Table S1: Root Mean Squared Errors over six ASOS locations (shown in Figure S1) for skin temperature, 2m air temperature, relative humidity and wind speeds at 10m during daytime (07-17 CDT) and nighttime (18-06 CDT).

		KENW	KVPZ	KARR	KRFD	KMDW	KPWK
TSK	ERA5	7.22, 2.55	4.15, 2.84	1.18, 2.91	4.27, 1.57	9.37, 1.73	9.07, 1.28
	CTRL	2.12, 1.29	2.93, 1.73	1.06, 1.98	2.70, 1.18	1.03, 5.19	1.83, 5.26
	BEP_BEM	2.03, 1.29	2.59, 1.73	1.48, 1.93	2.67, 1.19	1.09, 2.52	1.98, 2.44
T2	ERA5	2.80, 1.00	1.19, 0.59	0.78, 1.33	0.41, 0.96	1.90, 1.24	2.27, 0.79
	CTRL	0.31, 0.32	1.38, 1.25	0.48, 0.26	0.61, 0.52	1.37, 1.78	1.21, 2.38
	BEP_BEM	0.37, 0.35	1.30, 1.24	0.58, 0.34	0.66, 0.59	1.26, 1.02	1.10, 1.52
RH2	ERA5	9.67, 3.29	6.59, 2.21	3.39, 6.84	4.52, 2.81	10.07, 6.73	11.16, 5.33
	CTRL	0.78, 1.37	8.57, 8.04	1.27, 2.44	1.53, 3.30	10.04, 11.42	9.56, 13.13
	BEP_BEM	0.78, 1.33	7.45, 7.40	1.24, 1.98	2.00, 3.76	8.52, 7.16	7.98, 9.21
W10	ERA5	0.26, 0.22	0.14, 0.38	0.14, 0.17	0.16, 0.27	0.20, 0.20	0.10, 0.22
