University of Colorado Boulder

Aged Organic Aerosol in the UT: Aging of boundary layer aerosol during and after convective transport during DC3

Pedro Campuzano-Jost, Douglas A. Day, Brett B Palm, Amber M Ortega, Patrick L Hayes, Jose L. Jimenez, Megan Bela, Mary Barth, Jennifer R. Olson, James H. Crawford, Glenn S. Diskin, Luke Ziemba, Bruce Anderson, Benjamin Nault, Ron Cohen, Tomas Mikovini, Armin Whisthaler, Donald R. Blake, Ilana Pollack, Thomas R Ryerson

CU Boulder, NCAR, NASA LarC, UC Berkeley, NILU, UC Irvine, NOAA ESRL

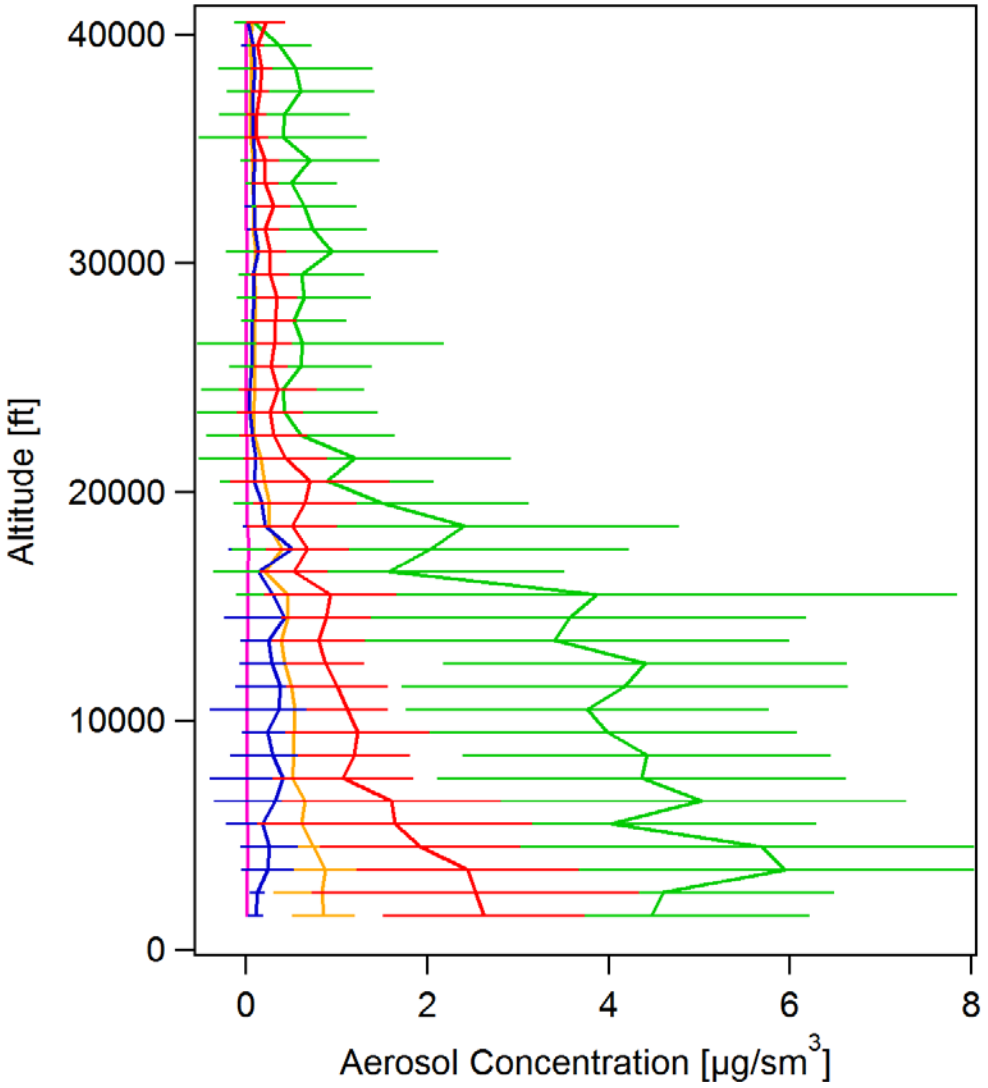
AGU Fall Meeting, Session A21I,

December 10th, 2013

University of Colorado Boulder

Submicron Aerosol in the UT during DC3

- Substantial aerosol mass, mostly OA, was found in the upper troposphere on almost every flight in the course of DC3.
- Convection and stratospheric transport are the main possible sources of UT aerosol.
- Strong convection can contribute to UT aerosol by:
  1. Direct lofting of particles from the boundary layer and the free troposphere that fail to be cloud activated
  2. Evaporation of cloud particles that are not wet deposited during the storm
  3. Formed from oxidation of lofted trace gases (ie secondary aerosol formation in the storm outflow)



University of Colorado Boulder

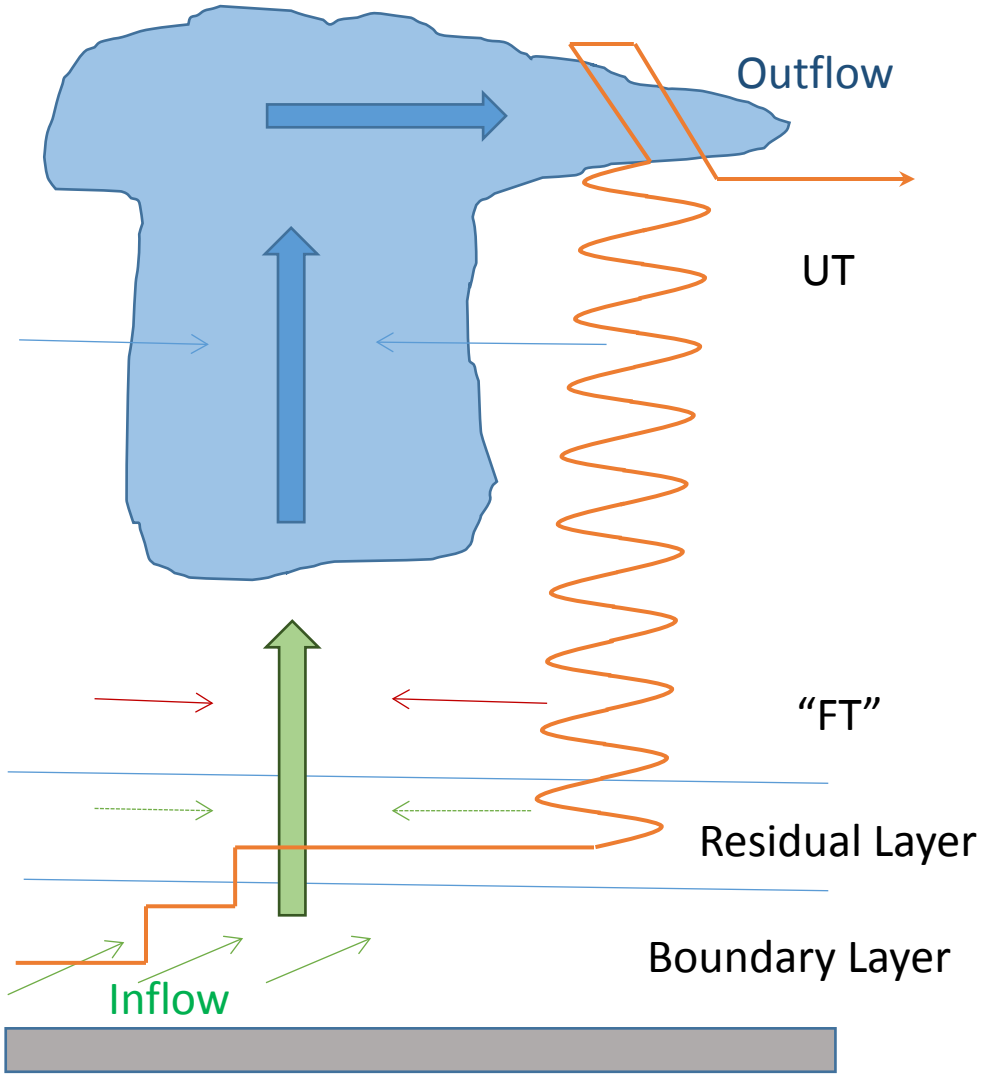
Quantifying and validating aerosol transport in fresh convection

Typical "Storm Day" DC-8 flight plan allows in principle to assess aerosol transport directly, but need to know:

- Dilution factor (if any)
- Where was the main inflow region?
- Is AMS data in the anvil reliable?

