# THE DEADLY EF-4 TORNADO OF AUGUST 3, 2008, IN NORTHERN FRANCE

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## I. INTRODUCTION

A strong tornado hit seven cities of northern France in the late evening of Sunday, 3 August 2008, causing severe damage along its 19 km path from Pont-sur-Sambre to Boussois. Three people were killed in the collapse of their house and 18 were injured. More than 1000 houses were damaged and several thousand of trees were uprooted or fallen down.

The authors led a damage survey in the hours that followed the disaster, then investigated this case, in order to determine precisely the characteristics of this tornado and to better understand the conditions that led to its formation.

## II. DAMAGE SURVEY

The site investigation shows that the tornado first touchdown occurred in a corn field at 20.28 UTC with an EF-1 intensity. During the first 3 minutes of its development, it produced two suction vortices, with a maximum wind speed estimated at 45 m/s. Few houses suffered minor damage and large branches of hard wood were broken.

Only 2 minutes later, the tornado reached an EF-2 intensity (many uprooted trees and several damaged houses), then, at 20.31 UTC, an EF-4 intensity, causing the total destruction of one solidly built house (FR12 DOD10, see Fig.1). Many trees were uprooted and some of them were completely debarked (TH DOD5).

FIG. 1: total destruction of a solidly built house in Boussières-sur-Sambre (FR12 DOD10 ; EF-4).

Keeping its EF-4 intensity during 2.5 km (until 20.33 UTC), with a maximum wind speed estimated at 85 m/s, the tornado crossed the *Fayt Wood*, uprooting and debarking all the trees on its 150 meters wide path. Then, it hit the city of Hautmont, where 3 people were killed by the total destruction of their house. Hundreds of houses were severely damaged all around the tornado path (sometimes as far as 500 meters from it), some of them were demolished down to the foundations in the central part of the path. Many cars were thrown to significant distances, and one was lifted up to the first floor of a severely damaged house. Some trees were ejected to more than 500 meters. Little objects, like photographs or chequebooks, were thrown to more than 30 km.

A few minutes later, the tornado weakened to EF-2 intensity, causing significant damage on the boroughs of Maubeuge. The bell-tower of a church collapsed. Many other infrastructures (factories, hospitals, the city-hall, the zoo) sustained moderate damage. Hundreds of trees were knocked down at the Public Garden and all around.

About 12 km after its touchdown, the tornado weakened to EF-1 intensity. It hit the Military Cemetery of Assevent, where large branches of hard wood were broken. Many little trees were also uprooted. Finally, at 20.40 UTC, the tornado weakened to EF-0 intensity on a 50 meters wide path. Two minutes later, it caused little damage on trees again, then it dissipated at 20.42 UTC near the Belgian border.

The damage survey reveals that this tornado case is of greatest interest, because it hit a wide variety of terrains with a wide variety of intensities (see Fig.2), from corn fields and woods to highly populated areas, from a narrow EF-0 vortex to a 150 m wide severe EF-4 tornado.


FIG. 2: the 19 km path of the "Hautmont tornado", from Pont-sur-Sambre (SW) to Boussois (NE) with EF-scale intensities and cities names.

## III. RADAR ECHO FEATURES

High resolution radar data show that the tornado was generated by a supercell that formed about 45 minutes earlier. Main radar signatures include a persistent rear inflow notch, a tornado vortex signature on Doppler radar and a discrete hook echo. This supercell was characterized by a 20° deviation to the right of the mean wind, and by a double heavy precipitation core, the first one imbedded in the forward front downdraft (F.F.D.) and the second one in the rear front downdraft (R.F.D.). Both produced heavy rain, but a major axis of 30 to 80 mm hourly rain accumulation is noticeable about 4 kilometres north of the tornado path, i.e. under the F.F.D..

The tornado touched the ground during the mature stage of the supercell storm, about 10 minutes after the beginning of the maximum F.F.D. rain intensity phase. In the meantime, radars show a sudden acceleration of the R.F.D. circulation, which began to wrap the mesocyclone about 3 minutes before the tornado touchdown. The R.F.D. development is particularly obvious during the 15 minutes of the tornadic stage. So, in this case, the evolution from a non-tornadic to a tornadic supercell may be related to the transition from a classic stage to a high precipitation stage supercell. In this respect, the role of the F.F.D. rain core intensification may have been significant in the minutes that preceded the tornado formation.

