Latitudinal Gradient in Dew Point Trends Along an Eastern U.S. North–South Transect (1973–2023)

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Introduction

Dew-point temperature provides an absolute measure of atmospheric moisture, crucial for understanding heat stress, storm potential, and energy demand. Unlike relative humidity, dew point directly links to moisture content and changes in climate warming, since a warmer atmosphere holds more water vapor. Although theory predicts rising dew points under global warming, few studies have examined long-term trends across different U.S. climate regimes. Here, we analyze hourly dew-point data (1973–2023) from five NOAA first-order stations along a north–south transect (New Orleans → Memphis → St. Louis → Minneapolis–St. Paul → International Falls) to (1) quantify annual and seasonal trends, (2) characterize monthly distribution shifts, and (3) compare diurnal cycles across latitudes.

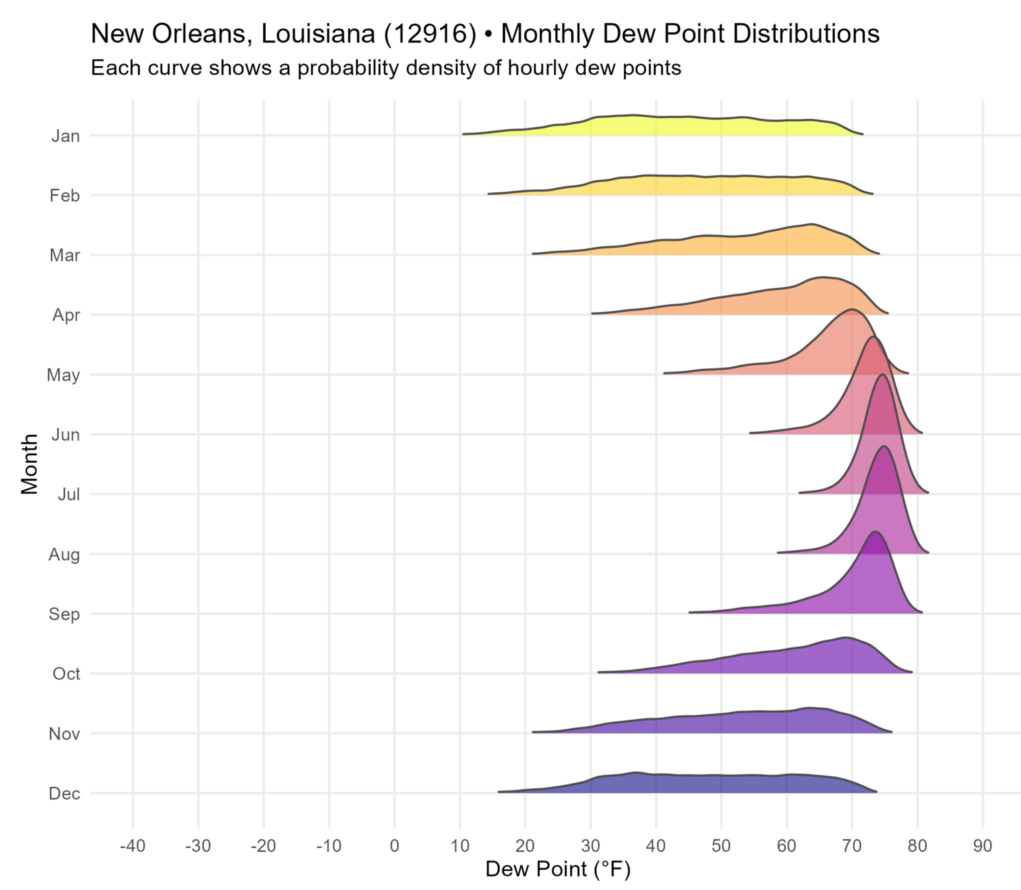
Methods

Hourly dew point data (1973–2023) were obtained from NOAA's Local Climatological Data for five first-order stations along the north–south transect. Data were organized and tested using Python, and all analyses and figures were produced in R.

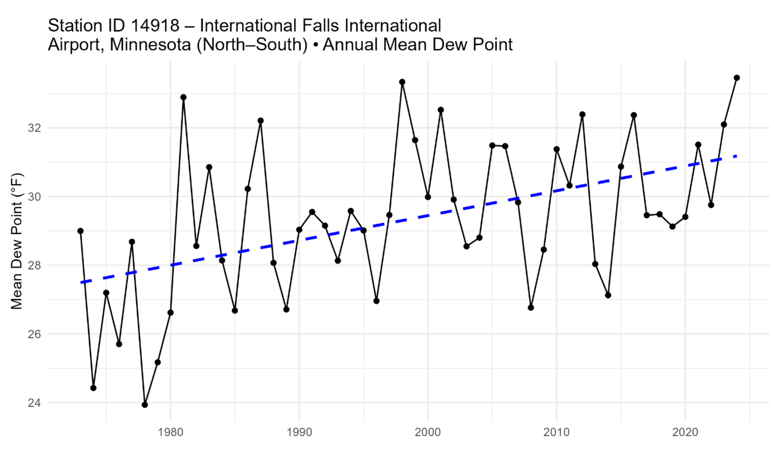
Annual & Seasonal Trend Analysis
• Annual averages were calculated for each calendar year.
• Seasonal averages were computed for winter (December–February), spring (March–May), summer (June–August), and fall (September–November).
• Mann-Kendall tests quantified the direction and strength of trends; Sen's slope estimated the rate of change (°F per year).

