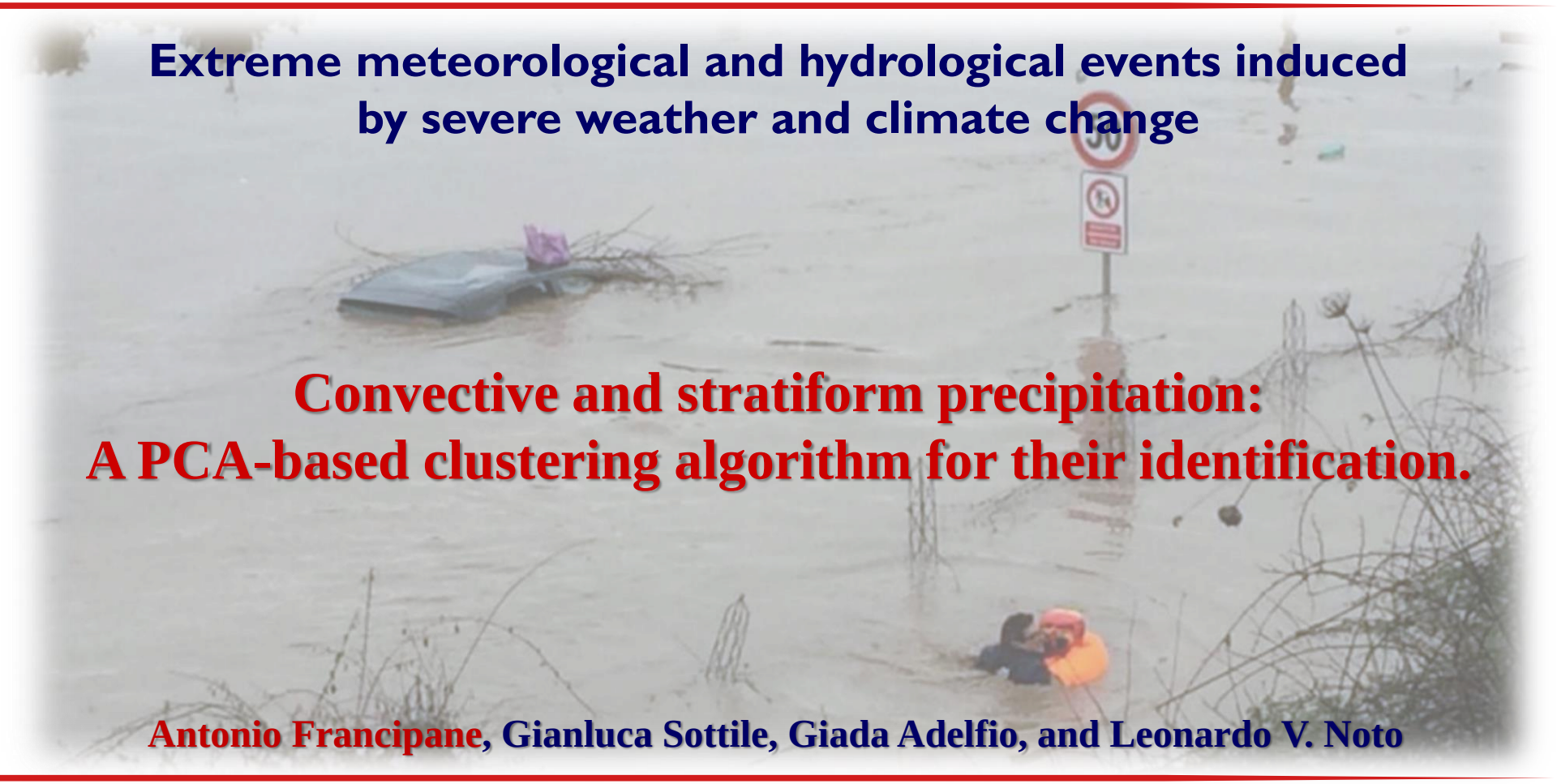
EGU General Assembly 2020
Online | 4–8 May 2020
SESSION NH 1.6

Extreme meteorological and hydrological events induced by severe weather and climate change



Convective and stratiform precipitation: A PCA-based clustering algorithm for their identification.

