N93-20073

Basic Studies of Baroclinic Flows

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a. <u>STRATEGY</u>: The combination of differential heating and rotation can result in numerous regimes of fluid flow, depending upon boundary conditions, etc. Of particular interest are baroclinic instabilities, including nonlinear behavior. Laboratory experiments and numerical models will be jointly used to study basic physical processes that are important in the Earth's atmosphere with the objective of contributing toward a better understanding of the requirements for and application of space-based sensor measurements and to develop a better understanding of methods for modeling the behavior of the Earth system, especially the atmosphere.

b. <u>PROGRESS</u>: A fully nonlinear 3-dimensional numerical model (GEOSIM), previously developed and validated for several cases of geophysical fluid flow, has been used to investigate the dynamical behavior of laboratory experiments of fluid flows similar to those of the Earth's atmosphere. The phenomena investigated are amplitude vacillation, and the response of the fluid system to uneven heating and cooling. The previous year's work included hysteresis in the transition between axisymmetric and wave flow. Investigation is also continuing of the flows in the Geophysical Fluid Flow Cell (GFFC), a low-gravity Spacelab experiment.

Much of the effort in the past year has been spent in validation of the model under a wide range of external parameters including nonlinear flow regimes. With the implementation of a 3-dimensional upwind differencing scheme (using a weighted average of upwind and centered differencing), higher spectral resolution, and a shorter time step, the model has been found capable of predicting the majority of flow regimes observed in one complete series of baroclinic annulus experiments of Pfeffer and co-workers. Detailed analysis of amplitude vacillation has revealed that the phase splitting described in the laboratory experiments occurs in some but not all cases. Through the use of animation of the model's output, a vivid 3-dimensional view of the phase splitting was shown to the audience of the Southeastern Geophysical Fluid Dynamics Conference in March of this year.

A study on interannual variability was made using GEOSIM with periodic variations in the thermal forcing. Thus far, the model has not predicted a chaotic behavior as observed in the experiments, although there is a sensitivity in the wavenumber selection to the initial conditions. Work on this subject, and on annulus experiments with non-axisymmetric thermal heating, will continue.

The comparison of GEOSIM's predictions with results on the Spacelab 3 GFFC experiments continued over the past year, on a "back-burner" basis. At this point, the study (in the form of a draft of a journal article) is nearly completed. The results from GEOSIM compared very well with the experiments, and the use of the model allows the demonstration of flow mechanics that were not possible with the experimental data. For example, animation of the model output shows that the forking of the spiral bands is a transient phenomenon, due to the differential east-west propagation of convection bands from different latitudes.

c. PLANS: The numerical model will continue to be used to investigate amplitude vacillation and nonaxisymmetric heating. Publications will be developed. The investigators will also begin to investigate shape vacillation, and hysteresis in wavenumber and other transitions. Comparison between model predictions and flows observed in the GFFC experiment on Spacelab 3 will be completed, and suggestions for future experiments on USML-2 will be developed.

d. BIBLIOGRAPHY:

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