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and Water Management*

Project Title: Volcano Ambient Noise Interferometry in the Caribbean (VANIC)
Host RI: The Guadaloupe Volcanological and Seismological Observatory (IPGP; OVSG)

PI: Reinoud Sleeman (KNMI, Netherlands)
Visit: 2 - 5 December 2019

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Motivation:

Volcanoes of the Lesser Antilles are often monitored with a sparse seismic network.

Such networks can however be used to monitor seismic velocity variations using the ambient noise interferometry technique.

Objectives:

a) Apply different types of ambient noise cross correlations (e.g. single station vs. multiple stations; auto, cross and cross-component correlations) on Guadeloupe seismic network GL.

b) Compare results with baseline data from the Caribbean Netherlands network NA.

c) Foster collaboration between OVSG and KNMI on monitoring and research of volcanoes in the Lesser Antilles.

Caribbean and Lesser Antilles volcanic arc

Volcanoes of the Lesser Antilles can erupt very violently.

Mt. Scenery (Saba) and The Quill (St. Eustatius): (very) high volcanic threat (de Zeeuw-van Dalfsen & Sleeman (2018))
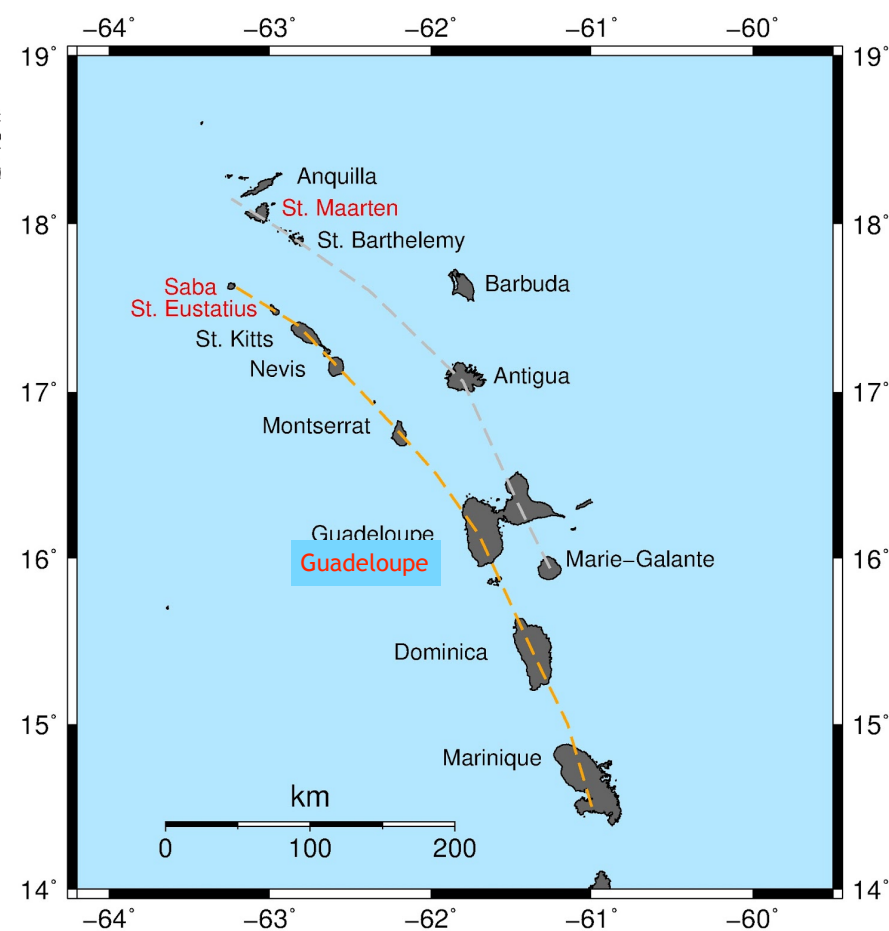
Northern part of the active volcanic arc of the Lesser Antilles

Ambient noise correlation: implementation

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Data quality selection (extremely important !):

