

Monthly Bulletin

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

ISSN 2610 – 5101

January, 2024

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)



Avant-propos

The observatory and its monitoring network were particularly affected by the Belal cyclone on January 15, 2024 (red alert from January 14 8pm to January 16 midday, including a purple alert on January 15 from 6am to 1pm).

During the cyclone's passage over the volcano, the OVPF-IPGP lost contact with a large part of its network.

By midday on January 16, the following stations were out of service or inaccessible:

- 70% of seismic stations on the volcano,
- 50% of GNSS stations,
- 78% of inclinometer stations,
- 33% of extensometer stations,
- 50% of geochemistry stations,
- 55% of webcams.

Despite the “deteriorated mode”, the OVPF-IPGP managed to maintain minimal operational monitoring of the volcanic activity throughout the cyclone.

Part of the data passing through the *Piton des Cascades* relay was no longer transmitted during the cyclone, due to a 4G network failure. On January 17, when the phone relay near *Piton des Cascades* was restored, data were again transmitted to the observatory.

On January 18, an OVPF-IPGP team carried out a helicopter survey to the Enclos. The mission revealed the cyclone's strong impact on the OVPF stations, particularly those installed at the summit and around the edges of the Enclos caldera (i.e. the areas exposed to the strongest winds). The following were observed:

- total destruction of a GNSS monitoring station (DERG) located on the eastern side of the summit zone (Figure A1),
- total destruction of a GNSS monitoring and meteorological station (DSRG) located in the southern part of the summit zone (Figure A2),
- the destruction of an infrastructure and a camera at the SFRC station located in the northern part of the summit zone (Figure A3),
- the loss of a rain gauge at station SFRI (below Soufrière),
- a door torn off at the BOR station hut (near the Bory crater),
- a door ripped off a cabinet at the BERN station, leading to the loss of a NOVAC SO₂ monitoring station.



Figure A1: DERG station (Dolomieu est) washed away and destroyed by cyclone Belal (photo January 18, 2024).



Figure A2: DSRG station (Dolomieu sud) washed away and destroyed by cyclone Belal (photo January 18, 2024).

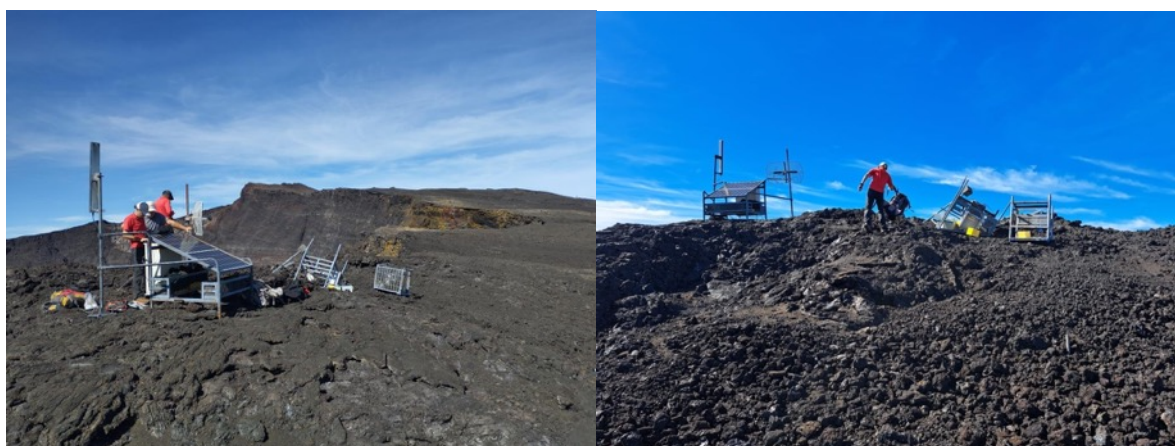


Figure A3: Soufrière station, where one of the structures and the camera were overturned and destroyed by cyclone Belal (photo January 18, 2024).

On stations that were spared by the effects of the cyclone, many antennas had to be redirected in order to re-establish the contact with the observatory; as well as some cameras. Following numerous field interventions and repairs by the OVPF-IPGP teams and the re-establishment of 4G networks by phone operators, at the end of January 2024, some stations are still out of service or inaccessible:

- 7% of seismic stations,
- 16% of GNSS stations,
- 66% of inclinometer stations,
- 33% of extensometer stations,
- 13% of geochemistry stations,
- 22% webcams.



