THROUGH *the* ATMOSPHERE

Summer/Fall 2019

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

Director's note

"I shall never be content until the beneficent influence of the University reaches every family of the state"

– Charles Van Hise
UW President, 1905

Van Hise's vision became The Wisconsin Idea, encompassing all aspects of the university and extending well beyond the boundaries of the state.

For the Space Science and Engineering Center (SSEC) and the Cooperative Institute for Meteorological Satellite Studies (CIMSS), our education and research activities extend around the globe. Tristan L'Ecuyer, the new director of CIMSS, and I agree that alongside our research, we must continue to engage and educate the next generation of scientists.

While this issue of *Through the Atmosphere* is rich with stories of our research, from advances in observing techniques (for which we are known) to incorporating AI into forecasting, the thread connecting them, whether explicitly stated or implied, is education.

To that end, our scholarship committee recently selected two Wisconsin high school seniors, Leila Jean Gabrys and Gabriel M. Karr, to receive a Verner E. Suomi Scholarship. The scholarship is awarded through CIMSS, to students who exhibit a strong aptitude for the physical sciences and who exemplify many of the qualities for which Suomi, the founding director of SSEC, was well known.

Also this spring, CIMSS, in cooperation with NOAA, awarded the first William L. Smith, Sr. Graduate Scholarship to incoming graduate student Nuo Chen.

The scholarship was established in partnership with NOAA to advance our common mission of education and our commitment to improving public safety through more accurate weather prediction. Smith, for whom the scholarship is named, is a UW–Madison alumnus, emeritus professor of AOS, and first director of CIMSS who is known worldwide for his decades-long leadership of remote satellite sounding capabilities.

Two other students are launching their post-baccalaureate work and graduate studies, following their experiences at SSEC. Grace Peterson and Kelton Halbert, both worked side-by-side with SSEC researchers to gain valuable experience. Peterson will apply that knowledge in the field of engineering and Halbert is pursuing a Ph.D. in atmospheric science here at UW–Madison.

We need innovative scientists and engineers who will help solve the environmental challenges facing our society. In the spirit of Suomi, Smith and the Wisconsin Idea, we are committed to engaging and educating the next generation of researchers.

Brad Pierce
SSEC Director

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CONTENTS

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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Perspectives on CIMSS

New director Tristan L'Ecuyer shares outlook

by Jean Phillips

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) Board of Directors met in Dec. 2018 and appointed Tristan L'Ecuyer as the institute's next director. He began his role in January 2019. L'Ecuyer is well situated to lead CIMSS into the future, bringing 20 years of experience at the "intersection of satellite remote sensing and climate science" to the position. Jean Phillips talked with him about his vision for CIMSS and the opportunities, as well as challenges, that he sees on the horizon.

Over the last few months what have you learned about CIMSS that surprised you or that perhaps you did not know? Are you where you thought you would be at this point in your transition to the leadership role?

The short answer is that things are going better than I had imagined. One of the things that I have learned is that I did not have an appreciation for how cutting edge the research really is in many areas, even though I knew in the back of my mind that there was a wealth of great research and science being conducted at CIMSS.

In the last few months I have been meeting with as many people as I can. I have learned, for example, that some of the data products and the interfaces between the algorithm developers and the end-users, like the National Weather Service, are far more advanced than I had imagined. I was aware of those activities, but as I have learned more detail, I am even more impressed with the people in CIMSS and the programs they have developed.

I would say that the reality has exceeded my expectations.

Talk about your vision for CIMSS.

Again, there is a short answer and that is I feel more confident than ever that my vision for CIMSS is a good fit.

Initially, my vision was based on my previous knowledge, obviously wanting to continue, and embrace, the strengths of the institute in calibration and validation, dataset production, supporting end users, state-of-the-art satellite data visualization, and disseminating data to the community. I also had the sense that we will not survive if we only do the same things, in the same way, as we have done them in the past. The world of satellite meteorology is evolving. The world of data products and their uses is evolving. We need to lead that evolution.

As part of that process, I was hoping we would embrace new computational techniques for observations that we already have and develop new applications such as data assimilation and more advanced warnings for severe weather, to name a few, thereby expanding that portfolio. And explore new climate applications for our data products or applications in the insurance and risk management industries.

These are all things that I had hoped we would be able to do and in speaking with many of the investigators within CIMSS, I have learned that people are further along in that vision than I expected. We are already beginning to lead the transition to the next generation of satellite products and data uses that I believe will serve to grow the institute as opposed to worrying about its decline.

Another aspect of my vision was that in order to expand the user base of our data products we should build more effective bridges to other agencies. CIMSS is primarily supported by the National Oceanic and Atmospheric Administration (NOAA), but there are a number of investigators who have funding from other agencies such as NASA or the Department of Energy. One of my goals is to make sure that the satellite products we generate are also of maximum use for these other agencies.

As an example, the recent National Academy of Sciences (NAS) Decadal Survey for Earth Science and Applications from Space includes a plan to move away from really large, expensive satellites to smaller platforms that observe individual atmospheric parameters. In order for that information to be useful, you need to add context — you need to

About Tristan L'Ecuyer

Credit: Angie Montgomery

- Born and raised in Halifax, Nova Scotia (plus Ottawa, Canada; Plymouth, England and Annapolis, MD as his father was in the Navy)
- B.S. and M.S., Dalhousie University Ph.D. Colorado State University
- Current research focuses on improving understanding of the climate system through satellite remote sensing, field experiments, data mining, and numerical modeling
- 2001-2011: Worked at CSU as post-doc and research scientist, primarily on the CloudSat satellite mission
- 2011: Accepted a faculty position with the UW–Madison Department of Atmospheric and Oceanic Sciences and established the Atmospheric Energetics and Climate Research Group (currently 14 students and researchers)
- 2018: New research: Principal investigator of the Polar Radiant Energy in the Far Infrared Experiment (PREFIRE), a NASA Cubesat mission collecting data to improve predictions of Arctic warming, sea ice loss, and sea level rise
- 2019: Appointed Director of CIMSS
- Interesting fact: An avid curler, he and SSEC curling colleagues hosted an outing this spring at the Madison Curling Club to teach others the sport

know what else is going on in the atmosphere as those measurements are gathered. This is where the geostationary satellites come into play, especially our newer satellites (that CIMSS has supported since the very first one was launched). I feel that we have an opportunity to use the products we have developed to provide support for the new NASA missions in the next decade and beyond.

So, coming back to the point — what have I learned — these activities are already happening. Our cloud research teams, for example, are already generating subsets of their datasets to support other missions. Others are exploring advanced computational techniques for detecting severe weather and more rapidly identifying fires. Our data assimilation capabilities are becoming more advanced.

In short, we are further along in some of my ideas for how we can continue the evolution of CIMSS than I ever anticipated.

Is there an internal awareness issue that perhaps we should be addressing?

Maybe. Moreover, this may dovetail a little bit with how I view my role as director. I think people understand the research they are doing very well because they know their expertise and their team's expertise. But I have a feeling that perhaps the interactions between groups within CIMSS might need to be bolstered. This extends also to the interactions with our external partners like UW–Madison Department of Atmospheric and Oceanic Sciences (AOS), NOAA, NASA, and DOE where interconnectivity and communication is key. They may have a grasp of what their team is doing, but I think there may be some gaps in that communication that we could look to address. It will be part of my role to make people more aware of the synergies between the various research programs within CIMSS and then, making sure that other units and agencies are aware that we have all of this expertise in-house.

How does your background in remote sensing mesh with CIMSS' strengths? What do you bring to this mission?

One of the reasons I was excited about taking on this role in the first place is that I have been a user of CIMSS products and have known many of the CIMSS scientists from the remote sensing world for a long time. I think I am now in a position to actually start to put together the pieces — like we just talked about — and apply the talents of the various CIMSS researchers to some of these broader, more interdisciplinary projects. Returning to my own background, I obtained an undergraduate degree in physics and then pursued a Ph.D. in atmospheric science. I began my career working on satellite retrieval algorithms for cloud products, which is a huge part of what we do in CIMSS. Expanding the uses of the resulting datasets is where I feel that some of my expertise can really benefit CIMSS. For example, I think those datasets can play an important role in understanding aspects of the climate system that we do not understand or verifying climate model predictions. The same argument can be made for weather models — forecast models. We need to verify that the models are producing the right answer and we need to integrate as many observations as we can, into models, to improve forecasts.

> The world of satellite meteorology is evolving. The world of data products and their uses is evolving. We need to lead that evolution.

These are topics that I have been working on for some time. My experience has been limited to a subset of remote sensing and over the last three months, I have been introduced to this entire team of outstanding scientists at CIMSS. I would say it is probably the highest concentration of remote sensing experts in the world, all of whom contribute to that broader goal of trying to improve climate prediction and weather forecasting for the public good. I think my expertise — and I am talking about the little research tasks that I have done throughout my career — is a good match for the types of research we could consider undertaking within CIMSS.

It is part of my vision to try to push even further along the path to be sure that CIMSS takes a leadership role in using the data products that we have been generating for so many years to improve climate prediction and weather forecasting.

Are there some other areas of emerging research that would be a good fit for CIMSS?

If we want to keep the thread of remote sensing going, remote sensing has evolved since the days of Verner Suomi and the launch of the first satellites. Our building has played a huge role in that


Credit: UW–Madison

evolution. The science has matured in terms of the way we exploit measurements to gain knowledge of the Earth but there are still many new directions in which we can go to improve the information that we gain from those measurements.

