IMPACT OF LEVEL 1 QUALITY ON SCIAMACHY CO RETRIEVAL

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ABSTRACT

The SCIAMACHY near infrared (NIR) channels 6-8 are suitable to retrieve vertical column densities (VCDs) of atmospheric gases such as CO, CH4, CO2 or H2O. BIRRA will be used in the coming version 5 of the offline Level 1b to 2 SCIAMACHY processor to retrieve CO values operationally. The quality of VCD retrievals depends on theoretical, computational and observational issues. Realistic atmospheric data as well as efficient yet accurate, robust radiation transfer models and inversion methods have to be used. However, especially operational applications require to keep computational time within strict limits and the best possible models are chosen according to this restriction. The quality of the measured spectra greatly affects the accuracy of the retrievals. Since model parameters are optimally varied during the inversion process to mimic the measured values, errors in the input spectra will lead to wrong retrievals. SCIAMACHY spectra are spectrally and radiometrically calibrated and corrected for several effects, namely: Leakage current, pixel-to-pixel gain, non-linear response, stray light, polarisation. Reflectances are calculated using in-flight sun diffuser spectra. Additionally, the degradation of the instrument is being monitored and the quality of the individual spectral pixels assessed. It turned out that the effect of the dead/bad pixel mask (DBPM) has a major impact on the retrievals. Focusing on carbon monoxide, this work aims at studying the effect of critical calibration steps on the retrieval of atmospheric gas VCDs.

1. INTRODUCTION

The BIRRA (Beer InfraRed Retrieval Algorithm) retrieval [5] uses a least squares fit of the measured radiance with respect to molecular column densities. CO retrieval is done in channel 8 of SCIAMACHY, which is hampered by two main effects: A number of damaged detector pixels increasing with time [3] and an ice layer deposited on the detector. In this paper we present very first results on the influence of these effects on the CO retrieval.

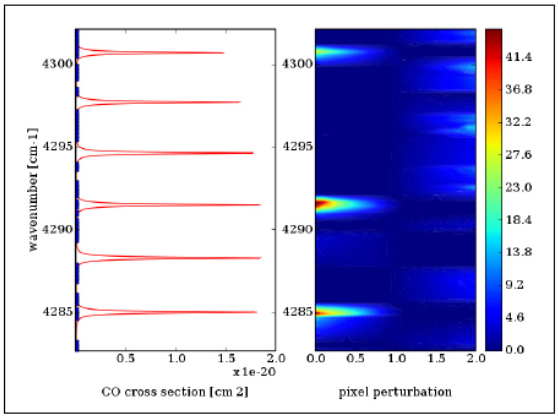

Figure 1. Sensitivity of BIRRA

2. SENSITIVITY TO SIGNAL CHANGES IN INDIVIDUAL PIXELS

In order to determine the sensitivity of BIRRA to changes in individual pixels, we generated a synthetic spectrum and subsequently changed the signal in pixels that are not flagged in the DBPM (see below). In total we made 1020 simulations, using the formula

$$I_{ij}^{pert} = a_i \times I_{syn} \tag{1}$$

with

$$a_i = 0.1 \cdot i;\ i = 0, \ldots, 20;\ j = 0, \ldots, 51 \tag{2}$$

The result in Figure 1 shows a contour plot of retrieved CO in units of the input VCD. Even small perturbations in the centre of the CO lines can lead to changes of a factor of 20 40. Therefore a good characterisation of instrument behaviour is essential for a reliable retrieval.

