Project ANR-LAVA: Modelling Lava Advance using an Integrated Satellite-Data-Driven Response to an Effusive Crisis and the Effect of Trees

M.O. Chevrel[1], A. Harris[1], N. Bernabeu[2], P. Saramito[2], D. Coppola[3], M. Ramsey[4], A. Hrysiewicz[1], S. Thivet[1], N. Villeneuve[5], M. Favalli[6], A. Peltier[5], A. Di Muro[5], P. Kowalski[5], J. Froger[1], L. Gurioli[1]

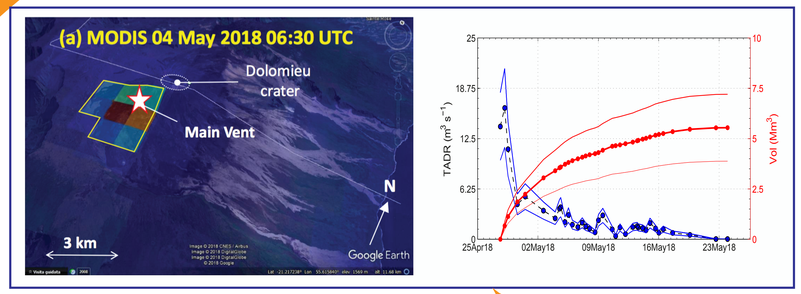
[1]Université Clermont Auvergne, CNRS-IRD-OPGC Laboratoire Magmas et Volcans, Aubière, France.
[2]CNRS and Grenoble University, Laboratoire Jean Kuntzmann, Grenoble, France.
[3]Università degli Studi di Torino, Dipartimento di Scienze della Terra, Turin, Italy.
[4]University of Pittsburgh, Department of Geology and Planetary Science, Pittsburgh, USA.
[5]Institut de Physique du Globe de Paris, Observatoire Volcanologique du Piton de la Fournaise, La Plaine des Cafres, France.
[6]Istituto Nazionale di Geofisica e Vulcanologia, Sez. Pisa, Pisa, Italy.

Satellite-based surveillance of volcanic hot spots can be coupled with modeling to allow ensemble-based approaches to crisis response. We build an effusive crisis response protocol aimed at delivering product for use in tracking lava flows. This involves integration of satellite data (TADR from MIROVA, TIR from ASTER and correlated InSAR images); numerical models for flow path projections and run-out (DOWNFLOW + FLOWGO) and field data for ground truth (from observatory).

We test the protocol during Piton de la Fournaise's April–May 2018 eruption, with product being delivered to the observatory. The first response was initialized few hours after the lava break out and revealed that flow at >120 m3/s could cut the island belt road. The first TADR (obtained via MIROVA) was available the next day. The latency between satellite overpass and TADR provision was 105 minutes, with the model result being posted 15 minutes later. An InSAR image pair was completed six hours after the eruption began, and gave a flow length of 1.8 km; validating the run-out projection obtained via DOWNFLOWGO.

Thereafter, run-outs were updated with each new TADR, and checked against flow lengths reported from InSAR and ASTER mapping. In all, 35 TADRs, 15 InSAR image pairs and 11 ASTER images were processed during the 35-day-long eruption.

This protocol is of service to Volcanoes Observatories to aid in monitoring needs for lava flow field evolution allowing both crisis management and appraisal of need to evacuate ground based monitoring stations falling in flow paths.




Bulletin du 27 avril 2018 – 20 : 30 heure locale
Observatoire Volcanologique du Piton de la Fournaise

Suite à la reprise de l'activité sismique à l'aplomb de la zone sommitale du Piton de la Fournaise le 21 avril 2018, et après une augmentation progressive de la sismicité depuis 17h45 (heure locale) le 27 avril 2018, une crise sismique est enregistrée sur les instruments de l'Observatoire Volcanologique du Piton de la Fournaise depuis 20h15 heure locale le 27 avril 2018.

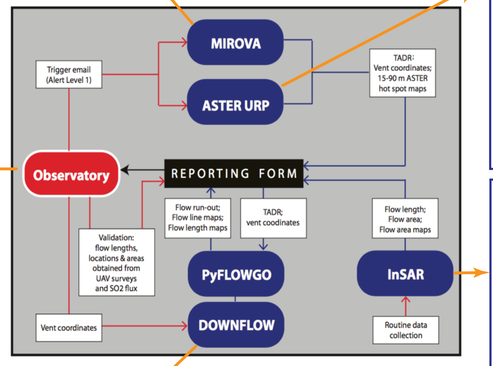
Cette crise sismique est accompagnée de déformation rapide, Ceci indique que le magma est en train de quitter le réservoir magmatique et se propage vers la surface. Une éruption est probable à brève échéance dans les prochaines minutes ou heures.

