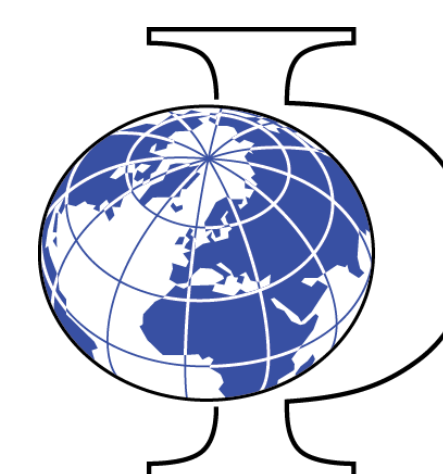




Variation of SO₂ and CO₂ in the volcanic gas plumes of Santa Ana and San Miguel volcanoes: an overview by real-time measurements

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Introduction and Motivation

Volcanic gas monitoring aims to track changes in chemical composition and gas fluxes released from a volcano in order to elucidate precursory signals of magma rise by in-situ and remote-sensing measurements. In this research, we applied:

- Portable Multicomponent gas analyzer systems (MultiGAS)
- Differential Optical Absorption Spectrometers (DOAS) from stations that are part of the Network for Observation of Volcanic and Atmospheric Change (NOVAC)

Focus of this study:

The aim of this research is to extend the characterization of Santa Ana and San Miguel volcanoes and the establishment of SO₂ and CO₂ inventories for them since they are the most active volcanoes in El Salvador, with only a few published gas data.

Methods

Method 1: SO₂ emission rates were acquired by the DOAS stations installed at the SW flank of Santa Ana and San Miguel volcanoes (Figure 1). Each instrument acquires spectra during daylight hours (6:00–18:00) using UV-scattered sunlight in a vertical plane of 180°. The long-term data evaluation is based on Dinger et al. 2018.

