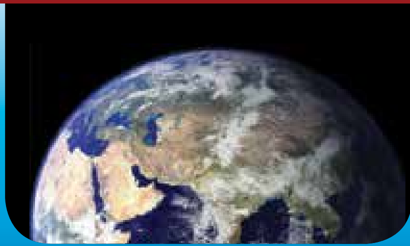
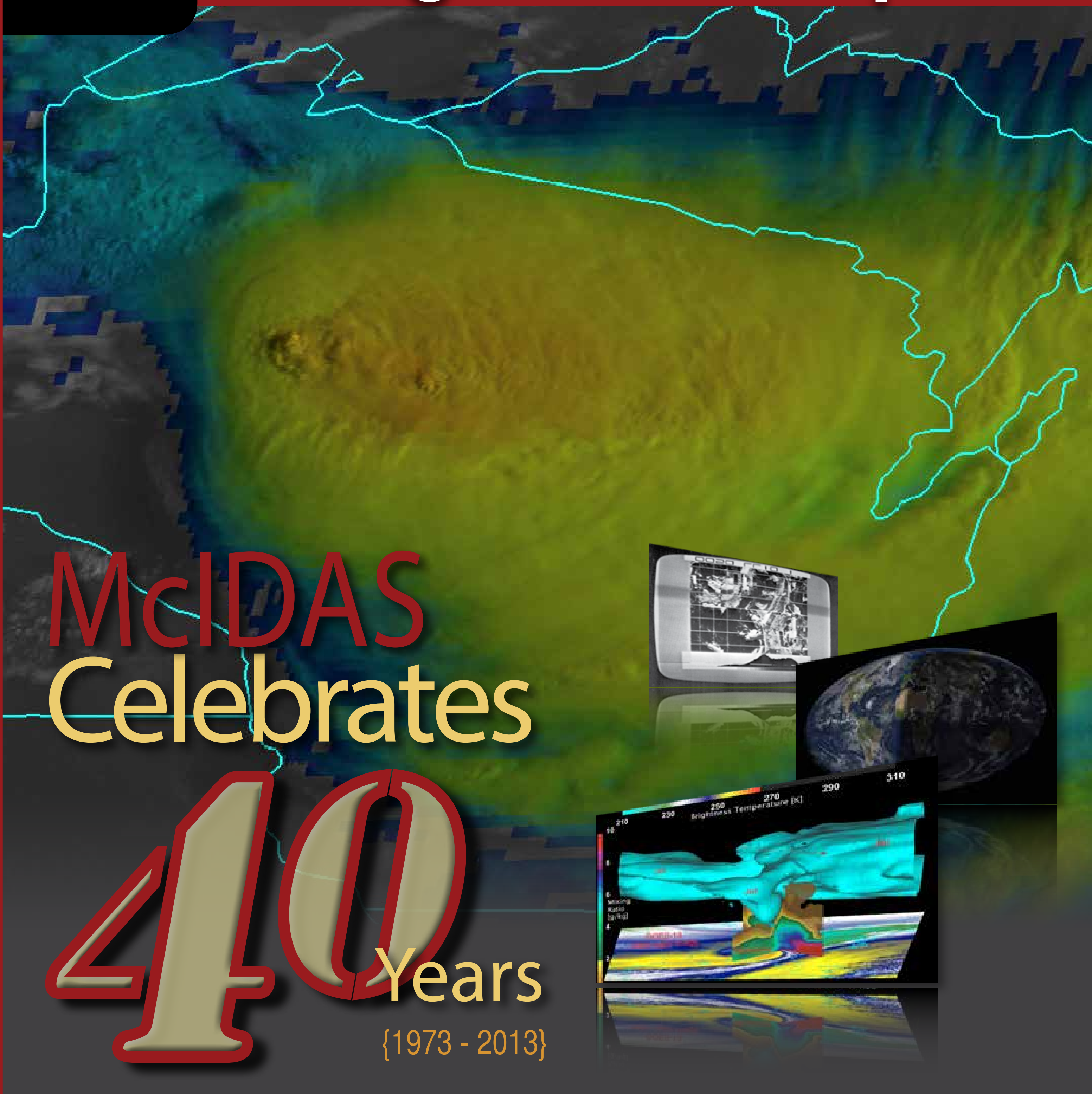
SPACE SCIENCE AND ENGINEERING CENTER • COOPERATIVE INSTITUTE FOR METEOROLOGICAL SATELLITE STUDIES • UNIVERSITY OF WISCONSIN-MADISON

TtA 2014
Winter / Spring



SSEC

through the atmosphere



McIDAS Celebrates 40 Years

{1973 - 2013}

TtA
Winter / Spring 2014

INSIDE This Issue

COVER Image

McIDAS-V processed image of rapidly evolving convection over Wisconsin. Image credit: Joleen Feltz and Mike Hiley, CIMSS.

INSETS

Top: Early McIDAS display; Middle: McIDAS generated global composite; Bottom: McIDAS-V generated baroclinic leaf signature (See McIDAS article, page 1).

DIRECTOR'S Note

SSEC is a major success story because of the combined achievements of its individual scientists and their research programs. Together, we strategically and successfully undertake a broad spectrum of research, from individual single year grants to large international collaborations. *Through the Atmosphere* illustrates the diversity of our research, both intellectually and thematically: from outreach programs that teach the value of satellite observations to exploring the clouds of Saturn.

Planetary atmospheres are complex systems. We continually devise methods to represent these systems in computer and conceptual models using a variety of data sets. Some of you have heard me say that there are five As in data – access, assemblage, analysis, artistry and archive. SSEC leads the world in all five of these As in the field of satellite observations. We just celebrated the 40th anniversary of McIDAS -- this visualization (e.g. artistry) and analysis system, along with the SSEC Data Center (archive and access), support the already strong arguments for our world leadership (assemblage and analysis) in satellite remote sensing.

Though located in the Midwest, CIMSS is home to a world renowned research group using satellite data to study tropical cyclones in order to improve hurricane intensity estimates and save lives. Some of their work has transitioned from the research lab to the routine activities of NOAA's applied researchers and forecasters. The tropical cyclone program at CIMSS has excelled for more than 20 years.

Fire detection from satellite observations is another program that has a long history at SSEC and CIMSS – a program developed for long-term monitoring of fires and associated aerosols and their impact on global climate. A more recent, innovative research program is exploring rapid-onset of extreme drought conditions. The basic research undertaken in that study will eventually have direct implications for decision-making as droughts lead to crop failures and threaten livestock, wreaking environmental and economic damage.

These programs exemplify our ability to couple basic science with applied science. The last essay in this issue of *Through the Atmosphere* ties it all together, thoughtfully outlining the intrinsic value to society of basic research and its varied applications.

Perhaps there are six As in data, with application the final cornerstone, and another in which SSEC researchers excel.

Steve Ackerman

Steve Ackerman
Director, CIMSS

Special Report

by Leanne Avila

More Than a Pretty Picture: McIDAS Celebrates 40 Years

▲Composite Image of the World: Processed using McIDAS, the image, from August 20th, 2009, is a mosaic of data from geostationary and polar orbiting satellites. Data were collected from meteorological agencies around the world including the United States, Europe, China and Japan. Image credit: Rick Kohrs, SSEC.

"[It] was a fascinating way to extract information out of satellite images. It was almost intoxicating."

Take it from Dave Martin, an SSEC scientist who was among the first to use the Man computer Interactive Data Access System (McIDAS) in a research project shortly after its development in 1973. A revolutionary visualization and data analysis system developed at SSEC, McIDAS celebrated 40 years of innovation in October 2013.

Over those four decades McIDAS has changed significantly, from a hardware and software system for which developers had to build their own hardware to today's fifth generation system of free, open-source software, known as McIDAS-V (for more technical details about the first four generations, please see the Bulletin of the American Meteorological Society article celebrating the 25th anniversary of McIDAS published in 1999). The one constant has been its pioneering capabilities that Martin and countless others have found not only alluring, but vital to their work.

Imagine using paper printouts of satellite images and data to analyze cloud movement and weather patterns. While not impossible, it was very labor intensive. Eager for a more efficient and automated approach, SSEC founder Verner Suomi devised a competition within SSEC to see who could construct a working model using cutting-edge technology. This strategy was very much in line with Suomi's management strategy, which embraced experimentation and conflict, according to SSEC Emeritus Senior Scientist Bill Hibbard. Martin noted that the competition took on life outside the building as Suomi was at the same time competing with University of Chicago researcher Ted Fujita, who developed the Fujita Scale which classifies tornado intensity based on the damage caused by the tornado. Each was trying to be the first to determine "the best way to analyze sequences of geostationary satellite images. And of course, we all know who won that competition," remarked Martin.

Suomi's internal competition pitted two alternate approaches, an analog method versus software. In the end the software approach, known as WINDCO, was more successful.

SSEC scientist Matthew Lazzara noted that Suomi was also enthralled with

continued on page 2 ▸▸

continued from page 1

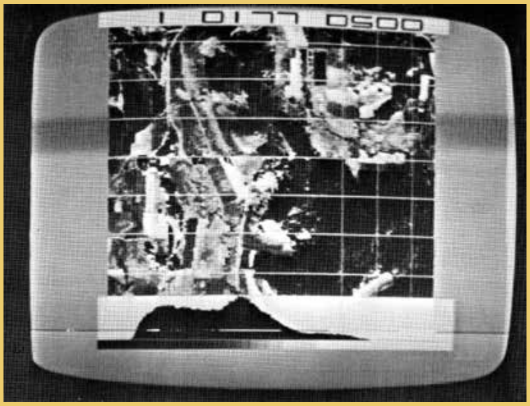
the idea of instant replay in football and how that new technology, or something similar, might be applied to what they were seeing on paper. According to Lazzara, Suomi wondered, "Why can't we animate them [the satellite pictures]? Let's do something with them." Determined to make that vision a reality, Suomi and his team did just that, animate the satellite images, using the same technology, the analog disk.

