SCIAMACHY ABSORBING AEROSOL INDEX: THE SCIENTIFIC PRODUCT COMPARED TO THE OPERATIONAL PRODUCT AND TOMS DATA.

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ABSTRACT

The KNMI scientific Absorbing Aerosol Index (AAI) product from SCIAMACHY is presented. It is compared to the operational SCIAMACHY level-2 AAI product and to the TOMS AAI on the basis of a recent dust outbreak on 5 April 2004 over the Sahara. The scientific AAI product is still very sensitive to calibration errors in the reflectance, but its values are in the right range compared to TOMS AAI and it produces physically meaningful results.

1. INTRODUCTION

The Absorbing Aerosol Index (AAI) is a measure for the presence of elevated absorbing aerosols in the atmosphere, using reflectances R at two wavelengths in the UV and comparing them to Rayleigh reflectances [1]. It is defined by

$$\mathrm{AAI} = -100 \cdot {}^{10}\log\left(\frac{(R_\lambda)_{\mathrm{meas}}}{(R_\lambda)_{\mathrm{Rayleigh}}}\right), \qquad (1)$$

where R_{meas} is a measured reflectance at a wavelength λ (usually 340 nm) and R_{Rayleigh} a calculated reflectance in a aerosol free (Rayleigh) atmosphere at a wavelength λ. To determine the Rayleigh reflectance a Lambertian surface albedo under the Rayleigh atmosphere is varied in such a way that the Rayleigh reflectance in Eq. 1 is equal to a measured reflectance at a wavelength λ_0 which is different from λ (usually 380 nm). In this way the AAI method is a spectral method.

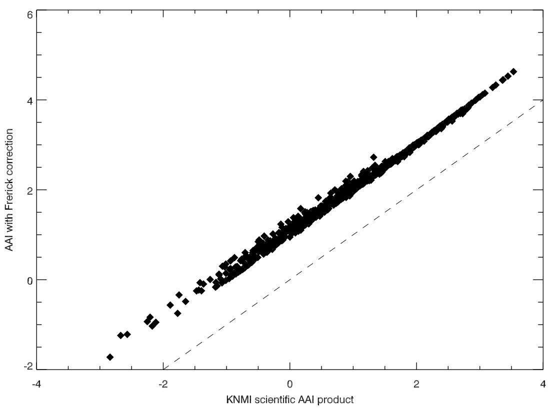

Fig. 1. Dependence between the DAK corrected scientific AAI and the Frerick corrected AAI.

Table 1. Reflectance correction factors for the AAI wavelengths.

method	correction R_{340}	correction R_{380}
DAK	1.210	1.130
Frerick	1.210	1.175

2. EFFECT OF REFLECTANCE ERRORS ON THE AAI

The AAI is very sensitive to calibration errors. The SCIAMACHY level-2 AAI product (L2-AAI) suffers therefore heavily from the underestimation of reflectances by SCIAMACHY in the UV [2]. The KNMI scientific AAI product (SC-AAI) was built to produce a reliable aerosol product using a correction factor for the reflectances. Several correction factors have been proposed to correct the reported errors in the SCIAMACHY reflectances. The

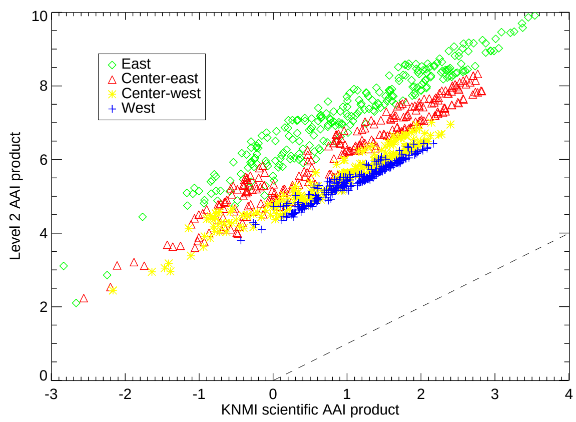

Fig. 2. The scientific AAI data compared to the operational level-2 AAI data for orbit 10969, states 5–9. The colours refer to pixels with approximately the same viewing geometry. The first 4 pixels in a forward swath are called East pixels, the next 4 Centre-east, the next 4 Centre-west and the last 4 West pixels.

