

Hail and its impacts: The interdisciplinary research project scClim in Switzerland

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19 Nov 2025 | ECCS2025, Utrecht



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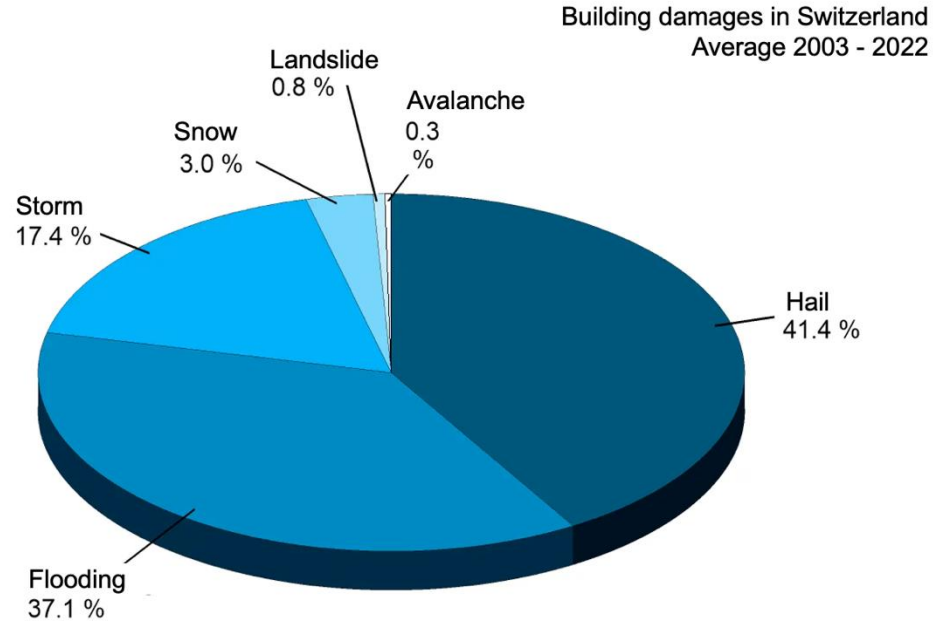
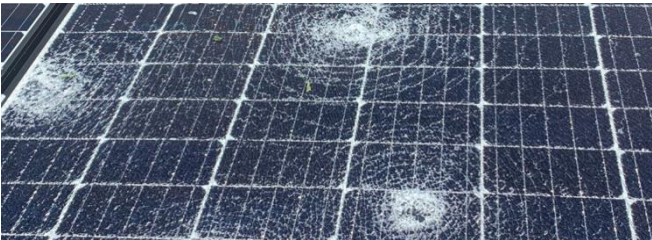
Agroscope

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**Federal Office of Meteorology and
Climatology MeteoSwiss**

 **Schweizerischer
Nationalfonds**

Hail damages in Switzerland



Source (adapted): Schadenstatistik der VKG

scClim project¹ overview

Demonstrator website

user: Nov

pw: 17



Fast prototyping and interaction with stakeholders

Modelling hail

- Numerical weather forecasts
- Climate simulations

Measuring hail

- Radar measurements and crowdsourcing
- Observed hail trends

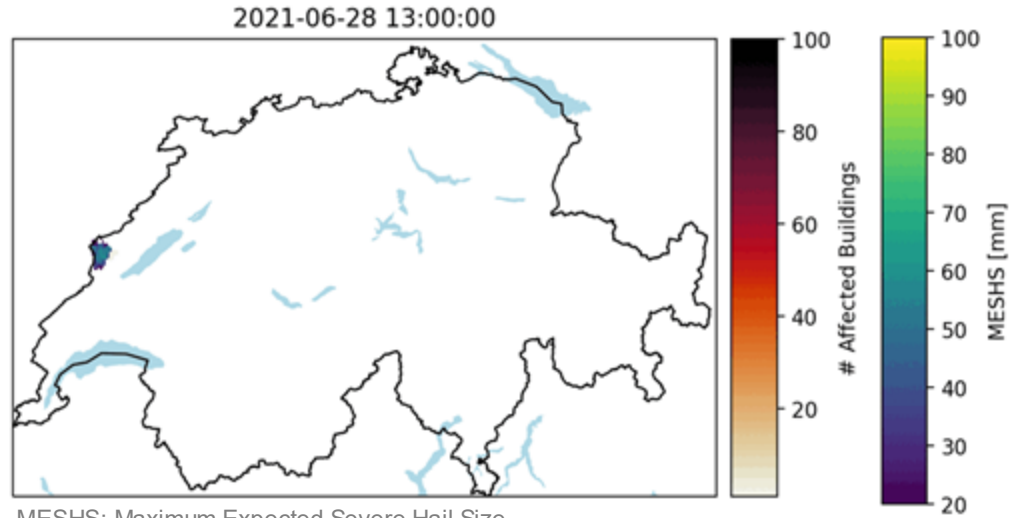
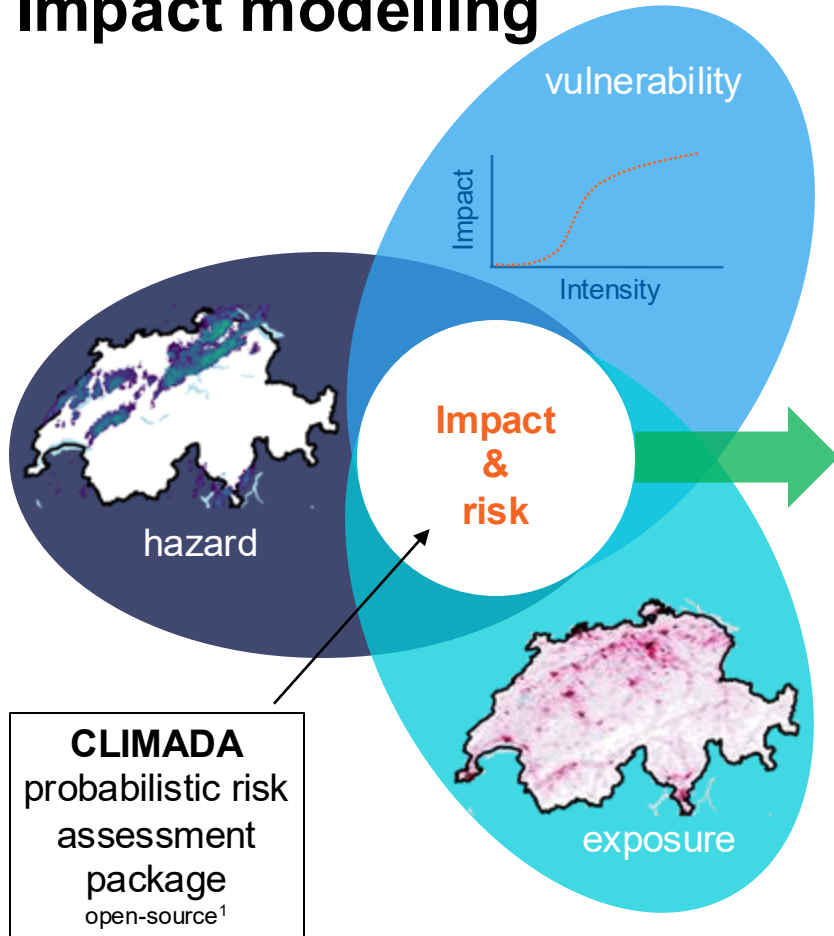
Modelling hail impacts

Exposed assets:

- Agriculture
- Buildings
- Vehicles

¹ <https://scclim.ethz.ch/>

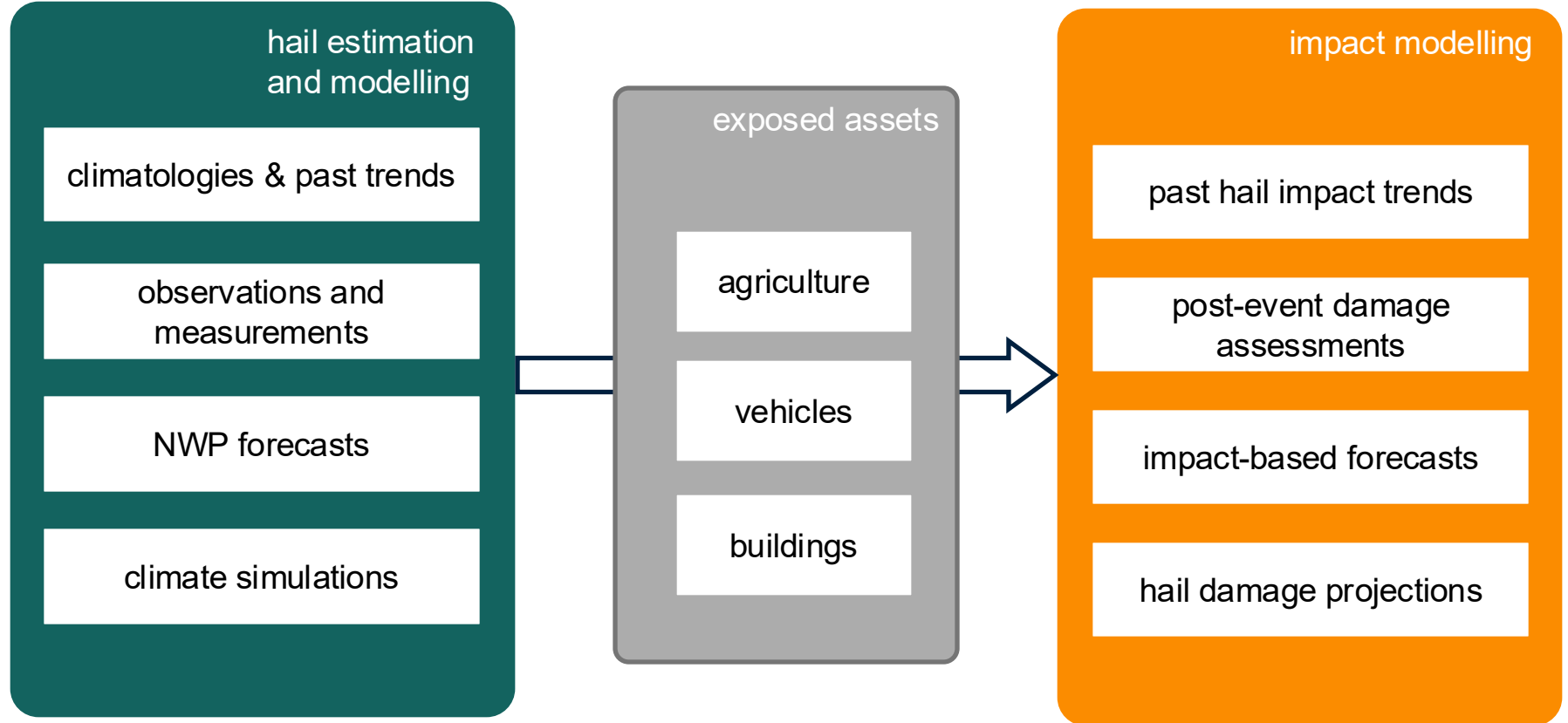
Impact modelling



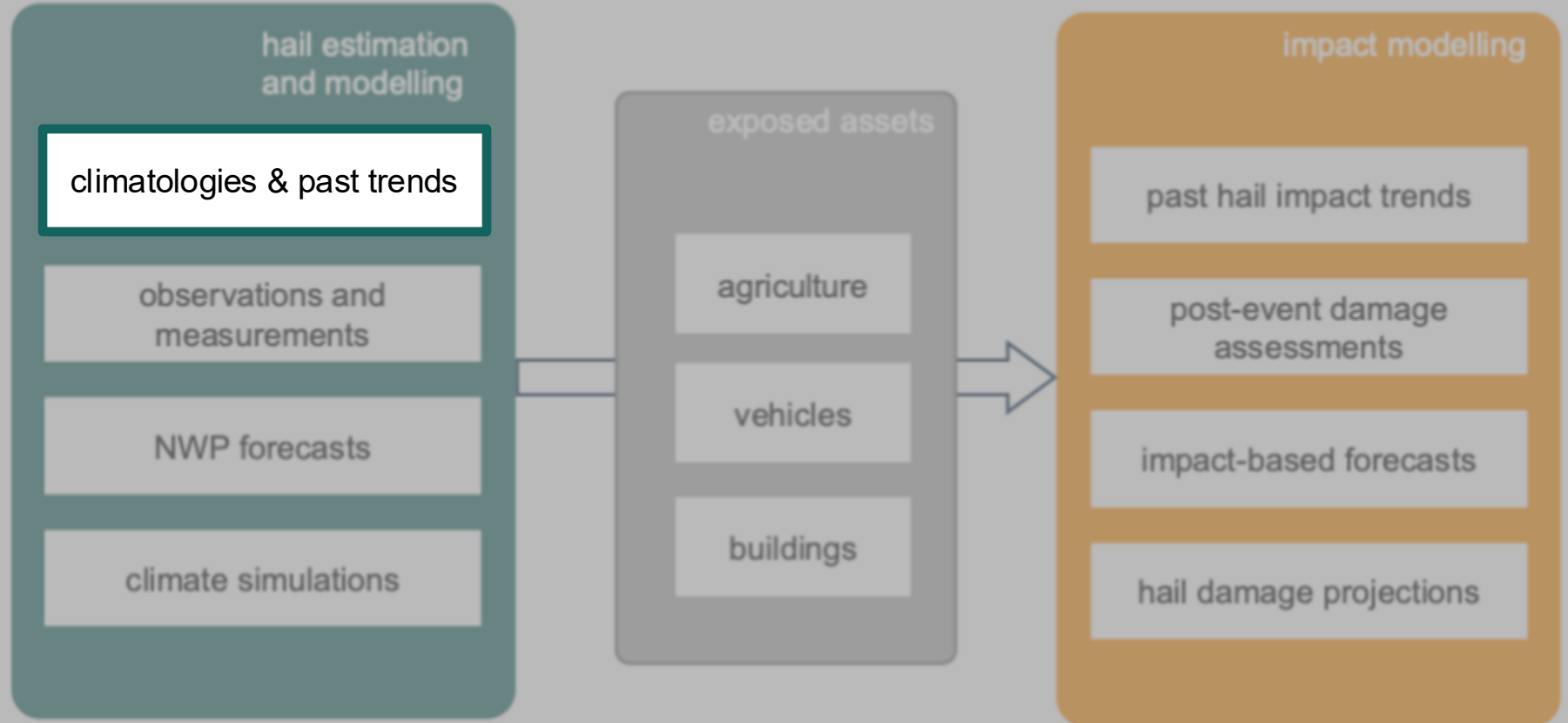
MESHS: Maximum Expected Severe Hail Size
Animation created by Timo Schmid: tschmid@ethz.ch

¹ <https://wcr.ethz.ch/research/climada.html>, Aznar-Siguan & Bresch, 2019: <https://doi.org/10.5194/gmd-12-3085-2019>

scClim modelling chain



scClim modelling chain

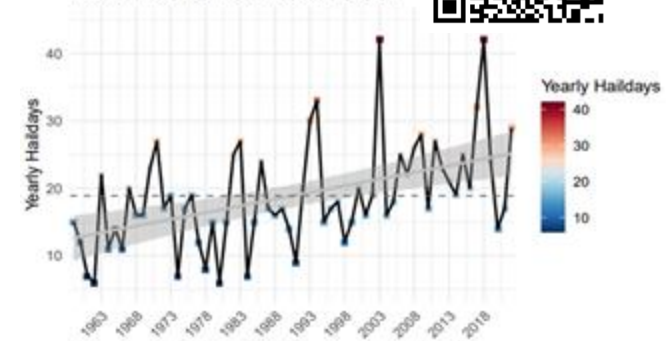


Hail climatology and trends

- **Statistical reconstruction of past hail days.** Significant positive trend in yearly aggregated hail days from 1959 to 2022, driven by moisture and atmospheric instability
- Identification of **drivers of large year-to-year variability** for seasonal predictability
- Influence of **Saharan dust on hail occurrence** in Europe

Wilhelm et al.,
NHESS 24, 3869 (2024)

Yearly Haildays North (1959–2022)



Oral I Friday, 21 Nov, 12:15–12:30 (CET) | Room Hertz Zaal

On Hailstorm Variability in Switzerland: Key Drivers for Seasonal Predictability

Lena Wilhelm¹, Katharina Schroeder², Cornelia Schwierz³, and Olivia Martius¹

Brennan et al.,
ACP 25, 10823 (2025)

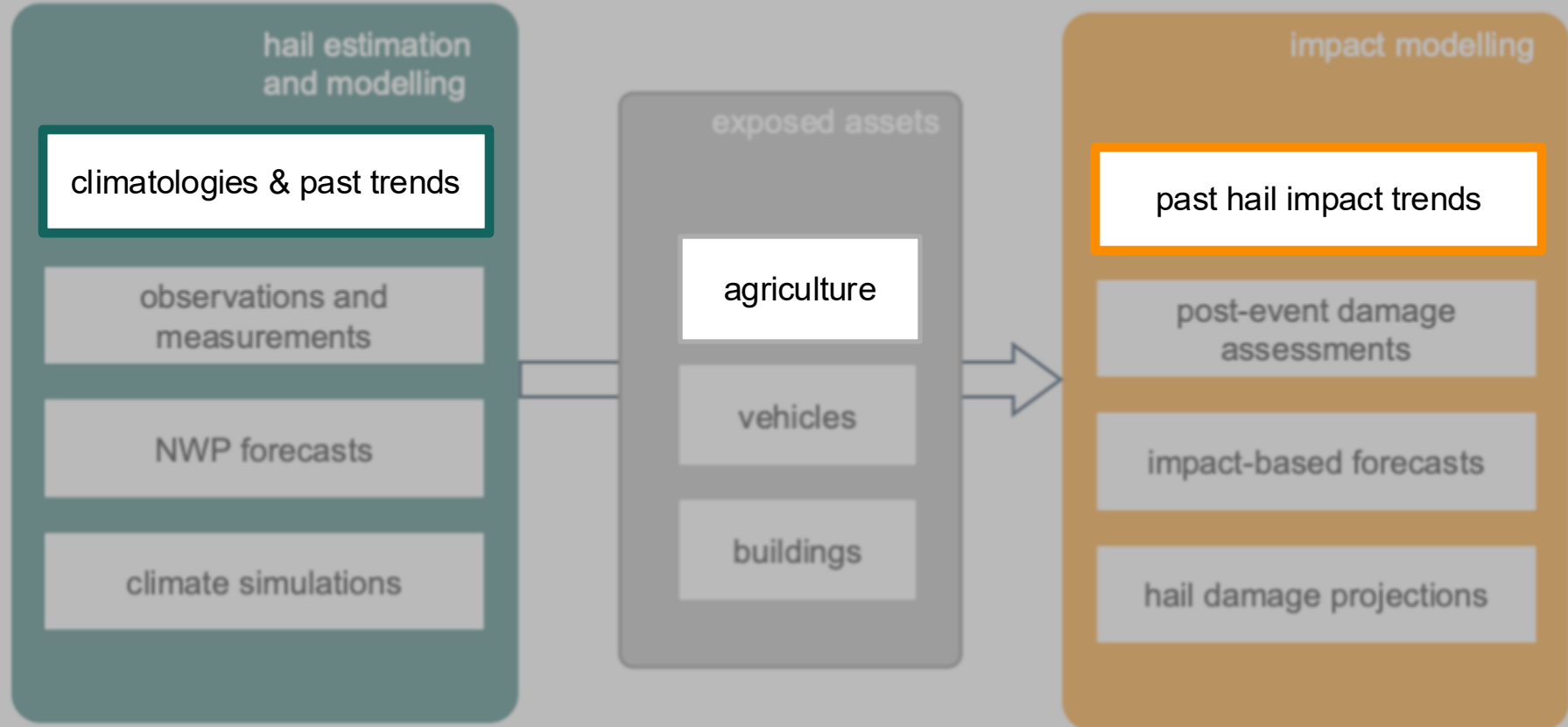


Oral I Wednesday, 19 Nov, 10:15–10:30 (CET) | Room Hertz Zaal

Saharan dust linked to European hail events

Killian P. Brennan¹ and Lena Wilhelm²

scClim modelling chain



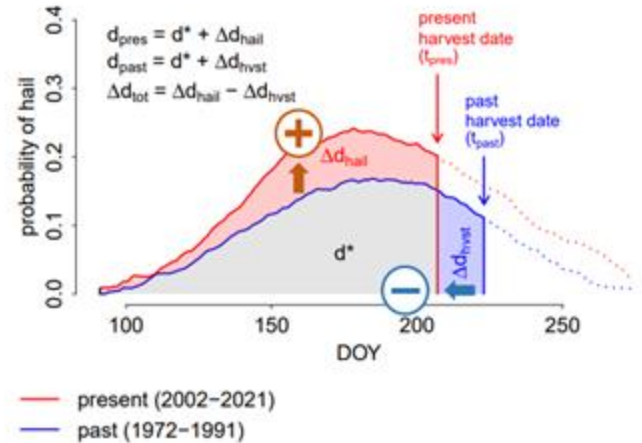
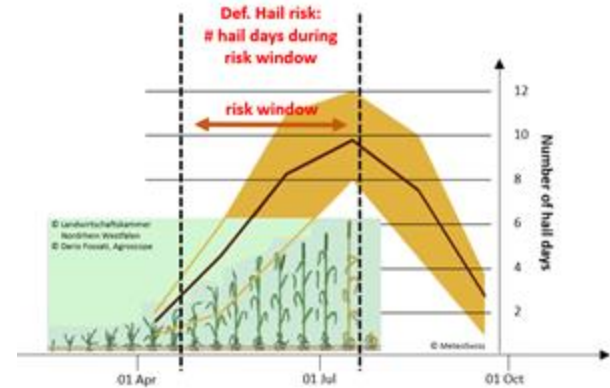
Earlier harvest but more hail

- Climate change has led to **earlier wheat harvest dates**, shortening time period during which wheat is exposed to hail
- Despite earlier harvests, **hail risk to winter wheat has increased** in the past 50 years by more than 30%.

