Convective Transport Overview

Goals

- “characterize convective transport”
  - entrainment/detrainment profiles
  - magnitude and depth of transport
  - passive tracers, reactive tracers, water vapor, aerosols
    - reactions at convective time-scale
  - variability due to regime and storm morphology
  - also: lightning, STE, downstream plume, …

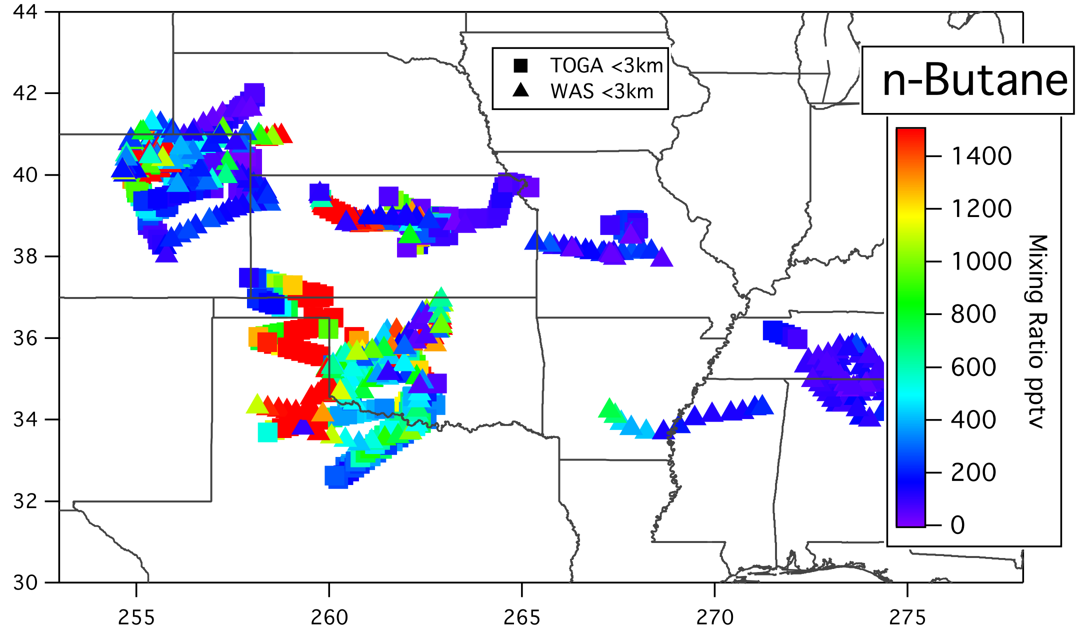
Tracer measurements

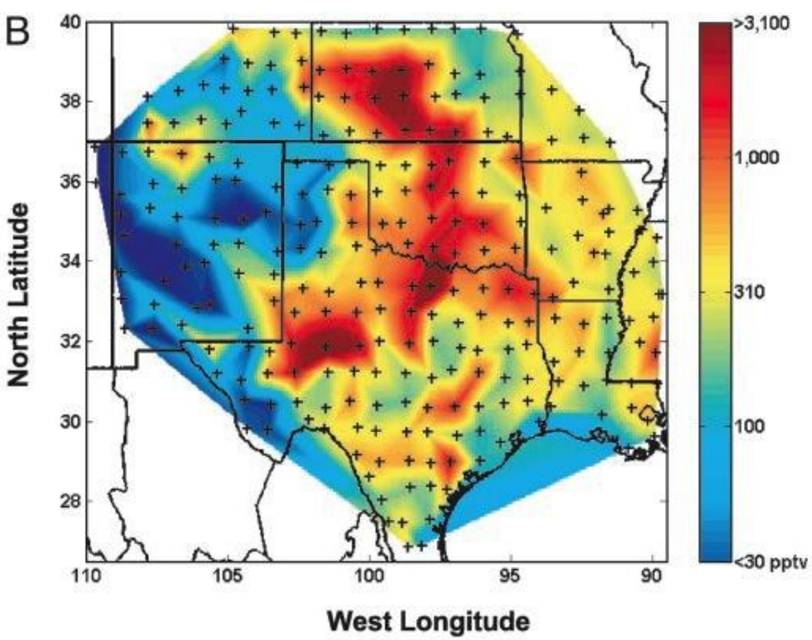
Nicola Blake, Eric Apel, Don Blake
UCI

DC3 2012

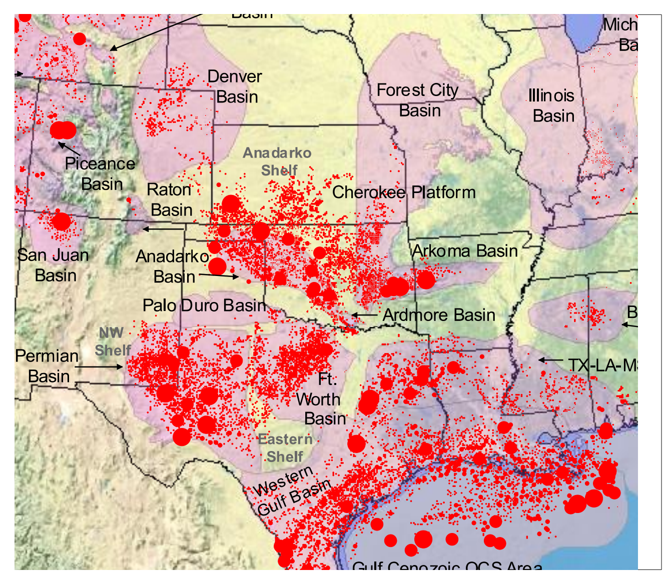
TOGA (GV) and WAS (DC-8) data at Palt <3km

The hydrocarbon – and particularly alkane levels were very high for many low altitude "inflow" regions - consistent with oil and gas production areas.





