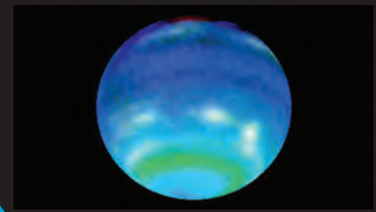
SPACE SCIENCE AND ENGINEERING CENTER • COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES • UNIVERSITY OF WISCONSIN-MADISON

TtA 2014
Summer / Fall





SSEC

through the atmosphere

Changes in tropical cyclones

MAXIMUM INTENSITY

SHIFTING TOWARD POLES

INSIDE

Absolute Radiance Interferometer declared ready for spaceflight (p. 12)

Graduate student Michelle Feltz leads a new validation method (p. 14)

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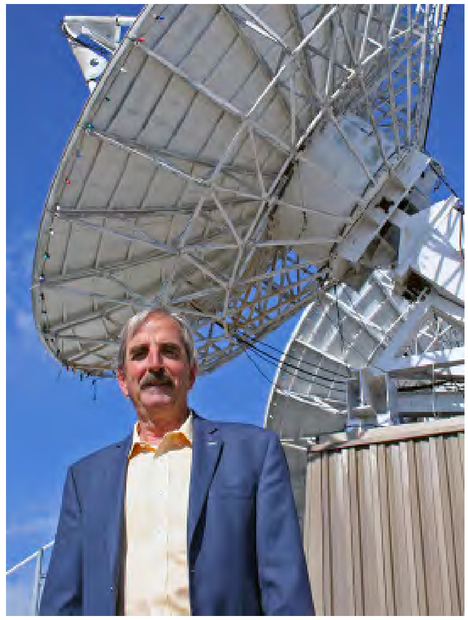
INSIDE This Issue

COVER Image

Hurricane Igor, 13 September 2010

Image Credit: CIMSS, University of Wisconsin-Madison.

DIRECTOR'S Note



In thinking about our recent achievements and where we are headed, it is illuminating to look to the past for events and perspectives that have set the stage and provided strong supporting roots. The experience of SSEC and AOS people in the 1974 GATE experiment (described in "The World According to GATE") is a great example of a key event from our past that provided a GATEway for many recent advances.

This issue of *Through the Atmosphere* is marbled with themes from the GATE experience. The collaborative experiment enabled strong connections for defining features of the Earth's climate, explored the unique role of satellites, and welcomed the invigorating contributions of young scientists. At the time of GATE, major advances were beginning to be demonstrated using geostationary images from the Visible and Infrared Spin Scan Radiometer (VISSR) imager on SMS-1. Among them were the identification of cloud clusters connected with deep moist convection and Professor Suomi's dream of accurate wind measurements from cloud tracking that was emerging from demonstrations of the new McIDAS computer system. These are both important roots for major achievements reported here, including the cover story on the poleward progression of tropical cyclones featured in the journal *Nature*, our tropical cyclones website that recently turned 20 years old and is used by a wide range of national and international forecasters, and the effort to make our satellite wind record truly global in extent.

Alongside geostationary satellites, SSEC now makes equal use of polar orbiting satellites in its research. One key research product developed to monitor the impacts of volcanic eruptions on aviation safety is now transitioning to operations. It was also the subject of a recent congressional briefing by Mike Pavolonis, a NOAA ASPB scientist stationed at CIMSS. Another example involves the research of graduate student, Michelle Feltz, using data from the new advanced infrared sounders on the Suomi NPP and MetOp platforms. Her work compares advanced sounder temperature profiles with accurate temperature information from GPS occultation data in a way that leads to a better understanding of their combined uncertainties, thereby providing an important foundation for climate change studies. Finally, our tradition of seeking new observing techniques like the Boundary Layer Instrumentation System (BLIS) developed by SSEC for GATE continues with the Absolute Radiance Interferometer (ARI), a prototype for the future NASA CLARREO climate benchmarking observatory. We are hopeful that recent programmatic developments will lead to a CLARREO pathfinder mission being flown on the International Space Station in the next few years.

Hank Revercomb

Hank Revercomb
Director, SSEC

CIMSS tropical cyclones website 20 years and counting

by Zhengzheng Zhang

Tropical cyclones are one of nature's most devastating natural hazards. The challenges for tropical cyclone forecasters are to determine the current and future intensity of the storm, as well as predict its track. Data obtained from satellites are crucial for addressing these forecast issues, due to their nearly constant and total coverage of the tropics in space and time.

In 1994, CIMSS tropical cyclone scientists Chris Velden and Tim Olander developed the first known website devoted entirely to tropical cyclones. Since then, the CIMSS tropical cyclone website, *tropic.ssec.wisc.edu*, has helped forecasters by providing near real-time imagery, derived atmospheric analysis products, and tropical cyclone intensity estimates from a variety of satellite platforms for global analysis of tropical cyclones and their surrounding environments.

From its inception, the site rapidly gained popularity with both the tropical cyclone community and the general public. It remains an accessible source for tropical cyclone information and is a portal for cutting-edge CIMSS research on tropical cyclones. During active phases of hurricane seasons, the site typically accrues several million "hits" per day. It is not unusual for the National Hurricane Center to mention the satellite-derived products available on the site in public forecast discussions during important hurricane events.

During the past 20 years, advances in web technologies have provided new opportunities for creative data displays and graphical interfaces. For example, in 2003, the tropical cyclone website team developed a more user-friendly interface — instead of multiple clicks to retrieve complete storm information, the new interface needed only one click on a selected tropical cyclone image and the entire storm profile would appear.

In 2007, the website was redesigned with a modernized look, offering new features. One of the most prominent additions was an interactive window showing current tropical cyclone activity. If an active storm is present, a symbol will appear in this "TC Trak" window. Clicking on the symbol will open a new window with myriad information about the storm that also allows user interaction.

The TC Trak window accesses utilities available through SSEC's visualization and analysis tool known as McIDAS, allowing multiple data and product overlays, animation capability, and satellite-based tropical cyclone estimates and diagnostics. Available products include multispectral imagery (infrared, visible, and microwave) from virtually all operational (and some research) geostationary and polar-orbiting satellites, sea surface temperature analysis, satellite-derived products such as winds, shear, and intensity estimates, scatterometer winds, conventional observations, current tropical cyclone track and forecast discussions and numerical model track forecasts.

TC Trak was designed specifically for more sophisticated users by providing detailed tropical cyclone analysis products in a "one-stop shop" framework that can be viewed in real-time.

The redesigned website also provides access to real-time tropical weather information via regional analyses based on satellite-derived variables, special satellite imagery, and examples of the SSEC/CIMSS tropical cyclone group research projects for tropical cyclone analysts, researchers, or even civilian hurricane aficionados.

CIMSS released the redesigned site during the 2007 Atlantic tropical cyclone season, and community feedback was overwhelmingly positive. Most users have embraced the added functionalities and interactive access to the data and products. In more recent years, the team has added new parameters in the TC Trak window, as new satellites and sensors have become available.

The website has also become a valuable web resource for the global tropical cyclone research community and general public. User feedback indicates the real-time, interactive and "one-stop shop" site also serves as an effective tool for tropical cyclone knowledge acquisition by the web-surfing public and for classroom instruction.

To facilitate longer-term data/product acquisition and analysis, the tropical cyclone web team led by Dave Stettner created an online satellite data and product archive. The archive allows interactive online browsing and retrieval of locally produced, historical, global tropical cyclone satellite data and products. The graphical user interface also enables researchers to easily peruse historical storms and access satellite data and products for their analyses.

For 20 years, the CIMSS tropical cyclone website has pioneered the proliferation of tropical cyclone-focused satellite data and products to its communities by providing unique and cutting-edge satellite information relevant to both tropical cyclone forecasting and education. The CIMSS tropical cyclone web team continues to respond to user requests and feedback in order to meet the growing interests of the tropical cyclone community. ■

The CIMSS tropical cyclones website may be found at: tropic.ssec.wisc.edu

Study shows poleward shift

by Jean Phillips

The latitude at which tropical cyclones reach their maximum intensity is migrating away from the tropics, shifting in the direction of the poles at a rate of about one-half degree of latitude per decade in both the Northern and Southern Hemispheres.

A new study published in the journal *Nature* on May 14th, 2014, documents this poleward migration by analyzing global historical tropical cyclone data for the past 30 years.