Here is one example of an area that some researchers at CIMSS have already been thinking about and it is something that is on my mind, too. When we retrieve a property of the atmosphere, we often look at a single satellite footprint and we apply some theoretical radiation calculations to it to try to determine what the satellite was looking at. However, if you think about the way humans interpret information, we actually gain much more information by looking at the broader context: looking at the spatial characteristics of a complete scene and how conditions have evolved over time. With the new geostationary satellites, GOES-16 and GOES-17, we now have 5-minute snapshots that can be stitched together to show very clearly how storms are growing. We now have a tremendous amount of information about the spatial context and temporal evolution at high resolution that, with very few exceptions, we do not typically use in our retrieval algorithms. We are still applying algorithms to each pixel of an image. I think the new area — and some CIMSS scientists are already trying to do this — will be to start to use advanced computational techniques, like machine learning, to try to extract information about entire systems as they evolve, switching our thinking to a whole system instead of its individual pixels. It is a much better reflection of the way humans interpret information.

We learn a lot more by looking at an evolving picture as opposed to looking at one single element. I see this as one direction, but there are several other research themes at CIMSS that could be considered emerging areas.

> If an institute is going to lead this [AI] effort, it makes sense that it is CIMSS.

In reference to the different ways that humans interpret information, do you see new collaborations in areas of science that analyze how humans interpret information? Using that knowledge to inform the type of research we want to conduct here?

Indirectly, this is what the artificial intelligence (AI) community is doing. That is their exact goal: to take our understanding of how humans interpret information and convert it into a machine code or program so that we can actually train a computer to do the same sorts of things with data.

We are going to want to engage the AI community. Some scientists at CIMSS are already doing this, which is very exciting to me. I think in the next decade this is where remote sensing will head because of the vast amounts of information coming from new satellite technology. More and more we will engage and work with experts in the AI community to help develop those algorithms. Again, it is already happening, but will increase over the next decade during which time we may see it explode.

A slightly different angle on the question is that we have a unique capability right here in Madison due to the availability of a super computer and access to data. Few places have this.

If an institute is going to lead this effort, it makes sense that it is CIMSS.

Both SSEC and CIMSS have had leadership changes in the past six months. How do you see that organizational change in the context of the health of both institutes?

I sense a shared optimism about how refreshing this new enterprise could be. It is a big change for me, too, so that is part of my excitement.

Organizations need change to grow and thrive but when you take a new job, there is always the possibility that you have made a mistake or that you have gotten in over your head. You ask yourself, "Will I fail miserably?" I can say that over these last few months, that thought has vanished. Again, it is because of all of the conversations I have had with everyone in CIMSS — not just leadership, but everyone. The more I learn, the more excited I become about future prospects. I think that sums it up nicely.

Both Brad Pierce (SSEC Director) and I have talked at length about diversity issues within the Space Science and Engineering Center and CIMSS. We both are committed to trying to improve the diversity of ideas and groups so that everyone feels welcome here. This is not a unique organizational issue, and it is not specific to any group within our building. We know from research that the more diversity of ideas you have, the better the health of the organization and the better the range of possible solutions to problems. This benefits the community as a whole. I think AOS has made positive strides in the diversity area and I think this will benefit all of us.

I have been raising this topic in conversations. It is something that we need to talk about openly, otherwise, we cannot change unintended bias where it exists.

In the end, it is all about the people. Because it is people who make organizations. The more I learn about the people and research of CIMSS, the more excited and optimistic I am for our future.

Do you have a mentor, or someone who has influenced your thinking or career trajectory?

I suppose I have had a series of mentors but I model my career after Graeme Stephens who was my Ph.D. advisor. Of course, he has given sound advice over the years, but I also just admire his level of creativity. His ideas are transformative. You can see over the course of his career how he has advanced science, advanced remote sensing and advanced the way we think about observations. In my opinion, many of the ideas represented in the new NAS decadal survey have his fingerprints on them. In terms of CIMSS and SSEC, we need people like that, like our founders, Verner Suomi and Bill Smith, who have been the architects of change in the field. Had I known Suomi myself, he would have been a mentor for me.

Actually, another person who worked directly with Suomi and who has influenced me, is Tom Vonder Haar. He graduated from the UW and went on to influence, and lead, the program at Colorado State University where I did my graduate studies. He, too, had that same ability to not only see what could be done today, but also think about the next generation of technology and its possibilities and trying to get the community ready for the next generation of sensors.

What have you enjoyed most about this transition period?

There is no doubt about it — it is all about meeting the people at CIMSS and hearing their ideas. I am stimulated by good scientific conversations. Every meeting I have had so far, and everyone I have met at CIMSS, has stimulated new ideas. I have been extremely impressed with what the scientists are doing and learning about all of their hidden talents. I had heard of, but had not met, many of them, so having these face-to-face conversations is critical. Hearing their ideas and seeing their reactions when I also share my ideas: that exchange has been so energizing.

GOES-16/17 Virtual Science Fair winners

by Leanne Avila

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) Education and Public Outreach (EPO) Office at the University of Wisconsin–Madison recently announced the winners of its inaugural GOES-16/17 Virtual Science Fair. Teams of middle school and high school students from Massachusetts, New Jersey, and New Mexico were awarded first place for their projects using geostationary weather satellite data.

Two teams tied for first place in the middle school category. The team from Auburn Middle School in Auburn, MA studied the impact of data from the Geostationary Operational Environmental Satellite (GOES) when forecasting weather in the Upper Mississippi Valley region. The other team from Medford Memorial Middle School in Medford, NJ compared rainfall amounts collected in a rain gauge with brightness temperature data from GOES-16.

The winning high school team from Santa Fe High School in Santa Fe, NM studied tropical cyclone activity using the GOES data to test a hypothesis about a correlation between yearly solar flare X-ray irradiation and worldwide yearly tropical cyclone activity.

The students, along with their teacher-coach, won invitations to watch the GOES-T satellite launch — though they will be responsible for their own travel costs. The invitations allow them each to bring three guests and explore Kennedy Space Center for three days (the day before, day of, and day after the launch). In addition, each student will receive a $25 gift card, while teachers will receive travel support to attend and make a presentation about their students' research at the American Meteorological Society (AMS) meeting in 2020.

The Virtual Science Fair was devised as a novel way for students and teachers to learn satellite meteorology, participate in a small research project, and share what they learned. To participate in the fair, small teams of students, with the guidance of a teacher-coach, created and submitted a scientific poster about their research, along with a video describing their poster and work.

Margaret Mooney, director of the CIMSS EPO office, described the Virtual Fair as the "next step" in the GOES-R Education Proving Ground program developed at CIMSS. Echoing the GOES-R program theme of launch readiness, Mooney said that they wanted teachers to be "launch ready" as well — to be able to explain to their students the importance and benefits of this weather satellite program.

"We wanted the educators to be ready to work with the data," said Mooney. "Now that the satellites are in orbit and the data is coming down, why not get students to use the data?"

To see the winning projects, visit the GOES-16/17 2019 Virtual Science Fair website: https://go.wisc.edu/n3hwhv

Funding for the GOES-R Virtual Science Fair is provided by the GOES-R program.

▼ Two middle school teams tied for 1st place in the inaugural GOES-16/17 Virtual Science Fair, Auburn Middle School, MA (left) and Medford Middle School, NJ (center). The winning high school team was from Santa Fe, NM (right). Credits: Karin Loach, Vicky Gorman, Derek Buschman

Machine learning and its radical approach to severe weather prediction

by Eric Verbeten

In the last decade, artificial intelligence applications have exploded across various research sectors, including computer vision, communications and medicine. Now, the rapidly developing technology is making its mark in weather prediction.

The fields of atmospheric science and satellite meteorology are ideally suited for the task, offering a rich training ground that is capable of feeding an AI's endless appetite for data. Anthony Wimmers is a scientist with the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) who has been working with AI systems for the last three years. His latest research investigates how an AI model can help improve short-term forecasting (or nowcasting) of hurricanes.

Known as DeepMicroNet, the model uses Deep Learning, a type of network that is arranged in "deep," interacting layers in order to find patterns within in a dataset. Wimmers explores how an AI system like DeepMicroNet can supplement and support conventional Numerical Weather Prediction (NWP) systems.

Wimmers' 2019 paper (with Chris Velden of CIMSS and Josh Cossuth of the US Naval Research Lab) describes a way to harness deep learning to estimate tropical cyclone intensity from satellite passive microwave imagery. Using 30 years of microwave sensor data collected from polar orbiting satellites, he demonstrates how the model can estimate — with increasing accuracy — a tropical cyclone's intensity. The study was published in the journal *Monthly Weather Review*.

"The results from the study show a lot of promise, not just for the model's nowcasting accuracy, but also because these results came from data not typically used to estimate hurricane intensity," he says.

Rapid analyses like these can give forecasters vital information about a storm's behavior and what to expect, like whether the storm will undergo eyewall replacements or rapid intensification.

When predicting a hurricane's maximum sustained winds, DeepMicroNet's results differed from the historical record of forecaster-estimated values by just over 14 knots. DeepMicroNet's results improved, however, when the datasets were limited to data measured directly by aircraft. Then, the error (or root mean-square difference) was off by less than 10 knots. By comparison, estimates using state-of-the-art methods are typically off by around 9 knots.

