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(Year **8** of **3***)

Proposal Title: **Solar Cycle Studies for the Miniature X-ray Solar Spectrometer (MinXSS) CubeSat Missions** (this is also known as the MinXSS-2 grant)

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☒ This report covers all subawards and parallel funding associated with my award.

☐ There are subawards and parallel funding associated with my award, but they will report separately.

☐ There are no subawards or parallel funding arrangements associated with my award.

**This grant has had multiple no-cost-extensions (NCE). What a great deal for NASA to get 8 years of CubeSat missions for the price of a 3-year grant!!!*

I) Summary of research originally proposed

***Proposed Objectives*.** The Miniature X-ray Solar Spectrometer (MinXSS) program is a science CubeSat mission for the H-TIDeS LCAS program, and we extended the MinXSS studies with a second launch with improved instrumentation. The original MinXSS-1 mission objectives were to better understand the energy distribution of solar flare soft X-ray (SXR) emissions and its impact on Earth's ionosphere, thermosphere, and mesosphere (ITM). These studies, funded through July 2017, focused on the solar SXR variability of active region evolution and flares during the MinXSS-1 eleven-month mission, modeling of the solar SXR variability, and understanding how the solar SXR energizes Earth's ionospheric E-region (80-150 km). The

MinXSS-2 mission extended these studies during the declining phase of solar cycle 24, cycle minimum, and rising phase of solar cycle 25. MinXSS-2 enhanced these original studies during the different solar cycle phases by characterizing the differences in (1) the active region heating / abundance, (2) flare energetics, and (3) solar forcing in Earth's upper atmosphere.

Proposed Methodology. MinXSS is a solar-oriented, 3-axis-controlled, 3-unit CubeSat to observe the solar SXR spectrum between 0.6 and 30 keV (0.04 and 2 nm). The X-ray spectrometer on MinXSS has a nominal spectral resolution of 0.15 keV full width half maximum (FWHM). The capabilities of this X-ray spectrometer have been flight-proven on MinXSS-1 and also previously on sounding rocket flights in 2012 and 2013. An improved version of this X-ray spectrometer is on MinXSS-2. The other major technology on MinXSS is the Attitude Determination and Control System (ADCS) from Blue Canyon Technologies (BCT); the BCT 0.5-unit ADCS has been flight proven on MinXSS-1 with precision solar pointing to ~10 arc-seconds. The MinXSS-1 was launched in December 2015 to the International Space Station (ISS) and deployed from the ISS on May 16, 2016. Starting from the ISS altitude of ~400 km, the MinXSS-1 mission life was limited, and it had re-entry on May 6, 2017. The MinXSS-2 spacecraft was built in parallel with MinXSS-1 and was delivered to Spaceflight Industries for its launch into a 575-km sun-synchronous orbit (SSO) on December 3, 2018. This free ride-of-opportunity for MinXSS-2 from Planet (formerly Google Terra Bella / Skybox Imaging) was not planned in the original MinXSS program that only provided support for development of the MinXSS spacecraft and the MinXSS-1 mission through 2017. This new effort supported the new MinXSS-2 mission and the follow-on MinXSS-3 mission as a flight of opportunity aboard the INSPIRESat-1 small satellite.

As with MinXSS-1, closure on the science objectives involves comparisons with SDO and RHESSI measurements, ITM modeling using the NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM), and improvements to the empirical Flare Irradiance Spectral Model (FISM) that is used for a variety of space weather research applications. New for MinXSS-2 is the addition of comparative studies with Hinode and NuSTAR solar measurements, studies correlating the measured photospheric magnetic field flux to soft X-ray spectra, and physics-based modeling of the SXR spectra. We have added two more Co-Is for supporting the extra research, and we also installed a second ground station at the Geophysical Institute (GI) in Alaska for increasing the daily data downlink by a factor of six over MinXSS-1.

II) Part A. Summary of accomplishments made during the past year

We continued to support the solar science operations of the INSPIRESat -1 small satellite through obtaining the solar SXR observations by MinXSS-3 and producing public data products for those solar SXR spectra. The MinXSS-3 instrument is also called the Dual Aperture X-ray Solar Spectrometer (DAXSS). The INSPIRE program partners in India, Taiwan, and Singapore are providing the mission operations support with daily passes at their ground stations. The INSPIRESat-1 completed its prime mission in late 2022, and India has continued the extended mission operations for INSPIRESat-1 into 2025 in order to download more of the mission data.

