

1 **Supplementary Materials: Lower urban humidity moderates heat stress**

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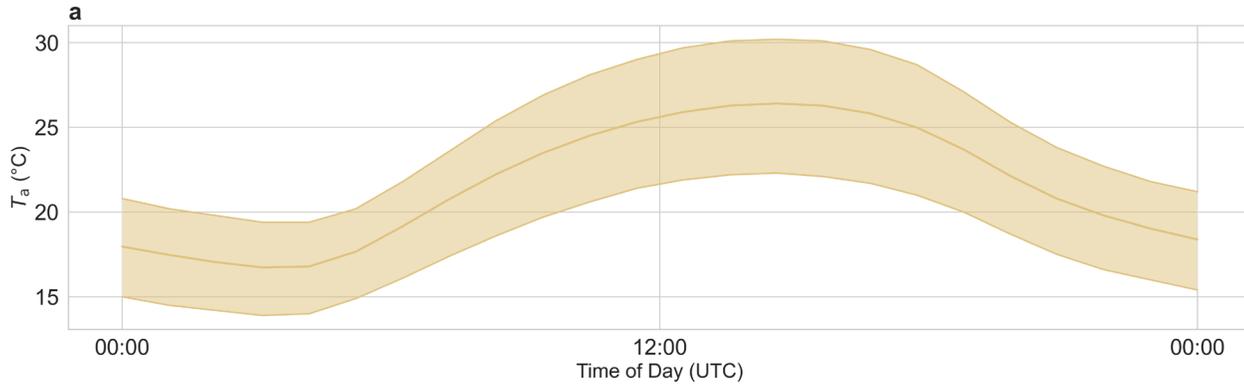
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