



# **Consequences of Tornadic Storms in Urban Areas: Case Study of the Paris Tornado (France) on September 10, 1896**

**Pierre MAHIEU, Emmanuel WESOLEK**

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[www.keraunos.org](http://www.keraunos.org)



**Consequences of Tornadoic Storms in Urban Areas:  
Case Study of the Paris Tornado (September 10, 1896)**

**Introduction**

1. Meteorological situation

- methodology
- 500 hPa analysis
- surface analysis

2. Characteristics of the Paris tornado

3. Impact of tornadoic storms on the population

Conclusion

**Introduction : urban tornadoes**

- **urban tornado** : a tornado that hits a continuous high density population area, without any natural zone (or marginally)

***urban tornadoes :  
a high potential for severe damage, due to strong population density***

***Example of a French urban tornado***

**Evreux tornado (France)**

May 4th, 1961

© Pelassy





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**Introduction : urban tornadoes**

**Statistics for France :**

[source : KERAUNOS French tornadoes database]

**urban tornadoes :**

- ◆ **only 20 tornadoes** hit major cities in France
- ◆ **i.e. only 4%** of French tornadoes



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- ◆ **only 20 tornadoes** hit major cities in France
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**« strictly » urban tornadoes :**

*a tornado which formed and dissipated in an urban environment*



**only 1 case** : the Paris tornado of September 10th, 1896

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**The Paris tornado : meteorological situation**

**• methodology**

synoptic patterns have been reconstituted thanks to **2 sources** :

- ◆ **weather observations** realised by the French weather stations network and compiled in *Les Annales du Bureau Central Météorologique de France*

Septembre 1896.

PARC DE SAINT-MAUR.

Longitude 0°9'23" E. — Latitude 48°48'34". — Altitude 49<sup>m</sup>.3.

DATES.	PRESSION (700 <sup>mm</sup> +).																							
	1 <sup>h</sup>	4 <sup>h</sup>	5 <sup>h</sup>	6 <sup>h</sup>	7 <sup>h</sup>	8 <sup>h</sup>	9 <sup>h</sup>	10 <sup>h</sup>	11 <sup>h</sup>	12 <sup>h</sup>	13 <sup>h</sup>	14 <sup>h</sup>	15 <sup>h</sup>	16 <sup>h</sup>	17 <sup>h</sup>	18 <sup>h</sup>	19 <sup>h</sup>	20 <sup>h</sup>	21 <sup>h</sup>	22 <sup>h</sup>	23 <sup>h</sup>	24 <sup>h</sup>		
1	56,91	56,82	57,00	57,20	57,23	57,05	57,06	57,02	56,66	56,71	56,75	56,30	55,91	55,78	55,63	55,60	55,81	56,05	56,26	56,21	56,18	55,80		
2	55,48	54,08	53,86	53,60	53,43	53,38	53,17	53,35	53,37	53,35	53,43	53,22	53,38	53,47	53,31	53,81	54,29	54,61	55,05	55,20	55,50	55,93		
3	56,00	56,59	56,72	57,13	57,41	57,56	57,82	57,88	57,85	57,82	57,71	57,53	57,25	57,30	57,35	57,32	57,43	57,59	57,69	57,77	57,82	57,80		
4	57,60	57,00	56,93	57,02	56,98	56,70	56,60	56,35	55,80	55,50	55,12	54,70	54,16	53,68	53,37	53,40	53,32	53,36	52,42	52,10	52,18	52,00		
5	52,23	52,20	52,20	52,21	52,07	51,32	51,31	52,31	52,07	51,88	51,91	51,70	51,69	51,66	51,91	52,30	52,61	52,93	53,14	53,13	52,90	52,56		
6	52,25	51,62	51,69	52,52	53,21	54,16	54,71	55,00	55,21	55,40	55,80	56,05	56,03	56,26	56,53	56,81	57,11	57,58	57,73	57,82	57,98	58,20		
7	58,00	57,60	57,48	57,61	57,76	57,70	57,81	57,89	57,81	57,71	57,57	57,10	56,91	56,76	56,58	56,56	56,63	56,73	56,67	56,59	56,41	56,12		
8	55,98	55,04	55,10	54,78	54,87	54,79	54,42	54,36	53,98	53,65	53,14	52,71	52,31	52,17	51,91	51,70	51,63	51,71	51,78	51,89	51,77	52,00		
9	51,81	51,89	52,12	52,62	53,78	54,80	55,12	55,02	55,02	54,59	54,85	54,76	54,33	54,13	54,02	54,10	54,40	54,80	54,82	54,70	54,31	54,41		
10	52,15	50,16	50,71	50,78	51,17	51,10	51,25	51,51	51,43	51,27	50,21	49,10	48,88	49,46	50,11	51,28	52,72	53,36	53,72	54,09	54,37	54,81		

- ◆ **reanalysis** and research program carried out jointly by the ESRL-PSD (NOAA) and the CIRES

