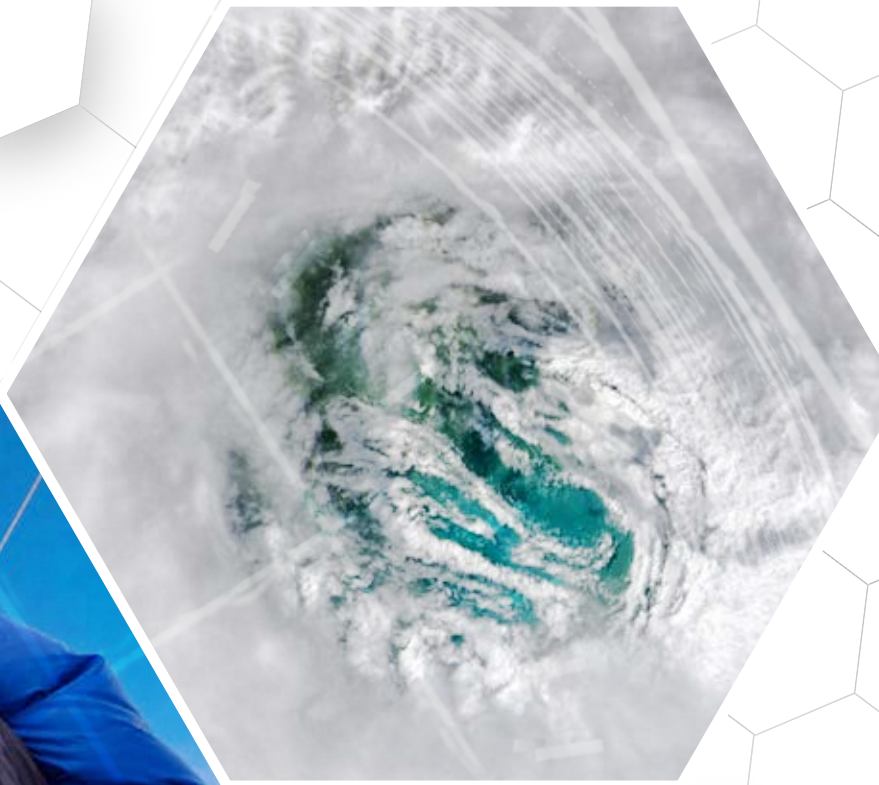


SSEC

Space Science and Engineering Center
University of Wisconsin–Madison

Biennial Report
2022-2023



From the director

Leveraging SSEC research to address real-world challenges



Research remains at the core of what we do — developing innovative scientific and technological approaches using satellite data to study the atmosphere, oceans, and environment of Earth and other planets. Developing applications of that research to address the challenges facing our state and beyond goes hand in hand.



Our research is well-suited to contribute to the Wisconsin Research, Innovation and Scholarly Excellence (RISE) initiatives. Specifically, **RISE-AI** (Artificial Intelligence) and **RISE-EARTH** (Environment: Adaptation, Resilience, Technology and Humanity). RISE-AI focuses on integrating social sciences with more traditional data and computer science so people are at the center of AI solutions. RISE-EARTH focuses on accelerating the growth of UW–Madison’s environmental sustainability research.



This biennial report highlights some of our research that forms the foundation for new collaborative opportunities in AI and environmental sustainability. This work includes developing an enhanced satellite-based wildfire detection and monitoring system called the Next Generation Fire



System, improving our AI-based Prob-Severe prediction model to provide earlier warnings for severe weather, and participating in cutting-edge CubeSat missions to provide new observations of weather systems, including tropical cyclones and climate. SSEC research continues to support developing strategies to minimize the impact of natural disasters, a key part of adaptation and resiliency necessary within a changing climate.

As we support these initiatives and look to apply our research to the real world, we continue our mission to improve understanding of weather, climate, and atmospheric processes for the benefit of all.



R. Bradley Pierce
SSEC Director



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Leadership

R. Bradley Pierce SSEC Director

Brad Pierce began serving as Director of SSEC at the University of Wisconsin–Madison in October 2018 following a nationwide search. His background includes more than 25 years as a scientist with the National Oceanic and Atmospheric Administration and NASA. Pierce is also a professor in the Department of Atmospheric and Oceanic Sciences.



Tristan L'Ecuyer CIMSS Director

Tristan L'Ecuyer began serving as Director of CIMSS in 2019. He is a professor in the Department of Atmospheric and Oceanic Sciences and brings more than 20 years of experience at the intersection of satellite remote sensing and climate science to the position.



SSEC's leadership also includes an executive director, administrative director, and associate directors for engineering and science. Their combined experience is guiding SSEC and CIMSS into the future.

Mark Mulligan Executive Director and Associate Director of Engineering

Chelsea Dahmen Administrative Director

Wayne Feltz Associate Director of Science

SSEC Advisory Council

The SSEC Advisory Council provides advice and guidance to SSEC leadership. Council members are elected by their peers or appointed by the SSEC director and represent a diversity of expertise from principal investigators, staff, faculty, and government scientists at UW–Madison.

SSEC Advisory Council members

Larissa Back
Professor - AOS Associate Chair of Graduate Studies
Designee

Tim Bertram
Professor - Chemistry
SSEC Director Appointee

Kyle Cranmer
Director - Data Science Institute
SSEC Director Appointee

Ankur Desai
Professor - AOS Chair
SSEC Director Appointee

Mark Kulie
Researcher - NOAA
SSEC Director Appointee

Mat Gunshor
Researcher - SSEC
Chairperson
Elected (PI)

Kathy Strabala
Assistant Scientist - SSEC
Elected (PI)

