



Analysing the detected and projected trends of extreme precipitation indices over the Pannonian plains

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Main goals

- i) to analyse the spatio-temporal changes in **extreme precipitation indices** for the **past** since 1950
- (ii) to **validate** the available historical simulations of the Euro-CORDEX regional climate models from this specific point of view
- (iii) to **evaluate the projected trends** of extreme precipitation indices for the plain area of the Pannonian basin using scenario runs for the 21st century from the Euro-CORDEX database in a fine, 0.11° grid resolution.

Altogether 17 climate indices were calculated

Both **the excessive precipitation** and **drought related** indices

Most of them defined by the Expert Team of Climate Change Indices (ETCCD).

Study area and methodology

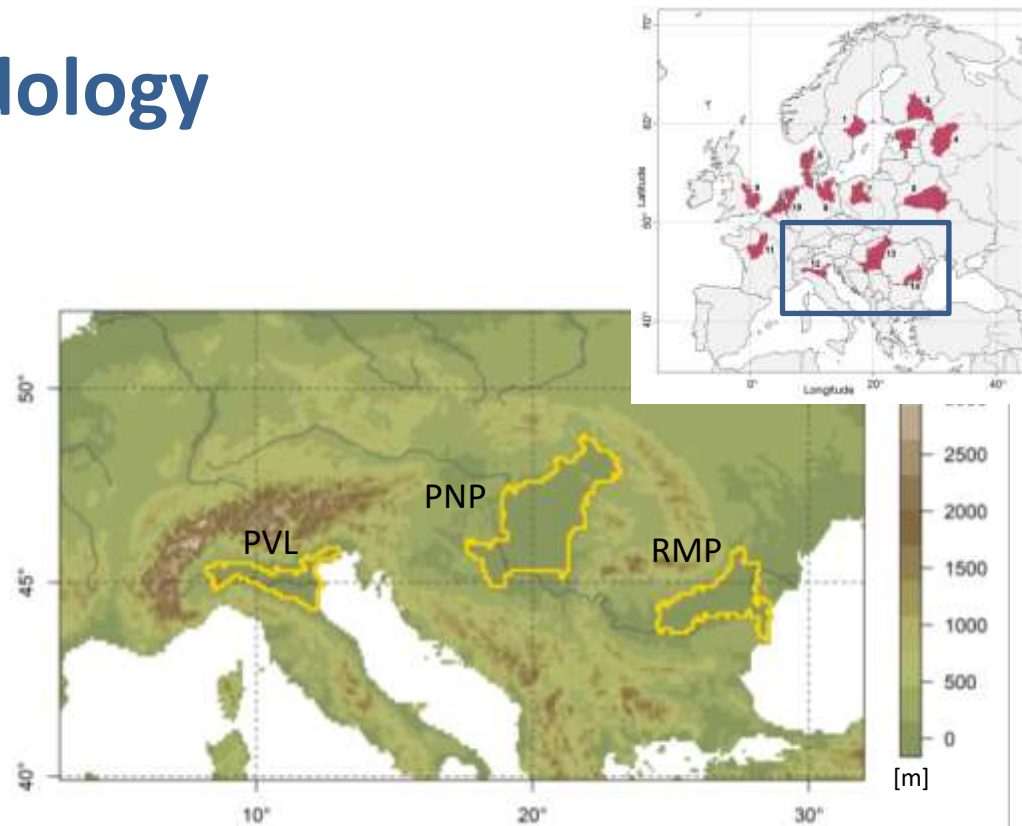
Measurement-based data (1950-2020):

E-OBS v.22 precipitation data
on a 0.1° resolution grid

Simulation-based data (1970-2100):

10 simulations from EURO-CORDEX
on a 0.1° resolution grid

Institute	GCM	RCM
CLMcom	MPI-ESM_LS	CCLM4
CLMcom	EC-EARTH	CCLM4
CNRM	CNRM-CM5	ALADIN53
DMI	EC-EARTH	HIRAM5
KNMI	HadGEM2-ES	RACMO22E
MPI-CSC	MPI-ESM_LS (r1)	REMO2009
MPI-CSC	MPI-ESM_LS (r2)	REMO2009
SMHI	HadGEM2	RCA4
SMHI	EC-EARTH	RCA4
SMHI	MPI-ESM_LS	RCA4



