Karlsruhe Institute of Technology

Willis Towers Watson

Hail frequency in Europe

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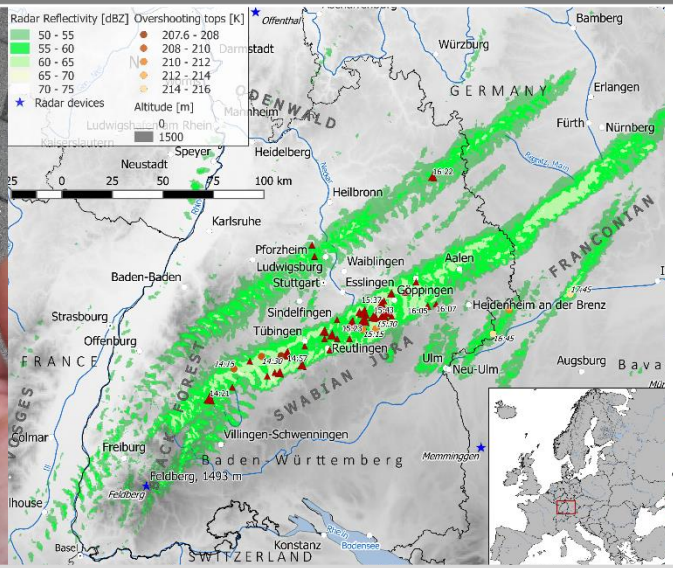
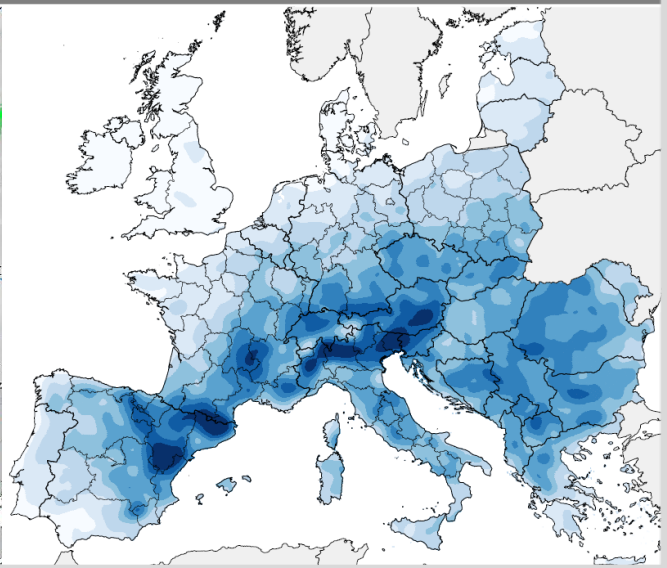
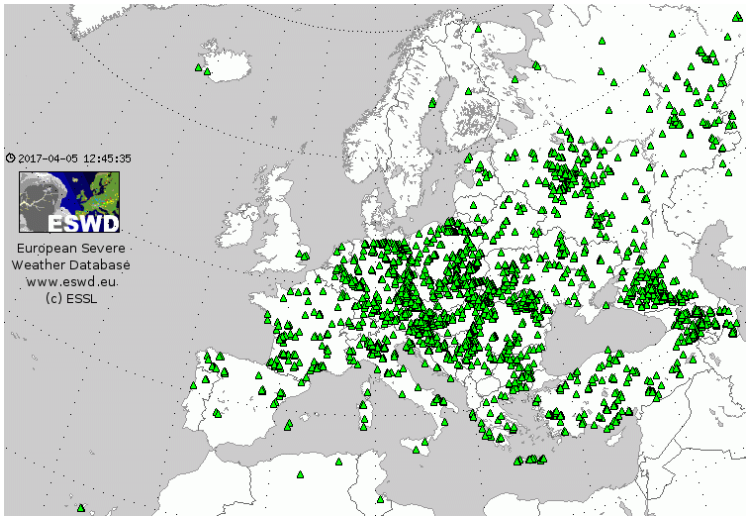




Hail perception – Local scale

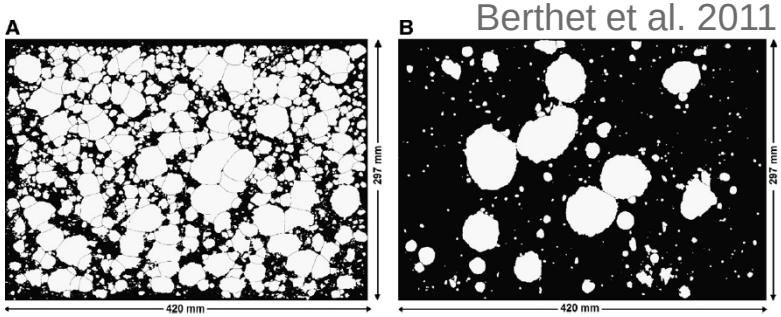
- Weather observation
- Damage inspection

Hail measurements on the local scale



Databases from news reports, spotters, apps (ESWD, EWOBS)

Conventional weather stations



Berthet et al. 2011

Hail pad networks (regional level)

Weather stations

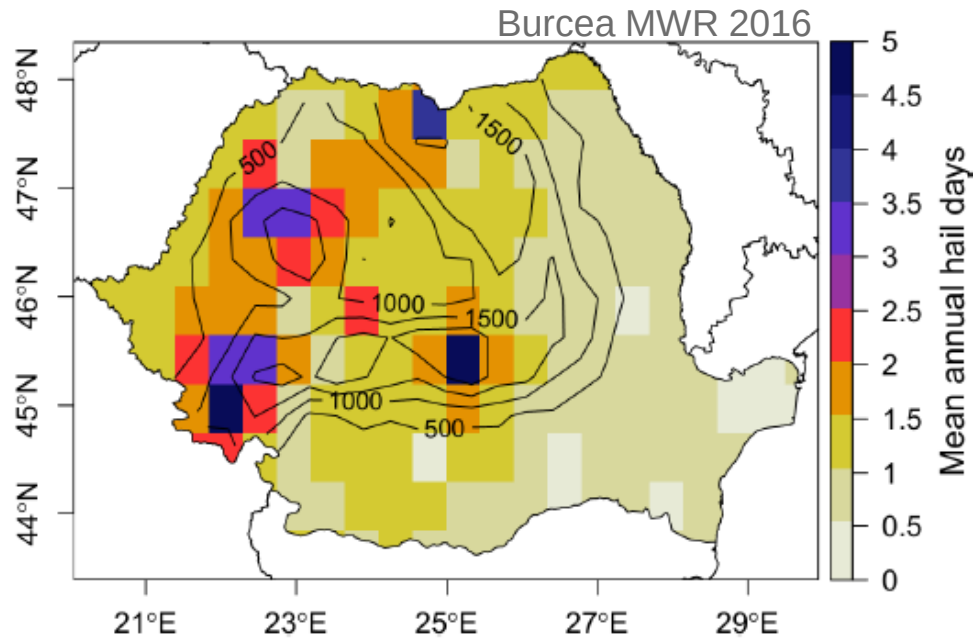
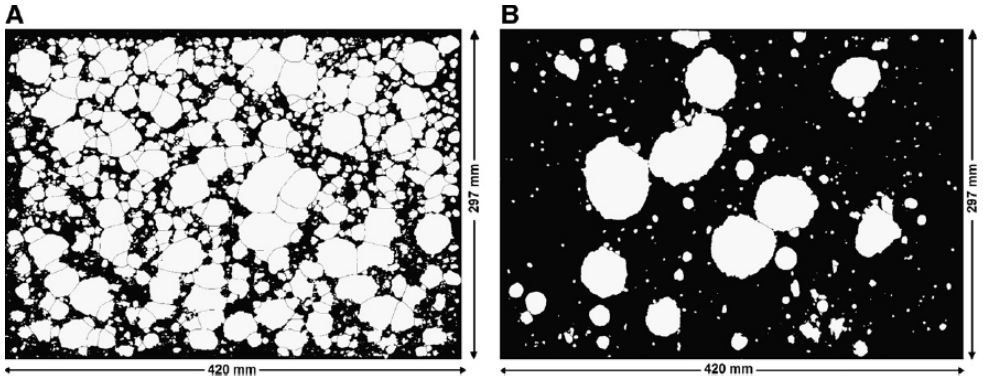
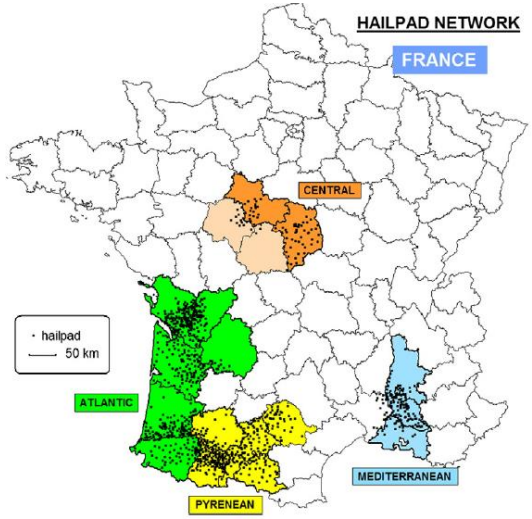


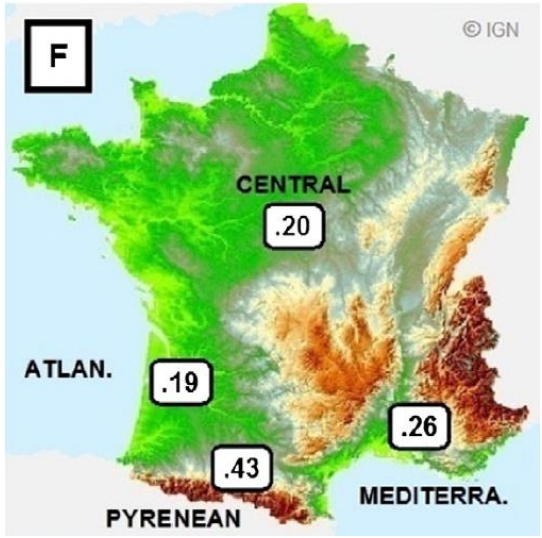
Figure 2: Spatial distribution of the mean hail days per year, for the period 1961–2014. The

- Sensitive to observer training
- Long time series needed
- Manned network often sparse

