Convective cold pool vertical structure analysis during FESSTVaL

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One main research focus of the Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg (FESSTVaL), which took place from June to August 2021, was on observing convective Cold Pools (CP) with unprecedented spatial and temporal resolution. Here, adding to the horizontal analysis based on a high-density near-surface network, we show novel insights into the vertical structure of cold pool passages using three ground-based remote sensing sites in a triangle configuration with ~6km legs. The three sites each included a Doppler Wind Lidar (DWL) operated in a quick scanning configuration, which enables to capture wind gusts with a temporal resolution of 3-4 s. In addition, microwave radiometer profilers (MWR) for temperature profiling and ceilometers for cloud base detection were available at each site. Based on this instrumentation, we analyze a cold pool case study as well the statistics of all cold pools observed during FESSTVaL.

The cold air outflow of the CP case study spreading radially from the CP center is nicely detectable. The observed MWR temperature profiles and the vertical shear of the horizontal wind can be used to derive the CP vertical extent. . Additionally, the profiles of the vertical wind vector component clearly show how the near-surface cold air lifts the preceding warmer air to heights well above the original boundary layer height. At the outer edge of the CP, new convection is triggered and the separation line between near-surface cold air and uplifted warm air meanders like a gravity wave.

The statistical analysis reveals typical CP heights between 800 m to 1000 m and gust front speeds up to 20 ms^{-1}. Strong updrafts of more than 1.5 ms^{-1} were present in all detected cold pool cases. These are followed by gust fronts, which exhibit immediate wind speed increases exceeding 10 ms^{-1} compared to conditions before the cold pool. On average, a temperature drop at 50 m height of 2 K can be detected, while the strongest temperature drops are 6 K.

Our analyses demonstrate the high potential of novel synergistic ground-based remote sensing approaches to provide both spatially and temporally high-resolution observations of CP.