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Large hail in Europe: a changing risk

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Large hail in Europe: a changing risk

Setting the scene

Annually, large hail (diameter of >2cm), causes billions of dollars' worth of damage worldwide to property and crops as well as loss of life (Hulton & Shultz, 2024; Púčik et al, 2019)

In 2023, large hail caused an estimated USD$12Bn insured loss across Europe, with $3Bn in Italy alone (Púčik, 2024).

The year before, France experienced over USD $3Bn in insured loss from large hail (Swiss Re).

2022 and 2023 are remembered not just for the damage and loss caused, but by the giant size of the hail. The 19cm diameter hail stone from Azzano Decimo, Italy was enormous.

However, large hail losses in Europe are NOT new, so were these events different? Do they highlight underlying changes for this peril in Europe?

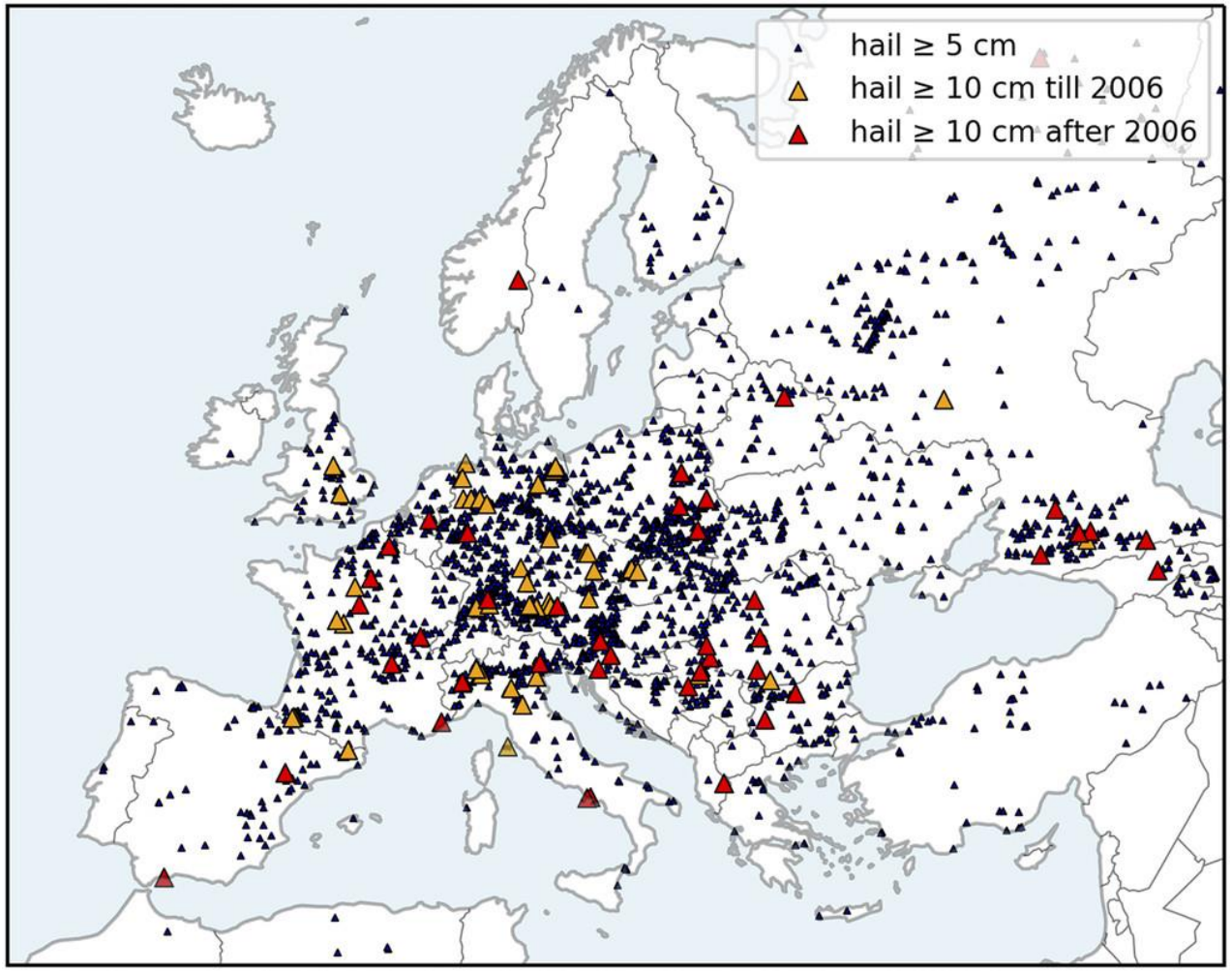

Figure 1 *Very large and 'giant' hail reports from 1980 to 2018 (Púčik et al, 2019).*

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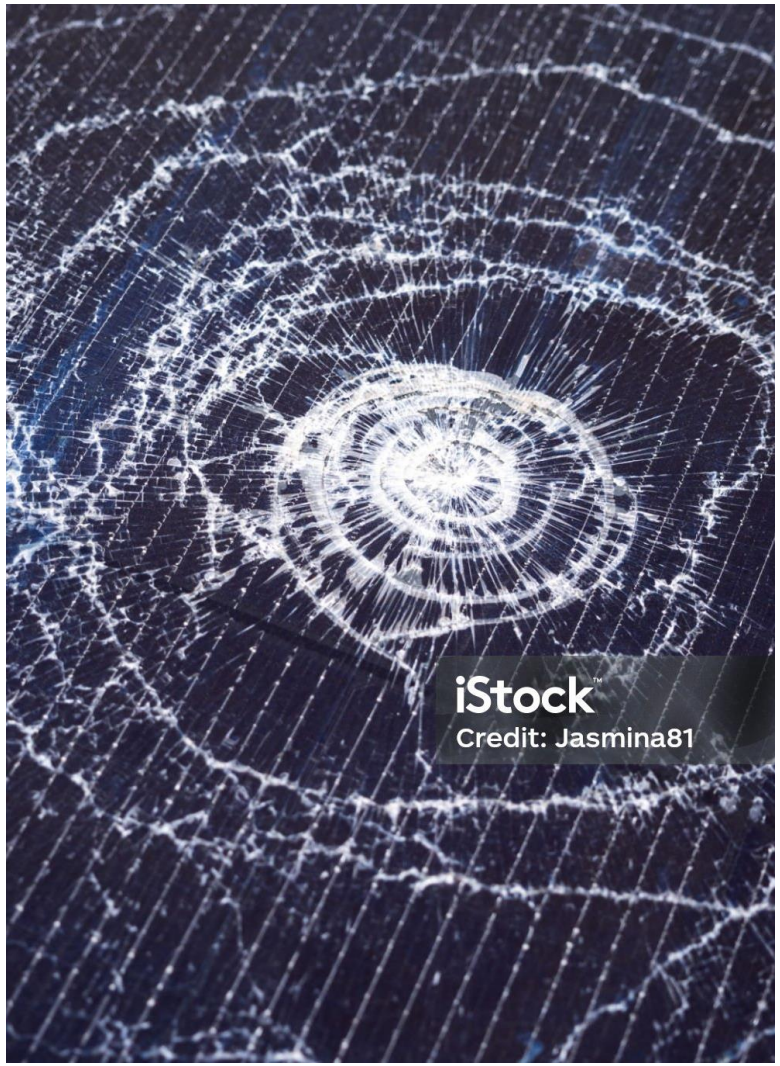
Setting the scene

We set out to investigate if the change is real, and what could be driving it.

