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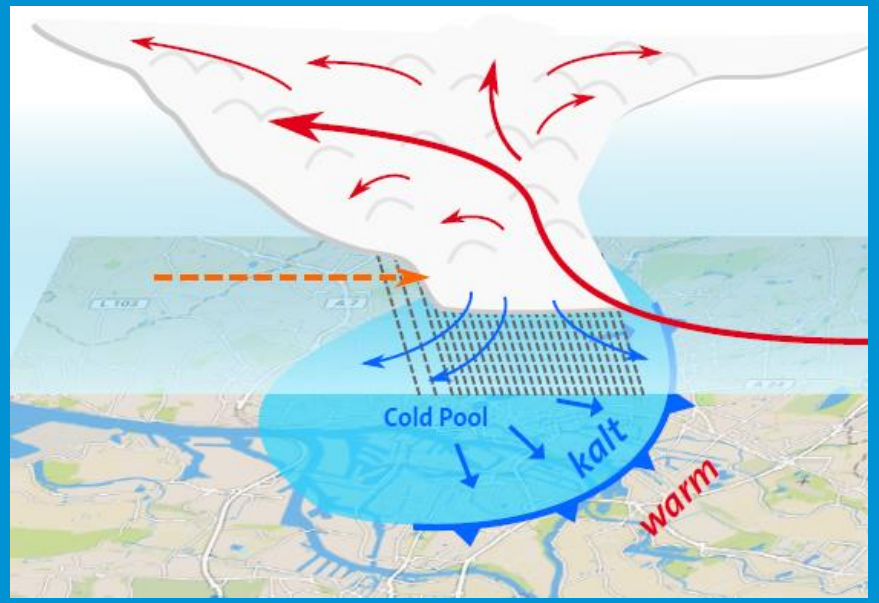
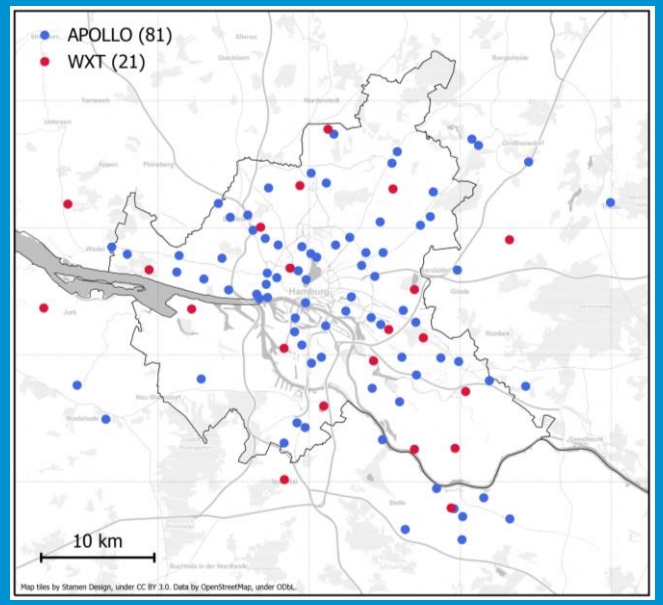
Illuminating the blind spot of **sub-mesoscale phenomena** with a **dense station network**





Bastian Kirsch, Cathy Hohenegger, Daniel Klocke, **Felix Ament**

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How to design of stations and network?

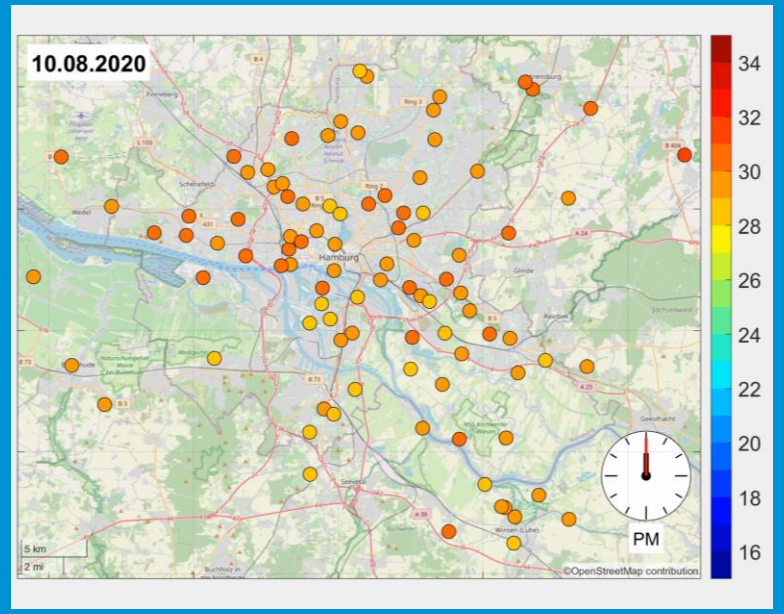
- Sensor & logger design
- Rapid temperature OBS
- Network layout







What do sub-mesoscale features look like?