Wimmers set out to answer three main questions. First, he wanted to determine how well the model performed compared to state-of-the-art methods for predicting hurricane intensity. Second, it was important to assess whether the results were meaningful and reproducible. Lastly, he wanted to demonstrate new ways to incorporate less commonly used data like microwave imagery into prediction models, while offering valuable insight into a storm.

"The reason Deep Learning systems have grown so much in satellite meteorology is because they are ready-made for these types of applications where you have tens of thousands of images available for training a model," says Wimmers. "It also applies to situations where you need an answer rapidly and the physical basis behind the answer is not so important."

THE SETUP

Basically, Wimmers designed his experiment to test how well an AI system could reproduce a hurricane's history. The hurricane intensities (already known) came from a combination of forecaster estimates based on other satellite data and aircraft observations. With no knowledge of the data types, DeepMicroNet's job was to estimate intensities from a large, independent dataset. In this case the data came in the form of microwave imagery measured in the 37Ghz and 89Ghz frequencies.

"Those two frequencies are useful for revealing different hurricane structures," says Wimmers. "Their relatively coarse resolution also means they can be analyzed and processed in a computer quickly."

Wimmers' AI program is capable of churning through more than 50,000 hurricane images in under two hours. It was coded using Python, a popular programming language that has become the standard for powerful machine learning applications. Wimmers says these systems reach peak performance after running at least tens of thousands of examples. Through repetitive processing of training images, the system showed it could detect and memorize patterns in a hurricane's structure.

DeepMicroNet delivered the final results after a validation test using a smaller subset of only 3,000 images. Here it applied what it learned during training and accurately assessed the intensity of the tropical cyclones.

In the past, running models with large data sets could take as long as a week to compute. Today though, advances in computing have reduced a training task like DeepMicroNet's to 90 minutes.

▲ **CIMSS researcher Anthony Wimmers' 2019 paper describes a way to harness deep learning to estimate tropical cyclone intensity from satellite passive microwave imagery. Credit: Eric Verbeten**

“These results were a promising demonstration of the kinds of things we can do with machine learning in the future,” says Wimmers. “We can interpret the results of Deep Learning networks to improve our physical models. We can find patterns that used to be beyond our reach because they were too complicated."

THE PARADOX

While Deep Learning systems can have powerful predictive capabilities, their design has an inherent drawback. Outside the AI community, the words “black box” are often used to describe AI systems and their results. A source of lengthy debate, “black box” refers to how difficult it can be, at times, to retrace the path an AI model took to reach its conclusion. It presents a major problem for the scientific community — one that is built on transparency and reproducibility.

Wimmers argues that despite some of AI’s opaque methodologies, researchers have much to gain by probing AI systems and their processes.

"On one hand, an image processing Deep Learning model can tell you quite a bit about itself based on its performance, or where it focused its efforts and which areas of an image were of highest consequence,” says Wimmers. “But on the other, we don’t have a good system for translating all that information into the physics and interpreting that to tell us what is happening in the natural world.”

NWP models are based on a series of equations and datasets derived from the actual physics of the atmosphere. They do this by running models using the interconnected physics of Earth's atmosphere to get an output. By contrast, an AI system often ignores any existing assumptions and focuses solely on finding patterns in the data.

These findings can then be used to supplement current NWP models and reveal trends worth further

▲ **DeepMicroNet, an AI program developed by Wimmers, rapidly analyzes tens-of-thousands of images of hurricanes to improve short-term forecasting and demonstrates new uses for machine learning programs. Credit: NASA**

investigation. In the best-case scenario, the AI system incorporates natural processes in the atmosphere that were previously overlooked.

THE FUTURE

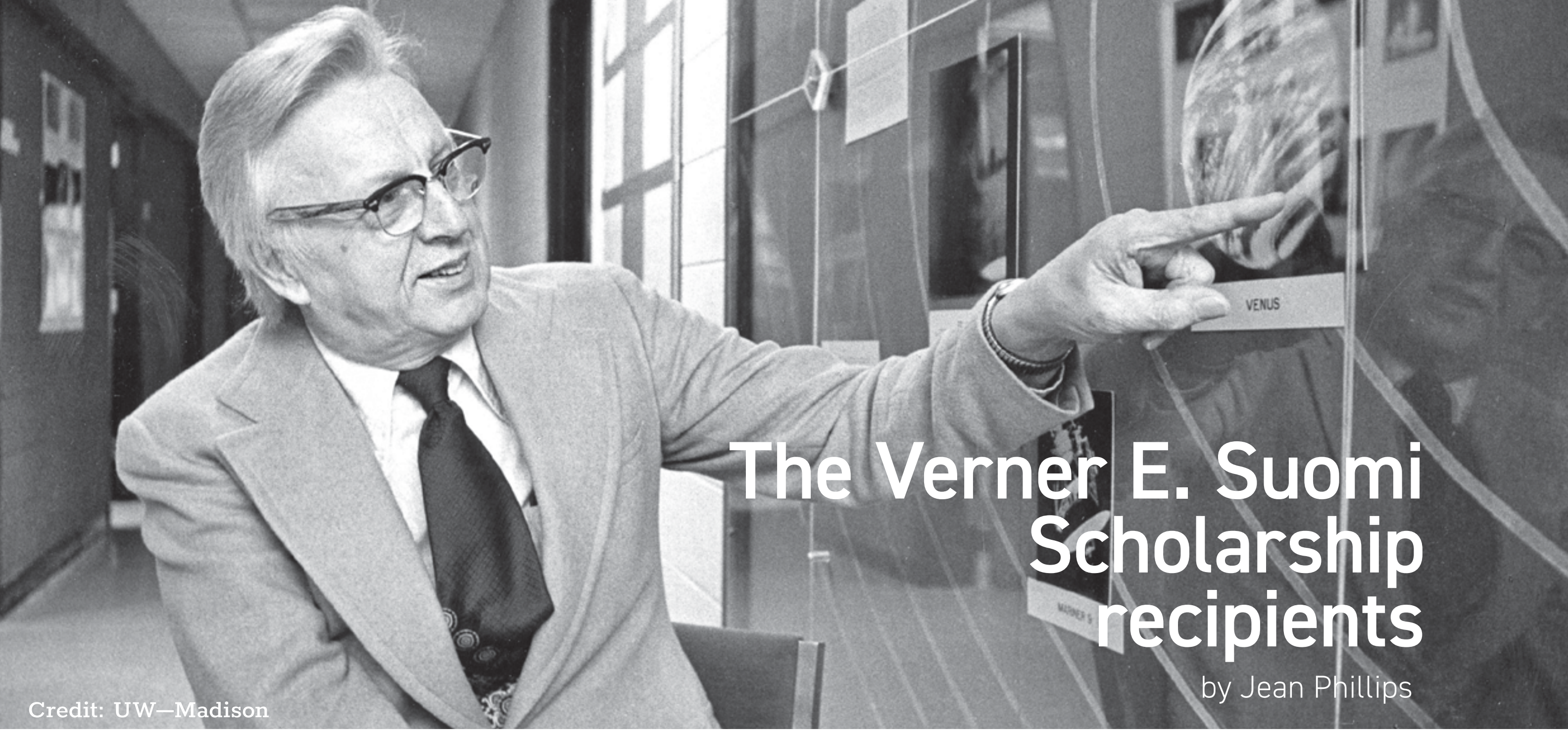
The field of AI research is evolving so rapidly that Wimmers says it can be a challenge to stay current. When asked about the future of AI machines versus conventional algorithms used in weather prediction, he doesn't see it as an impending battle between the two systems. Instead, he sees both playing complementary roles, each with their strengths and weaknesses. As noted earlier, AI systems can be limited in their ability to teach us about the underlying physics in a system, but their predictive capabilities are sure to help improve weather forecasts.

"While NWP and Deep Learning models already share a lot of similarities in how they function, they are two different tools that serve different purposes, and we can make use of both," he says.

Wimmers' research is one of several ongoing investigations into the use of AI for improving weather forecasts. CIMSS Director Tristan L'Ecuyer sees AI playing an increasingly important role for a number of areas in the atmospheric sciences such as identifying severe weather, identifying turbulence, predicting lake-effect snow, measuring air motion and sea ice movements.

"Now that high-resolution satellite images are captured every few minutes and generating enormous volumes of data to analyze, there is a need to develop innovative new ways of extracting practical information from them," says L'Ecuyer. "AI is going to play a critical role in the transition from data gathering to information production and action in the next decade and CIMSS is positioning itself to lead this effort in the coming years."

This work was supported by the US Naval Research Lab.



Credit: UW—Madison

The Verner E. Suomi Scholarship recipients

by Jean Phillips

Credits: Leila Gabrys and Gabriel Karr

Two Wisconsin high school seniors, Leila Jean Gabrys and Gabriel M. Karr, have been selected to receive a $2000 Verner E. Suomi Scholarship.

The scholarship is competitively awarded by the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) to students who exhibit a strong aptitude for the physical sciences and who exemplify many of the qualities for which Suomi, the founding director of the university's Space Science and Engineering Center (SSEC), was admired.

