Characteristics of the JPL-NDSC lidars and recent system upgrades.

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Abstract.

The JPL Atmospheric Lidar Group currently operates three ground-based differential absorption lidar (DIAL) systems within the framework of the Network for the Detection of Stratospheric Change (NDSC). These systems provide high-resolution vertical profiles of tropospheric and stratospheric ozone and aerosols, and stratospheric and mesospheric temperature. The original system located at the JPL-Table Mountain Facility, California (TMF, 34.4°N, 117.7°W) has been measuring nighttime ozone number density from ~18-50 km and temperature from ~30-75 km, since 1988. An improved system was installed at the Mauna Loa Observatory, (MLO, 19.5°N, 155.6°W), Hawaii, in 1993, allowing ozone, aerosol, and temperature measurements between 15-90 km. A new tropospheric system has been recently developed at TMF, operating routinely since late 1999, and providing high-resolution ozone profiles between 5-20 km. Each of these lidars makes observations 2 to 3 nights a week, on average, and a very large database of ozone profiles has been obtained since 1998 allowing climatologies to be developed and a wide range of temporal variability to be investigated. The original design of these lidars has been fully described in various publications. As part of a general upgrade and refurbishment program the optical receivers for these lidars are being replaced with a newly designed system.

Briefly, the stratospheric lidars use a xenon chloride excimer laser transmitting 308 nm as the absorbed wavelength in the differential absorption lidar (DIAL). In the original systems the DIAL reference, and temperature Rayleigh wavelength was 353 nm generated by stimulated Raman shifting a portion of the fundamental 308 nm beam. In the refurbishment program this has been replaced by the third harmonic of a Nd:YAG laser at 355 nm. The excimer lasers produce approximately 100 W at 200 Hz repetition rate while the Nd:YAG produces about 15 W at 100 Hz. From these transmitted wavelengths, the receiver collects the elastic scattering at 308 and 355 nm and also the Raman scattered signal from atmospheric nitrogen at 332 and 387 nm. The tropospheric systems uses the fourth harmonic of a Nd:YAG laser, Raman shifted in hydrogen and deuterium to give wavelengths of 289 nm and 299 nm.

In our new design we use multiple telescopes to collect the returns for each transmitted wavelength. For example, in the stratospheric DIAL the far range signals are collected by a 91 cm diameter telescope, the mid-range by a 7 cm telescope, and the near range by a 2 cm telescope. Thus, the ratio of the signals is approximately low:medium:high (near:mid:far) = 1:10:1500. Another benefit of the multiple telescopes is that the fields-of-view can be different. By having a relatively large fov on the smallest telescope the problems of overlap between the laser and telescope in a bistatic system can be minimized. Also, since the small telescopes are relatively inexpensive it is also possible to use a separate one for each wavelength. Again, this greatly simplifies and reduces the optics required in the detector chain. The small telescopes are placed close to the transmitter beam expanders to maximize overlap at low altitudes. Fiber optics are used to couple all of the receiver telescopes to the choppers and detectors.

A special dual-fiber arrangement is mounted at the focus of the large telescope. In this arrangement the fiber jacket is stripped away at the ends so that the fibers can essentially touch. The fiber core diameters are 1.5 mm and are used as the effective field-stops at the telescope focus. Each fiber views a different region in the atmosphere but because the FOV is only 600 μrad, these regions are small and close together, e.g., at 10 km each region is 6 m diameter and separated by essentially the same amount. This arrangement is used as the primary step in separating the two DIAL wavelengths. The transmitted beams are each aligned to one particular fiber, i.e., centered in the FOV. Since the laser divergence is much less than the FOV the beams are well separated in the atmosphere. One advantage of this method of separating the different wavelengths spatially is that it is wavelength independent. Thus, the lidar signal is divided into six fibers; near-range λ_1 and λ_2, mid-range λ_1 and λ_2, and far-range λ_1+λ_1(Raman) and λ_2+λ_2(Raman).

The fibers are then coupled to a rotating chopper wheel system. Two chopper blades are rotated 90° out of phase and the two lasers are triggered independently in this manner. This reduces the out of band blocking requirements of the interference filters on the detectors. A detector package is attached to the rear of the chopper housing which incorporates a collimating lens and a narrowband interference filter. Then, the light is refocused onto a metal-can photomultiplier. The only wavelength separation that needs to be carried out after the chopper is the Raman signals and this is done with short-wavelength pass dichroic filters. Since we need the Raman signals at relatively low altitudes it is necessary to open the chopper lower than would be optimum for the far-range signals. To prevent overload, the photomultipliers are electronically gated to turn on at higher altitudes.

A newly designed receiver is being implemented for the Rayleigh/Raman/DIAL lidars at Table Mountain and Mauna Loa and will be fully described in this paper. All components between, and including, the telescope and detectors are being replaced. The characteristics and performance of these systems will be summarized.

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