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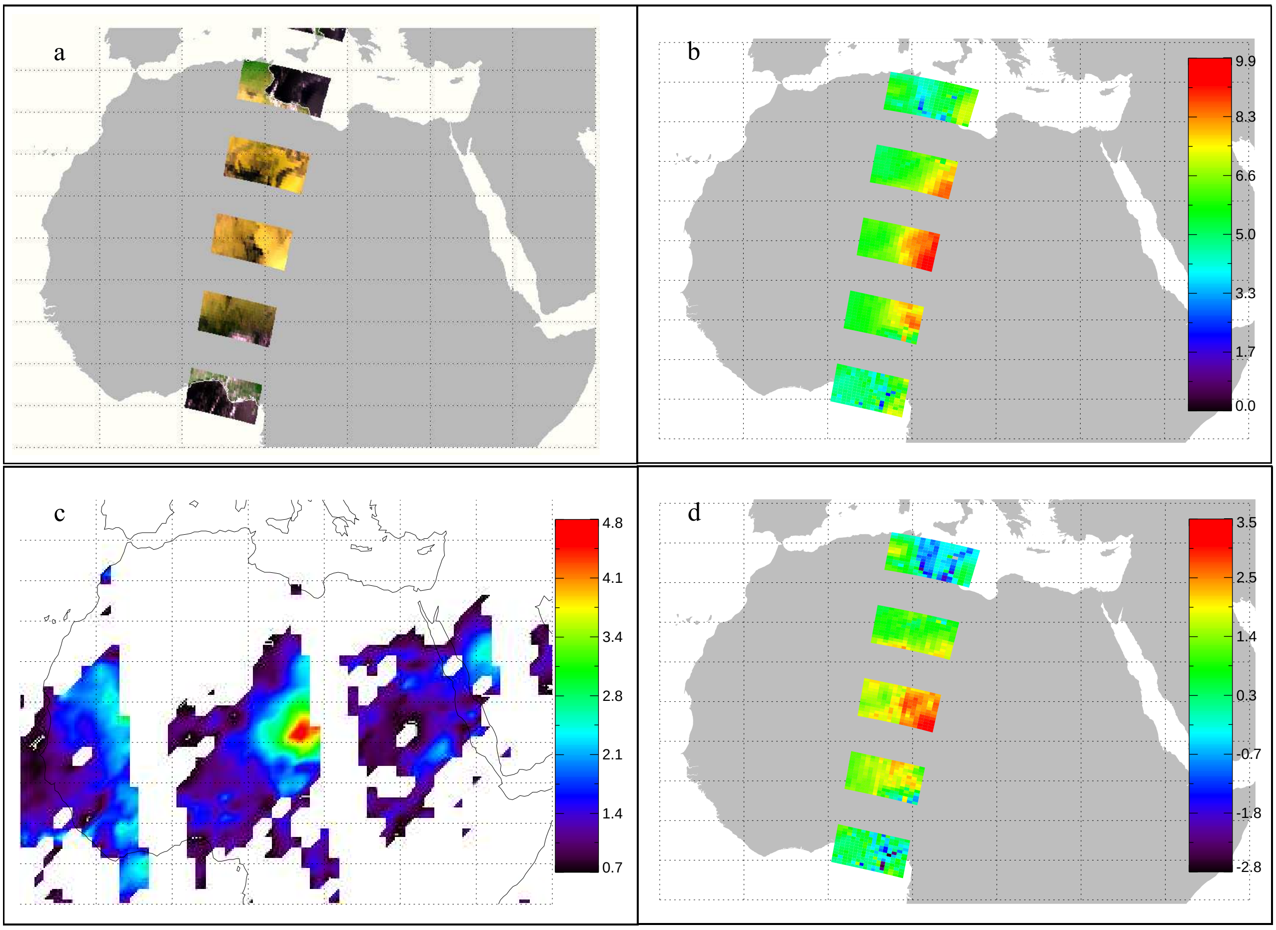


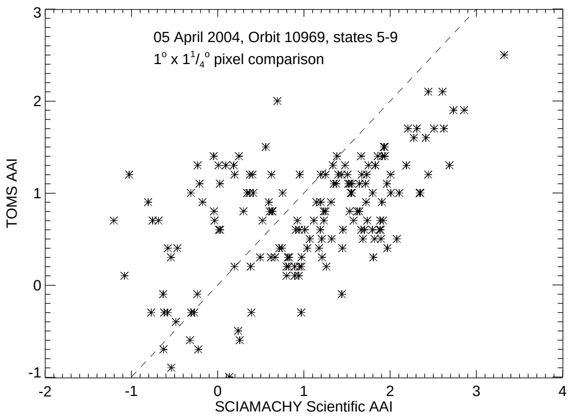
Fig. 3. Dust outbreak over the Sahara on 5 April 2004. (a) PMD real colour composite for SCIAMACHY orbit 10969, states 5–9, (b) AAI level-2 product, same as (a), (c) daily mean TOMS AAI for 5 April 2004. (d) KNMI scientific AAI product. Please note the different AAI scales.

values of two correction methods are listed in Table 1 for the wavelengths appropriate for the determination of the AAI. The DAK correction method is a correction factor using the radiative transfer model Doubling-Adding KNMI (DAK) developed at KNMI. It is compared to the key-data correction factor proposed by J. Frerick (ESA, private comm.). Using a different reflectance correction factor introduces a linear offset of the AAI. This is illustrated in Fig. 1, where the DAK corrected scientific AAI is compared to the AAI determined with reflectances that were corrected with the Frerick correction. This linearity is a feature of the AAI. In the case presented here the correction factors used are equal at 340 nm, but in general the AAI behaves linearly when either the reflectance at one of the wavelengths or at both are changed.

