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Interactive comment on "Surface pressure retrieval from SCIAMACHY measurements in the O_2 A Band: validation of the measurements and sensitivity on aerosols" *by* B. van Diedenhoven et al.

Anonymous Referee #1

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- General comments

This paper presents results of the retrieval of surface pressure from SCIAMACHY using measurements in the O2 A-band (755-775 nm) as well as the influence of aerosols. Surface pressure is an important parameter for meteorological models. In addition, for remote sensing applications, apparent pressure can be used in cloud masking, atmospheric correction or algorithms for gas retrieval. In the past, some studies have shown the capability to estimate this parameter from space, using for example the

MOS, POLDER or MERIS sensors. Note that these studies used measurements in broadband channels with a two-band ratio, defined as the ratio of two reflectances measured in the oxygen A-band and in a close non-absorbing channel respectively. These studies have shown that surface pressure retrieval is then possible with a theoretical accuracy of some hPa. However, this accuracy can not be achieved with operational algorithms, due to uncertainties on scattering processes, spectral dependence of geophysical parameters or instrumental calibration. The accuracy is then generally about 10-30 hPa for bright surfaces. Over dark surfaces, previous studies have shown that deviations between the apparent pressure and actual surface pressure can reach 300 hPa for dark surfaces.

In this context, the use of oxygen A-band measurements for surface pressure retrievals is becoming more common. However, SCIAMACHY offers interesting measurements in the oxygen band with a high spectral resolution. SCIAMACHY has a spectral resolution of about 0.25 cm-1 in the considered spectral range. The surface pressure determination is very sensitive to oxygen absorption and the use of high spectral resolution measurements should then improve the accuracy of retrievals. As mentioned by the authors, the surface pressure determination can also be an interesting parameter to test and improve the spectral calibration of the sensor. For example, a similar approach has been used for the MERIS spectral calibration.

The objectives of this paper are then relevant and the paper is appropriate to this journal. This paper presents an interesting work and improves existing methodology in this area. The paper has a logical structure and the case study or figures are well-chosen. The algorithm is described in a straightforward manner. A validation using meteorological surface pressures is presented. In addition, the paper presents an interesting and complete study about the influence of aerosol properties (optical thickness and vertical distribution) on the surface pressure retrievals. The influence of aerosols is presented as a function of the surface reflectance. At last, a bias on the surface pressure retrieval with SCIAMACHY is observed for the case study. This bias, due to calibration uncertainties, has been confirmed by comparisons with a similar sensor (GOME) and presented for the case study. A correction is proposed by the authors, with important consequences for SCIAMACHY algorithms. This study is then valuable for users of SCIAMACHY measurements and for potential applications with these data. Even though the methodology presented in this paper is not new, this study on the surface pressure retrieval from SCIAMACHY measurements will make an interesting contribution to improve the knowledge about this research field.

I think that the main shortcomings are related to the analysis of results and conclusions. In order for the article to be ready for publication, the authors should address the three following questions (specific comments) and perform other smaller revisions proposed in the 'additional comments' part of this review.

- Specific comments

1. Validation of the surface pressure product has been performed from a case study over Africa. This specific study is very useful for the comprehension. However, there needs to be additional case studies and validation to evaluate the efficiency and accuracy of the method (including various types or vertical distributions for aerosols, various atmospheric conditions and solar zenith angles). Did the authors perform additional case studies for the validation? I guess this is true since the authors write that 'the same correction was found by evaluating SCIAMACHY data from other geolocations' (section 4.2, page 1479 line 15). For example, a table should be added to the paper, including mean deviations and offsets on the retrieved surface pressure (from several case studies), as a function of the surface albedo. This would show that conclusions on surface pressure retrievals, as well as calibration uncertainties for SCIAMACHY (offset of 30 hPa) are still valid with an improved validation.

2. The first objective of this paper concerns the surface pressure retrieval, as well as its validation from meteorological data. However, there is no clear conclusion regarding the accuracy of the methodology. An expected accuracy should be clearly included and

discussed, at least in the conclusion and abstract. This information would be valuable for the readers. This accuracy could be easily deduced from the improved validation, proposed in the previous comment. The surface pressure retrieval depends strongly on the surface and the accuracy can be presented as a function of the surface reflectance (for bright or dark surfaces respectively).

3. The original approach of this study is the use of high spectral resolution measurements. With broadband channels (such as MERIS), the expected accuracy for surface pressure retrievals can be estimated to about 10-30 hPa for bright surfaces. With SCIAMACHY measurements, Figures 9a and 9b show uncertainties up to 20-30 hPa for bright surfaces (for apparent surface albedo ranging from 0.3 to 0.6) when reflectances are corrected by adding an offset of 1%. If this accuracy is confirmed with an improved validation, this study seems to show that the retrieval is not really improved by using high spectral resolution measurements. Could the authors comment and conclude? What is the main reason for these uncertainties? Are they related to the instrument (a large sensitivity to the spectral calibration) or mainly related to the variability and uncertainties of atmospheric parameters? Is there possible improvements? Especially, the authors note (Section 4: Page 1480 line 16) that some deviations are observed between simulations and measurements, that they might be due to errors in the spectroscopic data. Are the deviations systematic at a given wavelength? If yes, did the authors try to perform retrievals only for wavelengths with small deviations? What is the influence of these deviations on surface pressure retrievals? In addition, the authors write (Section 2) that the HITRAN 2000 database is used for simulations. However, a new version for HITRAN is now available. Did the authors test this new database? Indeed, new spectroscopic parameters for oxygen could have an influence on surface pressure retrievals.

- Additional comments

Table 1: Aerosol characteristics are presented in Table 1. The influence of aerosols on radiation mainly depends on the absorption and scattering properties which are

defined by the single scattering albedo. So, it would be useful to add in Table 1 the single scattering albedo of aerosol models (at ˜ 760 nm).

Section 2: (page 1474 line 6) the SRON code is used for simulations. It is noted that this code 'includes polarisation and multiple scattering'. Interactions between scattering and absorption are very important for this study. What method do the authors use to solve the radiative transfer equation? Please include more details on the coupling between absorption and scattering.

Section 2: (page 1474 line 9) it is noted that 'absorption lines parameters are taken from HITRAN2000 ... with a Voigt line shape': I suppose that oxygen absorption is calculated with a line-by-line model and averaged with a spectral resolution of 0.02 nm? Some details are needed in relation with the previous comment.

Section 3: Page 1476 line 18: in order to explain the influence of Rayleigh scattering on apparent pressure, the authors wrote that 'The large effect of Rayleigh scattering can be explained by the fact that the Oxygen A band contains a large number of optically thick absorption lines for which few photons penetrate through the atmosphere to high pressure levels and thus the reflectance at the wavelengths of these absorption lines is mainly determined by Rayleigh scattering occurring at low pressures'. I agree and it would be perhaps useful to specify that the scale height for the molecules is about 7 km and generally higher than for aerosols, with resulting lower apparent pressures in retrievals for Rayleigh scattering.

Section 4: Page 1477 line 18: The authors have noticed that 'cloudy pixels are excluded from the data'. How efficient is the cloud mask for thin cirrus clouds? What is the minimal optical thickness for cloud detection? Indeed, thin cirrus not detected by the cloud masking algorithm may have an influence on surface pressure retrievals. Please add some comments.

- Technical corrections

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Interactive Comment

The use of the word 'we' in the text should be avoided. Page 1478 line 13: '300 to -60 hPa' instead of '300 to -60' Page 1480 line 4: 'at a wavelength' instead of 'at a a wavelength'

Interactive comment on Atmos. Chem. Phys. Discuss., 5, 1469, 2005.