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Modelling hail risk in Europe based on convection-resolving climate simulations

Timo Schmid, Valentin Gebhart, David N. Bresch

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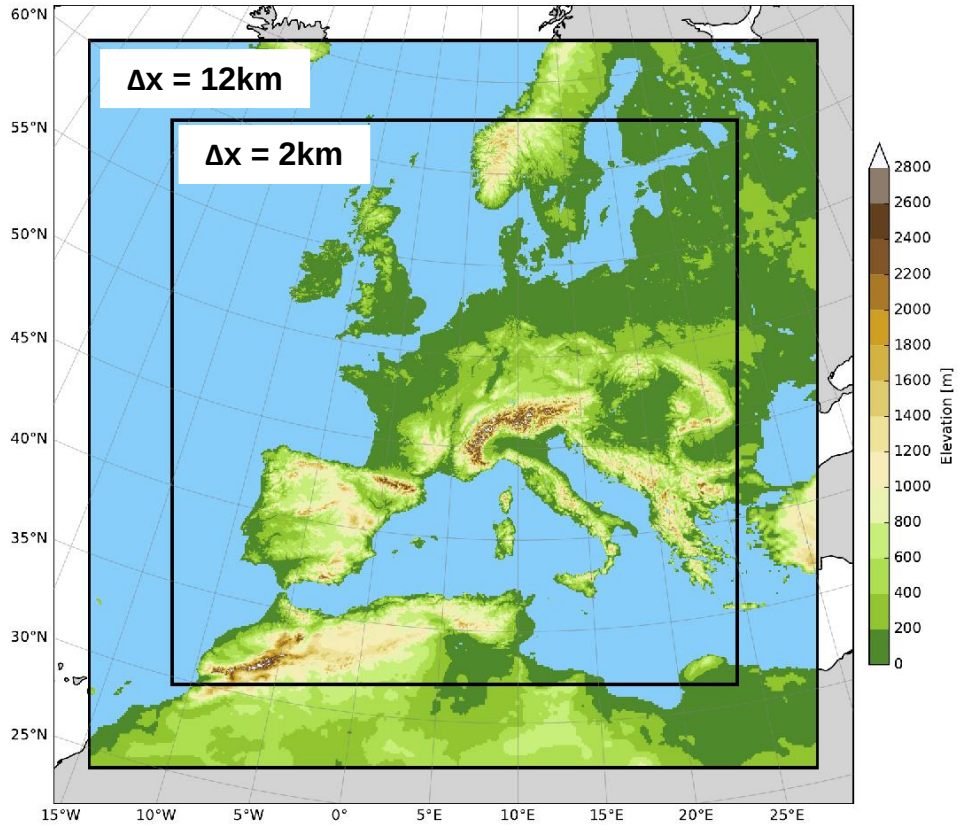
Image: Fire Department Wolhusen, Switzerland

Model setup

11-year present-day and future climate simulations

- COSMO 6.0
- HAILCAST[1] parametrization
  → 5-min maximum hail diameter
- Setup tested and explored in previous case-study and seasonal simulations [2]
- Using Pseudo Global Warming (PGW) approach



