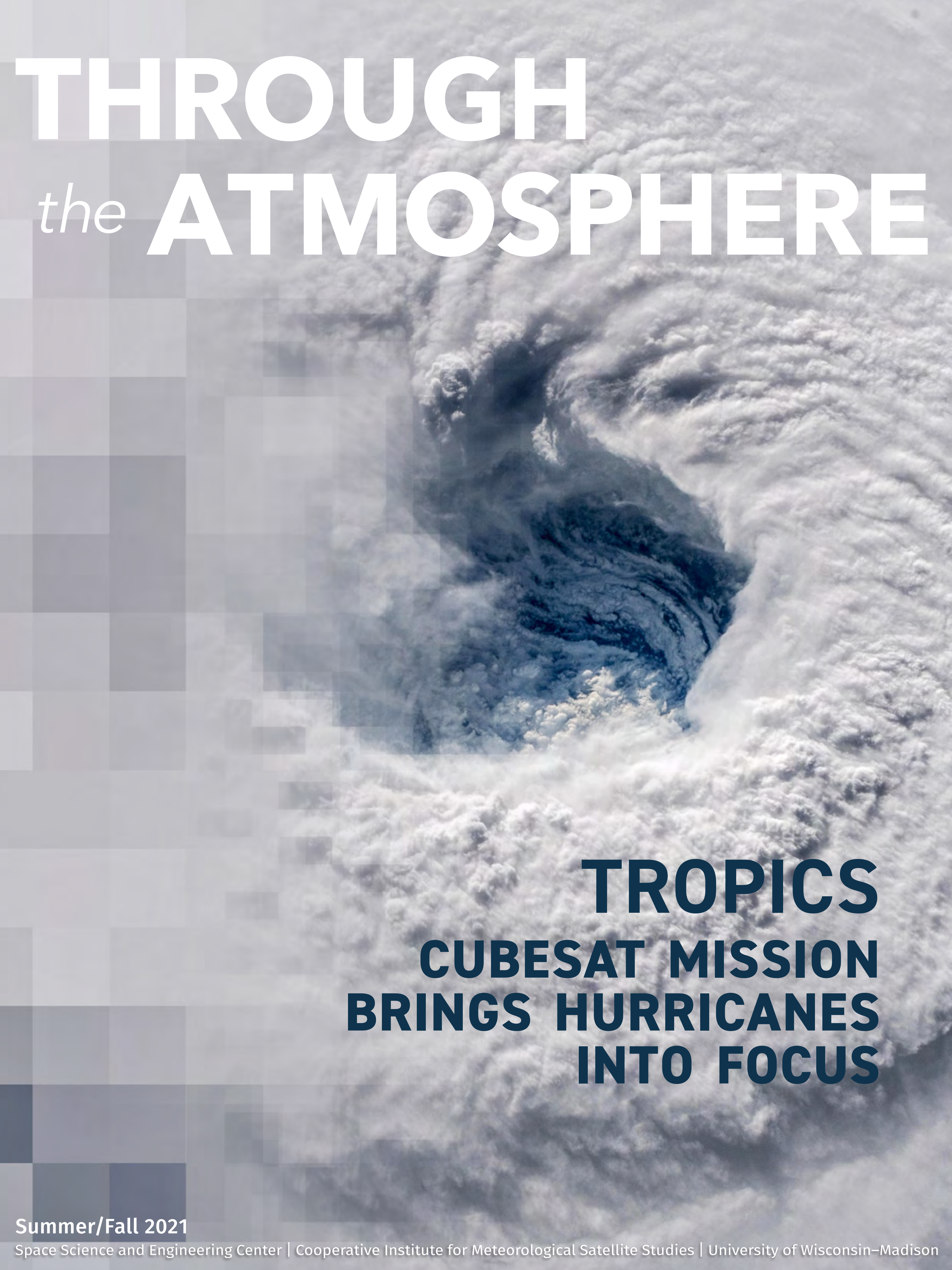
THROUGH *the* ATMOSPHERE



TROPICS CUBESAT MISSION BRINGS HURRICANES INTO FOCUS

Summer/Fall 2021

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

Director's note

Imagining the impossible. We've come a long way since Verner Suomi, founder of SSEC, envisioned Earth observing satellites carrying instruments that would return data that was freely shared for the benefit of global citizens. He was, by many accounts, ahead of his time.

That spirit continues.

Earth Science has traditionally relied on large satellites to deliver data that informs research about our atmosphere. But now, two pioneering NASA missions, PREFIRE and TROPICS, are being developed by a new generation of scientists at SSEC and CIMSS. They are part of a paradigm shift. Both missions are employing the newest, miniaturized technologies in the form of CubeSats — from mission design to launch in just a few years versus a decade or more for larger satellites.

And both missions are poised to quickly deliver crucial information ranging from radiant energy in the Arctic to the mechanics of mid-latitude tropical cyclones on a time scale that was unthinkable 50 years ago.

As our climate warms — Arctic icesheets are melting and threatening habitats, tropical cyclones are increasing in intensity and threatening coastal cities — Earth System science has never been more important. PREFIRE and TROPICS, along with other research at SSEC and CIMSS, from droughts to precipitation, are among the programs charting new paths to a sustainable future.

We imagine the impossible and make it reality.


Credit: Bryce Richter

Brad Pierce
SSEC Director


Credit: Bryce Richter/UW—Madison

THROUGH *the* ATMOSPHERE

Summer/Fall 2021

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).

If you would like to be added to our mailing list, please contact Maria Vasys: maria.vasys@ssec.wisc.edu, or view the latest issues online at ssec.wisc.edu/through-the-atmos

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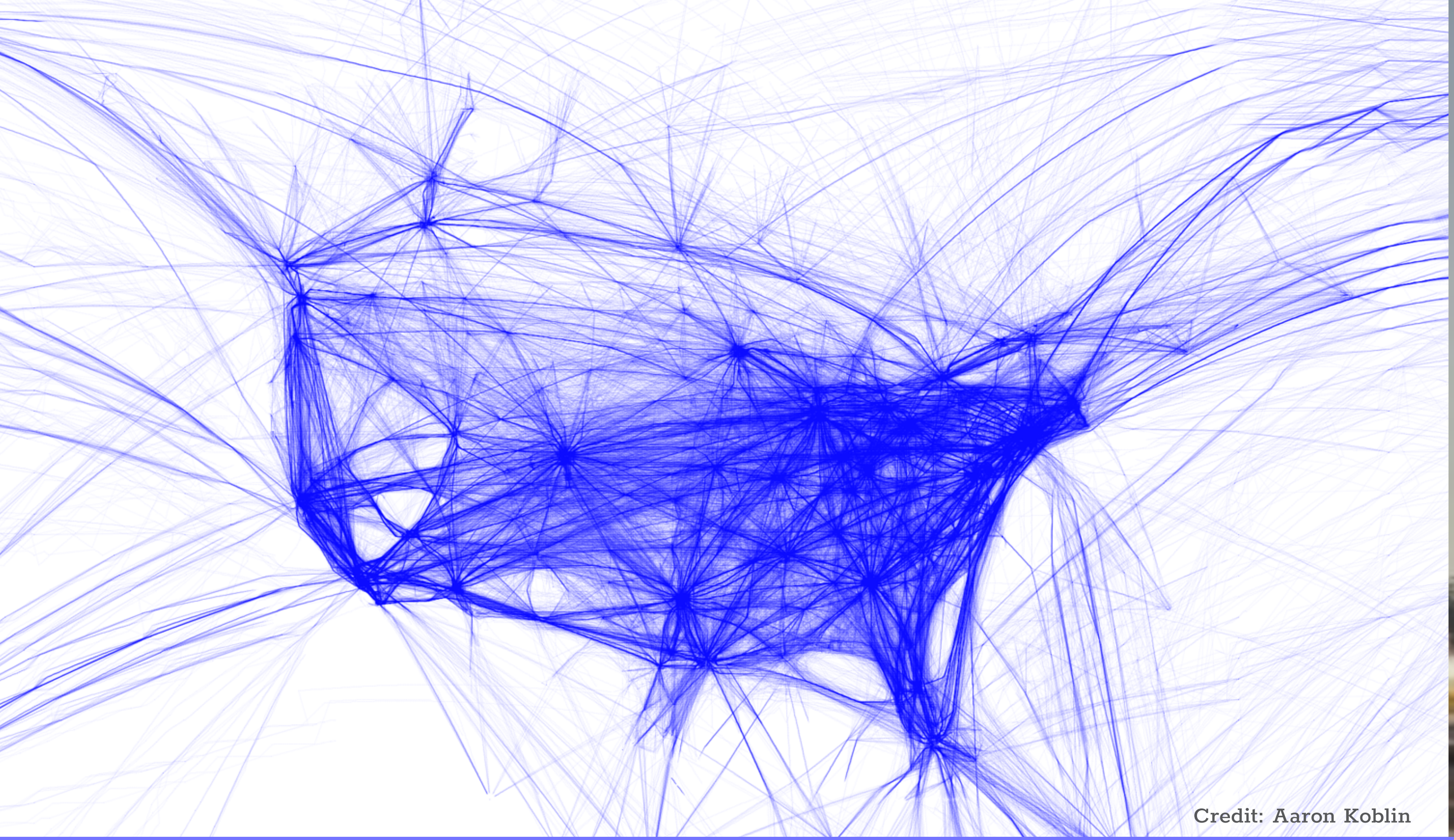
Cover image

Hurricane Florence, a category 4 storm in 2018 that impacted Eastern US coastal states like North and South Carolina. Credit: NASA


Credit: Aaron Koblin

▲ To help collect more frequent weather data across the US, about 150 commercial aircraft — operated by United Parcel Service and Southwest Airlines — have been equipped with a specialized Water Vapor Sensing System. Coordinated by the World Meteorological Organization Aircraft Meteorological Data Relay program, the arrangement makes data freely available to researchers and meteorological agencies worldwide. Credit: Bilal EL-Daou

Measuring atmospheric moisture from airplanes

A new approach to fill missing data gaps

by Jean Phillips

It may be little known, but some 3500 commercial airplanes worldwide are equipped with external sensors that make atmospheric measurements on their cross-country or global journeys. Measurements like wind speed and temperature are important for safe air travel, but others, like moisture, do not provide an immediate operational benefit to aviation. They do, however, play an important role in producing weather forecasts that the industry relies on.

With its central role in Earth's weather and climate, moisture, or water vapor, evaporates from the surface and condenses to form clouds which then release precipitation in a global and continuous cycle. How much water vapor is in the atmosphere, and where, is a crucial component of numerical weather prediction.

To improve the availability of these types of measurements, graduate student Skylar Williams joined researchers Tim Wagner and Ralph Petersen, researchers at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies who, were comparing water vapor data collected from sensors on commercial aircraft to water vapor data collected from weather balloons equipped with radiosondes.

Their work built on earlier studies by using United States radiosonde data from 2015 that provided a cross-section of locations, climates and seasons. Results were published in the Journal of Atmospheric and Oceanic Technology in Spring 2021.

"Weather data can be gathered from commercial aircraft and used on a daily basis to help with forecasting and other areas," says Williams. "It is great for gap-filling data, augmenting weather balloon data or for use in places that don't have the weather data access that we do."

Twice a day, at midnight and noon Greenwich Mean Time — 7:00 a.m. and 7:00 p.m. Central Daylight Time — weather balloons are launched around the globe to collect data that provide a snapshot of the atmosphere around a given location. The US National Weather Service operates or supports more than 100 of the nearly 800 locations worldwide. Those overseen by the NWS are located in North America, the Pacific Region and the Caribbean.

Despite the fairly large radiosonde network in the US, the locations are often spaced too far apart, especially when forecasters are analyzing mesoscale features of developing storms — storms that may span up to 1000 kilometers. In these larger storms, environmental conditions on one side of the storm boundary might be different than those where the balloon launch occurred, says Williams. These differences can impact the accuracy of forecasts.

To help collect more frequent data, about 150 commercial aircraft — operated by United Parcel Service and Southwest Airlines in the US — have been equipped with a specialized Water Vapor Sensing System. Coordinated by the World Meteorological Organization Aircraft Meteorological Data Relay program, the arrangement makes data freely available to researchers and meteorological agencies worldwide.