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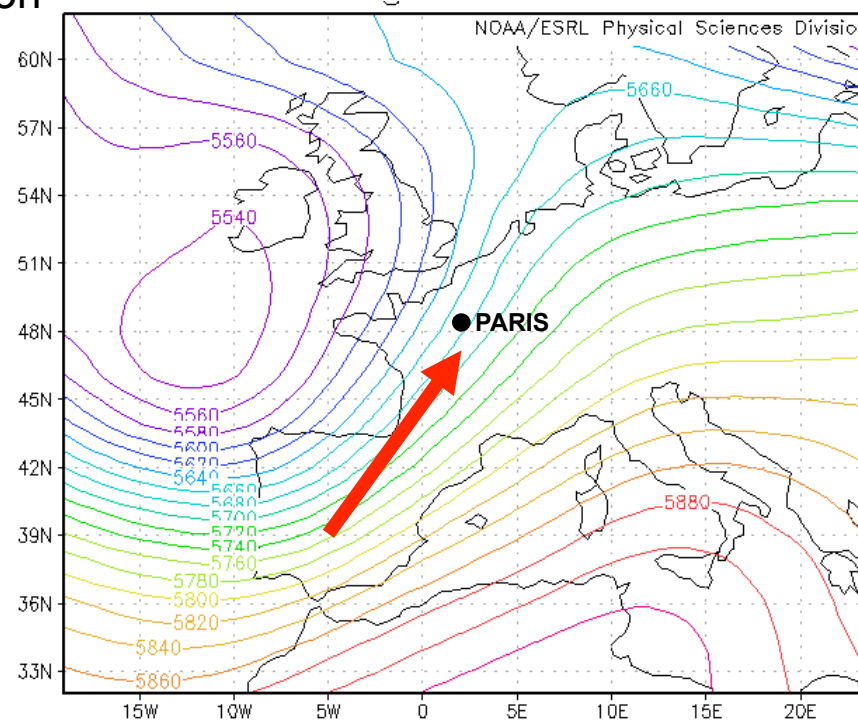
Conclusion

• **500 hPa analysis**

- ◆ a deep high level trough on the eastern Atlantic Ocean
- ◆ a rapid south-western cyclonic flow on the whole France
- ◆ tropical air mass advection

**500 hPa Geopotential Height**  
(meters).  
September 10th, 1896, 00h  
UTC.  
Source : NOAA/ESRL  
Reanalysis.

***The Paris tornado : meteorological situation***



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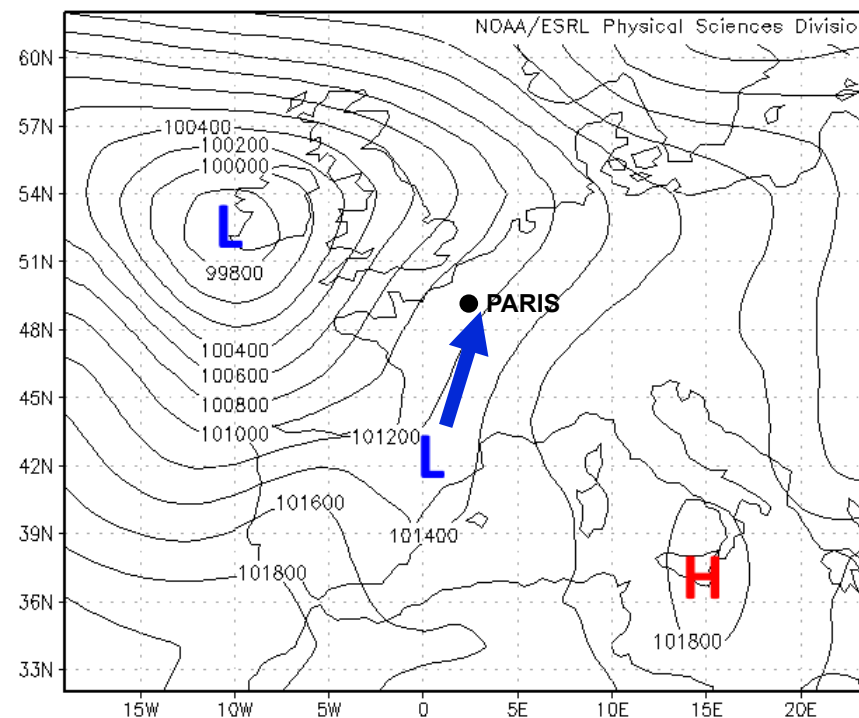
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***The Paris tornado : meteorological situation***

• **Surface analysis**

- ◆ a low level trough formed in Spain and moved towards Paris
- ◆ this surface mesolow concentrated severe storms activity
- ◆ a typical « Spanish Plume » configuration

**Mean sea-level pressure (Pa).**  
September 10th, 1896, 00h UTC.  
Source : NOAA/ESRL Reanalysis.





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**Characteristics of the Paris tornado**

• **methodology**

precise inventory of damage thanks to a **collection of testimonies** :

- ◆ in local newspapers
- ◆ in scientific literature

# LE CYCLONE

“Le Figaro”, newspaper

September 12, 1896

On connaît maintenant l'identité du malheureux surpris par le cyclone sur le quai des Orfèvres, en face du service de la Sûreté et qui a été écrasé par la chute des portes. C'est un nommé Alfred Eyears, âgé de vingt-sept ans. C'était un jockey anglais au service de M. Guinebert, propriétaire de chevaux de courses, route de Poissy, à Maisons-Laffitte. Eyears avait fait une chute assez grave aux courses de Saint-Germain. Il se rendait à l'Hôtel-Dieu pour y suivre un trai-

