High resolution observations and modelling during a heatwave: urbisphere-Berlin

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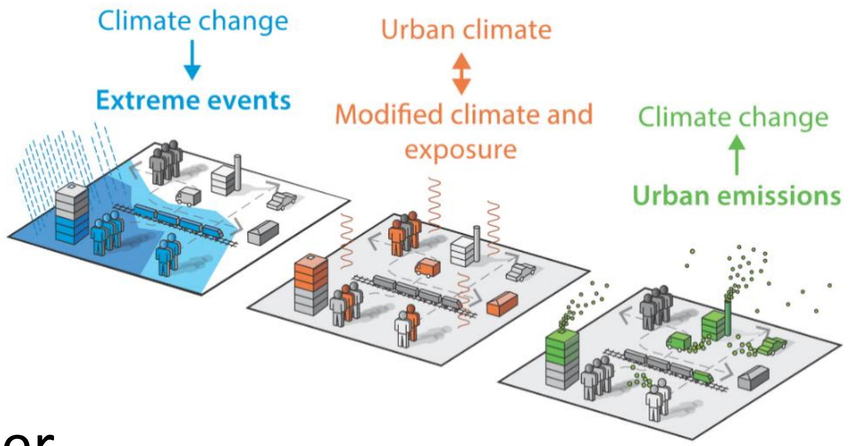
urbisphere

ERC Synergy Grant (2020-2027)

- **Goal**: Forecast and project urban futures and climates
- Develop *dynamic modelling framework* considering weather, exposure, and vulnerability of people using simplification of high-resolution simulations (neighbourhood to city scale)
- Understand links between climate change and urban transformation
- *Field campaigns* in different cities alongside model development



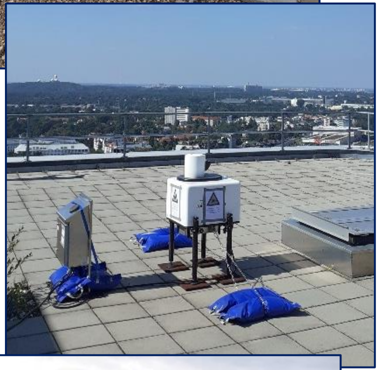
http://urbisphere.eu/

urbisphere

urbisphere-Berlin

<u>Focus</u>: **(urban) atmospheric boundary layer (ABL)**

- Gain understanding of interactions between city and ABL
- Investigate urban-rural & intra-urban variability of ABL

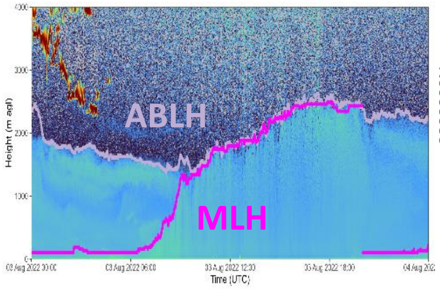


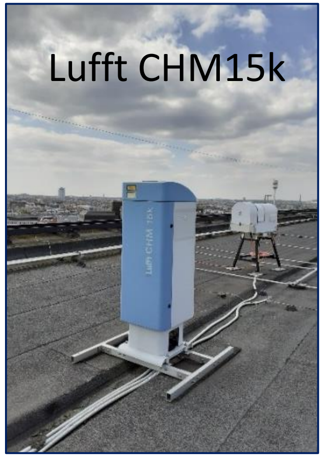
- October 2021 – September 2022
- Wide range of instruments for ABL observations
- Complement **existing observations by partners** (TU Berlin, DWD, FU Berlin, BTU)

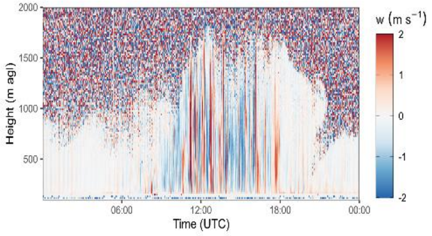
→ **create spatially dense, city-specific data set of ABL observations**

Systematic ALC & DWL network

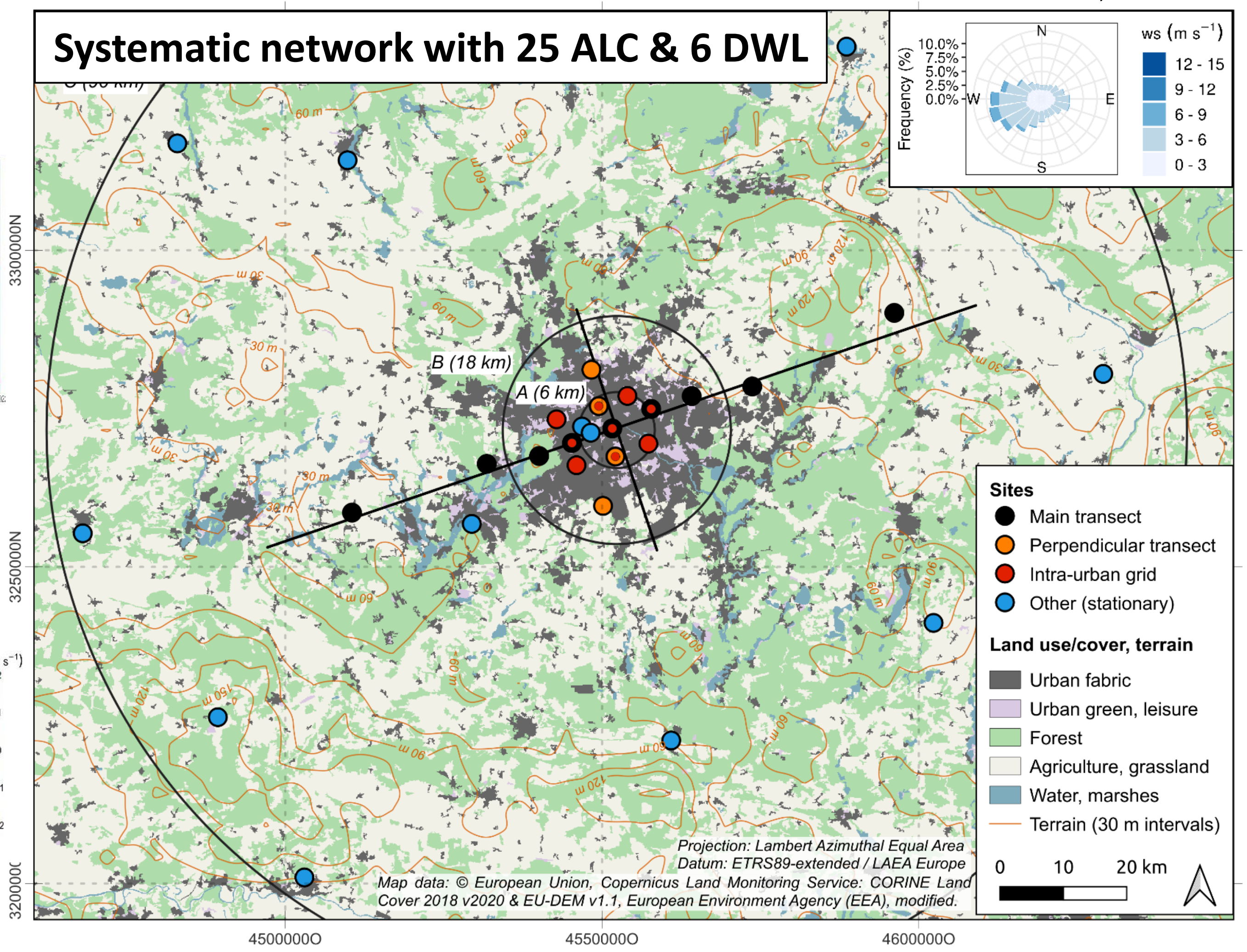
Automatic Lidars and Ceilometers (ALC) & Doppler-Wind Lidars (DWL) as a core component of the campaign for **determining mixed-/mixing-layer heights and wind profiles**





