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*Supplement of*

## **Long-term variance of heavy precipitation across central Europe using a large ensemble of regional climate model simulations**

**Florian Ehmele et al.**

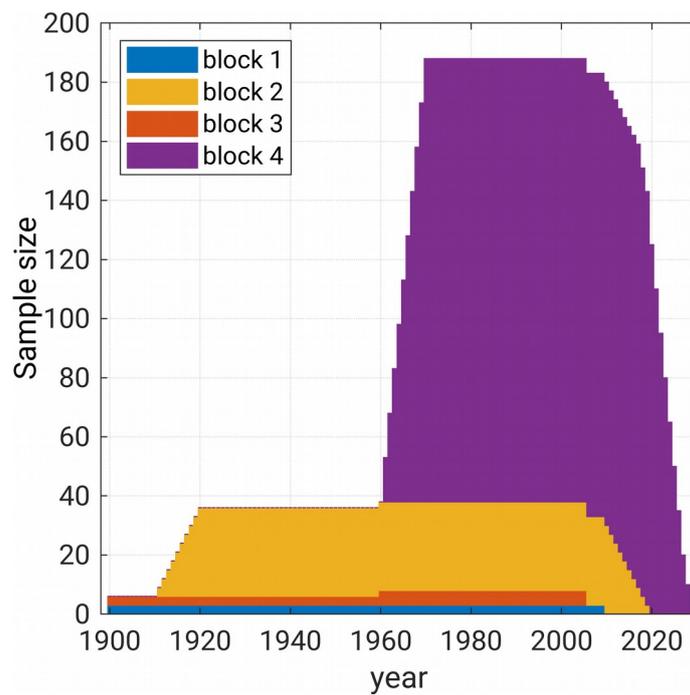
*Correspondence to:* Florian Ehmele ([florian.ehmele@kit.edu](mailto:florian.ehmele@kit.edu))

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# Supplemental Material

## 1. Data sets

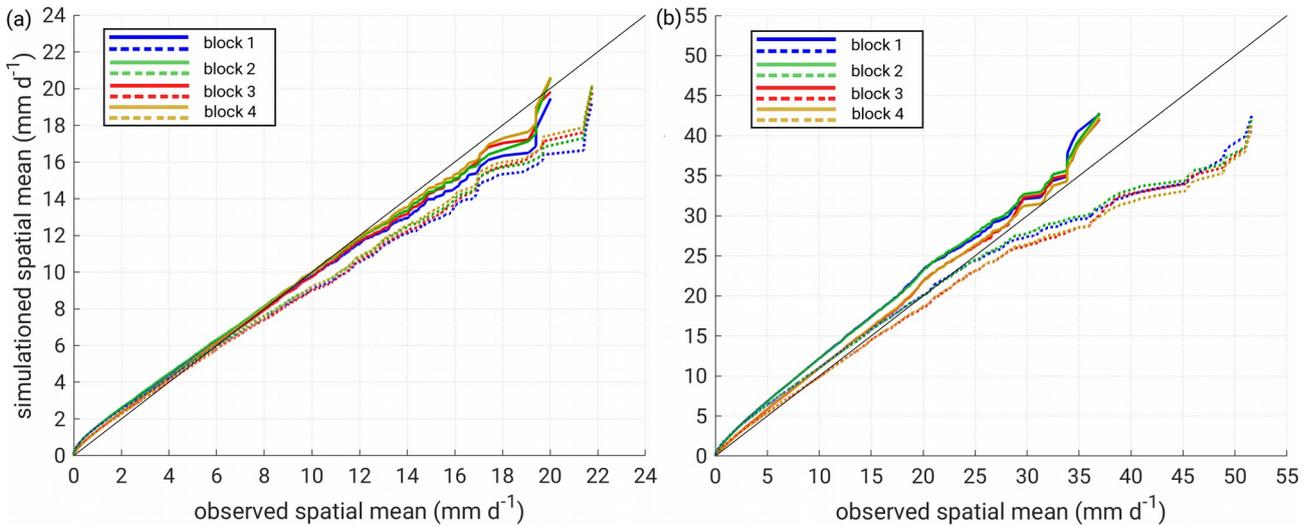
This section contains supplemental figures to the used RCM ensemble, which is discussed in Section 2 of the main paper.



