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Atmospheric Measurement Techniques Discussions

# *Interactive comment on* "Retrieval of aerosol optical depth and vertical distribution using O<sub>2</sub> A- and B-band SCIAMACHY observations over Kanpur: a case study" *by* S. Sanghavi et al.

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We present here a summary of the main changes, both structural and content-related, made in our corrected manuscript:

1. The title of the paper has been changed to "Retrieval of the optical depth and vertical distribution of particulate scatterers in the atmosphere using O2 A- and B-band SCIAMACHY observations over Kanpur: a case study" to reflect the fact



that we are interested in aerosols as well as clouds.

2. We have modified the abstract to briefly describe the main results, both quantitative and conceptual, of the paper. General descriptions have been moved to the Introduction.

3. References to work already done on the O2-bands with SCIAMACHY and other instruments have been added. Parts of the Introduction that were summarizing our own work have been moved to the Conclusions. An outline has now been provided to describe the structure of the rest of the paper,

4. A new section has been added to introduce the SCIAMACHY instrument to the reader.

5. The retrieval algorithm has been described in exhaustive detail and all parameters relevant to a reproduction of our methodology have been provided. An explanation of the inability of the SCIAMACHY intsrument to co-retrieve aerosol microphysical parameters has been provided. Implications of the resultant use of microphysical parameters fixed by climatology have been discussed.

6. Equations to explain "Depth of reflectance" in the section describing Jacobians have now been provided. Also the state parameters ($\tau_{700}$, $z_p$ and $\sigma_p$) and the sun-satellite geometry at which the Jacobians have been calculated have now been clearly stated.

7. We have added a detailed information content and error analysis (Section 3.2) to quantify the information content (Table 2) gained by our combined use of the O2 A- and B-bands, over three different surfaces, viz. black, moderate contrast and high contrast. A posteriori uncertainties (Table 3) have been provided to underpin our information content analysis and to demonstrate the effect of different levels of a priori constraints on our retrieval accuracy.

8. The error analysis uses the averaging kernel matrix to quantify the impact of error in our estimation of the Angstrom exponent (or $d\tau/d\lambda$) of the aerosol (Section 3.2.1, Table 4), as well as due to errors in our estimation of the surface reflectances around the A- and B-bands respectively (Section 3,2,2, Table 5).

9. We discuss various sources of measurement bias (radiometric calibration errors) and model bias (surface pressure, single scattering albedo of the assumed aerosol) in our retrieval. We use the gain matrix to calculate the effect of an arbitrarily chosen $6\%$ bias (Section 3.2.3, Table 6) and discuss the results obtained.

10. Section 4 covering Synthetic sensitivity studies now details the sun-satellite geometry at which the analysis has been made. The simplifications made in the synthetic study have been clearly contrasted with the complexity of representing real measurement data.

11. In Section 5 on Retrievals from SCIAMACHY measurements over Kanpur, the uncertainties associated with real SCIAMACHY measurements have been presented clearly. The residual error of Figure 8 has been explained on the basis of results obtained independently by van Diedenhoven et al. 2007. A correlation coefficient of $r = -0.788$ has been reported for the data plotted in the upper panel of Figure 9 (natural logarithm of the retrieved AOT plotted against the corresponding relative contrast). An explanation of the term "relative contrast" based on the work done in Sanghavi et al. 2010 has been provided. In Figure 11, a correlation correlation coefficient of $r = 0.92$ has been reported for non-monsoon monthly means (Jan-May, Oct-Dec) of AOTs obtained from AERONET and SCIAMACHY.

12. All statements attempting to validate our vertical profile retrievals on the basis of "retroactive" CALIPSO measurements have been removed, since we have not carried out a rigorous comparison of the two. The results of our sensitivity studies have been used as proof of our concept for retrieving a lognormal approximation of the vertical profile of cloud/aerosol.



13. All statements describing our results as "very good" have been removed, and have been replaced by arguments taking the uncertainties associated with SCIAMACHY measurements and other sources of error into consideration. The large pixel-size and the inter-channel radiometric irregularities have been identified as the main drawbacks of using the SCIAMACHY instrument for aerosol retrievals.

14. In conclusion, we note that while aerosol retrievals from SCIAMACHY have so far been limited to simple indices such as the Aerosol Absorbing Index (AAI) (de Graaf et al., 2007) or the SCattering Index (SCI) (de Vries et al., 2009) and physics-based retrievals of optical thickness have, to the best of our knowledge, been applied to thick clouds (Kokhanovsky et al., 2005), we present the first physics-based retrievals of aerosol using SCIAMACHY data. We show that the retrieval of aerosol optical thickness from satellites like SCIAMACHY is feasible and could be, given computational resources and speed-up of the current line-by-line radiative transfer calculations, extended to the global scale since it can be applied to dark as well as bright surfaces. However, we also mention that large-scale application to SCIAMACHY data is severely challenged by radiometric uncertainties which make a simultaneous retrieval of aerosol microphysical parameters by using more, spectrally farther-spaced wavelengths practically impossible. Addressing these issues in future instruments similar to SCIAMACHY can allow our approach to be extended to the global scale, especially because it is not restricted to dark surface types.

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