

Preliminary Comparisons of CMAQ and in-situ O₃, NO₂, and HCHO observations during DISCOVER-AQ



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DISCOVER-AQ: Investigation Overview



DERIVING INFORMATION ON SURFACE CONDITIONS FROM COLUMN AND VERTICALLY RESOLVED OBSERVATIONS RELEVANT TO AIR QUALITY

OBJECTIVES:

- Relate column observations to surface conditions for aerosols and key trace gases O₃, NO₂, and HCHO
- Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols
- Examine horizontal scales of variability affecting satellites and model calculations

DEPLOYMENTS:

Maryland – July 2011

California – January 2013?

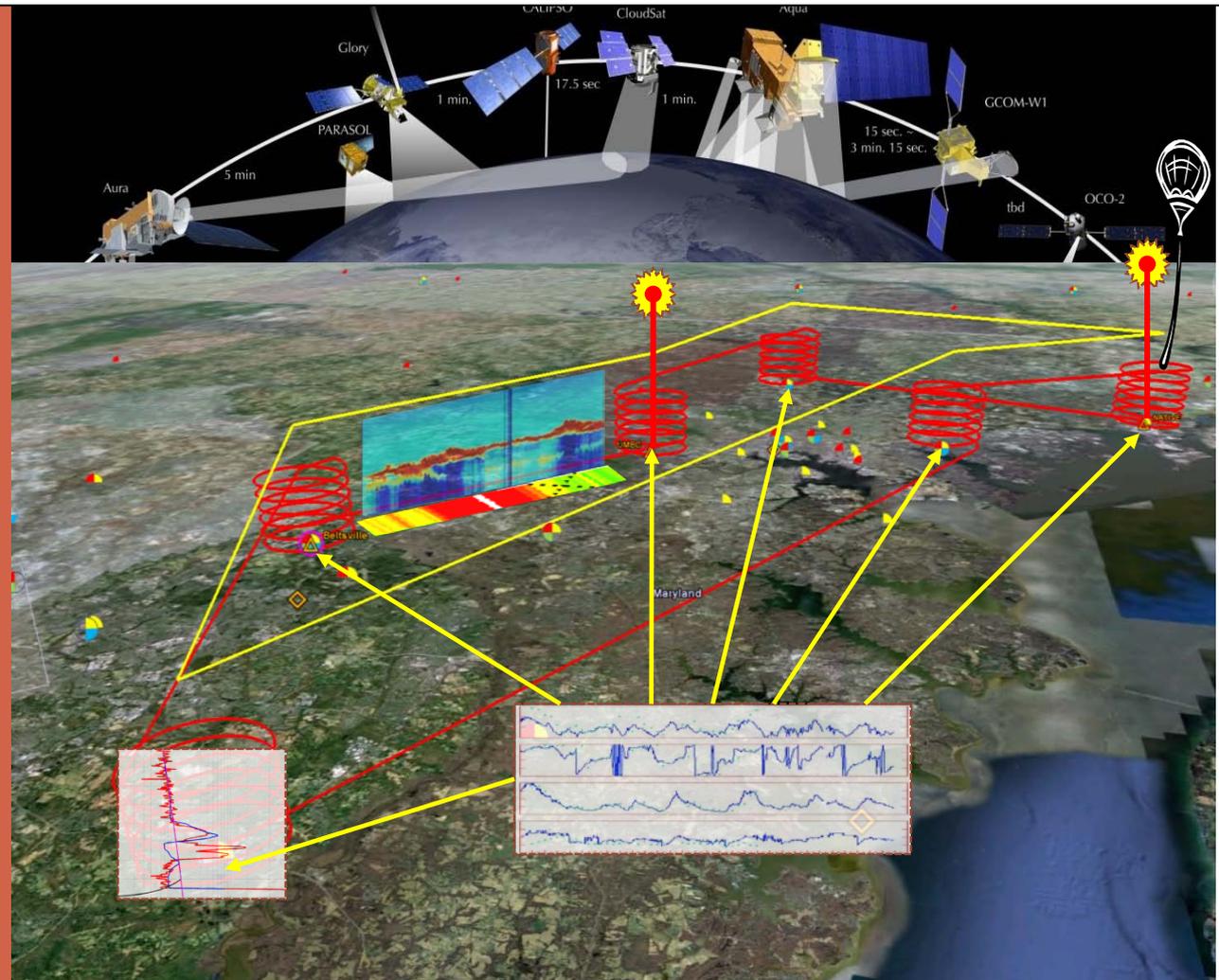
Texas – September 2013

TBD – Summer 2014

DISCOVER-AQ Deployment Strategy

Systematic and concurrent observation of column-integrated, surface, and vertically-resolved distributions of aerosols and trace gases relevant to air quality as they evolve throughout the day.

- **Continuous lidar mapping of aerosols with HSRL on board B-200**
- **Continuous mapping of trace gas columns with ACAM on board B-200**
- **In situ profiling over surface measurement sites with P-3B**
- **Continuous monitoring of trace gases and aerosols at surface sites to include both in situ and column-integrated quantities**
- **Surface lidar and balloon soundings**



DISCOVER-AQ: Investigation Overview

Sample Flight Path of P3 and spiral locations





