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Regional characteristics and spatial patterns of extreme precipitation in Southern Italy

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ABSTRACT

A data-base of hydrological disasters caused by extreme precipitations within the Campania Region (Southern Italy) during the last 30 years, has been set up to shed light on spatial patterns and regional characteristics of floods and on the processes that give rise to such patterns.

Hydrological events have been selected from the VAPI project (Rossi e Villani, 1995) and the AVI project (Census of Italian areas prone to hydrogeological calamities, Gndci-CNR, 1989). To increase the number of significative gauging stations and to analyze data at an hourly temporal scale, a number of rainfall strips have been vectoralized.

Rainfall strips are a graph of rainfall amount versus time and were used in the past to record rain gauges data, when digital data logging systems were not yet in use. The extreme event are analyzed with reference to the space-time distribution of ground precipitation and to the dominant meteorological characteristics, when it has been possible to identify particular anomalies.

Extreme precipitation space-time distribution, for rainfall of different lags, is derived by an interpolation model which also give a measure of estimation accuracy. In this way it is possible to assign intensity, duration and areal extension characteristics to each of the examined events. The data-base classify hydrological disasters by space-time evolution and by damages produced.

A DATA-BASE OF HYDROLOGICAL INFORMATION

This work starts from the results of “AVI Project (Census of Italian areas prone to hydrogeological calamities, Gndci-CNR, 1989)”. The AVI project of GNDCl (Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche) collects all the documentation available about the main flood and rainfall historical events occurred between 1985 and 1999, on the territory of the Campania Region. We have acquired various information about each event (<http://avi.gndci.cnr.it>), such as: duration, physiographic environment, damaged area, involved river basins and stream network and the effects that these have caused.

Date	City	Zone
02/02/1996	Aversa - Trentola Ducenta	
22/08/1996	Torre del Greco	Zona Porto
18/09/1996	Nocera Inferiore	Stanza dei Convi
09/10/1996	San Marzano sul Sarno	Abitato
16/10/1996	Ailano	Isola
20/11/1996	Baia e Latina	Baia e Latina
22/11/1996	Forino	Forino
26/11/1996	Alvignano	Alvignano
27/11/1996		
30/11/1996	Vitulano	Campoli - Vitulano
14/12/1996	Altiripalda	Abitato
09/01/1997	Ailano	Abitato
10/01/1997		
11/11/1997	Quindici	Quindici
12/11/1997		
29/11/1997	San Marzano sul Sarno	Campagne
30/11/1997		
20/12/1997		
21/12/1997	Santa Maria a Vico	San Marco
22/12/1997		
27/12/1997	San Felice a Cancello	San Marco Trotti
05/05/1998	Lauro	Lauro
06/05/1998		
26/05/1998	Avellino	Provincia
12/09/1998	Serino	Quartiere Casancino
13/09/1998		
27/09/1998	Bracigliano	Bracigliano
28/09/1998		
05/12/1998	Altavilla Silentina	Castelluccio
15/12/1999	San Martino Valle Caudina	
16/12/1999		

12 -13 September 1998

Event informations
Data : 12/9/1998
Event lag (days): 2

Damage zones:
Castellammare di Stabia - Castel San Giorgio - Roccapiemonte - Mercato San Severino
- Foce del Fiume Sarno - Serino - Volturara Irpina - Sarno - Agro Nocerino-Sarnese

Rivers:
Alveo Fontanelle - Canale - Canale Fontanelle - F. Sarno - T. Cavailli - T. Solofrana - T. Spineta

Reason: Flood
Effect: Embankment break

Figure 1: 12-13 September 1998 event features

Table 1: Historical flood events and extreme rainfall events occurred in Campania Region (Southern of Italy) from 1995 to 1999

FROM VARIOGRAM TO CLASSIFICATION: AN EXAMPLE



Figure 4: Historical rain-gauges of Campania Region, Italy

DATA

From the Italian data set of rainfall we extract the information about the 10th January 1997 event and calculate the average rain with the regional laws (F. Rossi e P. Villani, “Valutazione delle Piene in Campania”, 1995).