Present-day simulation

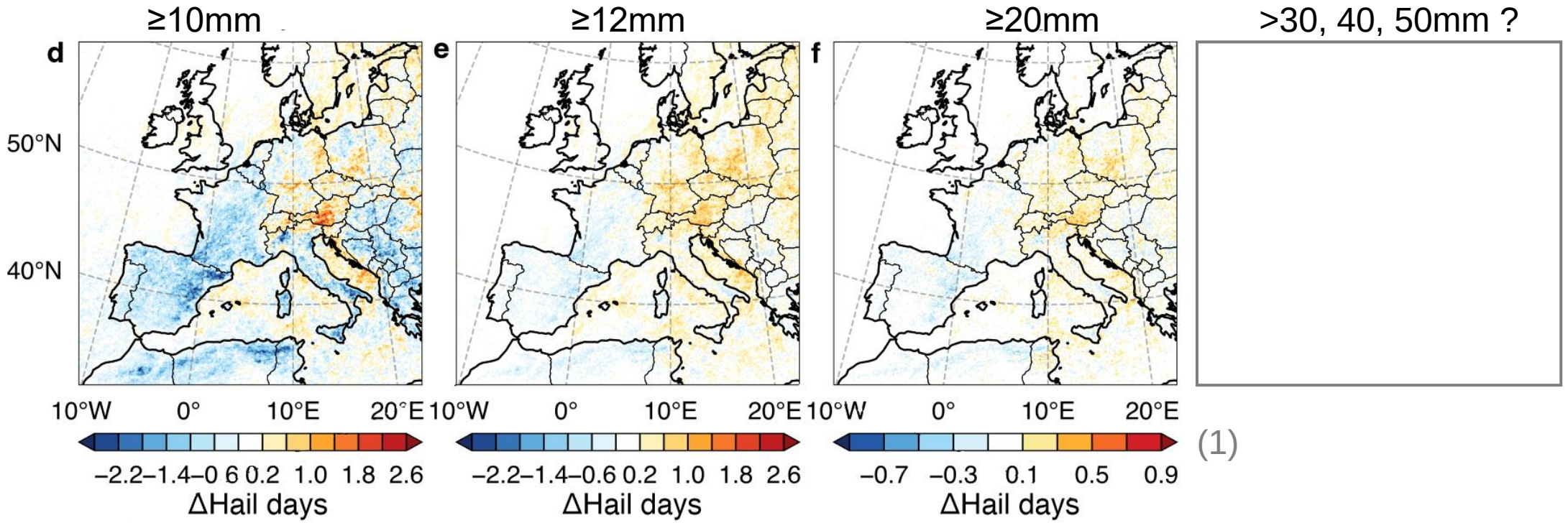
ERA5 reanalysis 2011-2021

Future simulation

ERA5 2011-2021 + 3K global warming using PGW approach (GCM: MPI-ESM-2-HR)

1) Adams-Selin and Ziegler (2016)
2) Cui et al. (2023, 2024); Malečić et al. (2024)

Hail frequency change



(1)

- **Spatially variable** hail frequency change for **different hail sizes**
- How can it be translated to changes in **expected losses**?

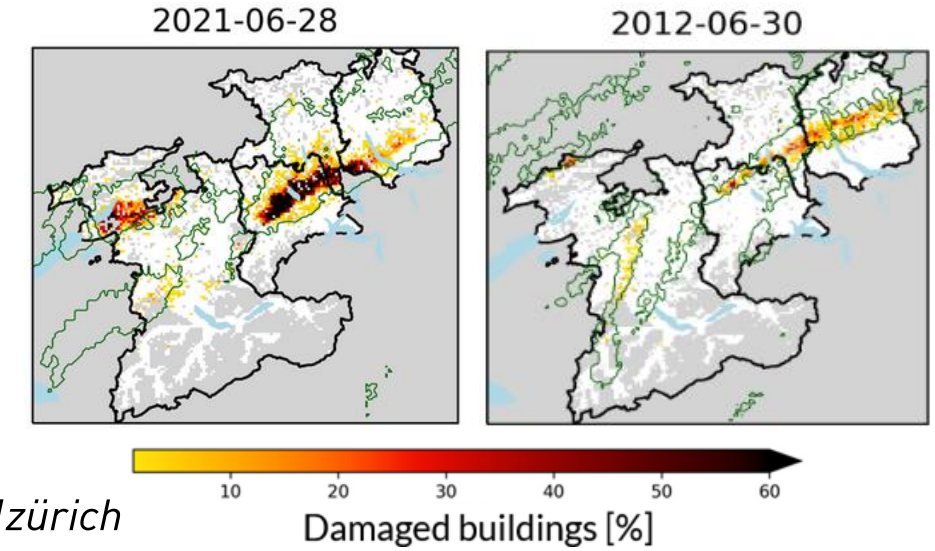
1) Thurnherr et al. (2025)
DOI:10.1029/2025GL114811