Jonathan Gero
Researcher - SSEC
Elected

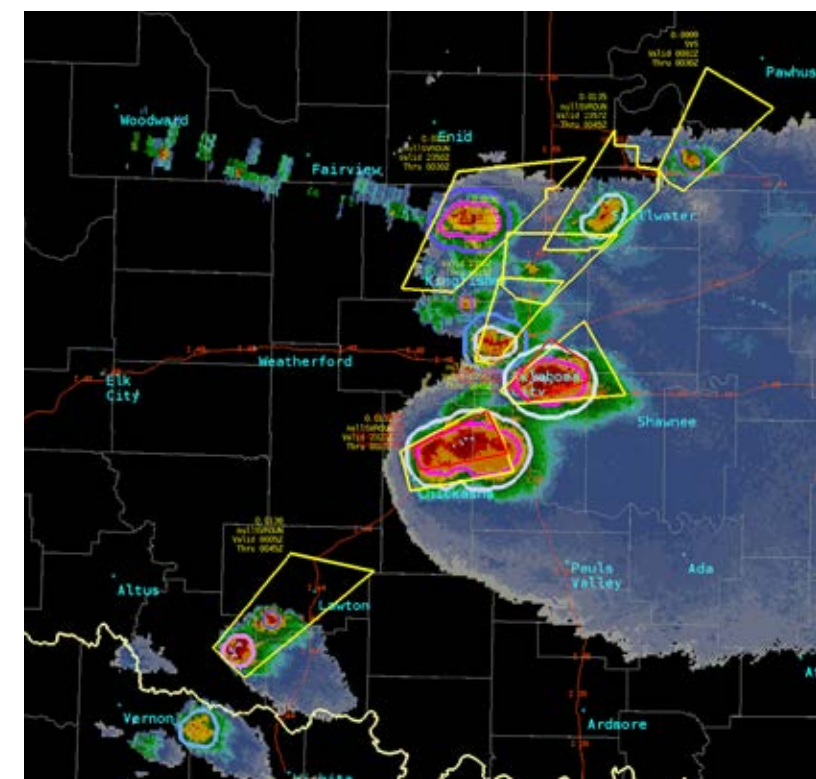
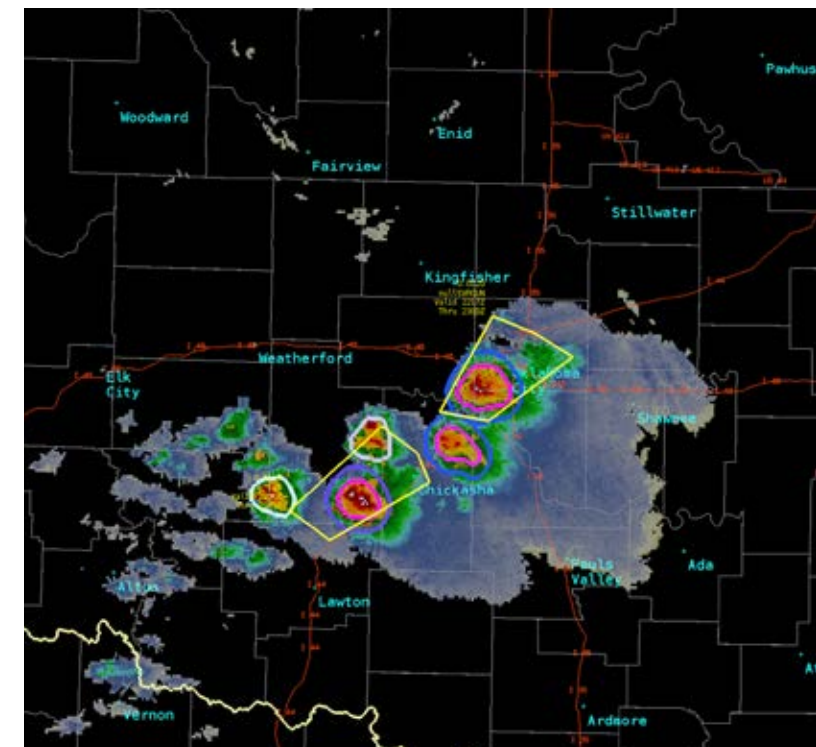
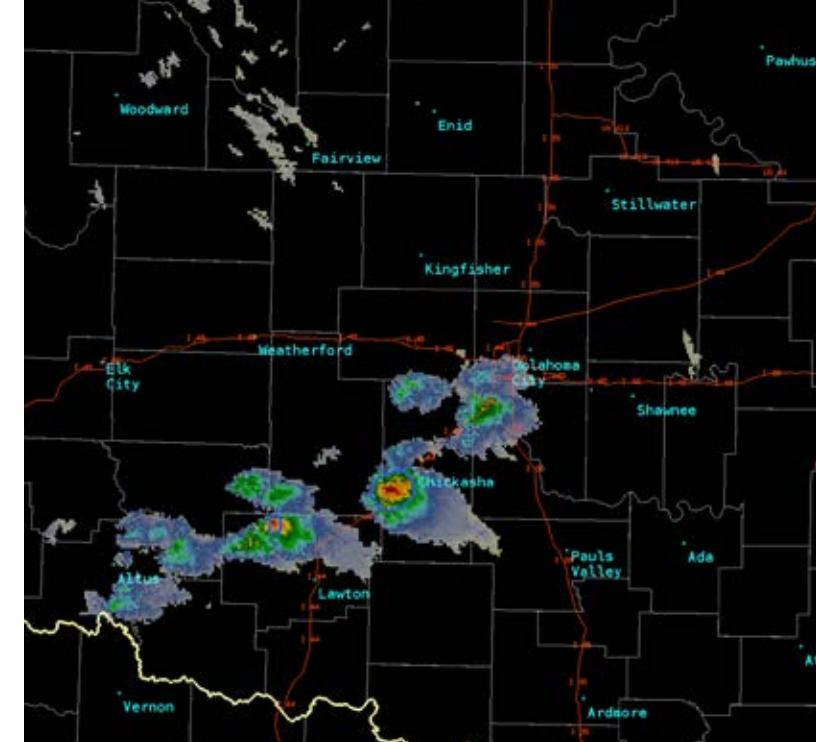
David Mikolajczyk
Researcher - SSEC
Elected

Angie Montgomery
Research Administrator - SSEC
Elected





Research to operations – advancing severe weather prediction



Next Generation Fire System

In 2023 smoke from Canadian wildfires blanketed large portions of the Midwest and Northeast, causing extremely poor air quality. Wildfires in the Western U.S. in 2021 burned millions of acres of land, with damages totaling more than \$11 billion.

SSEC is working with the National Oceanic and Atmospheric Administration to enhance the nation’s satellite-based fire detection and monitoring system. Satellite observations are critical to quickly identify new fires, particularly in areas where they are less likely to be noticed by people or cameras. SSEC has assembled a team of experts in fire research, DevOps, web development, software engineering, geographical information systems, and data science to create this streamlined approach.

The Next Generation Fire System, a future operational fire detection algorithm for NOAA

being developed at SSEC, uses a sensor-agnostic approach to be able to use observations from different satellite platforms. This allows NGFS to take advantage of the spatial resolution of polar sensors and the temporal resolution of geostationary sensors. And with the large amounts of satellite data available, the NGFS team is investigating machine learning techniques to predict which fires may experience extreme behavior.

In addition to processing and analyzing data, the project has been developing a prototype fire alerts dashboard to share information and imagery to help users to monitor fires throughout the U.S. in near real-time. These timely alerts will allow fire managers to make better decisions to help save lives and property.

Since 2020, meteorologists around the US have used the ProbSevere prediction model developed by SSEC, CIMSS, and National Oceanic and Atmospheric Administration scientists to forecast dangerous weather. The model helps to predict convective severe weather like tornadoes, lightning, hail, and wind gusts.

Improvements in ProbSevere have come through innovations in AI processing, allowing the model to incorporate more radar, satellite, lightning, and numerical weather prediction data. This additional information has led to earlier warnings for severe weather hazards.

“The increased real-time weather data has been shown to increase performance,” says John Cintineo, NOAA scientist. “Models like the ProbSevere LightningCast predict next-hour lightning, often before the first strike.”

During severe weather, it is these predictions — and the advanced warnings they can provide — that can help to make communities safer.