Experimental NOAA CMAQ forecast

- CMAQ v. 4.6
- Driven by WRF-NMM meteorology
- 48 hour forecasts issued each day at 12Z during the campaign
- Therefore, for each flight there are two relevant forecasts
 - '0 hr' – the forecast that was issued the day of the flight
 - '24 hr' – the forecast that was issued the day before the flight

Chemical mechanism	CB05
Aerosol module	Aero4
Emissions	NEI-05
Domain	Rotated Lat-Lon E grid 12 km horizontal resolution
Vertical coordinate	NMM Hybrid (60L)
Radiation / Photolysis	Lacis-Hansen Bulk
PBL	Mellor-Yamada-Janjic (MYJ) local TKE
Clouds	Ferrier cloud water, graupel/ice
Convective cloud mixing	Betts-Miller-Janjic Mass Adjustment
Land surface	NOAH LSM

Forecast evaluation: 0 hr vs. 24 hr

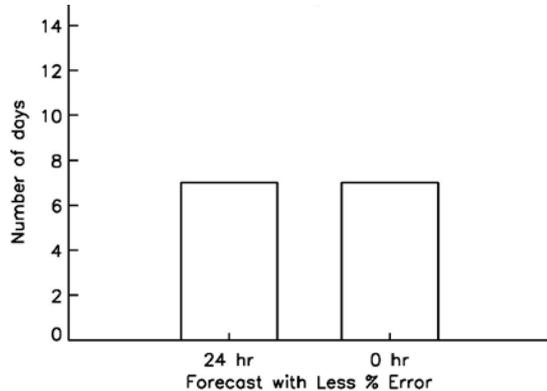


- *** All DISCOVER-AQ results are preliminary field data ***
- The flight data analyzed are 60 sec averages (rather than the native 1 sec resolution) for a more appropriate comparison to the 12 km CMAQ output
- The observations have been collocated in space and time with the CMAQ output
- Percent error =
 $(\text{model} - \text{observation}) / \text{observation} * 100$
- For all flight days during the campaign it was noted which forecast had lower absolute values of percent error
- These results are summarized in the following histogram plots

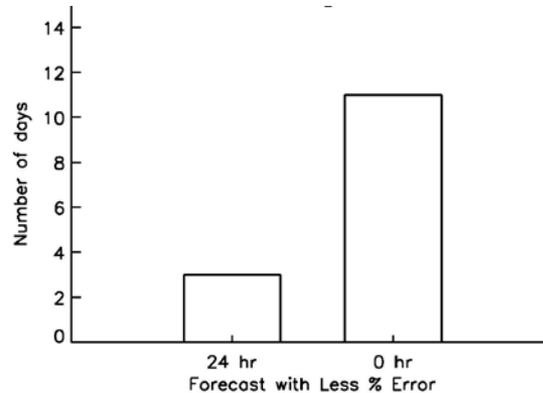
Forecast evaluation: 0 hr vs. 24 hr Histograms