Hailpads





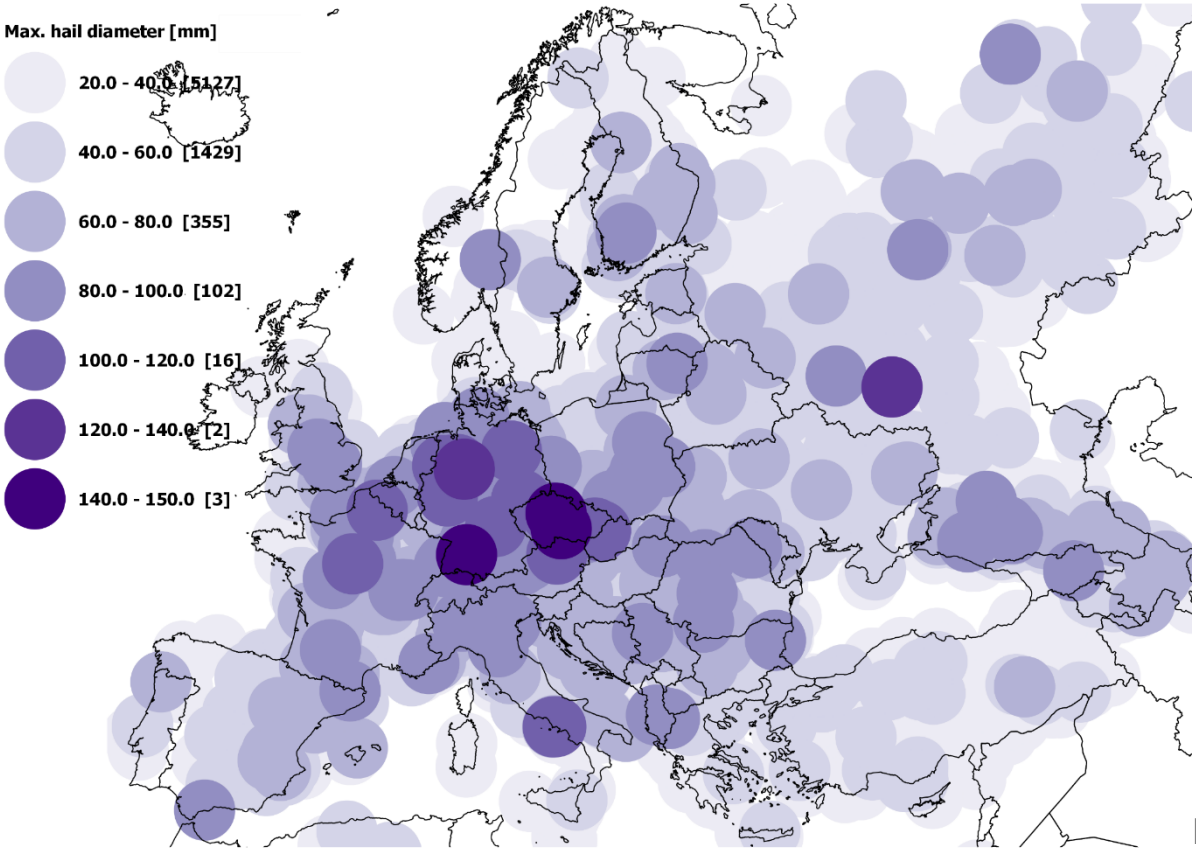


Berthet et al. AR 2011

Region	Country	Pad count	Area
Lower AT	Austria	126	500
Styria	Austria	164	700
East	Croatia	730	20000
Lleida	Spain	100	2500
Valdejon	Spain	176	2800
Léon	Spain	250	1000
FVG	Italy	360	4500
Trentino	Italy	271	2000
Napf	Switzerland	370	1200
Macedonia	Greece	140	2400
	France	~1000	66500

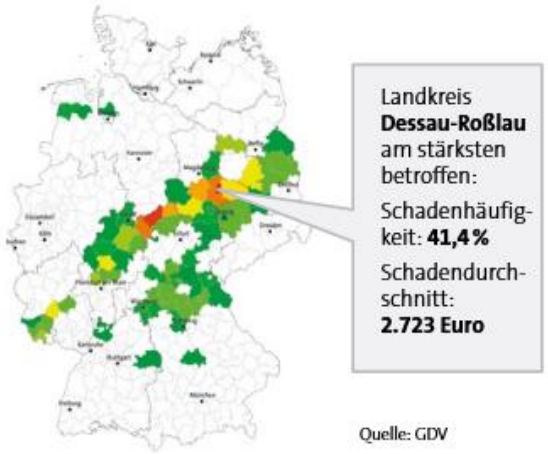
Hail frequency from reports?

- $p(d_{max}=d) \sim \exp(-\lambda\, d)$
- $E[\max(d)] = \lambda \sum_{k=1}^{N} 1/k$ for N observations
- $f_{hail} = N\, c\, /\, T$ with coverage fraction c, time period T

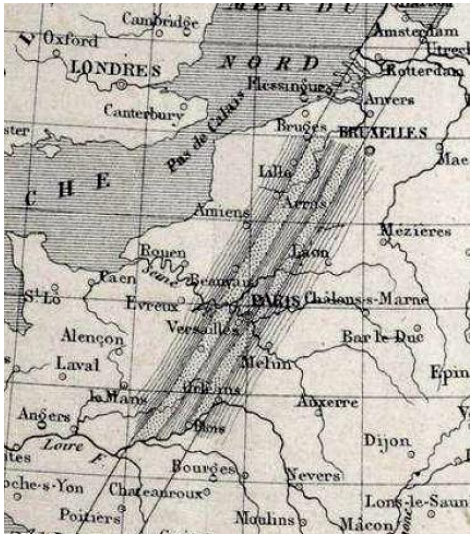


Punge and Kunz AR 2016

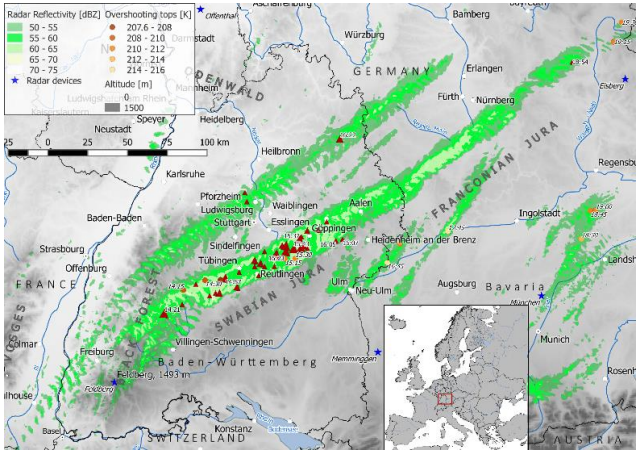
Hail perception – Regional scale



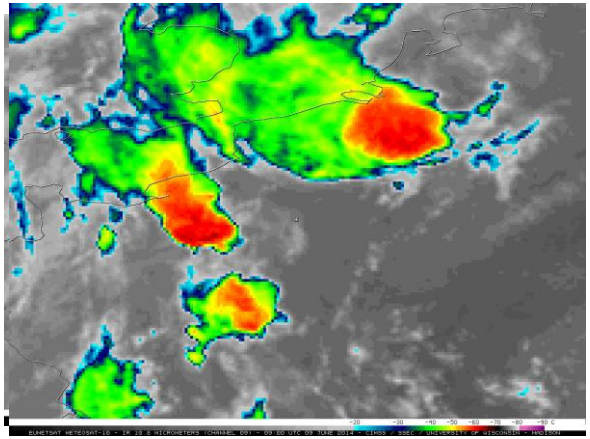
11 September 2011



13 July 1788, (Tessier)



28 July 2013



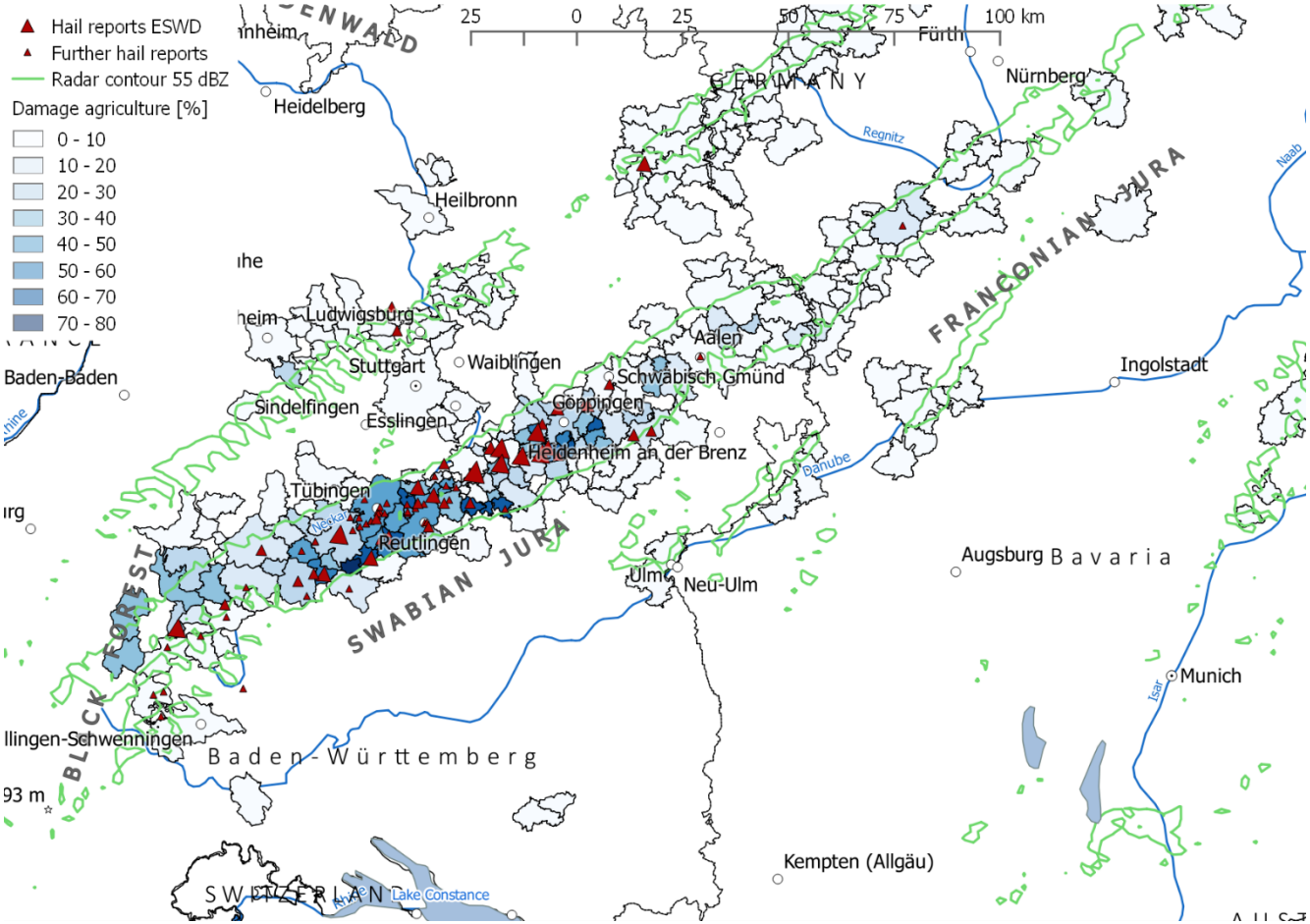
Damage view

- Event-based view for insurers
- Often a national view - but storms cross borders

