

# Regional Scale Modeling in Support of ICARTT

## Outline (G<sup>3</sup>)

- **Overview of models being used**
- **Examples of forecast uses and performance**
- **Preliminary results**
- **Future directions**

# Regional Models are an Integral Part of Atmospheric Chemistry Studies

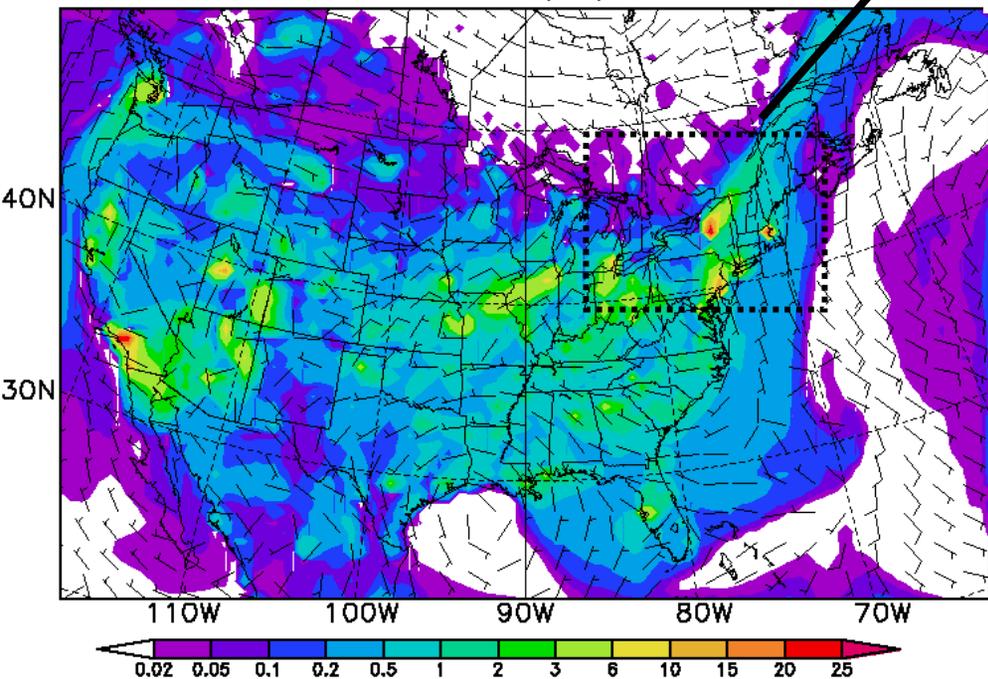
- **Flight planning**
- **Provide 4-Dimensional context of the observations**
- **Facilitate the integration of the different measurement platforms**
- **Evaluate processes (e.g., role of biomass burning, heterogeneous chemistry....)**
- **Evaluate emission estimates (bottom-up as well as top-down)**
- **Air quality forecasting**



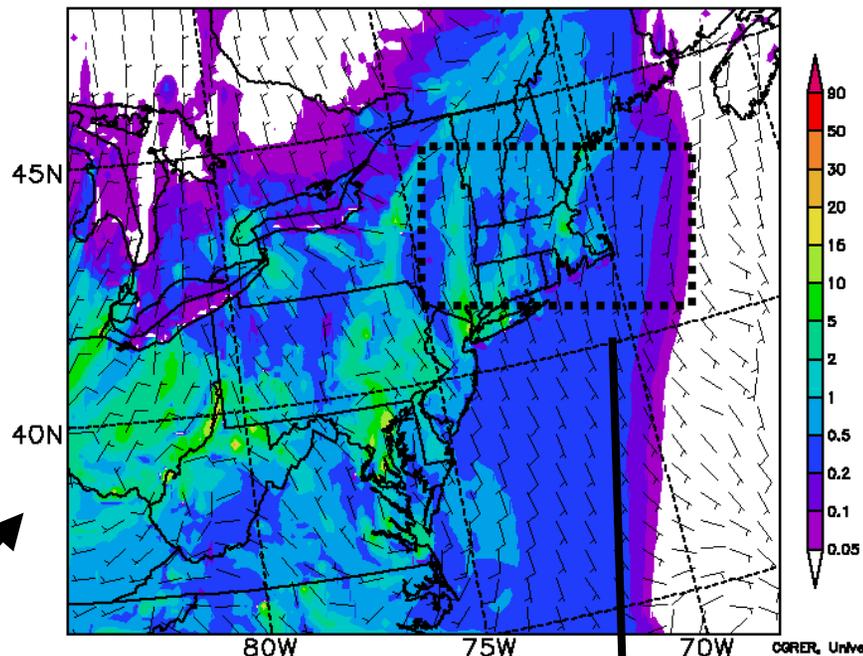
# STEM Forecasts Provided for 3 Domains (60, 12, & 4 km)

CORER, University of Iowa

Simulated  $\text{NO}_x$  (ppbv) in the Lowest layer  
at 15GMT, 07/23/2004

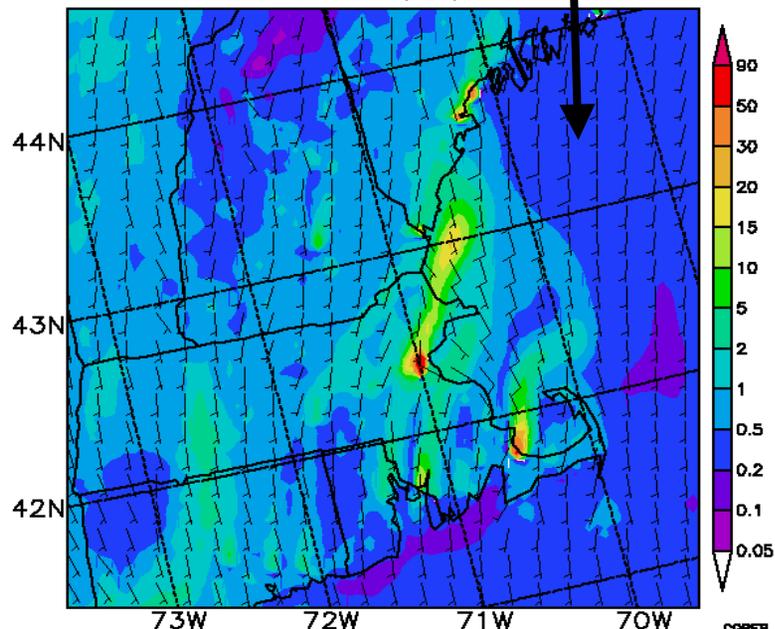


Simulated  $\text{NO}_x$  (ppbv) in the Lowest layer  
at 15GMT, 07/23/2004



CORER, University of Iowa

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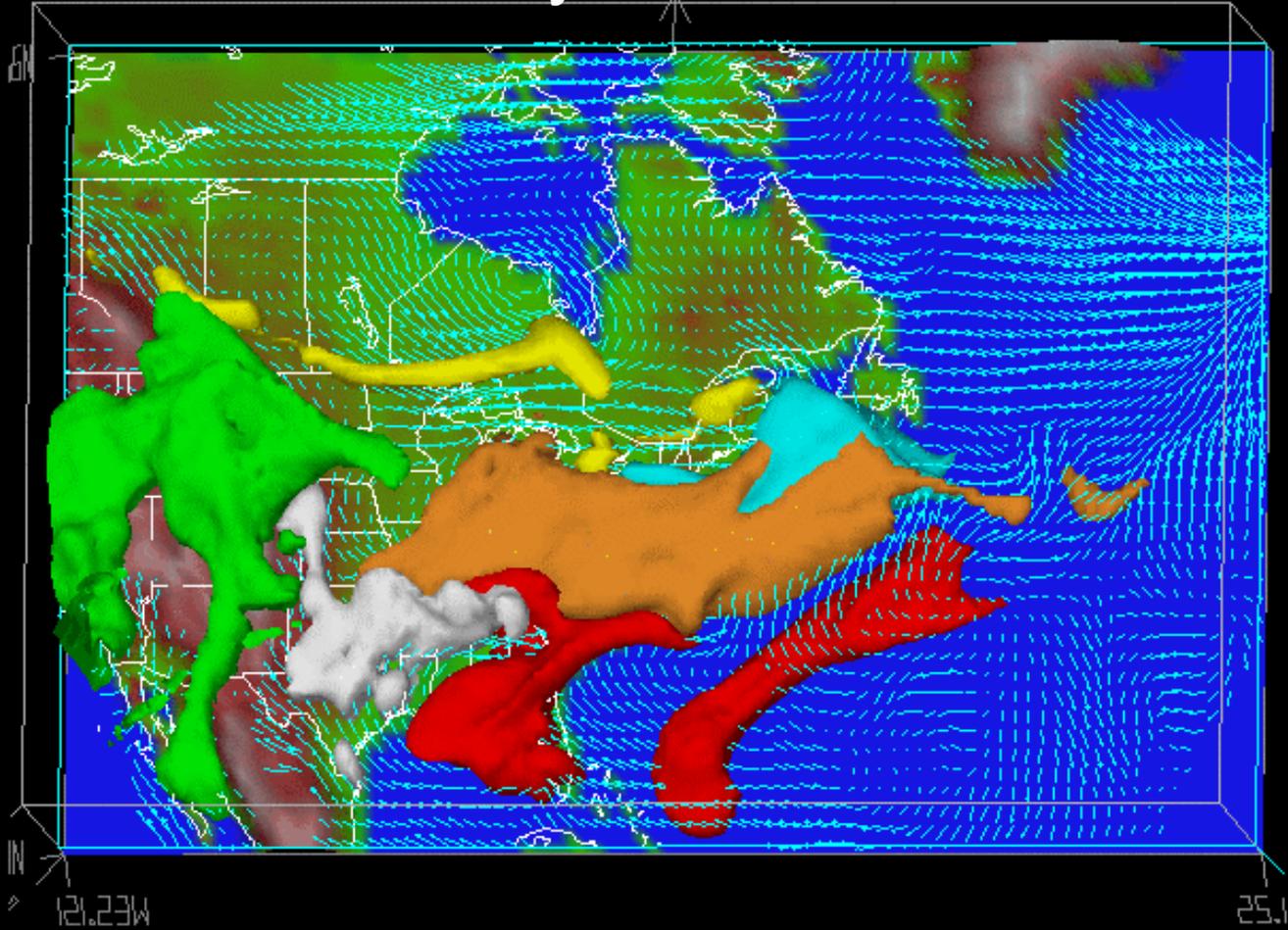
CORER, University of Iowa

