



VEÐURSTOFA ÍSLANDS

1920-2020

– vísindi á vakt



# SO<sub>2</sub> flux measurements during the 2021 eruption of Fagradalsfjall

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# DOAS- UV Spectrometer

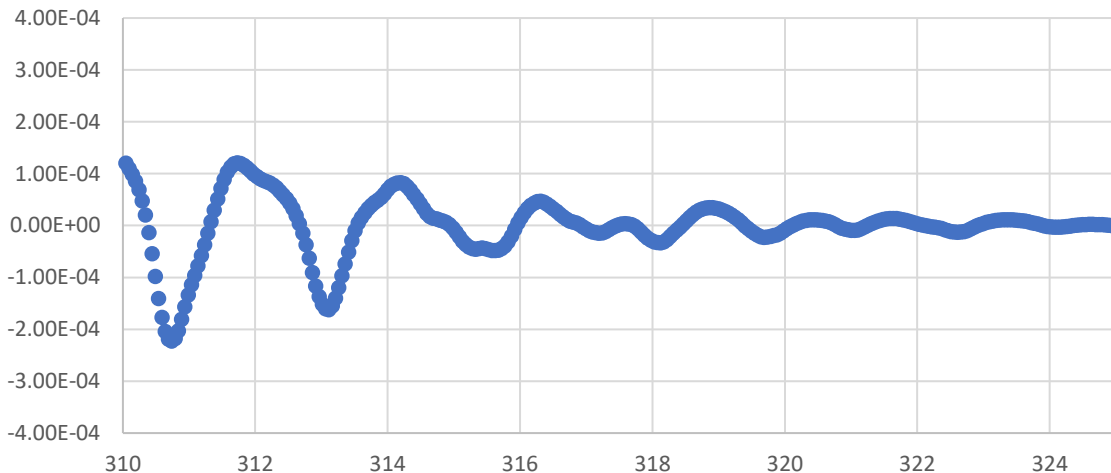
## Differential Optical Absorption Spectrometry

