Sub-mesoscale observations of cold pools during FESSTVaL

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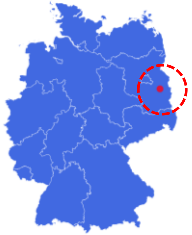
FESSTVaL
Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

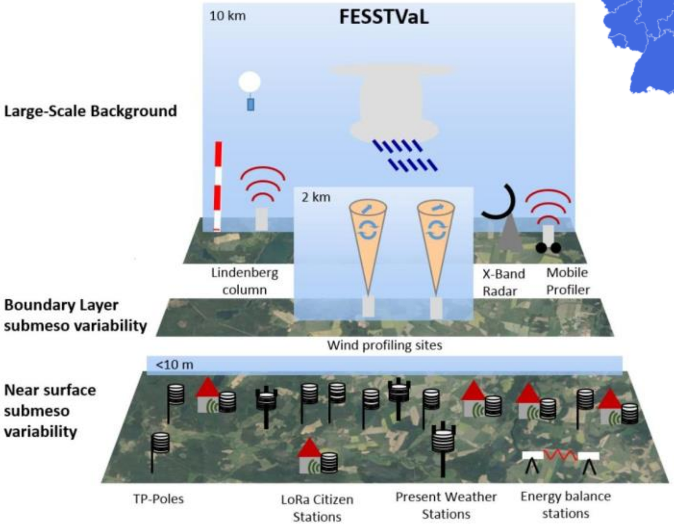
IMPRS-ESM
International Max Planck Research School on Earth System Modelling

FESSTVaL

Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

- Measurement campaign at Lindenberg Observatory in Jun–Aug 2020 (2021?)
- Focus: Sub-mesoscale boundary layer structures and processes
- High-resolution observations with different in-situ and remote-sensing instruments
- Goal: Validation of parametrized and unresolved small-scale phenomena in Large-Eddy simulations:
  - Sub-mesoscale boundary layer patterns
  - Cold pools
  - Wind gusts





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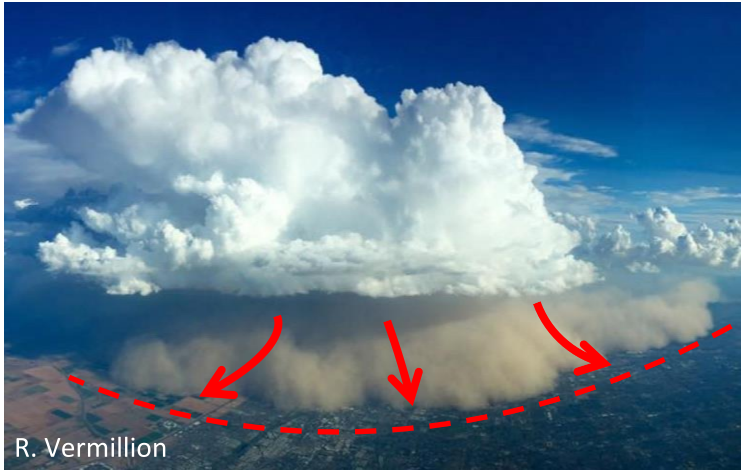
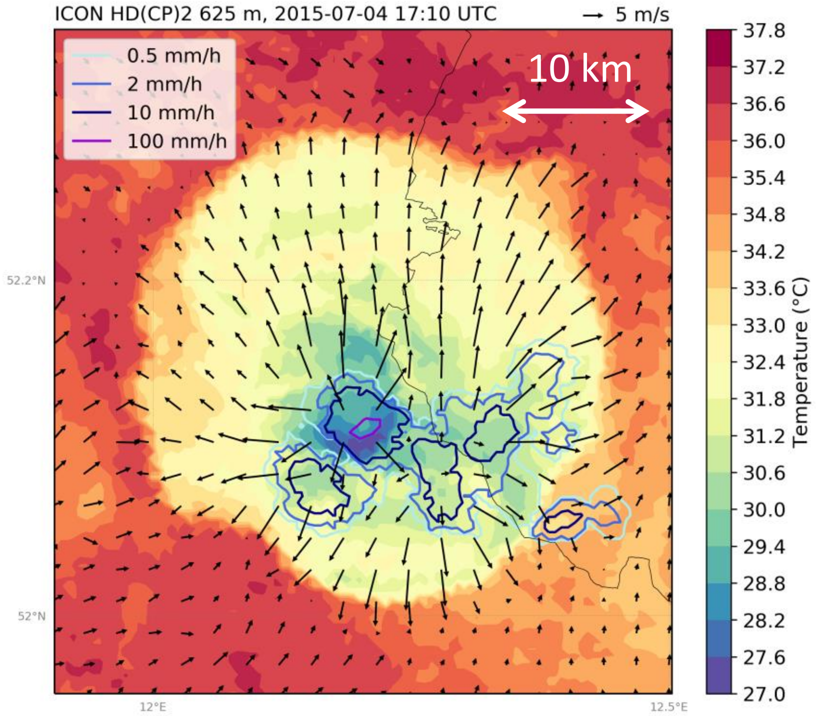
What is a cold pool?

