Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Hans-Ertel-Zentrum
für Wetterforschung

FESSTVaL

Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

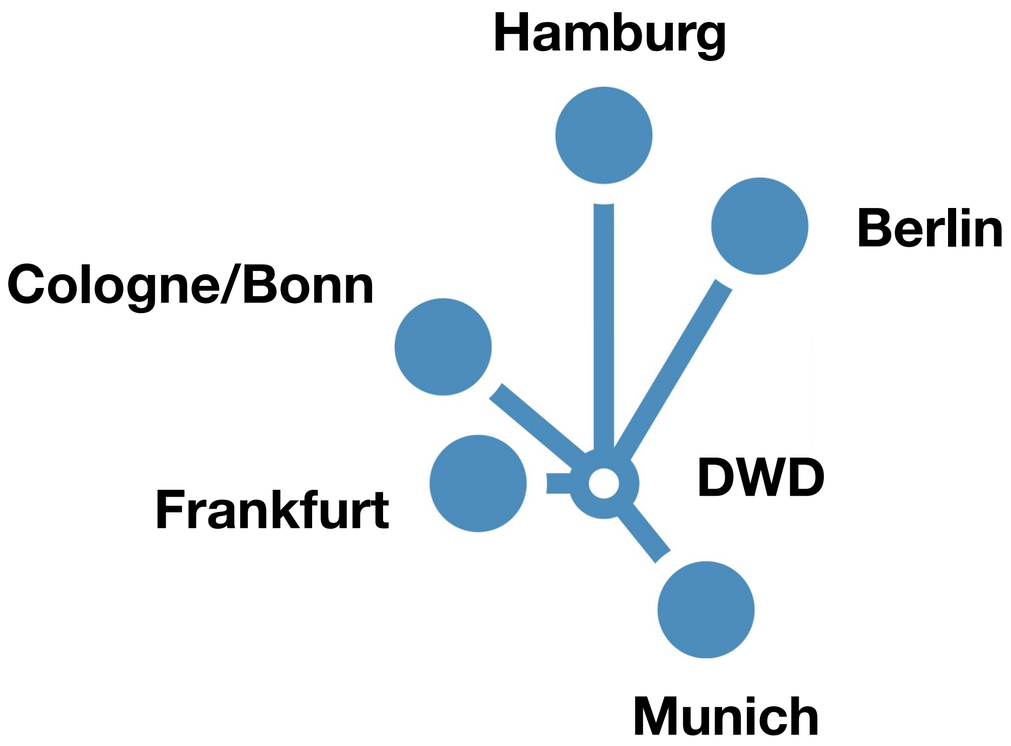
Daniel Klocke

Hans Ertle Center for Weather Research, Deutscher Wetterdienst

Hohenegger, Wahl, Schlemmer, Schmidli, Göber, Rust, Löhnert, Ament, Kirsch, Beyrich, Weissmann, Schomburg

Max-Planck-Institut
für Meteorologie

Hans Ertle Centre for weather research (HErZ)



Five research areas:

1. Atmospheric dynamics and predictability
   Munich

2. Data assimilation
   Munich

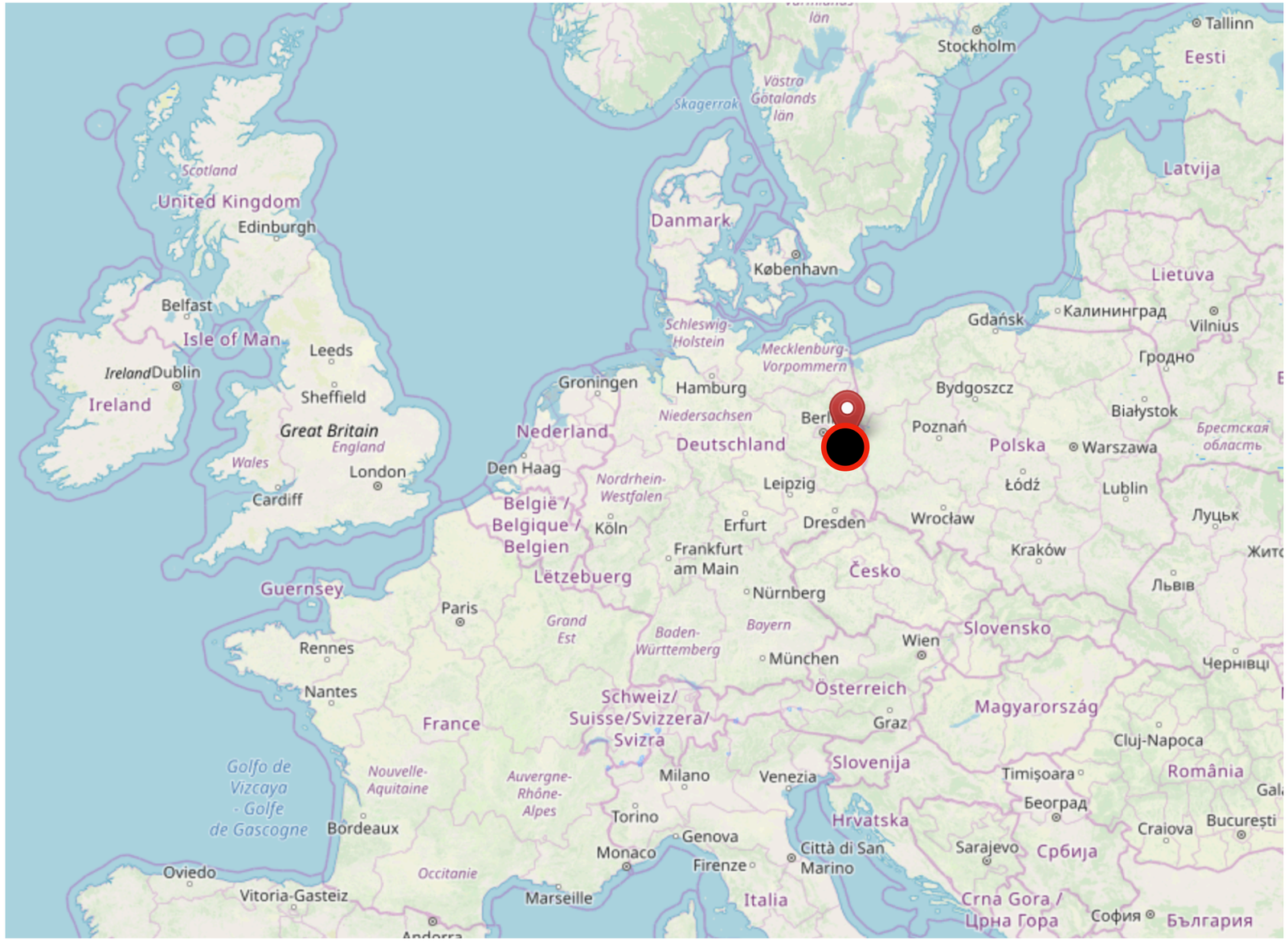
3. Model development
   Hamburg, Frankfurt

4. Climate monitoring and diagnostic
   Bonn/Cologne

5. Optimal use of information from weather forecasts and climate monitoring for the benefit of societyBerlin

And a cross-cutting theme:

The optimal use of appropriate observing systems

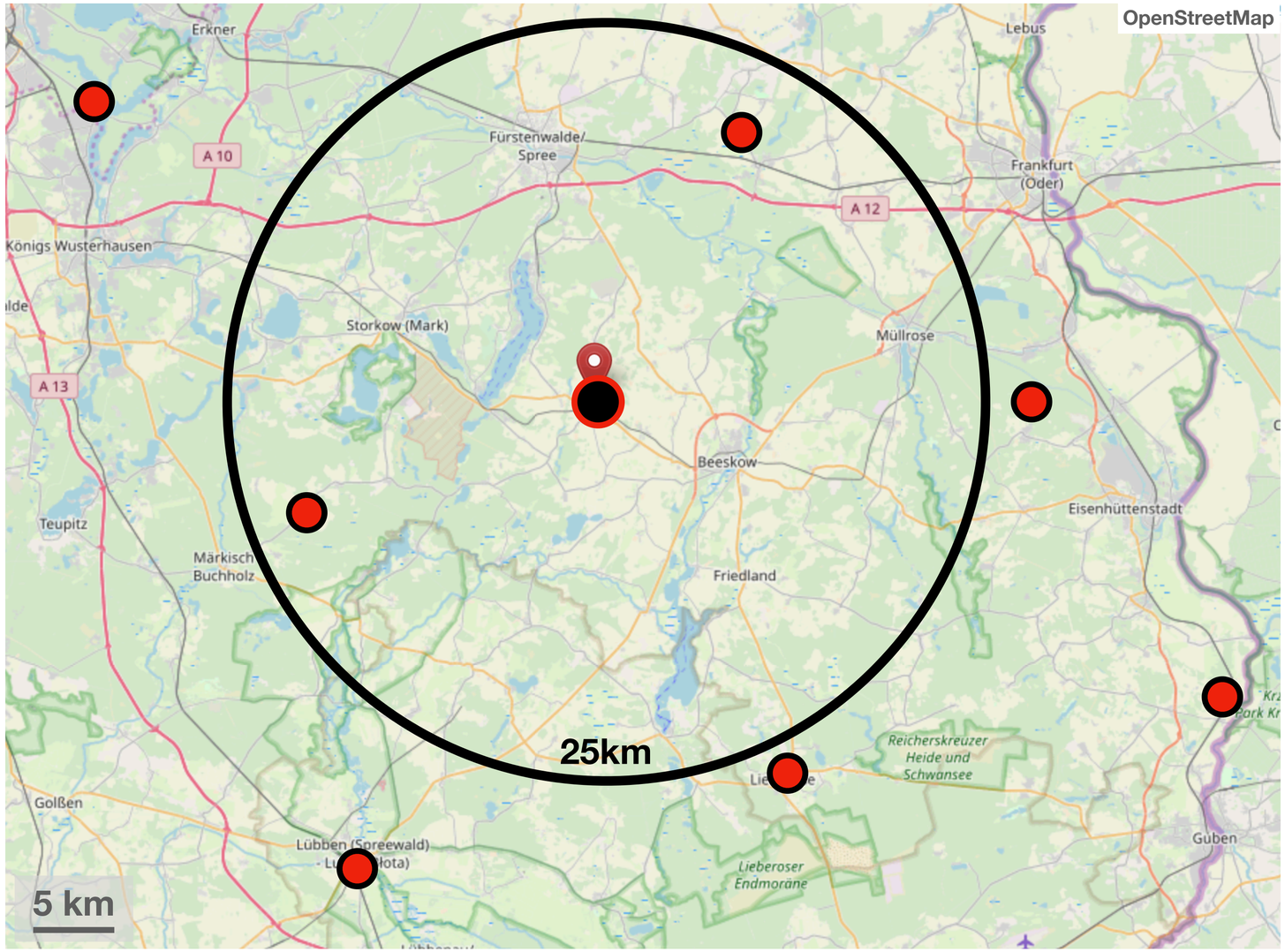


Meteorologische Observatorium Lindenberg – Richard-Aßmann-Observatorium (*MOL*-RAO)

