Monthly Bulletin

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

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

- 22 shallow volcano-tectonic earthquakes (0 to 2.5 km above sea level) below the summit craters;
- 20 deep earthquakes (below sea level);
- 18 long-period earthquakes;
- 99 rockfalls.

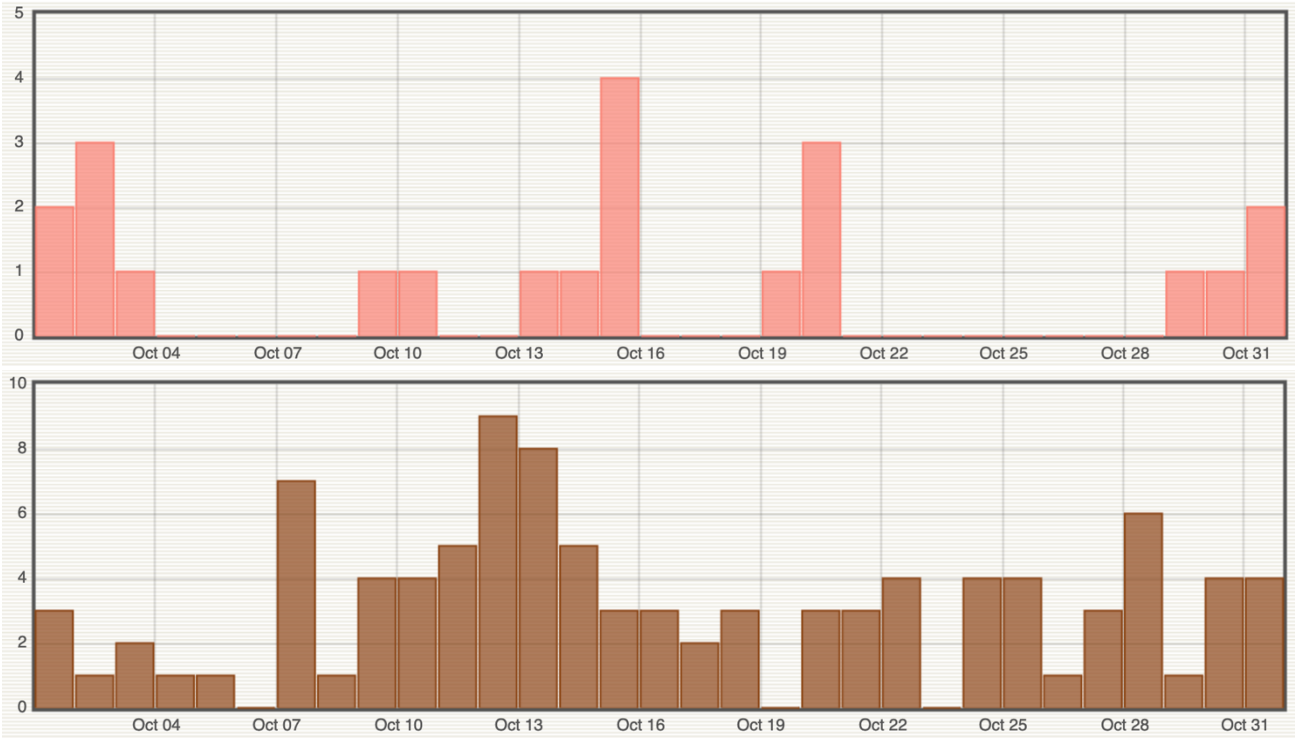

Figure 1: Number of (top) shallow volcano-tectonic earthquakes and (bottom) rockfalls per day recorded in October 2024 (© OVPF-IPGP).

The seismic activity in October 2024 was low, with only 22 shallow volcano-tectonic earthquakes (Figure 1) and 20 deep earthquakes.

Only 5 shallow volcano-tectonic and 1 deep earthquake could be located below the *Dolomieu* crater and the *Bory* crater, respectively (Figure 2). The other ones – of lesser magnitude – could not be located.

