The role of the spatial resolution of a three-dimensional hydrodynamic model for marine transport risk assessment*

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Abstract

The paper addresses the sensitivity of a novel method for quantifying the environmental risks associated with the current-driven transport of adverse impacts released from offshore sources (e.g. ship traffic) with respect to the spatial resolution of the underlying hydrodynamic model. The risk is evaluated as the probability of particles released in different sea areas hitting the coast and in terms of the time after which the hit occurs (particle age) on the basis of a statistical analysis of large sets of 10-day long Lagrangian trajectories calculated for 1987–1991 for the Gulf of Finland, the Baltic Sea. The relevant 2D maps are calculated using the OAAS model with spatial resolutions of 2, 1 and 0.5 nautical miles (nm) and with identical initial, boundary and forcing conditions from the Rossby Centre 3D hydrodynamic model (RCO, Swedish Meteorological and Hydrological Institute). The spatially averaged values of the probability and particle age display hardly any dependence on the resolution. They both reach almost identical stationary levels (0.67–0.69 and ca 5.3 days respectively) after a few years of simulations. Also, the spatial distributions of the relevant fields are qualitatively similar for all resolutions. In contrast, the optimum locations for fairways depend substantially on the resolution, whereas the results for the 2 nm model differ considerably from those obtained using finer-resolution models. It is concluded that eddy-permitting models with a grid step exceeding half the local baroclinic Rossby radius are suitable for a quick check of whether or not any potential gain from this method is feasible, whereas higher-resolution simulations with eddy-resolving models are necessary for detailed planning. The asymptotic values of the average probability and particle age are suggested as an indicator of the potential gain from the method in question and also as a new measure of the vulnerability of the nearshore of water bodies to offshore traffic accidents.

1. Introduction

Comprehensive progress in the environmental management of anthropogenic pressure on particularly vulnerable sea areas, such as the Baltic Sea (Kachel 2008), has now become feasible as a result of major advances in marine sciences leading to a rapid increase in the accuracy with which the current-driven transport of adverse impacts is represented. These advances comprise computational facilities, high-resolution circulation modelling, new technologies for in situ and satellite observations, an ever increasing flow of real-time information about the sea state, increasing experience in operational oceanography (including oil spill monitoring and forecasting), and increasingly accurate meteorological forecasts (Leppäranta & Myrberg 2009).

While a number of studies address environmental issues in terms of the Lagrangian transport of different adverse impacts (see Havens et al. 2010 and the references therein), very few attempts have been targeted at the preventive reduction of environmental risks caused by maritime industry and