# Tornado outbreak of 20 May 2022 - statistic classification and analysis at DWD

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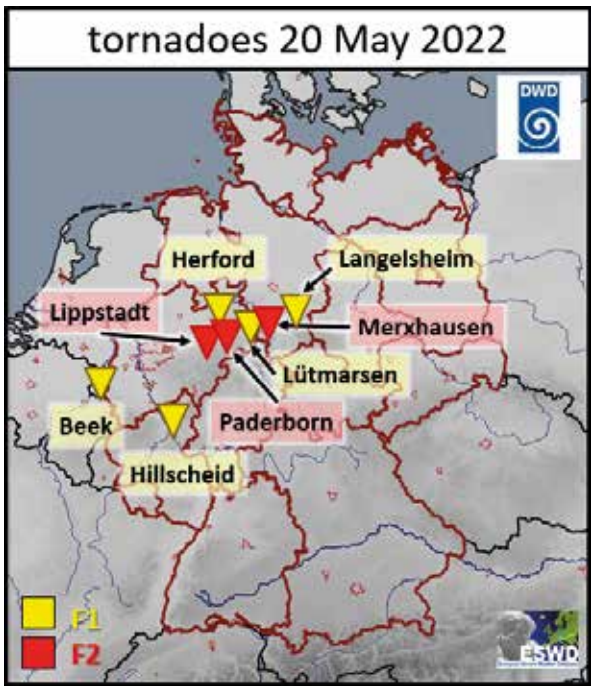
*On the 20th of May 2022, a severe weather outbreak took place over parts of Central Europe, including Germany. Besides excessive rain, large hail, and a severe windstorm at least eight tornadoes occurred, three of them were rated F2. This event can therefore be denoted as a tornado outbreak.*

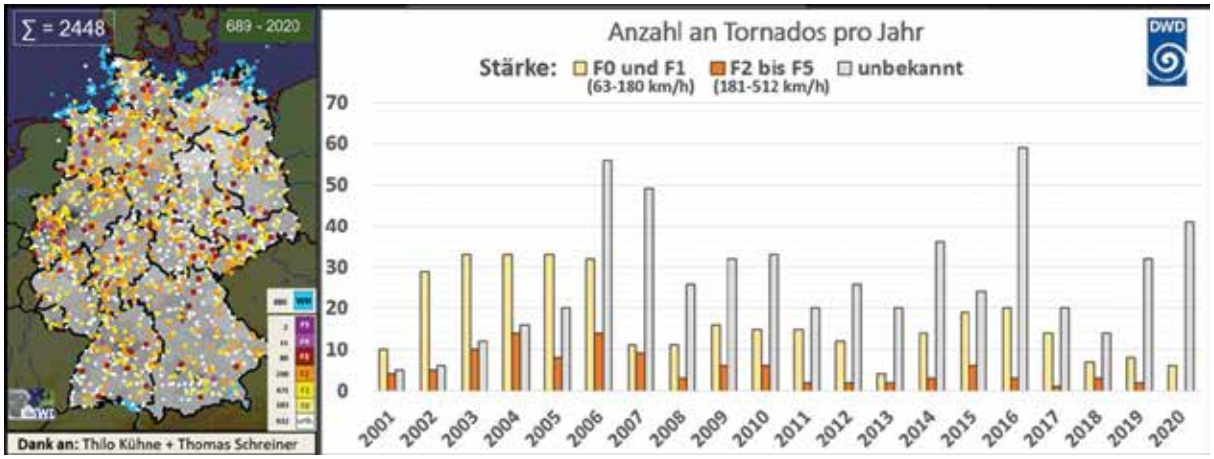
As a first step, this tornado outbreak is brought into context with the current tornado statistics for Germany. Thereafter, the weather situation and the ingredients that led to the tornadic storms are analysed and compared to the findings of the study about strong tornadoes in Germany between 2013 and 2020 [1].

Robust statistics about tornadoes in Germany are only available for the last twenty years. Before the Millennium, the statistics were not sufficient since the internet and digital photography were not available to the general public or were still in their infancy. The following numbers are thus based on the years 2001 to 2020 (20 years). Taking this period, about 49 tornadoes occur on average each year (including 17 waterspouts). Likely, there are still a few weak cases each year that do not end up in the statistics (suspected cases).

