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Numerical investigation of surface water-groundwater interactions in a river-dominated delta

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Deltas are fragile coastal wetland systems that are rapidly vanishing due to subsidence and sea level rise. In most wetland environments, groundwater plays a central role in carbon and nutrient cycles, vegetation community structure, and contaminant transport, yet little is known about groundwater in vanishing delta wetlands. Here, we characterize the basic patterns, rates, and residence times of groundwater flow in a model delta wetland. Delta topography was simulated by growing the delta in Delft3D, a morphodynamic flow and sediment transport model. Water surface elevations under mean annual discharge conditions were used to drive a steady groundwater flow model. Under these average hydrologic conditions, surface water-groundwater exchange represents a small fraction (<1%) of river discharge to the coast, but storm surge, waves, and tides likely increase exchange rates periodically. Groundwater residence times range widely from hours to years. The residence time distribution exhibits power-law tailing that is characteristic of surface water-groundwater exchange in single-threaded river channels. The patterns of groundwater residence times within delta networks are likely to control redox chemistry and may therefore influence the community structure of microbes, benthic invertebrates, and plants. This study illustrates the tremendous potential for numerical approaches to characterizing groundwater flow in delta wetlands. Continued efforts are needed to understand the role of groundwater in delta wetlands, particularly in light of growing initiatives to restore deltas and their ecosystems.