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## Monthly Bulletin

Institut de physique du globe de Paris  
Observatoire volcanologique du Piton de la Fournaise

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March, 2024

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**PITON DE LA FOURNAISE** (VNUM #233020)

**Latitude:** 21.244°S

**Longitude:** 55.708°E

**Summit elevation:** 2632 m

*Piton de la Fournaise is a basaltic hot spot volcano located in the southeastern part of La Réunion Island (Indian Ocean).*

*The volcano first erupted about 500,000 years ago. Its volcanic activity is characterized by frequent effusive eruptions (with emissions of lava fountains and lava flows) that occur on average twice a year since 1998. More rarely, larger explosive eruptions (with blocks covering the summit area and ash emissions that can disperse over long distances) have happened in the past with a centennial recurrence rate.*

*Most of the current eruptive activity (97% during the last 300 years) occurs from vents inside the Enclos Fouqué caldera. A few eruptions, however, have occurred from vents outside the caldera (most recently in 1977, 1986, and 1998). Such eruptions can potentially threaten communities that live in the surrounding areas.*

*Since late 1979, the activity of Piton de la Fournaise is monitored by the Piton de la Fournaise Volcanological Observatory (Observatoire Volcanologique du Piton de la Fournaise - OVPF), which belongs to the Institut de Physique du Globe de Paris (IPGP).*

**Alert level: Vigilance**  
**(Since August 31, 2023)**

*(cf. table in the appendix)*



## A. Piton de la Fournaise activity

### Seismicity

In March 2024, the OVPF-IPGP recorded at Piton de La Fournaise:

- 179 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) below the summit craters;
- 1 deep earthquake (below sea level);
- 24 long-period earthquakes;
- 184 rockfalls.

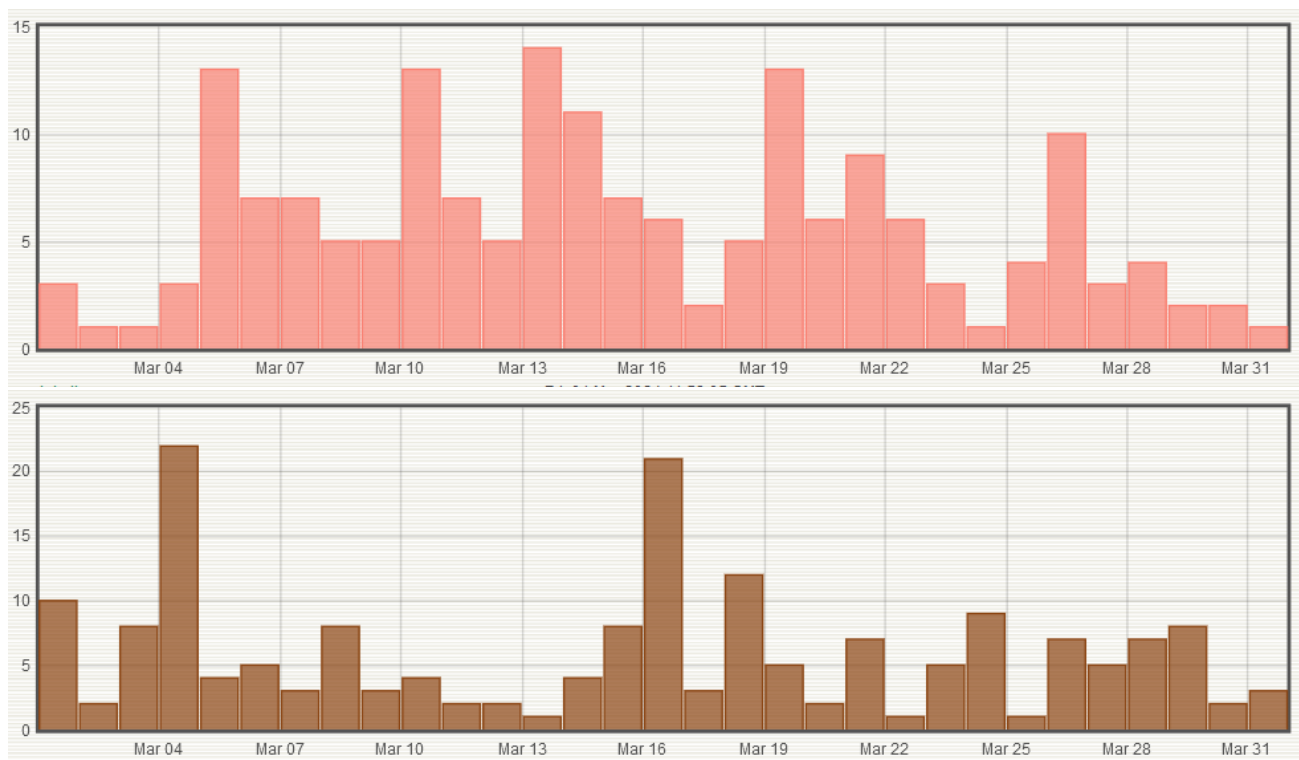


Figure 1: Number of (top) shallow volcano-tectonic earthquakes and (bottom) rockfalls per day recorded in March 2024 (© OVPF-IPGP).

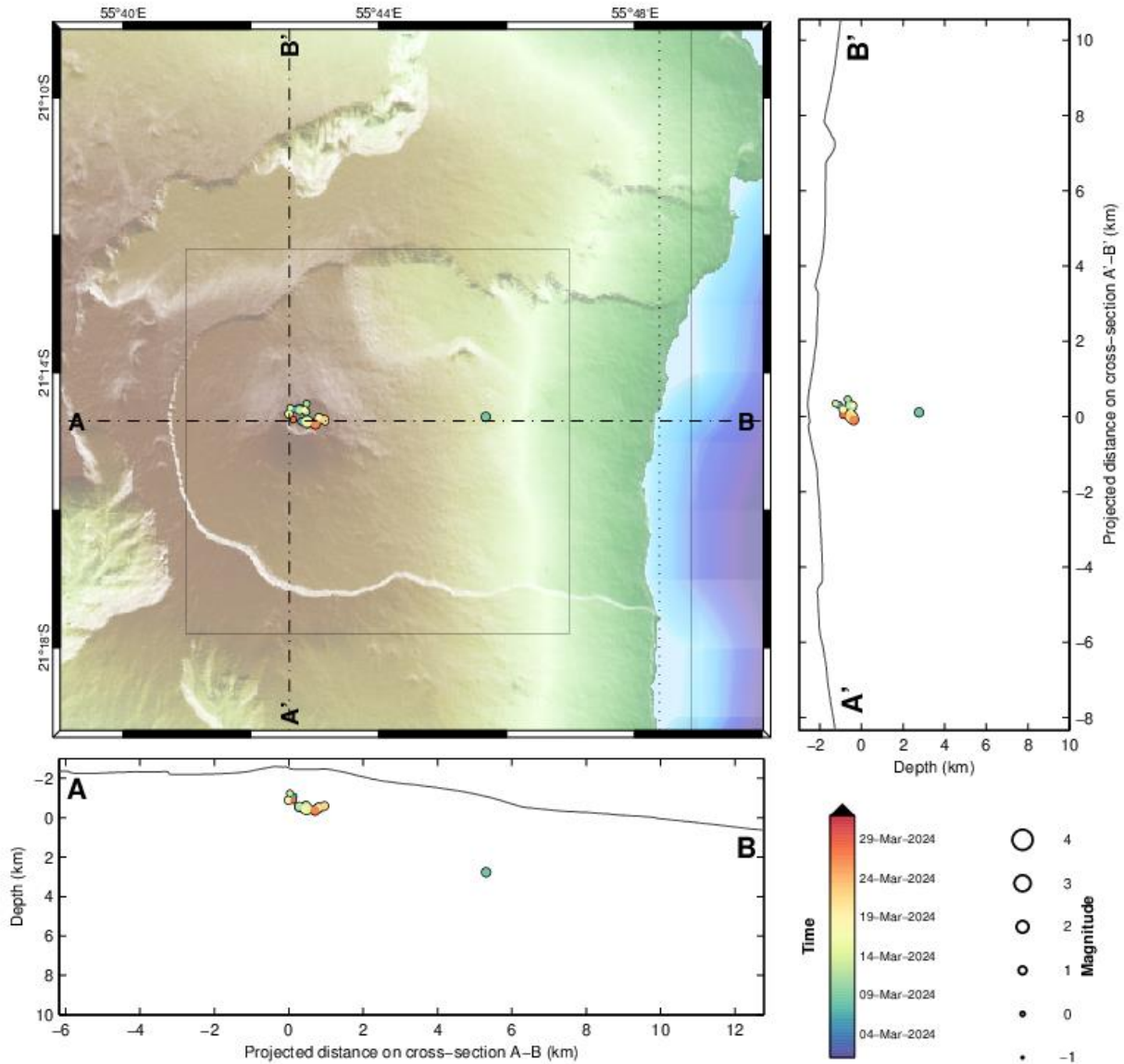
The seismic activity at Piton de la Fournaise in March 2024 was marked by an increase of the seismicity below the summit starting on March 5, from about 1 shallow volcano-tectonic earthquake per day at the beginning of the month to 5 per day in the middle of the month, and decreasing to 1 per day during the last 10 days (Figure 1).

Most of these low-magnitude earthquakes ( $M < 1$ ) could not be located, but 17 were located beneath the Dolomieu crater between -500 and 1200 m above sea level (Figure 2).

Numerous rockfalls (184) also occurred inside the *Dolomieu* crater, along the cliffs of the *Rivière de l'Est* and on the recent lava flows (Figure 1).



**PdF Enclos**  
© OVPF-IPGP, 2024



Filters: MAG ∈ [-1,6]; DEP ∈ [-3,30];

From: 01-Mar-2024 00:00  
To: 01-Apr-2024 00:00

Total events = 17  
Magnitude: min 0.2 – max 1.5  
Types:  
**Local (1),**

**Sommital (16),**

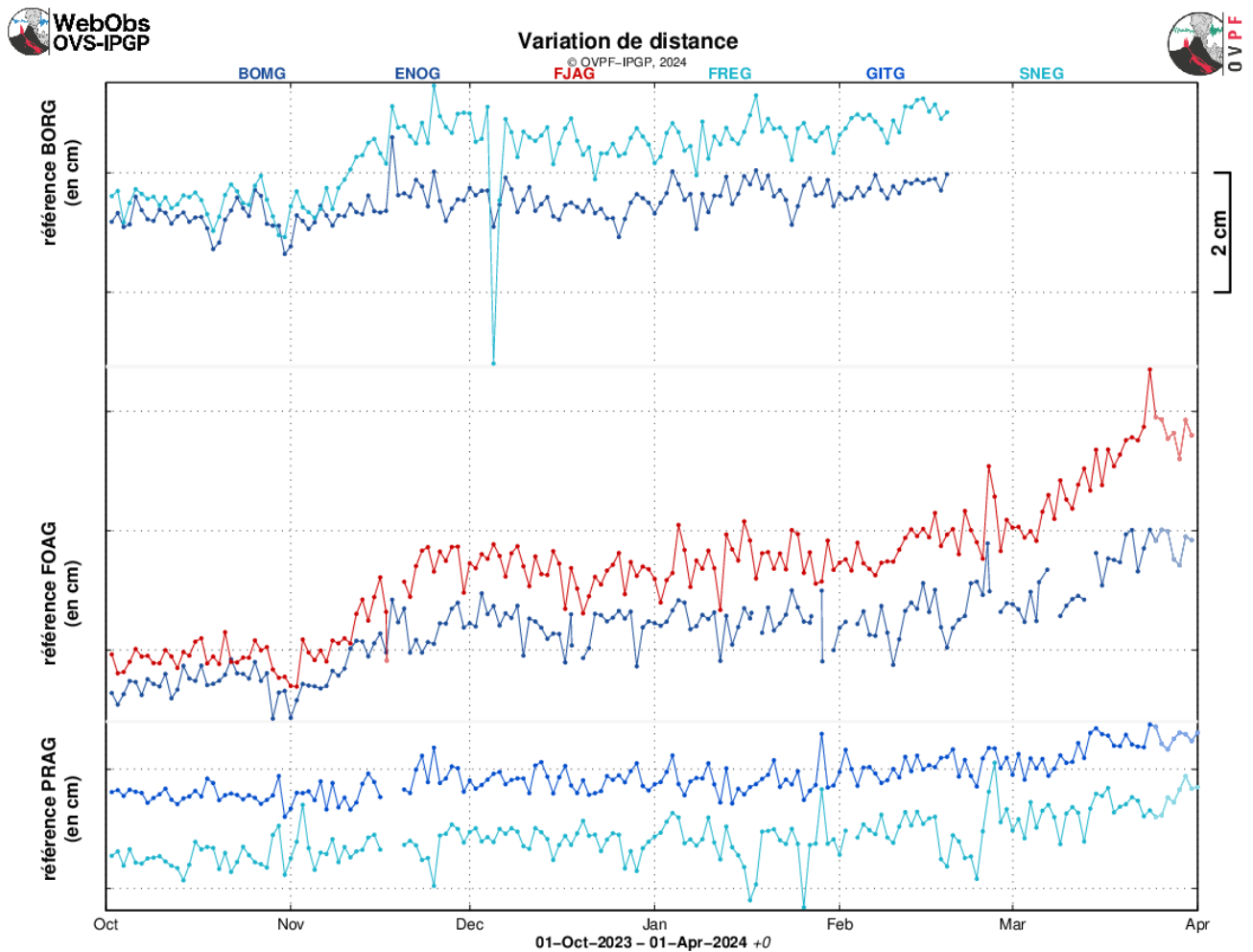
PROC.HYPO / Enclos - sysop@pitonidescaumets - 02-Apr-2024 05:57:07 +0 - hypomap.m (2023-02-14) / WebObs MMXXIV

Figure 2: Seismicity below Piton de la Fournaise in March 2024. Location map (epicenters) and north-south and east-west cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only manually located earthquakes are shown on the map (© OVPF-IPGP).



