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To cite this article: Michel C Boufadel and Xiaolong Geng 2014 Environ. Res. Lett. 9 081001

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Perspectives

A new paradigm in oil spill modeling for decision making?

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Abstract

Contingency plans for large oil spills rely on conducting numerical simulations that would predict the probable transport and fate of oil. Oil spill models vary in complexity from ones that assume a straight-line trajectory of oil on the water surface without any change in oil properties to fully three-dimensional models that account to all processes affecting the fate of oil. The model proposed by Bourgault et al (2014 Environ. Res. Lett. 9 054001) is intermediate in complexity in a sense that it accounts for the temporal variation of surface currents, but does not consider the transformation of oil. We believe that such an approach has a great merit as a screening tool for decision making.

Keywords: oil spill, oil trajectory, windage

The increase in oil exploration in the Gulf of St Lawrence is inadvertently accompanied by the risk of release of oil to the environment from a blowout or from a surface spill. A proposed oil well at Old Harry prospect in the Gulf of St Lawrence has mobilized the public and involved relevant government agencies with an environmental branch, such as the Department of Fisheries and Oceans, Canada.

The movement of oil through the water column and on the water surface is very complex as chemical and biological changes in the oil affect its physical properties, which, in turn, affects the fate of oil ASCE Task Committee on Modeling Oil Spills (1996). Modeling all these processes is computationally demanding, and could even be unnecessary in the absence of field observation. For this reason, the approach adopted by Bourgault et al (2014) is appropriate as a solid screening tool. In fact, the approach is similar to that conducted by the United States’s National Oceanic and Atmospheric Administration (NOAA) to evaluate the possible scenarios of the Deepwater Horizon oil deposition on the Gulf of Mexico shorelines (Barker, 2011). Such modeling has been common during response efforts to a spill, but using it for policy purposes is relatively new, and it is promising due to its simplicity and its focus on the bulk behavior of oil. For example, if this modeling indicates that no oil would arrive at a particular location, then using a more detailed 3D model at that location would not provide findings that are critical from a policy point of view (though they could be invaluable from a science point of view). Other considerations on the approach are presented below.

It is common to use daily (or hourly) data when evaluating the transport and fate of oil. Using seasonal averages should be discouraged unless proven otherwise. This is because contingency plans are based on the probable worst case scenarios rather than the most likely scenario (i.e., the average). In the words of Dr Jerry Galt (a former head of NOAA Hazmat Division) ‘contingency plans should aim on providing the minimum regret and not the best outcome’.

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The authors have not considered the transport of oil resulting from wind blowing on the oil floating on the water surface, which is known as ‘wind drift’ and could be up to 6% of the wind speed ASCE Task Committee on Modeling Oil Spills (1996). Thus, for a wind speed of 6 m s\(^{-1}\), the transport due to wind can be more than 0.30 m s\(^{-1}\), and thus, in one day, the oil could be transported an additional 26 km if the wind is blowing in the sense of currents. In addition, using an Eulerian framework that mixes oil in the top 5 m of the water provides considerable dilution of the oil because, in reality, a considerable volume of oil would remain at the water surface due to buoyancy and spread on the water surface due to interfacial tension and waves (Fay 1971, Fraga et al 1984). Waves, unless they are extremely violent, cannot transport all the oil into the water column (Delvigne, Sweeney 1988, Boufadel et al 2006, Zhao et al 2014a), as the large oil droplets would float immediately to the surface. Furthermore, the oil distribution on the water surface is patchy with narrow zones of high oil amount surrounded by vast extent of low oil amounts, which is due to Langmuir circulations and the fact that an oil spill has a comet shape (Elliot et al 1986, Boufadel et al 2006) where the thick part of the oil moves ahead of the plume. These considerations suggest that the approach pursued by Bourgault et al (2014) might have greatly underestimated the oil concentration at the water surface. On the other hand, Bourgault et al (2014) neglected the depletion of oil off the surface due to weathering, which could be up to 50% of the spilled oil, as noted for the Exxon Valdez oil spill (Wolfe et al 1993).

Improvements on the approach by Bourgault et al (2014) would require more field studies to evaluate the oil behavior in the Gulf of St Laurence, its interaction with ice, and its downwelling due to waves in ice infested waters. Also, a jet/plume model such as VDROP-J (Zhao et al 2014b) could be used to predict the oil droplet size distribution, which would determine the distribution of oil near the water surface.

Nevertheless, we expect the approach of Bourgault et al (2014) to become more widespread due to its simplicity and the ease of communicating its results to stakeholders. The approach could be improved through the incorporation of empirical equations that capture the basic elements of oil behavior in particular regions.

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