Phase Portraits of Superficial Flows for Risk Mitigation

V.P. Bongolan[a], D. D'Ambrosio[b], G. Iovine[c], R. Rongo[b], W. Spataro[b], G. Spingola[b]

[a] Department of Computer Science, University of the Philippines Diliman, Quezon City
bongolan@dcs.upd.edu.ph

[b] Department of Mathematics and Computer Science, University of Calabria, Italy

[c] CNR-IRPI, U.O.S. di Cosenza (CS) - Italy

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Cellular automata simulations of lava and debris flows have been performed over actual morphologies and idealized topographies (planes inclined at 20, 40 and 60 degrees), by using the latest releases of cellular automata models [1], [2]. In particular, an n-dimensional state space has been considered to describe the states of the flow centroids per each simulation, i.e. : its position in three dimensional space (for lavas, three variables each for the case of when the cooled portions are ignored, and with the cooled portions included); thickness of the deposit; three variables to describe the direction of the flow (momentum in the x and y directions, and the angle theta formed); temperature for lava flows. The momentum^2 was then derived. A decomposition of this n-dimensional space has revealed an empty gradient space, but no fractal attractors in the chain-recurrent part, as described in the entire space to be a gradient space, with no chain-recurrent part (subspace of attractors), as described in [3]. The modeling has resulted robust, with dynamics being largely preserved across inclinations. If we consider the 20-degree angle as producing the 'expected' flow, the 40 and 60-degree angles represent 'runny' or fast-moving flows, yet the dynamics looks preserved. Interesting complexities like kinks and knots have been obtained at the 60-degree angle. Among the most interesting portraits, the one for (height, temperature, momentum^2) shows a parabola-like curve that is not only robust across inclinations, but shows a good behaviour for an actual flow [4], comparable to an idealized one. Mitigation measures will be simulated based on such portraits, aiming at analysing changes in the evolution of the simulated flows.

References

[1] W. Spataro, M. V. Avolio, V. Lupiano, G. A. Trunfio, R. Rongo, D. D'Ambrosio. The latest release of the lava flows simulation model SCIARA: first application to Mt Etna (Italy) and solution of the anisotropic flow direction problem on an ideal surface. Procedia Computer Science, 1, 17-26, 2010.

[2] D. D'Ambrosio, S. Di Gregorio, and G. Iovine: Simulating debris flows through a hexagonal cellular automata model: SCIDDICA S3?hex. Natural Hazards and Earth System Sciences, 3: 545-559, 2003.

[3] X. Chen and J. Duan: State space decomposition for non-autonomous dynamical systems, Proceedings of the Royal Society of Edinburgh: Section A Mathematics / Volume 141 / Issue 05 / pp 957-974, 2011.

[4] Rongo R., Spataro W., D'Ambrosio D., Avolio M.V., Trunfio G.A., Di Gregorio S. (2008), Lava Flow Hazard Evaluation Through Cellular Automata and Genetic Algorithms: an Application to Mt Etna Volcano, Fundamenta Informaticae, 8, 247-268.