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Assessing and explaining future changes on sub-daily precipitation extremes using an ensemble of convection-permitting models

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Sharing is encouraged

1. Background and motivation

- Sub-daily rainfall extremes increase in a warming climate → assess their future changes for improving risk management
- Recent advance 1). High-resolution convection-permitting climate models (CPMs): more realistic representation of convection than coarser-resolution regional models; but 10 to 20yr-long runs limit the use of conventional extreme value methods for assessing rare events with low occurrence probability
- Recent advance 2). Novel non-asymptotic extreme value approaches: estimation of rare return levels with reduced stochastic uncertainty, even from short datasets

Objective: to project future sub-daily precipitation return levels in a region characterized by complex terrain by making leverage of a CPM ensemble and a novel non-asymptotic EV method; to explain the changes in their statistics

2. Data and study area

Alpine Region and North Italy

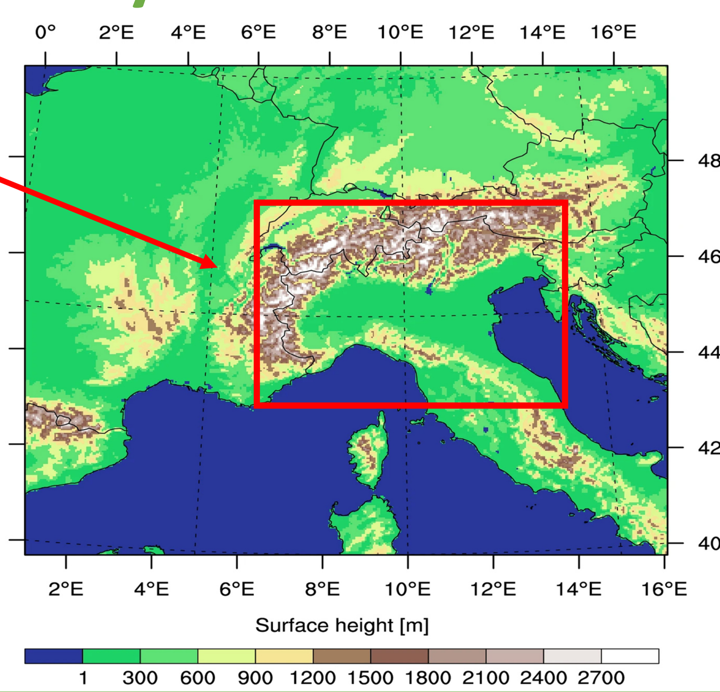


Figure from Ban et al., Climate Dynamics, 2021

9 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 Near future: 2041-2050 Far future: 2090-2099
KIT	COSMO-CCLM5	~3.05 km	
CMCC	COSMO-CCLM5	~3.05 km	
HCLIMcom	HCLIM38-ALADIN	3 km	
CNRM	CNRM-AROME41t1	2.5km	
KNMI	HCLIM-AROME	3 km	
ICTP	RegCM4	3 km	
MOHC	hADrem_um10.1	~2.22 km	
FZJ,IDL	WRF381CA	3 km	

3. Methodology

1. Frequency analysis

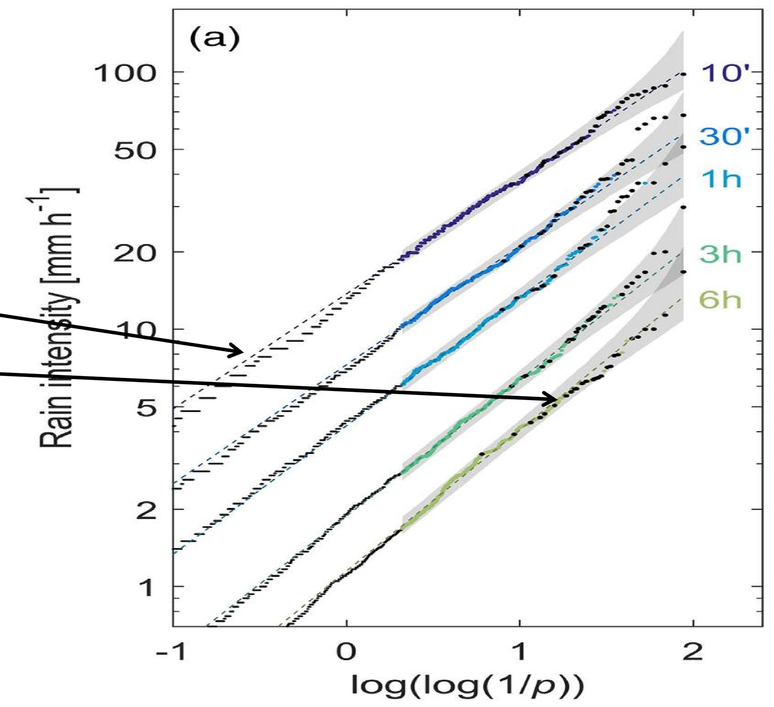
based on Simplified Metastatistical Extreme Value distribution (SMEV):

