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Temporal and Spatial Variations of Moist Enthalpy in the U.S. High Plains Region

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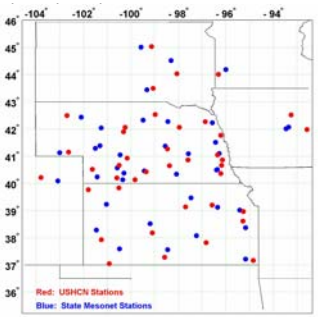
OBJECTIVES

- Understand surface Tx and Tn variations in current state mesonets from 1987 to 2007.
- Investigate surface heat content changes by daily Tex and Ten due to changes of air water vapor.

INTRODUCTION

Climate change and variability involved many aspects of the climate system and the assessment of anthropogenically-forced climate change has considerably focused on surface temperature as a primary variable. In this study, we investigated the temporal and spatial variation of surface heat content or moist enthalpy through using daily maximum (**Tx**) and minimum (**Tn**), and air water vapor variables (dewpoint temperature **Td** and mixing ratio **MR**).



The selection of stations used in this study was based on the availability of adequate data free of inhomogeneities as determined by monthly temperature and humidity series within study period. After maximizing the spatial and temporal coverage, 40 state-automated stations were selected from Jan 1 1987 to Oct 31 2007 (250 months) and paired 40 stations selected from the USHCN stations were also included.

Hourly data from the automated stations and daily data from the USHCN are used, respectively, for surface maximum (Tax and TX) and minimum (Tan and TN) temperatures. Soil temperature and air humidity are timed to the daily air temperatures for their maximum and minimum observations (soil temperature: Tsx and Tsn and dewpoint temperature: Tdx and Tdn).

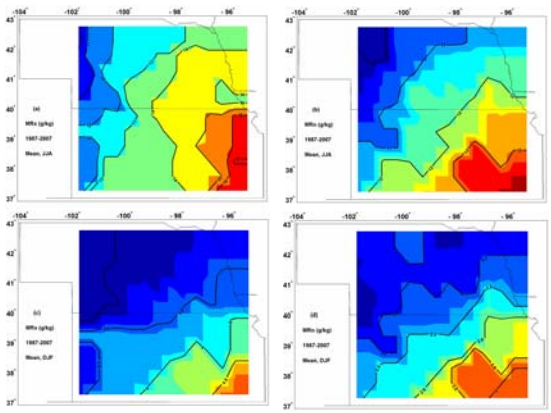
DATA ANALYSIS METHOD

The heat content of surface air (i.e., z right above ground level, so that z = 0 can be assumed) can be expressed as:

$$H = C_p T + Lq; \qquad T_e = H / C_p$$

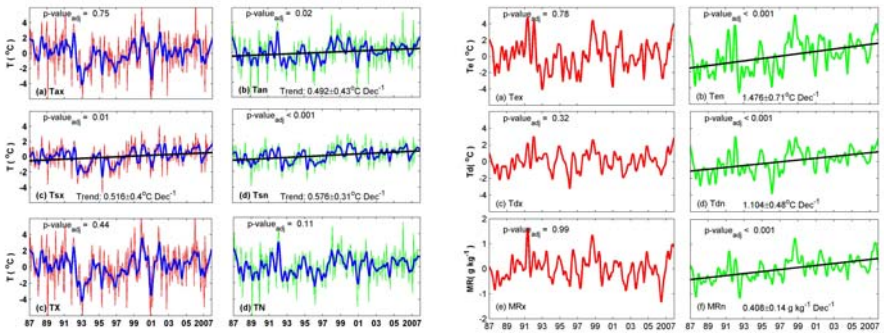
Where C_p is the specific heat of air at constant pressure, ***T*** is temperature, ***L*** is the latent heat of vaporization, and ***q*** is the specific humidity. The ***H*** is the moist enthalpy or moist static energy (J kg^{-1}). The ***Te*** is the surface equivalent temperature, which will better represent surface air heat content.

The statistical significance of regional temporal trends and individual station trends were evaluated using an adjusted standard error and adjusted degrees of freedom method, which is to account for the effect of temporal autocorrelation in the anomaly time series or residual series. This trend analysis method based on the first-order autoregressive model AR(1) was justified by examining the lag-1 versus higher lag values of the partial autocorrelation function (PACF) in the series that we analyzed in this study.

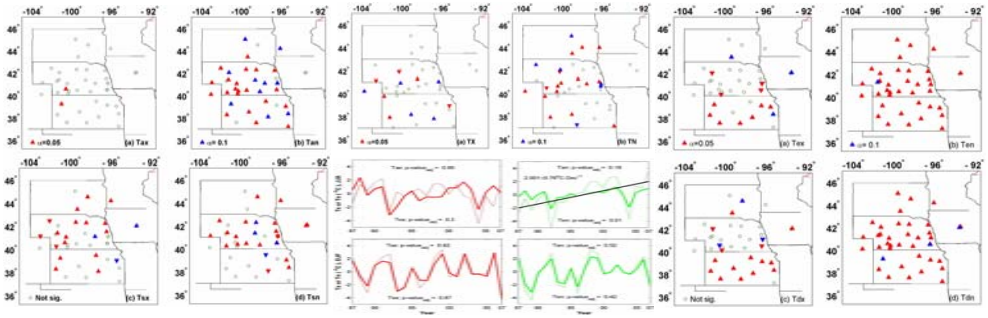


❖ Long-term (1987-2007) mean surface mixing ratio (MR) (g kg^{-1}) derived from automated stations for the MRx and MRn: (a) MRx, JJA season, (b) MRn, JJA, (c) MRx, DJF, and (d) MRn, DJF season.

RESULTS



❖ Station averaged series of Tax and Tan (left top), Tsx and Tsn (left middle), TX and TN (from USHCN, left bottom), Tex and Ten (right top), Tdx and Tdn (right middle), and MRx and MRn (right bottom). The straight line is a linear fit to the data and the ± values define the 95% confidence intervals for trends. The thick curves are time series of 7-month running averages (used as a smoother) of original monthly data.



❖ Left four: Statistical significance of individual station trends of daily Tax, Tan, Tsx and Tsn. The red triangles indicate 0.05 significant levels and blue 0.1 significant levels. Triangles with apex up (down) indicate warming (cooling) trends of station series. The blank circles refer to the station series not statistically significant.

❖ Middle four: Statistical significance of individual station in the USHCN of daily TX and TN (top two). The seasonal time series of Tax (red solid), Tex (red dash), Tan (green solid), and Ten (green dash) for the JJA (middle two) and DJF (bottom two) seasons.

❖ Right four: The same as the left four but for the daily Tex, Ten, Tdx, and Tdn.

CONCLUSIONS

Changes of regional daily maximum temperature in the Nebraska and Kansas were inconclusive in both the state mesonets and USHCN but a significant trend for the daily minimum temperature was detected (0.49 ± 0.43ºC per decade) in the state mesonets. No significant changes were detected for daily minimum temperatures in the USHCN series. The air water vapor increased at the rate of 0.41 ± 0.14 g kg^{-1} per decade and the surface minimum equivalent temperature (heat content) displayed a trend of 1.48 ± 0.71ºC per decade.

Spatially, most of stations exhibited significant increasing trends for daily minimum temperatures but not for the USHCN stations. The equivalent temperatures, dewpoint temperatures, and mixing ratio when timed to the daily minimum temperatures were significantly increased in the study areas.