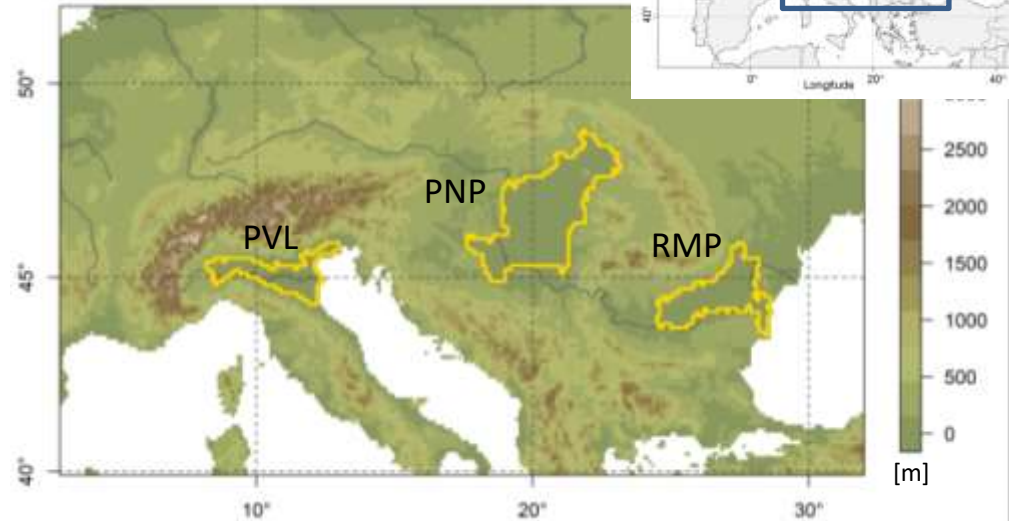
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Plains are defined by two criteria:

- 1) Elevation < 200 m
- 2) Elevation difference < 40 m
(for neighboring gridpoints)

Region	Abbr.	Countries	Station / 1000 km ²	Number of gridpoints	Average elevation (maximum deviation)
Po Valley	PVL	Italy	5.13	265	31 m (133 m)
Pannonian Plain	PNP	Hungary, Romania, Croatia, Slovenia, Slovakia, Ukraine	0.13	897	97 m (66 m)
Romanian Plain	RMP	Romania	0.13	308	52 m (106 m)