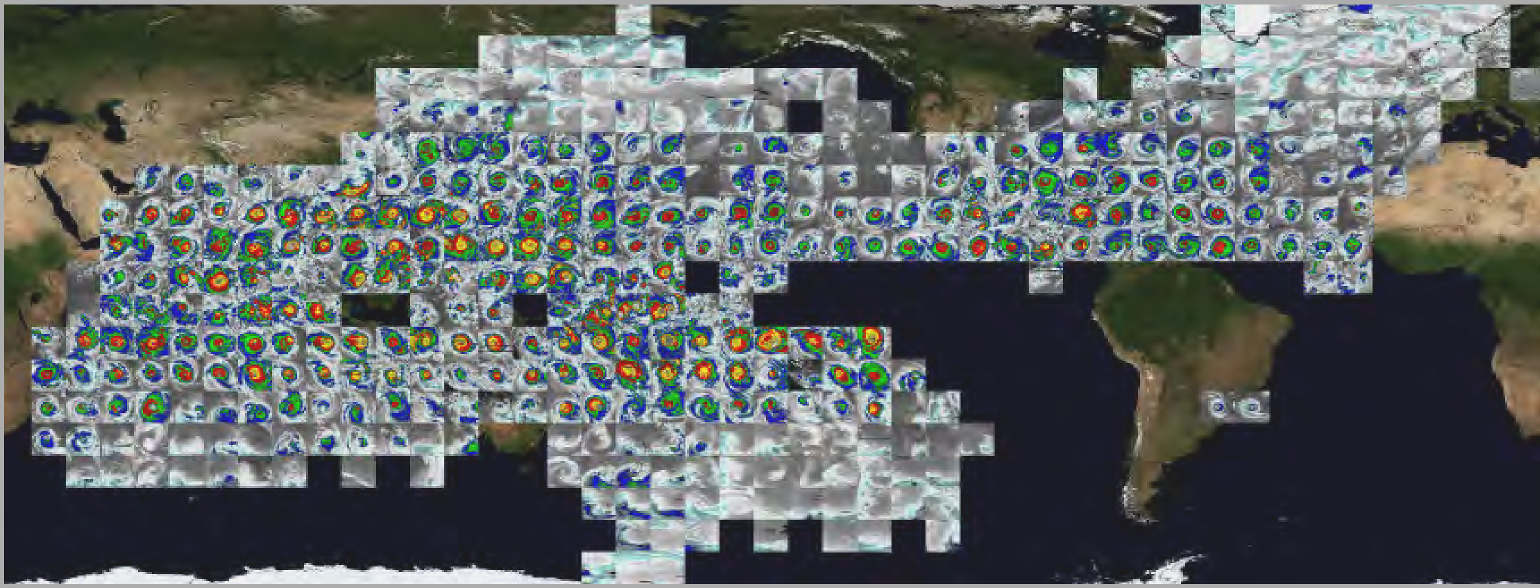
According to lead author Jim Kossin, NOAA National Climatic Data Center atmospheric scientist stationed at UW-Madison's Cooperative Institute for Meteorological Satellite Studies, "We've identified changes in the environment in which the deep tropics have become more hostile to the formation and intensification of tropical cyclones and the higher latitudes have become less hostile. This seems to be driving tropical cyclones out of the deep tropics and toward the poles."

> ***"We've identified changes in the environment ... driving tropical cyclones out of the deep tropics and toward the poles."***

Evidence for this migration of storms away from the tropics is based on observed trends in the latitude where storms reach their maximum intensity – this is the moment when a storm is strongest relative to its own lifetime.

Intensity estimates can vary from dataset to dataset, but the latitude of tropical cyclone maximum intensity is a much more stable value and less likely to be influenced by data discrepancies or uncertainties.

The 30-year trend is not necessarily indicative of a longer-term trend,



in tropical cyclone maximum intensity

explains Kossin. However, he says, the results are important because they may forewarn of changes to come in the regions where storms make landfall. Places closer to the equator could experience a reduced risk for landfalling tropical cyclones. And places farther away from the equator, including Northern and Southern Hemisphere coastal cities, could experience an increased risk.

This increased risk is particularly important given the devastating loss of life and property that can follow in the wake of a tropical cyclone. Further, regions that depend on precipitation from tropical cyclones to replenish local water supplies may, in the future, have less water available to them.

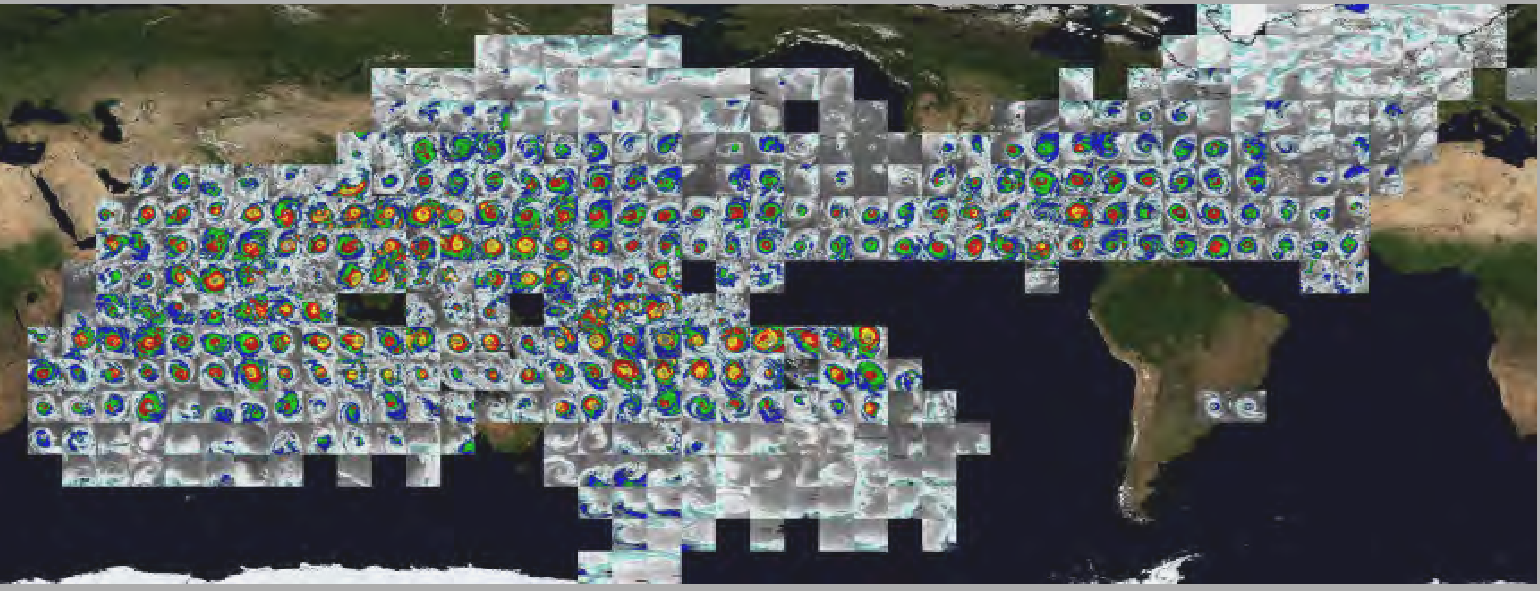
At the same time, regions that are less prepared may experience more frequent flooding.

From a scientific standpoint, Kossin notes, "The more compelling aspect is that the rate of migration fits very well into independent estimates of the observed expansion of the tropics," a phenomenon that has been widely studied by other scientists, and one that is attributed, in part, to increasing greenhouse gases, stratospheric ozone depletion, and particulate pollution that are by-products of human activity.

Whether the observed movement of tropical cyclone maximum intensity toward the poles is a result of the expansion of the tropics and its links to human activity requires more and longer-term investigation, says Kossin. Both phenomena, however, exhibit very similar behavior over the past 30 years, lending support to the idea that the two are closely related.

Co-authors on the Nature *paper are Kerry A. Emanuel, Program in Atmospheres, Oceans and Climate at the Massachusetts Institute of Technology and Gabriel A. Vecchi, NOAA Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey.* ■

▼ Global montage of satellite images of tropical cyclones. Each image represents the strongest storm recorded in that area for the period 1980-2008. Images are from infrared satellites with colors indicating the intensity of the convection, which relates to storm intensity. Grays are weakest, blues-greens are stronger, and yellow-reds are strongest. The graphic shows the overall equator-to-poles distribution of tropical cyclone intensity. Image credit: Ken Knapp, NOAA National Climatic Data Center, Asheville, NC.



UW-Madison becomes newest Intel Parallel Computing Center

by Jean Phillips

The University of Wisconsin-Madison has been selected to join the Intel Parallel Computing Centers (IPCC) program.

The program promotes public-private partnerships to modernize technical computing applications in areas important to society, from the development of personalized medical treatments to the delivery of better weather forecasts.

