A case-study of two severe hail storms over southern and eastern Germany

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estofex

The European Storm Forecast Experiment www.estofex.org

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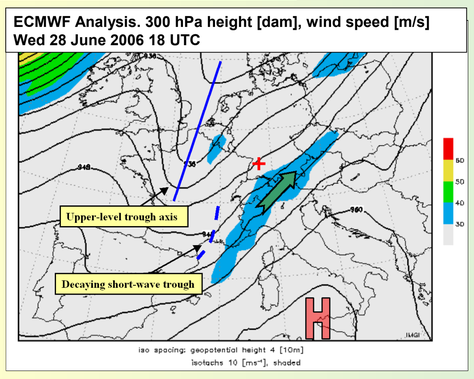
In 2006, two extreme hail events occurred in Germany. We describe the conditions under which they have developed and whether they were correctly forecast or not.

Large-scale flow

Villingen-Schwenningen 28 June 2006

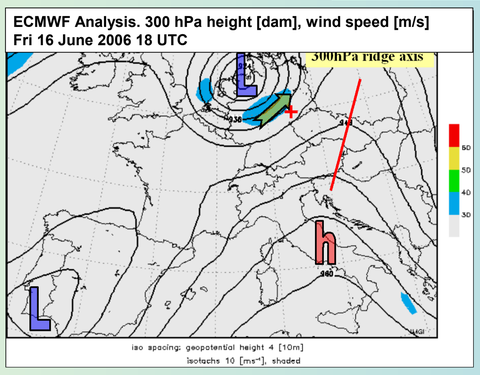
ECMWF Analysis. 300 hPa height [dam], wind speed [m/s]
Wed 28 June 2006 18 UTC



- A well defined, positively tilted upper-level trough west of Germany
- Main upper-level jet over Switzerland and southeast Germany was weakening while moving northeastwards
- Another jet developed south of Belgium, placing SW Germany under its right rear entrance region
- A weakening short-wave crossed SE France, while moving slowly towards the northeast
- Most parts of Germany saw weak ridging just downstream of the approaching upper-level trough

Leipzig 16 June 2006

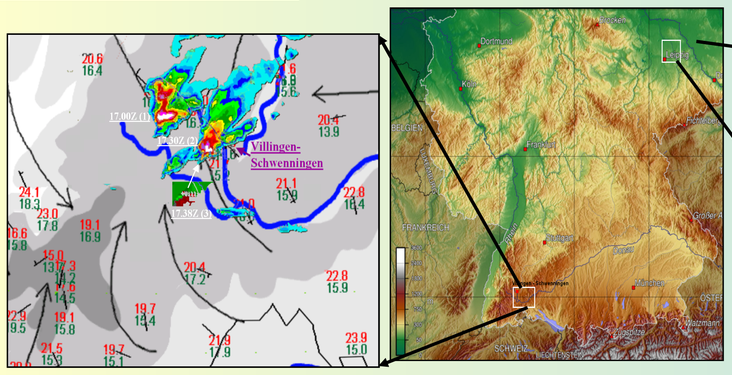
ECMWF Analysis. 300 hPa height [dam], wind speed [m/s]
Fri 16 June 2006 18 UTC



- On the 15th, an upper-level low was situated over the eastern English Channel, moving towards the northeast on the following day while strengthening
- Intensifying warm air advection over eastern Germany, the Czech Republic and Poland
- Wind field at mid-levels strengthened in response to the approaching low pressure system
- Moderate instability release, strong deep-layer shear and steep mid-level lapse rates created an environment, favorable for severe hailstorms

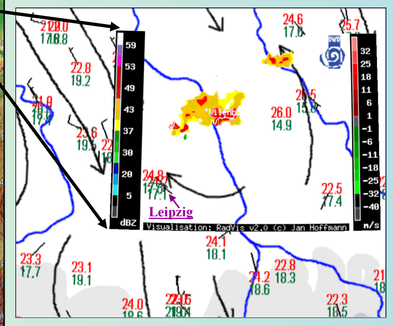
Radar

Villingen-Schwenningen 28 June 2006



Radar reflectivity at 17.00 Z (1) and at 17.30 Z (2), radar velocity at 17.38 Z (3) and surface station data (Meteomedia, 17.00 Z). The thunderstorm produced numerous reflectivity maxima of up to 65 dBz (between 17.00 and 17.40 Z west of Villingen-Schwenningen) and attendant updraft exceeded a height of 10 km for more than 90 minutes in all available radar data. Although noisy, doppler velocity data indicate a possible cyclonically rotating mesocyclone at the southern and partially hook-shaped end of the intense thunderstorm with an impressive hail core revealed in the vertical slices of the 2km layer reflectivity.

