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The different effects of aerosol and clouds on surface solar radiation

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Aerosol-radiation interactions not only change in average surface temperature, but also modulate atmospheric dynamics resulting from increased stability of Plenary Boundary Layer (PBL) and deteriorate air quality. The global average AOD is 0.126 during 2003 to 2012 and peak AOD could reach to 3 in North China Plain in January, 2013, under severe haze condition. Compared to that, annual average cloud optical thickness (COD) ranges from 5 to 20, much larger than AOD. Based on above facts, it is assumed that cloud play a more significant role in PBL development than aerosol does. To verify this assumption, we performed simulations using single-column model (SCM) version of the Weather Research and Forecasting (WRF) mesoscale meteorological model. The main physical options selected in this study included the Pleim-Xiu land-surface model, the Rapid Radiative Transfer Model for GCMs (RRTMG) radiation schemes for both longwave (LW) and shortwave (SW) radiations, and the Asymmetric Convective Model version 2 (ACM2) for the planetary boundary layer. Firstly, optical depth (τ), single scattering albedo (SSA, ω), and asymmetry factor (ASM, g) of aerosol and cloud, which are essential parameters in radiation estimation, were compared in this study. Then, the impacts of aerosol and cloud on downward solar radiation were simulated. Their sensitivities to initial condition, aerosol size and composition, and zenith angle were also analyzed. Our results show that the overall impacts of cloud on solar radiation and PBL height is larger than that of aerosol. While under same optical depth, such impact of cloud is one order of magnitude smaller than that of aerosol. This study highlights that multiple factors (e.g. SSA, ASM) should be taken into consideration in PBL development evaluation rather than optical depths only.