Use of a camera with the MAX-DOAS instrument, KCG

Stephen Wilson

2022-07-25

MAX-DOAS measurements look at scattered light at various angles (elevations above the horizon), and retrieves the aerosol vertical distribution and optical depth, along with the distribution and column amount of a number of trace gases, including NO2 and formaldehyde. Critically, the sensitivity of the technique is greatest in the lowest few hundred metres or so of the atmosphere (measured vertically).

Optically, the field of view of the MAX-DOAS is quite small (need to look up the exact limits, but it is defined by the slit on the front of the pyrheliometer housing).

The retrieval process involves comparing the observed amount of a particular component at each angle with the output of a model of the scattering of light through the atmosphere. As the impact of clouds is not, in general, unknown it is ignored. That is, the models run assuming a cloud free sky. While this seems to be very suspect(!) for a site like Cape Grim, there are some mitigating factors. First, the models do include aerosol scattering, so that low level clouds will tend to be included in the aerosol scattering. Secondly, due to the low sensitivity to the middle and upper troposphere higher clouds do not impact the retrievals too greatly.

There have been a number of attempts to make these statements more “quantitative”. There have been a number of attempts to use the MAX-DOAS measurements themselves to identify measurements that are cloud impacted (T. Wagner et al. 2014; Thomas Wagner et al. 2016; Gielen et al. 2014). There are references in these works to the use of a cloud camera in a campaign in Cabauw (Piters et al. 2012). However, I see little useful information in that paper (although I admit my reading of it was very rapid!!) The general agreement between these works is that they define a threshold where the “colour” is sufficiently different from the clear sky estimate that they reject the measurement. For a cloudy site the setting of this limit is crucial, given that we do not want to exclude measurements that actually contain information.

My intentions for a camera looking in the viewing direction of the MAX-DOAS are three-fold.:

1. Collect images when looking straight up (zenith measurements). For these I will want to compare estimates of cloudiness (and possibly contrast

between the cloud and the sky??) to those of the colour index derived from the MAX-DOAS instrument. Given the difference in view of the two instruments it would be surprising if it was a simple relationship. (Following the work of Gielen (Gielen et al. 2014) I may add 30 ^{o} as well).

2. Look at the 1 deg measurements versus the image. How significant is the "haze" (how clear is the horizon). Presumably this will correlate with the estimate of aerosol amount at the lowest levels. I am not sure whether this is an obvious relationship or if the amount of scattering will confuse the retrieval. (This is actually my 3rd priority).

3. As part of the calibration of the instrument there is a need to check that 0^{o} (i.e. looking horizontal) is truly horizontal. An error here will introduce significant errors into the retrieval. I have used horizon scans in 2 directions in an effort to quantify this. Either looking north at the islands or across Valley Bay. The horizon is scanned (from -3 to +3 ^{o}) looking for the change in colour in the MAX-DOAS measurements. Theoretically these should be done at least monthly. These have proven to be quite difficult to interpret, as changing amounts of cloud can make the colour change quite confusing. I would like to add images to try to unravel the information returned. Here I think it would be useful to have both the images (can we see the horizon clearly - is the view changing) but also an estimate of where the boundary lies and a measure of how the viewing conditions are changing during the 10 - 20 minutes of the calibration.

References

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