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GOME and SCIAMACHY solar measurements: Solar spectral irradiance and Mg II solar activity proxy indicator

J. Skupin, M. Weber, S. Noël, H. Bovensmann, and J. P. Burrows

Institute of Environmental Physics (IUP), University of Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany; e-mail: jochen.skupin@uni-bremen.de

Abstract. GOME (Global Ozone Monitoring Experiment, 1995-present) and SCIAMACHY (SCanning Imaging Absorption Spectrometer for Atmospheric CHartographY, 2002-present) provide solar observations in the visible and near UV since 1995. SCIAMACHY also measures in the near IR with some gaps up to 2380 nm. The solar spectral irradiance measured by SCIAMACHY is compared with results from other data sources such as SIM, SOLSPEC, SOLSTICE, and SUSIM and is generally in good agreement within 2 to 3% in most cases.
The Mg II index is derived from daily solar observations in the near UV spectral region which provides a good measure of the solar EUV variability. For the understanding of the solar-terrestrial climate interaction the establishment of a long Mg II time series spanning several decades is important. A continuous solar Mg II index from 1995 to 2005 composed from GOME and SCIAMACHY solar measurements is presented and compared with Mg II data available from NOAA.

Key words. SCIAMACHY, GOME, solar spectral irradiance, solar Mg II index

1. Introduction

GOME (Global Ozone Monitoring Experiment) and SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) are passive remote sensing instruments operating in the ultraviolet, visible, and near infrared (SCIAMACHY only) wavelength regions. Their primary objective is to determine the amounts and distributions of atmospheric trace constituents. In addition solar observations are performed regularly that offer the possibility to monitor solar spectral irradiance variations. GOME was launched on the ERS2 platform in 1995 while SCIAMACHY is part of the payload of ESA's Environmental Satellite ENVISAT launched on 2002-03-01 (Bovensmann et al. 1999). Together with the second European ozone monitoring experiment GOME2 (first launch in 2006), they complete a triple of similar instruments ensuring a continuous record of solar and atmospheric observations well into the second decade of the 21st century. This paper reports comparisons of SCIAMACHY solar spectral irradiance with other available solar spectra from Kurucz, SIM, SOLSPEC, SOLSTICE, and SUSIM.

Send offprint requests to: M. Weber

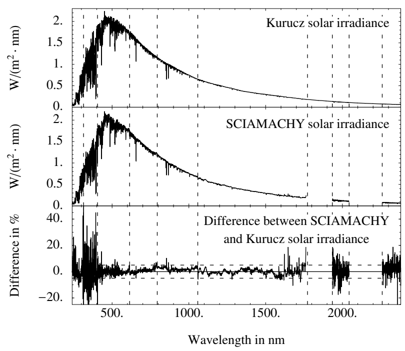

Fig. 1. Comparison of solar irradiance measured by SCIAMACHY with Kurucz spectrum. SCIAMACHY channel boundaries are marked by vertical dashed lines.

It has been shown that the Mg II index derived from daily solar observations in the near UV spectral region can be used as a reliable proxy to model extreme UV variability during solar cycle (Viereck et al. 2001). For the understanding of the solar-terrestrial climate interaction a long time series spanning several decades should be established that has to be combined from different instruments. The Mg II index as derived from SCIAMACHY is presented and is matched to the GOME time series (Weber et al. 1998) to provide a continuous time series from 1995 to 2005. This combined time series is compared with Mg II data available from NOAA.

2. SCIAMACHY solar spectral irradiance comparisons

SCIAMACHY is an eight channel spectrometer covering a wavelength range from 240 to 2380 nm thus including ultraviolet, visible, and near infrared spectral regions at moderate spectral resolution (0.2–1.5 nm). The calibration of the SCIAMACHY solar spectrum as presented here is preliminary in nature. Major differences with respect to the operational ESA data product are an alternative etalon correction and an improved absolute radiometric calibration.