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Introduction

- ✓ In the last years, heavy rainfall events have caused several damages (e.g., loss of human lives and economic damages) in many parts of the world.
- ✓ Since these kind of events are characterized by short duration and high intensity, are often associated to convective rainfalls.
- ✓ The increase of occurrence of heavy rainfall events in many areas of Sicily, has contributed to raising the importance of understanding which factors could be recognized as drivers of these events.

Sciacca (AG) - February 2017

Casteldaccia (PA) - November 2018

Palermo (PA) - September 2019

Goals

- ✓ To develop a methodology capable to separate heavy (short duration and high intensity) from light (high duration and low intensity) rainfall events.

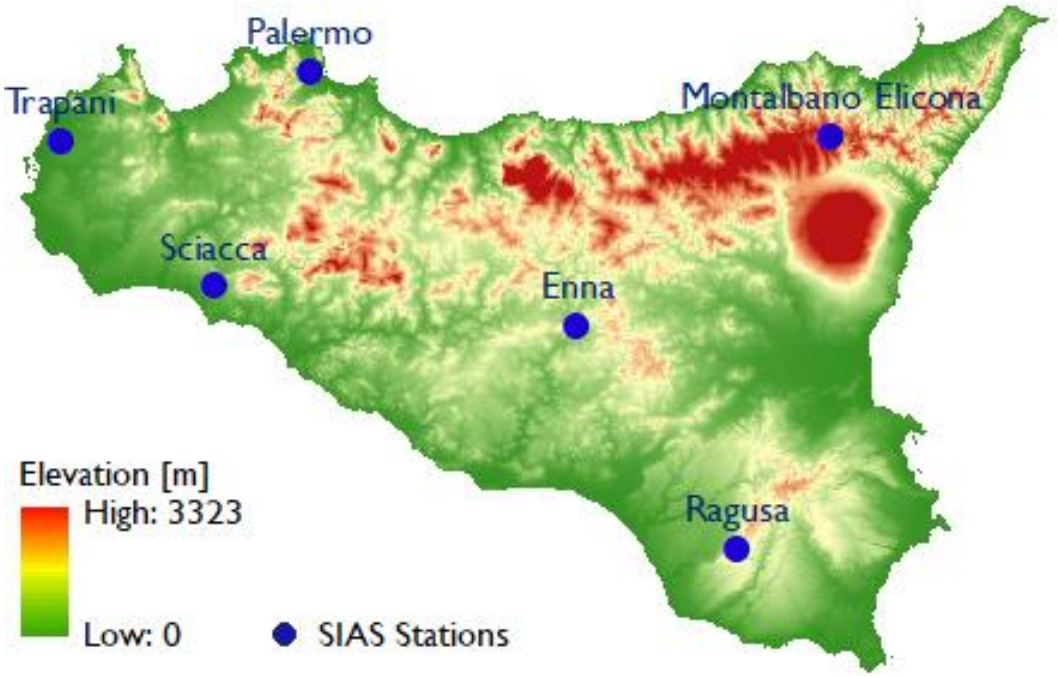
- ✓ To verify if the heavy and light rainfall events can be always led to convective and stratiform events, respectively, or if necessary to introduce new classes to classify mixed and/or unresolved rainfall.

Case Study - Sicily

- ✓ Sicily (Italy) is the largest island of the Mediterranean Sea and covers an area of about 25,000 km2.
- ✓ The elevation ranges from 0 to more than 3,000 m a.s.l. at the volcano Etna;
- ✓ Mean annual precipitation is ~700 mm over the region with higher (~1,900 mm) and lower (~ 360 mm) values in the northeast and the southeast, respectively.

DATASET

- ✓ SIAS (Agro-meteorological Information Service of Sicily)
- ✓ temporal resolution: 10 min
- ✓ period: 2003 – 2018



Clustering of rainfall data

- ✓ When data are observed as functions of time we refer to as functional data, referring to n pairs (t_i, y_i) where y_i is the value of an observable variable x at time t_i, and focusing on a set of functions defined on $[0, T]$, such that:

$$\{y_i = x_i(t); \quad i = 1,2,\cdots,I; \quad 0 \leq t \leq T\}$$

- ✓ If a functional for replication i can be represented by a set of discrete measured values $y_{i1}, y_{i2}, \cdots, y_{in}$, the first task is to convert these values to a function x_i with values $x_i(t)$ computable for any t, called functional objects.

- ✓ In the functional context, the counterparts of variable values are functional values $x_l(t), l = 1, \cdots, p$ and the discrete index j in the multivariate context is now replaced by the continuous index s, such that:

$$f_l = \int_{\Omega_s} \beta(s)\, x_l(s)\, ds$$

- ✓ with $\beta(s)$ weight functions and Ω_s a subset of R. In the literature, the term harmonic is used to refer to principal component of variation in curves analysis

Clustering of rainfall data

- ✓ The functional PCA-based clustering approach, denoted as the **FPCAC** algorithm and proposed by Adelfio *et al.* (2011), introduces a variation of the trimmed kmeans Robust Curve Clustering (RCC) algorithm (Garcìa-Escudero and Gordaliza, 2005) that is a kind of robust version of k-means methodology through a trimming procedure.

- ✓ FPCAC looks for clusters of functions according to the direction of largest variance, finding a linear approximation of each curve by a finite p dimensional vector of coefficients defined by the FPCA scores, assigning event to the cluster on the basis of a distance measure, considering the matrix of FPCA scores instead of the coefficients of a linear fitting to B-spline bases.

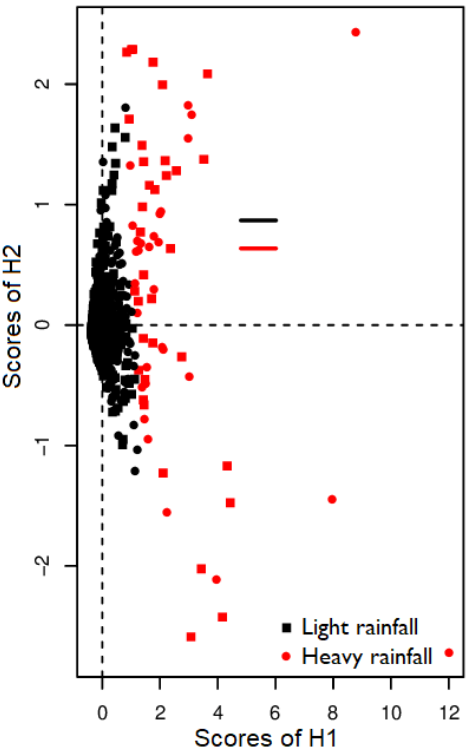
- ✓ For each rain gauge, the FPCAC clustering algorithm was applied using 5 harmonics to discriminate between **light** and **heavy** rainfall events.

