Sub-mesoscale evolution of gust patterns measured with three lidars

Julian Steinheuer[1,2,3], Ulrich Löhnert[1,2], and the FESSTVaL Team

[1] Institute of Geophysics and Meteorology, Universität zu Köln, Cologne;

[2] Hans-Ertel Centre for Weather Research, Climate Monitoring and Diagnostics, Cologne/Bonn;

[3] *Julian.Steinheuer@uni-koeln.de*

collaborative data here: *cen.uni-hamburg.de/icdc/*

Structure

1. Overview
2. Cold front passage on June 12, 2021
3. Cold pool on June 29, 2021
4. Conclusion

Objectives

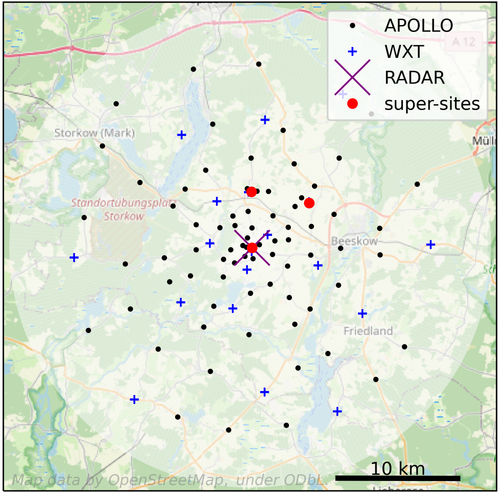


Figure 1: FESSTVaL area with 3 super-sites in 6 km distance from each other (red): Lindenberg (L ,North), Birkholz (B, Northeast), Falkenberg (F, center).

Within the FESSTVaL campaign we use Doppler wind lidar (DWL)

- to generate high-resolution wind profiles in the atmospheric boundary layer (ABL)
- to detect sub-mesoscale variability in wind field by using multiple DWLs
- to investigate storms with different remote sensing devices

Quick continuous scanning mode (CSM)

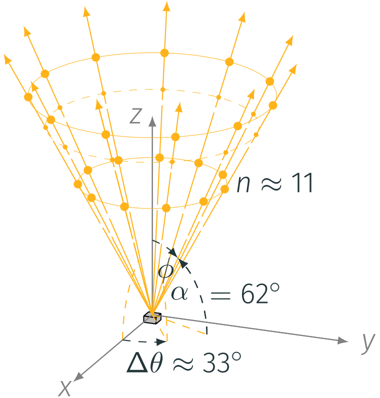


Figure 2: Observation principle of CSM with 11 measurements in 3.4 s and 3000 pulses/beam.

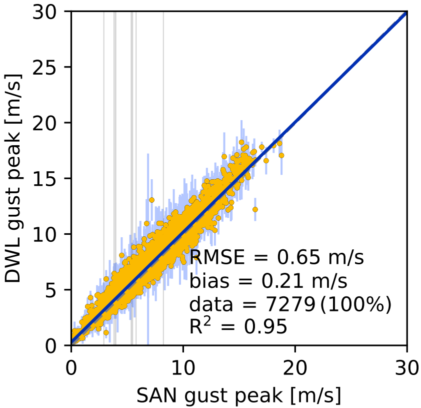


Figure 3: Sonic anemometer (SAN) gust (3 s in 10 min) vs. DWL gust (3.4 s in 10 min) at 90.3 m in Falkenberg (18.5.21 - 31.8.21).

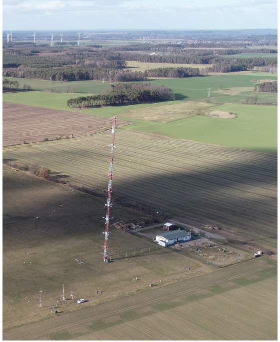


Figure 4: Meteorological tower in Falkenberg

→ see Steinheuer et al. 2022 for the gust retrieval

Cold front passage on June 12, 2021

Triangle measuring of cold front passage on June 12, 2021 (day)