**SO<sub>2</sub> can be identified by its molecular absorption structures in UV spectral regions**

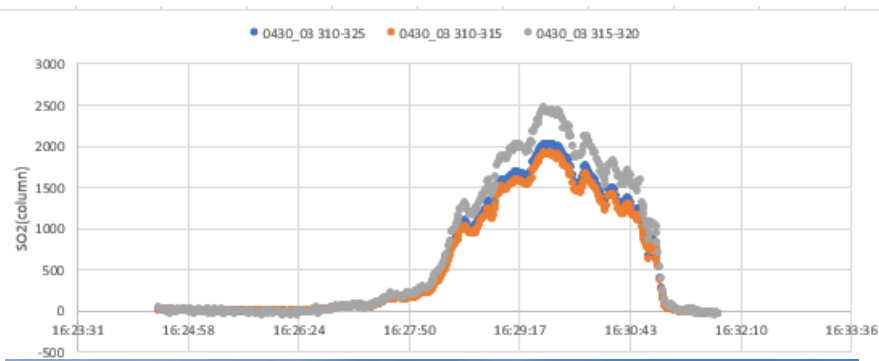
**Measurements only during sunlight**

**Very little SO<sub>2</sub> in clean, background atmosphere: relatively easy to identify deviations from background**

SO<sub>2</sub> reference spectrum

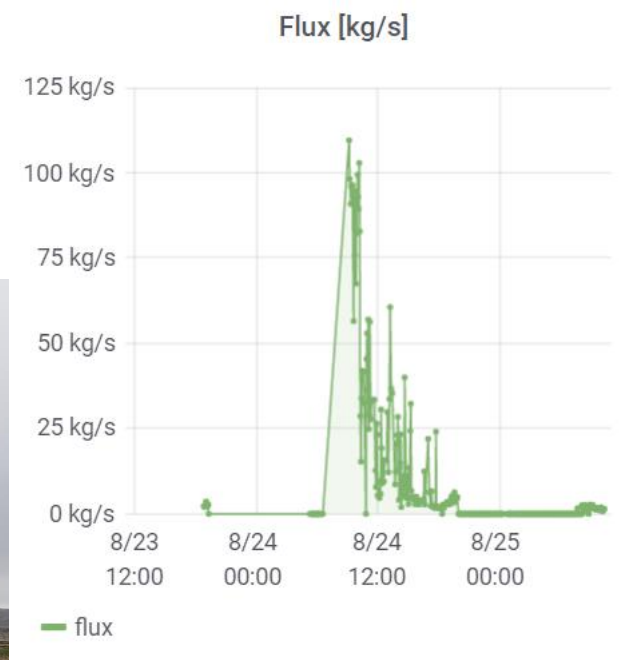
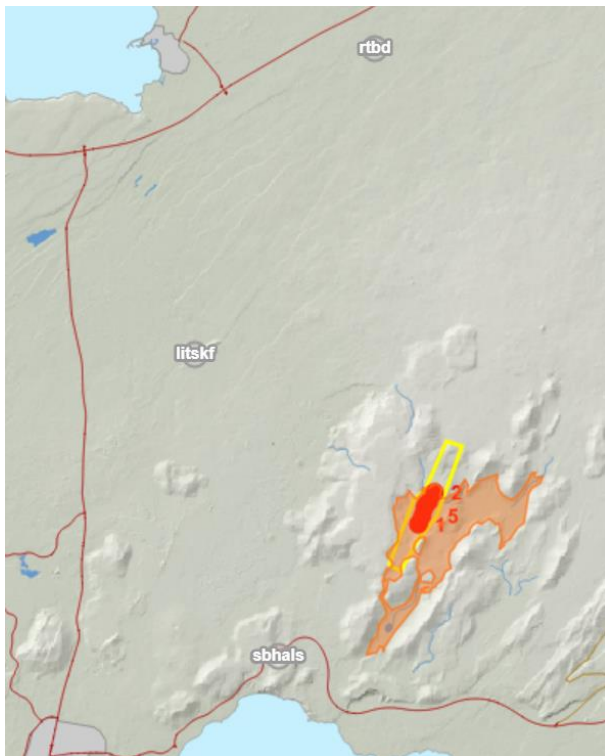


# DOAS- Traverses





# DOAS- Scanning instruments



# Best continuous wind data

Webcam image analysis: 1-1.3 km was common plume height

Scanners need wind data fed continuously and automatically- Harmonie

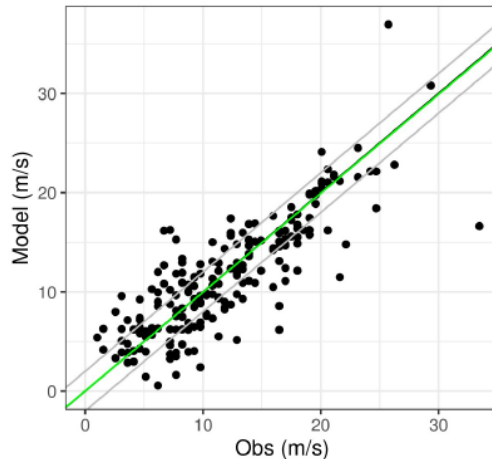
Keflavík radiosonde vs. HARMONIE-AROME  
12 hour forecast

Time period: All available data from 2021  
(201 data point)

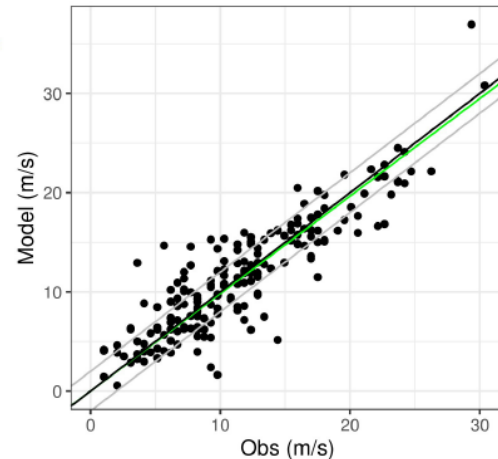
- 925 hPa (median 740 m a.s.l.)
- 850 hPa (median 1400 m a.s.l.)