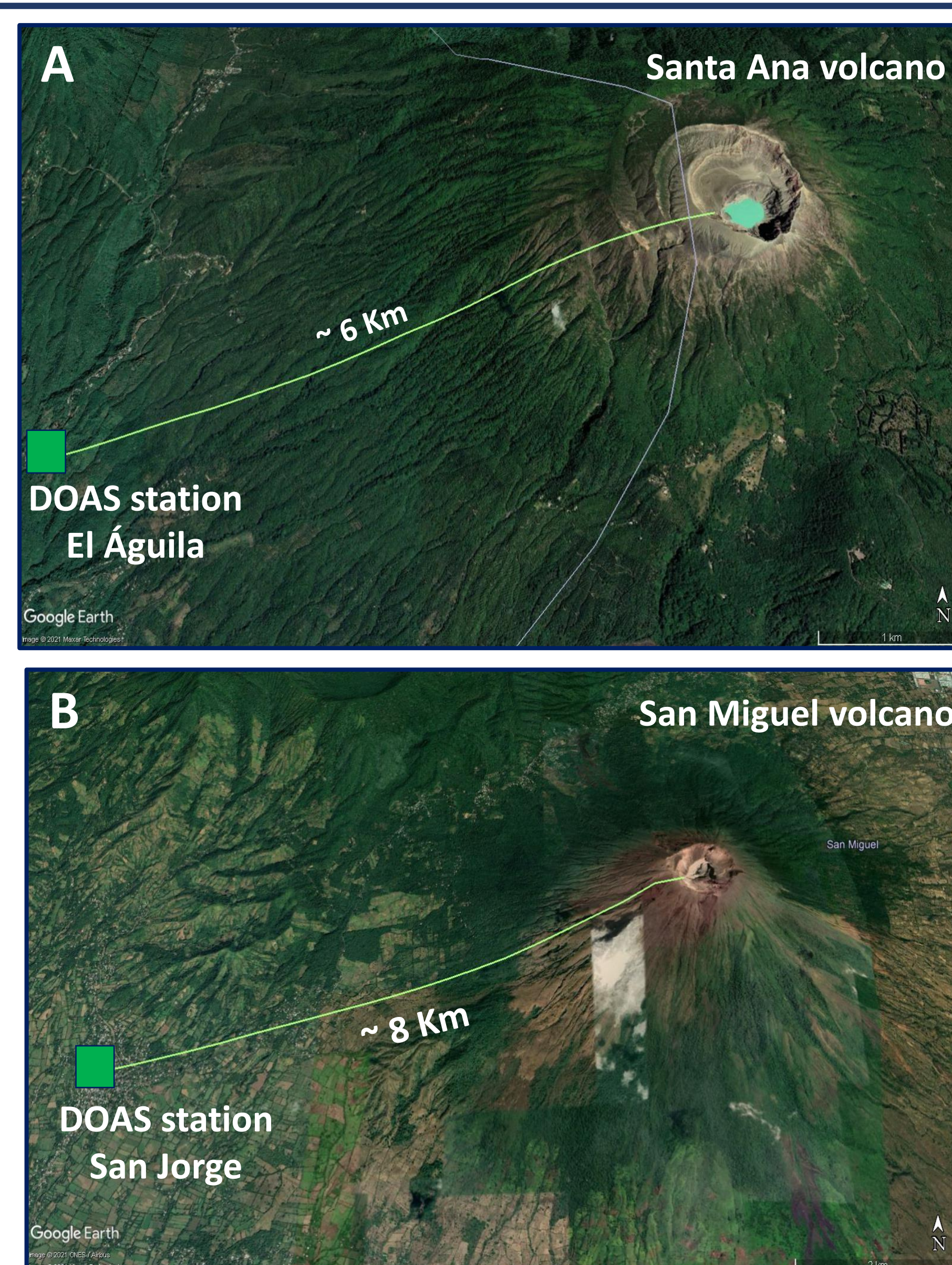


Figure 1. (A) Santa Ana and (B) San Miguel volcanoes with the location of their DOAS stations.

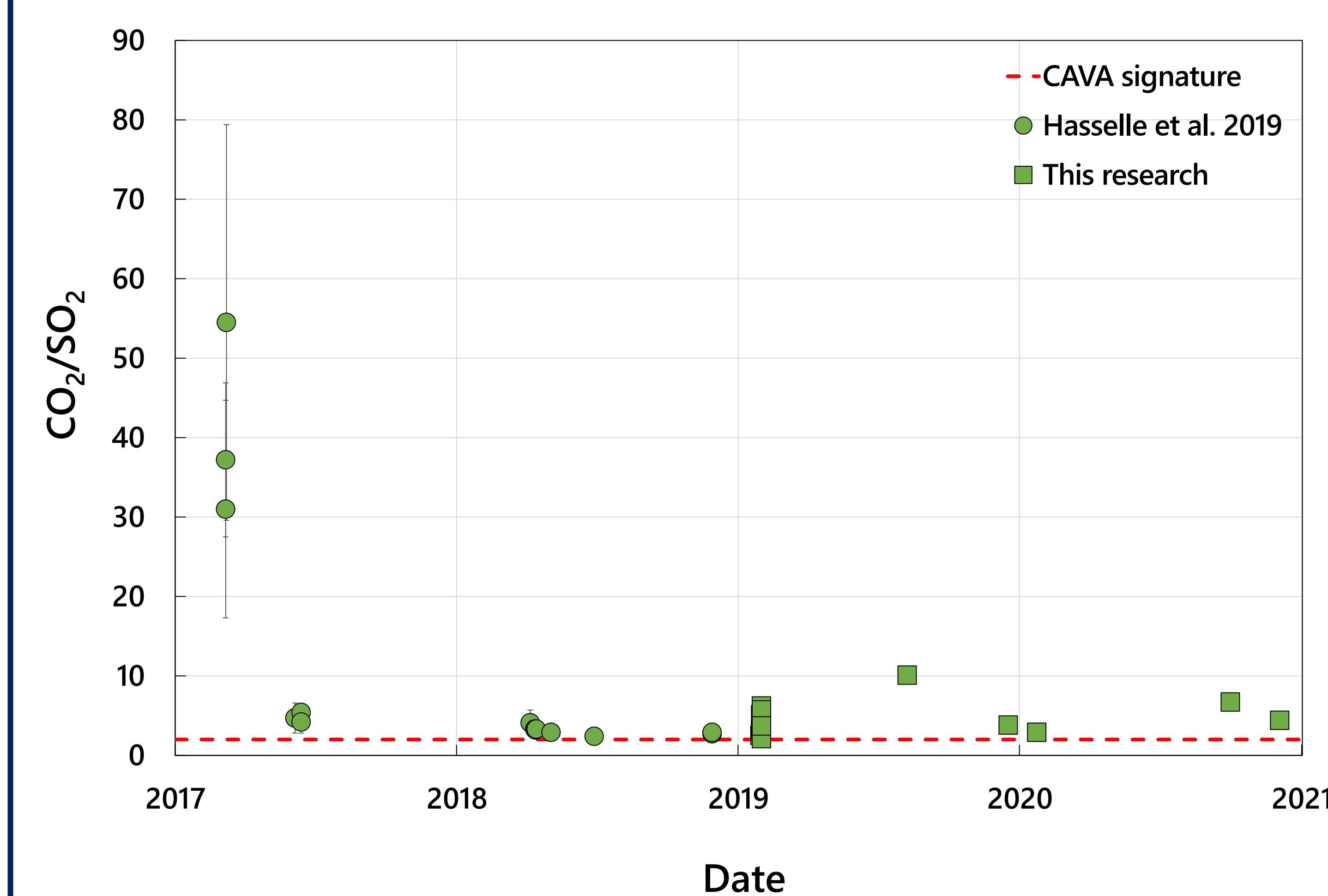
Method 2: MultiGAS devices were used at the summit of both volcanoes for the direct measurement of SO₂ and CO₂ at locations chosen according to accessibility and dominant wind direction, during regular monitoring (2018–2020) and field campaigns in El Salvador (2019 and 2020). All the data were post-processed using RatioCalc program (Tamburello 2015).