- Discard corrupted data (e.g large number of gaps, tilted sensor)
- Identify and discard waveforms with changed characteristics (e.g. due to changed site conditions)
- Identify and discard data with timing problems (e.g. GPS)

Workflow MSNoise (Lecocq et al., 2014):

- Time series sample alignment
- Interpolate remaining gaps
- Apply bandpass filter [0.05 - 14 Hz]
- Pre-whitening of amplitude spectra
- Compute cross correlations
- Averaging correlations by linear stacking [2, 5, 10 days; reference stack]
- Moving-Window Cross-Spectral method (MWCS) - measure time delay
- Velocity variations form time delay: $dv/v = - dt/t$
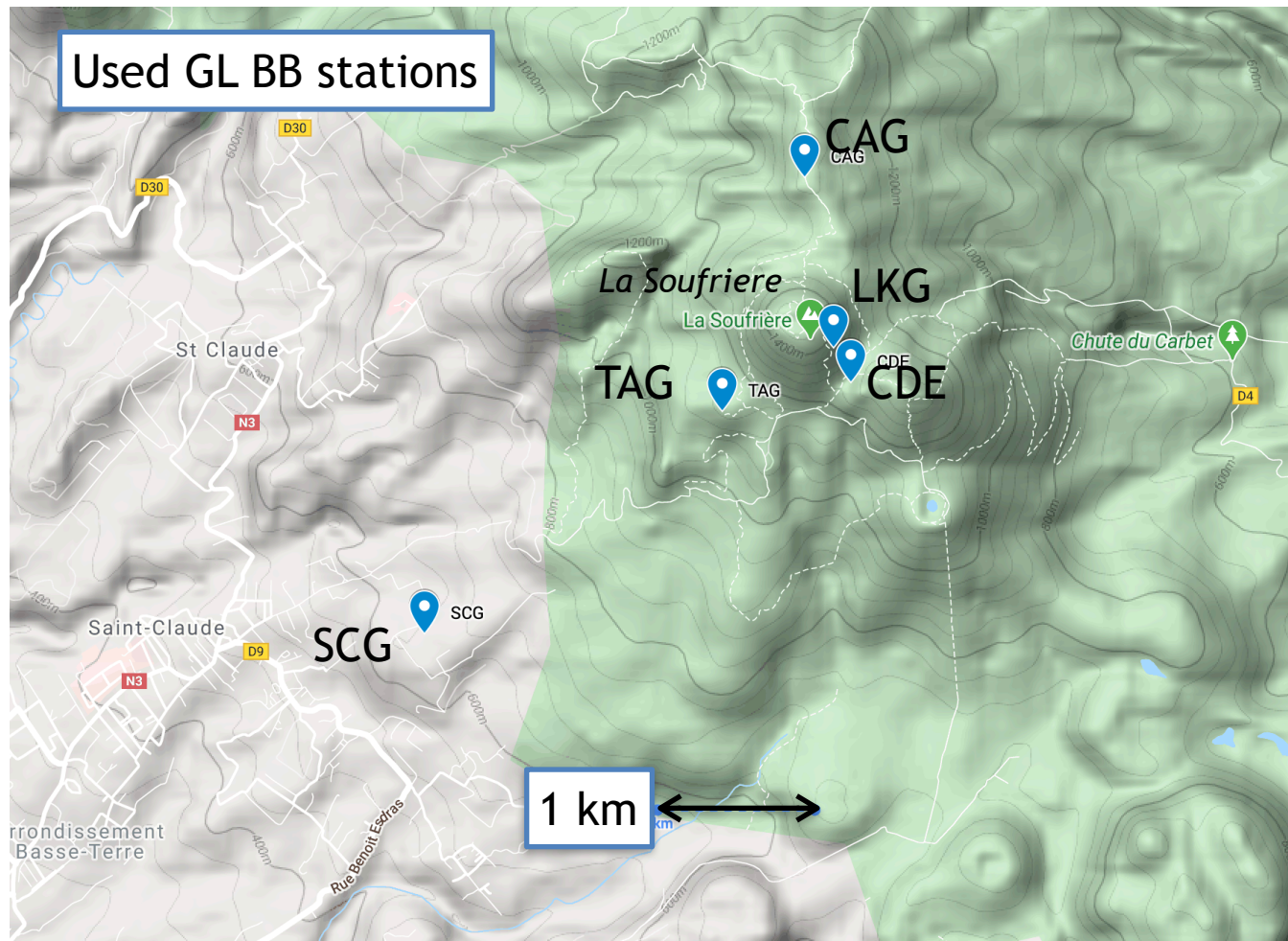
Data quality of GL network BB sensors

