DEVELOPING A DATA-DRIVEN HYDRODYNAMIC MODEL OF A MARINE ENVIRONMENT

USING SHIP-BASED ADCP MEASUREMENTS IN THE NORTH SEA

Hydrodynamic data play a vital role in various applications, such as morphological modelling. Currently, two primary sources of flow velocity data are used: buoys and coastal shelf models, but both have limitations. Buoys, while convenient, lack spatial resolution, and coastal shelf models tend to overestimate flow velocities. Last year the Royal Netherlands Navy equipped one of their ships with a Doppler Velocity Log (DVL) providing Acoustic Doppler Current Profiler (ADCP) velocity measurements made while sailing. Ship-based measurements offer several advantages, including higher spatial resolution and high accuracy. However, these measurements contain a spatial and temporal difference between each measurement. Therefore, the goal is to develop a method that considers temporal and spatial differences.

The provided data consists of four days of DVL measurements near the Dutch coast. Several measurement errors are identified and corrected, caused by synchronization issues, ship turbulence, and DVL side lobes. After this, outliers are filtered and the water column is divided into two layers based on velocity profiles, with velocities averaged within each layer. Harmonic analysis is employed to extract tidal signals for each depth layer. In the top layer, 6 tidal constituents are extracted, while the bottom layer yields only 2 constituents. Furthermore, the amplitude for the eastward velocities is overestimated, while for the northward velocities, the amplitude is similar to the measurements.

Two methods are introduced to predict tidal propagation within the model domain: the STEP (Spatial-from-Temporal Estimated Phase) and WC (Wave Celerity) methods. The STEP method tends to overestimate spatial phase differences, whereas the WC method predicts more realistic phase differences. Comparing the outputs of these methods with the Dutch Coastal Shelf Model (DCSM) the STEP method had a cross-correlation of 0 and a Root-Mean-Squared Deviation (RMSD) ranging between 0.4 and 0.6 m/s, while the WC method shows better alignment with a high cross-correlation of 0.9 and an RMSD of 0.2 m/s.

In conclusion, the WC method shows promising results, while the STEP method is not accurate yet. However, further steps need to be taken before one of the methods can be used. First, the measurements need to be improved by synchronizing the clocks and containing a longer period. Next, the model needs to be validated and additional physical processes need to be incorporated. Besides this, this research shows the first steps taken to use ship-based DVL measurements for the development of a hydrodynamic model.

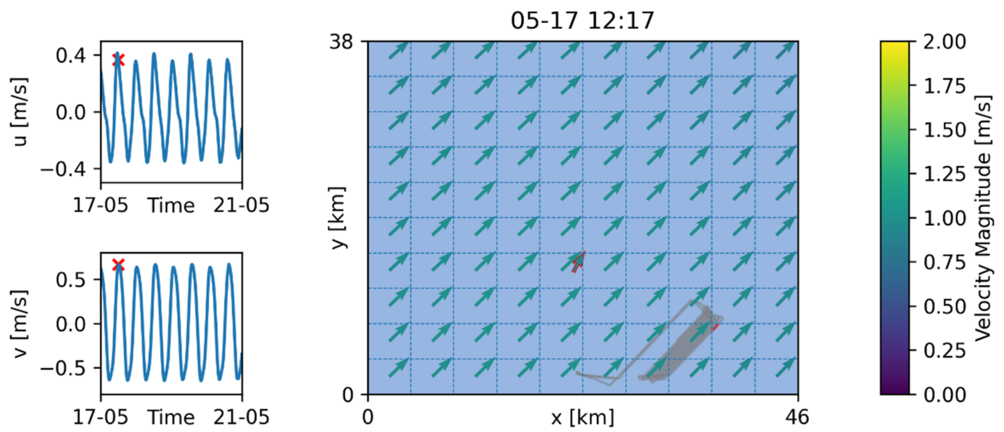

Figure 1: Predicted tidal velocities for the WC method for minimum eastward and northward velocities. The east and northward velocities are plotted in the left two plots, computed from the harmonic analysis. In these time series, the moment in the tidal cycle is indicated with a red cross. In the right plot, the red line indicates the measurements made around the time shown in the figure, and the grey lines are old measurement locations. The arrow with the red contour is the velocity at the reference location.

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Graduation Date:
2 October 2023

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