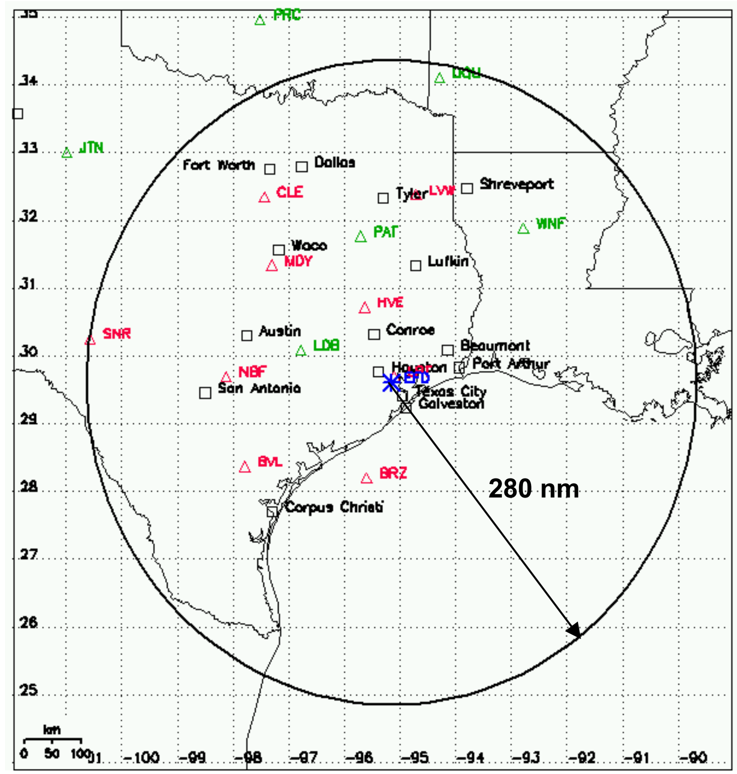
NOAA AOC Twin Otter N46RF

Aircraft specs (without auxiliary fuel tank):

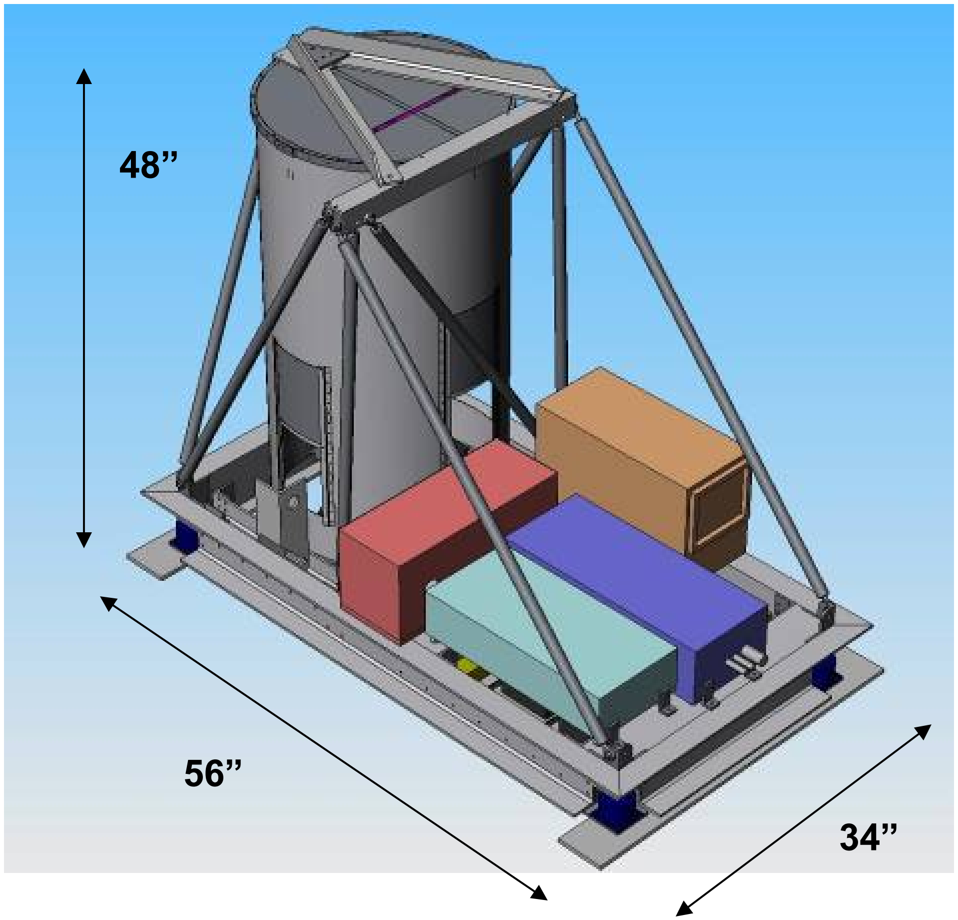
- Airspeed: 130 kts
- Endurance: 4.5 h
- Range: 560 nm
- Ceiling: 12,500 feet; 25,000 feet (w/O2)
- Useful load (personnel, cargo): 1900 lbs
- Overwater capability

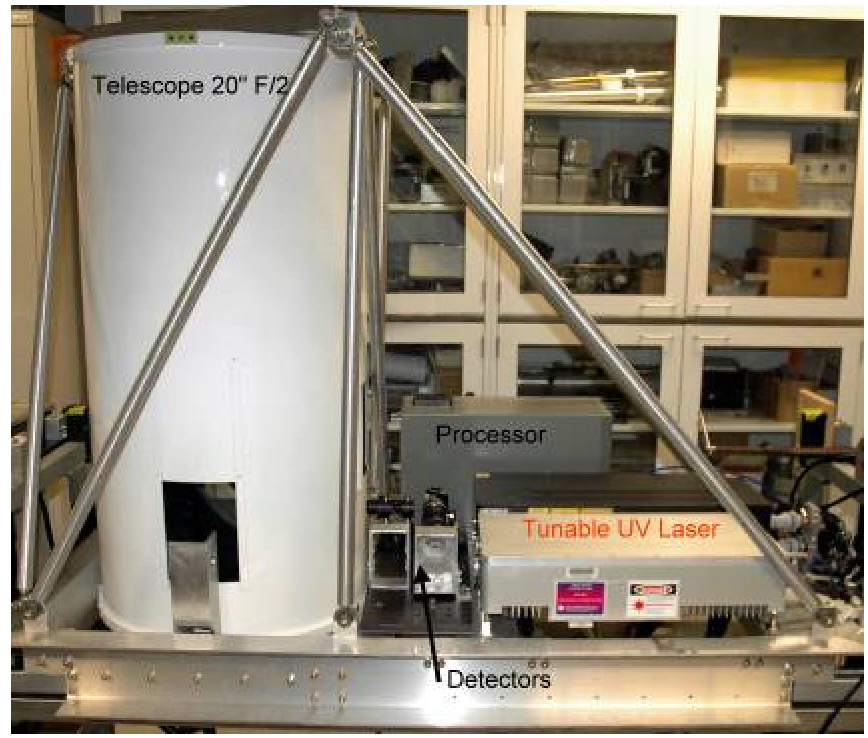


TexAQS 2006 deployment

- 130 flight hours
- 1 Aug – 15 Sep
- Max crew duty: 16 h / day
- Max flight time: 12 h / day
- Rest period between flight days: 12 h

TOPAZ (Tunable Optical Profiler for Aerosol and oZone)

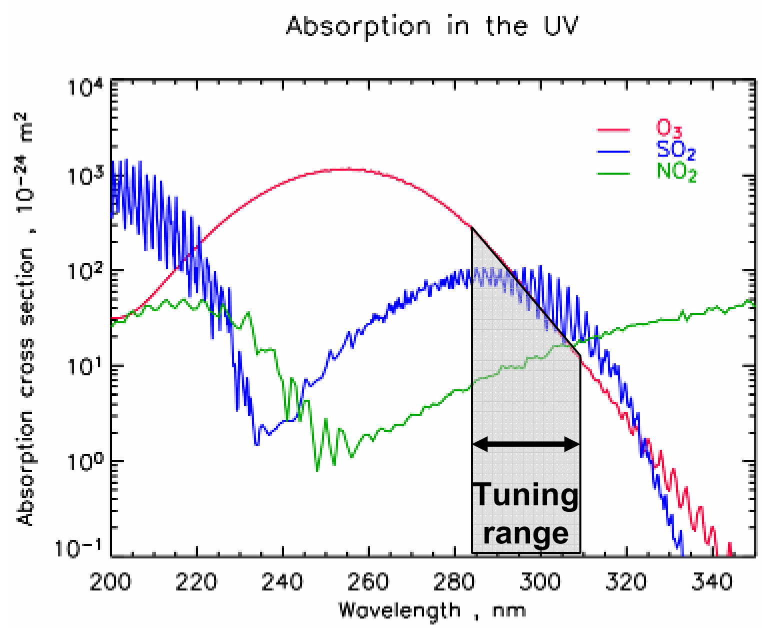




Weight (incl. computer & electronics racks): ~ 650 lbs.