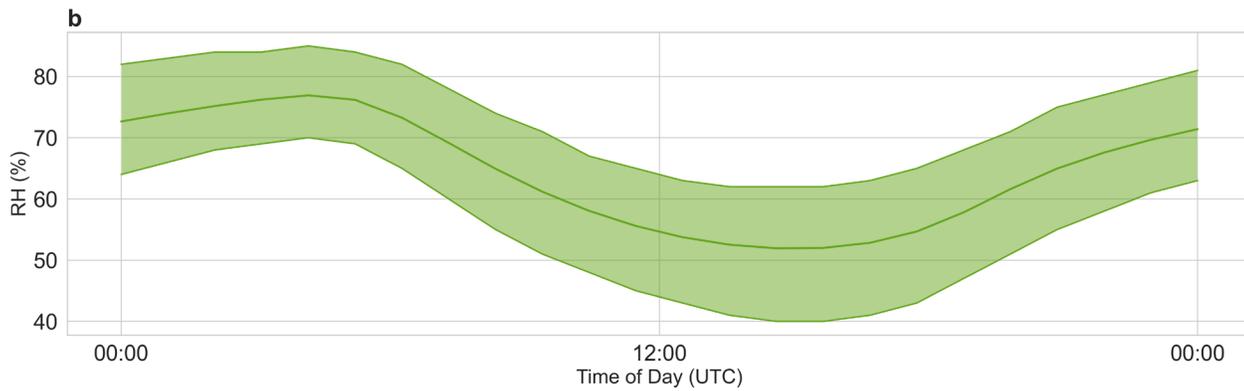
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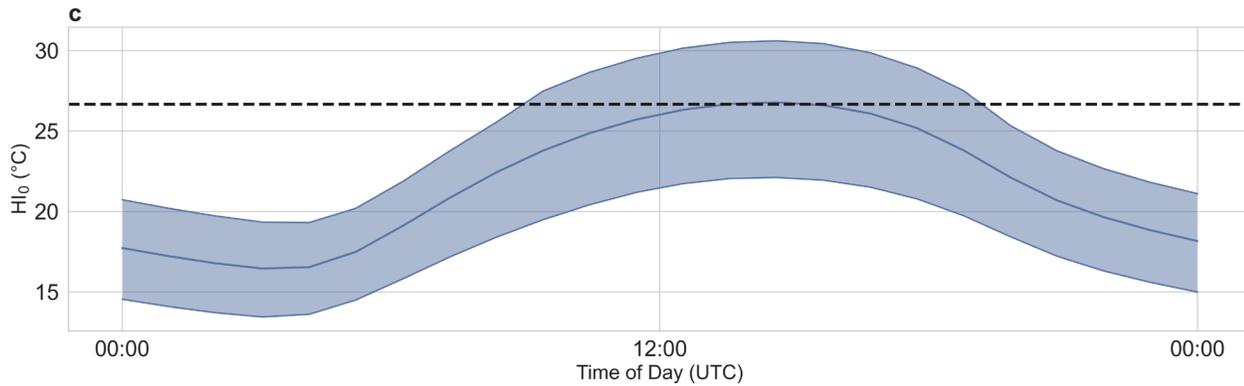
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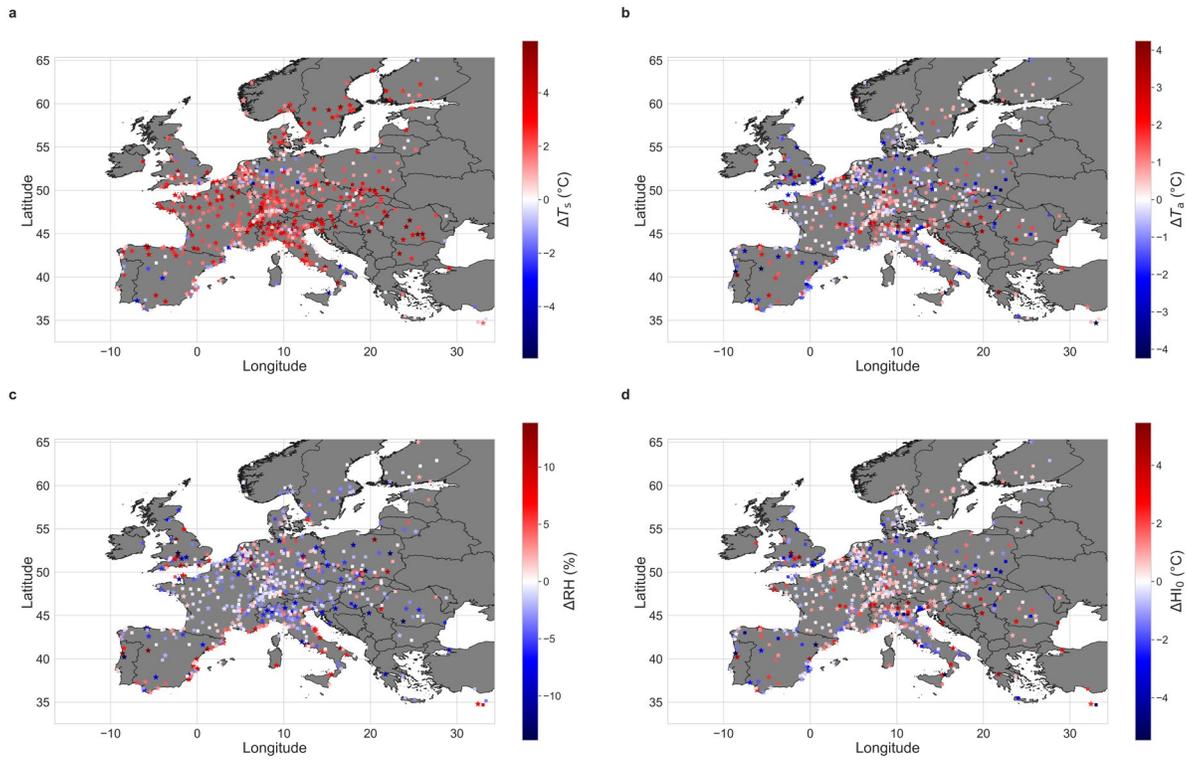


