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Assessing lidar ratio impact on CALIPSO retrievals utilized for estimating aerosol shortwave direct radiative effects over the NAMEE domain

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One of the most vulnerable regions to climate change is the NAMEE (North Africa Middle East Europe) domain, hosting a variety of aerosol species of both natural and anthropogenic origin. This is one of the reasons why NAMEE constitutes an ideal region for assessing the aerosol-induced direct radiative effects (DREs) within the Earth-Atmosphere system. The overarching goal of the present study is to estimate clear-sky shortwave DREs via a holistic approach involving spaceborne retrievals, radiative transfer simulations and aerosol/radiation observations. We emphasize on the importance and sensitivity of the aerosol-speciated lidar ratio (LR) on calculating DREs. Our main dataset consists of CALIOP-CALIPSO backscatter coefficient vertically resolved retrievals (Level 2, Version 4.20) extracted from the LIVAS (LIdar climatology of Vertical Aerosol Structure for space-based lidar simulation studies) database (2007-2020). Besides the CALIPSO aerosol optical depth (AOD) retrieval, the aerosol-speciated LRs based on the newly developed DeLiAn database, a collection of state-of-the-art ground-based measurements acquired by lidars operating at different regions of the world affected by various aerosol types, are also applied to the CALIPSO backscatter coefficient profiles for the calculation of a more representative AOD. Through a series of quality assurance filtering we conclude to 550 case studies collocated against ground-based AERONET stations characterized by either dust, marine, polluted continental/smoke, elevated smoke or clean continental aerosol layers according to the latest CALIPSO (V4) aerosol classification algorithm scheme. For the radiative transfer simulations, the libRadtran Radiative Transfer Model (RTM) is implemented for the spectral range of 250–5000 nm using a 4-stream plane parallel approximation. The CALIPSO aerosol-speciated AOD profiles at 532 nm along with lookup tables of spectrally resolved optical properties extracted from the AERONET almucantar

retrievals make up the aerosol RTM inputs. For the surface inputs, the MODIS snow-free BRDF/albedo dataset and the libRadTran built-in IGBP albedo library are utilized. The columnar concentrations of ozone and water vapour are extracted from the MERRA-2 reanalysis. The simulated solar fluxes at TOA and at the surface are evaluated against satellite (CERES) and ground-based (BSRN) observations for cloudless conditions, respectively. Our key finding is that the consideration of the DeLiAn-based LR leads to more representative DREs and improves the simulated solar fluxes when mineral particles dominate.

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