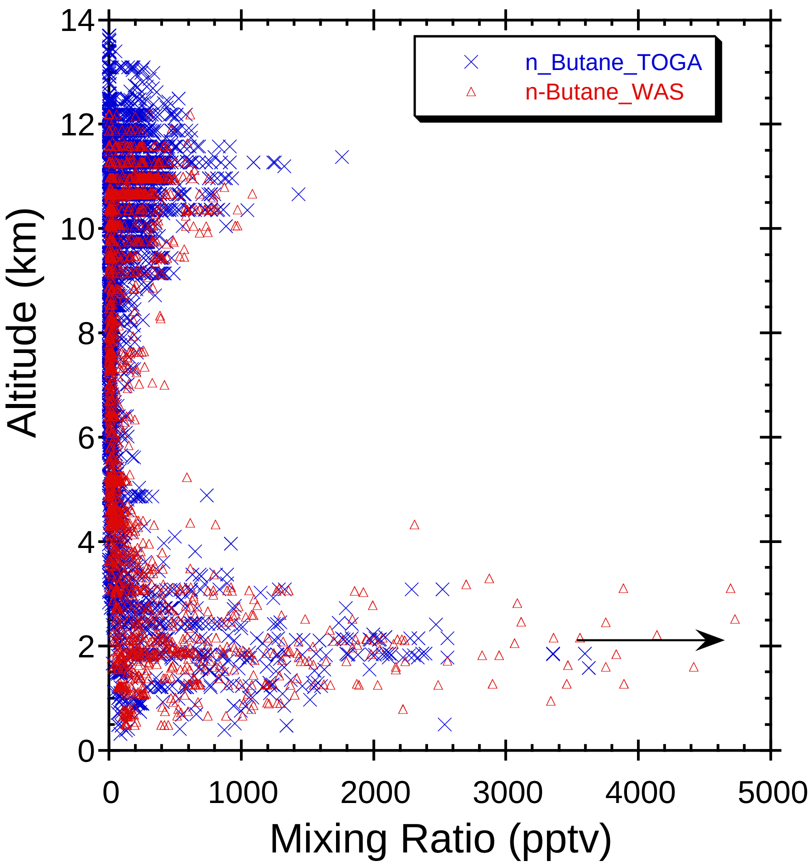
n-Butane (Katzenstein et al.)

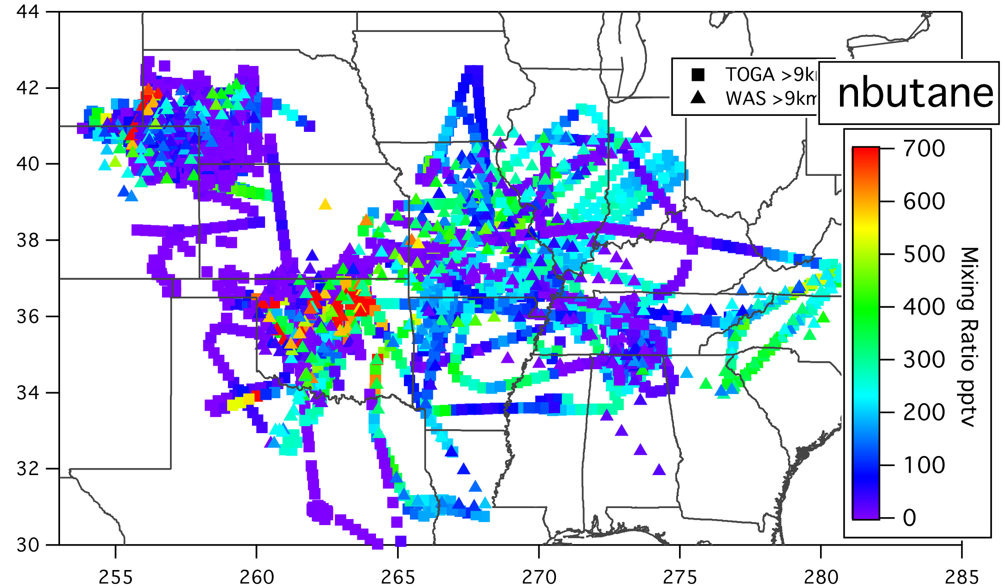


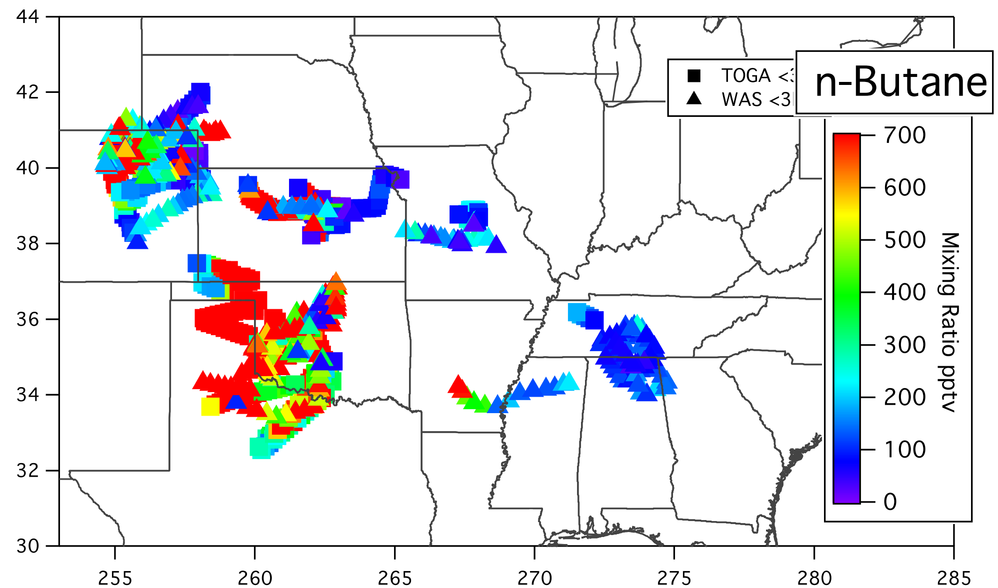
Gas Production in Conventional Fields (EIA)