TOPAZ specs:

- 3 channels (284 – 310 nm, tunable)
- Pulse energy: 0.1 to 0.4 mJ
- Rep rate: 1 kHz
- Nadir-looking



TOPAZ measurements:

- Ozone & aerosol backscatter profiles
- Altitude: surface up to 3.5 km
- Resolution: 10 s or 650 m horizontal,
  100 m vertical (O3), 6 m (aerosol)
- Expected precision: 3 – 15 ppb (highest near surface)

New features:

- Tunability → chose optimal wavelengths for given ozone loading
- Dual-DIAL → use 2 DIAL pairs to minimize uncertainties due to differential aerosol backscatter & extinction
- Use ground return over water to calibrate aerosol retrieval
- SO2 measurements? (future, not in 2006)

Ancillary measurement capabilities on NOAA Twin Otter

- Infrared radiometer for surface skin temperature
- In situ ozone, temperature, and pressure
- Drop sondes (50 sondes = $30k; currently not in budget)
- Nadir-looking camera
- Pursue improved ground communication and data upload/download

TOPAZ Timeline

- System test in lab: now - 5/1
- Test flights in Boulder: 5/2 - 5/19
- Final testing before TexAQS 2006: 5/20 – 7/20
- System installation in NOAA Twin Otter: 7/21 – 7/31
- TexAQS 2006 deploy: 8/1 – 9/15

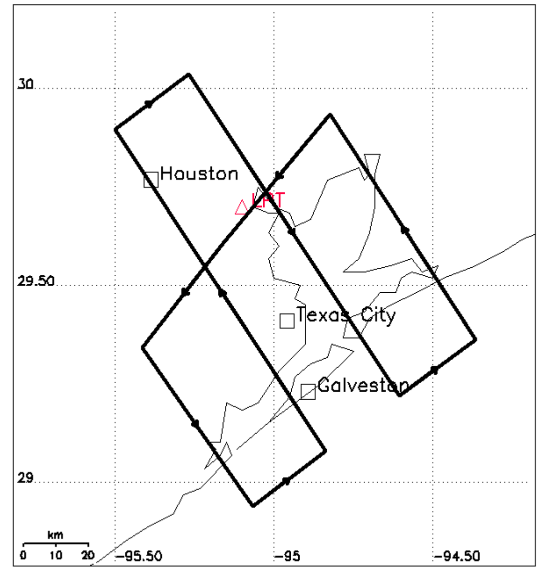
Temporal and spatial variability of PBL depth

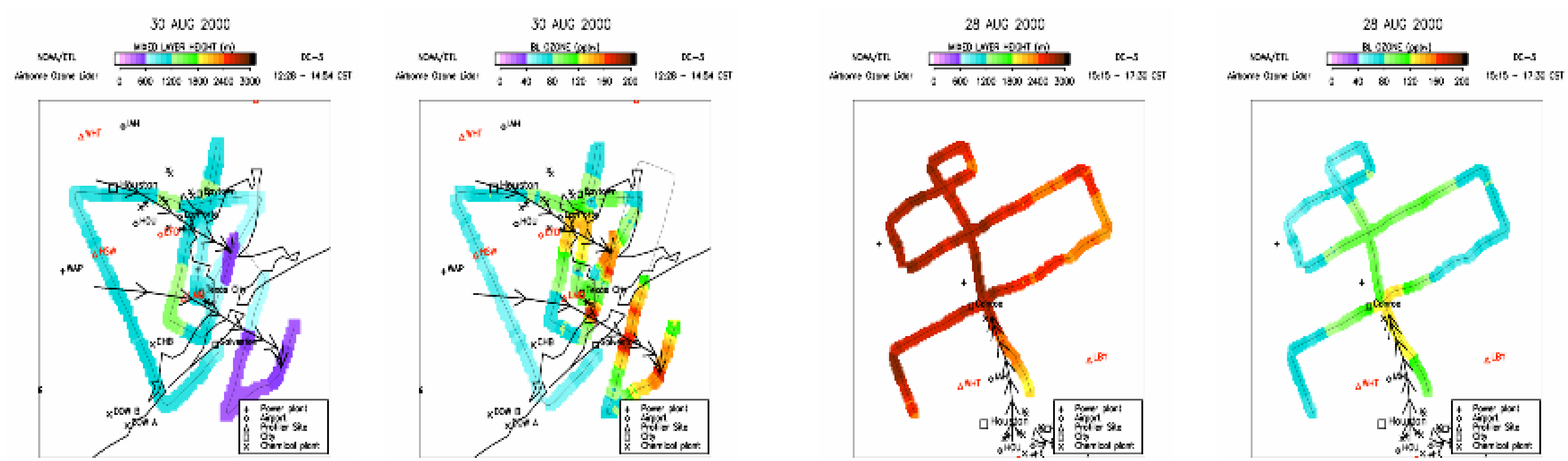
Objective: Quantify the effect of mixing height on pollutant levels. Focus on mixing height variability over Galveston Bay, coastal areas, near sea breeze front, Houston urban heat island.

Measurements: TOPAZ, Ron Brown ozone and Doppler lidar, wind profiler network, drop sondes, radio sondes, surface skin temperature, profile measurements from other aircraft, ACARS

Meteorological conditions: Mostly clear conditions (no or few low level clouds). Any flow direction. Stagnant conditions for urban heat island objective.

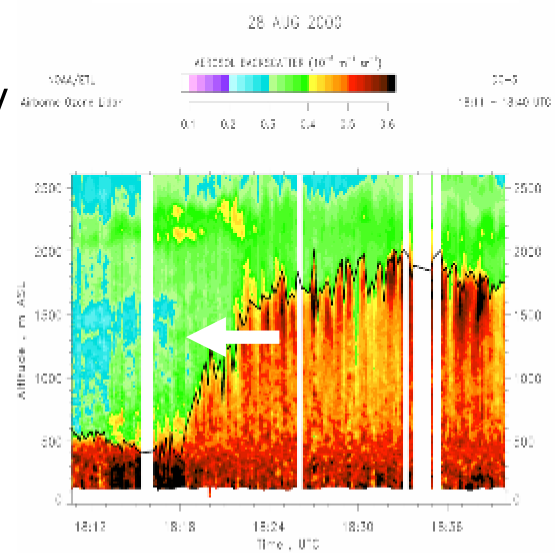
TOPAZ flight plan (~2h)





Detrainment of Pollutants to the free troposphere

Gulf of Mexico coast

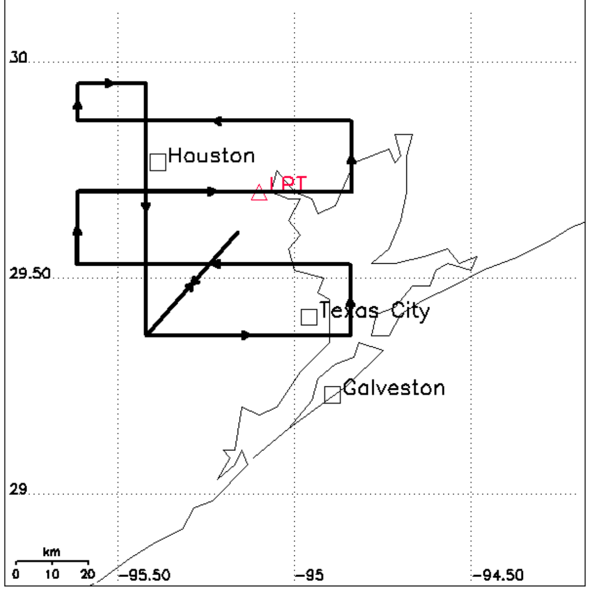


<u>Objective</u>: Assess the importance of detrainment of boundary layer pollutants. Is this a significant loss mechanism?

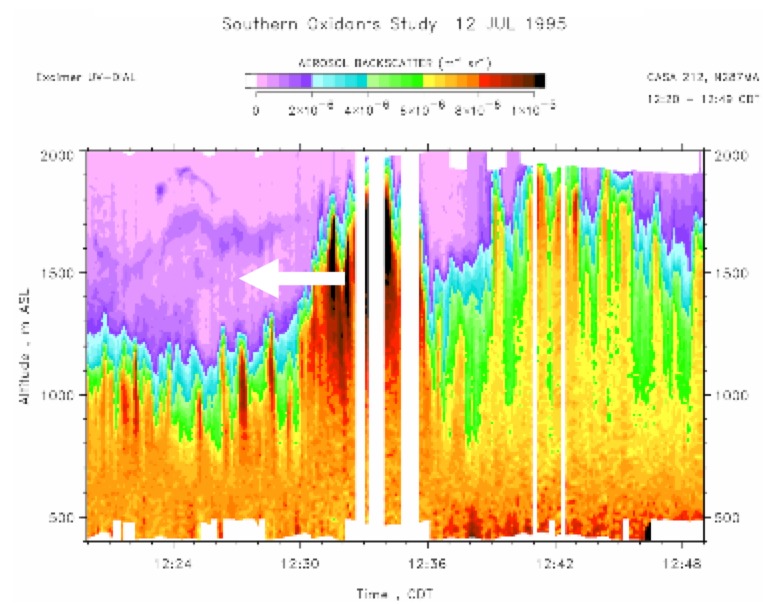
<u>Measurements</u>: TOPAZ, OPAL, Doppler lidar, wind profiler network, gust probe on lidar Twin Otter (?), P3

<u>Meteorological conditions</u>: Mostly clear conditions (no or few low level clouds). Any flow direction. Stagnant conditions for detrainment near urban heat island.

TOPAZ flight plan (~2 h)



Nashville urban heat island



Validation of air quality forecast models

Objective

In combination with other data sets, TOPAZ vertical profiles of ozone and aerosol backscatter can be used to test various meteorological, chemical, and radiation transfer models for use in weather and air quality forecasting. The goal is to enhance the accuracy and extend the periods of these forecasts.

Model validation issues:

-boundary layer properties and evolution over different surfaces is a primary issue for model validation

-Any aerosol data will be useful (structure and backscatter)

