JP4.9 QUANTIFYING THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THE EFFECT OF WINTER WHEAT

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1. INTRODUCTION

1.1 Vegetation-atmosphere interactions

Vegetation affects surface albedo, roughness, and the partitioning of the surface heat budget. These effects have an impact on temperature, dew point, and the development of the boundary layer. For example, Doran et al. (1995) observed lower temperatures and sensible heat fluxes over irrigated farmland than over an adjacent steppe due to a greater latent heat flux over the farmland. Similarly, Segal et al. (1989) found cooler daytime temperatures across irrigated cropland than surrounding dry land. The difference was attributed to greater evapotranspiration over the cropland.

1.2 Oklahoma's winter wheat belt

Oklahoma's winter wheat belt is a north-south oriented band in western Oklahoma where the primary land use is winter wheat or a mixture of winter wheat and grassland (McPherson et al. 2004). It is surrounded mostly by grassland and has been observed to have a significant impact on both temperature and dew point. McPherson et al. (2004) found significantly cooler maximum temperatures across the wheat belt than across surrounding regions from November through April, except during March. The wheat belt was found to have higher dew points than the surrounding regions during March. It is during these months that the winter wheat is growing but the surrounding grassland is dormant. Haugland and Crawford (2005) also found a reduction in afternoon temperatures over the winter wheat belt during the growing season.

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During the summer months, vegetation in the surrounding grassland became active, but the winter wheat had been harvested. After the wheat harvest, maximum and minimum temperatures were found to be significantly warmer than in the nearby grassland (McPherson et al. 2004). Haugland and Crawford (2005) also observed higher temperatures in the wheat belt than in the surrounding region.

2. DATA AND METHODOLOGY

2.1 The Oklahoma Mesonet

The Oklahoma Mesonet is a surface observing network of more than 110 stations across the state of Oklahoma. The density and statewide distribution of these stations make Mesonet data ideal for use in studying the effect of the winter wheat belt. Data for this research are taken from Mesonet observations of air temperature, relative humidity, pressure, incoming solar radiation, wind speed, and 25 cm soil moisture.

2.2 Moist enthalpy

To quantify the effects of the winter wheat belt, it is useful to consider moist enthalpy, defined in Pielke et al. (2004) as

$$H = c_p T + qL_v, \qquad (1)$$

where c_p is the specific heat at constant pressure, T is temperature, q is specific humidity, and L_v is the latent heat of vaporization. This quantity takes both sensible and latent heat into account. Effective temperature, a related quantity more comparable to temperature and dew point (Pielke et al. 2005), is defined as:

$$T_{eff} = H / c_p . \qquad (2)$$

3. CASE STUDIES

McPherson et al. (2004) demonstrated the influence of the wheat belt during three case study

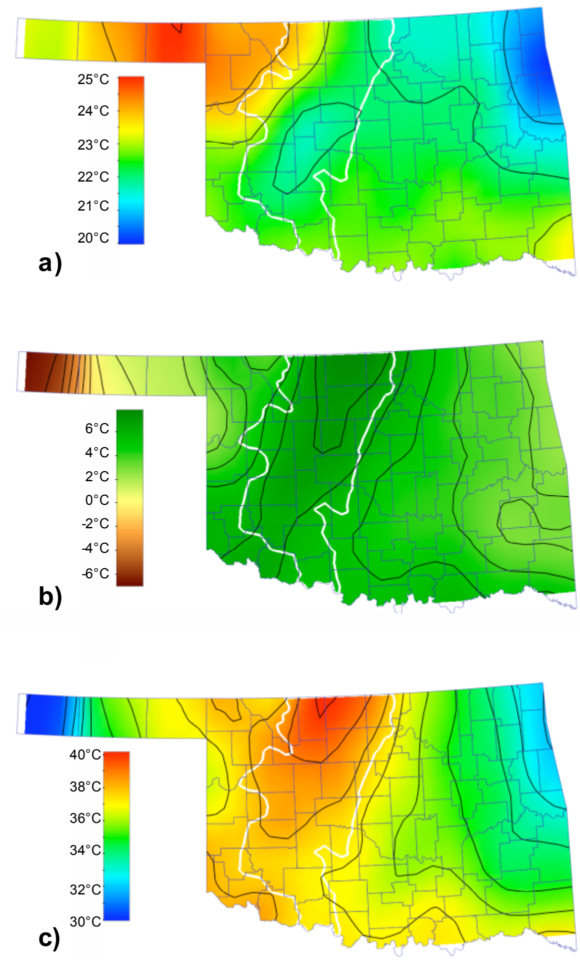

Figure 1. 27 March 2000 plots of (a) air temperature, (b) dew point, and (c) effective temperature in degrees Celsius. The white outline represents the boundary of the wheat belt. Black lines are contours in a 1°C interval.

days. Two of these days, 27 March 2000 and 5 April 2000, were during the growing season for winter wheat. The last, 10 July 2000, was after the winter wheat harvest. All three days had clear skies and light or moderate winds. Patterns of effective temperature, air temperature, and dew point are examined for each of these cases.

