SCIENTIFIC MANAGEMENT AND IMPLEMENTATION OF THE GEOPHYSICAL FLUID FLOW CELL FOR SPACELAB MISSIONS.

Supported Under CONTRACT NAS-8-31958

(NASA-CR-161612) SCIENTIFIC MANAGEMENT AND IMPLEMENTATION OF THE GEOPHYSICAL FLUID FLOW CELL FOR SPACELAB MISSIONS Quarterly Progress Report, period ending 30 Sep. 1980 (Colorado Univ.) 5 p HC A02/MF A01 CSCL 22A G3/12

N81-12123

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QUARTERLY PROGRESS REPORT

For the period ending 30 September 1980

Prepared for the NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MARSHALL SPACE FLIGHT CENTER AL 35812

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GEOPHYSICAL FLUID FLOW CELL
Quarterly Progress Report
Contract NAS08-31958

1. Scope of Work

Under contract NAS-8-31958 the University of Colorado GFFC team (Profs. Hart and Toomre, Department of Astro-Geophysics, Dr. Gilman, High Altitude Observatory, and associates) is developing scientific support for the spherical convection experiment to be flown on Spacelab III. This experiment takes advantage of the zero-gravity environment of the orbiting space-laboratory to conduct fundamental fluid flow studies concerned with thermally driven motions inside a rotating spherical shell with radial gravity. Such a system is a laboratory analog of large scale atmospheric and solar circulations. The radial body force necessary to model gravity correctly is obtained by using dielectric polarization forces in a radially varying electric field to produce radial accelerations proportional to temperature. This experiment will answer fundamental questions concerned with establishing the preferred modes of large scale motion in planetary and stellar atmospheres.

2. Work accomplished during the quarter 1 July, 1980 - 30 September, 1980

During this quarter we had expected to receive a test film from the GFFC experiment so we could begin to fine tune our data analysis software. However, this film did not arrive until early October. Thus our research work during this quarter focused on several theoretical problems aimed at providing further input for scenario selection, and generating background theoretical support for the extension of GFFC results to planetary atmospheres.

a) The linear stability studies of Hathaway, Gilman, and Toomre, that gave parameter values for which one might expect axisymmetric cloud bands on a rotating sphere heated differentially in both radius and lattitude, were extended to the non-linear regions. There it was found that the linear theory underestimated slightly the region of parameter space that favored axisymmetric rolls. However, the general character of the non-linear solutions obtained numerically indicates that pure roll-like solutions are hardly ever found. Usually non-axisymmetric plume-like objects occur near the equator, and a small number of axisymmetric jets appear at mid-latitudes.

b) Two-dimensional compressible convection calculations were continued. These model studies seem to indicate that for convection over several scale heights (probably up to 10, certainly for 4), the structure of the convection cells is qualitatively very similar to the Boussinesq case typical of the GFFC experiment. These results suggest that for statically unstable situations, the GFFC model may give qualitatively useful results concerning deep atmospheric convection.

c) Theoretical models for wave-number selection in non-rotating convection were continued. The main goal is to explain the fact that in many geophysical systems (convection in the planetary boundary layer, mantle convection), the convection cells have very small aspect ratios (height/width). The usual Benard model of convective instability predicts an order one aspect ratio. However the Bernard model has a rigid upper lid. It has been found that for penetrative convection, where thermally driven motions encounter a stable layer aloft, the entrainment of stable air from above modifies the net buoyancy work so that cells prefer (grow faster at) longer wavelengths.

3. <u>On-going and future work for the next quarter</u>

a) We shall continue our non-linear study of the 2-gradient convection problem. These further numerical calculations shall include more longitudinal wavenumbers, and some shall focus on the GFFC geometry ($1/r^5$ gravity, hot pole) directly. Although it is impossible to say too much conclusively from a small number of numerical experiments with perhaps special truncation and initial condition properties, we feel that a fairly reliable parameter space map for planetary convection can be obtained, and can be used to specify key experiments for the GFFC.

b) Two runs of the fully non-linear convection code will be made, including precessional effects as will be encountered aboard the space shuttle. These will be made for the fastest rotation rate expected for GFFC, the maximum wing-out-of-plane angle, and for two supercriticalities: one near critical and one very supercritical. These preliminary calculations will indicate if precession will quantitatively modify the GFFC dynamics from those of pure convection control cases. In fact we will simply take previous GFFC solutions and continue them in time, turning on precession and see if there are any significant changes.

c) The 2-D compressible convection model calculation and the penetrative convection instability study will be continued.

d) The test film received from Aerojet will be examined by the TV-digitizer constructed previously. In particular we will first make sure we can decode the dot matrices, then we will concentrate on inverting the shadowgraph images to get temperature contours of the motions.

4. Problem areas

None.