Altogether, the aircraft transmit about 900 profiles each day that are more frequent and at a greater density than those of the US radiosonde network. In addition, aircraft take measurements every

Skylar Williams earned her Ph.D. from the University of Wisconsin—Madison. Her dissertation, "Validation of water vapor measurements from commercial aircraft across the CONUS using radiosondes," formed the basis for the peer-reviewed paper referred to in this story. Credit: Skylar Williams

100 meters during ascent and every 300 meters during descent and at cruising altitude. The result is a robust set of measurements of the boundary layer — the atmospheric layer closest to the surface where most weather occurs — as well as tropospheric measurements.

"The ascent and descent are really what we care about because that creates the profile," says Williams. "But we also get the upper atmosphere, for a top-to-bottom slice, and I don't think there is another observing system that routinely provides this except for maybe a satellite which has a coarser resolution."

These slices are especially important because water vapor distribution in the atmosphere varies horizontally and vertically.

To transmit the water vapor data, the WMO has taken advantage of an existing communications system known as the Aircraft Communications Addressing and Reporting System, or ACARS, that facilitates transmissions between aircraft and ground stations using radio or satellite links. The water vapor data are transmitted along with all of the other aircraft flight data but are encoded as atmospheric measurement data without identifying the source as UPS or other aircraft.

"Some models are ingesting these data to help improve forecasts in areas that lack enough observations," says Williams. "In the last year; however, it's been a problem because there was a huge data loss when aircraft were grounded due to the pandemic."

There are several advantages to the WVSS data collection system over the radiosonde, says Williams. The WVSS can be used multiple times whereas the radiosonde is a one-time use instrument. In addition, it is not unusual for things to go awry with weather balloons. If it pops too early, for example, no data will be returned, effectively creating a data gap for that time period.

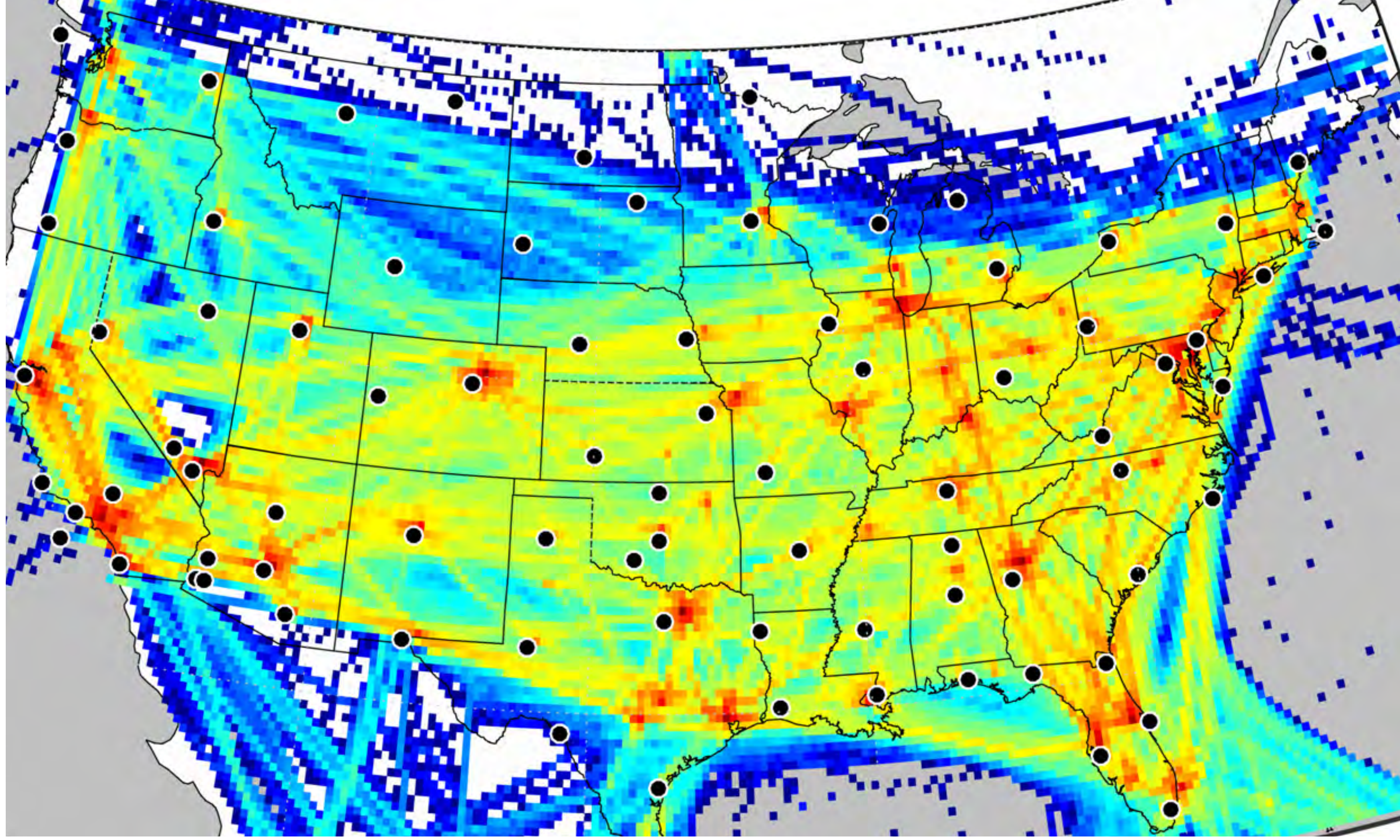
The team also considered previous research on the costs of operating both systems. Studies conducted in 2014 by the WMO and researchers at the UK Met Office showed that it is 5-8 times more costly to operate radiosondes at ten locations than it is to operate a fleet of sensors on 30 different aircraft. Radiosondes are limited to twice-daily reporting in contrast to multiple data collection instances with an aircraft-based WVSS, resulting in more profiles overall.

Expanding the number of sensors on aircraft as a way to fill gaps in upper-air observations and improve numerical weather prediction is cost effective, provides accurate data, and would not require an expansion of the US radiosonde network, says Williams.

In a return to her research roots, Williams is now an associate scientist with a company that specializes in identifying, measuring and mitigating the impact of weather on aviation. As Williams reflects on her graduate studies at UW–Madison, she does so with gratitude for the opportunity to work with Tim Wagner, her advisor at CIMSS and recommends UW–Madison to her own students.

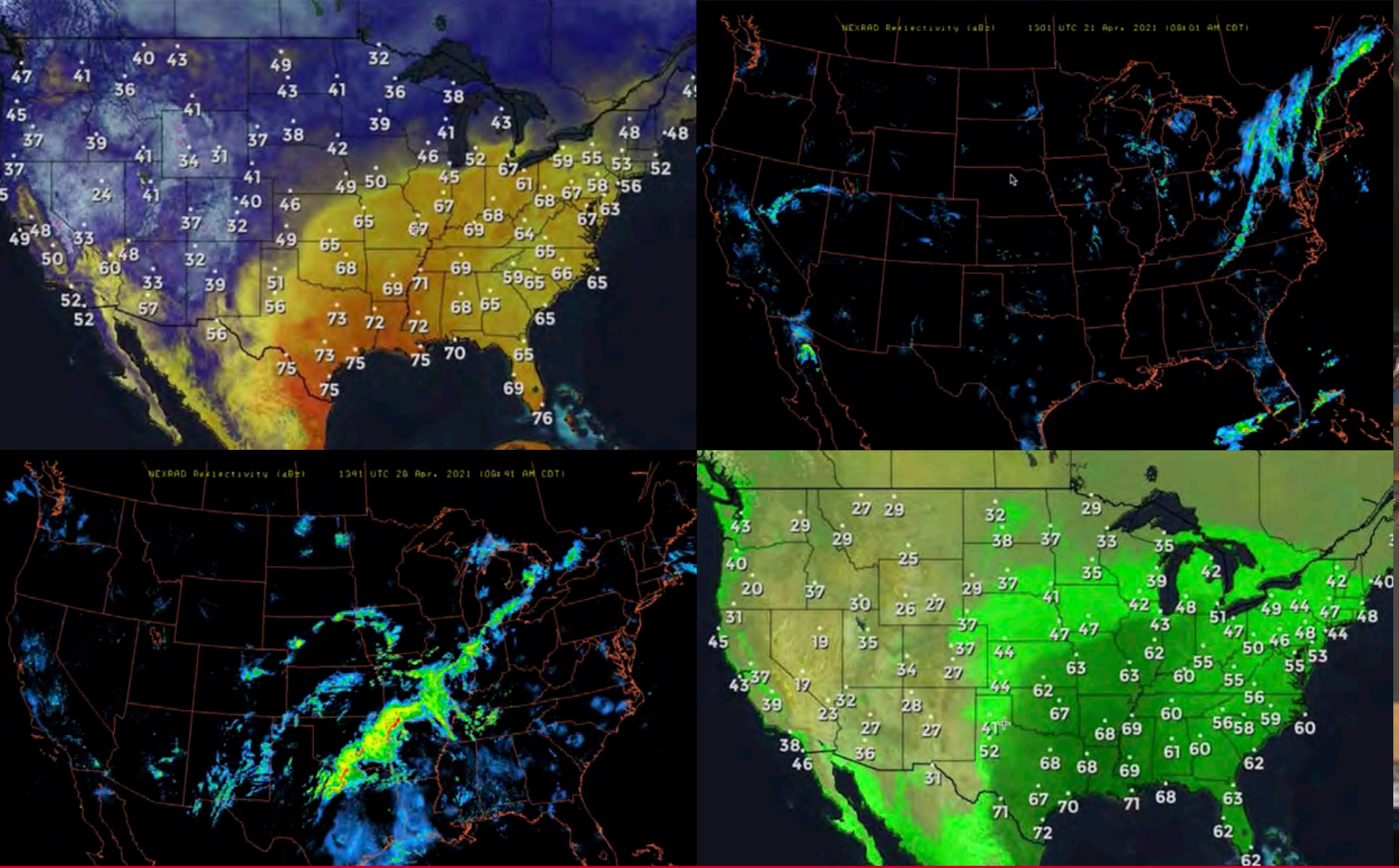
"I loved every second of grad school and this project," she says. "It confirmed for me that I wanted to do research. I don't think I could do meteorology if it were all theoretical, but the fact that people can use these data makes it the kind of work that I want to be a part of."

This research was supported by the National Weather Service Aircraft Based Observations Program through the Cooperative Institute for Meteorological Satellite Studies.



Map showing the density of the Water Vapor Sensing System observations for 2015. The black circles mark locations where the National Weather Service launches daily weather balloons. Credit: Skylar Williams

The Water Vapor Sensing System-II, mounted on the exterior of some commercial aircraft in the US and abroad, collects water vapor measurements that are used to improve forecast models. Credit: Spectra Sensors.



▲ **Jon Martin (right), professor in the UW–Madison Department of Atmospheric and Oceanic Sciences finds teachable weather moments whether on the radio or in the university classroom. Martin along with Steve Ackerman (left) host a weekly show, The Weather Guys, fielding weather questions from callers around the state of Wisconsin. Credit: Jeff Miller**

Weather discussions

Weekly weather makes teachable moments

by Eric Verbeten

A Noreaster hits New England, a tornado sweeps over the Great Plains and an atmospheric river crashes into the west coast — a lot of weather can happen in a week. For Professor Jon Martin at the University of Wisconsin–Madison Department of Atmospheric and Oceanic Sciences, these weather phenomena create teachable moments — opportunities to combine atmospheric science theory with real-world events to reinforce student learning.

As a result of lectures shifting online in 2020, Martin adapted his regular curriculum by recording a weekly series for his introductory Atmospheric and Oceanic Sciences 100 class. Known simply as "weather discussions," these online videos highlight recent and notable weather events around the US, augmenting them with the most recent coursework and theory. These videos are released on the AOS Youtube Channel and are available to the public.

"I build the discussions by starting at the same level as the lecture material. It's a natural progression," says Martin. "It starts out with fundamental ideas of pressure, temperature, density and the gas law. Then I find interesting weather patterns that demonstrate these principles."

Specialized weather satellite imagery and products developed at the UW–Madison Space Science and Engineering Center, the Cooperative Institute for Meteorological Satellite Studies and by AOS researchers are central to each discussion. Leveraging these images from the global network of satellites, Martin is able to peer through the different layers of Earth's atmosphere and show his students how storm systems form and why they behave the way they do.

Martin teaches AOS 100 during the Spring semester beginning in January. He says the depths of winter bring energetic weather systems to the northern US and almost guarantee exciting winter weather. March and April mark a transition to severe weather like thunderstorms and squall lines. As the course develops, Martin covers more complex topics including water vapor and radiative transfer to explain how energy circulates around the Earth.