Figure 3: Campania Region in Italy

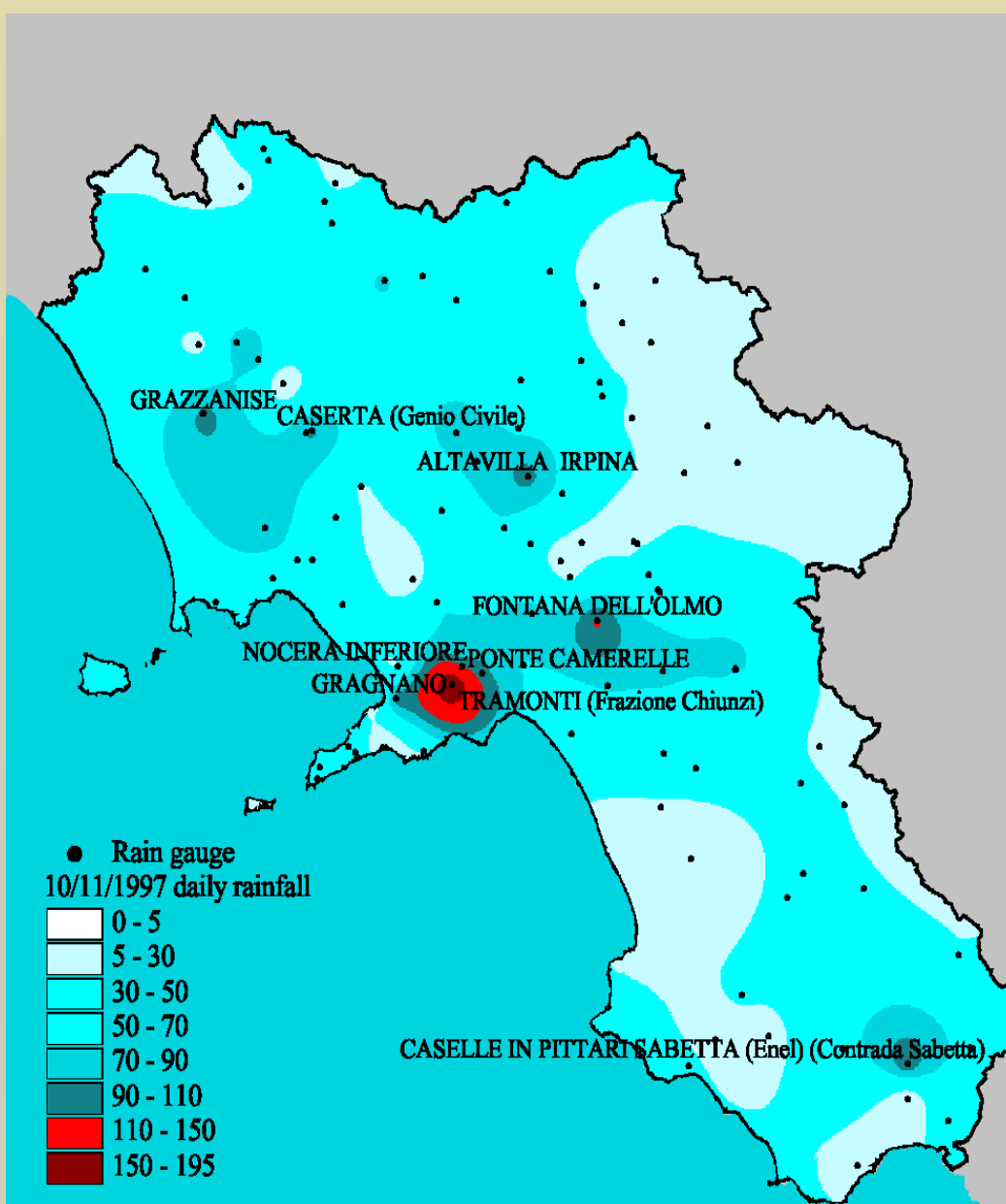


Figure 6: Output kriging grid

VARIOGRAM

We search the mathematical description of the relationship between the variance of pairs of observations (data points) and the distance separating these observations (h)

