Instabilities on model polar vortices generated in a rotating tank source-sink configuration

Tony Vo,[1] Luca Montabone[2] and Gregory J. Sheard[1]

1. Department of Mechanical and Aerospace Engineering, Monash University, VIC 3800, Australia
2. Atmospheric, Oceanic and Planetary Physics, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom

Abstract

The fundamental instabilities which form on polar vortices are discussed in this talk. Polar vortices are large-scale structures that reside at the poles of planets with atmospheres. Numerical models of these vortices are generated using a rotating tank source-sink model which represents a segment of the polar stratosphere. The simultaneous radial injection and withdrawal of fluid plus the rotation of the tank generates vortical structures which are visually similar to those seen in atmospheres.

This presentation focuses on the fundamental instabilities in the flow, which are explored via linear stability analysis and direct numerical simulation. The flow is solved using an axisymmetric spectral-element solver and a three-dimensional spectral element Fourier solver. Variation in two controlling parameters, poleward flow rate and Reynolds number, presents a wide range of structures exhibiting different dominant azimuthal wavenumbers on the polar vortex. We characterize the flow using two flow-dependent parameters, the Rossby and Ekman number. The observed azimuthal wavenumbers typically range from 2 to 6, in agreement with observed structures in various planetary atmospheres. For many cases, there are indications that non-linear effects are significant, with continuous competition between multiple wavenumbers over time.