Investigating the heat mitigation potential of public spray mist cooling in Zurich

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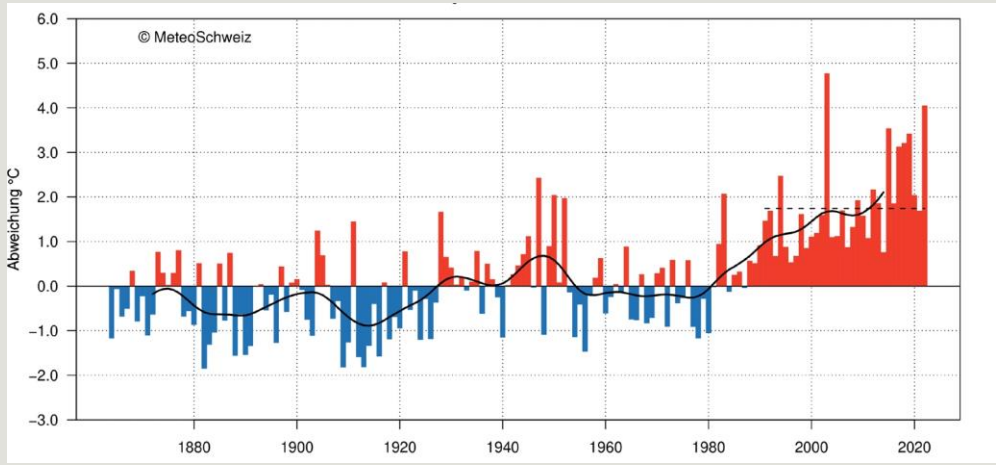
Problem

- Swiss Summers are getting hotter

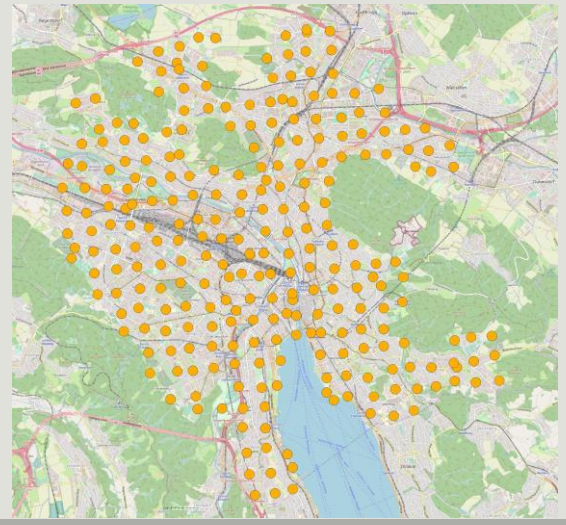
- Cities are aware of the problem, e.g. Zürich:
  - Published ‘Fachplanung Hitzeminderung’
  - Investigate UHI and proposes measures to reduce heat
  - 200+ pages

  - Dense network for temperature observations in the city (by ZHAW, meteoblue AG and City of Zürich)

- Scientific collaboration: city planning & mitigation measures



Deviations of summer mean temperatures from the 1961-1990 average. From ‘Klimabulletin Sommer 2022’ by MeteoSchweiz.



Measurement network in Zürich

Alto Zürrus, the cloud

- Installation of a ring for spray mist cooling
  - Approx. 9m diameter, 6m above ground
  - 7.8l water per minute
  - Operating only above temperature and below humidity threshold
  - by the company *Nephos*

