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On aquifer thicknesses and geological complexity affecting fresh/salt groundwater distribution

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Large coastal populations will face serious issues associated with global sea level rise in the near future. Among those are increased risk of coastal flooding and upconing of old saline groundwater caused by expected regional groundwater overexploitation initiated by growing urbanization. With predictions of rising sea level by 60-100cm by 2100 and a recent study suggesting even much larger changes than previously thought, it is essential to conduct a study to identify the most threatened coastal aquifers worldwide. Previous global studies dealing with salt water intrusion into coastal aquifers only considered homogenous geological conditions. However, literature and local data show a higher degree of heterogeneity. In our study, we consider possible geological scenarios and their impact on the fresh/salt groundwater distribution. The focus is on coastal aquifers that consist of unconsolidated sediments formed during the recent geological times and are underlain by a consolidated bedrock formation. Aquifer thickness and inland extent are the two most important parameters that determine the vulnerability of the coastal aquifer to salt water intrusion. To estimate these two parameters, a method using the latest global geological and elevation datasets is presented. By combining these inputs, we can estimate the slope of a bedrock formation that underlies a coastal aquifer consisting of unconsolidated sediments. Our estimated thicknesses are compared to a validation dataset of open source boreholes and literature information collected over numerous locations worldwide. While our results show that using our method to estimate coastal aquifer (made of unconsolidated sediments) thickness leads to satisfying results, it remains challenging to obtain information about the type of the sediments (gravel, sand, clay) themselves on such a scale. Therefore, we constructed a substantial set of 2D vertical variable-density groundwater flow models perpendicular to the shoreline and at equidistant spacing along the global coastline and modeled groundwater flow and salt transport using the SEAWAT code. In such manner, we can evaluate the range in simulated fresh/salt groundwater distribution based on different geological scenarios in which we stepwise increased the geological complexity. This method includes increasing the number of clay layers in the coastal aquifer and hence splitting it in multiple aquifers and aquitards. Our study provides a method and modelling tools that help to investigate the future impacts of climate change or human related risks that loom over coastal aquifer worldwide.