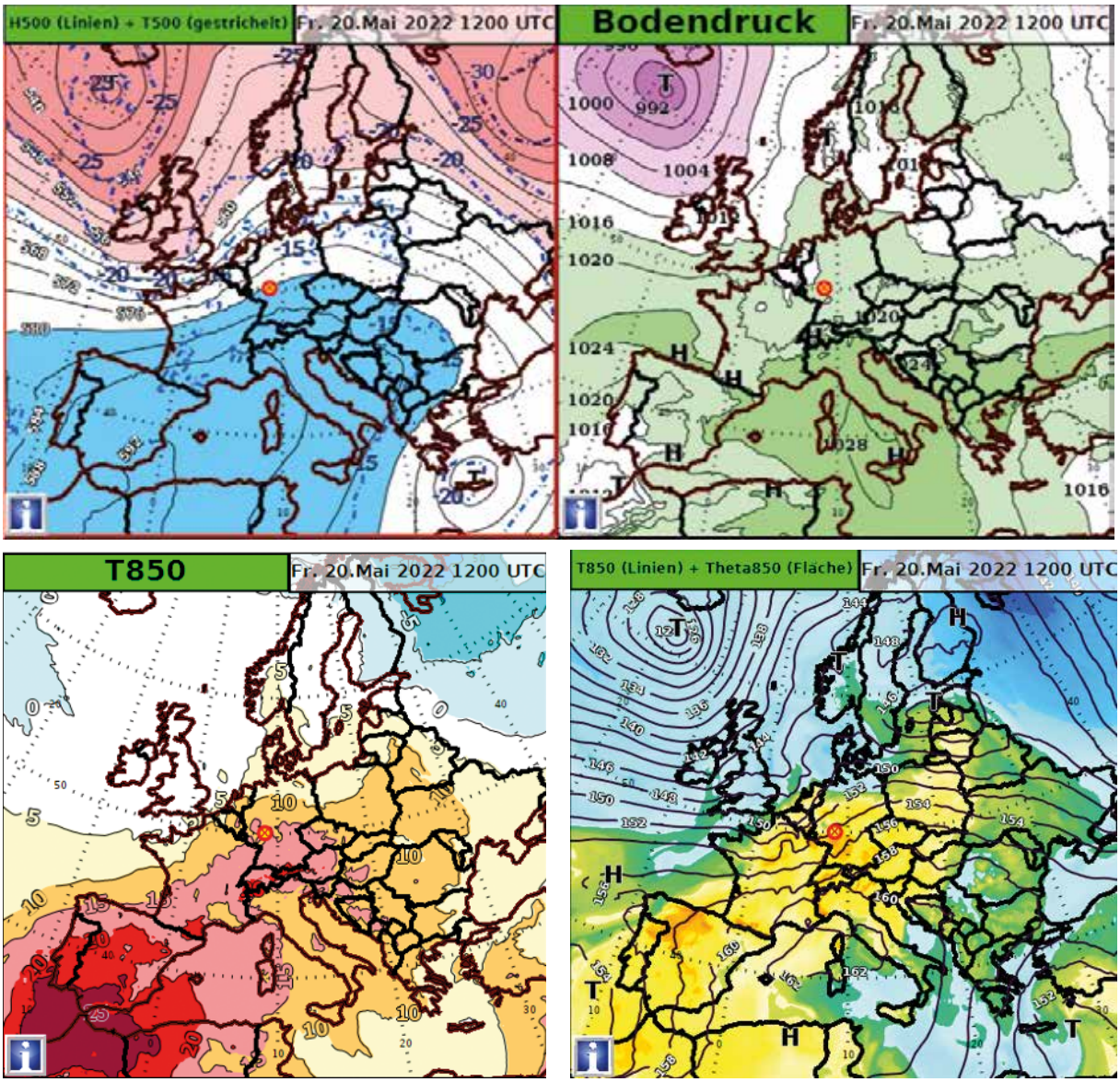
For sinificant tornadoes that have a strength of at least F2 one may be quite sure that all of them are indeed documented. On average five significant