Inspiring the next generation of scientists

CIMSS has a long history of preparing the next generation of scientists by developing and sustaining workshops for high school students, as well as teachers. Since 1995 CIMSS has hosted students on the University of Wisconsin-Madison campus to experience research and technology through hands-on activities working directly with scientists, graduate students, and professors.

After developing a virtual Weather Camp in 2020, CIMSS revived its residential Earth Science workshop in 2023, with 20 high school students traveling from 12 states. Students learned from experts at SSEC, university departments, and the National Weather Service. Venturing off campus, the students visited a meteorologist at a local TV station and studied geologic formations at Devil's Lake State Park.

"Many of these students go on to select science for their majors and careers," says Margaret Mooney, former CIMSS education and public outreach director. "In this way, CIMSS helps maintain a critical pipeline to tomorrow's workforce."

Teachers too have a chance to engage with hands-on learning with weather and climate science, gaining information and resources to share in their classrooms. After successful workshops at the launch of GOES-R from Kennedy Space Center in 2016 and at Lockheed Martin for GOES-S in 2017, CIMSS returned to Kennedy Space Center for a teacher workshop during the launch of GOES-U in 2024. These teachers serve as a vital partner in supporting students to become future atmospheric scientists.



A commitment to student scholars

Each year, the Cooperative Institute for Meteorological Satellite Studies awards the Verner E. Suomi Scholarship to outstanding high school seniors who seek to study the physical sciences at a Universities of Wisconsin school.

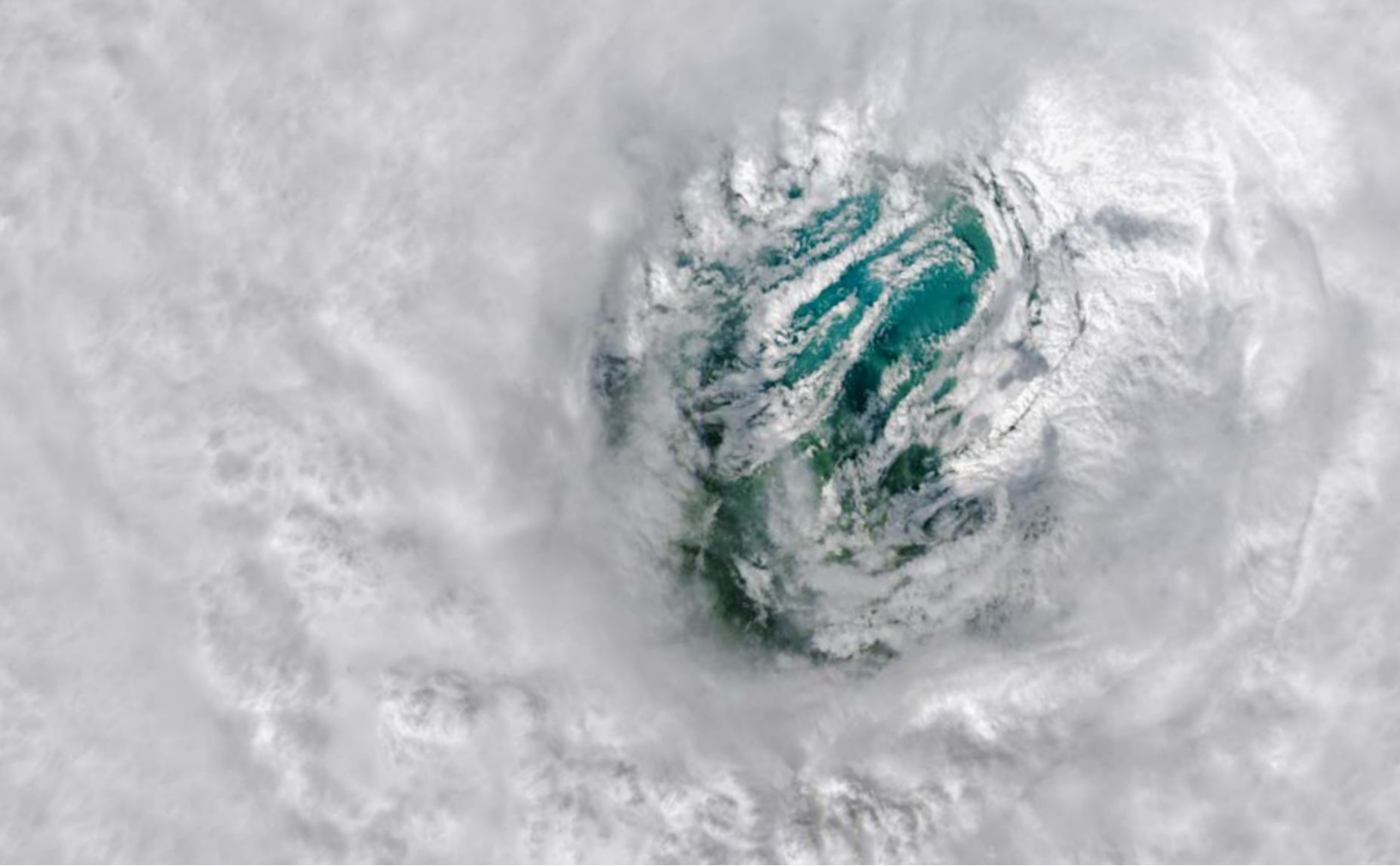
Over 25 years, CIMSS has awarded the scholarship to more than 35 high school students and continues its commitment to supporting the next generations of scientists.

The scholarship is named after the "father of satellite meteorology," Professor Verner Suomi, who founded SSEC and was passionate about teaching undergraduate students.

Scholarship recipients demonstrate

outstanding performance in the physical sciences through school and extracurricular achievements.

"Like Suomi, these students share a passion for the earth sciences and solving real problems that face our planet," says Tristan L'Ecuyer, director of CIMSS and chair of the Suomi Scholarship Committee. "They embrace the convictions of the next generation of change-makers to not only understand the physical environment but to use this knowledge to improve quality of life for all, including those most vulnerable to the effects of a changing climate."



Ancient Ice

From the Arctic to the Antarctic, and the latitudes between, glacial ice holds unlocked secrets to understanding regional and global climatology. Ice and rock core samples retrieved from these remote locations are essential for understanding the Earth's past, present, and future.

In 2000, the National Science Foundation selected SSEC to manage the U.S. Ice Drilling Program. Since then, SSEC engineers and U.S. scientists have been designing and deploying state-of-the-art ice and rock drills around the world to complete these crucial science missions.

In 2022, an expedition to the Quelccaya Ice Cap, located in the Andes Mountains in Peru, resulted in the successful coring and extraction of more than 900 kilograms (2000 pounds) of ice cores from the shrinking ice cap.

While operations in places like Greenland and Antarctica utilize an established infrastructure of logistical and mechanized transport, the Quelccaya expedition relied on a collective effort of scientists, engineers, community organizers, and Peruvians to successfully climb the 5,670 meter (18,600 ft.) ascent and safely return.

The following year in 2023, SSEC IDP members were essential in the drilling and extraction of the deepest bedrock core ever collected from the Greenland Ice Sheet, more than 516 meters (1,692 feet) below the glacier. These samples are informing researchers about the vulnerabilities of the Greenland Ice Sheet to human caused climate change and its resiliency to rising global temperatures.

