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Comparing extreme sub-daily rainfall projections from temperature-scaling and convection-permitting climate models across an Alpine gradient

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This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

1. Background and motivation

- Understanding projected changes in sub-daily extreme rainfall in mountainous basins can help increase our capability to adapt against current and future flash floods and debris flows. Leveraging from two recent advancements:
- 1). High-resolution convection-permitting climate models (CPMs): more realistic representation of convection than coarser-resolution regional models.
- 2). Novel non-asymptotic extreme value approaches: estimation of rare return levels with reduced stochastic uncertainty, even from short datasets

Objective: to compare the changes in extreme rainfall projections from apparent Clausius-Clapeyron (CC) temperature scaling against those obtained from convection-permitting climate model simulations.

2. Data and study area

5 CPMs from the CORDEX-FPS project (Ban et al, 2021), remapped on common ~3km grid

Institute	CPM	Horiz. Resolut.	Time periods
ETH	COSMO	~2.22 km	Historical: 1996 – 2005
KIT	COSMO-CCLM5	~3.05 km	
CMCC	COSMO-CCLM5	~3.05 km	Far Future: 2090 -2099
HCLIMcom	HCLIM38-ALADIN	3 km	
KNMI	HCLIM-AROME	3 km	RCP8.5

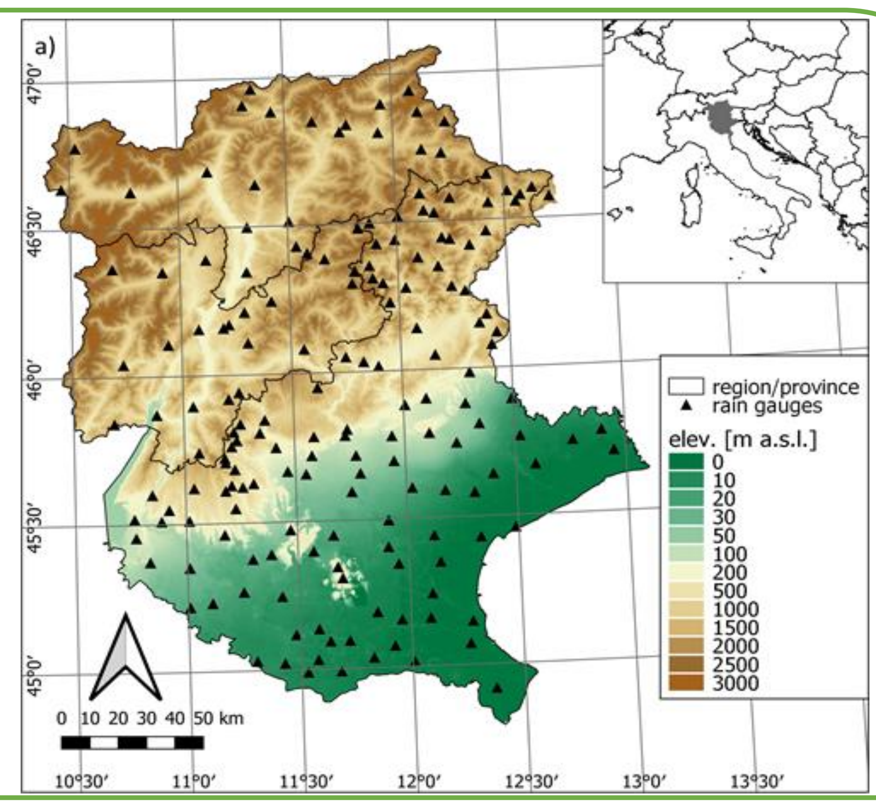


Figure from Dallan et al., 2022

3. Methodology

1. Statistical Method

based on Simplified Metastatistical Extreme Value distribution (SMEV):

- non-asymptotic method based on the idea that extremes are samples from ordinary events x
- 2-parameter Weibull distribution to fit the upper tail of the distribution of ordinary events x

$$F(x,\lambda,\kappa)=1-e^{-(x/\lambda)^\kappa}$$

- Applied at each grid point on hourly time series
- Rainfall durations: 1, 3, 6, 12, 24 h

2. Assessment of changes

At each grid point …	single member i …	.. ensemble
1) SMEV	Return levels up to 100yr	
2)CC-Scaling	$I_{fut} = I_{hist}\left[\frac{100+R_{sc}}{100}\right]^{\Delta T}$	
➢ Temperature to use:	○ Mean annual temperature ○ Temperature during extreme events (top 20% of ordinary events)	
3) Future change C	$C_i\,[\%] = \frac{X_{fut}-X_{hist}}{X_{hist}}\cdot 100$	$C\,[\%] = median(Ci)$

