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Quantifying hail hazard from convective overshooting

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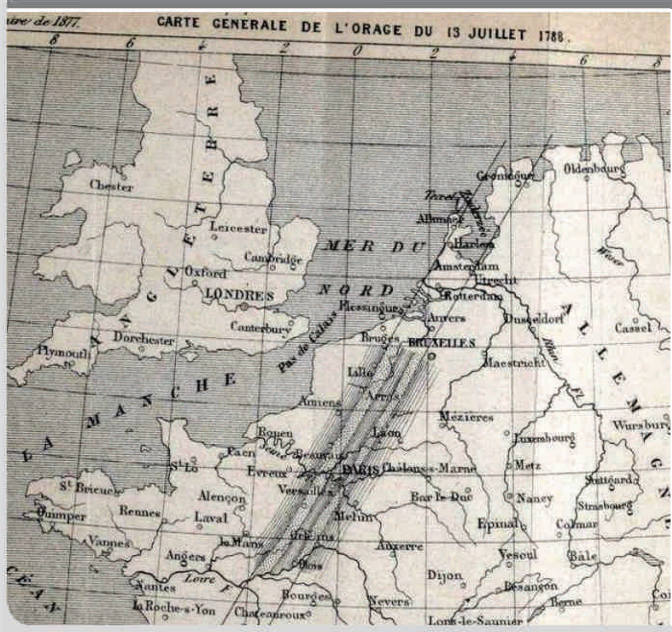
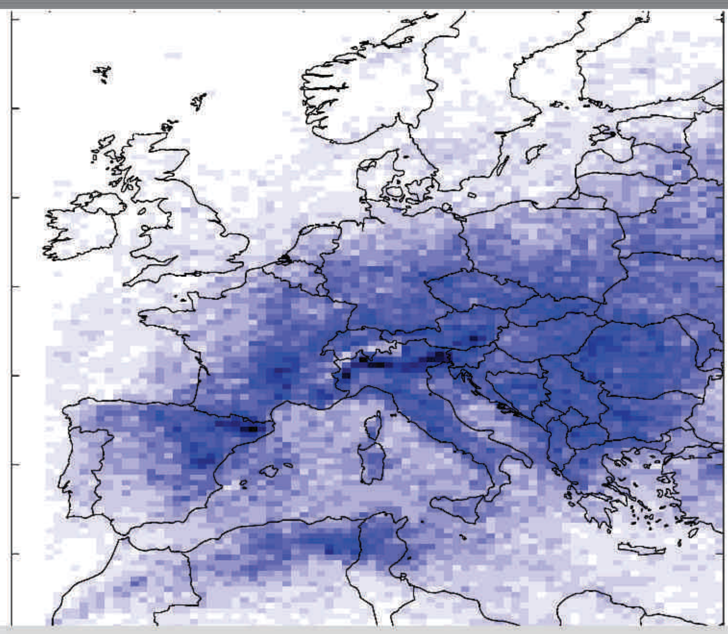




Hail in Europe

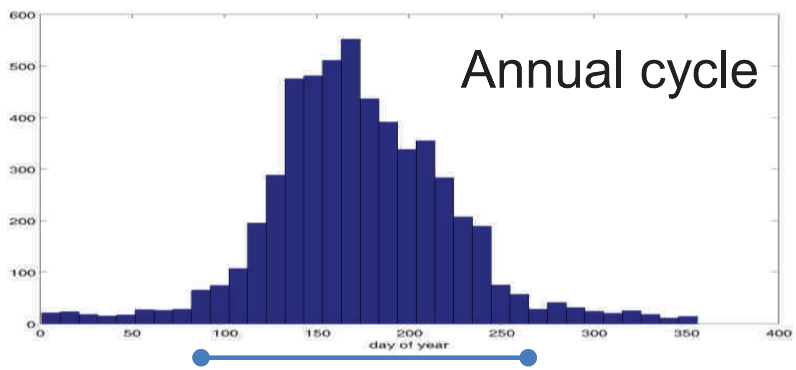
- One of the most costly natural hazards
- 2013 and 2014: largest loss events > 2 bn USD

- No continental scale climatology
- Diverging trends and projections for future climate

Hail reports

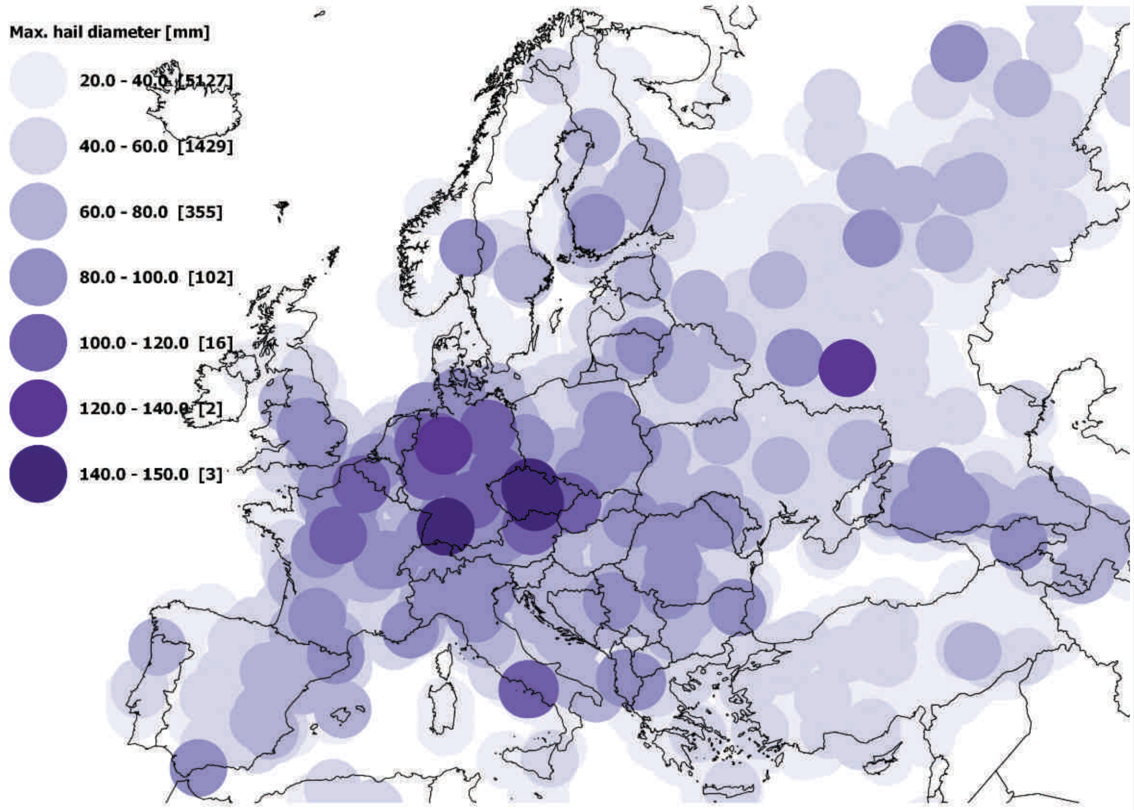
Large hail occurs in all parts of Europe