Since 2000 the IDP team have completed more than 160 field campaigns.

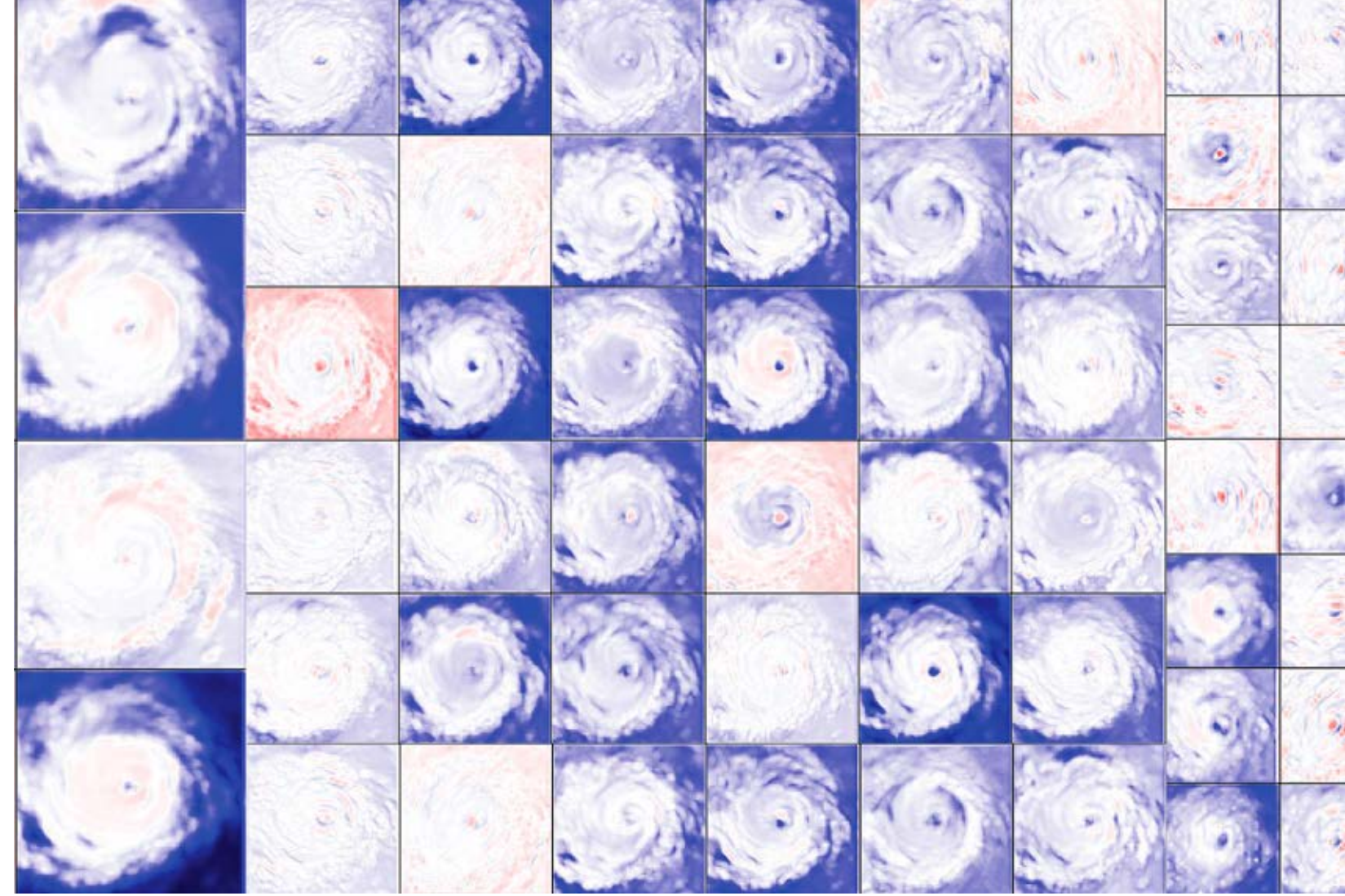
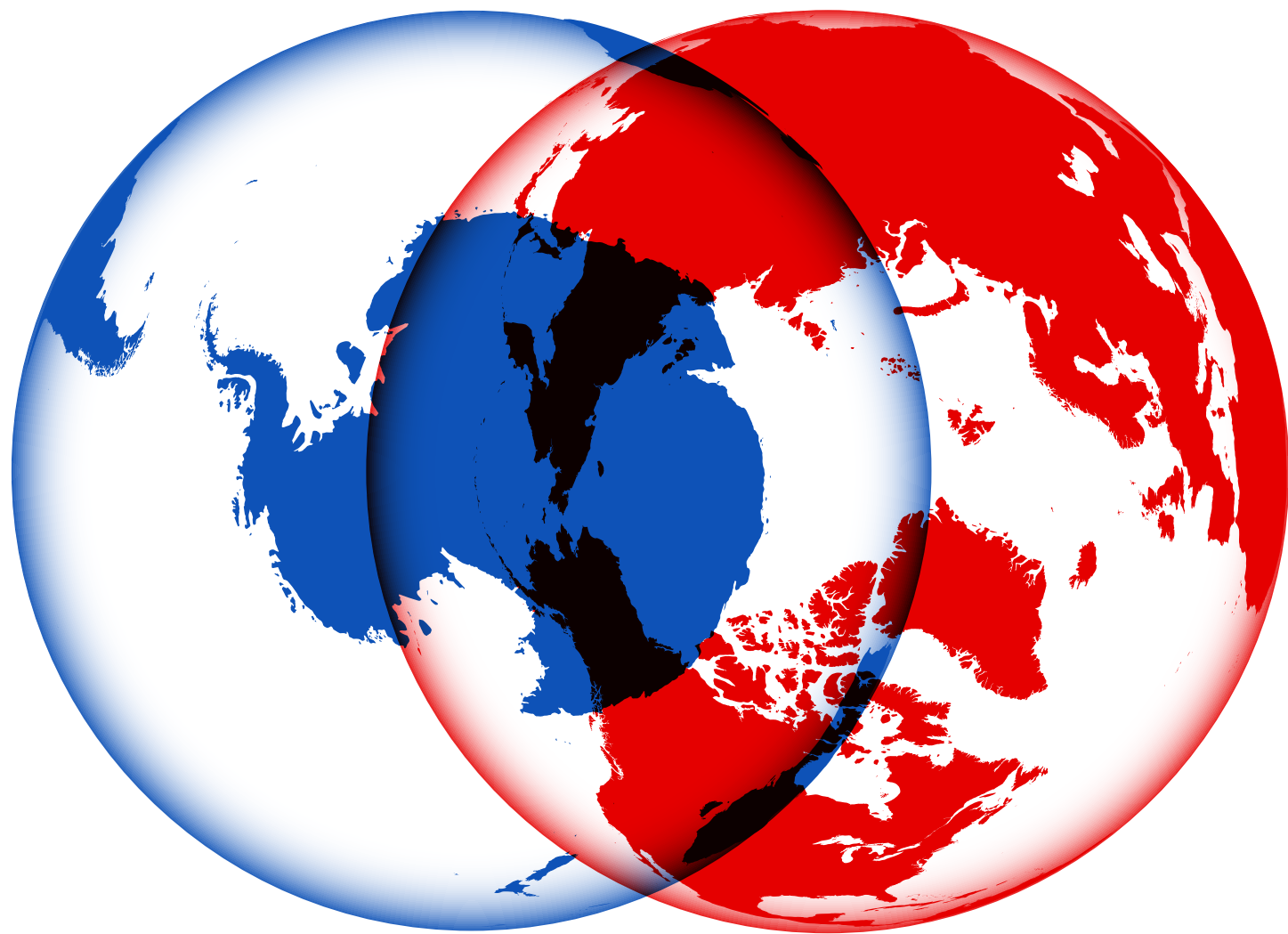
TROPICS

