NOAA Twin Otter

California 2010
Description and Research Plans

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Twin Otter General Description

- Operates as a remote sensing aircraft for studying the boundary layer
- Estimated flight altitude: 12000 – 18000 ft ASL
- Primary instrument: Downward-looking Ozone and aerosol lidar
- Potential additional instrument if proposal is funded: Airborne Multi-Axes Differential Optical Absorption Spectroscopy (AMAX-DOAS) Instrument
- Potential instrument but unlikely (no funding): Doppler lidar
- Twin Otter typical operating parameters
  - Speed: 65 m s^{-1}
  - Endurance 4 – 6 hours

Twin Otter Science Questions for 2010

- What is the 3-dimensional distribution of ozone and aerosol over different regions of California and how does it vary under different atmospheric conditions?
- What is the flow of ozone and aerosol between different regions of the state, and how does it vary?
- What is the role of up and downslope flows in the ventilation and recirculation of pollution between mountain regions and the Central Valley
- To what extent are pollutants lofted into the free atmosphere from the boundary layer?
- What happens to pollutants at night when the atmosphere becomes more stable?
- What is the role of the nocturnal low level jet in redistributing pollutants
- How well do models represent the transport and redistribution of ozone and aerosol?
- How much ozone and aerosol is imported into and exported from California?

Ozone Lidar Characteristics

TOPAZ specs:

- 3 channels (285 – 310 nm, tunable)
- Pulse energy: 0.2 to 0.4 mJ
- Rep rate: 1 kHz
- Nadir-looking

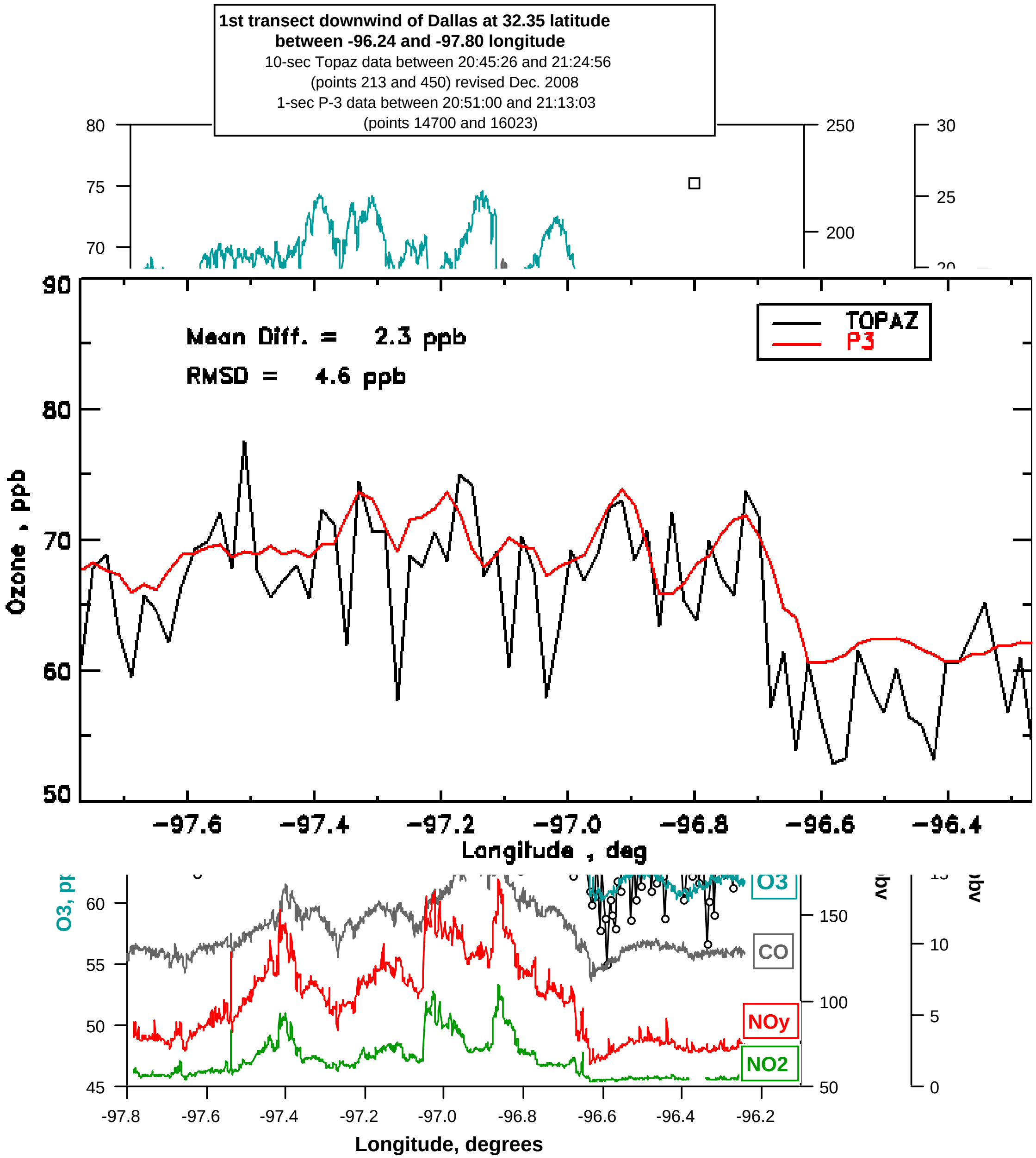
TOPAZ measurements:

- Ozone & aerosol backscatter profiles
- Range: ~ 300 m to ~ 4 km
- Altitude: surface up to 5 km
- Resolution: 10 s or 650 m horizontal,
  90 m (smoothed) vertical (O3),
  6 m (aerosol) vertical
- Precision: 3 – 15 ppb

