Horizontal Coriolis Vector: When Can We Neglect It?: A f-Plane Analysis

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Under the traditional approximations, the horizontal component of the Coriolis vector is neglected in large-scale atmospheric modelling. [A major exception to this rule is the UK Met Office Unified Model.] Almost any standard textbook assures us this is a valid approximation. A simple scale analysis can just suggest us that so long as the aspect ratio of the atmosphere is small enough (as the case with the standard parameters) this horizontal Coriolis vector can be neglected.

However, a straight linear-wave analysis on the f-plane shows that the
wave dispersion relationship is clearly different in large-scale limit (i.e. limit of vanishing horizontal wavenumber) between the cases with and without the horizontal component of the Coriolis vector. For this reason, Gerkema and Shrira (2005, JFM) suggest that the effect of the horizontal Coriolis vector constitutes a singular perturbation.

The goal of the present talk is to elucidate what kind of singularities is involved for generating such an un-intuitive wave-dispersion behavior. The key starting point of the analysis is to realize that in the large-scale limit, all the waves reduce to the inertial oscillations without horizontal structures specified. This is a state of degeneracy in the same sense as in the classical quasi-geostrophic problem. In order to resolve this degeneracy, we have to proceed to a higher-order of the equation system, to that order the horizontal Coriolis vector plays a critical role.

The full analysis will be presented during the talk.