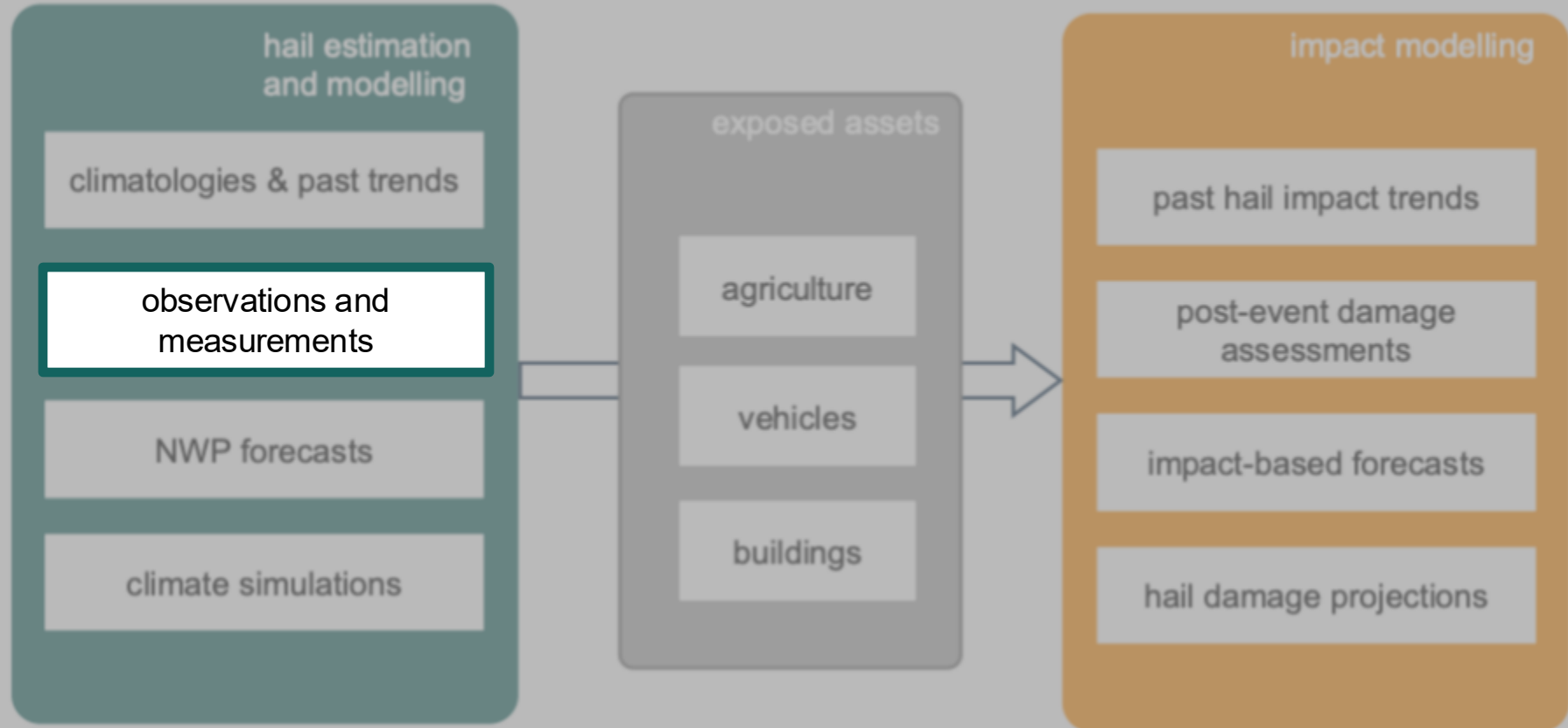
Portmann et al., in press

- Soon: Extension to European scope and climate projections

Cui et al., in preparation



scClim modelling chain

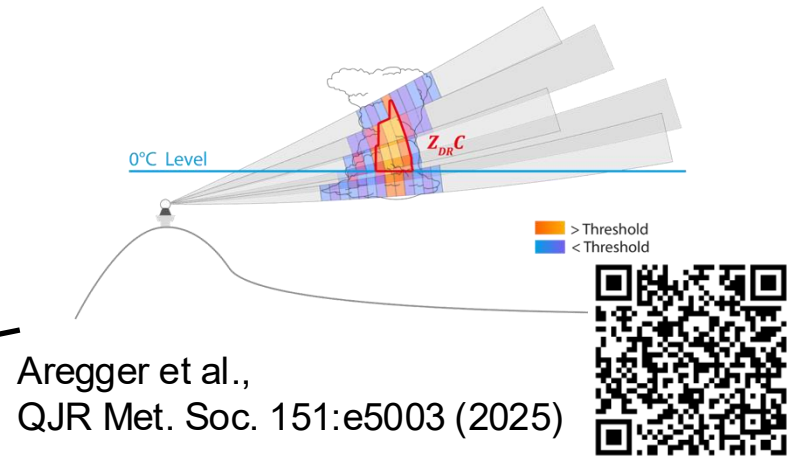


Observing and measuring hail

- Switzerland uses several approaches to address the challenge of measuring hail:

- radar proxies (POH, MESHS, ..)
- crowdsourced reports
- hail sensors
- drone measurements

- ML-based hail size estimation based on radar variables, trained with crowdsourced reports



Oral | Monday, 17 Nov, 10:30–10:45 (CET) | Room Hertz Zaal

Performance assessment of drone-based photogrammetry coupled with machine-learning for the estimation of hail size distributions on the ground

Jannis Portmann¹, Martin Lainer¹, Killian P. Brennan², Marlou Jourdain de Thieulloy¹, Matteo Guidicelli^{1,3}, and Samuel Monhart¹

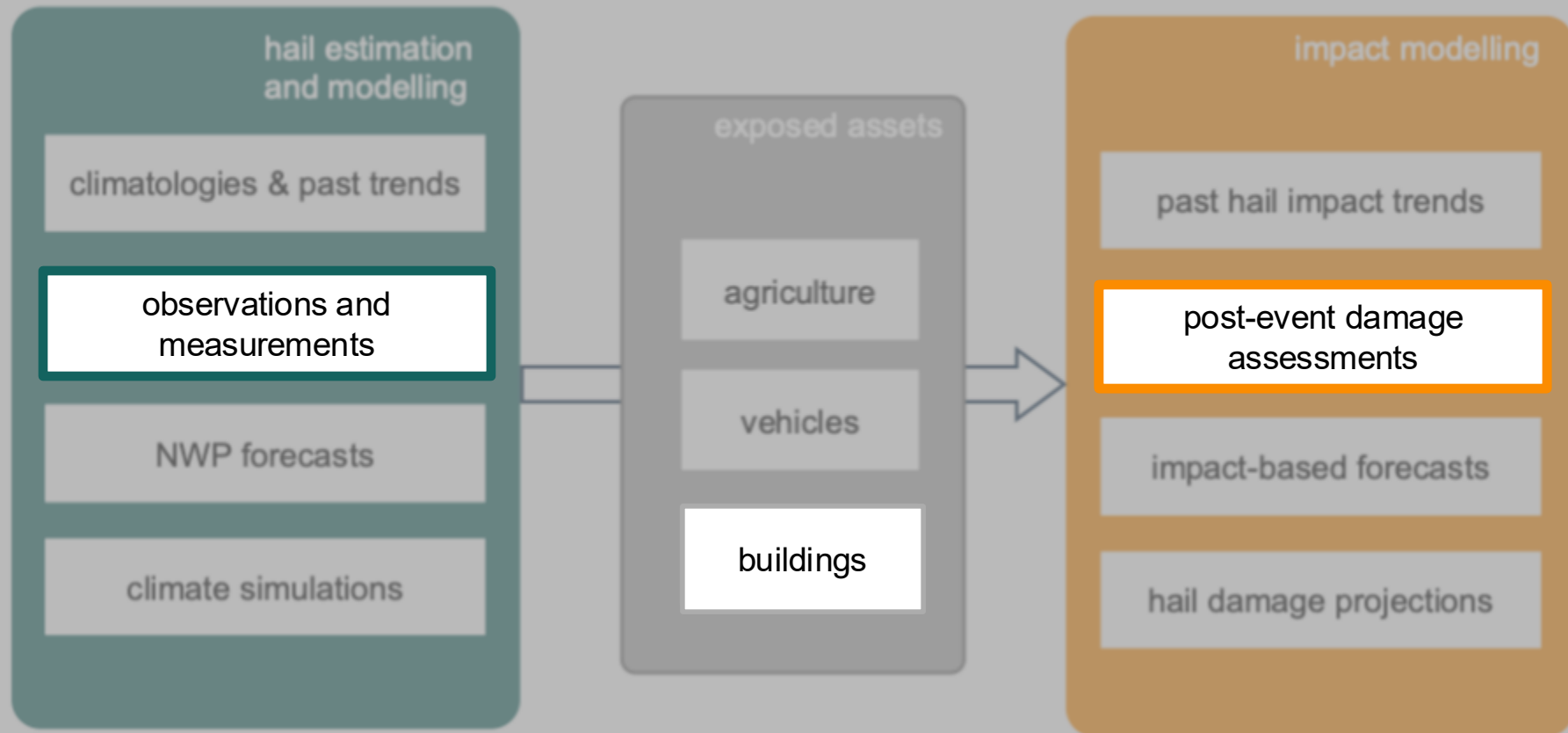
Portmann et al.,
Front. Environ. Sci.
13:1602917 (2025)

Oral | Thursday, 20 Nov, 17:00–17:15 (CET) | Room Hertz Zaal

Object-based hail-size detection and nowcasting in Switzerland using random forests on polarimetric radar data

