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Modelling of oil spills from deep sea releases

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Oil spills remain a serious environmental problem, which can have significant environmental and economic consequences. Despite the advantages of offshore drilling, deep-sea oil releases from accidents during offshore exploratory drilling or production activities are of particular concern, as the potential for such accidents increases dramatically with the expansion of the offshore industry to more extreme and demanding environments. During the 2010 Deepwater Horizon accident, huge amounts of oil were released into the Gulf of Mexico, adversely affecting marine wildlife. What prevented a worse outcome was the ability of nature to biodegrade oil.

Although oil biodegradation by native bacteria is one of the most important natural processes that can attenuate the environmental impacts of marine oil spills, very few oil spill models include biodegradation kinetics of spilled oil. To this end, the open source oil spill model MEDSLIK-II (http://medslikii.bo.ingv.it/), has been recently modified in the frame of the EU project Kill-Spill (http://www.killspill.eu/), to incorporate biodegradation kinetics of oil droplets dispersed in the water column. In this modified version, namely MEDSLIK-III, the "pseudo-component" approach has been adopted for simulating oil weathering process, under which chemicals in the oil mixture are grouped by physical-chemical properties and the fate of each component is tracked separately. Biodegradation of oil droplets is modelled by Monod kinetics. The kinetics of oil particles size reduction due to the microbe-mediated degradation at water-oil particle interface is represented by the shrinking core model.

Prompted by the international tenders for granting exploration and exploitation rights for the block areas of Southwest and West Crete, a new Lagrangian deep-water oil release module has been developed and coupled to MEDSLIK-III, for predicting the fate of the oil plume until reaching the sea surface. The Lagrangian plume model is represented by elements that trace the plume's trajectory. Each Lagrangian element represents a mixture of water, oil and gas, where the gas might be present in different states, i.e. as free gas in gas bubbles, dissolved in the water phase, or bound in gas hydrates. Changes in the mass and composition of the element are accounted for by the turbulent entrainment of ambient water, and by other processes such as leakage of gas bubbles and oil droplets from the plume, dissolution of gas in seawater, and formation or disintegration of gas hydrates. The motion of the element is computed from the conservation equations for mass, momentum and buoyancy. During model development, information and parameterizations from the literature have been incorporated regarding the processes that govern changes in the composition and mass of plume elements (i.e. formation of gas hydrates, gas bubbles within oil droplets, etc.). Based on the rate of the crude oil release and the type of pipe failure, we can estimate the initial droplet distribution generated by the crude oil jet. Furthermore, using existing models of dispersant's action, we can quantify the effect of mitigation measures on the biodegradation rates.

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