13B.3 EFFECTS OF SEA BREEZE AND LOCAL WINDS ON RAINFALL IN SOUTH FLORIDA

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1. INTRODUCTION

Sea breeze circulation in South Florida has been well documented over the years (Pielke (1974), Pielke and Cotton (1977), Blanchard and Lopez (1985), Simpson (1994), and Pielke et al. (1999)). However, its role in local precipitation is difficult to quantify. Current operational numerical weather prediction models are deficient in resolving sea breeze circulation due to relatively low grid resolution and inadequate model physics. This study is aimed at understanding the physical processes associated with the sea breeze. The impact of model grid resolution on precipitation forecasts in South Florida is evaluated.

2. MODEL AND DATA

We use the fifth generation PSU/NCAR non-hydrostatic mesoscale model (MM5) with multi-nested grids (36, 12, 4 and 2 km grid resolutions) to simulate the surface winds and rainfall in South Florida. The inner domains (at 4 and 2 km grid spacing) are fully cloud-resolving. There are 28 sigma levels in the vertical with 9 within the planetary boundary layer. The landuse data is from the USGS 1-km dataset with 24 land surface types built into MM5. The model initial and time-varying boundary conditions are from the NCEP ETA analysis fields. The model simulations have been evaluated and validated using the in situ station observations and the NEXRAD radar rainfall estimates as the High-resolution Digital Precipitation (HDP) products at 4 km resolution.

Two sets of simulations have been conducted in this study. First, to simulate the sea-breeze circulation without the influence of the synoptic flow, we designed an idealized simulation using an average thermodynamic condition for June without the background flow. Second, we conducted a month-long simulation using the real atmospheric conditions for June 1999.

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3. RESULTS

The idealized MM5 simulation describes the characteristics of the land-sea and land-lake breeze circulations in South Florida clearly.

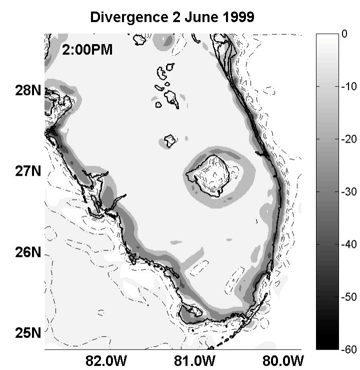

Figure 1. Idealized MM5 simulation of surface divergence (s^{-1}) at 2pm local time. Dotted line represents contours of divergence and shading indicates areas of convergence.

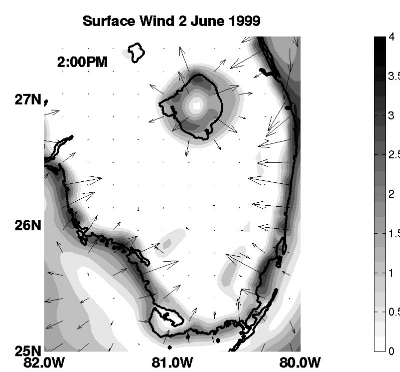

Figure 2. Idealized MM5 simulation of surface wind at 2pm local time. Arrows give the direction of flow. Shading designates wind speed (ms^{-1}).

Figure 1 and 2 show the sea breeze and associated convergence zones on both coasts of Florida as well as surrounding Lake Okeechobee. The idealized simulation depicts a stronger sea breeze on the east coast of Florida as opposed to the west coast. The larger magnitude of sea breeze on the east coast is contributed to by a larger temperature gradient on the east coast of Florida due to urban heating effects.

The idealized simulation is initiated without background flow. During the day, temperature over land increases at a faster rate than that over the ocean, setting up a temperature gradient on the order of 4-5 ^{o}C in the coastal area. It leads to a subsequent development of a strong pressure gradient and an onset of the sea breeze. The convergence inland near the coast can provide low-level forcing for convection.

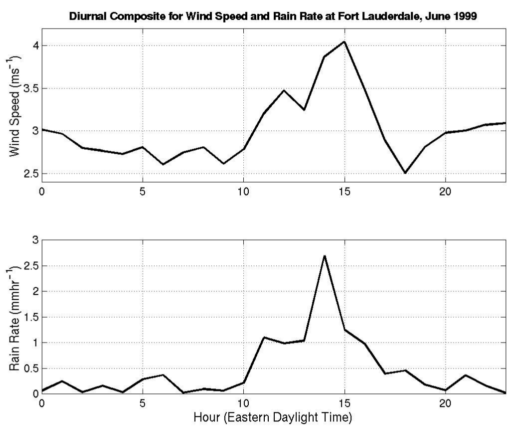

Figure 3. MM5 diurnal composites for wind speed and rain rate at Ft. Lauderdale, FL for the month of June 1999.

Figure 3 shows a composite of the diurnal cycle of surface wind and rainfall from the month long MM5 simulation for June, 1999. The results indicate that the highest average rain rate, of 2.7 mm per hour, occurs at about 2 pm local time. Highest average wind speeds proceed largest rain rates by about one hour for the entire month, showing strong correlation between sea breeze winds and precipitation. Current studies involve comparing diurnal composites to station observations in order to evaluate and validate MM5 results.

The simulation for June 1999 provides overall rainfall amounts that are similar to those from radar estimates. The 2 km simulations provided much more detailed precipitation patterns due to a better representation of land-sea and land-lake breezes. The pattern and time of the onshore and offshore winds are not only determined by the diurnal land-sea temperature difference and, therefore, pressure gradient, but also affected strongly by the large-scale background flow. While atmospheric disturbances, from synoptic scale to land-sea breeze scales, provide a generally favorable/unfavorable large-scale environment, the timing and location for convective initiation and subsequent rainfall are largely controlled by convergence zones.

The model simulation is evaluated and validated using surface observations and NEXRAD ground based radar rainfall estimates. Time series analysis is currently being performed allowing model output variables to be compared to station observations over the month of June 1999.

The radar data and model both depict that precipitation associated with sea breeze occurred on nearly 50% of the days for the month. Sea Breeze propagates inland 15 to 25 km with wind speeds at an average of 3 m s^{-1}. Further analysis of the model also indicates a lake breeze 15 to 20 km inland at a magnitude of close to 3 m s^{-1} near Lake Okeechobee. Vertical wind profiles show that the vertical extent of the sea breeze circulation is typically from the surface to the 1500-m level.

4. CONCLUSION

The model is capable of resolving sea breeze circulation at 2-km grid resolution. Our results show that the sea breezes play an important role in rainfall in south Florida. The model simulations will continue to be especially useful in research in order to gain more insight into the physical processes that drive this small-scale phenomenon.

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