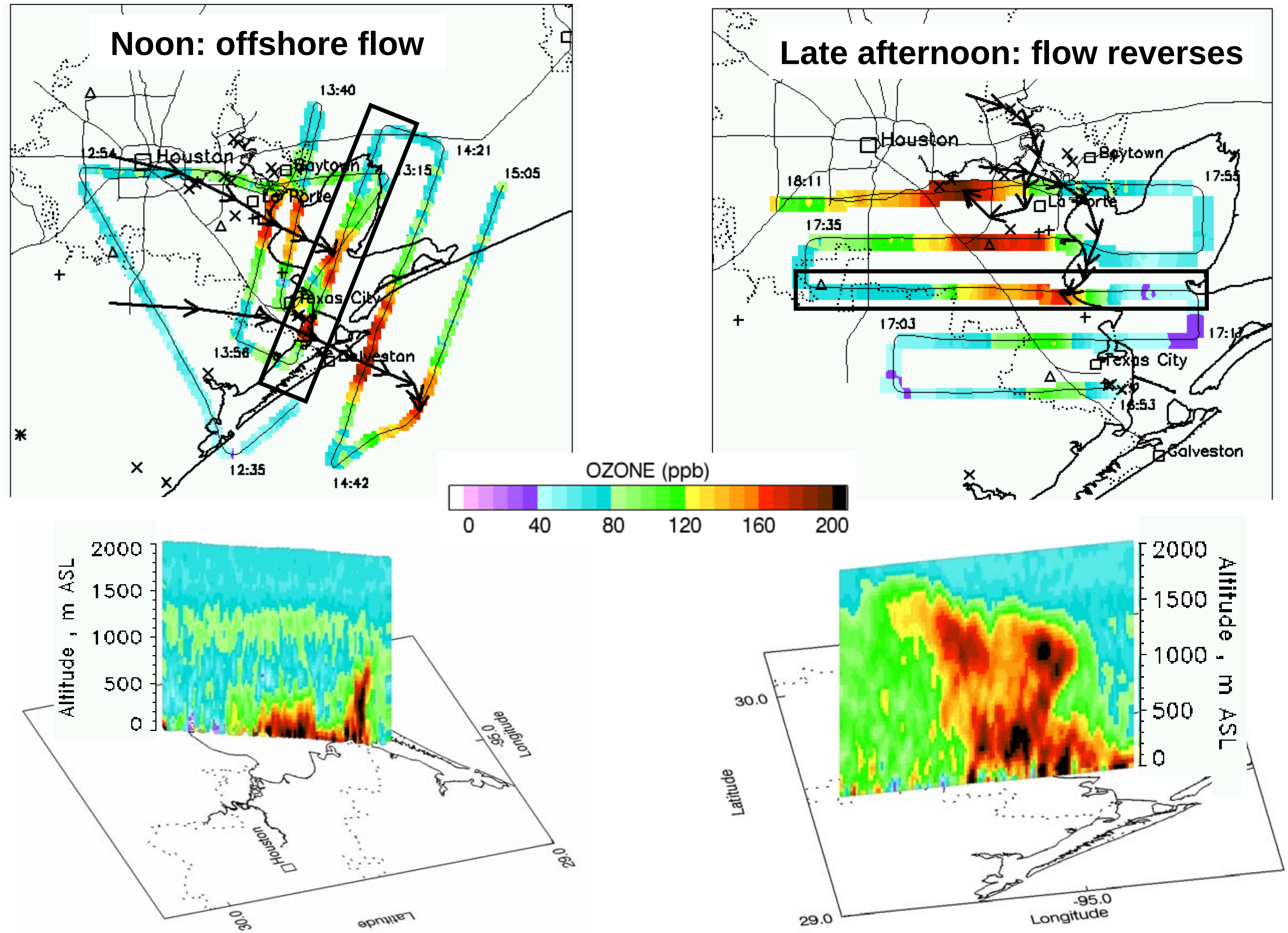
Recent improvements:

- No in-air warm-up time needed, higher reliability
- Ability to operate at 18000 ft for flights over mountainous terrain

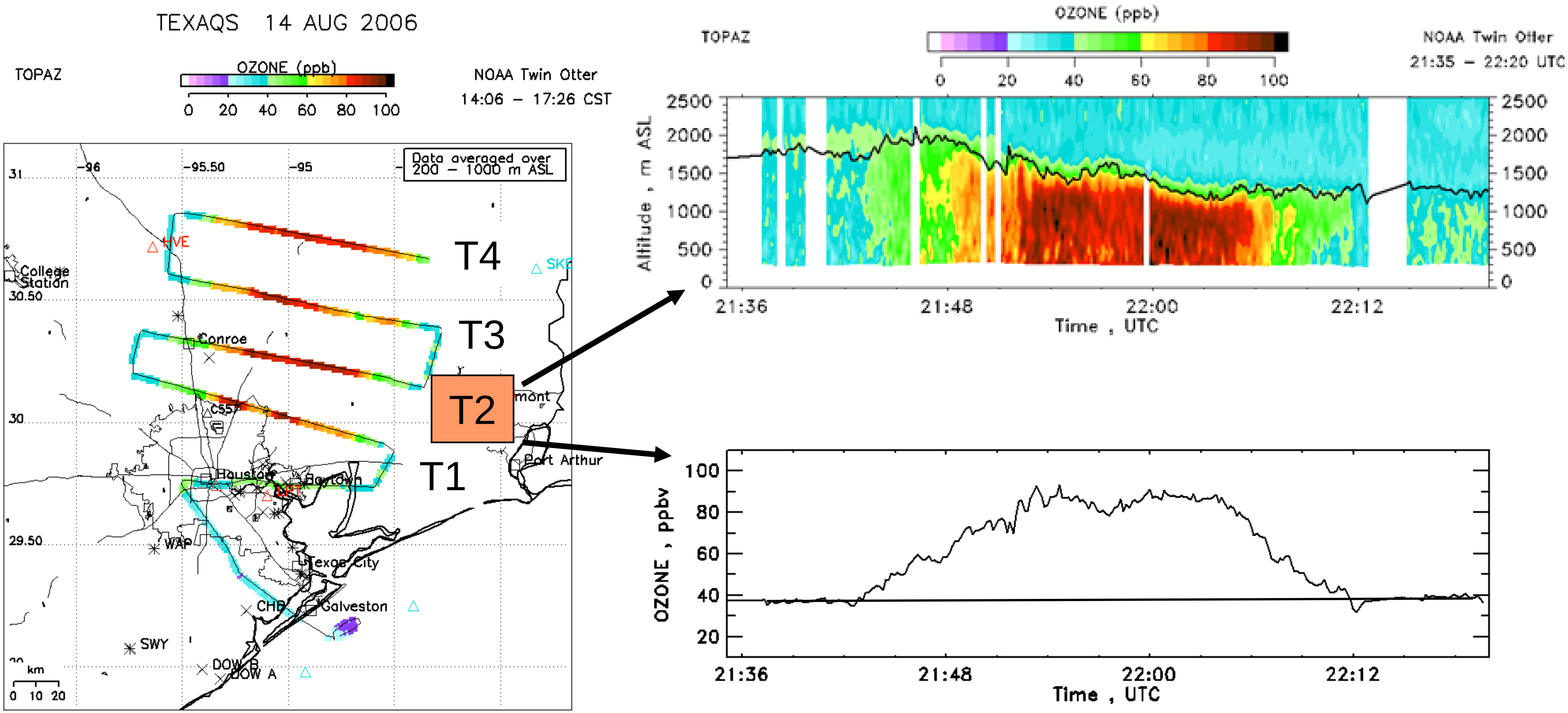
Comparison: Twin Otter Lidar with P-3 in situ sensor



