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Modelling the impacts of coastal hazards on land-use development

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Approximately 10% of the world's population live in close proximity to the coast and are potentially susceptible to tropical or extra-tropical storm-surge events. These events will be exacerbated by projected sea-level rise (SLR) in the 21st century. Accelerated SLR is one of the more certain impacts of global warming and can have major effects on humans and ecosystems. Of particular vulnerability are densely populated coastal urban centres containing globally important commercial resources, with assets in the billions USD. Moreover, the rates of growth of coastal populations, which are reported to be growing faster than the global means, are leading to increased human exposure to coastal hazards. Consequently, potential impacts of coastal hazards can be significant in the future and will depend on various factors but actual impacts can be considerably reduced by appropriate human decisions on coastal land-use management. At the regional scale, it is therefore necessary to identify which coastal areas are vulnerable to these events and explore potential long-term responses reflected in land usage. Land-use change modelling is a technique which has been extensively used in recent years for studying the processes and mechanisms that govern the evolution of land use and which can potentially provide valuable information related to the future coastal development of regions that are vulnerable to physical forcings. Although studies have utilized land-use classification maps to determine the impact of sea-level rise, few use land-use projections to make these assessments, and none have considered adaptive behaviour of coastal dwellers exposed to hazards.

In this study a land-use change model, which is based on artificial neural networks (ANN), was employed for predicting coastal urban and agricultural development. The model uses as inputs a series of spatial layers, which include information on population distribution, transportation networks, existing urban centres, and which are assumed as proxies for the natural, environmental and socio-economic parameters that drive the development of land use. Furthermore, using projected sea-level rise estimates, tropical storm surge maps, and tropical storm records rule sets are constructed, whereby frequently flooded urban residents may employ adaptive spatial behaviour leading to the abandonment of exposed land and migration to more suitable areas. In this context, different responses of residents to frequent flooding are explored and the impact of these responses to future land-use development is assessed.

The model has been applied to the region of south Florida, USA, which is heavily impacted by tropical storm-surge events and is particularly vulnerable to sea-level rise. A large number of simulations were performed exploring the evolution of land use in the next 100 years under different scenarios of possible increases in hurricane intensity, and local relative sea-level rise. Furthermore, various rule sets were employed reflecting urban residents' willingness to migrate based on the intensity and frequency of flooding and the availability of economic resources to rebuild. The results of this application are expected to give insights into the response, in terms of land-use development, of the natural and socio-economic system to these hazards and thus to provide useful information for land-use planning at regional scale.