J8.6 IMPACT OF LAND-USE MANAGEMENT PRACTICES IN FLORIDA ON THE REGIONAL CLIMATE OF SOUTH FLORIDA AND THE EVERGLADES

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1. INTRODUCTION

Since the early 1900s, South Florida, and particularly the Everglades region, has undergone extensive urbanization and land cover conversion to agriculture, with associated diversion of water resources for agricultural uses, domestic water supply, and flood prevention. In this work, we present a series of mesoscale modeling experiments using the Colorado State University Regional Atmospheric Modeling System (RAMS; Pielke et al. 1992) that have been designed to investigate the sensitivity of the regional climate of South Florida to these changes in the land-surface environment of Florida and the Everglades. Building upon the work of Pielke et al. (1999), highly detailed Florida land cover classification datasets for 1900 and 1992/93 are used to produce otherwise identical seasonal integrations of the mesoscale model. We examine the changes in surface energy budget parameters, and associated changes in seasonal/regional precipitation patterns associated with the anthropogenic change of land use in Florida. Key issues addressed in this work involve the relative impact of land use change on seasonal climate under different large-scale forcing regimes (such as those associated with ENSO), and whether the continued transformation of the land-surface environment is resulting in increased frequency and severity of drought in South Florida.

2. DATASETS AND METHODOLOGY

In this study, two separate RAMS simulations were run for two months (July and August) of three different years: 1973, 1989, and 1994. In order, each of these three years was subjectively determined to represent "normal", "dry" and "wet" conditions with respect to climatological annual precipitation in South Florida. All six simulations used the National Centers for Environmental Prediction (NCEP) Reanalysis (Kalnay et al. 1996) for initial and lateral boundary conditions. Two grids were used, the coarse one having a 40-km mesh size and 42X42 grid points, with a finer nested grid of 10 km with 48X50 grid points. Both grids were centered on a location near Lake Okeechobee, and used 30 vertical levels. The outer grid used a time step of 1 minute, and the inner grid 30 s. The Kuo cumulus parameterization (Tremback 1990) and Mahrer-Pielke radiative transfer scheme (Pielke et al. 1992) were employed on both grids.

For a given year, the two experiments differed solely in the specification of vegetation class. One simulation employed a reconstructed data set of 1900 vegetation, and the other used USGS land cover data for 1992/93. The 1900 land cover scenario is based on a GIS analysis of data from Davis (1943), McVoy (personal communiciation), Willard et al. (2000), Costanza (1975), and Kuchler (1964) potential natural vegetation. The 1992/93 data set is derived from USGS 30 m land-cover datasets based on LANDSAT TM and field surveys. For this work, the default 30 land-cover classes of the Land-Ecosystem Feedback Model (LEAF-2; Walko et al. 1998) in RAMS were modified, and 10 additional classes were added to accommodate the highly detailed subtropical, tropical, freshwater marsh, and other wetlands vegetation classes in Florida. Everywhere in the model domain, soil moisture was initialized as 40% of saturation at the surface to 60% of saturation at 0.5 m. For areas of South Florida identified as swamp or freshwater marsh, the soil moisture was initialized as saturated with 10 cm of standing water.

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3. RESULTS

Figures 1 and 2 show the difference in Bowen Ratio and two-month accumulated convective precipitation between the two different runs (1993 land cover minus 1900 land cover) for each of the three different simulation years. For 1973, the Bowen Ratio is increased substantially and is accompanied by a marked decrease in precipitation when the 1992 land cover data set is used. The average decrease in precipitation over all land grid points is about 12%, but there is considerable spatial variability in the results. The 1989 and 1994 simulations exhibit similar spatial behavior, with differences in the magnitudes of precipitation and Bowen Ratio change. The wet year simulations (1994) do not exhibit as large a difference in Bowen Ratio between the two land cover scenarios, but the accumulated precipitation difference is quite substantial, with decreases of as much as 100 mm in some locations. For all three simulation years, the magnitude of the precipitation averaged over all land grid points decreases by 25 to 30 mm when the 1992/93 land cover data set is used.

The largest increase in Bowen Ratio with the 1992/93 land cover is found along a northwest-southeast axis over central Florida that passes through Lake Okeechobee, and also along the length of the immediate east coast. This result is not surprising, as much of these areas were freshwater marsh in the 1900 data set, but had been drained and converted to agricultural land by 1992/93, with extensive urbanization along the immediate coast. It is interesting to note that the axes of greatest precipitation decrease are found immediately adjacent and parallel to the axes of greatest Bowen Ratio increase. Results will be shown at the conference that suggest the alteration of the land-surface may be associated with a marked impact on the climatological position of mesoscale circulations that are present when the 1900 land use data are employed. These circulations, and the associated surface convergence zones, appear to have been diminished with the use of the 1992/93 land cover, thereby significantly diminishing the associated cumulus convective rainfall. Rainfall also appears to decrease over the western Everglades. Though not apparently associated with a difference in Bowen Ratio, this change may be associated with the decrease in freshwater marsh area, which had become an expansive area of sawgrass by 1992/93. These patterns must also be considered in the context of interaction with the climatological easterly flow and sea breezes over the Florida Peninsula during mid-summer.