Remote sensing view

- Radar networks often national

Integrated assessment: 28 July 2013



Kunz et al,
Manuscript
submitted

Regional scale hail estimates - Radar

Switzerland 2002-2014

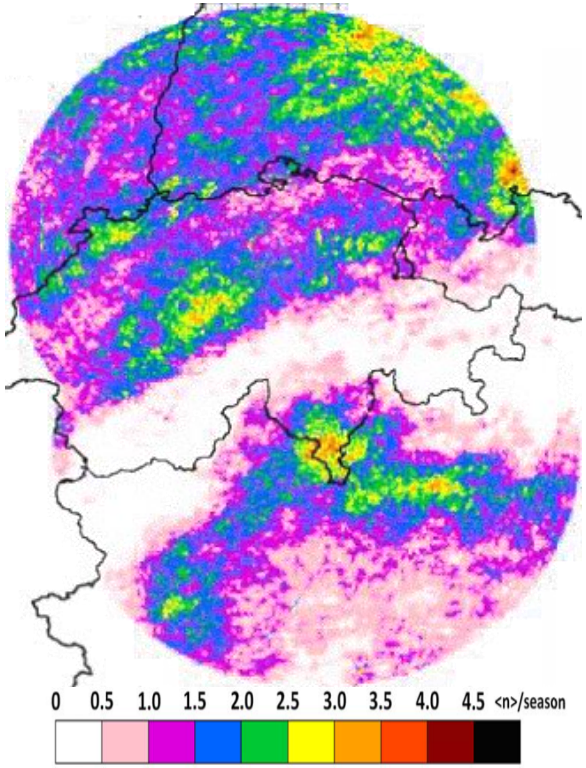
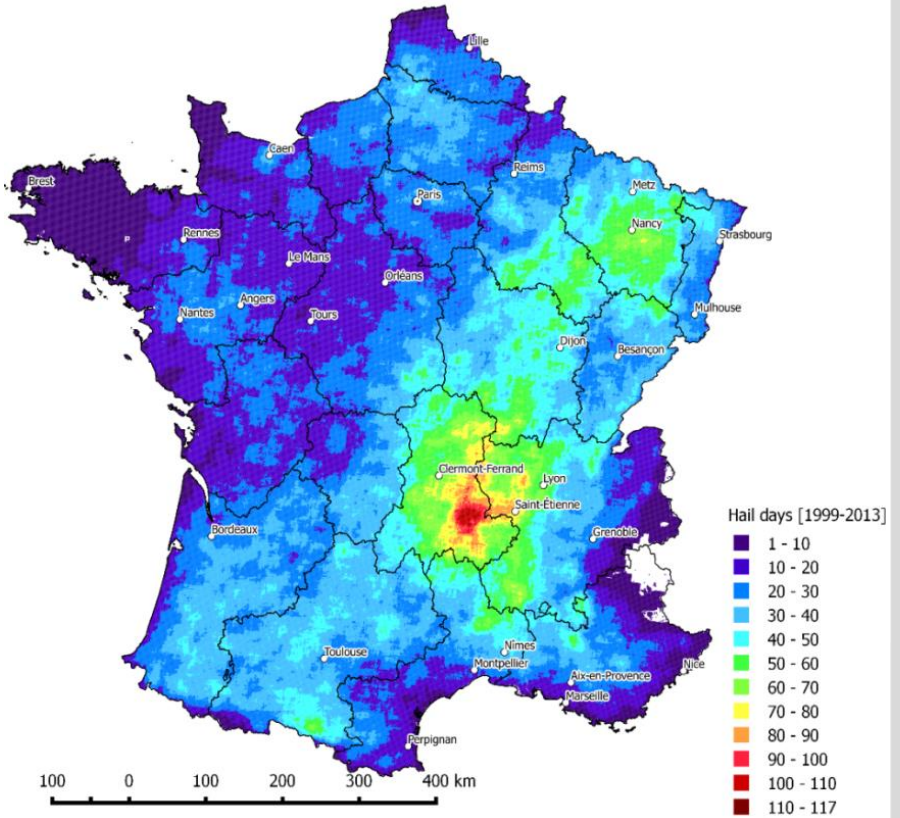


Figure 4. Left: average number of days with POH > 80% per season (April - September) and km^2 during the period 2002-2014;

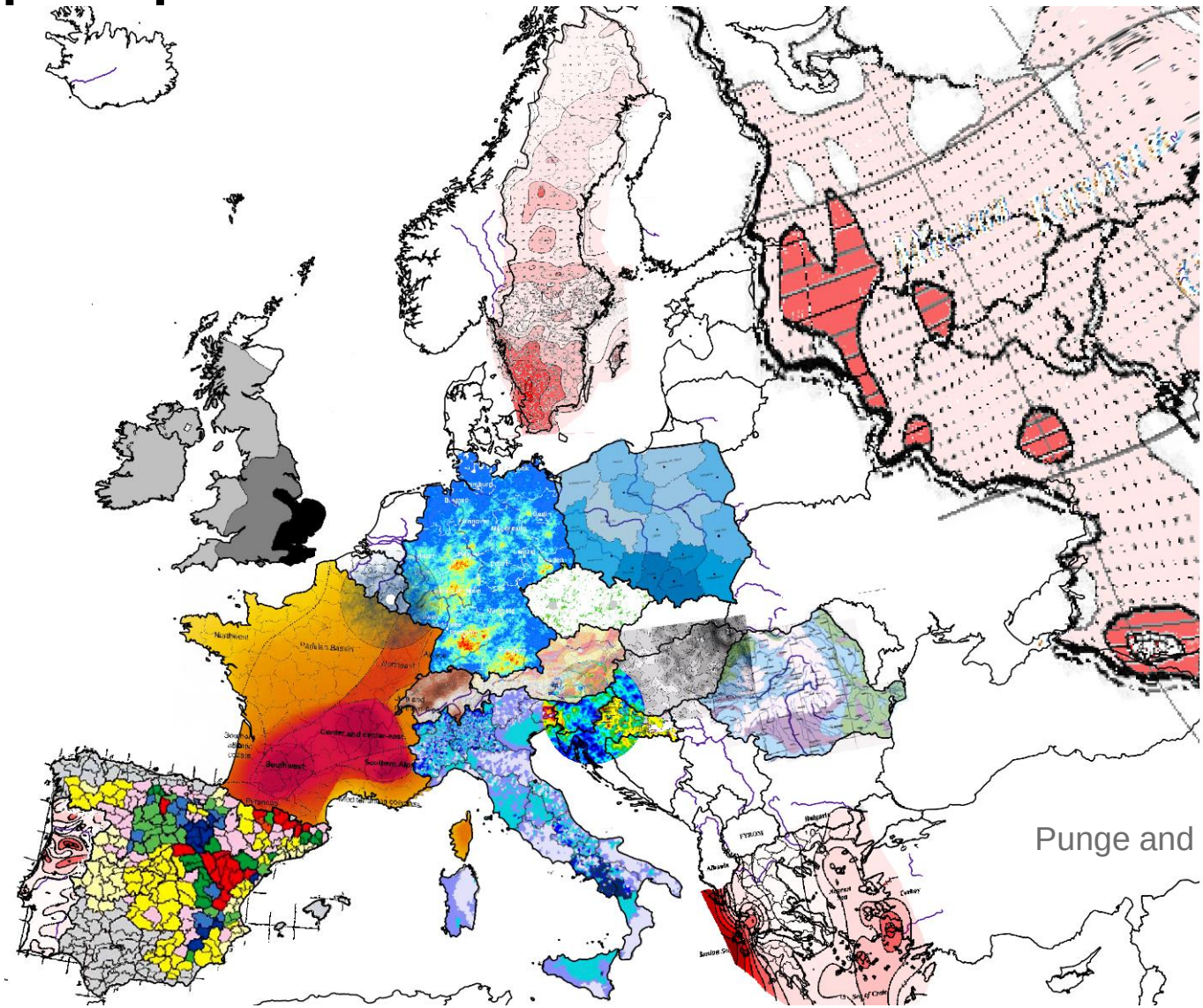
Nisi QJRMS 2016

France 1999-2013



Fluck, pers.comm.