- Cold Pool in space and time
- Urban heat island

Bastian Kirsch, Cathy Hohenegger, Daniel Klocke, **Felix Ament**

The observational blind spot

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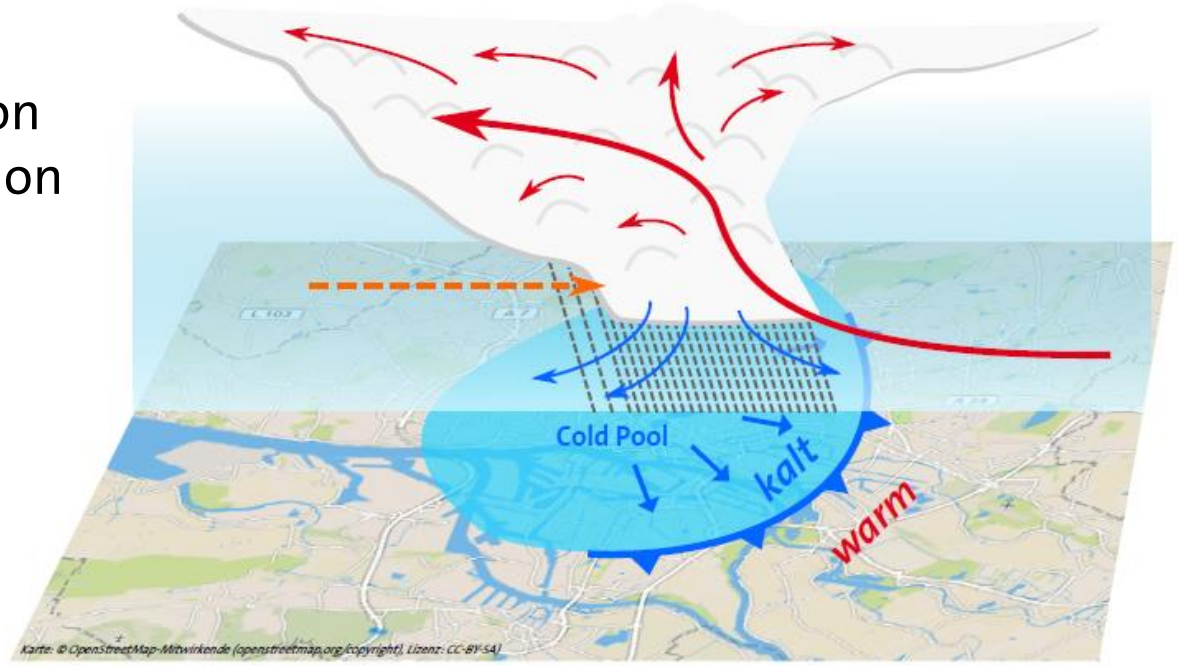
- **Motivation:**
  Resolution of conventional meteorological observation network:~25 km ➔ missing structures and processes on the sub-mesoscale (500 m – 5 km).
- **Sub-mesoscale processes:**
  - Cold pools: evaporatively cooled air underneath precipitating clouds spreading as density current and initiating secondary convection
  - urban heat island
- **Observational Concept:**
  Set up a station network at sub-mesoscale resolution to illuminate this observational blind spot and to better understand the controls on cold-pool characteristics.



FESST@HH: Catching cold pools at home

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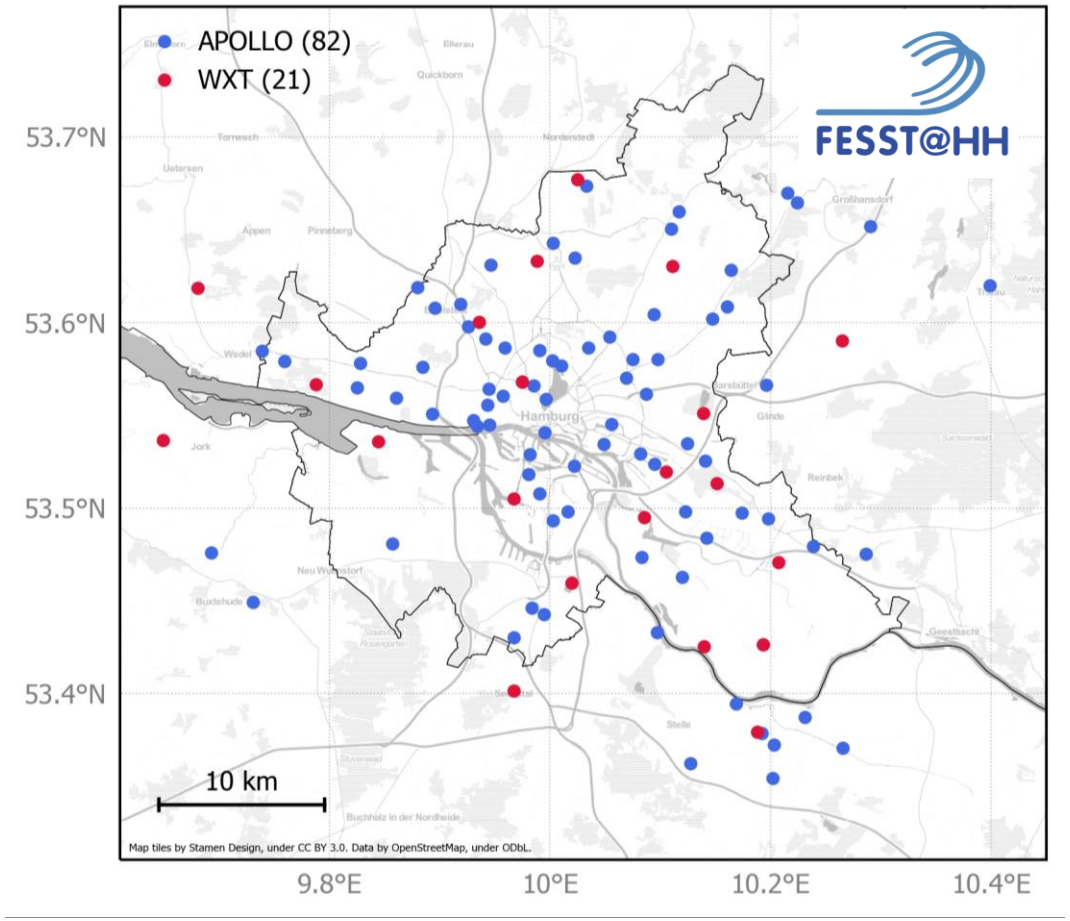
- The **F**ield **E**xperiment on **S**ub-mesoscale **S**patio **T**emporal **V**ariability in **L**indenberg (FESSTVaL, www.fesstval.de) had to be postponed due to the pandemic
  ➔ home-office based campaign at Hamburg "FESST@HH".
- Between June and August 2020, a network of 103 measurement stations
- Installation mostly in gardens of private ground owners