A. Piton de la Fournaise activity

Seismicity

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

- 4 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) below the summit craters;
- 2 deep earthquakes (below sea level);
- 0 long-period earthquake;
- 358 rockfalls.

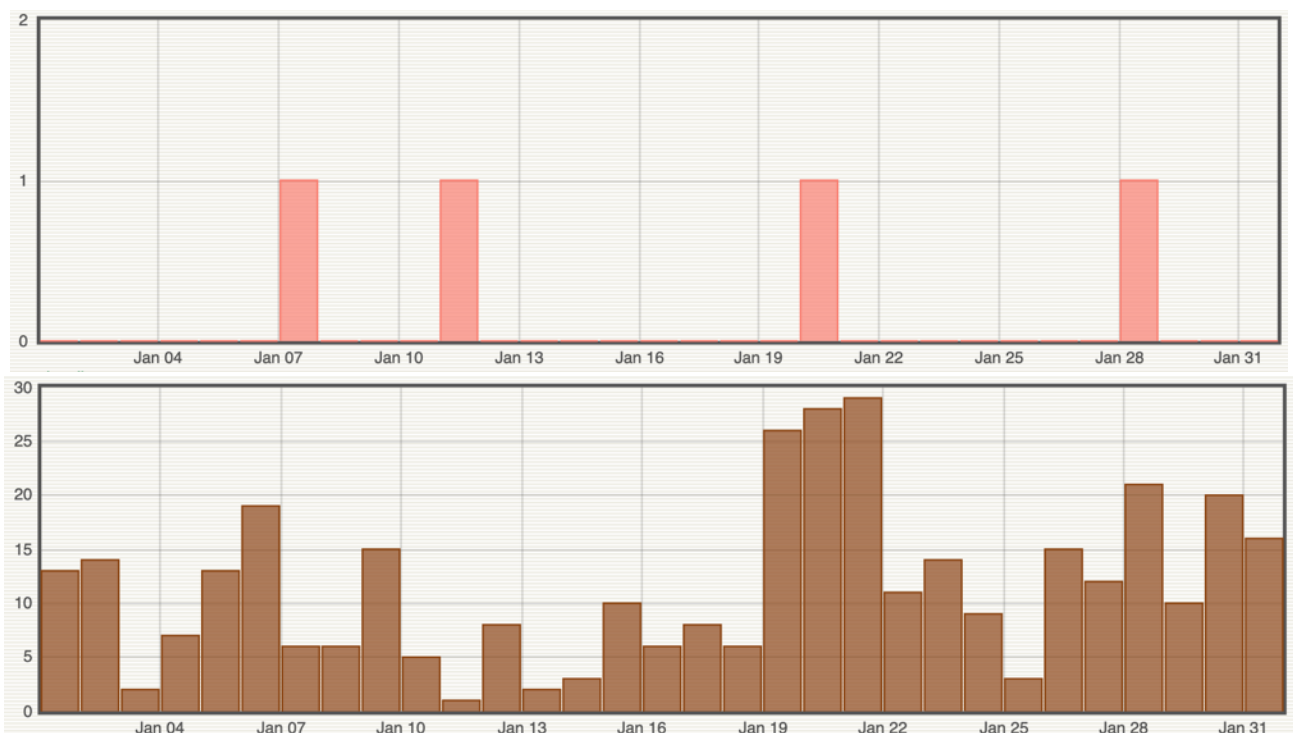


Figure 1: Number of (top) shallow volcano-tectonic earthquakes and (bottom) rockfalls per day recorded in January 2024 (© OVPF-IPGP).