Gabrys will graduate this spring from Pewaukee High School. She intends to study atmospheric and oceanic sciences when she comes to campus in the fall. Like Suomi, she is driven by a commitment to science and shares his "spirit of public service and desire to help people." She intends one day to use her knowledge to work for the National Weather Service as a forecaster.

Sharing a similar passion for Earth science, Karr hopes to approach it from the vantage of an environmental engineer. A student at Oregon High School, he has grown increasingly concerned about "fossil fuel emissions and their impact on the atmosphere." Karr envisions a time when he lends his expertise to help create a more sustainable future for planet Earth.

Suomi was one of the most influential meteorologists of the 20th century and is known worldwide as the "father of weather satellites." In addition to his role as SSEC director, he had an illustrious teaching career as a faculty member in the UW–Madison Department of Atmospheric and Oceanic Sciences. Beyond his scientific achievements, Suomi was well known for his love of teaching, especially undergraduates, who he taught until his retirement.

The scholarship, offered for one year, will be applied to the students' first year of undergraduate studies at UW–Madison.

The William L. Smith Graduate Scholarship recipient

by Jean Phillips

Credit: Bill Smith

This spring the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) selected Nuo Chen as the first recipient of the William L. Smith, Sr. Graduate Scholarship.

Chen will pursue a Ph.D. in the UW's Department of Atmospheric and Oceanic Sciences (AOS) and collaborate with CIMSS researchers to study tropical cyclone intensification and methods for improving their forecasts through data assimilation. She completed her undergraduate degree in atmospheric science at Nanjing University of Information Science and Technology in China.

Offered through the cooperative agreement between the National Oceanic and Atmospheric Administration (NOAA) and the UW–Madison that supports CIMSS, the scholarship was established to advance NOAA's education mission and strengthen its commitment to improving public safety through more accurate weather prediction. Chen's proposed research and commitment to improving quality of life aligns with this mission.

Credit: Nuo Chen

"Chen's research epitomizes the essence of the William L. Smith, Sr. Graduate Scholarship," says CIMSS Director Tristan L'Ecuyer. "She will be developing innovative ways to combine NOAA's satellite observations and weather models to improve hurricane forecasts, provide more accurate information to public safety officials, and ultimately minimize damage and save lives."

The award honors the career of Smith, an alumnus and emeritus professor of AOS, who is credited with developing and advancing the remote sounding capabilities of the global satellite observing system over the last 40 years.

The Smith Graduate Scholarship is awarded based on academic merit, research experience and alignment of the student's research interests with the missions of CIMSS and NOAA. It provides up to three years of support for a graduate research assistantship in CIMSS and AOS.

Publications & Awards

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▶ Bocanegra-Bahamon, T. M., G. M. Calves, L. I. Gurvits, G. Cimo, D. Dirkx, D. A. Duev, S. V. Pogrebenko, P. Rosenblatt, S. Limaye, L. Cui, P. Li, T. Kondo, M. Sekido, A. G. Mikhailov, M. A. Kharinov, A. V. Ipatov, W. Wang, W. Zheng, M. Ma, J. E. J. Lovell, and J. N. McCallum, 2019: **Venus Express radio occultation observed by PRIDE.** *Astronomy & Astrophysics.* 10.1051/0004-6361/201833160.

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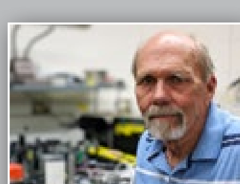
AWARDS

STEVE ACKERMAN
Sigma Xi/American Meteorological Society Distinguished Lecturer



ED ELORANTA
Lifetime Achievement Award, International Committee for Laser Atmospheric Studies

JEFF KEY
NOAA Bronze Medal for Scientific/Engineering Achievement

▶ Lim, A. H. N., J. A. Jung, S. E. Nebuda, J. M. Daniels, W. Bresky, M. Tong, and V. Tallapragada, 2019: **Tropical cyclone forecasts impact assessment from the assimilation of hourly visible, shortwave, and clear-air water vapor atmospheric motion vectors in HWRF.** *Weather and Forecasting.* 10.1175/WAF-D-18-0072.1.

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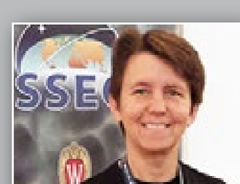
PAUL MENZEL
Yuri Gagarin Medal for contributions to environmental satellite applications, research and training



MARGARET MOONEY
Earth Science Information Partners (ESIP) 2019 Catalyst Award

Credits: UW—Madison, SSEC, Anne Pryor



PRECIP

Intersecting precipitation studies investigate global causes and impacts

by Jean Phillips

Precipitation, as rain or snow, is central to the Earth's water cycle and to sustaining life on the planet. Too much — or too little — can be catastrophic. New satellite-based instruments that collect data over broad swaths of the atmosphere are making it possible for scientists to better monitor what type of precipitation will fall, as well as where and how much. These precipitation patterns are an important piece of the weather and changing climate puzzle.

A trio of researchers from the University of Wisconsin–Madison Space Science and Engineering Center (SSEC) and the National Oceanic and Atmospheric Administration's (NOAA) Advanced Satellite Products Branch (ASPB), based at SSEC, are working on independent, but related, studies of snowfall as part of the new NASA Precipitation Measurement Missions (PMM). Their investigations all focus on snowfall to understand how these events are linked to regional — and global — hydrology.

"NASA was looking for studies in three areas: process studies, algorithm development and applications," says SSEC scientist Norm Wood. "Each of us is in a different area, but our research sits at the cross section of all three, so it is very complementary."

The PMM is an umbrella mission that consists of a worldwide network of satellites including the Global Precipitation Measurement (GPM) Core Observatory, a successor to the Tropical Rainfall Measuring Mission (TRMM) satellite. While no longer operational, data from TRMM's Precipitation Radar and Microwave Imager during its 20-year mission has been crucial to improved understanding of rainfall in the tropics, where much of the driving force behind Earth's water cycle originates.

While they lead projects that differ in scope and methodology, the three scientists are trying to do something similar, and that is, make a critical breakthrough for understanding snowfall events that will have global implications.

▲ **SSEC scientists Norm Wood (left), Claire Pettersen (center), and NOAA ASPB scientist Mark Kulie (right). Credit: Bill Bellon**

Mountain snowfall processes

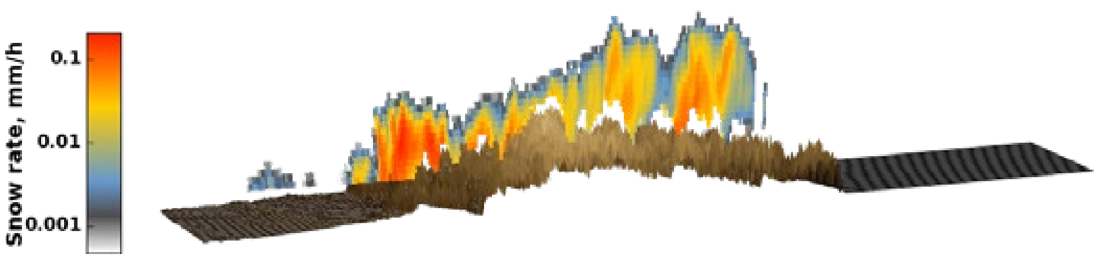
Two types of observations are available with the GPM mission: passive microwave observations from the multi-channel GPM Microwave Imager (GMI) and profiling radar observations from the Dual-frequency Precipitation Radar (DPR). Wood's validation study focuses on the latter of the two. He is looking at orographic snowfall to learn how changes in terrain elevation, shape and form influence snowfall over those areas. Mountain ranges and other types of topography, whether inland or along coasts, can influence the amount and intensity of snowfall.

Up until the age of satellites, many observations of precipitation in the atmosphere have come from ground-based radar systems, forcing the instrument to look up at elevated terrain. However, because the terrain may obscure the field of view, ground instruments are limited as to what they can actually see.

"By shifting this scenario to look at these types of systems using radars from space, we get better, more complete, representation of what is going on in the atmosphere over these regions," says Wood. "Another important part of our research is to fill in a data gap that exists right now [between our ground and satellite data]."

As the satellite orbits the planet, it passes over different mountain ranges allowing researchers to see them under varying meteorological conditions. The idea is to select certain regions of elevated terrain and observe how the production of snow changes as weather systems flow over the region.

Wood is zeroing in on precipitation efficiency, a measure of how well the available atmospheric water is converted to snowfall. If forecasters can accurately predict how much water will be converted to precipitation in the form of snow, it will serve a range of needs from local agriculture and city planning to climate studies and weather model improvements.



▲ **Snow rates retrieved from satellite-borne radar observations and collocated over a map of surface elevation. Credit: Norm Wood**

▲ **NOAA-20 image captured Feb. 12, 2019 showing all of the Great Lakes impacted by lake-effect clouds. Credit: Mark Kulie**

Algorithm development in the Great Lakes

Growing up in Michigan's Upper Peninsula, NOAA ASPB scientist Mark Kulie has seen his share of snowstorms, blizzards and white-outs. He has had a lifelong interest in snowfall patterns, especially in the Great Lakes region. Working with ground-based radars in Marquette, MI, his research, in collaboration with SSEC scientist Claire Pettersen, has isolated a specific type of snow known as convective snow.

Commonly known as lake or ocean effect snow, this type of snow is typically very shallow — often forming less than a kilometer from the Earth's surface — and results from the interaction of cold air over warmer water. Currently, lake effect snow warnings issued to the public are derived from ground-based radars that can miss the extent, as well as the amount, of accumulation.

