OVERVIEW:
Seasonal Transition of the Upper Tropospheric Composition

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DC3 Science Team Meeting, February 26, 2013

DC3 Science Program Overview (SPO)

Goal 2: Quantify the changes in chemistry and composition after active convection, focusing on 12-48 hours after convection and ***the seasonal transition of the chemical composition of the UT***

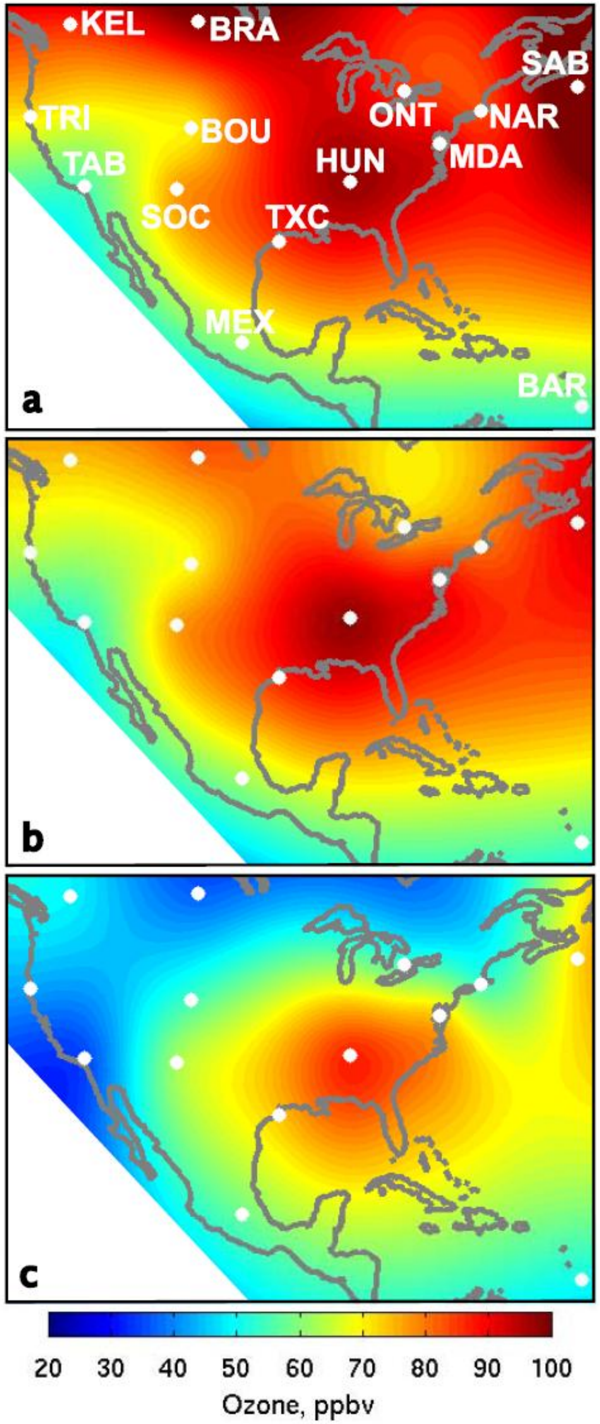
Hypothesis 8) Survey flights at the end of June from the central U.S. to the northern Caribbean will find the greatest UT ozone and NO_x mixing ratios above the Gulf of Mexico and Florida.

August 2006

Median ozone at 10-11 km from daily ozonesonde measurements using all available data.

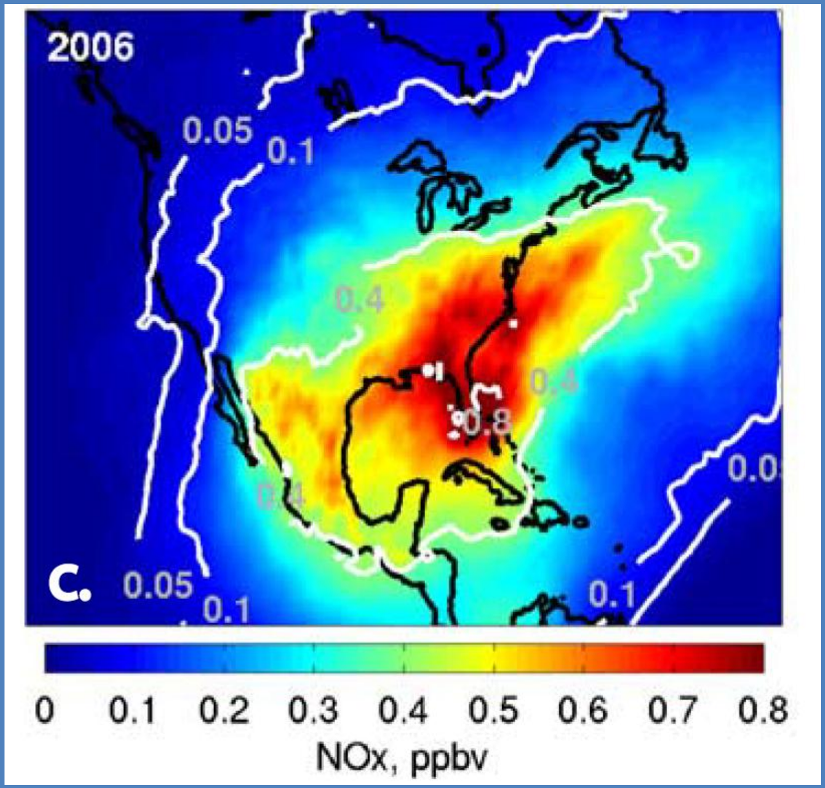
Same as above but for measurements made only in the troposphere.

Same as above but with model calculated aged stratospheric ozone removed.

