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A new method to calibrate Lagrangian model with ASAR images for oil slick trajectory

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ABSTRACT

Since Lagrangian model coefficients vary with different conditions, it is necessary to calibrate the model to obtain optimal coefficient combination for special oil spill accident. This paper focuses on proposing a new method to calibrate Lagrangian model with time series of Envisat ASAR images. Oil slicks extracted from time series images form a detected trajectory of special oil slick. Lagrangian model is calibrated by minimizing the difference between simulated trajectory and detected trajectory. mean center position distance difference (MCPD) and rotation difference (RD) of Oil slicks' or particles' standard deviational ellipses (SDEs) are calculated as two evaluations. The two parameters are taken to evaluate the performance of Lagrangian transport model with different coefficient combinations. This method is applied to Penglai 19-3 oil spill accident. The simulation result with calibrated model agrees well with related satellite observations. It is suggested the new method is effective to calibrate Lagrangian model.

1. Introduction

The high frequency of the oil spill accidents highlights the importance of tracing oil spill. Accurate trajectory simulations of oil spills could provide instructions on the possible areas to be polluted or locations of the accidents, which is beneficial to marine environment. The commonly used operational oil spill models, as reviewed by Galt, Reed and Hackett (Galt, 1994; Reed et al., 1999; Hackett et al., 2006), including MOTHY (Modèle Océanique de Transport d'Hydrocarbures, a French operational oil spill drift forecast system), OSCAR (Oil Spill Contingency and Response), OILMAP (Oil Spill Model and Response System), ADIOS2 (Automated Data Inquiry for Oil Spills), GNOME (General NOAA Operational Modeling Environment). The GNOME and OILTRANS model have been successfully implemented to track oil slicks in different sea waters (Beegle-Krause, 1999; Cheng et al., 2011; Farzingohar et al., 2011; Berry et al., 2012; Deng et al., 2013; Xu et al., 2013).

The systems above are usually developed to forecast or backtrack special or common oil slicks and the coefficients in their model are usually constant. While according to Garcı'a-Ladona and Price (Garcı'a-Ladona et al., 2005; Price et al., 2006), the optimal transport model coefficients usually vary with many factors: the input field (winds, currents, and waves) and the local bathymetry, and so on. Thus, it is necessary to calibrate Lagrangian transport model to get the optimal model coefficients for certain oil spill accident with the special datasets. Generally, Lagrangian model is calibrated by minimizing the difference between the numerical trajectories and the actual paths of buoy drifters. Abascal (Abascal et al., 2009) calibrate the PICHI model with a set of 13 buoys released in the Bay of Biscay during the Prestige accident. And the result suggests that optimal coefficients of current drift, wind drag, wave-induced stokes drift are as follow: $C_C = 0.266$, $C_D = 0.0345$ and $C_H = 0.068$. The current coefficient C_C is smaller than the typical values, stated by Sobey (Sobey and Barker, 1997), which is due to the difference between the real and numerical current fields. While, the result of calibration performed by Cucco (Cucco et al., 2012) suggests that optimal value of C_D and C_C in Lagrangian model are 0.005 and 1.2, respectively. In their experiment, referenced buoys datasets for testing the numerical result consist of trajectories of 8 surface Argo Drifter buoys, which are deployed in Strait of Bonifacio (SoB) during the early spring and summer periods except one in early autumn.

However, the enough drifter datasets in situ are not always available for sudden oil spills due to their limited quantity and dependence on weather. In this work, we propose a new method to calibrate Lagrangian model with time series of Envisat ASAR images for forecasting and backtracking oil slick trajectory. Envisat ASAR is an active microwave sensor. It can image the area in all weather conditions day and night. The optimal coefficients are obtained by reducing the difference between simulation results and corresponding extracted oil slicks from ASAR images. The method is then applied to Penglai (PL) 19-3 oil spill accident. The PL 19-3 oil spill occurred at Penglai 19-3 platform B and C in June 2011, as in Fig. 1. With the transportation by currents, prevailing winds, and wave-induced stokes drift, the oil slicks moved to the

