CL5.3.3

Exploring the potential of HAILCAST and LPI in km-resolution simulations over the Alpine-Adriatic region

Ruoyi Cui[1], Nikolina Ban[2], Marie-Estelle Demory[1], Christoph Schär[1]
ruoyi.cui@env.ethz.ch

[1] ETH Zurich, Institute of Atmospheric and Climate Science
[2] University of Innsbruck, Department of Atmospheric and Cryospheric Sciences

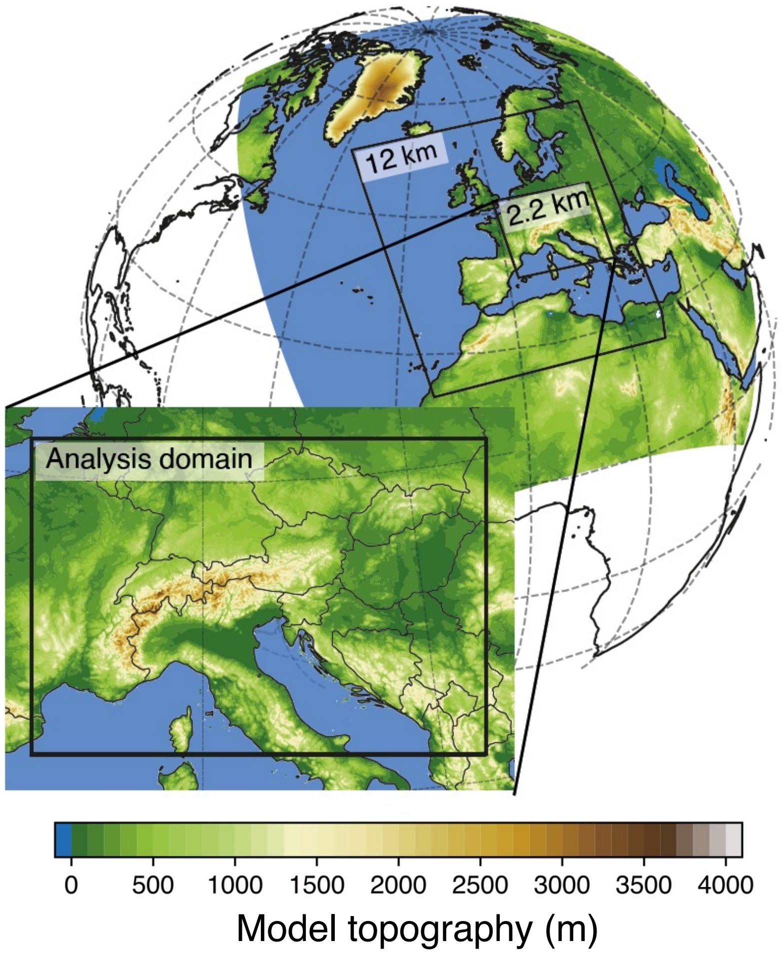
This presentation participates in OSPP
Outstanding Student & PhD candidate Presentation contest

Objectives

1. How well are severe convective events simulated by convection resolving models? -> **case studies**
2. How will severe convective events change under the future climate? -> **climate studies**

Approach

- **COSMO-crCLIM** on GPUs (Baldauf et al, 2011; Schär et al., 2020)
- Lateral boundary conditions: ERA5 reanalysis (Δx = 31 km)
- Two-step one-way nested domain:
  Δx = **12 km** (dt = 90 s): shallow convection (361× 361 x 60)
  Δx = **2.2 km** (dt = 20 s): explicit deep convection (800 × 600 x 60)
- **HAILCAST** (Adams-Selin, 2019) per 5 min
- **Lightning potential index (LPI)** (Lynn et al, 2010; Brisson et al, 2021) per 15 min
- Single-moment microphysics