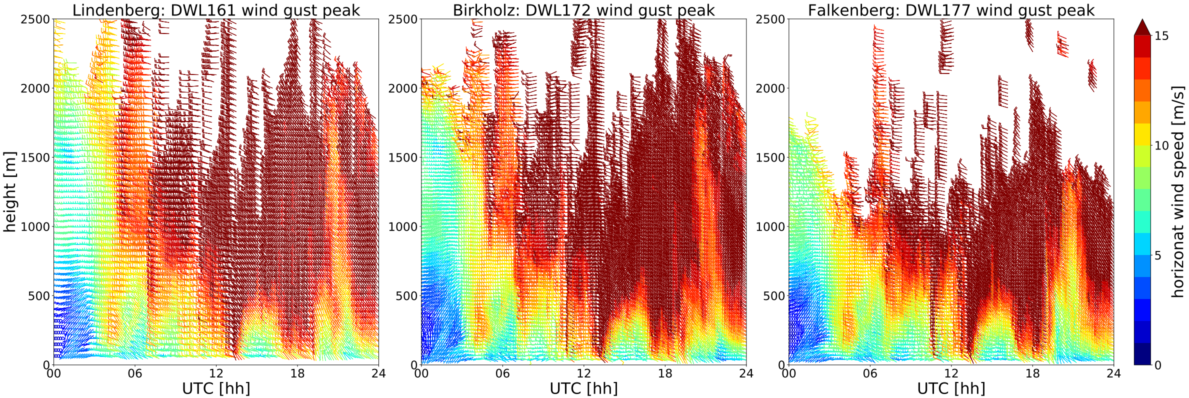
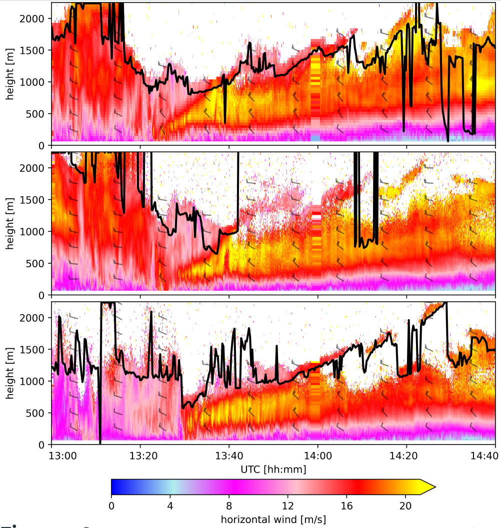


Figure 5: Wind barbs for 10 min gust peaks on June 12, 2021 for the three different FESSTVaL super-sites

→ DWL retrieves similar winds

→ 10 min resolution too coarse to distinguish features of front at 13-14 UTC

Cold front passage on June 12, 2021 ($13^{00} - 14^{40}$ UTC)



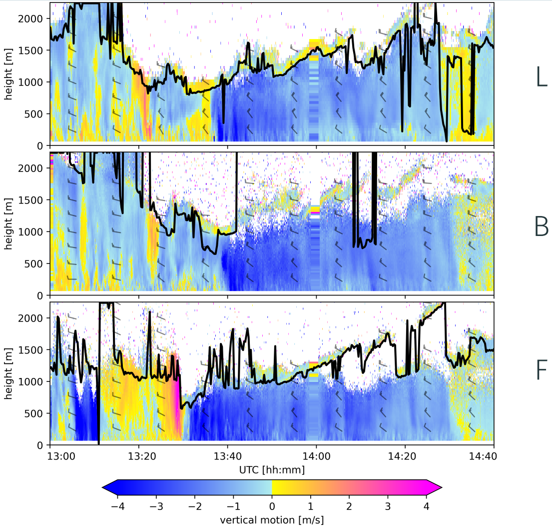


Figure 6: High-resolution (3.4 s) horizontal wind (top L, middle B, bottom F) with lowest cloud base height.

Figure 7: High-resolution vertical motion (top L, middle B, bottom F) with lowest cloud base height.

Cold front passage on June 12, 2021 (13^{00} – 14^{40} UTC)

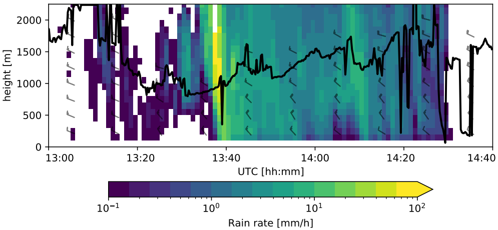


Figure 8: Rain rate from micro rain radar in L.

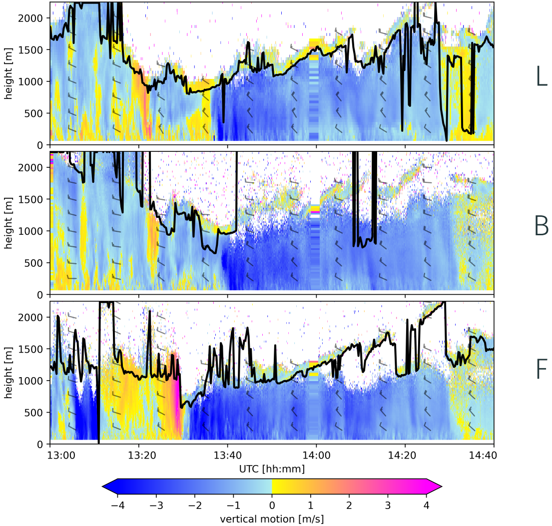


Figure 7: High-resolution vertical motion (top L, middle B, bottom F) with lowest cloud base height.

