

VALIDATION OF ENVISAT SCIAMACHY LEVEL 2 PRODUCTS WITH THE DATA OF RUSSIAN GROUND-BASED MEASUREMENTS

Y. Timofeyev⁽¹⁾, D. Ionov⁽¹⁾, M. Makarova⁽¹⁾, A. Poberovsky⁽¹⁾, A. Shalamyansky⁽²⁾, A. Elokhov⁽³⁾, A. Gruzdev⁽³⁾, N. Elansky⁽³⁾, A. Dzhola⁽³⁾, E. Grechko⁽³⁾, V. Sinyakov⁽⁴⁾, V. Semenov⁽⁴⁾, F. Kashin⁽⁵⁾, V. Aref'ev⁽⁵⁾

⁽¹⁾ St.Petersburg State Univeristy, Ulyanovskaya Str. 1, 198504 St.Petersburg, Russia, Email: ionov@troll.phys.spbu.ru

⁽²⁾ Main Geophysical Observatory, Karbyshev Str. 7, 194021 St.Petersburg, Russia, Email: ozon@peterlink.ru

⁽³⁾ Institute of Atmospheric Physics, Pyzhevsky Str. 3, 109017 Moscow, Russia, Email: elansky@omega.ifaran.ru

⁽⁴⁾ Kyrgyz National University, Manas Str. 101, 720033 Bishkek, Kyrgyzstan, Email: svk@elcat.kg

⁽⁵⁾ Institute of Experimental Meteorology, Lenina Str. 42, 249037 Obninsk, Russia, Email: las@typhoon.obninsk.org

ABSTRACT

The paper summarize results of comparisons between SCIAMACHY level 2 products and ground-based measurements at a number of stations in Russia and NIS, carried out for the period of ENVISAT commissioning phase validation in 2002 (ENVISAT AO-427). Basically, the study presents preliminary validation of SCIAMACHY ozone and NO₂ vertical column data, coming from nadir-mode measurements in July-December 2002, and generated with the processor version 5.01 (SCIAMACHY Validation MasterSet). The comparison involves regular observations of total ozone at about 20 locations over Russia and NIS, and 2 sites of twilight NO₂ vertical column measurements. In addition, CH₄ vertical column data was compared to ground-based observations at 3 sites. The main results are compared to those achieved before with the similar studies on SCIAMACHY data version 3.53.

1. INTRODUCTION

Russia and NIS (New Independent States) have a set of locations with regular ground-based measurements of the total content and near-surface concentration of ozone and other trace gases. The network is equipped with a number UV/visible and IR spectrometers, providing data on O₃, NO₂, CO, CH₄ and H₂O vertical column amounts [1, 2]:

1.1 Ground-based measurements of ozone vertical column by ozonometer M-124

- direct sun (20-70° SZA) or scattered zenith (20-85° SZA) radiation measurements,
- two spectral intervals with 302 and 326 nm maxima, 20 nm half-width,
- high latitude and practically all-weather observations,
- total ozone measurements with an accuracy of 3-4%.

1.2 Ground-based twilight measurements of NO₂ vertical column

- zenith-scattered solar radiation measured by grating spectrometer,
- 435-450 nm wavelength range with spectral resolution of 0.7 nm,
- twilight morning and evening observations at SZA 84-96°.

1.3 Ground-based spectroscopic measurements of CO, CH₄ and H₂O vertical columns

- direct sun IR measurements by grating spectrometer,
- ~3-5 μm spectral range with a resolution of ~0.3 cm⁻¹,
- the accuracy is ~7% for CO, ~5% for CH₄ and ~3% for H₂O.

Locations of ground-based measurements of ozone, NO₂ (Zvenigorod and Issyk-Kul), CO and CH₄ (Zvenigorod, Obninsk and St.Petersburg) vertical columns, that have contributed to the study, are shown in Fig. 1.

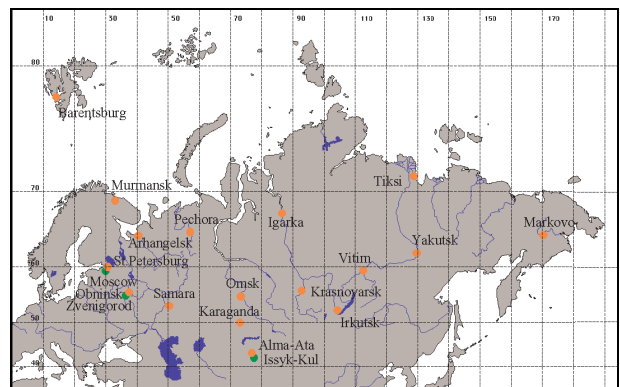


Fig. 1. Ground-based network of ozone, NO₂, CO and CH₄ vertical column measurements in Russia and NIS.

Most of the data used in comparison was converted to the uniform HDF data format and uploaded to

ENVISAT Calibration/Validation database at NADIR/NILU.

2. VALIDATION OF SCIAMACHY OZONE VERTICAL COLUMN DATA

17 stations of ground-based network in Russia and NIS (14-170°E/43-78°N) provided regular measurements of daily mean ozone vertical column in the period of 01.07-31.12.2002 (Fig. 1). Overall, about 2000 measurements were available for validation, and finally 507 of them were found to correlate with the data of SCIAMACHY. Nadir measurements collocated with the location of ground-based station within a range of 500 km were extracted from the data of SCIAMACHY and the nearest pixel was selected for the comparison. The average distance of selected SCIA pixel from ground-based station was 123 km; the Sun zenith angle varied from 31 to 86°, with an average of 56°. The scatter plot of comparison is presented on Fig. 2. On the average, the data of SCIAMACHY v5.01 is 4.2% lower (Δ) than ground-based measurements, with rms difference of 7.2% (σ), and correlation of 0.75 (R). The agreement is considerably better than it was for similar comparison of SCIAMACHY data v3.53 – Δ =-8.7%, σ =10.1%, R=0.79 (207 measurements for 12 stations, see Fig. 3).

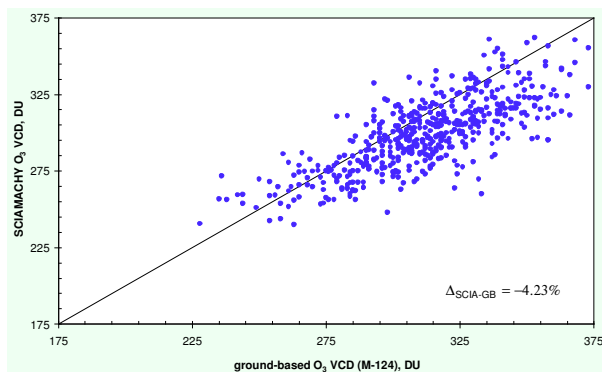


Fig. 2. Comparison of SCIAMACHY NRT (V5.01) ozone vertical column data with correlative ground-based measurements in Russia and NIS (14-170°/43-78°N, 18.07-16.12.2002).

3. VALIDATION OF SCIAMACHY NO₂ VERTICAL COLUMN DATA

During the validation campaign, the twilight measurements of NO₂ vertical column were carried out at 2 sites: Zvenigorod and Issyk-Kul (see Fig. 1).

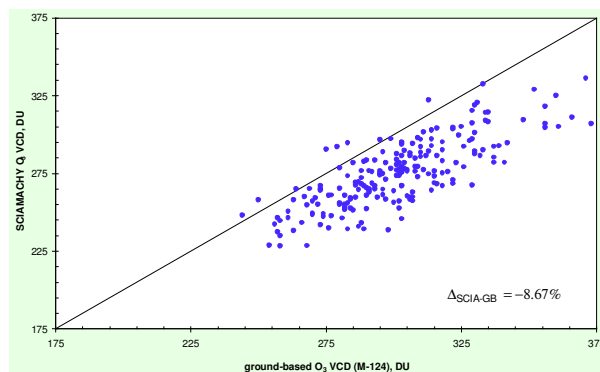


Fig. 3. Comparison of SCIAMACHY RV (V3.53) ozone vertical column data with correlative ground-based measurements in Russia and NIS (30-130°/43-68°N, 17.09-31.10.2002).

The overall number of successful daily measurements in the period of 01.07-31.12.2002 is ~90 at Zvenigorod and ~170 at Issyk-Kul. Only 103 of them were found to coincide with SCIAMACHY measurements provided in validation dataset, 65 at Zvenigorod and 38 at Issyk-Kul.

For the comparison, the nearest pixel of SCIAMACHY nadir measurements to the station was selected in the range of 1000 km. The corresponding time series plots of ground-based measurements (dawn and dusk) and coincident SCIAMACHY data are shown in Fig. 4, 5, consequently.

The data of SCIAMACHY is found to be high in comparison with ground-based measurements at Zvenigorod by the value of $\sim 1.2 \cdot 10^{15}$ mol/cm² (SCIAMACHY-GROUNDBASEDAM and $\sim 0.4 \cdot 10^{15}$ mol/cm² below sunrise at Issyk-Kul). This difference is less than it was for SCIAMACHY data v3.53: $\sim 3.6 \cdot 10^{15}$ mol/cm² at Zvenigorod and $\sim 0.7 \cdot 10^{15}$ mol/cm² at Issyk-Kul.

