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Simulating spatial adaption of groundwater pumping on seawater intrusion in coastal regions

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Coastal aquifer systems are used intensively to meet the growing demands for water in those regions. They are especially at risk for the intrusion of seawater due to aquifer overpumping, limited groundwater replenishment and unsustainable groundwater management which in turn also impacts the social and economical development of coastal regions. One example is the Al-Batinah coastal plain in northern Oman where irrigated agriculture is practiced by lots of small scaled farms in different distances from the sea, each of them pumping their water from coastal aquifer. Due to continuous overpumping and progressing saltwater intrusion farms near the coast had to close since water for irrigation got too saline.

For investigating appropriate management options numerical density dependent groundwater modelling is required which should also portray the adaption of groundwater abstraction schemes on the water quality. For addressing this challenge a moving inner boundary condition is implemented in the numerical density dependent groundwater model which adjusts the locations for groundwater abstraction according to the position of the seawater intrusion front controlled by thresholds of relative chloride concentration. The adaption process is repeated for each management cycle within transient model simulations and allows for considering feedbacks with the consumers e.g. the agriculture by moving agricultural farms more inland or towards the sea if more fertile soils at the coast could be recovered.

For finding optimal water management strategies efficiently, the behaviour of the numerical groundwater model for different extraction and replenishment scenarios is approximated by an artificial neural network using a novel approach for state space surrogate model development. Afterwards the derived surrogate is coupled with an agriculture module within a simulation based water management optimisation framework to achieve optimal cropping pattern and water abstraction schemes regarding multiple objectives like aquifer sustainability and profitable agriculture.

Results obtained for the above mentioned region show that the surrogate model has a very good interpolation capability i.e. it is able to reproduce unknown states obtained by numerical model simulations within the range of its training data. Furthermore, the importance of portraying the adaptive behaviour of farmers on water quality is underlined to develop management scenarios more realistically. However, results of a stop pumping scenario show that it is not possible to push back an advanced seawater intrusion in a time period of 200 years. Therefore, combinations of technical and adaptive measures are required.