The DAXSS (MinXSS-3) instrument provides much improved energy resolution and larger effective area (response) than its MinXSS-1 and MinXSS-2 predecessors. ***These improvements in energy resolution and effective area for DAXSS enables better emission feature identification and effectively improves the accuracy of DAXSS science results.***

DAXSS solar observations in 2022-2023 have been during the rising phase of Solar Cycle 25 with 9-sec cadence and often 24-7 observations from its Sun Synchronous Orbit (SSO). Due to issues with the INSPRIESat-1 SD-Cards for storing data, we can downlink DAXSS data from 2022-2023 but have been unsuccessful to store data from new observations since January 2024. ***The focus during 2024-2025 has been to downlink as much of the DAXSS data as is possible.*** Downlink with only its UHF communication system has limited the data downlink volume. Downlinking with the Indian and Taiwan S-band ground stations allow for additional downlink of the DAXSS data; however, their S-band ground stations have had significant downtime and issues with getting all of the necessary commands (about 12 total commands) during a typical 10-minute pass. Consequently, the downlink of DAXSS data using their UHF communication systems have been the most successful way to get INSPIRESat-1 data to the ground.

We archived in March 2025 the "final" version of the MinXSS-1, MinXSS-2, and DAXSS science products at the NASA's Space Physics Data Facility (SPDF) and Virtual Solar Observatory (VSO), and will shortly be archiving with the Solar Data Analysis Center (SDAC). The following are brief summaries of the MinXSS / DAXSS data products, which are available in netCDF file format from the archive site and also available in IDL saveset file format at LASP's MinXSS data site: https://lasp.colorado.edu/minxss/data/ . We are currently finishing processing of these files into FITS 4.0-compliant products – which are the preferred format for the SDAC – including a compliant World Coordinate System (WCS) for compatibility with astropy and sunpy Python packages, and will be archiving those for all three missions once that processing is complete in the next few weeks.

Level 0C	Raw data packets (science and housekeeping packets) merged over the full mission and sorted by time. These are only available on the MinXSS data site as IDL saveset files.
Level 0D	Combination of science and housekeeping data packets merged over the full mission and sorted by time and with additional ancillary data (e.g. orbit parameters) as needed for Level 1 processing.
Level 1	Calibrated solar soft X-ray (SXR) spectral irradiance results at native measurement cadence (9-s) that have been merged over the full mission and sorted by time. This product is a limited set of the Level 0D measurements because filters are applied to exclude night-side orbit (dark) observations, solar occultation periods, and any instrument issues (e.g., large flares that saturated the detector).
Level 2	Time averages of the Level 1 solar SXR spectra. There are two Level 2 files: 1-min averages and 1-hour averages. These have the data merged over the full mission and sorted by time.
Level 3	Daily (24-hour) averages of the Level 1 solar SXR spectra. This file has the data merged over the full mission and sorted by time.

Table 1 lists the number of solar spectra in the MinXSS and DAXSS Data Products. The latest DAXSS version 3.1.0 processing in April 2025 has 26% more data than the previous released of DAXSS version 3.0.0 data in 2024. The total number of Level 1 (best science quality) solar SXR spectra is 59,674. An interesting cost comparison is that each MinXSS/DAXSS Level 1 spectrum cost is $65 and cost for a typical sounding rocket flight is estimated to be about $36,000 per spectrum. For publication comparison, the MinXSS science team has written 42

papers, versus we have only published one paper per rocket flight of a MinXSS-type solar spectrometer. In addition, there have also been more than 150 presentations that the MinXSS-DAXSS team has made about those missions and science results. MinXSS-1 was featured in Spence et al. (2022) as a prime example of the cost efficiency of CubeSat science return.

