ACCESS TO RESEARCH INFRASTRUCTURES

Natural Impact of passive and active volcanic CO2 degassing activity on the atmosphere; NICO

PI: Marco Liuzzo; Co-authors: Andrea Luca Rizzo; Andrea Di Muro; Patrice Boissier; Philippe Kowalski; Guillaume Boudoire; Pierre Tulet; Jean-Marc Metzger

- **Introduction and motivation**

The primary aim of NICO project is the determination of the origin of volcanic gases and their incidence and modification in the atmosphere at Piton de la Fournaise (PdF) volcano (Reunion island), one of the most active volcanos in the world and an important source of gas released into the atmosphere, especially during eruption activity. The ENVRIplus TNA protocol facilitated an important opportunity for close collaboration and sharing of ideas and expertise between members of the Observatoire Volcanologique du Piton de la Fournaise (OVPF), the Maïdo Observatory and to the Instituto Nazionale di Geofisica e Volcanologia (Italy). The period of the fieldwork was carried out during the 1st and the 15th September 2017, when it was possible to visit the Maïdo Observatory and the OVPF Observatory. The period of the visit and the relative fieldwork started after the last eruption at the Piton de la Fournaise (14 July - 28 August), and the surveys, therefore, were conducted in period of volcano quiescence.

- **Multidisciplinary approach**

To achieve the objectives of the project, we planned to carry out field surveys to locate the most important emission areas and collect gas for laboratory measurements to define the origin of fluids and their evolution over distances. The obtained data, (currently in the phase of analysis and modelling) is to be integrated with geochemical and volcanological observations made in collaboration with the Observatoire Volcanologique du Piton de la Fournaise (OVPF) and by further atmospheric measurements made in cooperation with the local Maïdo Observatory.

- **Scientific objectives**

In this project we intended to address the existing gap in knowledge by 1) defining the chemical and isotopic characteristics of magmatic fluids (CO_2, SO_2 and noble gases) either at source or in distal areas; 2) quantifying the amount of volatiles emitted from the volcano and their evolution in the atmosphere; 3) evaluating the impact of volcanic emissions in the local atmosphere.

- **Methodology and experimental set-up**

The survey on Piton de la Fournaise started shortly after the last eruption (Jul-Aug 2017), therefore, a first attempt on the field was to try to collect gas samples from the vent of the recent eruption (Fig. 1). Unfortunately this attempt was unsuccessful, owing to the fact that the vent and the eruptive fissure was in an advanced state of cooling, releasing only water vapour. We decided, then, to work on two different fronts: 1) carrying out a soil CO_2 survey in the area of Cilaos, identified as an area potentially highly degassing soil CO_2 emissions, and sampling the free gas from the hydrothermal spring water in the same place in order to identify the isotopic signature of the gas released from the aquifer 2) focusing on the data collected from Maïdo and OVPF observatory related to the recently finished eruption (July - August 2017).

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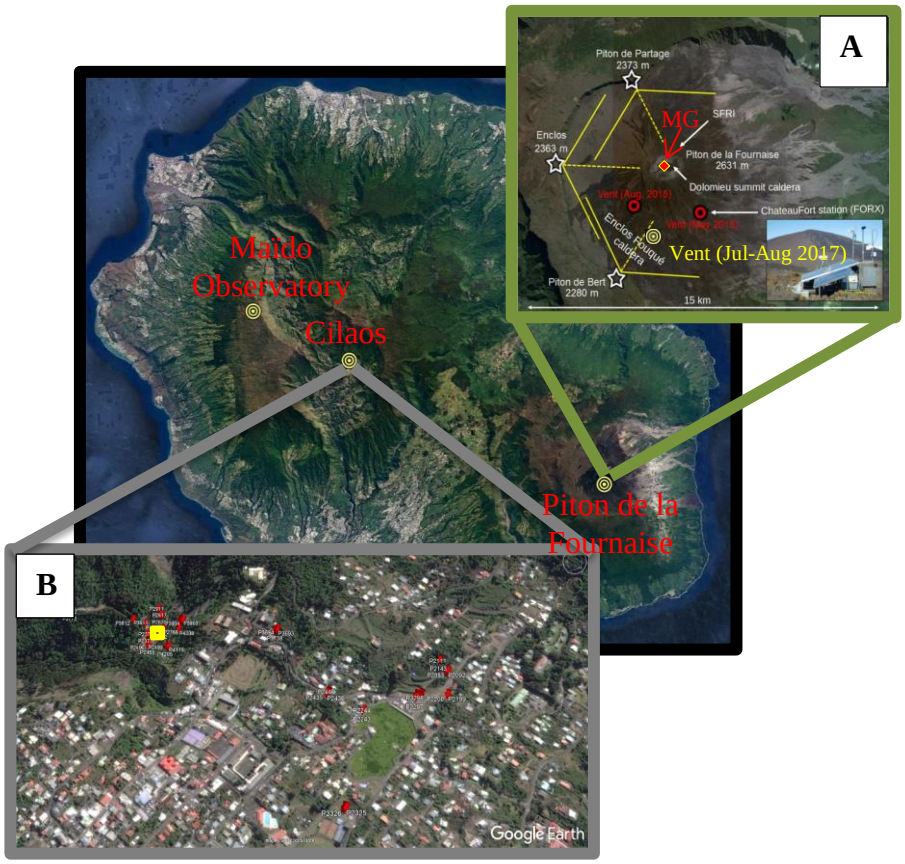

Fig. 1 : Map of La Reunion Island showing the location where measurements of gas were taken during the TNA visit at La Reunion. A (figure from Tulet et al. 2017 modified) shows the position of the last eruption (yellow point), the geometry of the NOVAC network of OVPF (stars symbols), and the position of the MultiGAS (MG) at the summit of the volcano. B shows the map of the soil CO_2 survey in the area of Cilaos (red points) and the site of the hydrothermal water springs at the Cilaos where free gases were taken for isotopic measurements (square in yellow).

- **Preliminary results and conclusions**

In order to explore the impact on the atmosphere by the gas emission from the volcanic activity of the recent eruption at Piton de la Fournaise we combined data collected in a multidisciplinary approach from a network of instruments (Fig. 1) located either close to the source of emission (MultiGAS) or in distal areas NOVAC-Enclose and Maïdo Observatory. Fig. 2 shows the time series of the SO_2 flux and SO_2 molar concentration measured in the atmosphere during the last eruption. Here it is possible to observe that a significant increase in the concentration of SO_2 was recorded at Maïdo Observatory after the start of eruption, which was also recorded well by both the near NOVAC station of Enclos and the MultiGAS station site on the summit of the volcano.

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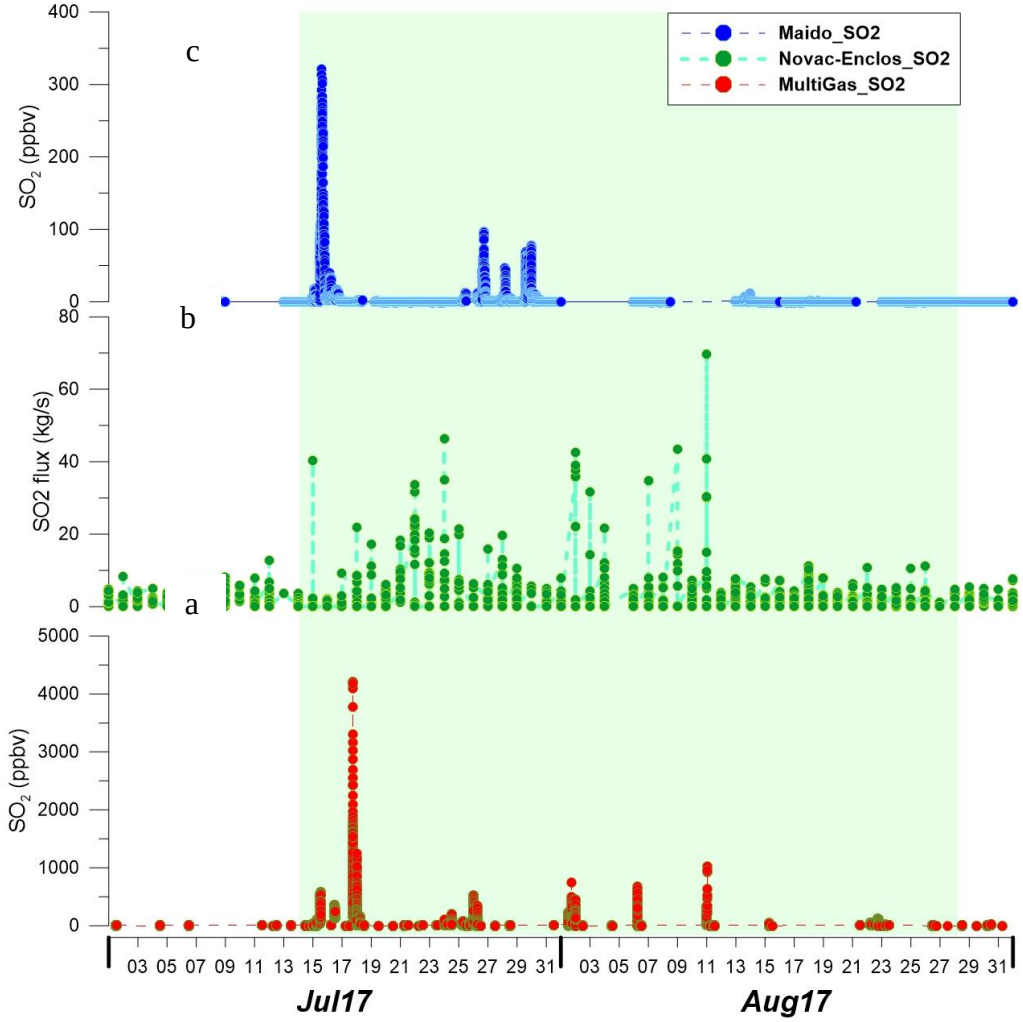

Fig. 2 : Time series of the SO_2 concentration measured from proximal to distal area on Piton de la Fournaise (bottom to top) during the 14 July 28 August eruption (green shadow). The lowest figure a) indicates: molar concentration of SO_2 measured with the permanent MultiGAS at Piton de la Fournaise by the OVPF (in red); while b) above indicates SO_2 flux (in green) measured by the NOVAC Enclos station of the OVPF network; c) at the top SO_2 molar concentration measured at the Maido Observatory (in blue).

Fig 3 shows the variation of isotopic data collected in the hydrothermal area of Cilaos. In this figure both helium and carbon isotopic signatures show a substantial variation before and after the eruption, consistent with the geochemical model which predicts isotopic variation during volcanic activity.

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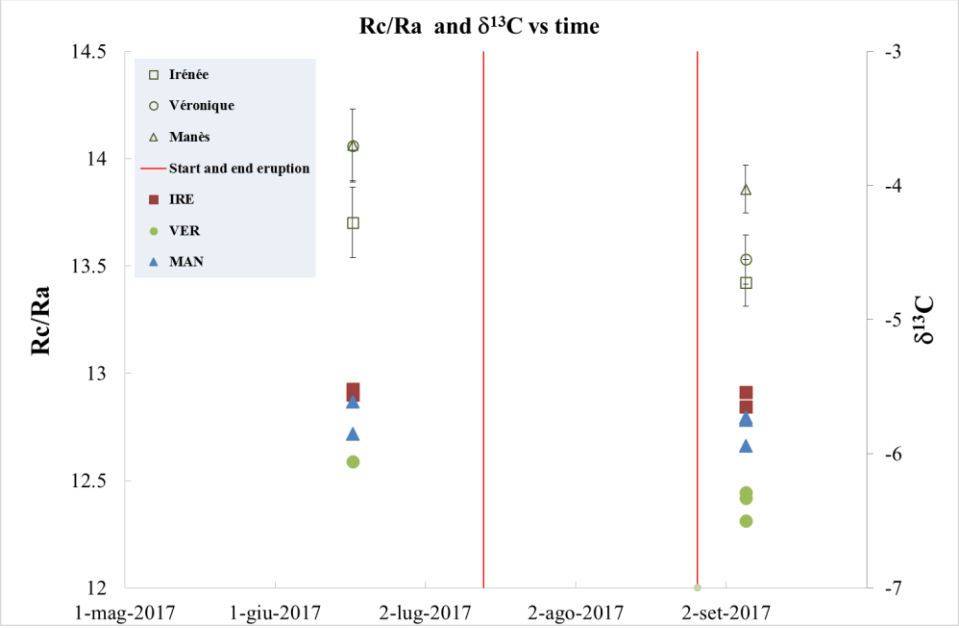

Fig. 3 : Noble gas and carbon isotopic signature from three different water springs at Cilaos hydrothermal area. Full symbols are plotted on the right axis ($\delta^{13}C$); empty symbols are plotted on the left axis (Rc/Ra). Regarding $\delta^{13}C$, samples were taken in three different amounts for each site and all the data are reported.

Fig 4 shows data from the soil CO_2 survey conducted at Cilaos. Consistent with isotopic data, the soil CO_2 emissions recorded in Cilaos also show that this is an important degassing area. This is a preliminary confirmation that Cilaos is an area of La Reunion that holds much potential for the recording of geochemistry variations (eg: in isotopic as well in flux and concentration rate) which may correlate with volcanic activity.

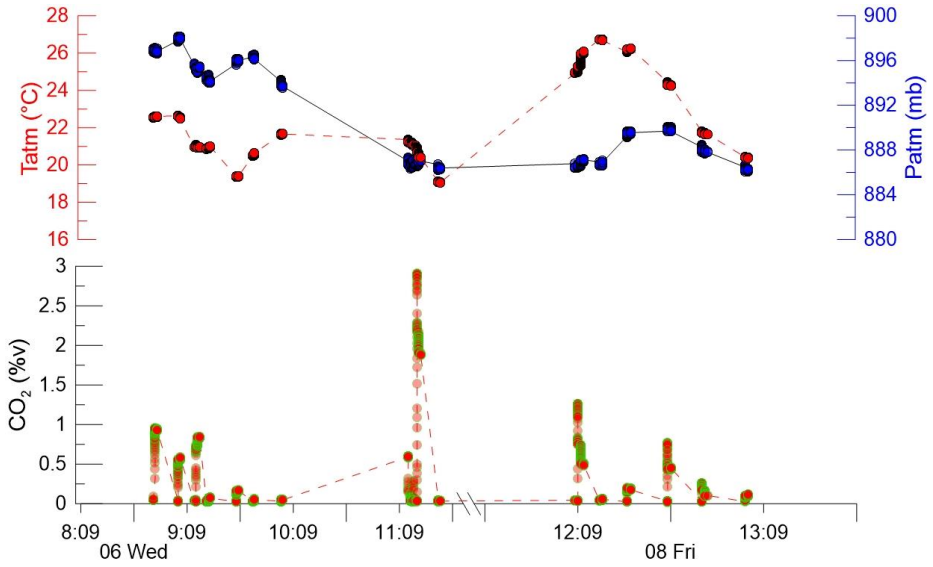

Fig. 4 : Soil CO_2 molar concentration, pressure and temperature, results from the survey at Cilaos (map in fig 1 B). The preliminary findings show that the Cilaos has a significant rate of CO_2 soil emission not affected by meteorological parameters.

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This preliminary data is in need of further and more careful interpretation. However, our data already clearly show that the impact from the last eruption on the atmosphere extends well beyond the immediate vicinity of the Piton de la Fournaise. Most noteworthy is that the connection between volcanic activity and its atmospheric impact can be tracked from an input originating from the deepest part of the volcano plumbing system to the dispersion into the atmosphere of one of the main pollutants (SO_2) released from the vent of the volcano in eruption. CO_2 emissions, however, were unfortunately not detected in concentrations above the atmospheric background at distal areas during the eruption period. Therefore, on this front, further investigations are needed in order to include within the existing framework the impact of carbon dioxide in the atmosphere from volcanic eruption at Piton de la Fournaise.

- **Outcome and future studies**

Outcomes from the present campaign of study include:

- *Soil CO_2 flux measurements*
- *SO_2 flux time series during the eruption period (14 July – 28 August 2017)*
- *Time series of SO_2 molar concentration in plume from proximal to distal area from the eruptive vent*
- *$\delta^{13}C$ isotopic signature of free gases from hydrothermal spring waters*
- *Helium isotopic ratio and concentration from free gases of hydrothermal spring waters*

Future studies will focus on the integration of the data collected and in the definition of an interpretative model for the volcanic gas emitted in the atmosphere during the last eruption of the Piton de la Fournaise volcano.

- **References**

Short list of references that are related to the topics and/or methods in this project:

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P.I. NICO project
Marco Liuzzo

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