JEB™
Website : www.jeb.co.in
E-mail : editor@jeb.co.in

Journal of Environmental Biology

ISSN: 0254-8704 (Print)
ISSN: 2394-0379 (Online)
CODEN: JEBIDP

Study on temporary resolution for offshore marine oil spill emergencies based on remote sensing system

Lan Guo-Xin*, Dong Kai-Xin and Lin Jun-Jie
College of Environmental and Chemistry Engineering, Chongqing Three Gorges University, Wanzhou - 404 100, PRChina
*Corresponding Author E-mail: **feman7122@163.com**

Publication Info

Paper received:
12 October 2015

Revised received:
27 April 2016

Re-revised received:
05 May 2016

Accepted:
23 June 2016

Abstract

Time is particularly critical for an oil spill occurring in the ocean as wind and current can rapidly spread the oil over a large area in a short time. Using the features of sensor surveillance system and mathematical trajectory models, the cooperation of surveillance and trajectory under oil spill emergency response is presented in this paper. Based on integration of equation simulating an oil spill trajectory, the method for remote-sensing application time (*Te*) has been described, and optimization of processing time described in the application time equation has been proposed. This contribution, which is integrated with remote-sensing and mathematical models, is expected to be a powerful tool for real-time contingency planning in the Dalian Xingang oil spill. According to these findings, the method allowed spills emergency alerts to make the best decision for choosing remote-sensing data, considering effective temporary resolution.

Key words

Dalian Xingang oil spill, Remote sensing system, Temporary resolution

Introduction

In the past few years, the frequency of accidental oil spills in marine environments has triggered the development of a large number of sensor technology for oil spill surveillance and mathematical models for oil spill trajectory simulation. The characteristics of oil spill mathematical models range from two-dimensional (2D) particle-tracking models GNOME, PICHI (NOAA, 2002; Castanedo *et al.,* 2006) to three-dimensional (3D) models, describing the physics of the oil spill processes OILMAP, MOHID (ASA,1997; Miranda *et al.,* 2000). These models focus on solving "where will the oil go" which is a critical question asked by the emergency responder during an oil spill. When rapid response is required, short-range trajectory modeling such as GNOME can be an excellent choice, therefore, it should be done on real time to give day-to-day support for oil spill contingency plan at a specific spill. However, forecasting the movement of an oil spill is often hampered by insufficient input data (NOAA, 2002), detailed data (location, volume lost, product type) are often sketchy and environmental data (wind and current observations and forecasts) are often sparse or unavailable, particularly in the first few hours of the release. The “Uncertainty", the "best guess" of the oil movement and fate depends on the length and time-scale of the spill (Beegle-Krause *et al.,* 2001). But these required key parameters that can be provided by multi-temporal imaging captured by remote sensing (Grüner *et al.,* 1991; Natural Resources Canada, 2007).

In view of the characteristics of sensor technology for oil spill surveillance and mathematical models for oil spill trajectory simulation, temporary resolution analysis of remote sensing monitoring for oil spill emergencies has been presented in this study, which was applied in 2012 Dalian Xingang oil spill.

Materials and Methods

Temporary resolution analysis : In actual operation, knowing the location of the spill gives critical guidance to protect resources and direct clean up. It has been assumed that the spill center distance from sensitive areas as D are normally known the location, when the spill arrived at d position. Therefore, assuming the velocity of oil slick center, V_{oil}, in the above situation, the displacement time moves from incident position to sensitive position. So, T_d, can be expressed as,

$$T_d = (D - d)/V_{oil} \quad (1)$$

As evident from the previous oil spill experience, wind drift and surface currents were the major advective transport mechanism. Sobey and Barker *et al.* (1997) showed the importance of wave-driven transport in nearshore areas. Castanedo *et al.* (2006) found that a C_{wa} around 0.05~1.5% of the wave-induced Stokes drift provided the best fit between the numerical predicted trajectory and the buoys' paths. Wu et al. (2009) indicated that wave of a greater energy input in Ekman layer only occurred at high speed and high-latitude conditions (Wu and Liu, 2008; Wang and Rui, 2004). In addition, it has been pointed out that the displacement time can be calculated before entering the sensitive areas. This means that offshore is the major place of suffering. Thus V_{oil} can be simplified as,

$$V_{oil} = C_c V_c + C_w V_w \quad (2)$$

Where, C_c is the surface current drift coefficient; V_c is the surface current velocity; C_w is the wind drag coefficient that varied, according to state-of-the-art measurements from 2.5% to 4.5% (ASCE, 1996); V_w is the wind velocity at a height of 10m sea surface.

