

Imaging measurements of volcanic BrO using Fabry-Pérot interferometer correlation spectroscopy



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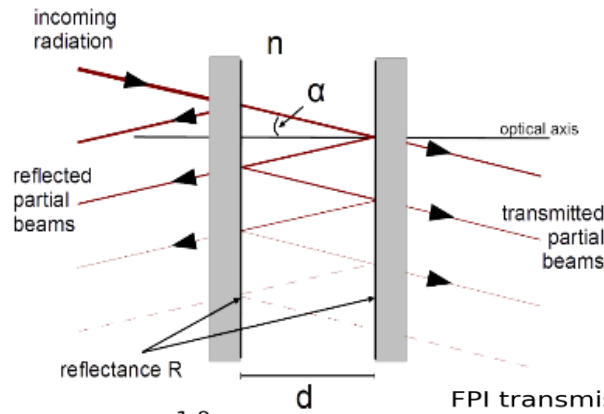
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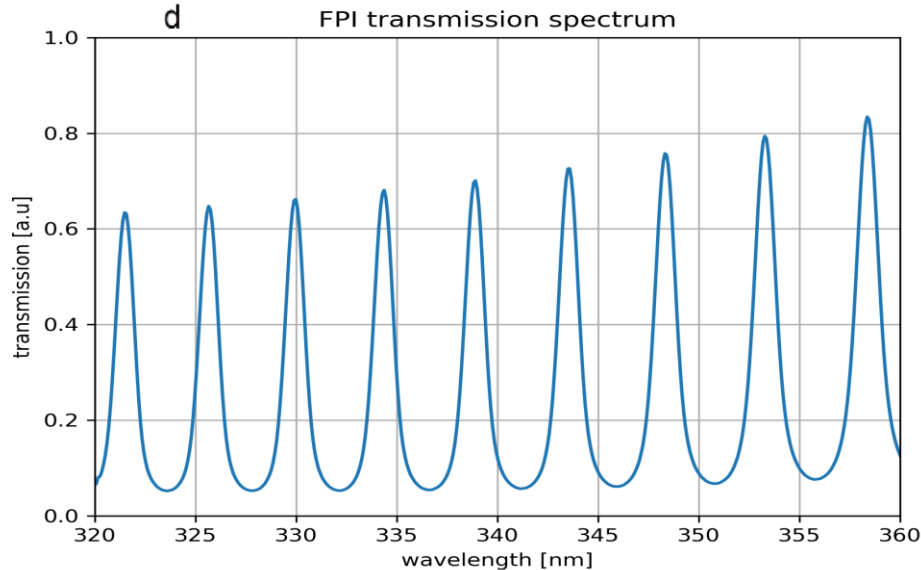
Imaging Fabry-Perot Interferometer Correlation Spectroscopy (IFPICS)



Fabry-Perot interferometer



Multiple reflections causing
interference pattern
→ Comb shaped transmission
spectrum

