SCIAMACHY COLUMN OZONE VALIDATION

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ABSTRACT/RESUME

Validation of SCIAMACHY column ozone amounts (Version 5.1 validation data set) was performed by comparing with the NOAA-16 SBUV/2 and the ERS-2 GOME instruments using two algorithms. As an interim step in evaluating the SBUV/2 comparisons, these ozone data were compared to Northern Hemisphere Dobson stations. Overall The SCIAMACHY validation data set is found to be low of the order of 3% with respect to the satellite data and about 1% low with respect to ground station data. There appears to be a seasonal and or a solar zenith dependence in the comparisons with SBUV/2. A longer validation data set with more coverage in both hemispheres are needed to unravel the cause of these differences. These comparisons demonstrate that SCIAMACHY version 5.1 column ozone amounts are a considerable improvement over the data from the previous release.

1. INTRODUCTION

SCIAMACHY was launched on Envisat in March 2002. The instrument has operated successfully since being powered on and there have been two major Level 2 processing since that time. A number of factors in both the Level 1 and 2 algorithms were corrected after the first processing. These corrections were made to the calibrations and to the retrieval software used in the Level 2 processor.

Satellite comparisons have an advantage over ground stations for validation since good statistics and a wide range of viewing conditions and ozone amounts are encountered. Equally important is that the test data are compared using a single instrument, which then overcomes the problem of possible ground station biases from one station to the next.

This paper focuses on validation of SCIAMACHY total column by comparing with near coincident NOAA SBUV/2 and ERS-2 data sets. The comparison parameters are described in the next section. This is followed by a comparison with the NOAA SBUV/2 data sorted by total ozone amount and solar zenith angle. The SBUV/2 data are then also compared to ground stations to provide an estimate of their validity. The SCIAMACHY data are then compared to ERS-2/GOME where both the Version 3 operational data and data using an algorithm developed by the University of Bremen are used.

2. COMPARISON PARAMETERS

Although SCIAMACHY has operated for over two years only a small data set called “5.1 Validation Data Set” are available for comparison. This data set covers the period July 17 to December 17 2002. The SCIAMACHY data were matched to SBUV/2 data when SCIAMACHY scans fell within 350 km of the center SBUV/2 180 km square scan. For the comparison period a total of 3080 matches were found for a 24 hour window and 1936 were within +/- 6 hours. Figure 1 illustrates the location of SBUV/2 SCIAMACHY 3080 matchups.

The NOAA-16 and SCIAMACHY spacecraft are both in polar orbits with and equator crossing time of 14:30 and 10:30 respectively, which results in most matchups appearing at high latitudes. Additional subsetting of SCIAMACHY data for the present validation data set resulted in matchups primarily occurring in the Northern Hemisphere.

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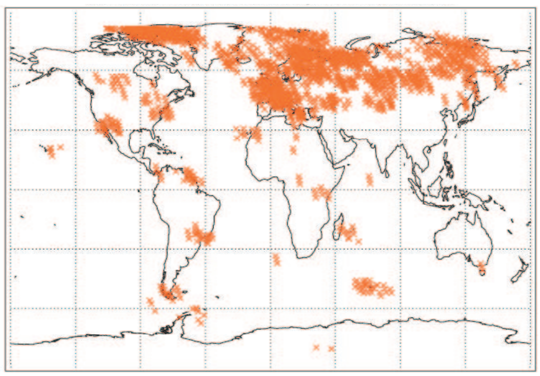

Fig. 1. Geographical location of SBUV/2 and SCIAMACHY matchups using criteria described in the text.

The SBUV/2 total ozone data were the integrated profiles using the Ver. 8 profile algorithm [1]. The data set used here is from the operational processor and has not yet undergone thorough the recalibration, external validation, and reprocessing normally done for SBUV/2 data.

3. SCIAMACHY WITH RESPECT TO SBUV/2

Past experience with SBUV/2 and TOMS has shown that calibration and algorithm errors can be diagnosed by analyzing comparison data as a function of solar zenith angle and total ozone. Such comparisons, between SBUV/2 and SCIAMACHY are shown in Figures 2a and 2b. Figure 2a shows that SCIAMACHY is low by about 3% with respect to SBUV where the bias has noticeable solar zenith angle dependence beyond 60 degrees. The standard deviation also increases after this solar zenith angle as well.

