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Optimal integrated management of groundwater resources and irrigated agriculture in arid coastal regions

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Abstract Groundwater systems in arid coastal regions are particularly at risk due to limited potential for groundwater replenishment and increasing water demand, caused by a continuously growing population. For ensuring a sustainable management of those regions, we developed a new simulation-based integrated water management system. The management system unites process modelling with artificial intelligence tools and evolutionary optimisation techniques for managing both water quality and water quantity of a strongly coupled groundwater–agriculture system. Due to the large number of decision variables, a decomposition approach is applied to separate the original large optimisation problem into smaller, independent optimisation problems which finally allow for faster and more reliable solutions. It consists of an analytical inner optimisation loop to achieve a most profitable agricultural production for a given amount of water and an outer simulation-based optimisation loop to find the optimal groundwater abstraction pattern. Thereby, the behaviour of farms is described by crop-water-production functions and the aquifer response, including the seawater interface, is simulated by an artificial neural network. The methodology is applied exemplarily for the south Batinah region/Oman, which is affected by saltwater intrusion into a coastal aquifer system due to excessive groundwater withdrawal for irrigated agriculture. Due to contradicting objectives like profit-oriented agriculture *vs* aquifer sustainability, a multi-objective optimisation is performed which can provide sustainable solutions for water and agricultural management over long-term periods at farm and regional scales in respect of water resources, environment, and socio-economic development.

Key words groundwater; saltwater intrusion; irrigated agriculture; integrated water resources management; simulation-optimisation; decomposition; Oman