Splitting Supercells over Berlin - July 10, 2020

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Background:

This case study takes a closer look at the organization of storms initiating in an urban environment that can have impacts on public life and infrastructure. Therefore an exemplary weather event over East Germany should be discussed in greater detail. While referring to our theoretical and conceptual knowledge about supercelluar convection, it is important to clarify questions around the synoptic pattern and convective environment. Local effects and short-term changes can greatly affect the development of deep moist convection and should be well considered.

Synoptic Pattern - ERA 5 Reanalysis | VIS Satellit

On July 10, 2020, a positively tilted trough moved into Central Europe, leading to the development of a surface low over North-East Germany. A lack of instability provided only light to moderate CAPE (800-1200 J/kg) available to storms. Nevertheless, the environment in which storms developed was highly sheared (25-30 m/s) favoring supercellular convection. As the day progressed, an east-west oriented surface warm front extended from Berlin (Germany) to near Białystok (Poland). Surface observations located the corresponding moisture convergence over the capital, overlapping with quite steep low level lapse rates originating from higher terrain over South-Central Germany. Due to the slight frontal expression forcing was reduced. With the shear vector perpendicular to the initiating boundary convective mode appeared isolated allowing storms, especially the right diviating ones, to coexist. Weak storm relative inflow winds (Peters et al. 2020 [8]) caused mainly small cells to develop. Better ingredients were given further east, where several storms produced large hail and servere wind gusts over Poland (Fig. 4).

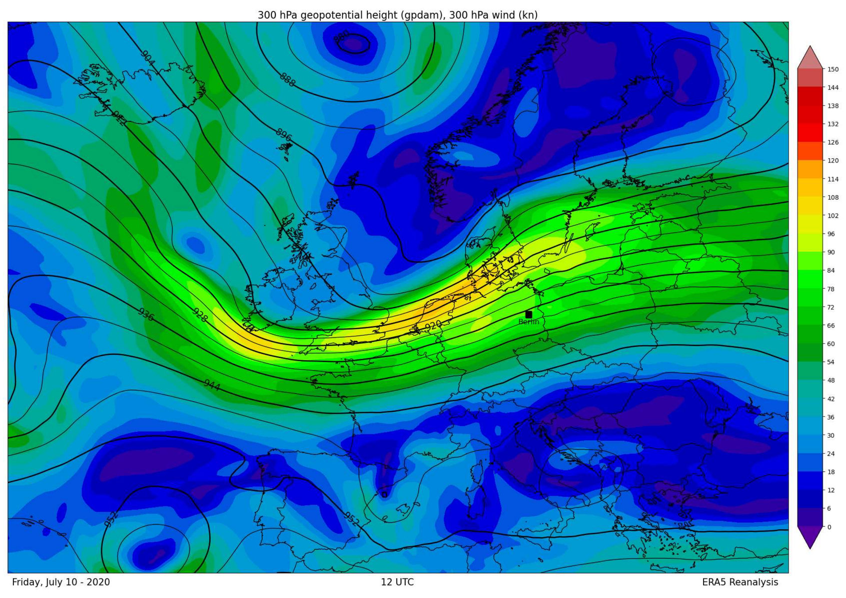


Fig. 1: Geopotential & Wind 300 hPa [4]