With success came additional funding which led to the unveiling of the first generation of McIDAS in 1973. McIDAS offered a new way of displaying, analyzing, interpreting, acquiring and managing geophysical data. Initially there was but one McIDAS system located inside SSEC. The first McIDAS installation outside of SSEC went to the Air Force Geophysics Laboratory (AFGL) in Massachusetts in 1975. According to Lazzara, AFGL "bought it off the floor and we had to build another one."

Interest in McIDAS grew tremendously in the late 1970s, particularly after the Wichita Falls, TX tornado of 10 April 1979. Forty-two people lost their lives. Following a Congressional investigation, which included a visit to SSEC, to determine how to minimize loss of life due to severe weather, the National Oceanic and Atmospheric Administration (NOAA) requested its own McIDAS system.

SSEC researcher Tom Whittaker was quick to identify what was critical to the broad success of McIDAS and what drove users to it: its unique ability to create composites. Users could layer multiple types of data, satellite, model observations, etc., in one display. At the 57th Annual Meeting of the American Meteorological Society held in Tucson, Arizona in January 1977, Whittaker demonstrated this capability to the public for the first time. According to Whittaker, McIDAS was in its very essence likely the first GIS (Geographic Information System) system in the world.

▲The Windco display and control console successfully demonstrated a means to access image matrix information so that meteorological parameters such as cloud motion, sunglint, cloud dynamics could be extracted and analyzed. Photo credit: SSEC, UW-Madison.



▲Though granular by today's standards, processing earth resources data was easier with the image comparison and measurement capabilities of McIDAS. Photo credit: SSEC, UW-Madison.

As groups acquired their own McIDAS systems from SSEC, they would frequently rename them. NOAA's version became IFFA for Interactive Flash Flood Analyzer. A version bought for space shuttle operation was named MIDDS (Meteorological Interactive Data Display System) – "still McIDAS" noted Lazzara. When CIRA (Cooperative Institute for Research in the Atmosphere) took McIDAS and added a user interface, they called it RAMSDIS (Regional and Mesoscale Meteorology Team Advanced Meteorological Satellite Demonstration and Interpretation System), which made its way not only to third world countries but into National Weather Service (NWS) Offices. "That was a big deal – getting McIDAS into NWS offices, getting satellite data in there," which happened before AWIPS (Advanced Weather Interactive Processing System), commented Dave Santek, the current McIDAS principal investigator. AWIPS is the processing system used by NWS to create forecasts.

Following up on Santek's statement, Lazzara emphasized the reach of McIDAS in the research and operational environments. A relatively unknown fact… anyone receiving satellite data from the NOAAport distribution in the form of GINI (GOES Ingest and NOAAPORT Interface) images has benefitted from McIDAS as those images are built using McIDAS "under the hood."

Lest you think that the impact of McIDAS is restricted to the realms of research and operations, consider Hibbard's words on its legacy. "If you were going to have one sentence to summarize what McIDAS means… every person in the world who has access to a television set uses Verner Suomi's invention." By invention Hibbard not only meant McIDAS, but also weather satellites in space, given Suomi's pioneering work in satellite technology as well.

Viewing the system from a computer science perspective, Hibbard attributed the longevity of McIDAS to its design and, by extension, one of its main designers, John Benson. While from a researcher's perspective, Martin commended Benson's design for its ability to work with quantitative measurements. "It wasn't just a pretty picture on the screen," Santek concurred.

Hibbard remarked that this philosophy of highlighting the importance of the data remained critical to visualization development at SSEC, from VisAD through McIDAS-V. Other groups took note of that success and sought to emulate those capabilities. However, as Santek pointed out, some users were not satisfied with what the competition was able to provide. Due to their unique set of requirements (from timeliness to the ability to manage a significant number of data sources), Cape Canaveral has had a McIDAS system for 25+ years because "nothing could compete with McIDAS in terms of performance and usability."

From the moment McIDAS systems went out into the world, the delicate task of balancing research and development with the need to support operational users began. Over time McIDAS has expanded into educational and commercial realms as well.

Today McIDAS continues to extend its reach around the globe. In recent years, environmental companies have shown interest in McIDAS as it not only allows access to current, but also archived, data. Current members of the McIDAS User's Group (those using the fourth generation McIDAS-X) number over 40 while hundreds have downloaded the fifth generation McIDAS-V. Weather services around the world, including Spain, Australia, and Greece, depend on McIDAS.

While SSEC will continue to support McIDAS-X through at least 2020 and the current generation of GOES weather satellites, McIDAS-V will be the focus for innovations. In recent years SSEC programmers have worked diligently to add new capabilities as new sensors, such as those on the Suomi National Polar-orbiting Partnership, come online.

Among its many achievements, McIDAS also can list a number of firsts. With the help of McIDAS, cloud tracking on Jupiter and Saturn using Voyager data was possible, as was imaging of biochemistry gels to analyze protein spots. It served as a catalyst for countless research endeavors.

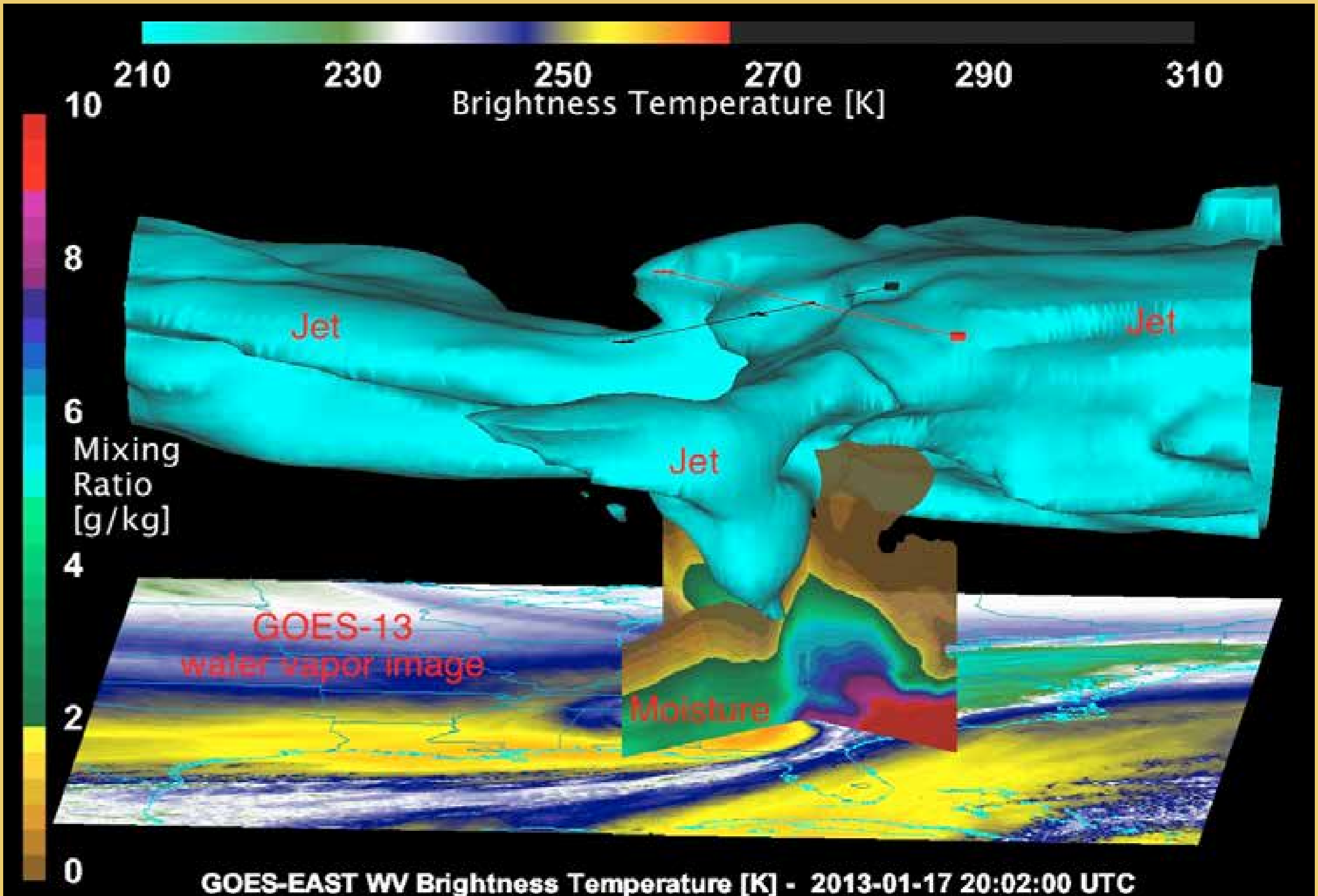
"McIDAS has been a facilitator for the development of other big things. CIMSS [Cooperative Institute for Meteorological Satellite Studies] wouldn't exist without the McIDAS project. Unidata wouldn't exist without the McIDAS project." Lazzara went on to note that Bill Smith came to the UW-Madison as a result of work Suomi was doing with McIDAS and satellite soundings; Smith would later become a director of CIMSS. With funding from NSF, Unidata would go on to bring software and data to colleges and universities without their own McIDAS-type system.

Over the 40 years McIDAS has undergone architectural changes and adaptations to suit the needs of its users. In its wake it leaves behind a legacy unlike any other visualization tool. **§**

NOTE: This article is the result of an interview conducted with SSEC's Dave Martin, Matthew Lazzara, Bill Hibbard, and Dave Santek on 19 November 2013, plus additional discussions with SSEC's Tom Whittaker.