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17 **Fig. S1** Diurnal composites of citizen weather station data. Diurnal composites of Netatmo **a** air
18 temperature (T_a), **b** relative humidity (RH), and **c** heat index (HI_0) from all stations in rural buffers
19 considered in the present study. The upper and lower lines represent the 75% and 25% percentile
20 of the measurements, and the middle line is for the mean from all the observations by hour of the
21 day. The dashed horizontal line in sub-figure **c** shows the threshold below which the simplified
22 equation is used for calculating HI_0 (Eq. 1 in Methods).

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Fig. S2 Urban-rural differences for Terra day across urban clusters in Europe. Spatial distribution of urban-rural differences in **a** surface temperature (ΔT_s), **b** air temperature (ΔT_a), **c** relative humidity (ΔRH), and **d** heat index (ΔHI_0) for urban clusters in Europe with sufficient data corresponding to the Terra satellite daytime overpass ($\approx 10:30$ am local time) for July 2019. The stars represent clusters with statistically significant ($p < 0.01$) differences between the urban and rural values.

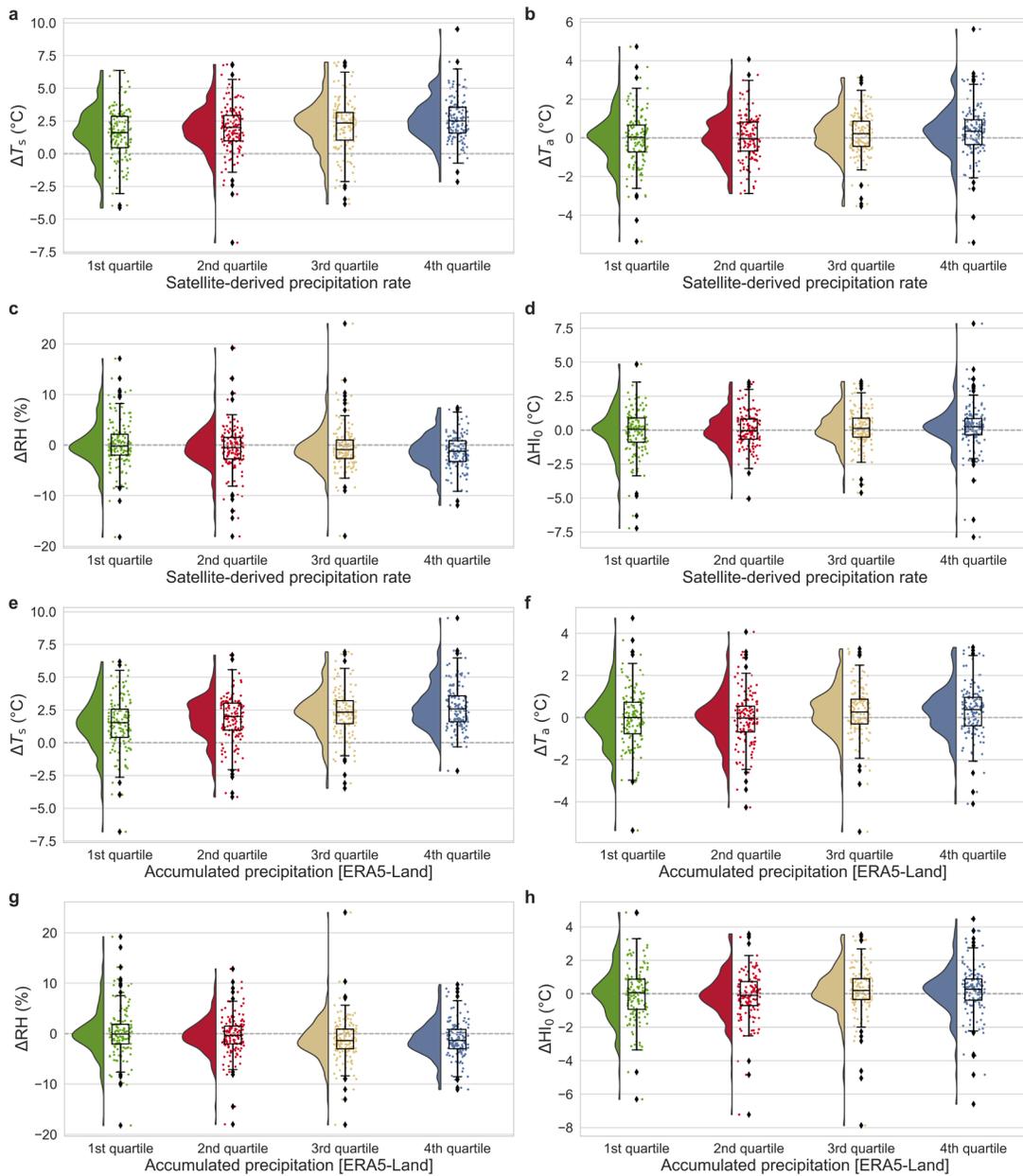
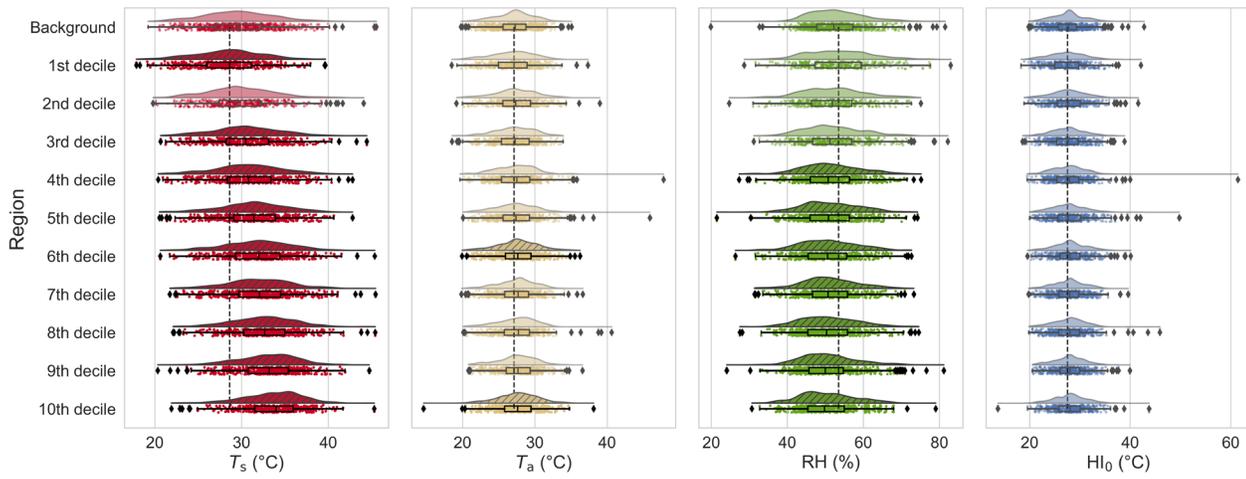


