TtA 2016
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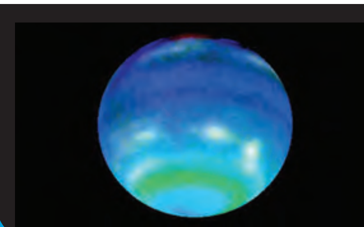

SSEC

through the atmosphere

An inside view:

From seasoned scientists to research interns

TtA Winter / Spring 2016

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

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Cover image, from left to right: SSEC research interns Amanda Gumber, Alexa Ross, Michelle Feltz, and Aaron Letterly below the AOSS building's rooftop MODIS receiver. Credit: Bill Bellon.

Director's Note

Science is often described as a systematic study of the physical and natural world through observation and experimentation. To many, the word science conjures up images of white lab coats, beakers, test tubes, telescopes, and microscopes. Others may think of it as merely a collection of facts.

Behind the instruments and facts are the people who conduct science for the benefit of others. And that makes science exciting.

At SSEC and CIMSS, science is a community endeavor, wherein the community is working to learn more about Earth's atmosphere, applying that knowledge to protect and improve our lives.

This edition of *Through the Atmosphere* introduces a few of our people who conduct scientific research: From seasoned scientists to research interns.

▶ Meet Bill Smith who has defined our young field of satellite meteorology, established CIMSS, and has received another award for a lifetime of scientific accomplishments.

▶ Meet Eva Borbas, a mid-career scientist who has helped us to understand the structure of our atmosphere through remote sensing.

▶ Meet Mike Foster, Jonathan Gero, and Tristan L'Ecuyer who are early in their science careers and already making important contributions in the areas of cloud climate data records, instrument development, and understanding Earth's energy balance, respectively.

▶ Meet the two Scotts, whose education and outreach through the CIMSS Satellite Blog reaches thousands of people seeking to better understand satellite observations.

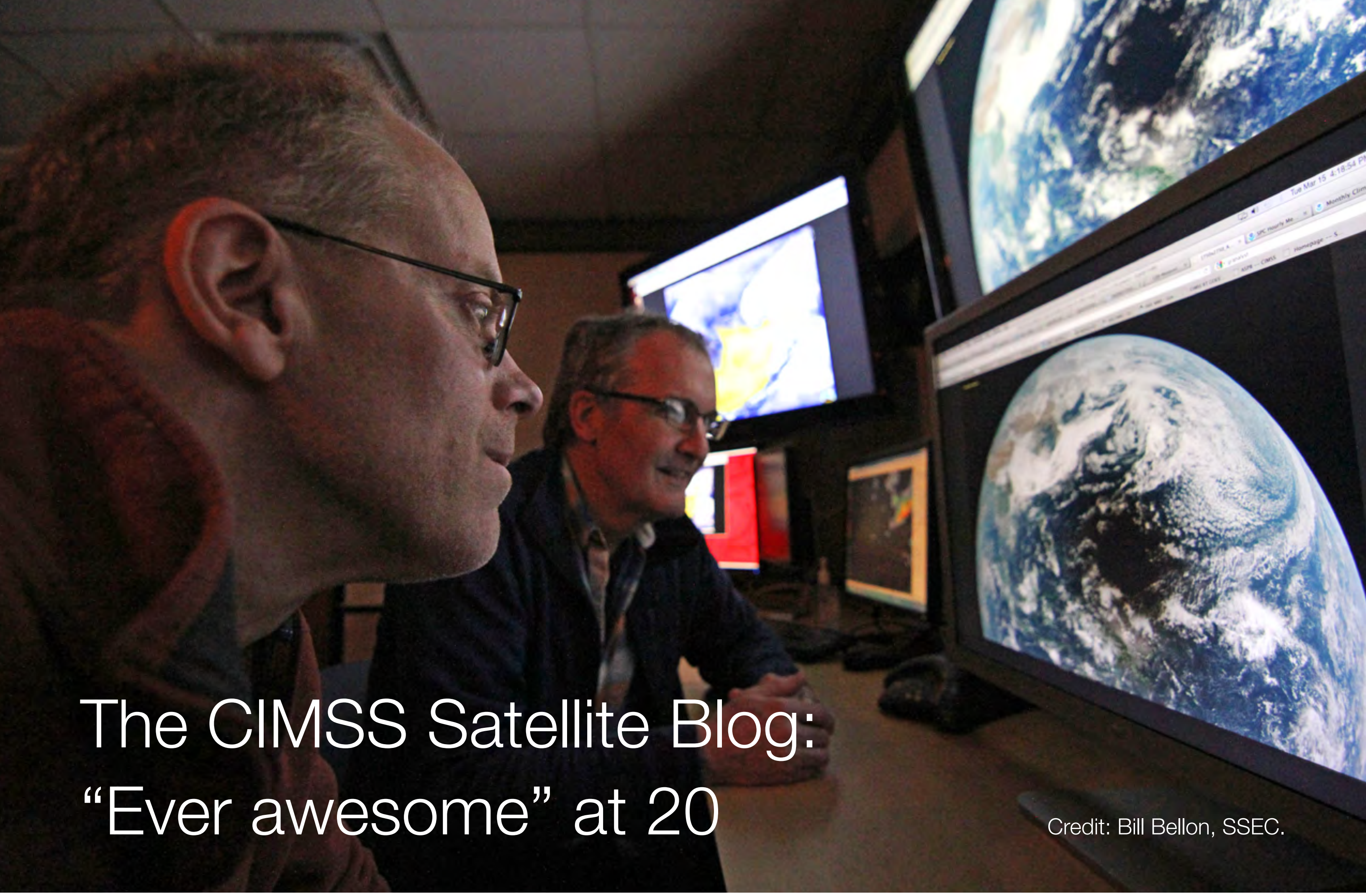
▶ Meet four recent atmospheric and oceanic science graduates who are just launching their promising careers.

These are a few of the SSEC and CIMSS scientists who are excited to discover – through their scientific inquiry – how our planet works and excited to share their discoveries with others.

Steve Ackerman

Steve Ackerman

Director, CIMSS



The CIMSS Satellite Blog: "Ever awesome" at 20

Credit: Bill Bellon, SSEC.

A perfect case study in and of itself, the CIMSS Satellite Blog circumnavigates the globe like the best Wisconsin Ideas.

For nearly 20 years, two Scotts – Bachmeier and Lindstrom – have taught the value of satellite imagery in the form of online case studies. They are atmospheric scientists at the University of Wisconsin-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) who know the benefits of satellite imagery as a means to increase our understanding of Earth's atmosphere.

Bachmeier and Lindstrom tell the compelling stories locked within those images.

Beginning in the early – and, by today's standards, primitive – days of the World Wide Web, Bachmeier began developing case studies based on satellite data for the Virtual Institute for Satellite Integration Training (VISIT). Established by NOAA, the program was designed to use distance learning technologies to train National Weather Service (NWS) forecasters.

The VISIT collaboration was a natural fit for Bachmeier because it extended the educational reach of CIMSS. He says that VISIT was developed as a way to "improve the transfer of research to operations." NWS forecasters anywhere in the world could learn about new ways to analyze remote-sensing data and imagery and incorporate it into their operational forecasts.

But disseminating large weather animations and images posed a challenge. So, in the mid-1990s, Bachmeier created the GOES Gallery. He says, "I began the GOES Gallery because I was gathering all of these cases and needed a library in which to store them." Instead of placing all of the images in a directory on a computer, it was easier and more sensible to place them on a web page where others could view them.

"But in those days," says Bachmeier, "it was a tedious operation, because I had to manually edit the HTML for every single page."

Fast-forward to the early 2000s, when Bachmeier was introduced to a new era of blogging: He quickly learned how to use the software, immediately understanding its potential.

"This was awesome and a huge eye-opener because now I could enter the images and text without bothering with the HTML," said Bachmeier. "I essentially started over."

About that time, 10 years ago, Lindstrom joined Bachmeier as a blogger.

Between the two of them, they've dramatically increased the number of case studies available for training purposes, populating the CIMSS Satellite Blog with nearly 1,700 posts in just the last decade.

The case study approach is an effective method of teaching in many disciplines. In remote sensing, the method allows Bachmeier and Lindstrom to use tools developed at CIMSS or satellite data available at CIMSS to analyze atmospheric phenomena or events. They may look at one-minute imagery of a developing thunderstorm or monitor volcanic ash plumes or study the life cycle of a typhoon and its potential to affect weather in the United States.

"There are other blogs out there, but for satellite imagery, I don't think anyone can approach the CIMSS Satellite Blog for quantity and quality," says Lindstrom.

Bachmeier agrees. The blog format allows easy access to beautiful, and sometimes ominous, animations and imagery that the two scientists update several times each week.

"That is how we differentiate ourselves," says Bachmeier, "I'm really proud of our consistency and quality."

They are constantly asking themselves, "I wonder what that looked like via satellite?" And therein lies the story.

Not surprisingly, the blog has become the go-to source for information and imagery on important weather events by other meteorologists. And, like many endeavors, new uses for the imagery and data have appeared over time and alongside the emergence of technologies such as social media.

How do they determine what is important?

As researchers at CIMSS, the two scientists tap into the SSEC Data Center, from which they have access to a wealth of data from satellite agencies around the world. They are constantly studying the satellite imagery, noting what looks interesting or what could prove to be instructive.

Bachmeier says, "I also pay attention to Twitter because a lot of what's going on there is conversation about what's going on in this or that part of the world." Twitter has become invaluable because it is impossible for the two of them to keep an eye on all potential case studies everywhere on the planet.

"Or we pay attention to what is happening in the news," adds Lindstrom. "Sometimes the really interesting images are linked to a high-impact news event. And if the images get out there quickly, people really pay attention to them."

They are constantly asking themselves, "I wonder what that looked like via satellite?" And therein lies the story.

