

Explaining recent trends in extreme precipitation in the Southwestern Alps by changes in atmospheric influences

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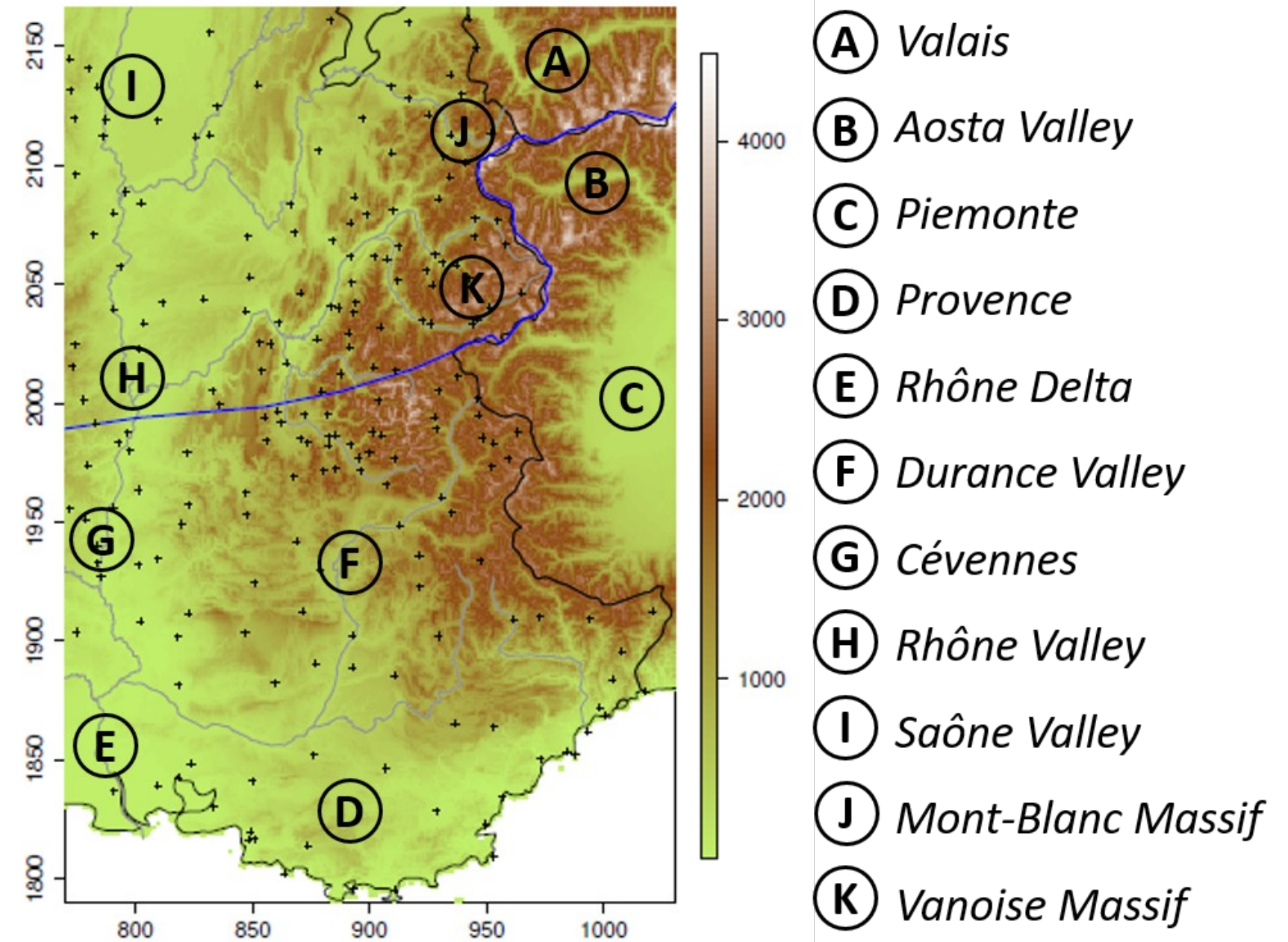
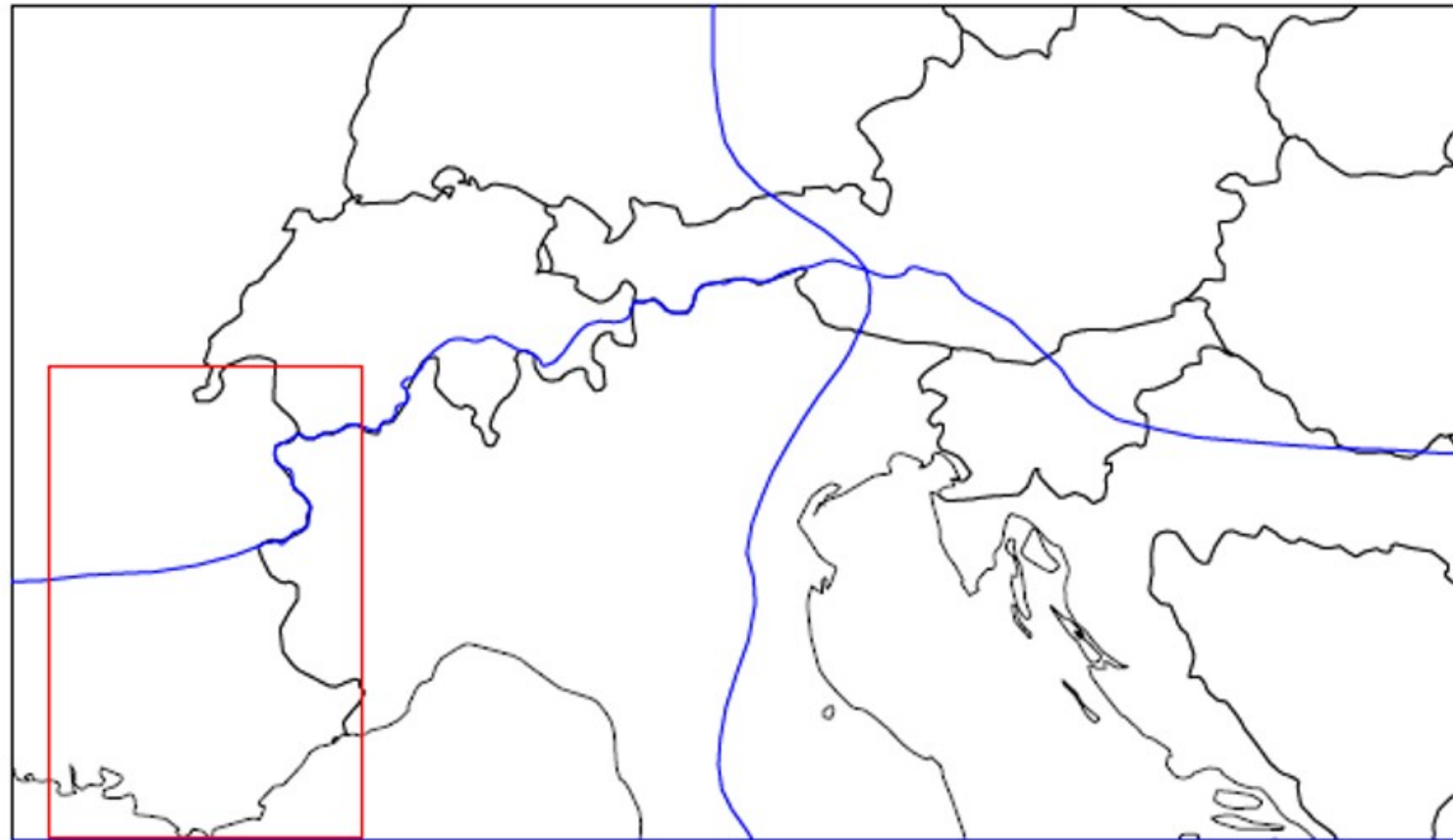
Introduction

- Quantifying past and future precipitation changes due to climate change is important but still very difficult, particularly for the extremes whose observations are by nature seldom and variable.
- In the literature, various trends in Alpine precipitation have been found depending on both the season, the temporal scale and the area of study.
- Several studies attempted to link the changes in extreme precipitation in the Alpine region to the *magnitude* of large-scale atmospheric variables.