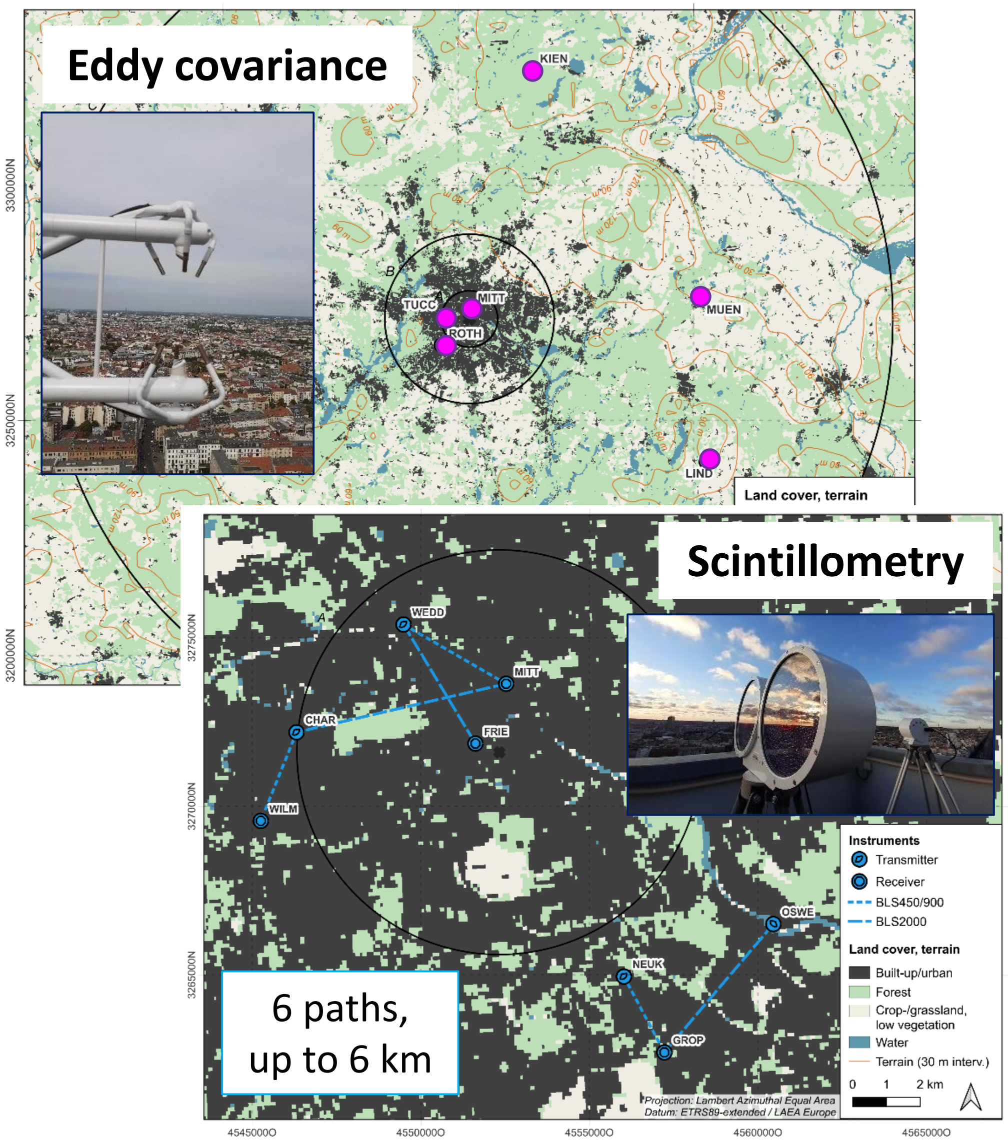


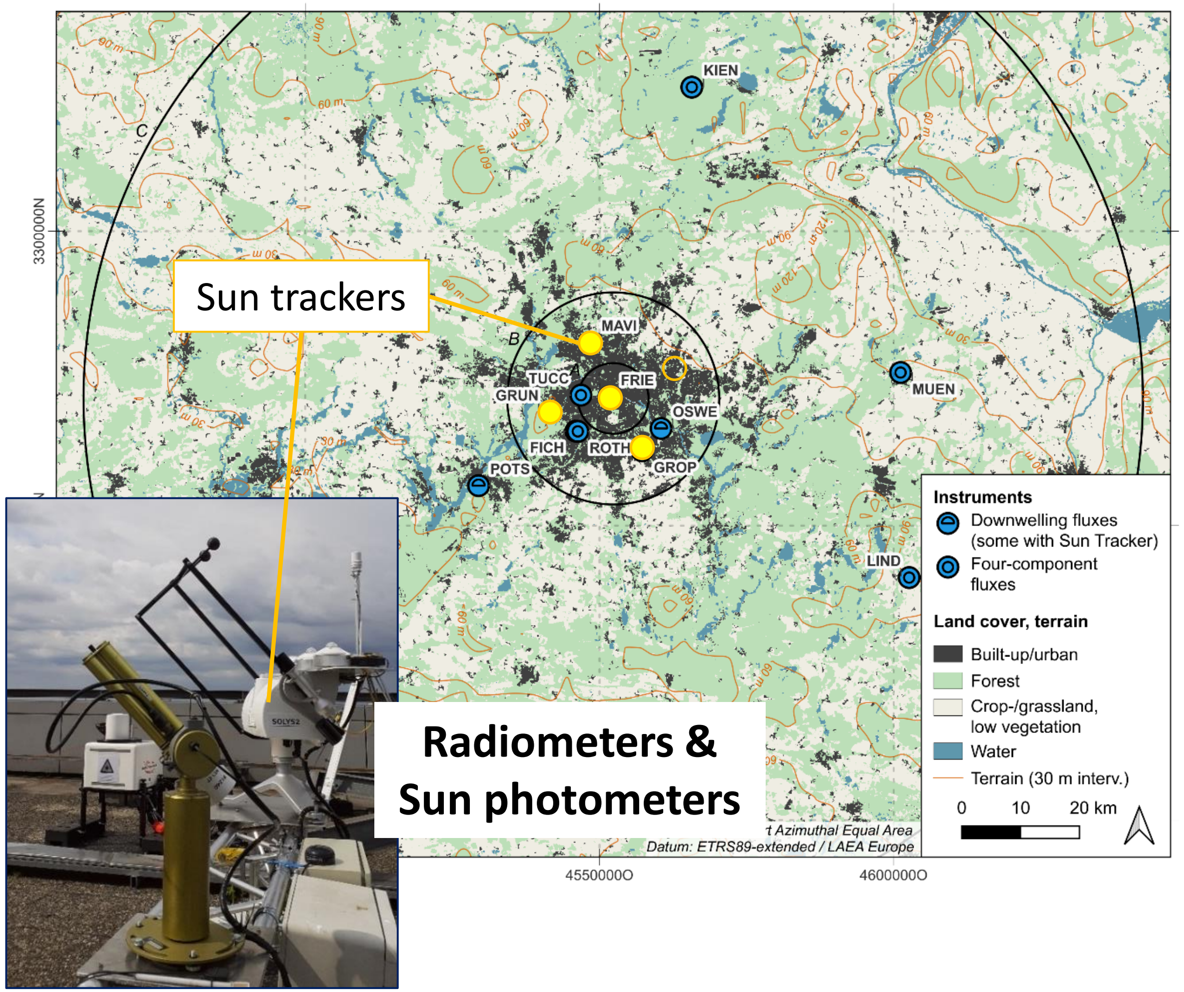
ERA5, 1991-2020



Turbulent-energy & radiation fluxes

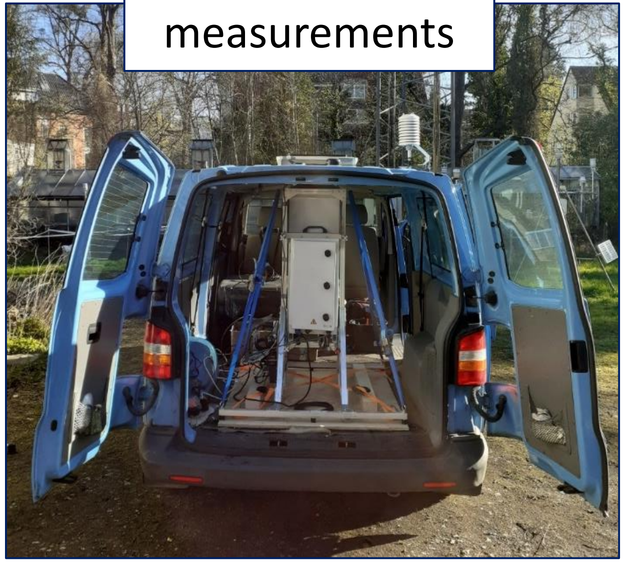
Observations of turbulent-energy and radiation fluxes in different urban & rural settings to **link surface fluxes with ABL characteristics**



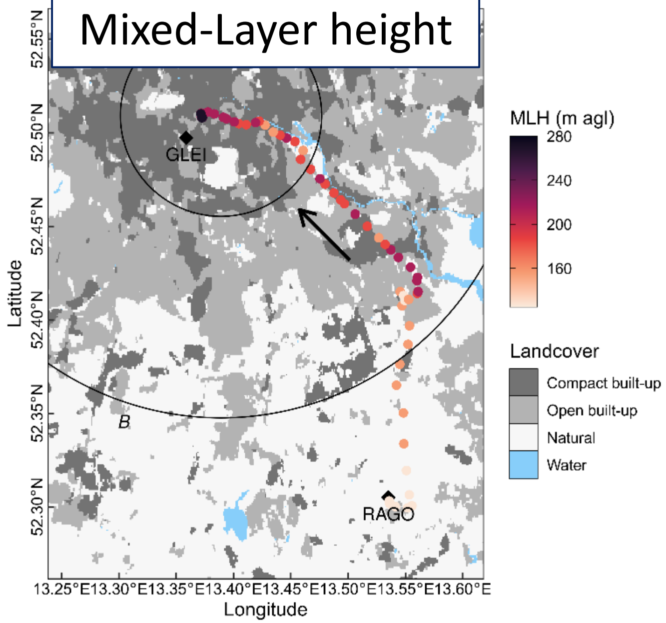


Further observations

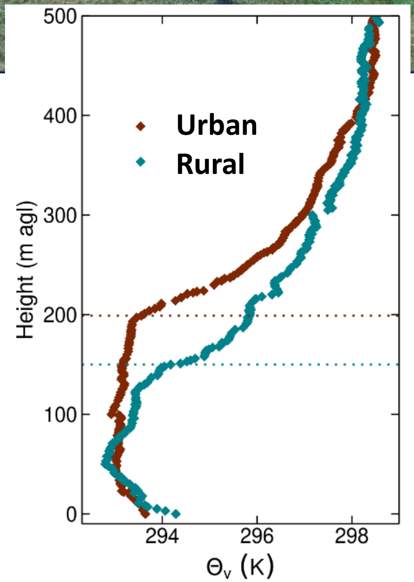
Mobile ALC measurements



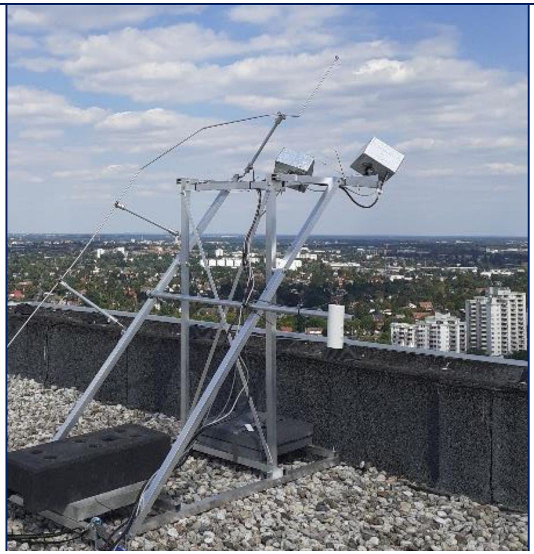
Mixed-Layer height

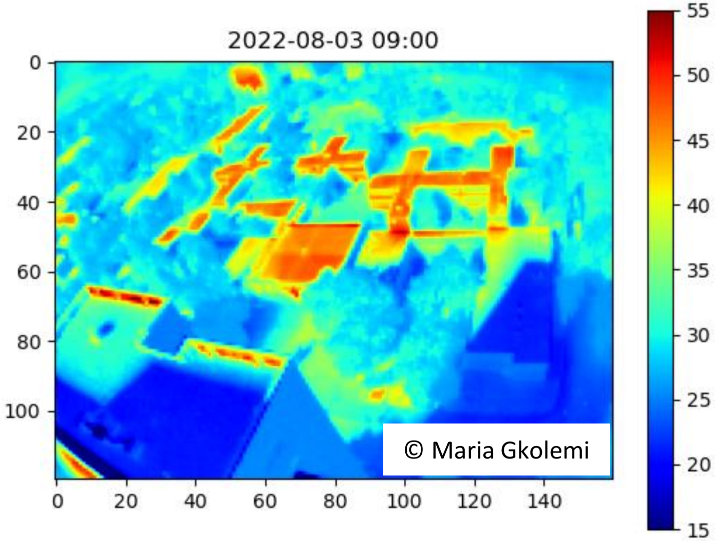


Concurrent urban & rural **radiosoundings**



Surface-temperature measurements (IRT, cameras, UAV)





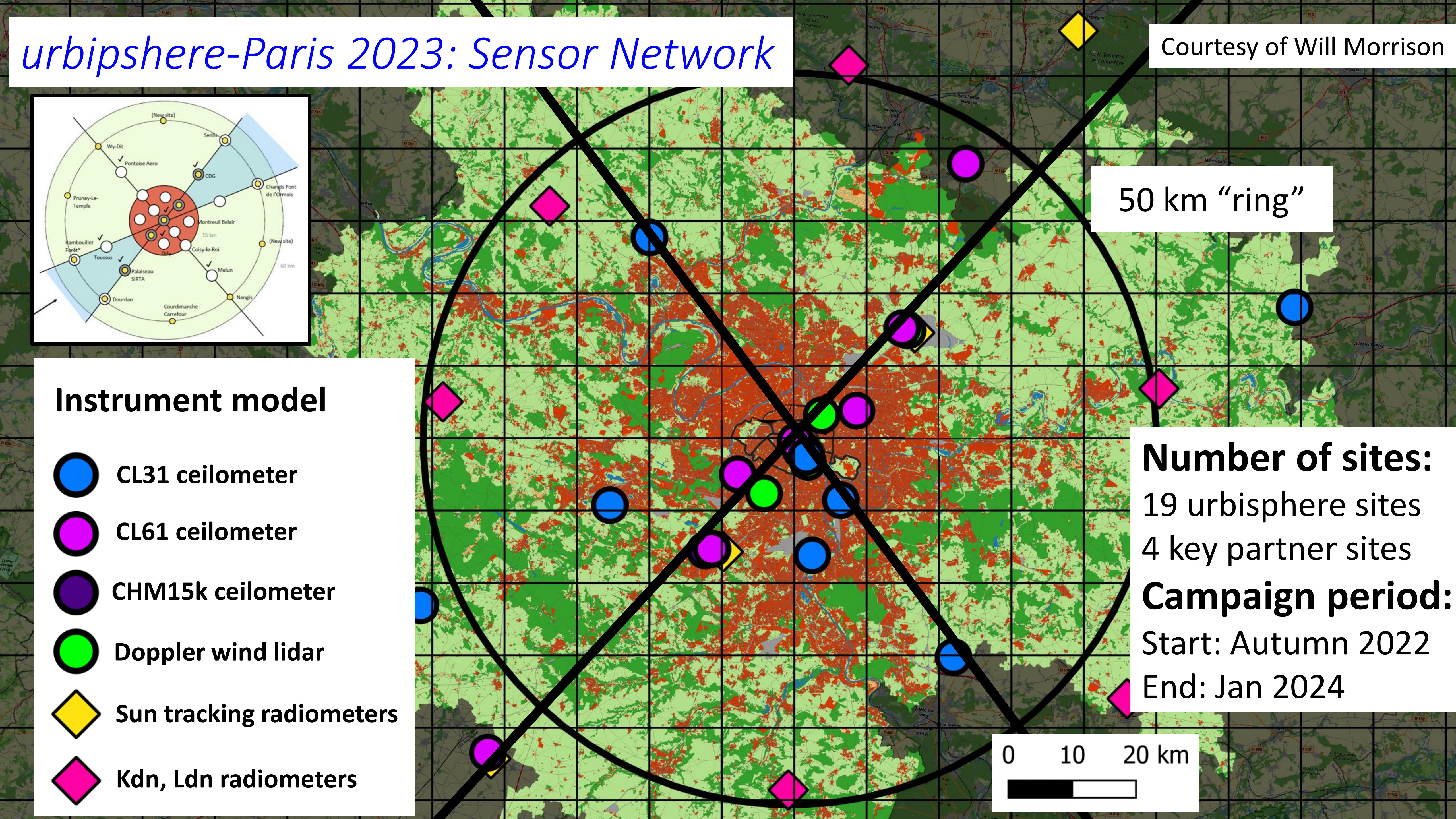
urbisphere-Berlin

<u>Focus</u>: **(urban) atmospheric boundary layer (ABL)**

- October 2021 – September 2022
- Wide range of instruments for ABL observations
- **spatially dense, city-specific data set**
- **Final stages of BAMS manuscript – Fenner et al.**