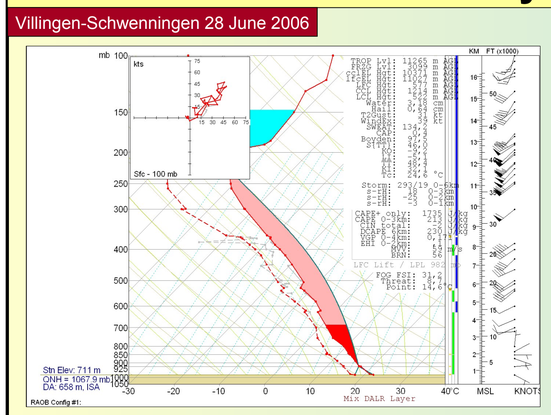
Leipzig 16 June 2006



Low-level reflectivity (17.15 Z [only 37dBz and higher]) and doppler velocity (17.08 Z [only velocity couplet]) data reveal a classic supercell thunderstorm northeast of Leipzig. Bad radar coverage just around Leipzig limited the available number of radar images. During this time an in-/outbound velocity of about 50m/s (in summa) was detected. The supercell gradually weakened during the next 45 minutes, while moving towards the northeast.

Proximity soundings

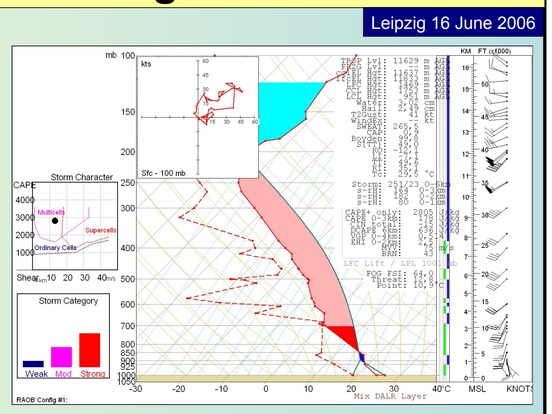
Villingen-Schwenningen 28 June 2006



RAOB sounding of *Villingen-Schwenningen* (modified by ECMWF data).

- moderate instability release in the favored (-10 to -25°C) hail growth zone
- mountain pumping effect / SE-erly flow at 850hPa is thought to have supported those high storm relative helicity values (0-3km) of more than 200 J/kg
- a very moist atmosphere (allowing for large amount of supercooled water) was present
- West-east aligned convergence zone just north of Villingen-Schwenningen along which the thunderstorm moved towards the east
- Strong upper-level winds and the resultant vertical wind shear helped to strengthen the updraft and separate up/downdrafts

Leipzig 16 June 2006

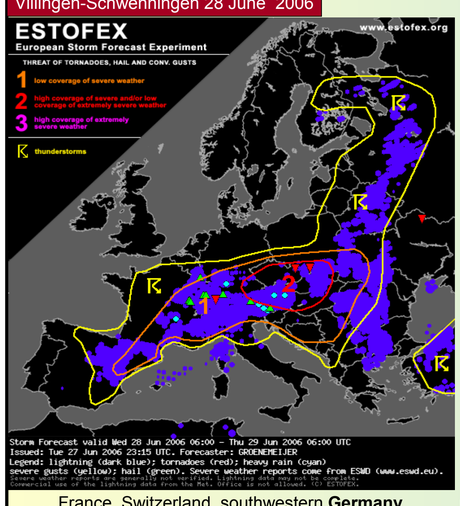


RAOB sounding for *Leipzig* (Lindenberg, 18Z).

- 0-6 km deep layer shear of 20 m/s
- Strong veering throughout the lower / mid-troposphere
- Strong instability release with up to 1000 J/kg MLCAPE and SBCAPE values approaching 3000 J/kg
- Robust buoyancy release in the favored hail growth zone
- Steep lapse rates at lower and mid-levels
- A dry and well mixed boundary layer was present.