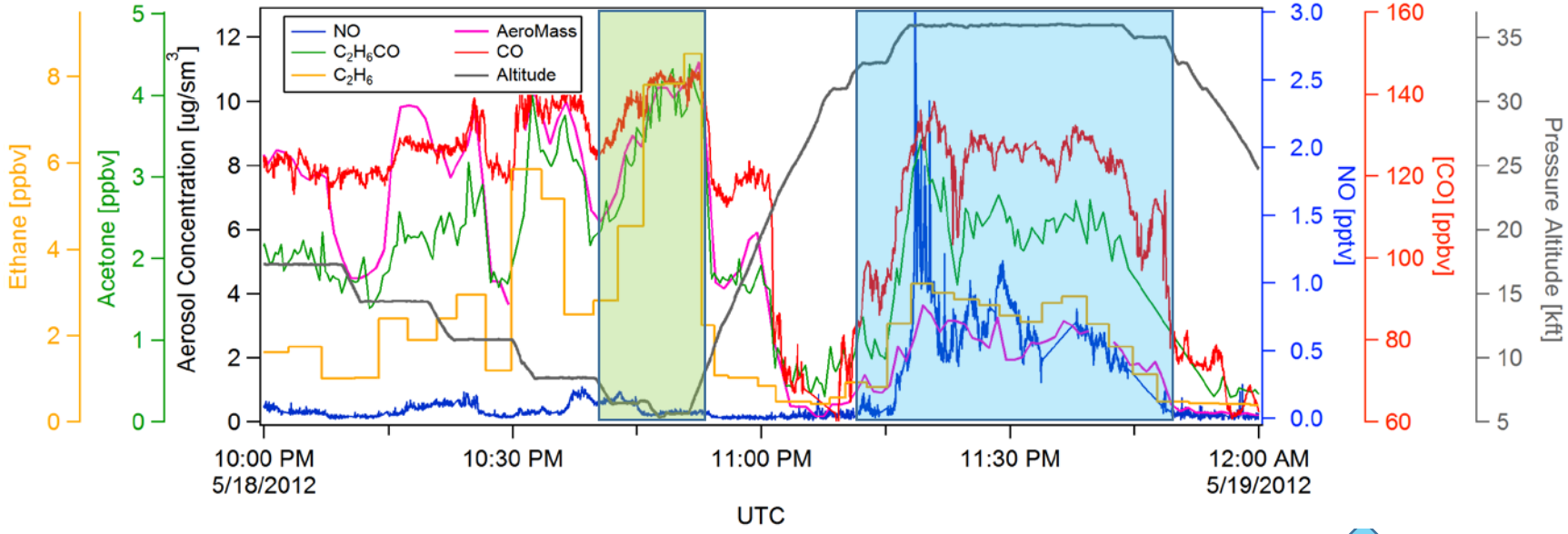
Evaluate transport efficiency and source by taking advantage of colocated measurements of low-reactivity, low-solubility gas tracers:

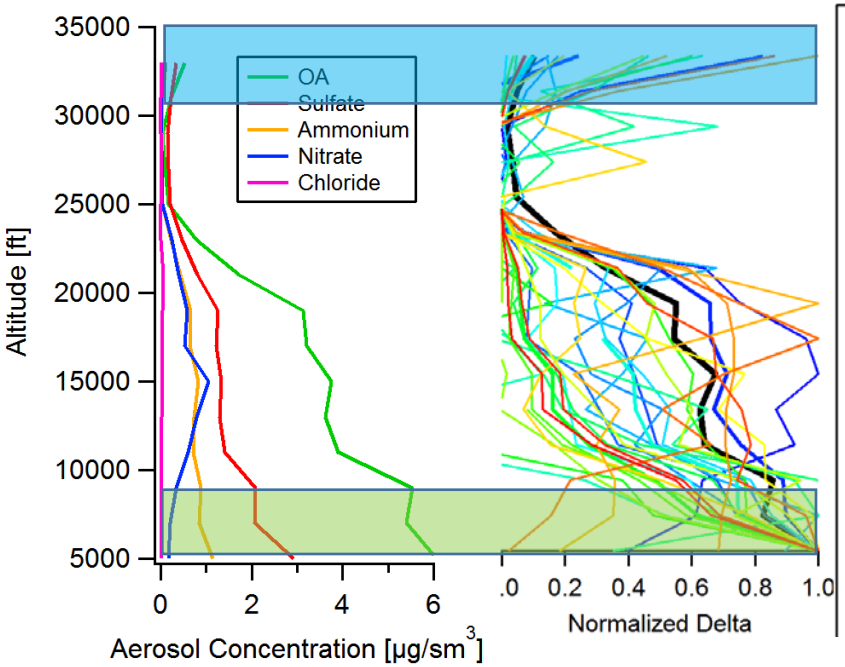
- Ratio of excess tracers in outflow and inflow provides dilution
- Vertical distributions of multiple tracers inform probability that selected inflow region is actually mainly transported
- Good correlation with multiple tracers in the outflow can be used to validate aerosol mass measurements

