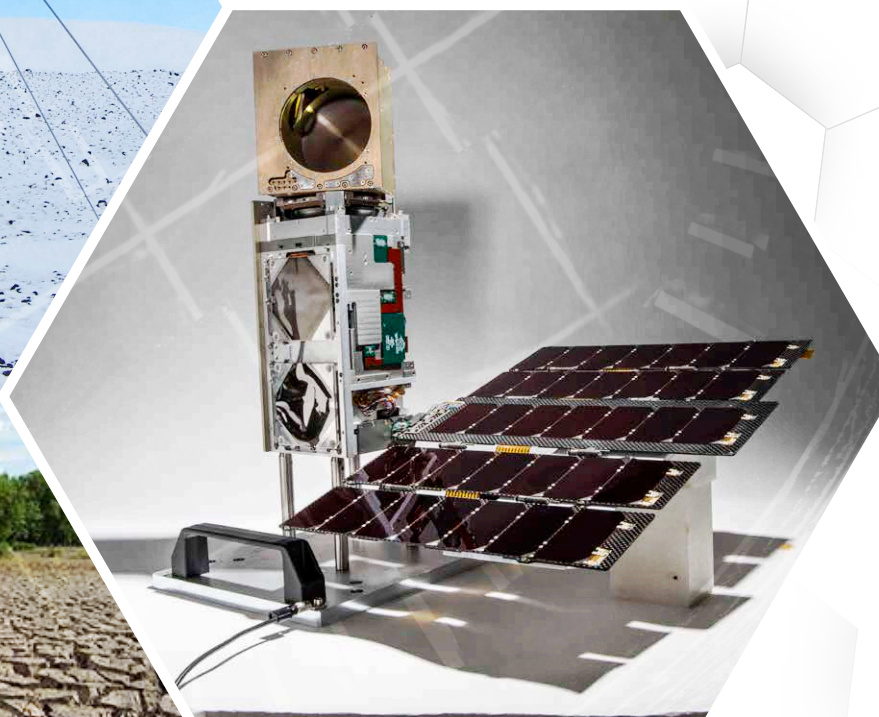
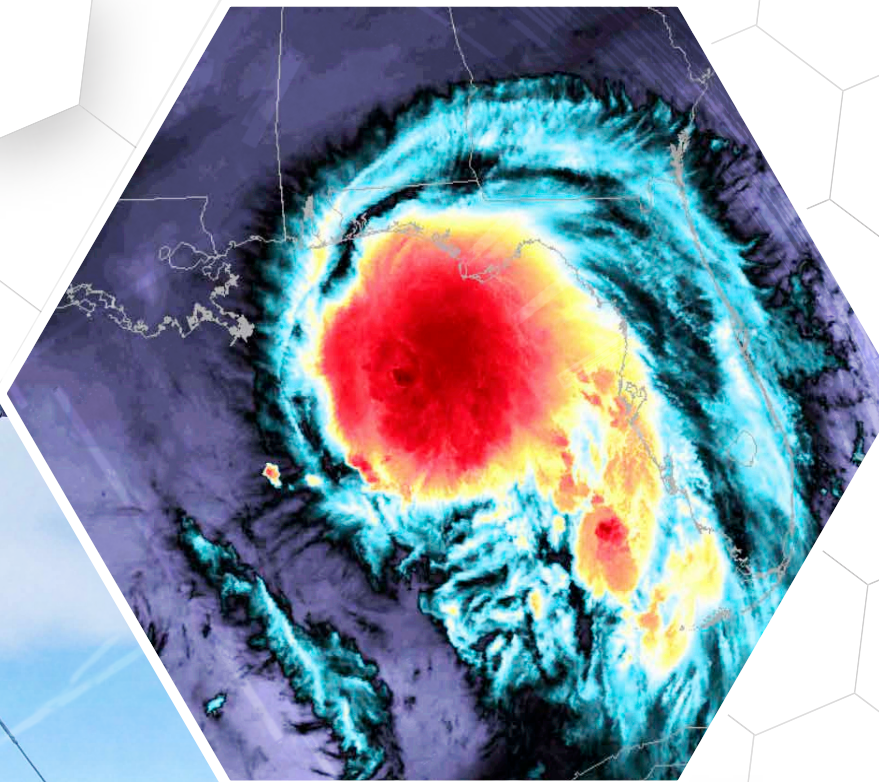


SSEC

Space Science and Engineering Center
University of Wisconsin-Madison

Biennial Report
2020-2021



From the director

Idea. Invest. Innovate.

Universities are incubators of new ideas. With the right investment, these ideas are realized as real-world innovations that improve, and save, people's lives.

From our earliest beginnings, SSEC and CIMSS have been testbeds for basic and applied science research in environmental remote sensing; testing and refining ideas until they mature.

Central to the success of that research has been federal government investment and partnership.