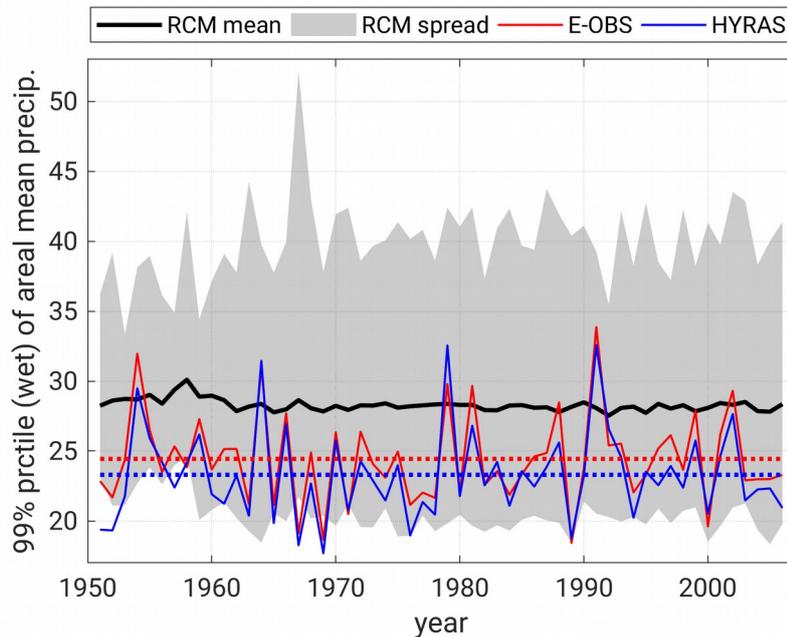
**Figure S1:** Temporal evolution of the number of members of the RCM ensemble. The colors correspond to the different data blocks, in which the RCM ensemble is divided to (cf. Table 1 in the main paper).

## 2. Validation of the RCM ensemble

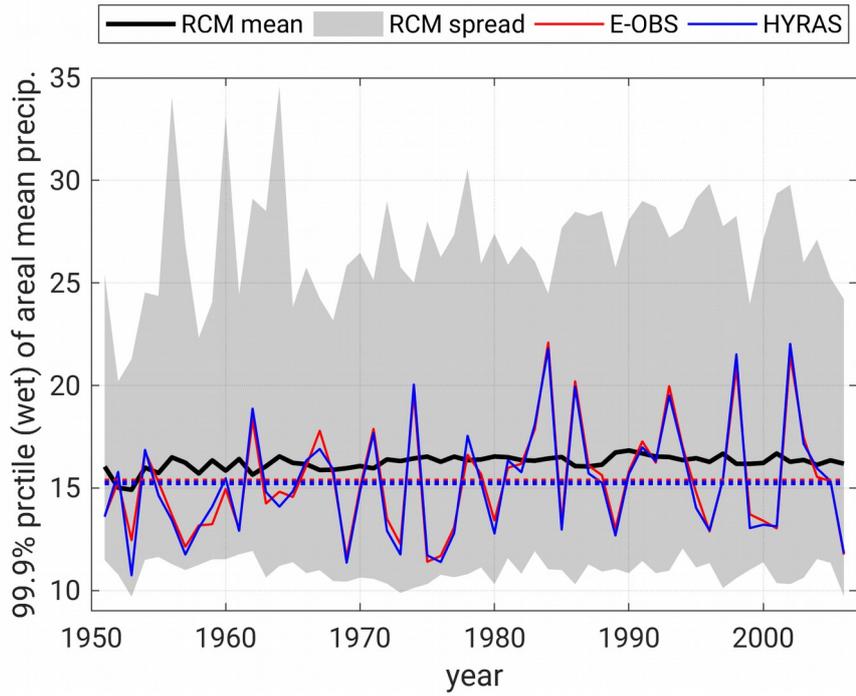
This section contains supplemental figures for the validation of the RCM ensemble, which is discussed in Section 4 of the main paper.



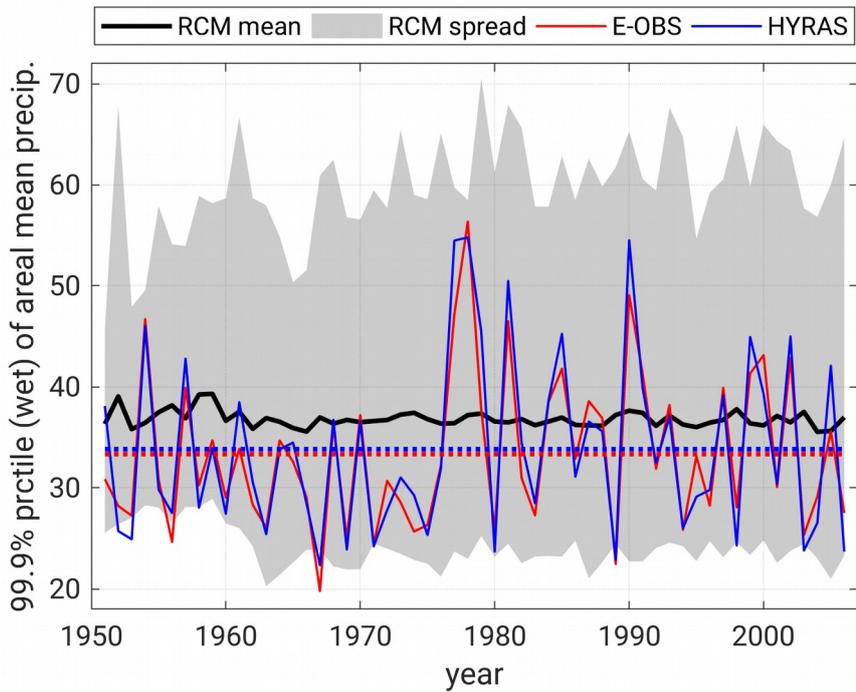
**Figure S2:** Quantile-quantile plot of spatial mean daily precipitation for investigation period TP1b (1951-2006) comparing the RCM simulations (block 1-4) with E-OBS (solid lines) and HYRAS (dashed lines) for (a) Mid-Europe (ME\*) and (b) the Alps (AL\*), only taking into account grid cells within the HYRAS area.



