Airborne Differential Absorption Lidar (DIAL) – High Spectral Resolution Lidar (HSRL)

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The NASA Langley Airborne Differential Absorption Lidar (DIAL) system uses four lasers to make DIAL O_3 profile measurements in the ultraviolet (UV) simultaneously with aerosol profile measurements in the visible and IR. Recent changes incorporate an additional laser and modifications to the receiver system that will provide aerosol backscatter, extinction, and depolarization profile measurements at three wavelengths (UV, visible, and NIR). The DIAL technique has a long history for the remote sensing of atmospheric gas profiles [e.g., Browell, 1989]. 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 (for stratospheric O_3 DIAL measurements these wavelengths are 301 and 310 nm, respectively). The UV pulsed laser light 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 on-line and offl-ine (e.g. 289 nm 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 DIAL instrument will include for the first time aerosol and cloud measurements implementing the High Spectral Resolution Lidar (HSRL) technique [Hair, 2008]. The modifications include integrating an additional 3-wavelength (355 nm, 532 nm, 1064 nm) narrowband laser and the receiver to make the following measurements; depolarization at all three wavelengths, aerosol/cloud backscatter and extinction at 532 nm via the HSRL technique, and aerosol/cloud backscatter at the 355 and 1064 nm via the standard backscatter lidar technique. Integration of the aerosol extinction profile at 532nm above and below the aircraft also provides aerosol optical depth (AOD) along the aircraft flight track. A summary of the measurements is provided in Table 1 and the basic laser, receiver, and system parameters are provided in Table 2. The DIAL system generates five wavelengths from two separate laser systems, and four separate laser beams at 289, 300, 355, and 532/1064 (combined) are simultaneously transmitted into the atmosphere above and below the aircraft. 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 gateable photomultiplier tubes (PMTs) for the 289/300, 355, and 532 nm returns, and avalanche photodiodes (APDs) for the 1064-nm returns. The nadir and zenith receivers also have polarization beamsplitters for simultaneously detection of the aerosol and cloud depolarization at 355, 532, and 1064 nm. All the signals in the zenith and nadir return signals are digitized at a 10-MHz rate by 14-bit transient digitizers with high and low gains to cover the dynamic range of the signal. **Atmospheric vertical and horizontal cross sections of O_3 and aerosol/cloud scattering and depolarization profiles above and below the aircraft are displayed in real-time on a color monitor and distributed on the aircraft network for in-flight real-time flight planning.**

The NASA airborne DIAL system has been used previously in 29 major field experiments over the past 31 years to investigate regional- and global-scale processes related to tropospheric and stratospheric O_3 and aerosols. Each of these field experiments has led to many journal publications utilizing the unique O_3 and aerosol data obtained from the airborne DIAL system. At the Lidar Group web site, (http://asd-www.larc.nasa.gov/lidar/lidar.html), users can access all the Campaign Data Set images that were obtained in each airborne field experiment starting in 1991.

References:

Browell, E. V., Differential absorption lidar sensing of ozone, *Proc. of the IEEE, 77*, 419-432, 1989.

Hair, J. W., C. A. Hostetler, A. L. Cook, D. B. Harper, R. A. Ferrare, T. L. Mack, W. Welch, L. R., Izquierdo, F. E. Hovis, 2008: Airborne High Spectral Resolution Lidar for Profiling Aerosol Optical Properties, *Applied Optics*, 47,doi: 10.1364/AO.47.006734

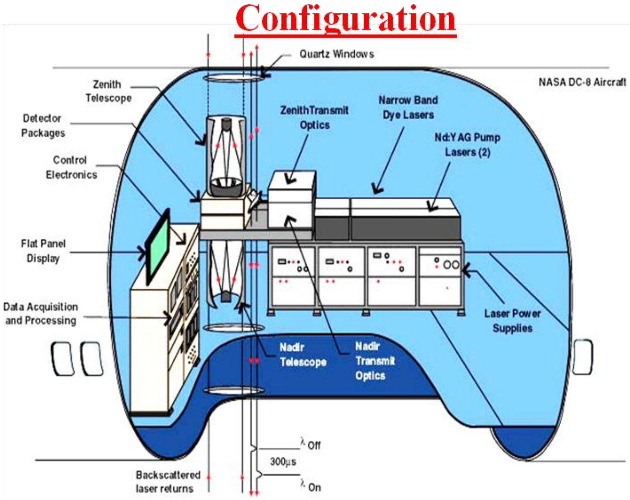
Measurement	Wavelength	Comment
Ozone Concentration	289 nm 300 nm	On- and off-lines for O_3 DIAL measurement
Aerosol backscatter coefficient	355 nm 532 nm 1064 nm	Additional wavelength in UV and calibration via HSRL technique.
Aerosol Extinction Coefficient	532 nm	Internally calibrated extinction via HSRL technique
Aerosol Optical Depth (AOD)	532 nm	Integration of aerosol extinction profile.
Aerosol Depolarization	355 nm 532 nm 1064 nm	Adds additional information on aerosol shape & type

Table 1. DIAL-HSRL measurement capability.

Ozone Transmitter		
Pump Laser	Big Sky CFR800	
	Repetition Rate, Hz	40
Dye Lasers	Continuum ND-6000	
	Energy mJ (289, 300 nm)	12,15
HSRL Transmitter		
SLM Laser	Fibertek, Inc. - Custom	
	Pulse Repition Rate, Hz	200
	Energy, mJ (355,532,1064 nm)	15,20,20
Receiver		
Telescope	Cassegrain, dia.	35.5 cm

Table 2. Basic Instrument Parameters

Airborne DIAL Configuration



Airborne DIAL on NASA DC-8 Aircraft