JUMPS IN THE SCIAMACHY LEVEL-1C REFLECTANCE SPECTRUM DUE TO FAILING POLARISATION CORRECTION

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ABSTRACT

Recently, many people have found polarisation features in the SCIAMACHY Level-1c spectrum, in the form of jumps. The jumps are found to be caused by the polarisation correction algorithm, which is evidenced by the fact that the jumps occur only when the polarisation correction is switched on, and only at cluster transitions where the integration time changes. We explain the origin of the jumps, which is the failing polarisation correction algorithm, and indicate how a change in the data processor can avoid the occurrence of these jumps even in the case of a failing polarisation correction.

1. INTRODUCTION

Fig. 1 presents the entire reflectance spectrum of a specific measurement taken by SCIAMACHY over the Sahara desert (orbit 2509, August 23, 2002). Different colours relate to different spectral channels. Because of the concept of different integration times [1], all the measurements having an integration time (IT) smaller than one second were added to produce the observations that would have been measured if the integration time had in fact been one second ('binning'). The ground pixels obtained in this way can be and were classified as 'east', 'center-east', 'center-west', 'west', and 'backscan' pixels. Fig. 1 presents the SCIAMACHY reflectance spectrum of the first 'east' pixel of the selected Sahara state.

The bad pixel mask was applied and blind pixels were removed, but the correction for polarisation was not switched on. The result is that, because of different channel sensitivities with respect to polarisation, the reflectances of the various spectral channels do not overlap in the overlapping regions. This is the expected behaviour for a non-polarisation corrected spectrum and forms no reason for concern. Clearly visible is the strong polarisation feature in channel 2, around 350 nm, that was reported late 2002 [2, 3]. The polarisation correction algorithm (PCA) will have to correct for it.

Switching on the polarisation correction does improve matters somewhat (cf. Fig. 2). In particular, the polarisation feature around 350 nm is suppressed considerably. However, although the spectral channels seem to match each other more closely in the overlapping regions, new (polarisation related) features are introduced in the form of jumps. These jumps were reported by amongst others Kerridge *et al.* [2]. The jumps occur precisely at the cluster transitions, but only when the integration times at both sides of the transition are different. If this is not the case, jumps at the cluster transitions are not found.

Figures 3 and 4 are meant to shed some more light on the subject. Fig. 3 is identical to Fig. 2 but presents a much smaller wavelength region. Fig. 4 is another observation taken from the same orbit but from a different state. The jumps are clearly visible in both figures, but Fig. 4 additionally shows that the polarisation feature around 350 nm in this case was not corrected for in a satisfactory way by the polarisation correction algorithm. The jumps in this window occur precisely at the cluster transitions 9→8 and 14→15, which both feature different ITs at either side of the cluster transition.

At this point it is important to note that there exist basically two types of polarisation features that exist in the SCIAMACHY Level-1c reflectance spectrum. First, we have polarisation features that are caused by (a wrong correction for) the instrumental polarisation sensitivity of the SCIAMACHY instrument. Examples of these are the polarisation feature near 350 nm and jumps occuring at channel transitions. However, these features are not discussed in this paper. Then there are also the cluster jumps discussed in this paper, which will turn out to be caused by an inconsistent calculation of polarisation for different ITs. This inconsistency is caused by the way in which the polarisation correction algorithm was set up [1].

2. EXPLANATION OF JUMPS

The existence of the jumps can be explained easily. First of all, they occur only when polarisation correction is applied, and secondly, they occur only at cluster transitions and then only when the ITs at both sides of this transition are different. In the SciaL1C tool (version 2.2.7), the polarisation correction is calculated independently for every IT. In the case of a failing polarisation algorithm, or in the case of an inconsistent polarisation calculation between various ITs, the correction made by the PCA for shorter ITs can be different from that at the longer ITs, which is still noticeable after binning. It is well known that especially at the shorter ITs [1] the SCIAMACHY polarisation correction of the Level-1 product is not working perfectly [4]. The existence of these jumps is, therefore, a symptom, as well as a strong indication, of a failing polarisation correction. A more technical and complete explanation is given in the next section.