	CTRL	0.13, 0.18	0.29, 0.35	0.27, 0.16	0.23, 0.28	0.29, 0.16	0.14, 0.17
	BEP_BEM	0.18, 0.15	0.27, 0.26	0.29, 0.12	0.18, 0.22	0.34, 0.31	0.10, 0.12
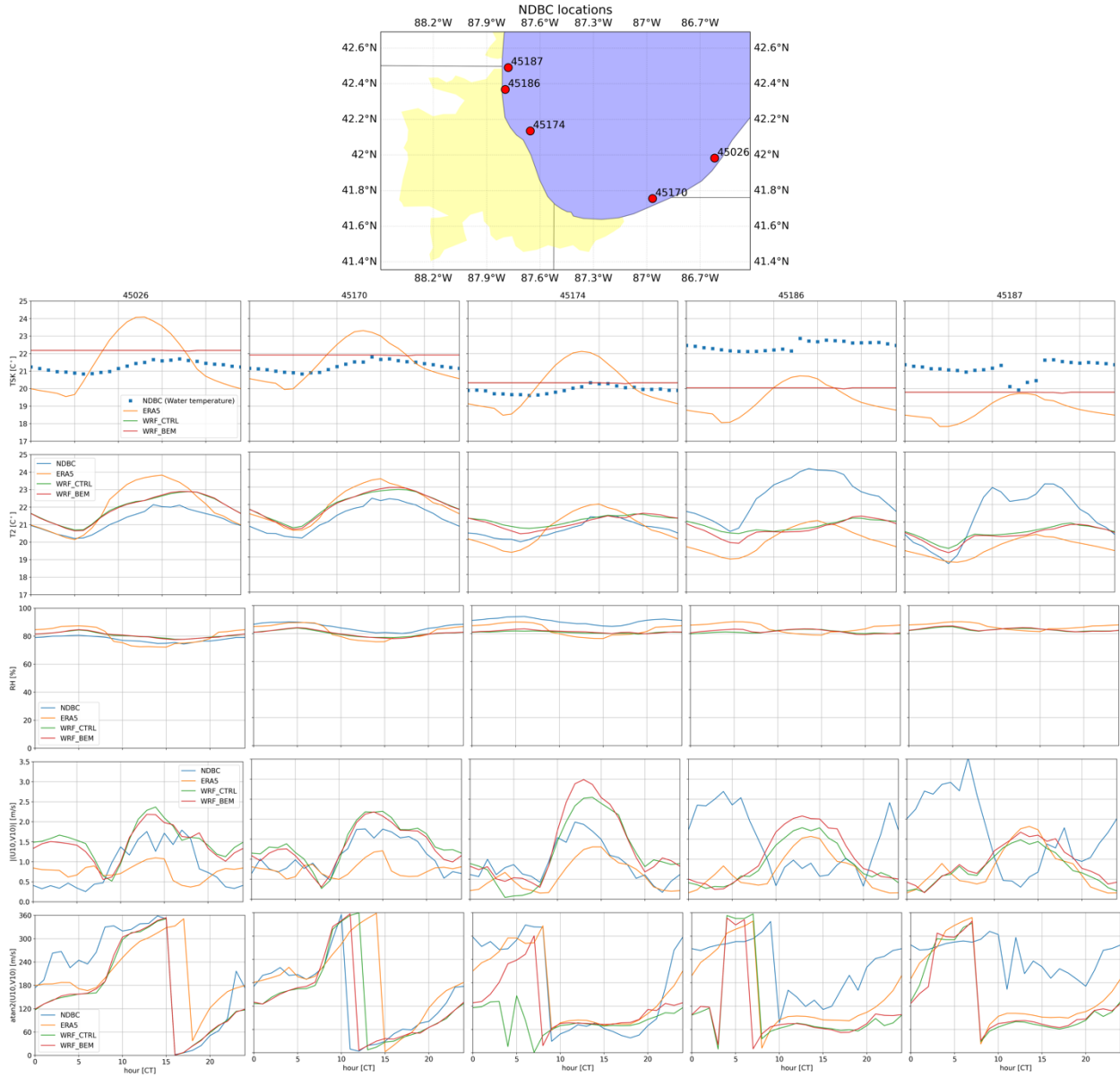
Figure S1. Mean diurnal quantities from buoy observations, ERA5, CTRL and BEP_BEM at five coastal NDBC buoy locations shown on the top. 2nd row: skin temperature (observations are water temperature at ~1-m depth). 3rd row: 2-m air temperature (T2), 4th: relative humidity (RH), 5th: |U10,V10|: magnitude of mean 10-m wind velocity, arctan2(U10,V10); and 6th: direction of mean 10-m wind velocity. For example, ERA5 clearly overestimates the diurnal range of lake surface temperature. WRF overestimates T2 over the buoy locations on the eastern side of Lake Michigan, and underestimates locations on the western side of the lake. ERA5's wind speeds are much lower than observations and WRF shows later wind speed peaks over some locations while earlier wind speed peaks over other locations.