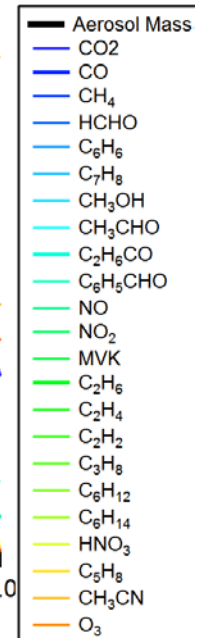


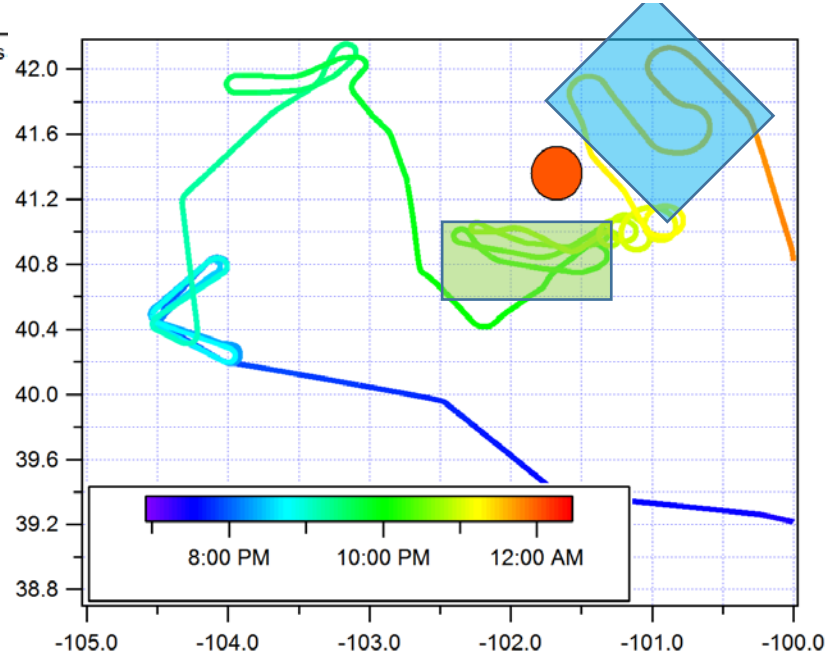
University of Colorado Boulder

Example: May 18th Flight, CO





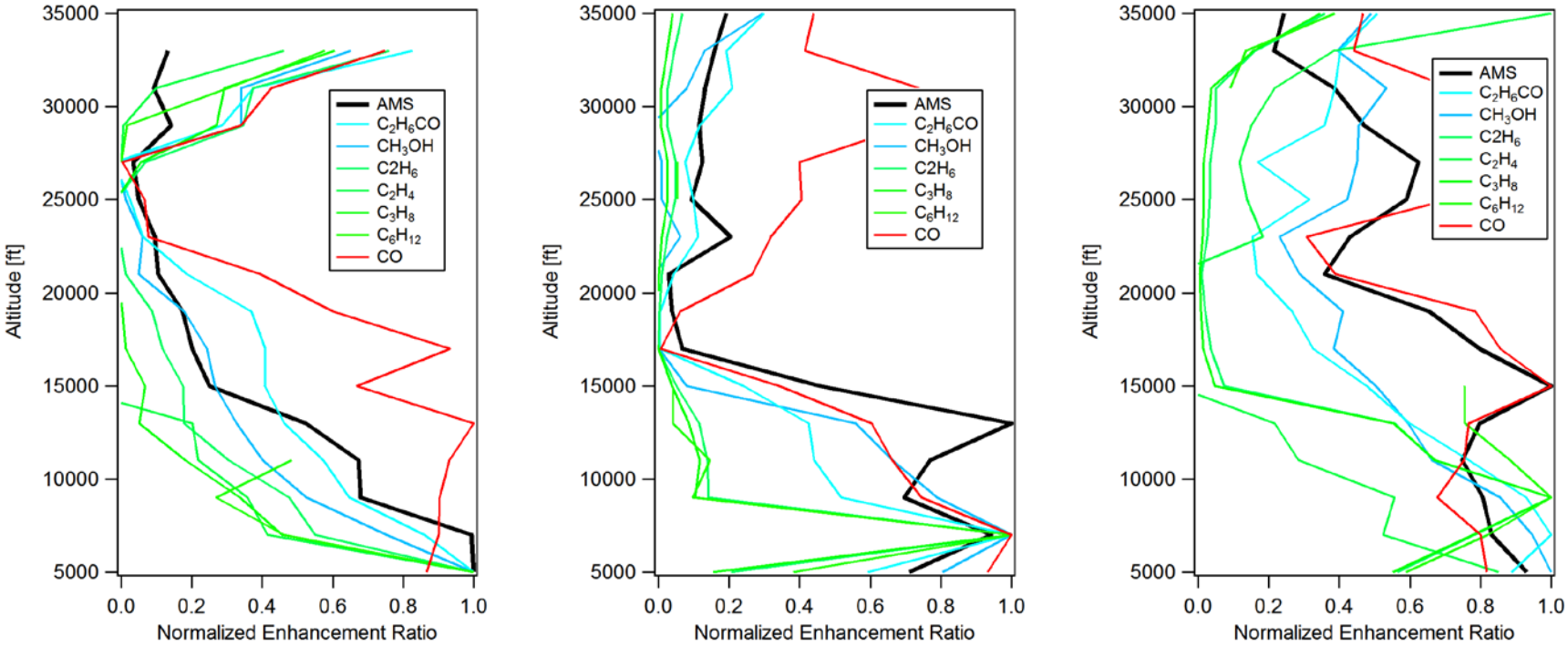




University of Colorado Boulder

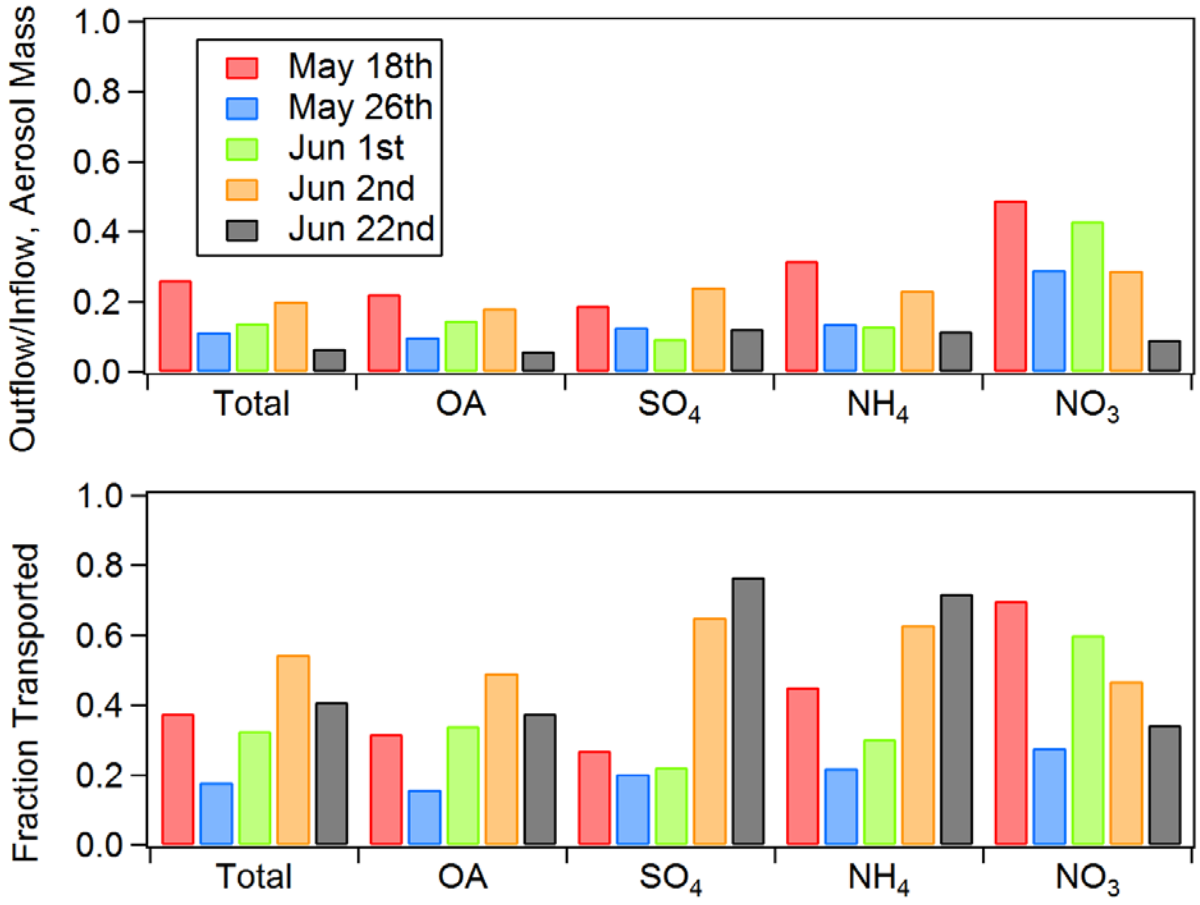
Survey of all sampled fresh storms

- Poor overall correlation of all outflows with LNO_x.
- Best predictor for submicron aerosol in the inflow and outflow is acetone, followed by CO
- When alkanes are well correlated as well and the FT is clean, this indicates a clear test case, ie: May 29th, Jun 2nd, Jun 22nd
