PROGRESS REPORT

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DOE Grant No. DE-FG02-91ER61220.A000

Title: Development of an Advanced Representation of Cumulus Convection

Principal Investigator: Kerry A. Emanuel

Development of the new representation of cumulus convection, emphasizing the role of microphysical parameters, was completed in 1991; a description of the scheme may be found in Emanuel (1991). A major step toward accomplishing the objectives of this research was taken by graduate student Nilton Renno, who coupled the newly developed cumulus scheme with a detailed representation of radiative transfer, in the context of a one-dimensional radiative-convective equilibrium model that includes the ocean as part of the calculations.

The adjustable parameters of the scheme are microphysical in nature. They include the *parcel precipitation efficiencies*, ϵ_i , which are defined as the fraction of condensed water converted to precipitation in samples of air lifted reversibly from the subcloud layer; σ_d , the areal fraction covered by unsaturated downdraft; and σ_s , the fraction of precipitation assumed to fall outside of cloud. A major remaining task is to use observations to optimize these parameters, as discussed in section 2. Provisionally, we set ϵ_i to zero for cloud depths less than PB_{crit} (in pressure), to unity for cloud depths greater than PT_{crit} , and linearly varying between these two limits. The results of the radiative-convective equilibrium calculations, for various

Table 1

Cloud Microphysical Parameters				
T (°C)	PB_{crit} (mb)	PT_{crit} (mb)	σ_d	σ_s
26.0	150	500	0.010	0.150
29.8	150	700	0.010	0.150
RUNAWAY	150	800	0.010	0.150
22.4	150	200	0.010	0.150
29.8	150	500	0.100	0.150
22.9	150	500	0.010	0.015
26.0	150	500	0.010	0.150

values of these parameters, are shown in Table 1.

Note the very large sensitivity of the equilibrium surface temperature to relatively small changes in the microphysical parameters. This confirms our suspicion that climate is sensitive to poorly known and poorly represented aspects of cumulus clouds. The next step, clearly, is to undertake a rigorous program of optimizing the parameters using real data.

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OUTLINE OF YEAR 2 ACTIVITY

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We plan to spend the second year optimizing the parameters of the scheme using real data, and implementing the scheme in various forecast models as one test of its efficacy.

First, we will use sounding data from the rawindsonde array operated as part of the GATE (GARP Atlantic Tropical Experiment) in the following way: From this data, we will calculate vertical motions from mass continuity, and directly derive horizontal advections of water vapor and temperature. We will also make estimates of the surface fluxes and the radiative transfer, supplied by Cox. All of these quantities will be produced for a period of several weeks. We shall then use these as input to a one-dimensional model, initialized at the beginning of the period in question, and which uses the new convection scheme to estimate the convective tendencies of temperature and water vapor. The verifying quantity will be the relative humidity as a function of pressure and time. We will then attempt to vary the parameters of the scheme to produce the best "prediction" of relative humidity. Unfortunately, this cannot be expected to work in the upper troposphere, where good humidity measurements are not available. We anticipate testing the optimized

scheme against an independent data set in the third year.

Out of this will also come realistic estimates of the errors of this and other schemes in predictions of atmospheric water vapor.

The second task will be to test the (unoptimized version of the) scheme in operational weather prediction models. The principal investigator will implement the scheme in the prediction model run operationally by Meteo France. This should provide an incomplete but valuable test of the new scheme against other commonly used schemes.

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