**Figure S3:** Time series of the yearly 99 % of spatial mean precipitation (wet days and HYRAS area only) for the Alps (AL\*) during TP1b (1951-2006) of the LAERTES-EU ensemble mean (black), the ensemble spread (minimum to maximum; gray), E-OBS (red), and HYRAS (blue). The dotted lines symbolize the mean values of the observations throughout TP1b.



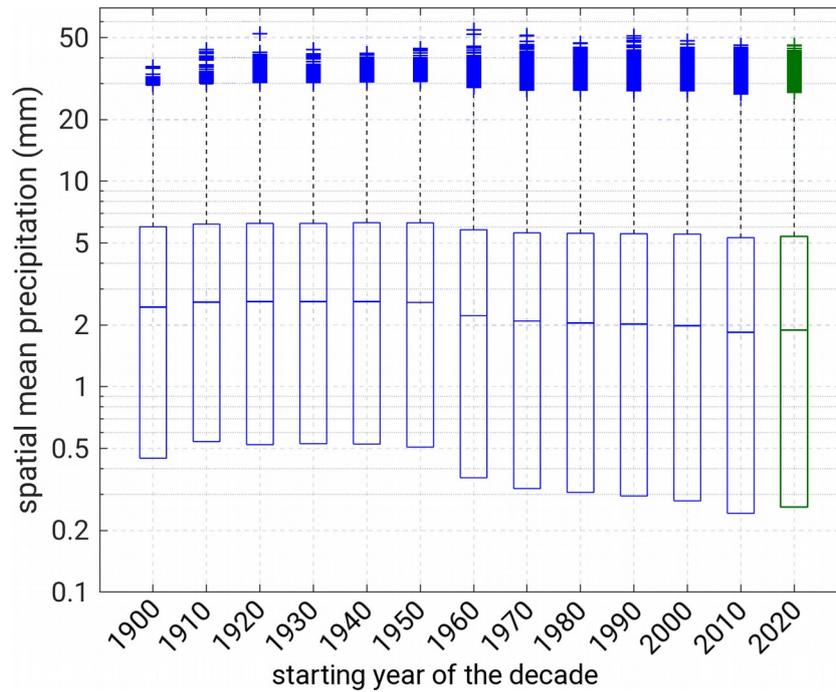
**Figure S4:** Same as Fig. S3, but for Mid-Europe (ME\*) and the 99.9 % percentile.



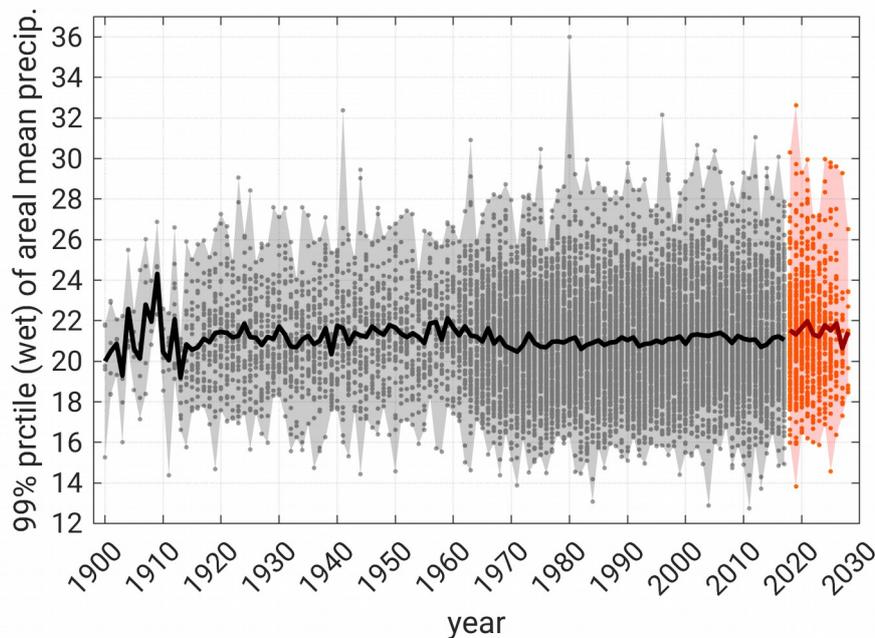
**Figure S5:** Same as Fig. S4, but for the Alps (AL\*).