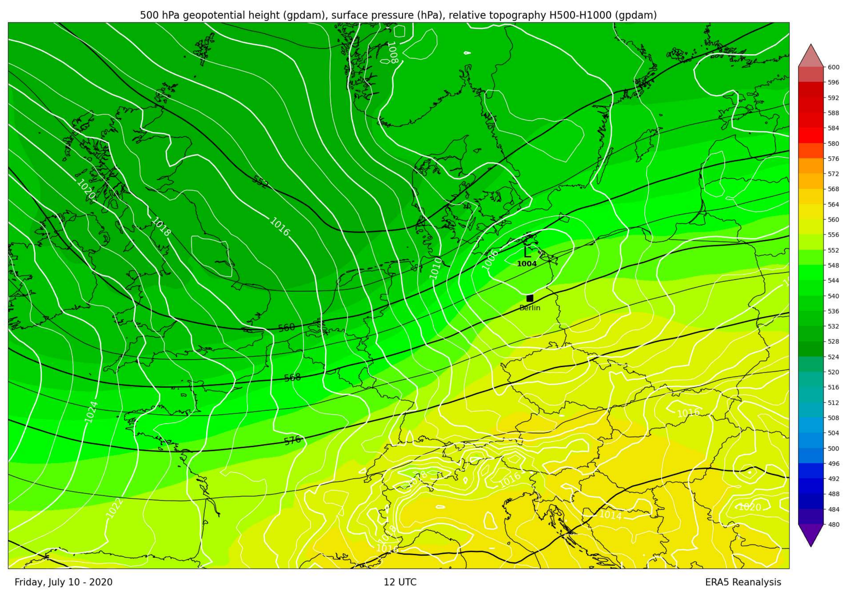


Fig. 2: Relative Topografie H1000-H500 [4]

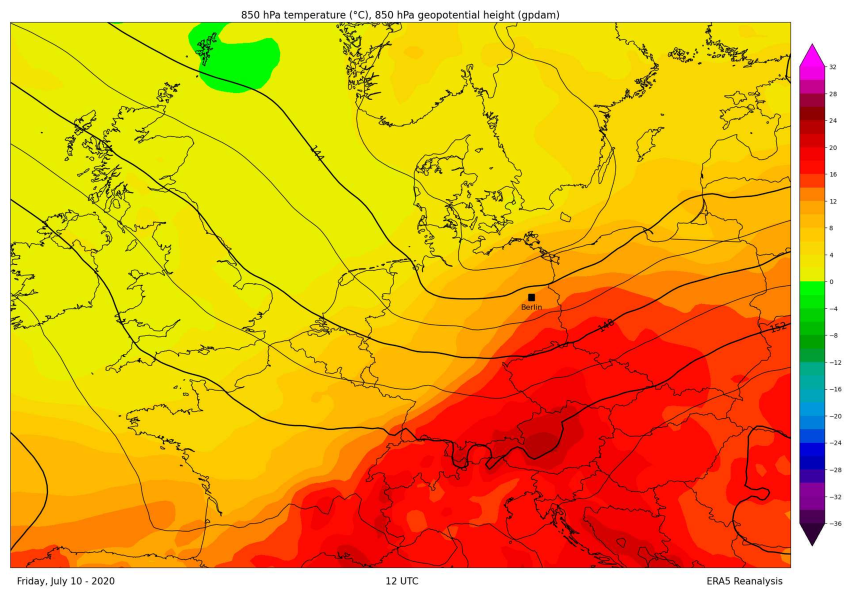


Fig. 3: Geopotential & Temp. 850 hPa [4]

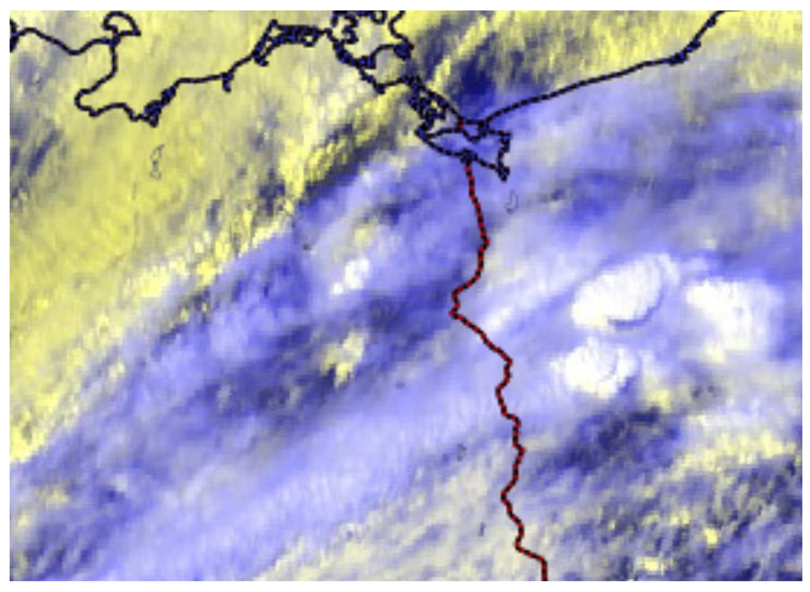


Fig. 4: Visible Satellit 13 UTC [6]

Forcasting

Convective allowing models like "Swiss Super HD" (1×1 km) operated by the Kachelmann GmbH simulated isolated convection with bean shape signatures + 38h prior initiation.