To do so we carried out a review of over 85 scientific / peer reviewed journals. The review uncovered many interesting findings, which we have split into the following:

- Historical hail trends
- Climate projections
- Physical science of hail
- Population changes



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Historical Trends

Reanalysis Data:

- Consensus amongst most reanalysis studies that hail favouring environments across Europe have increased.

- Between 1950 and 2021 the occurrence of large hail ≥ 2 cm and very large hail ≥ 5 cm has increased across most of Europe, with some regions such as Northern Italy seeing more significant trends.

Observational:

- Observational data from 2008-2020 shows an overall increase in the number of large hail days.
- Hail Pad data shows an increase in the size of hail.
- The data is limited, however.

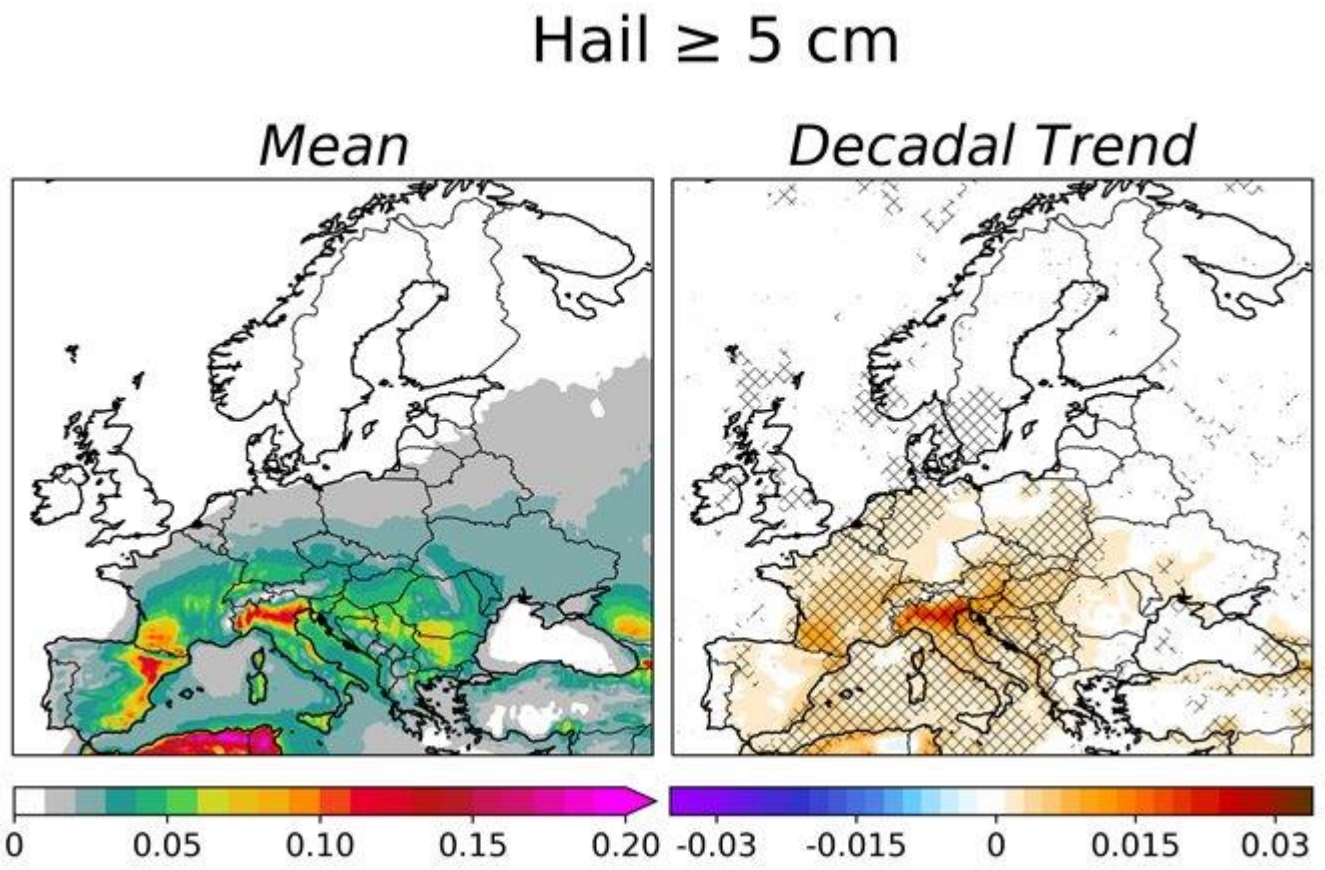

Figure 2: *Mean annual number of hours with hail >=5cm. Right map: Decadal change in annual number of hours with >=5cm hail. Significant trends (p<0.05) hatched. (Battaglioli et al., 2023).*

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Future Trends

- It is difficult to predict the future effects of climate change on large hail with any certainty.

- There is currently only 1 study that examines the future impacts of climate change for Europe *as a whole*, but there are a few country level studies.

- The result from the Europe wide study showed by the end of the century, under the RCP 4.5 scenario (warming scenario of roughly +2.6 °C) the occurrence of very large hail (≥5 cm diameter) is projected to become 30-40% more likely across most of Europe.

