Summary

Effects of ice clouds on barotropic and baroclinic processes over the deep tropical convective regime are examined through the analysis of differences in budget of perturbation kinetic energy between the control and sensitivity two-dimensional cloud-resolving model simulations. The sensitivity experiment excludes ice hydrometeor and associated microphysical processes. Both experiments are imposed by large-scale forcing from Tropical Ocean Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE) (Fig. 1). The exclusion of ice clouds generally enhances baroclinic conversion from perturbation available potential energy and reduces barotropic conversion from perturbation kinetic energy to mean kinetic energy (Figs. 2 and 3). The analysis of the root-mean-squared difference and linear correlation coefficient using data of difference budget between sensitivity and control experiments reveals that while baroclinic conversion processes play a major role in budget difference, barotropic conversion processes show a significant modification in the tendency difference in perturbation circulations (Fig. 4). While both experiments are imposed by the same large-scale forcing, the difference in barotropic conversion between the two experiments is associated with the difference in vertical flux of zonal momentum (Fig. 5). The differences in vertical flux of zonal momentum and barotropic conversion are positively correlated near the surface whereas they are negatively correlated in the mid and upper troposphere (Fig. 6). The differences in tendency of vertical flux of zonal momentum and zonal flux of ice hydrometeor have the smallest root-mean-squared difference, indicating that the difference in zonal flux of ice hydrometeor accounts for the difference in tendency of vertical flux of zonal momentum (Fig. 7).

Perturbation kinetic-energy budget

\[
\frac{\partial K}{\partial t} = C_1(\overline{K}, K) + C_2(\overline{K}, K) + C_3(\overline{P}, K) + G_1(P) + G_2(P)
\]

\[
K = \frac{1}{2} (u' + w')^2
\]

\[
C_1(\overline{K}, K) = -\frac{\overline{\rho w'w}}{\overline{G}}
\]

\[
C_2(\overline{K}, K) = -\frac{\overline{w'w}}{\overline{G}}
\]

\[
Perturbation kinetic-energy budget

\[
Perturbation kinetic-energy budget

Budget of vertical flux of zonal momentum

\[
BKEC_2 = BKEC_1 - \rho u'w'
\]

\[
BKEC_2 = BKEC_1 + \frac{\partial}{\partial t} BKEC_2 + BKEC_2_{31} + BKEC_2_{32} + BKEC_2_{33}
\]

\[
BKEC_2_{31} = -\rho g\frac{\partial T}{\partial z}
\]

\[
BKEC_2_{32} = -0.61\rho g\frac{\partial q}{\partial z}
\]

\[
BKEC_2_{33} = \rho g\frac{\partial q}{\partial z}
\]