In Proceedings of EGS-AGU-EUG Joins Assembly, Nice, France, April 2003,
EAE03-A-07915; OS2-1TU1P-0508;

Near-bed velocity and turbidity measurements at an intertidal estuarine sand-flat influenced by fluvial discharges

by Uchiyama, Y

Department Civil and Environmental Engineering, University of California, Berkeley, USA
Littoral Drift Division, Port and Airport Research Institute, Yokosuka, Japan

Abstract:

A 44-day field observation was conducted at an intertidal estuarine sand-flat, on which fluvial sediments discharged from an adjacent river must be considered, to investigate hydrodynamics, suspension and transport of sediments, and resultant short-term geomorphology. Instruments deployed at three points on the flat included acoustic Doppler velocimeters (ADVs) for high-resolution velocity measurements, pressure-type wave gages (PWGs) for surface wave measurements, optical backscatter sensors (OBSs) for sediment concentration measurements, photoelectric sediment surface meters (SSMs) for bed elevation monitoring, and conductivity-temperature sensors (CTs) for temperature and density measurements. Data was logged mostly in bursts of 180 seconds at the rate of 8-10 Hz, and repeated every 10-120 minutes, through wet and dry periods over about three spring-neap tidal cycles. A series of bed level surveys was also carried out during spring tides.

The results of the measurements and a cross-spectral analysis demonstrate that long-term fluctuations of the velocity are mainly induced by wind waves, however tidally forced currents cause diurnal or shorter-period fluctuations, suggesting that the wind-induced short waves and the tidal currents dominate the boundary layer processes including the bed shear stress generation of the sandy tidal flat. The topography of the tidal flat fluctuated by approximately 10 cm during the deployment with the significant wave height in excess of 0.7 m, which was relatively high for the study site, although the decadal accumulation rate was estimated to be only about 3.8 cm/y as reported in the previous study (Uchiyama et al., 2001). Whenever the seabed was eroded, appreciably high turbidity, which is calculated from the OBSs' outputs, was measured. The estimated bed shear stresses were also intense when the seabed was eroded, but the high turbidity was still observed even with the bed shear stress to be nearly zero. This result implies that the optically measured turbidity may represent not only suspended sediments due to the bed shear stresses, but also advective sediments suspended at other locations, for instance. The bed sediments of the tidal flat are mostly composed of incohesive fine sand with median grain size of about 0.17 to 0.20 mm. The acoustic backscatters obtained by the ADVs with a acoustic frequency of 6 MHz are know to respond well to the sediments with 0.7 to 1.0 times the size of the acoustic wavelength (Vincent et al., 1991), and thereby the acoustic backscatters are applicable to estimate concentrations of the sediments with grain size of 0.176 to 0.252 mm, which exactly coincides with the grain size of the bed sediments on the flat. The acoustic backscatters thus can be used to represent the concentrations of the incohesive bed sediments, and accordingly cohesive sediment concentrations can be simply inferred from the deference between the OBS turbidity and the ADV turbidity. The estimated sediment concentration due to the incohesive bed sediment suspension exactly varies with the bed shear stresses, and cohesive sediment concentrations are generally fluctuated in response to the river discharge. Consequently, the suspension of the incohesive bed sediments occurred with the intense near-bed shear stresses induced by the combination of wind waves and tidal currents, resulting in rapid erosion. On the other hand, the turbidity due to the cohesive sediments was high when the river discharges fluvial sediment onto the flat. However, it is not evident if the fluvial sediment discharges correlate to the bed level variations. Near the seaward edge of the tidal flat, the bed shear stresses during the accretions are evaluated to be around 0.2 Pa, which is the approximate threshold for the bed sediments at the study site to become bed load. Therefore, it is concluded that the incohesive bed sediments, which were once suspended and transported offshore during rough wind wave conditions, were transported back to the shoreward direction during calm conditions, and this resulted in the gradual accretions of the topography of the flat.