<u>Campaign lead and contact point:</u>

Daniel Fenner
daniel.fenner@meteo.uni-freiburg.de

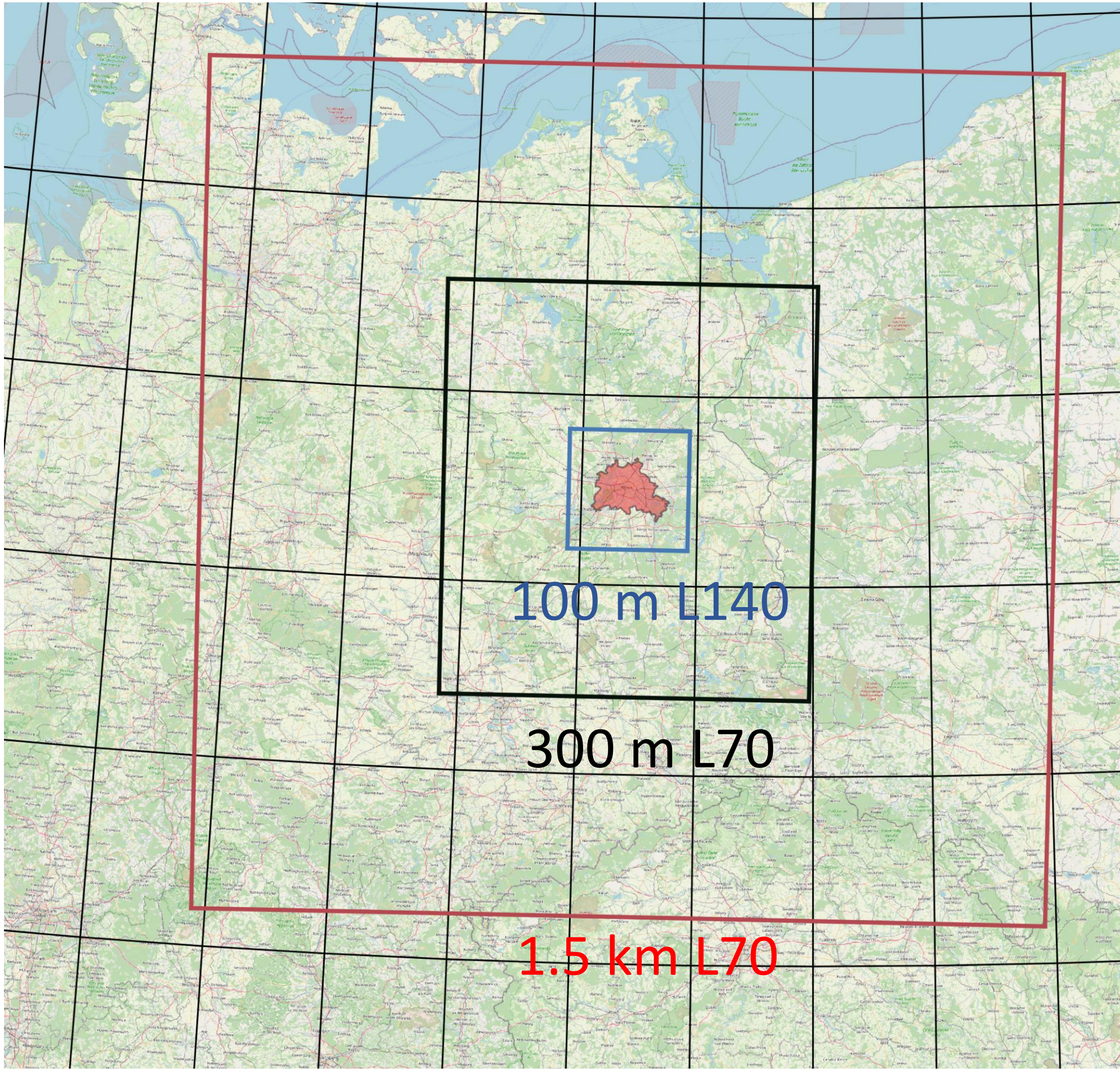

urbipshere-Paris 2023: Sensor Network
Courtesy of Will Morrison
(New site)
Senlis
Wy-Dit
Pontoise Aero
CDG
Changis Pont de l'Ormois
Prunay-Le-Temple
Montreuil Belair
15 km
Rambouillet Forêt*
Toussus
Coisy-le-Roi
(New site)
60 km
Palaiseau SIRTA
Melun
Dourdan
Courdimanche - Carrefour
Nangis
50 km "ring"
Instrument model
CL31 ceilometer
CL61 ceilometer
CHM15k ceilometer
Doppler wind lidar
Sun tracking radiometers
Kdn, Ldn radiometers
Number of sites:
19 urbisphere sites
4 key partner sites
Campaign period:
Start: Autumn 2022
End: Jan 2024
0 10 20 km

Model Configuration

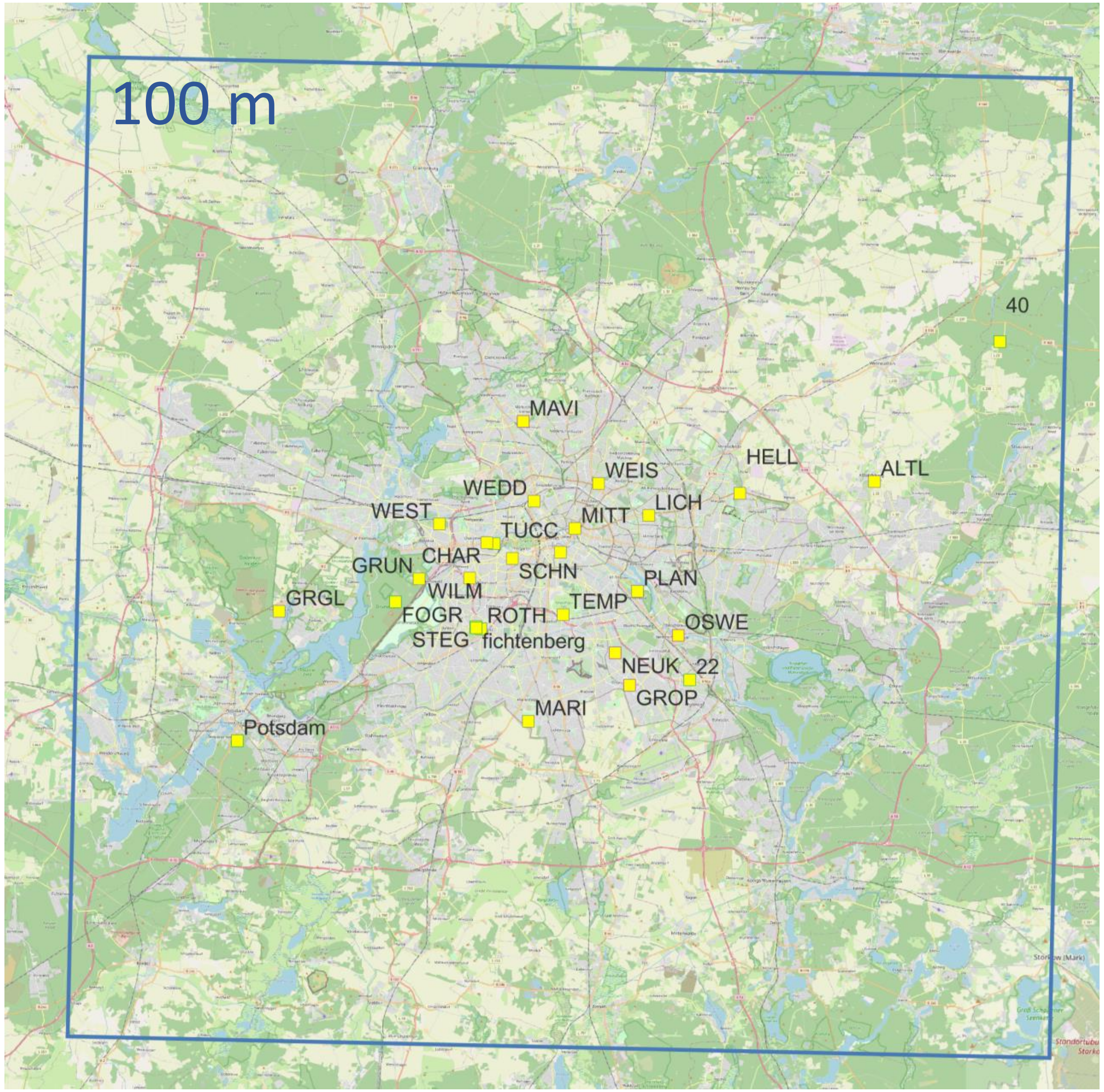
Met Office Unified Model (UM) RAL3.1

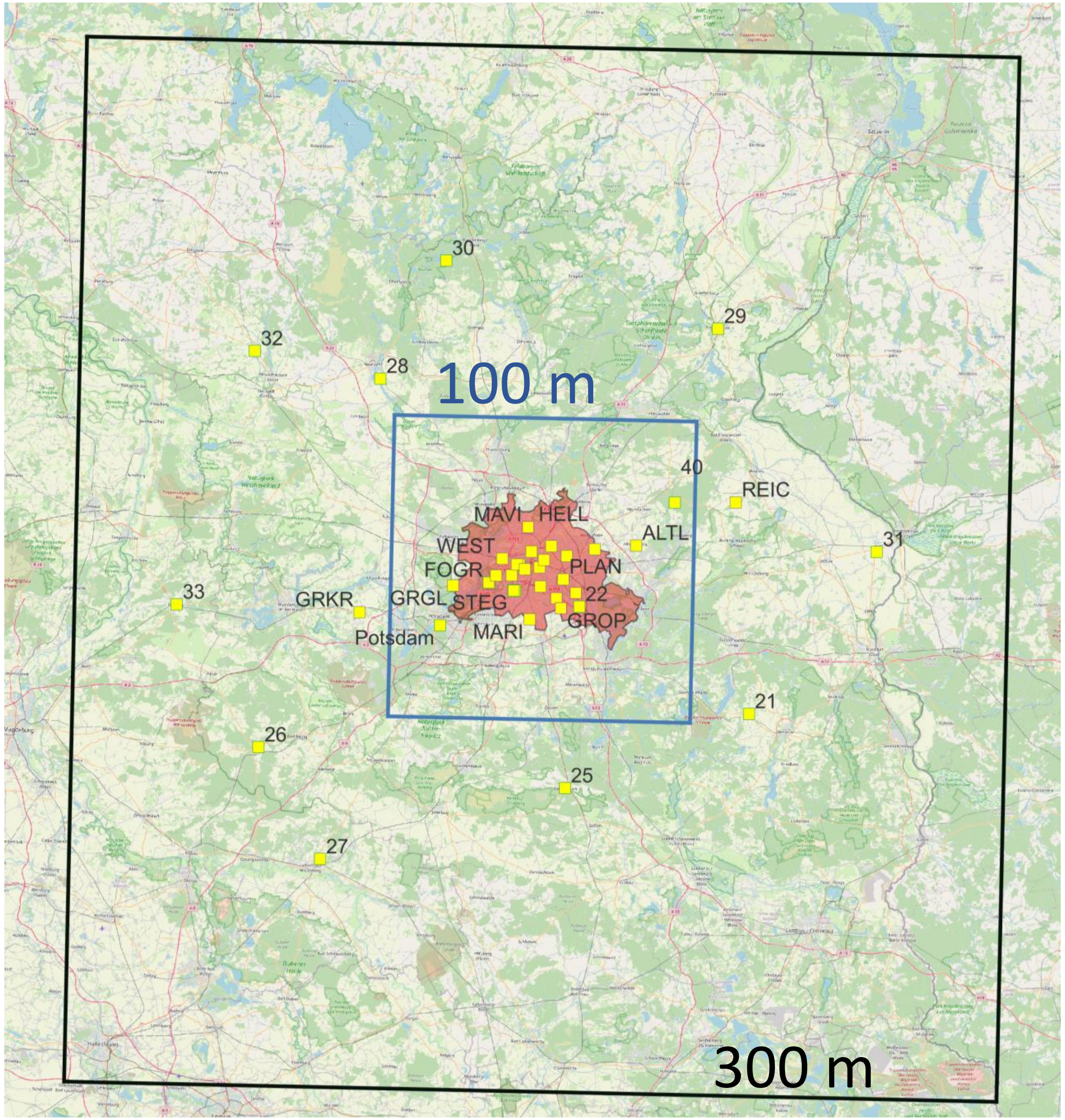
- Scale-aware turbulence scheme (Boutle et al. 2014)
- 3D Smagorinsky-Lilly preferred over 1-D scheme with higher grid-resolution

