Sub-mesoscale observations of cold pools during FESSTVaL

Bastian Kirsch (1), Felix Ament (1), Cathy Hohenegger (2), Daniel Klocke (3)
(1) Meteorologisches Institut, Universität Hamburg, Germany
(2) Max Planck Institute for Meteorology, Hamburg, Germany
(3) Deutscher Wetterdienst, Offenbach am Main, Germany

EGU2020: Sharing Geoscience Online, 7 May 2020
• 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:
  o Sub-mesoscale boundary layer patterns
  o Cold pools
  o Wind gusts
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 (Autonomous cold POoL LOgger)**
  – 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
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
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!

B. Kirsch et al.
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