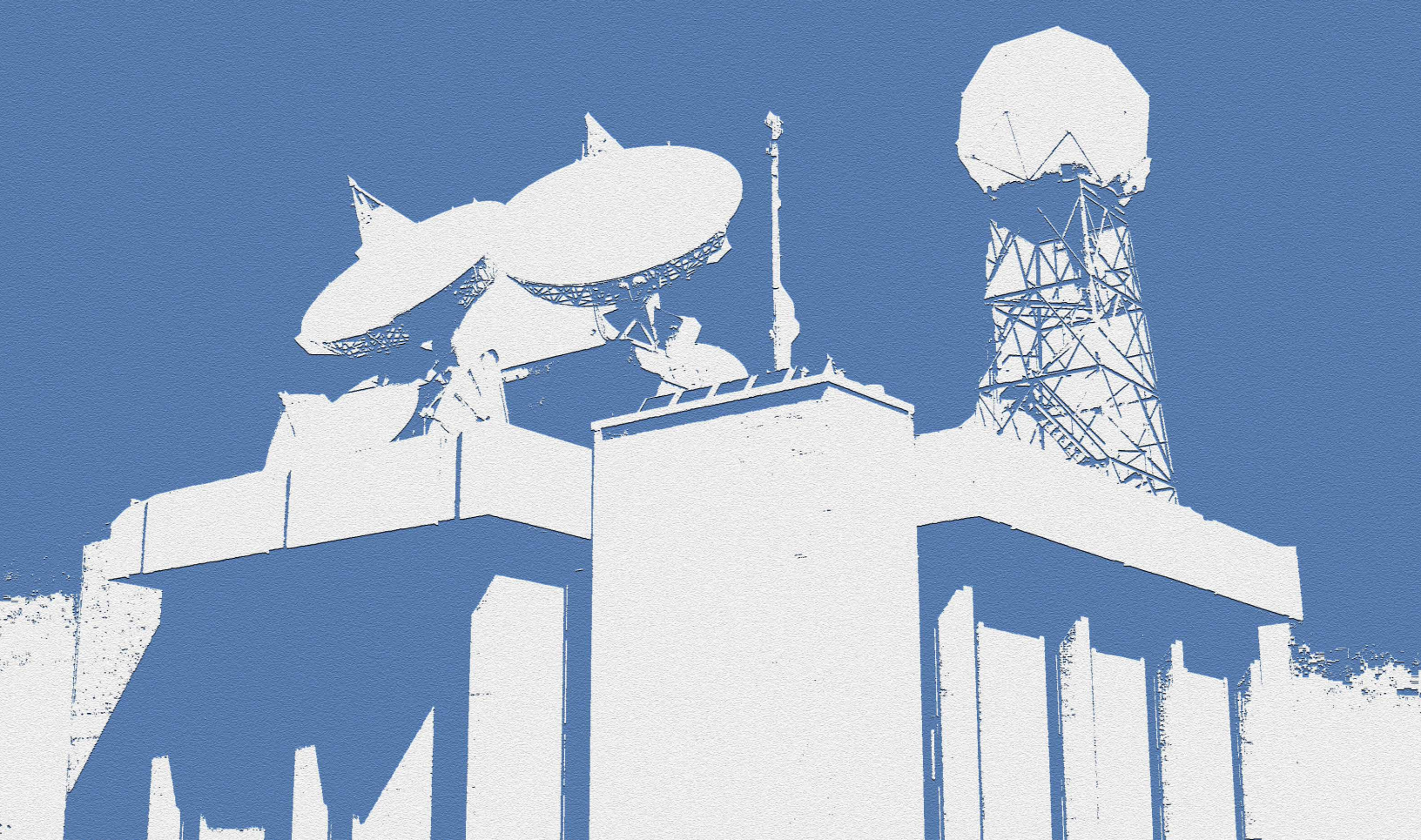
New instruments designed to gather atmospheric data – like the CubeSats for the PREFIRE and TROPICS experiments – have evolved over decades and are now ready to deliver crucial and timely information about Earth's climate and weather. The investment in research for these two programs came largely from NASA, but similar support from our partner agencies like NOAA and NSF enables the research highlighted in this report.

Innovation builds on earlier research to push the field forward. Sustained investment in research at SSEC and CIMSS from our federal partners demonstrates our shared commitment to improving understanding of weather, climate and atmospheric processes for the benefit of all.



R. Bradley Pierce
SSEC Director

Research highlights	04
SSEC2022	14
Publications	17
Partners and collaborators	22
Leadership	23
SSEC Advisory Council	24
SSEC by the numbers	25
Spending	26
Awards	28
Credits	30
Give	31



Preserving data to unlock climate changes



40 years and counting, NOAA renews partnership with UW

For more than 40 years, the National Oceanic and Atmospheric Administration has partnered with the University of Wisconsin–Madison to conduct critical research in satellite meteorology through its Cooperative Institute for Meteorological Satellite Studies.

In May 2020, NOAA announced that CIMSS will continue at UW–Madison for the next five years, recognizing the strength and value of their collaboration. The award brings up to \$150 million to the institute.

CIMSS is recognized internationally for its satellite expertise, spanning geostationary and polar-orbiting platforms. This network of satellites forms the backbone of a global observing system developed to monitor our planet and ensure public safety.

Collaborating with NOAA scientists based at CIMSS, university researchers are helping design and demonstrate new satellite sensor technologies, develop products and data applications, and transition research into operational forecast models that benefit the public.

From developing better ways to detect and forecast severe weather to improving analyses of environmental and climate trends, CIMSS scientists are providing crucial information to decision makers at the city, state and national levels.

Four decades of collaboration have resulted in significant scientific achievements as CIMSS and NOAA staff have transformed the field of satellite meteorology.

Like the Arctic, changes in Antarctica's climate can be an indicator of much larger shifts in the Earth's climate.

The Antarctic Meteorological Research and Data Center is building a data hub to serve the global Antarctic research community as it studies those changes. The AMRDC is a collaboration between the University of Wisconsin–Madison Space Science and Engineering Center and Madison College that is funded by the National Science Foundation.

The AMRDC repository will enable discovery, sharing and preservation of open meteorological data collected in Antarctica. SSEC has amassed more than 40 years of data from weather stations, satellite sensors and other observational data that will support novel, longitudinal research into Antarctica's changing climate. External organizations will be invited to deposit datasets for long-term archiving.

Beyond establishing the repository, program scientists will conduct climate-related research and provide meaningful research experiences for undergraduates, a cornerstone of the UW and NSF's mission.





New opportunities for mobile atmospheric research lab

In 2021, the Space Science and Engineering Center Portable Atmospheric Research Center, or SPARC, became part of the National Science Foundation Community Instruments and Facilities Program.

Its incorporation into the CIF program will allow researchers from external institutions to apply to use the SPARC's unique instruments in new field experiments, expanding the facility's utility and reach within the atmospheric science community.

The SPARC vehicle is outfitted with a suite of instruments to make ground-based atmospheric measurements in high-resolution. The instruments include the Atmospheric Emitted Radiance Interferometer, the High Spectral Resolution Lidar, a Surface Meteorology

station, a WindPro lidar system and a radiosonde receiving station. Also included in the CIF program is SPARC's sister facility, the SPARClet, which is a portable container capable of operating aboard seafaring research vessels.

Since its inaugural deployment in 2014, the SPARC has traversed the U.S. to support large-scale field campaigns and solo expeditions. The real-time, precision measurements from SPARC's instruments are leading to better understanding of atmospheric conditions that underpin severe weather forecasts, such as those that track development of damaging thunderstorms over the U.S. Great Plains, and climate studies.



Sneak preview of TROPICS mission with rare pathfinder launch

Space Science and Engineering Center researchers leading UW-Madison's involvement in the Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS) investigation are getting a sneak preview of their mission to study hurricane development. NASA, with help from SpaceX, launched an engineering model version of the satellite instrument on June 30, 2021. TROPICS is one of the first CubeSat missions funded by NASA.

Part of what makes the mission so novel is what also makes it possible – in particular, being able to reduce the spacecraft down to the size of a shoebox. The satellite instrument makes observations in the microwave – frequencies that are new and unique to this

mission – that allow for a much smaller signal receiving dish on the satellite. The pathfinder launch enables the team to test their observational and data processing approach.

TROPICS researchers will use the data to examine tropical cyclone warm cores. Understanding their characteristics and impacts on storm evolution will improve hurricane intensity and track forecasting.

Leveraging SSEC's infrastructure and expertise, the TROPICS Data Processing Center handles processing and reprocessing of all data – coordinating with the ground system and archive providers.