- 36-h simulation (12 h spin-up)
  - 12z 03 Aug – 00z 5 Aug 2022
- Model forcing:
  UM global (~10 km) – 1-way nested
- JULES
  - MORUSES – urban 2-tile scheme
    - Roof and street canyon
  - Land cover: CCIv1

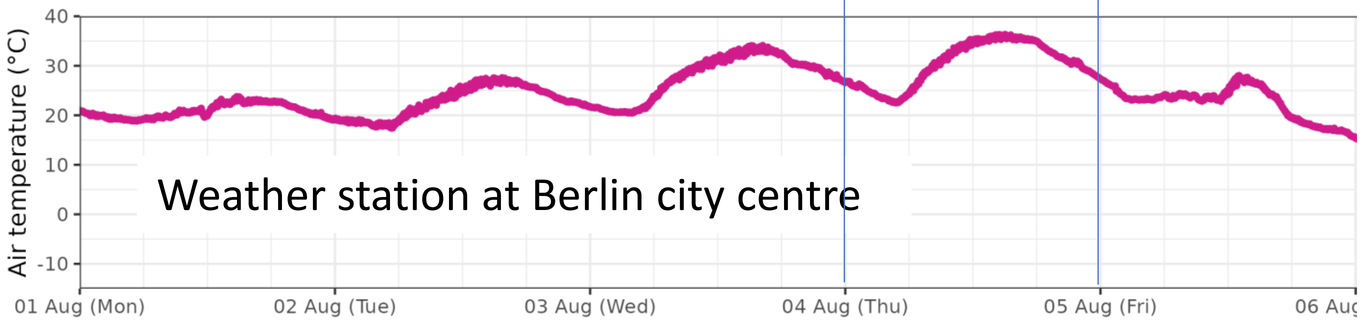


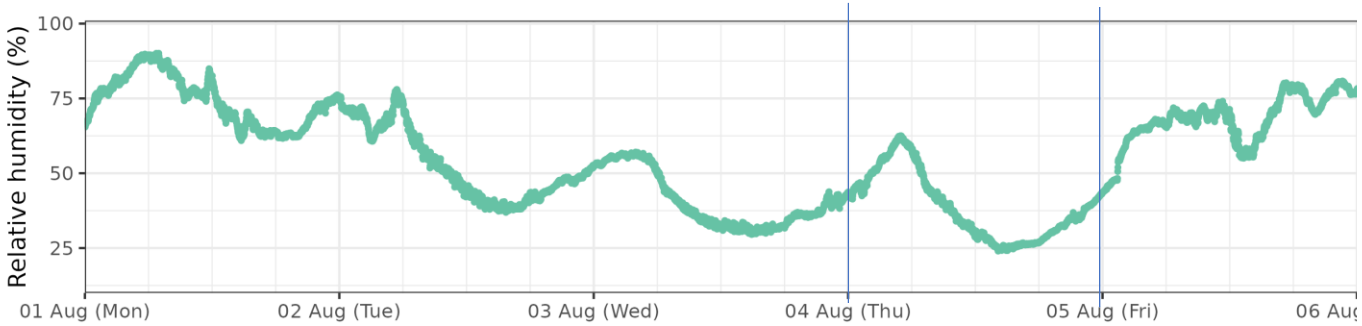
Observation Sites



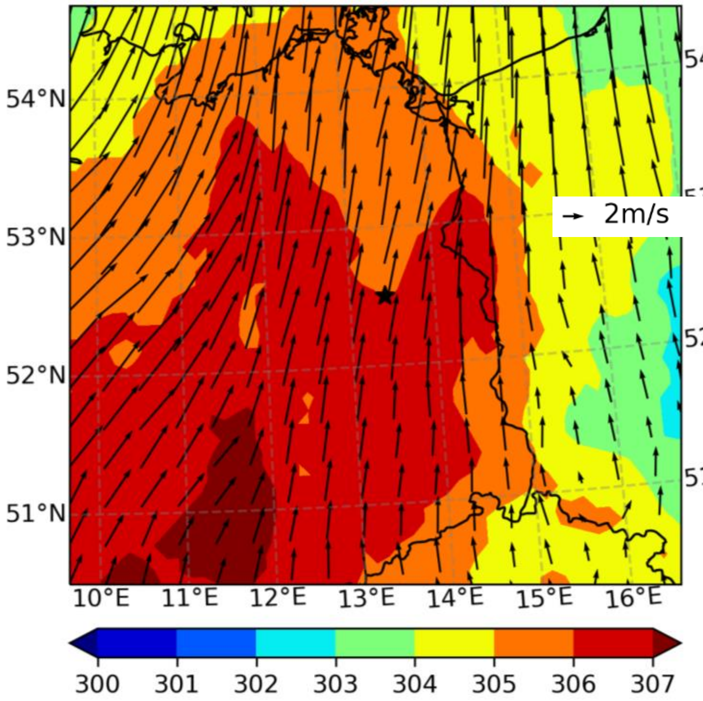


4 August 2022 Heatwave

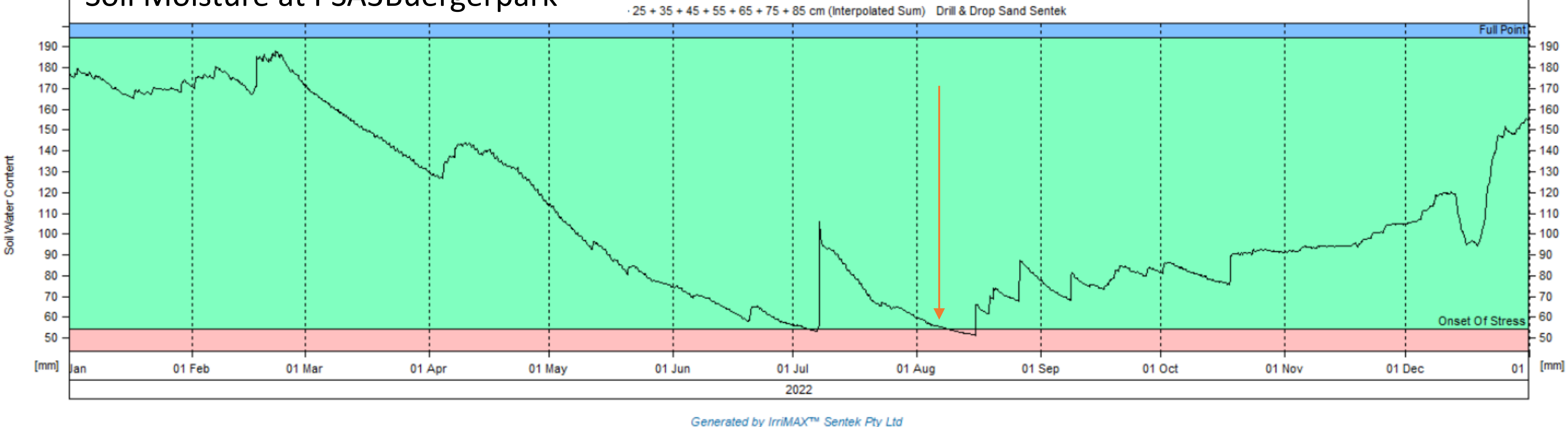




Global UM model ~10 km 14UTC
850hpa Wind and Θ

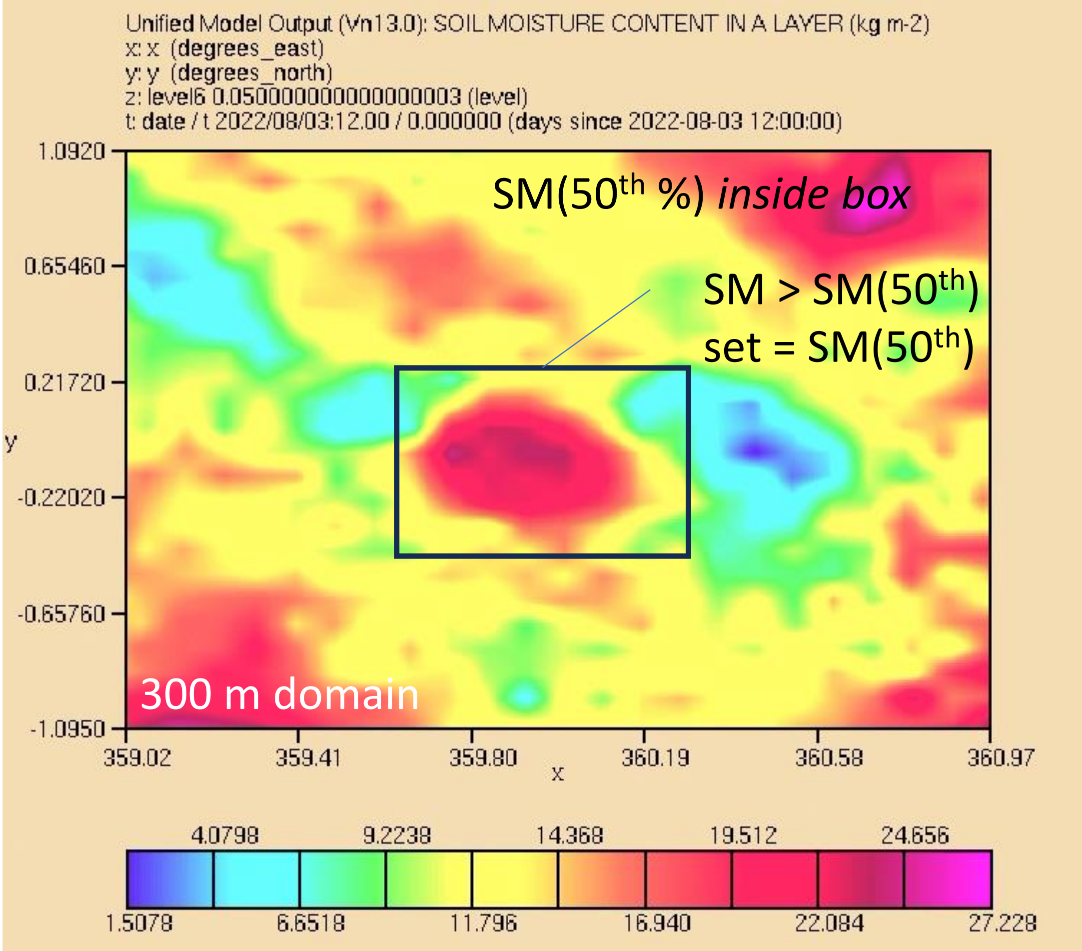