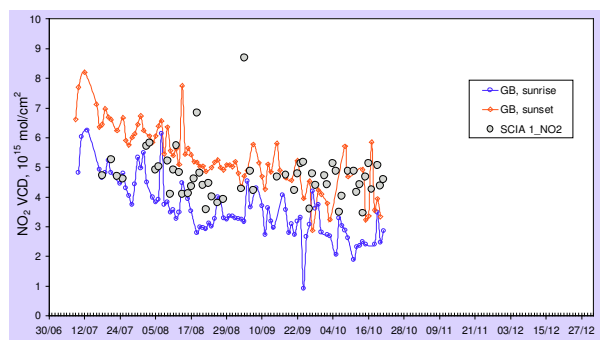


Fig. 4. Comparison of SCIAMACHY NRT (V5.01) NO₂ vertical column data with correlative ground-based measurements at Zvenigorod (37°E/56°N).

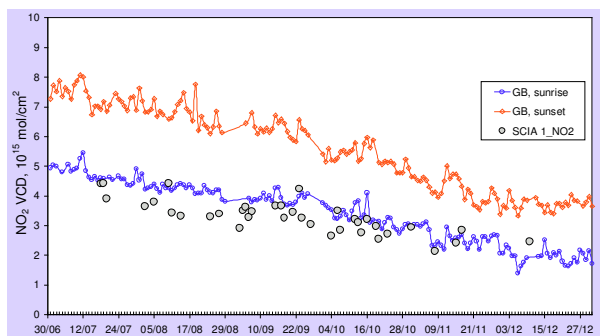


Fig. 5. Comparison of SCIAMACHY NRT (V5.01) NO₂ vertical column data with correlative ground-based measurements at Issyk-Kul (77°E/43°N).

4. VALIDATION OF SCIAMACHY CO AND CH₄ VERTICAL COLUMN DATA

The ground-based measurements of CO and CH₄ vertical columns were carried out at 3 sites: Zvenigorod, Obninsk and St.Petersburg (see Fig. 1).

The total amount of daily averaged data obtained from these stations in July-December 2002 is 95 for CO and 96 for CH₄ measurements.

For the comparison, the nearest pixel of SCIAMACHY nadir measurements to the station was selected in the range of 1000 km (same as for NO₂).

Unfortunately, CO vertical columns were found to be negative almost everywhere in operational products; so, only CH₄ operational data was considered here.

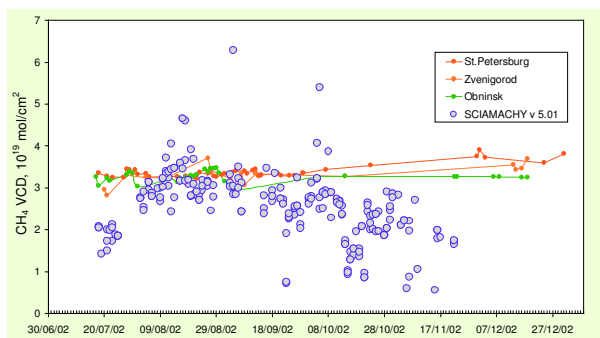


Fig. 6. Comparison of SCIAMACHY NRT (V5.01) CH₄ vertical column data with correlative ground-based measurements at St.Petersburg, Zvenigorod and Obninsk.

The time series plots of CH₄ vertical column measurements at St.Petersburg, Zvenigorod and Obninsk with a values of collocated SCIAMACHY data, are presented in Fig. 6. SCIAMACHY CH₄ measurements produce much scattered vertical columns

in comparison with ground-based ones, and 10-20% lower, on the average.

5. SUMMARY

According to the comparisons of O₃ vertical column data with a measurements at 17 locations over Russia and NIS, the data of SCIAMACHY (NRT, V5.01, DOAS_0) underestimates total ozone value, by 4% on the average.

The data of SCIAMACHY NO₂ vertical column was found to differ from ground-based measurements, by $\sim 1.2 \cdot 10^{15}$ mol/cm² at Zvenigorod (37°E/56°N) and $\sim 0.4 \cdot 10^{15}$ mol/cm² at Issyk-Kul (77°E/43°N).

The data of SCIAMACHY retrievals in IR range of spectra demonstrate negative value of CO vertical column, but reasonable data on CH₄ – the average deviation from ground-based measurements at 3 sites (St.Petersburg, Zvenigorod, Obninsk) is 10-20%.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

1. Timofeyev Y. M., et al., Validation of ENVISAT SCIAMACHY atmospheric trace gases measurements with the Russian ground-based monitoring network, in *Proc. Pre-launch Workshop on the Atmospheric Chemistry Validation of Envisat (ACVE)*, ESTEC, Noordwijk, 16-18 May 2001, ESA WPP-186, 2001.
2. Timofeyev Y. M., et al., Validation of ENVISAT SCIAMACHY atmospheric trace gases measurements with the Russian ground-based monitoring network, in *Proc. ENVISAT Validation Workshop, Frascati, 9-13 Dec. 2002*, ESA SP-531, 2003.