Geo-INQUIRE Transnational Access Project Report

Geo-INQUIRE installation: (TA2-531-2) OpenFOAM Applications in Volcanology

Project title: Multiscale Simulation of Pyroclastic Density Currents (PDCs) Across Complex Topography Using OpenPDAC

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Project acronym: TOPOVOLC

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Project report: The project is focused on the use of the ChEESE Flagship code OpenPDAC, to perform numerical simulations of multiphase flow experiments of pyroclastic flows.

We benchmarked OpenPDAC (OpenFOAM-based two-fluid model solver for volcanic flows) against the PELE large-scale flume experiments to support multi-model validation of pyroclastic density currents (PDCs). The measured 3D flume topography was imported into OpenFOAM and meshed with snappyHexMesh: a background hexahedral grid was snapped to the surface and locally refined where geometry is most complex (near interfaces, which enables capturing large concentration gradients where the flow becomes denser while reducing computational cost elsewhere in the flow and is practical for varying topography), enabling repeatable terrain-conforming meshes and mesh-convergence tests. Input conditions were aligned with experimental definitions, including a mass-flow inlet. From the PELE dataset we derived vertical, time-averaged profiles at fixed downstream sections: for each height above the bed we computed spanwise-averaged, occupancy-window time means of particle volumetric concentration, gas/solid temperatures, and gas/solid streamwise velocities; these were implemented as OpenPDAC as a boundary condition. Simulations ran robustly on the complex PELE topography, with relatively good agreement within the channel (Figure 1); Results suggest that further mesh refinement is required both (i) at the channel outlet, to better resolve ambient-fluid entrainment and associated flow dilution, and (ii) near the substrate, to more accurately capture the thin, concentrated basal layer. OpenPDAC remains computationally efficient relative to more complex multiphase solvers (e.g., MFIX), making it well suited to extensive parametric and sensitivity studies. We plan to present the extended results in a manuscript for Bulletin of Volcanology.

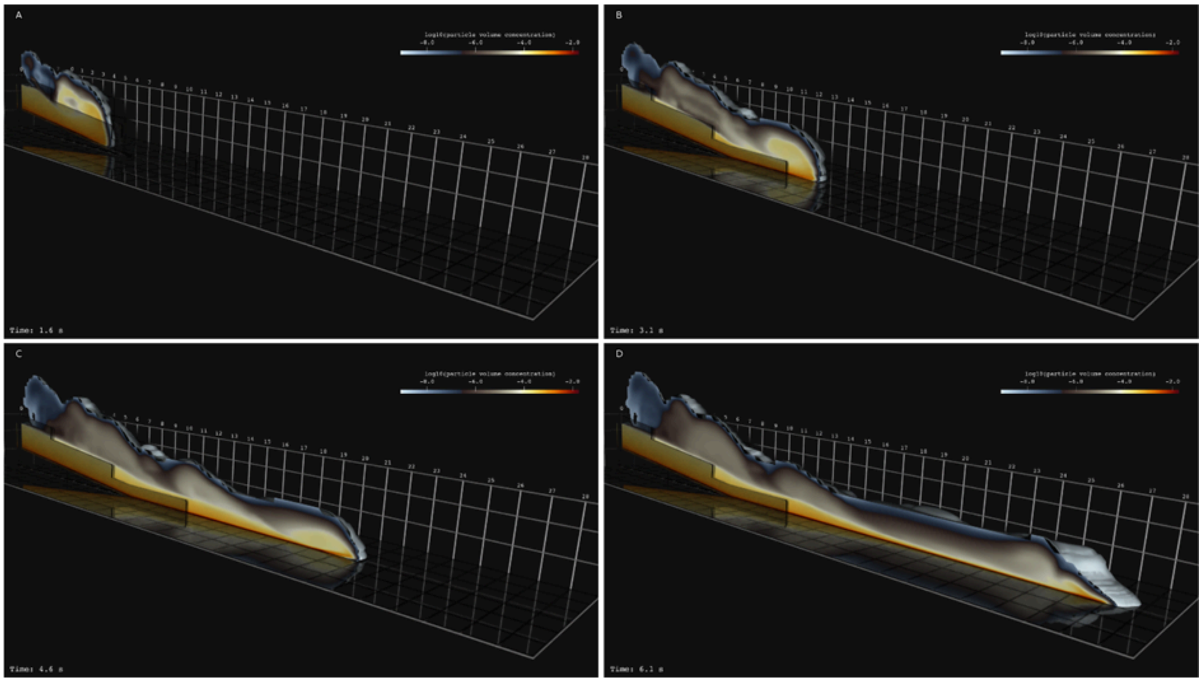

Figure 1. OpenPDAC snapshots from the PELE flume benchmarking exercise. Each panel shows a 2D slice and an isosurface cut in half at log10(particle volume concentration) = −9 at the indicated time (A: 1.6 s; B: 3.1 s; C: 4.6 s; D: 6.1 s). Visualisation of the OpenPDAC simulation: https://youtu.be/_Zc3vgGeVg8