Local Transport:
Houston land-sea breeze recirculation

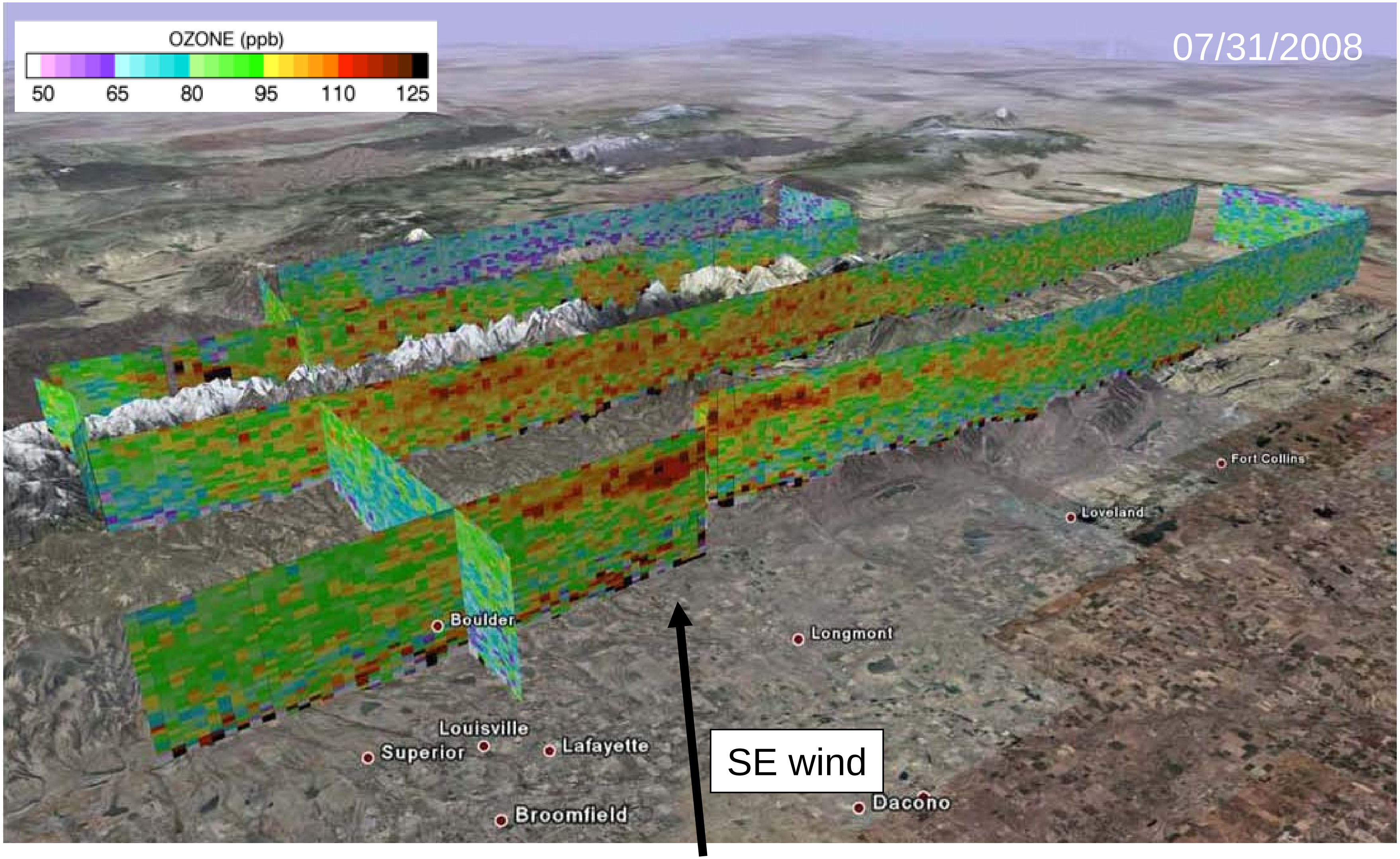


Measuring ozone transport

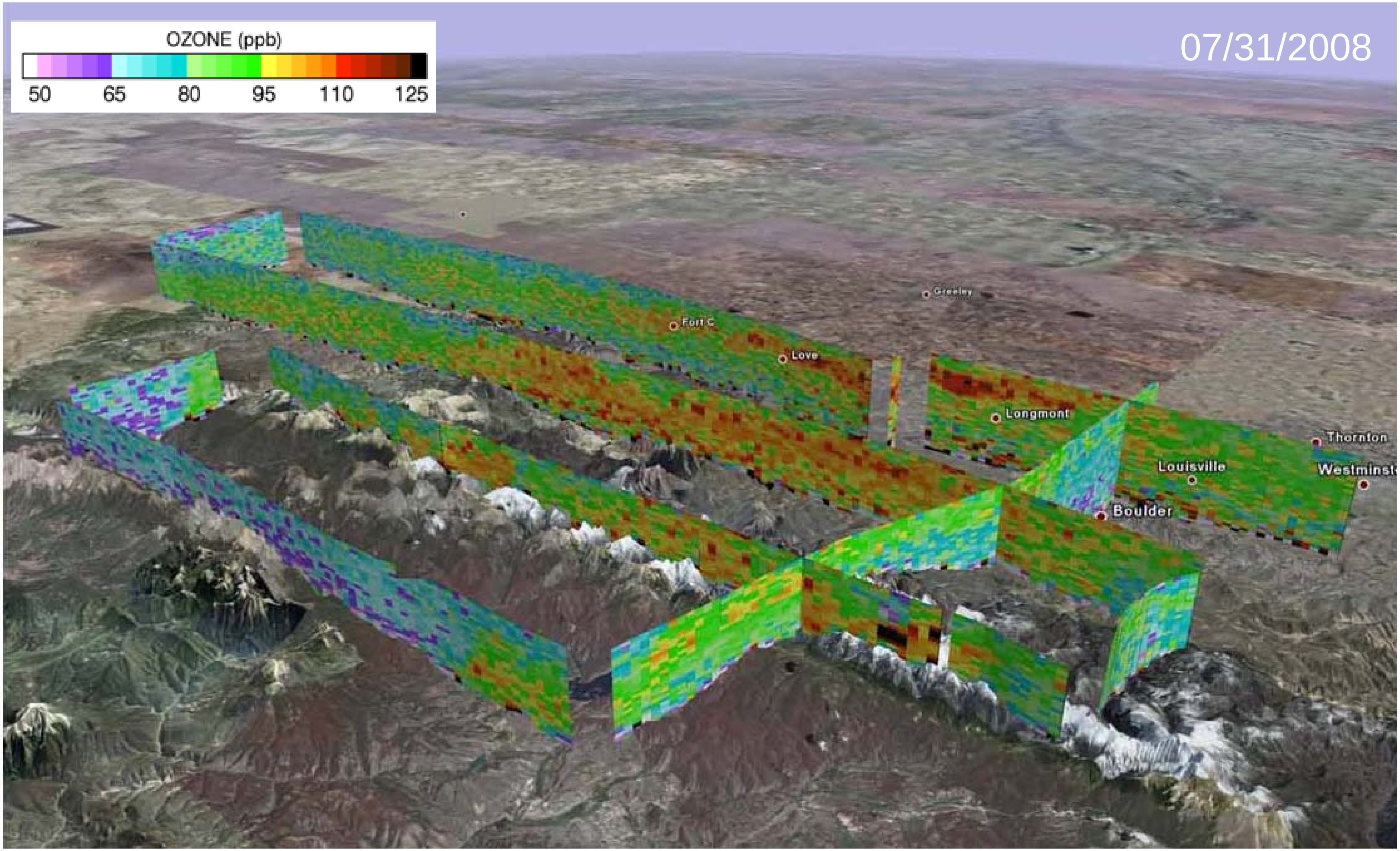


- Integrate excess ozone in plume (plume O_3 – background O_3) between surface and top of boundary layer and between horizontal plume edges.
- Multiply with horizontal wind speed (from wind profiler network) to yield flux in molecules O_3 / sec for each transect.
- Angle between flight transect and plume is taken into account.