The SCIAMACHY level-2 AAI product (L2-AAI) compares reasonably well with the scientific AAI product (SC-AAI), as shown before [3] and in Fig. 2. In this figure the SC-AAI and the L2-AAI are compared pixel by pixel for 5 states of orbit 10696 over the Sahara, which are the states that are shown in Fig. 3. Because L2-AAI does not account for polarisation in the Rayleigh LookUp Table (LUT) calculations it suffers from a viewing angle dependent error. This can be seen in Fig. 2 as parallel lines, caused by reflectance differences in different pixel types (East, Centre-east, Centre-west and West). This problem can be solved by replacing the LUTs used in the AAI retrieval algorithm by LUTs in which polarisation has been accounted for [3].

3. SAHARAN DUST STORM EVENT

Fig. 3 shows a dust outbreak over the Sahara of 5 April 2004. Fig. 3a is a true colour composite using the high spatial resolution of the PMD channels. Clouds show up in white in these plots and from Fig. 3a it can be seen that most states are cloud free. Only the first and the last state show some traces of clouds. The TOMS AAI (Fig. 3c) shows the main peak of the dust plume that day; the SCIAMACHY states just miss the highest values of the TOMS AAI, but all TOMS AAI values larger than 0.7 indicate the presence of dust aerosols. The L2-AAI (Fig. 3b)



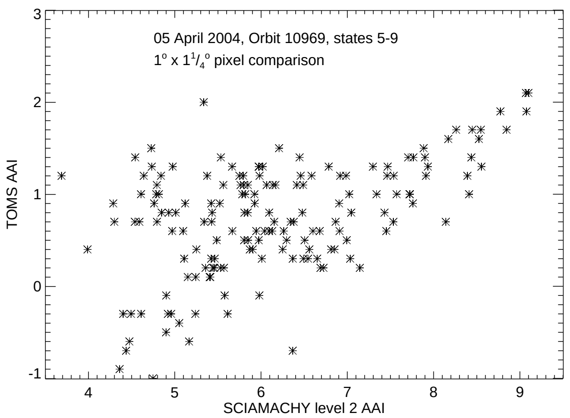


Fig. 4. (a) Pixel-to-pixel ($1^\circ \times 1.25^\circ$) comparison of TOMS AAI and SC-AAI for the area shown in Figure 1. (b) Same as (a) for TOMS AAI and L2-AAI.

values are too high but they show a smooth structure. The scientific AAI (Fig.3d) values are in the right range. The values are low in cloudy pixels and high where aerosols are expected, which is a promising result.

To compare the SCIAMACHY scientific AAI product with the TOMS AAI product, the SC-AAI of the five states shown in Fig. 3 and the L2-AAI were binned to the TOMS format, which is a 1.25° longitude $\times$ 1° latitude grid. Fig. 4 shows the correlations bin for bin. The SCIAMACHY scientific AAI is clearly in the right range, showing reasonable comparison with the TOMS AAI. Differences between the two can result from the time lag between the SCIAMACHY and TOMS overpasses and interpolation differences. So the SC-AAI is sensitive to absorbing aerosol events. The L2-AAI shows a similar behaviour as the SC-AAI (Fig. 4b), but the range of the L2-AAI is too large, as expected from the underestimation of the SCIAMACHY reflectances. Also the linear relation between the L2-AAI and the TOMS AAI is less obvious because of the polarisation error in the L2-AAI LUTs.

4. CONCLUSIONS

The SCIAMACHY level-2 AAI product is not corrected for the reflectance offset and therefore shows much too high values. Because polarisation was neglected during the reflectance lookup table generation procedure, the L2-AAI is sensitive to the viewing geometry. Replacement of the lookup tables is needed to overcome this problem.

The SCIAMACHY scientific AAI product shows a promising comparison with absorbing aerosol events, as shown with the comparison to the TOMS AAI. The AAI product is very sensitive to calibration errors, so the reflectance offset in the SCIAMACHY measurements disturbs the AAI values. Although the AAI is not directly derived from the reflectances but through a lookup table procedure constraining a Lambertian surface albedo, it responds linearly to reflectance changes at either of the two wavelengths. Therefore, with the right reflectance correction factors at the two wavelengths a reasonable range of AAI values can be achieved. More reliable data covering aerosol events are needed to improve the reflectance correction for the SCIAMACHY scientific AAI product .

5. REFERENCES

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