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, incorporating diabatic effects and use of satellite-derived, radiometric imagery data that are not used currently by operational centers.

Significant Accomplishments in the Past Year (May 1991–April 1992)

Impact of tropical initialization upon the spin-up of precipitation forecasts

Kasahara, Mizzi and Donner (1992) investigated the impact of various steps of data initialization on precipitation forecasts in the tropics. The data initialization is divided into three components: 1) application of diabatic nonlinear 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], 3) modification of the moisture and temperature fields by the cumulus initialization schemes [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.

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A unified approach to diabatic initialization for improvement in the analysis of divergence and water vapor fields in the tropics

The knowledge gained from the previous study enables us to develop a unified initialization to adjust the analyses of the horizontal divergence, moisture, and temperature fields simultaneously, rather than in the three separate steps described earlier, using "observed" precipitation rates as input. The regions of cumulus convection (upward motion) and cloud-free regions (downward motion) are identified in the tropics by using infrared and visible radiometric imagery data. The horizontal divergence and moisture in the ascending area are then adjusted based on a cumulus parameterization formulation using "observed" precipitation rates as a constraint. The details of this adjustment process based on the Kuo cumulus parameterization are described in Kasahara, Mizzi and Donner (1991). The adjustment procedures use a quadratic optimization algorithm with nonlinear and linear constraints and are tested using the ECMWF FGGE Level IIIb analyses. The horizontal divergence in the descending area is calculated from the estimate of vertical velocity based on the dynamical balance between adiabatic warming by advection and descending motion and radiative cooling, since the local time rate of change of the temperature in the tropics is small. At present, the vertical moisture distribution in the descending area is left unchanged.

Focus of Current Research and Plans for Next Year

Controlling the precipitation overshoot during the early part of a numerical forecast

In connection with our impact study of various steps of data initialization on precipitation forecasts described earlier, we observed that the evolution of a precipitation forecast during the early part of some forecast runs is not completely smooth, so that the reduction of the spin-up time is accompanied by an overshoot of precipitation. We will continue to investigate the cause of precipitation overshoot during the early part of a numerical forecast, as initiated by Mizzi, Kasahara and Donner (1991). It was noticed that this phenomenon is associated with an overshoot of the horizontal divergence. Therefore, a method was developed to adjust the vertical distribution of the horizontal divergence over convective areas to control the overshoot of precipitation and divergence. This adjustment

procedure requires the information on an upper bound of the vertically-integrated convective heating rate and is applied during the first few time steps of the numerical forecasts. While this adjustment procedure can control the overshoot of precipitation, the first and second derivatives of horizontal divergence D with respect to time, $\partial D/\partial t$ and $\partial^2 D/\partial t^2$ over the convective region at the initial time are still large, despite the initial reduction of D. Currently, work continues to diagnose the budget of $\partial D/\partial t$ and $\partial^2 D/\partial^2 t$ to understand the nature of dynamical balance under the influence of convective heating.

Use of satellite imagery data for improvement of the tropical analysis

The unified diabatic initialization, described earlier, is intended to be used to check the quality of the first-guess fields and to modify them, particularly the horizontal divergence and moisture, by incorporating information concerning convective activity in the tropics and proxy data for precipitation. We plan to test this initialization scheme for precipitation forecasts using the ECMWF analysis data with a Kuo-parameterization version of the NCAR Community Climate Model (CCM1). A period of January 1988 will be selected to coordinate our forecast experiments with the global analyses of water vapor and precipitation by Dr. F.R. Robertson (NASA/MSFC), who has been using the SSM/I moisture data for comparison with the ECMWF moisture analysis.

Key to our forecast experiments is the global distribution of precipitation. Actually, we are interested in such information only in the tropics, say ±30°. Since no daily analyses of precipitation are available, we must first construct the proxy data of daily tropical precipitation for the month of January 1988. Through efforts of the Global Precipitation Climatology Project (GPCP), five-day and monthly precipitation data have been constructed starting January 1986 for 40°S–40°N [Janowiak and Arkin, *J. Geophys. Res.*, **96** (1991), 3359–3373]. Data on 2.5° lat-long grids are archived at NCAR by the Data Support Section of the NCAR Scientific Computing Division. Since daily outgoing longwave radiation (OLR) data from NOAA-9 are available for the same period, we will estimate a daily precipitation distribution in the tropics by means of a regression relationship between the pentad GPCP precipitation and daily OLR data.

Publications

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