Climate indices used in the study -- 17

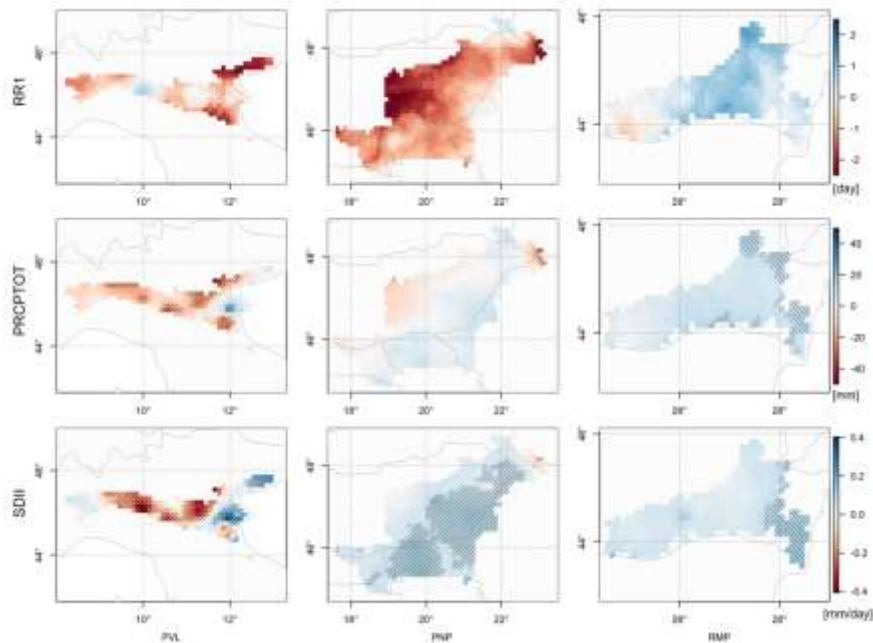
Index	Definition	Unit	Range of medians
Precipitation related indices			
RR1	Number of wet days, i.e. daily precipitation exceeding 1 mm ($R_{\text{day}} > 1 \text{ mm}$)	day	73.1 – 92.5
RR5	Number of days with precipitation exceeding 5 mm ($R_{\text{day}} > 5 \text{ mm}$)	day	35.8 – 49.5
RR10	Number of heavy precipitation days ($R_{\text{day}} > 10 \text{ mm}$)	day	10.4 – 24.0
RR20	Number of extremely heavy precipitation days ($R_{\text{day}} > 20 \text{ mm}$)	day	1.0 – 6.3
RRX1	Maximum 1-day precipitation ($\text{Max}(R_{\text{day}})$)	mm	21.9 – 40.3
RRX5	Maximum consecutive 5-days precipitation ($\text{Max}(\sum_{i=1}^5 R_{\text{day}})$)	mm	50.2 – 79.2
R90p	The 90th percentile of daily precipitation amount	mm	10.5 – 17.9
R95p	The 95th percentile of daily precipitation amount	mm	13.0 – 23.0
R95N	Number of days exceeding the 95th percentile of daily precipitation amount	day	3.2 – 4.1
PRCPTOT	Annual precipitation	mm	460.2 -686.9
SDII	Simple daily precipitation index	mm/day	5.5 – 8.9
Drought related indices			
CDD	Maximum number of consecutive dry days $\text{Max}(R_{\text{day}} < 1 \text{ mm})$	day	28.1 – 36.2
DD	Number of dry days ($R_{\text{day}} < 1 \text{ mm}$)	day	272.5 – 291.9
DS5	Number of dry spells with length above 5 consecutive days	-	19.1 – 20.7
DS10	Number of dry spells with length above 10 consecutive days	-	8.5 – 10.3
DS95p	The 95th percentile of the length of DS5	day	20.9 – 27.1
DS5N	Number of dry days in DS5	day	211.5 – 248.8

Results: Changes in main precipitation indices

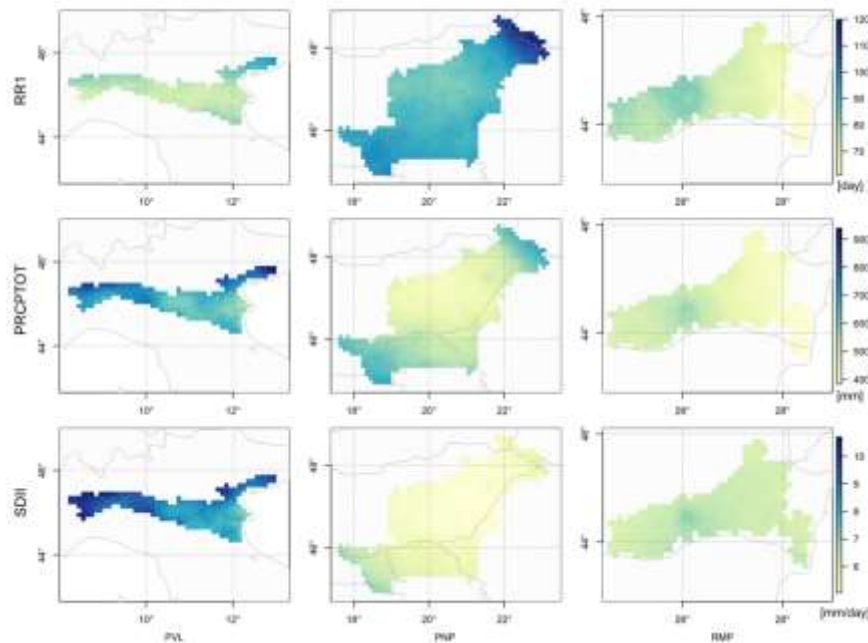
RR1, PRCPTOT, SDII

Decadal trends

Hatched areas indicate significant change.