• Noise, represented as Power Spectral Density of the ambient noise vs. time, at 3 frequencies:

    Blue: 0.1 Hz
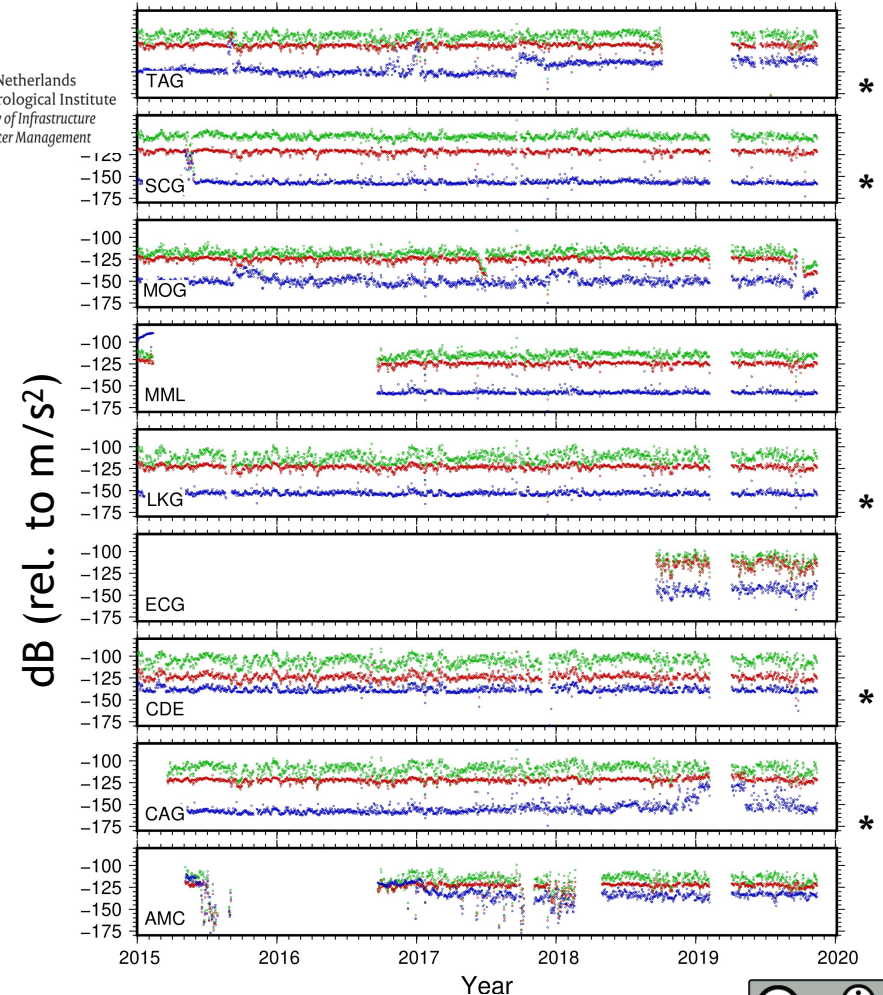   Red: 1   Hz
    Green: 10 Hz

