GV and DC-8 Aircraft Observations during the DC3 Campaign

Christopher Cantrell (University of Colorado)

Mary Barth (NCAR), William Brune (PSU), Steven Rutledge (CSU)

James Crawford (NASA-Langley), Frank Flocke (NCAR), Heidi Huntrieser (DLR)

GV Team

DC-8 Team

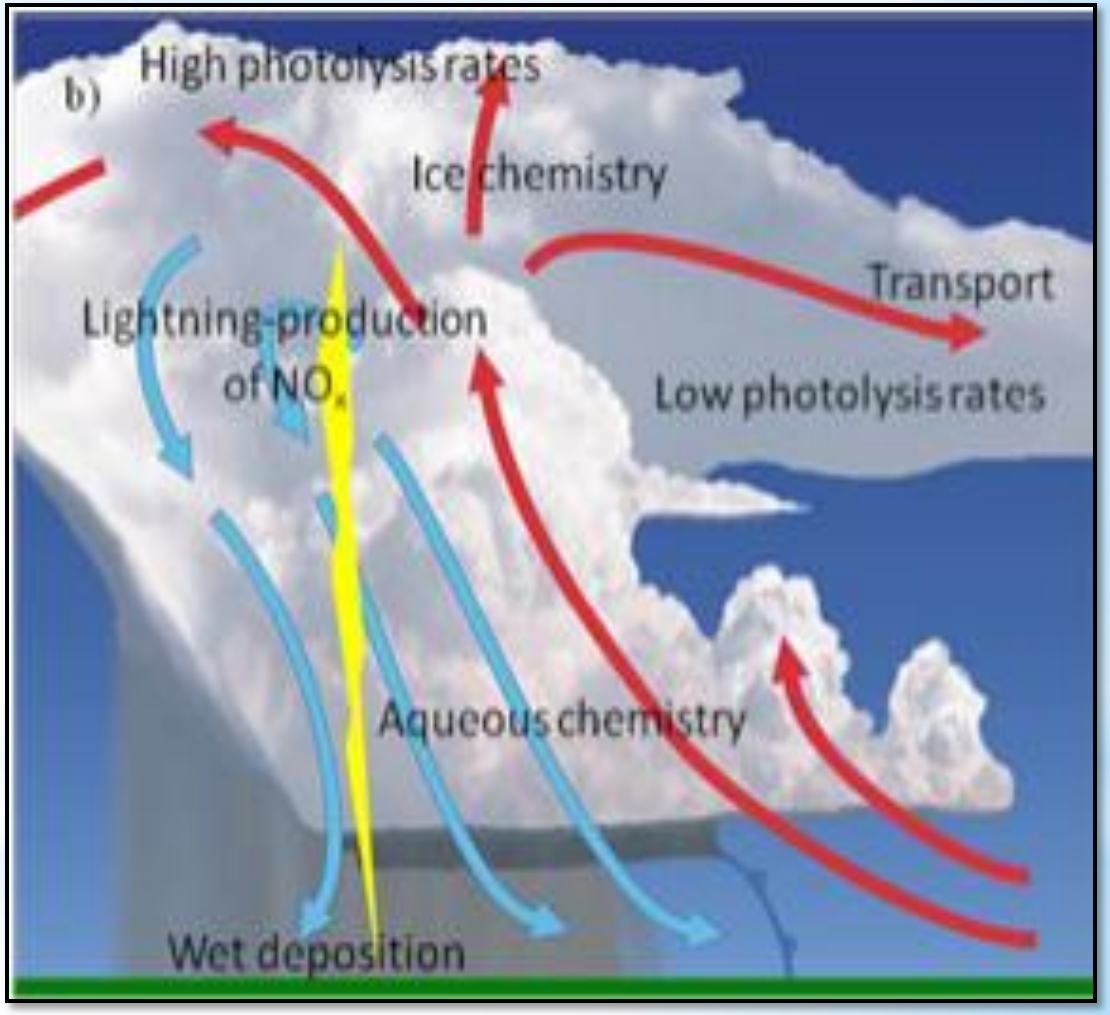
and the over 200 participants
including more than 100 students and 30 post-doctoral scientists

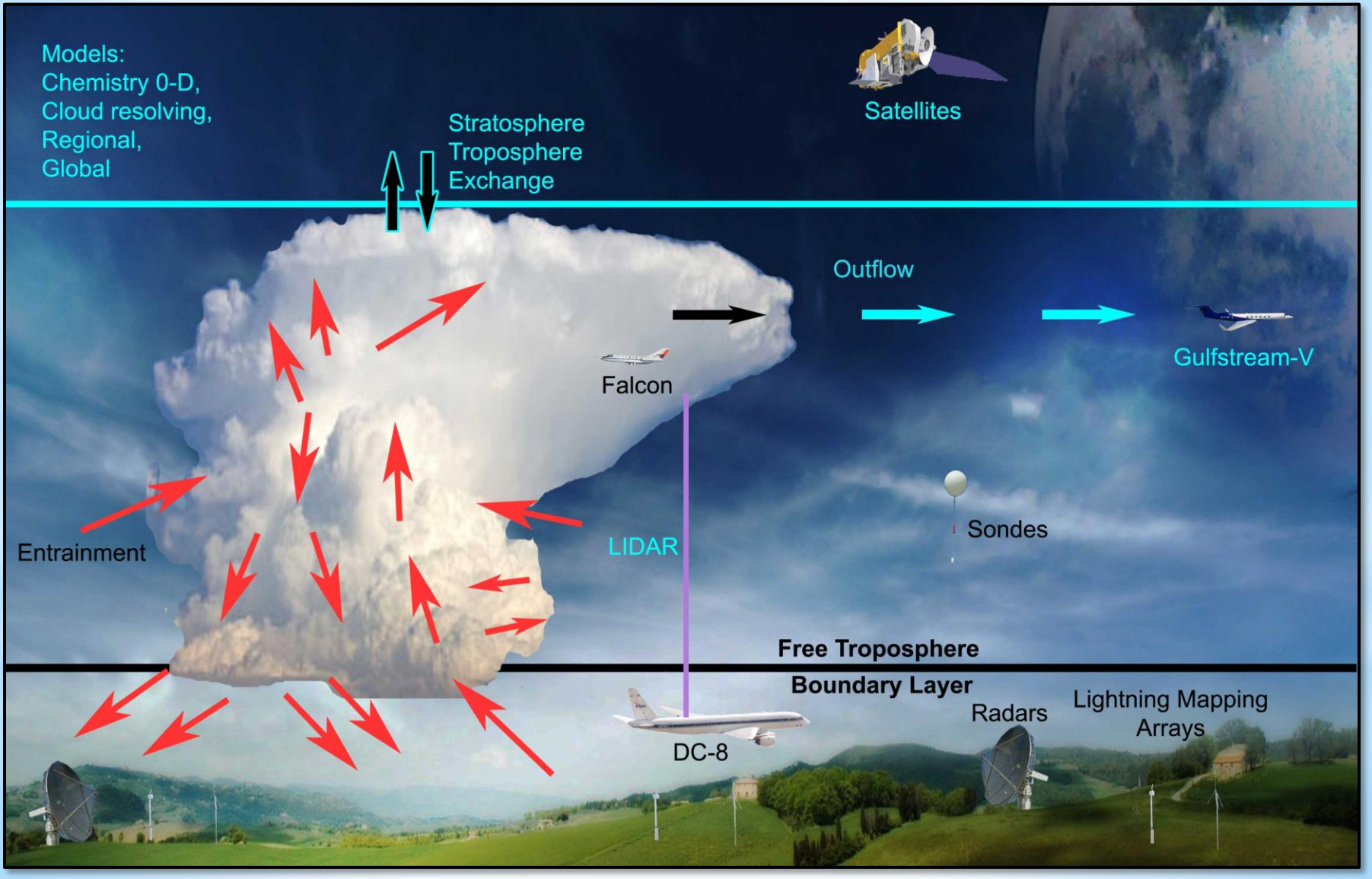
DC3 is sponsored by the National Science Foundation (NSF), NASA, NOAA, and DLR

Goals of the DC3 Field Campaign

* To characterize thunderstorms and examine how they process chemical compounds that are ingested into the storm **(transport, scavenging, lightning, chemistry)**

* To quantify the chemical changes in the storm outflow over the following 24 hours **(chemical aging)**




Models:
Chemistry 0-D,
Cloud resolving,
Regional,
Global
Stratosphere
Troposphere
Exchange
Satellites
Outflow
Falcon
Gulfstream-V
Entrainment
LIDAR
Sondes
Free Troposphere
Boundary Layer
Radars
Lightning Mapping
Arrays
DC-8

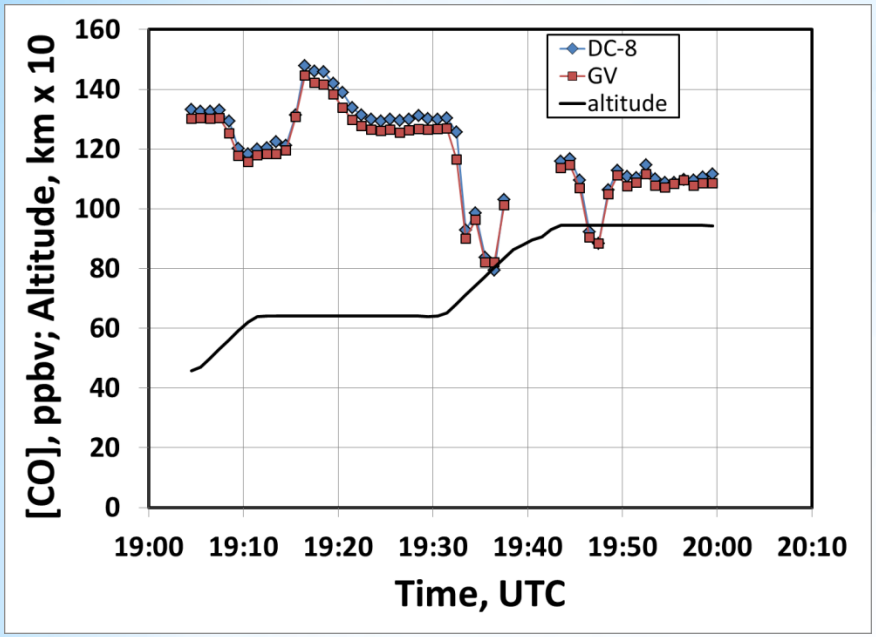
DC3 Airborne Platforms

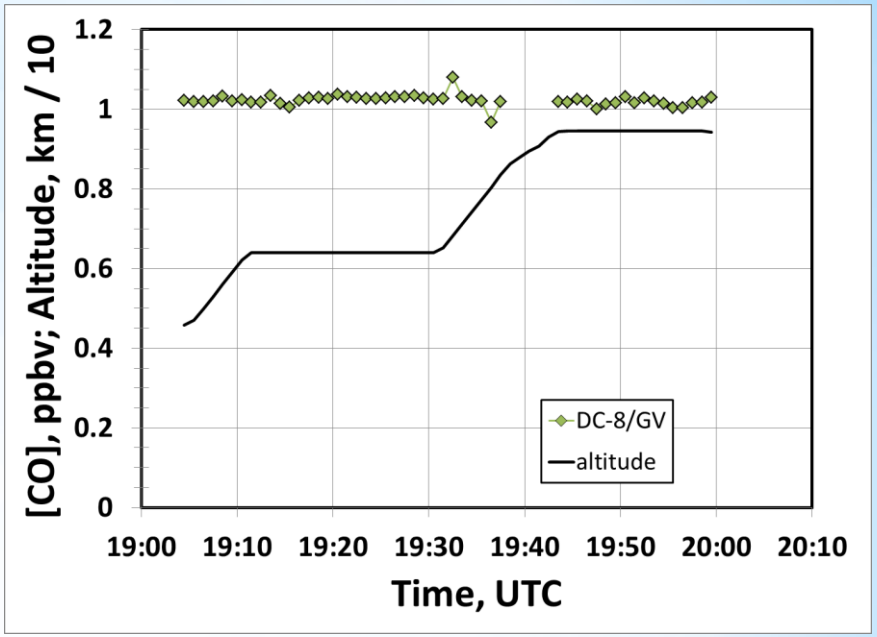
GV: NO_x, O_3, CO, CO_2, CH_4, CH_2O, VOCs, OVOCs, peroxides, SO_2, HNO_3, HNO_4, radiation, particle size distributions, cloud particle images, H_2O, CN

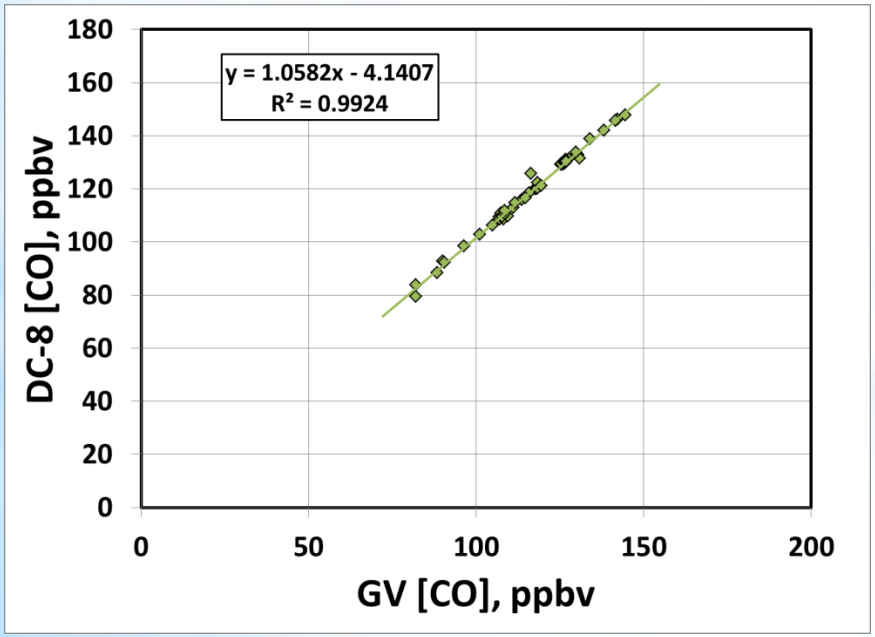
DC-8: O_3, O_3 & aerosol profiles, NO_x, HNO_3, NO_y, PANs, ∑ANs, ∑PNs, HNO_4, CH_2O, CO, CO_2, CH_4, VOCs, OVOCs, peroxides, HO_x, radiation, H_2O, SO_2, CN, particle size distributions, BC, f(RH), particle composition, aerosol optical properties

Falcon: O_3, NO, NO_y, CO, CO_2, CH_4, VOCs, SO_2, $j(NO_2)$, particle size distributions and number, aerosol absorption, BC

DC3 Airborne Platform Measurement Comparisons







***** Preliminary Data *****

GV data: Campos, Flocke (NCAR)

DC-8 data: Diskin, Sachse (NASA-Langley)

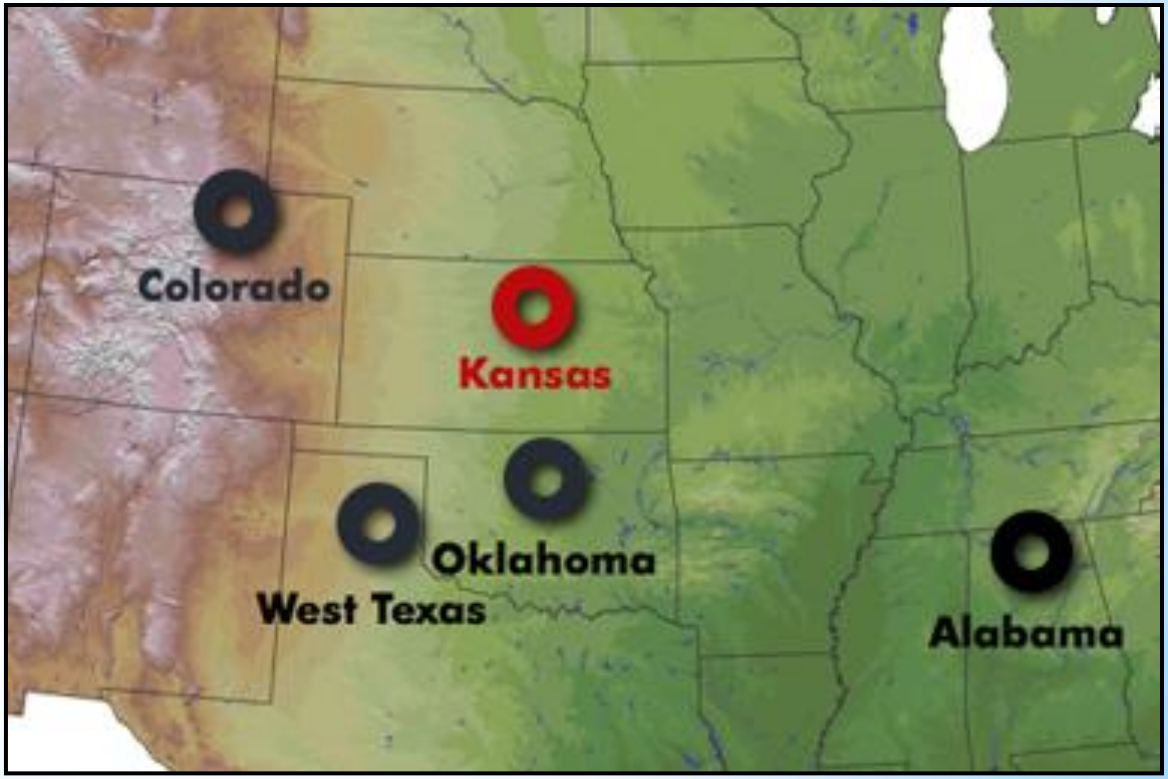
DC3 Study Regions – Active Storms

When: May-June 2012

Where: Aircraft based in Salina, KS

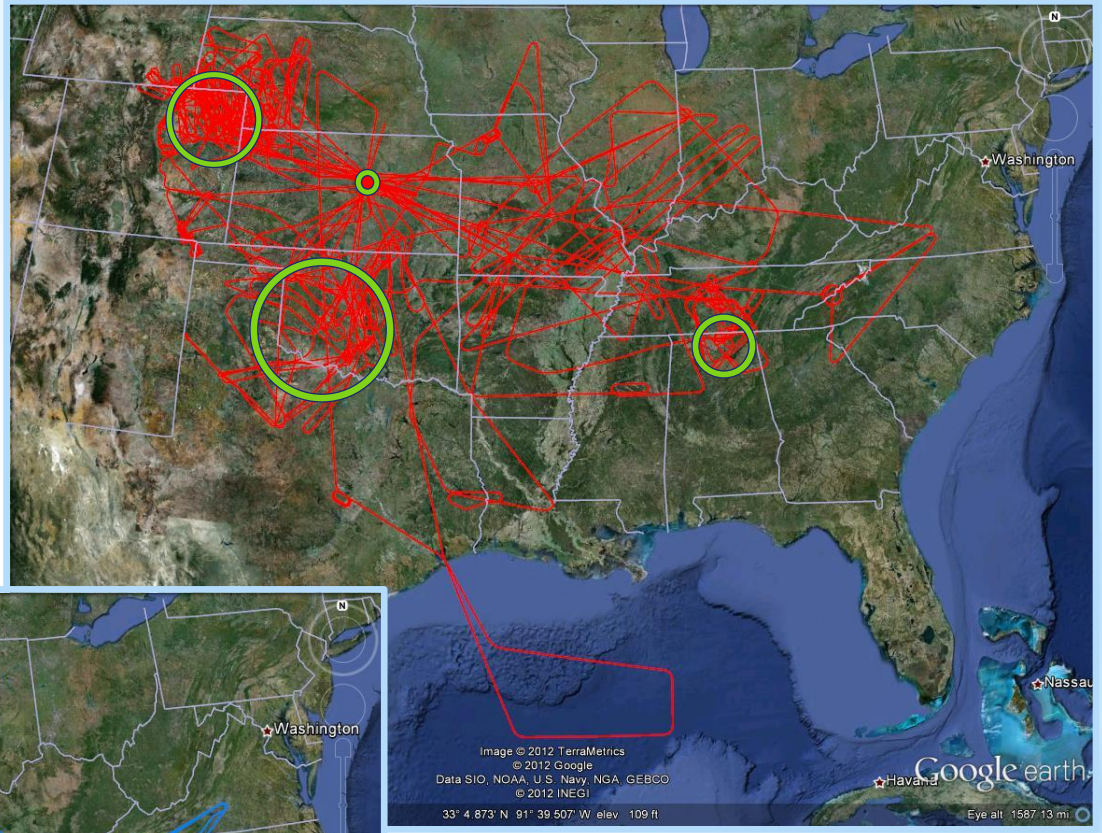
Sampled storms in:

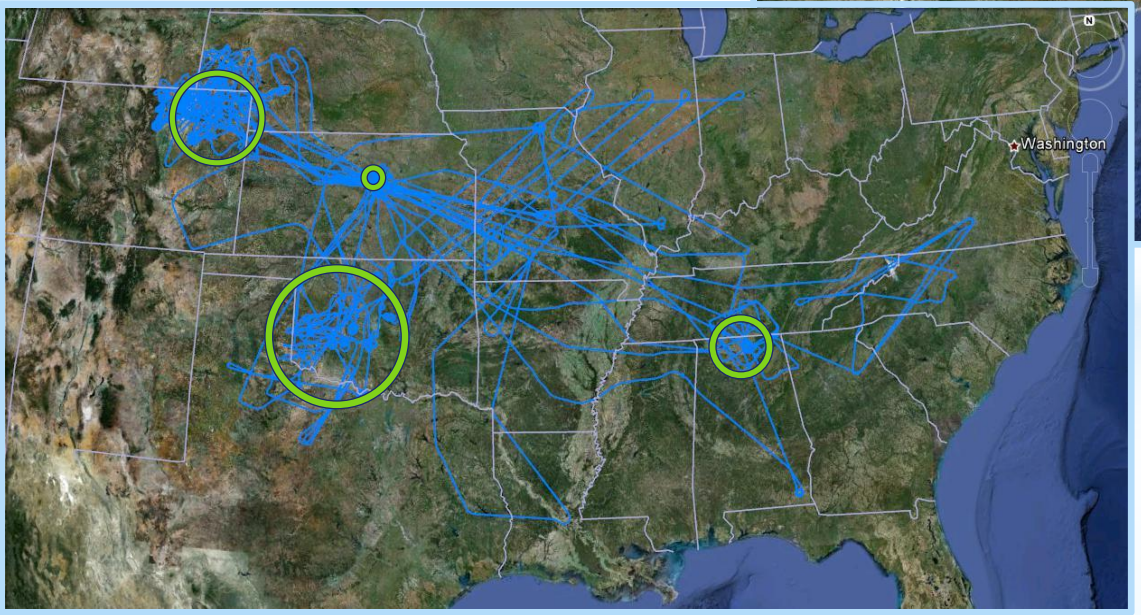
- Northeastern Colorado
- Western Texas to Central Oklahoma
- Northern Alabama
- MCSs Missouri/Illinois/Indiana



DC3 Flight Tracks

GV



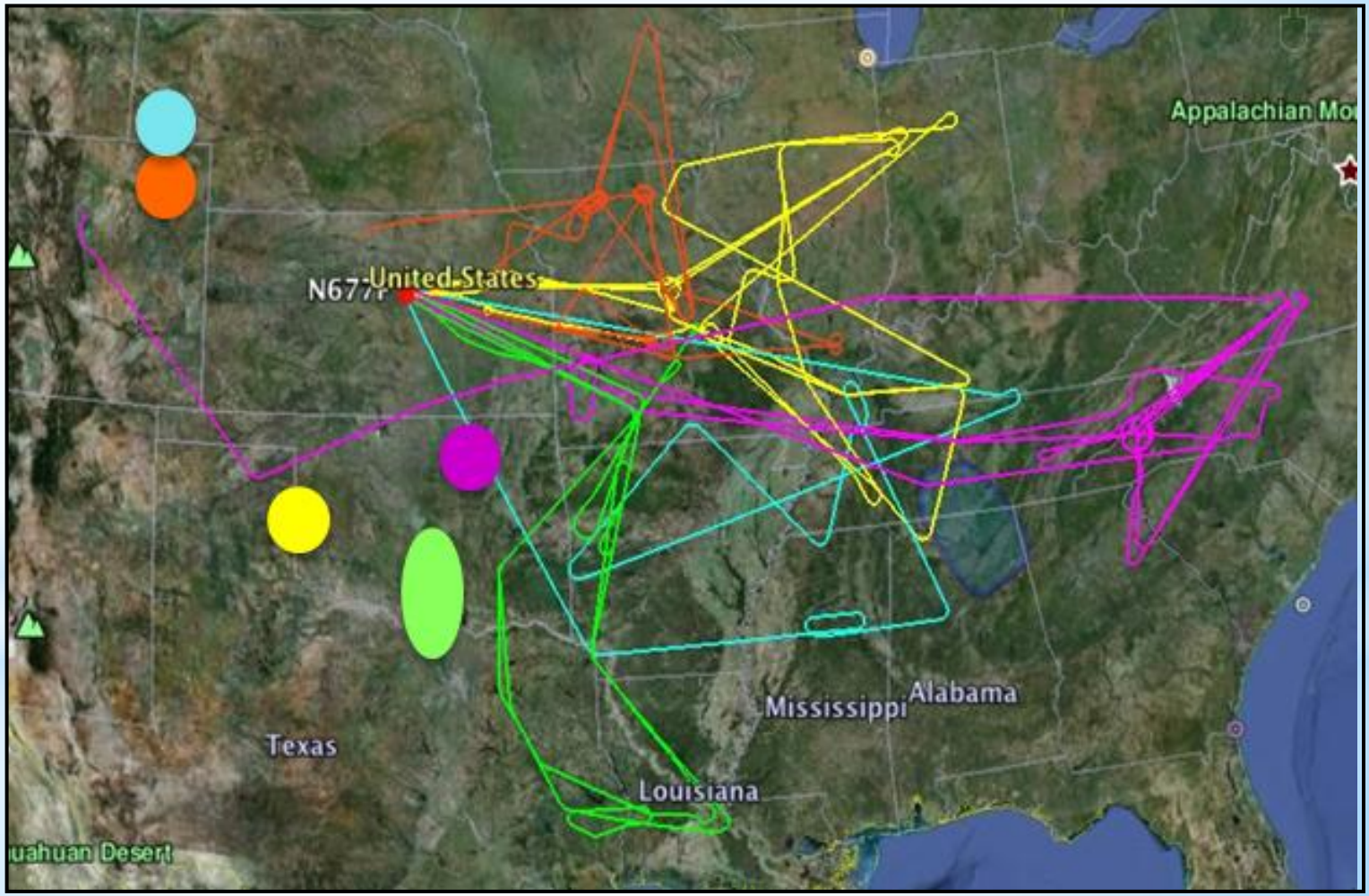


DC-8

DC3 Study Regions - Outflow Aging

Where: Sampled photochemical aging of convective outflow in the central to eastern U.S.

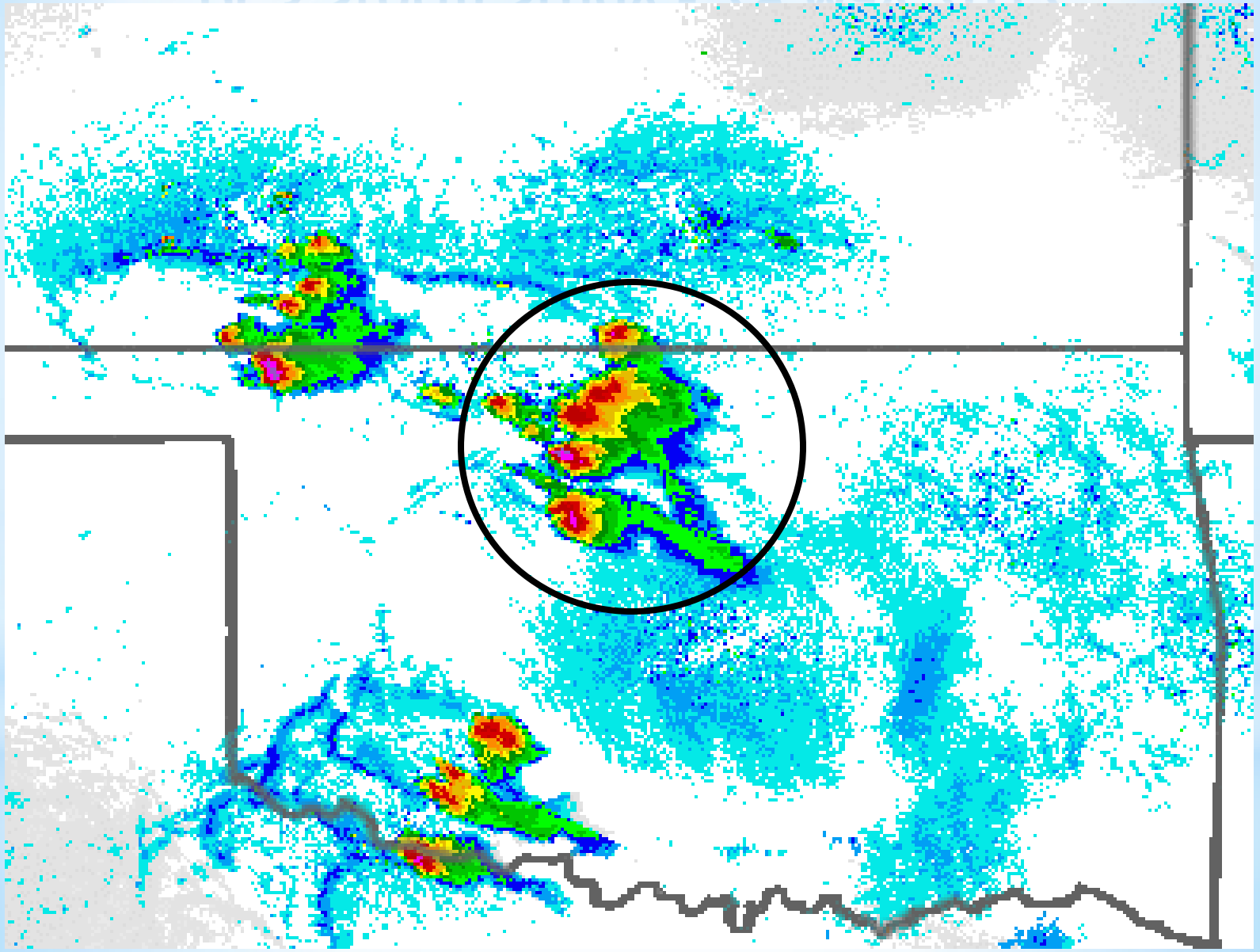
May 25, 26
May 29, 30
June 6, 7
June 16, 17
June 22, 23



Henry's Law Constants

Species	*H (298 K)*	*H (273 K)*
HNO_3	200,000	2,900,000
H_2O_2	84,400	872,000
CH_2O	3,230	29,100
CH_3OOH	300	1,560
CH_3OH	203	1,150
acetone	27.8	152
SO_2	1.36	3.42
O_3	0.00103	0.0244
CO	0.000981	0.00164

