Implementation of the Ground Based Infrared Lidar at 1.5 µm and 4.5 µm for Aerosol and Cloud Study

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Objective:

The objective of our project was to figure out why we specifically use Infrared LIDARs to detect aerosols.

Introduction:

Aerosols:

- Aerosols are particles in the atmosphere that scatter and absorb radiation, altering the Earth's radiation balance.
- Aerosols change the way sunlight is absorbed and reflected.
- Aerosols can contribute to health problems such as cardiopulmonary diseases.

LIDARs:

- LIDARs (Light Detection and Ranging) can detect aerosols. A LIDAR is a remote sensing instrument that uses light through the form of a laser to measure backscatter return from molecules and particles in the atmosphere.
- LIDARs use a laser to emit specific wavelengths in order to sense certain sized particles within the atmosphere. When the light is returned, one can detect aerosol backscatter where only a fraction of light that was transmitted returns after scattering off of the aerosols.
- Infrared LIDARs can detect aerosols because it uses a laser that emits a light into the atmosphere with a wavelength size that can detect particles approximately the size of that wavelength.

Materials and Methods:

Infrared Ground Based Lidar, Quantum Cascade Laser, Fiber laser Photodetector, Newtonian telescope, and MATLAB

Aerosols:

- Aerosols are solid or liquid particles suspended in a gas.
- Climate Effects:
  - -Direct : Scatters and absorbs sunlight back into space
  - -Indirect : A decrease in the radius and size of cloud droplets
    - ~An increase in the number of droplets in a cloud
- Health: Causes an increase in asthma, bronchitis, and heart and lung diseases
- Coarse Aerosols vary in size between 1-10 um. Examples are: Soot, Sulfate Aerosols (made when sulfur dioxide reacts with water vapor and other gases in the atmosphere), and dust.
- Aerosol backscatter occurs when light is scattered from a particle but only a partial amount of the light is scattered in the direction back towards the receiver.

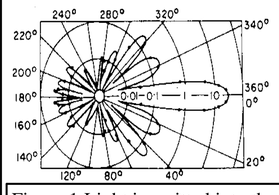

Figure 1:Light is emitted into the atmosphere and when it is returned only a fraction of what is emitted returns. http://www.dept.aoe.vt.edu/~devenpor/aoe3054/manual/expt4/

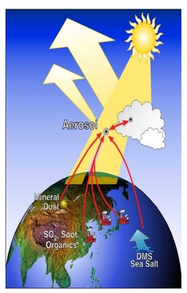

Figure 2: The sun sends off radiation to Earth, but the existence of aerosols causes radiation to be deflected back into space. This results in the cooling of the Earth. Source: http://saga.pmel.noaa.gov/Field/aceasia/prospectus/Image65.jpg

Figure 3: This is an image of the CCNY Ground Based Infrared LIDAR that was used to collect the data. Courtesy of Morann Dagan.

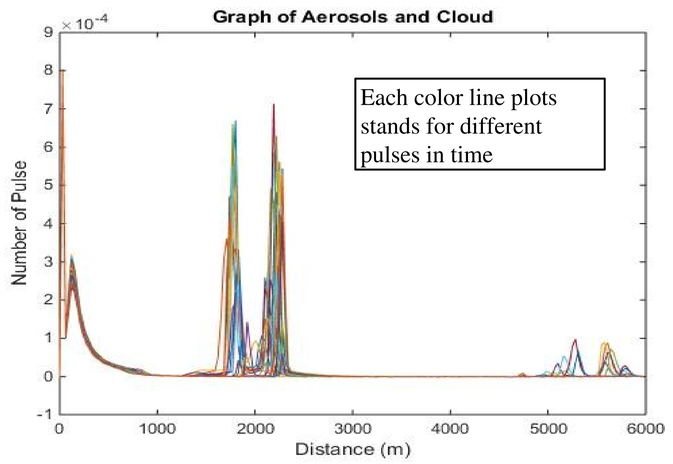

Figure 4: Line graph of aerosols and clouds and the number of pulses. The different colors represent the different pulses collected over time.

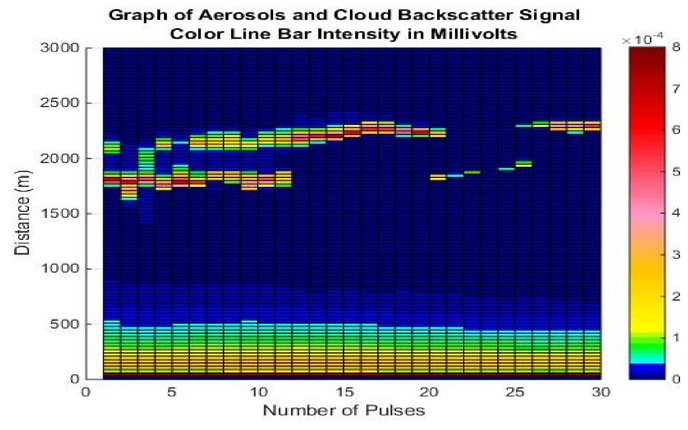

Figure 5 : The backscattered light collected from a LIDAR indicating aerosols below 1000 m and clouds at approximately 2000 m.

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LIDAR:

- A LIDAR can be used in airborne systems such as satellites and planes or as ground instruments

Parts:

- Transmitter- Light Source (laser)
  Provides laser pulses that rely on the application's needs. The LIDAR pulse varies for every application depending upon the study
- Receiver- Responsible for light collection and detection
  - collects returned backscattered light
  - consists of an optical telescope and photodetectors
- Data acquisition- turns signals into data and numbers

LIDARs in CCNY:

- The Raman LIDAR that is used at City College has three channels with wavelengths at 355 nm, 1064 nm, and 532 nm.
  - 355 nm - Displays Ultraviolet Light
  - 532 nm - Displays Green Light
  - 1064 nm - Displays Infrared
- The Coherent Doppler LIDAR system at CCNY enables a three dimensional view of the atmospheric aerosol content and wind profiling
- Infrared LIDAR has two lasers measuring 1.5 nanometers and 4.5 nanometers.

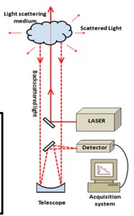

Figure 6: This is an image of a general LIDAR that demonstrates how the laser is transmitted into the atmosphere, and how backscattered light is returned. Courtesy of Benjamin Thomas

Conclusions:

- Infrared light from the electromagnetic spectrum transmits a longer wavelength than visible light. Therefore, while in the visible light a LIDAR can detect molecules and aerosols, an infrared LIDAR will only detect aerosols. This makes an infrared LIDAR a good tool for detecting aerosols based on the Mie scattering theory since the size of coarse aerosols is approximately the size of the wavelength of the laser source.
- In the data recorded and plotted, there were aerosols up to 900 feet up in the air, as shown in Figure 5.
- In the future, there will be an experiment using all the LIDARs in CCNY at the same time.

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