4. CONCLUSIONS AND FUTURE WORK

These preliminary results indicate that the numerical simulation of the regional climate of South Florida exhibits a marked sensitivity to land-use change. Future work will include simulations over entire annual cycles, to determine if this sensitivity extends to the cool season. A key question to address is whether or not the components of the annual water budget are significantly altered under the new land use scenario, and if water resources are suffering as a result. LEAF II will also be formulated to include hydroperiods for a realistic annual cycle of the variation of the depth of standing water in the Everglades, along with a more accurate soil moisture initialization outside of marsh and bog areas.

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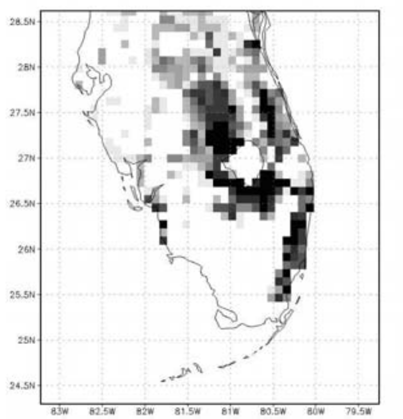
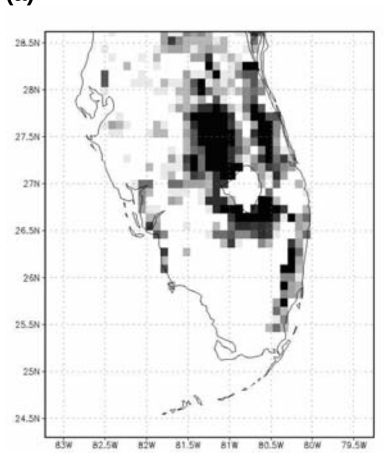


(a)



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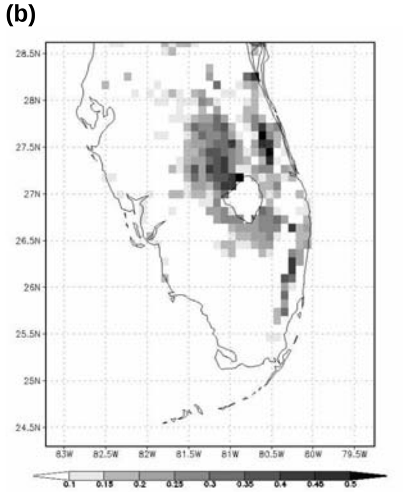
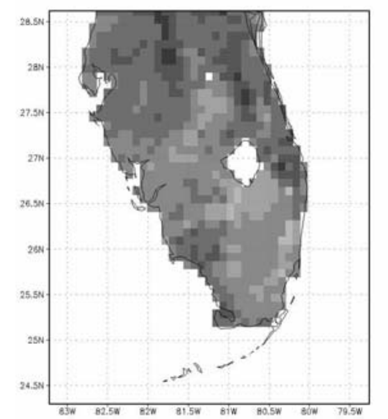
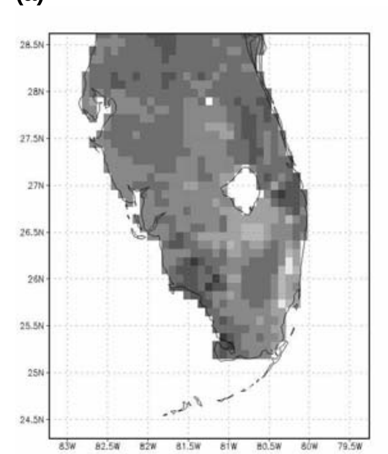


(c)

Fig. 1. Difference in Bowen ration (1992/93 Minus 1900 land cover scnario) for 1973 (a), 1989(b), and 1994 (c).



(a)



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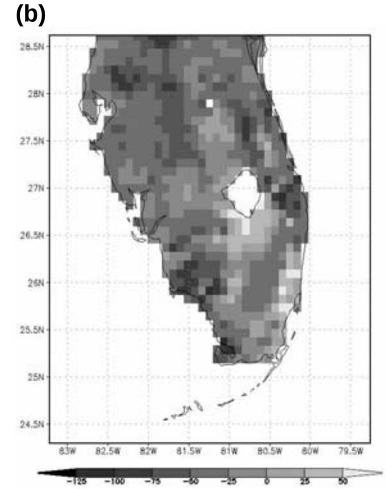

(c)

Fig. 2. Same as in Fig. 1, except for convective precipitation.