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Quantification of groundwater extraction-induced subsidence in the Mekong delta, Vietnam: 3D process-based numerical modeling

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The demand for groundwater in the Vietnamese Mekong delta has steadily risen over the past decades. As a result, hydraulic heads in the aquifers dropped on average 0.3–0.7 m/yr-1, potentially causing aquifer-system compaction. At present, the delta is experiencing subsidence rates up to several centimeters per year that outpace global sea level rise by an order of magnitude. However, the exact contribution of groundwater extraction to total subsidence in the delta has not been assessed yet. The objective of our study is to quantify the impact of 25 years of groundwater extraction on subsidence. We built a 3D numerical hydrogeological model comprising the multi-aquifer system of the entire Vietnamese Mekong delta. Groundwater dynamics in the aquifers was simulated over the past quarter-century based on the known extraction history and measured time series of hydraulic head. Subsequently, we calculated corresponding aquifer system compaction using a coupled land subsidence module, which includes a direct, elastic component and a secular, viscous component (i.e. creep). The hydrogeological model is able to reproduce the measured drawdowns in the multi-aquifer system of the past 25 years. Corresponding subsidence rates resulting from aquifer system compaction show a gradual increase over the past two decades to significant annual rates up to several centimeters. Groundwater extraction seems to be a dominant driver of subsidence in the delta, but does not explain the total measured subsidence. This process-based modeling approach can be used to quantify groundwater extraction-induced subsidence for coastal areas and at delta-scale worldwide.