- Local area of evaporatively cooled air forming underneath precipitating clouds
- Spreads on the surface as density current
- Associated with rapid temperature drop, air pressure increase and wind gusts
- Relevant for triggering and organizing convection



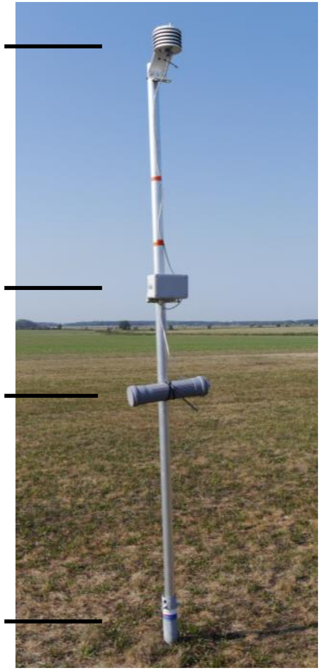
Why do we need FESSTVaL?



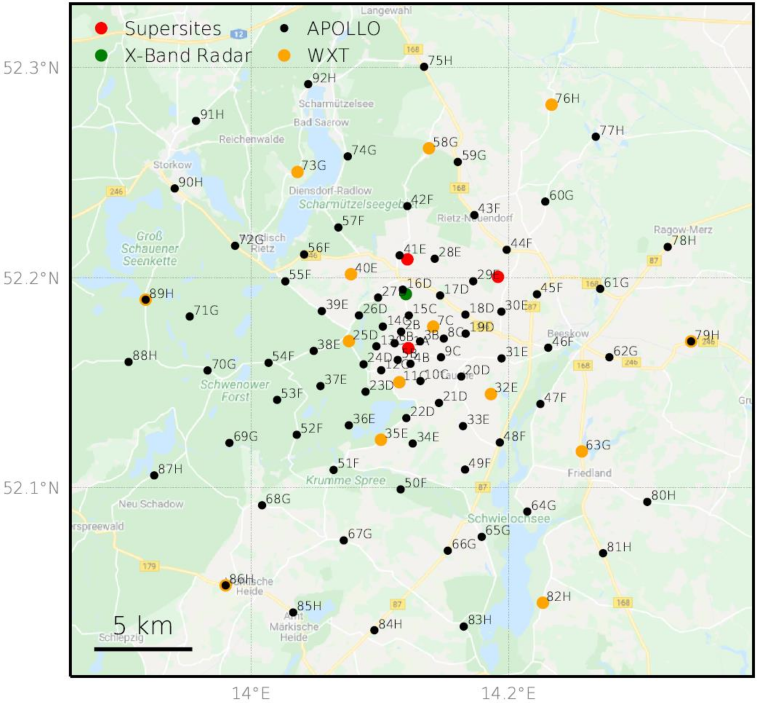
- Large-Eddy simulations explicitly resolve cold pools, but depend on parameterizations (e. g., microphysics).
- We need **observational validation data,** but current observational networks miss the **horizontal component** of cold pools.
- **How realistic are simulated morphological properties like propagation velocity, size and internal variability?**

