TITLE: Use of Satellite Data in a Diagnostic Parameterization of Convective Heating

RESEARCH INVESTIGATOR:

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SIGNIFICANT ACCOMPLISHMENTS IN FY-84:

1. Evaluation of AVE/SESAME-I Diagnosed Heating

Heating estimates derived from a diagnostic technique using observed rainfall and GOES IR digital imagery have been completed and evaluated for accuracy. Area-averaged values in the AVE/SESAME-I region are shown in Figure 1. A description of the diagnostic scheme is provided by Robertson (1983a). A sensitivity analysis was done to examine assumptions regarding shape of the normalized mass flux profile, cloud precipitation efficiency, and existence of convective-scale downdrafts. The results, which were derived using what are felt to be bounding limits of the assumptions, indicate that the heating estimates are reliable for use in diagnostic available potential energy (APE) budgets. Comparison to heating estimates derived as residuals in the thermodynamic equation show the level of maximum heating (near 300 mb) to be the same on a time-averaged basis.

2. Heating estimates have been used to study the response of the large-scale environment to the cumulus-scale thermodynamic forcing. An analysis of the thermally forced component of vertical motion through the omega equation

$$\nabla^2 \alpha \omega_h + f^2 \frac{\delta^2 \omega_h}{\delta p^2} = - \frac{R}{c_p p} \nabla^2 H ,$$

where ω_h is the thermally forced grid-scale vertical motion, α is the static stability and H is the diabatic heating rate, has shown that a significant fraction of the total grid-scale upward motion results from the heating provided by the condensation and vertical eddy heat transport in the convective cells.

3. The reformulated version of the available potential energy equation in pressure coordinates (Robertson, 1983) has been used to investigate the role of heating and local vertical overturning relative to boundary work and transport processes. The heating due to convection in the AVE/SESAME-I was

found to have induced both thermally direct and indirect circulations, but contributed only minimally to changing the available potential energy of the SESAME region.

CURRENT FOCUS OF RESEARCH:

Application of the diagnostic parameterization and analysis of the available potential energy balance is being conducted on a second cyclone system, Mar. 6-7, 1982. This analysis will be compared to a numerical simulation of that case using the LAMPS (Limited Area Mesoscale Prediction System) recently implemented at MSFC.

PLANS FOR FY 84/85:

During the remaining months of this contract the energetics analysis will be completed on the Mar 6-7, 1982, case study.

RECOMMENDATIONS FOR FUTURE RESEARCH:

The methodology developed in this research provides a means for obtaining accurate vertical profiles of convective heating. The technique should be extended to utilize satellite-derived estimates of precipitation as a substitute for hourly surface observations. The utility of the revised APE equation should be investigated further with emphasis on the boundary work and flux terms. This work will be conducted under two new contracts utilizing the NMC FGGE IIIb data sets.

PUBLICATIONS AND PRESENTATIONS:

Robertson, F.R., 1983a: Cumulus-scale heating and its influence on meso-dyanamics during AVE/SESAME I. Preprint 13th Conference on Severe Local Storms, Tulsa, OK, October 17-20, 1983, American Meteorological Society, Boston, MA, 02108, pp. 350-353.

Robertson, F.R., 1983b: Influence of convective heating on available potential energy during baroclinic development. 4th Extratropical Cyclone Workshop. Madison, WI, Nov. 1-2, 1983. (No preprint volume).

Robertson, F.R., 1984: Reference pressure change and the available potential energy of open systems. Conditionally accepted to Tellus.

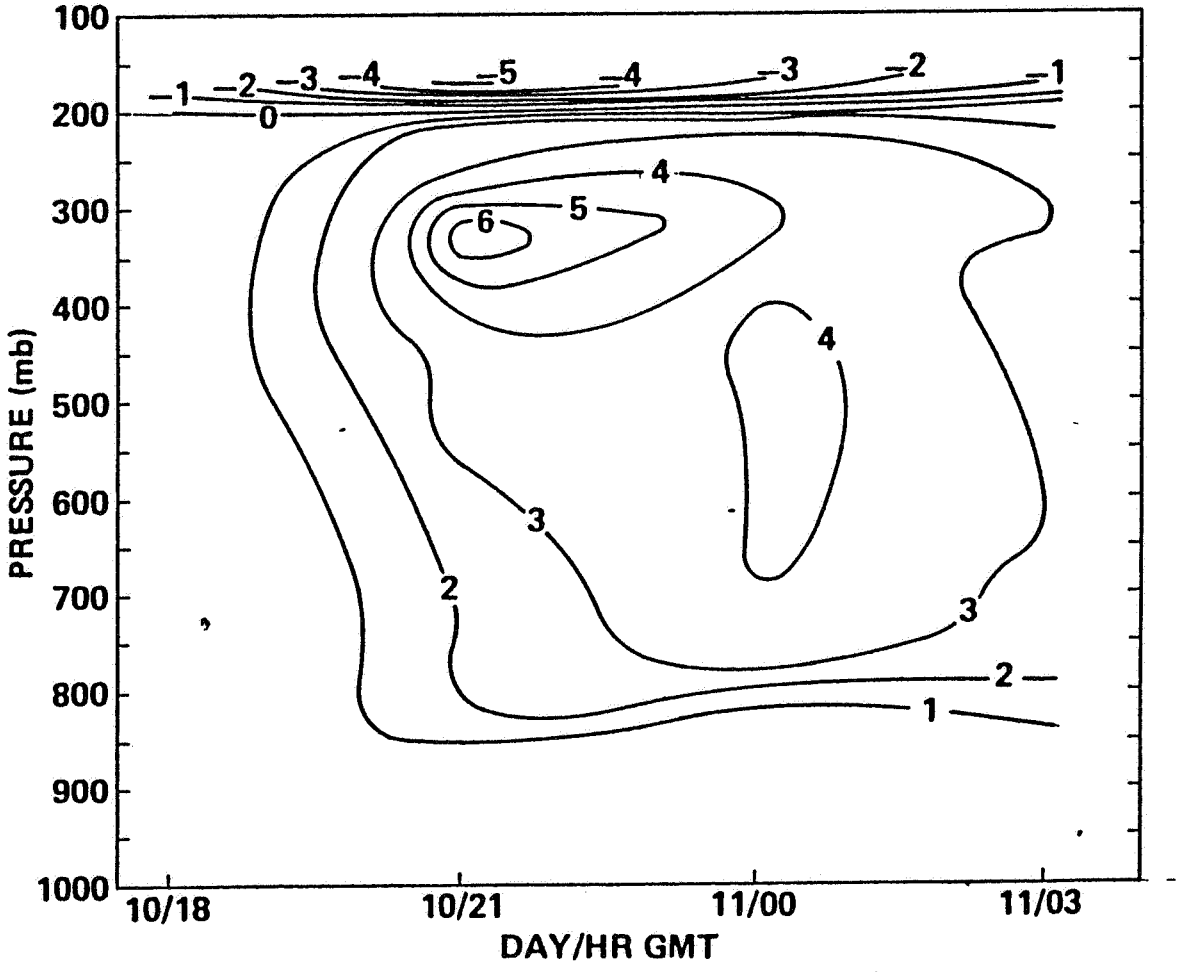

Figure 1. Convective diabatic heating rate in Deg/Day averaged over the SESAME network (1400 km on a side). Heating was diagnosed from a cumulus mass flux method using observed rainfall and cloud top heights determined from GOES data.