

UPDATE 6 Saba - January 2022

This update reports on the activities of KNMI in 2021 with respect to the volcanic/seismic monitoring network at Saba. The COVID-19 pandemic provided an extra challenge considering our work, mainly related to travel and contact restrictions. Nevertheless we managed to build the new off-grid station at Grey Hill in April 2021 (called "SABN") in cooperation with Korps mariniers. Also, regular observations of data at all stations continued throughout the year. The current monitoring network, and its extension planned for February 2022, is displayed in Fig. 1.

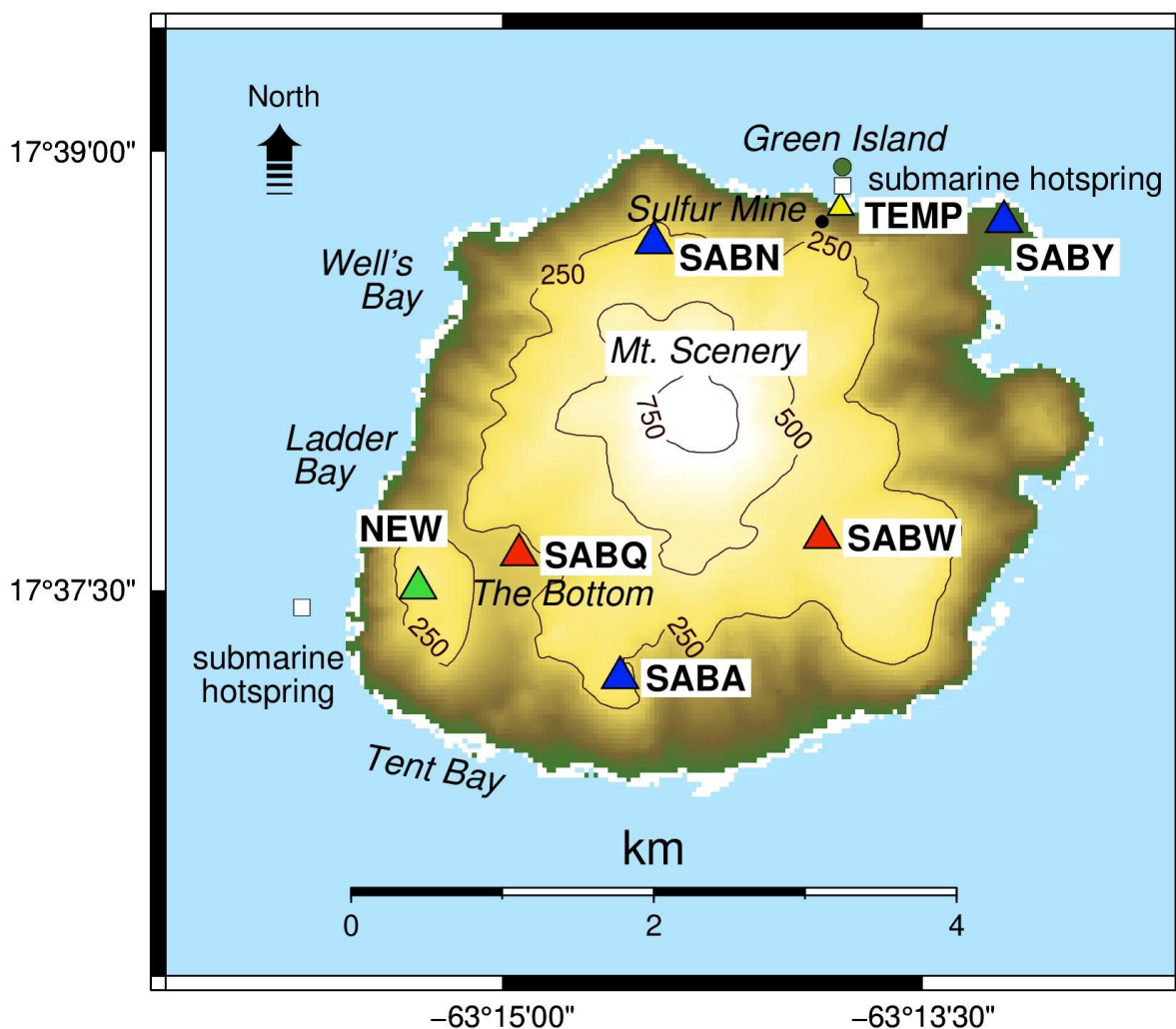


Fig. 1: Map showing the locations of current measurement sites on Saba with blue (GNSS/seismic stations) and red (seismic stations) triangles. Station SABN was built in April 2021. In green the location of the proposed GNSS station at the whale's tail (planned installation February 2022).