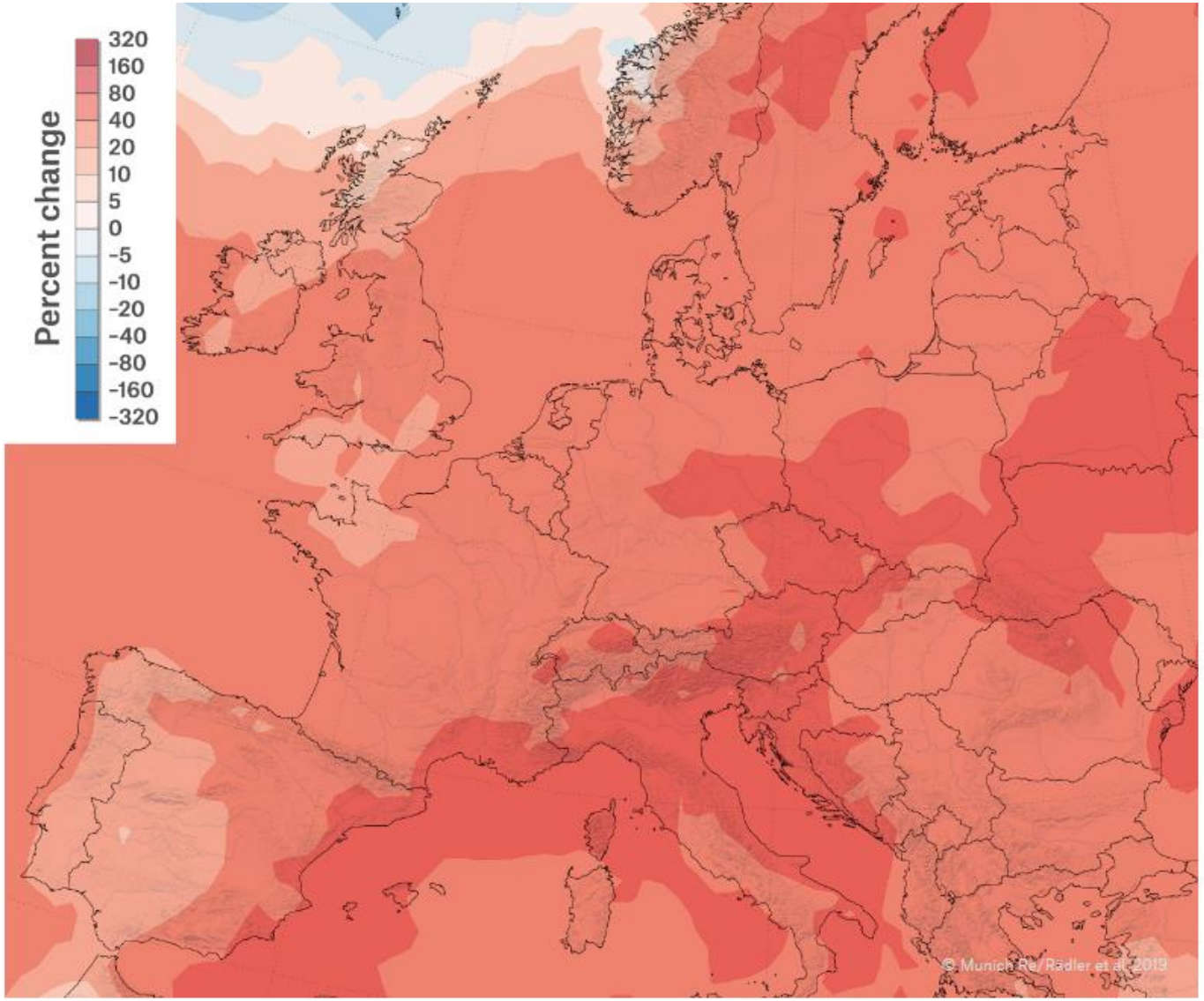

Figure 3: *Anticipated change in hailfalls with hailstones >5cm in a moderate climate scenario, with a temperature increase of approx. 2.6°C, 2071–2100 (Rädler and Faust, 2020).*

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Physical Science

Increase in CAPE:

- Climate change has led to an increase in air temperature, which is expected to raise tropospheric water vapour by approximately 7% per +1°C of warming
- Rising sea surface temperatures (SST) in the Mediterranean are also leading to an increase in low-level moisture.
- This rise in moisture and near-surface temperatures contributes to increased vertical thermodynamic instability.

Melting Level Height:

- As air temperatures warm due to anthropogenic climate change, the melting level height (MLH) is increasing, which affects the distribution of hailstones.

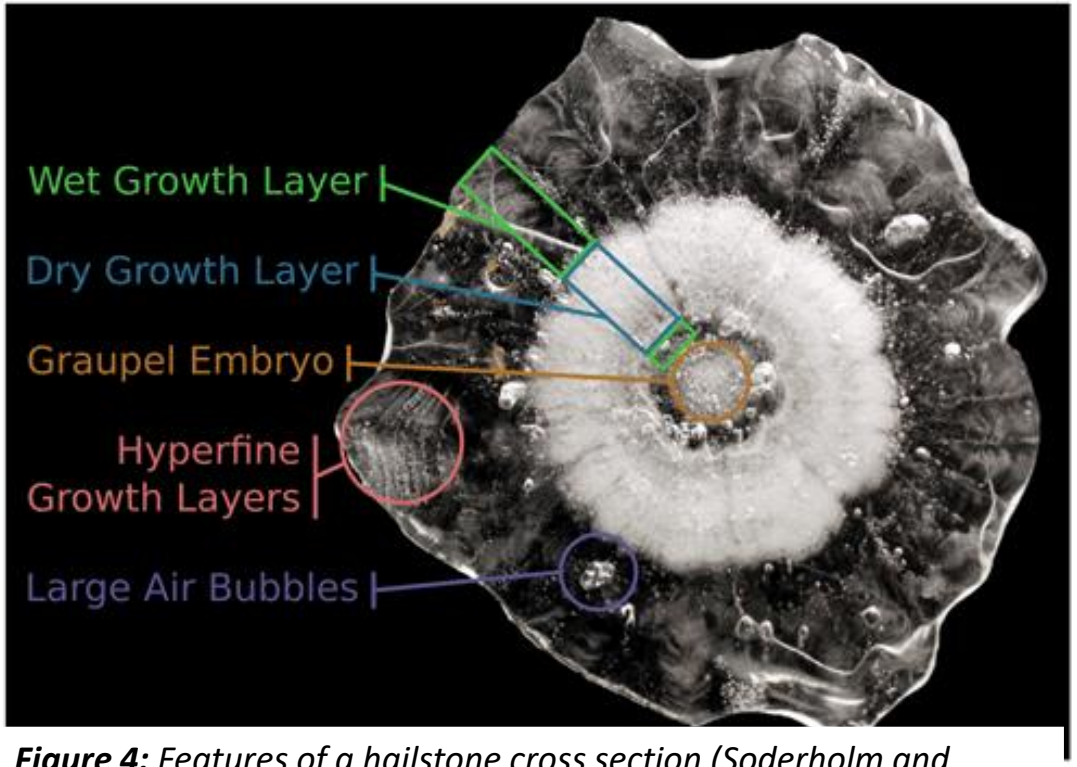

Figure 4: *Features of a hailstone cross section (Soderholm and Kumjian, 2023)*

Microphysics:

- The process of hail formation is complex and research on understanding the impact of climate change on the microphysics of hail is still emerging, and no consensus has yet been reached.

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Human Behaviour

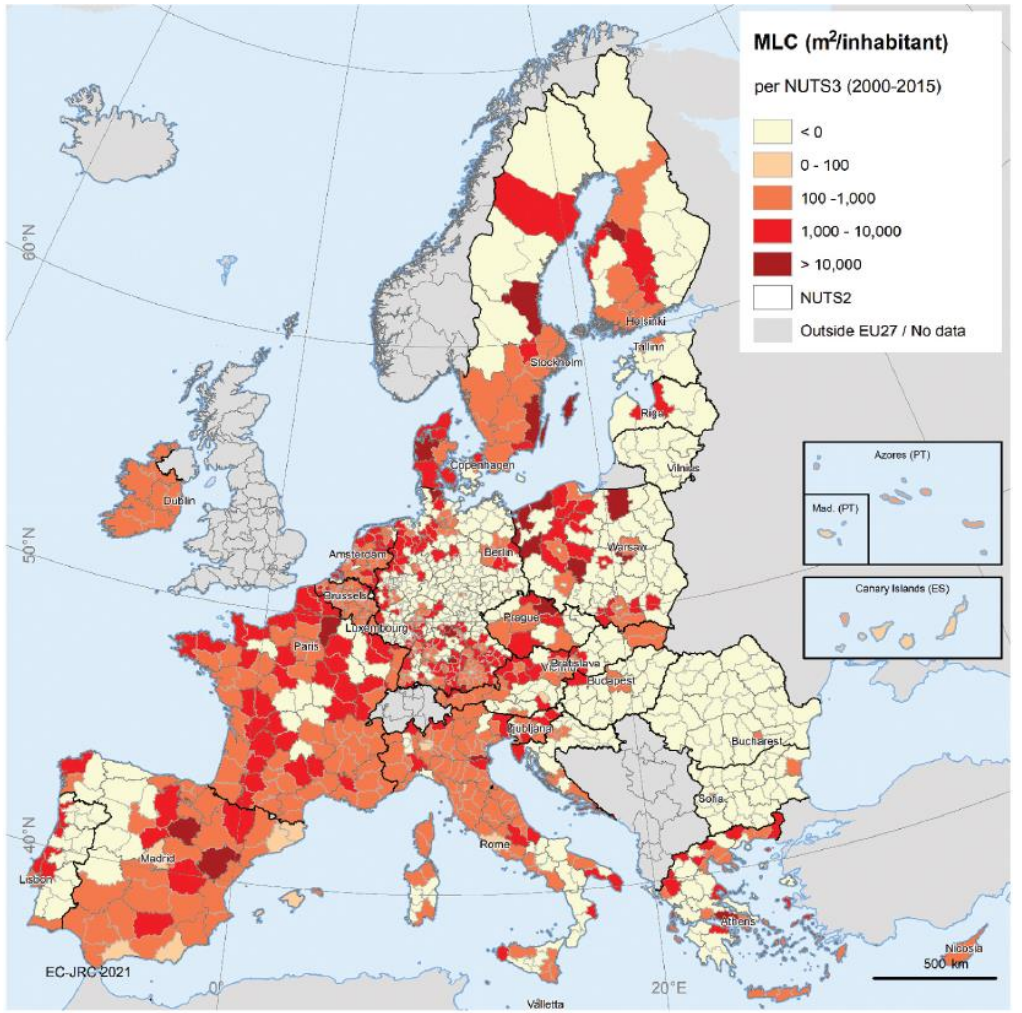
- Hail fall is irregular in all aspects (density, size, speed, area) within a single storm – meaning that it has a high miss factor – densely clustered European cities with wide open countryside tended to favour reduced hail risk