### 3. Long-term variances and trend

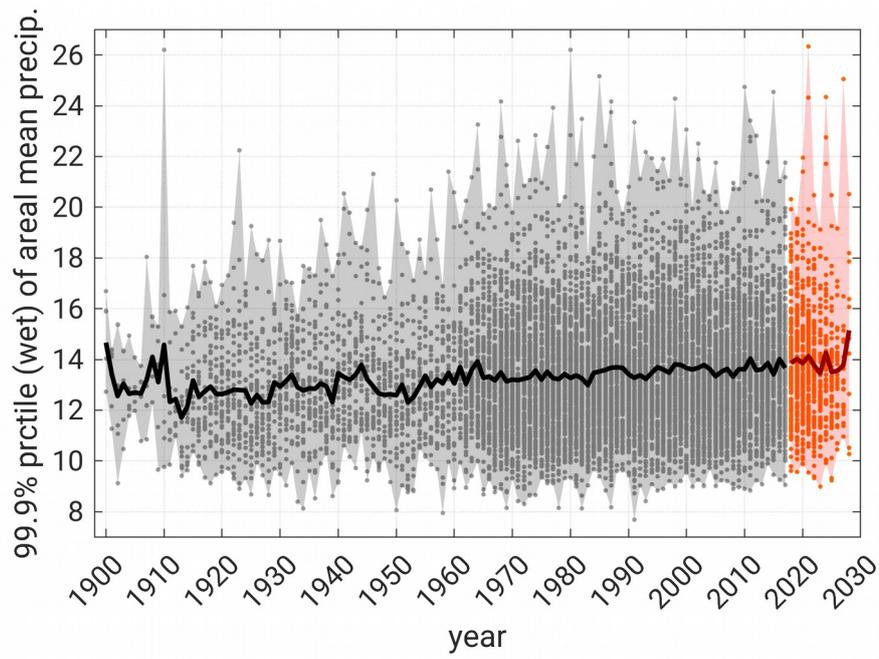
This section contains supplemental figures and tables for the analysis, which is discussed in Section 5 of the main paper.



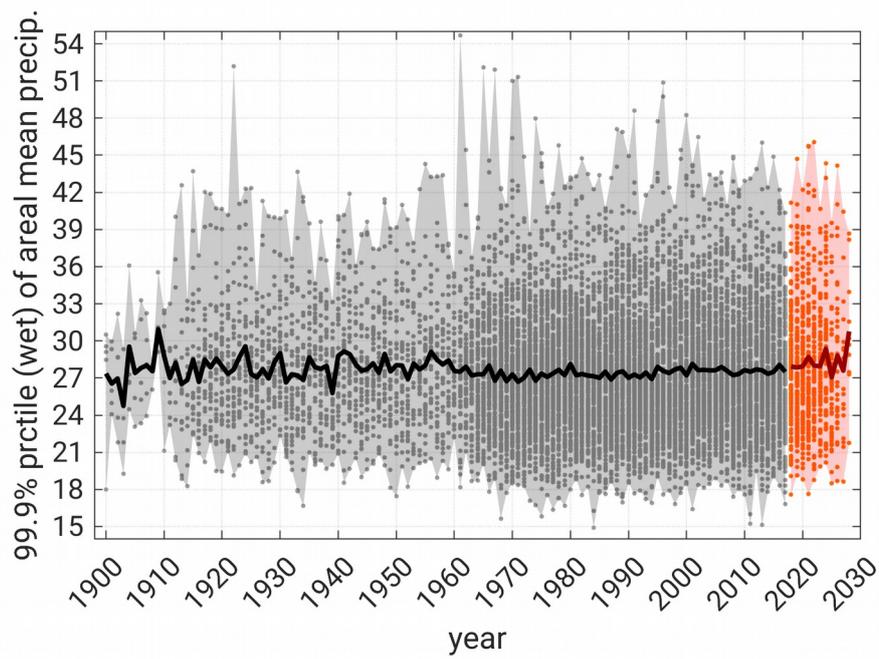
**Figure S6:** Boxplot of the distribution of daily spatial mean precipitation values (including dry days) for AL. Each decade was considered separately. The centerline of a box marks the median; the lower and upper end of the box mark the 25 % and 75 % percentile (interquartile range); the whiskers represent approximately the 99.9 % percentile; the prediction part is marked in green.



