COSI High Resolution Solar Reference Spectrum

Margit Haberreiter
PMOD/WRC, Davos, Switzerland, margit.haberreiter@pmodwrc.ch

Abstract

The precise knowledge of the solar spectrum is key for various applications in astrophysics as well as for the Earth Observing community. Due to the systematic differences between available solar spectra the community agreed to use one "nominal" spectrum as the reference. The new reference spectrum is based on a combination of two datasets. First, with the radiative transfer code COSI (COde for Solar Irradiance) we calculate the high-resolution spectrum. Second, the 2008 solar min spectrum is used to determine the absolute scale of the spectrum. The combination of both elements guarantees a that the best possible high-resolution spectrum is available which agrees with observations with the lowest uncertainty. We introduce a new high-resolution reference spectrum based with the associated uncertainties. The new dataset will allow to decrease systematic uncertainties for several applications.

Code for Solar Irradiance - Validation

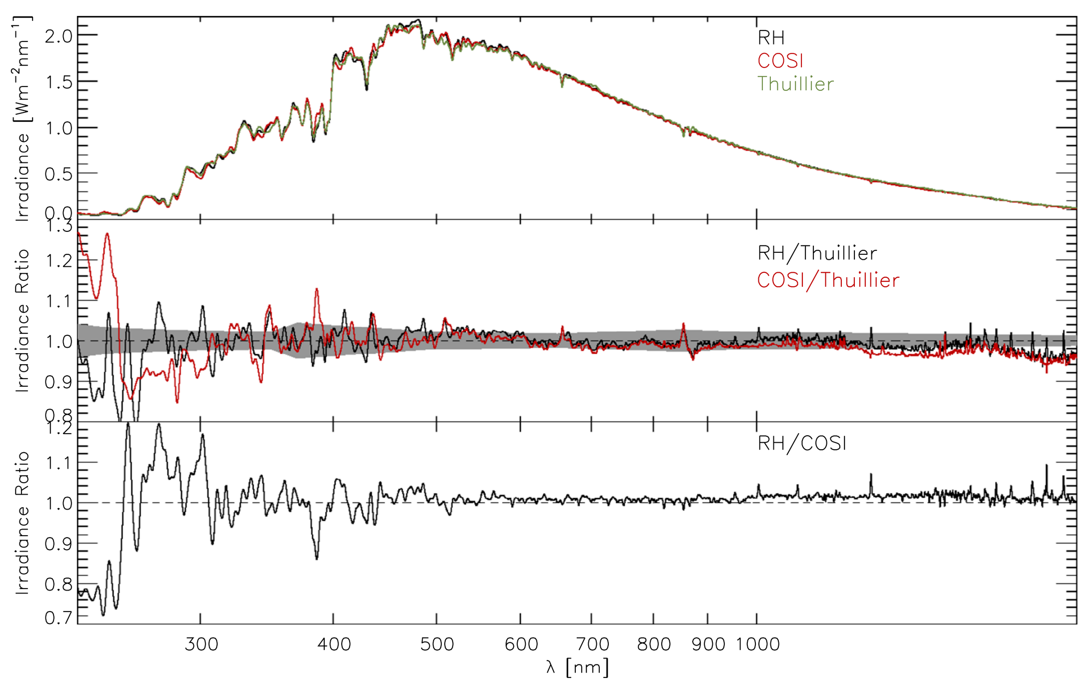

Fig 1: Top left panels: *Comparison of synthetic spectra obtained using the quiet Sun model FAL99-C with the COSI and RH codes, respectively, and the reference solar spectrum by Thuillier et al. (2004).* ***Left bottom panel****: ratio of spectra obtained using the COSI and RH codes. All spectra have been smoothed with a 3 nm-wide Gaussian function and then interpolated to a common spectral grid (Criscuoli et al., 2020).*