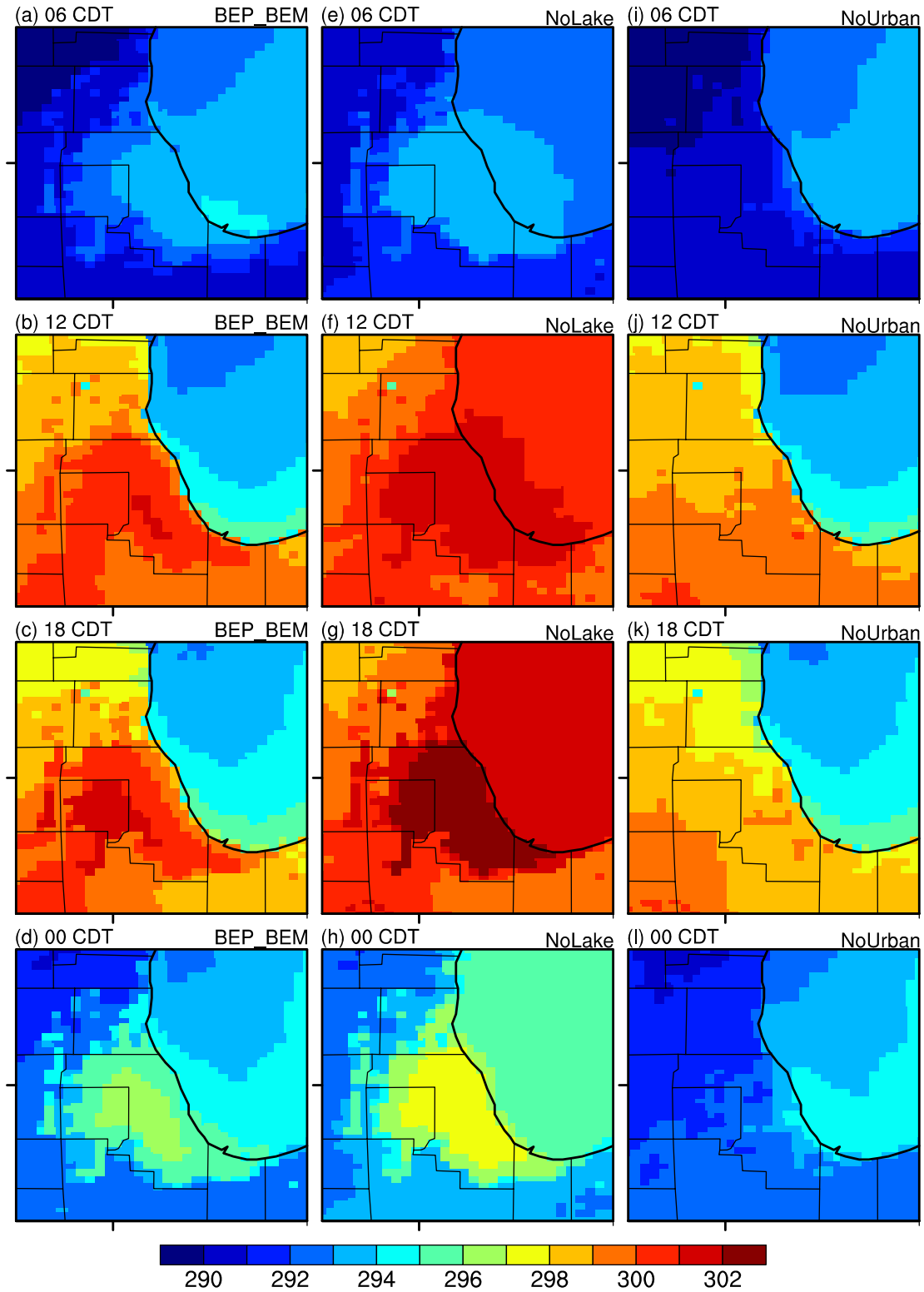
Figure S2. Near surface (2-m) air temperature simulated by BEP_BEM, No_LakeM and No_Urban at 06, 12, 18 and 00 CDT. All results are based on 5-member ensemble mean.