The APOLLO mission for FESSTVaL

- **Idea:** Set up a measurement network in "LES-resolution" to catch cold pools → we need many stations
- APOLLO (**A**utonomous cold **PO**o**L** **LO**gger)
  - Self-built and self-designed data logger
  - Temperature and pressure sensor (1 Hz)
  - Synchronized with GPS
  - Autonomous operation for 10–14 days with standard power bank battery
  - On-site data download and monitoring via WiFi interface
  - Remote monitoring via LoRa communication



Planned observational setup for FESSTVaL



- 95 APOLLO stations along public streets within 15-km radius and at 3 supersites
- 18 WXT weather stations with additional humidity, wind speed and rainfall sensors
- Energy-balance stations at supersites
- X-band rain radar (60 m resolution)
- Radiosonde launches before and after cold pool passages

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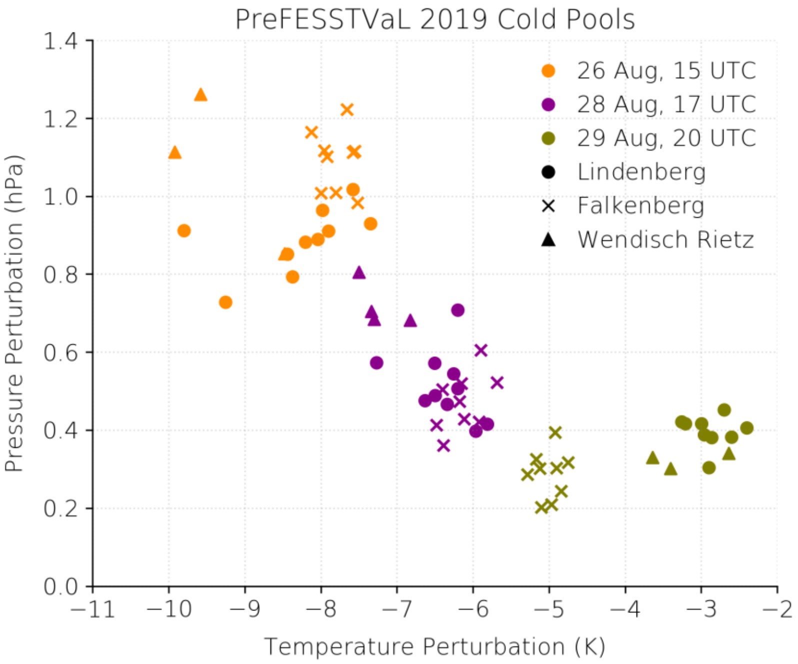
First field experience during PreFESSTVaL 2019

- 10-day trial experiment in Lindenberg in August 2019
- Test setup with 18 APOLLOs and 4 WXTs arranged in ~5 km triangle
- Very stable and reliable measurements
- Temperature and pressure signal of three cold pool events consistently captured at three locations