Numerous rockfalls (99) also occurred inside the *Dolomieu* crater, along the cliffs of the *Enclos Fouqué* caldera and *Rivière de l'Est* (Figure 1).

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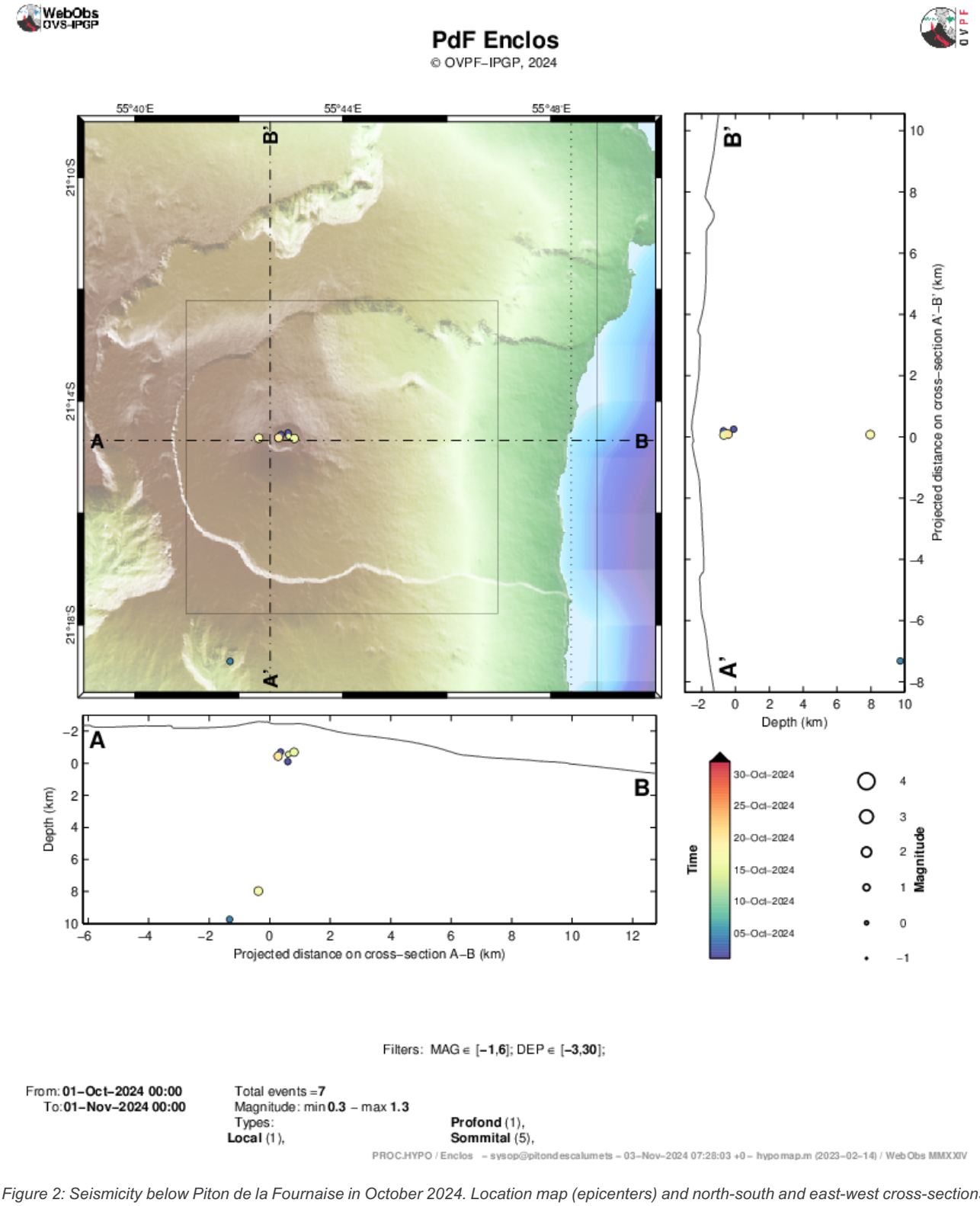

Figure 2: Seismicity below Piton de la Fournaise in October 2024. Location map (epicenters) and north-south and east-west cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only manually located earthquakes are shown on the map (© OVPF-IPGP).