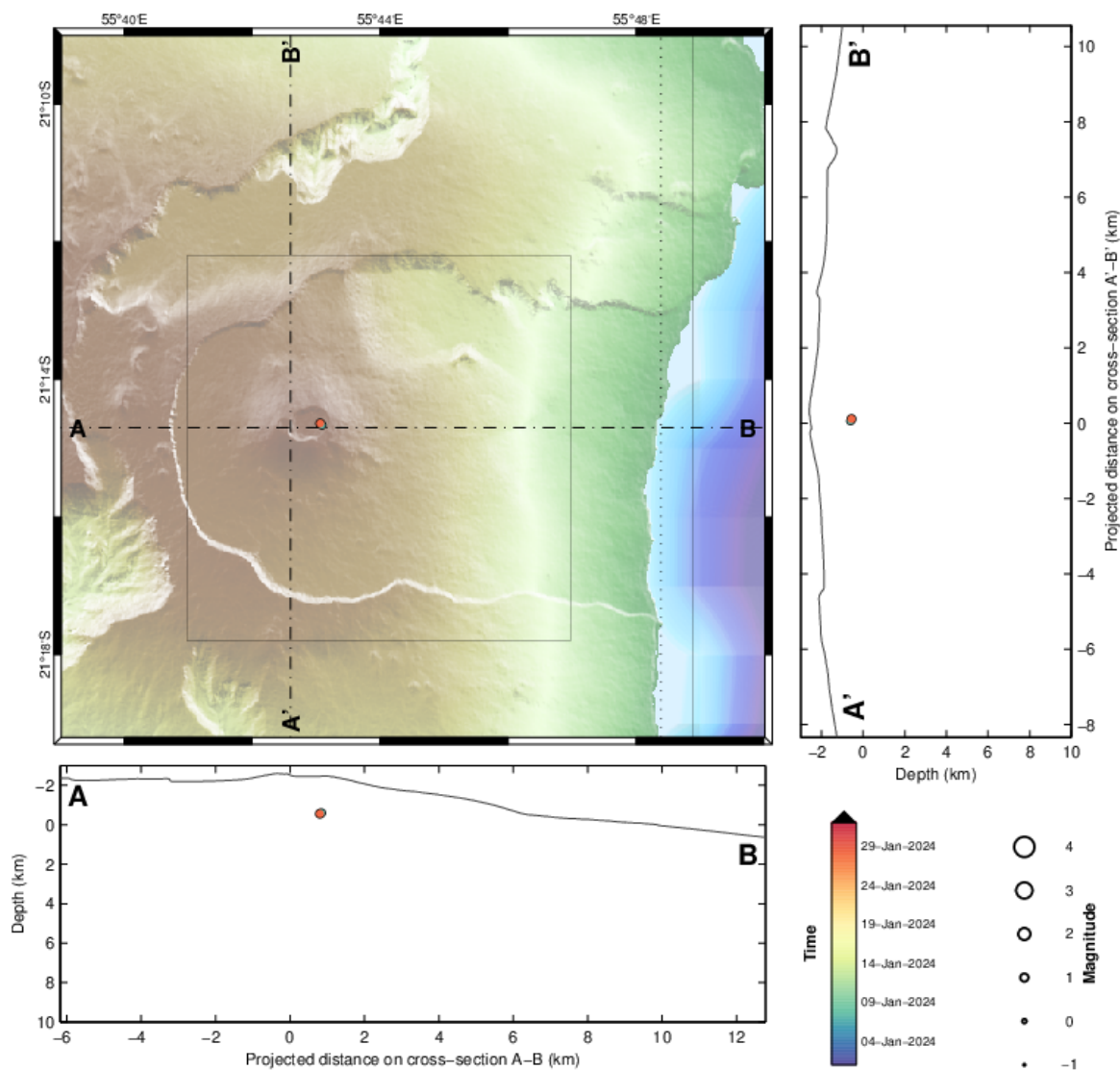
The seismic activity at Piton de la Fournaise in January 2024 was low, with only 4 shallow volcano-tectonic earthquakes (Figure 1) and 2 deep earthquakes recorded.

Only two volcano-tectonic earthquakes could be located, below the eastern part of the Dolomieu crater (Figure 2). The other volcano-tectonic earthquakes - of lesser magnitude - could not be located.

Numerous rockfalls (358) also occurred inside the *Dolomieu* crater, along the cliffs of the *Rivière de l'Est* and on the recent lava flows, particularly following the heavy rains on the volcano area in the last fortnight of January (Figure 1).



PdF Enclos
© OVPF-IPGP, 2024



Filters: MAG $\in [-1,6]$; DEP $\in [-3,30]$;

From: 01-Jan-2024 00:00
To: 01-Feb-2024 00:00

Total events = 2
Magnitude: min 0.6 – max 0.8
Types:
Sommital (2),

PROC.HYPO / Enclos - sysop@pitondescalumets - 01-Feb-2024 05:12:38 +0 - hypomap.m (2023-02-14) / WebObs MMXXIV

Figure 2: Seismicity below Piton de la Fournaise in January 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

In November 2023, a resumption of summit inflation was recorded (Figures 3 and 4). This inflation stopped at the end of November and a slight summit deflation was recorded until end of 2023.
In January 2024, no significant deformation was recorded.