ESWD: 12,282 reports in period 2004-2014

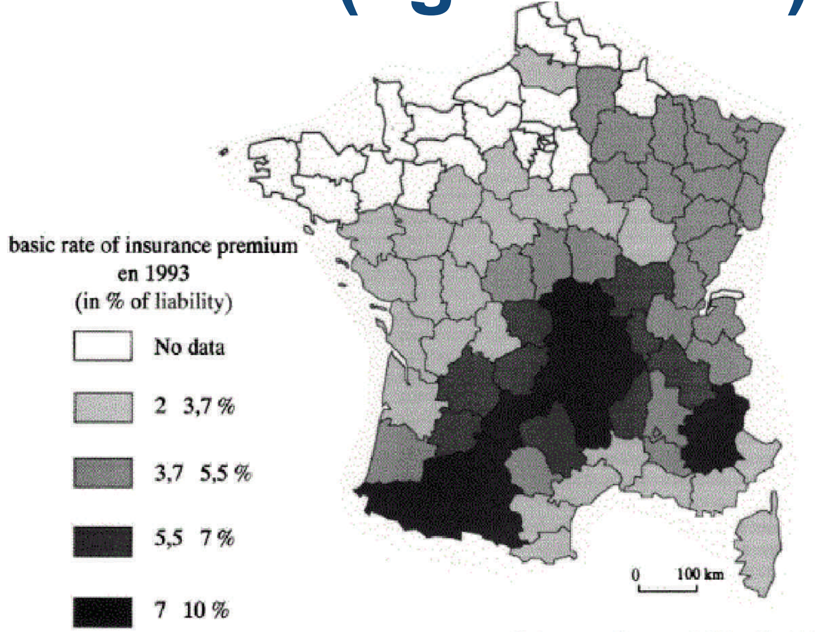


APR – SEP: 95%

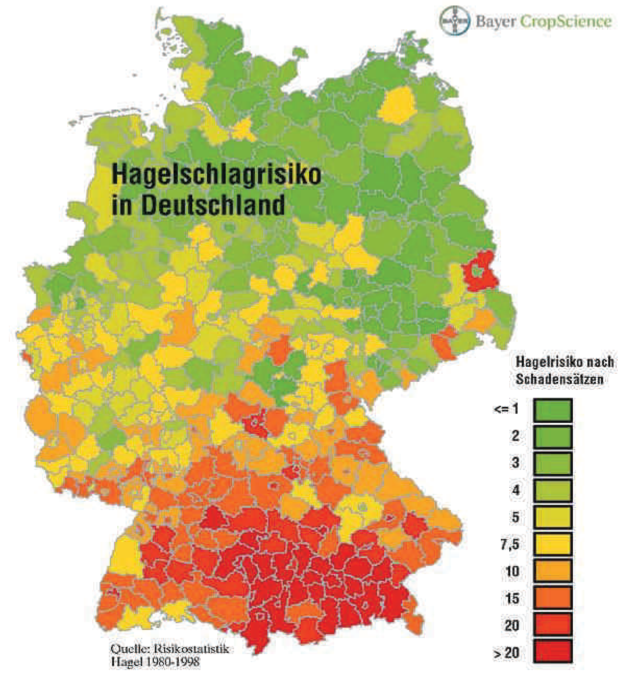
Reports of significant hail in the European Severe Weather Database (ESWD)

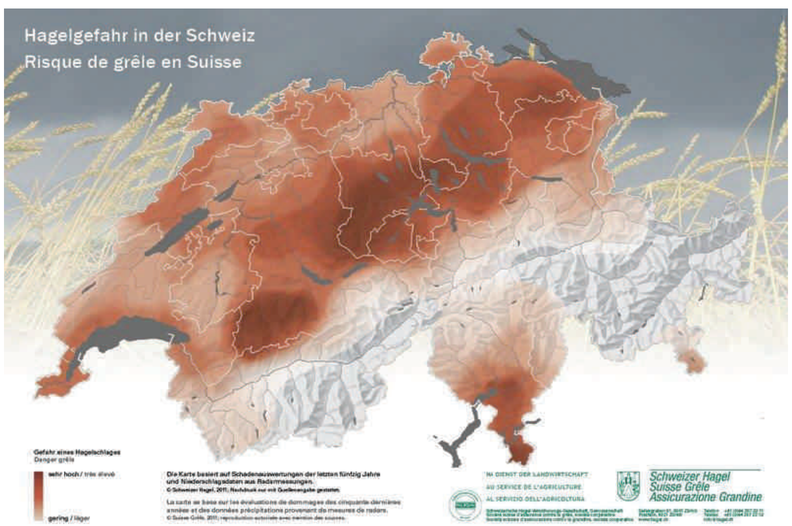


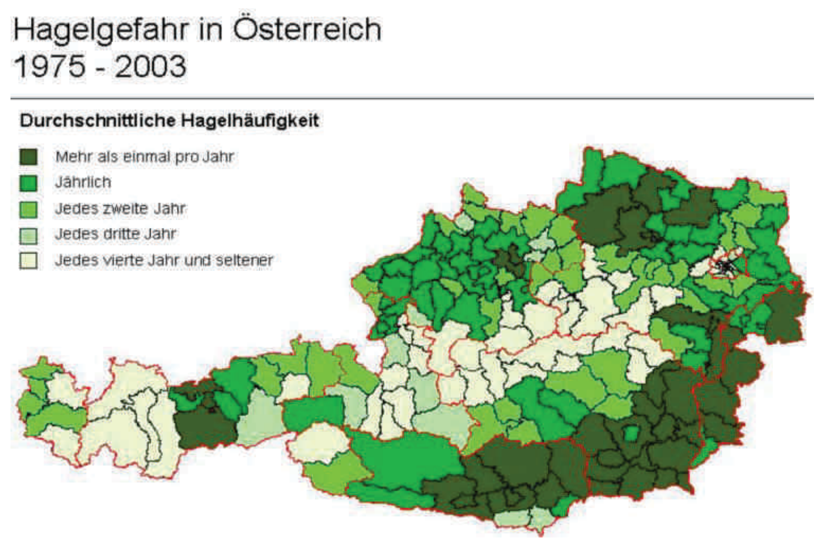
Hail climatology: Insurance (agriculture)



Data source : Groupama in Malaval L., 1995

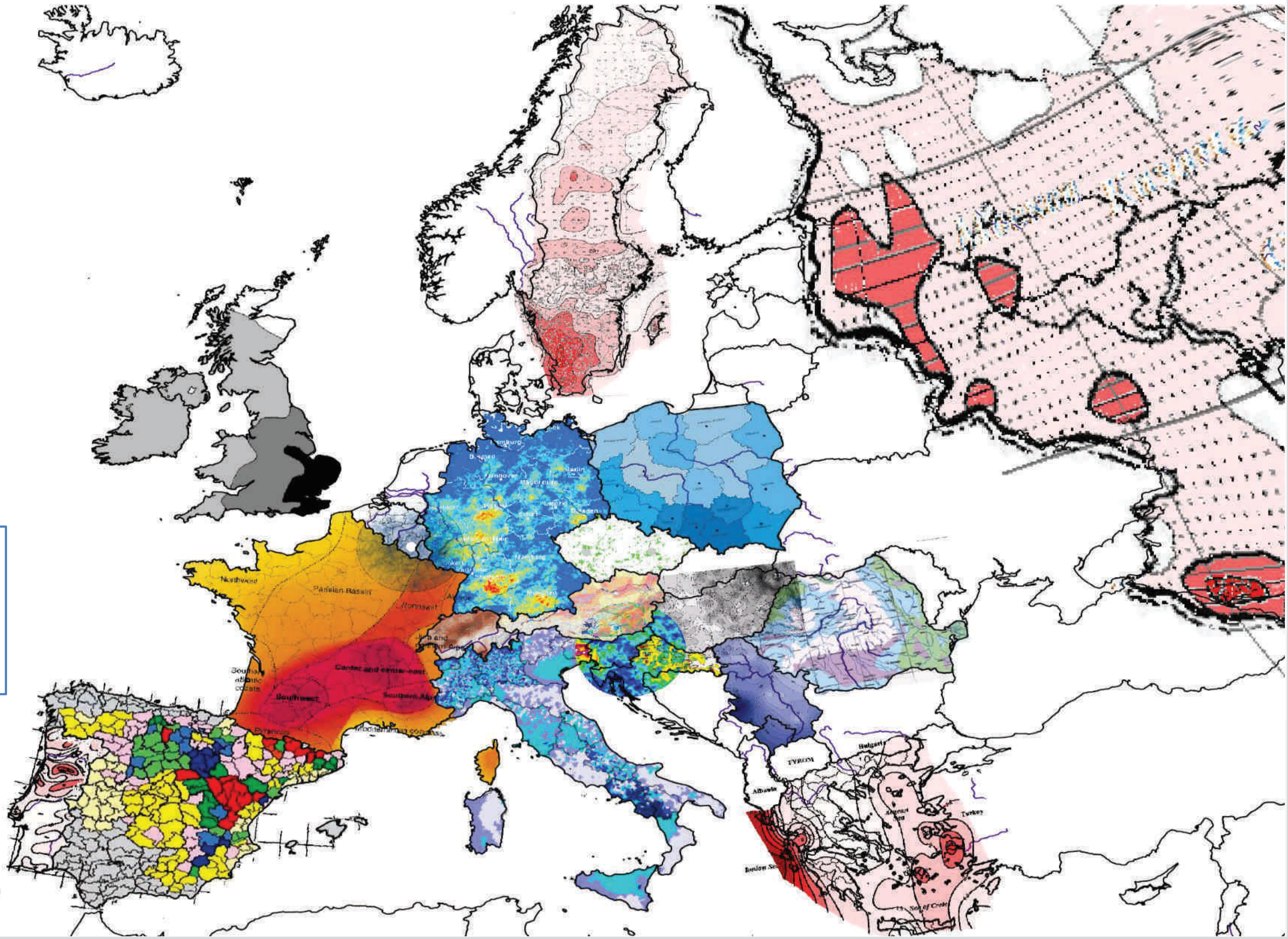






European hail climatology?