Can changes in extreme precipitation be explained by *changes* in large-scale climate variable ?

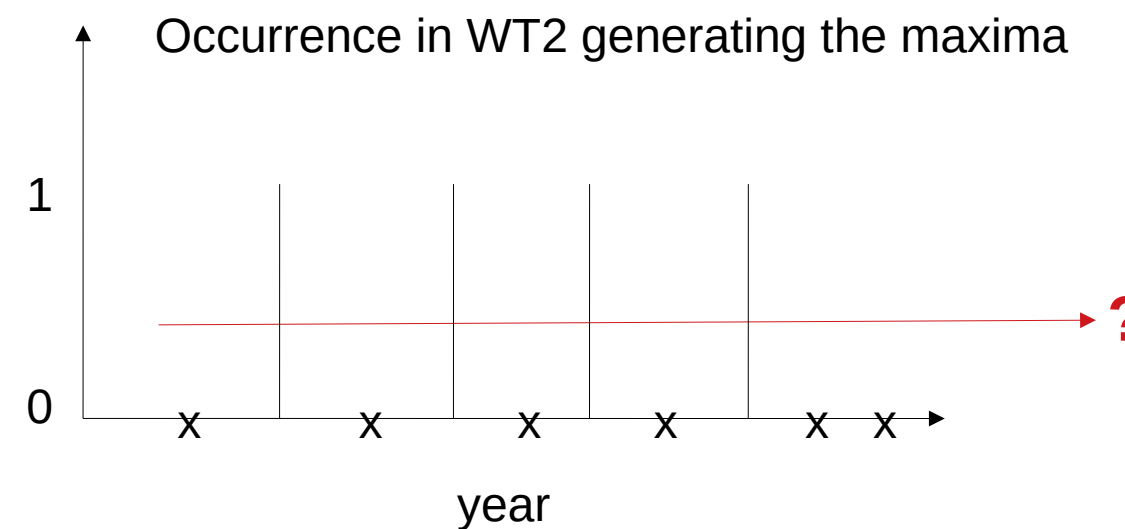
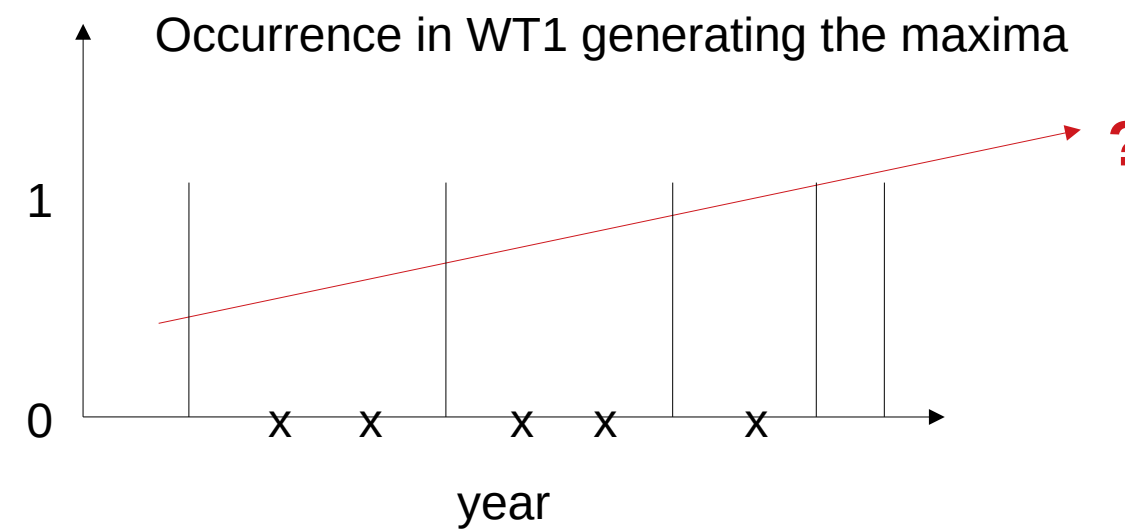
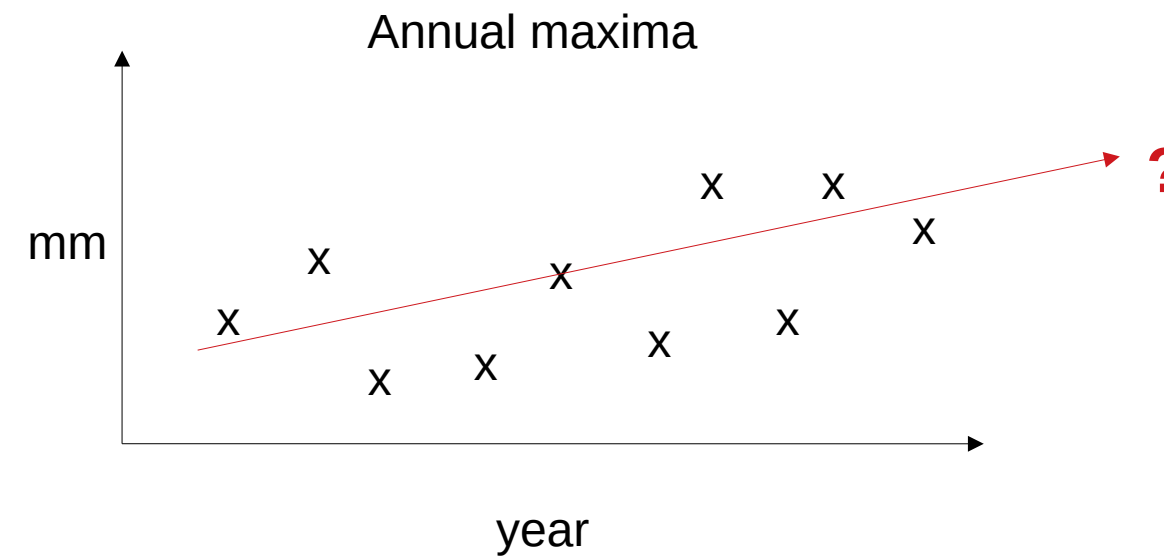
Region of study



- SPAZM dataset (Gottardi et al. 2012) : daily gridded precipitation 1958-2017
- We compute the series of seasonal maxima at each grid point (DJF, MAM, JJA, SON).
- We consider the series of weather types for the days of the maxima :
WT1 Atlantic, WT2 Mediterranean, WT3 Northeast, WT4 Anticyclonic (Garavaglia et al. 2012)