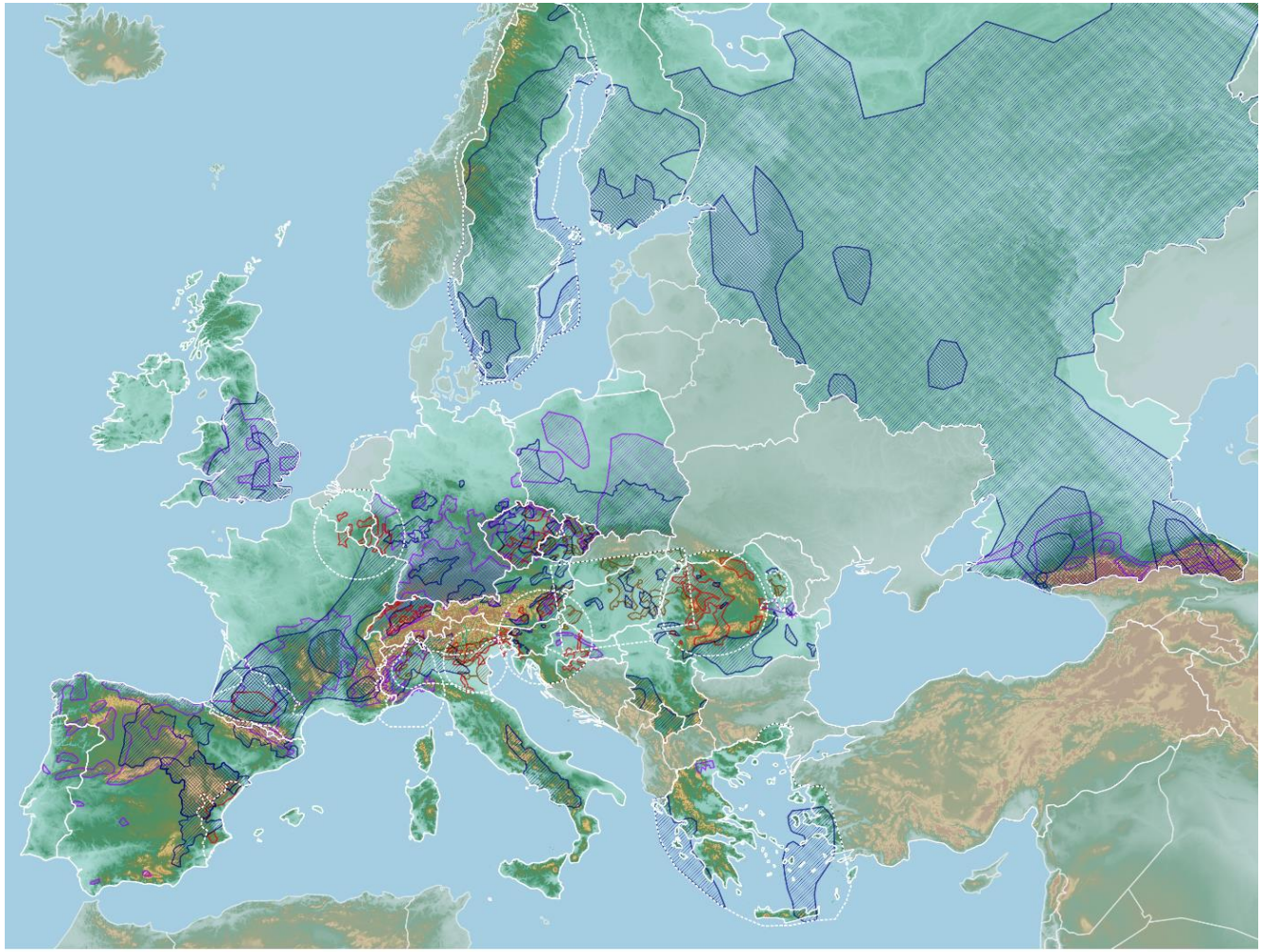
Hail perception – continental scale



Punge and Kunz AR 2016

Extract contour lines…

… from regional and national hail maps



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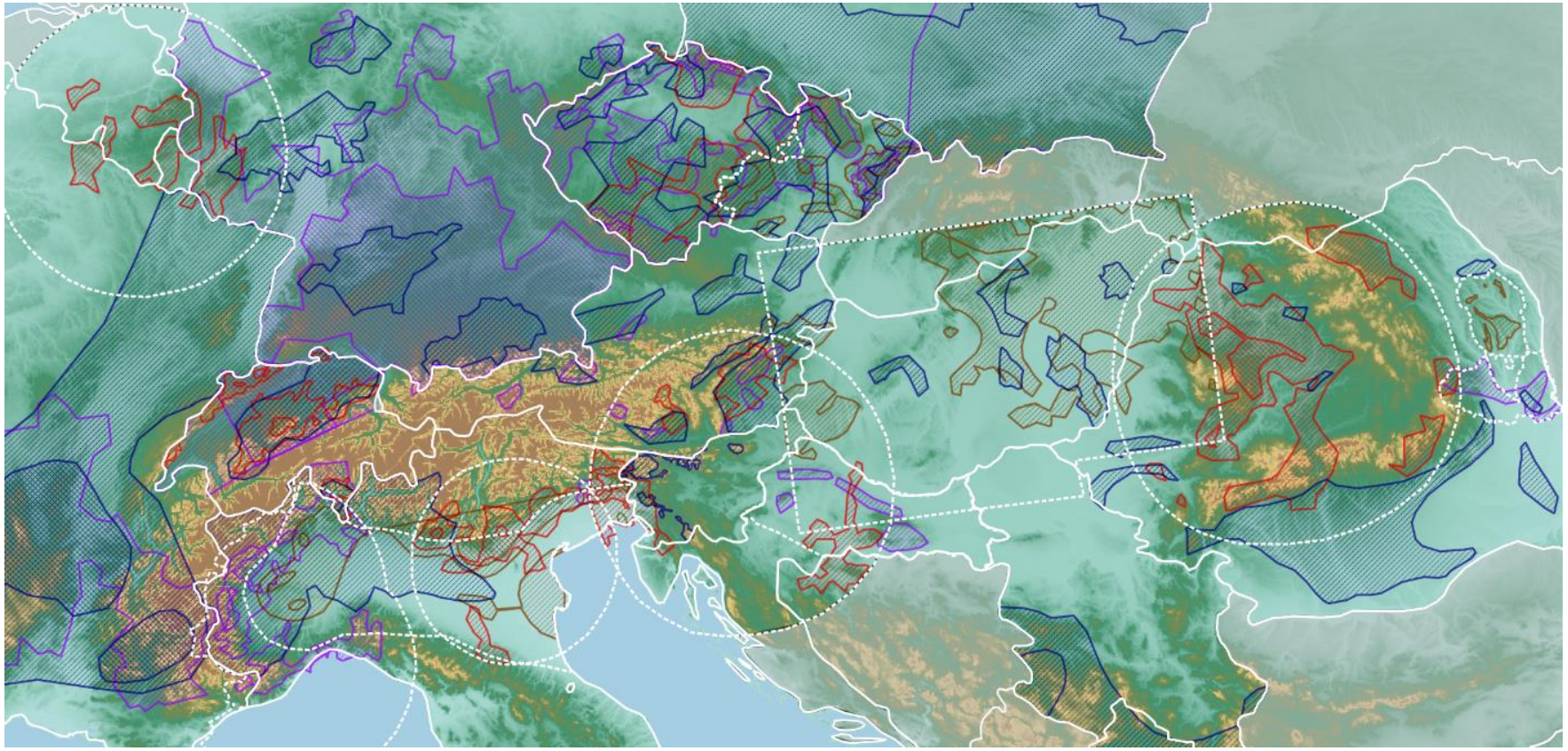
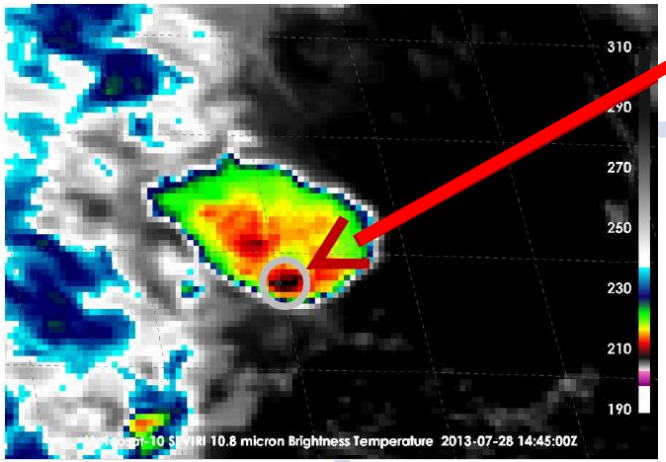


- Overlap frequent
- Regions missing
- Relative weights uncertain

A continental-scale hail proxy: Overshooting cloud tops

- Overshooting tops (OTs): intrusions of convective cloud to lower stratosphere
- Indicator of very strong convective updrafts
- Detection of cold pixels in IR satellite imagery