KIT Karlsruher Institut für Technologie



Observations from various data sources

Punge and Kunz, 2016

Overshooting cloud tops as a proxy

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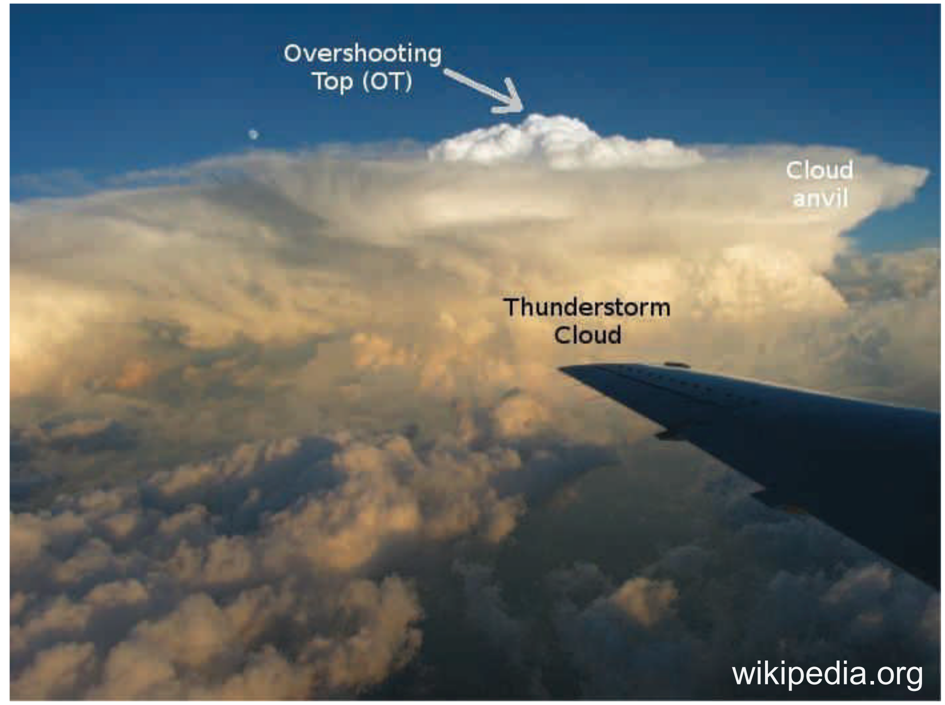
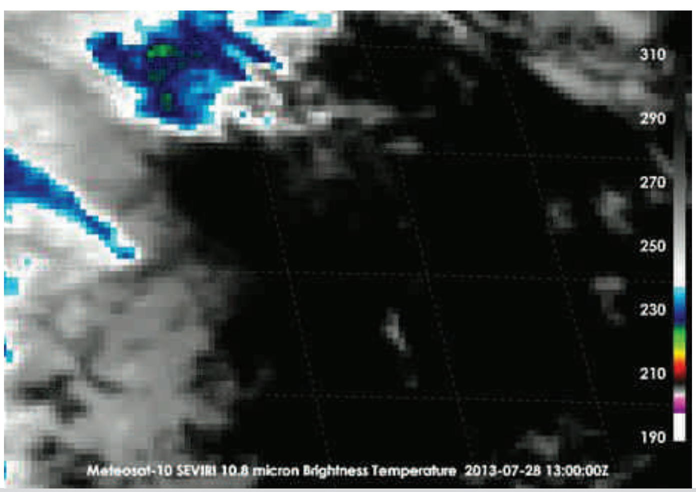
- Intrusions of the thunderstorm cloud above the equilibrium level
- Indicate very strong convective updraughts
- Unstable
- Detected as cold pixels in IR satellite imagery

(see talk K. Bedka)





Meteosat (MSG) - SEVIRI instrument cloud top temperatures 28 July 2013, 13-17 UTC; 15 min. time step

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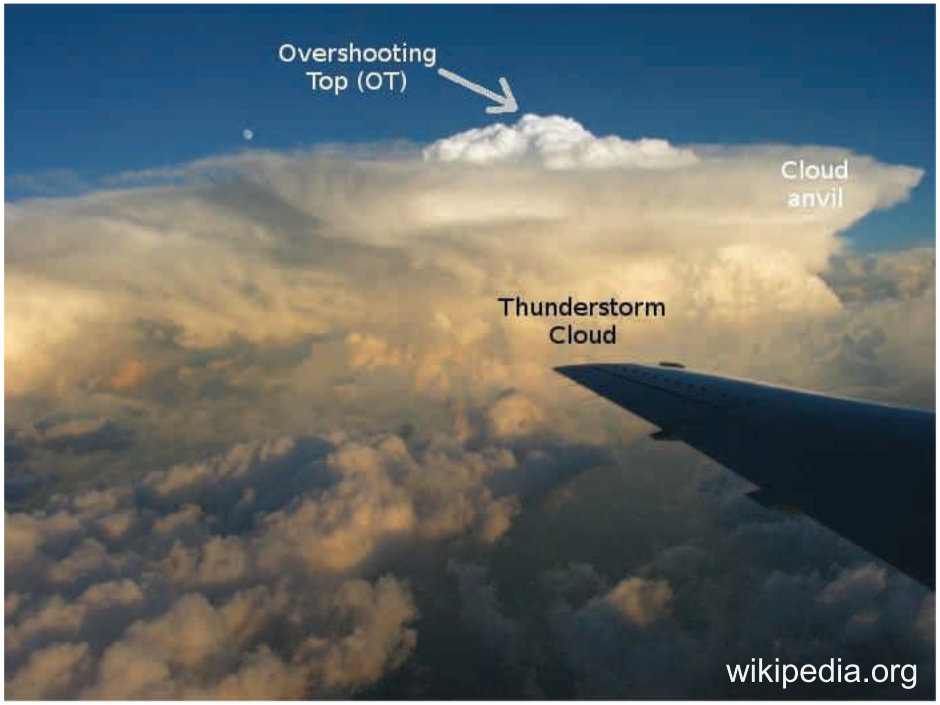

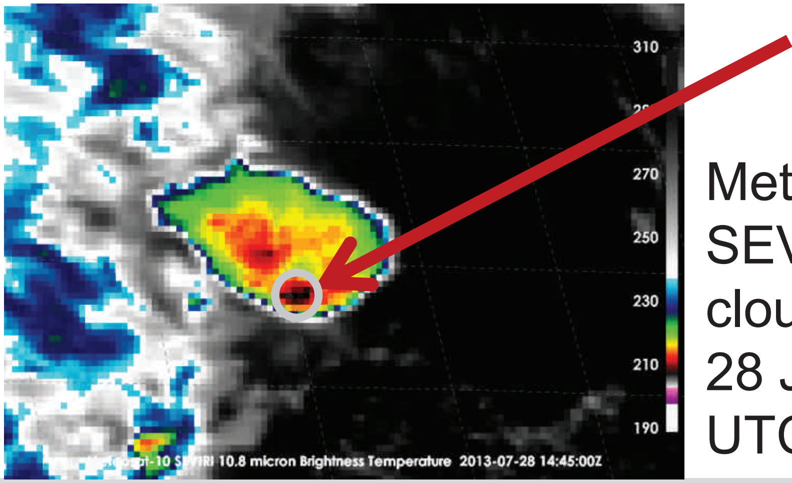

Meteosat (MSG) - SEVIRI instrument cloud top temperatures 28 July 2013, 13-17 UTC; 15 min. time step

