THROUGH *the* ATMOSPHERE

THE CLIMATE ISSUE

Summer/Fall 2020
Space Science and Engineering Center | Cooperative Institute for Meteorological Satellite Studies | University of Wisconsin–Madison

Director's note


Credit: Eric Verbeten

The need to understand climate change and how it is shaping our environment is more urgent than ever. The Climate Issue of *Through the Atmosphere* highlights research at the Space Science and Engineering Center and the Cooperative Institute for Meteorological Satellite Studies that is increasing understanding of our climate and offering paths to solutions.

A recently funded National Science Foundation project, for example, will continue SSEC's legacy of curating in-situ and satellite observations to provide access to crucial Antarctic climate data to researchers around the world. At the northern pole, ASPB scientist Yinghui Liu's novel sea ice thickness algorithm demonstrates that changes in thickness have had a greater impact on declining Arctic sea ice volume than sea ice area.

In the warmer tropical regions, NCEI scientist James Kossin demonstrates that hurricane intensity, speed and geographic reach have changed in response to anthropogenic climate change with serious societal consequences. Shane Hubbard's work translates such findings into actionable information by explicitly linking severe weather – and climate – changes to its societal impacts in order to provide officials and policy makers the tools they need to make informed decisions.

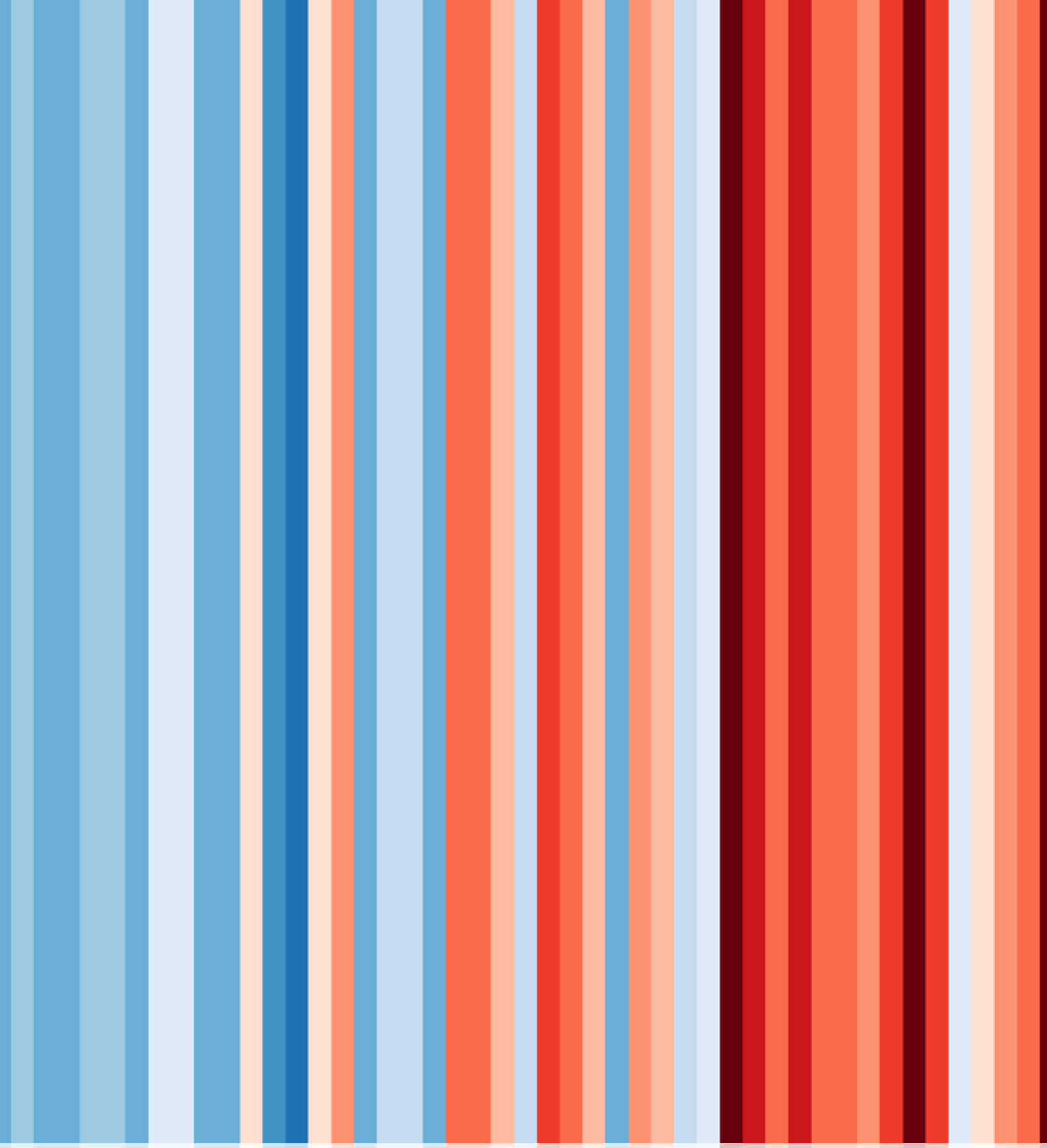
Our stories also celebrate the achievements of aspiring researchers like this year's Suomi Scholarship winners, Hansi Bartle, Naomi Raicu and Saksen Hathaway, who are embarking on their academic careers seeking to solve environmental and climate problems. Further along in their studies, CIMSS Ph.D. students, Chuck White and Anne Sledd, are already making important contributions to understanding the influence of clouds on climate. Ensuring the pipeline of young researchers remains strong in the future, Alexa Ross and collaborators Margaret Mooney and Scott Lindstrom are creating online educational materials to engage precollege students amid the pandemic.

From senior scientists to promising students, our climate research spans the globe, involving researchers at every stage of their career. These stories, and more, attest to our vigorous climate research programs and illustrate our commitment to training future scientists because our future depends on them.

Tristan L'Ecuyer
CIMSS Director

The need to understand climate change and how it is shaping our environment is more urgent than ever.

Research at SSEC and CIMSS is increasing understanding of our changing climate and offering paths to solutions.



Through the Atmosphere is a biannual publication featuring atmospheric, space science, and engineering research and education accomplishments of the University of Wisconsin–Madison's Space Science and Engineering Center (SSEC) and its Cooperative Institute for Meteorological Satellite Studies (CIMSS).

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Cover image
The "Warming stripes" graphics are a visual representation of the change in global temperatures for the past 100 years. This page features the warming stripes of the United States over the same time period.
Credit: Ed Hawkins (University of Reading) CC by 4.0

THROUGH *the* ATMOSPHERE

Summer/Fall 2020

Far-infrared

Sounder technology promises improved climate records, international benchmarks

by Eric Verbeten

◀ **A closeup of the Atmospheric Radiance Interferometer. An instrument designed and built by SSEC scientists that captures data in the far-infrared region of the electromagnetic spectrum, a crucial aspect to understanding Earth's energy budget. Credit: Joe Taylor**

▲ **SSEC researcher Joe Taylor with the Scanning High-resolution Interferometer Sounder, being tested on the NASA Global Hawk. The accuracy of the ARI builds on the success and lessons learned from hyperspectral IR sounders such as the S-HIS and adds the capability to verify on-orbit calibrations with absolute standards. Credit: Denny Hackel**

The global observing network of weather satellites — made up of polar orbiting and geostationary satellites — provides a comprehensive daily snapshot of Earth's atmosphere and weather. Onboard instruments like imagers and infrared sounders capture data needed by scientists to understand weather patterns and climate.

New instrument developments promise to expand that capability by capturing crucial information from the far-infrared region of the electromagnetic spectrum. Its role in regulating heat transfer in places like the Arctic is accepted. While the far-infrared region makes up nearly half of Earth's emission spectrum, current sensors are not designed to systematically collect data there.

To address this need, scientists and engineers at the University of Wisconsin–Madison Space Science and Engineering Center developed the Absolute Radiance Interferometer. It offers researchers a way to peer deeper into the inner-workings of the Earth's energy budget and observe climatological changes through highly accurate measurements in the infrared and far-infrared regions. Additionally, it is able to independently verify the accuracy of the data it collects through an onboard calibration system.

An overview of the ARI's development and capabilities was published in a special issue of the journal *Remote Sensing* in June 2020.

"There is a recognized need for this capability," says Joe Taylor, SSEC scientist. "The spectral coverage into the far-infrared and ultra-high accuracy of the ARI are needed to measure long-term changes of Earth's atmosphere and surface. This is valuable not only for the ARI measurements, but also would provide a reference standard for any of the international satellites that measure in the infrared."

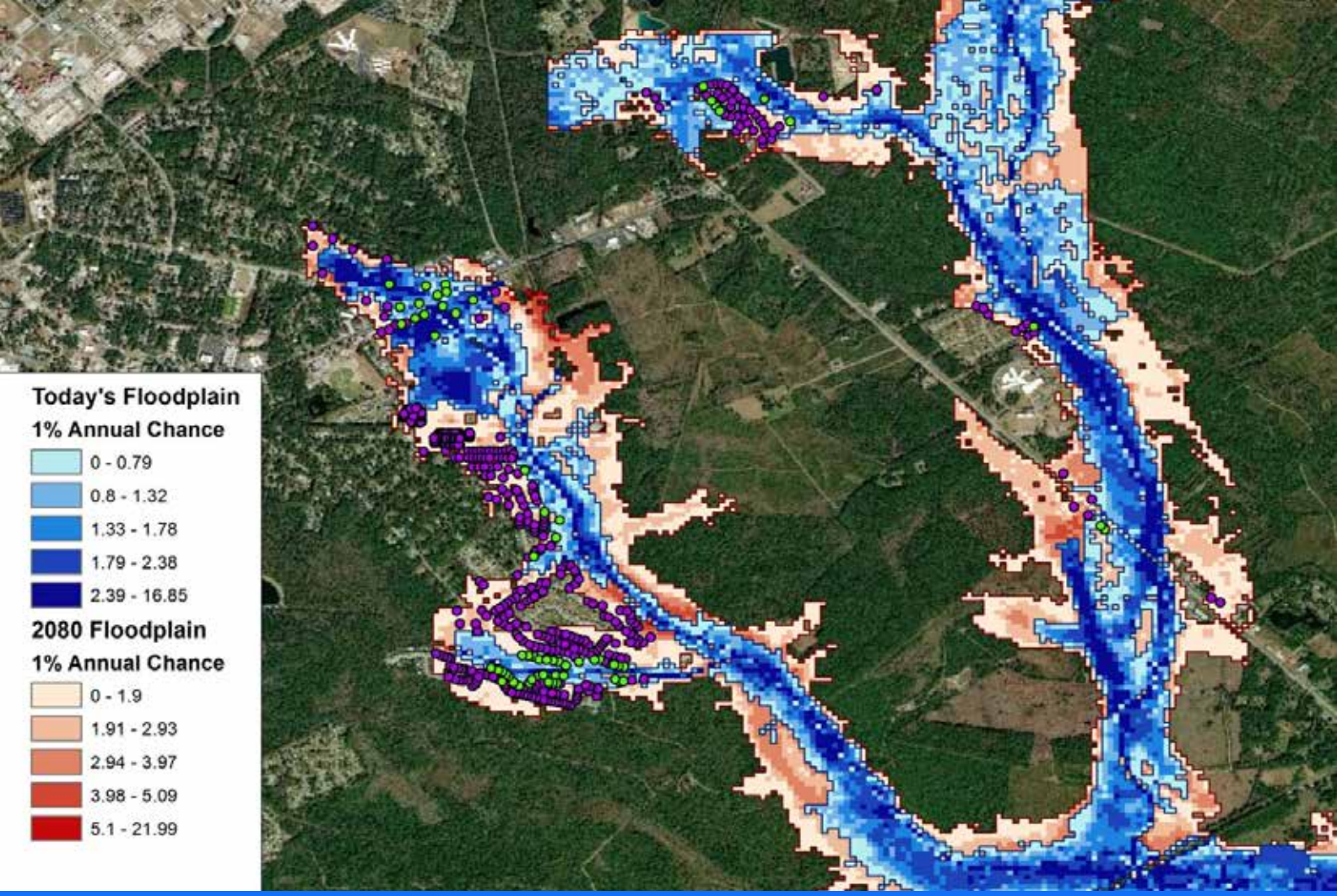
When a new weather satellite is launched and reaches its final orbit, it must undergo an extensive period of testing to assess the performance of its sensors. Throughout the life of the instrument, its measurements can be compared to measurements from other sensors on the same satellite or others. This is important, since small changes in temperature can have large impacts on the formation of severe weather, for example.

