

Analysis of the Swiss urban climate over the past five years

Other Conference Item**Author(s):**

Canton, Jacopo ; Dipankar, Anurag 

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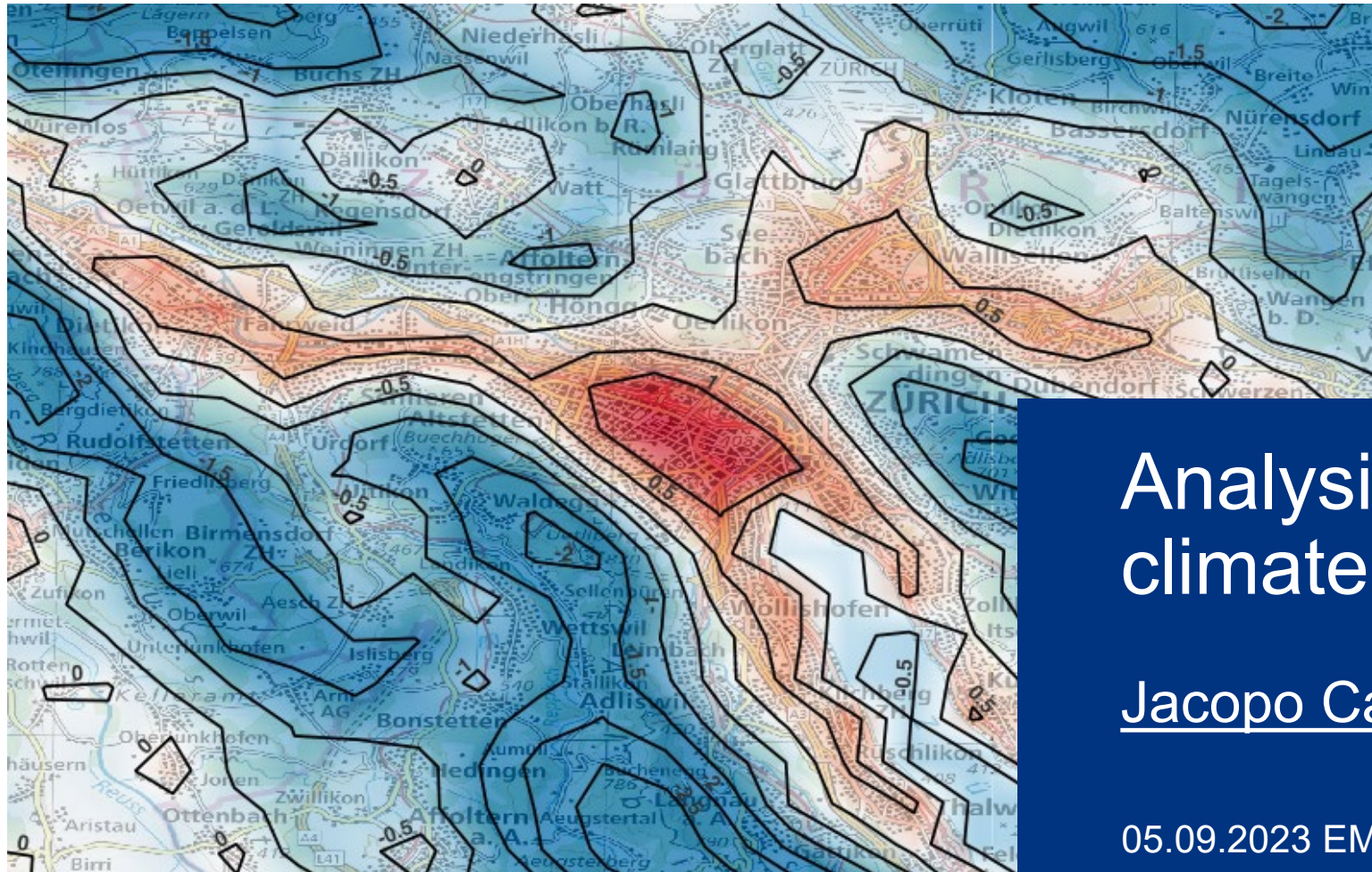
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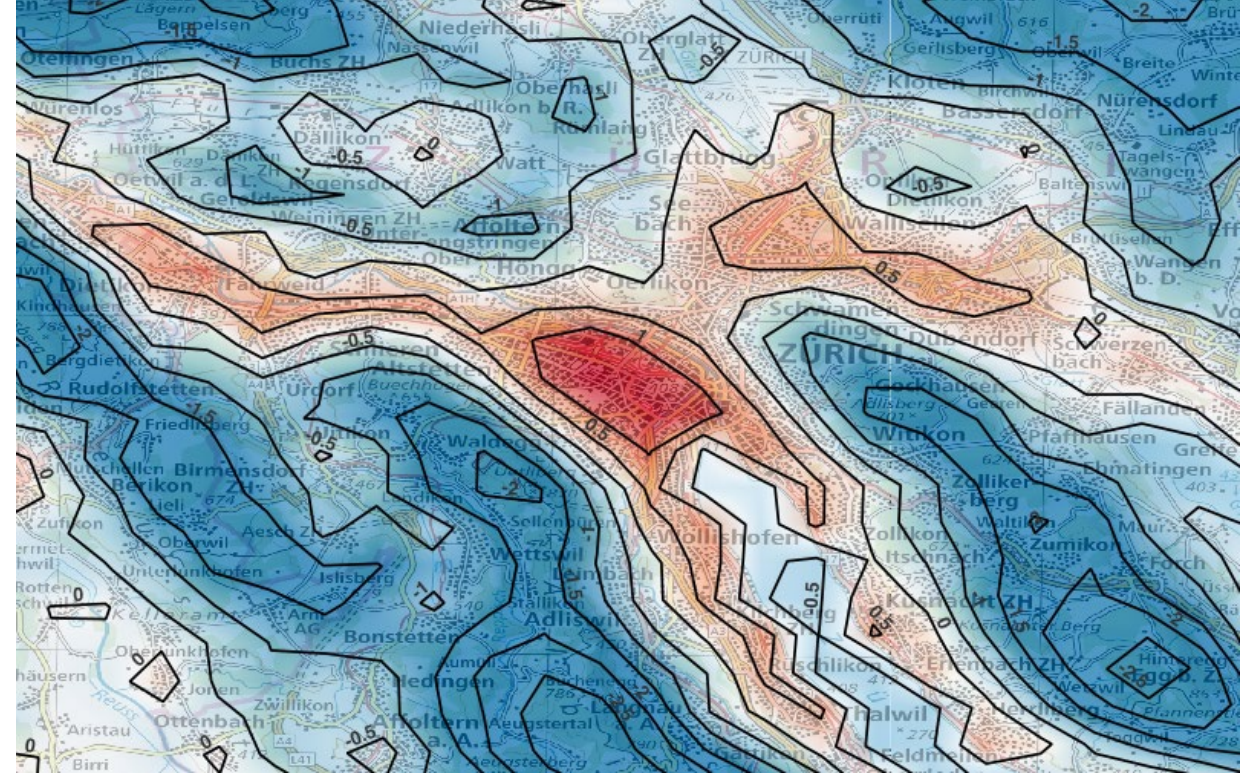
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Analysis of the Swiss urban climate over the past ~~five~~ years

Jacopo Canton & Anurag Dipankar

05.09.2023 EMS Annual Meeting



Introduction

Motivation and background

- More than 50% of people live in cities¹
- In Switzerland and EU the average is 70%¹
- Swiss cities are medium-small, near lakes/rivers and mountains
-> natural weather can have considerable effects on the heat island^{2,3}
- Several studies on individual cities^{4,5,6} but no country wide analysis

1. United Nations. World Urbanization Prospects: The 2018 Revision. NewYork (2018).
2. Wanner H, Hertig JA. Studies of Urban Climates and Air Pollution in Switzerland. J. Clim. Appl. Meteorol. (1984)
3. Zhao L, Lee X, Smith RB, Oleson K. Strong Contributions of Local Background Climate to Urban Heat Islands. Nature 2014
4. Christen A, Vogt R. Energy and Radiation Balance of a Central European City. Int J Climatol (2004)
5. Parlow E, Vogt R, Feigenwinter C. The Urban Heat Island of Basel – Seen from Different Perspectives. DIE ERDE - Journal of the Geographical Society of Berlin (2014)
6. Allegrini J, Carmeliet J. Simulations of Local Heat Islands in Zürich with Coupled CFD and Building Energy Models. Urban Climate (2018)

Numerical setup COSMO v6

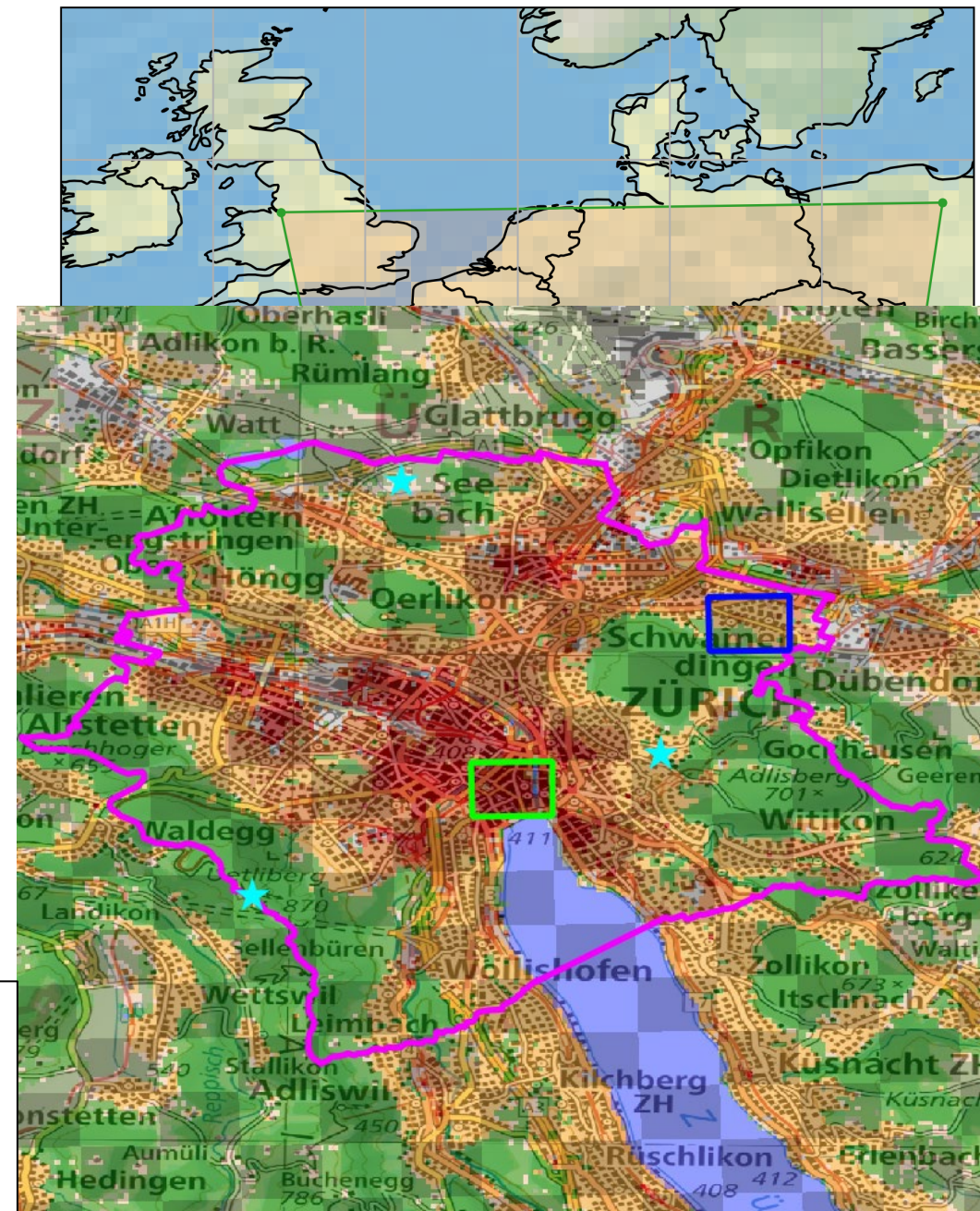
↓ ERA-5 data at hourly interval

↓ Nest 1 at 11 km res. 10 years spinup

↓ Nest 2 at 3.3 km res.