DC3 2012

- These oil and gas hydrocarbon emissions make excellent markers for recent convection
- Their wide range of decay rates make them useful tracers for convective transport



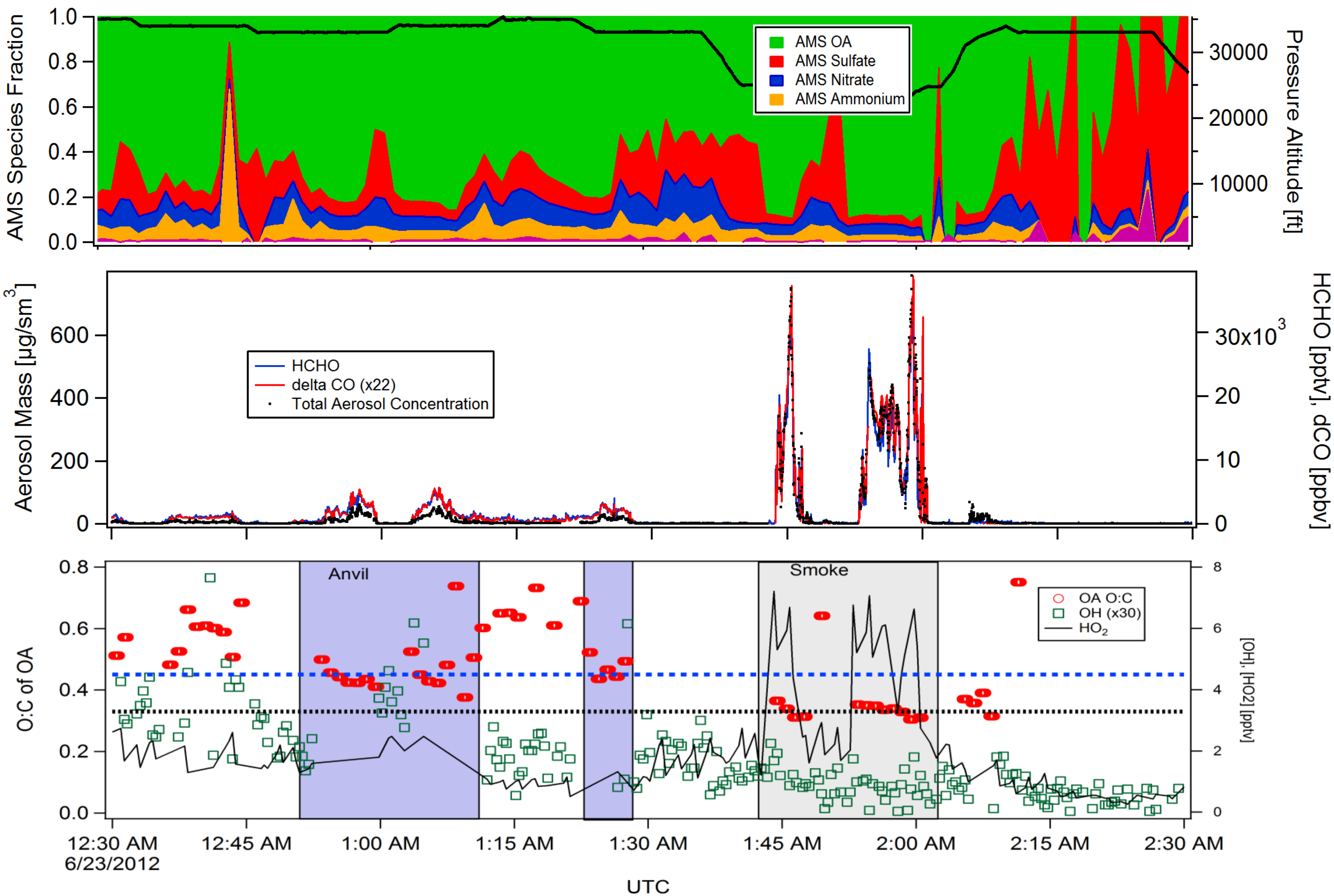




AMS DC3 Contribution, Convective Transport

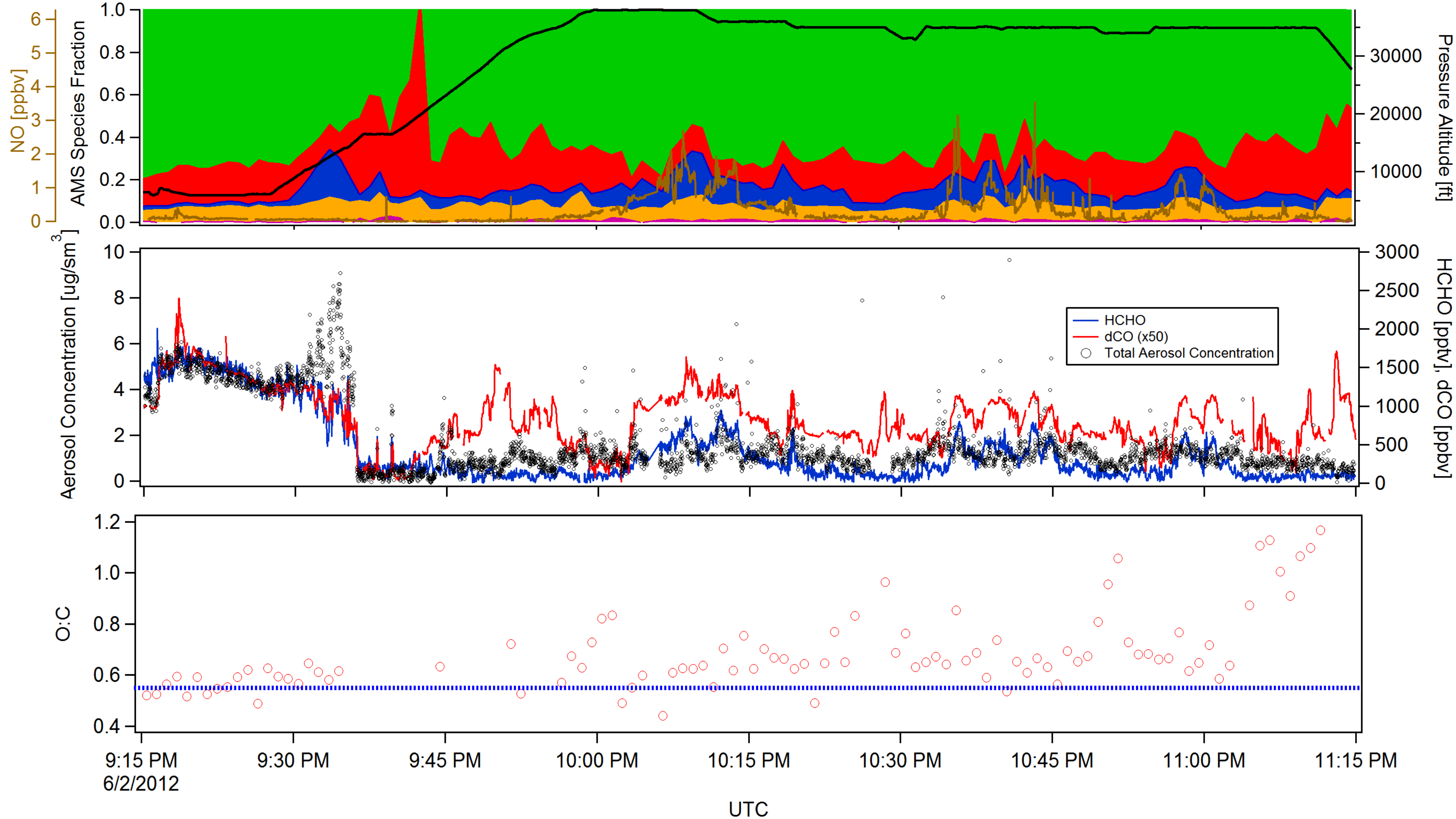
Pedro Campuzano Jost, Doug Day, Brett Palm, Amber Ortega, Patrick Hayes and Jose Luis Jimenez

Convective Transport from the FT: RF18 (6/22)



- About 50% of aerosol mass relative to the tracers is transported from the FT to the Anvil
- While some OA is lost in relation to inorganics, the remainder has been significantly oxidized (O:C 0.3 -> 0.45) despite the short time scales, mechanism unclear

Convective Transport from the BL? 6/2, RF9



Efficient transport (nearly 100% relative to HCHO transport), and some aging (~0.1 O/C increase) is observed. This is a general pattern for most flights, with transport efficiencies ranging between 20-100% of HCHO.