Deformation

After its resumption in February 2024, the edifice inflation stopped at the beginning of April 2024 (Figures 3 and 4). Since then, a slight deflation is recorded in the long-term (Figure 3).

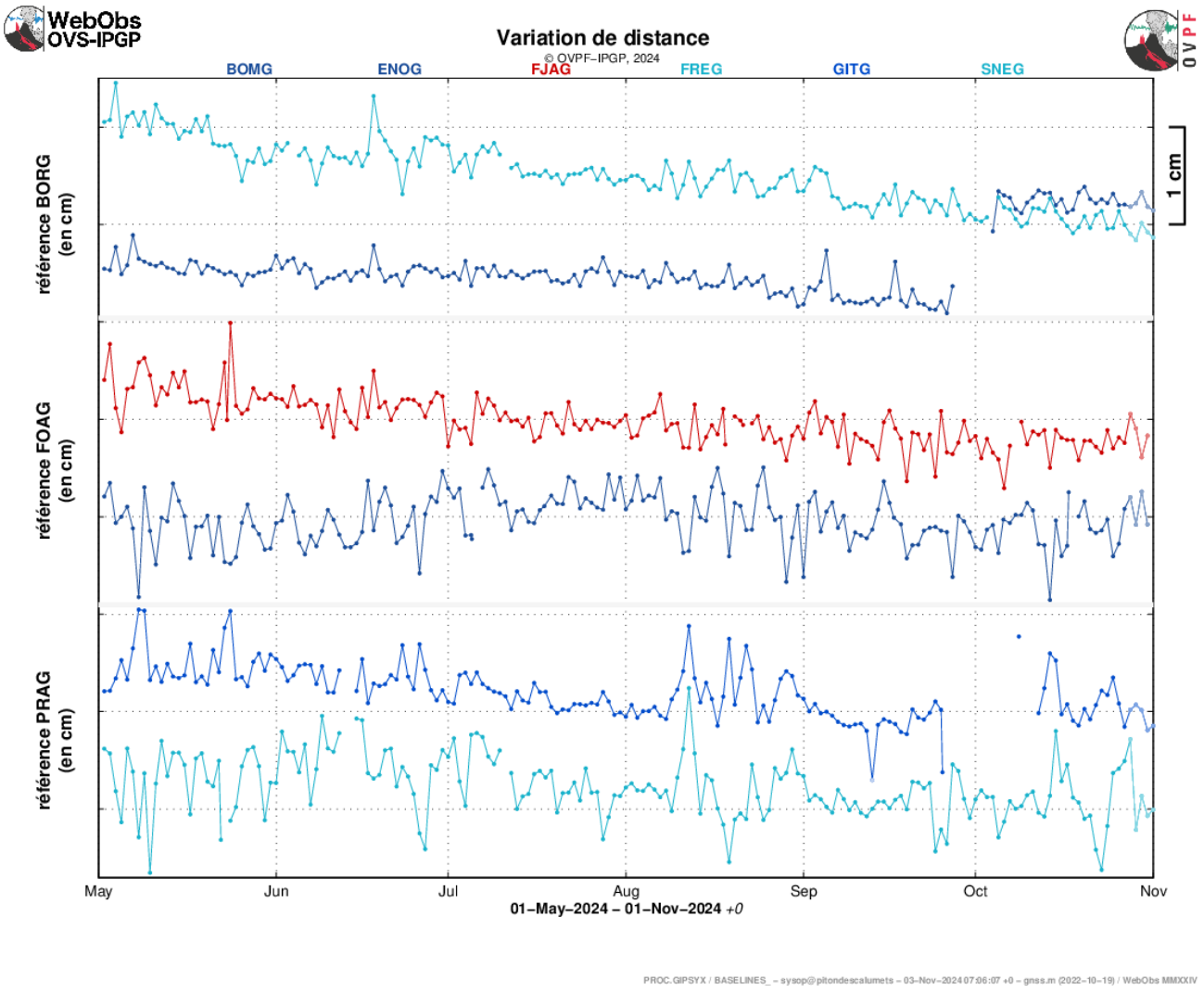

Figure 3: Ground deformation records over the past six months (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater (reference: 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. ***The jump on the BORG-BOMG baseline is linked to a receiver and antenna change on the BOMG station*** *(© OVPF-IPGP).*

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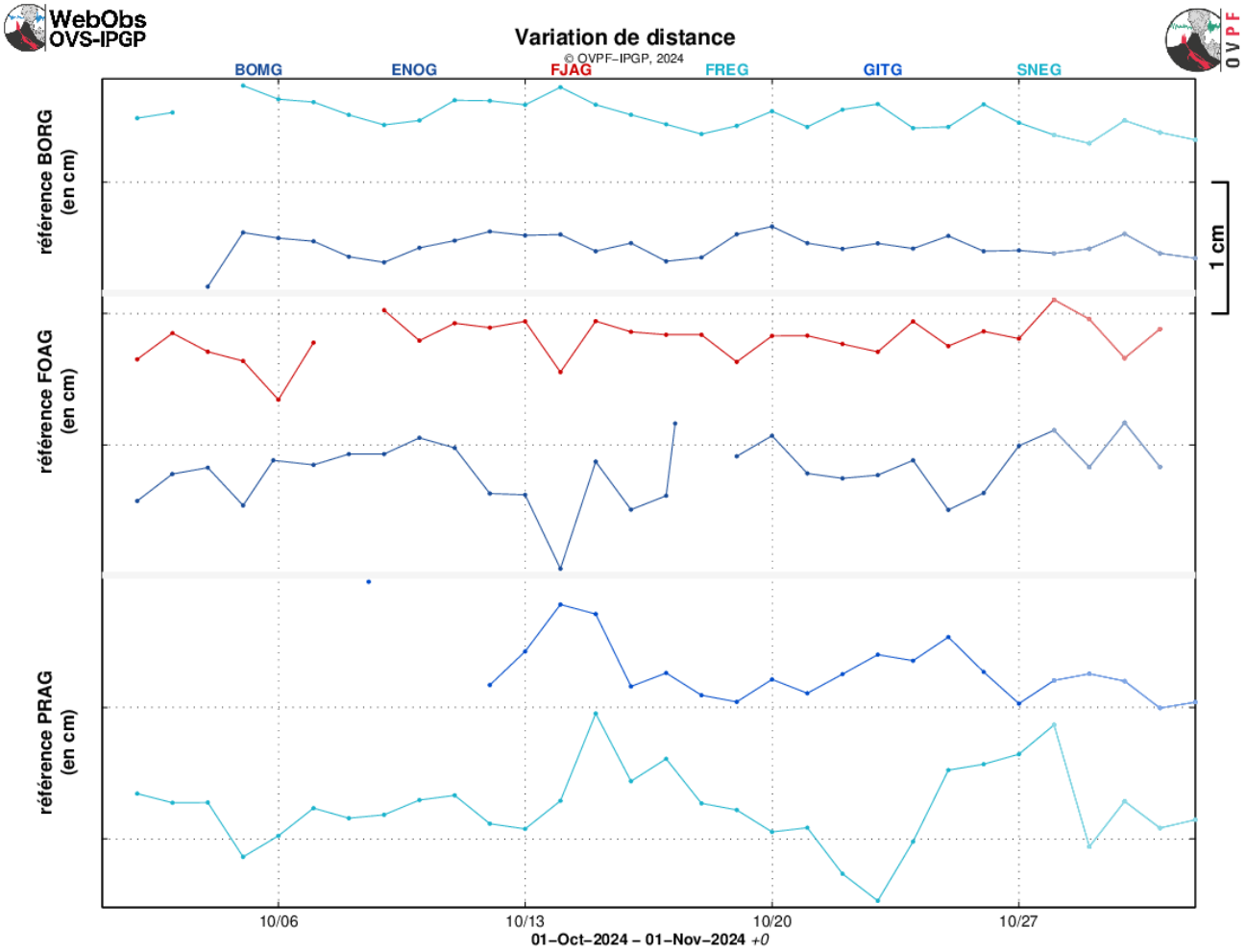

