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Land Use Effects on Energy and Water Balance-Developing A Regional Land Use Adapted Drought Index

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Water is one of Earth's most critical resources. Essential to every ecosystem, water sustains all life and also helps maintain the environmental balance of our planet. Water is essential in human development from the personal water needs of every individual demands to the demands of agriculture and industry.

However, climate change, resulting from increasing atmospheric concentrations of greenhouse gases, could have significant effects on water resources. Climate change is consistently associated with changes in a number of components of hydrological cycle and systems such as: changing precipitation patterns, intensity and extremes; widespread melting of snow and ice; increasing atmospheric water vapor; and change in soil moisture and runoff [1]. For example, the increasing frequency or magnitude of extreme rainfall events occurred in the winter or spring when the ground was frozen or soil moisture levels were high, producing more rapid runoff and greater flooding.

Moreover, climate change is expected to increase the frequency, intensity and duration of droughts in all parts of the United States (US). Already, reduced snow packs disappear earlier in the spring and summer, and reduced stream-flow, lower reservoir levels, higher temperatures, and greater precipitation variability have been observed [1]. Recent drought events in the US have threatened drinking water supplies for communities in Maryland and the Chesapeake Bay in 2001 through September 2002, Lake Mead in Las Vegas in 2000 through 2004, the Peace River and Lake Okeechobee in South Florida in 2006, and Lake Lanier in Atlanta, Georgia 2007 [2]. In 1995, the Federal Emergency Management Agency (FEMA) estimated annual losses from drought to be $6-8 billion, which is higher than any other natural weather related disaster, including hurricane and flood [3].

Drought is the most complex of all natural hazards. The lack of progress in drought preparedness planning and the development of national drought policies are reflections of this complexity. Although climate (particularly precipitation) is a primary contributor to hydrological drought, other factors such as land use also affect the water and carbon cycles and thus the regional climate. For example, trees tend to have deeper roots than herbaceous plants [4,5] and hence can maintain higher evapotranspiration (ET)than grasslands when the supply declines [6,7]. Decrease in ET during droughts generally is greater in agricultural areas because crops die or their foliage (and, therefore, their ability to transpire water) is severely stunted during prolonged droughts. Hence, the duration and intensity of drought would be different based on various land uses and a drought index should be able to reflect the level of severity in drought events in relation to land use effects. However, current drought indices could not fully demonstrate the land use effects and have limitations in data sources.

Moreover, ENSO influences the climate of Florida; where El Niño years tend to be cooler and wetter, and La Niña years tend to be warmer and drier than normal in the fall through the spring, with the strongest effect in the winter. Both prolonged heavy rainfall and drought potentially have impacts on land uses and many aspects of Florida's economy and quality of life. Hence, understanding local ENSO patterns on regional scales and developing a new land use drought index in Florida are critical in agriculture and water resources planning and managements.

Hence, the first and second research topics were investigating water and energy budgets on the specific and important land use areas (urban, forest, agriculture and lake) in the State of Florida by using the North American Regional Reanalysis (NARR) reanalysis data. NARR data were used to understand how drought events, EI Niño, La Niña and seasonal, inter-annual variations in climatic variables affect the hydrologic and energy cycle over different land use areas. The results showed that the NARR data could provide valuable, independent analysis of the water and energy budgets for various land uses in Florida. Finally, the high resolution land use adapted drought indices (32 km × 32 km) were developed based on the NARR data from 1979 to 2002. The new regional land use drought indices were developed from normalized Bowen ratio and the results showed that they could reflect not only the level of severity in drought events resulting from land use effects, but also La Niña driven drought impacts.

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