Dispersal of Mississippi and Atchafalaya Sediment on the Texas-Louisiana Shelf: Numerical Modeling Results

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Within the northern Gulf of Mexico, the Mississippi River is actively building land on the Mississippi delta and the Atchafalaya River is accumulating sediment within the Atchafalaya Bay and at the Chenier Plain. The timescales over which, and mechanisms by which material is transported from two fluvial sources (Mississippi and Atchafalaya) to these depositional sinks are still poorly understood. This has motivated the development of a three-dimensional coupled hydrodynamic-sediment model for the Texas-Louisiana continental shelf using the Regional Ocean Modeling System (ROMS). Including water and sediment delivery from Mississippi and Atchafalaya rivers, the model examined the dispersal of two sediment sources, seabed resuspension and sediment transport by wind-driven waves and currents. Waves were calculated using the Simulating WAves Nearshore (SWAN) model. Surface sediment concentrations were compared to calibrated MODIS satellite data collected near the Atchafalaya Bay, while bottom sediment concentration and transport flux were seen to be similar to multiple-month tripod observations of bottom boundary layer. Model runs were conducted for one-year periods to include seasonal variations and energetic storm periods. Much of the modeled fluvial sediment was deposited near the river mouths. Mississippi sediment was distributed around the Mississippi Delta within a radius of 20 to 40 km, and most Atchafalaya sediment was trapped landward of the 10-m isobath, with some westward dispersal toward the Chenier Plain. Sediment assumed to be flocculated traveled short distances before initial deposition, leading to small accumulation rates near the vicinity of the “dead zone” between 91W and 90W. Over the one-year time scale addressed by our model, a small amount of Mississippi and Atchafalaya sediment “mixed” southeast of Atchafalaya Bay, but they accounted <1% of fluvial sediment discharged during this time. During storm periods, strong waves and winds vertically mixed the water column and sediment flux was highest near fluvial sources. During fair-weather conditions, freshwater plumes spread onto the stratified shelf water column and the major transport was horizontal advection. Model results indicated that deposition on the Mississippi subaqueous delta occurs in lock-step with fluvial delivery, while dispersals to other sediment sinks take place over longer timescales and include periods of transient deposition and intermittent resuspension.