Supplement of

Urban heat forecasting in small cities: Evaluation of a high-resolution operational numerical weather prediction model

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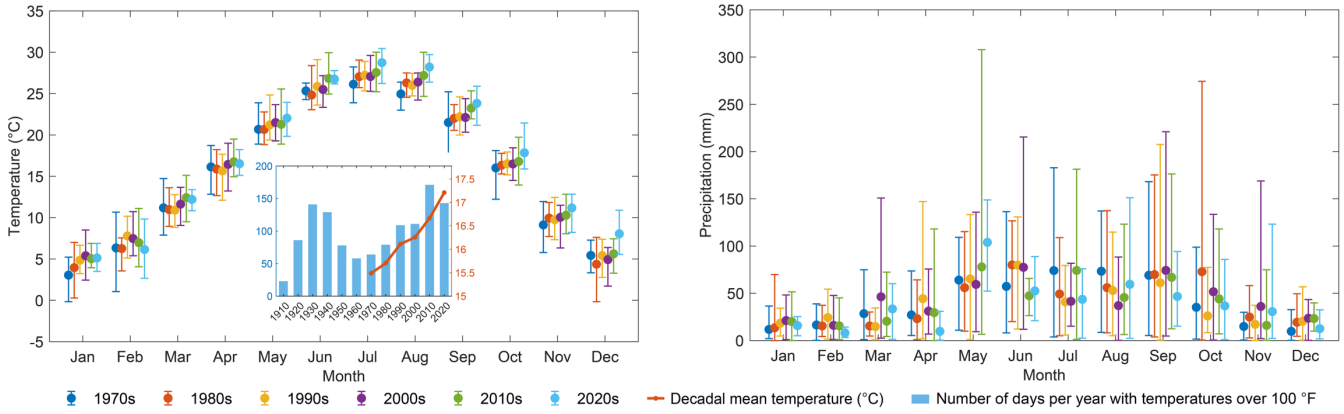


Figure S1. Local background climate characteristics of Lubbock, Texas: (a) Decadal average of monthly temperature variations, where error bars indicate the intra-decadal monthly maximum and minimum temperatures. The bar plot within the subplot denotes the total number of days per decade with maximum temperatures exceeding 37.78 °C (100°F), while the red line represents the decadal mean temperature. (b) Decadal average of monthly precipitation. Data source: NOAA Online Weather Data (https://www.weather.gov/wrh/Climate?wfo=lub).

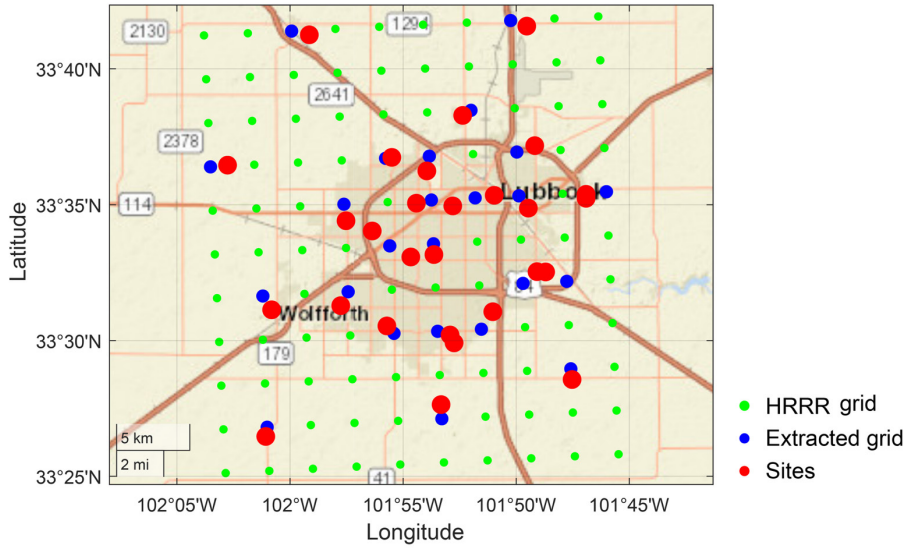


Figure S2. Locations of observation sites (red) and corresponding HRRR grid points (blue) used for model evaluation.