Martin Aregger^{1,2}, Olivia Martius^{1,2}, Urs Germann³, and Alessandro Hering³

scClim modelling chain



Post-event hail damage assessments

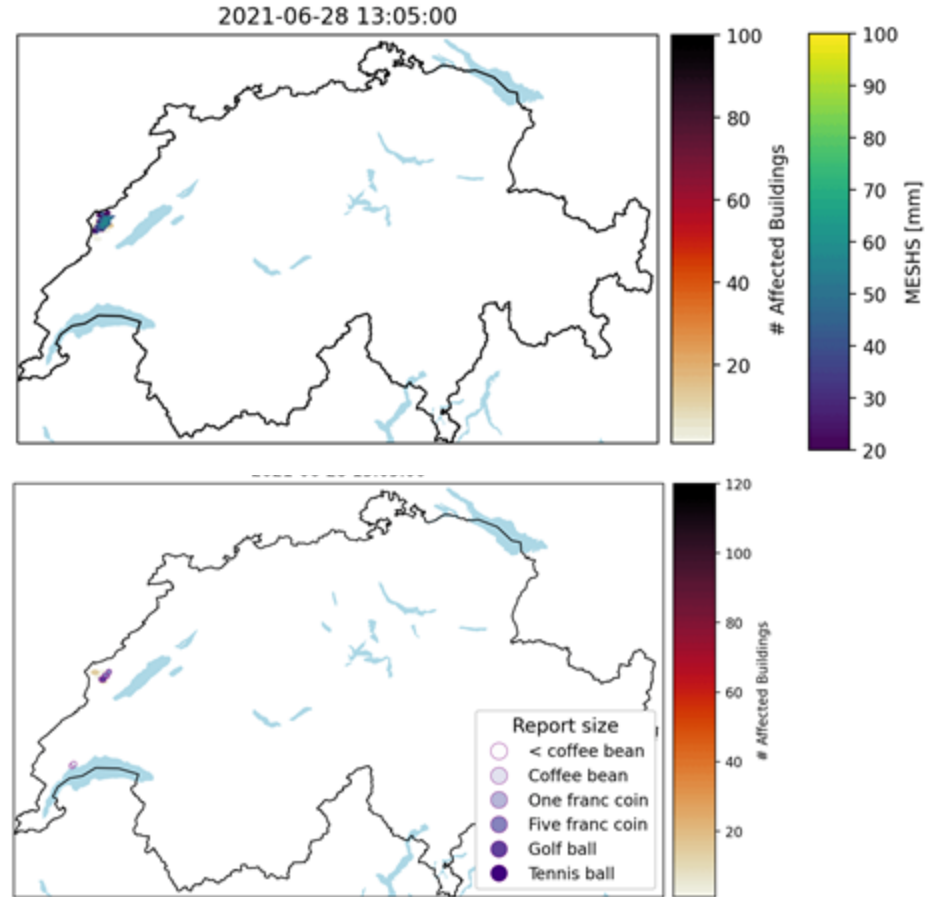
- Radar-based estimation for building and car damages, (using hail proxy MESHS)

Schmid et al.,
NHESS 24, 847 (2024)



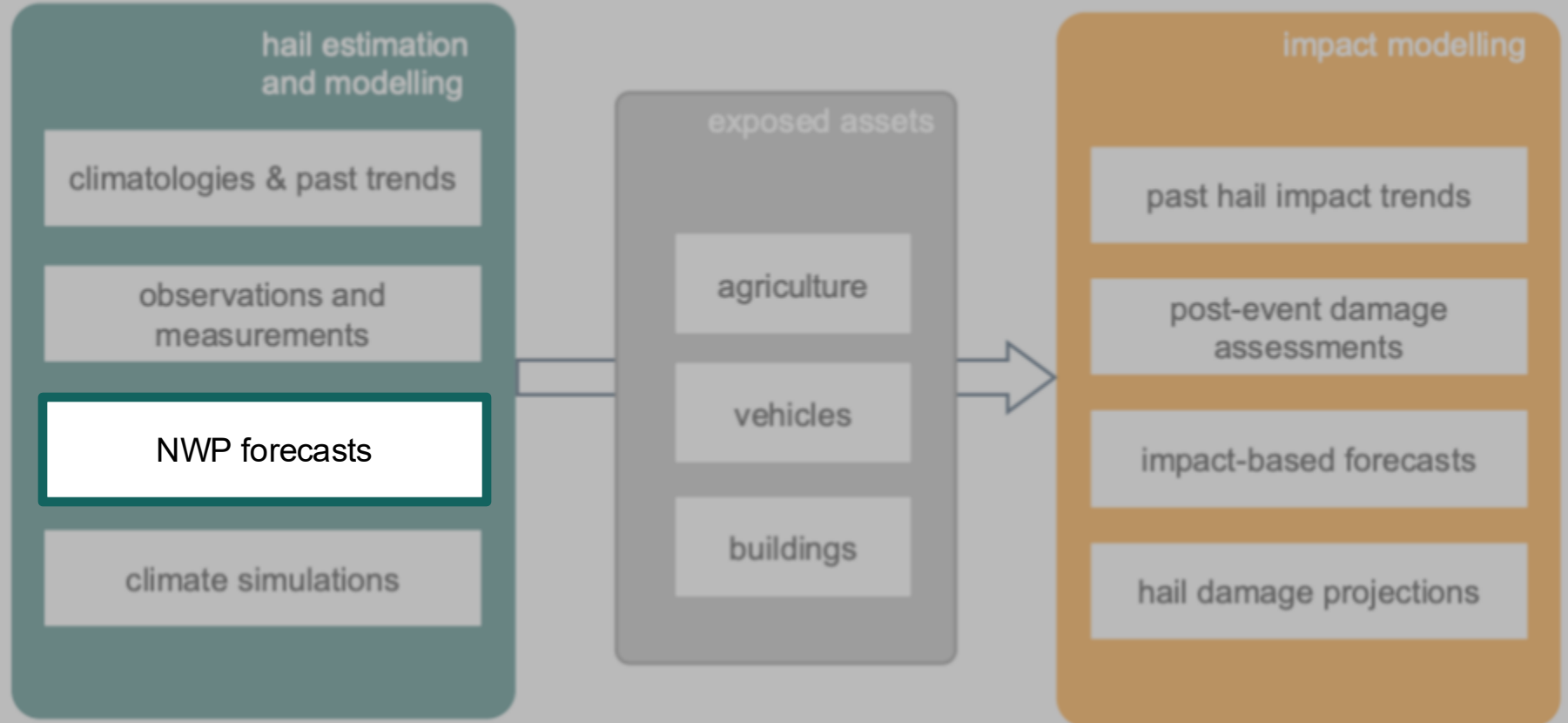
- Significant improvements for crowdsource-based estimation of building damages based

Schmid et al.,
Meteorol. Appl. 32, e70059 (2025)



Animations created by Timo Schmid: tschmid@ethz.ch

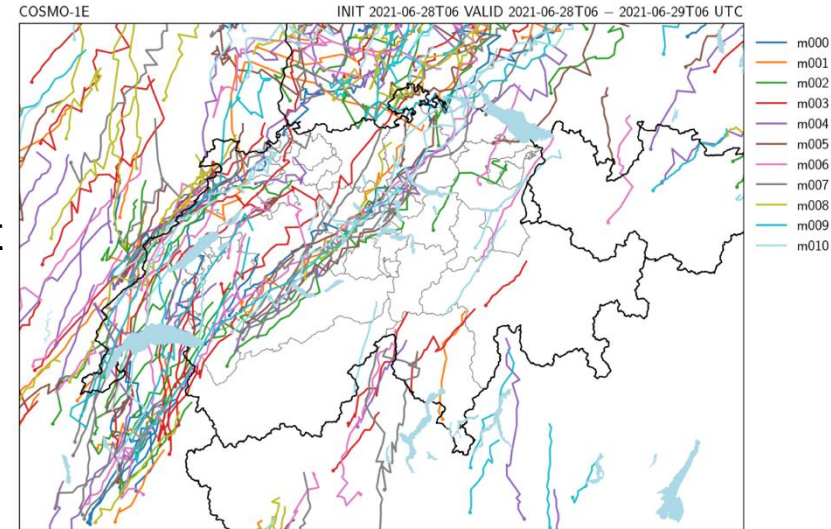
scClim modelling chain



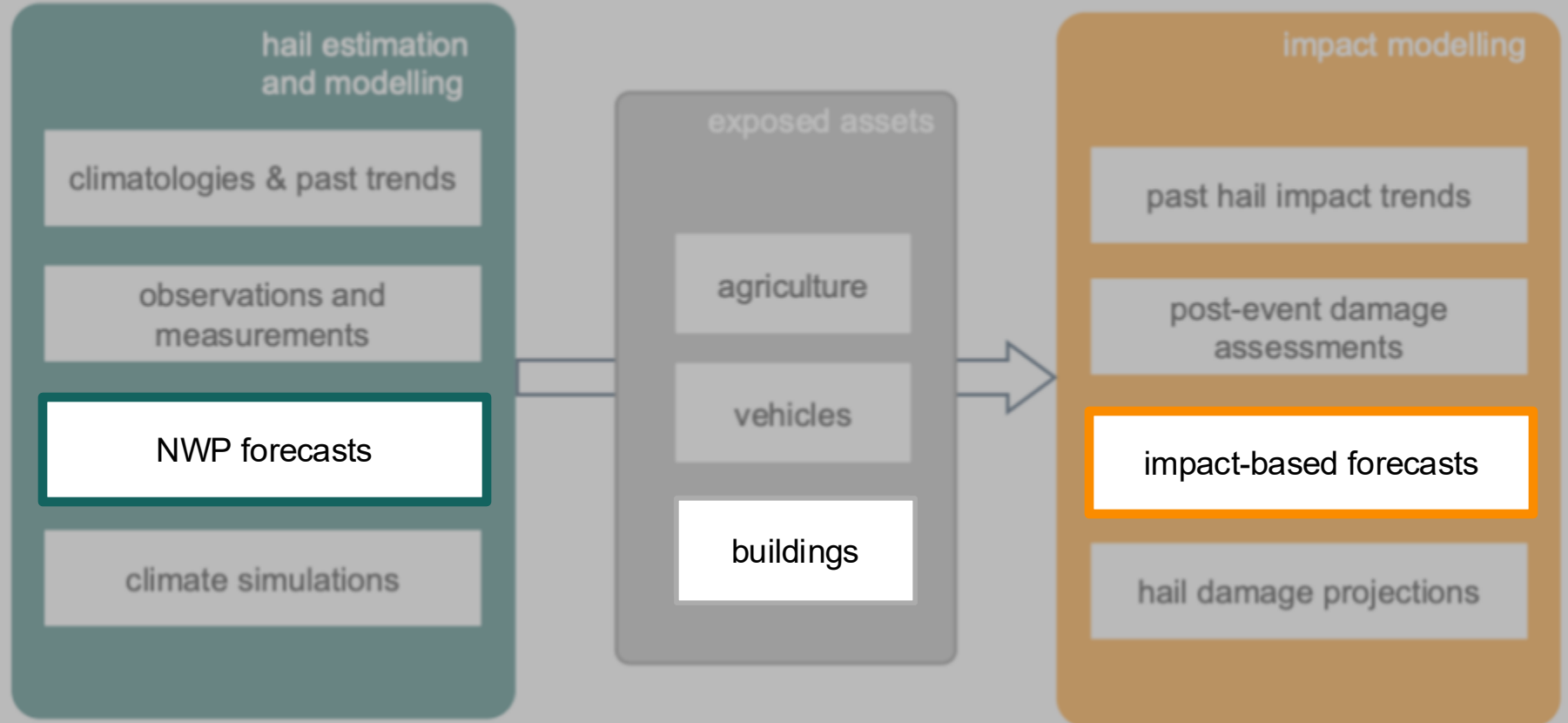
Numerical weather prediction

- Based on NWP, MeteoSwiss forecasts hail using the the add-on 1D hail-growth diagnostic HAILCAST
Adams-Selin et al., Mon. Wea. Rev. 144, 4919 (2016)
- Hail cell tracking algorithm based on NWP, and object-based analysis of large hail event in 2021