Example: Hail outbreak "Felix", 26 May 2009

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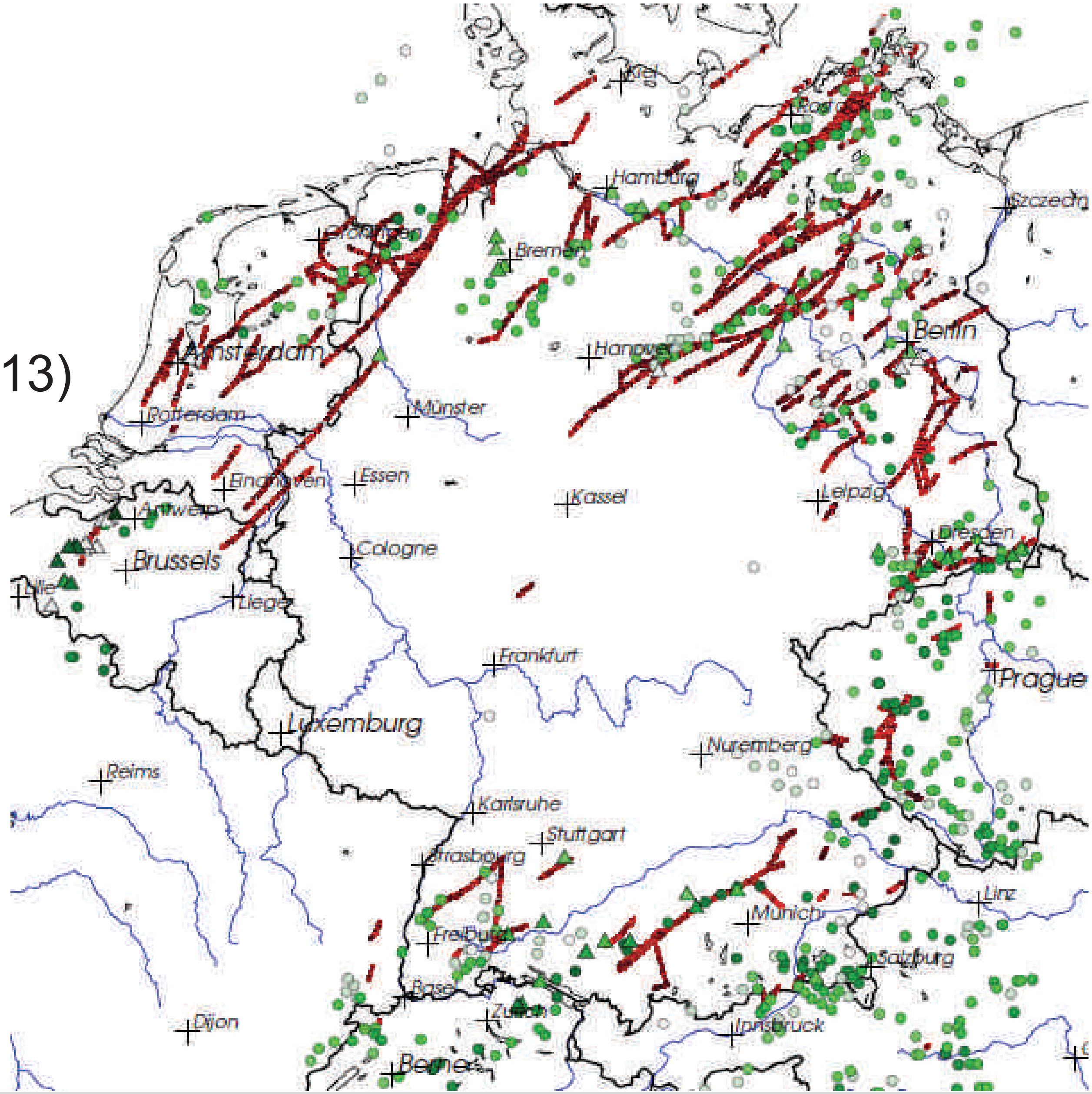
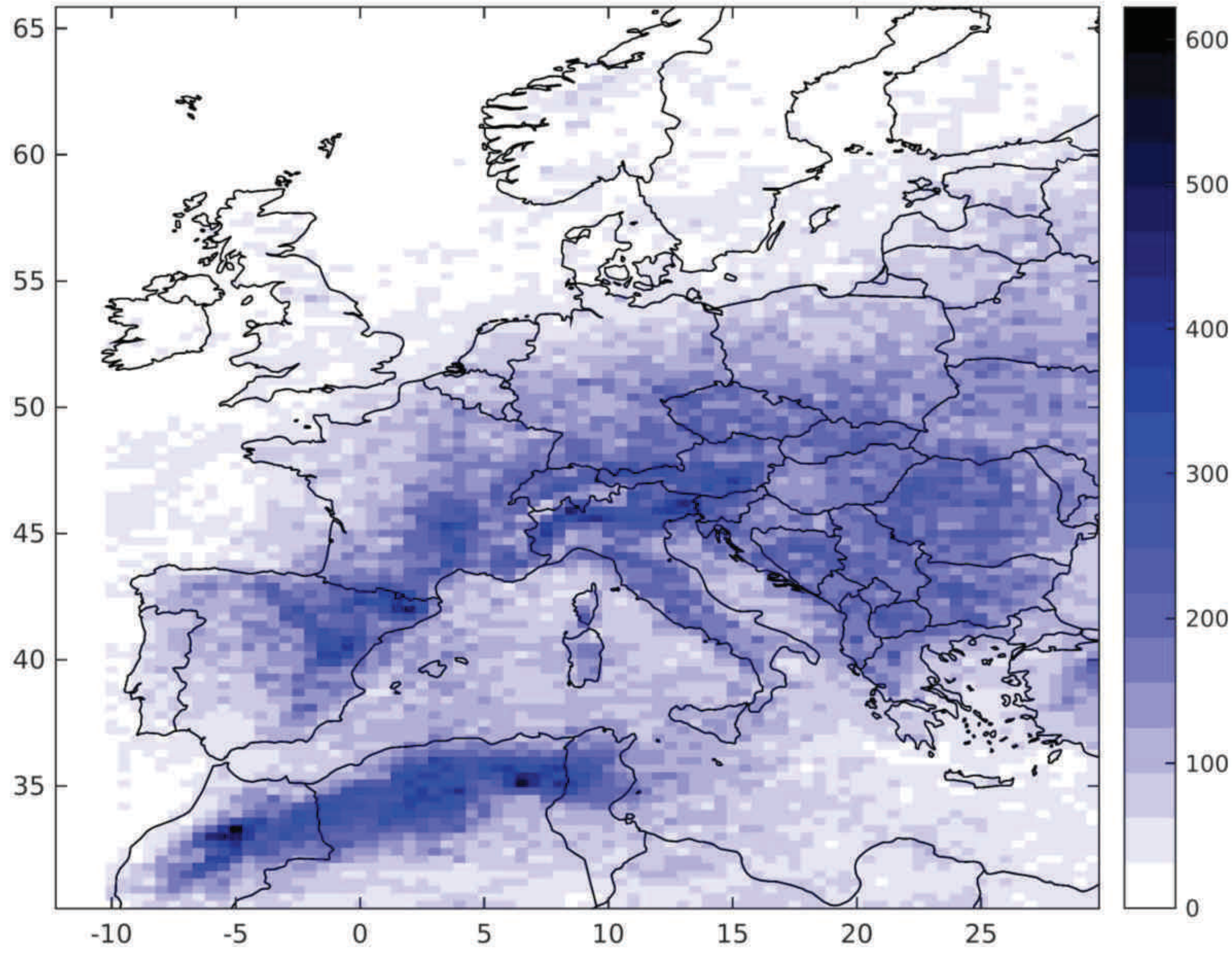


- Radar tracks (Puskeiler, 2013)
- ESWD large hail reports
- OT detections

Overshooting cloud top frequency

- MSG-SEVIRI
- **Detection algorithm by K. Bedka**
- 15 min. time step
- April-September
- 2004-2014
- 0.1° grid
- 700,000 OTs



Filter Approach: Eliminate OTs where hail is less likely

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1. Evaluate atmospheric conditions for each large hail event reported in the European Severe Weather Database (ESWD) from ERA-INTERIM reanalysis
2. For each variable v_i, define **lower** and **upper** thresholds :

$$v_i^{low} = p_5(v_i) - [p_{10}(v_i) - p_5(v_i)] \qquad v_i^{high} = p_{95}(v_i) + [p_{95}(v_i) - p_{90}(v_i)]$$

