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A dynamic adaptive flood risk management model to identify optimal defence policies in coastal areas under climate change uncertainties: Pontina Plain case study.

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Coastal areas are highly vulnerable to flooding, due to hydrological extreme events such heavy rainfalls and/or storm surges. Such events are supposed to be increasing in the next future due to the emission in atmosphere of anthropogenic greenhouse gases, although such predictions are affected by notable uncertainties, especially at the local scale. Due the particular value of coastal regions, which generally are densely populated areas, as well as, sites of agriculture and industrial activities, is crucial the assessment of the future hydraulic risks associated to hydrological extreme events, and then the identification of policies to mitigate such risks taking into account such climate uncertainties, e.g. a global sea level rise. In this study, in order to assess the future hydraulic risk in coastal regions, as well as, to identify optimal adaptive defence policies, a risk analysis model is developed to calculate the present day and future flood risk, accounting for climate change uncertainties and mitigation measures. Such model juxtaposes a number of coupled/nested models as: a) downscaling model to link heavy rainfall events at the local scale to large scale atmospheric circulation patterns; b) bivariate extreme value model to estimate the statistical dependence between rainfall extreme occurrence and sea level rise due storm surge; c) hydraulic simulation-optimization model to identify the optimal flood defence infrastructure size for given probability distribution of occurrence of hydrological extreme events; d) mathematical decision model which is aimed to identify the best policies of mitigation of hydraulic risk and the times taking in account the uncertainties in hydrological extreme event predictions. Sea level pressure and meridional and zonal winds fields were used to calculate storm surges. Bivariate Point Process Method (BPPM) is used to calculate Joint probability density function between extreme daily rainfall amount and daily extreme storm tide depth. The simulation-optimization model calculates, for assigned extreme rainfall events and sea levels joint density probability functions, sets of Pareto optimal solutions which are obtained by defining two optimality criteria consisting in: minimizing both the cost of the flood defence infrastructure system and the flooding hydraulic risk. This latter is calculated as Expected Annual Damage (EAD) expressed as the joint probability density function between extreme rainfall and storm surge and damages, which are related to a given defence system state, water depth – damage curve and land use (CORINE Land Cover). Then, we developed an adaptive dynamic decision process to select, among the different optimal Pareto solution sets, the most appropriate set of interventions to make in a flood defence system and the right time to make these interventions. The adaptive dynamic risk analysis model is applied to the study case of Pontina Plain, a large reclamation region (about 100000 ha) in the south of Lazio region (Italy), particularly vulnerable to extreme events - as extreme rainfall amount and sea level rise due to storm surge at the sea outfall of the river- which in the past caused the crisis of hydraulic network system with flooding of large areas and collapse of levees.