Catching Cold Pools During FESSTVaL 2020

Bastian Kirsch[1], Felix Ament[1], Cathy Hohenegger[2], and Daniel Klocke[3]

[1]Meteorologisches Institut, Universität Hamburg, Germany; [2]Max-Planck-Institut für Meteorologie, Hamburg, Germany; [3]Deutscher Wetterdienst, Offenbach am Main, Germany

Contact: bastian.kirsch@uni-hamburg.de

1. Why Cold Pools?

- Cold pools are areas of evaporatively cooled downdraft air that spread on the surface underneath precipitating clouds.
- Explicitly resolved by modern sub-km Large-Eddy simulations (LES; Fig. 1)
- Play a key role in **triggering and organizing convection**, but almost all knowledge is from (idealized) model simulations
- **We lack observational reference data:**
  - Dynamical properties realistic?
  - How controlled and modified by external parameters?

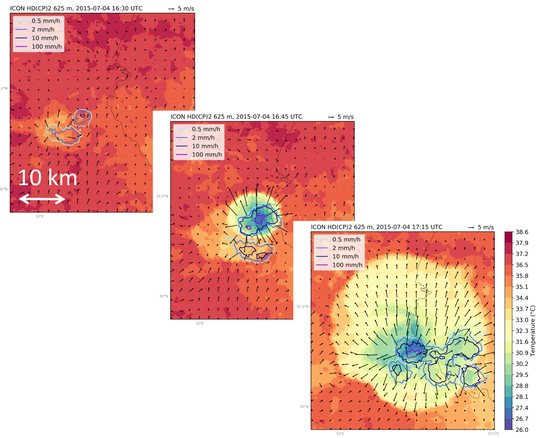

Fig. 1: Snapshots of a cold pool in the ICON-LES HD(CP)² 625 m simulation indicated by 2 m air temperature, 10 m horizontal wind vectors and surface rainfall intensity.

2. How to Catch Cold Pools?

- Field campaign **FESSTVaL** in 2020*:* High resolution observations of sub-mesoscale boundary layer structures and processes
- **Dense surface-based measurement networks** around Lindenberg observatory near Berlin (Fig. 2a):
  - Primary network: 100 autonomous data loggers (*TP-Poles*) for temperature and pressure (Fig. 2b; see box below)
  - Secondary network: 22 WXT weather stations for further parameters (Fig. 2c)
  - 3–5 energy balance stations as reference measurement points
  - X-band rain radar (20 km range)

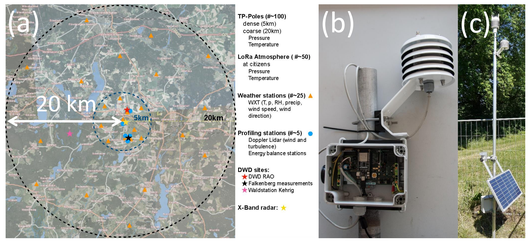

Fig. 2: (a) FESSTVaL observation networks, (b) prototype TP-Pole data logger, (c) WXT weather station on 3 m pole.

TP-Poles: The Backbone of FESSTVaL

- **Simple and cheap data loggers** based on ESP32 microcontroller boards (Fig. 2b), installed on 2 m poles
- Optimized for **low power consumption**, equipped with power banks
  → autonomous operation for 2–4 weeks
- Fast NTC **temperature** and BME280 **pressure** sensors with **1 s sampling rate**
- Synchronization with GPS
- Local data storage on SD cards
- Data download via WiFi
- Remote monitoring with LoRa technology

3. Which Cold Pool Signals Can We Expect?

- Detection of cold pool front passages from rapid temperature drops associated with rainfall
- **Consistent cold pool-related anomalies** in temperature, pressure, dew point and wind from **observations and model data**: Δ*T*≈-3 K, Δ*p*≈1 hPa, Δ*Td*≈-1 K, Δ*FF*≈3 m/s (Figs. 3a–d)
- Annual cycle in monthly cold pool number, peaking in July with an average of 11 (Fig. 3e)
- **Pronounced diurnal cycle** in cold pool activity with peak in strength delayed by 2 hours (Figs. 3f–g)

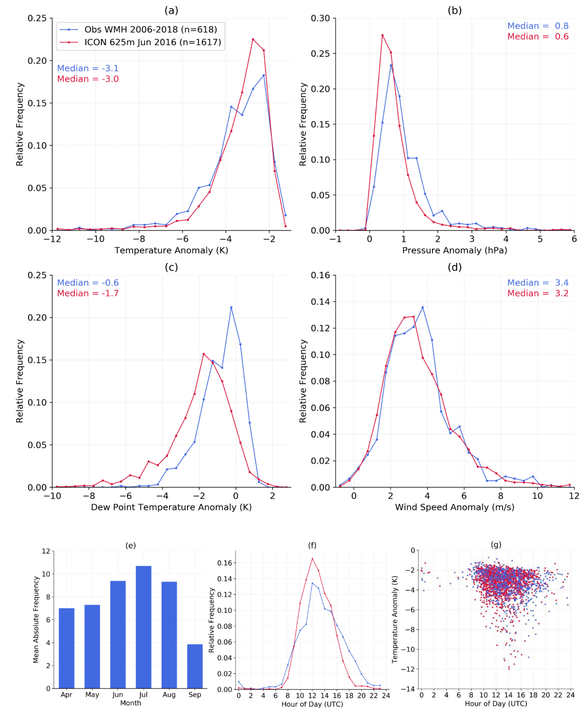

Fig. 3: Cold pool statistics from Hamburg Wettermast observations (2006–2018) and ICON-LES 625 m simulation (June 2016): (a)–(d) PDFs of air temperature, pressure, dew point and wind speed perturbations, (e) annual cycle of number, (f)–(g) diurnal cycle of number and temperature anomaly.

4. What's Next?

- Ongoing work on development of data loggers and manufacturing of measurement stations
- Further analysis of existing data sets
- Test campaign in summer 2019
- **Main campaign June–August 2020 with IOP and Summer School in July**