Wind speed and wind direction better at 850 hPa so used this data for automatic SO<sub>2</sub> flux calculation from the scanners

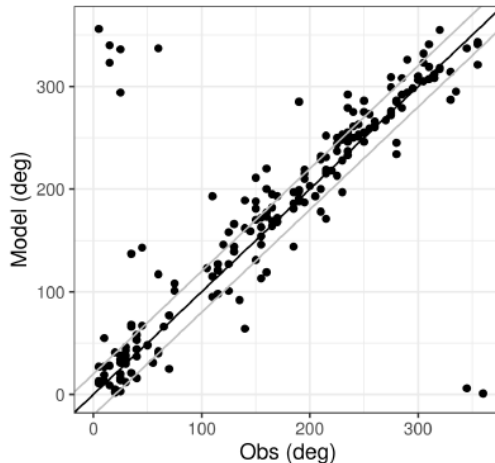
Wind speed at 925 hPa



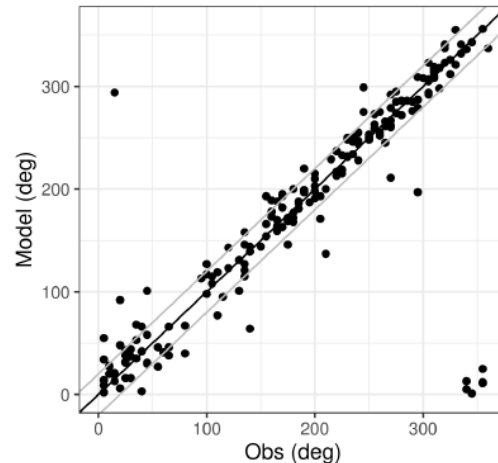
Wind speed at 850 hPa



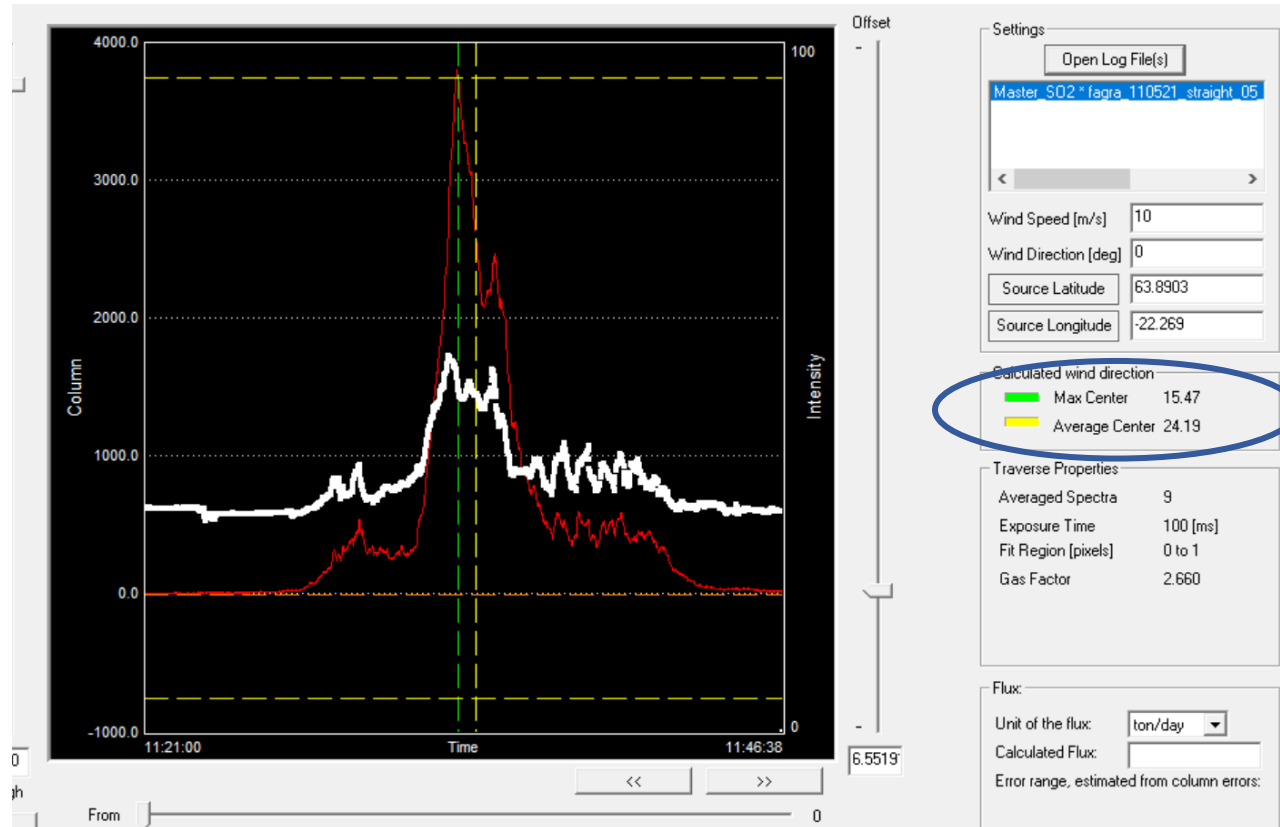
Wind direction at 925 hPa



Wind direction at 850 hPa



# Best wind data for the traverses



Traverse software provides dominant wind direction

This plus likely plume height used to select the best wind data:

- radiosonde
- ground stations
- Harmonie

End members of optimal wind speed and wind direction used to make:

Four flux calculations from each traverse

This attempts to constrain the uncertainty of each measurement

# Meteorological impacts on the calculations

UV SO<sub>2</sub> measurements can be affected by:

If the entire plume is not measured.

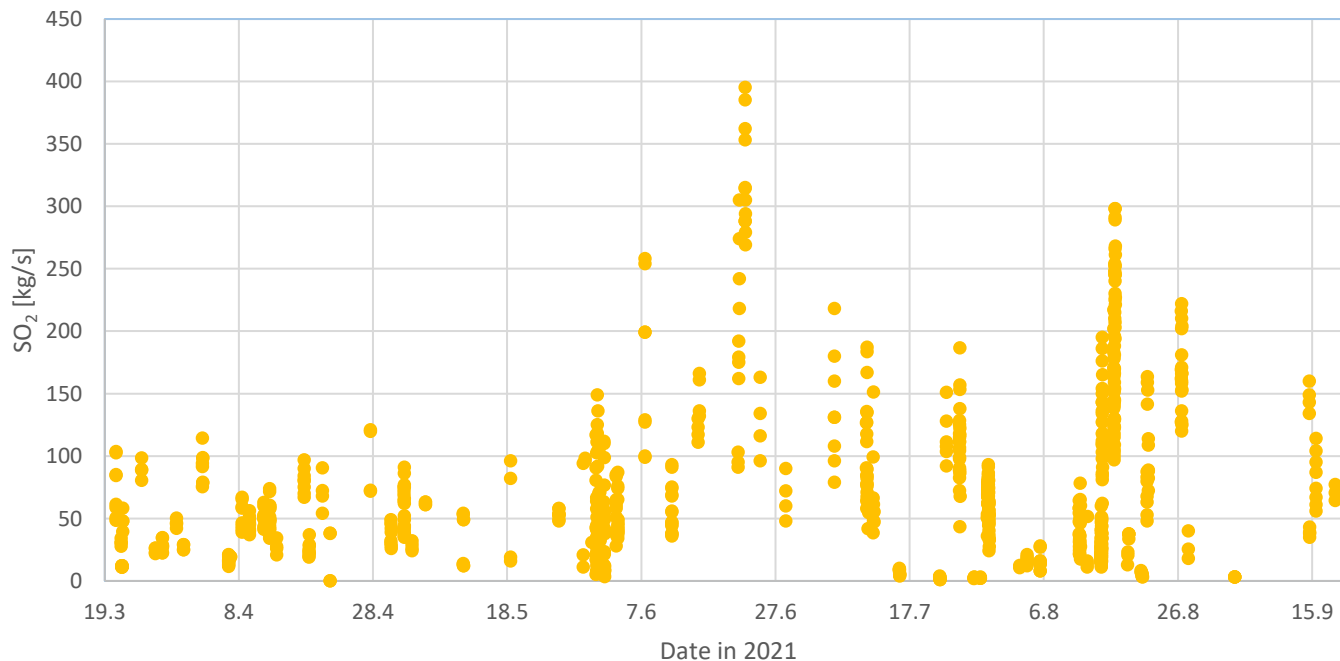
- The Harmonie wind direction was used to filter the data to include only measurements when the winds traveled from the eruption to the instrument +/- 15°
- Measurements also filtered based on software assessment of plume completeness  $\geq 0.8$  and if plume is peaking at the edge of the scan

If the SO<sub>2</sub> absorbance signals are diluted due to the scattering of ultraviolet light

- All available webcam data, both near the eruption and in the direction of the instrument, was looked at to remove times with full fog

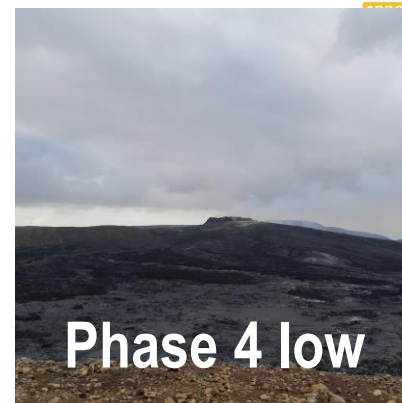
# All the SO<sub>2</sub> flux measurements that pass the quality checks