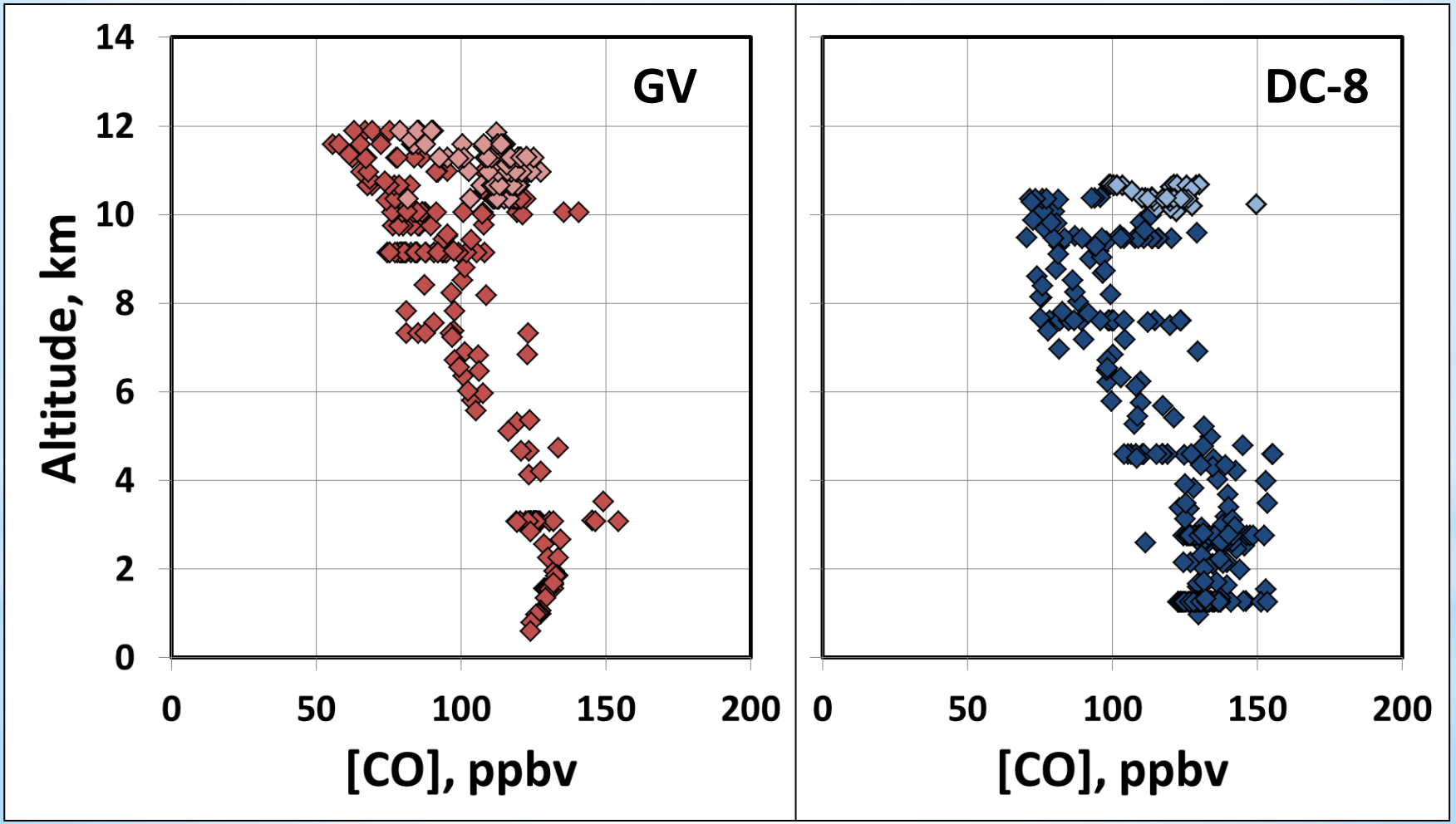
DC3 Storm Study - 29 May 2012



DC3 Transport and LNO_x - CO

When: 29 May 2012

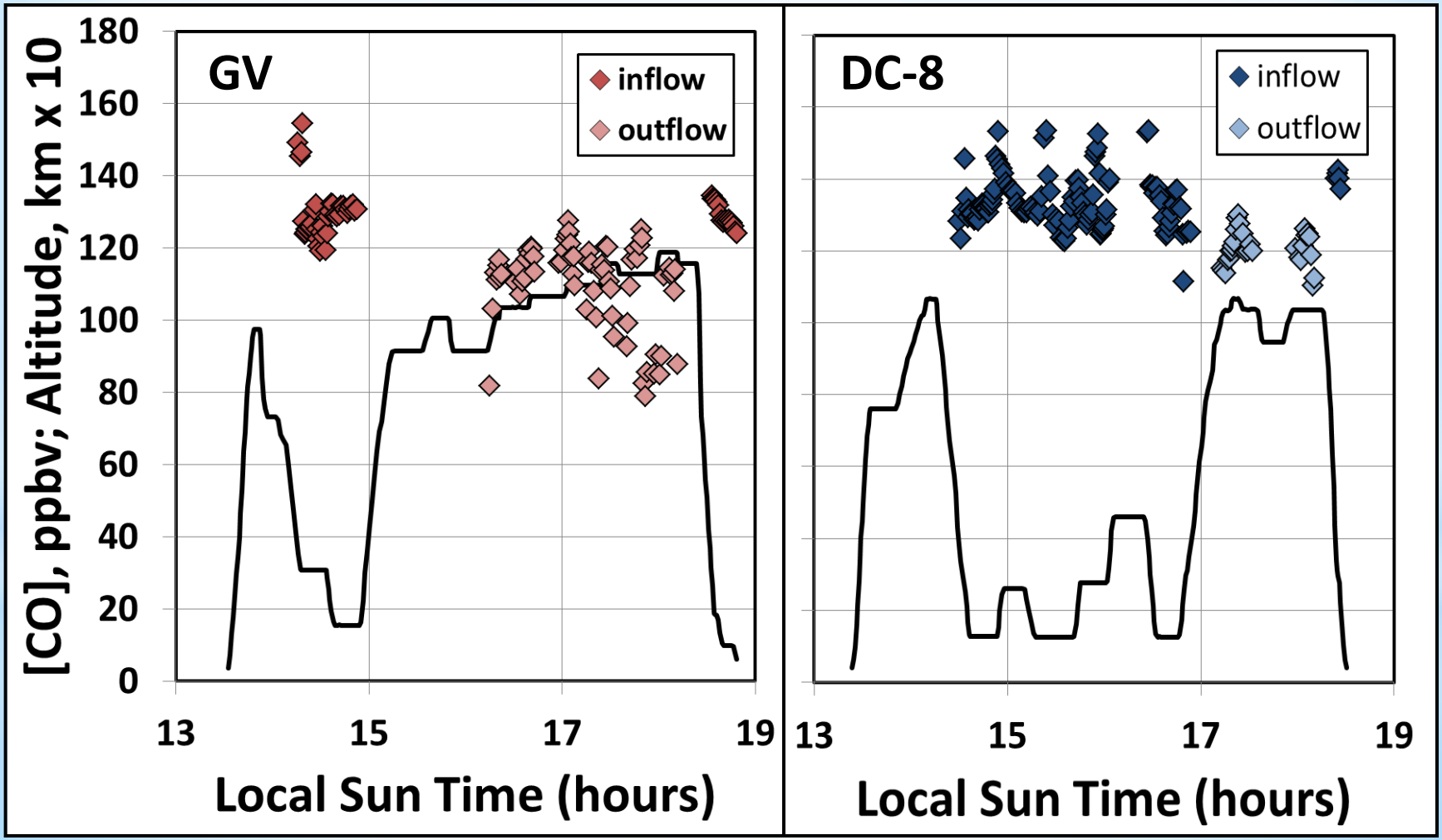
Where: N central Oklahoma



DC3 Transport and LNO_x - CO

When: 29 May 2012

Where: N central Oklahoma



DC3 Transport and LNO_x - NO_x

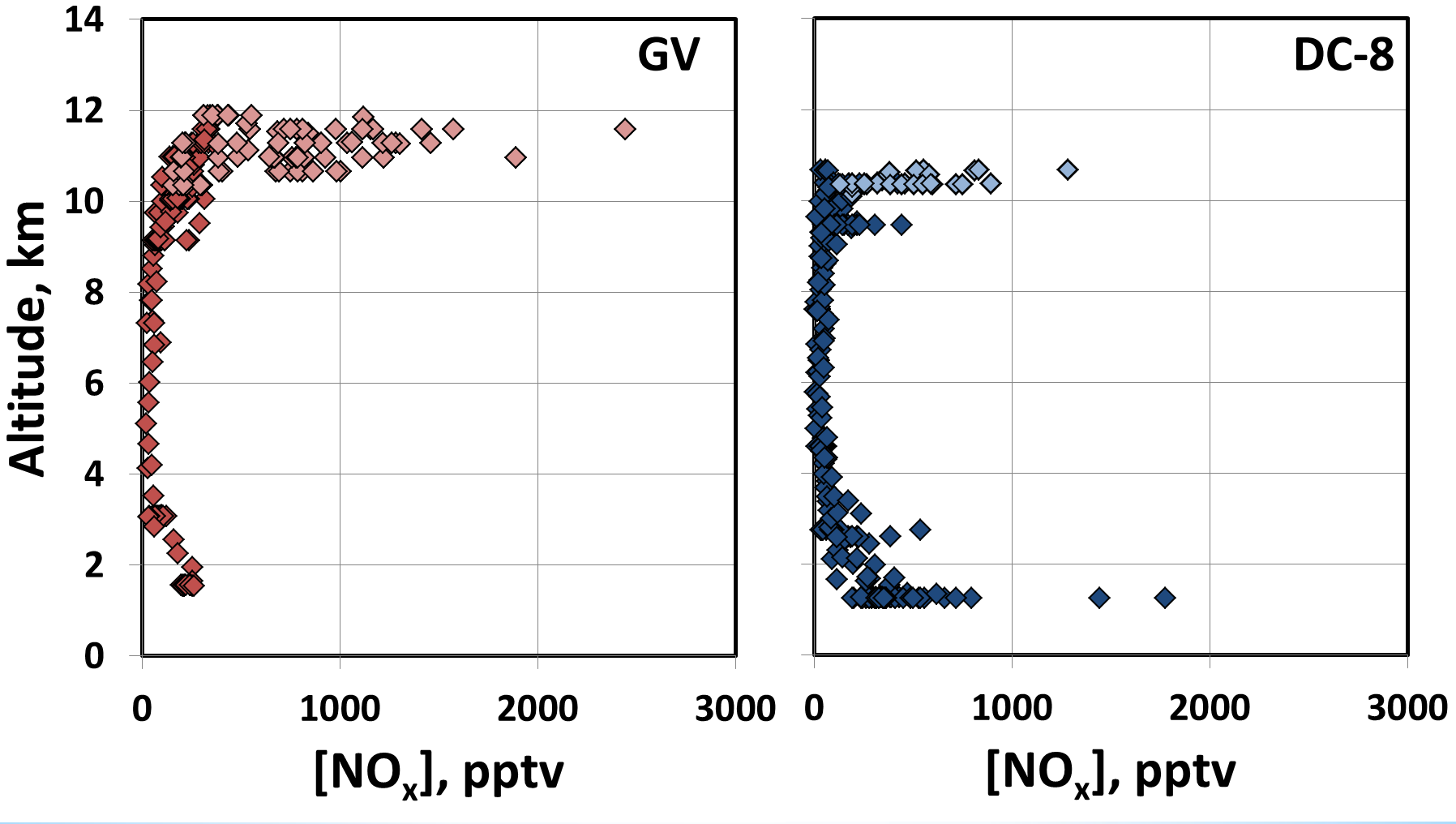
When: 29 May 2012

Where: N central Oklahoma

*** **Preliminary Data** ***

GV data: Weinheimer, Knapp, Montzka (NCAR)

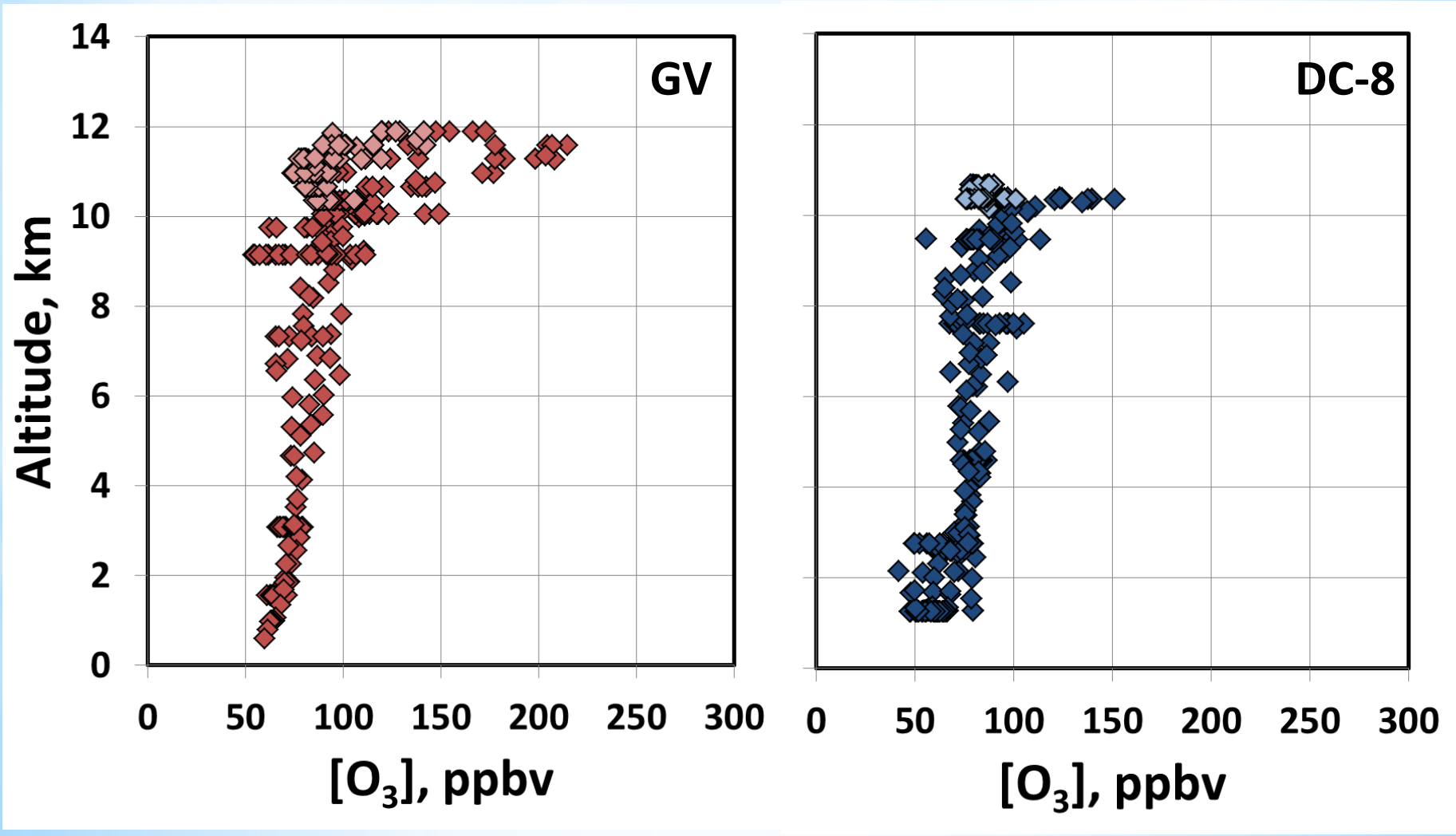
DC-8 data: Ryerson, Pollack (NOAA/ESRL)



DC3 Transport and LNO_x - O_3

When: 29 May 2012
Where: N central Oklahoma

*** **Preliminary Data** ***
GV data: Campos, Flocke (NCAR)
DC-8 data: Peischl (NOAA/ESRL)



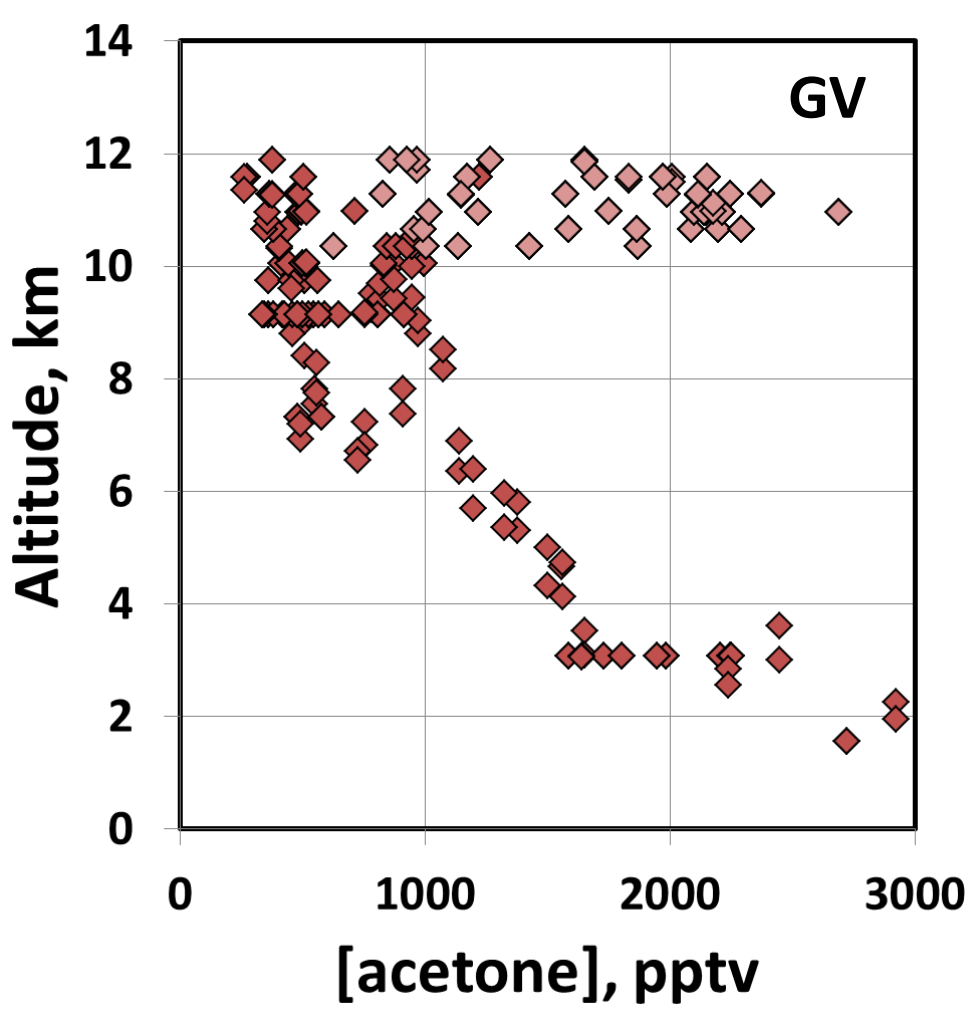
DC3 Transport and LNO_x - acetone

When: 29 May 2012

Where: N central Oklahoma

*** **Preliminary Data** ***

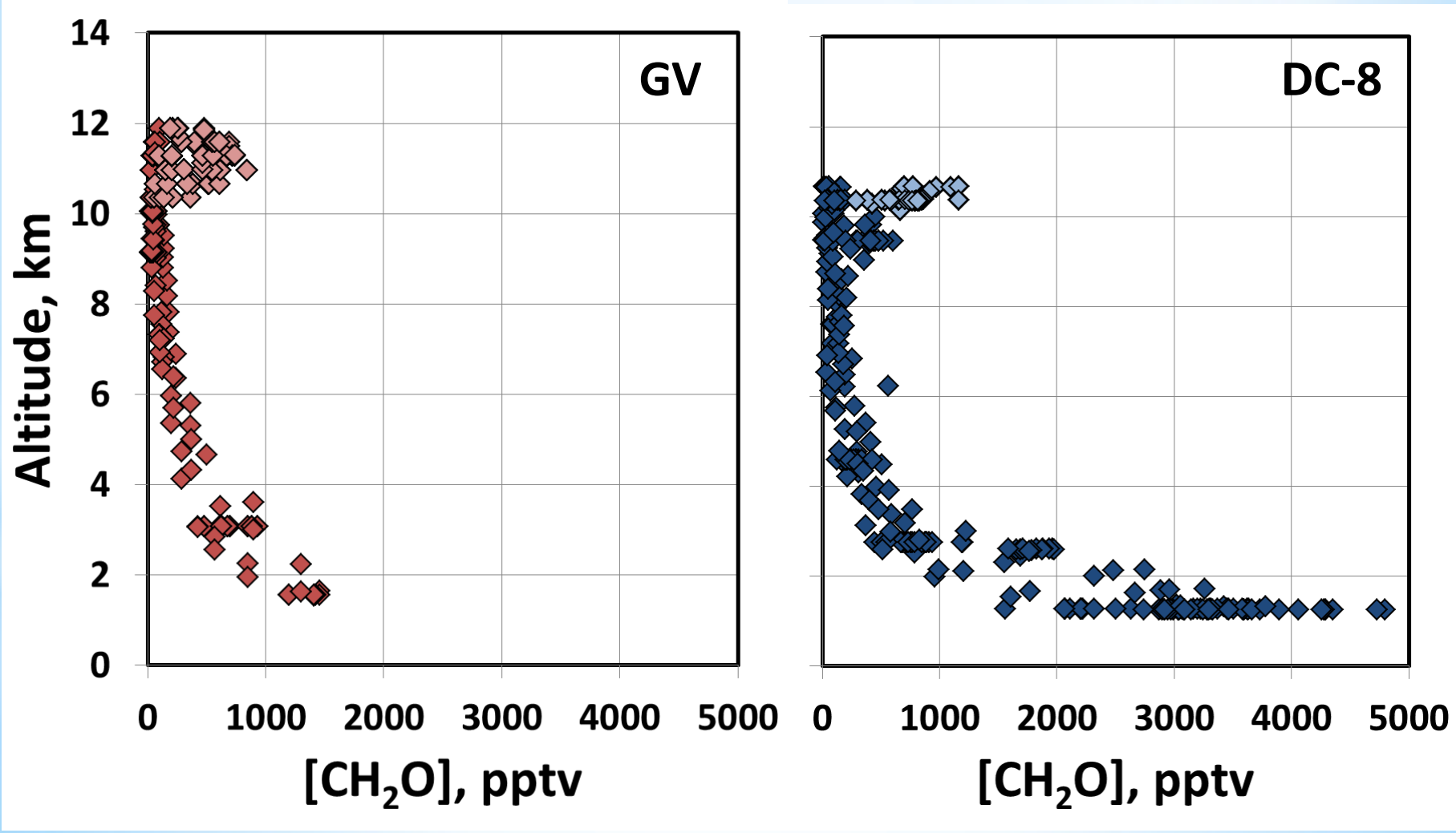
GV data: Apel, Hornbrook, Hills (NCAR), Riemer (Miami)



DC3 Transport and LNO_x - CH_2O

When: 29 May 2012
Where: N central Oklahoma

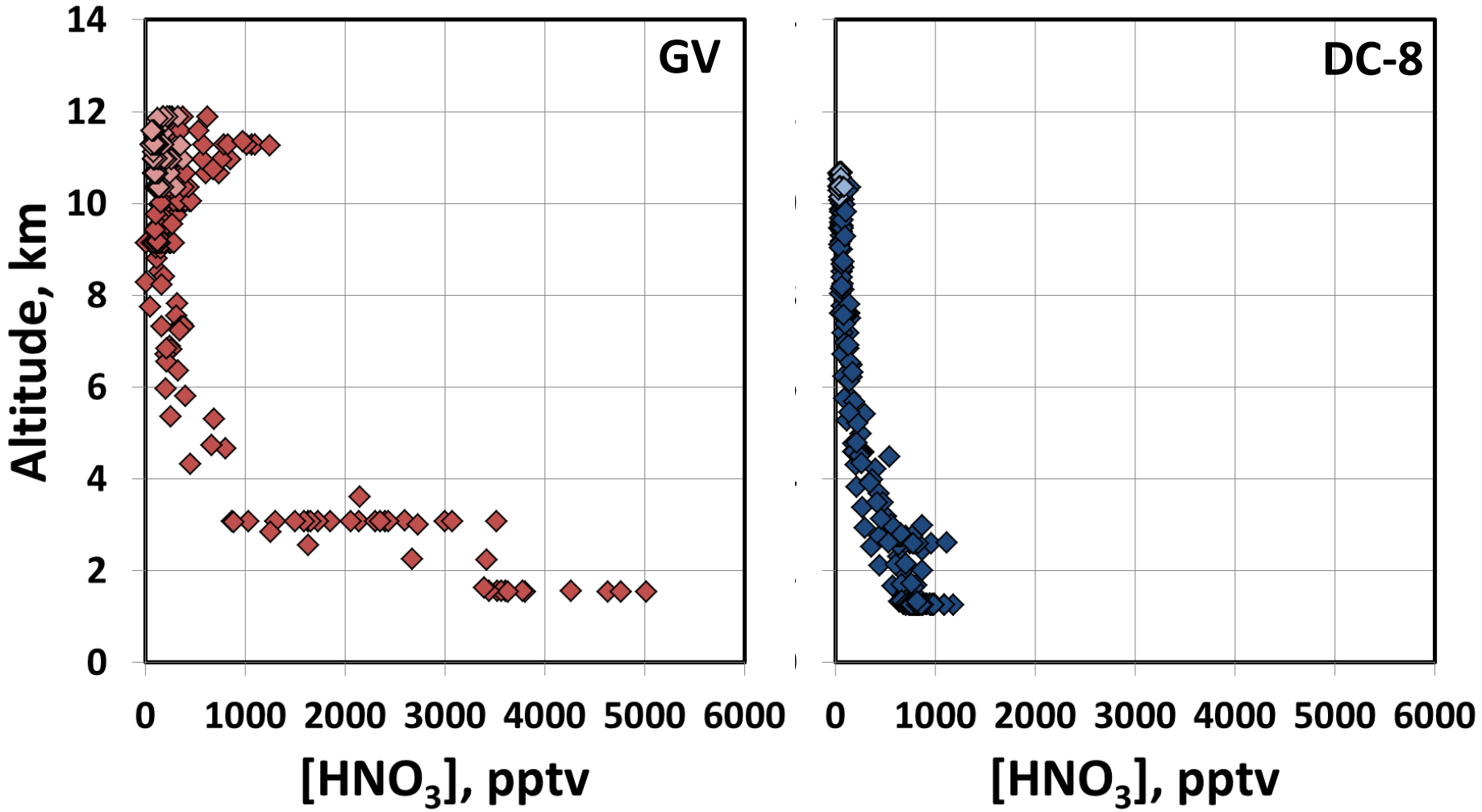
*** **Preliminary Data** ***
CH_2O data: Fried, Walega, Weibring, Richter (U. Colorado)



