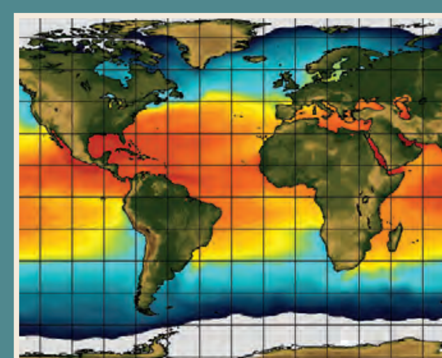
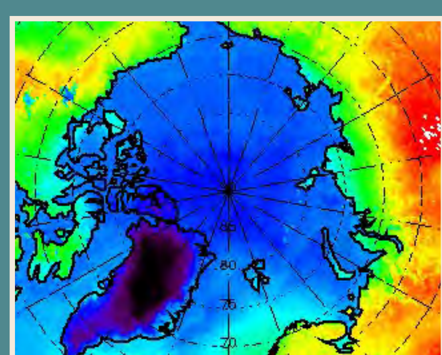
University of Wisconsin-Madison
Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies

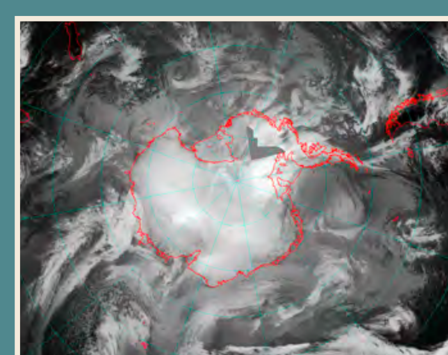
through the atmosphere

Winter 2009



CLIMATE SCIENCE AT SSEC





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Director's Note - Climate Studies at SSEC/CIMSS

Climate studies, inspired by the first look at the earth from space by Professor Verner Suomi's radiation energy budget experiment on Explorer VII in 1959, have always been an important thrust at the Center. But now, with the realization that the rapid increase of carbon dioxide from fossil fuel burning can jeopardize the well-being of the whole planet, this research has taken on a new sense of urgency. Exploring the implications of existing spaceborne records and defining approaches for new observing systems are both key activities for providing quantitative guidance to public policy decisions aimed at moderating the severity of future climate change.

As described in this issue of *Through the Atmosphere*, SSEC and its Cooperative Institute, CIMSS, are well equipped for exploring the implications of data from past and upcoming spaceborne missions. With the polar and geostationary environmental satellite record reaching back 30 years, the SSEC Data Center and the National Climate Data Center (NCDC) possess a wealth of remote sensing data for climate research. NCDC and SSEC are forming a close research and data partnership to ensure the successful continuation, and even enhancement, of climate data stewardship efforts.

The long record of NOAA Polar orbiting (POES) satellite imager and sounder data has enabled teams at SSEC/CIMSS to assemble long-term cloud climatologies, both globally and in the Arctic. Working with a 20+ year satellite record in collaboration with scientists at NCDC, Jim Kossin has assembled a unique global climatology of tropical cyclone intensity which answers important questions about tropical cyclone frequency and intensity and their relationship to climate change.

SSEC is also supporting NASA efforts to assess the quality of the forthcoming National Polar Orbiting Environmental Satellite System (NPOESS) data records for continuing and improving remote sensing climate data records. The Atmosphere PEATE at SSEC, one of five Product Evaluation and Algorithm Test Elements of the NASA NPOESS Preparatory Project (NPP), is the only PEATE not at a NASA center or JPL. Our Atmosphere PEATE supports the NPP Science Team's evaluation of data quality by providing multiyear comparisons for quantitative product validation with spaceborne and ground-based data sources.

However, we need to do more. In addition to existing and planned operational systems, there is a critical need for new and better measurements to definitively assess climate trends as soon as possible. For several years, we have been working with Professor Jim Anderson's group at Harvard University to define a critical new benchmark climate mission, named CLARREO in the 2007 NRC Decadal Survey. The goal of the CLimate Absolute Radiance and REfractivity Observatory is to record the current state of the climate with ultra-high accuracy for future generations and to repeat this type of observation at decadal intervals. SSEC is currently performing science definition studies funded by the CLARREO lead Center (NASA LaRC) and developing new instrumentation under the NASA Instrument Incubator program. We expect the mission to proceed into NASA Phase A next year.

We are excited that SSEC is continuing its history of offering innovative approaches to climate research for the benefit of mankind and developing ways to better understand our planet's climate, past, present and future.

Hank Revercomb

Through the Atmosphere

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The Future of Climate Data Records

The interactions between our planet and its atmosphere are complex, and not always (accurately) predictable. To understand the changes occurring on Earth and in its atmosphere over time, scientists need access to consistent global climate records. Because of SSEC's scientific expertise and history of collecting, processing, and distributing data from diverse Earth satellite projects, SSEC has been selected to play a vital role in providing this continuity with the next generation polar-orbiting satellite program, the NPOESS Preparatory Project (NPP).

NASA has established five Product Evaluation and Algorithm Test Elements (PEATEs) to enable the NPP Science Team to evaluate the operational Sensor Data Records (SDRs) and Environmental Data Records (EDRs) (both pre-launch and post-launch) from NPP for their suitability in continuing the NASA climate data record. The five PEATEs are organized into categories: Atmosphere, Land, Ocean, Ozone, and Sounder. The Atmosphere PEATE was established within SSEC at the University of Wisconsin-Madison (all other PEATEs are located at NASA centers).

The NPP EDRs which are assigned to the Atmosphere PEATE are:

- Cloud Mask (IP)
- Cloud Cover/Layers
- Cloud Effective Particle Size
- Cloud Top Height
- Cloud Top Pressure
- Cloud Top Temperature
- Cloud Base Height
- Cloud Optical Thickness
- Aerosol Optical Thickness
- Aerosol Particle Size
- Suspended Matter

In addition to evaluating data records for the NASA climate record, the Atmosphere PEATE at SSEC assesses the performance of the NPP Atmosphere EDRs through comparison with other ground-based and satellite-based measurements, incorporates new research advances to continually improve the products, and develops improved or alternative Atmosphere NPP EDR algorithms for the NPP products that are shown to be of insufficient quality. The SSEC PEATE team consists of NPP science team members, supporting scientists with extensive experience in deriving atmosphere-related products from past and existing environmental satellites, and data system developers.

The Atmosphere PEATE has a comprehensive approach to evaluate global NPP cloud and aerosol EDRs. Part of our strategy leverages our unique experience in both imager and interferometer radiance calibration, which is critical to the accuracy of the products. Once we have assessed the calibration of the instruments (e.g., detector striping, electronic crosstalk), we can generate and evaluate the EDR products, which are essentially pixel-level products, over a range of Earth environments (e.g., day, night, ocean, land, desert, snow, ice). The second part of our strategy uses Aqua MODIS and AIRS proxy data for VIIRS and CrIS, respectively, as years of global data and heritage products currently exist. The NPP cloud and aerosol EDRs will be generated using the latest available versions of the operational codes provided by the NPP instrument contractors. Assessment of the performance of the NPP algorithms will be gained through comparing global cloud and aerosol products to those obtained from CALIPSO and CloudSat data, as well as data from aircraft or ground-based systems such as AERONET and Atmospheric Radiation Measurement (ARM) Program Cloud and Radiation Testbed (CART) sites.

Artist's Conception of the NPP Satellite.

SSEC will ingest the full Raw Data Record (RDR) level data for VIIRS and CrIMSS from the NOAA CLASS archive. Additionally, SSEC will obtain validation data from ground-, aircraft-, and satellite-based sensors. In combination, this approach will allow the NPP Science Team to select and process subsets of the data from RDR all the way to CDR. To obtain a CDR evaluation, one must have the historical perspective where the entire decadal (global, gridded) record of a particular cloud property is available. Atmosphere CDR products are created, evaluated and then compared to existing satellite-derived global climate products (e.g., ISCCP/GOES, PATMOS-X/AVHRR, SSEC/HIRS, and EOS MODIS cloud climatologies). Without this effort, step changes in a set of properties can occur every time a new sensor is launched.

continued on page 4

continued from page 3

SSEC will store the RDR data from VIIRS and CrIMSS on low-cost network-attached servers for neartime access. Data and products will be distributed to the NPP Science Team on demand via a Web interface. Computer data processing will be provided by a cluster of UNIX servers. The cluster will enable interactive algorithm development and testing for NPP Science Team members, user-selectable batch processing of EDR and CDR datasets, and visualization of products at any level. The processing system is being designed to allow SDR and EDR product generation at more than 100 times the real-time processing speed.

Collocation and match-up software has been integrated into the PEATE processing system. Daily global match-up files will be created which contain MODIS or VIIRS imager observations and collocated CALIPSO lidar observations. This product will include the CALIPSO validation measurements averaged to the MODIS/VIIRS spatial resolution and the sub pixel variability measured by CALIPSO for each MODIS/VIIRS Field of View (FOV). The match-up files will allow global EDR algorithm performance statistics to be generated.

Because the validation system is integrated into the Atmosphere PEATE Science Processing System, the validation results are immediately available once the MODIS/VIIRS cloud products have been processed. This capability allows for efficient evaluation when changes are made to the MODIS/VIIRS cloud retrieval algorithms. Significantly, the PEATE's effort will assist the NPP Science Team in developing improved EDR algorithms that continually incorporate new research to mitigate problem areas, as well as in testing the improved algorithms on climatologically meaningful subsets of the NPP data record. An example of the collocated MODIS cloud top height retrievals compared to the CALIPSO cloud top heights for the months of August 2006 and February 2007 is presented in Figure 1. The figure was generated by computing the mean differences over a 5-degree global grid.