DWD measurement network

Lindenberg Observatory

DWD measurement network

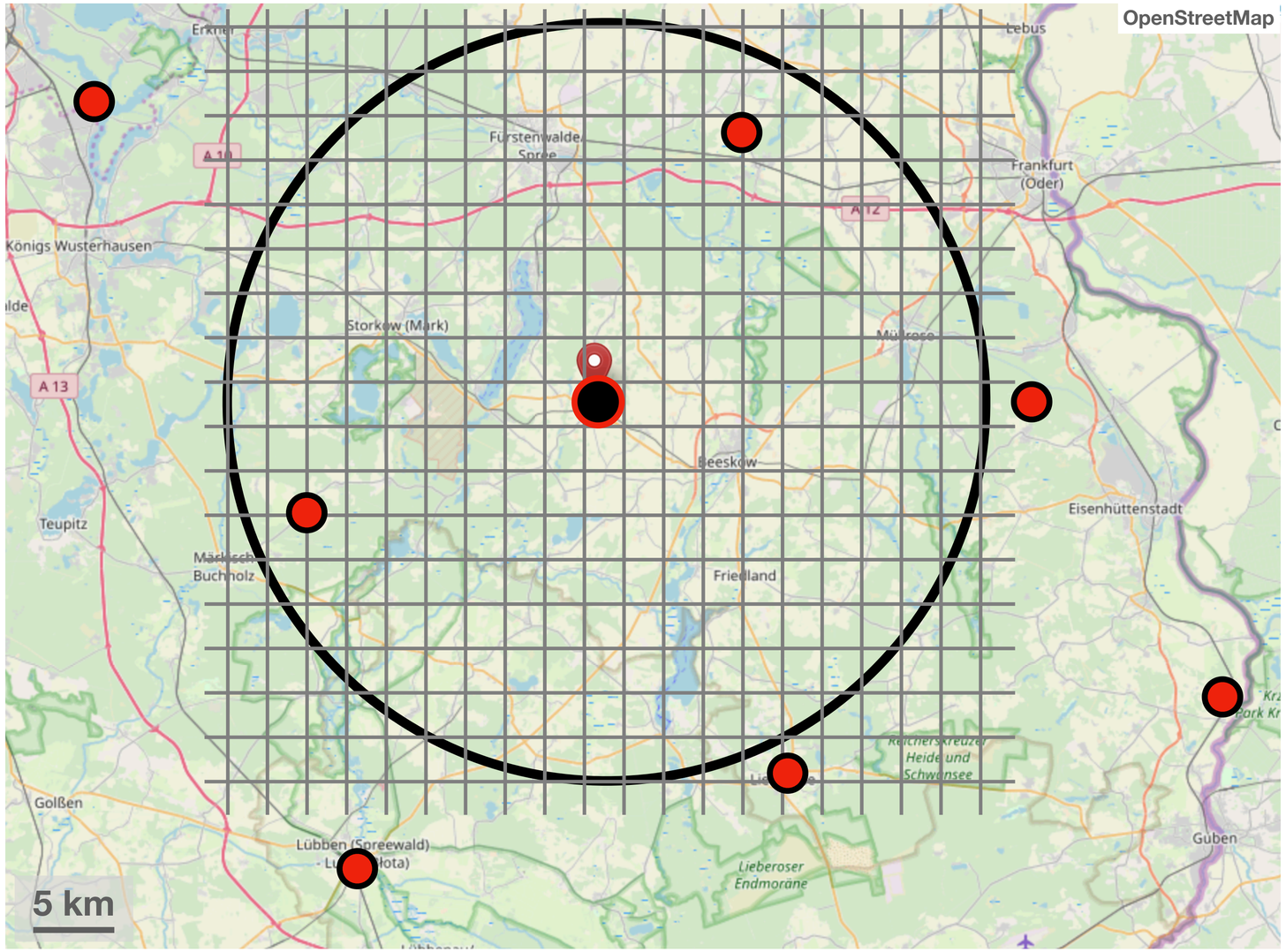


Measurement stations:
About 25 km resolution

Convection-permitting scales not well observed…

Lindenberg Observatory

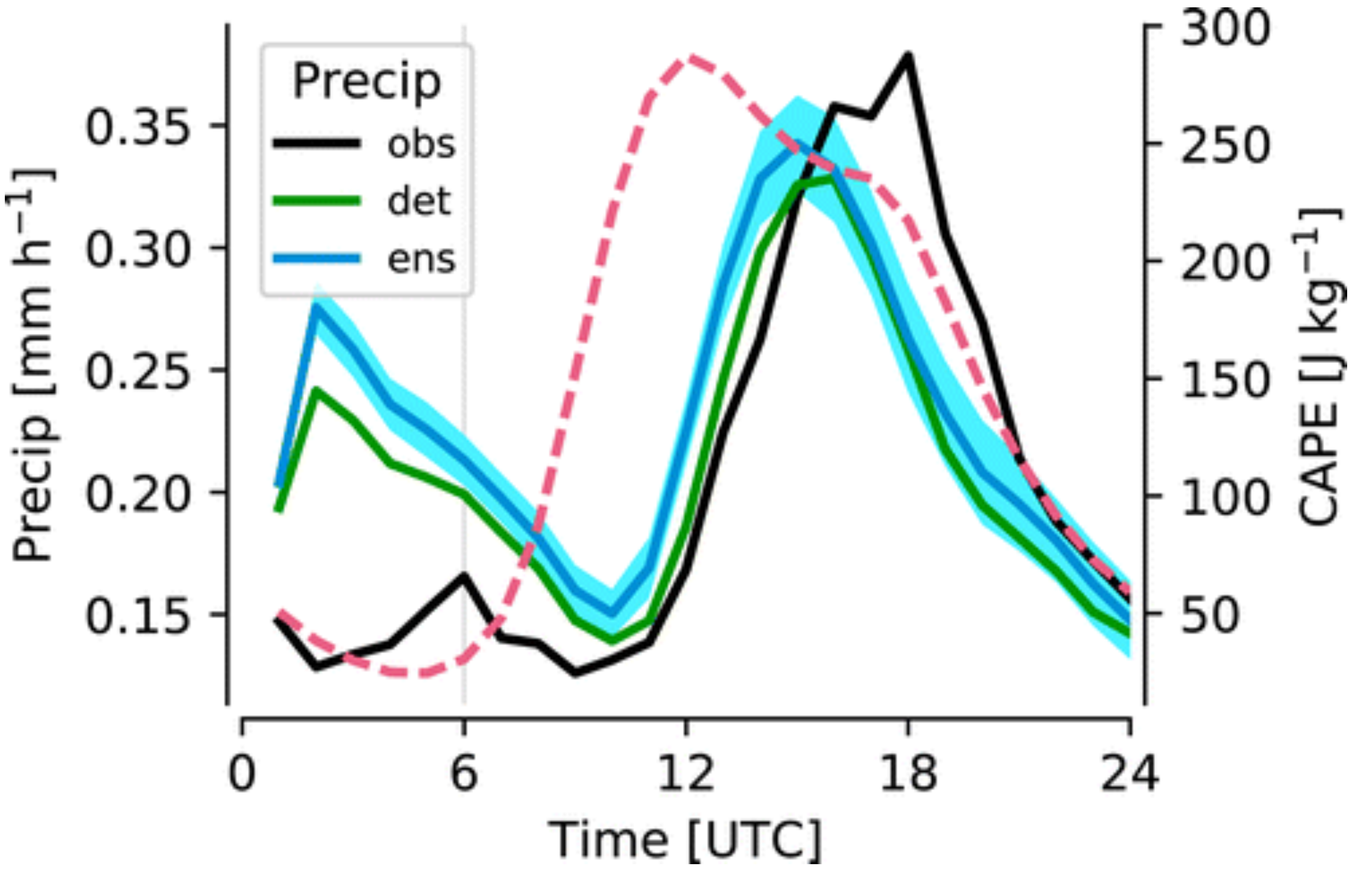
DWD measurement network



Measurement stations:
About 25 km resolution

COSMO-model
2.2 km resolution

… relevant processes remain under-resolved

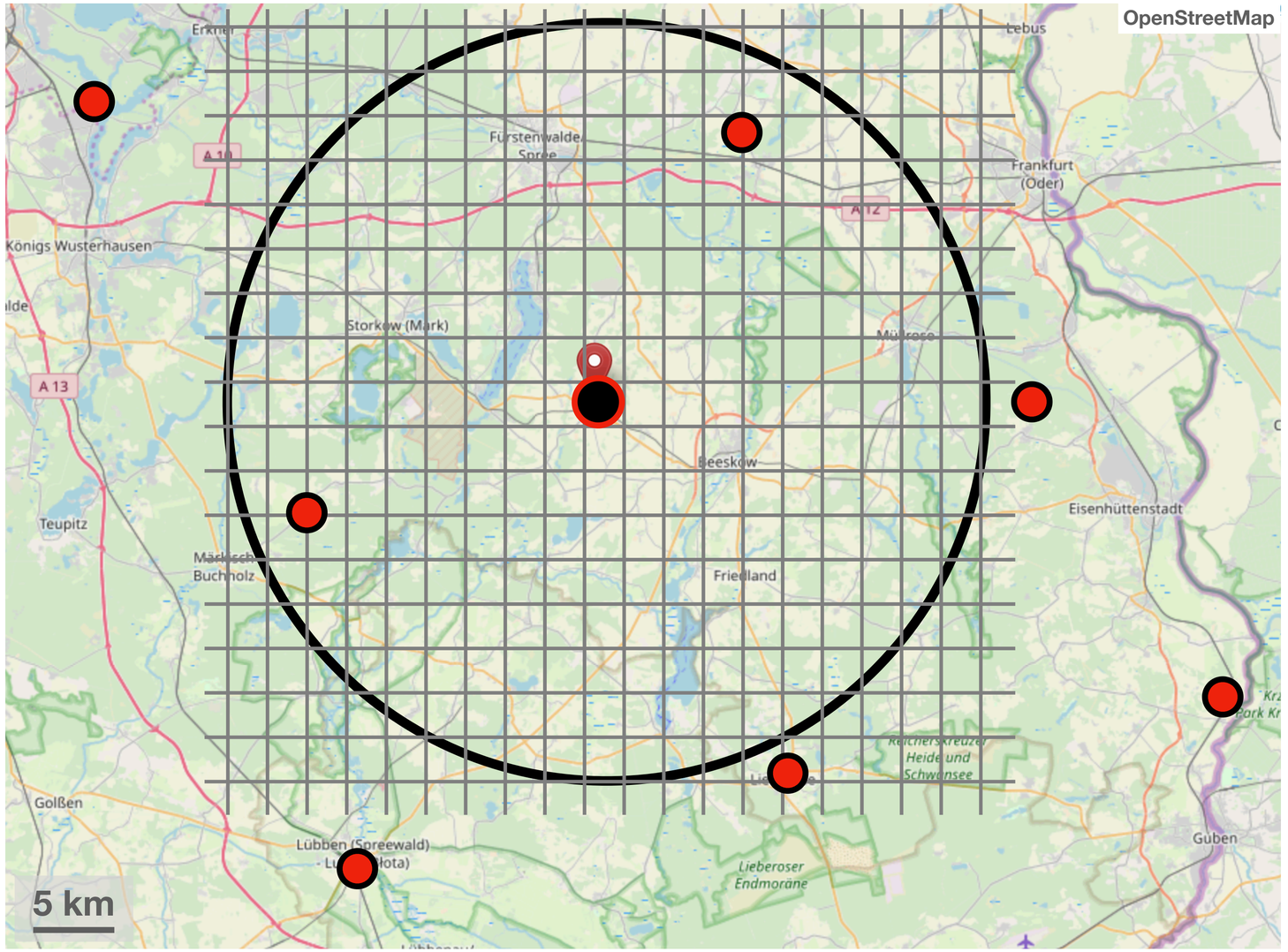


Rasp, Selz and Craig, 2018

What if we measure every 100m?

Lindenberg Observatory

DWD measurement network



Measurement stations:
About 25 km resolution

COSMO-model
2.2 km resolution

FESSTVaL

Focus

➡ measure sub-mesoscale variability: 100 m to 10 km

Goal

➡ How to measure sub-mesoscale variability?

➡ Do NWP models capture correctly sub-mesoscale variability?

➡ Process understanding: do observations support hypotheses derived from models?

