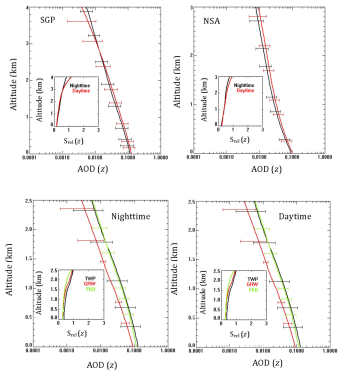
Micropulse Lidar-Derived Aerosol Optical Depth Climatology at ARM Sites Worldwide

Research Highlight

One of the largest uncertainties in estimating the impact of aerosols on atmospheric radiative forcing and cloud-aerosol interactions is due to lack of sufficient observational data describing vertical profiles of aerosol particles and aerosol optical depth (AOD). For the first time, a climatology of the vertical distribution of AOD (z) from micropulse lidar (MPL) observations, operating at 532 nm, for climatically different locations worldwide was obtained during the four-year period 2007–2010 at five different U.S. Department of Energy Atmospheric Radiation Measurement (ARM) Climate Research Facility sites—three permanent sites (Southern Great Plains [SGP] in north-central Oklahoma; Tropical Western Pacific [TWP] at Darwin, Australia; in the tropical western Pacific; and North Slope of Alaska [NSA] at Barrow, Alaska) and two ARM Mobile Facility (AMF) sites (GRW at Graciosa Island in the Azores and FKB in Germany's Black Forest). The MPL data were combined with an independent measurement of surface AOD obtained from a nearly collocated multifilter rotating shadowband radiometer (MFRSR) system to derive the AOD (z) profiles.

Most aerosols were found to be confined to 0–2 kilometers (approximately the planetary boundary layer [PBL] region) at all sites; however, all sites exhibited measurable aerosols well above the mixed layer, with different height maxima. The entire data set demonstrates large day-to-day variability at all sites. Significant inter-annual variability was observed at the SGP site. Clear seasonal variations in AOD (z) profiles exist for all five sites. The lower annual mean AOD (z) values (0.093±0.033 for daytime and 0.093±0.05 for nighttime) observed near the surface at GRW are not unexpected for maritime aerosols (mostly sea salt), and the corresponding higher values at SGP (0.118±0.038 for daytime and 0.11±0.05 for nighttime), FKB (0.124±0.042 for daytime and 0.127±0.047 for nighttime) and TWP (0.13±0.078 for daytime and 0.14±0.073 for nighttime) are usual for continental aerosols. The annual mean AOD (z) values observed near the surface during daytime and nighttime for NSA were 0.1±0.042 and 0.09±0.037, respectively.

These results from regular, extensive observations in diverse climate regimes are relevant to improved understanding of aerosol properties and boundary-layer dynamics, as well as to improving global climate models by incorporating aerosol radiative effects. These AOD (z) profiles will also serve as constraint to calculate the value-added product (VAP) for solar heating rates at various altitudes in the atmosphere at different ARM sites. Therefore, ARM scientific community will benefit because of both the nighttime and daytime availability of these results.



Vertical profiles of multi-year annually averaged AOD (z) at different ARM sites: SGP, NSA, TWP, GRW, and FKB. Inset plots are the profiles of corresponding relative standard deviation, Srel (z). The corresponding 1-sigma measurement errors are given in horizontal bars.

Reference(s)

Kafle DN and RL Coulter. 2013. "Micropulse lidar-derived aerosol optical depth climatology at ARM sites worldwide." Journal of Geophysical Research – Atmospheres, , . ACCEPTED.

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Working Group(s)

Aerosol Life Cycle