Kulie's interests lie in assessing the accuracy of GPM estimates of convective snow as compared to those obtained from ground measurements and then, improving those estimates to create more robust global convective snow datasets.

"What we have learned, though, is that while the GMI sees very distinctive signatures, or characteristics, that are unique to convective snow, the DPR is not as sensitive," says Kulie. His research will aim to translate those GMI signatures into snowfall rate estimates and use ground observations to validate and improve DPR estimates for heavier snow. Kulie anticipates this dual-pronged approach will result in better algorithms to monitor global snowfall because observational tools can be employed to check the accuracy of computer-generated snowfall. Improved GPM observations and products will be critical in evaluating snowfall datasets that are produced by computer model simulations. These include reanalysis datasets often used to study snowfall in remote regions that lack routine observations as well as in climate models developed to project future global snowfall amounts.

Just as in the higher elevations, this regional work must also account for differing topographies, like coastlines or lake ice versus open water that can influence precipitation.

"These lake-effect snow events are very important to regional hydrology around the world," explains Kulie. In a warming climate with diminishing sea ice and more open water, these types of events may occur more frequently, he says. Kulie's goal is to create a more robust and long-term, earth monitoring dataset to support better global forecasting and analysis of global trends.

Applications in Norway and Alaska

Atmospheric rivers are like conveyor belts of moisture, extending sometimes hundreds of miles, and are commonly associated with intense rainfall along the California coast. But, these well-defined ribbons of anomalously high water vapor flowing in the atmosphere are also responsible for extreme snow accumulation farther north, along the coasts of Norway and Alaska. In fact, they frequently occur in high latitudes and are associated with flooding, highlighting the need for better water resource management in Europe and the US.

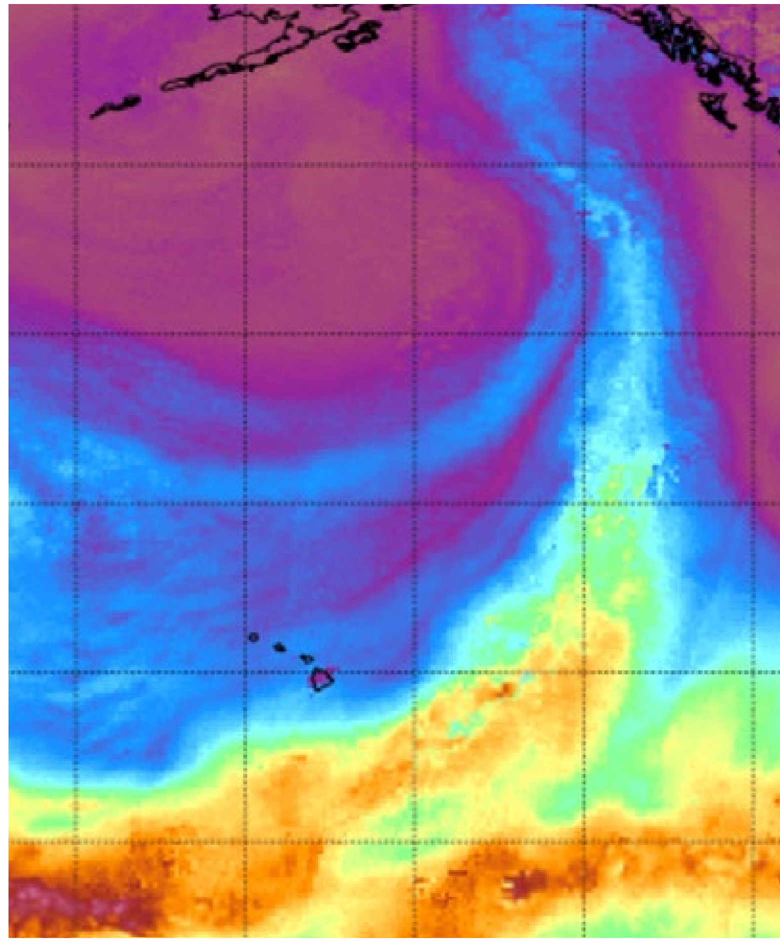
“My study will hone in on these two coastal routes, including over the ocean, to see if we can determine how atmospheric rivers may influence snowfall and mixed-phase precipitation,” says Pettersen. Importantly, she wants to determine whether snowfall amounts involving an atmospheric river event contribute disproportionately to the water cycle at high latitudes.

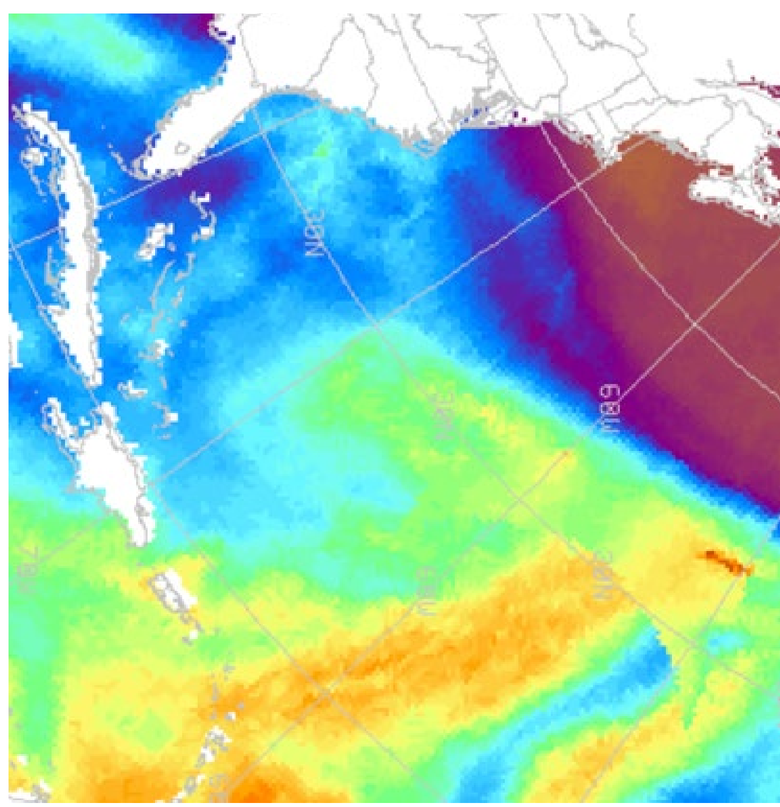
The Norway coast, with its fjords and surrounding mountainous areas, and Alaska, are situated between 50 degrees and 70 degrees north latitude, which is within the GMI footprint. In addition, the temporal coverage is relatively high due to the GPM orbit.

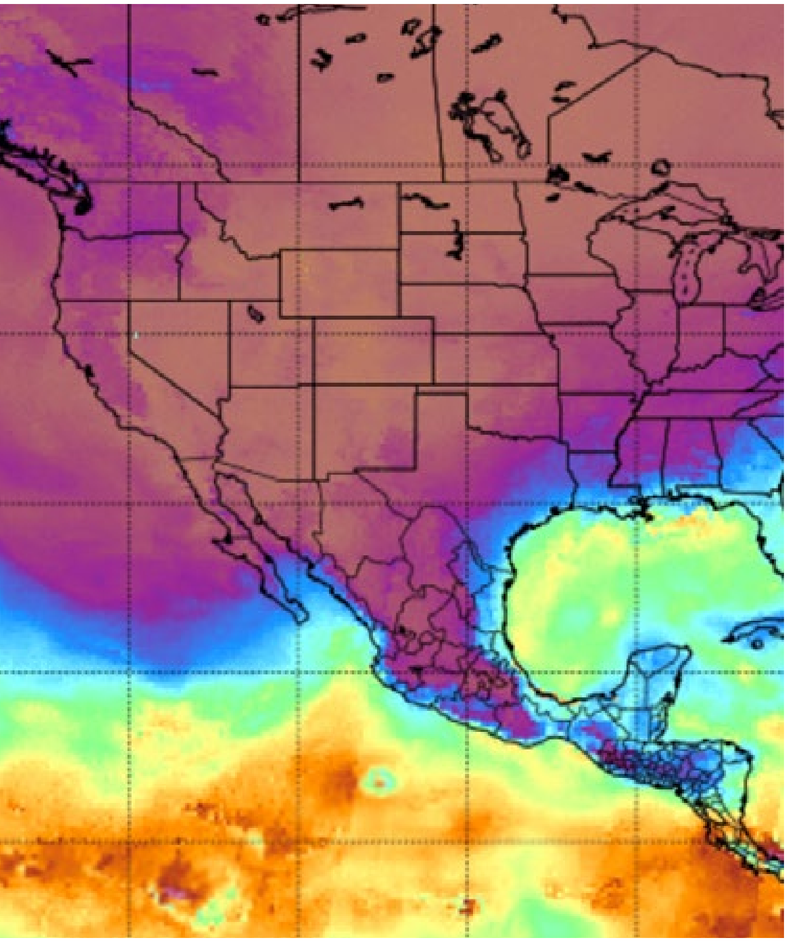
Pettersen's study will compare more than five years of GMI data to ground-based measurements and reanalysis products to assess the impact of these wintertime precipitation events.