Expressions or sources of sub-mesoscale variability

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Focus

1. **Sub-mesoscale boundary layer patterns**
2. **Cold pools**
3. **Wind gusts**
4. **Using citizen observations**

1. Sub-mesoscale boundary layer pattern

- **Characterize** sub-mesoscale boundary layer patterns ← using lidars and further instruments
- **Evaluate** ICON-SCM with different boundary layer schemes ← against profiles of mean observations and of turbulent quantities
- Process **understanding** ← identification of processes causing sub-mesoscale variability

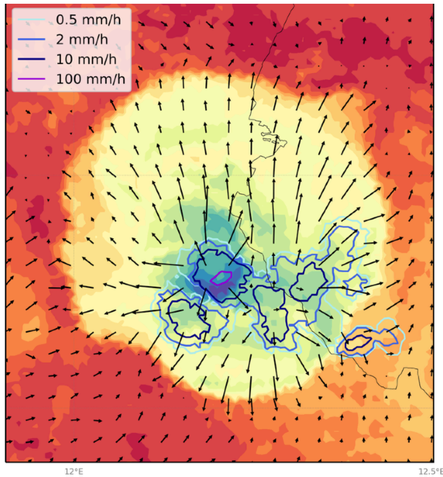
- Turbulent characteristics of typical summertime boundary layers (clear, cloud-topped, with cold pools)
  - diurnal evolution (CBL and SBL)
  - day-to-day variability (dry, cloudy, with cold pools)
- Dominant scales of turbulent & sub-mesoscale motions, the processes promoting these motions, and how well they can be identified
  - diurnal evolution, day-to-day variability (dry, cloudy, cold pools)
- Evaluate boundary layer parameterizations (typical summertime ABL regimes and transition between the regimes)

2. Cold pools

- **Measure** the two-dimensional structure of cold pools using a high-density surface network made of many new (and cheap) sensors

- **Compare** simulated cold pool statistics (size, temperature depression) to observations

- Process understanding: **Test** some of the following hypotheses:
  - ➔ Larger cold pools lead to larger clouds (Schlemmer and Hohenegger 2014)
  - ➔ Larger cold pools have stronger temperature perturbations (Schlemmer and Hohenegger 2014)
  - ➔ Cold pool properties are drastically impacted by the surface fluxes (Gentine et al. 2016)
  - ➔ Stronger sensible heat fluxes lead to a faster dissipation of cold pools (Grant and van den Heever 2016)
  - ➔ Recovery of the sensible heat flux is fast



What we know about cold pools is based on models (micr-physics!) or point measurements (size!).

What are the 2(3)d characteristics of cold pools?

3. Wind gust

- Use of doppler lidars to **measure** wind gusts
- **Evaluate** simulated wind gusts and develop new wind gust diagnostic
- Process understanding: **Study** the effect of the environment on wind gusts at different heights

How representative is a simulated wind gust in a 2 x 2 km^2 cell at a given height?

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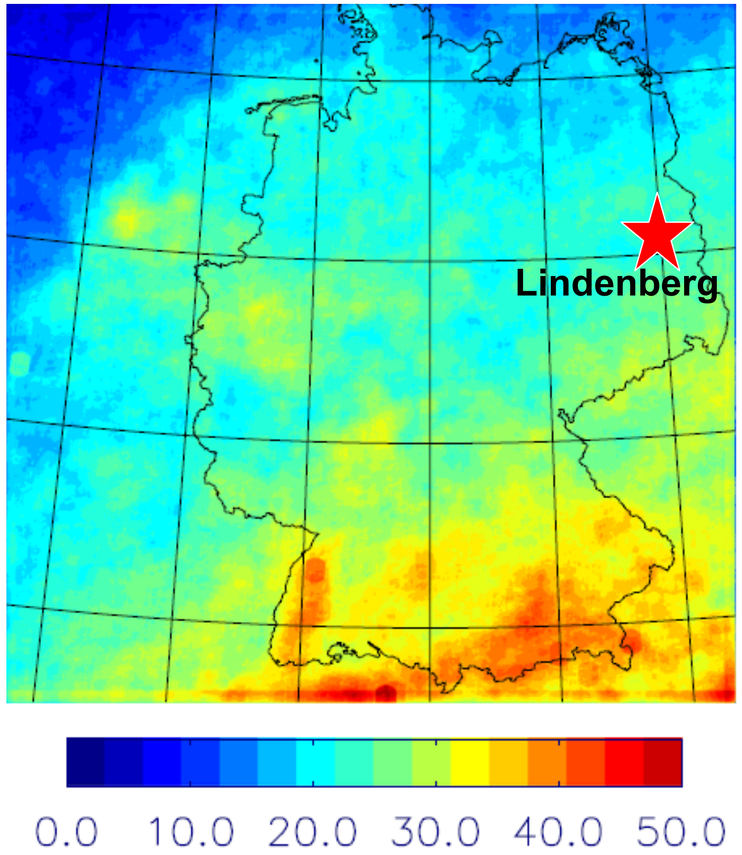
4. Citizen network

- Build low coast weather stations in dedicated workshops
- Statistical post-processing of the data to **integrate** it in measurement network
- To what extent does the involvement of citizen **raise** the interest in weather?
- Are citizen observations useful relative to the network installed by ‚experts‘?

How useful are low cost sensors built by citizen and for what?

Measurement strategy

Number of days with thunderstorm

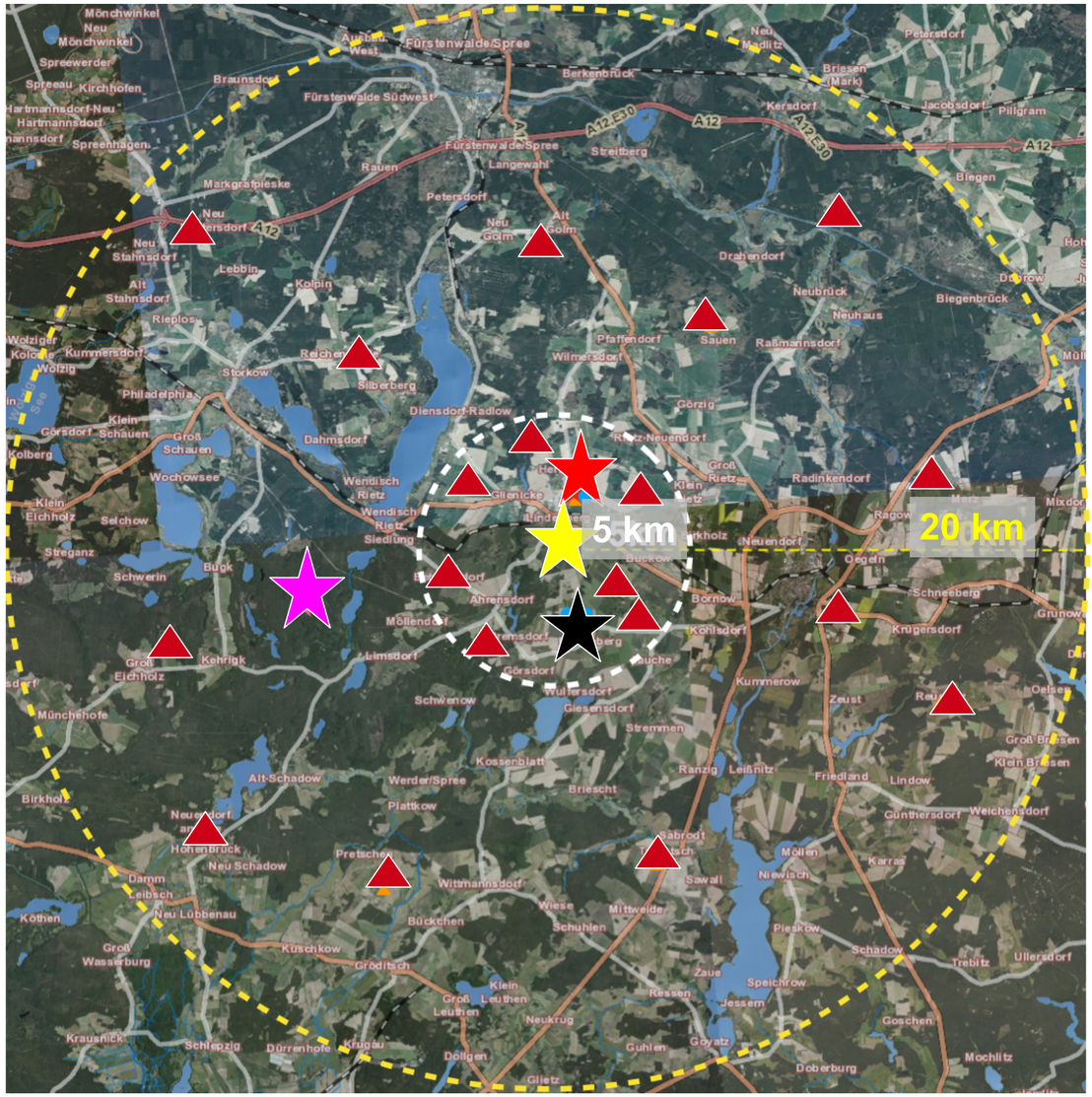


Wapler, K., James, P., 2015:

Why Lindenberg?