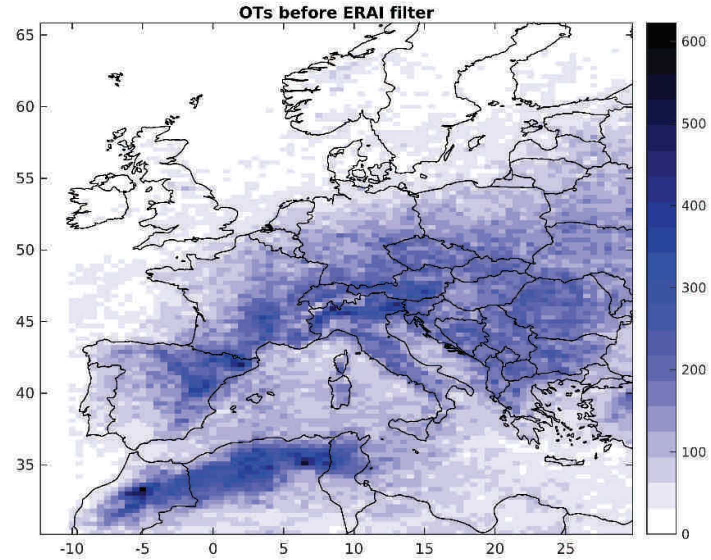
where p_k is the k^{th} percentile of the distribution

3. Evaluate conditions at OT occurrences v_i^{OT}
4. Filter OTs below/above thresholds **(22% in total)**

Lower thresholds ($v_i^{OT} < v_i^{low}$) for:
height of PV=2 tropopause,
dew point @ 2m,
total column water vapor,
eq. potential temperature @ 850hPa,
zero degree height

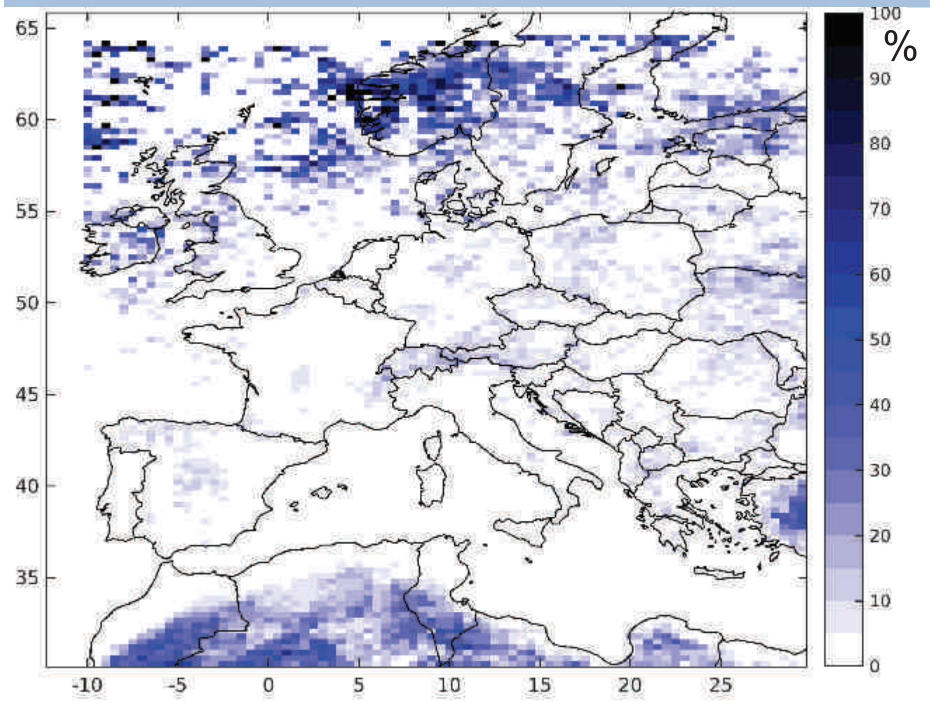
Upper thresholds ($v_i^{OT} > v_i^{high}$) for:
height of PV=2 tropopause,
temperature @ 700hPa
humidity @ 300hPa ,
eq. potential temperature @ 500hPa,
zero degree height

Filter examples:

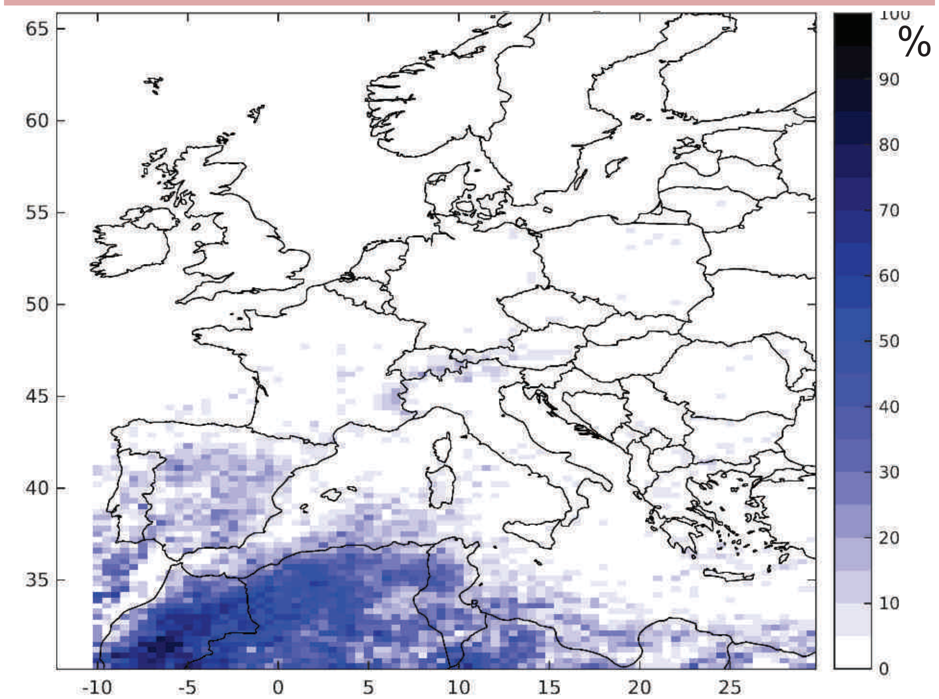


Percentage of OTs filtered for:

Low dew point temperature



High freezing level



Retained OTs

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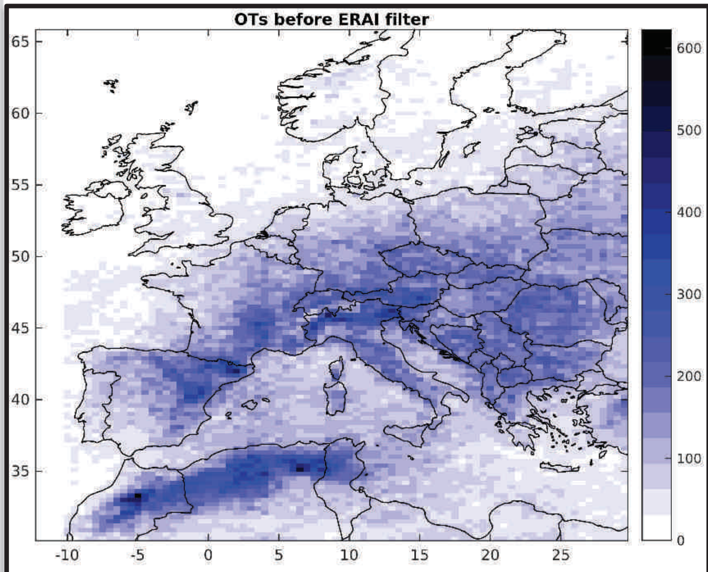
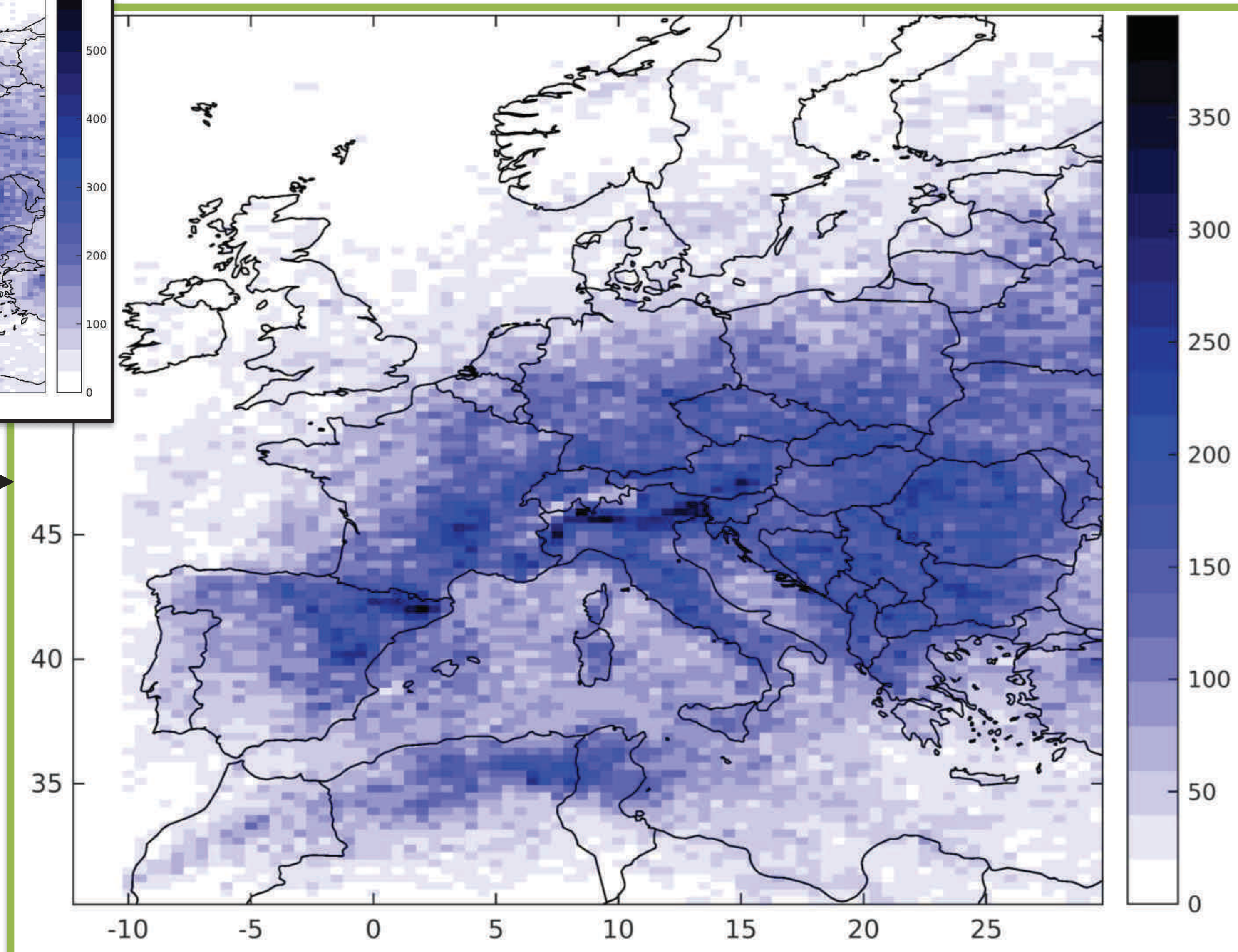
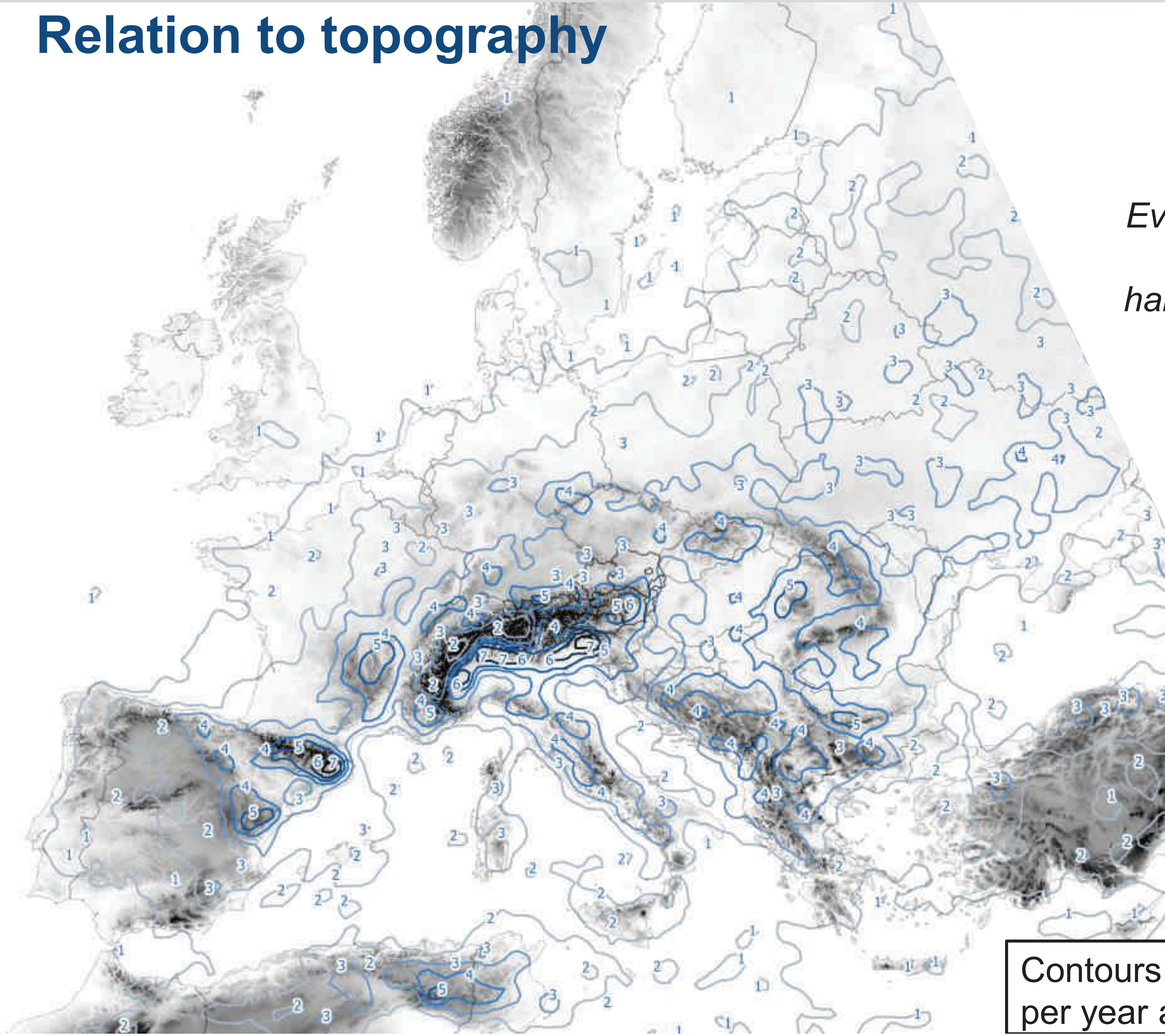