Martin is enthusiastic about weather, and it shows. His curiosity and passion for the weather guides the selection of phenomena to investigate and are crucial to the learning experience, he says. He enjoys exploring and analyzing a weather system alongside his students.

"I make it personal by introducing myself and how I became interested in weather," he says. "As someone who grew up in New England with a paper route, I had to pay attention to the weather and observe how it changed."

Atmospheric science can be abstract, but by pairing these real-world examples with a true love of science and weather, Martin has found an engaging way to reach students and others in the community.

You can find Professor Martin's lectures online by visiting the UW–Madison Atmospheric and Oceanic Sciences YouTube page.

Credits: Bill Bellon and David Henderson

NASA New Investigator Program

Two early career scientists receive awards

by Jean Phillips

Game-changing advances in Earth system science often come not only from seasoned researchers, but also from early career scientists with novel ideas. To encourage these ideas, every three years NASA provides a select group the opportunity to see where their research might lead.

In Spring 2021, two researchers from the University of Wisconsin–Madison Space Science and Engineering Center were chosen to receive competitively awarded funds through the NASA New (Early Career) Investigator Program to pursue their innovative research.

Claire Pettersen and David Henderson, both of whom received their doctorates in atmospheric science in 2017 — she, from UW–Madison and he, from Colorado State University — will lead research programs over the next three years to investigate different ways of improving satellite-retrieved information about snow and clouds.

Pettersen's research will focus on measurements of snow and snow properties from ground-based instruments like profiling radars and video imagers and use that data to validate and improve algorithms that rely on observations from satellite-based radar.

"Satellites have a hard time resolving snowfall," says Pettersen, "because of limitations of the radar and surface impacts on both active and passive microwave observations." Satellite measurements are crucial; however, because they provide snowfall information for regions where there are few instruments on the ground, such as the world's mountains, oceans, or high-latitude regions.

▲ A ground-based instrument called the Precipitation Imaging Package provides information about precipitation characteristics that can help improve estimates of snowfall rate and accumulation. It is shown here collecting measurements during a snowstorm at an observational site near Marquette, Michigan. Credit: Mark Kulie

Pettersen aims to collect information from both the surface and the satellite radar "blind zone" — the two kilometers closest to the Earth's surface. Satellites have particular trouble identifying precipitation rates, snow types or precipitation phase changes like snow to rain or rain to snow in this region.

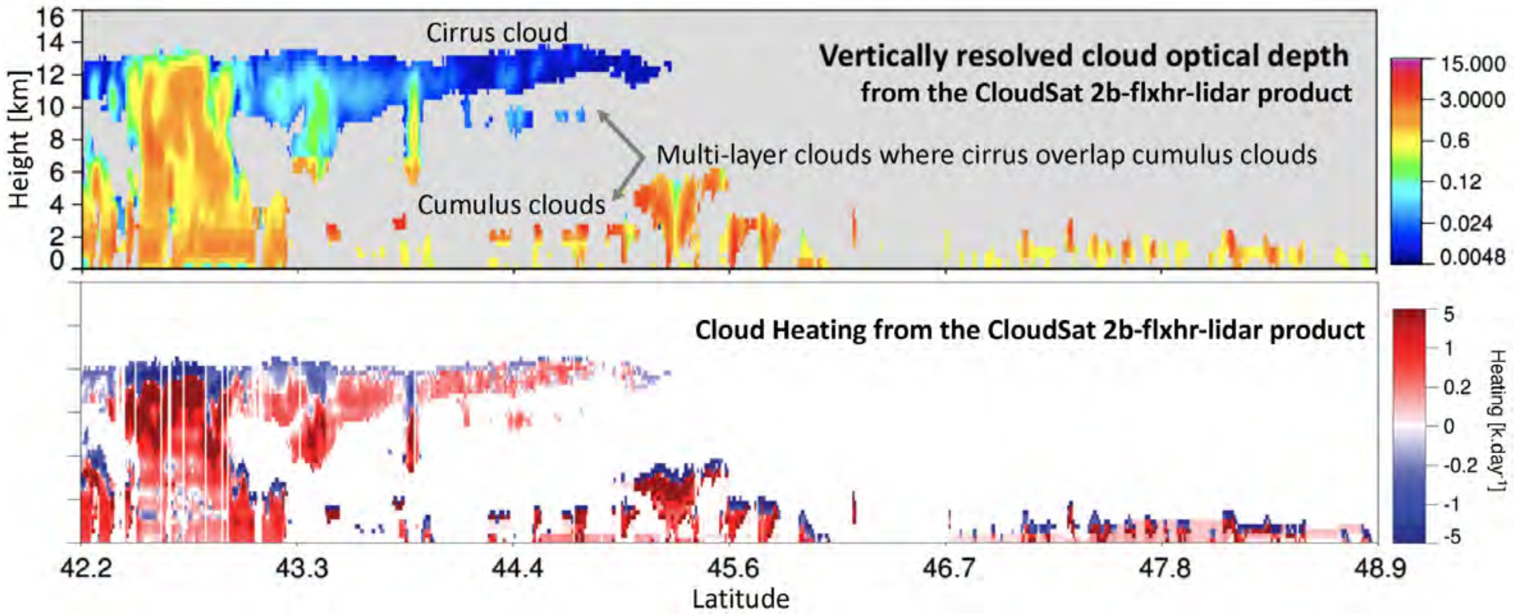
Providing this new level of detail about snow at the surface and in the blind zone to algorithm developers who are improving the accuracy of precipitation retrievals will benefit current and future missions, such as NASA's Aerosol and Cloud, Convection and Precipitation that is slated to usher in the next generation of atmospheric observing capabilities.

"A big thing that we want to do in the NASA community is to connect the people doing the ground validation to the people who are developing the satellite retrieval algorithms, so a big part of this work is building a bridge between the two and facilitating data sharing," says Pettersen.

Pettersen brings years of experience with ground-based instruments and field campaigns in the world's snowy regions including the Great Lakes, Norway, Sweden and Greenland. She hopes this experience, combined with her global network of collaborators conducting research in complementary areas will not only help to improve satellite retrieval algorithms for her NASA NIP award, but lead to new areas of research in the future.

In addition to bringing snow and other forms of precipitation, clouds play a complex role in warming and cooling our planet. Henderson's research aims to use satellite observations to gain a better understanding of Earth's energy budget — the balance between solar energy that is absorbed by Earth and the energy that is reflected back to space by features such as clouds.

Henderson collaborated on recent research, also conducted at UW–Madison, that determined cloud heating is a key driver of the energy imbalance that exists between the northern and southern



▲ An example of cloud locations detected by CloudSat and their optical depth for a case where multi-layer clouds are observed. Bottom, the corresponding estimates of the cloud radiative heating derived from the CloudSat 2b-flxhr-lidar data product. Credit: David Henderson

hemispheres. Specifically, cloud heating from multi-layered clouds, like cirrus over a stratus or stratocumulus cloud.

"The energy produced by the condensation of water or ice water formation of clouds in the atmosphere leads to a ton of heating in the tropics," says Henderson. It is one of the engines driving the global circulation. The imbalance between the hemispheres, however, also stems from clouds and their radiative properties, not just from this type of latent heating.

This research is important because the imbalance between the two hemispheres helps us understand where the Inter-Tropical Convergence Zone is located. The ITCZ is a low-pressure band that varies with the seasons and is typically located near the equator where winds from the Northern and Southern Hemispheres meet.

Changes in future climate could impact the location of the ITCZ and other circulation patterns, says Henderson. He aims to add to our understanding of clouds, their role in the energy balance that can shift global circulation and how those changes might impact future climate.

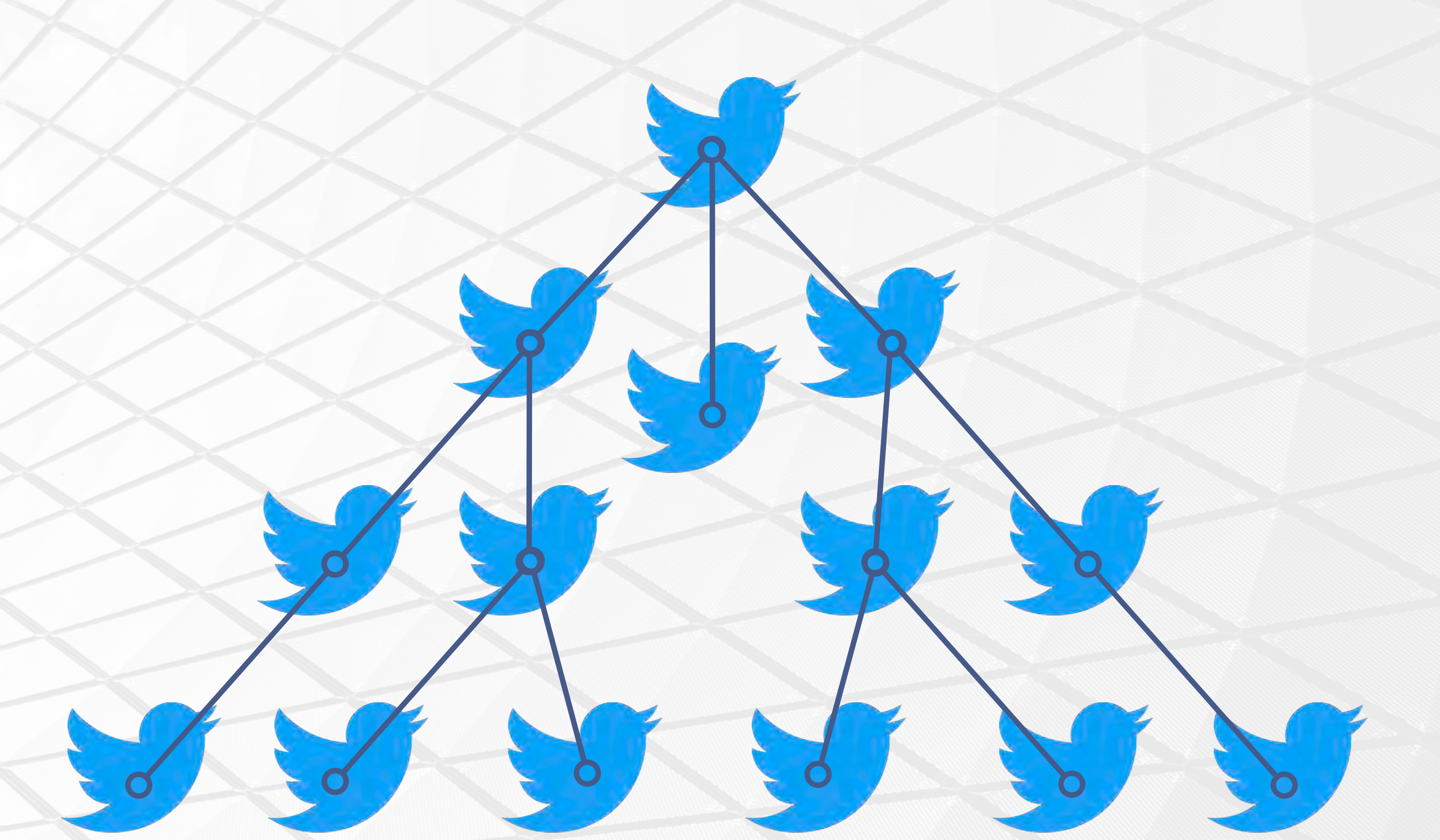
Ideally, researchers would study this phenomenon using satellite instruments, but another blind area for many satellites is their inability to see layers of clouds. They can sense the upper-most layer, but not below.

To account for this deficit, Henderson's NASA NIP will capitalize on space-based data on the vertical structure of clouds, cloud profiles and physical properties collected by NASA's CloudSat Mission and introduce CloudSat observations of cloud heating into an atmospheric model.

"The CloudSat dataset has multi-layered clouds in it that we will apply to a simple, dry model, one that is run without moisture and clouds," says Henderson. The satellite data provides the physical locations of clouds and their heating in the atmosphere. By changing the cloud parameters and cloud structures, shifting them higher or lower in the atmosphere, Henderson will observe the model responses to changes in cloud radiative heating. The process will tease out which clouds and cloud structures are important to pay attention to.

By applying this long-term dataset in a different way, says Henderson, he hopes to gain understanding into the role of clouds in the energy budget, its variability and influences on the global circulation.

This year, NASA received 238 proposals to the New Investigator Program in Earth Science and selected 38 for funding. Awards over the next three years total about $12.8M.



