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Comparison of an Upgraded Multiscale Modeling Framework Simulation with Merged CERES, CloudSat, CALIPSO and MODIS (C3M) Data

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This study presents a comparison of a two-year upgraded multiscale modeling framework (MMF) simulation with two-year satellite observations of cloud and radiative properties from an merged CERES, CloudSat, CALIPSO and MODIS (C3M) data set. The upgraded MMF has an advanced third-order turbulence closure in its cloud-resolving model (CRM) component that replaces a first-order turbulence closure in the original MMF. Differing from a traditional general circulation model (GCM), an MMF uses a CRM for representing cloud physical processes in each grid box of the GCM. Thus, a detailed description of cloud horizontal and vertical structures becomes a reality. Whether or not the simulated clouds are realistic needs to be validated with the state-of-the-art satellite data set like C3M that provides 3-D characterization of clouds from CloudSat and CALIPSO satellites. The C3M data set also provides radiative fluxes at the top-of-the atmosphere, surface and a few vertical levels within the atmosphere from CERES and MODIS sensors on Aqua satellite.

The global distributions of low-level cloud amounts in the subtropics in the upgraded MMF simulation show substantial improvement relative to the original MMF when both are compared to C3M. The cloud vertical structures show strong resemblance in the shallow cumulus and stratocumulus regimes. But the cloudiness in the (vertically-thin) stratus regime is underestimated due to the poor vertical resolution of the model. The upgraded MMF simulation also shows a close agreement in the vertical structures of liquid water content of midlatitude storm-track clouds and subtropical low-level clouds, compared with C3M observations. Since the upgraded MMF simulation does not produce excessive large amount of high-level clouds in both the tropics and midlatitudes as in the original MMF, the global mean albedo decreases. This characteristic of the upgraded MMF simulation reduces the positive bias in albedo and longwave cloud radiative forcing (CRF) and negative bias in shortwave CRF in the tropical convective regions of the original MMF simulation, compared to C3M observations.

A sensitivity simulation with a higher resolution in the lowest 3 km will be performed soon to further improve the performance of the upgraded MMF. Offline CRM testing shows that the increased vertical resolution is most beneficial to the stratus cloud regime. It is hoped that this will be the case in the MMF simulation. The new MMF results will be presented at the meeting.