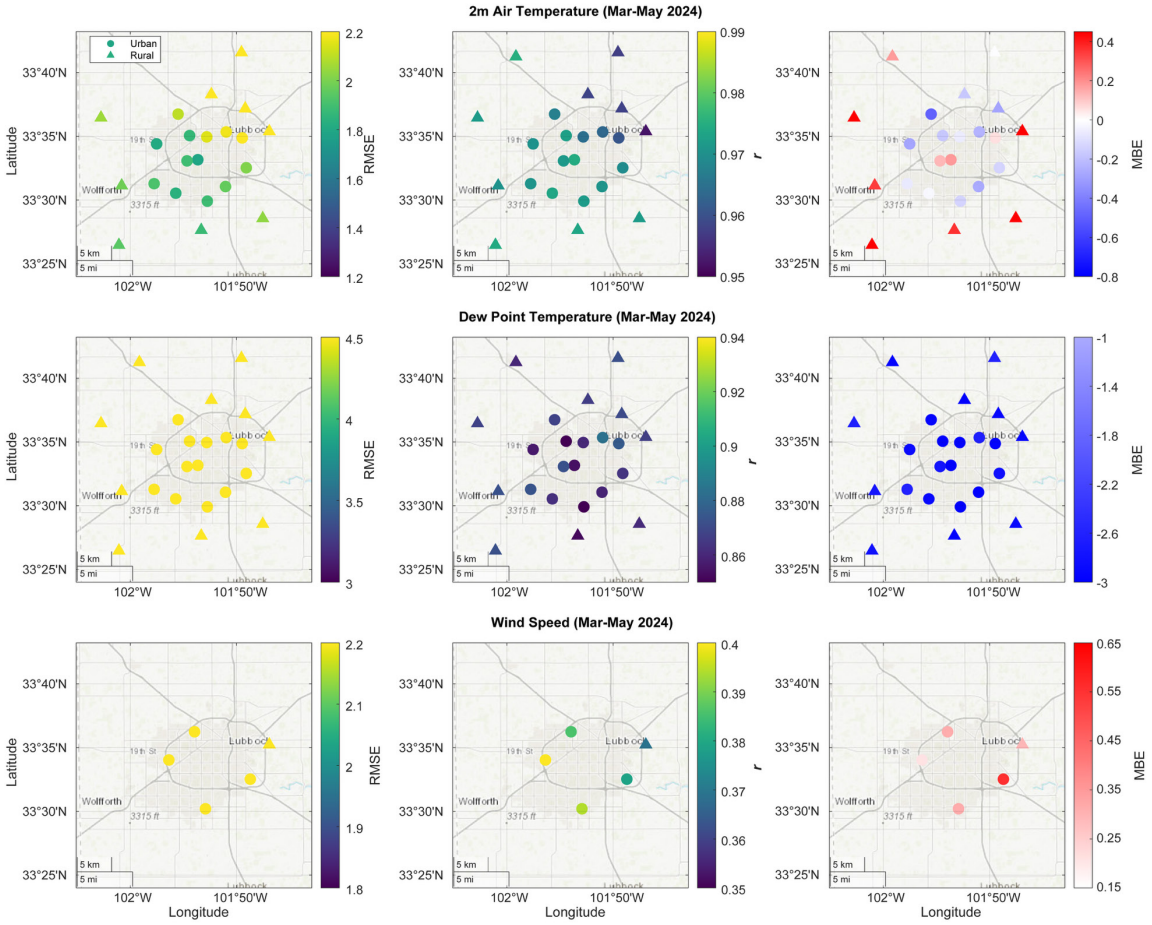


Figure S3. Site-specific evaluation of HRRR 18-h forecasts against in situ observations in and around Lubbock, Texas during spring (March 2024 to May 2024). Rows correspond to different variables: 2-m air temperature (top), 2-m dew point temperature (middle), and 10-m wind speed (bottom). Columns show spatial distributions of three statistical metrics: Root Mean Square Error (RMSE; left), correlation coefficient (*r*; middle), and Mean Bias Error (MBE; right). Urban and rural sites are color-coded by metric value, with urban and rural sites marked by circles and triangles, respectively.