Credit: Benjamin Brant

Tweets and machine learning

Helping the National Weather Service understand its social media impact

by Callyn Bloch

For more than a century, the National Weather Service has provided the US with local and national severe weather alerts. Changing with the times and new technologies, the NWS has reached its communities through newspaper, radio and television. More recently, the agency has added Twitter to its toolkit.

Through a flurry of daily postings, people are engaging with local NWS Weather Forecast Offices more than ever on Twitter. Each day, their likes, comments, retweets and tagging help to amplify weather information like impending snowfall or rainy conditions.

But what types of NWS tweets catch the public's attention? SSEC data scientist Iain McConnell aims to answer this question by building a model using machine learning that will be able to determine the effectiveness of an NWS tweet. This will help NWS WFOs craft more effective tweets, increase their reach and ultimately help save lives and protect property.

"Public attention is really fickle," says McConnell. "What drives it isn't necessarily the content of the tweet at all. It is hard to pinpoint what exactly spurs engagement."

◀ SSEC data scientis Iain McConnell uses machine learning models to determine the effectiveness of an National Wather Service tweet. Credit: Iain McConnell

McConnell describes the different factors that play into a tweet's engagement. One is the content itself: whether or not it includes a video, a photo, and the length and content of the message. However, McConnell has found no clear pattern with these factors alone.

McConnell says the environment at the time of the tweet, both social and atmospheric, influences engagement. If there is a big news story, scandal or trend that draws users to Twitter, an NWS tweet might get more attention as a result. Severe weather could also cause people to specifically look at the NWS Twitter accounts for updates and information.

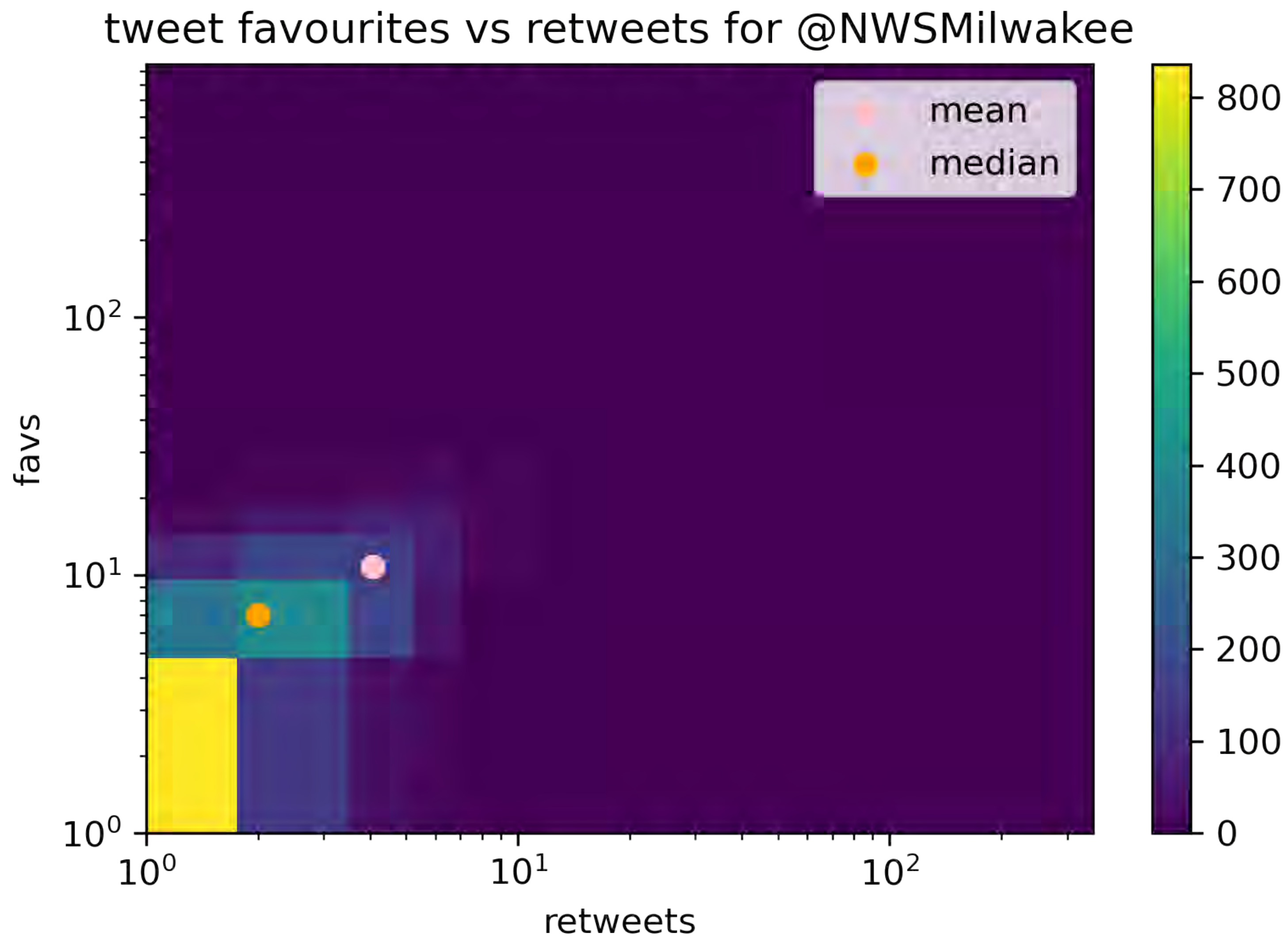
Other factors, such as who interacts with the tweet, also matter. If a Twitter user with a large following interacts with an NWS tweet, it can bring that information to new audiences by way of a trusted source, thereby increasing the post's engagement.

"In general, the majority of Twitter users are passive," says McConnell. "Roughly 10 percent of users are 'super users' who tweet a lot, and may have more followers than most. They can be signal enhancers for other users, which adds another layer of complication to understanding attention and engagement."

Currently, McConnell's project is focused on the Milwaukee NWS station's Twitter account, [@NWSMilwaukee](). His model is using one year of tweets from this account. To train the model, McConnell defines a popular tweet as having 10 or more likes. He explains that the definition of a popular tweet will be different for each WFO. Some offices will have higher engagement because they cover a larger metropolitan area. Other offices may have more engagement due to the type of weather that region experiences. For example, regions with more frequent supercells and tornadoes may attract more attention, including Norman, OK, Kansas City, MO, and Birmingham, AL.

> "Roughly 10 percent of users are 'super users' who tweet a lot, and may have more followers than most. They can be signal enhancers for other users..."

According to a study in [Weather, Climate, and Society]() by Eachus and Keim, there are now people that use Twitter as their primary weather information source. McConnell is studying the demographics, or characteristics, of this group to determine who makes up the NWS Twitter audience as a whole. The more we know about a group's demographics, like age, education, or previous interest in weather, the more researchers can assess their likelihood of engaging with NWS tweets.



▲ 2D Histogram comparing favorites and retweets per tweet for a year of @NWSMilwaukee tweets. Color bar represents tweet count. Note log-log axes. The data is clearly extremely skewed, with most tweets getting little interaction, and a few tweets receiving much higher interaction. Credit: Iain McConnell

Using the model to answer these questions; however, could introduce biases in the analysis. McConnell cautions that focusing on specific demographics might leave out many people who are not currently part of the NWS Twitter audience. He wants the model to be able to capture that group while increasing public attention for reliable weather information.

Ultimately, McConnell's goal is to enable and empower NWS forecasters to communicate more effectively on Twitter and to understand what makes someone want to engage with their tweets. At the same time, the public can learn about the benefits of more timely communications from their local weather stations. Although it is not part of the current project, this tool may help people stay informed about local weather, and may help them make better decisions as they respond to severe weather alerts.

Future goals of the project include using a larger historical dataset from the Milwaukee station and adding more NWS Twitter accounts to the model. Incorporating the time of the tweet, the weather at the time of the tweet and the social media environment into the model may yield better information that the NWS can use to reach even more people with important weather news or alerts.

This work is currently unfunded.

Eachus, J. D., & Keim, B. D. (2019). A Survey for Weather Communicators: Twitter and Information Channel Preferences, Weather, Climate, and Society, 11(3), 595-607.

Credit: Public Domain Photos

Flash drought

New index identifies important distinctions

by Jean Phillips

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 by Jason Otkin, a scientist at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies along with researchers at other agencies, aims to clarify what a flash drought is and to better quantify its severity. The new index, published in the journal Atmosphere, takes into consideration how rapidly a drought intensifies as well as whether the intensification is followed by a prolonged period of drought.

"I think that the community has coalesced around the idea that flash drought should be identified based on how quickly the drought develops," says Otkin. "But what we haven't done is combine rapid intensification with how severe the drought actually becomes over the next 2-3 months."

According to Otkin, this is an important omission and distinction because of land surface and hydrologic impacts — like those on vegetation and crops — that are linked to the rapidity of drought onset as well as to its severity over time. A drought that persists following rapid intensification is more likely to wither crops and evaporate critical water resources than one that intensifies in a similar timeframe but does not persist.

To create the index, the researchers analyzed soil moisture data for 1979-2017 from the Noah Land Surface Model for some known drought periods. The model characterizes land-surface interactions, like soil moisture and soil temperature, or how much moisture has evaporated from the soil due to warming conditions.

"If you think about 2012, which was the last really bad drought that we had in Wisconsin and elsewhere in the Central US, the data show that it intensified over 6-8 weeks in June and July, but the drought itself lasted for many months afterwards," says Otkin.

"... flash drought should be identified based on how quickly the drought develops and how severe the drought actually becomes over the next 2-3 months."

That summer, the combination of rapid intensification followed by a prolonged period of extremely dry conditions resulted in $34.5 billion in losses across 80% of the agricultural land in the Central US.

The Eastern US may experience more frequent and rapid drought intensification than in the Central or Western US; however, droughts in that region typically do not last as long because they are more often interrupted by rain. In contrast, when rapid intensification occurs in the Central and Western US the likelihood of rain is less. As a result, those regions get both: rapid intensification followed by prolonged drought making it more difficult to recover, says Otkin.

CIMSS scientist Jason Otkin and other researchers developed a new flash drought intensity index that aims to clarify what a flash drought is and to better quantify its severity. Credit: Eric Verbeten

Longer term drought can lead to devastating crop and livestock losses as well as increased wildfires, such as those ravaging the Western US and Pacific Northwest in 2021. In addition, hydrological impacts can lead to water rationing, less recreation and fire bans for both urban and rural dwellers. Once the drought is past the intensification stage and is becoming established and prolonged, we see the emergence of these markers.

Drought is a natural feature in Earth's climate. Otkin's research is aimed at arming those most affected by drought with more refined tools so that they can better plan for changes that come with it, like reduced water supply.

First coined by Mark Svoboda at the National Drought Mitigation Center, the term flash drought piqued Otkin's scientific interest around 2011. But he has a personal interest in drought and its aftermath, too.

"I grew up on a farm in Minnesota that was often affected by drought. So, it was a natural way for me to combine my interest in agriculture with a topic that impacted my family's livelihood and was fascinating to work on," says Otkin.

This work was supported by the NASA Water Resources Program, NASA Land Cover and Land Use Change Program, National Science Foundation, Northern Australia Climate Program, Queensland Government and University of Southern Queensland.

COLD DATA

by Eric Verbeten

A polar vortex in 2021 provided a unique opportunity to test the UW–Madison Space Science and Engineering Center's Absolute Radiance Interferometer without leaving campus. The instrument is designed to measure Earth's atmosphere in the infrared spectrum.

An extended stretch of cold and dry winter conditions such as might be found in higher elevations, at the poles or during a polar vortex, resulted in the perfect environment for collecting data that is expected to establish a new baseline for measuring the Earth's atmosphere in the far-infrared. These new data will help the global community of atmospheric scientists understand energy transfer in the atmosphere, which is critical to understanding Earth's climate.

This energy transfer known as Earth's energy balance — or the journey of the sun's rays to the Earth, and eventually back into space — is a complex interplay between different materials like water vapor, carbon dioxide, pollution or vegetation. Each emits a unique signature based on its composition, and understanding these signatures helps scientists learn how weather develops. All of this ultimately, is to improve forecasting methods such as numerical weather prediction.

"Current surface emissivity observations in the far-infrared spectral region are insufficient," says Eva Borbas, SSEC scientist and principal investigator for the project. "The ARI will be able to provide some of this baseline information but first we needed to redesign the instrument to be able to measure emissivity of different samples of materials during cold and dry weather conditions."

