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Coupling the GCM and CRM components in the quasi 3-D MMF

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A new framework for modeling the atmosphere, which is called the quasi 3-D (Q3-D) multiscale modeling framework (MMF), has been recently developed with the objective of including cloud-scale three-dimensional effects in a GCM without necessarily using a global cloud-resolving model (CRM). The preliminary tests following the single-column modeling approach show that the Q3-D algorithm can reproduce most of the important statistics of the 3D solutions. The main merit of the Q3-D MMF is that it can converge to a 3-D global CRM as the resolution of GCM approaches that of CRM. Consequently, the Q3-D MMF can be applicable to any resolution of GCM down to that of CRM without changing the formulation of model physics. In view of the convergence of the Q3-D MMF to a 3-D CRM, it is very important how to coupling the dynamics of the two model components. In the prototype MMF, the coupling strategy is such that the effect of large-scale processes is given to the CRM component in the form of forcing and the large-scale fields are adjusted to the horizontal average of the cloud scale effects simulated by the CRM. In the Q3-D MMF, however, the CRM grid extends beyond the GCM grid cell so that it can represent large-scale dynamics at least partially and therefore the CRM can generate its own large-sale forcing. Thus, if the coupling strategy of the prototype MMF is followed directly, the problem of "double counting" of large-scale dynamic processes in the Q3-D MMF is inevitable. This paper discusses various approaches in coupling the GCM and Q3-D CRM based on numerical experiments with the Q3-D MMF that has a non-trivial GCM, using an idealized setting with a domain of a few thousand kilometers.