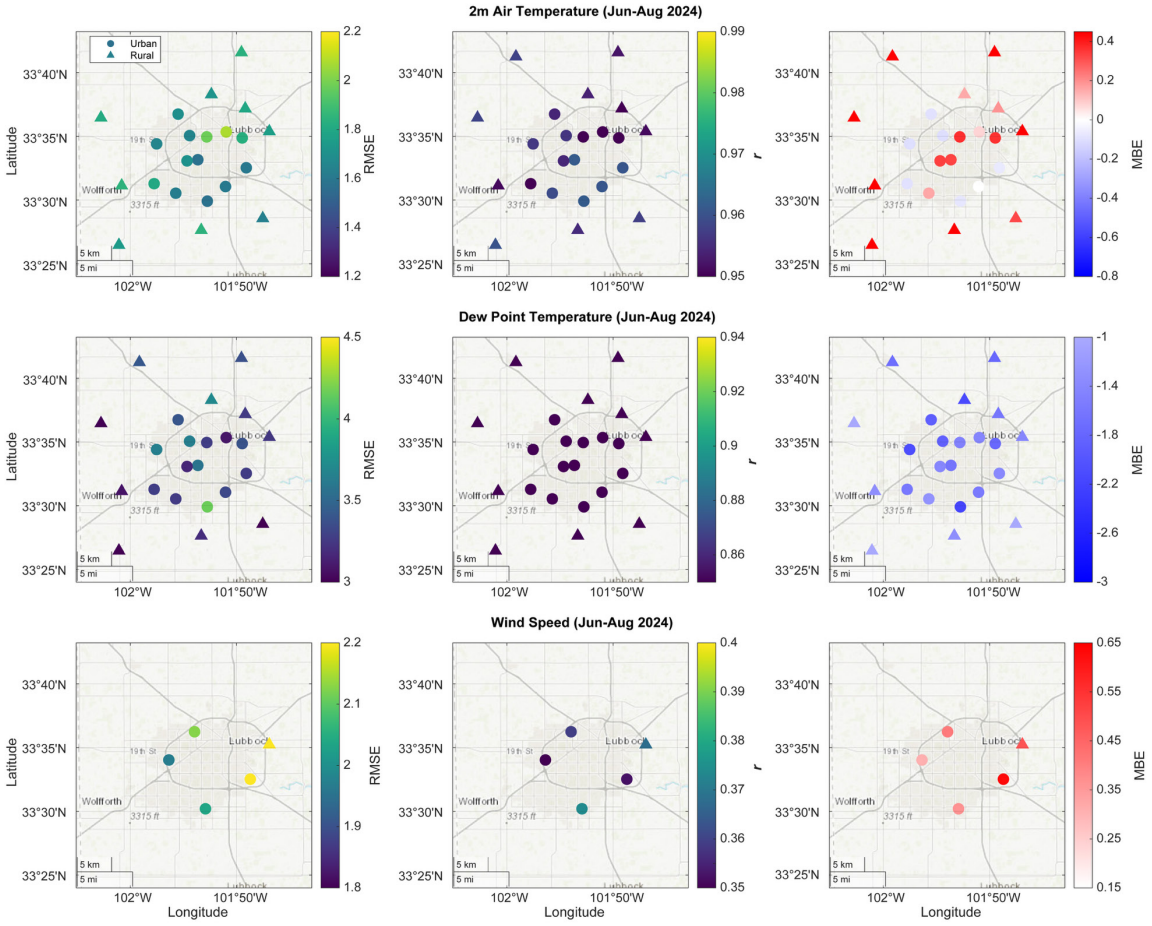


Figure S4. Site-specific evaluation of HRRR 18-h forecasts against in situ observations in and around Lubbock, Texas during summer (June 2024 to August 2024). Rows correspond to different variables: 2-m air temperature (top), 2-m dew point temperature (middle), and 10-m wind speed (bottom). Columns show spatial distributions of three statistical metrics: Root Mean Square Error (RMSE; left), correlation coefficient (*r*; middle), and Mean Bias Error (MBE; right). Urban and rural sites are color-coded by metric value, with urban and rural sites marked by circles and triangles, respectively.