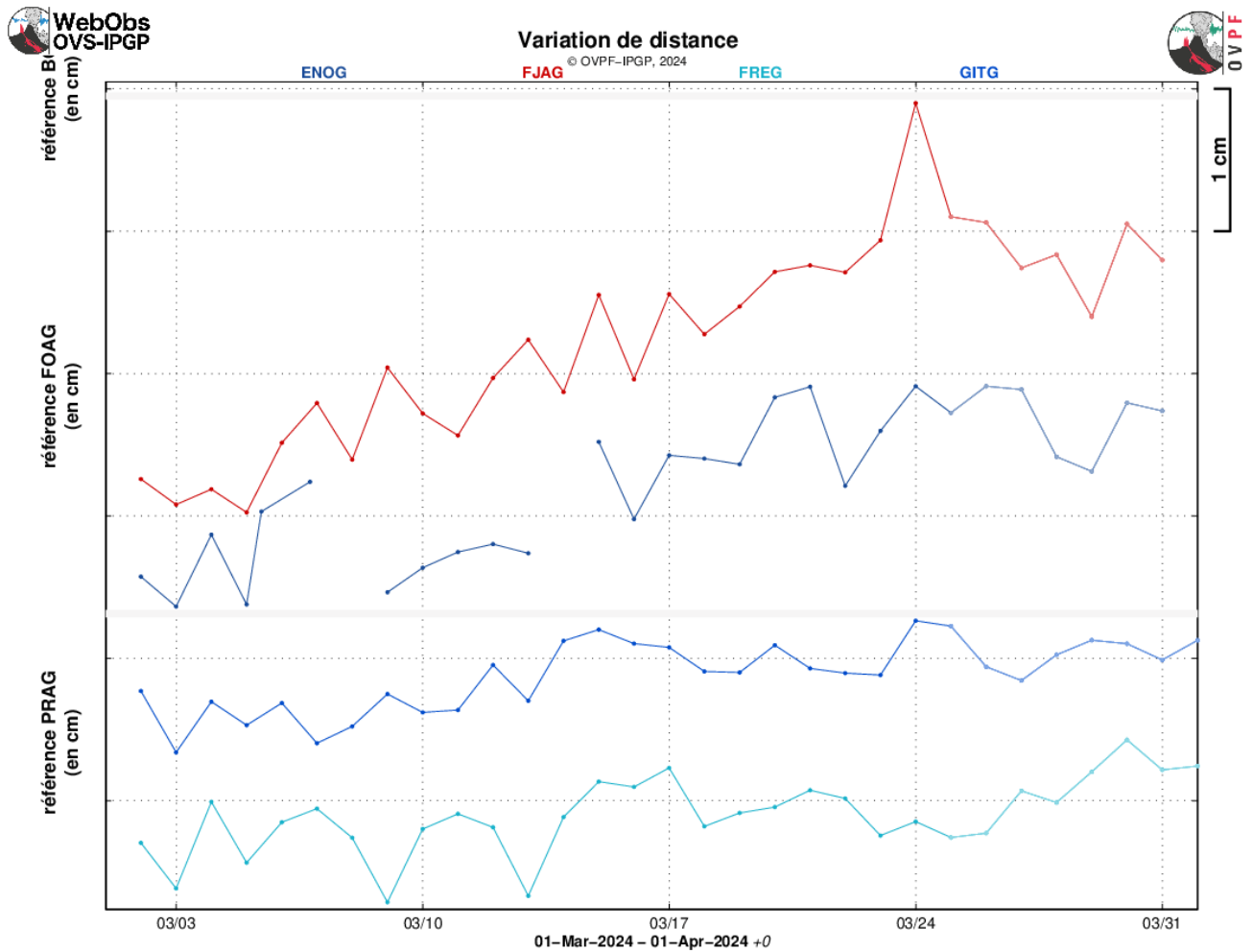
## Deformation

Summit inflation, which had been stopped at the end of November 2023, resumed in February 2024 (Figures 3 and 4). The slow inflation (the maximum elongation of the base of terminal cone was of about 2.5 cm in 1 month; Figure 4) is linked to the pressurization of the shallow magmatic reservoir located 1.5-2 km below the craters.



PROC.GIPSYX / BASELINES\_ - sysop@pifondescalumets - 02-Apr-2024 06:20:44 +0 - gnss.m(2022-10-19) / WebObs M0000V

Figure 3: Ground deformation records over the past six months (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: BORG; top graph), the terminal cone (reference: FOAG; middle graph) and the Enclos Fouqué caldera (reference: PRAG; bottom graph), from north to south (see location in Figure 5). Increasing distances (or baseline elongation) indicate volcano inflation, while decreasing distances (or baseline contraction) reflect edifice deflation. **Following the passage of cyclone Belal, 3 of the 5 GNSS stations located at the summit of the volcano are currently out of service, and a fourth one (BORG) has power failures** (© OVPF-IPGP).



PROC.GIPSYX / BASELINES\_ - sysop@pilotondescalumets - 02-Apr-2024 06:41:57 +0 - gnss.m (2022-10-19) / WebObs MMXXIV

Figure 4: Ground deformation records over the course of March 2024 (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the terminal cone (reference: FOAG; middle graph) and the Enclos Fouqué caldera (reference: PRAG; bottom graph), from north to south (see location in Figure 5). Increasing distances (or baseline elongation) indicate volcano inflation, while decreasing distances (or baseline contraction) reflect edifice deflation. **Following the passage of cyclone Belal, 3 of the 5 GNSS stations located at the summit of the volcano are currently out of service, and a fourth one (BORG) has power failures** (© OVPF-IPGP).

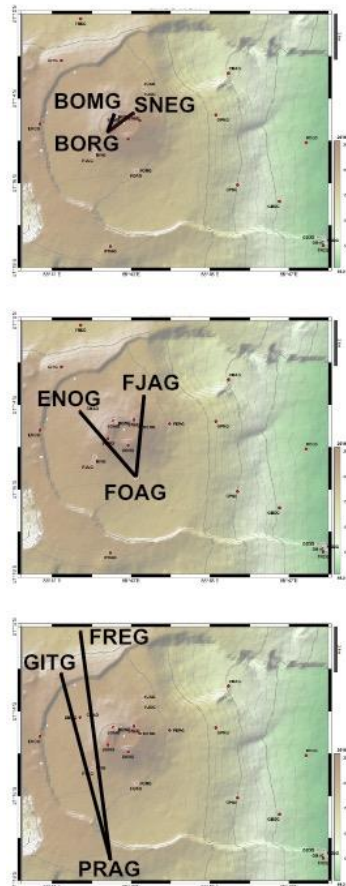


Figure 5: Location map of GPS stations and baselines as discussed in the text and shown in Figures 3 and 4 (© OVPF-IPGP).

\* Glossary: The summit GPS signals indicate the influence of a shallow pressure source below the volcano, while distant GPS signals indicate the influence of a deep pressure source below the volcano. Inflation usually means pressurization; and conversely deflation usually means depressurization.



## Gas geochemistry

### CO<sub>2</sub> concentration in the soil

In the proximal *Gîte du volcan* site, a sudden drop to very low CO<sub>2</sub> fluxes was detected after January 3, 2022. Since the end of the December 22 - January 17 eruption a new phase of increase was recorded, but with a lower rate.

The significant fluctuations observed during February 2022 are likely related to the environmental influence of two cyclonic events (Figure 6).

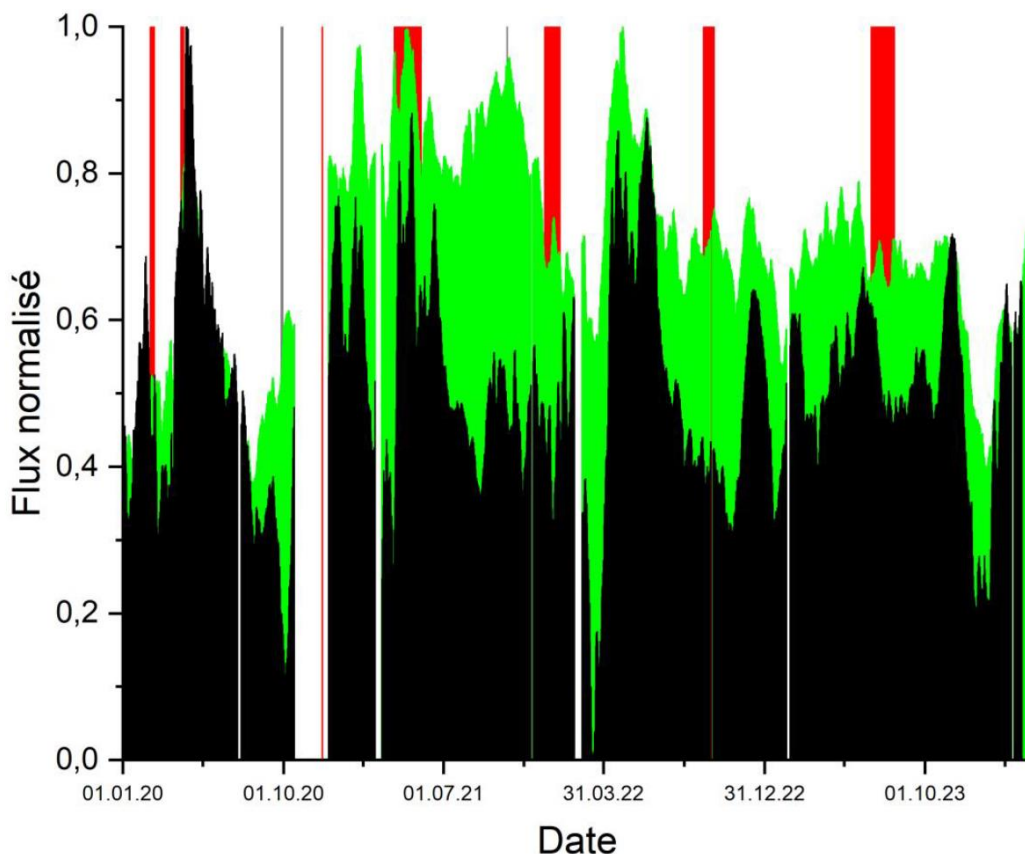


Figure 6: Comparison between the normalized average of corrected for short (OVPF-model; 15 days moving average; in green) and long-term influence of environmental parameters (INGV Malfit model; in black) soil CO<sub>2</sub> flux from all distal stations since October 2016 (last station set). Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

A new increase in soil CO<sub>2</sub> emissions was recorded in both distal (*Plaine des Cafres*, *Plaine des Palmistes*) and proximal (*Gîte du volcan*) stations at the end of February 2022 (Figure 6), with a strong acceleration from March 15. The new phase of increase in CO<sub>2</sub> soil emissions has lasted till May 05 in the distal area and till May 19, 2022 in the proximal area.

Since mid-May 2022, a trend of decrease in CO<sub>2</sub> gas fluxes is recorded in both proximal and distal sites. The September 19, 2022 eruption occurred after a significant decrease in CO<sub>2</sub> fluxes, likely recording the progressive transfer of magma to shallow crustal levels. Since the end of the September 19 – October 5, 2022 eruption CO<sub>2</sub> fluxes have remained on a stable level.



Interestingly, isotopic analysis of gas sampled at both distal (PNRN, BLEN, PCNR) and proximal (P0; GITN) sites shows a marked increase in the magmatic contribution in the March-April 2022 period (Figure 7). The magmatic contribution has then decreased in the second half of 2022.

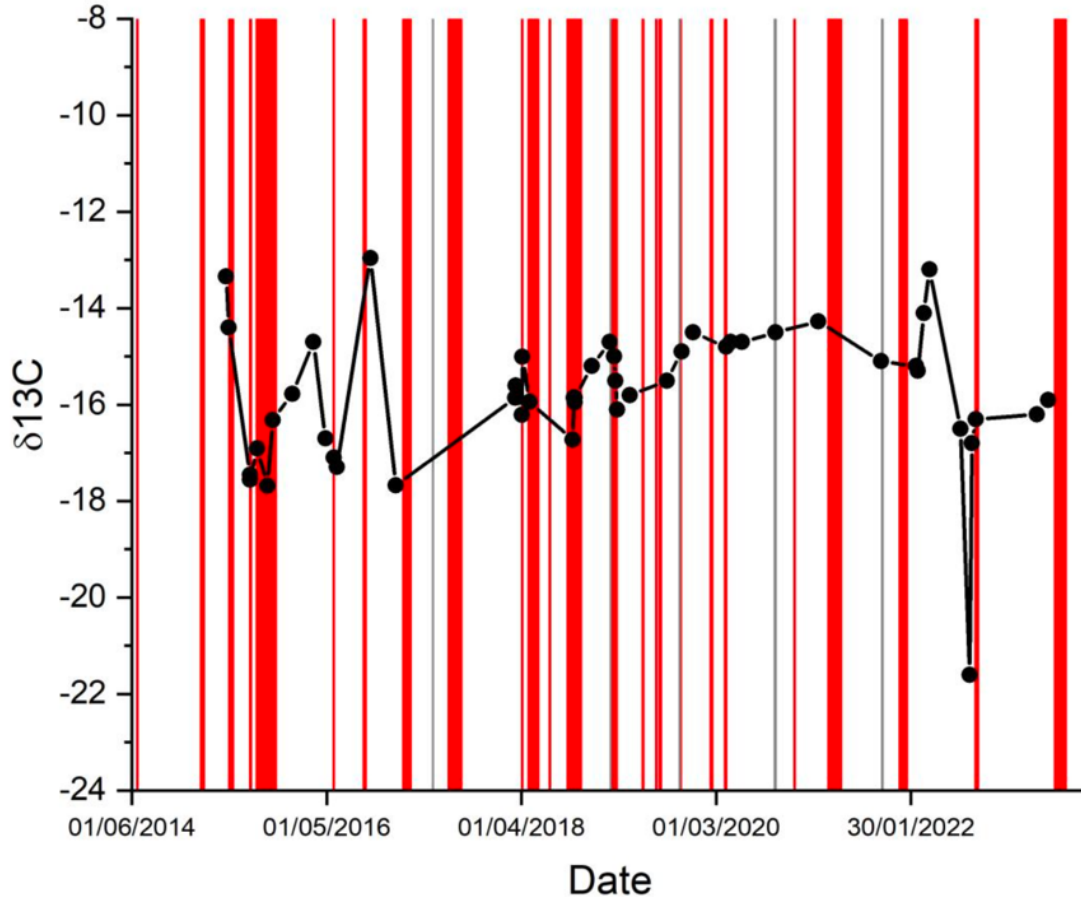


Figure 7: Carbon isotope ( $\delta^{13}C$ ) variations in  $CO_2$  from soil gas emitted from the control point with the highest flux in the proximal area (control point: GITO).

A continuous decrease in the  $CO_2$  emission rate in both the distal and the proximal stations was measured from mid-June 2023, possibly heralding a progressive transfer of magma to shallow depth.  $CO_2$  fluxes, stable at the end of the July – August, 2023 eruption, decreased continuously till October.

Starting from mid-October, a new trend of increase was measured in both distal and proximal stations. This pulse stops in mid-November 2023 and a continuous decrease is measured until end December. Then values remain stable to low levels.

Following the cyclonic event of January 15, a rapid increase is observed since January 19 in both proximal and distal locations. This increase is confirmed in March and attains unusually high values in the proximal GITN site.

\* Glossary:  $CO_2$  is the first gas to be released from deep magma (rising from the mantle), so its detection in the far field often means a deep rise of magma. Its near-field evolution may be related to magmatic transfer in the shallowest part of the feeding system (< 2-4 km below the surface).





#### Summit fumaroles composition obtained by the MultiGas method

- Awaiting replacement of the current station by a new one.

*\* Glossary: The MultiGaS method allows measuring the concentrations of H<sub>2</sub>O, H<sub>2</sub>S, SO<sub>2</sub> and CO<sub>2</sub> in the atmosphere at the summit of the Piton de la Fournaise volcano. Magmatic transfer in the Piton de la Fournaise feeding system can result in an increase in SO<sub>2</sub> concentrations and in the C/S ratio (carbon/sulfur).*

#### SO<sub>2</sub> flux in the air obtained by DOAS method

The SO<sub>2</sub> fluxes in the air were low; close or below the detection threshold.

*\* Glossary: During rest periods, SO<sub>2</sub> flux at Piton de la Fournaise is below the detection threshold. The SO<sub>2</sub> flux may increase during magma transfer in the shallowest part of the feeding system. During eruptions, it is directly proportional to the amount of lava emitted at the surface.*

## Phenomenology

No eruptive activity reported in March 2024.

## Summary

The increase in seismicity in March 2024 follows a renew of the edifice inflation since the second half of February 2024. This inflation - the source of which is centered beneath the summit - is linked to the pressurization of the shallow reservoir, located at a depth of around 1.5-2 km beneath the Dolomieu crater.

The increase of seismicity at the top of the reservoir shows that this pressurization process is intensifying, even if the number of earthquakes decreased in the end of the month, and the magnitudes remained moderate.

This process of pressurization of the shallow reservoir can last several days to several weeks before the reservoir roof weakens and breaks, leading to magma injection towards the surface and an eruption, but it can also stop without leading - in the short term - to an eruption.



## B. Seismic activity on La Réunion and in the Indian Ocean basin

### Local and regional seismicity

In March 2024, the OVPF-IPGP recorded:

- 86 local earthquakes (below the island, within a radius of 200 km around the island, Figures 8 and 9);
- 1 regional earthquake (in the Indian Ocean basin).

In March 2024, the OVPF-IPGP recorded 86 local earthquakes below the La Réunion island, and mainly the *Roche Ecrite* area (Figure 9).

These earthquakes were located between 10 km and 25 km depth in oceanic lithosphere on which was built the volcanic edifice at the origin of La Réunion island.

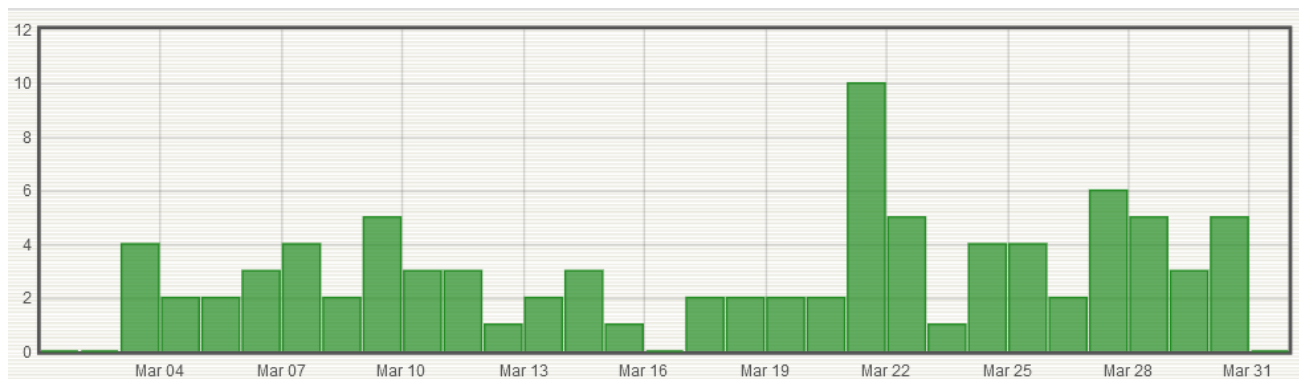
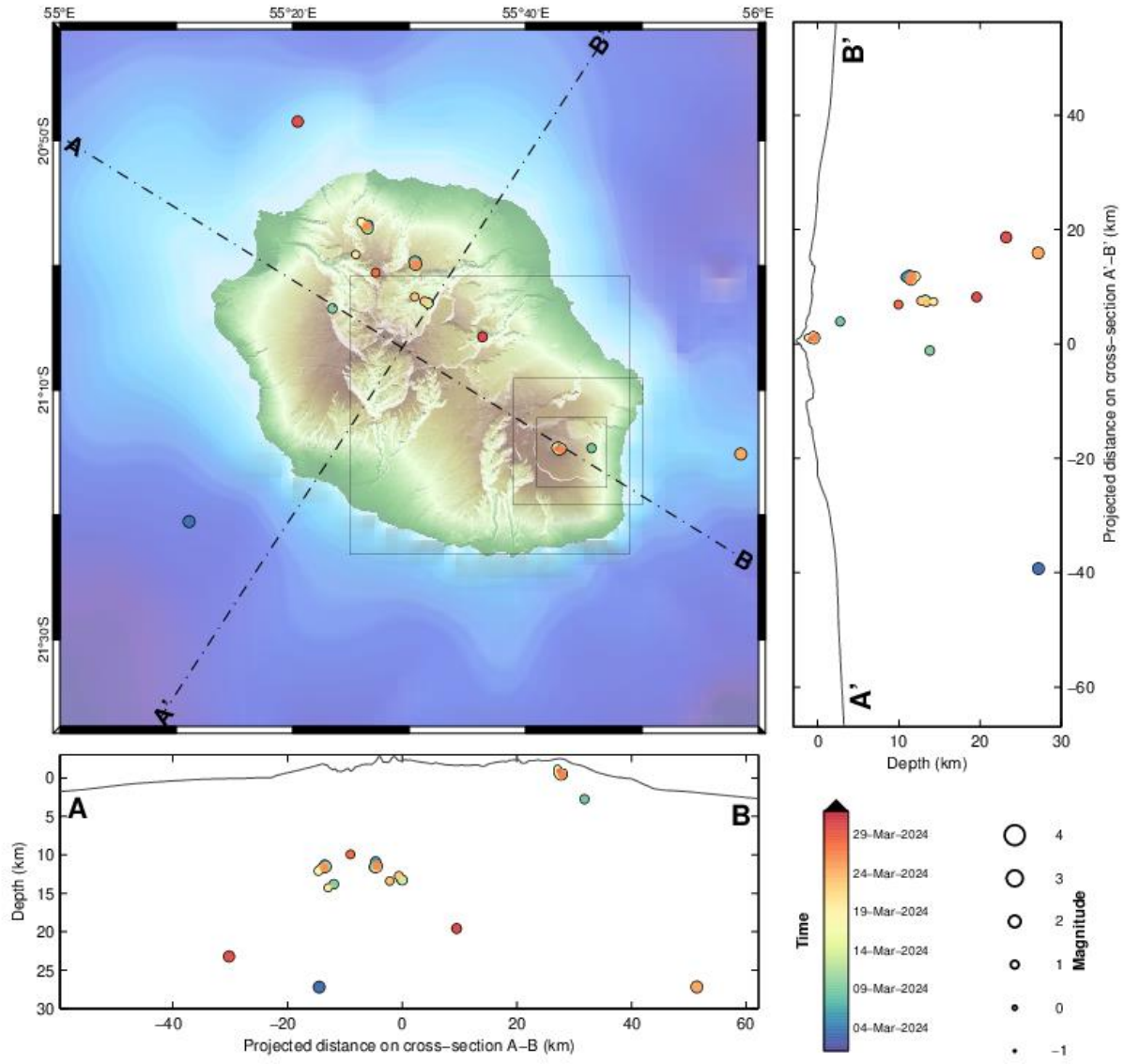


Figure 8: Number of local earthquakes (La Réunion island) per day recorded in March 2024 (© OVPF-IPGP).



La Réunion  
© OVPF-IPGP, 2024



Filters: MAG ∈ [-1,6]; DEP ∈ [-3,30];

From: 01-Mar-2024 00:00  
To: 01-Apr-2024 00:00

Total events = 38  
Magnitude: min 0.2 – max 1.6

Types:  
Local (22),

Sommital (16),

PROCHYPO / Réunion - sysop@pitonDESCALUMETS - 02-Apr-2024 05:57:07 +0 - hypomap.m (2023-02-14) / WebObs MIMXXIV

Figure 9: Seismicity below La Réunion in March 2024. Location map (epicenters) and north-west – south-east and south-west – north-east cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only localizable earthquakes are shown on the map (© OVPF-IPGP).



## Seismic-volcano activity in Mayotte

The « REseau de surveillance VOlcanologique et Sismologique de MAyotte (REVOSIMA) » is the structure in charge of the volcano and seismic monitoring of Mayotte. IPGP operates this network through the Piton de la Fournaise Volcanological Observatory in La Réunion with the support of the BRGM regional office in Mayotte. REVOSIMA is supported by a scientific and technical partnership. The REVOSIMA consortium: IPGP and Université Paris Cité, BRGM, IFREMER, CNRS, BCSF-RéNaSS, ITES and Université de Strasbourg, IGN, ENS, SHOM, TAAF, Météo France, CNES, Université Grenoble Alpes and ISTerre, Université Clermont Auvergne, LMV and OPGC, Université de La Réunion, Université Paul Sabatier, Toulouse and GET-OMP, Université de la Rochelle, Université de Bretagne Occidentale, IRD and collaborators.

All information on the REVOSIMA and the activity in Mayotte can be found on the dedicated webpages:

- <https://www.ipgp.fr/observation/infrastructures-nationales-hebergees/revosima/>
- <https://www.ipgp.fr/actualites-du-revosima/>
- <https://www.facebook.com/ReseauVolcanoSismoMayotte/>

April, 2 2024  
OVPF-IPGP Director



## C. Appendix

### Definition of Volcanic Alert Levels for Piton de la Fournaise

from *disposition spécifique « Volcan Piton de la Fournaise » - arrêté n°2242*- Emergency plan set up by the department responsible for the protection of the population in the event of unrest or activity of the Piton de la Fournaise

• **“Vigilance”**: possible eruption in medium term (a few days or weeks) **or** presence of risks on the sector (rockfalls, increase of gas emissions, still hot lava flows...).

Access to the Enclos Fouqué caldera and to the summit volcano are allowed with restrictions.

• **“Alert 1”**: probable or imminent.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited.

• **“Alert 2”**: ongoing eruption.

Alert 2-1: ongoing eruption inside the Enclos Fouqué caldera without threat to the safety of people, property or the environment.

Alert 2-2: ongoing eruption inside the Enclos Fouqué caldera with direct or indirect threat to the safety of people, property or the environment.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited. For Alert 2-2, evacuation of the people and vehicles depending on the issues.

• **“Alert 2-3”**: ongoing eruption outside the Enclos Fouqué caldera with threat to the safety of people, property or the environment.

Access to the Enclos Fouqué caldera and to the summit are closed and prohibited. Evacuation of the people and vehicles depending on the issues.

• **“Sauvegarde”**: end of eruption.

Evaluation of a partial reopening of the Enclos Fouqué caldera access.



## Monthly Bulletin - March, 2024

Observatoire volcanologique du Piton de la Fournaise - IPGP

### Acknowledgments

Thank you to organizations, communities and associations for publicly posting this report for the widest dissemination

### Information

All information on the Piton de la Fournaise activity can be found on the OVPF-IPGP media:

- Internet website : [ipgp.fr/fr/ovpf/actualites-ovpf](http://ipgp.fr/fr/ovpf/actualites-ovpf)
- Twitter : [twitter.com/obsfournaise](https://twitter.com/obsfournaise)
- Facebook : [facebook.com/ObsVolcanoPitonFournaise](https://facebook.com/ObsVolcanoPitonFournaise)

A preliminary automatic daily bulletin of the OVPF-IPGP, relating to the activities of the day before, validated by an analyst, is published daily. It can be accessed directly at this link:

[http://volcano.ipgp.fr/reunion/Bulletin\\_quotidien/bulletin.html](http://volcano.ipgp.fr/reunion/Bulletin_quotidien/bulletin.html)

The seismicity validated in continuous by OVPF-IPGP can also be followed on the RENASS portal: <https://renass.unis-tra.fr/fr/zones/la-reunion>

***The information in this document may not be used without explicit reference.***