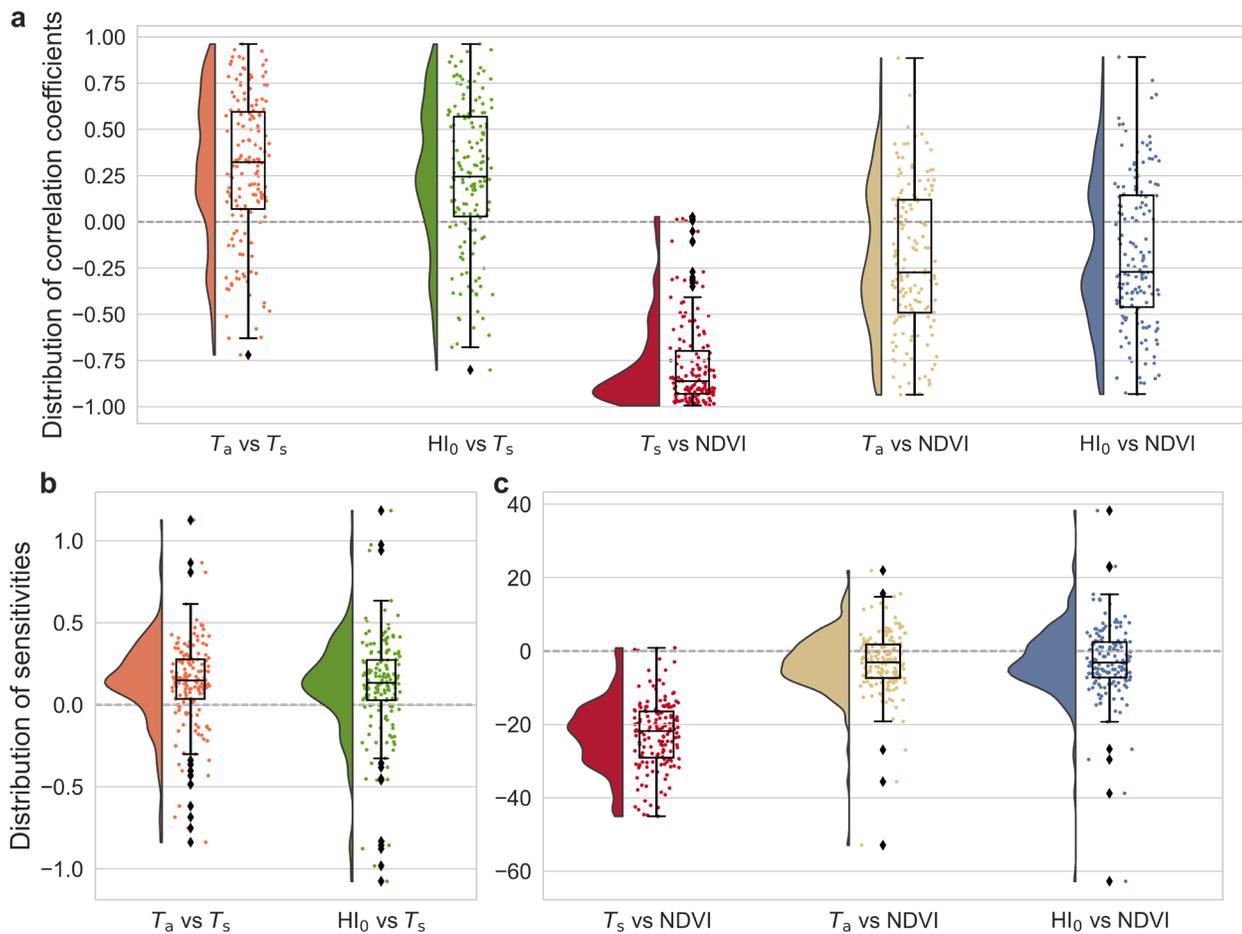
Fig. S3 Urban-rural differences in variables for precipitation quartiles. Distributions of urban-rural differences in **a** surface temperature (ΔT_s), **b** air temperature (ΔT_a), **c** relative humidity (ΔRH), and **d** heat index (ΔHI_0) corresponding to the Aqua daytime overpass ($\approx 1:30$ pm local time) for quartiles of satellite-derived precipitation rate in July 2019. Sub-figures **e**, **f**, **g**, and **h** are similar, but use quartiles of accumulation precipitation in July 2019 from the ERA5-Land reanalysis dataset.



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45 **Fig. S4** Intra-urban gradients of variables for Terra day. Distributions of composite mean surface
 46 temperature (T_s), air temperature (T_a), relative humidity (RH), and heat index (HI_0) in each of the
 47 T_s decile neighborhoods across the urban clusters considered. The vertical dashed lines mark the
 48 median of the distribution of the corresponding variable in the 1st T_s decile neighborhood. Decile
 49 neighborhoods that show statistically significant ($p < 0.01$) differences from the background
 50 reference values are shown using hatched density plots and darker shades. All calculations are for
 51 the Terra daytime overpass ($\approx 10:30$ am local time) for July 2019.