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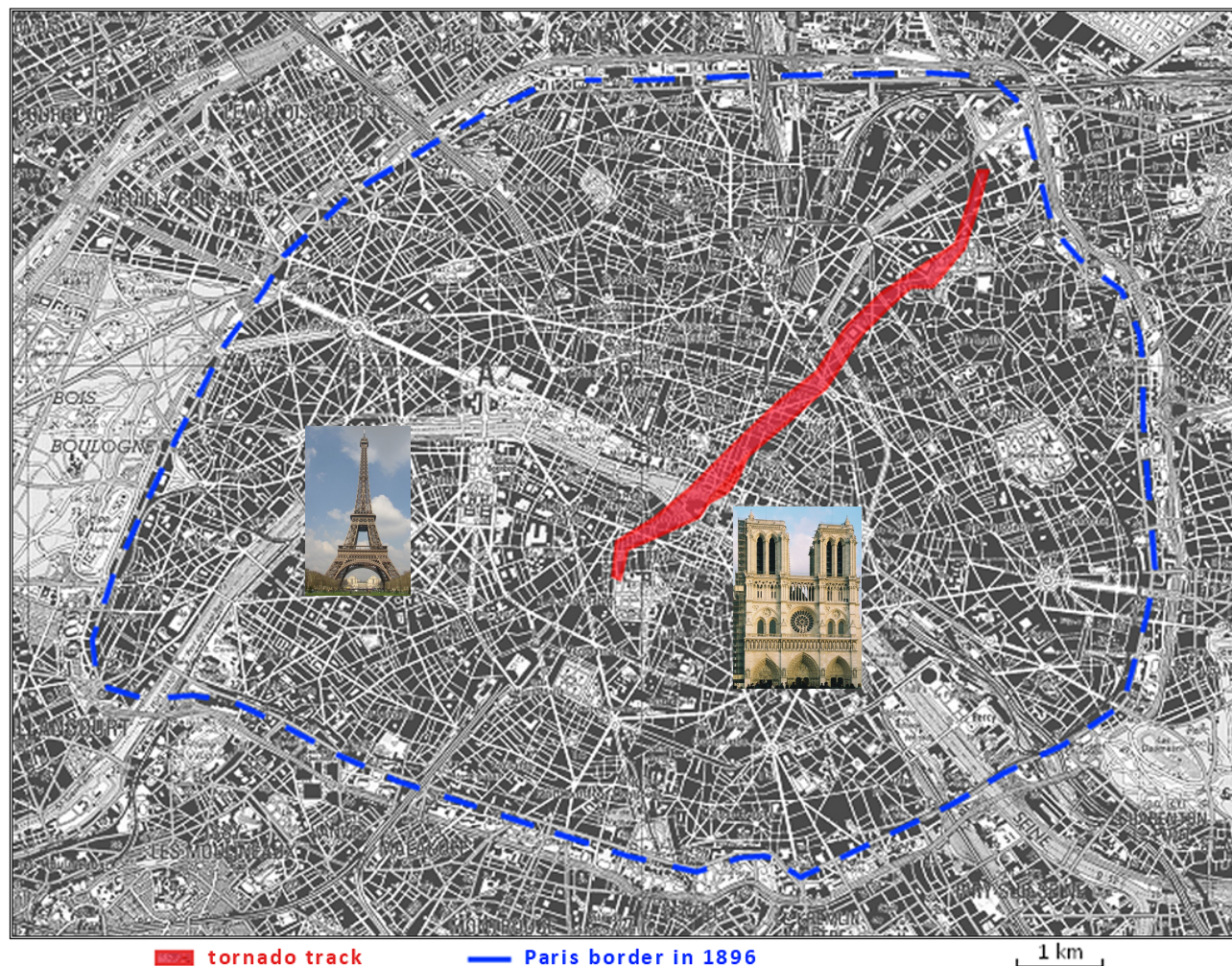
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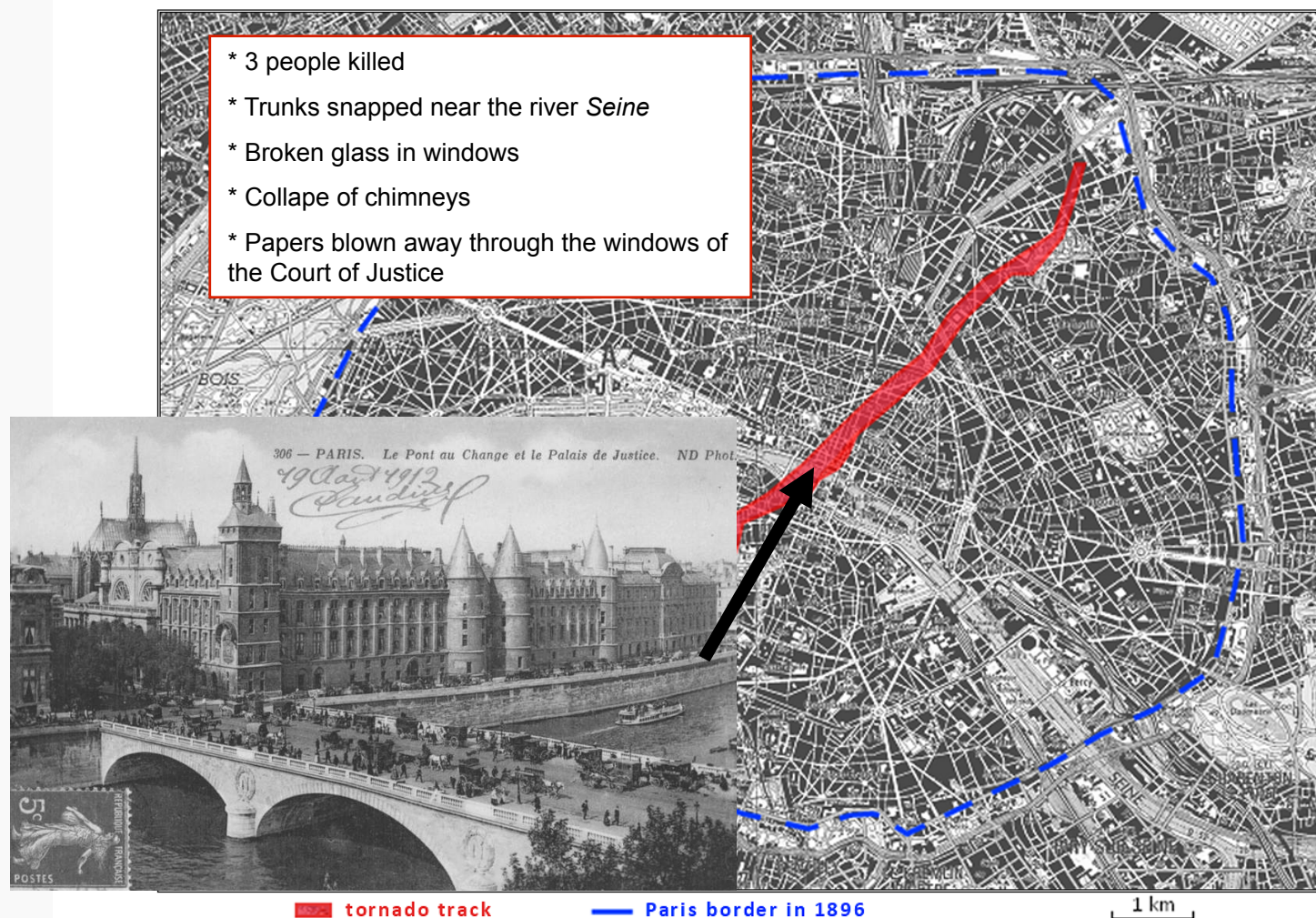
