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Effects of climate variability on saltwater intrusions in coastal aquifers in Southern Denmark

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As in many other regions of the world fresh water supply in Denmark is based on groundwater resources. Aquifers in the low-lying areas in the south-west of Jutland are particularly vulnerable to saltwater intrusions which are likely to intensify due to relative sea level rise. To understand the dynamics and development of this complex flow system, the initial hydrodynamic conditions imposed by the last Scandinavian Ice Sheet (SIS) must be taken into account.

The whole region has undergone changes in climatic and hydraulic conditions within the last 15000 years that may show influence on the present flow conditions. It is likely that the groundwater-flow dynamics, driven by the postglacial hydraulic head drop and the relative sea level rise are not yet equilibrated. Enhanced by the potential future sea level rise due to climate change, contamination of fresh-water aquifers will continue.

The 2800-km2 - large coast-to-coast study area located in the southern part of Jutland was partly overridden by the Weichselian ice sheet. Geophysical and geological mapping shows salt water intrusions up to 20 km inland from the present coast. Based on a geological voxel model spanning Miocene through Quaternary deposits a large-scale 3D numerical groundwater flow and salt water transport model has been developed. It includes density-driven flow and simulates the distribution of the current saltwater intrusions and their evolution during the last 15000 years. Particle tracking and direct age simulations are performed to identify recharge areas and constrain groundwater ages. The simulated ages are compared to ages derived from isotope analysis of groundwater samples both from Miocene and Quaternary aquifers. The origin of the groundwater is determined based on isotopic and chemical composition. Additionally, heavy noble gas analysis is carried out to estimate recharge temperatures and mechanisms at locations where groundwater recharge during the last glaciation is indicated.

This study shows how hydrogeological, geophysical and geochemical data can be complementarily used together with groundwater flow and transport simulations to understand the history of the groundwater systems and thus help adapting water resources to future changes.