Royal Netherlands
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An extended monitoring network for the volcanoes of St. Eustatius and Saba.

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The Quill and Mt. Scenery are active volcanoes in the Caribbean Netherlands. To be able to monitor their activity better, the current network of seismometers will be extended with other observation techniques, such as GNSS and temperature measurements. Establishing a 'null-line' is important to observe if the volcano enters from a state of quietness into unrest. This is essential to ensure adequate and timely hazard mitigation.

Introduction

The volcanoes of the Quill (St. Eustatius) and Mt. Scenery (Saba) are part of the Lesser Antilles volcanic island arc in the West Indies, which hosts seventeen active volcanoes. The last eruptive activity at the Quill occurred 1600-1800 years ago but Mt. Scenery erupted as recent as in 1640. The existence of heated groundwater at St. Eustatius and hot springs at Saba indicate that both the Quill and Mt. Scenery are active, but quiet, rather than extinct. Volcanic hazard is therefore present and monitoring of these volcanoes of utmost importance. Especially considering the fact that Soufréire Hills volcano, at the neighboring island of Montserrat and of comparable nature to Mt. Scenery, started to erupt in 1995 after 450 years of quietness.

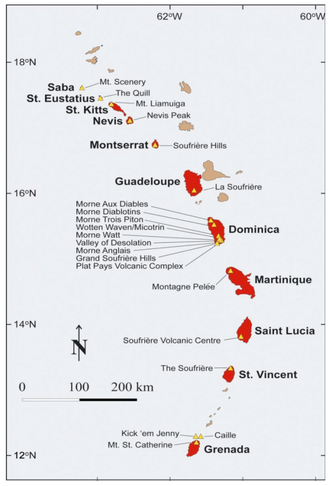

Figure 1: *Overview of the active volcanoes of the Lesser Antilles (yellow triangles), adapted from Lindsay et al. 2005. Saba (13 km²) and St. Eustatius (21 km²) are located at the northernmost end of the active volcanic arc.*

Seismic network

KNMI deploys a small network of broadband seismometers at both Saba and St. Eustatius. Data are transmitted in real-time to KNMI, IRIS, ORFEUS and the Pacific Tsunami Warning Center (PWTC) to monitor both local and regional seismicity as well as volcanic activity. In addition, at KNMI we use seismic interferometry to study temporal changes in seismic velocity in the interior of the volcanoes.

Figure 2: *Photos of the Quill, St. Eustatius (top) and Mt. Scenery, Saba (bottom). Note the difference in appearance and topography between the symmetrical cone of the Quill stratovolcano compared to Mt. Scenery stratovolcano, which is flanked by multiple andesitic domes.*

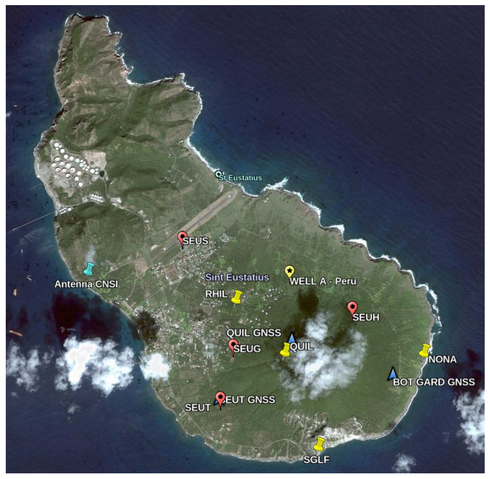

Figure 3: *Google Earth image of St. Eustatius showing all station locations.*

GNSS measurements

GNSS measurements are widely used to observe surface deformation at volcanoes. Continuous measurements provide real-time observations while campaign style measurements can be used to spatially densify the network. At Saba and St. Eustatius campaign style measurements were conducted in 1999, 2001, 2004 and 2009 (Mattioli et al.).

Figure 4: *Possible locations for continuous GNSS at St. Eustatius (left) and Saba (right).*

We propose to install continuous GNSS at both islands starting with one Septentrio PolaRx5 receiver combined with a PolaNt choke ring B3 antenna at each island. These stations will be integrated with COCONet. Important considerations for these stations are:

- Their location with respect to the volcano
- The geological stability and bedrock availability at the site
- A free sky-view and limited (future) vegetation cover
- The access to power and data transmission possibilities
- The type of monument required

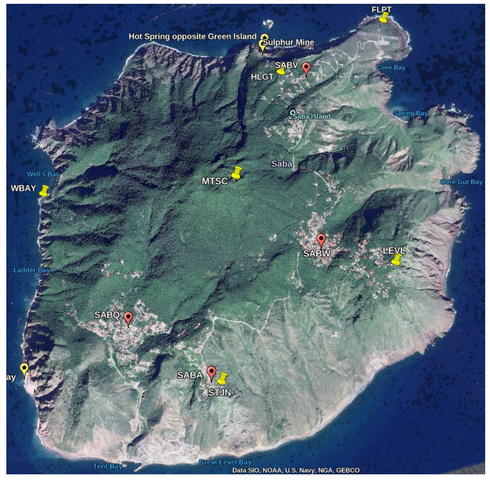

Figure 5: *Google Earth image of Saba showing all station locations.*

Temperature measurements

Saba hosts several hot springs and wells drilled for groundwater in the 1980s at St. Eustatius revealed elevated groundwater temperatures. Changes in surface temperature at these thermal features can occur before a volcanic eruption. To identify thermal anomalies, continuous monitoring is needed so that we understand the normal/background thermal characteristics.

Date, Reference	1903, Sapper	03/1950, Westermann	07/1979, Roobol	08/1981, Gunnlaugsson	03/1994, Roobool	04/1996, Johnson	09/1996, Buchan	01/1997, Roobol	08/1997, Smith	03/1998, NAVSO	04/1998, Johnson	05/1998, Hutttrer	05/1999, Kooistra	05/2005, Johnson	08/2005, Johnson	10/2007, Johnson	10/2008, Johnson
Ladder	54	56	53	67	54	80	82	62	62	64	79	84	88	-	-	-	-
Green Island	-	-	72	-	54	-	-	-	-	-	-	-	-	84	84	86	86
Sulfur Mine	-	-	32	-	33	-	-	-	-	-	-	-	-	36	34	47	45

Table 1: *Rounded temperature measurements (in °C) at the hot springs of Saba. Ladder Bay hot spring is located 900 m South of Ladder Bay. Green Island hot spring is located at the coastline opposite green island. * indicates minimum temperature due to partial submersion of the spring.*

Figure 6: *Sulfur mine (left) and Ladder Bay hot spring (right - photo Kai Wulf) at Saba.*

Conclusion

We plan to extend the monitoring effort at Saba and St. Eustatius by adding integrated geodetic observations (campaign and continuous GPS) and temperature measurements of the hot springs/wells. An improved geophysical characterization of the islands is of great importance both for the population and local governments. These combined efforts will greatly improve the chance to observe the onset and follow the evolution of a future volcanic crisis.

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