- Land
- Flat
- convective activity larger than flat regions in northern Germany
- sparsely populated
- Extensive atmospheric measurements
- Experience with measurement campaigns (eg LITFASS)
- Support through observatory

Measurement strategy



Super sites

- ★ Lindenberg
- ★ Falkenberg
- ★ Forest station
- ★ X-Band radar

Profiling stations

- ● Doppler lidar (#5)
  DIAL water vapor lidar
  Energy balance stations

Low-resolution network

- ▲ WXT (#25)

High-resolution network

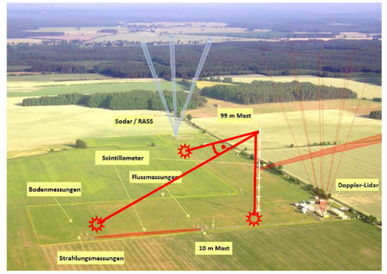
Polls (#100)

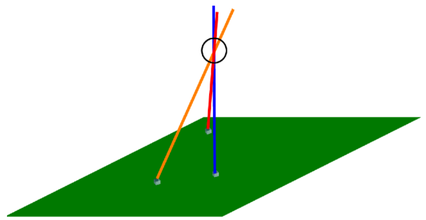
Citizen network

Low cost stations (#100)

Doppler lidar

- To measure mean wind, turbulence quantities and wind gusts
- At least 3 Doppler lidar close together, plus at least two different sites
- Test in 2019 to determine the optimal scanning strategy
- For 3D wind and TKE, strategy made of a vertical stare followed by about 5 scans at different azimuth angles with fixed elevation



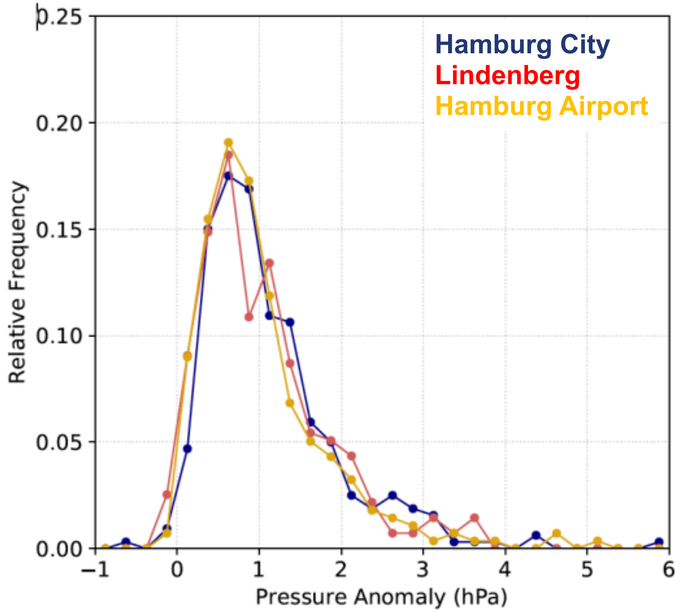


Virtual tower

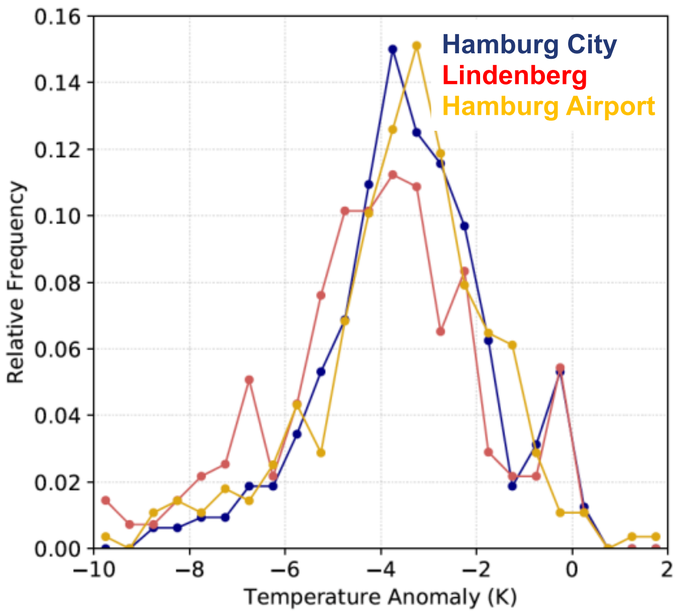
Lindenberg Doppler lidar

WXTs and poles

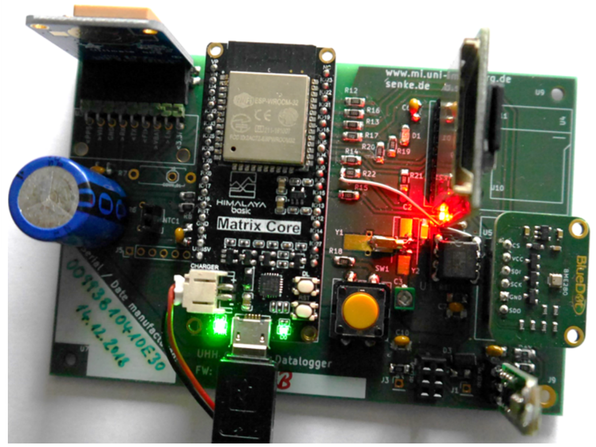
- ➔ To measure cold pools and wind gusts
- ➔ WXT stations (t, p, RH, precip, wind)
- ➔ Pole with a temperature and pressure sensor

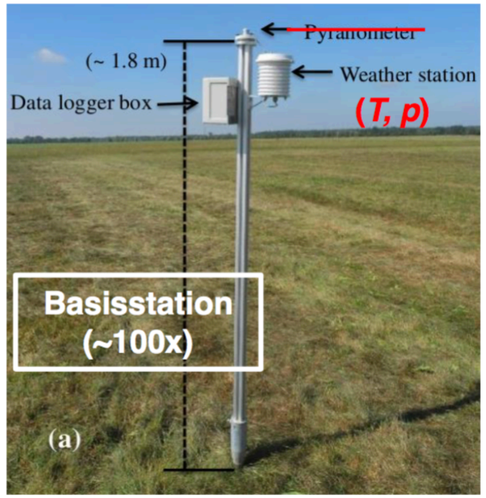


~ 0.5 – 1 hPa

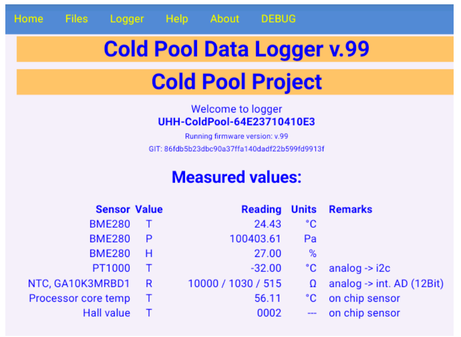


~ - 4 K





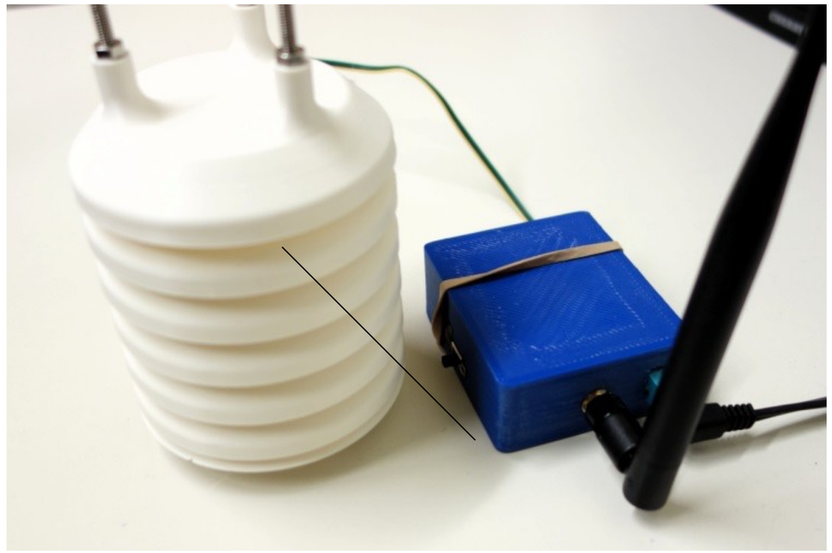
- NTC temperature 1s
- BME280 pressures 1s
- Cheap
- Low energy consumption



