Moist baroclinicity: a unifying perspective on polar low development

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Current ideas on the dynamical processes associated with polar low development are diffuse: postulated theories cover a broad spectrum between baroclinicity and convection, and the dynamical importance of upper level features during polar low development remains unclear.

A potential dominant forcing mechanism for polar lows is the the so-called Diabatic Rossby Vortex (DRV). A DRV consists of a solitary low-level vortex developing in a moist baroclinic environment, its growth rate depending both on the moisture content and baroclinicity. To gain insight into the dynamics of polar lows, we hypothesize that a significant fraction of polar low formation and intensification events is captured by this mechanism.

The advantage of the DRV mechanism over the currently proposed mechanism for polar low development is that it is a coherent dynamical structure based on both baroclinic and convective processes, and as it is independent of the far field the presence of an upper level disturbance in not essential.

To evaluate the applicability of the DRV mechanism to polar low development the WRF model is utilized. The setup is composed as an idealized baroclinic channel constituting environmental baroclinicity defined by a zonal jet and moisture content defined by relative-humidity profiles. Initiation of the polar low is achieved by superimposing a small, warm-core, cyclonic surface disturbance to the setup. This tool enables us to evaluate the DRV mechanism in the whole range of environmental conditions known to be conducive for polar low development.

The experiments are evaluated in terms of typical structural characteristics of the DRV and realistic polar low development on temporal and spatial scales. The relative importance of the generation of eddy available potential energy by diabatic versus baroclinic processes is used to differentiate between the dynamical processes contributing to disturbance growth.