00:00:00  
01 Jul 04  
1 of 105  
Thursday

# Mission Overview

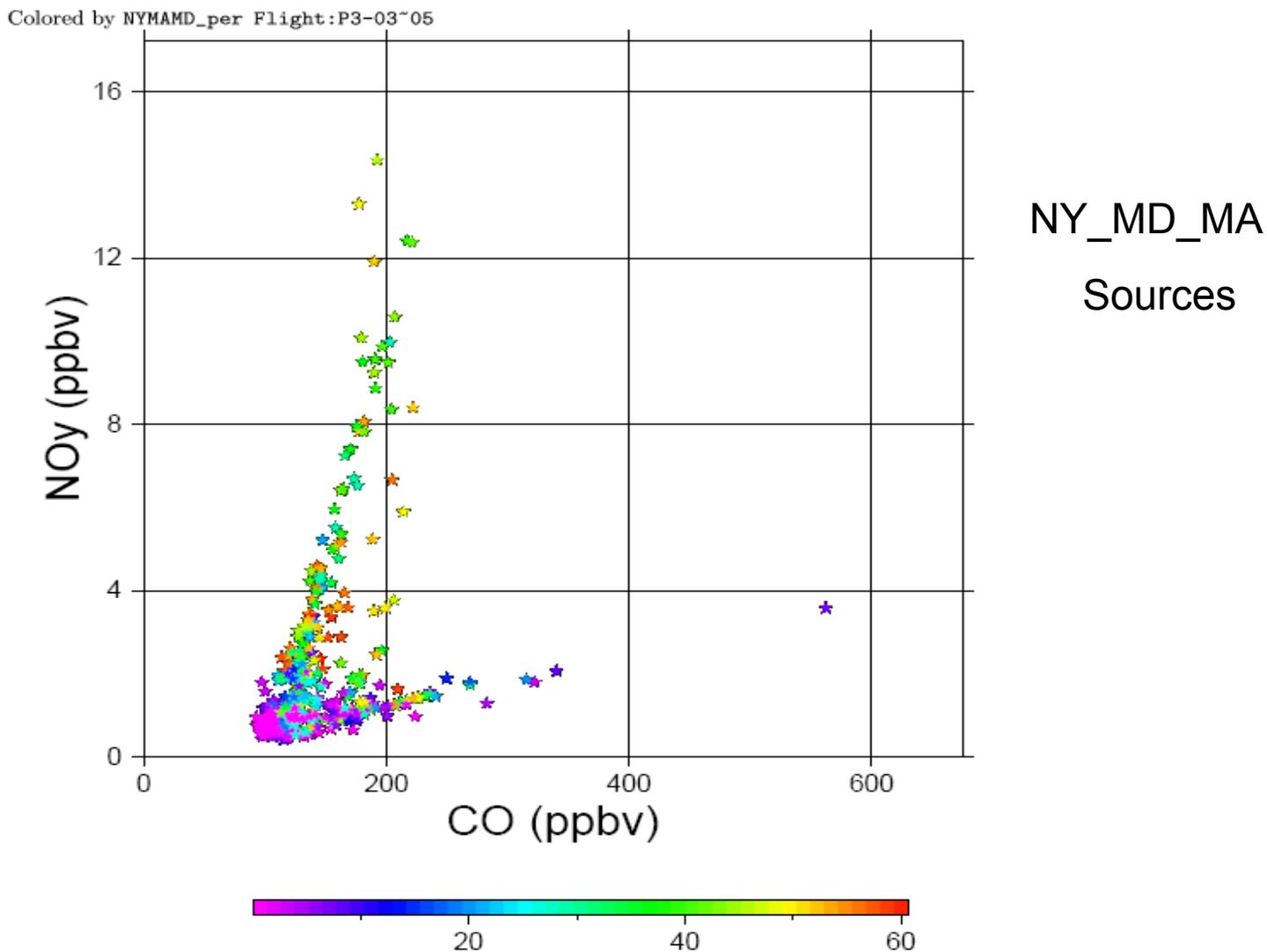
## July 1 to 25 Model CO

- Midwest
- Ohio etc
- NY-MA-MD
- TX-NM
- Southeast
- California
- Canada



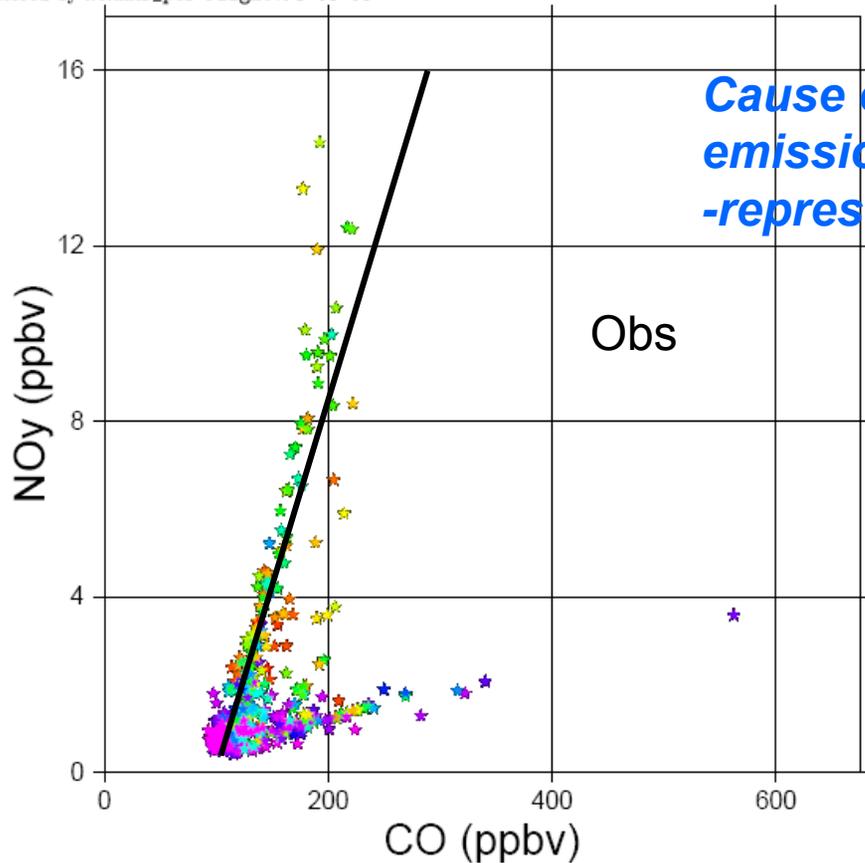
← 2km wind field

# Tagged Species Can Help Identify Source Regions (P3 flights 3-5)



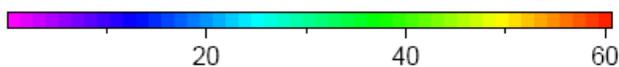
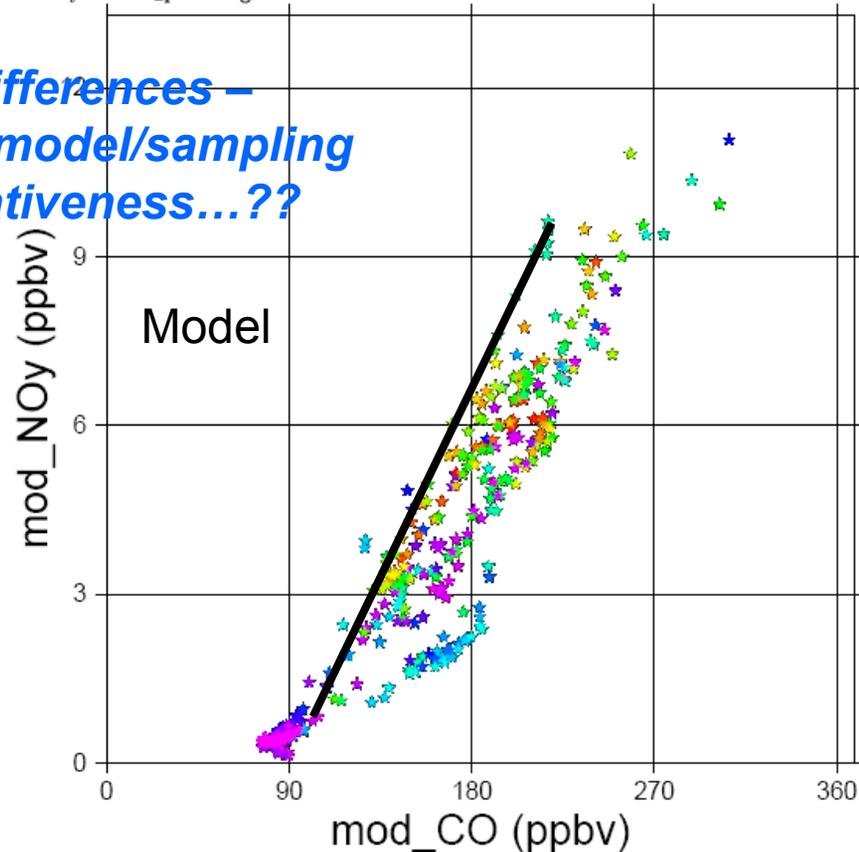
# Can be used to test emission signatures (P3 flights 3-5)

Colored by NYMAMD\_per Flight:P3-03~05

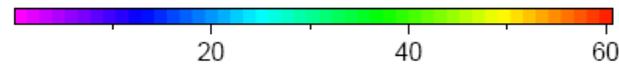


*Cause of differences –  
emissions/model/sampling  
-representativeness...??*

Colored by NYMAMD\_per Flight:P3-03~05

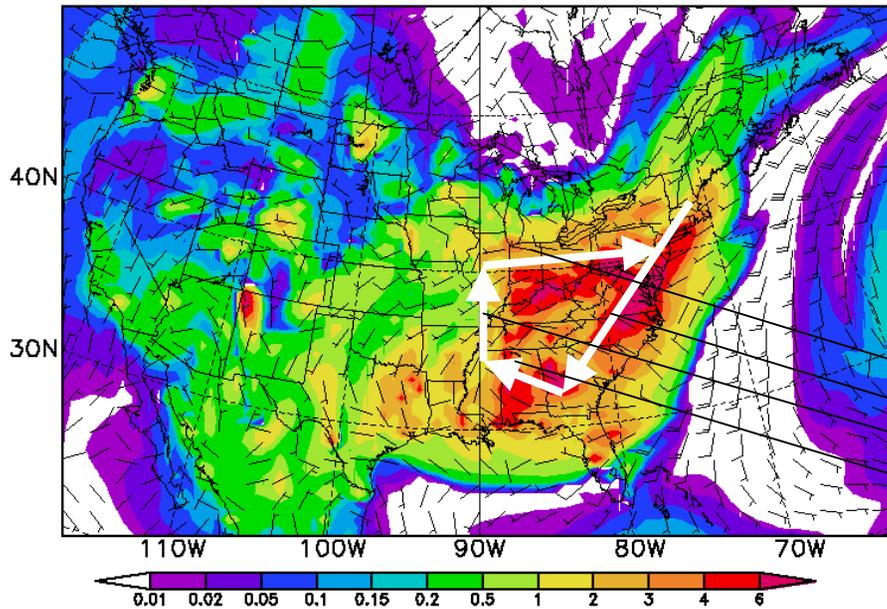


NY\_MA\_MD



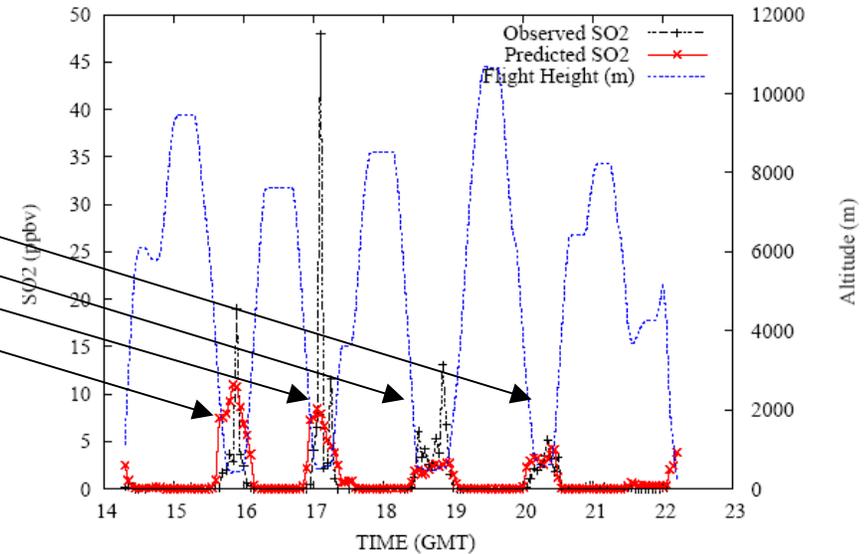
*(Model –no Alaskan fires)*

Simulated  $\text{SO}_2$  (ppbv) in the 1km layer  
at 18GMT, 07/20/2004

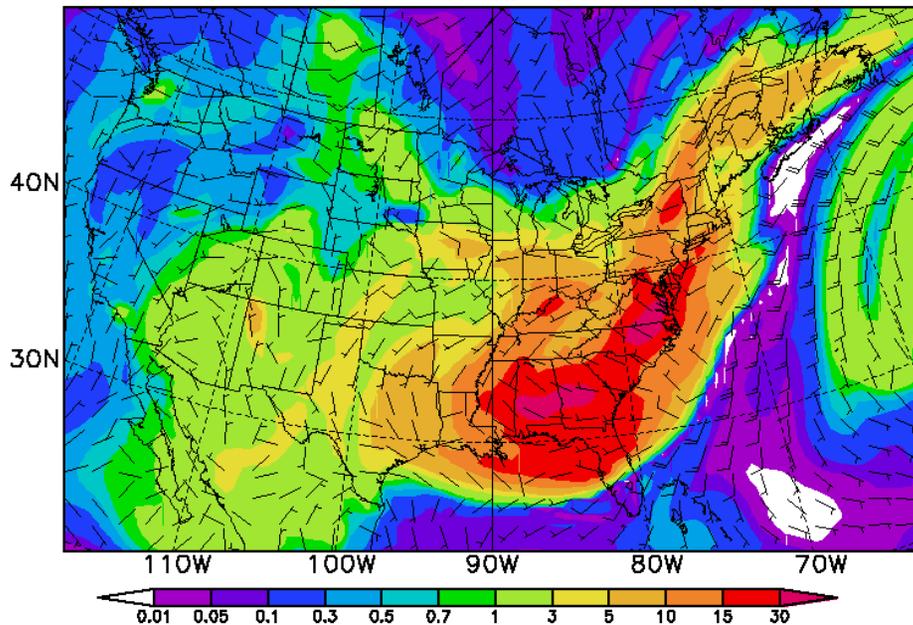


# DC-8 July 20 flight – High Sulfates in the SE

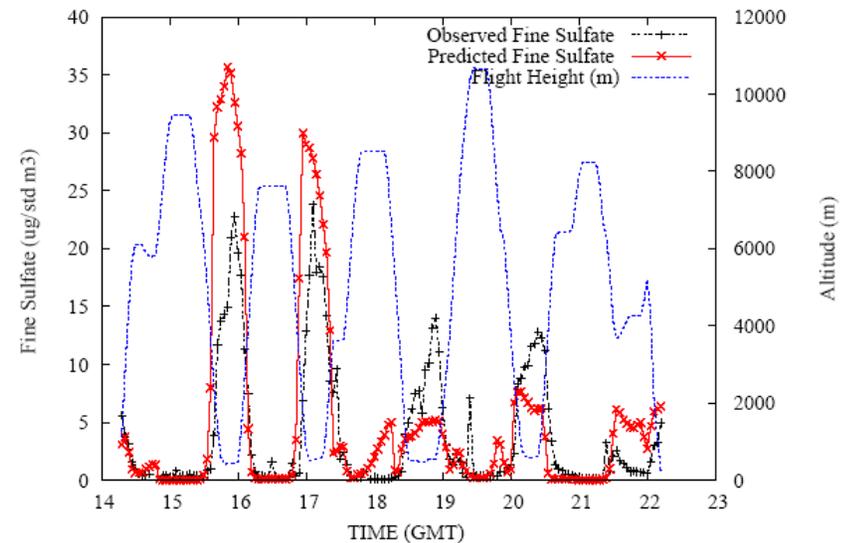
ICARTT DC-8 Flight #10  $\text{SO}_2$  on 7/20/2004



