Blog Help Files: Lidar

Lidar (Light Detection and Ranging) is a remote sensing technique that uses visible light to measure the properties of distant objects. Lidar is based on the same principle as radar (Radio Detection and Ranging), except radar uses radio waves. In the atmosphere, lidar can be used to measure the location and relative amounts of aerosols. Lidars can be ground-based, mounted on airplanes, or located on satellites such as CALIPSO.*

All lidar instruments work in the same basic way, as shown in Figure 1. A laser emits a pulse of light into the atmosphere. Particulates in the atmosphere scatter the light in all directions, including back toward the lidar system. A telescope collects this backscattered light and sends it to a photodectector. The photodetector, which is typically a photomultiplier tube (PMT) or an avalanche photodiode detector (APD), measures the amount of light backscattered by the atmosphere as a function of distance from the lidar system. The result is a vertical profile of the atmosphere, including the location of clouds and particulate matter.

The University of Maryland, Baltimore County (UMBC) operates three ground-based lidar instruments, each of which emits pulses of light into the atmosphere at different wavelengths: the LEOSPHERE ALS-450, the Sigma Space Micropulse Lidar (MPL), and the Elastic Lidar Facility (ELF). A detailed description of the UMBC ELF system and its processing algorithm are located at http://alg.umbc.edu/UMAP/elf_index.html.

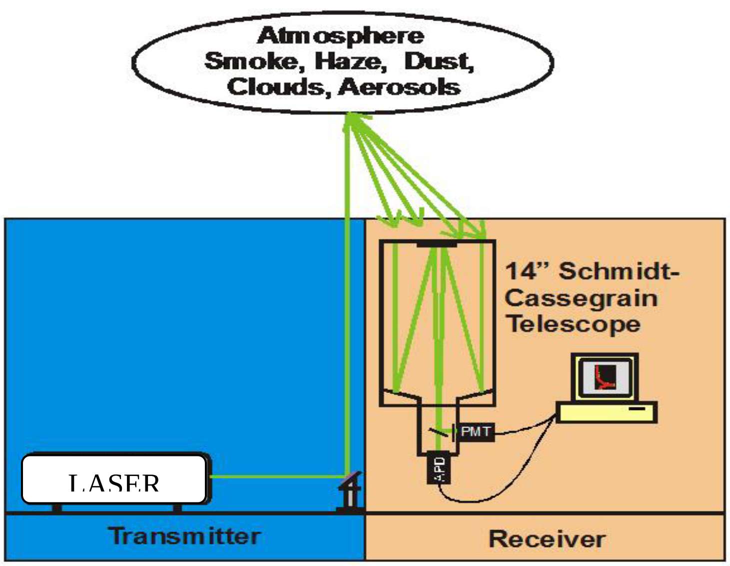

Figure 1. The basic components of a lidar system.

Ground-based lidar measurements are useful because they provide real-time information about particulates in the Planetary Boundary Layer (PBL), as well as information about the dynamics and evolution of the PBL itself. The PBL is the part of the atmosphere that is closest to the

Earth's surface. PBL height is variable in time and space, ranging from hundreds of meters to a few kilometers. It is a key parameter in the description of vertical processes in the lower troposphere and an important input parameter for air quality models. The PBL typically has a much higher concentration of aerosols than the free troposphere above it, and thus, it provides a stronger backscatter signal in lidar measurements.

The UMBC lidars are powerful tools for visualizing aerosol distribution, cloud-top altitudes, and pollution transport in the PBL. Figure 2 is a timeseries plot of data from the UMBC ELF (532 nm channel) for July 9, 2007, with altitude in kilometers on the *y*-axis and time in Universal Coordinated Time (UTC*) on the *x*-axis. The images are color-coded, with reds and yellows corresponding to high concentrations of "scatterers" (particulates or cloud drops), and blues indicating relatively clear skies. Figure 2 shows the typical evolution of the PBL during the morning, afternoon, and early evening. Overnight, in the absence of sunlight, the PBL shrinks to a narrow layer next to the Earth's surface, called the Nocturnal Stable Boundary Layer (visible from 06:00 UTC until approximately 13:00 UTC in Figure 2). After sunrise (9:48 UTC in Figure 2), the surface begins to warm, and the Nocturnal Stable Boundary Layer breaks down and mixes with the Residual Layer aloft to form the Mixed Layer (approximately 13:00 UTC to 21:58 UTC in Figure 2). The majority of the particulate matter in the PBL is concentrated near the surface, as indicated by the yellow colors in Figure 2.