- Studying the effect of this system in an open space

- Concerns about health impacts
  - Germs
  - Particulate Matter

Photo by Tabea Vogel

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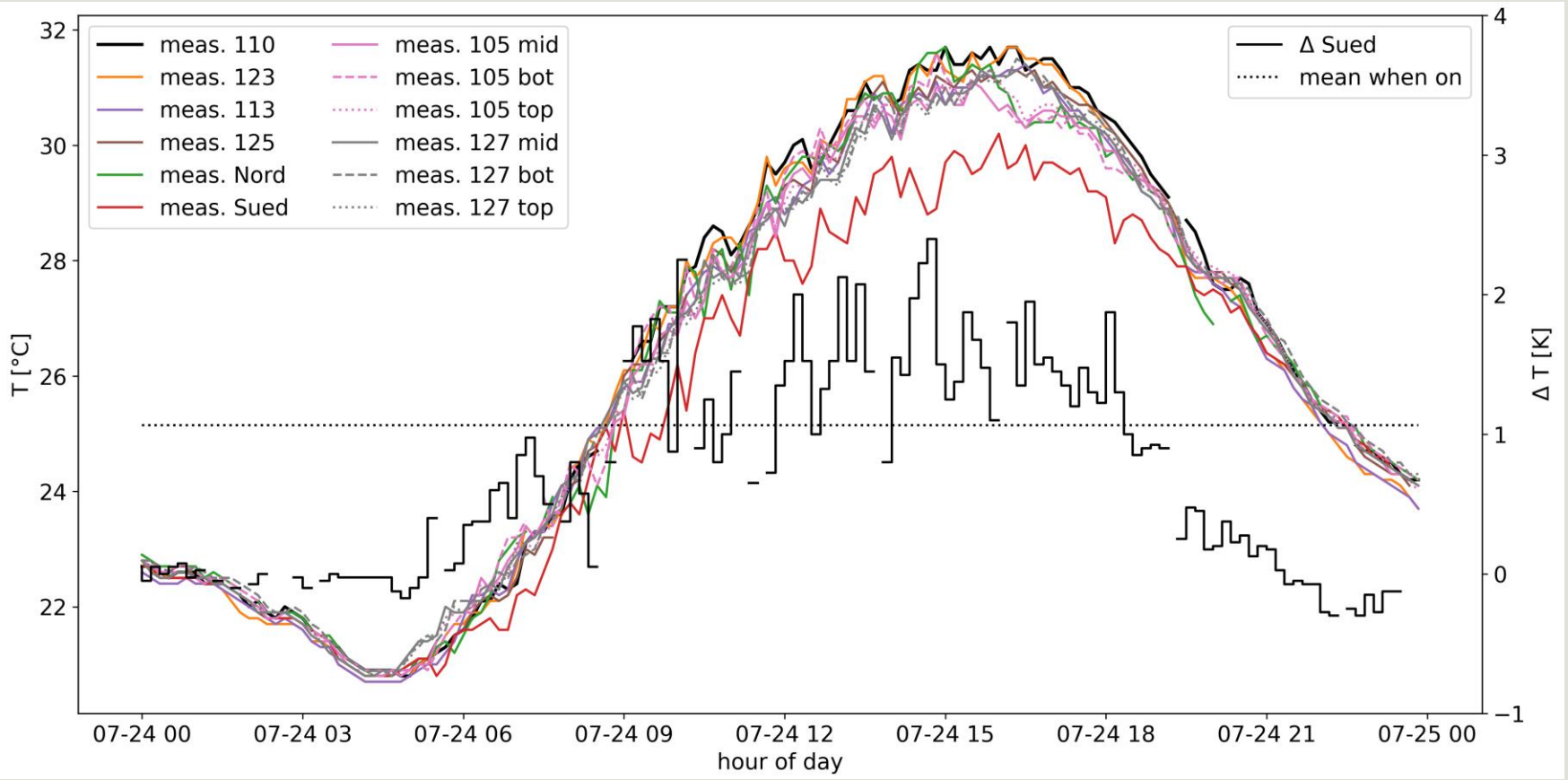
Measurements

Measured temperature deviation from the reference station (orange circle). Inverse distance interpolation between the measurement points.

- Temperature deviations from the reference station (orange cirle)
- ‘Sued’ directly south of the installation shows a ~1°C reduction

Measurements



- Most stations very similar
- ‘Sued’ directly south of the installation shows a ~1°C reduction

Measured temperatures on the 24.07.2022 (left y-axis). Temperature reduction of station ‘Sued’ (right y-axis). The station directly south of the ring (‘Sued’, in red) shows a clear reduction in temperature of ~1°C while water is being sprayed.