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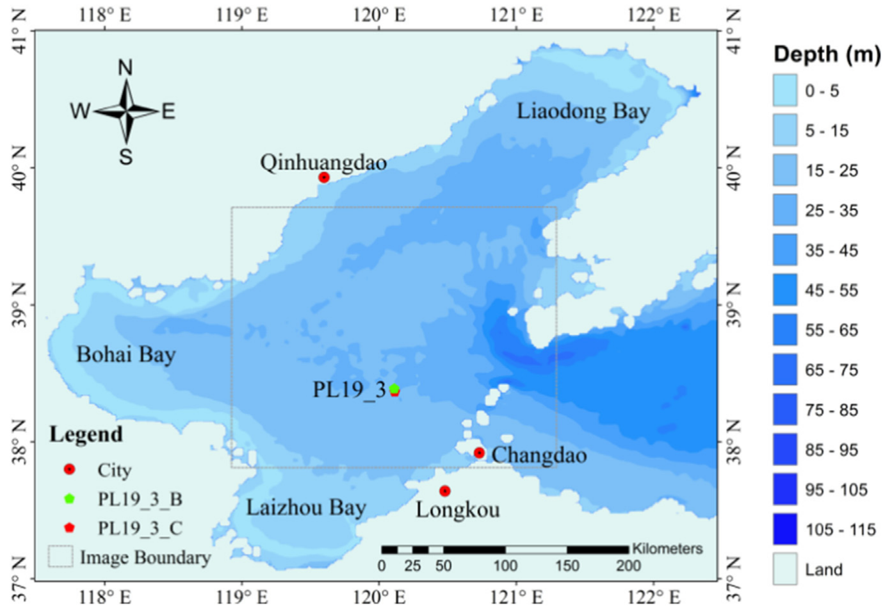

Fig. 1. Bohai bathymetry map and the locations of PL19-3 B and C platforms.

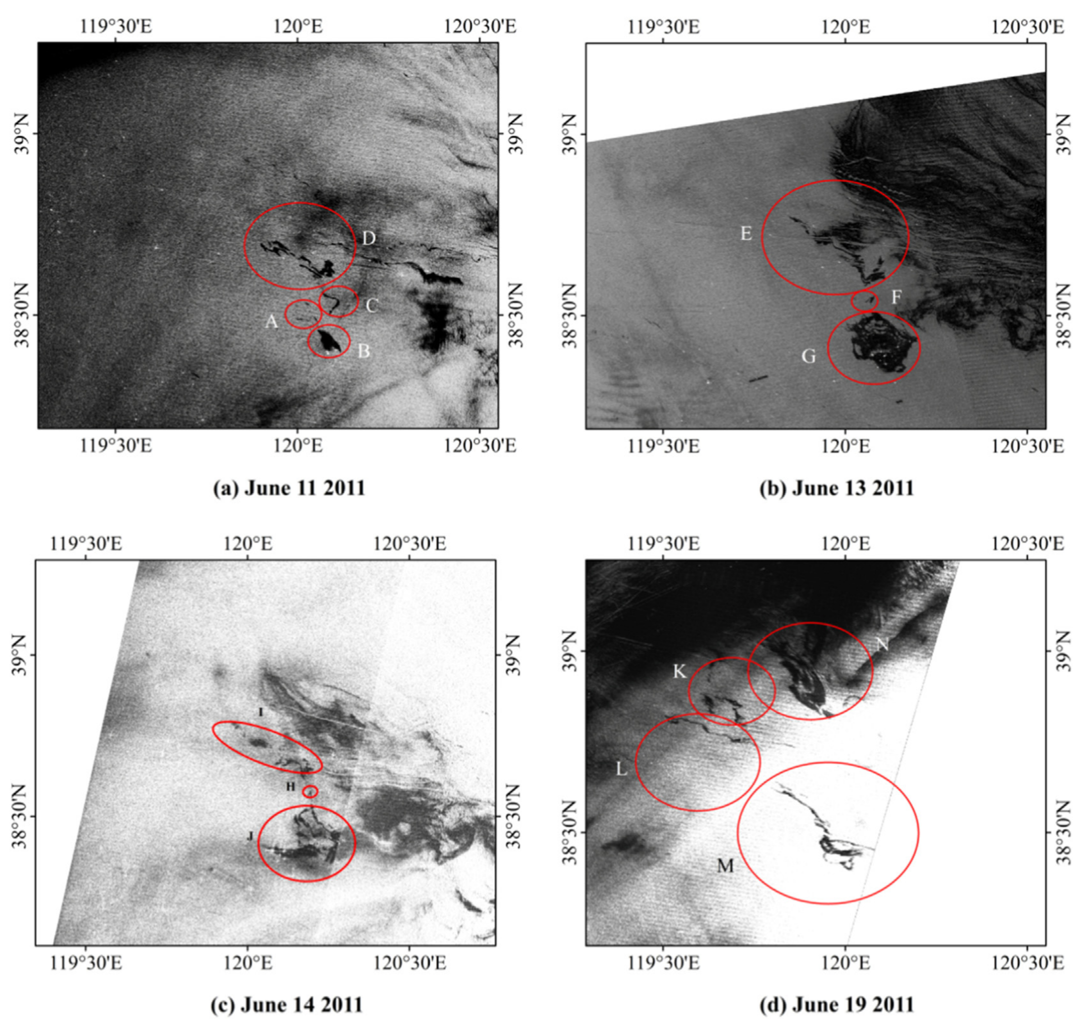

Fig. 2. ENVISAT ASAR images in the PL1-3 oil spill area on June 11(a), 13(b), 14(c), and 19(d). The dark spot in the red circles are oil slicks, marked with A–N. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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