Visit the CIMSS Satellite Blog for more information about this case and watch the animated Rapid Refresh model at: http://go.wisc.edu/xb7657

▼This image, produced in McIDAS-V, combines a GOES-13 observation of a classic baroclinic leaf signature from 17 January 2013 with concurrent NOAA Rapid Refresh (RAP) model wind and moisture fields. The system produced significant snowfall in Tennessee, North Carolina and Virginia. The drier signature in the water vapor imagery corresponds to the upper level dry intrusion visible in the jet stream (cyan) while the ascending moisture associated with the warm conveyor belt is clearly visible in the moisture cross section. Figure credit: Scott Bachmeier, CIMSS.



Tropical Cyclone Analysis:

An Important CIMSS Product Transitions from Research to Operations

by Jean Phillips

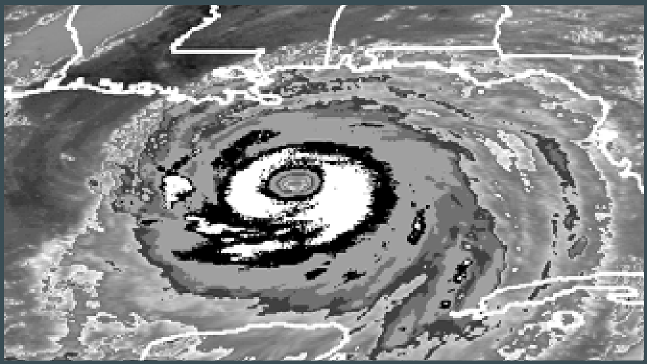
As longstanding, integral partners with the National Oceanic and Atmospheric Administration (NOAA), scientists from the Cooperative Institute for Meteorological Satellite Studies (CIMSS) routinely produce methodologies to refine and improve weather analysis and forecasting. In fact, a majority of quantitative geostationary satellite products currently operational with the National Weather Service (NWS) have direct or indirect links to CIMSS researchers.

These products detect the presence of everything from clouds to volcanic ash to tropical cyclone characteristics. The increasing number and density of people who live along the world's coastal regions may not know it, but they are direct beneficiaries of lifesaving improvements to hurricane forecasts due in part to contributions from CIMSS scientists.

This past hurricane season, NOAA implemented routine use of the newest version of an algorithm, known as the Advanced Dvorak Technique (ADT), a tropical cyclone analysis tool. Under development by tropical cyclone researchers at CIMSS since the late 1990s, the algorithm utilizes infrared imagery obtained from geostationary satellites to estimate tropical cyclone intensity through its lifecycle – from formation through dissipation.

According to Chris Velden, principal investigator of the ADT algorithm development at CIMSS, this newest release has resulted in more "consistent and statistically accurate estimates of hurricane intensity," critical information for forecasters around the world who monitor tropical cyclones and issue warnings to the public.

Invented nearly 40 years ago by NOAA scientist Vernon Dvorak, the Dvorak Technique remains the standard for monitoring tropical storm systems. Over time, the technique was shown to have some limitations due to its inherently subjective process for determining storm center and cloud pattern – a limitation that directly influenced the accuracy of intensity estimates and motivated the development of the ADT.



▲Infrared satellite image of Hurricane Katrina (2005) using the Basic Dvorak Hurricane enhancement curve for tropical cyclone classification, or "BD Curve." The black/white/gray shades represent different infrared temperature ranges employed to produce intensity classifications in the subjective Dvorak intensity classification technique. Figure credit: Tim Olander, CIMSS.

The most significant improvement to the ADT is the incorporation of microwave data directly into the infrared-based intensity estimates. In previous versions, CIMSS scientists transmitted the microwave information to NOAA in a process separate from the algorithm module itself – now, the data acquisition and the application module are combined. The net result is that intensity estimates can be immediately compared with microwave information yielding better estimates of hurricane maximum wind speeds.

The ADT algorithm package has officially transitioned from the CIMSS research environment to NOAA operations. This is an important step because ADT estimates are produced for all active tropical cyclones anywhere on Earth. Primary users of the ADT are the National Hurricane Center (NHC), the Central Pacific Hurricane Center and the Joint Typhoon Warning Center, but Velden points out that operational tropical cyclone analysis centers across the entire globe can access the ADT information via the CIMSS Tropical Cyclone website. Now, in addition to NOAA, there is a second "official" source for the ADT information.

Improvements to hurricane analysis tools like the ADT are increasingly important. In the United States alone, fifty million people have moved to coastal areas in the past twenty-five years. For those who live near the ocean, where population growth and construction rates remain high, major property losses are inevitable due to land falling hurricanes and related storm surges. Death tolls, however, can be reduced or minimized if people plan well and heed the warnings issued by the NHC.

While this new version of the ADT offers a significant improvement to NHC forecasters, continued feedback on the algorithm's performance from its users is critical. Velden's team relies on this feedback so that future versions, already underway, can be enhanced based on specific user observations and needs. §

Flash Drought

A New Early Warning System

by Zhengzheng Zhang

The year 2012 marked the largest drought occurrence in the 14-year history of the U.S. Drought Monitor (USDM) and was one of the most severe droughts to impact the U.S. since the Dust Bowl. At its peak, nearly 80% of the lower 48 states were abnormally dry, with more than half of the country experiencing severe to extreme drought conditions. Designated a "flash drought" by USDM climatologists, it was characterized by its unusually rapid onset. The 2012 drought led to widespread crop failure and large reductions in livestock populations across the south-central U.S., with the Midwestern Corn Belt experiencing lower grain yields. The U.S. Department of Agriculture's (USDA) Risk Assessment Agency estimated indemnity payments for the 2012 drought reached nearly $14 billion.

First coined in 2000 to describe the rapid-onset of extreme drought conditions in Oklahoma and Texas, flash droughts can rapidly attain peak magnitude in a matter of weeks; conventional droughts take several months or years to reach their maximum intensity and geographic extent. Flash droughts are particularly damaging to agricultural crops because they occur during prime growing seasons, allowing less time for those affected to respond to rapidly changing conditions. An improved early warning system would be especially useful in these situations.

▲Vegetation phenocam pictures taken at the Merena, Oklahoma, Mesonet site during a five week period during 2012 showing the rapid die-down of vegetation during a flash drought event. The USDM drought classification changed from abnormal dryness (D0) to extreme drought (D3) during this time period. Photo credit: Jeffrey Basara and Xiangming Xiao, University of Oklahoma.

Jason Otkin, an atmospheric scientist at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison, is working with colleagues to produce a flash drought early warning system. Their system, based on a drought stress index that describes the severity of water loss in plants, will provide better detection and prediction of flash drought. Improved detection and prediction will aid in drought mitigation and climate adaptation efforts. Otkin's research is pioneering, as flash droughts are not well understood and do not have a well-established forecast system.

"Our end goal is to produce a more robust or more accurate drought early warning system," said Otkin. "It will not only be capable of accurately depicting what the drought condition is now, but of providing advanced warning of drought development over short time periods for various stakeholders, such as farmers who are vulnerable to flash drought development. We are trying to provide weekly to monthly drought forecasts."

The early warning system is based on a drought indicator called the Evaporative Stress Index (ESI) that uses satellite observations to estimate evapotranspiration (ET). Martha Anderson's research group at the USDA has led the development of the ESI for many years. According to Otkin, ET shows water loss due to

Dryland corn north of York. Photo credit: Ken Dewey, University of Nebraska-Lincoln.

▸▸ *continued from page 5*

evaporation and plant transpiration to the atmosphere, and is an indicator of what the plants are experiencing.