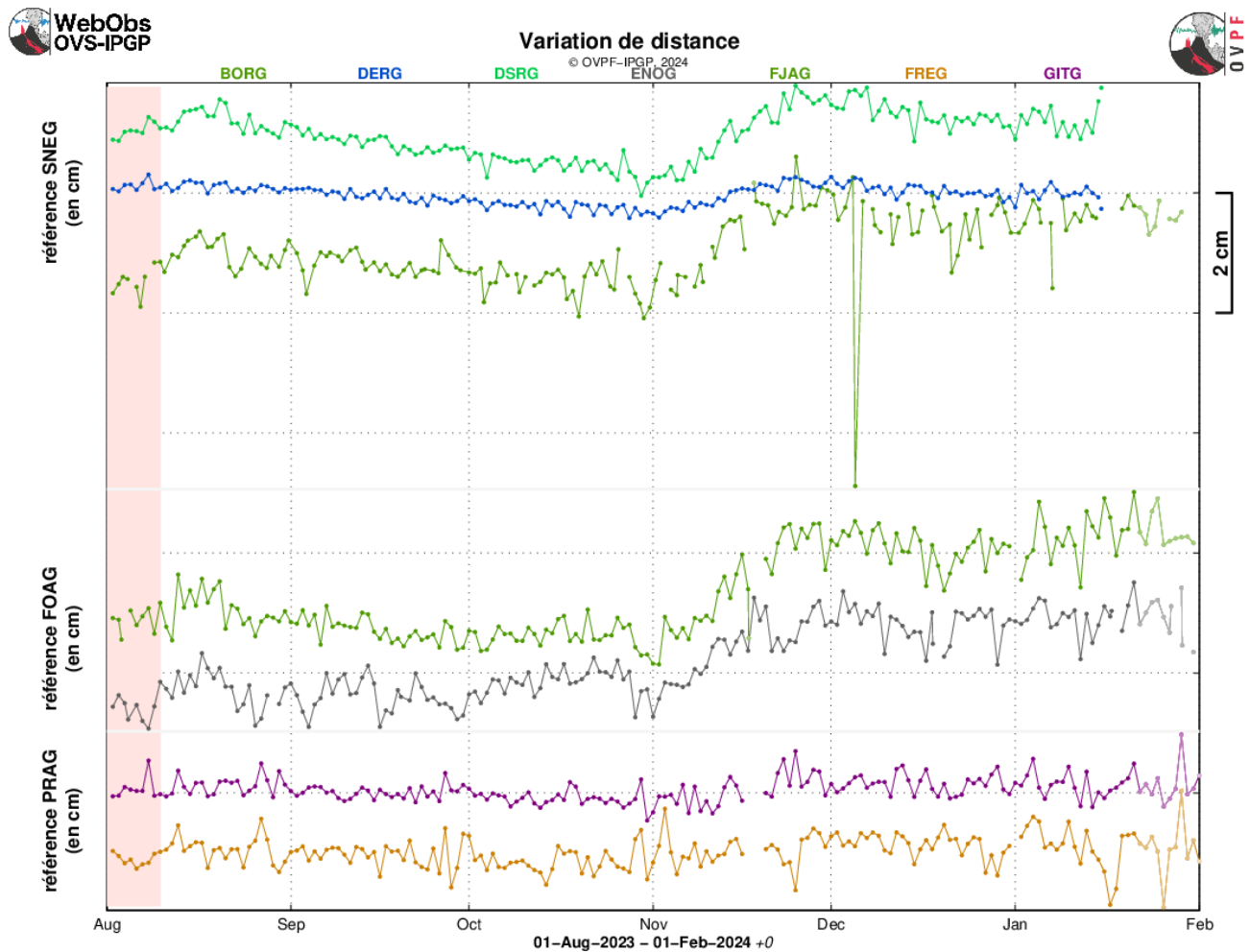


Figure 3: Ground deformation records over the past six months (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: SNEG; 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.** (© OVPF-IPGP).

