Spatio-Temporal Hydrodynamic Variability in a Small Tidal Creek: DNERR St. Jones Reserve

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Abstract

The purpose of this study is to quantify the forcing parameters, namely the three-dimensional velocities, turbulent kinetic energy, and stresses, within a tidal channel and explore the effectiveness of in-situ measurements to quantify fundamental hydrologic characteristics. Three methods of analysis are implemented to quantify these characteristics: the Logarithmic Profile Method (LP), the Covariance Method (COV), and the Turbulent Kinetic Energy Method (TKE).

A field study was conducted at St. Jones Reserve in Dover, DE from April 14, 2011 to April 18, 2011. At the analyzed location in St. Jones Reserve, a tertiary saltwater tidal creek intersected a secondary tidal creek. Equipment was deployed at three locations in the channels with two sensor rigs in the secondary channel and one in the tertiary tidal channel to measure changes caused by interaction between the water bodies and variations in hydrologic characteristics. Sensors were placed in the center of the channels to determine the distribution of sediment suspension and velocity. Field sensors used to investigate the distribution of hydrologic parameters include acoustic water level sensors (AWLS) to ascertain data on free surface elevations, optical backscatter sensors (OBS) to determine sediment concentrations, high-resolution acoustic Doppler Current profilers (ADCP) to measure near bed velocity profiles up to 3cm above the bed, and electromagnetic current meters (EMCM) to assess velocities higher in the water column. Sample recordings were collected in closely spaced time intervals, allowing for an accurate understanding of hydrologic changes during tidal cycles.

The study shows an oscillating tidal cycle resulting in asymmetric velocities and creating two velocity peaks during the tidal cycle: one during ebb and one during flood. The velocity peak during ebb is larger than the one during flood. Additionally, analysis of the three-dimensional velocity profile shows that the along-stream (x direction) and cross-stream (y direction) velocities are approximately three times larger than the vertical (z direction) velocities, making them the primary contributors to the other forcing parameters. In conjunction with the maximum along-stream and cross-stream velocity peaks, fluxes of suspended sediment occurred.

Analysis of the methods to compute the forcing parameters shows that not all methods provide equally accurate results for near bed computations. In general, methods utilizing all velocity components provide the best, most accurate calculation for TKE of the system. In general, the best method to compute bed stress is the logarithmic profile method. The
average bed stress computed throughout the tidal cycle using the LP method is most nearly reflected by the results obtained using the stress computed using only the vertical velocity component. The peaks in the forcing parameters coincide with increased elevations of sediment suspension, indicating that these parameters drive erosion within the channel.

In conclusion, levels of erosion increase when the peak velocities, turbulent kinetic energy, and bed stress occur. The most accurate methods to compute the turbulent kinetic energy of the system include three velocity components, while the logarithmic profile method provides the best method to calculate the bed stress within the system.