A Solar Irradiance Climate Data Record

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**Abstract**: We present a new climate data record for total solar irradiance and solar spectral irradiance between 1610 and present-day with associated wavelength and time dependent uncertainties, and quarterly updates. The data record, which is part of the National Oceanographic and Atmospheric Administration’s (NOAA) Climate Data Record (CDR) Program, provides a robust, sustainable, and scientifically defensible record of solar irradiance that is of sufficient length, consistency, and continuity for use in studies of climate variability and climate change on multiple time scales, and for broad user groups spanning climate modeling, remote sensing, natural resource and renewable energy industries. The data record, jointly developed by the University of Colorado Boulder’s Laboratory for Atmospheric and Space Physics (LASP) and the Naval Research Laboratory (NRL), is constructed from a two-component solar irradiance model that determines the changes from quiet Sun conditions when facular brightening and sunspot darkening features are present on the solar disk, where the magnitude of the delta changes in irradiance are determined from linear regression of proxy indices- the Mg II index and sunspot area, respectively- against the approximately decade-long solar irradiance measurements of the SOlar Radiation and Climate Experiment (SORCE). To promote long-term data usage and sharing for a broad range of user groups, the source code, the dataset itself, and supporting documentation are archived at NOAA’s National Climatic Data Center (NCDC). The dataset is also available through LASP’s Interactive Solar Irradiance Data Center (LISIRD) for user-specified time periods and spectral ranges of interest.

**The Role of the Sun in Climate**

The Sun is the dominant energy source for the Earth, establishing the structure of its surface and atmosphere, defining its external environment, and powering the complex and coupled dynamical, chemical, and land-atmosphere interactions that define its terrestrial habitat. Natural solar variability exhibits time and wavelength dependencies, spanning seconds to minutes and gamma rays (10-10 m) through radio waves (> 100 m). Because of selective absorption and scattering process in Earth’s atmosphere, the climate system responds in distinct ways to solar energy inputs in different spectral regions. For example, solar radiation at wavelengths shortward of 315 nm is completely absorbed in Earth’s atmosphere and is critical for the formation and destruction of ozone as well as middle atmosphere dynamics and temperature. Longer wavelength visible and near-infrared radiation penetrates to the lower atmosphere and to the Earth’s surface, where roughly half of the globally-averaged incoming solar radiation is absorbed (ref. Fasullo/Trenberth). The role of solar irradiance in Earth’s radiation budget – the balance of absorbed solar radiation to emitted longwave radiation- establishes its position as an *essential climate variable* (GCOS, ref.) whose long-term measurement is necessary for the understanding of past and present climate and the projection of future climate (Bojinsky, BAMS sept, 2014 ref; Holdren, 2014).

Determining the Sun’s role in climate variability and change requires uninterrupted time series of total solar irradiance (TSI) and spectral solar irradiance (SSI) that are of sufficient length, consistency and continuity to be useful for evaluating the natural variability in solar irradiance and for providing the baseline foundation for evaluating other forcings of climate change (Kopp and Lean Report B ref.). The National Oceanographic and Atmospheric Administration (NOAA) Climate Data Record (CDR) program defines a climate data record as the sustained and routine generation of products using observational records that span decades to centuries and assigns a “maturity matrix” level to quantify the reliability of a CDR for use in decision making across many socioeconomic sectors (Bates EOS article). Because the extant space-age observations of TSI and SSI (36 years for TSI, or approximately 3 solar cycles, and less for SSI) lacks the length and, with respect to SSI, the stability to resolve solar variability over multiple 11-year solar activity cycles, solar irradiance models are needed to extend the measurement record and provide the constraints needed for a solar irradiance climate data record.

In this article, we define the solar irradiance climate data record - consisting of extant solar irradiance data sets and a solar irradiance model - which exemplifies community best practices in a robust, sustainable, and scientifically defensible record of solar irradiance. The discussions will also touch on the level of the solar irradiance CDR in each of the six thematic areas of the maturity matrix:

* *Code stability*
* *Metadata and Quality Assurance*
* *Documentation (source code, dataset, supporting documentation)*
* *Validation*
* *Public Availability*
* *Utility for a broad user group*

**Solar Irradiance Datasets**

**Irradiance Variability Model**

**Uncertainty Analysis**

**Results and Validation**

**Deliverables**

**Operational Implementation**

**User Applications**

**Future Outlook**

**Conclusions**

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**References**

Holdren, J.P., 2014, National Plan for Civil Earth Observations, 62 pp. Natl. Sci. and Technol. Counc., Washington, D.C. [ Available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/national\_plan\_for\_civil\_earth\_observations\_-\_july\_2014.pdf.]