USING CLIMATE INFORMATION TO DETERMINE IRRIGATION REQUIREMENTS FOR CITRUS IN FLORIDA

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• Justification

- Florida ranks first in citrus production with nearly 68% of all U.S. citrus (2005-2006).
- The Southwest Florida Water Management District (SWFWMD) regulates the citrus irrigation permits. New strategy implemented in 2006 to help address water supply problems, so that permitted amounts were more representative of actual water use.
- The use of **climate information** is crucial for permitting calculation. However, the presence of missing data is often a constant characteristic in all historical databases and scientists need to deal with this problem.

• Objectives

- To compare the actual irrigation water use with permitted values as well as theoretical consumptive use values calculated by a daily water balance (Highlands, Hillsborough and Polk counties).
- To measure the uncertainty generated by a weather generator when estimating missing meteorological data.

• Materials and Methods

- **Water use by growers:** provided by the SWFWMD from 1994 to 2005 (Table 1). Also provided the permitted citrus irrigation amounts for each county per year (Fig. 5).

Table 1: Number of farms, mean monthly reported pumped water and mean production area.

Year	Highlands			Hillsborough			Polk		
	# of farms	Mean water use (mm)	Mean area (ha)	# of farms	Mean water use (mm)	Mean area (ha)	# of farms	Mean water use (mm)	Mean area (ha)
1994	46	385	125	5	174	166	44	277	111
1995	55	362	123	11	229	97	45	297	99
1996	84	527	107	24	229	77	136	426	70
1997	85	446	108	19	208	89	117	397	75
1998	60	501	115	7	157	66	76	465	85
1999	90	432	106	21	292	83	164	432	69
2000	96	557	100	31	428	58	163	554	69
2001	83	397	106	22	316	55	145	392	70
2002	86	377	101	13	294	64	118	341	79
2003	98	337	91	12	198	57	122	311	77
2004	75	320	105	17	205	62	71	310	88
2005	66	230	109	10	192	67	75	205	85

- **Soil data:**

Highlands and Polk: Astatula sand (ENTISOL), 7% field capacity, 4% permanent wilting point, 3% available water holding capacity.

Hillsborough: Basinger (ENTISOL),12% field capacity, 5% permanent wilting point, 7% available water holding capacity.

- **Weather station network:** Maximum and minimum temperature (T), incoming solar radiation (ISR), maximum and minimum relative humidity (RH), wind speed (WS), and rainfall (R) were available for two main weather stations from SWFWMD (Fig. 1). Rainfall data were available for 48 sites, from 1994 to 2005 (Fig. 1 and 2)

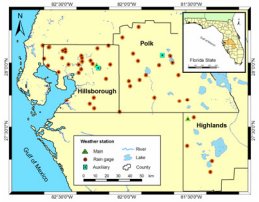

Fig. 1: Map showing the spatial distribution of weather stations across the area

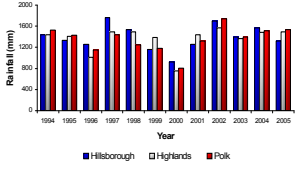

Fig. 2: Interannual variability of total rainfall for the three counties (average from all weather stations within each county)

Missing data problem

- Missing data ranged from: 25 to 49% (ISR), 20 to 58% (max and min T), 44 to 62% (max RH), 43 to 62% (min RH), 7 to 44 % (WS), 2 to 8% rainfall in Highlands, 0 to 23% in Hillsborough, and 0.8 to 8% in Polk counties.

Data estimation & generation

- The Hargreaves-Samani (1982) model was used to estimate incoming solar radiation data. Calibration was performed using the information from the auxiliary weather stations. The remaining weather variables were generated by a weather generator (**WGEN;** Richardson and Wright, 1984).
- Due to the uncertainty produced by filling the missing values (Figs. 3, 4, 5, and 6), the filling missing value process was repeated 20 times. Each new corrected historical record produced by assembling observed and generated data, constituted an ensemble member all of them equally probably to occur. These data were use to fed a daily water balance to estimate citrus irrigation.