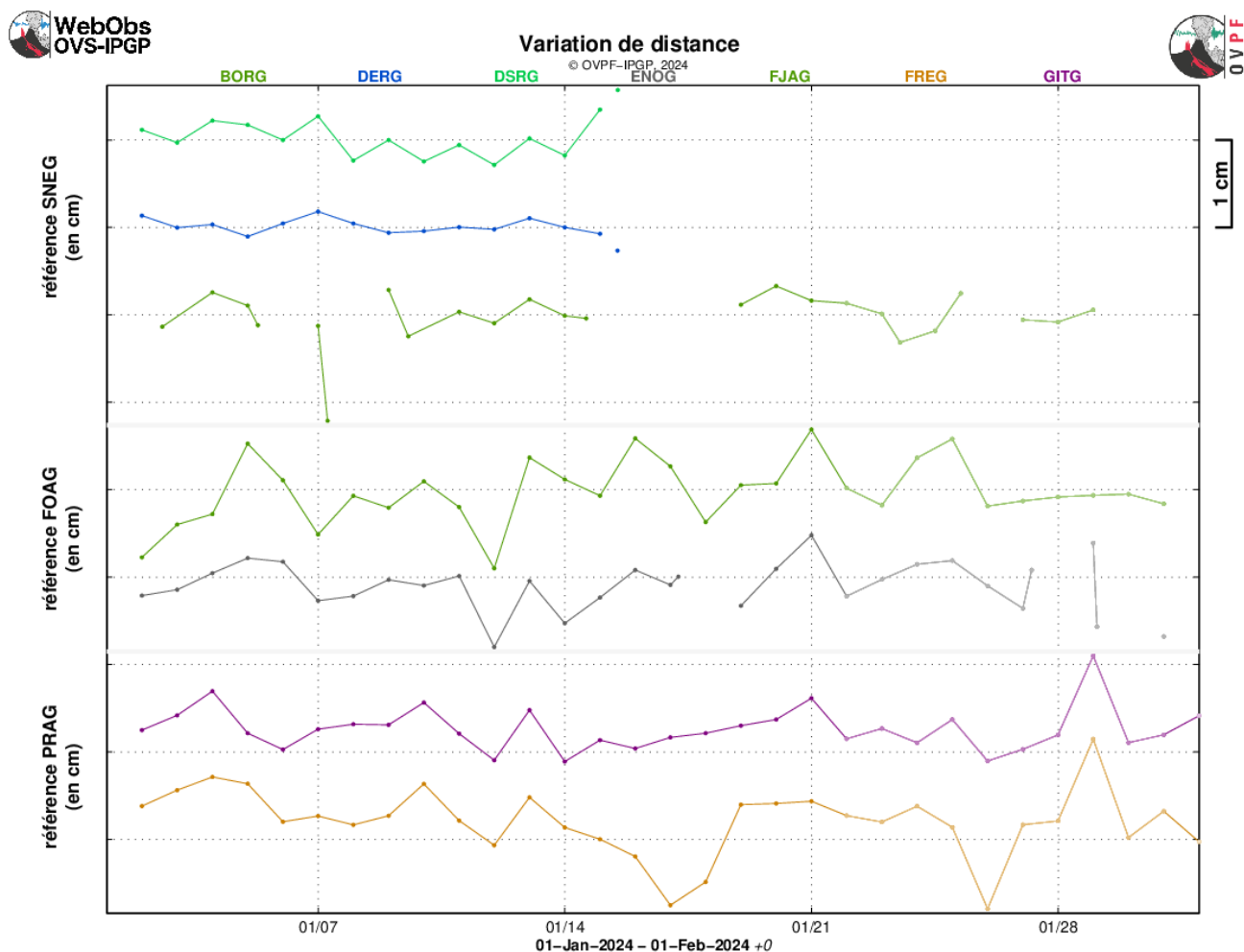


Figure 4: Ground deformation records over the course of January 2024 (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: SNEG; 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.** (© OVPF-IPGP).

