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Residual flood-risk: assessing the effectiveness of alternative large-scale mitigation strategies

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The EU Flood Directive (2007/60/CE) requires institutions and public bodies, in order to formulate robust flood-risk management strategies for large European rivers, to address several fundamental tasks. For instance, they have to address the problem of flood-risk mitigation from a global perspective (i.e. entire middle-lower river reaches) by identifying critical reaches, inundation areas and corresponding overflow volumes. To this aim, we focus on the identification of large-scale flood risk mitigation strategies for the middle-lower reach of the Po river, the longest Italian river and the largest in terms of streamflow. We refer to the so-called residual flood-risk and in particular to its portion referring to the possibility to experience events associated with larger return periods than the reference one (e.g. $\sim$200 years in our case). In particular, being a further levee heightening not technically viable nor economically conceivable for the case study, the study develops and tests the applicability of a quasi-2D hydraulic model for the identification of large-scale flood-risk mitigation strategies relative to a 500-year flood event. In particular, we consider and model in the study different geometrical configurations of the main embankment system for a $\sim$400km reach stretching from Isola S.Antonio to the Po river delta in the Adriatic Sea: overtopping without levee breaching, overtopping and natural levee breaching, overtopping and forced levee breaching. The simulations enable the assessment of the overflowed volumes and water depths on flooded areas. Expected damages are estimated using simplified graphical tools, which we termed “Vulnerability Hypsometric Curves” (HVCs) and report the extent of the area for a given land use category that is located below a certain elevation. The analysis aims at finding the optimal configuration that minimizes the expected damages in the areas prone to flood. The outcomes of our study indicate that coupling a large-scale quasi-2D model with empirical HVCs can be a very suitable tool for identifying the best scenarios to mitigate the residual flood-risk in case of an extreme flood event. Furthermore, the proposed numerical model can be also applied for generating reliable boundary conditions for smaller scale studies aimed at further analyzing the hypothesized flood mitigation strategies using more complex modelling tools (e.g., fully 2D approaches).