CIMSS researchers are gaining new insights into the structure and development of tropical cyclones as part of their involvement in the Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats mission. Focusing on observations in the microwave portion of the electromagnetic spectrum, TROPICS is a CubeSat mission funded by NASA.

Compared to traditional polar orbiting meteorological satellites, TROPICS CubeSats provide more overpasses — and more observations — over a targeted weather system such as a tropical cyclone. Data comes in every 90 minutes, instead of every 12 hours. CIMSS researchers can more closely track and monitor tropical cyclones as they evolve, noting changes in structure that correlate to changes in intensity. Observing rapid changes

in intensity are critical to accurate and timely forecasts, and particularly important for tropical cyclones that are likely to make landfall.

Following the launch of its four CubeSats in 2023, CIMSS researchers began applying their intensity estimation algorithms to TROPICS data, then validating with in situ measurements of Atlantic tropical cyclones from aircraft reconnaissance observations. Because CubeSats have a lifespan around 18 months, the team's goal is to share data with end users as quickly as possible. To disseminate these data and products for demonstrational purposes, CIMSS has developed a near real-time website to allow timely displays and access.



PREFIRE

The Arctic and Antarctic play vital roles in regulating Earth's temperature and moderating its climate. While these regions have been studied intensely, there remain gaps in our knowledge about how much energy escapes these regions each year.

The Polar Radiant Energy in the Far-Infrared Experiment fills that information gap through the use of two small CubeSat satellites collecting far-infrared and temporal data over the poles. Led by researchers at SSEC, CIMSS, the Jet Propulsion Laboratory, and NASA, the PREFIRE mission offers a pathway to improving polar climate predictions.

“Our planet is changing quickly, and in places like the Arctic, in ways that people have never experienced before,” says Tristan L'Ecuyer, CIMSS Director and PREFIRE principal investigator. “NASA's PREFIRE will give us new measurements of the far-infrared wavelengths being emitted from Earth's poles, which we can use to improve climate and weather models and help people around the world deal with the consequences of climate change.”

The PREFIRE satellites launched from New Zealand in May 2024 and are expected to operate for at least one year.

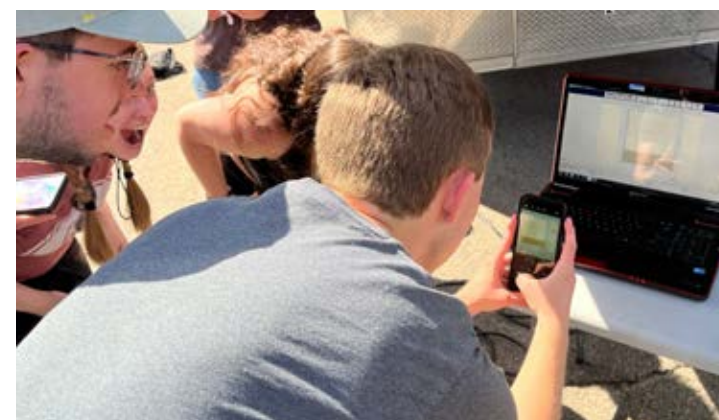
Advancing AI

As the fields of machine learning and AI rapidly advance, SSEC and CIMSS researchers are developing new ways to leverage AI models to support a variety of atmospheric research like cloud properties, tropical cyclones, severe weather, sea ice leads, climatology, and aviation turbulence.

The fields of satellite meteorology and atmospheric science provide an abundance of the necessary training data for machine learning and AI research. These automated approaches allow researchers to take advantage of large datasets more fully, particularly those that may have been under-utilized in the past, such as microwave imagery.

New AI models developed by SSEC and CIMSS scientists help track the development of tropical cyclones and determine maximum sustained winds. Convolutional neural network tools like D-MINT and D-PRINT can be used alongside well-established hurricane prediction methods to gain a more comprehensive look at a storm's development and to warn those in its path.

Through investments in next-generation computer hardware and infrastructure, SSEC and CIMSS researchers will continue leading the development of AI research to help improve weather forecasts and to save lives.



Field campaigns – Hands-on research for new scientists

While SSEC relies on satellites in the skies to study the Earth, we also develop instruments and infrastructure to collect data and in situ measurements in the field. Whether deploying instruments on aircraft or on the ground, our goals are to validate new satellite measurements and improve our understanding of atmospheric processes.

The SSEC Portable Atmospheric Research Center is a mobile research laboratory that has traveled across the continental US and completed more than 15 field campaigns since 2014. From rural countrysides to inner cities, the SPARC's suite of atmospheric instrumentation collects in-depth atmospheric profile data of wind, temperature, aerosols, water vapor, clouds, and solar radiation.

Beginning in 2021 the SPARC joined the

National Science Foundation Community Instruments and Facilities program to expand SPARC's reach and opportunities for young scientists to gain hands-on experience with field work and instrumentation. The CIF program allows researchers from external institutions to apply and use the SPARC's unique instruments in new field experiments, including studying eclipse totality, urban climate and cloud processes, and lake breeze circulation over the Great Lakes.