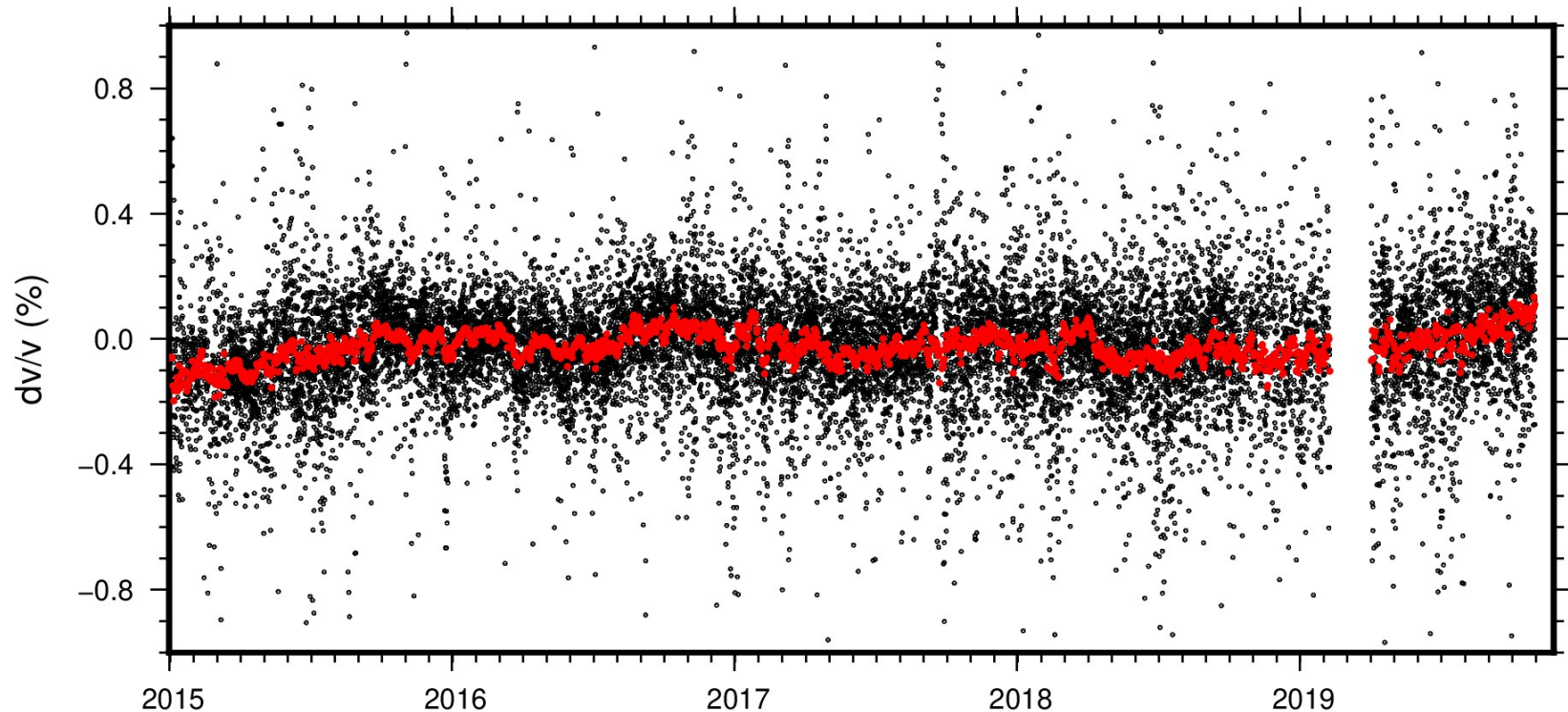• Overall:

    Stable noise level
    No indication of significant data quality losses
    Data gaps (e.g. 2019) filled during visit.