ESTOFEX convective forecast maps and texts

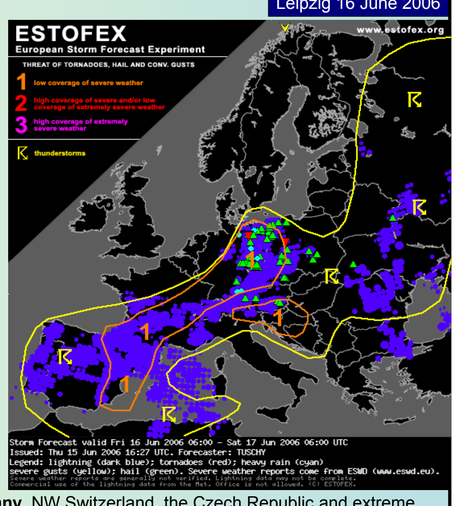
Villingen-Schwenningen 28 June 2006



…France, Switzerland, southwestern **Germany**, northern Italy…

[...] Approach of the trough […] rising motions […] over eastern France leading to the redevelopment of instability on the order of about **1000 J/kg MLCAPE** . Moderate **~15-20 m/s deep-layer shear** should prove sufficient for the development of well-organized multicells and supercells. […] main threat of **producing large hail** [...]

Leipzig 16 June 2006



...**Germany**, NW Switzerland, the Czech Republic and extreme western Poland....

Development of a broad 10-12 g/kg mixing ration belt […] in front of a slowly eastward shifting confluence zone [...] **deep layer shear in the order of 10-15 m/s** […] will be present […] each pulsating storm could pose a hail risk, matching the severe criteria. Wind field tends to increase over E and NE-Germany with **15-20 m/s DLS** and a few organized storms should develop...If indeed that much instability can be realized, what models indicate, an upgrade of this area to a **level-2** could become necessary due to the possibility of **isolated extremely large hail (>5cm)**.

The threat of severe and even damaging hail was recognized on both days by the forecaster as overall severe thunderstorm parameters hinted at the possible evolution of hailstorms but those events would have justified an upgrade to a level-2 threat.

The hailstorm of Villingen-Schwenningen was a very local event and benefited from an environment, where stout instability release, a mesoscale convergence zone just north of the town and shear (strong directional but weak speed shear) overlap. It is impossible to highlight a special area in a level-2 threat area more than 20 hours ahead, as such local events depend strongly on topography and mesoscale temperature / dewpoint and wind variations. Sparse available surface observation data and missing near real-time radars made it very hard to recognize the main area of interest even a few hours before the event took place.

An update / upgrade would have been a reaction of an already occuring local severe thunderstorm event but no forecast !

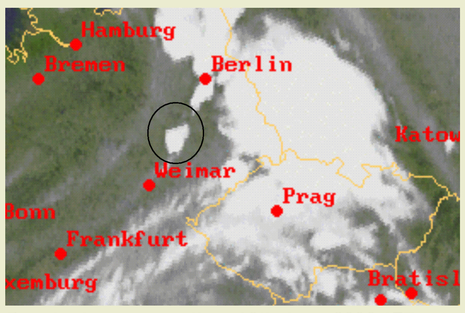
Clearer signals regarding an enhanced large hail potential were present on 16th June, when strong lift and a broad belt of up to 20 m/s deep layer shear (DLS) crossed an area with steep mid-level lapse rates and strong instability release. The main reason for not issuing a broad level-2 risk was the uncertainty as to whether or not indeed those robust instability values of the global models would verify and which type of storm mode would dominate. The voluntary character of ESTOFEX and the unavailability of a meteorologist on June 16th, unfortunately resulted in no update being issued that afternoon.

Photos of both severe weather days

- The 4 images of „Marco Kaschuba“ show the large hail and attendant damage to buildings (photos taken on the 29th June)
- The photos of „Guido Richter“ (as: geggo glaubitz) present the well developed supercell which was already in its decaying stage at this time (16th June)
- Severe hail damage to cars and buildings occured in parts of Leipzig as can be seen on the 2 photos of „spiegel“ (16th June)
- Later the day, a pronounced wall cloud evolved next to Berlin (16th June,@ Georg Myrcik)

IR Satellite

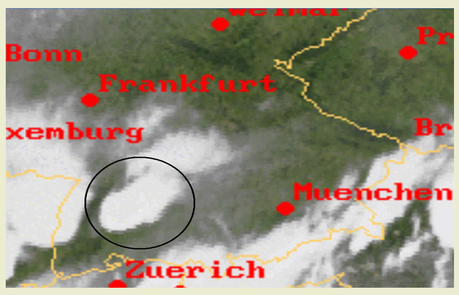
Leipzig 16 June 2006



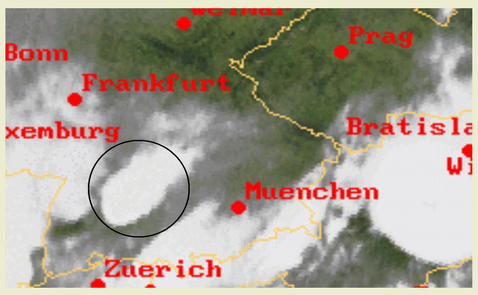
Developing supercell on 16th June 2006,17Z (crossing Leipzig)

Maturing thunderstorm south of Berlin at 16th June 2006, 18 Z

Villingen-Schwenningen 28 June 2006



Developing thunderstorm at 28th June 2006, 1745Z (crossing Villingen-Schwenningen)



Maturing thunderstorm at 28th June 2006, 1845Z

Conclusions

Two severe hail cases were examined, which occured in eastern Germany (Leipzig, 16th June 2006) and southwestern Germany (Villingen-Schwenningen, 28th June 2006). Although the environment was favorable for large hail in both events, there were a few differences.

The *Leipzig* hailstorm occurred on a day where numerous thunderstorms rapidly developed into organized storms with an attendant large hail and even tornado threat. The overall set-up favored the evolution of large and even isolated extremely large hail, as strong speed / directional shear, high instability and large lapse rates did overlap over eastern Germany.

The *Villingen-Schwenningen* hailstorm was very hard to forecast as this was a local event. Although the environment for organized thunderstorms became adequate during the evening hours of the 28th, the main uncertainty was where exactly and how many of those storms would develop in the rough terrain. A west-east aligned convergence zone just north of Villingen-Schwenningen could have enhanced the shear along the thunderstorm's path. The degree of instability and intense upper-level winds were sufficient to support a long-lived storm and updraft/downdraft separation.

Rotation was possible and detected in the velocitiy data, but can't be proven with the available data coverage (radar was quite noisy). Access to high resolution radar data and surface synoptic stations would help to handle such local events better as mesoscale environment has a big influence on such local events.

On both days the forecasters of ESTOFEX indeed saw the possibility for severe hailstorms although final hail report coverage/size of the hailstones would have justified at least a level-2 threat. The main reason for underestimating the hail threat on the 28th June was aforementioned missing additional data while on the 16th June uncertainty on exact storm mode and questionable instability release by models (e.g. Global forecast model (GFS)) precluded higher probabilities. *Experience suggests that signals for possible large hail are strong instability (especially in the favored hail growth zone between –10°C and –25°C), enhanced storm relative helicity (e.g. 0-3km), steep lapse rates at low-/mid-levels and deep layer shear at or above 15m/s*. The goal of the forecasters of ESTOFEX in the near future is to try to study and compare such obvious cases (Leipzig) with the more diffuse ones (e.g. Villingen – Schwenningen) to get a feeling for forecasting large hail although it is questionable if this goal can be reached with current marginal data coverage over most parts of Europe.

Acknowledgements

The authors would like to thank all the volunteers who provided data, photos and information about these severe weather events. We also want to thank Dr. Georg Mayr of the University of Innsbruck who provided surface observations and model data of the ECMWF, the Zentralanstalt für Meteorologie und Geodynamik (ZAMG), which provided the satellite images and the private weather service Meteomedia, which offered numerous surface observation data.

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Doswell, C.A.III (1996): What is a supercell ? Appears in Preprints, *18th AMS Conf. Severe Local Storms* (SanFrancisco, CA), 19-23 February 1996, Amer. Meteor. Soc.,p. 641.