Geo-INQUIRE Transnational Access Project Report

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

Project title: Investigating MultiPhase Analysis of Current Transport

Transnational access principal investigator: Brandon Keim (University at Buffalo, State University of New York, USA)

Project acronym: IMPACT

Project report ID: C1_TA2-531-2_2 (1st Call)

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Project report: The project is focused on the use of the ChEESE Flagship code OpenPDAC, to investigate pyroclastic surge deposition and sedimentation over various terrains and topographic configurations.

Summary of the outcomes (max 1500 characters):

Understanding the complex interactions between pyroclastic density currents (PDCs) and topography is critical for interpreting volcanic deposits. During his stay at INGV-Pisa, Brandon Keim applied OpenPDAC, a novel multiphase OpenFOAM solver, to investigate surge dynamics and sedimentation processes. The project aimed to numerically replicate flume experiments conducted at Arizona State University, where particle-laden gravity currents traversed a specific basal topography.

Brandon developed a workflow to simulate ten sequential "pulses" of current. A key outcome was the creation of specific post-processing tools capable of extracting particle volume fractions and dynamically modifying the mesh topography between pulses. This allowed the simulation to account for the cumulative effect of sedimentation on flow behavior over time.

The simulations successfully reproduced fundamental flow dynamics, including eddy formation and buoyancy reversal driven by particle settling. When comparing the numerical results to experimental data, the model captured characteristic depositional trends seen in natural dilute PDCs, such as stoss-side aggradation (thickening) and

topographic draping. While some configurations overestimated total thickness, the simulations successfully demonstrated the logarithmic decay of deposit thickness with distance. These results validate the efficacy of OpenPDAC in linking flow dynamics to deposit architecture.

These findings were presented by Brandon Keim at the 2025 IAVCEI Scientific Assembly (Session 3.9: Multidisciplinary Advances in Understanding Pyroclastic Density Currents).

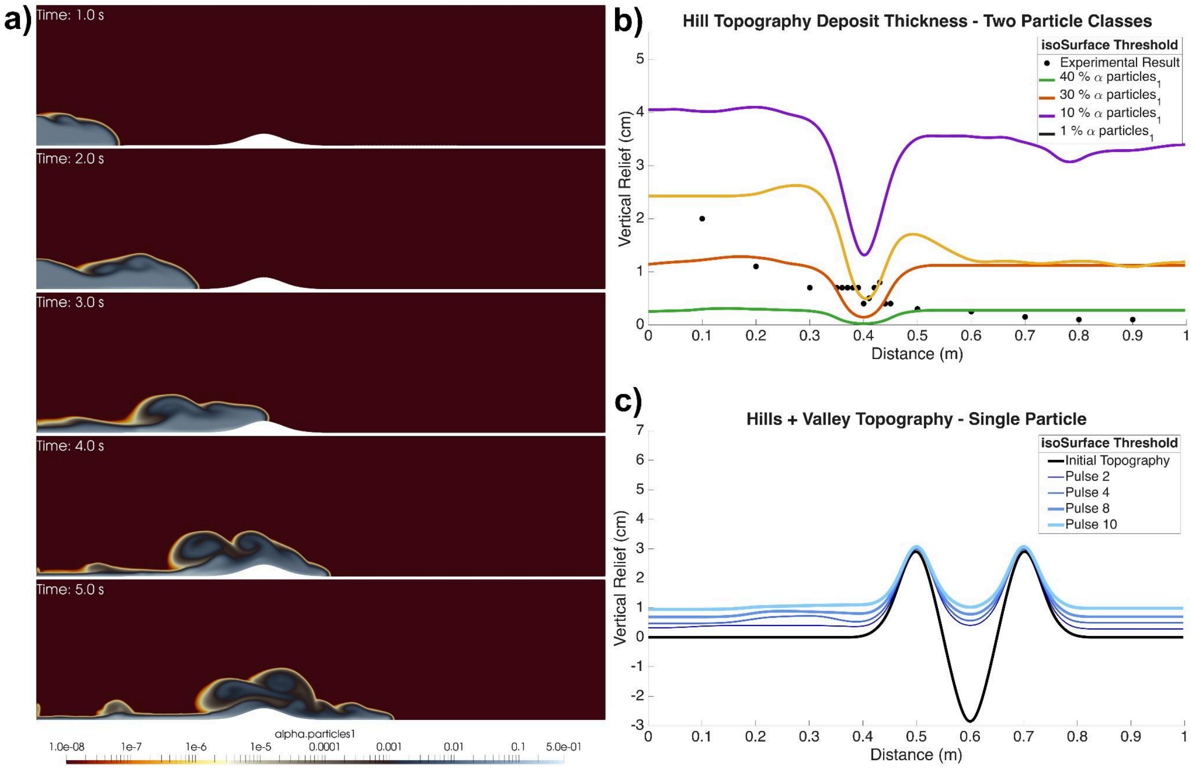

Figure: Multiphase flow simulations of dilute PDC dynamics and sedimentation over varying topography. The models utilize the OpenPDAC solver to simulate sequential pulses and extract deposit geometries: **a)** Time evolution (1–5 s) of the particle volume fraction (log scale) for a single pulse flowing over a mound. The current displays characteristic flow dynamics including turbulent eddy formation and flow thickening upstream of the obstacle. **b)** Comparison of simulated deposit thickness profiles against experimental results (black dots). The curves represent different particle volume fraction thresholds used to define the deposit interface. **c)** Sequential aggradation of the deposit layer over a complex "hills and valley" topography. The profiles illustrate the progressive modification of the basal surface after pulses 2, 4, 8, and 10, highlighting the cumulative effect of sedimentation in the valley and on stoss slopes.