Cold front passage on June 12, 2021 (13^{00} – 14^{40} UTC)

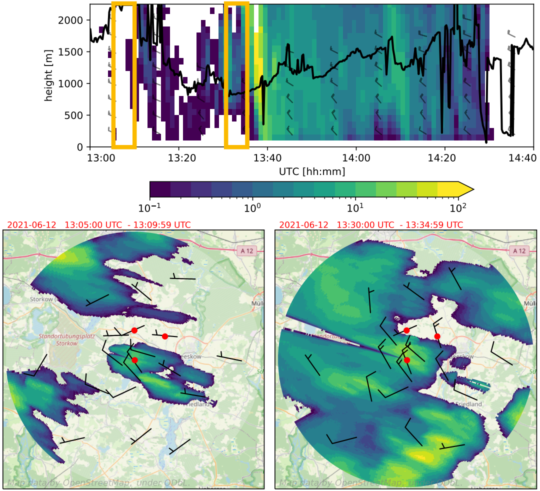


Figure 8: Rain rate from micro rain radar in L and HH mobile X-Band radar in F (5 min accumulated).

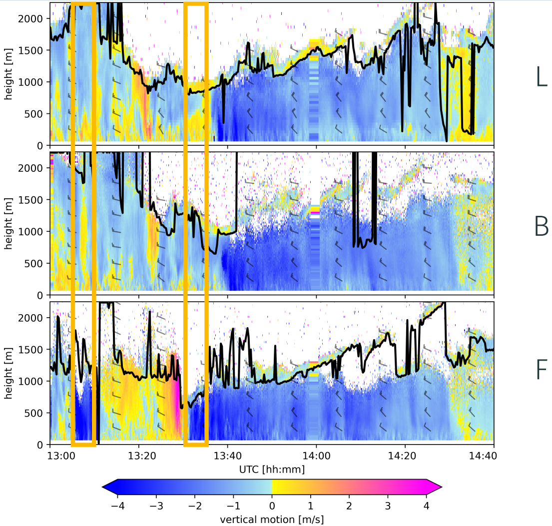


Figure 7: High-resolution vertical motion (top L, middle B, bottom F) with lowest cloud base height.

Cold front passage on June 12, 2021

→ increased wind speeds and wind direction jumps visible in the ABL

→ negative vertical velocities are an indicator for rain

Cold pool on June 29, 2021

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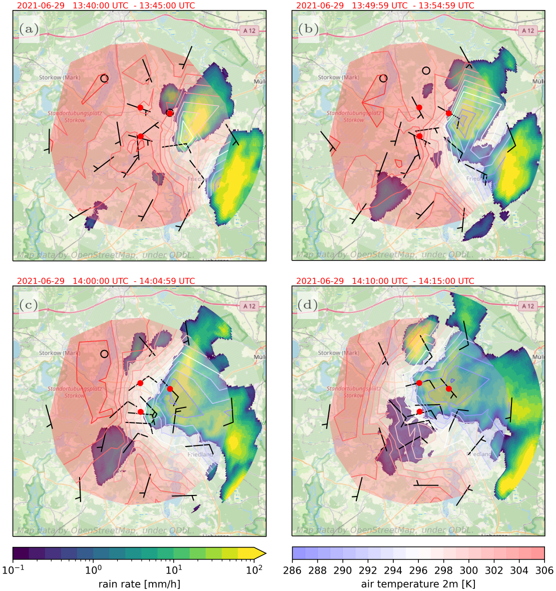

- forms in the southeast
- intensifies as it moves north
- reaches Birkholz and marginally Lindenberg
- does not cause rain in Falkenberg, but its temperature and wind influences are recognizable

Figure 10: Rain rate from HH mobile X-Band radar in F (5 min accumulated) with temperature field from interpolated WXTs/APOLLOs (HH network).

