Dear Odele,

Thank you very much for your comments and suggestions, which are very pertinent and will clarify our arguments.

See below our answers to the points you raised:

1a) We have done this reverse convolution you suggested using our previous results with the high resolution QASUMEFTS spectrum based on the campaign data from September 2016, which agrees well with the results you published in your TSIS-1 HSRS paper (Coddington et al., 2021, Figure 2). In contrast, here we are only using the medium-resolution datasets from our spectroradiometers, which have similar or even larger resolutions than the TSIS-1 SIM spectroradiometer, at least in the spectral range shorter than 400 nm. As you point out in 2), for the comparison between TSIS-1 HSRS, QASUME & QSAUME-IR are sufficient and BTS and PSR are not strictly needed for this argument, as QASUME & QASUME-IR have the lowest uncertainties.
Furthermore, also in response to your point 2), the PSR and BTS spectroradiometers are included in this study because they are commercial instruments in contrast to QASUME and QASUME-IR, and as we show, high fidelity spectral AOD can be retrieved with these calibrated instruments when using the TSIS-1 HSRS solar spectrum as reference.

1b) The comparisons are done at PTB in air, with the blackbody and TULIP facilities being in different buildings. Thus, we used small power lamp transfer standards to relate the measurements from both facilities. Since the spectral irradiance emitted from the blackbody is spectrally very smooth (Planck radiator with a radiation temperature around 3000 K), its measurement with QASUME and QASUME-IR is straightforward and was done within one day. In contrast, we spent several weeks at the TULIP facility to determine the spectral responsivity of QASUME at different central wavelengths, following two approaches:

1) We set TULIP to a specific wavelength and scan this laser wavelength with QASUME/QASUME-IR at fine spectral resolution as described in Hülsen et al., 2016, and we repeat this throughout the spectral range as shown in Figure 1. Unfortunately the QASUME-IR grating drive was found not to be sufficiently uniform at steps of 0.05 nm as required here, so we used a second approach described below:

2) We set QASUME-IR to a specific wavelength and keep monitoring the incoming irradiance, while we tune the laser wavelength across the spectral slit of the spectroradiometer, while nearly continuously monitoring the exact laser wavelength and irradiance using a wavemeter and reference trap detector respectively. We repeated these measurements up to 50 times per wavelength setting, in order to perform statistics on the results.

The scatter of the blue dots shown in Figure 1 at wavelengths longer than 600 nm are from the QASUME-IR measurements. We are also puzzled where it comes from, as the standard deviation of the measurements is less than the scatter between individual points. We also repeated several points on other days and with different intensity settings. Among the possible causes that could cause the observed scatter are:

a) Spectral stability of the laser line, which sometimes was unstable, and required a reset of the laser.

b) Possible instabilities of QASUME-IR and small power lamp calibration system, since the measurements shown in Figure 1) are related to each other using spectral irradiance calibrations performed typically once per day only.

The difference between the blackbody calibration and TULIP at wavelengths shorter than 400 nm seem to be systematic and were already observed in our previous campaign in 2014. We attach a figure below which shows the comparison between blackbody and TULIP in 2014 and 2022:

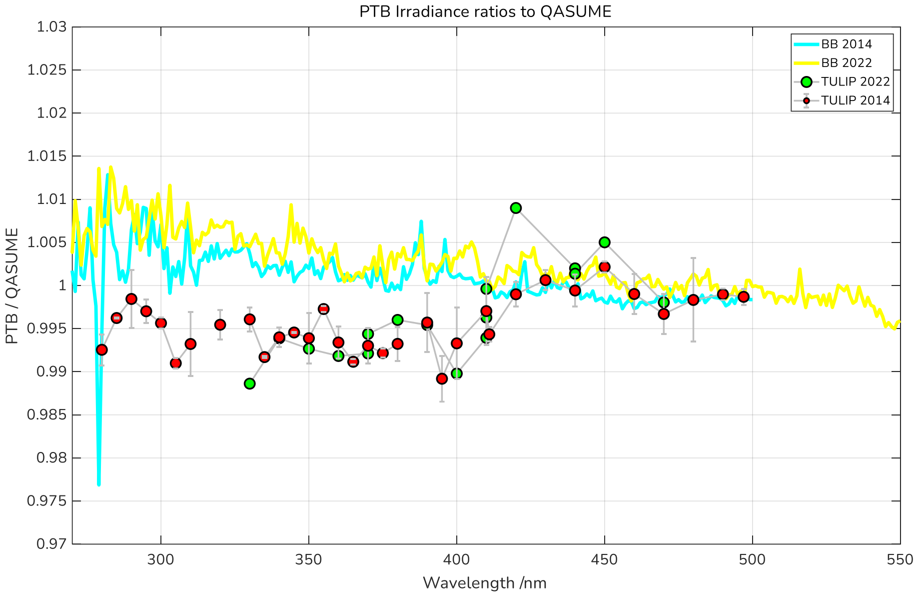

Figure 1 Spectral irradiance ratios obtained from the blackbody and TULIP facilities, compared to the spectral irradiance obtained from a set of FEL lamps at PMOD/WRC, which were themselves calibrated by PTB relative to their blackbody in previous years. (See Gröbner J., and P. Sperfeld, "Direct traceability of the portable QASUME irradiance scale to the primary irradiance standard of the PTB," Metrologia, 42, 134—139, 2005 for more details).

1c) As you correctly pointed out, the FTIR data was currently only used to assess the trace gas correction uncertainties. Future work will be needed to calibrate the FTIR data and combine it with the low-resolution spectroradiometers, as we did previously for the QASUMEFTS solar spectrum. However the FTIR data is available in the range from 950 nm to 2100 nm, and not at shorter wavelengths. The result from the Langley analyses of the FTIR data are available from the open-access project repository at https://zenodo.org/communities/19env04-mapp/

If you need additional information, we suggest to directly contact the responsible for this dataset, co-author Tom Gardiner (tom.gardiner@npl.co.uk).

2) I hope this was answered previously: BTS and PSR are commercial instruments which are available to interested users, and we have shown in this manuscript their potential in being able to retrieve spectral AOD, when following the procedures described here.

3) We are happy to rephrase this sentence, which was taken nearly literally out of the paper by Fox and Green.

4) This is a good point; we will add the reference to the ozone absorption cross sections which we used here. The following publication and references therein describe the impact of different ozone cross sections: Gröbner, J., Schill, H., Egli, L., and Stübi, R.: Consistency of total column ozone measurements between the Brewer and Dobson spectroradiometers of the LKO Arosa and PMOD/WRC Davos, Atmos. Meas. Tech., 14, 3319–3331, https://doi.org/10.5194/amt-14-3319-2021, 2021.

As the ozone absorption in the spectral range discussed here is relatively small (see section 5.1.2) the use of different ozone cross sections would not give a significant difference in the retrieved AOD.

5) This is a good suggestion, and we will add a brief outlook at the end of the manuscript.