Table 1. Number of Solar Spectra in the MinXSS and DAXSS Data Products

Data Product \ Mission	MinXSS-1	MinXSS-2	IS-1 DAXSS
Version Number	5.0.0	5.0.0	3.0.0 3.1.0
Date Range	2016/149 - 2017/123	2018/341 – 2019/006	2022/059 - 2023/297
Level 0D Spectra	54,011	5,529	54,811 65,394
Level 1 Solar Spectra	16,029	342	34,455 43,303
Level 2 Spectra: 1-min	11,808	274	5,842 7,242
Level 2 Spectra: 1-hr	3,802	84	334 374
Level 3 Spectra: 1-day	263	20	125 130

Students continued to play important roles in the MinXSS mission.

Robert Sewell is working as a CU graduate research assistant (GRA) in the Aerospace Science Engineering (AES) department for the MinXSS and OWLS cubesat projects. He has been involved in all aspects of the MinXSS-2 and DAXSS development, environmental testing, and mission operations for the past six years, and he also assists the Indian operations team in writing the scripts to downlink the DAXSS data from their UHF and S-band ground stations. Robert plans to complete his PhD in May 2027, including DAXSS solar occultation data analyses.

There are some other graduate students involved with MinXSS data analysis, although they are not funded directly from this MinXSS-2 grant. One is Anant Kumar Telikicherla Kandala, who completed his masters degree at University of Alberta in July 2024, and he is now at the University of Colorado Aerospace Engineering Science (AES) department since August 2024. Anant has been studying flare onsets using DAXSS solar SXR spectra, and he plans to complete his PhD in December 2027. Another graduate student is Crisel Suarez at Vanderbilt University, and her advisor is Dr. Chris Moore (MinXSS Co-I). Crisel is working on modeling the solar soft X-ray spectra using MinXSS data and X-ray images from Hinode/XRT. She completed her PhD dissertation in March 2025. There are also some Indian students working on DAXSS science data analysis.

We held a bi-weekly MinXSS science teleconference with the MinXSS science team and those students with the focus on MinXSS science results. We also had a monthly teleconference with the MinXSS science team and the Indian Solar X-ray Monitor (XSM) science team (14 scientists) in comparing / validating our solar SXR spectral results from the INSPIRESat-1 and Chandrayaan-2 satellite (Mithun et al., 2020, *Solar Phys*., 293, 21).

The lists of publications and presentations during this past year are provided in Section V.

II) Part B. Summary of accomplishments made during entire (8-years) grant period

There are three important findings from the research with the MinXSS/DAXSS measurements.

1) There are several papers (Caspi et al., 2015; Woods et al., 2017; Moore et al., 2018; Reep et al., 2020; Schwab & Sewell et al., 2020; Nagasawa et al., 2022; Woods et al., 2023; Suarez & Moore, 2023; and McTiernan et al., in prep) that clearly show that **the abundance of the first ionization potential (FIP) elements, such as Fe, Ca, Mg, and Si, decrease significantly during the impulsive phase of most flares studied with MinXSS observations**. This result is important in validating the chromospheric evaporation process expected during flares and is fundamental to the nanoflare theory for coronal heating. See Figure 1 for example.
2) Schwab et al. (2023) studied solar active region evolution for the SXR range using MinXSS-1 spectra and find that **daily variations of the SXR irradiance can be described by a static cool (2 MK) component and a warm (5 MK) component that varies over the solar cycle**. Those results are being incorporated into the Flare Irradiance Spectral Model (FISM-3) and will significantly help improve the FISM solar irradiance estimates in the SXR range.
3) Telikicherla et al. (2024) studied the onset period prior to a flare event and find **a hot (10-20 MK) component in the SXR range that precedes even the hard X-ray component in the impulsive phase**. Furthermore, they find that **there appears to be two sources of flare events, one related to two coronal loops interacting to form a larger loop, and the other related to lower loops rising and combining with higher loops**. Anant Telikicherla is now working on using this hot component part of the flare onset period to make improved flare nowcasts / forecasts.