Brennan et al.
Weather Clim. Dynam. 6, 645 (2025)



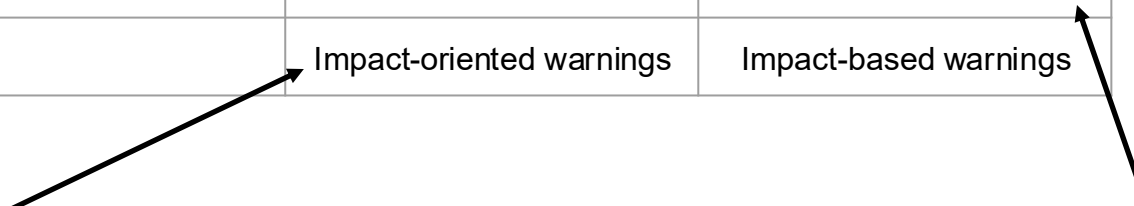
scClim modelling chain



Impact-based hail forecasts and warnings

Impact-based forecasts must be tailored to the addressed user group

	Hazard focus		Impact focus
			
Forecasts	NWP	Impact-oriented forecasts	Impact-based forecasts
Warnings		Impact-oriented warnings	Impact-based warnings



General population

- Local hazard-based warnings
- No exposure included, but vulnerability informs warning thresholds

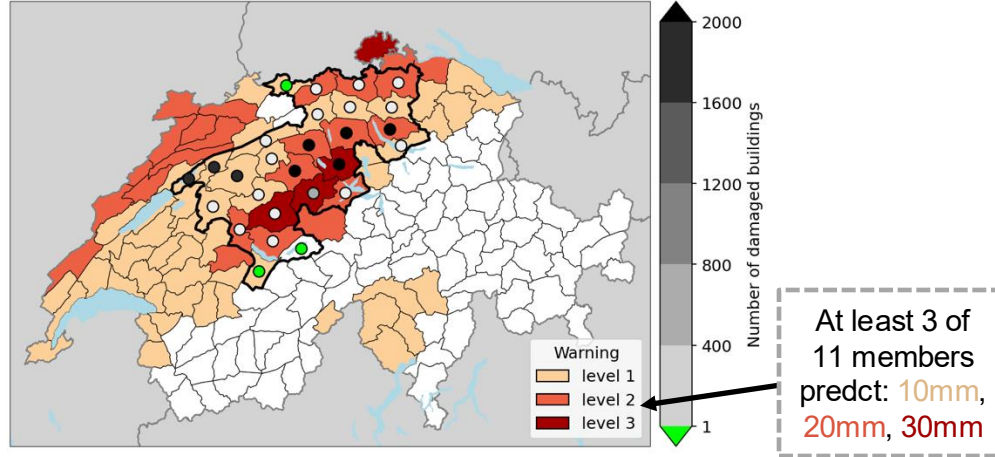
Cantonal or federal institutions, larger private institutions

- Full impact modelling aggregated to larger local scale
- Institutions can implement a warning chain customized to their needs

Impact-oriented warnings

Impact-oriented warnings

Regional impact-oriented hail warning for 2021-06-28

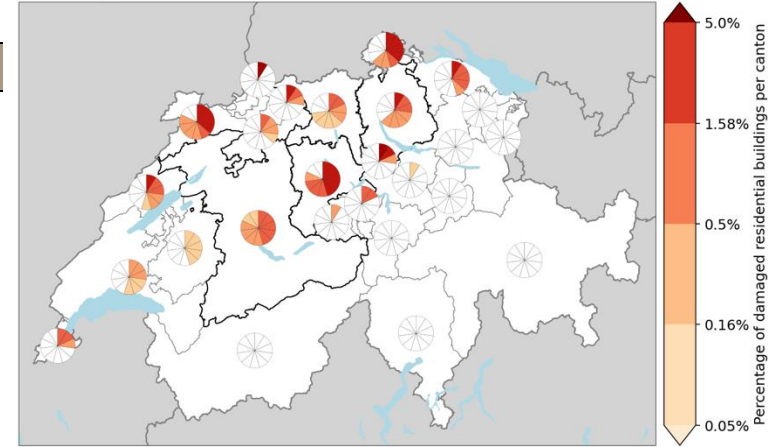


- Due to available damage data, we can evaluate forecasts and optimize thresholds
- Predictive skill too low for operational use, but cost-benefit analysis indicates potential usefulness for cheap preventive actions

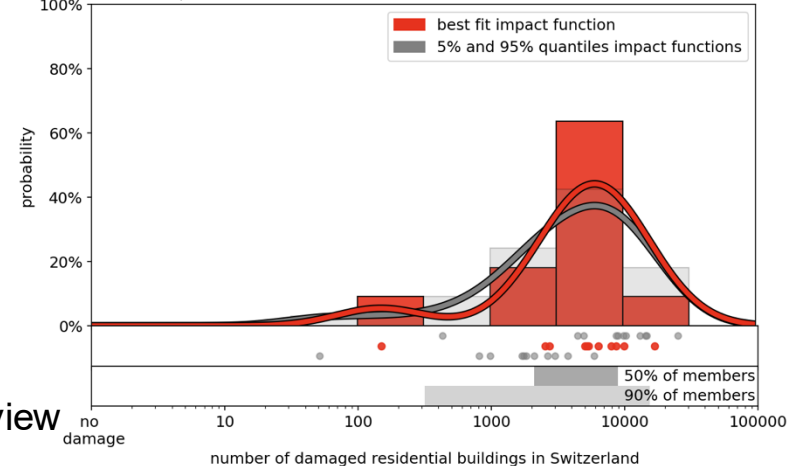
Gebhart et al., under review

Impact-based forecasts

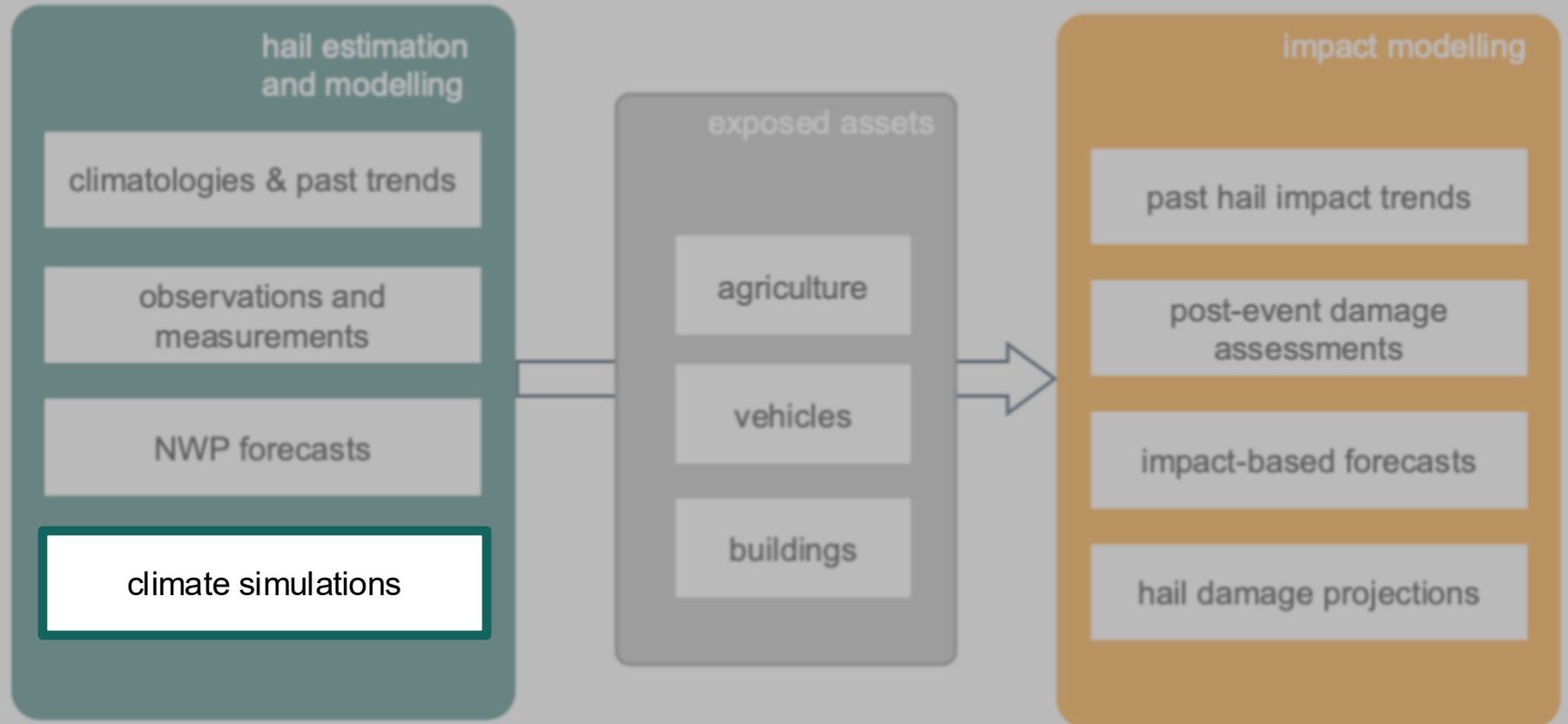
Cantonal impact-based hail forecast for 2021-06-28



National impact-based hail forecast for 2021-06-28



scClim modelling chain



European Pseudo-Global-Warming simulations

- Convection-permitting European PGW simulations at 2km resolution (11 years in current climate; 11 years in $+3^{\circ}\text{C}$ climate) with 1D hail-growth diagnostic HAILCAST



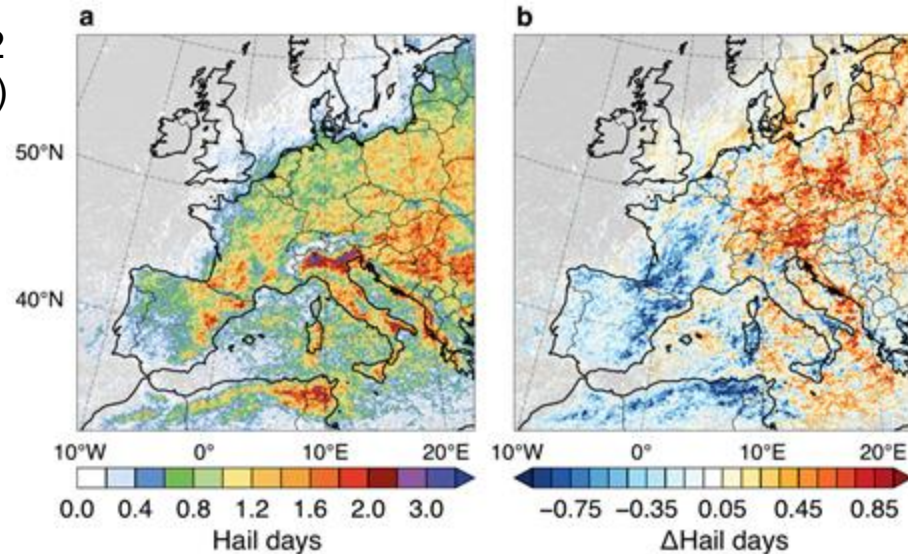
Cui et al., JGR Atmos. 130, e2024JD042828 (2024)