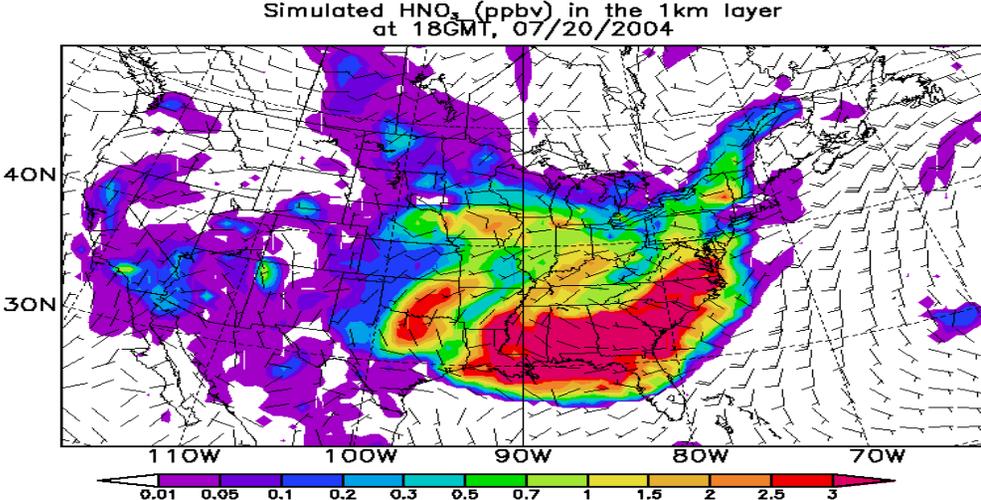
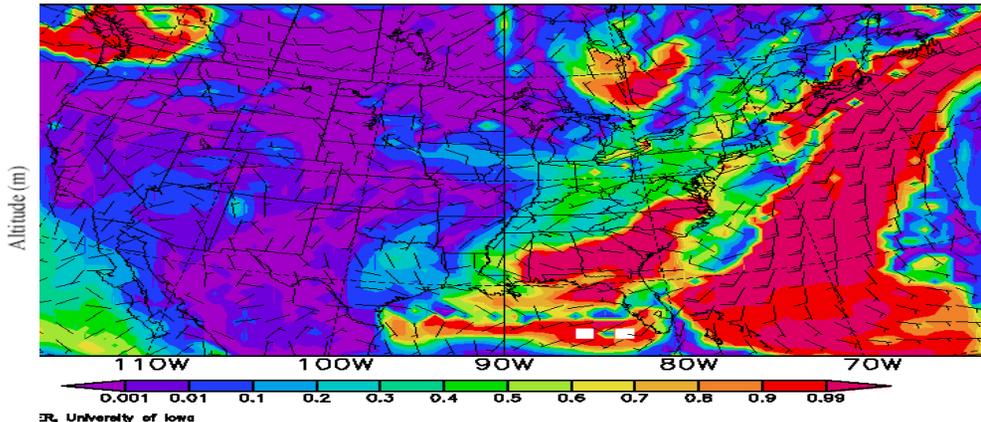
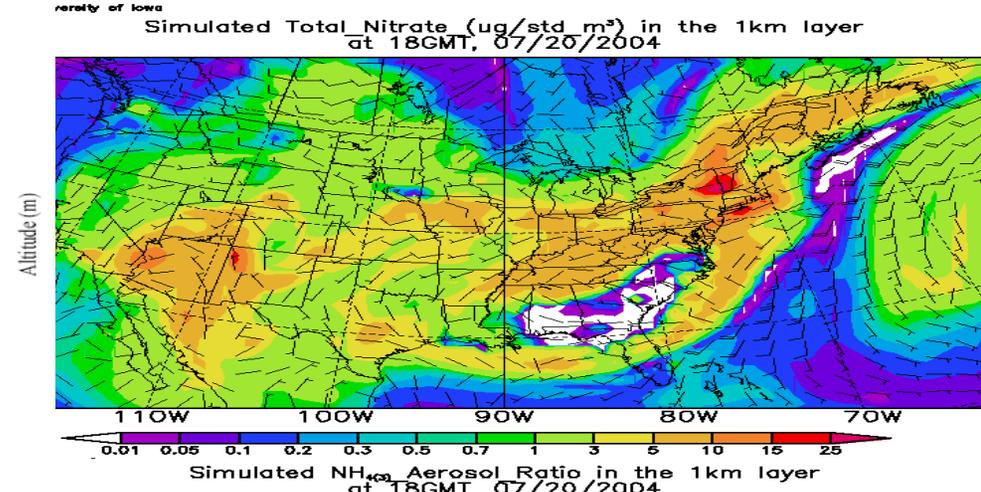
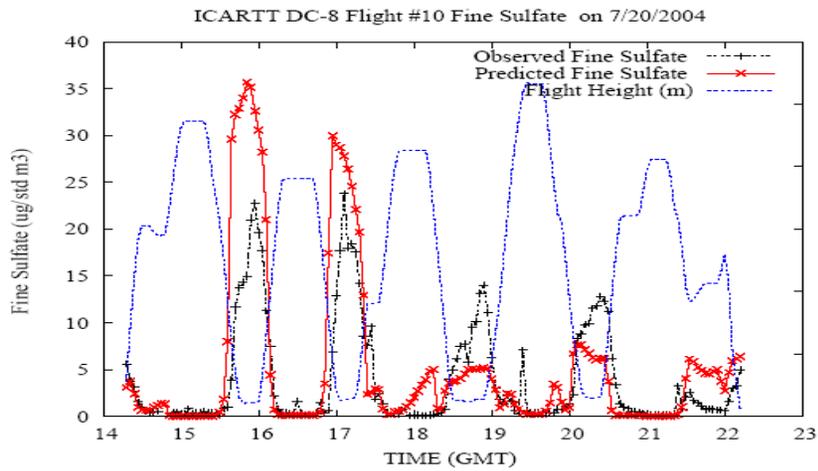
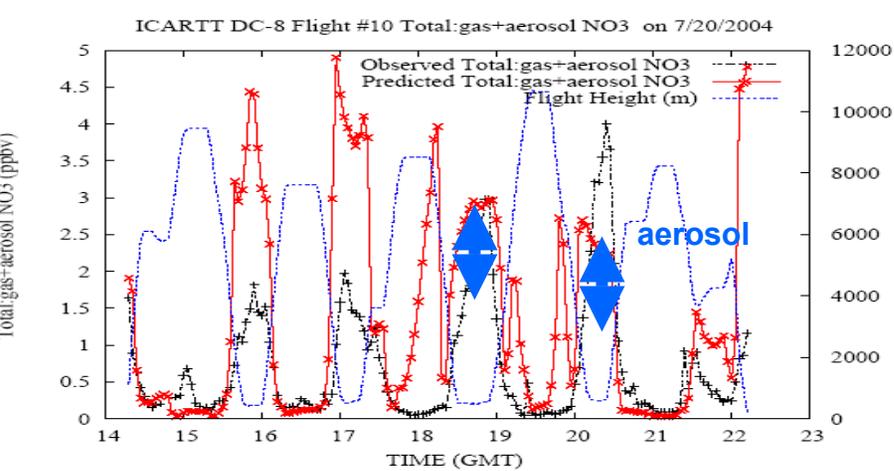
Simulated Total Sulfate ( $\mu\text{g}/\text{std m}^3$ ) in the 1km layer  
at 18GMT, 07/20/2004



ICARTT DC-8 Flight #10 Fine Sulfate on 7/20/2004



Data:GT-SO2/UNH-SO4

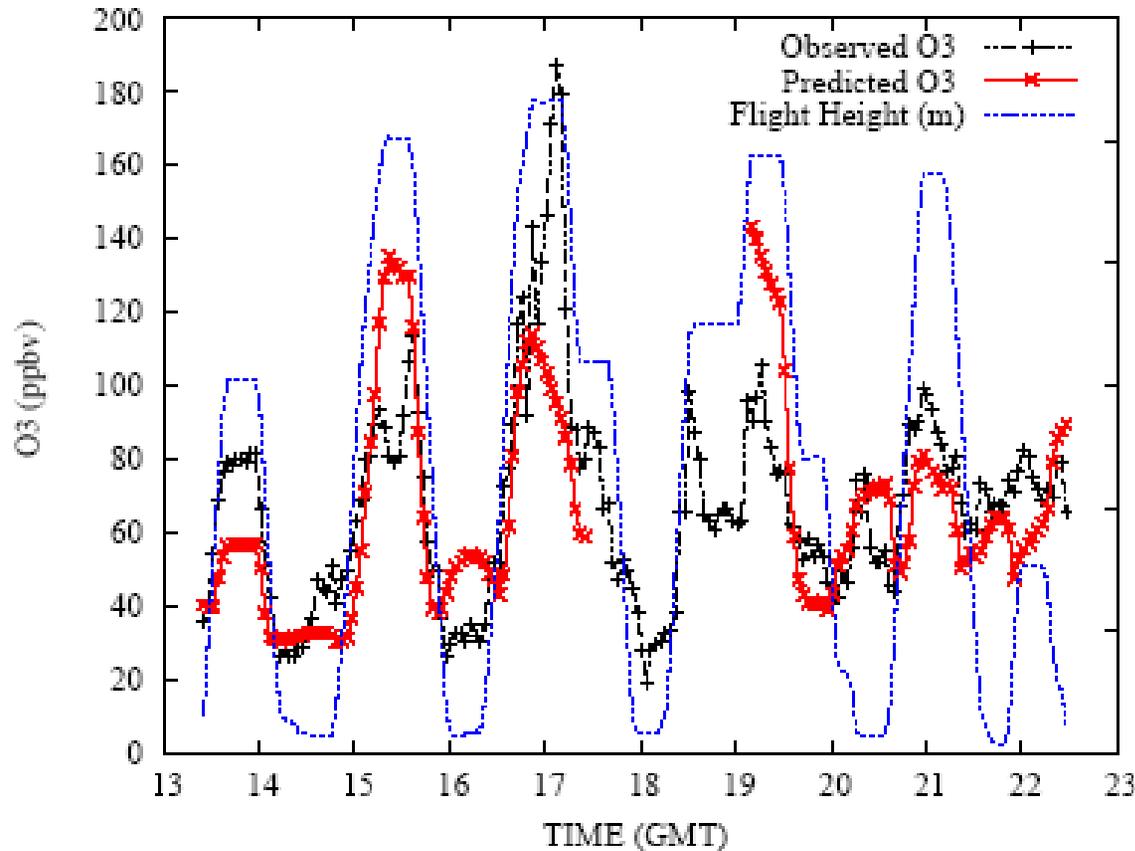


**Where is the nitric acid -- gas or aerosol phase? Is NH<sub>3</sub> limiting?**

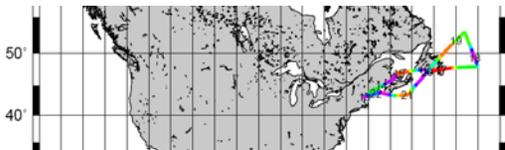
Data: HNO<sub>3</sub> / sulfate-UNH

# Re-analysis is Possible Using Formal Data Assimilation (e.g., 4dVar)

ICARTT DC-8 Flight #9 O3 on 7/18/2004



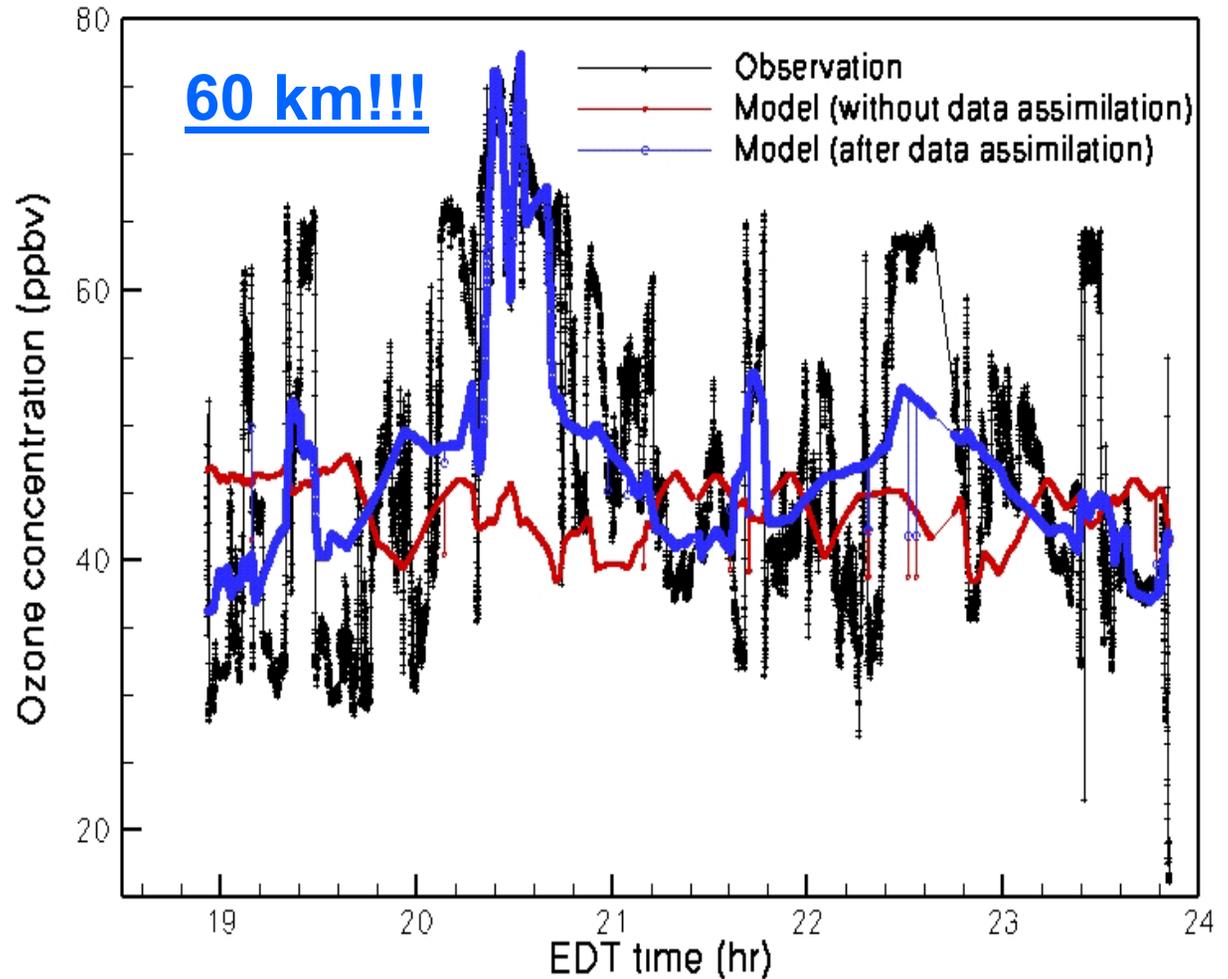
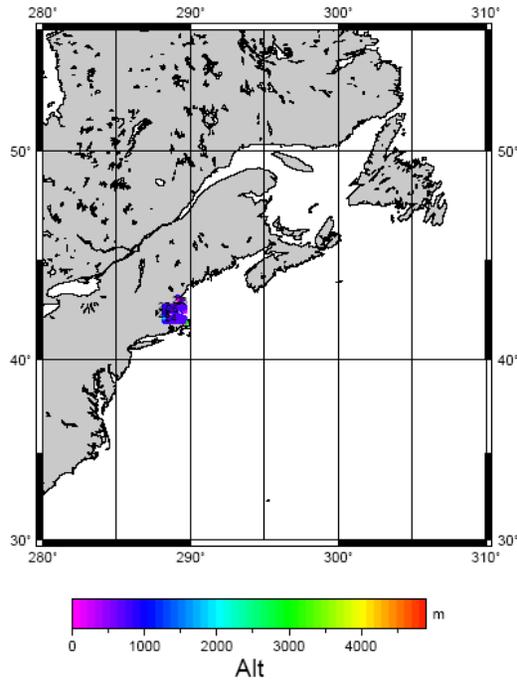
- Cost functional = model-observation gap.
- The analysis produces an **optimal state** of the atmosphere using:
  - Model information consistent with physics/chemistry
  - Measurement information consistent with reality