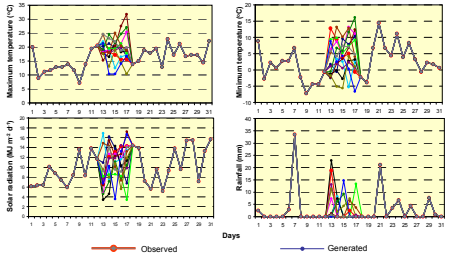

Fig 3: Example of an ensemble. Each graph show an ensemble formed by the overlapping of "n" ensemble members in a 31-day period of time. The solid dotted red-grayish line represents the observed data overlapped "n" times. The dotted colored lines other than red, represent the "n" generated data sets overlapped during a 5-day simulated missing data period.

To avoid working with a large ensemble, a set of different sub-ensemble members were analyzed. After calculating the gross irrigation per year for 20 ensemble members, the standard deviation among the ensemble members within a sub-ensemble were calculated. The mean multi-annual standard deviation was calculated. The optimum number of ensemble members was determined as 12, once the asymptotic curve became constant.

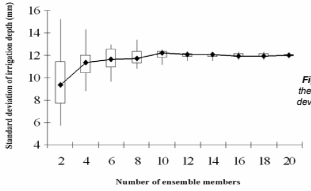

Fig. 4: Asymptotic curve showing the average multi-annual standard deviation of irrigation depth among sub-ensemble members

- **Reference ET_o** estimation: ASCE-EWRI (2005) Standardized reference ET equation used.
- **Water balance equation used:**

$$SW_t = SW_{t-1} - ETc_{t-1} + R_{t-1} + I_{t-1} - D_{t-1} - Roff_{t-1}$$

where SW_t is the soil water on day 't', SW_{t-1} is soil water content, $ET_{o,t}$ is the crop evapotranspiration, R_{t-1} is the rainfall, I_{t-1} is net irrigation, D_{t-1} is drainage and $Roff_{t-1}$ is runoff.

- Considerations: Soil depth: 0.9 m; Runoff and drainage: assumed as zero. K_c dataset from Morgan et al., (2006). Two wetted areas tested: 40 and 60%; Irrigation efficiency (microsprinkler irrig): 80%.

• Results

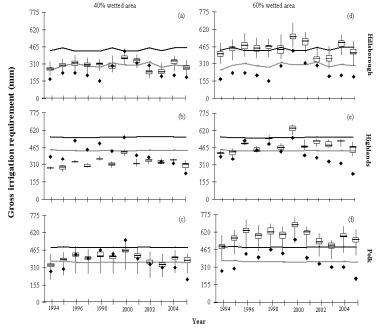

Fig. 5: The upper and lower edges of the whisker plots indicate the 75th and 25th percentiles of the simulated gross irrigation requirements. The end of the vertical lines indicates the 100th and 0th percentiles, from top to bottom. The median (50th percentile) is shown as a short line in the box. The black and gray lines represent the 2-in-10 and 5-in-10 permitted irrigation requirements, respectively. Diamonds represent the multiannual mean water pumped by growers.

• Conclusions

- The interannual average water consumption from growers ranged from 244 mm in Hillsborough to 406 mm in Highlands and the multiannual average irrigation requirement permits ranged from 295 to 557 mm.
- The annual simulated gross irrigation requirements followed the trend of the actual pumped water by growers. Pumped water by growers fell within the range of the simulated gross irrigation requirement.
- The results showed a range of simulated irrigation values per year, all probably equals, as a result of using the ensemble technique. This technique take into consideration the uncertainty due to the use of a the probabilistic method of filling missing values, therefore avoiding under- or overestimation of irrigation requirements since all possible variability is simulated and reported as probabilities.

References

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