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A Landscape Evolution Model to study volcanic landscape evolution

Wouter van Gorp (1), Arnaud Temme (1), Jantiene Baartman (1,2), Jeroen Schoorl (1), and Tom Veldkamp (3)

(1) Land Dynamics Group, Environmental Sciences Department, Wageningen University, PO Box 47, 6700 AA Wageningen, The Netherlands (wouter.vangorp@wur.nl), (2) Land Degradation & Development Group, Environmental Sciences Department, Wageningen University, PO Box 47, 6700 AA Wageningen, The Netherlands, (3) International Institute for Geo-Information Science and Earth Observation (ITC), PO Box 6, 7500 Enschede, The Netherlands

Over the last decades, Landscape Evolution Models (LEMs) have become popular as geomorphology's virtual laboratories. LEMs allow simulations of wide ranges of assumptions and hypotheses over large temporal and spatial scales, something that is clearly impossible with field-experiments. Furthermore, LEMs potentially can illustrate complex and non-linear landscape response to external and internal drivers. Because of the focus on geomorphic processes and their drivers, it is under some conditions possible to use existing models in new geomorphic environments. For instance, LEMs have recently been used for the first time in the simulation of karst landscapes. However, LEMs have not before been used to simulate volcanically influenced landscapes.

In this contribution, we argue that – with some adaptations – LEMs can also be used for the study of volcanic landscapes. Although it will clearly be difficult to model the more random aspects of volcanism – timing and location of eruptions, volume and nature of erupted material – LEMs can be adapted to simulate the post-eruption evolution of volcanic landscapes. LEMs could thus quantify the effect volcanic activity has on the catchment it alters for hundreds or thousands of years after the event took place. This could be done for a single event but also for repeated volcanic events, without losing the history of landscape response to each individual event.

Geomorphic features that should be simulated in such landscapes include a) relief inversion due to the presence of irregularly shaped, hardly erodible bodies of lava or lahars in drainage systems, b) the blocking of valleys and the creation of lakes by lava flows, c) the infilling of such lakes with sediment from upstream and the erosion of lava dams by lake overflow.

We ventured to add these functionalities to our LEM: LAPSUS, a multi-process LEM capable of modelling multiple geomorphic processes such as water runoff and erosion, landsliding, tillage erosion, creep, solifluction, biological and frost weathering and hillslope-fluvial interaction. We present the results of preliminary experiments with the adapted model in hypothetical volcanically influenced landscapes.

Ultimately, the changes to LAPSUS are meant to allow a numerical study of landscape evolution of the Kula Basin in SW-Turkey, where a series of volcanic eruptions starting about 1 Ma ago has covered large portions of the landscape with lava, dammed rivers and created lakes in which deposition occurred. The LEM is available for studies in other volcanic landscapes.