-Shallow nighttime boundary layer is important

--Smaller scales are more problematic

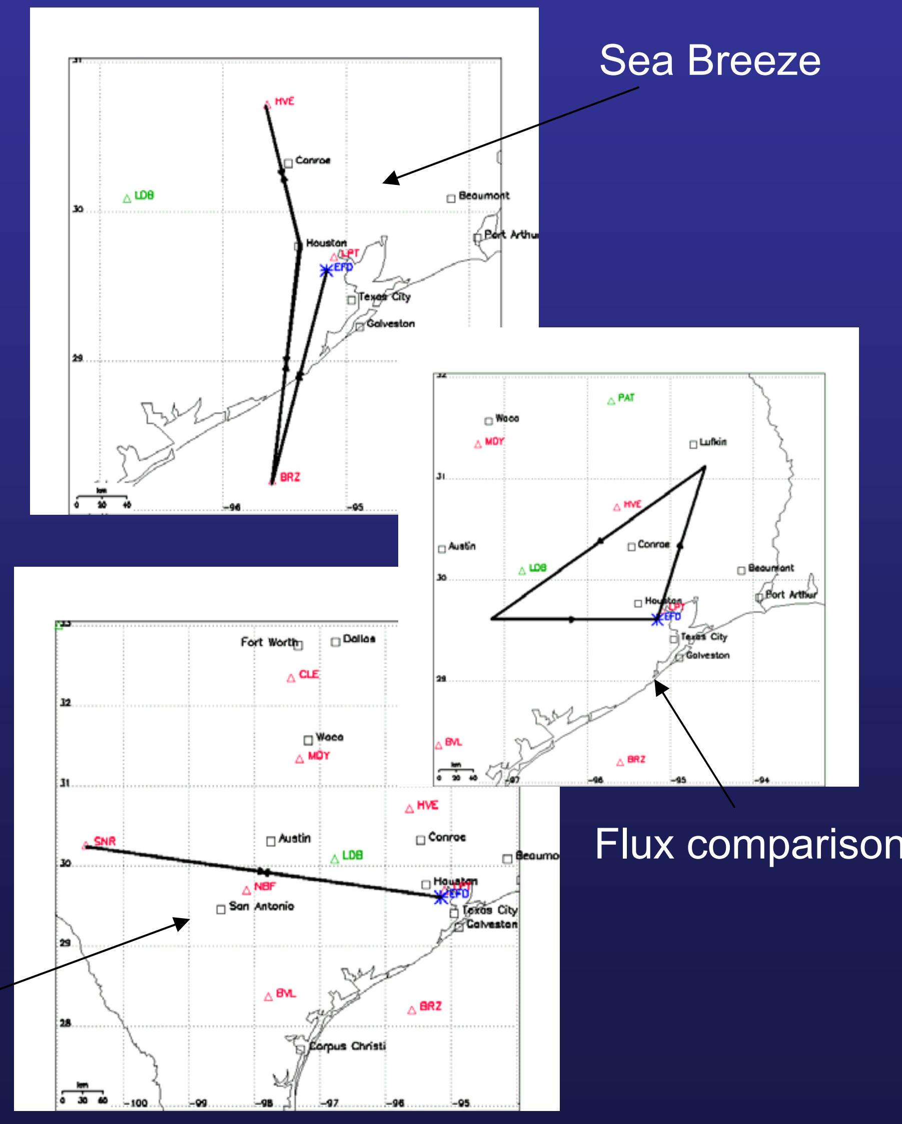
General flight criteria

- Plan routes to overpass ship, surface flux and profiler sites, and onshore ozone sonde launches.
- Preferred tracks are long, perhaps with repeated legs, to show spatial variations.

Forecast model validation

Twin Otter flight objectives

- Compare growth of boundary layer height over shore with that on land at various times of the day via long transects perpendicular to shore. Emphasize measurements over water, since meteorology over Gulf is not measured as well as that over land. Include dropsondes over water
- Examine mixing over varying vegetation with long flights parallel to shore. Try to pass over pair of surface flux and profiler sites where one is in an agricultural region and one is in the forest. (refueling may be necessary).
- Contrast urban versus rural areas with long flights parallel to shore.
- Measure inversion and the extent of land breeze over water with nighttime flights.



3-May-06

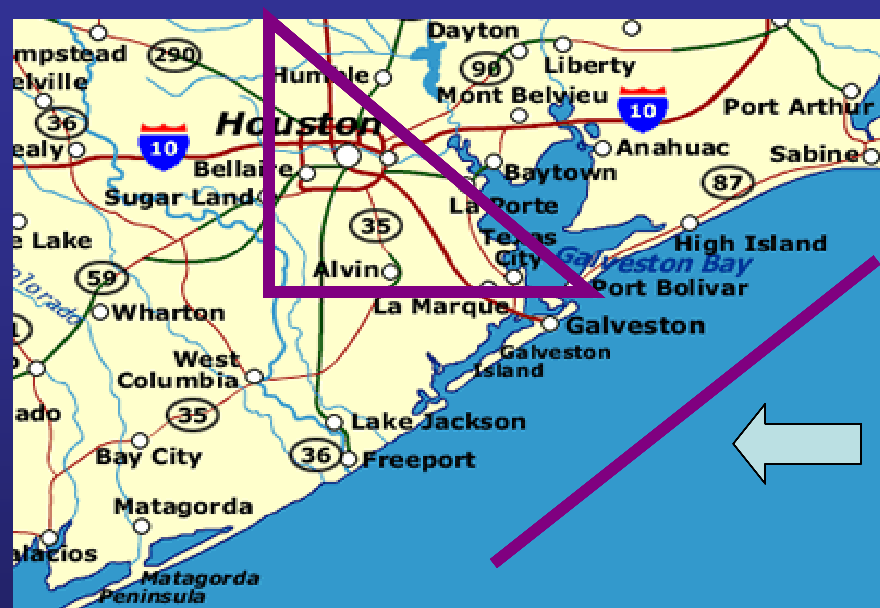
Data Assimilation in Models

Houston can provide an opportunity to examine value of data produced by future observing systems for A/Q forecasting

Twin Otter data can be used to run an Observing System Experiment by simulating a potential future ozone/aerosol profiling system

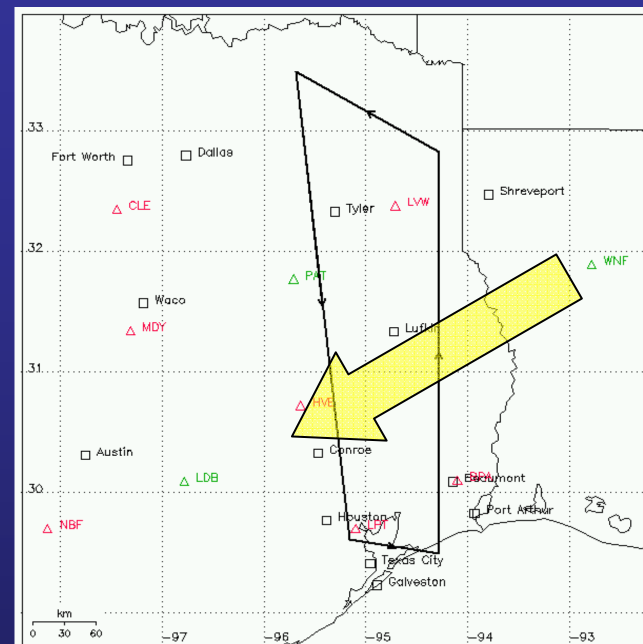
Most potential value to models would come by measuring ozone upstream in areas where measurements are not available (e.g., over the Gulf)

Identification of an elevated residual layer would also be potentially useful



P-3 could also show the value of upstream data (but this would not be an OSE)

Transport of Pollution into Houston

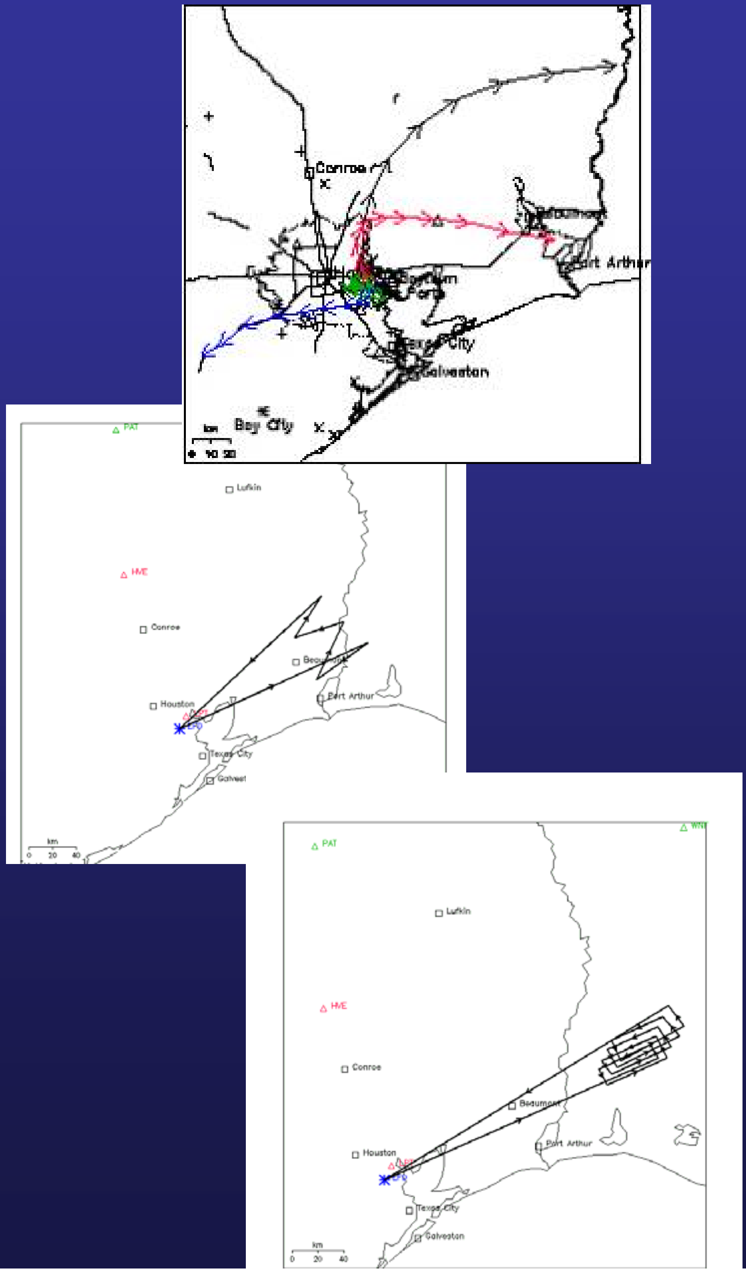


•Major Question: How much is Houston area pollution affected by transport from neighboring states?

•Twin Otter will do “border surveillance” to examine flux of ozone into Texas and evolution of ozone concentrations as plume is transported toward Houston

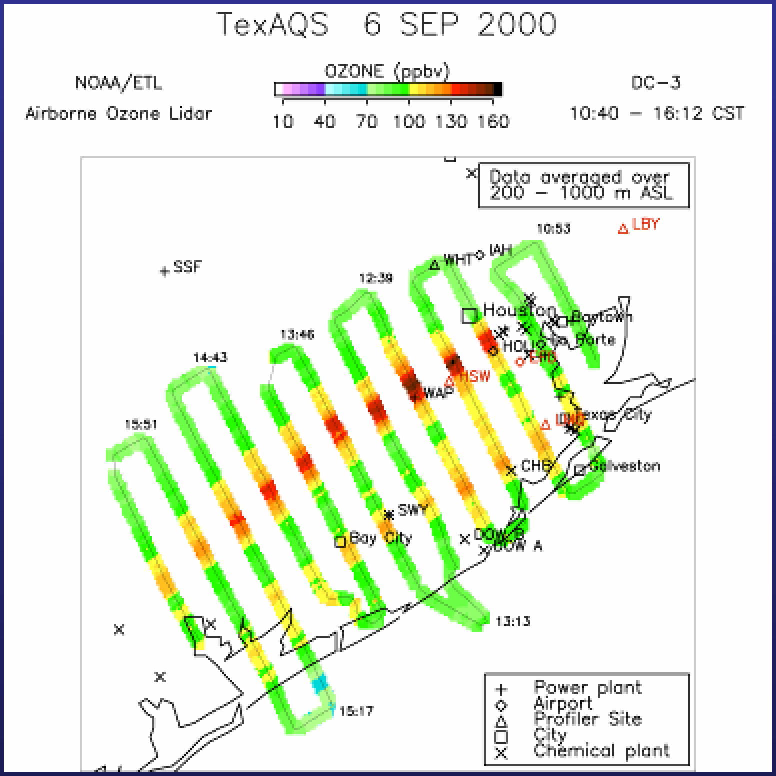
Nighttime transport of Houston Pollution