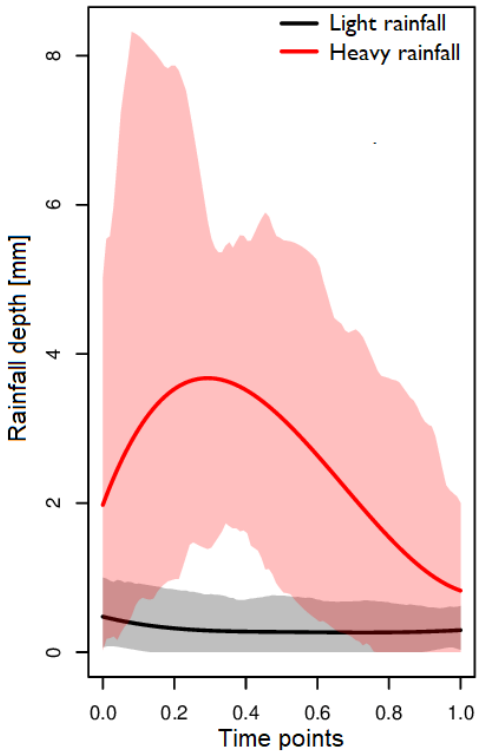
References

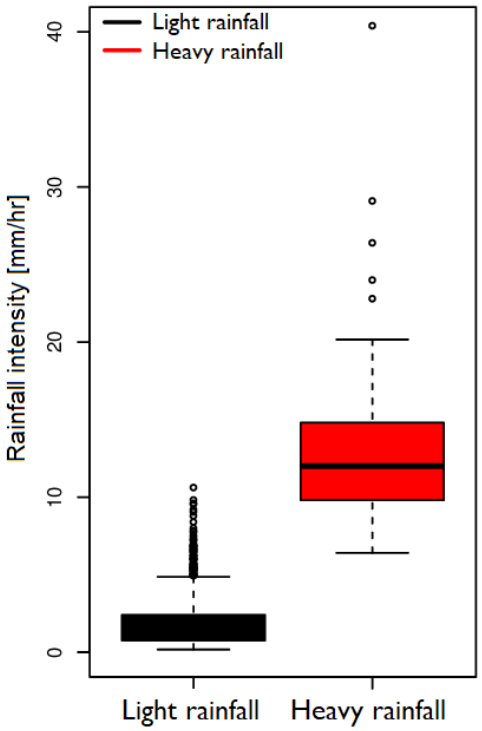
Adelfio, G., Chiodi, M., D'Alessandro, A. and Luzio, D.: FPCA algorithm for waveform clustering. Journal of Communication and Computer, 8(6), 494–502 (2011).

Garcìa-Escudero, L. A. and Gordaliza, A.: A proposal for robust curve clustering, Journal of classification, 22, 185–201 (2005).

FPCAC for rainfall data in Sicily







FPCAC for the rain gauge of Palermo

Left panel - scores of the first harmonic vs the second one;

Middle panel - mean rainfall depth of the two clusters and the interquartile range for each normalized time point;

Right panel - boxplots of rainfall intensity

Descriptive statistics of the **light** and **heavy** rainfall events identified for the six rain gauge stations: minimum, average (standard deviation) and maximum rainfall intensity (mm/hr).

Stations	Light rainfall				Heavy rainfall			
	N.	Min	Avg (SD)	Max	N.	Min	Avg (SD)	Max
Enna	1155	0.13	2.17 (2.64)	19.31	20	15.84	26.70 (11.59)	63.60
Montalbano Elicona	1343	0.13	1.47 (1.20)	10.00	43	5.00	11.23 (6.22)	32.64
Palermo	1402	0.17	1.81 (1.55)	10.62	65	6.40	13.62 (7.02)	45.60
Ragusa	1121	0.11	2.02 (2.03)	16.20	29	9.60	22.45 (11.52)	64.80
Sciacca	1216	0.16	1.99 (2.08)	15.90	28	8.70	18.50 (7.57)	46.60
Trapani Fontanasalsa	1319	0.16	1.79 (1.62)	13.52	53	6.40	14.38 (7.39)	43.20

Conclusions

Some preliminary conclusions of the study can be summarized as:

- the proposed algorithm seems to clearly distinguish between heavy and light rainfall;
- while the light rainfall have a similar behavior among the six rain gauge stations, the heavy rainfall seem to be dependent on geographical site;
- one of the advantages of the procedure is related to an immediate use of PCA for functional data avoiding some objective choices related to the splines fitting;
- deeper analysis will be carried out in order to:
  - ✓ individuate the main causes and features of the two components, based on dependence models accounting for spatial information;
  - ✓ understand if necessary to introduce new classes to classify mixed and/or unresolved rainfall

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Thank you for your attention!

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