Front Range Air Quality Study 2008: Transport of O_3 into and over the mountains (1)



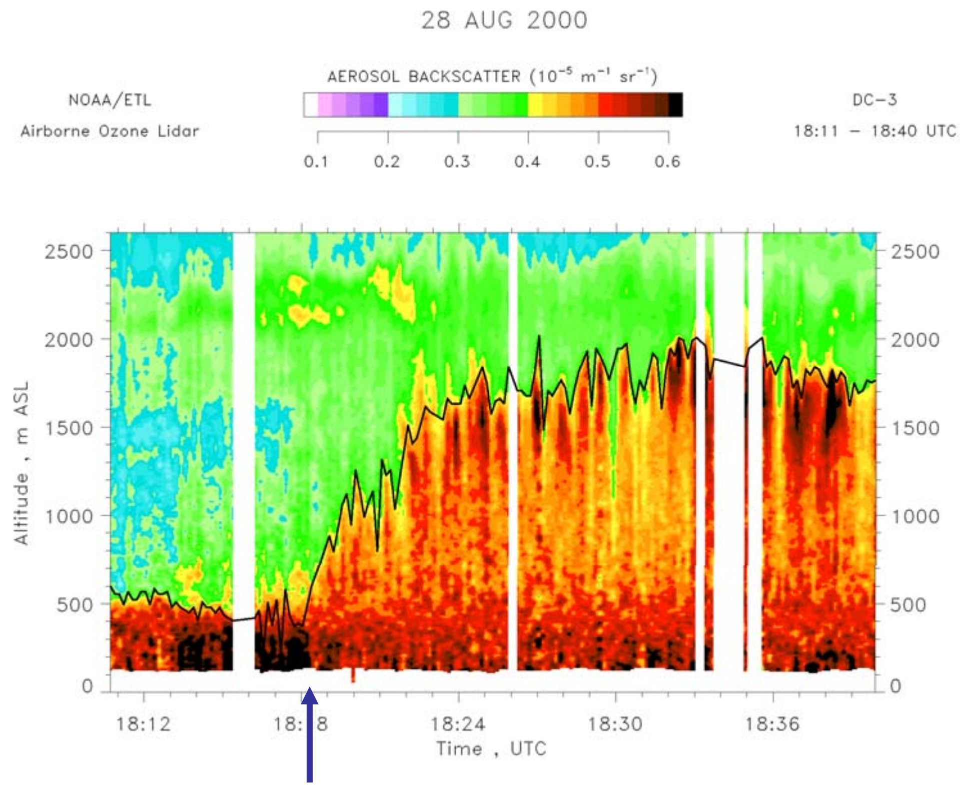
Front Range Air Quality Study 2008: Transport of O_3 into and over the mountains (2)



Aerosol structure and mixing layer height

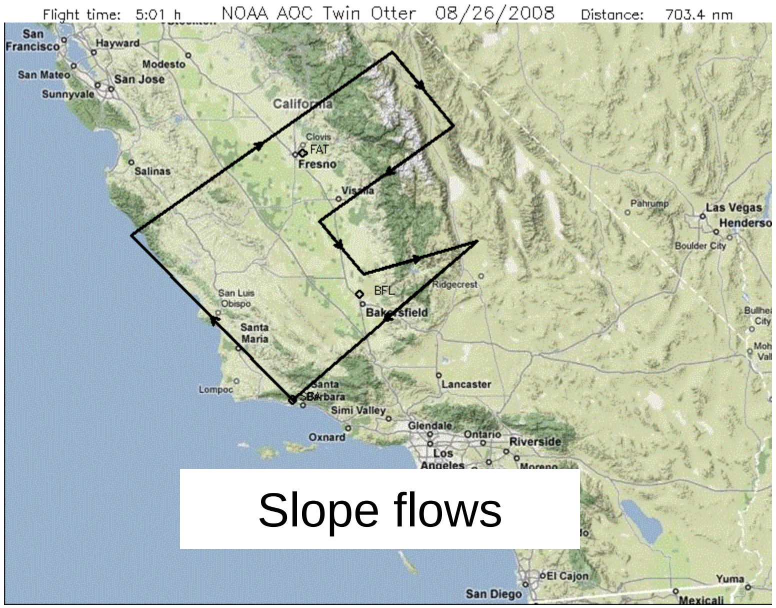
- In addition to ozone, lidar returns are used to compute aerosol backscatter coefficient.
- Mixing layer height can be estimated in most cases from the gradient in aerosol backscatter
- Lidar provides a continuous estimate of mixing layer height below the aircraft