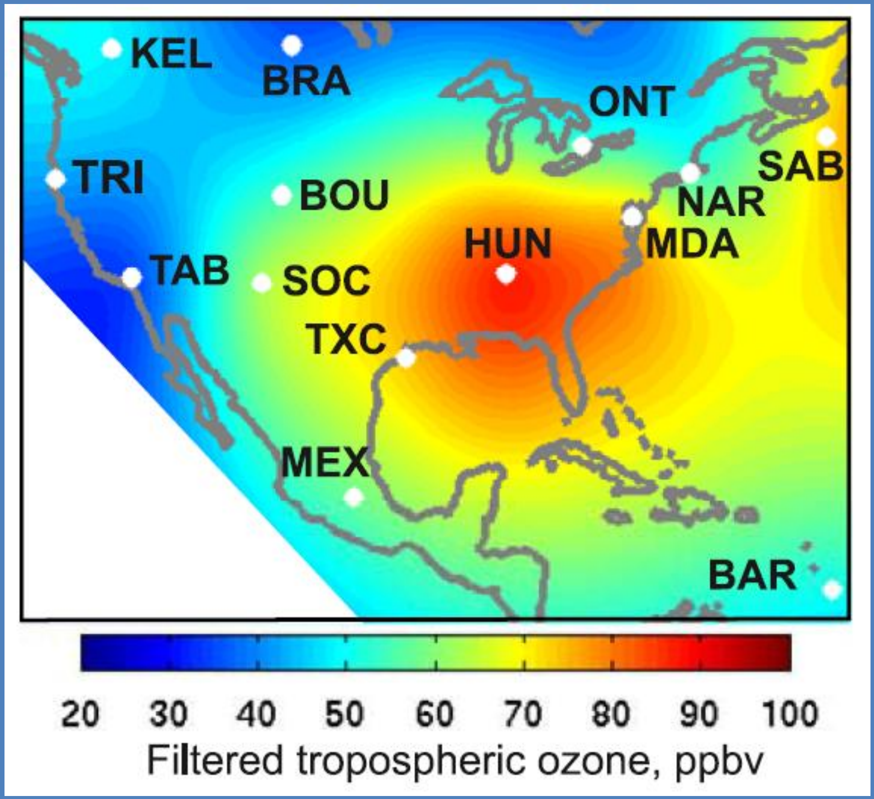


Cooper et al. (2007), Evidence for a recurring eastern North America upper tropospheric ozone maximum during summer, J. Geophys. Res., 112

During the summer monsoon (July-August) the upper tropospheric anticyclone traps LNO_x, leading to strong ozone production over several days.



Upper tropospheric NO_x from all sources as modeled by FLEXPART, summer 2006. Greater than 80% of the NO_x across the eastern US is produced by lightning.



Monthly average upper tropospheric ozone as measured by ozonesondes, August 2006, with stratospheric influence removed.

Cooper, O. R., et al. (2009), Summertime buildup and decay of lightning NOx and aged thunderstorm outflow above North America, J. Geophys. Res., 114, D01101, doi:10.1029/2008JD010293.

JGR Journal of Geophysical Research Atmospheres AGU

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 115, D22301, doi:10.1029/2010JD014062, 2010

Impact of lightning NO emissions on North American photochemistry as determined using the Global Modeling Initiative (GMI) model

Dale Allen,[1] Kenneth Pickering,[2] Bryan Duncan,[2] and Megan Damon[3,4]

Received 2 March 2010; revised 11 June 2010; accepted 18 June 2010; published 19 November 2010.

***Allen et al*. [2010] reviewed 13 recent studies on LNO_x production above North America:**

60-90% of UT NO_x and 15-35% of UT ozone has a lightning source

Models are generally biased low in terms of NO_x

Model simulations of UT ozone have biases of +/- 20%

More work is needed to reduce uncertainties in STE, ozone production rates, LNO_x emission rates and UT NO_x lifetimes.

Atmos. Chem. Phys., 12, 11003–11026, 2012
www.atmos-chem-phys.net/12/11003/2012/
doi:10.5194/acp-12-11003-2012

Atmospheric Chemistry and Physics

Thunderstorms and upper troposphere chemistry during the early stages of the 2006 North American Monsoon

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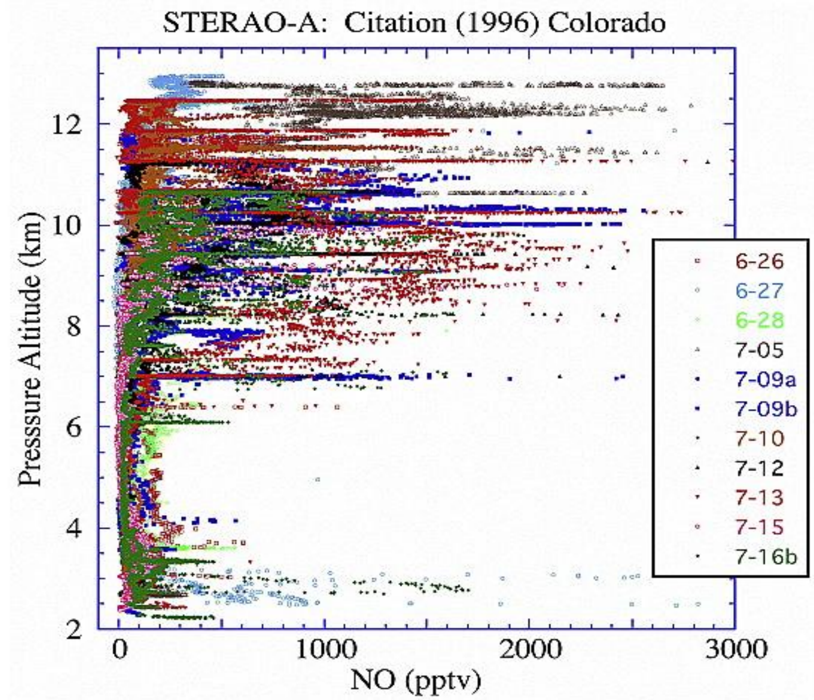
[2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA
[3]Department of Atmospheric and Oceanic Sciences and Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, Colorado, USA