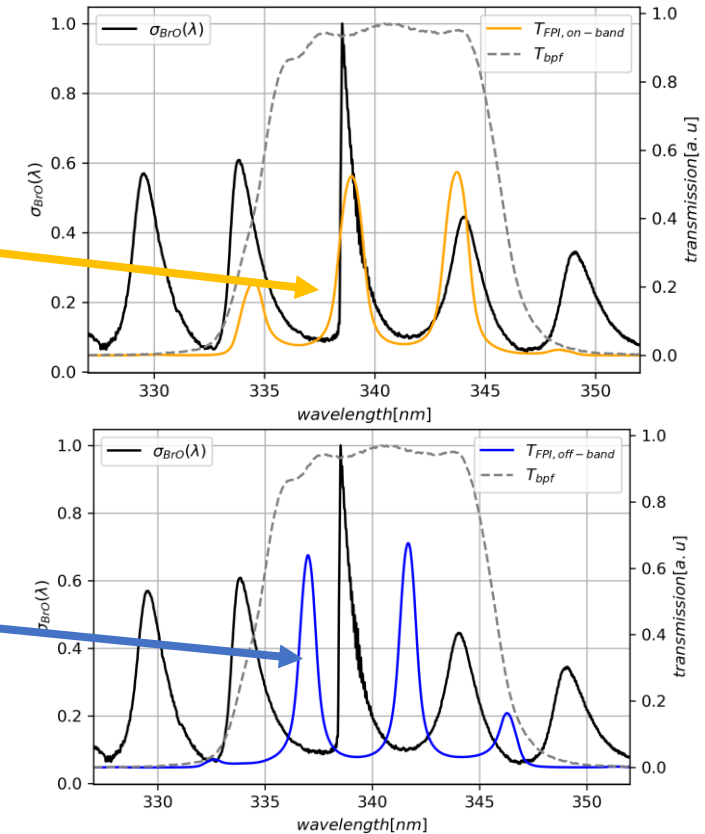


Trace gas detection

Transmission at max.
BrO absorption
(position A)



Transmission at min.
BrO absorption
(position B)



Differential evaluation of on-band and off-band setting
→ column density of target trace gas



Evaluation challenges



Plume speed limit:

Wind direction



Image in FPI
position A

Image in FPI
position B

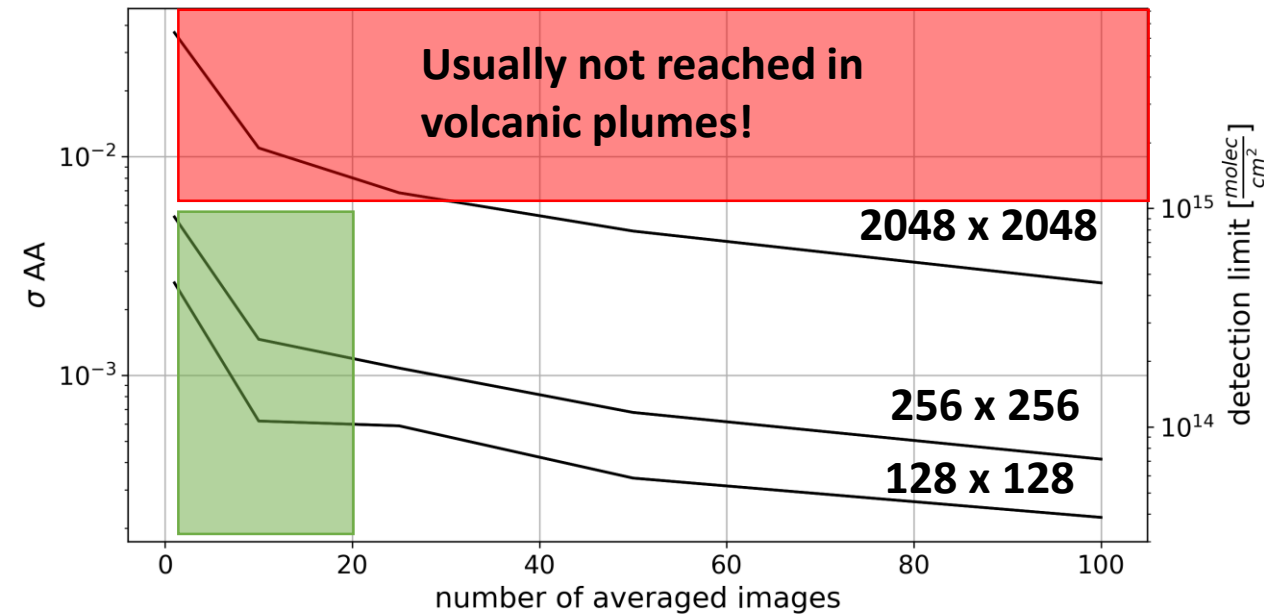
$\Delta t = 0.3 \text{ s}$

IFPICS

Solutions:

1. Higher frame rate (now: **2 frames per second**)
2. Optical flow correction

Noise Limit:



