SOME NUMERICAL EXPERIMENTS FOR THE SIMULATION OF THE ATMOSPHERIC AND OCEANIC CIRCULATIONS

By

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To those from whom I've learned;
And to my father.

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PREFACE

Various mathematical models in the recent years have been formulated to study certain phenomena in the atmosphere (i.e., frontogenesis and cyclogenesis) and in the ocean (i.e., westward intensification of oceanic gyres) by using different vertical coordinates. Though the normalized pressure coordinate, the sigma system (Phillips, 1957), has provided an efficient treatment of the lower boundary condition, the frontal surfaces resolved much better when modelled in isentropic coordinates (entropy constant). The most attractive feature of the isentropic surfaces is the non-existence of a vertical motion field under adiabatic conditions. This implies that the isentropic surfaces act like material surfaces in the free atmosphere.

This thesis has been divided into two parts. Part I includes mainly the development of a new mathematical model in isentropic coordinate system where we provide an efficient treatment of the lower boundary condition to overcome the difficulties arising due to the intersection of isentropes with the earth's surface. Here we have employed an enstrophy conserving finite-difference scheme to solve the governing equations of the model atmosphere. In this part of the thesis some numerical simulation experiments and real data (FGGE IIIb, data, 1979) analysis for a hydrostatic, inviscid and adiabatic atmosphere have been conducted for the atmospheric circulation. The results are discussed for different experiments which differ in their definition of initialization.

Numerical integration experiments with a primitive equation model in isentropic coordinates are also performed to investigate the influence of orography on cyclone formation. Results obtained in the presence of an isolated mountain in different locations in a baroclinic channel atmosphere are illustrated.

Part II deals with a finite element approach to the wind driven ocean circulation study. In the past, the numerical solutions of the wind-driven ocean circulation problems have mainly been achieved by the finite difference or analytical methods. In recent years finite element methods have begun to be used in calculations of fluid dynamics. These methods have the advantage over the finite difference method when the calculations are complicated by the presence of irregular boundaries. For a model barotropic ocean subject to a sinusoidal wind stress, the governing equations contain only two parameters, one a measure of friction and the other is a measure of non-linearity. This system is solved for different relative values of key parameters and the results are discussed here.

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