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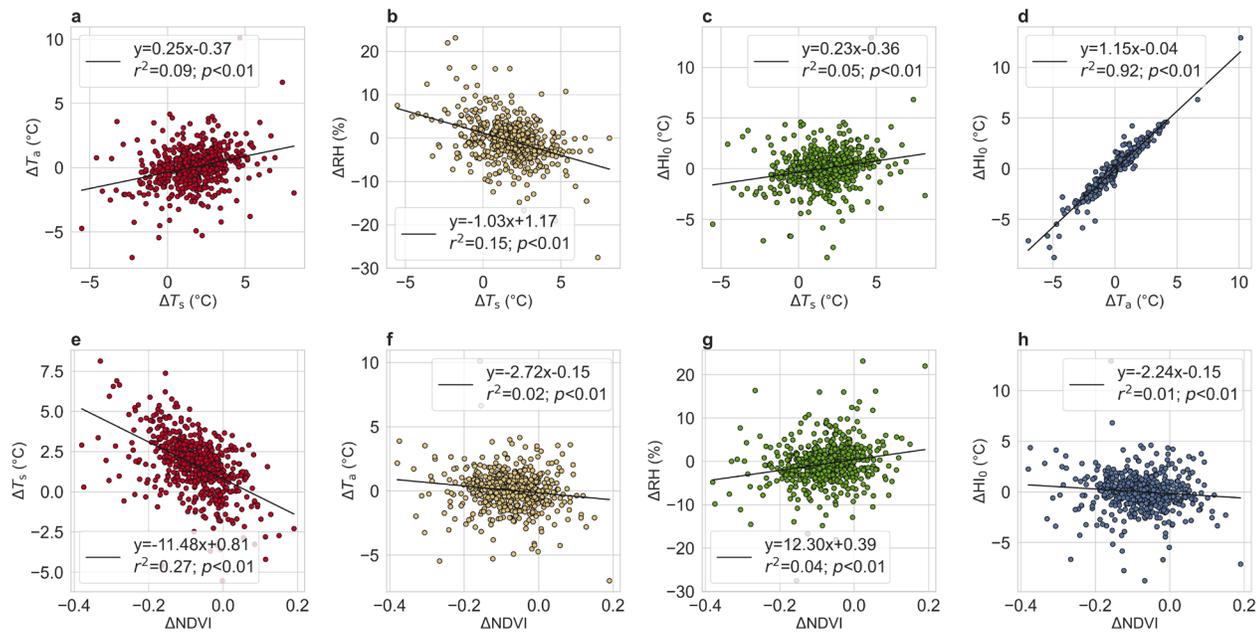


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55 **Fig. S5** Associations between variables within urban clusters for Terra day. Sub-fig **a** shows the
 56 distributions of the correlation coefficient (r) of linear regressions between surface temperature
 57 (T_s) and air temperature (T_a), T_s and heat index (HI_0), Normalized Difference Vegetation Index
 58 (NDVI) and T_s , NDVI and T_a , and NDVI and HI_0 , respectively, for urban clusters in Europe. Each
 59 data point is from a linear regression between pairs of variables for a cluster. The linear
 60 regressions have a sample size of ten (one for each T_s decile neighborhood). Sub-fig **b** and **c** show
 61 the distributions of the slope of those linear regressions, or the sensitivity of one variable to unit
 62 changes in the other. The unit of sensitivity in Sub-fig **c** is $^{\circ}\text{C}$ per unit NDVI. All calculations are
 63 for the Terra daytime overpass ($\approx 10:30$ am local time) for July 2019.

