Abstract

Lahars represent one of the most destructive natural disasters in terms of loss of human lives and property damage in their path. Lahars are very complex surface flows of two types: primary lahars originate directly from volcanic eruptive activity and secondary lahars originate in post-eruptive events or quiescent periods.

Lahars are a complex combination of many interrelated processes besides the process of surface flow: rainwater percolation in the soil (secondary lahars), volcanic stratum erosion, water inclusion and extrusion in lahar, ice melting and mixing with volcanic emissions (primary lahars). Evaluating the hazard posed by lahars constitutes one significant challenge within the framework of modeling and simulation of complex systems for reducing hazard in many, sometime very populous, inhabited areas next some dangerous volcanoes.

A variety of approaches has been taken to modeling the behaviors of lahars and the hazards posed to downstream communities: empirical models based on smart correlations of phenomenon observables, simple rheological and hydrological models and Partial Differential Equations (approximating numerical methods of fluid dynamics).

Cellular Automata (CA) represent an alternative approach for modeling and simulating complex systems evolving on the base of local interactions of their elementary components. Lahars may be classified as such a type of phenomenon. Moreover, a CA modeling methodology has been developed for simulating surface flows.

CA are a parallel computational paradigm for modeling complex systems by defining 'simple' laws at local level that generate a global 'complex' evolution. The research, reported in this thesis, adopts a Multicomponent (or Macroscopic) Cellular Automata (MCA) approach that was applied to other complex surface flows. The model LLUNPIY has been developed in this frame and successful simulations of real events were performed.

The goal of this thesis has been to develop a CA model, LLUNPIY (**L**ahar modeling by **L**ocal rules based on an **UN**derlying **PI**ck of **Y**oked processes, from the Kichwa word llunp'iy meaning flood), which is based on the CA semi-empirical approach to macroscopic phenomena of Di Gregorio and Serra, in order to simulate the complex dynamics of lahars, taking into account experience of models like SCIDDICA, SCIARA, PYR, VALANCA and SCAVATU.