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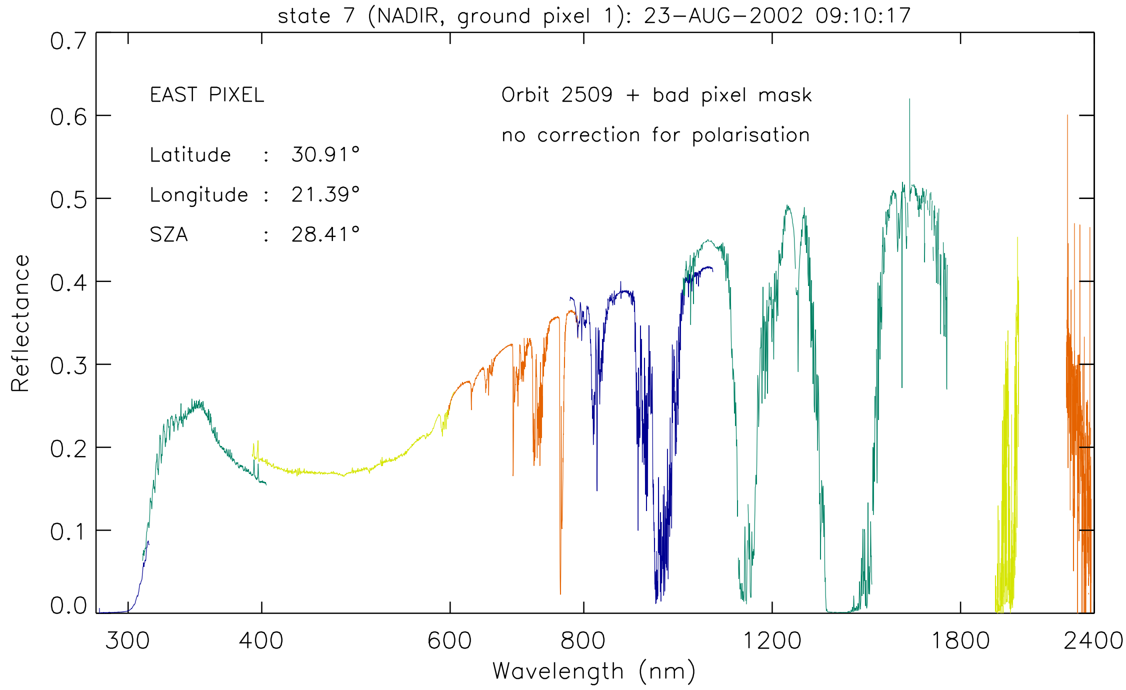

Fig. 1. The SCIAMACHY spectrum for a specific observation is plotted over its entire wavelength range. The orbit in question is orbit 2509 dated 23 August 2002. The bad pixel mask was applied but the spectrum was not corrected for the effects of atmospheric polarisation. As a result, jumps exist between overlapping channels.