The six satellites of the main TROPICS mission will launch in 2022 – bringing new data and understanding of tropical cyclones to improve forecasts, saving lives and property.

PREFIRE CubeSat mission over poles fills missing data

The Arctic and Antarctic are important for regulating Earth's temperature. They respond to warming with glacial melt; resulting in sea level rise, shifts in mid-latitude weather patterns and changes in global temperatures – all harbingers of broader climate change.

To learn more, NASA partnered with the Space Science and Engineering Center on a mission called the Polar Radiant Energy in the Far-Infrared Experiment. While 60 percent of radiation emitted into space over the Arctic is in the far-infrared region – and despite 50 years of satellite observations – scientists have little understanding of the processes that affect this key component of the polar energy budget. PREFIRE will address these missing data and help scientists better understand how the Arctic regions regulate Earth's temperature and climate.

Scheduled for launch in December 2022, two small CubeSats will carry a Thermal Infrared Sensor, or TIRS detector, to measure emissivities at various frequencies in the far-IR, with a focus on a range of 5–54 micrometers in wavelength. By filling the far-infrared observation gap and integrating these new observations into models, PREFIRE offers a pathway to improving polar climate predictions.



Identifying flash drought intensity

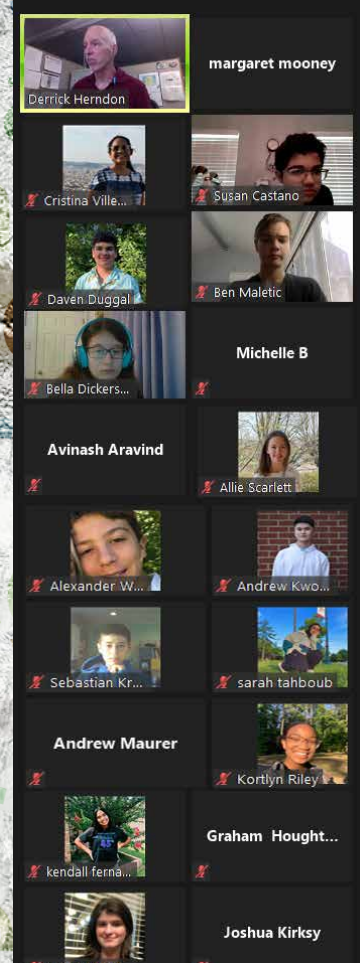
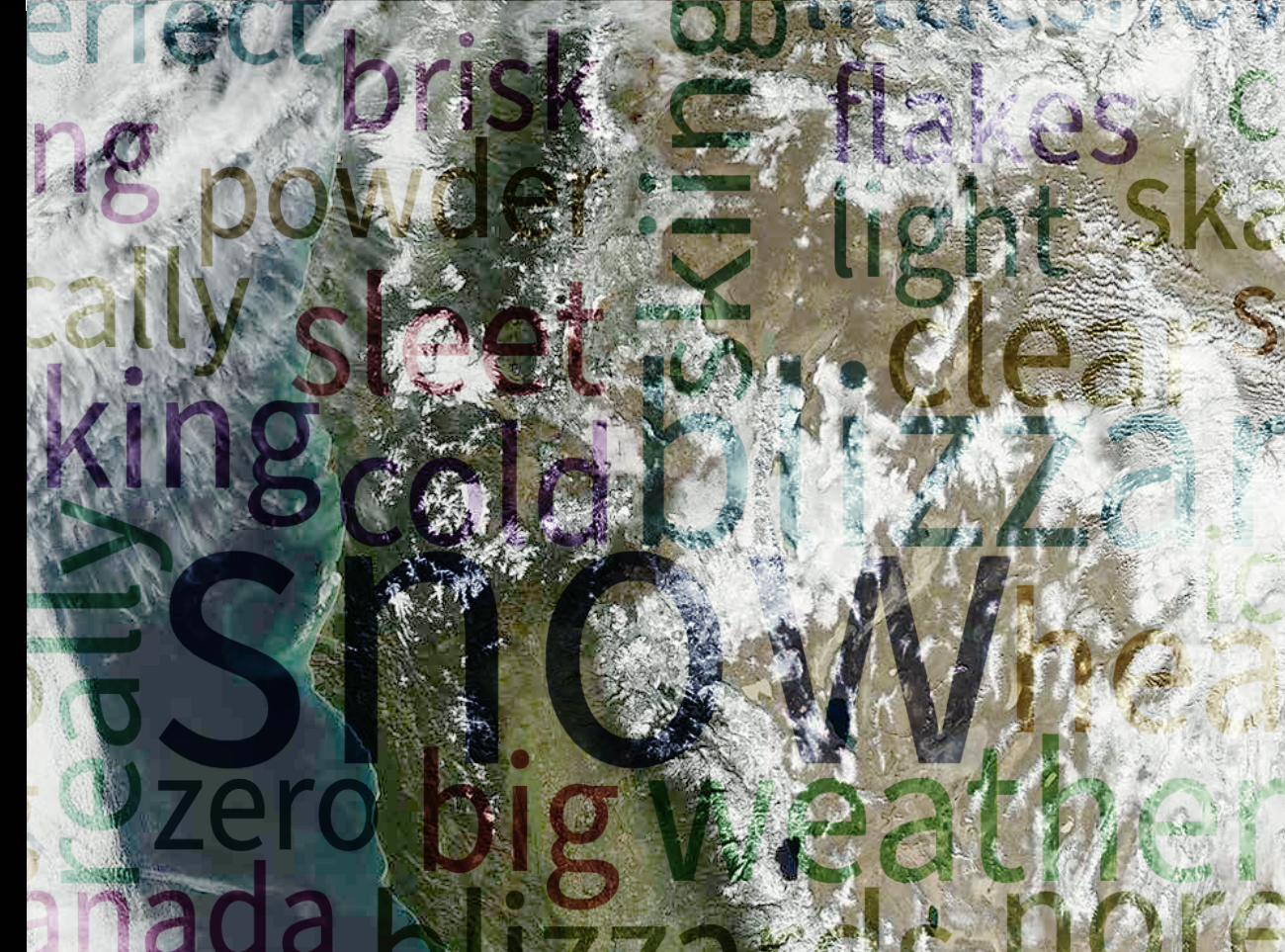
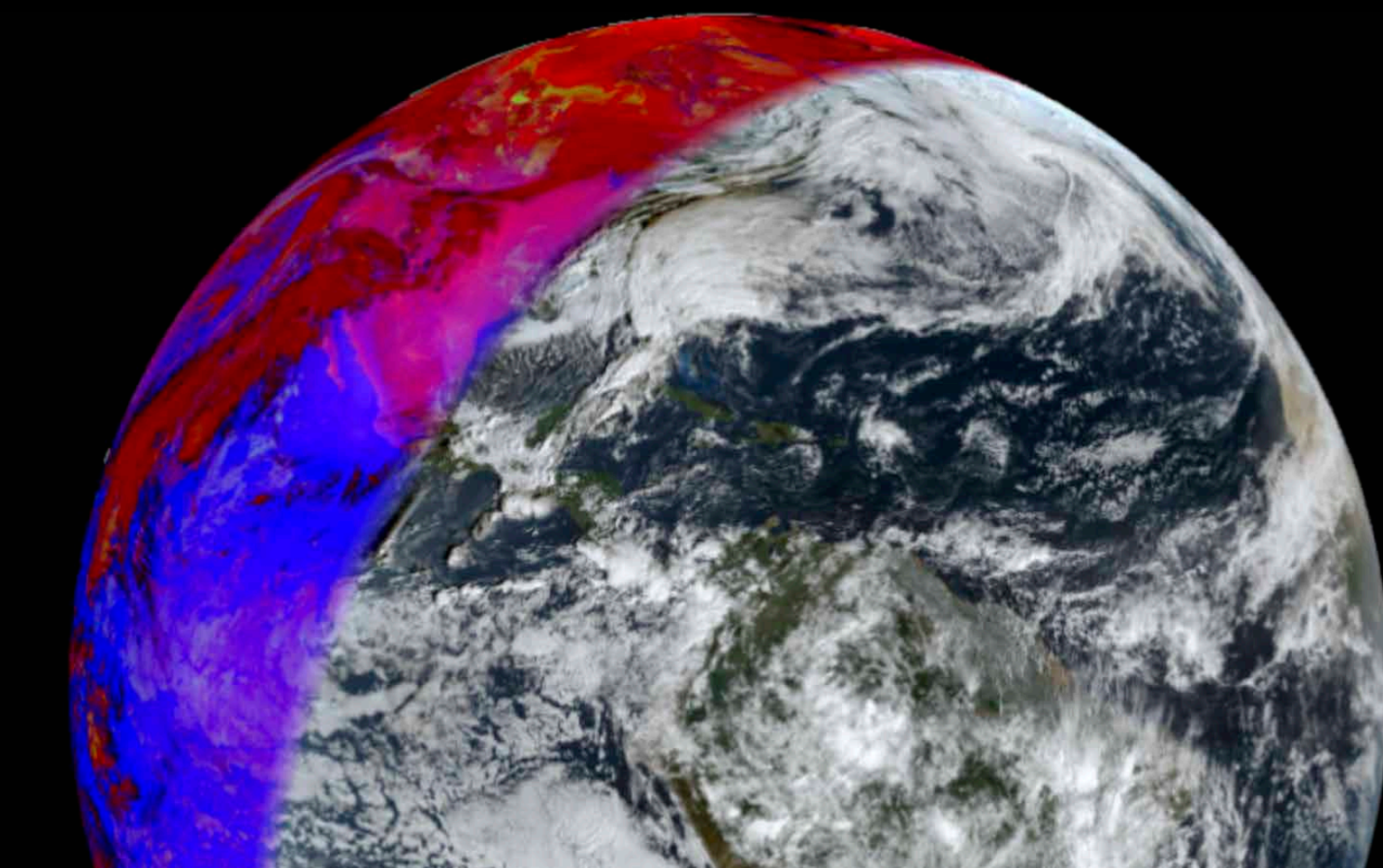
Dry weather compounded by hot temperatures can lead to drought. However, not all droughts follow the same pattern as they develop. Some, like flash drought, emerge rapidly and can have severe consequences depending on how long they last.