Median values calculated as the median of the time series in every grid point.



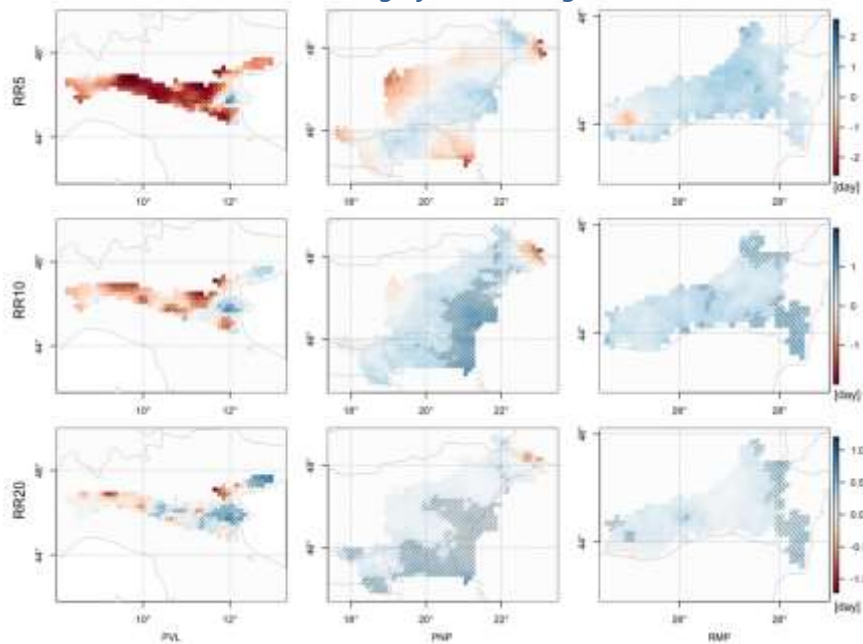
A **significant decrease** of RR1:
in the Po Valley and the Pannonian Plain.

Increasing, however **not significant PRCPTOT trend**
in the Pannonian Plain and the Romanian plain
→ significant increase of SDII
→ **Increase of extreme precipitation events and intensity**

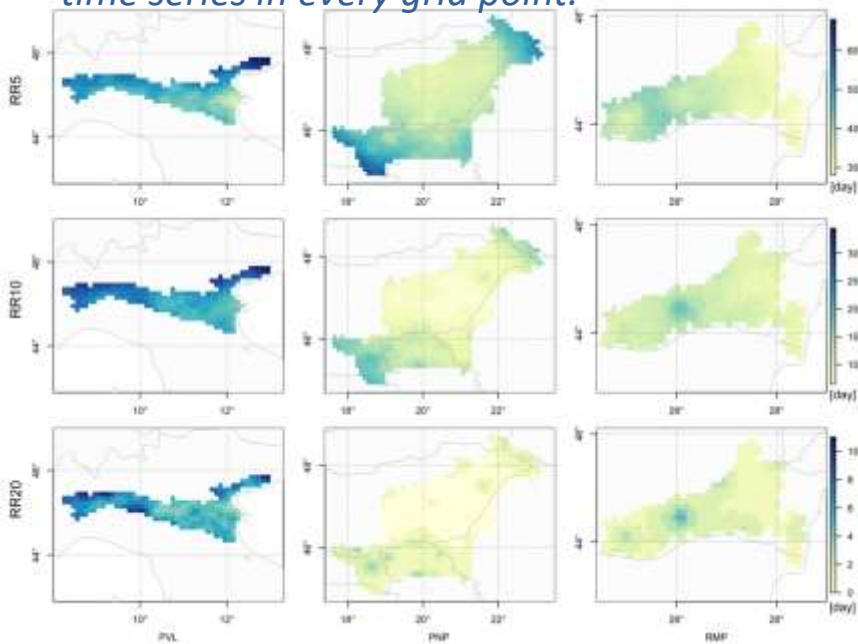
Results: Changes in extreme precipitation indices with fixed thresholds (RR5, RR10, RR20)

Decadal trends

Hatched areas indicate significant change.