- Across Europe (EU27), the population of urban areas has increased at a rate of +7.4% between 2000 and 2015, against a Europe wide increase of +3.6%

	Population growth (million inhabitants)			
	EU27	Rural	Intermediate	Urban
2000–2015	15.4 (+3.6%)	−1.6 (−1.6%)	4.8 (+2.9%)	12.1 (+7.4%)

- While cities build up, and out, to accommodate the increase, the exposure in the rural areas does not go away

- Global studies have found similarly that the share of the population of cities has increased from 37% to 48%



Figures 5-6: *Map showing population change represented by 'marginal land consumption' per new inhabitant between 2000 and 2015. Table shows actual changes by region type. (Schiavina, M, et al 2022)*

Large hail in Europe: a changing risk

Summary of findings

1. There is evidence of trends in **historical data** across observations, hail pads, and reanalysis data studies showing an increase in both frequency and severity of hail risk

2. **Projections** are limited, but what has been published shows continued warming will result in an increase in risk across Europe

3. The **science of hail** formation at a macro level supports these conclusions, but we must note that this understanding is incomplete and much more research is needed into particularly microphysics of hail

4. **Populations**, and exposures, are increasingly concentrated in urban centres which are potentially creating new 'hot spots', many where we have not seen large hail before

Taken together we find that **the risk of large hail in Europe has already increased and will continue to do so**. We acknowledge that there is a great deal of uncertainty as well, which should be considered in views of risk.

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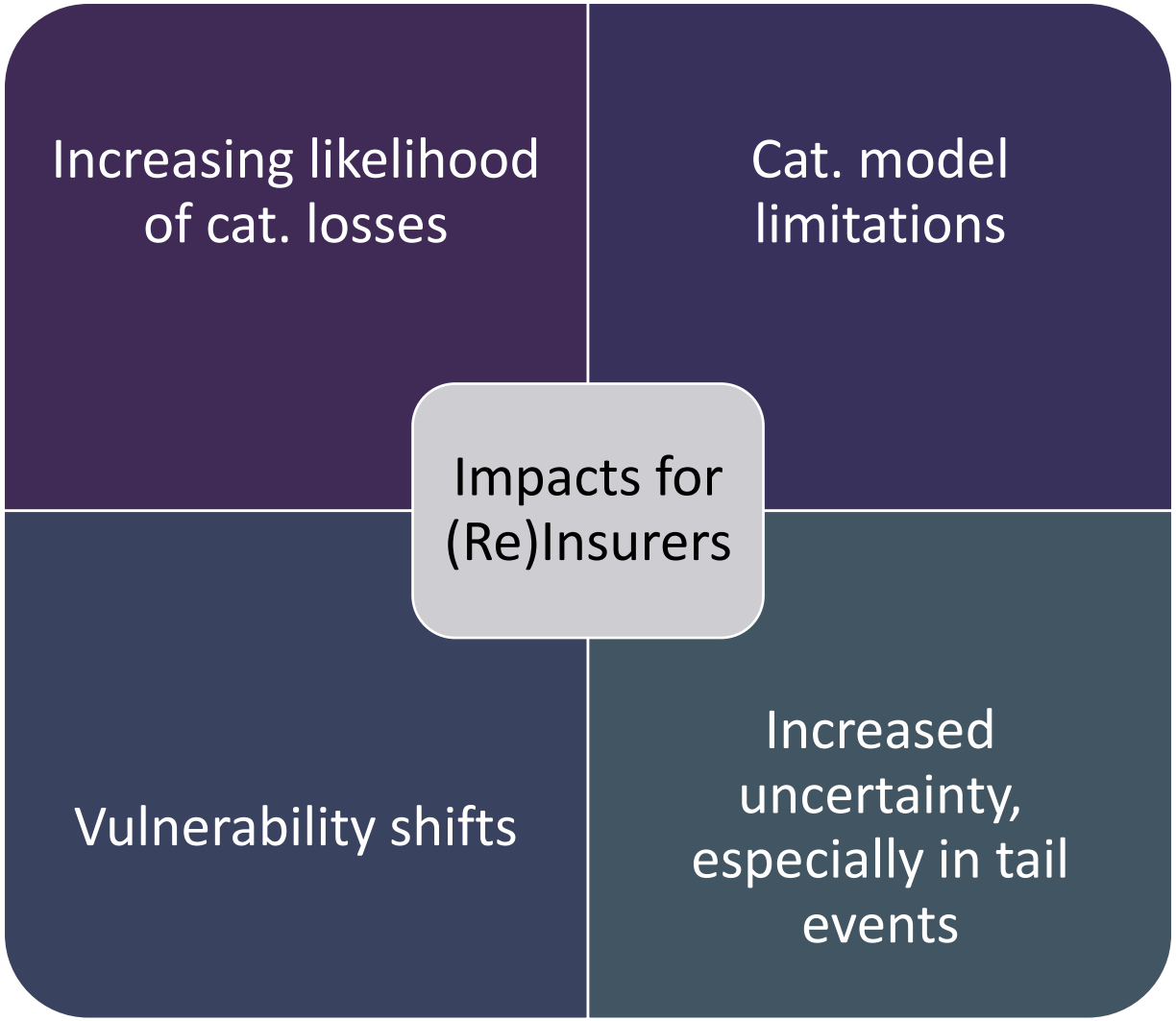
What might this mean for (re)insurance in Europe?