B. Kirsch, Uni Hamburg

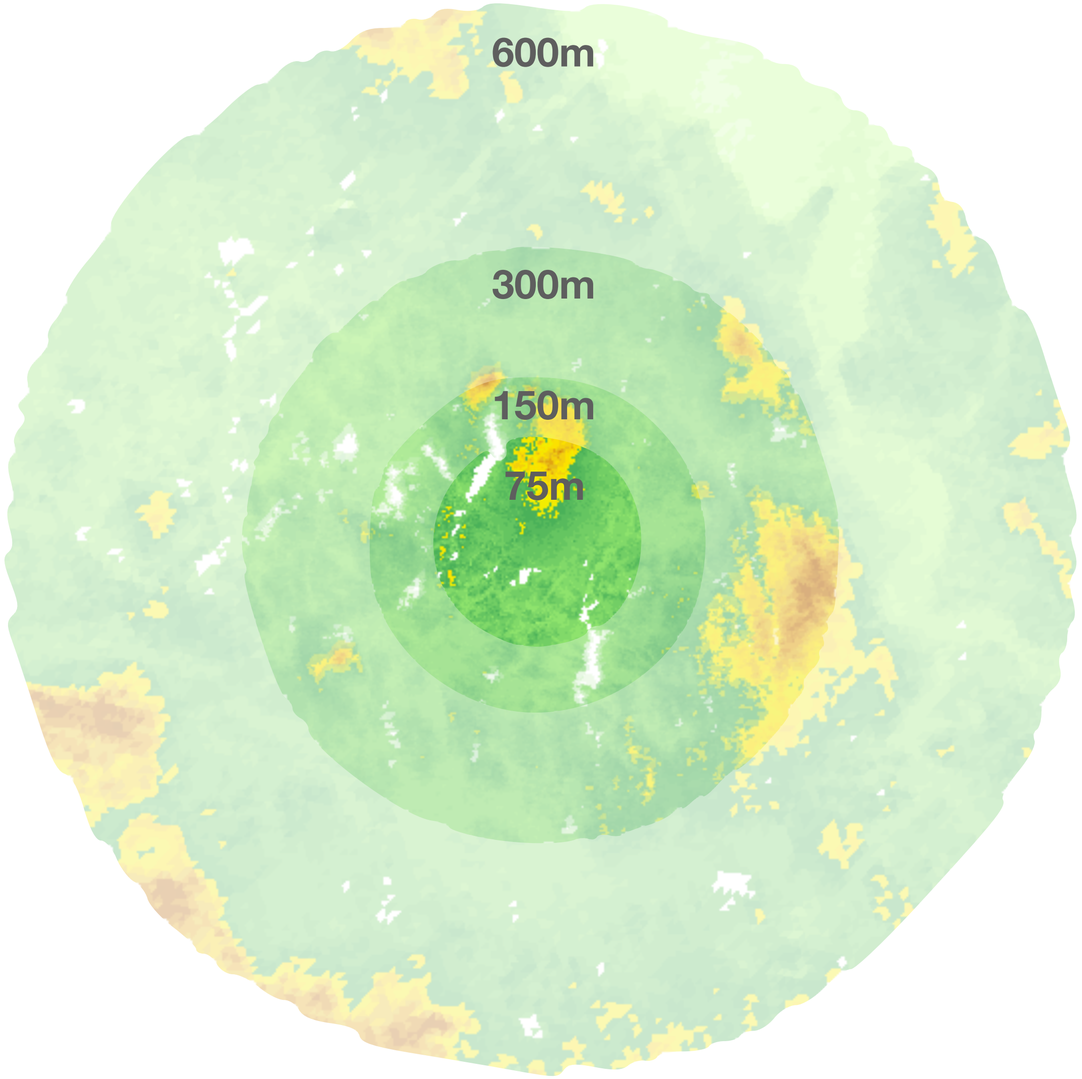
Citizen network

- Low-cost sensors for temperature, humidity, pressure and radiation with housing 3D-printed (Rust et al. 2018)
- Data communication based on LoRaWAN, a long-range wireless data communication protocol with low power consumption
- Instruments built with citizen in workshops

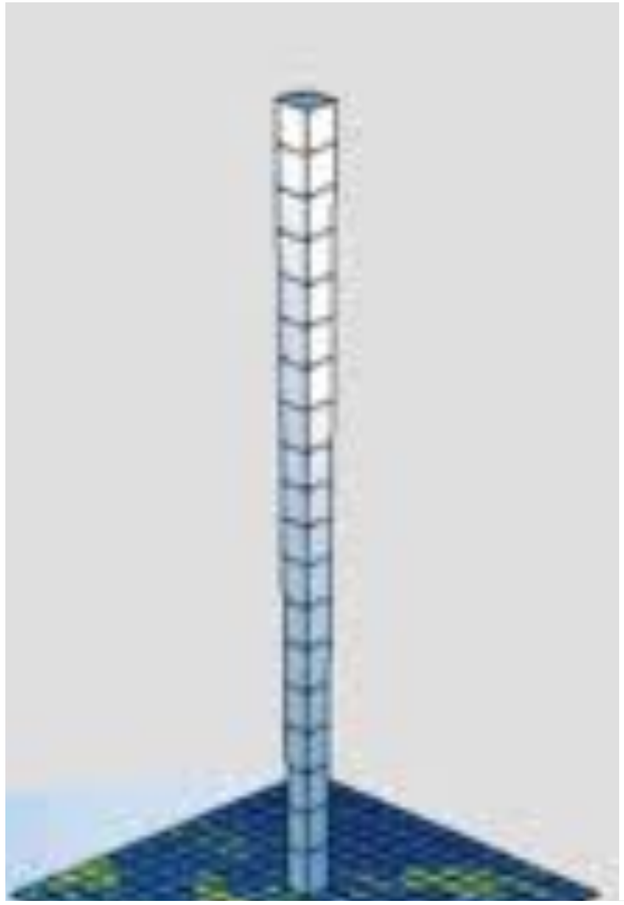


Modeling - evaluation and development

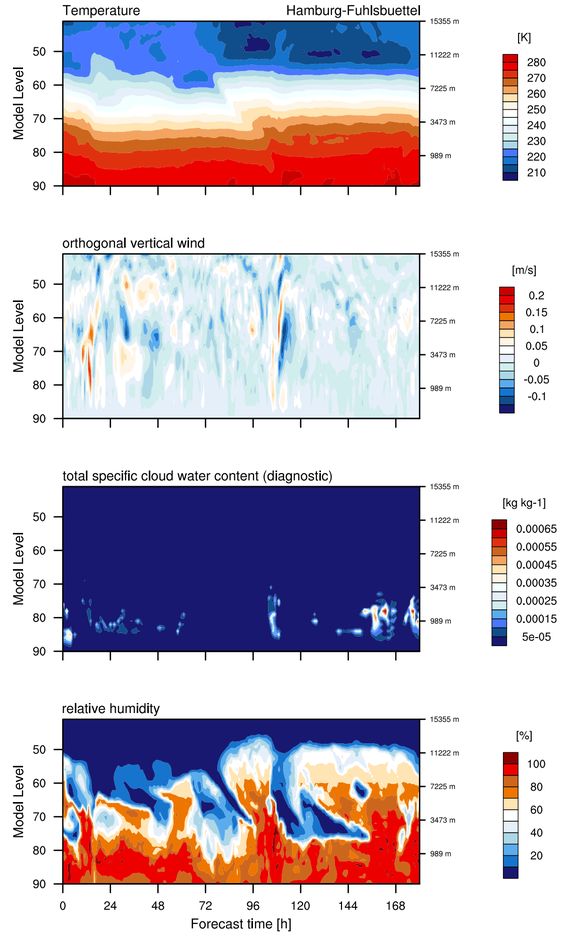
ICON-LES



ICON-SCM



Model point output



Test the new now-to-short-range system SINFONY

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Outlook and summary

FESSTVaL will take place next summer (May - September) in Lindenberg

Measurement strategy will be finalized after tests this summer

Several foci related to sub-mesoscale variability

Test hypotheses, did we learn the right things from models?