Analysis of 8 deep convective events over the Alpine-Adriatic region

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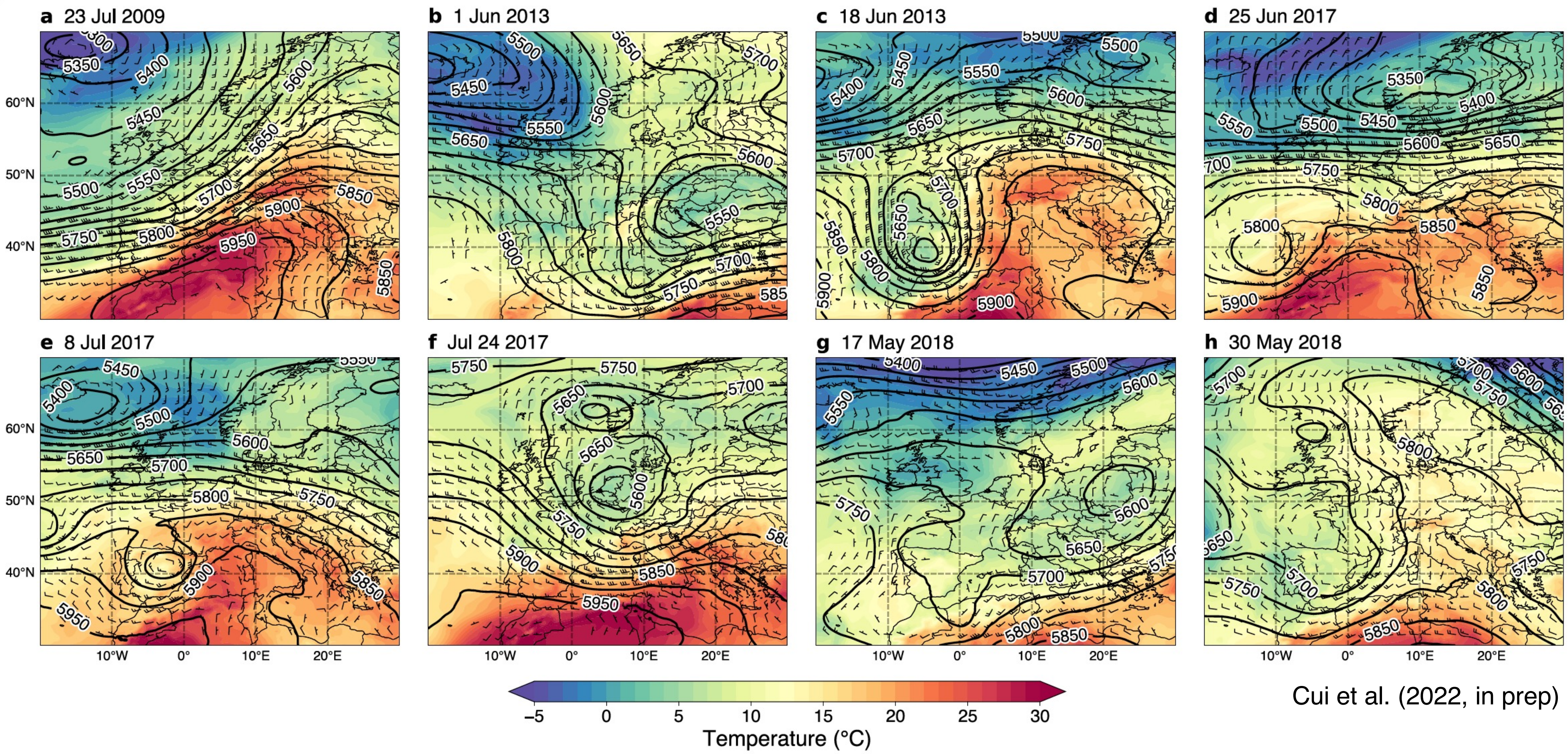

Cui et al. (2022, in prep)

Synoptic situations: ERA5 reanalysis of temperature (℃, shaded) at 850 hPa, wind barbs and geopotential height (m, black contours) at 500 hPa at 1200 UTC for 8 cases.

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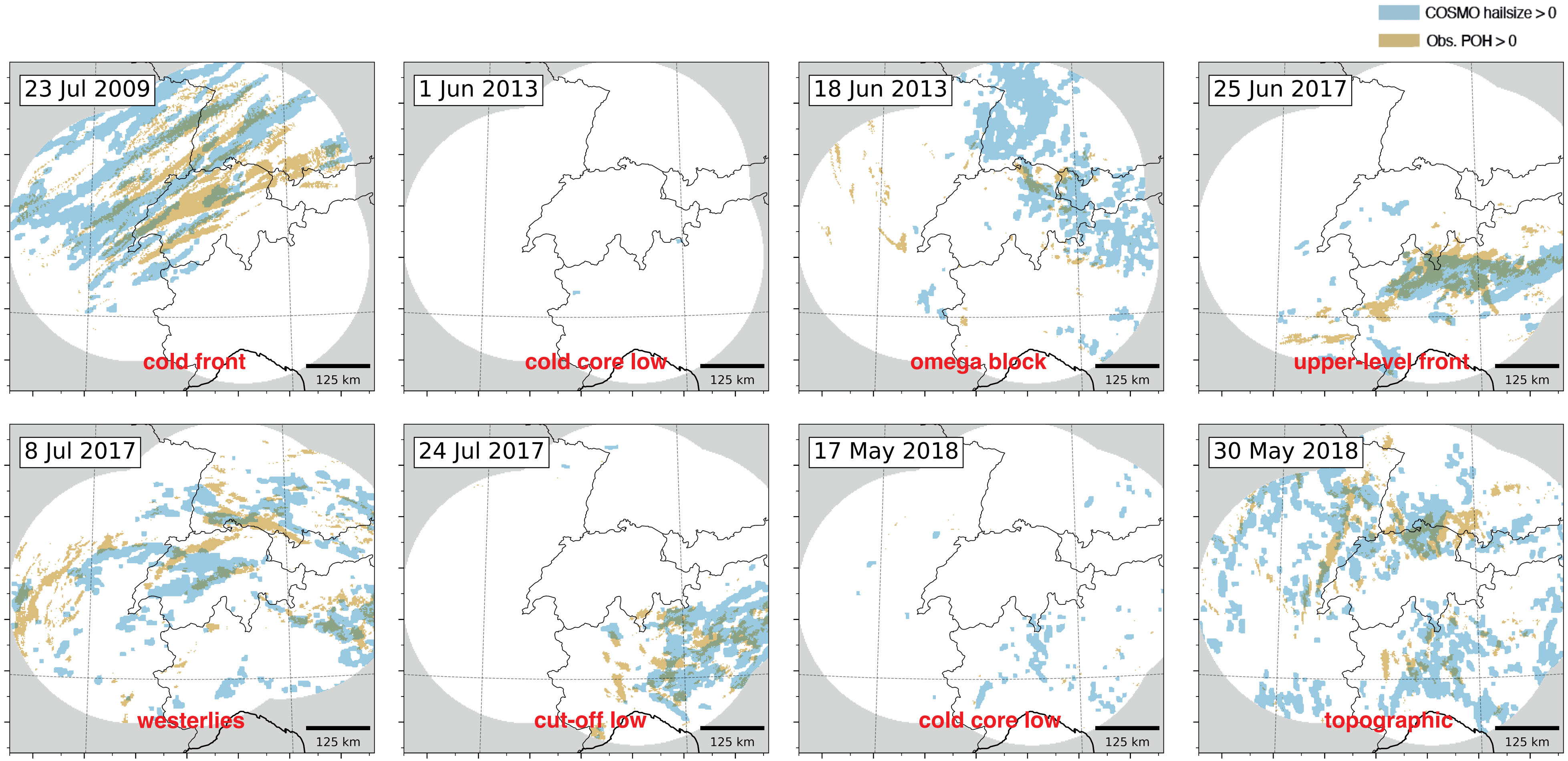

Cui et al. (2022, in prep)

Hail foot prints: daily radar-based Probability of Hail (POH) (> 0 %) and COSMO hail (> 0 mm) for 8 cases.

