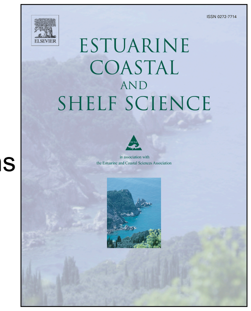
Accepted Manuscript



A hybrid hydrostatic and non-hydrostatic numerical model for shallow flow simulations

Jingxin Zhang, Dongfang Liang, Hua Liu

PII: S0272-7714(17)31076-4

DOI: 10.1016/j.ecss.2018.03.012

Reference: YECSS 5789

To appear in: *Estuarine, Coastal and Shelf Science*

Received Date: 10 November 2017

Revised Date: 6 March 2018

Accepted Date: 7 March 2018

A hybrid hydrostatic and non-hydrostatic numerical model for shallow flow simulations

Jingxin Zhang[1,2,*] Dongfang Liang[1,2] Hua Liu[1,2]

[1]MOE Key Laboratory of Hydrodynamics, Shanghai Jiao Tong University, Shanghai 200240, China

[2] School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

*Corresponding author: Jingxin Zhang (zhangjingxin@sjtu.edu.cn)

Abstract

Hydrodynamics of geophysical flows in oceanic shelves, estuaries, and rivers, are often studied by solving shallow water model equations. Although hydrostatic models are accurate and cost efficient for many natural flows, there are situations where the hydrostatic assumption is invalid, whereby a fully hydrodynamic model is necessary to increase simulation accuracy. There is a growing concern about the decrease of the computational cost of non-hydrostatic pressure models to improve the range of their applications in large-scale flows with complex geometries. This study describes a hybrid hydrostatic and non-hydrostatic model to increase the efficiency of simulating shallow water flows. The basic numerical model is a three-dimensional hydrostatic model solved by the finite volume method (FVM) applied to unstructured grids. Herein, a second-order total variation diminishing (TVD) scheme is adopted. Using a predictor–corrector method to calculate the non-hydrostatic pressure, we extended the hydrostatic model to a fully hydrodynamic model. By localising the computational domain in the corrector step for non-hydrostatic pressure calculations, a hybrid model was developed. There was no prior special treatment on mode switching, and the developed numerical codes were highly efficient and robust. The hybrid model is applicable to the simulation of shallow flows when non-hydrostatic pressure is predominant only in the local domain. Beyond the non-hydrostatic domain, the hydrostatic model is still accurate. The applicability of the hybrid method was validated using several study cases.

KEY WORDS: non-hydrostatic model, hybrid model, shallow flows, domain decomposition

1. INTRODUCTION

Many geophysical flows are confined between a solid bed that lies beneath and a free surface that is above the water body. These flows are common in oceanic shelves, estuaries, and rivers and they are generally referred to as shallow water flows (Borthwick and Barber, 1992; Fringer et al., 2006; Liang et al., 2006). Such flows are traditionally described by non-linear shallow water equations (NSW). The efficient solutions of the NSW enable the modelling of large-scale long wave dynamics, such as tides, storm surges, and tsunamis. NSW models are mostly based on the hydrostatic assumption of the pressure distribution, which allows considerable simplifications. An advantage of these simplifications is the higher efficiency of the models with relatively low