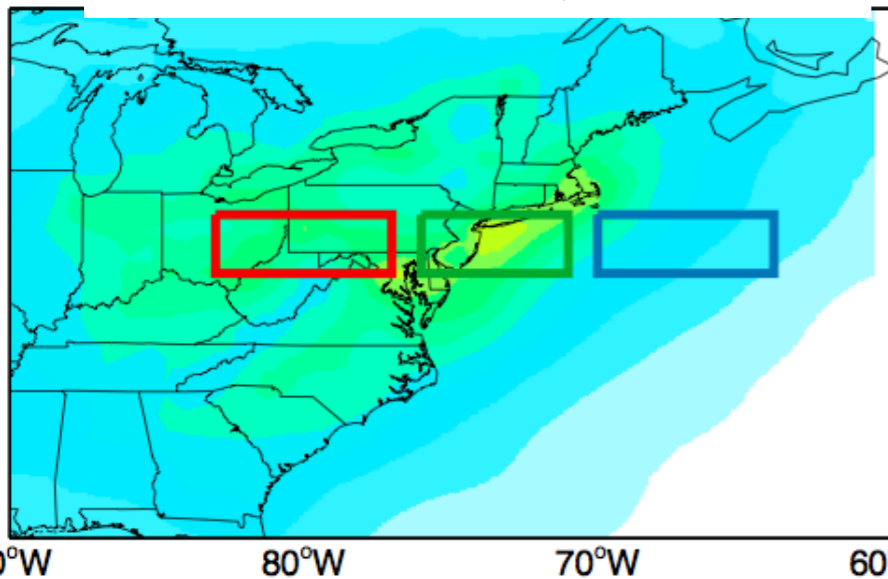


## Time evolution



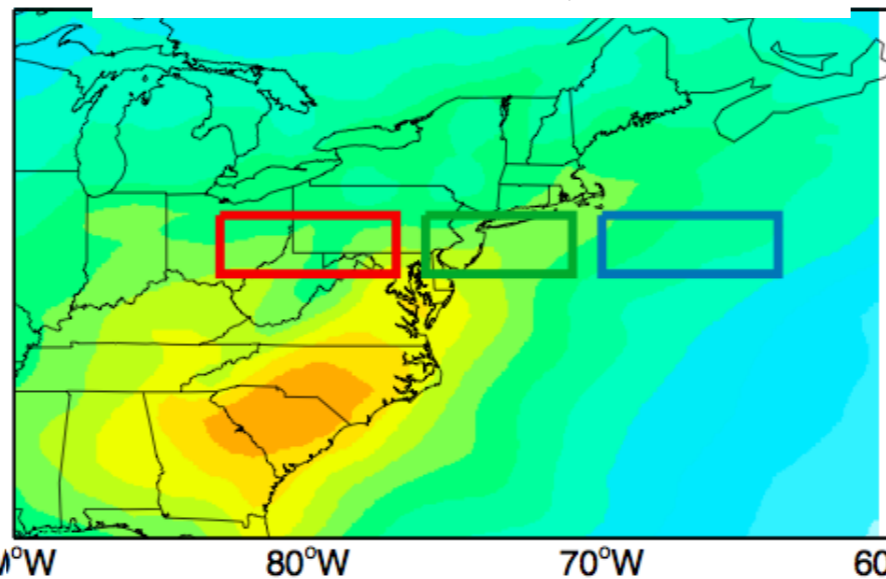
# Organic aerosols: Feb 2009

Anthro. POA, 0.6 km



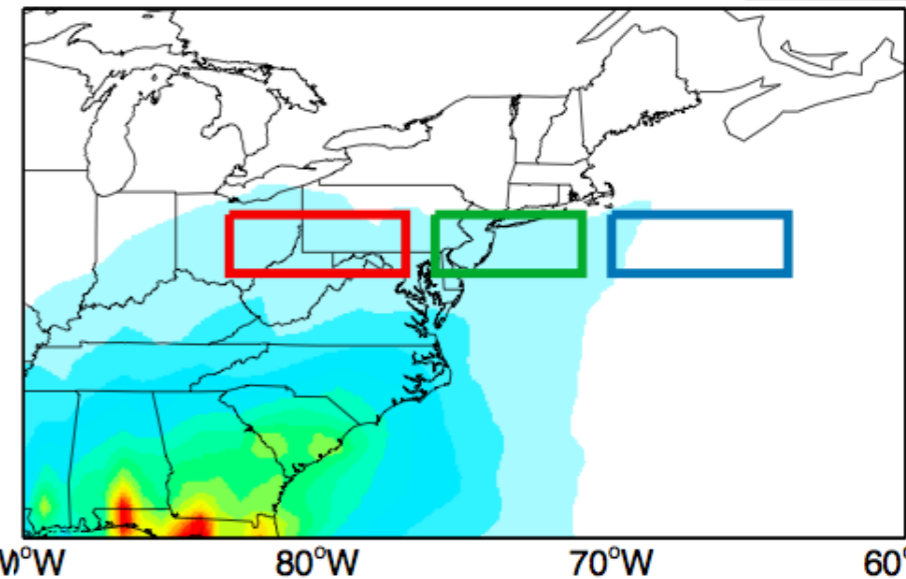
0.00 0.60 1.20 1.80 2.40 3.00 ppbv

Anthro. SOA, 0.6 km



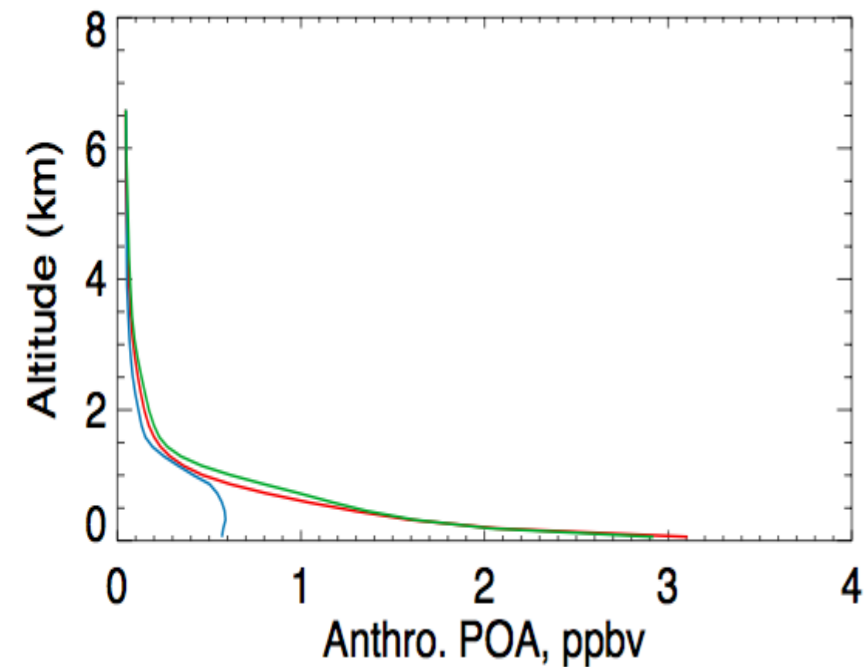
0.00 0.60 1.20 1.80 2.40 3.00 ppbv

BB POA, 0.6 km

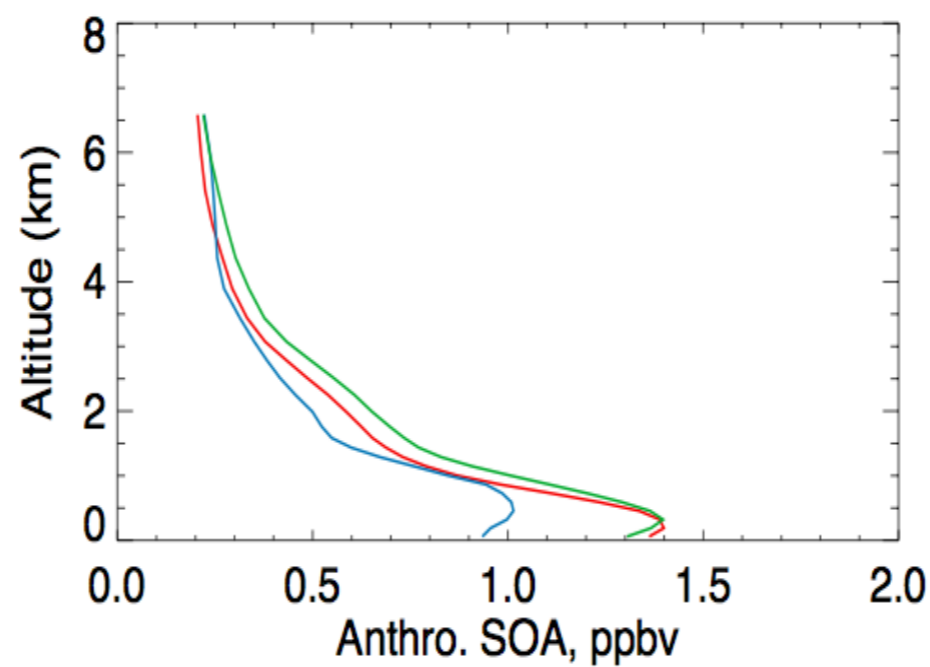


0.00 0.20 0.40 0.60 0.80 1.00 ppbv

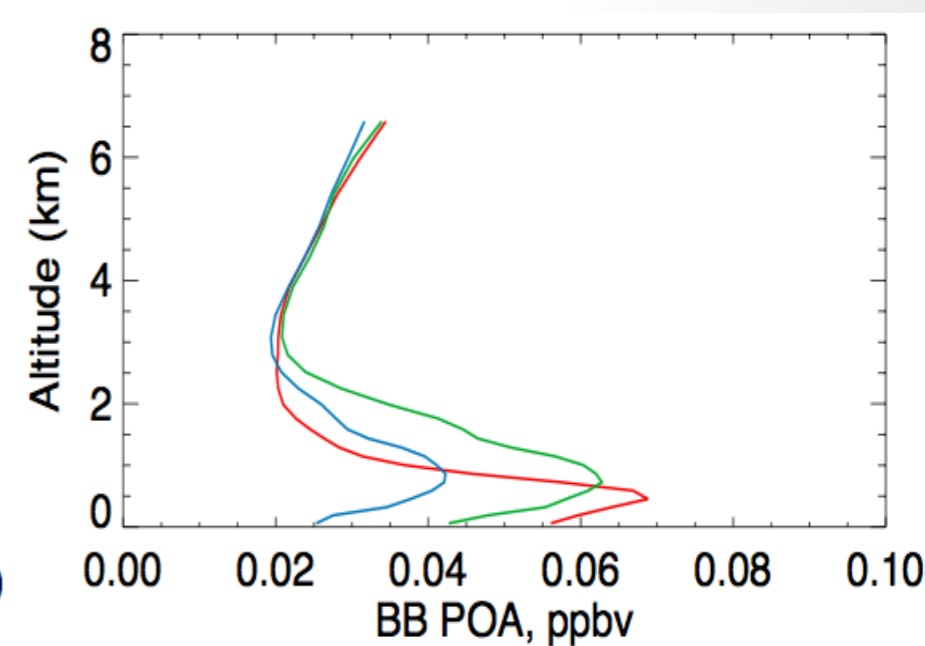
Profiles: Anthr. POA



Profiles: Anthr. SOA



Profiles: BB POA



→ dominated by anthropogenic primary and secondary organic aerosols

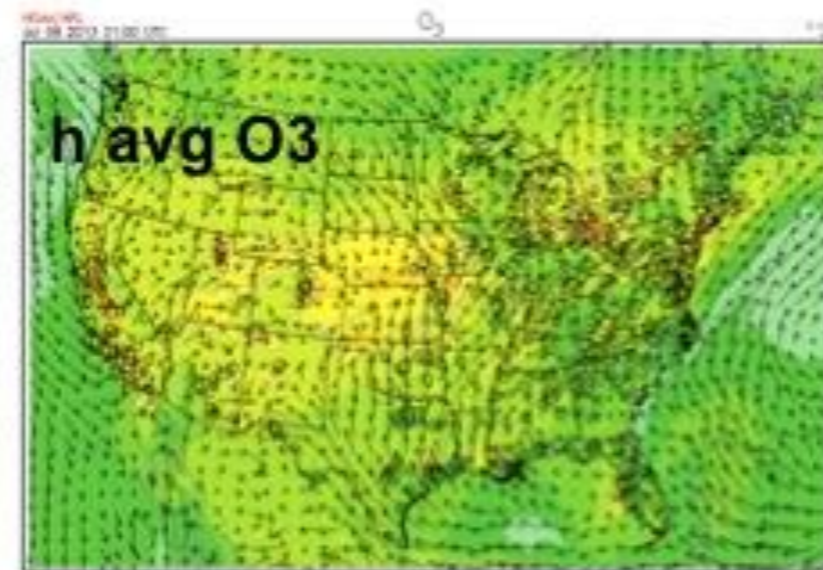




# Slide from Pius Lee and Rick Artz, NOAA ARL

Some resources at ARL to assist O3 and PM forecasting and near real-time verification

[http://testbed.arl.noaa.gov/AQ\\_forecast.php](http://testbed.arl.noaa.gov/AQ_forecast.php): Sample fields, plots, discussion



NAM AIR  
QUALITY  
DIAGNOSTIC  
DISCUSSION

<http://www.hpc.ncep.noaa.gov/discussions/aqm.html>