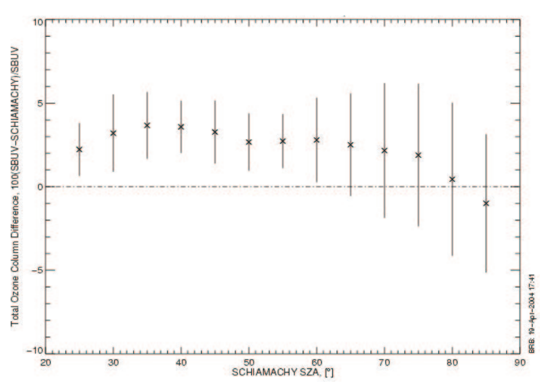

Fig. 2a. The ordinate is (SBUV/2-SCIAMACHY)/SBUV/2 and ranges from ±10%. The abscissa is solar zenith angle from 20° to 90°

The increase in standard deviation is likely due to atmospheric variability, which would be encountered at high latitudes especially towards the end of the data period in December. The bias is not explained here but likely due to calibration errors in one or both of the instruments. Some of the bias (~1%) could be due to ozone cross section differences used in the two instruments' algorithms. SBUV/2 is calibrated after launch using the "D pair" (wavelengths near 310 nm) [2] while the SCIAMACHY retrieval uses a window near 330 nm. The solar zenith angle dependence is likely due to the different sensitivities the two algorithms have to ozone profile shapes and air mass factors.

Figure 2b is similar to Figure 2a except the differences are plotted as function of total ozone. The results here show the bias increases with ozone amounts despite the fact that solar zenith angle and total ozone are could be correlated through latitude. But for the August through December data, this is likely not case. Nevertheless these results point to algorithm differences rather than calibration.

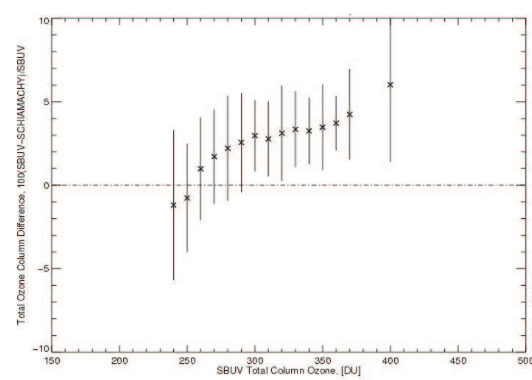

Fig. 2b. The ordinate is (SBUV/2-SCIAMACHY)/SBUV/2 and ranges from ±10%. The abscissa is SBUV/2 column ozone amount and ranges from 150 to 500 DU.

4. SBUV/2 VALIDATION WITH RESPECT TO GROUND STATIONS

The difference shown in figure 2a and 2b require further analysis to resolve where the algorithm errors lie with respect to sensitivities to ozone profiles and air mass factors. The validation data set provided for this analysis is of insufficient size to pursue this analysis. It is instructive to examine how SBUV/2 compares with the ground stations. Figure 3 compares SBUV/2 to 66

Northern Hemisphere ground stations that are known to be reliable over the period mid 2000 to the end of 2003. The match criteria are 200 km for a given day. There are about 40 matchups per day and the data are averaged over a week for the two and one half year data period.

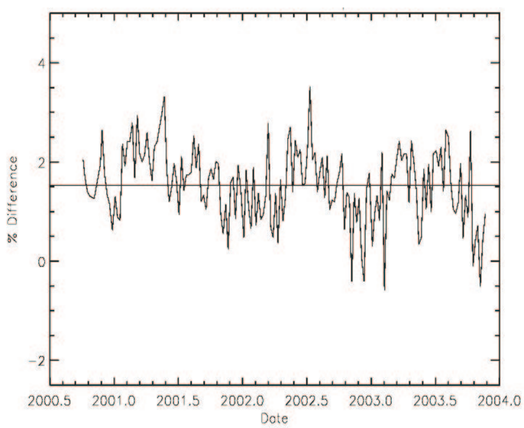

Fig. 3. SBUV compared to ground stations. The ordinate is (SBUV/2-Stations)SBUV/2. The ordinate is ±10% and the abscissa is time.

SBUV/2 shows a positive bias of about 1.5% with a 1% seasonal dependence. The bias implies that SCIAMACHY would be closer to the ground stations than SBUV/2. This was shown to be true by Lambert *et al.* in these proceedings[3]. The seasonal dependence shown in Figure 3 does not explain the results in Figures 2a and 2b. More comparisons are needed between SBUV/2 and SCIAMACHY in both hemispheres for a longer time period including more seasonal cycles to verify these conclusions.

5. SCIAMACHY COMPARISONS WITH RESPECT TO GOME

Further comparisons of SCIAMACHY total ozone amounts were made with GOME on-board ERS-2. Two orbits were selected in August 2002 and depicted in Figure 4.

Comparisons are made with GOME data processed using the Version 3.0 operational algorithm and using the Weighting Function DOAS (WFDOAS) developed at the University of Bremen[4]. Results of comparison with GOME WFDOAS are shown in Figure 5.

