The 14 July 2010 severe MCS event over parts of central Europe

Marcus Beyer [1], Helge Tuschy [1,2]

[1] Deutscher Wetterdienst (DWD), Offenbach am Main

[2] European Severe Storms Laboratory, ESSL

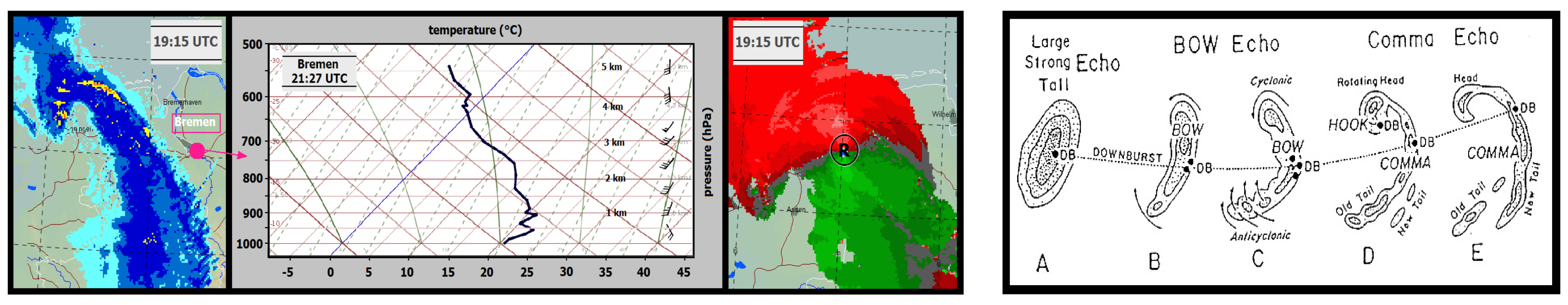
Motivation

On the 14th of July a squall line crossed great parts of northeastern France, Belgium, the Netherlands and Germany. In its mature stage it had a meridional extension of almost 1000 km. The squall line caused major damage due to severe wind gusts, a few hail and at least three tornado events. In addition three fatalities had to be complained. This study investigates the different live stages of the squall line, its internal structure and the pre-/postfrontal kinematic and thermodynamic conditions. In addition it will be shown how the Corfidi Vector Approach and remote sensing data can be used to improve nowcasting of such a mesoscale convective system.

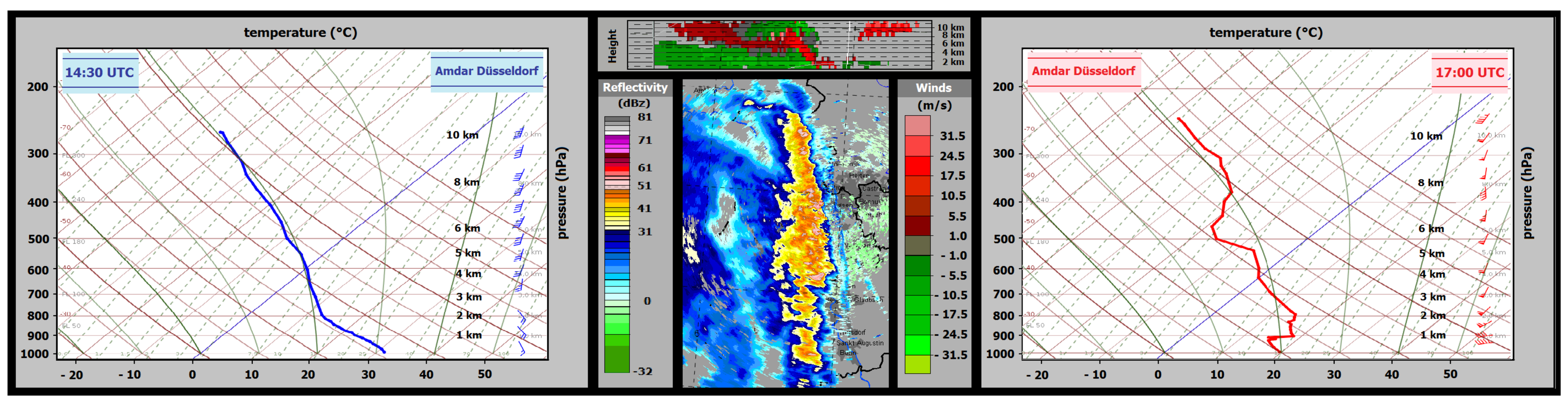
Synoptic Situation

The initial synoptic situation featured an highly amplified wave pattern with the most dominant through axis running from Ireland to Spain. A progressive short wave rounded its base, leading to the formation of a strengthening surface low over France and Benelux. Strong and deep warm air advection accompanied those features with 850 hPa temperatures surpassing 20°C and with the boundary layer air mass characterized by a mixing ratio of 12 g/kg. Also, an intense jet maximum overspread the moist and unstable warm sector. Forcing, shear and instability caused the development of a severe and progressive squall line over northeast France and Benelux. Over central Germany the dynamic environment gradually became much weaker as the short wave trough moved to the north and hence caused the MCS to progress into a diffluent streamline pattern. The thermodynamic environment however remained supportive for the squall line to continue until late the night.