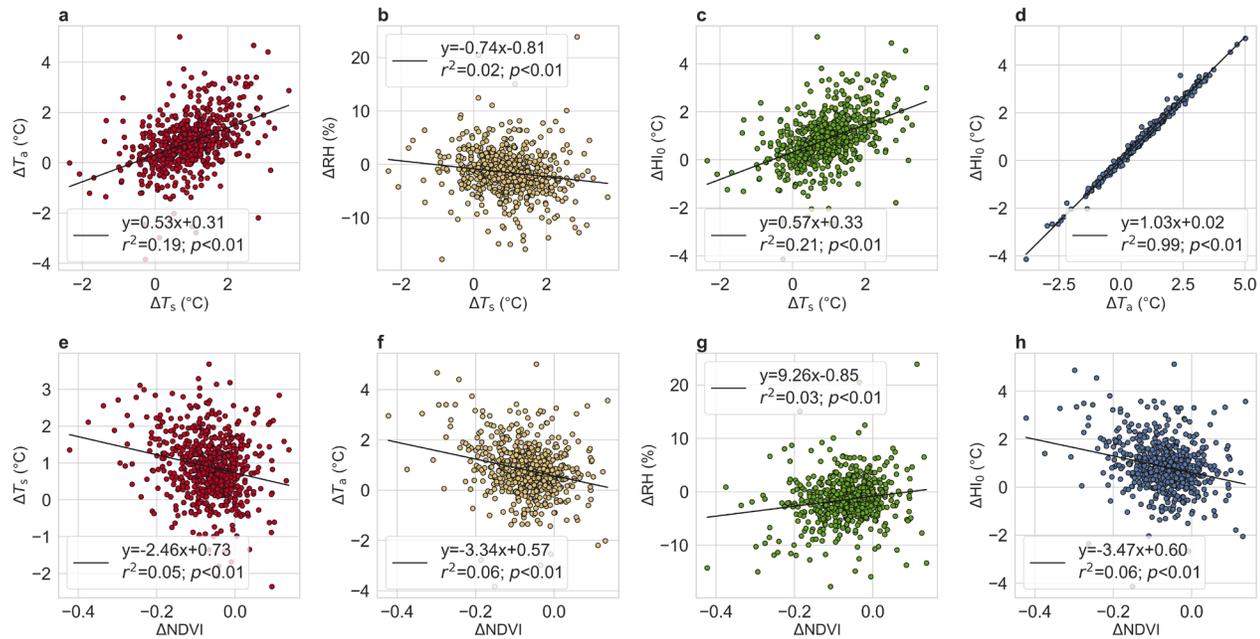
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66 **Fig. S6** Associations between variables across urban clusters for Terra day. Associations between
 67 urban-rural differences in **a** surface temperature (ΔT_s) and air temperature (ΔT_a), **b** ΔT_s and
 68 relative humidity (ΔRH), **c** ΔT_s and heat index (ΔHI_0), **d** ΔT_a and ΔHI_0 , **e** Normalized Difference
 69 Vegetation Index ($\Delta NDVI$) and ΔT_s , **f** $\Delta NDVI$ and ΔT_a , **g** $\Delta NDVI$ and ΔRH , and **h** $\Delta NDVI$ and
 70 ΔHI_0 across urban clusters in Europe. Each dot represents one cluster and the lines and equations
 71 of best fit are shown. All calculations are for the Terra daytime overpass ($\approx 10:30$ pm local time)
 72 for July 2019.

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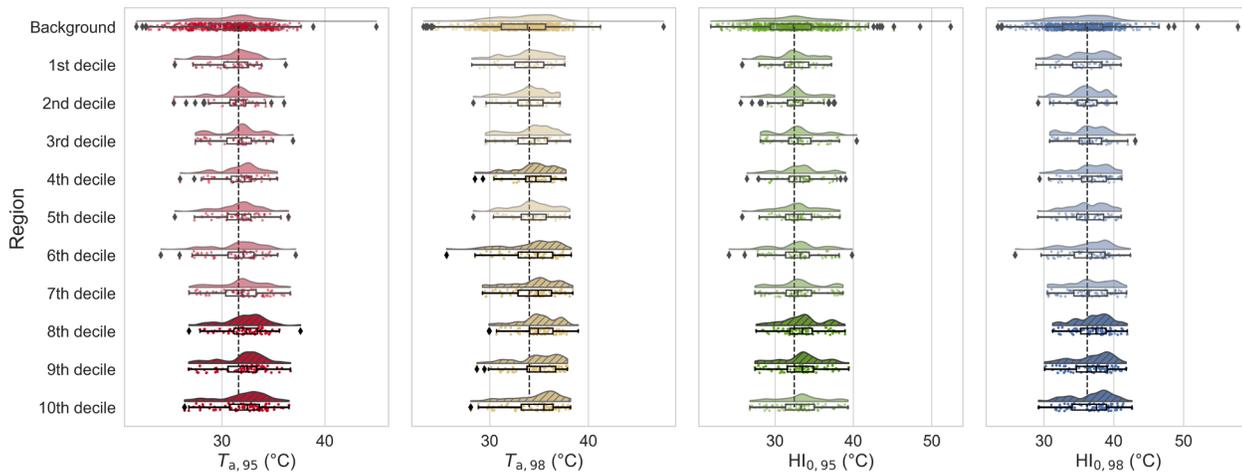
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76 **Fig. S7** Associations between variables across urban clusters for Aqua night. Associations
 77 between urban-rural differences in **a** surface temperature (ΔT_s) and air temperature (ΔT_a), **b** ΔT_s
 78 and relative humidity (ΔRH), **c** ΔT_s and heat index (ΔHI_0), **d** ΔT_a and ΔHI_0 , **e** Normalized
 79 Difference Vegetation Index ($\Delta NDVI$) and ΔT_s , **f** $\Delta NDVI$ and ΔT_a , **g** $\Delta NDVI$ and ΔRH , and **h**
 80 $\Delta NDVI$ and ΔHI_0 across urban clusters in Europe. Each dot represents one cluster and the lines
 81 and equations of best fit are shown. All calculations are for the Aqua nighttime overpass ($\approx 1:30$
 82 am local time) for July 2019.