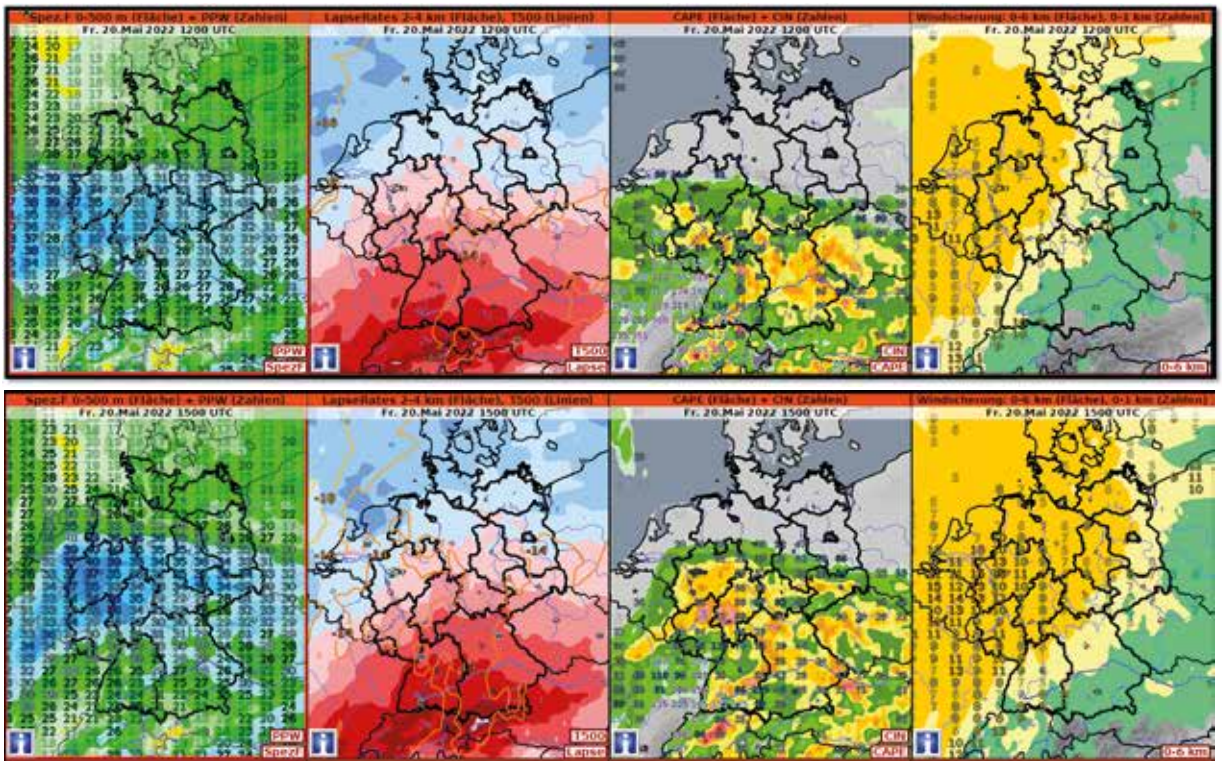

▲ *Figure 2: This map shows all tornadoes reported on 20 May 2022 named by the place of occurrence and coloured by their strength.*




▲ *Figure 1: This graphic shows a statistic about tornadoes in Germany. The map plots all reported tornado cases in Germany from 689 until 2020. The graphic illustrates the development of numbers of tornado reports since 2001 divided into weak and significant tornadoes.*




▲ *Figure 3: Those maps illustrate the general weather pattern of 20 May 2022.*



▲ *Figure 4: Basic ingredients for severe convection for 20 May 15 UTC (top) and 18 UTC (bottom).*