While O/C often is increased in the anvil over BL levels, background from previous storms (cf 11:05 CO plume in this flight, with very high O/C ratios around 1) need to be carefully considered. Also, in at least 2 flights, the inflow shows 2 layers with different chemical composition and simple tracer analysis cannot resolve what layer was transported.

WRF-Chem

Mary Barth (NCAR), Megan Bela (UCO),
Ken Pickering (NASA/GSFC), Yunyao Li (UMD), Kristin Cummings (UMD), Dale Allen (UMD)

Convective Transport in WRF-Chem Case Studies

Ken Pickering (NASA/GSFC), Yunyao Li (UMD), Kristin Cummings (UMD), Dale Allen (UMD), Mary Barth (NCAR), Megan Bela (UCO)

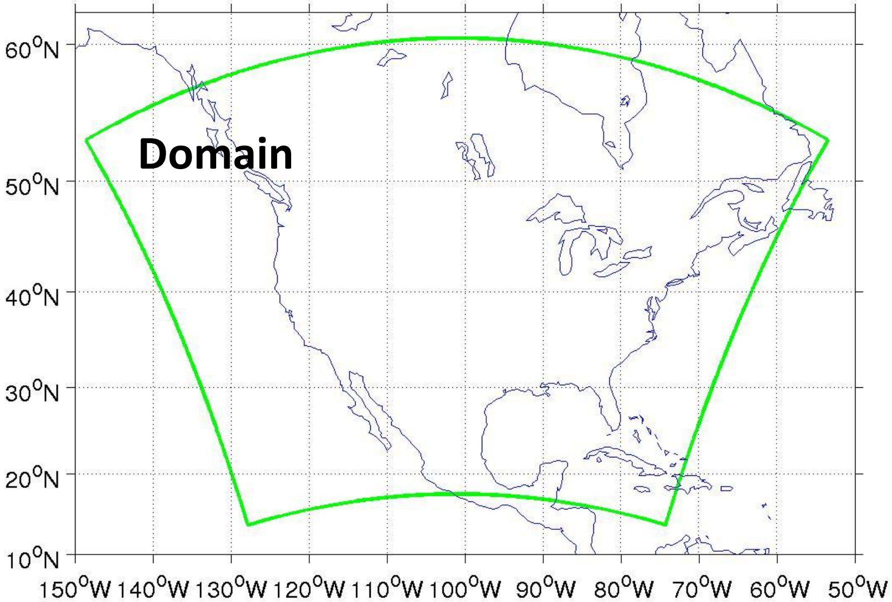
- **WRF-Chem cloud-resolved (3-km initially, 1-km later) simulations planned for four DC3 case study storms: May 21 (AL); May 29 (OK); June 6 (CO); June 22 (CO)**

- **Compute CO transport from BL to FT: compute increase in CO mass above each successive model layer as a function of time, after accounting for horizontal advection.**