***Barth et al*. [2012] studied UT ozone and LNOx production during the early stages of the North American monsoon:**

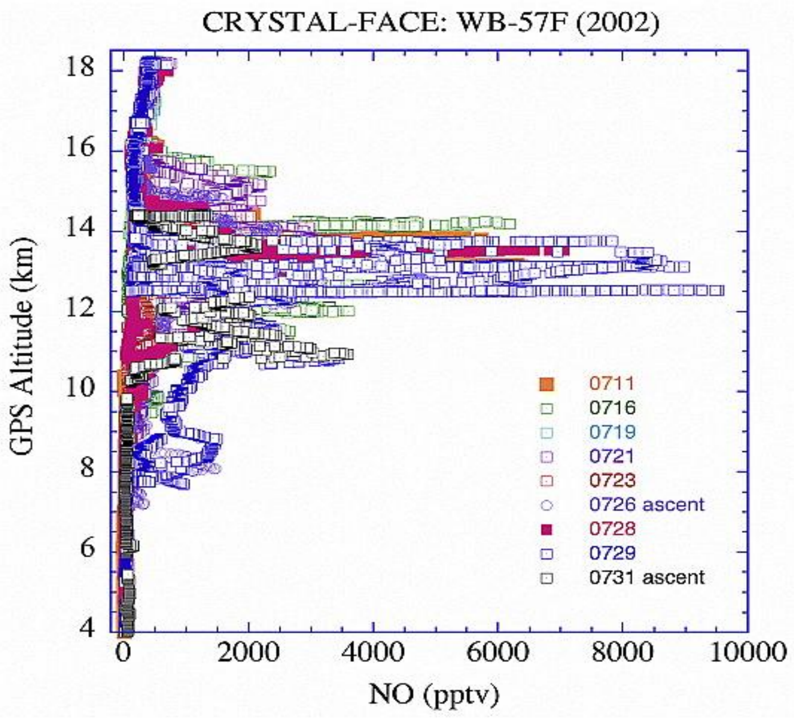
- Weak contrast in ozone within and outside of the UT anticyclone
- Most ozone production occurs within 24 hours of deep convection
- STE has a strong impact on UT ozone

CRYSTAL-FACE found enhanced LNO_x and ozone above the Gulf of Mexico and Florida during late June

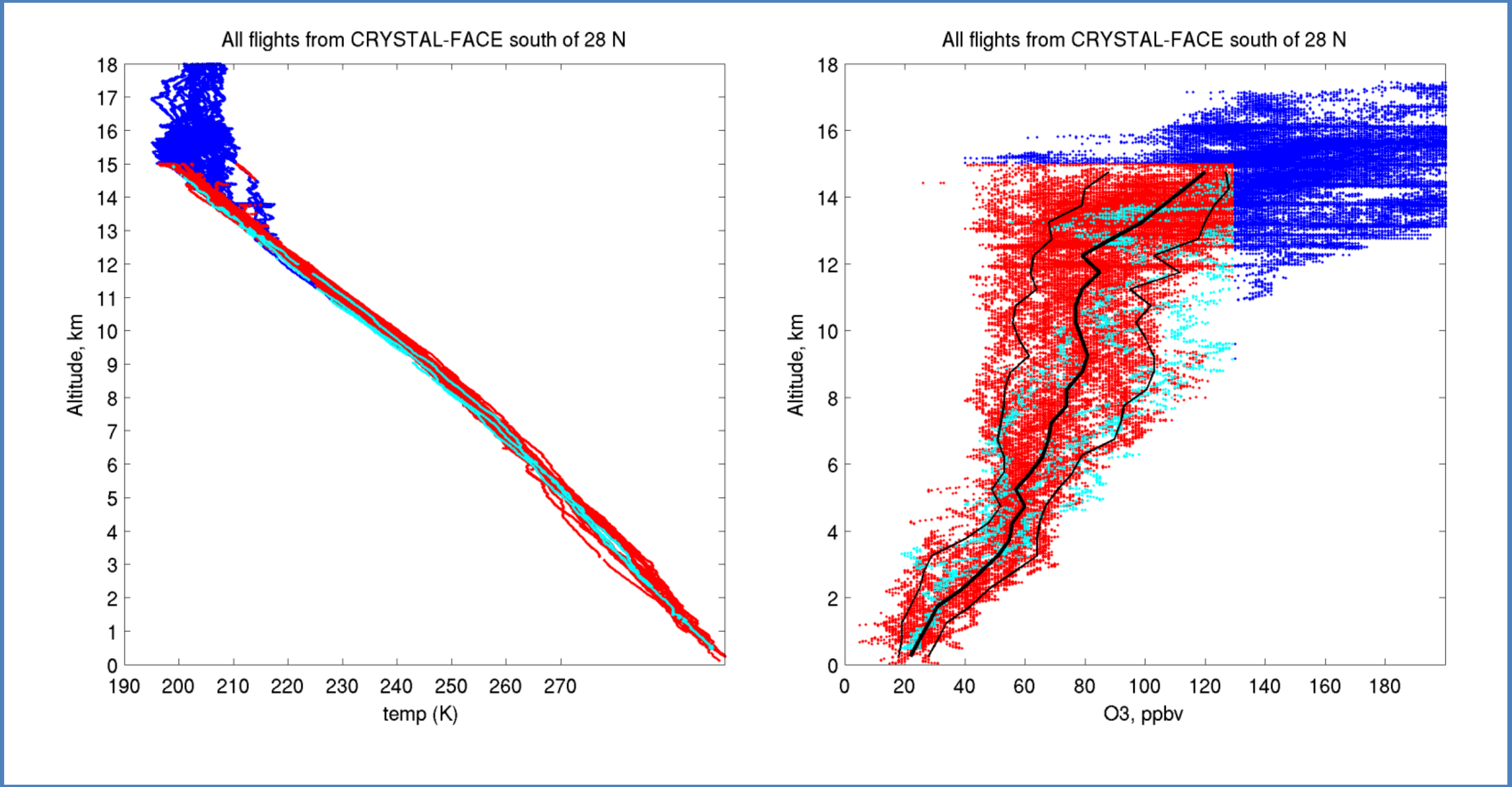
Measured NO above Colorado during the June-July 1996 STERAO experiment.