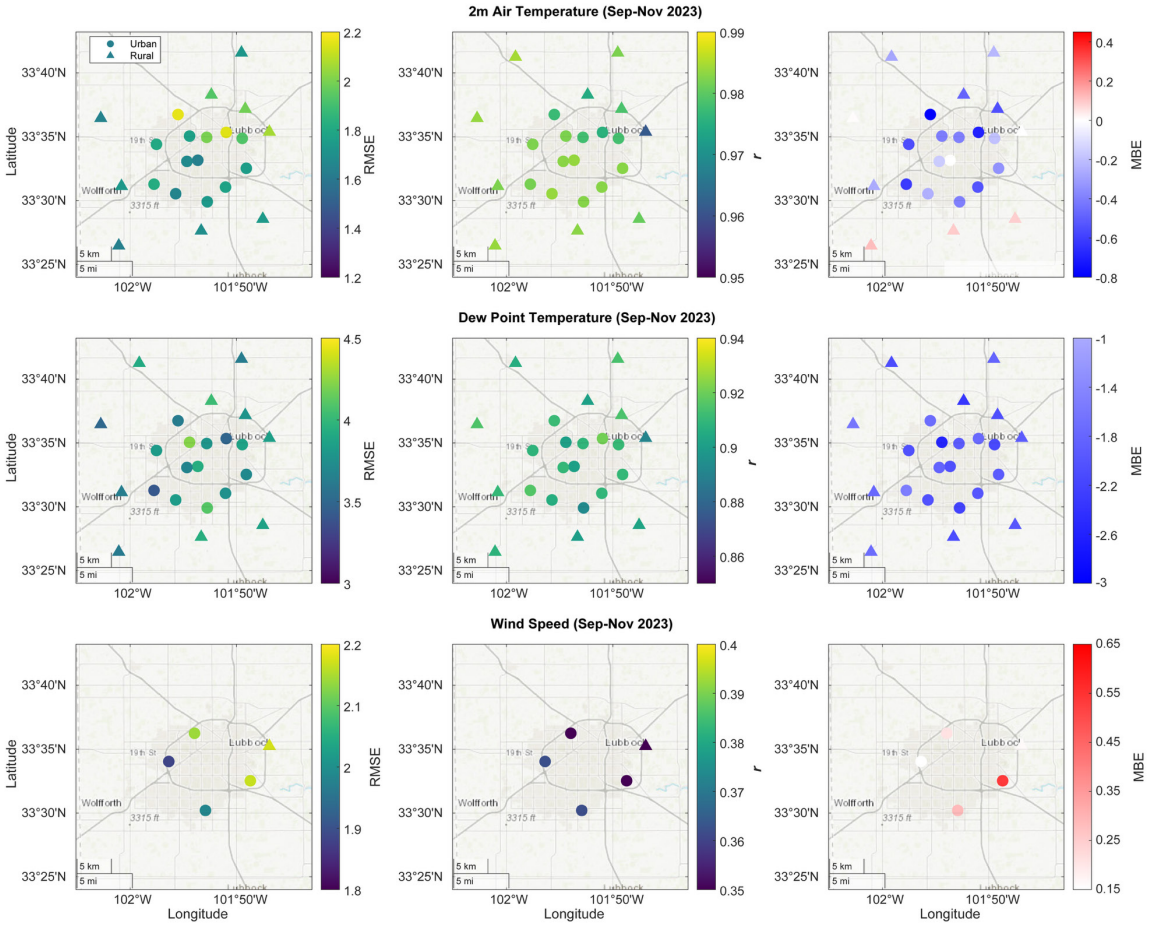


Figure S5. Site-specific evaluation of HRRR 18-h forecasts against in situ observations in and around Lubbock, Texas during fall (September 2023 to November 2023). Rows correspond to different variables: 2-m air temperature (top), 2-m dew point temperature (middle), and 10-m wind speed (bottom). Columns show spatial distributions of three statistical metrics: Root Mean Square Error (RMSE; left), correlation coefficient (*r*; middle), and Mean Bias Error (MBE; right). Urban and rural sites are color-coded by metric value, with urban and rural sites marked by circles and triangles, respectively.

