16.19 THE DIURNAL CYCLE OF DEWPOINT ACROSS OKLAHOMA'S WINTER WHEAT BELT

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1. INTRODUCTION

Oklahoma's Winter Wheat Belt is a near-ideal outdoor laboratory for studying the impact of vegetation on the atmosphere. The diurnal cycle of dewpoint across the region reveals the impact of the wheat fields on moisture in the atmosphere. This manuscript will document the impact before and after the harvest and under various atmospheric conditions.

2. THE WINTER WHEAT BELT (WWB)

The Winter Wheat belt is a 100km-wide strip stretching from north-central to southwest Oklahoma (Fig. 1). Winter wheat is a cold season crop planted during the fall. It grows until December when it becomes dormant. The winter wheat begins growing again by the end of winter, and flourishes during the spring. Winter wheat is harvested during late May or early June. By mid June, only bare soil and dead wheat stubble remain.

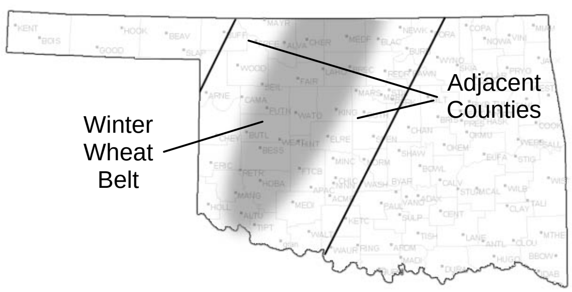

Figure 1. Map of Oklahoma and the WWB

The WWB is surrounded by mixed vegetation, primarily grassland. While the amount of green vegetation across most of the state increases from April to June, vegetation across the WWB is greatly reduced by the harvest. The impact of WWB can be isolated by comparing meteorological conditions observed at Mesonet sites across the WWB relative to adjacent counties before and after the wheat harvest.

The Mesonet is a statewide network of 114 weather stations, including 17 sites within the heart of the WWB. The adjacent counties are represented by 11 sites east of the WWB and 11 sites west of the WWB. Seven years of archived Mesonet data were used in this study.

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3. DIURNAL CYCLE OF DEWPOINT

At sunrise, evapotranspiration (ET) increases and dew is quickly evaporated, causing a sharp increase of the dewpoint during the first 2-4 hours after sunrise (Fig. 2). The stable atmosphere during this period allows the moisture to remain near the surface without being mixed to higher levels.

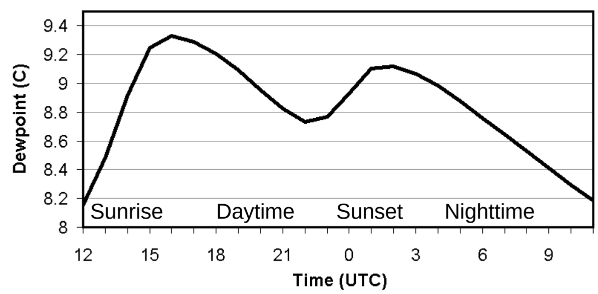

Figure 2. Annual Diurnal Cycle of Dewpoint Across Oklahoma (1994-1997).

As the temperature increases during the day, drier air above the morning boundary layer mixes down to the surface. That process is known as "dry air entrainment" (DAT). The result is a decrease of the surface dewpoint during the daytime, reaching a minimum during the afternoon hours. Evapotranspiration is at a maximum during the day when the surface relative humidity reaches a minimum. However, the surface-based moisture gained from ET usually does not offset the decrease of surface moisture caused by DAT across Oklahoma. By early evening, lower surface temperatures reduce vertical mixing and DAT. The result is an increase of surface dewpoint a few hours before sunset.

At sunset, solar heating ends and the atmosphere becomes stable, virtually ending DAT. The stable atmosphere traps moisture near the surface. Without DAT to offset ET, the dewpoint Across Oklahoma reaches a maximum within 4 hours of sunset.

During the nighttime, the temperature decreases, relative humidity increases, and less moisture is needed to saturate the air near the surface. When the relative humidity approaches 100%, water vapor in the atmosphere is converted to dew by condensation. The result is a steady decrease of the dewpoint until sunrise.

3.1 Before Harvest

During the growing season of winter wheat, visual greenness and evapotranspiration across the Winter Wheat Belt are significantly higher than adjacent counties.