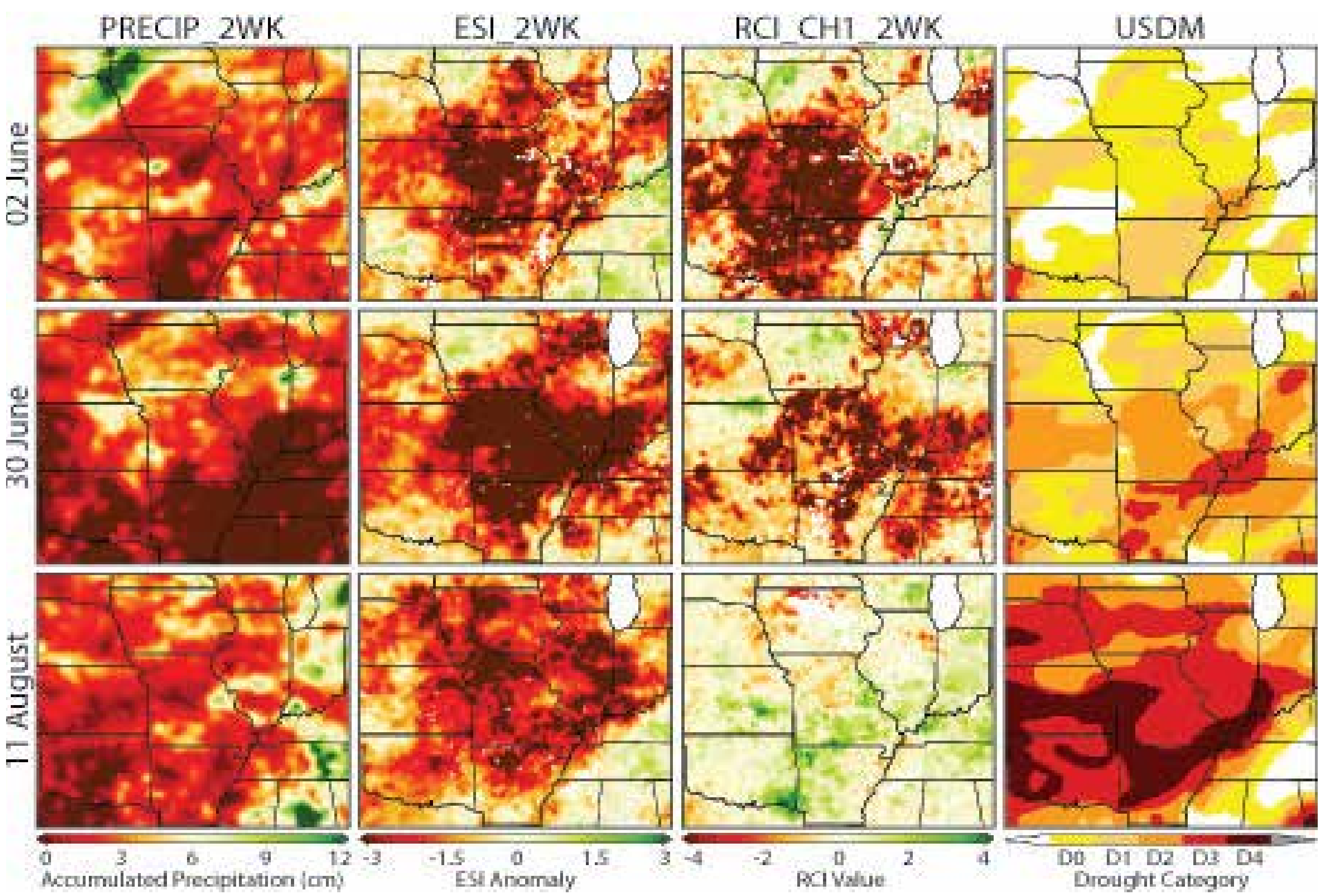
For example, in summer, if ET is higher than normal due to high temperatures, soil moisture can be depleted very quickly, resulting in drought conditions. In addition to temperature, ET is also influenced by other atmospheric factors like precipitation, humidity, solar radiation (sunlight) and wind. Any of these factors alone can produce higher-than-normal ET. The moisture loss resulting from enhanced ET can result in a rapid deterioration of vegetation health. Flash droughts can develop if several extreme atmospheric factors occur at the same time and remain constant over the same area for several weeks. The results can be disastrous.

Although ET is a good drought indicator, it is difficult to make direct measurements of it over large geographic areas. To solve this problem, Otkin uses satellite-based remotely sensed maps of land surface temperature (LST) and a land surface energy balance model to estimate actual ET, based on the relationship between land surface temperature and the amount of water in the soil. Dry soil usually releases more heat than wet soil and has a higher temperature. The process, known as "sensible heat flux," can be inferred from infrared satellite observations and used to calculate actual ET using an energy balance approach.

According to Otkin, the actual ET is often compared to how much ET would be possible if soil moisture were not limited. This is called potential ET. The Evaporative Stress Index describes the severity of drought conditions based on anomalies in the ratio of actual to potential ET. If there is sufficient soil moisture, actual and potential ET will have a similar magnitude and the ESI will be higher than normal. But if plants lack sufficient water, the actual ET will be lower than the potential ET, causing a decrease in the ESI. Decreases in the ESI are an indication of emerging drought and increasing moisture stress in plants.

Although there are many well-established drought indices, Otkin's group is especially interested in the ESI product because "it seems particularly suited for identifying cases of rapid drought onset, and it seems to get signals of developing drought earlier than other [drought] products."

Not all drought indicators work for flash droughts. For example, flash droughts are difficult to identify using traditional precipitation-based drought indices such as the standardized precipitation index (SPI), because precipitation deficits are the only input factor in that index. Unlike the ESI, it does not account for temperature, wind and radiation anomalies associated with flash



▲**Time evolution of 2-week rainfall, 2-week ESI composites, Rapid Change Index, and USDM drought depiction from 02 June until 11 August 2012. Figure credit: Jason Otkin, CIMSS.**

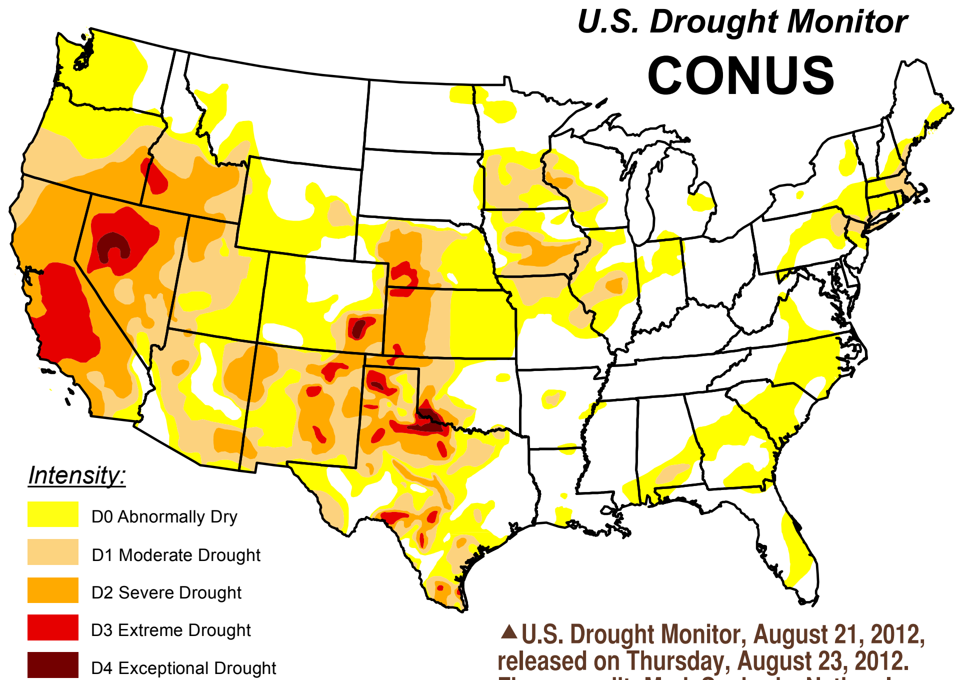
drought development. Some flash droughts, such as the 2011 and 2012 events across the central U.S., can occur even when the SPI indicates only a moderate precipitation deficit.

Otkin and his team wanted to evaluate the potential value of including the fast-response drought indicator ESI within the USDM process to improve early detection of flash drought. To do this, they examined the evolution of several recent flash drought events that affected different areas of the United States. They compared surface meteorological data, USDM drought analyses and ET anomalies inferred by the ESI.

Otkin also computed the ESI composite over different time periods to identify different kinds of droughts and evaluate anomalous ET conditions across different seasons and regions. To look at how quickly each of those multi-week ESI composites change over different time intervals, Otkin's group calculated ESI change rates or "standardized change anomalies." The ESI change rate helps scientists more easily identify areas experiencing rapid changes in ET. They convey useful information about the speed at which vegetation health and available water for plants are deteriorating while providing early warning of early impacts on crop conditions.

"Large negative change anomalies indicative of rapidly drying conditions were either coincident with the introduction of drought in the USDM or led the USDM drought depiction by several weeks," Otkin reported in a paper recently published in the Journal of Hydrometeorology.

Based on these standardized change anomalies, Otkin designed a new drought metric called the "Rapid Change Index (RCI)," which can more effectively provide early warning of an increased risk for flash drought intensification. Otkin is currently examining new methods to convert the RCI to drought intensification probabilities that may be more understandable and useful for stakeholders.



▲U.S. Drought Monitor, August 21, 2012, released on Thursday, August 23, 2012. Figure credit: Mark Svoboda, National Drought Mitigation Center.

"The rapid change index by itself probably takes some time for people to get used to and how to interpret it," Otkin said. "If I tell you the rapid change index has a value of -2, or has a value of -4, it probably does not mean a lot. But if I can tell you that -2 actually means a 40% chance that a flash drought is going to develop, and the -4 means a 70% chance of a flash drought, then people can use that information. I have done preliminary work to convert the RCI to drought probabilities and the results are all encouraging. It should hopefully provide some very useful probabilistic forecasts of drought development," Otkin noted.

Otkin also emphasized that the flash drought prediction system they are developing is a "probabilistic forecast," which means they can only tell the probability of future drought development; not its certainty. Based on the ESI alone, "there is no way to know exactly what is going to happen in the following days." To make the probability prediction more accurate, Otkin plans to take advantage of climate model or numerical weather prediction model data to modify these probabilities.

"If I have an RCI-based probability of 50%, and the climate model shows it [the future weather] will be hot and dry, then I would increase it [the probability]. If it shows cool and wet, then I would decrease it. My ultimate goal would be to have the ability to merge what we are seeing in the current state with the ESI with what the actual forecast models are indicating in the future as a way to get the most accurate drought forecasts," Otkin said.

In addition to evaluating and refining the ESI and RCI products for an effective early drought warning system, Otkin said future work will also include exploring alternative RCI formulations that adapt to the needs of drought-vulnerable stakeholder groups, such as ranchers and farmers across the central and eastern U.S.

Moving from scientific research to real-life application, in the spring of 2014, Otkin's group will present their early warning drought products to agricultural groups in Nebraska and Oklahoma. They hope to assess the usefulness of these products and learn how farmers might use the information.

"But to get from what we know to what they want, it takes a lot of interaction, that is what we are going to do in this project," Otkin noted. §

Highlights of Recent Publications

July 2013 - December 2013

♦ Anderson, M.C., C. Hain, J. Otkin, X. Zhan, K. Mo, M. Svoboda, B. Wardlow, and A. Pimstein, 2013: An intercomparison of drought indicators based on thermal remote sensing and NLDAS-2 simulations with U.S. drought monitor classifications. Journal of Hydrometeorology, 14, 1035–1056.