From equation 2, displacement time (T_d) was calculated by the following formula :

$$T_d = (D - d)/V_{oil} = (D - d)/(C_c V_c + C_w V_w) \quad (3)$$

In general, the oil movement was estimated as vector of sum of wind drift (using 3.5% of the wind speed) (Reed *et al.*, 1994), the surface current (using 100% of the current speed) (Abascal *et al.,* 2009) and spreading and larger-scale turbulence (diffusion).

Remote sensing data from customization, transmission, acquisition, preprocessing, information extraction to the product release takes some time. That is the processing time of remote sensing products. T_p., thus, application time (T_a) for remote sensing data was expressed as, T_a=T_d-T_p. This would provide spill decision-makers enough time to avoid damage on the coastal environments. It should be noted that the effective temporal resolution T_e of application should preferably be $T_e \leq T_a$.

Processing time analysis and optimizing : Optimizing scheme was proposed for the analysis of components of oil spill emergency monitoring system based on satellite information. The interval between processing and spill response decision-making decreases by one hour only (Gershenzon *et al.,* 2007). The time analysis for remote sensing application yields the following percentages:

Data acquisition:5-15min,~25%
Quick look generation: 5-10min, ~17%
Full resolution focusing:5min, ~8%
Pre-processing:10-15min, ~25%
Spillage detection and application: 5-15min, ~25%

The satellite data is transferred by a transmission scheme integration of numbers of data distribution units, particularly by an emergency channel when rapid response in needed. This takes less than 15 mins. The processing time of SAR/OPTICAL data was reduced due to protect the outcome and developed the software—Satellite Remote Sensing Oil Spill Monitoring System (V2.0.0) that supports automatic and manual oil spill detection and other functions.

Results and discussion

The Dalian Xingang Port oil spill occurred on 16th July 2010. 1,500 tonnes of oil spilled from the pipes and created an 180km^2 slick in the Yellow Sea. Based on equation 3, the spill film was not far away from the incident area, as evident from marine environmental data viz., high tide, south-west current and south wind (130°). Most of the oil beached, for the wind typically had been blowing onshore till the end of July (Fig.1). By 21st July, 2010 the spill speared to 946 km^2 (365 sq mi), and stretched as far as 90 km (56 mi) along the coast, with a driving force caused by the fragmentation and migration of wave. During this period, multi-source remote sensing technology timely accessed this oil spill information that included location, area and distribution, which overcame the adverse conditions such as bad weather, night surveillance, particularly in the beginning of accident.

However, weather changed on 1st August 2010 and southerly winds turned into northerly winds (4-5) with heavy