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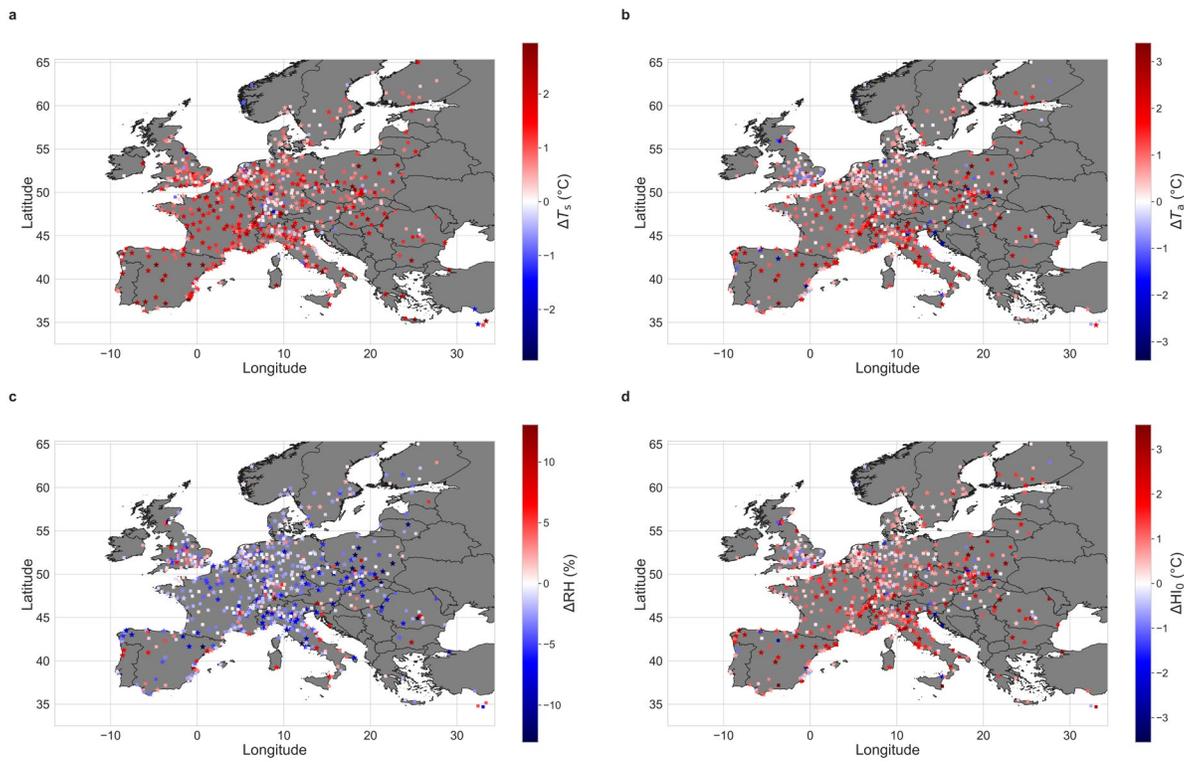
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87 **Fig. S8** Intra-urban gradients of extremes. Distributions of the 95th and 98th percentile of hourly
 88 observations in July 2019 of air temperature (T_a) and heat index (HI_0) in each of the T_s decile
 89 neighborhoods across the urban clusters considered. The vertical dashed lines mark the median of
 90 the distribution of the corresponding variable in the 1st T_s decile neighborhood. Decile
 91 neighborhoods that show statistically significant ($p < 0.01$) differences from the background
 92 reference values are shown using hatched density plots and darker shades.

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Fig. S9 Urban-rural differences for Aqua night across urban clusters in Europe. Spatial distribution of urban-rural differences in **a** surface temperature (ΔT_s), **b** air temperature (ΔT_a), **c** relative humidity (ΔRH), and **d** heat index (ΔHI_0) for urban clusters in Europe with sufficient data corresponding to the Aqua satellite nighttime overpass ($\approx 1:30$ am local time) for July 2019. The stars represent clusters with statistically significant ($p < 0.01$) differences between the urban and rural values.

104 **Table S1.** P-values of the Mann –Whitney two-sample statistic between the observations
 105 corresponding to the Aqua daytime overpass ($\approx 1:30$ pm local time) in the background reference
 106 region and the observations in the decile neighborhoods for surface temperature (T_s), air
 107 temperature (T_a), relative humidity (RH), US National Weather Service heat index (HI_0), four
 108 additional estimates of heat index (HI_1 to HI_4), and the humidex for July 2019.

Group	T_s	T_a	RH	HI_0	HI_1	HI_2	HI_3	HI_4	Humidex
1 st decile	<0.01	0.16	0.25	0.26	0.21	0.24	0.21	0.18	0.23
2 nd decile	0.25	0.23	0.06	0.25	0.27	0.25	0.32	0.23	0.39
3 rd decile	0.01	0.43	0.38	0.39	0.40	0.38	0.42	0.41	0.46
4 th decile	<0.0001	0.38	<0.01	0.74	0.72	0.74	0.94	0.43	0.91
5 th decile	<0.0001	0.09	<0.01	0.25	0.23	0.24	0.34	0.1	0.43
6 th decile	<0.0001	0.01	<0.01	0.05	0.05	0.05	0.09	0.02	0.14
7 th decile	<0.0001	0.02	<0.0001	0.13	0.11	0.13	0.24	0.03	0.37
8 th decile	<0.0001	<0.01	<0.0001	0.05	0.04	0.05	0.11	<0.01	0.20
9 th decile	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.01	<0.0001	<0.01
10 th decile	<0.0001	<0.0001	<0.0001	<0.01	<0.01	<0.01	<0.01	<0.0001	0.03