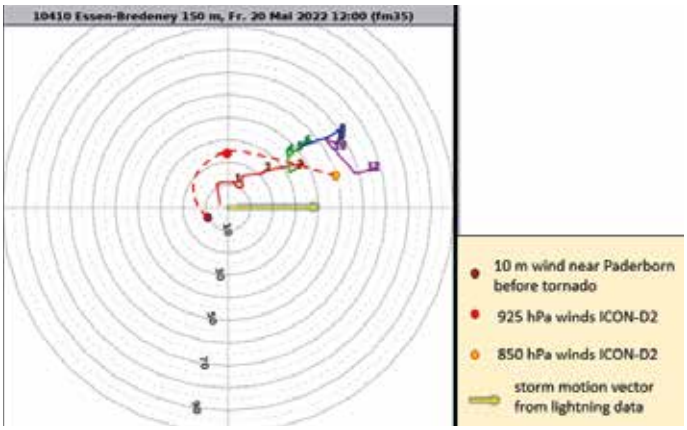



*Figure 5: Hodograph of 20 May 12 UTC sounding of Essen, adapted.*

tornadoes occur every year in Germany (four F2 and one F3). The ESWD database also includes violent tornadoes (F4 and F5) but their return period is much higher. The last F4 tornado happened on the 24th of May 1979 in Bad Liebenwerda.

The past few years have been quite calm concerning significant tornadoes (2019: only one F2 and one F3, 2020: no significant tornado, 2021: one F2).

Tornado outbreaks in Europe can be defined in the following way: At least five tornadoes occurred and could be attributed to the same synoptic-scale weather pattern. In addition one of these tornadoes has to have a rating of F2+. The latter restriction was made to ensure of a mesocyclonic tornado event. Using that definition, 20 May 2022 was the first outbreak of tornadoes in Germany since 2016 when six tornadoes were documented. Most of the site surveys and case studies are done and can be found at tornadomap.org [2].

They are all related to the surface low "Emmelinde" that was moving from Benelux to Northern Germany while intensifying. One of them affected far southeastern Netherlands close to the German