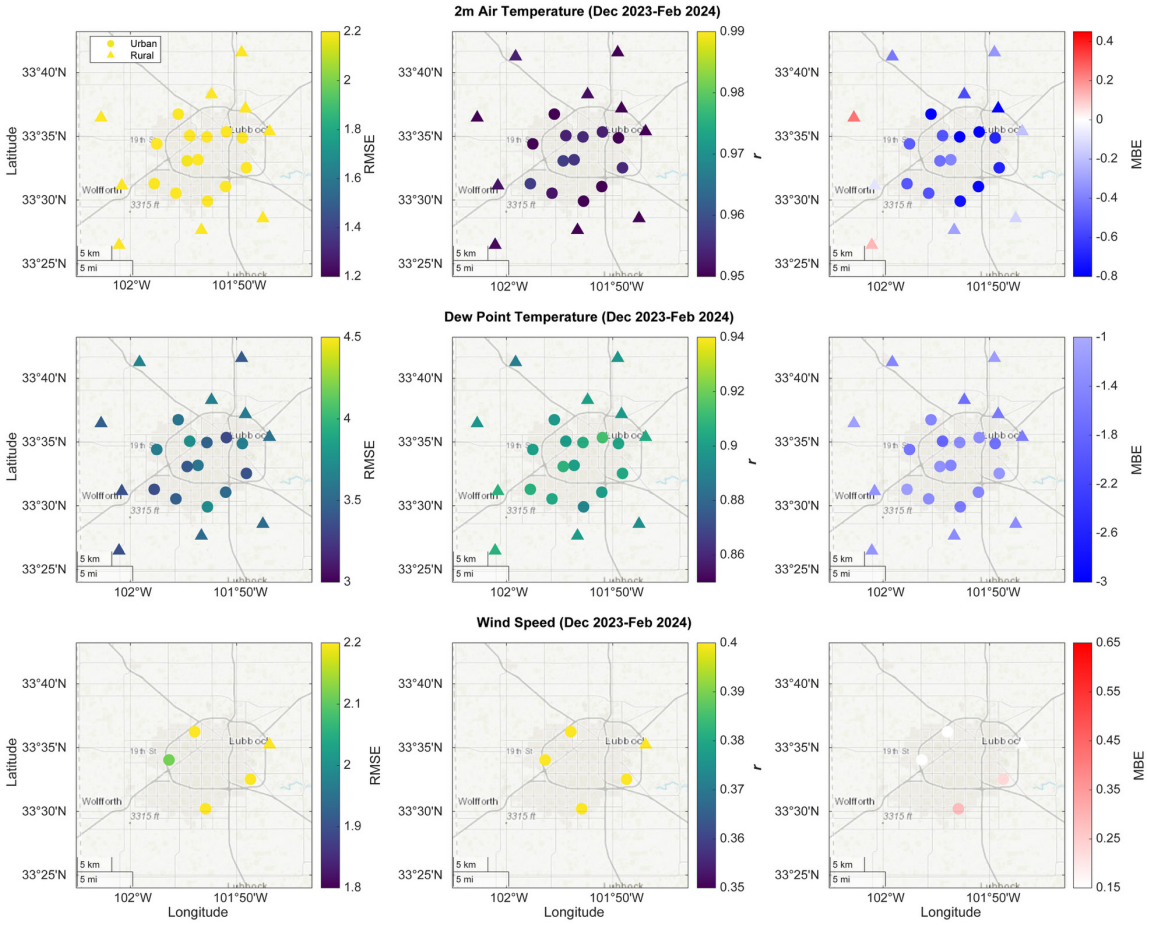


Figure S6. Site-specific evaluation of HRRR 18-h forecasts against in situ observations in and around Lubbock, Texas during winter (December 2023 to February 2024). Rows correspond to different variables: 2-m air temperature (top), 2-m dew point temperature (middle), and 10-m wind speed (bottom). Columns show spatial distributions of three statistical metrics: Root Mean Square Error (RMSE; left), correlation coefficient (*r*; middle), and Mean Bias Error (MBE; right). Urban and rural sites are color-coded by metric value, with urban and rural sites marked by circles and triangles, respectively.