Figure 4: Ground deformation records over the course of October 2024 (in case of eruptive or intrusive periods, red and green bars represent eruptions and intrusions, respectively). The time series plots show the changes in distance between pairs of GPS stations located around the Dolomieu summit crater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

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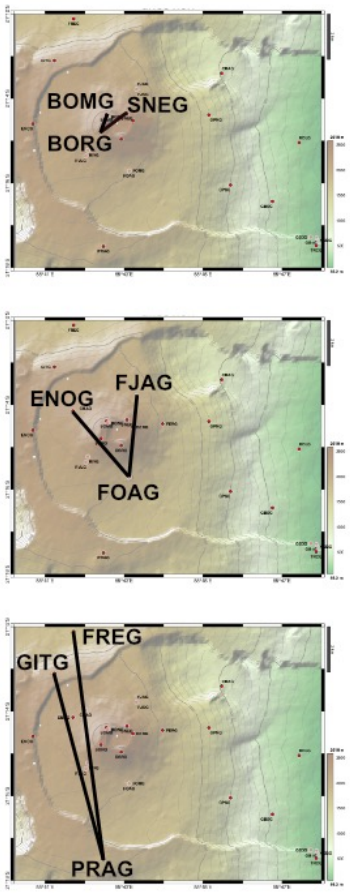

Figure 5: Location map of GPS stations and baselines as discussed in the text and shown in Figures 3 and 4 (© OVPF-IPGP).

** 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.*

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Gas geochemistry

CO_2 concentration in the soil

In the proximal *Gîte du volcan* site, a sudden drop to very low CO_2 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).