A new flash drought intensity index developed at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies, in partnership with researchers at NASA, the National Science Foundation, the Northern Australia Climate Program and the University of Southern Queensland, aims to clarify what a flash drought is and to quantify its severity. The new index considers how rapidly a drought intensifies as well as whether that intensification is followed by a prolonged period of drought.

The model is based on soil moisture data and characterizes land-surface interactions, or how much moisture has evaporated from the soil due to warming conditions.

While drought is a natural feature in Earth's climate, longer term drought can lead to devastating crop and livestock losses as well as increased wildfires, such as those that ravaged the Western United States and Pacific Northwest in 2021.

The new drought intensity index will provide critical information on changing conditions, such as reduced water supply, so that those most affected by drought can mitigate its costly — and deadly — impacts.



Leveraging cloud services to distribute satellite data

Alongside NASA and the National Oceanic and Atmospheric Administration, the University of Wisconsin–Madison Space Science and Engineering Center is piloting a new approach to satellite data acquisition, processing and distribution through the development of cloud services. The goal is to make data from weather satellites like GOES-16 and -17 more readily available and easier to access via the cloud so that users can improve weather forecasts where every minute matters.

SSEC’s initiative has transitioned open-source software that was developed under the Community Satellite Processing Package to a cloud-based operation. Launched in 2021, the GeoSphere website is built on the CSPP

platform and permits free access to near real-time data and imagery from the GOES-16 Advanced Baseline Imager. This shift in data delivery allows users to display imagery almost as soon as it is captured – as quickly as two minutes for mesoscale images and five minutes for full-disk images.

Future enhancements to the CSPP GeoSphere site include adding GOES-17 imagery and improving coverage of the Western U.S. and Pacific Ocean. These cloud-oriented techniques will inform the approach to algorithm development, data processing and product distribution in the GeoXO era that will usher in greater and more usable information to address Earth’s environmental challenges.

Weather Camp inspires next generation of scientists

Developing a weather camp for high school students during a pandemic calls for creativity. Previous in-person field trips, including visits to a National Weather Service field office and a local TV station, had to be canceled, and a new virtual approach was needed. This brings advantages by helping to expand the reach of the program, making it accessible to more students across the U.S.

In June 2021, 42 high school students from more than 30 states, including Alaska and Puerto Rico, attended a one-week online Weather Camp hosted by the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies. The agenda included an introduction to meteorology and

remote sensing, as well as topics such as climate change, winter storms and tropical cyclones. By the end of the week students were ready for a forecast challenge and gave presentations to share what they had learned.

Each day also featured a “Weather Jobs Guest Speaker,” providing a glimpse of what students might expect of a career in the atmospheric sciences. Some day one of them may be an undergraduate or graduate student at the UW–Madison or land a job at CIMSS. They would not be the first camp alumni to do so. And with our continued successful outreach, they won’t be the last.