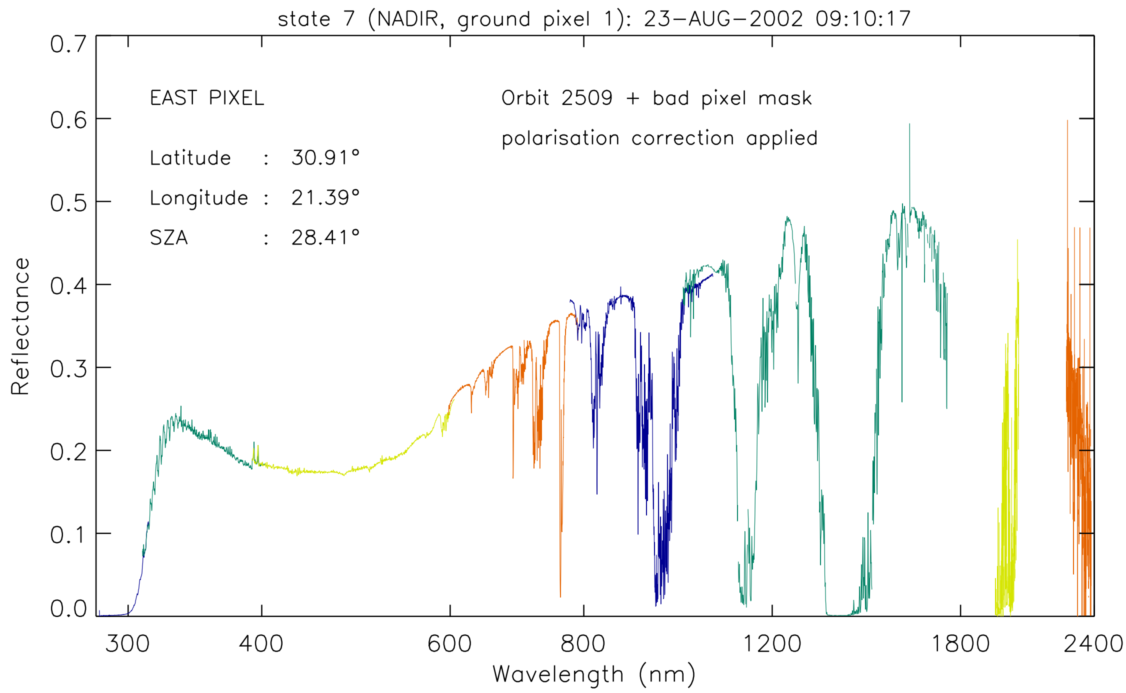

Fig. 2. The same data as in Fig. 1 but this time the polarisation correction was switched on. The spectrum does indeed improve near the channel overlaps, and the strong polarisation feature around 350 nm is almost completely removed. However, new polarisation related features are introduced in the spectrum (cf. Fig. 3).

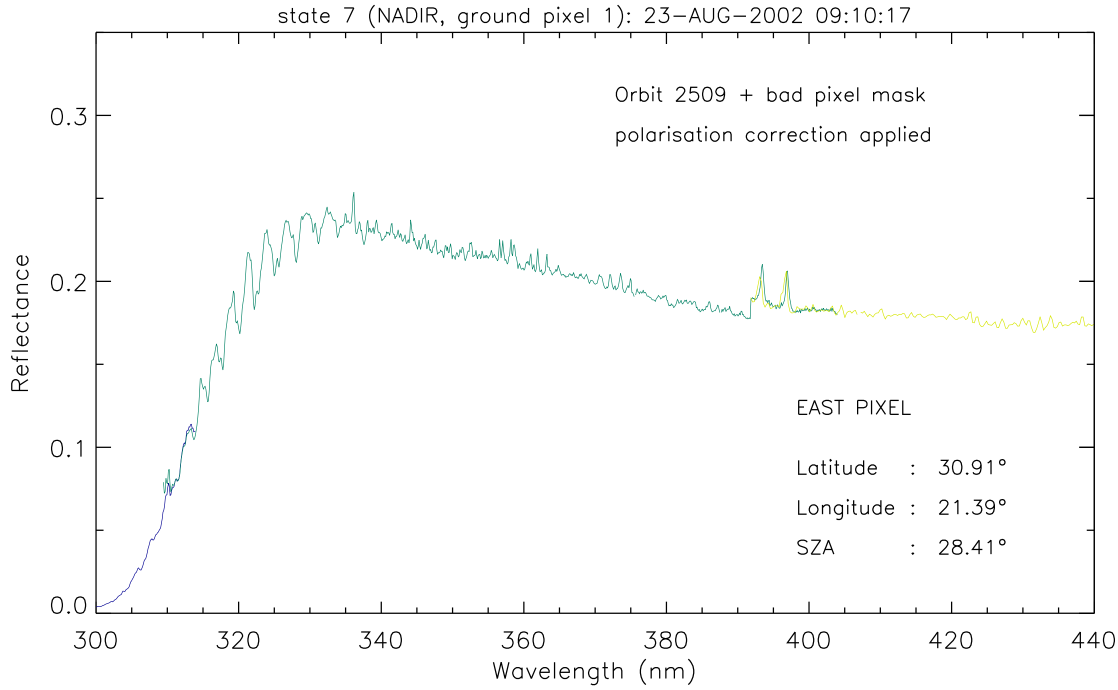

Fig. 3. A small portion of the same spectrum presented earlier in Fig. 2. The polarisation feature around 350 nm is obviously not completely removed and near a wavelength of about 390 nm, a sudden jump occurs right at a cluster transition (cluster 9→8 in spectral channel 2).