- *Objectives:*
  - **track overnight clouds of O_3** and other pollutants originating from Houston/ship channel; determine extent to which dilution and dark chemical reactions change concentrations and composition of pollutants in overnight cloud
  - follow pollutant blob through **next morning's mix-out**; observe and better understand importance of processes related to **buildup of rural background**
  - **Investigate Gulf-coast regional** pollutant buildup during multiday episodes – amalgamation of pollutants from Houston area with other Gulf Coast sources; role of diurnal sea-breeze cycle in distributing, recirculating O_3 and other pollutants through an episode



Transport of Houston cloud to other parts of Texas under strong wind conditions

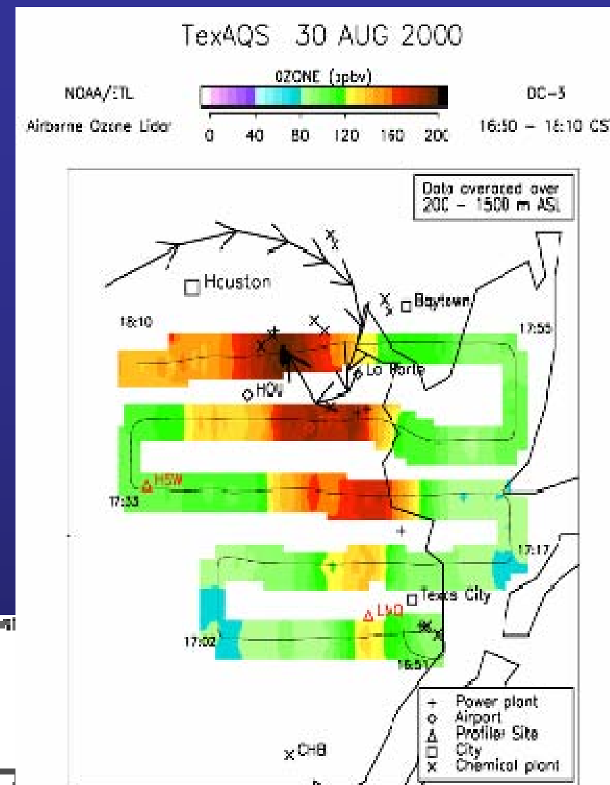
- Under strong wind conditions Houston ship channel plume can be transported significant distances downwind with little dilution
- Areas in the path of this transport can experience elevated pollution levels
- Twin Otter will document plume transport when such conditions exist

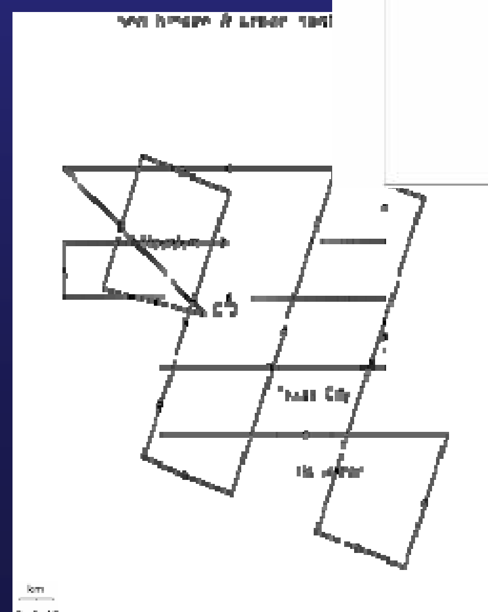


Local Sea Breeze Effects

- Investigate the vertical and horizontal distribution of ozone near the coastline of Galveston Bay, as controlled by the diurnal cycle of the local winds

- Addresses several relevant science issues
  - effects of thermally-driven flows
  - evolution of the PBL over Galveston Bay
  - assessing the nature of O_3 exceedances relative to local and gradient winds; forecasting
  - air quality modeling



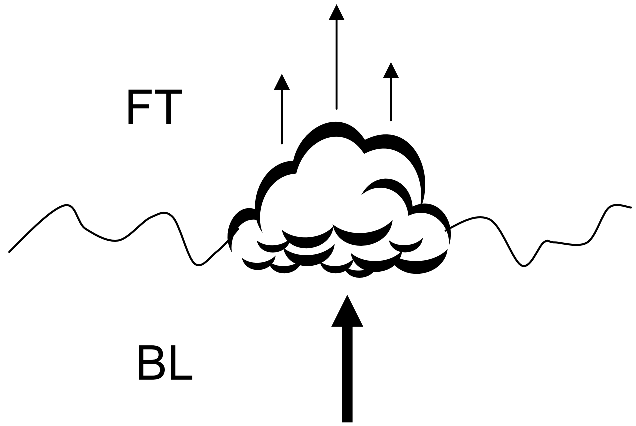


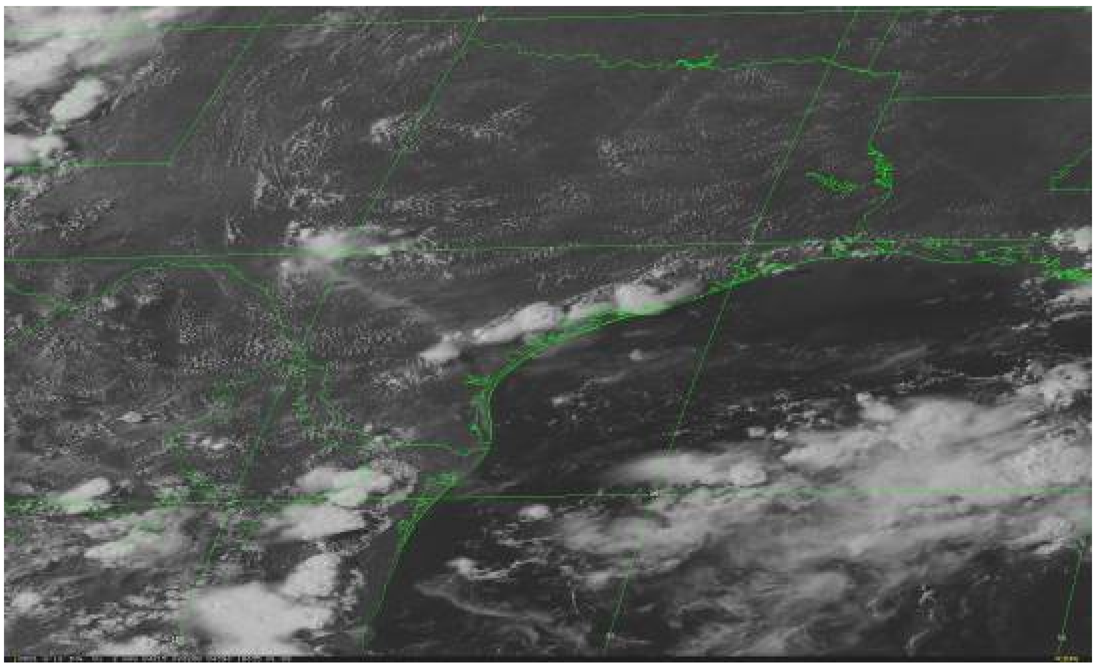
Cloud venting of pollution

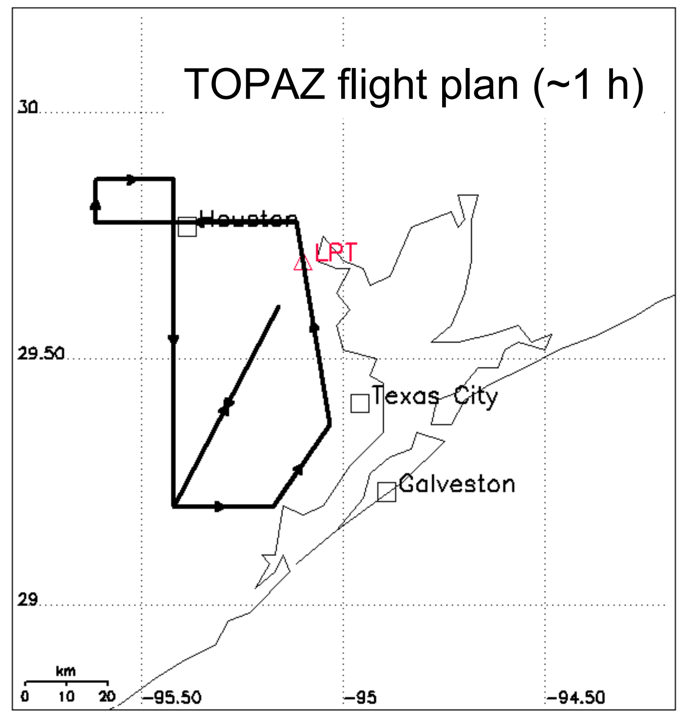
Objective: Assess the importance of cloud venting of boundary layer pollutants. Is this a significant loss mechanism?

Measurements: TOPAZ, P3, CIRPAS Twin Otter, OPAL, Doppler lidar

Meteorological conditions: Partly cloudy with ¼ to ½ Cu humilis or mediocris.