- Study domain at 1.1 km res. Monthly spinup
 - 6 years: 01.01.2017—31.12.2022
 - 1D turbulence parametrization (Raschendorfer)
 - Explicit convection
 - TERRA_URB + SURY urban parametrization¹
 - 100m global LCZ database²

- Municipality boundary
- City centre
- Rural reference
- ★ Measurement stations

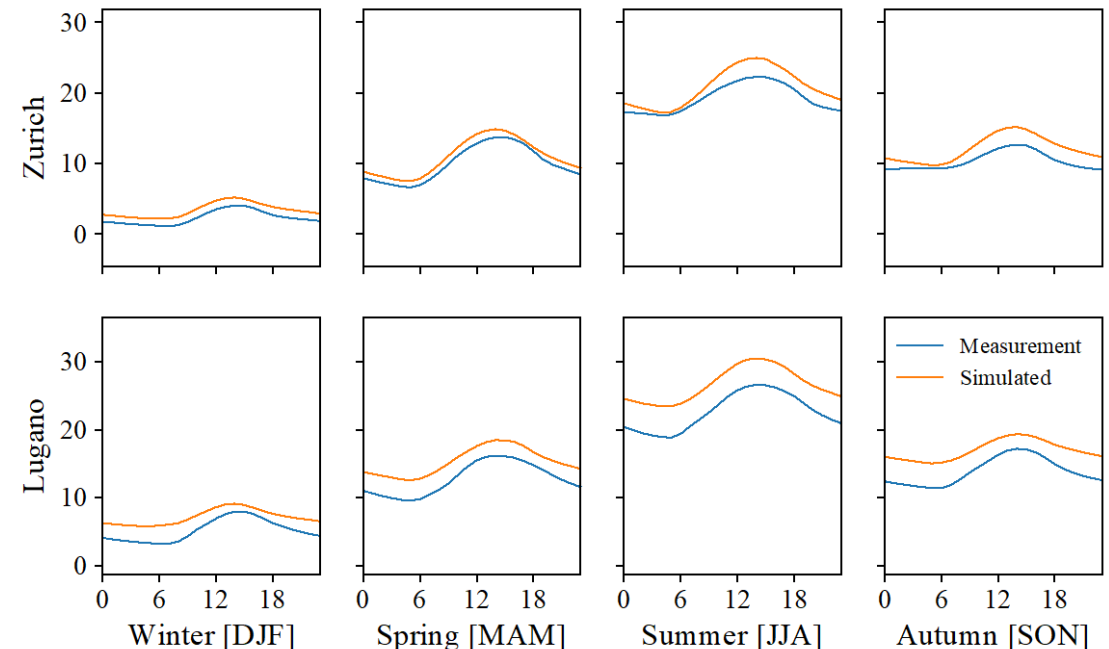
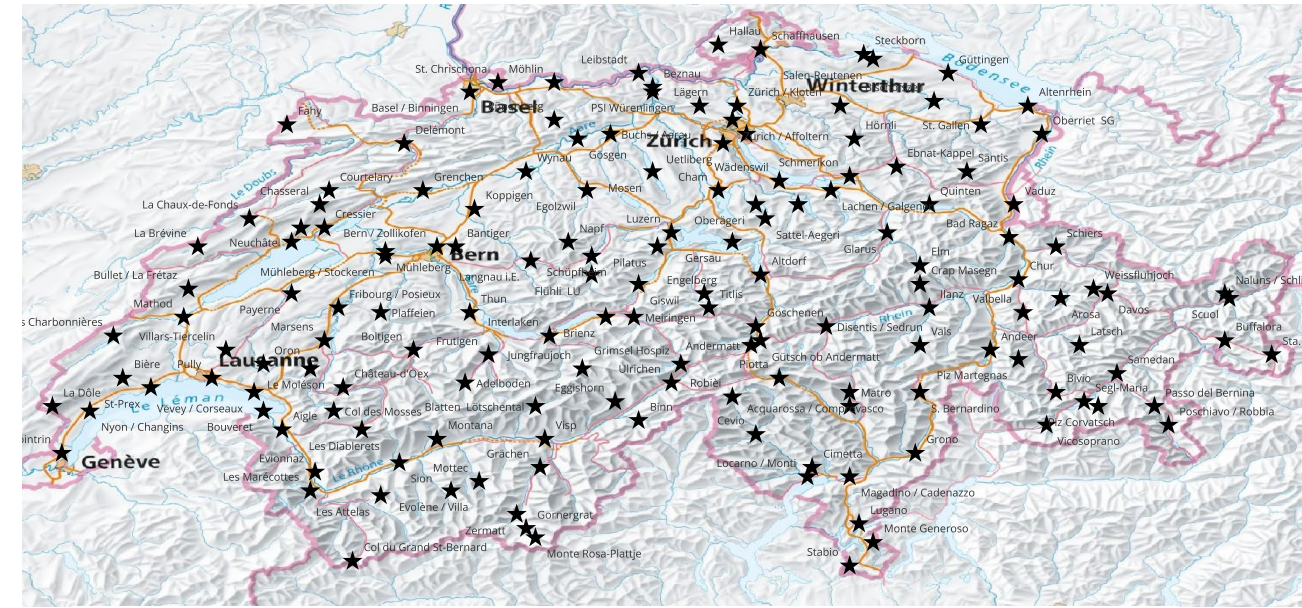


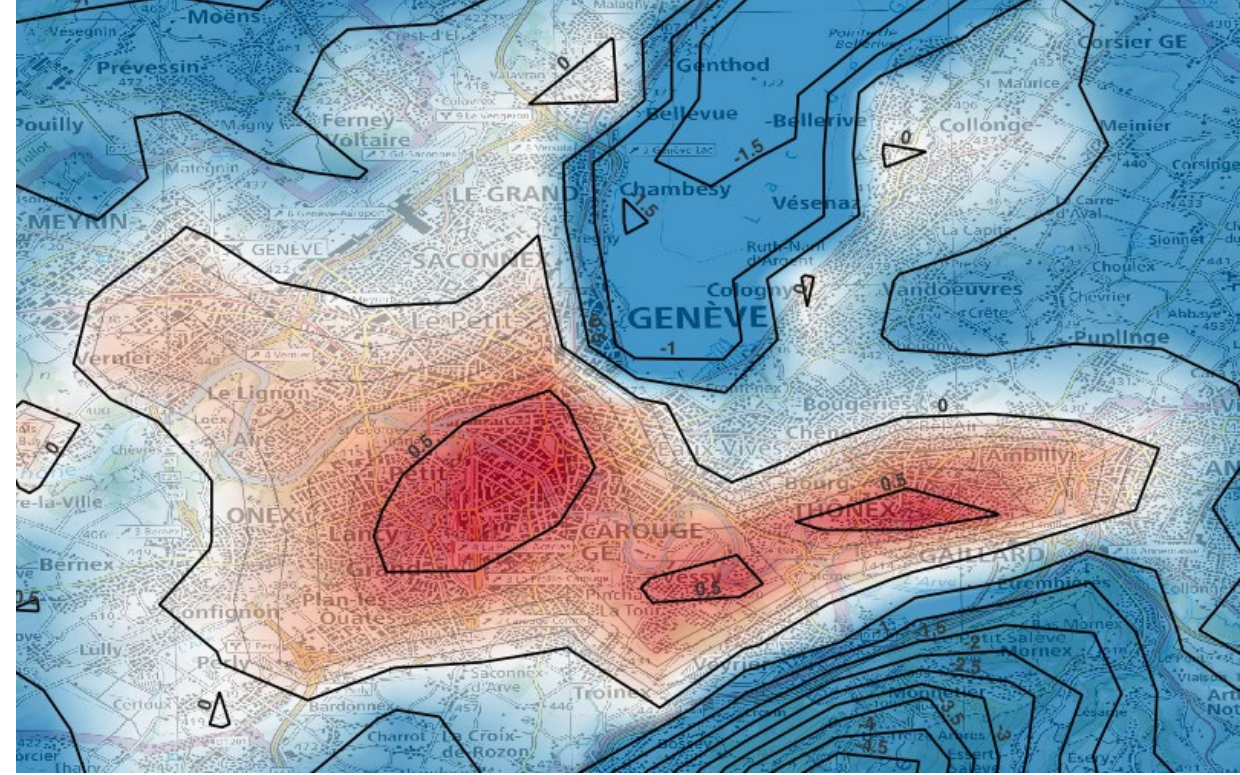
Validation

Hourly measurements from 156 automatic measurement towers (MeteoSwiss): T, P, humidity, wind

2m TEMPERATURE

- The temporal variability is very well captured
- Mean bias at some stations within expected values¹