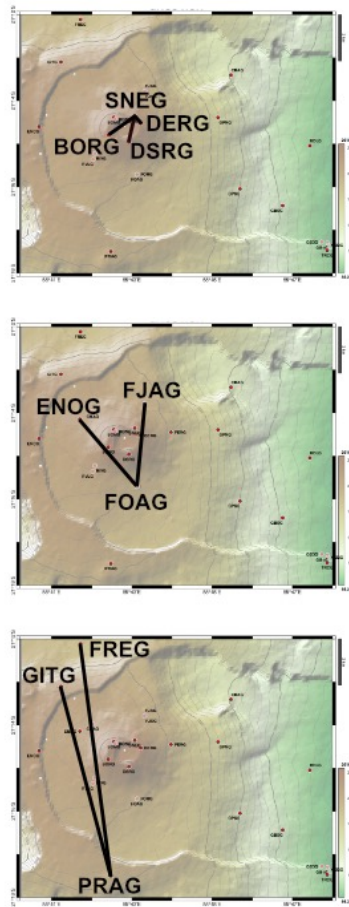


Figure 5: Location map of GPS stations and baselines as discussed in the text and shown in Figures 3 and 4 (© OVPF-IPGP).

* 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

CO₂ concentration in the soil

In the proximal *Gîte du volcan* site, a sudden drop to very low CO₂ 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).

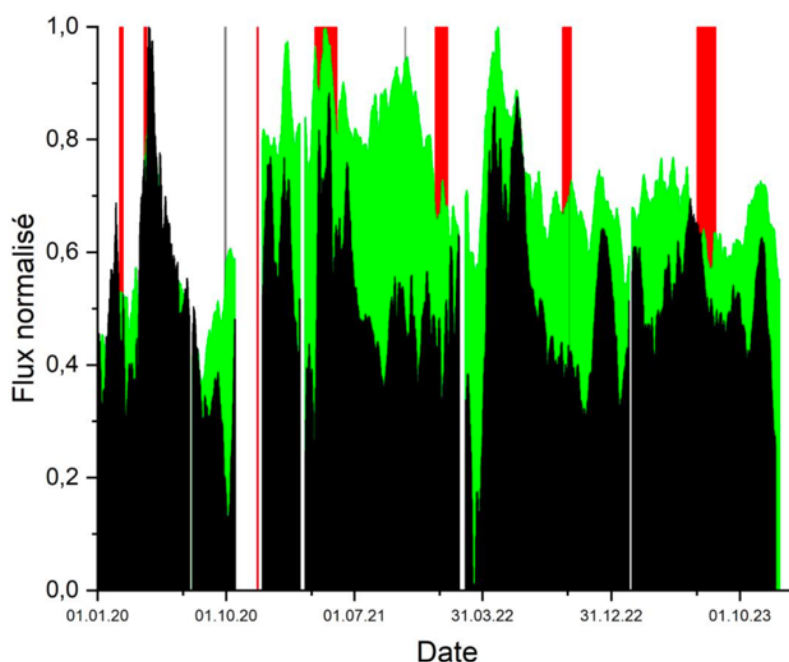


Figure 6: Comparison between the normalized average of corrected for short (OVPF-model; 15 days moving average; in green) and long-term influence of environmental parameters (INGV Malfit model; in black) soil CO₂ flux from all distal stations since October 2016 (last station set). Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

A new increase in soil CO₂ 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 CO₂ 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 CO₂ gas fluxes is recorded in both proximal and distal sites. The September 19, 2022 eruption occurred after a significant decrease in CO₂ fluxes, likely recording the progressive transfer of magma to shallow crustal levels. Since the end of the September 19 – October 5, 2022 eruption CO₂ 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.

