JP5.6 A TEST OF IRRIGATION'S INFLUENCE ON PRECIPITATION USING RAMS

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1. INTRODUCTION

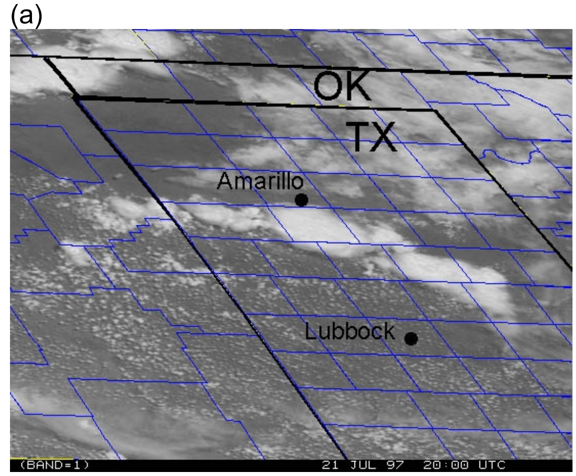
The Texas High Plains hosts one of the largest hydrologic disturbances in North America, with an area of over 6 x 10^9 m^3 of irrigation water annually. Irrigation enhances precipitation downwind, yielding storms of greater duration, length, and accumulation. Previous studies (Barnston and Schickedanz 1984; Pielke and Zeng 1989) have examined effects of irrigation and have identified relted changes in climate patterns. Analysis on an hourly timescale estimated that a 6% to 18% enhancement of summer precipitation attributable to irrigation falls ~90 km downwind of the irrigated region (Moore and Rojstaczer 2002). Qualitatively, this phenomenon can be explained by the increase in instability and latent heat flux caused by the irrigation water. The differential warming of wet and dry surfaces creates a larger sensible heat flux over dry (unirrigated) soil and a larger latent heat flux over wet (irrigated) soil. The latent heat flux adds moisture to convection over the area , raising moist static energy and making precipitation more likely.

Here we test this influence quantitatively through the use of a mesoscale circulation model (RAMS). Simulations of precipitation based on observed irrigation rates produce realistic (but not identical) spatial precipitation patterns in comparison to those observed in nature; relative humidity, surface temperature and other quantities showed a tendency towards drier and warmer conditions.

2. METHODS

We sought to examine what threshold in irrigation is necessary to significantly influence precipitation patterns from a series of simulations at various levels of irrigation, ranging from 25% to 100% of current application rates. We used the RAMS model (version 4.3) which incorporates the Land Ecosystem Atmosphere Feedback model (LEAF) (Walko et al. 2000). Our simulations were conducted for 1 July - 22 July, 1997 forced with NCEP reanalysis data. Soil moisture data for 1997 was not available, so we initialized soil moisture throughout the study area just above the permanent wilting point (PWP), which is not unreasonable for the area that year.

(a)



(b)

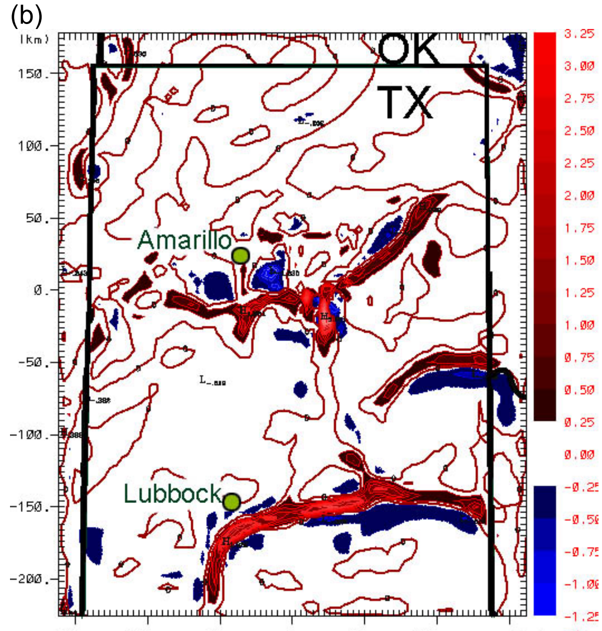


Figure 1. Comparison of (a) observed cloud formation from GOES with (b)vertical motion from RAMS simulation. A line of convection forms just north of the

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We used 4 nested grids with the smallest grid at 1 km resolution; this resolution is necessary to resolve mesoscale circulations. We applied irrigation to appropriate grid points based on LANDSAT imagery, and applied water to the model's surface when matric potential dropped to within 25% of PWP. We examined precipitation, vertical motion, and other factors for 21 July 1997. This day had ample radiative forcing, slow surface winds, and no large-scale systems dominating local weather. southern irrigated area (not shown). Red contours in (b) indicate upward vertical motion; blue, downward.

3. RESULTS AND DISCUSSION

Preliminary results indicate that intensive irrigation produces mesoscale circulations as described in Avissar and Liu (1996). Although the heterogeneity in this case is larger than optimal (~150km), a mesoscale circulation results that is able to create significant precipitation. Figure 1 shows a comparison of (a) GOES visible data and (b) RAMS simulated vertical motion. These results are from 21 July 1997, with the irrigated area at 100% (i.e. the soil surface receives water until the topmost layer is saturated). This simulation shows that the model captures real physical processes adequately. But mesoscale fluxes show a nonlinear response to soil moisture, so it is unclear whether this precipitation response is due to a peculiar set of conditions or a broader soil moisture response. We will further explore the effects of irrigation at reduced levels (e.g. 50%, 75%). These simulations are currently underway. We plan to determine the response of precipitation to irrigation forcing – is it linear? Is some threshold amount required?– and to evaluate the preponderance of an irrigation effect in observed data. Results from this model will be crucial in identifying conditions likely to yield irrigation-induced precipitation.

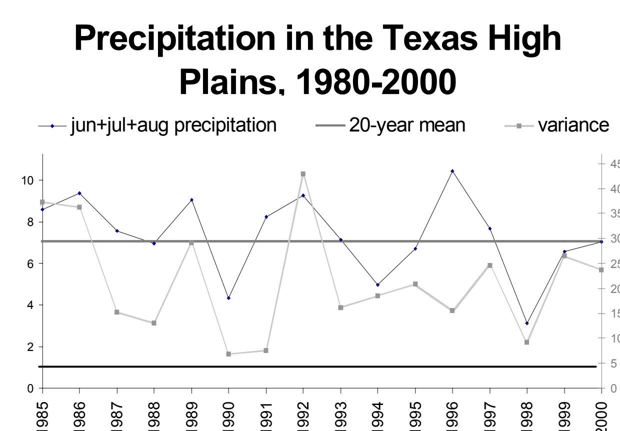

Figure 2. Summer Precipitation and Variance in the Texas High Plains.

Further simulations will extend to a seasonal realizations; Figure 2 shows precipitation and variance for 19 rain gauge stations in the Texas High Plains during the months of June, July and August, when precipitation is most intense. We plan to explore the seasonal effects of irrigation in the region by examining a wet year (1996), a dry year (1998), and an average year (1997). The extent of an irrigation effect should differ depending on the atmosphere's ability to initiate convection, and these seasonal cases will further refine our understanding of the feedbacks involved.

4. REFERENCES

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