Preliminary Results: Environmental ControlS on Updraft Regeneration Frequency in Numerically-Simulated, Isolated Multicellular Convection

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I. INTRODUCTION

The steadiness of updrafts is generally accepted as an important factor in the weather produced by deep moist convection (DMC) – the steadier the updraft, the greater the likelihood of severe weather. DMC can take many forms, but in numerical model simulations initiated with a "bubble" of buoyant air at low levels, it has proven difficult to produce isolated multicellular storms at will. Therefore, such storms have not been given the attention that they merit. If the mechanism by which DMC is initiated is sustained, as it is in nature, rather than being "released" at time $t = 0$ in the simulation, it has been found that our numerical cloud model can produce multicellular DMC at will, under the right environmental conditions.

II. PRESENTATION OF RESEARCH

The model used for the simulations is based on the ARPS model, but has been optimized for increased run-time speed. The domain for the simulations is 48 x 48 km in the horizontal, and 20 km in the vertical, with 100 m grid spacing in all directions. It is a fully compressible model, using a TKE turbulence parameterization. The simulations are run for 5400 s. To date, we have done 192 simulations, systematically varying the convective available potential energy (CAPE), the vertical shear of the initial wind profile, and various parameters related to the imposed parameterized forcing for acent that initiates convection.

The main goal of this work is to investigate what the updraft regeneration frequency depends upon, as the environmental conditions and the details of the initiating process are varied. Sustained (constant in time) forcing for ascent is used to initiate DMC – using either forced near-surface convergence or a thermal perturbation. Since the parameter space in this study has several dimensions, cross sections in this parameter space are used to begin to map out the behavior of the simulated storms within this parameter space.

III. PRELIMINARY RESULTS OF THE RESEARCH

Under some environment conditions, even sustained, forced ascent is unable to produce sustained DMC. For a few simulations, only one deep updraft was produced but was not sustained. In most of the simulations, sustained DMC resulted. For the sustained cases, when the fluctuations in the vertical velocity associated with successive updraft "pulses" are larger than any persistent ascent, the case is considered "bubble-like" (Fig. 1). Conversely, when the fluctuations in the vertical velocity associated with successive updraft "pulses" are smaller than the sustained ascent, the case is considered "plume-like" (Fig. 2). The character of the forcing is one factor influencing this distinction – the stronger the forcing, all other things being equal, the more plume-like the updraft becomes.

Early results suggest that the resulting DMC is sensitive to all of the parameters, but is most sensitive to convective available potential energy (CAPE). When CAPE is large, the resulting DMC is more likely to be plume-like than when CAPE is small. Shear tends to inhibit convection with small CAPE. Space does not permit an extensive presentation of the results as cross-sections within the multidimensional parameter space. Figure 3 illustrates one such cross-section. Each point represents a particular combination of CAPE and vertical wind shear, but for each such combination, there are several simulations with different parameters related to the parameterized momentum forcing (its geometry, its depth, its magnitude). Illustrated on the figure are the ratios of sustained convection for all the simulations using a particular combination of CAPE and shear. It can be seen that none of the simulations with low CAPE and high shear produced sustained DMC, whereas all of the simulations with high CAPE produced sustained DMC.

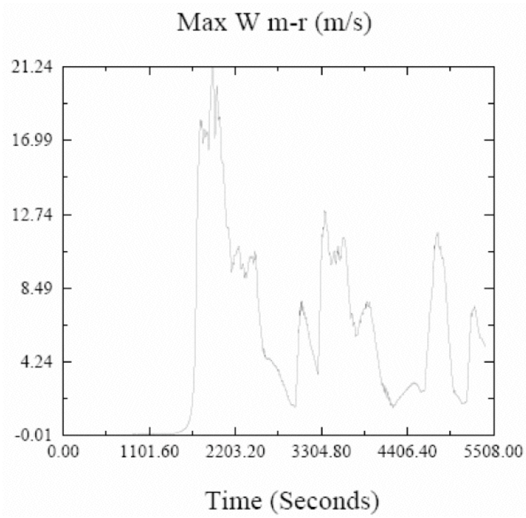

FIG 1. A “bubble-like” simulation

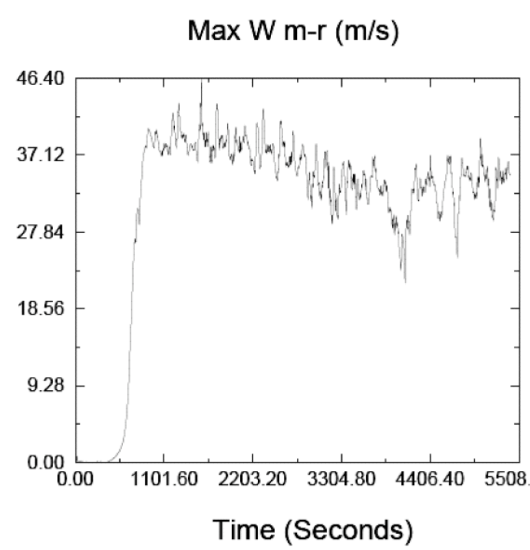

FIG 2. A “plume-like” simulation.

One example of how the updraft regeneration period depends on the parameters is shown in Fig. 4. For the combination of relatively weak forcing and large CAPE, the period shows a strong dependence on forcing depth for weak shear, but not much dependence when the shear is doubled. Further work is needed to analyze all the results, and many more simulations are required to span the parameter space and clarify the relationship between updraft regeneration and the environmental parameters. We anticipate doing up to around 1000 simulations

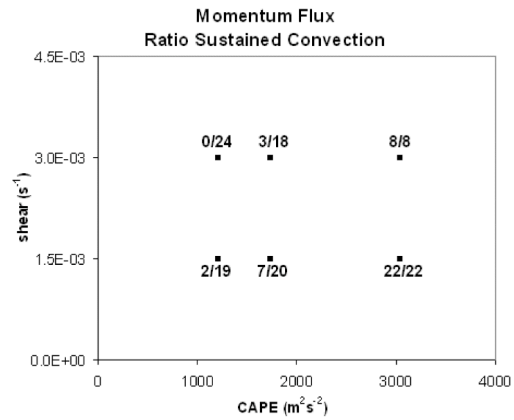

FIG 3. See text for explanation.

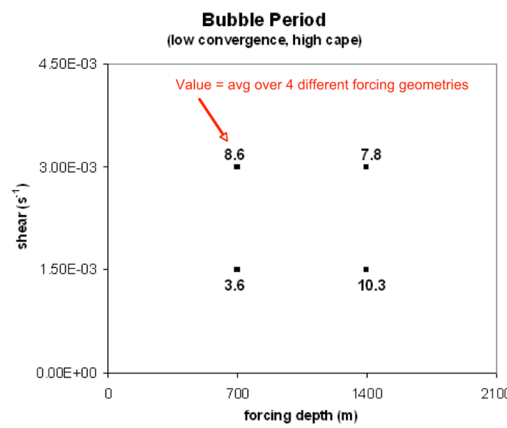

FIG 4. Dependence of the updraft regeneration period on focing depth and vertical wind shear.

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