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# Sensitivity of the aerosol direct radiative effect on the aerosol layer height

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Atmospheric aerosols are one of the largest sources of uncertainty for climate change and the perturbation of the Earth's radiative budget. The climatic role of aerosols is determined by their radiative effect, which in turn is sensitive to the detailed vertical profile of the aerosol optical properties. Such vertically resolved aerosol data are available nowadays through the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) on board the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite. In this study we investigate and quantify the sensitivity of the aerosol direct radiative effect (DRE) to the use of detailed vertically-resolved aerosol data. The aerosol DRE under both all-sky and clear-sky conditions is computed using the deterministic spectral radiative transfer model FORTH. We use AOD from the CALIOP Level 2 Version 4.10 profile product as input to our radiation transfer model, for a period of 3 complete years (2007-2009). We use cloud data from the International Satellite Cloud Climatology Project (ISCCP), while the aerosol asymmetry factor and single scattering albedo are taken from the Max-Planck-Institute Aerosol Climatology version 2 (MAC-v2).

The aerosol DRE is computed a) based on the original CALIOP AOD profile and b) assuming that the vertical AOD profile is characterized by an exponential decrease with globally constant scale heights of 1, 2 and 3 km. The exponential AOD profiles are scaled in order to have the same columnar values with the CALIOP data. Comparing the DREs calculated from the CALIOP AOD profile and the exponential "standard" profiles, we found that the aerosol effects within the atmosphere (columnar) and at the Top Of the Atmosphere (TOA) are much more sensitive to the selected aerosol profile than the aerosol effect at the surface. On a mean annual level, the aerosol DREs calculated with exponential AOD profiles are generally similar to those derived from CALIOP data, especially when the assumed scale height is 2 km. The changes in the DREs are found to be primarily associated with the type of aerosols and their altitude relative to clouds. When relatively absorbing aerosols are located higher, the outgoing shortwave radiation at TOA decreases, due to the enhancement of the particle absorption of UV and Visible radiation. This process intensifies when clouds (especially low) are present, due to the increase of the above-cloud aerosol load. On the other hand, when scattering particles are located higher we found an increase of the outgoing radiation at TOA (enhancement of the cooling effect), due to the decrease of the NIR absorption by atmospheric gases below aerosols.