Radar and Lidar Sensing of Aerosols, Clouds, and Precipitation

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Radars and lidars estimate characteristics of atmospheric particles, namely, aerosol, clouds and precipitation at various temporal and spatial scales. Radars and lidars are active remote sensing instruments. The sensitivity of these instruments for detecting atmospheric particles is proportional to the concentration and average size of the particles.

Atmospheric particle sizes and concentration detected by these instruments span many orders of magnitudes. Lidars emit shorter wavelengths than radars. They detect and characterize atmospheric particles in the nanometer to millimeter size range. Lidar and radar measurements together provide a better characterization of shape, size, and composition of the atmospheric particles of sizes between μm and cm. Aerosols, clouds and precipitation particles are the primary constituents of the atmosphere.

Atmospheric remote sensing instruments transmit electromagnetic energy at various frequency bands between visible and microwave wavelengths. Visible frequency corresponds to 0.532 μm wavelength, and the lower end of the microwave frequency corresponds to 10 cm wavelength. Thus the range of transmit frequencies and wavelengths of remote sensing instruments span four orders of magnitudes. Minimum and maximum detection ranges of these instruments vary between 10 m and 300 km. Since the spatial structure of aerosol, clouds, and precipitation range between meters and kilometers, these instruments are designed to detect a wide range of temporal and spatial scales.

The transmitting energy pulse length determines the spatial resolution of the measurement. Shorter pulse lengths correspond to finer spatial resolution. Typically the transmitting pulse lengths vary between 25 ns and 1000 ns for resolving 1 m to 100 m scales. To cover a large volume and obtain a fine spatial resolution of atmospheric features, these instruments are designed to transmit the maximum allowable power. Radars are capable of pulsing megawatts of power at microwave frequencies, whereas lidars can transmit only kilowatts of power at visible wavelengths due to inherent engineering limitations and constraints for transmitting larger amounts of power.

This presentation will describe how lidar, cloud and precipitation radars detect atmospheric particles at various spatial and temporal scales. Examples of scientific products, namely, particle types, mean particle size, and liquid water contents derived from lidar and radar measurements will also be presented.