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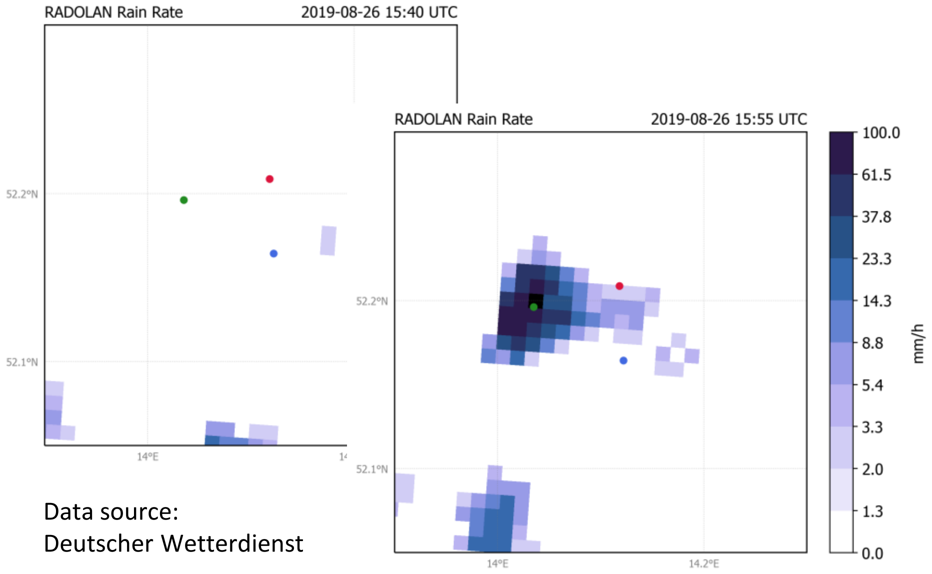
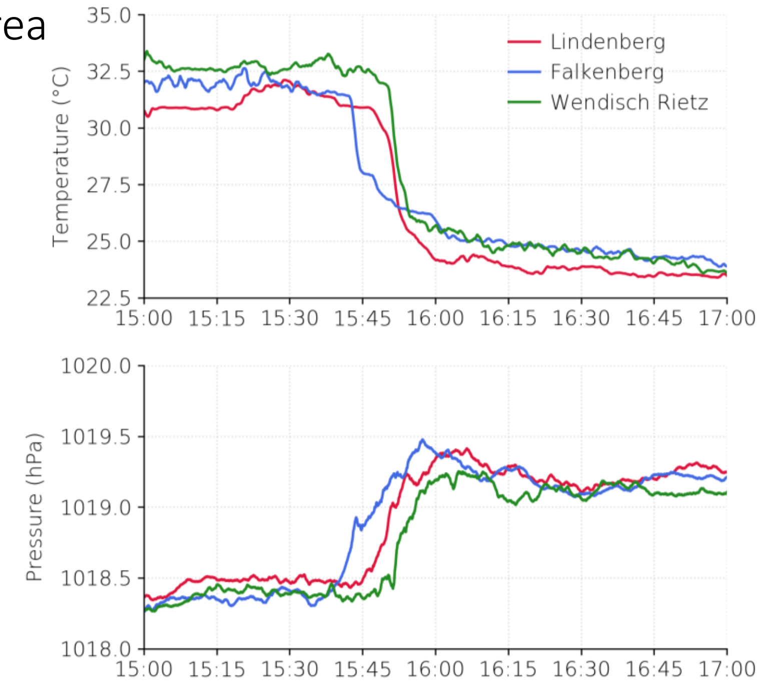
Significant cold pool event on 26 August 2019

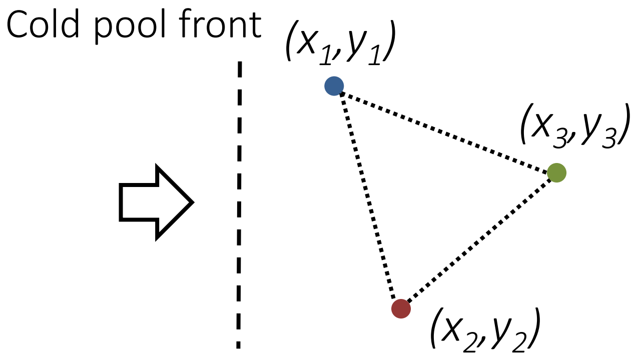
Convective cell rapidly developed over target area

