Temperature monitoring of the hot spring opposite Green Island on Saba, Caribbean Netherlands

Saba, the northernmost island of the Lesser Antilles volcano. The existence of hot springs on the island testifies to the volcano being active rather than dormant even though the last eruption probably occurred more than 375 years ago. The hot springs of Saba are all located close to the shoreline and orientated along a NE-SW line crossing the island. We focus on the hot spring opposite Green Island.

Introduction

The Mt. Scenery volcano on Saba is part of the Lesser Antilles volcanic island arc in the West Indies, which hosts seventeen active volcanoes (Fig. 1). The most recent eruption probably occurred as recent as 1640. The existence of hot springs indicate that the volcano is active, but quiet, rather than extinct. Volcanic hazard is therefore present and monitoring of these volcanoes of utmost importance.



Figure 1: Overview of the active volcanoes of the Lesser Antilles (red triangles) with Saba (13 km²) in the far North. Soufréire Hills volcano, at the neighboring island of Montserrat and of comparable nature to Mnt. Scenery, started to erupt in 1995 after ~450 years of quietness.

Monitoring network

Since 2006, the Royal Netherlands Meteorological Institute (KNMI) deploys a small network of broadband seismometers, continuous GNSS and temperature sensors on Saba (Fig. 2). Observations are used to monitor volcanic activity as well as local and regional seismicity, which may induce tsunamis.

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Figure 2: KNMI monitoring network on Saba. Blue triangle shows the location of a collocated seismometer and GNSS, the red triangle is a single seismometer, the green triangle a single GNSS. The squares show the locations of four hotsprings. The yellow triangle depicts the monitored hotspring.



Figure 3: Photo of the island of Saba.

Temperature monitoring hotspring

Hot springs are manifestations of volcanic activity generated by the interaction of groundwater with magma or solidified, but still hot, igneous rocks at shallow depths. Changes in the temperature and/or in the chemical signature of hot springs may result from a change in volcanic activity. Early 2018, we installed two Gemini Tinytag Plus 2 dataloggers at the hotspring opposite Green Island (Fig. 4), connected to two waterproof stainless steel thermistor probes, which are capable of monitoring temperatures from -40°C to +125°C. Every 20 minutes, the highest temperature measured during a 6o-second interval is recorded.



Figure 4: Temperature measurement set-up at the hot spring opposite Green Island, in January 2018 (left), November 2018 (middle) and February 2019 (right). Temperature probes are buried in the ocean bed and covered with rocks to keep them in place. The Tinytag Plus 2 data loggers are the small yellow cases mounted on the rock above the spring and housed in a black pelican case for additional protection from the elements in the most recent setup.

Challenges

Maintaining the temperature monitoring of the hotspring operational is a challenge. Seawater spray destroys the data loggers while the acidic spring water mixed with seawater ruins the temperature probes (Fig. 5). Another challenge is to keep the probes in position (in the spring) by protecting them against upward forces generated by buoyancy and waves. Finally accessibility is limited due to the remote location resulting in delayed data downloads and/or potential poor data quality.



Figure 5: Effect of the harsh environmental conditions on the equipment: corrosion of bolts and probes and water ingress of the data loggers.

Data Analysis

First continuous temperature data were collected in November 2018. Only one data logger survived this time period for the duration of just over one month. New data were collected in February 2019. This time both temperature probes recorded data for 3 months, although 1 probe started to fail after the first month (Fig. 6). Spectrum analysis was applied to the second data set and show correlation with existing pressure gauge data from the harbour of Saba (Fig. 7).



Figure 6: Recorded temperature (in degrees Celsius) at the hot spring opposite Green Island. Blue line depicts good data, black line shows compromised data quality with time due to failure of the probe (see Fig. 5).



Figure 7: Normalised amplitude Fourier spectra of a) temperature time series in the hot springs (in black) and the water pressure time series measured in the harbour (in red). Indicated are the diurnal tidal components O1 and K1, and the semi-diurnal components M2 and S2. Temperature time series is from 01 Feb 2019 until 16 Feb 2019. Temperature time series is from 4 Nov 2018 until 6 Feb 2019.

Future work

We plan to improve the robustness of the installation and will continue data analyses to remove tidal effects from temperature recordings. Installation of a continuous PH probe and pressure gauge would be useful to improve understanding of the dynamics of the hotspring.