Soil Moisture at PSA3Buergerpark

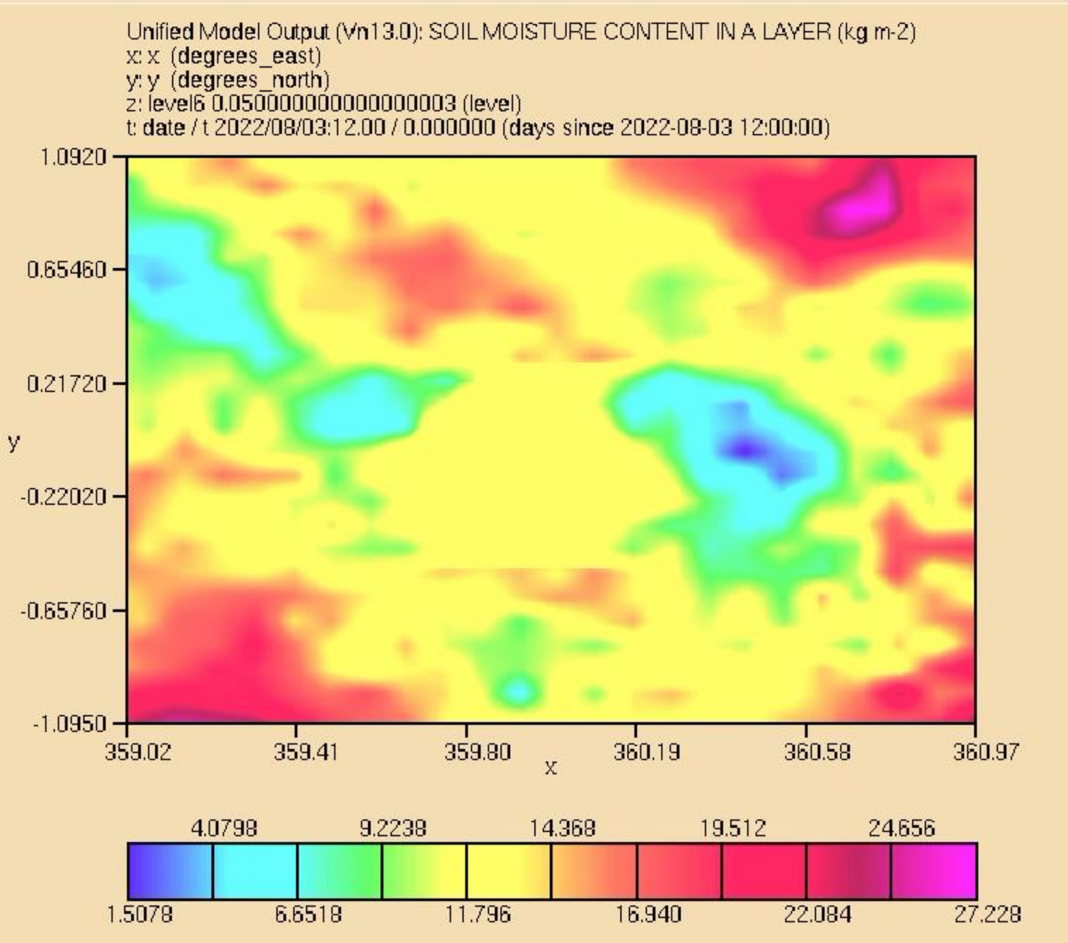


Known Soil Moisture (SM) Data Assimilation (DA) issue

DA from ASCAT → global UM
results in high SM for urban areas



After SM modification

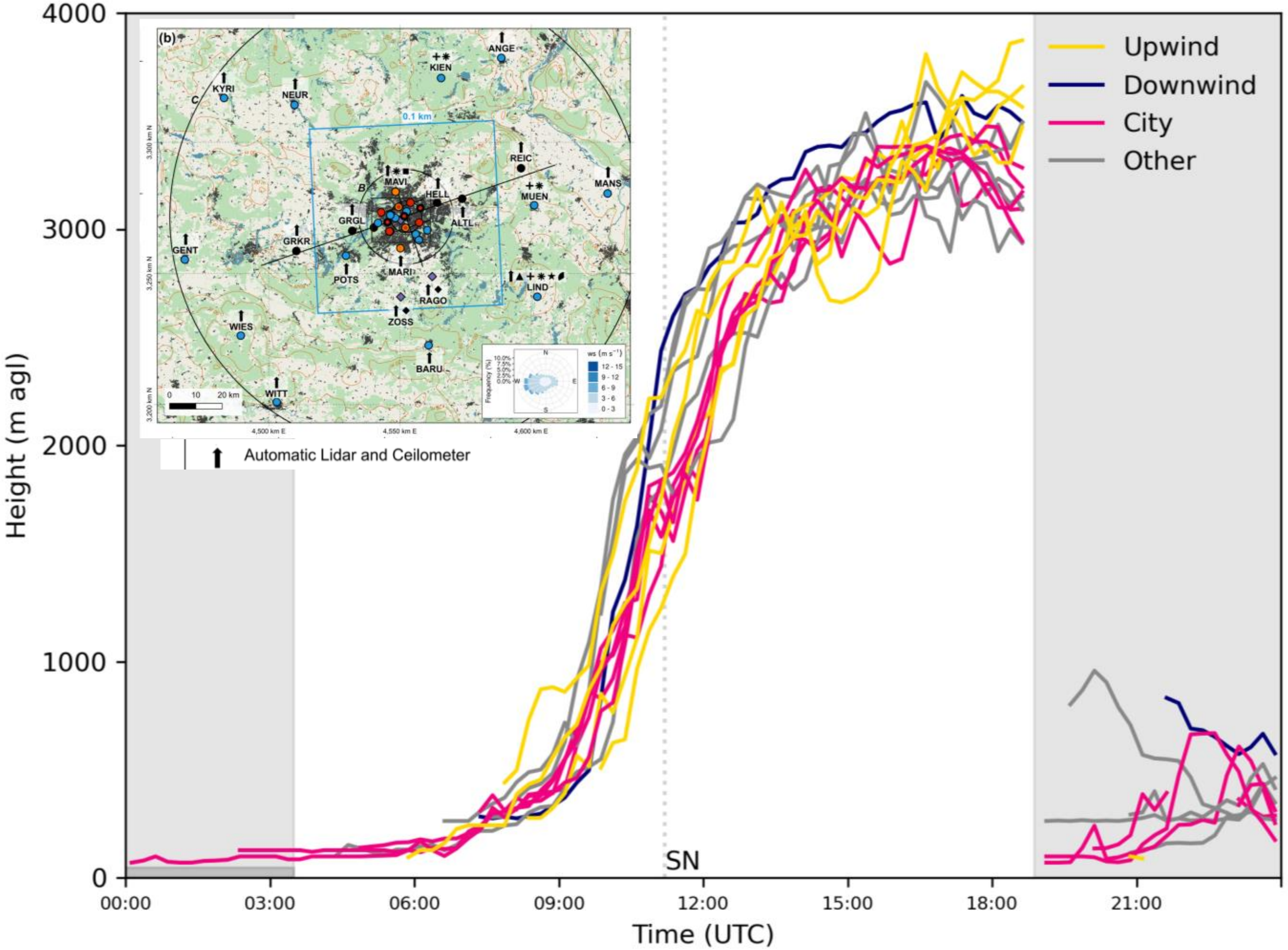


Initial simulation: issues

City
Upwind
Downwind
Other

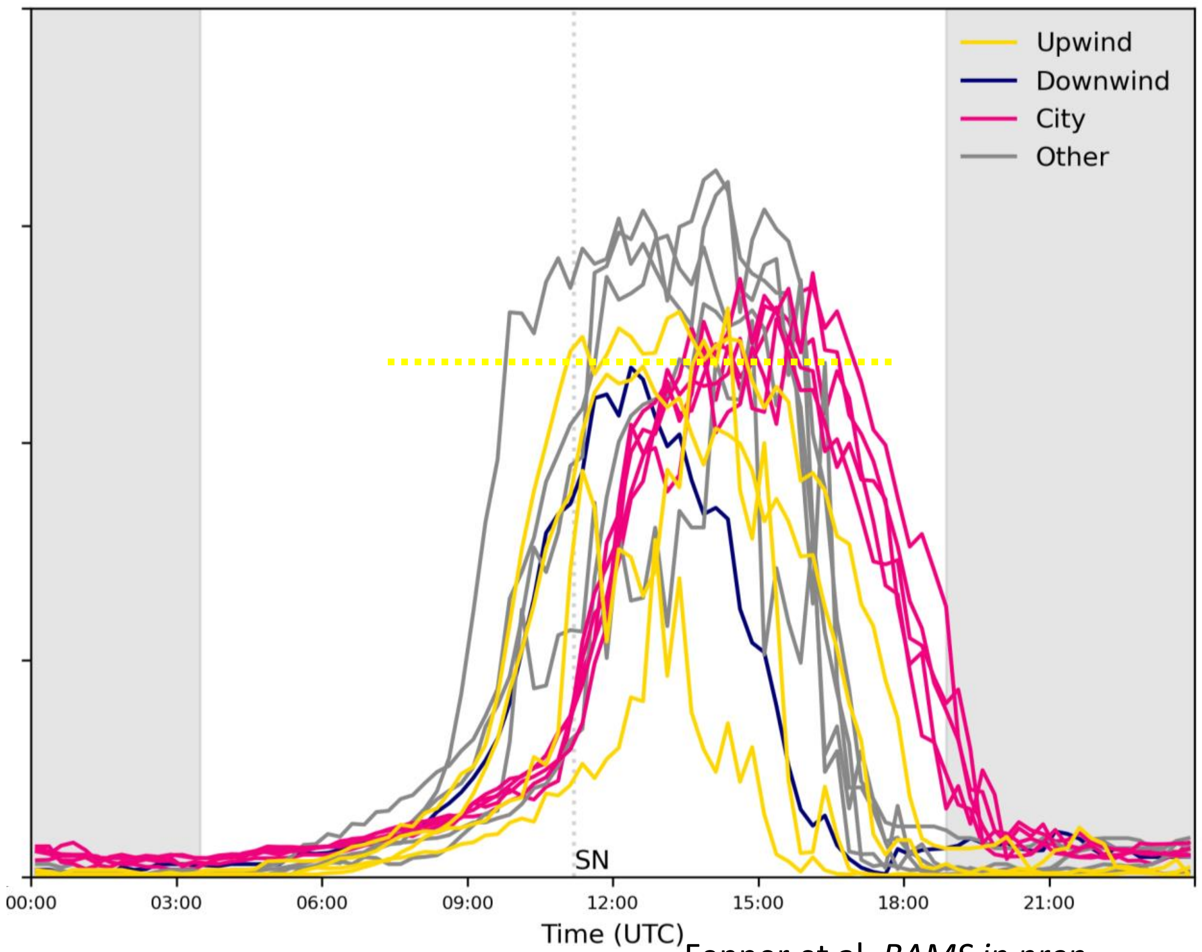
Observations

MLH – ALC analysed with STRAT*finder*



Initial 300 m model

Model default BLD diagnostic – (*Parcel method*)



