

Interactive comment on “Averaging kernels for DOAS total-column satellite retrievals” by H. J. Eskes and K. F. Boersma

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Reply to referee 1

We thank the referee for her/his useful specific remarks, and the positive general comments. We will quote the remarks of the referee and provide our reply below.

"The recommended approach redefines the retrieved product to reduce associated with the a priori profile, but limits interpretation of the retrieved product to users with access to a priori information on the trace gas vertical profile."

Our suggestion is certainly NOT to limit the use, but to extend the use of the DOAS retrievals. With kernel information in the data product there are TWO ways of using the data:

1) The vertical trace gas columns are still a best possible estimate of this column. This

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quantity is unchanged and can be used as always (by people that do not have profile information). The kernels help with the interpretation of these columns, because they describe the sensitivity of the measurement, especially important in the case of tracer concentrations in the boundary layer.

2) The kernel information should be exploited for detailed model-satellite comparisons, for data assimilation and for detailed validation studies with independent tracer profile information.

Apparently this extension of the use of the data sets has not been mentioned clear enough. We have changed the discussion in the manuscript in the section *Use of averaging kernel information* to further clarify this point on the use of the DOAS products.

"The present tone of the manuscript implies that the authors have removed the a priori dependence in the retrieval, i.e. the conclusion states that 'the use of the AK together with the retrieved column removes the dependence on a priori assumptions'."

The referee uses the words 'tone' and 'philosophical nature' to refer to the discussion on the importance of the kernel information. Indeed it is important to be precise in the formulation and quantify these remarks. We have gone through the manuscript and have replaced several lines by more detailed statements.

In particular, our statement is also related to the error estimate. A new paragraph has been added to the section *Use of averaging kernel information* on these errors. For the total column retrieval, the VCD error includes contributions from profile shape uncertainties, slant column errors and errors related to the retrieval parameters, such as cloud fraction, albedo, etc.. When eq. 9 is used, the error consists of DOAS slant column and averaging kernel components. This averaging kernel errors amounts to the same retrieval parameter errors, but there is no profile shape related contribution to the error because the sensitivity function is independent of the profile for optically thin absorbers.

"Actually the authors appear to advocate that the responsibility of providing accurate a

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priori information should be placed upon the user who desires to interpret the retrieved columns."

This point has been discussed above. There are two ways of using the data, and kernels are an additional source of information. When comparisons are made with 3D model fields or independent profile measurements one should use the kernel functions for the most reliable comparisons. Alternatively, one can use the total column as usual, but one should be aware that this product depends on the a-priori profile choice.

"The AK is dependent upon clouds, aerosols, and surface reflectivity, and needs to be provided for every satellite observation. This will increase the data volume significantly."

This is indeed a point of concern: future instruments like for instance OMI will generate large amounts of data. In our own NO₂ data product we provide the kernel on 19 pressure levels. Our choice for these pressure levels is fully specified by the surface pressure, taken from the ECMWF model. We also specify two additional error estimates when kernels are used. In total we have 22 extra numbers in the data product. However, it is important to note that a data product already consists of many data fields, i.e. for each pixel many quantities are of importance: time and location of measurement, total, tropospheric and stratospheric columns plus error estimates, quality flag(s), geometry of the measurement, corners of the ground pixel, air-mass factors, slant column, cloud parameters, albedo. Our product consists of 55 numbers for each pixel, and the kernel related data fields are 40A paragraph has been added to the text to discuss this data volume issue.

Specific comments:

The wavelength at which the calculation was done has been included in the caption of the figure.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 895, 2003.