Median values calculated as the median of the time series in every grid point.

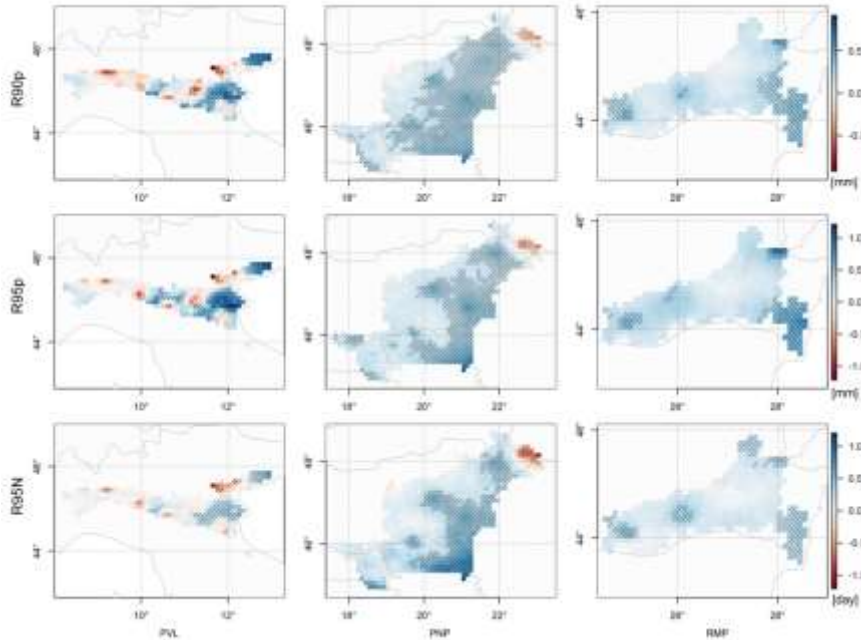


The **decrease of RR5** in the **Panonian Plain** and the **Po Valley**, and the **decrease of RR10** in the **Po Valley** indicate a shift towards **more extreme precipitation events**, which can be more severe in the future.

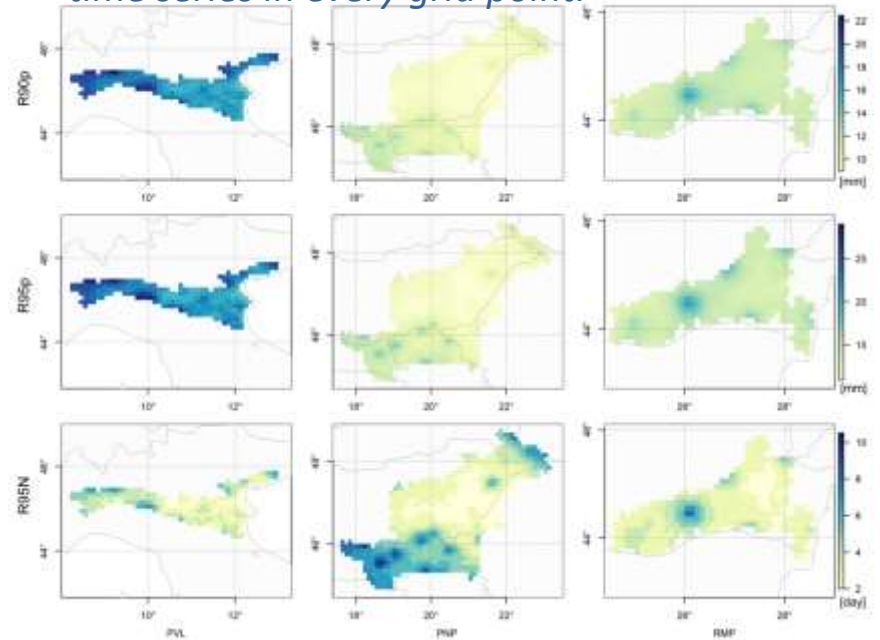
Results: Changes in percentile based extreme precipitation indices (R90p, R95p, R95N)

Decadal trends

Hatched areas indicate significant change.



