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A revised event synchronization method. Hydro-meteorological extreme events analysis and associated risk evaluation in Lazio Region in Italy.

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The understanding of the mechanisms that drive extreme precipitation in a given region is crucial in order to effectively assess hydrogeological hazards, such as flood and landslide, and plan emergency operations and response. Therefore, there is a strong interest to develop methods to assess the frequency, magnitude and consequences of these hydrological extreme events. Recently, the awareness that radiative effects of anthropogenic changes in atmospheric composition are expected to cause climatic changes - especially enhancement of the hydrological cycle leading to an increased hydrogeological risk - has put in discussion the basic paradigms of traditional approaches until now followed by hydrologists and water resources engineers: stationarity, randomness of rainfall event processes bounded at catchment scale. A number of scientists are emphasizing the necessity to enlarge the approach to estimate rainfall magnitude and frequency, including spatial and temporal large-scale circulation patterns and global climate mechanisms. In fact, rainfall and other hydroclimatic extremes may represent specific states of organization of the atmospheric circulation. Given this hypothesis an open question is how best to identify such states, and their space-time persistence. Such a mapping would facilitate a physically meaningful identification of the potential severity, frequency and duration of such events, allowing for a more efficient risk management in emergency situations and for improving projections of future hydrogeological risk under climate change. With this in view, in this study, the link between large scale atmospheric circulation and extreme rainfall in Lazio Region - Italy is investigated by a combined Kohonen Networks and Complex Networks approach. Lazio is a central Italian region particularly exposed to hydrogeological risk, in fact the 98% of the municipalities in the region has at least one area at high hydrogeological risk identified by the Regional Hydrogeological Risk Map. Historical data from over 220 rainfall gages in Lazio Region – Italy, European Climate Assessment and Data set (ECA&D) and the Reanalysis Historical Data of the 850 hPa geopotential fields bounded from 90W to 70E and from 20N to 80N are used for the purpose. The common period of record is from 1950 to 2012. A finite number of typical atmospheric configurations of the considered region are identified by using the Kohonen Networks approach. Then the historical sequence of the atmospheric fields, by using k-nearest neighbor methods, is transformed into a binary matrix which assigns the atmospheric configuration of each time step to one of the typical configurations identified by the Kohonen Network. A further binary matrix is constructed by using as a threshold the 99th percentile of the rainfall values. Then, the Event Synchronization method is applied determining synchronization, causality and delay between the rainfall at each rainfall gage and the associated atmospheric circulation cluster. Finally, Modularity Method is applied in order to identify common behavior among the binary series. We find that the proposed approach can be useful and effective to identify the most critical atmospheric circulation patterns responsible for triggering rainfall and thus to be used as part of a prediction strategy.