CIRPAS Twin Otter

- CIRPAS TO will be the primary platform for cloud studies
  - Complementary measurements from WP-3, RHB, and NOAA TO

- Measurements below, within and above cloud to measure in-situ aerosol properties used to calculate CCN (size distribution, chemical size distribution), CCN, cloud droplet number concentration, drop size distributions, updraft velocities, liquid water content, and cloud radiative properties;

- Statistical sampling rather than single cloud studies;

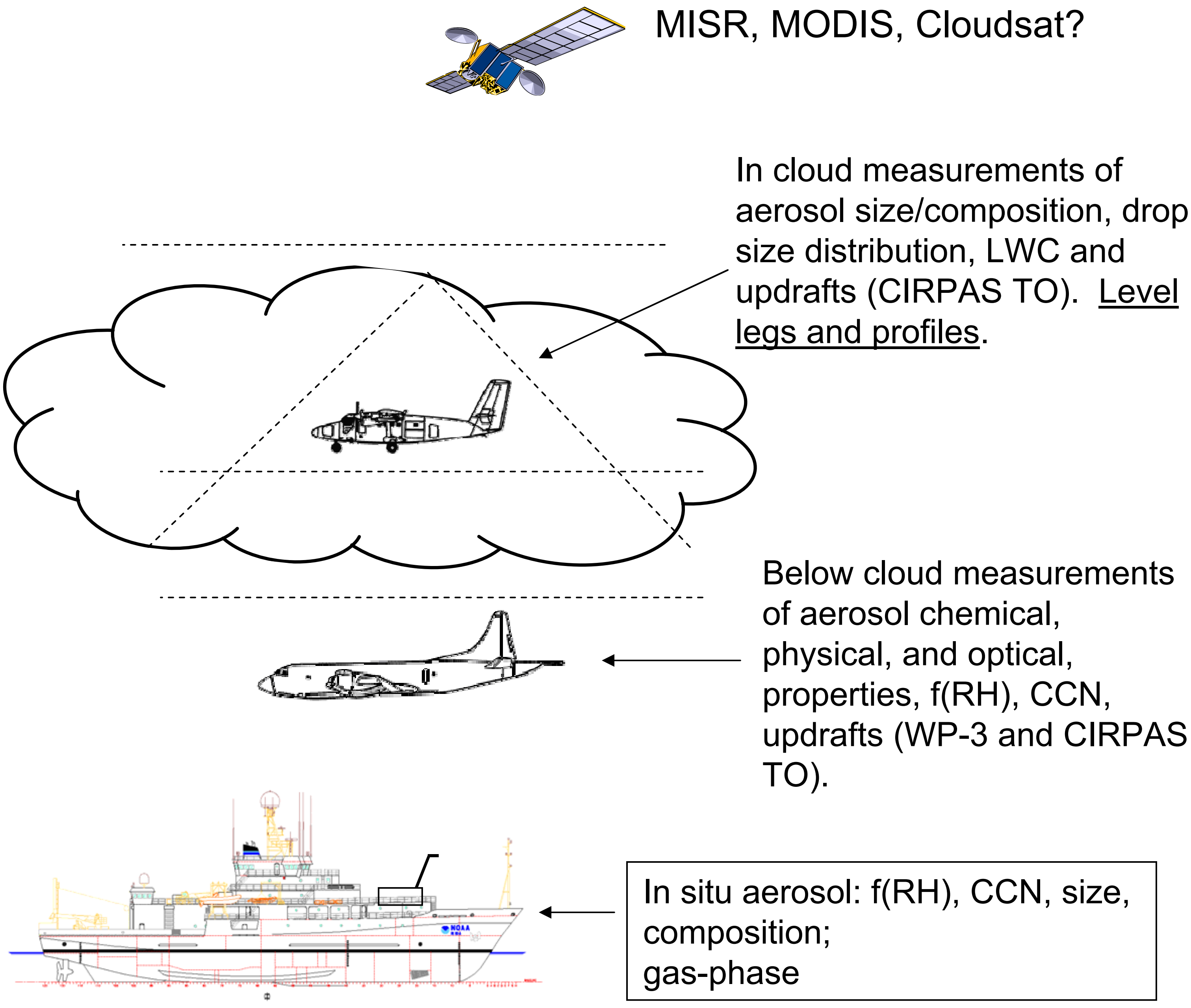
- Attempt to study wide variety of aerosol conditions with consideration of sources;
- Target warm phase cumulus (mediocris)

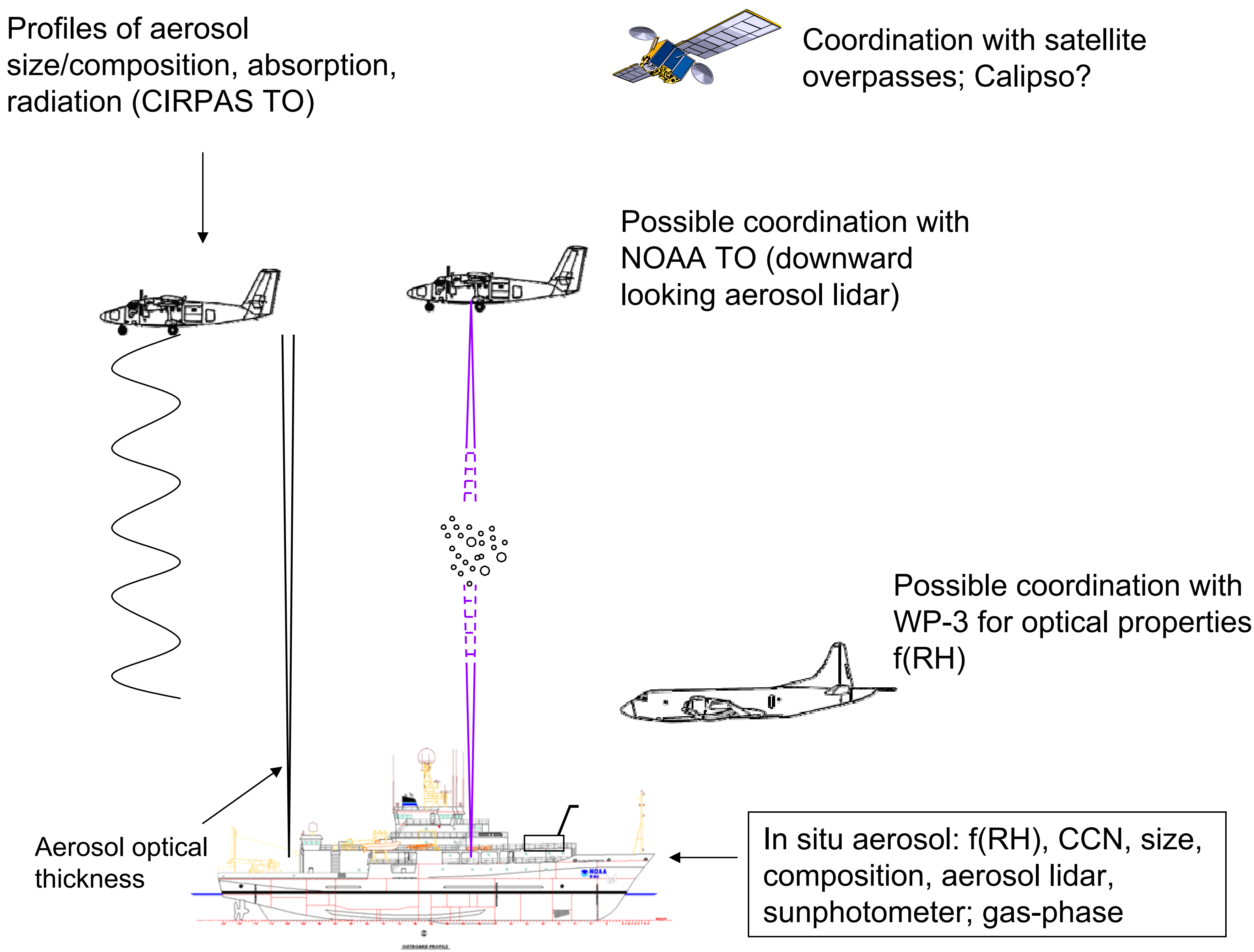
Deployment Strategy

- Coordination with
  - WP-3 for near-simultaneous “column” measurements of below cloud aerosol and cloud microphysics. Also support WP-3 air quality objectives;
  - Ron Brown to support direct effect studies
  - satellite overpasses
    - Indirect: warm clouds
    - Direct: clear skies
    - Work with Jim Coakley (AVHRR) and Larry DeGirolamo (Aster) (funded via OGP)

Measurement Package for CIRPAS TO

- Aerosol size distributions: PCASP, total CN
  Twin DMAs
- Cloud drop size distributions: FSSP-100, CAPS, Phased-Doppler (Chuang), PVM (Gerber)
- CCN (Nenes)
- CVI (composition of drop residuals) – upstream of CCN or AMS
- Soot photometer, photoacoustic
- SSFR (Pilewskie)
- Aerosol composition (AMS, PILS)
- Gust probe for high quality updraft measurements
- Meteorological package


MISR, MODIS, Cloudsat?
In cloud measurements of aerosol size/composition, drop size distribution, LWC and updrafts (CIRPAS TO). Level legs and profiles.
Below cloud measurements of aerosol chemical, physical, and optical, properties, f(RH), CCN, updrafts (WP-3 and CIRPAS TO).
In situ aerosol: f(RH), CCN, size, composition;
gas-phase

