Solar Spectral Irradiance Variability in the Ultraviolet over Cycle 24 with SOLAR/SOLSPEC 9 Years of Data from the ISS

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1 - Introduction/Objectives

Accurate measurements of solar spectral irradiance (SSI) and its temporal variation are of primary interest to better understand solar mechanisms and the links between solar variability and Earth’s atmosphere and climate. We present an extensive ultraviolet (UV) SSI observations performed by the SOLAR/SOLSPEC instrument onboard the International Space Station. SOLAR/SOLSPEC observations cover the essential part of the solar cycle 24, from April 2008 to February 2015. We provide an evolution of the solar spectral irradiance during Cycle 24 using the SOLAR/SOLSPEC data thanks to refined engineering corrections, improved calibration and comprehensive solar records to account for thermal and aging corrections of the instrument. The SOLAR/SOLSPEC observations are compared with other measurements (SORCE/SOLSTICE, SOCRE/SIM, and models (SATIRE-S, NRLSSI)). Importance of results justify a new mission (e.g. SoSWEET-SOUP) with enhanced SSI measurements (the SOLSIM newly designed SSI instrument).

2 - The SOLAR/SOLSPEC Instrument

The SOLAR/SOLSPEC instrument is a space qualified spectroradiometer measuring the Solar Spectral Irradiance (SSI) from 166 nm to 3088 nm. This instrument, developed under a fruitful LATMOS/BIRA-IASB collaboration, is part of the Solar Monitoring Observatory (SOLAR) payload, externally mounted on the Columbus module of the International Space Station. SolaSOLSPEC consists of three separated double-monochromators that have concave holographic gratings (Jobin Yvon) to cover: 165-371 nm; "VIS" (385-908 nm); and "IR" (646-3088 nm) spectral ranges. Detectors are Jobin-Yvon. The detector outputs are processed by the Data Acquisition System (Jobin-Yvon) and the data are transmitted in real-time through Radio Frequency Intercommunication (RFI) to the ISS and SRPM in the ultraviolet band.

3 - Absolute SSI Variability

The SOLAR/SOLSPEC instrument was calibrat. In the visible band (400 – 700 nm), all the spectra studied are identical within 2.5%. In the infrared band (700 – 2400 nm), only the solar reference spectrum is closer to the WHI 2008 solar spectrum (best match). In the ultraviolet band (165-300 nm), the discrepancies are quite small between SOLAR-ISS and ATLAS 3. From 1500 nm, the discrepancies become larger between SOLAR-ISS and other solar spectra. From 2000 nm, the discrepancies are comparable to SOLSTICE and ATLAS 3, although some differences are noticeable in the UV below 1800 nm. A comparison SOLSPEC/SORCE in UV is of prime interest for an absolute calibration attempt of these measurements and confirmation of aging corrections.

4 - SSI in the UV Reference ‘Quiet Sun’ UV Spectrum

The SOLAR/SOLSPEC ‘quiet Sun’ UV spectrum allows the measurement of the SSI UV variability over Cycle 24. The SSI UV spectra are measured using a SOLSTICE and a model (SATIRE-S and NRLSSI).

5 - SOLAR-ISS (new Reference Spectrum 165 – 3000 nm)

The SOLAR-ISS reference spectrum 165-3000 nm is closer to the WHI 2008 solar spectrum (best match). From 1500 nm, the discrepancies are quite small between SOLAR-ISS and other solar spectra. From 2000 nm, the discrepancies are comparable to SOLSTICE and ATLAS 3, although some differences are noticeable in the UV below 1800 nm. A comparison SOLSPEC/SORCE in UV is of prime interest for an absolute calibration attempt of these measurements and confirmation of aging corrections.

6 - Highlights and Conclusions

- Robust performances of the instrument in orbit for 9 years since 2008.
- High accurate characterization: determination of the measurement equation thanks to the exhaustive pre-flight radiometric characterization and absolute calibration.
- In-flight improvement of the characterization (thermal tests) allowing to understand and correct degradation (aging and data dispersion in RI-3 visible atmospheres).
- SOLAR/SOLSPEC 9 years of SSI variability measurements provide important contributions:
  1) Retrieval of highly sensitive SSI UV variability during Solar Cycle 24.
  2) New UV (165-400 nm) and IR (660 to 3000 nm) reference spectra.
  3) New values for the level of the SSI in the UV and IR, challenging earlier solar reference spectra.
  4) New comparison to the reference spectrum SOLAR-ISS from 165 to 3000 nm for the 2004 and 2017 cycles.

7 - Future Steps for SSI

1 - Detailed SSI UV determination during Cycle 24, using SOLAR/SOLSPEC data from April 2008 to February 2017 (work in progress).
2 - Improvement of our quantitative understanding of the effects of solar irradiance variability on the atmosphere and climate (AIR program proposed).
3 - Design a new improved SSI space instrument based on the long experience acquired in design, production, integration and qualification with the SOLSPEC instrument: SOLSIM (Solar Spectral Irradiance Monitor).

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References

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The SOLAR Facility on the ISS was decommissioned February 5 after almost 9 years of observations (longest experiment on ISS)