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Numerical Simulation of Submarine Fresh Groundwater Discharge and Preservation at the New Jersey Shelf

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Continental shelves typically harbor reservoirs and aquifers, which provide vital resources such as oil, natural gas and freshwater. The existence of fresh groundwater has been recorded at several continental shelves around the world. The New Jersey shelf represents one of the best documented occurrences of this phenomenon. Two different hypotheses explaining the emplacement and survival of freshwater reservoirs offshore New Jersey are currently debated, either regarding them as active aquifers that are dynamically linked to onshore areas or as paleo freshwater lenses that were emplaced during past glacial periods. Here, we present results from numerical simulations on a geologically representative shelf model in order to understand the mechanisms and time scales of fresh groundwater emplacement and preservation at the New Jersey shelf. Utilizing 2D depth migrated seismic and well data, we built a detailed hydrogeological model, with a vertical resolution of 10 m and a horizontal extent of 127 km. Our model captures the highly heterogeneous shelf environment and incorporates porosity compaction trends measured on IODP 313 core data. Initial transient coupled simulations of groundwater flow, heat and salt transport were performed based on the assumption that submarine freshwater reservoirs existed after the last glacial period. Results provide insight into discharge and preservation of fresh groundwater during the Holocene period. We find that freshwater is preserved preferentially in low-permeability sediments and yield simulated borehole salinity profiles consistent with field observations. Further, our simulations show that freshwater intervals which extend tens of kilometers offshore may be have been preserved from the Last Glacial Maximum until today. We find that approximately 30 % of the initial freshwater volume remains preserved after 15 000 years, depending on the recharge boundary condition. Currently ongoing numerical simulations focus on the emplacement history of submarine freshwater reservoirs offshore New Jersey, incorporating a Pleistocene sea-level curve as a time-varying boundary condition. Finally, our results improve the understanding of submarine fresh groundwater through an interdisciplinary approach which integrates seismic imaging, hydrogeological modeling and high-performance numerical simulation.