The Role of the Polar Vortex in Whole Atmosphere Coupling

V. Lynn Harvey[1,2], C. E. Randall[1,2], E. Becker[3], L. Goncharenko[4], J. France[1,5], C. Bardeen[1,6]
[1]*University of Colorado Laboratory for Atmospheric and Space Physics, Boulder, CO.*
[2]*University of Colorado Atmospheric and Oceanic Sciences Department, Boulder, CO.*
[3]*Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany.*
[4]*Massachusetts Institute of Technology, Haystack Observatory, Westford, MA.*
[5]*GATS, Inc., Boulder, CO.*
[6]*National Center for Atmospheric Research, Boulder, CO.*

The polar vortices play a central role in vertically coupling the atmosphere from the ground to geospace by shaping the background wind field through which atmospheric waves propagate. For a variety of reasons, the geographic distribution of gravity wave (GW) activity depends on the strength and shape of the polar vortex (e.g., see Figure 1). GWs generated in the troposphere break in the mesosphere, decelerate the flow, and launch a new spectrum of "secondary" and "tertiary" GWs that can propagate up into the thermosphere. These higher order GWs are largely unaccounted for in global models.

Energetic particle precipitation (EPP) generates nitrogen oxides ($NOx=N+NO+NO_2$) in the mesosphere-lower thermosphere (MLT) polar regions. In the wintertime, the polar vortices play a key role in downward coupling the thermosphere to the stratosphere by focusing the descent of EPP-NOx within its interior. State-of-the-art global climate models severely underestimate EPP-NOx transport during disturbed Arctic winters.

This talk will first present the current state of understanding regarding the role of the polar vortex in coupling different atmospheric layers. Vortex characteristics at both stratospheric and mesospheric altitudes will be shown. Unexpected variability in the mesosphere will be highlighted, including recent results that indicate a contraction of the mesospheric vortex following large planetary wave disturbances in the stratosphere. Comparisons will be made between the mesospheric vortex based on satellite observations and in the "Specified Dynamics" version of the Whole Atmosphere Community Climate Model.

Outstanding questions and future directions will be discussed. Namely, "Do secondary GWs act to vertically extend the polar vortex to higher altitudes?", "Are GWs at the polar vortex edge related to traveling ionospheric disturbances?", and "Do Lagrangian Coherent Structures in the MLT impact the descent of EPP-NOx?"

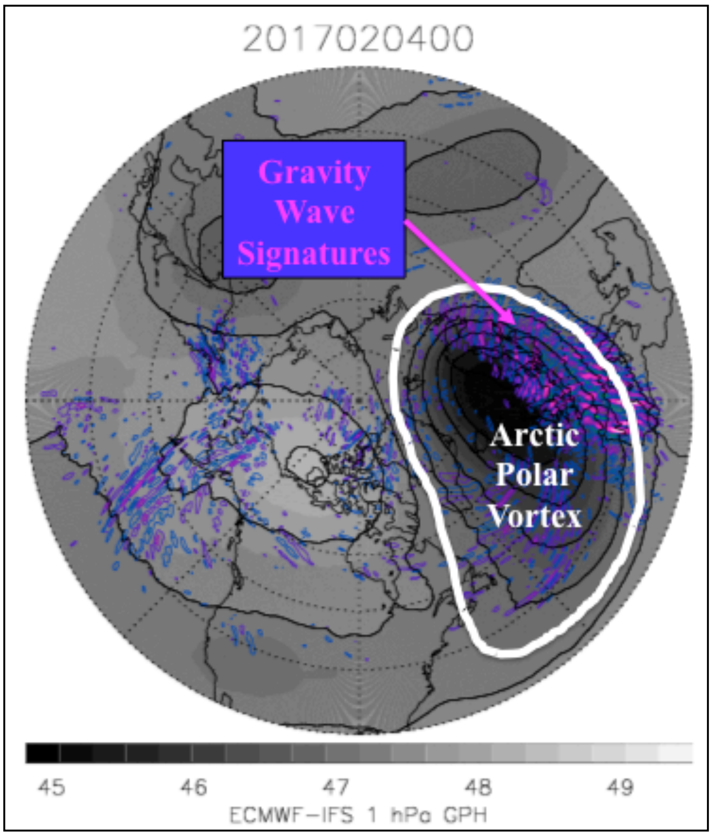

Figure 1. Northern Hemisphere polar map of ECMWF geopotential height (gray shading) and gravity wave signatures in the vertical velocity field (pink/purple) near the stratopause on 4 February 2017 at 00UT.

References

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