# Mixing weather types and daily precipitation modelling as an approach to obtain climatic precipitation regions in mountain areas

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## Objectives

The present study addresses three main objectives:

1. to perform an **objective synoptic classification** centred on Western Europe, and therefore valid for the Pyrenees;
2. to **interpolate the mean daily precipitation (MDP)** values for each weather type;
3. to present an improved-proposal for **objective regionalization of precipitation regimes** in the Pyrenees by means of a non-supervised clustering method;
4. generating a **synthetic annual precipitation series for each region** derived from the previous clustering

## Study area and database

- Daily mean sea level pressure (mslp) was provided by the ERA-20C reanalysis at 18 UT, enveloping the area 30°N-55°N and 12°W-15°E at a spatial resolution of 1° for the 1961-2010 period.
- The precipitation database used was provided thanks to the international cooperative effort of 4 meteorological institutions within the framework of the Interreg Project POCTEFA CLIM'PY: AEMET (Spain), MeteoFrance (France), SMC (Catalonia, Spain) and CENMA-IEA (Andorra).
- We used 349 daily precipitation series distributed throughout the study area.
- All the covariates used in the regression models were developed from a 90 x 90 m DEM extracted from the Shuttle Radar Topography Mission (SRTM).

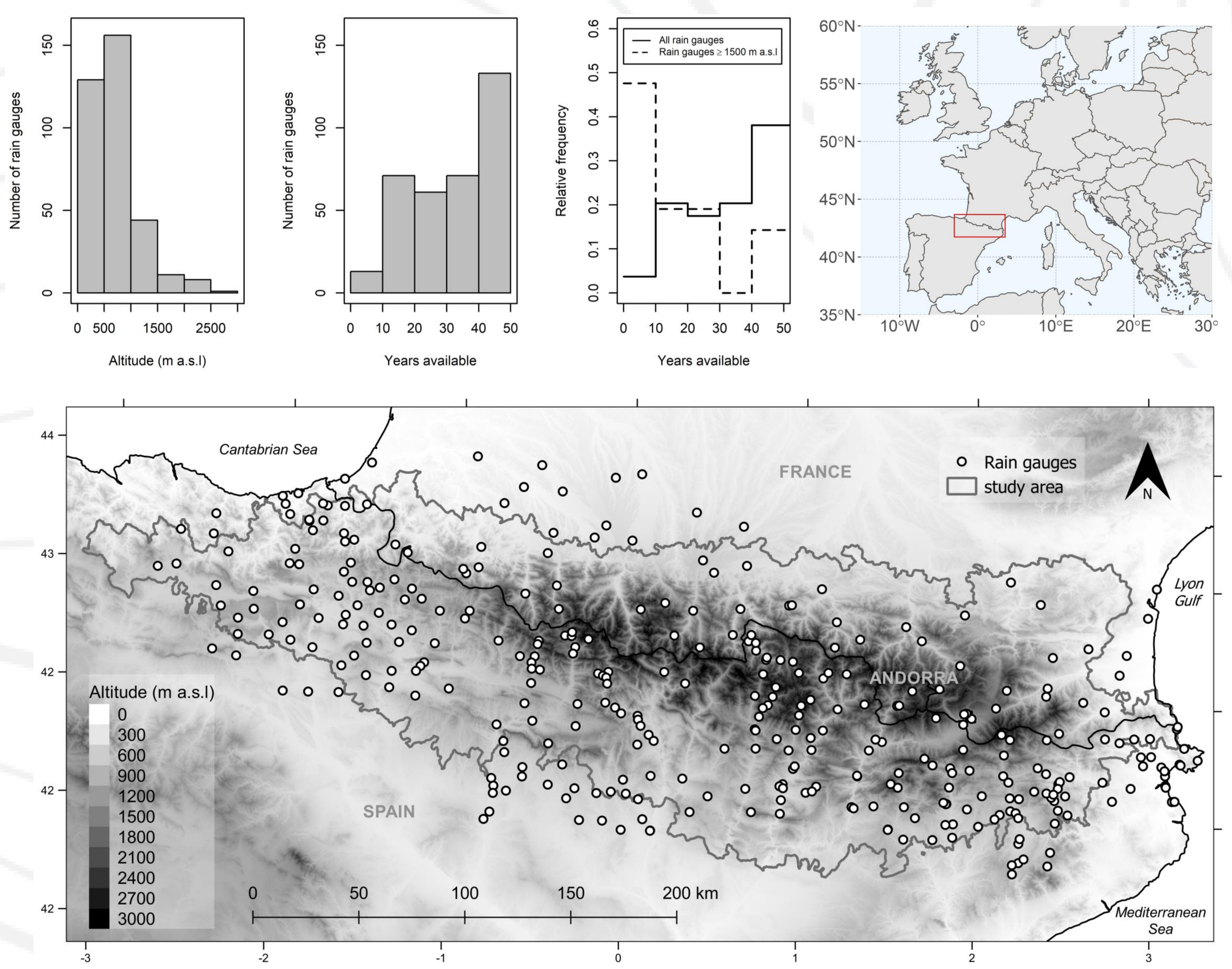


**Fig.1: Topographic map of study area (bottom), setting within Europe (top right), and elevation and yearly availability distribution of rain gauges (top left)**

## Methods

- To derive the **atmospheric circulation catalogue**, we applied a S-mode **PCA** and a **K-means** clustering to the mean sea level pressure data.
- Then, **mean daily precipitation maps were computed by each weather type** and for 3 different regression models: Generalized Linear Models (**GLM**), Generalized Additive Models (**GAM**) and Regression Kriging (**RK**).
- Finally, we used the mean daily precipitation models based on the weather types to derive **precipitation regions and their annual trends, following the scheme** showed in **Fig. 2**.

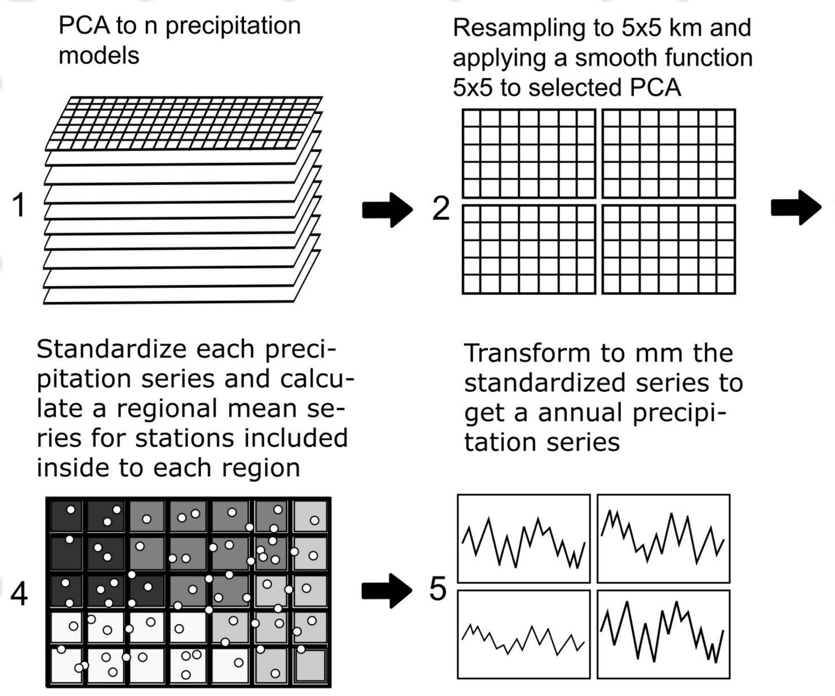


**Fig.2: Step-by-step flow chart showing the procedure designed to obtain the precipitation regions (clustering map) and the annual precipitation regional series.**