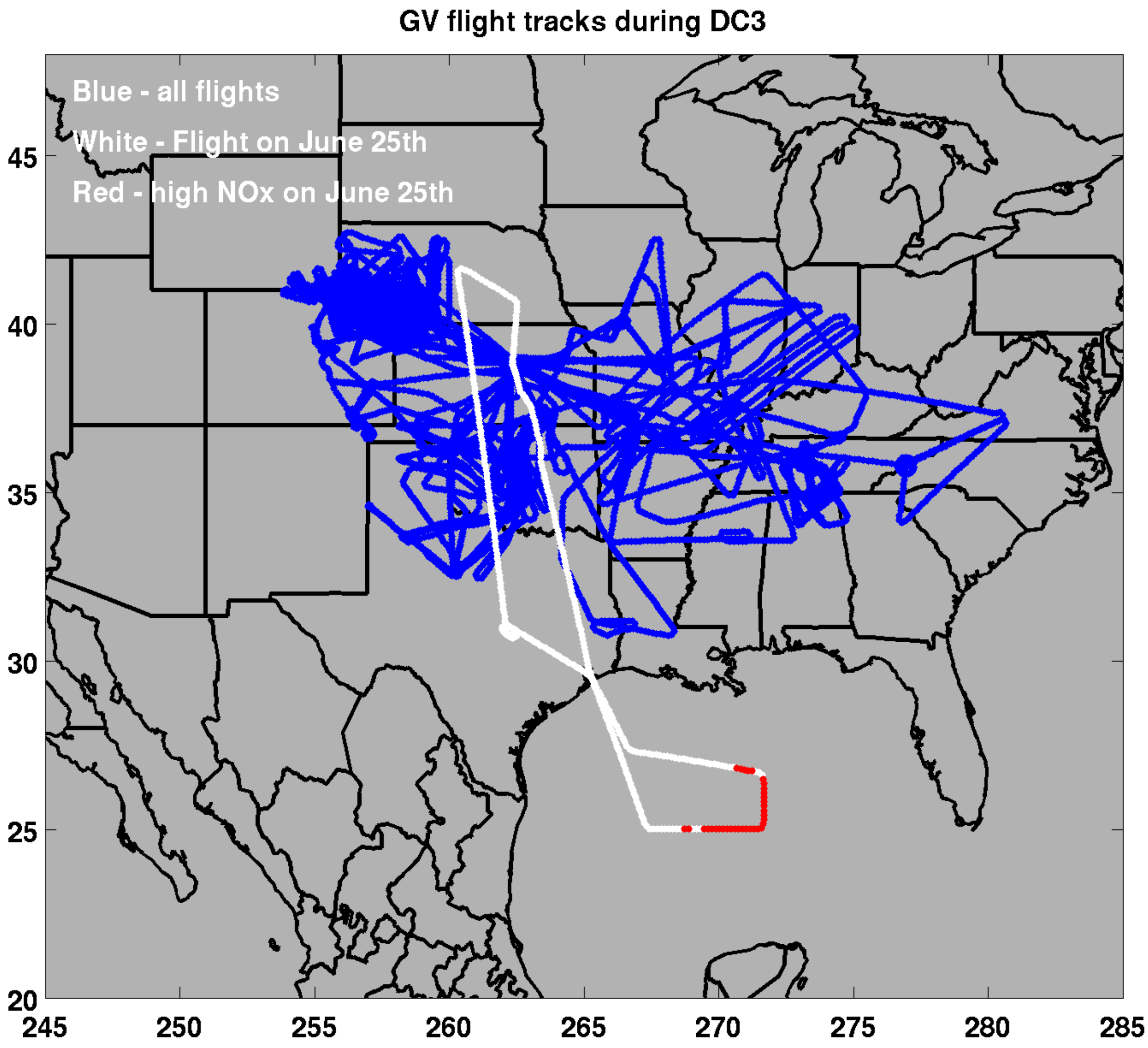
Measured NO above Florida during the June 29 – July 31, 2002 CRYSTAL-FACE experiment.