3.1 27 March 2000

A plot of temperature at 1500 CST for 27 March 2000 reveals air temperatures over the winter wheat belt comparable to those of central and eastern Oklahoma (Fig. 1a). The plot of the dew point field at the same time shows higher dew points over the winter wheat belt than over the surrounding area (Fig. 1b). A similar pattern was observed by McPherson et al. (2004) for this day. The pattern of effective temperature closely resembles that of dew point (Fig. 1c). Greater effective temperatures are seen over the wheat belt than the surrounding regions. The higher temperatures across western Oklahoma are not evident in the effective temperature field.

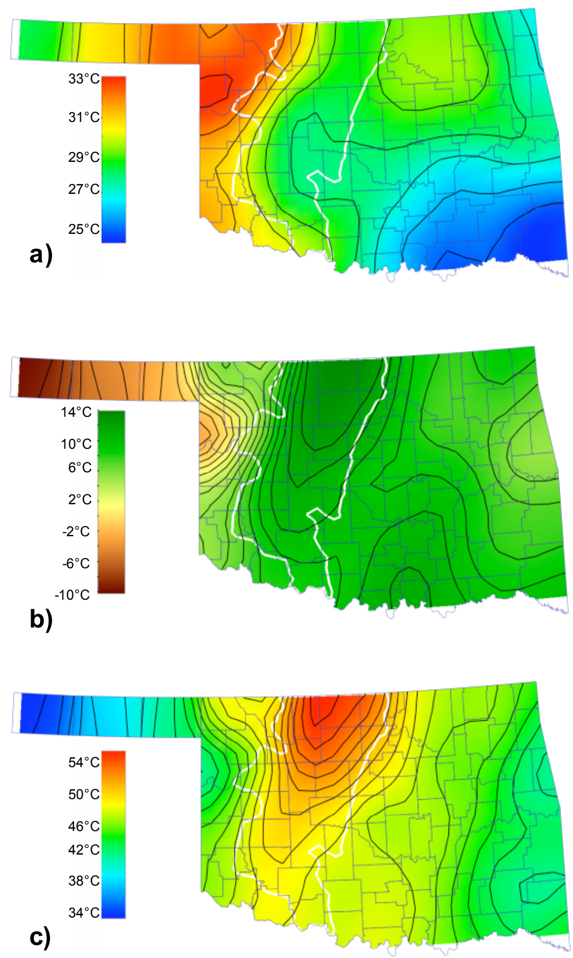

Figure 2. 5 April 2000 plots of (a) temperature, (b) dew point, and (c) effective temperature in degrees Celsius with isopleths every 1°C. The wheat belt is outlined in white.

3.2 5 April 2000

A plot of air temperature at 1500 CDT on 5 April 2000 reveals warm air over western Oklahoma, while temperatures over the wheat belt and most of eastern and central Oklahoma are cooler (Fig. 2a). In the corresponding plot of dew point, low-level moisture is greater over the wheat belt than across the rest of Oklahoma (Fig. 2b). McPherson et al. (2004) also observed high dew