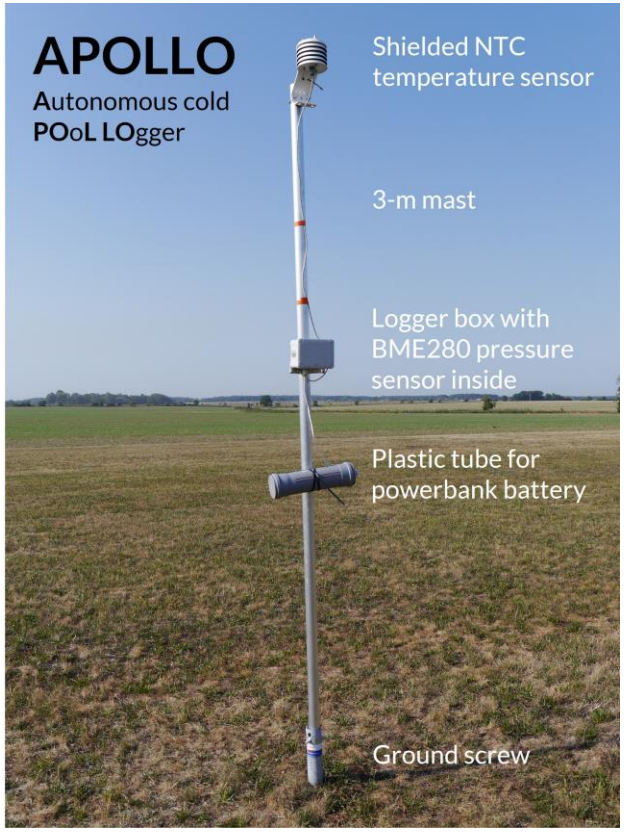






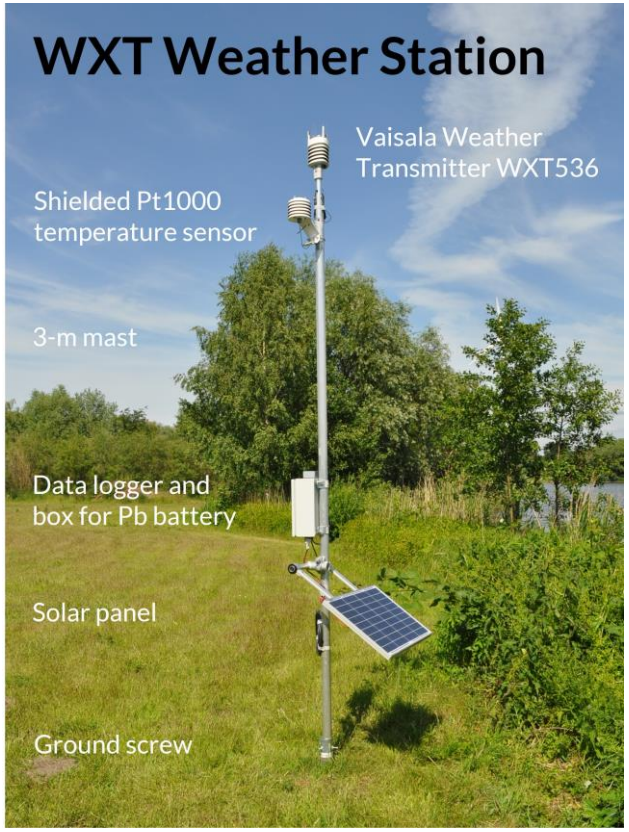
Instrumentation overview

T, p @ 1 s



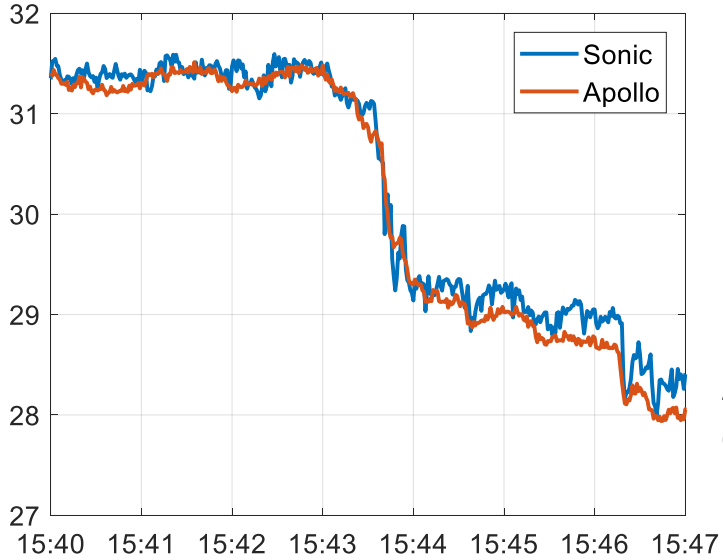
82 ×

T, p, RH, FF,RR @ 10 s



21 ×

- Low-cost and self-manufactured stations
- autonomously operation for at least 10 days.
- GPS for time synchronization
- Data availability: 90% during the FESST@HH
- Rapid response temperature sensors:

