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Climate and cloud response of the Super-Parameterized Community Atmosphere Model with additional super-parameterization of low clouds

Marat Khairoutdinov
Stony Brook University, School of Marine and Atmospheric Sciences, Stony Brook, United States
(marat.khairoutdinov@stonybrook.edu)

A multiscale-modeling framework (MMF) is the class of general circulation models (GCMs) in which the effects of unresolved-by-GCM-grid cloud processes are explicitly represented by a cloud-resolving model (CRM), also known as super-parameterization (SP), inserted into each column of the GCM grid. Traditionally, due to high computational cost, the SP in MMFs has usually been configured to run with grid spacings that are, in general, barely sufficient to represent deep and extensive convective systems. As the result, the effects of small shallow clouds and, to a lesser extent, mid-level clouds in MMFs have generally been underestimated. The situation is particularly aggravated by the notion that the shallow low clouds are believed to have particularly important feedbacks in the Earth's climate system.

A simple decrease of horizontal grid spacing from a few kilometers to a few hundred meters keeping the domain size unchanged is prohibitive as it would increase the already high computational cost of running the MMF by about a factor of a hundred. One of the solutions, which is currently being explored by various modeling groups, is to use some sophisticated higher-order parameterization of shallow clouds; however, the whole premise of super-parameterization has been to minimize parameterization of cloud dynamics as much as possible under assumption that cloud feedbacks are better represented by the dynamically and physically consistent CRMs rather than by parameterizations based, for example, on the entraining-plume model.

In this study, several global climate simulations are performed using the super-parameterized Community Atmosphere Model (SP-CAM) that employs an additional super-parameterization nicknamed (perhaps misleading) as MiniLES, to better represent the low-level shallow clouds with the horizontal grid spacing of a few hundred meters. In particular, the SP-CAM/MiniLES MMF seems to significantly improve the simulation of the observed low-cloud global climatology over the traditional SP-CAM with less than a factor-of-two increase of computational cost. The climate sensitivity of the new model as estimated from the response to SST anomaly derived from one of the IPCC AR4 future-change projections, will also be discussed.