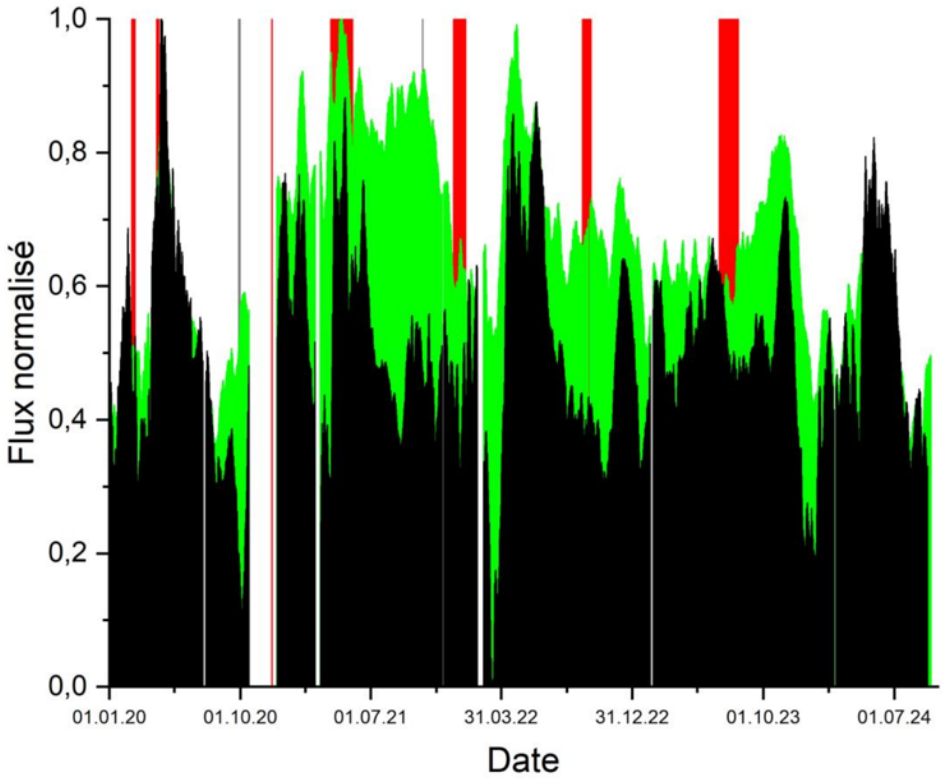

Figure 6: Comparison between the normalized average of corrected for short (OVPF-model; 15 days moving average; in green) and long-term influence of environmental parameters (INGV MALFIT model; in black) soil CO_2 flux from all distal stations since October 2016 (last station set). Red bars: eruptions; Gray bars: intrusions (© OVPF-IPGP).

A new increase in soil CO_2 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_2 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_2 gas fluxes is recorded in both proximal and distal sites. The September 19, 2022 eruption occurred after a significant decrease in CO_2 fluxes, likely recording the progressive transfer of magma to shallow crustal levels. Since the end of the September 19 – October 5, 2022 eruption CO_2 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.

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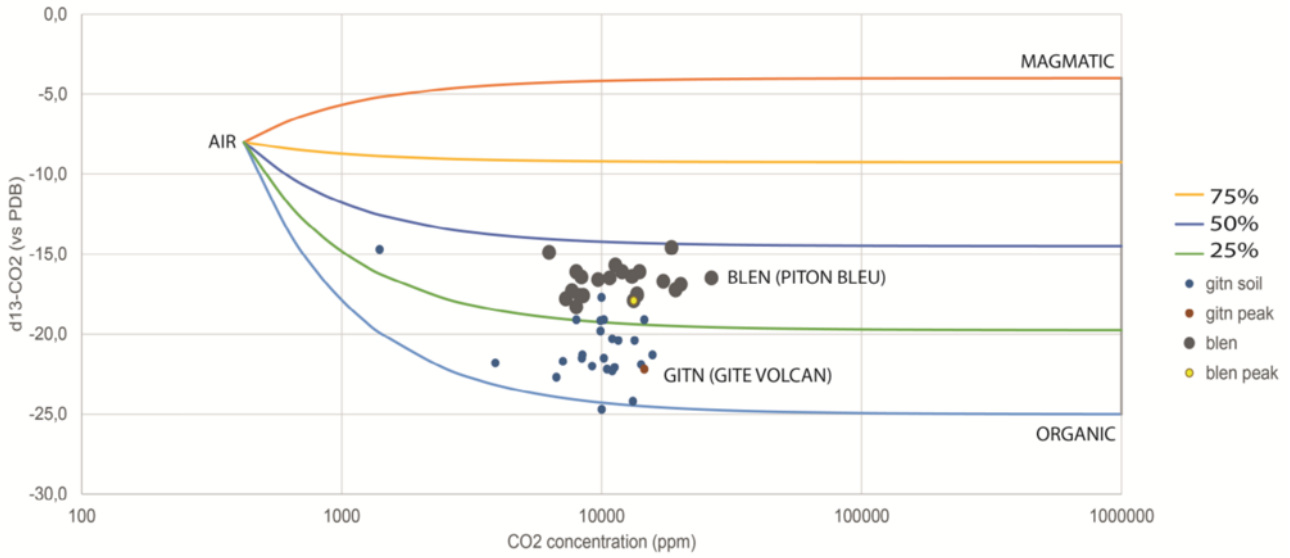

Figure 7: Carbon isotope (δ13C) variations in CO_2 from soil gas emitted from a proximal (GITN) and distal (BLEN) station. Measurements performed at the beginning (March 2024) of the peak phase in CO_2 emissions do not show a strong increase in magmatic contribution.