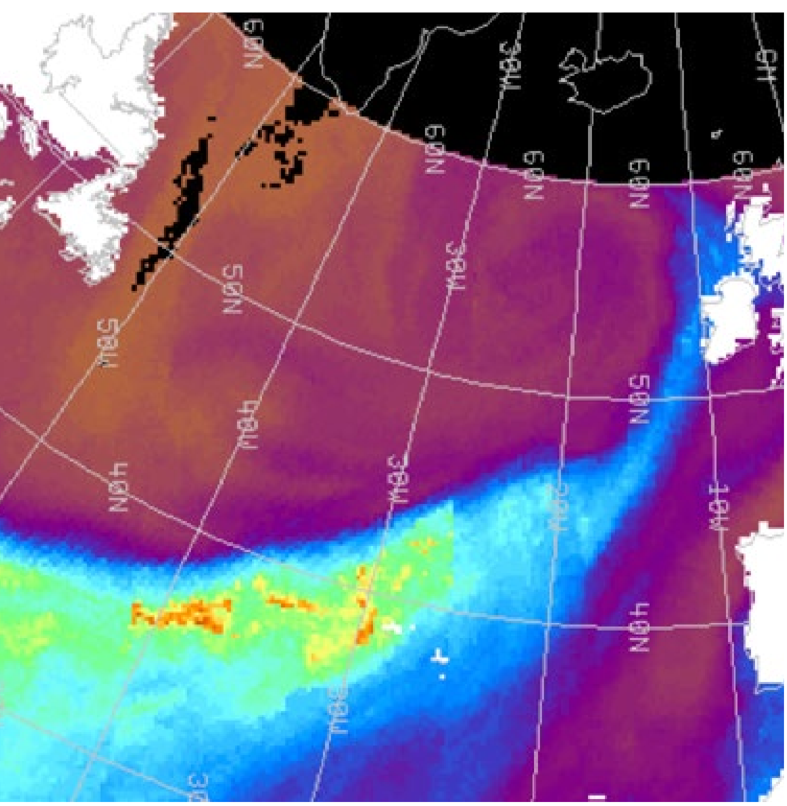
Pettersen aims to apply the results of this research to help fine-tune hydrological models in order to improve predictions of natural hazards like flooding.

“Like California, Scandinavia and the United Kingdom, are well aware of the impacts of atmospheric rivers,” says Pettersen.









New knowledge builds on existing knowledge

Whether from the ground or from a satellite, the roots of measuring Earth's atmosphere run deep at SSEC. The earliest glimpses of cloud motions and atmospheric circulation, came with SSEC's Spin Scan Cloud Camera on ATS-I in the mid-1960s setting the stage for what are now crucial observing capabilities. Once demonstrated, the era of satellite-borne instruments quickly became the norm, each generation improving on the one that preceded it.

SSEC researchers have been involved with TRMM since its launch, adding to our collective knowledge about tropical rainfall, the hydrological cycle, and the global energy budget of the planet. In fact, Kulie's first job involved working with TRMM data in 1997.

Wood, Kulie and Pettersen bring their individual strengths to the PMM collaboration along with their expertise using both satellite and ground observations. "It is advantageous because we are complementing, and enhancing each other's unique work, rather than competing with each other," says Pettersen.

Each of the three-year studies is supported by NASA.

◀ **An atmospheric river brought precipitation to south central Alaska on Nov. 12, 2018 (top) and another affected parts of Europe on Nov. 18, 2009 (bottom). Credit: CIMSS**

BRIDGE Map

Using satellite data to save lives after a wildfire

by Eric Verbeten

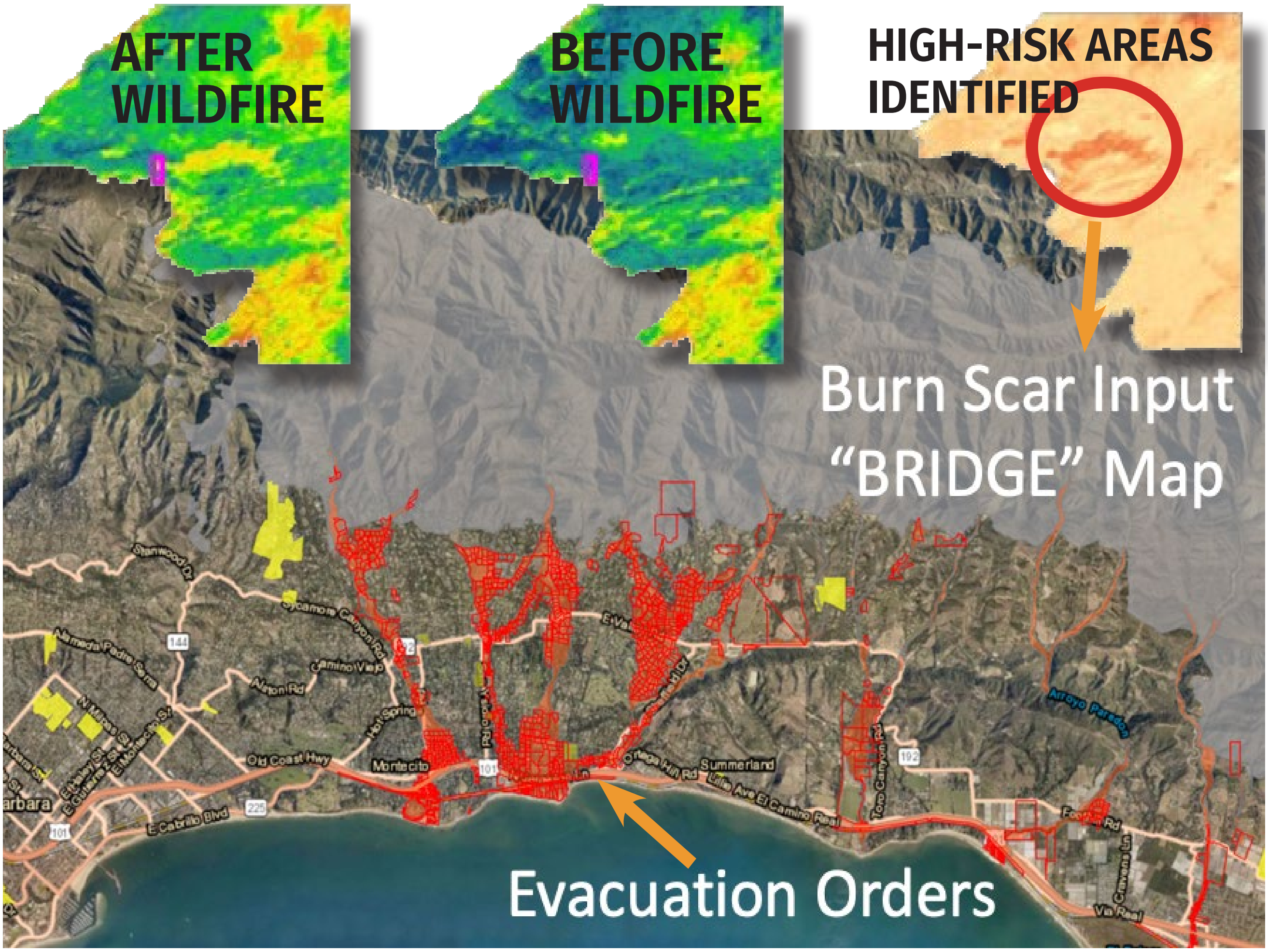
Each year, deadly wildfires scar millions of acres of land across the US causing billions of dollars in property damage. But even after a fire is contained and the flames extinguished, soils from burned areas are prone to erosion, creating the risk of devastating mudslides and debris flows when rainy weather moves in.

Sam Batzli, a research scientist with the University of Wisconsin–Madison Space Science and Engineering Center, is taking advantage of high-resolution satellite data to help the National Weather Service (NWS) forecast landslides and debris flows.

Often, the rains that help contain a wildfire are responsible for washing away the weakened landscape because it is no longer held in place by vegetation. In many cases, a burned area can be vulnerable to erosion three years after a fire.

Batzli and his colleagues are using imagery from the VIIRS imager on the Suomi NPP and NOAA-20 polar orbiting satellites to help NWS hydrologists create models to map debris flow hazards based on fire intensity estimates. Currently, the methods for mapping these areas rely on infrequent or delayed imagery from the Landsat-8 satellite. Batzli says that although the Landsat-derived map is more detailed and useful for experts on the ground, it often comes too late to be of use to NWS hazard forecasters.

Firefighters like the Burned Area Emergency Response (BAER) teams who deploy to these burned areas — sometimes before the fire is contained



▲ Example evacuation order map from 5 March 2019. Using the Normalized Difference Vegetation Index (NDVI), BRIDGE Map measures the amount of vegetation before and after a wildfire to determine areas at risk for future landslides. Credits: Santa Barbara County Sheriff and Emergency Operations Center and Sam Batzli, SSEC

— rely on up-to-date information to assess the landscape, make repairs, and fortify weak areas.

"When it comes to the safety of response teams and the people in nearby neighborhoods, getting accurate and timely information for forecasting debris flows is crucial," says Batzli. "We're working to speed up that process by producing a preliminary burn intensity map."

The map is called a Burn Intensity Delta Greenness Estimate Map or BRIDGE Map. It incorporates before and after vegetation health data from overhead passes of the satellites. With this information it calculates changes in vegetation caused by the fire. This data is fed into NWS hydrology models — and combined with other variables such as terrain, slope and predicted rain rates — helping forecasters better identify areas prone to erosion.