DC3 Transport and LNO_x - HNO_3

When: 29 May 2012
Where: N central Oklahoma

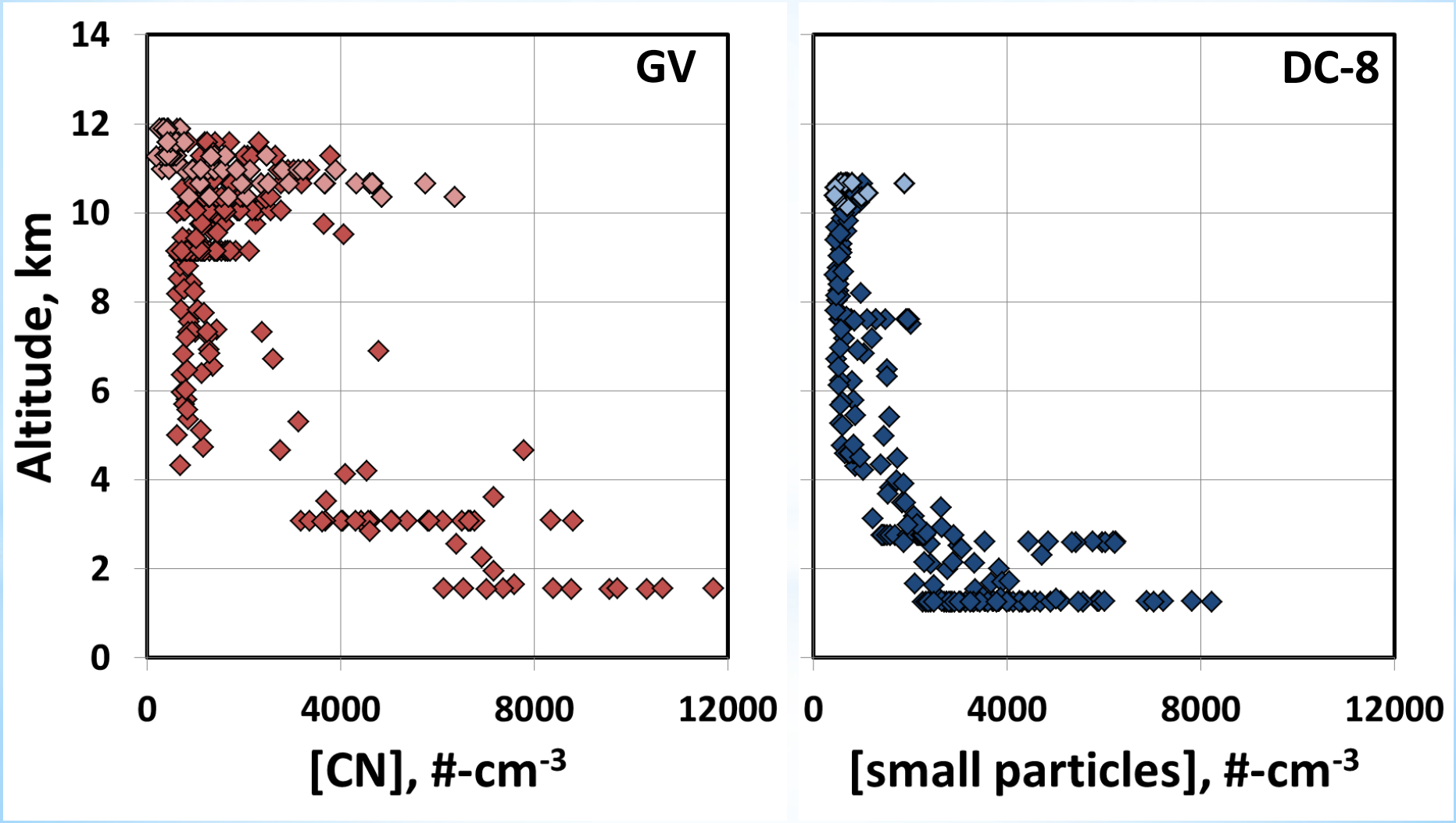
*** **Preliminary Data** ***
GV data: Huey (Georgia Tech)
DC-8 data: Dibb (U New Hampshire)



DC3 Transport and LNO_x - Particles

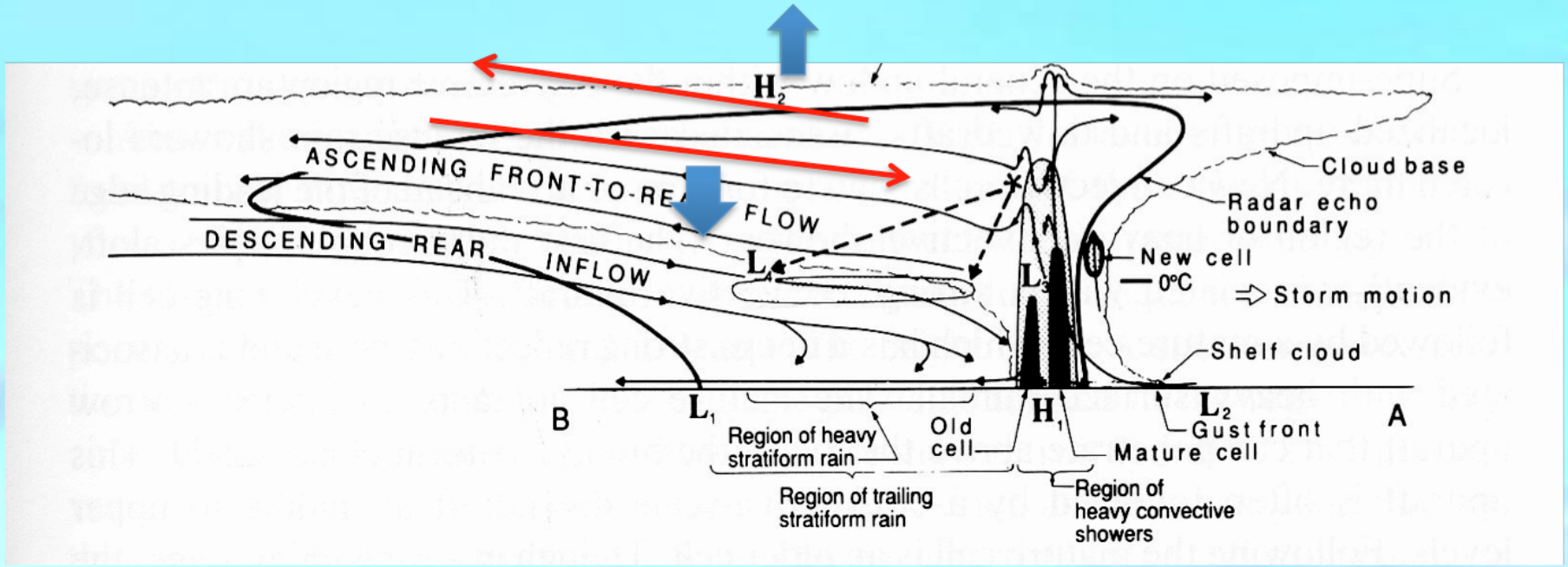
When: 29 May 2012
Where: N central Oklahoma

*** **Preliminary Data** ***
DC-8 data: Ziemba, Anderson (NASA)
GV data: J. Smith, J. Ortega (NCAR)

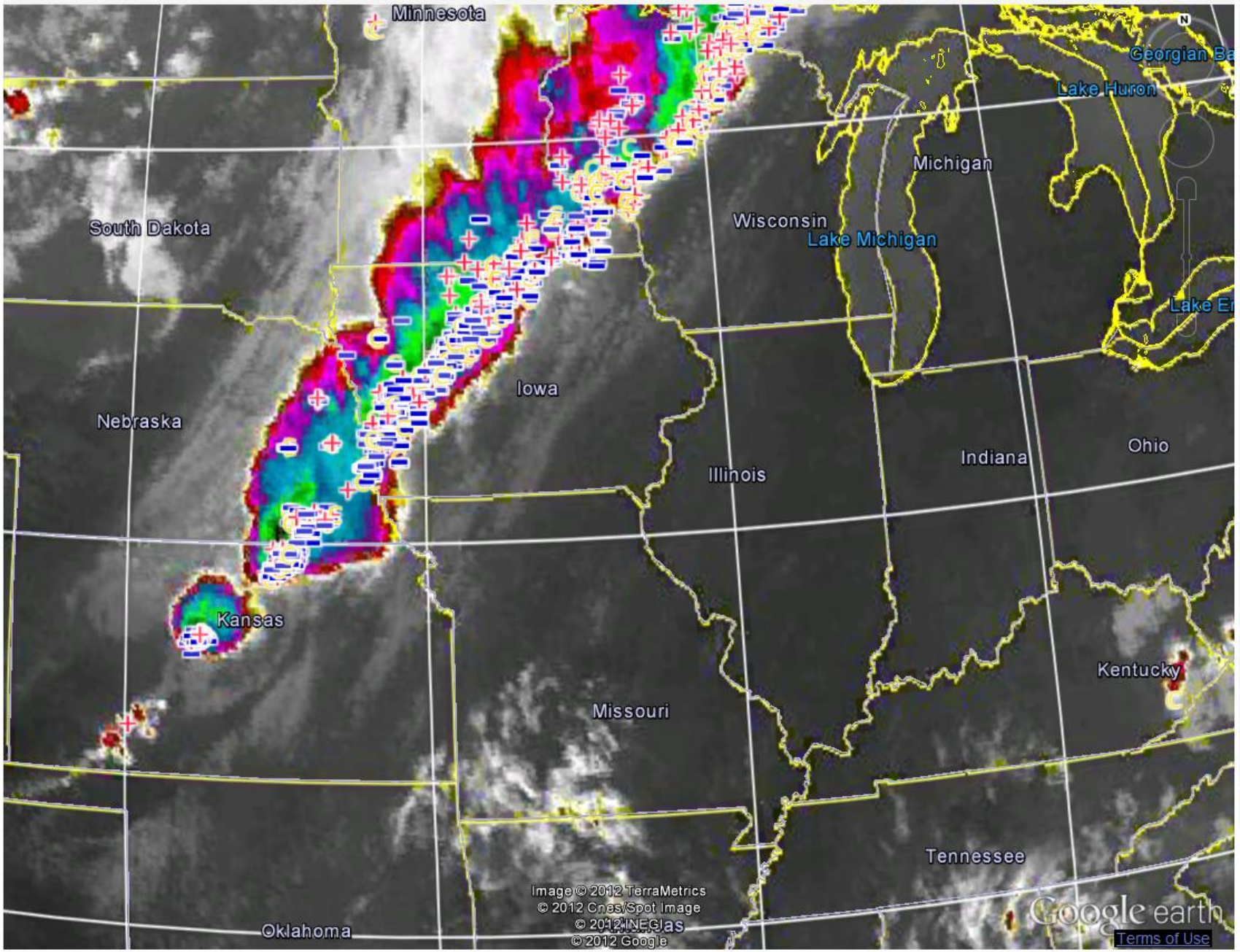


Photochemical Aging Case: 21 June 2012

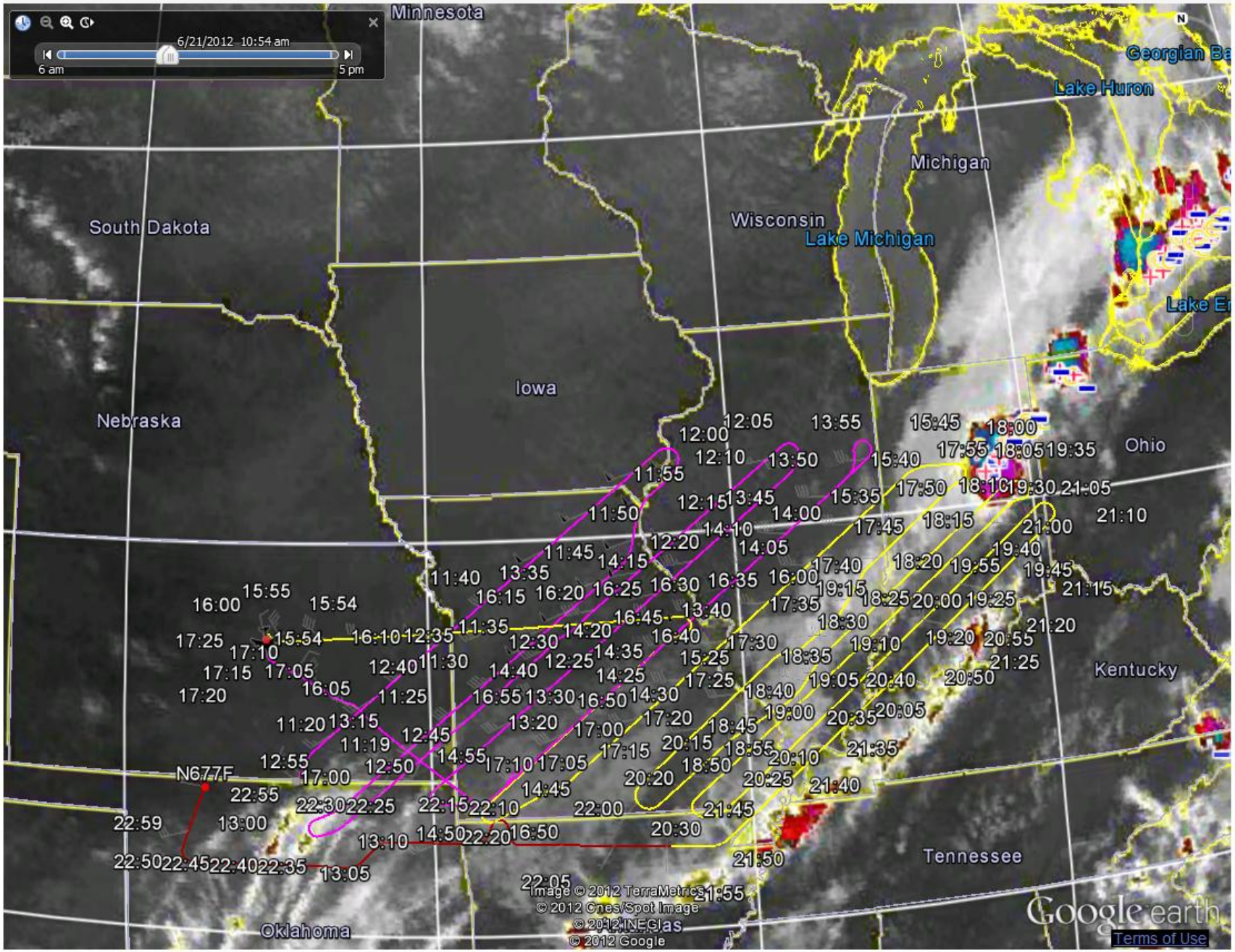
Mesoscale Convective System



Houze, Rutledge, Biggerstaff and Smull (1989), BAMS

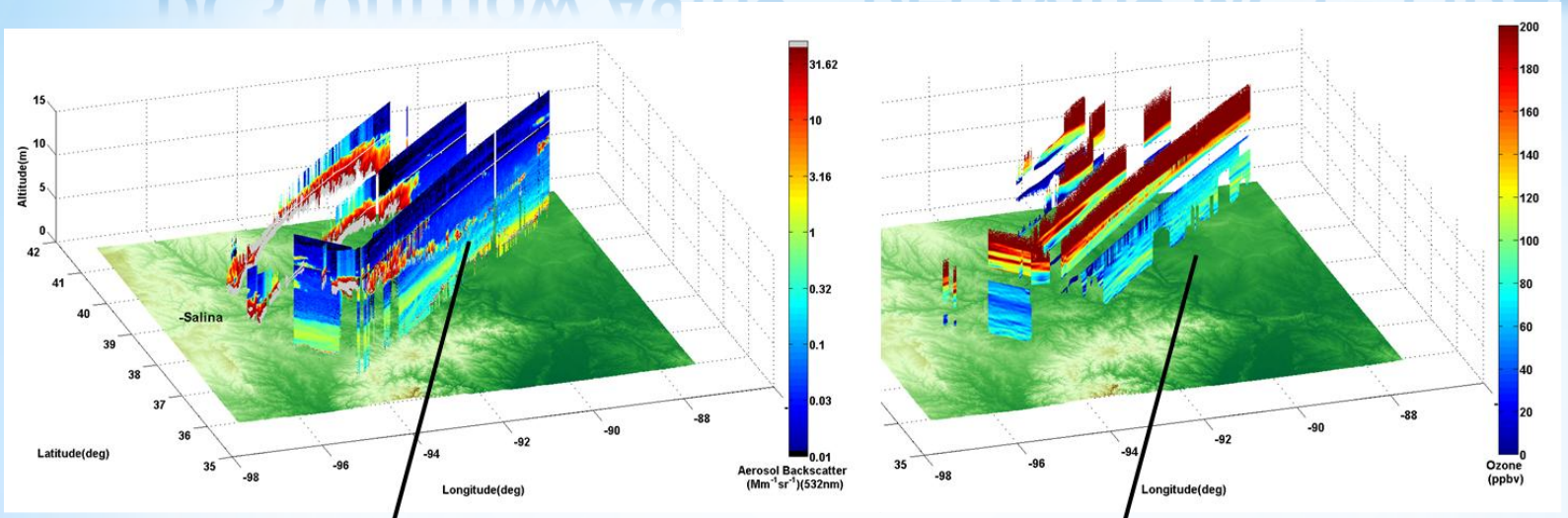


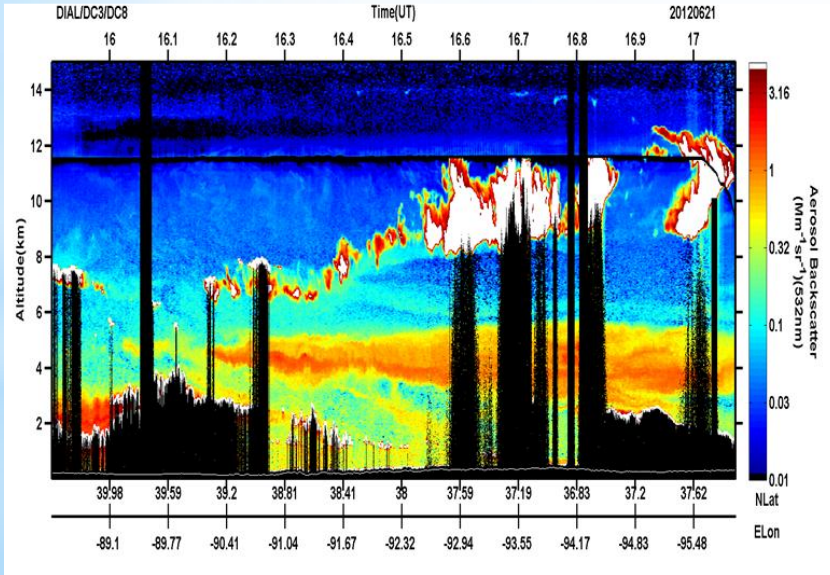
The selected date/time display is 2012-06-21 00:00 UTC