Data: Larc

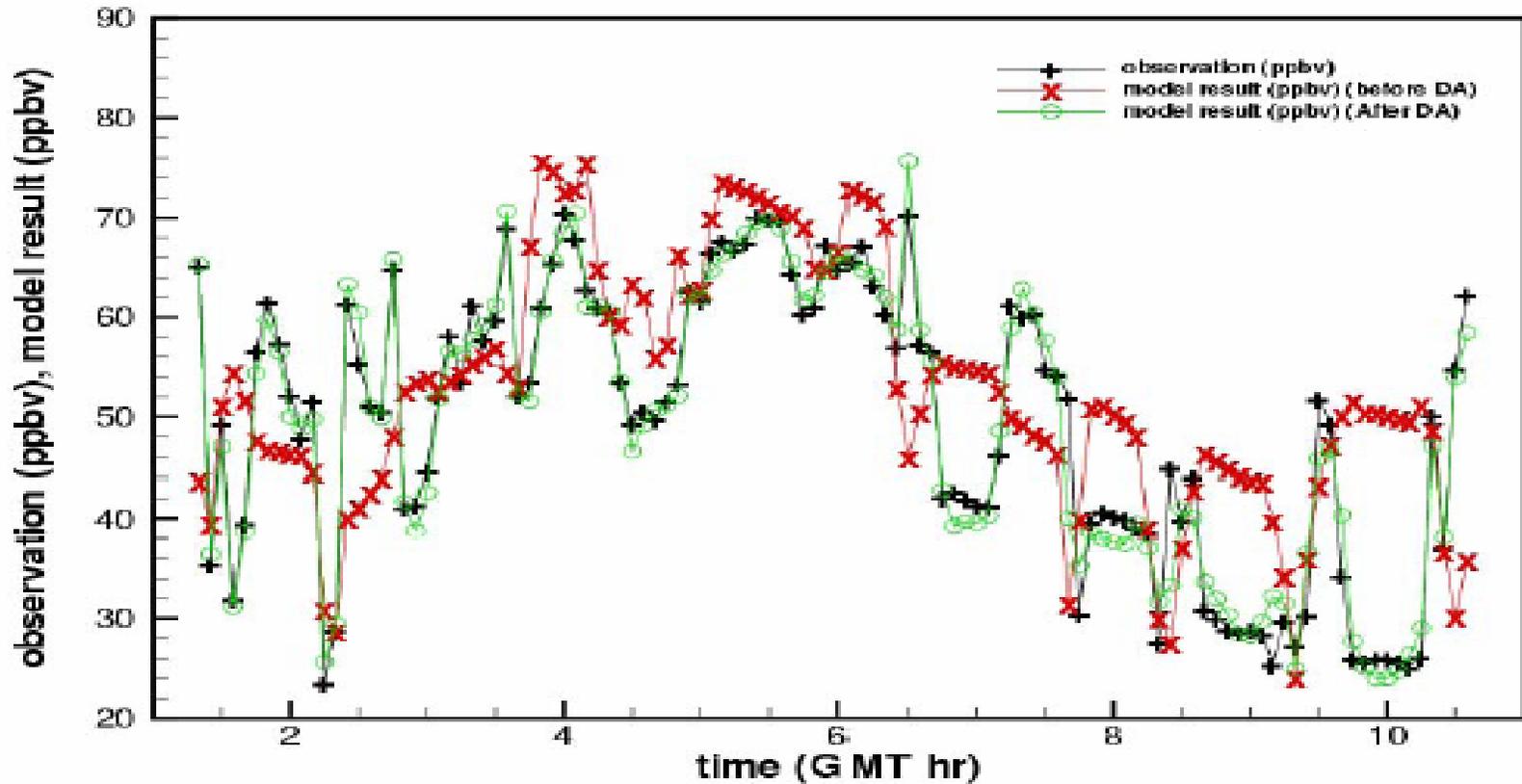
# Reanalysis of Ozone for the P3 Flight #4

P3 July-11



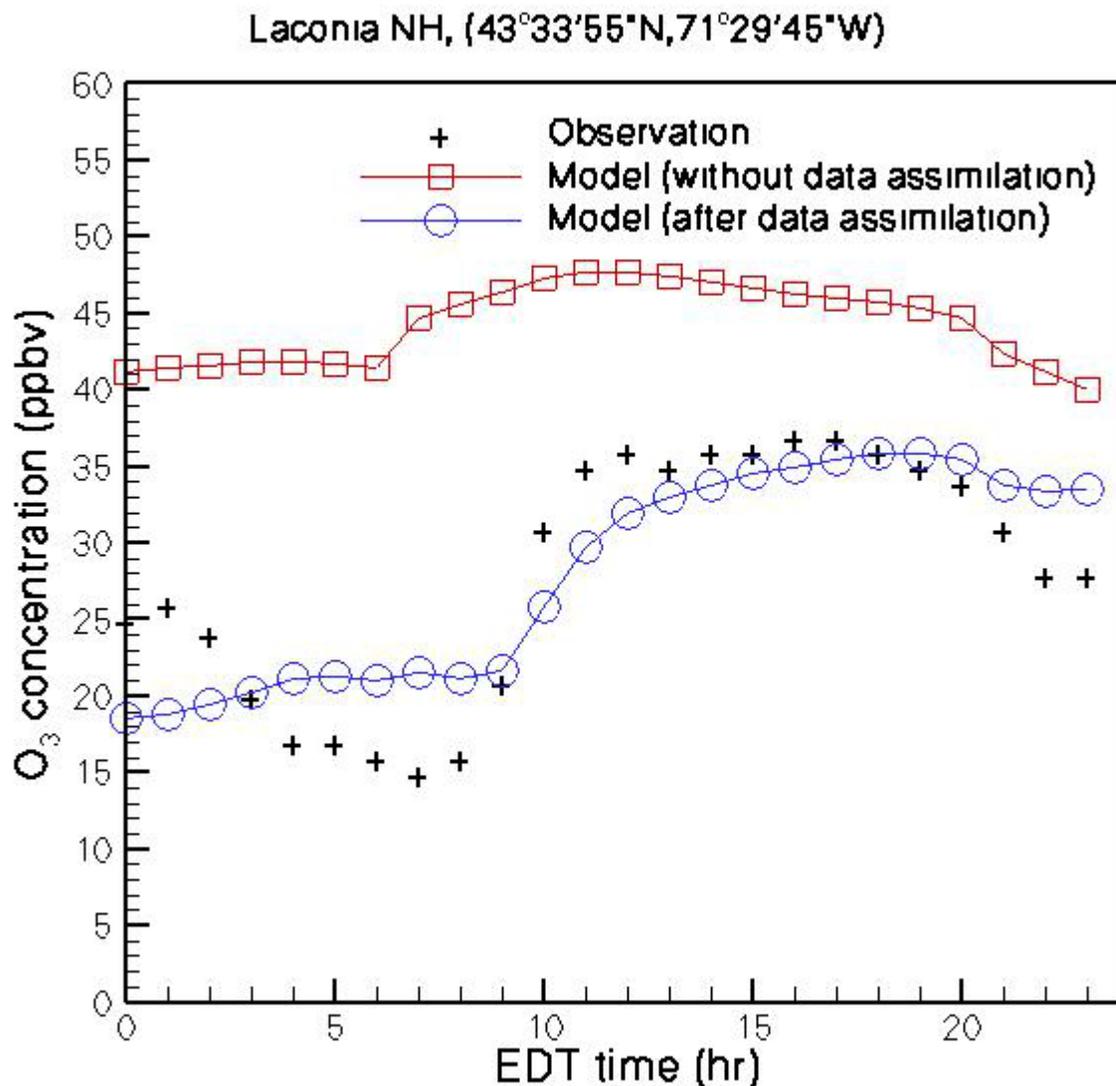
# Re-analysis is Possible Using Formal Data Assimilation (e.g., 4dVar)

## *Trace-P Example*

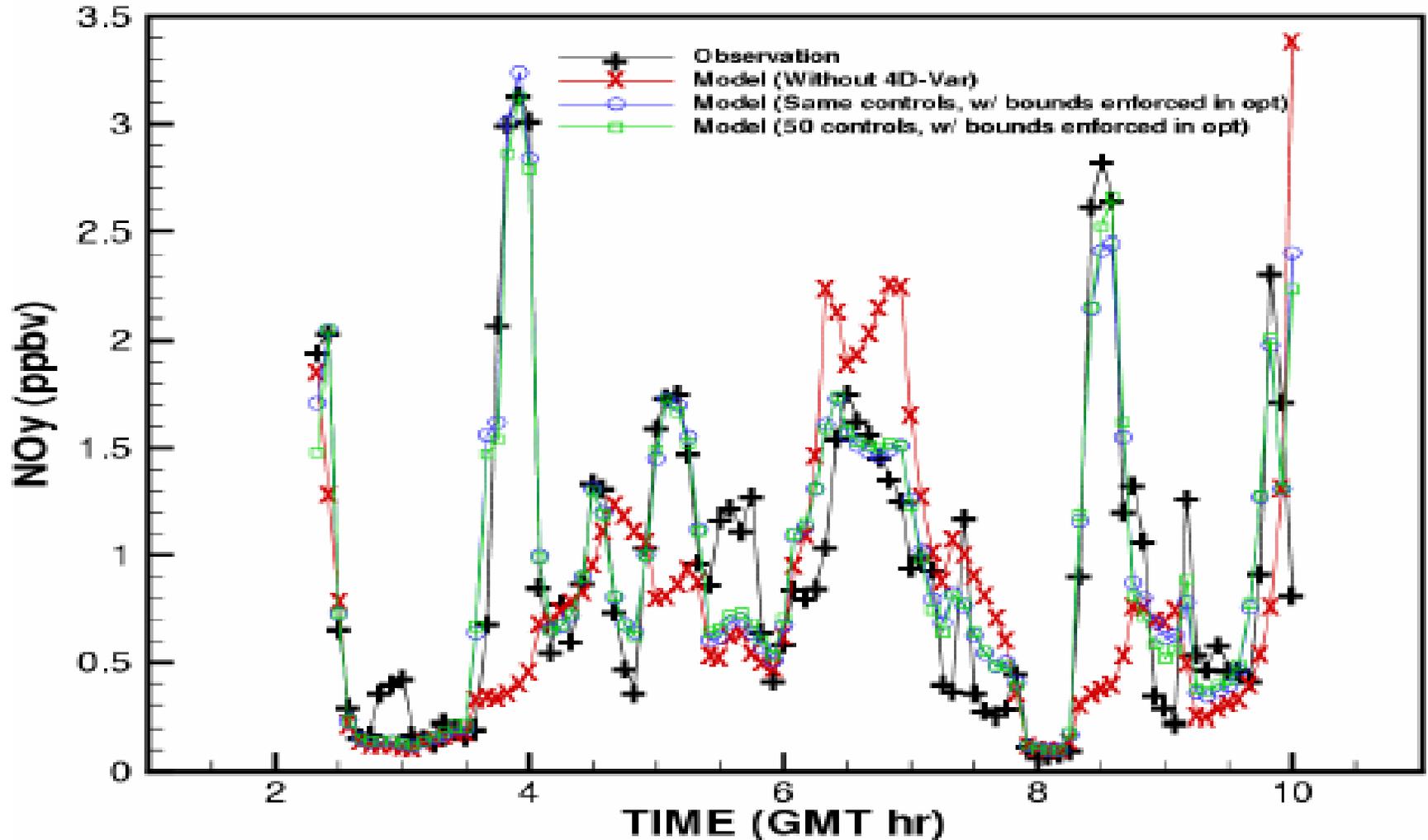


Observations from DC-8 and their model counterparts

# Reanalysis Using AirNow Data

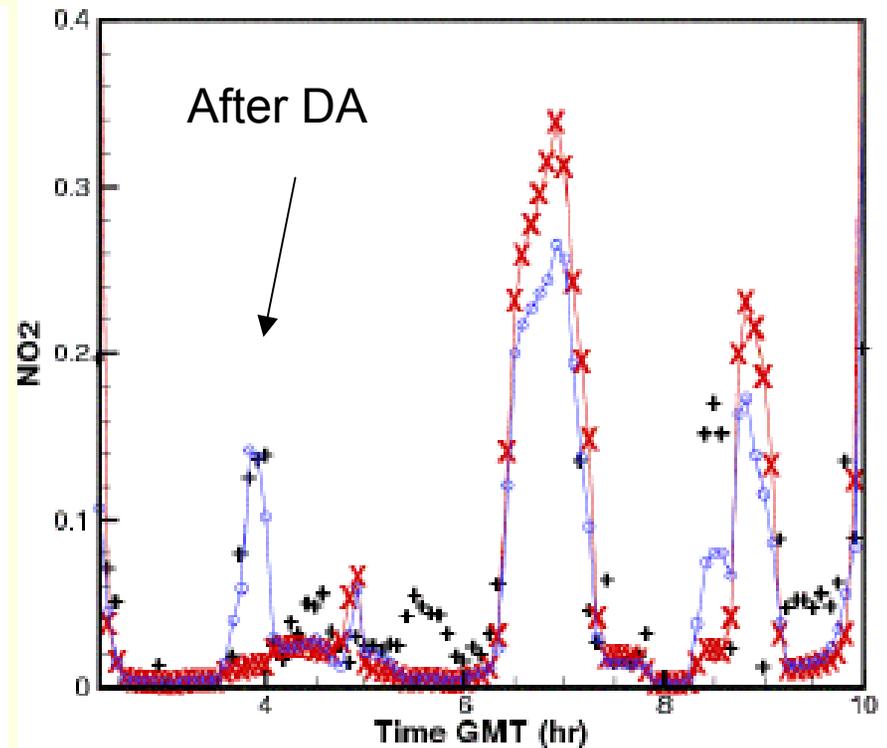
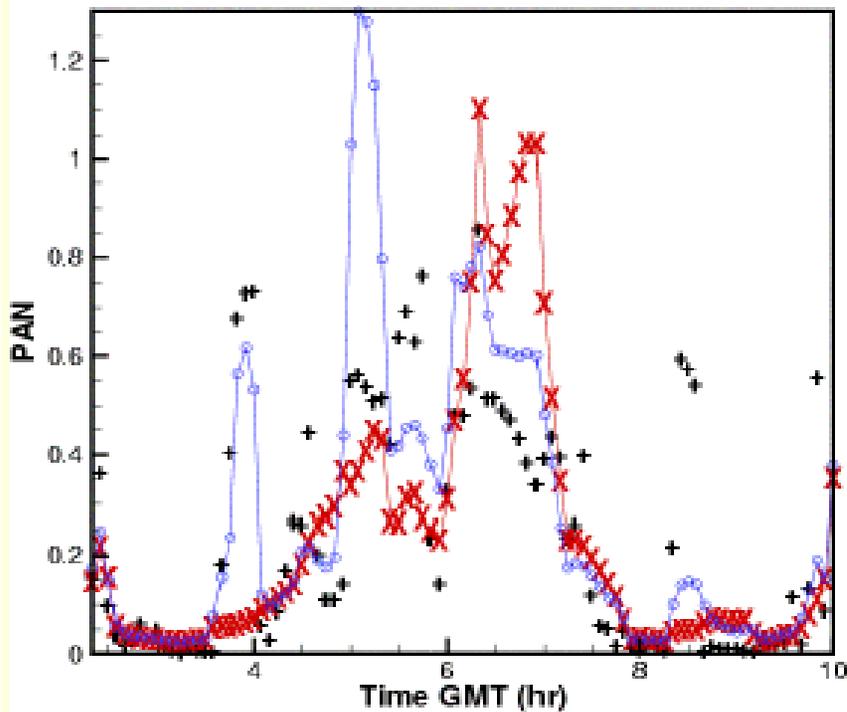