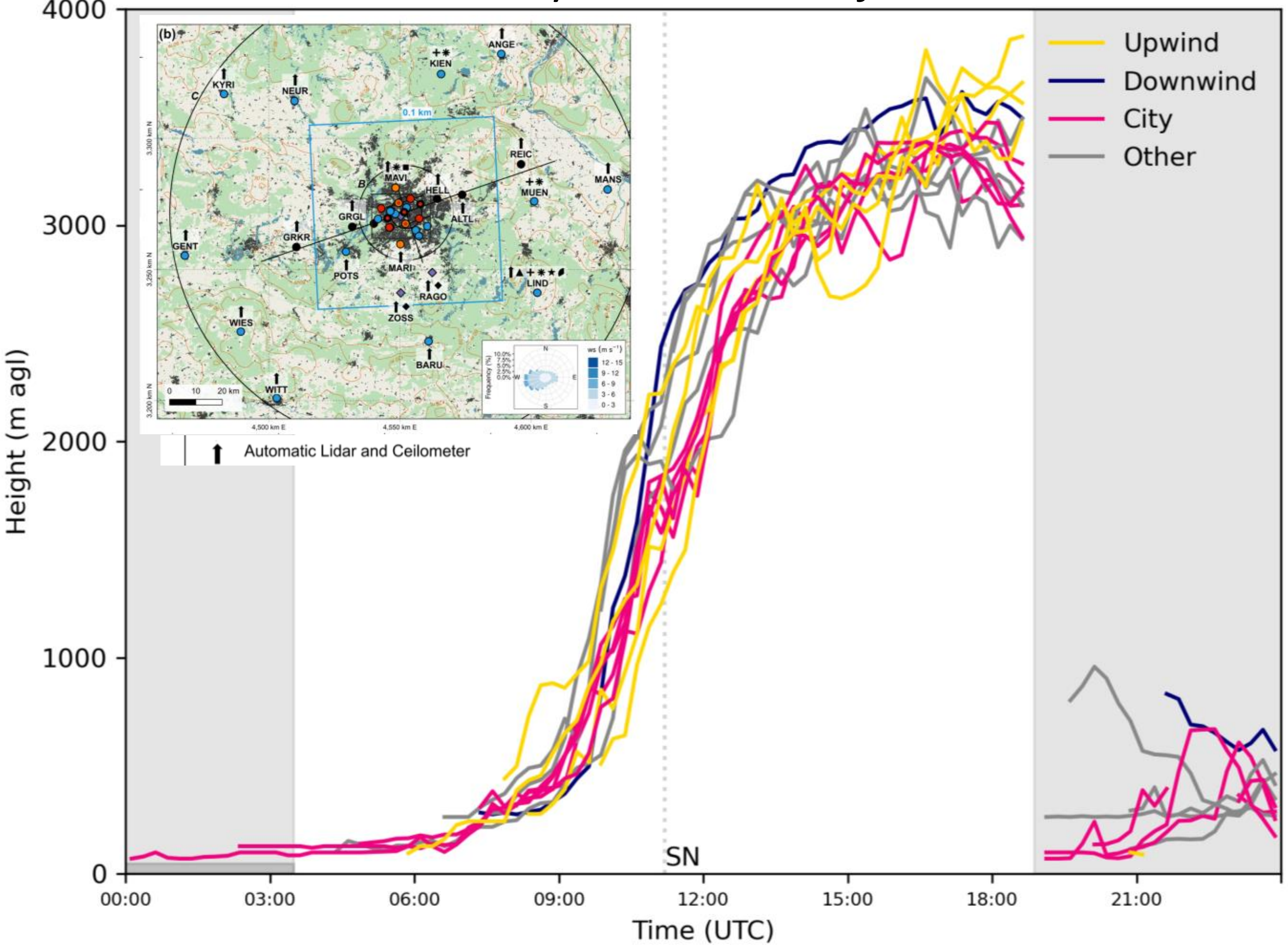
Fenner et al. *BAMS in prep*

Impact of SM modification on BL

City
Upwind
Downwind
Other

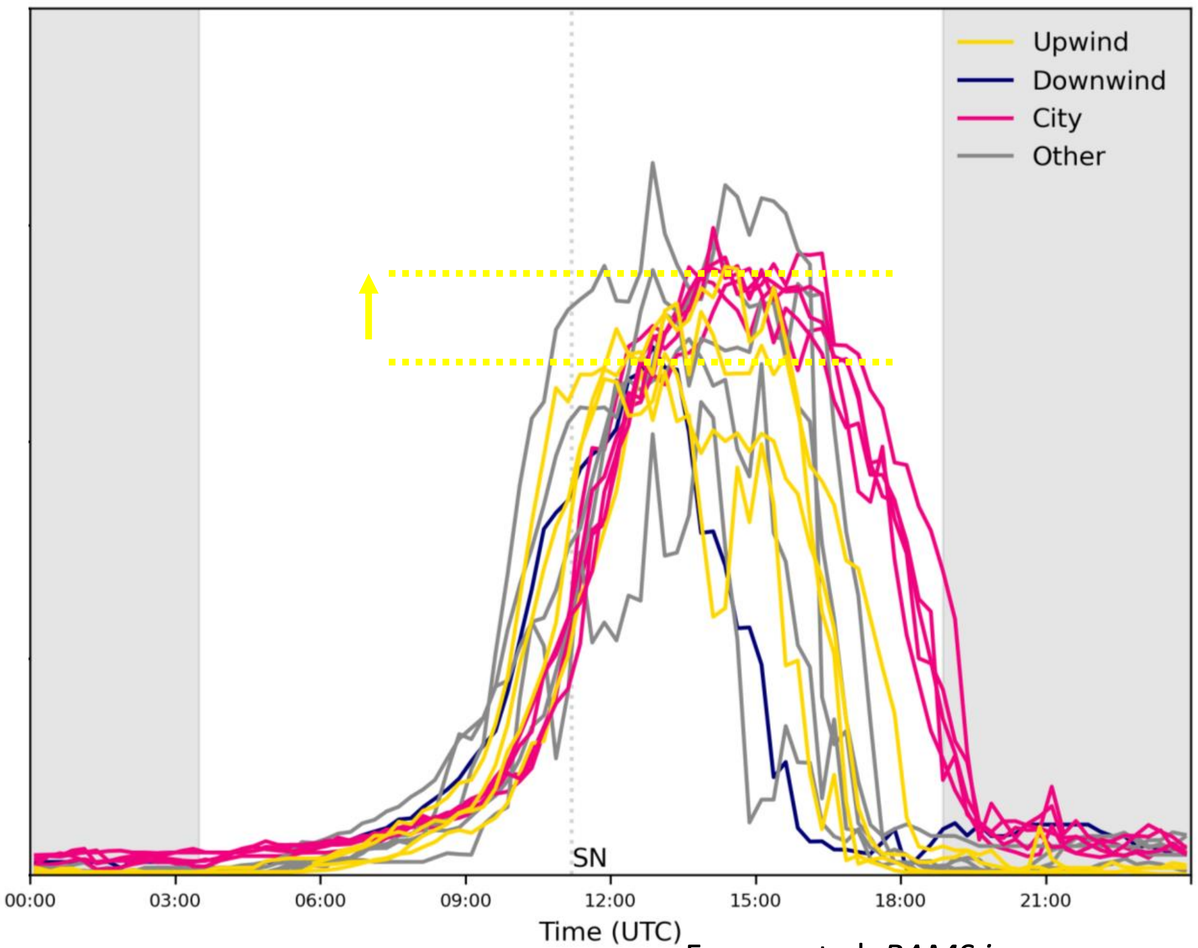
Observations

MLH –ALC analysed with *STRATfinder*



300 m model after SM modified

Model default BLD diagnostic – (*Parcel method*)

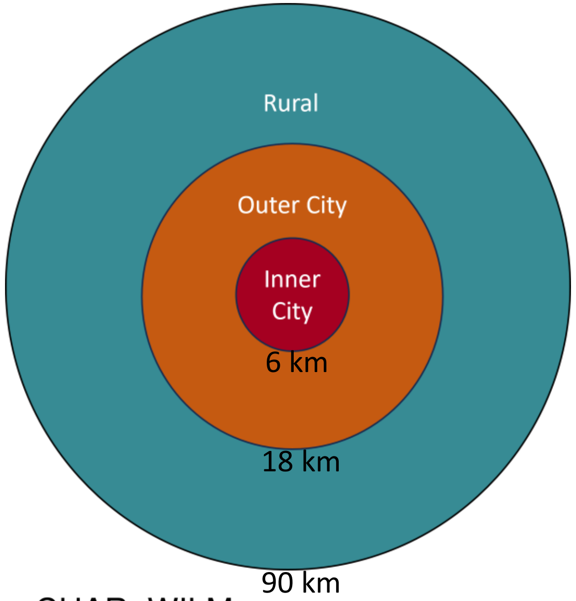


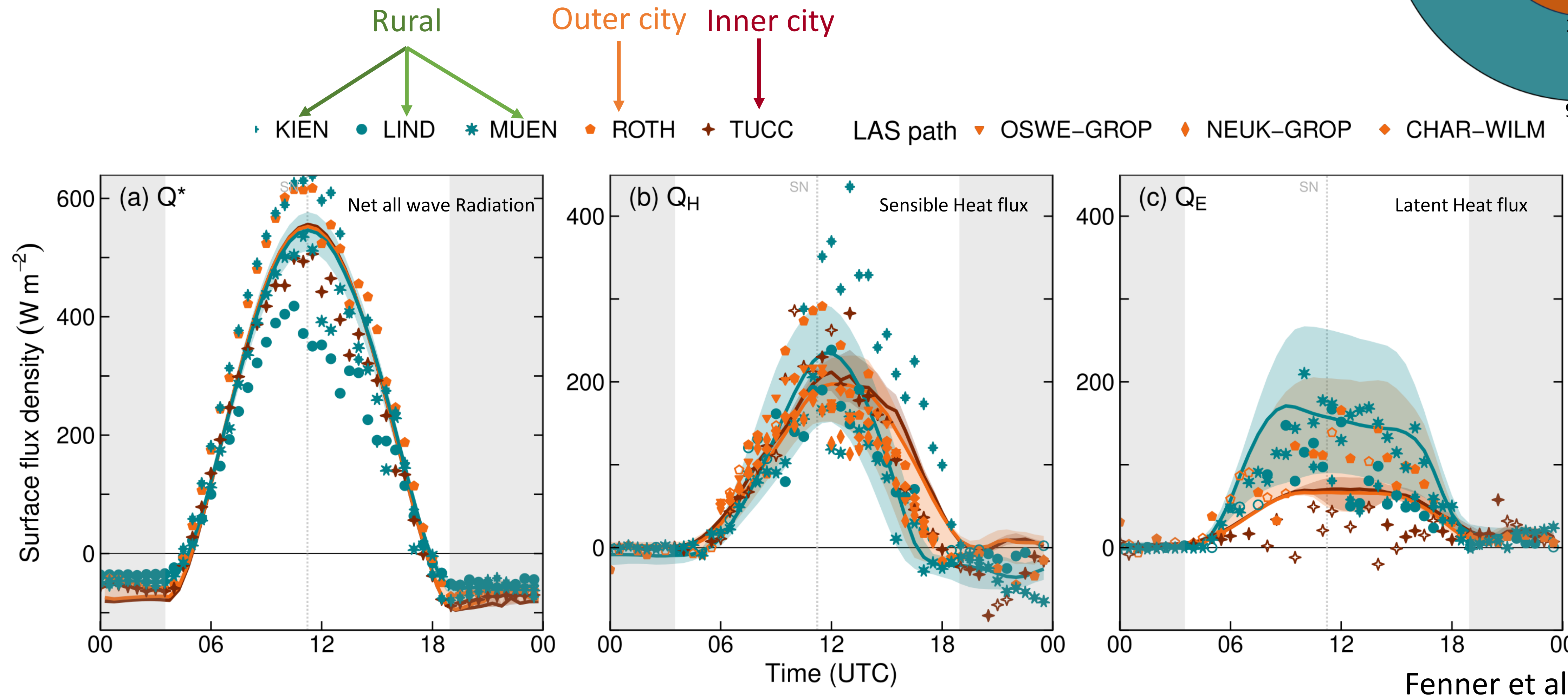
Fenner et al. *BAMS in prep*

Surface fluxes urban and rural

Observations:
- Radiometers
- Eddy covariance, Large Aperture Scintillometry (LAS)