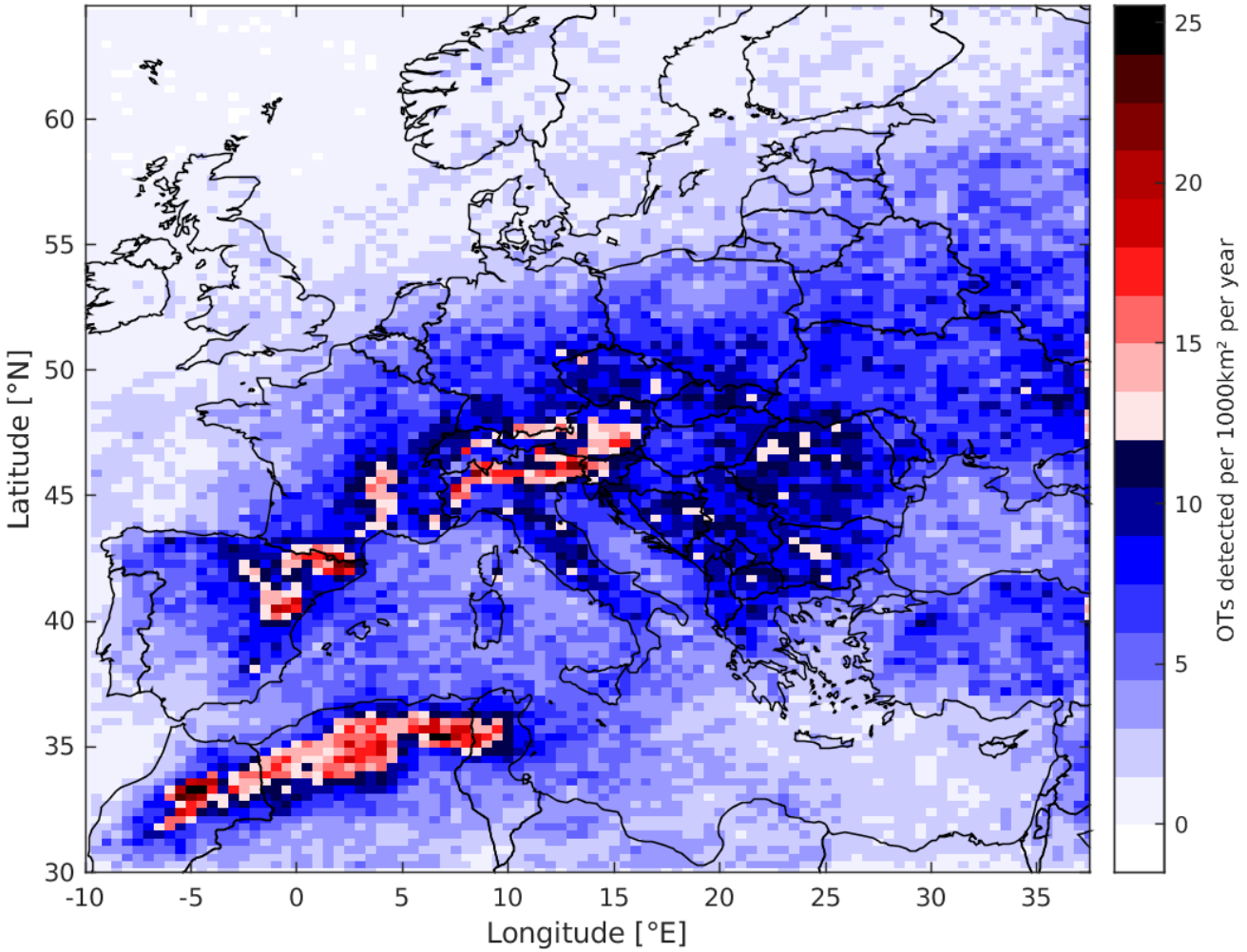


OT

Meteosat (MSG):
SEVIRI instrument
cloud top temperatures

28 July 2013,
13-17 UTC

OT frequency Europe 2004-2014

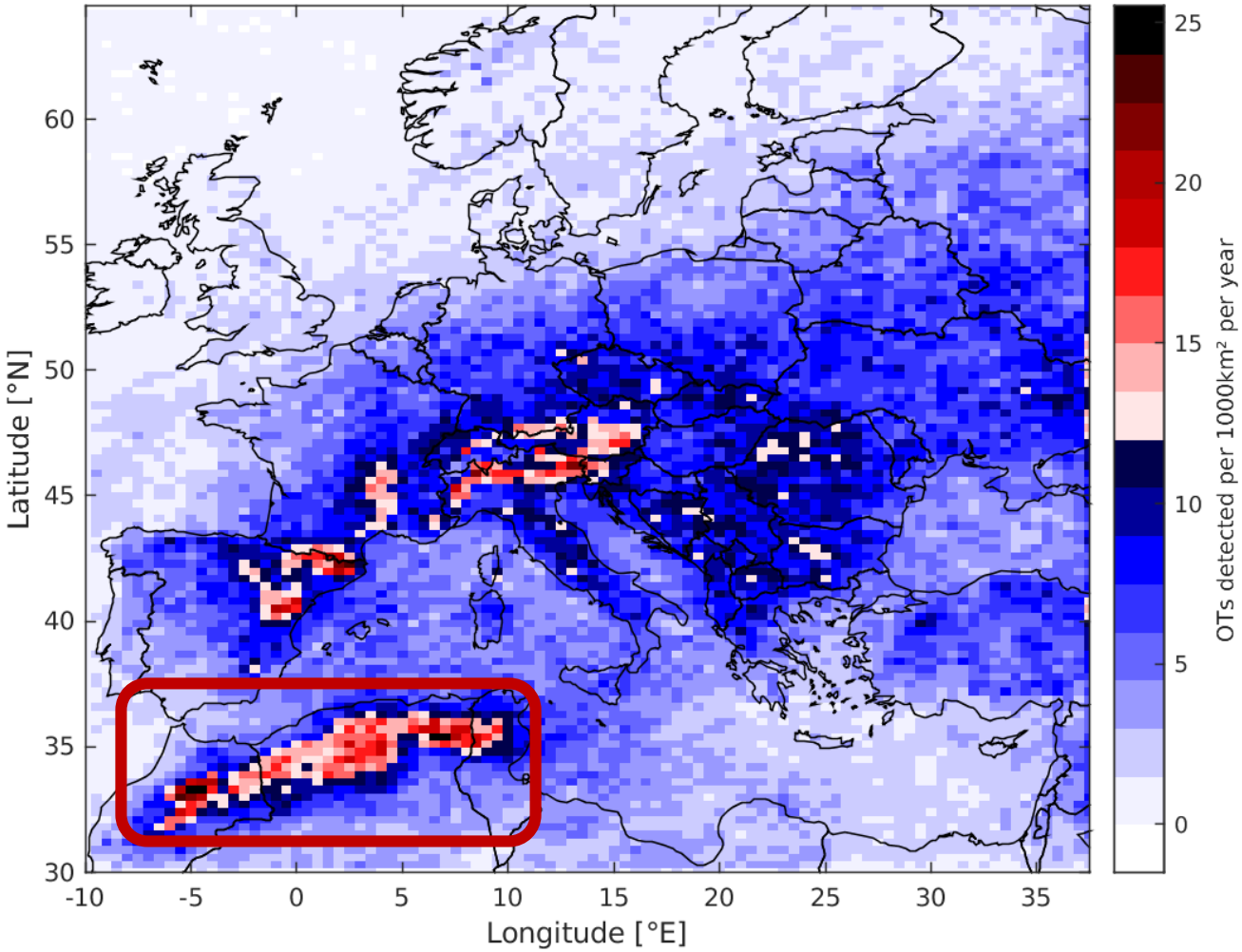


MSG SEVIRI

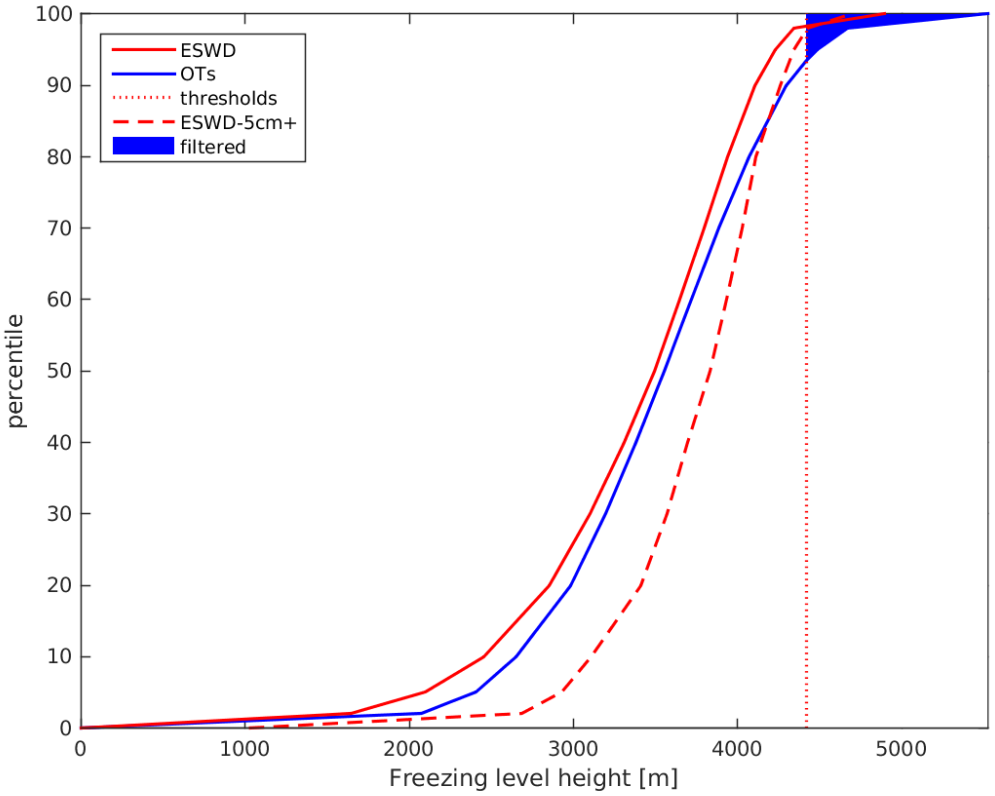
15-minute scan interval

April to September

OT frequency Europe (MSG SEVIRI), 2004-2014



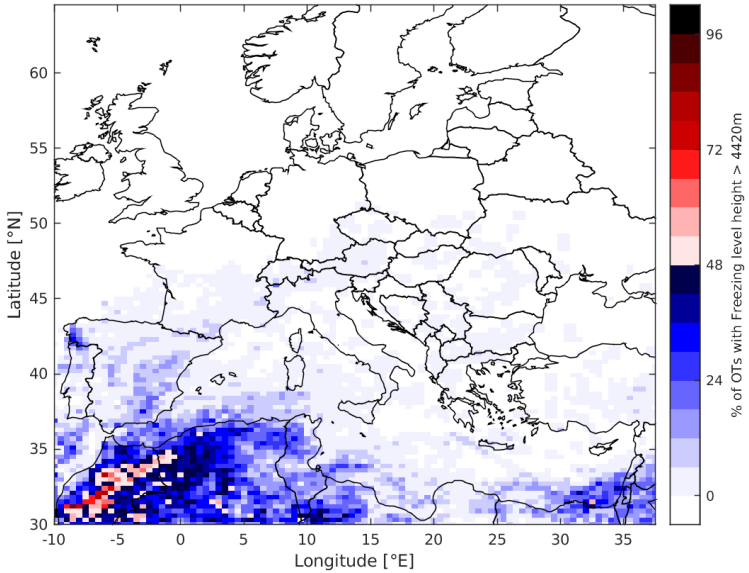
A filtering procedure



