



SPACE WEATHER ISSUE

Features: ISS-deployed CubeSat studies sun-Earth connection • Finally... TSIS will fly • GOES-R EXIS launches in fall

Letter from the director

Daniel Baker



Modern societies are ever-more dependent on technologies and systems that can be negatively impacted by changes in the environment of space.

The term “space weather” refers to changing conditions on the sun, throughout space, and in the Earth’s magnetic field and upper atmosphere that can influence the performance and reliability of space-borne and ground-based technological systems. Severe space weather can endanger human life and health both directly for astronauts in space and in many ways on Earth as well. Adverse conditions in the space environment can cause disruptions leading to a whole host of socioeconomic losses and impacts on our security.

This issue of *LASPSPACE* provides a perspective on LASP’s involvement in space weather research. In doing so, the issue touches on the many and varied impacts that space weather can have on technological systems. The lab has worked to characterize the sun since 1948 when it began as the Upper Air Laboratory. LASP’s ongoing efforts contribute to the growing body of knowledge on everything from the sun-Earth climate connection to future mitigation of damage caused by severe space weather events. Space weather is a key threat to our modern world and LASP is proud to be part of the solution—now and into the future. 📧

IN FOCUS

LASP’s first ISS-deployed CubeSat studies sun-Earth connection

The sun has been the subject of scientific study with ever-increasing detail for centuries. Its emissions have been measured from the ground and space, from radio to gamma rays, and from electrons to neutrinos. However, there are still critical gaps in some parts of the electromagnetic spectrum and our understanding of solar physics. How can the sun’s corona be millions of degrees while the photosphere is only 10,000° F? What specifically is the corona made

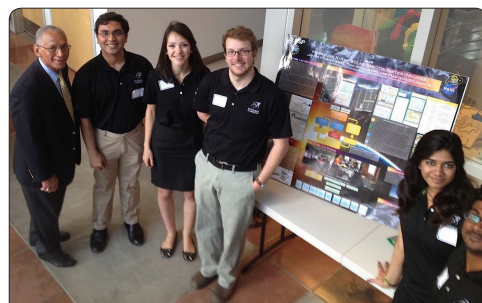
of? How is energy distributed across the spectrum during a solar eruptive event? What is the impact of high-energy emission from the sun on the Earth’s upper atmosphere, satellite communications, and our personal electronics? Data from the NASA-funded Miniature X-ray Solar Spectrometer (MinXSS) CubeSat will help scientists address these questions, which have important implications for space weather studies.

MinXSS was launched on December 6, 2015 to the International Space Station (ISS) and is scheduled to be deployed from the airlock in May. It is the first CubeSat LASP has deployed from the ISS. This 3.52-kilogram satellite will measure solar soft x-rays (SXR), a wavelength range that has not been well observed in the past. Solar flares are expected to have a jump in brightness in the SXRs that is greater than in any other part of the spectrum, and the number of photons at each SXR wavelength makes a major difference in the chemistry of Earth’s ionosphere.

More than 40 graduate students have worked on the MinXSS project, from proposal through operations and data analysis. LASP professionals acted as mentors to these students, many of whom are taking the extensive experience they have gained into new and exciting careers in the aerospace industry.

For more information, visit <http://lasp.colorado.edu/home/minxss>. 📧

By James Paul Mason, graduate research assistant at LASP and PhD candidate at CU-Boulder.



MinXSS students speak with NASA Administrator Bolden at the CU Aerospace Industry Symposium in April 2014. Left to right: Charles Bolden, Siddhesh Naik, Bena Mero, James Paul Mason, Sindhura Bandapalle, and Rohit Kandurwar. (Courtesy University of Colorado)

Mission status

Instrument Development (Pre-Phase A)

IIP Compact SIM (cSIM)
MatISSE LAMA

Phase A/B (funded concept study)

Europa Multiple-Flyby Mission/SUDA
Emirates Mars Mission (EMM)

Phase C (design and fabrication)

Phase D (assembly and test)

GOES-T/EXIS and GOES-U/EXIS
GOLD
ISS-TSIS
Solar Probe Plus

Launch/Early Orbit [launch date]

MinXSS CubeSat [Dec. 6, 2015]
GOES-R/EXIS [Oct. 2016]
GOES-S/EXIS [2017]