Nearly 60 percent of Arctic emission occurs at wavelengths longer than 15 micrometers that have never been systematically measured, uniquely positioning the ARI to make these measurements.

Credit: Jeff Miller/UW–Madison

◀ The ARI collects emissivity measurements of five samples, including vegetation, sand, ice, snow and water. During testing, the team launched radiosonde balloons to collect real-time atmospheric data. Credit: Doug Adler

The ARI is roughly the size of a refrigerator and was designed to measure brightness temperatures to within five millikelvin (.005 Kelvin) in the infrared and far-infrared at a spectral range of 3.7 to 50 micrometers. Infrared rays are invisible to the human eye, but can be felt in the form of heat, such as the warmth emitted by an incandescent light bulb.

The ARI measurements began in February 2021 and were repeated over several weeks when conditions were favorable for capturing consistent data with minimal interference from moisture in the air. Ultimately, future weather satellite missions could include an ARI onboard which would serve as an absolute calibration reference for other satellites in the global fleet. But before that happens, capturing in situ measurements in a controlled environment is an important step to understanding the kinds of things it will see when it is in space.

Setting up the test on the rooftop of the Atmospheric, Oceanic and Space Sciences building presented an engineering challenge due to the ARI's construction which requires some parts to face the outside elements and others to remain inside. The researchers positioned the ARI so that half of it was inside the building and the other half, outside. Insulation used to protect parts of the instrument sensitive to cold also reduced background noise in the signal.

The science team tested five samples, including vegetation, sand, ice, snow and water.

"We needed to prepare a pure and undisturbed sample because we are trying to simulate what the ARI would see if it were aboard a weather satellite looking at large swaths of the Earth," says SSEC engineer Doug Adler. "For the case of ice, we had to find way to freeze pure water and measure it during its phase change."

Similarly, Adler needed to devise a way to place undisturbed snow samples in view of the ARI's detector. The coldest days reached −25 degrees Celsius (−15 Fahrenheit), confirmed by radiosondes that were launched concurrently during some days

▲ SSEC engineer Doug Adler braved the cold over several weeks to test the ARI and collect far-infrared data from different materials. Credit: Doug Adler

of the testing.

Many instruments are designed with scientific applications in mind and the ARI is no different.

The far-infrared emissivity spectra will be added as an extension to an existing infrared emissivity database as a way to calibrate other far-infrared instruments, verify their accuracy and provide realistic assumptions for surface emissions for global climate modeling.

"We developed the infrared CAMEL Emissivity Database containing data for every month between 2000-2016 at high- spatial and spectral resolution," says Borbas. "Adding these new ARI far-infrared measurements to it will be very unique for the whole science community and for those who need this kind of information for data simulation, climate modeling, retrievals and radiative transfer calculations."

The ultimate goal of these cold measurements is to make ARI a more readily deployable instrument, obtain highly accurate observations for advancing far-infrared science and serve as a validation for new missions like PREFIRE (see pg. 34). This work will further the understanding of emissions over the Artic and Antarctic.

This work is supported by SSEC.

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TROPICS

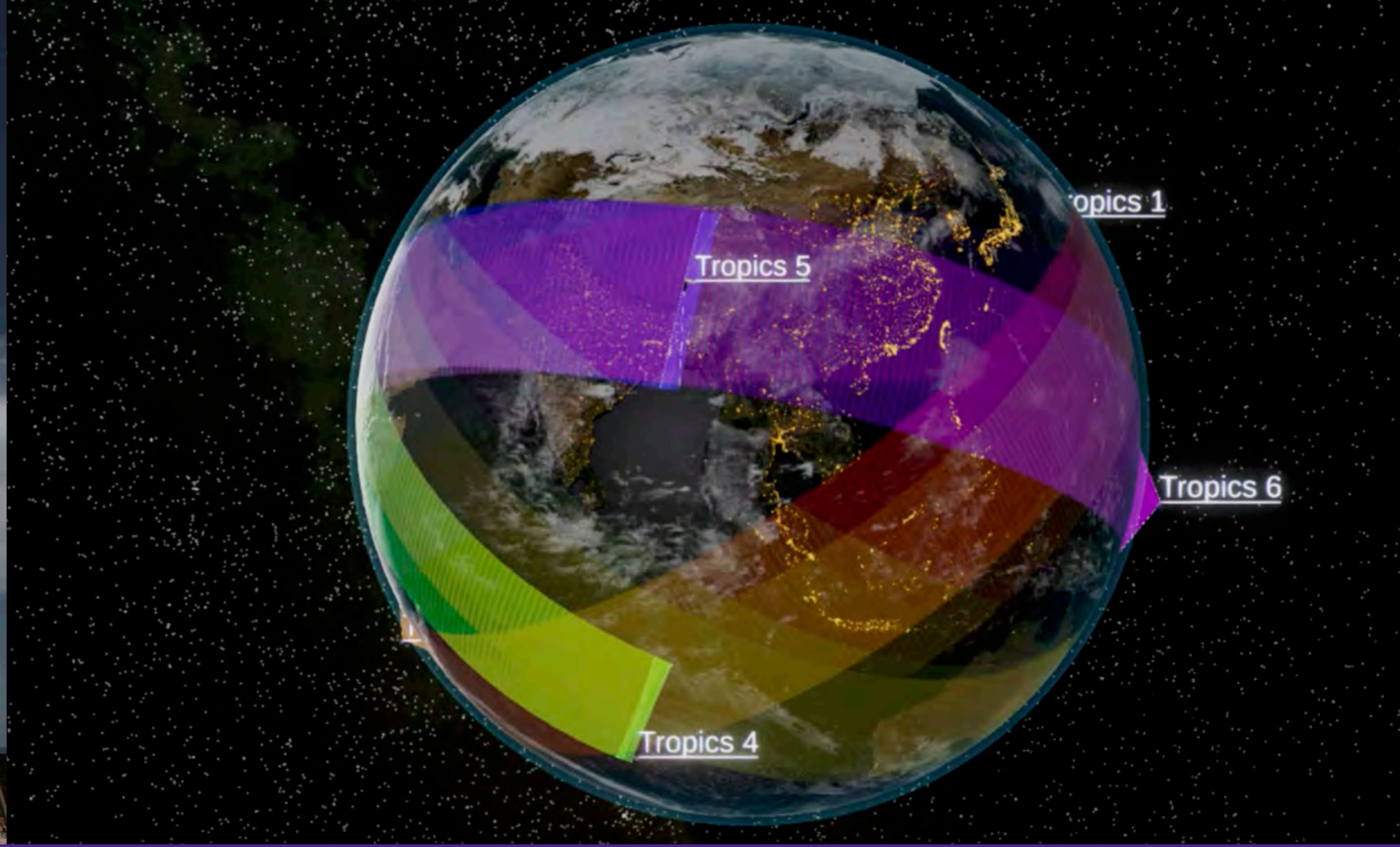
New cubesat mission brings hurricanes into focus — saving lives with better storm predictions

by Leanne Avila

This summer University of Wisconsin–Madison Space Science and Engineering Center researchers leading 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 launched an engineering model version of the TROPICS satellite instrument on June 30, 2021 on a SpaceX rocket. This rare opportunity is providing a dry run to test the capabilities of TROPICS' six small satellites known as CubeSats ahead of the official launch in 2022.

On June 30, 2021 Falcon 9 launched the Transporter-2, SpaceX's second dedicated SmallSat Rideshare Program mission, from Space Launch Complex 40 at Cape Canaveral Space Force Station in Florida. The TROPICS Pathfinder satellite successfully detached from the Transporter-2 about an hour after takeoff. Credit: SpaceX



The TROPICS mission will provide rapid-refresh microwave measurements over the tropics that can be used to observe the thermodynamics of the troposphere and precipitation structure for storm systems at the mesoscale and synoptic scale over the entire storm lifecycle. TROPICS comprises a constellation of CubeSats in three low-Earth orbital planes. Credit: MIT Lincoln Laboratory

"It's one of the first CubeSat missions that NASA is funding. For $30 million, you get seven satellites with state-of-the-art instrumentation," says Ralf Bennartz, SSEC senior scientist and principal investigator for UW–Madison's involvement in the mission. Bennartz is also a professor of Earth and Environmental Sciences at Vanderbilt University.

Most remote sensing satellites currently in orbit, like the Joint Polar Satellite System and Suomi National Polar-orbiting Partnership from the National Oceanic and Atmospheric Administration, are the size of a school bus. In contrast, the much smaller CubeSats are about the size of a shoebox. However, as Bennartz notes, their performance is expected to be similar to their much larger and more expensive satellites counterparts.

One of the keys to studying tropical cyclones is high temporal resolution data and imagery — that is, very frequent or continuous observations in order to closely monitor changes in the evolution of a tropical storm. For this research, scientists typically use geostationary orbiting satellites because they fly in a fixed location above the Earth, thereby providing the necessary high temporal resolution. TROPICS will instead operate in three orbital planes that are non-sun synchronous but with a focus on the tropics region. However, the number of satellites in the mission constellation will allow scientists to gather measurements of tropical cyclones roughly every 90 minutes, compared to 6 hours for today's operational low-earth orbiting satellites.

"The pathfinder satellite will allow us to test all our algorithms on real data to see if there might be any issues that we could take care of before the main constellation is launched." — Ralf Bennartz

"That's not your standard orbit," says Bennartz of the non-sun synchronous orbit. And so finding a launch partner would take some time. With that in mind, NASA agreed to launch the engineering model into a more typical polar orbit to help the team test their observational and data processing approach. Working with real data will allow them to assess data quality, and by extension, the quality of the algorithms that they've developed. The instrument is making measurements in parts of the spectrum that have not been used before in previous research or operational missions.

"Since everything is so novel, we don't have any direct heritage for the instrument; we don't have any direct heritage for the observations. Everything is built on simulations and very few aircraft observations. So the pathfinder satellite that is being launched will allow us to test all our algorithms on real data to see if there might be any issues that we could take care of before the main constellation is launched," says Bennartz.

The science of TROPICS

Part of what makes this mission so novel is what also makes it possible — in particular, being able to shrink the spacecraft down to the size of a shoebox.

"We're going to be exploring some unique frequencies in the microwave that haven't been used or tested before in meteorological applications. These are higher frequencies, which means we can have a smaller signal receiving dish on the satellite," says Chris Velden, a TROPICS co-investigator and SSEC senior scientist.

These new frequencies they'll be studying are very similar in principle to ones currently used on large

▲ Ralf Bennartz, SSEC senior scientist and principal investigator for UW—Madison's involvement in the TROPICS mission, is leading a team that is producing temperature and moisture retrievals to study hurricane intensity, as well as conducting brightness temperature simulations to improve hurricane forecasts. Credit: Ralf Bennartz

▲ SSEC Senior Scientist and TROPICS Co-Investigator Chris Velden leads a team studying tropical cyclone warm core anomalies and their effect on storm intensity and evolution. Credit: SSEC

operational satellites that provide atmospheric temperature and moisture profile information, explains Velden. They plan to use these data to examine tropical cyclone warm cores, and in particular some observed temperature anomalies to better understand their characteristics and impact on the evolution of the storm.

"We're going to focus on this upper-tropospheric warm thermal anomaly in the storm core, which relates to the intensity and the structure. And hopefully we'll be able to deduce whether our algorithms that currently work with the NOAA satellites can work just as well with these new frequencies," says Velden.

SSEC's Derrick Herndon, also a TROPICS Co-I, has been updating their existing algorithms that estimate a storm's maximum surface winds and minimum sea level pressure from satellite-depicted warm core anomaly magnitude, to modify them to work with the new TROPICS frequencies. In addition to demonstrating the ability to use different microwave bands for their research, the team will help determine whether smaller and less-expensive CubeSats can play a role in the future of operational satellite systems.

Consequently, another key piece to this research is studying the impact of these new microwave data on numerical weather prediction model forecasts. While SSEC's Tom Greenwald is working with Bennartz to produce microwave retrievals of temperature and moisture from the radiances to investigate hurricane intensity, Bennartz has also been conducting brightness temperature simulations. Observed brightness temperatures are important for data assimilation. And while the simulations have shown positive impact in numerical weather prediction forecast models, real data from TROPICS will bolster their case for improvements in hurricane intensity and track forecasting.

