Ozone, Aerosol, and Cloud Investigations as part of MILAGRO/INTEX-B
NASA Langley's Airborne Differential Absorption Lidar (DIAL)

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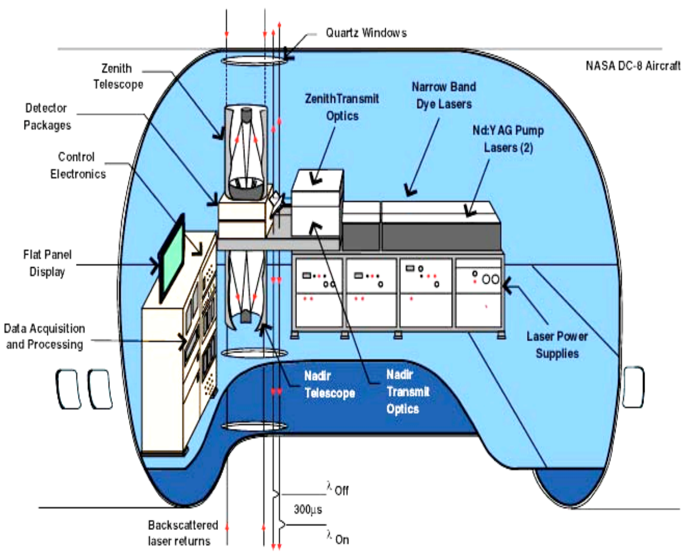
Large-scale distributions of ozone (O_3), aerosols, and clouds will be investigated in the troposphere over North America, the northern Atlantic Ocean, and the eastern Pacific Ocean and as part of the INTEX-NA (Intercontinental Chemical Transport Experiment - North America) field experiments. During the INTEX-B investigation, we specifically will study the vertical and horizontal distributions of O_3 and aerosol concentrations over the United States, Mexico, Canada, and the eastern Pacific Ocean and relate the observed O_3 and aerosol distributions to pollution and natural sources and their transformation and transport across the Pacific Ocean. The airborne DIAL data will provide high-resolution cross sections of O_3 (300 m in the vertical and 70 km in the horizontal) and aerosol backscattering and depolarization (60 m in the vertical and 470 m in the horizontal) from the surface to above the tropopause along the DC-8 flight track. These measurements are considered to be essential to the interpretation of the data related to the objectives of this mission.

In this investigation, remote lidar measurements of O_3 and aerosol distributions will be correlated to several atmospheric properties including atmospheric structure, long-range advection of gases and aerosols in the free troposphere, vertical transport of gases and aerosols between the boundary layer and the free troposphere, and exchange between the troposphere and stratosphere. In addition, by combining these data with in situ and satellite measurements of other trace gases and model analyses, a better picture can be obtained regarding air mass composition, transport, and evolution. Air mass types and their respective fluxes will be examined to estimate the relative impact of each air mass type on the tropospheric O_3 budget as a result of photochemical production/destruction and transport of O_3. Aerosol optical properties will be derived from the multiple-wavelength lidar backscatter and depolarization ratios, and aerosol types and distributions will be studied. Airborne DIAL O_3 and aerosol profiles will be obtained across the troposphere and into the lower stratosphere in conjunction with intercomparison opportunities with the Aura satellite. The spatial variability in O_3, aerosols, and clouds observed with the airborne lidar in the vicinity of the intercomparisons will be used to help validate O_3 and aerosol measurement capabilities of Aura instruments.

The NASA Langley Airborne Differential Absorption Lidar (DIAL) system (see picture below) makes simultaneous O_3 and aerosol backscatter profile measurements with four laser beams: two in the ultraviolet (UV) for O_3 and one each in the visible and infrared for aerosols. The DIAL technique has a long history for the remote sensing of atmospheric gas profiles. For tropospheric O_3 DIAL measurements, one of the lasers is tuned to an "on-line" wavelength of 289 nm in the Hartley-Huggins absorption band of O_3 while the other is tuned to an "off-line" wavelength of 300 nm near the edge of this absorption band. The UV DIAL wavelengths are selectable to optimize the range and sensitivity of the O_3 measurements depending on the emphasis of the campaign. The UV pulsed laser radiation is transmitted into the atmosphere and backscattered from molecules and aerosols to a telescope that is collocated with the lasers. The backscattered UV radiation is detected by a photomultiplier tube (PMT) mounted to the telescope, and the analog signal from the PMT is digitized and recorded as a function of time, which corresponds to range from the lidar. Differences between the lidar return signals at 289 and 300 nm are primarily due to the absorption by O_3 as a function of range, and thus a profile of O_3 can be determined by examining the relative amount of energy absorbed between the on- and off-line wavelengths as a function of range.

The laser transmitter of the airborne DIAL system consists of four pump lasers and two dye lasers that are then frequency-doubled into the UV to produce the DIAL on and off wavelengths for tropospheric or stratospheric measurements. The residual 1064-nm energy from the frequency-doubling process of the pump lasers is transmitted along with the residual visible energy from the frequency-doubling process of the dye lasers. In total five laser wavelengths (289, 300, 578, 600, and 1064 nm) in six beams (note that there are two 1064 nm beams) are generated in this lidar system. Four laser beams (289, 300, 578/600, and 1064) are then simultaneously transmitted into the atmosphere above and below the aircraft. The DIAL on and off wavelengths are produced in sequential laser pulses with a time separation of 300 µs. This close spacing ensures that the same atmospheric scattering volume is sampled at both wavelengths during the DIAL measurement. The laser beams are transmitted collinearly with the receiver telescopes through 40-cm diameter fused silica windows in the top and bottom of the aircraft. The receiver system consists of two 35-cm diameter Cassegrain telescopes (nadir and zenith pointed) with optics to direct the received signals through narrowband optical filters and onto detectors. The detectors include PMT's for the UV and 600-nm returns, and avalanche photodiodes (APD's) for the 1064-nm returns. The nadir and zenith receivers also have polarization beamsplitters for simultaneously detection of the aerosol and cloud depolarization at 578/600 nm to provide information on aerosol and cloud shape.



A schematic of the UV DIAL system is shown on the left and a picture of the UV DIAL system on the DC-8 aircraft is shown on the right.

More information on the UV DIAL system, data, and publications from previous field missions can be found at the following website: http://asd-www.larc.nasa.gov/lidar/lidar.html