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The role of three-dimensional radiative transfer on cloud formation

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Formation of convective clouds is driven by heating of the surface which is controlled by the incident solar radiation. Radiation transfer and therefore the distribution of the surface irradiance, in particular reduction in cloud shadows and enhancement between clouds, depends on cloud geometry, cloud liquid water content and cloud droplet size distribution. Three-dimensional radiative transfer codes provide an accurate way to calculate the irradiance distribution, but their high computational demands inhibit their use in practical applications. For an accurate yet fast calculation of the surface irradiance, a tilted independent pixel approximation (TIPA) method has been developed and validated by comparison with a detailed three-dimensional radiative transfer code. In contrast to the widely employed plane-parallel or independent pixel approximations, the TIPA correctly approximates mean values and the spatial distribution. The radiation scheme has been implemented into the anelastic non-hydrostatic large eddy simulation model EuLag (Smolarkiewicz and Margolin, 1997). The feedback of incoming solar surface radiation on cloud formation is represented by adaptation of the surface sensible heat flux to the calculated solar irradiance. By comparing simulations with and without differential surface heating the influence on cloud formation is investigated.