Thurnherr et al. GRL 52 e2025GL114811 (2025)



- Hail days increase over land in northeastern and decrease over south-western Europe



European Pseudo-Global-Warming simulations

- Larger hail storm areas (15-30%) and double frequency of large hail (>50mm). Increase of compound hazards like precipitation (20%) and wind (5%)
→ Dataset with ~80'000 hail swaths available ongoing project for stochastic resampling
- Average increase of supercell thunderstorm occurrence by 11%
- Synoptic hail conditions and compound heat waves

Agayar et al., in preparation

Brennan et al.,
NHESS 25, 3693 (2025)



Feldmann et al.,
Sci. Adv. 11,
eadx0513 (2025)



Oral | Monday, 17 Nov, 15:30–15:45 (CET) Room Hertz Zaal

Supercell thunderstorms in Europe – insights from km-scale climate simulations

Monika Feldmann¹, Michael Blanc², Sandro Beer¹, Lena Wilhelm¹, Kilian Brennan², Iris Thurnherr², Patricio Velasquez², Olivia Martius¹, and Christoph Schär²

Poster | Thursday, 20 Nov, 14:30–16:00 (CET), Display time Wednesday, 19 Nov, 09:00–Thursday, 20 Nov, 18:30! Poster area, P4

Exploring uncertainty in future hail trends: A comparison of proxy-based and diagnostic approaches using convection-permitting climate simulations over Europe

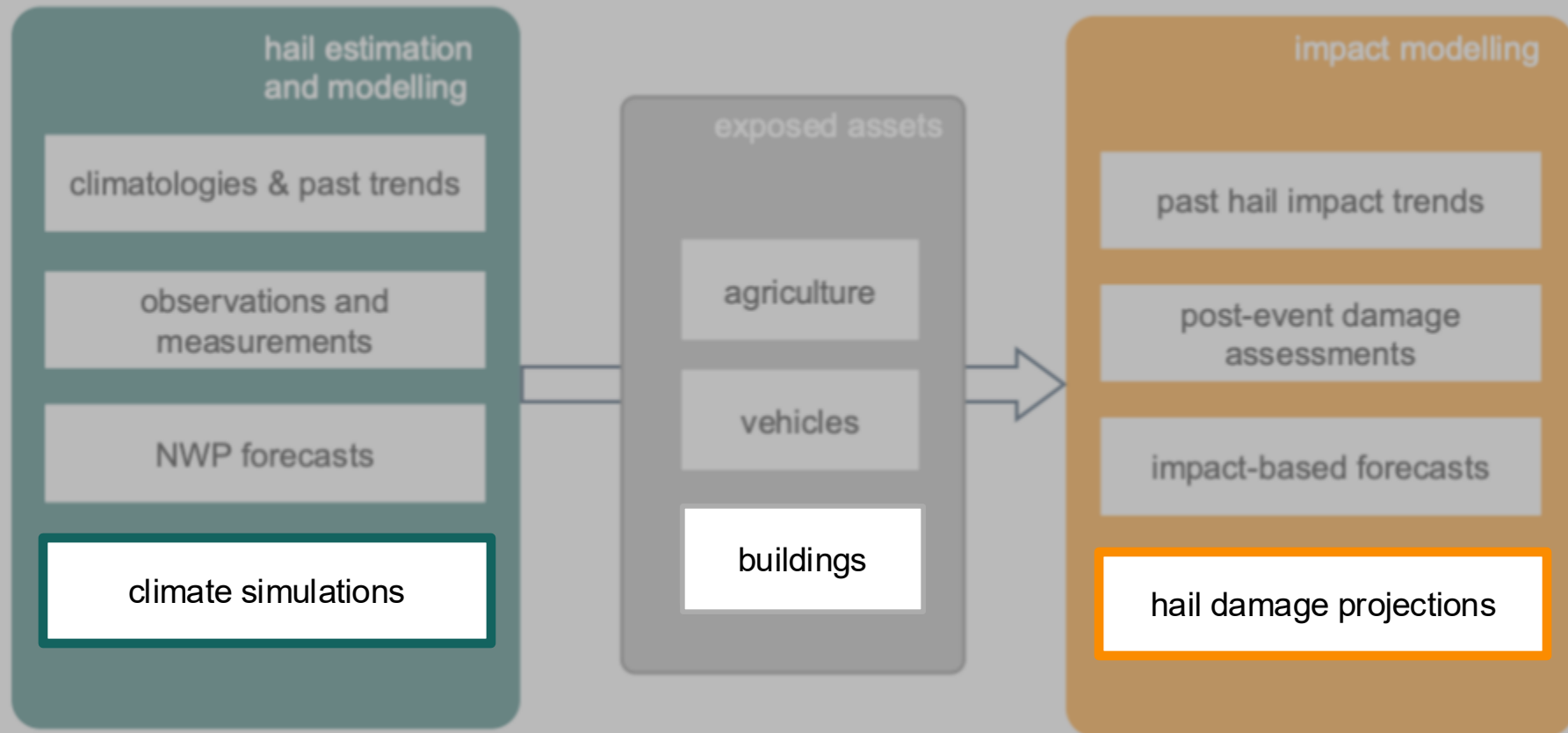
Iris Thurnherr¹, Lena Wilhelm², Tim Raupach², Francesco Battaglioli⁴, Monika Feldmann², Kilian Brennan¹, Ruoyi Cui², Heini Wernli¹, and Olivia Romppainen-Martius²

Poster | Thursday, 20 Nov, 14:30–16:00 (CET), Display time Wednesday, 19 Nov, 09:00–Thursday, 20 Nov, 18:30! Poster area, P5

Will today's proxies work tomorrow? Revisiting the stationarity assumption for severe convective environments

Iris Thurnherr¹, Monika Feldmann², Kilian Brennan¹, Sandro Beer², Lena Wilhelm², Ruoyi Cui³, Michael Sprenger¹, Heini Wernli¹, and Olivia Romppainen-Martius²

scClim modelling chain



Hail Damage Projections

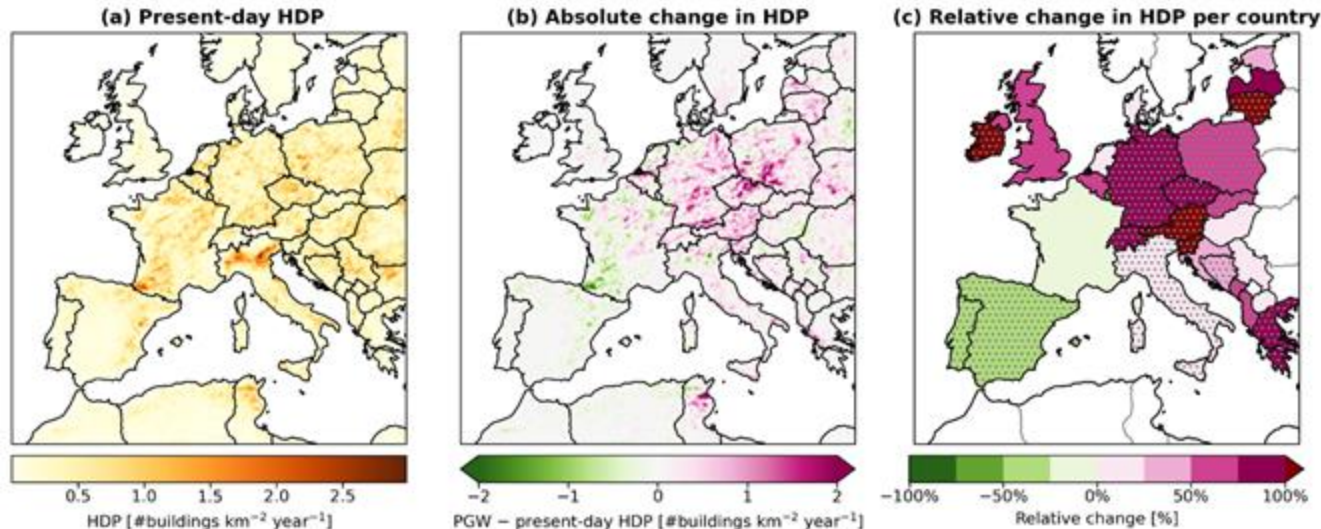
After calibration of an impact functions, frequency changes of large hail can be translated to in corresponding changes in hail damage risk

Schmid et al., under review

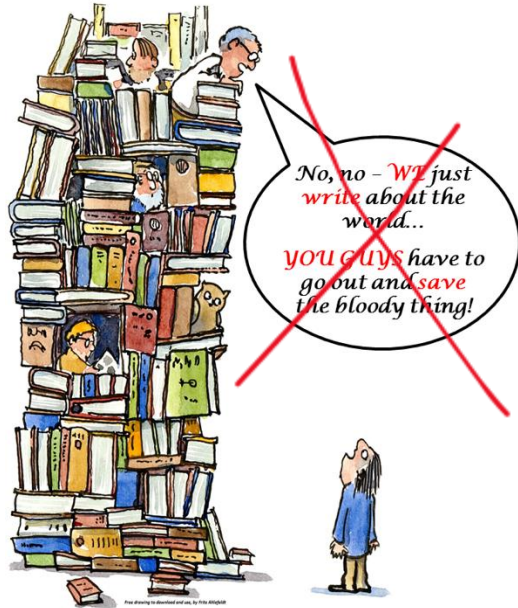
Oral | Monday, 17 Nov, 14:30–14:45 (CET) | Room Hertz Zaal

Modelling hail risk in Europe based on convection-resolving climate simulations: Methods and expected changes in a warming climate

Timo Schmid^{1,2}, Valentin Gebhart^{1,2}, and David N. Bresch^{1,2}



Stakeholder engagement



Academics-ivory-tower (adapted) by
Frits Ahlefeldt

- Frame research around real stakeholder needs
- Increase chances that project outputs and knowledge are used and sustained beyond the project