Climate simulations of hail and lightning

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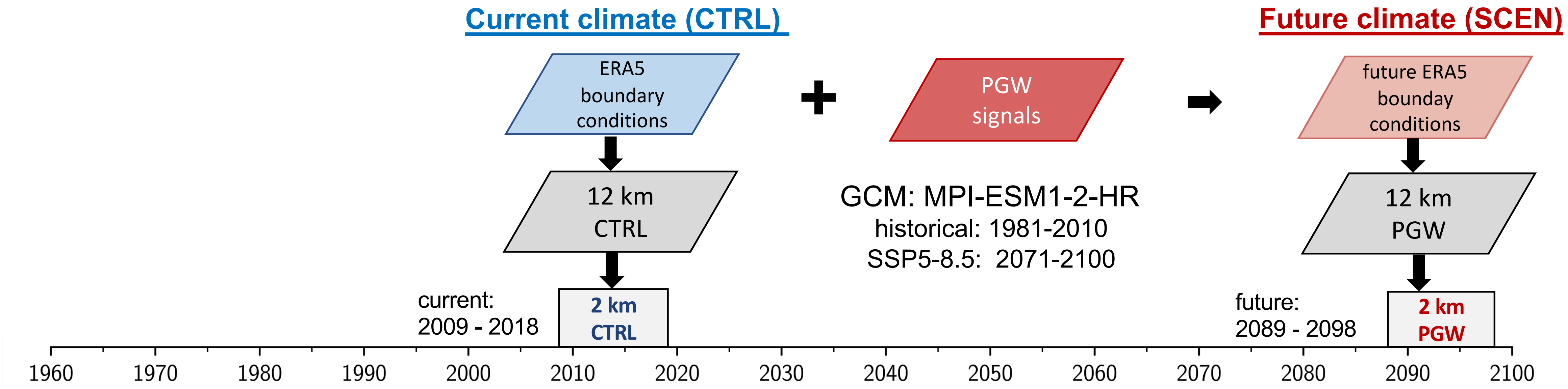
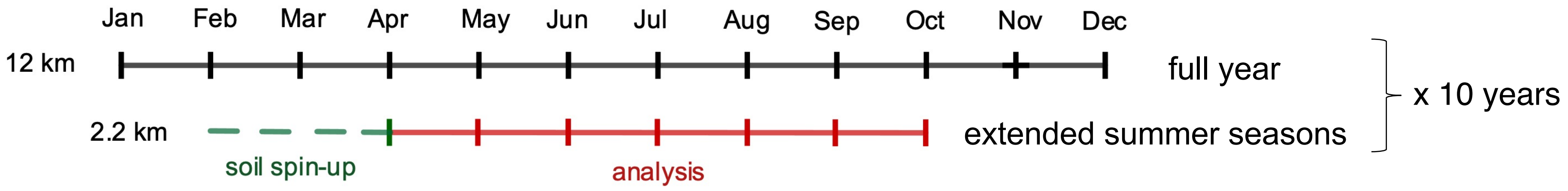
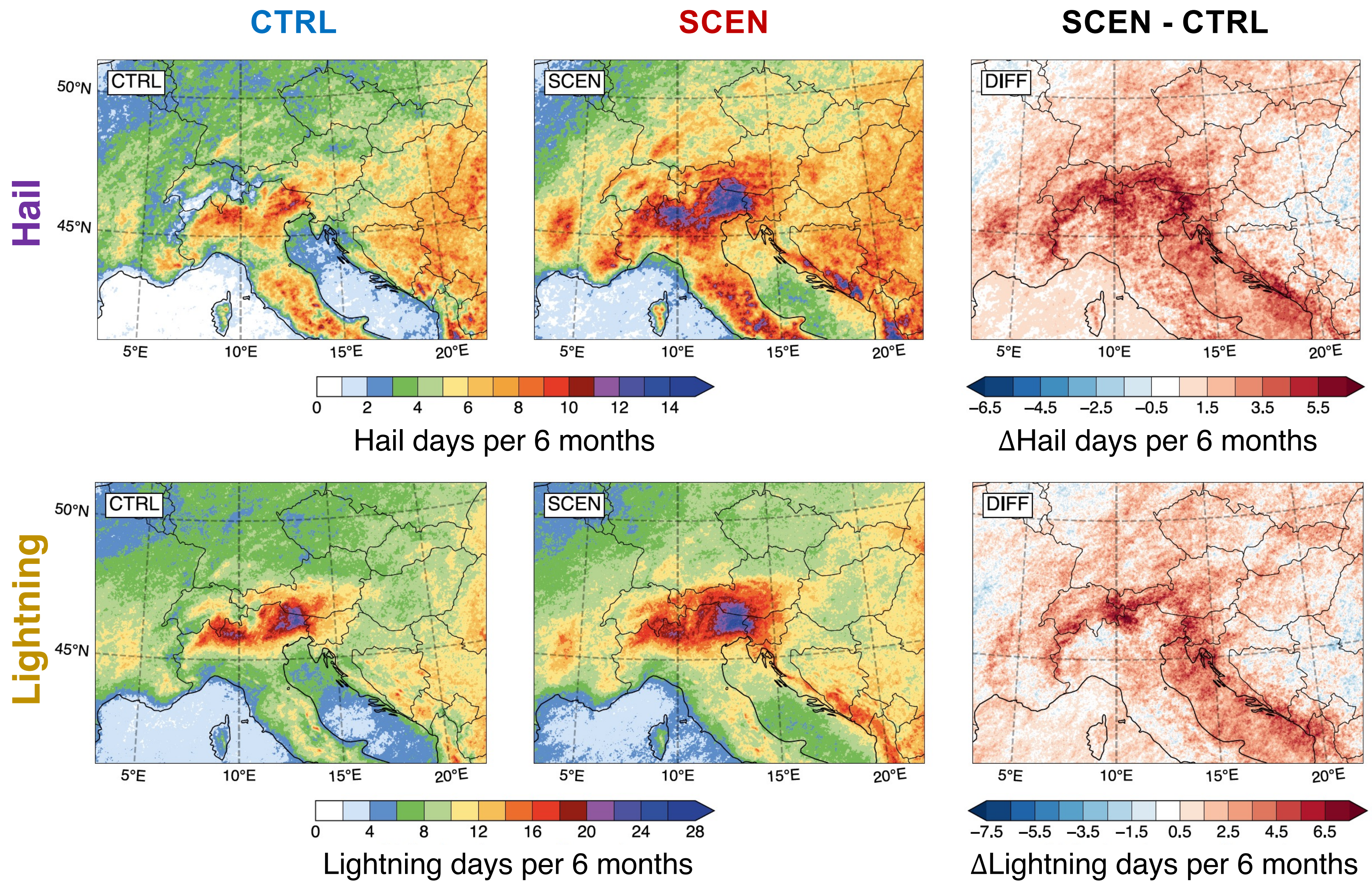
- Pseudo-global warming (**PGW**) approach (Schär et al, 1996; Kröner et al., 2016; Brogli et al., 2019; Liu et al., 2016, Rasmussen et al., 2011; Sato et al., 2007)