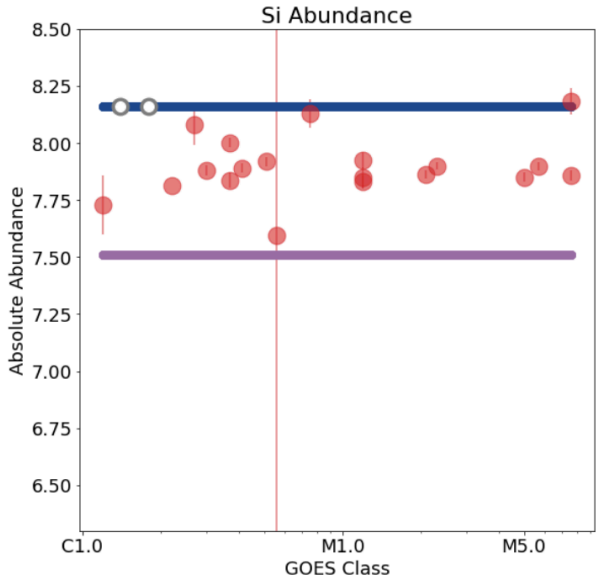

Figure 1. The Si abundance change is shown for 21 flares studied with MinXSS-1 spectra (graphic is from Figure 3 in Suarez & Moore, 2023). The blue line is the coronal abundance (expected pre-flare level), and the purple line is the photospheric abundance (expected lower limit for the abundance change during flares). **Almost all flares show a decrease in the Si abundance during a flare event and thus support the chromospheric evaporation process that is expected for flares.**

The MinXSS / DAXSS missions are also technology demonstration missions that have highlighted the highly successful development of the compact Amptek X123 SXR spectrometer for CubeSat missions (Woods et al., 2016; Mason et al., 2016; Moore et al., 2018; Schwab & Sewell et al., 2020; Woods et al., 2023) and the Blue Canyon Technologies XACT attitude and control system for CubeSat missions with 3-axis control with 10 arc-sec pointing precision (Mason et al., 2017). The MinXSS heritage of the X123 has directly led to another NASA-funded mission, CubIXSS, which will feature four of these detectors to continue MinXSS-inspired science in 2026 and onwards.

The biggest challenge for all three MinXSS missions has been the limited volume of data downlinked due to using only UHF communication. While the MinXSS satellites have been able to store about 10,000 solar spectra per day, only about 500 solar spectra can be downlinked during two 10-minute passes per day (using a single ground station). Of course, we are selective on what we downlink to get the best flare spectra, but with only 5-10% of the total data being possible to downlink means that there are many recorded spectra that never make it down to the ground. The obvious solutions are to have higher rate downlink communication systems, such as S-band and X-band, or to have more UHF ground stations if UHF communication is the only radio option flown.

Another challenge has been the lifetime of SD-cards, which are used to store the data, in the higher radiation environment of the polar orbits that MinXSS-2 and INSPIRESat-1 / DAXSS resided. The MinXSS-1 mission in its ISS-like orbit did not have any SD-card issues, but MinXSS-2 mission ended early because of its SD-card failure, and INSPIRESat-1 mission had storage capabilities limited between launch in February 2022 to early 2024 when its two SD-cards started having issues. The mitigation is to not fly SD-cards in polar orbits and instead use rad-tolerate / rad-hard memory modules, as is the case for all recent and future LASP cubesat missions.

The following are brief summaries about the MinXSS/DAXSS key project milestones and papers published by MinXSS/DAXSS science team members during the MinXSS CubeSat era. A complete list of MinXSS-related publications (37 total papers) are organized by year at https://lasp.colorado.edu/minxss/science/publications/ .

2013: CU Aerospace Department Graduate Student project started the MinXSS mission concept with CU professors Xinlin Li and Scott Palo and project advisors Tom Woods and Rick Kohnert.

2014: MinXSS-1 grant started: MinXSS-1 deployed from ISS in May 2016.

2015: Caspi et al. (*Astrophys. J. Lett*., 802, L2) present results from flying the first version of the MinXSS instrument (Amptek X123) on a sounding rocket flight.

2016: MinXSS-1 team wins the SmallSat Mission of the Year award for its very successful science mission and flying the first version of the Blue Canyon Technology's XACT attitude and control subsystem with 3-axis control to about 10 arc-sec.

2017: Woods et al. (*Astrophy.. J. Lett*., 835, 122) describe the MinXSS-1 mission and the first-light measurements of the solar soft X-ray spectral irradiance with the MinXSS instrument.

2016: Moore et al. (*Proc. SPIE 9905, Space Telescopes and Instrumentation 2016: Ultraviolet to Gamma Ray*, 990509) provide the details for the calibrations of the MinXSS instrument.