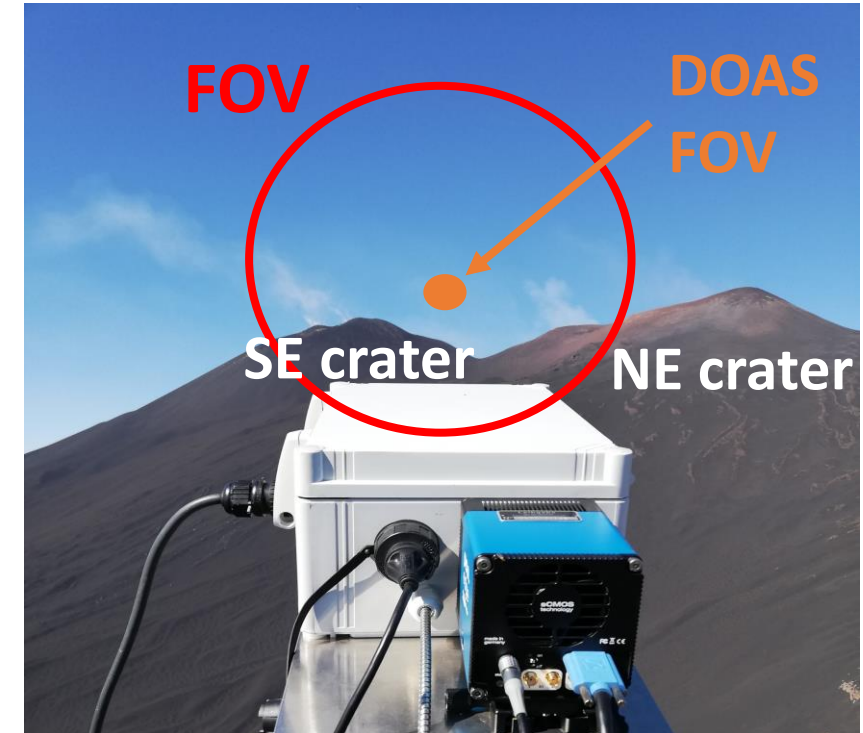
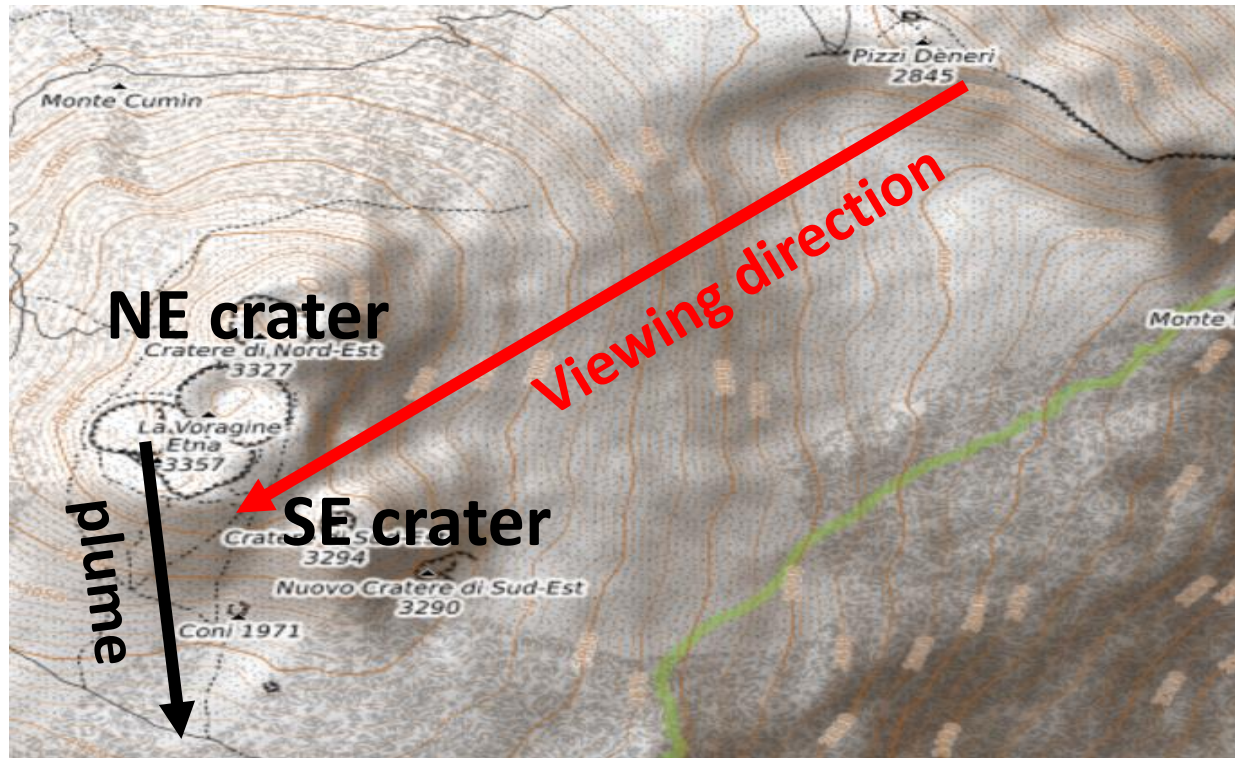
- Determining instrument signal of clear sky under field conditions
- Detection limit $\approx 1 \times 10^{14} \text{ molec/cm}^2$ for a time resolution of 10 s and 200 x 200 pixel



