Geophysical Research Abstracts
Vol. 16, EGU2014-6309-2, 2014
EGU General Assembly 2014

Evaluating effusive volcanic hazard from thermal remote-sensing: insight from analogue experiments

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During an effusive volcanic eruption, crisis management is mainly based on the prediction of lava flow advance. The spreading of a lava flow depends mainly on its rheology and on the effusion rate, and can be modeled as a gravity current. A thermal proxy, based on the power radiated by lava flows and measured by remote-sensing, has been quite widely used in the literature to evaluate the effusion rate in near real-time. But firm physical bases are still lacking for such modeling to be used to assess robustly the time variation of the effusion rate. To gain a better understanding of the physical processes underlying lava flow advance and to better assess the validity of thermal proxies, we have performed and analysed analogue experiments using a solidifying wax material. Two aspects of volcanic hazard mitigation are studied: (i) how supply rate relates to surface thermal signal, and (ii) how flow advance relates to supply rate. We find that, for material injected at a constant rate, flow advance is discontinuous and occurs through a succession of stagnation phases and overflows. Stagnation phases are longer for lower supply rates, whereas flows with higher supply rates are less affected by solidification. The total radiated power also grows by stages, but the signal radiated by the hottest and liquid part of the flow reaches a quasi-steady state after some time. This plateau value is shown to scale with the theoretical thermal response of an isoviscous gravity current. The experimental scaling yields satisfying estimates of the effusion rate from the total radiated power measured on a range of basaltic lava flows. However, even though lava lava flow effusion rate can be estimated, our experiments show that prediction of lava advance remains difficult due to chaotic emplacement of solidifying flows.