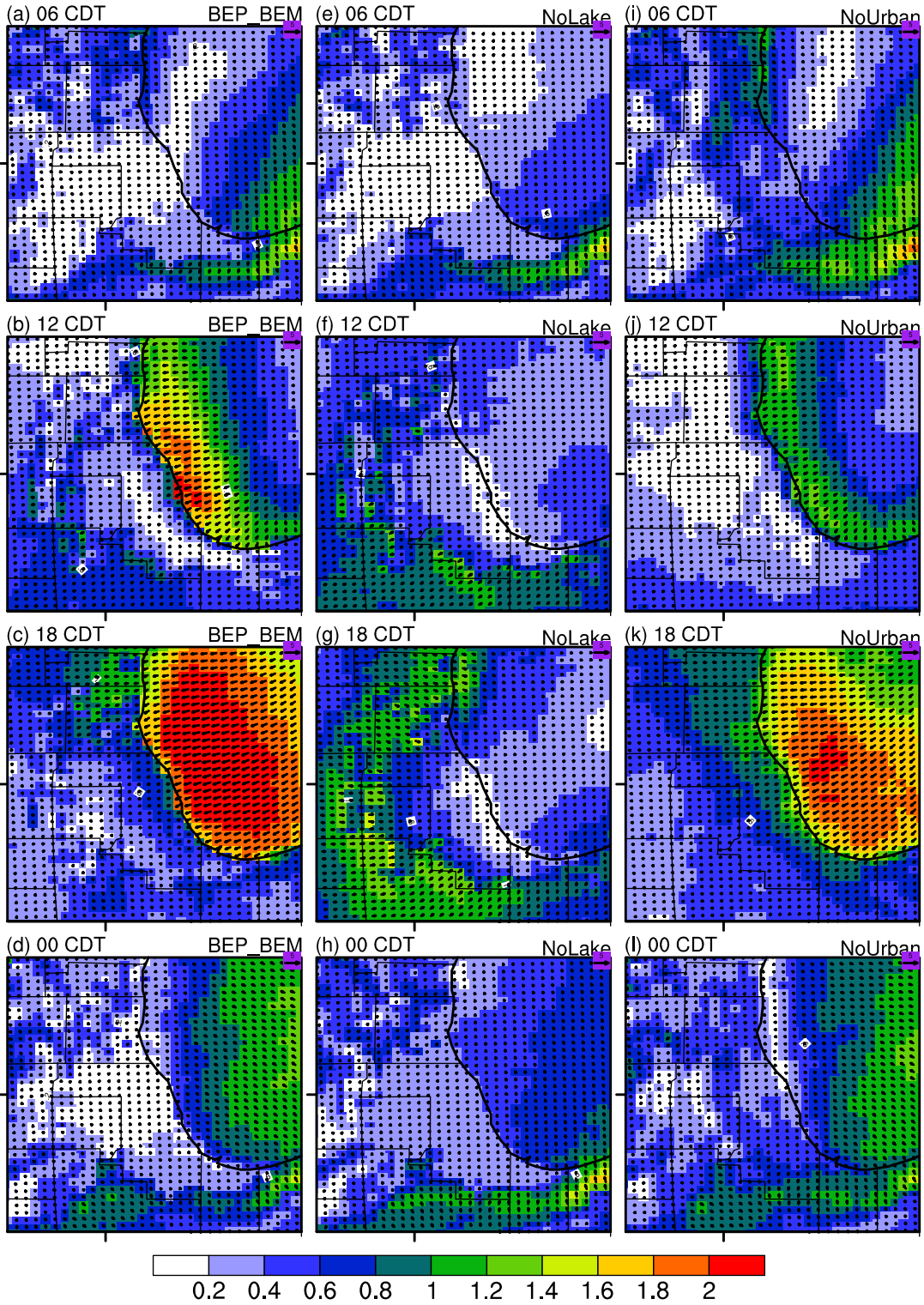
Figure S3. Summer averaged near surface (10-m) wind speed and direction simulated by BEP_BEM, No_LakeM and No_Urban at 06, 12, 18 and 00 CDT. All results are based on 5-member ensemble mean.
