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Radiation closure and diurnal cycle of the clear-sky dust instantaneous direct radiative forcing over Arabian Peninsula

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To better quantify radiative effects of dust over the Arabian Peninsula we have developed a standalone column radiation transport model coupled with the Mie calculations and driven by reanalysis meteorological fields and atmospheric composition. Numerical experiments are carried out for a wide range of aerosol optical depths, including extreme values developed during the dust storm on 18-20 March 2012. Comprehensive ground-based observations and satellite retrievals are used to estimate aerosol optical properties, validate calculations and carry out radiation closure. The broadband surface albedo, fluxes at the bottom and top of the atmosphere as well as instantaneous dust radiative forcing are estimated both from the model and from observations. Diurnal cycle of the the shortwave instantaneous dust direct radiative forcing is studied for a range of aerosol and surface characteristics representative for the Arabian Peninsula. Mechanisms and parameters responsible for diurnal variability of the radiative forcing are evaluated. We found that intrinsic variability of the surface albedo and its dependence on atmospheric conditions along with anisotropic aerosol scattering are mostly responsible for diurnal effects. We also discuss estimates of the climatological dust instantaneous direct radiative forcing over land and the Red Sea using two approaches. The first approach is based on the probability density function of the aerosol optical depth, and the second is based on the climatologically average Spinning Enhanced Visible and Infrared Imager (SEVIRI) aerosol optical depth. Results are compared with Geostationary Earth Radiation Budget (GERB) derived top of the atmosphere climatological forcing over the Red Sea.