- **Compare model estimates of CO transport with aircraft observations: bin observations within model layers for various distances downwind from convective core. Compute means and sigmas and compare with model. Construct probability distribution functions of model output and obs.**

- **Try other gases such as O_3, halocarbons inserted into model as tracers**

WRF-Chem 15km May 29 OK Storm Simulation (Bela, Barth)



Grid spacing: dx = 15 km, 40 vertical levels to 50 hPa (~650 m in UT)

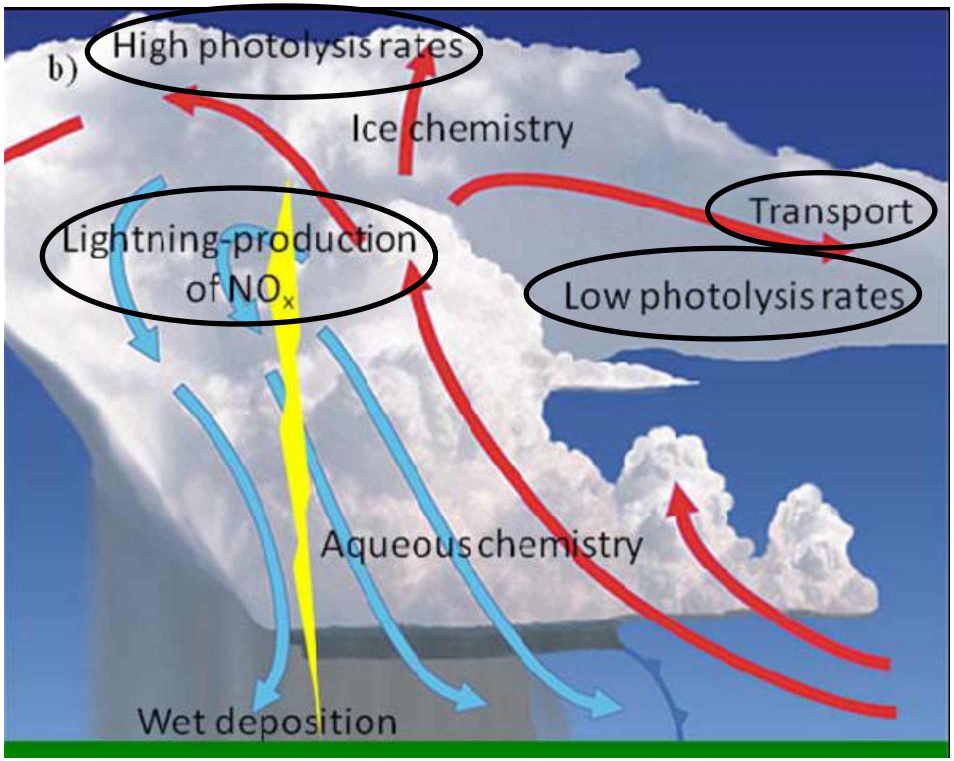
Initial/Boundary Conditions: DART (met), MOZART (chem)

Physics: Grell 3D convection, Morrison cloud microphysics, MYJ PBL

Chemistry: MOZART gas chemistry mechanism; GOCART aerosol scheme

Emissions: EPA NEI 2005 anthropogenic (2012 NO/NO2 based on OMI NO2), aircraft from Baughcum (1999), MEGAN v2.0.4 biogenic, FINN fire

Included processes:



https://www2.acd.ucar.edu/sites/default/files/dc3/thunderstorm-airmass_squall-line.jpg

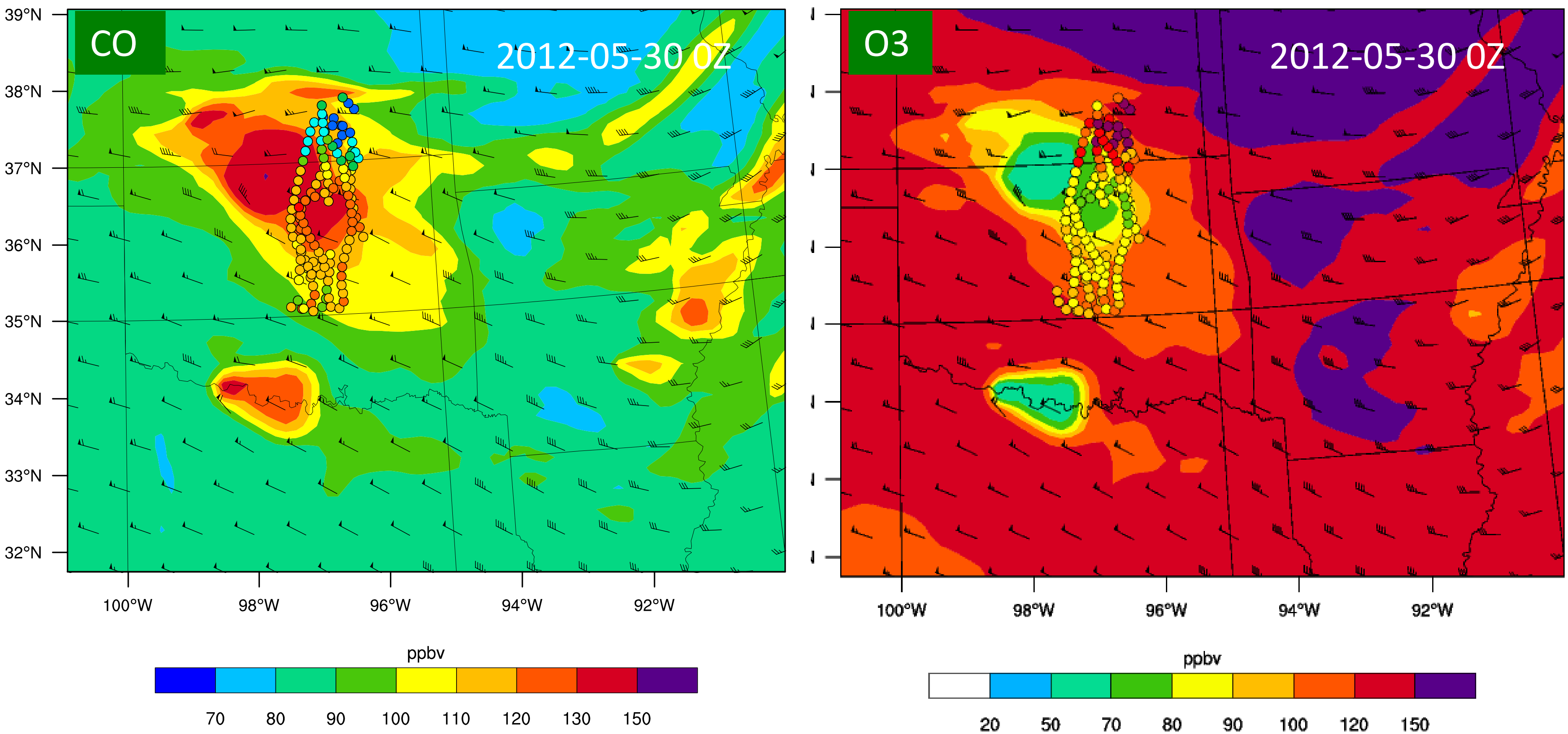
Lightning-NOx : FR = $3.44\times10^{-5}\, z_{top}^{4.9}$