# Re-analysis of NO<sub>y</sub> (Trace-P Example) Will do for ICARTT

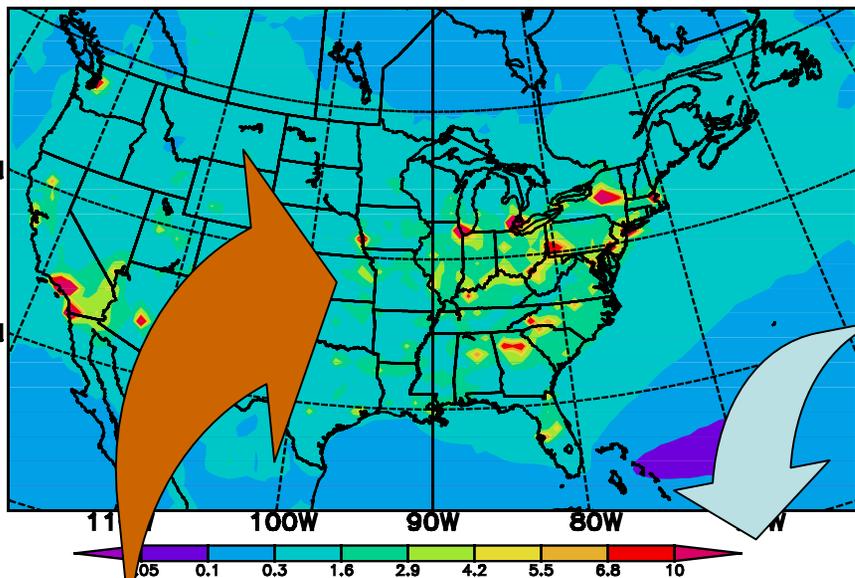


# Re-analysis of NO<sub>y</sub> Improves (Trace-P example) Predictions of Individual Species

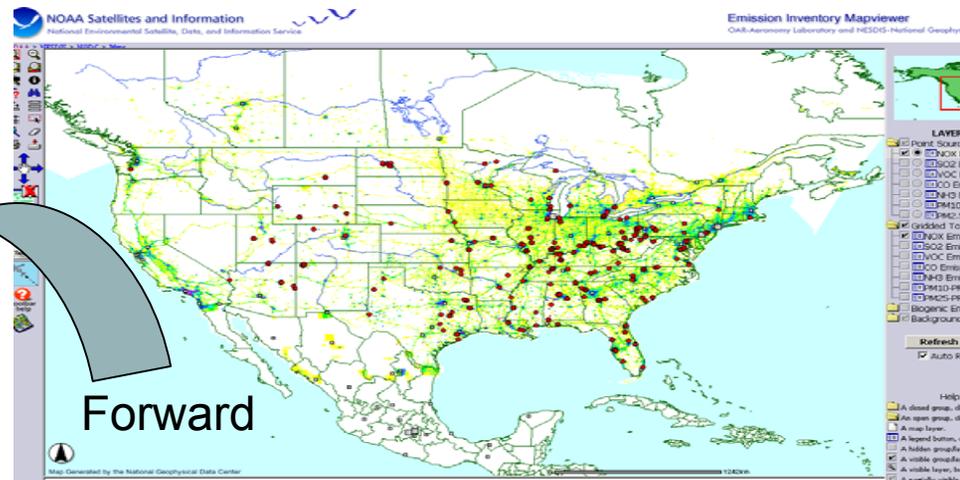
*(Trace-P example)*



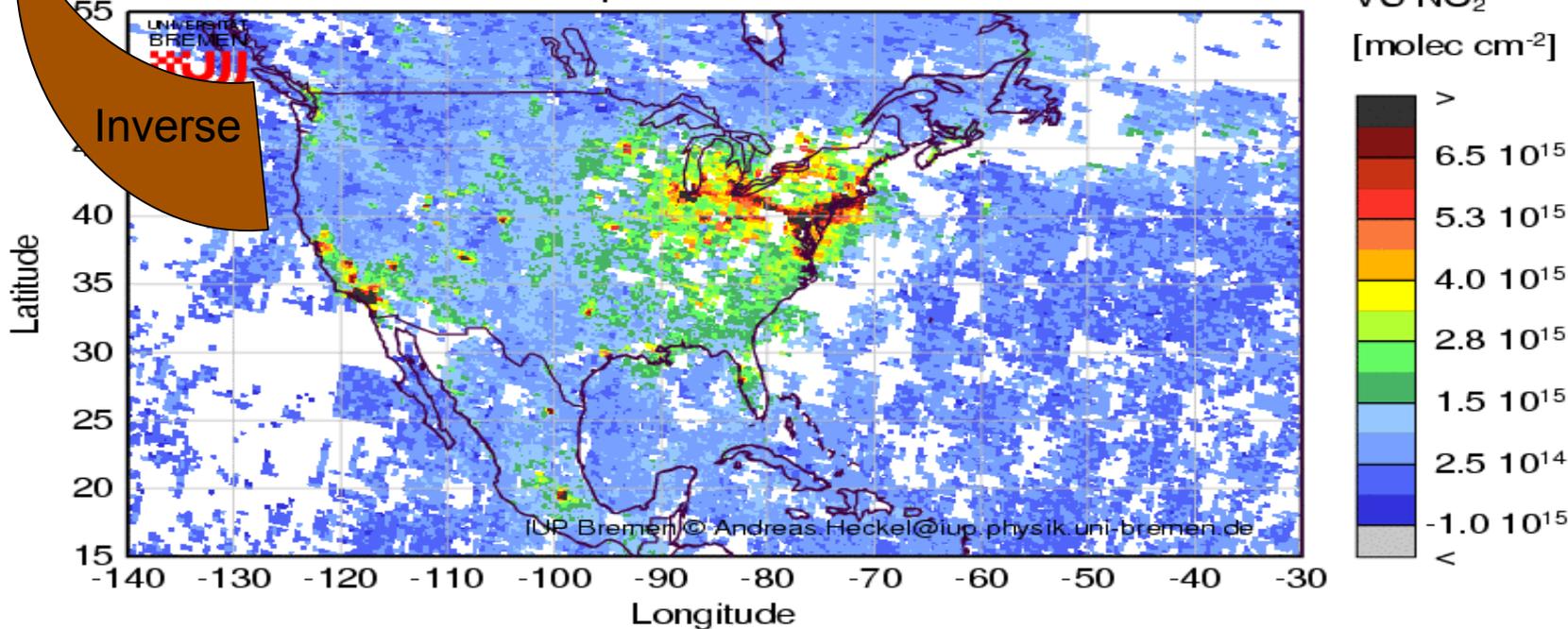
Monthly Averaged Forecasted NO<sub>2</sub> (10<sup>18</sup> molecules/cm<sup>2</sup>)



# Same techniques can be used to recover emissions



SCIAMACHY trop NO<sub>2</sub> RSM 2004/07/01-22



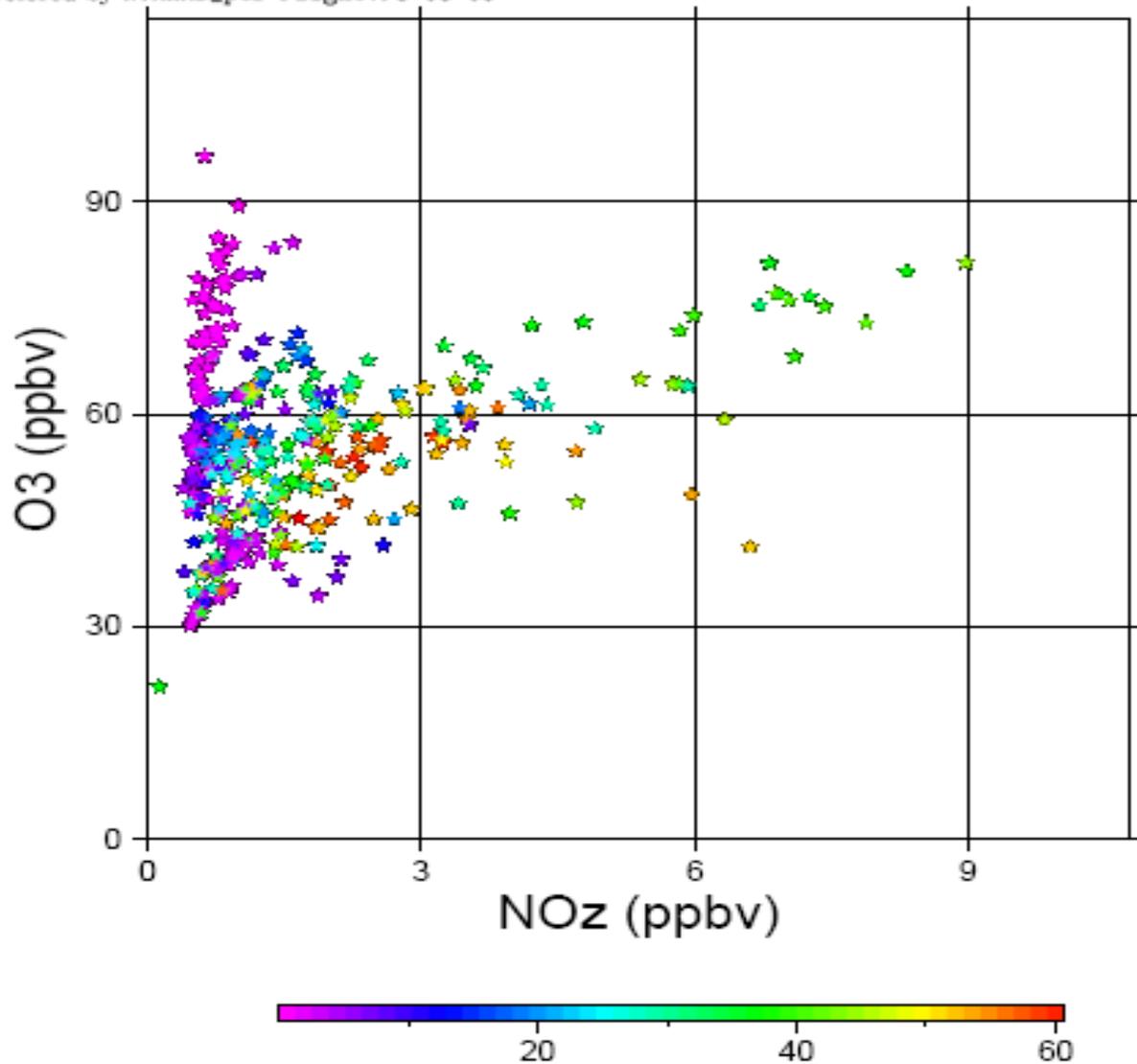
# Future Plans

- Re-analysis using aircraft, surface, satellites, sondes, etc.
- Emission inversions
- Impact of assimilation on forecasts
- Ensemble forecasts