Test and improve the models

Summer school in 2020

Website: fesstval.de

FESSTVaL
Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

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DWD

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Should modelers be allowed to the field?

FESSTVaL
Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

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FESSTVaL

Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

Status - CP-Logger

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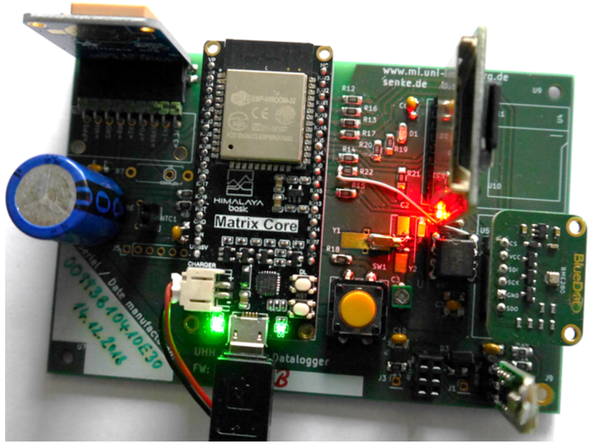
Data logger basierend auf ESP32 Microkontroller entwickelt von Uni. Hamburg



- NTC Temperatur- und BME280 Drucksensor mit 1s Messrate
- Niedriger Energieverbrauch (autonom für 2-4 Wochen - noch keine Dauertests)
- GPS Synchronisierung (Stündlich)
- Datenspeicher auf SD-Karten (ca. 2 MB pro Tag)
- Datendownload via WiFi
- Monitoring mit LoRa (noch nicht integriert)

5 Prototypen im Test

Home Files Logger Help About DEBUG

Cold Pool Data Logger v.99

Cold Pool Project

Welcome to logger
UHH-ColdPool-64E23710410E3

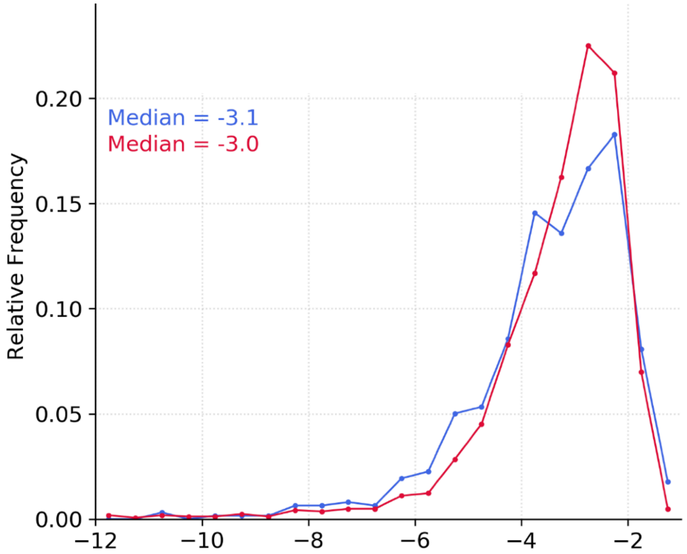
Running firmware version: v.99

GIT: 86fdb5b23dbc90a37ffa140dadf22b599fd9913f

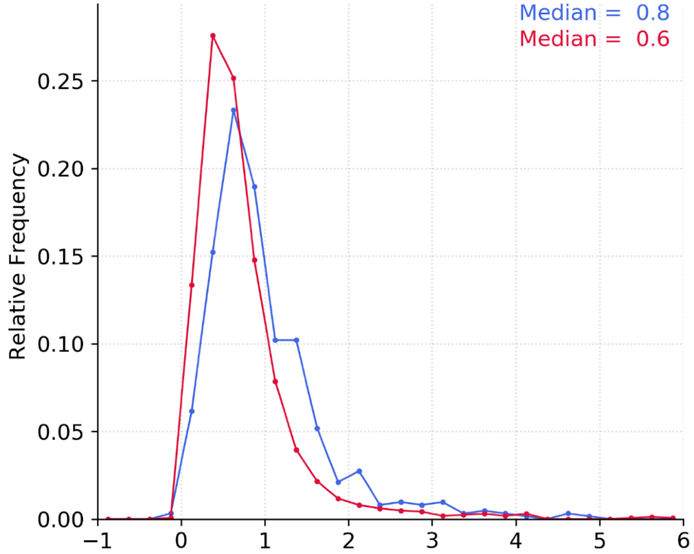
Measured values:

Sensor	Value	Reading	Units	Remarks
BME280	T	24.43	°C	
BME280	P	100403.61	Pa	
BME280	H	27.00	%	
PT1000	T	-32.00	°C	analog -> i2c
NTC, GA10K3MRBD1	R	10000 / 1030 / 515	Ω	analog -> int. AD (12Bit)
Processor core temp	T	56.11	°C	on chip sensor
Hall value	T	0002	---	on chip sensor

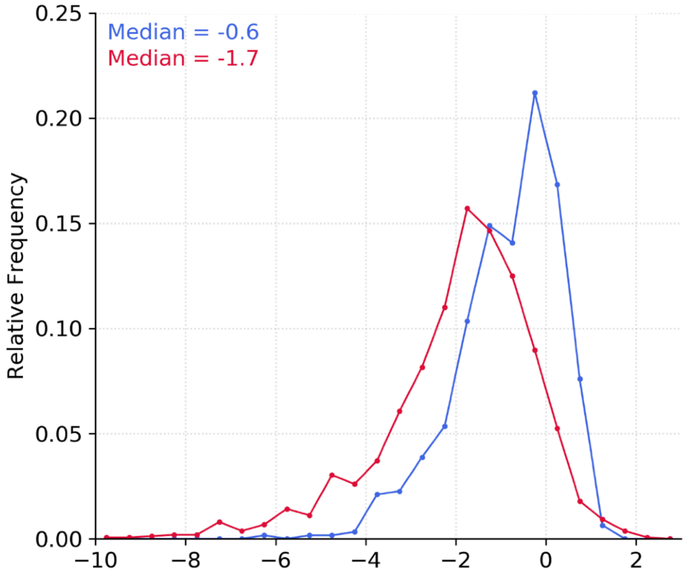
Status - Cold pool detection



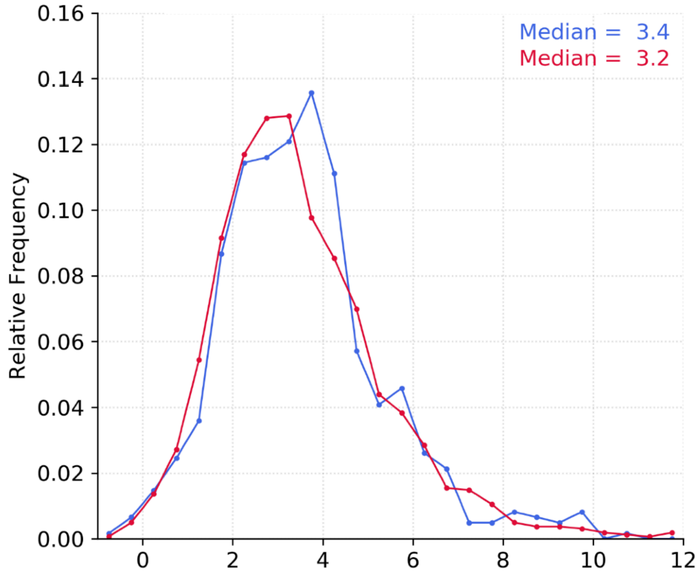
Temperatur Anomalie (K)



Druck Anomalie (hPa)



Taupunkt Temperatur Anomalie (K)



Windgeschwindigkeit Anomalie (m/s)

Beobachtungen und Modelle zeigen konsistent:

$\Delta T > 2$ K
$\Delta p > 0.5$ hPa
$\Delta Td > 1$ K
$\Delta FF > 1$ m/s

Model 625m: Juni 2016 (n=1617)
Wettermast Hamburg 2006-2018 (n=618)