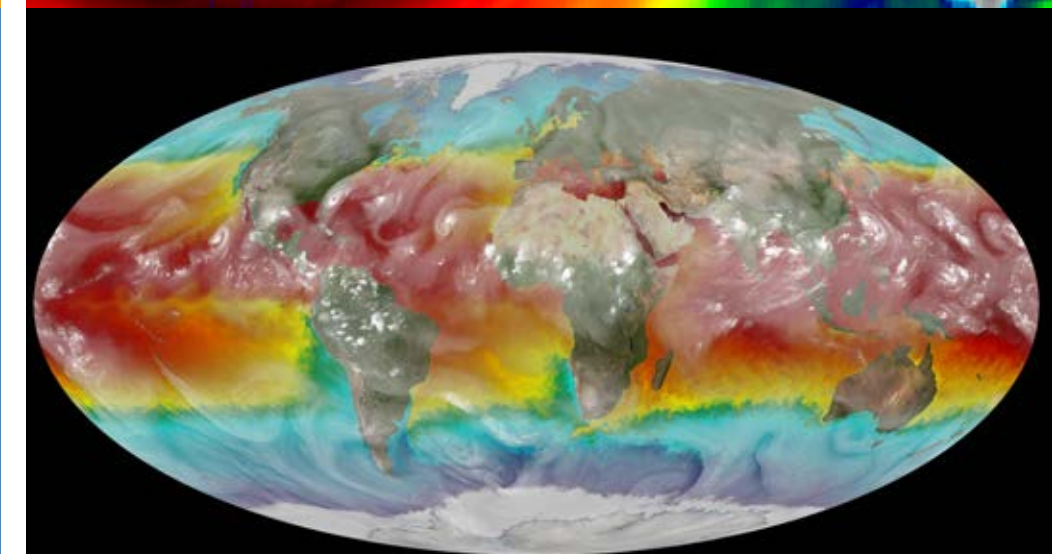
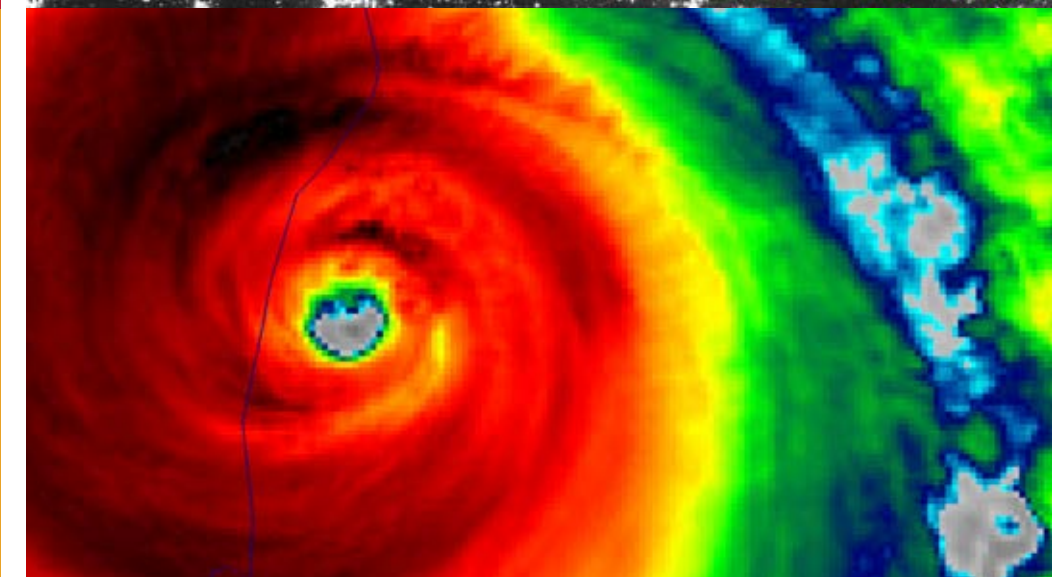
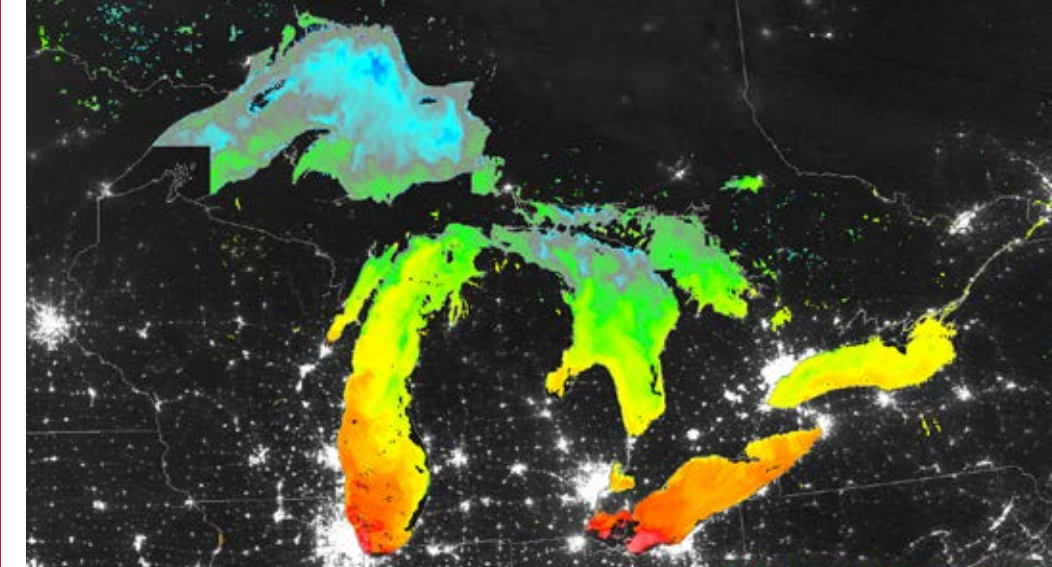
Field work has been at the core of SSEC research since its founding more than 50 years ago. Continuing that tradition SSEC researchers and engineers have spanned the globe to collect real-time data in remote locations like Antarctica, Greenland, New Zealand and beyond.