Installation Station SABN

In April 2021 a GNSS and seismometer were installed at Grey Hill with the courageous help of the Korps Mariniers (Fig. 2).



Fig. 2: Korps Mariniers helped to carry >2000 kg of materials up to Grey Hill.

The monitoring station “SABN” (Fig. 3) consists of a seismometer recording vibrations and a GNSS instrument measuring deformation. It is powered by solar panels and batteries. Data are sent 24/7 to KNMI using satellite communication.

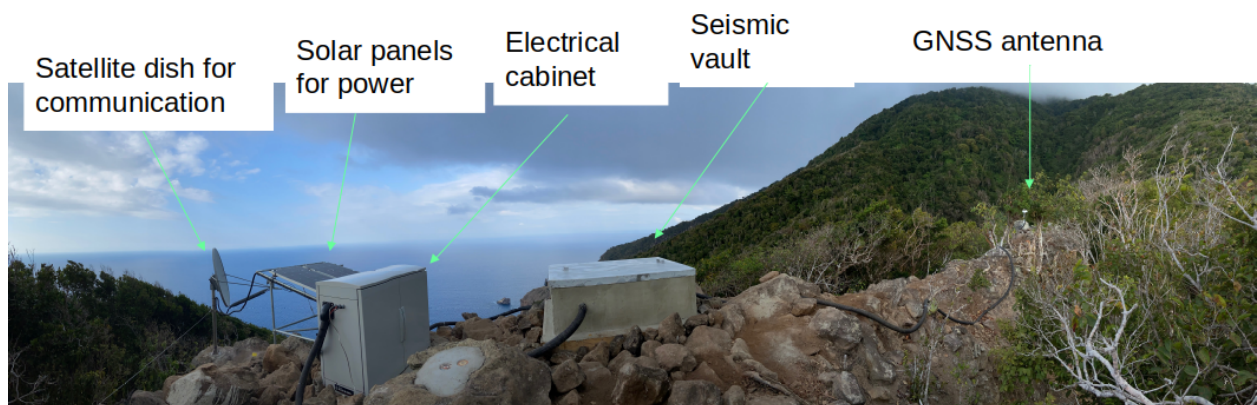


Fig. 3: The monitoring site “SABN” at Grey Hill.

Seismic data

Seismometer “SABQ” in The Bottom was repaired. All seismometers, including the new station “SABN”, are functioning well and produce data of good quality (Fig. 4). “SABA”, “SABQ”, “SABW” and “SABY” transmit data in near real-time to KNMI for the purpose of detecting earthquakes. Data from “SABN” are transmitted once a day by satellite.