Lindstrom recalled the 2014 Air Algerie flight that crashed in Mali less than an hour after takeoff. He happened

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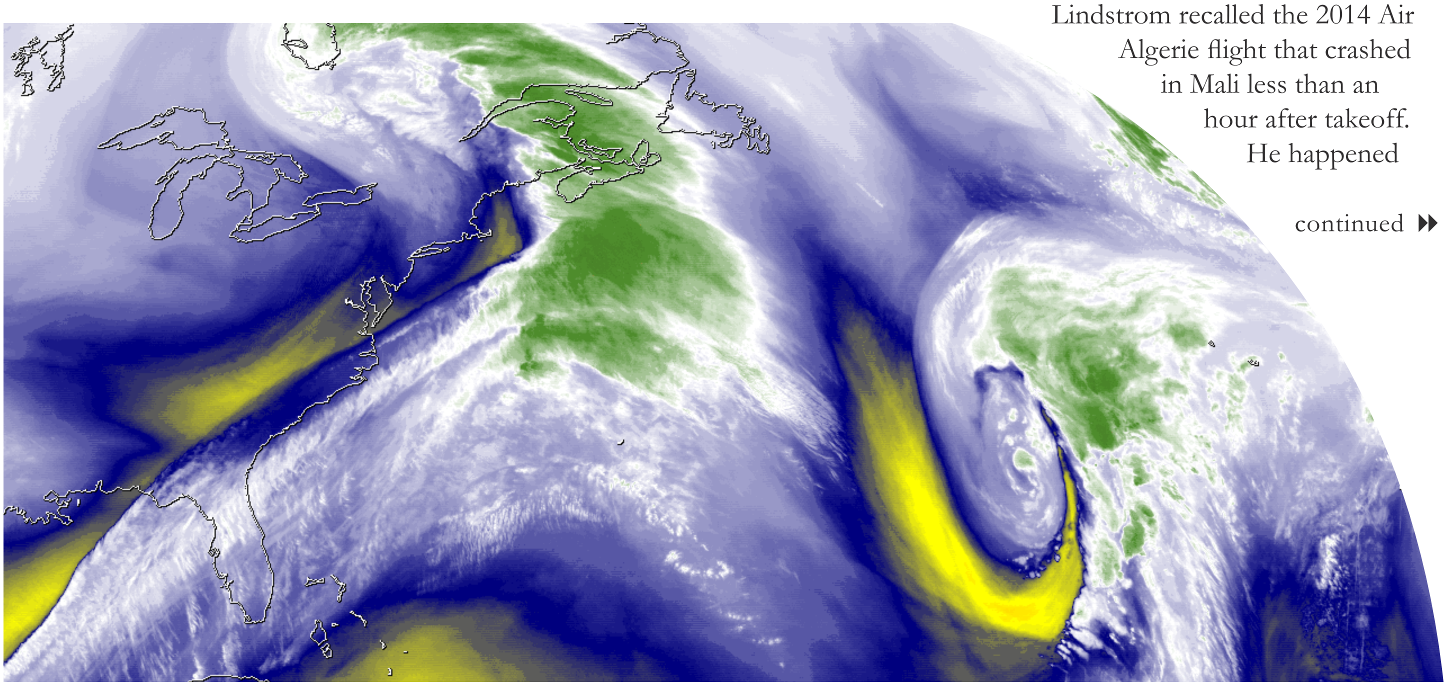

This animation, featured on Discover magazine's ImaGeo blog (http://go.wisc.edu/617j23), shows the evolution of a cyclonic storm that became Hurricane Alex in January 2015. The CIMSS Satellite Blog was referred to as "ever awesome." Credit: CIMSS.

to look at the Suomi NPP track and discovered that the satellite had passed over the area precisely at the time of the crash. He wondered, "Could we see this with the day/night band?"

The answer was yes. The satellite provided high-resolution infrared and Day/Night Band imagery along the flight path: The plane had flown through a strong convective storm, causing the crash.

The scientists are meticulous about the details and analysis they provide in each blog post. Sometimes Bachmeier will "blast out" a few images via Twitter in advance of the post. This serves two purposes, says Bachmeier. "It is a way to alert offices of responsibility about an emerging event and it gives me time to process a blog entry in my brain first."

In writing each post, they consider the kind of story they want to tell and what other images – upper air, radar, water vapor – would improve the story. Their goal is to be as comprehensive as possible with writing that is appropriate for other scientists as well as a public audience.

"We want to create understanding of how the imagery is important, so there is a lot of thought that goes into each post to make sure that what gets published is correct," says Lindstrom.

Because of this attention to detail, the blog has established a dedicated and growing audience – with 40-50,000 hits daily, readership has expanded well beyond meteorologists to include students, educators, the public, government agencies, and many others.

Bachmeier fields questions from students on a regular basis.

"They are often writing a paper and need an explanation of an image enhancement or tool that we've used to process the data."

The volcanic plume from the eruption of the Popocatépetl Volcano in Mexico was evident in Suomi NPP VIIRS true-color Red/Green/Blue (RGB) imagery on 23, 24, and 25 January 2016, as viewed using the SSEC RealEarth web map server. Credit: SSEC/CIMSS.

It's been referred to as the "ever awesome" CIMSS Satellite Blog, with posts routinely picked up by media outlets around the world – from bloggers, to print media, to national evening newscasts – further spreading the word about the value of satellite data.

Other high-impact posts included the January 2016 eruption of the Popocatépetl Volcano in Mexico. The hot spot of the erupting summit as well as movement of the volcanic plume were visible on Suomi NPP VIIRS and Terra MODIS imagery. In 2012, Hurricane Sandy initiated many posts, all of them linking back to CIMSS research websites to explain how the storm formed, weakened, re-strengthened, and evolved.

"Our images draw the eye and, in the process, our readers are learning something," says Lindstrom.

"I'm really glad that Scott is a co-author because he and I are able to look at a wider variety of cases," says Bachmeier.

"It would be fantastic if we could do a post every day because every day there is an interesting event somewhere on the globe – but how do you monitor the entire planet?"

Both Bachmeier and Lindstrom continue to be surprised at how grateful and appreciative people are when they talk about the blog.

"I do it because it is interesting," says Lindstrom, "but that other people find it interesting, too, is very gratifying."

| Jean Phillips

Eva Borbas: Collaborating her way to success

Credit: Bill Bellon, SSEC.

Good collaborators can make all the difference in the success of a research project. But, more importantly, those working relationships can have a positive impact on a researcher's career path. Since arriving at the University of Wisconsin-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) back in 2000, scientist Eva Borbas has become known for her land surface emissivity work, leading to collaborations in the U.S. and Europe.

That success in land surface emissivity began with a desire to improve temperature and water retrievals in clear skies using infrared measurements and understanding that improvements to emissivity would be key.

Algorithms to retrieve temperature and water vapor require measurements for a number of parameters, including information about the land surface. The more accurate the inputs to the algorithm, the more accurate the retrievals. The land surface measurements used in past algorithms had either been highly approximate or uniform – not necessarily an accurate reflection of the actual changes at the surface. As a result, retrievals were not as accurate either.

Borbas and colleague Suzanne Wetzel Seemann had been developing an algorithm to produce integrated water vapor (total precipitable water, TPW) from MODerate-resolution Imaging Spectroradiometer (MODIS) measurements, specifically for the MOD07 product. Using the only IR remotely sensed land surface emissivity measurements available at that time, Seemann and Borbas set out to create a land surface emissivity global database from MODIS measurements that would be useful for high spectral users and numerical weather prediction (NWP) applications; the more accurate land surface emissivity would improve the accuracy of temperature and water vapor retrievals and radiance simulation over clear skies.

The UW Baseline Fit Emissivity Database consists of 5-kilometer spatial resolution, global monthly mean infrared land surface emissivity and laboratory measurements to create that high spectral emissivity information. Today it covers 15 years of data, from 2000-2015. Since 2006, the database has been available online to registered users – more than 200 users to date.

Due to the success of the database, Roger Saunders of the United Kingdom's Met Office asked Borbas if she would help incorporate it into the UK radiative transfer model, RTTOV. Since their collaboration began in 2008, the number of users of the database have increased, and the feedback on the database has been overwhelmingly

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positive. Today, the database has been integrated into a number of other applications, including the Community Satellite Processing Package, a hyperspectral retrieval software package for direct broadcast applications developed at CIMSS.

In 2013, Simon Hook and Glynn Hulley of the NASA Jet Propulsion Laboratory asked Borbas to collaborate on a NASA emissivity project called MEASUREs (Making Earth Science Data Records for Use in Research Environments). JPL had already created an emissivity database using measurements from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on the Terra satellite.

"Aster is a good complement to MODIS… This MEASUREs project combines the UW Baseline Fit Emissivity with the ASTER-based global emissivity database to create an Environmental Data Record (EDR) of land surface temperature and land surface emissivity," said Borbas.

When the 5-year project concludes in 2019, the result will be a 17-year record of these combined measurements.

Continuing her work with water vapor retrievals, Borbas has been developing a VIIRS clear-sky TPW retrieval algorithm – a continuation of the MOD07 work, but with infrared data from the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument flying on the Suomi National Polar-orbiting Partnership (Suomi NPP) satellite.

Borbas is also working with historical water vapor measurements to create a climatological database. Collaborating with CIMSS senior scientist Paul Menzel, she processed the overall TPW, as well as water vapor in the upper, middle, and lower troposphere. Using data from the the National Oceanic and Atmospheric Administration's (NOAA) High-resolution Infrared Radiation Sounder (HIRS) instruments, which cover the years 1979-2015, they were able to create a Climate Data Record (CDR) that is now housed at NOAA's National Centers for Environmental Information (NCEI).

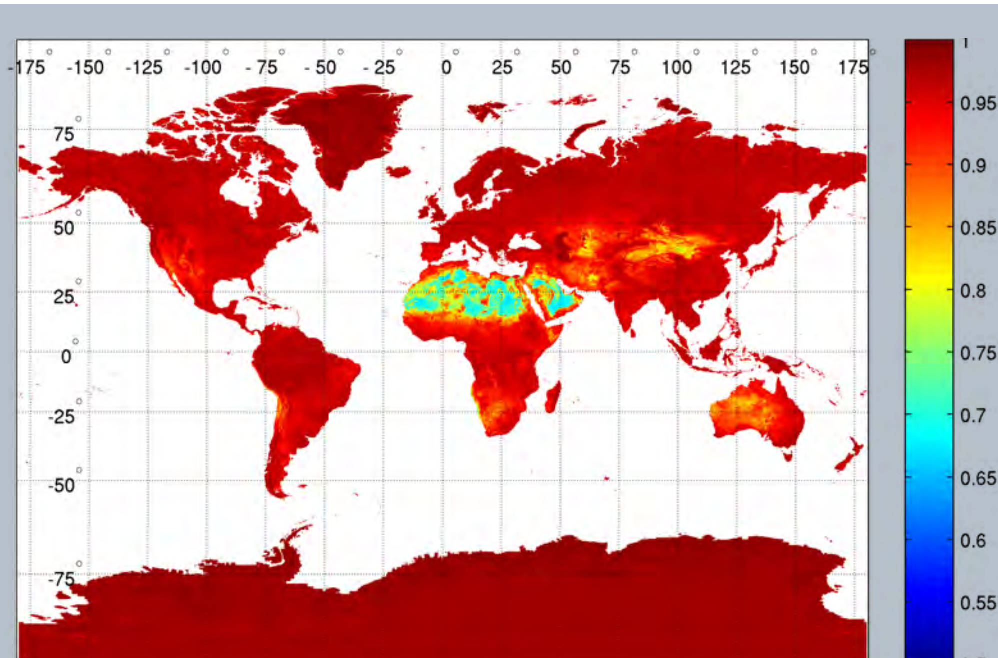
"We provided the algorithm and 10 years of data to the NOAA NCEI. But, in-house, with the help of the Atmosphere-SIPS (the NASA-supported Science Investigator-led Processing System at the Space Science and Engineering Center), we processed the whole 35 years of data," said Borbas.