Processing the data

Long before this first launch, the TROPICS Data Processing Center based at SSEC has been preparing for the flow of data. One of the first steps is accepting the delivery of the science algorithms from the TROPICS science teams and integrating them into their data processing system, explains Jessica Braun, project manager of the TROPICS DPC. While the science teams ensure that their algorithms meet the requirements to be integrated, the DPC ensures that the processing will include any ancillary data necessary for the algorithms to run. Over the course of the mission, as they gain more experience with the data, the scientists will adjust their algorithms and provide updates to the DPC.

> "We're going to be exploring unique frequencies in the microwave that haven't been used or tested before in meteorological applications."
> — Chris Velden

After launch the DPC will have two main areas of responsibility: processing TROPICS data as it comes in from Blue Canyon Technologies as part of the continuous forward stream and reprocessing data as needed and requested by the science team members. Blue Canyon is managing the ground system portion of the mission; the DPC has been working closely with them to test connections and ensure the flow of data. Similarly, the DPC has been preparing to deliver data to Goddard Earth Sciences Data and Information Services Center, which will serve as the data archive for the mission.

The DPC will also have a website to allow team scientists to examine the data during the mission — by browsing imagery and being able to choose which data to download. For example, using this site, a scientist can determine which CubeSat(s) would have observations of a specific tropical cyclone or even what other satellites overlap with these CubeSat measurements for comparisons, allowing them to focus their data search.

Braun says that she and the rest of the DPC team are eager to begin working with real data — and feeling fortunate that will happen months before they originally expected to receive data from any of the six satellites.

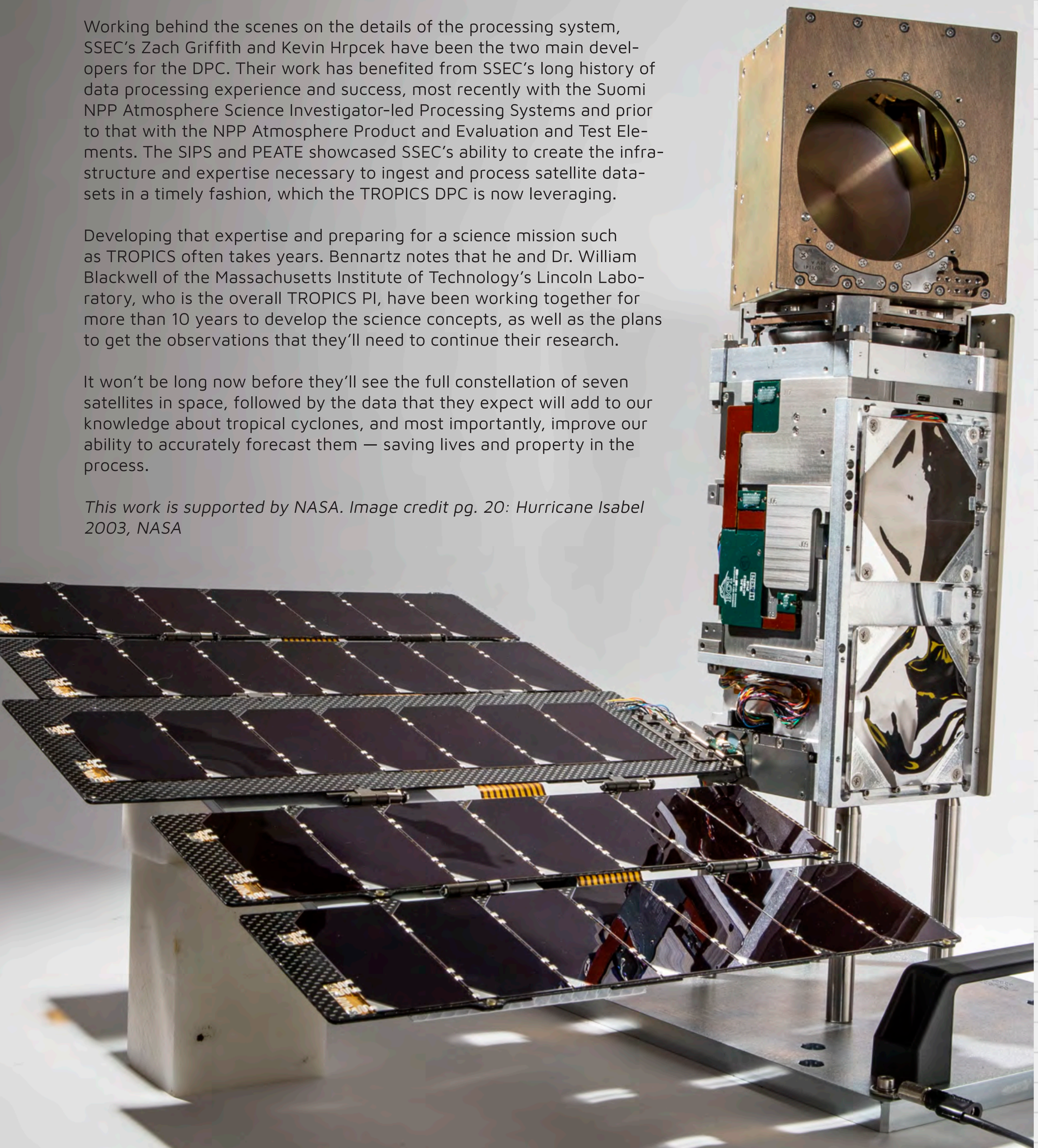
"To be able to get it earlier is really great for us, so that come constellation mission, it should be a much smoother process. And hopefully, we can get data out to the public much sooner," says Braun.

Working behind the scenes on the details of the processing system, SSEC's Zach Griffith and Kevin Hrpcek have been the two main developers for the DPC. Their work has benefited from SSEC's long history of data processing experience and success, most recently with the Suomi NPP Atmosphere Science Investigator-led Processing Systems and prior to that with the NPP Atmosphere Product and Evaluation and Test Elements. The SIPS and PEATE showcased SSEC's ability to create the infrastructure and expertise necessary to ingest and process satellite datasets in a timely fashion, which the TROPICS DPC is now leveraging.

Developing that expertise and preparing for a science mission such as TROPICS often takes years. Bennartz notes that he and Dr. William Blackwell of the Massachusetts Institute of Technology's Lincoln Laboratory, who is the overall TROPICS PI, have been working together for more than 10 years to develop the science concepts, as well as the plans to get the observations that they'll need to continue their research.

It won't be long now before they'll see the full constellation of seven satellites in space, followed by the data that they expect will add to our knowledge about tropical cyclones, and most importantly, improve our ability to accurately forecast them — saving lives and property in the process.

This work is supported by NASA. Image credit pg. 20: Hurricane Isabel 2003, NASA



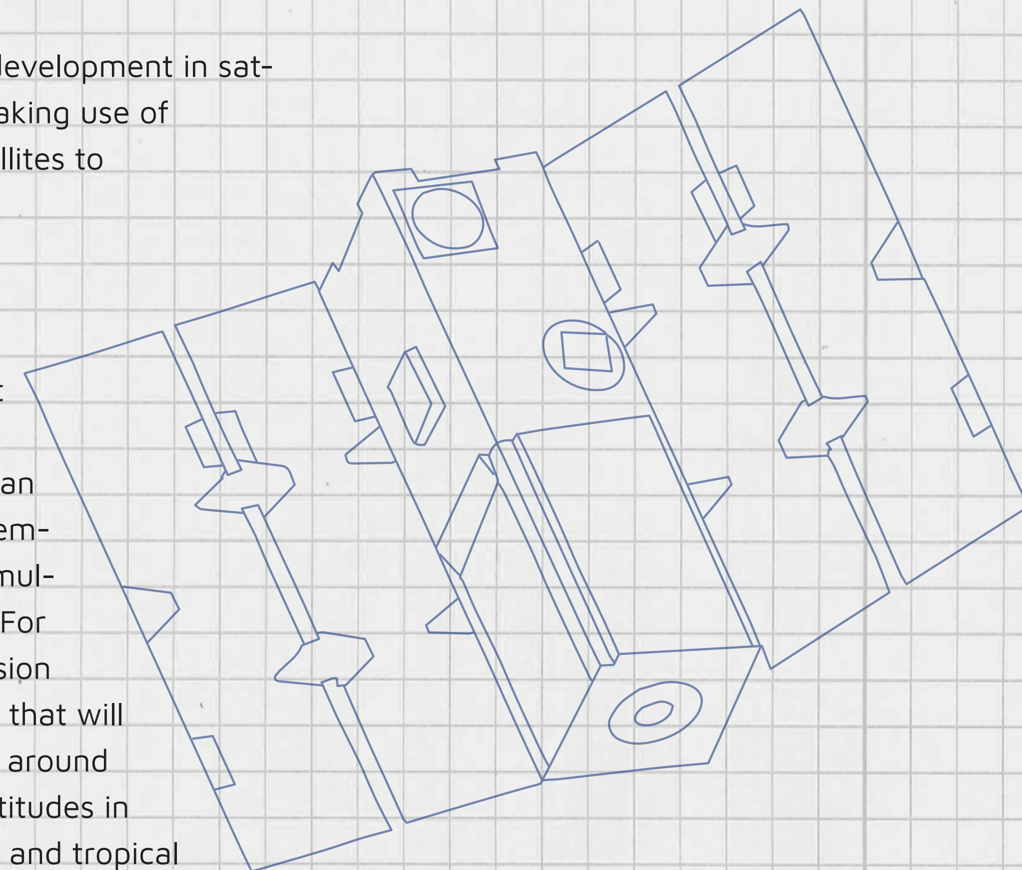
▲ The TROPICS Pathfinder satellite is roughly the size of a shoebox and is one of seven satellites to make up the entire TROPICS constellation. Credit: Blue Canyon Technologies, LLC

WHAT IS A CUBESAT?

by Eric Verbeten

It's a small satellite. Compared to previous generations of large, school-bus sized satellites that orbit the Earth, CubeSats' diminutive sizes vary from a loaf of bread to an air conditioner unit and can be more readily deployed in space.

CubeSats mark the latest development in satellite remote sensing by making use of small and inexpensive satellites to answer specific scientific questions at a fraction of the cost of conventional Earth-observing satellites. CubeSats are not intended to carry multiple sensors or detectors, but can cover a wide spatial (and temporal) range by deploying multiple satellites per mission. For example, the TROPICS mission will launch seven CubeSats that will collect specific information around Earth's equator and mid-latitudes in order to improve hurricane and tropical cyclone predictions.



▲ Credit: Blue Canyon Technologies, LLC

Until now, satellites were designed as large, multi-purpose platforms intended for mission timelines of more than 10 years. Weather satellites such as GOES-16, Himawari-9 and NOAA-20 carry an impressive array of detectors and sensors, each requiring significant planning and design for function and longevity. These extra parameters add significant time to mission planning and construction. They also increase costs.

With the combined information gathered through long-term satellite missions and CubeSat deployments, atmospheric and climate scientists will have a more comprehensive understanding of the forces at play in Earth's atmosphere.

PREFIRE

CubeSat mission bolsters Arctic datasets for improved climate predictions

by Eric Verbeten

Like thermostats, the Arctic and Antarctic are important for regulating Earth's temperature. The poles respond to warming with glacial melt that results in sea level rise, shifts in mid-latitude weather patterns and changes in global temperatures that can be harbingers of broader climate change. To date, limitations in satellite technology have hindered scientists' ability to gather consistent information about the poles — the resulting data gaps have implications for the long-term accuracy of climate models and weather prediction.

A new NASA mission called the Polar Radiant Energy in the Far-InfraRed Experiment, or PREFIRE, is on track to address these missing data and help scientists better understand how the Arctic regions regulate Earth's temperature and climate.

Over the Arctic, nearly 60 percent of radiation that is emitted to space is in the form of far-IR radiation, yet despite more than 50 years of satellite observations, scientists have little understanding of the processes that affect this key component of the polar energy budget. Credit: Jcrane

"By filling the far-infrared observation gap and integrating these new observations into models, PREFIRE offers a pathway to improving polar climate predictions," says Tristan L'Ecuyer, director of the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin–Madison and principal investigator of PREFIRE.

NASA is scheduled to launch PREFIRE's two small CubeSats — roughly the size of a thick laptop computer — in December 2022. Each CubeSat will orbit Earth every 90 minutes, with staggered orbits to provide new data every 45 minutes. The detectors inside will scan the Earth's surface and measure emitted energy in the far-infrared region of the electromagnetic spectrum, an important piece of Earth's energy budget and one that is approximately balanced by incoming sunlight. When outgoing and incoming energy are in balance, Earth's climate is in equilibrium and global temperatures do not change. But when Earth absorbs more radiation than it emits, as is the case today, then the planet warms.