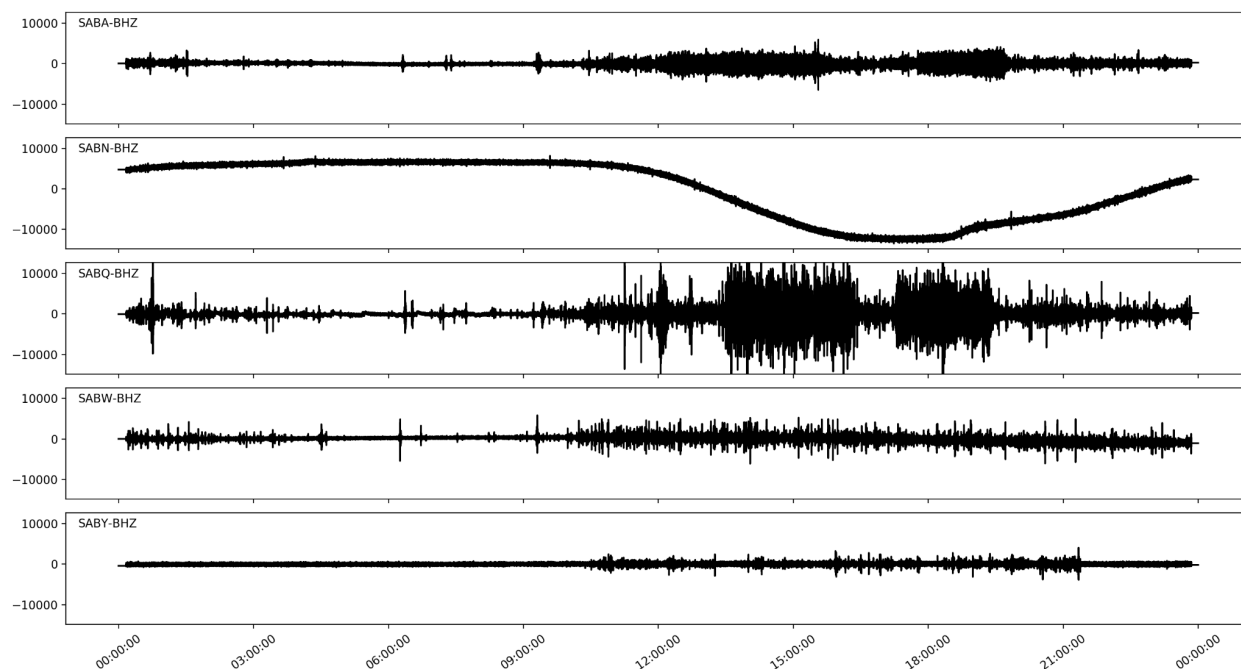


Fig. 4: Vertical ground motion recorded by the seismic stations at Saba on 01-09-2021. Notice the increase of human induced seismic noise during the day, except at SABN. Here, however, a daily variation is clearly visible due to temperature variation. This is suppressed at the other stations by temperature regulation (air conditioning). Both the human induced noise and temperature variation do not limit the functioning of the seismometer and the detection of earthquakes.

Live seismograms, with a delay of about 15 minutes, are available at our website: <https://www.knmidc.org/seismology/>. Please note that data from SABN are not displayed there because of the delay in data transfer. Furthermore, continuous data collection can be affected by communication problems, e.g. due to lightning damage or by power failure.

A new technique, called coincidence trigger, was implemented at KNMI to better detect small, local earthquakes, using data from all seismometers. Such automatic detections are manually reviewed by a seismologist. Fig. 5 shows an example of such an

earthquake detection and the manually reviewed earthquake location.