That 35-year dataset was also provided to the Global Energy and Water Cycle Experiment (GEWEX) Global Water Vapor Project (GVaP), a project designed to compare and evaluate water vapor datasets.

"We believe this HIRS 35-year dataset is the longest ever water vapor record," noted Borbas.

Borbas stated how lucky she had been with her collaborators, speaking highly of them and their support for her work. She has clearly enjoyed the research opportunities provided by each new colleague – the proof is in their success.

| Leanne Avila



A figure depicting the UW Baseline Fit Global IR Land Surface Emissivity Database (emissivity at 8.3 micrometers for July 2012). Credit: Eva Borbas.

Tristan L'Ecuyer: Atmospheric, climate research group leader

Credit: UW-Madison.

"Opening observational portals into Earth's climate system," beckons the homepage of the Atmospheric Radiation and Climate research group, a team of students and scientists in the University of Wisconsin-Madison's Department of Atmospheric and Oceanic Studies (AOS).

Led by AOS associate professor Tristan L'Ecuyer, the group's research encompasses a range of foci: Earth's energy balance, cloud-aerosol interactions, climate, satellite remote sensing, and ground validation. The current group comprises 12 master's and PhD students, and four researchers (including L'Ecuyer).

Earning both his bachelor's and master's degrees in physics, L'Ecuyer has always had an eye on how his studies could be applied to make direct real-world change. He earned a PhD in Atmospheric Science at Colorado State University, and then started a post-doc position working on NASA's CloudSat satellite mission.

Using CloudSat data, he explains, he and other scientists were able to examine not just the tops of clouds, but scan through them, allowing them to study the processes within. He worked on the mission extensively for 10 years, later as a research scientist, and it was there that he developed some of the fundamental principles that guide the Atmospheric Radiation and Climate research group today.

L'Ecuyer started out as an assistant professor at UW-Madison in 2011, and established the group shortly afterward. His goal was to study the intricate, interconnected processes involved in the Earth's changing climate, such as atmospheric energy balance and the global water cycle. Not only does the group aim to better understand these phenomena, but to improve the methods by which data are collected and integrated into climate models.

About half of L'Ecuyer's funding still comes from CloudSat; he and other researchers use data detected by the radar onboard to study global rain and snowfall. The group also uses other satellites within NASA's Earth Observing System to develop and distribute new datasets for studying how energy emitted from the Earth flows through the different layers of the atmosphere which has a strong influence on weather conditions.

Aside from those satellite products, the group's research emphases fall under three general categories: Earth's Energy Balance, including refining observational estimates of the global energy balance that defines our climate; Climate Applications, including applications of satellite data to understand the influence of clouds on Arctic sea ice extent, study the factors responsible for the rapid melting of the Greenland ice sheet, the role of sunlight and thermal radiation in defining heavy rainfall patterns in the tropics, and evaluating how well climate models simulate the flow of energy through

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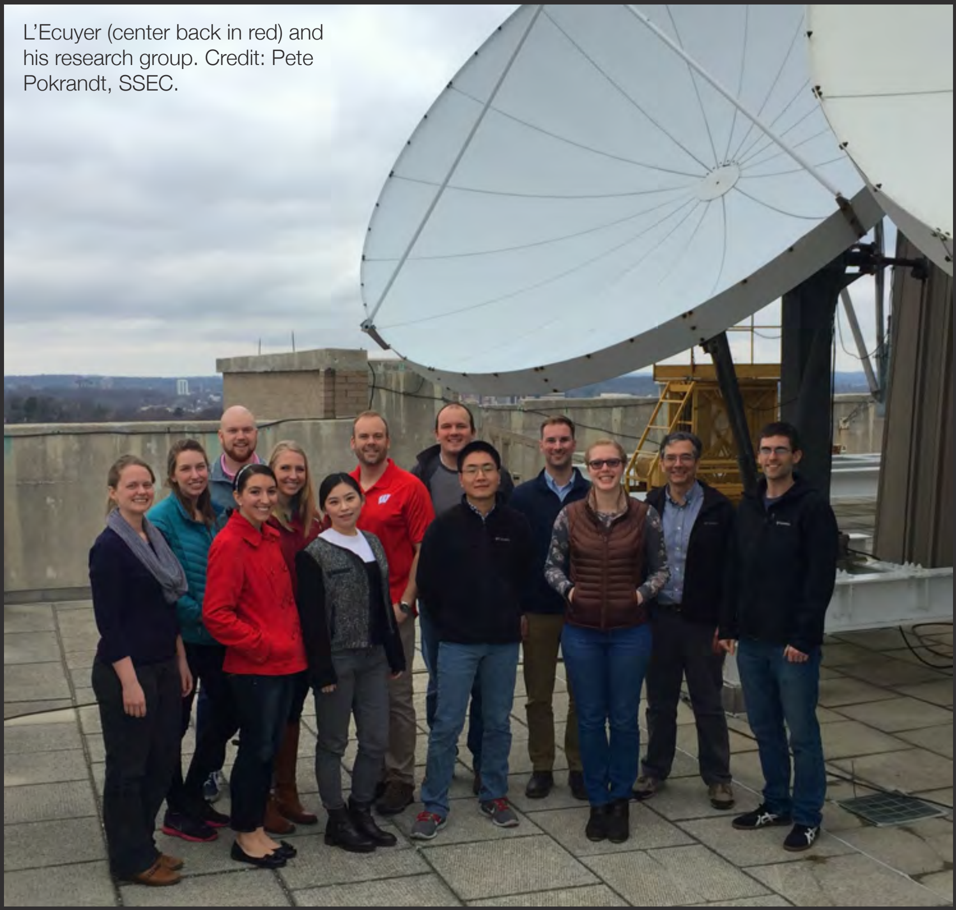

L'Ecuyer (center back in red) and his research group. Credit: Pete Pokrandt, SSEC.

the atmosphere; and Aerosol Effects – primarily, quantifying the effects of pollution on rainfall around the world.

The work they do is highly collaborative. For example, group-members are working with colleagues in NASA's Energy and Water Cycle Study (NEWS) program to continuously improve satellite-based estimates of the flows of energy and water through the climate system and the vertical structure of atmospheric heating to improve weather and climate predictions.

Additionally, a paper published last year by the American Meteorological Society, on which L'Ecuyer was lead author, was co-authored by scientists from a stunningly wide variety of top institutions: NASA Goddard Space Flight Center, NASA Langley Research Center, Princeton University, NASA Jet Propulsion Laboratory, MIT, the University of Washington, and a number of others. Benchmark estimates of global energy and water cycle values established in the paper, titled "The Observed State of the Energy Budget in the Early Twenty-First Century," are an important step toward identifying issues in today's climate models so that their predictions may be improved in the future.

"We use satellite measurements to try to verify how well a climate model works," L'Ecuyer says. "Once we know what's going on, we can compare the data to climate models and identify how we can improve them."

Being housed in the Atmospheric, Oceanic and Space Sciences building on the UW-Madison campus – home to the Space Science and Engineering Center (SSEC), the Cooperative Institute for Meteorological Satellite Studies (CIMSS), the Center for Climatic Research (CCR), and the AOS department – is a major asset for collaboration as well.

"For me it's really great having SSEC, CIMSS, and CCR in the same building as us, because it gives us access to large computing resources, data, and the people who have the expertise to use them," he says. "It's a really big benefit, and it's one of the main reasons to come to Wisconsin for research in this field — these institutions are recognized by reputation nationally and internationally."

L'Ecuyer has worked with a number of SSEC scientists, such as Mark Kulie, Matthew Lazzara, Bob Holz, and Andy Heidinger on various research projects. He also says it's been helpful to join forces with CIMSS director and AOS professor Steve Ackerman on student mentorship, as they both lead large research groups.

"We try to combine our efforts," he says. "Our students share ideas, since they are often working on related topics: using satellite observations to understand weather and climate. They share their experiences and expertise and do career-building."

L'Ecuyer's verve for applied sciences, thinking about how the research will impact the public at large, is a value he tries to impart on students coming into the program – many of whom, like himself, did not start out with an atmospheric sciences background.

Another point of emphasis, he says, is diversifying their skill sets: learning how to use observational data, satellite observations, and models.

"I think this has the potential to open up more doors and possibilities. My philosophy, my approach, is versatility. More and more jobs are looking for skills in this, this, and that — not just one specific area," he says.

One aspect of this – fieldwork – is particularly near and dear to him. “To appreciate the uncertainty of data, you need to go out and make real measurements,” he says.

In the winter of 2007, L’Ecuyer and other members of the group were involved in the Canadian CloudSat/CALIPSO Validation Project (C3VP), a field campaign led by the Meteorological Service of Canada. They were in charge of operating a mobile, ground-based instrument, NASA Jet Propulsion Laboratory’s W-band Airborne Cloud Radar (ACR); conducting quality-control for its W-band observations; and analyzing the data to develop a new CloudSat snowfall retrieval algorithm.

In the fall of 2010, the group coordinated an international collaboration called the Light Precipitation Validation Experiment (LPVEx), a field campaign designed to evaluate and improve satellite precipitation estimates at high latitudes. Scientists from the United States, Finland, and Canada worked together to make ground-based, aircraft-based and satellite-based measurements of liquid and frozen precipitation in and around Helsinki, Finland. The group is currently analyzing the data in order to evaluate and improve CloudSat light rainfall and snowfall retrieval algorithms.

