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Geophysical modelling of subsidence on the Mississippi Delta

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The Mississippi Delta (MD) is experiencing relative sea level rise of approximately 10 mm/yr (Penland and Ramsey, 1990). This rate is caused by a combination of global sea level rise and local subsidence of the land surface. The relative importance of processes thought to be responsible for this subsidence is vigorously debated. Many previous studies have postulated that isostatic subsidence of the Pleistocene basement caused by sediment loading of the MD itself is the major contributor. GPS surveys have produced subsidence rates greater than 5 mm/yr in the MD (e.g. Dokka et al. 2006). Computational modeling studies of vertical land motion on decadal timescales have reproduced these high rates, but required extreme and arguably unrealistic parameter values to do so. Additionally, subsidence rates in the MD on thousand year timescales due to delta loading are found to be an order of magnitude lower than GPS rates (e.g. Törnqvist et al., 2006; Yu et al., 2012).

In an attempt to understand the source of this disagreement between data types and better understand the uncertainties in the modelling process, we carried out a sensitivity analysis using a spherically symmetric visco-elastic deformation model. The model included sediment, ice, and ocean load histories from the last 80 kyr. The model results were compared with observations of vertical land motion over three different time scales (past 80 kyr, past 7 kyr, past ~15 years). We found that glacial isostatic adjustment is likely to be the dominant contributor to present-day deformation of the Pleistocene and underlying basement. Basement subsidence rates solely due to sediment loading were found to be less than 0.5 mm/yr. In general, sedimentary processes such as compaction of the Holocene strata appear to contribute more to land surface lowering than subsidence of the basement rock.

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