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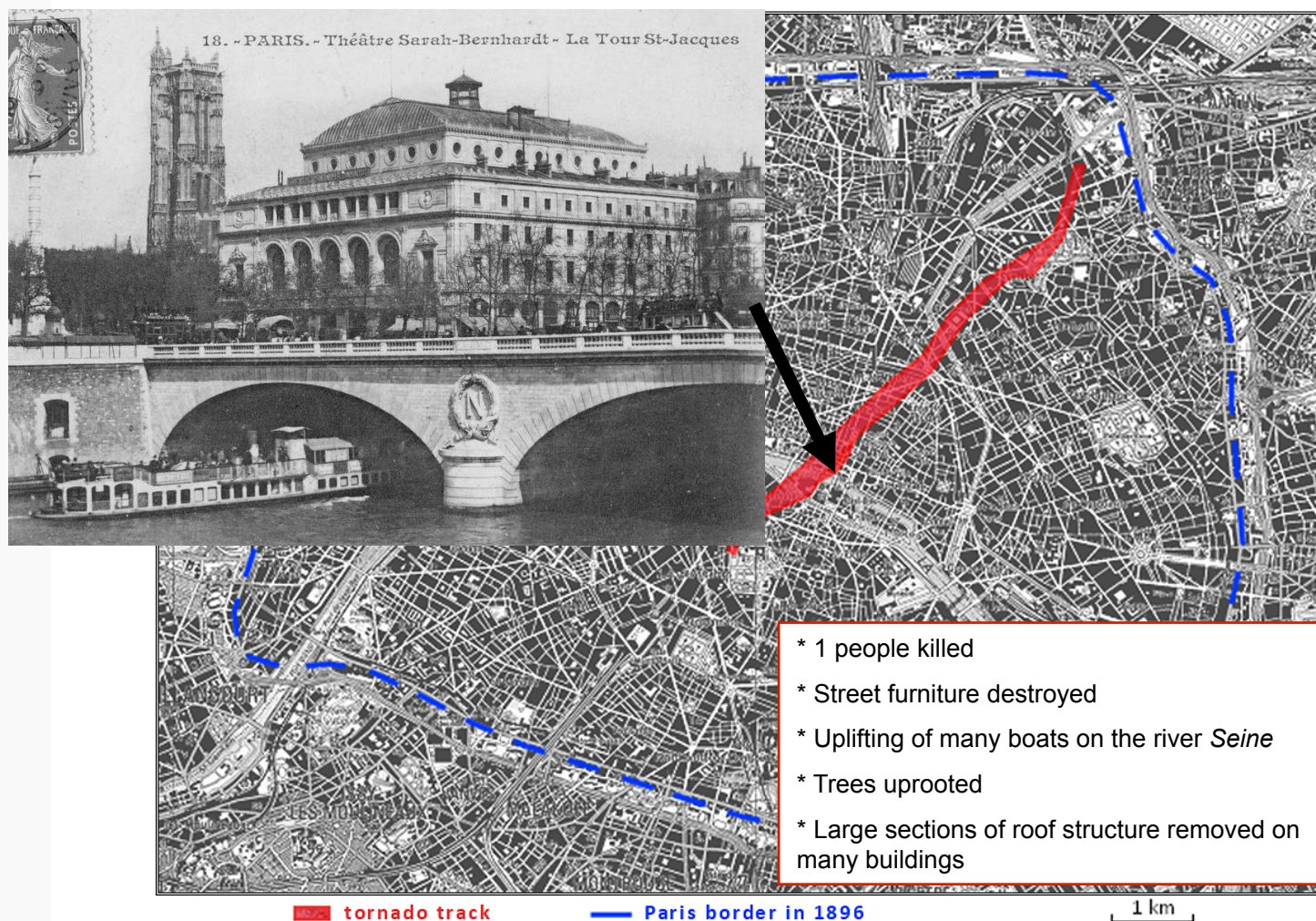
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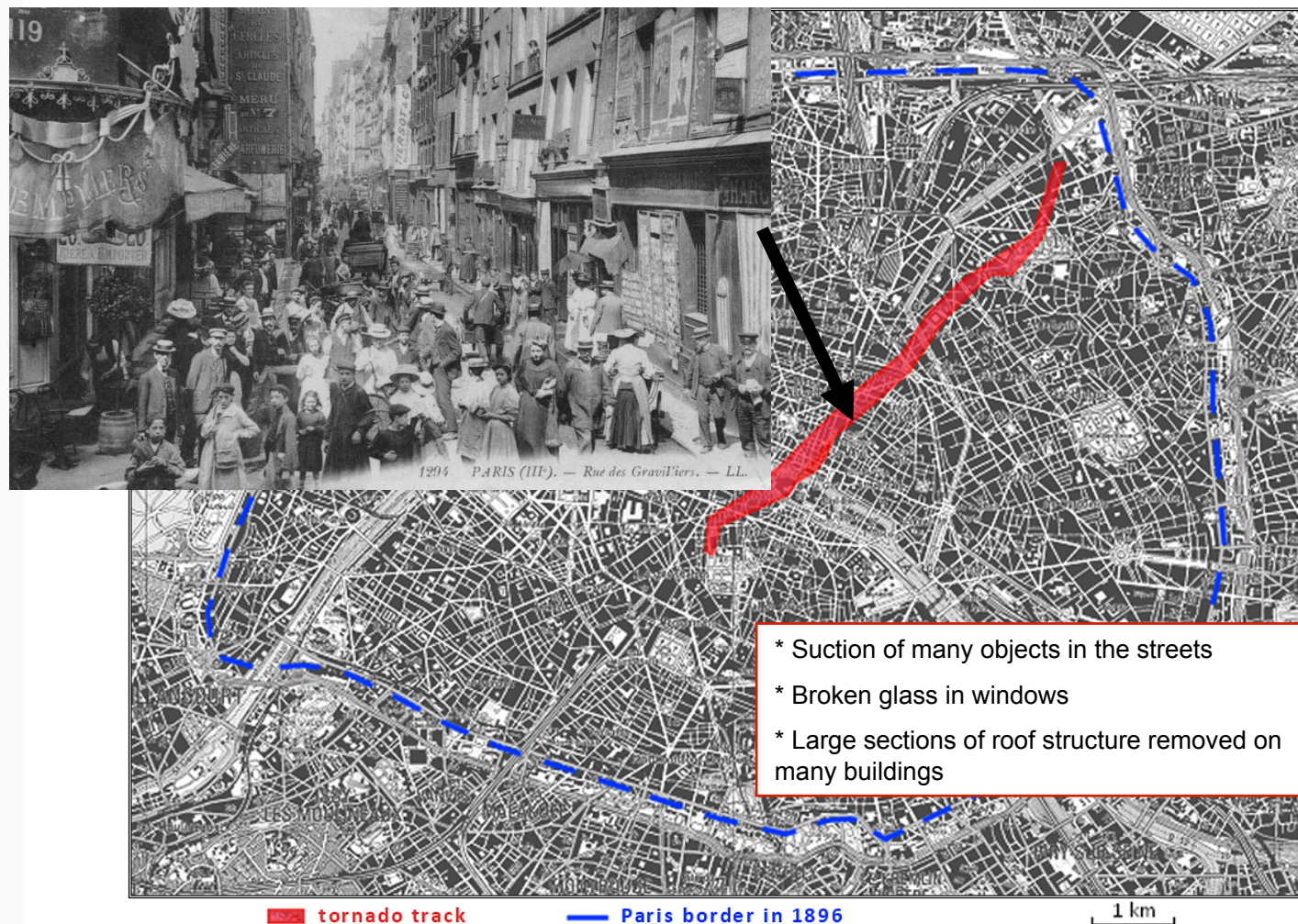
