

Interactive comment on “A high resolution extra-terrestrial solar spectrum determined from ground-based solar irradiance measurements” by Julian Gröbner et al.

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We would like to thank the referee for his careful review of the manuscript and the useful comments which we have addressed in the revised manuscript.

As a general remark, we would like to acknowledge the preliminary review of the original manuscript by the same referee which already led to accounting for some comments raised by the referee in the published manuscript in AMTD. Our response to the specific comments of the referee are listed below:

The referee raised an important point concerning the contribution of scattered radia-

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tion in the field of view (FOV) of the instrument. Since the measurements took place at high elevation with low aerosol optical depth, the fraction of diffuse radiation scattered into the FOV of the instrument is expected to be very small. We have now modelled this contribution for the FOV of QASUME with the radiative transfer model libRadtran using as basis for the radiative transfer calculations the atmospheric conditions found at Izana, namely atmospheric pressure of 772 mbar and aerosol optical depth of 0.02 with an assumed asymmetry factor of 0.76. The model calculations were carried out for several airmasses between 1 and 3.5 and for the wavelength range between 290 nm and 500 nm, in order to simulate the effect of the scattered radiation on the Langley-plot retrieval. The contribution of scattered radiation in the FOV of QASUME with respect to the direct irradiance is largest at short wavelengths and large airmasses: at an air-mass of 3.5 the contribution is 0.55% and 0.14% at 300 nm and 310 nm respectively. At smaller airmasses and longer wavelengths, this contribution decreases to less than 0.1%. The significant dependence on wavelength suggests that the dominant contribution comes from Rayleigh scattering, while the forward scattered radiation from the aerosols is negligible. Finally, we have included the modelled scattered radiation in one of the Langley-plot retrievals of QASUME to determine its effect on the retrieved zero-airmass irradiance: The resulting zero-airmass extrapolation differs by less than 0.1% from the original retrieval, demonstrating that scattered radiation into the FOV of QASUME for the condition encountered at Izana during the measurements has a negligible effect on the retrieved extraterrestrial solar spectrum. While this effect is expected to be approximately a factor of 3 larger for the FTS due to its larger FOV with respect to QASUME, we have not taken it explicitly into account since any resulting bias in the retrieved solar spectrum of the FTS will be slowly varying in wavelength and will be implicitly taken into account when the QASUME and FTS spectra are combined, as explained in section 2.4.

The calibration of QASUME during the field measurements was based on a set of three 250 W tungsten halogen lamps as described in Gröbner et al.,2005, which can be mounted in the portable field calibrator.

The airmass range used at Izana for the Langley-plot was in fact between 1.1 and 3.5 (lowest SZA was 27°). We have not encountered any atmospheric instabilities at noon during our measurements, maybe due to the fact that in September the atmospheric conditions were more stable than in the summer months when the sun reaches lower solar zenith angles.

As described in the text, we have only taken into account the Rayleigh extinction component in equation 4 and have refrained from removing the ozone and aerosol component. The reason is that the atmospheric pressure was known very well and did not vary significantly during each half-day. In contrast, the observed variability of the total column ozone and the aerosol optical depth measurements from co-located instruments resulted partly from instrumental noise (for example ± 1 DU in individual total column ozone measurements from the Brewer spectrophotometer) so that we did not want to introduce artificial noise from other instruments in the Langley-plot retrievals of QASUME.

The Langley-plot simulations to determine the contribution from the finite resolution of QASUME were performed with a high resolution spectrum based on KittPeak combined with the solar spectrum of Thuillier for the absolute irradiance level.

The last point raised by the referee concerning the dates when the different SSI were measured is important and can be found in the respective references for each solar spectrum. The SORCE spectrum used here was measured on 27 November 2004 and the Sciamachy spectrum on 27 February 2003. SOLSPEC-A represents the average over the period 6 June 2008 to 29 April 2009 while SOLSPEC-B represents the average for the period April to June 2008. Finally the ATLAS-3 Spectrum (Thuillier) was measured on several days in November 1994. Thus all solar spectra shown here, including QASUME were either measured during solar minimum or in the declining phase of the respective solar cycle.

Current studies provide only an upper limit of the SSI variability throughout a solar cycle

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of the order of 1% to 2% due to the low solar variability in this wavelength region. Based on the results from SORCE SIM discussed in Harder et al., 2009, the variability of SSI between 300 nm to 500 nm is at most 0.5%. In that respect, the conclusions drawn from the comparisons shown in Figure 5 of the solar spectra from SORCE SIM, Sciamachy, ATLAS-3 from Thuillier, SOLSPEC and QASUME should not be significantly affected from being measured on different dates.

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