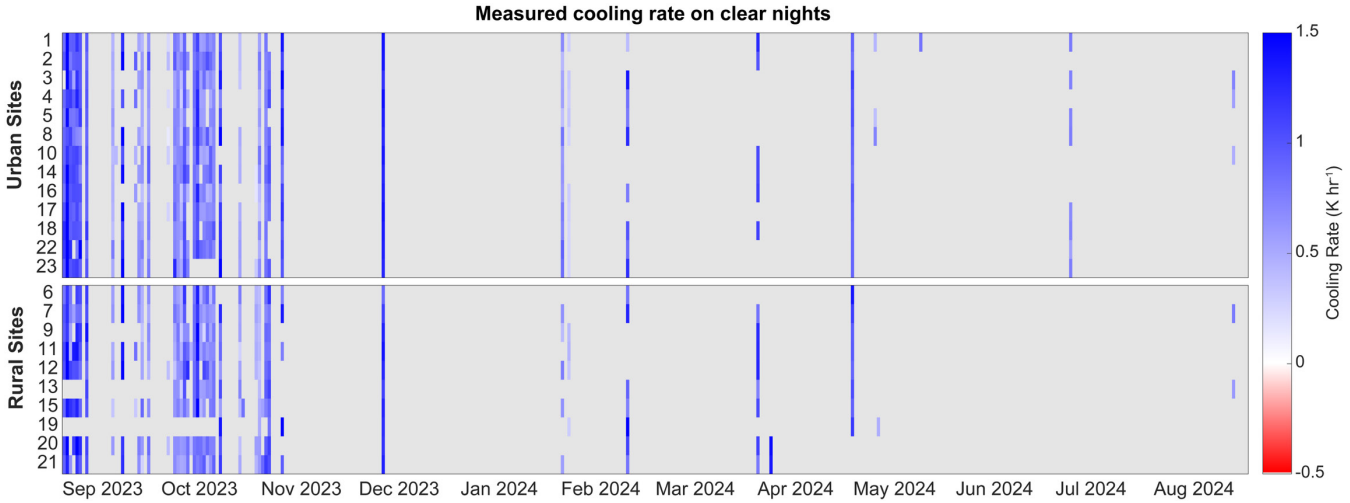
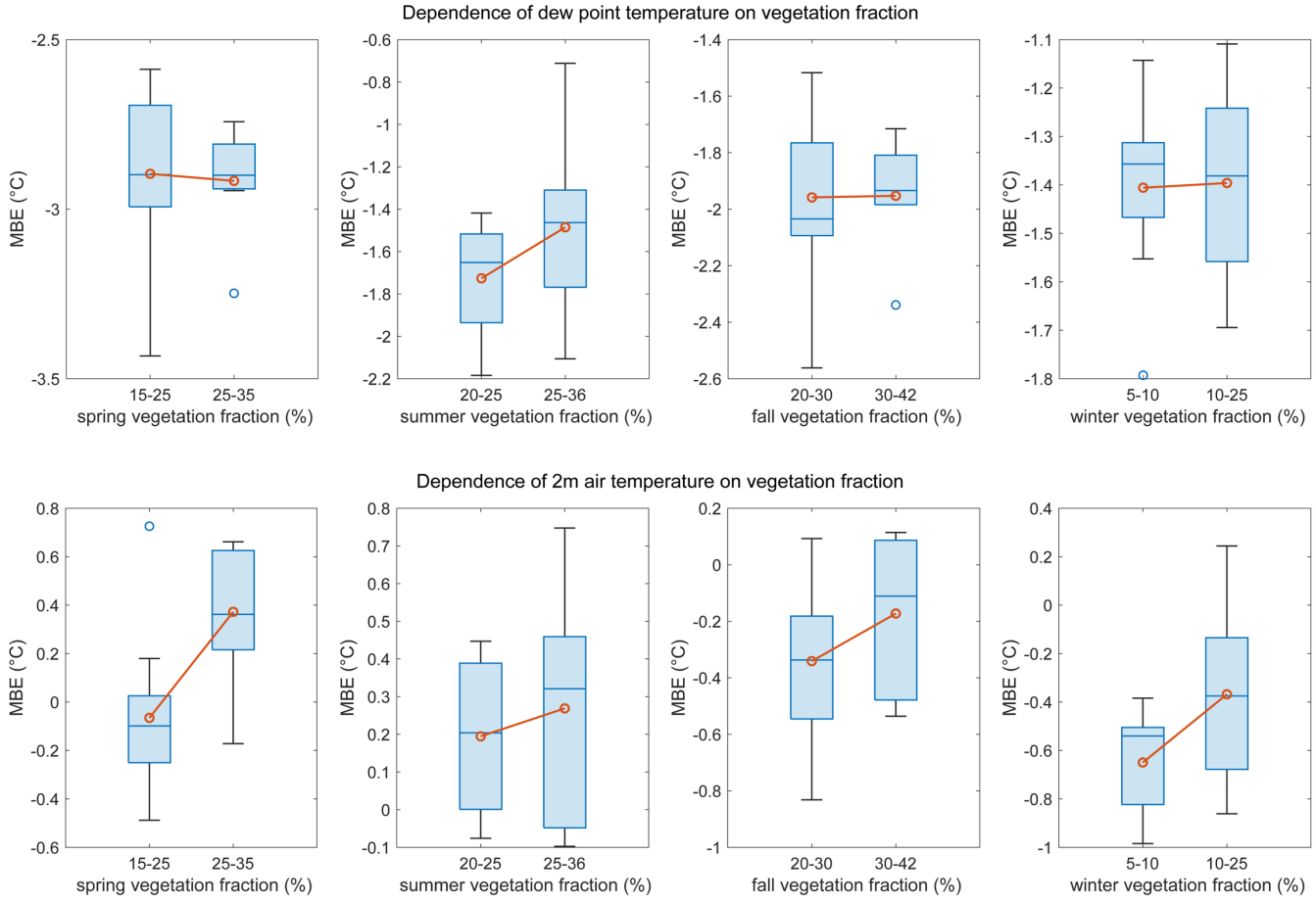