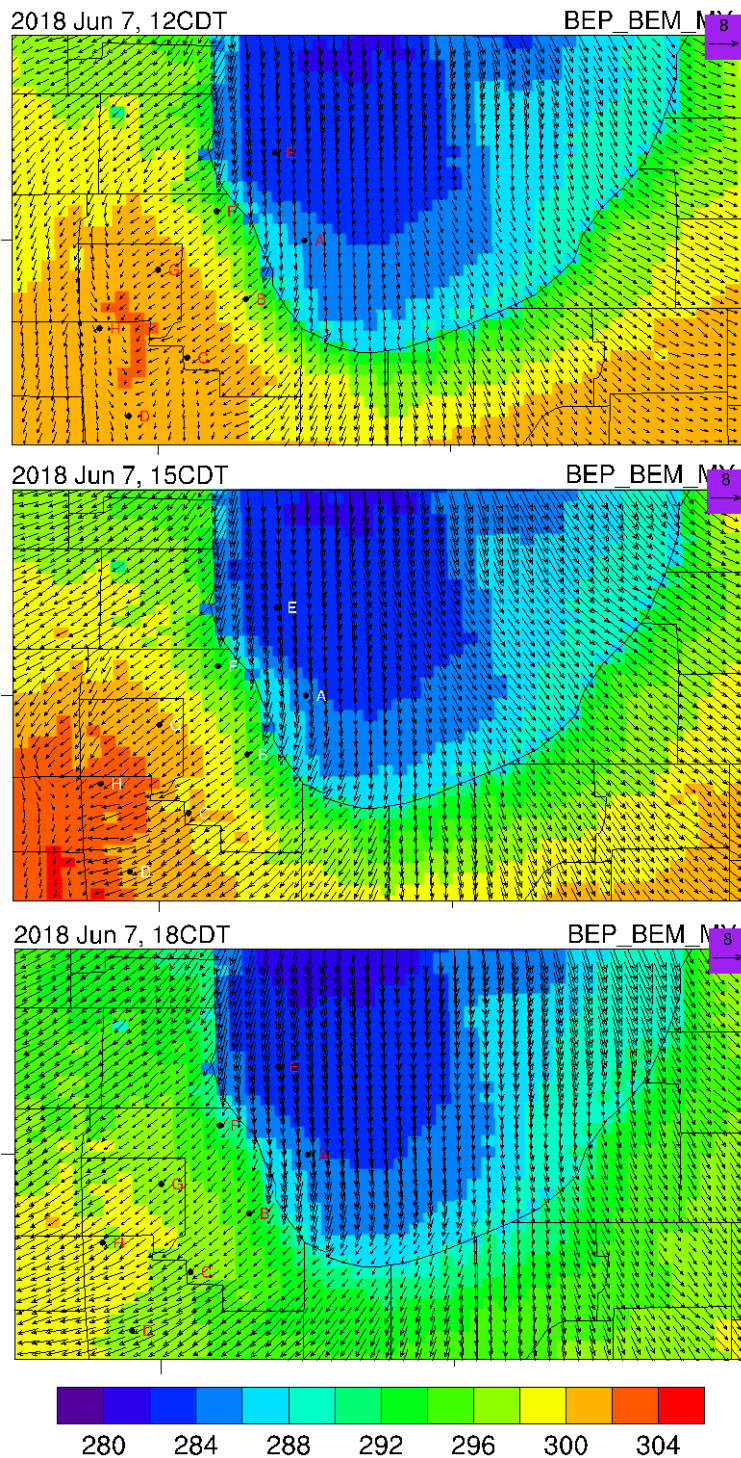
Figure S4. Lake breeze event on June 7, 2018. The contour is 10m wind speed, and arrows are wind directions. A, B, C, D are 4 locations used for air temperature and planetary boundary layer analysis shown in Figure S5. Distant between each of the two locations is ~25 km. To investigate the robustness of analysis using these 4 locations, another 4 locations (E, F, G, H) with same distance but different latitudes and longitudes are also analyzed.