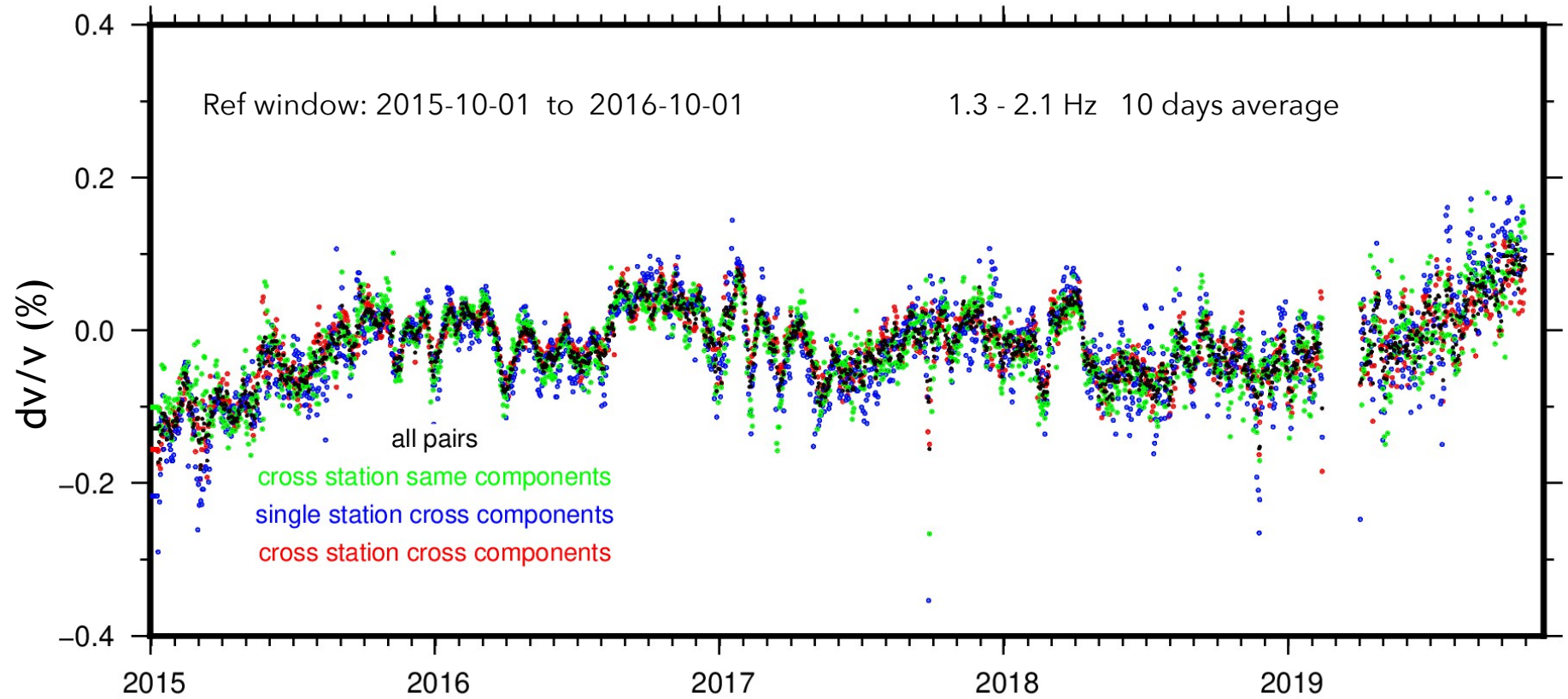(*) TAG, SCG, LKG, CDE, CAG used in this project for their availability over ~ 5 years