The group also participated in a follow-on experiment, the Global Precipitation Mission (GPM) Cold-season Precipitation Experiment (GCPEx), which was led by scientists at NASA’s Goddard Space Flight Center over the winter of 2012. GCPEx measured properties of falling snow over Ontario, Canada, including radiative signatures and snow microphysics associated with a strong lake-effect snowstorm that dumped more than 18 inches of snow in about eight hours. These datasets will be used to developing and evaluate satellite snowfall retrievals from CloudSat and GPM observations.

Next up for the group is a large, five-year project based in Namibia, Africa, called Observations of Aerosols above CLouds and their intEractionS (ORACLES). A group of more than 90 scientists, including students from the Atmospheric Radiation and Climate Resarch Group, will collect data using multiple aircraft to understand how smoke from fires in Africa affect clouds, rainfall, and climate.

“You can make good measurements on the ground, but they just represent one point. The goal of a satellite is to take that measurement and extrapolate it over the whole Earth...”

Looking to the future, L’Ecuyer has also been in talks with scientists in SSEC’s Lidar group and the SSEC Portable Atmospheric Research Center (SPARC) to possibly collaborate on fieldwork.

Combining ground-based data with aircraft and satellite remote sensing, L’Ecuyer explains, has the ability to take fieldwork to the next level.

“You can make good measurements on the ground, but they just represent one point. The goal of a satellite is to take that measurement and extrapolate it over the whole Earth,” he says. “You’re doing the same thing, but all over the planet.”

Developing a familiarity with applying satellite data now will better enable students to think about next-generation technologies for the future, L’Ecuyer says, empowering them to take on leadership roles.

“Scientists are always thinking about future satellite missions, so I try to have my students prepare: ‘What are we not measuring now?’ Students can be developing the next concepts,” he says. “That puts them in the position to be the science leaders of tomorrow.”

| Sarah Witman

Satellite imagery of dust plumes off the coast of Namibia, Africa; a region where, in the near future, L’Ecuyer’s group will collaborate on the Observations of Aerosols above CLouds and their intEractionS (ORACLES) project. Credit: NASA Earth Observatory.

GOES-R Education Proving Ground 2016 Activities

Credit: CIMSS.

As university, government, and industry researchers anticipate the launch of GOES-R in October 2016, the GOES-R Education Proving Ground at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) has been developing learning opportunities for teachers and students.

The goal is to raise visibility and awareness around new instruments and capabilities coming with the GOES-R satellite series. GOES-R will feature new solar sensors and the Geostationary Lightning Mapper (GLM) which will measure lightning over the Americas. The most exciting and advanced technology will be the Advanced Baseline Imager (ABI) instrument, which will provide more data in greater detail faster than previously possible.

According to Margaret Mooney, project lead and director of CIMSS Education and Public Outreach, advancements coming with GOES-R align perfectly with national goals to advance skills in science, technology, engineering, and math (STEM). "What better way to promote STEM education than a new satellite?" said Mooney, "By engaging teachers around GOES-R, we can reach their students and recruit more young people to Earth science careers."

Mooney originally enlisted six teachers to work with CIMSS researchers and NOAA scientists to develop lesson plans and provide feedback on new web applications, or web apps (applications run in a browser that are used to teach concepts). Last year, the group expanded in preparation for the 2016 GOES-R launch. Currently, 29 teachers from 12 states and Puerto Rico are participating in the program for 2016, which includes a 4-part webinar series.

The first webinar took place on Saturday, February 20th and featured NOAA scientist Tim Schmit and CIMSS scientist Scott Lindstrom. Feedback from teachers indicates that several have already demonstrated what they learned about special GOES 1-minute imagery to their classes. Additional webinars are scheduled for Saturday mornings on March 12th, April 23rd and September 17th. Topics, log-in details, and recorded webinars are all available on the GOES-R Education Proving Ground web page (go.wisc.edu/iws64r).

The April webinar will include demonstrations of the new web apps developed by CIMSS and NOAA's Advanced Satellite Products Branch. These web apps will support awareness around the new capabilities coming with GOES-R. The newest app, called RGB (go.wisc.edu/fzwoit), allows users to explore, via an interactive tool, how meteorologists combine satellite data from different spectral bands to create a blended colorized image that often provides more information than separate images. The app even has an option to blend spectral bands using real-time data processed at the Space Science and Engineering Center (SSEC) data center from seven different geostationary satellites.

This fall, CIMSS is organizing a 2-day teacher workshop at Kennedy Space Center (KSC) in October. Middle and high school science teachers will tour KSC, learn all about GOES-R – and watch the GOES-R satellite launch live from the KSC Visitor Center!

The workshop, new resources, year-long events and growing network of GOES-R educators will benefit science students around the country, and, ultimately, all of society.

| **Margaret Mooney, Jean Phillips, and Tim Schmit**

Jonathan Gero: Scientist, mentor, leader

Jonathan Gero was a sophomore in college when he first met Space Science and Engineering Center (SSEC) Director Hank Revercomb. Little did he know that, less than a decade later, he would be working with Revercomb at the same institution on two major instrumentation projects.

Back in 2000, Gero was completing a summer research internship at the University of Toronto, where he was earning a bachelor's degree in engineering. The internship was part of NASA's Measurements Of Pollution In The Troposphere-Aircraft (MOPITT-A) project, an effort to develop an airborne instrument that could validate carbon-monoxide and methane measurements taken by the MOPITT instrument launched with Terra, a NASA polar-orbiting satellite.

It just so happens that the MOPITT-A collaboration was involved in NASA's SAFARI 2000 campaign to study smoke and other aerosols over South Africa – which was also one of the first deployments of SSEC's Scanning High-Resolution Interferometer Sounder (S-HIS) instrument. Staying in the same hotel and working in the same lab space throughout the campaign, Gero was introduced to Revercomb, and SSEC scientist Dan Laporte, who worked extensively on the S-HIS until his retirement earlier this year.

> "In order to do good science — good experimental science, that is — you have to understand how the instruments work..."

The internship was Gero's first experience with atmospheric science instrumentation, but it was certainly not his last. He continued to be involved with the Earth, Atmospheric, and Planetary Physics (EAPP) group at the University of Toronto until graduation, by which point he had decided to pursue graduate studies in atmospheric science.

This would lay the groundwork for the work he does now, research "at the interface of engineering and science," he says. "In order to do good science – good experimental science, that is – you have to understand how the instruments work. The two really go hand in hand."

Gero studied under James Anderson, one of the best atmospheric experimenters in the world (of which there are few), for his PhD at Harvard University. Anderson, who leads a research group on the chemistry and physics of climate and Earth-system change, was an early proponent of a NASA satellite mission dedicated to studying climate change: what would come to be known as the Climate Absolute Radiance and Refractivity Observatory, or CLARREO.

"Jim was one of the visionaries who was pushing for CLARREO before CLARREO even existed," says Gero.

Throughout Gero's postgraduate education, he and Anderson worked together to build a prototype of the instrument: how it would work, what uncertainties they would need to analyze. Afterward, NASA decided to fund the project through an Instrument Incubator Program (IIP) grant, and Gero was hired by SSEC to continue his work on CLARREO at the Center.

"It was a smooth transition," he says.

And so it happened that, in 2008, Gero started working alongside Revercomb (the principal investigator

SSEC scientist Jonathan Gero onboard a National Oceanic and Atmospheric Administration (NOAA) research vessel in the Pacific, where he led a field study last winter to better understand atmospheric rivers. Credit: Marcus Smith, ARM.

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for CLARREO at SSEC) and the rest of the team to deliver a technologically mature version of the prototype he had developed with Anderson.

Meanwhile, Gero became involved in another major project at SSEC: the Atmospheric Emitted Radiance Interferometer (AERI), an instrument developed by a team of SSEC scientists and engineers, including Revercomb, in the 1990s for the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) program.

The AERI makes highly accurate measurements of radiant energy emitted downward from the Earth's atmosphere. It uses the same common-core technology as both the S-HIS and CLARREO instruments – a specialized field of study known as Fourier transform spectroscopy (FTS).

FTS, Gero explains, is a technique for observing the atmosphere in the infrared region, which contains "a wealth of information" about temperature, water vapor, and trace gases.

"It's a very powerful measurement, which is why we're so interested in it," he says. "You could launch a weather balloon to take a profile of these quantities, but with FTS you can have an instrument on the ground or on a plane or satellite to look at an entire column and derive information about each level of the atmosphere."

In 2010, Gero was appointed by the ARM program to be the "mentor" for the AERI instrument. In this role, he oversees all nine AERI instruments under ARM's jurisdiction, including three permanent facilities (the Southern Great Plains site in Lamont, Oklahoma; the North Slope of Alaska site in Barrow, Alaska; and the Eastern North Atlantic site on Graciosa Island, Azores), a series of three mobile facilities (currently, McMurdo Station in Antarctica, Oliktok Point in Alaska, and in transit to Ascension Island in the southern Atlantic Ocean), and a network of three additional AERIs that will be deployed in Oklahoma this spring.

For the most part, Gero says, being the AERI mentor entails keeping these nine instruments "happy and functioning and producing good data."

There is also a 10th AERI, a spare, housed at SSEC so that the scientists "can tinker with it" when needed, he says. Furthermore, ARM recently purchased a marine AERI that can take measurements from onboard ships.

Last winter, Gero spent a month on a National Oceanic and Atmospheric Administration (NOAA) research vessel in the Pacific operating the marine AERI. He and a team of SSEC scientists used its measurements to examine weather patterns, including atmospheric rivers, to better understand California's historic drought.

In about a year, there will be another deployment of the marine AERI off the shores of Antarctica. A ship will ferry the AERI between Hobart, Tasmania, and Australia's Antarctic bases for a full year, in order to study the radiative processes of ice and clouds.

"It's a pretty exotic array of destinations," Gero says, "but each deployment is science-driven. These are places that have scientific questions we want to address."

Because the first AERI was deployed in 1995, there is now a 20-year continuous data record of the AERI's highly accurate thermal infrared radiance measurements. This record provides a valuable resource for long-term climate studies, such as a collaboration led by Daniel Feldman at Lawrence Berkeley National Laboratory that made the first-ever experimental verification of the greenhouse effect: carbon dioxide heating up the Earth's surface.