Model: line median
: shading IQR
- full ring/donut
Observations: symbols





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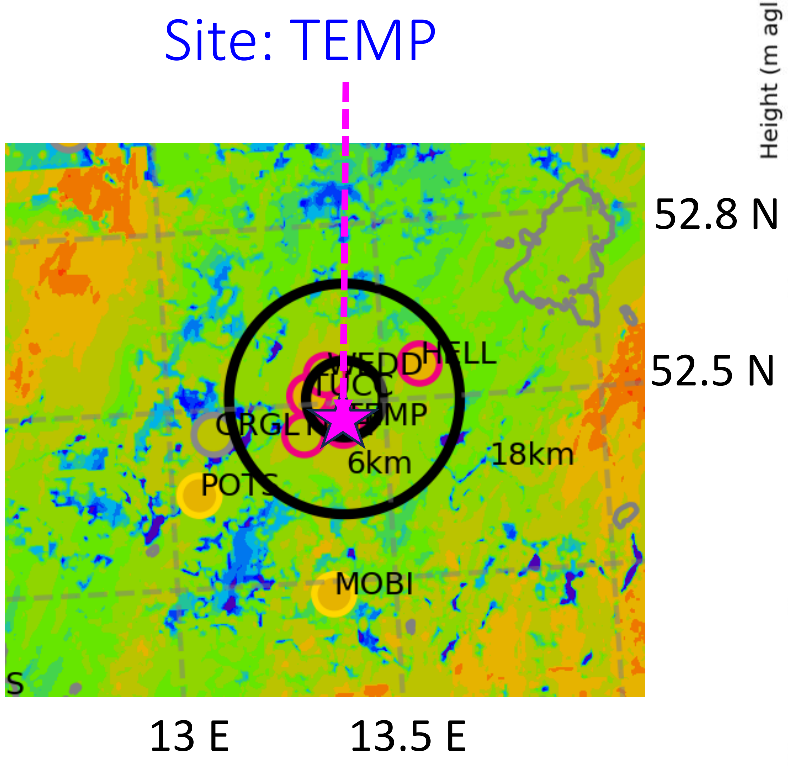
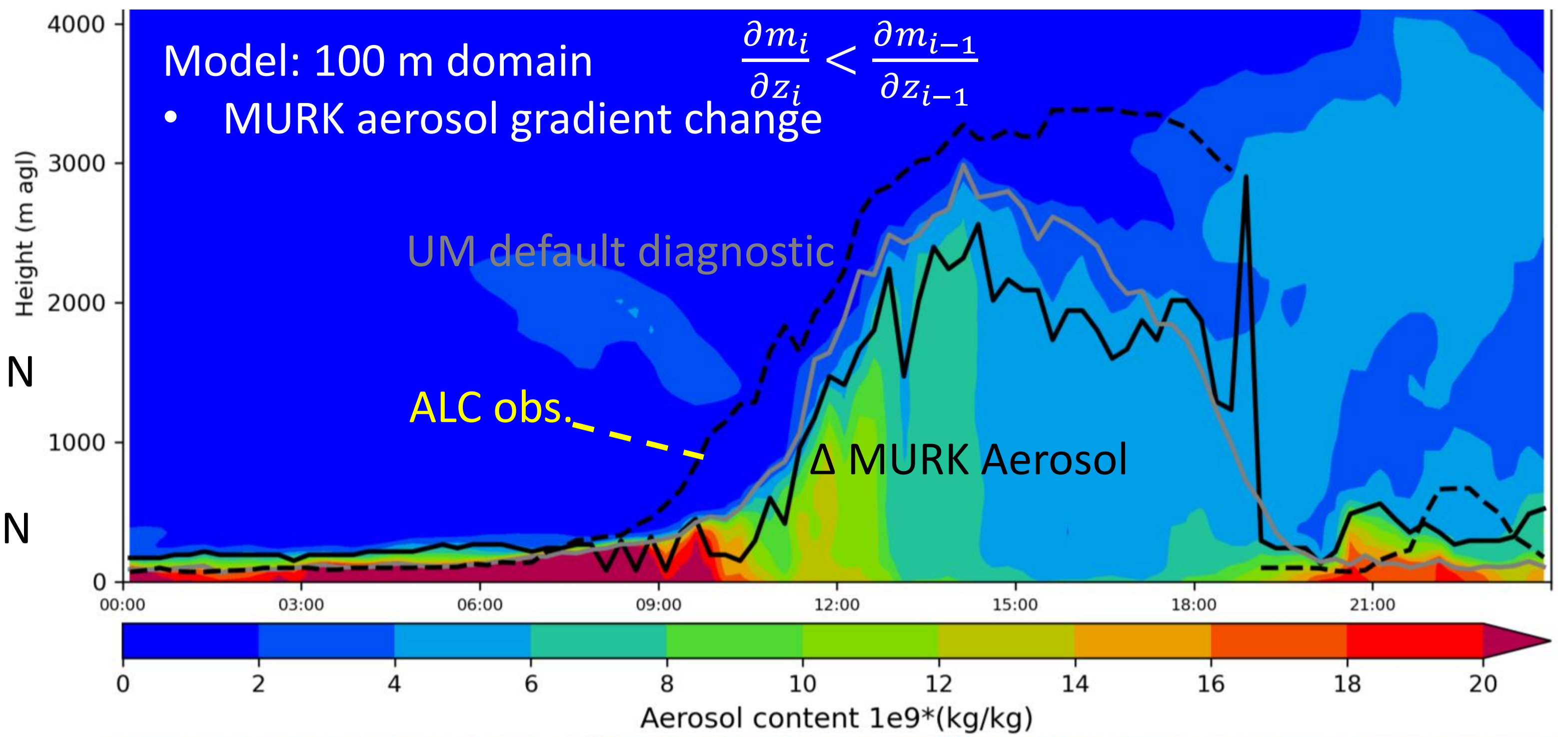
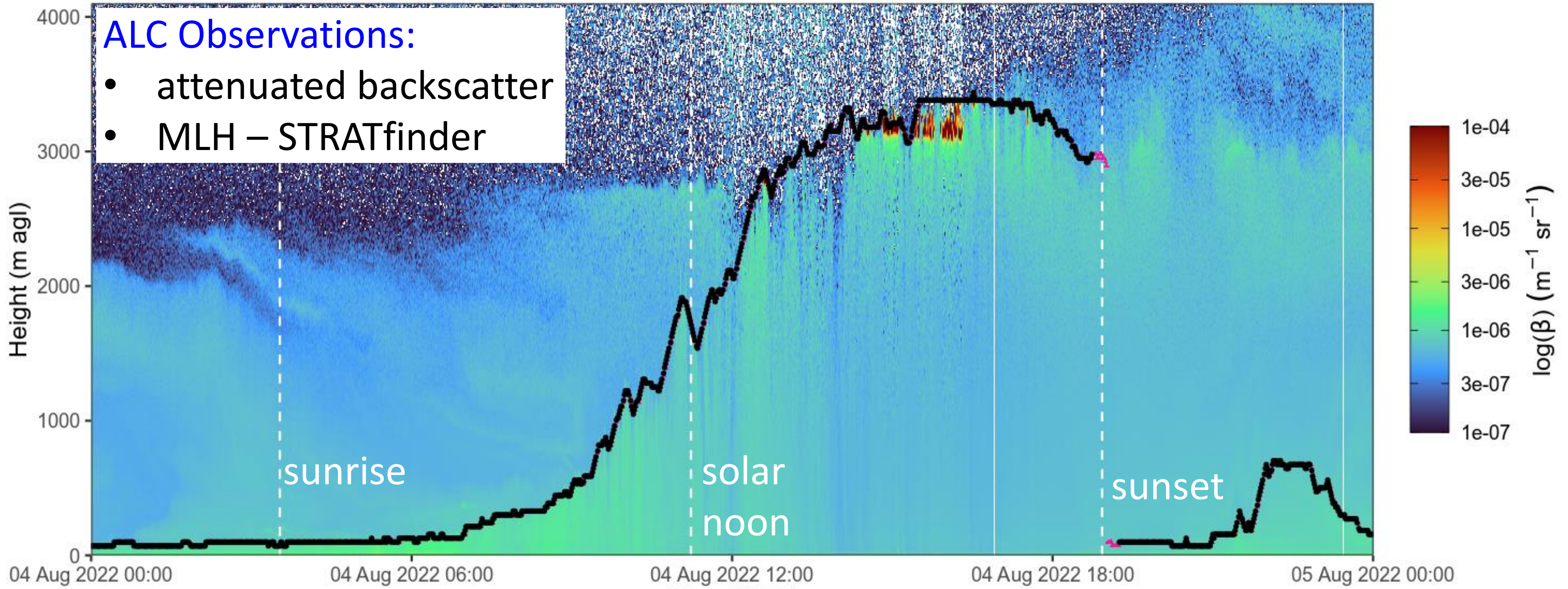






Other BLH metrics to be analysed

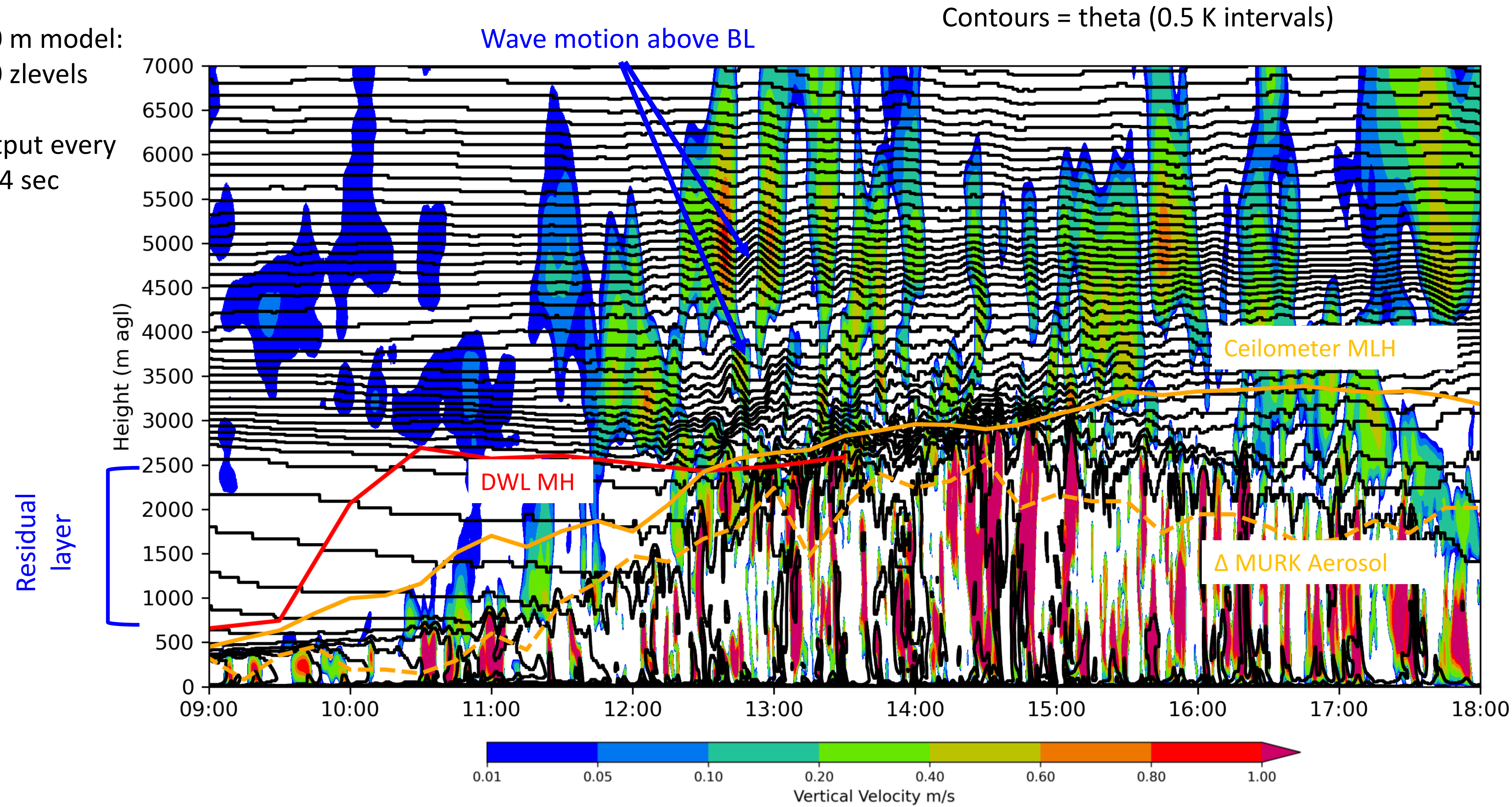
-Forward operator: Warren et al. (2018)

-Doppler wind lidar (W variance)