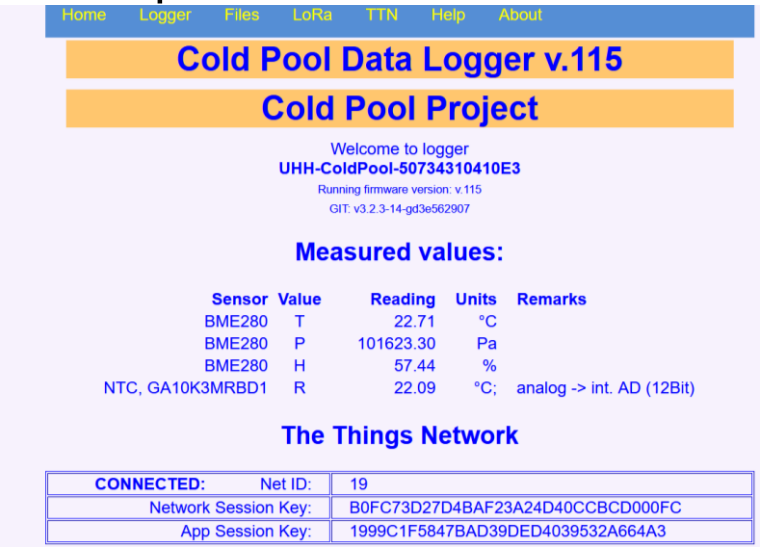


Cold pool passage
Summer August 2019
at Lindenberg

Apollo Logger



- EPS32 Arduino bases microcontroller
- Hourly time synchronization by GPS model
- Shielded NTC temperature sensor, BME280 pressure sensor
- Powered by conventional power bank
- LORA connection to monitor operation
- Wifi connectivity for maintenance and data download



Apollo Web Interface by Wifi connection

The catch: 37 cold-pool events

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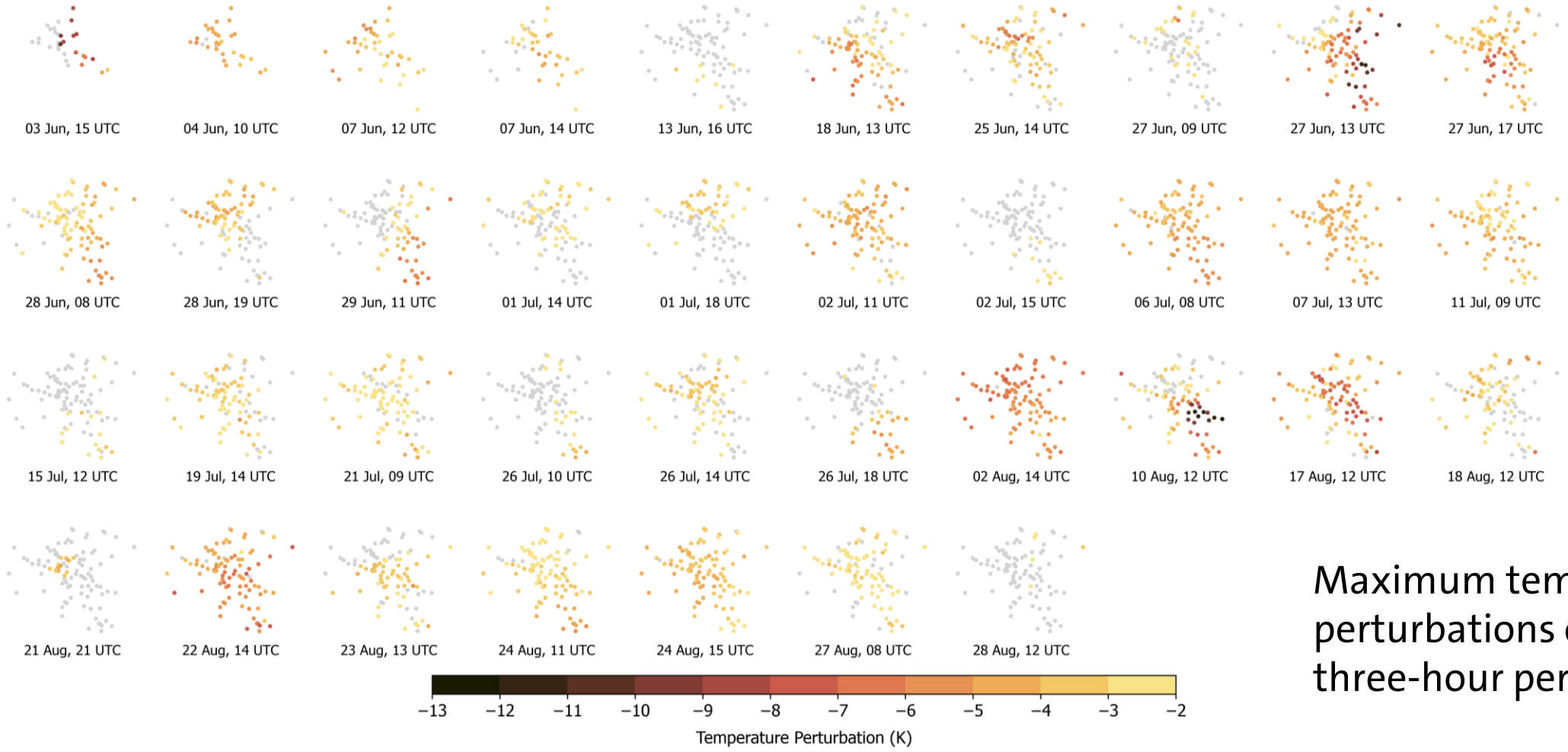