Results of comparison of multiple hydrologic indicators suggest a merged ESI-CM change indicator may provide valuable early warning of rapidly evolving "flash drought" conditions.

♦ Cintineo, J.L., M.J. Pavolonis, J.M. Sieglaff, and A.K. Heidinger, 2013: Evolution of severe and nonsevere convection inferred from GOES-derived cloud properties. Journal of Applied Meteorology and Climatology, 52, 2009–2023.

This paper seeks to link the temporal trends in robust GOES-derived cloud properties with the future occurrence of severe-weather radar signatures during the development phase of thunderstorm evolution. The relationship is used to show that the satellite-based approach can potentially extend severe-weather-warning lead times.

♦ Hoover, B.T., C.S. Velden, and S.J. Majumdar, 2013: Physical mechanisms underlying selected adaptive sampling techniques for tropical cyclones. Monthly Weather Review, 141, 4008–4027.

Four tropical cyclone cases are used to perform an intercomparison of several objective targeting guidance techniques to find underlying common physical mechanisms. To effectively prioritize resources, adaptive observations can be targeted by using objective criteria to estimate potential impact an initial condition in a specific region would have on the future forecast.

♦ Jones, T.A., J.A. Otkin, D.J. Stensrud, and K. Knopfmeier, 2013: Assimilation of satellite infrared radiances and doppler radar observations during a cool season observing system simulation experiment. Monthly Weather Review, 141, 3273–3299.

An observing system simulation experiment is used to examine the impact of assimilating data from satellite and Doppler radar observations. Assimilating both satellite and radar data creates the most accurate model analysis and illustrates the potential for these datasets for improving mesoscale model analyses and ensuing forecasts.

♦ Khatuntsev, I.V., M.V. Patsaeva, D.V. Titov, N.I. Ignatiev, A.V. Turin, S.S. Limaye, W.J. Markiewicz, M. Almeida, Th. Roatsch, and R. Moissl, 2013: Cloud level winds from the Venus Express Monitoring Camera imaging. Icarus, 226, 140-158.

Six years of continuous observations by the Venus Monitoring Camera provides the longest and most complete set of ultra violet images. Includes discussion of mean circulation, trends, variations and periodicities of cloud level winds on Venus and presentation of first results of tracking features in the VMC near-IR images.

♦ Kossin, J.P., T.L. Olander, and K.R. Knapp, Kenneth R, 2013: Trend analysis with a new global record of tropical cyclone intensity. Journal of Climate, 26, 9960–9976.

Historical global "best track" records of tropical cyclones are encumbered by temporal heterogeneities in the data. State-of-the-art automated algorithm applied to a globally homogenized satellite data record creates a more temporally consistent record of tropical cyclone intensity to better investigate robustness of trends.

♦ Miller, S.D., W.C. Straka III, A.S. Bachmeier, T.J. Schmit, P.T. Partain, and Y.-J. Noh, 2013: Earth-viewing satellite perspectives on the Chelyabinsk meteor event. Proceedings of the National Academy of Sciences of the United States of America, 110, 18092-18097.

Examination of satellite observations of the Chelyabinsk superbolide debris trail. Discussion of the ability of Earth-viewing satellites to provide valuable insight on trajectory reconstruction when there are sparse surface observations.

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

Honors and Awards

Steve Ackerman
Elected AMS Fellow

Jacola Roman
Best Poster, IASI International Conference (CNES/EUMETSAT)

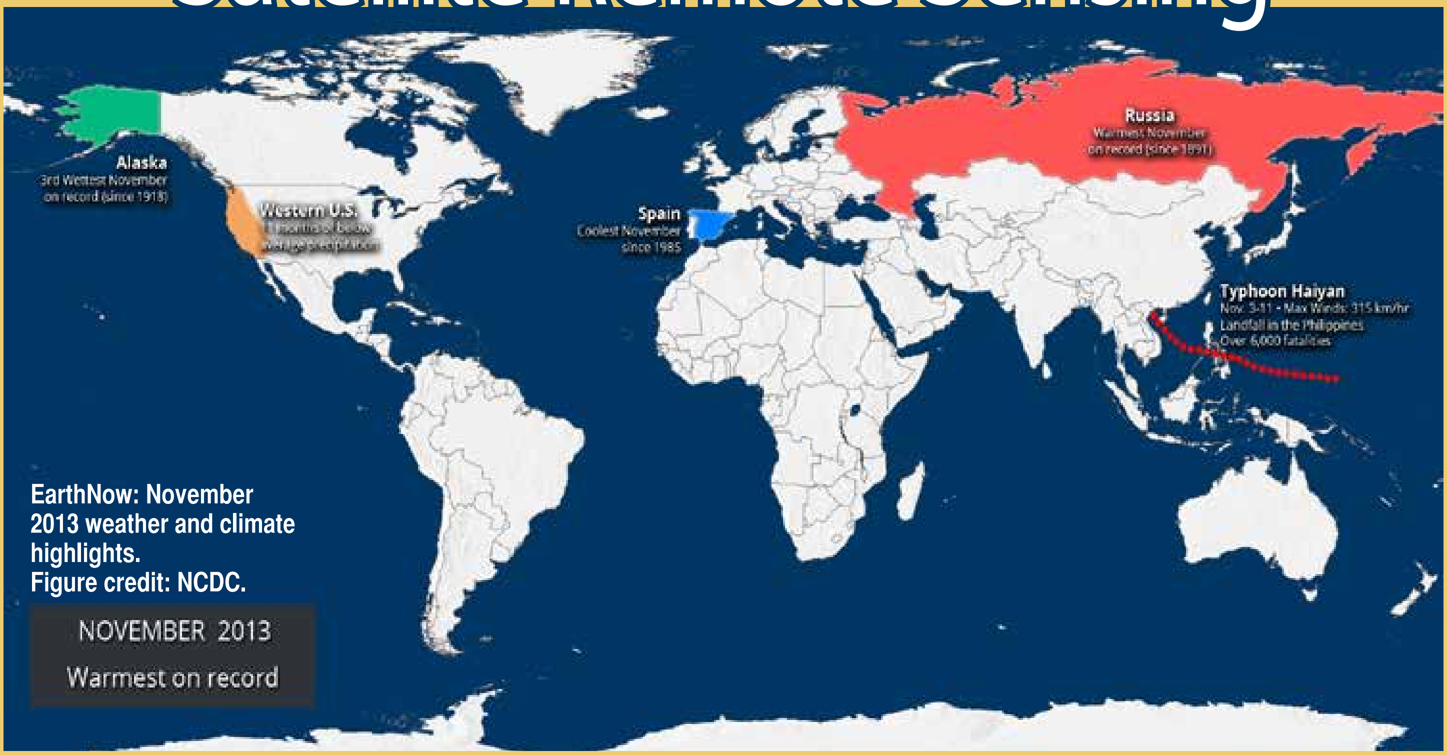
Bormin Huang
Elected SPIE Fellow

Dave Tobin
Appointed to International Radiation Commission (IRC)

Wayne Feltz
Certificate of Appreciation for "commitment, dedication and leadership as Vice Chair of Graduate School Committee on Academic Staff Issues (CASI) since July 2009"

by Margaret Mooney

Raising Awareness of Satellite Remote Sensing



EarthNow: November 2013 weather and climate highlights. Figure credit: NCDC.

Satellites have enormous benefits for society but it's important to get the message out. While scientists at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) and the Space Science and Engineering Center (SSEC) pursue cutting-edge research, outreach specialists at these Centers work to share science with the public. Along with on-going programs like building tours, workshops and web-based resources, the CIMSS Office of Education and Public Outreach (EPO) is especially excited about two current projects designed to raise awareness and advance science literacy in society.

The first venture involves select trainings for Science on a Sphere (SOS) docents and a new partnership with the National Park Service. Patrick Rowley and Margaret Mooney from the CIMSS Office of EPO traveled to Colorado and Arizona in the fall of 2013 where Rowley led on-site trainings at the Space Foundation and the Grand Canyon Visitor Center. The Space Foundation training reached three audiences: professional staff, volunteer docents, and company executives. The Grand Canyon training focused solely on National Park Service Interpreters. One element of both trainings included demonstration of the monthly *Climate Digest* from the CIMSS EarthNow Blog (http://sphere.ssec.wisc.edu). Impressed with the product, the National Park Service immediately incorporated the *Climate Digest* into its SOS programming, showing it three times each hour. Now hundreds of visitors to the Grand Canyon see this educational content on a daily basis!

The CIMSS *Climate Digest* is developed collaboratively using data from NOAA's National Climatic Data Center and Climate Prediction Center. In addition to producing large *Climate Digest* animations for SOS exhibits, CIMSS creates short videos, with audio, for viewing online. Each video features major weather and climate highlights around the world, illustrating significant storms, precipitation amounts or trends, global land and sea surface temperatures, as well as snow and ice cover. By watching a *Climate Digest* video, whether it's on a 6-foot SOS exhibit or a hand-held mobile device, viewers can get an educational, global climate brief in less than four minutes.

Another exciting new initiative is the GOES-R Education Proving Ground. CIMSS has identified three teams of two teachers from Wisconsin, New Jersey and Florida who are working to develop middle and high school level lesson plans related to the GOES-R mission. CIMSS outreach staff will work closely with these educators to test classroom activities prior to the satellite launch. The Education Proving Ground will, in turn, rely on close coordination with CIMSS/ASPB (Advanced Satellite Products Branch) scientists who routinely check data quality from satellite launches. In this way, teachers and students will be "launch-ready" for new types of satellite imagery and products in the upcoming GOES-R era. §

Saturn's Great Storm Parts the Veil

by Mark Hobson

In 2010 a massive convective storm tore its way through the northern hemisphere of Saturn, providing a unique window into the inner workings of this mysterious gas giant. At 35 degrees north latitude, the storm grew to 15,000 kilometers wide with a tail that stretched 300,000 kilometers (190,000 miles), encircling the planet.

Operating much like convective storm systems on Earth, though far larger and more violent, the 2010 Saturn storm hurled materials toward Saturn's stratosphere from as deep as 370 kilometers at speeds models suggest would reach 150 meters per second (335 miles per hour).

SSEC researchers Larry Sromovsky, Kevin Baines, and Pat Fry used data collected by the Visual and Infrared Mapping Spectrometer (VIMS) aboard the Cassini Mission satellite to analyze the composition of the storm particles brought from far below to the upper layer of Saturn's atmosphere.

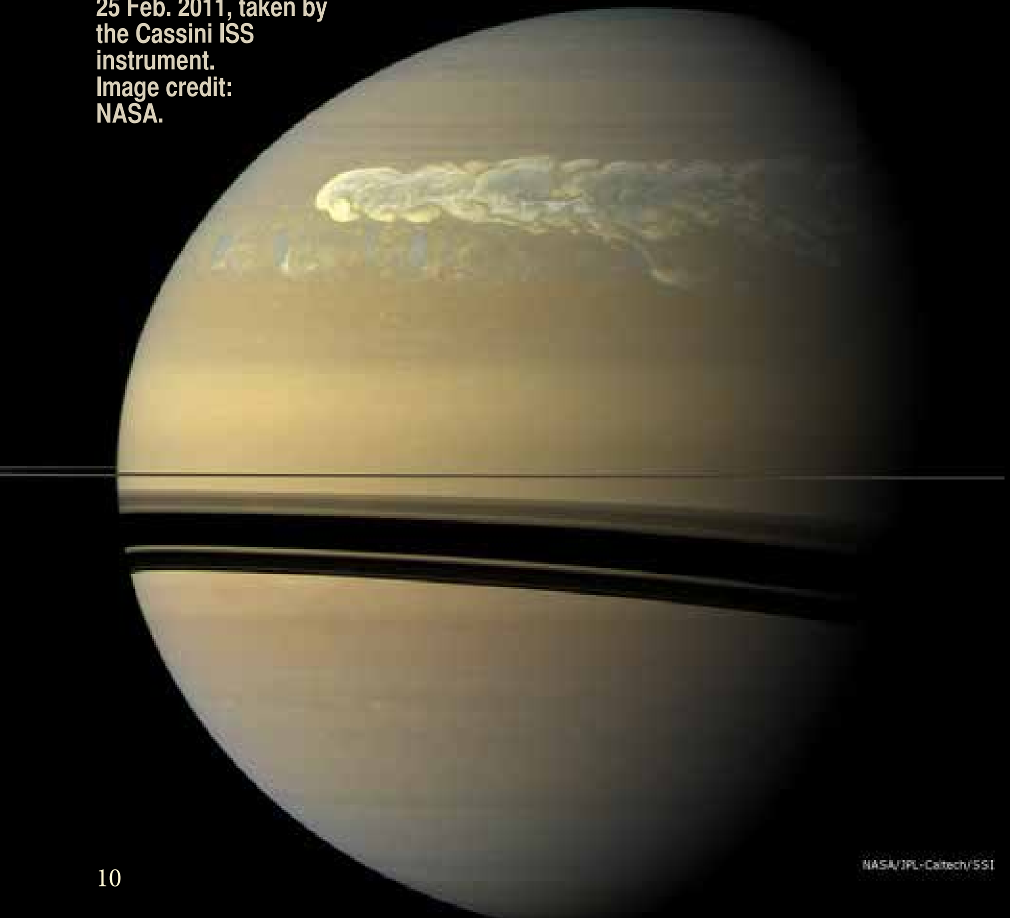
Saturn presents a nearly opaque face to any outside observation. The main visible cloud layer on Saturn is optically thick and has no obvious absorption features in the infrared, which make its components virtually impossible to identify. In addition, Earth-based observations of Saturn are limited by the absorption properties of our own atmosphere, which block the important 3-micron spectral range.

However, a significant storm can provide enough upward convective transport to bring material up from the depths and penetrate the haze layer.

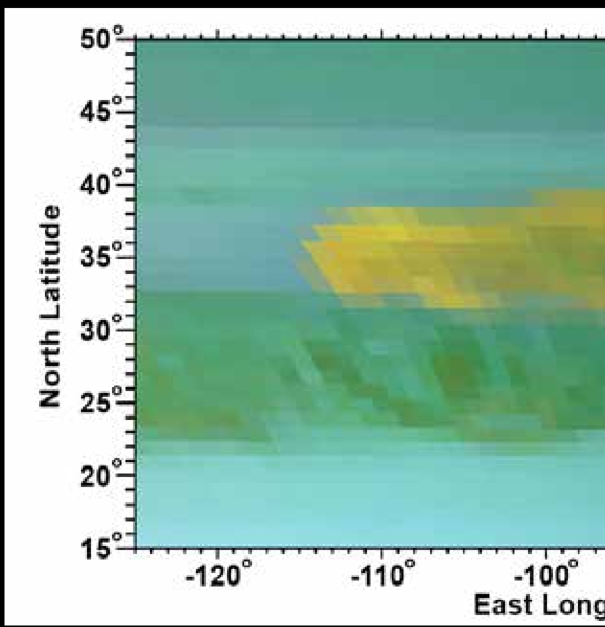
"The Cassini spectrometer covers the spectral range from 0.4 to 5.15 microns," says Sromovsky, "and is able to sample both reflected sunlight and emitted planetary radiation. This covers the important 3-micron region where methane, ammonium hydrosulfide, and water have strong absorption bands."

The cloud top particles have a very different infrared signature from

▶Great Storm in visible light on 25 Feb. 2011, taken by the Cassini ISS instrument. Image credit: NASA.



▼ Near infrared color image from Cassini VIMS obse
by ammonia and water ices. Image credit: NASA.



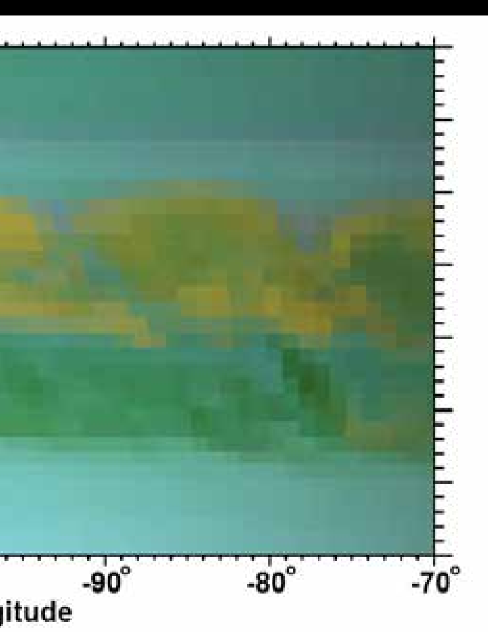
the material of the surrounding atmosphere, and offer a rare look at the composition of the hidden layers below.

“The most prevalent material was ammonia ice,” Sromovsky says. “The second was water ice, and the third was either ammonium hydrosulfide or a relatively non-absorbing substance, perhaps the same material from which the upper haze particles are made.”

These findings confirm the classic model of Saturn’s atmosphere consisting of stratified layers with water clouds at the bottom, ammonia hydrosulfide clouds in the middle, and ammonia clouds near the top. They also suggest that Saturn’s biggest storms are driven by water condensation deep in the atmosphere.

Understanding the similarities in process, if not in size, of Saturn’s mega-storms to Earth’s own storm systems will bring us closer to grasping the complexities the giant planet’s atmosphere, and perhaps our own. §

rvations. An orange color indicates absorption



FEATURED PHOTO

The October 2, 2013 aurora from the rooftop of the Atmospheric, Oceanic and Space Sciences Building with POES (Polar Operational Environmental Satellite) direct broadcast antenna in the foreground. Photo credit: John Lalande, SSEC.

Global Wildfire ABBA Fire Prod

Ground fire at Norris Geyser Basin, August 20, 1988. Photo credit: NPS Photo by Jeff Henry.

Every day significant amounts of trace gases and particulate matter are released into the atmosphere by biomass burning worldwide. Although recent research strongly suggests that fire by-products are an important factor in climate change calculations, both the actual extent of burning and the precise impact of aerosols emitted by fires are not well understood.

Cooperative Institute for Meteorological Satellite Studies (CIMSS) Researcher Chris Schmidt leads the CIMSS Biomass Burning team which operates and maintains the Wildfire Automated Biomass Burning Algorithm (WFABBA). Developed at CIMSS in collaboration with the National Oceanic and Atmospheric Administration (NOAA), WFABBA uses geostationary satellite data to detect and analyze instances of biomass burning worldwide.

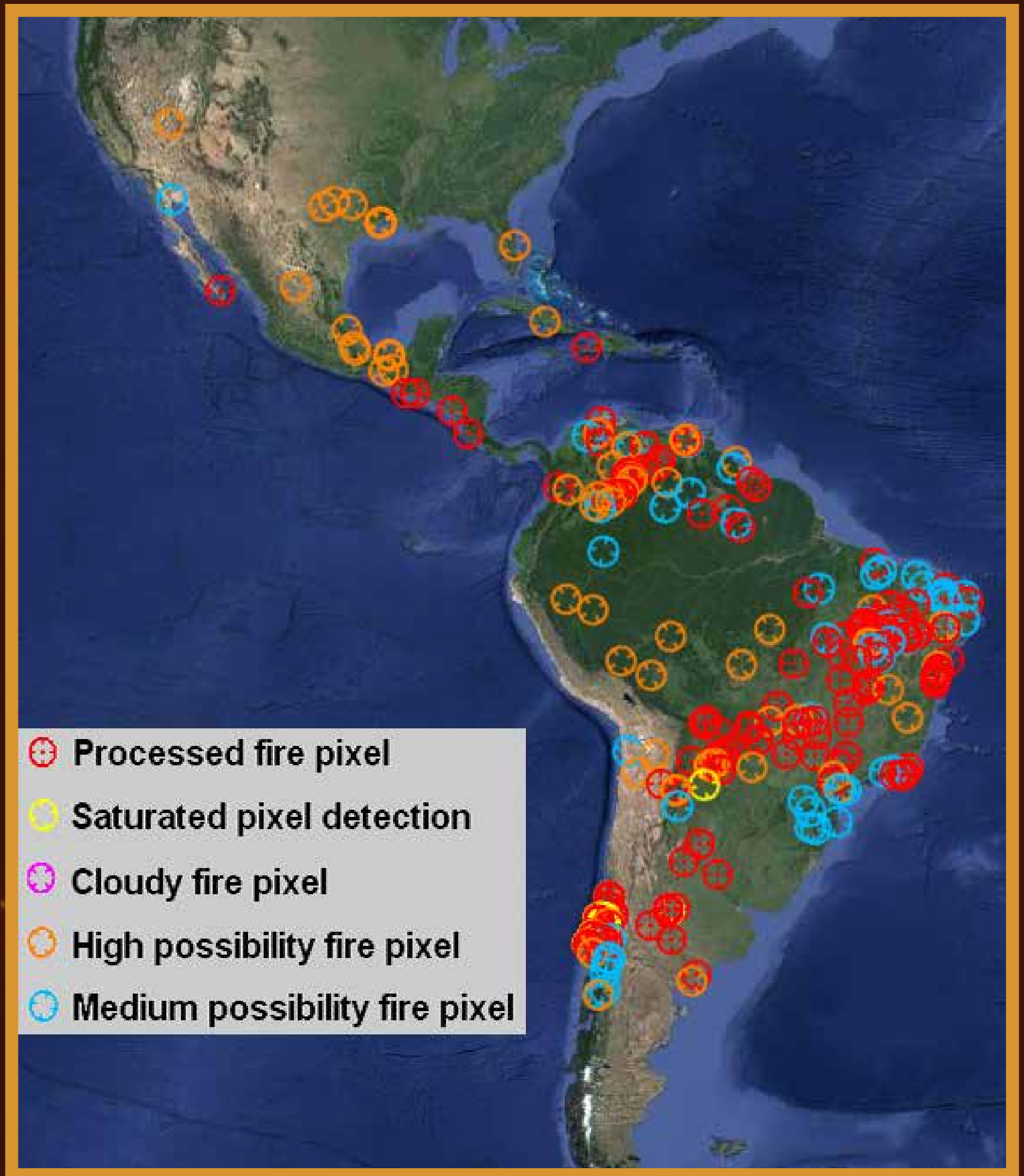
The WFABBA fire algorithm uses a middle infrared band of 3.9 μm, and a longwave infrared band of 11.2 μm to locate and analyze "hot-spot" pixels in satellite imagery. When run, the algorithm shows the fire's location, an estimate of fire extent, and supplies possible reasons, such as the presence of too many clouds and bad or missing data, that a fire may not be visible on the satellite imagery.

"We look for those pixels with spikes where the temperature is higher in the 3.9 μm rather than the 11.2 μm," Schmidt explains. "In the 3.9 μm band the change of radiance in respect to observed temperature is larger and increases faster than in the 11.2 μm band. We can use that difference in behavior to locate fires and calculate size, temperature, and radiative power of the fire. But because we look at single pixels, we really have to understand the instrument providing the pixels."

Properly analyzing pixel information is critical. Different meteorological satellites capture images with different native resolutions. A single pixel from a NASA Geostationary Operational Environmental Satellite (GOES) covers an area 4 km wide, but they are spaced only 2km apart East to West, whereas pixels generated from the Spinning Ehnanced Visible and Infrared Imager (SEVIRI) on the European Meteosat cover 5 km, but are spaced every 3 km in all directions.

Further complicating the analysis is the optical diffraction inherent in uct

by Chris Schmidt



▲Caption: View of the Global WFABBA composite overview from the GOES-13 satellite at 15:11 UTC 08 January 2014. Fire symbols do not represent the size of the fire or the exact location. Imagery via Google Map, courtesy of NASA, Terrametrics.

capturing temperature across a 4 km square area with one pixel. Fire is a strong, but often very localized, heat source. If it burns in the center of the pixel under analysis, it may register twice as much energy as it actually has. Conversely, if the fire is near the boundary of the pixel, it may register as little as ¼ or less of the actual energy.

“Fires are much more difficult to accurately capture and analyze than cloud patterns that span larger areas and many pixels,” Schmidt says, “In addition to the pixel information, we also need the background temperature so we can extract fire properties.”

Processing time for a single image took over three hours 20 years ago, but today even the largest satellite image can be processed in about 5 minutes. The biggest single user of the product is NOAA, but it is being used worldwide to monitor burning patterns. Air quality managers and modelers use the WFABBA as a baseline estimate of burning activity. Pilots can check to see if their flight plan might lead them into significant smoke. A power company in South Africa is using the data to track fires in remote areas to see if they threaten power lines, and sends out warning alerts based on the WFABBA data.

“Although the algorithm is not designed as an early warning system,” Schmidt says, “we have picked up some major fires several minutes before they were detected on the ground. The instruments on the next generation of GOES satellite will give us a better chance to detect fires early.”

Biomass burning and the aerosols they loft into the atmosphere play a significant role in climate change calculations. Remote sensing using the WFABBA algorithm offers a cost effective and globally applied means to monitor fire events and their effect on climate. §

SSEC Dat
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Over the course of 30 years, the SSEC Data Center has amassed the world's largest geostationary weather satellite data archive, all of it online. It exists to support SSEC and CIMSS scientists and their global collaborators with timely, high quality, geophysical data, as well as real-time data access, archive and retrieval services.

Established by SSEC in 1972 to support users of the new McIDAS (Man-computer Interactive Data Access System) software program, the Data Center, currently led by Jerrold Robaidek, has kept pace with the ever-increasing demands of scientific computing.

Its satellite data archive extends back to the Global Atmospheric Research Program's Atlantic Tropical Experiment (GATE) in 1974. Recognizing the value of maintaining an archive, the Data Center began routine, continuous storage of United States geostationary satellite data in 1978, and the process continues today.

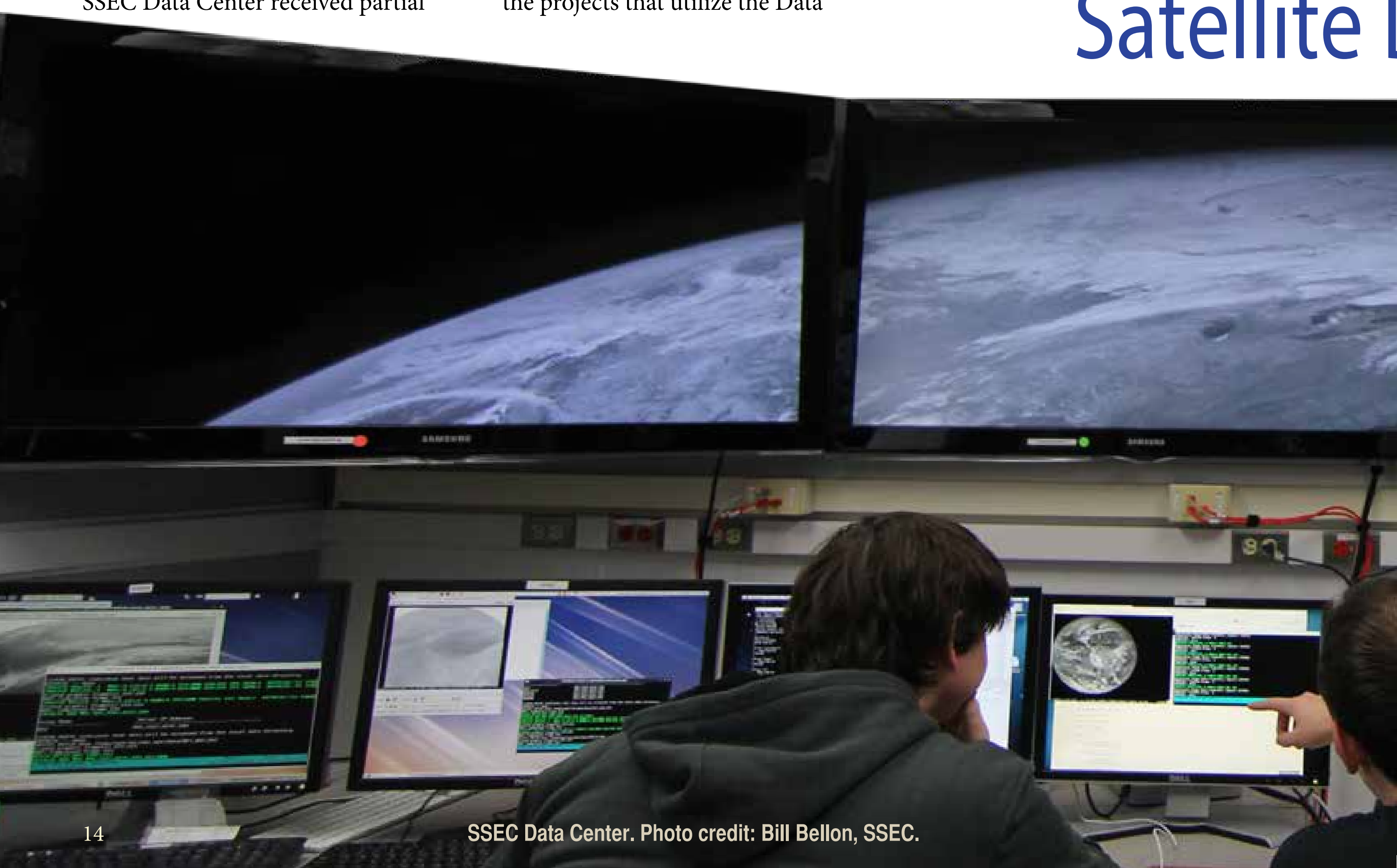
From 1979 through July 2004 the SSEC Data Center received partial funding from NOAA to continue the GOES archive and to provide the data to customers of NOAA's National Climatic Data Center.

Today, the archive includes weather satellite and radar data, in-situ observational reports, and gridded numerical forecasts. Serving as a direct broadcast reception facility for NASA's Earth Observing Satellites, Terra and Aqua, the Data Center receives data for much of North and Central America. Access to this wealth of data is critical to SSEC science as well as to our research partners, commercial companies, organizations, and individual researchers worldwide.

As of March 2013, the Data Center holds over 740 terabytes of online satellite data in its archive, including a complete record of all GOES data since 1978, and a number of international geostationary satellites (European and Asian). Each day, the Data Center ingests over 300 gigabytes of data, and archives over 230 gigabytes online with tape backup.

The real-time ingest is only one of the projects that utilize the Data Center resources. One of the largest projects in the Data Center is SSEC's Product Evaluation and Algorithm Test Elements (PEATE) project, which supports the Suomi National Polar-orbiting Partnership mission. This project alone ingests nearly 1.8 terabytes of data per day and archives another 1.3 terabytes. The combination of all projects consumes over five petabytes of disk storage.

The SSEC Data Center offers immediate, near real-time data access for scientists primarily via the Abstract Data Distribution Environment (ADDE) server. Approximately 2.5 terabytes of data are distributed from the Data Center via ADDE daily, and



SSEC Data Center. Photo credit: Bill Bellon, SSEC.

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over one terabyte of data is distributed through other methods like ftp, http and ldm.

In addition to its data archiving activities, the SSEC Data Center generates and maintains real-time data products for the SSEC website, provides NOAA with satellite data they do not receive (e.g. GOES-Test SRSO, South Korea's COMS satellite data, India's Kalpana satellite data) and acts as a data backup to their systems. The Center also provides data to cooperating programs in the Unidata Internet Data Distribution (IDD) project, utilizing the Unidata Local Data Manager (LDM). The satellite data feed is provided by SSEC, who also archives the data. The meteorological data products are provided to more than 150 universities and colleges for research and educational purposes.

Other data users include researchers around the world and organizations with unique needs. For example, aerospace equipment providers contract with the Data Center to provide weather information that is then transmitted to the cockpits of commercial planes. Using proprietary software, pilots can view products that contain information about clouds, winds, turbulence, and storm activity especially over oceans where ground radar is not available. Commercial fishing companies utilize the temperature data of ocean surface water to determine the best places to fish.

As a self-supporting facility, SSEC's Data Center also sells customized data products to commercial companies (e.g. Prada and Sony for developing art displays in retail stores and designing online video games) and museums. Another product, the global infrared satellite composite, was developed for and is used by Mitsubishi Electric. Mitsubishi displays the infrared imagery on the world's first large-scale spherical display which uses LED panels for lighting. Known as the "GEO-Cosmos," it is a hallmark of the National Museum of Emerging Science and Innovation in Tokyo and features near real-time data with a spatial resolution of four kilometers.

The most recent innovation at the Data Center involves transferring its entire data archive onto a type of parallel distributed file system, called Lustre – a system often used for large-scale cluster computing. The system features high-performance computing with the capabilities of processing hundreds of simultaneous accesses. Expected to be operational in spring of 2014, early tests show a tenfold improvement in data processing speeds, promising a more rapid and efficient data computing platform for future scientists.

The Data Center continues to look to the future, anticipating and meeting the needs of scientific computing. **§**

by Zhengzheng Zhang

Thoug
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by Paul Menzel a

Fifty years ago, the Kennedy Administration promoted national investment in basic scientific research as a way to spur meaningful technological growth. As John F. Kennedy said in his address to the National Academy of Sciences (NAS) on October 22, 1963, "We realize now that progress in technology depends on progress in theory; that the most abstract investigations can lead to the most concrete results; and that the vitality of a scientific community springs from its passion to answer science's most fundamental questions."

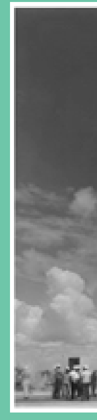
That realization encouraged renewed investment in science throughout the United States, and significantly in Madison. The building housing the Space Science and Engineering Center (SSEC) was one example. Built with financial support from NASA and the National Science Foundation (as well as from the State of Wisconsin), the building was dedicated in October 1969 "to the understanding of man's physical environment and its use for the benefit of mankind."

From the beginning, SSEC has conducted basic and applied science and technology research. To encourage cross-collaboration between theory and its practical applications, Verner Suomi, SSEC founder, placed several lab rooms and a machine shop amidst the conference rooms and offices housing scientists. The results were noteworthy. Suomi's theoretical ideas for a new flux radiometer led to real instruments designed with engineering colleague Robert Parent. After their construction at UW, instrument test flights from Cape Canaveral and Vandenberg Air Force Base were part of the trial and error process that produced the first satellite measurements of the sun-earth energy balance; the earliest measures of climate. The 1959 advent of earth remote sensing relied on the Suomi-Parent freedom to create, to fail, to try again, and to ultimately succeed. Those early endeavors ushered in a whole new era of investigations of earth and its atmosphere based on measurements from satellite-borne instruments.

Since the beginning of the 20th century, the University of Wisconsin has unveiled major advances in science to the state and the Nation. They include Harry Steenbock's process to enhance vitamin D content in food through UV irradiation in the 20s, Verner Suomi and Robert Parent's spin scan camera in the 60s, Larry Landweber's fledging internet in the Computer Science Network in the 80s, and Henry Guckel's first working metal micromotor in the 90s (Jenny Price, OnWisconsin Magazine: http://onwisconsin.uwalumni.com/features/seven-wonders/). The benefits of discoveries resulting from basic scientific studies were not always immediately apparent, but they became evident over time, creating a fertile field for technological development. University of Wisconsin-Madison Chancellor Rebecca Blank, an economist by training, recently noted, "America's future economic prosperity depends on increased investments in research and education that will accelerate innovation and inspire future generations of scientists."

1959 1st try

Verner Suomi (left) and Robert Parent's instrument for measuring the heat balance of the earth was included in the payload of Vanguard SLV-6, launched on 22 June. A faulty second stage pressure valve caused mission failure.



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Trial, Error, Success: Three Hea

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hts on cience nd echnology

and Jean Phillips

SSEC benefits from investment in science. With sustained state and federal investment, SSEC has continued to thrive. Its scientists and engineers devise innovative solutions to environmental remote sensing problems that have real world implications in terms of saving lives and mitigating property loss.

The private sector has also benefitted from federal support of university research. For example, the SSEC-developed Man-computer Interactive Data Access System (McIDAS) not only enabled scientists to derive winds from the geostationary images offered by the spin scan cameras but it also created opportunities for spin-off companies to market weather visualization techniques. SSEC experiments with Fourier Transform Systems (including the High resolution Interferometer Sounder (HIS) on the ER2 airplane and the Atmospheric Emitted Radiance Interferometer (AERI) on the ground) achieved better vertical profiles of atmospheric moisture and temperature. The improvements in atmospheric profiles led to the construction by the aerospace industry of high spectral resolution instruments placed on NASA (Advanced Infrared Sounder, AIRS) and NOAA (Cross track Interferometer Sounder, CrIS) space platforms. As a further consequence, improved information about the atmospheric state from these remote sensing systems offered (and continues to offer) new opportunities to agricultural and weather forecast industries.

There are many more examples of basic science conducted at universities and associated research parks leading to technological advances that in turn have created spin off companies and jobs. The fiscal payoff from the research dollars spent has been multiplied by factors of more than one hundred. The science of today feeds the technology of the future; when the science coffer is empty, there is nothing for technology to advance.

Kennedy finished his address to the NAS with hope and a sense of urgency. "Science has made all of our lives so much easier and happier in the last 30 years. I hope that the people of the United States will continue to sustain all of you in your work and make it possible for us to encourage other gifted young men and women to move into these high fields which require so much from them and which have so much to give to all of our people. So the need is very great. Even though some of your experiments may not bring fruition right away, I hope that they will be carried out immediately. It reminds us of what the great French Marshall Lyautey once said to his gardener: 'Plant a tree tomorrow.' And the gardener said, 'It won't bear fruit for a hundred years.' 'In that case,' Lyautey said to the gardener, 'plant it this afternoon.' That is how I feel about your work."

Those trees planted more than fifty years ago are bearing fruit. The need to continue to plant more trees still exists. §

Photo credit: NASA

59 2nd try

entation developed by nd Parent to measure 's heat balance uded in the payload rer 7X (also known rer S-1), launched ly. The rocket was nally destroyed five lf seconds after liftoff power supply failure.

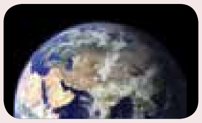
Photo credit: SSEC

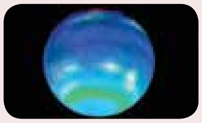
1959 3rd try

Verner Suomi with Explorer 7 which carried the successful Thermal Radiation Balance Experiment, the first earth-focused weather experiment.

t Balance Launches in One Year

through the atmosphere





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