Title: Observational and Theoretical Studies of the Evolving Structure of Baroclinic Waves

Investigators:

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Significant Accomplishments FY-84):

1) Dynamical processes involved in comma cloud formation, and passive tracer evolution, in a baroclinic wave. An analytical solution has been obtained demonstrating the complex nongeostrophic flow pattern involved in the redistribution of low level constituents in a finite amplitude baroclinic wave, and in the formation of the typical humidity and cloud distributions in such a wave. (Saltzman and Tang)

2) Observational and theoretical studies of blocking weather patterns in middle latitude flows. A series of studies have now been completed showing the differences in the energy and enstrophy cascades in blocking and nonblocking situations; it is established that pronounced upscale flow of both of these quantities, from intermediate to planetary scales, occurs during blocking episodes. The upscale flux of enstrophy, in particular, suggests that the persistence of blocking periods may be due to reduced dissipation of the large scale circulation and therefore entail some above normal predictability. The observational results also indicate that smaller scale transient eddies play an important, regime-dependent, role in interactions with atmospheric circulations on the scale of blocking.

In a theoretical study, some of the effects of these smaller scale, higher-frequency, eddies are modelled as both a stochastic white and red noise forcing of a bistable orographically induced stationary flow of the type studied by Charney and

Devore. An important new time constant thus emerges, namely the 'exit time' for reversal between the two attractor domains of the steady flow representing blocking and normal states. These exit times were found to range widely as a function of the zonal forcing, and in the red noise case it is found that the bimodal nature of the barotropic model can be obscured depending on the prescribed variance of the perturbations and the model parameters. (Hansen)

3. Satellite-based measurements of the generation of available potential energy due to infrared radiative fluxes. Using global temperature data and satellite data it is estimated that the global pattern of IR causes destruction of both zonal and eddy available energy of magnitudes $G_z \approx -5.0 W\ m^{-2}$ and $G_E \approx -0.6\ W\ m^{-2}$, respectively. The destruction in the eddies is almost entirely due to the very long stationary disturbances of wavenumbers 1 and 2. (Hansen and Nagle)

Focus of Current Research and Plans for FY-85:

We are now well along in the development of a low-order non-linear forced dissipative baroclinic model that can replicate most of the classical results of baroclinic stability theory and open the door to a fuller study of the finite amplitude behavior of mid latitude disturbances and their evolutionary and statistical properties. Preliminary work is extremely promising for elucidating the influence of land-sea surface temperature contrasts (such as are found on the eastern coasts of the major continents) in the intensification of the waves. We hope to tie this theoretical study in with synoptic/satellite observational studies of cyclone intensification over oceanic regions.

Also underway is a large data-processing and analysis effort to examine an 8-year record of satellite measurements of the daily global distribution of outgoing infrared radiation for signatures of significant baroclinic wave activity leading to the formation of major blocking episodes. This work will form the basis for a thesis by R. Nagle, and already gives promise that further spinoff studies will follow.

Publications Prepared Since June 1983:

1) Saltzman, B. and C.-M. Tang, 1984: The effect of finite-amplitude baroclinic waves on passive, low-level, atmospheric constituents, with applications to cloud distribution and evolution. Tellus, (in press).

2) Tang, C.-M. and G. Fichtl, 1984: On non-quasigeostrophic effects in baroclinic waves with latent heat release. J. Atm. Sci. (in press).

3) Hansen, A.R. and A. Sutera, 1984: A comparison of the spectral energy and enstrophy budgets of blocking versus nonblocking periods. Tellus, 36A, 53-63.

4) Brown, P.S., A.R. Hansen, J.P. Pandolfo, and A. Sutera, 1984: Average characteristics of blocking and nonblocking events, (submitted).

5) Hansen, A.R. and A. Sutera, 1984: Observational aspects of the predictability of atmospheric blocking. Proc. Workshop on Predictability of Fluid Motions, AIP, New York, N.Y.

6) Benzi, R., A.R. Hansen, and A. Sutera, 1984: On stochastic perturbation of simple blocking models. Quart. J. Roy. Met. Soc., (in press).

7) Hansen, A.R. and R.L. Nagle, 1984: Estimates of the generation of available potential energy by infrared radiation. Mon. Weath. Rev., (in press).