The Intel Parallel Computing Center at the UW-Madison is directed by Bormin Huang of the Space Science and Engineering Center. Along with co-investigator Jarno Mielikainen, Huang seeks to boost the performance of the Weather Research and Forecasting (WRF) model by adopting the Intel Many Integrated Core Architecture (MIC). The WRF is a next-generation mesoscale numerical weather prediction system that serves atmospheric research and operational forecasting needs in more than 150 countries.

Huang notes, "Our selection as an Intel Parallel Computing Center will allow us to showcase the ability of the latest Intel parallel accelerators to run a large existing code base, like the WRF, at a higher speed than CPUs can."

With access to Intel technologies, partners in the program are committed to developing new applications that take advantage of advances in parallel computing technologies. By harnessing the power of parallel processing, the centers accelerate discovery across scientific fields, including weather forecasting, moving toward more reliable, accurate forecasts over longer time scales.

"We are applying computing technologies to new branches of our discipline, and, in the process, using that technology for the benefit of society," Huang explains.

There are many areas of study across the university that could also benefit from the faster computational speeds that parallel computing can deliver, adds Huang. He is optimistic about the possibilities for new cross-disciplinary collaborations.

The university joins a small number of institutions worldwide selected to become Intel Parallel Computing Centers. ■

Online learning the CIMSS way

by Jean Phillips

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) is developing two new online courses related to changing weather and climate.

The first, Changing Weather and Climate in the Great Lakes Regions, is one of six new Massive Open Online Courses (MOOCs) to be offered by the University of Wisconsin-Madison starting in January 2015. The MOOC will be taught by CIMSS Director and AOS Professor Steve Ackerman and Margaret Mooney, Director of the CIMSS Office of Education and Public Outreach.


Steve Ackerman


Margaret Mooney

The course will build on the increasing importance of sustainability and environmental stewardship in relation to the Great Lakes ecosystems and will be freely accessible to learners around the world.

The university launched an initial series of four MOOCs in 2013, reaching more than 135,000 people across more than 140 countries.

The second class, Teaching Climate Change On-Line, also led by Ackerman and Mooney, was made possible through a competitive award from the University of Wisconsin-Madison Office of Sustainability. The for-credit academic course is modeled after a NASA-funded Madison College class developed by Scott Lindstrom (Principal Investigator) and Matthew Lazzara, both from SSEC, and Monica Harkey, from the Center for Sustainability and the Global Environment at UW-Madison.

The new climate change course will educate university students on practical issues related to climate science and challenge them to become discerning consumers of climate-related media. The course curriculum will then be adapted for use by middle and high school science teachers.

True to the basic tenets of the Wisconsin Idea and the educational mission of CIMSS, Ackerman and Mooney are part of a team of faculty and researchers aiming to improve people's lives beyond the physical boundaries of the classroom. ■

The World according to GATE (and GARP)

by Jean Phillips

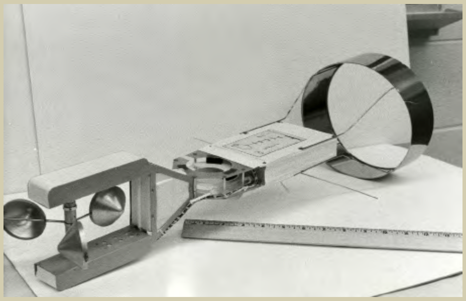
By nearly any measure, it was the largest and most complex international field experiment ever conducted in meteorology up to the mid-1970s.

▲ University of Wisconsin Chancellor Hugh Edward Young (left) presents V.E. Suomi (standing), J.A. Young, and D.D. Houghton with awards in recognition of their contribution to GATE in 1974. Photo Credit: University of Wisconsin Communications.

Known as the GARP Atlantic Tropical Experiment (GATE) it was the first observing phase of the Global Atmospheric Research Programme (GARP) lasting 100 days during the summer of 1974. The experiment region spanned the tropical Atlantic Ocean from South America to Africa, between 20° N latitude and 10° S latitude.

Graduate students and scientists who went on to spend their careers at the University of Wisconsin-Madison Space Science and Engineering Center (SSEC) or the Department of Atmospheric and Oceanic Sciences (AOS) played crucial roles in planning, data collection, testing, and post-analysis during GATE. Most of them were early career scientists, exhilarated by the intellectual and physical challenges posed by the experiment.

Before, during, and after GATE they made important and lasting contributions to their fields.



▲ A tethered sonde, the Boundary Layer Instrumentation System, was designed to be used from ships during the GARP Atlantic Tropical Experiment (GATE). Photo Credit: Space Science and Engineering Center (SSEC), University of Wisconsin-Madison.

GATE uniquely marshaled the resources of more than 70 nations — nations such as the Soviet Union and the United States set aside their Cold War political differences for the benefit of scientific cooperation. Participating countries not only committed thousands of personnel to the program, but contributed ships, research aircraft, instruments, and meteorological satellites to collect observations of the tropical atmosphere on an unprecedented scale.

The planners were well aware of the difficulties and risks of such a large collaboration — there were great successes along with disappointments in data collection methods and data quality. SSEC and GATE emeritus scientist Dave Martin commented, "the more people involved, the greater the risk of diffusing the goals of the experiment."

According to AOS Emeritus Professor and GATE scientist John Young, "There were more minds, more instruments, more resources, more technology made available by every nation in order to measure the atmosphere in the GATE region."

Organizers of GARP, which fell under the auspices of the World Meteorological Organization, included the late Verner Suomi, SSEC founder. Suomi was an influential member of the larger GARP planning committee, helping to formulate strategic objectives for the experiment. As a prominent voice from the United States, he and other leaders of the program envisioned an intensive observing period to study the tropical Atlantic atmosphere and its role in driving the general circulation. There also was a growing demand for better numerical modeling and prediction capabilities and better representation of clouds in simulations.

Scientists wanted to study more closely convective rain systems in the tropics where disturbances develop and produce vertical transport of energy in the form of heat and water vapor. This transport is a critical link between the sun's energy absorbed by the ocean, evaporation into the air, and ultimately, the warming of the tropical atmosphere by condensation from rain systems.

Associated convective clouds (cumulus clouds) tend to form "cloud clusters" from which energy and water vapor are released. This energy is often transported well into the middle latitudes where it can influence weather patterns.

Don Wylie, emeritus SSEC scientist, participated in GATE as a graduate student. As Crew Chief on the Oceanographer, a NOAA ship, he helped run the Boundary Layer Instrumentation Systems (BLIS) on that vessel. The BLIS instrument was designed by Suomi and constructed at SSEC. It was accepted as the balloon-borne boundary layer instrument from the United States.

"BLIS was a system of four balloon-borne instruments flown at altitudes up to 1,000 meters for collecting data on temperature, humidity, and winds," recalls Wylie. The BLIS instruments were lifted by a small helium-filled blimp tethered to the ship, attached to a tether line at four levels.

According to Wylie, the biggest obstacle to BLIS was the hot, humid, and salty tropical atmosphere. Together, the humidity and salt corroded the electronic circuit boards. Mold was also a problem, often growing inside the instrument packages after exposure of just a few hours.

Another problem for BLIS was vibration of the balloon's nylon tether line. The vibration frequently damaged or broke sensitive parts of the instrument.

Suomi had been optimistic about the performance of BLIS but Wylie explains that while it provided useful information about the tropical atmosphere, it was less than anticipated. Scientists required far more precise measurements and a larger sample than could be collected from one time period in order to accurately measure the upward movement of moist tropical air. Previously, the best measurements had come from stable, tower-mounted instruments or instruments on aircraft.

For Wylie, it was a tremendous education. He "learned about the development and deployment of new atmospheric observational equipment and about the politics of working in large groups."

Beyond the BLIS system, there were other challenges. The best instrument at that time for collecting wind, temperature, and humidity data was the radiosonde, which performs very well over land, employing a simple radio tracking antenna to detect winds and wind direction. It does not perform well on the ocean where ships drift. Today, scientists might use the Global Positioning System for tracking, but in 1974, GPS did not exist.

To manage this problem, organizers decided to equip all ocean vessels with another system, the Omegasonde, an alternative to the conventional radar-tracked radiosonde. It involved Omega signals broadcast from ground stations, using the time delay in receiving the signals from three distant locations to track the package, and thus monitor winds.

The original GATE experiment design called for most ships to be stationary. The NASA Vanguard, however, would travel north and south looking upward in the boundary layer, taking frequent measurements. All other ships would take wind field and other measurements from their assigned locations. The general idea was that a ring of ships providing data would show in-flow and out-flow of winds, producing a smaller-scale budget study.