"The ARI would provide a calibration reference standard for other instruments and could be used to help calibrate them to a similar measurement accuracy," says Taylor.

Development of the ARI began more than a decade ago. It evolved from the Climate Absolute Radiance and Refractivity Observatory mission, established after NASA's 2007 Decadal Survey identified the need for improved infrared sounder capabilities and hyperspectral infrared instrument development. The World Meteorological Organization, in its "Vision for a Global Observation System in 2025" further recognized the need for at least six geostationary satellites equipped with advanced infrared sounding capabilities like those provided by the ARI and other hyperspectral sounders.

"It is encouraging to see some agencies in the international community, such as the Chinese Meteorological Agency and the European Organisation for the Exploitation of Meteorological Satellites, moving forward with plans to expand the global fleet of satellites and their capabilities in the infrared spectrum," says Taylor.

This work is supported by NASA.



Natural disaster risks

Resilience research in a changing climate

by Jean Phillips

Extreme weather, like heavy precipitation, is increasingly linked to climate change. Preparing for those events involves gauging community risk and resilience. These adaptations to climate change and pandemic impacts are now part of the equation to avoid tragic loss of lives and property.

Shane Hubbard dedicates his time and expertise to quantifying and visualizing those risks. He is a researcher at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies who uses data and geospatial modeling techniques to identify areas at risk of hazardous events like floods, tornadoes and hurricanes. Armed with that information, the communities he assists can better anticipate — and weather — these events.

For example, if communities want to be resilient, they need to think about whether certain areas should be designated as floodplains, which would prohibit any building on them. Estimating the location of future floodplains is another important aspect to Hubbard's work. In addition to the loss of life and property, the financial impact of severe weather can be devastating.

"Each year there are larger dollar losses due to disasters and more people impacted, even when

◀ **Flood depth grid for areas near Hinesville, Georgia showing the impacts climate change will have on the floodplain along with the number of damaged buildings. Hubbard is involved in similar work along the Baraboo River in Wisconsin.**
Credit: Shane Hubbard

adjusted for inflation," says Hubbard.

According to NOAA's National Center for Environmental Information, during the period 1980-2020 (through Oct. 7, 2020), the United States experienced 279 hazardous events each costing $1 billion or more; however, nearly 30 percent of those events occurred since 2015.

Overall, tropical cyclones have caused the most damage and losses. That is because about 127 million people, or 40 percent of the US population, live in counties that border a coast. While the land mass on the coasts is small relative to that of the contiguous US — only 10 percent of its total — the population density is five times greater than it is inland. This density is an important factor that increases the threat of damage and loss of life.

"The way that we construct our communities is a detriment to having any sort of buffer for climate change," says Hubbard. "People continue to want to live in areas that are becoming more vulnerable to disaster as the climate changes."

Tools such as flood maps can help to identify who is at risk and who needs flood insurance, but their boundaries are binary. That is, they prevent construction inside the boundary, but allow it immediately outside: there is no gray area. One more foot of water during a storm can cause flooding in areas where people live and work.

"This is very apparent on the coasts where floods can push in quite far, over a mile," says Hubbard.

He adds that climate change is not a one-to-one ratio that results in a linear change to the hazard risk. Rather, the way communities are built exposes them to an exponential increase in risk while at the same time, rendering them less resilient to changes in climate. Making adjustments in our built environment in anticipation of weather and climate change is one way to moderate their harmful effects.

After Hurricane Andrew — a storm that destroyed 63,000 homes and bankrupted nine insurance companies in August 1992 — Florida began adopting stronger building codes. Emergency services, insurance companies, firefighters, and engineers were among the groups in support of them. As a result of adopting more rigorous codes, Floridians who lived in homes built after Andrew weathered subsequent Hurricane Irma in September 2017 much better than those who lived in older homes.

However, not everyone supports more robust codes. "These can be wildly unpopular for various reasons, but one of the biggest reasons is that stronger building codes can result in more expensive buildings," says Hubbard.

Closer to home, Wisconsin lakes, streams and rivers are not immune from hazardous weather events. Hubbard notes that annual precipitation amounts are not increasing much across the Midwest, but places like Wisconsin are experiencing shorter periods of intense rainfall accompanied by flash flooding.

"We are now seeing our biggest floods in June, with torrential rains, rather than in May as a result of spring melting," says Hubbard.

This shift is changing how planners think about seasonal flooding. It is also pushing planners to focus more on the pre-flood environment and to consider mitigation strategies.

> "Climate change is not a one-to-one ratio that results in a linear change to the hazard risk."
> — Shane Hubbard

Hubbard, along with UW–Madison climate researchers Steve Vavrus and Michael Notaro, is working with officials in Sauk County, Wisconsin to provide outlooks on future precipitation patterns.

In August 2018, parts of the Baraboo River in Sauk County met, or exceeded, the one percent annual chance for a 100-year flood, causing widespread

▲ **Shane Hubbard is a researcher with CIMSS who uses data and geospatial modeling techniques to identify areas at risk of hazardous events like floods, tornadoes and hurricanes. Armed with that information, the communities he assists can better anticipate — and weather — these events. Credit: Shane Hubbard**

flooding, evacuations and property damage.

Rather than revising existing flood maps with recent flood data, the researchers will be providing Sauk County with estimates of future floodplains based upon simulations of future precipitation for the area.

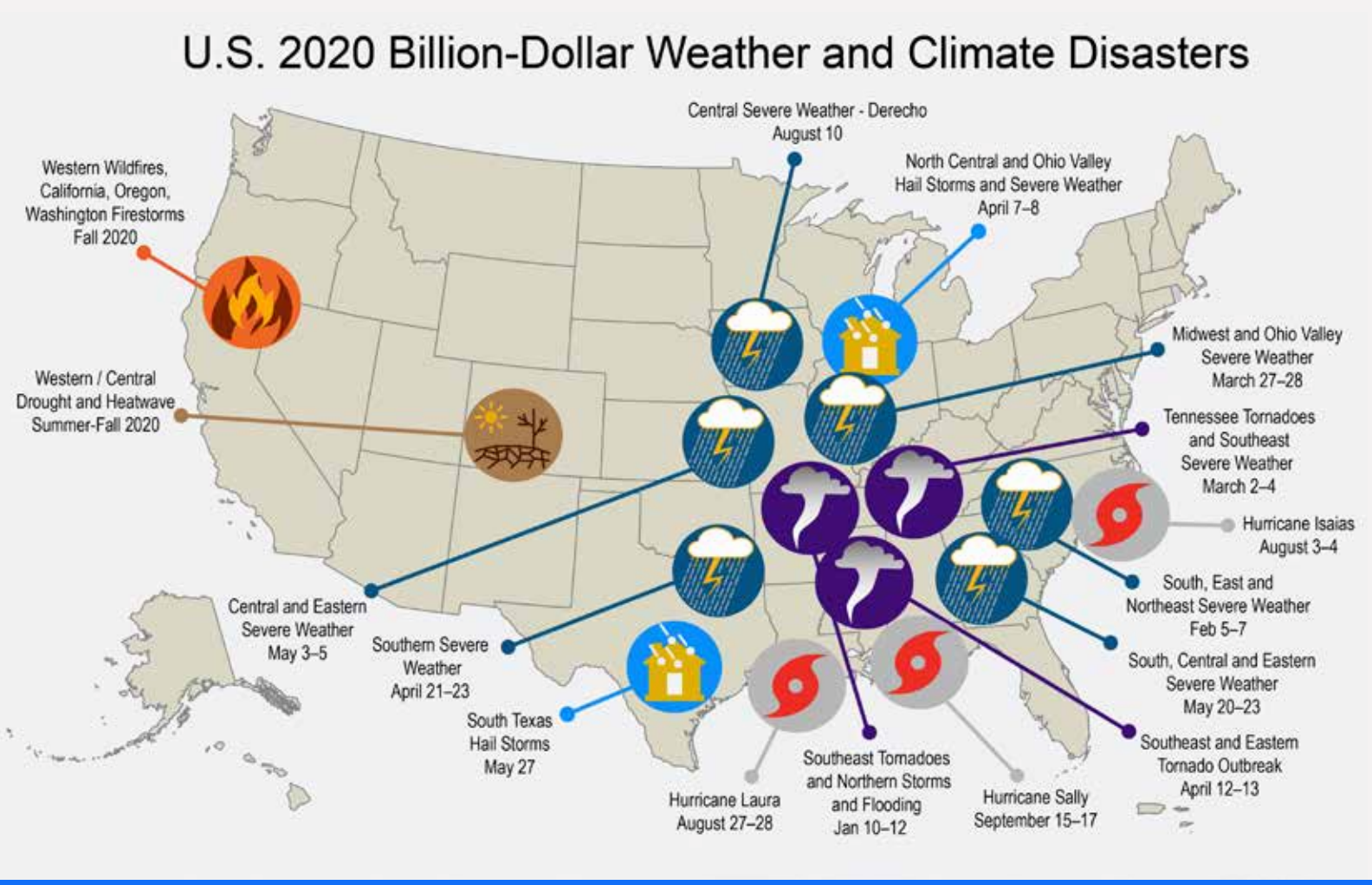
Hubbard will combine those flooding estimates with information on at-risk individuals, property and agricultural areas to show how different parameters might change the possible impacts or outcomes in the future. Understanding these possible scenarios today will guide planning for Sauk County's future growth.

Hubbard says that in any area prone to natural disasters, like flooding or hurricanes, the more financially stable a population is, the more resilient that population will be. Adequate financial resources make people more mobile and able to relocate if disaster strikes; however, people who lack those resources may find themselves at even greater risk, thereby further widening the gap between those who are financially secure and those who are not.

Viewing these layers of data over floodplains or other areas gives local leaders a picture of at-risk populations.

In an expanded project, Hubbard will be reviewing current floodplains across Wisconsin as part of a statewide flood assessment to aid preparation for — and adaptation to — a near future that may include more torrential rains.

What concerns Hubbard most this year is that several hurricanes, from Category 1 to Category 4, have made landfall in the US at a time when the nation is dealing with a pandemic. The combination



▲ **Map showing the approximate location for each of the 16 separate billion-dollar weather and climate disasters that impacted the United States from Jan.-Sept. 2020. Credit: NOAA, NCEI**

creates another type of perfect storm. For a large metropolitan area, a strong hurricane could pose problems in transporting the injured to hospitals where they can receive medical care, especially if they are already overwhelmed with COVID-19 cases.

"The recovery will be longer, too." says Hubbard. "With Hurricane Irma, people went a week or two without electricity, but in the current environment I see the potential for people to be without power for four to six weeks because fewer resources may be available in areas where positive COVID-19 numbers are high and physical distancing a challenge."

The same is true for those who must evacuate to a shelter during a storm as well as those who volunteer to help in its aftermath. Hubbard says that when appropriate, people may be advised to shelter-in-place and because of the physical distancing requirements to limit transmission of the virus, he fears we may see fewer volunteers.

While combating COVID-19 is an urgent national need that must be addressed, it may create an all-too-familiar scenario where future appropriations to activities such as disaster planning and mitigation are reduced.

"Historically, funds for pre-disaster mitigation — like elevating a house out of a floodplain or building a flood wall — is the type of thing that gets cut when we have budget constraints," says Hubbard.

With these concerns in mind, Hubbard continues his work of helping communities to prepare — because natural disasters are not going away.

This work is supported by the Federal Emergency Management Agency and administered through Sauk County, Wisconsin.

Arctic sea ice trends

The connection between ice age and thickness

by Leanne Avila

Credit: Jonny Carstensen

▲ CIMSS scientist Yinghui Liu Credit: Yinghui Liu

The decline in sea ice in the Arctic presents a stark picture of a changing Earth climate. And while the area covered by sea ice remains a valuable measurement, scientists are beginning to investigate other parameters that can also serve as key indicators.