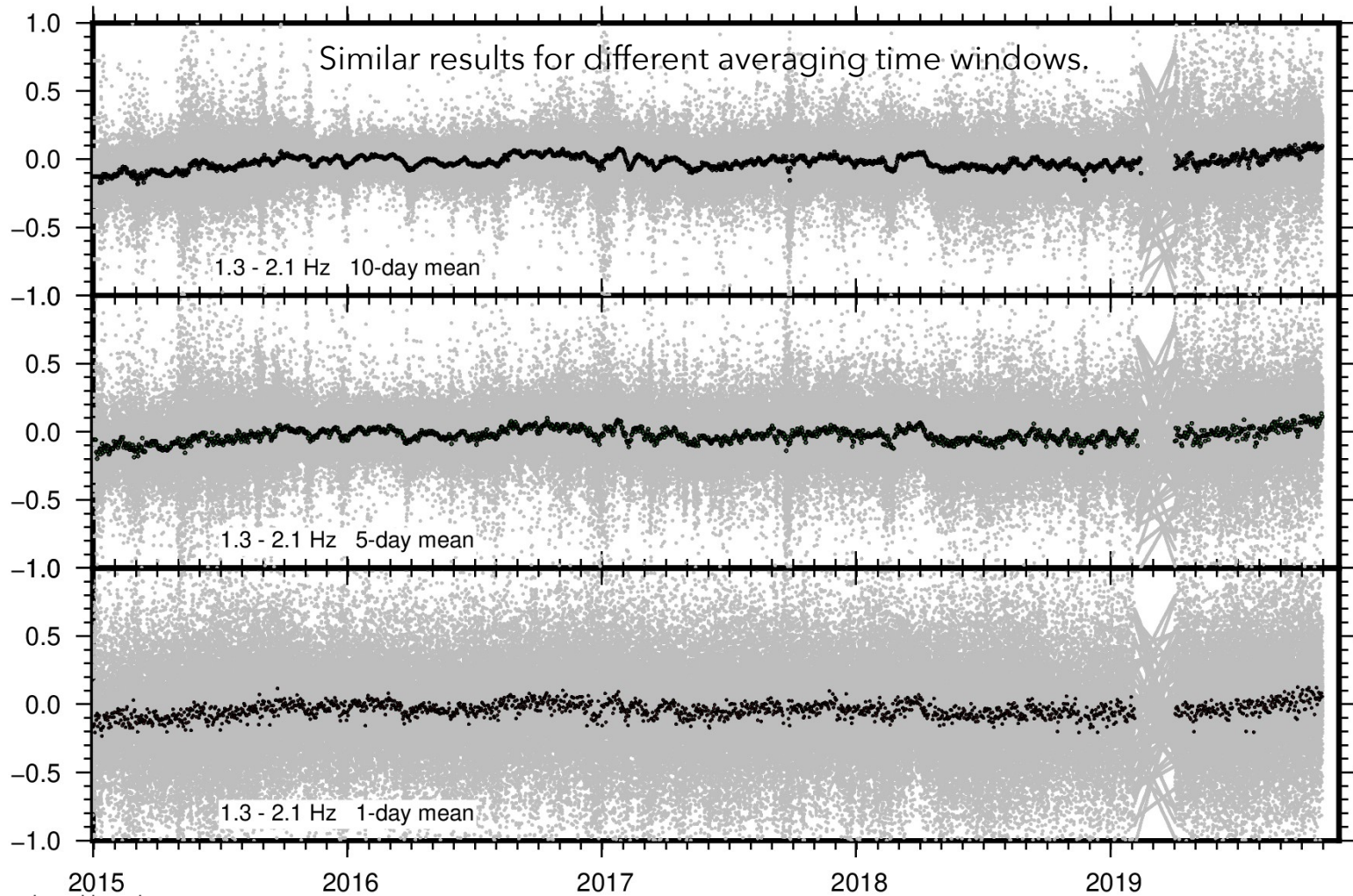Seismic velocity variations GL data (and daily mean in red) in 1.3 - 2.1 Hz.

La Soufriere: steady increase of dv/v in 2015 and 2019, no clear annual variation.

Average seismic velocity variations GL data arranged by pair type.

Ref window: 2015-10-01 to 2016-10-01   1.3 - 2.1 Hz   10 days average

all pairs

cross station same components

single station cross components

cross station cross components

Similar results in dv/v obtained from cross correlating different pairs of sensors/components.

Similar results for different averaging time windows.