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Thank you

References

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Appendix

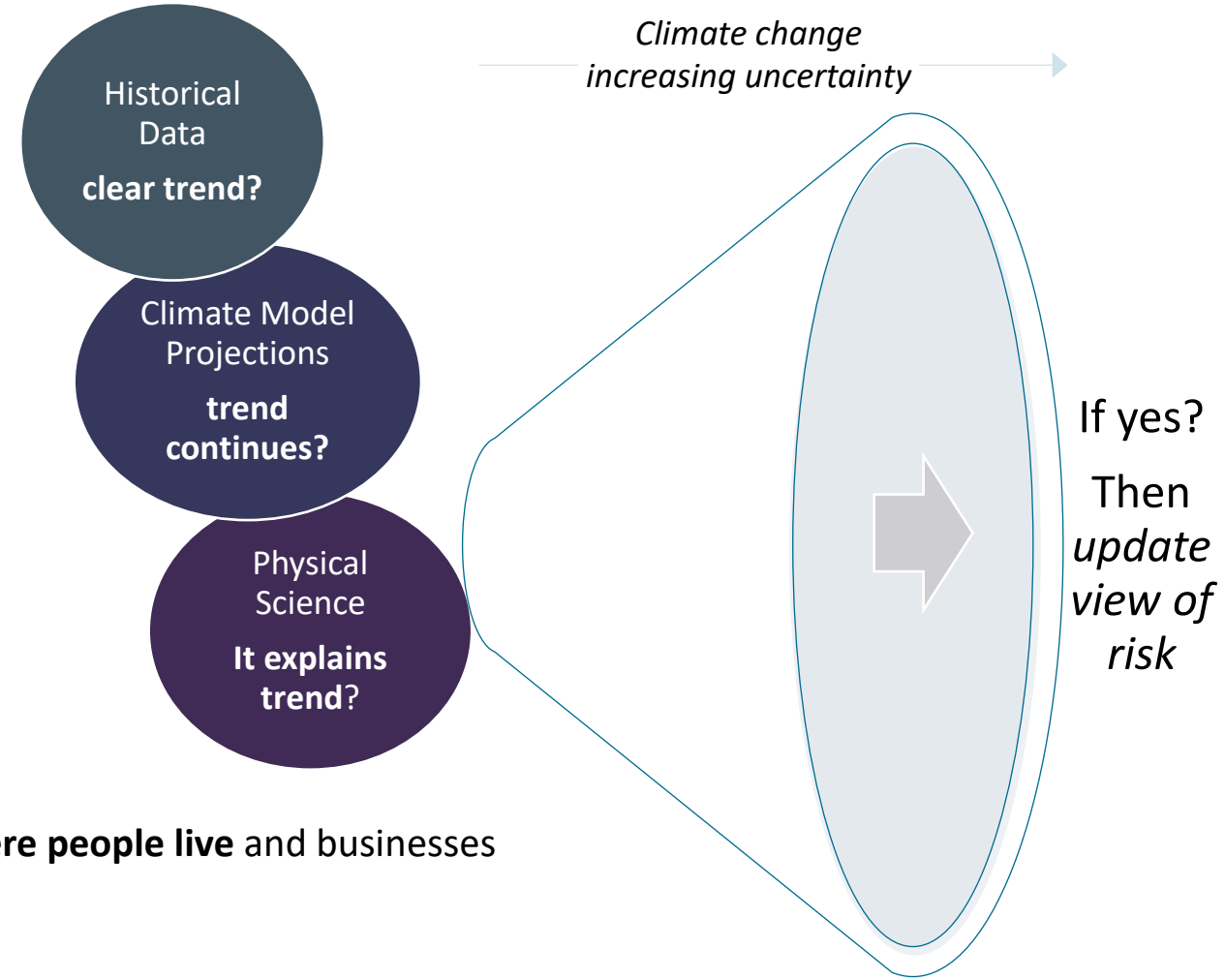
Large hail in Europe: a changing risk

Setting the scene

There are many factors causing the changes which drove such large losses. We set out to investigate what some of those are, and undoubtedly, we wanted to know if global warming was a driver.

We look at three key pillars to determine if the climate change signal is significant:

1. Is there a **historical trend** in some data?
2. Do we see a similar trend in **climate model projections**?
3. Is there a reasonable explanation for the trend grounded in **physics**?



Other potential drivers of change we look for are changes in **where people live** and businesses operate, changes in **exposure**, and changes in **vulnerability**.

EUROPE HAIL

May 2025

Hail Data

Hail hazard in Europe

Hail Vulnerability

Data Acquisition

Censors

Recording Hail impact, old censors used sheets, recent one use kinetic impact

Strength - Recent censors do capture real damage produced by hail

Bias - Expensive
- Local capture of a hail event, data private, and not uniformely captured

Solution is keen for a local parametric solution with limited cover.

ESWD

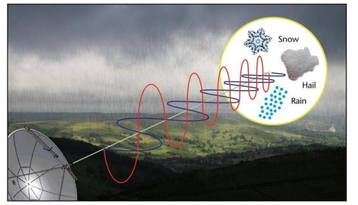
Database which reference Severe Windstorm events

Strength - Global European Coverage at affordable cost

Bias - Multimodal Data acquisition (Social Networks, Public Submission, Media Report) without scientific validation
- No geographical footprint of Events

Solution is keen for macro analysis not for model / pricing

Doppler Radar Data



Costly data acquisition and retreatment to assess hail strength by combining reflection, atmospheric models and DTM.

Strength - Uniform data acquisition throughout territories

Bias - Small bias in mountains areas on data acquisition
- Reflection model Hail interpretetion depends on DTM and atmospheric model

Solution with most data accuracy and homogeneous data acquisition

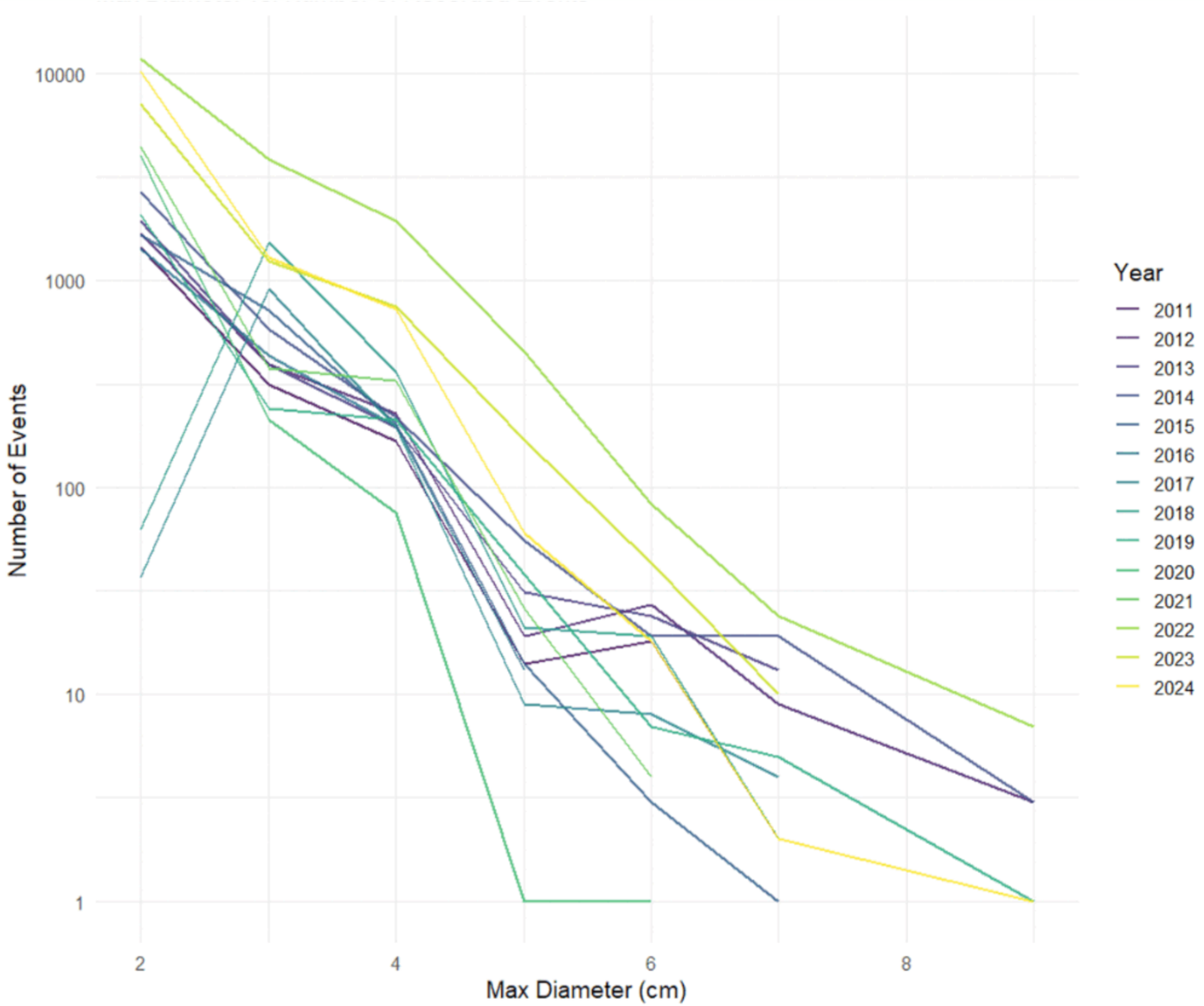
All analysis showed are based on Doppler radar datasets

