



**HAL**  
open science

## Stochastic extreme rainfall simulations around Montpellier

Fátima Palacios Rodríguez, Gwladys Toulemonde, Julie Carreau, Thomas  
Opitz

► **To cite this version:**

Fátima Palacios Rodríguez, Gwladys Toulemonde, Julie Carreau, Thomas Opitz. Stochastic extreme rainfall simulations around Montpellier. 8èmes journées scientifiques du LabEx NUMEV, Nov 2019, Montpellier, France. hal-02417687

**HAL Id: hal-02417687**

**<https://inria.hal.science/hal-02417687>**

Submitted on 13 Jan 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Palacios-Rodríguez, F.<sup>1</sup>, Toulemonde, G.<sup>2</sup>, Carreau, J.<sup>3</sup> and Opitz, T.<sup>4</sup>

<sup>1</sup>Facultad de Ciencias Económicas y Empresariales. Universidad Complutense de Madrid. Madrid, España. [fatima.palacios@ucm.es](mailto:fatima.palacios@ucm.es)

<sup>2</sup>Institut Montpellierain Alexander Grothendieck, Université de Montpellier. Équipe LEMON, Inria. Montpellier, France. [gwlady.toulemonde@umontpellier.fr](mailto:gwlady.toulemonde@umontpellier.fr)

<sup>3</sup>HydroSciences Montpellier, IRD, Université de Montpellier. Montpellier, France.

<sup>4</sup>BioSP, INRA. Avignon, France.



**Generic Direction:** Data, Algorithms & Computations.

**Training:** Post-doc.

**Key words:** Extreme-value theory; Space-time Pareto processes; Stochastic simulation; Heavy rainfall events.

**Abstract :** To better manage the risks of destructive natural disasters, impact models can be fed with simulations of extreme scenarios to study sensitivity to temporal and spatial variability. We propose semi-parametric stochastic simulation of realistic spatio-temporal extreme fields using a moderate number of observed extreme space-time episodes to generate an unlimited number of extreme scenarios of any magnitude. Our framework draws sound theoretical justification from extreme value theory, building on generalized Pareto limit processes. For illustration on hourly gridded precipitation data in Mediterranean France, we calculate risk measures using extreme event simulations for yet unobserved magnitudes.

## MOTIVATION

Heavy rainfall events have a considerable human and economic impact  
Requirement of a wide catalogue of realistic extreme rainfall scenarios in order to lead impact studies  
But scarcity of observed extreme episodes  
Reconstructing spatial forcing scenarios as close to reality as possible is essential  
Study of rainfall-induced flood risk in urban areas

## High-dimensional rainfall data-set

Rainfall is one of the most complex meteorological processes

- \* Reanalysis data-set= Radar signals + precipitation totals from gauges.
- \* Hourly rainfall totals (mm).
- \* 10914 cells covering a 133,2 kms x 104,3 kms area in Mediterranean France.
- \* Years: from 1997 to 2007.

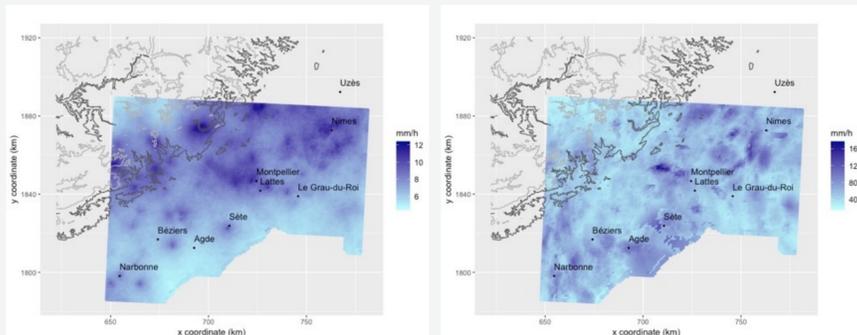


Figure 1. Empirical return levels at 98 % (left panel) and maxima (right panel) of hourly precipitation intensities for each grid cell in our study area from 1997 to 2007.

## How to define extreme episodes?

Extreme rainfall episodes could be  
- localized with high intensity and lasting a few hours  
- long-lasting events with moderate intensities affecting large areas

- \* Using a cost-functional depending on: the nature of the considered phenomenon, on the data set, on the objective of the study.
- \* Cost-functional in a space-time window exceeds a threshold  $u$ .  
Examples: mean, accumulation, maximum.
- \* Cost-functional over  $u$ :  $h$  consecutive hours with precipitation, in average, always above  $u$ .