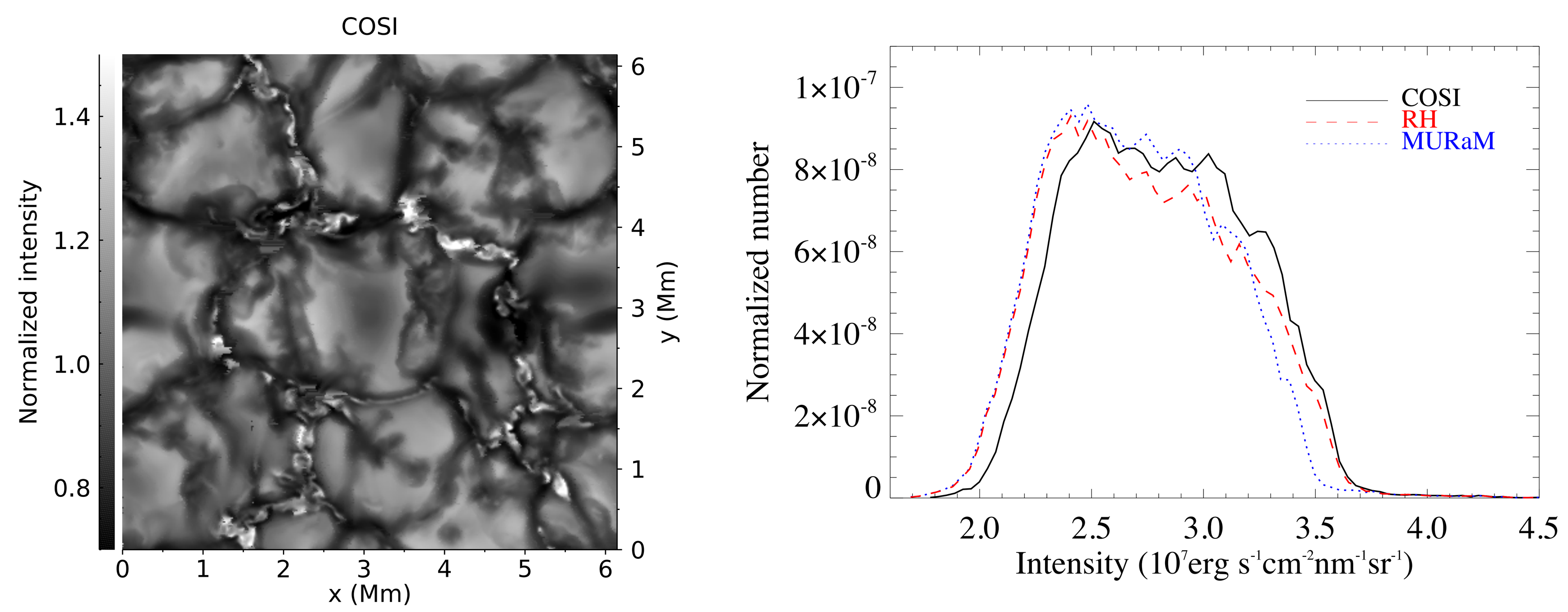

Fig. 2: Left panel: *Relative intensity calculated with COSI based on 3D MHD simulations (100G), and the respective intensity distributions calculated with COSI, RH and the MURaM radiative scheme (from Haberreiter et al., 2021). The COSI code gives consistent results compared to other spectral synthesis codes and observations.*

Method

1. Observational SSI Data

The absolute scale of the reference spectrum is determined using the solar minimum spectrum of the observational SSI composite by Haberreiter et al. (2017). We take the average of the 2008 solar minimum spectrum at 1-nm spectral resolution as the absolute scale for the reference spectrum. The wavelength integrated spectrum agrees with the TSI value recommended by the IAU 2015 Resolution B3 (Prsa et al., 2016).

2. Radiative Transfer Code

The high-resolution component of the reference spectrum is obtained with the Code for Solar Irradiance developed at PMOD/WRC (Haberreiter et al., 2008, 2021). Figure 1 and 2 show recent validation of the performance of COSI. With the spectral synthesis code COSI we are in the position to provide the spectrum at a resolution higher than

3. Absolute scale

To ensure the correct absolute scale of the high-resolution reference spectrum we bin the high-resolution spectrum to 1nm and determine the wavelength-dependent ratio of the low-resolution spectrum with the observational solar minimum spectrum (Figure 3, bottom right panel).

4. Results

The reference spectrum in high resolution is shown in Figure 3 (top left) and is compared to the TSIS HSRS spectrum (Coddington et al, 2021) on the top right panel. The COSI reference spectrum at 1nm resolution is compared with the TSIS HSRS-1nm spectrum and the Thuillier et al. (2003) spectrum on the bottom left. The agreement is within the uncertainty.