- For 1/3 of the flights the S/N is too poor to rule out impacts from ice impaction on the inlet
- For most flights both the boundary layer and the residual layer contribute to the inflow
- For smoky flights, background in the lower UT is too large enough to use this approach



University of Colorado Boulder

Transport efficiencies…
…for BL and residual layer transport



When significant transport does occur from either the BL or the residual layer, dilution corrected efficiencies of about 50% are calculated

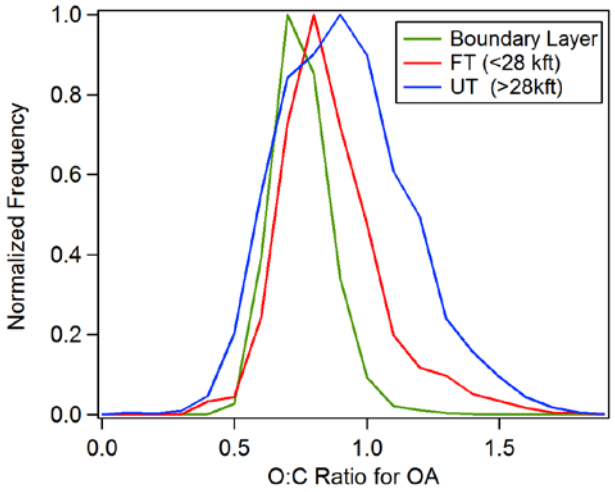
This is fairly independent of the average height where the aerosols are ingested