General method

	Annual maxima (mm)	
1958	69	→ Max on Oct 11 1958 = WT1
1959	75	→ Max on Nov 7 1959 = WT2
1960	58	→ Max on Nov 27 1960 = WT1
⋮	⋮	
2017	77	→ Max on Sep 22 2017 = WT2

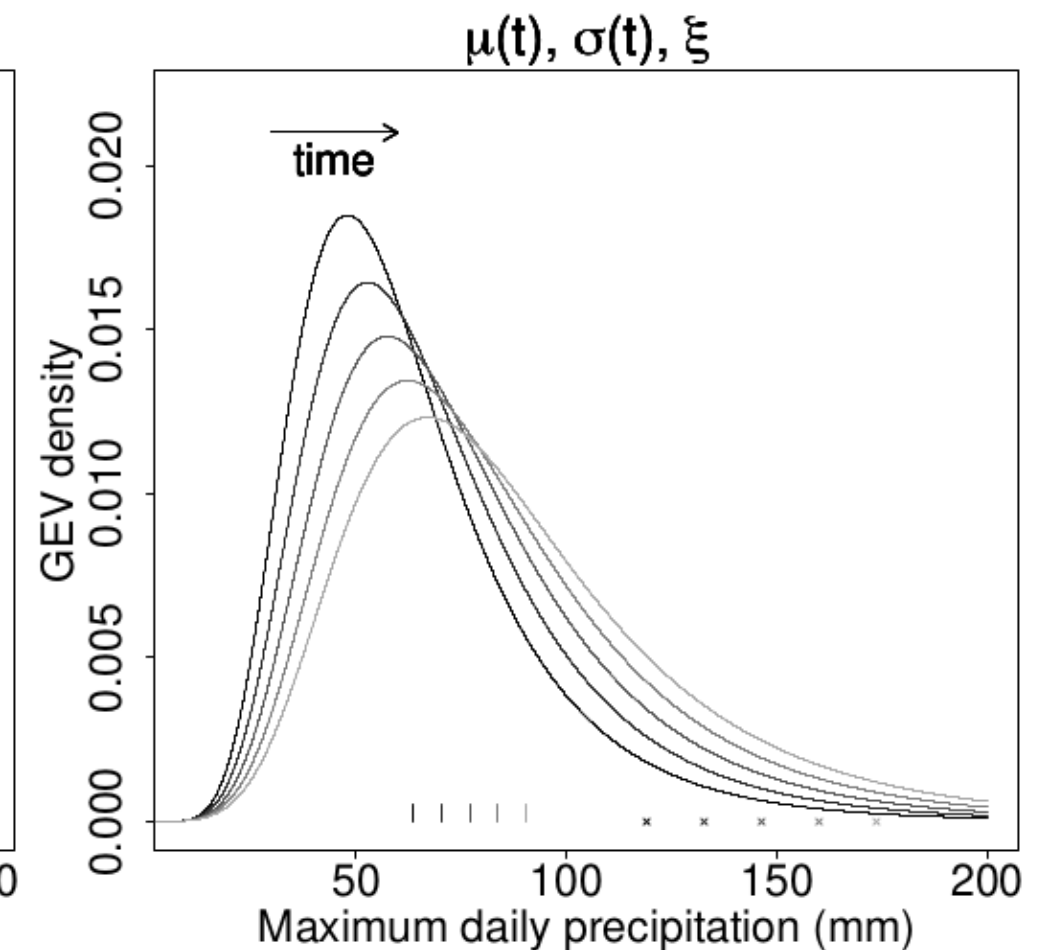
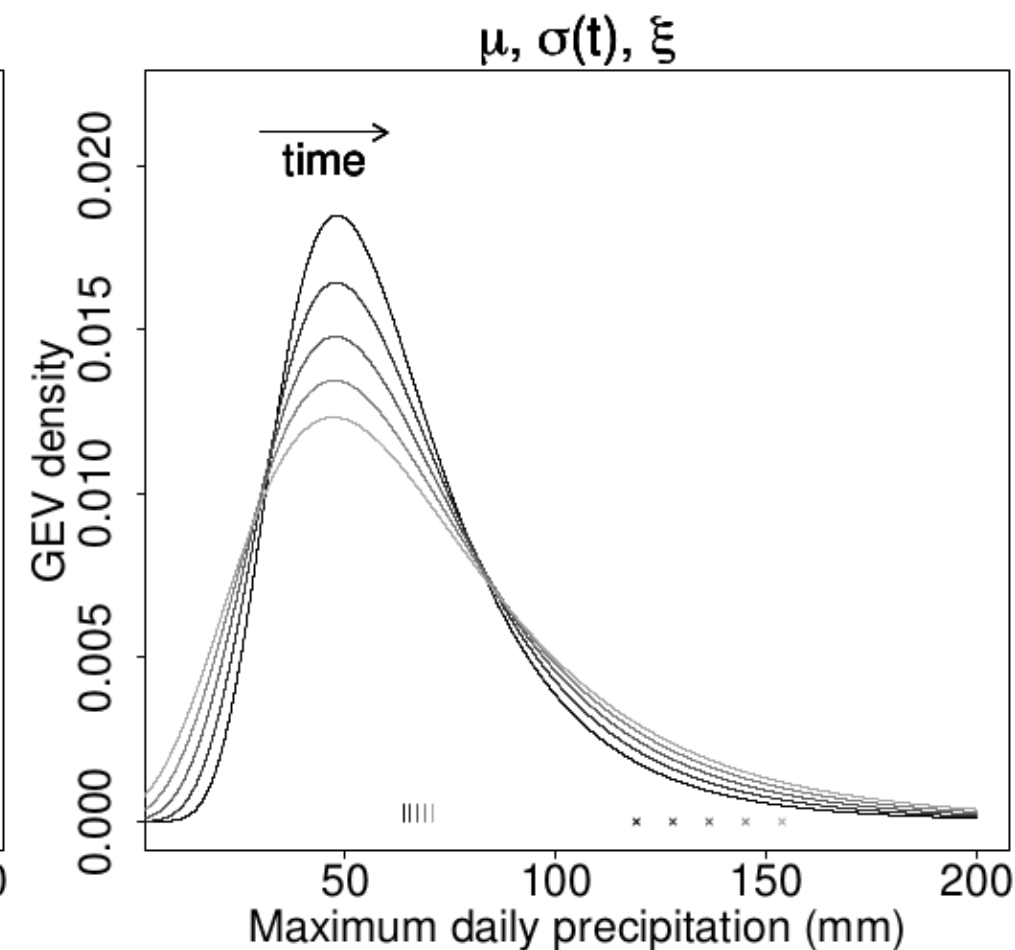
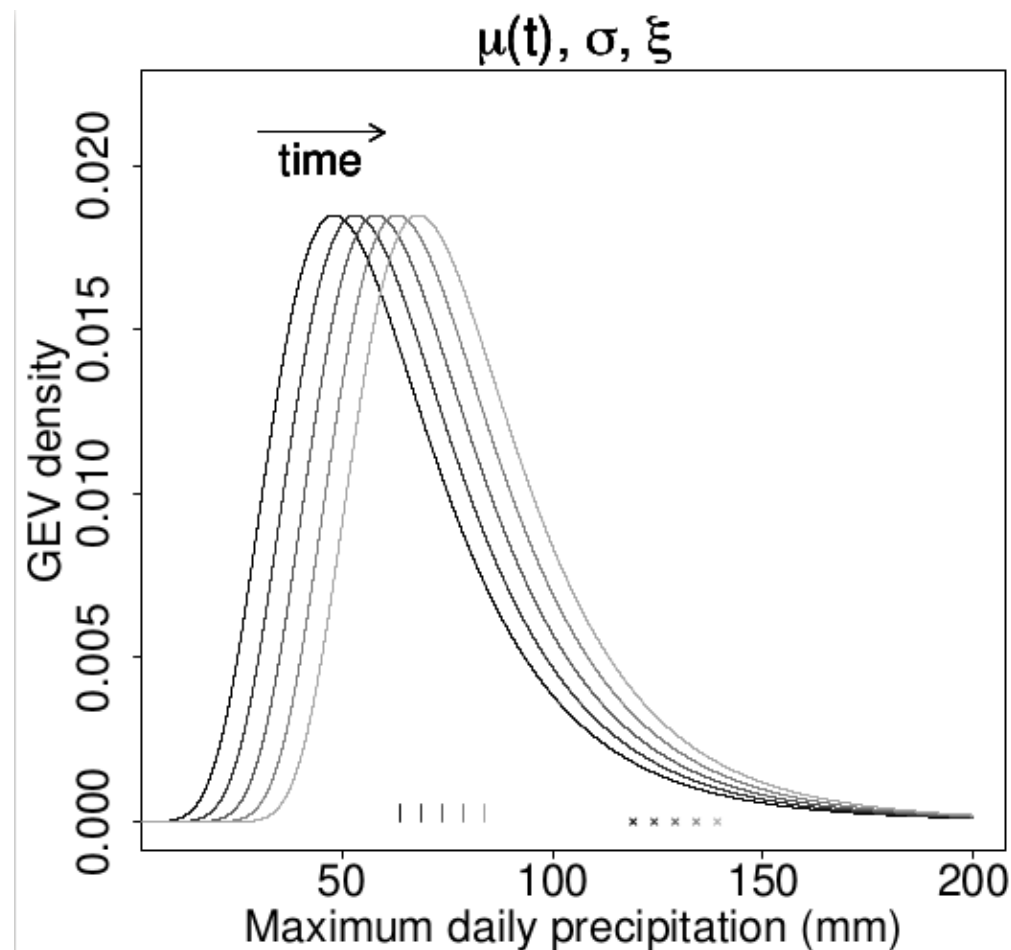
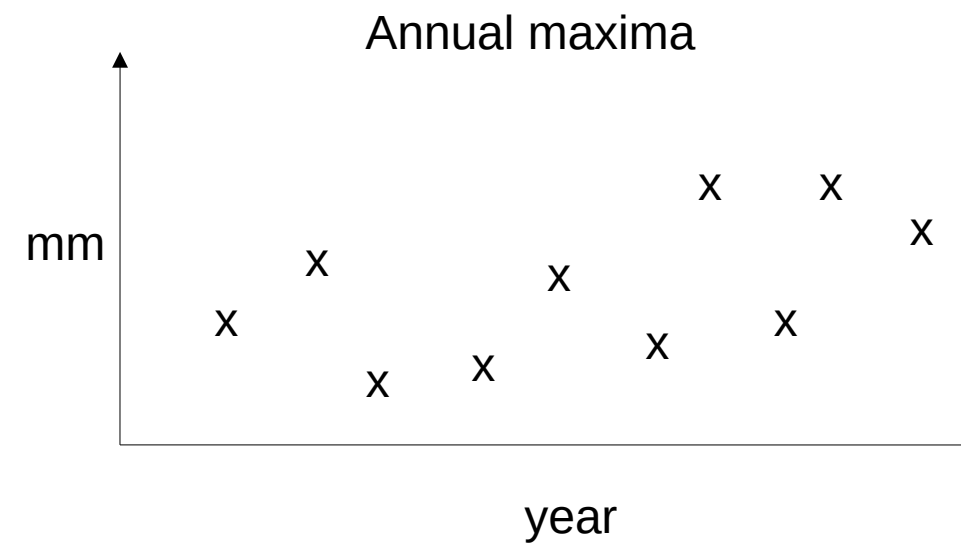


