Process-based climate model development harnessing machine learning: III. The Representation of Cumulus Geometry and their 3D Radiative Effects

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We analyze the role of cloud geometry parameters (vertical overlap, horizontal heterogeneity and cloud size) that appear in the parameterization of radiation. The solar component of a radiative transfer scheme that includes a parameterization for 3D radiative effects of clouds (SPARTACUS) is run on an ensemble of input cloud profiles synthesized from LES outputs. The space of cloud geometry parameter values is efficiently explored using the High-Tune:Explorer tool. SPARTACUS is evaluated by comparing radiative metrics to reference values provided by a 3D radiative transfer Monte Carlo model. The best calibrated configurations yield better predictions of TOA and surface fluxes than the one that uses parameter values computed from the 3D cloud fields: the root-mean-square errors averaged over cumulus cloud fields and solar angles are reduced from ~ 10 W/m² with LES-derived parameters to ~ 5 W/m² with adjusted parameters. However, the errors on absorption remain around 2 to 4 W/m².