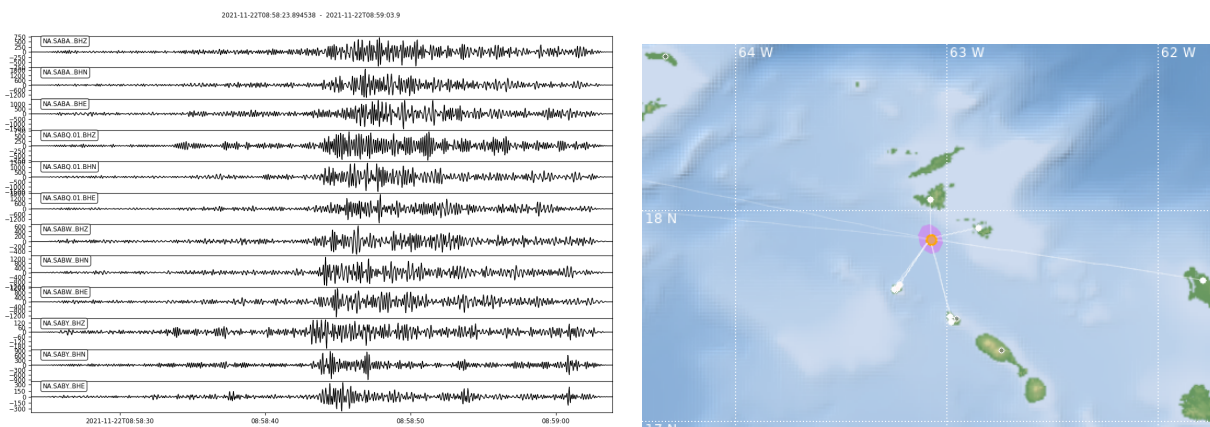


Fig. 5: Seismic recordings (left) from the seismometers at Saba of an automatically detected earthquake in between Saba and St. Maarten (right). The earthquake took place at 22-11-2021, 08:58:20 UTC, at a depth of 76 km and has a magnitude of 2.7.

You can help us to detect earthquakes by filling out the next form in case you have felt an earthquake: <https://www.knmi.nl/nederland-nu/seismologie/aardbevingen/melden>

GNSS data

The two regular GNSS stations, at the SATEL facility at St. Johns (called “SABA”) and at the airport (called “SABY”) worked well during 2021. The new off-grid remote site at Grey Hill (called “SABN”), installed in April 2021, also performed as expected since its installation. SABN transmits its data once a day via satellite communication to KNMI.

For each GNSS instrument on the island, a daily position is calculated very precisely and evaluated against external reference data by the KNMI. Each day, a new position is obtained and added to the timeseries as a new point. This creates a timeseries dating back to the instrument installation. The GNSS station SABA (at St. Johns) has been operating since January 2018. Station SABY (airport) became operational in February 2019. The recently installed station SABN (at Grey Hill) is operational from April 2021. Figure 6 shows the GNSS positioning time series from the year 2021.

With a long enough time series, trends in these components can be observed. The graphs in Figure 6 show a horizontal movement in the East and North direction for all stations. This effect is caused by the Earth’s tectonics. For Saba, the movement is attributed to the movement of the Caribbean Plate whereby the North and South

American plates subduct underneath the Caribbean Plate.

To evaluate local deformations on the island, caused by e.g., slowly moving landslides or land deformation caused by geophysical processes, the plate tectonic signal is removed from the timeseries. Typically, deformations on the flank of a volcano preceding a volcanic eruption are in the order of multiple centimeters to decimeters, visible especially in the horizontal components. The bottom graphs in Figure 6 show the time series of SABA and SABN after removing the plate tectonic movement. They show very little deviation from a horizontal line. It thus indicates no significant deformation happening at the investigated sites.