Median values calculated as the median of the time series in every grid point.



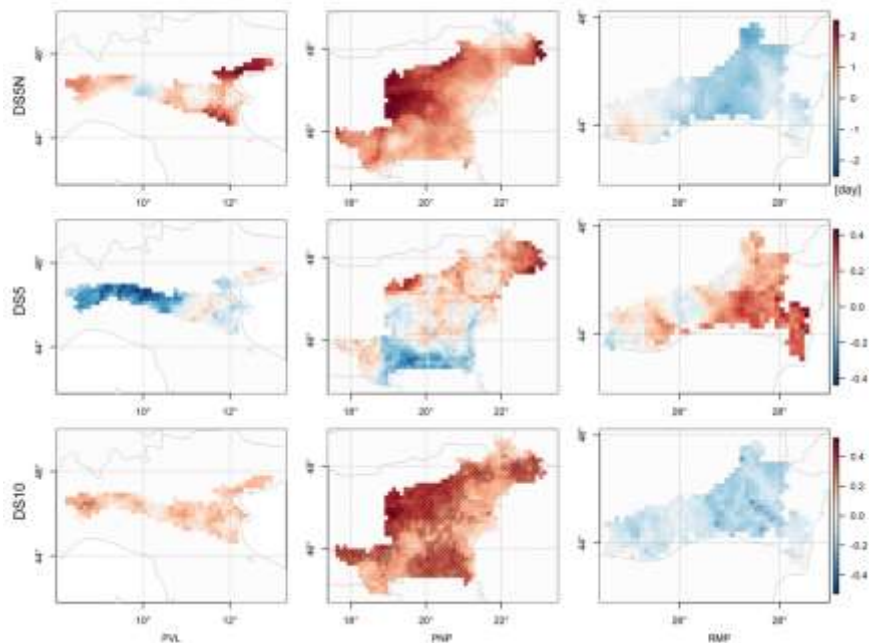
Increasing trends, which indicate a **shift from moderate** precipitation events **to extreme** events.

This is also justified by the increasing trend of **RX1 and RX5**.

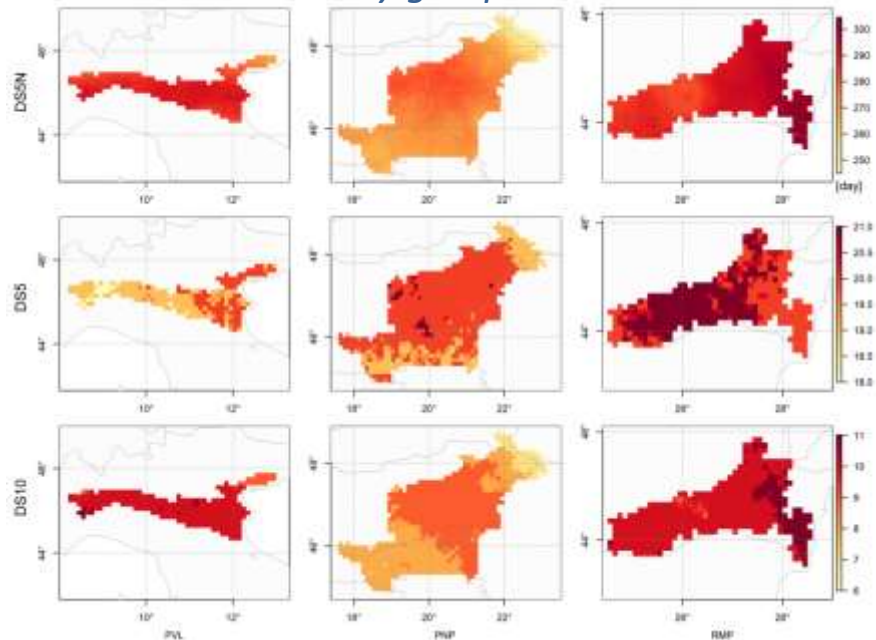
Results: Changes in drought-related indices (DS5N, DS5, DS10)

Decadal trends

Hatched areas indicate significant change.