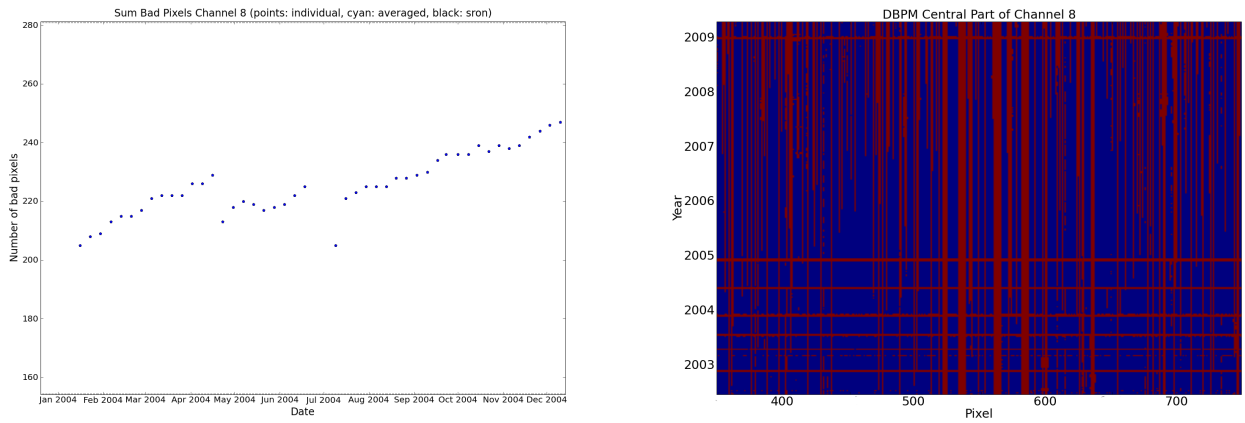

Figure 2. Sum of flagged pixels for 2004 (left) and pixel mask from 2002 to 2009 (right). Good Pixels are marked blue and bad pixels red. Several decontaminations are visible as horizontal lines.

3. DEAD & BAD PIXEL MASK

The DBPM contains pixels that are deemed unusable for the retrieval due to damage mostly caused by heightened particle flux during the passing of the Southern Atlantic Anomaly (SAA). Consequences of the damage are, e.g. high noise values, disconnection or very high leakage currents. Dark, sun and internal lamp measurements are used to determine bad pixels [see e.g. 4]. From these measurements parameters such as mean noise or error of dark parameters are calculated. If the parameters violate certain thresholds it is flagged as a bad pixel. Currently these thresholds are defined channel wise, i.e. for all pixels in a given channel of SCIAMACHY the same thresholds are defined. A pixel is always bad or good, there are no intermediate values. Figure 2 shows the evolution of the number of bad pixels in the year 2004 for channel 8 and the evolution of the pixel mask from the mission start to June 2009. It can be seen that the number of bad pixels rises with time. In June 2009 around 60 % of the pixels in channel 8 are marked as bad. Figure 3 shows the effect of using a constant mask for one year vs using a continuously updated mask. Even though the total number of flagged pixels does not change dramatically between February and October 2004, the result differs significantly, meaning that the result depends on the quality of the signal in individual pixels. This result was already found earlier for the CO retrieval IMLM of SRON [1]. In order to better reflect the dependency on individual pixels, for future calculations of the DBPM it is planned to determine thresholds for each pixel in a channel and give a noise level and a quality indication. In this way it is possible to exclude a pixel on the basis of the requirements of a given application or retrieval.

Apart from the flagging on the basis of physical changes in the detector, one must also consider insufficient knowledge of the cross sections of the trace gases or interference with other lines in the spectral window of interest. The effect of using different lines for the retrieval is shown in figure 4. A more detailed comparison can be found in the paper by S. Gimeno Garcia et al in this proceedings.

4. ICE LAYER AND INSTRUMENT TRANSMISSION

The NIR detectors of SCIAMACHY are the coldest point of the instrument. Since not all water was removed from ENVISAT during the commissioning phase, an ice layer is deposited on the detector surface. It is regularly removed by heating the detectors. The ice reduces the transmission in dependence of the wavelength and scatters the light and leads generally to broader lines. Figure 5 shows the sun mean reference shortly after a decontamination, i.e. with only a thin or no ice layer and a sun spectrum several weeks later. The change of the spectral shape due to the ice absorption is clearly visible.

