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Identification and estimation of groundwater inflow to a brackish coastal lagoon: Field observations and numerical steady-state modeling

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Groundwater discharge to a brackish lagoon, Ringkøbing Fjord, Denmark, has been studied using a combination of hydrogeological field investigations and variable-density flow and transport modeling. Discharge is believed to occur mostly near the shoreline decreasing exponentially off-shore. The main focus has thus been on the near-shore flow processes. A conceptual model, which can help determine the dynamics controlling the interaction between the more saline lagoon water and groundwater, is being developed on the basis of different tracers. Sampling of groundwater every two months in the upper 2 m have been carried out and EC-profiles have been used to estimate changes in the width of the groundwater discharge zone. Furthermore, temperature as a tracer, and seepagemeter measurements were used to indirectly and directly estimate groundwater discharge. Field observations show that the salinity of the lagoon is highest in summer, when groundwater discharge is lowest and, vice versa, lowest when the discharge is highest (winter). This indicates that the force of saline intrusion and freshwater discharge is off-set in time. The Hydrogeosphere code (HGS) was applied based on a conceptual three-layer model of hydraulic conductivity (mapped on the basis of slug tests). Steady-state modeling of the interaction between the lagoon and groundwater shows that the simulated discharge to the near-shore environment compares well with field observations (on the order of a few cm/day). Furthermore, the modeling results also are in line with the changes in the observed widths of the groundwater discharge zone. A 12 m deep EC-depth profile shows variable salinity in the top followed by increasing salinity approaching the lagoon summer salinity near the bottom of the shallow aquifer. The numerical model shows a similar trend. A sensitivity analysis on the steady-state model was conducted to observe the effects on discharge and salinity distributions by using different heterogeneity scenarios (homogeneous versus layered) and dispersion parameters. The discharge zone is affected in the near shore environment, whereas dispersion mainly impacts the location of the brackish water-freshwater interface. Transient simulations will be carried out in the future to help understand how seasonal dynamics in salinity of the lagoon and discharge affect the width of discharge zone and the salinity distribution below the lagoon bed.