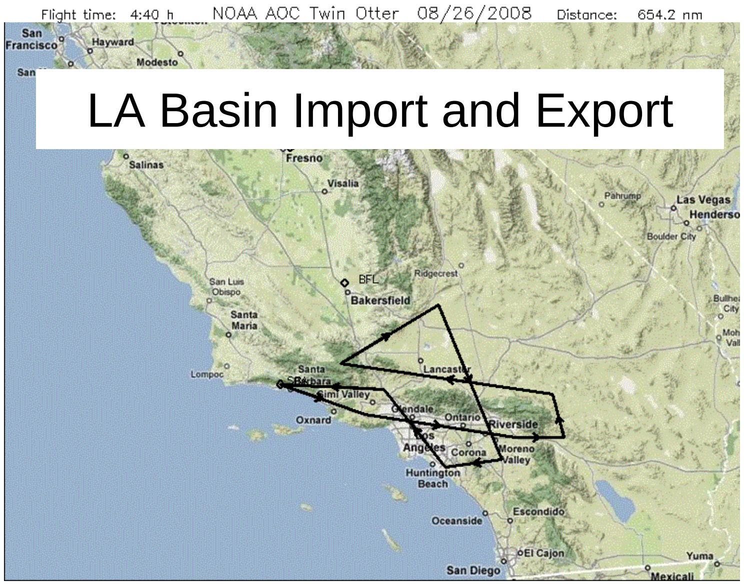
Mixing height retrieval from airborne lidar data

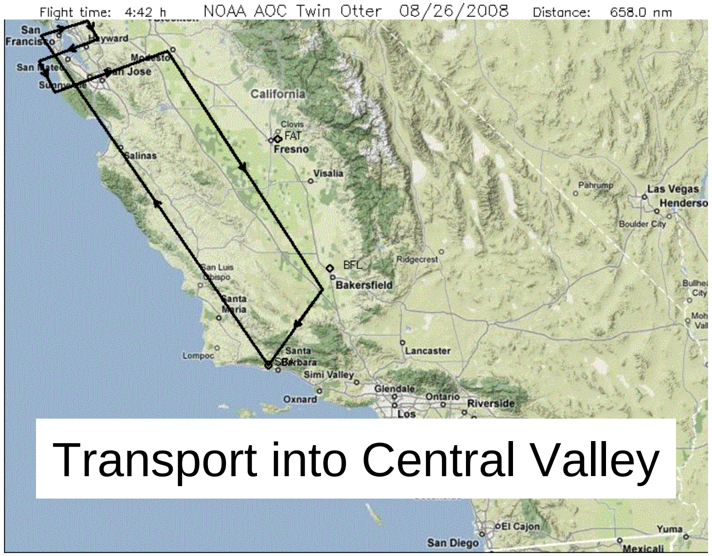


Shoreline of Galveston Bay

Twin Otter 4-hour Flight Scenarios







CU AMAX-DOAS – principle and instrument

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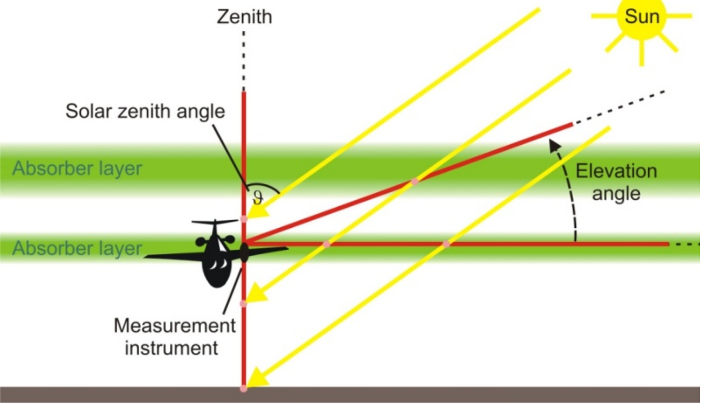
Bold: **Gases were detected during validation flights (summer 2008)**

Brackets: Indicate new potential (recently added capabilities)

PBL: **NO_2, CHOCHO, O_4** (SO_2, HCHO, HONO, BrO , IO, OIO, I_2)

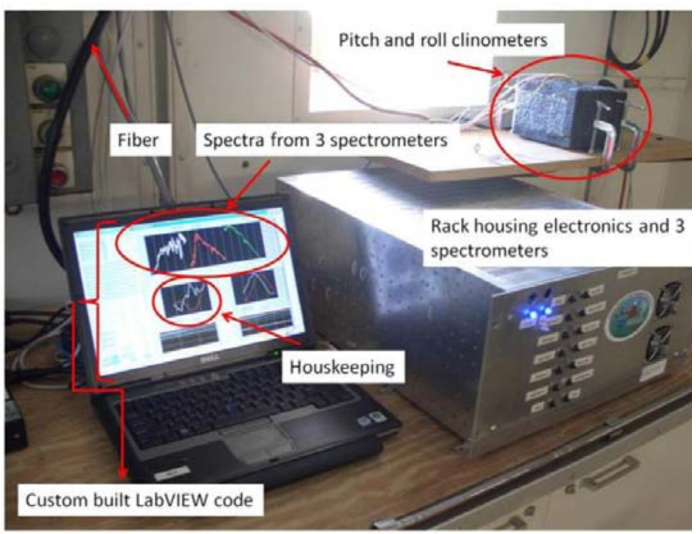
FT/UTLS: **NO_2 , O_4** (SO_2, HCHO, HONO, CHOCHO, OClO, BrO, OBrO, IO, OIO, I_2)



Successful test flights during summer 2008 !