The BRIDGE Map team is building a website for on-demand mapping. It will function as an interface for producing and displaying this kind of information as rapidly as possible. They expect to have the site functional by the beginning of 2020.

"Although our focus is on the major US wildfires that happen in the western parts of the country, the global coverage from Suomi NPP and NOAA-20 satellites can potentially provide this information nearly anywhere around the globe," says Batzli.

This research is supported by NOAA's Joint Polar Satellite System Program.

Credit: Kelton Halbert

UW CHANGES LIVES

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, are changing student lives by providing them with opportunities to help solve real world problems in science, technology, engineering and mathematical fields.

Kelton Halbert

A passion for weather

by Natasha Kassulke

Kelton Halbert has a stormy relationship with UW.

He is pursuing a Ph.D. in high resolution weather prediction modeling. He's also a storm chaser hobbyist and his photo of more than a dozen twisters won a recent Space Science and Engineering Center (SSEC) photo contest.

Halbert was an undergraduate studying meteorology at the University of Oklahoma when he was invited to present at a National Weather Association conference. Wayne Feltz, senior scientist and executive director of UW–Madison's Cooperative Institute for Meteorological Satellite Studies (CIMSS) at SSEC, stopped Halbert at the conference to discuss graduate school plans. Two weeks later, Feltz invited Halbert to UW to give a talk on a piece of software that Halbert wrote called SHARPpy, a program that looks at severe weather forecasting and is a way of displaying information.

"UW–Madison was not in my plans, but I fell in love with Madison during that visit and met Leigh Orf (associate scientist with CIMSS) who does severe thunderstorm and tornado research resolution modeling using super computers," Halbert recalls. "Today, Leigh is my advisor and nobody is doing the research that Leigh is."

Using real-world observational data, Orf's research team studies weather conditions present at the time of large storms that spawn EF5 tornados. Halbert grew up in Tennessee in a family that was interested in extreme weather and tornadoes. In fact, he chased his first storms with his mother. Most of his family, though, are musicians.

"The joke is that I'm the rebellious son who went on to a steady career path," he says. "And it's my research at UW–Madison that has put me solidly on that path."

Grace Peterson

Hands-on learning environment benefits engineering student

by Eric Verbeten

Recent University of Wisconsin–Madison graduate Grace Peterson earned a Bachelor of Science degree in engineering mechanics and astronautics. This unique combination of interests landed her an internship at the Space Science and Engineering Center (SSEC) with the Ice Drilling Program (IDP) during her senior year.

While at SSEC, she gained invaluable experience helping to design and build several different types of ice and rock drills that are at the heart of IDP's mission.

IDP's team of engineers and scientists design, build, and operate rock and ice core drills in support of National Science Foundation funded research in cold regions around the world. Over the years, they have deployed to remote places to uncover atmospheric and climate mysteries buried in the ice in places like Alaska, Greenland, Antarctica and Norway.

While at SSEC, Peterson worked on several drill projects including the AGILE Sub-Ice Drill and the RAM Drill. One of her favorite projects, however, involved working with the Badger Eclipse Drill, an electromechanical drill that can extract 3.2'' diameter cores down to a depth greater than 900 feet.

"It was a project where I was able to work through the entire process — from design, to construction and finally testing the drill," she says.

Peterson says the yearlong internship gave her a lot of hands-on experience that she wouldn't have found in the classroom, like learning about the unique tolerances and specifications required for some of the drilling projects and using 3D modeling tools like CADD (computer-aided design and drafting).

Starting in 2020, Peterson plans to serve in the Peace Corps as a teacher in Thailand.

"The internship experience here was helpful for me in a lot of ways and I definitely think it will help me be more marketable in the future," she says.

Credit: Grace Peterson

Cracking the code of Arctic sea ice leads

by Leanne Avila

Cracks or fractures in the Arctic sea ice, known as leads, leave lines of open water. Scientists are increasingly looking at sea ice leads to determine whether their presence is related to diminishing ice in the Arctic and to learn more about ocean-atmosphere dynamics. Answering these questions, however, requires reliable data and methods for detecting them.

Using satellite instruments to detect and study sea ice leads is not new, but what has changed dramatically are the sensor technologies and improved resolutions that provide more and better detail. Taking advantage of those improvements, researchers at the University of Wisconsin–Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) have developed an updated algorithm to detect and characterize sea ice leads and to analyze trends.

Principal Investigator Steve Ackerman wanted to take a new look at sea ice leads using Moderate Resolution Imaging Spectroradiometer (MODIS) data. He partnered with Jeff Key, a scientist with the NOAA Advanced Satellite Products Branch (ASPB) stationed at CIMSS, who has unique experience using Landsat data to study Arctic sea ice leads. Rounding out the collaboration are Yinghui Liu, another NOAA ASPB scientist stationed at CIMSS with knowledge of polar region retrievals, and Jay Hoffman, the CIMSS researcher who developed the new algorithm.

Their updated method begins with a number of tests (cloud mask, ocean mask, and thermal contrast) of the MODIS data to eliminate areas that do not contain leads. Once leads are initially detected, additional tests (e.g., shape, width, and symmetry) are applied to verify the initial detection or further eliminate any areas that have been falsely identified as containing leads. A Hough Transform looks for linear features in the data. The last step is to characterize any detected leads in terms of length, width, area, and orientation. The output of the sea ice leads algorithm, in the form of NetCDF files, is available on their website: ssec.wisc.edu/leads.

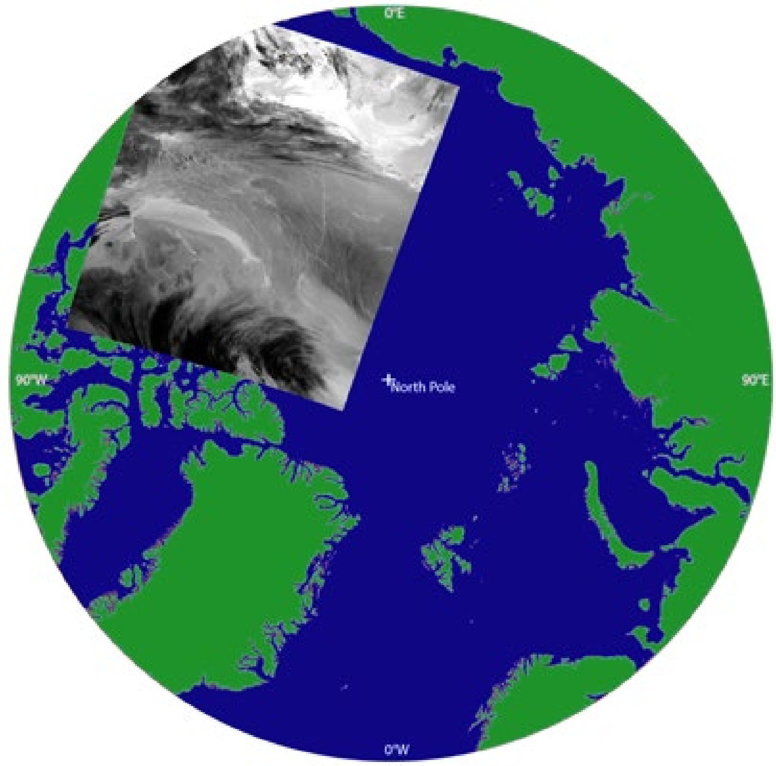
The researchers placed two constraints on the MODIS data used in the algorithm, one to manage clouds and the second to maximize the benefits of two MODIS sensors flying simultaneously. Because of clouds, only data from January through April are currently considered, though the team is discussing the possibility of expanding that to November through April. Any further attempts to broaden the algorithm to include other months would face significant issues in the form of increased cloud cover and the lack of temperature differences between sea ice and water or thin ice in the leads. As Hoffman notes, "the algorithm works fundamentally by temperature contrast."

In addition, while the first MODIS instrument was launched on the Terra satellite in 1999, the algorithm is applied to MODIS data only as far back as 2003. That was the first year in which two MODIS instruments were in orbit — with a second one flying on the Aqua satellite — allowing for multiple overpasses and observations of the same features over time.

"That's one of the advantages of having a two-satellite system — typically, upward of 30 overpasses everywhere in the Arctic [per day]. You want to detect a lead feature at the same location multiple times to have some confidence that it is actually a lead, rather than clouds that have similar thermal contrast signatures but tend to be much less stationary," says Hoffman.

The new algorithm development builds on Key's work on sea ice leads in the early 1990s. While Key describes his efforts as "a proof of concept," Ackerman notes that "it really laid the foundation of how we thought about detection." At their core, both algorithms were designed to make the best use of available satellite data, given the state of sensor technology at the time.

"The goal is the same, which is to detect leads in satellite imagery and characterize those leads in terms of their width, distribution, their orientations, length and area," says Key.



