TITLE: Variational Objective Analyses for Cyclone Studies

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SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-84

I. Theoretical development of the first analysis model (Model I).

The basic analysis equations, i.e., the two horizontal momentum equations, the hydrostatic equation, and the integrated continuity equation were derived for the nonlinear vertical coordinate, non-dimensionalized, and expressed in finite differences on a staggered grid. Special care was taken to transform the hydrostatic equation and the pressure gradient terms of the horizontal momentum equations to nearly eliminate truncation error over steeply sloping terrain. This formulation also eliminated explicit reference to orographically induced variations in the thermodynamic variables so that the variational adjustments are on the scale of the meteorological perturbations.

The analysis equations were subjected to the Euler-Lagrange operations as expressed for finite differences and an additional set of five partial differential equations was derived, bringing to nine the number of equations in Model I. Higher order terms, terms containing observed quantities, and terms containing none of the variables to be adjusted were grouped into forcing functions and the equations were solved for the zero-order terms. Zero-order variables were eliminated between these equations and there resulted two diagnostic equations which take the form of general linear second-order partial differential equations with non-constant coefficients. These will be solved with standard relaxation methods.

FOCUS OF CURRENT RESEARCH ACTIVITIES

The major current research activity is the translation of the Model I equations into computer code. This task has been broken into five program modules that are small enough to fit on the University of Illinois CYBER computer. The five program modules contain the following:

a. Terms and equations that need be calculated only once,

b. Equations that are calculated at one cycle below the highest cycle,

c. Equations that solve 3-dimensional, 2nd order partial differential equations with nonconstant coefficients,

d. Equations that are at the highest cycle level, and

e. Equations that monitor the convergence of the method.

In addition, an objective analysis of the 3-h AVE-SESAME I data set covering all of the United States east of 105 degrees west (except for New England) is underway. This analysis will serve as an independent data set to compare with the output from Model I. The analysis uses a modified Barnes method on a 40 x 25 x 10 grid with a horizontal grid spacing of 100 km and a vertical grid spacing of 100 mb above 700 mb. The analysis is done on the nonlinear sigma coordinate surfaces for three levels between the surface and 700 mb.

PLANS FOR FY-85

We plan to develop the theory and computer code a second variational objective analysis model (Model II), and to complete the performance analysis of Model I. Model II will contain the energy equation as an additional constraint.

PUBLICATIONS PREPARED SINCE JUNE 1983

Achtemeier, G. L.: An experiment in variational objective analysis for a limited area wind field. Accepted with revisions by J. Atmos. and Oceanic. Tech.

Achtemeier, G. L., Ochs, H. T., and S. Q. Kidder: A diagnostic numerical model for the application of satellite data for the study of global weather systems. To be presented at the Conference on Satellite Meteorology/Remote Sensing and Applications 25-29 June 1984.