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Long-term effects of climate change on the hydrological system of a lowland area at the German North Sea coast

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Coastal areas are highly vulnerable to the impacts of climate change. In particular for the winter season, global sea level rise is expected to be combined with increased precipitation and higher storm surge frequency. During summer, due to the increase of temperature, enhanced evapotranspiration with an increase of groundwater intrusion has been observed. It is expected that the salinization of the surface will rise under drier conditions by upward seeping groundwater. Coastal water resource management requires a better understanding and predictions of these dynamic systems. Therefore, a long-term monitoring programme has been established at the German North Sea coast, located at the estuary of the River Ems. The research area is dominated by a dense canal system that is regulated by pumping stations and tidal gates. Landuse of the area is mainly dairy farming with 30 % of the area below sea level. The underlying aquifer is confined and brackish, and it is connected to the surface water by geological faults of old paleo-channels. Observations in those areas indicate a high salinity with concentrations peaking during the summer period.

This study investigates the effects of climate change on water balance and salt transport by applying regional climate models (RCMs) based on the IPCC emission scenarios for the period until 2100 as drivers for a hydrological and solute transport model. To investigate the impact of different meteorological scenarios, the RCM results for the climate scenarios A1B, A2 and B1 are used to cover an increase of future temperature between 1 and 3.5 K. As changes in water level and salinity are expected to influence vegetation patterns (and water management aims to guaranty agricultural use) two alternative landuse scenarios are considered. The first scenario assumes that the technological level of the management will be adapted to rainfall and sea level but without additional drainage from the hinterland to reduce salt water concentration. A second scenario includes the adaptation to increasing precipitation and the sea level with a polder system and wetland areas designated as potential buffer for winter storm surges and inland floods and as freshwater storage for dry summer periods.

The coupled groundwater - surface water model GSFLOW is used to simulate the integrated water balance. In a second step, salt transport is simulated with the solute transport model MT3DMS. Model simulations are carried out in an uncertainty framework based on the Sobol/Saltelli global sensitivity analysis in order to analyse the parameter space of the models.

First results show that a polder- wetland system is capable to reduce flooding of the hinterland up to a return period of an hundred years, but consuming 20% of the arable land whereby the businesses as usual scenario would be able to manage the water balance but with strong salinization effects.