**Figure S7** Time series of the yearly 99 % percentile of daily spatial mean precipitation (wet days only) for the Alps (AL) of the LAERTES-EU ensemble mean (solid line), and the ensemble spread (minimum to maximum; dots and shaded area) during TP1 (1900-2017; black/gray) and TP2 (2018-2028; reddish).



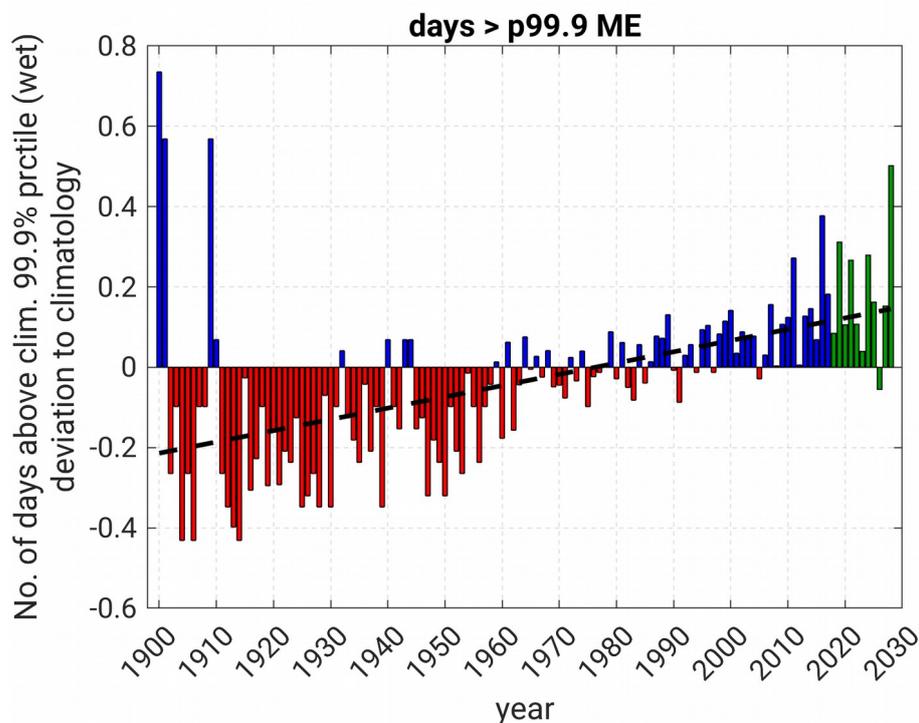
**Figure S8:** Same as Fig. S7 but for the 99.9 % percentile for ME.



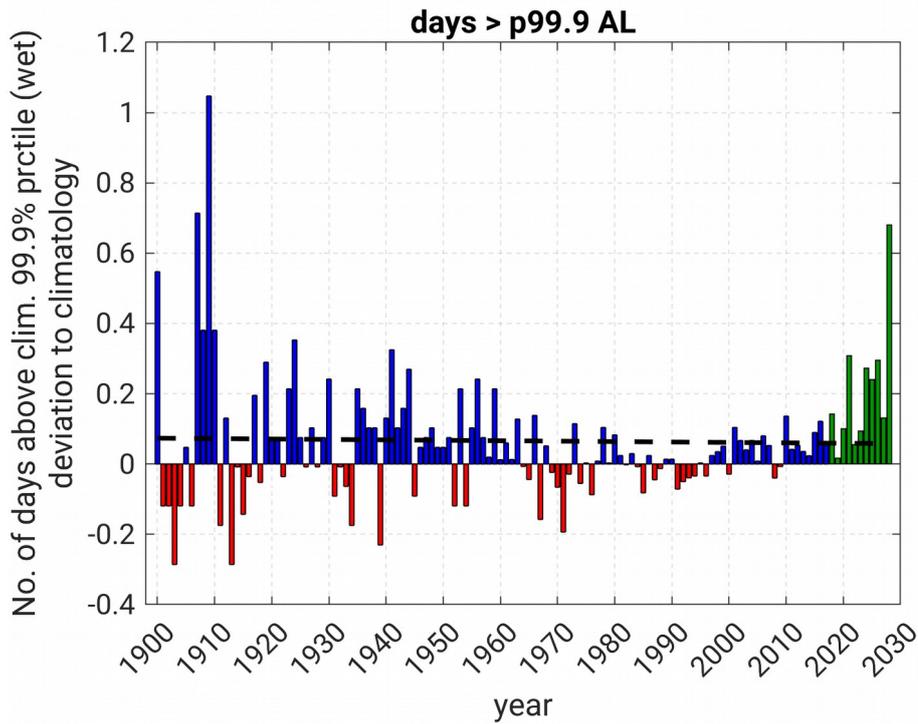
**Figure S9:** Same as Fig. S8, but for the Alps (AL).