Maximum temperature perturbations over a three-hour period

Stationary cold pool as seen in observations

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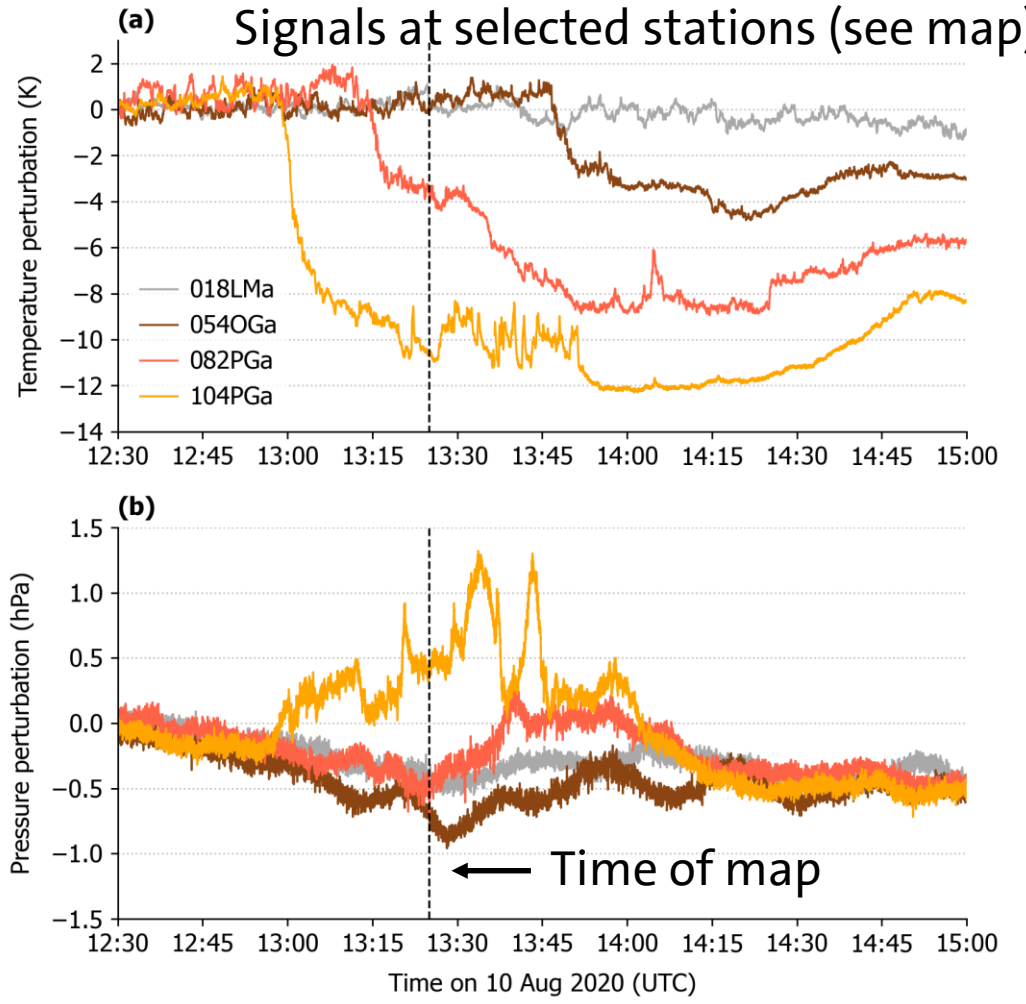
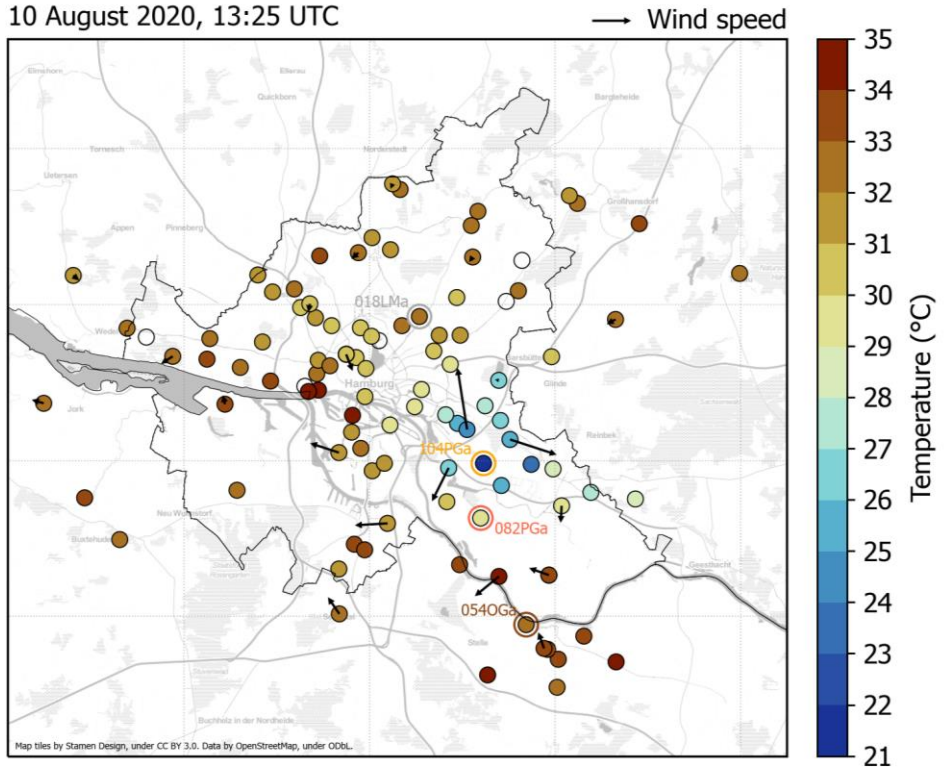
ΔT

Δp





- Time lag in ΔT due to cold pool propagation
- ΔT weakens during propagation
- highly variable Δp at cold pool center

