Multi-Vehicle Oceanographic Feature Exploration


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ABSTRACT

Oceanographic features such as jets and vortices are often found downstream of obstacles and landforms such as islands or peninsulas. Such features have high spatial and temporal variability and are, hence, interesting but difficult to measure and quantify. This paper discusses an experiment to identify and resolve such oceanographic features in Selat Pauh, in the Straits of Singapore. The deployment formation for multiple robotic vehicles (Autonomous Surface Craft - ASC), the measurement instruments, and the algorithms developed in extracting oceanographic field variables are described. These were based on two ocean field predictions from well-known geophysical flow dynamic models. Field experiments were carried out and comparison of the forecasts with measurements was attempted. To investigate an unexpected behaviour of one ASC, hindcasts with wind effects and simulation with vortex feature extraction on a larger domain with more involved bathymetry were also partially carried out.

KEY WORDS: Marine robotics; adaptive sampling; ocean jets and vortices.

INTRODUCTION

This paper describes work in progress under a research initiative funded by Singapore’s National Research Foundation. This has led to the establishment of the Singapore-MIT Alliance for Research and Technology (SMART, 2008) and the creation of MIT’s first research center outside the USA. One of the interdisciplinary research projects within SMART is the Center for Environmental Sensing and Modeling (CENSAM, 2008). One component of CENSAM involves oceanographic modeling, forecasting and experimentation with a network of robotic vehicles both surface and underwater. The overall objective of this part of the project is to develop adaptive sampling and assimilation strategies that would enhance our ability to forecast physical, chemical and biological oceanography fields through suitable optimized use of the measurement resources operating in a coupled fashion with computational models of the dynamic ocean behavior. This paper describes recent collaborative research and experiments over the last twelve months, carried out by MIT scientists and engineers and counterparts at the National University of Singapore (NUS). The overall project involves 4 professors, 2 research scientists, 3 postdoctoral associates, 6 research engineers and 2 PhD students.

Oceanographic features such as jets and vortices are often found downstream of obstacles and landforms such as islands or peninsulas and can be also the results of instabilities of jet-like currents (Jochum et al., 2004). Such features have high spatial and temporal variability and are, hence, interesting but difficult to measure and quantify. This paper discusses field experiments to identify and resolve such oceanographic features in the Selat Pauh channel, in the Straits of Singapore. The deployment formation for multiple robotic vehicles - ASC; the measurement instruments, and the algorithms developed in extracting oceanographic features are described. The planning of these experiments at sea was based on two ocean field predictions from well-known geophysical flow dynamic models, one from the Tropical Marine Science Institute (TMSI) of NUS and the other from the Department of Earth, Atmospheric and Planetary Sciences (EAPS Department) at MIT. Field experiments were carried out in January 2009 in the Selat Pauh channel, and comparison of the forecasts with measurements were also carried out in preliminary fashion following basic statistical and spectral analyses of the data. Hindcasts with wind effects and simulation on a larger domain with more involved and accurate bathymetry were also partially carried out followed by the application of a vortex identification algorithm to investigate the unexpected behaviour of one drifting ASC.

This paper is organized as follows. The first section describes the forecasting work and the models employed by TMSI and EAPS. The results of these models were used to plan meaningful field experiments in the Straits of Singapore, that were attached to a more general experimental program under CENSAM in January 2009. The next section describes the field experiments planned and carried out during two days in January 2009. The following section describes the results obtained and comparison of the measurements with forecasts. The paper concludes with recommendations for further work.

SIMULATION AND FORECAST

Field experiments were carried out in the Selat Pauh channel in the Singapore Straits. The dates of the experiments were January 14 and 21, 2009. As the area of operation and dates when the experiments were to be carried out were fixed, forecasts of the oceanic properties in the specific area for the dates of experiments were produced to aid in the design of the experiments to be conducted. Different forecasts of the same day and time were carried out by two independent groups. Both