RESEARCH ON DIABATIC INITIALIZATION

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The objective of this research is to contribute to the improvement of the analyses of irrotational wind and moisture fields in the tropics through advancement in the technique of initialization by incorporating diabatic effects.

Significant accomplishments in the past year (May 1990–April 1991)

Estimation of the uncertainty of daily synoptic analyses in the tropics

In order to learn where weakness exists in the present objective analysis procedures, we have conducted the intercomparison of three different FGGE analyses produced by ECMWF (European Center for Medium-Range Weather Forecasts) and NMC (National Meteorological Center) for the period of 26 January to 11 February 1979. One notable finding is that, while FGGE has succeeded in describing the quasi-rotational state of the atmosphere, further improvement is necessary to accurately describe the diabatically driven irrotational circulations in the tropics (Kasahara and Mizzi, 1990).

Normal modes of Laplace's tidal equations for zonal wavenumber zero

In conjunction with the normal mode initialization procedure, it became necessary to investigate which form of normal modes is appropriate for the zonal wavenumber zero component. We compared the characteristic differences between the two sets, one derived by A. Kasahara [*J. Atmos. Sci.*, **35** (1978), 2043–2051] and another by Y. Shigehisa [*J. Meteor. Soc. Japan*, **61** (1983), 479–493]. This work was done jointly with Dr. H. L. Tanaka, University of Alaska, Fairbanks (Tanaka and Kasahara, 1991).

Tropical initialization to ameliorate the spin-up problem of precipitation forecasts

In order to ameliorate the precipitation spin-up problem (prediction models' inability to produce realistic precipitation rates at the beginning of the forecast period), we investigated the impact of a tropical initialization procedure on precipitation forecasts.

The procedure is divided into the three components: 1) Application of diabatic nonlienar normal mode initialization (NNMI), 2) Modification of the initial divergence by incorporation of satellite imagery data [Kasahara *et al.*, *Mon. Wea. Rev.*, **116** (1988), 866–883], and 3) Modification of the moisture and temperature fields by the cumulus initialization scheme [Donner, *Mon. Wea. Rev.*, **116** (1988), 377–385]. Numerical experiments were conducted by running 10.5 hour forecasts (42 time steps), starting from various initial conditions after application of some combination of the three initialization components. A triangular-42 version of the NCAR global spectral model (CCM1) and its associated NNMI package were used. The results of a case study from reanalyzed FGGE Level III data show that 1) even if a good estimate of diabatic heating rates were available, diabatic NNMI alone would not solve the spin-up problem, 2) the adjustments of moisture and temperature using the cumulus initialization are essential to ameliorate the spin-up problem, and 3) the divergence adjustment, assisted by satellite imagery data, is beneficial when used in conjunction with the cumulus initialization and diabatic NNMI procedures (Kasahara, Mizzi, and Donner, 1991).

Focus of Current Research and Plans for Next Year

Improvement in the analyses of vertical velocity and water vapor fields in the tropics

Accurate analyses of large-scale vertical velocity and water vapor are needed to describe and to predict the weather systems involving cloud and precipitation processes. Although the current data assimilation systems are satisfactory in the Northern Hemisphere, the analyses of horizontal divergence and moisture are unreliable in the tropics and the Southern Hemisphere.

We need a revolutionary idea to improve the analyses of atmospheric state in the tropics. In fact, it has been noted that satellite temperature and humidity soundings (SATEMs) are no longer giving a significant impact on analyses and forecasts in the Northern Hemisphere, due primarily to large errors of SATEM data and to improvement in the prediction models used for data assimilation.

The idea we are pursuing is that the analysis quality of the rotational wind (or vorticity) and mass (or temperature) in the tropics will be improved through the synergetic effects of four-dimensional data assimilation, which will produce a better prediction of the vorticity by improving the analysis quality of the divergence and moisture.

Clearly, we need more accurate wind observations, and various new wind measurement techniques are coming on the horizon. Similarly, observational programs to

measure tropical rainfall, such as one being planned by the Tropical Rainfall Measuring Mission (TRMM), will improve our understanding of tropical convection activity, as well as obtaining diabatic heating information in the tropics. However, we should not delay our efforts to improve the analyses of the vertical velocity and moisture until then, since we can still ameliorate current deficiencies by using the vast amounts of infrared and visible radiometric imagery data, which have not be incorporated in the present objective analyses of meteorological data. For example, outgoing longwave radiation (OLR) measurements have long served as a proxy for tropical deep convection. Yet, this information has not been used routinely in operational meteorological analyses. Similarly, passive microwave measurements from the Defense Meteorological Satellite Program's (DMSP) Special Sensor Microwave/Imager (SSM/I) are a complementary data source for use in determining the column-integrated precipitable water and precipitation. Thus, we need to develop the method to utilize these untapped data.

We are currently developing a unified approach to diabatic initialization, including traditional diabatic NNMI and combining the adjustment procedures to the first-guess fields of temperature, horizontal divergence and moisture through incorporation of satellite radiometric imagery data, which provide proxy data of total precipitation. Since only the first-guess fields are modified, this approach can be adopted at operational centers in conjunction with the current data assimilation systems.

Publications

Kasahara, A., 1991: Transient response of planetary waves to tropical heating: Role of baroclinic instability. To appear in *J. Meteor. Soc. Japan*, **69**.

—— , and A. P. Mizzi, 1990: Estimates of global analysis differences in daily values produced by two operational centers. Submitted for publication to *Monthly Weather Review.*

—— , —— , and L. J. Donner, 1991: Impact of cumulus initialization upon the spin-up of precipitation forecasts in the tropics. Submitted for publication to *Monthly Weather Review.*

Tanaka, H. L. and A. Kasahara, 1991: On the normal modes of Laplace's tidal equations for zonal wavenumber zero. Submitted for publication to *Tellus.*