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Generation and development of a polar low under the influence of a vortex aloft

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Polar lows are mesoscale cyclones that develop over high-latitude oceans in winter. The influence of an upper-level vortex on the generation and development of a polar low is investigated through numerical simulation in an idealized atmosphere.

In previous works which focus on this mechanism, the initial configuration is modeled by an upper-level vortex upstream of a lower-level vortex, and the importance of the relative distribution of these vortices has been shown. However, it is possible that a lower-level disturbance is formed by the influence of an upper-level disturbance. Therefore, it is investigated whether a lower-level disturbance is initiated by an upper-level vortex to develop into a polar low. The three-dimensional nonhydrostatic model simulated the polar low that is spinuped due to the influence of upper-level vortex and developed into a polar low with comma-shaped cloud pattern.

The process of formation of lower-level vortex due to upper-level vortex is investigated. Two mechanisms have been suggested in formation of a surface disturbance due to upper-level vortex. One is that a surface vortex is stretched by the upward motion aloft driven by the upper-level vortex and the other is that a surface vortex is stretched by surface potential temperature deviation in association with potential temperature advection, where the lower-level baroclinicity is emphasized. Considering that the condensation is of less importance in the generation stage of a polar low, the results of a dry-experiment without moist process are analyzed. It was shown that lower-level vortex is formed by the stretching in association with upward motion aloft driven by the upper-level vortex. On the other hand, the vortex moves southward so that the latter mechanism did not contribute to the formation of the lower-level vortex.

The southward displacement of the lower-level vortex was investigated. In this experiment, polar low moves not only eastward but southward during the most part of the calculation time, although it displaces northward a little in its mature stage. It was found that the northward displacement of the vortex is caused by a vorticity stretching on the northern side of the vortex due to the active convection with condensation, while an existence of an anticyclone vortex behind the vortex which form a vortex pair caused the southward displacement of the vortex.

Keywords: polar low, vortex aloft, baroclinicity, comma-shaped cloud