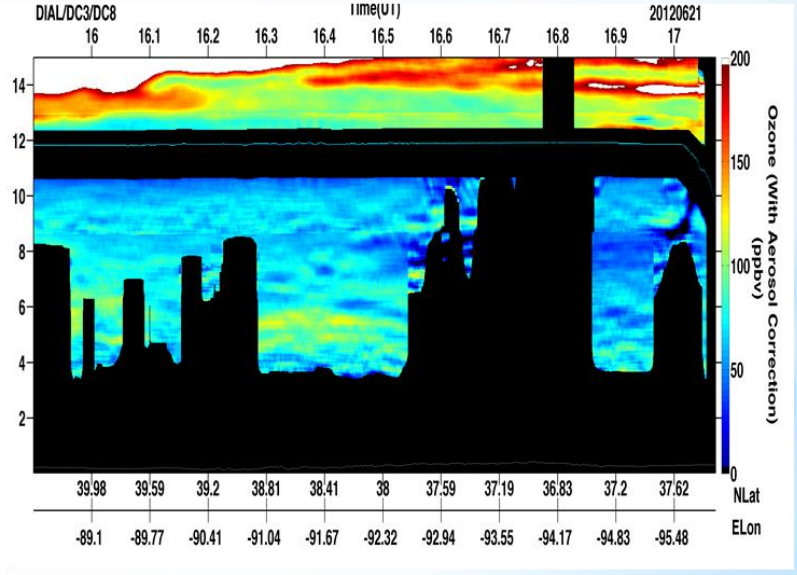


The selected date/time display is 2012-06-21 23:00 UTC

DC3 Outflow Aging – Decaying MCS - LIDAR



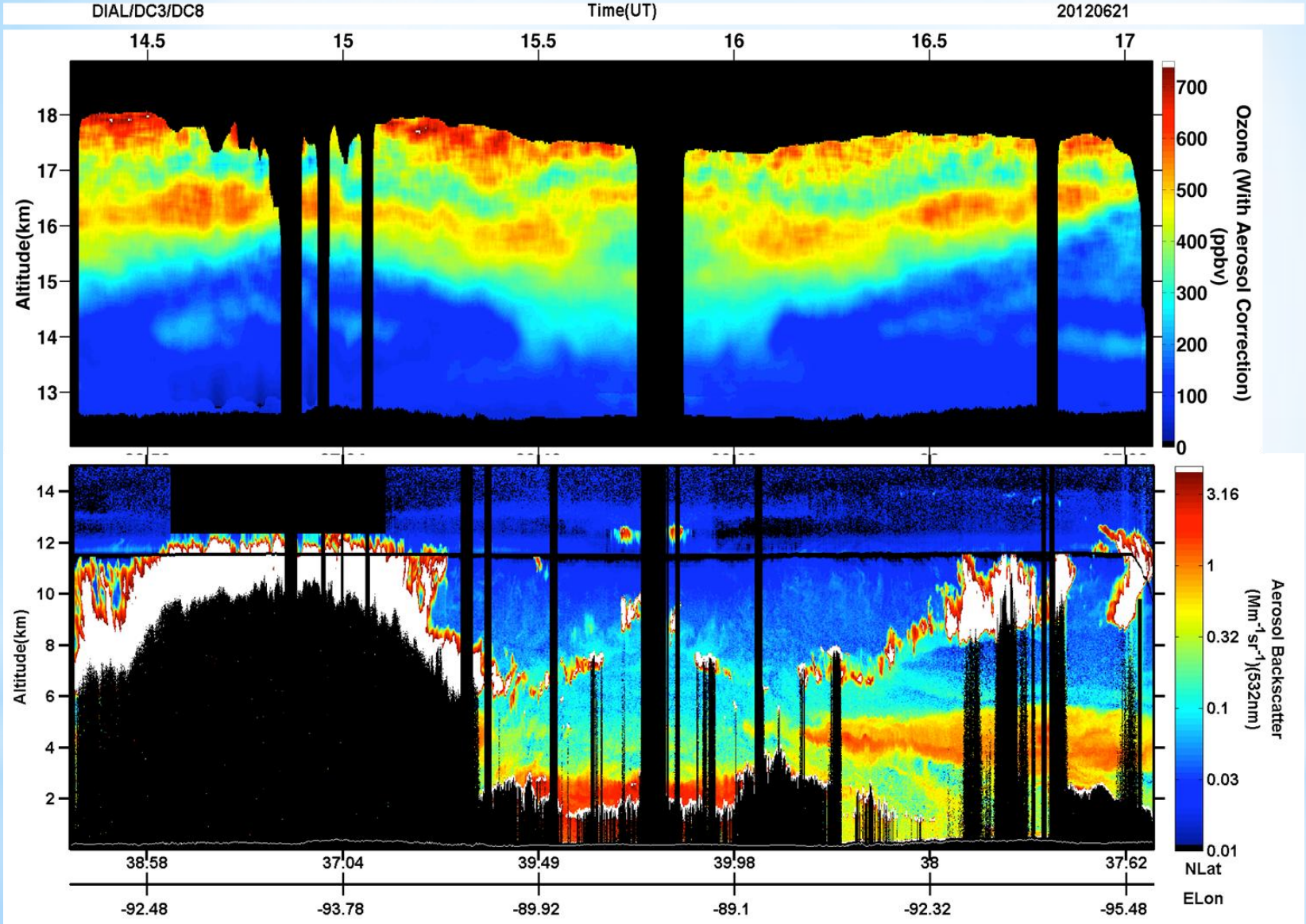




***** Preliminary Data *****

DC-8 data: J. Hair and NASA LIDAR group

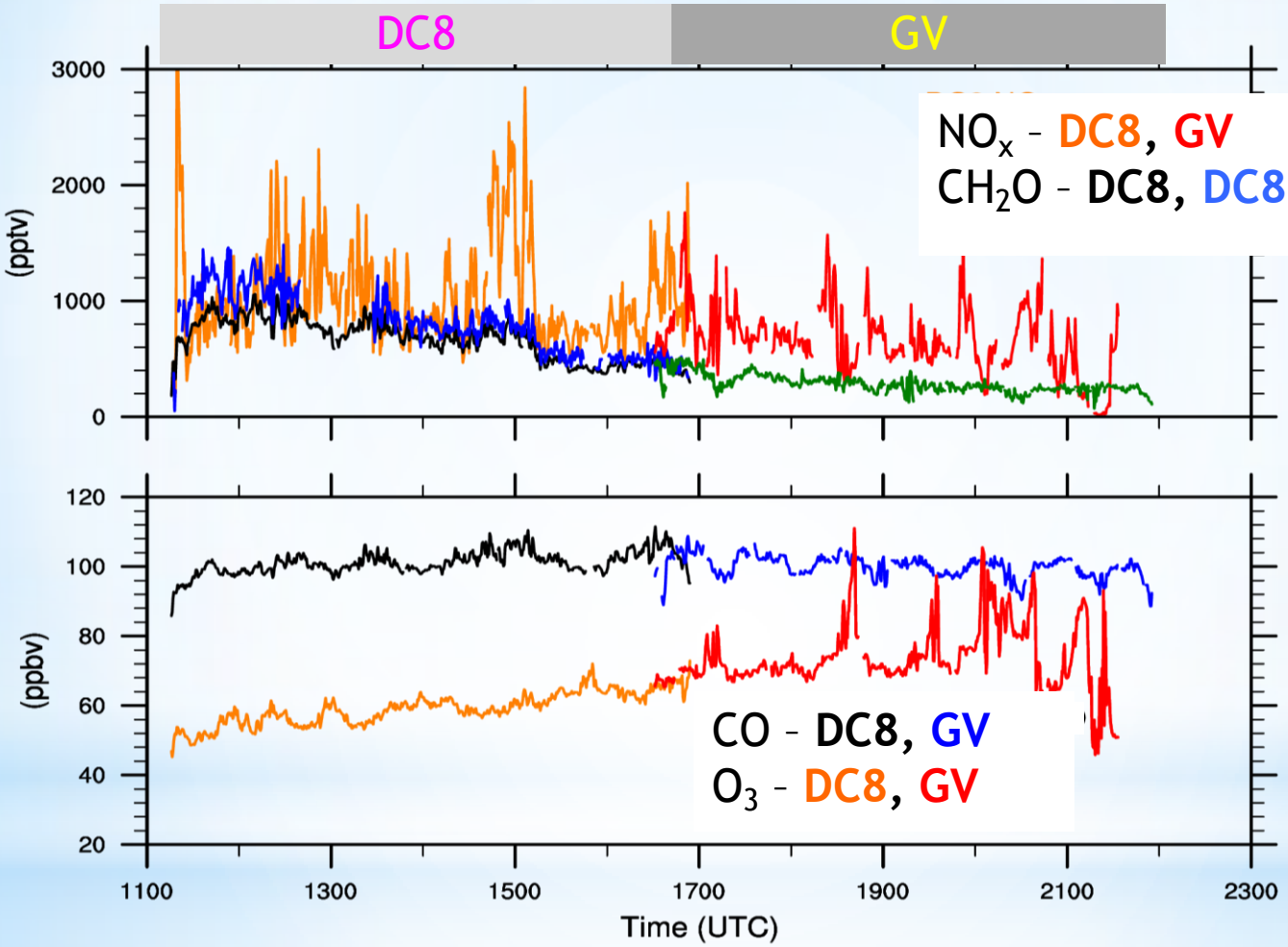
DC3 Outflow Aging – Decaying MCS - LIDAR



***** Preliminary Data *****

DC-8 data: J. Hair and NASA LIDAR group

DC3 Outflow Aging – Decaying MCS – Gases

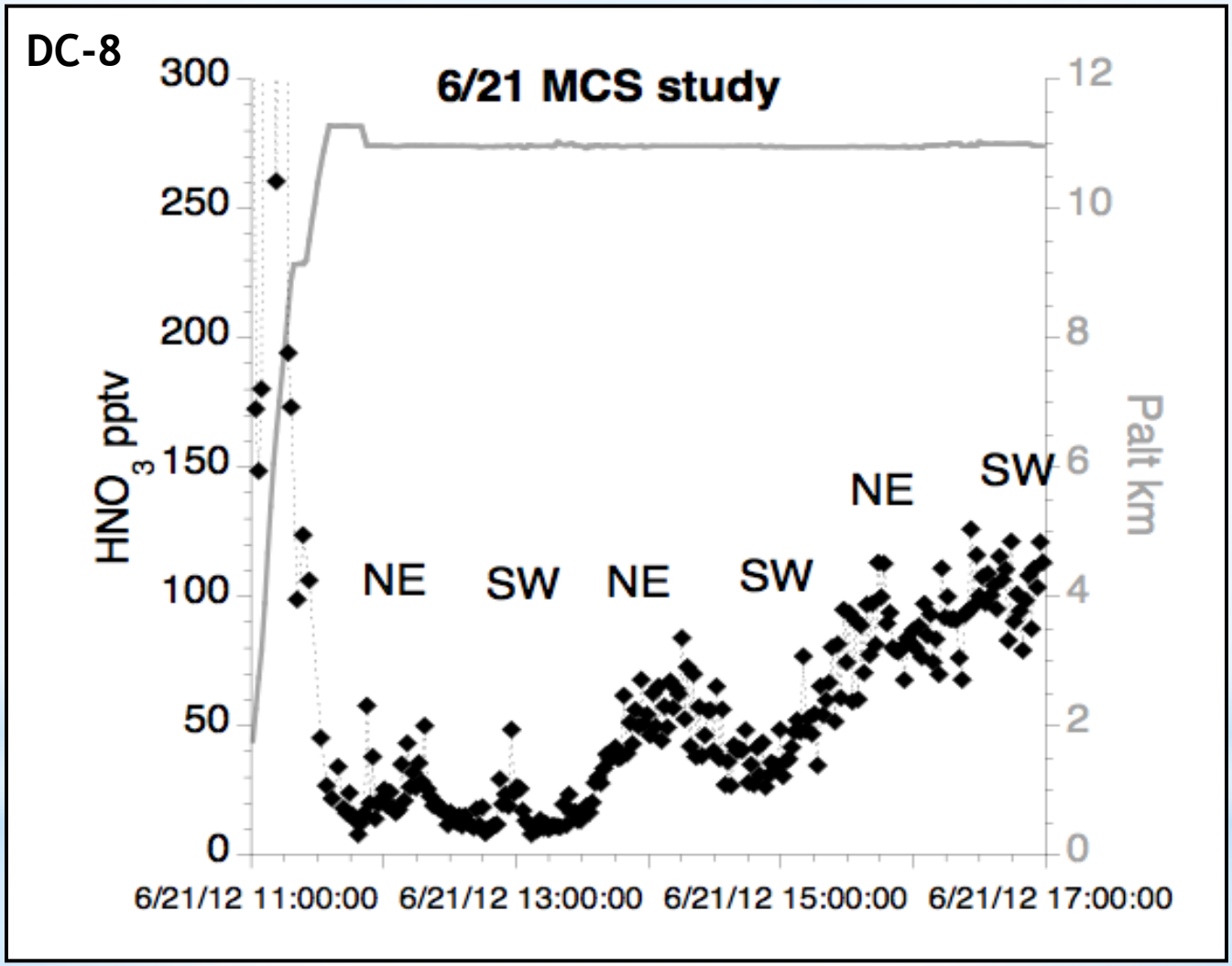


*** **Preliminary Data** ***

DC-8 data: T. Ryerson, I. Pollack, J. Peischl (NOAA/ESRL); T. Hanisco (NASA/GSFC); A. Fried, J. Walega (now at U. Colorado); G. Diskin, G. Sachse (NASA/LaRC)

GV data: A. Weinheimer, F. Flocke, T. Campos, D. Knapp, D. Montzka (NCAR); D. Richter, P. Weibring (now at U. Colorado)

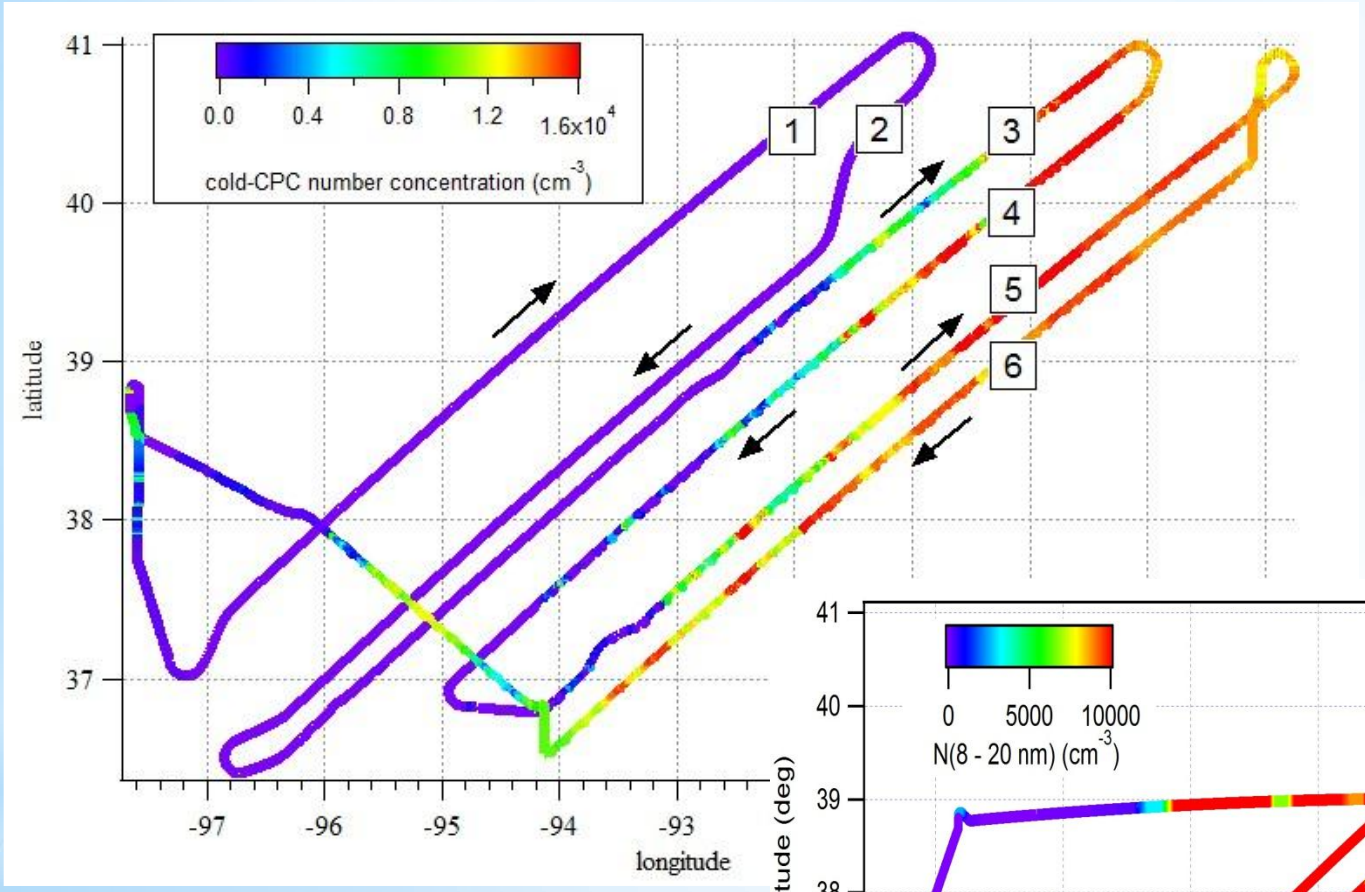
DC3 Outflow Aging – Decaying MCS – HNO_3



