Geophysical Research Abstracts
Vol. 19, EGU2017-12232, 2017
EGU General Assembly 2017

How Significant is the Slope of the Sea-side Boundary for Modelling Seawater Intrusion in Coastal Aquifers?

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A large number of people live in coastal areas using the available water resources, which in (semi-)arid regions are often taken from groundwater resources as the only sufficient source. Compared to surface water, these usually provide a safe water supply due to the remediation and retention capabilities of the subsurface, their high yield, and potentially longer term stability. With a water withdrawal from a coastal aquifer, coastal water management, however, has to ensure that seawater intrusion is retained in order to keep the water salinity at an acceptable level for all water users (e.g. agriculture, industry, households).

Besides monitoring of water levels and saline intrusion, it has become a common practice to use numerical modeling for evaluating the coastal water resources and projecting future scenarios. When applying a model, it is necessary for the simplifications implied during the conceptualization of the setup to include the relevant processes (here variable-density flow and mass transport) and sensitive parameters (for a steady state commonly hydraulic conductivity, density ratio, dispersivity).

Additionally, the model's boundary conditions are essential to the simulation results. In order to reduce the number of elements, and thus, the computational burden, one simplification that is made in most regional scale saltwater intrusion applications, is to represent the sea-side boundary with a vertical geometry, contrary to the natural conditions, that usually show a very shallow decent of the interface between the aquifer and the open seawater.

We use the scientific open-source modeling toolbox OpenGeoSys [1] to quantify the influence of this simplification on the saline intrusion, submarine groundwater discharge, and groundwater residence times. Using an ensemble of different shelf shapes for a steady state setup, we identified a significant dependency of saline intrusion length on the geometric parameters of the sea-side boundary. Results show that the additional effort to implement a sloped sea-side boundary may have a significant impact for assessing coastal water resources, and its influence may be of a similar magnitude as that of other common uncertainties in numerical modelling.

Literature

[1] Kolditz, O., Bauer, S., Bilke, L., Böttcher, N., Delfs, J. O., Fischer, T., Görke, U. J., et al. (2012). OpenGeoSys: an open-source initiative for numerical simulation of thermo-hydro-mechanical/chemical (THM/C) processes in porous media. Environmental Earth Sciences, 67(2), 589–599. doi:10.1007/s12665-012-1546-x