Earth and Space Science

INTRODUCTION TO A SPECIAL COLLECTION
10.1029/2019EA000773

Special Section: Results from the Initial NASA Solar Irradiance Science Team (SIST) Program

Key Points:
• Providing solar irradiance data for climate science requires combining information from satellite observations, solar activity proxies, and model results.
• NASA implemented the Solar Irradiance Science Team (SIST) program to address this need.
• This paper describes the investigations carried out within the SIST program during 2015–2018.

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Citation:
DeLand, M. T., Kopp, G., & Considine, D. B. (2019). Overview of the NASA Solar Irradiance Science Team (SIST) Program Special Section. Earth and Space Science, 6, 2229–2231. https://doi.org/10.1029/2019EA000773

Received 27 JUN 2019
Accepted 5 OCT 2019
Accepted article online 12 NOV 2019
Published online 7 DEC 2019

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Overview of the NASA Solar Irradiance Science Team (SIST) Program Special Section

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Abstract: Solar irradiance represents the dominant energy source heating the Earth's atmosphere and climate. Both total solar irradiance and spectral solar irradiance vary over the 11-year solar cycle. Characterizing these variations with sufficient accuracy for climate studies over multidecadal timescales requires a combination of multiple observational data sets, solar activity proxies, and irradiance models. NASA established the Solar Irradiance Science Team (SIST) program in 2015 to pursue this goal using a range of technical approaches. This paper summarizes those investigations, whose results are reported in separate papers in a special section of this journal.

1. Introduction

The Sun's radiant output provides nearly all the energy powering the Earth's climate system. Solar irradiance, the disk-integrated solar radiant energy at 1 AU, thus represents the primary source of forcing energy for the Earth's atmosphere and climate. The spectrally integrated solar irradiance, or total solar irradiance (TSI), only varies by ~0.1% over the 11-year solar cycle, although short-term decreases of ~0.3% occur when large dark sunspots transit the solar disk. The variability of the spectrally resolved solar irradiance (SSI) is much greater at the shortest visible wavelengths and throughout the ultraviolet (UV) region (λ < 400 nm). The UV region can be further subdivided into the near-UV (NUV = 300–400 nm), mid-UV (MUV = 200–300 nm), and far-UV (FUV = 100–200 nm) regions to reflect changes in the magnitude of irradiance variations. While solar cycle variations in the visible region are comparable in magnitude to TSI variations, these variations increase to a few percent in the MUV region and grow to tens of percent in the FUV region. The magnitude and temporal variability of SSI at specific wavelengths are key factors to properly representing the effects of solar radiation in models of the chemistry and climate of the atmosphere. Gray et al. (2010) provide a comprehensive overview of solar activity effects on climate, while WMO (2014) focuses on ozone variations and the impact of different representations of SSI spectral variability.

The Earth's atmosphere both absorbs and scatters solar radiation at many wavelengths due to contributions from atomic and molecular species, clouds, and aerosols. These effects preclude accurate ground-based measurements of TSI, as well as SSI. As a result, satellite instruments are required to accurately measure both SSI and TSI, and many have been flown during the past 40+ years. Even these space-based measurements of solar irradiance, however, remain difficult because of the high accuracy and stability requirements for measurement of climate-relevant variability, the large dynamic range and spectral coverage required, the need for precise wavelength registration to deal with the inherent spectral structure in the SSI, and the need to correct degradation of optical elements in any direct solar-viewing instrument. Only rarely has any single instrument been able to provide a data set lasting more than 10–15 years.

Satisfying climate science requirements for both multidecadal temporal coverage and broad spectral coverage thus requires integrating observations from multiple instruments, often flying on separate platforms. In addition, the need to fill data gaps and evaluate the quality of a combined instrument-based data set can benefit from comparisons with solar activity proxies and irradiance models.