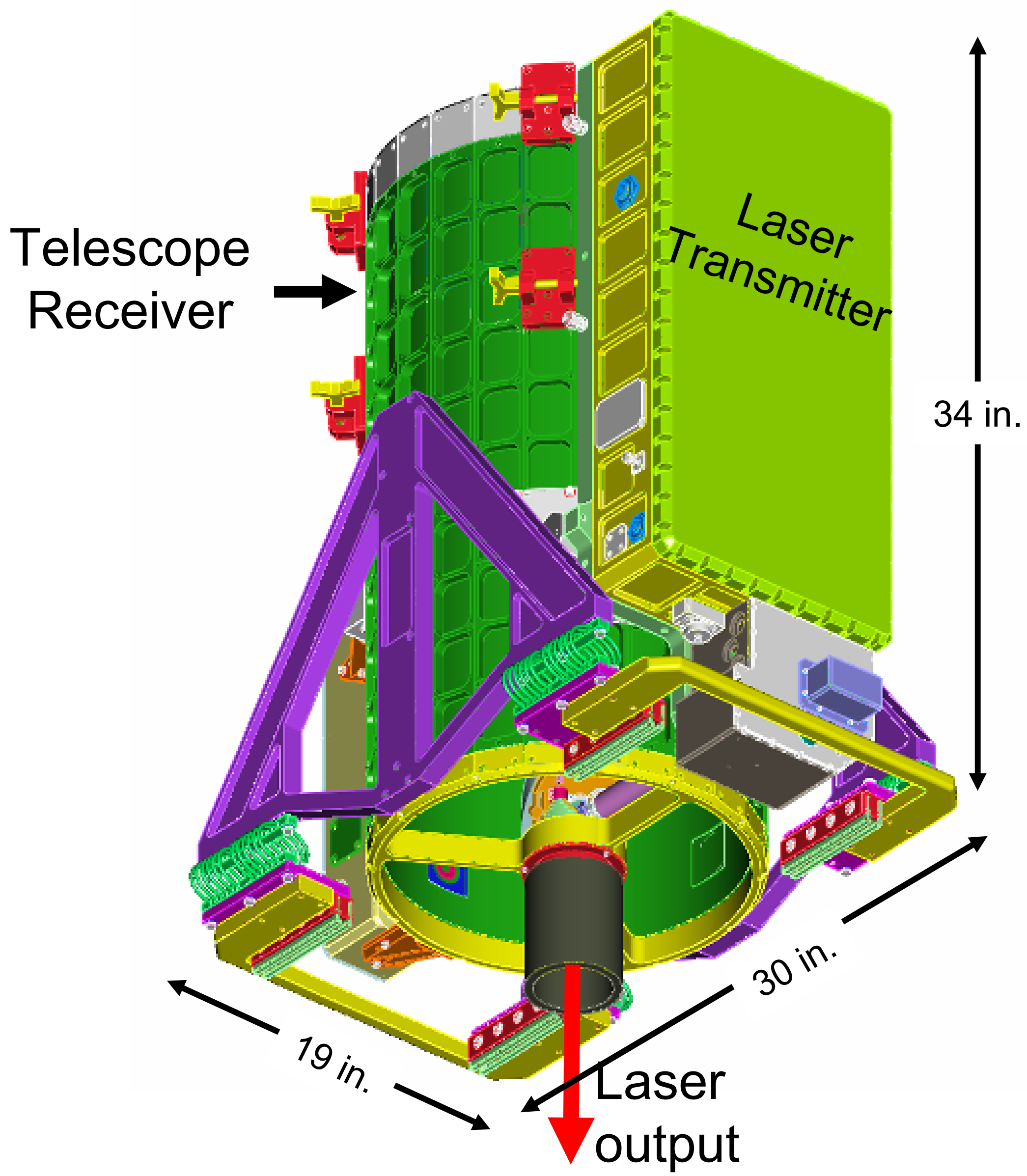

Profiles of aerosol size/composition, absorption, radiation (CIRPAS TO)
Coordination with satellite overpasses; Calipso?
Possible coordination with NOAA TO (downward looking aerosol lidar)
Possible coordination with WP-3 for optical properties, f(RH)
Aerosol optical thickness
In situ aerosol: f(RH), CCN, size, composition, aerosol lidar, sunphotometer; gas-phase

LaRC King Air Be-200

Altitude	35,000 ft (10.7 km), maximum operating
Range	800 nmi (1,300 km) at sampling speed
Endurance	3.5 hr, maximum (with IFR reserve)
Speed	259 KIAS (133 m/s) cruise

Payload	2500 lb (1,136 kg), maximum 500 lb (227 kg), with full fuel
Electrical Power	two 250A 30V DC generators, two 1400VA, 400 Hz inverters supply 115V AC

Airborne High Spectral Resolution Lidar



- **Independently measures aerosol/cloud extinction and backscatter at 532 nm**
- **Includes**
  - Backscatter channels at 1064 nm
  - Polarization sensitivity at 532 and 1064 nm
- Measurement capabilities
  - Extensive measurements
    - Backscatter at 532 and 1064 nm
    - Extinction at 532 nm
  - Intensive measurements
    - Color ratio (or Angstrom coeff.) for backscatter (β_{1064}/β_{532})
    - Extinction-to-backscatter ratio at 532 nm
    - Depolarization at 532 and 1064 nm

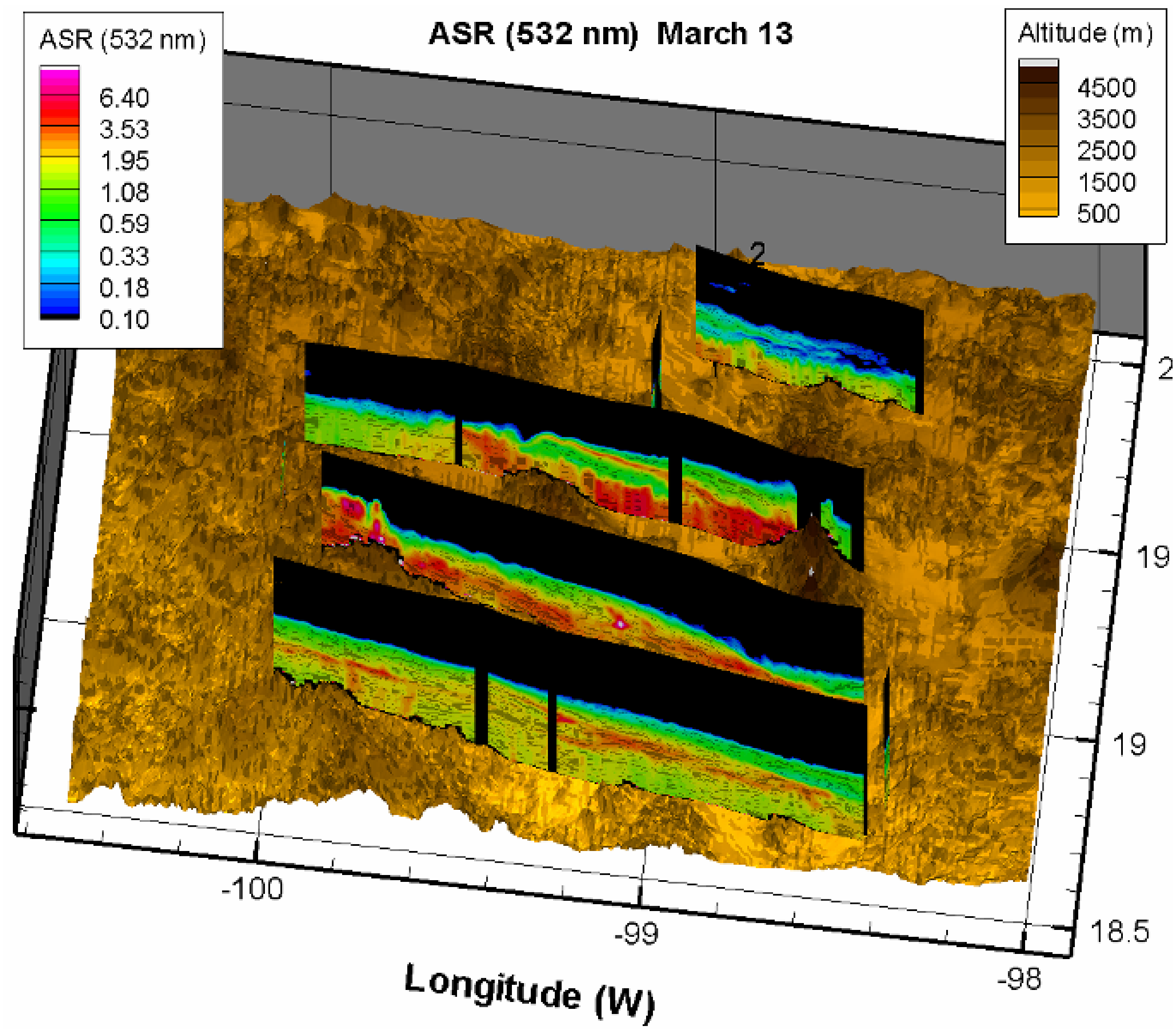
Data Products

- Aerosol scattering ratio (aerosol/molecular backscatter) (532 nm) (ASR532) (Δx ~ 1 km, Δz ~ 60 m)
- Aerosol extinction coefficient at 532 nm (Δx ~ 6 km, Δz ~ 300 m) (EXT532)
- Aerosol wavelength dependence (532/1064) (i.e. Angstrom exponent for aerosol backscatter) (WVD)
- Total depolarization (532 nm) (Δx ~ 1 km, Δz ~ 60 m) (DEP532)
- Aerosol backscatter coefficient at 532 nm (Δx ~ 1 km, Δz ~ 60 m) (BETA532)
- Aerosol extinction/backscatter ratio (532 nm) (Δx ~ 6 km, Δz ~ 300 m) (EXT532)
- Aerosol depolarization (532 nm) (Δx ~ 1 km, Δz ~ 60 m) (DEPA532)
- Aerosol depolarization (1064 nm) (Δx ~ 1 km, Δz ~ 60 m) (DEPA1064)

Black = Preliminary and final data archive

Red = Final data archive

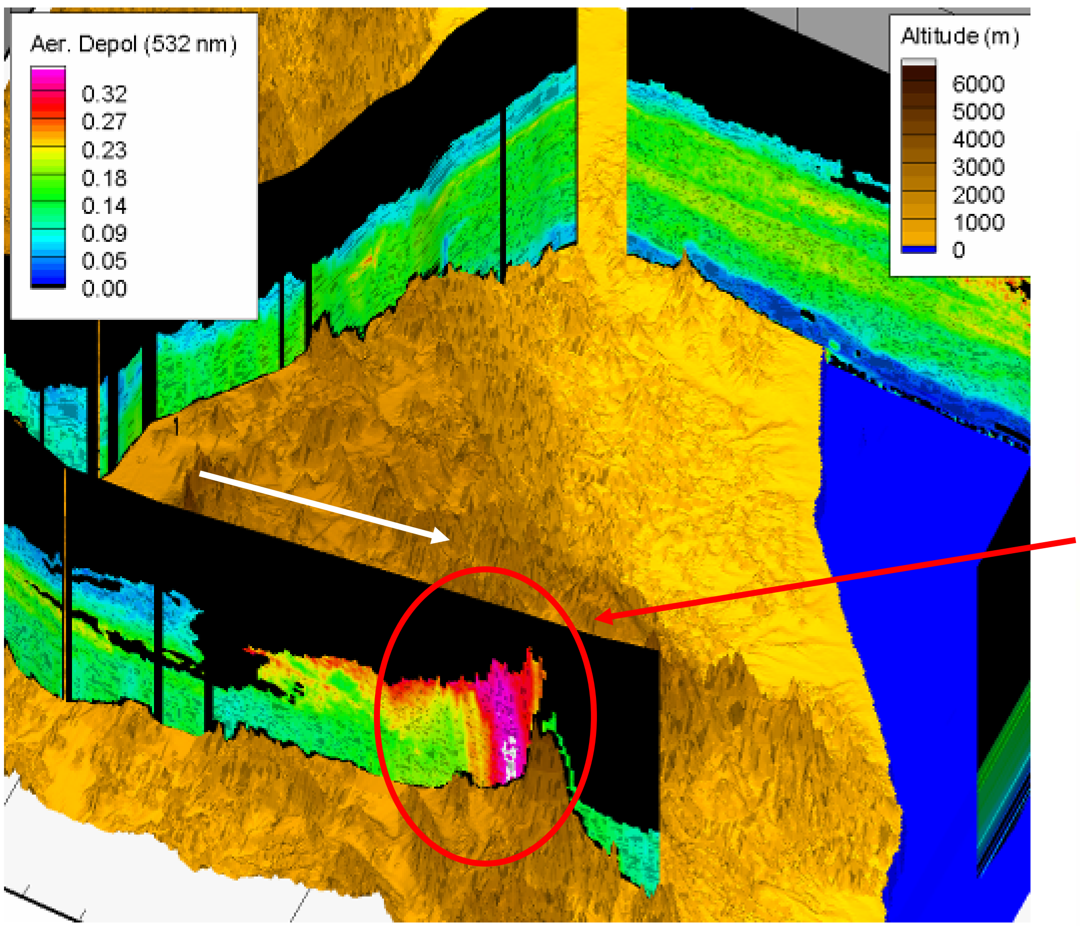
Map the vertical and horizontal distribution of aerosols