## Step 1 : Selection/extraction of extreme episodes from data

Episode	Spatio-temporal mean	Spatial maximum
1st	2005-09-06 12:00:00	2005-09-06 14:00:00
2nd	1999-09-03 07:00:00	1999-09-13 23:00:00
3rd	2001-07-05 14:00:00	1999-08-28 11:00:00
4th	2006-10-12 12:00:00	1999-09-03 04:00:00
5th	2005-09-09 07:00:00	2001-07-05 18:00:00
6th	2003-11-16 02:00:00	2006-10-11 15:00:00

Table 1. Starting times of the most extremes episodes extracted by considering two cost functionals.

But observed extreme episodes are rare by definition !

Requirement of a wide catalogue of realistic extreme rainfall scenarios

Solution

Stochastic simulations

Our procedure draws sound justification from asymptotic theory for threshold exceedances with a strong probabilistic interpretation

## Step 2 : Stochastic simulations

Selected Episodes from data (Step1)

+

Extreme Value Theory / Pareto processes [1]

→

[2]  
Stochastic extreme rainfall scenario simulation

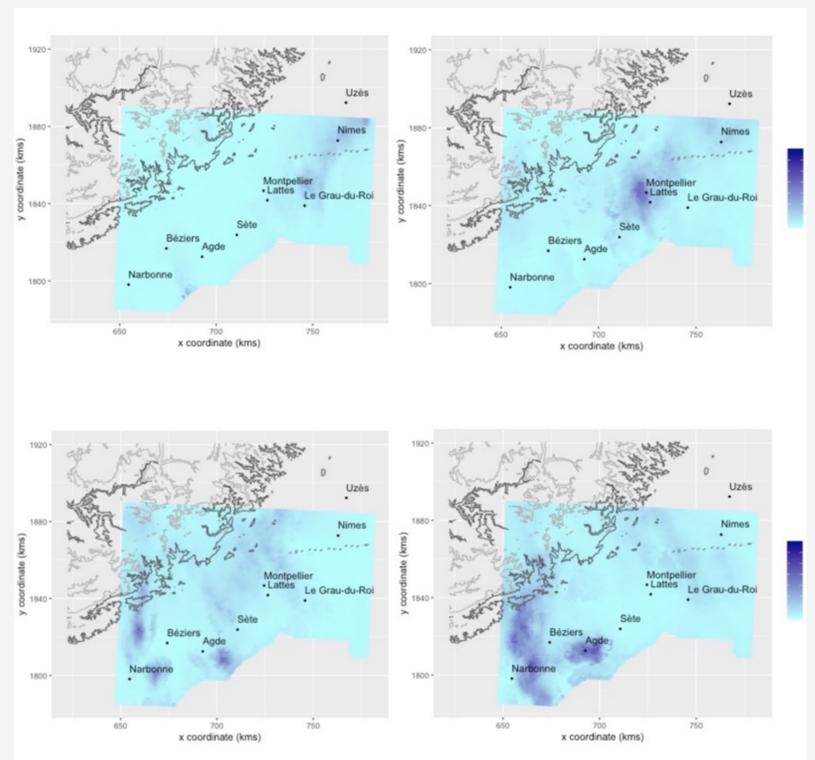


Figure 2. Uplifted episodes based on the spatio-temporal mean associated to the first extreme episode (from 2005-09-06 16:00:00 to 2005-09-06 19:00:00). We consider spatio-temporal neighborhoods of 15 kms and 12 hours, respectively.

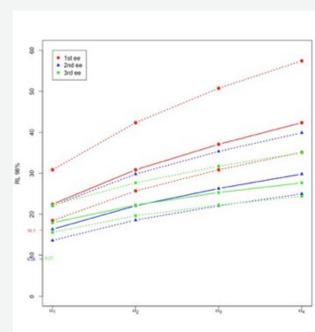


Figure 3. Return level at 98 % are computed for the original episode and for each uplifted episode, where we first aggregate values respectively for each spatial grid cell by taking its temporal average over the 12 hours. The legend indicates the extreme episode (ee). For each episode, the lines correspond to different uplifting levels using the 0.25-, 0.5- and 0.75-quantile (from bottom to top). The considered cost-functional is the spatio-temporal mean:

$$\ell(\tilde{X}^*; s, t) = \frac{1}{|N(s, t)|} \sum_{(z, k) \in N(s, t)} \tilde{X}^*(z, k).$$

## Outlook :

- Hydraulic simulations of a rainfall-induced urban flood using extreme forcings
- Construction of a space-time stochastic rainfall generator geared towards extreme events