According to John Young, chief scientist on the Vanguard, "It turned out the Omega signals on the other ships were varied and weak right where the experiment was to go on." This was due to the distance of the ground stations.

As a remedy, the Vanguard, which was equipped with a radar satellite tracking system, was placed in the middle of the array to collect wind data. Responding to the severity of the problem, the Soviet Union also repositioned one of its ships in the array.

"The first time I saw what our winds looked like, I knew that it would work," recalls Young, "It was golden!"

The NASA-developed tracking software along with ship radar would determine the location of a small, aluminum reflector in the package as it moved, converting this information to winds.

The Vanguard accumulated a reliable, believable, high quality set of upper-air wind data during the GATE experiment that would prove useful in comparison studies, notes Young. The data set suggested unique wind features in the atmospheric layers of the GATE region, adding to the growing body of knowledge about tropical atmosphere properties.

The Omega data quality raised concern among the organizers of GATE, prompting a large meeting of the committee members to discuss possible solutions. Suomi and senior leadership of GATE wanted to find a way to improve the omega signal sufficiently to get useful data from the soundings. According to Young, very careful — and costly — post-processing by computer programmers in Washington turned the raw signals into useful wind information, salvaging some of the data.

Rather than surface-based data collection, GATE scientist Dave Martin's contributions focused on using geostationary satellite images to identify cloud clusters and the deep moist convection associated with them known to move heat from the oceans to the free atmosphere.

The Synchronous Meteorological Satellite 1 (SMS-1) was launched on 15 May 1974, only weeks before the start of GATE. It was a prototype for a new generation of operational geostationary satellites. It wasn't entirely clear whether the satellite would perform well, but it successfully sent images to the NOAA receiving station at Dakar, Senegal, the command post for the experiment where Martin was stationed.

Forecasters for GATE reviewed SMS images from the afternoon of one day to help prepare aircraft forecasts for the following morning. Anyone — forecasters, scientists, synopticians — had access to the images.

Once forecasts were complete, Martin could examine the images, looking for cloud clusters, working in a lag of one day.

"I don't think I've ever worked harder than I did during the three-month period of GATE," remembers Martin. "It was a daily grind of keeping up with the flow of SMS images — not much time for sightseeing. It was exciting, stimulating, arduous, and at times, frustrating."

Utilizing a satellite convective code that had been developed at SSEC, Martin evaluated the convective intensity of a cloud cluster — its size, lifetime, movement, and duration over the area. As a consequence of GATE, Martin constructed an enormous catalog of cloud cluster information that demanded analysis, interpretation, and understanding.

In Dakar, Martin experienced challenges with navigation of the SMS images. Navigation, or properly aligning the satellite image to the corresponding land location, was improving but was still less than perfect.

Upon his return to the university, Martin and colleagues began analyzing the data, for nearly ten years, until the main body had been reviewed. There were conferences, workshops, special sessions devoted to GATE findings. In addition to his work with cloud clusters, Martin used the visible and infrared SMS images to examine and define conditions for Saharan dust outbreaks. The images provided a mechanism for tracing the source of dust clouds over water seen in visible and infrared images back in time, to West Africa. Satellite imagery proved it could be a powerful tool for identifying dust cloud transport. Related research continues at SSEC today.

By the time GATE concluded, geostationary satellites were rapidly becoming the tool for recognizing tropical disturbances before they made landfall. Wylie notes this was very important to the hurricane warning system and SSEC's Man-computer Interactive Data Access System (McIDAS), only recently demonstrated to a public audience in 1973, was rapidly becoming one of the most important tools for visualizing geostationary satellite data.

The flood of satellite data collected and archived for GATE spurred the further development of McIDAS, providing another proof-of-concept for the system.

Even during GATE, scientists at SSEC were actively trying to resolve the satellite navigation problems experienced by Martin in Dakar. Ultimately, according to Martin, that problem was solved at SSEC, post-GATE, together with engineers and mathematicians from the National Oceanic and Atmospheric Administration. The SSEC-developed system transformed geosynchronous satellite coordinates to a reference point on earth and could handle sequences of images such as those generated from the SMS satellite. Martin notes that SSEC has evolved because of satellites and it's been a magnificent success.

"Any young scientist given an opportunity like this should seize it. GATE was a unique, marvelous experience. Very rewarding," adds Martin, "It impressed upon us the value of cooperation, of free and open exchange of data, of having good people in positions of responsibility, and the importance of grassroots participation by the scientific community."

An important legacy of GATE, says Don Wylie, is that it "left behind energy in many countries to maintain better weather observation and forecasting systems."

The follow-on to GATE was the First GARP Global Experiment in 1979 which was appropriately renamed the Global Weather Experiment. Planners incorporated the lessons learned from GATE into the next experiment.

Four decades hence, John Young provides an interesting perspective on our technological and scientific progress, saying, "We had all this high tech equipment, but back in 1974 if I wanted to call home from our ship in the tropical Atlantic, I had to have the call patched through ham radio — and maybe it would work. Compared to today's technology, it pales."

Note: Many scientists and engineers from SSEC and AOS made contributions to GATE, either at the experiment site or through the provision of support from Madison. Among them were: Brian Auvine, Ken Bures, Stan Burns, Bob Herbsleb, David Houghton, David Martin, Jim Maynard, Fred Mosher, Dennis Phillips, Evan Richards Dhirendra Sikdar, Eric Smith, John Stout, David Suchman, Verner Suomi, Donald Wylie, John Young. ■

Highlights of Recent Publications

January 2014 - June 2014

♦ Cintineo, R., J.A. Otkin, M. Xue, and F. Kong: 2014: Evaluating the performance of planetary boundary layer and cloud microphysical parameterization schemes in convection permitting ensemble forecasts using synthetic GOES13 satellite observations. *Monthly Weather Review* v.142, 163182.

The study examines the ability of several cloud microphysical and planetary boundary layer parameterization schemes to accurately simulate cloud characteristics within 4 km gridspacing ensemble forecasts over the contiguous United States, evaluating them through comparison of synthetic Geostationary Operational Environmental Satellite (GOES) infrared brightness temperatures with observations.

♦ Feltz, M.L., R.O. Knuteson, H.E. Revercomb, and D.C. Tobin, 2014: A methodology for the validation of temperature profiles from hyperspectral infrared sounders using GPS radio occultation: Experience with AIRS and COSMIC. *Journal of Geophysical Research Atmospheres* v.119, 16801691.

This paper presents a methodology for the validation of vertical temperature profile retrievals from infrared and microwave sounders by intercomparison with Global Positioning System (GPS) radio occultation (RO) profiles matched in time and space.

♦ Kataoka, F., R.O. Knuteson, A. Kuze, H. Suto, K. Shiomi, M. Harada, E.M. Garms, J.A. Roman, C. Robin, J.K. Taylor, H.E. Revercomb, N. Sekio, R. Higuchi, and Y. Mitomi, 2014: TIR spectral radiance calibration of the GOSAT satellite borne TANSOFTS with the aircraftbased SHIS and the groundbased SAERI at the Railroad Valley Desert Playa. *IEEE Transactions on Geoscience and Remote Sensing* v.52, 89105.

The thermal infrared (TIR) band of Thermal and NearInfrared Sensor for carbon Observations Fourier Transform Spectrometer (TANSOFTS) on the Greenhouse gases Observing SATellite (GOSAT) measures a wide range of scene temperatures using a single detector band with broad spectral coverage. This work describes the vicarious radiometric calibration over a large footprint (10.5 km) and high temperature surface using wellcalibrated groundbased and airborne FTS sensors.

♦ Kohrs, R.A., M.A. Lazzara, J.O. Robaidek, D.A. Santek, and S.L. Knuth, 2014: Global satellite composites: 20 years of evolution. *Atmospheric Research* v.135136, 824.

Over the past 20 years the University of Wisconsin Space Science and Engineering Center and the Antarctic Meteorological Research Center have made great improvements to algorithms used to produce global composites of satellite data. Increased computing power and a distributed data environment has provided the opportunity to increase the frequency, spatial resolution and number of spectral bands of our composites.

♦ Kossin, J.P., K.A. Emanuel, and G.A. Vecchi, 2014: The poleward migration of the location of tropical cyclone maximum intensity. *Nature* v.509, 349 352.

Analysis of global historical satellite data in the Northern and Southern hemispheres reveals a statistically significant, poleward migration of 1° of latitude per decade in the average latitude at which tropical cyclones have achieved their lifetime maximum intensity over the past 30 years.

♦ Kulie, M.S., M.J. Hiley, R. Bennartz, S. Kneifel, and S. Tanelli, 2014: Triple frequency radar reflectivity signatures of snow: Observations and comparisons with theoretical ice particle scattering models. *Journal of Applied Meteorology and Climatology* v.53, 10801098.