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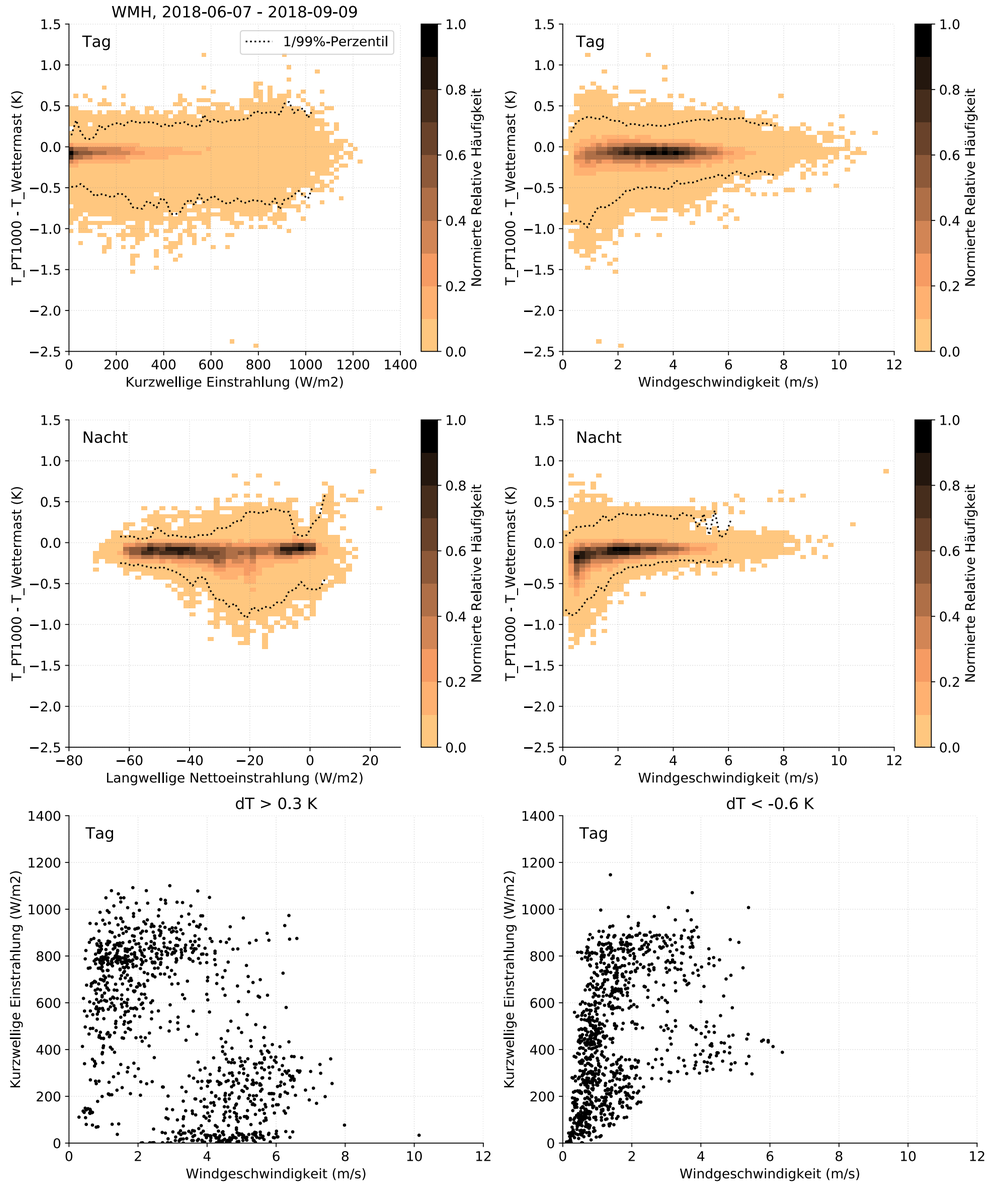
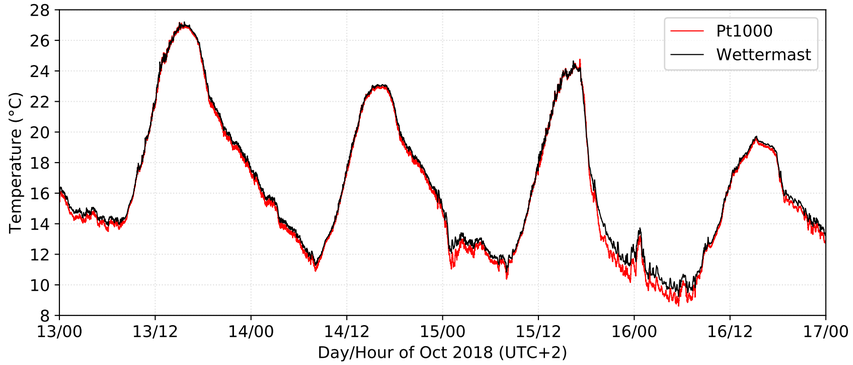
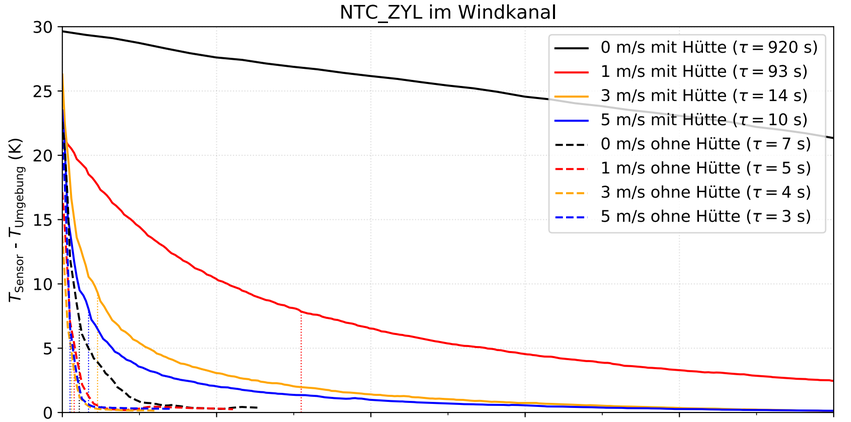
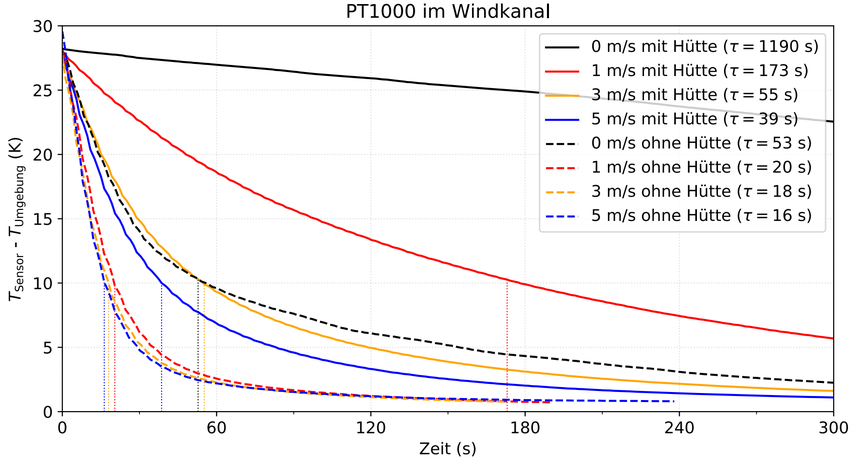
Status - Sensor Charakteristik

Strahlungsfehler und Windeinfluss









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Sommer 2019

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HErZ-HH Instrumente:
- ca. 20 CP-Stagen werden aufgebaut
- ca. 10 WXT (ab Mai schon ein paar)
- Fokus Falkenberg, aber auch ein bisschen Fläche abdecken.
  - Falkenberg ca 5, Holzlager, Strasse zwischen Falkenberg und Lindenberg, Lindenberg, bei Mitarbeitern, Wald, verschiedene Bodentypen

Zusätzliche Daten:
- Scintilometer, Energiebilanz, Wolkenradar (was auch immer da ist), Turbulenz, Regenradar (Prötzel), Satellite (um Grösse abzuschätzen)
- Standart Meteorologie (T, u, v, P_surf) minütlich?
- Wie oft werden die Daten gespeichert und Verfügbarkeit?