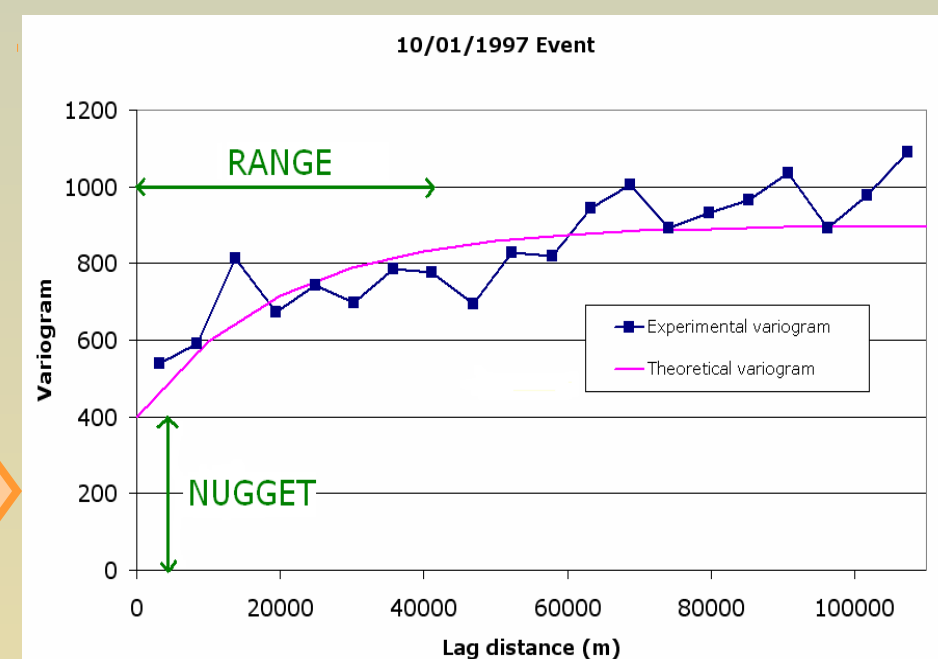


Figure 5: Variogram

From the family of linear least squares estimation algorithms, we use the Kriging method to interpolate the value of the rainfall from data observed at known locations, assigned the variogram. Variogram analysis consists of the experimental variogram evaluation from the data and the theoretical variogram model fitted to the data. The experimental variogram is computed by averaging one-half the difference squared of the rain values over all pairs of observations with the specified separation distance and direction. It is plotted as a two-dimensional graph (figure 5). The theoretical variogram model is chosen from a set of mathematical functions that describe spatial relationships. The appropriate model is chosen by matching the shape of the curve of the experimental variogram to the shape of the curve of the mathematical function.

RELATION BETWEEN DURATION AND T/T_{max}

For each rain-gauge we have calculated the average maximum of data event and have obtained the spatial average for different time step. From figure 7 we can see that frontal events (FP) are characterized by maximum normalized return period (T/T_{max}) for the greater durations while convective events (CP or IC) reach the T/T_{max} for the smaller durations.