Atmospheric conditions from ERA-INTERIM

Compare CDF for OTs and hail reports

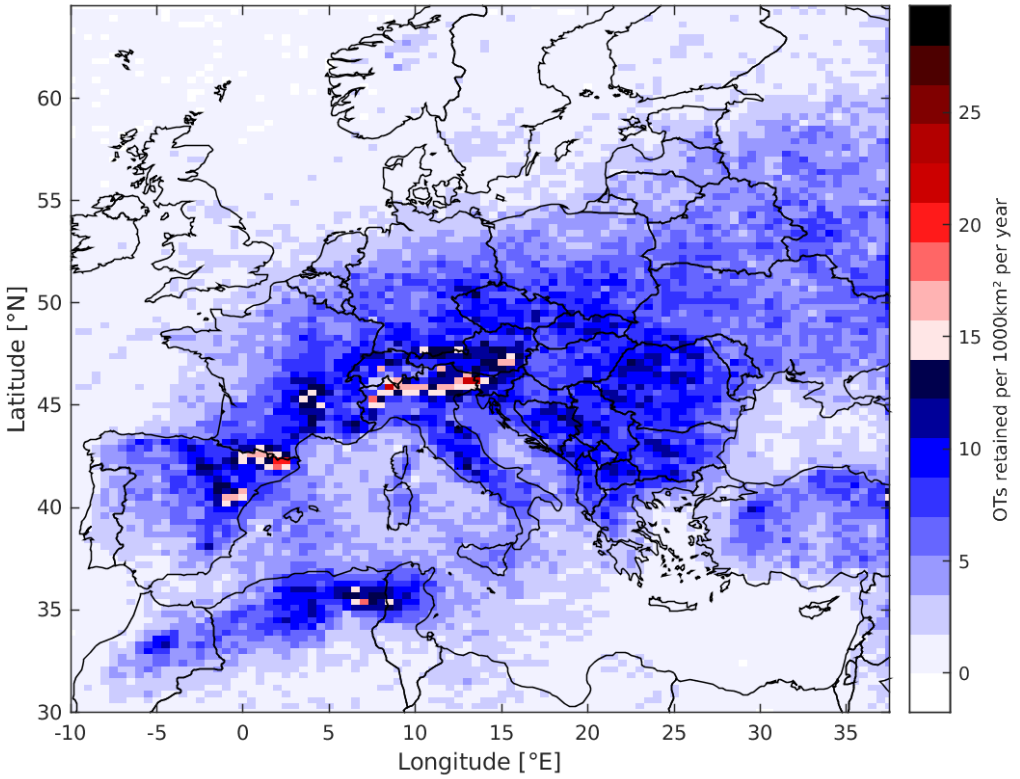
Define threshold



OT frequency Europe, filtered

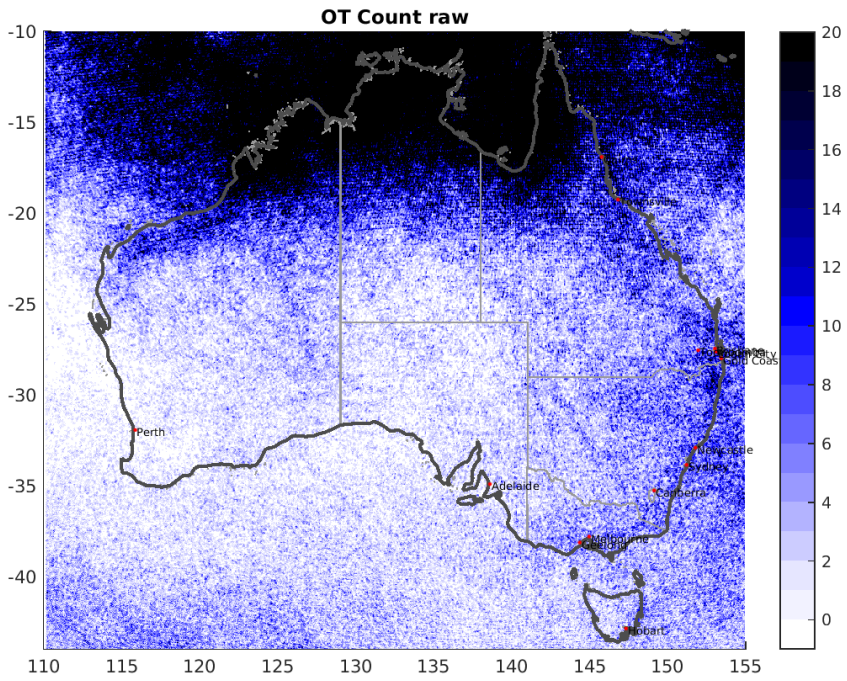
Filter for:

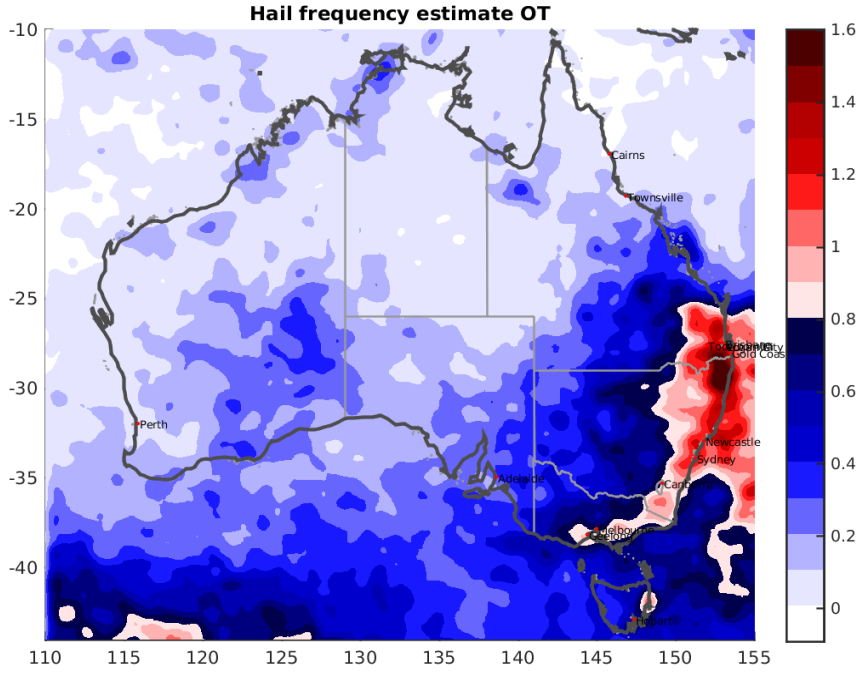
- CAPE > 5 J/kg
- Bulk wind shear > -0.97m/s
- Freezing level height, <4420m



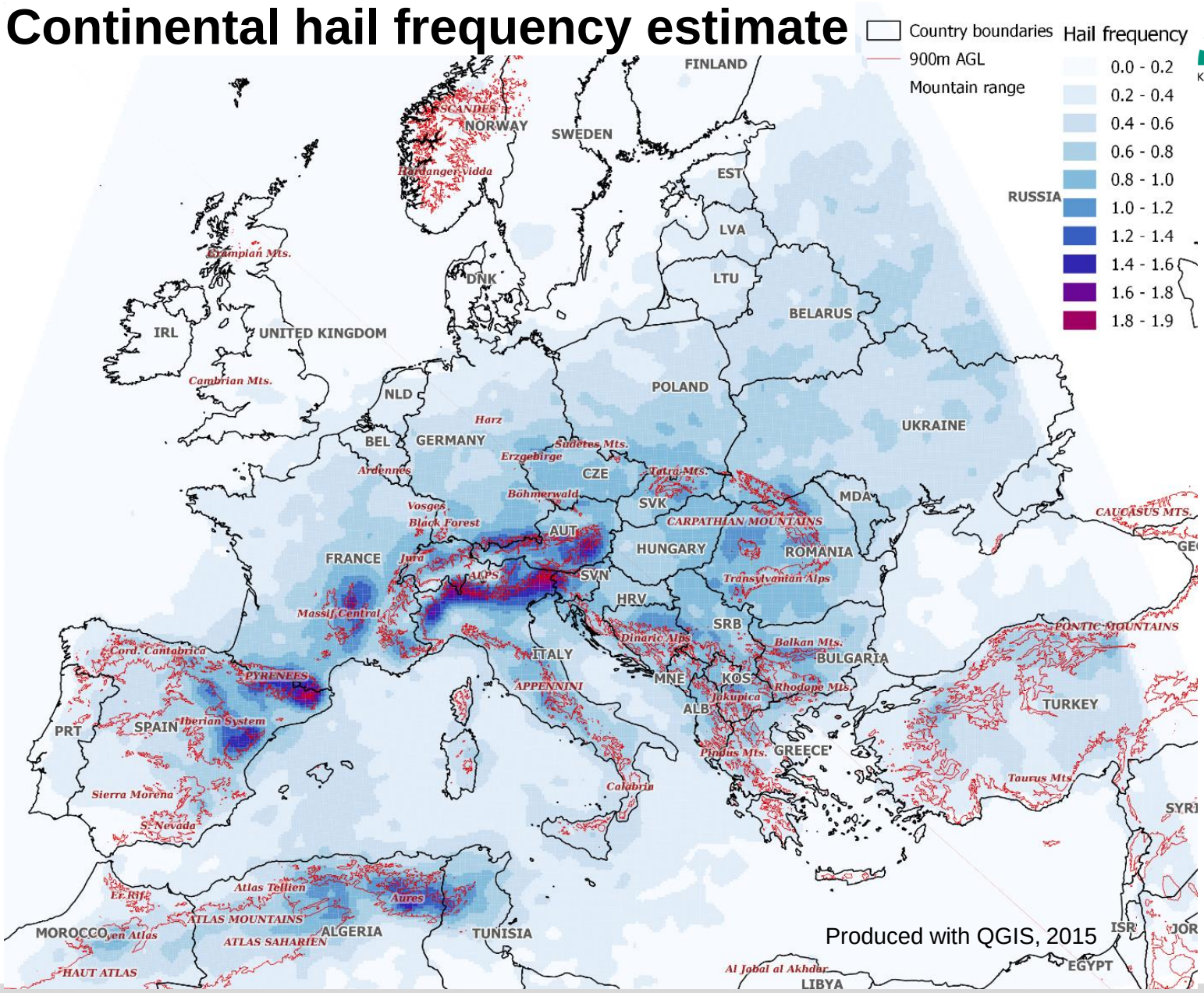
Application for Australia

JMA MT-SAT hourly scans
(2005-2015)