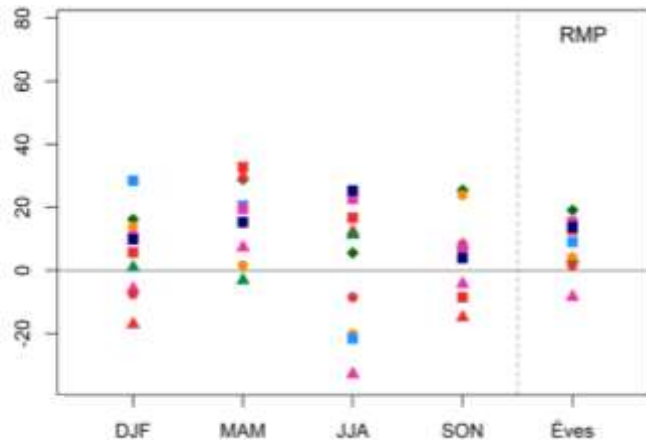
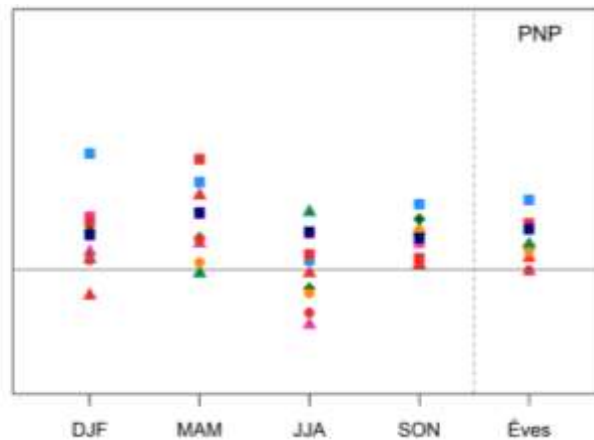
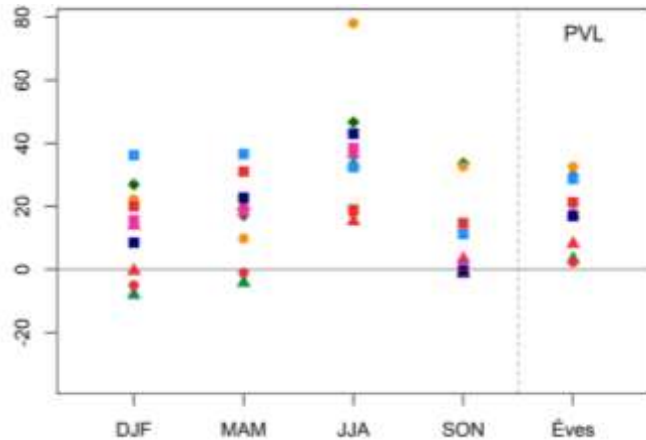
Median values calculated as the median of the time series in every grid point.



The **increase** of longer **droughts** and DS5N in the **Po Valley and the Pannonian Plain**.

As the possible number of dry periods within a year is limited in the case of the longer dry periods, the decrease of DS5 can be seen in the Po Valley and the Pannonian Plain, while the Romanian Plain shows opposite tendencies.

Seasonal and yearly average differences (%) of RR1 index compared to the reference database (E-OBS)



- CLMcom_CCLM4_MPI-ESM-LR
- ▲ CLMcom_CCLM4_EC-EARTH
- ◆ CNRM_ALADIN53_CNRM-CM5
- ▲ DMI_HIRAM5_EC-EARTH
- KNMI_RACMO22E_HadGEM2-ES
- MPI-CSC_REMO2009_MPI-ESM_r1
- MPI-CSC_REMO2009_MPI-ESM_r2
- SMHI_RCA4_HadGEM2
- ▲ SMHI_RCA4_MPI-ESM-LR
- SMHI_RCA4_EC-EARTH

