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Application of Computational Fluid Dynamic to Numerical Simulation of Lava Flow using Open-Source Code

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Among various types of volcanic hazards, lava flow is the slowest but the deadliest one to the area adjacent to the volcano, which enables the mitigation measure if the region of affection can be predicted in advance. Due to its nature of extreme temperature and sophisticated composition, experimental estimation in the laboratory level is nearly impossible. Instead, many efforts have been carried out to numerically predict the potential hazard from the lava effusion from volcanic eruption; however, the available developed methods are yet far from reliable or practical tool in spite of many accomplishments. There are a couple of reasons for the imperfection in the numerical simulation of lava flow at present; one of the computational difficulties is the large difference in the spatial scale, where the thickness of the lava flow is several orders less than the horizontal scale, while one of the physical difficulties is the high uncertainty in the non-Newtonian behavior of viscosity of molten rocks with the influence of temperature-varying properties. These complicate the generalization of the problem and the related methods are still in the developing phase. This study presents a numerical approach to simulate the unsteady flow of molten rocks effusing from a vent using open source code of computational fluid dynamics utility called OpenFOAM with two phase modeling for lava and surrounding atmosphere. The viscosity of the lava is modeled as a Bingham plastic or Herschel-Bulkley fluid. In order to validate the method, we carried out numerical simulations for the well-known cases of eruptions from Mt. Etna, Italy. We have conducted quantitative evaluations including the extent of damage, travel distance and thickness of the lava flow. This research was supported by a grant [MPSS-NH-2015-81] through the Disaster and Safety Management Institute funded by Ministry of Public Safety and Security of Korean government.