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Regional-scale assessment of tipping points for Mediterranean Coastal Aquifers

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Along the densely populated Mediterranean coasts several aquifers are already suffering sea-water intrusion. This phenomenon can accelarate in the future due to increased fresh groundwater abstractions, along with climate-driven sea-level rise and possible decline of the natural recharge of aquifers. Acceleration of sea intrusion is a major concern for the sustainability of coastal populations that depend on groundwater for their water supply.

We use the recently developed, generalized analytical model of Koussis et al. (2012) that accounts for the generally present and usually hydraulically significant aquifer slope that has previously been ignored in analytical sharp-interface solutions of seawater intrusion. Koussis et al (2012) extended the Strack–Girinskii discharge-potential approach to steady interface flow in sloping phreatic aquifers by approximating the gravity-driven flow component. This model uses the Ghyben–Herzberg sharp interface relationship and the Dupuit-Forchheimer approximation.

We investigate, at the regional scale, sea intrusion changes in unconfined sloping Mediterranean aquifers due to sea-level rise and recharge decline and subject to different inland boundary (control) conditions and groundwater abstraction rates. We focus our study on three well-known Mediterranean aquifers (slopes 0.3 – 1.7 %): (a) The Nile Delta Aquifer (middle and east section), (b) the Israeli Coastal Aquifer, and (c) the Akrotiri aquifer, Cyprus.

We validate our simulation results for these aquifers with results from previous studies performed with variable-density models for the same present and future climate and sea-level conditions. We then use the new analytical model to assess seawater intrusion into Mediterranean aquifers under various scenarios of future sea-level rise and recharge decline, combined with different levels of aquifer exploitation for the Mediterranean region.

Some scenarios for these aquifers show non-linear responses to future changes, implying important thresholds, or tipping points, beyond which seawater intrusion shifts abruptly from a stable state of mild change responses to sea-level rise, to a new stable state of large responses to even small change, implying rapid change to deep seawater intrusion into these aquifers, including complete invasion. Coastal aquifers should be managed so that flow conditions do not approach these thresholds. This work extends our previous generic investigation on tipping points (Mazi et al., in review) with field applications at specific Mediterranean aquifers.

References

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