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**KERAUNOS** - Observatoire Français des Tornades et des Orages Violents <u>www.keraunos.org</u>



# • a tornado can be defined by 3 parameters :

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2. From F-scale to EF-scale

3. Specific damage indicators and degrees of damage

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1 : the width of its path





# Introduction

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# a tornado can be defined by 3 parameters :

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- 1 : the width of its path
- 2 : the length of its path



• a tornado can be defined by 3 parameters :

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- 1: the width of its path
- **2** : the length of its path
- **3** : the wind speeds produced by the vortex, especially at house level

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- 2 : the length of its path
  - **3** : the wind speeds produced by the vortex, especially at house level

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a real challenge to determine it

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France

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indicators and degrees of

Contribution to an European adaptation of the Enhanced Fujita Scale : Analysis of Damage caused by Tornadoes in a tornado can be defined by 3 parameters : 1 : the width of its path quite easily determined by ground Introduction **2** : the length of its path 1. Methodology **3** : the wind speeds produced by the vortex, especially at house level 2. From F-scale to EF-scale



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Introduction



# Introduction

• the only way to evaluate the intensity of a tornado remains to **analyse the damage** caused by it on the ground

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The issue here consists in determining if these American bases can be augmented by the analysis of the damage caused by tornadoes on European buildings and infrastructures, which have different characteristics than American ones



# Methodology

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## • our study is based on the KERAUNOS French tornadoes database :

KERAUNOS is a meteorological team which seeks historical tornado cases and documents all recent tornado cases in France.



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# • our study is based on the **KERAUNOS French tornadoes database** :

Methodology

KERAUNOS is a meteorological team which seeks historical tornado cases and documents all recent tornado cases in France.

◆ 513 tornado cases to date (in the « main list »)

- tornado cases from 1157 to 2011
- ♦ a database built on strict rules and divided into 2 lists

Main list : fully verified tornado cases

Precise information about the **nature** of the damage and about the **organisation** of the damage is required.

# our study is based on this « main list »

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Second list : very probable

but not fully verified criteria





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France Introduction	until 2006	<b>Fujita scale</b> (F-scale) was used in order to rate tornado intensities in France, firstly by Prof. Jean Dessens (1989), then by KERAUNOS	
1. Methodology	2007	publication of the Enhanced Fujita Scale (EF-scale)	
2. From E coolo to EE coolo			

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publication of the Enhanced Fujita Scale (EF-scale)



2007

until

2006

**New perspectives** : the F-scale is a useful tool, but we think it is not fully adapted to French/European tornado\_damage

The F-scale is conceived as a **wind speed** scale (inspired from the Beaufort scale).

The EF-scale is conceived as a **damage** scale.

The EF-scale is **more pertinent** during damage survey, because the **testimony** left by a tornado on terrain is an **explicit damage**, **not an explicit wind speed**.

Many tornado ratings were not very precise in France insofar as the **damage observed could not be interpreted directly on the "original" F-scale** (for example : the « **well-built frame home** » is not a typical French construction).



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From F-scale to EF-scale

• many studies were realised these last years in order to modulate the "original" F-scale and to adapt it more precisely to the European area characteristics



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From F-scale to EF-scale

• we propose a **new and complementary approach**, which consists of using an "EF-scale approach" in order to apply the principles of the EF-scale to French tornado cases.



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From F-scale to EF-scale

• we propose a **new and complementary approach**, which consists of using an "EF-scale approach" in order to apply the principles of the EF-scale to French tornado cases.

Why ?

The "EF approach" is the only one that distinguishes various damage indicators and thus takes into account in a more precise way the solidity of each sort of building, infrastructure or vegetation damaged by the tornadoes.



# List of tornado damage in France

• the damage caused by each one of the 513 tornado cases of the KERAUNOS database has been compiled in order to build an **exhaustive list of landscape elements that have been hit by tornadoes in France** :

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# List of tornado damage in France

• the damage caused by each one of the 513 tornado cases of the KERAUNOS database has been compiled in order to build an **exhaustive list of landscape elements that have been hit by tornadoes in France** :

- vegetation (trees, vines,...);
- ♦ rivers;
- ♦ fields;
- buildings (houses, barns or factories);
- civil and religious monuments (churches), castles;
- high-rise buildings;
- retail buildings;
- $\diamond$  cemeteries;
- vehicles (cars, agricultural carts, trucks,...);
- electrical transmission lines;
- ◆ street furniture;
- humans and animals.