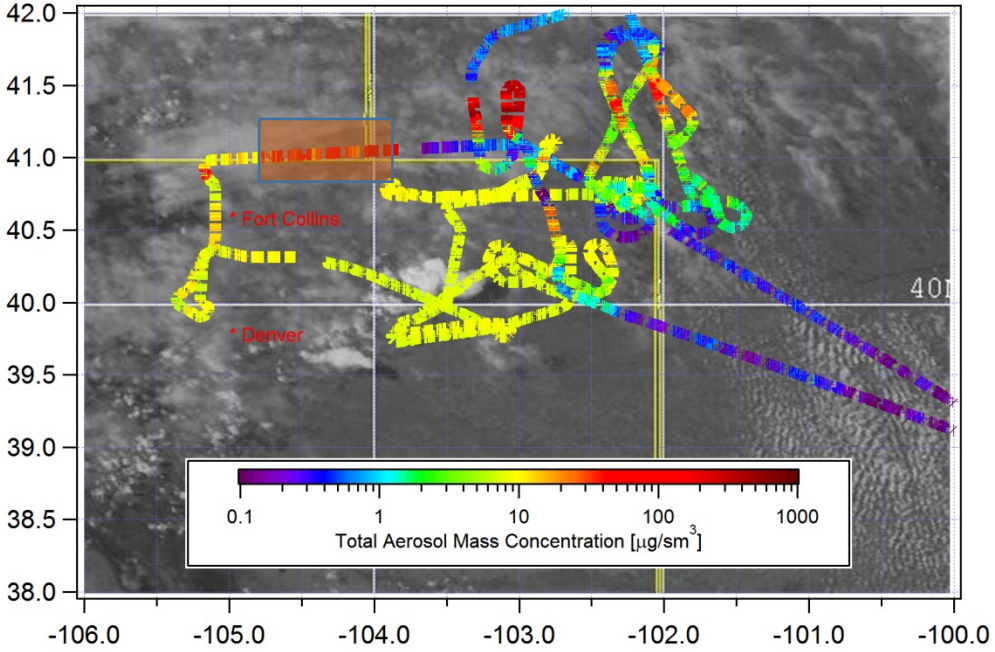
There is not much of a species specific transport efficiency

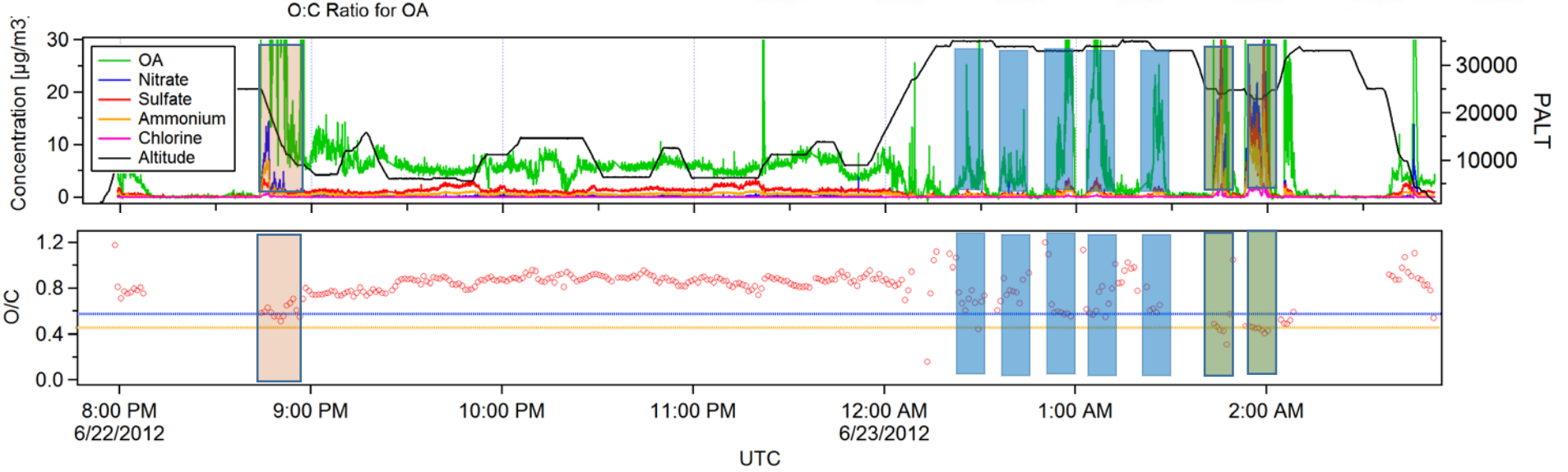
University of Colorado Boulder

Aging of OA in the UT

- Overall OA in the FT and UT are more oxidized than in the boundary/residual Layer.