Hail Data

Hail hazard in Europe

Hail Vulnerability

Number of Towns impacted by hail size per year



FRANCE

Hazard increase

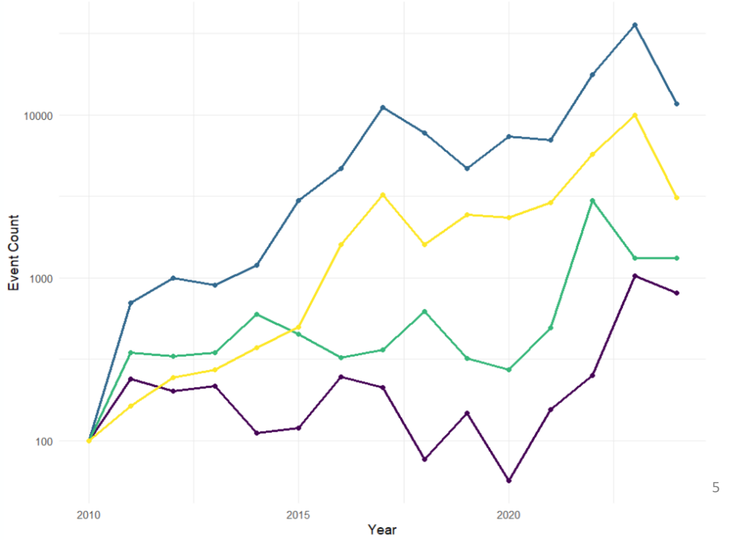
Frequency

Number of Towns impacted by hail is increasing in Europe.

Severity

Hail diameter is increasing with record of 19cm observed in Italy in 2023.

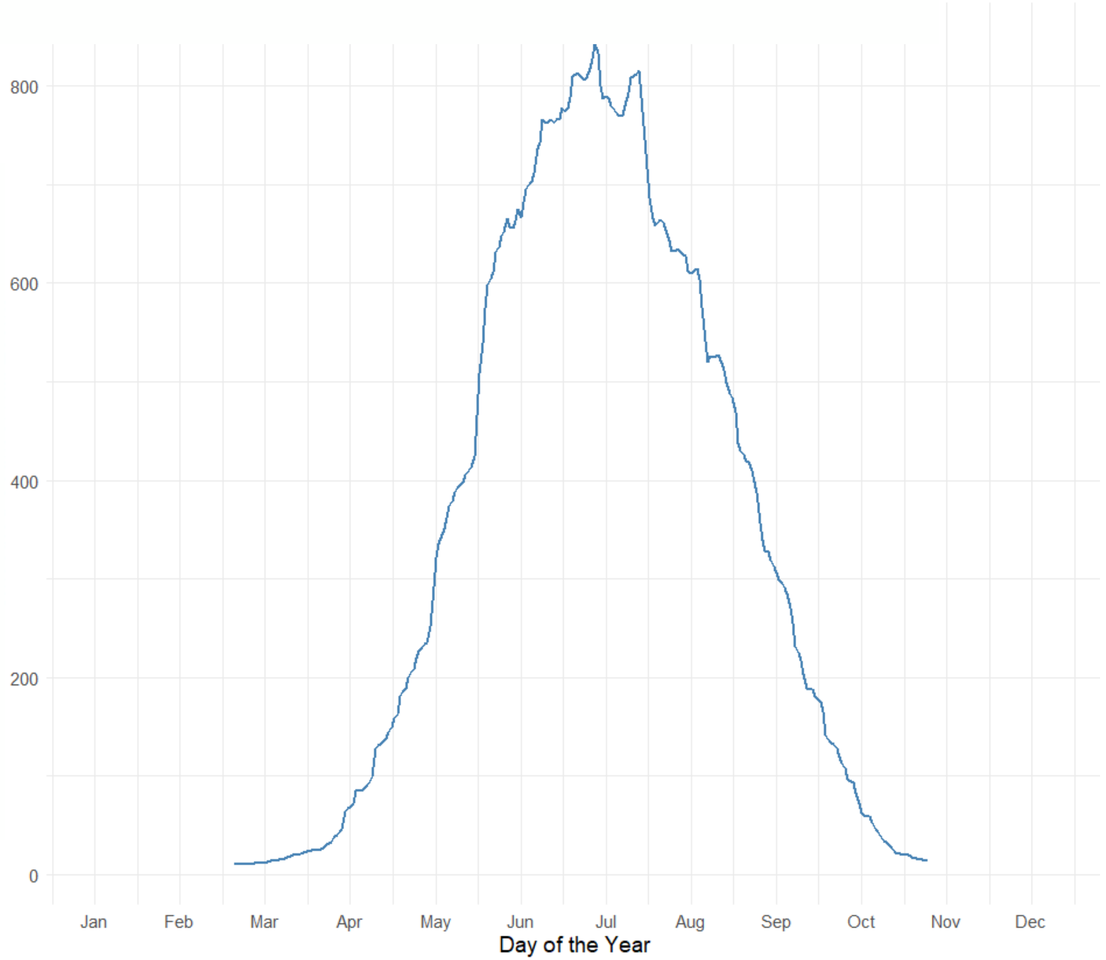
Number of Towns impacted by large Hail



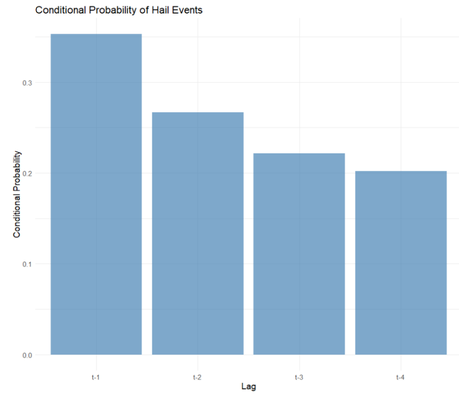
Seasonality & Clustering

Hail is highly seasonal as it requires convective energy i.e. :