"To actually measure that radiating effect is not easy, and that's where the AERI comes in," Gero explains. "With those extremely accurate measurements of radiance at the surface for 20 years, we were able to exactly look at how CO2 is causing the greenhouse effect, how it's heating up the earth."

The results of the experiment, published in the journal Nature last year, were precisely consistent with previous measurements and calculations. The experiment, says Gero, "really set the record straight in that everything we know about how CO2 works is factually correct."

Looking back, Gero says he is grateful to the many people who helped him get to this stage. For example, when he was first getting acclimated to the scientific mechanics of the AERI, he recalls, there was "a bit of a learning curve," even with everything he knew about FTS from working on CLARREO. What made the difference is that he was able to work directly with the scientists and engineers who pioneered the technology, at one of only a handful of groups in the world studying this technology. Gero credits this to an innate quality of SSEC.

"That's one of the enormous strengths of working at SSEC. The people who designed the instrument, who came up with the ideas, were here for the initial deployment, and have seen an array of problems – and solved them – are still here today and we can work alongside each other," he says. "When you see a problem, you don't have to start from scratch in solving it. There's an excellent pool of expertise to draw upon."

"Not only are the scientists at SSEC of an excellent caliber," he continues, "but the people who work here like it and

Credit: Jonathan Gero.

stay here for a long time, so you have people who stay through the entire life-cycle of a project. It's invaluable."

Throughout his seven-plus years at the Center, Gero himself has been a mentor for numerous students – sharing his expertise in the same way that Anderson, Revercomb, and plenty of other scientists did for him.

"I am very much an academic at heart, in that I really value teaching. The whole premise of academia is that you are always learning and teaching at the same time," he says.

In particular, Gero has had many students work with him on the AERI project. The students get hands-on experience doing relevant work in a lab setting, and SSEC benefits from the extra set of hands (and minds) contributing to the project.

Moreover, he says, "The most rewarding part is when some of these people take an interest in this field and decide to pursue graduate degrees and professional careers in atmospheric science."

It's a win-win-win.

Coda Phillips, a University of Wisconsin-Madison engineering and computer sciences student who started working at SSEC as a freshman, was inspired to pursue a graduate degree in atmospheric science after working on AERI projects over the past four years. Phillips was a key part of the team that deployed an unprecedented network of AERIs across the Great Plains last summer for the Plains Elevated Convection At Night (PECAN) field campaign.

As a senior in high school, current UW-Madison student Matthew Westphall worked with Gero for a summer through Madison Metropolitan School District's Science Research Internship Program. Westphall is double-majoring in atmospheric and computer sciences, and has also continued to work on AERI-related projects at SSEC.

Looking further into the future, Gero says that a potential revival of the CLARREO mission could lead to a demonstration of the instrument on the International Space Station (ISS).

"Building an instrument for the Space Station could be a great opportunity for the Center," says Gero. "It will help build our expertise even more, if that comes to fruition."

| Sarah Witman

Mike Foster: Advancing research on cloud climate data records


Credit: Bill Bellon, SSEC

Two years ago, Mike Foster, a researcher with the UW-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS), and a team of colleagues made a milestone dataset delivery to the National Centers for Environmental Information (NCEI). The dataset was the PATMOS-x (Pathfinder Atmospheres Extended) cloud properties Climate Data Record (CDR) – a unique, continuous record of global cloud products strung together from Advanced Very High Resolution Radiometer (AVHRR) instruments flown on 15 different satellites beginning in 1981.

These days, Foster is helping to expand on that work, advancing research on climate datasets to make them more useful for climate applications and studying climate trends.

With the PATMOS-x AVHRR CDR delivery as a guide, the same team led by NOAA scientist Andrew Heidinger of the Advanced Satellite Products Branch (ASPB) is now developing a PATMOS-x AVHRR + HIRS CDR to deliver to NCEI.

"I am trying to add spectral information from the HIRS sounder to address shortcomings in the AVHRR imager. The sounder is good at detecting polar inversions. It's really hard for an imager to detect cloud over cold reflective surfaces, like snow or sea ice," says Foster.

In addition, the team has been dabbling in the creation of a PATMOS-x Geostationary Operational Environmental Satellite (GOES) dataset. This version using geostationary data will complement the PATMOS-x AVHRR dataset created from polar satellite measurements. They have begun processing the GOES data, but as Foster noted, they have yet to release an official product.

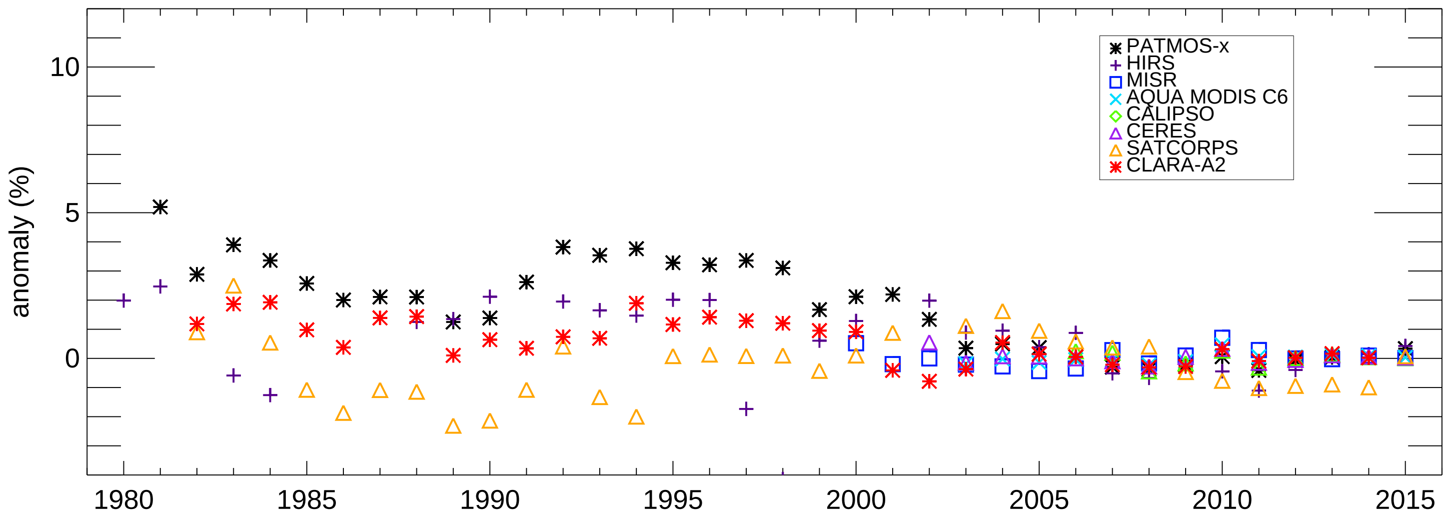
However, data from this new PATMOS-x GOES dataset, as well as data from the PATMOS-x AVHRR cloud dataset, can be accessed online through a newly created CIMSS Climate Data Portal. CIMSS programmers Tommy Jasmin and Mike Hiley have been instrumental in creating the portal, which is in beta release (www.ssec.wisc.edu/cdp/main).

In addition to helping to create PATMOS-x datasets, Foster is also studying how the use of reanalysis data affects PATMOS-x when retrieving cloud properties to look for patterns over time. Because AVHRR is only a five-channel imager, for certain cloud property retrievals it is necessary to bring in additional information, such as atmospheric profiles of temperature and moisture, from outside sources. However, using reanalysis data to fill these gaps is not without pitfalls.

"There's been some question as to how appropriate it is to use reanalysis data for trend detection. Because you're reliant on a model, and you're reliant on a changing observing system, so you can get artificial signals inserted into your record," says Foster.

Foster examined a number of different reanalysis datasets that could be used augment the PATMOS-x data: Climate Forecast System Reanalysis (CFSR, from the National Centers for Environmental Prediction); ERA-Interim (from the European Center for Medium-range Weather Forecasting); and Modern-Era Retrospective analysis for Research and Applications (MERRA, from NASA).

"The thing that interests me is trying to



Annual global cloudiness anomalies for 1981-2015. The anomaly is defined as the annual value minus the mean, derived for a period common to the satellite records excluding CALIPSO, where the entire record was used instead. The datasets include (a) PATMOS-x, (b) HIRS, (c) MISR, (d) AQUA MODIS C6, (e) CALIPSO, (f) CERES Aqua MODIS, (g) SatCORPS and (h) CLARA-A2. Credit: Mike Foster.

figure out where the shortcomings are for these long-term datasets and how we adjust for them," says Foster.

Foster also leads an effort documenting global cloudiness for the State of the Climate issue published annually by the Bulletin of the American Meteorological Society. Foster has played (and enjoyed) this role since 2008, back when he was a CIMSS postdoc. He contacts other scientists who have also developed cloud datasets derived from satellite data to gather information on their performance over the last year and compare them.

"In the last 10 to 15 years everything is in good agreement. But as you go farther back you see more variability among the datasets," says Foster.

Foster noted that one theory had been that strong El Niños were responsible for the variation. However, 2015 ushered in the first strong El Niño since 1998, and the datasets continue to show excellent agreement.

Foster also spoke about how coordinating this contribution to the State of the Climate effort has changed dramatically over the years. Not only did he have to learn how to manage the project, but research and processing advances, such as the creation of the PATMOS-x CDR, have made the task less labor intensive. Foster mentioned how he appreciated the opportunity to maintain contact with scientists conducting similar research and to review the previous year's work.

Foster was also awarded funding through the NASA New Investigator Program in Earth Science. According to NASA, this highly competitive program is "designed to support outstanding scientific research and career development of scientists and engineers at the early stage of their professional careers."

With this funding Foster and Amanda Gumber, a CIMSS research intern, are using a 3D Monte Carlo model to study how cloud field morphology affects solar fluxes and using a fit method he developed as a postdoc to "simulate the in-cloud distribution of the optical properties." Foster jokingly noted that "it's one of the few projects [that I'm working on] that's not PATMOS-x related" as they are using MODIS to conduct this research.

As NOAA has launched its last AVHRR, Foster is looking ahead to continuing the cloud climate data record with the Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi National Polar-orbiting Partnership (NPP) satellite. VIIRS has improved spatial resolution, as well as additional channels. The key to a successful transition lies in maintaining consistency between the two instrument records.