Mature Stage

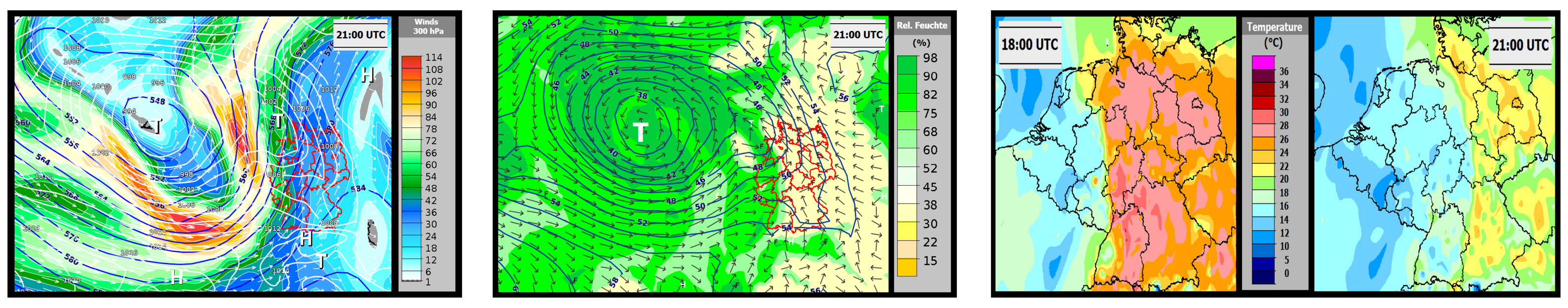


Left: Base radar reflectivity, **right**: Base velocity for comparison at radar station Emden at 19:15 UTC. **Middle:** AMDAR Bremen at 21:27 UTC. **Far right:** Sketch of the lifetime of an evolving and maturing bow echo (Fujita, 1978).

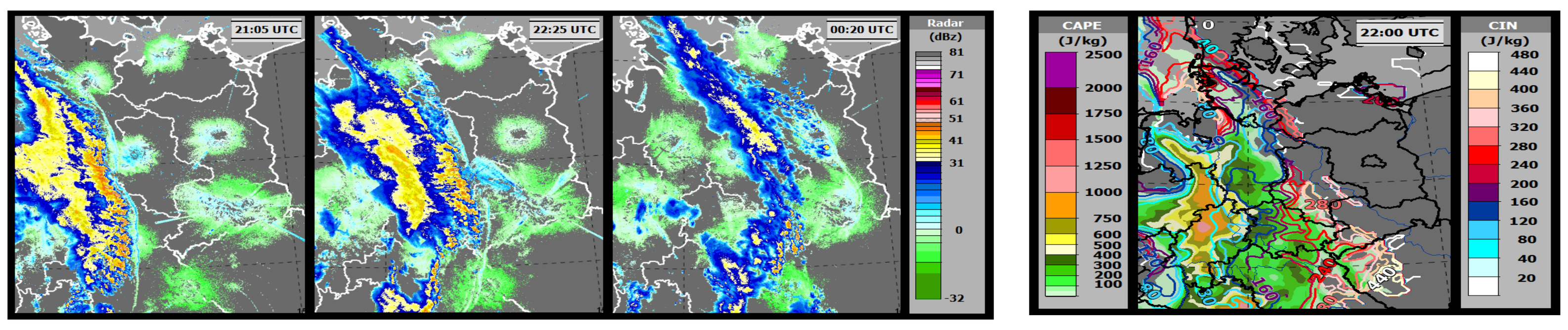


Base radar reflectivity and base velocity at 16:45 UTC centered with AMDAR Düsseldorf, **left:** 14:30 UTC and **right:** 17:00 UTC. Mature bow echo ongoing with fully developed front to rear flow (red/outbound velocity) and rear inflow jet (RIJ) (green/inbound velocity).