Cold pool on June 29, 2021 ($13^{20} - 15^{00}$ UTC)

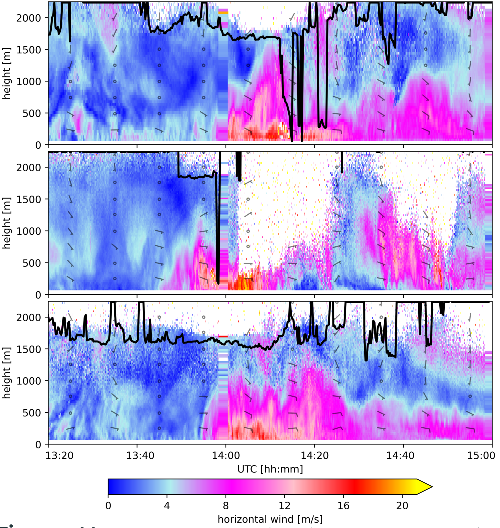

Figure 11: High-resolution (3.4 s) horizontal wind (top L, middle B, bottom F) with lowest cloud base height.

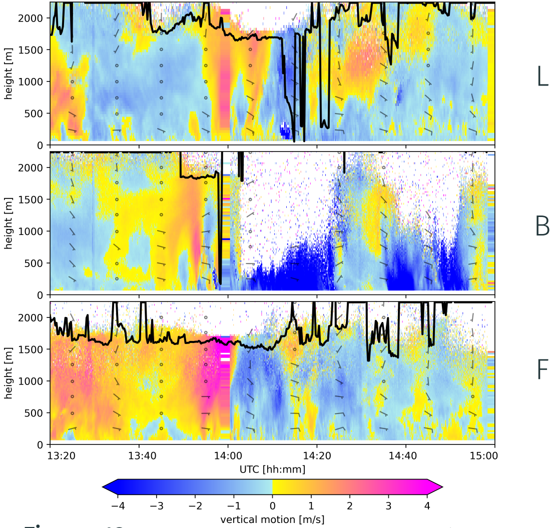

Figure 12: High-resolution vertical motion (top L, middle B, bottom F) with lowest cloud base height.

Cold pool on June 29, 2021 (13^{20} – 15^{00} UTC)

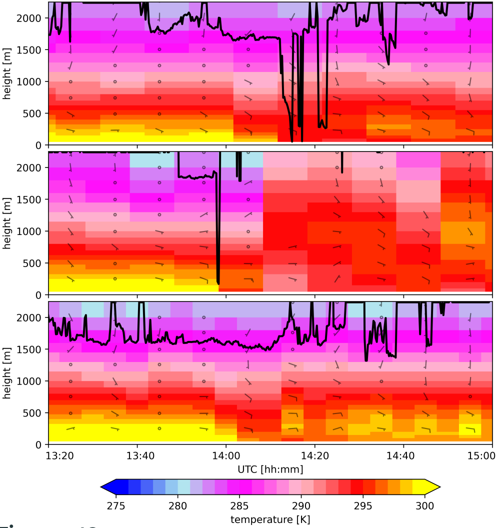

Figure 13: Temperature profiles from micro wave radiometers in elevation scan (at L, B, F).

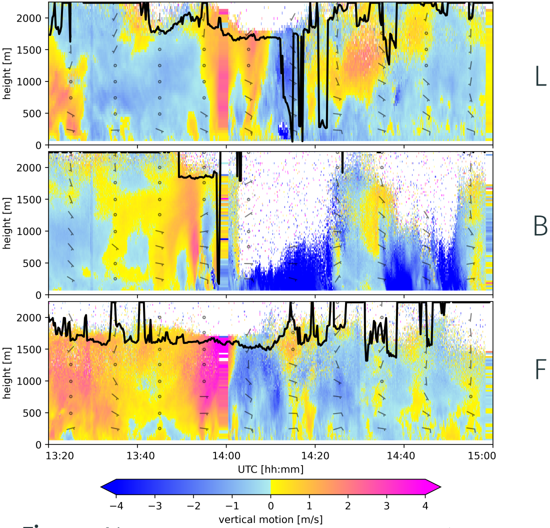

Figure 14: High-resolution vertical motion (top L, middle B, bottom F) with lowest cloud base height.

Conclusion

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→ DWLs are capable of accurately measuring high-resolution winds

→ small-scale variability is resolvable (updrafts, downbursts, rain)

→ new option to study weather phenomena

… further case studies possible, including statistical analysis of cold pools

References

Steinheuer, J. et al. (2022). “A new scanning scheme and flexible retrieval for mean winds and gusts from Doppler lidar measurements”. In: *Atmospheric Measurement Techniques* 15.10, pp. 3243–3260. DOI: *10.5194/amt-15-3243-2022*. URL: *https://amt.copernicus.org/articles/15/3243/2022/*.

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