Prime Mission [end date]

New Horizons/SDC [2016]
MMS, four spacecraft [2017]
STPSat-3/TCTE [2017]

Extended Mission [end date]

QuikSCAT [2016]
AIM [2017]
Cassini/UVIS [2017]
Kepler/K2 [2017]
SDO/EVE [2017]
SORCE [2017]
THEMIS and ARTEMIS [2017]
TIMED/SEE [2017]
Van Allen Probes REPT/FIELDS [2017]
MAVEN [2018 pending]

For more information on current missions, as well as full instrument and mission names, visit <http://lasp.colorado.edu>.

GOES-R EXIS launches in fall, GOES-U ready for delivery




The four GOES-R+ EXIS flight models as displayed in a LASP cleanroom on February 10, 2014. One was ready to ship, one finishing tests, one beginning tests, and one just finished assembly. (Courtesy LASP)

LASP eagerly awaits the launch of the GOES-R satellite from Cape Canaveral in October and the subsequent launch of GOES-S, T, and U in the coming years. These four satellites in the Geostationary Operational Environmental Satellites - R Series Program (GOES-R+) represent a technological leap for the NASA/NOAA GOES-R collaboration that monitors terrestrial and space weather.

LASP designed and built the Extreme ultraviolet and X-ray Irradiance Sensors (EXIS) to launch aboard the four GOES-R+ satellites. We are the first university institute to build instruments for this long-running program and have produced all four flight models ahead of schedule and under budget.

LASP won a NASA/NOAA Significant Achievement Award for its project management and early delivery, and a NASA Group Achievement Award for the new technology incorporated into the instruments. On April 19, LASP delivered the final EXIS instrument for the GOES-U satellite.

EXIS monitors solar output in the extreme ultraviolet and soft X-ray wavelengths. It provides an important early warning of space weather events such as solar flares and solar proton events that can affect communications, navigation, and power grids on Earth.

For more information, visit <http://lasp.colorado.edu/home/missions-projects/quick-facts-goes-r>. 

By Frank Eparvier, lead scientist of EXIS and senior research scientist at LASP.

Finally...TSIS will fly

The Total and Spectral Solar Irradiance Sensor (TSIS) has endured a long, rocky road since LASP was selected to build the dual-instrument package for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) in 1998. The

goal of TSIS was to continue measuring incoming solar radiation from space, which is Earth's longest, most continuous climate data record.

The initial launch was anticipated around 2007 but quickly slipped. Later,



Mission & technical stats

- LASP operates four satellites.
- LASP operates 114 instruments in space on 15 spacecraft.
- LASP is currently developing 2 spacecraft and 11 instruments for 8 missions.

Administrative stats

(March 11, 2016)

Scientific researchers	58
Tenure-track faculty	19
Professionals	261
Graduate students	48
Undergraduate students	88
Total	474
Open positions	36

For employment information, visit <http://lasp.colorado.edu/home/about/jobs>.

TSIS was removed due to NPOESS program cost overruns. It was reinstated in 2008 based, in part, on a report by the National Academy of Sciences. In 2010 NPOESS was restructured, then dismantled and the NOAA-NASA Joint Polar Satellite System (JPSS) took over responsibility for TSIS. But funding delays triggered further slips. By 2014 TSIS was separated from JPSS.

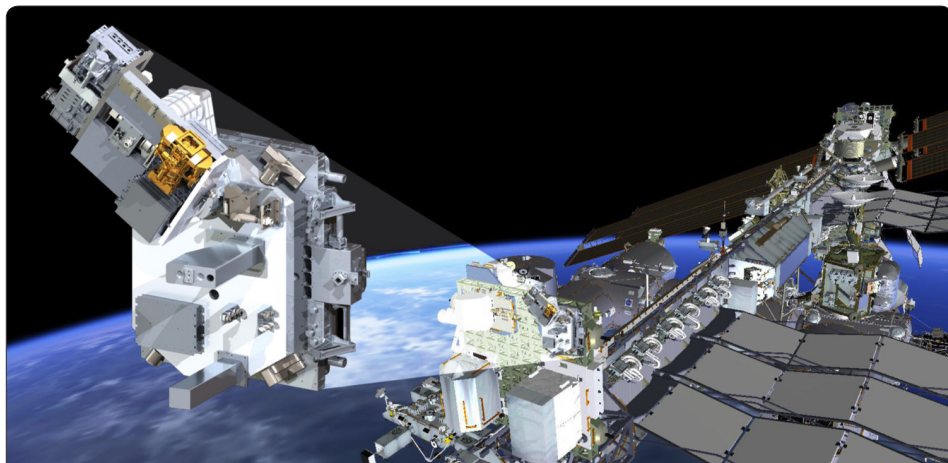
Finally in March 2014, NOAA approved a plan to deploy TSIS on the International Space Station (ISS). TSIS is now preparing