▲ MODIS-Terra 11 µm brightness temperature greyscale image from Feb. 15, 2018 at 0545 UTC. Notice leads appear as bright (warm) features relative to the darker (colder) ice and clouds. [Granule projection onto a 1 km Equal-Area Scalable Earth Grid version 2 (EASE2-Grid). The region shown is north of 65° N, with the North Pole in the center of the map.] Credit: Jay Hoffman, CIMSS

With their success in developing the algorithm to use MODIS data, the team received a second grant from NASA to adapt it to work with Visible Infrared Imaging Radiometer Suite (VIIRS) data. One challenge is the difference in resolution between the two sensors. In contrast to MODIS, VIIRS has two different 11 micron channels — the channel used in sea ice lead detection — with two different resolutions, notes Hoffman. In addition, the higher resolution did not automatically translate to improved detection of more leads.

"With the VIIRS finer spatial resolution, we thought that maybe we would see more leads than MODIS. But sometimes it detects more, sometimes it doesn't. That's part of what we're trying to figure out," says Ackerman.

Hoffman explains that part of the problem is cloud artifacts producing more noise, which affects the algorithm's ability to accurately detect leads.

Clouds pose a unique problem in their research. Not only do leads play a role in cloud formation, those clouds can then obscure the leads, making them undetectable. Or alternatively, the clouds may be semi-transparent and leads can sometimes

▲ **The Arctic sea ice leads team at CIMSS (from left to right: Steve Ackerman, Jay Hoffman, Yinghui Liu, and Jeff Key) has developed an improved algorithm to detect and characterize sea ice leads using MODIS data and is adapting the algorithm to use higher resolution VIIRS data. Credit: Eric Verbeten**

be detectable through thin clouds. Then the question is how to utilize a cloud mask — to prevent false lead detections primarily along cloud edges — while also minimizing lead detection omissions in the presence of thin clouds. The solution lies in choosing the best cloud mask, a critical step in adapting the algorithm for VIIRS.

While they continue their algorithm work, the team is already considering the questions they would like to answer when analyzing the data on sea ice leads and possible trends over time. First and foremost on their minds is how leads are changing with respect to thinning Arctic sea ice.

"One of the first hypotheses we had was that with decreasing sea ice we would see more leads. But we really haven't found that to be true," says Hoffmann. "One of the trends that we have detected is that we are finding fewer leads. But we haven't been able to say with any statistical confidence that leads are decreasing. It might be that leads are becoming more numerous but more difficult to detect."

Beyond quantifying the number of leads, future trend analyses include investigating possible correlations with changes in sea ice leads. For example, are the characteristics of sea ice leads such as width, orientation, and area changing in response to less and thinner sea ice? Similarly, the team plans to examine measurements of wind direction and strength and ocean current, looking for patterns suggesting potential connections. Pattern recognition is another area of future research. With more than 15 years of sea ice leads products using MODIS data, the team is investigating whether machine learning could be used to detect leads in VIIRS data.

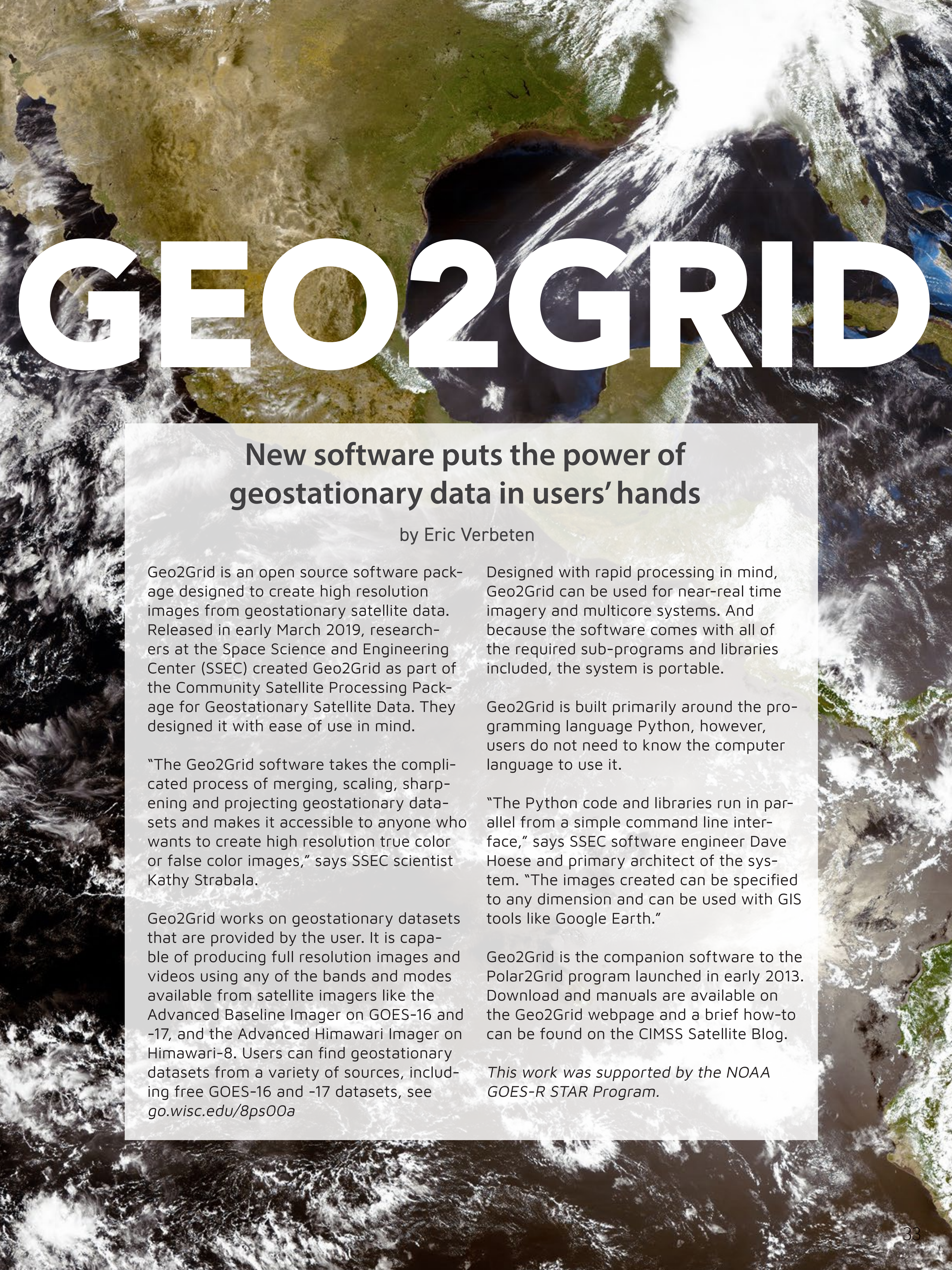
"The idea is we could use our archive of MODIS results — knowing what leads should look like — and if we see that same object shape in VIIRS, can we use a machine to tell us that that's a detection?" says Hoffman.

As Key mentions, their team is far from the only group interested in studying this special area of ocean-atmosphere dynamics. Changing trends in the Arctic, and with regard to sea ice in particular, are indeed a hot topic. And yet, as Liu adds, their current work owes a debt to research begun several decades ago.

"Jeff [Key] did this 30 years ago, and this subject slept for almost 25 years. In recent years, people are starting to look at leads more ... in observation, detection, and modeling," says Liu.

To learn more about the algorithm, please read their paper "The Detection and Characterization of Arctic Sea Ice Leads with Satellite Imagers" recently published in the journal Remote Sensing.

This work was supported by NASA.



GEO2GRID

New software puts the power of geostationary data in users' hands

by Eric Verbeten

Geo2Grid is an open source software package designed to create high resolution images from geostationary satellite data. Released in early March 2019, researchers at the Space Science and Engineering Center (SSEC) created Geo2Grid as part of the Community Satellite Processing Package for Geostationary Satellite Data. They designed it with ease of use in mind.

"The Geo2Grid software takes the complicated process of merging, scaling, sharpening and projecting geostationary datasets and makes it accessible to anyone who wants to create high resolution true color or false color images," says SSEC scientist Kathy Strabala.

Geo2Grid works on geostationary datasets that are provided by the user. It is capable of producing full resolution images and videos using any of the bands and modes available from satellite imagers like the Advanced Baseline Imager on GOES-16 and -17, and the Advanced Himawari Imager on Himawari-8. Users can find geostationary datasets from a variety of sources, including free GOES-16 and -17 datasets, see *go.wisc.edu/8ps00a*

Designed with rapid processing in mind, Geo2Grid can be used for near-real time imagery and multicore systems. And because the software comes with all of the required sub-programs and libraries included, the system is portable.

Geo2Grid is built primarily around the programming language Python, however, users do not need to know the computer language to use it.

"The Python code and libraries run in parallel from a simple command line interface," says SSEC software engineer Dave Hoese and primary architect of the system. "The images created can be specified to any dimension and can be used with GIS tools like Google Earth."

Geo2Grid is the companion software to the Polar2Grid program launched in early 2013. Download and manuals are available on the Geo2Grid webpage and a brief how-to can be found on the CIMSS Satellite Blog.

This work was supported by the NOAA GOES-R STAR Program.

AOSS 2019 photo contest

With a universal passion for weather, the atmosphere, and the natural world, photographers from around the Atmospheric, Oceanic and Space Sciences community seek to capture nature in its most complex and simplest states. For the ninth year in a row, the AOSS Photo Contest entries again capture these moments in nature, some powerful, others serene, and always inspired.

1st place
Andrew Dzambo
Burning refraction medium at large

2nd place
Sam Batzli
-15° F

3rd place
Hank Revercomb
Calm at the lake

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