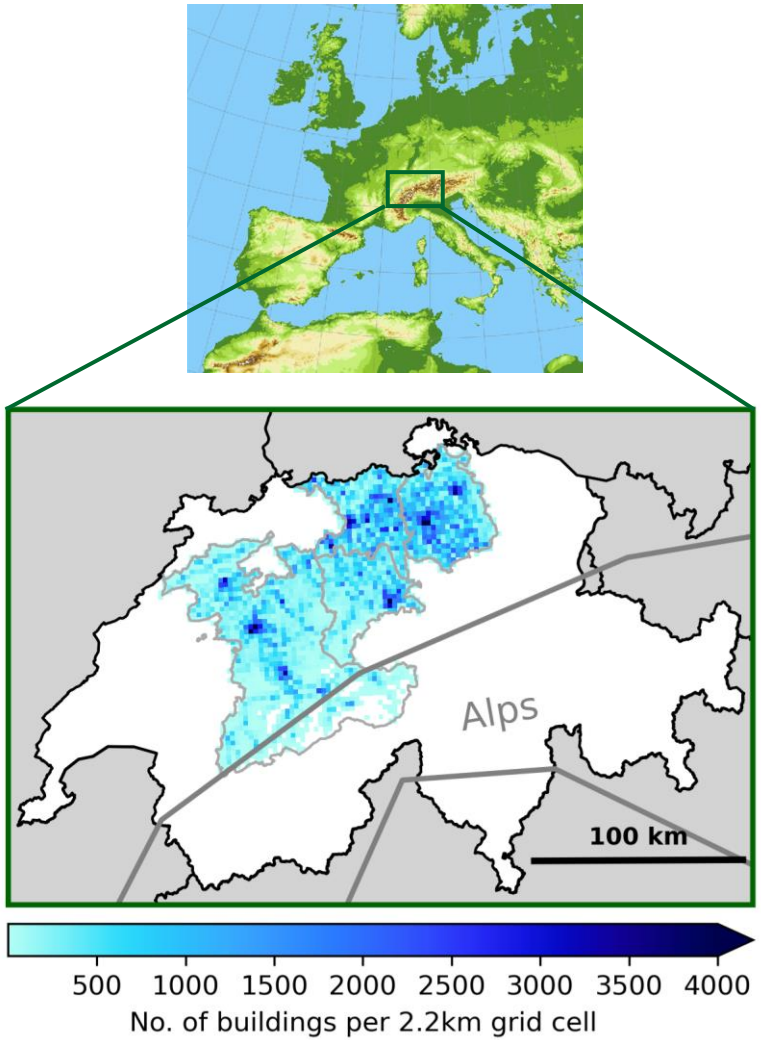
Hail Damage Data

- In central Switzerland
- 1M exposed buildings
- 120’000 claims with a total volume of 947M CHF in 11 years