Filter



Relation to topography

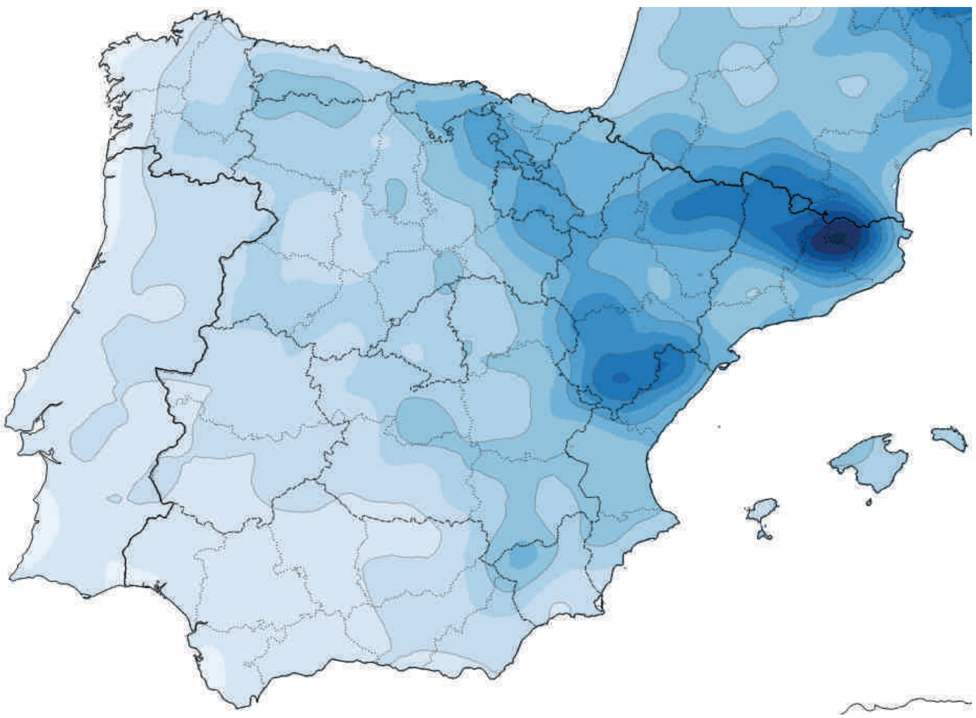


Everybody can confirm that hail clouds rest on mountain flancs.
Orioli, 1827

Contours: Occurences per year and 100km²

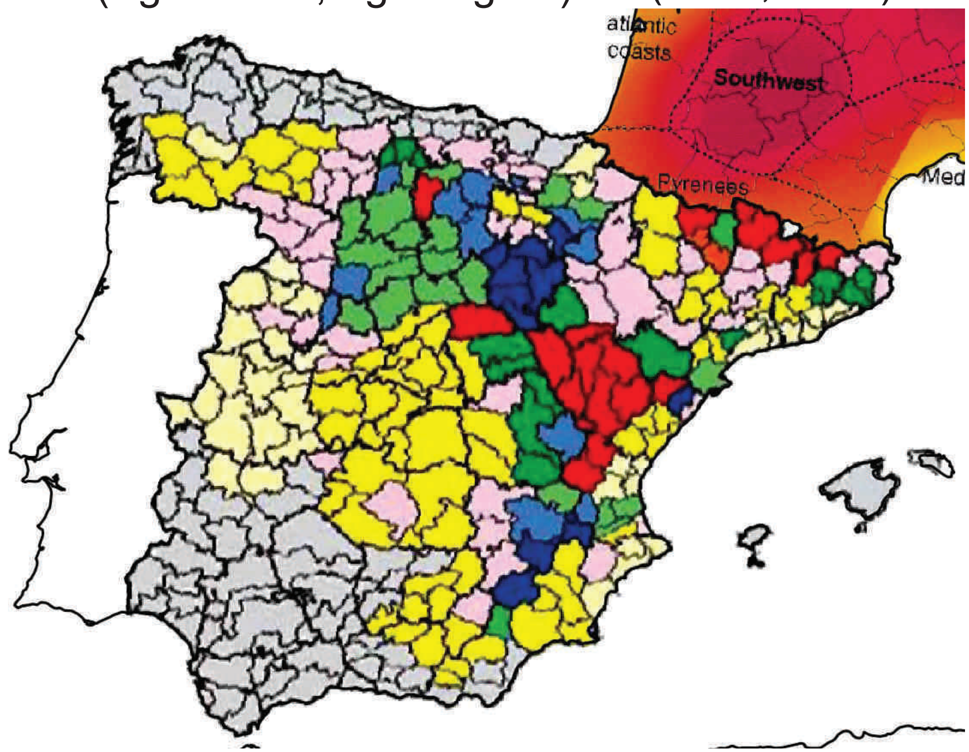
OT-based hail climatology: Iberian Peninsula

Hazard map based on OT detections



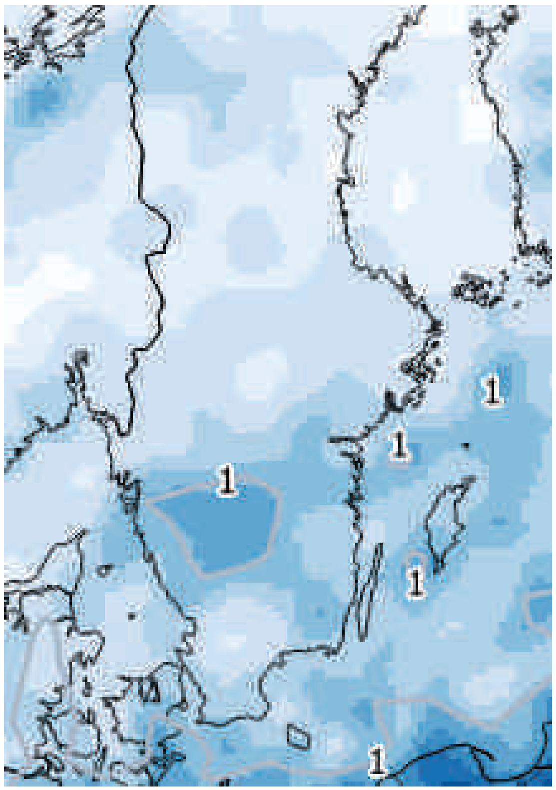
Frequency of hail damage in Spain (Agriculture, Agroseguro)

Frequency of hail in France (Vinet, 2001)

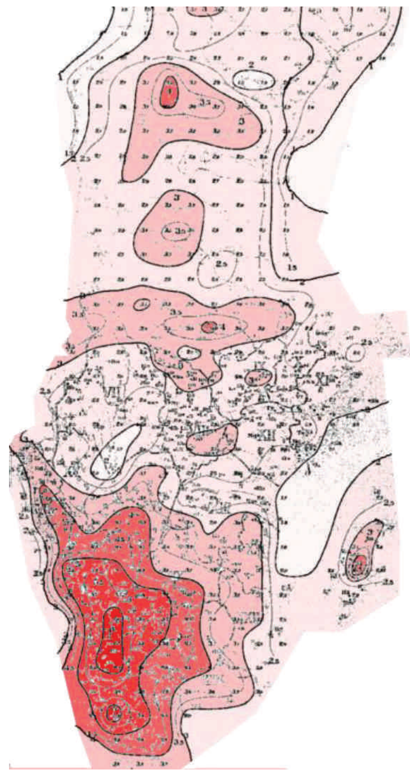


OT-based hail climatology: Sweden

This work, 2016



Hamberg, 1917



OBSERVATIONS MÉTÉOROLOGIQUES SUÉDOISES

PUBLIÉES PAR

L'INSTITUT CENTRAL DE MÉTÉOROLOGIE

VOL. 59

2:IÈME SÉRIE, VOL. 45

1917

FRÉQUENCE DE LA GRÊLE EN SUÈDE 1865—1917

STOCKHOLM

ALMQVIST & WIKSELLS BOKTRYCKERI-A.-B.

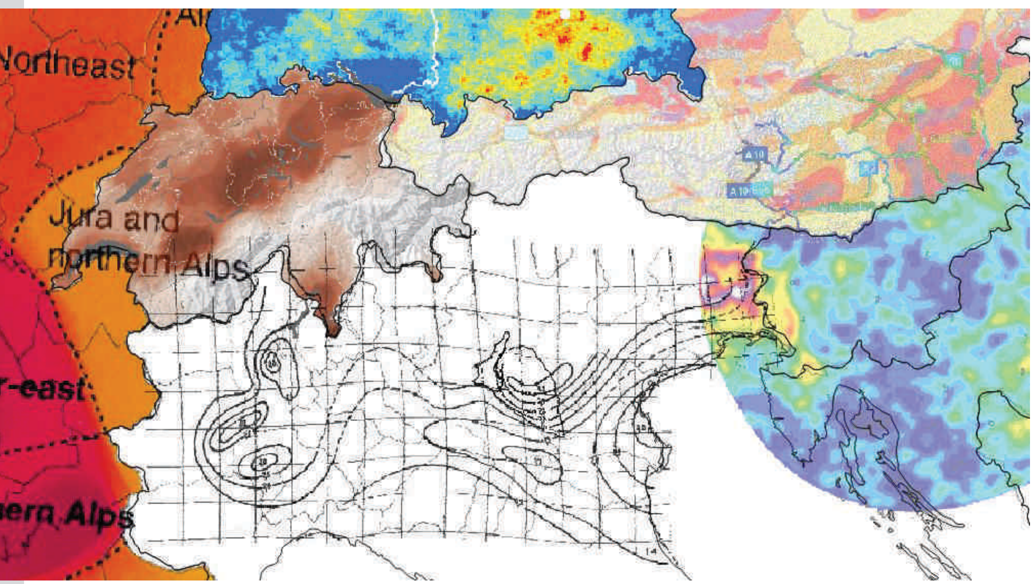
Tab. 19. *Nombre des jours de grêle et de jours de tonnerre observés 1881—1915.*

Antal observerade hageldagar och åskdagar 1881—1915.