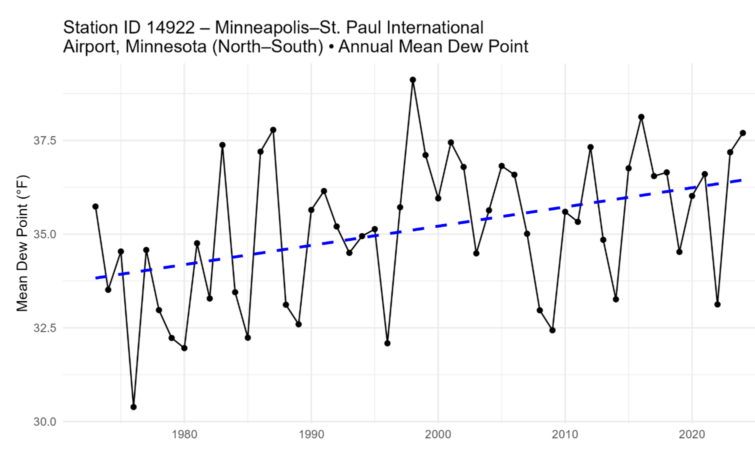
Monthly Distribution (Ridge-Plot) Analysis
• Kernel density estimates were generated for each month's hourly dew points.
• Stacked density curves ("ridge plots") visualized how monthly dew-point distributions shift in central tendency and spread.

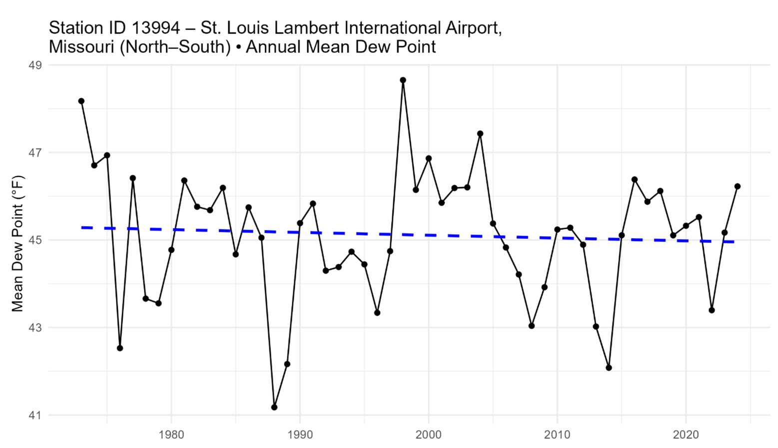
Diurnal Cycle Analysis
• Dew points were averaged by hour of day (1–24) across the full record.
• A smooth daily curve highlights typical morning minima and afternoon maxima at each station.