COSI high-resolution reference spectrum

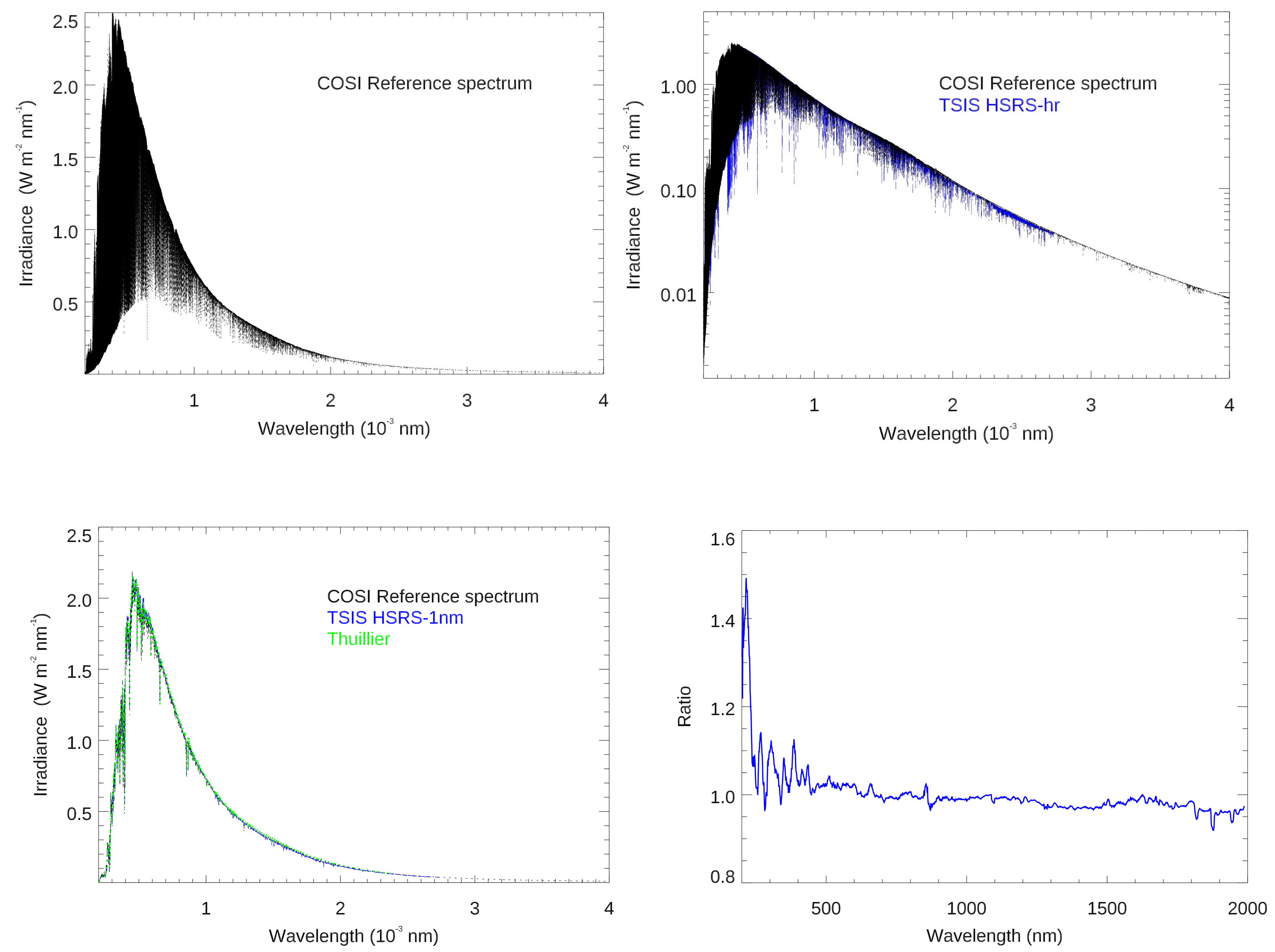

Fig 3: Top left panel: *Reference spectrum at high resolution.* ***Top right panel:*** *COSI reference spectrum at native resolution (black) compared with the TSIS high resolution spectrum (blue)* ***Bottom left panel:*** *COSI reference spectrum at 1nm-resolution (black) and low resolution (black), TSIS-1nm (blue) and the Thuillier spectrum (green).* ***Bottom right panel:*** *Ratio between the observational SSI spectrum and the COSI synthetic spectrum at 1nm resolution.*

5. Summary

We presented the COSI high-resolution and 1-nm resolution reference spectrum from 200 nm to 15 microns. The combination of the observational spectrum with the COSI high-resolution theretical spectrum ensures a consistent reference spectrum that can be convolved to any instrumental resolution as required by the users.

References

Coddington, O.M., E.C. Richard, D. Harber, P. Pilewskie, T.N. Woods, K. Chance, X. Liu, and K. Sun, 2021, The TSIS-1 Hybrid Solar Reference Spectrum, Geophys. Res. Lett., 48 (121) 7,9e91709, doi:10.1029/2020GL091709.
Finsterle, W., Montillet, J. P., Schmutz, W., et al. 2021, Scientific Reports, 11, 7835
Haberreiter, M., S. Criscuoli, M. Rempel, and T.M.D. Pereira, 2021, Solar atmosphere radiative transfer model comparison based on 3D MHD simulations, A&A, 653, A161, doi = 10.1051/0004-6361/202039237.
Haberreiter, M., M. Schöll, T. Dudok de Wit, M. Kretzschmar, 138 S. Misios, K. Tourpali, and W. Schmutz, 2017, A new observational solar irradiance composite, Journal of Geophysical Research (Space Physics), 122, 5910–5930, doi:10.1002/141 2016JA023492.
Prša, A., Harmanec, P., Torres, G., et al. 2016, Nominal Values for Selected Solar and Planetary Quantities: IAU 2015 Resolution B3, AJ, 152, 41, doi: 10.3847/0004-6256/152/2/41
Thuillier, G., Floyd, L., Woods, T. N., Cebula, R., Hilsenrath, E., Hersé, M., Labs, D., 2004, Solar irradiance reference spectra for two solar active levels, Advances in Space Research, Volume 34, Issue 2, p. 256-261.