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 2023 and a continuous decrease was measured until end December. Then values remained stable to low levels.

Following the cyclonic event of January 15, 2024 a rapid increase in soil CO_2 fluxes was observed from January 19 in both proximal and distal locations on the western flank of Piton de la Fournaise. This increase lasts till May and attains unusually high values in the proximal GITN site. Isotopic fluid compositions do not show an increase of the magmatic component in the fluids (Figure 7).

A decrease of CO_2 fluxes on all sites is recorded since mid-May 2024.

** 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

- Since the installation of the new MultiGaS station at the summit in June 2024, SO_2 and H_2S concentrations at the volcano summit remain below detection levels.

** 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).*

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SO_2 flux in the air obtained by DOAS method

The SO_2 fluxes in the air were low; close or below the detection threshold.

** Glossary: During rest periods, SO_2 flux at Piton de la Fournaise is below the detection threshold. The SO_2 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 October 2024.

Summary

Since April 2024, magma recharge and pressurization of the shallow magma reservoir stopped.
In October 2024, seismicity remained low - with only 22 shallow and 20 deep volcano-tectonic earthquakes recorded below the summit craters.

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

Local and regional seismicity

In October 2024, the OVPF-IPGP recorded:

- 63 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 October 2024, the OVPF-IPGP recorded 63 local earthquakes located mainly below the *Cirque de Salazie* and *Roche Écrite areas* (Figure 9). Most of these earthquakes have magnitude less than 1 and are difficult to locate.

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.

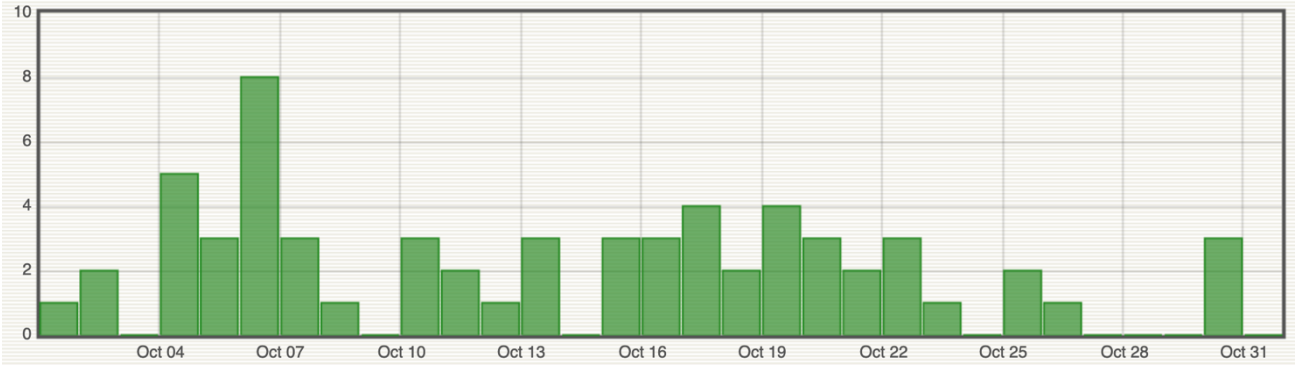

Figure *8: Number of local earthquakes (La Réunion island) per day recorded in October 2024 (© OVPF-IPGP).*