Measurement at Mt Etna 24.07.2021



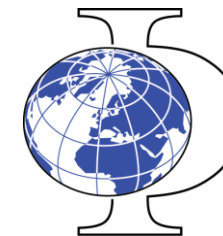
- Location: 37 ° 45' 53" N, 15 ° 01' 02" W (2900 m A.S.L.)
- Camera viewing direction: 205° SW, 18° elevation
- Camera field of view (FOV): 17°
- 2500 images with an integration time of 0.6 s per image



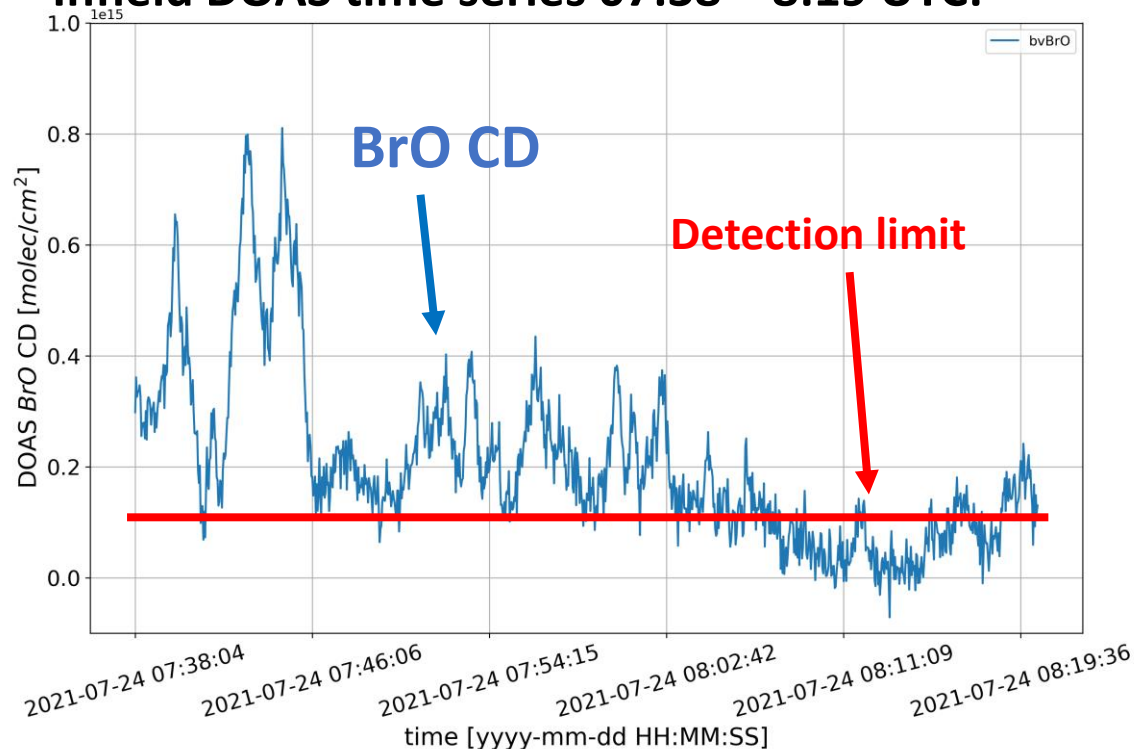
FOV: camera field of view
DOAS FOV: infield DOAS field of view
SE crater: south eastern crater
NE crater: north eastern crater