Solving real world problems through mentorship

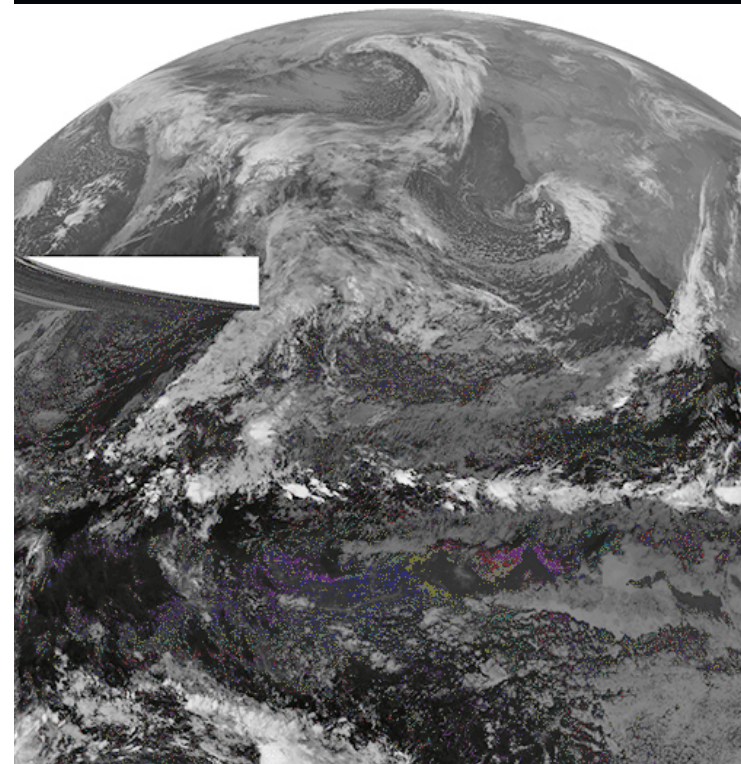
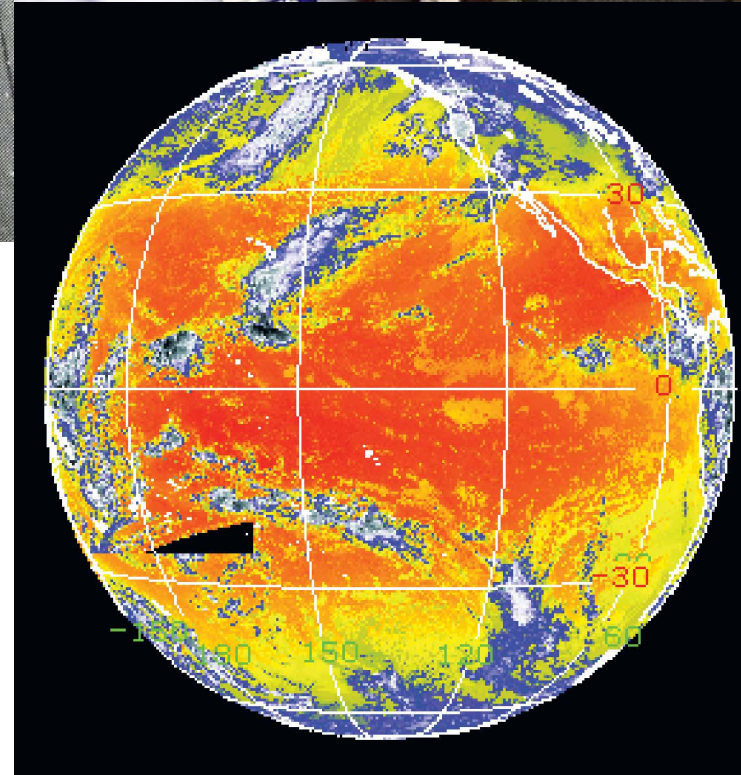
Experiential learning opportunities in science are crucial for graduate students as they gain expertise in their fields.

To support this approach to learning, the NOAA Experiential Research and Training Opportunities internship provides funding for research fellows to work alongside a NOAA scientist. Graduate students gain hands-on experience designing and completing a research project that fits within NOAA's mission.

In 2021, Ronald Adomako, a master's student from City College of New York in the Center for Earth System Sciences and Remote Sensing Technologies, completed a 12-week internship with NOAA scientist Tim Schmit, who is based at the University of Wisconsin-Madison Cooperative Institute for Meteorological Satellite Studies.

Adomako's project involved automating the identification of "shark fins," so called because of their shape, in GOES-16 and -17 Advanced Baseline Imager data using machine learning. Shark fins are errors that emerge due to a processing anomaly. Adomako's tool will eventually be able to detect these artifacts without human intervention and help fix the anomalies.

Adomako and Schmit intend to publish about their collaboration. Schmit is also encouraging Adomako to teach other CIMSS researchers about the benefits of the shark fin detection tool so that they can adapt the technique to identify and predict other types of artifacts in satellite data.



A commitment to student scholars

Three exemplary high school seniors were awarded the UW-Madison Cooperative Institute for Meteorological Satellite Studies Verner E. Suomi Scholarship for the 2021-2022 academic year.

They are: Emily Sautebin from Marshfield, Wisconsin, Hollyn Gaffner from Aledo, Texas, and Ikhbayar Khurelbaatar from Ulaanbaatar, Mongolia. While their hometowns may be scattered around the globe, all three students are freshmen at the University of Wisconsin-Madison and united in their pursuit to study environmental sciences.

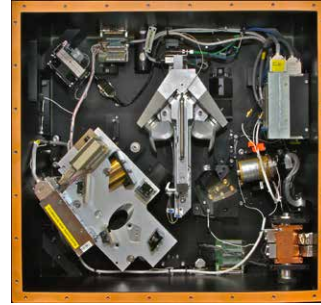
The scholarship is named after the "father of satellite meteorology," Professor Verner Suomi, who was passionate about teaching

undergraduate students. Scholarship recipients demonstrate outstanding performance in the physical sciences through school and extracurricular achievements.

"Like Suomi, Emily, Hollyn and Ikhbayar 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."

SSEC2022

New pathways to innovation



The goal of SSEC2022 is to stimulate transformative and innovative research and applications at SSEC that are consistent with the center's mission and the Wisconsin Idea to promote knowledge beyond the university.

This third and final year of seed funding, provided by SSEC, is opening new pathways to collaborative research, establishing strategic partnerships and improving infrastructure. Projects selected for funding in 2021-2022 are listed below.