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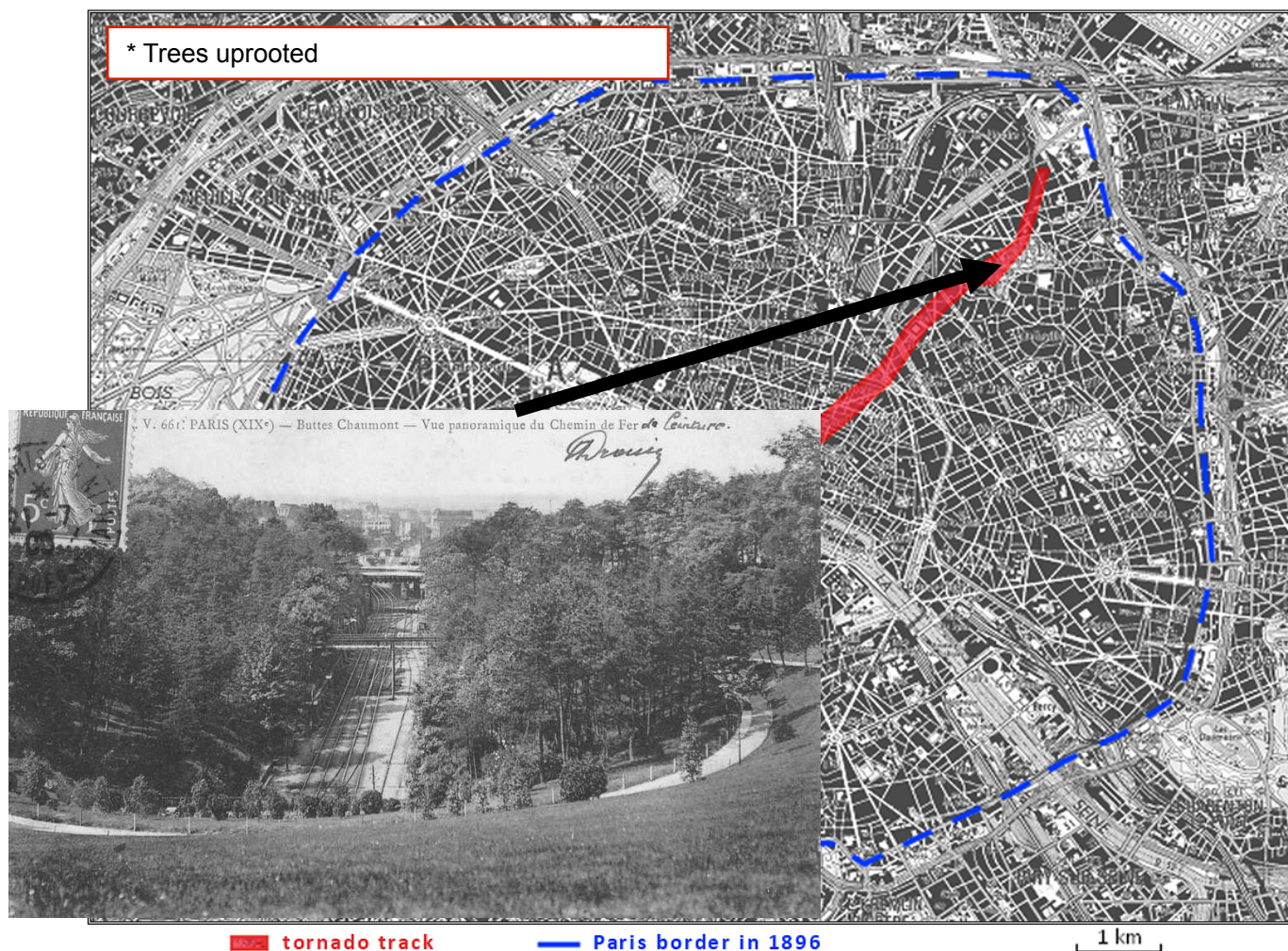
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**Tornado highlights**