3.8
petabytes
archived
weather data

740
blogposts for
analysis and
training

208
research projects
managed
2022-2023

25.2
million
SSEC and CIMSS
web visits

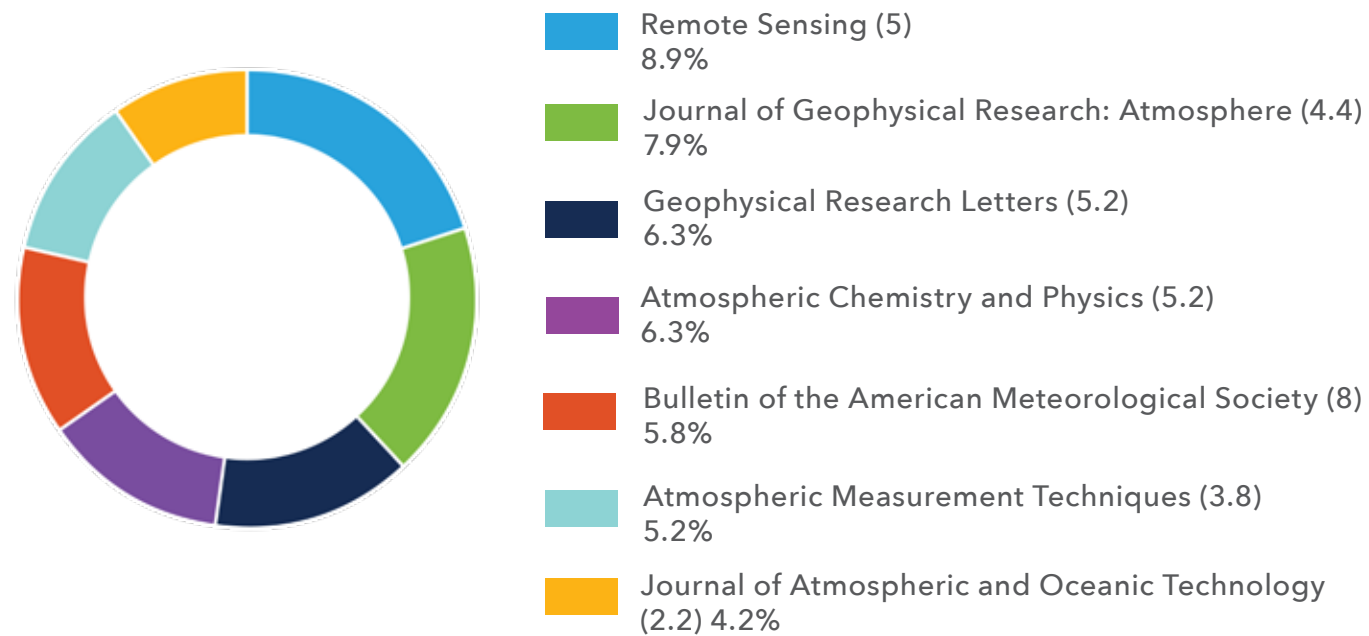


Publications

2022-2023



Top 7 journals (2-year Journal Impact Factor)



Highly cited articles

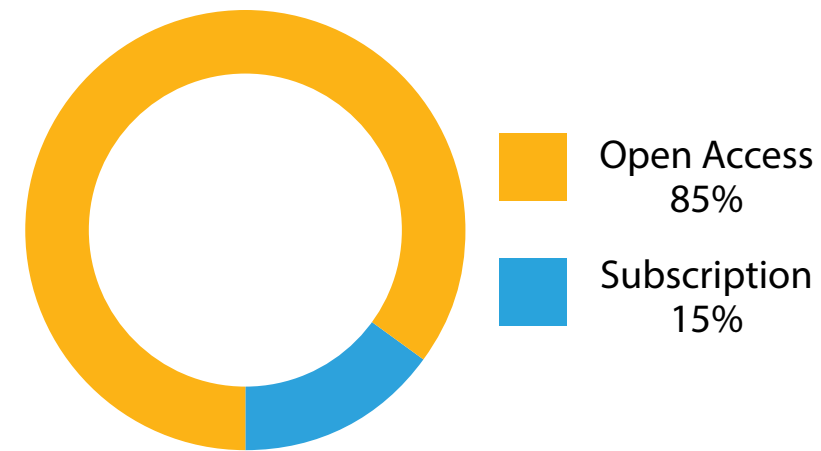
Otkin, J. A., and Coauthors, 2022: Getting ahead of flash drought: From early warning to early action. *Bulletin of the American Meteorological Society*, 103, 10, 2188-2202, <https://doi.org/10.1175/BAMS-D-21-0288.1>.

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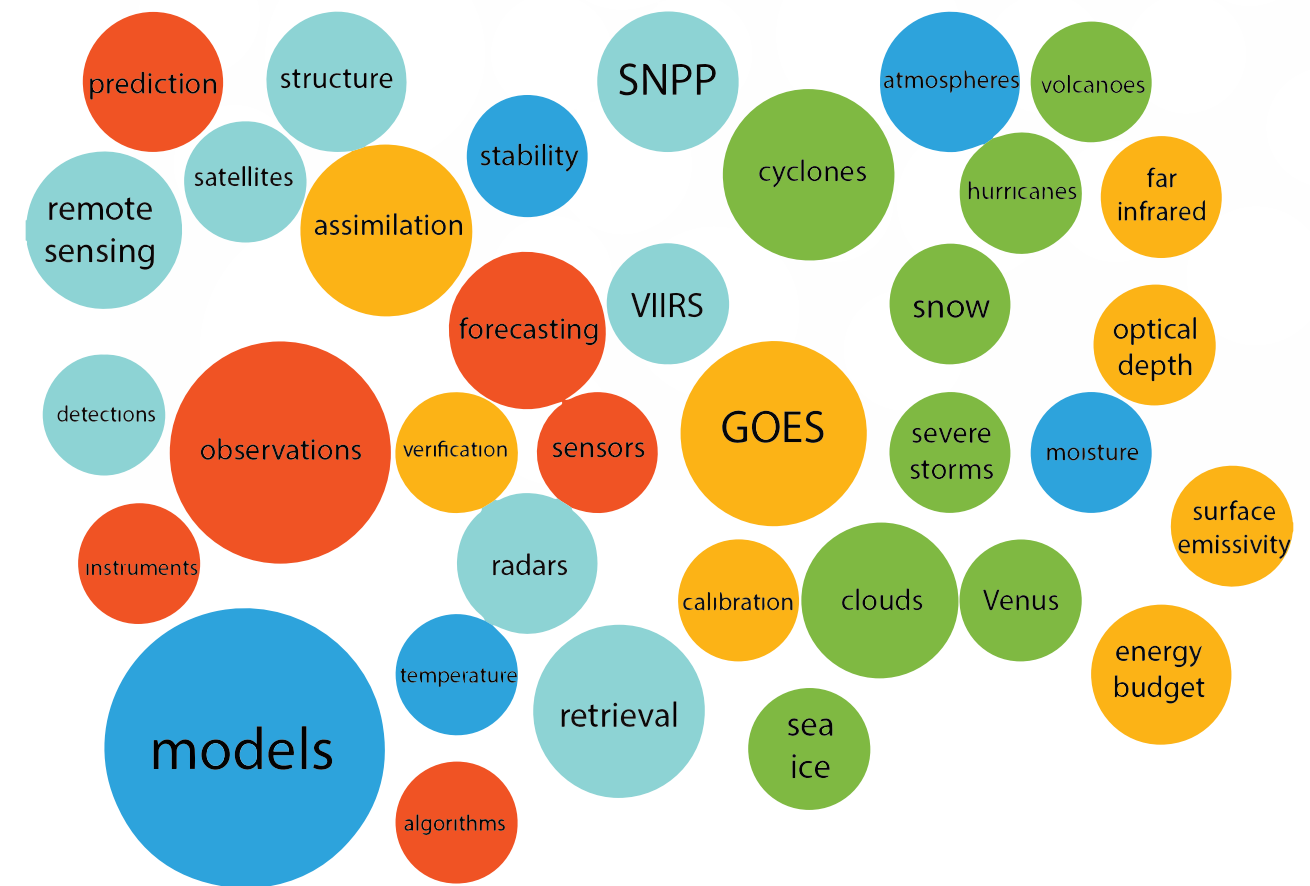
189