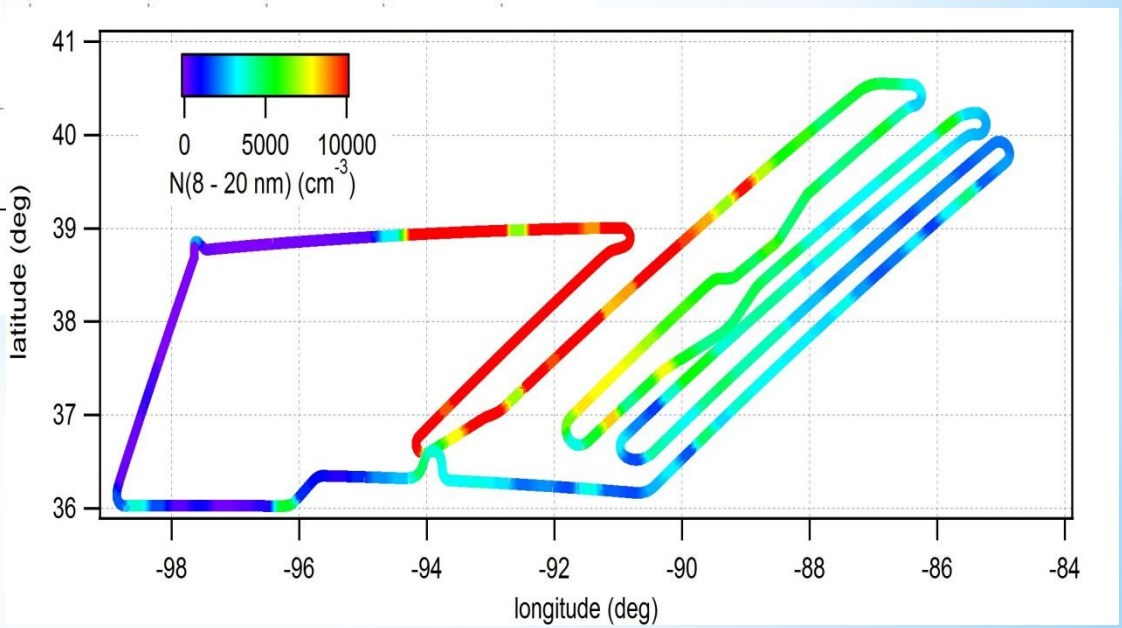
*** **Preliminary Data** ***
DC-8 data: J. Dibb (UNH)

DC3 Outflow Aging - Decaying MCS - Particles

DC-8



GV



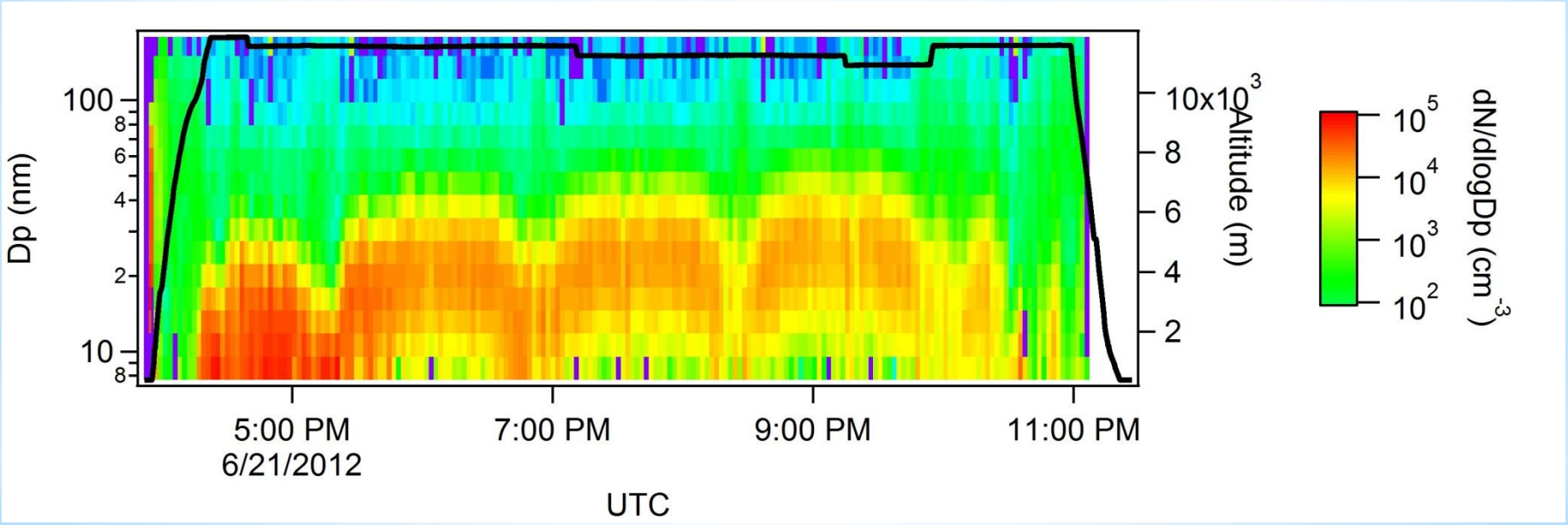
*** **Preliminary Data** ***

DC-8 data: L. Ziemba, B. Anderson (NASA/LaRC)

GV data: J. Smith, J. Ortega (NCAR)

DC3 Outflow Aging – Decaying MCS - Particles

GV



*** **Preliminary Data** ***

GV data: J. Smith, J. Ortega (NCAR)

Acknowledgements

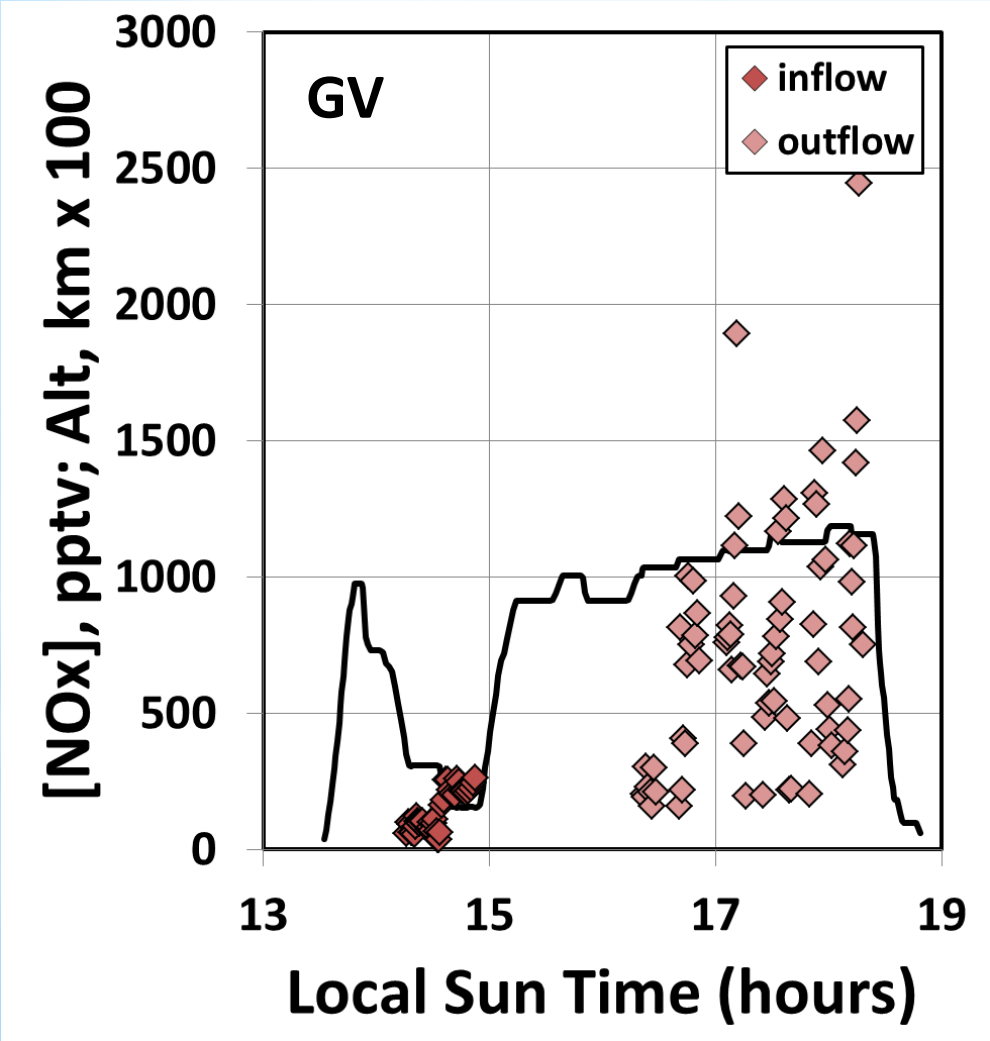
- Primary financial support: NSF, NASA, DLR
- Additional support: Univ of OK, Univ of AL-Huntsville, CSU, NCAR-NESL, DOE, NOAA
- Logistics/Operations: NCAR Earth Observing Laboratory
- Aircraft: NCAR RAF, NASA, DLR
- Aircraft based measurements: many, many instrument teams on GV & DC-8
- Ground based measurements: regional teams for radar, lightning, and soundings
- Weather Forecasting: central and regional teams
- Decision making: core team in collaboration with entire science team