2021 projects

Principal investigator

Continuation of extending CAMEL emissivity database to far IR with ground-based ARI measurements

Eva Borbas

Development of a Low Cost Rubidium HSRL Suitable for Network Deployment

Ed Eloranta

SSEC Support of NOAA Next Generation IR Sounder Activities Prior to Phase-A Start-up

Bob Knuteson

CSPP Geo Cloud Demonstration and GeoSphere Website

Graeme Martin

Development of A Satellite All-Sky Correlated Observation Error Model for Data Assimilation

Jason Otkin

Augmenting Microphysical Remote Sensing Mixed-phase Capabilities for Precipitation Process Studies

Claire Pettersen

Satellite Data Services (SDS) LEO Satellite Data Repository (funded by FFS)

Jerry Robaidek

Continuing Python ADDE Server Development and Investigating Additional Python Interfaces to McIDAS

Becky Schaffer

Observation System Experiments Supporting Satellite Instrument and Development and Sounding Applications of the Data

Bill Smith Sr.

Hardware Testbed for the Next-generation Hyperspectral Infrared Imaging Sounder

Joe Taylor

A Synoptically-aware Bayesian Precipitation Retrieval Framework Incorporating VIIRS/ABI Cloud Information

Norm Wood

2020 projects

Principal investigator

Development of a Global Water Quality Portal Using the SSEC RealEarth™ Framework

Sam Batzli

Extending CAMEL Emissivity database to far IR with ground-based Absolute Radiance Interferometer measurements

Eva Borbas

An Exploratory Study of Stratiform Mixed-Phase Clouds using Multi-Sensor/Multi-Spectral Satellite Measurements

Tom Greenwald

Low Latency Reception, Processing, and Applications for Cross-track Infrared Sounder

Liam Gumley

Support NOAA BAA Study Awarded to GeoMetWatch, as a Teaming Partner, to Study Pricing Options for a GeoMetWatch Commercial Sounder

Liam Gumley

Summer internships and academic year student programmer pool

Denny Hackel

Satellite Detection of Sea Ice Leads Using Machine Learning

Jay Hoffman

Cloud-clearing for GEO-XO hyperspectral IR sounder cloudy radiances with collocated imager data using machine learning

Jinlong Li

A machine learning based quality control method for Advanced Baseline Imager water vapor band radiance assimilation

Zhenglong Li

Implementation of the convective scale Unified Model over CONUS at SSEC and the assimilation of GOES-16 ABI observations

Agnes Lim

Developing Convolutional Neural Network Methodologies for Denoising VIIRS Day-Night-Band and Cloud Layer Detection of GEO Imager Observations

Willem J. Marais

Leveraging the High Temporal Resolution of the Advanced Baseline Imager to Improve Daily Evapotranspiration Estimates over US

Jason Otkin

Digitizing the Applications Technology Satellite image collection

Jean Phillips

Satellite Data Services Satellite Data Archive Expansion (Part II)

Jerrold Robaidek

Observation System Experiments Supporting Future Satellite Sounding Instrument Development

Bill Smith Sr.

Enhancing capabilities to retrieve H₂S distributions on Uranus and Neptune

Larry Sromovsky

International MODIS/AIRS Processing Package

Kathleen Strabala

Support of NOAA BAA Studies for Next Generation LEO and GEO IR Sounders

Joe Taylor

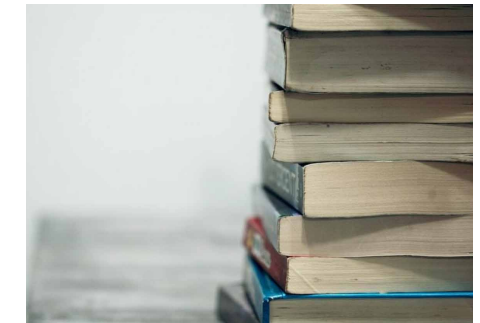
Optimizing ABI Clear Sky Radiance Assimilation in Regional NWP for Local Severe Storm Forecast

Pei Wang

Expanding GPU-enabled computing at SSEC

Anthony Wimmers

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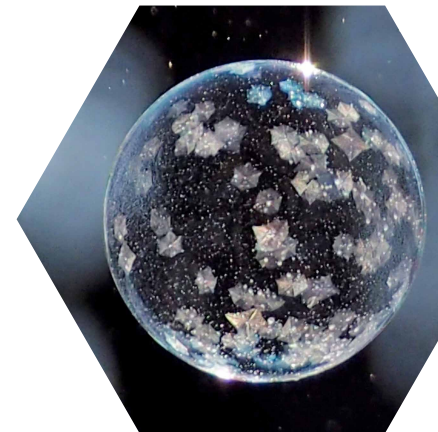
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SSEC has built key research and education partnerships with federal agencies as well as departments and centers across the University of Wisconsin–Madison campus and beyond. With our partners we are working towards understanding Earth-atmosphere processes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

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National Aeronautics and Space Administration (NASA)

- Earth Science
- Planetary Science

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- Energy Analysis and Policy
- Office of the Vice Chancellor for Research and Graduate Education (OVCRGE)
- Physical Sciences Laboratory
- College of Engineering (COE)
- Department of Civil and Environmental Engineering



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 (AOS).



Tristan L’Ecuyer CIMSS Director

Appointed by the CIMSS Board of Directors, AOS Professor Tristan L’Ecuyer assumed his role in January 2019. L’Ecuyer is well situated to lead CIMSS into the future, bringing 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 as well as associate directors for engineering, administration and science. Their combined experience is guiding SSEC and CIMSS into the future.

Mark Mulligan Executive Director and Associate Director of Engineering

Chelsea Dahmen Associate Director of Administration

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.