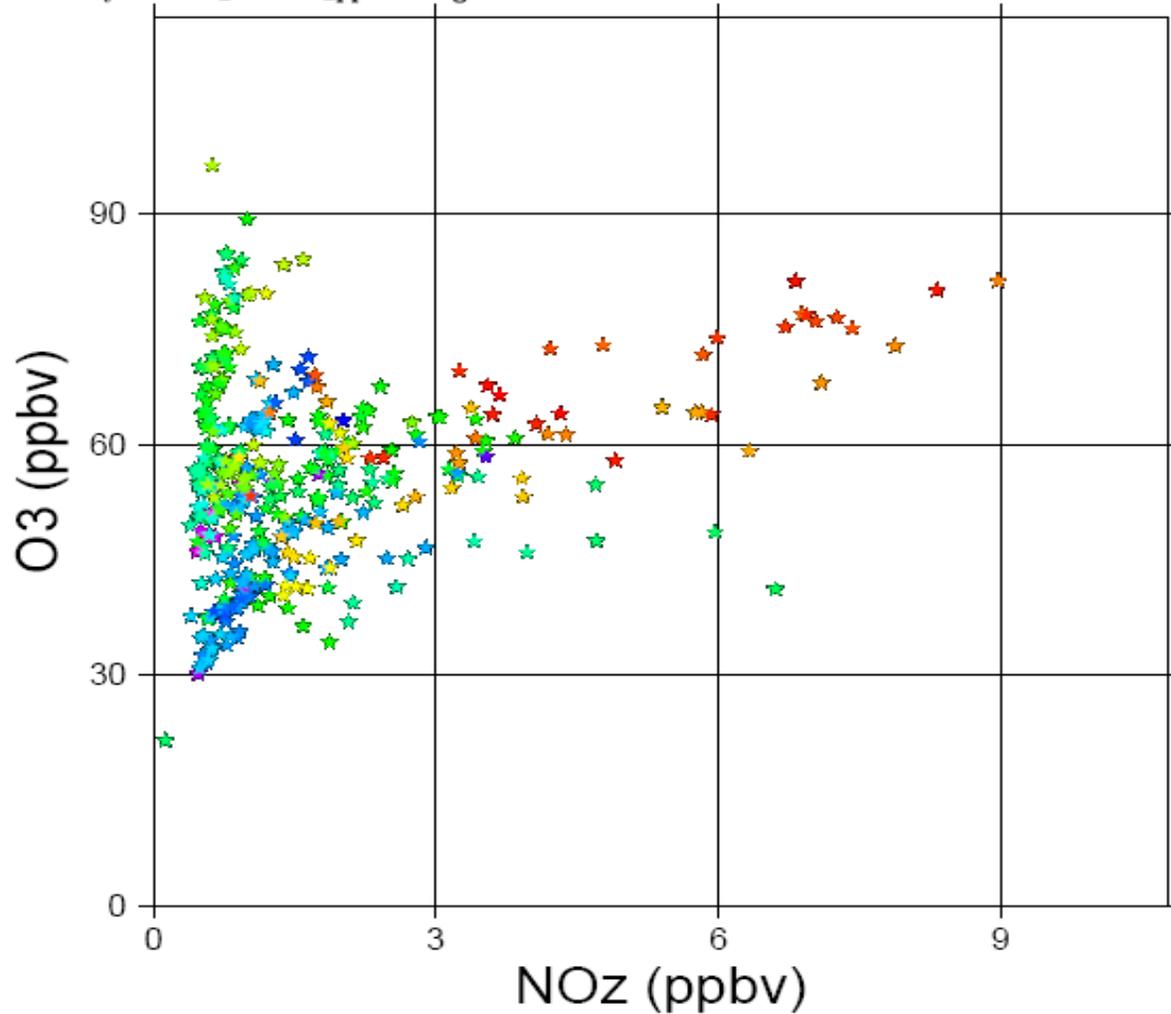
# NY\_MA\_MD Influence

Colored by NYMAMD\_per Flight:P3-03-05



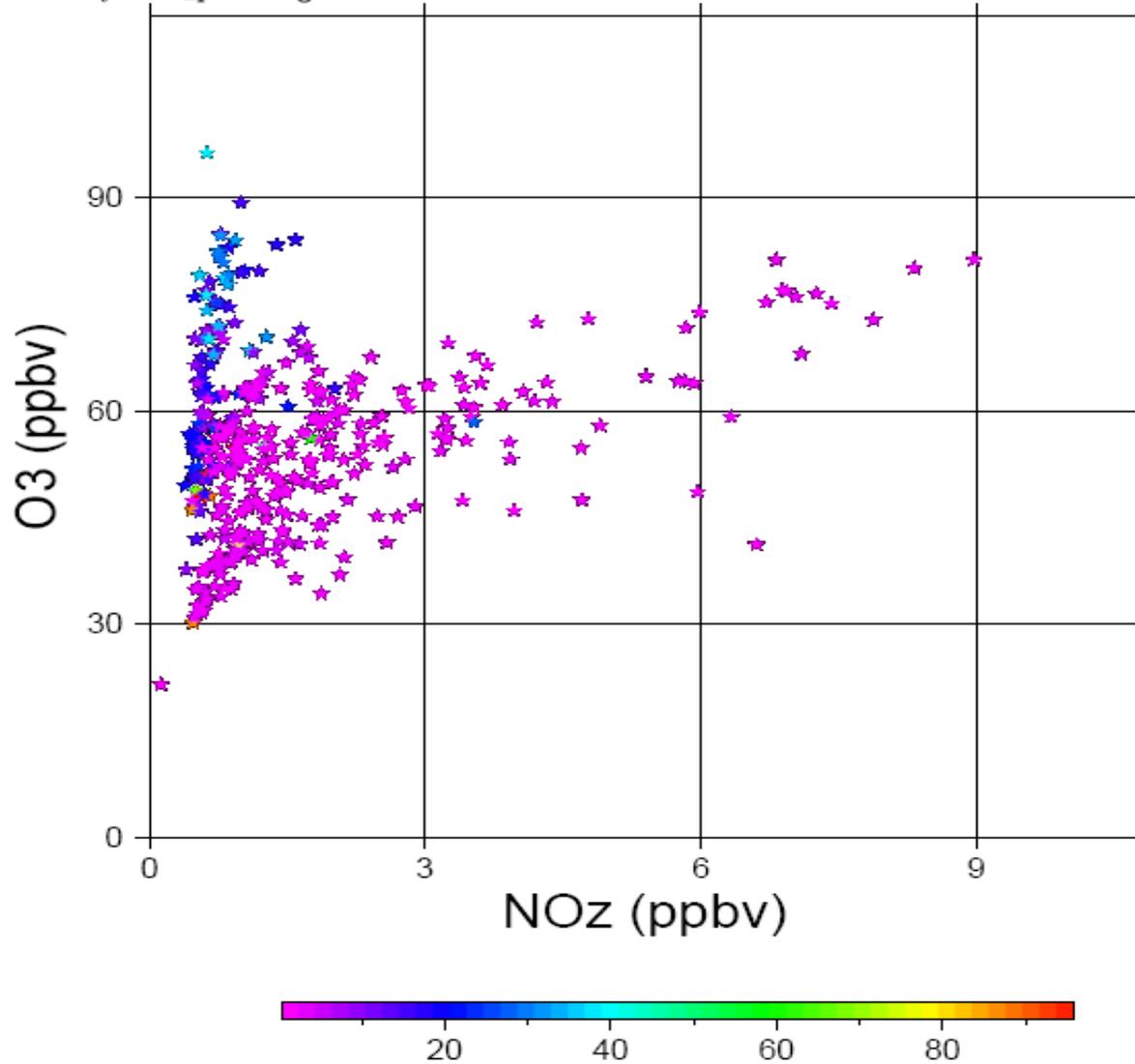
# Biomass Burning Influence

Colored by tracer\_biomco\_ppbv Flight:P3-03~05

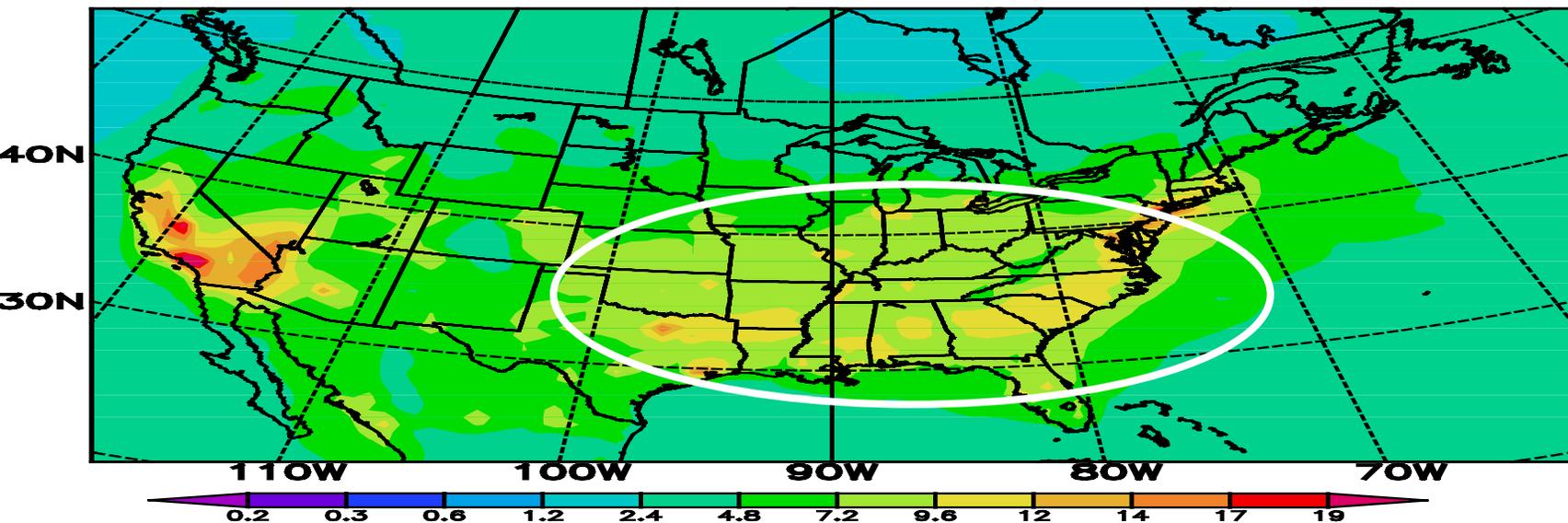


# Asia Influence

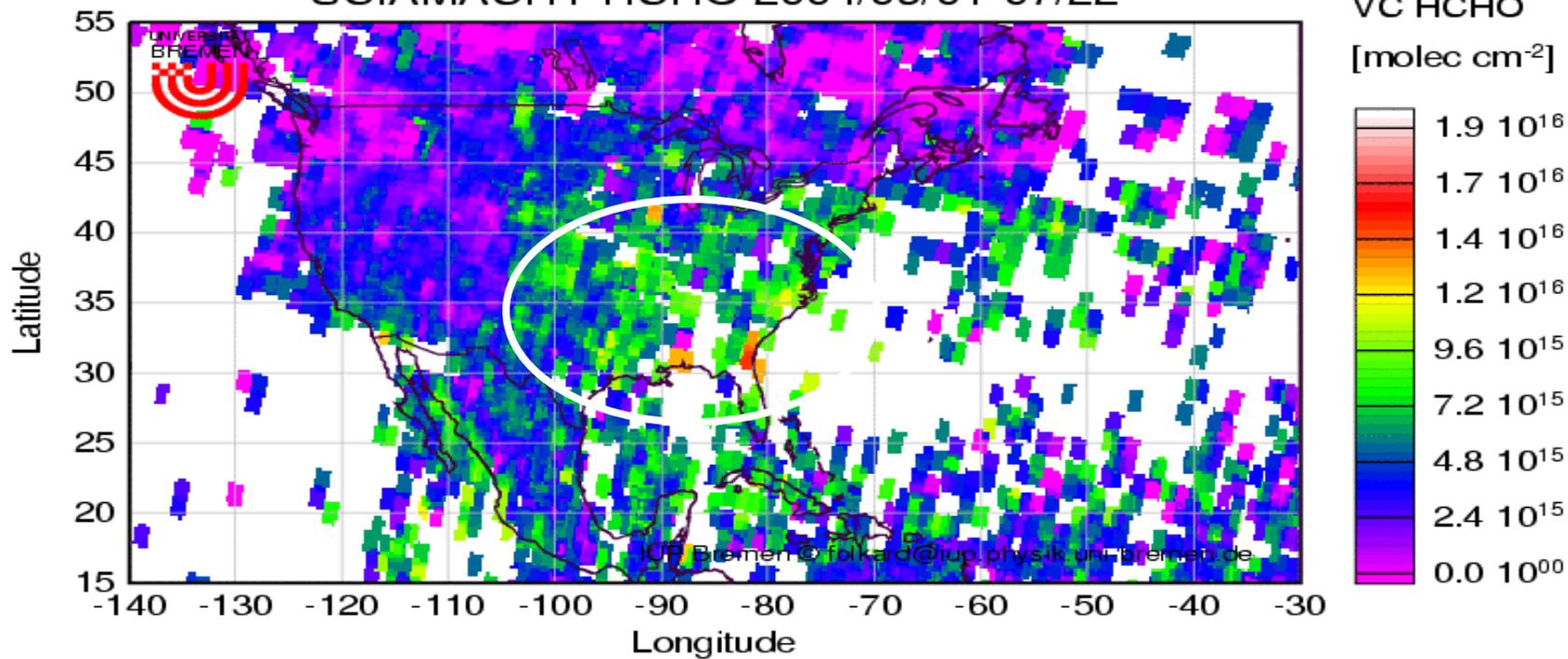
Colored by Asia\_per Flight:P3-03~05



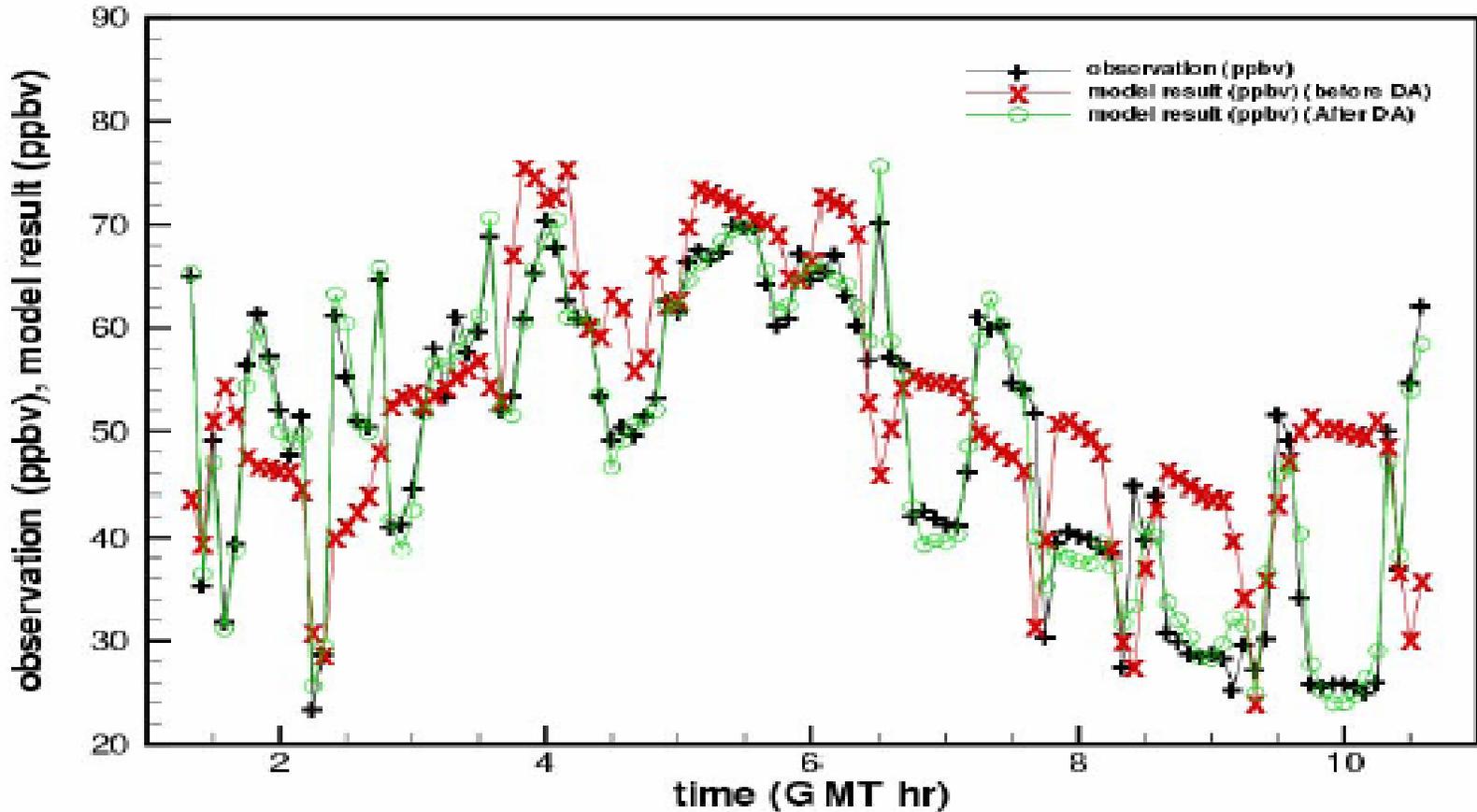
# Monthly Averaged Forecasted HCHO ( $10^{18}$ molecules/cm<sup>2</sup>)



