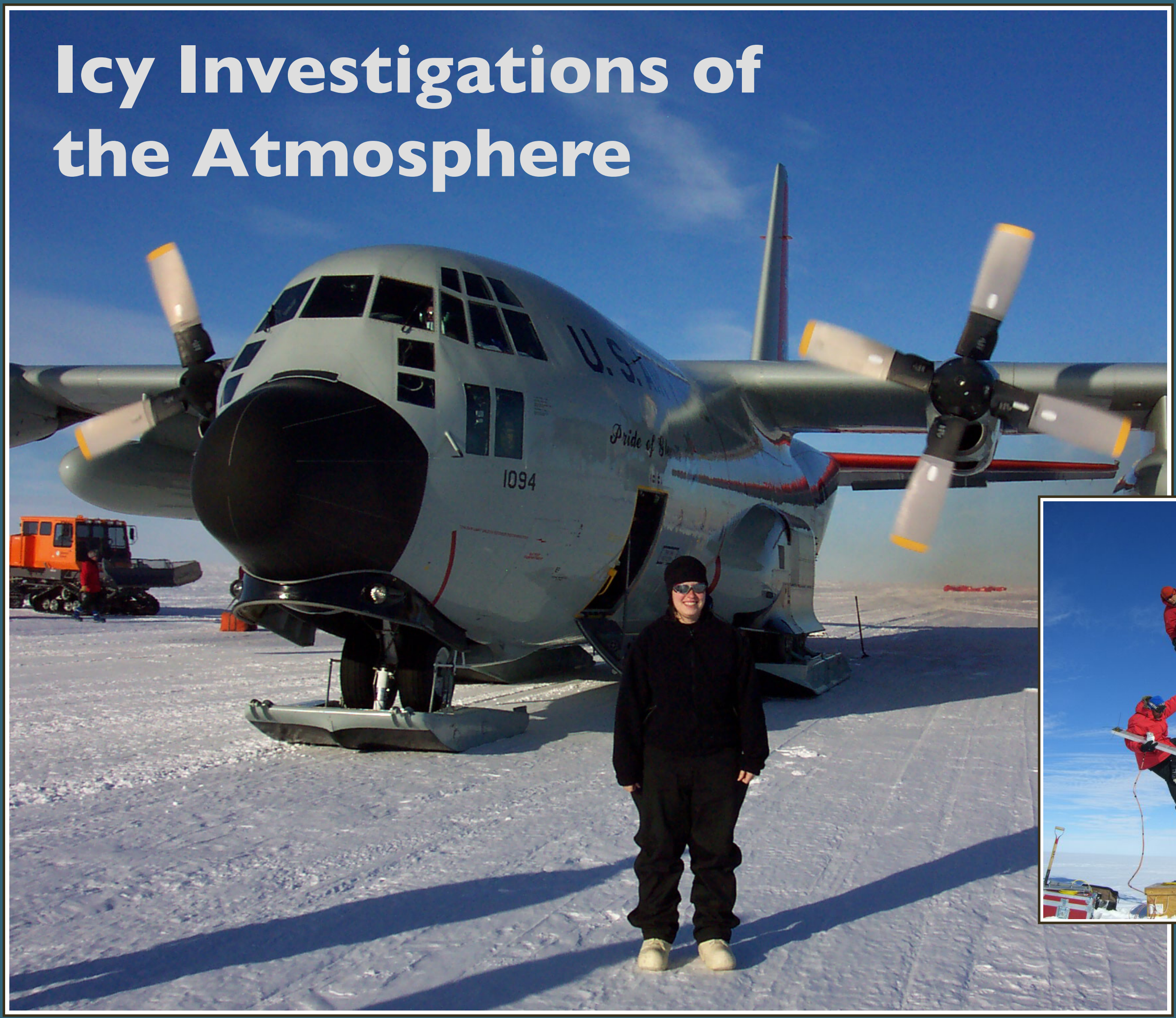
University of Wisconsin-Madison
Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies

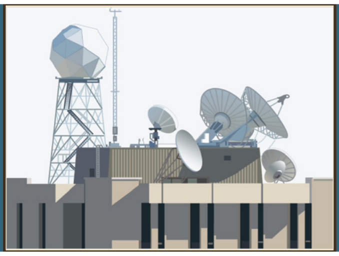
through the atmosphere

Fall 2008

Icy Investigations of the Atmosphere



SSEC heads South



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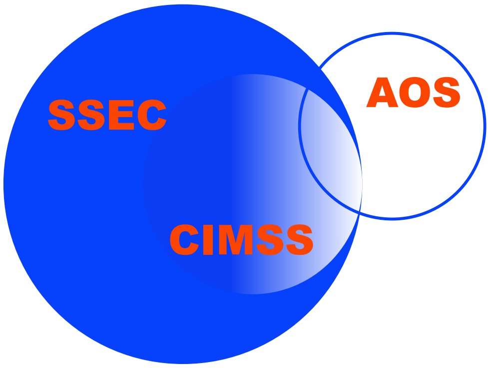
Director's Note

In explaining CIMSS' relationship to SSEC and AOS (the department of Atmospheric and Oceanic Sciences) at the UW-Madison, I often use this Venn diagram. CIMSS is a research institute within the SSEC, which is part of the UW–Madison Graduate School. While some activities within CIMSS and SSEC are distinct, there are many close research associations, as suggested by the blending between the CIMSS and SSEC circles. AOS is a department within the College of Letters and Sciences; thus CIMSS and AOS are administered by separate entities within the UW–Madison. Students provide the strong link between CIMSS and AOS, with AOS faculty serving as teachers, research advisors, and collaborators.



This issue of *Through the Atmosphere* demonstrates aspects of the synergistic nature of these three entities. For example, the SSEC Data Center is a critical resource to CIMSS and NOAA's Advanced Satellite Products Branch (ASPB) scientists stationed at CIMSS. The Data Center fills a critical need of many of our research and education projects by providing quality satellite data sets that are well calibrated, geo-referenced and easy to access. SSEC engineers maintain a unique resource in the Scanning-HIS, whose well calibrated observations are used by many CIMSS scientists to study the atmosphere and develop new remote sensing methods. As an example of AOS and CIMSS collaboration, Jon Martin (chair of AOS) and I celebrate a 10-year partnership as the Weather Guys on Larry Meiller's Wisconsin Public Radio show.

Throughout its 28-year history, CIMSS scientists have worked closely with ASPB, AOS and SSEC scientists and engineers. This unique symbiotic relationship has proven to be effective in establishing strong research and education programs.

Steven A. Ackerman
Director, CIMSS

Through the Atmosphere

Fall 2008

THE UNIVERSITY of WISCONSIN MADISON
SSEC
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University of Wisconsin-Madison
Space Science and Engineering Center
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Cover photo: Shelley Knuth in front of a C-130 at Patriot Hills in West Antarctica

Inset: Jonathan Thom (top) and Kirk Beckendorff (bottom), adding the instruments back onto the tower after raising it.

Studying Western Pacific Typhoons

Forecasting Tropical Cyclones in the Atlantic Ocean is difficult enough, but doing it in the Western Pacific is even harder. Without the benefit of the aircraft reconnaissance routinely flown in the Atlantic, satellite observations are even more indispensible over the expanses of the Pacific Ocean.

To understand this vast region better, PI Chris Velden and members of the CIMSS Tropical Cyclone group participated in the THORPEX Pacific-Asian Regional Campaign (T-PARC) during August and September of 2008. T-PARC is an international collaboration investigating tropical cyclones in the Western Pacific. The field program was primarily supported by the Office of Naval Research and the National Science Foundation.

CIMSS participation included providing real-time MTSAT satellite imagery (from Japan's geostationary satellite) and derived products, including hourly atmospheric motion vectors (AMV)s and diagnostic analyses. These winds and analyses are crucial for understanding a tropical system's genesis, structure and intensity variation.