## IV. SYNOPTIC AND MESOSCALE PATTERN

From a synoptic point of view, this tornadic supercell was generated during a prefrontal convective event. The cell formed in a moderately unstable but highly sheared environment, characterized by a coupling between a low-level jet and a highly divergent jet-stream left exit region. The LLJ was associated with a rapidly moving baroclinic mesoscale wave, just ahead of a deepening mid-level trough in-phase with a rapidly moving upper-level PV anomaly. This synoptic pattern is known to be severe weather conducive, by forcing deep convection and by insuring high deep shear and high storm-relative helicity values.

A reconstructed vertical profile for the city of Hautmont at 22.30 UTC, based on surface observations from nearby meteorological stations, on proximity soundings and on numerical simulations, shows interesting features. Indeed, the low level environment was characterized by a warm and moist air advection (high dew points), producing low LCLs and low LFCs (about 400 m AGL), with a highly accelerating and veering wind profile. Wind speeds in the upper-level WSW flow were in excess of 45 m/s, with favourable mid- and upper-level storm relative winds from 8 to 20 m/s (Kerr and Darkow, 1996). In the meantime, a discrete mid-level layer of drier air was present around the 700 hPa level, resulting in an effective downdraft production. Nonetheless, vertical profiles were over-all dominated by a well saturated air mass, generating a quite weak DCAPE (200 J/kg) and high values of K Index (34). Instability parameters show a moderately unstable profile, with a CAPE of 700 J/kg (EL at 285 hPa), a MULI of -2,6°K and a Significant Severe Parameter of 12,927. On the other hand, shear parameters show very high values : 0-1 km SRH (607 $m^2/s^2$), 0-3 km SRH (692 $m^2/s^2$) and Low Level Shear (22 m/s) reach critical values. All these parameters produce a vertical profile which is tornado and supercell conducive (EHI of 2.94 and SCP of 10.5).

It is worthy to note that high resolution numerical models succeeded in forecasting this event, despite its mesoscale component characteristics. The Tornado and Severe Storms French Observatory forecasters tested for this case, with the contribution of Avel Olejnikov, a 2.8 km horizontal resolution WRF model grid centred on northern France, nested on a 7.5 km grid covering whole France, nested itself on the GFS 1° model (2 August 18h UTC initialisation, i.e. 24 hours before the tornadic event). Results based on a 3D-Var assimilation show an impressive precise result (see Fig.3). Nonetheless, GFS- and NMM-based routine forecasts which are produced daily by the French Observatory (Keraunos) highlighted this tornado risk on northern France for the August, 3, 2008 evening, about 12 hours before the event. Estofex forecasters produced nearly the same prediction as Keraunos forecasters : that shows that moderate resolution models are partly sufficient to point out tornado risk areas with a valuable efficiency.

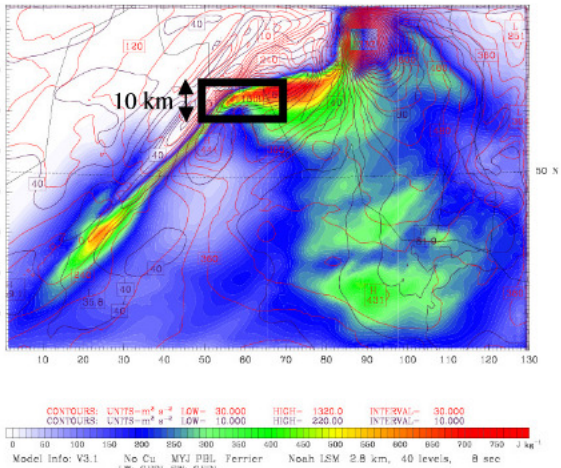


FIG. 3: 27h forecast of CAPE (shaded), 0-3km SRH (red lines) and BRN (black lines) for August, 3, at 21h UTC (2.8 km resolution WRF field). The area hit by the tornado is outlined in black.

## V. RESULTS AND CONCLUSIONS

The tragic events of August, 3, 2008, in northern France, are related to a severe supercell-induced tornado, that hit seven cities on a 19 km long and 150 m wide path. Site investigation shows that the vortex reached an EF-4 intensity and had a translation speed of about 80 km/h.

This tornado confirm that the Nord – Pas de Calais French region counts among the European regions which are the most frequently hit by severe tornadoes (Dessens and Snow, 1989). Indeed, in this 12,400 km² area, we count no less than 2 EF-3 (1965, 1998), 2 EF-4 (1967, 2008) and 1 EF-5 (1967) tornadoes on the modern period. That means that the tornado risk in this area could be considered as significant.

Furthermore, despite a quite original synoptic configuration in comparison to usual tornadic synoptic patterns in France, this case proves the liability and the legitimacy of convective forecasts experiments that are led in France (Keraunos) or in Germany (Estofex) in order to improve severe storms prediction.

## VI. AKNOWLEDGMENTS

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## VII. REFERENCES

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