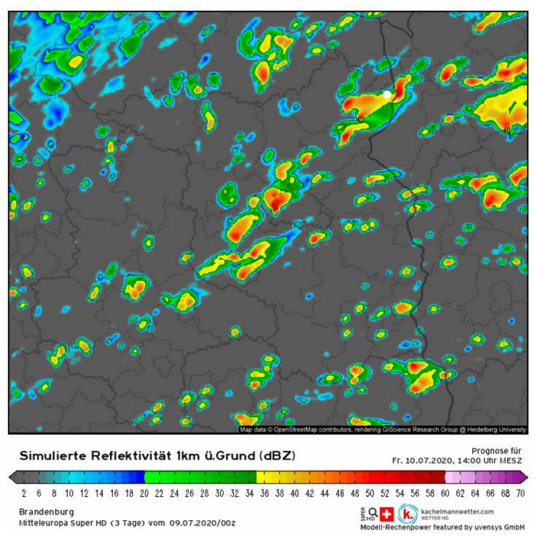


Fig. 5: Forecast (+ 38h) [1]

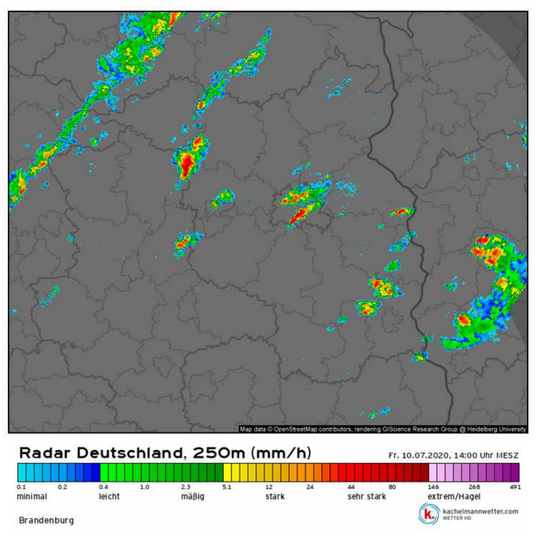


Fig. 6: Radar observation [1]

Nowcasting

Radar based Celltracking-Systems help forecasters in their decision-making process. The Nowcasttool managed to detect the splitting storms. In case of an impactful development, a warning could have been issued for city districts in path of these storms.

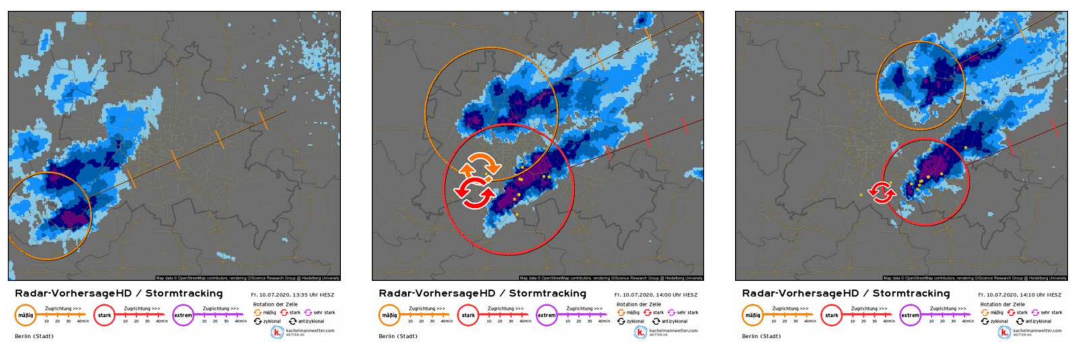


Fig. 7-9: Detected by the Stormtracking-Nowcasttool [1]

Storm Scale Dynamics

Initial splitting. Horseshoe vortex might indicate crosswise orientation of vortex lines and their tilt by convection.