2016: Mason et al. (*J. Spacecraft & Rockets*, 53, 2) describe the details of the MinXSS-1 instrumentation and spacecraft design.

2017: **MinXSS-2 grant started**: MinXSS-2 launched into sun-sync orbit in December 2018.

2017: Mason et al. (*J. Small Satellites*, 61, 651) describe in detail the in-flight performance of the MinXSS-1 spacecraft subsystems with a focus on pointing and power performance.

2018: Moore et al. (*Solar Phys*., 293, id.21) provide details about MinXSS-1 and MinXSS-2 calibrations and some flare results from the MinXSS-1 observations.

2018: Mason et al. (*J. Thermophysics & Heat Transfer*, 32, 237) present the MinXSS-1 thermal design, ground testing of the thermal design, and on-orbit temperature performance.

2019: MinXSS-2 has failure of its SD-card causing spacecraft processor reboot failure. Two lessons learned are to allow longer watchdog timer period (minutes, instead of seconds) and to use rad-tolerant / rad-hard memory for polar orbits.

2019: Spare MinXSS parts allowed the development of MinXSS-3 with newer technology and with a new name of DAXSS and a free launch / mission operations by international partners for the INSPIRESat-1 spacecraft.

2020: Mason et al. (*Adv. Space Research*, 66, 3) describe the improvements of the MinXSS-2 spacecraft and instrument over the MinXSS-1 design.

2020: Reep et al. (*Astrophys. J.*, 895, 30) present a model of multithread heating of flare arcades through combining MinXSS-1, GOES XRS, and SDO AIA solar data.

2020: Schwab & Sewell et al. (*Astrophys. J*., 904, 20) introduce the improved design of MinXSS-3, that is also called the Dual-zone Aperture X-ray Solar Spectrometer (DAXSS), and they present the instrument calibrations and the measurement results on the solar SXR spectral irradiance during a sounding rocket flight in 2018. This rocket DAXSS instrument is then later flown on the INSPIRESat-1 small satellite in 2022.

2021: Chandran et al. (*Adv. Space Research*, 68, 2616) describe the INSPIRESat-1 satellite design, its two science instruments to study the ionosphere and the solar SXR radiation, and mission operation plans.

2022: Schwab et al. (*IEEE Aerospace Conference Proc*., March 2022) present the design of the battery test and acceptance system developed for the INSPIRESat missions.

2022: Spence et al. (*Space Weather*, 20, e2021SW003031) present the many achievements and lessons learned from science-based CubeSats. MinXSS results are highlighted in this paper as a prime example of cost-efficiency of CubeSat science return.

2022: Although DAXSS was ready for launch in 2018, the INSPIRESat-1 was not launched until February 2022 due to initial delays in the spacecraft development and then a long delay due the world-wide COVID-19 pandemic.

2022: Nagasawa et al. (*Astrophys. J*., 933, 173) provide detailed modeling of the MinXSS-1 and RHESSI spectra during an M-Class solar flare and show results for cool (3 MK), hot (15 MK), and super-hot (30 MK) components of the flare plasma.

2023: Schwab et al. (*Astrophys. J*., 945, 31) present solar active region evolution for the SXR range using MinXSS-1 spectra and find that daily variations of the SXR irradiance can be described by a static cool (2 MK) component and a warm (5 MK) component that varies over the solar cycle.

2023: Woods et al. (*Astrophys. J.*, 956, 94) provide an overview of the DAXSS instrument and present first-light results for DAXSS solar SXR spectral irradiance. The improved energy (spectral) resolution and enhanced sensitivity of DAXSS as compared to MinXSS-1/2 are highlighted. The improved energy resolution enables higher accuracy for studying abundance variations that can change by up to a factor of four during flares, and thus confirm that flare processes are important for heating the hot corona.

2023: Suarez and Moore (*Astrophys. J.*, 957, id.14) present results from studying 21 flare events observed by MinXSS-1 and find that the abundance of the FIP elements are significantly depleted during those flare events, and thus validate the chromospheric evaporation process expected during flares.