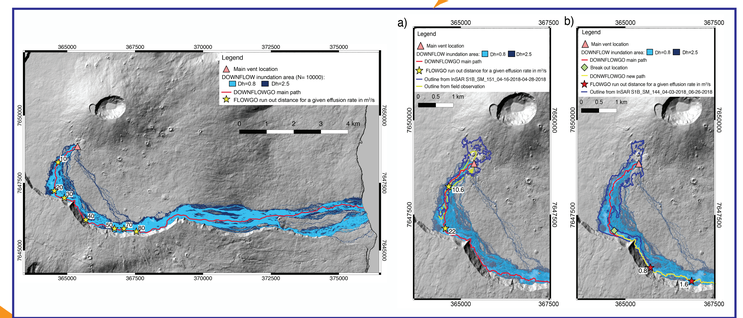
Des informations complémentaires vont suivre concernant le secteur impacté par cette propagation magmatique vers la surface.

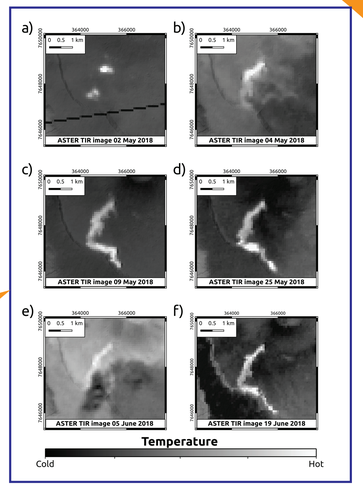
Niveau d'alerte : Alerte 1 – Eruption Imminente

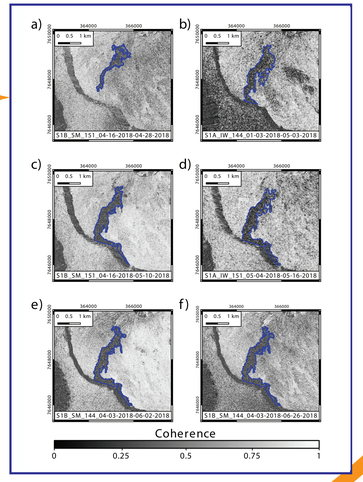
Aline Peltier
Directrice de l'Observatoire Volcanologique du Piton de la Fournaise

INSTITUT DE PHYSIQUE DU GLOBE DE PARIS

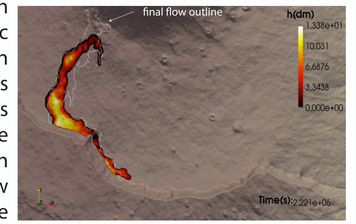




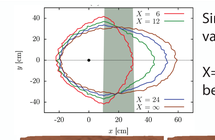




A model based on shallow depth approximation of a viscoplastic fluid flowing on a DEM has been built and validated for this eruption. The input parameters include the decreasing TADR, the final extruded volume, a given viscosity and yield strength. Flow outline and thickness are recovered. The open source software, SHALAVA, will be soon available.

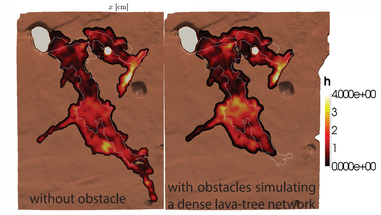


This model can also be adapted to compute flow crossing an array of vertical obstacles. For this a porous medium is introduced to reduce the array of obstacles (via Darcy model extended for viscoplastic Bingham fluids).



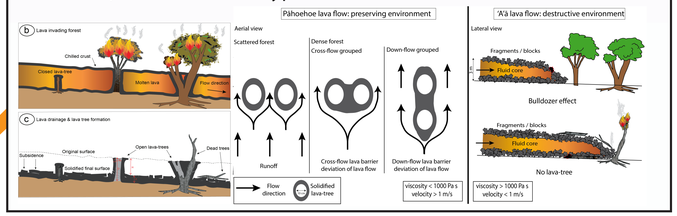
Simulations on a plane to validate the model.

X= relative distance between obstacles



Exemple of Kilauea July 1974 lava flow.

A detailed study of the effect of trees on the emplacement of Kilauea July 1974 lava flow show that trees do not affect the cooling of the lava at the scale of this flow but may locally affect the flow lines where lava-trees form. To form lava-trees, the viscosity must be $<10^3$ Pa s. Above this threashold, the lava is of a'a' type which causes destruction of the trees.



This work was funded by the Agence National de la Recherche through project ANR-LAVA (ANR Program: DS0902 2016; Project: ANR-16CE39-0009) and is published under:
Validation of an integrated satellite-data-driven response to an effusive crisis: the April–May 2018 eruption of Piton de la Fournaise. ANNALS OF GEOPHYSICS, 61, 2018

scan me

Bernabeu, N., P. Saramito, and A.J.L. Harris. (2018) Laminar Shallow Viscoplastic Fluid Flowing through an Array of Vertical Obstacles. Journal of Non-Newtonian Fluid Mechanics 257: 59–70.
Chevrel MO, Harris A, Ajas A, Biren J, Gurioli L, Calabrò L (2019) Investigating physical and thermal interactions between lava and trees: the case of Kilauea's July 1974 flow. Bull Volcanol 81:6