=> **Independent** estimation of trends in :

A) extreme precipitation B) occurrence of the weather type generating the extremes, for each WT.

A) Trend in extreme precipitation

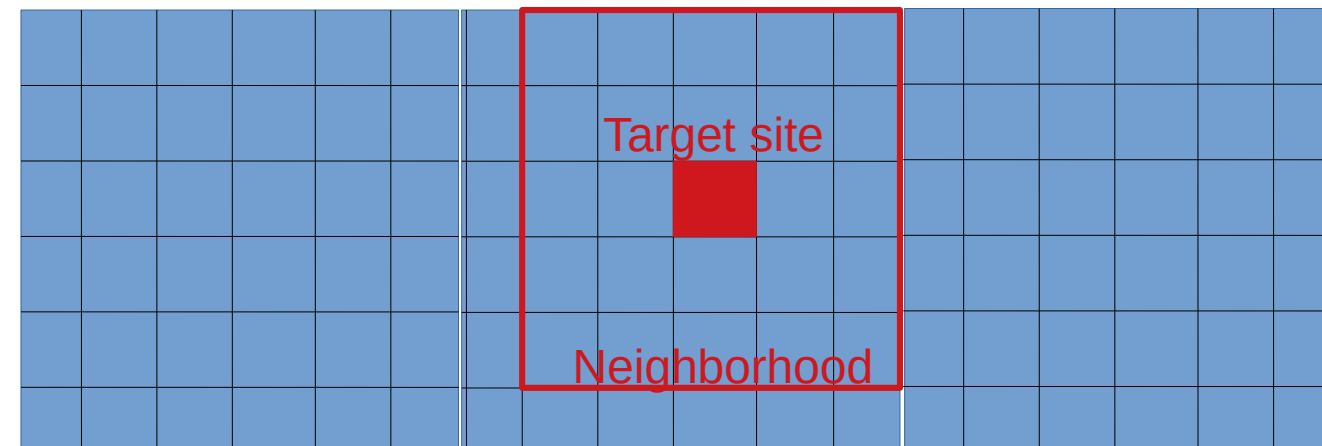
Method : non-stationary GEV distribution