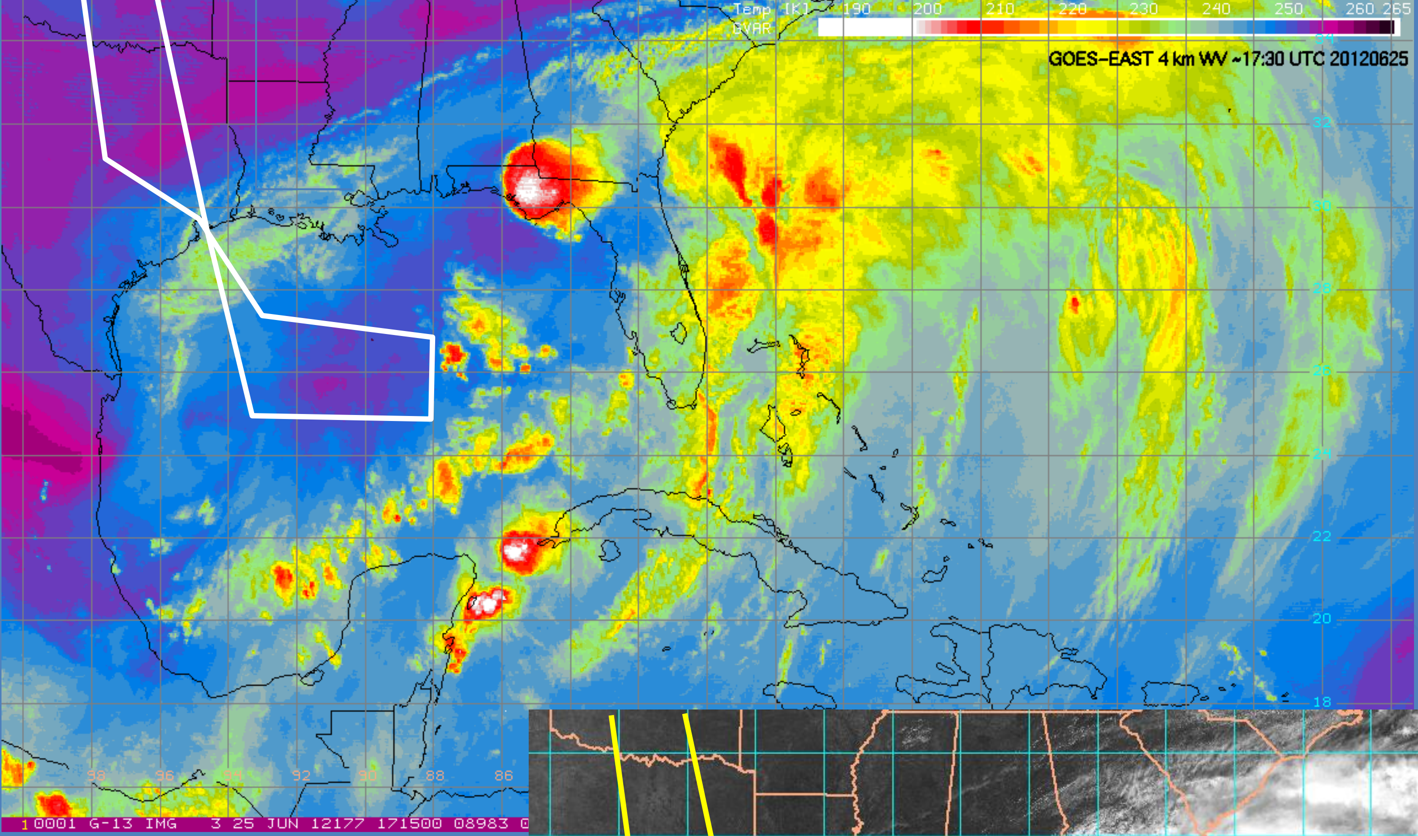


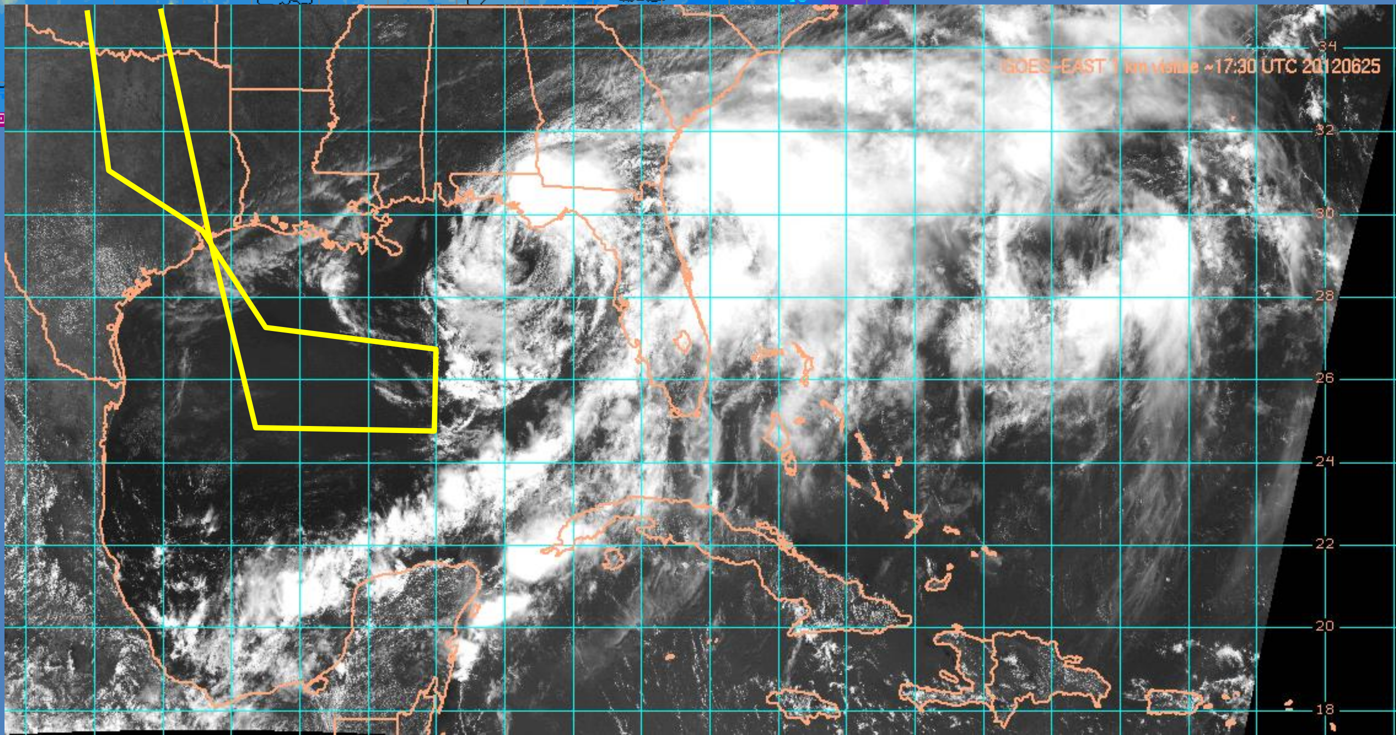
Ridley et al. (2004), Florida thunderstorms: A faucet of reactive nitrogen to the upper troposphere, J. Geophys. Res., 109, D17305, doi:10.1029/2004JD004769.