Decaying Stage

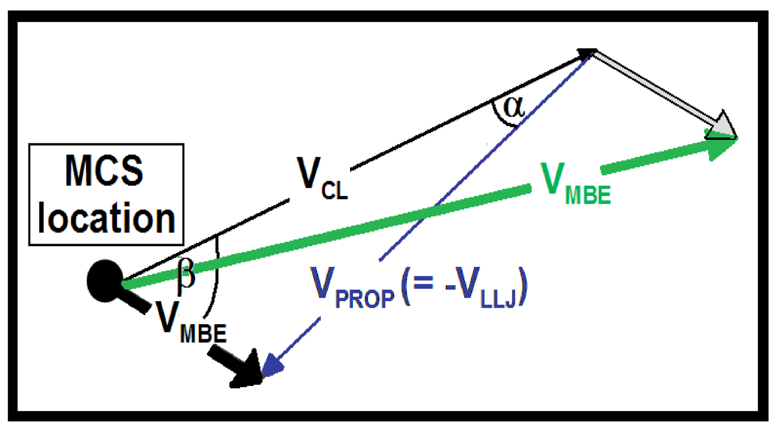


Decay of the MCS due to the following: Squall line outruns the environmental dynamic forcing, persisting advection of drier air from the east and a decreasing horizontal temperature gradient. **Left:** Isohypses 500 hPa (blue lines), Isobares (white lines), winds 300 hPa (shaded, arrows), **middle:** 950 hPa isohypses (blue lines), humidity (shaded), winds (arrows), **right:** Temperature 2 m (shaded).



Triggering of new, elevated convection due to the lifting of initially stable air parcels by the advancing gust front. **Left:** Evolution of reflectivity (21:05 UTC, 22:25 UTC, 00:20 UTC), **right:** CAPE (shaded) and CIN (contours), 22:00 UTC.

The Corfidi Vector Approach



$$V_{CL} = (V850 + V700 + V500 + V300) / 4$$

LLJ = the wind speed at the level of maximum wind is over 12 / 16 / 20 ms^{-1} and decreases by at least 6 / 8 / 10 ms^{-1} to the next higher minimum or the 3 km level, whichever is lower.

$$V_{MBE} = \{(VCL)^2+(-VLLJ)^2-2((VCL)(-VLLJ))\cos\alpha\}^{1/2}$$

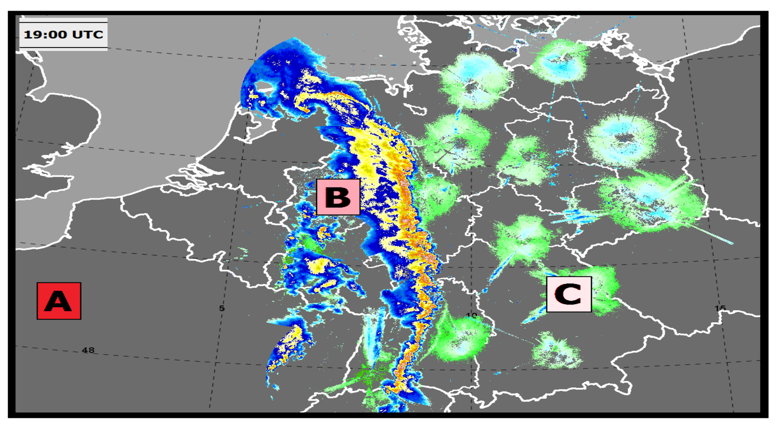
$$\beta = \arcsin\{(-VLLJ)\sin\alpha / VMBE)\}$$

(Corfidi, 2003)