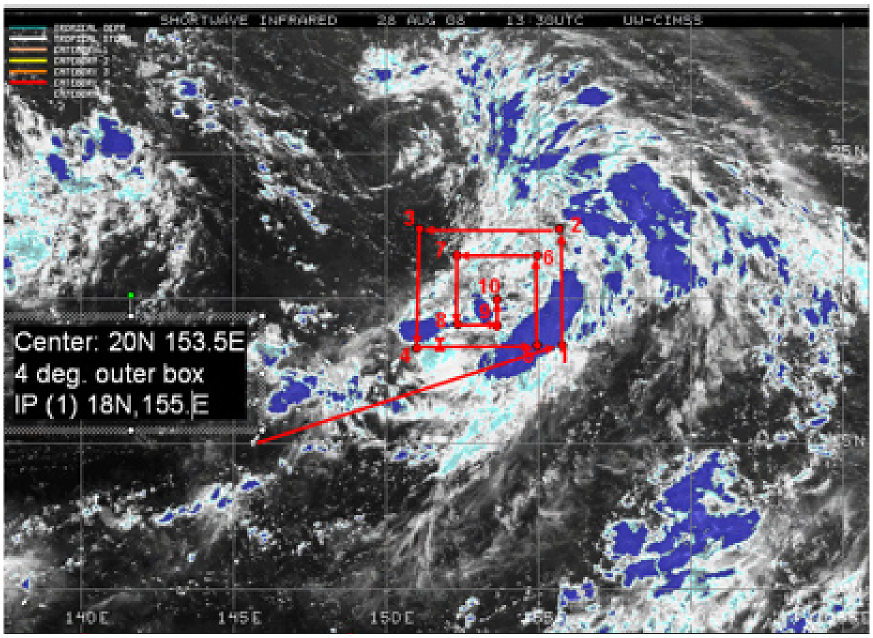
In addition to the MTSAT images and products, the team also produced intensity estimates from their SATCON algorithm, which optimizes estimates from the Advanced Microwave Sounding Unit (AMSU) and the Advanced Dvorak Technique (ADT). The AMSU detects tropospheric warming in the upper-levels of tropical storms that is directly related to intensity. The ADT is an objective version of the classic IR-based pattern-matching Dvorak technique that has been used by tropical cyclone analysts for decades.

The satellite data provide critical support for the planning of aircraft missions and initializing/verifying numerical weather prediction models during TPARC. In turn, the aircraft observations afforded a rare *in situ* validation for the satellite measurements, which is vital for calibrating the accuracy of the various objective remotely sensed methods in the Western Pacific.

During the first half of September, Velden and Co-I Derrick Herndon were on-site as mission analysts at the TPARC operations center, located at the Naval Postgraduate School in Monterey, California.

A daily planning meeting involving interactive Internet communications with several international and "in the field" elements of TPARC was conducted to coordinate the aircraft missions, discuss science objectives, and brief on the outlook for tropical activity in the region. A dedicated web site constructed by Co-I Howard Berger was instrumental in the analysis of weather events during TPARC. An example is shown below. This web site can be accessed at: http://cimss.ssec.wisc.edu/tropic2/tparc/tparc.

Chris Velden
Howard Berger



Flight route planning using CIMSS Tropical Cyclone Imagery. The red arrows represent a proposed flight pattern to investigate a potential Tropical Cyclone in the Pacific. The satellite imagery helps the mission planners identify the critical storm structure for further investigation.

Navigating Terabytes in the SSEC Data Center

What do a tropical cyclone forecaster on La Reunion Island in the Indian Ocean, a scientist preparing to depart McMurdo base in Antarctica to service field equipment, and a trans-oceanic aviation weather support team all have in common? They are using data supplied by the SSEC Data Center to support their work. The SSEC Data Center receives environmental satellite data in real-time or near real-time from 9 geostationary and 7 polar orbiting satellites (Figure 1). It also provides data in real-time or near real-time from NOAAport, including NEXRAD data, and operational model output from NCEP and ECMWF. These data are made available to scientists at SSEC, their collaborators, U.S. and International government agencies, as well as industries around the world. Products from these data, created by SSEC/CIMSS scientists, are also made available through the web and other resources for use by the global community. The SSEC Data Center is a very important resource, not only for our own scientific work, but for many people and groups the world over.

Our Mission

The SSEC Data Center mission is to create and maintain the facilities, human expertise and technology necessary to provide SSEC scientists and their collaborators with the highest quality geophysical data in a timely fashion, and to provide real-time data access, archive and retrieval services as necessary to support SSEC's scientific programs. Through its rooftop antennas (Figure 2) and later the Internet, the SSEC Data Center facility has been ingesting and archiving real-time satellite data since the 1970s. While this essential activity has been present throughout its existence, the Data Center has evolved over the past three decades to better support the science and computing activities of SSEC's scientific investigators and their collaborators.

The growth and evolution of the SSEC Data Center have been driven by science opportunities in the atmospheric and earth sciences, primarily in support of NASA and NOAA science objectives. Long gone are the days of IBM mainframes and rows of magnetic tape drives; in their place are Linux servers, rack mounted clusters and multi-terabyte disk arrays. Rooms full of decades old satellite data on ¾" U-matic video cassettes and computer compatible tapes are in the process of being migrated to disk arrays taking up no more space than the average refrigerator. Currently the online data archive is over 500 TB and grows by about 50 TB each year. An online inventory of the satellite data and data browse is available to help the user choose the data they need.

Although the Data Center is only staffed 16 hours per day, Monday-Friday, the operations are automated so data ingest and archiving continues 7 days a week, 24 hours per day. Staffing can be extended to 24/7 during field programs or other times needing such support.

Besides the data reception, archiving and serving data, additional Data Center activities include:

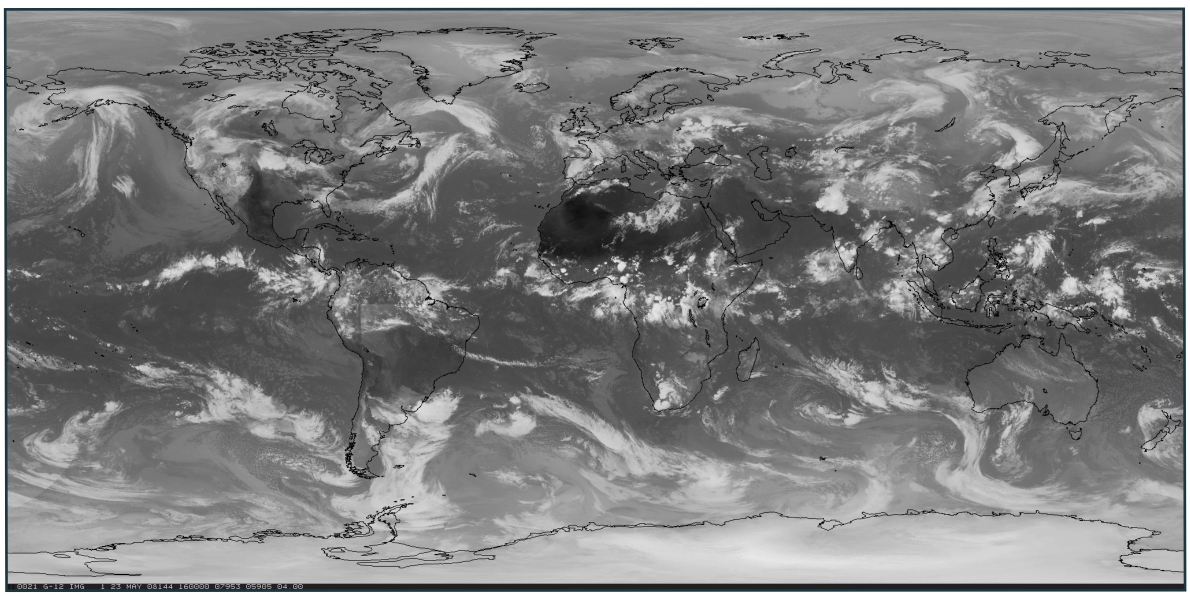


Figure 1: A composite global image using infrared window observations from geostationary and polar orbiting satellite data, which updates as new data is received.

