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Improved Solar Spectral Irradiance from SCIAMACHY Satellite Observations using Optimised Degradation Corrections

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Abstract

The SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) on-board the Environmental satellite (Envisat) provided daily solar spectral irradiances (SSI) measurements in the wavelength range from 0.24 to 2.4 µm and at a spectral resolution of 0.2 to 1.5 nm. The instrument was operating for nearly a decade, from August 2002 to April 2012.

In a first step, the new SCIAMACHY solar reference spectrum was generated. To account for instrumental changes due to the transition from pre-launch to in-orbit conditions, an on-ground to in-flight correction was developed from measurements by SCIAMACHY's internal white light source (WLS). The resultant SCIAMACHY solar reference spectrum is in good agreement with several available spectral solar irradiance (SSI) references for most parts of the spectral range. Together with the recent re-calibration of the SOLAR/SOLSPEC data (Meftah *et al*., 2018) and new ground-based measurements from Mauna Loa (Pereira *et al*., 2018), the SCIAMACHY solar reference spectrum could contribute significantly to solve discrepancies in the NIR between several solar references. Our results support the conclusion that the ATLAS-3 composite (Thuillier *et al*., 2003) is very likely high biased in the NIR. The investigations further demonstrated the value of careful re-analysis of available measurements.

The second part of this work addresses the full SSI data record obtained by SCIAMACHY and investigates its potential of establishing SSI variability and trends. One of the main limitations for long-term space-based measurements is the (continuous) optical degradation of the instrument in the harsh space environment. Therefore, the focus is here on the improvement and optimisation of SCIAMACHY's degradation correction, which in particular improves the solar spectral data. An essential part of the modifications is the use of measurements from SCIAMACHY's internal white light source (WLS) in combination with direct solar measurements. As an independent light source, the WLS provides the opportunity to better separate instrument variations and natural solar variability.

However, the WLS emission depends on its burning time and is changing with time as well. Therefore, the WLS emission change as a function of accumulated burning time (WLS ageing) was successfully determined and was found to be qualitatively consistent with detailed laboratory lamp studies by Sperling *et al*. (1996) at the Physikalisch-Technische Bundesanstalt (PTB).
The optimised degradation correction was used to re-calibrate the SCIAMACHY solar spectral irradiances in the wavelength range 320 – 1600 nm. Comparisons with the previous data version showed an overall improvement. However, the current degradation correction is not yet sufficient to account for all instrumental effects, such as a remaining positive drift in the SSI time series. The study demonstrated the potential for the use of an internal WLS for degradation monitoring of other satellite instruments that also include this type of lamps, such as the Global Ozone Monitoring Experiment (GOME)-2, the Ozone Monitoring Instrument (OMI), and the TROPOspheric Monitoring Instrument (TROPOMI).

To further investigate the potential of SSI variability studies, a simple solar proxy model was applied to the re-calibrated SCIAMACHY SSI data set. The modelled time series were elongated for the period from 1979 to 2014. Comparisons with other SSI reconstructions, namely the NRLSSI2 (Coddington *et al*., 2016), SATIRE-S (Yeo *et al*., 2014b), and the SCIA proxy model (Pagaran, 2011), show good agreement on shorter, i.e. solar rotational, time scales but indicate limitations for solar cycle time scales, especially at higher wavelengths. The relative SSI change between solar cycle maximum and minimum was derived for solar cycles 21 to 23 and matches well with the considered reference data sets.