Urban heat island

Two-point-delta measures

UHI: temporal dynamics

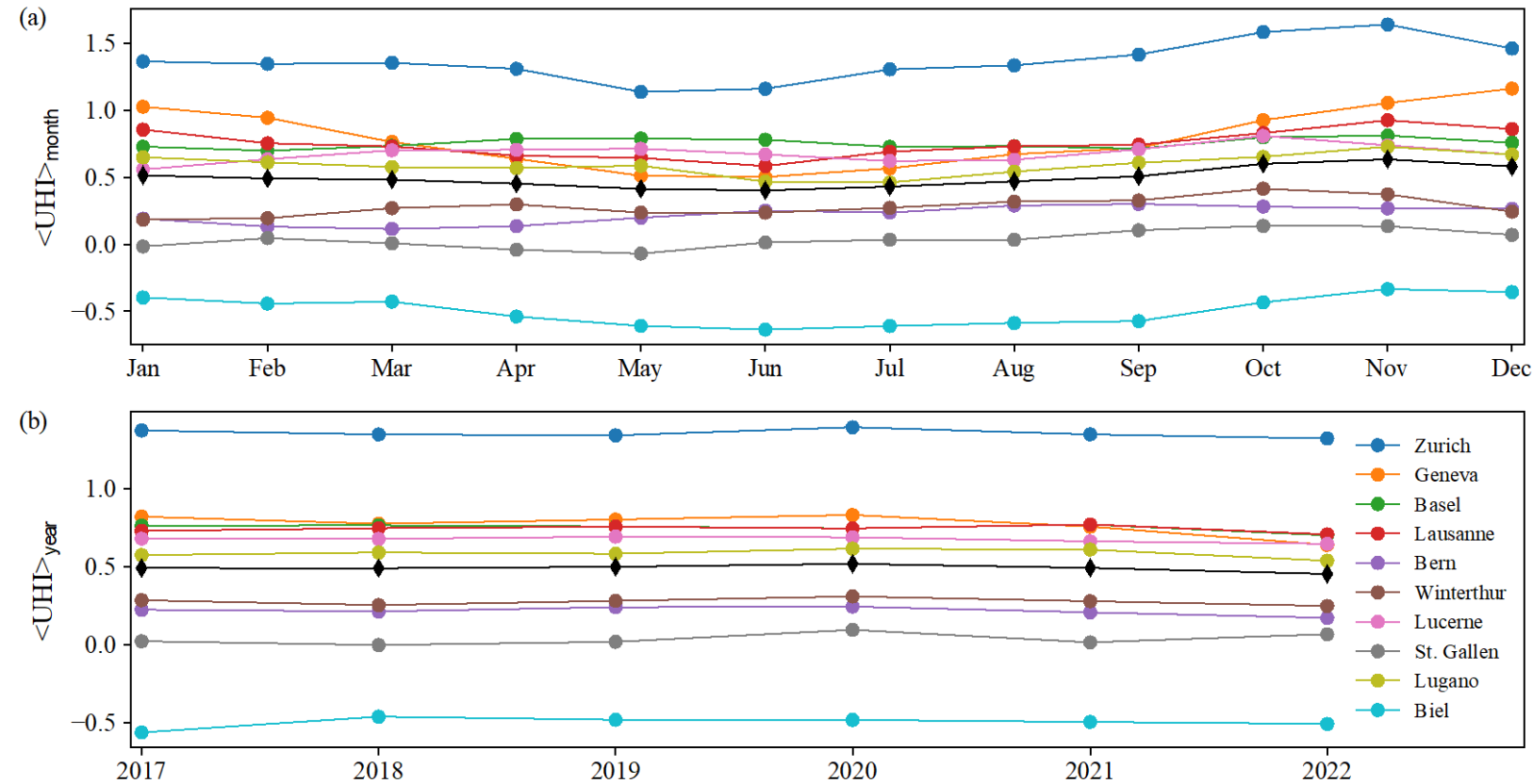
- Typical diel cycle:
min around midday
max during night-time
- Winter presents an early morning peak^{1,2}
- All cities present a cool island effect in summer
- Difficult to find features common across all cities and seasons



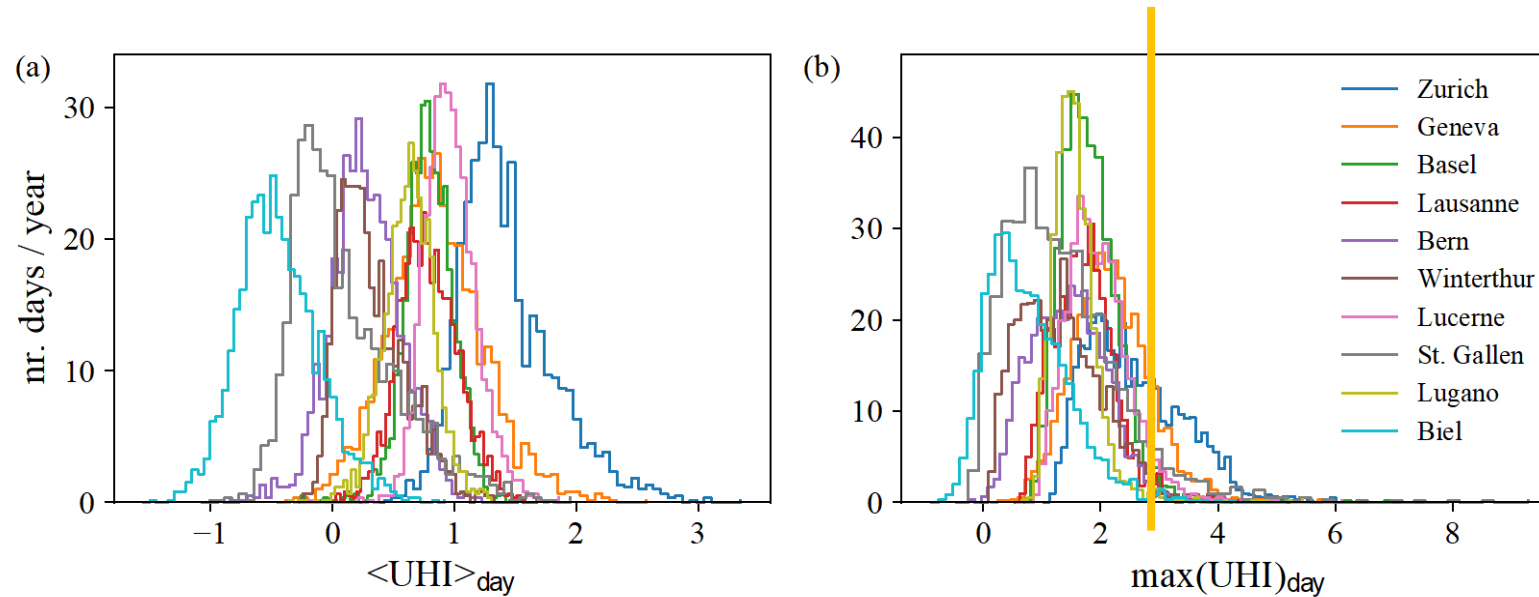
Ensemble seasonal diel cycles of ΔT

UHI: temporal dynamics (2)

- Monthly variations are relatively similar across cities
- Yearly variations *of the mean value* are almost absent

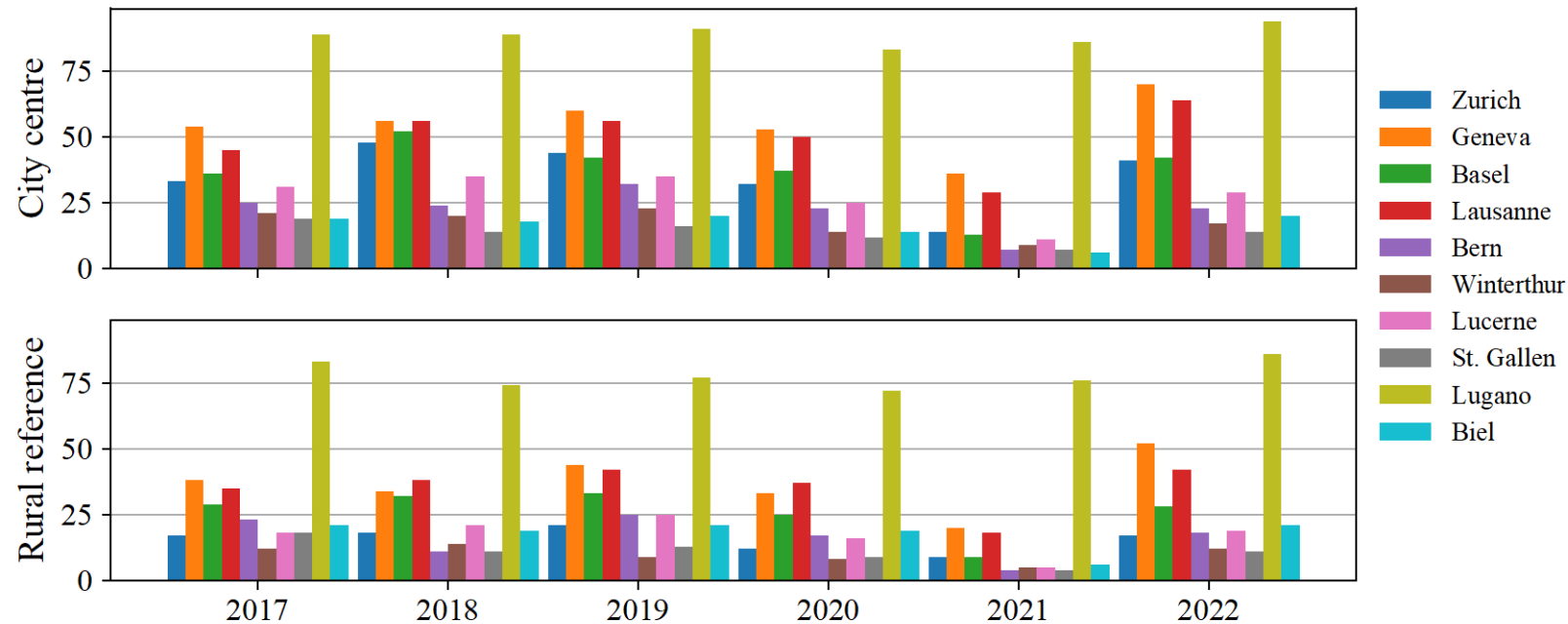


UHI histograms and extreme events

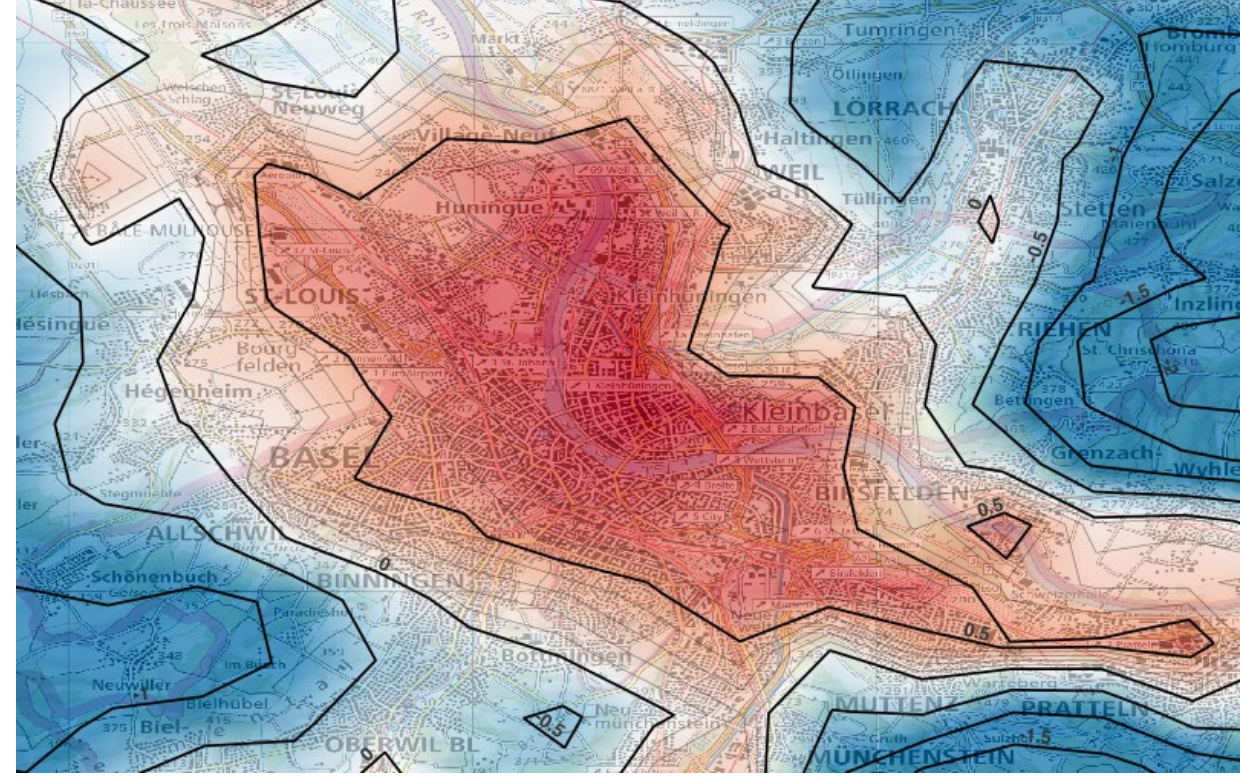


- Zurich and Lausanne have only positive $\langle \text{UHI} \rangle$
- All cities present UHI_{\max} exceeding 3°C
- Extreme values will increase more in cities¹