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Angie Montgomery
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Assoc. Instr. Innovator - SSEC
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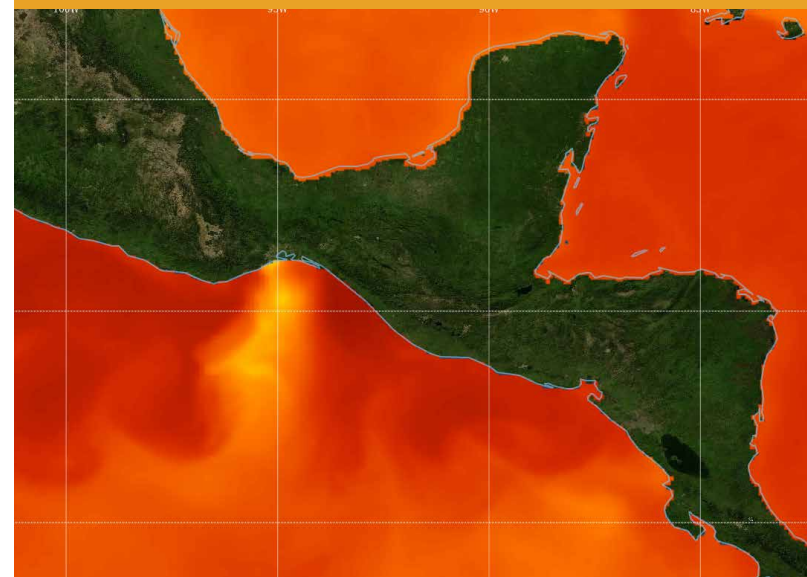
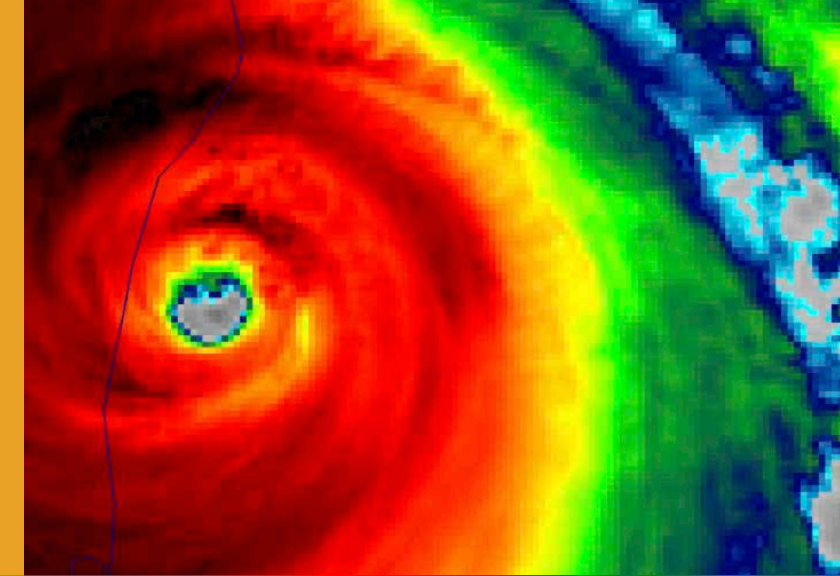
Kathy Strabala
Assistant Scientist - SSEC,
Chairperson
Elected (PI)

Dave Tobin
Senior Scientist - SSEC
Elected (PI)



