Modeling moderate and extreme urban rainfall at high spatio-temporal resolution

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Precipitation modeling is of great interest for flood risk analysis. While severe floods can result from extreme rainfall events, some of them can appear due to moderate ones. This is particularly true when such moderate events persist over a long period of time or when the ground is already saturated with water. The flood risk is even greater in urban areas where water absorption is reduced by impervious surfaces. This shows the importance of analysing both extreme and moderate rainfall events and their variability in terms of space and time in urban areas.

Significant rainfall events, known as Mediterranean episodes, are common in Montpellier, in the south of France. In our study we focus on 17 rain gauges in Montpellier in the water catchment of the Verdanson, a tributary of the Lez (see Figure 1). The rainfall measurements from these stations are provided by the urban Observatory of the HydroScience Montpellier (OHSM) (see Finaud-Guyot et al., 2023). They cover a period of 4 years with a high temporal resolution of 5 minutes. In terms of spatial granularity, we also have a high resolution with a distance between two stations ranging from 77 to 1531 meters. We propose to model the spatio-temporal characteristics of these rainfall data in order to better understand the rainfall behaviour over this area. To extend our analysis to a longer period but with a less fine resolution, we combine these data with the French COMEPHORE mosaic from Météo France (see Tabary et al., 2012).

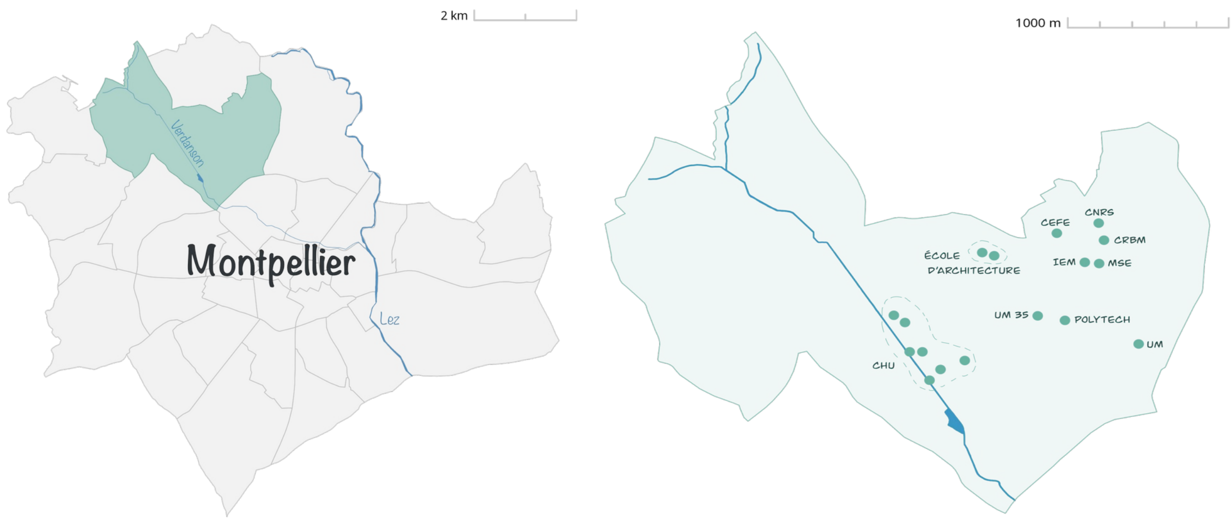

Figure 1: Study area in Montpellier and the 17 rain gauges location

For our univariate modeling approach, we consider moderate and intense rainfall simultaneously using the Extended Generalized Pareto Distribution (EGPD) introduced in Naveau et al., 2016. This family of distributions allows us to avoid explicit threshold selection to distinguish extreme from moderate rainfall events, which is often difficult in extreme statistics. This approach also simplifies parameter estimation. Our analysis on both datasets (OHSM and COMEPHORE) shows a robust fit with the EGPD, indicating a strong suitability for representing univariate distributions.

The spatio-temporal dependence is then modeled by using a spatio-temporal Brown-Resnick process and by incorporating advection, which refers to the transport of properties such as heat or moisture by the horizontal movement of air masses. The Brown-Resnick process establishes a direct relationship between the spatio-temporal extremogram and the spatio-temporal variogram. Both of which provide insight into the spatio-temporal dependence behavior and they measure the similarity or dissimilarity between process values at different locations and time points. While the variogram measures variability across the entire distribution, the extremogram focuses on the extreme part of the distribution. These autocorrelation indices show the overall variability of the rainfall distribution even for short spatial distances and short observation periods. Contrasting our dependence model with a simpler separable model highlights the importance of including advection, which is estimated using an optimization method.

References

Finaud-Guyot, P., Guinot, V., Marchad, P., Neppel, L., Toulemonde, G. (2023), Rainfall data collected by the HSM urban observatory (OMSEV).

Naveau, P., Huser, R., Ribereau, P., & Hannart, A. (2016). Modeling jointly low, moderate, and heavy rainfall intensities without a threshold selection. Water Resources Research.

Tabary, P., Dupuy, P., L'Henaff, G., Gueguen, C., Moulin, L., Laurantin, O. (2012), A 10-year (1997-2006) reanalysis of quantitative precipitation estimation over france: Methodology and first results. IAHS-AISH publication, (351), 255-260.