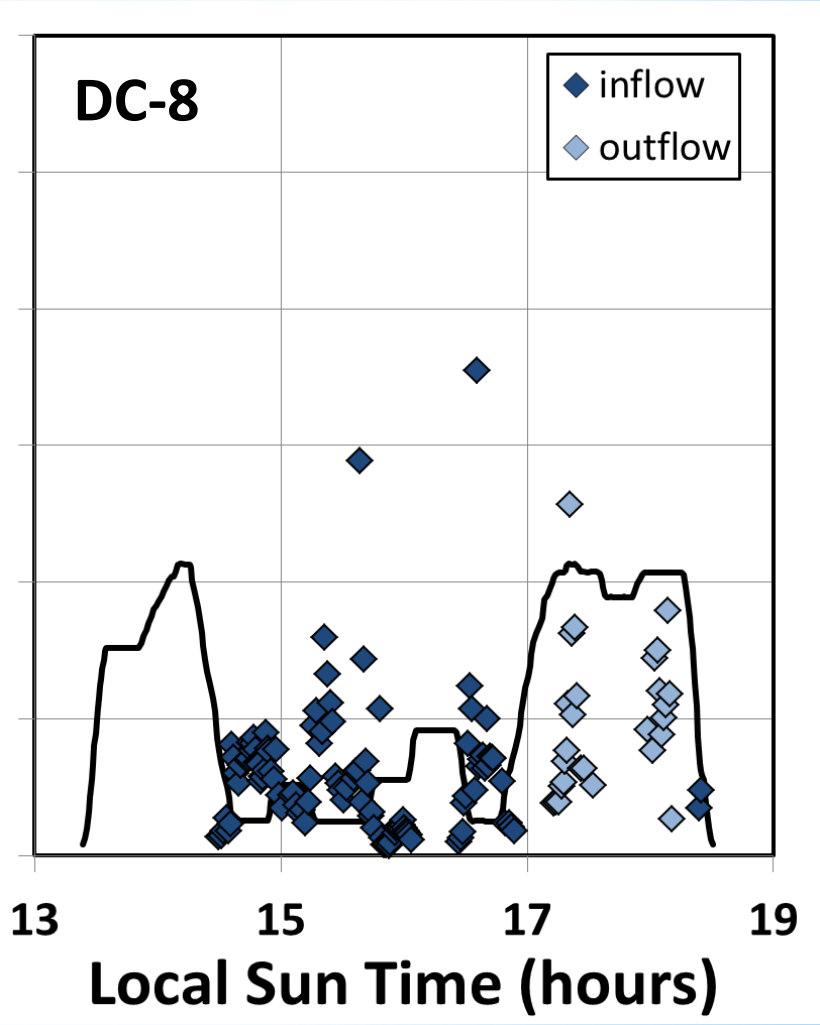
Extra Slides

DC3 Transport and LNO_x - NO_x

When: 29 May 2012

Where: NE Colorado

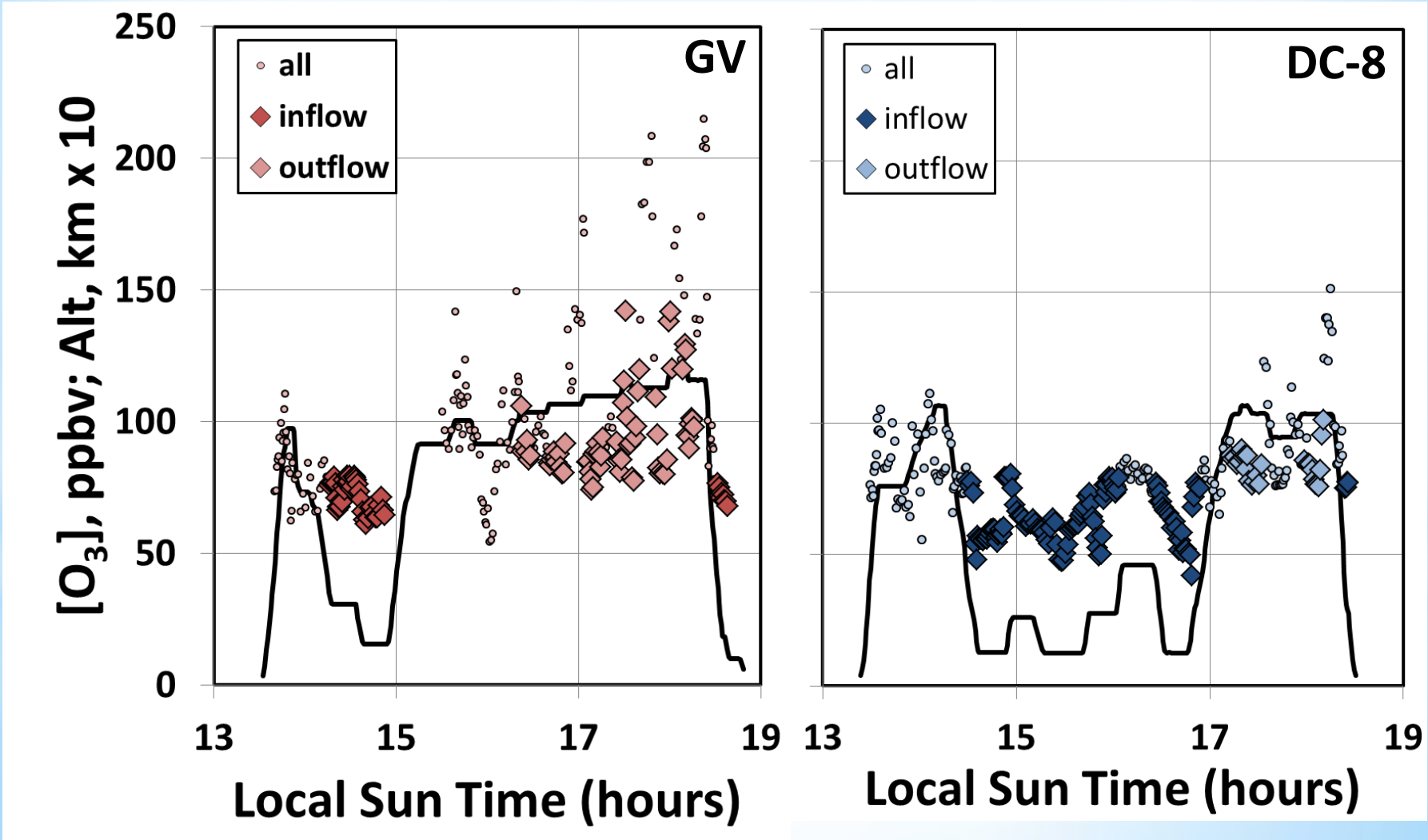




DC3 Transport and LNO_x - O_3

When: 29 May 2012

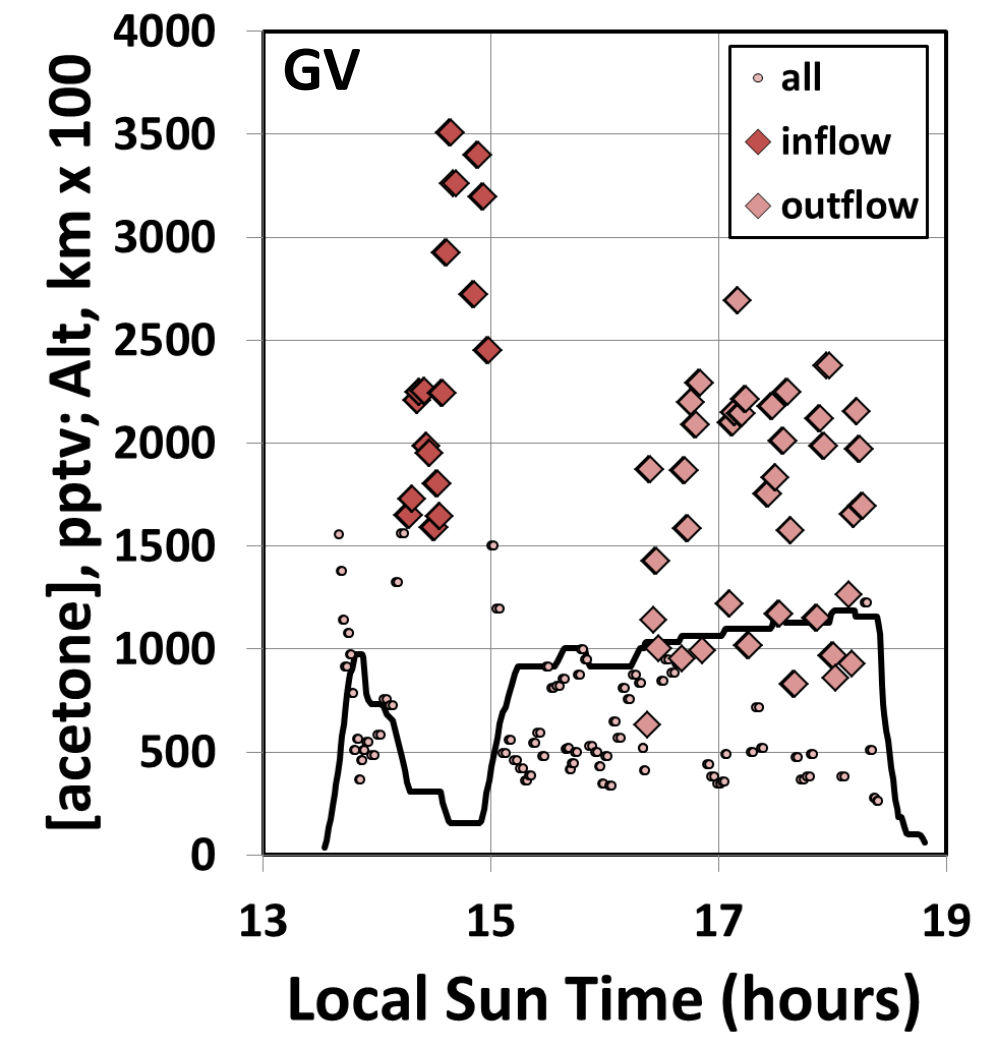
Where: NE Colorado



DC3 Transport and LNO_x - acetone

When: 29 May 2012

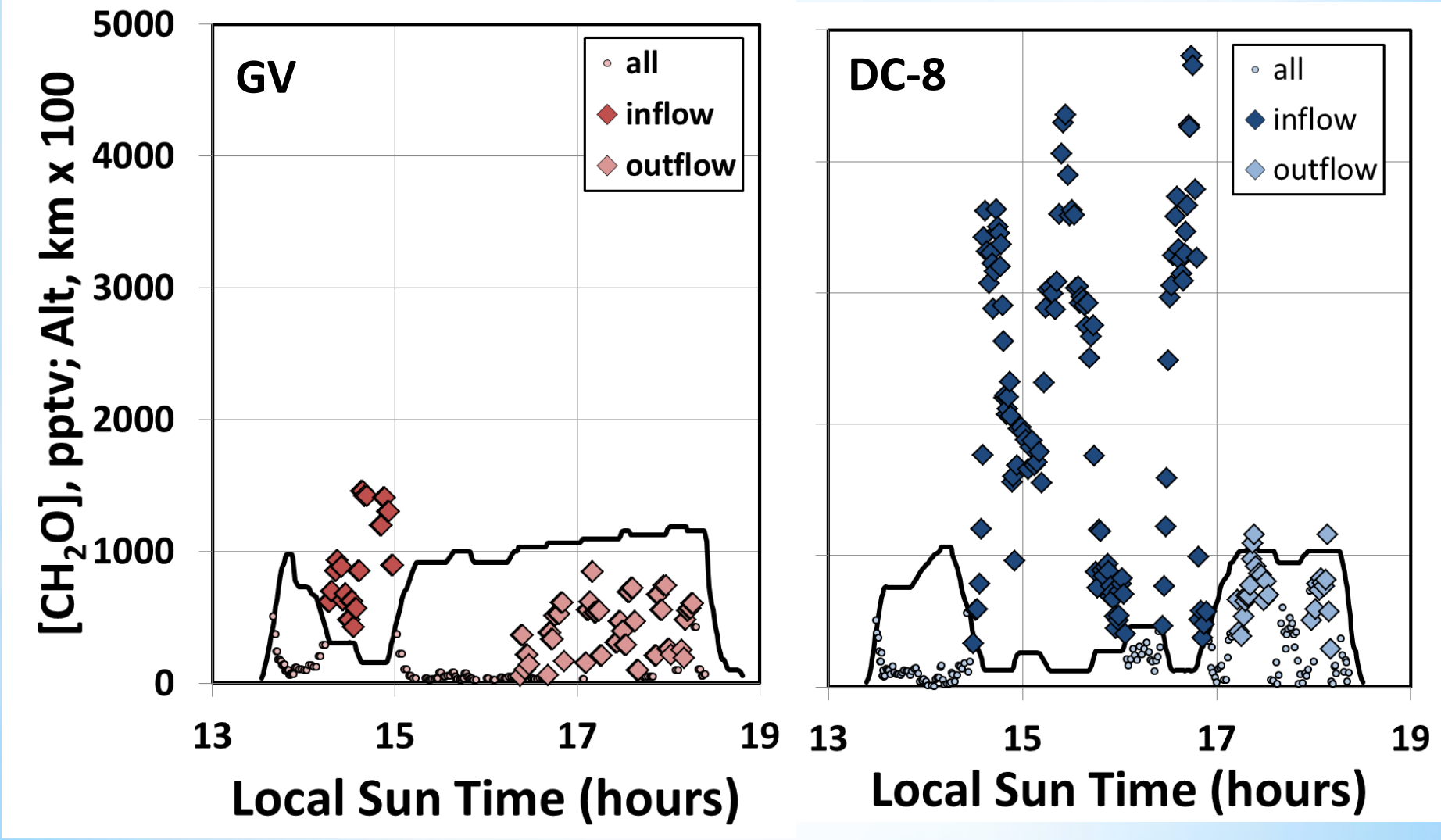
Where: NE Colorado



DC3 Transport and LNO_x - CH_2O

When: 29 May 2012

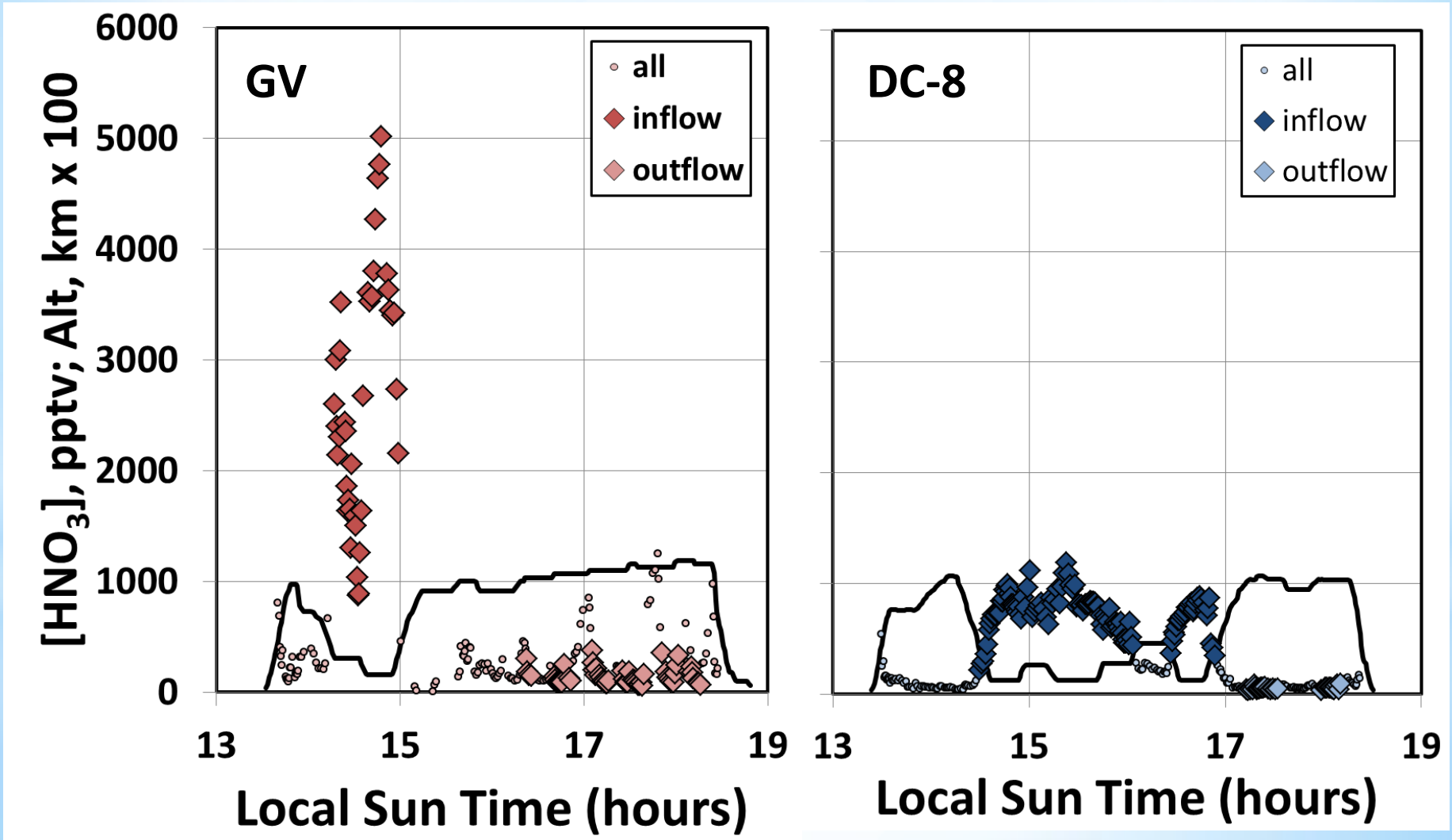
Where: NE Colorado



DC3 Transport and LNO_x - HNO_3

When: 29 May 2012

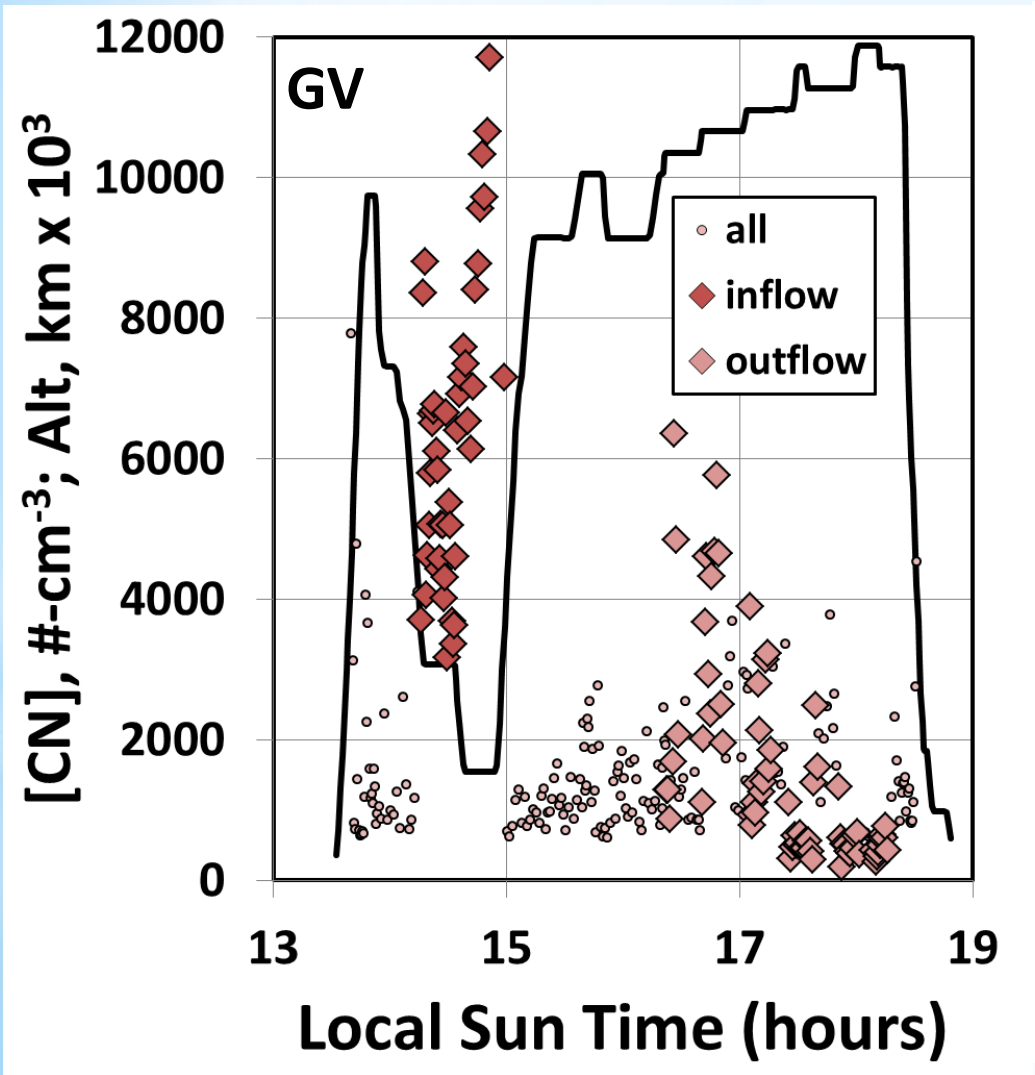
Where: NE Colorado

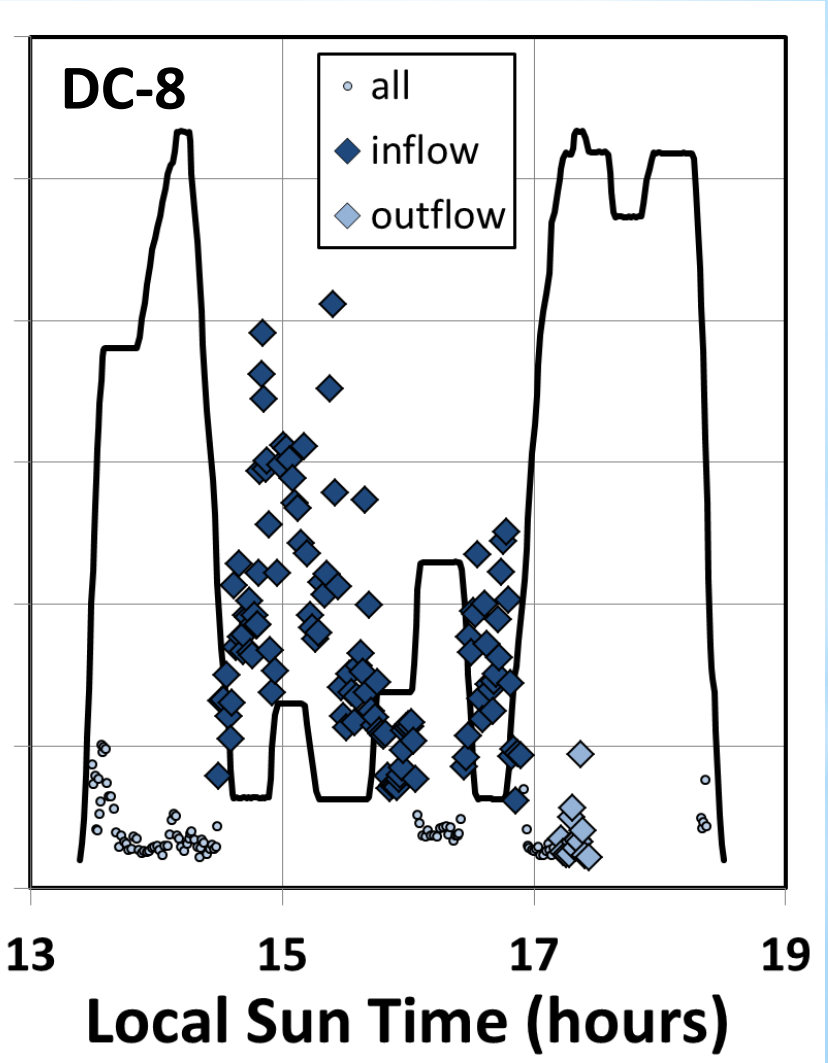


DC3 Transport and LNO_x - Particles

When: 29 May 2012

Where: NE Colorado





Using the 3 aircraft, DC3 sampled:

19 cases of active thunderstorms; >6 cases of photochemical aging

NSF/NCAR GV and NASA DC-8 flew 17 coordinated flights

8 storms in northeast Colorado

5 storms in West Texas to central Oklahoma

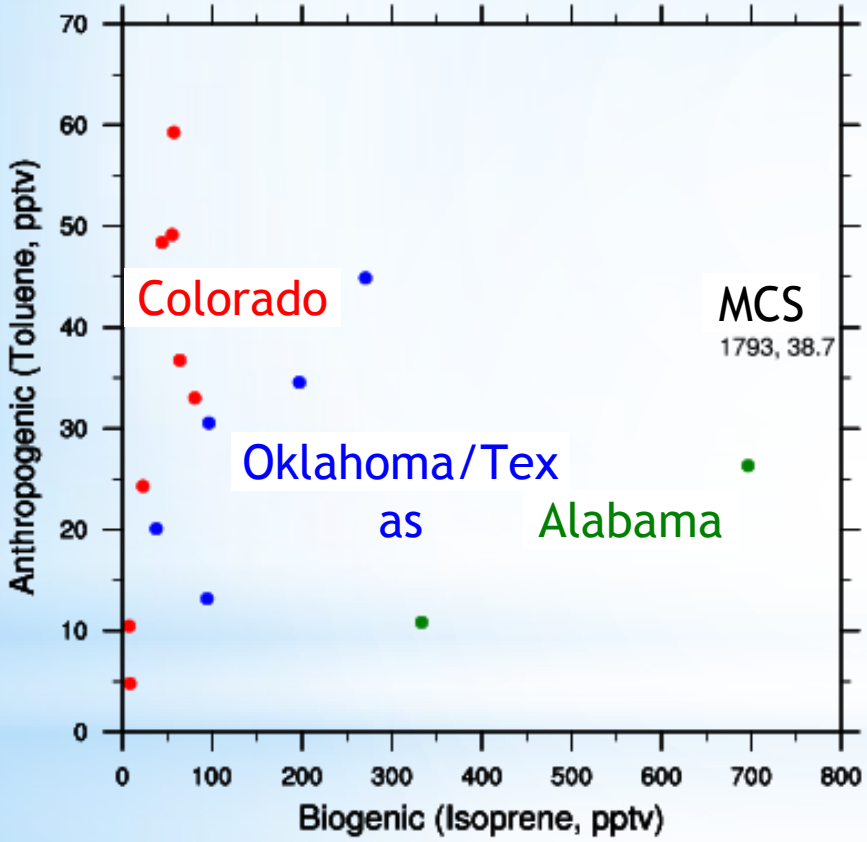
2 storms in Alabama & Mesoscale Convective System (MCS) over Missouri

3 cases of photochemical aging from TX/OK storms

2 cases of photochemical aging from NE Colo. Storms

1 case of chemical aging of the 0-12 hr dissipating MCS outflow

Preliminary data of average concentrations within 2 km of the ground color coded by the sampling region. All points are from DC-8 data except the June 27, 28 storms.



→ General separation of anthropogenic and biogenic influences among regions

→ The MCS occurred over a region with very high isoprene emissions

***** Preliminary Data *****

PTR-MS – Proton Transfer Reaction Mass Spectrometry: A. Wisthaler (U. Innsbruck)

TOGA – Trace Organic Gas Analyzer: E. Apel (NCAR) and D. Riemer (U. Miami), R. Hornbrook, A. Hills (NCAR)

Daily Science Team meetings

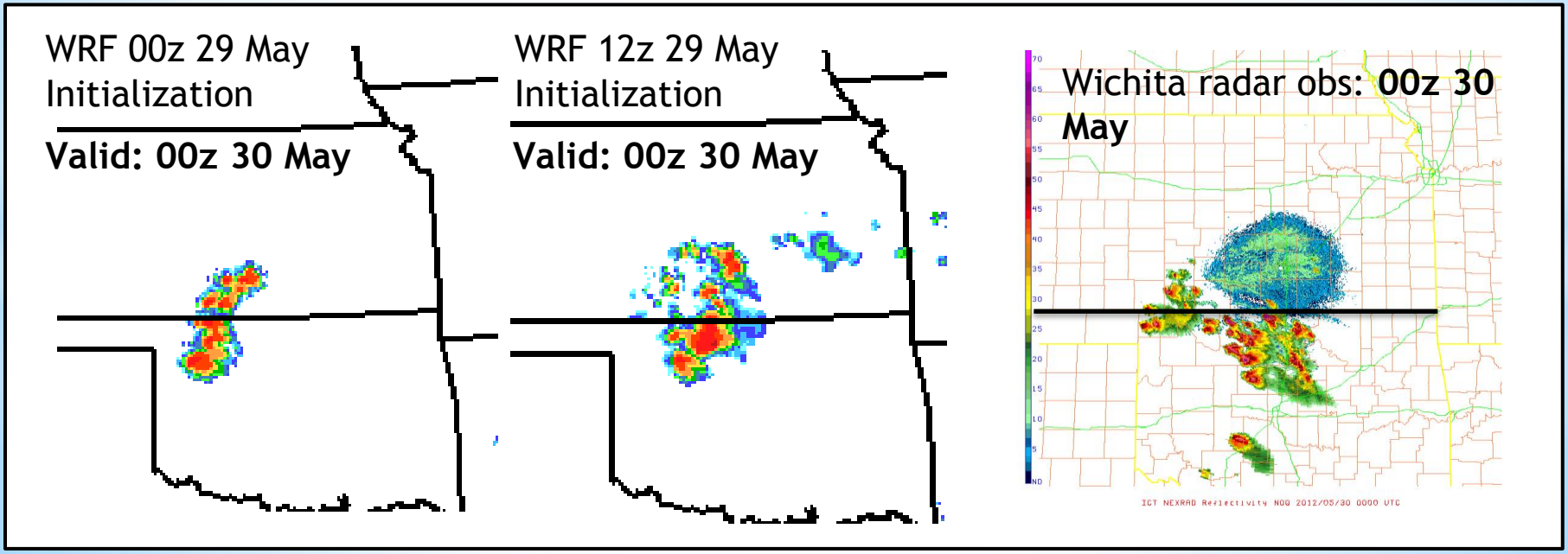
weather forecasts (overview & regional) – included WRF 3-4 km simulations twice/day

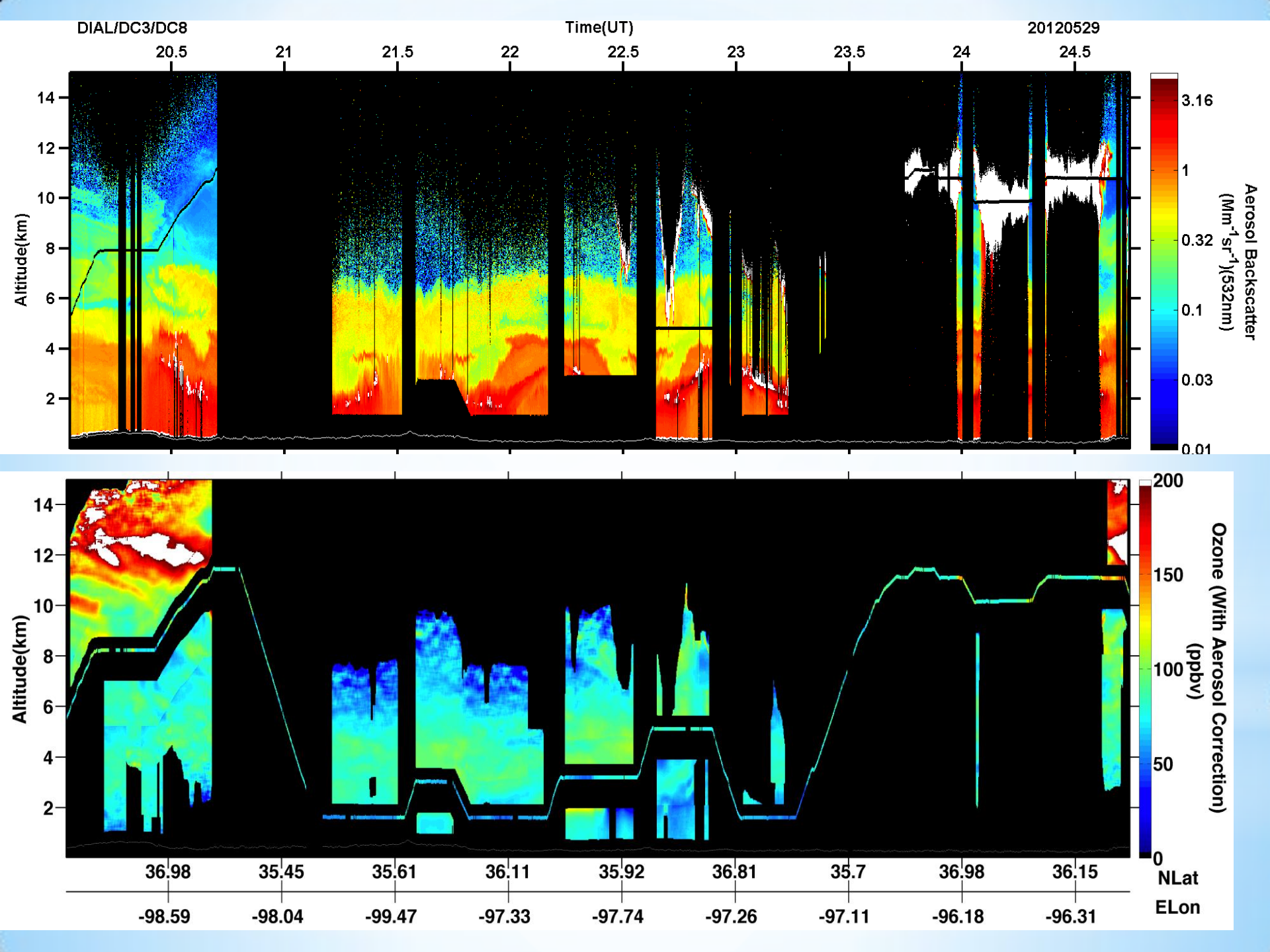
tracer forecasts

platform readiness

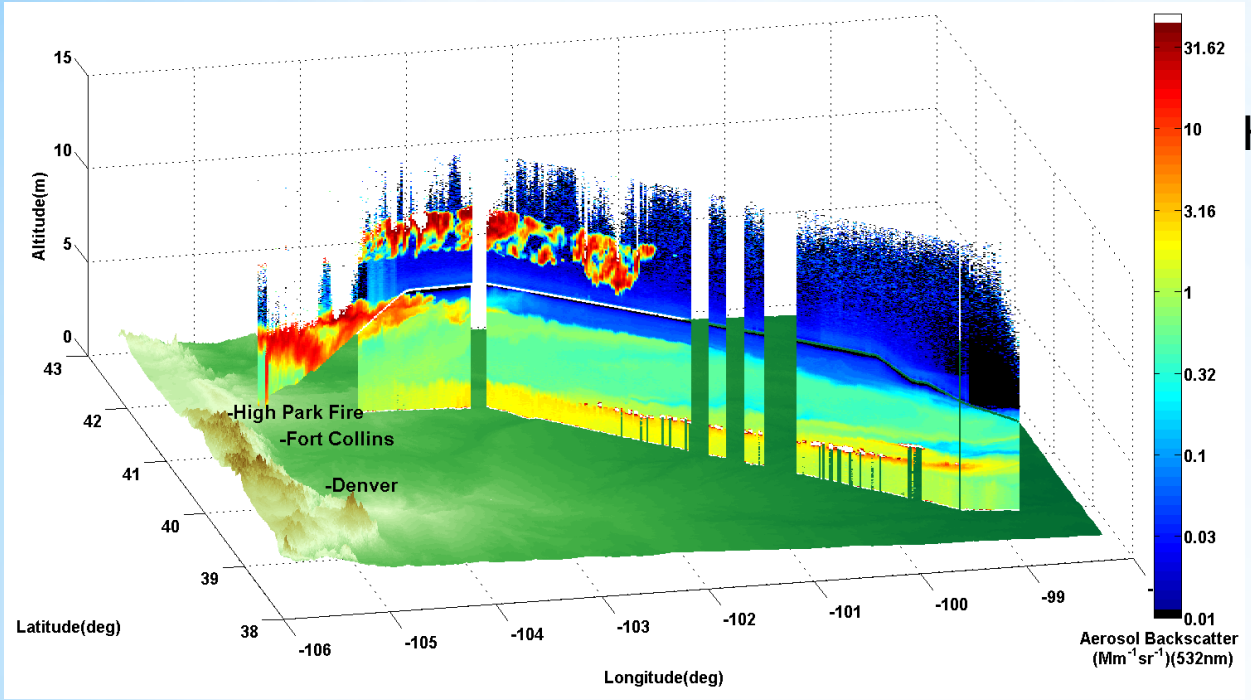
instrument readiness

Decision on whether to fly, type of flights, locations of flights



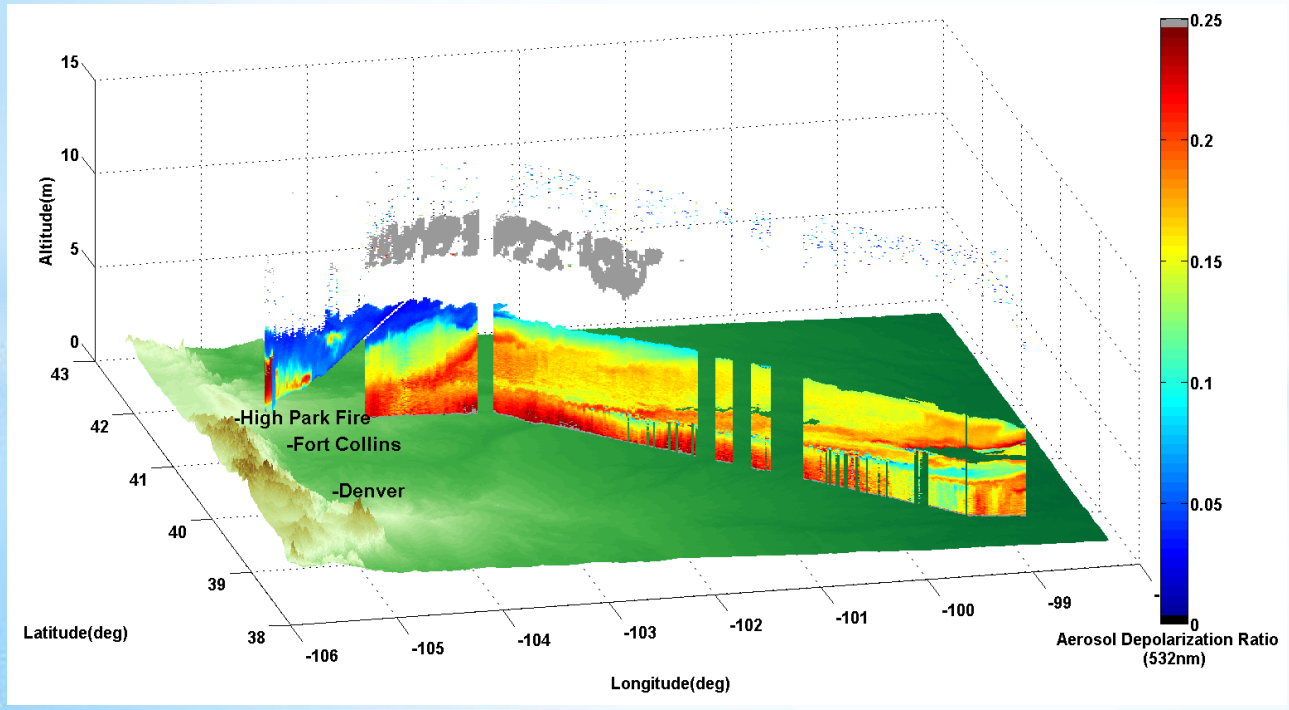

DIAL/DC3/DC8
Time(UT)
20120529
20.5
21
21.5
22
22.5
23
23.5
24
24.5
Altitude(km)
14
12
10
8
6
4
2
3.16
1
0.32
0.1
0.03
0.01
Aerosol Backscatter (Mm-1sr-1)(532nm)
Altitude(km)
200
150
100
50
0
Ozone (With Aerosol Correction) (ppbv)
36.98
35.45
35.61
36.11
35.92
36.81
35.7
36.98
36.15
NLat
-98.59
-98.04
-99.47
-97.33
-97.74
-97.26
-97.11
-96.18
-96.31
ELon

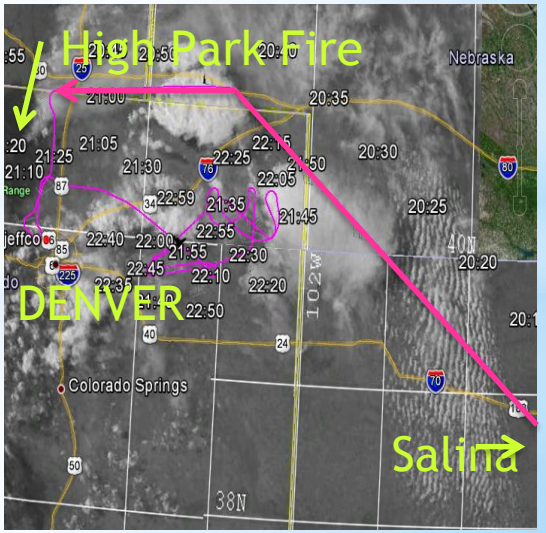
June 22
High Park Fire & Colorado Convective Storm



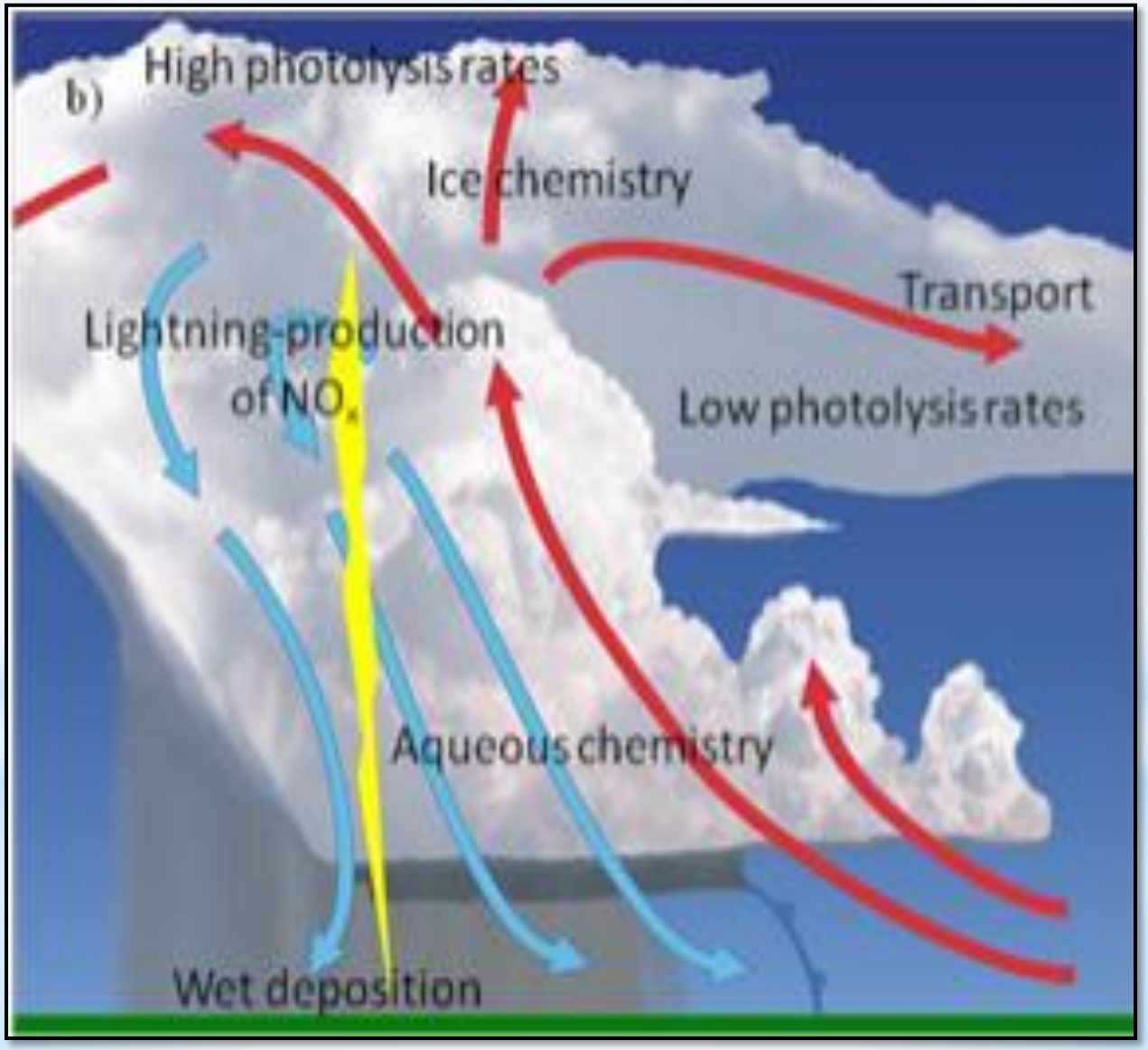
Fire Plume

- extinction range: 300 to >1000 Mm^{-1}
- Large contrast in the aerosol depolarization within smoke plume and regional aerosols (dust and urban)





DC3 Storm Studies – Transport, Scavenging & Chemistry



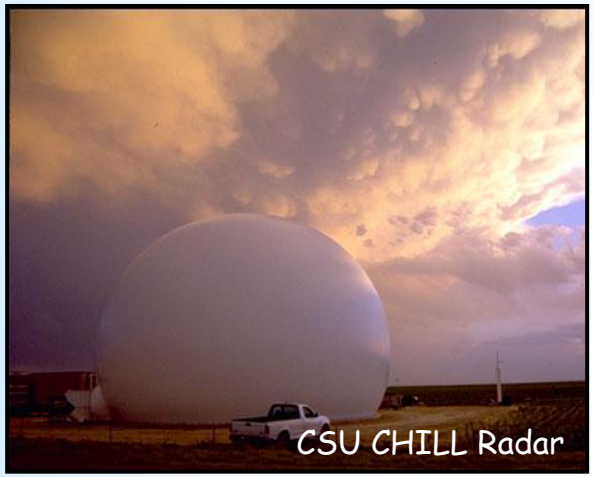
DC3 Ground Facilities – Cloud Characterization

At each of the three study regions:

RADAR: Fixed and mobile multi-Doppler polarimetric radars

LMA networks: used to derive lightning properties

Sondes: pre-storm and storm penetrating profiles


CSU CHILL Radar


UA-H ARMOR Radar


NMT Lightning Antenna


OU SMART Radar


Weather Balloon Launch

DC3 Schedule and Summary

- DC3 was a highly successful campaign to study the impacts of storms on UT composition
- DC3 Dataset:
  - Extensive: aircraft, radar, lightning, soundings, models, & satellite products
  - Address the goals and hypotheses of DC3 and other related scientific questions
  - Apply that knowledge to weather and climate models
- DC3 data will be made public in July 2013