Cold-pool life cycle – spatial dimension

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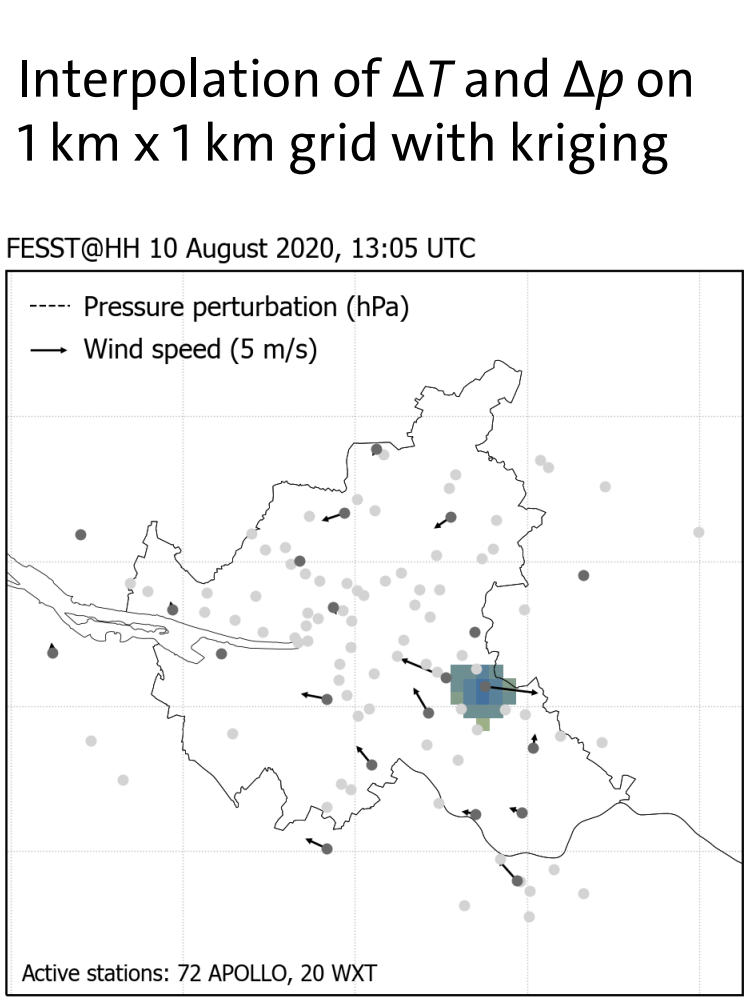
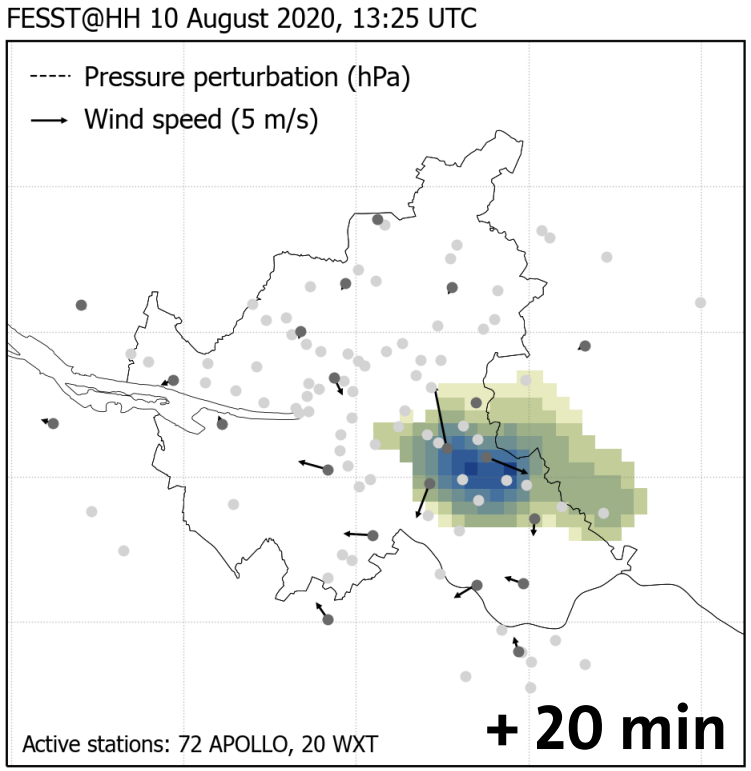
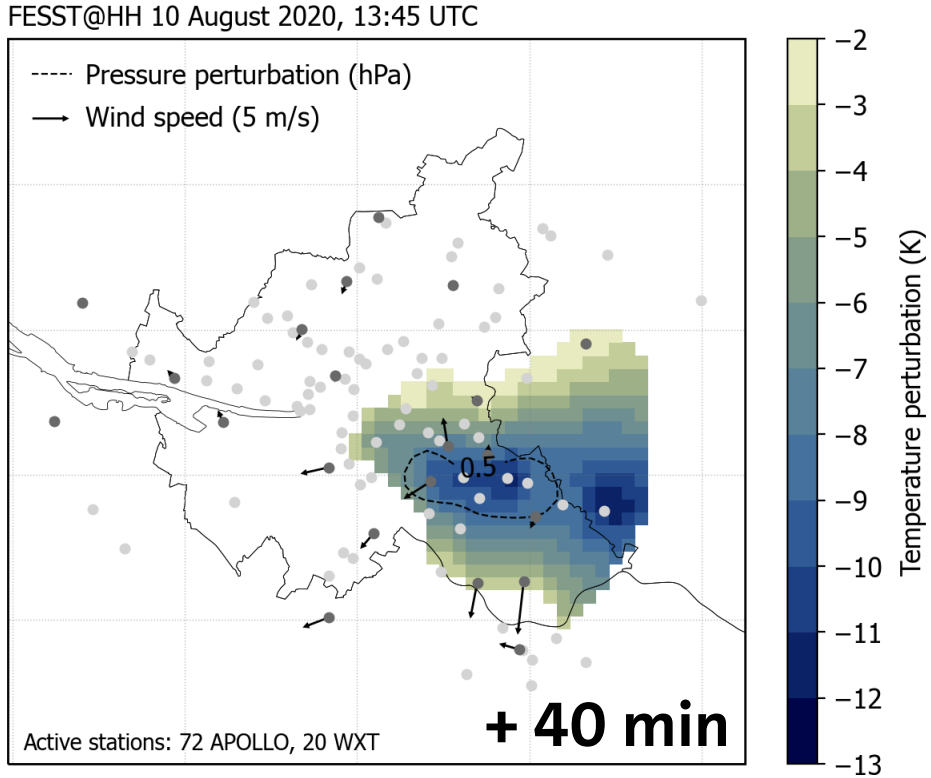
Interpolation of ΔT and Δp on 1 km x 1 km grid with kriging