A) Trend in extreme precipitation

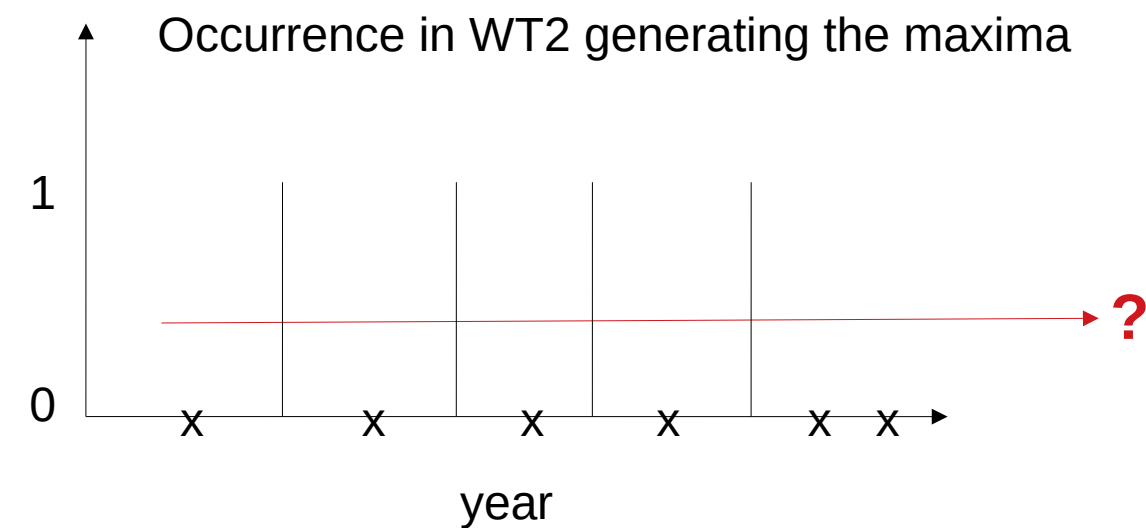
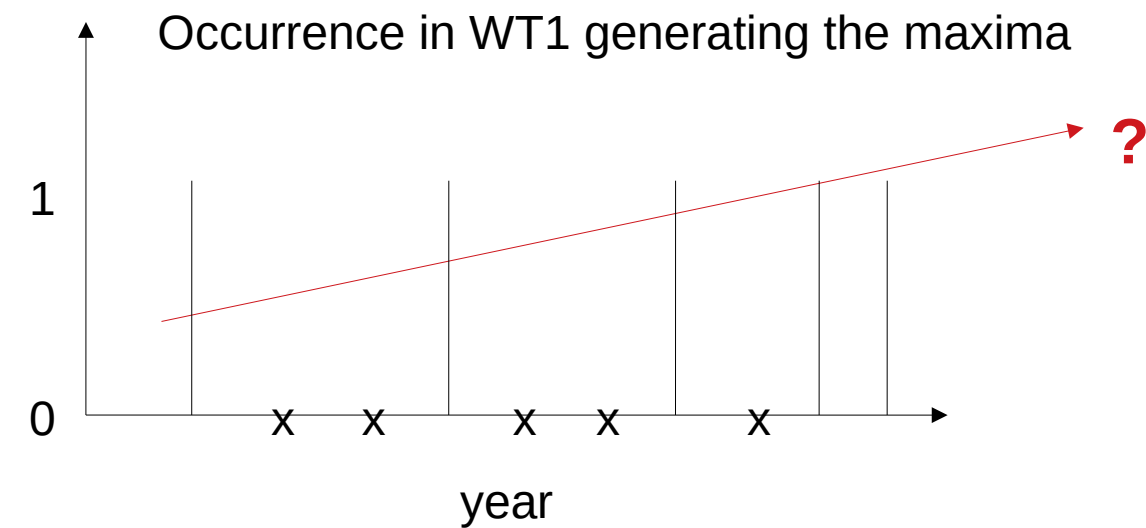
Model inference : neighborhood approach

- Pooling the data in the neighborhood of a given site in order to create a (much) bigger time series of precipitation maxima, and thus to increase robustness of estimation.



- The neighborhood must be such that the pooled data are homogeneous in distribution after appropriate normalization.
- Here : normalization by the mean annual maxima.
- The largest homogeneous neighborhood for the normalized variables is determined with the method of Hosking et al. 1985 (testing the L-CV).
- The neighborhoods are considered as circles centered on the target sites, whose radii are allowed to change from one site to another in order to fulfill the homogeneity assumption.
- Spatial declustering : whenever more than one maximum occur the same day among the sites of the neighborhood, we assume that these maxima are associated to the same meteorological event and we keep only the largest maximum.
- Maximum likelihood estimation (independence) and likelihood ratio test for assessing trend significance

B) Trend in atmospheric influences generating the maxima Method



For each WT and each grid point, we fit a logistic regression with time as covariate.