"Researchers have realized that maybe sea ice volume is a more sensitive parameter that we need to look at," says Yinghui Liu, a scientist with the National Oceanic and Atmospheric Administration's Advanced Satellite Products Branch stationed at the University of Wisconsin–Madison's Cooperative Institute for Meteorological Satellite Studies.

In early 2020 Liu and several of his colleagues published a paper in the journal *The Cryosphere* detailing new sea ice volume research. Liu, working with Jeff Key of NOAA ASPB, Xuanji Wang of CIMSS, and Mark Tschudi of the University of Colorado in Boulder, Colorado, studied the relationship between sea ice age and thickness and how that information can be used to estimate sea ice volume as another way to study changes in Arctic sea ice over time.

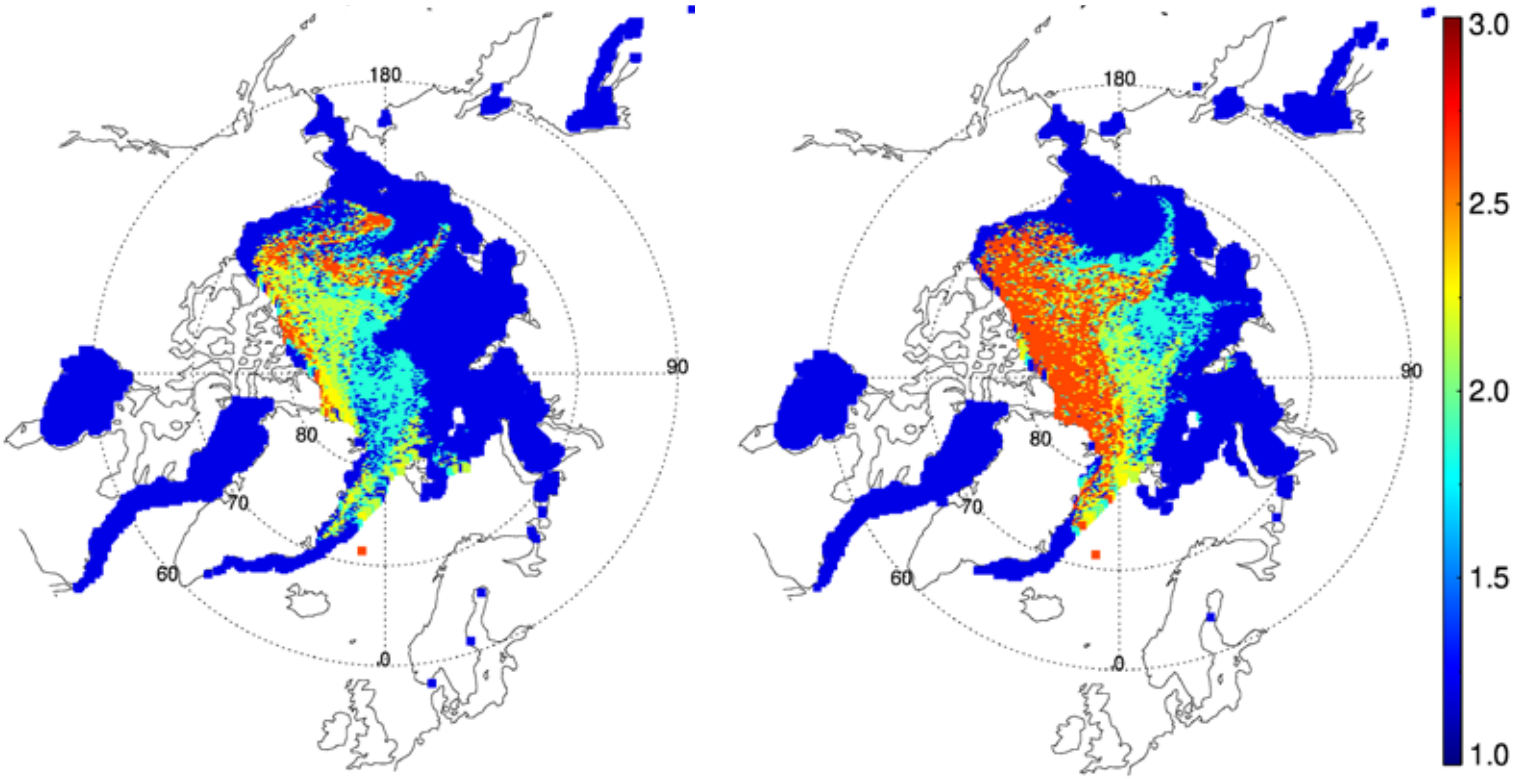
"Sea ice change is one of the most active research areas in recent years," says Liu. "Based on the satellite images and the long-term monitoring, there has been a lot of research on the sea ice extent trends in the Arctic … you can clearly see shrinking of the sea ice cover in the Arctic in the summertime."

However, sea ice research continues to evolve as scientists pursue other approaches to studying trends in the Arctic, including changes in sea ice volume.

Previous work on sea ice volume tended to use observations over relatively short time periods. To be useful for climate studies, scientists need several decades of observations — typically on the order of 30-plus years — and while there have been studies of sea ice volume on these larger time scales, they also tend to have significant uncertainties, according to Liu. The key is developing a more accurate approach to estimating sea ice thickness over long periods of time.

> "Sea ice thickness and sea ice volume retrievals from satellite are very important parameters."
> — Yinghui Liu

Liu also notes that prior research had observed and used a linear relationship between sea ice age and thickness, but only in the month of March over several years. With this new study, Liu and his



▲ **Arctic ice thickness (in meters) derived from ice age Jan. 1-7, 2005 (left), and Jan. 1-7, 2015 (right). Credit: Yinghui Liu**

colleagues explored the relationship between sea ice age and thickness and then applied this knowledge to determine thickness and volume throughout the entire year as the amount of ice fluctuates.

"Our work tries to extend the relationship in one month to relationships in every month of the year, from 1984 to the present," says Liu.

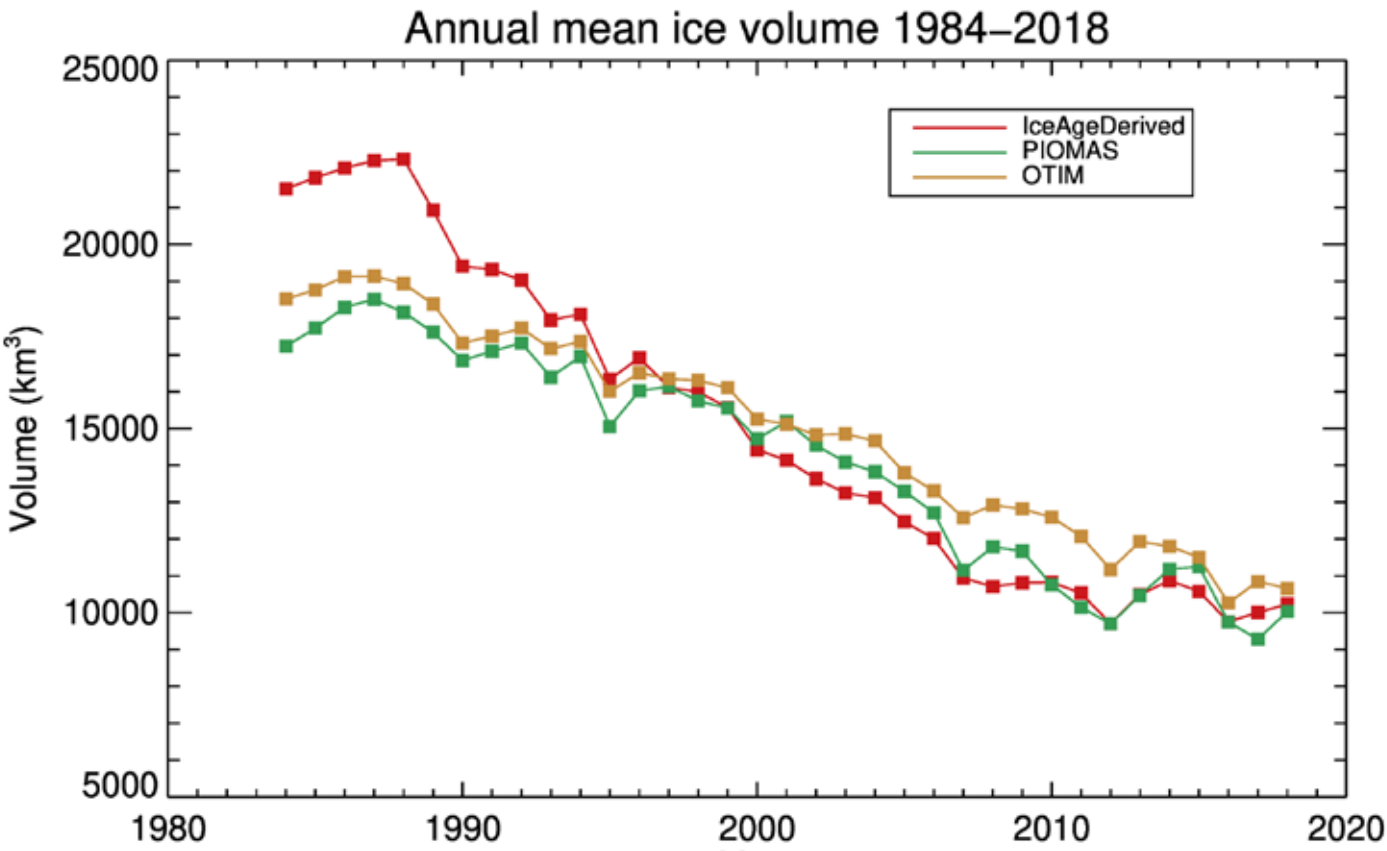
In order to develop and train their algorithm, they used a number of different datasets in addition to ice age, including upward-looking sonar observations from submarines from 1984-2000 to estimate sea ice thickness and then later satellite altimeter measurements of sea ice thickness and volume from 2003-2008. That algorithm then needs to be evaluated and validated using different datasets to ensure its accuracy independently. For their comparisons, Liu and his colleagues used sea ice thickness and volume products from the Pan-Arctic Ice-Ocean Modeling and Assimilation System model for the period 1984-2018, as well as sea ice thickness and volume products from CryoSat-2 altimeter data from 2011-2018.

"Our products agree well with the evaluation and validation dataset. That gives us confidence in our algorithm," says Liu.

Although sea ice cover remains the most easily visible reminder of Arctic sea ice changes, Liu notes that their research showed that changes in sea ice thickness often have a far greater impact on sea ice volume, particularly during the winter in the Arctic.

"Changes in the thickness contribute 80 percent or more to the decreasing sea ice volume trend from 1984-2018, November to May," says Liu.

With sea ice extent at its maximum during these Arctic winter months, changes in sea ice volume are easily attributable to changes in thickness. However, during August and September, when the sea ice cover is at its minimum, the sea ice thickness still contributes more to the changing volume trend — contributing approximately 50 percent. Throughout the entire year changes in sea ice extent contribute approximately 30 percent



▲ **Time series of annual mean Arctic ice volume from 1984 to 2018 derived from ice age, the Pan-Arctic Ice-Ocean Modeling and Assimilation System and OTIM data. Credit: Yinghui Liu**

towards the changes in sea ice volume. Liu states that more research is needed to understand why sea ice extent does not have a greater impact on sea ice volume during August and September, when sea ice cover is at its minimum.

"Changes in the thickness contribute 80 percent or more to the decreasing sea ice volume trend from 1984-2018, November to May."
— Yinghui Liu

As Liu and his colleagues continue to study the changing Arctic sea ice, they plan to take a closer look at their use of a linear relationship between sea ice age and sea ice thickness. As Liu concedes, "it's more likely not linear." Similarly, their current approach assumes that sea ice melt and sea ice growth are both linear during the year, while both are more likely non-linear as well. Liu would like to address and refine these assumptions in future research efforts and suggests that engaging the broader sea ice community would prove beneficial.

"Sea ice thickness and sea ice volume retrievals from satellites are very important parameters. We still have large uncertainties. As individuals we need to work on decreasing those uncertainties. And probably we will need to work with the whole community to come up with better products by combining all the sea ice thickness and volume products by knowing each product's limitations and strengths," says Liu.

This work is supported by the NOAA National Centers for Environmental Information Climate Data Records Program and the Joint Polar Satellite System Program Office.

