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THE APPLICATION OF LIDAR TO STRATOSPHERIC AEROSOL STUDIES

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The trend in stratospheric aerosol column mass and, in general, lidar peak backscatter ratio is driven by volcanic perturbations. During the period 1979 through 1982, a number of volcanic eruptions powerful enough to place material into the stratosphere occurred. The largest of these impacts, many times the others, was due to the March-April 1982 eruptions of El Chichon in Mexico. Fortunately, during this period of increased volcanic activity, both groundbased and airborne lidars and satellite instruments for measuring stratospheric aerosols were in place and operational. Seasonal variations are also observed in the stratospheric aerosol. In the polar regions during winter, for example, polar stratospheric clouds (PSC's) form in regions of cold temperatures at altitudes of about 100 mb to 30 mb. These PSC's are thought to form by growth of existing aerosol particles, and after the winter season and evaporation of the PSC's, the aerosol population reaches a relative minimum due to sedimentation of these particles and the subsidence of air that occurs in these regions. Large variations in stratospheric aerosols are also observed over short geographical distances in the polar regions in the absence of PSC's. These variations are associated with the polar night jet stream which defines the stratospheric polar vortex. In the winter months, a very strong vortex forms in the Antarctic region which is much more long lived and larger geographically than in the Arctic region. Isolation causes large variations of stratospheric aerosol to exist between the inside and outside of the vortex. The vortex dissipates later in the winter during a warming period, and aerosols from lower latitudes mix with those previously inside the vortex. At mid-latitudes, variations in stratospheric aerosols are also observed near regions of the downward transport of stratospheric air associated with tropopause folds. Evidence is also becoming available that aerosol layers at mid- and high latitudes at 20-30 km are appearing in the winter hemisphere originating from equatorial latitudes.

Studies of stratospheric aerosols are important to various disciplines. The understanding of the effects of aerosols on radiation budget and climate, heterogeneous chemistry (especially ozone destruction), and transport are examples. In addition, it has been shown that aerosols can be used as tracers for stratospheric diffusion, advection, sedimentation, and subsidence. Also, aerosols were shown to affect various remote sensors during the period after the 1982 eruption of El Chichon, producing artifacts in their data sets, which again shows the importance of properly understanding stratospheric aerosols on a global scale.

This paper will present the global climatology and present understanding of stratospheric aerosols evolving primarily from lidar and satellite measurements. The importance of validation of these remotely sensed data with in situ measurements will also be discussed. The advantages of lidar for providing high vertical and horizontal resolution and its independence from a remote source for measurement will become evident with examples of long-term lidar data sets at fixed sites and the use of lidar on airborne platforms. Volcanic impacts of the last 20 years will be described with emphasis on the last 8 years where satellite data are available. With satellite and high-resolution lidar measurements, an understanding of the global circulation of volcanic material will be attempted along with the temporal change of aerosol physical parameters and the stratospheric cleansing or decay times associated with these eruptions. Finally, through both satellite and airborne lidar measurements, the dynamics associated with the polar regions and characteristics of PSC's will be presented.