The only strictly urban tornado ever observed in France.

- ◆ **hour** : 2:30 pm
- ◆ **intensity** : F2
- ◆ 6500 meters long path
- ◆ 300 meters large path
- ◆ **devastation area** : 195 hectares (i.e. 2,5% of Paris territory in 1896)

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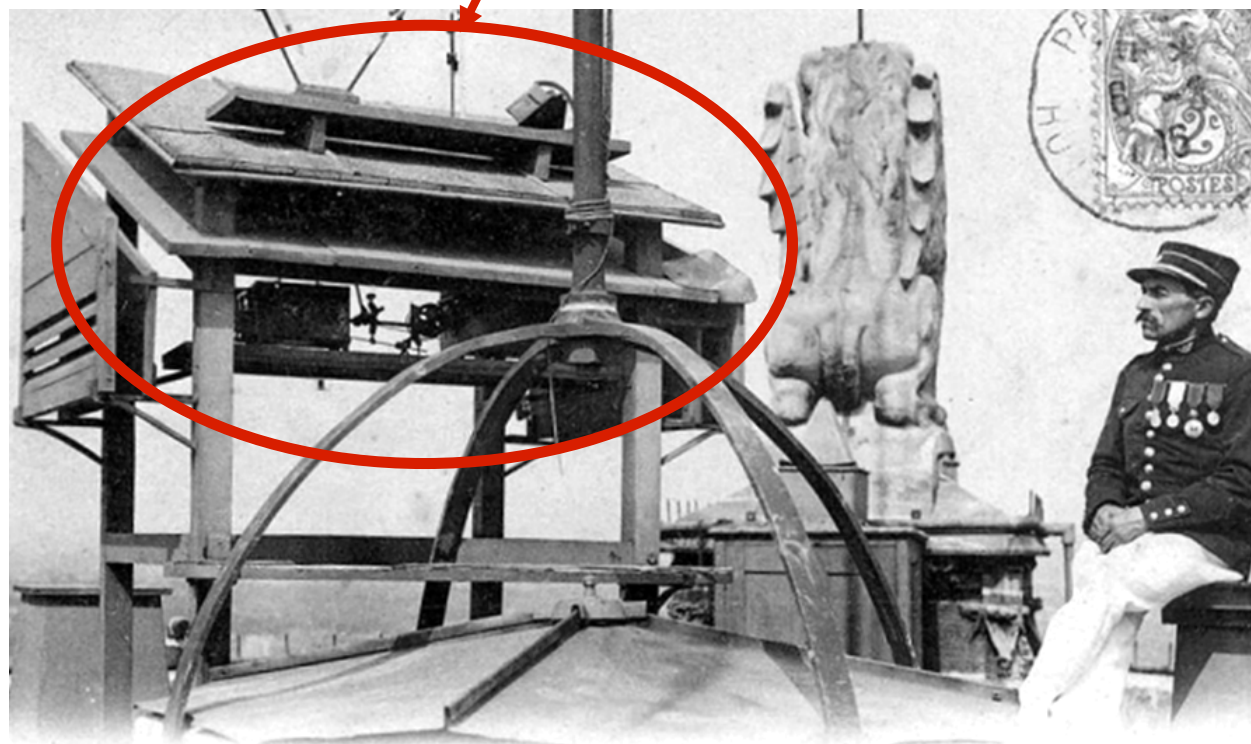
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**Barographic measure**

