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Using Numerical Models in the Development of Software Tools for Risk Management of Accidents with Oil and Inert Spills

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The increasing ship traffic and maritime transport of dangerous substances make it more difficult to significantly reduce the environmental, economic and social risks posed by potential spills, although the security rules are becoming more restrictive (ships with double hull, etc.) and the surveillance systems are becoming more developed (VTS, AIS).

In fact, the problematic associated to spills is and will always be a main topic: spill events are continuously happening, most of them unknown for the general public because of their small scale impact, but with some of them (in a much smaller number) becoming authentic media phenomena in this information era, due to their large dimensions and environmental and social-economic impacts on ecosystems and local communities, and also due to some spectacular or shocking pictures generated.

Hence, the adverse consequences posed by these type of accidents, increase the preoccupation of avoiding them in the future, or minimize their impacts, using not only surveillance and monitoring tools, but also increasing the capacity to predict the fate and behaviour of bodies, objects, or substances in the following hours after the accident - numerical models can have now a leading role in operational oceanography applied to safety and pollution response in the ocean because of their predictive potential. Search and rescue operation, oil, inert (ship debris, or floating containers), and HNS (hazardous and noxious substances) spills risk analysis are the main areas where models can be used.

Model applications have been widely used in emergency or planning issues associated to pollution risks, and contingency and mitigation measures. Before a spill, in the planning stage, modelling simulations are used in environmental impact studies, or risk maps, using historical data, reference situations, and typical scenarios. After a spill, the use of fast and simple modelling applications allow to understand the fate and behaviour of the spilt substances, helping in the management of the crisis, in the distribution of response resources, or prioritizing specific areas. They can also be used for detection of pollution sources. However, the resources involved, and the scientific and technological levels needed in the manipulation of numerical models, had both limited the interoperability between operational models, monitoring tools and decision-support software tools.

The increasing predictive capacity of metocean conditions and fate and behaviour of pollutants spilt at sea or costal zones, and the presence of monitoring tools like vessel traffic control systems, can both provide a safer support for decision-making in emergency or planning issues associated to pollution risk management, especially if used in an integrated way.

Following this approach, and taking advantage of an integrated framework developed in ARCOPOL (www.arcopol.eu) and EASYCO (www.project-easy.info) projects, three innovative model-supported software tools were developed and applied in the Atlantic Area, and / or the Portuguese Coast.

Two of these tools are used for spill model simulations - a web-based interface (EASYCO web bidirectional tool) and an advanced desktop application (MOHID Desktop Spill Simulator) – both of them allowing end user to have control over the model simulations. Parameters such as date and time of the event, location and oil spill volume are provided the users; these interactive tools also integrate best available metocean forecasts (waves, meteorological, hydrodynamics) from different institutions in the Atlantic Area. Metocean data are continuously gathered from remote THREDDS data servers (using OPENDAP) or ftp sites, and then automatically interpolated and pre-processed to be available for the simulators. These simulation tools developed can also import initial data and export results from/to remote servers, using OGC WFS services.

Simulations are provided to end user in a matter of seconds, and thus, can be very useful in emergency situations. The backtracking modelling feature and the possibility of importing spill locations from remote servers with observed data (per example, from flight surveillance or remote sensing) allow the potential application to the evaluation of possible contamination sources.

The third tool developed is an innovative system to dynamically produce quantified risk levels in real time, integrating best available information from numerical forecasts and the existing monitoring tools. This system provides coastal pollution risk levels associated to potential (or real) oil spill incidents, taking into account regional statistic information on vessel accidents and coastal sensitivity indexes (determined in EROCIPS project), real time vessel information (positioning, cargo type, speed and vessel type) obtained from AIS, best-available metocean numerical forecasts (hydrodynamics, meteorology - including visibility, wave conditions) and simulated scenarios by the oil spill fate and behaviour component of MOHID Water Modelling System (www.mohid.com). Different spill fate and behaviour simulations are continuously generated and processed in background (assuming hypothetical spills from vessels), based on variable vessel information, and metocean conditions, and results from these simulations are used in the quantification the consequences of potential spills.

Dynamic Risk Tool was not designed to replace conventional mapping tools, but to complement that type of information with an innovative approach to risk mapping.

Taking advantage of interoperability between forecasting models, oil spill simulations, AIS monitoring systems, statistical data and coastal vulnerability, this software can provide to end-users realtime risk levels, allowing an innovative approach to risk mapping, providing decision-makers with an improved decision support model and also an intelligent risk-based traffic monitoring. For instance, this tool allows the prioritisation of individual ships and geographical areas, and facilitates strategic and dynamic tug positioning.

As referred, the risk levels are generated in realtime, and the historic results are kept in a database, allowing later risk analysis or compilations for specific seasons or regions, in order to obtain typical risk maps, etc. The integration with metocean modeling results (instead of using typical static scenarios), as well as continuous background oil spill modelling, provide a more realistic approach to the estimation of risk levels – the metocean conditions and oil spill behaviour are always different and specific, and it’s virtually impossible to previously define those conditions even if several thousands of static scenarios were previously considered. This system was initially implemented in Portugal (ARCOPOL project) for oil spills. The implementation at different regions in the Atlantic and the adaptation to chemical spills will be executed in the scope of ARCOPOL+ project.

The numerical model used for computing the fate and behaviour of spilled substances in all the tools developed (MOHID lagrangian & oil spill model from MOHID Water modelling System) was also subject of several adaptations and updates, in order to increase its adaptability to the developed tools – horizontal velocity due to Stokes Drift, vertical movement of oil substances, modelling of floating containers, backtracking modelling and a multi-solution approach (generating computational grid on-the-fly, and using the available information from the multiple metocean forecasting solutions available) are some of the main features recently implemented.

The main purpose of these software tools are mainly to reduce the gap between the decision-makers and scientific modellers - although the correct analysis of model results usually requires a specialist, an operational model user should not loose most of the time converting and interpolating metocean results, preparing input data files, running models and post-processing results – rather than analysing results and producing different scenarios.

The harmonization and standardization in respect to dissemination of numerical model outputs is a strategic effort for the modelling scientific community, because facilitates the application of their results in decision-support tools like the ones presented here.