z_{top} = cloud top height = level neutral buoyancy – 2 km (Wong et al., 2012)

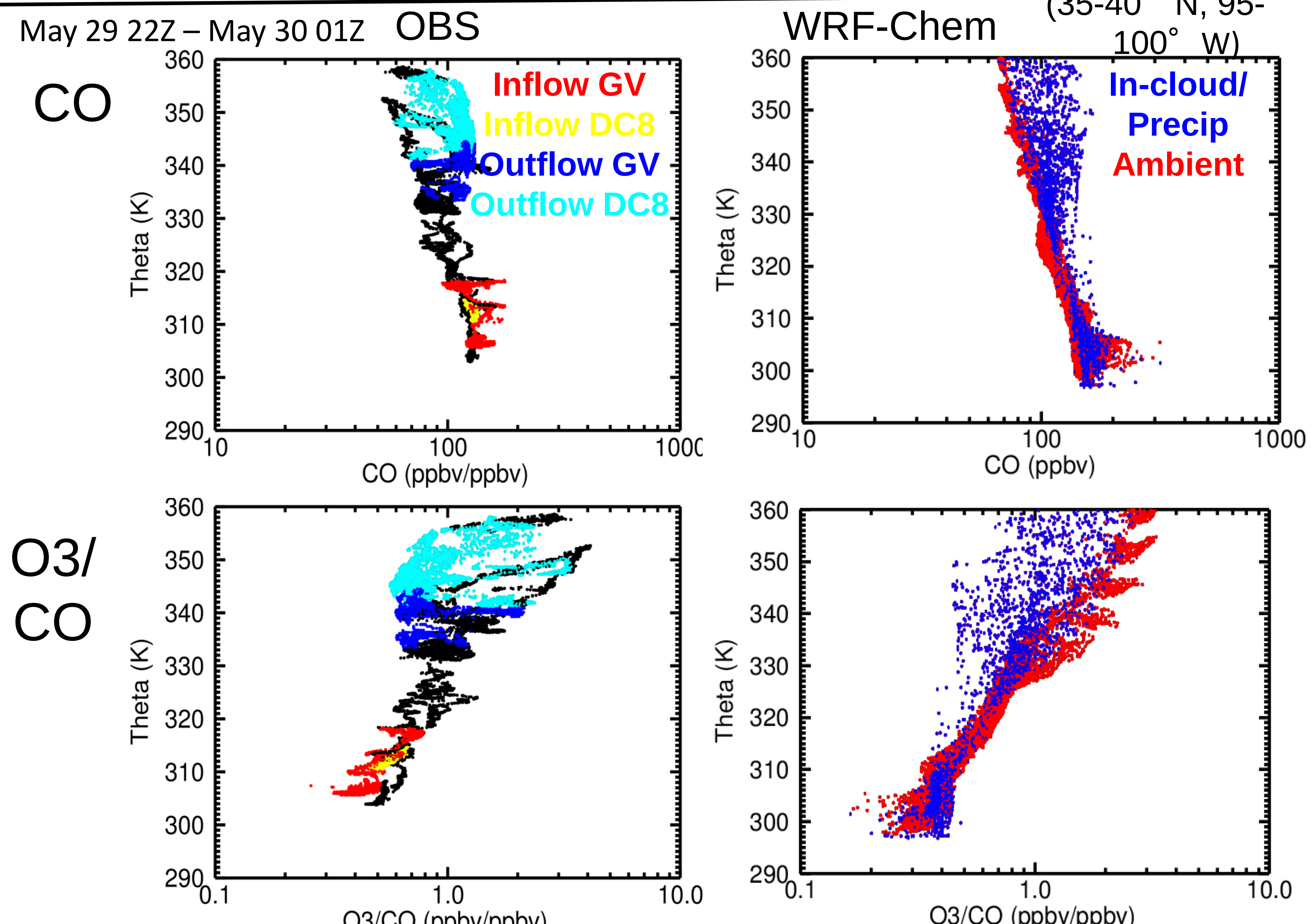
500 moles NO/flash placed vertically following Ott et al. (2010) curves

WRF-Chem CO and O_3 values at 11km compare well with DC8 and GV observations in May 29 storm

CO and O_3 (ppbv) simulated by WRF-Chem at 11km and observed by DC8 and GV for 10<z<12km