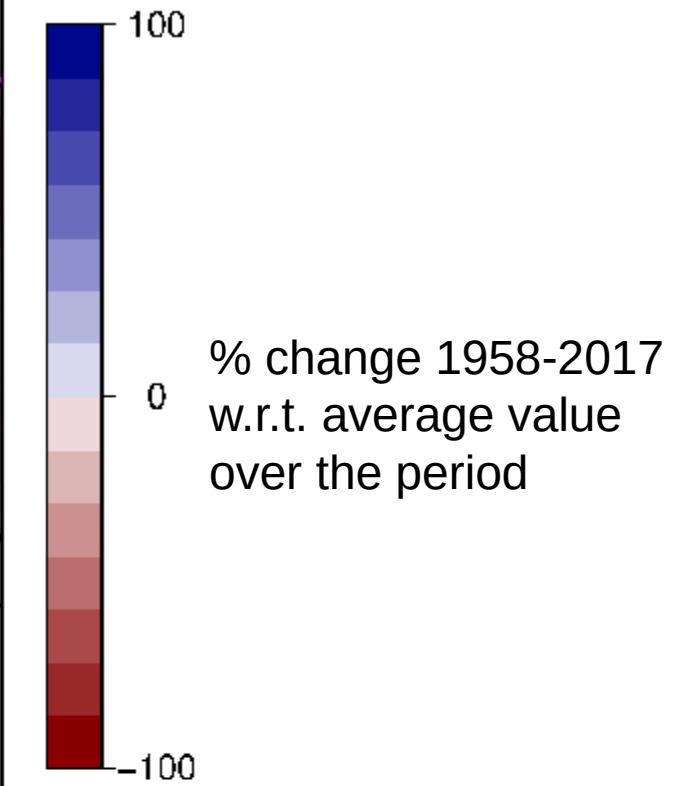
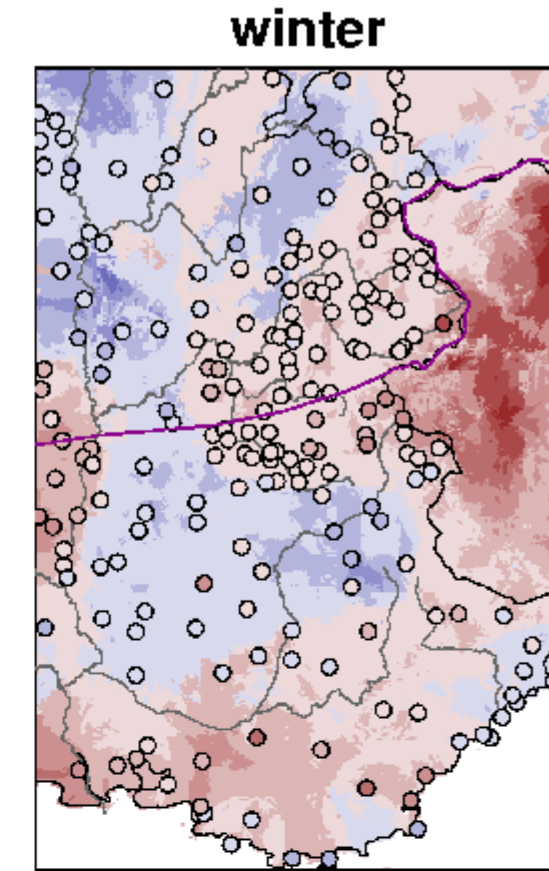
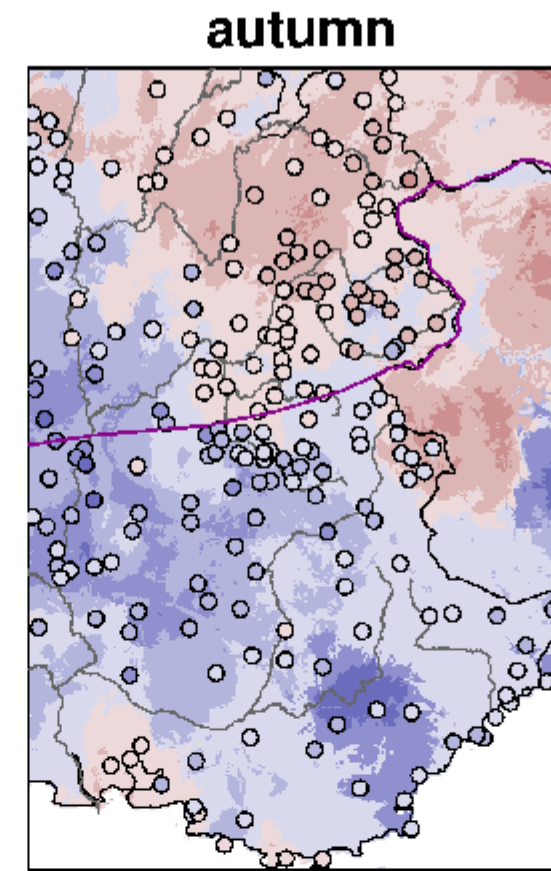
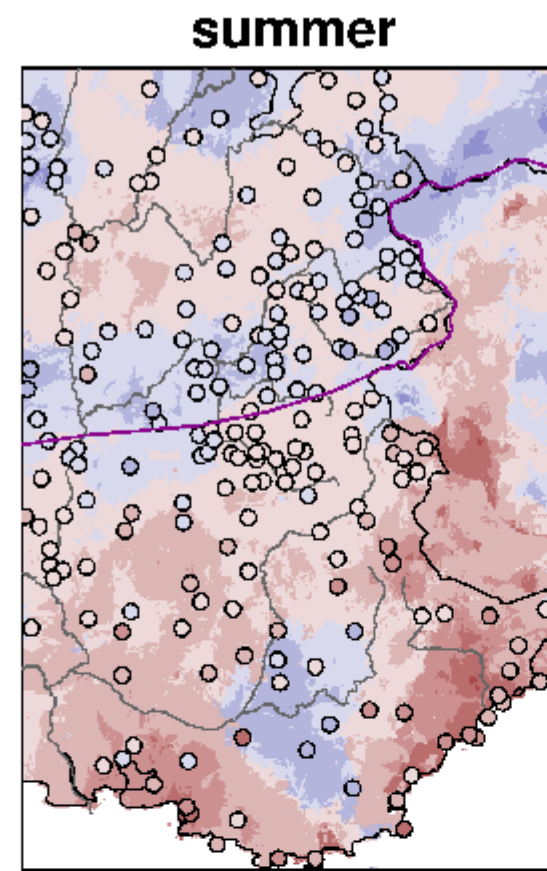
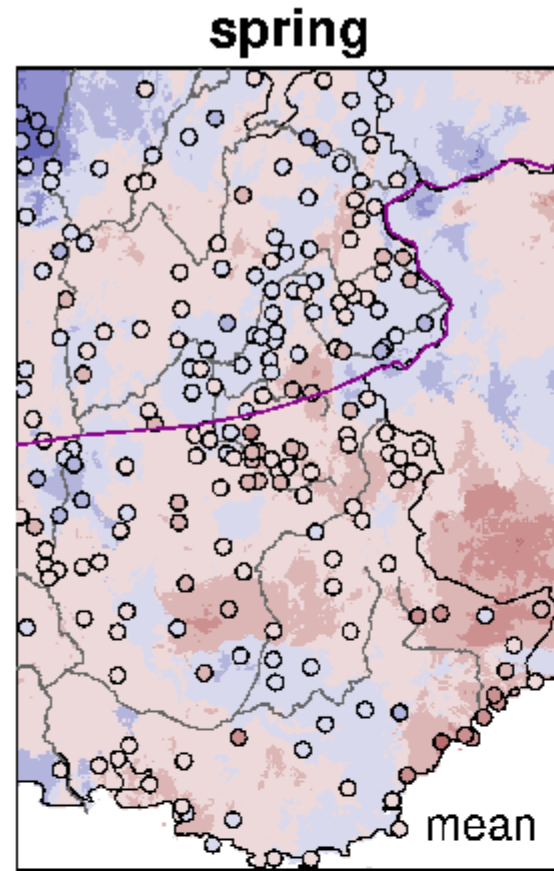
Reference : Blanchet et al. 2020

Finally, we predict for each grid point:

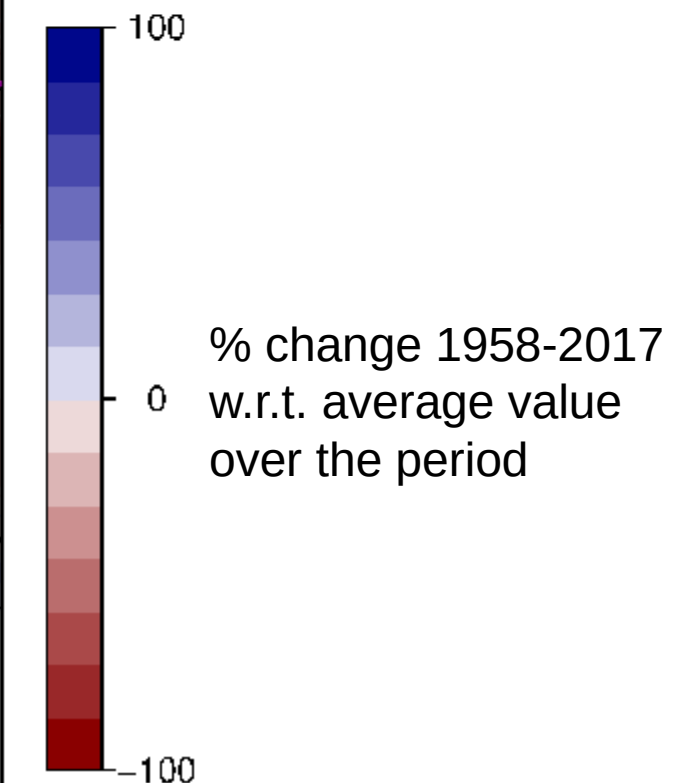
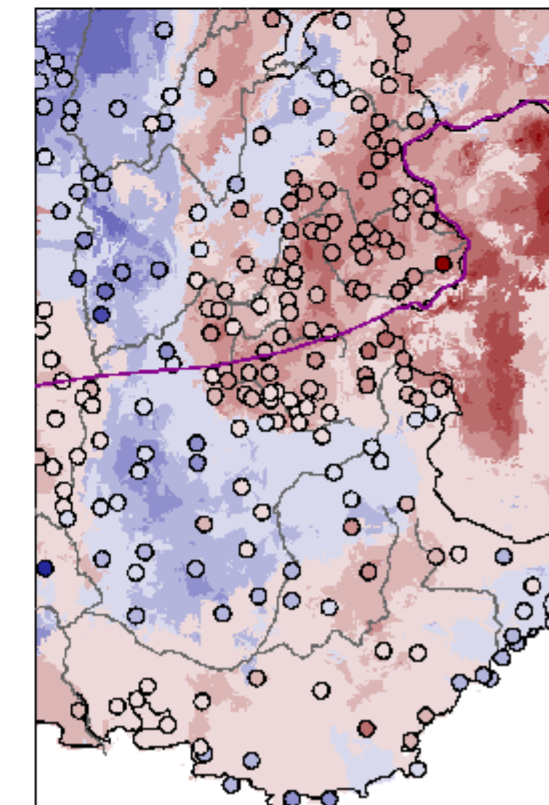
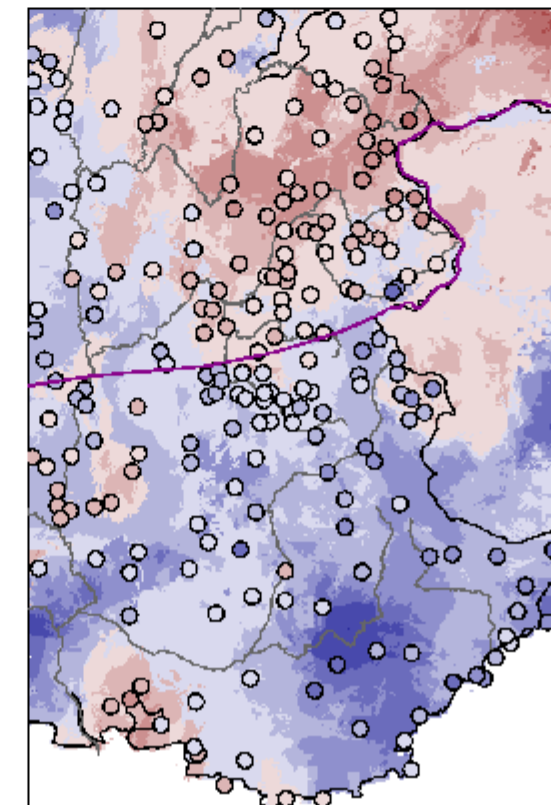
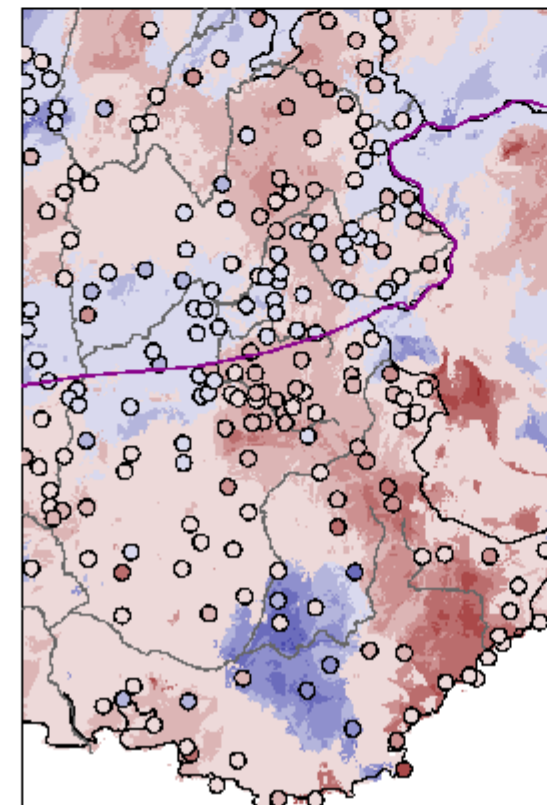
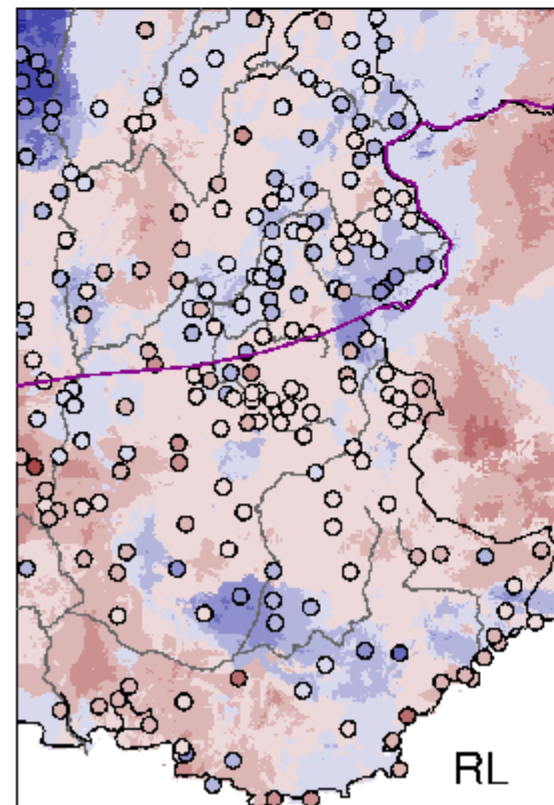
- the most likely WT generating the max in 1958
- the most likely WT generating the max in 2017

Results : Trend in extreme precipitation

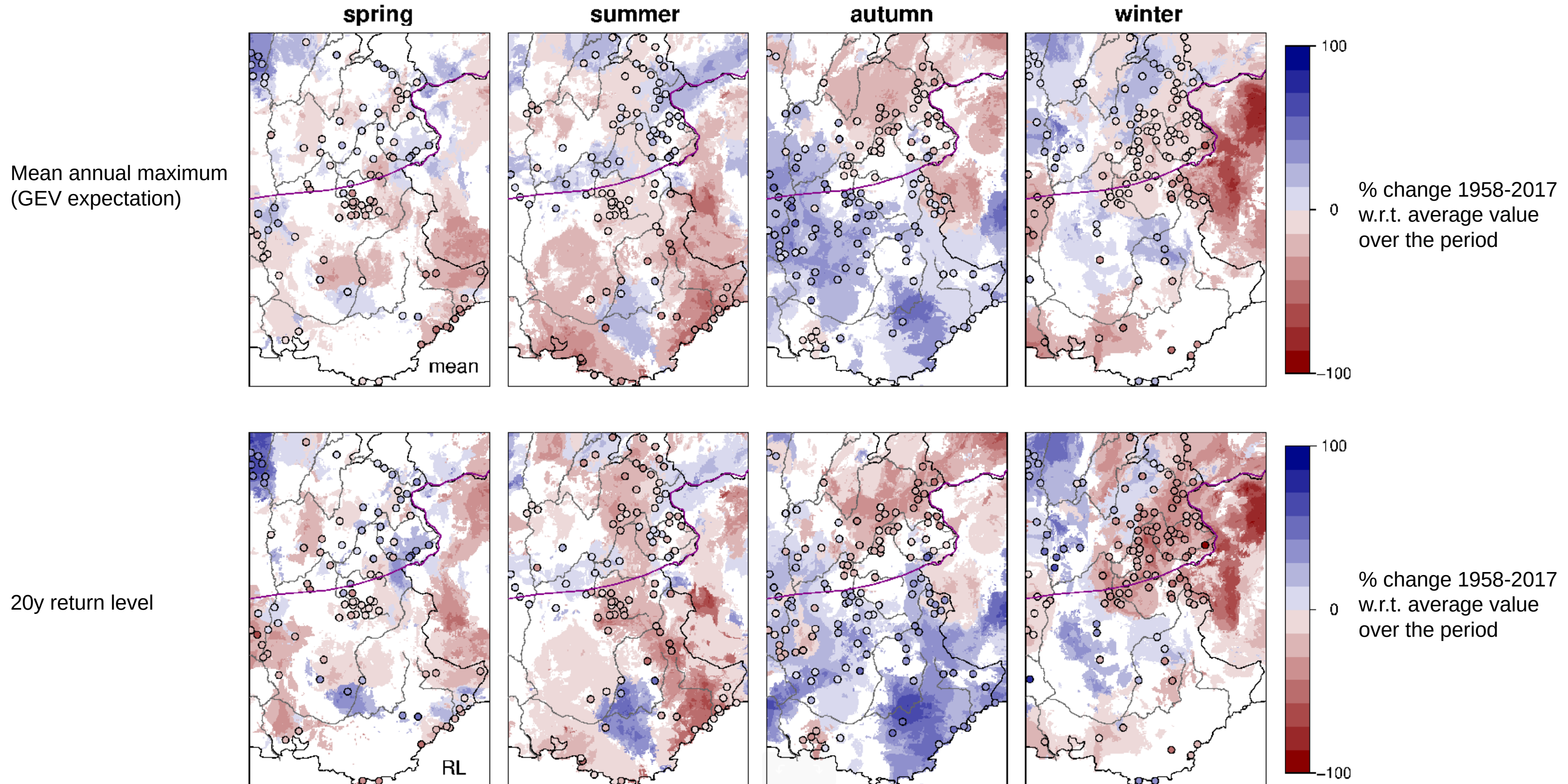
Mean annual maximum
(GEV expectation)