4. Results and take home messages

Bias evaluation of models' precipitation

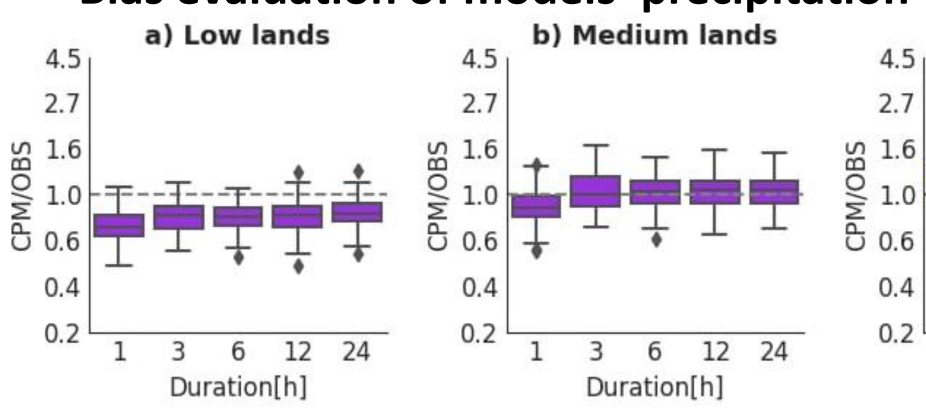
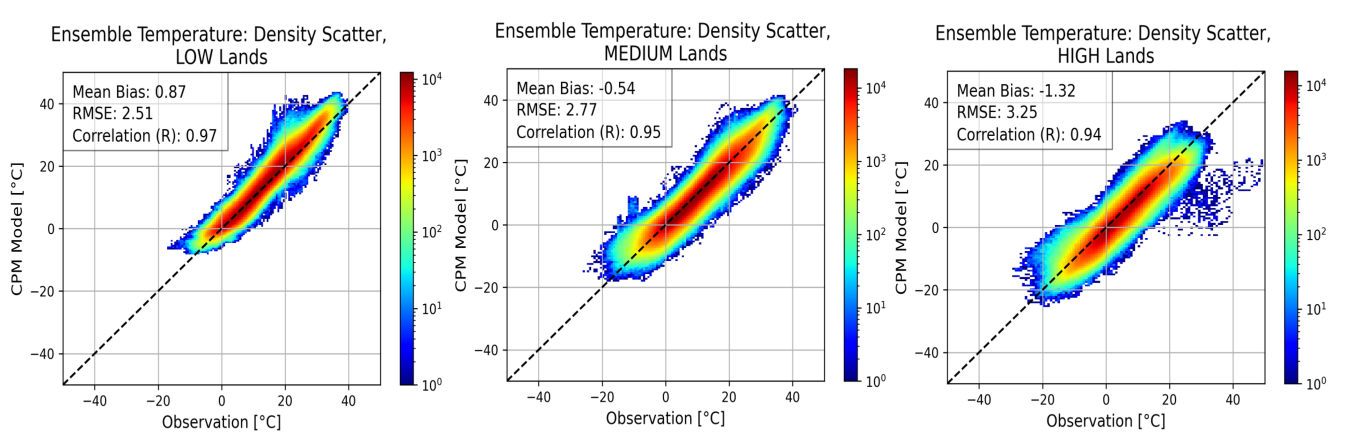
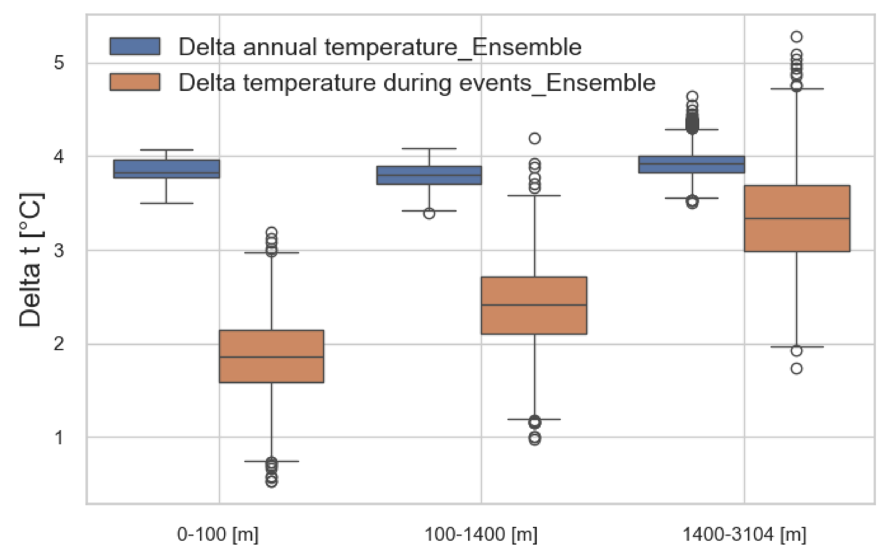


