Marine and continental controls of groundwater flooding in coastal areas

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Groundwater flooding is a critical issue in relatively flat coastal areas such as the coasts of Normandy (Western France). It is expected to become more severe in the coming century due to climate change, especially because of the elevation of the mean sea level and the evolution of the precipitation and recharge regimes.

Starting from field observations, we build a numerical groundwater flow model of a coastal aquifer near Bréville-sur-Mer (Normandy, France) to assess the impact of marine (tidal and mean sea level variations) and continental (recharge) forcing on groundwater dynamics and vulnerability to flooding. We show that tidal variations have a limited influence that extends only over some tens to hundreds of meters from the shore. Inland penetration is further reduced by low transmissivities. Low transmissivity however enhances the vulnerability to continental influences. It decreases the drainage capacity of the aquifer and its resilience to intense precipitation events.

We also show that the expected mean sea level rise may induce significant groundwater table elevations thousands of meters away from the ocean. Local topographical depressions through their capacity to offer natural drains may significantly alleviate vulnerability. They may control the existence of intersection points between the ground surface and the water table and act as drains that limit the propagation of the marine influence inland and protect the upstream zones (Figure 1). They focus most adverse effects and vulnerability by concentrating discharge flows coming from both the inland and the marine-influenced parts of the aquifer. They thus play a key role in the coastal system which may prevent flooding inland, but also constitute particularly sensitive structures that should be clearly identified and managed.

While pertaining to the selected study site, these observations could be extended into a more general framework, where correlations between the marine and continental components of vulnerability to groundwater flooding in coastal areas are expressed through geomorphological correlations. Such correlations would derive for example from the distributions of local topographical depressions or flat areas. They could be further integrated as indicators within methods of vulnerability assessment.

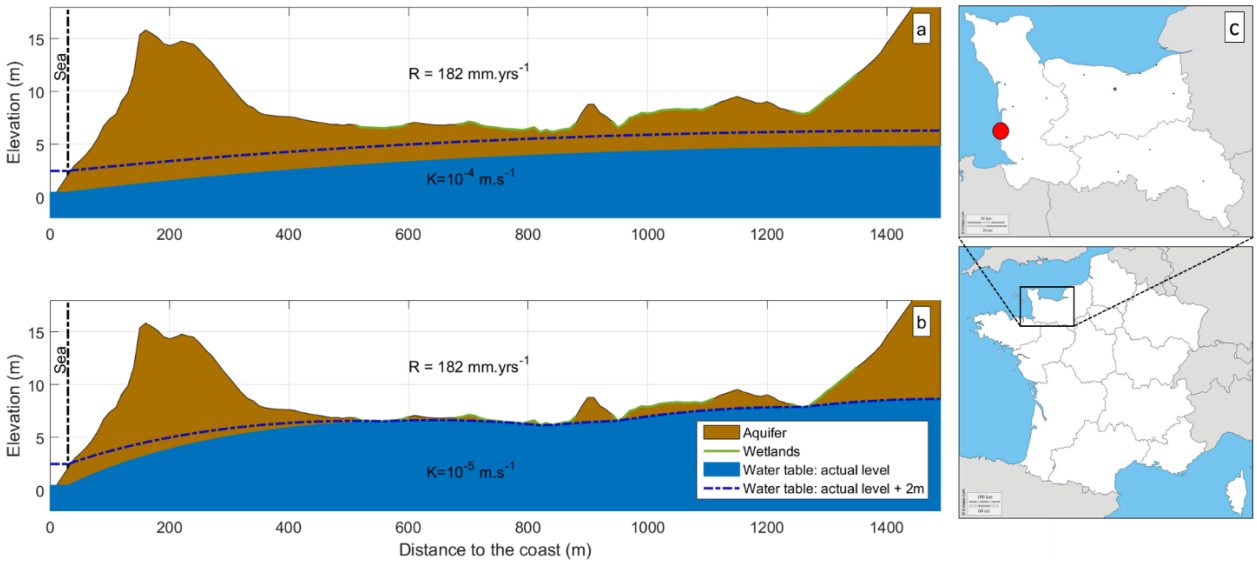

Figure 1: Water table elevation modeled in the coastal aquifer of Bréville-sur-Mer for two values of aquifer permeability (a) $K=10^{-4}$ $m.s^{-1}$ and (b) $K=10^{-5}$ $m.s^{-1}$. Profiles are calculated at steady-state for the current mean recharge (R=182mm/y) and two values of mean sea level imposed on the left side: the current mean level (area filled in blue) and the current level plus 2 meters (dotted-and-dashed line). Wetlands observed on the field are represented in green on the topography. (c) Localization of the study site of Bréville-sur-Mer (Normandy, France).