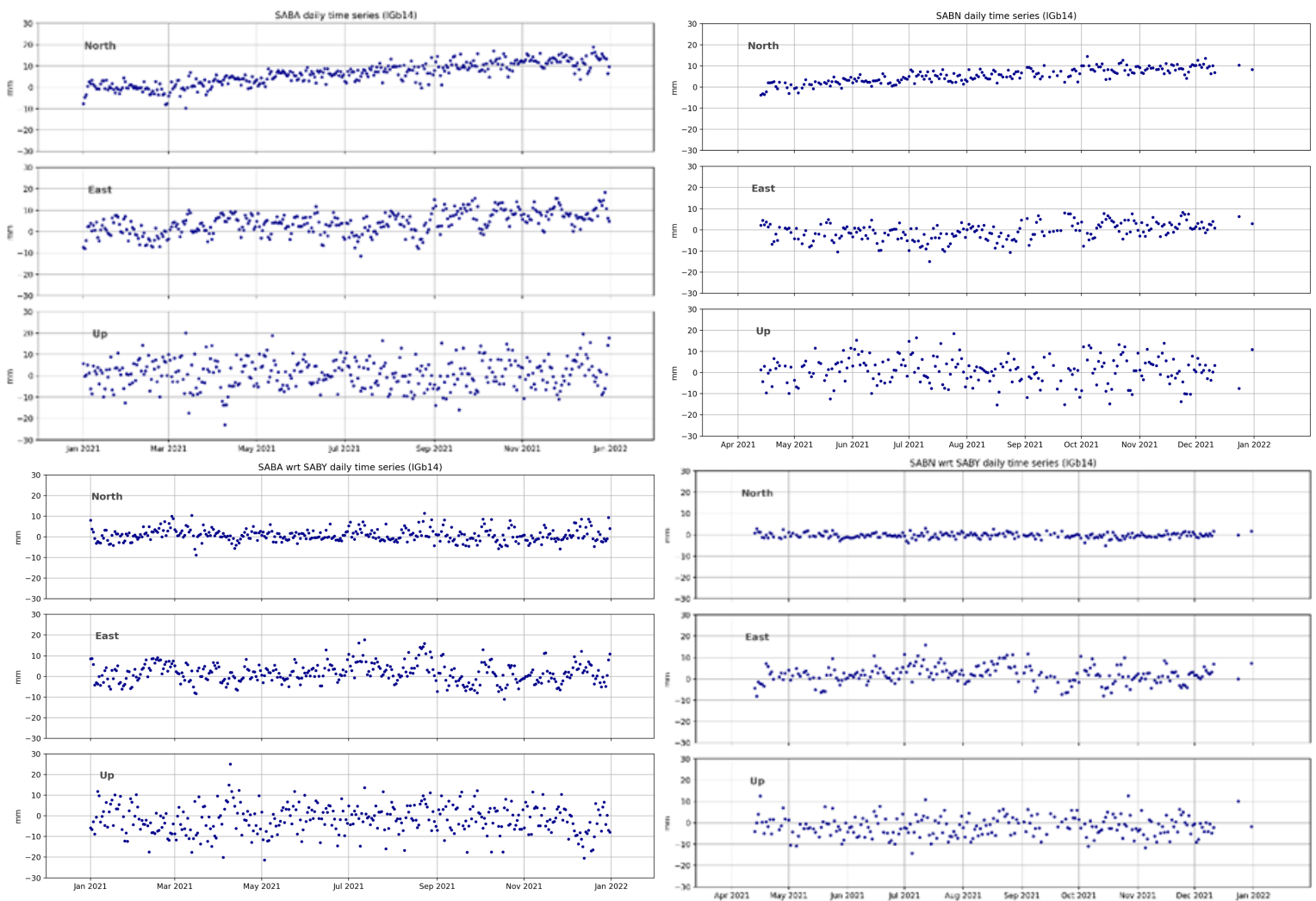


Fig. 6: GNSS data from stations SABA (upper left) and SABN (upper right) from 2021. When the plate movement signal is removed, the data shows very little deviation from a horizontal line (bottom graphs SABA and SABN).

Installation new site at Parish Hill

A new GNSS installation is planned for February 2022 at Parish Hill close to the Whale's Tail. This installation will not have a seismometer because it is relatively close to the operating seismometer located in the SATEL building in The Bottom. All materials for this installation arrived on Saba in January 2022. The new installation will be powered by solar panels/batteries.



Fig.7: Location of the new GNSS station close to the Whale's tail.

Temperature data hot spring

Every visit to the hot-spring opposite Green island we measure the temperature and install new data sensors. The maximum temperature of the spring is fairly constant at



around 82 degrees Celsius. The hot spring environment is very harsh for the equipment. Chemical weathering (Fig. 8) resulted in the loss of both temperature sensors during 2021. Therefore we only have a few measurements during 2021. We replaced the sensors in October 2021 and hope to retrieve data in February 2022. To improve the robustness of the set-up we will use special tape to protect future temperature sensors. This tape is vulcanising and resistant to high temperatures and acidic environments.

Fig. 8: Chemical weathering of temperature sensor

Cracks Green Gut - Thermal images

In 2021 the Green Gut area was surveyed twice with the use of a thermal camera (Fig. 9). Most of the cracks observed in 2020 were covered with sand and rubble. The only remaining crack along the wall showed a maximum temperature of around 31 degrees celsius. Between April and October this feature was covered with vegetation. The hot air rising from this crack has no smell. It could be caused by the decomposition of underlying green waste or it could be a volcanic vent. If the latter, such a feature is completely normal and nothing to be concerned about. We will continue observations in this area.