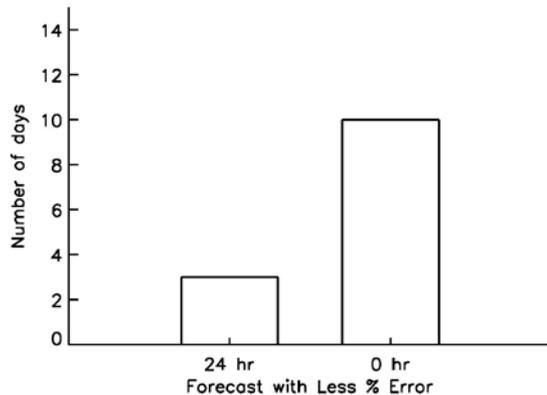
O_3



NO_2 (NCAR)



HCHO



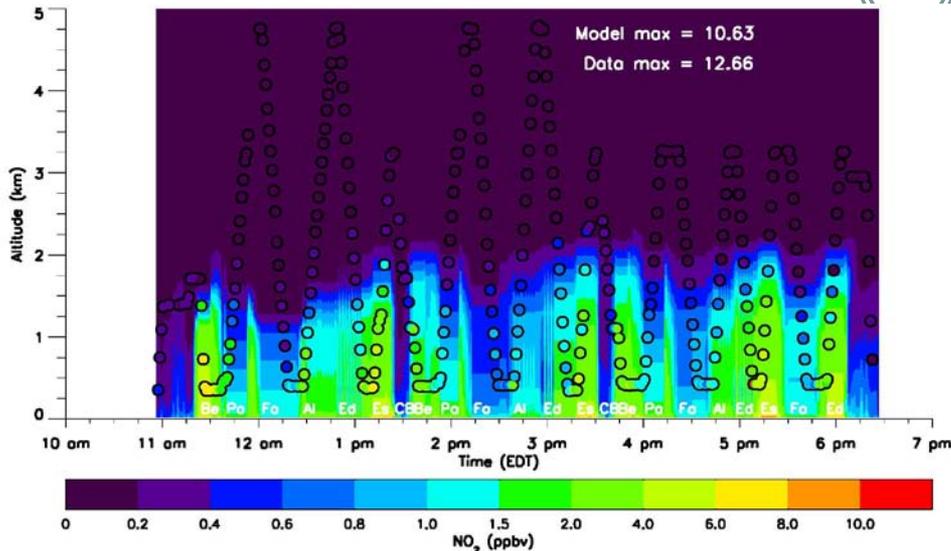
- With respect to the O_3 observations, the forecasts perform equally in terms of percent error
- The 0 hr forecast performed better than the 24 hr when compared with the HCHO and NCAR NO_2 observations
- The following comparisons will therefore show the 0 hr forecast results

Forecast evaluation: Model Biases in the PBL and FT

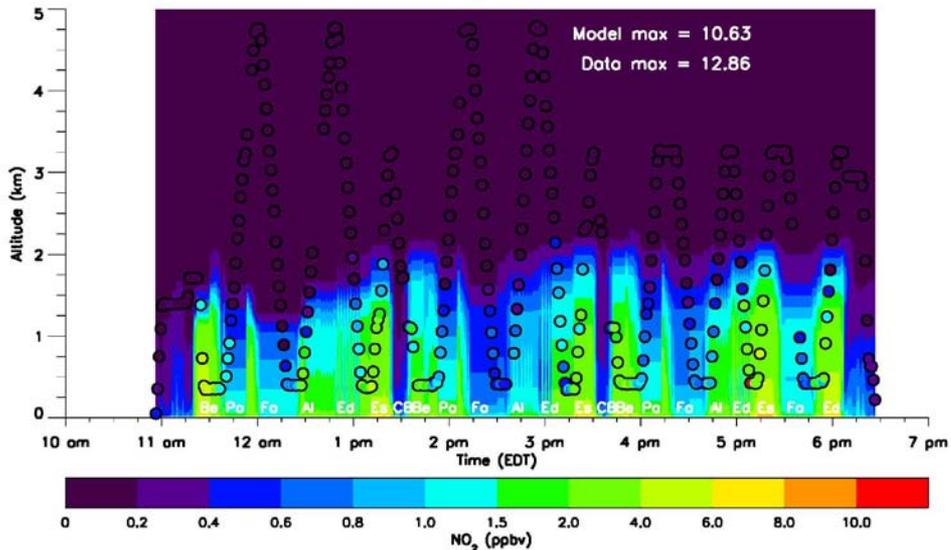


- Aircraft observations overplotted onto CMAQ output curtain plots
- Scatterplots of observations vs CMAQ

