Using Rapid Repeat SAR Interferometry to improve Hydrodynamic Models of flood propagation in Coastal Wetlands

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The propagation of tides and riverine floodwater in coastal wetlands is controlled by subtle topographic differences and a thick vegetation canopy. A precise quantification of fluxes of water, sediments and nutrients is crucial to determine the resilience and vulnerability of coastal wetlands to sea level rise. High-resolution numerical models have been used in recent years to simulate fluxes across wetlands. However, these models are based on sparse field data that can lead to unreliable results. Here, we utilize high spatial-resolution, rapid repeat interferometric data from the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) to provide a synoptic measurement of sub-canopy water-level change resulting from tide propagation into wetlands. These data are used to constrain crucial model parameters and improve the performance and realism of simulations of the Wax Lake wetlands in coastal Louisiana (USA). A sensitivity analysis shows that the boundary condition of river discharge should be calibrated first, followed by iterative correction of terrain elevation. The calibration of bed friction becomes important only with the boundary and topography calibrated. With the model parameters calibrated, the overall Nash-Sutcliffe model efficiency for water-level change increases from 0.15 to 0.53 with the RMSE reduced by 26%. More importantly, constraining model simulations with UAVSAR observations drives iterative modifications of the original Digital Terrain Model. In areas with dense wetland grasses, the LiDAR signal is unable to reach the soil surface, but the L-band UAVSAR instrument detects changes in water levels that can be used to infer the true ground elevation. The high spatial resolution and repeat-acquisition frequency (minutes to hours) observations provided by UAVSAR represent a groundbreaking opportunity for a deeper understanding of the complex hydrodynamics of coastal wetlands.