Geophysical Research Abstracts
Vol. 21, EGU2019-10477, 2019
EGU General Assembly 2019

A NO_2 Camera prototype for highly resolved Gas Correlation Spectroscopy measurements

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Fast imaging of atmospheric trace gases is becoming more and more important as the temporal and spatial scales of the observed processes of interest decrease. Conventional trace gas remote sensing techniques often use dispersive absorption spectroscopy (e.g. Differential Optical Absorption Spectroscopy, DOAS), which is very selective but due to the wavelength mapping (at moderate to high spectral resolution), is significantly limited in spatio-temporal resolution.

Several atmospheric trace gases can, however, be detected by using only a few carefully selected trace gas specific spectral channels. By using non-dispersive elements for spectral filtering without spatial mapping of continuous spectra, the spatio-temporal resolution can be vastly enhanced. While SO_2 cameras (based on two bandpass filters) start to be routinely used for SO_2 flux analysis at volcanoes, for other trace gases only a few examples for imaging measurements exist.

Nitrogen Dioxide (NO_2) plays a major role in urban air pollution, where it is primarily emitted by point sources (power plants, vehicle internal combustion engines), before undergoing chemical conversions. The corresponding spatial gradients can neither be resolved with the established in-situ techniques nor with the widely used DOAS remote sensing method.

We propose fast imaging of spatial NO_2 distributions employing Gas Correlation Spectroscopy (GCS) in the visible wavelength range. Two spectral channels are used, one with a gas cell that is filled with a high amount of NO_2 in the light path and one without. An additional band pass filter preselects a wavelength range containing structured and strong NO_2 absorption (e.g. 400 - 450 nm). The NO_2 containing gas cell serves as a NO_2 specific spectral filter, almost blocking the light at wavelengths of the strong NO_2 absorption bands within the preselected wavelength range. Absorption by atmospheric NO_2 has therefore a lower impact on the channel with gas cell compared to the channel without gas cell. This difference is used to generate NO_2 images.

Compared to other proposed NO_2 Camera implementations (e.g. acousto optical tunable filter or commercial hyperspectral cameras), the GCS technique has the advantages of allowing for an instrument design with a very high light throughput and large field of view. In addition, a compact, lightweight (< 5kg) and low-cost (<1k € NO_2 Camera can be implemented.

First proof of concept measurements were performed with a prototype instrument. The prototype uses a 2 dimensional CCD detector with a lens and an interference filter. A cell disc mounted on a servo motor allows for moving the two cells (one filled with NO_2 the other empty) in and out of the detector's lightpath. The proof of concept measurements yielded detection limits for NO_2 column densities within the order of magnitude (1E16 molec/cm̂2) that were predicted by a shot-noise-only instrument model beforehand. Such detection limits would be sufficient to resolve typical NO_2 column densities in street canyons mainly due to car emissions.

It is planned to take further measurements of vertical NO_2 profiles above street canyons or highways and compare those to measurements taken with conventional dispersive absorption spectroscopy methods.