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Influence of diurnal cycle of aerosol optical properties on clear-sky aerosol direct radiative effect and forcing

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Aerosols influence the Earth's radiation budget directly by scattering and absorbing solar radiation (direct radiative forcing) and indirectly by modifying the microphysical properties and lifetimes of clouds (indirect forcing). Radiative forcing by aerosols is considered as one of the largest uncertainties in the current understanding of anthropogenic radiative forcing of climate. The influence of anthropogenic aerosols on radiative fluxes is usually defined as aerosol radiative forcing, which is distinguished from the aerosol radiative effect of the total aerosol (natural plus anthropogenic).

Usually both the aerosol direct radiative effect (ADRE) and the aerosol direct radiative forcing (ADRF) calculations are based on either monthly or daily averaged aerosol optical properties. In this study we analyzed the influence of systematic daytime variations of aerosols on ADRE and ADRF estimates at the top of atmosphere (TOA) and bottom of the atmosphere (BOA). We included all the available data from the Aerosol Robotic Network (AERONET) and calculated for each site the seasonal mean diurnal cycle, as a mean departure of AOD from the daily mean at each hour of local solar time. We also considered the possible systematic differences of single scattering albedo between morning and afternoon measurements. We then calculated, in a seasonal basis, diurnally averaged clear-sky ADRE at TOA and BOA with two different assumptions: assuming diurnally constant aerosol optical properties and taking into account the observed local diurnal cycles. We also made an attempt to estimate the influence of these diurnal aerosol cycles on ADRF, by using the anthropogenic AOD fractions from Oslo CTM-2 global aerosol model. The analysis resulted in a wide range of variability in ADRE and ADRF estimates based on these two assumptions about diurnal variability in aerosol optical properties, while the mean influence from all the sites was relatively small (e.g. about on average of 0.1 W/m^2 increase in ADRE at TOA, if the diurnal cycles are taken into account). In addition, we discuss the regional patterns and possible reasons of estimated ADRE variability due to the assumed diurnal aerosol cycles.