BrO detection

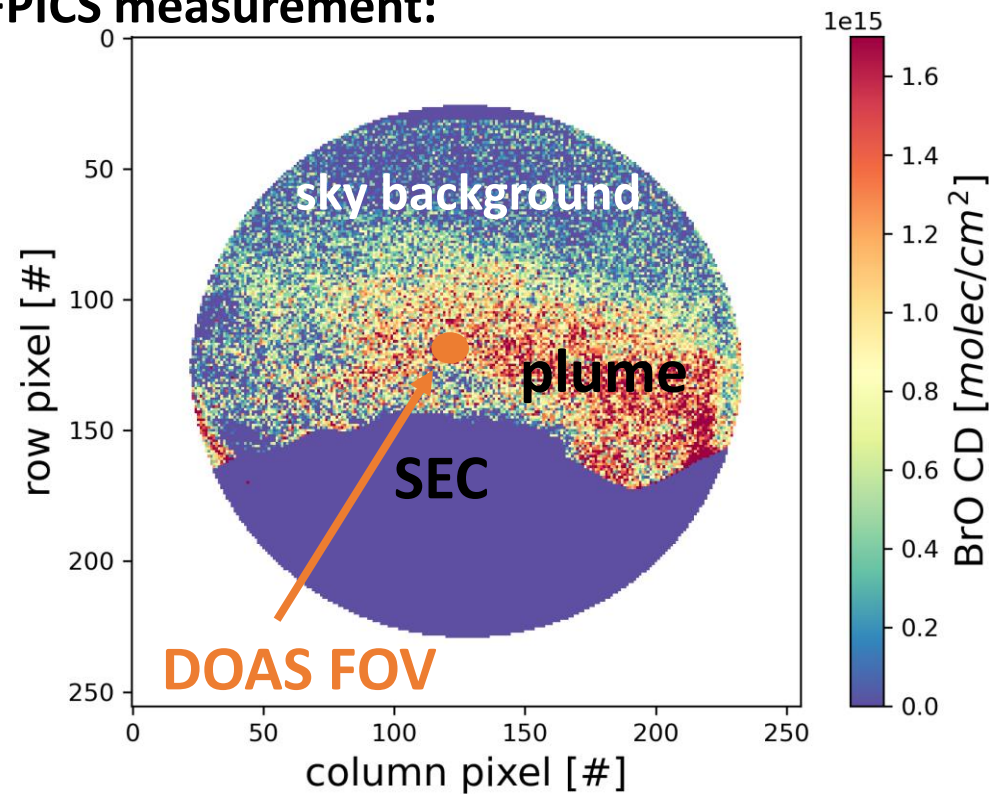


Infield DOAS time series 07:38 – 8:19 UTC:



- Used for validation and calibration
- BrO column densities in the range of **1 – 8 x 10¹⁴ molec/cm²**

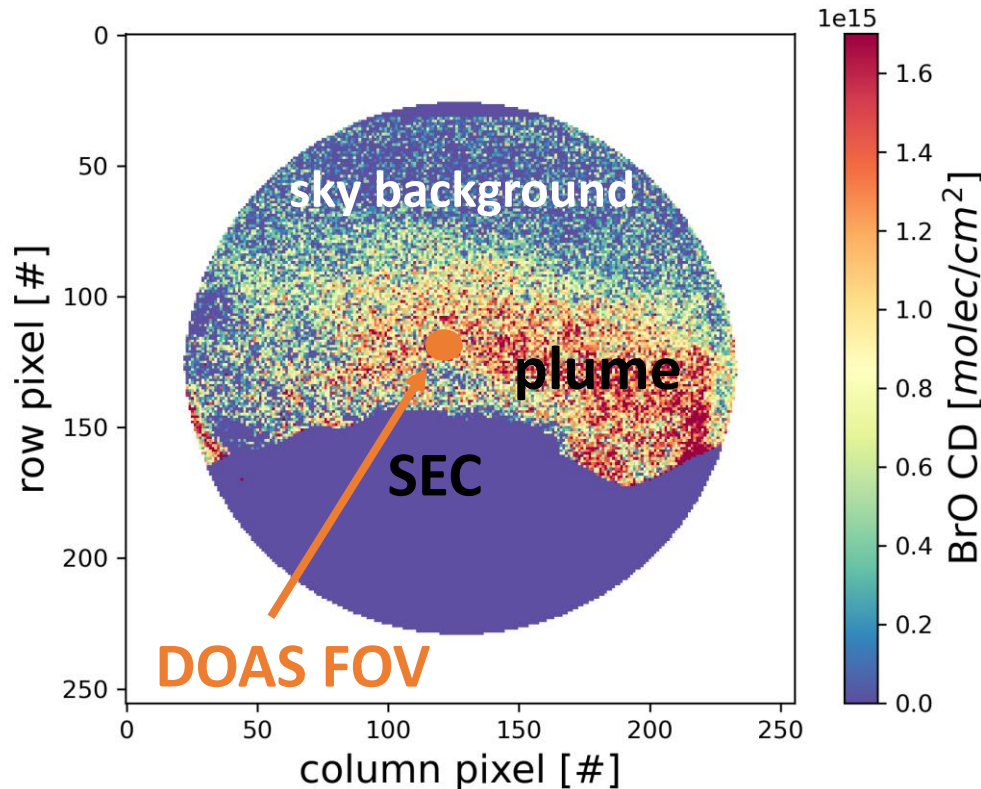
IFPICS measurement:



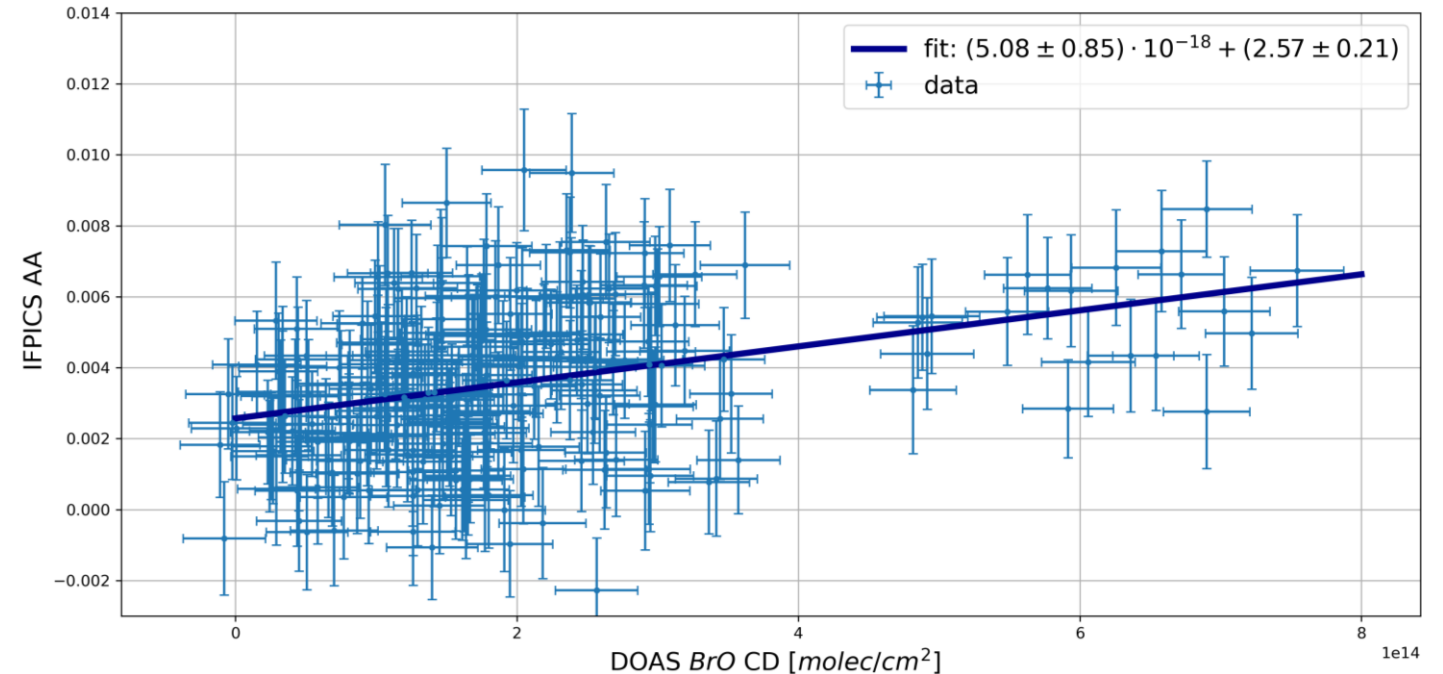
- Spatial resolution of 200 x 200 pixels with a size of 2.2 x 2.2 m²
- Time resolution of 10 s



Comparison of DOAS and IFPICS measurements



Calibration curve:



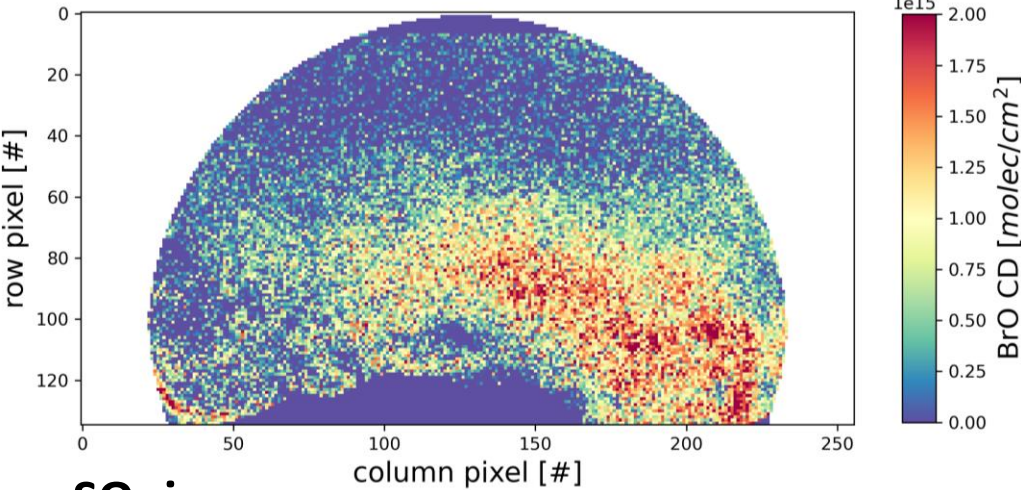
- Linear fit of calibration curve (slope: $(5.08 \pm 0.85) \times 10^{-18} \text{ cm}^2/\text{molec}$)
- Slope matches model calculation ($5.8 \times 10^{-18} \text{ cm}^2/\text{molec}$) based on literature values
- In-plume offset of $5 \times 10^{14} \text{ molec/cm}^2$ cannot be explained yet



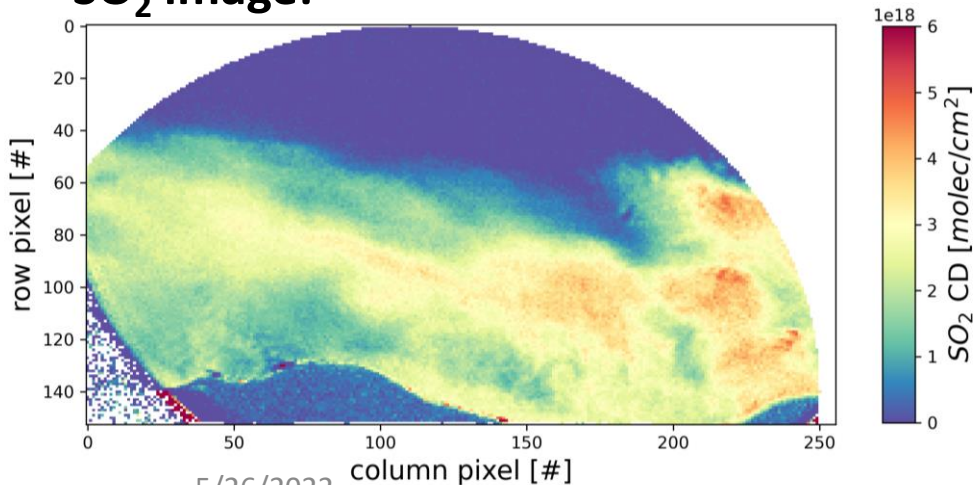
BrO/SO₂ ratios



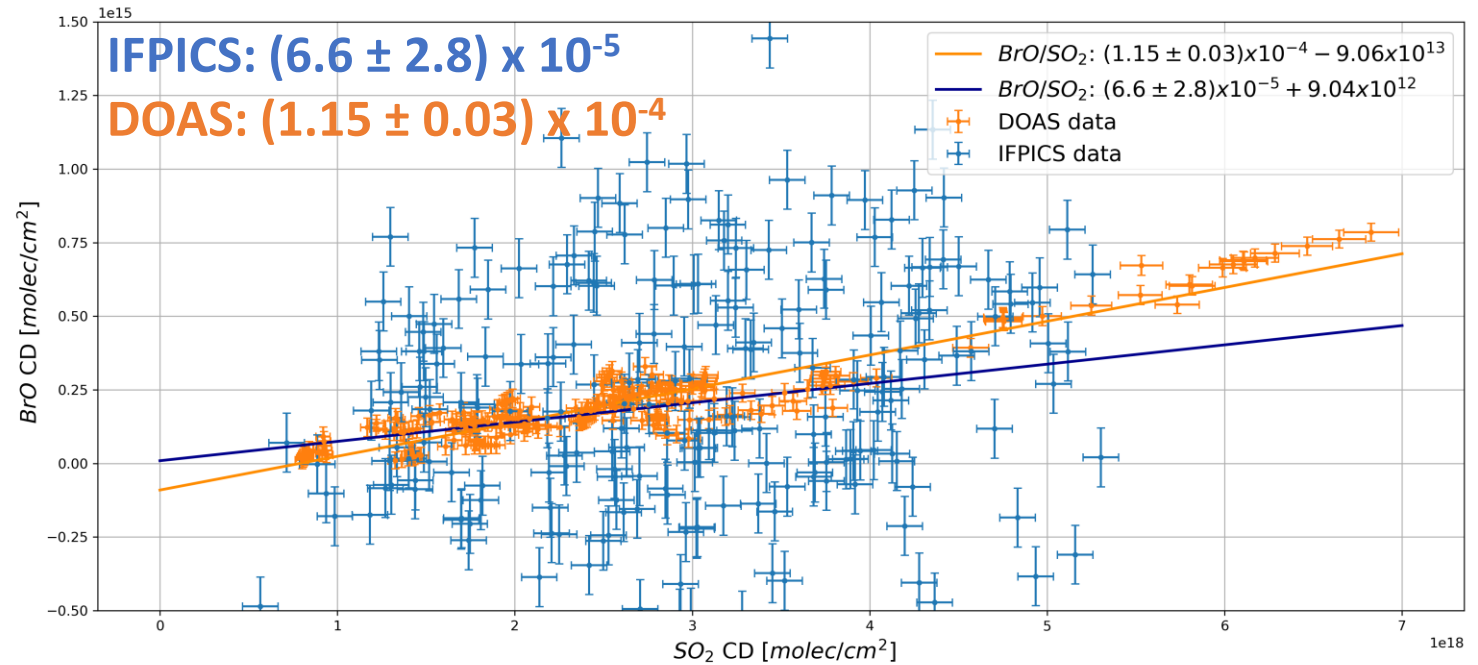
BrO image:



SO₂ image:



5/26/2022



- Measurements of BrO/SO₂ with two IFPICS instruments
- Aligning FOV of both instruments with infield DOAS
- IFPICS instrument has same order of magnitude than DOAS



Conclusion & Outlook



Conclusions:

- First successful BrO imaging measurements with IFPICS instrument
- Note: BrO signal is 2 orders of magnitude smaller than SO₂ signal**
- Good fit between model expectation and in-field DOAS calibration
- In-plume offset not explained yet
- First BrO/SO₂ ratios measured with 2 IFPICS instruments

Outlook:

- 2D BrO/SO₂ ratios with IFPICS instruments
- More field measurements
- Extend IFPICS technology to further trace gases e.g. NO₂, OClO