Median UT ozone values during CRYSTAL-FACE were ~80 ppbv


GV flight tracks during DC3
Blue - all flights
White - Flight on June 25th
Red - high NOx on June 25th
45
40
35
30
25
20
245
250
255
260
265
270
275
280
285

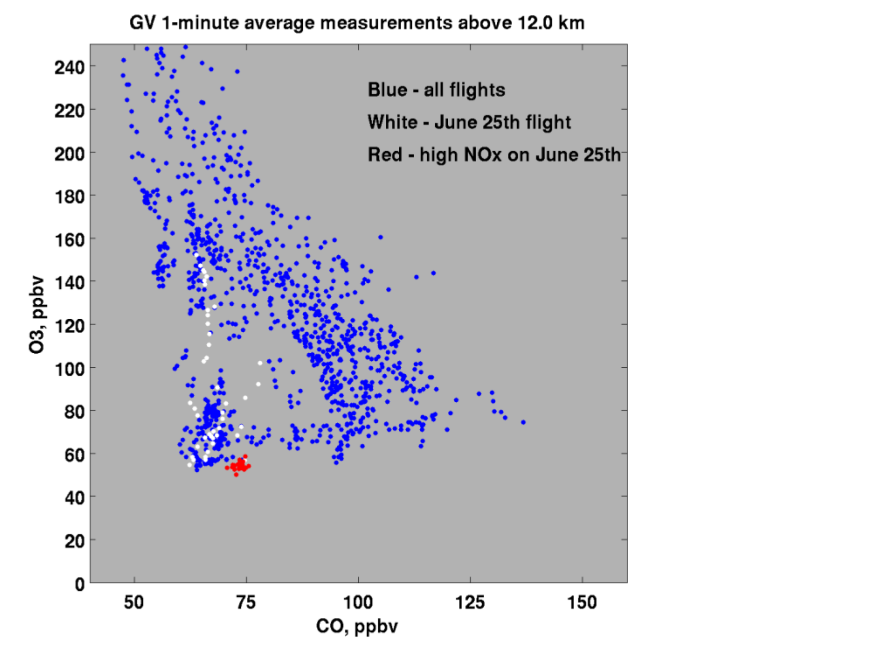

GOES-EAST 4 km WV ~17:30 UTC 20120625
Temp [K]
GVAR
190
200
210
220
230
240
250
260
265
1 0001 G-13 IMG 3 25 JUN 12177 171500 08983

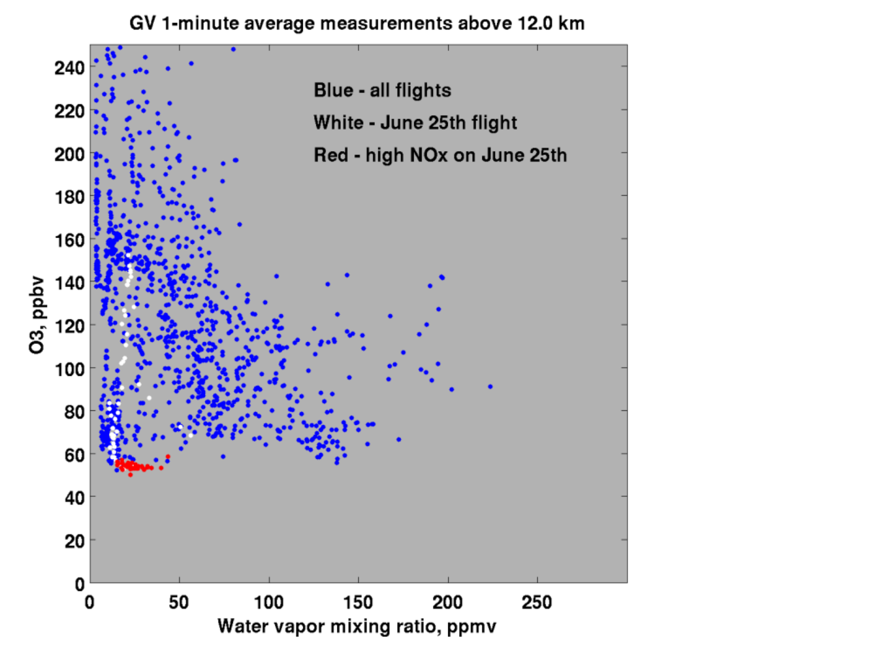

GOES-EAST 1 km visible ~17:30 UTC 20120625

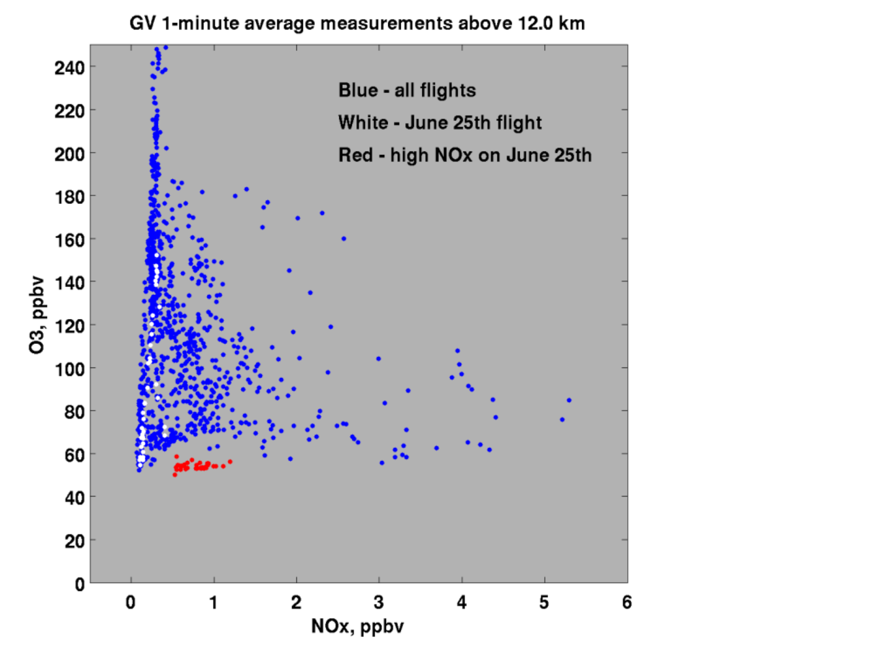
The June 25 GV flight to the Gulf of Mexico did not find aged thunderstorm outflow.

Instead the UT was heavily influenced by aged stratospheric air and relatively clean convective outflow less than 24 hours old.