Similarly, with the success of integrating the HIRS data with the AVHRR, Foster will also be looking at integrating data from the Cross-track Infrared Sounder on Suomi NPP.

Each additional satellite instrument and passing year allows Foster to help improve and lengthen the current climate records. His research aims not only to improve the quality and consistency of the satellite cloud records but also to subsequently enhance our understanding of climate processes on a global scale.

| **Leanne Avila**

Highlights of recent publications

▶ Baldassarre, G.; Pozzoli, L.; Schmidt, C. C.; Unal, A.; Kindap, T.; Menzel, W. P.; Whitburn, S.; Coheur, P.-F.; Kavgaci, A., and Kaiser, J. W., 2015: **Using SEVIRI fire observations to drive smoke plumes in the CMAQ air quality model: a case study over Antalya in 2008**. Atmospheric Chemistry and Physics v.15, no.14, pp8539-8558.

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▶ Gravelle, Chad M.; Mecikalski, John R.; Line, William E.; Bedka, Kristopher M.; Petersen, Ralph A.; Sieglaff, Justin M.; Stano, Geoffrey T., and Goodman, Steven J., 2016: **Demonstration of a GOES-R satellite convective toolkit to "bridge the gap" between severe weather watches and warnings: An example from the 20 May 2013 Moore, Oklahoma, tornado outbreak**. Bulletin of the American Meteorological Society v.97, no.1, pp69-84.

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▶ Kaplan, John; Rozoff, Christopher M.; DeMaria, Mark; Sampson, Charles R.; Kossin, James P.; Velden, Christopher S.; Cione, Joseph J.; Dunion, Jason P.; Knaff, John A.; Zhang, Jun A.; Dostalek, John F.; Hawkins, Jeffrey D.; Lee, Thomas F., and Solbrig, Jeremy E., 2015: **Evaluating environmental impacts on tropical cyclone rapid intensification predictability utilizing statistical models.** Weather and Forecasting v.30, no.5, pp1374–1396.

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▶ Limaye, Sanjay S.; Markiewicz, W. J.; Krauss, R.; Ignatiev, N.; Roatsch, T., and Matz, K. D., 2015: **Focal lengths of Venus Monitoring Camera from limb locations.** Planetary and Space Science v.113-114, pp169-183.

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▶ WAIS Divide Project Members; Buizert, Christo; Adrian, Betty; Ahn, Jinho; Albert, Mary; Alley, Richard B.; Baggenstos, Daniel; Bauska, Thomas K.; Bay, Ryan C.; Bencivengo, Brian B.; Bentley, Charles R.; Brook, Edward J.; Chellman, Nathan J.; Clow, Gary D.; Cole-Dai, Jihong; Conway, Howard; Cravens, Eric; Cuffey, Kurt M.; Dunbar, Nelia W.; Edwards, Jon S.; Fegyveresi; Ferris, Dave G.; Fitzpatrick, Joan J.; Fudge, T. J.; Gibson, Chris J.; Gkinis, Vasileios; Goetz, Joshua J.; Gregory, Stephanie; Hargreaves, Geoffrey M.; Iverson, Nels; Johnson, Jay A.; Jones, Tyler R.; Kalk, Michael L.; Kippenhan, Matthew J.; Koffman, Bess G.; Krautz, Karl; Kuhl, Tanner W.; Lebar, Donald A.; Lee, James E.; Marcott, Shaun A.; Markle, Bradley R.; Maselli, Oliva J.; McConnell, Joseph R.; McGwire, Kenneth C.; Mitchell, Logan E.; Mortensen, Nicolai B.; Neff, Peter D.; Nishiizumi, Kunihiko; Nunn, Richard M.; Orsi, Anais J.; Pastens, Daniel R.; Pedro, Joel B.; Pettit, Erin C.; Price, P. Buford; Priscu, John C.; Rhodes, Rachael H.; Rosen, Julia L.; Schauer, Andrew J.; Schoenemann, Spruce W.; Sendelbach, Paul J.; Severinghaus, Jeffrey P.; Shturmakov, Alexander J.; Sigle, Michael; Slawny, Kristina R.; Souney, Joseph M.; Sower, Todd A.; Spencer, Matthew K.; Steig, Eric J.; Taylor, Kentrick C.; Twickler, Mark S.; Vaughn, Bruce H.; Voigt, Donald E.; Waddington, Edwin D.; Welten, Kees C.; Wendricks, Anthony W.; White, James W. C.; Winstrup, Mai; Wong, Gifford J., and Woodruff, Thomas E., 2015: **Precise interpolar phasing of abrupt climate change during the last ice age.** Nature v.520, pp661–665.

▶ Wang, Pei; Li, Jun; Goldberg, Mitchell D.; Schmit, Timothy J.; Lim, Agnes H. N.; Li, Zhenglong; Han, Hyojin; Li, Jinlong, and Ackerman, Steven A., 2015: **Assimilation of thermodynamic information from advanced infrared sounders under partially cloudy skies from regional NWP.** Journal of Geophysical Research-Atmospheres v.120, no.16, pp5469-5484.

▶ Weisz, Elisabeth; Smith, Nadia, and Smith, William L. Sr., 2015: **The use of hyperspectral sounding information to monitor atmospheric tendencies leading to severe local storms.** Earth and Space Science v.2, no.9, pp369–377.

▶ Wimmers, Anthony J. and Velden, Christopher S., 2016: **Advancements in objective multisatellite tropical cyclone center fixing.** Journal of Applied Meteorology and Climatology v.55, no.1, pp197–212.

For a complete list of publications, please visit: go.wisc.edu/lx74ac

Awards

William L. Smith
Senior Scientist, SSEC
Awarded the 2016 Losey Atmospheric Sciences Award for "visionary and pioneering hyperspectral resolution sounding techniques."

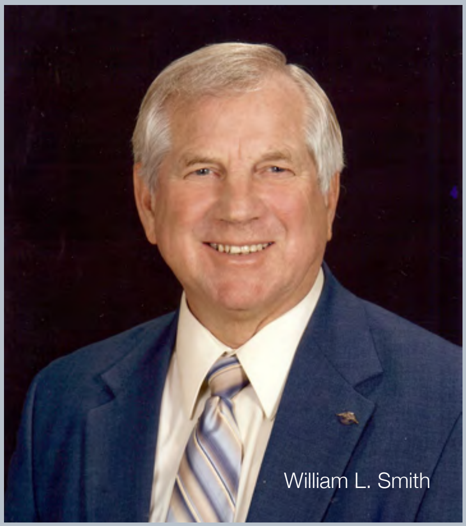
Donald R. Johnson
Professor Emeritus, SSEC
Awarded honorary member status by the American Meteorological Society.

Jun Li
Distinguished Scientist, CIMSS
Awarded the Distinguished Scientist prefix by the University of Wisconsin-Madison, a title reserved for a small number of academic staff whose superlative accomplishments are evidenced by peer recognition.

Michael Pavolonis
Physical Scientist, NOAA Advanced Satellite Products Branch
Awarded the 2015 Earth Science and Applications Award from the American Astronautical Society for developing cutting-edge methods to convert satellite data into actionable information for mitigating hazards caused by volcanic eruptions and severe convection.

Michelle Feltz
Research Intern, SSEC
Selected to receive the Lettau Award for Outstanding Master's Thesis: "Guidance for Stratospheric Temperature Products: Comparing COSMIC Radio Occultation and AIRS Hyperspectral Infrared Sounder Data." (Advisor: Steve Ackerman.)

UW satellite pioneer garners top atmospheric sciences award



Pushing the boundaries of satellite remote sensing, Bill Smith has been a catalyst for increasingly sophisticated instruments and methods to gather good data about Earth's atmosphere in order to improve weather forecasts.

A senior scientist at the University of Wisconsin-Madison Space Science and Engineering Center, professor emeritus with the Department of Atmospheric and Oceanic Sciences, and distinguished professor at Hampton University, Smith is responsible for "visionary and pioneering hyperspectral resolution sounding techniques" – techniques that are being used on current polar-orbiting satellites and planned for future polar-orbiting and geostationary satellites.

It is this work, sustained over the course of 50 years, that has landed him the 2016 Losey Atmospheric Sciences Award.

Nominated by his peers and awarded by the American Institute of Aeronautics and Astronautics (AIAA), the honor is given in memory of Captain Robert Losey, a United States Army observer and the first casualty of World War II. The award recognizes outstanding contributions to the atmospheric sciences as applied to the advancement of aeronautics and astronautics.

A scientist and an aviator, Smith has professional and personal interests in better weather forecasts. The sounding techniques he has pioneered are crucial for many fields, including aviation, where measures of the stability of the atmosphere are necessary to predict turbulence.

According to National Weather Service (NWS) director Louis Uccellini, "Bill has been at the forefront of satellite sounding of the atmosphere and its application to weather forecasting since its earliest days. There are many within the atmospheric science community today who consider Smith to be the father of satellite atmospheric sounding."

Smith's legacy extends back to the early NASA Nimbus missions – in 1972 he was the principal investigator for a radiometer that flew on Nimbus 5, successfully measuring carbon dioxide, temperature, and water vapor content in the troposphere and lower stratosphere.

Since then, he has spearheaded the field's progression to hyperspectral soundings, collecting increasingly accurate and detailed information about the vertical structure of the atmosphere with instruments on satellites, aircraft, or on the ground. In addition to temperature and moisture profiles at different levels of the atmosphere, hyperspectral infrared measurements are providing precise information on greenhouse gases, giving scientists a long view of changing climate.

"All of the work that I've done that led to this award was done at the UW-Madison," says Smith. But what makes it such a great honor for Smith is the association with "brilliant scientists" who received the award before him. Among them are Harry Wexler, Jule Charney, Moustafa Chahine and "Verner Suomi, the most notable," says Smith. "They were heavily involved in atmospheric sounding instruments and retrievals and that's what makes it so meaningful."

An alumnus of the UW-Madison Department of Meteorology, Smith received his PhD in 1966. Even then, he was examining the possibilities of using meteorological satellites to infer the temperature structure of the atmosphere from infrared radiation observations.

While studying in Madison, Smith would cross paths with Suomi, another giant in the field of satellite meteorology, who founded SSEC in 1965. Their professional interests would frequently converge over the next three decades.

