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Uncertainty analysis of numerical model simulations and HFR measurements during high energy events

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The identification and decomposition of sensor and model shortcomings is a fundamental component of any coastal monitoring and predictive system. In this research, numerical model simulations are combined with high-frequency radar (HFR) measurements to provide insights into the statistical accuracy of the remote sensing unit. A combination of classical tidal analysis and quantitative measures of correlation evaluate the performance of both across the bay.

A network of high frequency radars is deployed within the Chesapeake study site, on the East coast of the United States, as a backbone component of the Integrated Ocean Observing System (IOOS). This system provides real-time synoptic measurements of surface currents in the zonal and meridional direction at hourly intervals in areas where at least two stations overlap, and radial components elsewhere. In conjunction with this numerical simulations using EFDC (Environmental Fluid Dynamics Code), an advanced three-dimensional model, provide additional details on flows, encompassing both surface dynamics and volumetric transports, while eliminating certain fundamental error inherent in the HFR system such as geometric dilution of precision (GDOP) and range dependencies. The aim of this research is an uncertainty estimate of both these datasets allowing for a degree of inaccuracy in both.

The analysis focuses on comparisons between both the vector and radial component of flows returned by the HFR relative to numerical predictions. The analysis provides insight into the reported accuracy of both the raw radial data and the post-processed vector current data computed from combining the radial data. Of interest is any loss of accuracy due to this post-processing. Linear regression techniques decompose the surface currents based on dominant flow processes (tide and wind); statistical analysis and cross-correlation techniques measure agreement between the processed signal and dominant forcing parameters. The tidal signal extracted from HFR measurements is cross-correlated against numerical simulations driven by tidal forcing alone. Results demonstrate a close statistical relationship, diminishing with distance from the HFR unit. To further analyse the relative performance of both, correlation statistics are computed during two different sampling periods: a seven day period of relatively calm conditions and a subsequent seven day period encompassing the highly dynamic effects of “Hurricane Sandy” on the region. During both these periods complex correlation coefficients between surface currents and measured wind speeds are computed and the data adopted to evaluate the performance of both. Of particular interest is the relative performance of the HFR during periods of both high and low-energy forcing, and the ability of a technically advanced model to mathematically simulate these complex flow features.