In contrast to the DC3 continental air masses the fresh tropical convective outflow was: very clean, very dry, with enhanced NO_x







Results from DC3 (May-June) can be used to improve our understanding of UT ozone production during the North American monsoon (July-August)

- Use DC3 chemical and meteorological observations to improve the dynamics, chemistry and lightning parameterizations in CTMs

- Run the improved models for the May-August 2012 time period

- Evaluate model performance against chemical observations (limited) during July and August.

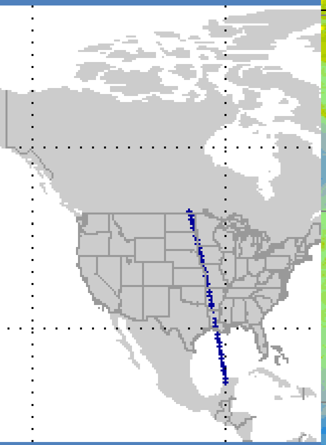
Data available for model evaluation:

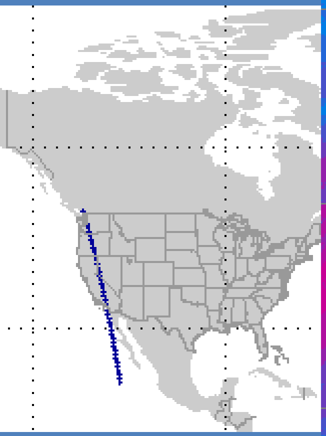
17 ozonesondes (weekly) from Huntsville, May 1 – Sept 1, 2012
16 ozonesondes (weekly) from Boulder, May 1 – Sept 1, 2012
14 ozonesondes (weekly) from Trinidad Head, May 1 – Sept 1, 2012
22 ozonesondes (weekly) from Wallops Island, May 1 – Sept 1, 2012

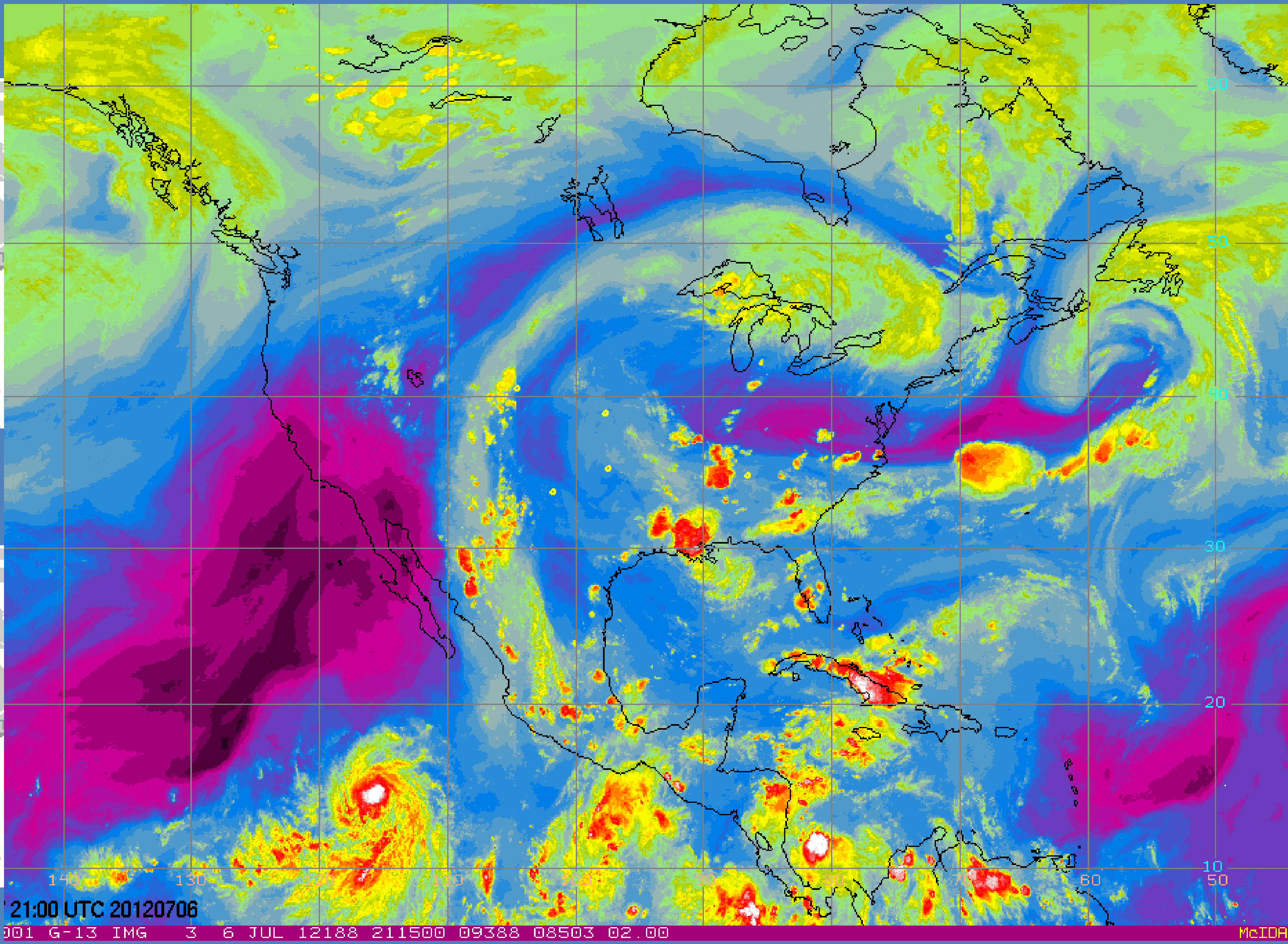
Huntsville LIDAR profiles from 11 days in June (from Mike Newchurch)

TES tropospheric O_3 and CO retrievals: daily in May-June, every 2-3 days in July-August
http://tes.jpl.nasa.gov/visualization/SCIENCE_PLOTS/SO/main_SS_DC3_2012.html