This observation based study utilizes aircraft data from the 2003 Wakasa Bay Advanced Microwave Scanning Radiometer Precipitation Validation Campaign to assess recent advances in the modeling of microwave scattering properties of nonspherical ice particles in the atmosphere.

Honors and Awards

Steven Ackerman
Colorado State University's Atmospheric Science Outstanding Alumni Award

Wayne Feltz
University of Wisconsin Police Chief's Award in honor of providing weather forecasts for Camp Randall Stadium home football games, 2000-2014

Bormin Huang
NVIDIA CUDA Fellow & Director of Intel Parallel Computing Center

Dave Tobin, Jacola Roman & Jonathan Gero
Best Poster Presentations at ITSC -19 (gold, silver & bronze, respectively)

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

SSEC News

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http://go.wisc.edu/lz8jwe

4th annual AOSS Photo Contest winners

▲ First Place
"Steam fog over Fort Peck Lake, Montana"
Photographer: Bill Bellon

▲ Second Place
"Methane pancakes, Picnic Point Bay, Lake Mendota"
Photographer: Hank Revercomb

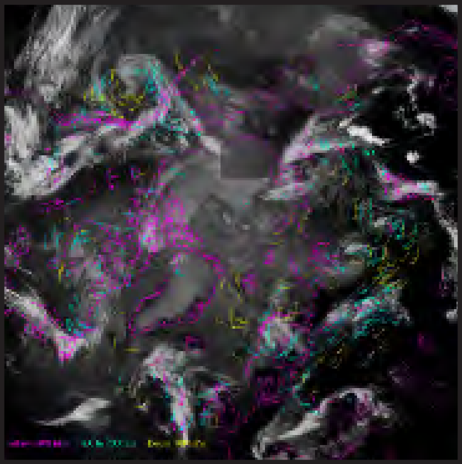
▲ Third Place
"A near miss, late afternoon storm, Wisconsin"
Photographer: Dave Jones

▲ Honorable Mention
"Smoke and lenticular clouds over Denali, Alaska"
Photographer: Dave Stettner

The full 2014 photo contest gallery is available at:
http://go.wisc.edu/o2ovni

▲ Honorable Mention
"Aurora Borealis and the SSEC Direct Broadcast Antenna, AOSS building roof"
Photographer: John Lalande

SSEC group helps fill in gaps on remote wind measurements



▼ An Arctic infrared satellite composite image from June 3, 2010 at 10 UTC. Image courtesy of Matthew Lazzara.

by Sarah Witman

For decades, weather satellites have provided the instruments of choice for monitoring atmospheric wind speed, movement and direction, especially in places less accessible by other modes of measurement. Until recently, though, researchers still grappled with incomplete and inconsistent imagery. A team led by Matthew Lazzara at the University of Wisconsin's Space Science and Engineering Center (SSEC) has turned a new page on generating high-quality wind imagery, with a technique that promises improvements for forecasting and numerical weather prediction.

Scientists typically track patterns of atmospheric motion—wind, essentially—swirling and unfolding over a large area by inspecting many successive sets of satellite images called Atmospheric Motion Vectors, or AMVs. They have been able to generate and use AMVs from geostationary (GEO) satellite observations over mid-latitudes and the tropics since the late 1960s, while AMVs from low earth-orbiting (LEO) satellites over polar regions have been in use since the early 2000s, concepts that both started at SSEC.

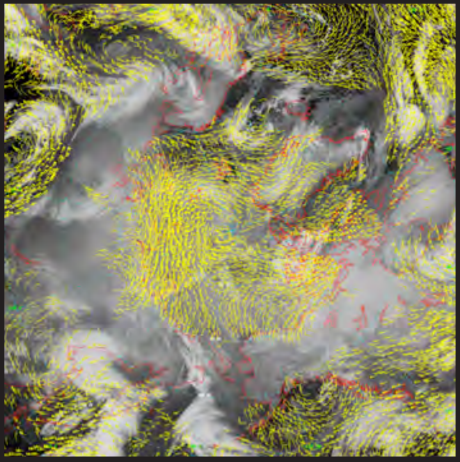
Each satellite provides a different type of coverage: Low earth-orbiting satellites circle the Earth above the poles, making observations from an altitude of about 500 miles, whereas geostationary satellites hover more than 22,000 miles above the equator, rotating with the Earth. Yet, there was always a coverage gap—specifically, in the latitude band poleward of 60 degrees and equatorward of 70 degrees, encompassing both hemispheres.

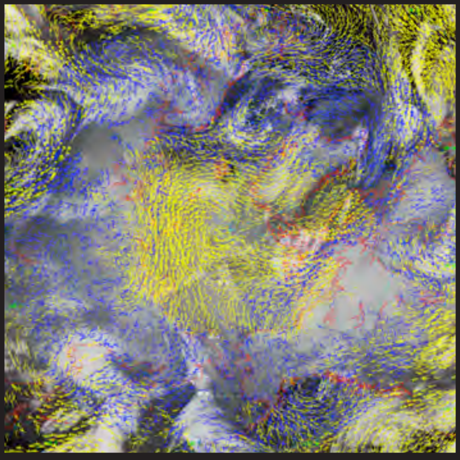
"Both [types of satellites] have natural stopping places," Lazzara said, explaining that geostationary satellites' observations get cut off because of basic geometry. "There is inherent error in looking at the curved surface of the planet from way out in space; it gets very skewed. Rather than introducing erroneous winds, we would just stop and say that's as far north or south as we can calculate."

To address this gap, Lazzara, joined by researchers Richard Dworak, David Santek, Brett Hoover and Chris Velden from the University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies (CIMSS), and Jeffrey Key from the National Oceanic and Atmospheric Administration (NOAA), explored a novel approach: Collect LEO and GEO satellite observations of a desired area, and combine them to create "composites."

Composites are the patchwork quilts of satellite science, as they take observations made by various satellites around the same time and stitch them together to create a more

▼ A team at the University of Wisconsin has generated high-quality Atmospheric Motion Vectors from LEO/GEO composite satellite images (shown below on the right, compared with the more visible "gap" in coverage below-left). These vectors (AMVs) could improve numerical weather prediction. Images courtesy of Matthew Lazzara.





complete picture. The team developed an algorithm to create AMVs from LEO/GEO composites, which can in turn be used by forecasters to assess meteorological conditions and make weather predictions.

To calculate each wind vector, Lazzara said they selected pixels with the highest resolution from each data source. This technique resulted in reduced error and ensured data quality and integrity. Furthermore, they started to keep metadata: tracking information such as parallax and the specific time the satellite made each observation.

"That allows us to make a better wind," he said, explaining that if the time is not recorded accurately, it is impossible to calculate velocity effectively.

AMVs are especially important for monitoring wind over oceans, as there is less coverage from other sources. Normally, weather balloons, scatterometers in orbit, water vapor targets and satellites work in tandem to make wind observations around the globe, but satellites have the best position over the oceans.

"When I fly to Antarctica, there are no wind observations on this route," Lazzara said, citing personal experience of the importance of high-quality wind forecasting information. "I've been on the airplane, flown halfway—beautiful day—then looked down to see white caps on the ocean. It is so windy that we have had to turn around. Because those are headwinds, they wouldn't have had enough gas onboard to get to Antarctica."

"That will happen a lot less these days," he said, "and it's partly because these winds, the good ones, are being used in numerical weather predictions. It's a good thing."

Lazzara noted that, before they could be sure the technique would work, they developed composites with satellite "snapshots" taken three hours apart. Concerned that they weren't capturing the intended type of motion, they constructed them more frequently, about every hour.

The researchers adjusted their process again when they discovered their allowed error was too large compared to GOES or MODIS. They addressed this by acquiring data for a composite almost every 15 minutes instead, using every other measurement to make a wind set, creating AMVs on a half-hourly basis.

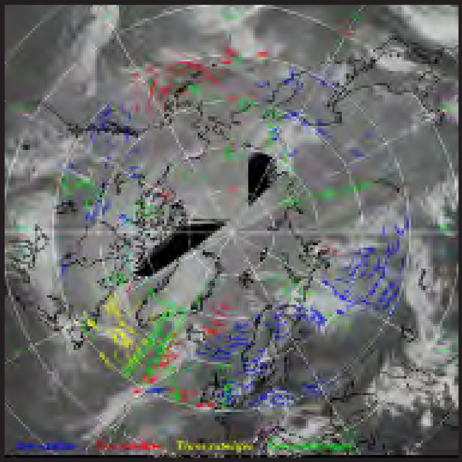
To test their process, the team conducted validation studies over the Antarctic and southern ocean gap region and Arctic gap region over a multiyear period. They used a type of weather balloon called a rawinsonde that measured wind speed and direction, comparing its observations to their AMVs. They also ran a numerical model impact study for two seasons using the National Weather Service Global Forecast System, a global weather prediction system, as a way to check their work. In the future, Lazzara said, they hope to also check the AMVs against available airplane data and conduct a more complete model study.