1.3 - 2.1 Hz   10-day mean

1.3 - 2.1 Hz   5-day mean

1.3 - 2.1 Hz   1-day mean

Seismic velocity variations derived from BB data at St. Maarten, St. Eustatius and Saba in 1.3 - 2.1 Hz.
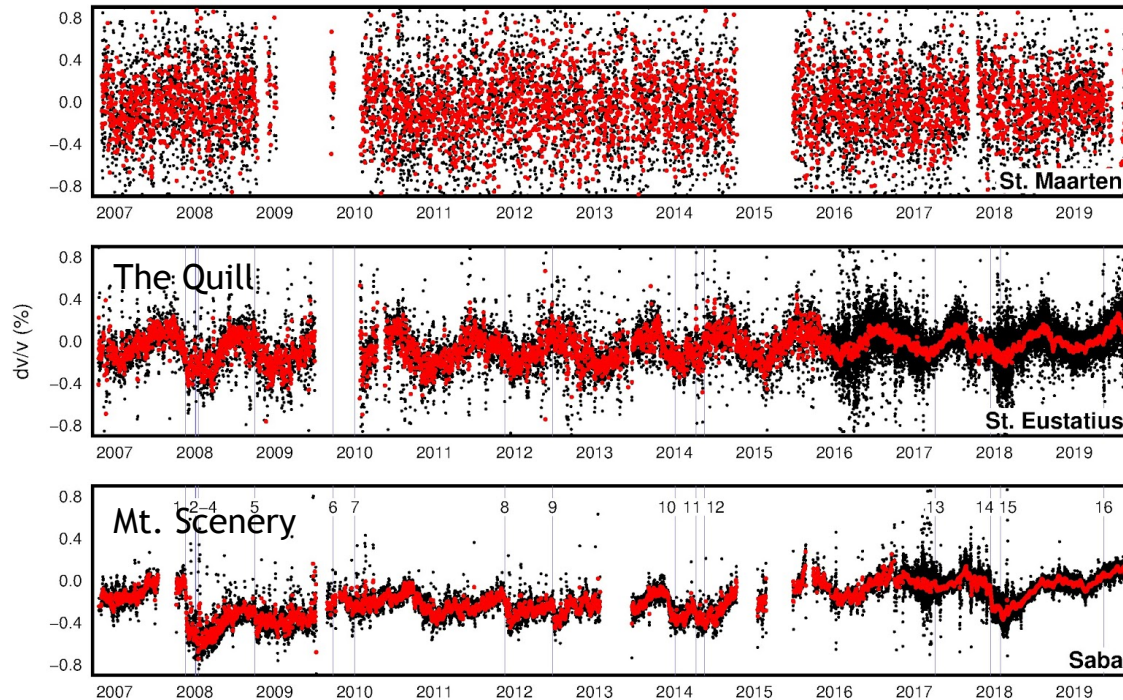
seismic sources may not be distributed homogeneously

dv/v dominated by air temperature variations

dv/v characterized by co-seismic drops

Figure from: "Cross-correlation analysis of long-term ambient seismic noise recordings in the Caribbean Netherlands to monitor the volcanoes on Saba and St. Eustatius" - R. Sleeman and E. De Zeeuw-van Dalfsen (*accepted BSSA, 2020*).

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Achievements:

• Data collection, selection and completeness
• Data quality characteristics and station site characteristics
• Data preparation and initial processing
• Access to IPGP/OVSG earthquake waveform database

Preliminary results/conclusions:

• Velocity variations (dv/v) in La Soufriere, Mt. Scenery and The Quill: similar amplitudes, different characteristics (1.3 - 2.1 Hz).
• La Soufriere: steady increase of dv/v in 2015 and 2019, no clear annual variation.
• Similar results in dv/v obtained from cross correlating different pairs of sensors/components.
• The Quill: dv/v dominated by air temperature variations(Sleeman & de Zeeuw-van Dalfsen, 2020).
• Mt. Scenery: dv/v characterized by co-seismic drops (Sleeman & de Zeeuw-van Dalfsen, 2020).

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The PI thanks

EuroVolc

to provide Transnational Access opportunities

and OVSG and IPGP

for their hospitality and support

during the visit to the facility in Guadeloupe !

<u>*Stay at OVSG:*</u>

- *Excellent facility to work*
- *Very supportive and friendly group of experts*
- *Open access to raw seismic data and volcanic earthquake waveforms*
- *Excellent organization (e.g. logistics, transport, administration, support) by IPGP and OVSG*