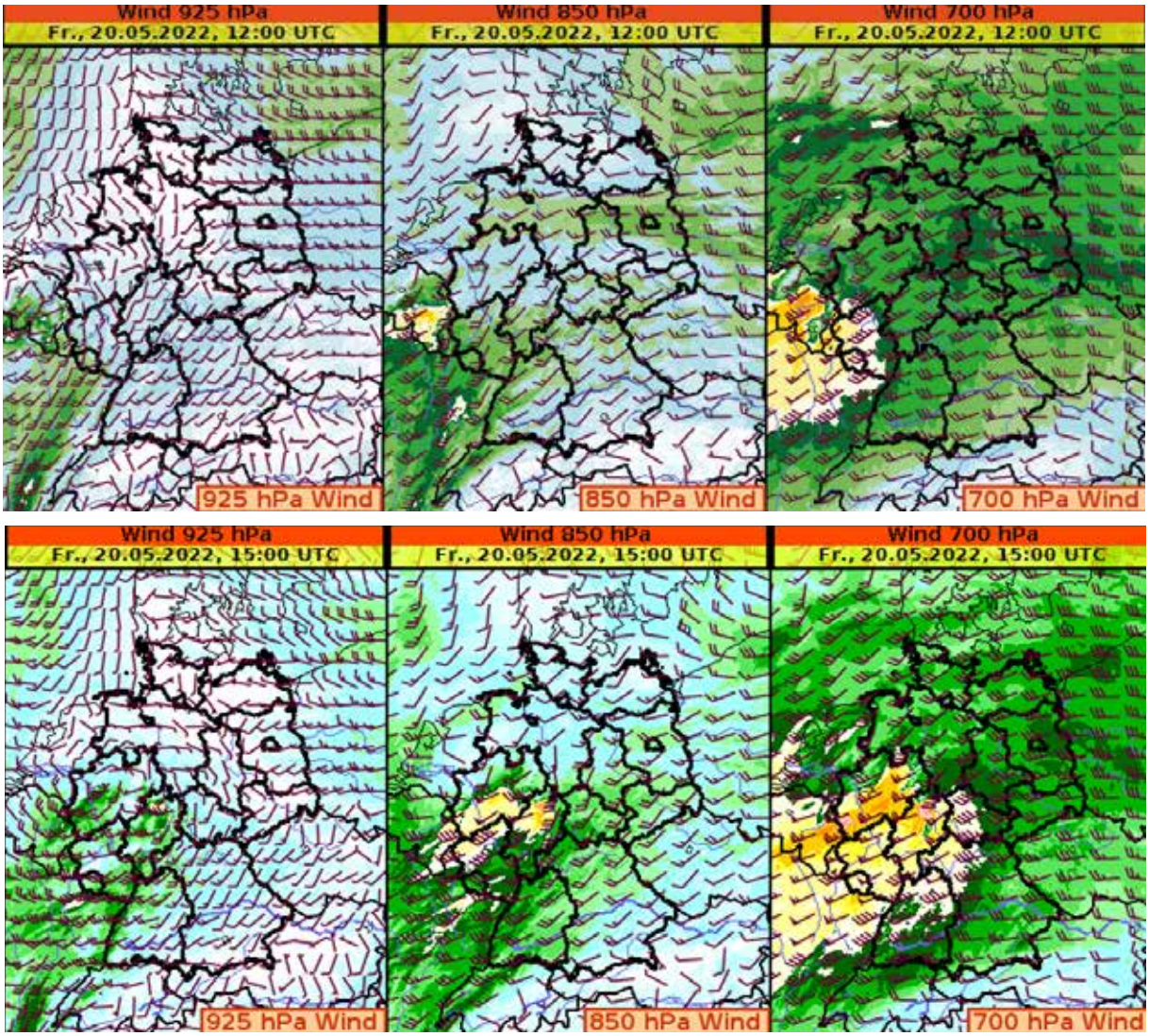
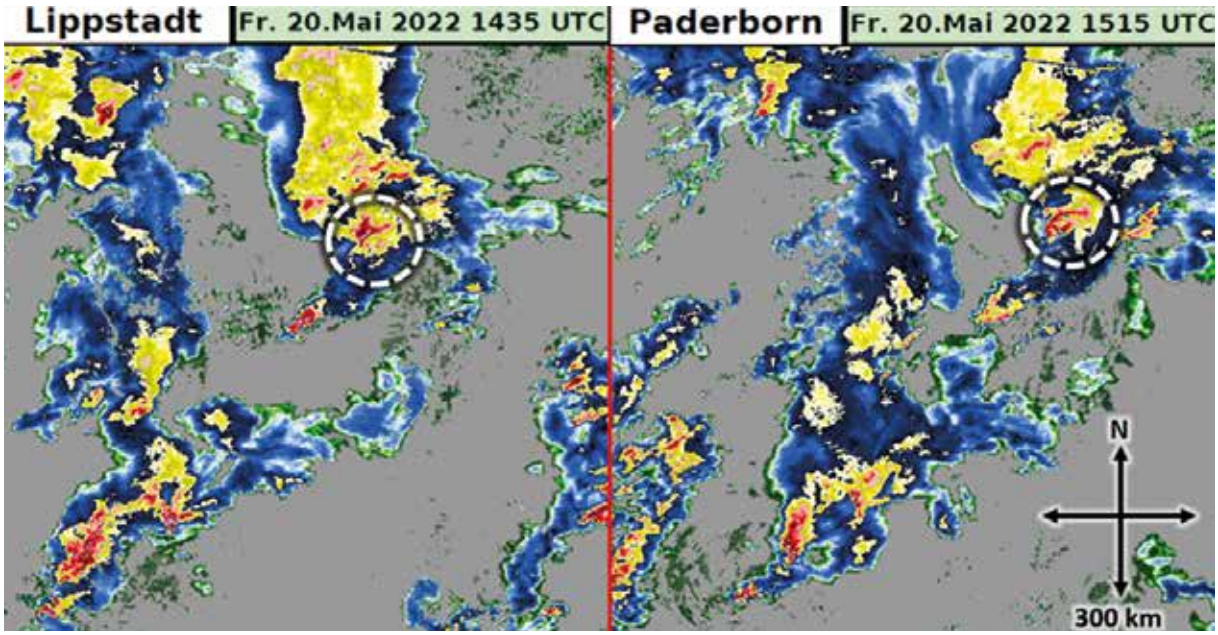



*Figure 6: Wind speed and direction at 925 hPa, 850 hPa and 700 hPa (left to right) at 20 May 12 UTC (top) and 15 UTC (bottom).*