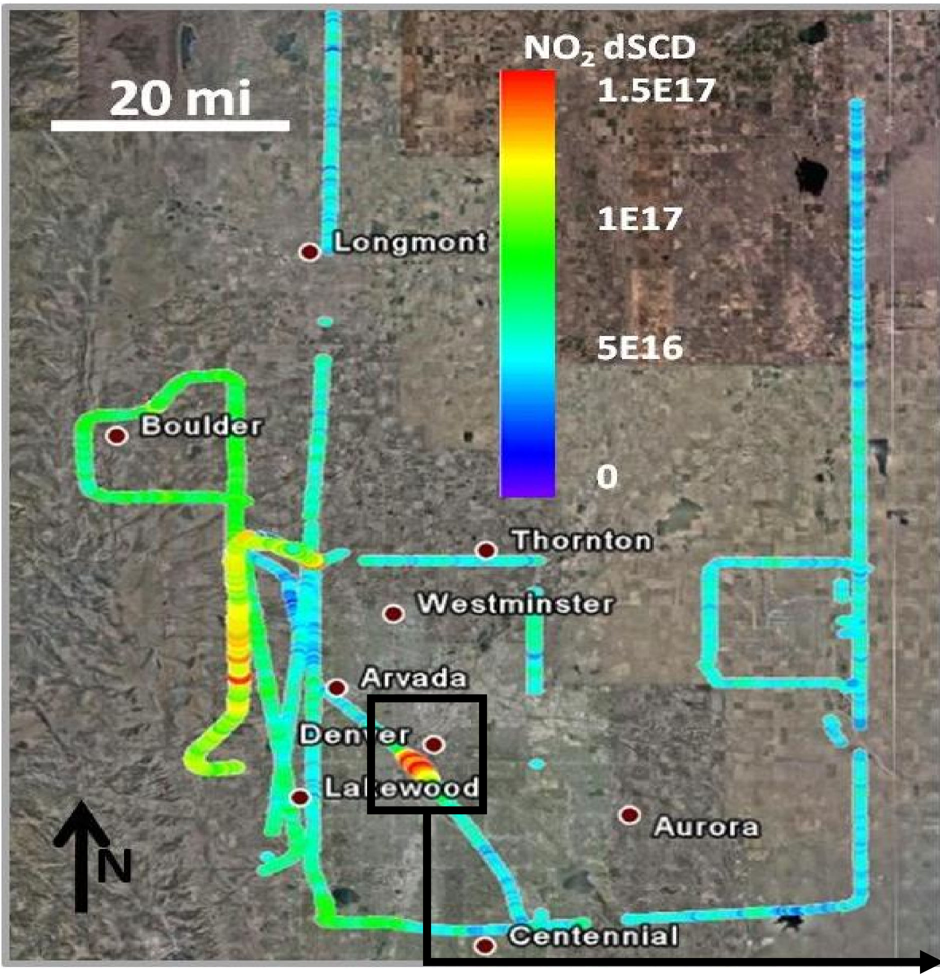
Further flights are planned for 2009

Objective: a mature (validated) instrument is available for CalNex 2010; the deployment in California is pending funding

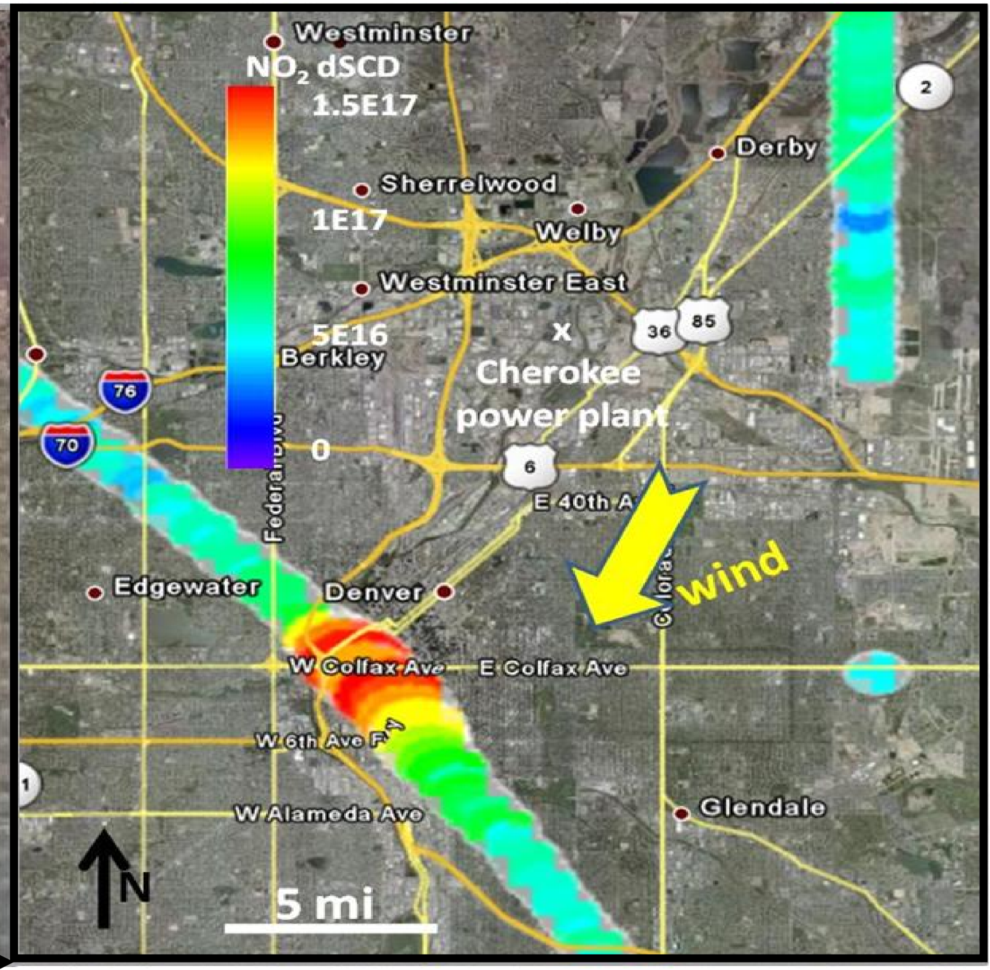


Flight #8, Aug 6, 2008

NO_2 slant column density below aircraft
NADIR telescope, QE65000 spectrometer #2, 5 sec data



