TOLOSA-SW: A NEW FINITE-VOLUME MODEL FOR PREDICTING STORM SURGES

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INTRODUCTION

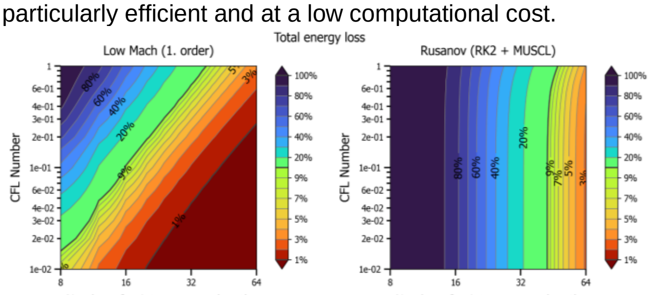
Resolving the complex geometry of coastal areas is of utmost importance to numerically reproduce the physical processes involved in storm surges. In recent years, a few numerical models using unstructured meshes have been developed to seamlessly reproduce these small-scale features as well as larger scale processes such as tides, while retaining limited computational costs (e.g. Dietrich et al. 2012, Zhang et al 2016). Whilst providing a major step forward, these models suffer from a number of shortcomings, such as strong numerical stability constraints, or over-dissipation of short wavelengths by the numerical scheme. Here we present TOLOSA-SW, a new finite-volume model for predicting storm surges.

PRESENTATION OF TOLOSA-SW

Tolosa-SW (part of the TOols Library for unstructured Ocean models and Surge Applications project, https://tolosa-project.com/) resolves the non-linear shallow water equations on unstructured meshes, in a CPU MPI parallel environment. It uses original numerical schemes allowing for a low dissipation, especially at high frequencies (Couderc et al. (2017), Duran et al. (2020)). It preserves motionless steady states and positivity of water height, and gives a robust and efficient representation of both large- and small-scale oceanic flows.

NUMERICAL SCHEME PERFORMANCE

We will first present the globally explicit first-order "Low Mach" scheme used in Tolosa-SW, and the methods used to ensure the scheme stability and theoretical energy dissipation. The results of numerical tests that have been performed in order to assess the performance and computational cost of this scheme will be explored. Comparisons with the classical second order Rusanov approach show that the Low Mach scheme has the energetic behavior of a second-order scheme, making it particularly efficient and at a low computational cost.



Infragravity waves (1D). Energy dissipation comparison between Low Mach (first order) and Rusanov (second order in time and space).

TIDE AND SURGE MODELLING

A configuration using TOLOSA-SW, that covers french Atlantic coasts, has been built to simulate water levels and currents and to replace the HYCOM model in the French storm surge warning system operated by Météo-France and maintained through the state-funded HOMONIM project. Using a stochastic approach similar to the one developed by Boutet (2015) and Pasquet et al. (2021) to estimate the bottom friction, we show that the model reduces the tidal residuals by a factor 2.5 compared to the current french storm surge forecast system (Pasquet et al.,2016). The new model also performs well in reproducing historical storm surges, both for long-term runs during winter periods and for extreme events, except in areas where the wave setup component cannot be neglected.

PERSPECTIVES

We will discuss the on-going developments and potential applications of the vertically integrated non-hydrostatic version of the TOLOSA toolbox, Tolosa-LCT, as well as the coupling of TOLOSA-SW with the wave spectral model WW3, using the OASIS coupler.

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