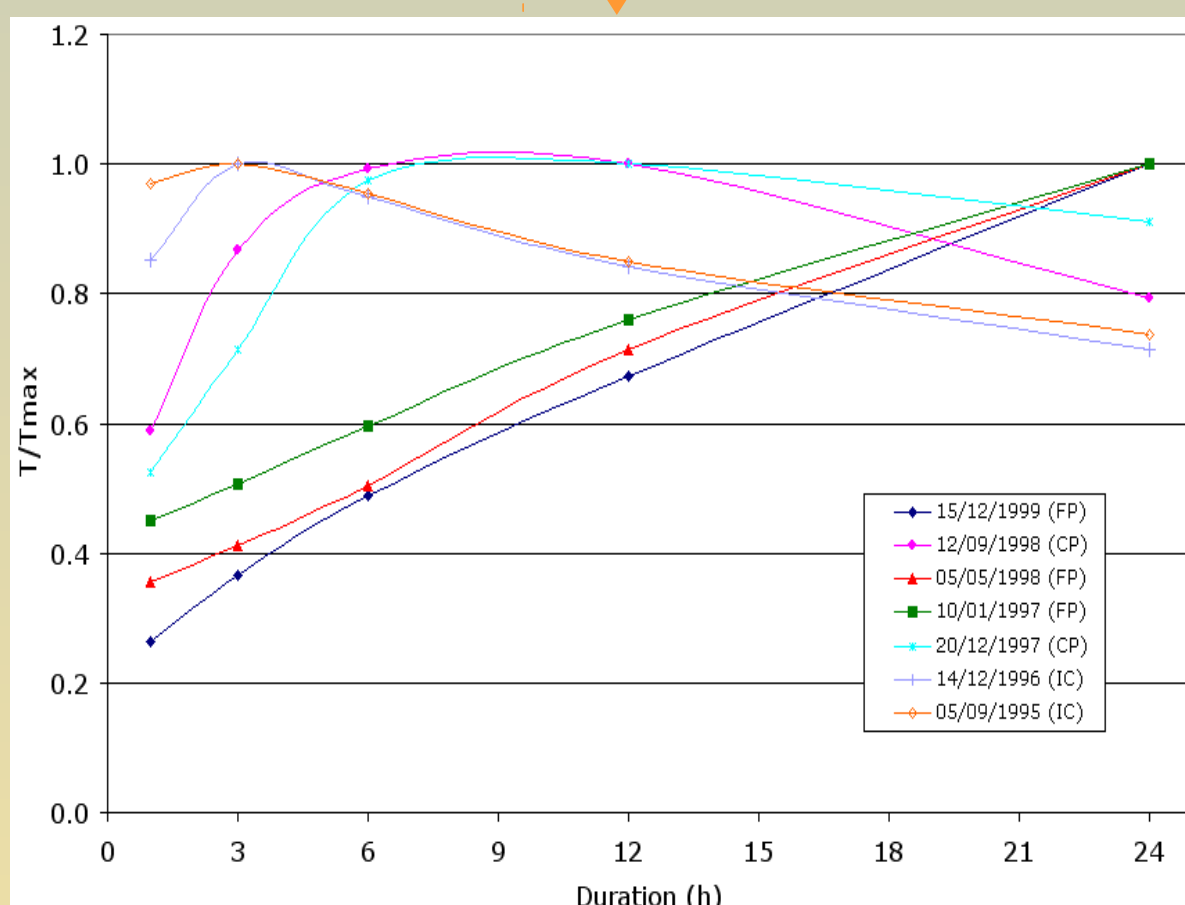


Figure 7: Relationships between duration (hr) and normalized return period T/T_{max}

CLASSIFICATION

RAINFALL EVENTS CLASSIFICATION

From figure 8 we can see that the variogram of different event typology are characterized by different range and different nugget.