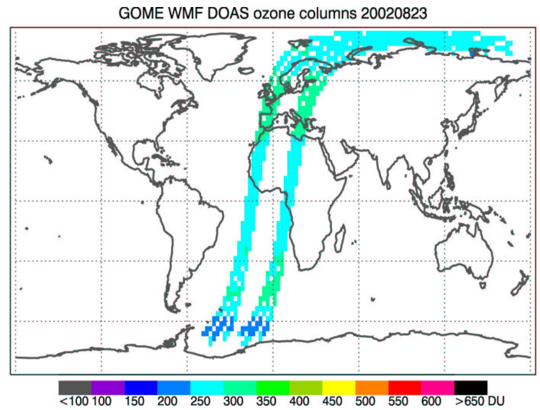

Fig. 4, Location of GOME data compared to SCIAMACHY. Ozone ranged from about 250 to 300 DU for the two orbits tested.

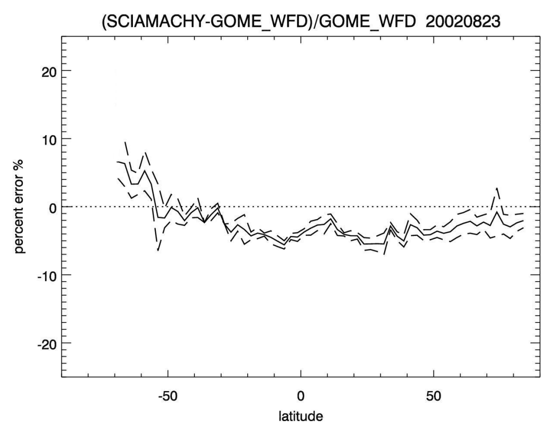

Fig. 5. Comparison of SCIAMACHY with GOME using WFDOAS. The ordinate is ±20% and the abscissa is latitude.

From about 50°S to 50°N SCIAMACHY is low about 3%, which implies that GOME/WFDOAS is high with respect to ground stations of order of 1% and is consistent with SBUV/2 comparisons and Coldewey-Egbers, et al. [4]. The solar zenith and or latitude dependence seen in Figure 6 is primarily due to the performance of the two algorithms. Lambert [3] has evidence that SCIAMACHY has a strong solar zenith angle dependence that may explain the high latitude differences in Figure 6.

As further cross check of algorithms, the same SCIAMACHY data are compared with the GOME 3.0 operational data set and shown in Figure 6.

Figure 6 shows that the GOME data agrees with SCIAMACHY with respect to biases between 50°S and 50°N, but the latitudinal dependence persist. The agreement is likely due to common heritage for the two algorithms. With regard to the latitude differences, one might further conclude that SCIAMACHY has solar zenith angle errors as discussed above.

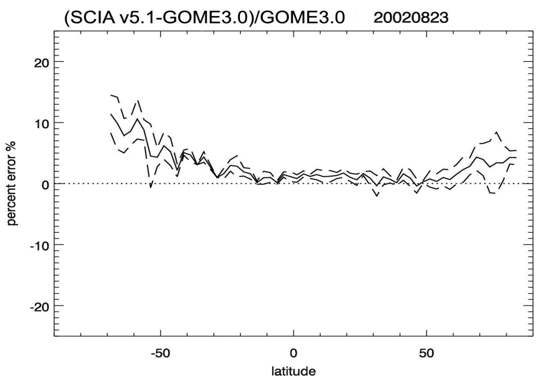

Fig. 6. Comparison of GOME processed using operational algorithm and WFDOAS. The ordinate and abscissa are the same as in Figure 5.

6. SUMMARY AND CONCLUSIONS

Satellite data with demonstrated accuracy afford the most reliable way of validating new satellite data. Satellites comparisons have an advantage over ground stations since good statistics and a wide range of viewing conditions and ozone amounts are encountered. Equally important is that the data are tested using a single instrument, which then overcomes the problem of possible ground station biases from one station to the next which is manifested as noise in an intercomparison data set.

It was shown that SCIAMACHY Version 5.1 total ozone validation data set agrees to within 3% percent of the operational NOAA-16 SBUV/2 data. Comparison of SBUV/2 with ground stations imply that SCIAMACHY data should agree with them to about 1%, which is confirmed by other results shown in these proceedings. Systematic errors are likely due to calibration or cross sections errors but are of the order of 1%. Latitudinal dependent errors range from 1 to 10% and are most likely depend on how the algorithms respond to solar zenith angle changes. These errors can result from unrepresentative ozone profiles used in the radiative transfer models or lookup tables and in the calculation of airmass factors. Validation at high solar zenith angles are particularly challenging since ground stations suffer from equally difficult problems.

The SCIAMACHY data has been vastly improved over the previous processing, however the available validation data set is small, covers only one full season, and was located primarily in the Northern Hemisphere resulting in incomplete validation. The next step for validating SCIAMACHY data is to use a larger data set that is more representative of a range of atmospheric conditions. This paper has shown that there remain small systematic errors of the order of 2% in the various algorithms used for total ozone. Continued development is needed to resolve these differences in order produce a data set suitable for climate research.

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