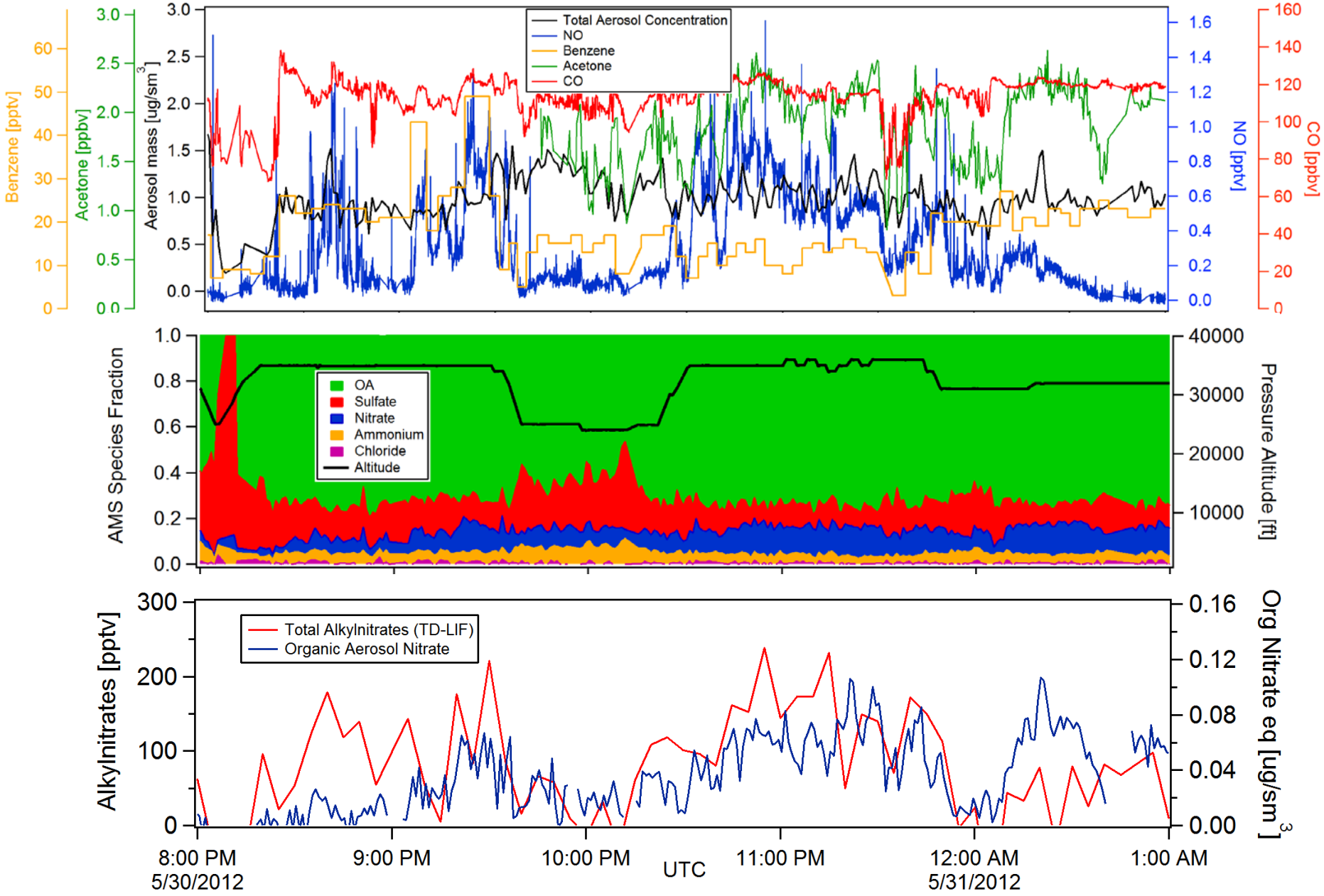






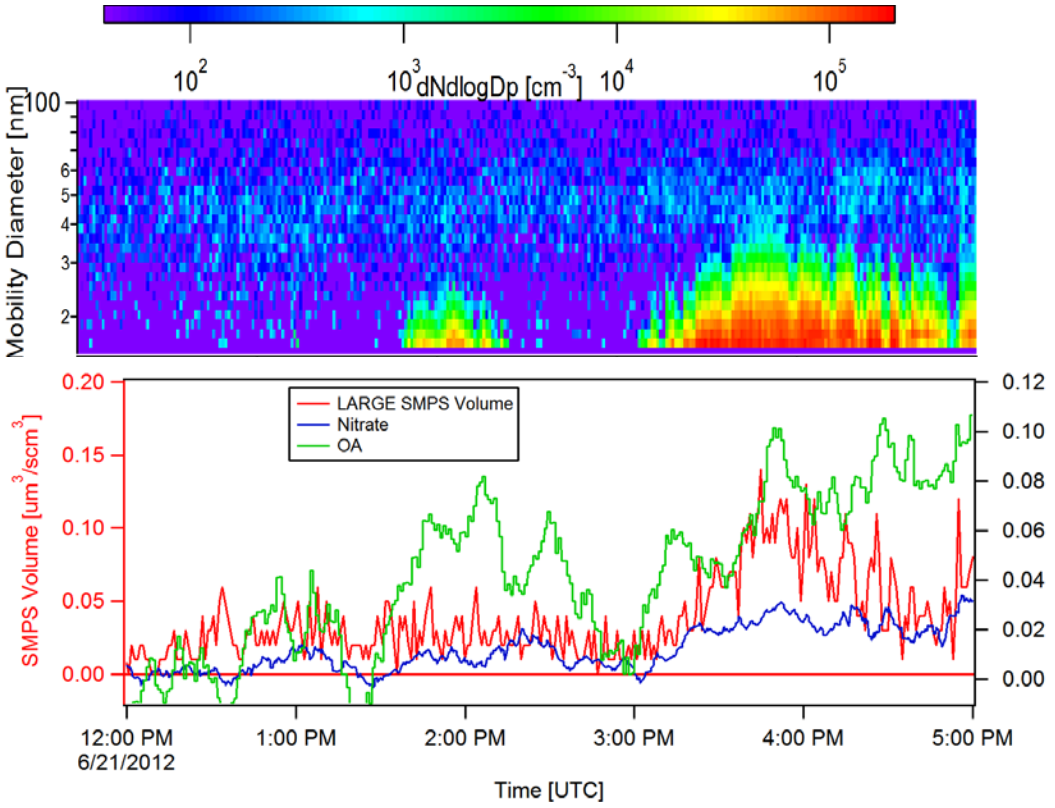
University of Colorado

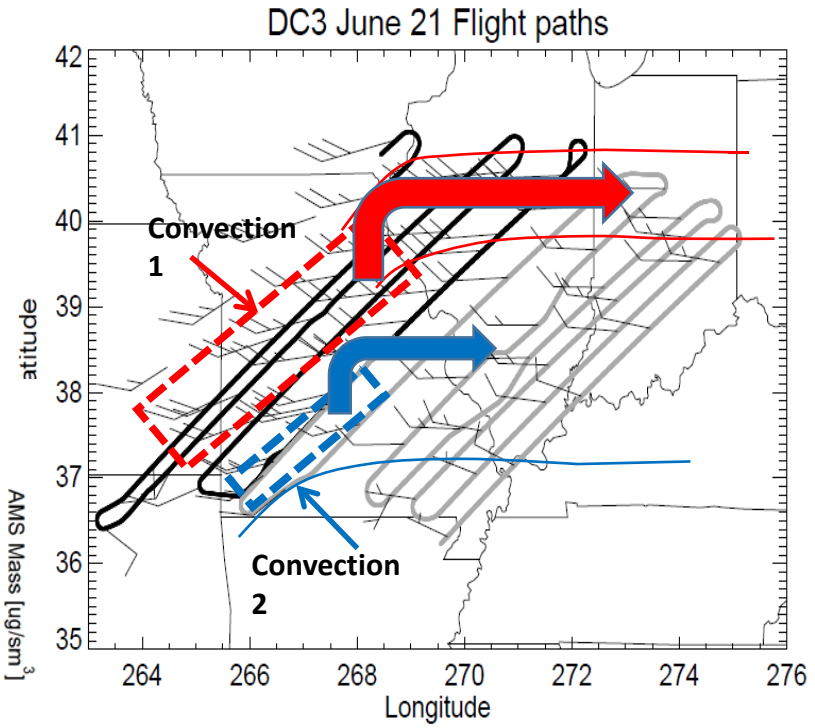
What about a day after?

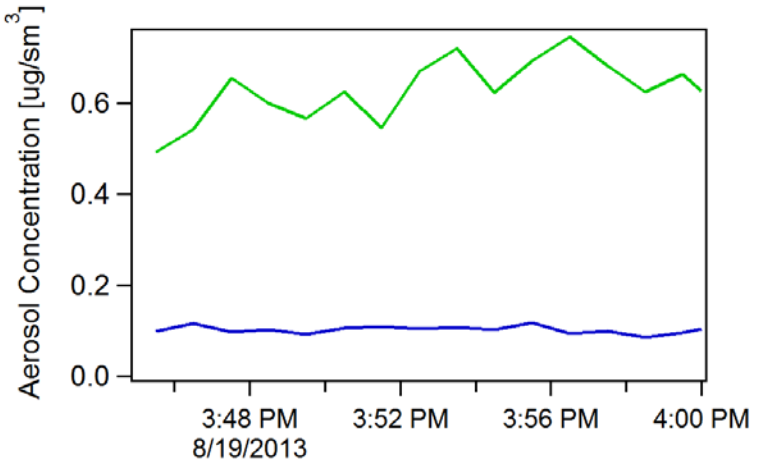


University of Colorado Boulder

New Particle Formation in MCS outflow







SEAC^{4}RS, Aug 19th, NE TX

- 36 kft, dissipating MCS ([NO_x]/[HNO_3] ~2
- Similar acidity & Mass ratio
- O/C ~ 1.4
- BUT: No fine particle mode left

University of Colorado Boulder

In Summary…

- While many storms showed significant aerosol outflow, quantifying transport of longer lived species such as aerosol in an environment with many storms is challenging.
- When clear inflow/outflow regions could be established efficiencies for aerosol transport were on average 30-50% with little indication of chemically selectivity .
- FT entrainment typically is 30-40% of the anvil aerosol in well defined cases
- While there is no strong evidence for selective transport/scavenging, most of the transported aerosol is organic (65% campaign average).
- UT OA is fairly oxidized. O/C increases in fresh convection are often observed, FT entrainment accounts for a significant yet still undetermined part of this.