TES retrievals on July 6, 2012 (images courtesy of NASA JPL)

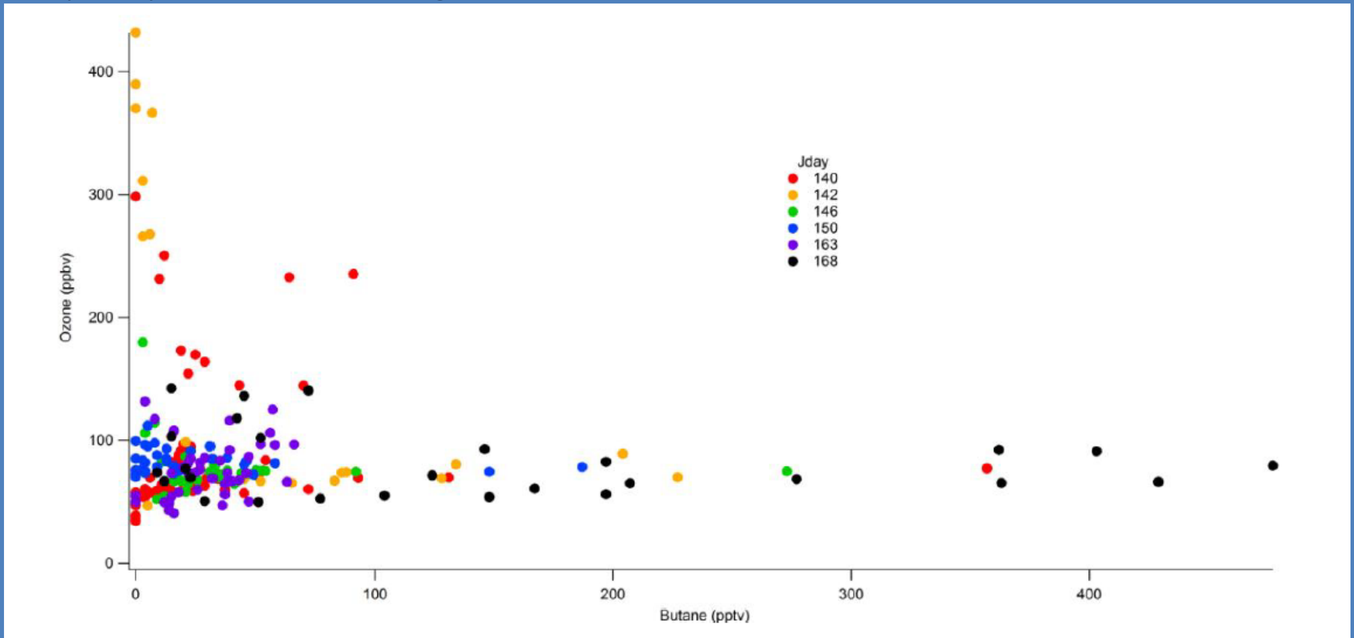


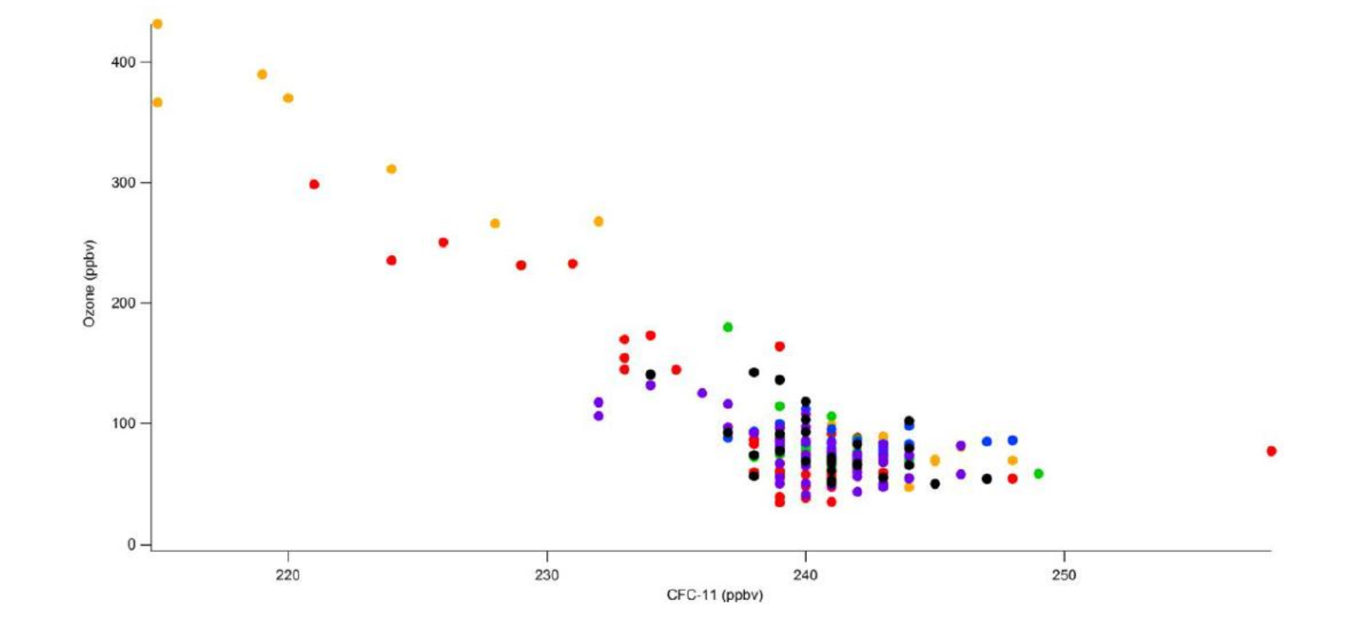




Hydrocarbon samples in background air at 4-12 km above OK and AL

Analysis by Jason Schroeder, graduate student with Don Blake, UCI





Hydrocarbon samples in background air at 4-10 km above OK and AL

Analysis by Jason Schroeder, graduate student with Don Blake, UCI