Flight #9 Thursday 7-21-2011



**CMAQ NO₂ Curtain with
NCAR NO₂
R=0.84**



**CMAQ NO₂ Curtain with
Berkeley NO₂
R=0.83**

**CMAQ reproduces
variability seen in the
observations in both the PBL
and FT**

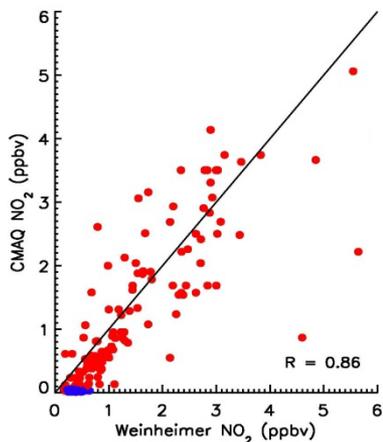
IWAQFR November 30, 2011

* Berkeley NO₂ has less coverage than NCAR NO₂ due to cycling through N species

CMAQ NO₂ vs. NCAR NO₂



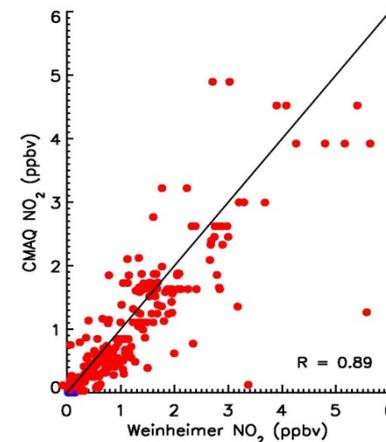
07/10/2011



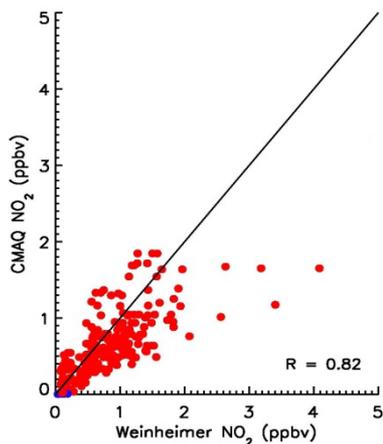
< 2.5 km

> 2.5 km

07/14/2011

