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Atmospheric Measurement Techniques Discussions
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Interactive comment on "The AOTF-based NO_2 camera" *by* Emmanuel Dekemper et al.

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General Comments

This manuscript describes the development of an optical device specifically for imaging nitrogen dioxide (NO2) gas plumes. The NO2 camera measures incident scattered solar radiation in the visible spectral (blue) region. An acousto-optical tunable filter (AOTF) is used to isolate a relatively narrow (0.6 nm) spectral window, only allowing radiation with wavelengths within this bandpass onto the detector. The central wavelength of the bandpass is adjusted by setting the driving piezoelectric transducer to the matching frequency. This novel design is highly innovative, and the manuscript is well-written. I recommend publishing this paper in Atmospheric Measurement Techniques and have only a few, relatively minor comments.

Specific Comments

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Discussion paper

P2, L3 – Perhaps also cite Platt et al 1979, as to my knowledge, this was the first DOAS measurement of NO2. Platt U, Perner D, Patz HW. Simultaneous Measurement of Atmospheric CH2O, 03, and NO2 by Differential Optical Absorption. J Geophys Res. 1979;84(C10):6329-6335.

P2 L9 – Here you discuss the time resolution of imaging DOAS instruments vs that of the AOTF-based camera. It occurs to me that it could be useful to mention some relevant physical considerations here. Both instruments can only collect radiation that is available, i.e. solar scattered radiation. Both use similar detectors, so there is no advantage of one over the other in terms of being able to detect available light. While the imaging DOAS only records one line (or, in the case of whisk-broom imaging, one pixel) at a time, it does record a large number of different wavelengths (typically 1,000 or more) coincidentally. The AOTF camera does the opposite – it records the full image, but only 1 wavelength at a time. So the question is whether there really is a physical advantage of one technique over the other. I guess one could argue that not all the wavelengths measured by the imaging DOAS are necessary, but that depends on the application and can actually be adapted as wanted and e.g. tuned to a very specific wavelength range if only interested in NO2. And because so many independent wavelengths are measured, the signal to noise ratio for a single acquisition is significantly better than if only 1 pair of wavelengths is measured (as you mention and show later on in the paper). So I'm curious whether there actually is a physical advantage of one technique over the other and if so, where does it come from? Or is it just that the camera is particularly well-suited to measuring NO2, while the imaging DOAS instruments that have been built in the past have not been optimized just for NO2?

P2 L11 – I disagree that the main measurement technique for quantifying volcanic SO2 has moved to SO2 cameras, and I don't think this will happen in the near future. There are many more scanning DOAS instruments still in use than there are cameras, and the DOAS have some very important advantages too (e.g. being able to measure other gases like BrO and OClO, having a slightly better detection limit, being essen-

tially calibration-free, and having the ability to correct for some scattering effects using additional spectral information that is available).

P3 L9 – I may be wrong, but I don't think it's physically possible to design an optical system such that all rays propagate through the AOTF exactly in parallel. Are you sure this is true? I guess a pupil will reduce beam divergence, but will also reduce the amount of light entering the system. Is there some optimal configuration?

P3 L21 – I don't understand why the acoustic power depends on the wavelength. Can you please clarify?

P4 L5 –Does this mean that you can resolve 350 independent wavelengths and 700 spatial pixels? Can you explain where these numbers come from? I'm not quite following.

P7 L7 – Can you explain a little bit what factors are relevant for 'carefully selecting' the two wavelengths for the measurement? I guess the spectral radiance of the incident scattered radiation and the differential optical depth of the absorption cross-section features play a role.

P9 L14 – Please clarify what you mean with 'not enslaved'. Does this mean that the temperature is not monitored? Or is the instrument not temperature-stabilized? It occurs to me that the errors associated with temperature drift of the bandpass center wavelength could be considerable greater than 5 to 10% if the temperature is not stabilized. For example, if the temperature changes by 5K, thus causing a shift in transmittance wavelength of 0.5nm, then the differential absorption cross section at this wavelength can change by approximately 50%. (e.g. looking at the difference between differential absorption at 448.2 and 448.7nm. In other words, instead of centering the bandpass on an absorption band, the bandpass would move to about the center between an absorption band and the next transmission band, reducing the measured absorption signal by about half!

P11 L1- Can you please clarify what you mean by 'relative error'? Is this the precision of an individual pixel? I'm somewhat surprised that the value is so low, as the pixel-to-pixel 'noise' in SCD values seems to be about 5e16 molec/cm2, which would correspond to about 12%. I think this is the number you mention below. Or is the 0.5% the accuracy? But that seems very ambitious too, based on your previous discussion of errors associated with different sources.

P12 – Can you comment on whether the plumes from the stacks were visible, i.e. did they contain condensed water vapor or were the translucent. Perhaps add a photograph to figure 5? If the plumes did contain water droplets close to the stack, they may not have been optically thin at this point. In other words, the aerosols could influence the light paths through the plume. This could lead to an underestimation of gas concentration in the plumes and may influence the conversion rate estimates calculated from this data. See Kern et al 2013 for a description of the effect on SO2 cameras, though your NO2 camera will react somewhat differently. Kern C, Werner C, Elias T, Sutton AJ, Lübcke P. Applying UV cameras for SO2 detection to distant or optically thick volcanic plumes. J Volcanol Geotherm Res. 2013;262:80-89. doi:10.1016/j.jvolgeores.2013.06.009.

Technical Corrections

P2 L27 – Potential applications INCLUDE urban and industrial pollution. . .

P2 L31 – ALTIUS is a space mission project AIMED at the retrieval of atmospheric COMPOSITION with . . .

P3 L3 – I think you mean that an optical PROTOTYPE of the visible channel was built on a BREADBOARD.

P3 L6 – The instrument IMAGES a 6 degree field of view onto a . . .

P4 L12 - . . . in order to QUANTIFY the extinction. . .

P5 Figure 3 caption – consider replacing MEASURED with AOTF, since both cross-

sections were actually measured, just with different instruments.

P6 L3 – and . . . IS THE attenuation along the extinction axis.

P6 L8 – I believe T is the transmittance of the lenses, not the extinction

P6 Equation 3 – The second '=' sign should probably be replaced by an 'approximately equals' sign because this step is an approximation.

P6 L21 – Please give this equation a number too.

P6 L 23 – Under these assumptions, one can INSERT Eq. 4 . . .

P7 L13 – I'm not sure that the coefficients rho i,j have been defined yet. I think they describe the detector sensitivity? Is this the same as QEij?

P7 Equation 10 – Consider using a different symbol for the gain, as G is already used for the STF.

P8 L1 – the straylight IS ASSOCIATED with general illumination conditions (e.g. solar angles) AND it will vary with time.

P8 L21 – Do you mean that the ACCURACY is limited by the difficulty in identifying plume-free pixels?

P9 L28 - . . . campaign IN which we participated. . .

P9 L30 - . . . two types of SITES:. . .

P9 L33 - . . . of which more than 93% IS GENERATED FROM coal.

P10 L4 - . . . close to ideal an BEST illustrate. . .

P11 L1 - . . . image areas UNAFFECTED by the plume.

P13 L4 - . . . camera cannot DISTINGUISH their respective SIGNATURES.

P13 L16 – SCDs are retrieved from at least two images TAKEN AT WAVELENGTHS

where absorption. . .

P13 L20 – A mathematical FRAMEWORK FOR DATA EVALUATION has been developed. . .

P13 L22 - .. offering longer INTEGRATION TIMES or more . . .

References – Please check the references for errors in displaying subscripts, particularly with the words SO2 and TeO2.

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