Figure S7. Observed nocturnal cooling rates (blue) on clear nights during the study period. Here, negative cooling rates (red) represent nocturnal warming. Clear nights are defined as having less than 25% cloud cover between 12:00 and 05:00 local time. Only statistically significant cooling rates ($p < 0.05$) are shown. Station numbering is listed in Table S1.



65 **Figure S8.** Dependence of MBE on dynamic vegetation fraction for 18-hour 2-m dew point temperature (top) and air temperature (bottom) forecasts across seasons.

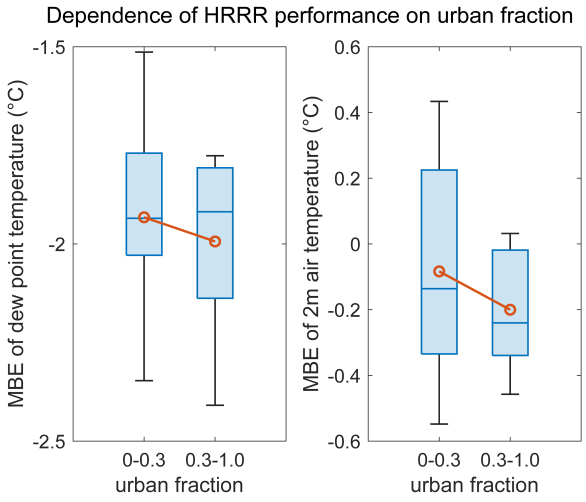


Figure S9. Dependence of MBE on urban fraction for 18-hour 2-m dew point temperature and air temperature forecasts.

Table S1. A summary of site locations, numbering as in Figure 6 and Figure S7, and their urban/rural classification

Number	Site name	Latitude	Longitude	Site type
1	Ed George	33.5528	-101.8940	urban
2	Satsang	33.5215	-101.9626	urban
3	Windmill Museum	33.5813	-101.8244	urban
4	Kaitlin Schueth	33.4986	-101.8791	urban
5	South Plains Food Bank	33.5423	-101.8180	urban
6	TAMU AgriLIFE	33.6928	-101.8256	rural
7	Stanford St house	33.6196	-101.8197	rural
8	Lubbock Civic Center	33.5891	-101.8495	urban
9	Llano Estacado Winery	33.4761	-101.7922	rural
10	Mark Conder	33.5090	-101.9286	urban
11	Charles Aldrich	33.4411	-102.0179	rural
12	Fenship HS	33.5189	-102.0136	rural
13	Jorge Salazar-Bravo	33.6381	-101.8728	rural
14	Robert Gentry	33.5735	-101.9587	urban
15	Justin Weaver	33.4607	-101.8887	rural
16	HTL	33.5177	-101.8506	urban
17	Covenant Church	33.5513	-101.9110	urban
18	Susanne Gillette	33.5843	-101.9069	urban
19	TTU Fiber research center	33.5897	-101.7819	rural
20	Reece Center	33.6076	-102.0460	rural
21	Bruce Haynie	33.6875	-101.9858	rural
22	MCOM	33.5826	-101.8801	urban
23	Sandip	33.6124	-101.9250	urban