- **the tornado hit the barograph** of the meteorological observatory of the Saint-Jacques Tower (at the summit of the tower)



443 PARIS. — L'Observatoire de la Tour Saint-Jacques. — LL.



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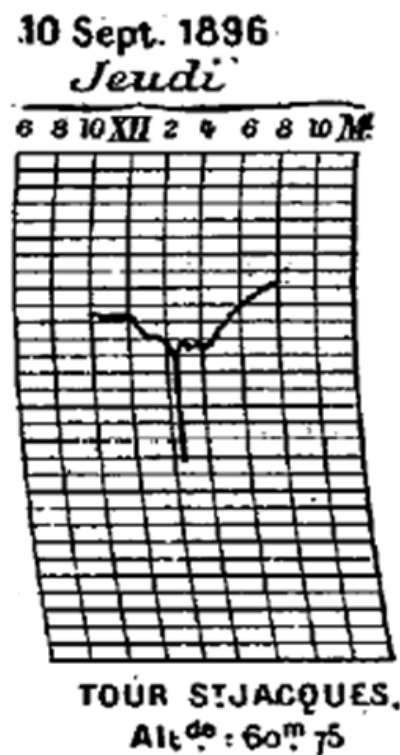
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## Barographic measure

- the sea-level pressure suddenly dropped from **997 hPa** to **989 hPa** at 2:43 pm



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**• vulnerability of urban areas**

- death and injury causes
- tornado damage

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***Vulnerability of urban areas***

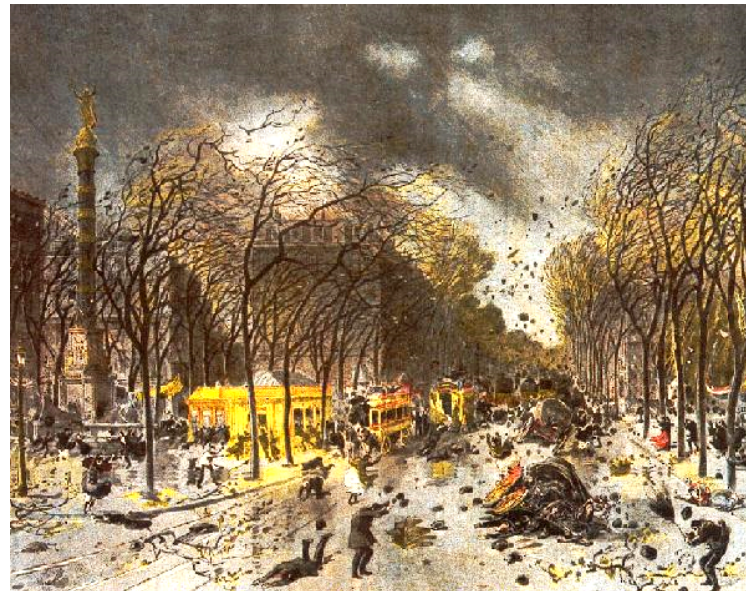
◆ the Paris tornado of 1896 **killed 5 people**, and injured **more than 70** other people

◆ this tornado is the **9th deadliest tornado** in France

◆ this tornado is the **deadliest F2** tornado in France

**Engraving of the Paris tornado**

Place du Châtelet, Paris





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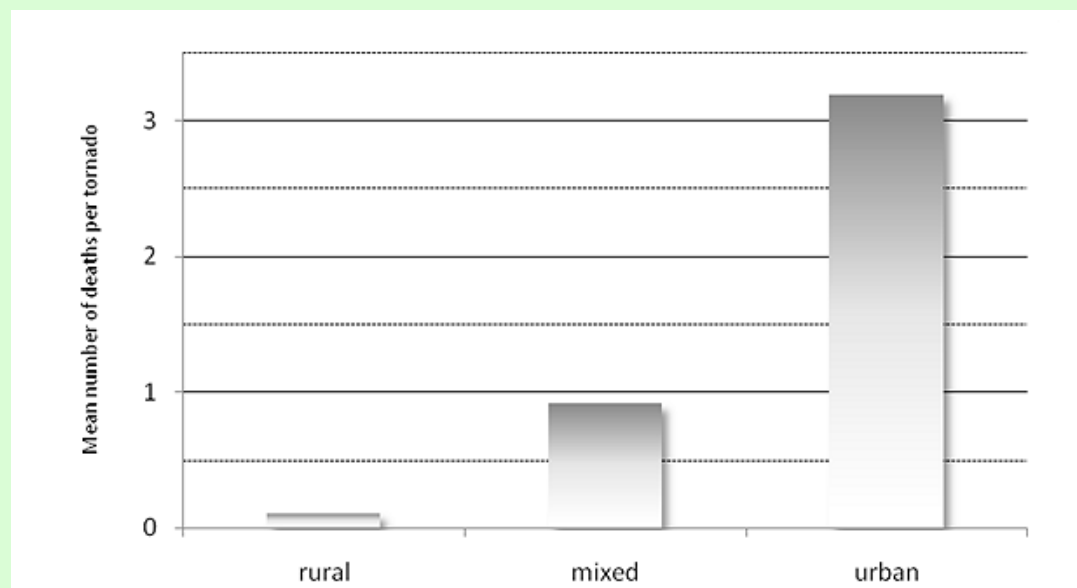
- **vulnerability of urban areas**
- death and injury causes
- tornado damage