**Table S1:** Overall trend of daily spatial mean precipitation during TP1b (1951-2006) using a linear regression of the yearly series of the 99 % and 99.9 % percentile (pct; wet days only) ME and AL; Given are absolute values and the relative changes (RC) compared to the climatological mean (climTP; 1961-1990) for the ensemble minimum (min), the ensemble mean, and the ensemble maximum (max) percentile values within LAERTES-EU, and the related significance (p-value;  $\alpha = 0.05$ ).

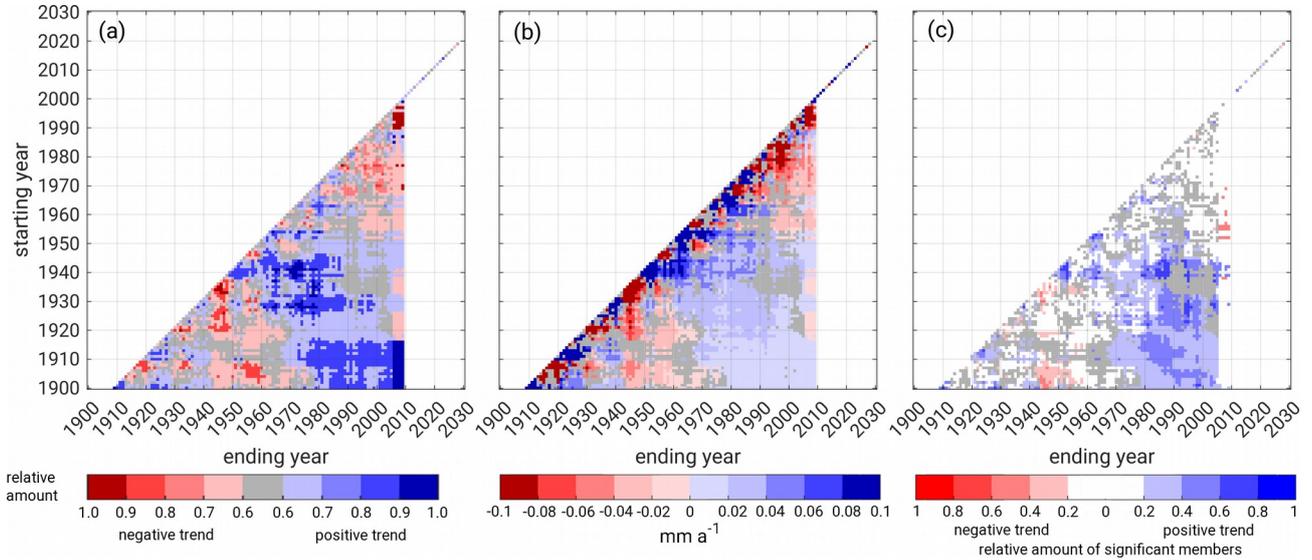
area	pct	variable	trend (mm)	RC (%)	climTP (mm)	$p_\alpha$
ME	99	min	-0.2	-3.2	7.8	0.4980
		mean	0.5	4.6	10.3	1.0000
		max	1.3	9.5	13.9	0.9989
ME	99.9	min	-0.2	-2.6	9.0	0.2602
		mean	0.6	4.7	13.5	1.0000
		max	2.8	12.8	21.6	0.9975
AL	99	min	-1.6	-10.2	15.4	0.9971
		mean	-0.6	-3.0	21.0	0.5673
		max	3.1	10.8	28.4	1.0000
AL	99.9	min	-2.1	-11.7	17.8	0.9976
		mean	-0.2	-0.8	27.3	0.4890
		max	2.0	4.4	44.7	0.8318



