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Introduction

Gravity currents are buoyancy-driven flows arising from horizontal density differences, occurring in both natural systems (Rebesco et al., 2014; Gong et al., 2018) and anthropogenic contexts such as brine discharge and oil spills (Ammendola et al., 2025). They influence climate regulation, sediment transport, and submarine infrastructure stability. Laboratory lock-exchange experiments offer direct observations but are limited in dimensionality (Kneller & Buckee, 2000; Westerweel et al., 2013), while numerical simulations provide full 3D datasets at high computational cost (Piomelli, 2001; Härtel et al., 2000; Ammendola et al., 2025). LES offers an effective accuracy–cost compromise (Comte & Lesieur, 1996), and WMLES further reduces near-wall resolution requirements using wall functions (Spalding, 1961; Jayatilleke, 1966; Menter, 1994), enabling coarse-grid simulations with cost reductions up to two orders of magnitude (Ammendola et al., 2025).

Two simulation setups were run on Galileo 100, using different turbulence-modeling approaches and spatial resolutions:

- Fine grid (wall-resolved LES): 320 processors, 120 h runtime, 80 GB storage.
- Coarse grid (WMLES): 320 processors, 1 h runtime, 4 GB storage.

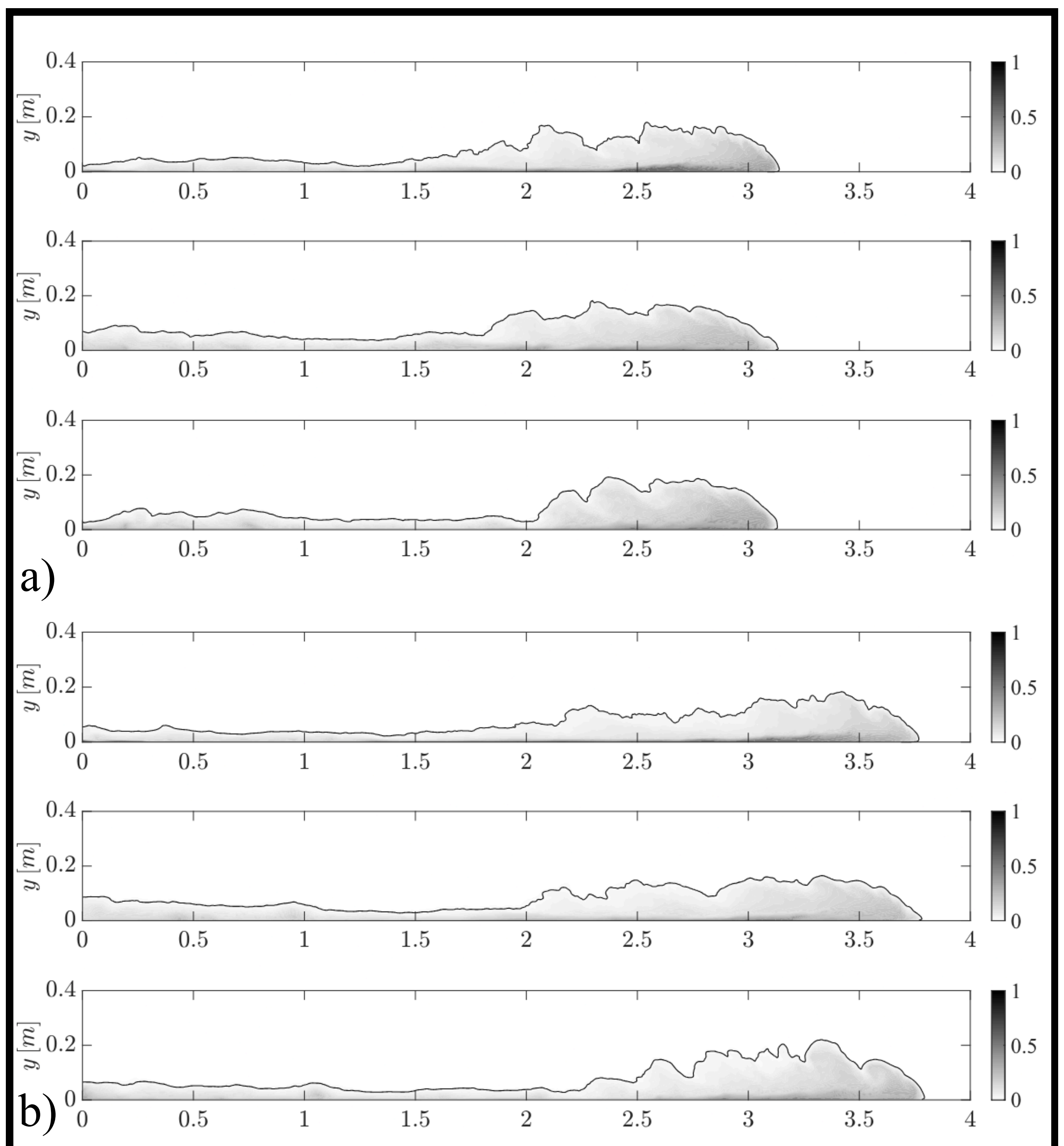

Fig. 1. $\langle \varrho^* \rangle$ fields, a confrontation between different mesh resolution at different time steps: (a) time T = 27s, (b) time T = 35s,