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# List of tornado damage in France

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- high-rise buildings;
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- vehicles (cars, agricultural carts, trucks,...);
- electrical transmission lines;
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- humans and animals.

Which damage indicators are relevant in order to efficiently represent this whole list ?



Contribution to an European adaptation of the	<ul> <li><i>EF-scale damage indicators available today</i></li> <li>the EF-scale already counts 28 damage indicators :</li> </ul>			
Enhanced Fujita Scale : Analysis of Damage caused by Tornadoes in				
France Introduction 1. Methodology	1 Small Barns or Farm Outbuildings (SBO) 2 One- or Two-Family Residences (FR12) 3 Manufactured Home – Single Wide (MHSW) 4 Manufactured Home – Double Wide (MHDW) 5 Apartments, Condos, Townhouses [3 stories or less] (ACT) 6 Motel (M) 7 Masonry Apartment or Motel Building (MAM)	Many indicators, <b>but</b> :		
<ul> <li>2. From F-scale to EF-scale</li> <li>3. Specific damage indicators and degrees of damage</li> <li>Conclusion</li> </ul>	8 Small Retail Building [Fast Food Restaurants] (SRB)9 Small Professional Building [Doctor's Office, Branch Banks] (SPB)10 Strip Mall (SM)11 Large Shopping Mall (LSM)12 Large, Isolated Retail Building [K-Mart, Wal-Mart] (LIRB)13 Automobile Showroom (ASR)14 Automobile Service Building (ASB)15 Elementary School [Single Story; Interior or Exterior Hallways] (ES)16 Junior or Senior High School (JHSH)17 Low-Rise Building [1-4 Stories] (LRB)18 Mid-Rise Building [5-20 Stories] (MRB)	<pre>many differences between this list and the list of tornadic damage in France.</pre>		
	<ul> <li>19 High-Rise Building [More than 20 Stories] (HRB)</li> <li>20 Institutional Building [Hospital, Government or University Building] (IB)</li> <li>21 Metal Building System (MBS)</li> <li>22 Service Station Canopy (SSC)</li> <li>23 Warehouse Building [Tilt-up Walls or Heavy-Timber Construction](WHB)</li> <li>24 Transmission Line Towers (TLT)</li> <li>25 Free-Standing Towers (FST)</li> <li>26 Free-Standing Light Poles, Luminary Poles, Flag Poles (FSP)</li> <li>27 Trees: Hardwood (TH)</li> <li>28 Trees: Softwood (TS)</li> </ul>	causes sometimes a problem for precise tornado rating in France		



# An « augmented » EF-scale ?

Our study consists in determining the EF-scale damage indicators which are likely to be applied in France without modification, and isolating the others.

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	Common
	indicators :
	EF-scale
	damage
	indicators
	which can be
	directly or
	partly
1	applied in
	France





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An « augmented » EF-scale ?

Specific	Common
American	indicators :
indicators : EF-	EF-scale
scale damage	damage
indicators which	indicators
can be almost	which can be
only used in the	directly or
USA	partly
	applied in
EF-sc	ale <sup>e</sup>





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An « augmented » EF-scale ?

Our study consists in determining the EF-scale damage indicators which are likely to be applied in France without modification, and isolating the others.



Our proposal thus consists in **adding specific indicators** which are not specific to the United States, but **specific to France** - and probably to **Europe** in a general way.





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# *Our proposal of specific indicators for France (and Europe)*

<u>HOUSES</u>:
 ♦ cottages, cob houses ;





# *Our proposal of specific indicators for France (and Europe)*

### HOUSES :

 $\diamond$  cottages, cob houses ;

urban contiguous houses (stone and/or brick);

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# *Our proposal of specific indicators for France (and Europe)*

## HOUSES :

- ◆ cottages, cob houses ;
- urban contiguous houses (stone and/or brick);
- urban apartments (18th or 19th centuries) built in large avenues;

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### <u>OTHER BUILDINGS :</u>

 $\diamond$  mills ;





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### <u>OTHER BUILDINGS :</u>

- 🔶 mills ;
- manufactures and factories ;
  - churches ;
- medieval castles ;





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### **OTHER BUILDINGS**:

- $\diamond$  mills :
- manufactures and factories ;
- churches;
- medieval castles ;
- other castles (Renaissance style).