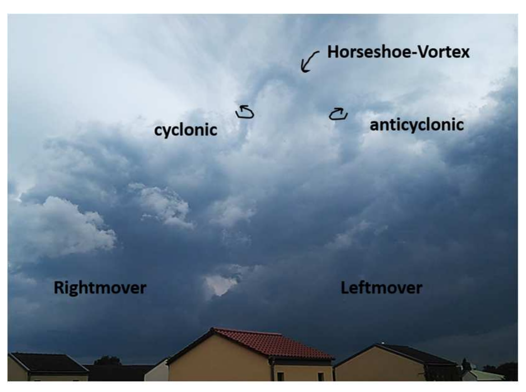


Fig. 10: Ahead L & RM [7]

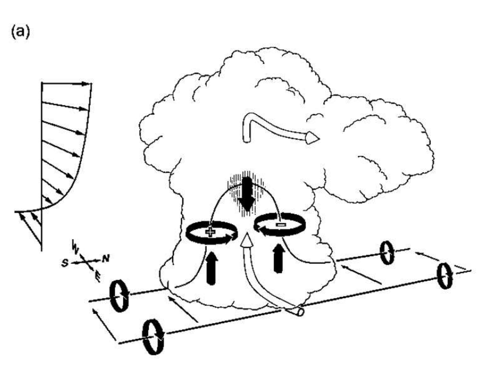
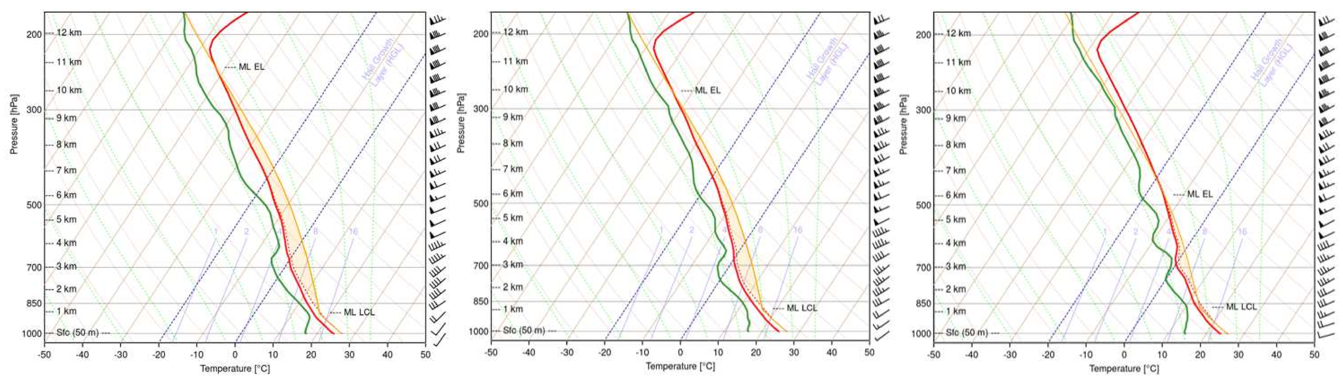


Fig. 11: Conceptual Model [5]