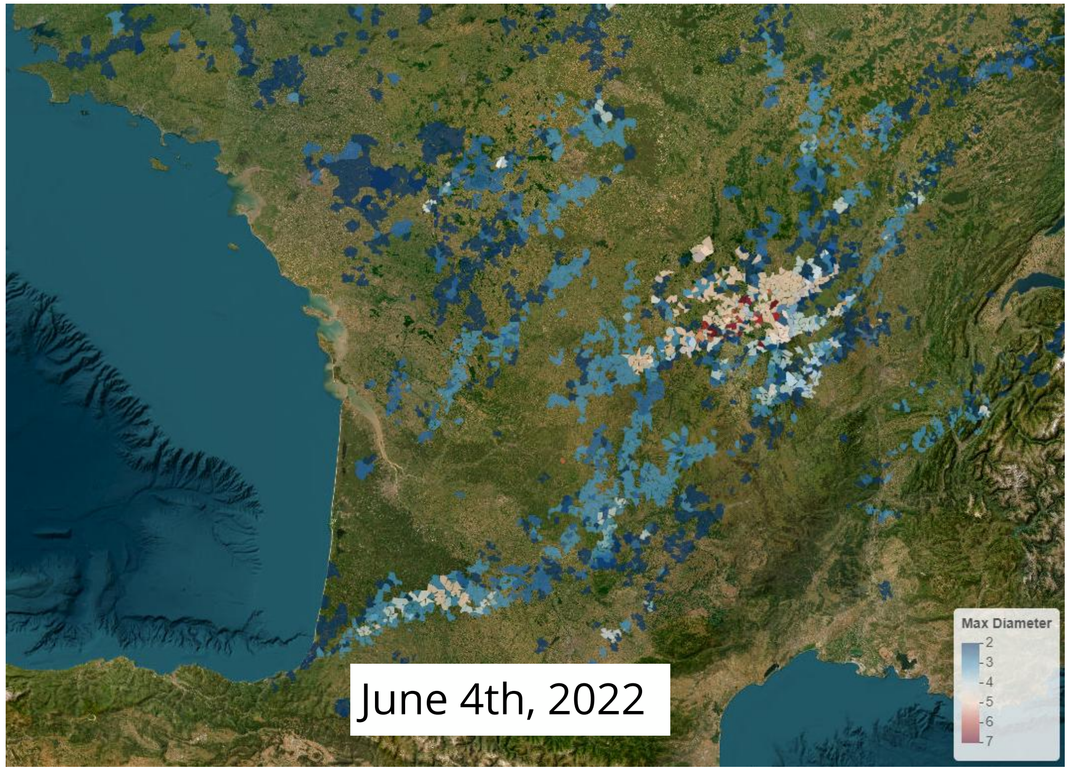
- High temperature gradient in the atmosphere
- Moisture
- Wind Shear

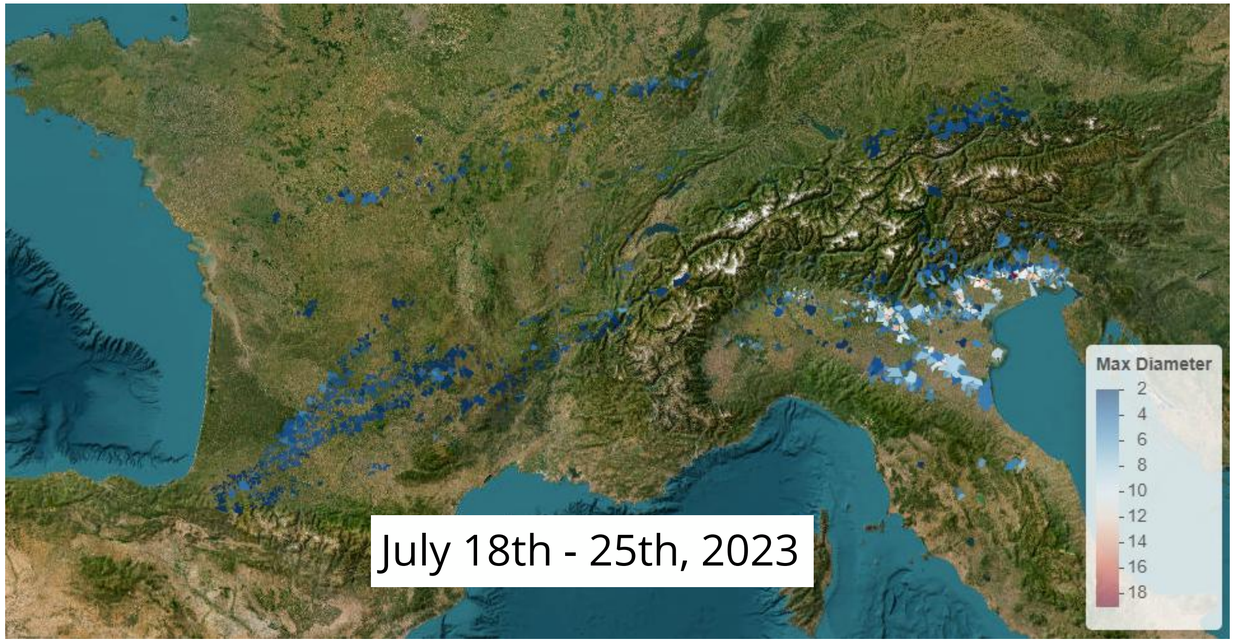


Clustering effect as hail-favorable conditions often persist for several days.



Reinsurance treaties apply hours clauses ranging from 24 to 216 hours.





Scattered Footprint

Unlike other perils, Hail has a discontinued footprint through space & time.

Large Hail storms are usually a combination of :

- Numerous streaks
- Large Hailstone diameters
- Large streak

Hail streaks are highly regional :

- Localized streak in Oceanic / Mediterranean regions / Mountains regions
- Large streak in High tempered / Continental regions

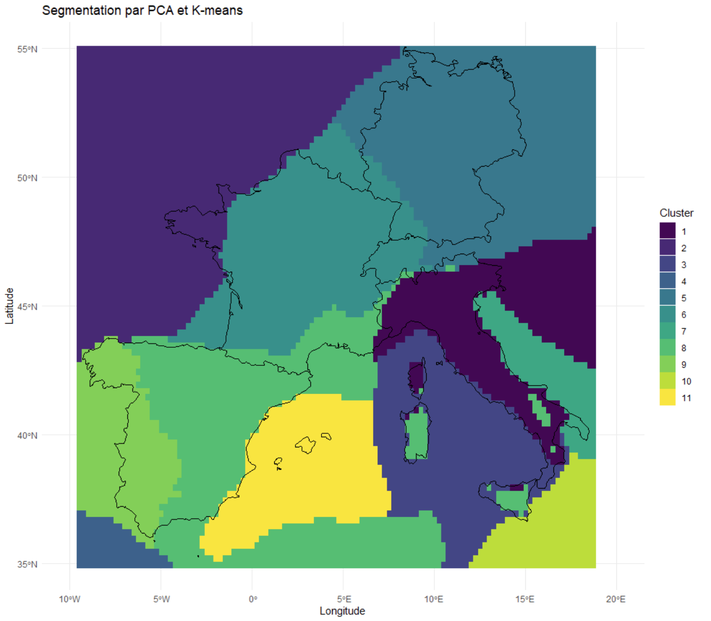
Impact of distance to shore and DTM.