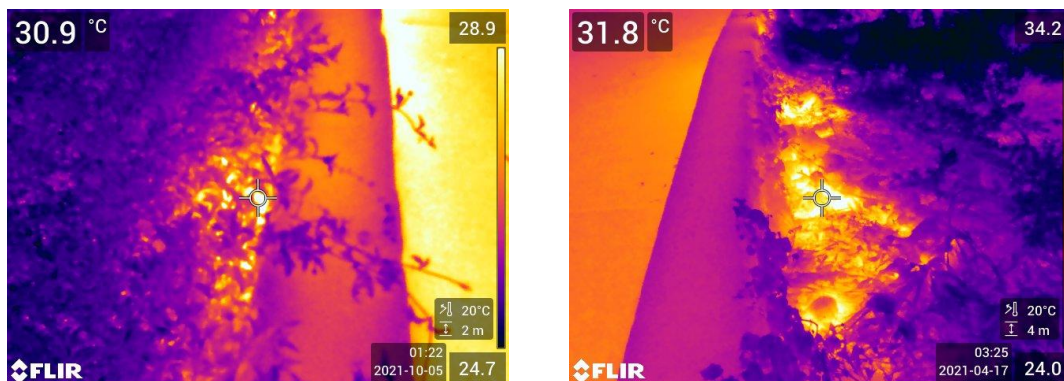


Fig. 9: Thermal camera images of the crack along the wall at the green gut measured in April 2021 (left) and October 2021 (right).

Volcanic activity in the region

In 2021 the Caribbean region experienced the explosive eruption of La Soufriere at St. Vincent. In December 2020 a dome (a mount built by fresh lava) was observed in the crater (Fig. 10). Over time this dome grew from a small black circular mount to a u-shaped mount filling the area between the crater rim and the vegetated old dome.

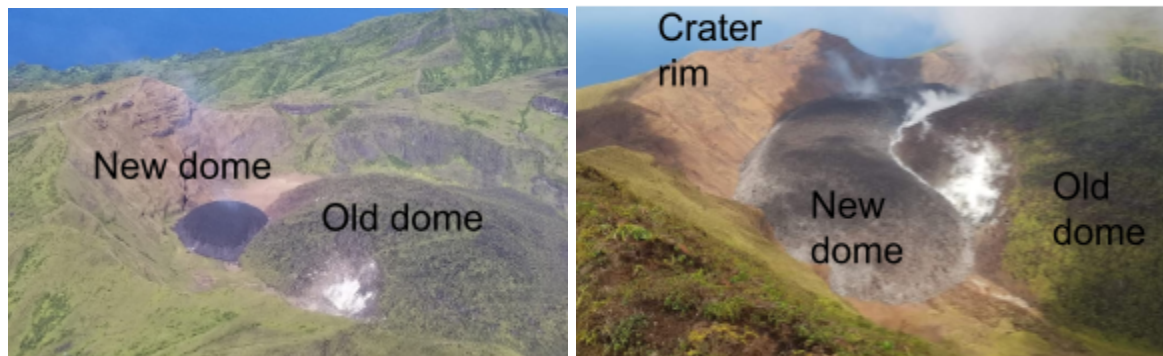
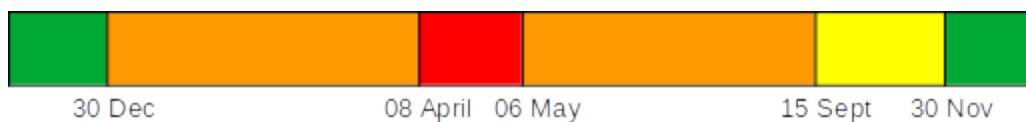


Fig. 10. Dome growth in the crater of St. Vincent between December 2020 and February 2021. Photos credit of UWISeismic.

On 30 December 2020 the alert level of the volcano (see table below) was raised to orange after the initial observation of the new dome. On 8 April 2021 seismic activity and gas output increased dramatically and the alert level was raised to red and evacuations started. From 9-22 April, 26 explosive eruptions occurred, with ash reaching 20 km altitude. On November 30, UWISeismic declared that the eruption was over.



Due to favorable wind conditions ash and volcanic gasses were mostly blown towards the ESE during the eruption so little was noticeable on Saba.

