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Toward the interpretation of geological dust records: Links between surface wind speed and particle size distribution in the atmospheric column

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Dust emitted from desert environments into the atmosphere is one of the most abundant aerosols (about 70% of the total aerosol dry mass), affecting the Earth's climate through radiative forcing and by altering biogeochemical processes of terrestrial and oceanic ecosystems. Geological records of dust from ice cores, deep sea sediments and loess deposits are often used as indicators for past changes in environmental conditions, documenting a variety of processes such as emission, transport and deposition. One assumption that has been made with respect to the interpretation of these dust records is that an increase in the average particle size indicates stronger winds in the source regions. Although measurements confirm this assumption for the saltation layer (for grain sizes $>$60 um) and the near surface atmospheric layer, no observational proof is available for the long-range transport of dust toward remote ocean basins or glaciers, which normally occurs at higher altitudes.

In this study, we use surface observations of particle size distributions and other dust properties derived from 13 Robotic Aerosol Network (AERONET) sites located in arid environments of North Africa and the Middle East. AERONET observations of dust properties are based on the whole atmospheric column above the saltation layer. Multiple measurements are available during day time covering periods of several years within the last decade. The AERONET data are compared with contemporaneous surface wind speed and visibility observations from meteorological stations close (average within 40 km) to the AERONET sites.

We show that at most AERONET sites the median particle size is in the range of 1-2 um, which is in contrast to many marine core measurements that show average particle sizes in the range of 4-8 um. Differences in the measurement techniques are discussed. We also show that the median particle size significantly increases with wind speed at most stations (an exception is Banizoumbou where the opposite was observed). Analyses regarding specific wind directions vary between sites. Surprisingly, AERONET measurements turned out to be available for wind speeds of up to 10 m/s only, which can be traced back to the instruments (CIMEL) inability to take measurements during stronger dust haze conditions when the sun was blocked. This previously ignored measurement threshold has important implications for the dust community because AERONET measurements are often used as a validation dataset for global and regional dust models and in other studies related to atmospheric dust variability.