Model set-up

Orthofotos SWISSIMAGE by Swiss Federal Office of Topography

- Urban LES PALM
  - Resler et al., 2017
  - Maronga et al., 2015
- Local orography, land use, buildings, …
- Three nested domains
  - $(15{,}360\text{m})^2$ x 960m, @32m
  - $(2{,}304\text{m})^2$ x 480m, @4m
  - $(264\text{m})^3$, @1m
- COSMO KENDA 1 @ ~1.1km driving on the lateral boundaries

Parameterisation

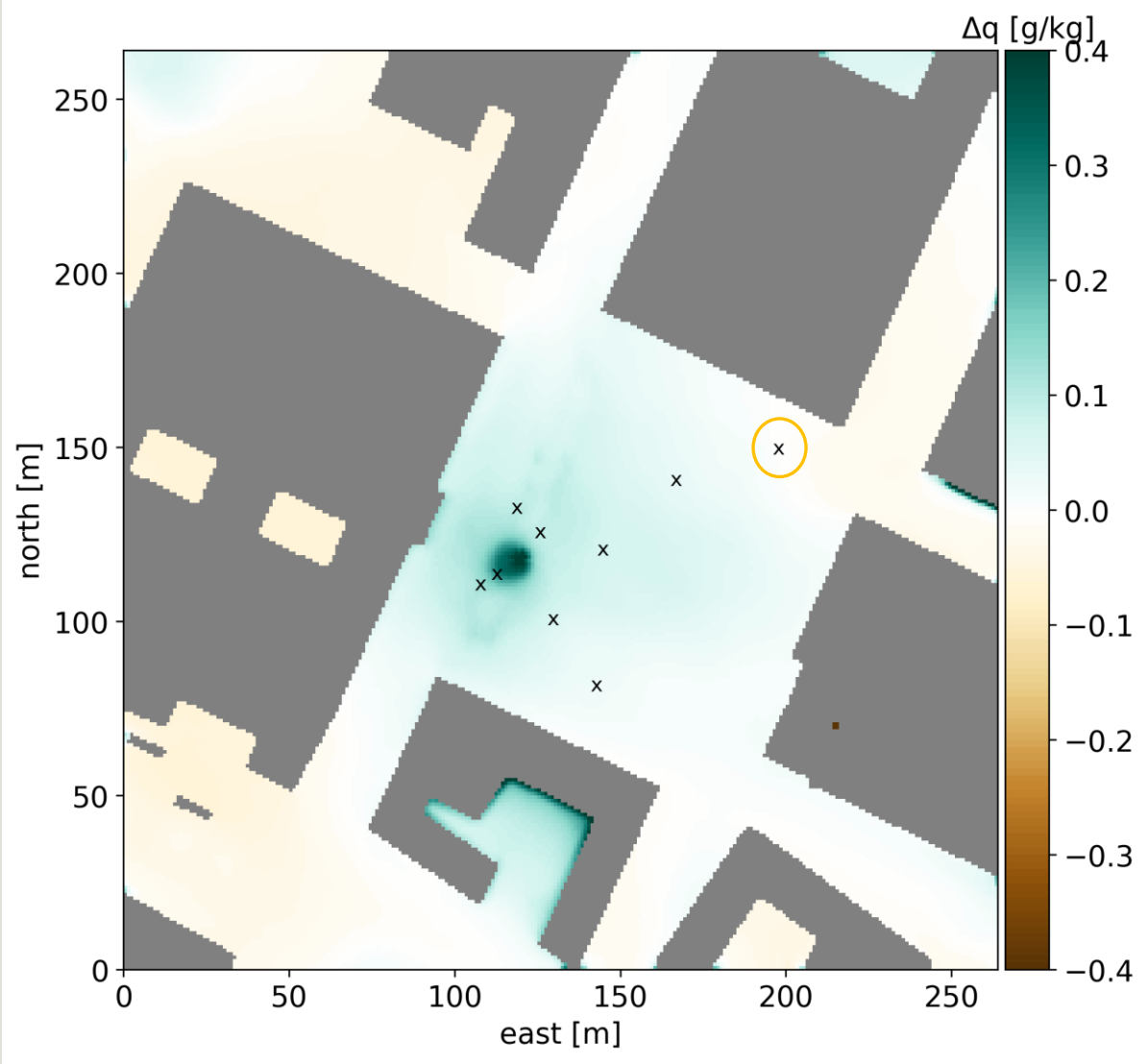
- Define the location of the ring -> mask
- Assumption that water evaporates instantaneously
  - Avoid costly aerosol / cloud droplet processes
- Update corresponding prognostic equations in PALM