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### **OTHER BUILDINGS**:

- $\diamond$  mills :
- manufactures and factories ;
  - churches :
- medieval castles ;
- other castles (Renaissance style). **OTHERS** :
- tombstones and other components of cemeteries





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### **HOUSES**:

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### **OTHER BUILDINGS**:

- $\diamond$  mills :
- manufactures and factories :
- churches :
- medieval castles ;
- other castles (Renaissance style).

### **OTHERS**:

tombstones and other components of cemeteries

This list of specific damage indicators could be augmented by five complementary indicators:

- rivers
- humans or light animals (lifted off the ground or not)
- heavy animals (lifted off the ground or not)
- light vehicles (lifted off the ground or not)
- heavy vehicles (lifted off the ground or not)



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### **HOUSES**:

cottages, cob houses;

urban contiguous houses (stone and/or brick);

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+

🔶 farms.

### **OTHER BUILDINGS**:

 $\diamond$  mills :

manufactures and factories :

churches :

**OTHERS**:

- $\diamond$  medieval castles ;
- other castles (Renaissance style)

these 10 specific indicators

the already defined « common » EF-scale indicators

= all French tornado cases can be precisely

♦ tombstones and other components of cemeteries

This list of specific damage indicators could be augmented by **five** complementary indicators:

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Degrees of damage and EF-scale rating

• Each one of these 10 specific indicators has been analysed in order to determine the **relevant degrees of damage for each indicator**.

 The last stage finally consists in determining, for each degree of damage, the level which could be associated on the EF-scale.
 Our method consists in gauging each degree of damage of a specific indicator while referring to the damage undergone by a common indicator (already listed in the EF-scale) hit at the same time by the same tornado.





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# **Example for the specific indicator « church »**

• EF-scale rating proposal for each degree of damage defined for the specific indicator "church" (established on about 100 cases out of 513) :

The typical church is built with bricks or stones, measures more than 50 meters long, have a solidly built roof structure, a 30 to 40 meters high bell-tower, and 1 meter thick walls.

degree of damage	description	EF-scale proposal
1	Threshold of visible damage	EF 0
2	Loss of roof covering material (<20%)	EF 0
3	Loss of significant roof covering material (20-50%) ; light damage on the bell-tower summit	EF 1
4	Collapse of the bell-tower summit (spire)	EF 2
5	Large sections of roof structure removed (50-80%); walls remain standing	EF 2
6	Roof structure significantly removed (> 80%) and blown away ; some walls collapsed ; damage on the bell-tower structure	EF 3
7	Roof structure totally removed; many walls collapsed; bell-tower partly destroyed	EF 4
8	Bell-tower significantly destroyed ; most of walls collapsed (1 case)	EF 5
9	Total destruction of entire building (0 case)	EF 5



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Degree of damage : 4

**EF 2** 



« Oostmalle » tornado (Belgium) June 25, 1967





EF 3



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# **Conclusion and further research**

• Our work and our proposal consists in an **"augmented" EF-scale**, which takes into account new **"specific**" damage indicators which are relevant for French (and probably European) buildings and infrastrutures, in order to improve the reliability of tornado ratings in France and probably in other European countries.



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- Our aim would be to widen these proposals on a **European scale** and thus to be able to validate, on an international level, all the specific indicators which are relevant for Europe, in complement of those already defined in the current EF-scale.



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- Our aim would be to widen these proposals on a **European scale** and thus to be able to validate, on an international level, all the specific indicators which are relevant for Europe, in complement of those already defined in the current EF-scale.
- **Tornado ratings would undoubtedly gain in precision and homogeneity** with such a method, and would make it possible to carry out more rigorous climatological analysis for contemporary and historical tornado cases.



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# Thank you for you attention