Extreme events 2: tropical nights ($T_{\min} \geq 20^{\circ}\text{C}$)



- Connected with a change in the mortality rate in Switzerland¹
- Lugano (south of the Alps) has more than 2x
- Highly influenced by local climate (e.g., Geneva Lausanne)
- Not connected to UHI intensity

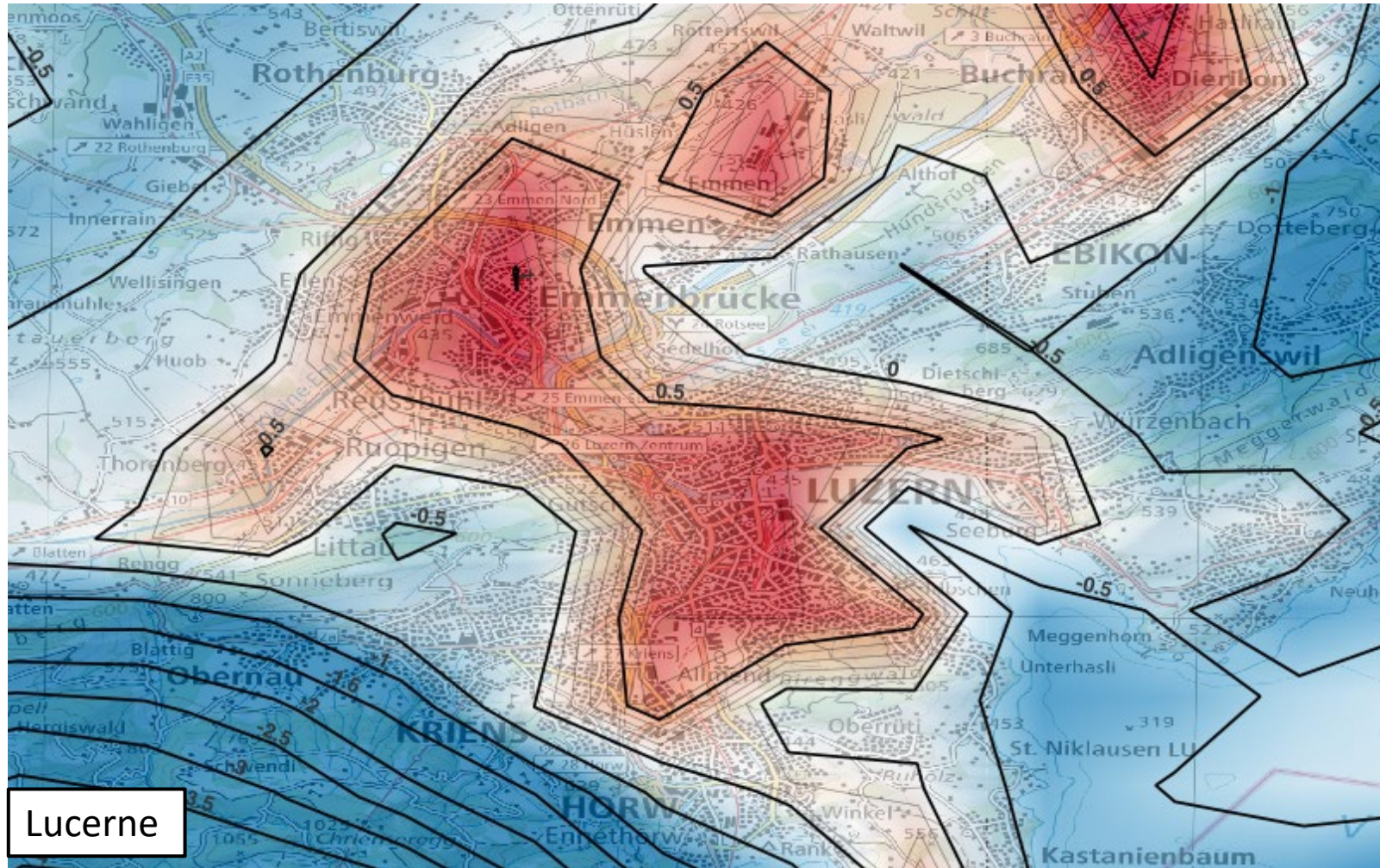


Urban heat island

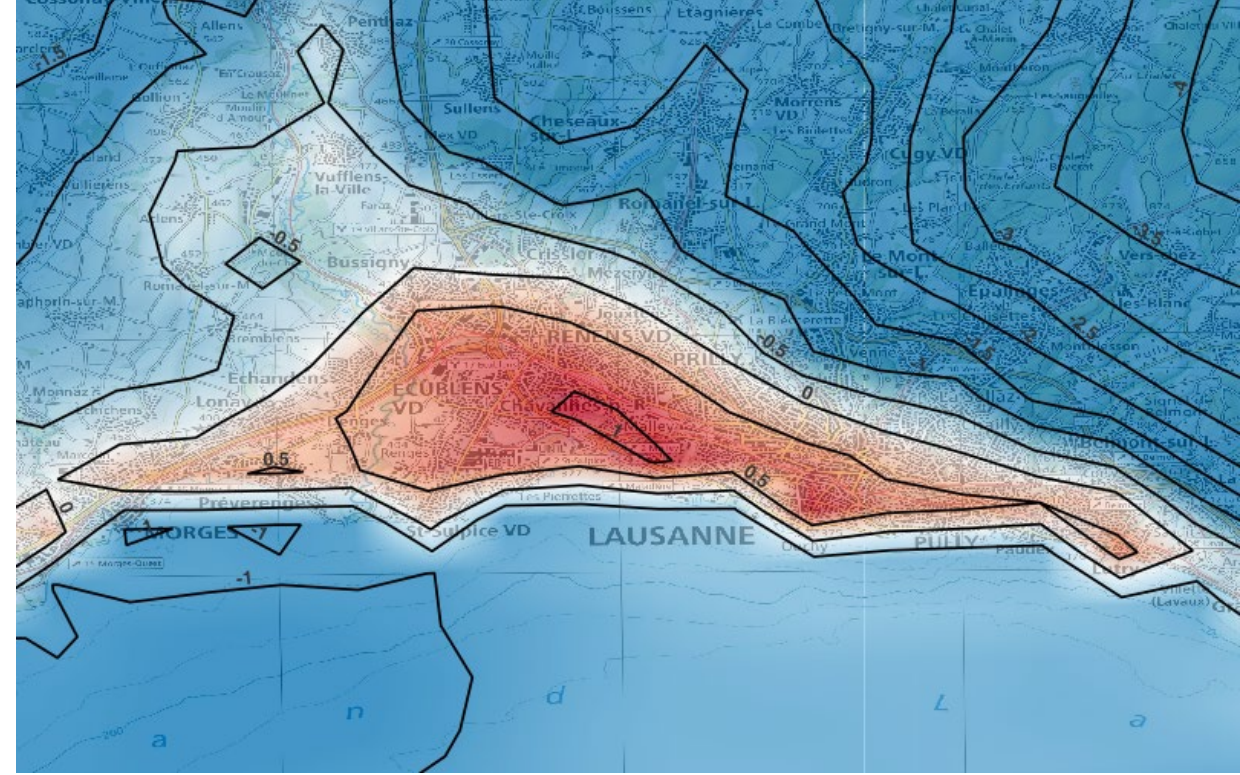
Spatial maps

Spatial maps

- Geographical features can be readily identified by steep gradients (e.g., mountains)
- Clearly shows the spatial nature of the phenomenon
- Highlights that downtown ≠ heat centre



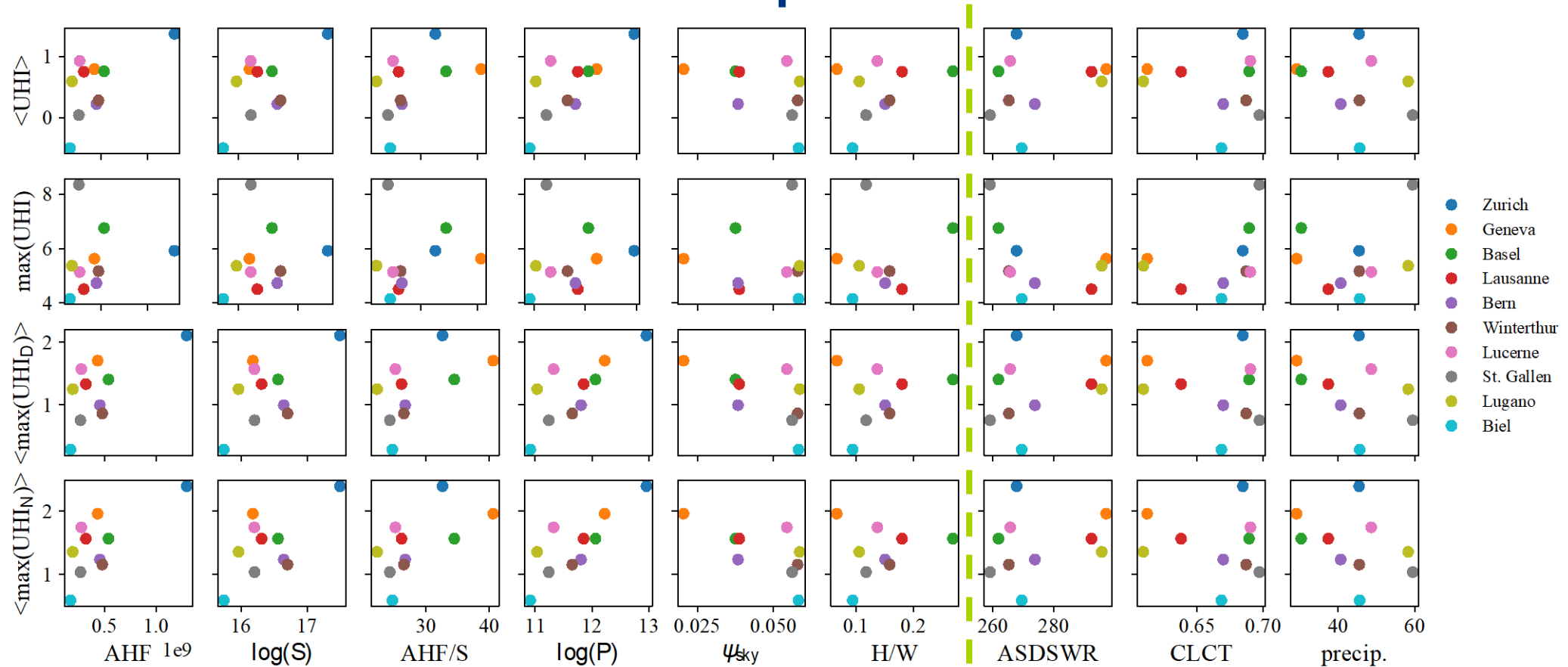
<UHI> over the summer season (June, July, August). Blue=neg, Red=pos