20y return level

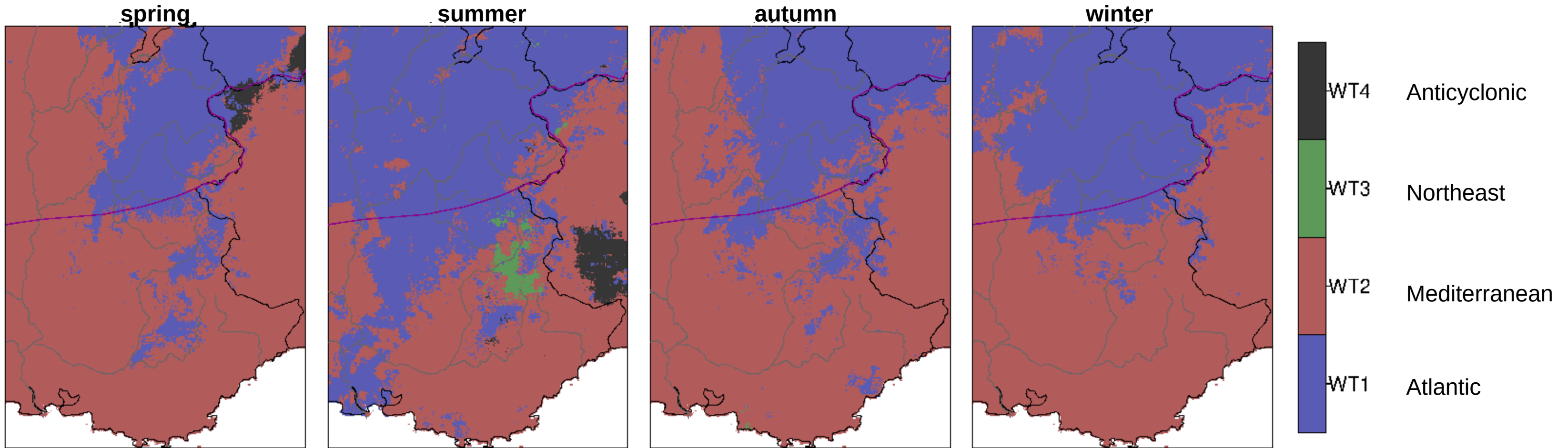


Results : Trend in extreme precipitation (non-signif. masked)

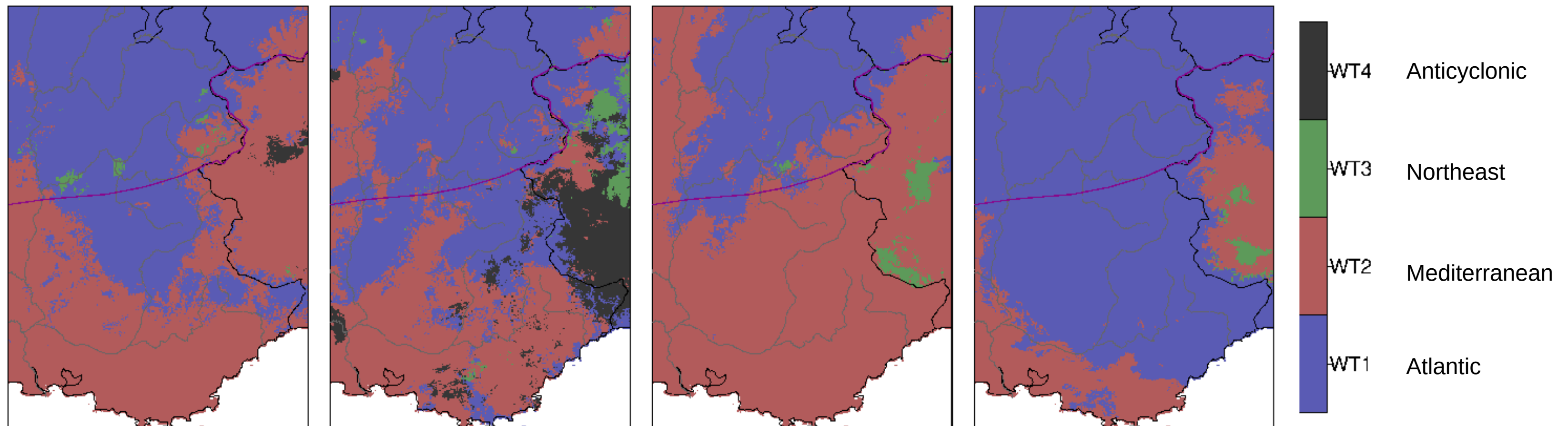


Results : Trend in atmospheric influence generating the maxima

Most likely
influence
generating
the max in
1958



Most likely
influence
generating
the max in
2017



Conclusion: Trend in extreme precip. vs. atmospheric influence

- **Extreme precipitation :**

- The results show contrasting trends in extreme precipitation depending on the season.
- In autumn, the trends are significantly increasing in most of the Southwestern Greater Alpine Region, with an increase up to 100% the average 20-year return level between 1958 and 2017, while the French Alps show mainly decreasing extremes.
- In winter, the valleys and medium mountain areas surrounding the Northern French Alps show significant increasing extremes, while the inner French Alps, the Swiss Valais and the Aosta Valley show significant decreasing trends.
- In the other seasons, the significant trends are mostly negative in the Mediterranean area, while the French Alps show less organized and contrasting trends.
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- **Link with change in atmospheric influence generating the maxima :**

- For all seasons, part of the significant changes in extremes can be related to changes in the dominant atmospheric influences generating the maxima, particularly in the Mediterranean influenced region that shows the most organized trends.
- In particular, the strong positive trends in autumn in Southern France are concomitant with an increase in Mediterranean influence generating the maxima.
- However some exceptions are notable with counter-intuitive trends in extremes given the trends in dominant influences.

References

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