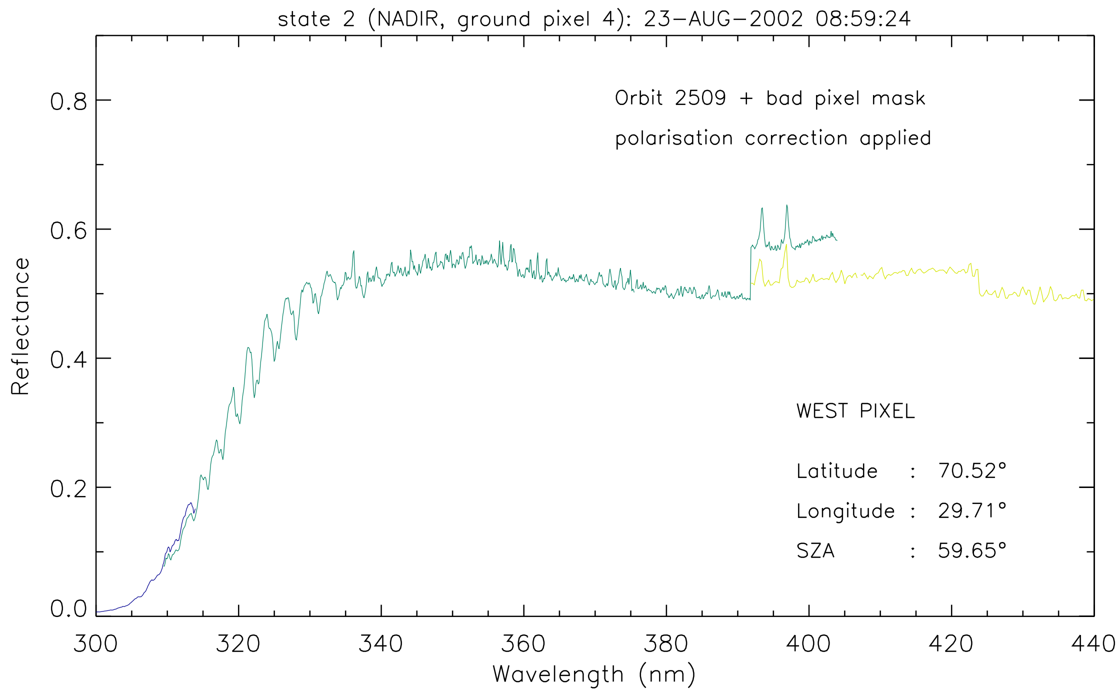

Fig. 4. A spectrum taken from another state of orbit 2509, closer to the polar region. For this observation, the polarisation correction algorithm is not able to suppress the polarisation feature around 350 nm. Also, the two jumps that occur are fully related to cluster transitions (9→8 and 14→15).

3. FURTHER EXPLANATION & SOLUTION

3.1 Inconsistency between different ITs

Suppose we are looking at two subsequent nadir measurements both having ITs of 0.5 seconds (as in Fig. 5). Let's call the intensities of the non-polarisation-corrected pixels i_1 and i_2, respectively. The task of the Polarisation Correction Algorithm (PCA) is to find the polarisation correction factors c_1 and c_2 for these measurements. Alternatively, we could also decide to bin the two non-polarisation-corrected pixels into a 1-second pixel. This 'new' pixel has intensity I, for which we can write down