for flight on a SpaceX Falcon 9 launch vehicle in late 2017 or early 2018.

Trying to understand Earth's climate without knowing the sun's energy input is like trying to balance a checkbook without knowing your income. TSIS will provide data critical to understanding our climate, giving policy makers the information necessary to make informed decisions to mitigate and adapt to climate change.

For more information, visit <http://lasp.colorado.edu/home/missions-projects/quick-facts-tsis>.

By Peter Pilewskie, director of the LASP-Goddard Sun Climate Research Center and professor of atmospheric and oceanic sciences at CU-Boulder.



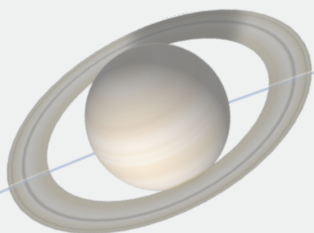
An artist's conception shows a close-up view of TSIS as deployed on the International Space Station's EXPRESS logistics carrier (ELC)-3. (Courtesy NASA/LASP)

FIELD NOTES

Antarctic aerosols as a window into the Earth's past

Antarctica offers a unique window back in time to the Earth's past atmosphere and climate through the ice core record. One of the main proxies for the atmosphere during Earth's geologic past comes from analysis of aerosol particles embedded in ice cores that have been deposited over hundreds of millennia. However, our current understanding of the formation and

transport mechanisms of these particles is limited. The 2-season Ozone Depletion, Ice, Aerosol Campaign (2ODIAC) field experiment, led by LASP scientist Lars Kalnajs and Peter DeCarlo from Drexel University, entailed spending four months at a field camp on the frozen ocean surrounding Antarctica making the first real-time, high-resolution measurements



Education events

Events are held at LASP in Boulder, CO unless otherwise noted.

Research Experience for Undergraduates (REU) Program in Solar and Space Physics (Funded by the National Science Foundation)
June 5–July 30, 2016

MAVEN Elementary Teacher's Summit Workshop, for elementary educators
June 14–17, 2016

For more information, visit <http://lasp.colorado.edu/education>.

Student news

Ben Busby graduated in December 2015 with a bachelor's degree in computer science. He is now a software engineer and jack-of-all-trades at Forge Aeronautics in Boulder, CO.

Quintin Schiller graduated with a PhD in space sciences in August 2015 and received a post-doctoral fellowship at NASA's Goddard Space Flight Center.

Jamey Szalay accepted a postdoctoral position at SwRI in San Antonio, TX after graduating in December 2015. He continues to work on the LADEE/LDEX experiment as he did at LASP and has joined the Juno-JADE mission.

Hong Zhao, who graduated in December 2015 with a PhD in space sciences, is currently working at LASP as a postdoctoral scientist.



Lars Kalnajs at the ZODIAC sea ice camp, near Ross Island, Antarctica. (Courtesy Andrew Slater, NSIDC)

of aerosol composition and size. In order to probe the mechanisms of aerosol formation, processing, and deposition in one the harshest environments on Earth, the team deployed sophisticated aerosol instrumentation, including an aerosol mass spectrometer, laser-sizing spectrometers, and trace gas and meteorological

instruments. These measurements are some of the first to identify blowing snow as being a dominant source of aerosol formation during the dark and windy Antarctic winter.

For more information, visit <http://www.2odiac.com>.

By Lars Kalnajs, principal investigator of 2OIDAC and research scientist at LASP.