2024: Telikicherla et al. (*Astrophys. J.,* 966, 198) present new findings about the hot component in the SXR range during the onset period prior to a flare event. They find that there appears to be two sources of flare events, one related to two coronal loops interacting to form a larger loop, and the other related to lower loops rising and combining with higher loops.

2025: **End of the MinXSS-2 grant**. MinXSS-1, MinXSS-2, and DAXSS latest versions of their data products are archived by NASA GSFC. INSPIRESat-1 is still in operation and downloading DAXSS data from 2022-2023 solar observations. McTiernan et al. (in prep) analyzes joint observations by MinXSS-1 and RHESSI of multiple flares and pre-flare times, using both instruments together, to determine flare differential emission measures and abundances for Fe, Si, Mg, S, and Ca. Suarez et al. (in prep) uses MinXSS-2 data to analyze quiescent times and 2 B-class flares. Both are expected to be submitted and published in the near future.

There have been four American PhD dissertations concerning the MinXSS / DAXSS instrument development, flight operations, and heliophysics science results, plus there are two more American PhD dissertations expected to be completed in 2027. There are additional International Masters and PhD degrees concerning the INSPIRESat-1 mission.

James P. Mason, 2016, University of Colorado, *Solar Eruptive Events: Coronal Dimming and a New CubeSat Mission*, CU Scholar Publication 10150872.

Christopher S. Moore, 2017, University of Colorado, *Atomic Layer Deposition Reflective Coatings for future Astronomical Space Telescopes and the Solar Corona viewed through the MinXSS (Miniature X-ray Solar Spectrometer) CubeSats,* ProQuest Publication 10680697.

Bennet D. Schwab, 2022, University of Colorado, *Solar X-Ray Irradiance Variations: Instrument Design, CubeSat Mission Design, and Science Analysis of Solar Observations from Sounding Rocket and CubeSats*, ProQuest Publication 29258089.

Crisel Suarez, 2025, Vanderbilt University, *Diagnostics of Soft X-Ray Emission from the Sun: Energetic Solar Flares and Gentle Quiescence*.

III) Summary of future plans

Because this is the end of the MinXSS-2 grant support, there are no future plans for work on the MinXSS-2 grant. However, we note that Bennet Schwab and Robert Sewell have a NASA Heliophysics Guest Investigator (H-GI) grant to continue science research with MinXSS/DAXSS solar SXR spectra and that Amir Caspi has related solar physics research with solar SXR measurements planned on the CubeSat Imaging X-ray Solar Spectrometer (CubIXSS) mission with a no-earlier-than October 2025 launch. Two papers are still in preparation under separate funding and will be submitted in the near future.

IV) Publications and Presentations during the past year (January 2024 - March 2025)

- Peer-reviewed articles (6)

  Suarez, C., *Diagnostics of Soft X-Ray Emission from the Sun: Energetic Solar Flares and Gentle Quiescence*, PhD Dissertation, Vanderbilt University, March 2025.

  Soto, E., Evans, J. S., Meier, R. R., Tashiro, M., Sakib, MD. N., and Yigit, E., A Missing Piece of the E-Region Puzzle: High-Resolution Photoionization Cross Sections and Solar Irradiances in Models, *J. Geophysical Research: Space Physics*, 129, e2023JA031870, 2024.

  Telikicherla, A., Woods, T. N., and Schwab, B. D., Investigating the Soft X-Ray Spectra of Solar Flare Onsets, *Astrophys. J.*, 966, id.198, 2024.

  Valluvan, A. B., Goyal, A., Jain, D., Samantaray, A. S., Sarwade, A., and Sankarasubramanian, K., Solar Flare Catalogue from 3 Years of Chandrayaan-2 XSM Observations, *Solar Physics*, 299, id.8, 2024.

  Woods, T. N., Eden, T., Eparvier, F. G., Jones, A. R., Woodraska, D. L., Chamberlin, P. C., and Machol, J. L., GOES-R Series X-Ray Sensor (XRS): 1. Design and Pre-Flight Calibration, *J. Geophysical Research: Space Physics*, 129, e2024JA032925, 2024.

  Suarez, C., and Moore, C. S., Estimations of Elemental Abundances during Solar Flares Observed in Soft X-Rays by the MinXSS-1 CubeSat Mission, *Astrophys. J.*, 957, id.14, 2023.