$$I = (i_1 + i_2)/2 \; , \qquad (1)$$

which is a trivial statement. For all the 1-second pixels, a polarisation correction factor C is calculated by the data processor as well. Using this, we can, if we should want to, obtain a polarisation-corrected 1-second ground pixel of intensity $C \cdot I$. Additionally, the polarisation-corrected pixels $c_1 \cdot i_1$ and $c_2 \cdot i_2$ on their turn, when binned, should in principle also result in a polarisation corrected pixel with intensity $C \cdot I$, according to

$$C \cdot I = (c_1 \cdot i_1 + c_2 \cdot i_2)/2 \; . \qquad (2)$$

However, as the correction factors (c_1 and c_2) and C are calculated somewhat independently by the Level 0-1c data processor, Eq. 2 is unfortunately *not* always obeyed and when this happens, an inconsistency is found between the different ITs. Eq. 2 and the binning procedure can therefore be used as a consistency-check.

3.2 Cluster jumps

The inconsistency described above is also the cause of the 'cluster jumps' we observe if we bin all the various clusters into a 1-second ground pixel to form a complete SCIAMACHY spectrum. Suppose that at some cluster transition, there are 0.5-second pixels on the left and 1-second pixels on the right (having nearly the same wavelength). Eq. 1 still holds, of course, but when Eq. 2 is not obeyed, a jump in the (binned) spectrum is found. If Eq. 2 *is* obeyed, jumps are not found. The PCA should therefore, ideally, not violate Eq. 2 in order to avoid inconsistencies and jumps in the reflectance at cluster boundaries. If this is achieved, i.e. if the polarisation correction is calculated correctly, the jumps will disappear.

3.3 Solution

It is probably better not to rely on (or wait for) a proper polarisation correction. If the data processor would not calculate the polarisation correction factors (like c_1, c_2, and C in Fig. 5) separately, but instead use the relation given in Eq. 2, it would make the polarisation parameters for different ITs consistent *by definition*, and apart from this advantage, it would make it impossible for cluster jumps to exist. The polarisation correction could still be wrong, of course, but it would be consistent, and cluster jumps would not occur in the reflectance spectrum.

In the SCIAMACHY data processor, inconsistencies between different ITs are mainly caused by the fact that for the shorter ITs, the PCA needs radiance information that is only available for the longer ITs. This radiance information is cut into pieces to be able to calculate the polarisation for the shorter ITs [1]. This is why the polarisation correction for the longer ITs is more reliable than that for the shorter ITs. It also means that the PCA should start at the longest IT, and the data processor should work its way down to the shortest IT obeying Eq. 2.

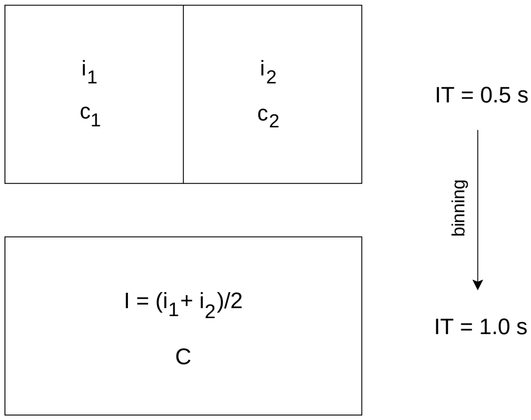

Fig. 5. The binning of radiance or reflectance signals (in this case two belonging to a cluster of 0.5-second IT) in order to compare these with measurements having a longer IT (in this case a single 1-second measurement) is not trivial because of the polarisation correction that needs to be applied: do we apply it before binning, using c_1 and c_2, or do we apply it after binning, using C? For SCIAMACHY, C turns out to be the better choice.

4. SUMMARY & CONCLUSION

We have found jumps within the spectral channels in the SCIAMACHY Level-1c spectrum. The jumps occur after applying the polarisation correction and only at cluster transitions. They are completely caused by errors in the applied polarisation corrections, which are not the same for different ITs (even after binning). The existence of jumps in the spectrum is therefore completely understood, and will be automatically solved when the polarisation correction algorithm is working properly. However, it would be better to solve the problem without waiting for a better polarisation correction. The obvious solution (change in the data processor) is given in this paper.

Acknowledgement

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5. REFERENCES

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