Figure 2. Portable MultiGAS system used for measurements at San Miguel volcano's rim in December 2020.

Results

Santa Ana volcano



San Miguel volcano

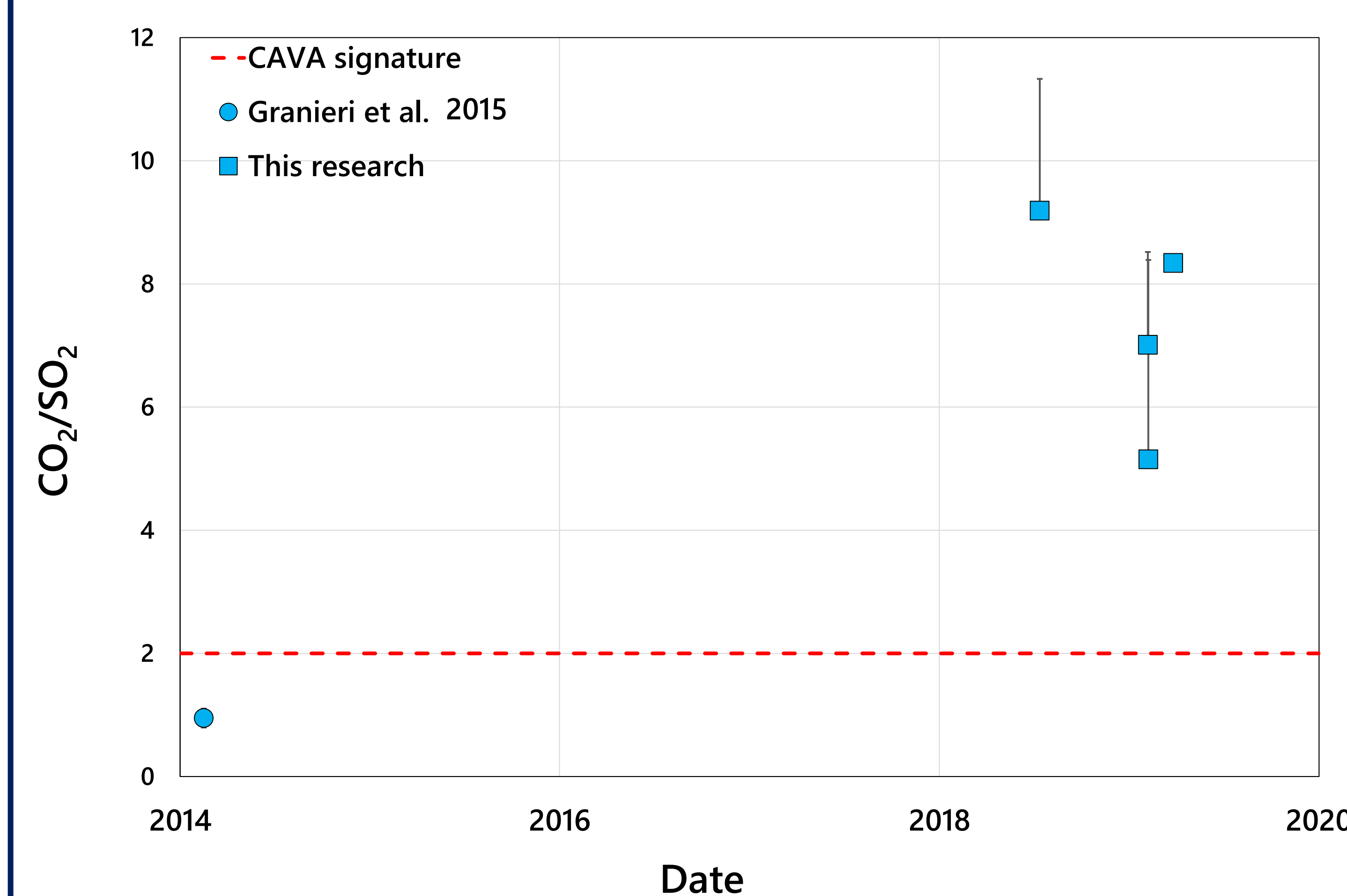


Figure 3. SO₂/CO₂ mixing ratios obtained during this research for each volcano compared with data obtained by other authors in previous years. Red dot line indicates the mean CO₂/SO₂ signature of Central American Volcanic Arc – CAVA volcanism given by Aiuppa et al. 2017.