2. SIST Program

The NASA Solar Irradiance Science Team (SIST) was established in 2015 under NASA's 2014 Research Opportunities in Space and Earth Science program to support the development of improved and merged...
The SIST program understands that progress on multiple avenues is necessary to reach the following goals:

- Accurate assessment and correction of long-term instrument drifts
- Reviewing and improving calibration data for existing data sets
- Reprocessing historical measurements using updated calibrations
- Determining inter-instrument calibration offsets required to create a merged data product
- Intercomparing SSI and TSI data sets
- Developing techniques for evaluating the effectiveness of different merging approaches
- Improving and extending relevant solar proxy data sets
- Improving models of TSI and SSI variability
- Comparing irradiance measurements, proxies, and model results to develop increased understanding of irradiance variations over longer time periods

Seven investigations were selected for funding by the initial SIST program, touching on all aspects of the topics listed in the previous paragraph. The papers collected in this special section of *Earth and Space Science* present the key results from these investigations. Some papers utilize the results obtained by other SIST teams in order to create the best version of their own product, demonstrating the synergy within this cohesive program. Table 1 (listed in alphabetical order by principal investigator) briefly summarizes the topics covered by these papers.

### Table 1

**Summary of Products From the SIST Program**

| Principal investigator | Product and reference                                                                 | Data type | Analysis method | Wavelength range | Time period      |
|------------------------|---------------------------------------------------------------------------------------|-----------|-----------------|------------------|------------------|
| M. DeLand              | Update of existing V1 composite SSI data set and extension in time to create V2 product—DeLand et al. (2019) | SSI       | Measurement     | 120–500 nm       | 1978–2018        |
| M. DeLand              | Creation of an improved Aura OMI SSI data set for Cycle 24—Marchenko et al. (2019)   | SSI       | Measurement     | 265–500 nm       | 2006–2018        |
| J. Harder              | Characterization of the time evolution of facular regions using Precision Solar Photometric Telescope (PSPT) images—manuscript in preparation | SSI       | Measurement     | 170–617 nm (selected) | 1999–2015        |
| J. Harder              | Extend spectral and temporal coverage of SORCE SSI measurements using physics-based model to create SSI product for climate models—Harder et al. (2019) | SSI       | Measurement + Model | 200–10,000 nm | 2001–2014        |
| G. Kopp                | Create “community consensus” TSI composite data set that utilizes all available measurements with statistically based merging techniques—Dudok de Wit et al. (2017) | TSI       | Measurement     | All              | 1978–2018        |
| J. Lean                | Evaluation of NRLSSI2 and NRLTSI2 model data sets against measurements—Coddington et al. (2019) | SSI, TSI  | Model           | 115–100,000 nm (SSI); All (TSI) | 850–1882 (annual); 1883–2018 (daily) |
| J. Lean                | Creation and validation of improved NRLSSI3 and NRLTSI3 semi-empirical models—manuscript in preparation | SSI, TSI  | Model           | 115–100,000 nm (SSI); All (TSI) | 1978–2018        |
| E. Richard             | Compare archived SORCE SIM data [V25] to two versions of SIM data with alternative instrument degradation corrections, as well as independent SSI and TSI data sets—manuscript in preparation | SSI       | Measurement     | 240–2,300 nm     | 2003–2018        |
| M. Snow                | Creation of improved composite Lyman alpha irradiance data set for 1947–2018—Machol et al. (2019) | SSI       | Measurement     | 121.5 nm         | 1947–2018        |
| M. Snow                | Creation of revised Mg II index solar activity proxy data set from SORCE SOLSTICE—Snow et al. (2019) | Proxy     | Measurement     | 277–283 nm       | 2003–2018        |

TSI and SSI data sets and models of TSI and SSI variability. The SIST program understands that progress on multiple avenues is necessary to reach the following goals:

3. **Conclusion**

The intent is that the papers in this special section provide a sense of the importance of improved characterizations of solar irradiance for climate studies. A second SIST program was initiated in the summer of 2018, and it will build and expand on the work described in this collection.
Acknowledgments
The authors claim no real or perceived financial conflicts of interest.

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