Figure from Correa Sánchez et al., 2024

Bias evaluation of models' temperature

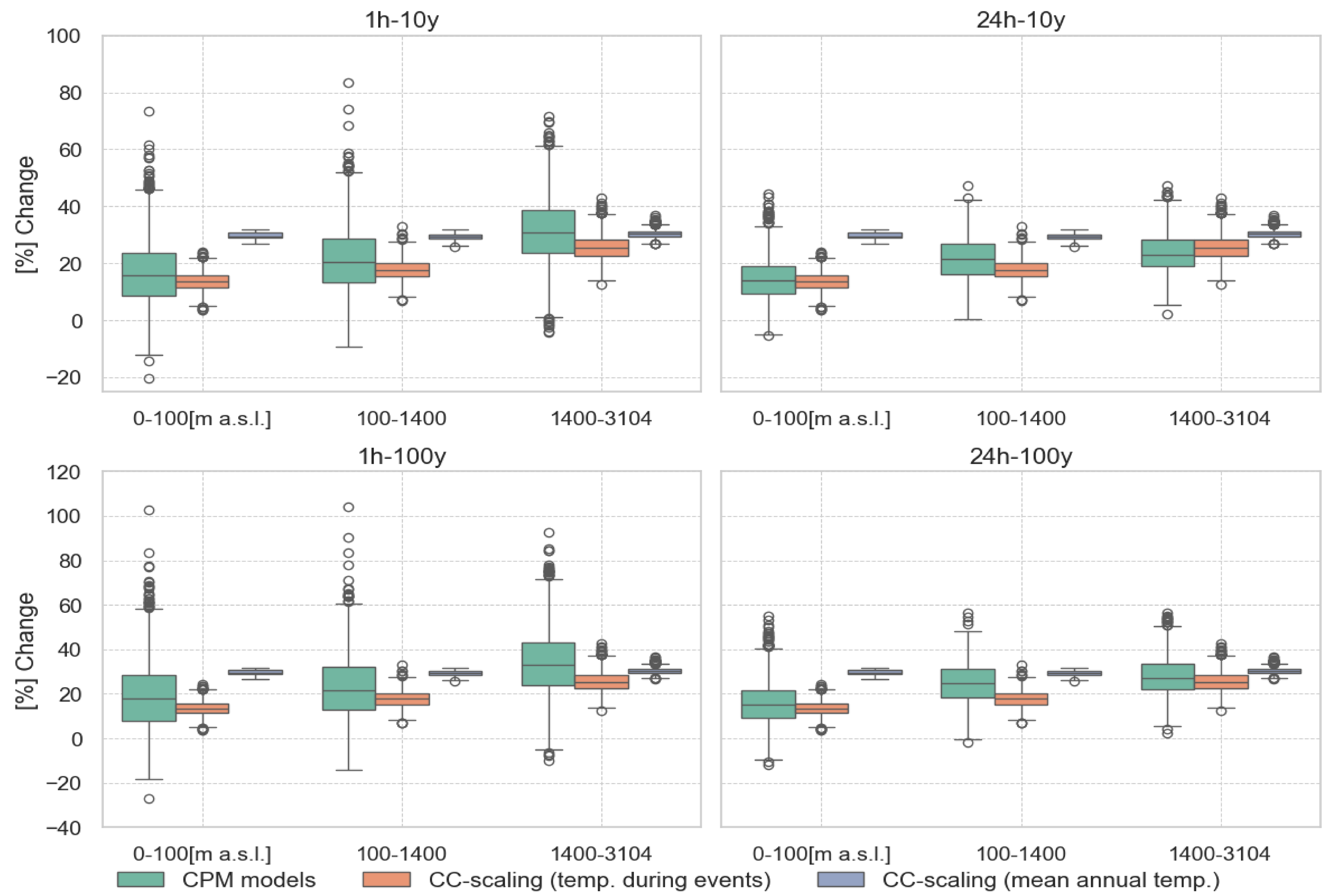


Temperature difference between historical (1996-2005) and far future periods (2090-99) considering elevations for models ensemble



- **Temperature changes:** elevation has an influence on changes on temperature during storms. Higher elevation ⟶ larger temperature changes in the future.
- **CPM changes:** CPM changes are influenced by elevation across all durations and return periods. Higher elevation ⟶ higher changes.

Changes in return levels of CPM models ensemble and CC-scaling with respect to different elevation (between historical (1996-2005) and far future periods (2090-99))



Abstract:

- **Final remarks:** CC-scaling does not fully capture changes in CPMs.

  When using storm temperature, it underestimates future changes in 1-hour rainfall, particularly at higher elevations, while for 24-hour rainfall, the underestimation is more pronounced at medium elevations.

  Conversely, when using mean annual temperature, CC-scaling consistently overestimates extreme precipitation changes compared to CPMs and fails to account for elevation effects.

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