### Conclusion

## Vulnerability of urban areas

- **great urban centers** could have a **negative influence** on the formation of the weakest tornadoes (F0-F1) [source : Elsom D.T., Meaden G.T., 1982 : Suppression and Dissipation of Weak Tornadoes in Metropolitan Areas: A Case Study of Greater London. *Monthly Weather Review*, 110, 745-756 ]
- the probability for a tornado to kill people is **significantly higher** in a urban area

Median number of death per occurrence of tornado, in France, according to the type of environment (rural / mixed / urban)





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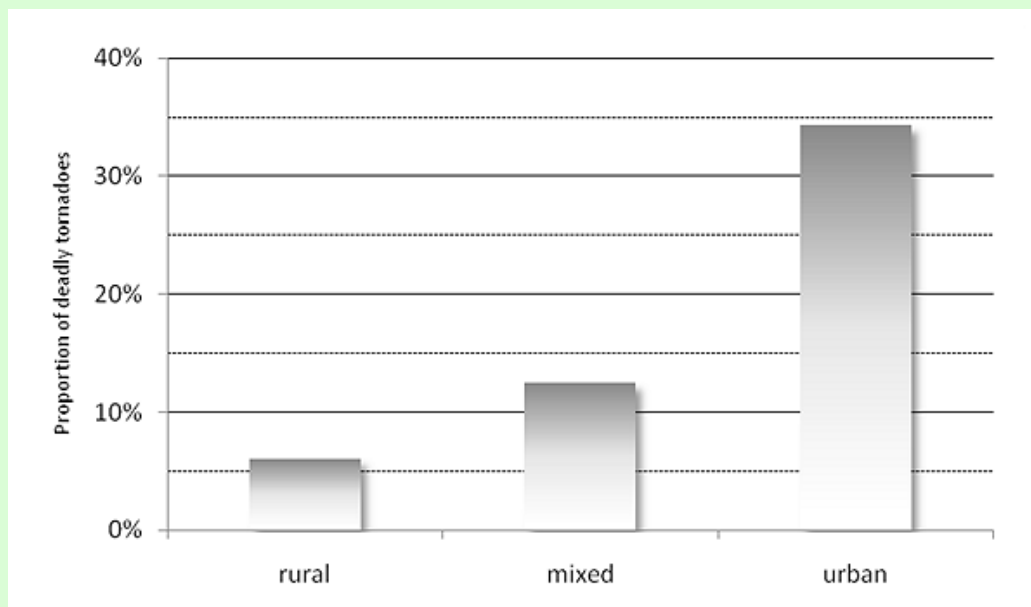
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## Vulnerability of urban areas

- even if the urban tornadoes are not very common, they present a **significant risk of death, even for moderate tornadoes**

Proportion of deadly tornadoes in France, according to the type of environment





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**Death and injury causes**

- the 5 deaths caused by the Paris tornado have all been the **consequence of a fracture of the skull**

fall of heavy objects

violent thrown of victims on the ground

- various **other fractures** (especially on legs)
- simple **public safety recommendations** could probably avoid most of these injuries

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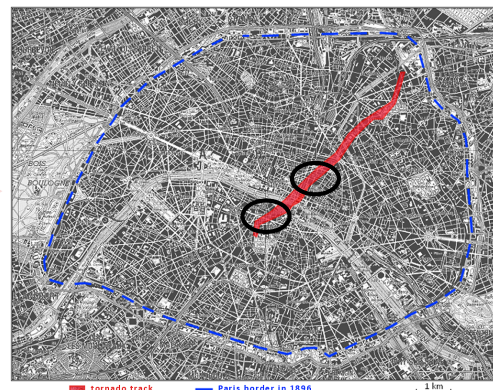
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**Tornado damage in an urban environment**

- a **straight track** and **little peripheral damage** in the districts composed by **very dense habitat**

Example of very dense habitat

Rue Saint-André-des-Arts  
(Paris, 6<sup>ème</sup>)



**0 death**

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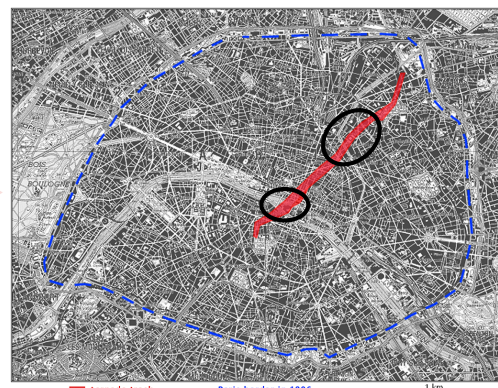
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**Tornado damage in an urban environment**

- a more **irregular track** and **numerous peripheral damage** in the districts composed by **less dense habitat**, large avenues and public gardens

Example of less dense habitat

Place de la République  
(Paris, 6<sup>ème</sup>)



**5 deaths**  
in these  
areas

Areas of less dense habitat



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- urban tornadoes are rare in France (38 cases of 513) but **urban areas are much more exposed to extensive damage, injuries and deaths** (urban tornadoes are about 30 times more deadly than rural tornadoes, in France) : **a special attention is needed** in severe weather forecast and nowcast when thunderstorms are imminent in those areas



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- **simple public safety recommendations**, especially to cover ones head and to go in the nearest building, **could avoid most of the severe injuries** during urban tornado events



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- **simple public safety recommendations**, especially to cover ones head and to go in the nearest building, **could avoid most of the severe injuries** during urban tornado events
- **urban areas composed with large avenues** and public gardens seem to be exposed to the **most extensive damage** and to the **highest risk of deaths** in case of tornado



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***Thank you for your attention***