Discussion

About the influence of weather and bulk parameters

UHI as a function of bulk parameters

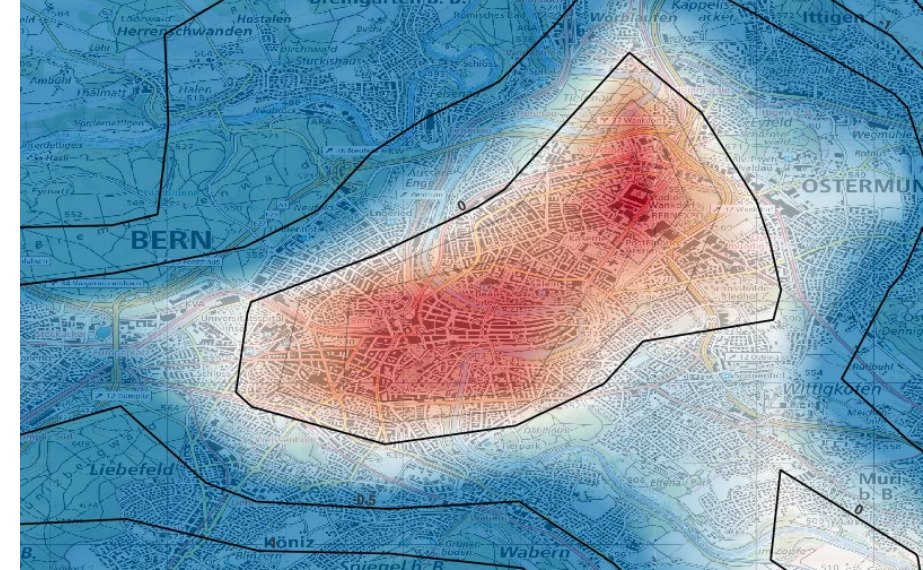


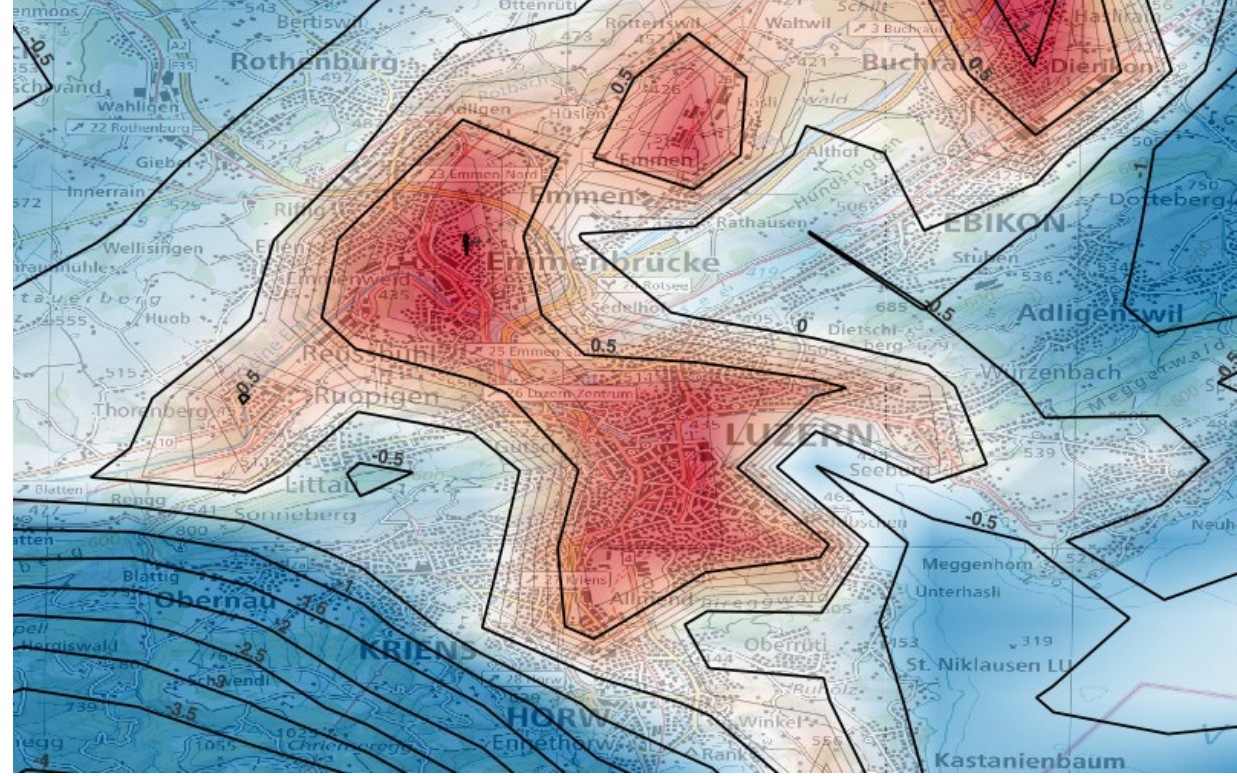
- Empirical relationships between UHI and geometrical parameters^{1,2,3}
- Does not apply to any UHI measurement and any parameter investigated

1. Zhou B, Rybski D, Kropp JP. The Role of City Size and Urban Form in the Surface Urban Heat Island. Sci Rep (2017)
2. Zhao L, Lee X, Smith RB, Oleson K. Strong Contributions of Local Background Climate to Urban Heat Islands. Nature (2014)
3. Oke TR. Canyon Geometry and the Nocturnal Urban Heat Island: Comparison of Scale Model and Field Observations. J. Clim. (1981)

Summary and outlook

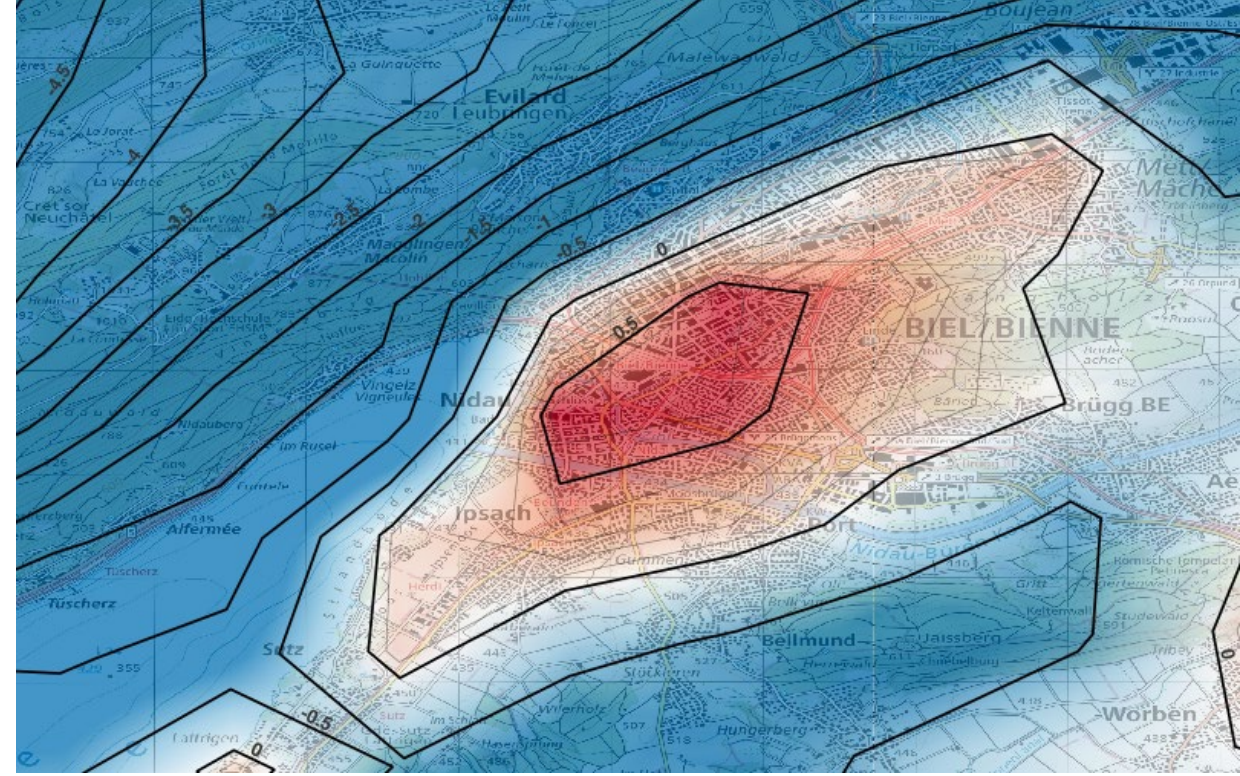
- First comprehensive analysis over CH
- Data publicly available for further analysis
- Higher UHI effect than expected (more than 3°C)
- Time- weather- and city-specific analyses are necessary, it makes little sense to say, e.g., Bern's UHI is 2°C
- Yearly variations are visible in extreme values, not so much in the mean
- Spatial maps are necessary for meaningful analyses





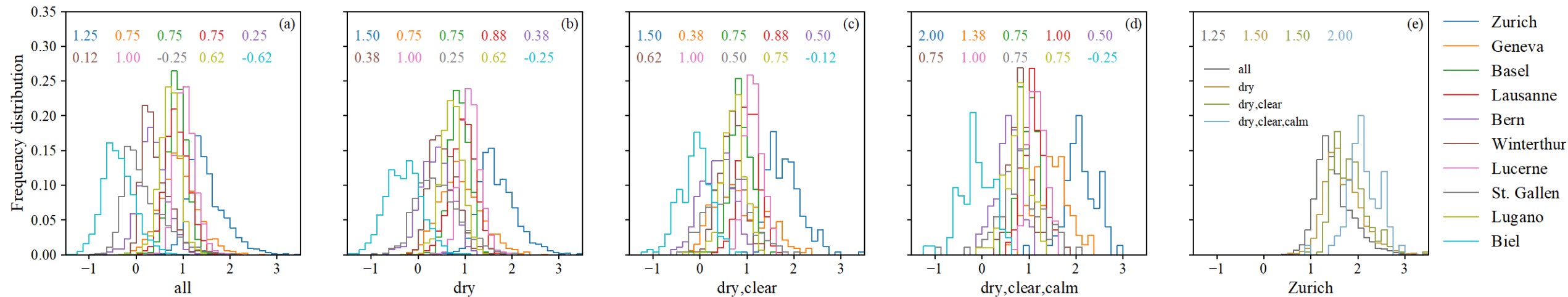
Thank you for your attention

Any questions?