- Providing data and maintaining the Unidata Local Data Manager (LDM) real-time broadcast to over 150 universities and colleges
- Generating and maintaining real-time data products for the SSEC Web site
- Assisting NOAA and SOCC with initial satellite post-launch instrument and bit stream checkout with periodic check-ups during the instrument lifetime
- Providing satellite data to NOAA for data they do not receive directly (e.g. GOES-10, China's FY-2, India's Kalpana) and acting as a data backup to their system
- Processing user data requests and product generation for real-time and archived data
- Providing help desk support to users of the SSEC Desktop Ingestor (SDI)
- Testing software changes for the SDI-104 and providing information for the user's manual
- Acting as a focal point for satellite information

Past and Present

The Data Center data acquisition and distribution system is continually expanding and improving. Only 12 years ago data ingest was handled by an IBM mainframe and GOES data were archived onto U-matic video cassette tapes. Due to the deterioration of the original U-matic video cassettes, on which GOES data were recorded from 1978 to 1997, the archive was transcribed ("rescued") onto faster, more efficient 3590 computer compatible tapes. In the fall of 2005, the Data Center began migrating the archive to multi-terabyte disk arrays, allowing researchers access to archived data 24/7 without operator intervention.

Unlike a near-line robotic tape archive, an online disk archive makes processing of large datasets orders of magnitude faster. This rapid and easy access to the entire GOES archive and data from the non-GOES geostationary satellites, such as Meteosat, GMS, MTSAT, and Kalpana, will support numerous weather and climate studies.

The current Data Center configuration utilizes both Unix and Windows servers for data ingest and serving. The system allows users the ability to stream data via ADDE to their local server and process it as it is being ingested. Locally developed SSEC SDI ingestors are used for most satellite data ingest, the exceptions being MODIS and MSG (Meteosat-9) which uses third party supplied data ingestors. The GOES acquisition and archive system was built with reliability and timely data access in mind. All systems in the GOES data ingest chain are hot spared – from the antenna on the roof to the ingestors and servers in the computer room. This redundancy insures that all data sent by GOES-EAST and GOES-WEST make it into our real-time system and online archive reliably. Over 500 TB of online storage provides easy access to years of satellite data to our users via ADDE. The SSEC Data Center has successfully recorded over 99% of all the data sent from the GVAR/GOES satellites since it began keeping records in 1985.

The table below provides an overview of the SSEC Data Center holdings, current and archival.

Data	Archived Dates	Archive Media
GEO Satellites (Operator)		
GOES (USA)	1978 - Present	Online
METEOSAT 0° (Europe)	1999 - Present	Online
METEOSAT 57 °E (Europe)	1999 - Present	Online
GMS (Japan)	1998 - Present	Online
MTSAT (Japan)	2005 - Present	Online
FY-2x (China)	2005 - Present	Tape
Kalpana (India)	2004 - Present	Online
LEO Satellites		
NOAA 15, 16, 17, and 18	Real-time Only	N/A
EOS MODIS, AIRS	Real-time + Archive	TBD
METOP	Real-time Only	N/A
Other Data		
Radar		
NEXRAD	Real-time Only	N/A
Conventional and Model Output		
Conventional SFC & RAOB	1976 - Present	Tape
NOAAPORT GRID/GRIB	1996 - Present	Tape
CONDUIT GRIB1 (Selected GRIB)	2003 - Present	Tape
CONDUIT GRIB2	Real-time Only	N/A
Other Model Output	Real-time Only	N/A

Navigating Terabytes in the SSEC Data Center (cont.)

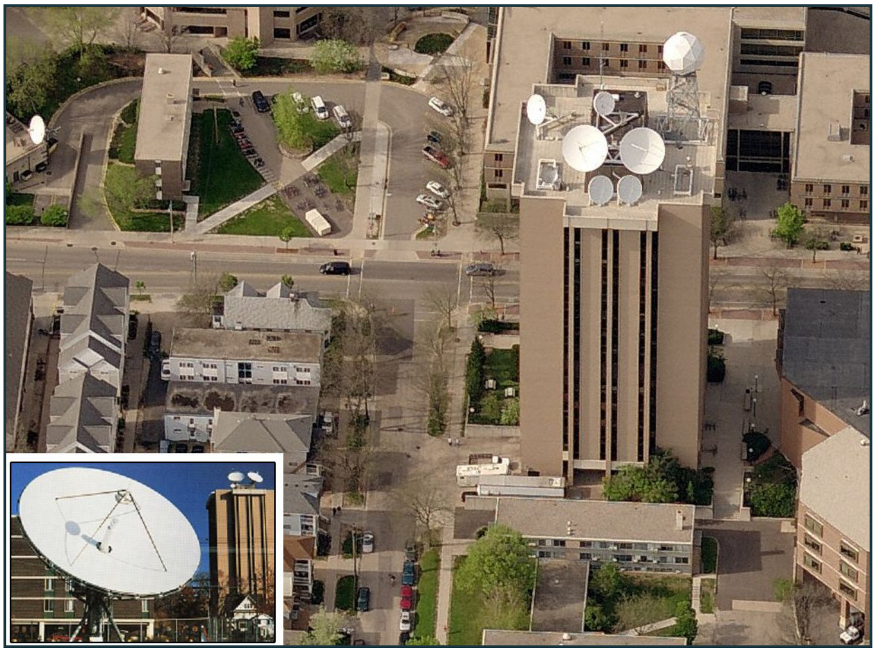


Figure 2. SSEC rooftop image showing the antenna systems that receive satellite and other data. An additional 11m dish is located on the ground 1 block to the south.

Not Just Hot Air

As the Data Center increases the number of computing clusters, high density racked servers and multi-disk raid arrays, its power requirements, the amount of heat generated and the noise increases significantly. A room designed in the 1960s for use in the 70s and 80s does not meet 21st century needs. To accommodate recent growth, the Data Center has embarked on a multi-phase extreme makeover.

The first phase of the project had two major components. The first being the creation of a separate computer room control center and the second component to update the computer room power. A new operations center was built on the south end of the computer room to isolate personnel from the loud noise in the computer room and to maintain a "human comfortable" temperature (Figure 3). The operations staff no longer need sound canceling earphones and gloves while typing at a keyboard! A wall of large windows provides easy viewing and monitoring of the hardware in the computing facility. Also during this first phase the power supplied to the computer room was switched to two 72 Kilowatt UPSs (un-interruptible power supply), with a third scheduled to be added in the next few years. This should supply the computer room with projected power needs for the next decade of growth.

The second phase of the project was just recently completed. This phase involved increasing airflow and optimizing the cooling for the computing facility. New ducts were installed to accommodate a cold and hot aisle configuration to better use current cooling capabilities. Airflow was increased by reconfiguring the system exhaust and supply fans. While these modifications only increased the cooling capacity of the room 10% - 15% from the existing system, the hot and cold aisle configuration has greatly improved airflow where it is needed.

The goal for the next major phase is to implement modular cooling units placed throughout the room to provide cooling where it is needed most. These updates should more than triple our current cooling capabilities. The first modular units should be in place in the next year or two. Additional units can easily be added as the need arises.

Into the Future

The U.S. is developing major environmental satellite programs, both polar and geostationary orbiting, to fly advanced technology instruments as our operational satellite systems. As the data volumes grow, the SSEC Data Center will continue to acquire in real-time both the U.S. operational satellite data and those data from other countries that provide weather satellite data. Important research satellite, aircraft and other data will also continue to be acquired and archived to support calibration and validation programs at SSEC/CIMSS.

The NASA-funded Atmosphere Product Evaluation and Analysis Tool Element (PEATE) project at SSEC has been created to support atmosphere product evaluation from the NPP satellite mission, the first stage of the NPOESS program scheduled for launch in 2010. The Atmosphere PEATE project relies heavily on the expertise of the Data Center in order to ensure that the data from the VIIRS and CrIMSS instruments on NPP required to complete the PEATE mission are acquired and analyzed. The atmosphere products from NPP will be rapidly analyzed and evaluated to assess whether they can be used to create accurate Climate Data Records (CDRs). Large cluster computing systems located in the Data Center will also retrospectively process global data sets as algorithm updates are introduced. The Data Center staff will be responsible for insuring the health and performance of the cluster hardware, and the timely and reliable reception and analysis of the data. With these issues resolved, the scientist can devote their attention to evaluating the atmosphere products from NPP. Testing of the system is in process using MODIS and AIRS data as a proxy for VIIRS and CrIS.

Figure 3: The GOES active archive with operator room in background.

Many of the SSEC/CIMSS atmospheric scientists are involved in algorithm development for the GOES-R/S program, with an initial launch planned around 2015. Large computer systems in SSEC and at the National Center for Supercomputing are creating simulated data sets for the GOES-R Advanced Baseline Imager (ABI). Cluster computers are using the science algorithms to generate products to insure their effective use on Day 1 after commission. The demonstration of data processing for the PEATE program may well aid in the design and development of similar types of large scale data processing systems for the GOES-R program. Thus the Data Center of the future will be designed to more closely involve the scientists who are creating the products and evaluating their accuracy, while continuing to ensure that the highest quality data is delivered on time.

Tom Achtor, Jerry Robaidek, Dee Wade, and Mark Werner
http://dcdbs.ssec.wisc.edu/inventory/

Honors and Awards

Dave Tobin
Received the International Radiation Commission (IRC) Young Scientist Award, presented at the International Radiation Symposium in Brazil.

Steven Ackerman
Received the American Meteorological Society Teaching Excellence Award.

Anneliese Lenz
Received the AMS Macelwane award, recognizing an original student research paper. She worked with Kris Bedka and Wayne Feltz on transverse bands and turbulence using satellite observations and aircraft reports of turbulence.

Chris Velden
Elected as a new AMS Fellow.

Allen Huang
Named as SPIE Fellow for his career contributions.

Wayne F. Feltz
Patrick W. Heck
Anthony J. Wimmers
Michael J. Pavolonis
Received the 2007 Paul F. Holloway Non-Aerospace Technology Transfer Award as part of the NASA Advanced Satellite Aviation-weather Products (ASAP) Project Team.

Matthew Lazzara
Earned his Ph.D. from the Department of Atmospheric and Oceanic Sciences. Thesis: "A diagnostic study of Antarctic fog."

Jordan Gerth
The 2008 Wisconsin Space Conference undergraduate nominee to represent Wisconsin at the joint NASA Future Forum and Great Midwestern Space Conference in Chicago on October 10th with his poster, "Enhancing Numerical Weather Prediction Initial Conditions with MODIS."

NIST Measurements at SSEC Validate Scanning HIS Radiance Accuracy

Accuracy is vital in environmental remote sensing where tenths of a degree may have a significant impact. In addition, future climate missions will require this level of accuracy for timely detection of the climate change signature. For many years SSEC has played a large role in calibration and validation of satellite instruments and measurements. The ability to accurately validate satellite infrared spectral radiances by direct comparison with airborne spectrometer radiances was first demonstrated using the SSEC developed Scanning High-resolution Interferometer Sounder (Scanning HIS) aircraft instrument flown under the Atmospheric Infrared Sounder (AIRS) on the NASA Aqua spacecraft in 2002. Subsequent comparisons in 2004 and 2006 have had similar success that now span a range of conditions, including arctic and tropical atmospheres, daytime and nighttime, ocean and land surfaces. These results show brightness temperature differences of about 0.1 K over much of the spectrum. Similar excellent agreement has been demonstrated with the Infrared Atmospheric Sounding Interferometer (IASI) on the European satellite METOP-A. This close agreement shows great progress, is encouraging for achieving consistent remote sensing applications, and will lead to new climate applications. The absolute calibration of the Scanning HIS will provide the direct link between measurements from the National Institute for Standards and Testing (NIST) and on-orbit environmental satellite observations.

With this goal, independent tests of Scanning HIS absolute calibration have been conducted at SSEC using the NIST Thermal-Infrared Transfer Radiometer (TXR). The TXR was used to accomplish a more direct connection to the blackbody reference sources maintained by NIST than the traceability to temperature standards and paint reflectivity. Two basic tests were conducted: (1) comparison of radiances measured by the Scanning HIS to those from the TXR, and (2) emissivity measurements of an SSEC blackbody by using the TXR as a stable detector. The radiance comparison involved the Scanning HIS and the TXR each observing a highly stable (and accurate) Atmospheric Emitted Radiance Interferometer (AERI) blackbody over a wide range of temperatures (227 to 290 K). The AERI

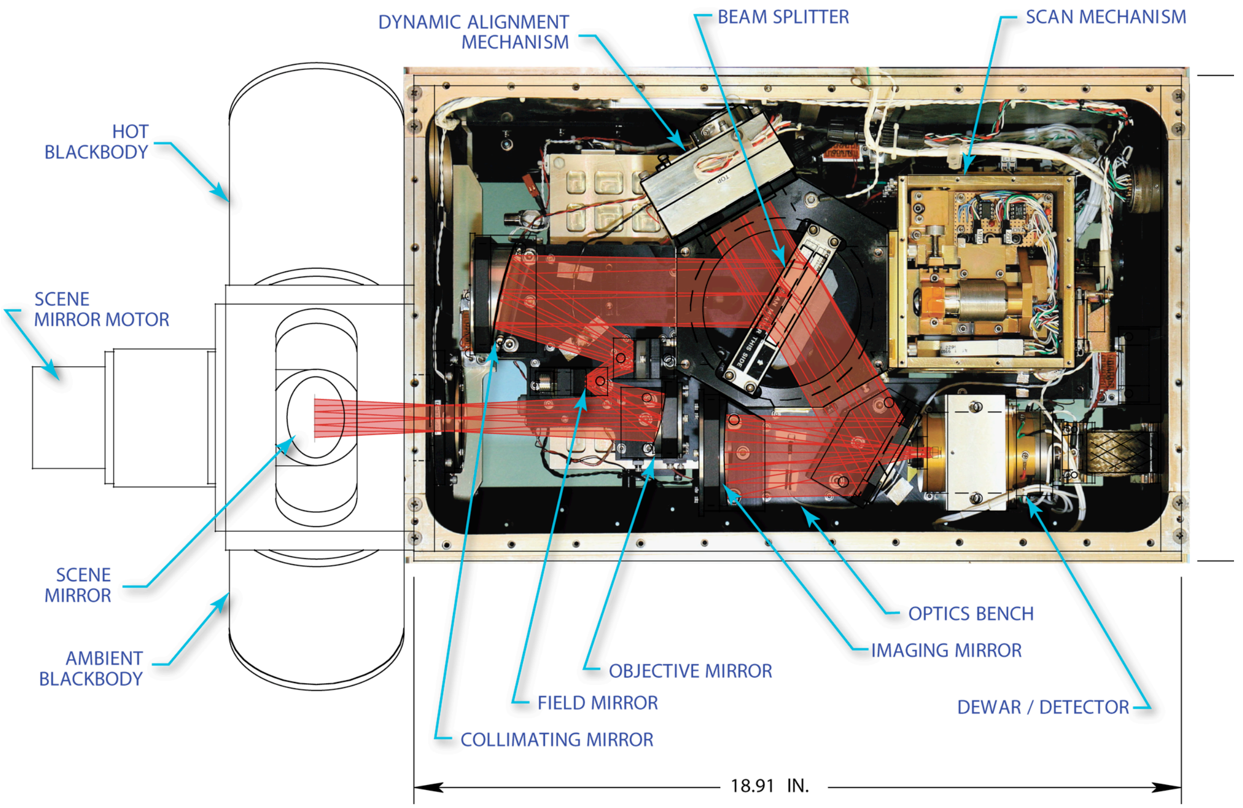


Figure 1: The Scanning HIS Interferometer Assembly. The front-end assembly outlined at the left contains the scene mirror and calibration blackbodies. The red rays trace the optical path through the fore-telescope, Michelson interferometer, and detector imaging optics. The rays from the beamsplitter to the Michelson scan mirror are not shown.

blackbody emissivity measurement used a heated tube placed between the TXR and the blackbody (axis co-aligned with the TXR viewing axis and normal to the center of the AERI blackbody aperture). The tube was heated to about 100 K over the ambient environment of about 225 K. Preliminary results from both tests are very promising for confirming and refining the expected absolute accuracy of Scanning HIS.

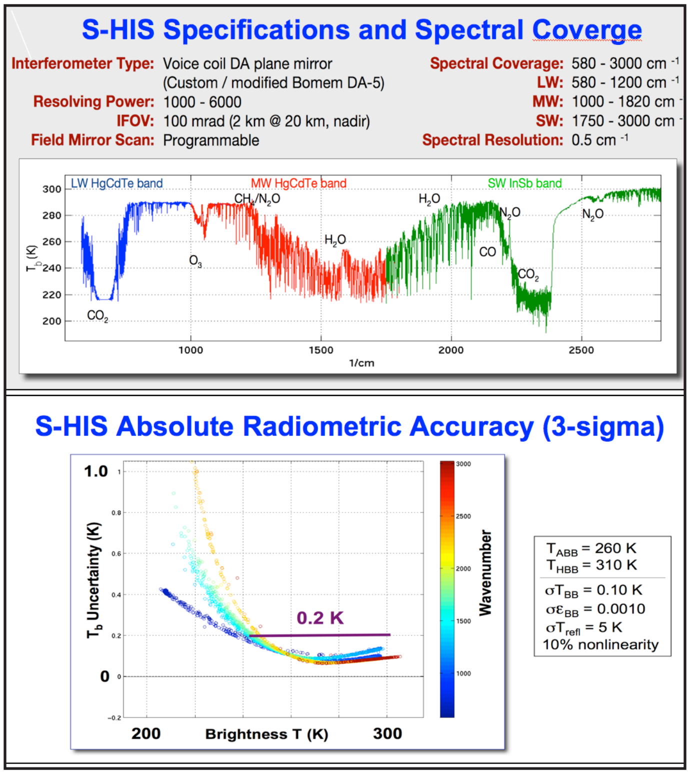


Figure 2: The top panel shows the Scanning HIS three detector bands providing continuous spectral coverage from 3.3 to 17.2 µm. The bottom panel illustrates the absolute radiometric accuracy of the instrument for various scene temperatures.

S-HIS Aircraft Instrument

The S-HIS employs a customized commercial interferometer (DA5 from Bomem, Inc, Quebec), with dynamically aligned plane mirrors and an SSEC developed Michelson mirror drive (see Figure 1). The spectral characteristics of the measurements are very well known and stable because of the use of a Helium-Neon (HeNe) laser to control optical delay sampling. The radiometric calibration of the S-HIS is accomplished by periodically viewing two high emissivity, uniform temperature blackbody references that provide the responsivity and offset parameters needed to convert measured spectra to radiances. These blackbodies were developed at SSEC using the heritage from the highly successful AERI instrument that was developed for the DOE Atmospheric Radiation Measurement program. A key property of blackbodies is their emissivity (or blackness). An emissivity of 1.0 would be perfectly black.

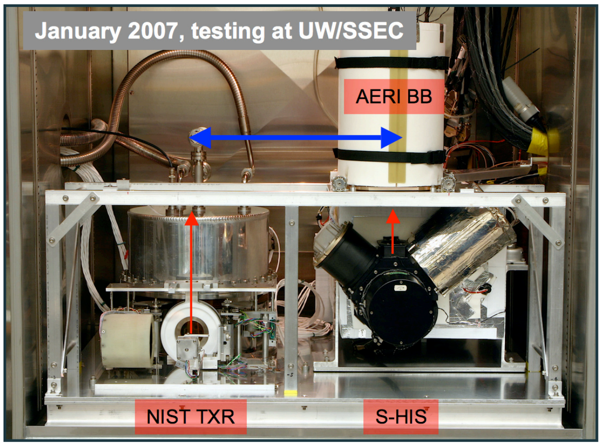
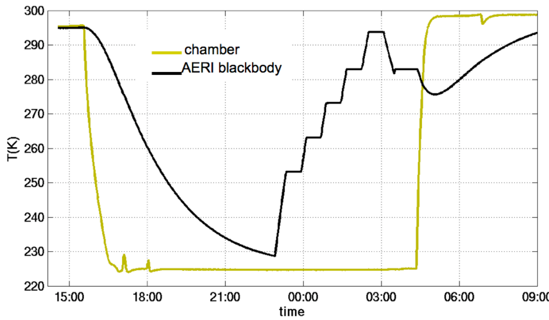
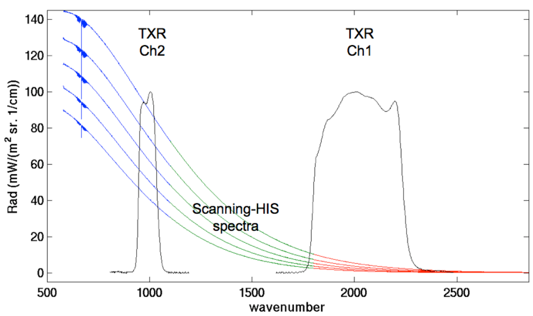


Figure 3: The photo at top shows the side-by-side configuration to the S-HIS and NIST TXR in the temperature chamber. The plot at below left shows the chamber temperature being held at close to flight ambient levels near 225 K, while the AERI Blackbody is sequentially raised in temperature up to 295 K. The plot at right shows five Scanning HIS spectra corresponding to five different blackbody temperatures. The spectral response function of the TXR at 5 and 10 µm is also shown.





The S-HIS has continuous spectral coverage from 3.3 to 16.7 µm at 0.5 cm-1 resolution. This coverage is divided into three bands with separate detectors (two PC HgCdTe (Photo Conductive Mercury Cadmium Telluride detectors) and one InSb (Indium Antimonide)) to achieve the required noise performance. The longwave band provides the primary information for temperature sounding for cloud phase and particle size. The midwave band provides the primary water vapor sounding information and further cloud property information. Finally, the shortwave band provides information on cloud reflectance and augments sounding information. S-HIS specifications, spectral coverage and absolute radiometric accuracy are depicted in Figure 2.

S-HIS /TXR Radiance Intercomparison

End-to-end radiance evaluations of the Scanning HIS were conducted at SSEC, under flight-like conditions using a temperature chamber with the Scanning HIS along side the NIST TXR - each viewing a common blackbody target (see Figure 3). An SSEC developed AERI blackbody was run at various temperatures and positioned between the NIST TXR and the S-HIS. Calculated radiances from the AERI blackbody were compared with measured radiances from the NIST TXR. These intercomparison measurements provide the basis for satellite validation analyses that are traceable to the NIST radiance scale (see_http://physics.nist.gov/Divisions/Div844/facilities/emet/eos.html). The test showed excellent agreement (on the order of 40 mK (0.040K) between the Scanning HIS and NIST TXR (see Figure 4).

AERI BB Emissivity Measurements Using the NIST TXR

To measure the emissivity of the AERI blackbody, the NIST TXR, a heated scene tube, the blackbody, and a radiation shield were placed in a temperature chamber that was maintained at -50 °C. As shown in Figure 5, the TXR was configured to view only the blackbody (no view to the scene tube). The scene tube temperature was sequentially raised in a stair-step fashion to 60 °C, and the

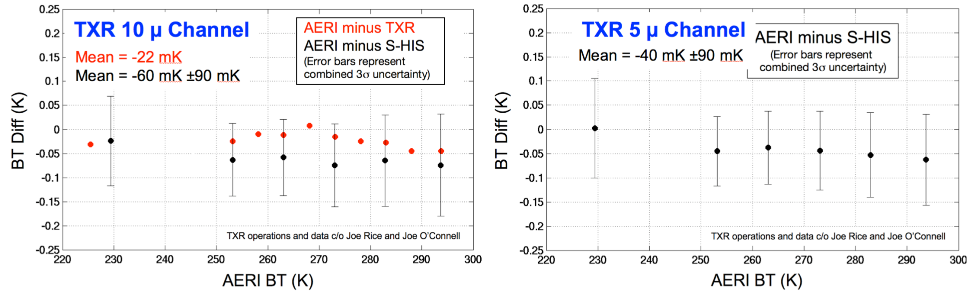


Figure 4: The difference between the predicted AERI blackbody radiance and the measured S-HIS radiance (at both 5 and 10 μm), and the AERI blackbody minus the measured TXR radiance at 10 μm (the TXR 5 μm analysis is not yet completed). At 10 μm the differences between the NIST TXR and Scanning-HIS are in excellent agreement - on the order of 40 mK.

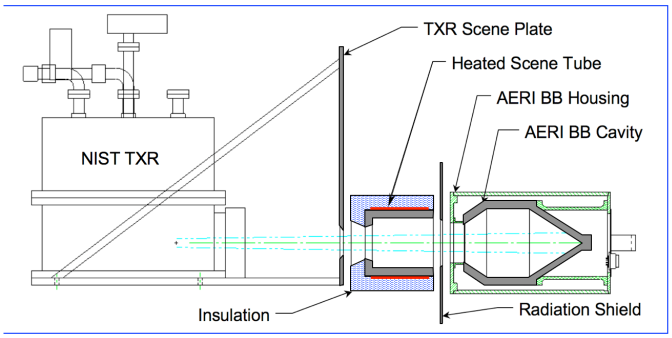


Figure 5: The test configuration used for measuring the emissivity of the AERI blackbody cavity allows the TXR to view the heated scene tube only by reflection from the blackbody. Because the geometry and all key temperatures are well known, the blackbody emissivity can be determined.

TXR measured radiance was recorded. These measurements, combined with the knowledge of the test configuration geometry and key temperatures allow the blackbody emissivity to be calculated.

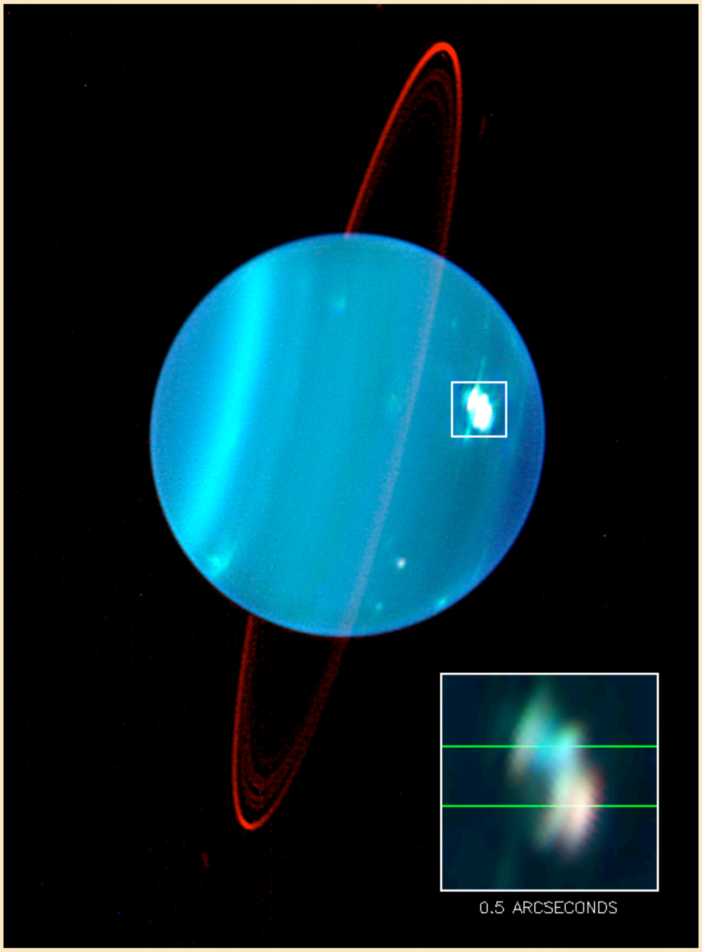
The results from the SSEC analysis of these measurements for the 10μm TXR channel indicate that the AERI blackbody emissivity at 10 μm is 0.9995 with a 3-sigma uncertainty of 0.0003; and at 5 μm is 0.9997 with a 3-sigma uncertainty of 0.0001. These results have been corroborated by an independent analysis at NIST for the 10 μm case; they are still working on the 5 μm analysis.

Future Work

SSEC continues to play a major role in the validation of space-based infrared observing systems, using its aircraft-based Scanning-HIS as a basis for performance assessment (see, for example, the JAIVEX experiment article in the Winter 2008 issue of *Though the Atmosphere*). The accuracy of radiances and derived products on current and future systems such as the European METOP and the U.S. NPOESS will rely on accurate, ongoing radiance calibration. Future space-based systems will provide the highly accurate on-board calibration needed to provide long-term measurement data sets for climate analysis. NASA is currently funding SSEC to participate in the initial stage of the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission that will deploy accurate, space-based instruments employing on-orbit calibration references that are traceable to international standards.

Fred Best

Uncovering the Dynamic Atmosphere of Uranus



While gathering information about Uranus using one of the world's largest telescopes, SSEC's Larry Sromovsky and Pat Fry captured images of the brightest cloud feature ever observed on this outer planet.

In August 2005, Sromovsky and Fry traveled to Mauna Kea, the highest mountain on Hawaii's Big Island, to peer deep into space using the 10-meter Keck II telescope. Equipped with adaptive optics, the Keck II corrects for image distortions caused by the Earth's atmosphere. This technology is responsible for the crisp, high quality images retrieved using the telescope.

The two Madison researchers planned to record images of the small, bright features commonly found in the northern hemisphere of Uranus, but which are not as bright or frequent in the southern hemisphere. By tracking these features and measuring their brightness at different wavelengths, scientists can learn about atmospheric circulation and composition as well as cloud pressure and composition. During the first night of observation, the team noticed a particularly bright cloud feature at 30° north latitude.

The next night, Sromovsky and Fry captured a striking image of what turned out to be the brightest cloud feature ever observed on Uranus. A multi-wavelength composite image of the feature appeared on the cover of the December 2007 issue of *Icarus*, the premier journal of planetary science. Their paper about the feature was also published in that issue. After the discovery, Sromovsky and Fry tried to track the feature's long-term behavior with the help of other Uranus observers, using both Keck II and Hubble Space Telescope images. The team located the feature in earlier observations when it was much dimmer, and followed the feature as it brightened and then rapidly disappeared. The feature was named the Bright Complex, because it was actually composed of multiple components, as shown in the above image (from the cover of *Icarus*).

This image is a color composite made from images taken on 15 August 2005 using the Keck II telescope and NIRC2 camera. Filters K′ (1.95-2.3 microns), H (1.49-1.78 microns), and J (1.17-1.33 microns) were assigned to red, green, and blue color components respectively. The complete image is enhanced to show normal features on the full disk while the inset is enhanced to show the structure of the 30° north Bright Complex, which is saturated in the full-disk image. At its observed peak in the K′ band, the feature was 100 times brighter than the background atmosphere and responsible for 13 percent of all the light reflected by the planet. During an eleven-month span of observations, the feature also exhibited non-uniform motions and variations in altitude and effective area.

Uranus has a surprisingly dynamic atmosphere considering how little energy it receives from the sun. At Uranus the sun is 400 times less bright than it appears on Earth. Uranus' atmosphere is so cold that cloud particles consist of materials that are unusual in Earth's clouds. The brightest of Uranus' clouds are likely made of frozen methane. Clouds deeper in the planet's atmosphere are possibly condensed hydrogen sulfide. Water clouds, if present at all, are so deep in the atmosphere that they cannot be seen from above.

Larry Sromovsky

Back from the Ice


The ICDS DISC Drill Team. Photo by Dave Ferris

Constituting approximately 135,000 lbs of cargo, SSEC's Deep Ice Sheet Coring (DISC) drill traveled around the globe from Madison, WI to the West Antarctic Ice Sheet (WAIS) Divide. The WAIS Divide is the site of a major ice coring effort that will illuminate many details of Earth's climate history.

The goal of this effort is to collect 3,500 meters of ice core from the flow divide in central West Antarctica. The scientists will use the ice core to retrieve the most detailed record of the last 100,000 years of Earth's climate history, including a precise year-by-year record of the last 40,000 years. The results of this study will influence future climate change predictions and provide a more accurate description of the climate change process.

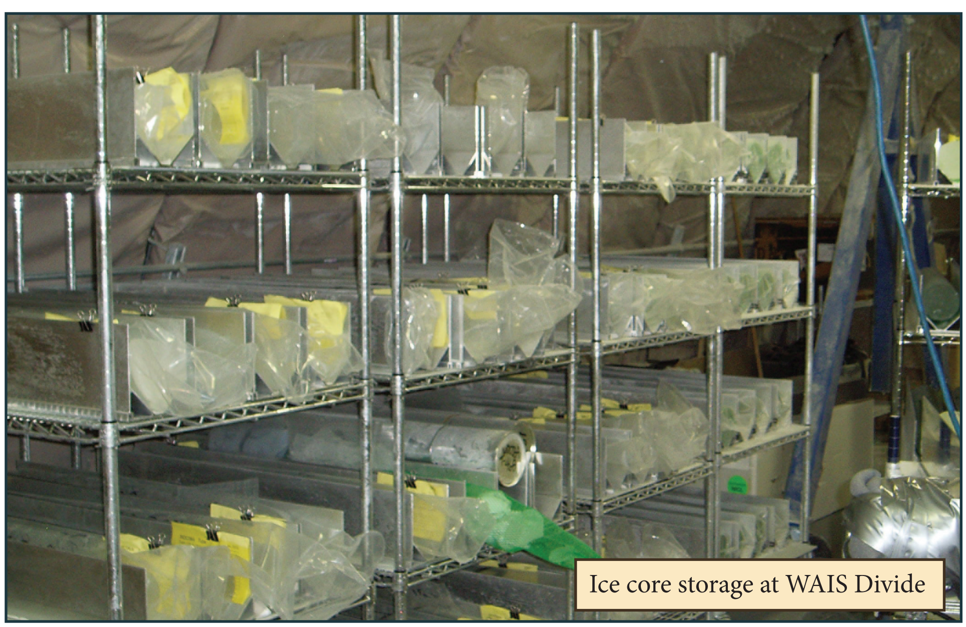
There are several organizations participating in the project. SSEC's Ice Coring and Drilling Services (ICDS) designed, built and now operates the state-of-the-art DISC drill, which is capable of penetrating up to 4000 m into the ice. The U.S. Geological Survey National Ice Core Laboratory (NICL) in Denver, CO designed the core handling system, and Raytheon Polar Services Corporation (RPSC) has provided the logistical support. The NSF Office of Polar Programs-U.S. Antarctic Program has funded the project. NICL will archive the ice core, which will be used by numerous scientists for different research projects.

Last year was very busy for the DISC Drill Team. After a successful season of testing the drill in Greenland during the summer of 2006, the team implemented numerous modifications and improvements to the drill system. These improvements included major design changes to the winch, electronics, control system, drilling fluid handling system and screen cleaning system.

ICDS devoted considerable time and effort to complete all planned changes before August 2007 when the drill system began its journey to Antarctica. Getting the ICDS equipment to WAIS Divide was no small task. 135,000 lbs of DISC cargo traveled from Madison to WAIS Divide, a trip that included eight LC-130 Hercules flights from McMurdo to the drilling site.

During mid to late November 2007, the first group of ICDS engineers and contract drillers made the long trip to Antarctica to start the first production season of deep drilling at WAIS Divide. The production season is very short in Antarctica; if the weather is good, the drilling season lasts six to seven weeks. This year, however, the weather at WAIS Divide did not cooperate.

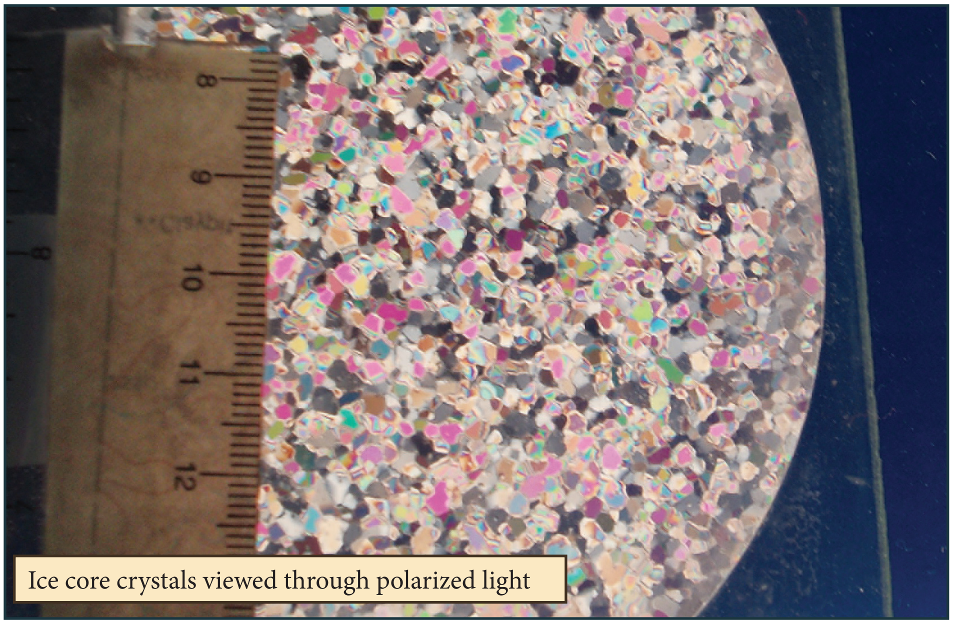
The crew weathered continuous storms and high winds. At one point during the season, the entire camp had to sleep in the galley because the


Ice core storage at WAIS Divide

weather made it too dangerous to go outside to the sleeping tents. The weather conditions also impeded drill installation and delayed the arrival of the remainder of the drilling crew. At the end of the season, production drilling was stopped earlier than planned so RPSC could close Antarctic field camps in a timely manner. Overall, the crew had eight fewer days to drill than planned.

In spite of these challenges, the field season was very successful, and ICDS team completed 180 drill runs. Running a 24/7 operation, the crew drilled an average of 40 m of ice per day. The core ranged in length from 2.6 to 3.0 m. The DISC drill produced excellent core quality. The final borehole depth was 581 m with 467 m of ice drilled.

Scientists have already started to process the cores from this season. Electrical properties were measured on all of the ice. Twenty-one samples, taken from depths of up to 520 m, were cut for physical properties. A total of 464 m of ice was shipped to NICL where it will be processed during summer 2008.



Ice core crystals viewed through polarized light

The 2008-2009 season will be even more challenging than this season because the drill will reach and have to go through a section of brittle ice. This ice is prone to cracking and shattering, so the ice will sit at the site for a whole year to “relax” (to reduce stress in ice) before being shipped to Denver for scientific processing and storage.

The most scientifically interesting ice sits just above the bed. The bottom 40 m of the ice core may hold as much as 20% of the time in the climate record that can be recovered from WAIS Divide. The drill sonde requires substantial modifications before the team can drill to the bed. Also, a special environmental permit will need to be obtained before water at the base of the ice sheet is encountered.

ICDS plans to finish the first stage of the project – coring to just above the bed – by January 2011. The next stages will be completed by January of 2014 and will include bore hole logging, sampling of basal water and geologic material, and replicate coring to recover additional 350-400 m of ice from depth intervals of special interest. The basal sampling and replicate coring systems for the DISC Drill still need to be developed, so ICDS still has to do a lot of design, engineering, fabrication, and testing activities.

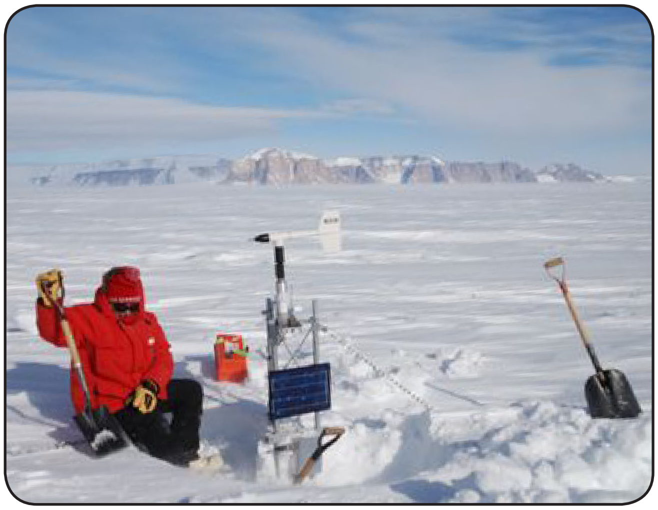
Alex Shturmakov

ICDS:
www.ssec.wisc.edu.icds/

WAIS project:
www.waisdivide.unh.edu/

Investigating Antarctica

The Antarctic Automatic Weather Stations Project (AWS) and the Antarctic Meteorological Research Center (AMRC) had a successful 2007-08 field season to Antarctica. The work completed for AMRC had to do with maintaining the computing systems that are on station, and for AWS, maintaining the automated weather stations in the field. The six field team members making the trip to Antarctica this year were George Weidner, Jonathan Thom, Shelley Knuth, Kirk Beckendorf, Jonas Asuma, and John Cassano. Kirk Beckendorf joined the AWS group for the first time this year as a part of the Polar Trec program, which gives primary and secondary teachers a chance to do field work in the polar regions. Kirk is an 8th grade teacher at Blanco Middle School in Blanco, TX, and was able to give his students a hands-on experience of the life of a scientist in Antarctica. The group also had a seventh honorary member – Jelly the Bear. Jelly travels around the world with different people and reports back to the students of Ms. Pavlik's 2nd grade class on her adventures.



George Weidner digging out a nearly buried AWS at the Theresa AWS site. Photo by Kirk Beckendorf.

There were several AWS sites visited this year, including Cape Bird, Schwertdfeger, Mary, Windless Bight, Ferrell, Pegasus South, Carolyn, and Williams Field. The group also visited sites in West Antarctica, the Dry Valleys, and near the South Pole. Jonathan and Shelley were the two deploying field members to South Pole. Getting there in itself was quite an adventure. After being delayed a day due to weather, the team was finally off, but found it difficult for the LC-130 to gain enough speed to be able to take off due to the fresh snow on the runway. It took three passes and all the passengers to sit in the back of the plane before the plane could finally become airborne. The temperature was a balmy -24F upon arrival. The purpose of the trip was to service automated weather stations Nico and Henry, which hadn't been visited in five years. Nico was easy to find, but Henry took a few passes before the team was able to locate it on the ground. Both sites were serviced, and are again sending data.

Soon after Jonathan and Shelley returned from South Pole, George and Kirk left for West Antarctica. They stayed at the WAIS (West Antarctic Ice Sheet) camp. From that site, the team was able to take trips via the Twin Otter to service the Swithinbank, Theresa, Brianna, and Byrd AWS sites. Kominko-Slade, the AWS site at WAIS, was also visited.

Jonathan, Shelley, and George also visited the Dry Valleys during the season to service the Mt. Friis and Mt. Fleming AWS sites. Jelly came along for the ride as well, but was lost at Mt. Friis! Jonathan and Shelley immediately dispatched search and rescue, and Jelly was found soon afterward. The surprising part of the trip was discovering that the wind sensor at Mt. Fleming had been sheared off the boom and was lying on the ground next to the AWS. The team also deployed a CR-1000 and iridium system at Williams Field for testing. We tested three types of temperature sensors, two types of wind sensors, and an acoustic depth gauge at this site.

There were many other adventures in Antarctica this year for the AWS and AMRC teams. The team was invited by the Malaysian Antarctic Research Program to Scott Base for Sunday dinner. One of the field team members was also attacked by a skua bird when walking outside with food. All in all, it was a successful field season.

The AWS team raising Schwerdtfeger AWS Site. Photo by Shelley Knuth.

Shelley Knuth

amrc.ssec.wisc.edu

Publication Highlights

Cloud Detection with MODIS. Part I: Improvements in the MODIS Cloud Mask for Collection 5

Journal of Atmospheric and Oceanic Technology v.25, no.7, 2008

Frey, Richard A., Ackerman, Steven A., Liu, Yinghui, Strabala, Kathleen I., Zhang, Hong, Key, Jeffrey R., and Wang, Xuangi

Significant improvements have been made to the Moderate Resolution Imaging Spectroradiometer (MODIS). Most of the modifications are realized for nighttime scenes where polar and oceanic regions will see marked improvement. Land and sea surface temperature maps provide crucial information for mid- and low-level cloud detection and lessen dependence on ocean brightness temperature variability tests.

Cloud Detection with MODIS. Part II: Validation

Journal of Atmospheric and Oceanic Technology v.25, no.7, 2008

Ackerman, S. A., Holz, R. E., Frey, R., Eloranta, E. W., Maddux, B. C., and McGill, M.

An assessment of the performance of the Moderate Resolution Imaging Spectroradiometer (MODIS) cloud mask algorithm for Terra and Aqua satellites is presented. The MODIS cloud mask algorithm output is compared with lidar observations from ground [Arctic High-Spectral Resolution Lidar (AHSRL)], aircraft [Cloud Physics Lidar (CPL)], and satellite-borne [Geoscience Laser Altimeter System (GLAS)] platforms.

Two-Season Impact Study of Four Satellite Data Types and Rawinsonde Data in the NCEP Global Data Assimilation System

Weather and Forecasting v.23, no.1, 2008

Zapotocny, Tom H., Jung, James A., Le Marshall, John F., and Treadon, Russ E.

Extended-length observing system experiments (OSEs) during two seasons are used to quantify the contributions made to forecast quality by conventional rawinsonde data and four types of remotely sensed satellite data. The impact is measured by comparing the analysis and forecast results from an assimilation–forecast system using all data types with those excluding a particular observing system. The impact of the particular observing system is assessed by comparing the forecast results over extended periods.

Development of a Global Infrared Land Surface Emissivity Database for Application to Clear Sky Sounding Retrievals from Multispectral Satellite Radiance Measurements

Journal of Applied Meteorology and Climatology v.47, no.1, 2008

Seemann, Suzanne W., Borbas, Eva E., Knuteson, Robert O., Stephenson, Gordon R., and Huang, Hung-Lung

A global database of infrared (IR) land surface emissivity is introduced to support more accurate retrievals of atmospheric properties such as temperature and moisture profiles from multispectral satellite radiance measurements. Emissivity is derived using input from the Moderate Resolution Imaging Spectroradiometer (MODIS) operational land surface emissivity product (MOD11). The baseline fit method, based on a conceptual model developed from laboratory measurements of surface emissivity, is applied to fill in the spectral gaps between the six emissivity wavelengths available in MOD11.

Ocean Temperature Forcing by Aerosols Across the Atlantic Tropical Cyclone Development Region

Geochem. Geophys. Geosyst., 9, Q05V04, doi:10. 1029/2007 GC001774.

Evan, Amato T., Heidinger, Andrew K., Bennartz, Ralf, Bennington, Val, Mahowald, Natalie M., Corrada-Bravo, Hector, Velden, Christopher S., Myhre, Gunnar, and Kossin, James P.

Recent work has shown a statistical climatological link between African dust outbreaks and North Atlantic tropical cyclone frequency and intensity. However, a definite causal link between year-to-year changes in African dust and Atlantic tropical cyclones has yet to be proven. Here we show that variability in Atlantic dust cover is linked to changes in tropical cyclone activity through the aerosols' surface radiative forcing, which has a net cooling effect on tropical Atlantic Ocean temperatures. We describe a new methodology for incorporating more than 25 years of satellite observations of aerosols into a simple model that estimates the aerosol direct effect and its impact on tropical eastern Atlantic Ocean temperatures.

Weather Guys' 10th Anniversary

This summer the "Weather Guys" celebrated the tenth anniversary of their first on-air rendezvous with Wisconsin Public Radio's Larry Meiller. Since July 1998, CIMSS Director Steve Ackerman and UW-Madison Professor Jon Martin have been regular guests of Meiller's call-in show during which they explain the mysteries of the weather.

Handling topics ranging from rainbows to tornados, hurricanes to climate change, the Weather Guys are popular with WPR listeners. Ackerman and Martin provide palatable descriptions of the more technical aspects of weather and always add a bit of humor to the conversation.

Initially added to Meiller's call-in show as a substitute for a cancellation, Ackerman and Martin have enjoyed the last ten years and will continue to answer listeners' questions for the foreseeable future. The pair values the call-in show so much that each will go to great lengths to appear on air each month, including using cell phones and pay phones from different countries.

For answers to all your questions about weather and climate, listen to The Weather Guys on WHA on the last Monday of every month. In or near Madison, listen on 970 AM or 90.7 FM. Or go to the Web at: www.wpr.org/webcasting/live.cfm

Jen O'Leary

If you would like to be added to our mailing list for *Through the Atmosphere*, please contact Maria Vasys at maria.vasys@ssec.wisc.edu

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