Convective Environment - ERA 5 Reanalysis | Observation

1. Thermodynamics:

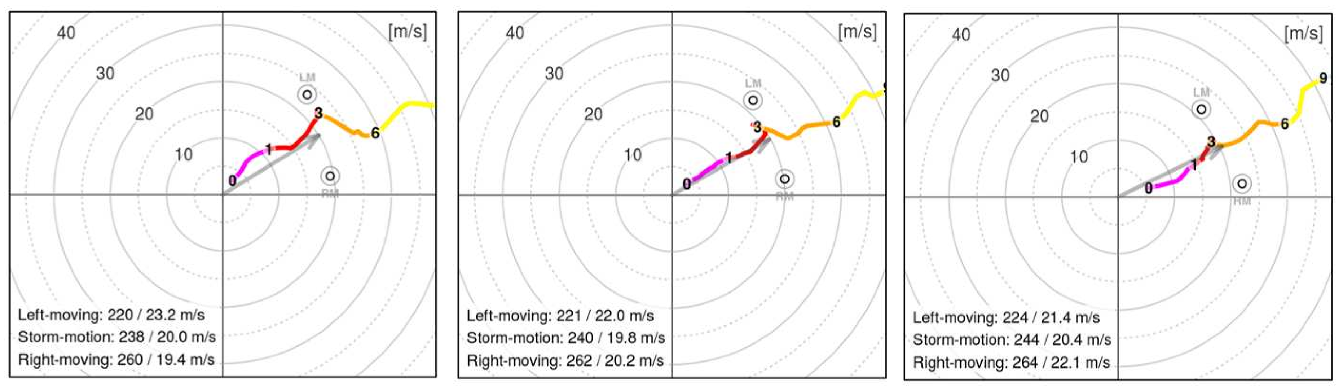
Whith the approaching cold front instability decreased, while the proximity sounding remained sufficiently moist. A dewpoint reaching 19°C and enough daytime heating primed the enviroment for early initiation. Increasing surface temperatures further south provided greater instability for Rightmovers, but also higher cloud bases within a well-mixed, drying boundary layer. Profiles on the cold side were more stable, making it difficult for Leftmovers to persist. Closer to the front, however, they experienced enhanced forcing.



★ Fig. 12-14: Change of vertical profile between 11 & 13 UTC [2]

2. Kinematics:

With initiation on a surface boundary, low level winds shifted from south to west. The shear vector pointed parallel to storm motion vector, creating a crosswise environment with equal amounts of SRH available for the left- and rightmoving storm. Using bunkers technique (Bunkers et al. 2000 [9]) storm motion could have been estimated very simple. Keep in mind that the hodograph alone cannot predict storm behavior if there is external forcing acting on storms (C. Nixon 2022 [10]).



★ Fig. 15-17: Change of wind profile between 11 & 13 UTC [2]

3. Radar:

Two rounds of splitting storms moved over Berlin in the early afternoon hours. The first couple (Fig. 18) entered the capital around 11:30 UTC. Anvil SR-winds ventilated the stratiforme precipitation of both storms straight to the direction of the mean wind that determined their general movement in the initiation stage. The second couple of storms moved into Berlin around 13 UTC and was pretty soon dominated by its righmover (Fig. 19).
A loss of effective shear (Thompson et al. 2004 [11]) may explain their shorter DBZ core, as they tend to be more low topped (Fig. 13-14). During the period, the given wind profile experienced almost no change (Fig. 16-17).

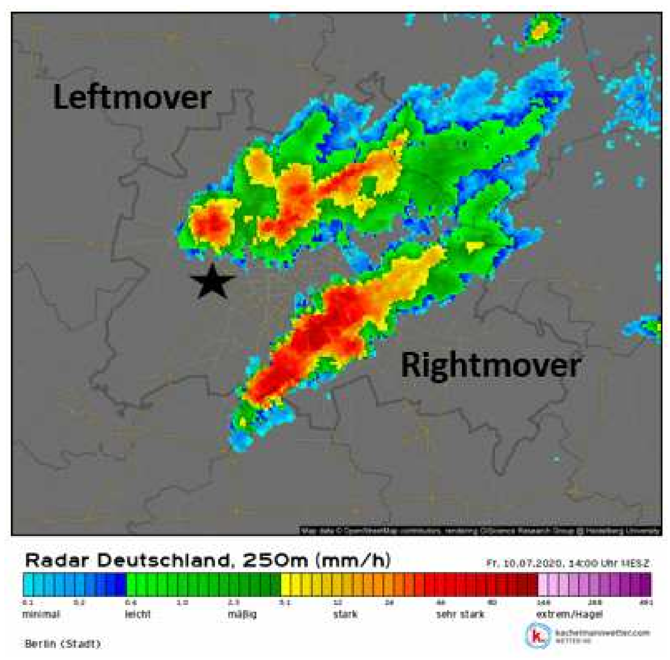


Fig. 18: Cellsplit 1 (12 UTC) [1]