Mathematical model and aims

The mathematical model in Ammendola et al. (2025) is based on the filtered Navier–Stokes equations in the Boussinesq approximation, coupled with a salinity transport equation, with subgrid stresses closed using the WALE (Wall-Adapting Local Eddy-Viscosity) approach. This formulation allows the simulation of buoyancy-driven flows while capturing turbulence effects at scales smaller than the computational grid. The implementation was carried out in OpenFOAM® using finite-volume discretization and the PISO algorithm for pressure–velocity coupling, with a Schmidt number representative of saline water. Validation against lock-exchange benchmark studies (Ottolenghi et al., 2016, 2017) confirmed that the model accurately reproduces flow topology, wall shear stresses, and near-wall physics, achieving Reynolds numbers on the order of 10^5, close to real-scale conditions. Figures 1 and 2 show high-Reynolds results from Ammendola et al., 2025 including bottom density fields and velocity fluctuations, illustrating the flow structures captured by the model.

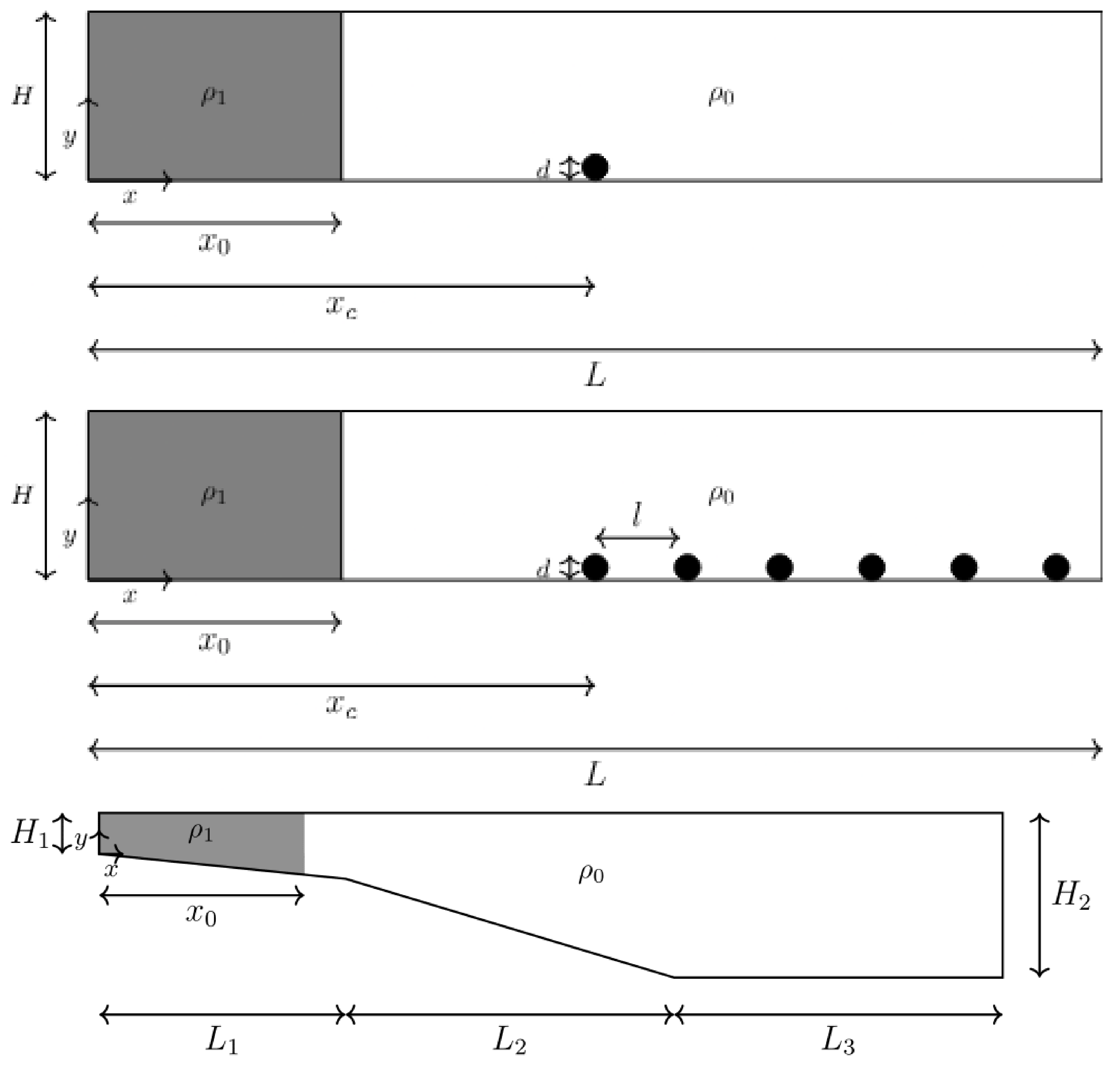

Fig. 3. Different configurations of domains to be tested with TeRABIT Resources