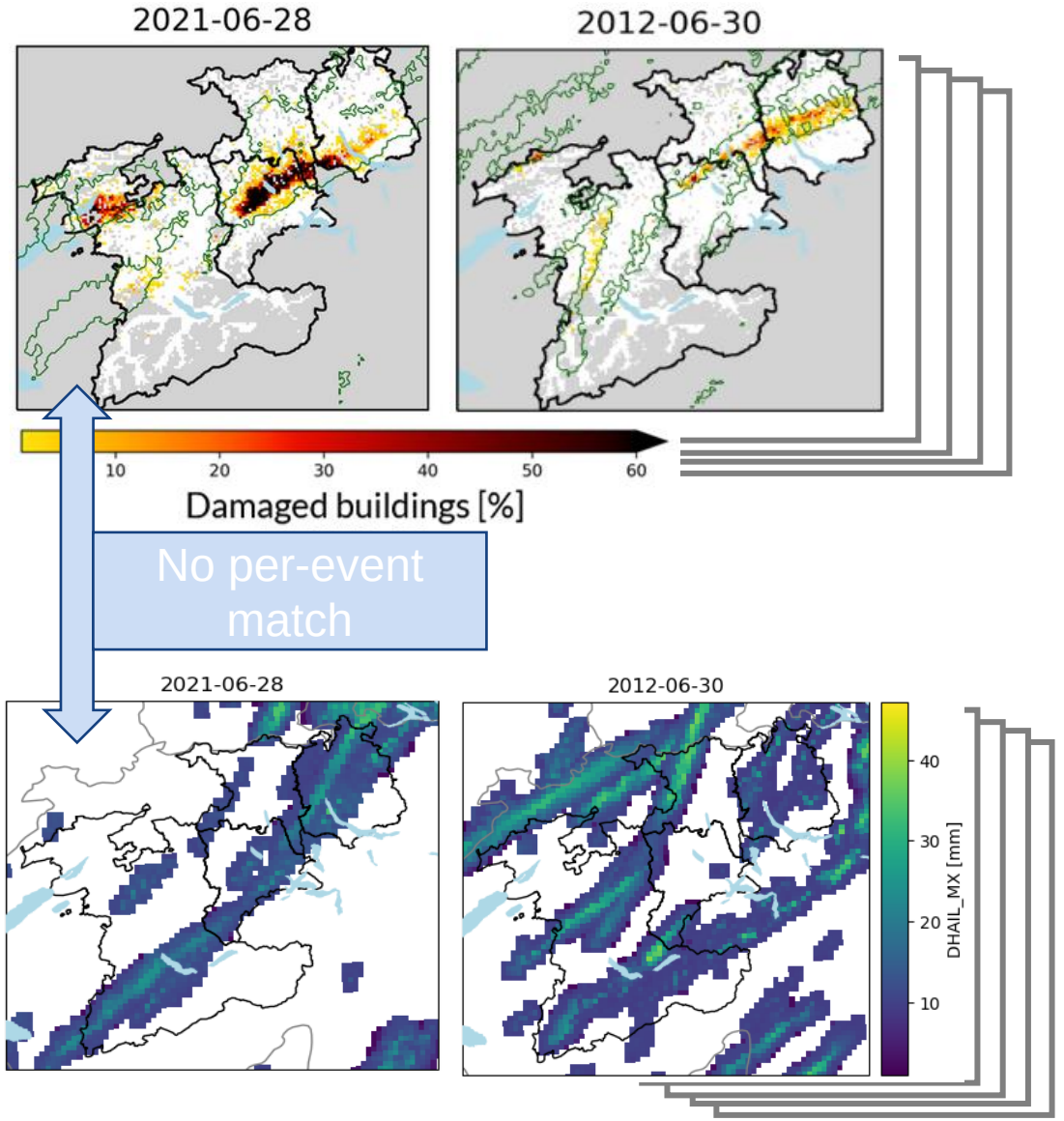
- Overall, **>70% of reports** and **85% of losses** occur in only **10 events**

- Within those, losses are concentrated in small hail streaks



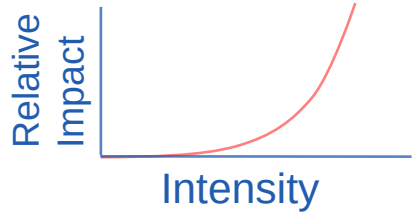


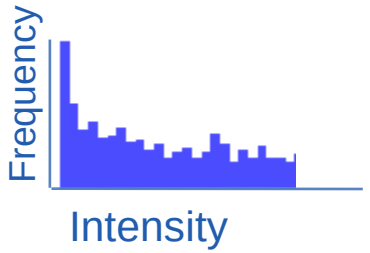
Calibration approach



11 years of observed *relative* impacts (Fraction of buildings with hail damage)