Using the daily measured SMR should remove the effect of the changed spectral shape. This can be seen in the middle panel of figure 6: The plot shows the daily retrieval results for a Sahara ground pixel from 2004. In this year two decontaminations, one in January and one in June, were performed. The middle panel shows the fitted reflectivity terms for the first two orders. Except for the quadratic term, no effect of the changing instrument transmission can be seen. However, the methane scaling factor, which is used as an auxiliary gas for the retrieval still shows a very clear dependence on the transmission. The reason for this is not clear at the moment and will be investigated in further studies. Possible causes

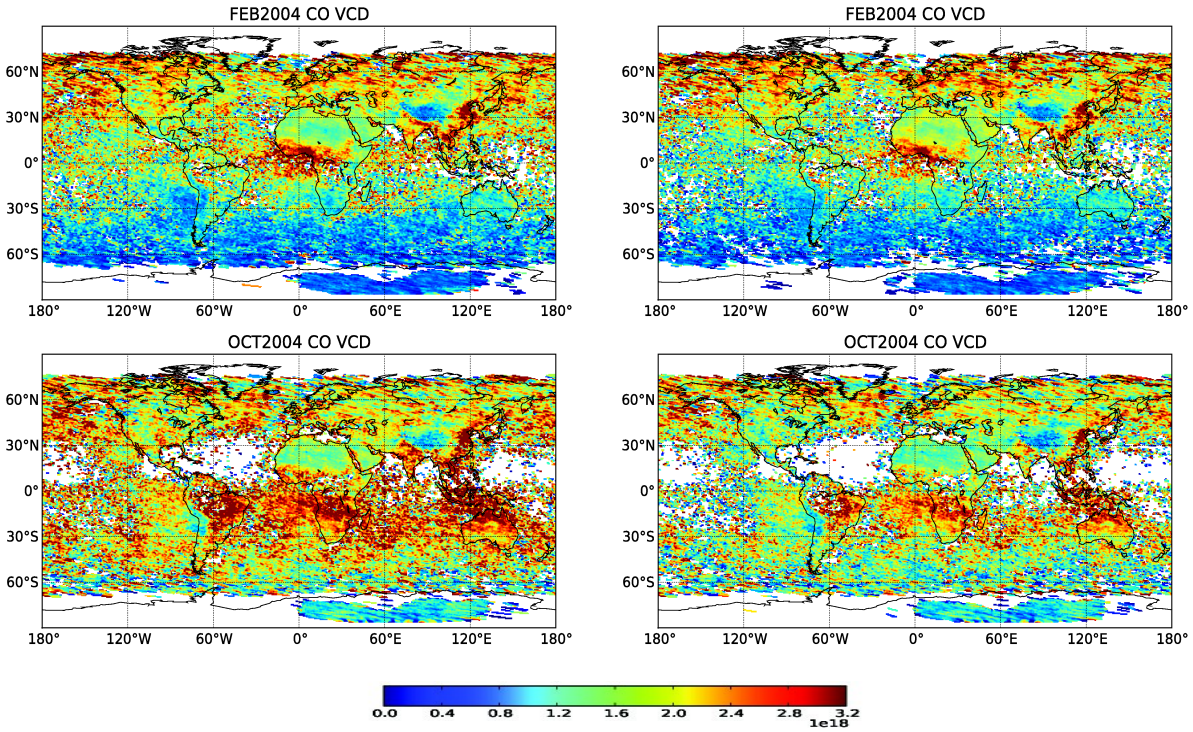

Figure 3. Comparison of a retrieval using a constant mask flagging only pixels that are marked as bad for at least half of the cases of the year 2004 (left) and a retrieval using a dynamic mask appropriate for each measurement (right). In February (top) the results look similar while the result for October is noisier for the constant mask. The constant mask flags not all bad pixels in October, here the dynamic mask gives the better result.