Antarctic hub

Bringing together data from across the continent

by Eric Verbeten

Each year, thousands of researchers and support staff descend to the frozen continent of Antarctica to study and observe its changing conditions. Scientists from around the world have been studying the region for decades — producing sizeable amounts of meteorological and atmospheric data.

In early 2020, the University of Wisconsin–Madison Space Science and Engineering Center and Madison College were awarded a five-year $2.4 million grant from the National Science Foundation to establish a data repository to serve the global Antarctic research community.

"The goal of the new Antarctic Meteorological Research and Data Center will be to serve as a coordinated data hub for researchers to access information over the long term and make use of it," says Matthew Lazzara, director of SSEC Antarctic Meteorological Research Center and principal investigator for the project. "These data, among others, have been important to understanding Antarctica's changing climate as well as weather predictions that keep crews working on the continent safe."

Since 1980, AMRC has collected more than four decades of in situ data and more than 25 years of satellite data across the continent; however, a central meteorological storehouse for these types of data does not exist. Recent reviews from the United States Antarctic Program identified a need for a centralized repository to share, discover, access and preserve meteorological data collected in Antarctica.

To date, AMRC has collected several terabytes (thousands of gigabytes) of data and Lazzara says

▲ **Matthew Lazzara, director of the UW—Madison Antarctic Meteorological Research Center, on site at Minna Bluff Automatic Weather Station. AMRC scientists maintain a network of more than 60 weather stations, and support numerous other nations and partners who operate a fleet of more than 150 weather stations across the continent. Long term AWS data (more than four decades) is helping to understand climate change in the Antarctic and the world. Credit: Matthew Lazzara**

that amount will continue to grow, especially as they incorporate other Antarctic research campaign data from partners.

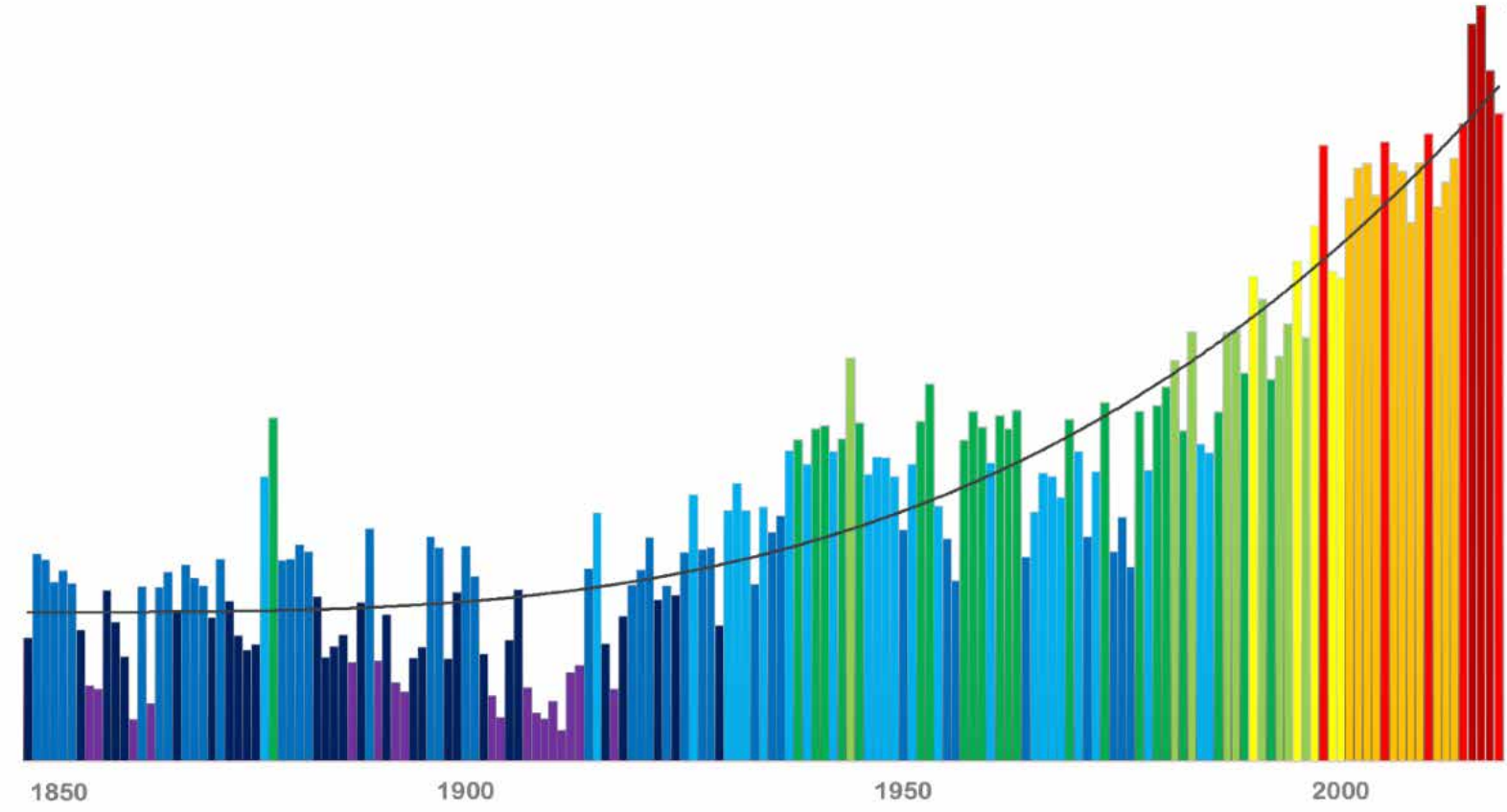
The multi-stage project includes establishing the framework for the repository, tools for data submission and construction of a web interface. Datasets will include ground-based data from researchers in Antarctica, satellite composite imagery, weather balloon radiosonde data, and meteorological data captured from aircraft.

Ground-based instruments such as AMRC Automatic Weather Stations provide continuous physical measurements of air temperature, humidity, pressure and wind speed and send that data to polar-orbiting satellites to transmit back to SSEC. AMRC scientists maintain a network of more than 60 weather stations, and support numerous other nations and partners who operate and maintain a fleet of more than 150 weather stations across the continent.

The project will rely on an advisory board to guide its activities. The Antarctic Advisory Board includes experts in weather forecasting, numerical modeling, meteorological observing, data archiving, scientific research, cyber infrastructure, and other content experts. Lazzara says students will also play an integral role throughout the entirety of the project.

"The project will utilize SSEC's longstanding expertise in data and information management to build an accessible hub for researchers to find and use the data," says Lazzara.

This work is supported by the National Science Foundation, Geoscience Directorate, and the Office of Polar Programs.



Public issues forum — Climate crisis

Spurring local action from a global climate crisis

by Eric Verbeten

As a global issue, the scale of climate change could not be larger — but its consequences are local. Which is why cities and towns, both large and small, have taken to addressing the issues of mitigation and adaptation.

For this same reason, some university scientists are committed to sharing the foremost science behind climate change, and its impacts, in their free time. One such scientist is Ralph Petersen, with the University of Wisconsin–Madison Space Science and Engineering Center. He has partnered with the League of Women Voters of Dane County (located in Wisconsin), a non-profit, non-partisan, chapter of a national organization whose purpose is to promote informed and active participation of citizens in government at all levels.

Georgiana Hernandez, Chair of the Program Committee with the LWVDC, has helped organize forums and committees for the local chapter's nearly 700 members.

Starting in 2019 the committee chose the climate change crisis as a focal issue and began planning a series of interactive forums as a way for members to learn more about the science behind it and ways to get involved.

"There was a growing concern among some

◀ **Global comparisons of average annual temperature from 1850 to 2018, with the total temperature range (y-axis) of 2.5° F. Credit: Hadley Centre, UK**

▲ **Georgiana Hernandez is the Chair of the Program Committee with the League of Women Voters of Dane County and helped organize climate change forums for the chapter's nearly 700 members. Credit: Georgiana Hernandez**

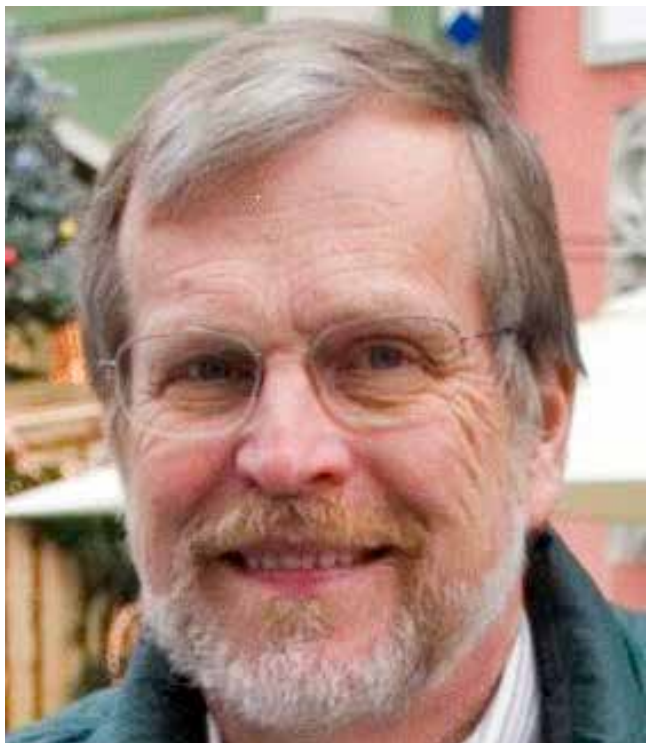
members about the climate crisis and that it is becoming more apparent with things happening in [places like] California," says Hernandez. "Even for people who haven't been real tuned into it or haven't seen it as a pressing issue, they're increasingly seeing the importance of addressing and mitigating the issues of climate change."

From the beginning, Petersen was invited to participate both as a presenter and as a member of the climate change steering committee. For the forums, Petersen prepared presentations that drew on his 45 years as an atmospheric scientist with NASA, the National Oceanic and Atmospheric Administration and UW–Madison.

"My objective is not only to help people understand the ramifications of climate change but also inform people as to its causes," says Petersen. "The first forum was an introduction to the subject and what we are seeing, with the goal of raising public and private sector awareness."

The challenge was to present the topic in a way that was understandable to an audience with diverse interests and backgrounds.

"As a non-scientist it's just incredible. Ralph has helped us to understand how much more precise the data has gotten in just the last 50 years," says Hernandez.



▲ **Ralph Petersen has studied atmospheric science for more than 45 years and was invited to share his climate expertise with the League's members. Credit: Ralph Petersen**

Forums consist of educational and informational sessions centered around key themes. In 2019 these included: climate and public health, why local government actions matter, and how agricultural stewardship can mitigate climate impacts.

"We investigated who was doing what related to climate research in Dane County," says Hernandez. "The first topic was why is climate a public health emergency? It was a good way to bring people into the issue because everyone can relate to public health."

One of Petersen's presentations included historical climate records from Lake Mendota, a large inland lake familiar to locals that is one of the most studied bodies of water in the world. The University of Wisconsin–Madison Department of Limnology and the Department of Aquatic Sciences have maintained an impressive ice-on and ice-off record dating back to 1855.

"From 1900 to 1975, Lake Mendota averaged about 265 days of open water," says Petersen. "It's now averaging about 285-290 days of open water with many more low-ice-cover peaks in the extremes. These are the secondary effects of climate change around us. The primary effect is earlier, and warmer, temperatures that then produce delayed, but notable, effects."

> "As a non-scientist it's just incredible. Ralph has helped us to understand how much more precise the data has gotten in just the last 50 years,"
> — Georgiana Hernandez

Later in the year, forum topics shifted to learning about efforts of local government in Dane County and ways to get involved, even at the state level. The last forum in 2019 included information about agriculture and how farmers are adapting to a changing climate by using sustainable practices to better protect the environment.

In total, more than 250 members participated in the 2019 forums, spurring the committee to extend the climate change forums into 2020-2021. The format, now largely virtual, includes town-hall style videos and presentations for members to view, but the message and mission remains the same.

