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Monitoring of levee breaching through remote sensing and artificial intelligence

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The study of flooding events resulting from bank over-flooding and levee breaching is of large interest for both society and environment, because flood waves, resulting from levee failure, might cause loss of lives and destruction of properties and ecosystems. Understanding the subsoil mechanics and the fluid-solid interplay allows the stability condition estimate of dams, embankments and slopes and the development of early warning alarm systems. Changes in soil and hydraulic parameters are usually monitored by geotechnical and geophysical investigations that also provide the basic assumptions for developing hydraulic models. Nowadays, remote sensing approaches, including satellite techniques, are mainly used for flooding simulation studies. Indeed, remote sensing observations, such as discharge, flood area extent and water stage, have been used for retrieving flood hydrology information and modeling, calibrating and validating hydrodynamic models, improving model structures and developing data assimilation models. Although all these studies have contributed significantly to the recent advances, uncertainty in observations, as well as in model parameters and prediction, represents a critical aspect for using remote sensing data in the flooding defence. Compared to past and current methods for monitoring the fluvial levee failure, we propose a new procedure that provides a wide and fast alert system. The proposed methodological path is based on presumed relationships between ground level deformation and hydrological and surface soil properties, due to physical mechanisms and exhibited by geodetic and hydrological time series. The procedure is accomplished first through multi-methodological comparative analyses applied to geodetic, hydrological and soil-properties patterns, then through the mapping of the river zones prone to failure. Since the input consists of time series satellite-derived data, the geospatial Artificial Intelligence is applied for extracting knowledge from spatial big data and for increasing the performance of data computing. In particular, machine learning is initially developed for selecting the relevant geographical areas (i.e. rivers, levees and riverbanks) from large geo-referential datasets. Then, since the spatial-distributed points are also time-dependent, the trends of different datasets are compared point by point by selected analytical techniques. Finally, in accordance with the acquired knowledge from previous steps, the system extracts information on the correlation indexes in order to make sense of patterns in space and time and to identify hierarchic orders for the realization of hazard maps. The proposed method is "wide" because, unlike other direct surveys, it is able to monitor large spatial areas since it is based on satellite-derived data. It is also "fast" because it is based on the Earth's surface observation and is not

connected with Earth's inland investigations (such as the geotechnical and geophysical ones) or with forecasting models (e.g. hydraulic and flooding simulations). Due to these peculiarities, the method can support flood protection studies and can be used for driving the localization of river portions prone to failure, where focusing detailed geotechnical and geophysical surveys.