Vertical aerosol structure and aerosol mixed layer heights determined with scanning lidars during the TEXAQS II Study

Brandi McCarty, Sara Tucker, Christoph Senff, Richard Marchbanks, Janet Machol

Cooperative Institute for Research in Environmental Sciences, University of Colorado/NOAA Earth System Research Laboratory 325 Broadway, Boulder, CO 80303, USA

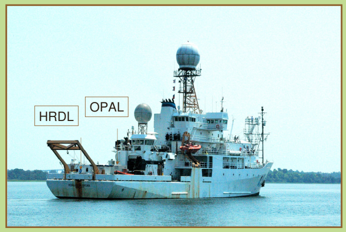
W. Alan Brewer, Wynn Eberhard

National Oceanic and Atmospheric Administration, Earth System Research Laboratory

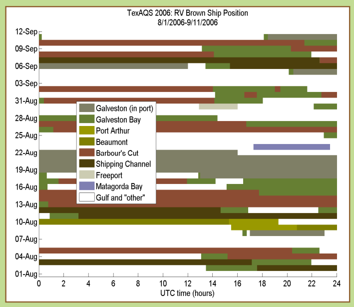
Brandi.Mccarty@noaa.gov (303) 497-6448

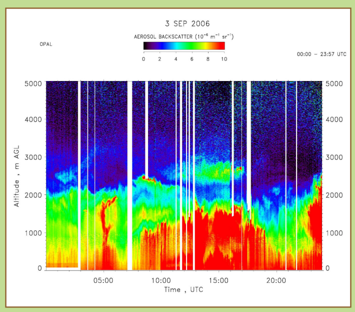
Background

The ship-based portion of the 2006 Texas Air Quality Study (TexAQS II) took place late July through mid-September in Texas. Measurements were concentrated in the Galveston Bay and Houston Ship Channel area. Objectives for the ship-based study included characterization of pollution sources, study of chemical/pollution transport and transformation processes, study of coastal impacts on air quality, as well as, study of the radiative effects of aerosols.
During the campaign, NOAA's Ozone Profiling Atmospheric Lidar (OPAL) provided high vertical resolution aerosol backscatter at 355 nm. Meanwhile, NOAA's High Resolution Doppler Lidar (HRDL) performed measurements of relative 2 micron aerosol backscatter. In addition to their unique remote sensing observations, measurements from both instruments provide context and transport information, including boundary layer mixing and aerosol layer heights, for the in-situ aerosol and gas-phase chemistry measurements.



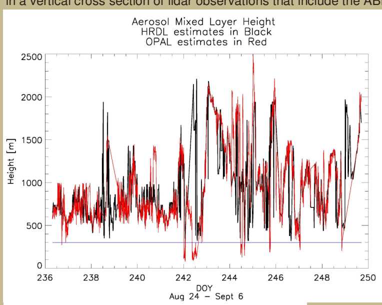
Co-located Lidars, OPAL and HRDL on the fantail of NOAA's Research Vessel Ronald H. Brown



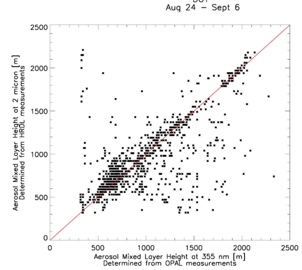


Aerosol Mixed Layer Heights

The Aerosol Boundary Layer (ABL) typically contains greater aerosol concentrations than the free troposphere and therefore aerosol backscatter in the ABL is usually larger. We use a Haar wavelet technique to detect backscatter boundaries (regions of high aerosol gradient) in a vertical cross section of lidar observations that include the ABL.



We compare Aerosol Mixed Layer Height as determined from backscatter data from two co-located lidars. Both data sets were retrieved with a Haar wavelet analysis, using like dilations and search windows.



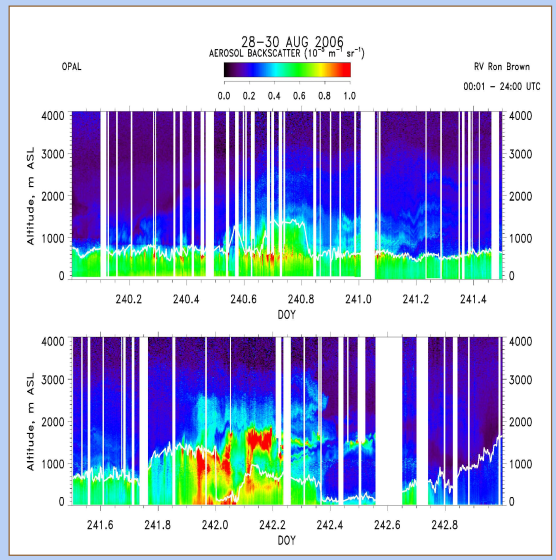
The aerosol mixed layer height estimates from the 355 nm instrument were derived from 2 cycle (approximately 180 seconds) averaged aerosol backscatter data.
The estimates from the 2 micron instrument were derived from 6 minute continuous vertical stares (acquired approximately every 15 minutes) of relative aerosol backscatter.