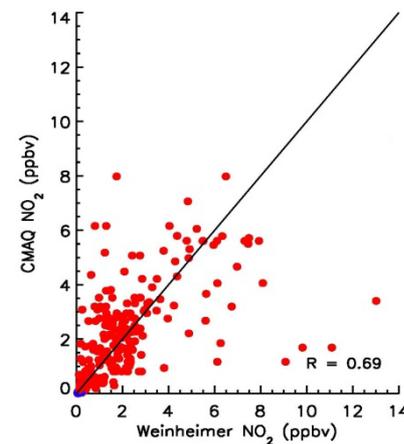


07/27/2011



CMAQ agrees relatively well with both NO₂ datasets

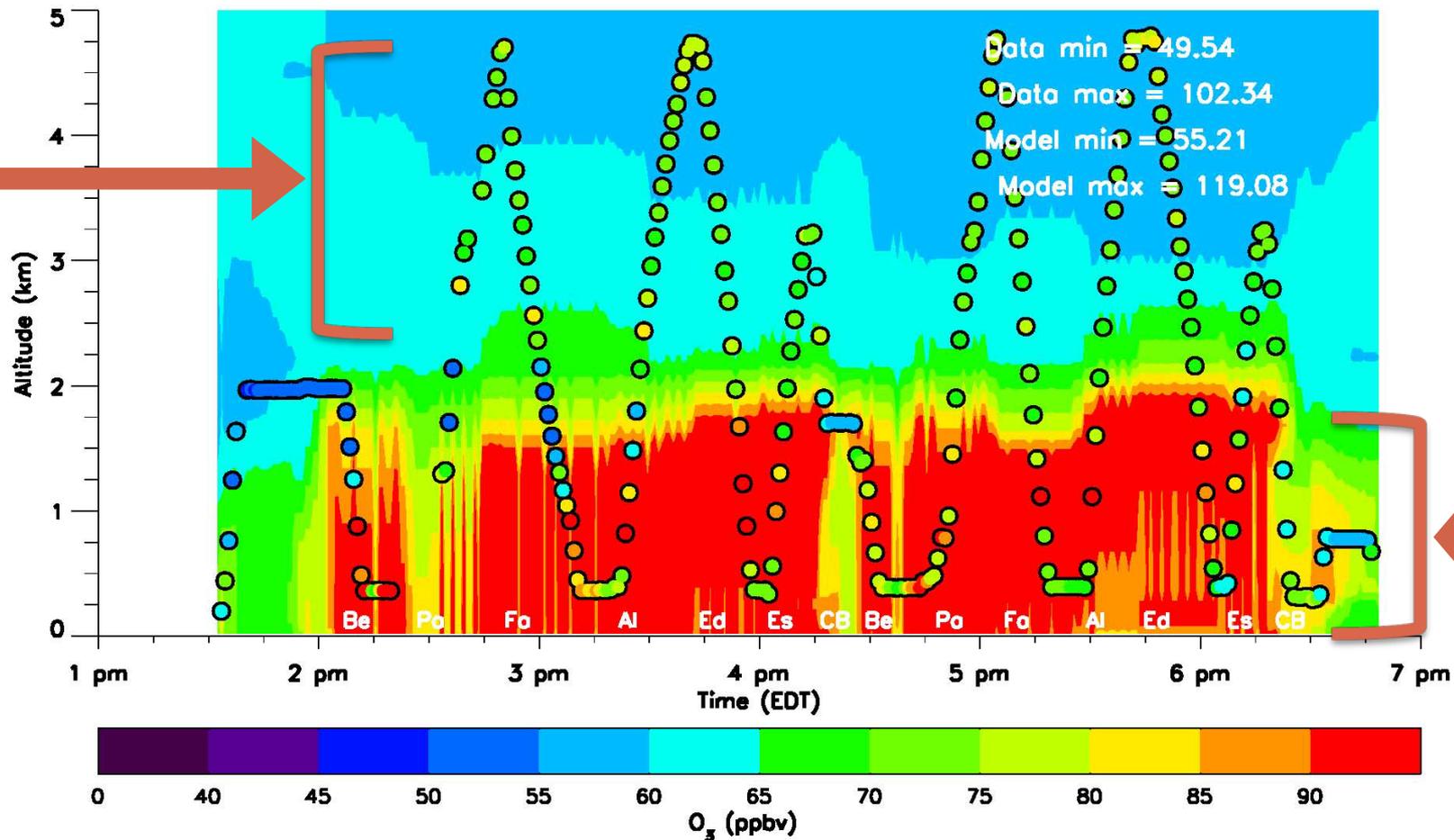
07/28/2011



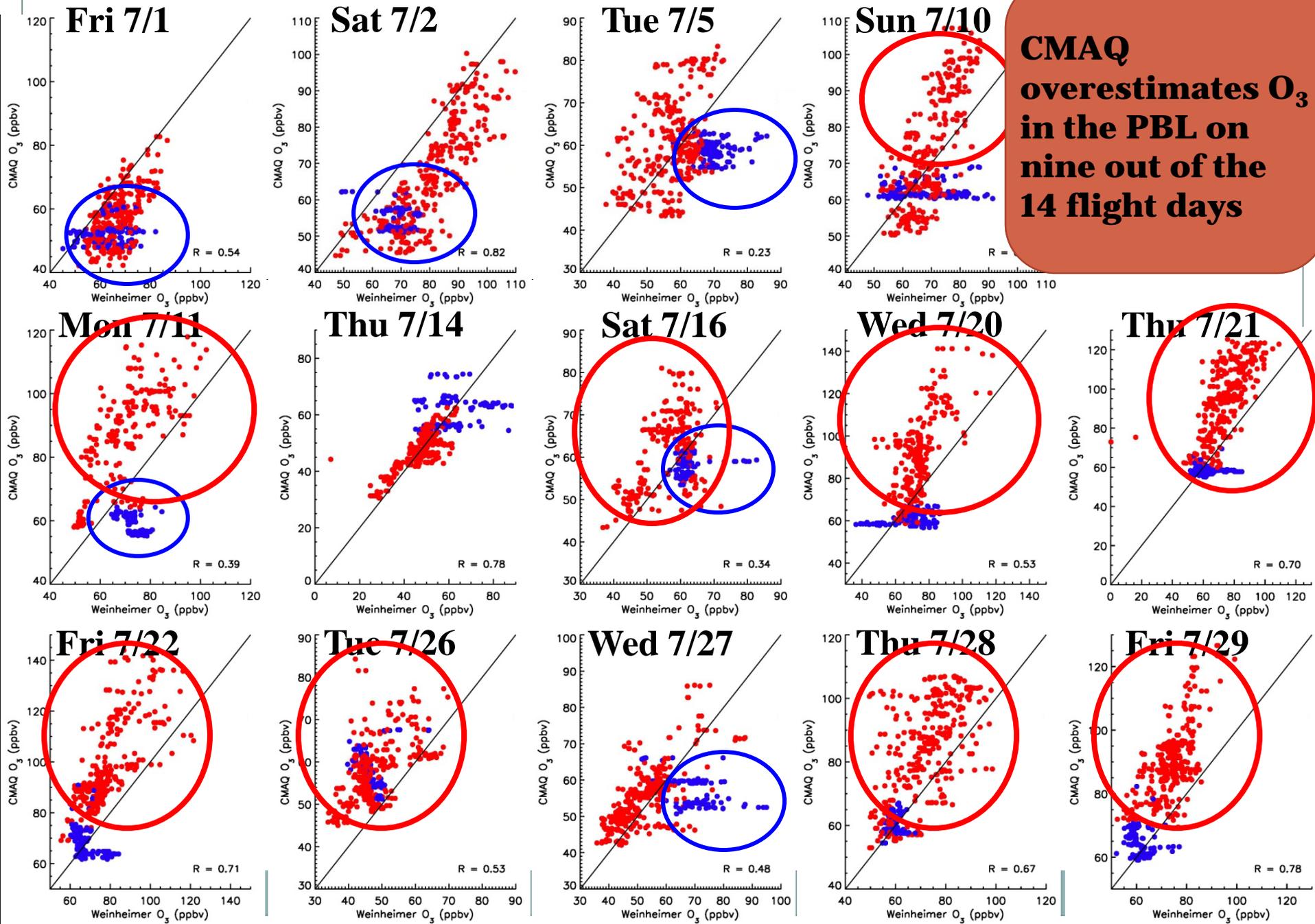
CMAQ O₃ Curtain with NCAR O₃ Flight #12 Wednesday 7-27-2011