- non-asymptotic method based on the ordinary events x
- 2-param. Weibull distribution to fit the upper tail of the distribution of 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

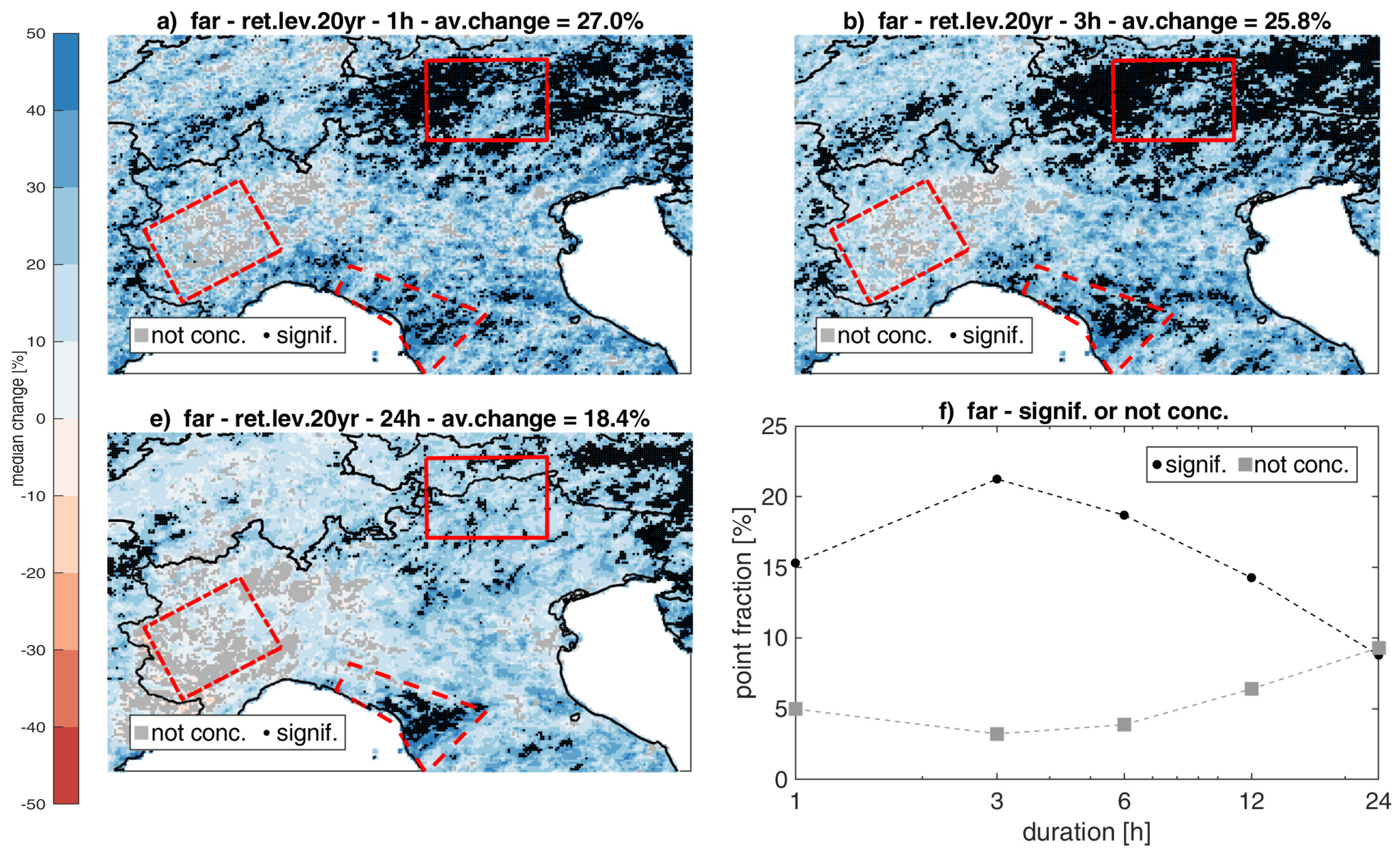


2. Assessment of changes

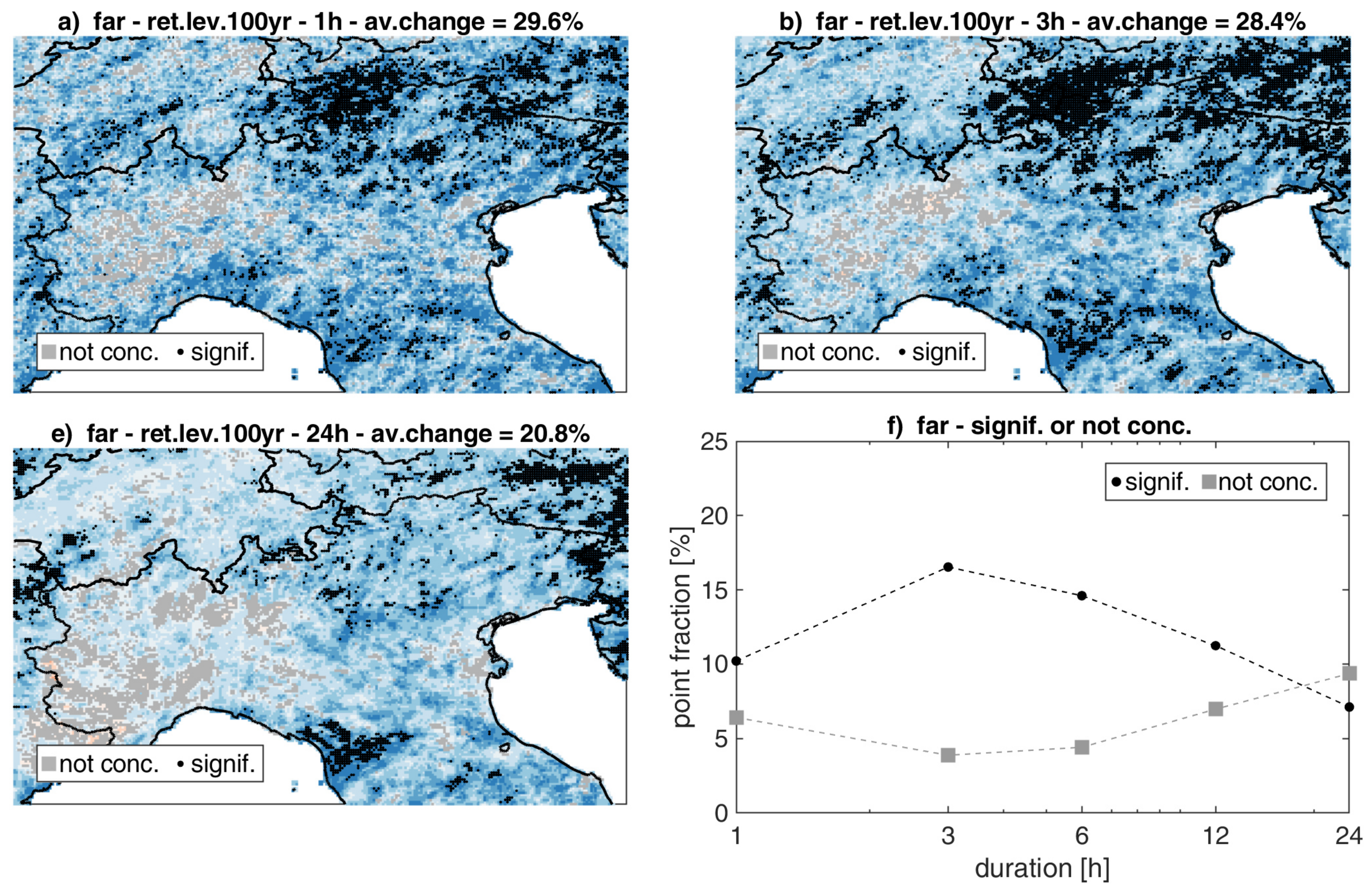
At each grid point ...	From single member i ...	.. to the ensemble
1) Applying SMEV	Return levels up to 100yr Parameters scale λ, shape κ Number of events n	
2) Future change C	$C_i\,[\%] = \frac{X_{fut} - X_{hist}}{X_{hist}} \cdot 100$	$C\,[\%] = median(Ci)$ (not shown if 3/9 models discordant)
3) Significance of changes Permutation test	Significant at 5% α-level: if pvalue< 0.05	**Significant** if: significant for ≥50% members