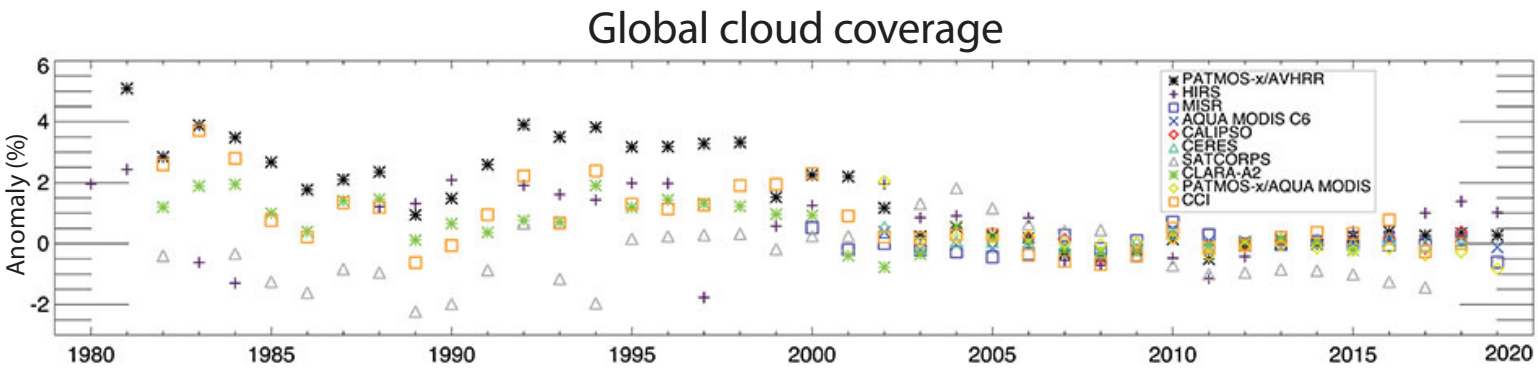
Petersen continues to be an active contributor to the conversations through blog posts hosted on the LWV of Dane County's website. These address some of the nuanced issues surrounding climate change, such as what it means when new "normals" are established by organizations like the World Meteorological Organization and the US National Weather Service.

"Once every 30 years the NWS averages its "normals," which is the reference used to compare current temperatures and conditions," says Petersen. "Starting January 2021, the new normal will remove the 1980s from the record, and replace it with warmer data from 2010 and later, so the apparent impact of climate change will appear less severe and may even appear to have decreased."

These kinds of analyses are important to understanding the greater climate issue and are part of the global dialogue, says Petersen. Through the LWV of Dane County, he plans to continue to share this kind of information in an approachable way.

When looking back on the climate forums, Hernandez is thrilled at the participation and interest expressed by the League's members.

"They are all volunteers, and what has been really fantastic about the LWV of Dane County is the incredible amount of time and dedication people have to carry out the work that constitutes the LWV," she says. "It's heartening."



▲ **Annual global cloudiness anomalies for 1981-2019. The anomaly is defined as the annual value minus the mean, derived for a period common to the satellite records. Credit: Mike Foster, CIMSS**

State of the Climate — 2019

Global cloud trends

by Leanne Avila

Research on clouds is vital to our understanding of the hydrological cycle — for predicting and monitoring droughts and flooding — and the global energy budget and the effect of clouds on Earth's climate.

Scientists from the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin–Madison and National Oceanic and Atmospheric Administration Advanced Satellite Products Branch stationed at CIMSS recently contributed an update on global cloudiness trends to the State of the Climate in 2019 report published by the American Meteorological Society.

"The average global cloudiness doesn't tend to change too much year-to-year, but the global distribution of cloudiness can vary quite a bit," notes Mike Foster, CIMSS researcher and the lead author on the global cloudiness section of the report.

That distribution can lead to unique and severe impacts across the globe, as it did in Australia in 2019.

In general, the distribution of clouds across the globe is often impacted by changes in circulation patterns such as the El Niño–Southern Oscillation, which affects winds and sea surface temperatures in and near the tropics through El Niño and La Niña. Foster explained that in 2019 ENSO was less of a factor than another similar pattern known as the Indian Ocean Dipole, which alters sea surface temperatures in the Indian Ocean.

"When the IOD is in a positive phase, eastern Africa tends to be more cloudy and Australia is less cloudy, compared to average. The positive IOD in 2019 was one of the strongest events seen in decades, and it led to some very dry conditions in Australia that contributed to the massively destructive wildfires," states Foster.

Long-term studies of clouds with highly accurate measurements are critical to monitoring their trends and impacts on the climate. Foster mentions how small changes in any number of cloud parameters — coverage, thickness, cloud height — can have a dramatic effect. Understanding these impacts remains key in their research.

"In fact, the treatment of clouds, and specifically cloud feedbacks, is the largest source of deviation among climate models for future climate scenarios," states Foster.

State of the Climate is published by the AMS as a special supplement to the Bulletin of the American Meteorological Society. This year marks the 30th such report. Assisted by CIMSS, ASPB and other colleagues, Foster has been contributing updates on global cloudiness to the report since 2008.

Find the State of the Climate in 2019, as well as past years' reports online here.

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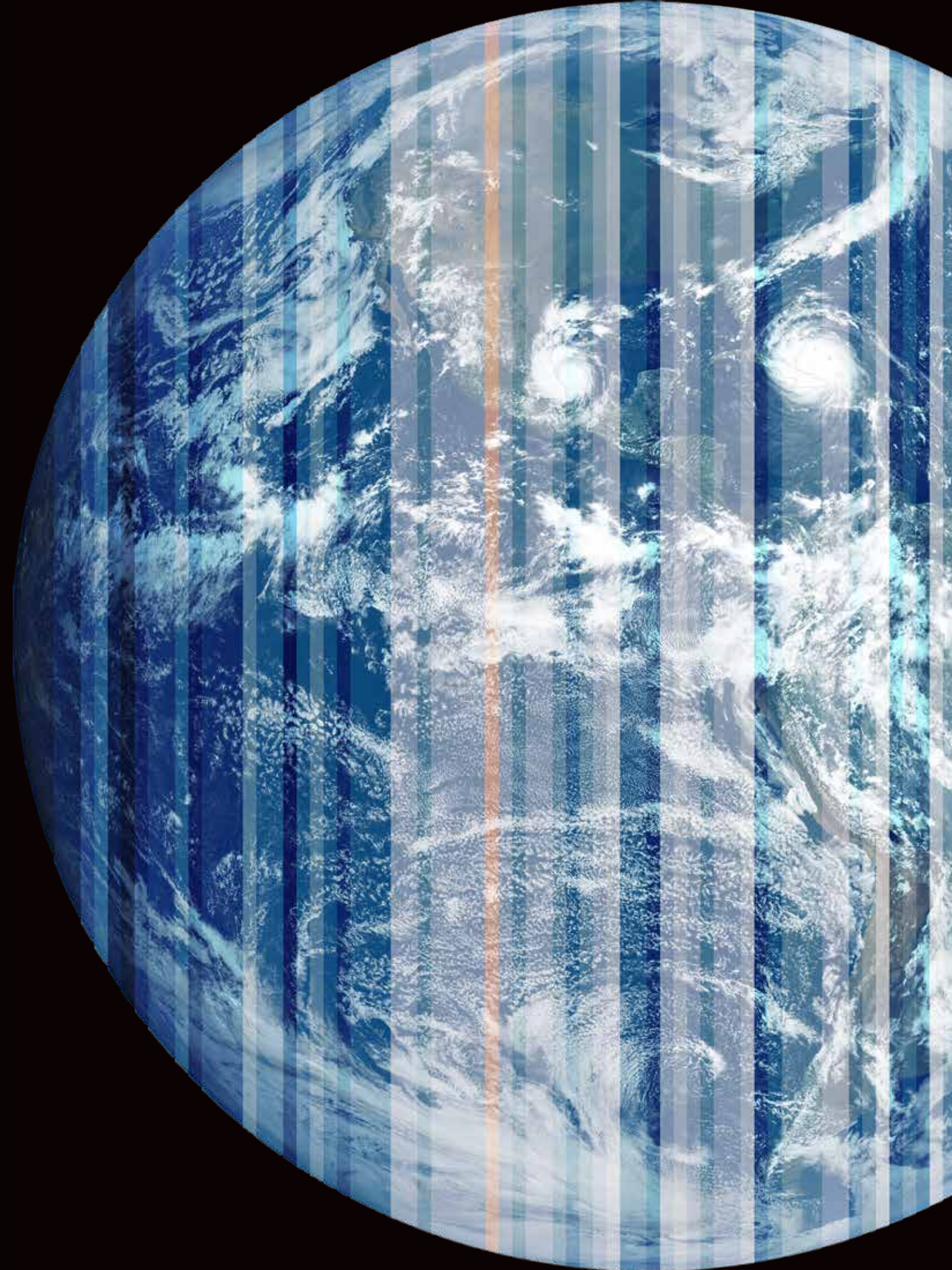
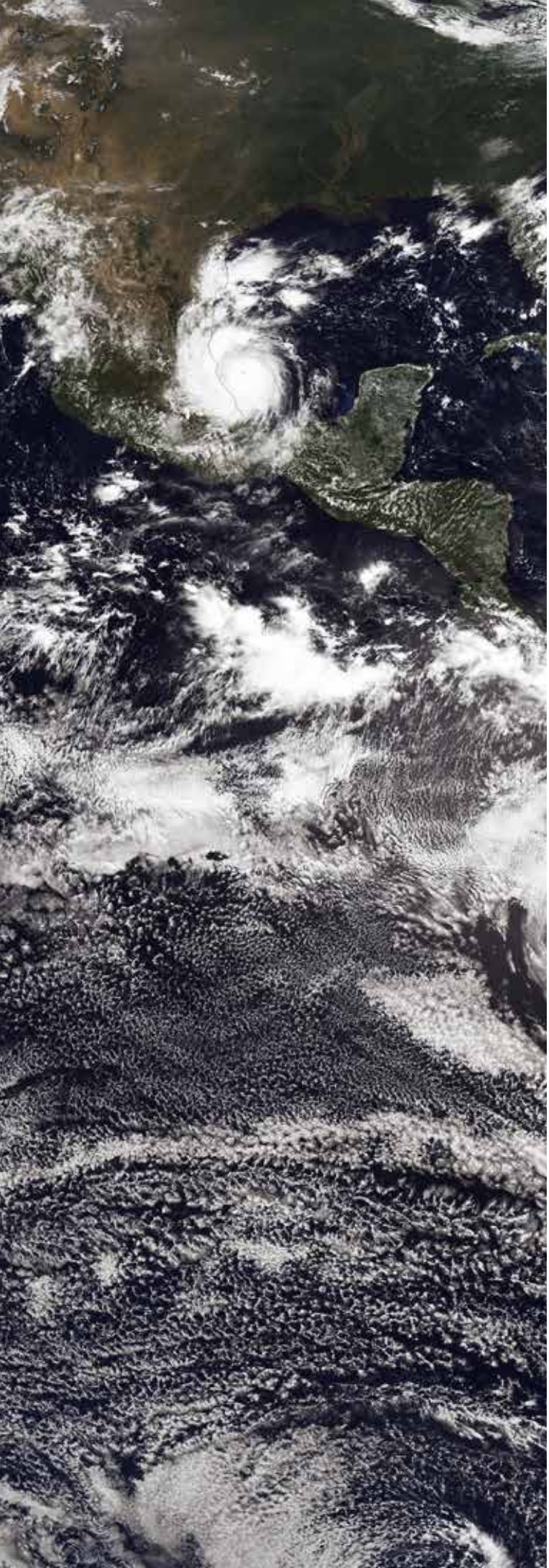


HURRICANE SHIFTS

Trends show stronger, slower and far-reaching storms

by Eric Verbeten

A new normal is taking shape as a warming planet is changing hurricane behaviors and patterns. Research over the last decade has shown alarming trends resulting in more destructive hurricanes. Global trends suggest hurricanes are getting stronger, moving more slowly over land and deviating farther north and south of the equator.



With these changes come stronger winds, increased flooding, and risks posed to cities that historically have not been hit by these types of storms.

Also known as tropical cyclones or typhoons, hurricanes are low-pressure storm systems that form over warm ocean water and can strengthen to massive sizes, bringing with them heavy rain, intense wind and storm surges. They can even spawn tornadoes.