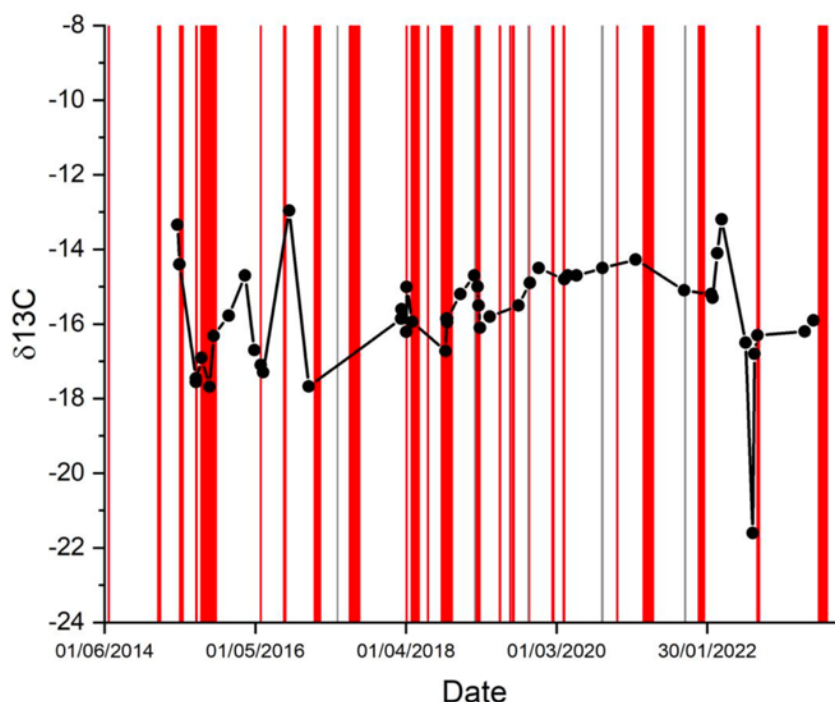


Figure 7: Carbon isotope ($\delta^{13}\text{C}$) variations in CO_2 from soil gas emitted from the control point with the highest flux in the proximal area (control point: GIT0).

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 stopped in mid-November and a continuous decrease is measured since then.

* 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_2O , H_2S , SO_2 and CO_2 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_2 concentrations and in the C/S ratio (carbon/sulfur).



SO₂ flux in the air obtained by DOAS method

The SO₂ fluxes in the air were low; close or below the detection threshold.

** Glossary: During rest periods, SO₂ flux at Piton de la Fournaise is below the detection threshold. The SO₂ 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 January 2024.

Summary

Since December 2023, magma recharge and pressurization of the shallow magma reservoir stopped.
In January 2024, seismicity remained low with only 4 volcano-tectonic earthquakes recorded below the summit craters.

Note that since 2016, magma recharge of the shallow magma reservoir below Piton de la Fournaise is discontinuous and occurs in pulses. For example, several periods ranging from 15 to ~80 days that were characterized by no deformation and low seismic activity have been observed several times between 2016 and 2023.



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

Local and regional seismicity

In January 2024, the OVPF-IPGP recorded:

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

In January 2024, the OVPF-IPGP recorded 34 local earthquakes below the La Réunion island, and mainly near *Roche Ecrite* (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.

