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ScienceDirect

Energy Procedia 107 (2017) 345 – 350

Energy Procedia

3rd International Conference on Energy and Environment Research, ICEER 2016, 7-11 September 2016, Barcelona, Spain

Prediction of Surface Currents Using High Frequency CODAR Data and Decision Tree at a Marine Renewable Energy Test Site

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Abstract

In this study, Decision Tree (DT) was employed to predict surface currents in a ¼-scaled marine renewable energy test site—Galway Bay. In training and testing models, wind speed, wind direction and tidal water elevation from a forecasting model, and observations of surface velocity components during previous hours were taken as input variables; surface velocity components were taken as the output variable. Appropriate value of Complexity Parameter (CP) in decision tree models was determined based on experiments producing the minimum Root-Mean-Square-Error (RMSE) values compared with the radar data. Statistics including RMSE, bias, correlation (R) and Scatter Index (SI) were computed between predictions and radar data to assess predictions. Results indicated that the DT model can produce satisfactory predictions of surface currents. Good performance of DT model indicated that it can be regarded as a promising approach for future applications.

Keywords: surface currents; decision tree; marine renewable energy; prediction; Galway Bay; scatter index; correlation; CODAR; radars

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doi:10.1016/j.egypro.2016.12.171

1. Introduction

Accurate real-time information of surface currents is becoming more and more important for a sea of aspects. Good understanding of surface currents can help human to better deal with matters such as oil spill treatment, marine renewable energy extraction and climate forecasting and so on. In addition, green energies such as marine renewable energy is currently becoming a hot topic owing to pollution issues in air, water and soil using traditional energies.

In general, two approaches—numerical models and observation platforms based on remote sensors are widely used to investigate dynamics of water movement in coastal areas. However, numerical model which approximates dynamic processes in a mathematic way inevitably results in model errors. These errors mainly result from the discretization of model grids in space, simplification of initial and boundary conditions. Although numerical models can produce forecasting information, quality of predictions is not easily met. Observation platforms such as radars and satellites can monitor water parameters over a large spatial domain even global with short observation window, but they can not provide information of future status of water parameters of interest. An alternative approach has been proposed and widely applied in a variety of fields due to development of Artificial Intelligence (AI). Decision Tree (DT), Artificial Neural Networks (AANs) and Deep Learning (DP) and so on have been employed to predict states of interest in many fields, such as Partal, Cigizoglu and Kahya [1], Timofeev [2], Makarynskyy, Pires-Silva, Makarynska and Ventura-Soares [3], Solomatine and Xue [4]. In this work, authors focused on predicting surface currents for a 1/4-scaled marine renewable test site—Galway Bay. Observation of surface currents from the CODAR observation system, wind speed and wind direction from a forecasting model and tidal water elevation from an inversion model were applied to develop DT models. Three locations with high coverage by the CODAR system were used for analysis. Surface east-west and north-south velocity components were predicted separately using DT models.

Structure of this paper is organized as: Section 2 introduction the High Frequency radar observation system. Section 3 presents the Decision Tree algorithm. Results are presented in Section 4, followed by conclusions in Section 5.

2. High frequency radar data

The total surface current velocity vector is determined by summing surface currents radial velocity components from at least two radar locations. There are various applications of radar data, including search and rescue support, oil-spill mitigation in real time and larval population connectivity assessment when viewed over many years [5]. Two CODAR SeaSonde high frequency radar stations have been deployed in Galway Bay since summer in 2011 as shown in Fig. 1; they are located at Mutton Island Waste Water Treatment Plant (C1 in Fig. 1) and Spiddal Pier (C2 in Fi. 1). This radar system provides 300 metres horizontal resolution of surface currents data every hour.

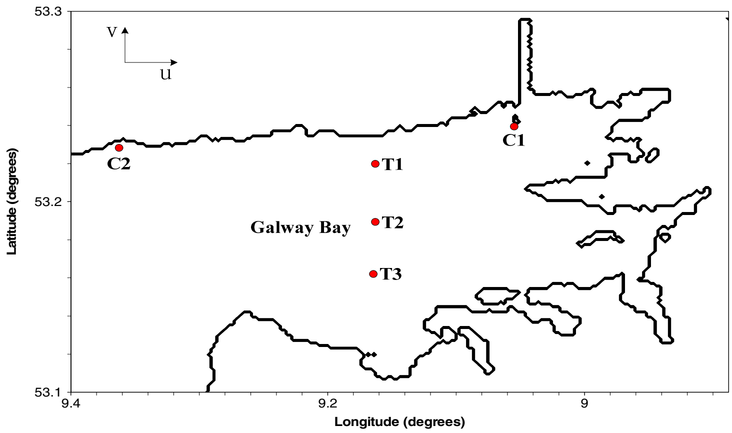

Fig. 1. Station locations of radar in Galway Bay

(C1 and C2 indicate radar stations; T1-T3 indicate three analysis locations)