Evapotranspiration from winter wheat also alters the surface energy balance. Evapotranspiration causes more of the incoming solar radiation to be partitioned into latent heat flux (evaporation) relative to sensible heat flux (increasing the temperature; Rabin et al. 1990). During the growing season of winter wheat, maximum temperatures across the Winter Wheat Belt are usually 1-3°C lower than in adjacent counties. The lower temperature moderates vertical mixing and dry air entrainment.

At sunrise, the dewpoint across the Winter Wheat Belt is the same as that observed across surrounding areas during March (Fig. 3). During the day, dry air entrainment reduces the surface dewpoint across most of Oklahoma. However, the dewpoint within the Winter Wheat Belt increases throughout the day because of greater evapotranspiration, cooler conditions, less vertical mixing, and less dry air entrainment. The average dewpoint across the WWB peaks during the late afternoon, but the average dewpoint in adjacent counties peaks after sunset. Between afternoon and sunset, the average dewpoint across the WWB is 2-3°C higher than in adjacent counties.

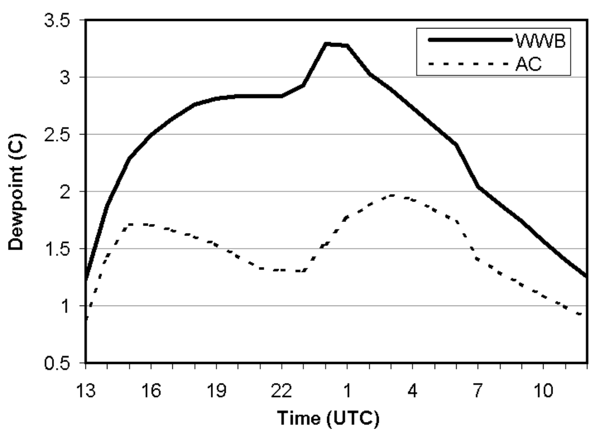

Figure 3. Diurnal Cycle of Dewpoint Across the Winter Wheat Belt (WWB) and Adjacent Counties (AC) During March (1994-2000).

3.2 After Harvest

The late-spring wheat harvest reduces the wheat fields to bare soil and dead wheat stubble. Evapotranspiration is greatly reduced and most of the incoming solar energy is partitioned into sensible heat flux (Rabin et al. 1990). Maximum temperatures across the WWB during the summer are usually 1-3°C higher than in adjacent counties. While the diurnal cycle of dewpoint outside the WWB changes very little from spring to summer, dramatic changes occur within the WWB (Fig. 4).

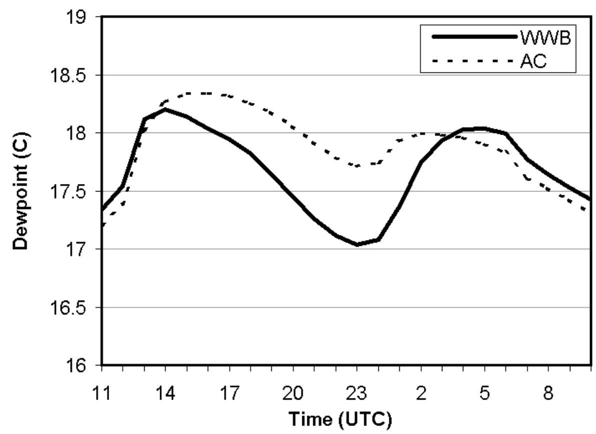

Figure 4. Diurnal Cycle of Dewpoint During June (1994-2000).

As observed during March, the dewpoints within and outside the WWB are approximately equal at sunrise. However, compared to adjacent counties, DAT reduces the dewpoint across the WWB earlier in the day. During the afternoon, the average dewpoint outside the WWB decreases, but remains higher than was observed shortly before sunrise. Within the WWB, the afternoon dewpoint is lower than that observed shortly before sunrise. After the harvest, the diurnal cycle of dewpoint across the WWB is dominated by dry air entrainment. This is not the case in adjacent counties.

4. OTHER FACTORS AFFECTING THE DIURNAL CYCLE OF DEWPOINT

The diurnal cycle of dewpoint illustrates the combined interaction of soil moisture, vegetation, and the atmosphere. Oklahoma received above-average rainfall during June 2000, which provided abundant soil moisture during the month of July. The average diurnal cycle of dewpoint observed at Mesonet sites during July 2000 revealed significant differences between sites within the WWB and sites in adjacent counties (Fig. 5). These differences were more pronounced than during a typical July represented by seven years of archived Mesonet data.

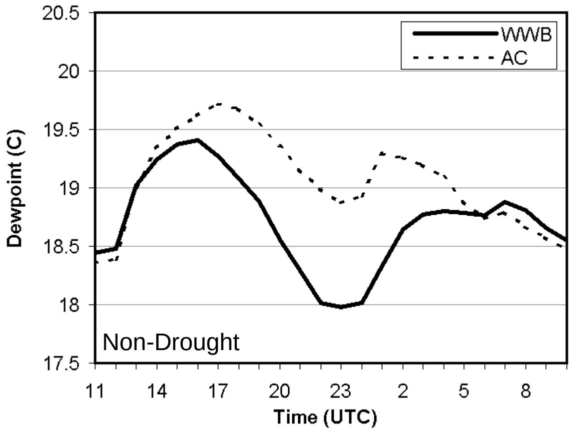

Figure 5. Diurnal Cycle of Dewpoint During July 2000.

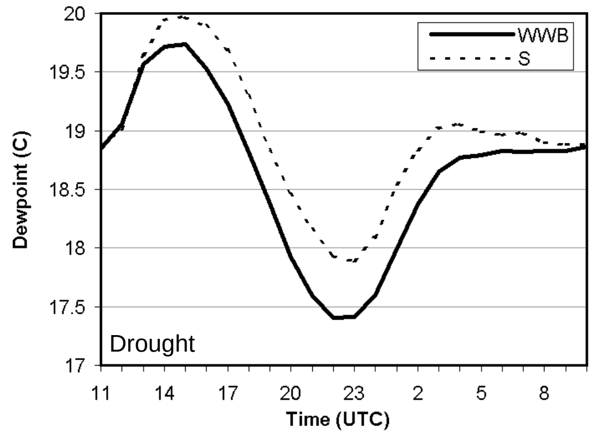

Figure 6. Diurnal Cycle of Dewpoint During July 1998.

During the late-morning hours, the dewpoint across the Winter Wheat Belt (mostly bare soil and dead wheat stubble in July) decreased more quickly than observed in surrounding areas. The vegetation outside the WWB appeared more effective at transporting ground moisture into the atmosphere. The higher rate of ET also kept the temperature lower in the counties adjacent to the wheat belt, reducing vertical mixing and DAT there. By mid-afternoon, the dewpoint across the WWB was 1℃ lower than that observed across adjacent counties. From sunset to sunrise, the dewpoint outside the WWB decreased 0.9℃. Within the WWB, the dewpoint decreased 0.4℃, indicating less condensation at night.

During a drought when soil moisture is minimal, the amount of water transported to the atmosphere by vegetation is reduced. For example, during the spring of 1998, very little rainfall occurred across Oklahoma. As a result, Oklahoma experienced drought conditions by July. Shortly after sunrise during the average day in July 1998, evapotranspiration was quickly overcome by dry air entrainment and the dewpoint across both regions decreased sharply until mid-afternoon (Fig. 6). The average dewpoint during the afternoon was 1-1.5℃ lower than the average dewpoint shortly before sunrise. The dewpoint increased during the late afternoon as solar heating decreased, but it did not reach a distinct peak near sunset. Instead, the dewpoint remained steady from sunset to sunrise, indicating minimal ET during the day, minimal condensation at night, and minimal soil moisture.

Unlike July 2000, the diurnal cycle of dewpoint within and outside of the WWB were almost identical during July of 1998. Without sufficient soil moisture, the meteorological impact of geographic vegetation differences was minimal. However, the impact was amplified when soil moisture was abundant, such as during July 2000.

The vertical moisture profile is another important factor. Dry air entrainment plays such a major role in Western Oklahoma because the region often has a shallow moist layer near the surface and much drier air above the 850 mb level. On days when the dewpoint near 850 mb decreased rapidly with height, the harvested wheat fields had the greatest impact on the diurnal cycle of dewpoint. It is hypothesized that, if the Winter Wheat Belt was located in a region with deeper boundary layer moisture such as nearer the Gulf Coast, the WWB's impact on the diurnal cycle of dewpoint would be minimized.

5. CONCLUSION

The diurnal cycle of dewpoint across Oklahoma's Winter Wheat Belt illustrates the importance of vegetation to transport moisture from soil to the atmosphere. The cycle also reveals how a mesoscale climate can be modified by human agricultural practices.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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