CMAQ underestimates ozone above the boundary layer

CMAQ overestimates ozone in the boundary layer



< 2.5 km > 2.5 km

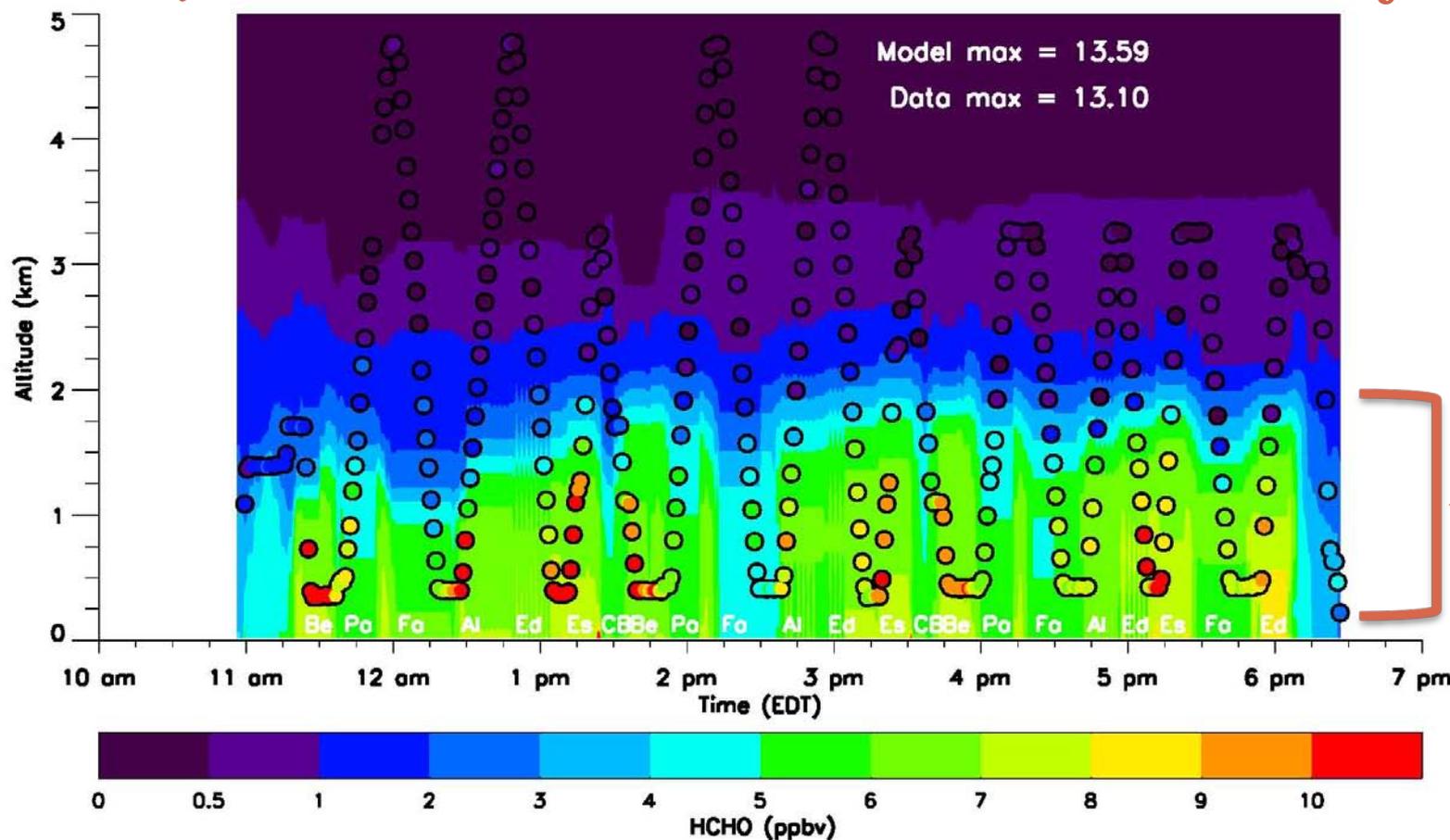


CMAQ HCHO Curtain with HCHO measurements

Flight #9 Thursday 7-21-2011

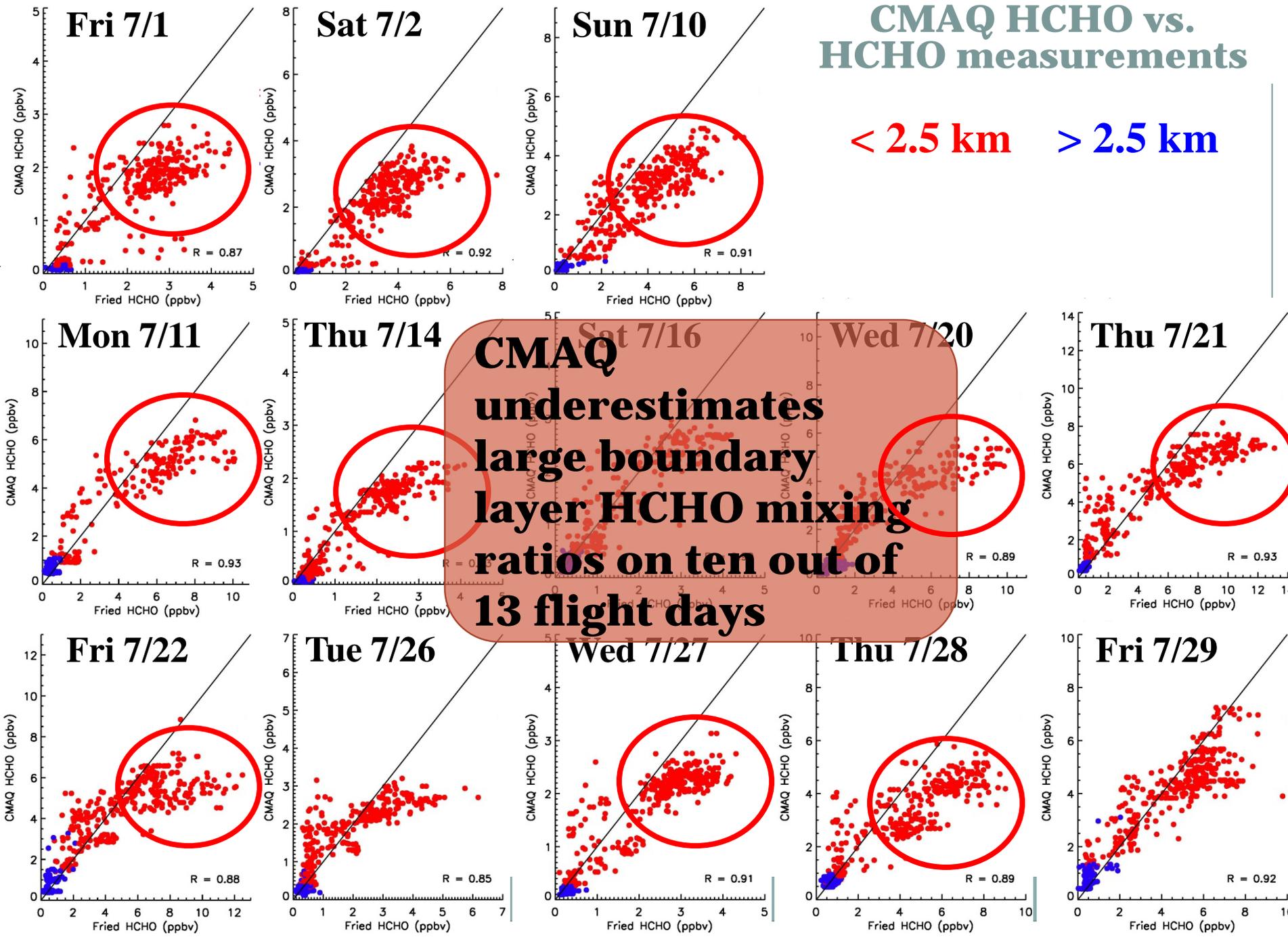


CMAQ underestimates HCHO in the boundary layer



CMAQ HCHO vs. HCHO measurements

< 2.5 km > 2.5 km



Summary



- Observations taken during DISCOVER-AQ were averaged to a temporal resolution of 60 sec to compare with two CMAQ forecasts
- When compared with HCHO and the NCAR NO₂ observations, the 0 hr forecast displayed lower absolute values of percent error
- The 0 hr and 24 hr forecasts performed equally with respect to the O₃ observations
- CMAQ reproduced the variability seen in the NO₂ observations, and no bias was observed
- CMAQ underestimated O₃ above 2.5 km on six out of the 14 flight days, and overestimated O₃ below 2.5 km on nine out of 14 flight days
- CMAQ underestimated HCHO below 2.5 km on ten out of 13 flight days