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Application of different 3D radiative flux parameterizations in the global atmospheric circulation model ECHAM 5

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Radiative transfer calculations in climate models are usually based on 1D radiative transfer routines using plane parallel clouds. Vertical variability is accounted for by assuming maximum or random overlap of adjacent cloud layers or a combination of both. Horizontal variability in cloudy layers is not accounted for as no information about subgrid variability of cloud parameters is passed to the radiative transfer routines of GCMs. This study presents first results of a radiative transfer parameterisation originally developed by Schewski and Macke (2003) (Schewski-Parameterisation, SP) applied to different ECHAM5 data sets and compares the radiative fluxes to those computed by the model internal radiative transfer routines. The SP has been derived from 3D Monte-Carlo radiative transfer calculations using a mesoscale cloud model (GESIMA) and therefore fully accounts for 3D radiative transfer effects. In the first part the comparison of the differences between the SP and ECHAM5 is used to improve the parameterisation. By comparing snapshots and seasonal mean values it is shown that the corrected SP produces a higher absorptivity and lower reflectivity of the atmosphere compared to ECHAM5 radiative transfer routines whereas transmissivity shows deviations of both signs. Despite the fact that transmissivity, reflectivity and absorptivity are parameterised independently the SP does not violate energy convservation. The global annual mean SW energy budget from ECHAM5 and the SP will be discussed and compared to corresponding results from Kiehl und Trenberth (1997). The last part of this work analyses timeseries and diurnal variability in different climate regimes and shows that even a simple cloud type like marine Stratocumulus exhibits large differences in the radiative properties when a parameterisation accounting for 3D radiative effects is applied.