SOLAR-ISS, a new solar reference spectrum

The precise measurement of the solar spectrum outside the atmosphere and its variability are fundamental inputs for solar physics (Sun modeling), terrestrial atmospheric photochemistry and the Earth's climate (climate's modeling). The role of solar variability on climate change remains a topic of strong scientific and societal interest. An international scientific team has accurately determined a new solar reference spectrum from measurements made by the SOLAR/SOLSPEC instrument onboard the International Space Station. This study was published in the journal Astronomy and Astrophysics in November 2017.

The "Laboratoire Atmosphères, Milieux, Observations Spatiales" (LATMOS, formerly known as the "Service d'Aéronomie du CNRS") has been working on solar spectral irradiance and its variability since the 1970s. LATMOS has acquired an undeniable international reputation, notably with the solar reference spectrum ATLAS-3 15 years ago. The recently published study (M. Meftah, L. Damé, D. Bolsée et al., 2017) allowed to go further and to develop a new reference solar spectrum covering a large wavelength range from far ultraviolet (165 nm) to infrared (3000 nm). The new Solar Reference Spectrum (SOLAR-ISS) was obtained from the measurements made by the SOLAR SPECtrometer (SOLSPEC) instrument of the SOLAR payload onboard the International Space Station (Figure 1). SOLAR/SOLSPEC is the result of a long collaboration between LATMOS and the Royal Belgian Institute for Space Aeronomy that already made possible to measure the solar spectrum from several space missions (ESA and NASA).

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Figure 1: SOLAR/SOLSPEC instrument onboard the International Space Station. Between April 5, 2008 and February 15, 2017, SOLAR/SOLSPEC observed the Sun without any anomalies. Credits: NASA & ESA.

Different fields of physics highlight the need for an absolute reference solar spectrum with known uncertainties. SOLAR-ISS (Figure 2) represents a new solar reference spectrum with known accuracy. Before the SOLAR/SOLSPEC instrument was put into orbit in February 2008, a radiometric calibration was carried out on the ground using the black body of the Physikalisch-Technische Bundesanstalt (PTB) as primary standard. Measurements made at the PTB have made it possible to obtain the calibration coefficients of the SOLAR/SOLSPEC instrument as a function of the wavelength. The uncertainties of the calibration coefficients introduce errors in the absolute determination of the solar spectrum measured by SOLAR/SOLSPEC (about 1.26% error across the spectrum). SOLAR-ISS is the first solar spectrum obtained outside the atmosphere over a wavelength range of 165 to 3000 nm with a low and known level of uncertainty. Above 1500 nm, SOLAR-ISS shows significant differences with other reference spectra (NASA CV-990 (1996), ATLAS-3 (2003), WHI2008 (2009)). In addition, the scientific team in charge of the instrument has a complete traceability of the SOLAR/SOLSPEC spectrometer device functions which allow to establish a high resolution spectrum without any ambiguity. The article published in Astronomy and Astrophysics provides the main results of this study. Data of this new solar reference spectrum are available from the Strasbourg Astronomical Data Center (CDS), which manages the collection and distribution of astronomical data worldwide.

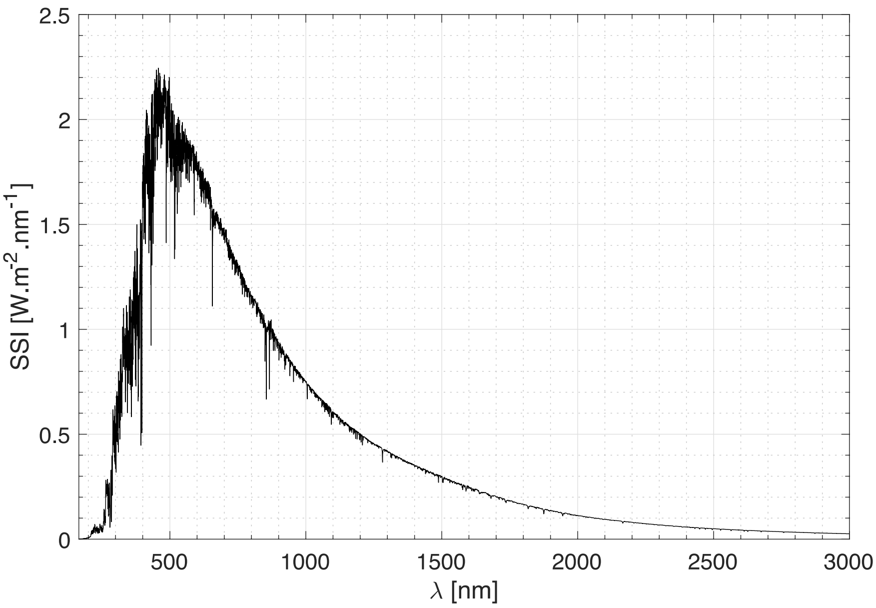

Figure 2: SOLAR-ISS, a new reference solar spectrum with low and known uncertainties over an extended range of wavelengths (165 to 3000 nm). SOLAR-ISS is characteristic of a minimum of solar activity (April 2008). Credits: CNRS.