$$\frac{dq}{dt} = \frac{dq}{dt} + q_{flux} * mask$$

$$\frac{dT}{dt} = \frac{dT}{dt} - q_{flux} * \frac{L_v}{C_p} * mask$$

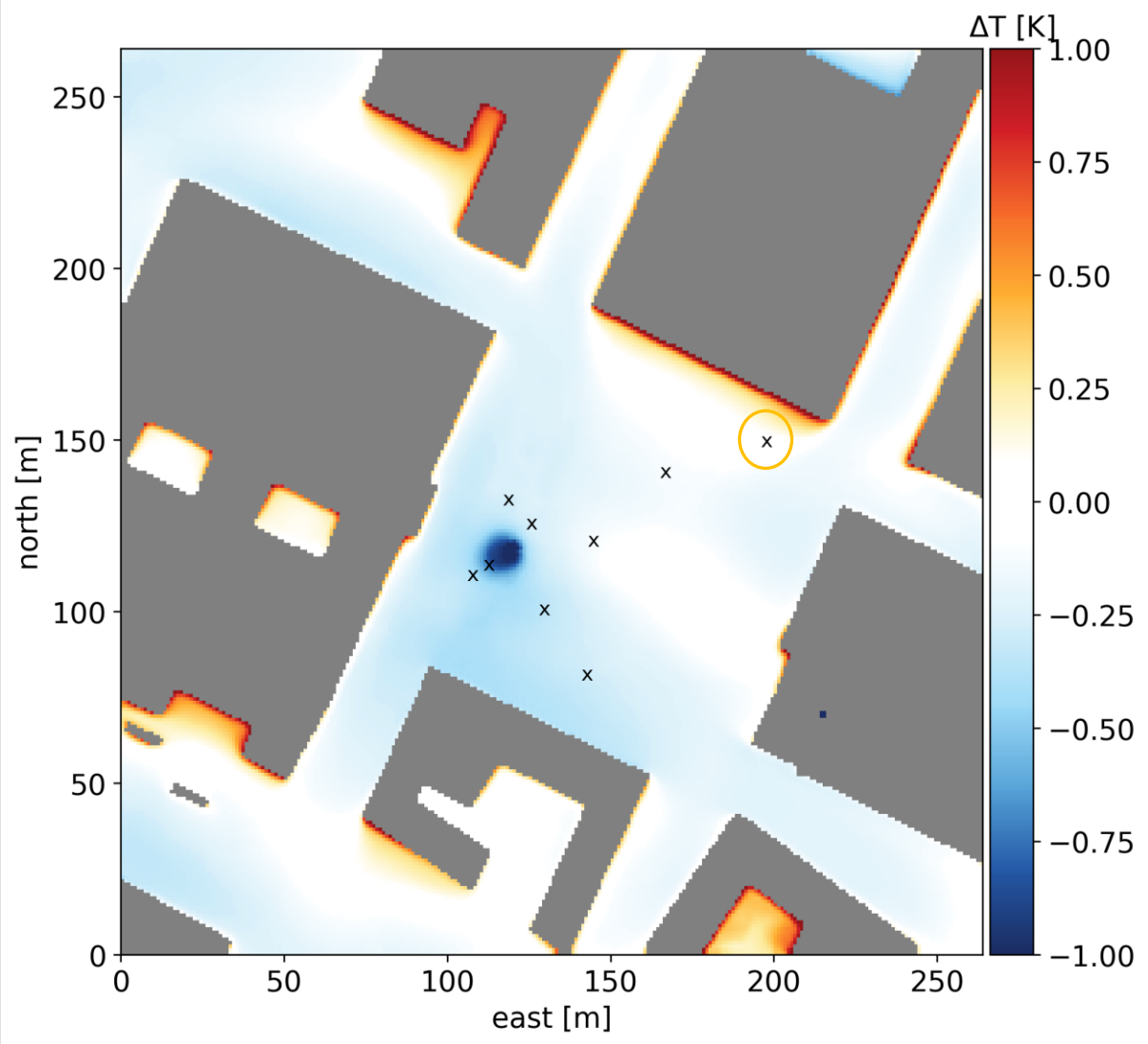
Humidity

- Modelled deviation of specific humidity from the refence station
  - Daily mean
- Roughly an increase of 2% RH close to the cloud
- Strongest effect directly below and south-west of installation