James Kossin has been studying hurricane patterns for more than 30 years as a researcher with the NOAA National Centers for Environmental Information. He is based at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies.

Kossin's latest research, published in May 2020 in the Proceedings of the National Academy of Sciences, examined more than 40 years of hurricane data captured by weather satellites from 1979 to 2017. His analysis revealed an increasing trend of higher maximum sustained winds in hurricanes.

In short, stronger hurricanes.

"What we're finding globally is about six percent per decade of change," says Kossin. "If you have a hurricane, there is an increased chance of it being at major hurricane intensity compared to storms in past decades."

Hurricanes begin their lifecycle as smaller tropical depressions but are not classified as a major hurricane until wind speeds exceed 178 kph (111 mph). Kossin's work suggests hurricanes globally are now about 25 percent more likely to exceed this sustained wind speed threshold, compared to 40 years ago.

Kossin's hurricane intensification research adds to a growing body of work on other hurricane attributes that are affected by a warmer planet, like

◀ **Left and right images show three concurrent Atlantic hurricanes captured by geostationary weather satellite GOES-East on Sept. 08, 2017. The three hurricanes, Katia, Irma and Jose were among several destructive storms that year which devasted many parts of the Caribbean, Gulf of Mexico and the US. Credit: CIMSS and Rick Kohrs**

hurricane slowdown and migration. While high winds due to intensification pose serious risks to cities and its residents, the flooding caused by hurricanes is the deadliest impact.

Hurricane slowdown

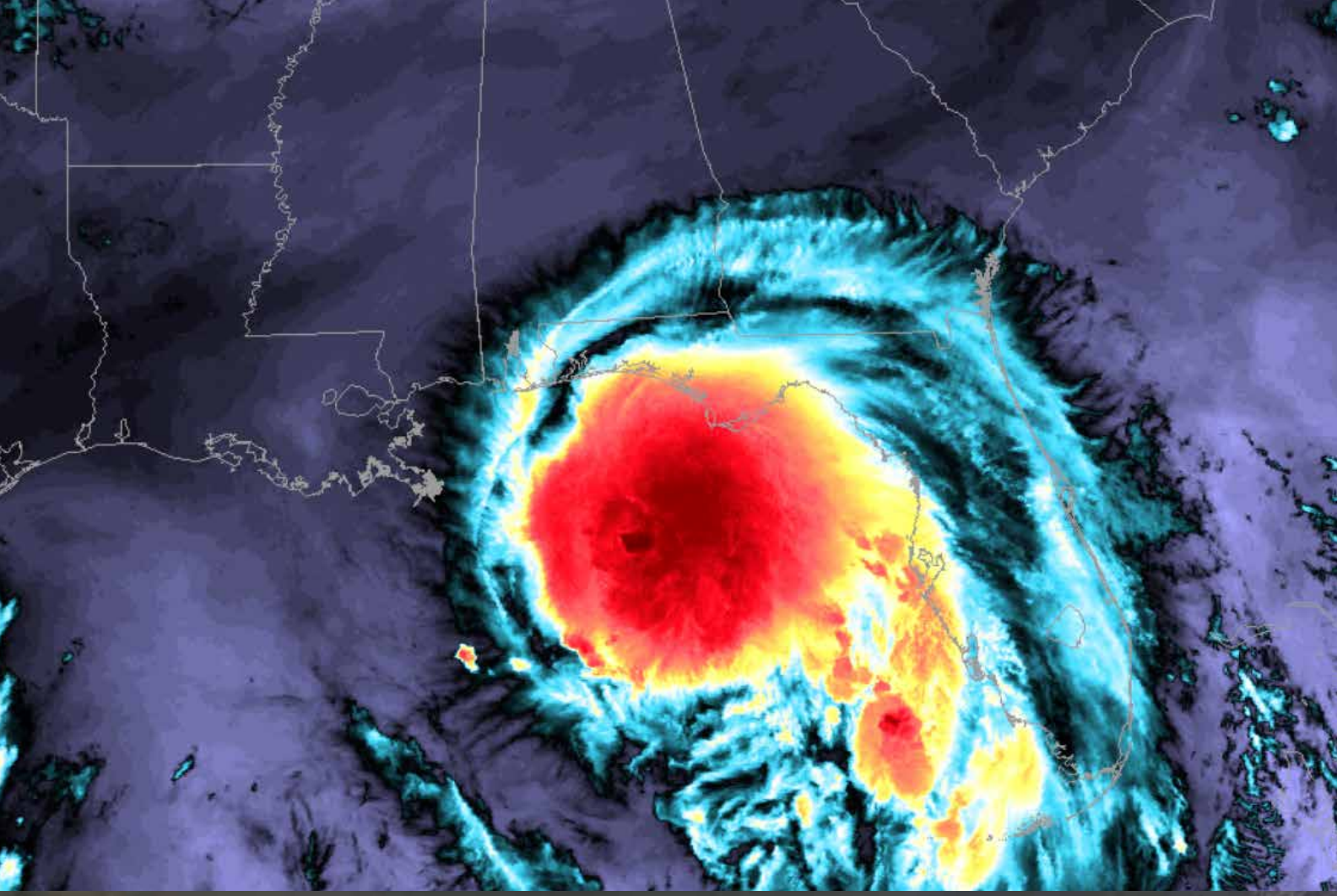
In a related paper published in *Nature* in 2018, Kossin compared 68 years (1949-2016) of worldwide hurricane track and intensity data (known as best-track data) from NOAA and other agencies to identify changes in forward translation speeds – the speed at which a hurricane moves. Kossin found that, worldwide, hurricane translational speeds have slowed down by an average of 10 percent.

"Just a 10 percent slowdown in hurricane translational speed can more than double rainfall totals caused by a one-degree Celsius increase of global warming," says Kossin.

In 2017, Hurricane Harvey spent several days over Houston, Texas, dousing the city and surrounding areas with more than 127 centimeters (50 inches) of rainfall. Similarly, in 2020 Hurricane Sally inundated states like Florida, Mississippi and Alabama when the storm "stalled" because it lacked a high-pressure system to push it back into the North Atlantic Ocean.

> "Just a 10 percent slowdown in hurricane translational speed can more than double rainfall totals caused by a one-degree Celsius increase of global warming." — James Kossin

The slowing hurricanes are likely to be a result of high- and low-pressure systems becoming more balanced. A warming planet smooths out these differences between the two pressure systems resulting in less forceful movements needed to push hurricanes along. Additionally, a warmer atmosphere holds more moisture, allowing for an already saturated storm like a hurricane to carry more water and drop it over land. Roughly, a one-degree Celsius difference in atmospheric temperatures translates to an atmosphere that can hold seven percent more moisture.



When comparing hurricane tracks during their time over land and water, the study reveals regional variability in the slowdown rates of hurricane translation speeds.

There are four distinct hurricane regions around the globe and each one is experiencing different rates of slowing. Over the past 68 years, the North Atlantic Region has seen a slowdown of six percent, while the Western North Pacific Region, an area that includes southeast Asia, has experienced a slowdown of 20 percent, the most significant of all of the regions. Kossin identified a reduction of 15 percent for the nearby Australian Region and the US has seen a slowdown of 17 percent since 1900.

Although Hurricane Harvey's and Sally's behaviors are not directly attributable to climate change, Kossin says storms like these are examples of the increased risks cities face when storms slow down.

▲ **NOAA scientist James Kossin has been studying hurricanes for more than 30 years. His research has shown a number of startling changes in hurricane behavior which results in more deadly and destructive storms. Credit: Bryce Richter**

Poleward migrations

Most hurricanes form and are sustained in warm ocean waters of 26°- 32° Celsius (80°-89° Fahrenheit). Those warm temperatures are typically found within an area north and south of the equator. Kossin's research from a 2014 paper in *Nature* identified a trend of hurricanes traveling beyond their usual ranges — reaching farther north and south.

Referred to as poleward migration, the analysis was based on 30 years of hurricane data and looked at where the storms reached their maximum sustained winds. Over those three decades, Kossin identified a shift of 53 kilometers (32 mi.) per decade in the northern hemisphere, and 62 kilometers (38 mi.) per decade in the southern hemisphere. The study further breaks down specific hurricane regions like the North Atlantic and the Western North Pacific.

"This can have huge impacts to cities that are not used to seeing these types of storms hit their shores," says Kossin. "Since the research came out in 2014 we continued to look at these trends and we now have a medium confidence that the polar migration in the Western North Pacific Ocean has a human fingerprint on it."

This means that anthropogenic climate change is — in part — causing these hurricanes to reach beyond their typical boundaries, at least in certain regions. Further, it indicates that ocean temperature increases are not the only forces driving hurricane development. A warming planet also interferes with global wind patterns.

As a hurricane travels farther north and south from the tropics, it encounters stronger vertical wind shear, which can distort the hurricane and weaken it. However, due to climate change, wind shear at certain latitudes is thought to be diminished, enabling the poleward shift.

Continuing to assess the impact of climate change on hurricanes will be instrumental to protecting communities most affected by these devastating storms. With each new year of hurricane data, Kossin has more observations to study and map out the trends — whether it's hurricane strength or movement over time. To date, his research results raise concerns.

"It's becoming increasingly clear that tropical cyclone behavior is changing in very dangerous ways all across the globe as the planet warms," says Kossin.

This work is supported by NOAA.

◀ **Two images (color-enhanced infrared and true color) capture Hurricane Sally in 2020. A storm that "stalled" and dumped massive amounts of rainfall over parts of Southeastern US. Credit: Rick Kohrs and CIMSS**

The Verner E. Suomi Scholarship recipients

by Jean Phillips

Three high school seniors, who hail from Wisconsin to as far as Oregon State, were awarded the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies Verner E. Suomi Scholarship for the 2020-2021 academic year.

"We are very excited to award scholarships to these promising future scientists who each share Professor Suomi's vision for applying physics and engineering principles to solve the environmental and climate challenges of today and tomorrow," says CIMSS Director Tristan L'Ecuyer.

The $2000 Verner E. Suomi Scholarship is awarded annually to one or more college-bound high school seniors who exhibit outstanding achievement in the physical sciences and who plan to attend a University of Wisconsin System school for their freshman year. As founder of the Space Science and Engineering Center and CIMSS, Professor Suomi is considered one of the most influential meteorologists of the 20th century. His academic interests spanned the fields of engineering to atmospheric science and he was known for his genuine love of teaching.

"This year's scholarship recipients also embody CIMSS' desire to increase diversity in STEM," says L'Ecuyer. "We hope to inspire others from under-represented groups to pursue careers in the environmental sciences or related fields."

Hansi Bartle

From Science Olympiad to advanced placement courses, Hansi Bartle of Brooklyn, Wisconsin, invites challenges rather than shying away from them, an attitude that she will bring to her studies at the UW–Madison College of Engineering in Fall 2020. Bartle says that she discovered her love for aeronautics while participating in a Science Olympiad event that required teams to build and design a model plane that could fly long distances. She would like to extend her interest in aeronautics to "developing a cheaper and environmentally friendly way of utilizing aircrafts."


Credit: Hansi Bartel


Credit: Saksen Hathaway

Saksen Hathaway

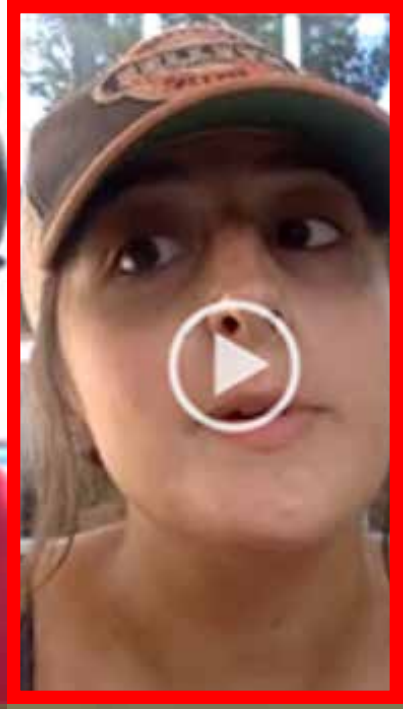
Saksen Hathaway, of Portland, Oregon, notes that her interest in environmental science was sparked in fifth grade when she participated in a water quality experiment that involved pH testing of ponds and streams near her home. That interest has persisted. A recent high school project involved pH testing of soil from wetlands on her campus. Further extending the experiment, Hathaway discovered another study that had examined soil pH after the eruption of Mt. Saint Helens in Washington State. She was able to compare her locally-gathered data to data that had been collected and analyzed after a significant environmental event. "I cannot wait to build off of what I have learned," she says. Hathaway will study environmental science at the UW–Madison.