INNER SPACE

News

LASP is partnering with Axiom Research Labs' Team Indus, one of three milestone prizewinners competing for a \$30 million Google Lunar XPRIZE. The prize will be awarded to teams "that can land a robot on the surface of the Moon, travel 500 meters over the lunar surface, and send images and data back to the Earth." The competition has renewed public interest in Moon landings.

LASP will provide the Bangalore-based company with the OASIS operations software to control the spacecraft, which is being built in India.

After winning the initial milestone

challenge, Axiom staff traveled to Colorado for a meeting at Lockheed Martin where they met Mike McGrath, director of engineering at LASP. During their trip, the team visited Boulder to tour the LASP facilities, including the Lab's mission operations centers. The visitors invited McGrath and LASP engineer Amal Chandran to Bangalore in June 2015 and a partnership was born. In April 2016, a LASP mission operations team, led by Mat DeNeen, returned to Bangalore to install the OASIS software and train Team Indus controllers.

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LASP homepage



Newsletter archives

Links to a variety of social media networks can be found on our homepage, <http://lasp.colorado.edu>.

If you know someone who might like to receive LASPSpace, please encourage them to email Laura Bloom, publisher, at laura.bloom@lasp.colorado.edu to subscribe. Should you prefer not to receive future issues, please email with "Unsubscribe" in the subject line.

To view LASPSpace archives, visit <http://lasp.colorado.edu/home/about/publications/newsletters/>.

Public outreach

School goes all-out for LASP's MAVEN mission

More than 800 students from Acres Green Elementary School in Colorado have learned about the Mars Atmosphere and Volatile Evolution (MAVEN) mission over the last five years due to the work of Carol Kendall, the school's dedicated hands-on science instructor. Kendall is an advisor for the MAVEN *Red Planet: Read, Write, Explore!* elementary school program, and one of 90 MAVEN Educator Ambassadors in the U.S.

She works with students in grades K–6, and sees them year-to-year, so they learn more challenging MAVEN content as they

progress. Kendall most enjoys exploring magnetism and the effects of the solar wind on Mars with students.

Kendall said, "The greatest moment is when I can tell by their work or class discussions that they have an understanding of Mars today, in the past, or of the MAVEN mission." Students are talking about it outside the classroom as well. "At the bus stop, I overheard a student ask another, 'What's up?' The other student enthusiastically responded, 'MAVEN,'" she said, "That made me smile."

Achievement awards

Daniel Baker, director of LASP and CU-Boulder professor of astrophysical and planetary sciences, has been elected a 2016 fellow of the American Institute of Aeronautics and Astronautics (AIAA), the world's largest aerospace professional society. AIAA Fellows are "persons of distinction in aeronautics or astronautics, who have made notable and valuable contributions to the arts, sciences, or technology thereof." Baker will receive the award at the AIAA Fellows Dinner and AIAA Aerospace Spotlight Awards Gala on June 14 in Washington D.C.

Michael King, LASP senior research scientist, was inducted as a Faculty Fellow of the Texas A&M University (TAMU) Institute for Advanced Study at a gala on February 25. The award celebrates his leadership on NASA's Terra and Aqua satellite projects which play a vital role in developing the revolutionary capabilities of the U.S. space program to monitor Earth's atmosphere, oceans, and land. As a fellow, King will collaborate with faculty-researchers and graduate students in the Department of Atmospheric Sciences in the College of Geosciences.

Administration update

LASP expands vacuum tank capabilities

In an effort to increase test capabilities, LASP and the Center for Astrophysics and Space Astronomy (CASA) teamed up to convert an existing large vacuum tank into a \$1.5M thermal vacuum (TVac) and thermal balance test facility. The tank, housed at CASA, will be utilized by LASP staff who moved into the building recently to work on the Emirates Mars Mission.

The TVac facility will be large enough to test small spacecraft and space station assemblies that require extra vacuum tank

space due to deployable mechanisms. The chamber will have a 10 ft. internal diameter and a platen 13 ft. long and 6 ft. wide. The platen will be capable of holding 2000 kg of mass. The temperature range for the platen and the shroud is -180°C to +150°C. The TVac facility will greatly expand LASP and CASA testing capabilities and will be a unique resource for CU. The project is scheduled to be completed by January 2017.

