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Integrated Numerical Modeling of Oil Spills-Sediment Transport by FVM Method

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Abstract

An Integrated 2DH numerical model based on Eulerian approach including hydrodynamics, suspended sediment transport and oil-slick transport modules has been developed. FVM method and ADI (Alternating Direction Implicit) scheme have been employed for disceritization and solving governing equations. The second order Lax-Wendrof and second order central difference schemes have been used for advective and diffusive terms respectively. Multiphase oil spill model (MOSM) approach has been taken to simulate oil slick and flow interaction. All three modules of the numerical model have been validated against experimental data.

Keywords: Oil Spill, Sediment transport, Oil-Sediment Interaction, 2DH, FVM

1. INTRODUCTION

The increasing development of economy has considerably raised the demand for fossil fuels all over the world. Consequently, oil spill disasters in coastal areas, which may be the result of oil production or transportation, have become one of the most serious threats against marine environment. Understanding the nature of oil spills in coastal areas plays a crucial role in alleviating destructive impacts of oil spill disasters on marine environment.

A better understanding of the fate of oil spills and the nature of sediment transport together with the interacting processes of them has been the aim of this study. Therefore advection and diffusion processes have been implemented in the new model and prediction show the interactly transport process of oil spills and sediment for tidal currents. Oil distribution in the water column and its mixture with suspended and bed sediment, is followed by approaching the seashore, and interaction of the contaminants with shoreline. Secondary mixing contaminants with the shoreline sediments due to oscillatory back and forth water flow, results in the change of nature and properties of sediments such as adhesiveness and specific gravity. In order to get deeper understanding of oil slick transport in coastal areas, the effects of interaction between oil, sediment and other contaminant on oil slick transport has to be taken into account.

2. MODEL DESCRIPTION

A two dimensional depth-averaged numerical model including hydrodynamics, sediment transport and oil slick transport modules has been developed. Hydrodynamic module predicts horizontal depth-averaged velocities and water surface elevation, solving shallow water equations. Finite volume technique has been utilized for discretization of the equations. In order to solve the resulting system of equations, the Alternating Direction Implicit (ADI) method has been employed.

Suspended sediment transport module predicts suspended sediment concentration solving depth-averaged advection-diffusion sediment transport equations. Oil spill module uses the depth-averaged equations with the consideration of emulsified, dissolved and particulate phases, physical-chemical kinetics and water oil interaction with the multiphase oil spill model (MOSM) approach. The combined Oil Spill-Sediment transport module has been developed at the same idea of (MOSM) approach with some modifications.

2.1. Hydrodynamic Module

Shallow water set of equations including depth-averaged turbulence and bottom stress are represented as follows [1]: