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Towards Carbon Dioxide imaging using Fabry-Pérot interferometer correlation spectroscopy

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Carbon dioxide (CO₂) emissions are the major driver of anthropogenic climate change. While strong point sources contribute significantly to overall emissions, their source strength is not always well quantified by bottom-up estimates or in situ measurements. Passive remote sensing of CO₂ emissions could provide a simple tool to substantially refine source strength estimates. However, current approaches from ground-based to space-borne platforms only suit exceptionally strong emitters.

We propose a ground-based CO₂ imaging technique based on Fabry-Perot interferometer (FPI) correlation spectroscopy. The free spectral range (FSR) of an FPI is matched to the spectral separation of individual rovibrational absorption lines of the CO₂ 1.57 μm absorption band. This allows to compare the radiance of sky-scattered sunlight between “online” and “offline” wavelengths, i.e., the FPI transmission spectrum correlating and anti-correlating with the CO₂ absorption lines, respectively. The advantage of a high FPI light throughput enables imaging measurements of the CO₂ column density with a resolving power of 18,000.

Instrument simulations based on available optics suggest an integration time of approximately 10 seconds to record a CO₂ plume image with 300 by 300 pixels of a medium-sized power plant (7 Mt CO₂/yr). This is about two orders of magnitude faster compared to grating-based imaging spectrometers. For recording the emission plume of a passively degassing volcano at the same spatial resolution integration times are on the order of ten minutes. Additionally, we present ongoing work on developing a prototype instrument to validate the feasibility of this CO₂ imaging technique.