Over the Arctic, nearly 60 percent of radiation that is emitted to space is in the form of far-IR radiation, yet despite more than 50 years of satellite observations, scientists have little understanding of the processes that affect this key component of the polar energy budget. Historically, measuring far-IR wavelengths has been a technological and engineering challenge due to the small energies they carry that can easily be overwhelmed by noise or interference in the signal.

However, while developing instruments for studying the Moon and Mars in the early 2000s, NASA's Jet Propulsion Laboratory developed breakthroughs in detector design that enabled low-cost and effective far-IR measurements for the PREFIRE mission. Each of the two PREFIRE satellites will carry a Thermal Infrared Sensor, or TIRS detector, to measure emissivities at various frequencies in the far-IR range. While loosely defined as a range of 5 to 1,000 micrometers in wavelength, the far-IR measurements captured by the PREFIRE mission will focus on a narrower range of 5–54 micrometers in wavelength.

"Unlike current instruments whose measurements are limited to wavelengths less than 15 micrometers which only cover about half of the energy Earth emits to space, the range of wavelengths measured by PREFIRE encompasses more than 97 percent of Earth's emission," says L'Ecuyer.

He also notes that while the focus of the mission will be Earth's poles, the satellites will collect data from other regions such as the mid-latitudes and the tropics because it is important to consider the Earth as one large system when trying to understand its energy budget. The mission is currently planned to last one year and L'Ecuyer says that timeframe should provide a comprehensive picture of far-IR emissions over the poles and the rest of the Earth.

From beginning to end, student research crucial to PREFIRE mission

L'Ecuyer's vision for the PREFIRE mission included students at every level of the project. Since 2017, undergraduate and graduate students have supported the mission through research, algorithm development, data analysis and most recently, communications. Altogether, there are 10 students working on the project from the University of Wisconsin–Madison, the University of Colorado and the University of Michigan.

CIMSS Director and Principal Investigator for PREFIRE Tristan L'Ecuyer. Credit: Eric Verbeten

"We have more students on the project than science team members," says L'Ecuyer. "It's a statement of what you can do with these smaller missions. We have a small staff, a focused science question and we're able to involve students to help answer these critical questions and arrive at solutions."

Compared to previous satellite missions, PREFIRE's $33 million budget is a fraction of the larger satellite programs like GOES-16 which cost more than $1 billion and took more than a decade to launch. L'Ecuyer sees smaller CubeSat missions as a promising way to answer urgent science questions with an added flexibility and responsiveness.

"There is no shortage of enthusiasm on the team," says L'Ecuyer. "This work goes beyond an experiential internship for students — the mission's success depends on their success and that brings a lot of positive investment and commitment to the project."

One student, James Anheuser is a third year Ph.D. candidate who has been working with the PREFIRE mission since 2019. His research is focused on verifying the PREFIRE data as it is transmitted to a receiver on Earth. When a new satellite launches, a calibration period is required to ensure transmissions are usable, accurate and verified. This is done

◀ Ph.D. candidate James Anheuser has been working with the PREFIRE mission since 2019. His research is focused on verifying the PREFIRE data as it is transmitted to a receiver on Earth. Credit: James Anheuser

partly through a process known as collocation or comparing the new satellite's data to other satellites currently in operation to confirm those data are within an acceptable range.

"My research involves the creation of algorithms that will collocate the observations of PREFIRE far-IR measurements with other satellites," says Anheuser. "The idea is to match the far-IR observations with those of physical features such as clouds, ice thickness and ice concentration, to see how we can identify connections between atmospheric and surface features and how they radiate in the infrared."

> "There is no shortage of enthusiasm on the team. This work goes beyond an experiential internship for students — the mission's success depends on their success and that brings a lot of positive investment and commitment to the project."
> — Tristan L'Ecuyer

For decades, the global fleet of weather satellites have provided scientists with abundant information about atmospheric features like clouds, water vapor, ice crystals and surface measurements. Many of these radiate in the near-, to mid-IR providing a long-established database used to understand their radiative transfers. PREFIRE will collect new data not previously recorded in a systematic way, so verifying these measurements will be critical to its success.

"By studying those connections we can learn more about local weather, climate and the outgoing far-infrared and connect that with the greater climate picture," says Anheuser. "Currently we are simulating what that data will look like and using those simulations to write algorithms that will take the data from the instrument and turn it into something more meaningful for climate and research."

Other student-led PREFIRE research includes the development of machine learning algorithms for cloud detection, creating water vapor retrieval datasets, web design and preparing Antarctic data sets (provided in part by the UW–Madison Antarctic Meteorological Research Center) to help with satellite validation.

In June 2021, the PREFIRE mission passed a major planning milestone, known as the Critical Design Review, and is on track to complete the next phase at the end of the year.

"We're at a sort of frontier in the Arctic regarding climate models," says L'Ecuyer. "Climate models are fairly accurate, but they vary, resulting in disagreement on what the Arctic temperature and sea ice levels will be in 50 years."

This research is supported by NASA. Image credit pg. 28: freevectormaps.com

Credit: Eric Verbeten

At the intersection of climate change politics and chemistry

Grad student Jerrold Acdan focuses on Lake Michigan ozone production

by Leanne Avila

University of Wisconsin–Madison graduate student Jerrold Acdan found his research niche at the intersection of climate change politics and chemistry — in atmospheric chemistry. Acdan's participation in a NASA program known as DEVELOP taught him how to analyze satellite data and helped him see that Earth observations could be used to address environmental and public policy issues. At that point, Acdan set out to explore how to use satellite data to study atmospheric chemistry.

For the last two years Acdan has worked with Brad Pierce, SSEC director and UW–Madison Atmospheric and Oceanic Sciences professor, to study ozone production around Lake Michigan using satellite data. Due in part to ozone transport from other regions, that area has struggled to keep ozone levels below federal air quality standards set by the US Environmental Protection Agency. Acdan's research builds on results from the Lake Michigan Ozone Study field campaign of 2017 to look at the precursors of ozone.

UW—Madison graduate student Jerrold Acdan has been studying ozone production around Lake Michigan using satellite data. Credit: Jerrold Acdan

"Ozone production can be thought of as NO_x (nitrogen oxides) sensitive or VOC (volatile organic compound) sensitive," says Acdan.

Acdan used data from the TROPOspheric Monitoring Instrument on the Copernicus Sentinel-5 Precursor satellite and EPA Photochemical Assessment Monitoring Stations on the ground as input for a formaldehyde (a type of VOC) to nitrogen dioxide ratio (FNR) to study these sensitivities over time. A higher ratio indicates more NO_x sensitivity while a lower ratio indicates more VOC sensitivity. Previous studies have attempted to establish the appropriate threshold between NO_x sensitivity and VOC sensitivity. Acdan, however, focused on comparing thresholds from two studies to determine which would better apply to satellite data.

Acdan compared ozone season and ozone exceedance day composites and found that on Chicago ozone exceedance days, ozone production in the Chicago Metropolitan Area remains VOC sensitive, but the western shore of Lake Michigan tends to be more NO_x sensitive. The same analysis also led Acdan to conclude that the FNR thresholds for ozone-NO_x-VOC sensitivity published by Duncan et al. 2010 are more appropriate for interpreting surface measurements while those published by Jin et al. 2020 are more appropriate for interpreting satellite data in the Lake Michigan Region.

Acdan is finishing up a Master's thesis and preparing to start his Ph.D. work in Fall 2021. He'll be tackling a similar research project but looking at a different area of the country — analyzing data from the 2018 Long Island Sound Tropospheric Ozone Study field campaign using high resolution models and NASA airborne measurements. Long term, he plans to continue in the field of atmospheric chemistry.

"Hopefully I can go back home one day and maybe work for something like the California Air Resources Board or the EPA in California and make an impact on public health related to air quality," says Acdan.

This work was partially supported by the Lake Michigan Air Directors Consortium (LADCO).

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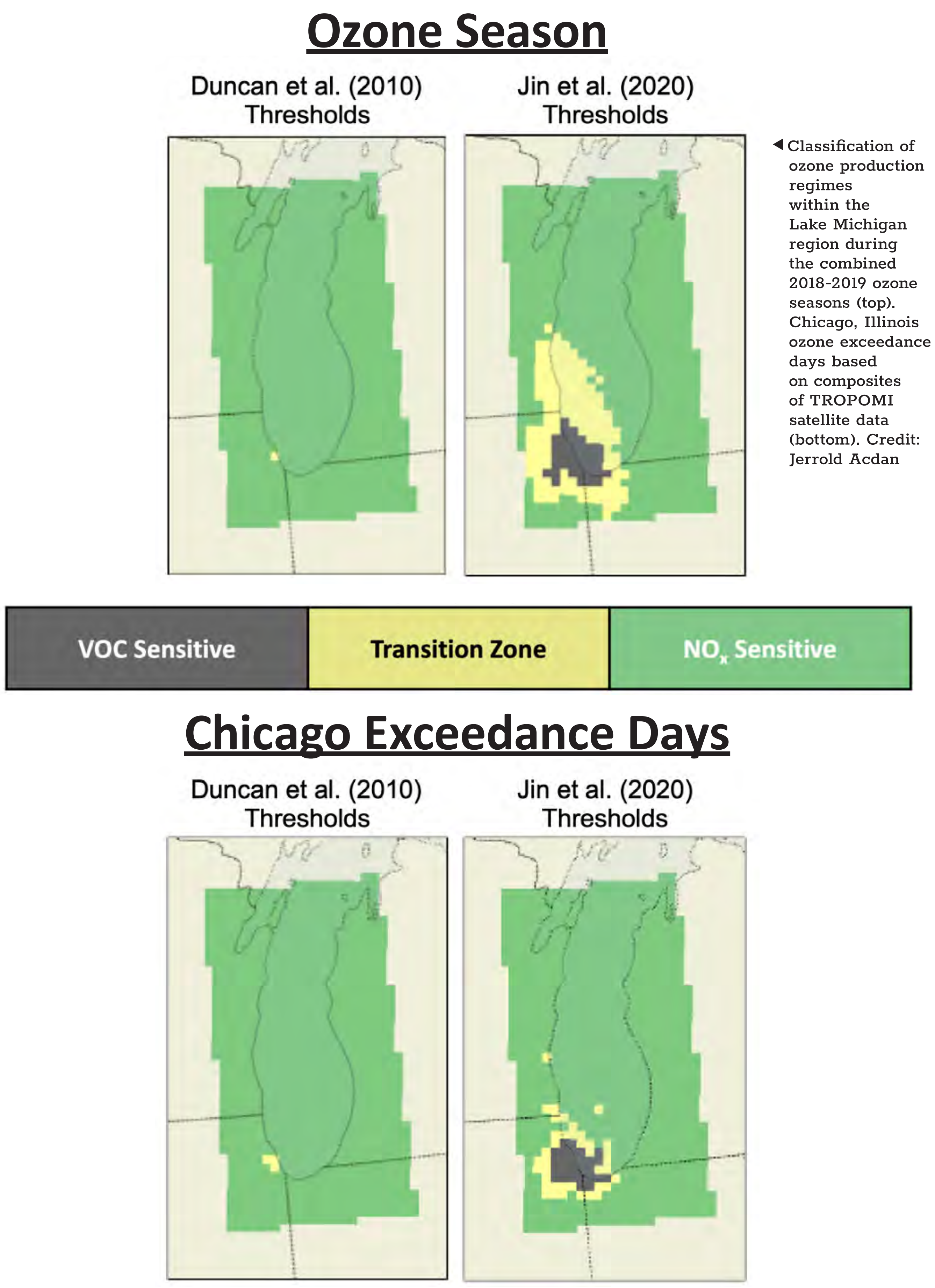
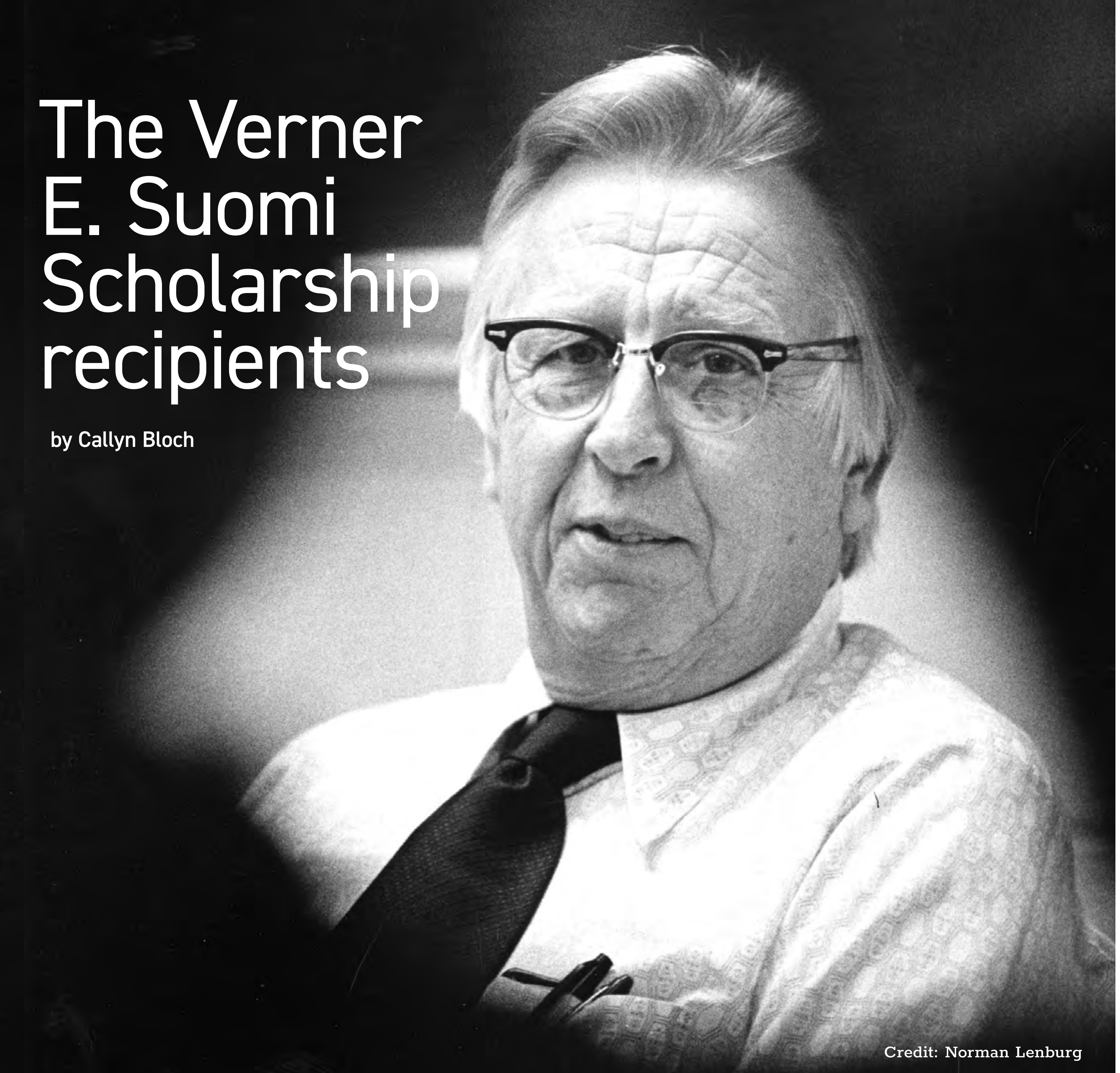


Classification of ozone production regimes within the Lake Michigan region during the combined 2018-2019 ozone seasons (top). Chicago, Illinois ozone exceedance days based on composites of TROPOMI satellite data (bottom). Credit: Jerrold Acdan



The Verner E. Suomi Scholarship recipients

by Callyn Bloch

Credit: Norman Lenburg

This year, 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.

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

Each year, the $2,000 scholarship is awarded to high school seniors who plan to attend a University of Wisconsin System school and major in the physical sciences. Named after the "father of satellite meteorology," Professor Suomi, was passionate about teaching undergraduate students. Scholarship recipients demonstrate outstanding performance in the physical sciences and extracurricular achievements.

Emily Sautebin

Credit: Emily Sautebin

High school senior Emily Sautebin has always been fascinated with the environment. A passion that extends beyond school, she received a sponsorship to attend the World Affairs Seminar and placed first in a Science Olympiad competition. Emily discovered she wanted to pursue a career in environmental sciences during an Advanced Placement Environmental Science trip to a local park in her hometown, Marshfield, Wisconsin. "My class spent the day testing the quality of the Yellow River, and I realized that I could see myself doing that kind of work for the rest of my life," Emily explained. This fall, she will attend the University of Wisconsin–Madison in hopes of becoming an environmental consultant or hydrologist after graduation. "Whether I am collecting samples in the field or contributing to important conversations about the environment," she says. "I want my work to make a difference."

Hollyn Gaffner

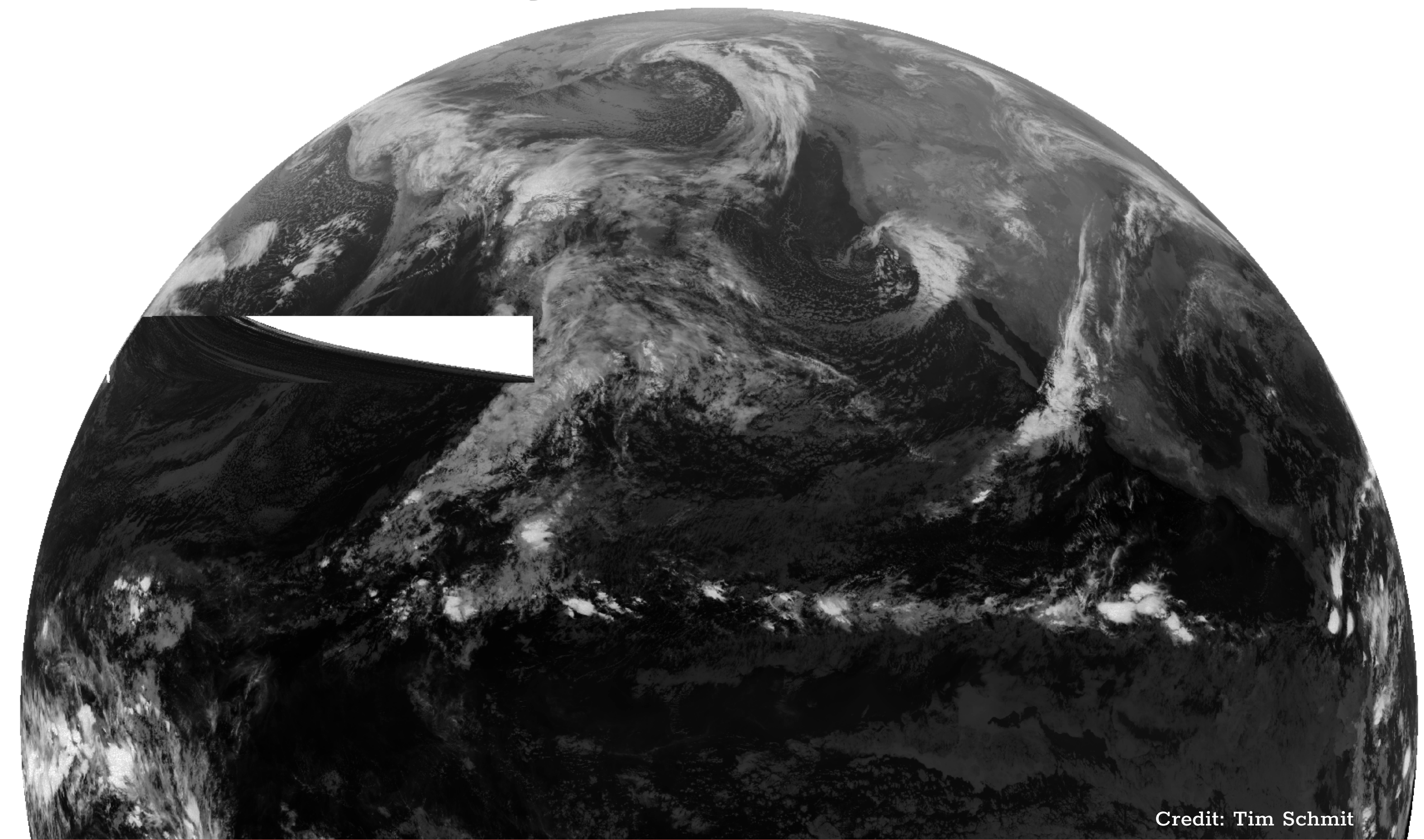
Credit: Hollyn Gaffner

Hollyn Gaffner from Aledo, Texas is planning to major in environmental sciences at the University of Wisconsin–Madison to create change. "I hope to make a positive and lasting impact on people's lives," Hollyn says, "and I am determined and driven to achieve my goals." Throughout her high school career, Hollyn excelled in AP physics courses and because of her in-depth understanding, was selected to be a teacher's aid for a physics class. She is recognized as a Rural and Small Town National Merit Scholar and a College Board AP Scholar with Honor Recognition. Outside of class, she volunteers as a tutor and participates in her high school theater program. As she looks ahead to career paths, Hollyn is considering becoming a renewable energy research scientist, an environmental lawyer or policymaker to help make a change at the governmental level.

Ikhbayar Khurelbaatar

Credit: Ikhbayar Khurelbaatar

Ikhbayar Khurelbaatar noticed the effects of climate change and pollution in his city, Ulaanbaatar, Mongolia, and he decided to make a documentary to shed light on the issue. "The cameras revealed so much about inequality and the human factors of pollution," he explains. In addition to working on his documentary, Ikhbayar continues to spread awareness of the societal impacts of climate change through his blog. He has excelled in courses and has competed in many International Science Olympiad events. Ikhbayar is passionate about studying environmental science, and green energy specifically, to help populations that are most vulnerable to the effects of climate change. To achieve these goals, he will pursue environmental engineering at the University of Wisconsin–Madison this fall. While on campus, Ikhbayar plans to join the University of Wisconsin–Madison Chapter of Engineers Without Borders.



▲ GOES-R Algorithm Working Group Imagery Team taken during the Spring 2021 virtual internship. Adomako (top-right) completed a 12-week NOAA internship with NOAA scientist Tim Schmit (bottom-right), and CIMSS scientists Mathew Gunshor (top-left) and James Nelson (bottom-left). Credit: Ronald Adomako

Shark fins and internships

Solving real world problems through mentorship

by Callyn Bloch

Ronald Adomako is looking for "shark fins," but not necessarily in the ocean; he is looking at GOES-16 and -17 images for artifacts that are not supposed to be there.

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.

Through his project, Adomako automated 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. This tool will eventually be able detect these artifacts without human intervention and help fix the anomalies.

GOES-16 and -17 transmit thousands of images per day back to Earth, so automating the error detection process is an important time-saving technique. Scientists using large datasets will benefit from the program's ability to ignore the shark fin anomalies in the future, without affecting the analysis of the dataset.

By flagging these anomalies it increases the accuracy of the data, while ensuring the public is viewing accurate weather data.

"Since GOES-16 and -17 data are open source, I'm motivated to ensure these data make sense to the public," says Adomako. "I strive to make my projects and presentations understandable to a wide audience."

Adomako's passion for science extends to mentoring high school students interested in following science, technology, engineering, mathematics careers. In addition, he promotes open access to data by publishing his code for others to use and learn.

The NOAA Experiential Research and Training Opportunities internship provides NOAA Cooperative Science Center funded research fellows opportunities to work alongside a NOAA scientist. Masters and Ph.D. students gain hands on experience learning about the NOAA mission while completing a research project in "science, technology, engineering, mathematics, policy, natural resource management, or social science."

Now that the internship is completed, Adomako and Schmit intend to publish about this work. 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.

"It's always fun working with students," says Schmit. "Adomako has taught our team valuable new skills in machine learning and even taught us how to use Slack."

Adomako finished his last semester of his master's program and is considering a Ph.D. in hopes of becoming an astronaut in the future.

This work is supported by NOAA.

2021 AOSS PHOTO CONTEST

A challenging 2020 could not stop members of the UW–Madison Atmospheric Oceanic and Space Sciences community from capturing stunning images of our natural world. Photographs submitted to the 11th AOSS Photo Contest transport us to far-flung locales, sharing severe weather and atmospheric phenomena on large and small scales.

Each year university students, scientists, staff and professors show off their passion and camera skills to bring us these outstanding photos.

1st place
David Mikolajczyk
Halo in Tent City

2st place
Rich Selin
Monument Valley Storm Clouds at Sunset

3rd place
Carissa Bungee
Hope on the Horizon


Credit: UW-Madison

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