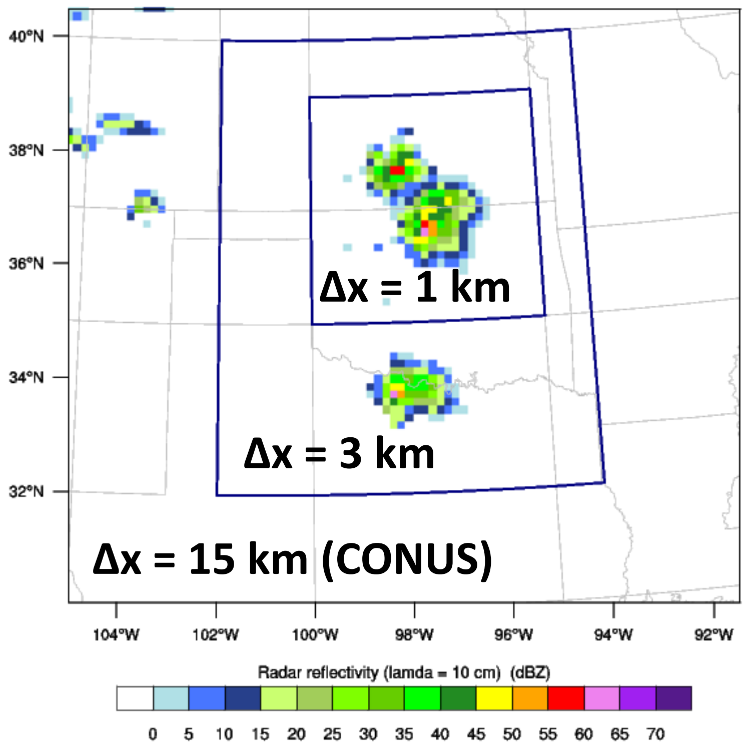


CO and O_3 show good agreement between model and observations, indicating reasonable source emissions and convective transport



Next Step: Cloud-Resolving Scales

Increase horizontal (3/1 km) and vertical resolution

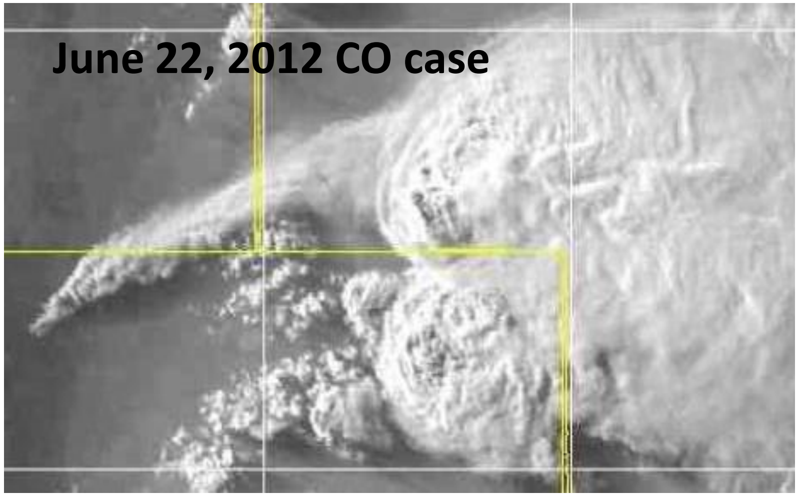


Simulate other cases:

June 22 NE CO storm (interaction with High Park Fire)

In collaboration with U. Maryland:

May 21 AL storm, June 6 CO storm



Science Questions:

How well does WRF-Chem represent cloud dynamics and transport at convection-parameterizing and cloud-resolving scales?

Budgets for chemical species: transport vs. production vs. removal

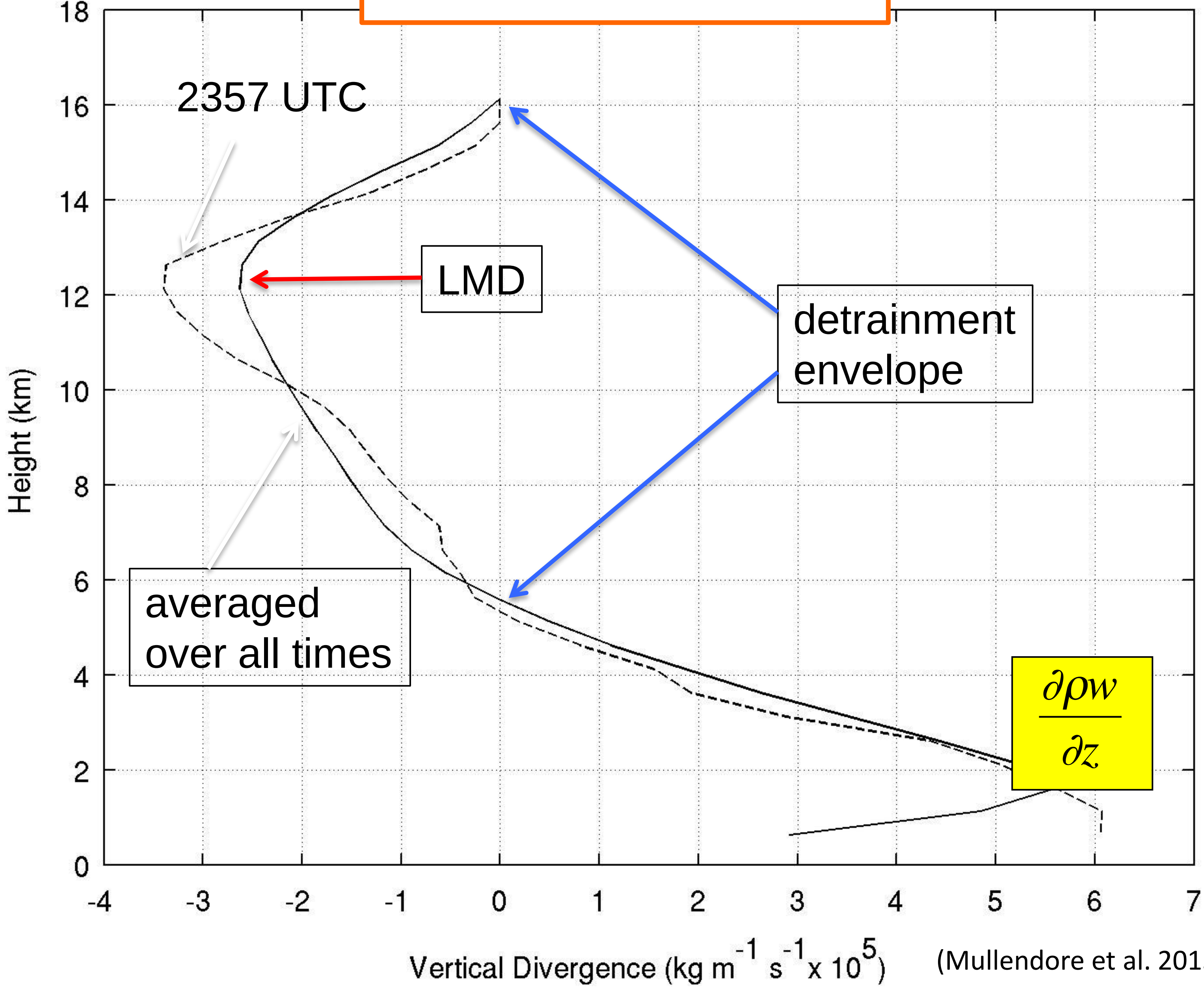
Entrainment of BB plume at 7 km altitude