Extra slides

UHI histograms and dependence on weather

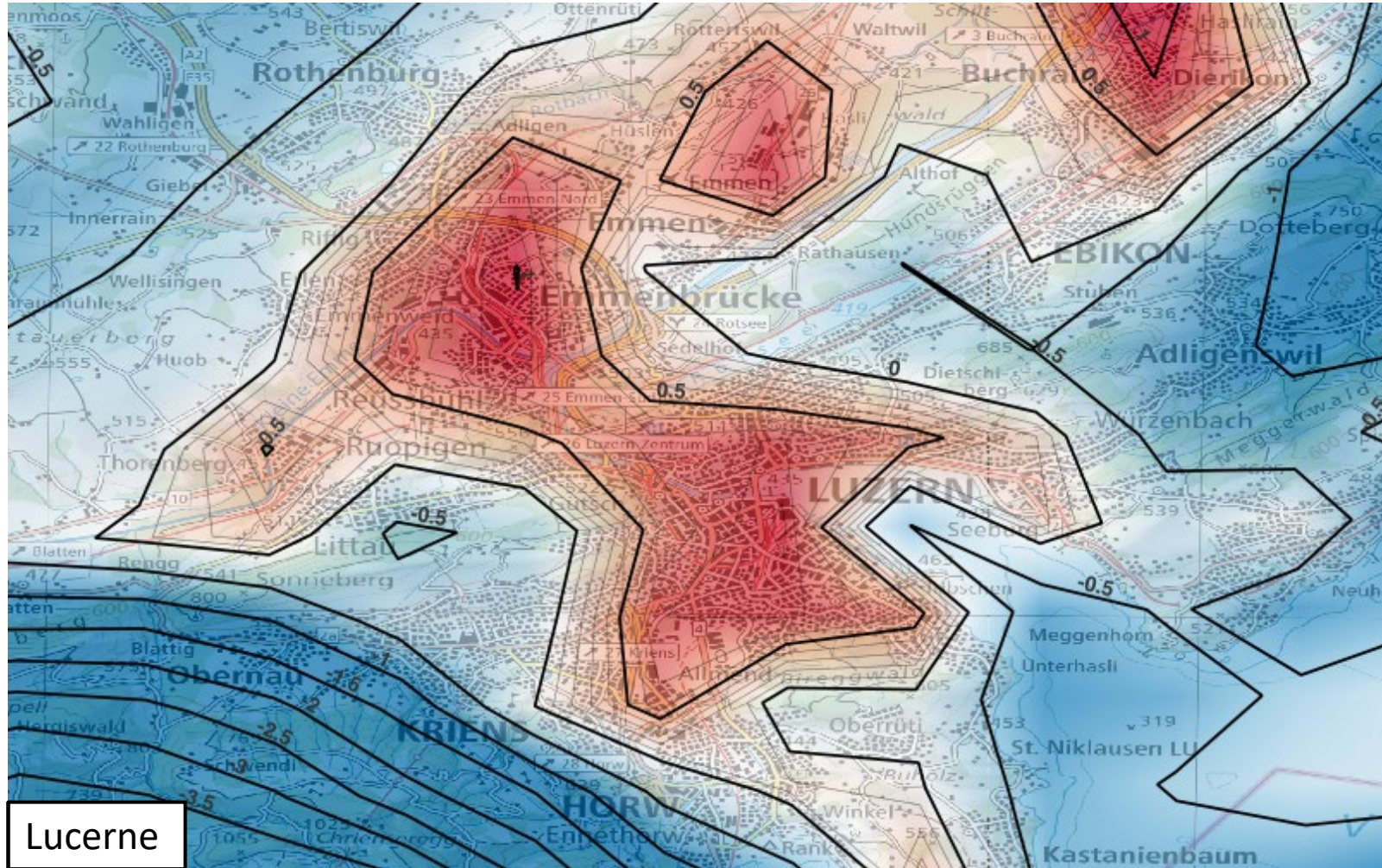


Histograms of daily maximum UHI intensity for different weather conditions

As reported by Roth et al.¹, the local weather has a large effect on UHI magnitude

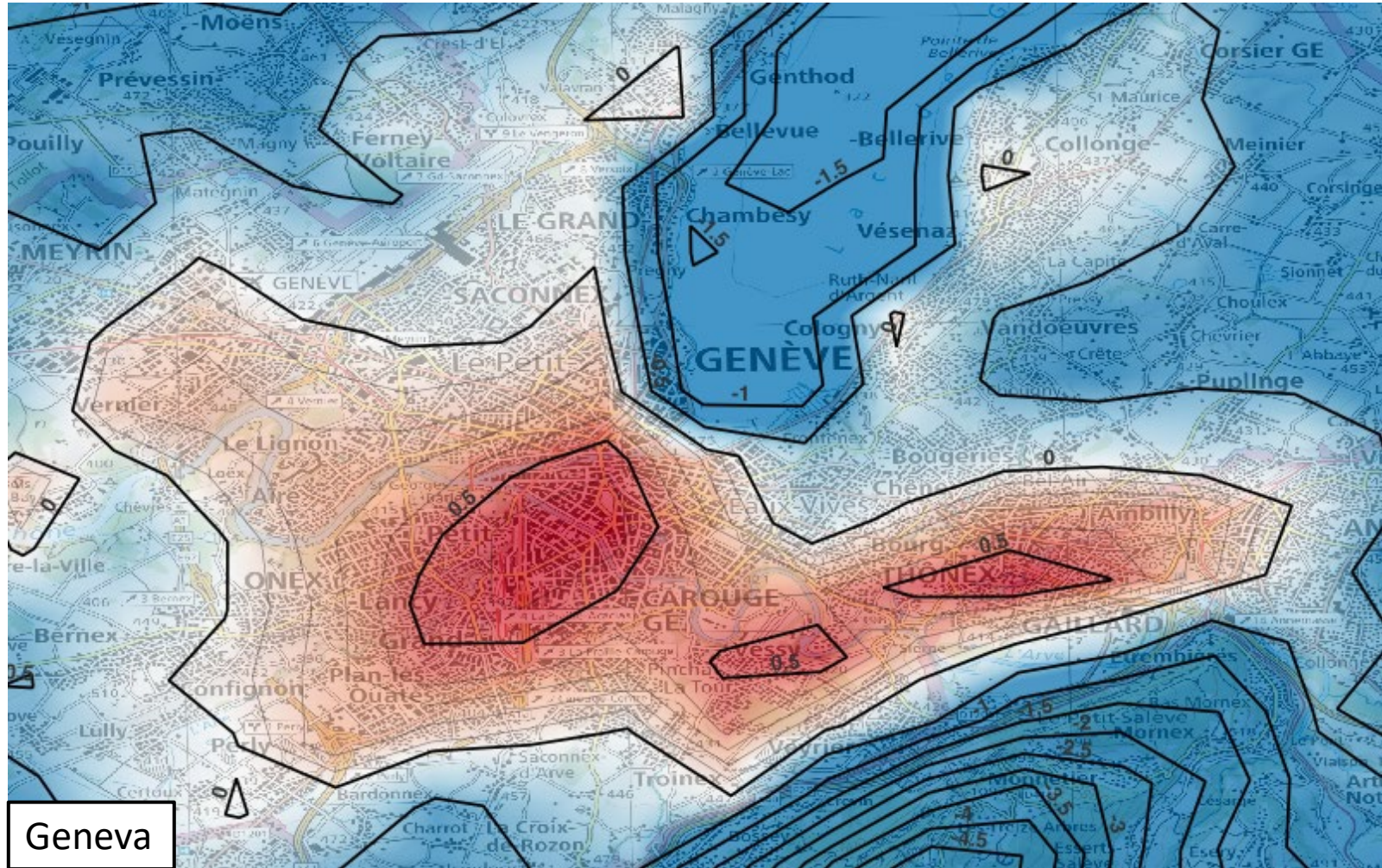
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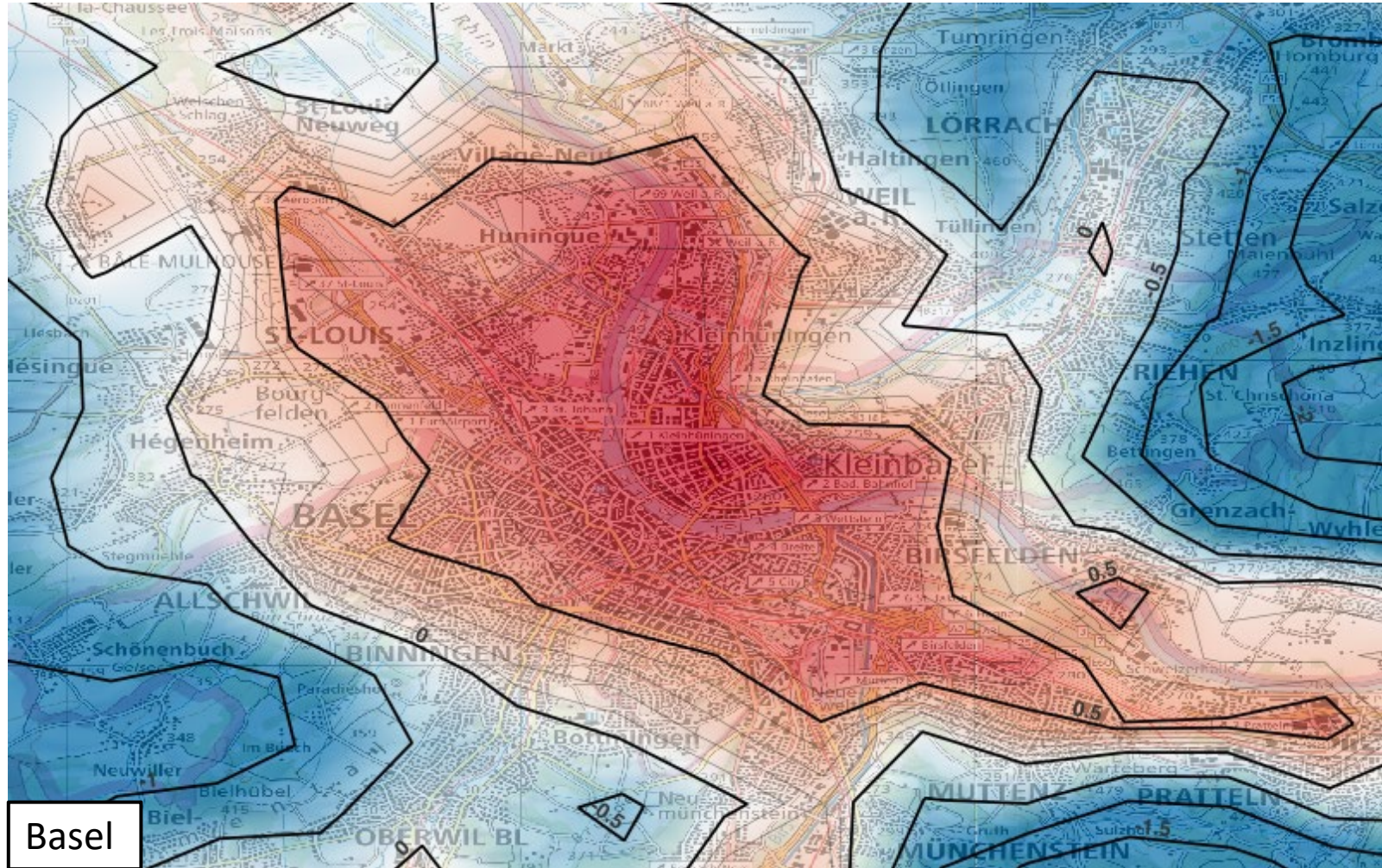