Influence of solar spectral variability on stratospheric ozone

The SOLAR/SOLSPEC instrument data will also be used to track the spectral variability of solar irradiance over nearly a solar cycle (from 2008 to 2017). These are essential and valuable data for modeling the Earth's climate with climate chemistry models of the atmosphere. Indeed, it is now known that the influence of solar variability on the Earth's atmosphere and climate is associated with extremely complex mechanisms and that their understanding can not be reduced to mere considerations with regard to the radiation balance of the Earth. The spectral variations of solar irradiance (influence of wavelength) play a significant role in the chemistry of the Earth's atmosphere and climate. During an 11-year solar cycle, the variability in UV is, for example, much higher (~ 5-10%) than that of total solar irradiance (0.1%). Disturbances of UV radiation do not directly affect the lower atmosphere (troposphere, 0-10 km) but the average atmosphere (stratosphere/mesosphere, 10-90 km), where UV radiation is absorbed by ozone and molecular oxygen. UV fluctuations directly modulate the concentration of ozone and temperatures in the average atmosphere. These disturbances induce dynamic changes that can affect the tropospheric circulation by stratosphere-troposphere couplings. A better understanding of the influence of solar UV variability on the climate therefore requires a precise knowledge of the radiative forcing and the direct disturbances that its fluctuations cause.

LATMOS researchers have quantified the impact of UV variations of the 27-day rotational solar cycle on ozone in the stratosphere using satellite observations and simulations of the LMDz-Reprobus climate chemistry model. As shown in Figure 3, the model is able to accurately simulate the observed solar signal in the ozone data. The use of a large set of LMDz-Reprobus simulations, however, has revealed that the internal variability of the stratosphere is masking the response of ozone to the 27-day solar cycle and that long-term ozone series are needed to obtain a robust estimate of the signal. In general, 10 years of analysis can reduce the uncertainty on the solar signal of ozone to less than 20%. These results could account for past discrepancies in solar ozone signal estimates that were inferred over different and generally short (less than 2 years) satellite observation periods. The next step is to use the SOLAR/SOLSPEC data covering most of Solar Cycle 24 (2008 to 2017).

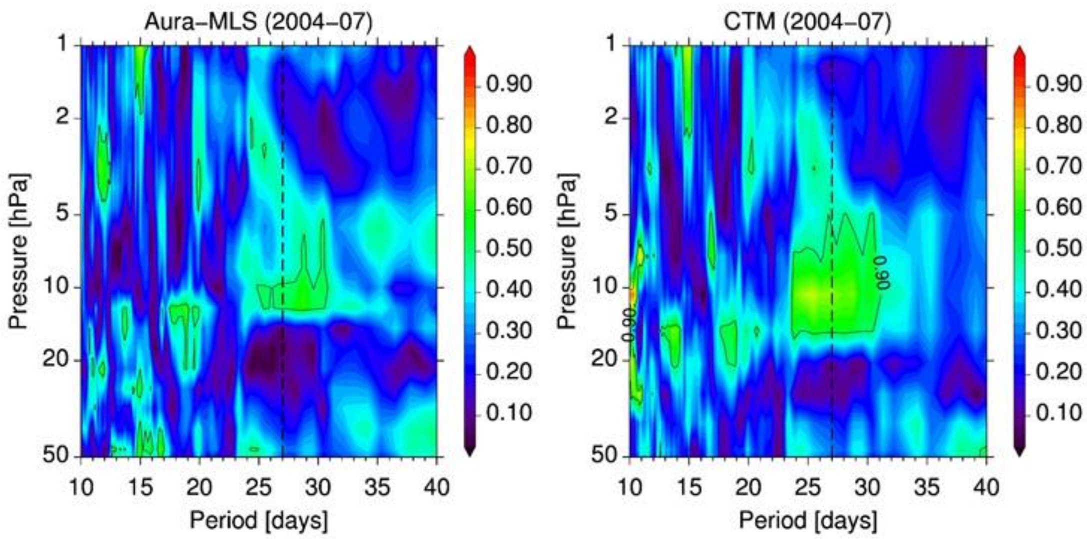

Figure 3: Coherence between solar UV flux and time series of stratospheric tropical ozone (50-1 hPa) (left) measured by Aura MLS and (right) simulated by the LMDz-Reprobus model in its guided configuration (meaning that the dynamic is recalled with the meteorological re-analysis) over the period 2004-2007. Observations and results of models show a coherent and significant ozone response to the UV solar flux which seems centered on a period of 27 days at 10 hPa (~ 30 km). Credits: CNRS.

References:

SOLAR-ISS: a new reference spectrum based on SOLAR/SOLSPEC observations, M. Meftah, L. Damé, D. Bolsée, A. Hauchecorne, N. Pereira, D. Sluse, G. Cessateur, A. Irbah, J. Bureau, M. Weber, K. Bramstedt, T. Hilbig, A. Sarkissian, R. Thiéblemont, M. Marchand, F. Lefèvre, S. Bekki, Astronomy and Astrophysics, November 2017.
DOI: https://doi.org/10.1051/0004-6361/201731316

Sensitivity of the tropical stratospheric ozone response to the solar rotational cycle in observations and chemistry-climate model simulations, R. Thiéblemont, M. Marchand, S. Bekki, S. Bossay, F. Lefèvre, M. Meftah and A. Hauchecorne, Atmos. Chem. Phys., 17, 9897-9916, 2017.
DOI: https://doi.org/10.5194/acp-17-9897-2017

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