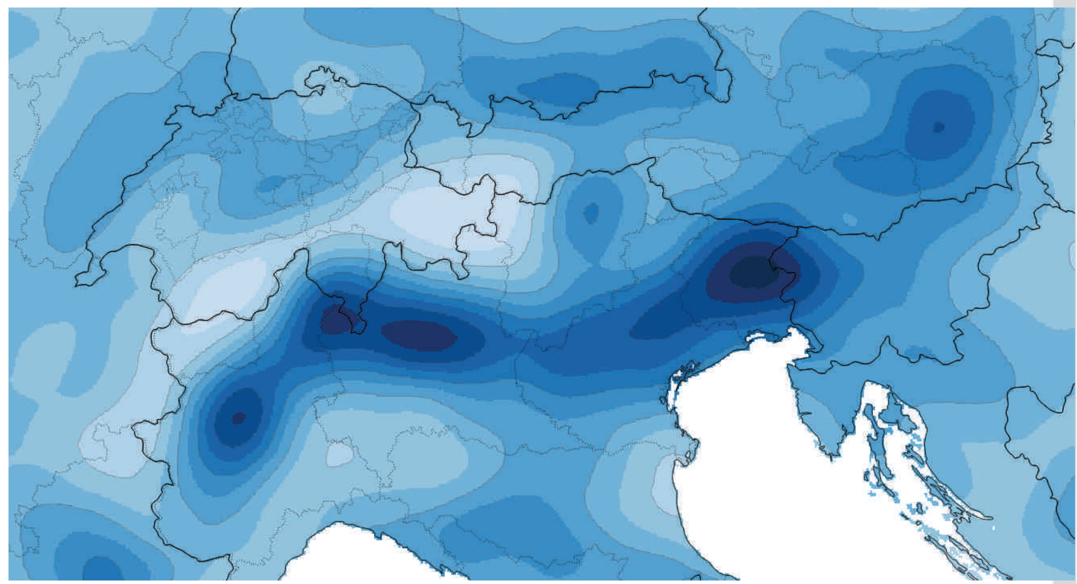
	Janv.	Févr.	Mars	Avril	Mai	Juin	Juillet	Août	Sept.	Oct.	Nov.	Déc.	Année År
	Jours de grêle. Hageldagar.												
Norrland	48	25	60	217	783	918	413	334	312	126	51	29	3316
Svealand	54	56	185	809	2044	1412	800	613	596	417	129	48	7163
Götaland	297	222	685	2079	3306	1584	885	847	1077	1656	1054	692	14384
[Uppsala obs. 1878—1916	1	0	4	20	34	31	14	16	9	8	1	1	139]
Suède. Sverige	399	303	930	3105	6133	3914	2098	1794	1985	2199	1234	769	24863
	Jours de tonnerre. Åskdagar.												
Norrland	29	11	26	77	1075	4291	8318	4520	553	68	6	11	18985

OT-based hail climatology: The Alpine region

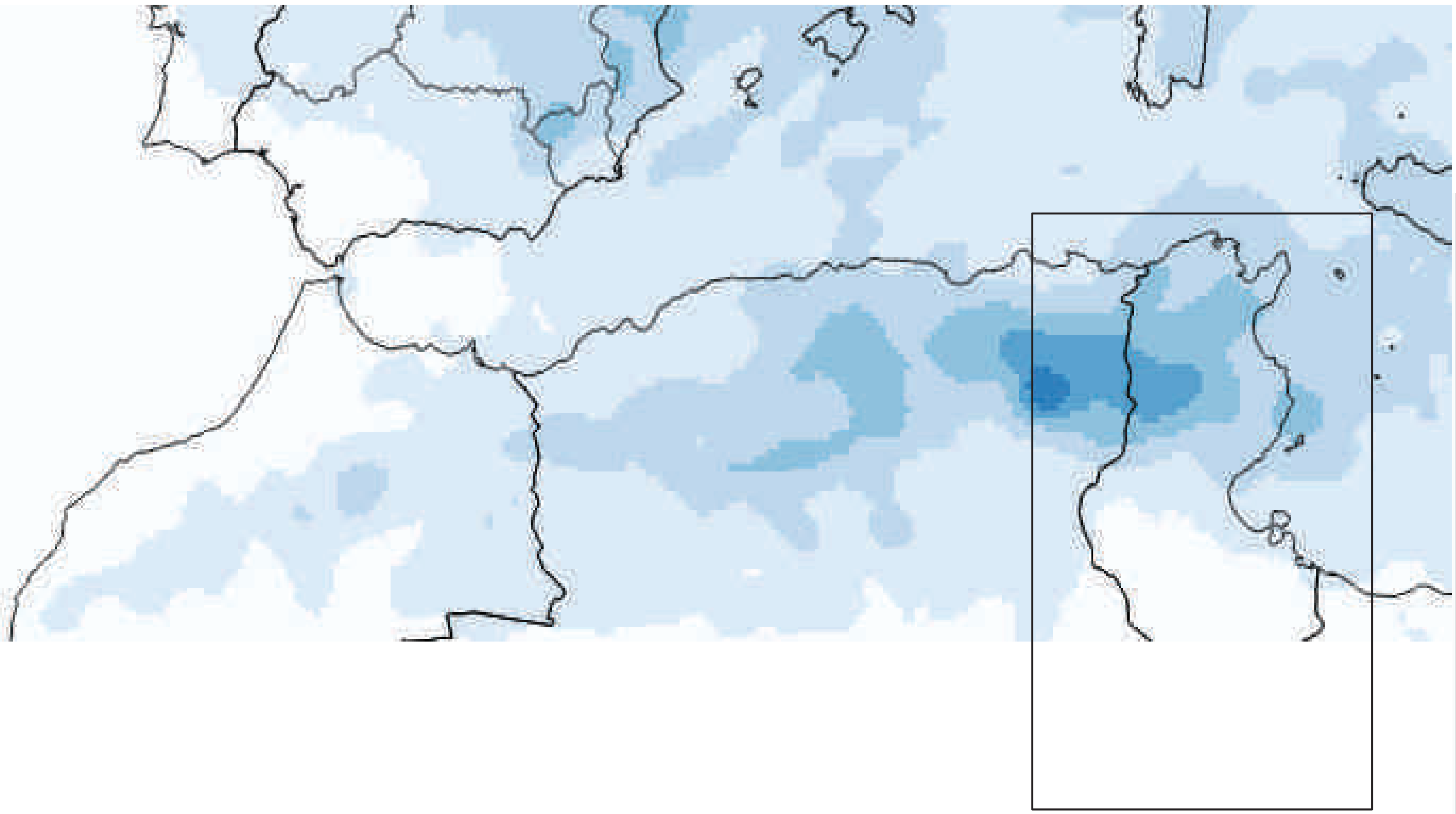
Maps of hail frequency in
Switzerland (Schweizer Hagel),
Austria (Svabik, 2013),
Germany (Puskeiler, 2013),
France (Vinet, 2001),
Italy (Prodi, 1974),
Slovenia (Skok, 2014)



Hazard map based on OT detections



OT-based hail climatology: Maghreb



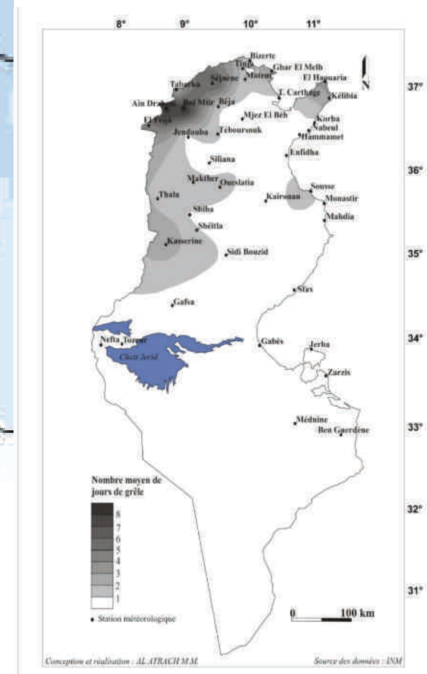


Figure 5. Répartition du nombre annuel moyen de chutes de grêle en Tunisie entre1976 et 2005.

Latrach (2013)

Summary

- Satellite-based overshooting cloud top (OT) data is used as a proxy for hail frequency
- Obtained climatology agrees well with existing, national-scale climatologies

Limitations

- Available resolution limits reproduction of individual events
- Time period insufficient for trend analysis
- Analyzed summer half year only