Smith spent 11 years in Washington DC, from the mid-1960s until the mid-1970s, leading several satellite programs for the National Oceanic and Atmospheric Administration (NOAA). During that time, both he and Suomi were working on different aspects of the same program: the Visible-Infrared Spin-Scan Radiometer (VISSR) Atmospheric Sounder (VAS) that could obtain atmospheric soundings as well as images from the early geostationary satellites.

Smith's group in Washington DC was working on the program from the data processing point of view, and Suomi, in Madison, was working on it from the instrument point of view.

"We thought, 'Why are we doing this separately?'" Smith recalls. "It just made sense to join our forces to improve the VAS retrievals."

And so in 1976, working with Suomi, NOAA, and UW-Madison administrators to iron out the details, Smith moved eight federal scientists, plus himself, to Madison to work alongside university researchers – a move that, over the years, has repeatedly proven its value in the form of better environmental data and better weather forecasting tools. That move would result in the establishment of NOAA's Cooperative Institute for Meteorological Satellite Studies (CIMSS) at UW-Madison, with Smith as its first director.

"Beyond coming back to my alma mater," says Smith, "I wanted to come here because I saw the application of McIDAS (SSEC's Man-computer Interactive Data Access System developed for data visualization) for editing bad data and displaying sounding product results."

McIDAS was still in beta in the 1970s, but Smith, like Suomi, saw its potential, "not just for producing winds, but for quality controlling and for getting sounding information to forecasters." The story of the McIDAS innovation spread beyond SSEC and Wisconsin. After demonstrating its capabilities, the SSEC research and engineering teams installed the first McIDAS system at the National Severe Storms Forecast Center (now the NOAA Storm Prediction Center) in Kansas City, Missouri, in 1982. It was the first time "we were able to get forecasters to look at and actually use atmospheric sounding data," says Smith. "We made derived product images so they were not looking at numbers, but pictures of atmospheric features."

It was a monumental advance: McIDAS, by providing a way to animate satellite images, made the data usable to NWS forecasters who were interested in improving forecasts for severe weather.
Smith has been at the leading edge of developing atmospheric sounding systems flown by the world's premier weather agencies. In fact, generations of satellite instruments – for polar orbiting and geostationary satellites – had their genesis with Smith and his SSEC colleagues.

For example, the Cross-track Infrared Sounder (CrIS) on the Suomi National Polar-orbiting Partnership (NPP) satellite is slated for operations on the 2017 Joint Polar Satellite System: It is a direct descendent of polar-orbiting sounders developed at SSEC. Data from CrIS will improve model forecasts, aiding in both short-term and long-term weather forecasting, and provide more information about atmospheric chemistry.

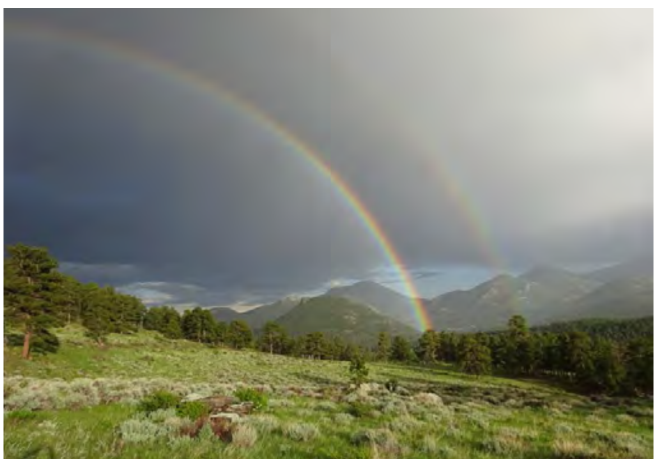
On the geostationary side, the United States has yet to include a hyperspectral sounder on one of its satellites, but China and Europe are proceeding with this capability – its lineage linked directly to the SSEC model. Smith is certain that both instruments will provide "a real demonstration of capabilities, and then maybe we'll do it."

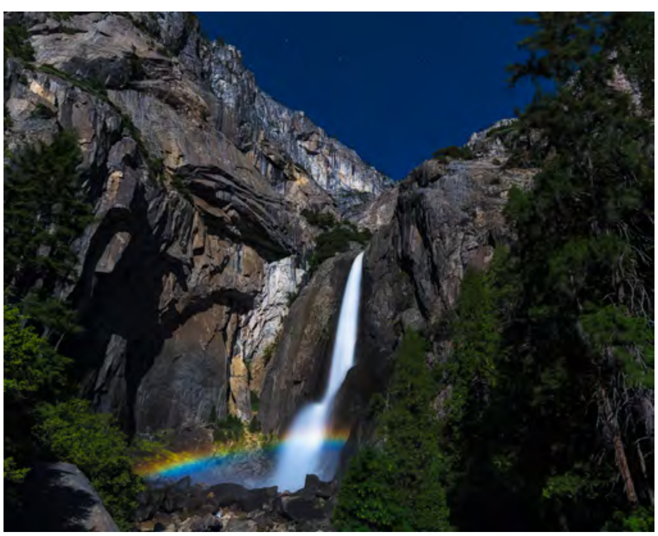
"All of this work and development was really from here," says Smith. "My name may be on the award, but there are many people at SSEC who deserve recognition for it."

| Jean Phillips

The first federal research group arrived in Madison in 1976 to collaborate with SSEC scientists. Standing, from left to right: Leroy Herman, Frederick Nagle, John Lewis, Hugh Howell, Geary Callan, William Togstad. Sitting: Harold Woolf, William Smith, Christopher Hayden. Credit: CIMSS.

2015 AOSS Photo Contest





Counterclockwise from top:

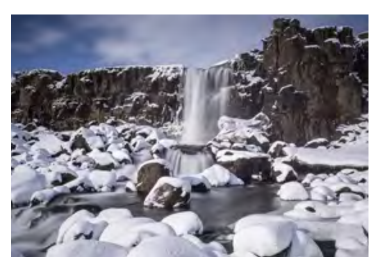
First Place
Ilya Razenkov, “Ice crystals forest,” Lake Mendota.

Second Place
Dave Stettner, “Rainbow,” Rocky Mountain National Park.

Third place
Paolo Veglio, “Moonbow,” Yosemite National Park.

Honorable Mention
Ilya Razenkov, “Pressure ridge, with Mt. Erebus in background,” Antarctica.

Honorable Mention
Dan DeSlover, “Oxarafoss waterfall after fresh snowfall,” Iceland.



SSEC's research interns forge studious camaraderie

It is uncommon, perhaps even unprecedented, for four graduate students from the same class to be hired on as Space Science and Engineering Center (SSEC) research interns straight out of school. But, in the past year, current interns Amanda Gumber, Michelle Feltz, Aaron Letterly, and Alexa Ross have done just that. Once office-mates on the Atmospheric, Oceanic and Space Sciences building's 13th floor (informally known as the graduate student office), these atmospheric scientists are using the skills and interests they developed as students to pursue real-world applications. While each of them works with a different SSEC scientist on different research projects, the relationships they built in room 1311 continue to serve them well now, as they face the challenges of full-time research.

continued ▸▸

From left to right: Research interns Alexa Ross, Amanda Gumber, Michelle Feltz, Aaron Letterly sit in front of four MODIS images of the Great Lakes in the AOSS building. Credit: Bill Bellon, SSEC.

Alexa Ross

Of the four interns, Ross has perhaps strayed the furthest from her original area of study: She did her undergraduate degree in physics, at a small liberal arts college. Unlike the University of Wisconsin-Madison, one of the most prolific research universities in the country, there were almost no research opportunities available to her as an undergraduate. She had very little programming experience.

By the time she started applying to graduate schools, though, she had set her sights on studying something within the Earth sciences.

"Climate was interesting to me," she recalls. Furthermore, she knew she wanted to work with big data.

"I liked the idea of big data, so I was looking into remote-sensing programs. Satellite remote-sensing piqued my interest because I had a little bit of a background in astronomy," she explains. "So I was used to working with satellites, just looking outward instead of inward at the Earth."

Upon starting graduate school at UW-Madison, Ross got involved in a modeling project with professor Tracey Holloway, working to answer big-picture questions about climate – but it wasn't for her. She wanted the hands-on element of working with data. From then on she has worked under SSEC scientist Bob Holz.

"[Bob] gave me a big data project and I absolutely loved it. I took a programming class that semester, using MATLAB. Programming has always been super daunting to me, because I had never had someone to walk me through things, but I fell in love with the puzzle-solving aspect of it," she says. "That was what got me into physics in the first place."

Ross' master's thesis on the microphysics of a specific type of cloud ice offered a great many puzzles to solve. Her work centered upon a year's worth of data collected by the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite. When the satellite was first launched, in 2006, its lidar was initially pointed almost straight down, or what's known as "nadir" in satellite science. At that viewing angle, it was possible to differentiate between two types of ice crystals: randomly oriented crystals and a flatter oriented type that appear at the very top of some types of clouds. When the flat type of ice crystal was present, Ross explains, the signal coming back to the sensor was strong, with very little polarization (like shining a laser-pointer into a mirror, she says).

The lidar has since been repositioned, but in the meantime this specific type of ice microphysics data was collected for all of 2007. For her thesis, Ross compared the 2007 CALIPSO data to CloudSat surface precipitation data, and found that the presence of randomly oriented ice crystals was correlated to a much higher chance of surface precipitation. While the reasons for this result are unclear, it was an interesting finding nonetheless. And, in the process of discovering it, she learned a set of invaluable skills: The research she is doing now builds directly on the work she did as a graduate student.

It also helps that she is working with the same team of scientists, she says. For the most part, these include programmers in SSEC's Science Investigator-led Processing System (SIPS) office. Ross says that, despite being the youngest one and often the only female in the room, she has always felt welcome.

"I'm working in a place where I feel like my opinions are really respected. When I present something I've done to my research group, people assume it's correct," she says. "They don't see me as a rookie. … They see me as an equal, a colleague, and I think there's something really special about that."

Currently, Ross' biggest project centers on preparing for the launch of GOES-R, a next-generation geostationary satellite, scheduled for later this year. Her role is to help develop software that can be used to validate the collocation of multiple satellites, matching up their different fields of view (something that has been done by SSEC scientists, such as Fred Nagle, for decades). She and the rest of her team work together to write code that incorporates desired variables, such as cloud-top height, into the finished product: an entire record of data.