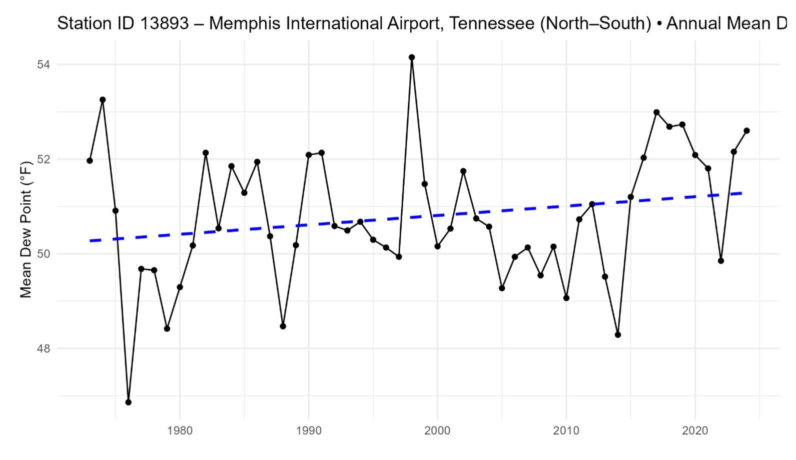


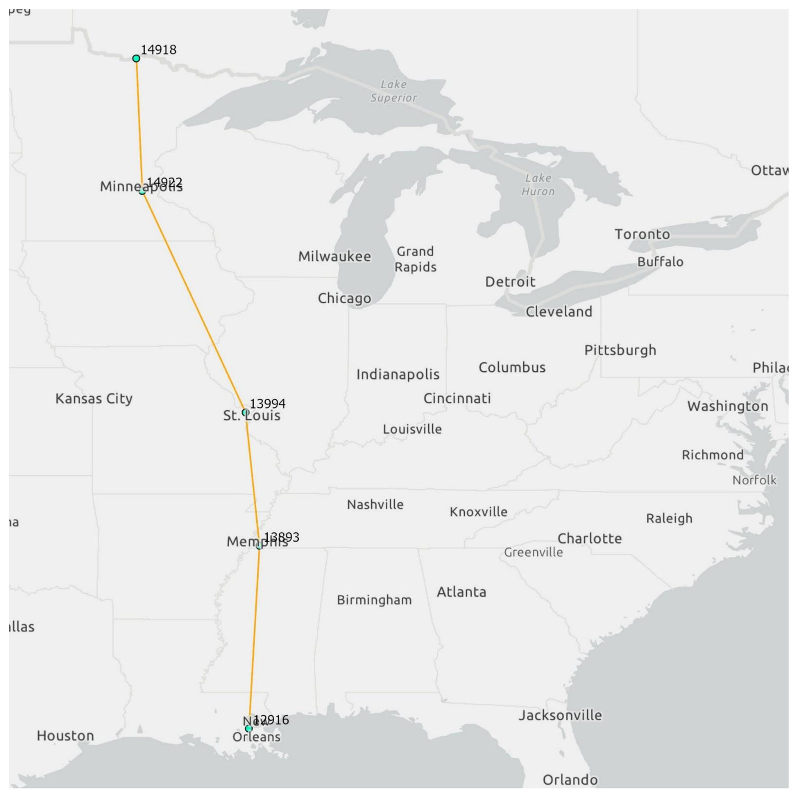
Monthly Dew Point Distributions Along the Transect

