The Impact of Dimensionality on Barotropic Processes during KWAJEX

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In this study, the two-dimensional (2D) and three-dimensional (3D) cloud-resolving model simulations of the Tropical Rainfall Measuring Mission (TRMM) Kwajalein Experiment (KWAJEX) are compared to study the impact of dimensionality on barotropic processes during tropical convective development. Barotropic conversion of perturbation kinetic energy is associated with vertical transport of horizontal momentum under vertical shear of background horizontal winds. The similarities in both model simulations show that (1) vertical wind shear is a necessary condition for barotropic conversion, but it does not control the barotropic conversion; (2) the evolution of barotropic conversion is related to that of the vertical transport of horizontal momentum; (3) the tendency of vertical transport of horizontal momentum is mainly determined by the horizontal transport of cloud hydrometeors. The differences between the 2D and 3D model simulations reveal that (1) the barotropic conversion has shorter time scales and larger amplitudes in the 2D model simulation than in the 3D model simulation; (2) kinetic energy is generally converted from the mean circulations to perturbation circulations in the 3D model simulation. In contrast, more kinetic energy is transferred from perturbation circulations to the mean circulations in the 2D model simulation; (3) there is no statistical relation in barotropic conversion between the 2D and 3D model simulations.. The same large-scale vertical velocity may account for the similarities whereas the inclusion of meridional winds in the 3D model simulation may be responsible for the differences in barotropic conversion between the 2D and 3D model simulations.

Keywords: Cloud-resolving model, barotropic conversion, vertical wind shear