Time series of SO<sub>2</sub> flux measurements





# Behavior used to define phases



Eruption phases		Start	End
Phase 1	effusive eruption from one main fissure	19.3.2021 20:30:00	5.4.2021 11:49:00
Phase 2a	effusive eruption from up to 8 fissures + opening of new fissures	5.4.2021 11:49:00	14.4.2021 00:00:00
Phase 2b	effusive eruption from up to eight fissures	14.4.2021 00:00:00	27.4.2021 05:18:00
Phase 3a	lava fountains from one main vent	27.4.2021 05:18:00	2.5.2021 05:30:00
Phase 3b	pulsating lava fountains from one main vent	2.5.2021 05:30:00	11.5.2021 21:00:00
Phase 3c	outpouring of lava from the main crater with occasional lava fountains and persistent intra-crater activity	11.5.2021 21:00:00	28.6.2021 15:00:00
Phase 4a	intermittent activity in the crater with long repose time	28.6.2021 15:00:00	2.9.2021 16:45:00
Phase 4b off	off	2.9.2021 16:45:00	11.9.2021 07:00:00
Phase 4b on	intermittent activity in the crater with long repose time	11.9.2021 07:00:00	18.9.2021 14:00:00

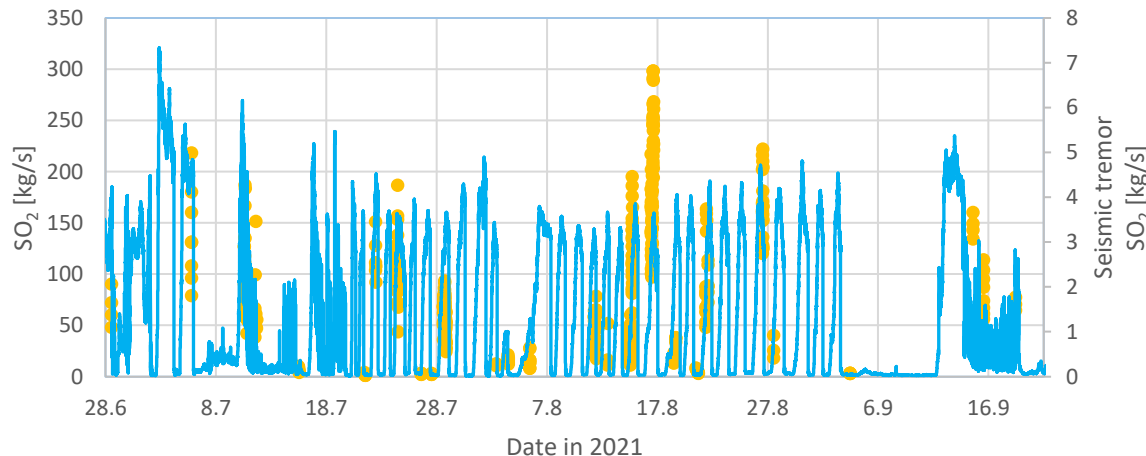
# Behavior used to define phases



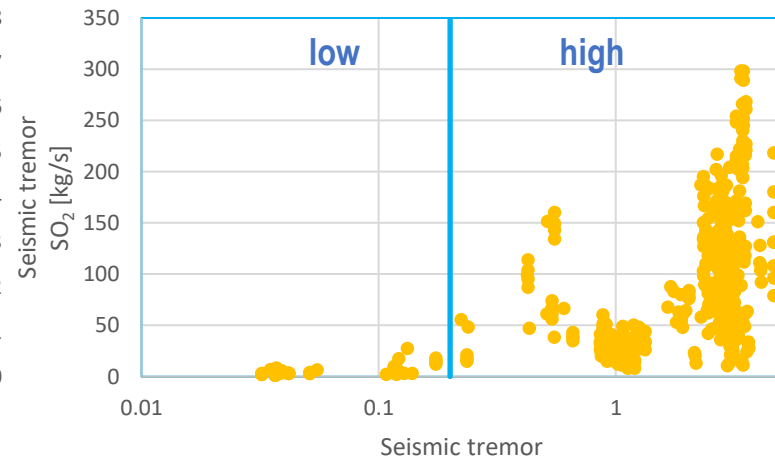
Phase 3

# Seismicity to constrain time of high/low degassing

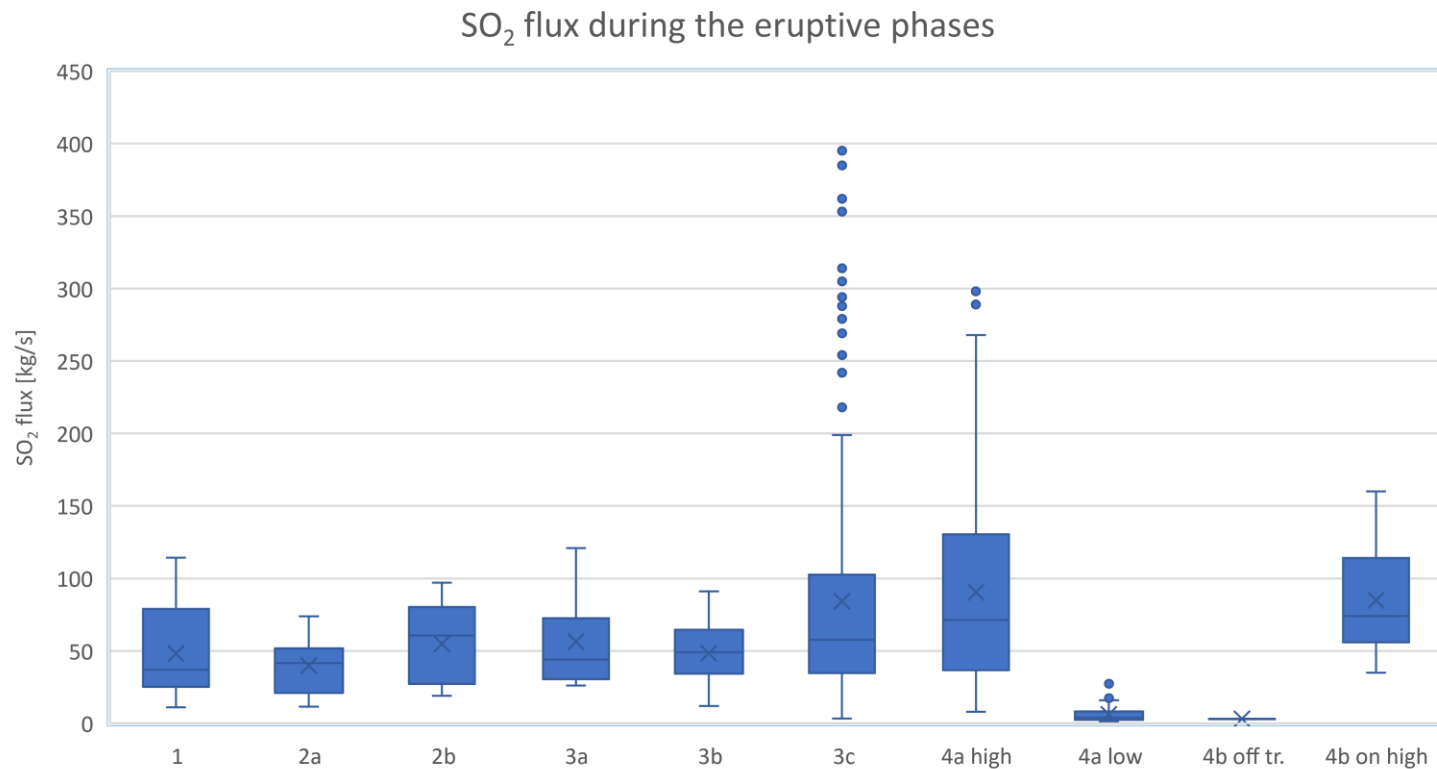
Phase 4 SO<sub>2</sub> flux measurements and seismicity



Phase 4 SO<sub>2</sub> flux and seismicity



# Eruption phases



# Total emissions of SO<sub>2</sub>

0.4 – 1.3 with a mean value of  
1 Mt SO<sub>2</sub>

Holuhraun:

6.7 – 14.3 with a mean value of  
9.6 Mt SO<sub>2</sub>

2019 Emissions from Iceland:  
0.058 Mt

1/10 Holuhraun

18 times Iceland's annual  
anthropogenic emissions  
(mostly H<sub>2</sub>S from electricity  
production)





Thank you!