Quantile mapping

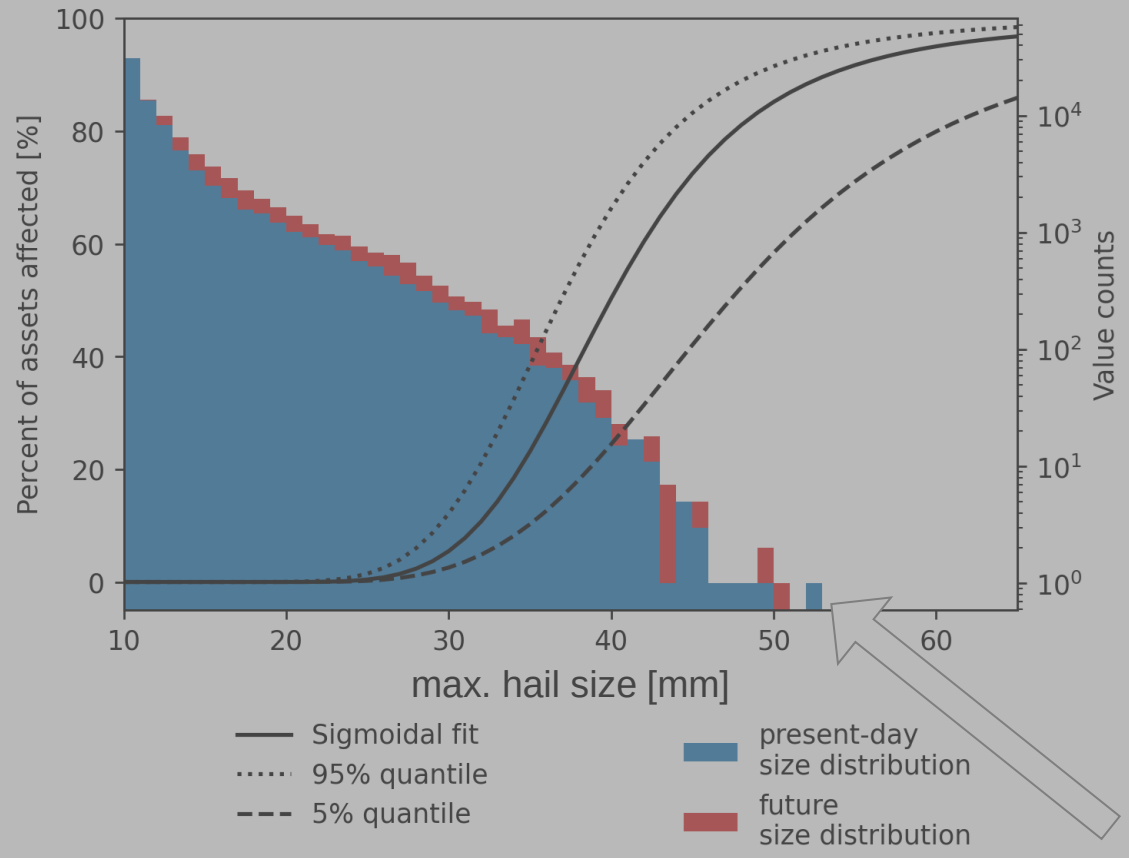




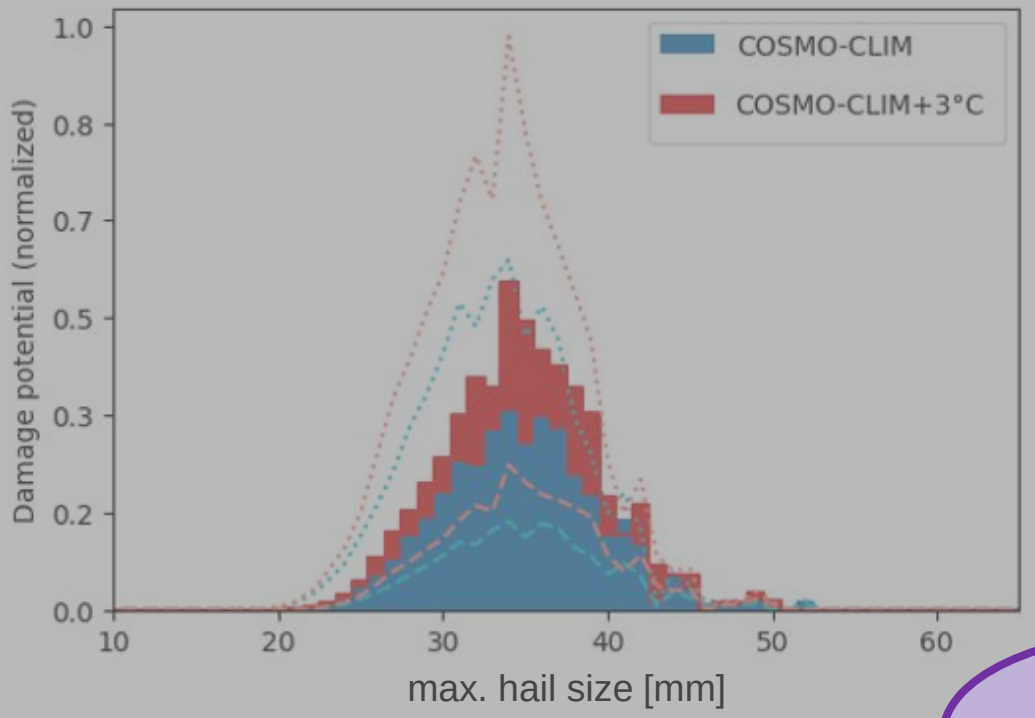
11 years of modelled DHAIL_MX (COSMO-HAILCAST present-day simulations)