## Synoptic classification: deriving the main weather types (WT)

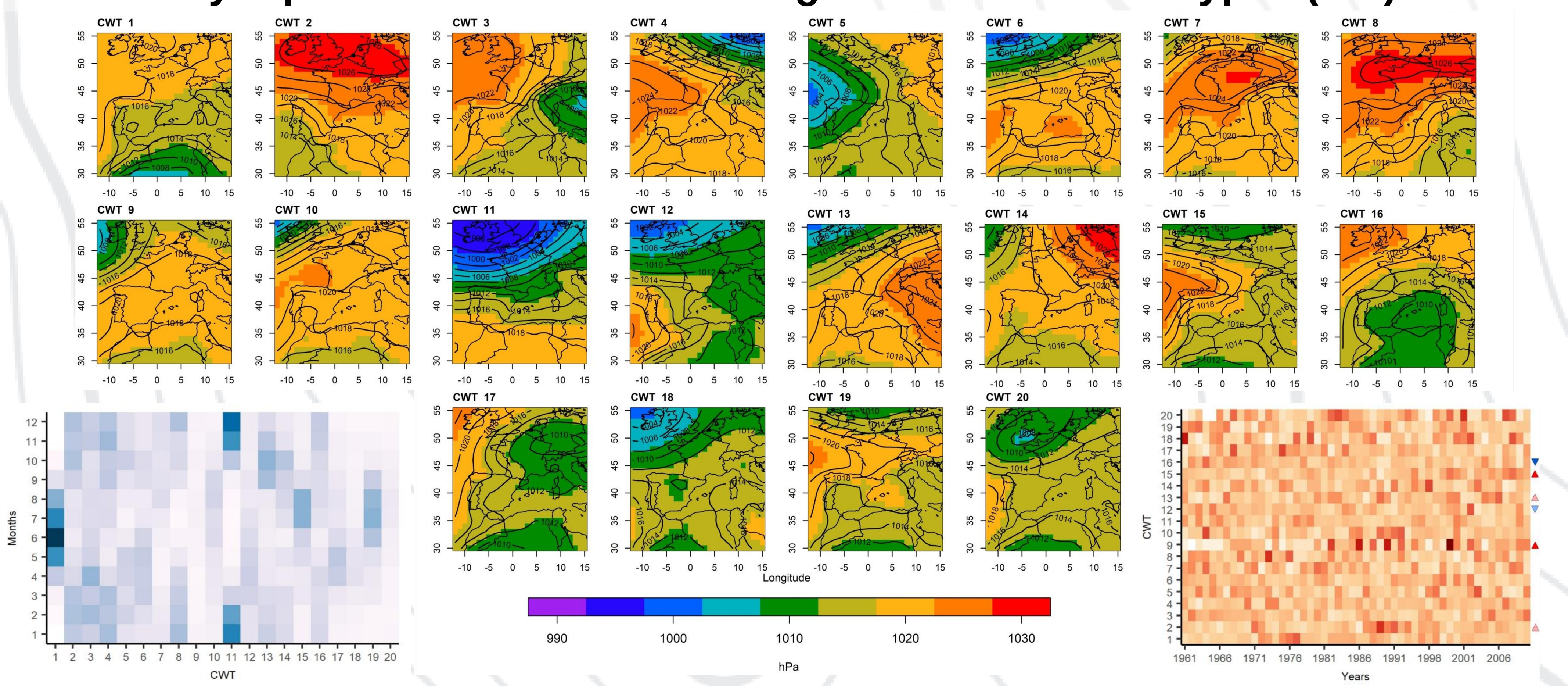


**Fig.3: Spatial representation of the mslp field obtained for each WT over the study area (centre). Relative frequencies in percentage of each WT by months (bottom left) and annual relative frequency in percentages of each WT during the 1961-2010 period (bottom right).**