A number of countries have already shown interest in using these high-quality AMVs generated from LEO/GEO composite satellite images, including groups from the United Kingdom, China and Australia. Notably, the Japan Meteorological Agency (JMA) just published a paper on its use of the AMVs, saying, "Significant positive impacts are seen until three-day forecasts, especially in the tropical and southern hemisphere."

"The new AMVs [were] introduced into the JMA operational NWP system on July 1, 2013," it continued. (K.Yamashta 2014. Introduction of LEO-GEO and AVHRR Polar Atmospheric Motion Vectors in the JMA Operational Global NWP System. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model, Submitted.)

The U.S. Navy is also incorporating the AMVs into its atmospheric data assimilation system, NAVDAS.

Getting to this point was an experimental and multi-step process,

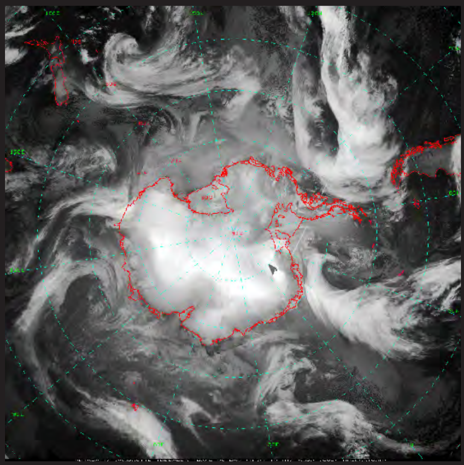


▲ An Arctic infrared satellite composite image from April 26, 2011 at 14 UTC with LEO/GEO Atmospheric Motion Vectors plotted. Image courtesy of Matthew Lazzara.

and one that required the participation of the entire SSEC AMV team. Lazzara in particular has directed the production of Antarctic composite images for many years, and was able to bring this experience and expertise to the LEO/GEO project. The project was made possible by support from the National Science Foundation, NOAA and SSEC.

"I'm glad people in the numerical modeling and winds communities have shown interest and seem to be happy with the initial look. It's been a great success so far," Lazzara said. "I'm thrilled that others took a chance on our work and it is paying off." ■

▼ An Antarctic infrared satellite composite image from May 26, 2010 at 12 UTC. This composite was the inspiration for the LEO/GEO Atmospheric Motion Vectors project. Image courtesy of Matthew Lazzara.



Benchmarki
Climate fr

SSEC's IR instru
ready f

by Lear

Developing new satellite instrument technology often takes years of hard work, not to mention perseverance. Despite all the possible bumps in the development path, the end goal always is to see the concept become a reality, orbiting the Earth and operating as designed.

In September 2013, SSEC researchers reached an important milestone, bringing them one step (or, in this case, a giant leap) closer to fulfilling that goal when their instrument called the Absolute Radiance Interferometer (ARI) was declared ready for a spaceflight opportunity by NASA's Earth Science Technology Office. ARI had successfully completed rigorous thermal vacuum testing, operating in simulated space-like conditions.

SSEC's Director Hank Revercomb and Executive Director for Technology Fred Best are optimistic that SSEC's efforts on ARI will lead to an opportunity to demonstrate the instrument and its new technologies in space, perhaps on the International Space Station (ISS). Revercomb noted that the expected lifetime of the space station has recently been extended to 2024. This extension would inevitably lead to additional opportunities for spaceflight-ready experiments, added Best.

What makes ARI a particularly attractive option for the space station is that SSEC has already designed and built a successful prototype. Revercomb does not foresee any issues with developing an ARI to fly on board the ISS.

He asserted that "we've eliminated essentially all of the fundamental questions of being able to do this. From the start we tried to make it as close to a flight prototype as possible."

That start noted by Revercomb was more than seven years ago and began with the release of the National Research Council 2007 Decadal Survey.

Specifically, SSEC worked with Jim Anderson of Harvard to define a satellite mission known as the Climate Absolute Radiance and Refractivity Observatory (CLARREO), which was recommended in the survey as a Tier 1 mission – meaning that it was important and recommended for development; CLARREO was one of four such missions.

Designed to create a benchmark for climate measurements, CLARREO consists of three instruments: infrared (IR), solar, and Global Positioning System/Radio Occultation (GPS/RO).

Revercomb described ARI as "a prototype for what's needed for the IR portion of CLARREO."

In collaboration with Harvard, SSEC developed the ARI through NASA's Instrument Incubator Program, which supported technology development for the decadal survey missions.

However, Best remarked that the initial concept for one of ARI's new technologies, the phase change cells used for absolute temperature calibration, was funded under internal seed funding.

For CLARREO, accuracy requirements are very strict. SSEC engineers were aiming to meet a tenth of a degree (Kelvin) three sigma absolute accuracy.

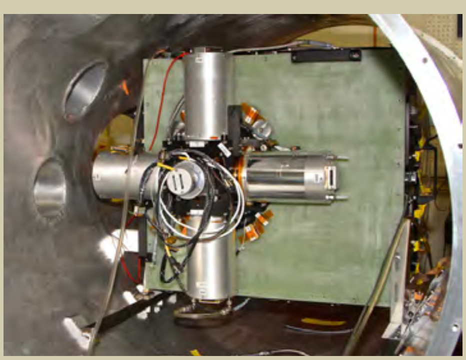
According to Revercomb, "It's unique to have that level of accuracy, but what really makes it stand apart is that it can be verified on orbit. The new technologies that we developed here allow you to do that testing on orbit."

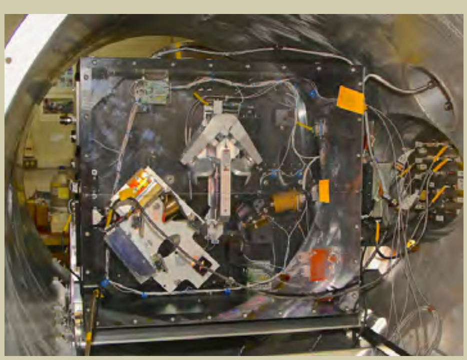
Revercomb noted that there are "three basic categories that our technologies fall into: ones that test radiometric accuracy, ones that test spectral properties, and ones that are diagnostic."

Specifically, the key new technologies for on-orbit verification are:

- On-orbit Absolute Radiance Standard (OARS), a high emissivity blackbody cavity;

▼ The Absolute Radiance Interferometer (ARI) in a vacuum chamber. Above left, the front end of the instrument is shown with two calibration blackbodies, the On-Orbit Absolute Radiance Standard, and a simulated Earth scene blackbody. Above right, the back end of the ARI instrument, including the interferometer, which provides spectral splitting.





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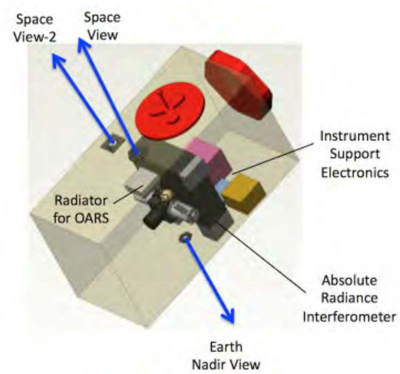
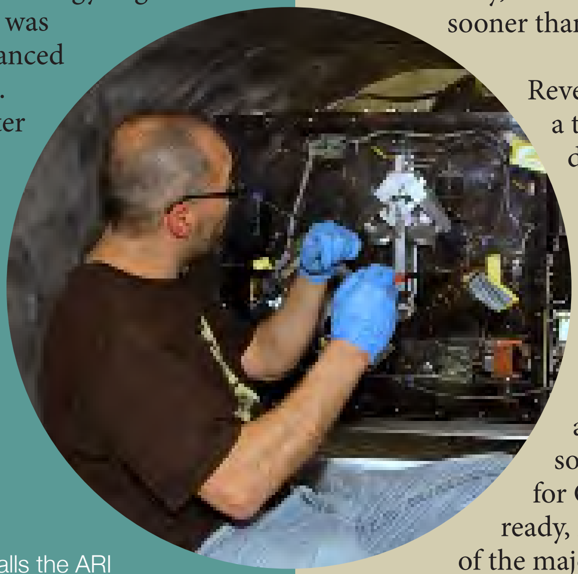
- Absolute temperature calibration using phase change cells;
- Blackbody emissivity measurements using a heated halo;
- On-orbit instrument spectral response measurement using a CO_2 laser; and
- Blackbody emissivity and spectral response measurements using a quantum cascade laser.