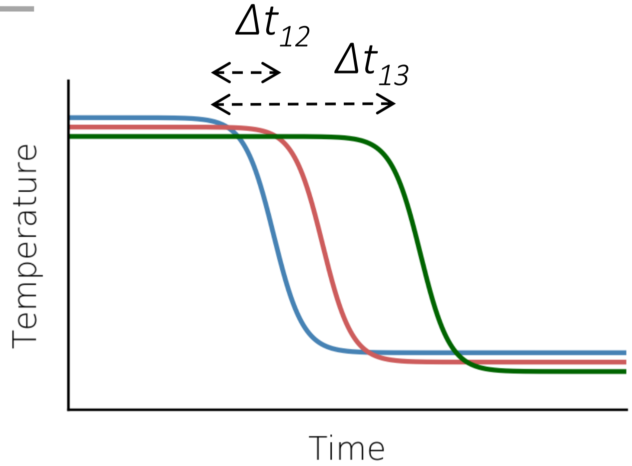


Data source:
Deutscher Wetterdienst



Estimating cold pool propagation



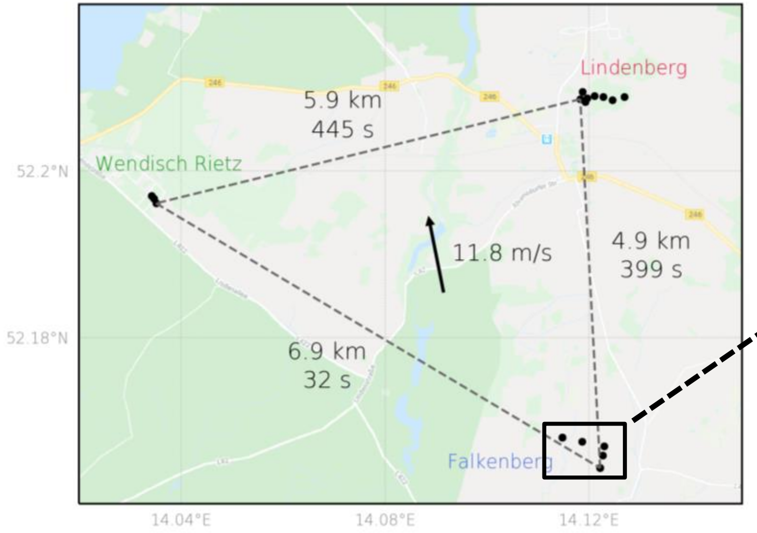


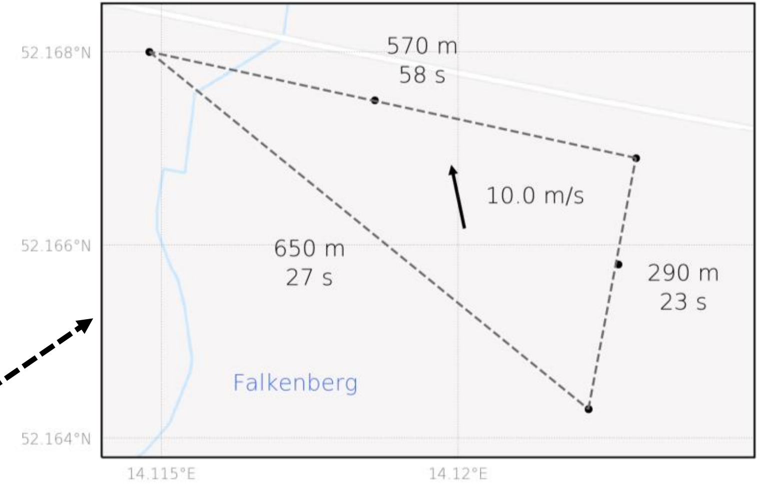
Deriving cold pool propagation from triangle of temperature point measurements:

1. Determine time lags from maximum cross correlation.
2. Calculate $d_x\Delta t$ and $d_y\Delta t$.
3. $(u_{cp}, v_{cp}) = (d_x\Delta t/[(d_x\Delta t)^2+(d_y\Delta t)^2],\ d_y\Delta t/[(d_x\Delta t)^2+(d_y\Delta t)^2])$

Cold pool signal on (sub-)km scale

Propagation of cold pool signal consistently detected on km- and sub-km scale





- Intensification and acceleration of cold pool within 5 km
- **Proposed measurement strategy works!**

How to proceed during the pandemic?

- Plans for FESSTVaL campaign need to be adjusted due to travel restrictions
- Most likely scenario:
  - Main campaign at Lindenberg postponed to summer 2021
  - PreFESSTVaL 2.0 in Hamburg during this summer
  - Approx. 50 APOLLOs and 20 WXTs mainly on private grounds and maintained by UHH and MPI-M members