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Combination of geomorphic classifiers through Machine Learning-based techniques for flood hazard assessment

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Every year flood events cause worldwide vast economic losses, as well as heavy social and environmental impacts, which have been steadily increasing for the last five decades due to the complex interaction between climate change and anthropogenic pressure (i.e. land-use and land-cover modifications). As a result, the body of literature on flood risk assessment is constantly and rapidly expanding, aiming at developing faster, computationally lighter and more efficient methods relative to the traditional and resource-intensive hydrodynamic numerical models. Recent and reliable fast-processing techniques for flood hazard assessment and mapping consider binary geomorphic classifiers retrieved from the analysis of Digital Elevation Models (DEMs). These procedures (termed herein "DEM-based methods") produce binary maps distinguishing between floodable and non-floodable areas based on the comparison between the local value of the considered geomorphic classifier and a threshold, which in turn is calibrated against existing flood hazard maps. Previous studies have shown the reliability of DEM-based methods using a single binary classifier, they also highlighted that different classifiers are associated with different performance, depending on the geomorphological, climatic and hydrological characteristics of the study area. The present study maps flood-prone areas and predicts water depth associated with a given non-exceedance probability by combining several geomorphic classifiers and terrain features through regression trees and random forests. We focus on Northern Italy (c.a. 100000 km^2, including Po, Adige, Brenta, Bacchiglione and Reno watersheds), and we consider the recently compiled MERIT (Multi-Error Removed Improved-Terrain) DEM, with 3sec-resolution (~90m at the Equator). We select the flood hazard maps provided by (i) the Italian Institute for Environmental Protection and Research (ISPRA), and (ii) the Joint Research Centre (JRC) of the European Commission as reference maps. Our findings (a) confirm the usefulness of machine learning techniques for improving univariate DEM-based flood hazard mapping, (b) enable a discussion on potential and limitations of the approach and (c) suggest promising pathways for further exploring DEM-based approaches for predicting a likely water depth distribution with flood-prone areas.