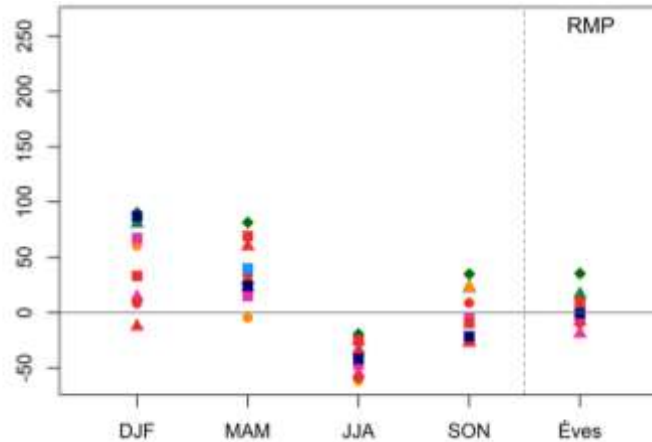
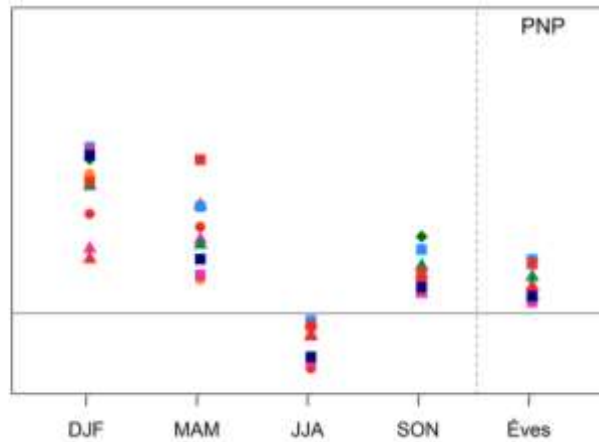
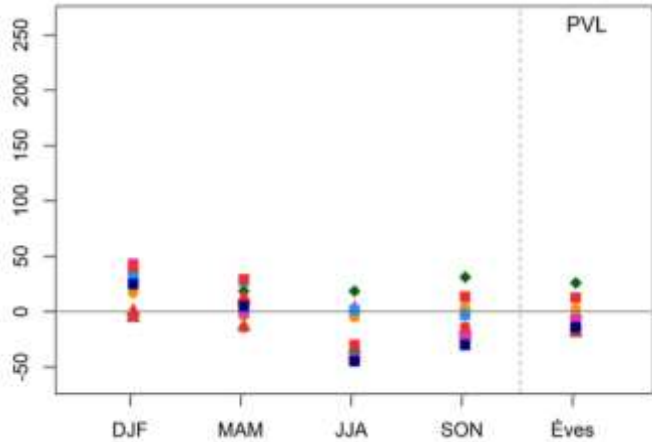
RR1 index:

PVL -- **over-estimation**

PNP -- **over-estimation**

RMP -- **slight over-estimation**

Seasonal and yearly average differences (%) of **RR10** index compared to the reference database (E-OBS)



- CLMcom_CCLM4_MPI-ESM-LR
- ▲ CLMcom_CCLM4_EC-EARTH
- ◆ CNRM_ALADIN53_CNRM-CM5
- ▲ DMI_HIRAM5_EC-EARTH
- KNMI_RACMO22E_HadGEM2-ES
- MPI-CSC_REMO2009_MPI-ESM_r1
- MPI-CSC_REMO2009_MPI-ESM_r2
- SMHI_RCA4_HadGEM2
- ▲ SMHI_RCA4_MPI-ESM-LR
- SMHI_RCA4_EC-EARTH

RR10 index:

PVL -- small differences
PNP -- seasonally different bias
RMP -- seasonally different bias
 (mostly overestimation, except in summer)

Conclusion

- The occurrence and intensity of extreme precipitation events **increased** in all regions, while the number of **RR1 days decreased** in two regions. These results imply the **general intensification of all precipitation events**.
- The significant increase of DS10 and DS5N indices in two regions imply the **occurrence of longer dry periods**.



Which means: Precipitation events in these regions occurs **less often** and **become more severe**. Together with the longer dry periods the extreme precipitation events **result in higher natural and hydrological hazards**.



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Thank you for your attention