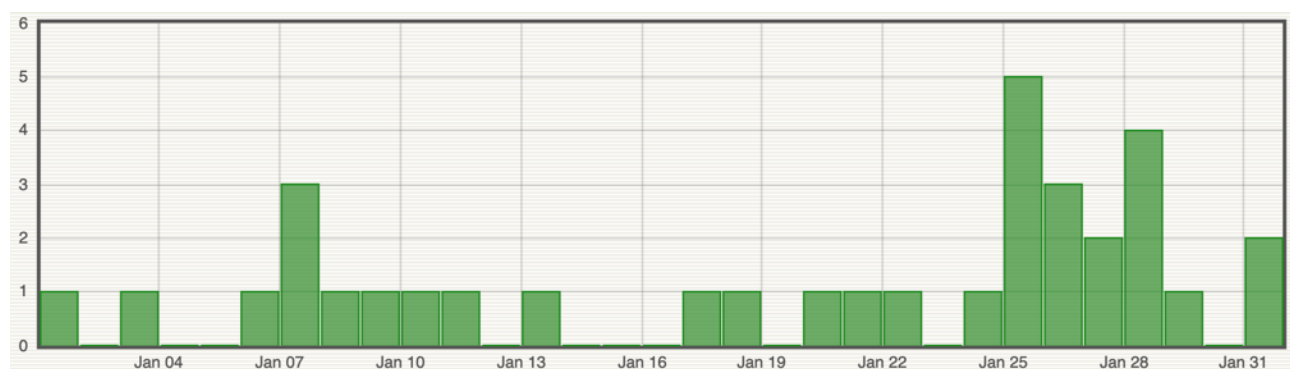
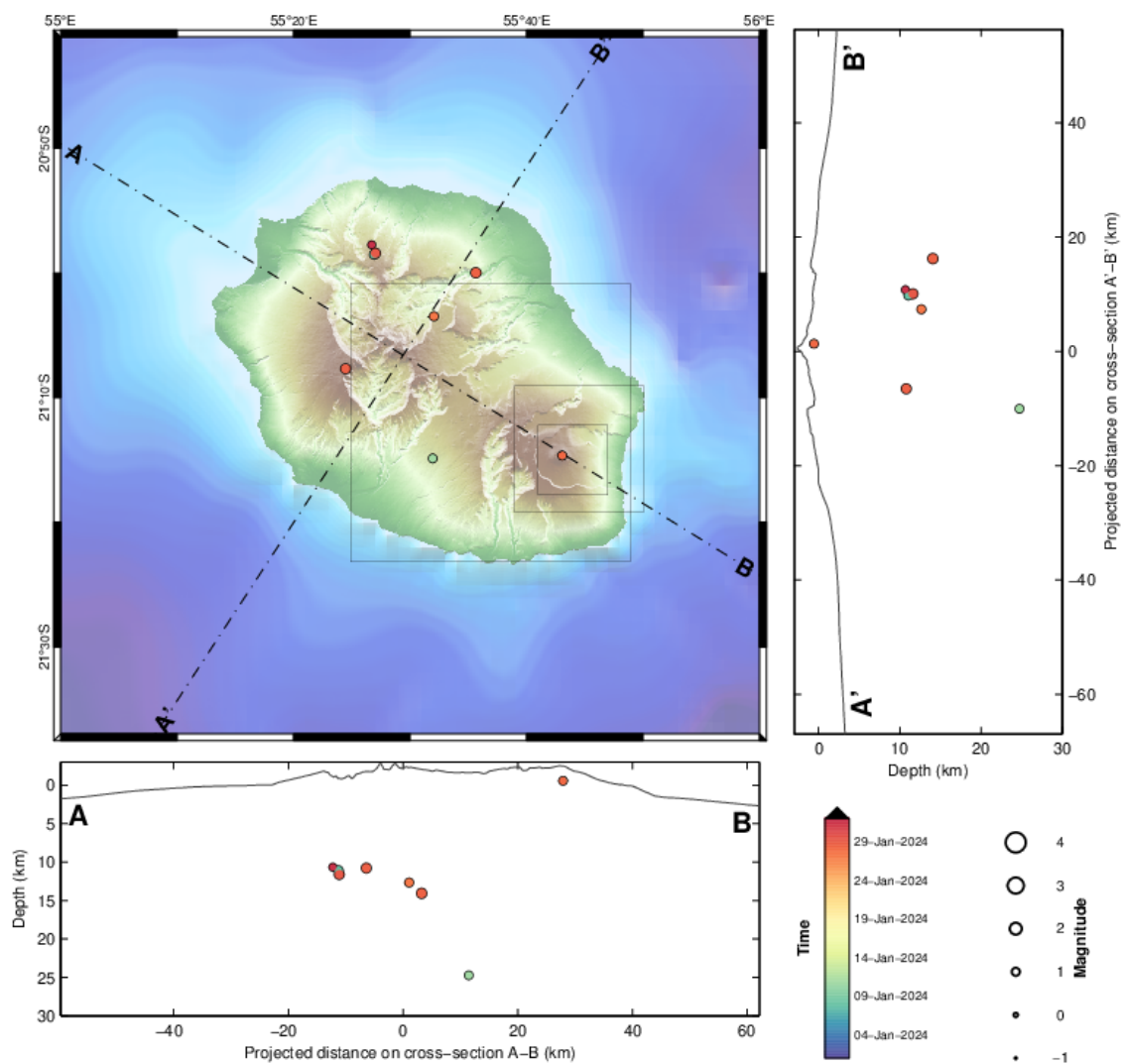


Figure 8: Number of local earthquakes (La Réunion island) per day recorded in January 2024 (© OVPF-IPGP).



La Réunion

© OVPF-IPGP, 2024



Filters: MAG $\in [-1,6]$; DEP $\in [-3,30]$;

From: 01-Jan-2024 00:00
To: 01-Feb-2024 00:00

Total events = 9
Magnitude: min 0.6 – max 1.3
Types:
Local (7),

Sommital (2),

PROC.HYPO / Réunion - sysop@pitondescalumets - 01-Feb-2024 05:12:36 +0 - hypomap.m (2023-02-14) / WebObs MIMXXIV

Figure 9: Seismicity below La Réunion in January 2024. Location map (epicenters) and north-west – south-east and 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/>

February, 1 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 - January, 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
- Twitter : twitter.com/obsfournaise
- Facebook : 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

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.