1. INTRODUCTION

Simulations of deep convection along the Florida sea-breeze front have previously been carried out in two dimensions (Nicholls et al. 1991; Weissbluth, 1991) using the Colorado State University Regional Atmospheric Modeling System (CSU-RAMS). These experiments were in good agreement with observations, capturing the propagation of the sea-breeze fronts and the associated convection as well as the eventual collision of the two sea-breeze fronts from opposite shores, leading to more fully developed deep convection. We have extended this simulation by adding enough points in the third dimension to capture the three-dimensional convective cells.

We have two goals with this work. First we will use this experiment as a step towards fully three-dimensional simulations of Mesoscale Convective Systems (MCSs) in which interactive-grid nests are used to explicitly simulate convective processes. A second goal is to use the results of these simulations as a synthetic data set. We can then run simulations of the same case using a convective parameterization scheme, compare the results of the parameterization run to the synthetic data set, and use diagnostic analyses to refine the parameterization scheme.

2. EXPERIMENTAL DESIGN

The experimental domain was set up to roughly simulate the Florida Peninsula with a coarse (4.5 km) grid of 95 x 17 points, and a nested fine (1.5 km) grid of 152 x 35 points. The domain is set up to be long enough in the x-direction (east-west) to stretch over approximately 200 km of land (dark band in Fig. 1a) and 100 km of sea extending from each shore. In the y-direction (north-south) the domain is wide enough to capture three-dimensional convective cells; we have used cyclic boundary conditions on the northern boundary. The fine-grid nest extends over the land area and a few kilometers to sea so that regions of convective activity are fully resolved. In the vertical we have 36 levels with a Δz of 250 m at the lower boundary stretching to a maximum Δz of 1000 m at upper levels. We used a horizontally-homogeneous initialization, that is, we used one representative sounding (the Type I sounding in Nicholls et al. 1991, their Figs. 1 and 2) to initialize the model. The model was run out for 12 hours beginning 0800 eastern daylight time (EDT) with a time step of 10 seconds. The model includes parameterizations of cloud water, rainwater, pristine ice crystals, and snow, as well as a surface parameterization of vertical heat, vapor, and momentum fluxes. Surface values

Fig. 1 Vertical velocity at z = 4.66 km for a) 1330 EDT, b) 1400 EDT, c) 1430 EDT. Contour interval is 0.3 ms⁻¹. The dark band in (a) represents the land area, which runs from x = -100 km to 100 km in all figures.
of temperature and moisture are predicted from the top level of a prognostic soil model. For this simulation eight soil levels are used with a sandy clay loam for the soil and soil moisture varying from 0.35 at the lowest layer to 0.65 at the top layer.

3. RESULTS

The initial flow field features surface easterly winds of 3 $\text{ms}^{-1}$ increasing to almost 10 $\text{ms}^{-1}$ at 200 mb then decreasing slightly above that level. Sea-breeze circulations begin in the late morning and by early afternoon strong deep convection is occurring along the east coast sea-breeze front. The west coast sea-breeze front is less active at this time and has not propagated as far inland due to the ambient easterly flow. Figure 1 shows vertical velocity over the domain at $z = 4.96$ km for three times. There is more activity along the east coast sea-breeze front with maximum vertical velocities at this level on the order of 4 $\text{ms}^{-1}$. The line of convection looks well organised at 1330 EDT but becomes less organised by 1430 EDT, at which time it appears that a new line is forming about 40 km west of the line at 1330 EDT. Some weak activity is occurring along the west coast sea-breeze front at 1430 EDT. The difference in activity on the two sea-breeze fronts can be seen more clearly from the condensate mixing ratio (Fig. 2a) and the accumulated precipitation (Fig. 2b) at 1400 EDT. The east coast sea-breeze activity dominates, although as seen from the accumulated precipitation there has been convective activity as well along the west coast sea-breeze front.

![Figure 2a](image-url) Condensate mixing ratio (g/kg). Contour interval is 0.3 g/kg with a maximum value of 3.4 g/kg. b) Accumulated precipitation (mm), with a contour interval of 1 mm and maximum value of 35 mm.

![Figure 3](image-url) Vertical velocity along $y = 4.5$ km. Contour interval is 1 $\text{ms}^{-1}$ with a maximum of 12.9 $\text{ms}^{-1}$. 
A vertical section along $y = -4.5$ km was taken through one of the stronger cells at 1400 EDT (Fig. 3). Maximum vertical velocities at this time were 12.8 ms$^{-1}$. Although these cells are strong and deep, they are rather short lived, horizontally narrow, and do not lead to longer-lived stratiform regions as do MCSs.

By 1730 EDT, sea-breeze fronts from both coasts have collided at $x = 65$ km (Fig. 4a). This area of convection is longer lived and remains somewhat better organised than along the individual sea-breeze fronts. It is interesting to note from the accumulated precipitation for this time (Fig. 4b) that convection did not remain strong across the entire peninsula, but weakened after the first strong convection along the east coast sea-breeze front. This line of convection is intense and long lived enough to produce considerable convective debris, as seen by a vertical section of pristine ice mixing ratio (Fig. 5) at 1830 EDT. Upper-level easterly flow is shearing the anvil westward. After 1800 EDT, some convection continues to form along and just inland of the west coast, although never as intense as during the collision of the sea-breeze fronts. As evening approaches (near the end of the simulation), convection moves westward offshore and dissipates.
4. COMPARISON WITH THE CONVECTIVE PARAMETERIZATION SCHEME

Comparisons were made between this simulation and a quasi-three-dimensional run using the convective parameterization scheme developed by Weissbluth (1991). The two simulations compared well: both simulations produced deep convection along sea-breeze fronts which propagated inland and in both simulations the sea-breeze fronts collide in the late afternoon. Details varied between the two simulations. For instance, the north-south location and exact timing of individual cells differed. Also, as anticipated, due to the coarser resolution used in the parameterization run (4.5 km), resolved vertical motion tended to be weaker for that simulation. Currently, we are averaging the explicitly-resolved convection run results to those of the parameterization run. This will give us a more quantitative indication of how well the parameterization scheme behaves.

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6. REFERENCES


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