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g. Abstract:

"Thermally driven flows in rotating laboratory containers with cylindrical geometry can be axially symmetric or they can be wavelike, depending on experimental parameters. In the traditional regime diagram of thermal Rossby number versus Taylor number the region of axially symmetric motion is separated from the regime of wavelike motion by a knee-shaped boundary. The simplest theoretical model that predicts the shape of this curve is due to Barcilon (1964) and consists of the Eady model of baroclinic instability applied to a rotating channel with Ekman layers at the top and bottom. Anticipating that rotating fluid experiments might soon be done in spherical shell geometry, we have extended Barcilon's model to a beta-plane channel. The purpose of our study is to predict with a simple model the changes which the beta-effect should produce in the shape and position of the boundary separating the regions of axially symmetric and wavelike motion."

A model experiment of the general circulation of the atmosphere has been proposed for Spacelab by Marshall Space Flight Center scientists. In this experiment a fluid will be confined between two concentric spheres subject to rotation and to a radial electrostatic force field that simulates the (radial) field of terrestrial gravity. The driving force for motions in this model of the earth's atmosphere will be a latitudinal gradient of temperature applied at the lower boundary (that is, the inner sphere). In this experiment the rotation models the spin of the earth and the latitudinal temperature gradient models the equator-to-pole temperature gradient. In the earth's atmosphere, the observed response to this differential latitudinal heating is axially-asymmetric (that is, dependent on longitude). Some of this asymmetry is due to the presence of axial asymmetry in the lower boundary (mountain ranges; continents and oceans). The remainder is thought to be due to a particular type of instability of fluid flow known as baroclinic instability. Present opinion is that even in the absence of mountain ranges, continents, and oceans the response of the atmosphere would be axially-asymmetric because of baroclinic instability of the (hypothetical) axially-symmetric response.

The proposed spacelab experiment contains no analogue of topography, continents, and oceans. Thus, if the response of the fluid is to resemble the response of the atmosphere, the experimental parameters must be such that the response is baroclinically unstable. The scientific objective of the work supported under this contract was to employ simple mathematical models to establish the allowable range of experimental parameters that permit a baroclinically unstable response. The answers obtained by this study furnish some guidance for design of the experiment, but are not definitive. More realistic mathematical models will be used in future contract work in order to refine these answers.

This work has been published in a reviewed journal. A copy of this journal article is attached. All results are presented in diagrams and are described in the text. These results are summarized in the last two pages of the article. The title of the article is "Theoretical Regime Diagrams for Thermally Driven Flows in a Beta-Plane Channel." The abstract of this article appears on the title page of this report.