Surface-measured Trends of Aerosol Optical Depth as an Indicator of Stratospheric Aerosol Trends

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Measurements of aerosol optical depth (AOD) at five wavelengths in the visible and near infrared have been made at GMD's U.S. SURFRAD sites in concert with surface radiation budget measurements for the past 20 years. This valuable dataset has been used to assemble a modern AOD climatology for the U.S., quantify the second indirect effect of aerosols, and assess the mean surface radiative forcing of aerosols. AOD time series from each SURFRAD station show recurring features such as a minimum in winter, maximum in summer, and a secondary maximum in Spring from strong baroclinic springtime storms in the U.S. and the transport of Asian dust from similar storms in the dry regions of northwest China and Mongolia. An unexpected feature is that all stations show a slow increase of their annual AOD minimum from the beginning of the dataset (1997) to about 2011, followed by a dramatic decrease to the present (see figure). Given that AOD minima represent a very clean troposphere, could those trends in AOD minima be indicative of trends in stratospheric aerosol loading? Until the early 2000s, the general belief was that only explosive equatorial volcanoes affected aerosol loading in the stratosphere. Proof of the contribution of minor extratropical volcanic eruptions to stratospheric aerosols came with the launch of the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) space-borne lidar in 2006. Time series of CALIOP data averaged over the northern hemisphere (30°N - 60°N) show distinct trajectories of plumes from several northern hemisphere eruptions entering the stratosphere between 2006 and 2011, and a dramatic clearing thereafter. The influence of each plume lasted only on the order of months but sequential eruptions within that period kept the stratosphere populated with volcanic aerosol. When compared to the magnitude of stratospheric AOD, the ground-based AOD minima are greater because they include background-level tropospheric aerosol loading. However, the trends of the surface-based AOD minima show a similar behavior as trends of stratospheric AOD. AOD minima from stations with more turbid atmospheres are noisier and show trend magnitudes that differ from those in the stratosphere. However, trends in annual AOD minima from cleanest SURFRAD site (Desert Rock, Nevada) match those of stratospheric aerosol quite well and may serve as a useful proxy.

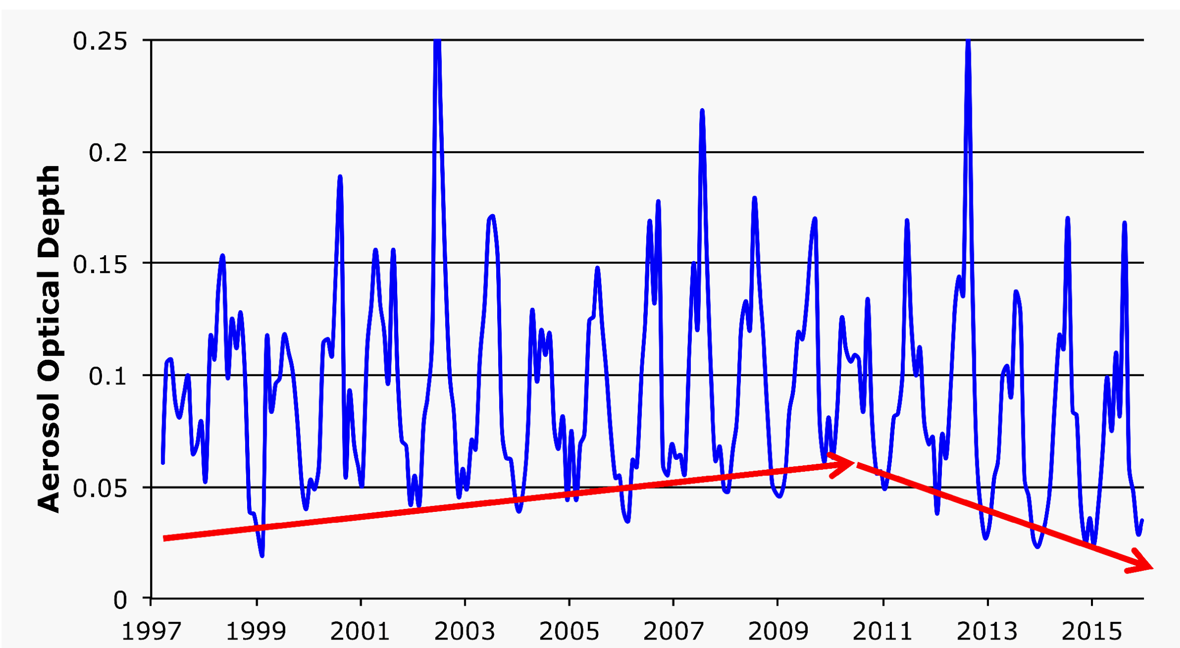

Figure 1. Time series monthly mean 500 nm aerosol optical depth for the Table Mt., Colo. SURFRAD site. Red arrows indicate direction of trends of AOD minima.