4. Results and take home messages

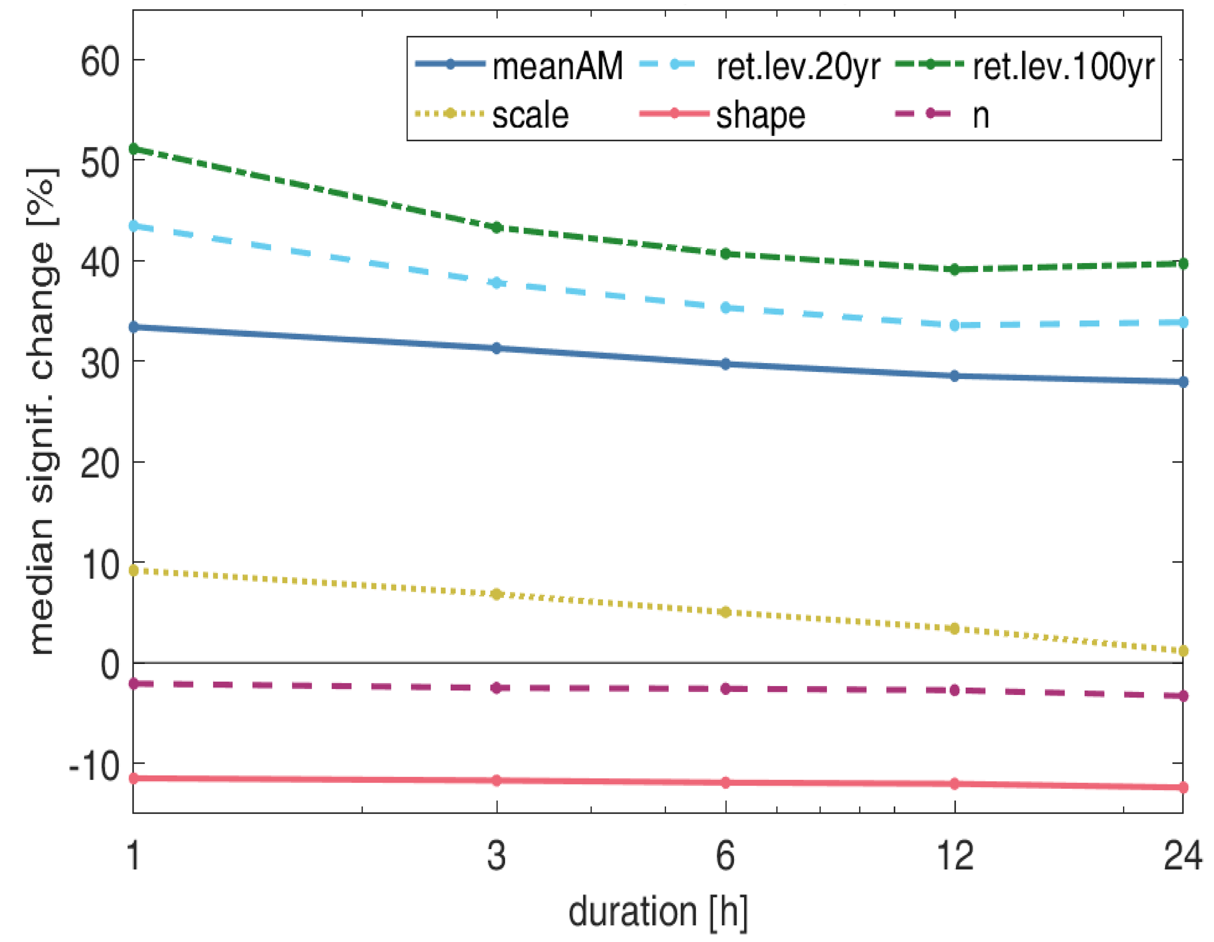
Far future change – 20 yr return period



Far future change – 100 yr return period



Median of far future change on significant points *



1. **Consistent information in the ensemble**: concordant change in most of the domain, consistent significance in the regions with the higher increase
2. **The higher and significant increase is** at short duration in the mountainous areas (eastern Alps and upper Apennines)
3. **For 100yr return period** spatial pattern of change and significance are similar to those at 20yr return period
   → signal-to-noise similar for rare return levels
   → **Limited increase of SMEV uncertainty** allows detection of significant changes consistently across return periods
4. **Intense precipitation**: positive change, higher for shorter durations and higher return periods
5. **Parameters' change** (*calculated on points where the 20yr return level is signif.) gives understanding on the positive change in intense precipitation, that is linked to
   - lower shape → heavier tails (local dynamics?)
   - increased scale → thermodynamics plays a role at short durations
   - even if n decreases → large scale dynamics ?

Abstract:

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