Currently three volcanoes in the Caribbean (Fig. 11) have a yellow alert level: Mount Pelée in Martinique, La Soufrière in Guadeloupe and Kick 'em Jenny just North of Grenada. All other volcanoes have a green alert level.

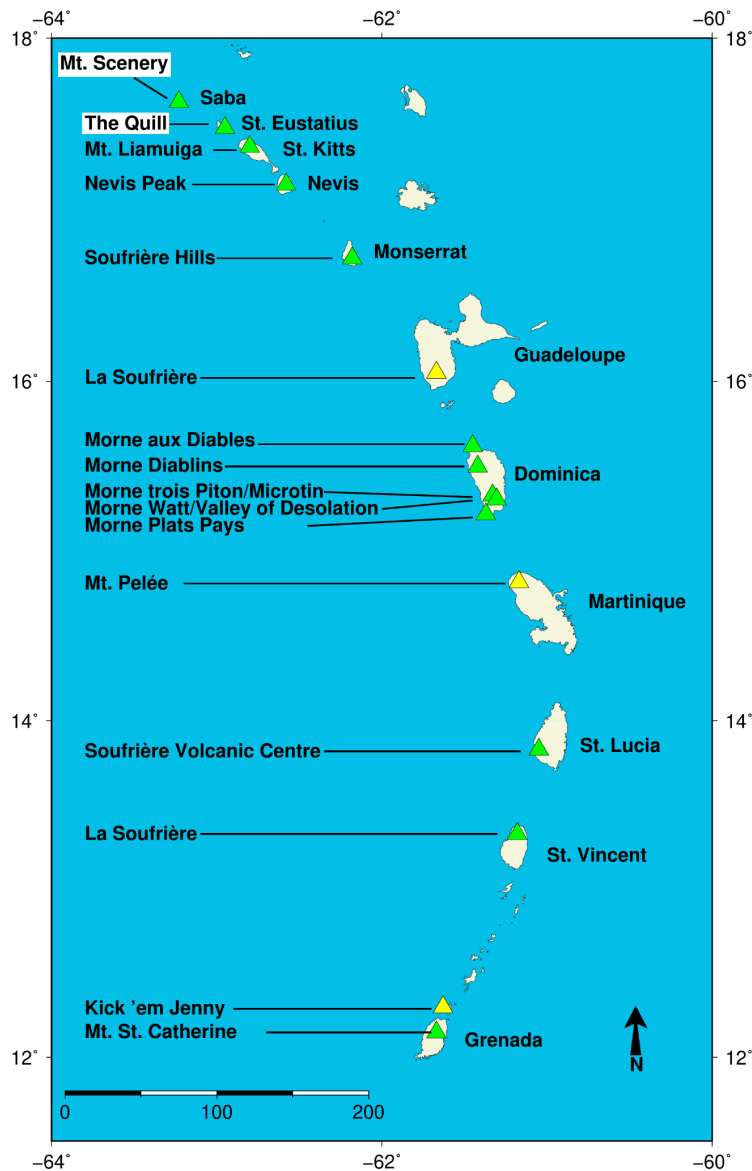


Fig. 11: The active arc of the Lesser Antilles showing the islands of Saba and St. Eustatius in the far north, as well as the other islands of the chain. The triangles depict the location of an active volcano, and their names are shown on the left.

Mnt. Scenery and The Quill are highlighted. The color of the triangle depicts the state of the volcano as of 26 Jan 2022 whereby green = normal and yellow = advisory.

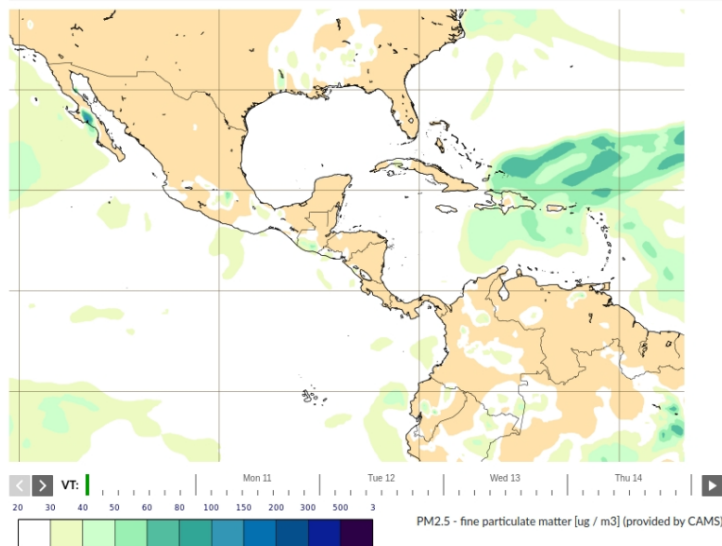
For more information on the activity of other Caribbean volcanoes see:

- <http://uwiseismic.com> and <http://nemo.gov.vc/nemo/index.php/home/welcome> for Grenada, Grenadines, St. Vincent, St. Lucia, Dominica, St. Kitts and Nevis
- <https://www.ipgp.fr/fr/ovsm/observatoire-volcanologique-sismologique-de-martinique-ovsm-ipgp> for Martinique
- <https://www.ipgp.fr/fr/ovsg/actualites-ovsg> for Guadeloupe
- <http://www.mvo.ms/> for Montserrat.

Volcanic gasses from other volcanoes reaching the Caribbean

Volcanic gasses can travel long distances and affect populations several thousand kilometers away from a volcano. The journey of the volcanic gasses can be observed with the use of satellites as is done by the Copernicus Atmosphere Monitoring Services (CAMS). For example, in October 2021, sulfate aerosols from the eruption of the Cumbre Vieja volcano in La Palma, Canary Islands, reached the Caribbean region (Fig. 12). These aerosols may cause itching of eyes, skin irritation or respiratory difficulties especially for younger children, the elderly or people with asthma. When affected it is advised to avoid strenuous activities and remain indoors with windows closed.

PM10 - coarse particulate matter [$\mu\text{g} / \text{m}^3$] (provided by CAMS)
Sunday 10 Oct, 00 UTC T+3 Valid: Sunday 10 Oct, 03 UTC



Sulphate aerosol optical depth at 550 nm (provided by CAMS, the Copernicus Atmosphere Monitoring Service)
Sunday 10 Oct, 00 UTC T+3 Valid: Sunday 10 Oct, 03 UTC

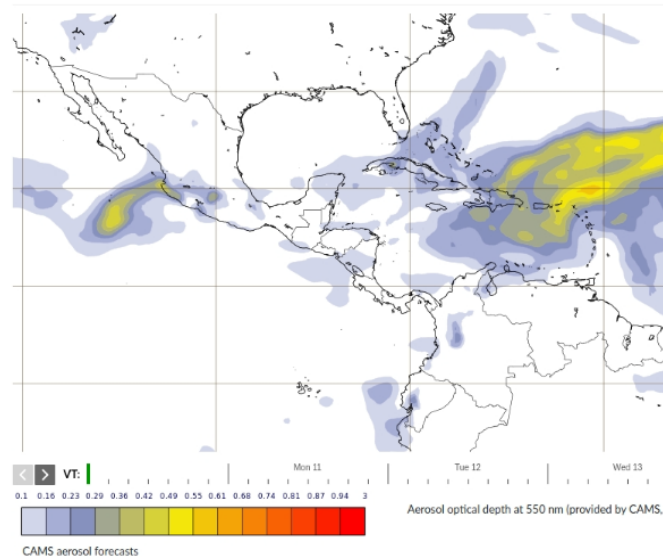


Fig. 12: Volcanic gasses reaching the Caribbean area on October 10th 2021. Dark green shows the highest concentration of particles in the air (left) and yellow/orange indicates high concentrations of sulfate aerosols (right).

“Volcano Monitoring Group” on Facebook

We created a Facebook group “Volcano Monitoring” (<https://www.facebook.com/groups/191096753226885>). This is a place where we will share information and photos of our activity. We will also post information about seismic and volcanic activity in the region from sister organisations such as UWI-seismic and IPGP. At the same time the public can also share their observations concerning volcanic or seismic activity with us. We hope many interested people will join us in this group.