- 10 extended summer (**Apr** – **Sep**) seasons 2.2 km simulations in current and future climate



Change in hail and lightning days



- In **CTRL**, the north of the Po Valley, northern pre-alpine region, the Jura mountains and eastern Europe are hot spots of hail and lightning.
- In **SCEN**, the hail and lightning days over the southern Alpine region and the coast of Adriatic Sea will increase.
- Over eastern Europe, the increase is less pronounced.

Change in different categories of hail diameter

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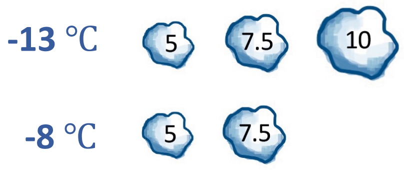


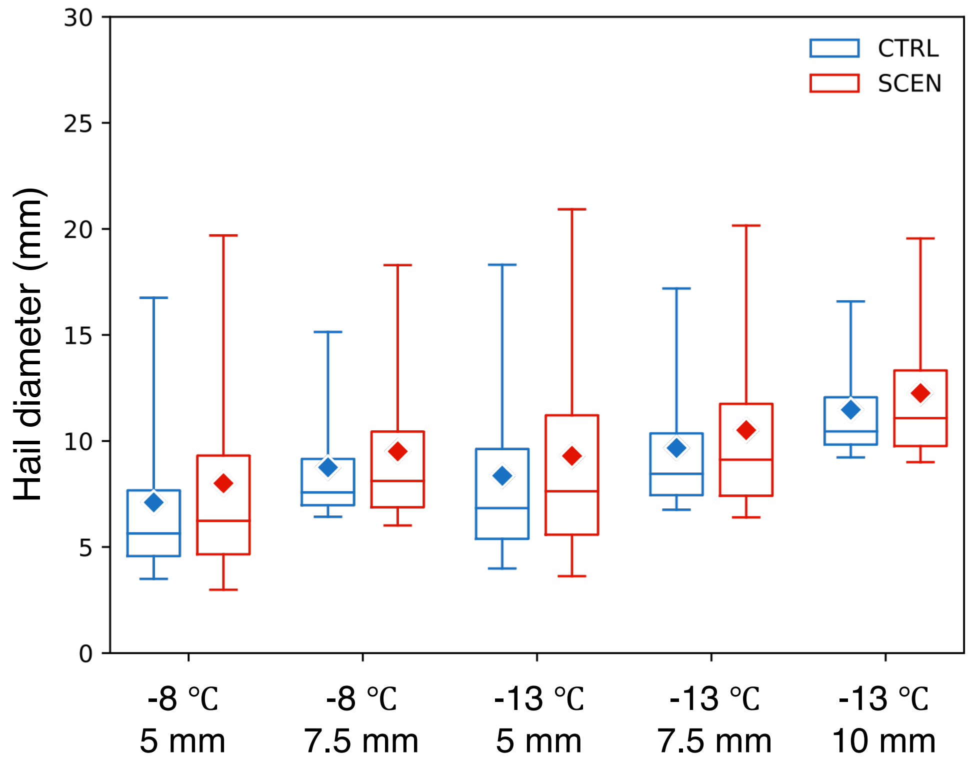
5 embryos in **CTRL**/**SCEN**

- In **CTRL**:

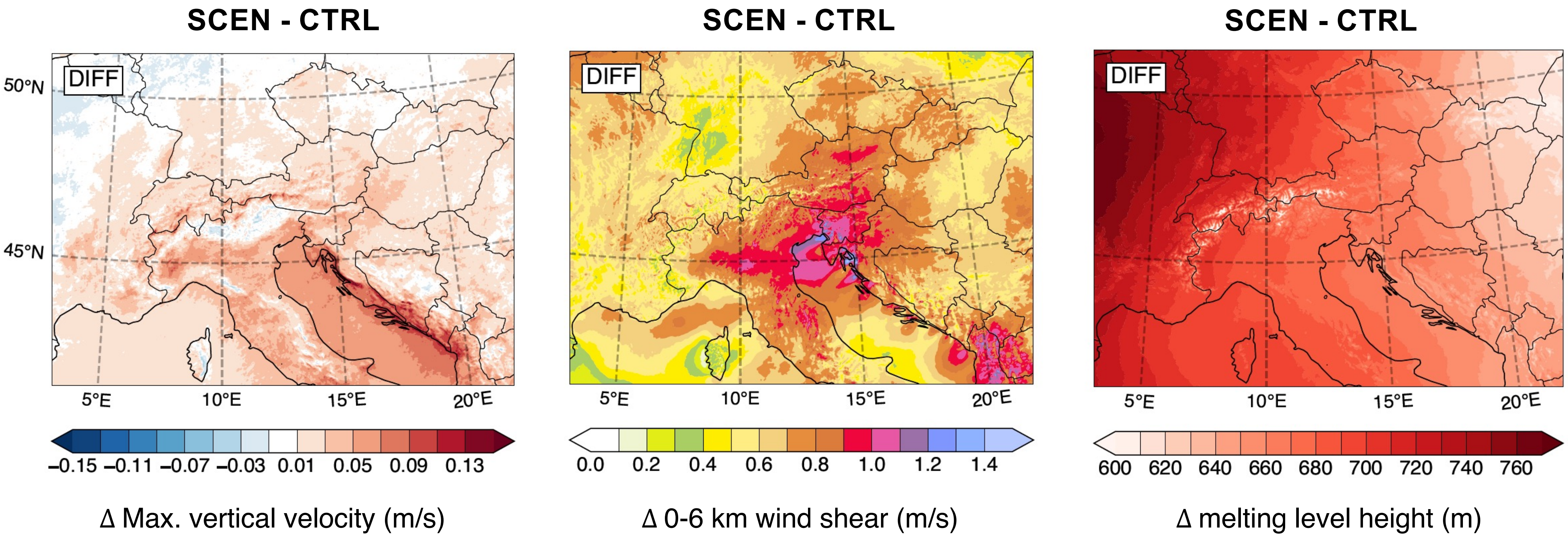
  larger initial hail embryos → larger hailstones on the ground
  smaller initial hail embryos → wider hail size distribution

- In **SCEN,** compared to **CTRL**:

  larger mean hail diameter (diamond dots)
  wider hail size distribution (5 – 95 percentiles)



Change in hailstorm environments



- **Increased max. vertical velocity →** higher energy to overcome low-level stability → hailstone/lightning ↑
- **Increased deep layer shear →** promotes the sustainability of the storm → hailstone/lightning ↑
- **Increased melting level height →** more significant increase over western Europe/northern Alpine region → melting process ↑ → smaller hailstone ↓

Summary

- The COSMO-crCLIM convection-resolving climate model is able to realistically simulate observed severe weather events of hail and lightning.
- Hail and lightning days are projected to increase with further warming of the atmosphere.
- The mean hail diameter is getting larger with the warming of the atmosphere, and the hail size distribution is getting wider.
- Currently, we are working on futher evaluation of the conducted simulations and exploring the mechanisms for the changes.

Thanks for your attention