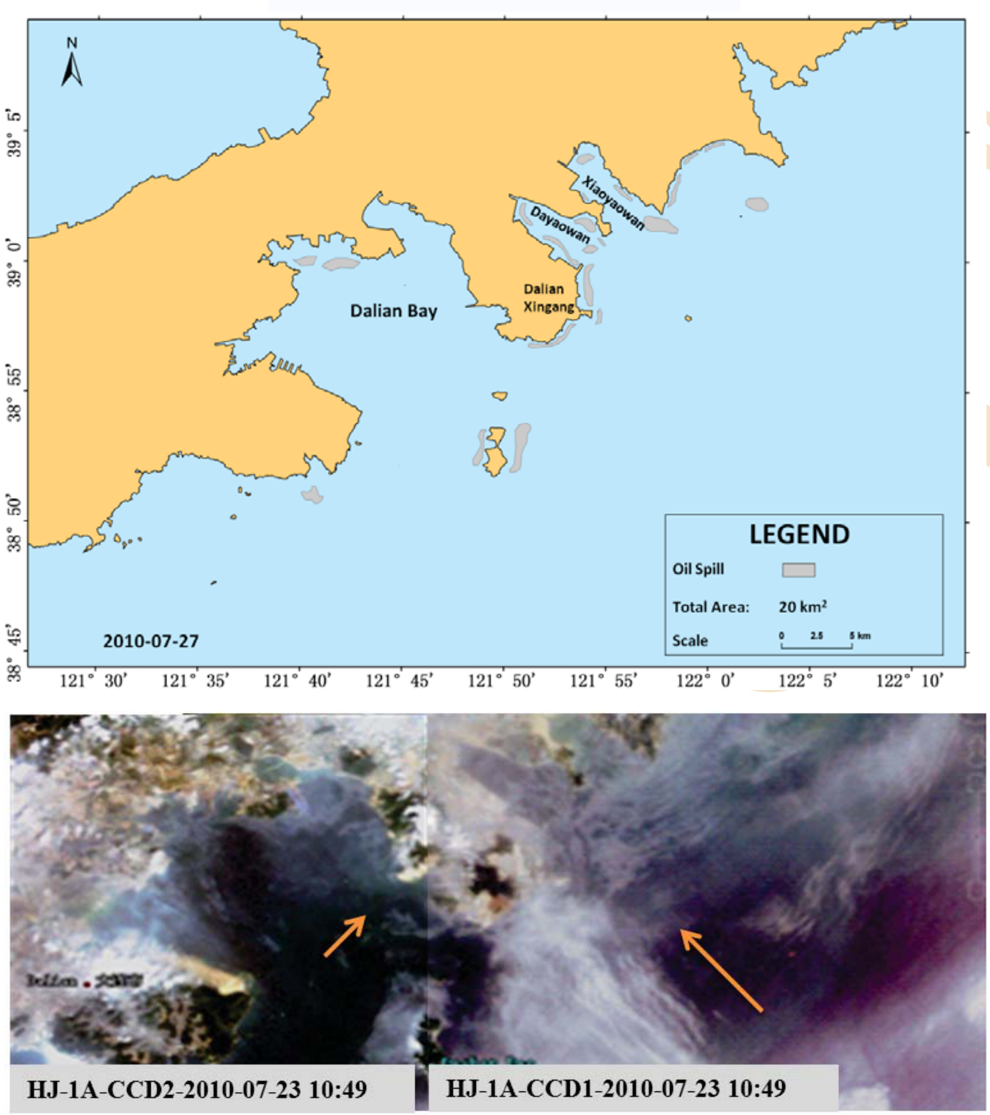

Fig. 1 : Multi-source remote sensing oil spill monitoring results at the end of July

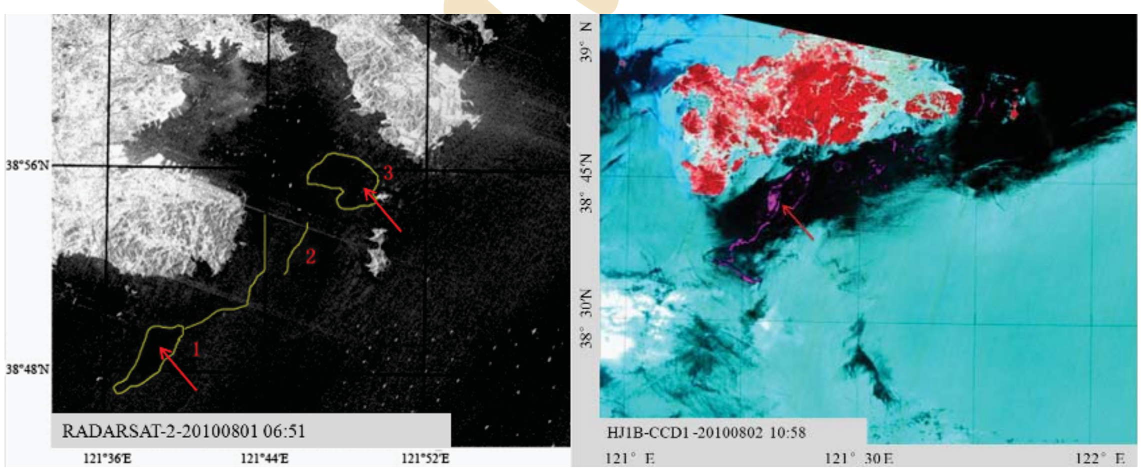

Fig. 2 : Multi-source remote sensing oil spill monitoring results as of the beginning of August

precipitation. This abrupt change broke the original sub-balance. Based on equation 3, according to marine environmental data: high tide, south-west current (0.15m sec^{-1}), north wind (320°, 7.0m sec^{-1}) and assumption of the processing time T_p as 1h, initial time as 00:00 am 1st August, incident location as originating plate , the application time was calculated as: Access to sensitive area Xiaoshan Island, $T_d \approx 5.20h$, $T_a \approx 4.20h$; Access to sensitive area Haizhiyun Park, $T_d \approx 12.31h$, $T_a \approx 11.31h$ and Access to sensitive area Laopian Island, $T_d \approx 22.15h$, $T_a \approx 21.15h$.

Accordingly, satellite data selected with satellite ephemeris, of which RADARSAT-2 transit time was 2010-08-01 06:51 (Fig.2), the time interval from the original time was 6:84 hrs. This data was applied in monitoring sensitive area 2 to verify the results in sensitive are 2 in comparison to other data and to provide base data for trajectory prediction of sensitive 3. Similarly, Optical data: HJ1B-CCD1 transit time was 2010-08-02 10:58 and was applied to estimate the response of monitoring and evaluate the effectiveness of clean up operation on 2nd August 2010 (Fig. 2). The results showed that clean up effect was obvious the spill on 1st August 2010 and the area of spill had failed to expand. Thus, Chinese local government arranged clean up program, deployed over 30 specialist ships to clean up target area.