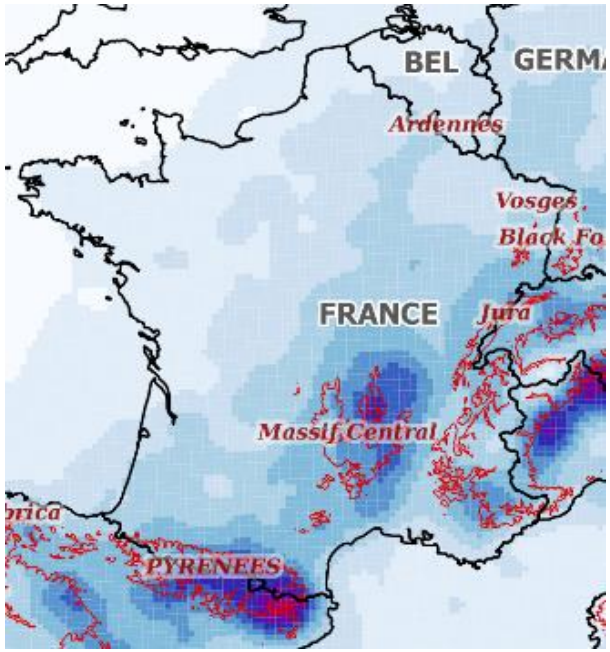




Continental hail frequency estimate

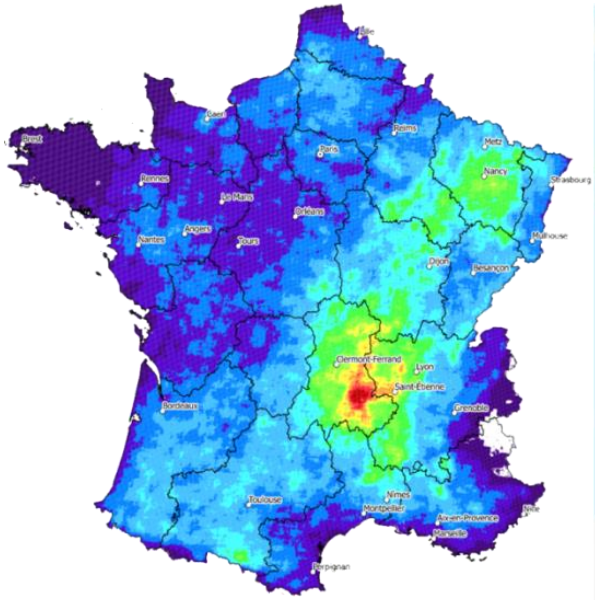


Continental hail frequency estimate



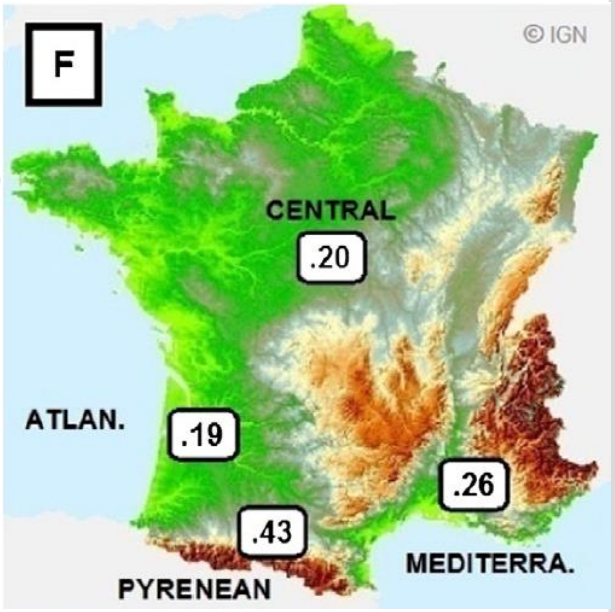
Hail frequency

- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 1.8
- 1.8 - 1.9

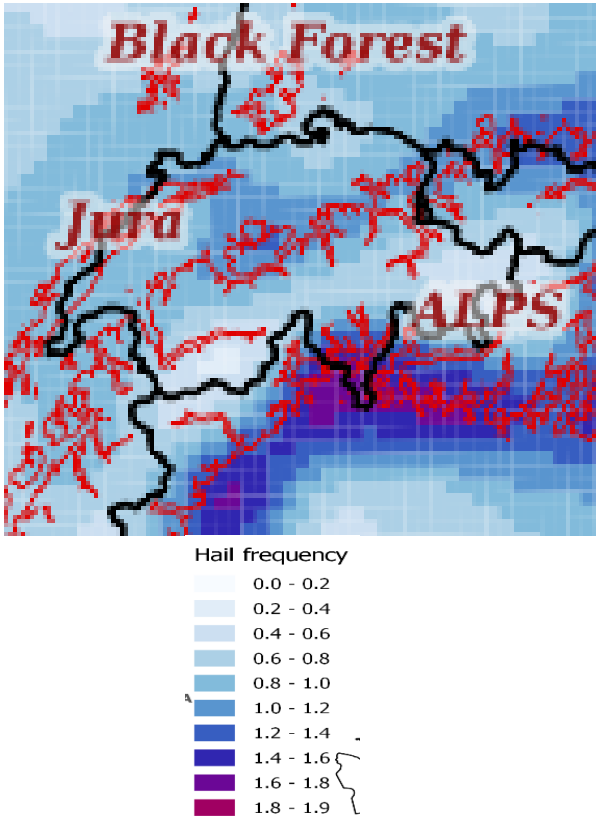


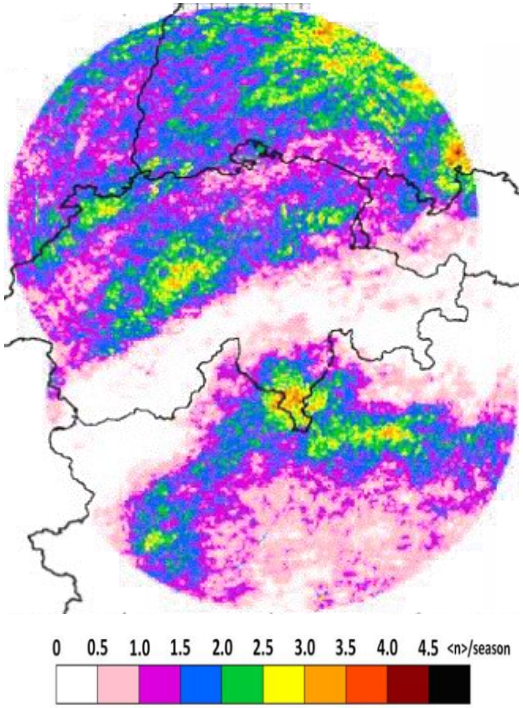
Hail days [1999-2013]

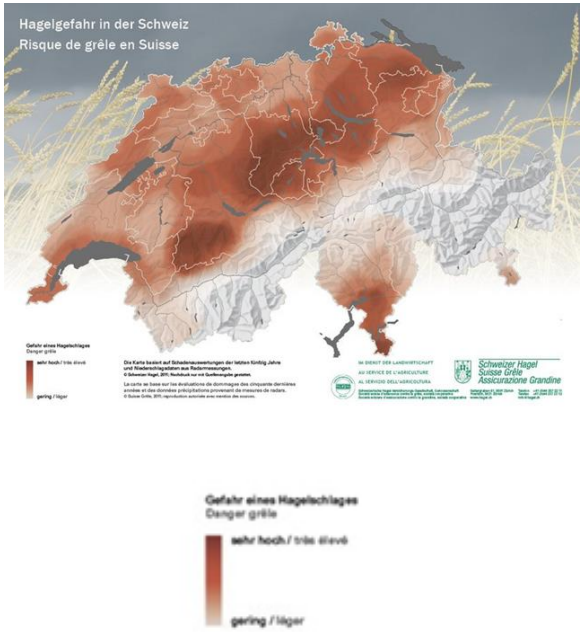
- 1 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 110 - 117