Workshop the agricultural advisory centre AGRIDEA
January 2023



scClim annual stakeholder workshop
September 2024

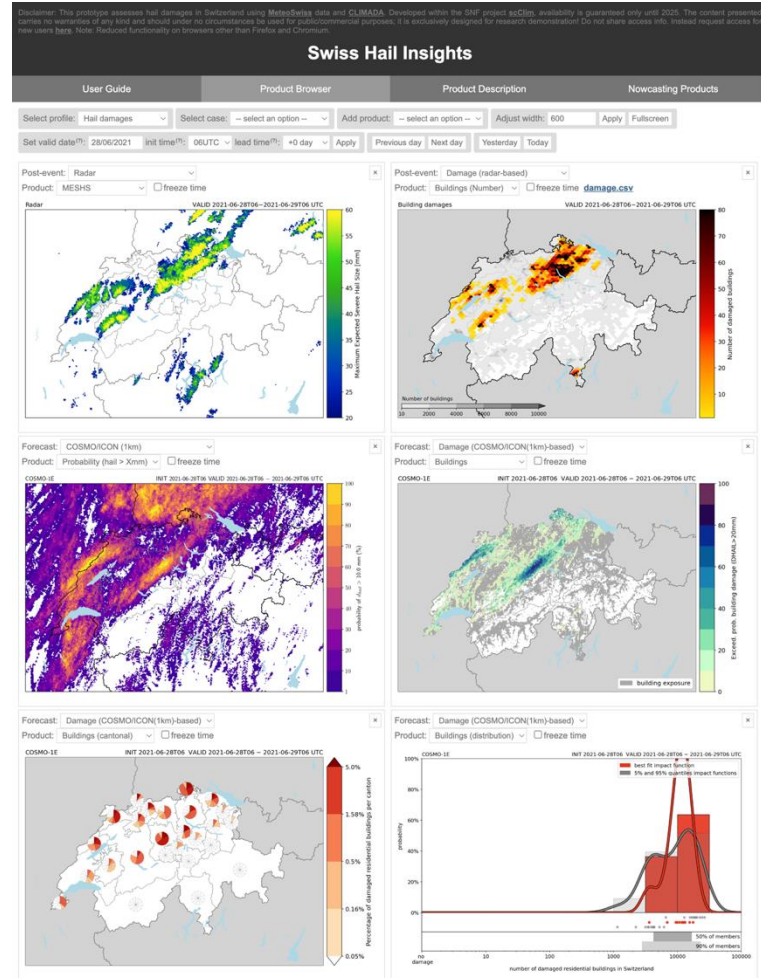
Stakeholder engagement

Knowledge transfer and fast prototyping:

Swiss hail risk demonstrator website with daily updates

Demonstrator website

user: Nov pw: 17



Thanks to the scClim Team

Demonstrator website
user: Nov pw: 17



Conclusions

- Development of a model chain combining NWP and hail measurement techniques with impact models for different sectors and across multiple time scales
- Production of several open-source datasets, climate simulations, and impact functions
- Prototype for inter- and transdisciplinary user-oriented climate-risk research
→ fast prototyping as useful tool

BAMS article under review

Demonstrator website
user: Nov pw: 17



Poster | Thursday, 20 Nov, 14:30–16:00 (CET), Display time Wednesday, 19 Nov, 09:00–Thursday, 20 Nov, 18:30 | Poster area, P19

Hail risk to photovoltaic systems in Switzerland

Lena Wilhelm¹, Valentin Gebhart², Olivia Martius¹, and Aessia Boukhatmi³

Coming up: Climate Risk Workshop 2026

Benasque Science Center, Spain
Sep 20 - Oct 03, 2026

Interdisciplinary and unconference-style workshop about all things related to climate change, including

- climate risk assessment
- impacts on society, ecosystems, and economy
- adaptation strategies
- policy development
- evaluation of mitigation efforts
- limits and tipping points
- communication

More info and registration:



benasque.org/2026climate/

Organizers: Chahan M. Kropf & Valentin Gebhart, ETH Zürich

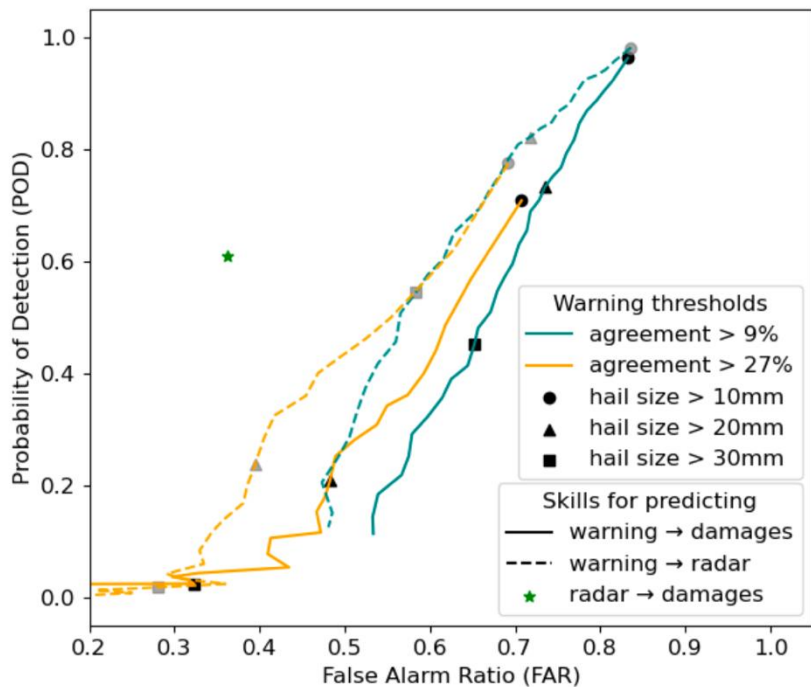


**Unconference-style
workshop**

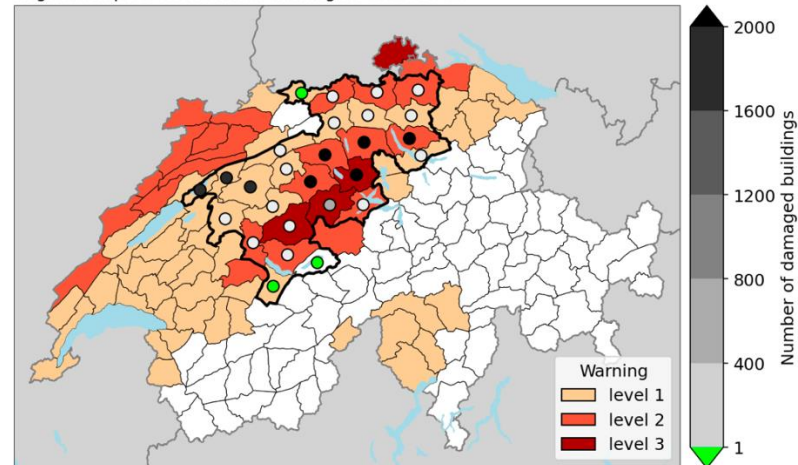
—
no schedule, open spaces,
creative dialogues,
diverse perspectives,
inspiring location

Additional slides

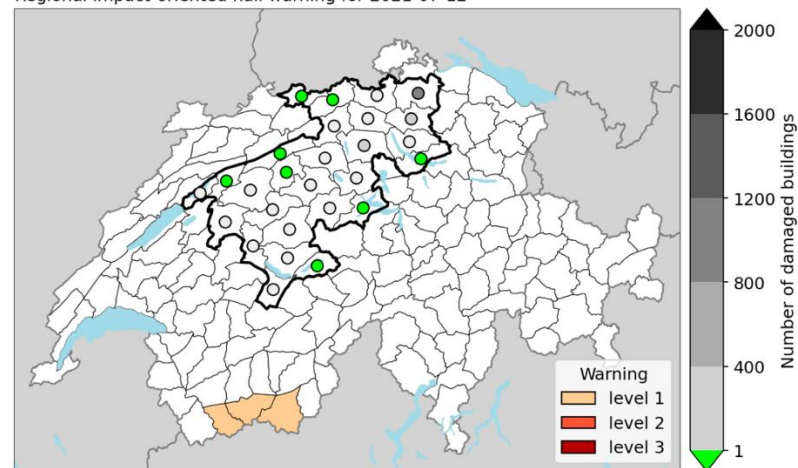
Impact-oriented warnings



Regional impact-oriented hail warning for 2021-06-28



Regional impact-oriented hail warning for 2021-07-12

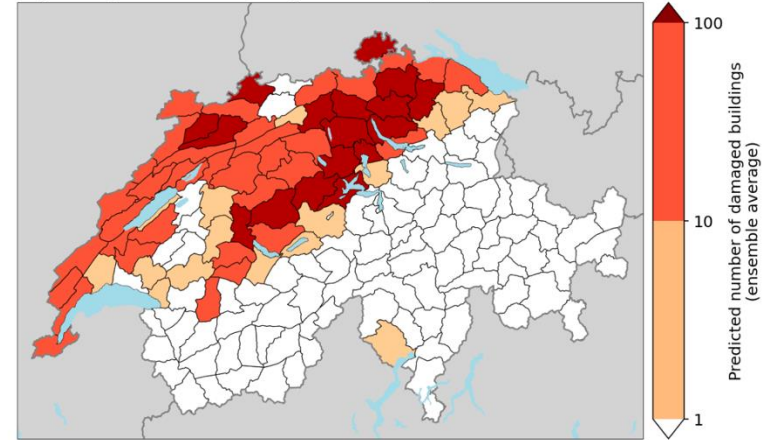


Impact-based forecasts

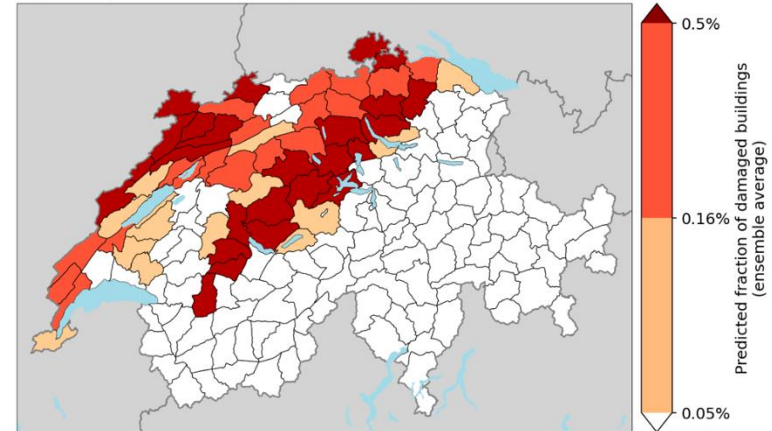
Skill metric	Cantonal forecast	National forecast
Reported damage within ensemble range	95%	90%
Reported damage within (25 – 75%)-quantile range	90%	81%
Nonzero reported damage within ensemble range	58%	64%
Nonzero reported damage within (25 – 75%)-quantile range	27%	27%
Zero reported damage and median forecast ≥ 1 building	1.3%	1.0%
Zero reported damage and 95%th-quantile forecast ≥ 1 building	8%	10%