To take care of the different spectral resolutions of the instruments, high resolution data are adapted to the lower resolution of the data they are compared with, i.e. the Kurucz spectrum distributed with the atmospheric radiative transfer model MODTRAN 3.7 (Kurucz 1995) is convoluted with the SCIAMACHY slit function to match SCIAMACHY spectral resolution. On the other hand SCIAMACHY solar irradiance is re-binned to match the spectral resolution of SIM (Harder et al. 2000), SOLSPEC (Thuillier et al. 2003), SOLSTICE (Rottman & Woods 1994), and SUSIM (Floyd et al. 2003). For the latter two UARS instruments data are only available for wavelengths up to 420 nm with a spectral resolution of 1 nm. At low spectral resolution the UV Fraunhofer structures are smoothed out and a generally better agreement is achieved as with higher resolution data from SIM, SOLSPEC, and Kurucz.

The comparisons are shown in Figs. 1 to 3. The mean differences (per channel) between SCIAMACHY and other data sources are given in Table 1. SCIAMACHY is in agreement with the Kurucz solar spectrum over the

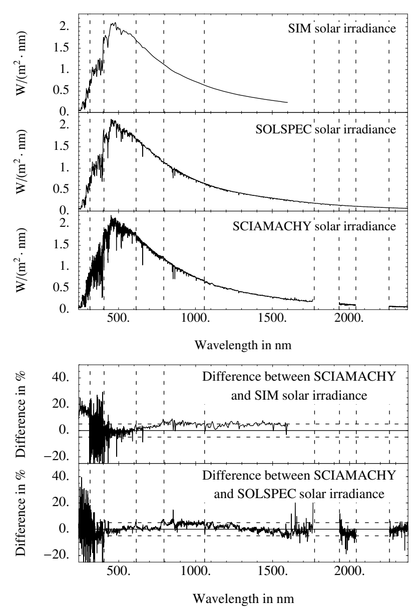

Fig. 2. Comparison of solar irradiance measured by SCIAMACHY (2004-03-05) with SIM (2004-05-03) and SOLSPEC spectra. Upper: solar irradiances, lower: difference between SCIAMACHY and other data, SCIAMACHY channel boundaries are marked by vertical dashed lines.

Table 1. Mean differences (per channel) between SCIAMACHY and other data in percent.

	SCIAMACHY channels (in plots marked by vertical dashed lines)							
	1	2	3	4	5	6	7	8
	Wavelength ranges in nm							
Difference with	240–314	309–405	394–620	604–805	785–1050	1000–1750	1940–2040	2265–2380
Kurucz	0.62	-1.16	-0.18	0.82	1.96	-0.04	-0.27	2.87
SIM	+11.95	-1.09	-1.30	+2.60	+5.44	+4.25	–	–
SOLSPEC	4.2	-2.73	0.	1.25	4.28	0.11	-3.27	0.02
SOLSTICE	0.8	-1.42	–	–	–	–	–	–
SUSIM	3.49	-0.42	–	–	–	–	–	–

entire wavelength range from 240 to 2380 nm within 2 to 3%. The same can be concluded from the comparison with other data for channels 2 to 4 (309–805 nm) and for channel 8. The other channels agree to within 6% except for channel 1 in comparison with SIM where SCIAMACHY is almost 12% higher.

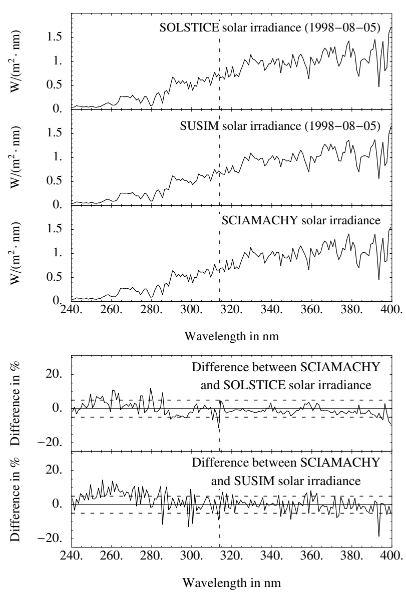

Fig. 3. Comparison of solar irradiance measured by SCIAMACHY with data of the UARS instruments SOLSTICE and SUSIM. Upper: solar irradiances, lower: difference between SCIAMACHY and UARS, SCIAMACHY channel boundaries are marked by vertical dashed lines.