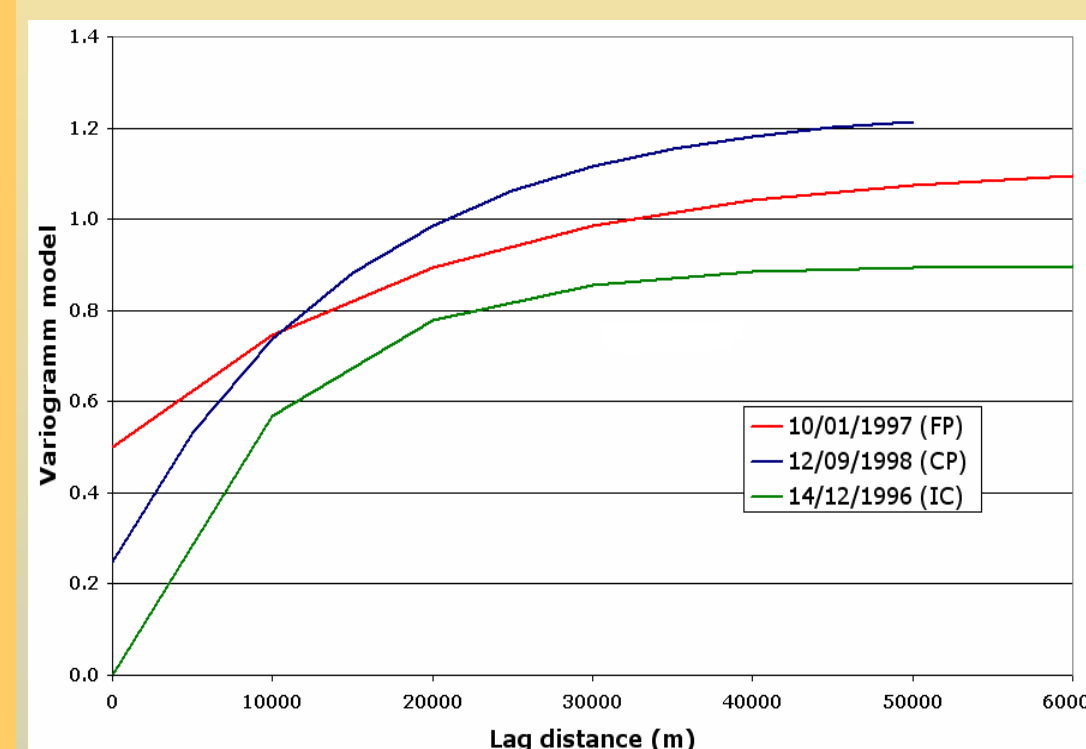
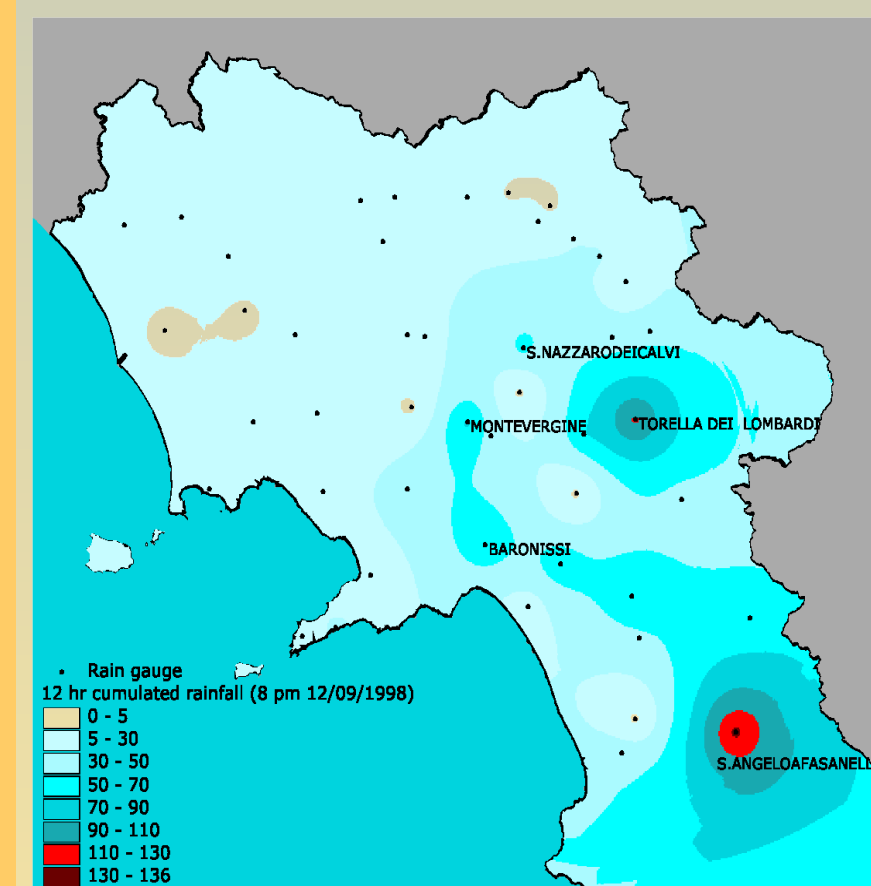


Figure 8: Variogram for the three example events

FRONTAL PRECIPITATION (FP): this is the most frequent case in the Mediterranean area and is related to a baroclinic cyclo-genesis. In this case, the interaction between the baroclinic wave and the orographic barrier produces a surmounting wave with anti-cyclonic vorticity on the crest and cyclonic vorticity downwind. An example of this one occurred on 10/01/1997.



CONVECTIVE PHENOMENA (CP): extreme rainfall produced by isolated convective cells or by meso-scale cyclones that are similar to tropical cyclons (hurricanes), with storm cells aggregated along a vertical axis. An example of this one occurred on 12/09/1998.

ISOLATED CELLS STORM (IC): rainfall of convective nature, associated to local events, like typical summer stormy phenomena. An example of this one occurred on 14/12/1996.

DATA COLLECTION

The collection of the data is a very important phase. Rain-gauges installed after the 1994 are equipped with sensors for continuously reading of cumulated rainfall over a variable fixed time step. For the historical gauges, instead, manual reading of rainfall strips is needed. Mechanical instrument traces on a rotary cylinder, covered of paper, a graph in which hourly rainfall is plotted against time (see the picture below).