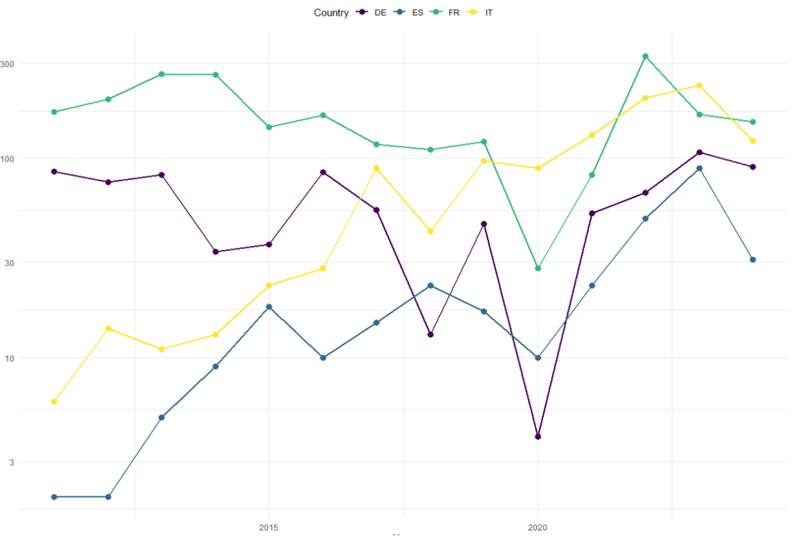
Hail streaks are highly correlated with winds.

Climate Change Impact

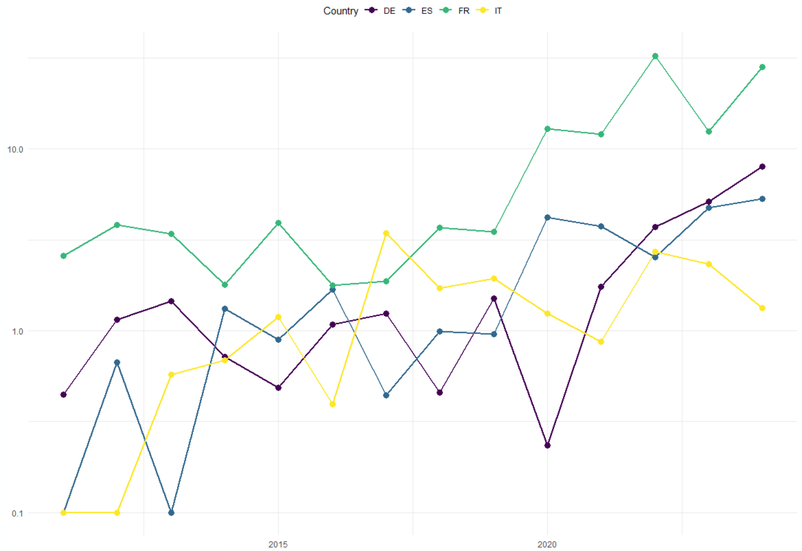
Climate Change Impact is an observed 2 vectorial effect :

- Increase in Streak frequencies :
    - Spain, South of France and Italy have a strong Frequency increase of 5 - 7%
    - France & Germany are more contained with an increase of 2%
- Higher probability of large Hail Streak implies larger footprints :

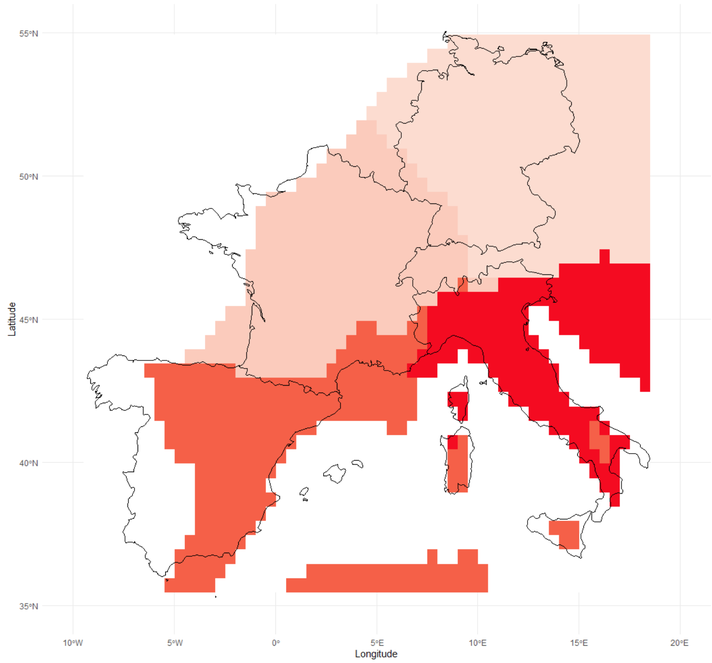




Streak Length



Streak Spreading



Hail Data

Hail Hazard in Europe

Hail Vulnerability

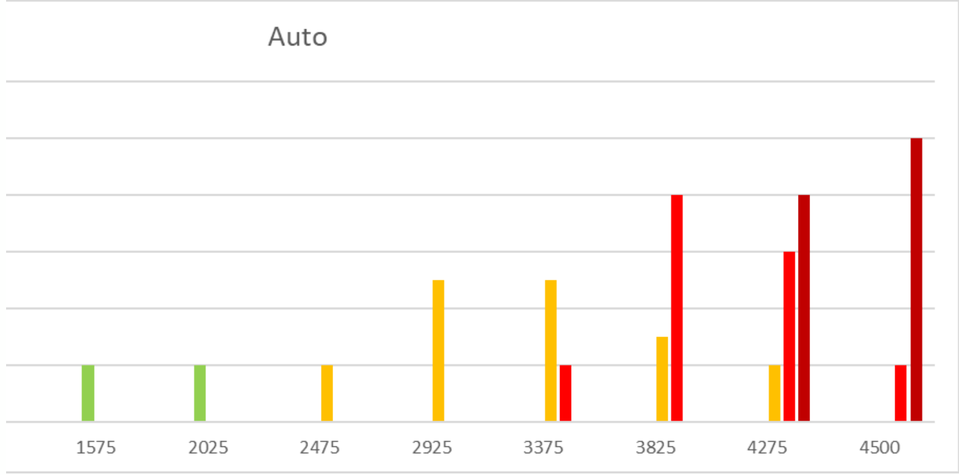
Vulnerability Prone

Motor Own Damage :

- The proportion of total wreck is high. The DR approach is inadequate as cost is linked to body repair and Glass Breakage rather than actual car value.

  IPE implemented a variable Loss Forfeit based on SRA Classification (French Classification of All Vehicles based on Repair Cost, highly used by Insurers for pricing).

- Very high demand surge on Body Repair upon large events.
- Higher cost of Glass Hood cars with replacement above 5cm diameter.
- Social Inflation Cost of networks like Carglass.
- Cars are a moving asset, there is a high uncertainty over localization though Hail usually occurs during the afternoon early evening near declared localization. Highly kept within probability of claims.



Vulnerability Prone

Residential

- France drought peril proved to be highly correlated in vulnerability with Hail.
- Solar Panels equipment increasing. AI process on Claims report (over a 40% market share) observed a breaking point at 6 Hail diam - full replacement of solar panel
- Roof Type are regional with different replacement costs. Slate brings 50% higher cost than tiles. Different post loss amplification.

Industrial

- Hail is highly binary, whether no loss or very high Damage ratio loss.
- Main vector is Flat roof structure, fiber cement, glass roof
- Identified vectors have been capture through AI Claim reports automation though there are not captured exposure wide.