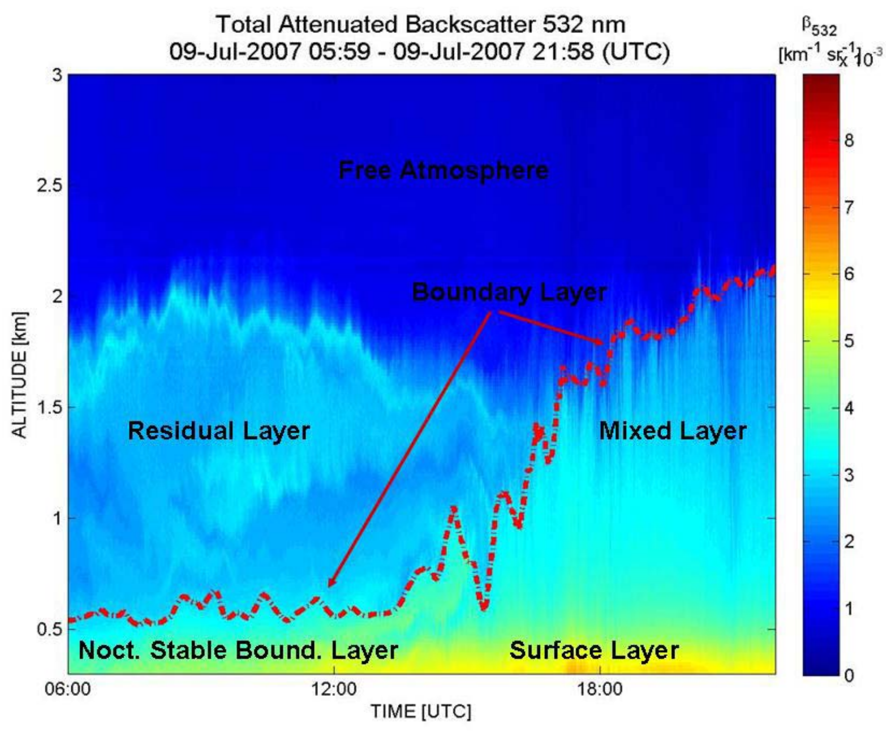

Figure 2. UMBC ELF 532 nm total attenuated backscatter (β_{532}) timeseries plot for July 9, 2007. The red line represents the height of the planetary boundary layer during the course of the day.

Figure 3 is a timeseries plot of data from the UMBC ELF (532 nm channel) for August 1-3, 2007, which shows a more complex troposphere than the profile in Figure 2. The light blue feature at 5.5-8 km in Figure 3 is due to smoke transported to the Baltimore area from forest fires in Montana and Wyoming. The dark red areas at approximately 2 km represent clouds. The dark blue vertical bands above the clouds are similar to the shadows that clouds cast on the ground, except in reverse, since the lidar's laser emits light from the ground up into the sky.

ELF also detected a nocturnal low level jet (LLJ) at 0.2-1.1 km for a period of 11 hours during the evening of August 2 and the morning of August 3, indicated by the semi-circle in Figure 3. A LLJ is a stream of fast moving air, typically with maximum wind speeds of approximately 22-45 mph; the base of the jet is generally located 100-300 m above the surface. It is primarily a nocturnal phenomenon that occurs most often during spring and summer. LLJs can extend to 100-300 km in width and approximately 1000 km in length. Nocturnal LLJs can impact local air quality conditions because they can transport high concentrations of pollutants to areas which would otherwise have relatively good air quality. More information on LLJs and their impact on pollution transport in Maryland is located at http://alg.umbc.edu/MDELLJ.

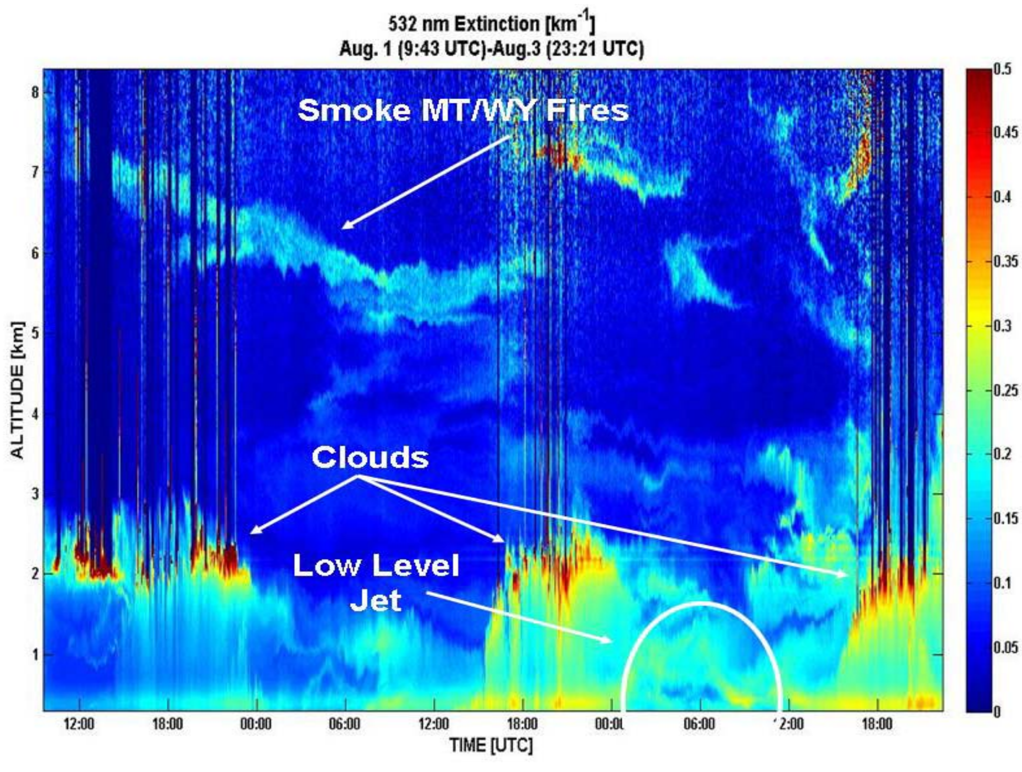

Figure 3. UMBC ELF 352 nm extinction timeseries plot for August 1-3, 2007.

*For more information about:

- CALIPSO, see the **CALIPSO Help File**
- Universal Coordinated Time (UTC), see the **UTC Help File**