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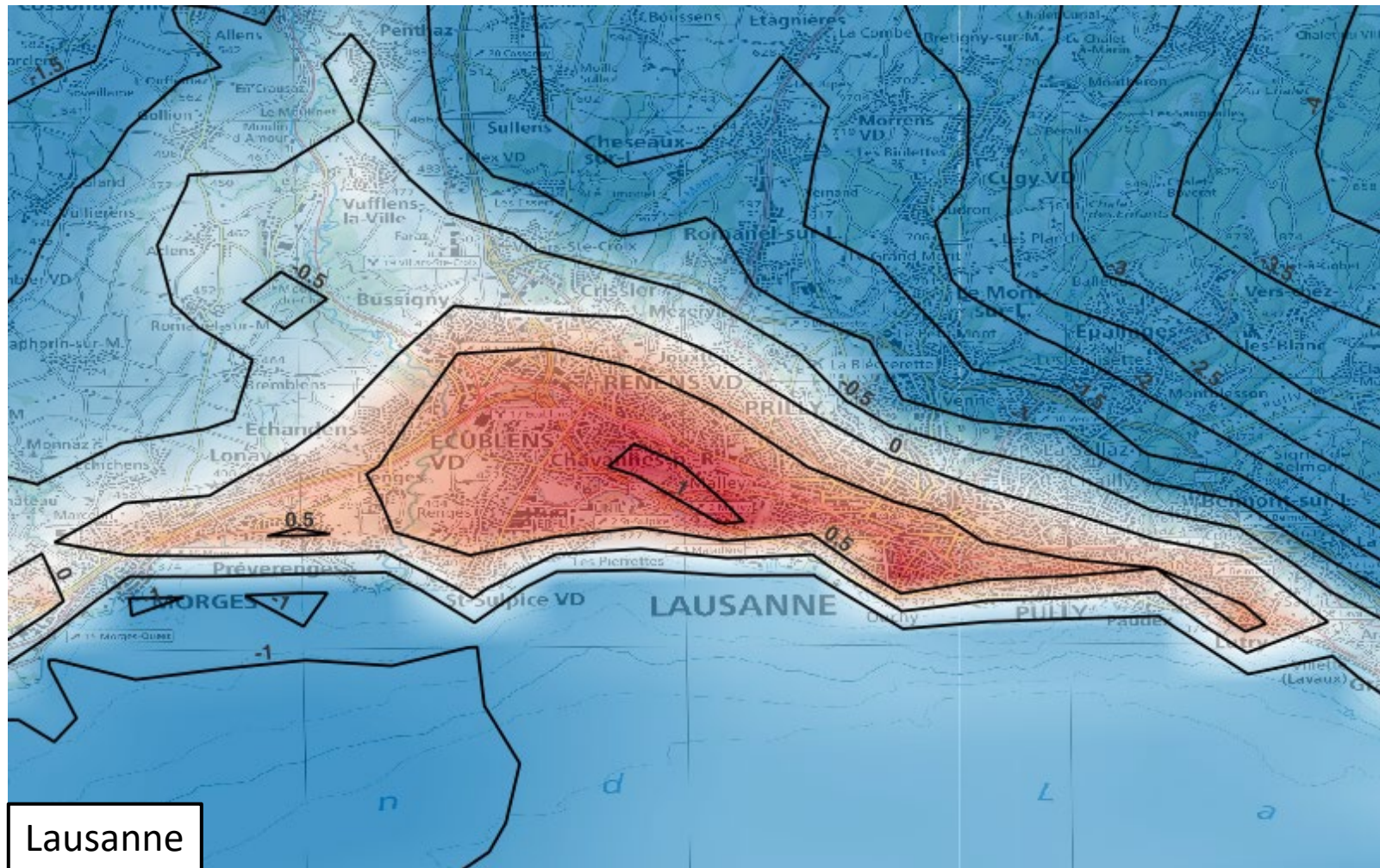
Spatial maps



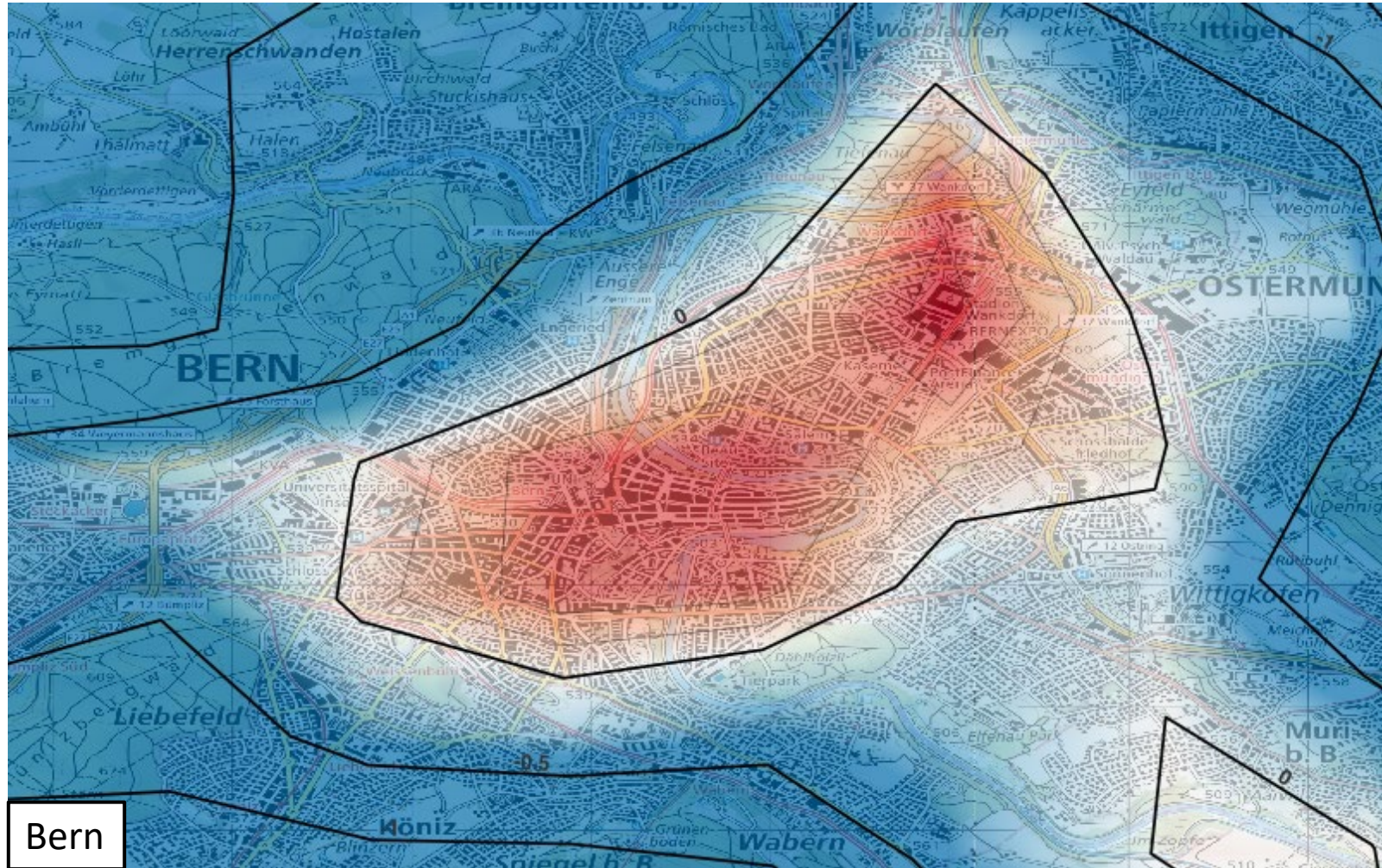
Spatial maps



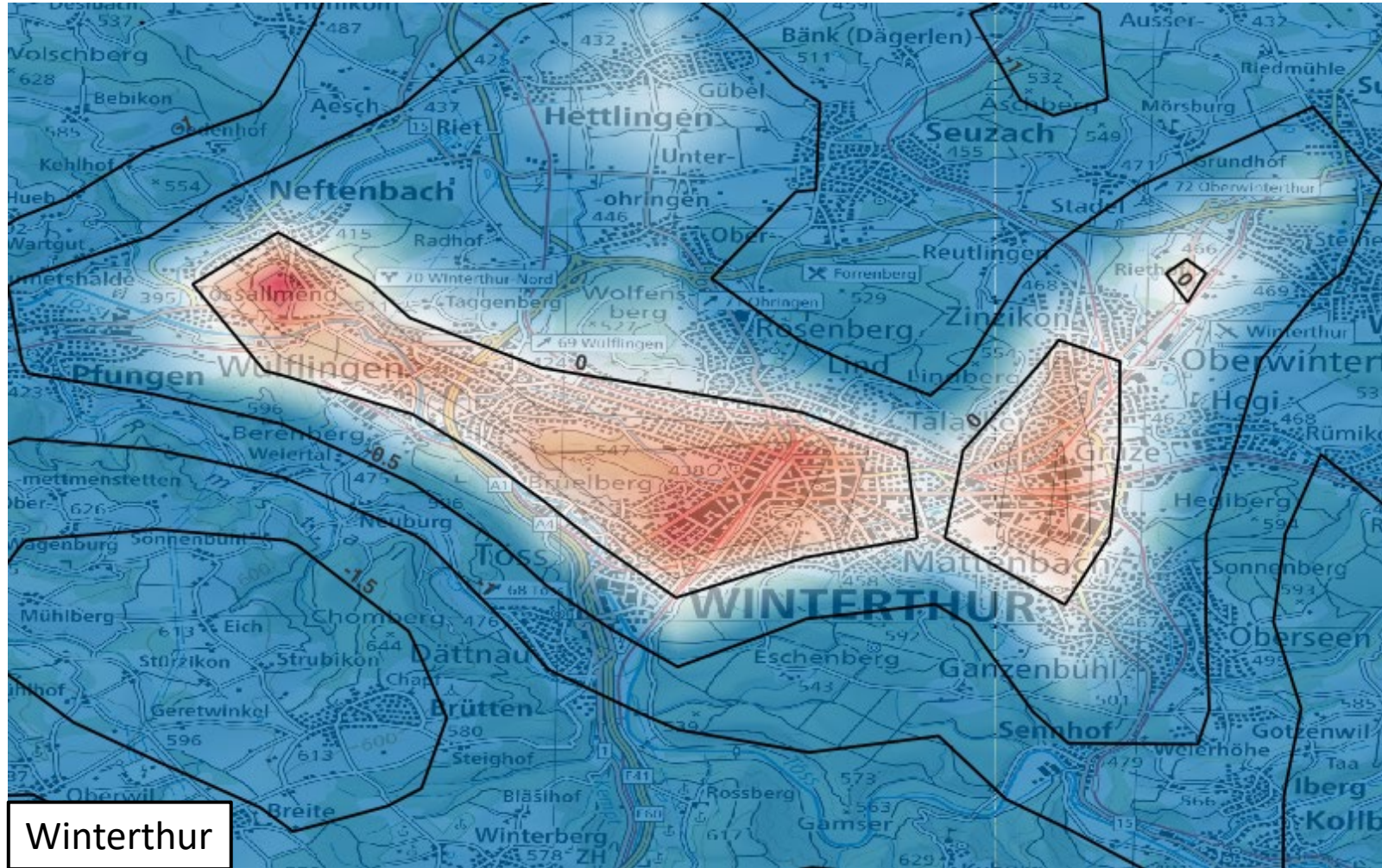
Spatial maps



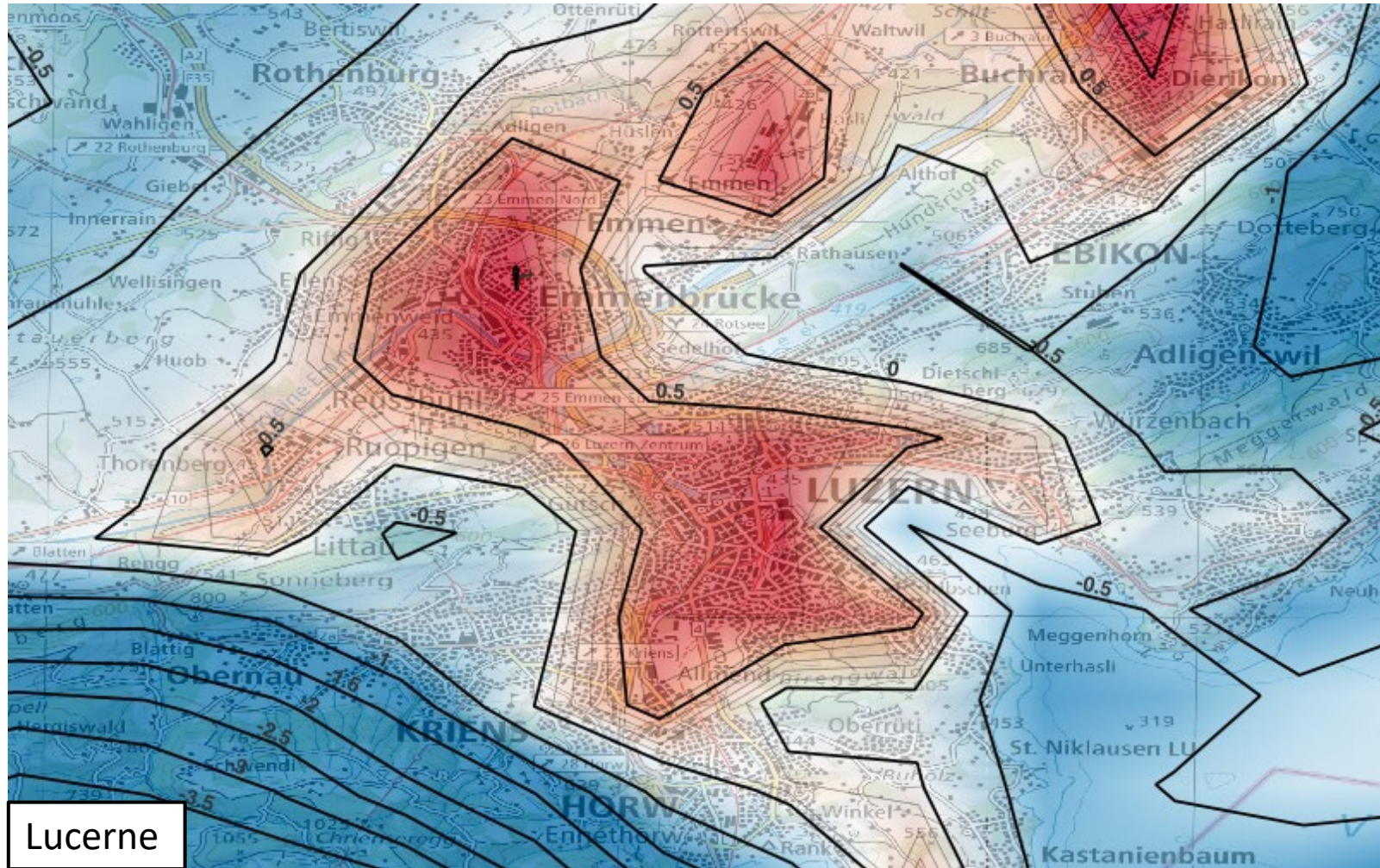
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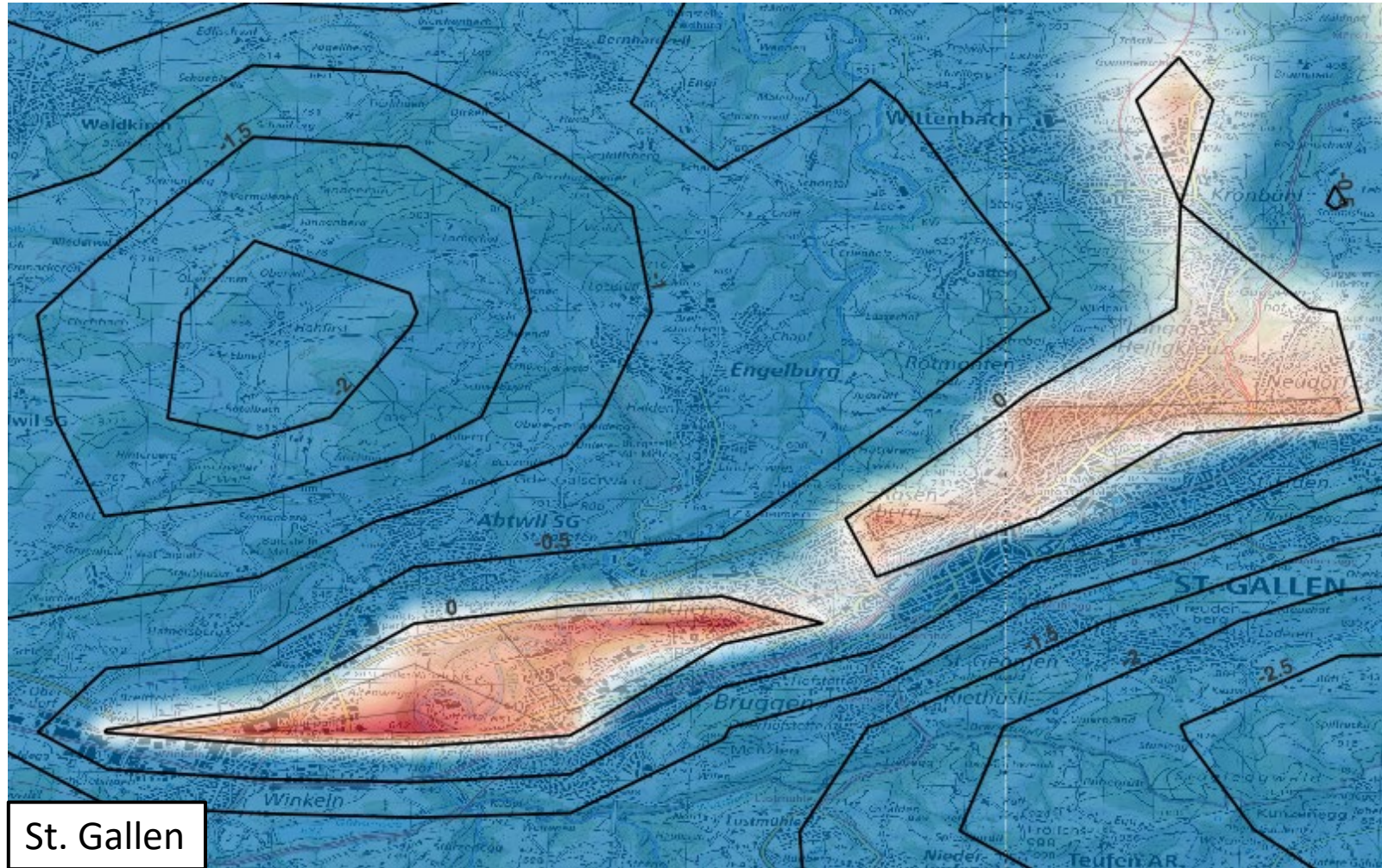
Spatial maps



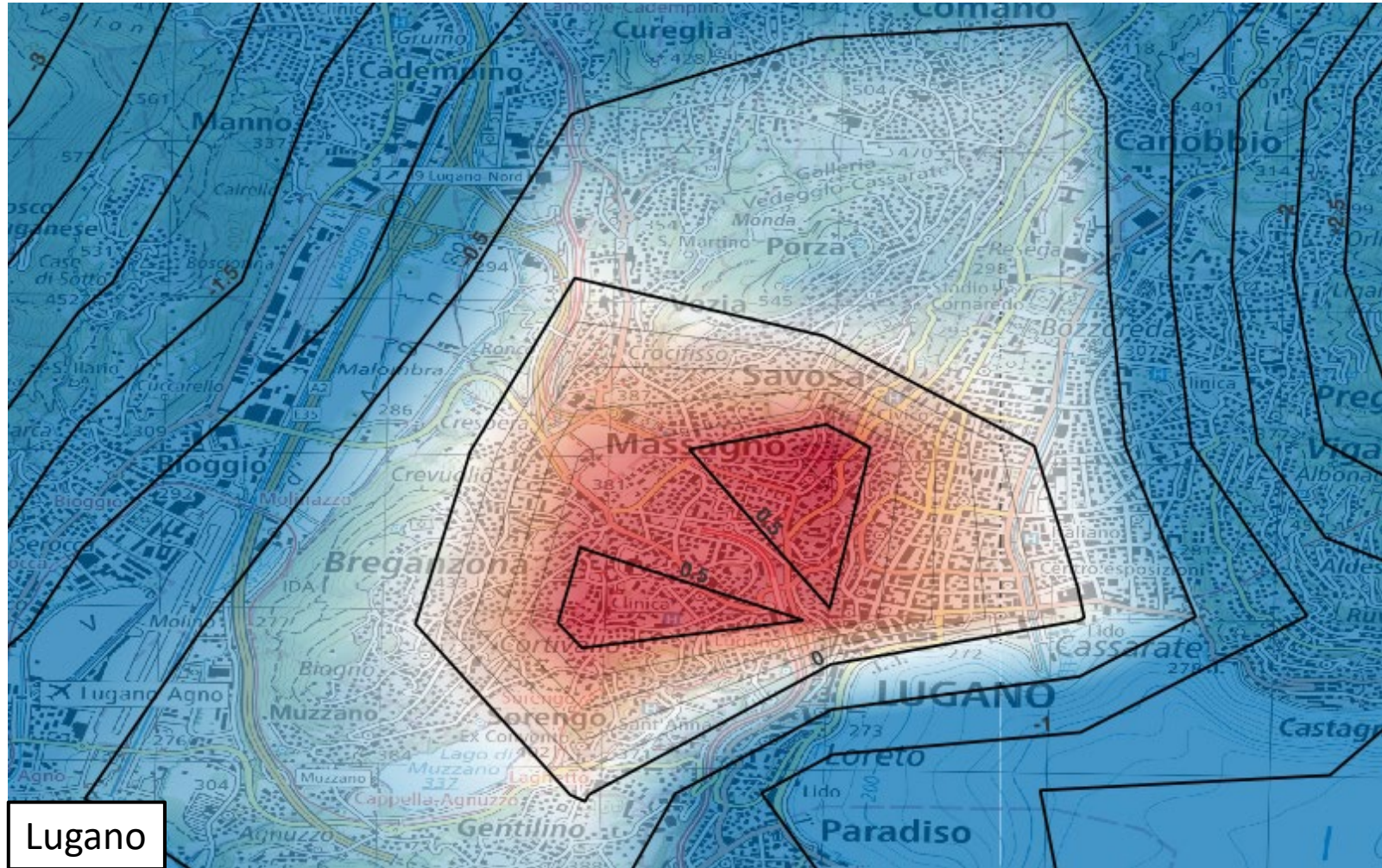
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