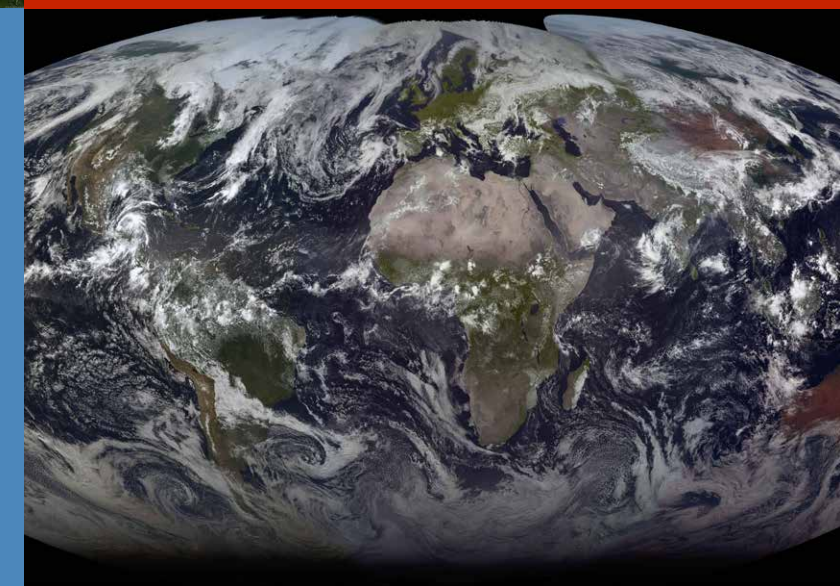
2.5
petabytes archived
weather data

200
terabytes tropical
cyclone data
distributed worldwide



299
blogposts for analysis
and training

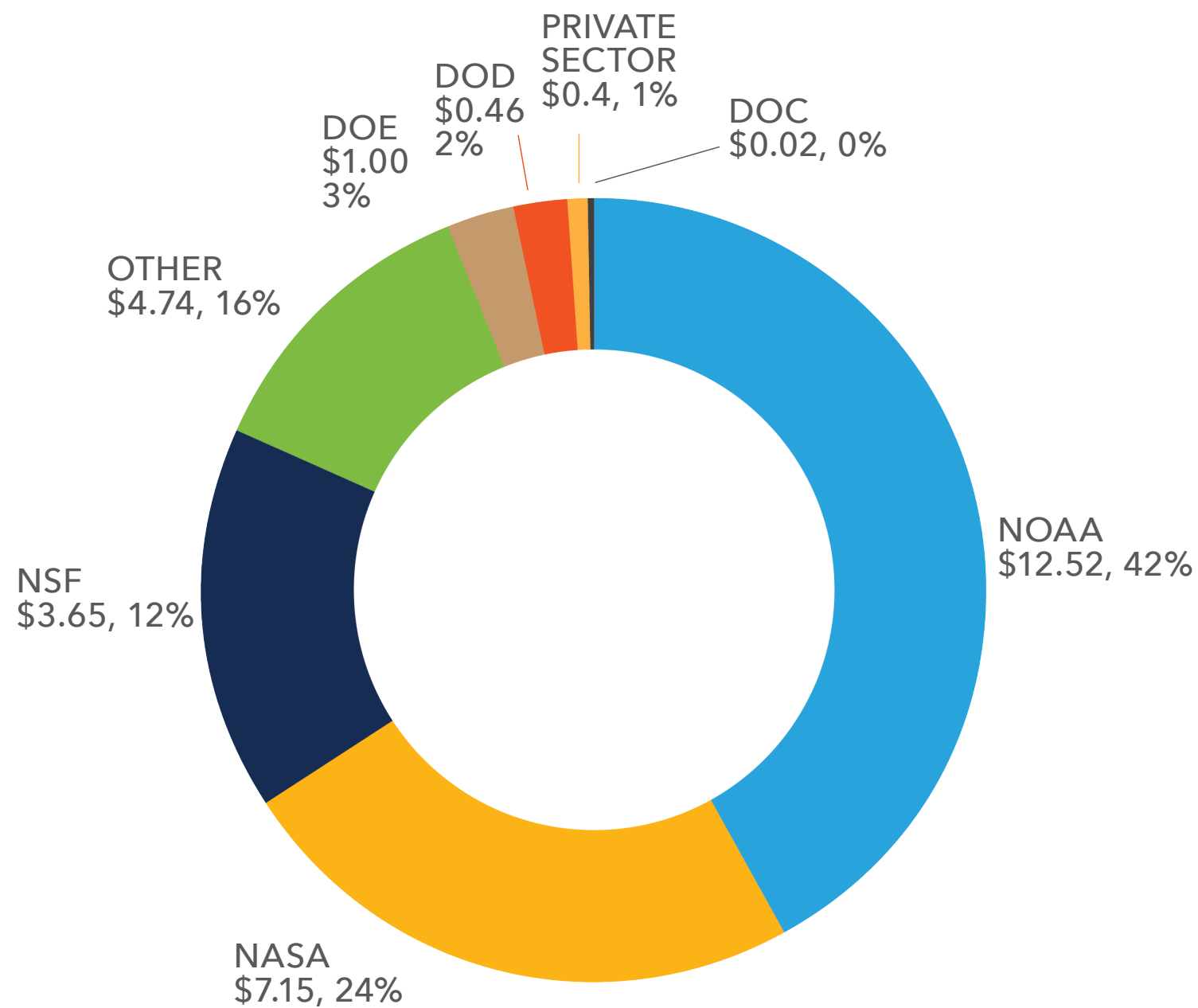
5.5
million
SSEC and CIMSS
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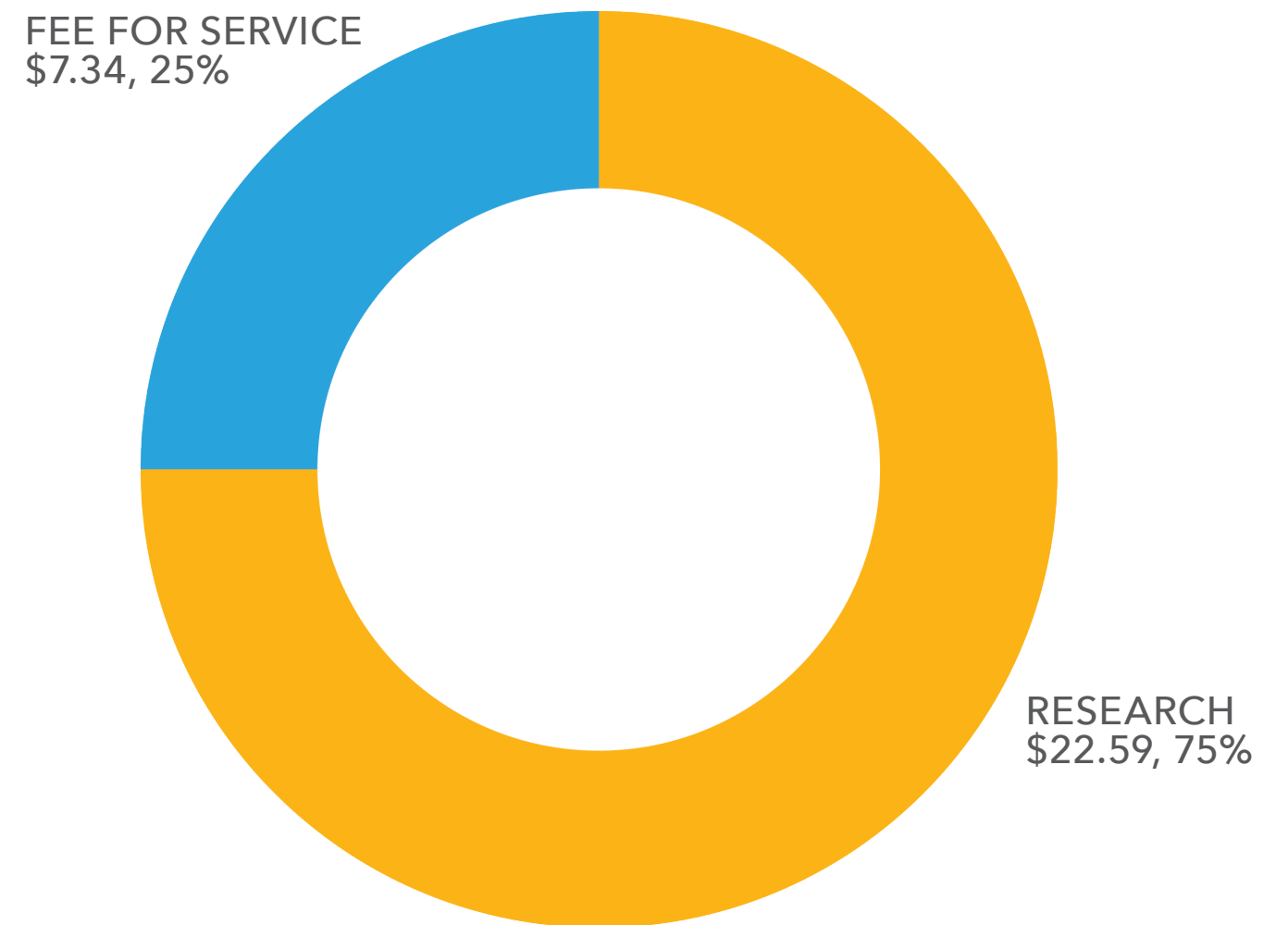
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(in millions)

Total spending \$29.9M



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Awards

2021

Jordan Gerth

NOAA Bronze Medal Award in Scientific or Engineering Achievement

Wei Han

International TOVS Study Conference-23 Best Oral Presentation

Jeff Key

NOAA Distinguished Career Award in Scientific Achievement

Tristan L'Ecuyer

Outstanding Alumni Award from the Department of Atmospheric Sciences at the Colorado State University

Scott Lindstrom

Joint Polar Satellite System Unseen Hero Award
National Environmental Satellite, Data, and Information Service Collaboration Award

David Tobin

International TOVS Study Conference-23 Best Poster Presentation

2020

Jay Hoffman

National Environmental Satellite, Data, and Information Service Outstanding Science and Research Employee

Tristan L'Ecuyer

American Geophysical Union Atmospheric Sciences Ascent Award

Jerry Robaidek

University of Wisconsin–Madison Chancellor's Award for Excellence in Research: Critical Research Support

Timothy Schmit

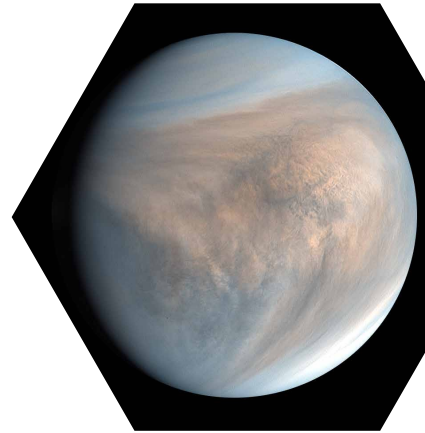
National Oceanic and Atmospheric Administration Administrator's Award

William Straka

Joint Polar Satellite System Innovation Award

Anthony Wimmers

National Environmental Satellite, Data, and Information Service Outstanding Science and Research Employee





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