

Contrasting interactions between urban heat islands and heat waves in Seoul, South Korea, and their associations with synoptic patterns

Motivations

- With increasing urbanization and heat waves across the world, synergistic UHI-heat wave interactions (intensification of UHI during heat waves) have received much attention.
- UHI—heat wave interactions could vary with characteristics of heat waves. However, previous studies have not examined this aspect.

Objectives

- Examine UHI-heat wave interactions in Seoul, South Korea
- Investigate their associations with meteorological conditions and accompanying synoptic patterns

Study period: 45°N **Observational data:** Urban (inside Seoul): Rural (outside Seoul): 25°N -115°E 125°E 127.5°E 126.5°E 127°E 135°E Reanalysis data: 200 350 500 650 800 950 1100 00 400 700 1000 1300 1600 1900 220 terrain height (m) terrain height (m) (C) 37.8°N -Barren Wetland - Grass Heat wave (HW): Forest - Agricultural land **Public facilities** Transportation 37.2°N -- Cultural facilities Industrial/ Commercial • **UHII_{Tmin}:** $T_{min,u} - T_{min,r}$ Residential • UHII_{Tmax}: T_{max.u} – T_{max.r} 126.5°E 127.0°E 127.5°E





Figure 2 Box plots of (a) UHII_{Tmin} and (b) UHII_{Tmax} under HW and nonHW.

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Data and methods

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• The existence of the negative UHI-heat wave interactions

Results



Figure 3 Scatterplots of UHII_{Tmin} versus (a) nighttime wind speed, (b) relative humidity, and (c) cloud fraction and (d) volumetric soil water for HW and nonHW, respectively.



- **S-UHI:** HW days with UHII > 90p (strong positive UHI–heat wave interactions)
- **W-UHI:** HW days with UHII < 10p (negative UHI–heat wave interactions)
- The S-UHI days are concentrated in recent years (after 2010).

Figure 4 Number of occurrences of the S-UHI days and W-UHI days. UHII on the individual S-UHI days and W-UHI days and mean UHII under nonHW for each year. The gray shaded area indicates 1 std of UHII under nonHW for each year.

Conclusions

- interactions
- Both positive and negative UHI—heat wave interactions appear, depending on meteorological conditions and synoptic patterns under HW
- The prominent positive UHI-heat wave interactions are frequent in recent years

Significantly varying UHII under HW with background meteorological and soil conditions

• Overall, UHIs strengthen under HW, indicating synergistic UHI-heat wave

30°N -

Figure 5 Composite fields of 850-hPa geopotential height and specific humidity for the S-UHI and W-UHI days based on UHII_{Tmin} and their respective differences.



References

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S-UHI: hot, calm, dry, and clear HW with strong subsidence. Pacific-Japan (PJ) pattern (a north-south dipole pattern). • W-UHI: less hot, less calm, humid, and cloudy HW with weak subsidence. The expansion of the western North Pacific subtropical high (WNPSH).

- **P-PJ:** The HW days with difference in normalized 850-hPa GPH anomaly (35–40°N/125–130°E minus $25-30^{\circ}N/120-125^{\circ}E$ > climatological mean + 1 std
- **E-WNPSH:** The HW days with 850-hPa GPH anomaly $(30-40^{\circ}N/120-150^{\circ}E) > climatological mean + 1 std$
- P-PJ overall exhibits larger UHII_{Tmin} than E-WNPSH.
- P-PJ is concentrated in recent years (after 2010).

Figure 6 Box plot of UHII_{Tmin} under P-PJ and E-WNPSH.

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