TURBINS: A computational tool for three-dimensional, high-resolution simulations of particle-laden flows
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Introduction

Turbidity currents are underwater avalanches traveling along the seafloor, as a result of the density difference between the suspension and ambient water. They play an important role within the global sediment cycle, and in the formation of deep-sea hydrocarbon reservoirs.

Due to the infrequent and unpredictable occurrence of turbidity currents in remote areas, and their destructive nature, field data regarding their structure and evolution are very difficult to obtain. Consequently, high resolution simulations have become an important tool for the exploration of their dynamics, and for the prediction of the deposit properties.

TURBINS (TURBidity currents via Immersed boundary Navier-Stokes simulations) is a highly parallel three-dimensional DNS based code developed to simulate gravity and turbidity currents propagating over complex topographies.

Modeling approach

- Divergence free velocity field \( \nabla \cdot \mathbf{u} = 0 \)
- Incompressible Navier-Stokes equations (Boussinesq).
- Transport equation for describing particle motion
- Constant settling velocity
- Lock-exchange configuration

Numerical Method


Parallelism

Domain decomposition approach is adopted to parallelize TURBINS. PETSc is used to distribute data among processors, update ghost nodes, and solve the linear systems via parallel Krylov solver (e.g., GMRES). HYPRE is incorporated to solve pressure Poisson equation via Algebraic MultiGrid preconditioner: BoomerAMG.

Results

Validation

1) Uniform flow over a cylinder: Surface pressure and wall shear stress are calculated very accurately (important for erosion).

2) Gravity current in a sloping channel:

Bidisperse turbidity current interacting with a bump
Deposit profiles of fine and coarse particles demonstrate the non-linear coupling between particles of different sizes. Information such as runout length, instantaneous bottom shear stress and final deposit profiles are obtained via depth-resolved simulations by TURBINS.