Since geostationary satellites hover over the same point on the globe constantly, the team is "collocating to this same footprint each time," she explains, so they are able to match them up in real time.

They plan to apply the same process for validating GOES-R data upon its launch, "which everyone is super excited about," she says.

"For the first time, I feel like I'm able to relate what I'm doing to something that is operational," she says. "This could actually be helping forecasters when GOES-R gets launched. It's really cool to think that I'm contributing."

Amanda Gumber

Gumber works with SSEC scientist Mike Foster, primarily working to finish up a project she began as a master's student: manipulating data from the Moderate Resolution Imaging Spectroradiometer (MODIS), an instrument onboard NASA's Terra and Aqua polar-orbiting satellites, to examine 3D radiative cloud effects.

"I play with the data," she summarizes jokingly, explaining that she uses a method developed by Foster to retrieve distributions of cloud liquid-water path over partially cloudy scenes.

She has applied Foster's method over the MODIS record in order to create a dataset that adjusts for distributions of cloud liquid-water path in marine liquid clouds. Essentially, the method adjusts horizontal distributions of cloud optical properties to be more consistent with the observed visible reflectance, which is useful in areas where cloud optical retrievals have either failed or are considered to be low-quality.

They have used the method to do comparisons among other satellites and data sets, too. Ultimately, they use a 3D Monte Carlo radiative transfer model to identify and quantify the 3D radiative cloud effects that occur from using these adjusted distributions of cloud optical properties throughout the MODIS record.

Gumber became interested in studying clouds early on, particularly via satellite. Because of their close proximity, clouds are ultra-accessible to satellite instrumentation – especially polar-orbiters, such as MODIS, that soar a few hundred miles above the Earth's surface. Satellites also offer the advantage of a global view in just a day or two, versus highly localized ground-based instruments that cover a much narrower swath.

"Satellites have offered the opportunity to get a global record of clouds for the first time," she says. "I like it because it's a field that still has a lot to be explored."

And, with more than three decades' worth of global cloud data available, Gumber says, it's a thrilling time to be entering the field.

"We're getting to a cool part in time, where satellites have been getting cloud data for 30-plus years, so it's helping with climatology," she says. "You can use the record for climate-related analyses."

As an undergraduate student at UW-Madison, Gumber had the opportunity to do some software testing for SSEC's longest-running data visualization program, the Man-computer Interactive Data Access System (McIDAS). She would use the program and provide feedback to SSEC scientists in the McIDAS working group. After that experience, she enrolled in a remote-sensing course offered through the Department of Atmospheric and Oceanic Sciences (AOS) that gave her exposure to the full range of capabilities offered by satellites and other instrumentation. From there, she set her sights on a graduate degree in remote sensing.

Aside from making eye-catching data visualizations of her own, Gumber says her favorite part of research has been the satisfaction of getting results.

"It's great when you see something you made actually work," she says. "You apply a specific method and you get this output and you see how cool it looks. To know that you actually did something, and it's not just random noise…that's really rewarding."

To get to that scientific sweet-spot, Gumber often enlists the help of Foster or other scientists in the building, including the other interns. Having them as a sounding board has been a big help as she tackles coding challenges for the first time.

Being able to focus on her research full time has helped, too, as she works on developing her master's thesis into a paper for publication. For now, she explains, there is still at least another year to go with that project. And afterward?

"I think one day it would be cool to work on more of the algorithm development side of the process," she says. "I think that's fascinating."

No matter what role she may take on in the future, she says, one thing will stay the same: "Ultimately, you're always working toward the same goal: Let's get good measurements, so we can input them into models to get reliable results."

Michelle Feltz

Feltz has been working with SSEC scientist Bob Knuteson since she was an undergraduate student. Transitioning from undergraduate to graduate coursework was fairly seamless, she recalls. But the transition to research intern, while an informal process, has involved more of a mental shift.

"There's more responsibility, more independence," she describes. "I'm learning how research is done."

While she is unsure what will happen when her one-year internship ends, for now she says she is enjoying the opportunity to learn more about what she might want to do next.

"I really enjoyed research during grad school, so I thought being a research intern would be a good opportunity to continue working on those projects and test out if I really want to do research as a career."

Knuteson has been a wonderful mentor to help find funding and projects that would interest Michelle, she says. Her time is currently divided among three distinct projects.

Fifty percent is spent working with Knuteson and SSEC scientist Eva Borbas on NASA's Making Earth System Data Records for Use in Research Environments (MEASURES) endeavor. Borbas has already done a great deal of work on MEASURES, including validating the accuracy of a land emissivity variable: a job that has been passed on to Feltz. Using code that Borbas developed, she compares a calculated brightness temperature quantity to a satellite-measured brightness temperature to validate that their high spectral resolution emissivity algorithm is working properly. That algorithm will then transition to use in operational weather models that could be used by the numerical weather prediction community to improve weather forecasts.

Another 25 percent of Feltz's time is focused on a validation project for SSEC scientist Lori Borg related to the National Oceanic and Atmospheric Administration (NOAA) Unique CrIS/ATMS Processing System (NUCAPS). Feltz's role in the project is essentially an extension of her master's thesis topic, which recently earned her the Lettau Award for Outstanding Master's Thesis. In her thesis, she explored the use of radio occultation – a means of making atmospheric measurements by detecting changes in radio signal caused by electromagnetic radiation passing through the Earth's atmosphere – to validate soundings from satellites. She and Borg are currently working on a paper that will compare all available operational temperature products to radio-occultation temperature data.

A third project that Feltz has just recently gotten involved with is particularly exciting, she says, because the real-world applications are readily apparent. An aviation safety initiative out of Alaska, the project is examining the "cold pool" phenomenon. Aircraft cannot fly through cold air aloft, Feltz explains, because it's too dangerous. So, scientists are trying to find ways to get real-time 3D observations available to forecasters. A number of forecasters have been working with SSEC scientist Elisabeth Weisz and scientists based at other institutions to use infrared sounders to provide these observations. Feltz's expertise in validation using radio occultation could potentially be useful to the project.

"If you can offer something to solve a problem that has societal benefits, that's pretty cool," she says. "It's nice to be able to see you are making a difference."

The group also sees some potential for international collaboration, perhaps with Johannes (Joe) Nielsen, a visiting scientist at SSEC from Denmark. Right now, Feltz says, the project's focus is on the U.S. But "those applications should be made widely available. A lot of potential opportunities are there for us to follow."

As she's come to understand, "that's kind of how research goes. You have to be really proactive. If you see an opportunity to start a new project, and solve a new issue, you should follow that lead."

For the time being, Feltz says, she's excited to stay in research. It has taken a while to get comfortable, build her skills, and to figure out how best to do her job – and she says she's glad to have the opportunity to take her time exploring.

"Research in this field is really fun because it's always changing. You are constantly learning new things and getting to solve problems," she says. "You might be working with other people to solve a problem or sitting at your desk all day trying to figure something out – both are fun in their own way."

Aaron Letterly

Letterly has been working with Jeff Key, a NOAA Advanced Satellite Products Branch (ASPB) scientist based at SSEC, for more than two years: as a research intern since June 2015 and as a graduate student since August 2013. Their focus is Arctic sea ice.

The past few months, Letterly has been editing and adapting his graduate student thesis, discussing winter clouds and how they affect sea ice later in the summer, to turn it into a manuscript fit for a peer-reviewed journal – it was recently accepted to be published.

His tasks as a research intern, he says, are for the most part continuations of what he did as a graduate student, however, his "responsibilities are expanding." For example, he helps provide weekly products for sea-ice motion and weekly Advanced Very High Resolution Radiometer (AVHRR) values for cloud, sea, and ground surface temperature – important Arctic parameters related to sea ice. This involves receiving data from satellite overpasses – typically 20-35 per day – and arranging the data together to create one mosaic-like image of the Earth.

"A neat thing you can do with a satellite image," explains Letterly, "is compare it to the image you made yesterday, to see how far the sea ice has moved in a day – or a week, or a few months. … That's how you derive sea-ice motion."

Applying this technique over a longer period of time, scientists are able to look at averages in sea ice behavior over a span of years.

"Our satellite data goes back to 1982. … Pretty significant for sea ice," he says. "We can look at a mini-climatology, changes that happen. It's nice to have that track record. And that's only going to expand further as time goes on."

The end goal for the products that Letterly and others create is an online resource allowing scientists around the globe to access the data.

"We want to have a web-space … that provides these Arctic parameters, since we get a large volume of data and can do so much with it here," Letterly explains. "If you are interested in the Poles, most likely, [we have] something that will interest you."

Letterly became interested in sea ice through a small research project he did as an undergraduate at the University of Illinois at Urbana-Champaign in 2011. He was immediately drawn to the possible climate-change applications the data offered.

"When you look at an IPCC (Intergovernmental Panel on Climate Change) report, they talk about 20-year or 100-year changes. That always seemed so far away, like so much of an estimate. … But I did this project where we just looked at year-to-year changes of just sea ice. I was fascinated to see how changes in just this one substance (sea ice at the Poles) could change the albedo of the Earth so rapidly and so drastically in the course of a year. … The fact of whether or not there was ice had so much of an implication," he recalls.

He did not know then that he would spend a substantial amount of his graduate and post-graduate years studying the subject, but "it's evolved into some pretty fun research," he says, "because it's always changing."

The concept of less ice growth indicating warmer temperatures, and more ice growth indicating colder temperatures, is more intuitive than many other environmental processes. Letterly says this is an advantage that sea ice has toward explaining climate science to a lay audience, who are able to see satellite images and easily draw important scientific conclusions from them. "I think that's really fun," he says.

Becoming a research intern was the "most attractive option" after graduate school for a number of reasons, Letterly says. Firstly, it would allow him to continue to build the relationships he had fostered as a student: with Jeff and the rest of his team at SSEC, and with the other interns.

Furthermore, he says, the position has enabled him to immediately jump into applying the skills and knowledge he has learned over the past few years, as well as begin to develop some new ones: how to make a job run faster, or how to write code so the output is cleaner. Everything he has learned on the job thus far, says Letterly, has been at an accelerated pace.

"As a research intern, if I need to learn something, it's probably because I'm going to be using it every day for the next three months," he says, "Things stick with me more than they did in grad school because of the constant repetition of tasks reinforcing what I've learned. It's less theory, more application."

He says, he is enjoying the chance to learn as much as possible in a positive environment.

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