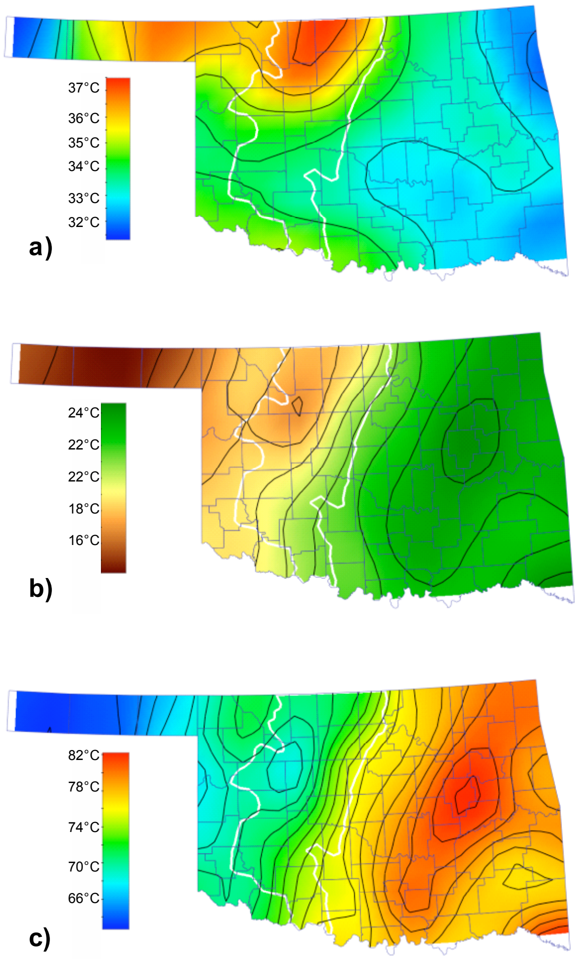

Figure 3. 10 July 2000 plots of (a) air temperature, (b) dew point, and (c) effective temperature in degrees Celsius with isopleths every 1°C. The white outline represents the wheat belt.

points over the wheat belt on this day. The 1500 CDT effective temperature field has a similar pattern to the dew point field, with higher effective temperatures across the wheat belt than across the surrounding region (Fig. 2c). Features seen in the air temperature field are not evident in the effective temperature field.

3.3 10 July 2000

Relatively warm temperatures were observed in the winter wheat belt on 10 July 2000 (McPherson et al. 2004). The 1300 CDT plot of temperature shows relatively high temperatures over the northern part of the wheat belt, with cooler temperatures over eastern Oklahoma and another area of relatively high temperatures in the Panhandle (Fig. 3a). A plot of dew point from the same time reveals dry air through western Oklahoma and much of the wheat belt, while eastern Oklahoma has relatively high dew points (Fig. 3b). The corresponding effective temperature plot shows a region of relatively high effective temperature in the eastern part of the state, while the western half of the state is characterized by low effective temperatures (Fig. 3c). As in the previous two cases, the effective temperature field more closely resembles the appearance of the dew point field than that of the temperature field.

4. SUMMARY AND DISCUSSION

The winter wheat belt appears to have an impact on the effective temperature in the two growing season cases. The effective temperature is higher across the wheat belt than the surrounding region during both days. In the post-harvest case, however, no distinct pattern is seen in the effective temperature field in the wheat belt. Warmer temperatures in the northern and central parts of the wheat belt are not reflected well in the effective temperature field. In all cases, the pattern of effective temperature resembles the pattern of dew point closer than that of the temperature.

This poster will describe the climatology of effective temperature across Oklahoma, with particular attention given to gradients surrounding the winter wheat belt. The influence of solar radiation, wind speed, and soil moisture on the gradients of effective temperature also will be discussed.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Doran, J. C., W. J. Shaw, and J. M. Hubbe, 1995: Boundary layer characteristics over areas of inhomogeneous surface fluxes. *J. Appl. Meteor.*, **34**, 559-571.

Haugland, M. J., and K. C. Crawford, 2005: The diurnal cycle of land-atmosphere interactions across Oklahoma's winter wheat belt. *Mon. Wea. Rev.*, **133**, 120-130.

McPherson, R. A., D. J. Stensrud, and K. C. Crawford, 2004: The impact of Oklahoma's winter wheat belt on the mesoscale environment. *Mon. Wea. Rev.*, **132**, 405-421.

Pielke, R., A., C., Davey, and J. A. Morgan, 2004: Assessing global warming with surface heat content. *Eos*, **85**, No. 21, 210-211.

Pielke, R. A. Sr, K. Wolter, O. Bliss, N. Doesken, and B. McNoldy, 2005: The July 2005 Denver heat wave: How unusual was it? [Available online at http://ccc.atmos.colostate.edu/pdfs/Denver%20Heat%20Wave_21Nov2005_final.pdf].

Segal, M., W. E. Schreiber, G. Kallos, J. R. Garratt, A. Rodi, J. Weaver, and R. A. Pielke, 1989: The impact of crop areas in northeast Colorado on midsummer mesoscale thermal circulations. *Mon. Wea. Rev.*, **117**, 809-825.