V_{MBE} = velocity meso-beta scale convective elements

V_{CL} = mean flow in the cloud layer

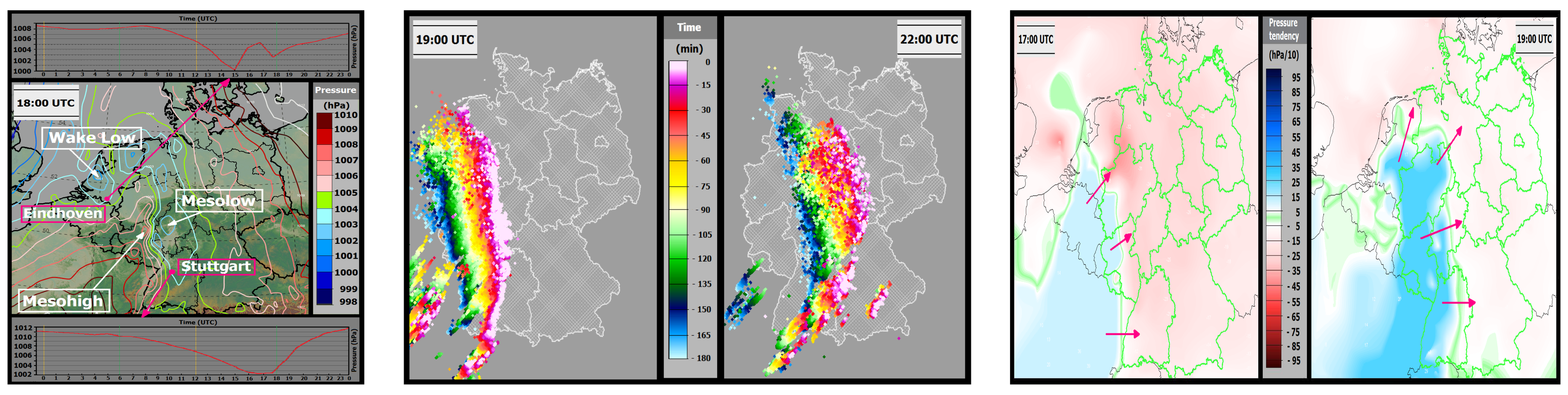
V_{LLJ} = velocity of the low level jet



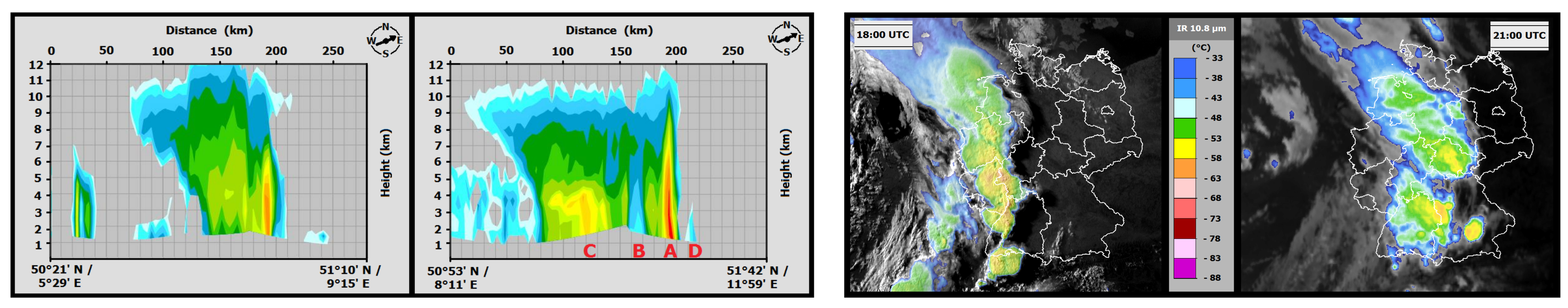
old method / new method / reality

	location	VMBE (m/s)	motion (°)
A	Trappes	~ 20 ~ 39	~ 245 ~ 215
B	Essen	~ 7 ~ 24 ~ 32	~ 215 ~ 200 ~ 240
C	Kümmersbrück	~ 5 ~ 11 ~ 10	~ 255 ~ 245 ~ 250

Nowcasting Tools



Left: Isobares, showing the current pressure distribution (lines), 18:00 UTC, **middle:** 3 h - flash distribution along the squall line, 19:00 UTC and 22:00 UTC, respectively, **right:** Pressure tendency (shaded) and the isallobaric wind (arrows), 17:00 UTC and 19:00 UTC.



Left: Reflectivity (distance to height projection). There is a narrow convective line (18:00 UTC) developing into one with three typical characteristics: Leading convective line (A), transition zone (B) and trailing stratiform area (C). Also the gust front (D) can be seen. **Right:** Cloud top temperature (IR 10.8 µm, enhanced), 18:00 UTC (background: HRV), 21:00 UTC (background: IR 10.8 µm).

Conclusion

- MCS featured classic bow echo structures and a well evolved book-end vortex over Benelux / NW Germany, fostered by intense deep layer shear. Corfidi vector analysis revealed the chance of a progressive MCS, moving northeastwards.
- Descending RIJ and evolving wake low were good tracers for operational forecasters
- Further east, over central/east Germany, MCS decreased its rate of speed. The cold pool promoted the development of elevated convection beside weakening background shear.
- Limited hail reports due to warm mid-tropospheric layer and isolated tornado reports as storm relative flow increased during the evening hours (over north-central Germany) as the surface low passed.

Source

Fujita, 1978: Manual of downburst identification for project NIMROD. Satellite and Meso-meteorology Res. Pap. No. **156**, University of Chicago, Dept. of Geophysical Sciences, pp. 104.

Corfidi, S.F., 2003: Cold pools and MCS propagation: Forecasting the motion of downwind-developing MCSs. Wea. Forecasting, **18**, 997-1017

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Helge.Tuschy@dwd.de and Marcus.Beyer@dwd.de