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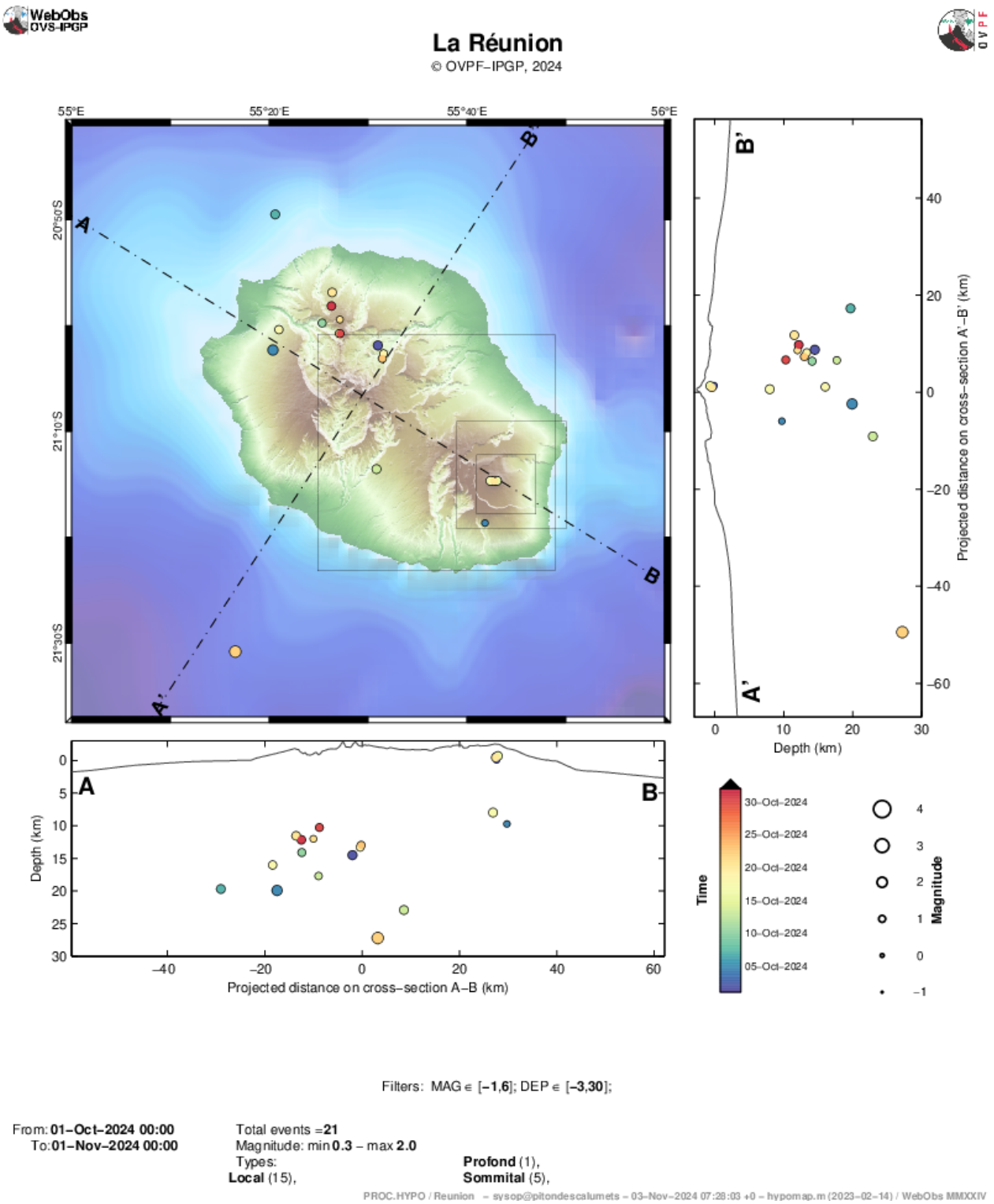

Figure 9: Seismicity below La Réunion in October 2024. Location map (epicenters) and north-west – south-east and south-west – north-east cross-sections (hypocenters) of earthquakes as recorded by OVPF-IPGP. Only localizable earthquakes are shown on the map (© OVPF-IPGP).

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 and BRGM coordinate and manage REVOSIMA. Operational monitoring of seismo-volcanic activity is carried out by IPGP (OVPF), under the joint responsibility of BRGM and in close association with IFREMER and CNRS. 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/

November, 5 2024
OVPF-IPGP Director

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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.

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
- X (ex-twitter) : x.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.unistra.fr/fr/zones/la-reunion

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