## SCIAMACHY HCHO 2004/06/01-07/22



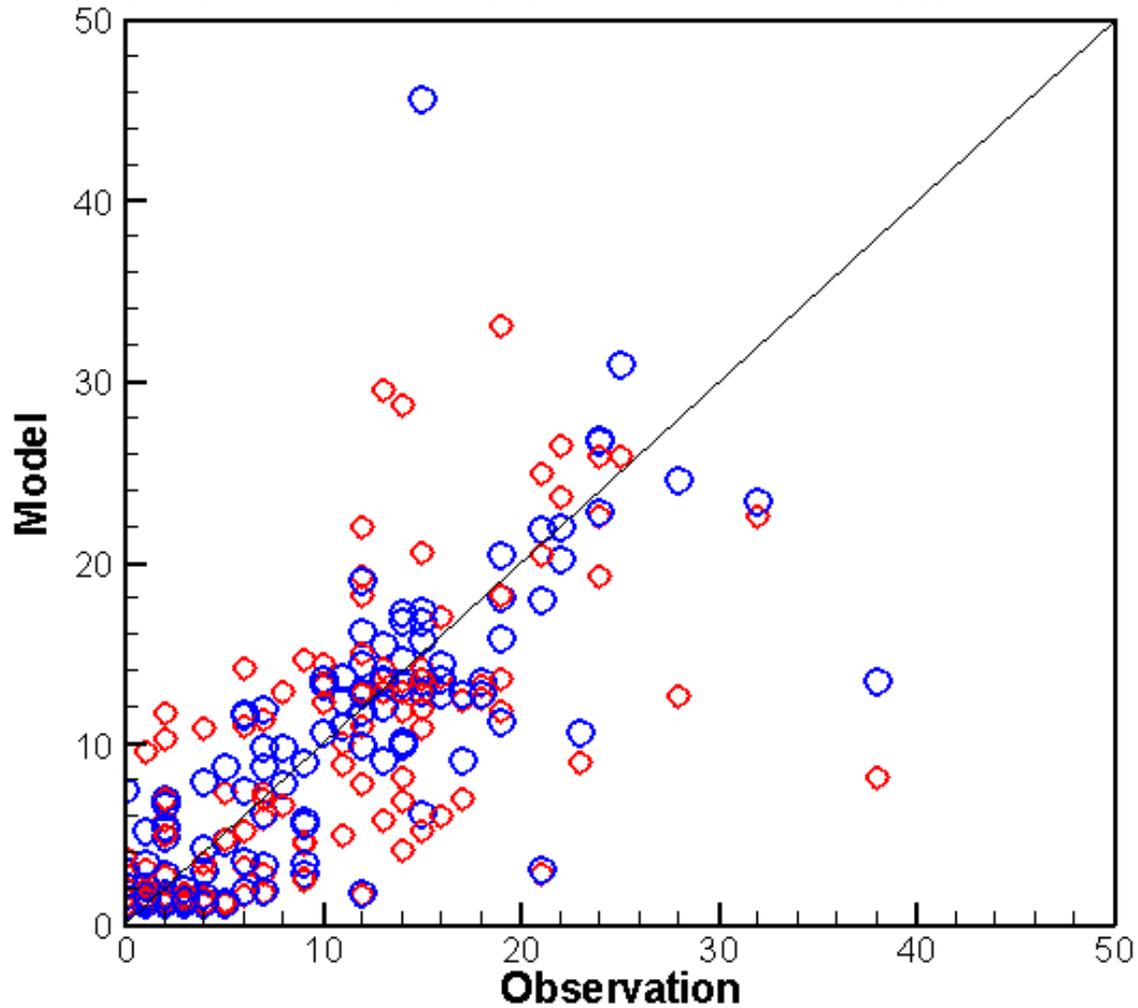
# Re-analysis is Possible Using Formal Data Assimilation (e.g., 4dVar)



Observations from DC-8 and their model counterparts

# PM2.5 (um/m3)

Hour 0 from 0 EDT 6/28/04 *w/o* & *w* data assimilation



# Ozone Concentration (ppbv)

Hour 0

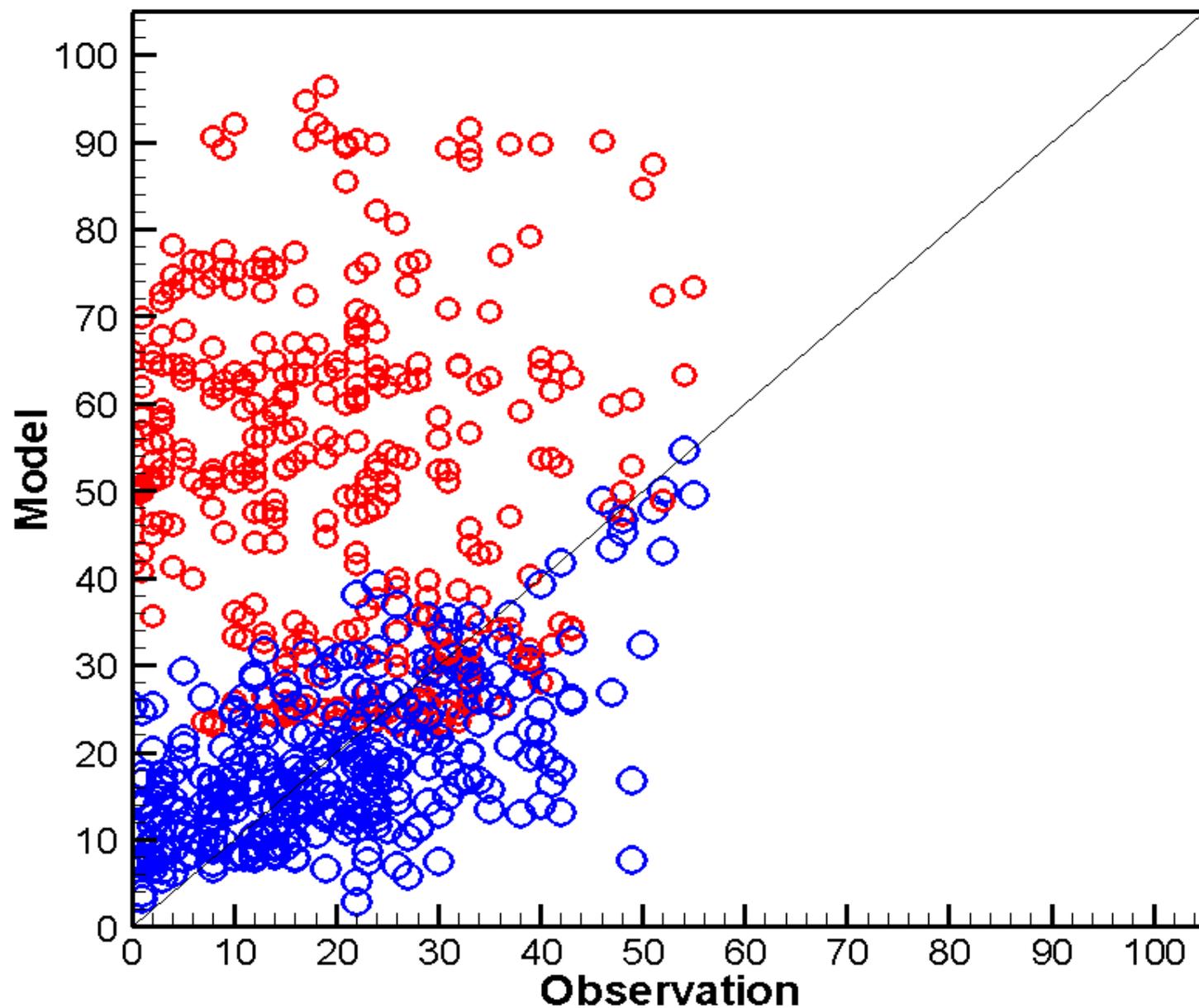
from 0 EDT 6/28/04

w/o

&

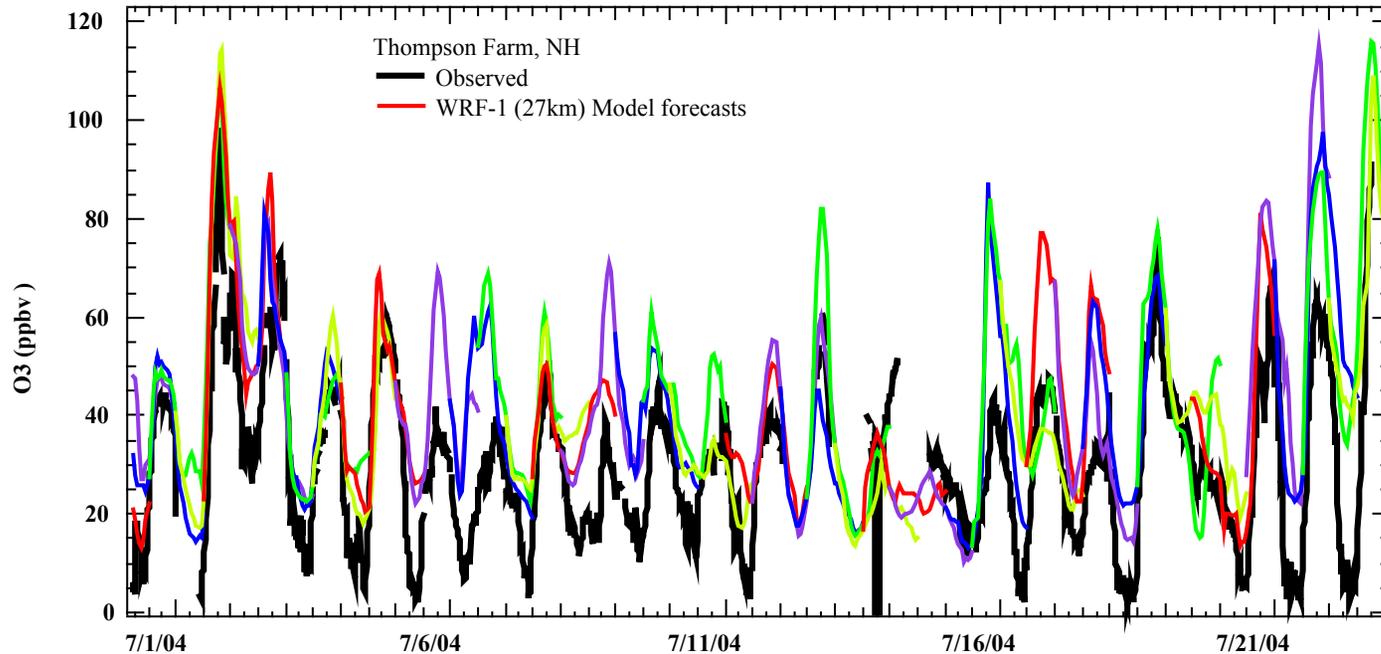
w

data assimilation



# Model Statistics - Thompson Farm (6/30/04 -7/22/04)

Statistics for 11am - 7pm LDT, 00Z forecasts only



Date

**O<sub>3</sub>**

**r<sup>2</sup>**

**median bias**

<b>O<sub>3</sub></b>	<b>r<sup>2</sup></b>	<b>median bias</b>
BAMS-15	0.65	0.5 ppb
BAMS-45	0.58	5.3 ppb
WRF1-27	0.48	12.3 ppb
AURAMS-42	0.37	26.5 ppb
CMAQ-12	0.36	9.9 ppb
STEM-12	0.32	18.3 ppb
CHRONOS-21	0.27	17.5 ppb