Journal articles published

60

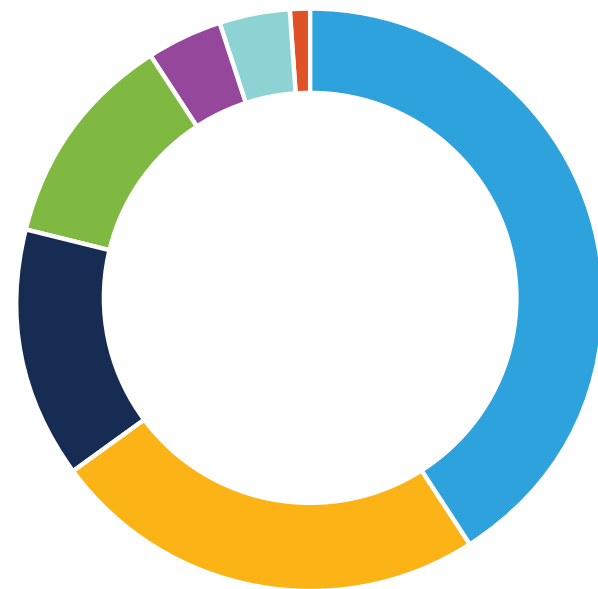
Total journals

Research topics keyword frequency

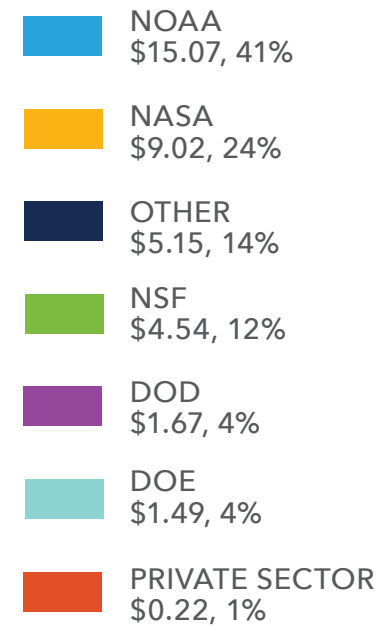


Spending

SSEC 2023 Spending by source (in millions)



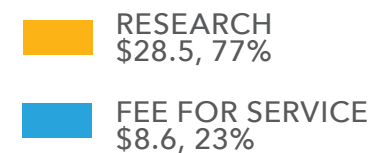
Total spending
\$37.2M



SSEC 2023 Spending by Research & Fee for service (in millions)



Total spending
\$37.2M



Partners and Collaborators

SSEC has built key research and education partnerships with federal agencies as well as departments and centers across the University of Wisconsin–Madison campus and beyond. With our partners we are working towards understanding Earth-atmosphere processes to improve society’s resilience to hazardous weather and climate events.

Federal Partners

National Aeronautics and Space Administration (NASA)

- Earth Science
- Planetary Science

Department of Commerce (DOC)

National Oceanic and Atmospheric Administration (NOAA)

- National Environmental Satellite, Data, and Information Service (NESDIS)
- Center for Satellite Applications and Research (STAR)
- National Severe Storms Laboratory (NSSL)
- NOAA Cooperative Institutes

National Science Foundation (NSF)

- Office of Polar Programs

Department of Energy (DOE)

- Office of Science
- Atmospheric Radiation Measurement (ARM) user facility

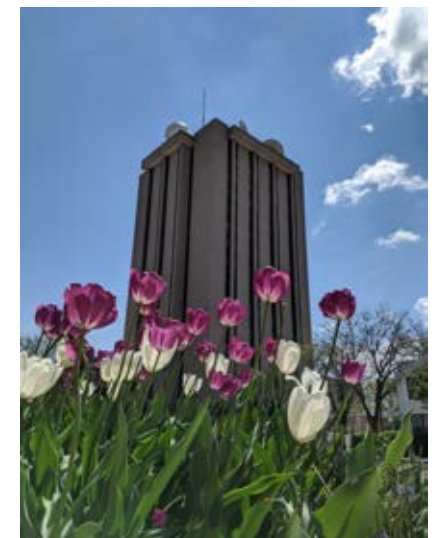
Department of Defense (DOD)

- Office of Naval Research
- Air Force

University of Wisconsin-Madison Campus Partners

- College of Letters and Science (L&S)
- Department of Atmospheric and Oceanic Sciences
- Department of Astronomy
- Department of Chemistry
- Department of Geoscience
- Center for Limnology
- Data Science Institute powered by American Family Insurance
- Nelson Institute for Environmental Studies
- Center for Climatic Research (CCR)

- Center for Sustainability and the Global Environment (SAGE)
- Aquatic Sciences Center
- Energy Analysis and Policy Program
- Office of the Vice Chancellor for Research (OVCR)
- Physical Sciences Laboratory (PSL)
- College of Engineering (COE)
- Department of Civil and Environmental Engineering



Awards

2023

Lori Borg

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Dan DeSlover

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Mike Foster

NOAA-CIMSS Collaboration Award

Mat Gunshor

NOAA-CIMSS Collaboration Award

Robert Knuteson

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Zhenglong Li

NOAA-CIMSS Collaboration Award

Michelle Loveless

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Aronne Merrelli

NOAA-CIMSS Collaboration Award

Nate Miller

NOAA-CIMSS Collaboration Award

Chris Moeller

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Kyle Obremski

1st place graduate poster presentation at the NOAA Corp Symposium

Hank Revercomb

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Tim Schmit (NOAA)

NASA Goddard Group award: GeoXO Program Science Working Groups

William Straka

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Joe Taylor

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Dave Tobin

NASA Robert H. Goddard Exceptional Achievement for Science Awards

Andi Walther

NOAA-CIMSS Collaboration Award

2022

Callyn Bloch

2nd place poster presentation in the Joint Conference Student Competition at the AMS Annual Meeting

Danica Fliss

1st place Outstanding Poster Presentation at the 25th Conference on Satellite Meteorology, Oceanography, and Climatology

Mat Gunshor

UW-Madison 2022 Cool Science Image Contest winner

Andy Heidinger (NOAA)

NOAA Administrator's Award

NOAA Bronze Medal Award

NASA Goddard Group Achievement Award

Jeff Key (NOAA)

NOAA Silver Sherman Award

Jim Nelson

UW-Madison 2022 Cool Science Image Contest winner

Stephanie Ortlund

1st place oral presentation at the NOAA Corp Symposium

Tim Schmit (NOAA)

NOAA Bronze Medal Award

NASA Goddard Group Achievement Award

UW-Madison 2022 Cool Science Image Contest winner

Jongjin Seo

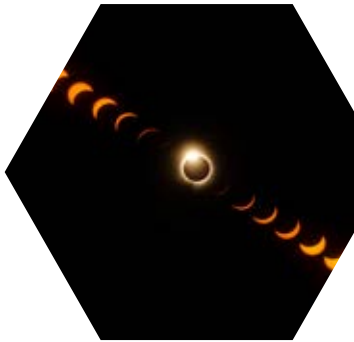
2nd place Outstanding Poster Presentation at the 25th Conference on Satellite Meteorology, Oceanography, and Climatology

William Smith

Gold Medal of the International Radiation Commission

William Straka

JPSS Unseen Hero Award





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Lindsay Giovanonne

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Give to SSEC

There are many ways to support SSEC and CIMSS. Gifts benefit our areas of greatest need and strengthen our areas of greatest opportunity. Targeted giving through the University of Wisconsin Foundation allows you to direct your contribution to a specific program.

To give please visit: ssec.wisc.edu/give

For more information on making a gift to SSEC or CIMSS, please contact:

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SSEC Administrative Director
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SSEC Director
608.890.1892



