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INFLUENCE OF LANDUSE ON MESOSCALE ATMOSPHERIC CIRCULATION

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1. OVERVIEW OF TALK

It has been recognized for years that mountains and sea shores are associated with local, diurnally varying wind circulations. Referred to as sea breezes, mountain winds, etc., they exert a significant influence on the climate and weather in regions where they occur. Pielke (1974) and Pielke et al. (1986), for example, have shown how thunderstorm activity over the Florida peninsula is strongly modulated by the sea breeze. The sea breeze provides both mesoscale ascent as well as enriched convective available potential energy in the sea breeze convergence zones.

Recently, observational and modeling work has documented that thermally-forced atmospheric circulations of a similar strength to sea breezes can occur over any sufficiently large area in which land surfaces with different sensible heat fluxes to the atmosphere are juxtaposed.

Twenty-seven mid-day satellite images for the period July 23 through August 30, 1986 were analyzed to identify the hottest IR temperature at each pixel location for this period. Figure 1 presents those results. Only those days which were clear to partly cloudy were considered and only pixels which were not affected by cloudiness were included in the overall results. Thus, we are looking at the extreme clear ground radiance for the last week of July and the entire month of August, 1986. Clearly evident in the image are the large gradients of surface temperature which occur throughout the region. For example, the gradient of irradiance temperature between east central and north central Kansas (path 'A', Figure 1) is 14°C. The gradient between east central and south central Kansas (path 'B', Figure 1) is 16°C! Pielke et al. (1990a,b) shows that explanations for this variability include spatial differences in the amount of transpiring biomass resulting from variations in vegetation type, differences in vegetation stress, and in albedo. Thus, as will be shown in the oral presentation, the Great Plains is not a region with a uniform transition between a short and tall grass prairie, but contains considerable horizontal non-homogeneity.

Such landscape differences will result in mesoscale circulations when their spatial scale is sufficiently large so that a horizontal thickness gradient (where the thickness is defined as the distance between the surface and the convective mixed

layer top) persists through the daylight period of the day. The gradient is forced by diurnal and spatial variations in the surface sensible heat flux. Dalu et al. (1990) demonstrates using linear analysis that the Rossby radius and the depth of heating over flat terrain are crucial parameters in determining the importance of these features on the mesoscale. The optimal size of the inhomogeneity for zero synoptic flow occurs when convergence zones generated at the sides of the area merge around the time of maximum surface heating. The presence of a larger scale prevailing flow results, in general, in a need
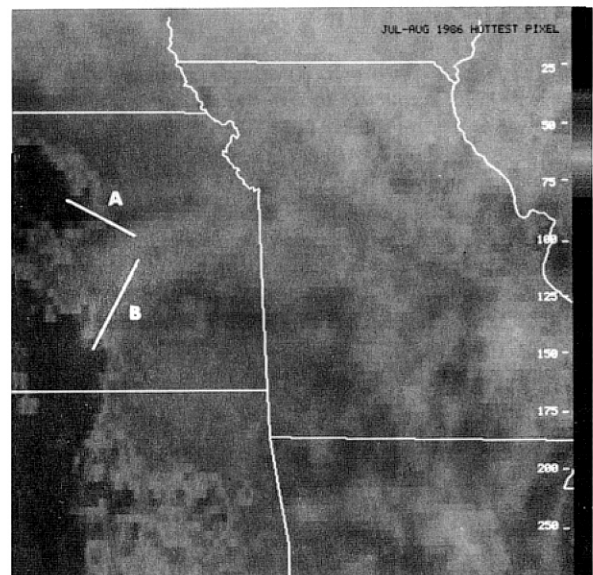

Figure 1: Image illustrating an analysis of the hottest midday surface irradiance temperatures as sensed by the GOES-IR imager during the period July 23 through August 30, 1986. Daily images were from 1815 UTC. The hottest value at each IR pixel location (from the 27 image data set) was identified objectively, and inserted into the image file shown here. Temperature difference across path 'A' is 14°C, that along 'B' is 16°C.

for larger spatial scales before a heat patch can substantially influence local winds.

This work demonstrates the importance of variable land-use on mesoscale wind circulations. A quantification of observed spatial variability in landscape (analyzed using two-dimensional spectral decomposition) would assist in further documenting their importance in generating mesoscale circulations. For numerical weather prediction, such information needs to be inserted into the model as a bottom boundary condition.

While this paper will focus on surface thermally-forced systems, propagating mesoscale and synoptic features will also be significantly influenced as they interact with the landscape forced circulations.

2. ACKNOWLEDGEMENTS

3. REFERENCES

Pielke, R.A., 1974: A comparison of three-dimensional numerical model of the sea breezes over south Florida. *Mon. Wea. Rev.*, **102**, 115-139.

Pielke, R.A., J. Weaver, T. Kittel, and J. Lee, 1990a: Use of NDVI for mesoscale modeling. *Workshop on the "Use of Satellite-Derived Vegetation Indices in Weather and Climate Prediction Models"*, Camp Springs, MD, February 26-27, 1990.

Pielke, R.A., J. Lee, and J.F. Weaver, 1990b: Influence of vegetation on the water and heat distribution over mesoscale sized areas. Eighth Conference on Hydrometeorology, Kananaskis Provincial Park, Alberta, Canada, October 22-26, 1990.

Dalu, G.A., R.A. Pielke, R. Avissar, G. Kallos, and A. Guerrini, 1990: Impact of terrain thermal inhomogeneities on mesoscale atmospheric flow: Theory of subgrid-scale parameterization. *J. Atmos. Sci.*, (submitted).

Pielke, R.A., J.-L. Song, M. Segal, P.J. Michaels, and R.W. Arritt, 1986: The predictability of sea breeze generated thunderstorms. *Proceedings of the WMO International Workshop on Rain-Producing Systems in the Tropics and the Extra-Tropics*, July 21-25, 1986, San Jose, Costa Rica, 101-107.