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Title: Dynamics of Baroclinic Wave Systems

Investigators:

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Significant Accomplishments in the Past Year:

The research carried out in the past year dealt with nonlinear baroclinic wave dynamics. The model consisted of an Eady baroclinic basic state and uneven Ekman dissipation at the top and bottom boundaries with/without slopes. The method of solution used a truncated spectral expansion with three zonal waves and one or two meridional modes. Numerical experiments were performed on synoptic scale waves or planetary scale waves with/without wave-wave interaction.

(1) **Wave-wave vs. wave-mean flow interactions in an Eady-type model.** The relative importance of wave-wave interaction versus wave-mean flow interaction in the dynamics of baroclinic flows is examined by means of numerical experiments. It is shown that in some parameter regions where both solutions with and without wave-wave interaction have the same steady single-wave state, wave-wave interaction does not play a role in determining the equilibrium state of the flow at that parameter setting. This region is not necessarily near the marginal curves. In some other parameter regions, wave-wave interaction may destabilize a baroclinic flow, resulting in more temporal and spatial degrees of freedom of the flow. Therefore, wave-wave interaction may reduce the region of steady waves while enlarging the region of aperiodic flows in the parameter space. The experiments also show that, in a multi-wave system, the dependency of the final state on the initial condition is generally larger in a flow with wave-wave interaction than that in a flow without.

(2) **The effect of sloping boundaries with Ekman dissipation in a nonlinear baroclinic system.** A modified Eady channel model with sloping top and bottom Ekman layers is used to examine the effect of sloping boundaries on baroclinic flows in a linear and nonlinear systems with/without wave-wave interaction, respectively. In the linear system, the sloping boundaries render the linear waves dispersive, stabilize unstable waves, and may shift the most unstable wavenumber to a higher one. In nonlinear systems, when wave-wave interaction is absent, the sloping boundaries reduce the region of vacillation and aperiodic flows, and enlarge

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the region of single-wave steady wave where the preferred nonlinear wavenumber may also be shifted to a higher one by the slopes. When wave-wave interaction is included, most flows are destabilized. At some parameter settings, multi-steady wave states are observed in which the resultant flow exhibits vacillation. This additional mechanism of vacillation, besides the mechanism due to pure baroclinic instability, is caused by the interference of these steady waves which translate with different phase speeds. In contrast to the system without wave-wave interaction, the region of vacillation in a nonlinear system with wave-wave interaction is enlarged. The effect of sloping boundaries on both linear and nonlinear baroclinic waves is similar, in some sense, to the β-effect due to variation of Coriolis parameter with latitude in two-layer models.

Focus of Current Research and Plans for Next Year:

We are not currently supported by NASA. The new research for the next fiscal year, starting October 1988, is **Potential Vorticity Index.**

(1) We will calculate potential vorticity on specific isentropic surfaces (IPV) for Northern Hemisphere, from both GLA and ECMWF FGGE data sets. The comparison between these two data sets will be performed through all the proposed data analyses.

(2) We will do data analyses of the IPV climatology and try to find the relationship between IPV systems and blocking and cyclogenesis for Northern Hemisphere.

Papers supported by NASA grant NAG 8-075 in the Past Year:

(1) Weng, H.-Y. and A. Barcilon, 1988: Wavenumber selection for single-wave steady states in a nonlinear baroclinic system. *J. Atmos. Sci.*, **45**, 1039 – 1051.

(2) Weng, H.-Y. and A. Barcilon, 1988: Wavenumber transition and wavenumber vacillation in Eady-type baroclinic flows. *Quart. J. Roy. Meteor. Soc.*, in the **July** issue.

(3) Weng, H.-Y., 1988: Wave-wave interactions in an f-plane baroclinic model. Submitted to *Tellus*

(4) Weng, H.-Y., 1988: The effect of sloping boundaries with Ekman dissipation in a nonlinear baroclinic system. Submitted to *Quart. J. Roy. Meteor. Soc.*

Presentations:

Some of the above work was presented by A. Barcilon at: Imperial College, Cambridge University, Bristol University, University of Reading, UK; Laboratoire de Meteorologie Dynamique, Paris; NCAR, University of Miami.