# A physics-compatible spectral element solver for turbidity currents.

Gonzalo Gonzalez de Diego, Marc Gerritsma, Artur Palha

January 9, 2017

Turbidity currents are an essential agent of sediment transport from shallow to deeper waters and their deposits, known as turbidites, form an important class of hydrocarbon reservoirs [3]. Although extensive laboratory experiments have been conducted, detailed measurements of the velocity field or particle concentration are only available by means of accurate numerical simulations [4].

In this paper, a DNS solver for turbidity currents based on an equilibrium-Eulerian model for gravity currents is presented [2]. The incompressible Navier-Stokes equations are described with a velocity-vorticity formulation and are discretized with a *physics-compatible* spectral element method [5]. Lagrange, Raviart-Thomas and discontinuous Lagrange elements are used for the vorticity, velocity and pressure respectively; this sequence of finite element families proves to be a subsequence of the de Rham complex of differential forms [1] and is capable of exactly representing the divergence-free nature of the velocity and the diffusion of momentum, hence the term *physics-compatible*.

As a result, a robust and accurate solver is constructed which can exactly preserve mass, energy and vorticity in unstructered grids. Initial results indicate that these conserving properties are independent of both mesh size and the time step. Flow problems can be computed in coarse grids such that essential physical features are captured and the characteristic *blow-up* of conventional solvers is avoided. Further formulations are being investigated in order to stagger the variables in time and also conserve enstrophy.

## References

[1] Bochev, P., and Hyman, M. Principles of mimetic discretizations. In *IMA*, vol. 142. Springer Verlag, 2006.

[2] Ferry, J., and Balachandar, S. A fast eulerian method for disperse two-phase flow. *International Journal of Multiphase Flow 27* (2001), 1199–1226.

[3] Meiburg, E., and Kneller, B. Turbidity currents and their deposits. *Annual Review of Fluid Mechanics 42* (2010), 135–156.

[4] Necker, F., Härtel, C., Kleiser, L., and Meiburg, E. Mixing and dissipation in particle-driven gravity currents. *Journal of Fluid Mechanics 545* (2005), 339–372.

[5] Palha, A., and Gerritsma, M. A mass, energy, enstrophy and vorticity conserving (MEEVC) mimetic spectral element discretization for the 2D incompressible Navier-Stokes equations. Preprint submitted to Journal of Computational Physics. Accesible at arXiv:1604.00257, April 2016.