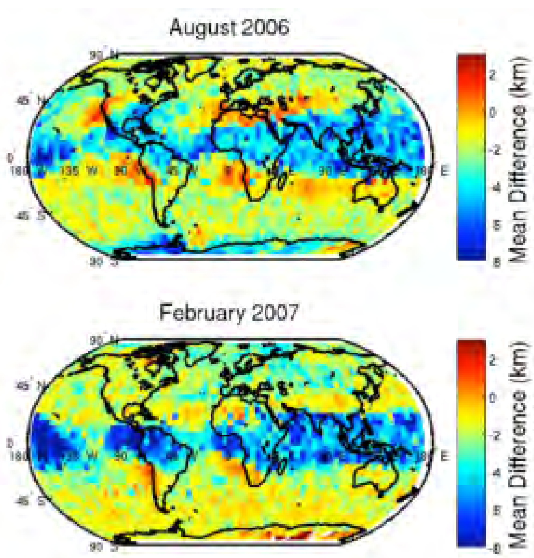


Figure 1: EDR Evaluation Example: Cloud Height (MODIS-CALIPSO).
Figure courtesy of Robert Holz, SSEC.

Since inception of the project, the Atmosphere PEATE has completed several reviews, including the System Requirements Review and the Preliminary Design Review, and successfully deployed the processing system. In January 2006 we began ingesting and storing Aqua MODIS global Level 1A data, and we have already processed one month of global Aqua MODIS proxy data using MODIS, MODIS VIIRS-like, and VIIRS OPS cloud mask algorithms. We have adapted existing software (LEOCAT) to create the infrastructure for running VIIRS OPS EDR code on Linux. In addition, the PEATE team has already demonstrated several important processes, one for global evaluation of VIIRS Cloud Mask, Cloud Top Height, and Cloud Optical Depth using Aqua MODIS proxy data collocated with CALIPSO lidar data and another for evaluating VIIRS SDR using Aqua MODIS data as proxy for VIIRS and Aqua AIRS hyperspectral data as proxy for CrIS.

In the future, the Atmosphere PEATE Team at SSEC will complete the process of porting all the VIIRS Atmosphere EDR algorithms to LEOCAT, thereby allowing the NPP Atmosphere Science Team members to conduct in-depth evaluations of each of the algorithms for generating cloud products. We will run the algorithms on global proxy data from Aqua MODIS at time scales from one year to the complete Aqua mission. We will also complete the installation of the NPP launch-ready Science Processing System which will include approximately 250 CPU cores and 200 TB of disk space in preparation for evaluating the operational VIIRS global products. The infrastructure being assembled for the Atmosphere PEATE project will provide an excellent foundation for future climate product generation and evaluation at SSEC.

Liam Gumley
Leanne Avila

NPP Satellite: First of New Generation

The NPOESS Preparatory Project (NPP) satellite mission is a joint project between NASA and the NPOESS Integrated Program Office (IPO). Currently scheduled to launch in mid-2010, NPP will provide a first look at a new generation of products from U.S. operational polar-orbiting Earth observing satellites. The NPP mission will (a) provide a bridge mission between the current constellation of NASA Earth Observing System (EOS) satellites including Terra, Aqua, and Aura and the future constellation of NPOESS satellites; (b) continue the record of global climate observations established by EOS; and (c) provide the NPOESS project and customer community with risk reduction for selected NPOESS instruments, algorithms, products, and ground processing.

The NPP spacecraft will be launched into a sun-synchronous polar orbit at an altitude of 825 kilometers with an equator crossing time of 1:30 pm, a period of 100 minutes, and a repeat cycle of 16 days. The planned mission duration is five years. Global data will be downlinked via the Svalbard Ground Station once per orbit, and all mission data will be made available in real-time via X-band direct broadcast.

The NPP instrument payload includes the following sensors:

- Visible Infrared Imager Radiometer Suite (VIIRS): Multispectral scanning radiometer with 22 spectral bands, FOV 370/740 meters;
- Cross-Track Infrared Sounder (CrIS): Michelson interferometer with 1297 spectral bands, FOV 14 kilometers;
- Advanced Technology Microwave Sounder (ATMS): Passive microwave radiometer with 22 channels, FOV 75/33/15 kilometers;
- Ozone Mapping & Profiling Sensor (OMPS): three hyperspectral imaging spectrometers (Nadir Mapper, Nadir Profiler, Limb Profiler);
- Clouds and the Earth's Radiant Energy System (CERES); broadband scanning radiometer.

The prime contractor for NPOESS (Northrop Grumman) is responsible for NPP product generation within the Interface Data Processing Segment (IDPS) of the NPOESS Ground System. The IDPS will create global products in real-time from VIIRS, CrIS, and ATMS, while OMPS and CERES products will be generated by NASA GSFC and LARC, respectively. NPP products generated by the IDPS will include:

- Raw Data Records (RDRs): raw instrument packet level data
- Sensor Data Records (SDRs): calibrated and geolocated Earth observations
- Environmental Data Records (EDRs): derived geophysical products

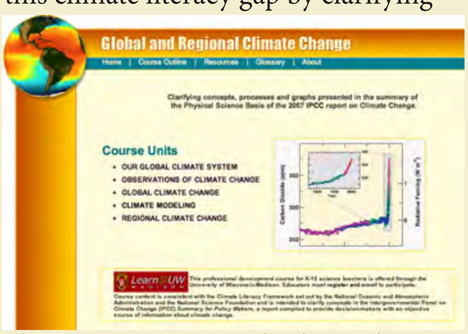
Liam Gumley

New On-line Climate Change Curriculum for G6-12 Science Educators

In an effort to advance climate literacy across society, the Cooperative Institute for Meteorological Satellite Studies (CIMSS) led the development of an on-line curriculum for grades 6-12 science teachers covering global and regional climate change topics.

Course content is consistent with the Climate Literacy Framework set out by NOAA and NSF and features audio, text and interactive activities designed to clarify concepts and graphs in the Intergovernmental Panel on Climate Change (IPCC) 2007 Summary for Policy Makers.

While the IPCC laid the foundation for measures needed to counteract climate change, a chasm remains between the well-documented evidence compiled by IPCC scientists and the public's ability to comprehend climate system mechanisms. This course helps bridge this climate literacy gap by clarifying the processes and data presented in the IPCC summary report specifically for middle and high school science teachers. Feedback from embedded questionnaires and phone interviews conducted by an outside evaluator during the 2008 course debut will be incorporated into a revised and final version of the web-based material in 2009. As educators incorporate new knowledge into their formal lectures and informal discussions, they will enhance the climate literacy of our nation's youth while introducing pre-college students to environmentally responsible career paths.



http://cimss.ssec.wisc.edu/climatechange/

Margaret Mooney

CLARREO – NASA's New Climate Related Spaceflight Mission

Given the rapid increase of carbon dioxide pumped into the atmosphere by fossil fuel burning, new measurement systems are urgently needed to quantify the impact on the Earth's climate. To deal with climate change wisely, society needs the best possible understanding of what changes are occurring and accurate predictions of what changes will ensue, depending on the actions we do, or do not, take.

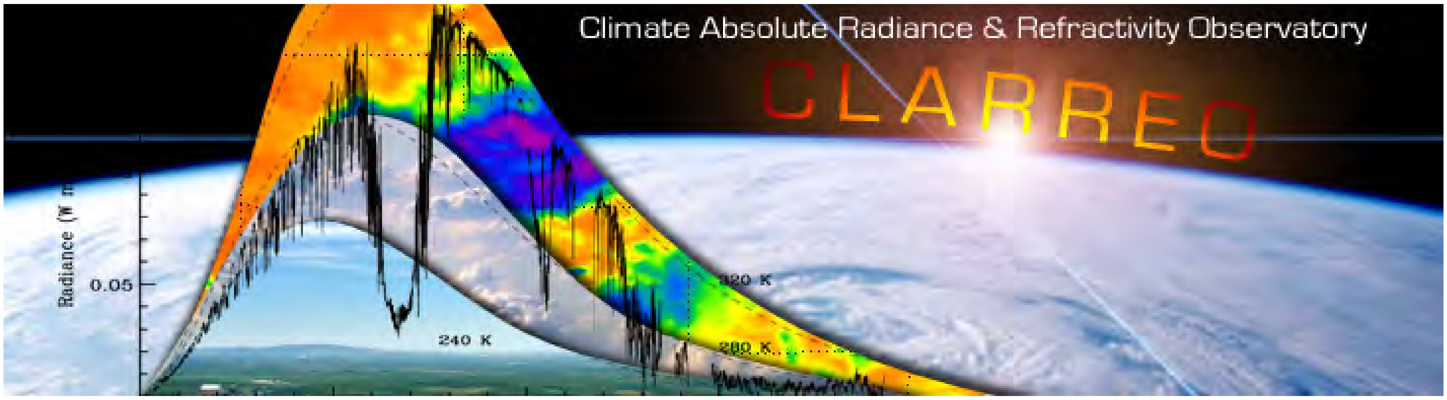
A new spaceborne observatory, the CLimate Absolute Radiance and REfractivity Observatory (CLARREO), is being planned to respond to this need. CLARREO was recommended by the 2007 Decadal Survey of the US National Research Council and is being pursued by NASA, with the Langley Research Center as the implementing center (http://clarreo.larc.nasa.gov/).

CLARREO is one of NASA's four highest priority "Tier 1" missions. As a key climate-observing system, CLARREO will initiate an unprecedented, highly accurate record of climate change that is tested, trusted and necessary to provide sound policy decisions. It will provide a record of direct observables with the exacting information content necessary to detect long-term climate change trends and to test and systematically improve climate predictions.

CLARREO will observe the spectrally resolved radiance and atmospheric refractivity with the accuracy provided by international standards (SI) and sampling required to assess and predict the impact of changes in climate-forcing variables on the climate.

The CLARREO mission is based on new paradigms for making climate benchmark observations. First, radiation measurements for a climate benchmark should be chosen to maximize the information content about atmospheric and surface properties. Previous efforts, particularly climate benchmark missions first designed by Professor Verner E. Suomi at the beginning of the space age (launched in 1959), focused on monitoring the total radiative energy budget. CLARREO will use spectrally resolved radiances to gain sensitivity, because the spectrally integrated total energy budget can miss significant changes that cancel each other out. Observing regional averages and distributions of nadir-viewing spectra will reveal signatures of changes in climate forcing and response related to changes in temperature and water vapor structure, atmospheric stability, cloudiness or aerosols, surface properties, and trace gases. The far infrared region of the spectrum will provide sensitivity to thick ice clouds and upper-level water vapor.

Second, to reduce the time to unequivocally resolve climate trends, a new standard in accuracy is needed. The new paradigm is to use SI calibration standards flown on the same spacecraft for on-orbit confirmation of the ultra-high accuracy achieved by careful design and testing on the ground. For infrared radiance spectra, a brightness temperature accuracy of 0.1 K confirmed on orbit is practical (with a 99% confidence that the limit is not exceeded). For refractivity measured using transmissions from the Global Positioning System, the accuracy depends on time measurements that can be made extremely accurately. The accuracy corresponds to an accuracy for upper level temperature that is also better than 0.1 K. Techniques to realize corresponding accuracy for reflected solar radiance spectra are being developed. Establishing highly accurate SI traceable measurements in space alleviates the need to overlap subsequent generations of satellites to establish a climate record.



Third, CLARREO needs to achieve spatial and temporal sampling that will maintain this high measurement accuracy in climatically significant regional and seasonal spectral products. Sampling biases have equal importance to measurement errors. A new sampling approach being explored for CLARREO would use three, equally-spaced, truly polar orbits (90º inclination) that do not precess in inertial space. These orbits will cover all latitudes and longitudes, and give equal sampling for all times of day every two months. Recent simulations show that these orbits will also allow CLARREO to be used for highly accurate cross-calibration of operational and research instruments flying in sun-synchronous orbits.

SSEC is currently under NASA funding to perform optimal sampling and IR Sounder cross-calibration trade studies that will help define CLARREO science requirements and measurement capabilities. Additionally, we are expecting to start systems engineering studies that will help define the CLARREO IR instrument requirements and a candidate payload concept that will allow estimates to be made of overall mission power, mass, size and cost. The current concept for making the CLARREO infrared spectrally resolved radiance measurements is to use two interferometers: one much like the SSEC-developed Scanning-HIS for the shortwave to midwave (3.3 to 13 microns); and another similar interferometer for the longwave (out to 50 microns).

In yet another connection to CLARREO, SSEC is teamed with Harvard University under funding from the NASA Instrument Incubator Program to develop key technologies that will provide on-orbit absolute instrument calibration – a fundamental requirement of the CLARREO mission. At SSEC this work will concentrate on using phase change materials to provide absolute calibration of the instrument blackbody temperature sensors, and on advancing our concept for making highly accurate measurements of blackbody emissivity. We will also be building a prototype interferometer system to demonstrate the performance required by CLARREO. The interferometer will be integrated with state-of-the-art detectors cooled by a pulse tube microcooler. Each element of the prototype system will have strong spaceflight heritage, so that taking the next step to the CLARREO flight system will involve minimal risk.

CLARREO's use of spectrally resolved radiances for more sensitivity, new standards for accuracy, and a three-satellite sampling approach can dramatically reduce the impact of data gaps on decadal change data records across many climate variables. Its ability to calibrate other instruments across the full solar and infrared spectrum can result in increased programmatic flexibility and savings. While other missions may be focused primarily on one climate process or discipline, the CLARREO mission is unique in its broad interdisciplinary impact on climate change science.

We have an essential responsibility to current and future generations to develop an operational climate forecast that is tested and trusted. Through a disciplined strategy using state-of-the-art observations with mathematically rigorous techniques, this forecast can be realized. CLARREO will establish a climate benchmark record that is global in its extent, accurate in perpetuity, tested against independent strategies that reveal systematic errors, and pinned to international standards on-orbit.

Fred Best
Robert Knuteson
Mark Hobson

Cross-calibration Trade Study

Transferring the CLARREO calibration to operational sounders such as AIRS, IASI and the Cross-track Infrared Sounder (CrIS) enhances the observations available for process studies. An initial study has been performed using MODIS data to investigate the accuracy to which CLARREO can be used to inter-calibrate operational sounders (IASI and CrIS). The study also determined the necessary noise characteristics of CLARREO to meet the inter-calibration requirements.

The study will be expanded to investigate the impact of CLARREO field-of-view size on sampling uncertainties and to refine estimates of CLARREO noise requirements. In addition, an inter-comparison of MetOp-A IASI and Aqua AIRS will be conducted using simultaneous nadir overpasses to test the framework for cross-calibration and to investigate the accuracy of the comparison methods. The accuracy assessment for this inter-comparison will make use of results obtained in the MODIS-data sampling accuracy study.

Fred Best
Robert Knuteson

Temperature Sensor Calibration Using Melt Signatures of Phase Change Materials

Future NASA climate spaceflight missions such as the anticipated Climate Absolute Radiance and Refractivity Observatory (CLARREO) will hinge upon the ability to fly absolute standards that can provide the basis to meet stringent requirements on measurement accuracy. For example, instrumentation designed to measure spectrally resolved infrared radiances to detect a climate signature of 0.1 K per decade will require high-emissivity calibration blackbodies having absolute temperature uncertainties of better than 0.045 K (3 sigma). A key requirement for these future missions is to provide traceability to SI standards on-orbit.

This emerging need provided the motivation to develop a simple, low mass, absolute temperature calibration system that could be incorporated into an existing spaceflight blackbody design – the on-board blackbody calibration system developed for NASA's Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) instrument (see Figure 1). The engineering development model of the GIFTS has successfully undergone thermal vacuum functional testing and calibration at the Utah State Space Dynamics Laboratory.

The demonstrated state-of-the-art performance of the on-board blackbody system makes it nearly suitable for a CLARREO type climate mission. What is lacking is the on-orbit traceability to SI standards, such as ties to the melt points of standard reference materials for absolute temperature calibration, and the capability of making absolute reflectance measurements of the emitting surface. A NASA Instrument Incubator Program (IIP) grant has been awarded to advance the technical readiness of this pioneering research to Technical Readiness Level (6), which will involve demonstration in a relevant environment.

The novel scheme for absolute temperature calibration is based on a new concept that is expected to have wide applicability for the remote temperature calibration of devices. It uses transient temperature melt signatures from three (or more) different phase change materials to provide absolute calibration for the blackbody thermistor sensors covering a wide, continuous range of atmospheric temperatures. The system uses very small masses of phase change material (<1 g), making it well suited for spaceflight application.

A prototype of this absolute calibration scheme using gallium, water, and mercury has been demonstrated at the UW-Madison under internal funding, using a duplicate of the GIFTS blackbody system.

Key Parameter	Specification	As Delivered
Measurement Range	233 to 313 K	233 to 313 K
Temperature Uncertainty	< 0.1 K (3σ)	< 0.056 K
Blackbody Emissivity	> 0.996	> 0.999
Emissivity Uncertainty	< 0.002 (3σ)	< 0.00072
Entrance Aperture	1.0 inch	1.0 inch
Mass (2 BBs + controller)	< 2.4 kg	2.1 kg
Power (average/max)	< 2.2/5.2 W	2.2/5.2 W

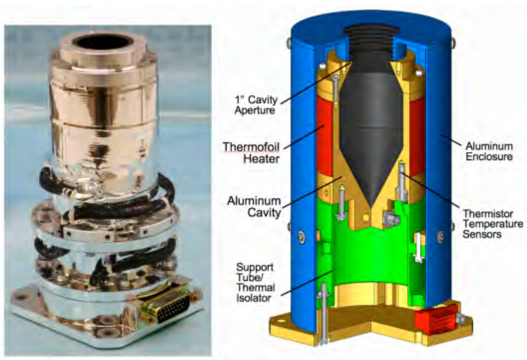


Figure 1: The GIFTS EDU blackbody top-level specifications and as-delivered performance are shown in table at left. A photo of the as-delivered hardware is shown in the middle without the enclosure. The cut-away figure on the right illustrates the key features of blackbody, including the thermistor locations and painted aluminum cavity.

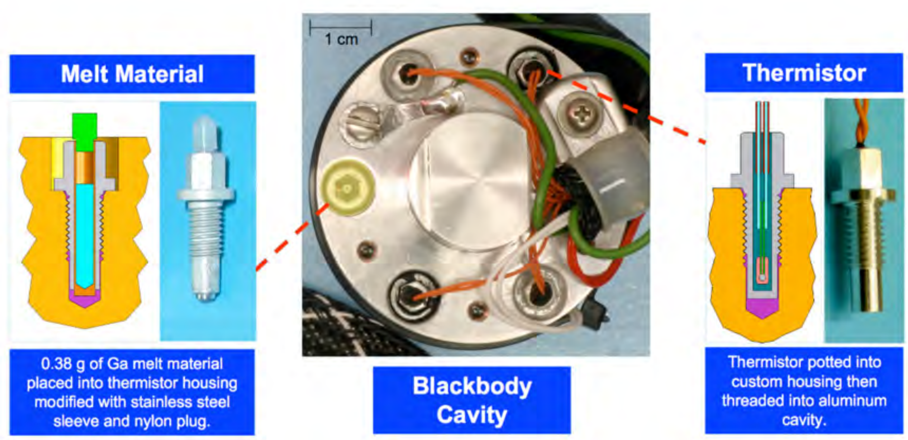


Figure 2: Configuration used to demonstrate the absolute temperature calibration concept, using a UW-SSEC mock-up blackbody. Small quantities (<1g) of different phase change materials are integrated into custom housings that have the same geometry as the temperature sensors. Threaded holes in the blackbody cavity accept either thermistors or one of the phase change materials (gallium is shown).

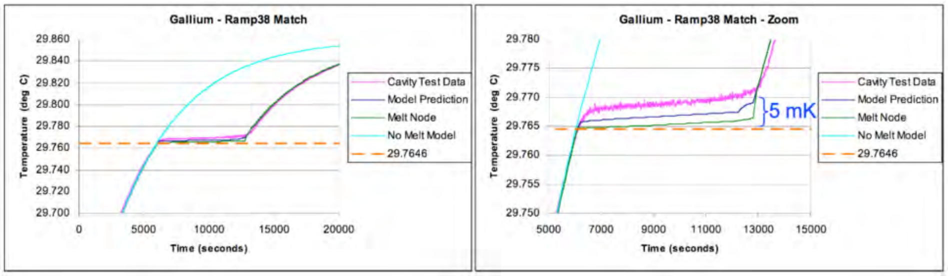


Figure 3: Typical gallium melt signature obtained with UW-Madison blackbody mock-up system. The plot on the right is an expanded view of the data potted on the left. The aqua colored rising exponential shows the temperature response of the blackbody cavity to constant power if no gallium were present. The plot on the right clearly shows that this melt event can be distinguished to within 5 mK.

Figure 2 illustrates the modifications to the GIFTS blackbody design that were implemented to demonstrate the new scheme. The middle photo in the figure is a view looking into the back of the blackbody cavity showing the six possible circumferential locations for the custom packaged thermistors (shown in the right of the figure). The packaging for the small quantities of phase change materials closely resembles that of the thermistors – allowing them to be threaded into the cavity in similar fashion. The image on the right of Figure 2 illustrates the phase change material gallium; other phase change materials are packaged similarly, and are threaded into separate locations. For example, the existing GIFTS design allows three different phase change materials to be interleaved with three different thermistors.

Figure 3 shows a typical transient temperature response of one of the blackbody cavity thermistors during a gallium melt event, where it can be seen that the melt plateau is clearly discernable to within 5 mK of the known melt temperature.

Thermistor temperature sensors can be very well characterized by using three calibration coefficients that can be determined by measuring sensor resistance at three known temperatures. Using the melt signatures from three different materials provides the means to obtain the necessary calibration data. Figure 4 illustrates melt data obtained from mercury, water, and gallium to establish a temperature scale from -39 to +30 °C. For each of these melts, the phase change material was configured as is shown in Figure 3. The resulting melt plateau represents the true melt temperature within 10 mK.

With the temperature sensor calibration scheme clearly demonstrated, what needs to be done next? Under the NASA IIP grant, we will concentrate on bringing this technology from component mock-up status to spaceflight readiness. Tests will be conducted to show that the phase change materials have not been unacceptably contaminated via dissolution, and that the containment materials are not mechanically compromised via mechanisms such as liquid metal embrittlement – a liquid metal attack of the containment metal grain boundaries. Our efforts will focus on optimizing the phase change material containment system for space flight, and verifying performance after extensive accelerated-life testing that simulates full mission lifetimes.

Fred Best
Robert Knuteson
Mark Hobson

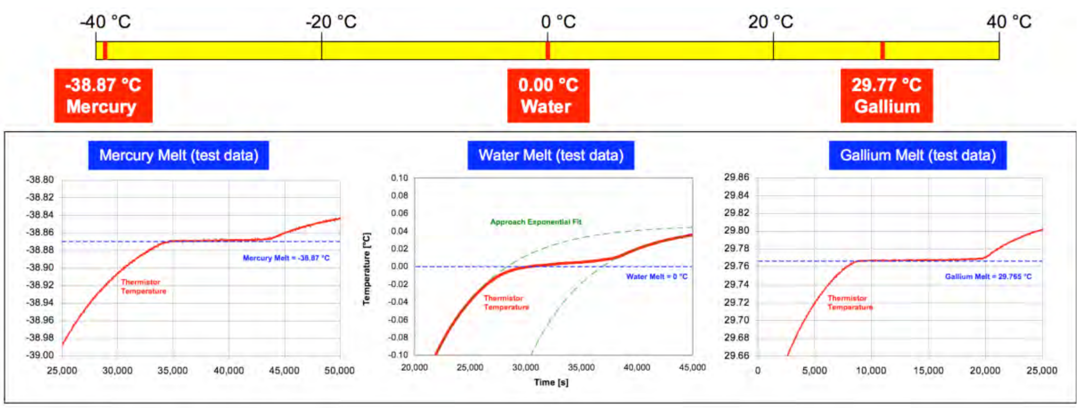


Figure 4: Melt signature test data for mercury, water, and gallium configured as illustrated in Figure 3 show that the melt plateau can be easily distinguished to within 10 mK. These three melts establish the thermistor calibration from -39° to 30° C.

In the Meantime - CLARREO Sampling Trade Study

Although existing observations lack the full spectral coverage of CLARREO and do not provide unbiased temporal or complete spatial coverage, they do provide key spectral properties that should be studied as part of CLARREO development.

In this trade study, potential climate products are evaluated using spectrally resolved infrared data sets from the Atmospheric Infrared Sounder (AIRS) and the Infrared Atmospheric Sounding Interferometer (IASI) as well as temporally resolved infrared spectra bands using the GOES satellite. Measured, spectrally resolved radiances will be used to investigate the characteristics of monthly and annual mean, and regional spectral products.

The AIRS record provides a 5+ year record for characterizing multi-year properties of a 13:30 afternoon orbit. Figure 1 illustrates the seasonal variation in the mean global radiance observed by the AIRS sensor.

The IASI will provide sampling of a different time of day (10:30) for 1½ years with spectral properties that allow rigorous emulation of AIRS observations for evaluating the time-of-day effect. MetOp-A will allow us to start accumulating CLARREO-like data records with complete spectral coverage from 3.3 to 15 microns from IASI along with coincident GPS vertical profile observations of pressure, temperature, and humidity from the Global Navigation Satellite System Receiver for Atmospheric Sounding. In addition, the University of Maryland, under subcontract, is investigating the importance of the diurnal and semi-diurnal cycles of outgoing infrared radiance for several distinct climate zones.

The goal is to characterize the fundamental information content that can be extracted from such products, and measure short-term climate and weather “noise” properties. These products will be created with a number of different assumptions on field-of-view size and with a range of ancillary information to aid interpretation (e.g. “clear sky” products and/or mean atmospheric state).

Fred Best
Robert Knuteson
Mark Hobson

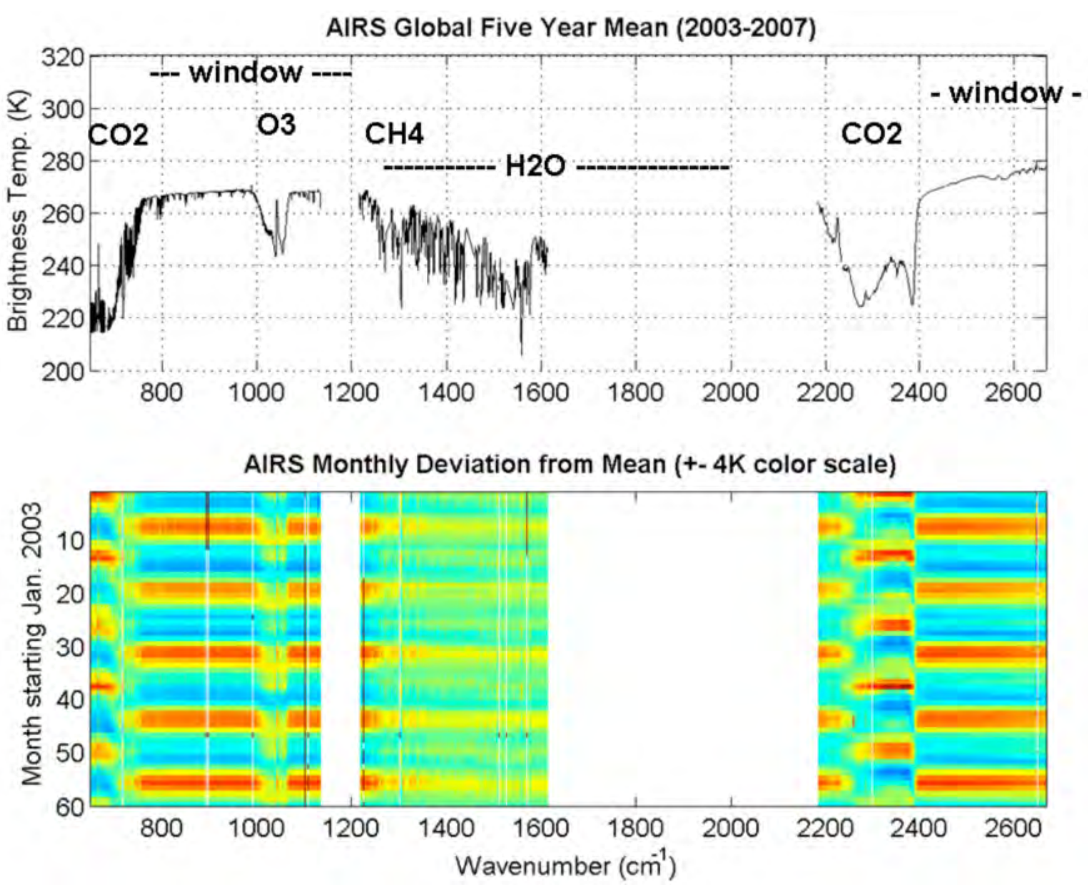


Figure 1: The upper panel is the global average of five years of AIRS data. Lower panel is the deviation from this mean for each spectral element showing the seasonal variation of the atmosphere and surface. (Courtesy S. Dutcher)

Strong Tropical Cyclones Getting Stronger

Is climate change making strong tropical cyclones stronger?

As the Earth's climate changes, it becomes increasingly apparent that those changes will impact our lives in many ways. Human populations are expanding in low-lying coastal areas, such as Florida or Bangladesh, making a greater understanding of tropical cyclones and the environment that creates and shapes them vital. How does climate change affect strong tropical cyclones? Is there a correlation between the changing climate and tropical cyclone intensity?

In order to reveal such a connection, the first requirement would be an accurate, complete record of tropical cyclones and their intensities. Although tropical storms have been measured for decades, if not centuries, it took satellite technology to finally create an accurate global record of their inceptions, durations and size. For more than 30 years, polar orbiting and geostationary imagers have been documenting storms as they occur around the globe.

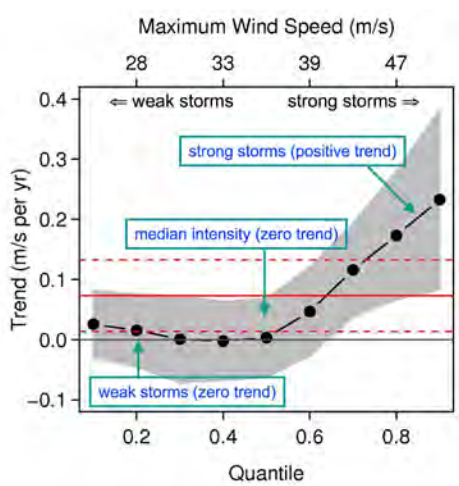


Figure 2: Trends in lifetime-maximum intensity of all recorded storms that occurred globally in the past ~30 years.

Instrumentation has evolved through the past three decades. To achieve the necessary homogeneity across the satellite record, more recently collected data must be degraded to be consistent with the old data. The result, however, is a homogeneous three-decade record of global tropical cyclone satellite data.

In a recent article published in *Nature*, James Elsner of Florida State University, James Kossin of SSEC, and Thomas Jagger of Florida State University took advantage of this new data set to determine whether the strongest storms were getting stronger. Theory suggests that this may occur in conjunction with rising sea surface temperatures.

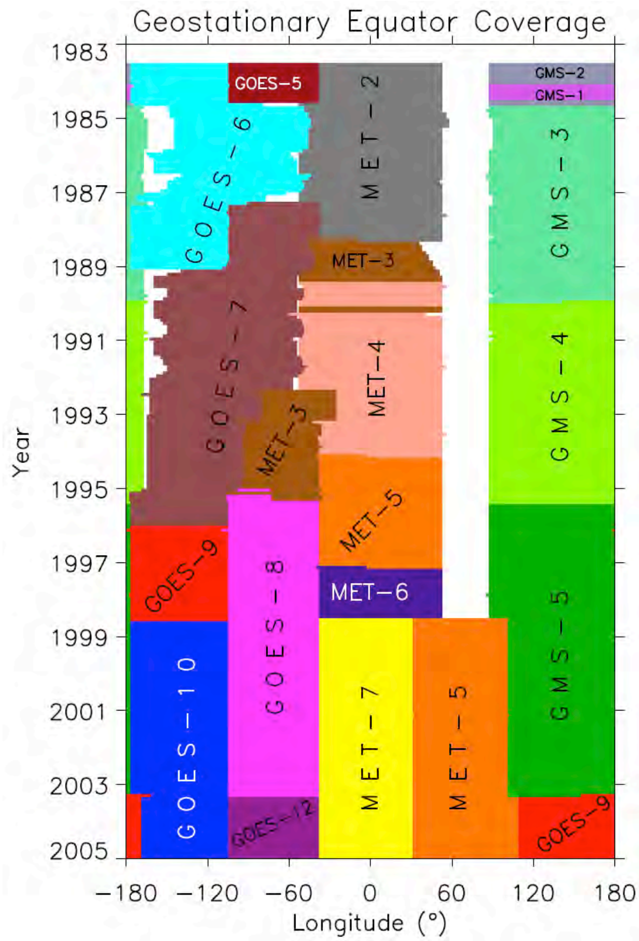


Figure 1: Temporal and spatial equatorial coverage from the geostationary satellites which make up the new homogeneous dataset (shading is limited to a view zenith angle less than 60° for illustrative purposes).

The scientists used quantile regression to estimate the trend in lifetime-maximum wind speeds as a function of storm strength and found that wind speeds in the strongest tropical cyclones have increased about 2-3 meters per second per decade. Increases were identified in all ocean basins with the largest upward trend found in the North Atlantic.

All else being equal, the potential intensity of a tropical cyclone is directly related to sea surface temperature below the cyclone. These results show significant increasing trends in the satellite-derived lifetime-maximum wind speeds of the strongest tropical cyclones globally, and are qualitatively consistent with the heat-engine theory of cyclone intensity. Thus, as seas warm, the ocean has more energy that can be converted to tropical cyclone wind.

According to their results, the strongest global tropical cyclones, on average, are getting stronger.

Mark Hobson
Jim Kossin

Global Cloud Studies Mine Decades of Data

The Advanced Very High Resolution Radiometer (AVHRR) on the NOAA polar orbiting environmental satellites, while no longer on the cutting edge of technology, offers something that is very important to climate research – decades of data.

With recent advances in computer archive capability, easily accessible on-line storage of the entire AVHRR data record is possible for the first time. The AVHRR Pathfinder Atmospheres - Extended (PATMOS-x) project, a mature set of algorithms and data formats, analyzes this archive and generates multiple products (cloud, aerosol, surface and radiometric). Researchers can catalog changes in atmospheric and surface climate records over a period of nearly three decades. PATMOS-x results are available four times per day since 1991 and twice per day since 1981.

PATMOS-x is currently the only global multi-decadal AVHRR-based cloud data set and is an important part of the global satellite-based cloud climate observing system. Other key components of this system include the International Satellite Cloud Climatology Project (ISCCP) and the NOAA/University of Wisconsin HIRS Cloud Climatology Project led by Dr. Paul Menzel (see accompanying article, page 14).

The first AVHRR instrument, launched aboard the TIROS-N satellite on October 13, 1978, was a four-channel radiometer, using four detectors to collect different spectral bands of radiation. The most recent version of the AVHRR, launched 10 years ago, is a six-channel instrument, though only five channels are recorded at any one time.

The six frequency channel detectors, all focused on the same view, allow multi-spectral analyses. For example, three of the detectors work within the thermal infrared frequency range and detect heat radiation, measuring and comparing the temperatures of land, water, sea surfaces and the clouds above them. The other three detectors measure reflected solar radiation and provide additional information on clouds, aerosol and vegetation.

For the past two years, new techniques have been developed to exploit the accuracy of advanced satellite imagers to improve the radiometric calibration of the AVHRR reflectance channels. Geolocation accuracy has been improved as well.

AVHRR has recorded many important events that can reveal mechanisms that affect our climate, including the major volcanic eruptions of El Chicon (1982) and Pinatubo (1991), and the major El Nino events of 1982-83 and 1997-98. The past 25 years also witnessed major changes in the industrialization of Eastern Asia and the cessation of the 15-year Sahelian Drought (which ended in 1985). AVHRR has collected that data for years; now the PATMOS-x project can further analyze all of these events.

It is important to note that the extraction of definitive statements on climate variability from the AVHRR is still in its infancy. Current efforts are aimed at addressing the following questions:

1. What confident statements can be made about trends in cloud properties over the last three decades?
2. Are the differences in climate variability reported by PATMOS-x, ISCCP and UW-HIRS consistent with our expectations based on the differences in sensors and sampling?
3. Which parameters and methodologies allow for direct inference of meaningful climate changes?

In addition to those broad and global questions, PATMOS-x data has been applied to research specific regional climate variability studies. As described in the *Bulletin of the American Meteorological Society's* State

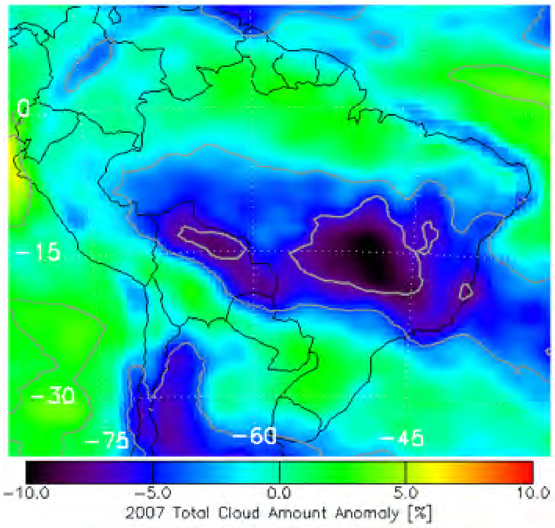


Figure 1: Total cloud cover anomaly for 2007 over Brazil. The thin gray contour represents anomalies that are one standard deviation from the climatological mean value, and the thick gray contour represents anomalies that are two standard deviations from the mean state.

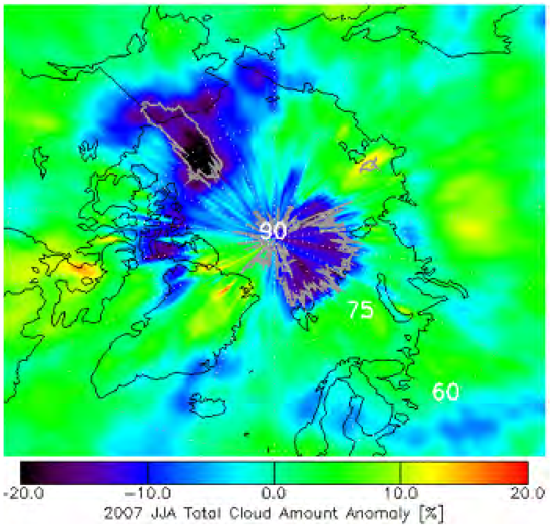


Figure 2: Total Arctic summer cloud cover anomaly 2007. Cloud cover anomaly for the months of June, July, and August over the northern polar regions. The thick gray contour represents anomalies that are two standard deviations from the mean state.

of the Climate in 2007, SSEC's Andrew Heidinger, Amato Evan, and Yinghui Liu are investigating global cloudiness patterns using data from AVHRR PATMOS-x.

They found a strong negative anomaly in cloud cover over a vast area in the center of South America. Centered in Brazil, just south of the dense tropical rain forest of the Amazon basin, and stretching into areas of Bolivia and Paraguay, the decreases in cloudiness coincided with areas of significant biomass burning activity. "Cut and burn" agriculture practices create a heavy smoke cover that impedes cumulus cloud development by warming the air and reducing evapo-transpiration (see Figure 1).

Using the quarter of a century of data collected by AVHRR, the NOAA and CIMSS researchers could determine how much of this cloud loss was within the expected range, and how much was unusual.

At another climate extreme, the researchers also found 10 - 20% reductions in the 2007 summer cloud cover stretching north of Alaska into the Arctic Ocean. Data suggests that there was a strong summer high-pressure anomaly over much of the western Arctic that contributed to the reduction of cloudiness (Figure 2).

Then, although the unusual high pressure persisted, in the fall months an area of increased cloudiness, much larger than the summer event of decreased clouds, extended north from Siberia and the Bering Strait (Figure 3).

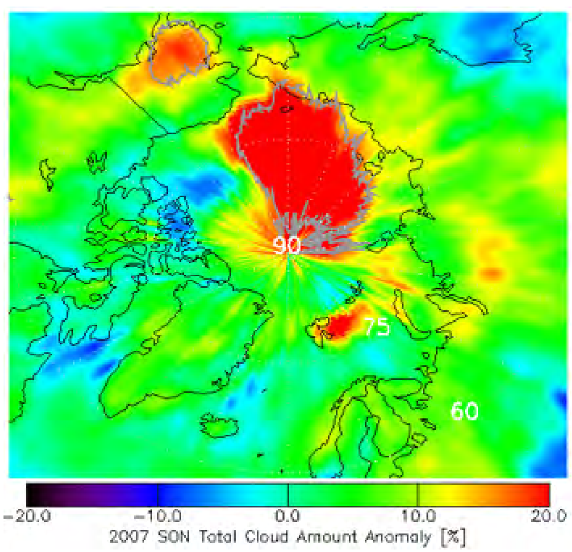


Figure 3: Total Arctic autumn cloud cover anomaly in 2007. Cloud cover anomaly for the months of September, October, and November over the northern polar regions. The thick gray contour represents anomalies that are two standard deviations from the mean state.

PATMOS-x functions as part of the collection of research tools that examine the complex mechanisms of climate change. Comparing the history of surface temperatures in the region of the increased cloudiness with sea level pressure information from the National Center for Environmental Prediction suggests a connection between a northward flow into the low pressure area and warmer surface temperatures that contributed to the increased fall cloud development.

The 6-channel AVHRR is not as adept at detecting clouds over ice, so the 36-channel MODIS (Moderate Resolution Imaging Spectroradiometer) imager can be used to confirm AVHRR findings. The data from the newer instrument works in conjunction with the years of data mined by PATMOS-x.

AVHRR PATMOS-x results recently enjoyed a moment in the media spotlight as stories discussing possible causal links between hurricanes and African dust storms became widely publicized. In addition, the PATMOS-x track record of developing a stable cloud climatology is benefitting efforts to derive optimal real-time cloud properties from current and future satellite imagers. As global climate change gathers more public interest, the research opportunities enabled by accessing this multi-decade data set become more exciting and provide an excellent opportunity for global climate studies.

Andrew Heidinger
Mark Hobson

Inferring Cloud Trends with HIRS Data

Clouds are a strong modulator of the amount of solar heating and thermal cooling of the Earth system. We are currently in a warming trend that is often attributed to the increase in carbon dioxide (CO_2) in the atmosphere. However, clouds cover nearly three-fourths of the Earth, and a small increase in cloud cover could offset the warming from increased CO_2 in the atmosphere. Because clouds vary greatly over the Earth, just as weather does, their effect on warming and cooling has to be inferred from the combined effect of all clouds in all places. While darker thicker clouds cool the Earth by reflecting sunlight, thin ice clouds, called cirrus, allow sunlight to enter the Earth system but trap thermal radiation attempting to leave, thereby warming the planet.

The International Satellite Cloud Climatology Program (ISCCP) has collected the largest global cloud data set using visible and infrared measurements from the international suite of weather satellites. As a supplement, multi-spectral infrared measurements from the National Oceanic and Atmospheric Administration's polar-orbiting High Resolution Infrared Radiometer Sounders (HIRS) have been used for enhanced cirrus detection.

Using regions of the infrared spectrum with differing sensitivity to atmospheric CO_2, the HIRS measurements probe the atmosphere to different depths and reveal thin ice clouds high in the atmosphere. The CO_2 slicing technique is based on the atmosphere becoming more opaque due to CO_2 absorption as the wavelength increases from 13 to 15 µm, thereby causing radiances obtained from these spectral bands to be sensitive to a different layer in the atmosphere. Only the highest clouds appear in the most opaque spectral bands and thus are uniquely identified.

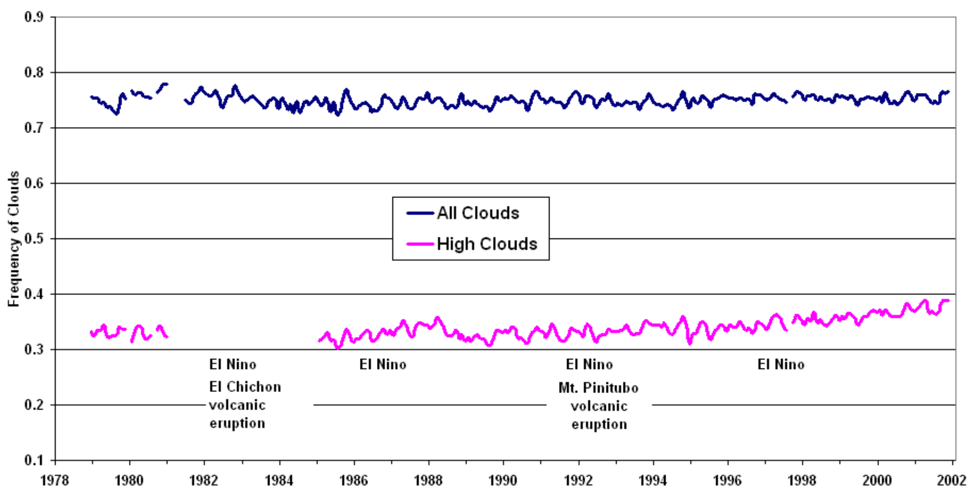


Figure 1: The monthly average frequency of clouds and high clouds (above 6 km) from 70 south to 70 north latitude from 1979 to 2002.

The three decades of HIRS data have been used to infer cloud properties; corrections have been necessary for orbit drift, CO_2 increase in the troposphere, and sensor-to-sensor differences. Since 1979, HIRS measurements have found clouds most frequently in two locations: (1) the Inter-Tropical Convergence Zone (ITCZ) in the deep tropics where trade winds converge and (2) the middle to high latitude storm belts where low pressure systems and their fronts occur. In between are latitudes with fewer clouds and less rain called sub-tropical deserts over land and sub-tropical high pressure systems over oceans.

Our studies show that the decadal average cloud cover has not changed appreciably from the 1980s to the 1990s. Small increases occurred in the tropics, mainly in the Indonesian Islands. Small decreases occurred in the sub-tropics, the eastern Sahara and in the central Pacific Ocean from Hawaii westward. The decreasing trend in Antarctica is uncertain because cloud detection itself is very difficult due to the continent's cold temperatures. High cloud cover has changed some in the northern hemisphere winter season. Increases of 10% in the last decade for clouds above 6 km altitude occurred in the western Pacific, Indonesia, and over northern Australia. Other fairly large increases occurred in western North America, Europe, the Caribbean, western South America, and the Southern Ocean north of Antarctica. Decreases in high clouds occurred mainly in the tropical South Pacific, Atlantic and Indian Oceans south of the ITCZ.

While jet aircraft contrails have been suspected of increasing cirrus cloud cover, these data do not reveal such a trend. Increases of high clouds seem to occur in areas of high air traffic, such

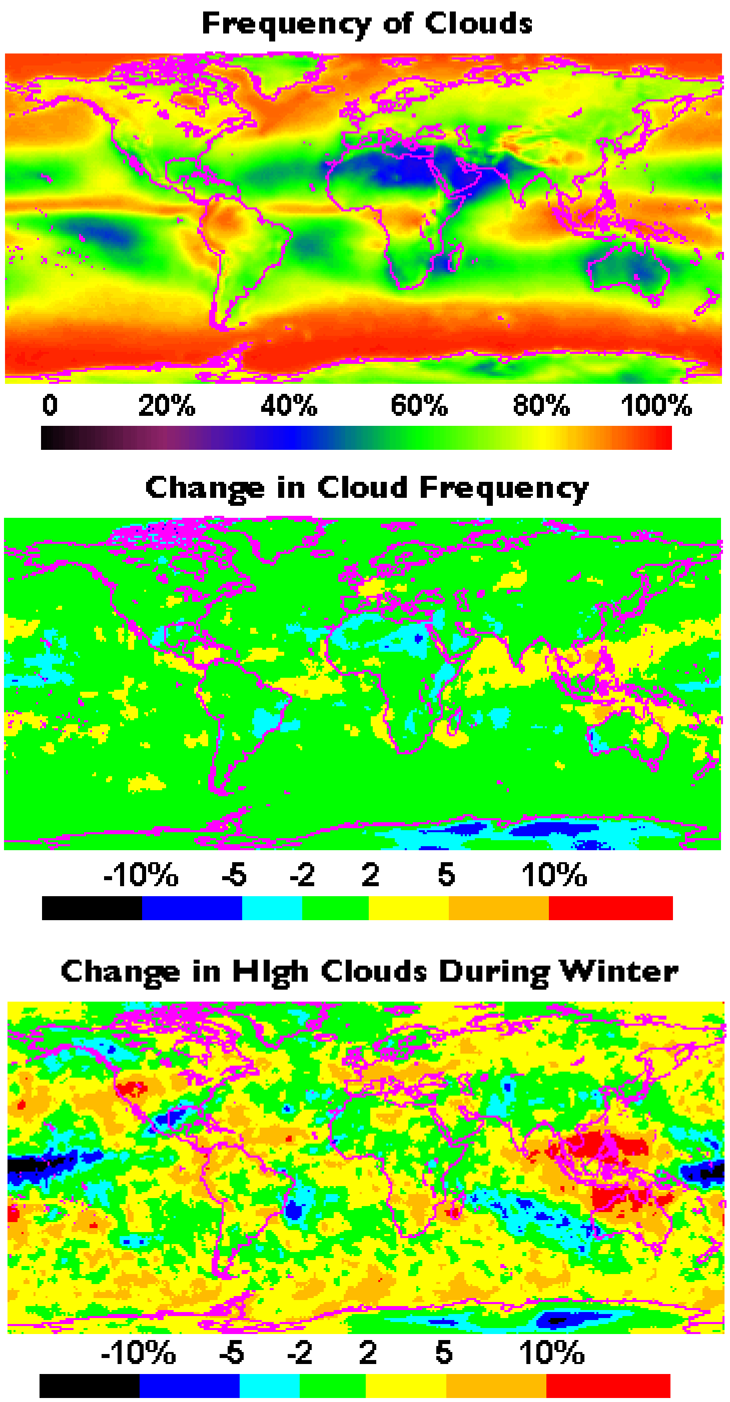


Figure 2: Change in cloud frequency from the 1980s to the 1990s (90s minus 80s).

as central and western North America and Europe, as well as areas of rare air traffic, such as the Southern Ocean around Antarctica. Changes in high cloud cover appear to be caused by larger weather systems.

Figure 1 shows the globally averaged frequency of cloud detection (excluding the poles where cloud detection is less certain) has stayed relatively constant at 75%; there are seasonal fluctuations but no general trends. High clouds in the upper troposphere (above 6 km) are found in roughly one third of the HIRS measurements; a small increasing trend of ~ 2% per decade is evident.

A surprising feature of these data is that the globally averaged cloud cover has shown little change in spite of dramatic volcanic and El Nino events (see Figure 2). During the four El Nino events winter clouds moved from the western Pacific to the central Pacific Ocean, but their global average in the tropics did not change. El Chichon and Pinitubo spewed volcanic ash into the stratosphere that took 1-2 years to fall out, but cloud cover was not affected significantly.

HIRS data reprocessing is underway in order to mitigate several known issues. These include (a) using simultaneous nadir overpasses on HIRS to extend the Earth Observing System calibration back to 1979 and thus establish a consistent calibration record, (b) developing and implementing improvements to radiative transfer models used in the data reduction, (c) allowing O_3 as well as CO_2 concentrations to change over time and location, (d) using surface emittance maps to better evaluate clear sky radiances, (e) refining radiance adjustments to mitigate calculated versus measured differences, and (f) using CO_2 slicing for all ice clouds and infrared window determinations for all water clouds. It is anticipated that with these improvements in the HIRS data processing, the decadal changes in cloud cover can be mapped more accurately.

Paul Menzel
Don Wylie

Unraveling the Mysteries of the Arctic: A New Look at the Changing Climate

Nowhere is climate change more evident than at Earth's poles as less and less sea ice cover appears each year. In September 2007 the Arctic experienced a record minimum sea ice extent. In an effort to understand what is happening at the Earth's surface, scientists have turned to the sky for answers. Using satellite data from the past 25 plus years, SSEC scientists have been looking at the trends and spatial variability in cloud cover in the Arctic and how that may relate to changes at the surface.

Using data from the Advanced Very High Resolution Radiometer (AVHRR) from 1982-2004, scientists have created the extended AVHRR Polar Pathfinder product to investigate Arctic surface, cloud and radiation properties. The product's algorithms were created by Jeff Key, a NOAA scientist stationed at SSEC, and later refined by Xuanji Wang (SSEC). Key, Wang, and SSEC colleague Yinghui Liu examined the data to look for identifiable trends.

To their surprise a distinct cooling was noted in the central Arctic in winter. That unexpected trend was initially suspected as an error in data processing, because the general scientific consensus was that the Arctic had been warming over the last few decades. However, after consulting other datasets, SSEC scientists were able to verify that the central Arctic was indeed cooling strongly in winter.

Not only has the Arctic cooled in the winter, it has become less cloudy. Wintertime cloud cover has decreased at an annual rate of –0.60%; most of the decrease has been noted over the central Arctic Ocean north of 80˚N where the annual rate is –1.2%. In contrast, the Arctic has warmed and become cloudier in the spring and summer, with cloud fraction increases at 0.32% and 0.16%, respectively. Overall, on an annual time scale the seasonal trends more or less cancel, resulting in no cloud fraction trend over most of the Arctic. Consequently, examining trends on regional and seasonal time scales becomes critical.

As a way to explain the decreased cloud cover in winter, Liu, Key, and Wang investigated the trends in cyclonic activity and the relationship between cyclones and cloud cover. While the trends at the Arctic are not as clear cut as in the mid-latitudes, they did note that in the winter a decrease in cyclones and a decrease in moisture led to a decrease in clouds, which led to the decreasing surface temperatures. Over the Arctic Ocean north of 60˚N, there is a strong decreasing trend in precipitable water (PW) during winter at an annual rate of –0.0001 cm. During spring, summer, and autumn, PW has been increasing in this region at annual rates of 0.0014 cm, 0.0030 cm, and

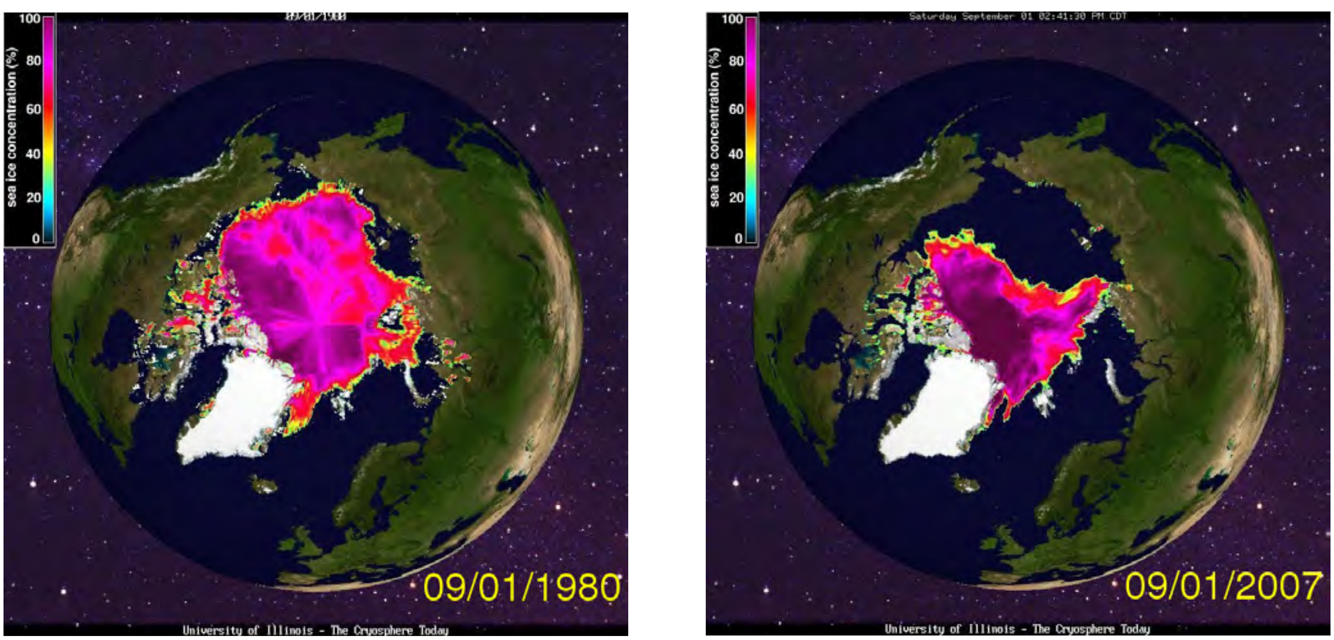


Figure 1: Contrast in sea ice concentration over the Arctic on 1 September 1980 and 1 September 2007. Images courtesy of the University of Illinois.

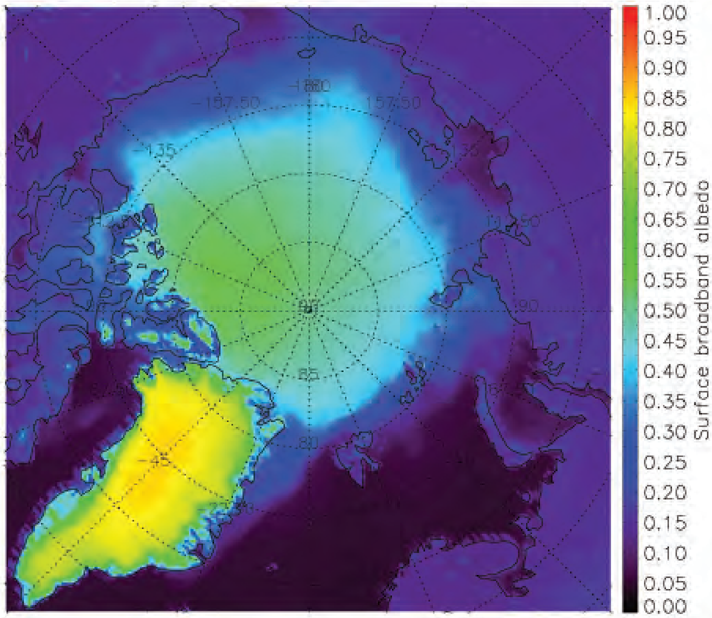


Figure 2: Satellite-derived surface albedo of the Arctic during August, averaged over the period 1998 - 1994.

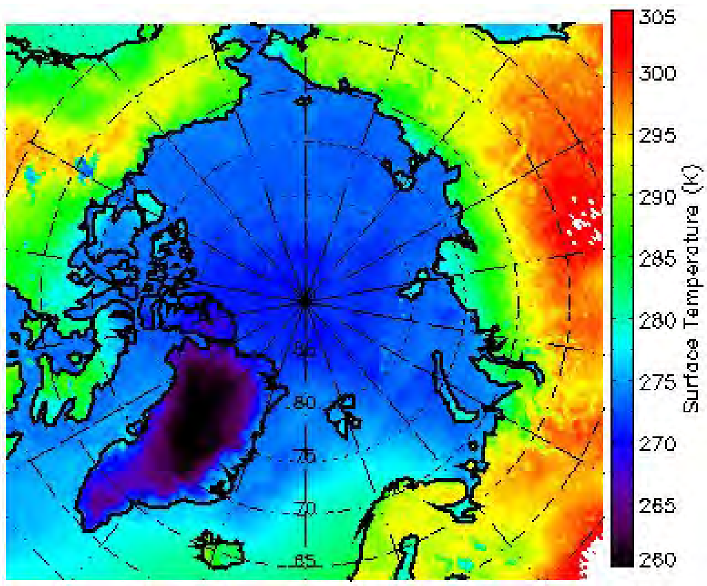


Figure 3: Satellite-derived surface temperature over the Arctic during June, averaged over the period 1982 - 1994.

0.0021 cm, respectively. Furthermore, reduced cloud amounts over the Nansen Basin and parts of the Barents and Kara Seas have led to decreased cloud cover over the entire central Arctic because less cloud cover is advected to other regions.

Despite trends in cloud and surface properties, no significant trends in the net radiation budget were found. During spring and summer, changes in sea ice albedo that result from surface warming tend to modulate the radiative effect of increasing cloud cover. The increase in springtime cloud cover amount radiatively balances changes in surface temperature and albedo, but during summer, fall, and winter cloud forcing has tended toward increased cooling. Consequently, if seasonal cloud amounts had not changed the way they did (increasing in spring and summer but decreasing in winter), surface warming would have been even greater than what was observed.

The record minimum sea ice case of 2007 provides another opportunity for scientists to look at the relationship between clouds and the surface. What impact did the clouds have or how were the clouds impacted? If there is less ice, more water is exposed, leading to more evaporation and more moisture in the atmosphere, which could lead to greater cloud cover. However, other factors may have led to greater cloud cover over the areas of minimum sea ice: increased moisture advection into those regions or increased cyclonic activity. Despite research to date, the answers are unclear.

Other questions pertinent to understanding the trends in the Arctic remain. What exactly are the interactions between cloud cover, sea ice, and moisture advection? Why did cloud cover change with changes in cyclonic activity? In addition, while past research has looked at the relationship between groups of parameters, SSEC scientists would like to spend more time examining the larger picture. The Arctic is expected to be ice free in the summer relatively soon. Understanding the processes taking place will allow scientists to help predict what will happen in the future.

Leanne Avila
Jeff Key

Highlights of Recent Publications

Global Moderate Resolution Imaging Spectroradiometer (MODIS) cloud detection and height evaluation using CALIOP.

J. Geophys. Res., 113, 2008, doi:10.1029/2008JD009837.

Holz, R. E., S. A. Ackerman, F. W. Nagle, R. Frey, S. Dutcher, R. E. Kuehn, M. A. Vaughan, and B. Baum

A global 2-month comparison is presented between the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) and the Moderate Resolution Imaging Spectroradiometer (MODIS) for both cloud detection and cloud top height (CTH) retrievals. To facilitate the comparison, a computationally efficient and accurate collocation methodology is developed. With the collocated MODIS and CALIOP retrievals, nearly instantaneous comparisons are compiled regionally and globally. Globally, it is found that the MODIS 1-km cloud mask and the CALIOP 1-km averaged layer product agreement is 87% for cloudy conditions for both August 2006 and February 2007. For clear-sky conditions the agreement is 85% (86%) for August (February).

Synergistic use of AIRS and MODIS radiance measurements for atmospheric profiling.

Geophys. Res. Lett., 35, 2008, doi:10.1029/2008GL035859.

Liu, C.-Y., J. Li, E. Weisz, T. J. Schmit, S. A. Ackerman, and H.-L. Huang

Retrieval of atmospheric profiles from combined radiance measurements of the Atmospheric InfraRed Sounder (AIRS) and the MODerate resolution Imaging Spectroradiometer (MODIS) onboard the NASA Aqua satellite is investigated. The collocated operational MODIS cloud mask product and the clear-sky infrared radiance measurements are used to characterize the AIRS sub-pixel cloud fraction and improve the atmospheric sounding and the surface parameters at the AIRS single field-of-view (SFOV) resolution.

The GOES-R Advanced Baseline Imager and continuation of current sounder products.

Journal of Applied Meteorology and Climatology, v.47, no.10, 2008.

Schmit, T. J., J. Li, J. J. Gurka, M. D. Goldberg, K. J. Schrab, J. L. Li, and W. F. Feltz.

The first of the next-generation series of Geostationary Operational Environmental Satellites (GOES-R) is scheduled for launch in the 2015 time frame. One of the primary instruments on GOES-R, the Advanced Baseline Imager (ABI), will offer more spectral bands, higher spatial resolution, and faster imaging than does the current GOES Imager. Measurements from the ABI will be used for a wide range of qualitative and quantitative weather, land, ocean, cryosphere, environmental, and climate applications.

The temporal evolution of convective indices in storm-producing environments.

Weather and Forecasting, v.23, no.5, 2008.

Wagner, T. J., W. F. Feltz, and S. A. Ackerman.

Temporal changes in stability and shear associated with the development of thunderstorms are quantified using the enhanced temporal resolution of combined Atmospheric Emitted Radiance Interferometer (AERI) thermodynamic profile retrievals and National Oceanic and Atmospheric Administration (NOAA) 404-MHz wind profiler observations. From 1999 to 2003, AERI systems were collocated with NOAA wind profilers at five sites in the southern Great Plains of the United States, creating a near-continuous dataset of atmospheric soundings in both the prestorm and poststorm environments with a temporal resolution of up to 10 min between observations.

Deriving atmospheric temperature of the tropopause region-upper troposphere by combining information from GPS radio occultation refractivity and high-spectral-resolution infrared radiance measurements.

Journal of Applied Meteorology and Climatology, v.47, no.9, 2008.

Borbas, E. E., W. P. Menzel, E. Weisz, and D. Devenyi.

Global positioning system radio occultation (GPS/RO) measurements from the Challenging Minisatellite Payload (CHAMP) and Satelite de Aplicaciones Cientificas-C (SAC-C) satellites are used to improve tropospheric profile retrievals derived from the Aqua platform high-spectral-resolution Atmospheric Infrared Sounder (AIRS) and broadband Advanced Microwave Sounding Unit (AMSU) measurements under clear-sky conditions. This paper compares temperature retrievals from combined AIRS, AMSU, and CHAMP/SAC-C measurements using different techniques.

McIDAS-V Reaches Beta

A team of SSEC software developers has been collaborating with groups of scientists on the development of McIDAS-V, the fifth generation of the Man computer Interactive Data Access System. McIDAS-V is a Java-based, open-source, freely available data analysis and 3-D visualization system that continues the strong McIDAS support for atmospheric scientists. New capabilities and features support multispectral and hyperspectral researchers and algorithm developers, providing powerful new data manipulation and visualization tools.

McIDAS-V provides expanded capability and performance to support innovative techniques for developing and evaluating algorithms, visualizing data and products, and validating results. The McIDAS-V data analysis and visualization system will support both researchers and operational users of the advanced measurement systems on MetOp, NPP/NPOESS and GOES-R, while also providing a “bridge” to support current McIDAS-X users to easily migrate to the new software environment.

In the figure, for example, groups of pixels can be selected in the scatter plot (boxes) and color enhanced on the imagery, identifying specific features. For example, cold 11μm brightness temperature and high reflectance indicate thunderstorm clouds (green); midrange 11μm brightness temperatures and slightly lower reflectance show mixed but thick cumulus and some clear sky (blue), and warm 11μm brightness temperatures and low visible reflectance show warm land surface in the high plains (magenta). Groups of pixels can also be identified on the image (box in northwest Oklahoma) and colorized in the scatter plot. This HYDRA capability within McIDAS-V allows detailed interrogation of spectral data and is also valuable for education and training.

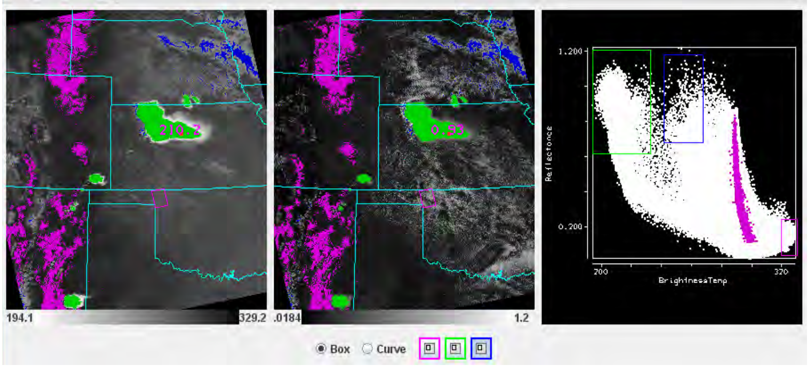


Figure 1: MODIS IR window channel (band 31 - left) and visible channel (band 1 - middle) with scatter plot of visible reflectance vs. IR brightness temperature (right).

McIDAS-V software, training exercises and data sets, and additional information can be found at the McIDAS-V website (http://www.ssec.wisc.edu/mcidas/software/v/).

A user forum has been set up (http://www.ssec.wisc.edu/mcidas/forum/) where McIDAS-V users can browse and post questions, ideas, and technical help. Users should be aware that this is a beta version of the software, which means that the software may contain bugs and not always work as expected. The beta release of McIDAS-V follows 2 years of “alpha” development, and many new features have been incorporated to reach beta.

Tom Achtor
Becky Schaffer

Honors and Awards

Chris Velden
Named to the AMS Committee on Data Stewardship.
Chaired the AMS Annual Meeting in New Orleans.

Wayne Feltz
Co-chair and Natural Hazard Session Chair of the Satellite Meteorology and Oceanography Conference at 89th Annual AMS meeting in Phoenix, Arizona, January 2009.

Ed Eloranta
Named Fellow of the Optical Society of America.

Tom Whittaker
Named as co-chair of the AMS IIPS Conference.

Tim Schmit and Paul Menzel
Shared in a Group Achievement Award from NASA as part of the GOES-N Series Team.

Chian-Yi Liu
Received Graduate Student Mentor Award from the UW-Madison Graduate School.

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