Title of the thesis: Conciliating volcanic CO_2 degassing and hazard assessment: new constrains from numerical modeling

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Summary : Among major volatiles released from the Earth's interior, CO_2 is an important focus of international scientific research. This interest is keenly motivated by the major contribution of volcanic CO_2 in the Earth's carbon budget and its role in climate dynamics. Volcanic CO_2 emissions also represent a serious risk to local populations and may be responsible for deathly catastrophic events such as in 1986 at Nyos lake (Cameroon) (Baxter & Kapila, 1989). Paradoxically, spatial variations of soil CO_2 emissions are also often used to detect "buried" preferential magma pathways or unstable zones of volcanic edifices and are thus of primary importance in the identification of potentially hazardous areas for human sustainability (Boudoire et al., 2017). Additionally, temporal variations of CO_2 emissions are known to be reliable long to medium-term tracers of magma transfers and volcanic unrest, sometimes with the lack of geophysical precursors (Boudoire et al., 2018).

Volcanic CO_2 emissions play thus an important role in volcanology, being both a source of hazards but also a support for risk mitigation. However, this role still be poorly constrained. Methods to identify the zones of soil CO_2 degassing are now well-known but related studies generally stop at the identification of these preferential paths for magmatic fluids. Can we go beyond this identification? Can we develop scenarios of local CO_2 dispersion in the low atmosphere? What are the main internal and/or external parameter constraining these models? Can we elaborate scenarios of lava propagation in case of future eruptions along these structures? How can we integrate these scenarios in local and global strategies of risk mitigation?

This project aims at focusing on the role of volcanic CO_2 emissions in the imbalance between natural hazard and monitoring strategies. A fieldwork part will be dedicated to identify and constrain the zones of soil CO_2 degassing on well-targeted volcanoes by combining soil CO2 surveys with ground temperature, pH and vegetation cover from satellite imagery. Based on this mapping, numerical modeling will be performed to simulate gas dispersion (DISGAS, TWODEE; Folch et al., 2009; Granieri et al., 2014) and lava propagation (DOWNFLOW; Favalli et al., 2005; Harris et al., 2019). A careful analysis of the influence of internal (soil CO_2 flux, minimum nodes, lava rate, proxy…) and external (wind, pressure …) parameters on the simulations will be performed to (i) provide realistic hazard maps and (ii) contribute to real-time risk mitigation. Ideally, the surrounding areas of Goma

(Democratic Republic of Congo: DRC) will be targeted. The city (about 2 million of inhabitants) is expanding on the flanks of the volcano Nyiragongo characterized by massive CO_2 discharging. In 2002, a lateral eruption occurred has left 170 people dead, 120 000 people homeless and destroyed more than 80% of the economic infrastructure at Goma, causing major socio-economic disruption. In addition, and according to the evolution of the political situation in the East of the DRC, other volcano (e.g. Vulcano (Italy), Masaya (Nicaragua) …) could be targeted.

The project will be carried out at the Laboratoire Magmas et Volcans (LMV) under the supervisation of A. Harris (lava flow modelling) and G. Boudoire (soil CO_2 degassing) and with the collaboration of both local (LAboratoire de Météorologie Physique: LAMP) and international (Istituto Nazionale di Geofisica e Vulcanologia: INGV) institutes. Skills and interests in computer programing (Python, C++, Fortran…) are fundamental. Candidates familiar with mesoscale WRF atmospheric modelling and/or the use of GIS softwares are welcomed. This PhD thesis is already funded by the Challenge 4 “Catastrophic natural risks and socio-economic vulnerability” of the I-Site CAP 20-25.

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