Detrainment Variability

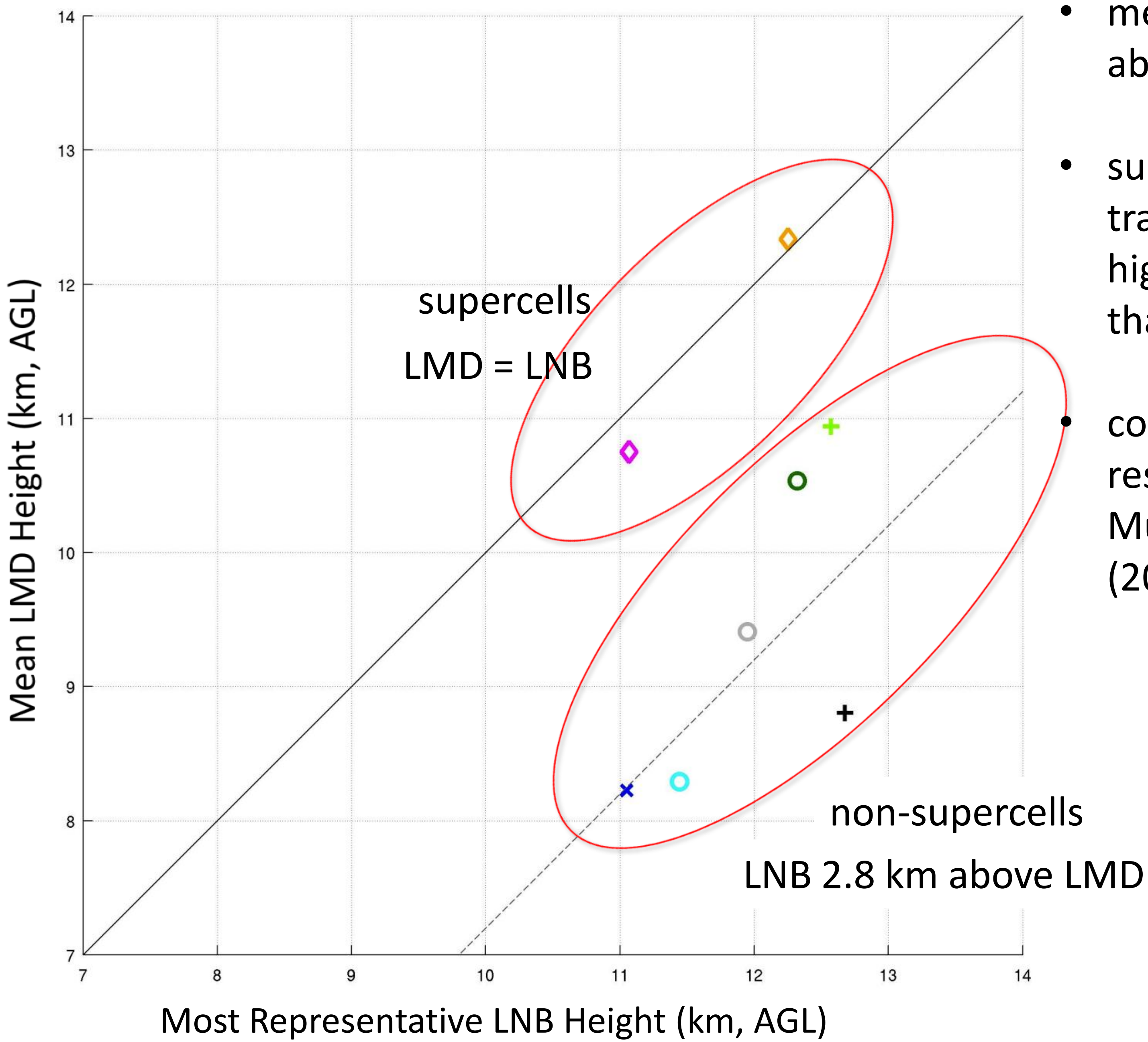
Gretchen Mullendore, Nicholas Carletta, Scott Jorgenson, …

UND

LMD calculation



(Mullendore et al. 2013)



- mean LNB 2.2 km above LMD
- supercells transport to higher altitudes than multicells
- consistent with results of Mullendore et al. (2005)

Radar as Proxy

Mullendore et al. 2009; Takahashi and Luo 2012

dual-Doppler vertical velocity

Reflectivity only