## Spatial modelling of mean daily precipitation amounts based on the WTs

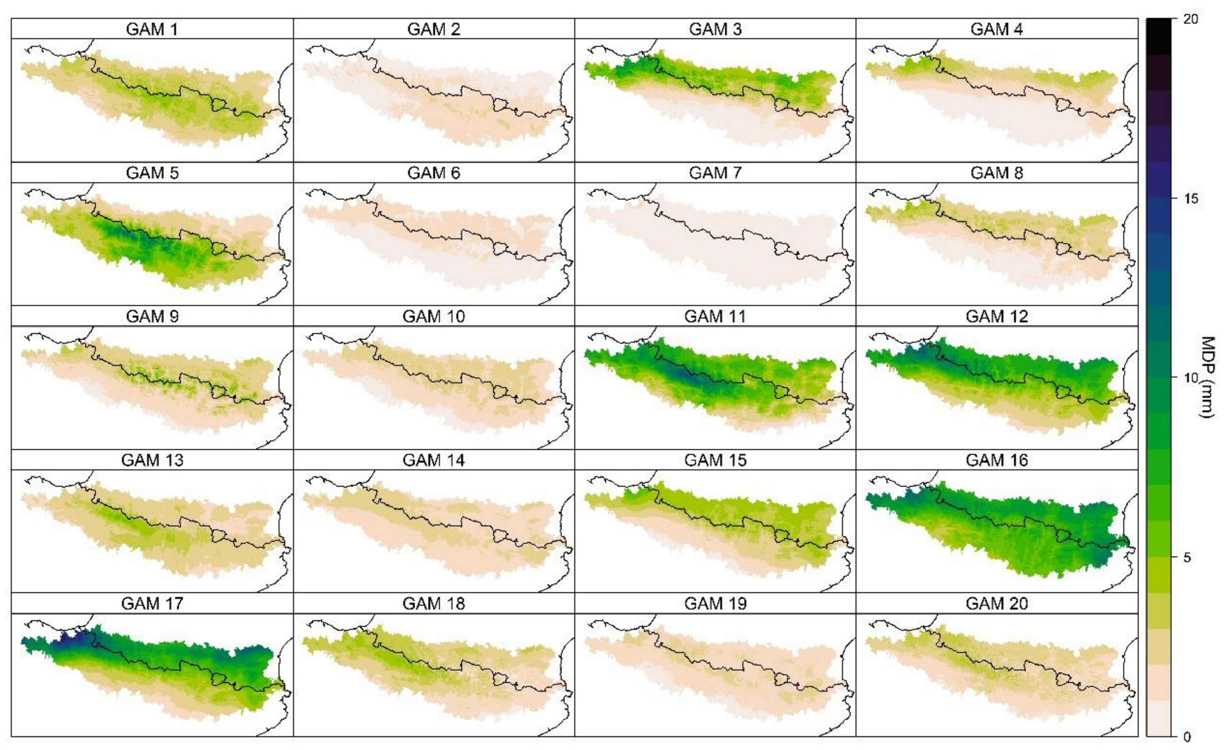


**Fig.4: Results of the GAM interpolation method for each model related to each WT. Despite of RK models obtained the best adjustment (Fig.5), the GAMs were used to perform the spatial regionalization (Fig.6) due to its greater spatial continuity.**