- Presentations (12)

  Caspi, A., and 34 co-authors, CubeSat Imaging X-ray Solar Spectrometer (CubIXSS): science motivation and current development status for a new 16U mission to understand heating of coronal plasma in solar flares and active regions, *AGU Fall Meeting*, Poster SH33D-2768, Dec 2024.

  Caspi, A., and 28 co-authors, The CubeSat Imaging X-ray Solar Spectrometer (CubIXSS): a new 16U mission to understand heating of coronal plasma in solar flares and active regions, *SDO Science Workshop: A Gathering of the Helio Hive*, Feb 2025.

  Caspi, A., and 28 co-authors, The CubeSat Imaging X-ray Solar Spectrometer (CubIXSS): science and current status of implementation for a new mission to understand heating of coronal plasma, *Hinode-17/IRIS-15/SPHERE-3 Workshop*, Talk #C67, Jul 2024.

Caspi, A., and 28 co-authors, The CubeSat Imaging X-ray Solar Spectrometer (CubIXSS): science and current status of implementation for a new mission to understand heating of coronal plasma, *TESS 2024*, Talk #415-01, Apr 2024.

Mandayapuram, Asif M., Pandya, M. R., Mithun, N.P.S., Vadawale, S. V., and Woods, T. N., Simultaneous observations of elemental abundance evolution during solar flares using InspireSat-1 DAXSS and Chandrayaan-2 XSM, *Astronomical Society of India (ASI) Conference*, Feb 2025.

Moore, C. S., and 9 co-authors, Spectral Soft X-ray Measurement Improvements of the three Miniature X-ray Solar Spectrometer (MinXSS-1, -2, -3) CubeSats and New Instrumentation to Open New Parameter Space, *Hinode-17/IRIS-15/SPHERE-3 Workshop*, Poster #P52, Jul 2024

Schwab, B., Woods, T. N., Sewell, R., Telikicherla, A., and Crotser, D., New Secondary Science Instrument on Rocket EVE, *SDO Science Workshop: A Gathering of the Helio Hive*, Feb 2025.

Suarez, C., and 9 co-authors, Solar Flares X-ray Irradiance Observations from the Miniature X-ray Solar Spectrometer (MinXSS) CubeSats, *Hinode-17/IRIS-15/SPHERE-3 Workshop*, Talk #C08, Jul 2024

Telikicheria., A., Woods, T., and Schwab, B., Investigating Solar Flare Offsets using Multi-wavelength Spectroscopy and Imaging, *AGU Fall Meeting*, Talk SH12B-04, Dec 2024.

Telikicheria., A., Woods, T., Schwab, B., and Sewell, R., Statistical Investigation of Solar Flare Onsets: Physical Properties and Short-term Flare Forecasting Potential, *SDO Science Workshop: A Gathering of the Helio Hive*, Feb 2025.

Woods, T. N., and A. Chandran, DAXSS Instrument and INSPIRESat-1 Spacecraft, NASA SmallSat LEARN Forum, on-line seminar, 27 March 2024 (invited).

Xie, X., and 7 co-authors, Thermal diagnostics on an M-flare observed with Hinode/XRT, SDO/AIA, and MinXSS-1, *Hinode-17/IRIS-15/SPHERE-3 Workshop*, Talk #C09, Jul 2024

V) Science highlights

See Section II Part B above and also the Science Nuggets and News web pages on MinXSS web site at http://lasp.colorado.edu/home/minxss/science/ .

Here are some fun facts for the MinXSS CubeSat project.

MinXSS by the Numbers

1	Trophy: 2016 AIAA Small Satellite Mission of Year
3	Missions: MinXSS-1, MinXSS-2, InspireSat-1
4	PhD Dissertations (3 CU-Boulder, 1 Vanderbilt Univ.)
5	2 Mission Goals + 3 Science Questions
12	Years of Development, Flight, and MO&DS
30	DAXSS sensitivity improvement over MinXSS-1
39	LASP staff who worked on MinXSS
42	Published papers
49	CU students who developed MinXSS
60	Cost (USA $) per high-quality solar Soft X-Ray spectrum
59,674	High-quality solar Soft X-Ray spectra
124,934	Downlinked solar Soft X-Ray spectra