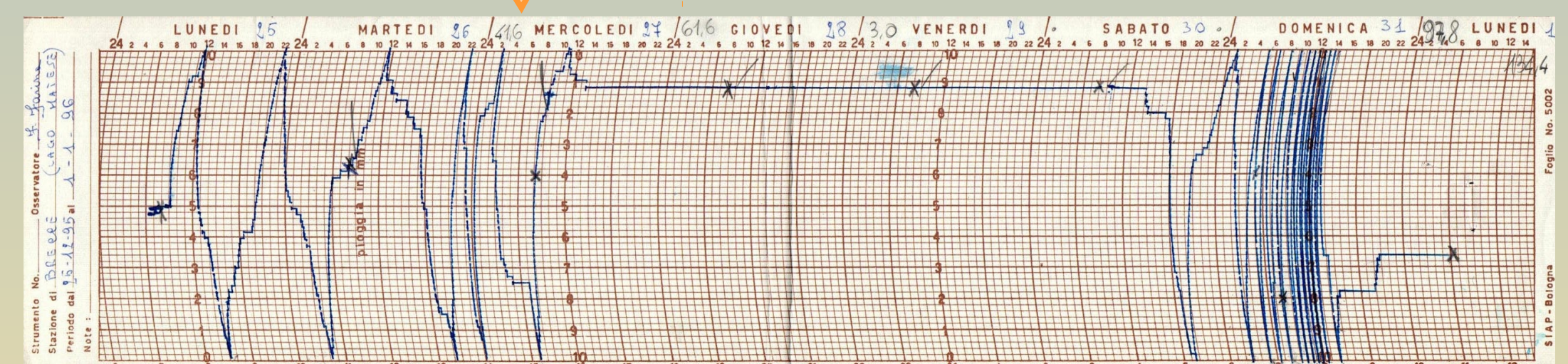
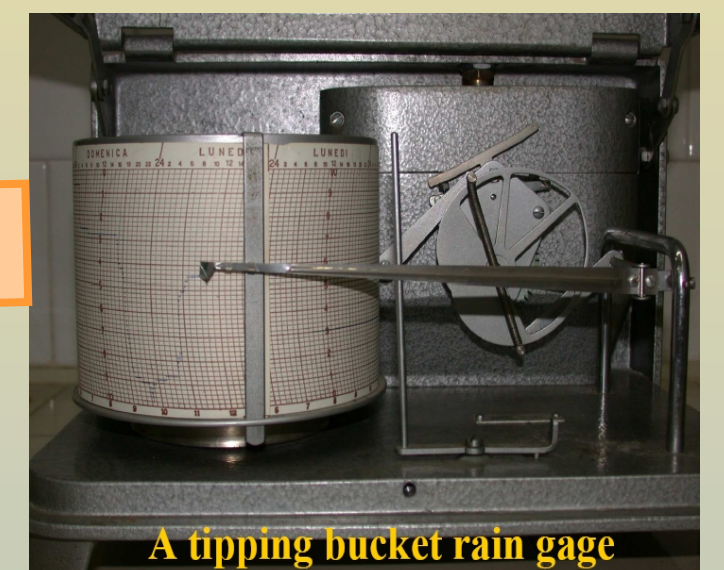


Figure 2: The rain gauge and an example strip – Station of “Lago Matese Breccia” for period from 25/12/1995 to 01/01/1996

On the x-axis there is the time (in hours) and on the y-axis there is the rain (in millimetres). We have scanned and read about 1800 strips for 50 events. The manual reading is a very difficult operation, because these graphics are subjected to numerous errors of appraisal and interpretation. Often the oldest ones are faded or they can't be read. Moreover, instruments could be broken off, especially in the severe events. All these difficulties involve that the usable information is reduced of approximately 20% compared with initially available one.

CONCLUSIONS

Hydrological disasters caused by extreme precipitations within the Campania Region (Italy) has been set up to shed light on spatial patterns and regional characteristics of floods and on the processes that give rise to such patterns. Hydrological events have been selected from the VAPI project and the AVI project. The aim of this work is a classification of rainfall events by duration and spatial distribution. To obtain this result we have increased the daily rainfall data-base with hourly temporal scale data. This information is available in rainfall strips, a graph of rainfall versus time. From data set we have constructed the variogram for each events and with the kriging method we have obtained the spatial distribution. At last, the analysis of spatial distribution (by means of variogram) and the time lag (by means of relationship T/T_{max} and d) allows us to identify three main event classes: 1) Frontal precipitation; 2) Convective phenomena; 3) Isolated cells storm; and some intermediate cases. This approach is important to improve the forecast of extreme events and to obtain classification of damages produced after a natural disasters.

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