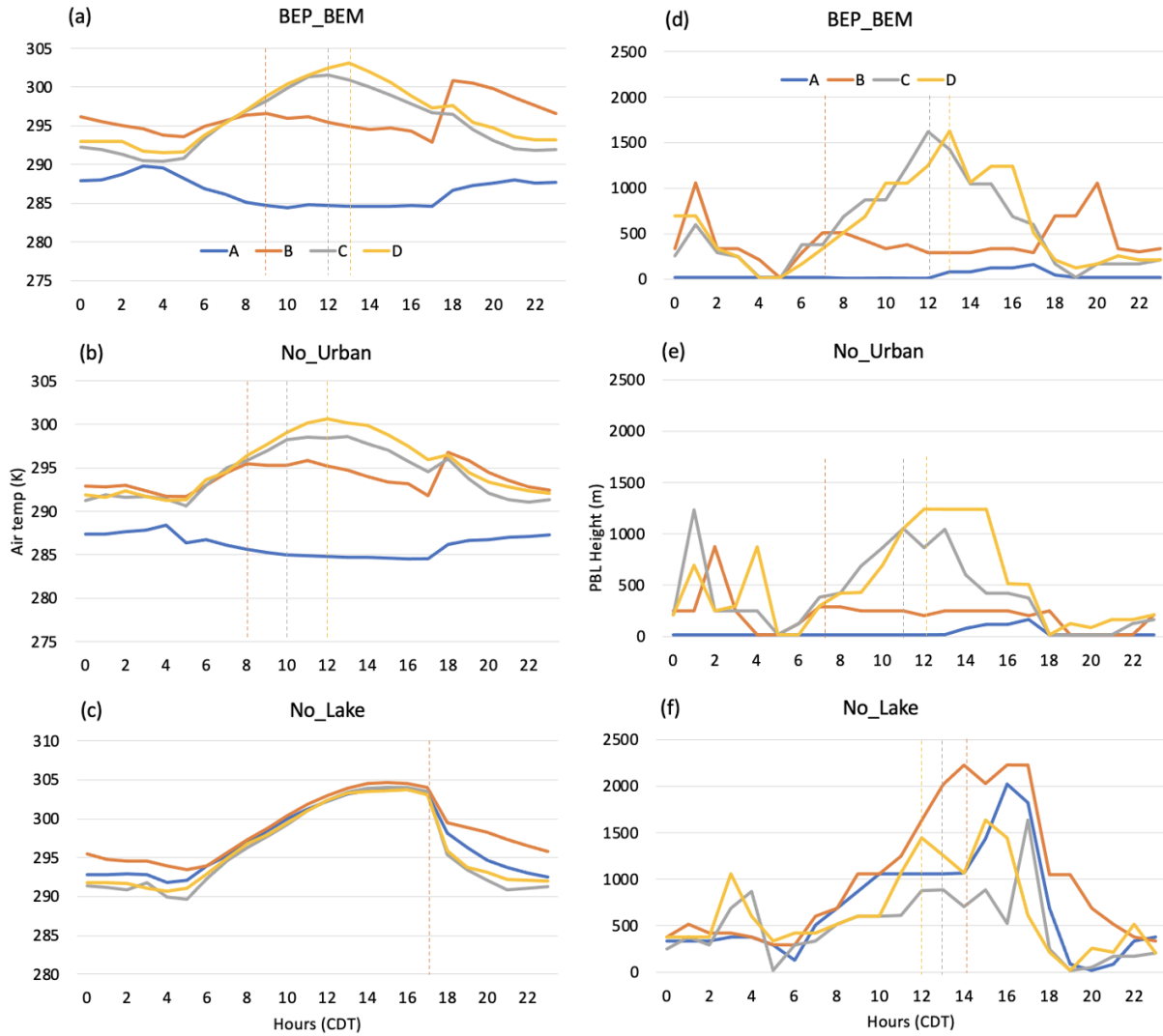
Figure S5. (a-c) 2-m air temperature diurnal evolution over A, B, C, and D (marked on Figure S4) in BEP_BEM, No_Urban, and No_LakeM experiments. (d-f) same as (a-c) but for planetary boundary layer height (PBLH). The vertical dashed lines indicate the timing when the air temperature/PBLH dropped due to the arrival of lake breeze front.