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111 **Table S2.** P-values of the Mann –Whitney two-sample statistic between the observations
 112 corresponding to the Terra daytime overpass ($\approx 10:30$ am local time) in the background reference
 113 region and the observations in the decile neighborhoods for surface temperature (T_s), air
 114 temperature (T_a), relative humidity (RH), US National Weather Service heat index (HI₀), four
 115 estimates of heat index (HI₁ to HI₄), and the humidex for July 2019.

Group	T_s	T_a	RH	HI ₀	HI ₁	HI ₂	HI ₃	HI ₄	Humidex
1 st decile	<0.0001	0.27	0.27	0.25	0.27	0.29	0.26	0.28	0.25
2 nd decile	0.49	0.41	0.08	0.55	0.58	0.49	0.70	0.44	0.80
3 rd decile	<0.001	0.85	0.06	0.86	0.82	0.89	0.60	0.91	0.49
4 th decile	<0.0001	0.28	<0.01	0.50	0.58	0.48	0.81	0.32	0.98
5 th decile	<0.0001	0.44	<0.001	0.81	0.86	0.74	0.85	0.52	0.70
6 th decile	<0.0001	<0.01	<0.0001	0.04	0.04	0.04	0.09	<0.01	0.16
7 th decile	<0.0001	0.05	<0.001	0.15	0.17	0.14	0.33	0.07	0.49
8 th decile	<0.0001	0.03	<0.0001	0.13	0.14	0.12	0.31	0.04	0.47
9 th decile	<0.0001	0.01	<0.0001	0.06	0.07	0.06	0.18	0.02	0.29
10 th decile	<0.0001	<0.01	<0.0001	0.03	0.04	0.02	0.09	<0.01	0.16

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119 **Table S3.** P-values of the Mann –Whitney two-sample statistic between the 95th and 98th
 120 percentile of hourly observations in July 2019 of air temperature (T_a) and US National Weather
 121 Service heat index (HI₀) for CWSs in the background reference region and the corresponding
 122 observations in the decile neighborhoods.

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Group	$T_{a,95}$	$T_{a,98}$	HI_{0,95}	HI_{0,98}
1 st decile	0.48	0.36	0.63	0.41
2 nd decile	0.40	0.34	0.54	0.69
3 rd decile	0.06	0.05	0.15	0.18
4 th decile	0.01	<0.01	0.04	0.02
5 th decile	0.05	0.03	0.13	0.11
6 th decile	0.03	<0.01	0.11	0.06
7 th decile	0.01	<0.01	0.06	0.03
8 th decile	<0.001	<0.0001	<0.01	<0.01
9 th decile	<0.001	<0.0001	<0.01	<0.01
10 th decile	<0.001	<0.0001	0.01	<0.01

125 **Table S4.** P-values of the Mann –Whitney two-sample statistic between the observations
 126 corresponding to the Aqua nighttime overpass (\approx 1:30 am local time) in the background reference
 127 region and the observations in the decile neighborhoods for surface temperature (T_s), air
 128 temperature (T_a), relative humidity (RH), US National Weather Service heat index (HI_0), four
 129 additional estimates of heat index (HI_1 to HI_4), and the humidex for July 2019.

Group	T_s	T_a	RH	HI_0	HI_1	HI_2	HI_3	HI_4	Humidex
1 st decile	<0.0001	0.27	0.12	0.21	0.21	0.20	0.16	0.26	0.14
2 nd decile	0.14	0.42	0.01	0.46	0.48	0.30	0.57	0.43	0.61
3 rd decile	0.79	0.15	<0.01	0.18	0.18	0.21	0.25	0.16	0.28
4 th decile	0.01	0.02	<0.01	0.02	0.02	0.56	0.02	0.02	0.03
5 th decile	<0.001	0.01	<0.01	0.01	0.01	0.38	0.02	0.01	0.02
6 th decile	<0.0001	<0.0001	<0.0001	<0.000 1	<0.0001	0.45	<0.0001	<0.0001	<0.0001
7 th decile	<0.0001	<0.0001	<0.0001	<0.000 1	<0.0001	0.63	<0.0001	<0.0001	<0.0001
8 th decile	<0.0001	<0.0001	<0.0001	<0.000 1	<0.0001	0.56	<0.0001	<0.0001	<0.0001
9 th decile	<0.0001	<0.0001	<0.0001	<0.000 1	<0.0001	0.47	<0.0001	<0.0001	<0.0001
10 th decile	<0.0001	<0.0001	<0.0001	<0.000 1	<0.0001	0.02	<0.0001	<0.0001	<0.0001

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