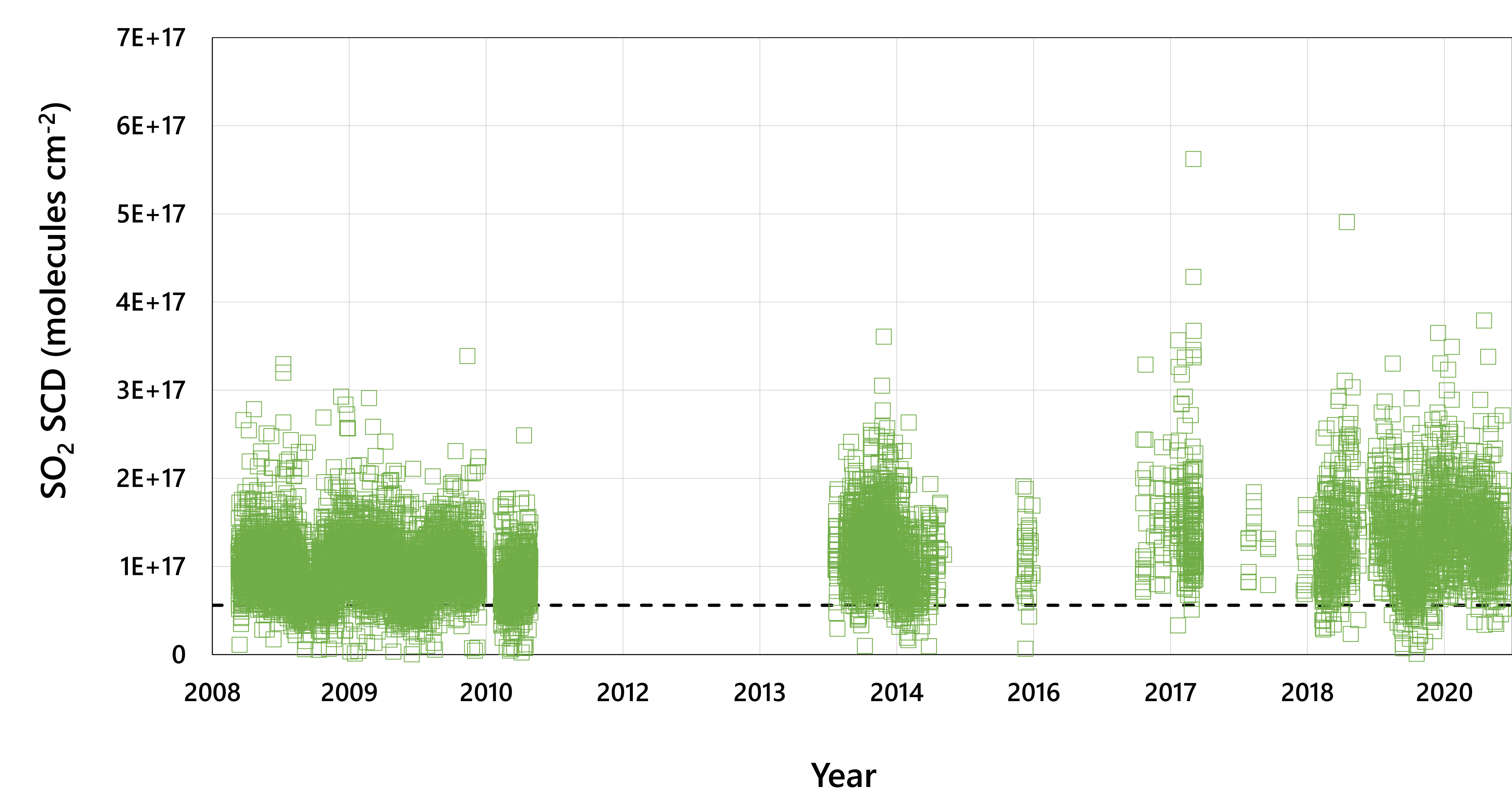
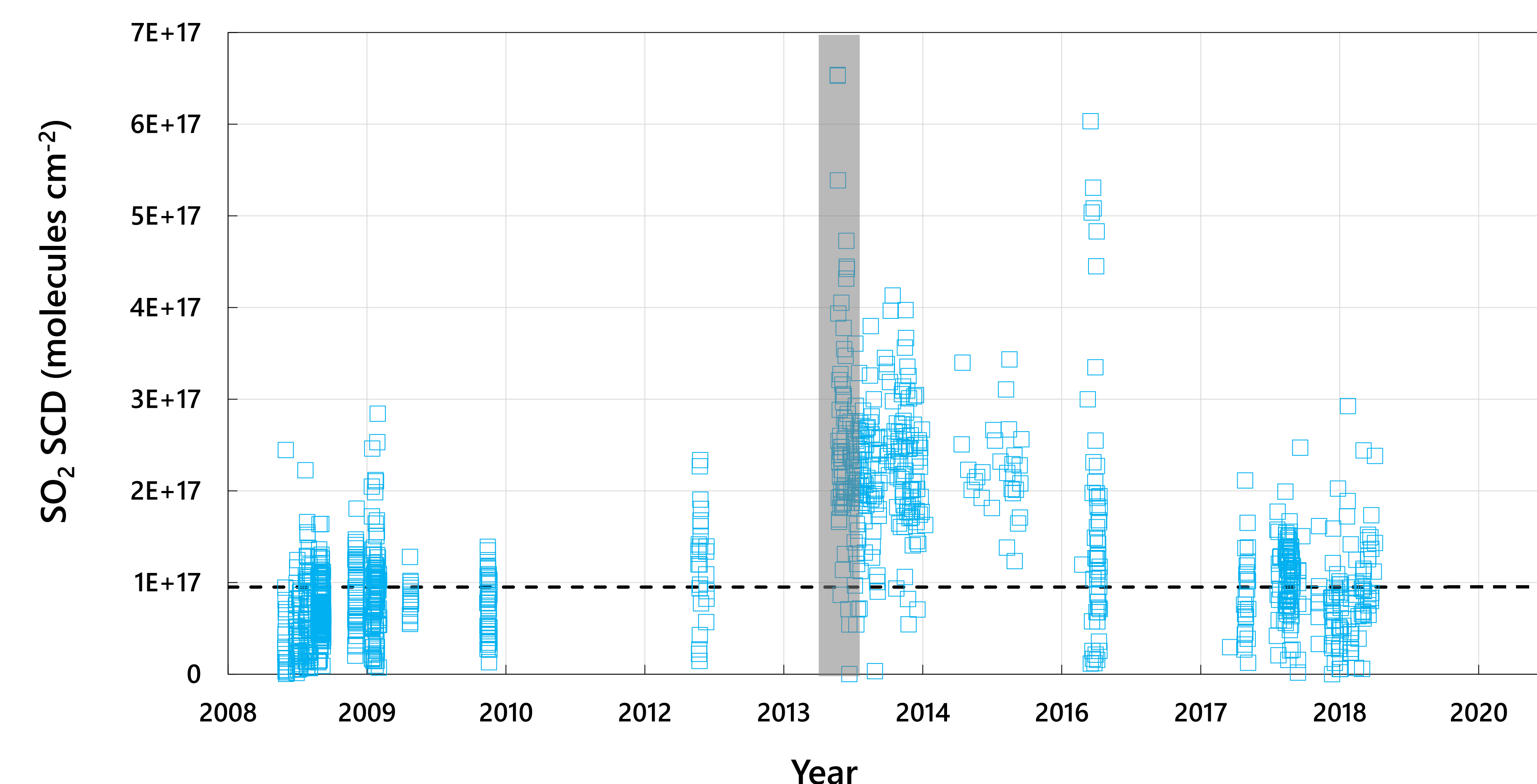