March 13
Raster scan

Characterize the vertical distribution of aerosol types

High depolarization associated with dust plumes

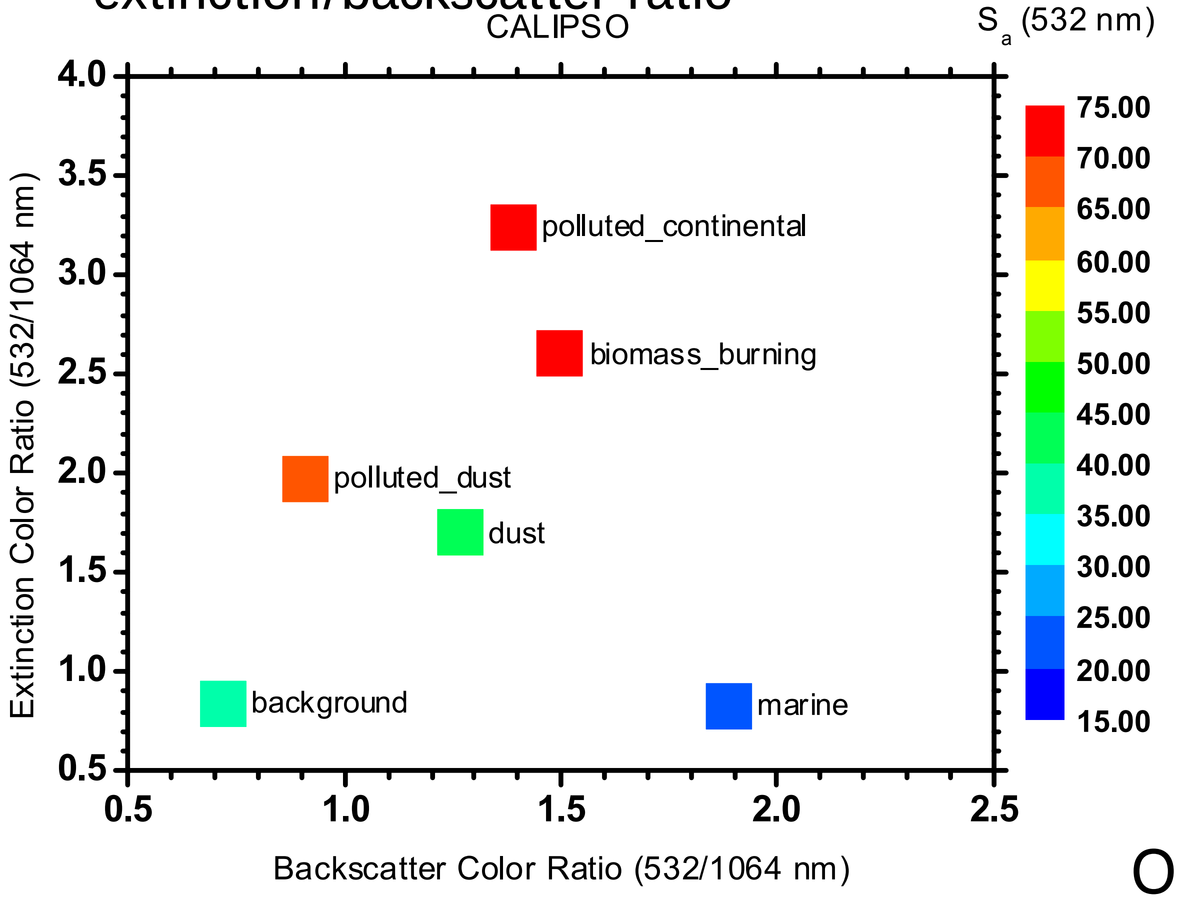


March 12

Characterize the vertical distribution of aerosol types

Use aerosol intensive parameters to infer aerosol types

- backscatter, extinction wavelength dependence
- depolarization
- extinction/backscatter ratio



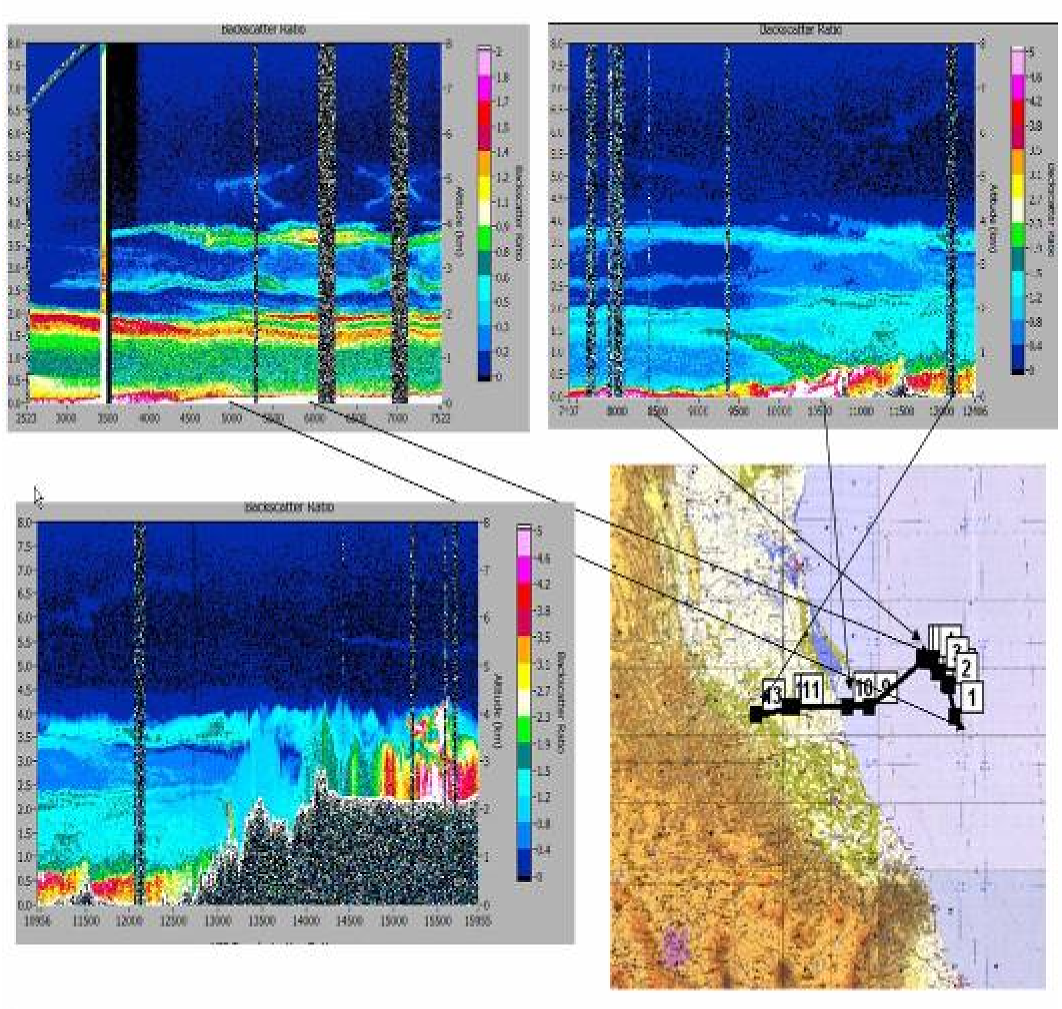
Omar et al. JGR, 2005

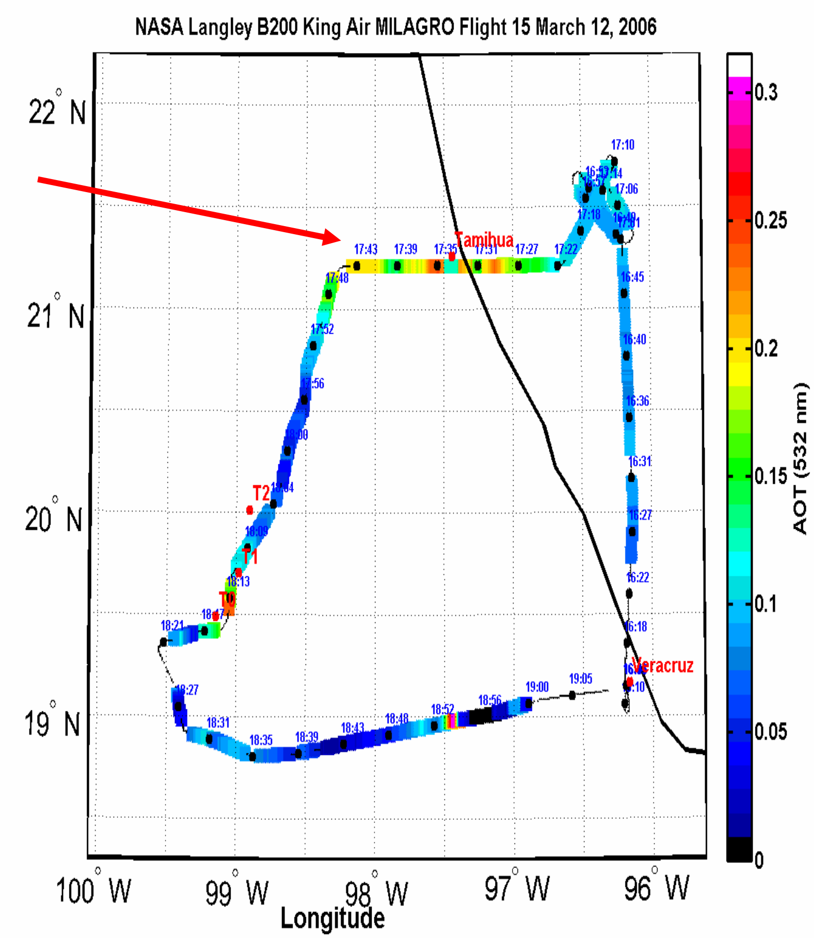
Vector in situ aircraft to altitude/location of greatest interest