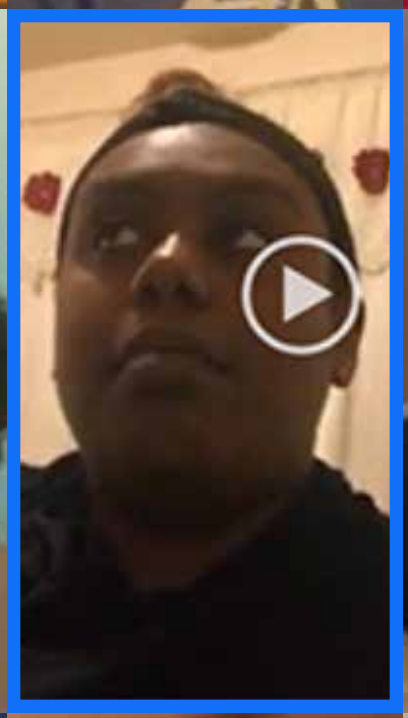
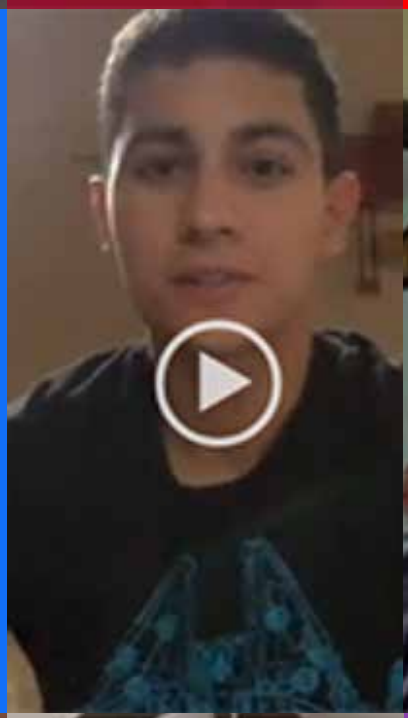
Naomi Raicu

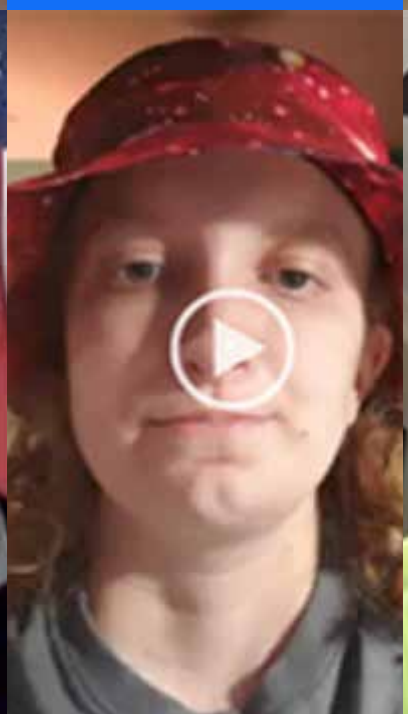
A senior who lives in Shorewood, Wisconsin, Naomi Raicu characterizes her passion for physics as a drive to understand the rules of the game, whether in literature or science. She quickly realized that "since physics requires this process of questioning and reflection that I regularly employ in my studies, I simply had to pursue the subject." Raicu's dream is to employ her background in physics, along with a dose of creativity, to work towards solutions to our changing climate, possibly working on developing alternative forms of energy. In addition, she plans on mentoring girls, "especially immigrant girls like myself, to inspire them to pursue careers in STEM." Raicu will enter the UW–Milwaukee in Fall 2020.


Credit: Naomi Raicu



AOS 102

by Callyn Bloch

"Climate change, while it may be something very big and obscure to many people, as it was to me, should actually be something we take very personally. That would benefit us in ways we wouldn't expect, it will make us healthier in our lifestyles and will make us even more culturally aware. For these reasons I think everybody should have at least a basic knowledge of climate change and what's going on in our world." — Kate

"Climate change shouldn't be seen as a political issue or a topic that people have sides on or debate on. We need to realize it's a reality for our planet and its something we need to work toward diminishing." — Damitu

"There's so much information and it all seems so overwhelming. But I feel like the first place to start making a change is to start having conversations like these and educating yourself on this topic." — Maleee

For nearly a decade, the Cooperative Institute for Meteorological Satellite Studies Education and Public Outreach Director Margaret Mooney has taken up the challenge of designing a course for non-atmospheric science majors at the University of Wisconsin–Madison to teach them about the essentials of climate change.

Titled AOS 102, the course aims to give students a basic understanding of the science behind Earth's climate and how it is changing. The curriculum was developed collaboratively between staff at the UW–Madison Department of Atmospheric and Oceanic Sciences and CIMSS. Since its inception, Mooney has co-taught the course with AOS Professor Steve Ackerman. In Summer 2020, a total of 78 students completed the eight-week online course.

At the beginning of the course, students are polled about their knowledge and beliefs about climate change, and are re-tested at the end. Historically, students have come away with increased climate literacy. In the last week of class, students are tasked with a video project to give an elevator pitch to answer the question: 'So what do you think about climate change?'

"It's really my favorite week of the semester," says Mooney. "This year's [videos] were so powerful."

Mooney and her colleagues published a paper in 2020 in the *Bulletin of the American Meteorological Society* that details the syllabus, as well as the students' climate literacy before and after the course.

The quotes above exemplify the wide range of student perspectives, viewpoints and ways to talk about climate change.

Visit the AOS 102 website to watch the other powerful student responses.


Credit: Eric Verbeten

Tristan L'Ecuyer wins AGU Ascent Award

by Jean Phillips

Tristan L'Ecuyer, director of the Cooperative Institute for Meteorological Satellite Studies and professor of atmospheric science at the University of Wisconsin–Madison has been selected to receive the 2020 American Geophysical Union's Atmospheric Sciences Ascent Award. The award recognizes exceptional mid-career scientists.

L'Ecuyer is being honored for his innovative leadership and influential research that utilizes satellite remote sensing to advance our understanding of the Earth's climate system. His cross-disciplinary research is increasingly important as evidence mounts about global climate change and policy makers look to science for guidance on measures to address the problem.

"I am honored to be recognized by the AGU for my contributions to advancing the use of satellite observations in climate research," L'Ecuyer says. "Through global coordination, satellite observations provide a unique and irreplaceable view of our planet that will play a key role in mitigating the impacts of climate change."

Ascending, and accelerating, are apt descriptors of L'Ecuyer's career trajectory. Associate Dean for Research at Texas A&M University Ping Yang notes in his nomination letter, "L'Ecuyer is in the unique position of simultaneously leading a NASA mission to observe the polar energy budgets and directing a large, National Oceanic and Atmospheric Administration cooperative institute whose mission is to address the nation's weather and climate needs."

NASA and NOAA have long worked together to transfer NASA research results into NOAA operational programs. L'Ecuyer has leveraged his expertise that intersects both agencies to promote stronger and better coordination of the US Earth observing satellite program. To that end, he is an invited member of NASA and NOAA committees that are defining observational requirements, science objectives and satellite observing system architectures for the future.

According to Yang, L'Ecuyer has published some of his most influential work in the last few years. In 2015, he led a large team of researchers for a NASA-funded study that constructed state-of-the-art views of Earth's energy and water cycles. "This work has become the benchmark against which modern climate models are being assessed," says Yang.

As a professor, L'Ecuyer is known for involving graduate students in his programs, in conducting the research and publishing the results. Since arriving at UW–Madison, he has mentored and graduated 19 students, many of whom are now making their own important contributions to the field.

Through his leadership nationally and internationally, L'Ecuyer is poised to influence the future direction of global observations and their crucial role in climate science.

The award will be presented to L'Ecuyer, along with three other recipients, at the AGU Fall Meeting in December 2020.

NESDIS Outstanding Science and Research Awards

by Callyn Bloch

In late 2020, three scientists with the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies received the 2020 NESDIS Outstanding Science and Research Award, one for geostationary research, and the other two for polar orbiting research.

CIMSS scientist Anthony Wimmers received the 2020 NESDIS award for developing a novel and innovative probabilistic turbulence detection product using the GOES-16/17 Advanced Baseline Imager. The high-resolution imagery from the ABI can better resolve turbulence signatures at high levels of the atmosphere not captured in current forecast models. An important applied outcome of this research is pinpointing the location of thunderstorm updrafts that can be hazardous to aviation. Wimmers' colleagues in the GOES-R Series Office nominated him for this award.

Jay Hoffman and William Straka III also received the NESDIS award for their work in producing a satellite-based flood detection map from daytime Suomi-NPP/VIIRS data. Their contributions provided "critical operational capabilities to Alaska forecasters during Spring Break-up." These flood products are now available internationally through GEONETCast-Americas and GEO-GloWS. Colleagues in the Joint Polar Satellite System Office nominated Hoffman and Straka for the award.

Anthony Wimmers Credit: Eric Verbeten

Credit: Jay Hoffman

William Straka III Credit: Eric Verbeten

UW–Madison Chancellor's Award for Excellence in Research

Critical Research Support

by Doug Erickson


Credit: Karen Moncher

Jerrold O. Robaidek, manager of Satellite Data Services at the Space Science and Engineering Center, was the 2020 recipient of the Chancellor's Award for Excellence in Research: Critical Research Support.

Guided by the principles of the Wisconsin Idea, Robaidek has extended and enhanced the research capabilities of scientists worldwide through his expert management of the Satellite Data Services facility at SSEC.

"Through his dedication, initiative, creativity and professional relationships, Jerry has built upon our national reputation as the premier source for high-quality satellite data and is an outstanding representative of the core values of our university."
— R. Bradley Pierce, Director, Space Science and Engineering Center

Robaidek makes sure clients in both the public and private sectors have 24/7, unfettered access to the latest weather satellite data. It's not a stretch to say his work impacts everything from public safety to the global economy.

Yet colleagues say Robaidek bears this responsibility with enthusiasm and energy. As the leader of the Satellite Data Services group, he's known as an effective, yet humble, supervisor and mentor.

Nationally, Robaidek is praised for designing and implementing innovative software and online projects that have dramatically improved access to historic satellite datasets — an effort that one NASA scientist calls "a game-changer for many researchers."

One of Robaidek's most recent innovations involves the Unidata Internet Data Distribution project, which supplies meteorological products to more than 150 universities and colleges for research and educational purposes. Robaidek, tasked with providing data to the project's partners, led an effort to migrate the data archive to a file system that can process hundreds of simultaneous accesses, thereby dramatically increasing the data processing environment.


Credit: Eric Verbeten

Tim Schmit honored with agency award

by Jean Phillips

National Oceanic and Atmospheric Administration scientist Tim Schmit was one of several honored with the 2020 NOAA Administrator's Award for "achieving a fully operational GOES-R constellation, culminating a decades-long effort to bring a new generation of NOAA satellites into service."

To say that Schmit has been involved with the entire GOES-R constellation is no exaggeration.

Planning for the GOES-R series of satellites, which now includes GOES-16 and -17, began in the late 1990s. Even then, Schmit was one of the scientists advocating for the most advanced imager with the most spectral bands — 16 in all — knowing that the instrument lifespan would be at least a decade.

That persistence resulted in the Advanced Baseline Imager, or ABI, on GOES-16 and -17 (GOES-East and -West). The ABI allows for frequent imaging with rapid refresh rates over the contiguous US. Schmit and others saw the utility of frequent imaging to forecasters especially during extreme weather events like fires, tornadoes or hurricanes.

Schmit has been deeply involved in the formal process of reviewing ABI imagery from both satellites for its integrity and reliability. In either satellite's case, the imagery has now passed to "full-maturity stage" which means that known anomalies have been documented and shared with the scientific user community, says Schmit.