Evolution of BL near City Centre in 100 m model

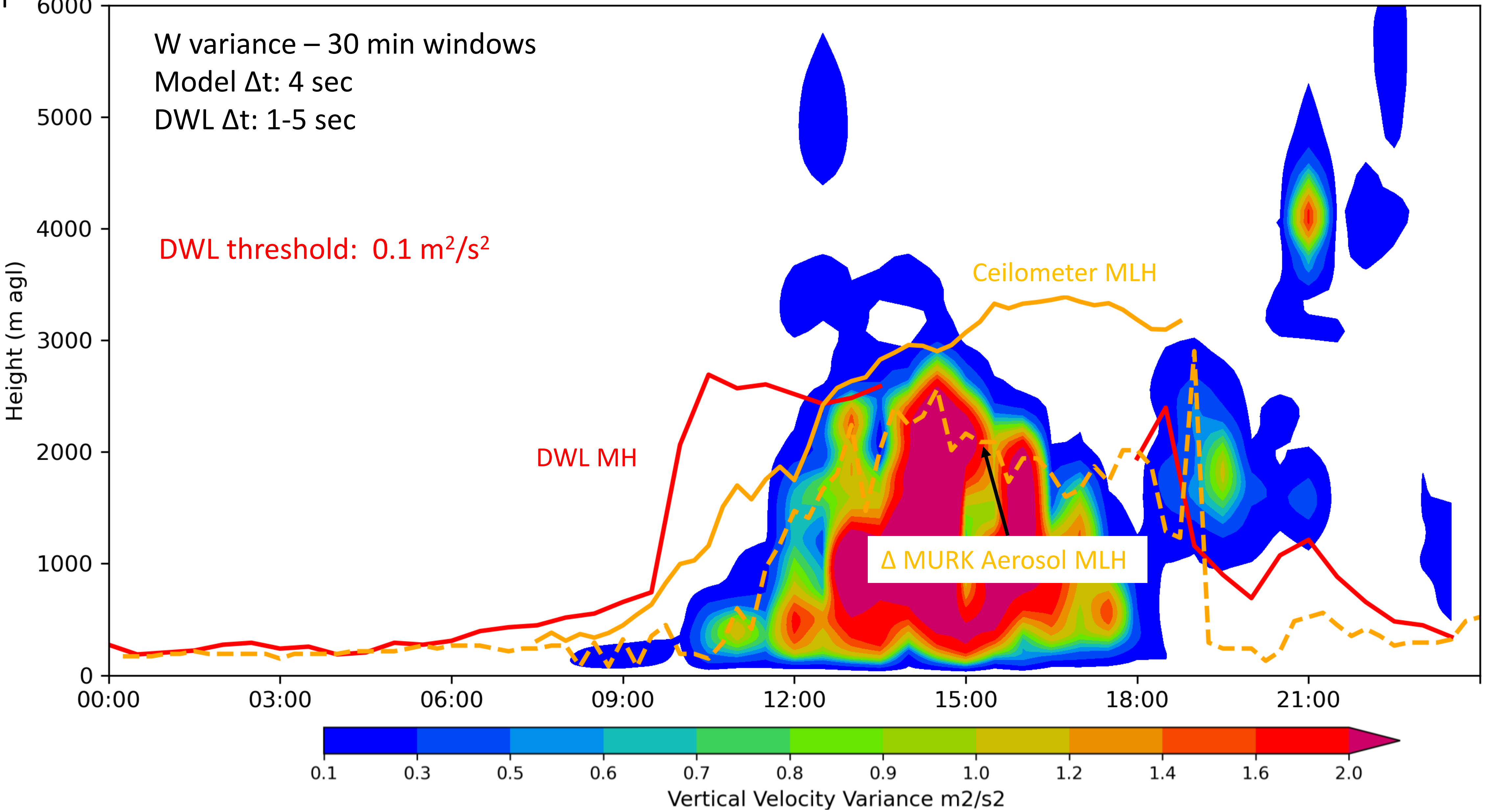
100 m model:
140 zlevels

Output every
Δt: 4 sec



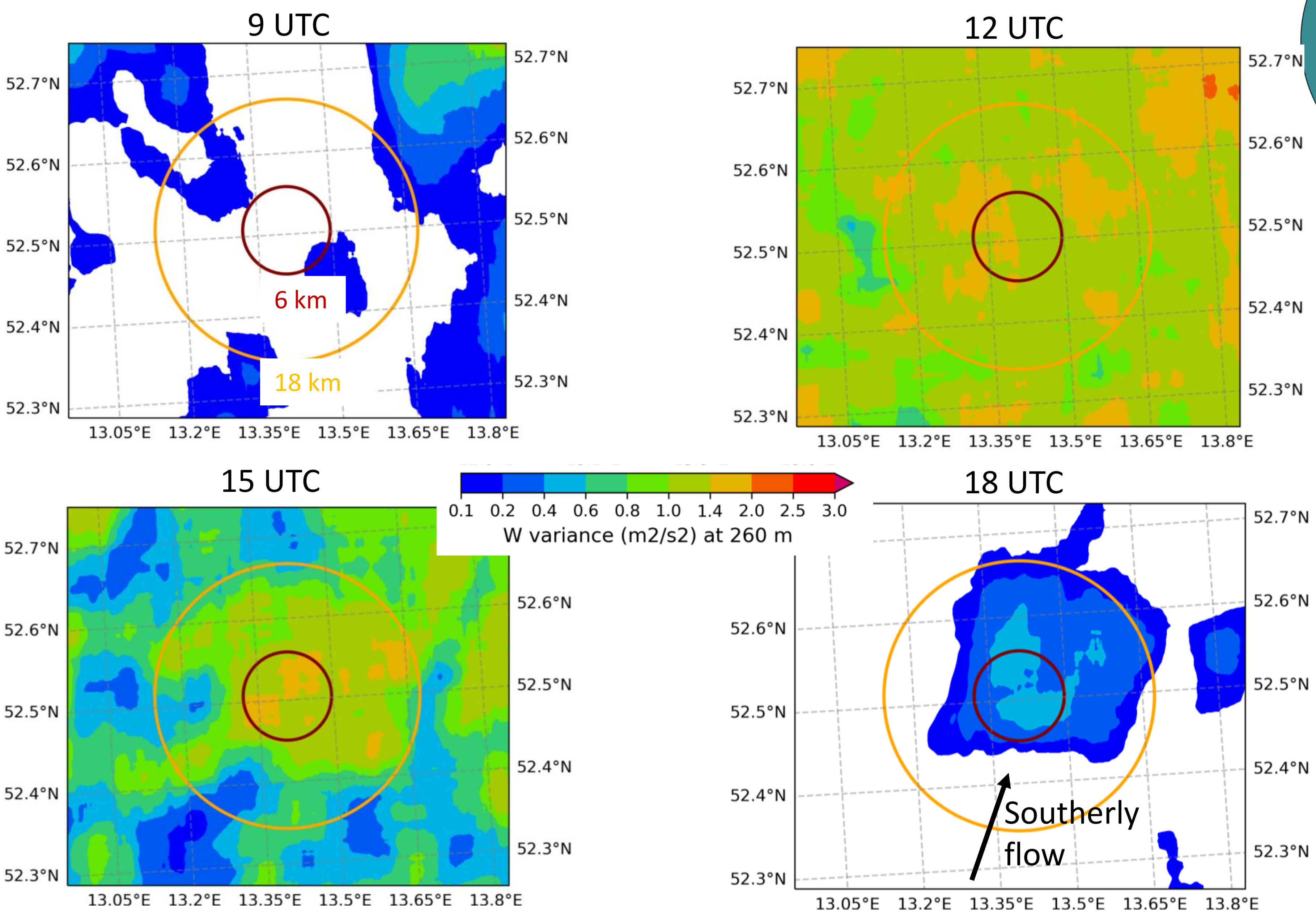
Model w variance compared to DWL (FRIE)

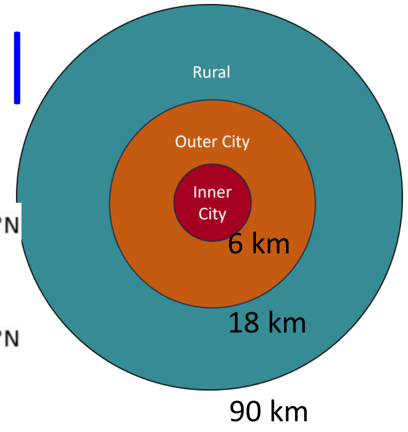
100 m model



Spatial variance of w at ~6 km scale: 100 m model

at 260 m



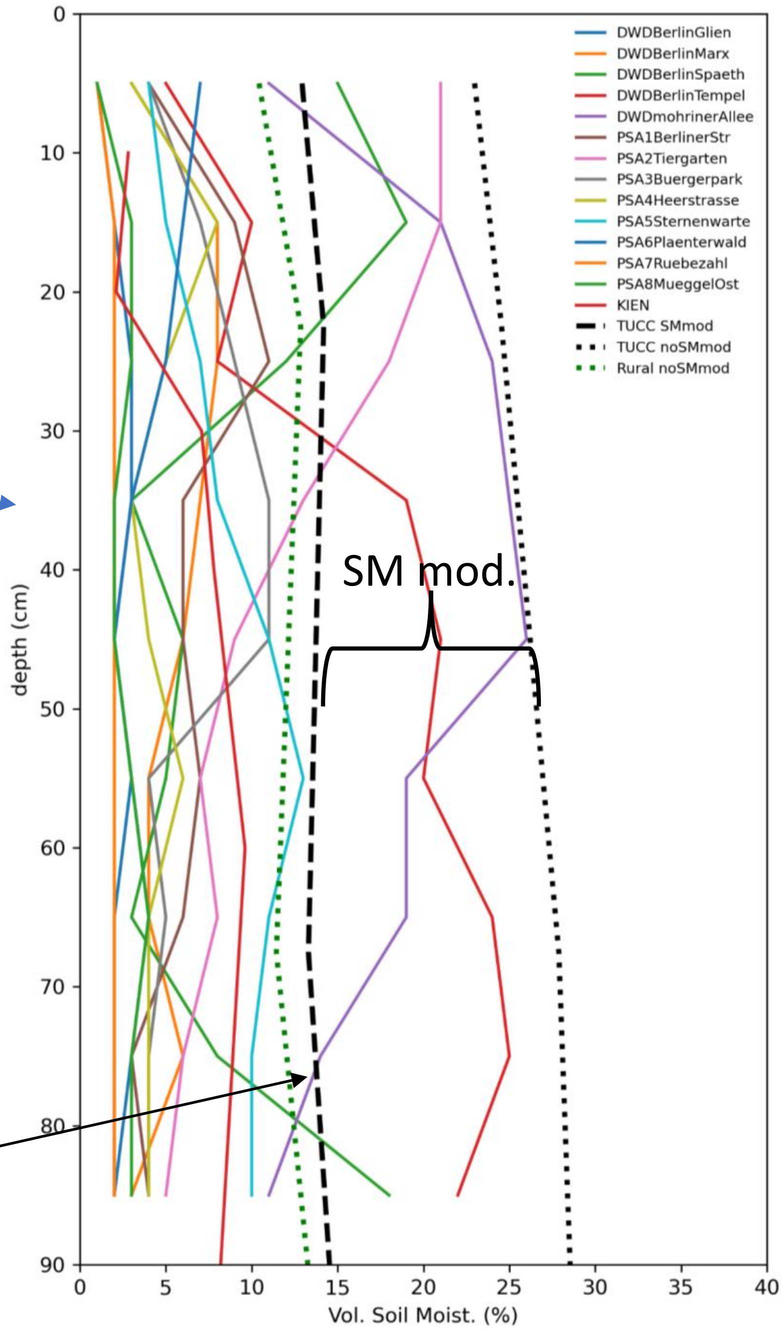


Final Comments

- 4 August: clear sky, dry, low soil moisture → observed urban – rural differences are minimal

- Soil moisture: correction in urban areas necessary
    - Revisit urban SM issue: use obs. profiles
    - Model sensitivity to SM: Heatwave specific?

- Model issues:
    - a) Near surface urban areas: high thermal inertia, too little Q_H during day – too much at night
    - b) BL collapses too early before sunset in rural **but not inner city**
- BL turbulence over the city continues into evening in 100 m model – what about intra-urban variability?
- **Future**: use more realistic urban form in model from urbisphere data



Still too wet!