Provide real-time images of ASR and DEP via internet during flight

- http://webpages.charter.net/dbharper1/
- Password = milagro

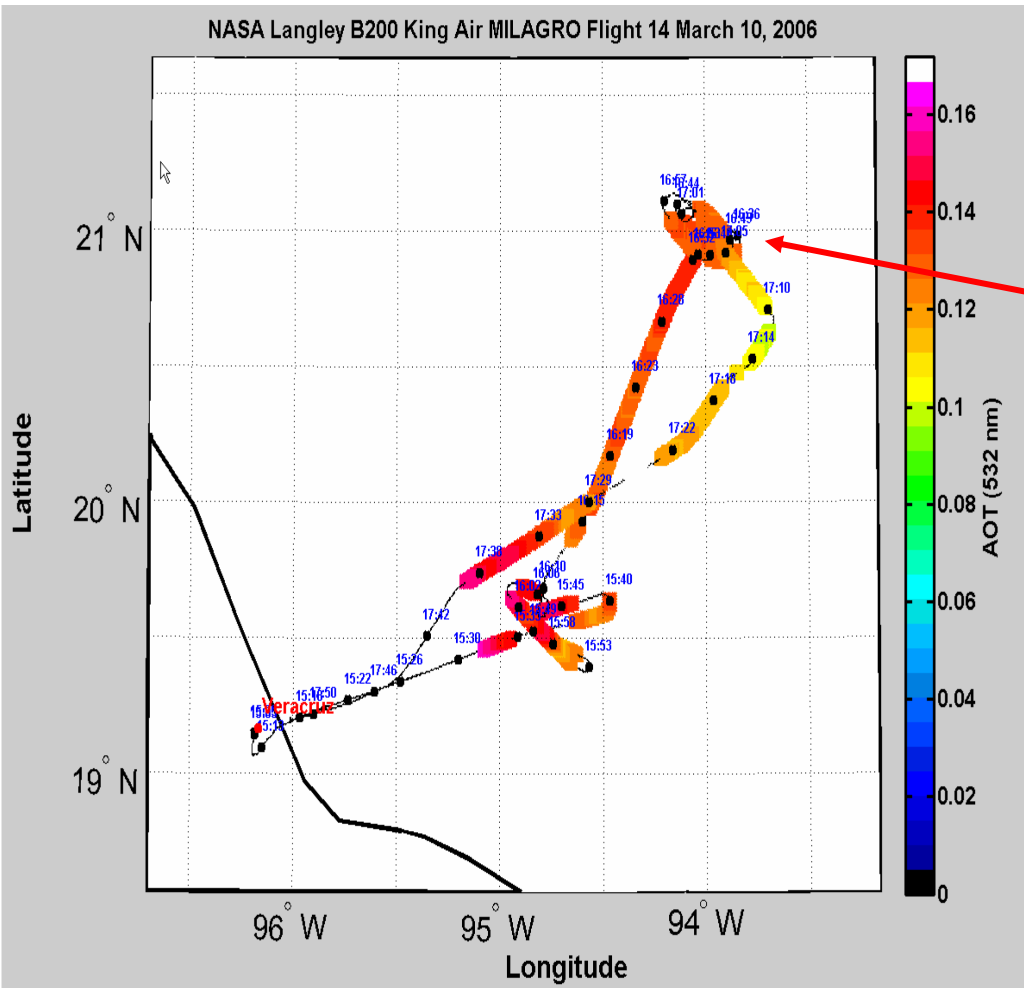
Ex. March 12 flight

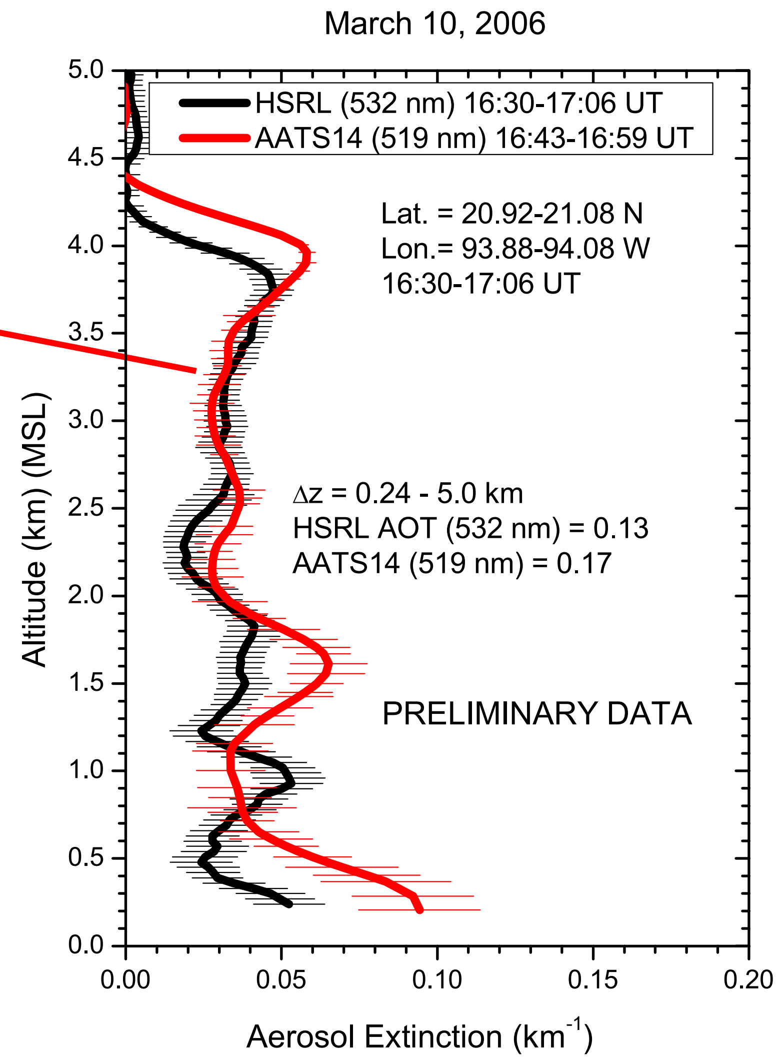




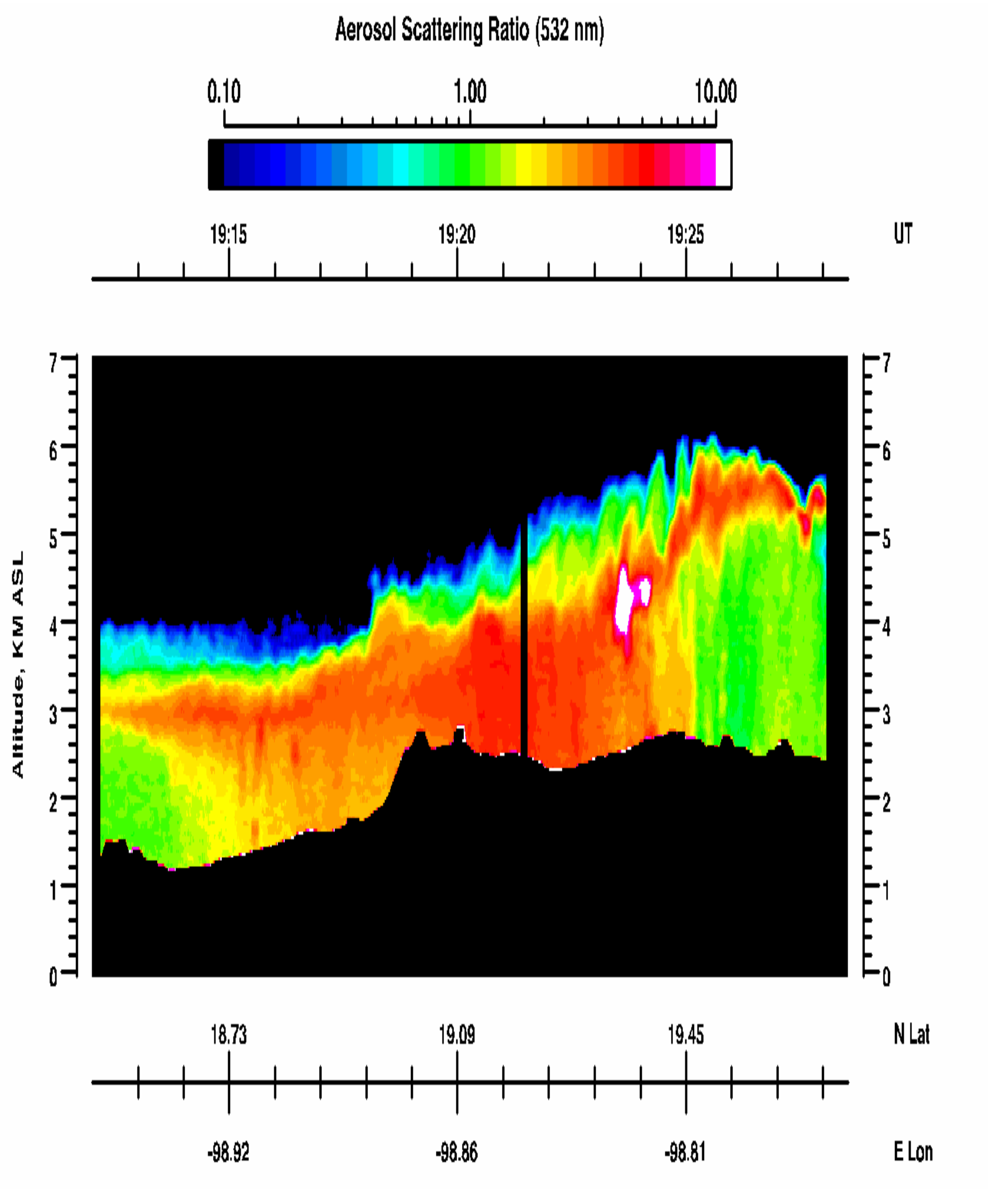
Evaluate / validate the retrieved profiles of aerosol extinction

- Compare aerosol extinction/optical thickness with AATS14 on J-31
- AATS14 data courtesy of Russell, Redemann, Livingston





Evaluate model predictions



March 13

WRF 18 hour forecast