3. Combined Mg II index from GOME and SCIAMACHY 1995–2005

The Mg II index is defined as the core-to-wing ratio of the Mg II Fraunhofer line at 280 nm, where the core is given by the chromospheric Mg II h and k emission doublet (see Fig. 4). The combined GOME/SCIAMACHY Mg II index is derived from daily solar observations using a diffuser plate. In Fig. 5 it is compared with the NOAA Mg II index time series that covers almost 3 solar cycles starting in 1978 (Viereck et al. 2004). The NOAA time series is composed of several instruments including GOME. The GOME data contained in the NOAA time series have been excluded when calculating scaling factor, difference, and correlation.

It has to be noted that the absolute value of the Mg II index depends on spectral resolution and slit function of the used instruments. Therefore the SCIAMACHY values

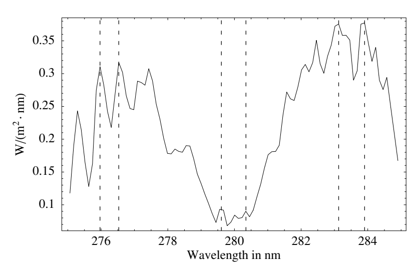

Fig. 4. Mg II Fraunhofer line at 280 nm. Wing values are derived from four maxima (outer vertical dashed lines), core values from the h and k doublet emission lines (two center vertical dashed lines).

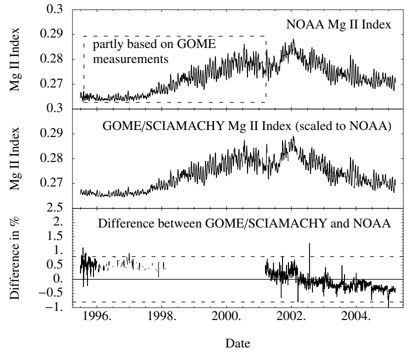

Fig. 5. Comparison of NOAA Mg II index with the combined GOME/SCIAMACHY index. GOME data contained in the NOAA time series is omitted in difference shown in lower plot.

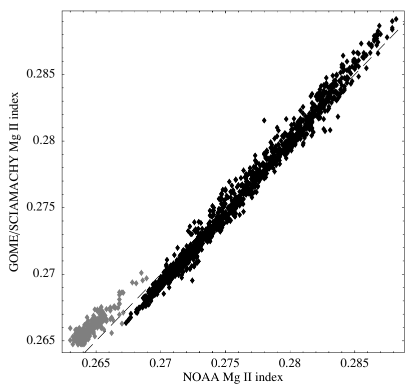

Fig. 6. Correlation of NOAA Mg II index with the combined GOME/SCIAMACHY index. GOME data contained in the NOAA time series is omitted, the gray cluster represents measurements before 2000.

had to be linearly scaled to match the GOME data and the combined GOME/SCIAMACHY Mg II index again was scaled to match the NOAA values (using the complete time interval from 1995 to 2005). The correlation coefficient between GOME/SCIAMACHY and NOAA data is 0.988 for a time period of almost 10 years, thus indicating excellent agreement. Apart from a few outliers differences are below ±0.8%. The downward trend in the lower graph in Fig. 5 after 2000 is still under investigation (see Fig. 6 also).

4. Conclusions

The SCIAMACHY solar spectral irradiance was compared with other solar data sources and due to the improved calibration applied the agreement is within 2 to 3% in most cases.

A combined GOME/SCIAMACHY solar Mg II index starting in 1995 was presented and successfully verified with data available from NOAA. The high correlation coefficient of 0.988 between GOME/SCIAMACHY and NOAA indices demonstrates that GOME and SCIAMACHY can be used in conjunction with other space instruments to provide a continuous long-term time series of solar variations. However, further studies are needed to understand the drift after 2000 between GOME/SCIAMACHY and NOAA data.

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