Optical remote sensing contributes to earth-atmosphere radiation research

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Observation of aerosols and clouds ongoing at Pune, a tropical station in India, has implications for global climate studies.

Optical remote-sensing techniques for observing aerosols and clouds have contributed profoundly to studies in the comparative incoming and outgoing radiative energy of Earth’s atmosphere. While a great deal of attention has been directed toward the influence of stratospheric aerosols on climate, the treatment of tropospheric aerosols, particularly in the boundary layer, is a difficult task, mainly due to their short lifetime in the atmosphere. Investigations indicate that the direct scattering of short-wave radiation by enhanced anthropogenic aerosol sources, together with the indirect influence of these aerosols through modification of cloud reflectance, produces a cooling effect similar in magnitude to the warming perturbations induced by anthropogenic gases. Aerosol measurements in the troposphere are important for climate studies on a regional scale, while those in the stratosphere play a major role in climate research on a global scale. Such studies in the tropics are particularly important because complex tropical processes—especially the convective motions and large vertical wind components associated with high-altitude thunderstorms—have an impact on global weather and climate. An observational program begun in the late 1980s at the Indian Institute of Tropical Meteorology (IITM) in Pune, India, aims to address these issues.

Active remote-sensing techniques, that is, those in which the user controls the transmission signal, are employed at IITM to monitor aerosol and cloud characteristics such as composition and aerosol shape.1–5 Light detection and ranging, or lidar, systems function here in both monostatic (monoaxial and biaxial mode) and bistatic configuration. A differential absorption lidar system is in use for ozone profiling,6 and a simple Raman technique for line-of-sight determination of trace gases has also been developed (see Figure 1). A bistatic helium-neon lidar was used to characterize aerosols in the lowest few hundreds of meters for a short period during 1985–86. Subsequently, an argon-ion lidar was put into operation in October 1986, and since then observations have been extended up to about 8km above ground level (AGL). This bistatic lidar has been fully computer-controlled since 1992, enabling real-time observations of aerosols and clouds. An argon-ion pumped dye lidar was added in 1993 to determine the space-time variations in aerosol size distribution through multiwavelength laser light-scattering experiments. Recently, a dual-polarization micropulse lidar capable of sounding the atmosphere up to about 120km AGL with tremendous spatial (30cm) and temporal (less than a second) precision has been installed with the aim of investigating aerosol-cloud-climate interactions. A monostatic transverse

Figure 1. Lidar systems monitor aerosols, gases, and clouds over Pune, a tropical station in India. DIAL: Differential absorption lidar. LOS: Line of sight.
excited atmosphere carbon-dioxide lidar was installed to enlarge the scope of the study of atmospheric aerosols, trace gases, and state variables such as winds up to stratospheric altitudes. Lidas are operated every Wednesday (Regular Geophysical Day) and also on Thursday to synchronize with the radiometersonde and ozonesonde measurements of the India Meteorological Department, also located at Pune.

Simultaneous measurements of aerosol and precursor gaseous optical depth using passive remote-sensing techniques, which rely on uncontrollable transmission input like sunlight, have been in practice at IITM since 1992 (see Figure 2). Total column measurements of aerosol optical depth, ozone, and precipitable water content are taken using different types of solar radiometers such as Microtops, a spectroradiometer, and sun-sky radiometers. An observational program records between two and seven vertical profiles during nighttime clear-sky conditions every month. By combining these active and passive remote-sensing methods, atmospheric aerosol, gas, and cloud measurements over Pune are being obtained day and night. The observational program is primarily aimed at construction of a long-term database for studying the possible influence of the vertical distributions of aerosols and clouds on the dynamical, physical, and radiative processes leading to climate variations in the locality, where meteorological conditions vary markedly from continental (winter) to maritime (summer) environments. Several results have been published using the multiyear database accumulated at IITM. The lidar and radiometric systems have been extensively used in several national and international campaigns as well as for developing methods to correct for atmospheric effects in satellite data retrieval techniques.

Future plans for optical remote-sensing work at IITM broadly include providing reference climatology against which to measure trends, removing effects of aerosols and gases from satellite atmospheric observations, and continuing to investigate the impact of aerosols and clouds on weather and climate.

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References


Figure 2. Solar radiometers record aerosol characterization and radiative forcing. SW: Short-wave. LW: Long-wave.