According to these findings, it can be concluded that the methodology of spills emergencies is the best option to make best decision in choosing remote sensing data, taking into account the effective temporal resolution (T_e). The optimization of T_e rely on achievements of 2013 National Award for Technological Invention Second Prize "Oil film recognition technology and application based on offshore-ship-airborne base remote sensing". If the space borne remote sensing does not allow this revisiting time, the observation on the sensitive marine area should be made as frequent as possible by means of ships or aircrafts.

Acknowledgments

This work has partly been founded by the National Natural Science Foundation of China (41071260) and The Science and Technology Project Affiliated to the Education Department of Chongqing Municipality(KJ1401007).

References

Abascal, A.J., S. Castanedo, F.J. Mendez, R. Medina and I. J. Losada: Calibration of a lagrangian transport model using drifting buoys deployed during the prestige oil spill. *J. Coastal. Res.*, **25,** 80–90 (2009).

ASA (APPLIED SCIENCE ASSOCIATES) : OILMAP for Windows (technical manual). Narragansett, Rhode Island : ASA Inc (1997).

ASCE Task Committee on Modeling Oil Spills, State-of-the-art review of modeling transport and fate of oil spills, Water Resources Engineering Division. *J. Hydraul. Eng. Asce.*, **122,** 594-609 (1996).

Beegle-Krause, C.: General noaa oil modeling environment (gnome): A new spill trajectory model. Paper presented at Internation Oil Spill Conf., Mar. (2001).

Brekke, C. and A.H.S. Solberg : Oil spill detection by satellite remote sensing. *Remote Sensing of Environment*, **95**, 1-13, (2005).

Castanedo, S., R. Medina, I.J. Losada, C. Vidal, F. J. Méndez, A. Osorio, J. A. Juanes and A. Puente: The prestige oil spill in Cantabria (Bay of Biscay). Part I: Operational forecasting system for quick response, risk assessment and protection of natural resources. *J. Coastal. Res*., **22**, 1474-1489 (2006).

Deborah, P.F., Z.S. Heidi and I. Tatsusaburo : Probabilities of oil exceeding thresholds of concern: examples from an evaluation for florida power and light. AMOP 99 Technical Seminar, Calgary, Alberta, Canada, pp. 243-270 (1999).

Gershenzon, O.N., V.E. Gershenzon and S.V. Osheyko : Integral solution for oil spill detection using SAR data. Anais XIII Simpósio Brasileiro de Sensoriamento Remoto, Florianópolis, Brasil, INPE, 4873-4878 (2007).

Grüner, K., R. Reuter and H. Smid : A new sensor system for airborne measurements of maritime pollution and of hydrographic parameters. *Geojournal*, **24,** 103-117 (1991).

Jha, M.N., J. Levy and Y. Gao : Advances in remote sensing for oil spill disaster management: state-of-art sensors technology for oil spill surveillance. *Sensors.-Basel.*, **8**, 236-255 (2008).

Kurup, P.G. : Oil slick drift trajectories for hypothetical spill in Arabian Sea. *Indian J. Mar. Sci.*, **12**, 1-10 (1983).

Li, Q.H., J.F. Zhao and Y.G. Zhang : Three-dimensional numerical stimulation for tidal and current near dalian. *Hydrographic Sur. Chart.*, **23**, 48-52 (2003).in Chinese.

Miranda, R., F. Braunschweig, P. Leitao, R. Neves, F. Martins and A. Santos: MOHID 2000, a coastal integrated object oriented model. Hydraulic Engineering Software VII. South-ampton, UK : WITPress. (2000).

Natural Resources Canada Website. Available online:http://ccrs.nrcan.gc.ca/resource/tutor/fundam/chapter5/28_e.php. Last accessed on Dec 20, (2007).

NOAA, GNOME. General NOAA Oil Modeling Environment User's manual. Seattle, Washington : Office of Ocean Resources Conservation and Assessment. National Oceanic and Atmospheric Administration. 2002.

NOAA trajectory analysis handbook. Available at : http://response.restoration.noaa.gov/book_shelf/939_trajanalysis.pdf

Reed, M., C. Turner and A. Odulo : The role of wind and emulsi cation in modelling oil spill and surface drifter trajectories. Spill. *Sci. Technol. B.*, **1**, 143–157 (1994).

Sobey, R.J. and C.H. Barker : Wave-driven transport of surface oil. *J. Coastal. Res.*, **13**, 490-496 (1997).

Wang, W. and X.H. Rui: Wind energy input to the Ekman layer. *J. Phys. Oceanogr.*, **34**, 1267–1275 (2004).

Wu, K.J. and B. Liu : Stokes drift–induced and direct wind energy inputs into the Ekman layer within the Antarctic Circumpolar Current. *J. Geophys. Res.*, **113**, C10002 (2008).

Wu, K.J.: Wind energy input to the Ekman-Stokes Layer: Reply to comment by jeff a. *Polton. J. Oceanogr.*, **65**, (2009).