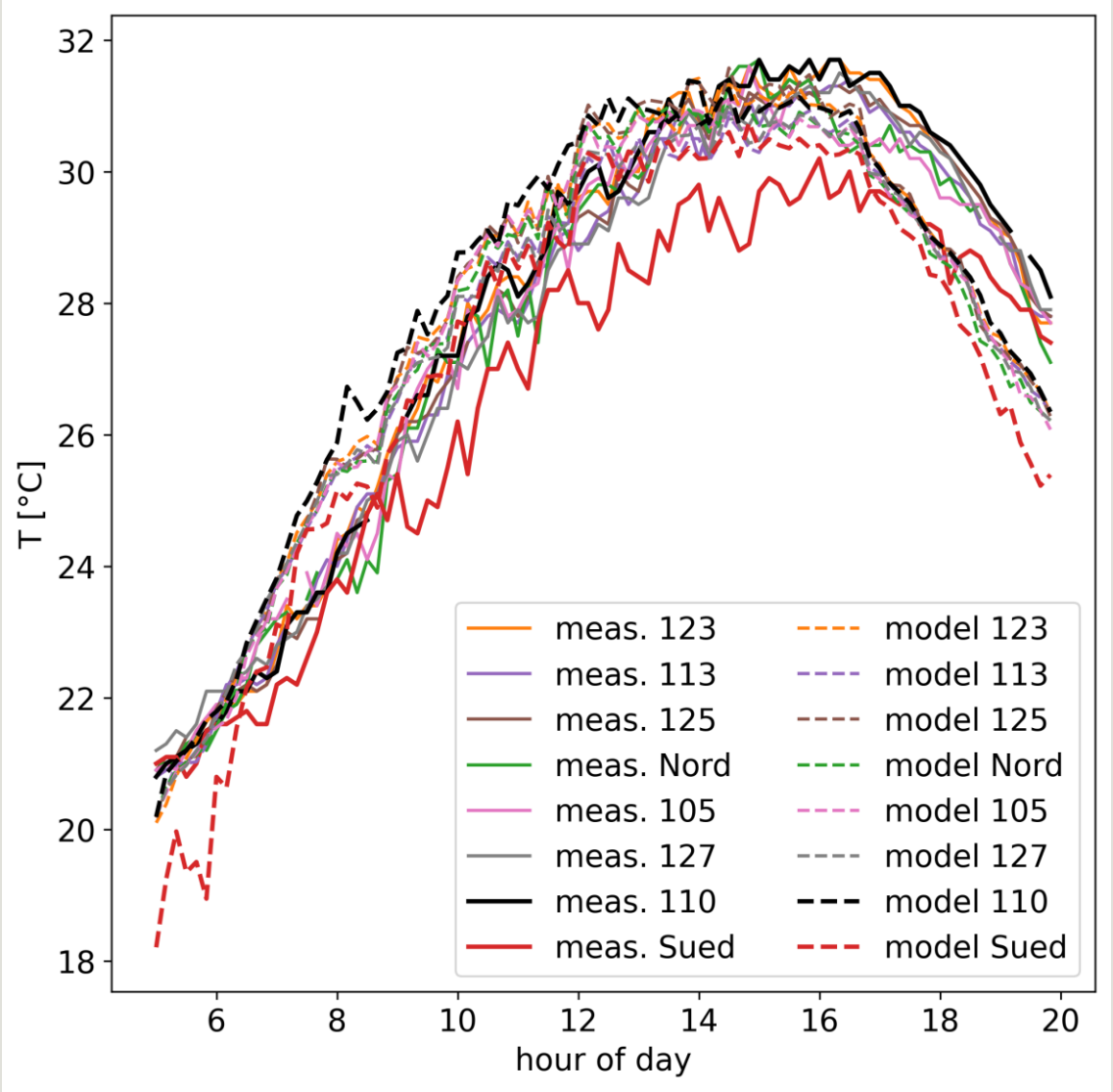
Temperature

- Modelled deviation of air temperature from the refence station
  - Daily mean
- Temperature reduction of roughly 0.5°C south-west of installation
- Reference station potentially affected by nearby south-facing wall



Comparison to measurements

- Model run had a general cold bias of approx. 1.75°C
  - Offset taken into account in the figure ->
- Model underestimates local cooling at station ‘Sued’ during the day
- Implementation (instant evaporation) leads to strong effects during cooler periods



Summary

- The installation of a spray mist cooling system was measured and modelled
- The effects in the vicinity of the installation on temperatures on pedestrian level are approximately -0.5°C
- Model and measurement generally show good agreement
- Model can be used to assess future applications

Thank you

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