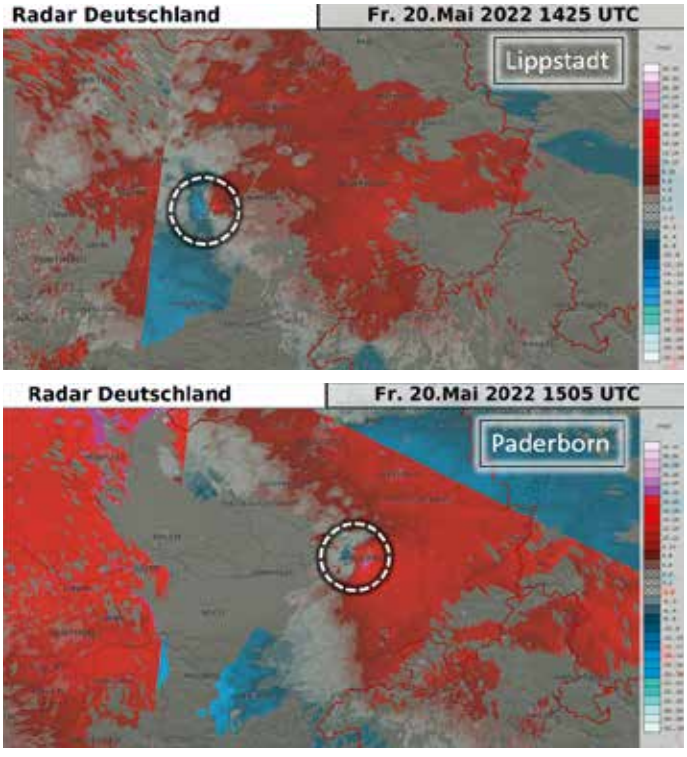

▲ *Figure 7: Radar reflectivity images taken at the time of occurrence of the two F2 tornadoes in Lippstadt and Paderborn.*

border. The other seven occurred mainly over W Germany while three of them had a strength of F2 (Lippstadt, Paderborn, and Merxhausen)

Now let us have a look at the general ingredients on 20 May and compare them to recent findings about significant tornadoes in Germany [1]. This study investigates all significant tornadoes between 2013 and 2020 (20 tornadoes on 17 different days). The 20 May was a rather typical setup with a pronounced short wave trough moving from W Europe into Germany. This was the second most frequent setup in the study. The trough led to an intensification of a downstream surface low that was moving from Benelux into N Germany during the day. The warm front of that surface low was the starting point for the first convective activity already in the morning hours. The following warm sector influenced central and southern parts of Germany with moist and unstable airmasses.

Specific humidity was highest over W Central Germany, while the steepest lapse rates could be found in S Germany. The overlap should have led to moderate values of MLCAPE of around 1000 J/kg following ICON-EU. However, soundings in W Germany only showed values of around 500 J/kg with one (Idar-Oberstein) or two (Essen) capping inversions. It seems likely that those were broken with enhanced lift due to the approaching cold front in the afternoon hours. It is also possible that CAPE values were a bit higher than measured.

Shear values were extraordinarily high for both DLS (deep layer shear, 0-6 km) and LLS (low-level shear, 0-1 km) with the best values to the north. In the region of interest DLS at 12 UTC was around 25 m/s at the sounding station in Essen. LLS was only around 6 m/s during noon but models showed that




▲ *Figure 8: Radar doppler wind at 0.5° elevation angle taken at the time of occurrence of the two F2 tornadoes in Lippstadt (top) and Paderborn (bottom).*

it should have significantly strengthened during the afternoon hours, with the approaching surface low. The same is true for storm-relative helicity which was only 200 m²/s² (0-3 km) and around 100 m²/s² (0-1 km) at 12 UTC. ICON-EU forecasted values >500 m²/s² (0-3 km) at 15 UTC for W Germany.

Wind shear was not only due to speed shear. Monitoring the 10 min winds at 10 m height one could see that several surface stations had a clear easterly wind component before the storms arrived. That was also true for Lippstadt, Paderborn, and further downstream. With the passing thunderstorm, a clear wind shift of almost 180° to westerly winds occurred.