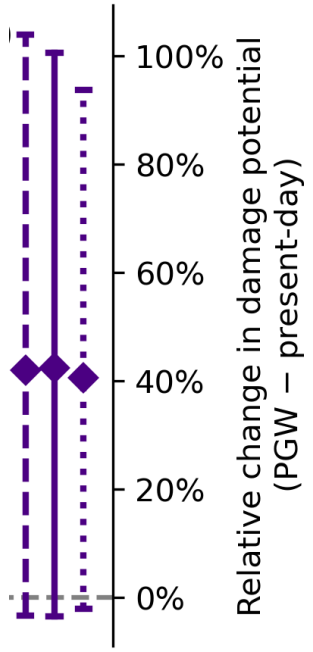
Impact function & damage potential

Impact function and hail size distribution for Switzerland



Damage potential (Switzerland)



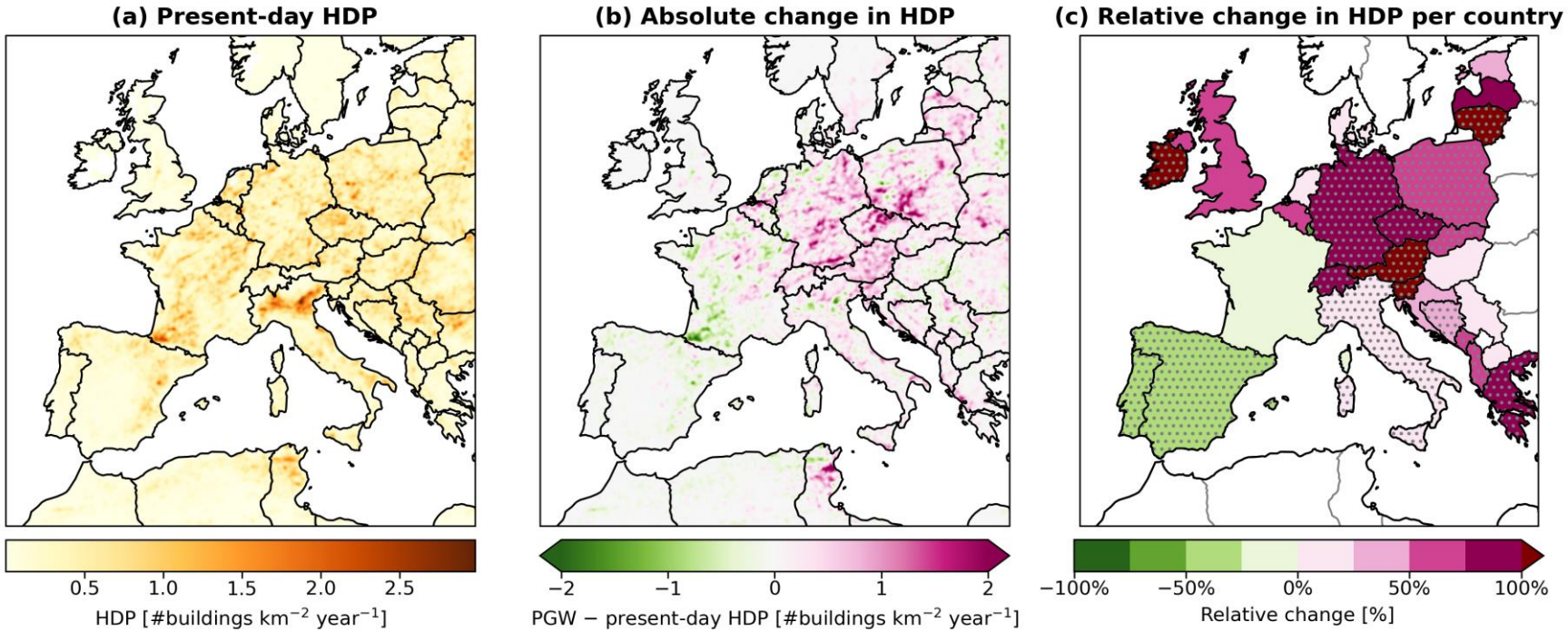


Bootstrap sampling uncertainty

Largest modelled hail: 52mm
Largest observed hail: ~100mm

Hail Damage Potential (HDP) changes over Europe

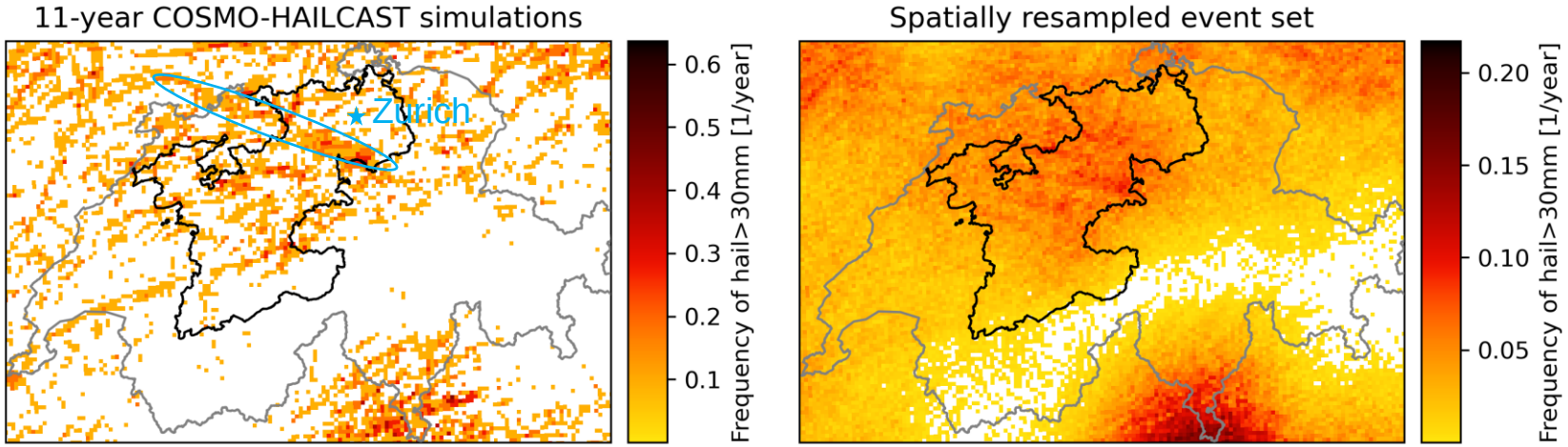
- Assuming a building vulnerability as calibrated over Switzerland



- **Per country,** the 90% CI based on bootstrap sampling **commonly exceeds 100%**
- For Europe overall, we expect an increase of 33% (CI of **25-42%**)
- **Locally**, the HDP depends on **few storms** over 11 years

Available spatially resampled data

- Given local dependence of HDP on **single storms**, **spatial resampling** is needed for local-scale damage estimates
- Allows usage with **custom portfolio** of buildings (or other assets)
- **Whole domain** available on the **CLIMADA Data API**
- Further version with more sophisticated resampling is in development



Conclusion

- **42% (-5 to +101% CI)** increase in hail damage potential in the 3°C PGW scenario over the calibration region in **Switzerland**
- Assuming comparable building vulnerability, results indicate a **25-42% increase** in hail damage potential over Europe, with **high spatial variability** and **large uncertainty for local changes**
- Given the **high concentration** of damages in **few events** with small footprints, **long simulations** or further assumptions are needed to project **hail damage potential on local scales**.
- **Spatially resampled hail footprints** are available on the CLIMADA data API, and allow for damage estimation on a custom building portfolio

Preprint: Schmid et al. (2025)
https://doi.org/10.2139/ssrn.5281477

Contact: Timo Schmid
timo.schmid@usys.ethz.ch
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