**NO<sub>y</sub>**

**r<sup>2</sup>**

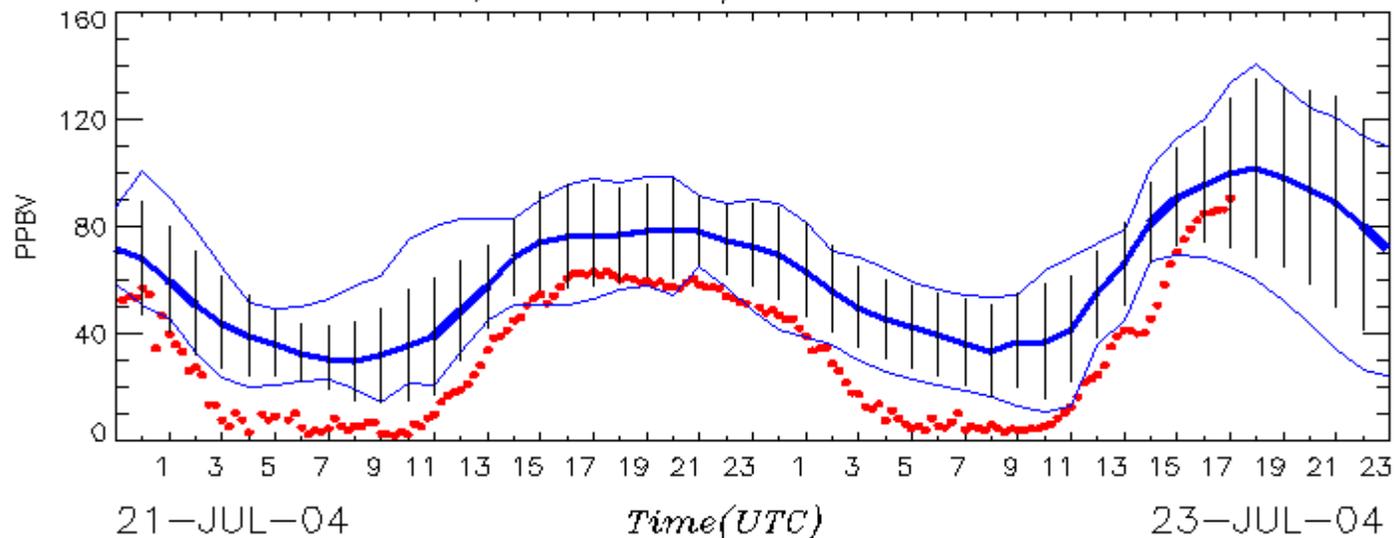
**Median bias (ratio)**

STEM-12	0.62	1.47
BAMS-45	0.59	1.04
CHRONOS-21	0.54	2.05
WRF1-27	0.43	3.89
BAMS-15	0.42	1.73
AURAMS-42	0.09	2.27

# NOAA/ETL SURFACE CHEMISTRY

O3 Ensemble: DHM, 0 Z

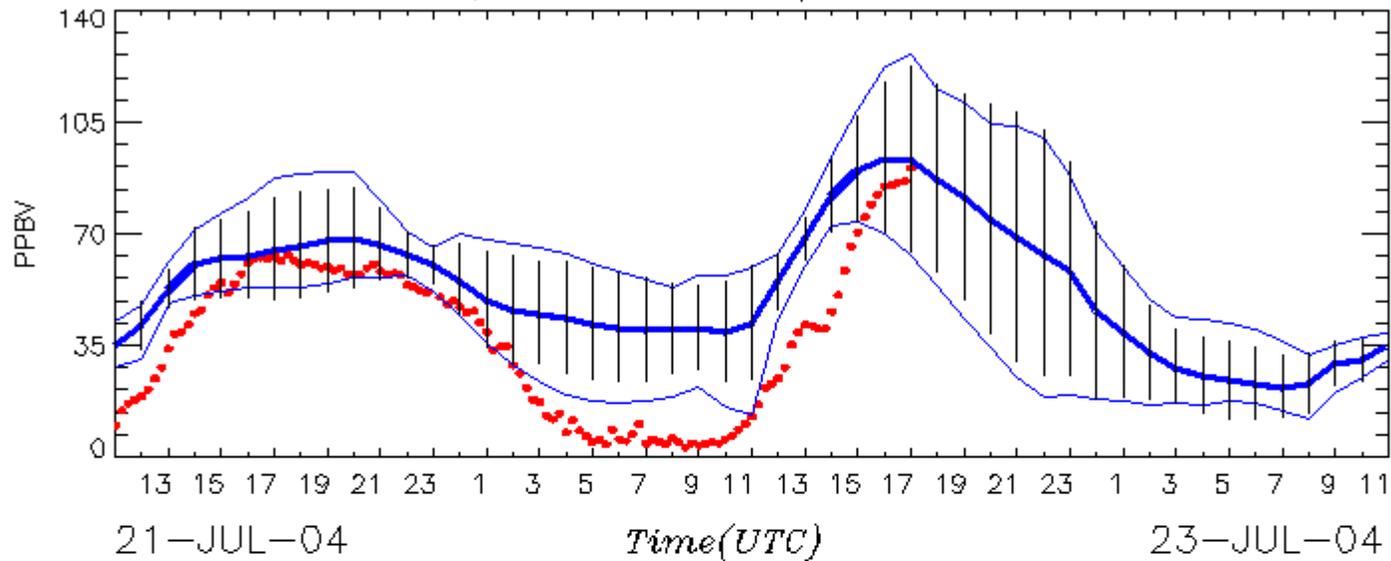
6/8 AUR CHR W1 W2 W3 B45 B15 ST



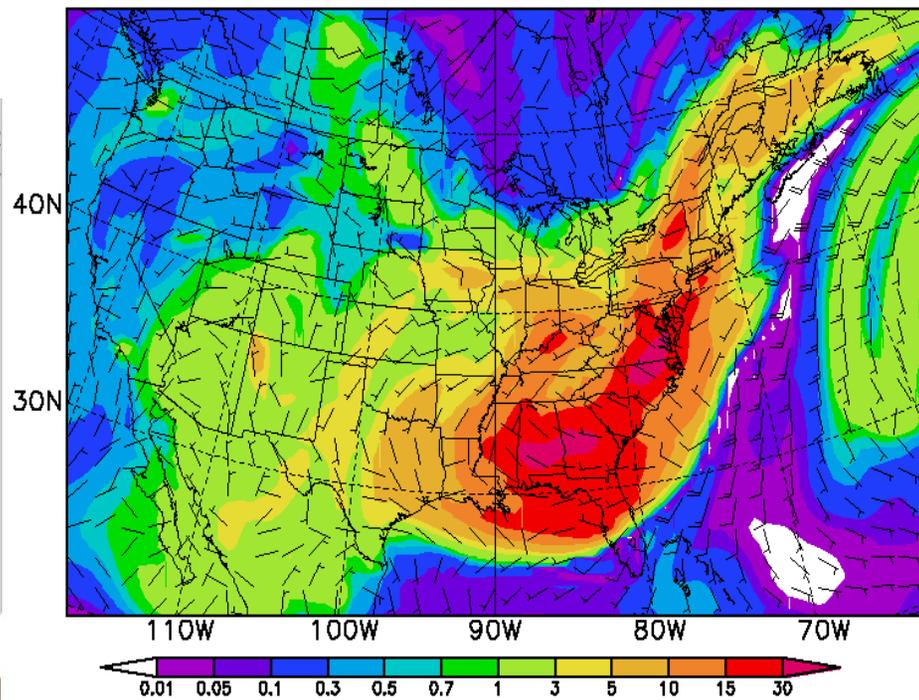
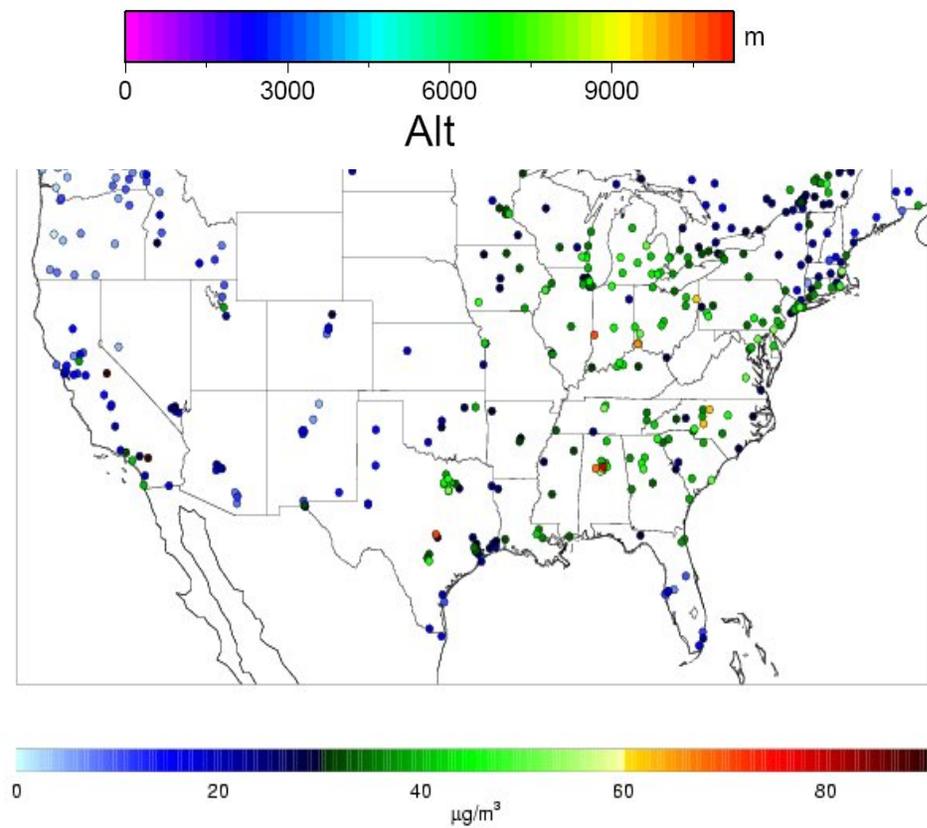
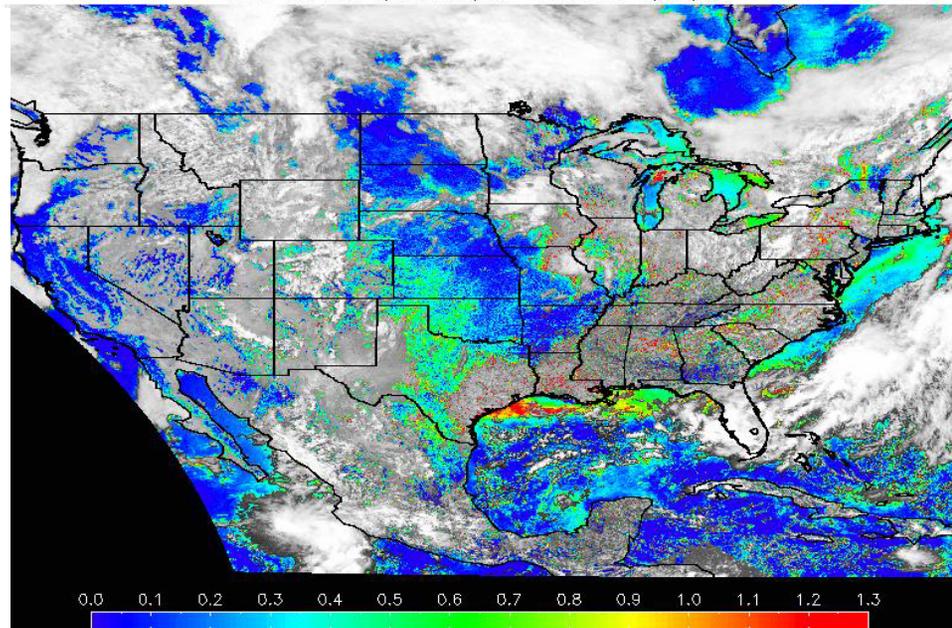
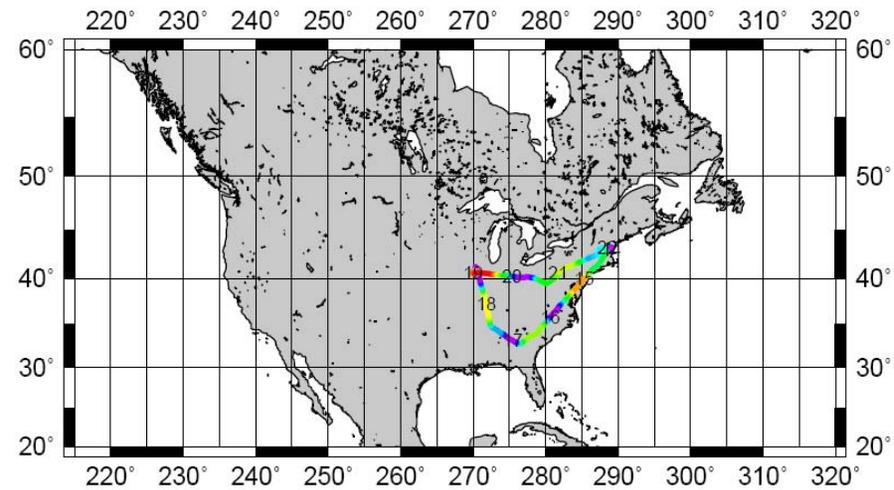
# NOAA/ETL SURFACE CHEMISTRY

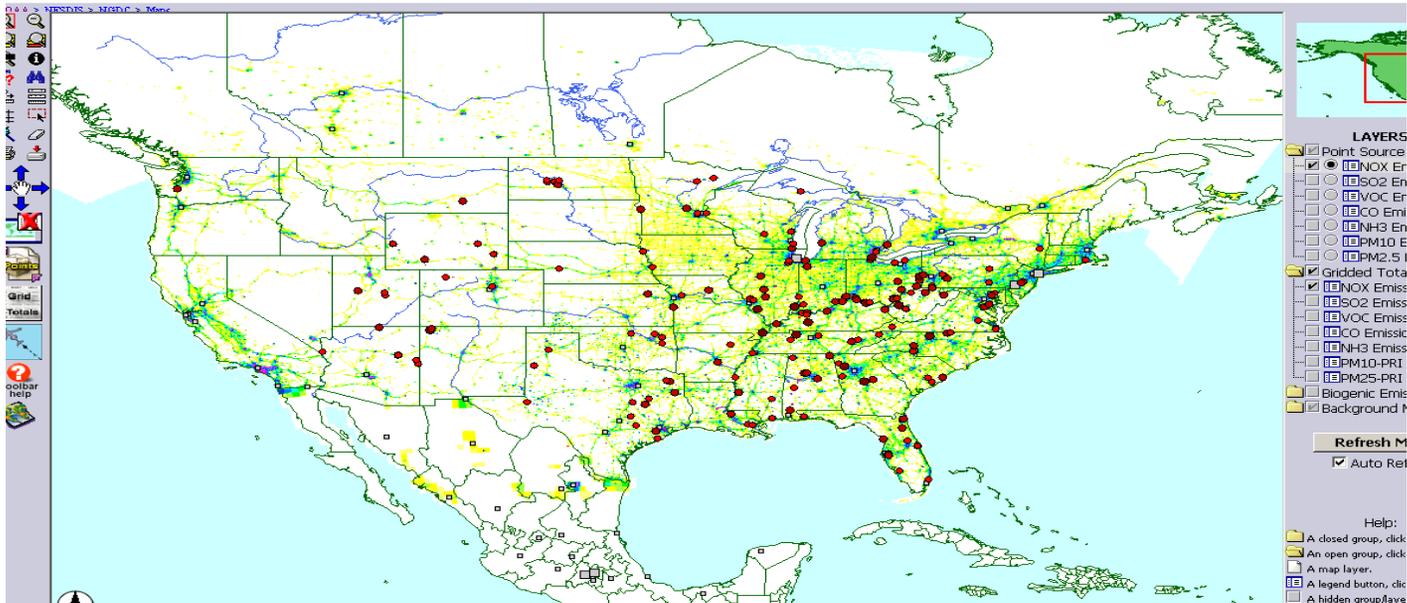
O3 Ensemble: DHM, 12 Z

5/7 CHR CMQ W1 W2 W3 B45 B15

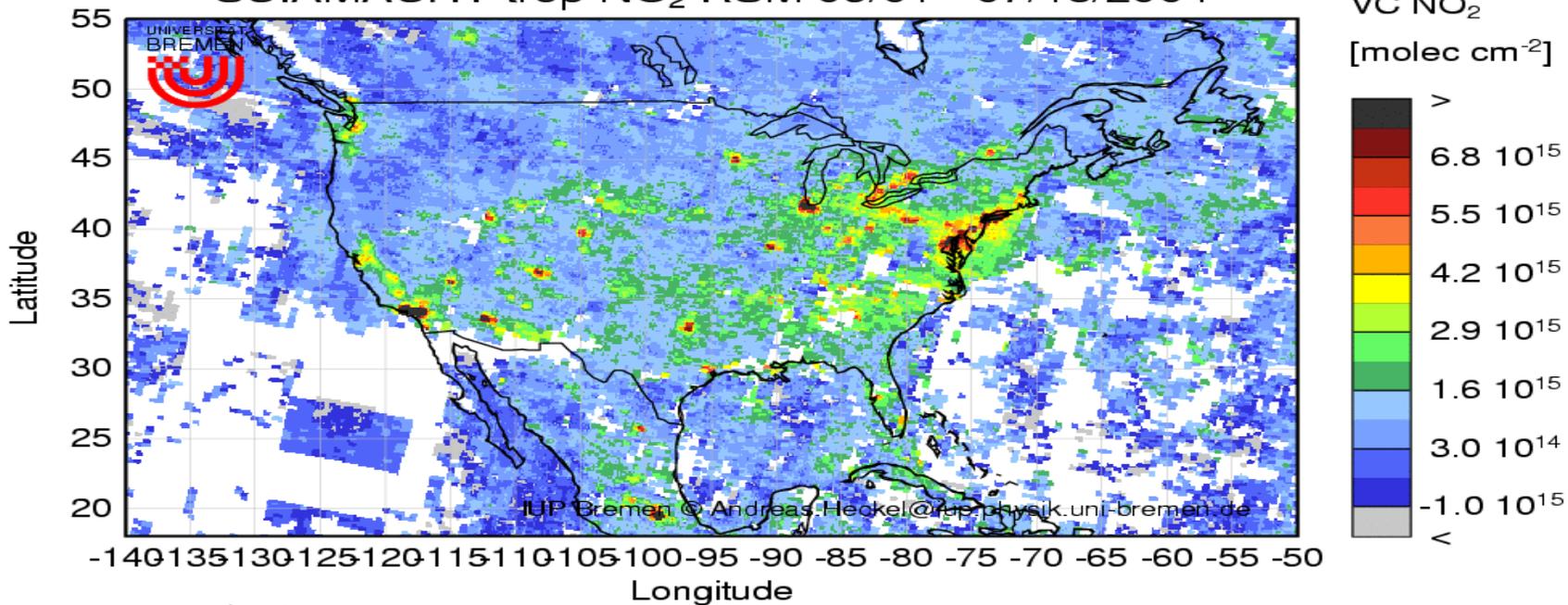


- CHR \_\_\_\_\_
- CMQ \_\_\_\_\_
- W1 \_\_\_\_\_
- W2 \_\_\_\_\_
- W3 \_\_\_\_\_
- B45 \_\_\_\_\_
- B15 \_\_\_\_\_





### SCIAMACHY trop NO<sub>2</sub> RSM 06/01 - 07/18/2004



Global airmass factors