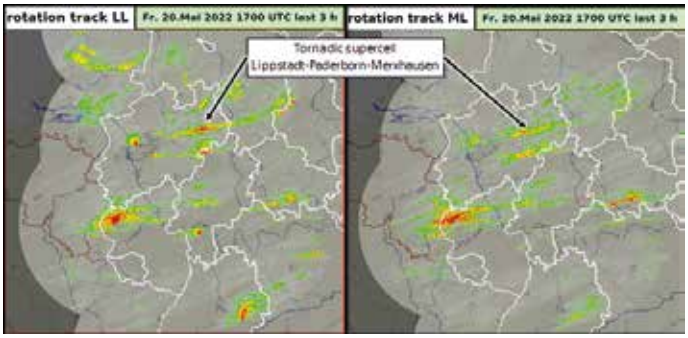
The backing surface wind with a strength of around 5 m/s should also have improved the 12 UTC hodograph of Essen, making it more favourable for tornadoes.

Comparing the findings of thermodynamic and dynamic parameters of this tornado outbreak with the values of the study one can conclude that they have been quite typical. Most of the significant tornadoes occurred in a HSLC situation

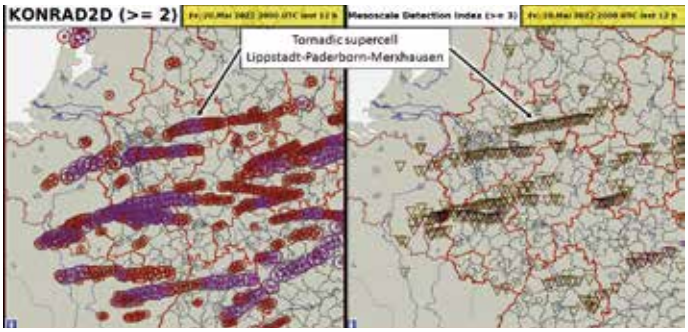
There is another interesting thing that one can mention. In the afternoon hours, a distinctive jet maximum at 850 hPa was developing and moving over the area of interest in W Germany. ICON-D2 simulated wind velocities of 25 to 30 m/s and a shift from southerly to westerly directions right at the time of the occurrence of the tornadoes. Unfortunately, this was also not covered by the 12 UTC soundings of Essen or any other neighbouring sounding station. It is likely that this jet maximum also has improved shear conditions and enhanced the probability of tornadoes.

Finally, two other typical things were figured out in the tornado study. It was found that in most of the cases it was raining a few hours before the event or another shower/storm was moving over the region just before the tornadic supercell occurred. This was also the case for the Lippstadt-Paderborn-Merxhausen case. Radar images reveal convective activity before the supercell arrived. This activity may have moistened the lower troposphere and may have additionally lowered the LCL. It is also interesting to note that there was another supercell just to the south of the tornadic storm. This non-tornadic supercell was even stronger concerning the rotation of the mesocyclone. However, its track was free of any previous convective activity and thus rain.

Finally, the study revealed that on most days with more than one tornado, several tornadoes were produced by the same storm. This was also the case on 20 May when the tornadoes of Lippstadt, Paderborn, and Merxhausen were all produced by the same storm. At least one or even two other tornados can be attributed to its lifetime. On the other hand, there have been several strong supercells on that day not producing any tornadoes.




▲ *Figure 9: Low level (left) and mid level (right) rotation tracks summarising the last 3 h hours between 14 and 15 UTC on 20 May 2022.*




▲ *Figure 10: Konrad2D cell detection and MDA (mesoscale detection algorithm) for the time between 08 UTC and 20 UTC on 20 May 2022.*

One can summarise 20 May 2022 as a day with a classic tornado setup that led to an outbreak of at least eight tornadoes. This outbreak fits very well with the recent Wapler & Beyer study about significant tornadoes [1]. After several calm years concerning significant tornadoes, this was the first notable event.

[1] Analysis of significant tornado events in Central Europe: synoptic situation and convective development, Wapler K., Beyer M., Meteorologische Zeitschrift 2022, Vol. 31 No. 5, p. 367 – 388. DOI: 10.1127/metz/2022/1126. At: https://tinyurl.com/TornadoStudyGermany

[2] tornadomap.org (https://www.tornadomap.org/analysen/2022/).