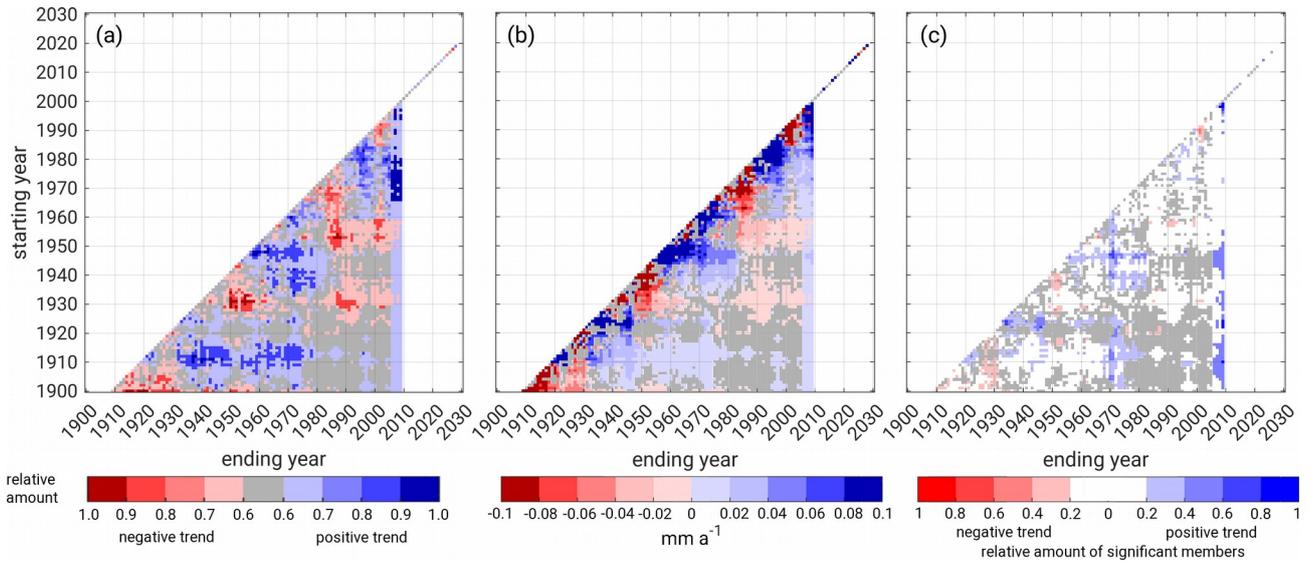
**Figure S10:** Deviation of the mean yearly number of days above the 99.9 % percentile (wet days only) compared to the climatology (climTP; 1961-1990) for ME. Red bars indicate negative anomalies (less days), blue bars positive anomalies (more days). The predictions (TP2; 2018-2028) are given in green; the black line indicates a linear regression.



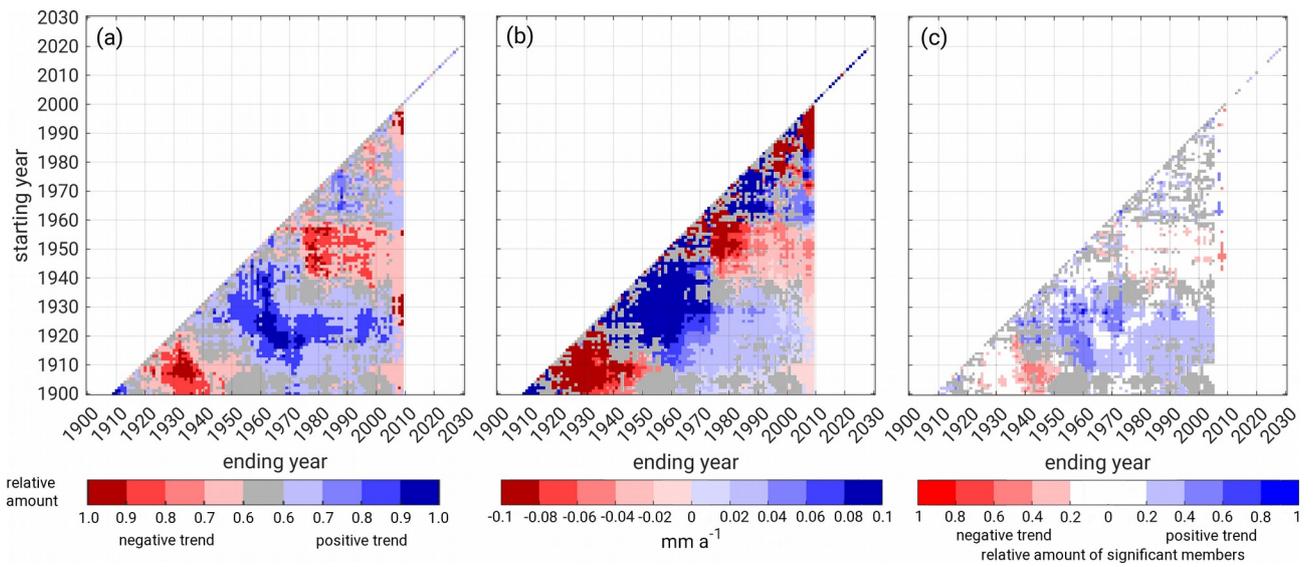
**Figure S11:** Same as Fig. S10, but for the Alps (AL).