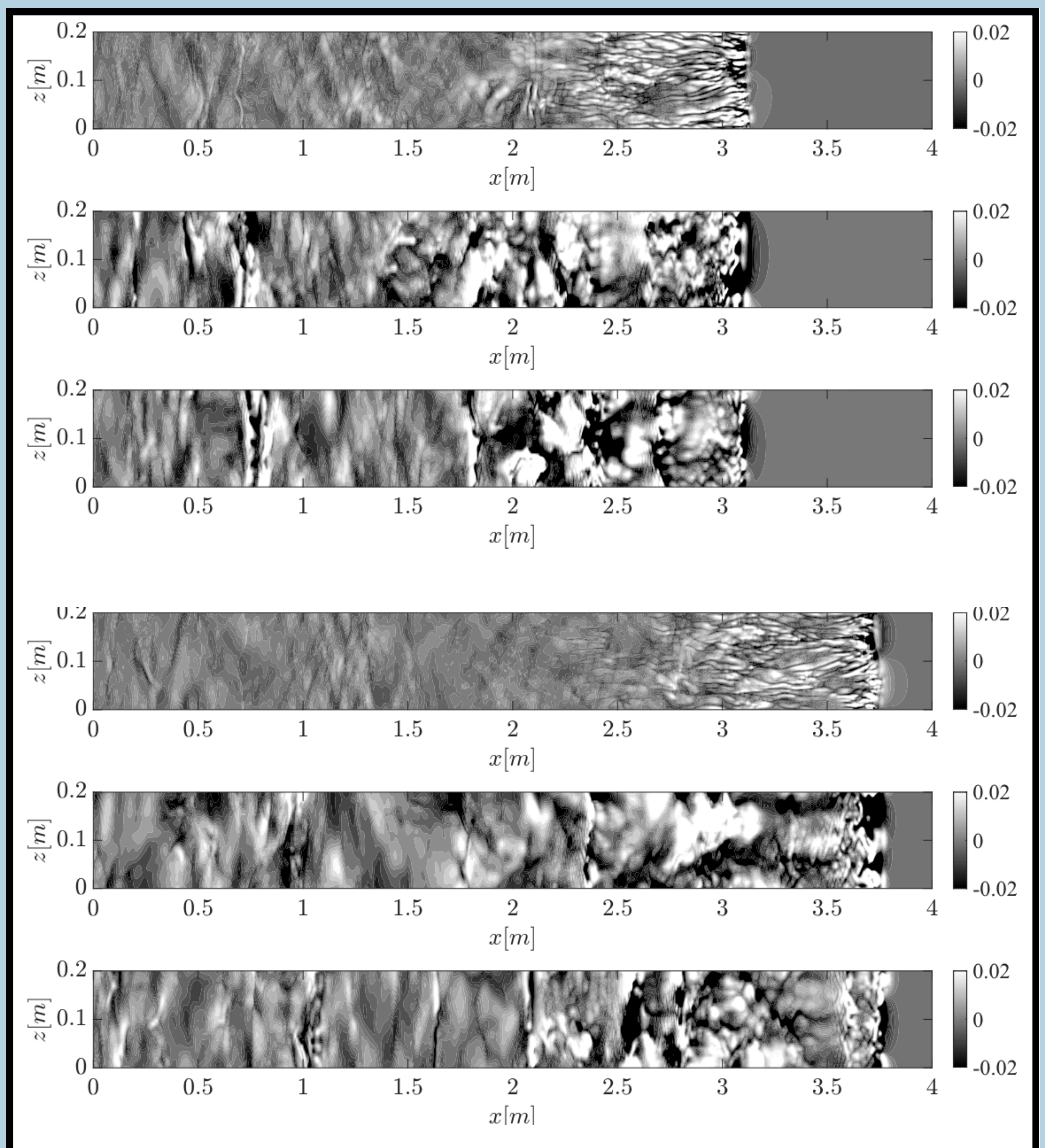

Fig. 2. Velocity Fluctuations fields, a confrontation between different mesh resolution at different time steps: (a) time T = 27s, (b) time T = 35s,

Leveraging the expanded computational resources and workflow optimization provided by the TeRABIT project, the aim is to extend this modeling framework to study turbidity currents in more complex and realistic domains, incorporating cylindrical bottom macro-roughness elements and a variety of slope configurations. This enhanced computational capability will enable a detailed investigation of how large-scale seabed features, geometric constraints, and bathymetric variations influence key processes such as entrainment, mixing, flow structure, and the overall evolution of the current under conditions that more closely resemble natural environments (Figure 3).

Bibliography

Ammendola et al. 2025, Rebesco et al. 2014, Gong et al. 2018, Kneller & Buckee 2000, Westerweel et al. 2013, Adduce et al. 2012, Piomelli 2001, Härtel et al. 2000, Comte & Lesieur 1996, Chapman 1979, Spalding 1961, Menter 1994, Jayatilleke 1966, Ottolenghi et al. 2016, Ottolenghi et al. 2017

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