The first three technologies were developed at SSEC, while the last two were developed at Harvard. Initially, each technology began as a concept and was individually advanced to a mature level. The interferometer was developed in a similar manner with a number of maturity milestones met along the way.

In the end, Best stated, “We integrated all those technologies into a prototype instrument and demonstrated the required performance in a space-like environment of a vacuum in a presence of expected on-orbit temperature fluctuations.”



▲ Shown above-left, the On-orbit Absolute Radiance Standard (OARS), including miniature phase change cells that provide absolute temperature calibration and the heated halo for measurement of the cavity emissivity. Shown above-right, a possible implementation for the Absolute Radiance Interferometer (ARI) on the International Space Station.



▶ A technician installs the ARI instrument into the thermal vacuum chamber.

That fully functional and tested prototype now awaits an opportunity to fly. Clearly proud of their team’s achievement, Revercomb and Best are eager to find that opportunity and demonstrate what ARI can do, especially given the fact that the CLARREO mission has been delayed indefinitely, with a launch no sooner than 2023.

Revercomb described a technical demonstration of the ARI on the space station as “the best way to move forward.”

Even more promising is that a prototype of the solar instrument for CLARREO is also ready, meaning that two of the major CLARREO instruments could conceivably fly on the space station. However, this opportunity would serve as more than just a technical demonstration.

Revercomb noted that it would provide a head start on CLARREO’s science goals by using the data for intercalibration studies, focusing on IR sounders already in orbit – the Atmospheric InfraRed Sounder (AIRS), Infrared Atmospheric Sounding Interferometer (IASI), and Cross-track Infrared Sounder (CrIS) – and working toward unifying the data records so that they will be useful for climate research.

“This would be a technology demonstration, but one that actually stands a very high probability of starting the benchmark measurements of CLARREO,” he said.

Whatever happens, the work continues. Not only do these new technologies have applications beyond CLARREO, but also, as Revercomb and Best pointed out, SSEC Engineer Joe Taylor has just completed his PhD through Laval University in Canada based on his ARI-related efforts.

He will defend his dissertation in early July – yet another major milestone in ARI’s development path. ■

FELTZ'S FRONTIER

Graduate student researcher sees improved accuracy with new temperature validation method

by Sarah Witman

SSEC graduate student researcher Michelle Feltz in Tucson, AZ in May 2013. Photo Credit: Bob Knuteson, SSEC.

Validating the measurements taken by instruments onboard a satellite is a basic and necessary process of satellite meteorology. Another measure, sometimes a non-satellite measurement, is used as a reference point or standard in order to verify the integrity of the satellite data – a process that can be further complicated with variations in time and space. The method of choice for this type of data validation, then, varies slightly among scientific communities.

Researcher Michelle Feltz, as an undergraduate at the University of Wisconsin-Madison, undertook the challenge of developing one such method. The results of her research were recently published in the Journal of Geophysical Research, in a paper on which she was lead author.

Feltz, now a graduate student in the University's Department of Atmospheric and Oceanic Sciences, never thought that years of data analysis would culminate in an entirely new methodology for validating temperature measurements from weather satellites, with potential applications for studying climate. Nor did she likely envision her work would one day lead to correspondence with a group of scientists from the University Corporation for Atmospheric Research (UCAR) regarding the way it processes data.

The investigation began when Feltz's adviser, Bob Knuteson, a Senior Scientist with the Cooperative Institute for Meteorological Satellite Studies, suggested that she begin an analysis of vertical temperature profiles in the atmosphere. Scientists would normally retrieve temperature data from satellites, and then validate those data by using forecast models, or by comparing them with data collected from radiosondes.

While radiosondes and forecast models remain the standard for temperature validation, Feltz said she no longer sees them as the best tools for this job. Her paper offers an alternative validation method using a remote sensing technique called GPS radio occultation.

GPS radio occultation is a technique for measuring properties in the atmosphere—in this case, temperature—which works by detecting a change in the radio signal emitted as electromagnetic radiation passes through the atmosphere. Knuteson describes the GPS radio wave as “a ribbon that cuts through the atmosphere.”

As it does this, it gets refracted and can be detected with specialized instrumentation onboard low Earth-orbiting satellites.

Knuteson and Feltz theorized that GPS radio occultation data could be used to validate temperature profiles from infrared sounders, but the degree to which it could be done was unknown. They found that this method offered multiple advantages over traditional approaches.

To validate satellite sounder measurements—specifically, hyperspectral infrared sounders that collect and process information across the electromagnetic spectrum—GPS radio occultation offers the advantage of homogeneous global coverage: complete coverage that is unbiased with regard to land or sea.

“Traditionally, it’s been radiosondes that have been used to validate the infrared sounder temperature profiles. But radiosondes are very limited in their sampling, globally, because you can only launch so many weather balloons—usually over land, in the northern hemisphere. You are missing a lot of sampling,” she said. “With GPS, there is a lot more sampling.”

While the radiosonde provided the best estimate for atmospheric temperature, Feltz explained that she would feel more comfortable, as a researcher, relying upon GPS radio occultation rather than sounder data because it is capable of providing higher, and higher quality, vertical resolution in the temperature profile.

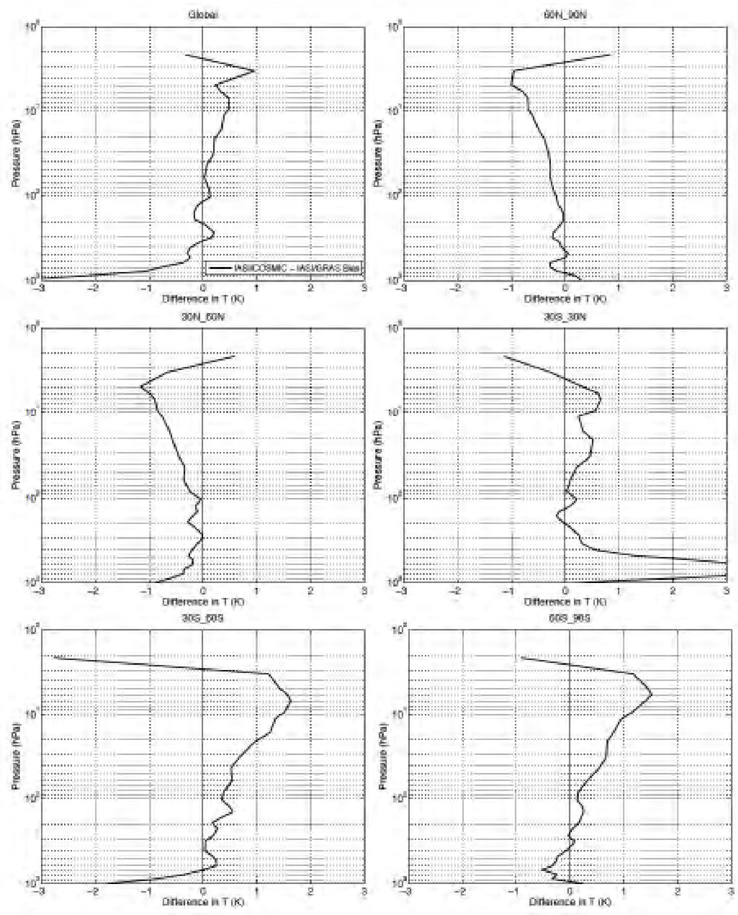
“It has advantages in the upper atmosphere rather than lower,” she said. A primary thesis of Feltz’s paper, she said, is questioning whether GPS radio occultation could be used in place of radiosonde data.

“I don’t know if it should necessarily replace it, but it definitely offers a new viewpoint, a new way of looking at things,” she said. “It’s never a bad idea to look at something new and see what you can get out of it.”

GPS radio occultation has other advantages—it is thorough in terms of time and space as it collects data on a full diurnal cycle and at each latitudinal zone.

Additionally, while Feltz said she thinks a forecast model is still valuable in its own right, she has found modeling to be less accurate when dealing with data from sounders. The sounders onboard polar orbiting satellites scan in-sync with the sun in highly repeatable orbits, collecting swaths of data at distinct times of the day. GPS radio occultation offers pseudo-random sampling in time and space to validate those data.

Feltz explained that the trick to validation is matching up the time of the GPS retrieval with the satellite measurement at that precise time.



▲ Feltz's data analysis, shown in the above figure, revealed a bias between METOP-A/GRAS and COSMIC temperature profiles.