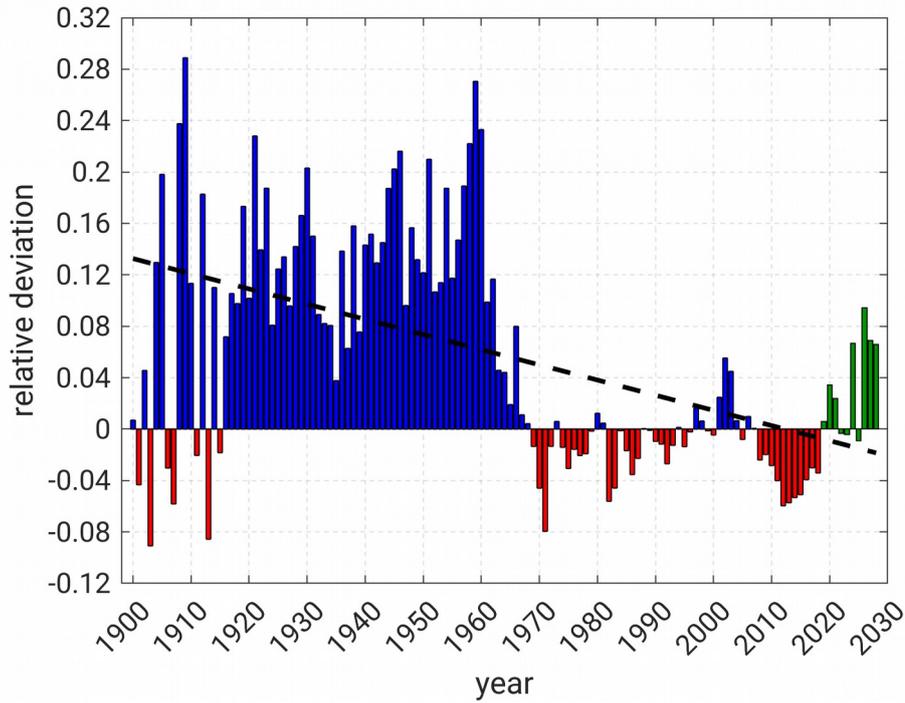
**Figure S12:** Trend analysis of the 99 % percentile (wet days only) of daily spatial mean precipitation for AL with (a) the relative amount of members of LAERTES-EU with a positive (blue) or negative (red) trend; (b) the trend in millimeter per year averaged over the members from (a), and (c) relative amount of members from (a) with a significant trend; cases with no distinct number (less than 60 % of members with same trend sign) are marked in gray in (a)-(c).



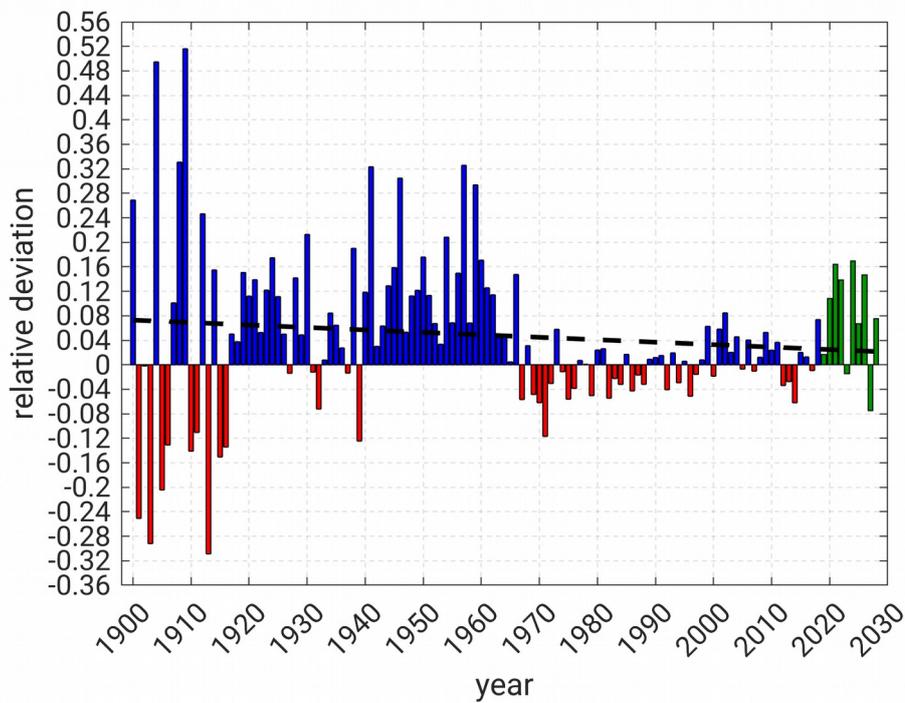
**Figure S13:** Same as Fig. S12, but for the 99.9 % percentile of ME.



**Figure S14:** Same as Fig. S13, but for the Alps (AL).



**Figure S15:** Relative deviation of (a) the R95pTOT index and (b) the R99pTOT index of the LAERTES-EU ensemble mean of daily spatial mean precipitation (wet days and land only) compared to the climatology (climTP; 1961-1990) for the Alps (AL). Red bars indicate negative (dry) anomalies, blue bars positive (wet) anomalies. The predictions (TP2; 2018-2028) are given in green. The black line indicates a linear regression.



**Figure S16:** Same as Fig. S15, but for the R99pTOT index.