Impact-based warnings

Regional impact-based hail warning for absolute impacts for 2021-06-28



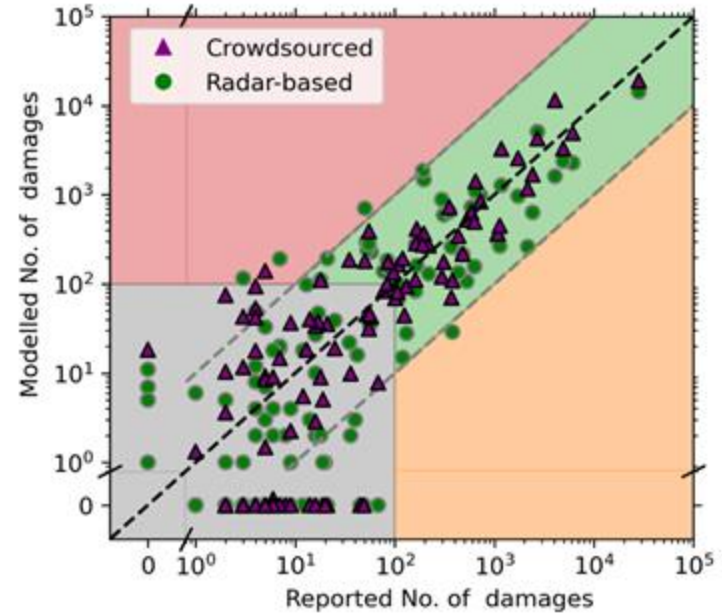
Regional impact-based hail warning for relative impacts for 2021-06-28



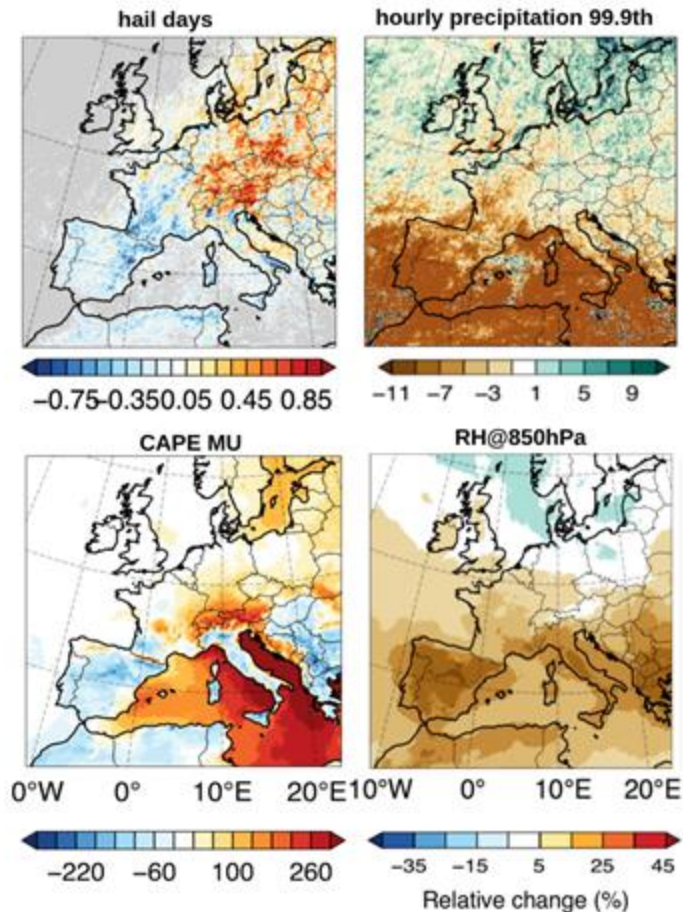
Post-event hail damage assessments

- Both models retain large uncertainties, particularly when considering local estimates
- The crowdsource-based model shows higher performance

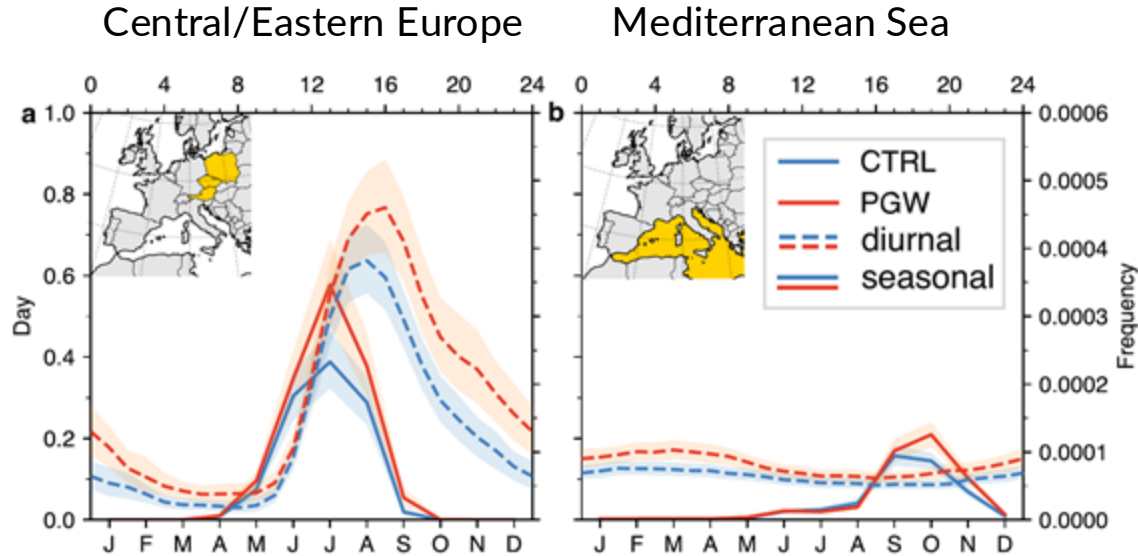
Schmid et al., *Meteorol. Appl.* 32, e70059 (2025),
<https://doi.org/10.1002/met.70059>



European Pseudo-Global-Warming simulations

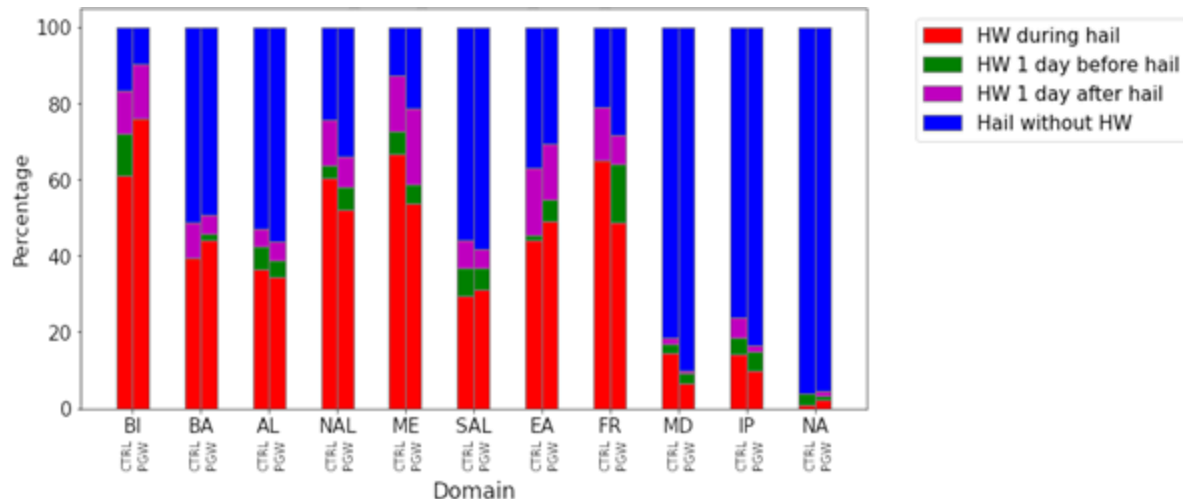


European Pseudo-Global-Warming simulations

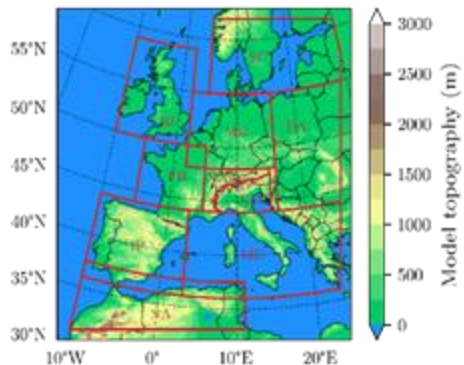


- Central/Eastern Europe: Strongest increase in late evening during summer
- Med. Sea: strongest increase in autumn, all day
- Providing seasonal and diurnal cycles for 26 European countries

Time of occurrence of the heat waves and large hail



- Heatwaves occur during hail events in most regions, with the exception of southern areas.
- One day before hail events, heatwaves are frequently detected in Britain, Germany, and the Alpine region.
- One day after hail events, heatwaves are most commonly observed in Germany and Eastern Europe.
- In the Mediterranean basin and other southern regions, hail mostly occur without heatwaves.



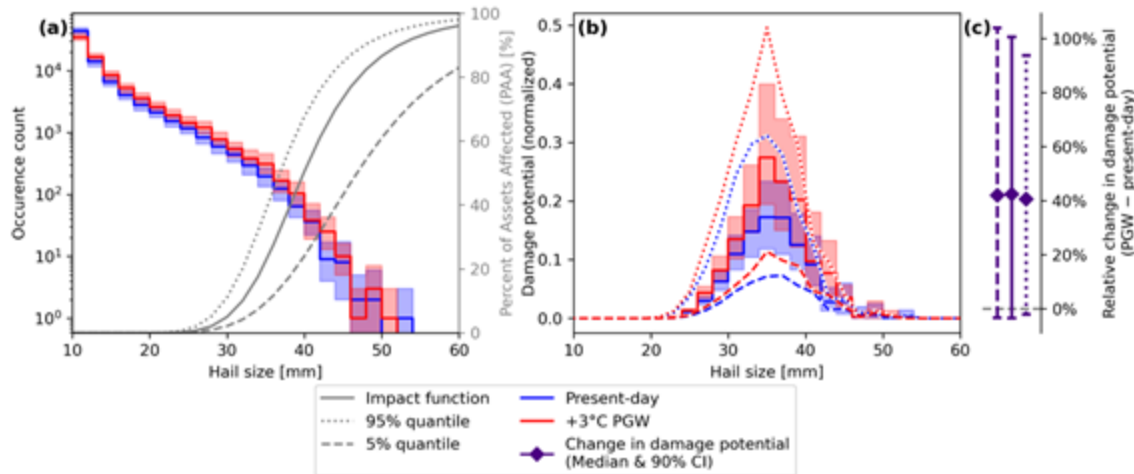
preliminary results

Ellina Agayar
ellina.agayar@env.ethz.ch

Hail Damage Projections

Note on impact modelling with climate simulations:

- Independent of a bootstrap sampling, **>90% of hail damages** (both absolute & exposure normalized) in Switzerland occur in few events with a small spatial extent, corresponding to the area covered by HAILCAST hail sizes **larger than ~30 mm**
- Thus, the climate change signal locally has a large uncertainty, even when ignoring the additional “random” effect of the co-location of hail swaths with cities.



Hail Damage Projections

