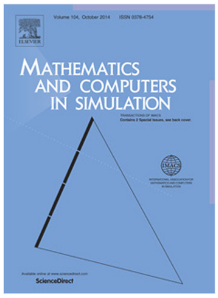
Accepted Manuscript



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PII: S0378-4754(17)30378-6
DOI: https://doi.org/10.1016/j.matcom.2017.11.008
Reference: MATCOM 4522

To appear in: *Mathematics and Computers in Simulation*

Received date : 7 August 2013
Revised date : 5 May 2017
Accepted date : 29 November 2017

Please cite this article as: M. Lastra, M.J.C. Díaz, C. Ureña, M. de la Asunción, Efficient multilayer shallow-water simulation system based on GPUs, *Math. Comput. Simulation* (2017), https://doi.org/10.1016/j.matcom.2017.11.008

Efficient multilayer shallow-water simulation system based on GPUs

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Abstract

The computational simulation of shallow stratified fluids is a very active research topic because these types of systems are very common in a variety of natural environments. The simulation of such systems can be modeled using multilayer shallow-water equations but do impose important computational requirements, especially when applied to large domains.

General Purpose Computing on Graphics Processing Units (GPGPU) has become a vivid research field due to the arrival of massively parallel hardware platforms (based on graphics cards) and adequate programming frameworks which have allowed important speed-up factors with respect to not only sequential but also parallel CPU based simulation systems.

In this work we present simulation of shallow stratified fluids with an arbitrary number of layers using GPUs. The designed system does fully adapt to the many-core architecture of modern GPUs and several experiments have been carried out to illustrate its scalability and behavior on different GPU models. We propose a new multilayer computational scheme for an underlying 2D mathematical model. This scheme is capable of handling an arbitrary number of layers. The system adds no overhead when used for two-layer scenarios, compared to an existing 2D system specifically designed for just two layers.

Our proposal is aimed at creating a GPU-based computational scheme suitable for the simulation of multilayer large-scale real-world scenarios .

Keywords: Shallow-water, finite volumes, simulation, GPU, CUDA

1. Introduction

The simulation of free surface or internal waves in shallow stratified fluids are commonly modeled by the multilayer shallow-water equations formulated as a conservation law with non-conservative products and source terms. Stratified fluids are ubiquitous in nature: they appear in atmospheric flows, ocean currents, estuarine systems, etc. For instance, in the Strait of Gibraltar, surface water from the Atlantic eastwards flows over saltier westwards-flowing Mediterranean water. Simulating these phenomena requires very long lasting simulations in big computational domains which is why very efficient implementations are needed to be able to analyze those problems in affordable computational times.

A 2D multilayer shallow-water system can be discretized by the natural extension to 2D domains of a first order PVM (Polynomial Viscosity Matrix) path-conservative type finite volume scheme. PVM schemes have been introduced in the framework of balance laws and non-conservative hyperbolic systems [8] . They are defined in terms of viscosity matrices computed by a suitable polynomial evaluation of a Roe matrix. These methods have the advantage that they only need some information about the eigenvalues of the system and

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