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CA and SPH Models for Lava Flow Simulations at Mt. Etna

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The study of the lava flow requires the development, validation and application of accurate and robust physico-mathematical models able to forecast their spatial and temporal evolution. Simulations of lava flow emplacement attempt to understand how the complex interaction between flow's dynamics and lava physical properties lead to the final flow dimensions and morphology observed in the field. The advance of lava flows produced by volcanic eruptions has been studied through field observations as well as through analytical and numerical modeling. Differential equations for complex phenomena mostly lack analytical solutions. Approximated numerical methods, commonly based on a discretization of space-time, are now possible thanks to computer power. These methods have greatly extended the class of problems, which can be solved in terms of differential equation systems. In order to perform forecasting simulations of lava flow in near real time and to predict the evolution of the phenomena during the ongoing eruptions a MAGFLOW cellular automata model (CA) was developed. An algorithm based on Monte Carlo approach to solve the anisotropic problem was introduced. A steady state solution of Navier Stokes equation, in the cas e of non-isothermal laminar pressure-driven Binghamian fluid, was taken into account as evolution function of CA. To furnish a more detailed physical description of emplacement processes, a Smoothed Particle Hydrodynamics model (SPH) was included. This algorithm allow us to solve the equations of motion of a compressible fluid by a Lagrangian approach. SPH systems are unstructured, since the interactions between point masses (particles) depend on their distance. The SPH determines the characteristics of fluid by interpolating from a set of non-ordered particles. Inter-comparison between simulations of lava flows down on Mt Etna using CA and SPH models were performed. Moreover, using both MAGFLOW and SPH models, we estimated the areas exposed to inundations of lava flows during different kind of eruptions for selected sensible sites around the volcano. The application of these fast-running codes allow multiple run changing the initial and boundary conditions of the system (i.e.: the vent position, the flux-rate, the rheological properties, etc.). Also a parametric study on the major computational variables in order to guarantee an adequate resolution of the main large-scale processes and to optimize computer time was done.

Keywords: Lava Flow Simulation, Cellular Automata, SPH.