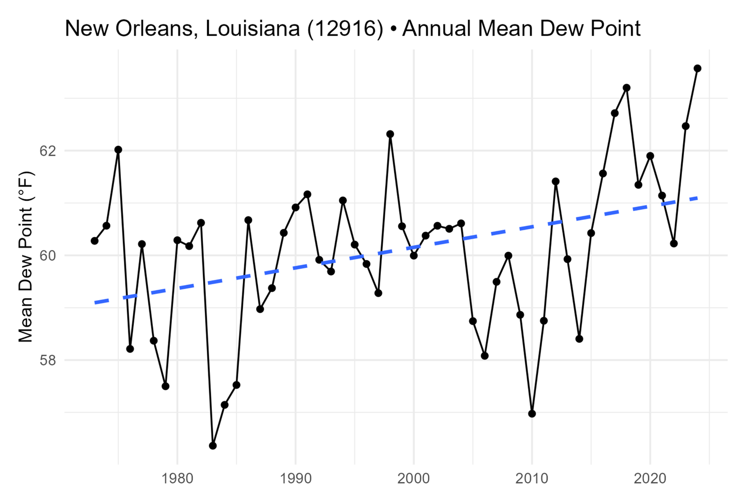




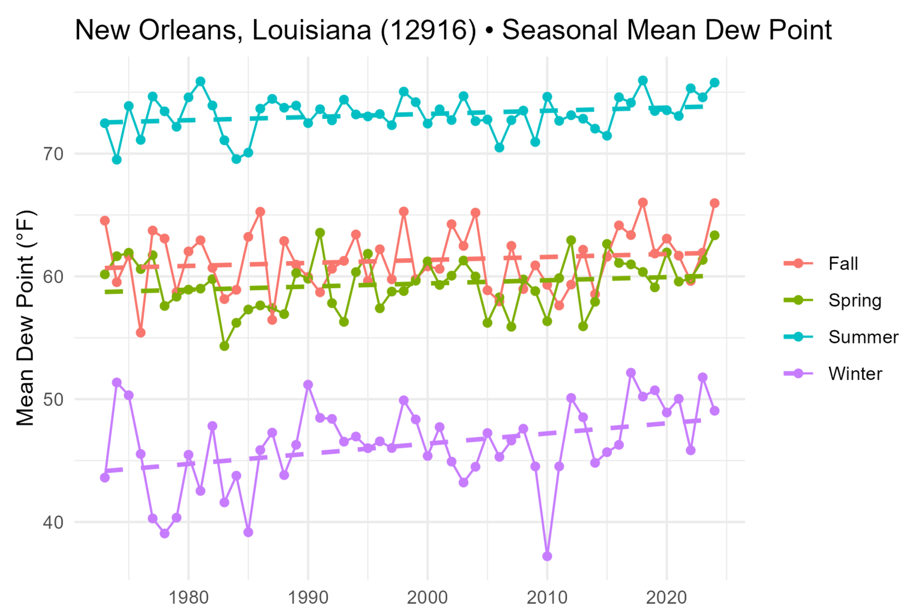


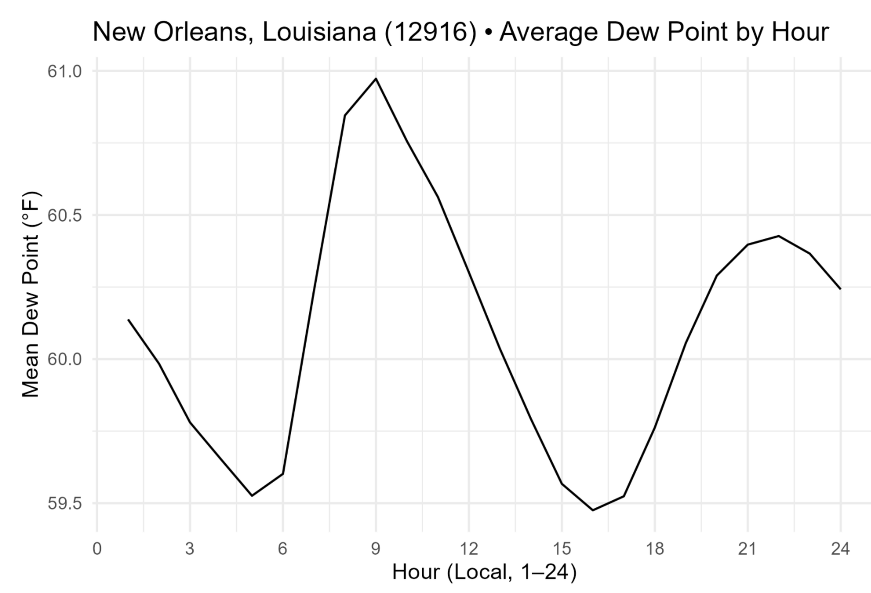






New Orleans Dew Point Patterns





Results

Annual Trends
- International Falls (MN) showed the strongest, highly significant upward trend in mean annual dew point (Kendall's τ = 0.33, p = 0.001), with a Sen's slope of +0.074 °F yr^{-1}, indicating rapid moisture increase.
- Minneapolis–St. Paul (MN) also rose significantly over the study period (τ = 0.26, p = 0.006; slope = +0.055 °F yr^{-1}).
- New Orleans (LA) experienced a modest but statistically significant increase (τ = 0.23, p = 0.015; slope = +0.036 °F yr^{-1}).
- Memphis (TN) (τ = 0.13, p = 0.19) and St. Louis (MO) (τ = –0.06, p = 0.53) showed no statistically meaningful long-term change.

Seasonal Trends
- Winter (December–February) dew points rose significantly at all stations except St. Louis, with $p < 0.05$ at New Orleans, Memphis, Minneapolis–St. Paul, and International Falls.
- Fall (September–November) increased only at International Falls (τ ≈ 0.25, $p < 0.01$); spring (March–May) and summer (June–August) showed no clear long-term shifts ($p > 0.05$ at every site).

Monthly Distributions
- Ridge plots reveal a pronounced north–south gradient:
- Northern stations (Minneapolis–St. Paul, International Falls) exhibit a rightward shift of their winter distributions, consistent with their significant winter trends.
- Southern stations (New Orleans, Memphis) maintain consistently high summer peaks with little change in distribution shape.
- Variability (width of the density curves) increases in shoulder months (April–May, September–October), particularly at mid-latitude sites (St. Louis, Memphis), indicating greater month-to-month moisture swings.

Diurnal Cycles
- All five stations display a clear daily pattern: dew-point minima just before dawn (around 5 AM) and maxima in mid-afternoon (2–3 PM).
- The amplitude of this cycle decreases slightly from about 3 °F at New Orleans to roughly 2 °F at Minneapolis–St. Paul and International Falls, reflecting the stronger daytime heating and nocturnal cooling in the deep South.

Conclusion

Our analysis reveals a clear latitudinal gradient in long-term moisture changes across the transect. Northern stations (International Falls and Minneapolis–St. Paul) experienced the strongest and most statistically significant increases in annual dew point, especially in winter, while St. Louis, Memphis, and New Orleans showed little to no meaningful change apart from a modest winter rise in New Orleans. Despite these baseline shifts, all sites maintain a simple daily rhythm—dew points fall to their lowest just before dawn and rise to a peak in the early afternoon—with slightly larger morning-to-afternoon swings in the humid South. Together, these results highlight how latitude shapes both long-term moisture trends and the everyday cycle of humidity, underscoring the importance of tracking winter dew point rises at northern sites for agriculture, infrastructure, and public health planning.

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