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Implementation and experimental benchmark of a two-layer CPU+GPU hydrodynamics model

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Large-scale geophysical flows often exhibit clear separation of fluid masses due to density imbalances, posing specific conceptual and numerical challenges in mathematical modelling. Density-driven flows range from global ocean circulation to estuarine plumes and turbidity currents generated from outfalls or dams. In addition, a seldom studied density-driven flow is the one of washed ashes from wild fires during the first winter showers.

Given the particular case of Portugal, where forest fires coupled with climate uncertainty were the leading natural disaster in 2017, concerns were raised regarding the quality of drinking water reservoirs. The severity of such scenario contrasts with the lack of trusted tools for its forecast and assessment.

STAV-2D, a high-performance shallow-water model suited for territorial applications developed at CEris. (Canelas et al., 2013; Conde et al., 2013), is herein introduced and adapted for two-layer flows in natural and built environments. The proposed model is fully suited to high-perfomance computing on distributed systems and different parallel processor architectures (Central and Graphics Processing Units).

The particular stage of development addressed in this work is the validation of the two-layer numerical model with experimental data on complex density-driven flows from Salgueiro et al. (2017). The experimental setup comprises a point source in a confined basin, thus generating a complex 2D two-layer flow with an advancing wave front and multiple shocks due to flow reflections. Comprehensive data on this intricate flow structure poses a challenging scenario for model validation. The results of this benchmark are analyzed and model applicability to real-world applications is assessed.

The successful benchmark of STAV-2D with experimental data constitues a relevant step towards the validation of a fast and reliable tool for geophysical applications on shallow-flows at the territorial scale.

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