NO_2 enhancements downwind of Denver / over foothills

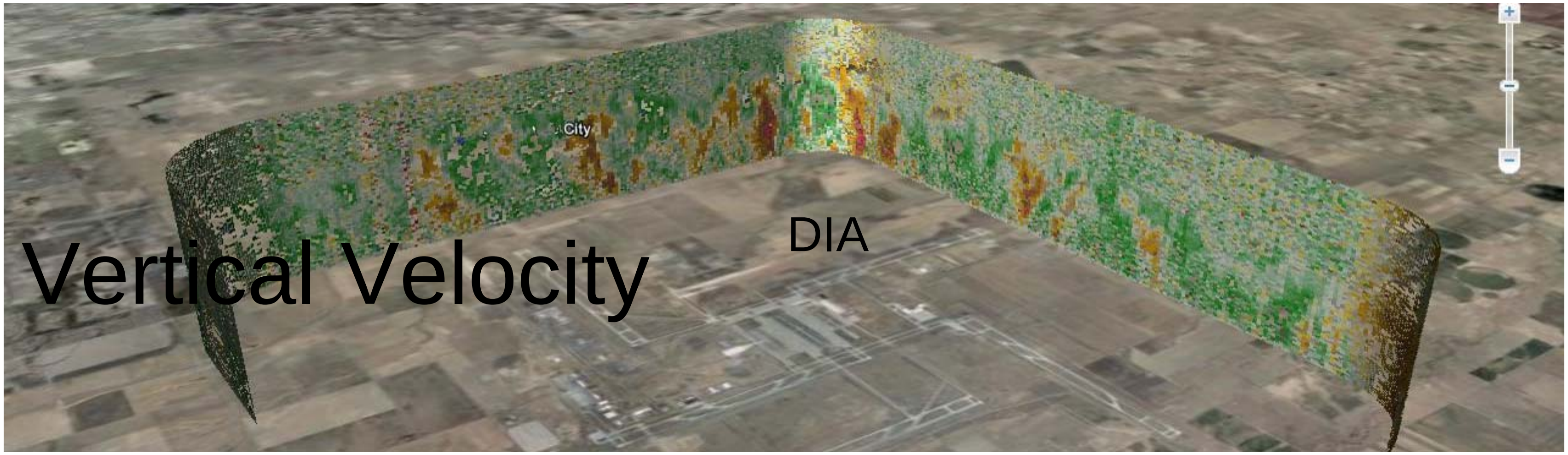


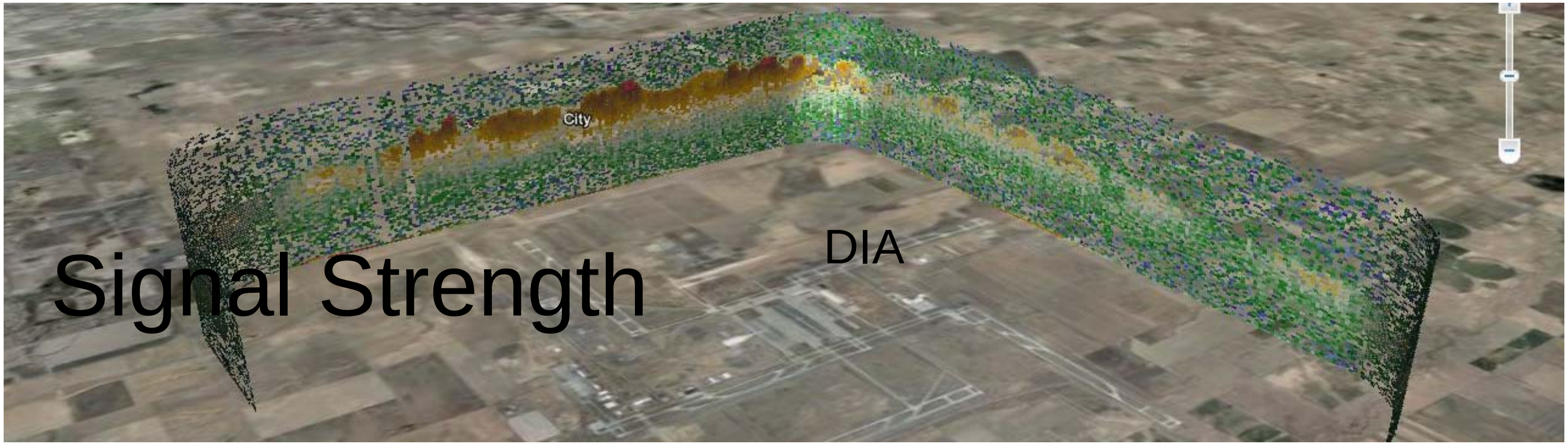
Expanded inset (from the left): NO_2 plume downwind of the Cherokee power plant

AMAX-DOAS Science goals for CalNex 2010

- Enable the use of validated satellite data for use for the management of air resources:
  - Validate satellite retrievals by constraining aerosol effects on the radiation field, and measuring the same observables
  - Bridge spatial scale between satellites, ground based observations (super sites) and models by direct observations of trace gas columns
- Exploit synergies between AMAX-DOAS and LIDAR:
  - AOD observations by AMAX-DOAS at multiple wavelengths
  - Constrain the effect of light absorbing organic aerosol (other then BC)
  - Calibrate relative aerosol extinction vertical profiles by LIDAR
  - Refined air mass factor retrievals for use with satellite validation
  - Constrain O_x ($O_x = NO_2 + O_3$)
- Map out the horizontal and vertical distribution of NO_2, HCHO, CHOCHO (and indicator for SOA formation) to learn about sources, transport, and transformations