Figure 4. Time series of slant column densities (SCD's) of SO₂ in the plume emitted by Santa Ana (top – green squares) and San Miguel (bottom – light blue squares) volcanoes, obtained from the Scanning-DOAS recorded spectra. Dash black lines indicate the limit of detection (LOD) for each volcano. Gray shadow indicates period after eruption.

Summary

- At Santa Ana observed CO₂/SO₂ ratios range from 1.9 to 11.8, while San Miguel ratios range from 5.1 to 11.1. In both cases, a more CO₂-rich composition than the mean CO₂/SO₂ ratio for the CAVA is observed (Figure 3).
- CO₂/SO₂ ratios for Santa Ana, corresponding to the period 2019–2020, are in agreement with the data presented by Hasselle et al. 2019 for measurements performed in 2018. However, it differs greatly with the data presented by the same author for measurements done in 2017, where it is discussed that these high values are due to an increase in the gas supply from the magmatic/hydrothermal system. Unfortunately, there is no DOAS data available for that period (March 2017).
- Mean SO₂ emission rates for the period presented in this research for Santa Ana and San Miguel are 1.1 x 10¹⁷ molecules cm⁻² with 5.7 x 10¹⁶ molecules cm⁻² LOD and, 1.3 x 10¹⁷ molecules cm⁻² with 9.5 x 10¹⁶ molecules cm⁻² LOD, respectively.
- San Miguel volcano shows a strong degassing (> 4.0 x 10¹⁷ molecules cm⁻²) in the following years after the 2013 eruption (gray shadow in Figure 4). Low CO₂/SO₂ ratio was measured in this period, hypothesized by Granieri et al. 2015 as a consequence of the high SO₂ emissions. Nevertheless, higher ratios are observed for the quiescent period between 2017 to 2019 (7.4 ± 1.8 CO₂/SO₂).

Future work

- Calculation of SO₂ and CO₂ fluxes
- Analyze halogens data set to improve the characterization of the volcanoes

References

- [1] Aiuppa et al. (2017), Earth-Science Reviews 168, 24–47, [2] Dinger F. et al (2018), Solid Earth, 9, 247–266, [3] Hasselle et al. (2019), Bull Volcanol 81, 66, [5] Granieri, D., et al. (2015), Geophys. Res. Lett., 42, 5847–5854