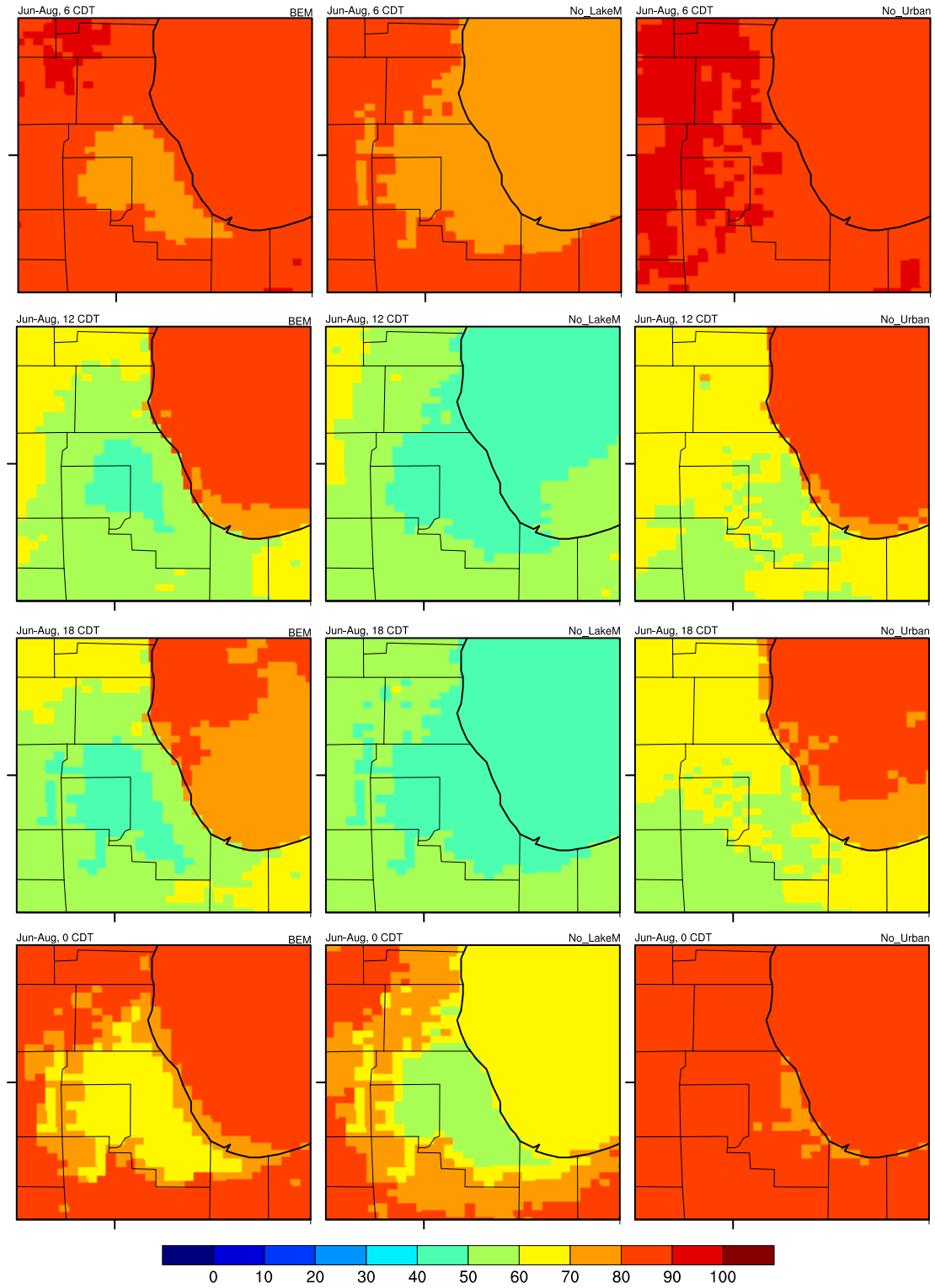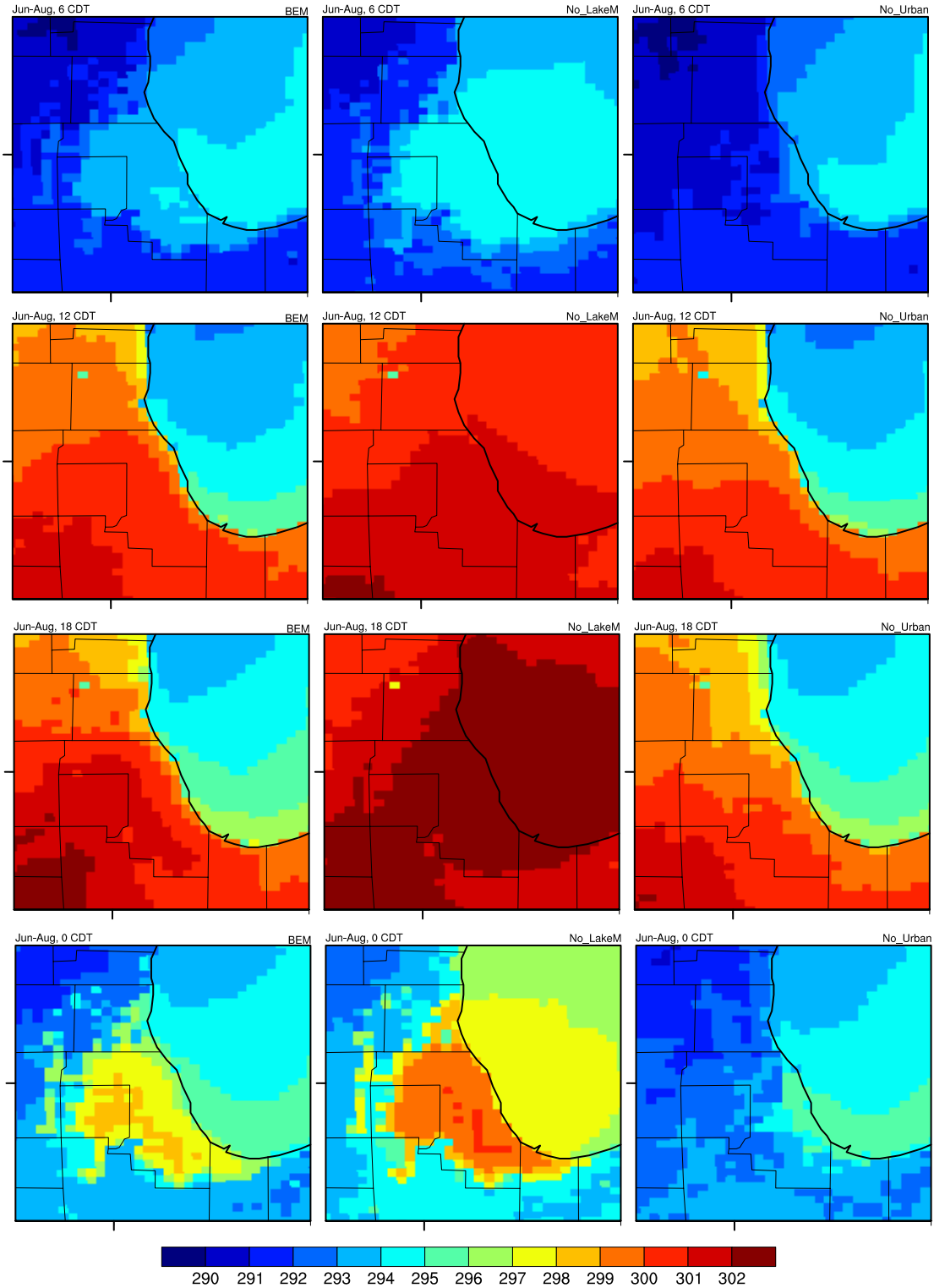
Figure S6. Same as Figure S2 but for 2-meter relative humidity.

Figure S7. Same as Figure S2 but for heat index.