Geophysical Research Abstracts
Vol. 14, EGU2012-3841, 2012
EGU General Assembly 2012

A Preliminary Analysis of the Structure of a Northeast cold vortex and the Mechanism for its Evolution

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The thermodynamic and dynamic structure of a northeast-cold-vortex and its changes in the associated three-dimensional currents and cloud-series characteristics are analyzed using the NCAR/NCEP reanalysis data, the data from FY2C and CloudSat as well as the conventional observations, and a preliminary investigation into the possible mechanism responsible for the genesis and development of the vortex is addressed in this paper. The results show that the cold-core structure of the cold vortex is initiated at the higher levels and then extended downwards. The cold vortex at its mature stage shows a cold-core structure throughout the troposphere with the cold centre located in the mid-higher troposphere above which (i.e. in the lower stratosphere) there exists a warm-core structure. On both the eastern and western sides of the centre the updrafts tilt to the outside with height with the longitudinal winds tending to symmetrize. At the initial stage the temperature trough lags behind the height trough with its axis tilting toward the west, showing a strong baroclinity. During its maturity the temperature centre tends to coincide with the height centre with the axis tending to be vertical. The axis-line tilts toward the west again at the stage of decay owing to a distinct reduction of the northerly in the lower levels. The generation of the cloud bands associated with the cold vortex is substantially caused by the low-level convergence zone. The analytic results based on the data from the satellite CloudSat show that there are a lot of the convective cloud clusters of heterogeneous pattern developed within the cold vortex circulation. The genesis and development of the cold vortex are closely related with the dynamics of the formation and the intensification of the cut-off low in the mid-upper troposphere and of the gradual coupling with the corresponding depression at the surface. It is found that a dipole forms around the cold vortex centre as a result of the spiral mutual migration of updrafts and downdrafts by the warm and cold air, respectively, and that the downward extension of the upper cold air plays a key role in the development of the cold vortex. Crossing through the isobaric surfaces, the upper dry cold currents intrude downward, along the isentropic surface, into the area near the cold vortex centre, which is able to cause the cold vortex to develop and maintain its structure of cold core. The mechanism responsible for dry intrusion can, in nature, expressed as the intrusion and downward extension of high potential vorticity. This demonstrates an important indicative implication in forecasting the development and evolution of a cold vortex.