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Evaluating and improving model predicted top-of-atmosphere radiation and cloud parameters over Africa using observations from GERB and SEVIRI

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In this paper we compare the KNMI Regional Atmospheric Climate Model version 2 (RACMO2) with satellite data by simultaneously looking at cloud properties and top-of-atmosphere (TOA) fluxes. We use cloud properties retrieved from Spinning Enhanced Visible and Infrared Imager (SEVIRI) data and TOA short-wave and long-wave outgoing radiative fluxes measured by one of the Geostationary Earth Radiation Budget (GERB) sensors. Both SEVIRI and GERB resolve the diurnal cycle extremely well with 96 images per day. To test the physical parameterizations of the regional climate model, which is equipped with the physics package of the ECMWF model, including cycle 31 or alternatively cycle 33, we have applied the model to a domain enclosing Africa and part of the surrounding oceans. Simulations for July 2006, forced at the lateral boundaries by ERA-Interim re-analyses, show generally accurate positioning of the various cloud regimes, but also some important model-observation differences, which we have tried to reduce by altering model parameterizations. These model-observation differences are: 1) TOA albedo differences in clear-sky regions like the Sahara and southern Africa. These differences could considerably be reduced by prescribing the surface albedo from MODIS satellite data. 2) A considerable overestimation in the version carrying cycle 31 physics of outgoing long-wave radiation within the continental ITCZ caused by the fact that modeled cirrus clouds are far too thin. 3) Underestimation by the model of cloud cover, condensed water path and albedo of the stratocumulus fields off the coast of Angola. We reduced these underestimations by suppressing the amount of turbulent mixing above the boundary layer, by prescribing droplet radii derived from SEVIRI data and by assuming in-cloud horizontal homogeneity for the radiation calculations. 4) Overestimation by the model of the albedo of the trade wind cumulus fields over the Atlantic Ocean. We argue that this overestimation is likely caused by a model overestimation of condensed water path. In general, our analyses demonstrate the power of the simultaneous evaluation of the TOA fluxes and cloud properties.