However, reaching that milestone for GOES-17 proved to be more difficult. Shortly after the satellite reached its orbit, the loop heat pipes designed to cool the ABI detectors began to overheat from exposure to the sun resulting in data that were unusable. NASA and NOAA responded by forming teams to analyze the overheating problem. Schmit, along with scientists at CIMSS, helped develop a unique data quality flag that involved monitoring precisely when the data were degraded due to temperature changes and then, monitoring the calibration algorithm to accommodate those changes.

Weather satellites are a complicated business. Scientists like Schmit have dedicated their careers to making sure that the instruments on them are designed to return data and imagery of the highest quality for the benefit of science and the public. Also on their minds is planning for the long-term success of these satellite missions, as the GOES-R project extends into the next decade with future missions of GOES-T and -U.

Schmit is quick to acknowledge that his research is not a solitary pursuit. "My work with the GOES-16 and -17 ABIs was supported by many at SSEC and CIMSS, including my colleagues in SSEC Satellite Data Services and the GOES Algorithm Working Groups, especially the imagery team."

The NOAA Administrator's Awards recognize employees who have demonstrated exceptional leadership, skill and ingenuity in their significant, unique and original contributions that bring unusual credit to NOAA, DOC and the US Federal Government.

Credit: Anne Sledd

STUDENT RESEARCH

CONTRIBUTIONS TO CLIMATE SOLUTIONS

by Jean Phillips and Eric Verbeten

As part of the University of Wisconsin–Madison, the Space Science and Engineering Center and the Cooperative Institute for Meteorological Satellite Studies are known for providing experiential research and learning exposure to undergraduate and graduate students. These experiences, as the following two stories suggest, offer training opportunities for future scientists while leveraging their creative approaches to help solve real world problems in science, technology, engineering, mathematical and climate fields.

Anne Sledd

WHY STUDY CLIMATE?

"Bluntly, studying climate is important because we live in it. In addition to the lofty ideal of furthering humanity's knowledge, studying climate also has real-world implications for us since it impacts all manners of society — agriculture, resources, cultures. Understanding how our environment behaves and how it's changing is especially critical given the impacts of global climate change already being observed."

Anne Sledd is a graduate student with the University of Wisconsin–Madison Department of Atmospheric and Oceanic Sciences who also works with CIMSS scientists to better understand how clouds and cloud cover regulate Arctic temperatures.

Her recent research, published in 2019 in the journal *MDPI Atmosphere*, investigates Earth's albedo (or reflectivity) and how changes on the surface impact the albedo higher in the atmosphere. Pairing satellite data and climate models, Sledd has begun to document how the Arctic is changing and estimate how it might change in the future.

"The Arctic is an important area to study because it is warming at a higher rate than the rest of the globe," says Sledd. "In the past few decades it has warmed 2-5 degrees Celsius, that's 2-3 times greater than the rest of the world has seen."

Energy from the Sun enters the atmosphere as short-wave radiation which is absorbed by the Earth's surface. Generally, darker surfaces like land and ocean water absorb short-wave energy more rapidly than reflective surfaces like sea ice or snow cover (such as in the Arctic). The absorbed energy radiates back toward space in the form of long-wave radiation, but due to the composition of the atmosphere, some of that long-wave radiation never escapes. That stored radiation heats the planet.

This interplay between surface and upper atmosphere albedo is a focal point for her research. She says that while a decrease in sea ice and snow cover result in a lower surface albedo, the atmospheric albedo decreases only half as much as on the surface. This supports the idea that atmospheric albedo is influenced more heavily by other factors such as clouds and is less affected by changes on the surface.

"The Arctic is the 'canary in a coal mine' for global climate change, but we still have a lot to learn about it," says Sledd.

Chuck White

WHY STUDY CLIMATE?

"It impacts everyone. We only get one planet and it's our home and we have to look after it. Studying climate change and understanding it — and preventing it to the extent we can — is crucial to society as a whole. We've grown accustomed to the current climate we have now. The rate that it's changing currently has huge social and economic consequences."

Chuck White is a graduate student in the Department of Atmospheric and Oceanic Sciences and has been working with SSEC and CIMSS scientists to use artificial intelligence to detect the presence of clouds in satellite data.

Weather satellites have played a major part in understanding our climate through continuous data collection since the late 1960s. However, crucial measurements needed to determine the current state of our climate — such as sea surface temperatures or lake temperatures — can be thrown off or obscured by clouds. From a satellite's point of view, it struggles to identify cloud cover over places like the Arctic due to similarities in ground temperatures and the low-altitude clouds.

"Cloud properties are critical to our understanding of weather and climate variability," says White. "Clouds are one of the biggest uncertainties in future climate projections and knowing whether or not a cloud is present is the most fundamental of cloud properties."

Using machine learning techniques, White compares a large database of images captured by the VIIRS imager (onboard the Suomi-NPP satellite) to measurements captured by NASA's CALIPSO satellite. After running several training modules, the accuracy of the algorithm increases and becomes more consistent, with early results showing improvements of 10 to 25 percent in cloud detection over regions like Antarctica and Greenland.

"The goal is to develop methods that help us better understand one part of the climate system," says White. "Building confident observational records of global cloud properties helps give context to our current climate and allows us to more accurately diagnose current observed trends and assess future climate projections."

Credit: Chuck White

Credit: Alexa Ross

Badger Summer Scholars

Creating a virtual experience for high school students

by Leanne Avila

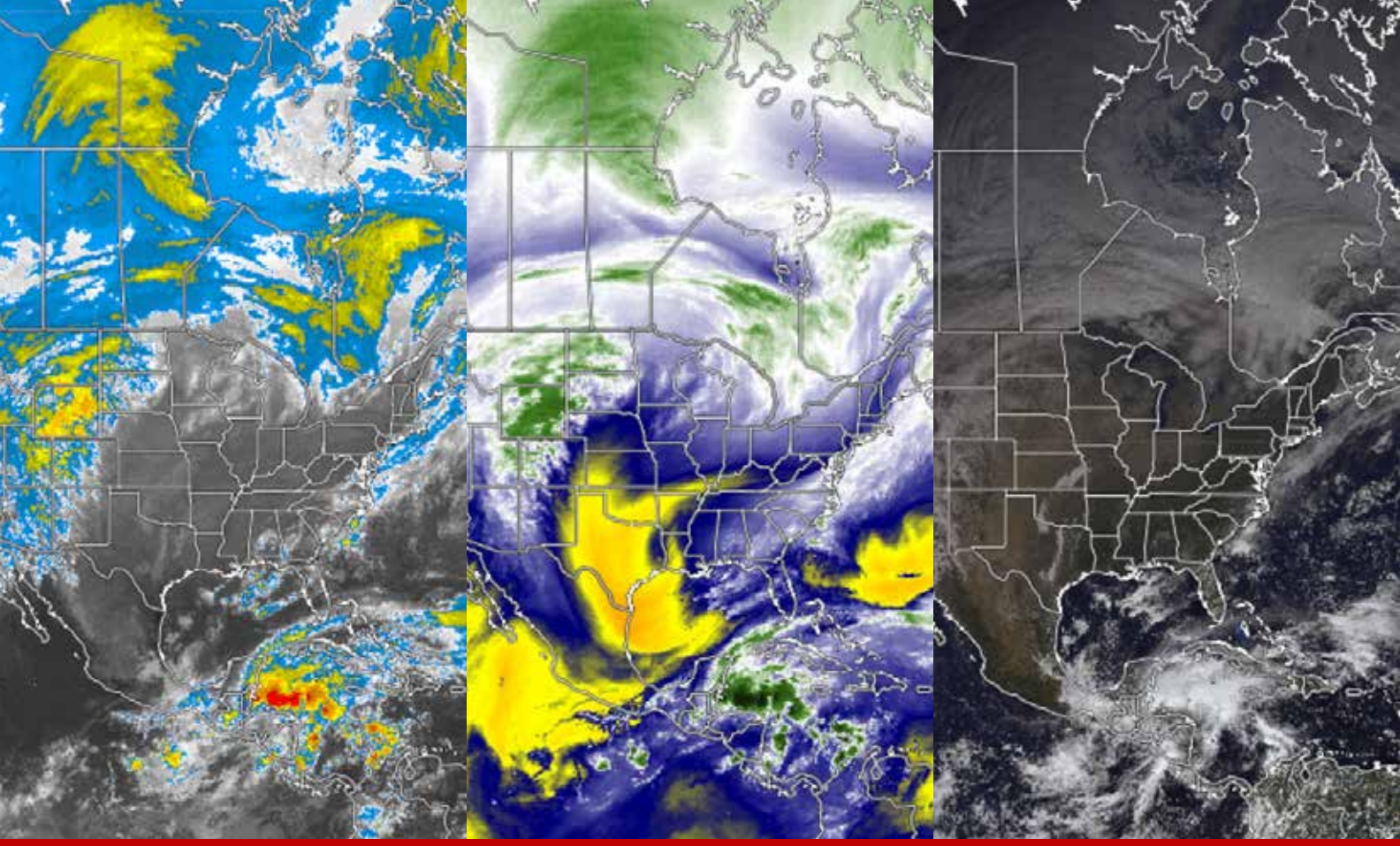
COVID-19 has turned education on end, including how university instructors deliver STEM learning experiences to high school students.

Earlier this year Space Science Engineering Center researcher Alexa Ross was creating the curriculum for what would become the inaugural "Satellite Science and Programming for Meteorology" residential camp for high school students. It was set to be part of the Badgers Summer Scholars program offered through the University of Wisconsin–Madison's Badger Precollege.

Unfortunately, due to COVID-19 and the cancellation of in-person programming at the UW–Madison over the summer, Ross and co-collaborators, Margaret Mooney (Director of Education and Public Outreach at the Cooperative Institute for Meteorological Satellite Studies) and Scott Lindstrom (SSEC scientist) had to rethink whether, and how, they might repurpose their content to share with students and teachers at home.

In June, Chris Harry, assistant dean for Badger Precollege, contacted the team to see if they would be interested in creating a video to be posted on the Badger Precollege YouTube channel as part of their Enrichment Wednesdays series.

To take advantage of the visual YouTube format, Ross compiled and created a series of movie clips that would allow viewers to learn more about weather satellites and the data that they provide. An introductory lesson on weather satellite history and basics had already been developed by SSEC's Rick Kohrs and Clayton Suplinski for use on a 3D globe for SSEC outreach. Ross then narrated a screen demonstration of RealEarth, an



▲ **Alexa Ross (opposite) narrates a video on RealEarth weather satellite imagery for the UW-Madison Badger Summer Scholars program. The video highlights the advantages of the different types of available imagery such as infrared (left), water vapor (middle) and true color (right) images from GOES-East. Credit: SSEC**

SSEC-developed software tool to visualize satellite data and imagery — highlighting the different imagery types available from one of the latest geostationary satellites, the Geostationary Operational Environmental Satellite GOES-16.

"The goal of the video is to give precollege students a taste of what they would have learned in person," says Ross.

Ross focused on the specific benefits of a few different spectral bands available on GOES-16 and what information each provides, whether it's tracking cloud features and severe storms or monitoring hurricanes.

Despite the cancellation of this year's in-person programming, Ross remains hopeful that the Badger Summer Scholars camp might be available next year. She looks forward to working with students and providing them with a positive precollege experience.

In addition, she is proud of SSEC's commitment to serving underrepresented students: SSEC had set aside funding for five scholarships for students to attend this year's camp and learn more about satellite meteorology. She hopes to be able to award those scholarships next year.

For now, the video serves as a mini preview of not just the camp, but also the power of technology and the beauty that is our planet.

Watch the YouTube video: https://www.youtube.com/watch?v=rNt80G5Wf-U

This work is supported by SSEC2022 and the University of Wisconsin–Madison Badger Summer Scholars program.

AOSS 2020 photo contest

For the 10th year, the 2020 Atmospheric, Oceanic, and Space Sciences Photo Contest showcases the passions of weather photographers — university students, scientists, staff and professors — as they seek to understand and capture our natural world through the camera's lens. Their pictures offer glimpses into the intricacies, and mysteries, of our atmosphere. See all the other submissions here.

1st place
Isaac Schleusche
Auroras over northern Minnesota

2nd place
Sarah Griffin
Lightning over the family farm

3rd place
Shane Hubbard
Stormy seas at sunset

From senior scientists to promising students, our climate research spans the globe, involving researchers at every stage of their career.

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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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