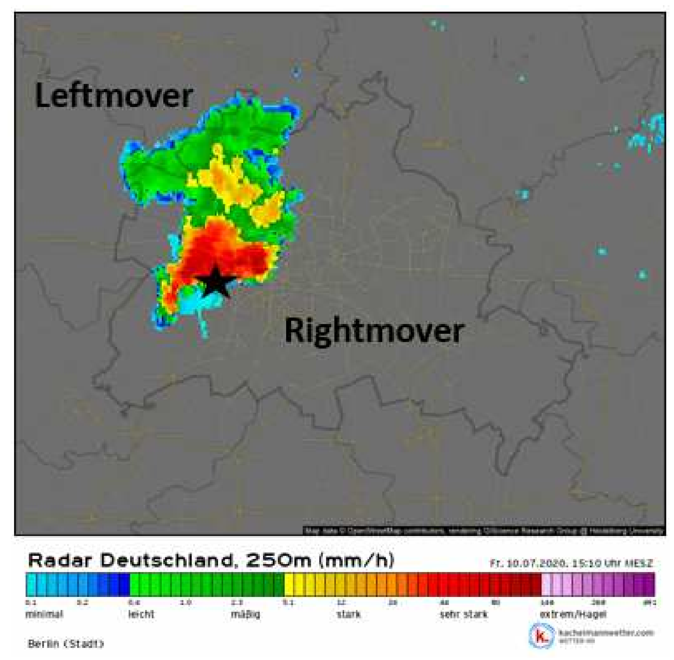


Fig. 19: Cellsplit 2 (13:10 UTC) [1]

4. Mesocyclone Detection:

A radar-based algorithm developed by the German Weather Service (DWD) detects and classifies mesocyclones according to their severity.
A severity level 2 persisting for 2 sweeps was detected for the first rightmoving storm (Fig. 18). Considering that the algorithm only evaluates cyclonic rotation, the authors assume that the single detection of same severity can be associated with the second Rightmover (Fig. 19), which choosed a track further north.

Fig. 20: Mesocyclones detected by DWD-Algorithm [3]

Conclusion & Future Work

Convective Pattern:

- Warm season setup (zonal flow regime, surface low development, jet exit region)
- Isolated convective mode (shear vector orientation, frontal expression & amount of lift, CAM simulations)
- Reduction of hazard risk (lack of CAPE), Supercellular and splitting storm behavior (high & linear bulk shear)
- Good idea of storm motion (mean wind & bunkers technique)

Context & Purpose:

- Educational example for monitoring convective storms in urban environments
- Supportive study for storm forecasters and meteorologists in the field of forecasting and nowcasting

Further Work:

- Research on interactions between the urban boundary layer and storm behavior

References

[1] Kachelmann GmbH, URL: https://kachelmannwetter.com
Used with permission of Jörg Kachelmann
[2] ERA5 sigma levels browser Europe (thundeR package)
URL: http://rawinsonde.com/ERA5_Europe
[3] Deutscher Wetterdienst, URL: https://opendata.dwd.de
Mesocyclone Detection visualized by Morten Kretschmer
[4] Climate Data Store, URL: https://cds.climate.copernicus.eu
ERA5 Reanalysis Data visualized by Christian Horn
[5] Yvette Richardson, Paul Markowski, 2010, Mesoscale Meteorology in Midlatitudes, S. 235 based on Fig. 8.35 (a)
[6] EUMETSAT from ESSL Testbed
[7] Foto by Hendrik Feige
[8] Journal of the Atmospheric Sciences, 2020
[9] AMS, Weather and Forecasting, 2000
[10] How to Hodograph, YT: @cameronnixon4771, 2022
[11] 22 nd Conf. on Severe Local Storms, Hyannis, MA, 2004