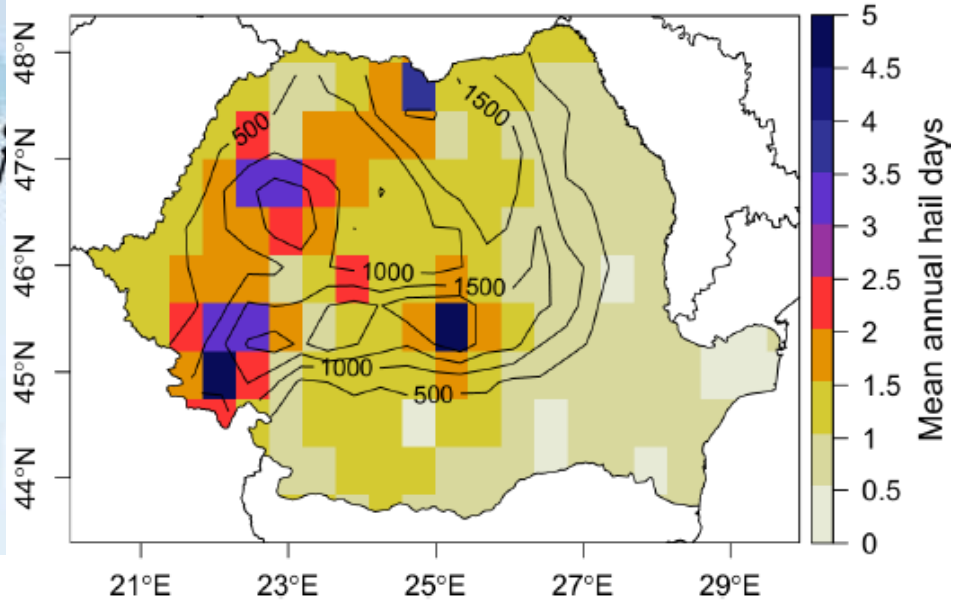
Continental hail frequency estimate

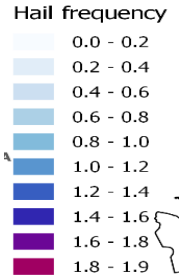






Continental hail frequency estimate

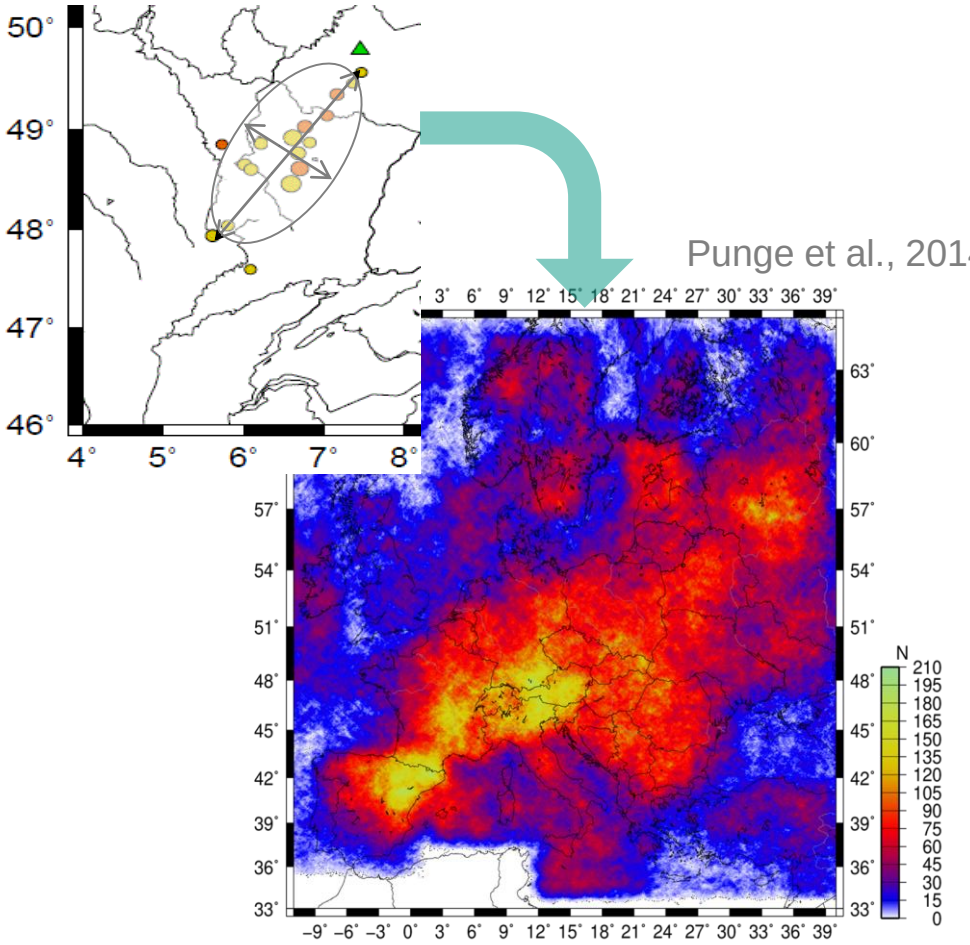




Willis Re European Hail Model

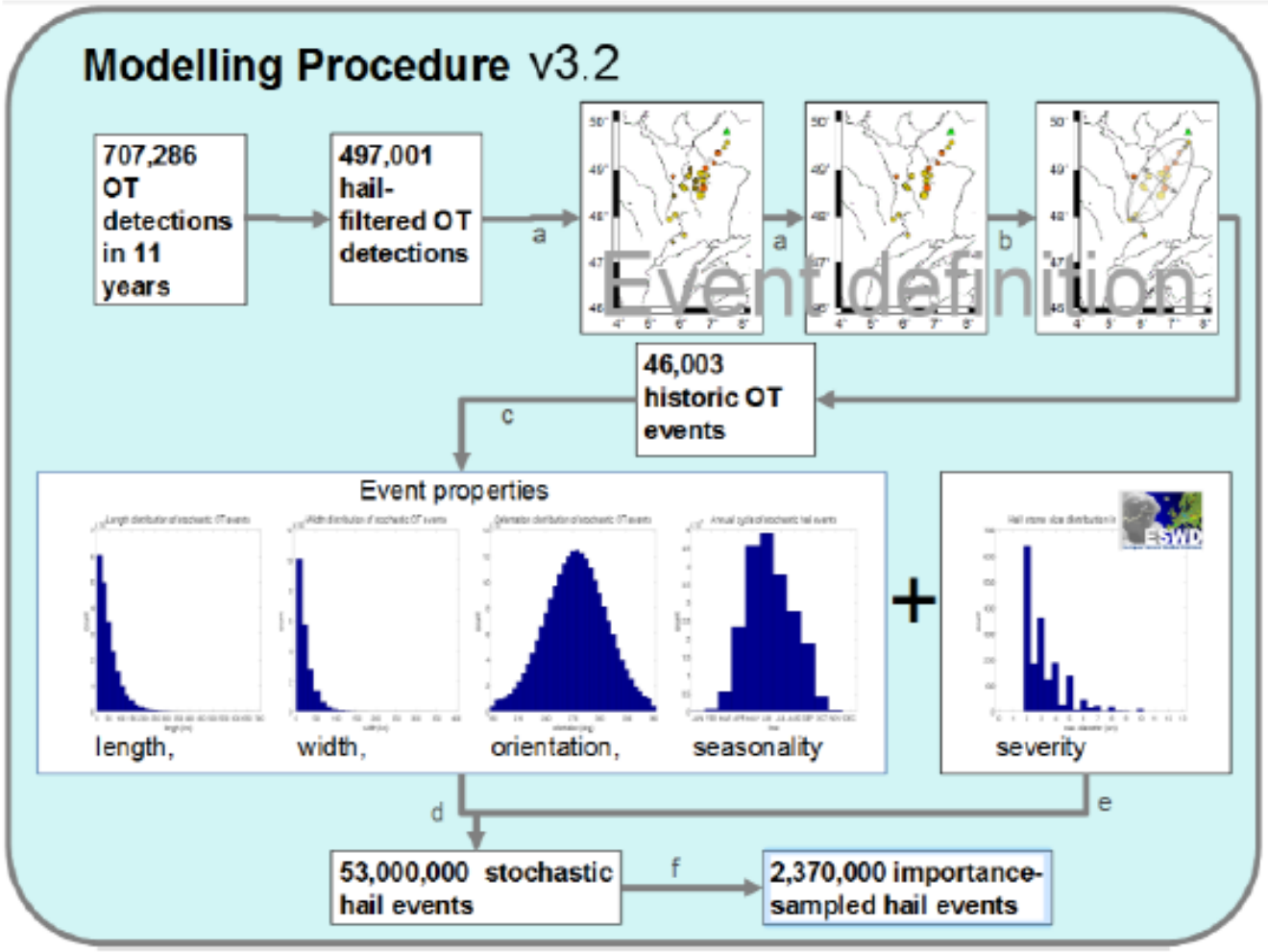
- Stochastic generation of >1.000.000 events (over land; ~5.000 years)
- Reliable spatial distribution of events
- Methods consistent for all European areas

- Add portfolio data to estimate loss vs. Return period, e.g., PML200

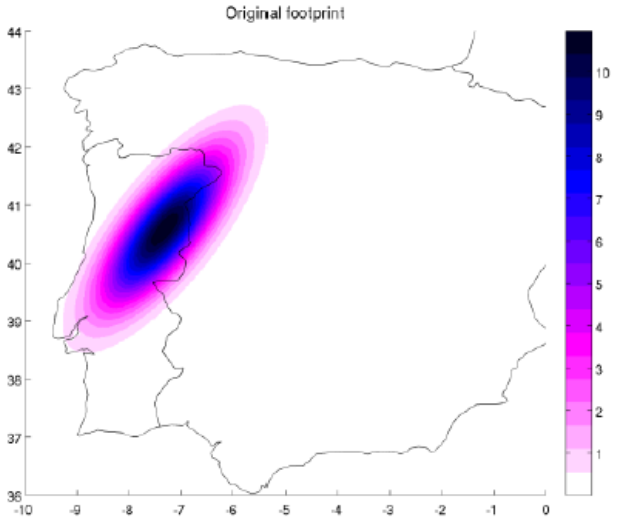


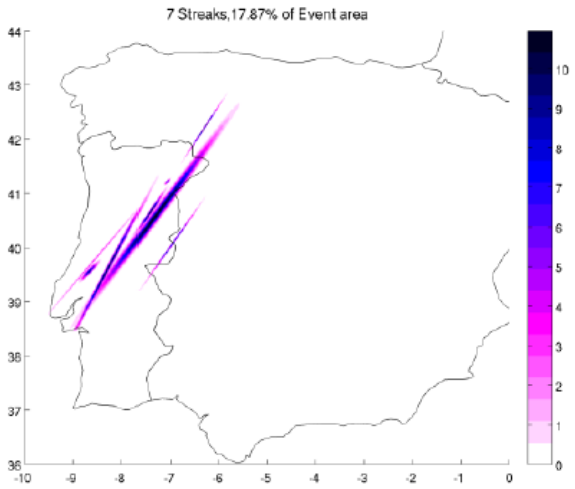
Number of stochastic hail events per grid box (~1 km²) in (estimated) 225 years

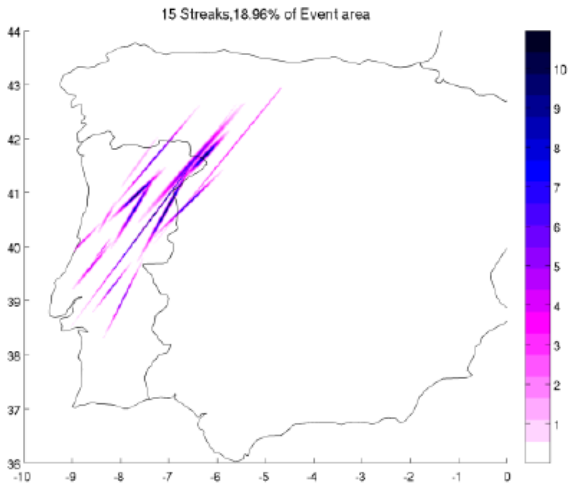
Hail event modelling



Subsampling of events to mimick storm clusters



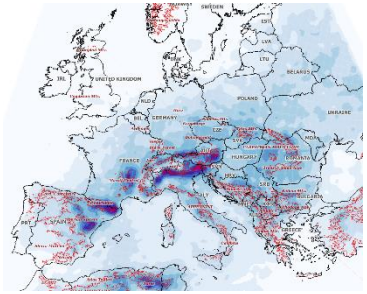




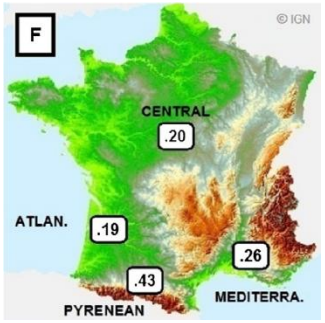
Summary

Satellite and radar data enables reliable hail frequency estimates

- Impact of orography: Highest around Alps and Pyrenees
- constrained by environmental conditions



Point observations and measurements are valuable for calibration



Stochastic event sets for hazard/risk modelling on continental scale

- Reproduction of historic “event” properties
- Challenge to represent clusters of storms on the same day