Airborne Doppler Lidar Measurement of Wind Profiles



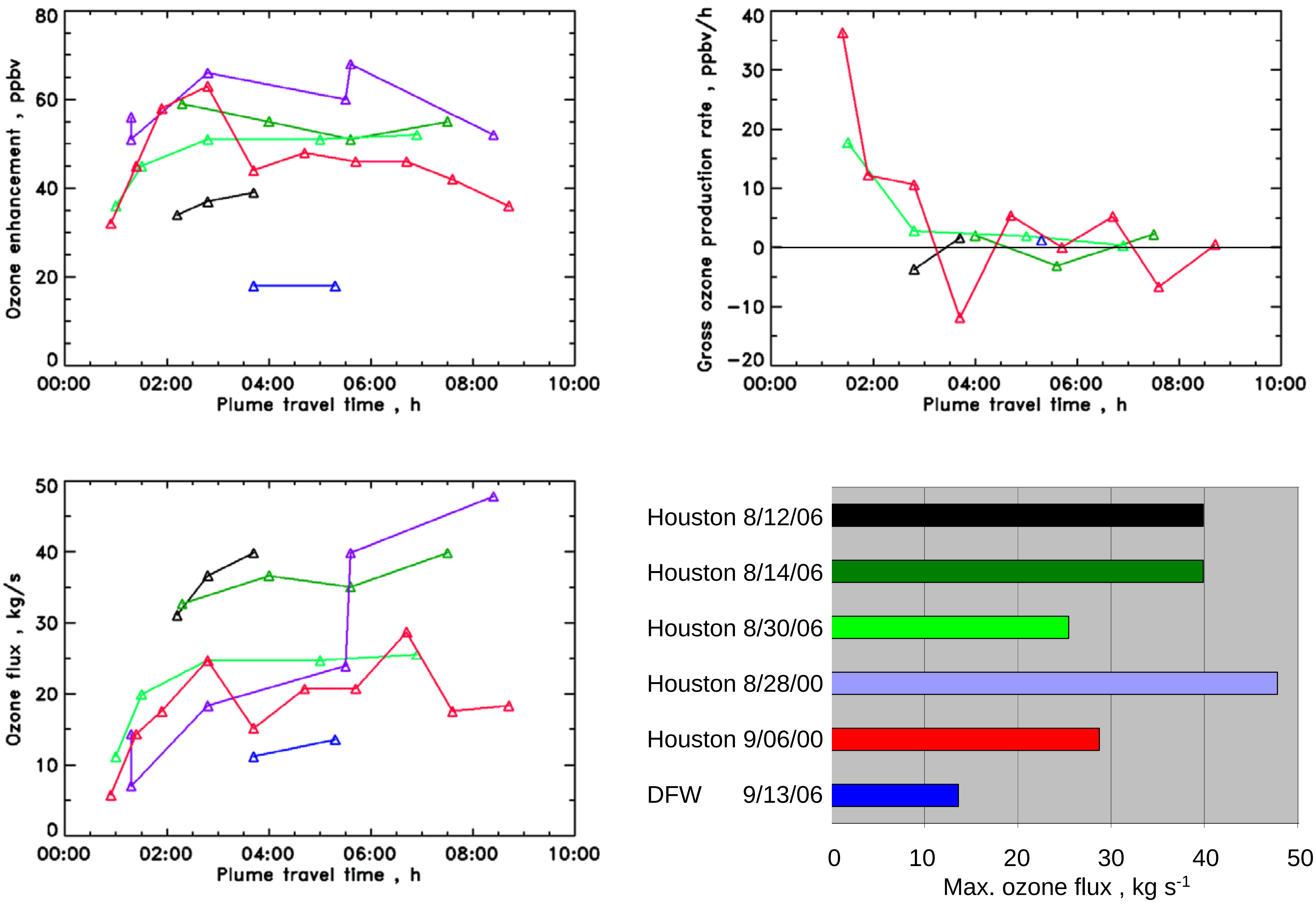


Courtesy Sara Tucker and Alan Brewer

Twin Otter Deployment Scenarios

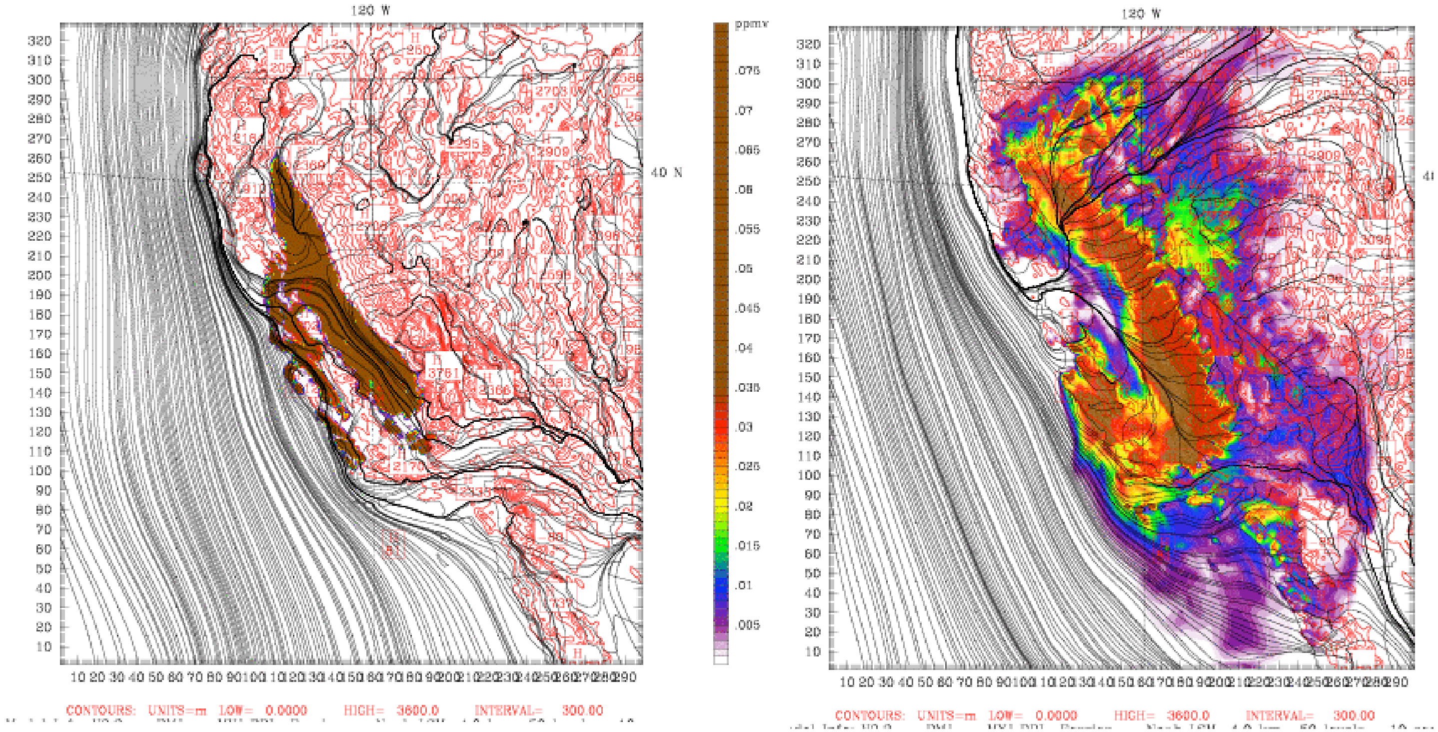
- Anticipate approximately 120 flight hours, 6 week deployment (dependent on funding)
- Proposed scenarios:
  - Maximum overlap with the P-3 and CSD modeling effort (May 1 through June 15) *Preferred*
  - Partial overlap with the P-3, more overlap with Ron Brown, and more measurements in the high pollution season (May 15 – July 1)
  - Split deployment (May 15 – June 15, July 1 – July 15)
- Availability of the aircraft is not certain, but typically we can get it if we request in early in 2009 – request is in
- No feedback from NOAA Aircraft Operations Center on the feasibility of a split deployment

Horizontal ozone flux and ozone production



Model Validation

WRF/Chem Passive Tracer Model Run



1200 UTC, 29 July 2000

33 Hours later