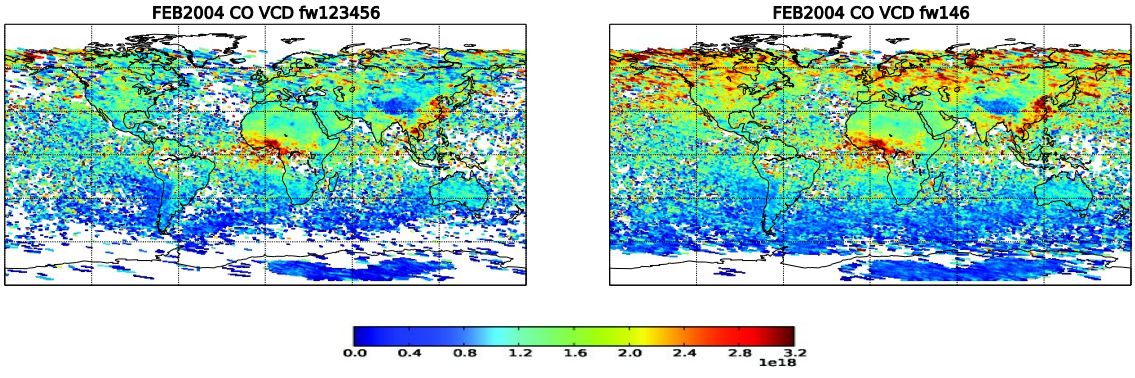

Figure 4. Figure 4: Comparison of two retrievals for February 2004. Left: All CO lines in the retrieval window are used. Right: Lines with strong water vapour interference are excluded. In the latter case several features like enhanced CO values in South-East Asia and the North-South trend are more clearly visible.

Figure 5. SMR with ice layer (green) and with clean detector (blue), normalised to the signal in an arbitrary pixel to illustrate the change in the spectral shape.

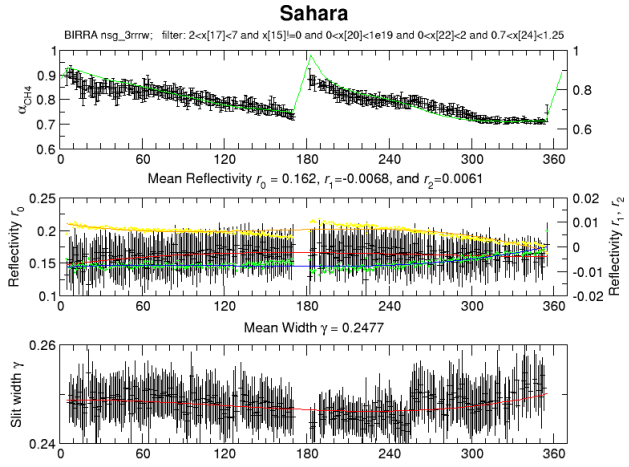

Figure 6. Daily retrieval results for BIRRA for a Sahara ground-pixel from 2004. Top: Methane scaling factor. Middle: Polynomial coefficients for the reflectivity. Bottom fitted slit function width.

are the changing signal-to-noise [2] or the change of the slit-function (shown in the bottom panel).

5. SUMMARY

The retrieval of trace gases in the NIR detector of SCIAMACHY is strongly influenced by damaged pixels and the ice layer on top of the detectors. Both effects are changing in time, requiring a monitoring and the application of up-to-date calibration parameters like the daily SMR and the dynamic pixel mask. At the same time the CO retrieval is very sensitive to small perturbations of the signal and insufficient knowledge of trace gas cross sections impact the retrieval. As was already shown in other studies, for an accurate retrieval, the sensitivity of the retrieval to both, the instrument (or calibration) aspects, and the quality of the a-priori knowledge for the retrieval have to be considered. In this paper we presented first results of the investigation into calibration effects on the BIRRA CO retrieval. A thorough study, additionally taking into account calibration parameters such as thermal background and pixel-to-pixel gain is planned to investigate the sensitivities of BIRRA. In this study we also plan to investigate the remaining dependency of methane to the transmission changes.

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