Geophysical Research Abstracts, Vol. 9, 02881, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02881

Stochastic Baroclinic Instability

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The dynamics of baroclinically unstable waves in a steady zonal shear flow in the framework of the two-layer Phillips model has been well studied (Pedlosky, 1987). Even though any physical system will have some time variation, there are some cases when the stability of the time-averaged state is comparable to that of the time dependent state. It is for these cases that the analysis of the steady basic state is useful. The stability of time dependent states is harder to analysis and consequently is not nearly as prominent in the literature.

Recently, Pedlosky and Thomson (2003) studied the linear stability of the two-layer Phillips model when the shear velocity oscillates periodically in time, as may arise in systems with tidal forcing. This is perhaps the simplest type of time variation, however even this scenario demonstrates that time variation can significantly alter the stability properties of a basic state. They, as well as others, have observed that linear waves can either be stabilized or destabilized when subject to an oscillatory basic state when compared to the time averaged state. Since then Flierl and Pedlosky (2007) addressed the nonlinear dynamics that arises from linearly unstable oscillatory state.

In this work we will present our recent findings of the nonlinear dynamics of baroclinically unstable waves that arises due to a basic state that changes stochastically in time. Erratic variations, which we idealize to be random, are common in nature and thus understanding the stability of such systems is of real importance. Our work studies both a simple truncated model as well as the fully nonlinear Phillips model. We will demonstrate not only that instability can occur in this stochastic system but we will also illustrate the structure of the growing instability and the nonlinear saturation.