

Modal analysis of near-bank velocity profiles in a tidal river.

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We apply two decompositions to long-beam velocities of a 600 kHz 3-beam Horizontal Acoustic Doppler Current Profiler (HADCP) at West Point on the Hudson River Estuary, so as to efficiently characterize the spatiotemporal variation of near-bank velocity. One main motivation is to test statistical tools with which to benchmark computations. The HADCP is deployed next to the USGS gauging station at West Point, some 100 km upriver from Manhattan, on the inner bank downstream of a sharp bend and its associated 40 m deep trough. We analyzed a time series of 1-minute averages from October 2011, out to 80 meters from the bank with 1 m bins.

The first decomposition we apply is Principal Component Analysis. The PCA generates an optimally convergent set of spatial eigenfunctions or "principal components" (PC), with which are associated temporally-varying amplitudes called "temporal coefficients". The first principal component captures more than 96.3% of the variance in velocity measured along the three HADCP beams, while the second PC captures about 2%. There appears an asymmetry between ebb and flood, as seen clearly from a phase plot of the temporal coefficient of the first PC versus that of the second.

The second is Fourier-based Koopman Mode Decomposition, i.e. decomposition into harmonic averages of the measurement vector. KMD associates a spatial structure with each of a series of temporal frequencies. For Oct 2011, the semidiurnal mode captured 74.33% of the variance. KMD also quantifies the phase lags at different distances from the river bank (and between normal and tangential velocity). Phase lags of tangential velocity between 10 and 80 m from the bank were about 1 hour for the semidiurnal mode, and 2 hours for the first (with a period of about 6 hours.), and this difference grew to a factor of four when considering flow within 10 m.

Keywords: principal component analysis, Koopman mode decomposition, ebb-flood asymmetry