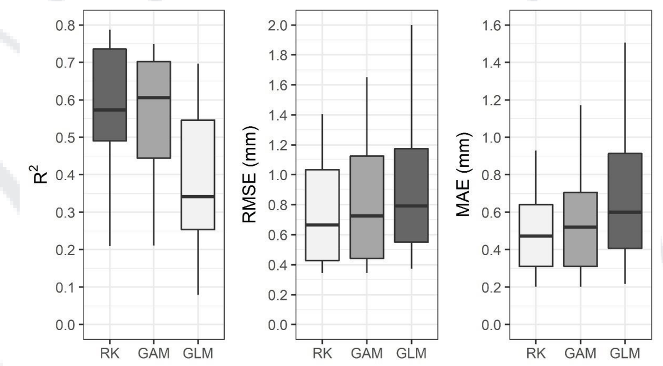


**Fig.5: Global fitness of regression models GLM, GAM and RK evaluated through R2, RMSE and MAE indices.**

## Precipitation regions and their annual trends

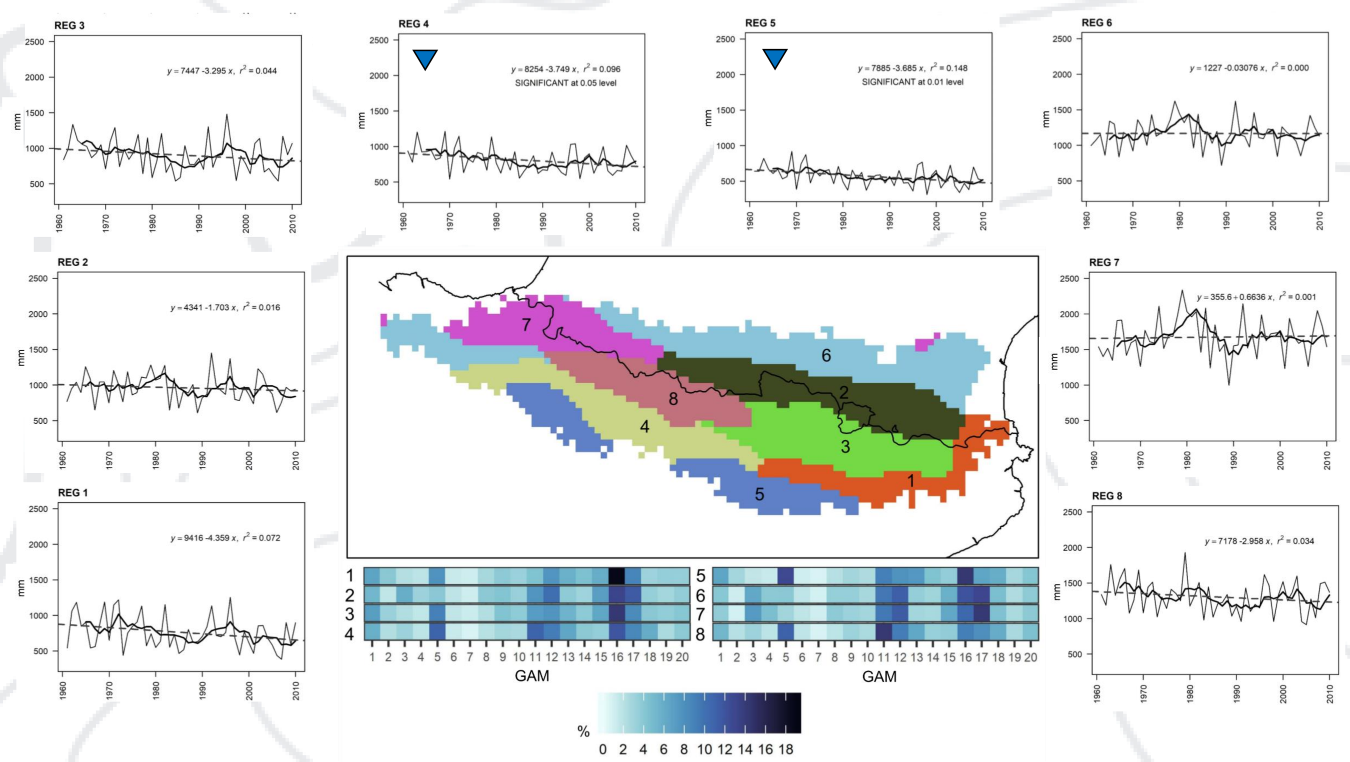


**Fig.6: Result of the clustering procedure. The daily precipitation efficiency of each WT model is calculated for each region and shown below the map. Around the map, the annual temporal evolution and trend of precipitation (mm) over each cluster region are showed.**

## Results

- The results obtained from the annual trend of the daily frequency of the WTs (Fig.3) indicated a **statistically significant decrease in WTs dominated by low pressures**, i.e. types that denote high MDP records. 4 WTs with a **predominance of high pressures** and low MDP values **tended to show an statistically increase**.
- The **RK** and **GAM** methods obtained a better accuracy than the **GLM**, because of the linear dependence between the dependent and independent variables (Fig.4).
- **8 precipitation regions were obtained** (Fig.6) for the Pyrenees using the proposed procedure. Of these 8 regions, 2 located in the southern Pyrenees indicated a significant trend to decrease annual precipitation.

## Conclusions

- A robust method to obtain precipitation regions in mountain areas mixing weather types and spatial daily precipitation amounts was presented.
- This regionalization allowed us to study the behaviour of precipitation by regions with the same pluviometric characteristics.

## Reproducibility

**synoptReg** is an R package that contain a set of functions to perform the whole process presented in this poster.

***Step-by-step tutorial for using synoptReg***

## Acknowledgements

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