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Investigations into influences of wind field resolution on simulating surface currents for Galway Bay

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Abstract

Inaccurate wind data can lead to inaccuracies in the surface currents computed by three-dimensional hydrodynamic models. In the present research, a wind forecast model is coupled with a 3D hydrodynamic model to investigate the effect of surface wind data resolution on model accuracy. High resolution and low resolution wind fields are specified to the model and the computed surface currents are compared with measurements obtained from the High-Frequency (HF) radar observation system and Acoustic Doppler Current Profile. Modelled surface currents show good correlation with observations and the resolution of the surface wind data is shown to be important for model accuracy.

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Keywords: ADCP; CODAR; EFDC; galway bay; hydrodynamic model; radars; surface currents; wind field

1. Introduction

Coastal waters have always been used as a convenient means to dispose of unwanted materials such as domestic and industrial wastes and dredged material. Due to these continually increasing demands on coastal waters, investigation into hydrodynamic process of water body in coastal areas is necessary. Hydrodynamic circulation within an estuary is primarily driven by tides, river inflows and winds. Accurate definition of dominant forces (tide

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and wind) is of great importance for good simulation. Tide data are easy to observe. However, wind data in coastal areas are difficult to obtain owing to the limit of observations systems and adverse weather conditions. Model inaccuracy due to wind forcing can result from twofold: firstly, the wind data used in hydrodynamic models are usually measured on land and can be quite different in magnitude and direction from offshore winds. Secondly, surface winds are spatially-varying in estuaries but due to a lack of data it is commonly practical to specify a non-varying wind speed and direction across the full extents of a model domain.

A number of researchers studied hydrodynamic circulation of Galway Bay, such as Booth [1] Nolan [2], Nolan [3]. However, no models had been developed using high resolution wind fields in this area. In order to investigate the impacts of wind force on surface currents in Galway Bay, estimated high resolution wind fields from the Autoregressive Integrated Moving Average (ARIMA) model are applied to drive the three-dimensional hydrodynamic Galway Bay model surface layers in this paper [4-6]. The rest of this paper is organized as: Section 2 introduces the research domain, Galway Bay. Available wind data for Galway Bay are presented and analyzed in Section 3. Water currents measured by ADCP and HF radar CODAR in this area are introduced in Section 4 in detail. Section 5 gives a brief description of the three-dimensional hydrodynamic model EFDC, followed by results in Section 6. Conclusions are presented in Section 7.

2. Research domain

Galway Bay shown in Fig. 1 is a large bay located on the west coast of Ireland. It can be divided up geographically into two sub-bays: Inner Bay and Outer Bay. The Inner Bay is relatively shallow, with maximum depths of around 30 m. The Outer Bay has maximum depths of approximately 70 m and widens from the mouth of the Inner Bay to the mouth of the Outer Bay. The bay is semi-enclosed with three islands acting as land barriers between the Outer Bay and the open Atlantic Ocean to the west and providing some shelter to the Outer Bay from the prevailing south-westerly winds. The bay is linked to the Atlantic Ocean through four Sounds.

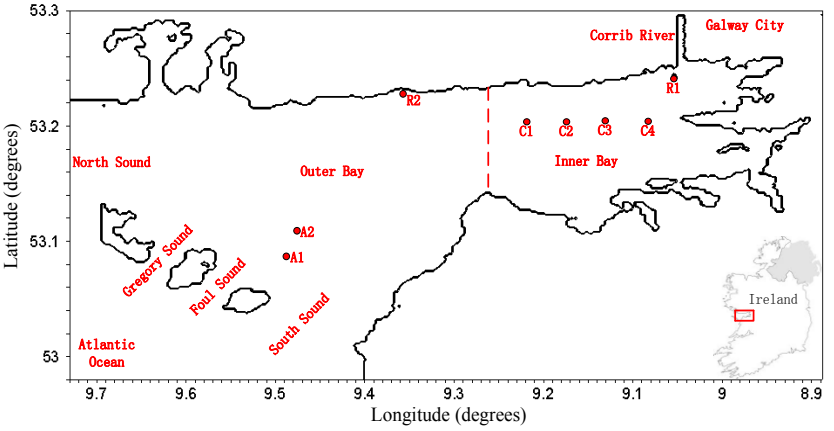

Fig. 1. Study area of Galway Bay (R1 and R2 indicate radar station at Mutton Island and Spiddle, respectively; A1 and A2 indicate ADCP sites; C1-C4 indicate reference points for comparison).

3. Wind data

Two wind data sets were available for this research. The first wind data comprised a two-month wind time series from Julian Day 274 to Julian Day 334, 2011. These data were measured by the Informatics Research Unit for Sustainable Engineering (IRUSE) weather station. The second wind data comprised a series of short-term forecasts of offshore winds during the same two-month period. The wind forecast model used was Harmonie cy361.3 running on 2.5 km and 0.5 km resolution coupled spatial grids [7, 8]. Detailed description about the high resolution wind forecast ARIMA model is given by Ren, Sheahan, Nash, Nagle and Hartnett [6]. The high resolution forecast