Stability, compressible Rossby waves and failure of the anelastic model

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Abstract

The configuration under interest is that of Rayleigh-Bénard in the presence of a background rotation. In the compressible regime, a lateral density gradient plays a role analogous to the classical beta effect and the first mode of instability is a travelling Rossby mode when a critical Rayleigh number is reached. In that configuration we have studied the linear stability of the full compressible model and also the linear stability of the anelastic model. In the anelastic model, the temporal variations of density perturbations are discarded in the continuity equation. Considering different planetary rotations, characterized by an Ekman number, Rossby waves of different frequencies are generated. It is then possible to investigate when the anelastic model departs significantly from the full compressible model in terms of critical Rayleigh number and frequency of the Rossby waves at the threshold for convection. This happens when the frequency of Rossby waves exceeds a value intermediate between the inverse of thermal and viscous diffusion timescales. The relevance of the study will be discussed in the context of both the dynamics of the Earth's core and in an experimental design we are currently working on.

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