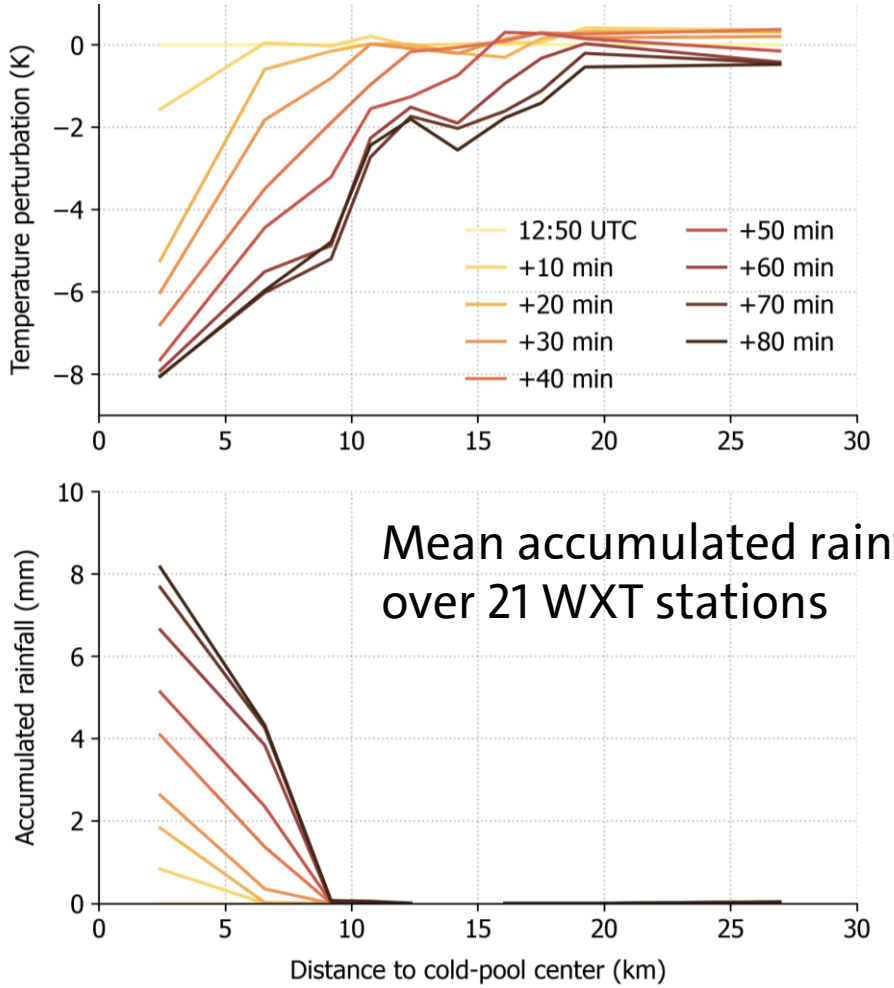






Cold-pool life cycle – temporal evolution

- Mean ΔT (top) and local accumulated rainfall (bottom) as a function of time and distance to a fixed cold-pool center
- Analysis suggests, that growth and intensification of cold pool are coupled to rainfall.