OPAL Aerosol Measurements

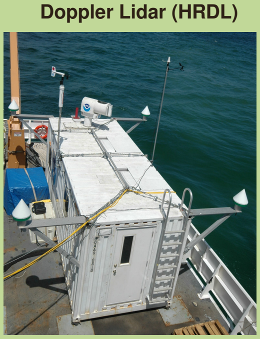
http://esrl.noaa.gov/csd/ors/data_pages/TexAQS06/opal/

OPAL uses a 355 nm channel to obtain information on aerosol backscatter and extinction. Displayed below are 3 example days of calibrated aerosol backscatter, calculated using a modified Klett retrieval method.

Modified Klett Retrieval: A reference region (typically around 4000 m in height, and 1 km in depth) was chosen where the total signal indicated very little backscatter contributed by particulates. A small reference value (about 0.05) is assumed for the ratio of particulate to molecular backscatter. Backscatter returns are calibrated by assigning the reference value to the average signal in the reference region. A two component (molecular and particulate) retrieval technique is performed from the middle of the reference region toward the lidar. The particulate extinction to backscatter ratio is estimated and assumed constant with height.

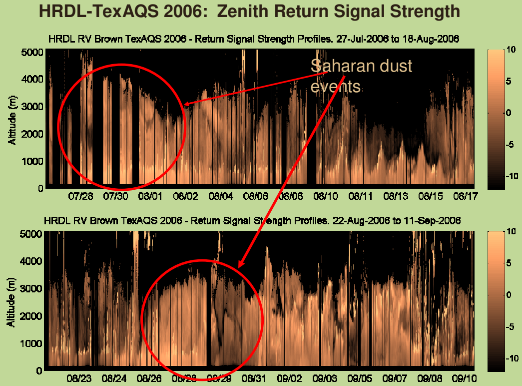


High Resolution Doppler Lidar (HRDL)

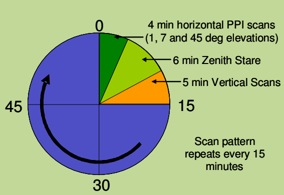


Wavelength	2.02 micron
Max Range	4-8 km
Range Res.	30 m
Beam rate	2 Hz
Scanning	Full Hemispheric
Precision	10 cm/s

HRDL-TexAQS 2006: Zenith Return Signal Strength



5 minute averages of relative 2 micron aerosol backscatter profiles for the TexAQS II experiment, as derived from HRDL vertical signal strength data.

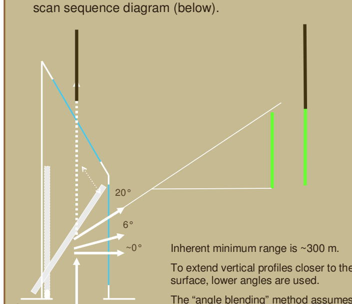


Derived HRDL products

- Aerosol and mixing layer (i.e. boundary layer) heights
- Vertical profiles of relative aerosol backscatter

Ozone Profiling Atmospheric Lidar (OPAL)

OPAL on the R/V Ron Brown (above). Scanner and scan sequence diagram (below).



OPAL Products

- Un-calibrated Total Backscatter (includes signal from molecules and particulates)
- Calibrated Backscatter
- Aerosol Mixed Layer Height Estimates
- Vertical Profiles of Ozone

The OPAL is a Differential Absorption Lidar (DIAL) which emits laser pulses at four ultraviolet wavelengths [266, 289, 299 and 355 nm]. Aerosol measurements utilize the 355 nm wavelength.

The scanner and scanning technique is unique to OPAL . Staring at multiple angles in sequence and blending the data from each angle, allow for the extension of the aerosol profiles to near the surface.

The lidar beams can be scanned in elevation from -2. to 22. degrees, and can also be pointed vertically. The angle limitations are due to the locations of the windows and mirror.

http://esrl.noaa.gov/csd/ors/data_pages/TexAQS06/opal/
mixed layer: brandi.mccarty@noaa.gov
mixed layer: sara.tucker@noaa.gov
aerosols: wynn.eberhard@noaa.gov
ozone: janet.machol@noaa.gov