“You really have to think about where and at what time you’re taking these measurements. … You have to look at their different characteristics,” she said. “We had to learn about the different measurement techniques, and then go from there.”

Current sounders measure infrared radiation emitted by the Earth, whereas GPS radio occultation, she said, is more like sending out laser beams to do the same job.

“A lower earth orbiter satellite tracks this laser as it is being occulted, or partially concealed by, the atmosphere,” Feltz continued. “The measurement is based on the time difference, or the phase difference, of the wave, how it interacts with the Earth’s atmosphere.”

Furthermore, she said GPS radio occultation provides an independent, SI-traceable measurement, meaning it has a high level of certainty with internationally accepted standards. In contrast, sounder products are sometimes tuned to agree with medium range forecast model analyses and thus are not independent in the way GPS radio occultation offers.

“Models also ingest satellite data, so when you’re comparing satellite data against models that ingest it, you don’t know exactly what you’re comparing it to because it’s not completely independent,” Feltz explained. “Measurements from GPS RO and sounders are very independent from each other, which allows you to make a decent comparison."

Her paper states that GPS radio occultation has potential for high accuracy in the upper troposphere to middle stratosphere, places where there is little water vapor. The high-accuracy clocks on GPS are known for providing highly stable, highly reproducible results, helping to prevent bias as well as total error. GPS radio occultation data has inherently less noise. During the reprocessing of data, noise can cloud results and impact bias.

There are a number of possible applications that could benefit from the ability to pair GPS radio occultation and radio sounder datasets, Feltz said, in terms of validation. In particular, minimizing bias and error could be especially important when studying climate, she pointed out, because it is a topic that relies on trends over many decades.

▲ Feltz launching a radiosonde in Park Falls, Wisconsin, as part of her group's research. Photo Credit: Amanda Gumber, UW AOS.

"Climate research is an important use of the data, especially," she said. "In order to detect trends in climate, you really need an accurate measurement, because any uncertainty in your data is going to affect how long of a time period you need to detect a certain trend. So, by using these [GPS RO and sounder] measurements together you can have a greater certainty in what trends you are seeing in the data."

She continued, saying, "I think this could become an interesting issue in the future—what kind of measurements you need to detect climate change. I think you have to look at the best of both products and not necessarily say that one is better than the other."

Feltz is not the only researcher anticipating the application of her methodology to climate studies. In the process of her data analysis, she found an interesting result, one that UCAR—the organization responsible for processing all radio occultation data in the United States—has said may hold advantages for their climate data processing.

Under Knuteson's supervision, Feltz had begun investigating and comparing temperature profiles: data that had been retrieved using COSMIC, an NCAR/UCAR network of six satellites, and GRAS, a EUMETSAT instrument, both of which collect atmospheric data through GPS radio occultation.

When Feltz embarked on that project, Knuteson expected that the measurements would agree with one another—after all, these instruments are supposedly collecting the same type of data: vertical temperature profile measurements in the Earth's atmosphere. He thought Michelle would write a paper highlighting the similarities found, along with some slight deviations.

To their surprise, though, she found something quite different. Contrary to their expectations, the instruments were reporting highly disparate results, especially at high and low pressures.

"The Feltz comparison suggests a systematic bias between COSMIC and GRAS temperature profiles," Knuteson wrote in a CIMSS weekly report earlier this month, "which increases with altitude in the stratosphere and can exceed one degree."

To confirm what she had found, Feltz wrote to the COSMIC Data Analysis and Archive Center team at UCAR in July 2013, the organization from which she and Knuteson obtain all of their GPS radio occultation data. She asked UCAR for documentation that would show any specific differences in the processing of data from either source, either supporting or disproving a possible temperature bias between them.

"When we compared the bias results from [COSMIC and GRAS] for five different latitude bands, we found an interesting result," she wrote to UCAR in an email. "We see an interesting pattern."

Feltz corresponded with UCAR-COSMIC Software Engineer Doug Hunt, explaining the results of her study and its potential uses. One day, Hunt responded with exciting news: A couple of scientists in his group, Sergey Sokolovskiy and Ben Ho, had taken an interest in her query, discussed it, and attempted to duplicate her results. He reported they had gone on to confirm her results independently, using only the UCAR-processed COSMIC and GRAS temperature data.

"For the currently available data on the CDAAC website, our results matched yours pretty closely for temperature," Hunt wrote.

They explained that the difference in results stemmed from differences in data processing. A climatology technique called "first guess" had been used to a greater degree with the COSMIC data, to account for more noise in those data, while less of that technique had been applied in processing the less-noisy GRAS data. Hunt said they found this practice could lead to latitudinal biases. They found that when they tried an alternative type of computation, known as bending angle, one that does not employ first guess, that bias disappeared.

"We are working on a new version of our radio occultation inversion code that mixes in first guess in the same way for each occultation regardless of how noisy it is," Hunt continued. "This has advantages for climate processing."

To mitigate this bias, UCAR plans to alter its method for processing COSMIC data, starting later this year.

"This is a neat example of how science should work," Knuteson said of the experience with UCAR. "You do good work independently, and then other people who are interested in it and its implications will evaluate it."

While the discovery may be a small one, Knuteson feels it is a praiseworthy example of Feltz's work ethic.

"I am excited. The sounding data Michelle put so much time into, all this work she did—and the first thing she found was this bias," he said. "She is very skeptical, so it was important to her to confirm and do everything herself. It's a good scientific trait."

Feltz's manner of speaking about her research is very deliberate, selecting each word carefully so as not to mislead or overreach. At the same time, it is clear that she personally enjoys the topics she and Knuteson have been working on—especially a side project where they launched radiosondes from the roof of their workplace, the 15-story Atmospheric, Oceanic and Space Sciences building at UW-Madison, as well as from Park Falls in northwoods Wisconsin. Feltz grew up in the Midwest and enjoys the outdoors, but she had more to say about the chance to validate her data firsthand.

"We launched weather balloons and we could compare different temperature profiles from each instrument. That was a really fun project for us to look at, for ourselves, what the temperature profiles looked like compared to each other, how well the different instruments performed, and in what conditions they do better," she said.

"I definitely enjoy the topics we have been working on," she added. "Looking at instrumentation of the satellites and working with the data in a way that you can actually use it."

She said other scientists seem to be receptive and accepting of the method, during the few conferences at which she has presented her research so far.

Next on the horizon for Feltz? She will look at the best way to combine the information provided by GPS radio occultation and from the new CrIS sounder on the Suomi-NPP satellite. ■

Mike Pavolonis briefs House, Senate

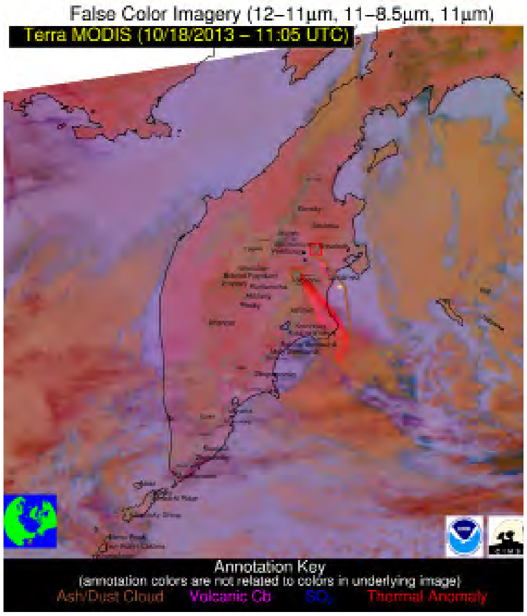
by Jean Phillips

Mike Pavolonis, a NOAA Advanced Satellite Products Branch scientist stationed at UW-Madison's Cooperative Institute for Meteorological Satellite Studies, briefed U.S. House and Senate members in June on the importance of satellites for monitoring the impacts of volcanic eruptions.

One area that directly benefits from Pavolonis's research is aviation safety. The ash clouds released during a volcanic eruption frequently disperse over wide areas and can cause serious problems for air travel. Ash can cause engine failure when taken into the combustion chamber of an aircraft.

Many volcanoes are located in remote areas and are difficult to observe from the ground, making satellites "absolutely critical for mitigating the impacts of volcanic eruptions," Pavolonis said.

The image to the right shows a volcanic eruption on Russia's Kamchatka Peninsula on October 18, 2013, and was generated in near real-time by the VOLcanic Cloud Analysis Toolkit (VOLCAT), a software system developed by Pavolonis. ■



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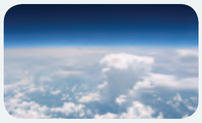

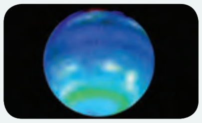

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