Urban heat island

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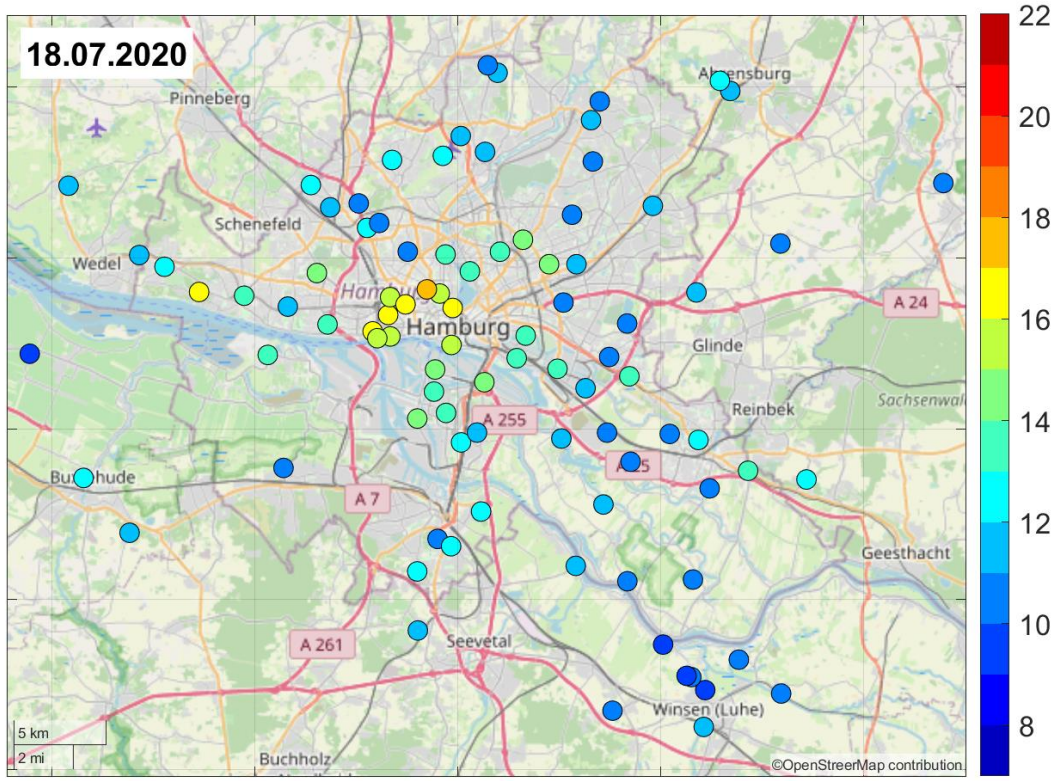
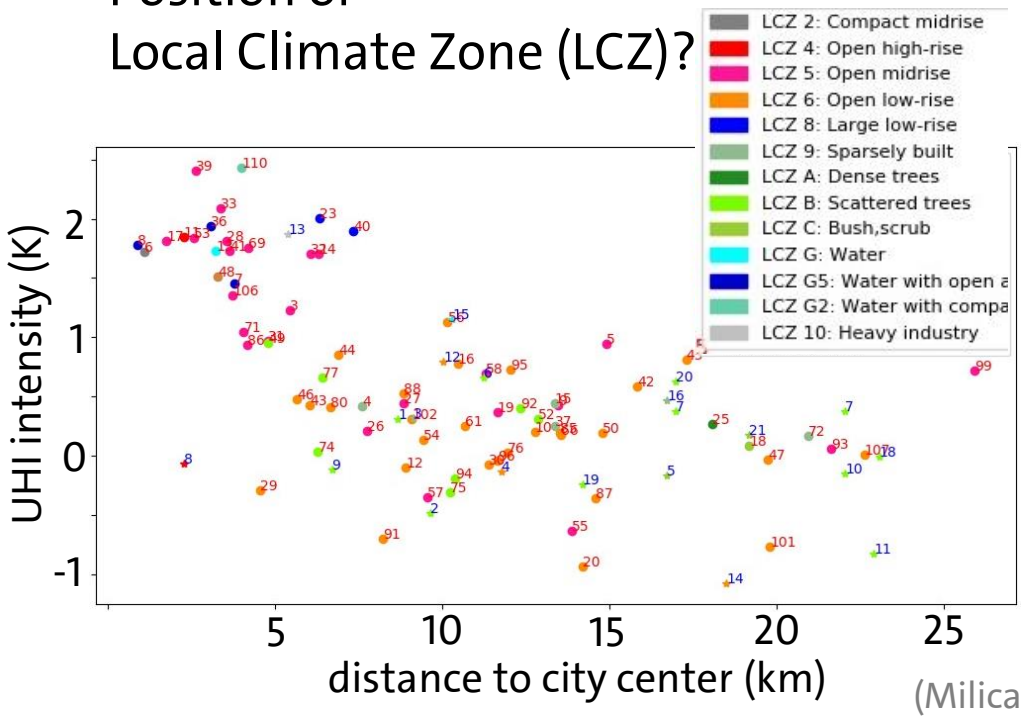
Example: Nighttime Minimum Temperature



What controls UHI Strength?
Position or
Local Climate Zone (LCZ)?



(Milica Stankovic)

Summary and Conclusions

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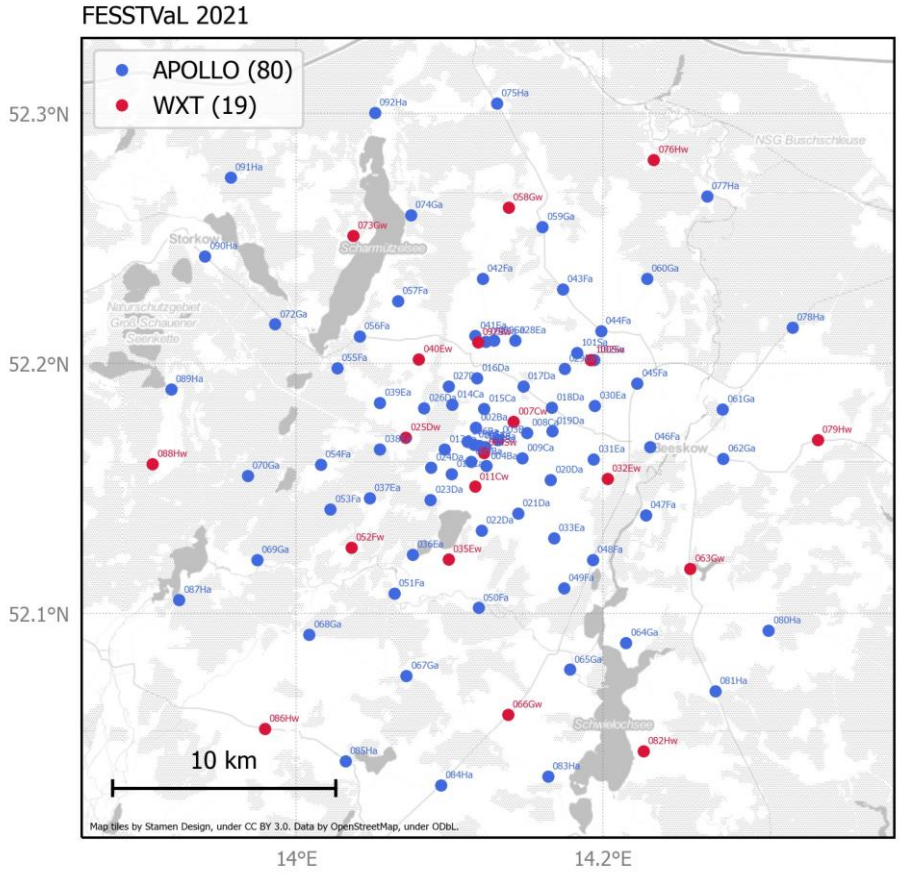
- FESST@HH was successful: 90% data availability; high resolution in space and time.
- Data set is openly available (https://doi.org/10.25592/uhhfdm.8973).
- Specific features of cold pools have been observed for the first time, providing novel insights into their horizontal structure and life cycle.
- Urban heat island, gravity waves (not shown) and turbulent temperature (not shown) are also recorded
- FESSTVaL 2021 (s- right) – just finished – complements FESST@HH by rural observations close to the observatory Lindenberg (Germany).



FESSTVaL
Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg