through the atmosphere

Summer / Fall 2015

SPECIAL ISSUE

Our first 50 years, 1965-2015

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

Director's note

This year marks the 50th anniversary of the Space Science and Engineering Center (SSEC) and 100 years since the birth of Verner E. Suomi. In recognition, our summer issue of *Through the Atmosphere* celebrates the pioneering accomplishments of SSEC during its first 50 years and foreshadows future innovations that will succeed them into the next 50.

The serendipity that these two monumental milestones, 50 and 100, should take place in 2015 is appropriate for SSEC, the progeny of both national and international forces as well as Suomi's rare mind and personality. At the 30th anniversary of Sputnik in Moscow, Suomi acknowledged that the stimulus for advancing space-borne technology in the United States was fueled by the success of the first man-made satellite.

"Spasibo Sputnik!" Suomi exclaimed, expressing his gratitude to our Soviet hosts. Yes, thank you for getting us motivated.

The first article in this issue, Noteworthy Beginnings, summarizes how Suomi and others "took their bravery pills," using the resulting momentum to found SSEC and to convince the State of Wisconsin, NASA, and the National Science Foundation to support the 15-story building that has been SSEC's home on campus for most of those 50 years.

Making the Center work required not only technical and scientific skills, but also the people-sense to marshal a diverse range of talents into an effective team. Vern always said, "Find good people, and get out of their way."

The heart of this issue is a chronology of advances and applications that characterize SSEC's accomplishments over the decades. It is interesting to note that many of these activities have grown from Suomi's own work: his early exploration into net flux measurements (studying the energy budget of a corn field for his PhD thesis), his extensive space-borne earth radiation budget observations with both spherical and flat plate radiometers, his spin-scan camera imaging concept, geosynchronous time sequence imaging for wind measurements, and geostationary temperature and water vapor sounding for quantifying severe weather threats.

One thing often led to another. The desire to track clouds that were visible in satellite images led to advanced computer processing techniques, the direct acquisition of volumes of satellite data so necessary for research drove advances in data archiving, and efforts to improve the vertical resolution of satellite sounding products resulted in a new standard in accuracy for infrared radiances. The technical capability developed for one program not only enabled other programs, but also often helped them to succeed. This speaks to the strong, interdisciplinary nature of SSEC which over the years has supported scientific successes in physics, astronomy, cosmology, and geology, in addition to atmospheric sciences.

The final article, Imagining the Future, summarizes some key concepts and approaches needed for continued success: For, as we know, the goal of providing society with better weather information remains a noble challenge.

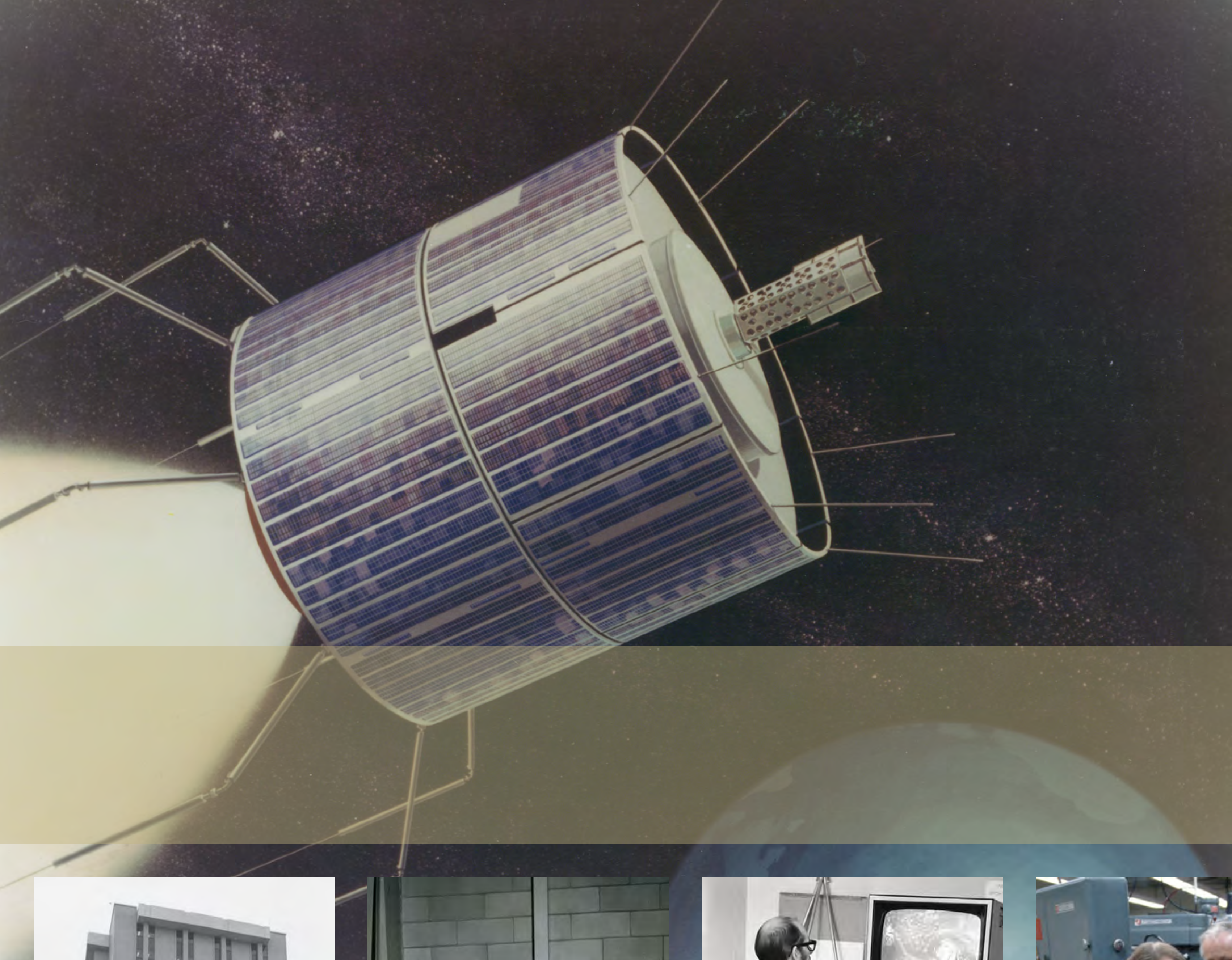
So, congratulations! And I hope you enjoy reminiscing. I think our 2015 celebrations of the last 50 years will be inspirational and help remind us that tackling the challenges facing us in the next half-century will be equally as exciting and very rewarding.

| Hank Revercomb, SSEC Director

Hank Revercomb

Below, from left to right: Hank Revercomb, Larry Sromovsky, and Verner Suomi study net-flux radiometer observations from Pioneer Venus in 1978. Credit: University of Wisconsin Communications.

Above: An aerial view of the central University of Wisconsin-Madison campus in the fall of 2013. The Atmospheric, Oceanic, and Space Sciences building, which houses SSEC, is pictured top-left. Credit: Jeff Miller, University of Wisconsin Communications.



Cover image: One of the first full-disk Earth images from Verner Suomi's Spin-Scan Cloud Camera, launched with the ATS-1 satellite in December 1966. These sequential images revolutionized scientists' ability to measure and track clouds, weather, pollution, and natural disasters. Credit: Schwerdtfeger Library, SSEC.

Top left: An artist's rendering of the ATS-3 satellite, launched in November 1967. It carried a variety of communications, meteorological, and scientific instrumentation. Credit: NASA.

Below, from left to right: View of completed building from the east. Occupants moved in October 1968. Credit: Gary Schultz, University of Wisconsin Archives.

Verner Suomi and Robert Parent with the electronic assembly for Explorer VII. Credit: University of Wisconsin Archives.

A user at the WINDCO terminal with McIDAS First Generation. Credit: University of Wisconsin Communications.

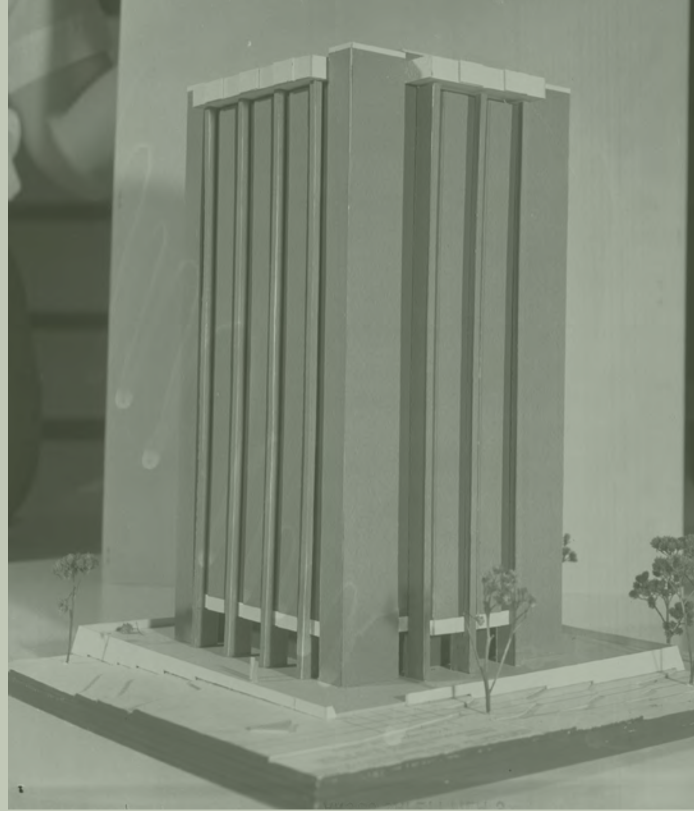
John Short, Jerry Sitzman, and Fred Best examine the High-resolution Interferometer Sounder (HIS) in the SSEC machine shop. Credit: Norman Lenburg, University of Wisconsin Archives.

Nick Ciganovich in SSEC's clean room with the Diffuse X-ray Spectrometer (DXS) proportional counter. Credit: University of Wisconsin Communications.

An artist's rendering of the Suomi NPP satellite, so named in 2012. Credit: NOAA.

Inside this issue

Noteworthy beginnings



An approved model of the Earth and Space Science Building, planned for the corner of West Dayton and North Orchard Streets. Construction was set to begin by November 1966 and completed by November 1968. Credit: University of Wisconsin Archives.

The race to space began in earnest in the fall of 1957 when the Soviet Union successfully launched Sputnik 1, placing the first satellite in Earth orbit.

This technological push sent reverberations throughout science and engineering fields, not only across the world, but across the country and specifically here in Madison, WI. As a result, the science of meteorology was gaining international importance, and the ideas for using satellite-borne instruments to explore Earth's atmosphere were becoming reality.

Two professors at the University of Wisconsin-Madison would emerge as key figures in this promising discipline. In 1957, meteorology professor Verner Suomi and engineering professor Robert Parent organized a small group of scientists and by the mid-1960s they secured formal office and laboratory space for the research group at 601 E. Main Street in downtown Madison. They wanted to obtain low-resolution measurements of the radiation budget of the earth from a satellite platform. After considerable trial and error, their instrument, designed and fabricated by university scientists and technicians, was successfully launched on Explorer VII in 1959.

By the early 1960s, the Suomi-Parent research and development programs, no longer fledgling, had grown so large that they required management and administrative support beyond that which the meteorology or engineering teaching departments could provide.

Charles Stearns (left) and Verner Suomi with the Vanguard satellite that carried Suomi's early heat balance experiment in 1959. The launch was unsuccessful. Credit: University of Wisconsin Archives.

They also needed more space and better facilities.

Noting that "Meteorology is on the move, we must decide how to move with it," Suomi, working with meteorology professors Reid Bryson, Lyle Horn, Robert Ragotzkie, and others, drafted the scientific justification for a new, multidisciplinary research facility.

In a document titled "Meteorology at Wisconsin, a Plan for the Future," the authors opined that "perhaps the most important development of the past few decades … has been the slow but steady evolution of the atmospheric sciences from an empirical – even intuitive – pursuit into an analytic discipline employing the most rigorous methods."

Also fueling the momentum for a new facility was the NASA-supported research of UW astronomy professor Arthur Code. While their research looked in different directions – Suomi, at the Earth, and Code, into space – their respective groups had pressing needs for more and better-equipped research space. As a result, the two joined forces to make the facility a reality.

In 1964, the UW achieved an agreement with NASA, the National Science Foundation, and the State of Wisconsin to support construction of a ten story building on the southeast corner of Orchard and Dayton Streets. The building was to house the Department of Meteorology and the Suomi and Code research groups. Typical of most building projects, the collaborators discussed — and negotiated — various plans and space allotments.

The vision for the Earth and Space Science Complex, as it was initially named, included an expectation that it be utilized for active space research programs, that would be conducted with assistance from Suomi's team.

The building grew to 15 stories with 133,700 square feet. True to its cross-disciplinary mission, the new facility included office space, student rooms, lecture rooms, computer rooms, machine shops, a vacuum lab, a plasma wind lab, a space biology lab, a stable isotope lab (cloud physics), conference rooms, and storage space.

Space assignments and locations were shuffled many times in pre-planning discussions. Some of those same types of discussions continue today.

The University of Wisconsin-Madison Board of Regents officially recognized the importance of this new research center at their meeting on August 20, 1965. According to the minutes, "Chancellor R. W. Fleming reported on the establishment of the Space Science and Engineering Center [SSEC] and the appointment of [meteorology] Professor Verner Suomi as the Director of the Center."

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Top left: Construction of the Earth and Space Science Complex in 1967. The Camp Randall arch is visible at the end of Dayton Street. Credit: University of Wisconsin Communications.

Bottom right: The completed building as seen from the west, overlooking the Shell. Credit: University of Wisconsin Archives.

At that time, Suomi's name was already becoming synonymous with satellite meteorology. His success in securing large grants, initially from NASA, along with his vision to explore and monitor the Earth's atmosphere using satellite technology had been noticed by the university's governing body, too.

Thus, SSEC was formed and organized within the Graduate School to continue — and expand — its research and satellite experiments at the university.

SSEC moved from its home on Main Street to its campus location at 1225 West Dayton Street on 25 October 1968 with chief technician Leo Skille managing logistics. Professor Suomi commented that "the rooms are very nice" but felt that while there was ample lab space, office space was over-committed.

The Center's first executive director, Kirby Hanson, ably met the challenges of managing a new organization. In addition to his executive duties, he rearranged room assignments, organized mail delivery (Suomi was not getting his high priority mail in a timely fashion), and wrote guidelines to ensure that exterior doors were locked at the close of every business day. One weekend, for example, a number of high school kids had the run of the building, having entered through a door that was ajar due to air pressure differences.

The building had other safety issues that needed to be addressed. The first fire drill was ignored by building occupants because the alarm — a bell with a "rather deep, raucous sound" — was not recognized as an emergency bell. In addition, the alarm indicating a stuck or stalled elevator sounded very much like a class bell and it, too, was ignored.

Soon, however, most issues were resolved and the new occupants resumed their education and research activities with renewed vigor.

The lab rooms were quickly filled with engineers constructing and testing the flat plate radiometers slated for the ESSA, TIROS, and NOAA-1 satellite missions. The roof would soon be adorned with a large antenna to receive data from the geostationary satellites that carried the Suomi-Parent Visible Infrared Spin Scan Radiometer (VISSR). This single installation multiplied into the antenna farm of today where data from all systems — satellite, ship, balloon, model — enter the building for analysis and archive.

A few years later in the 1970s, the computer room housed the Man-computer Interactive Data Access System (McIDAS, "not a Scotsman but a bargain") that consisted of a modest Harris/5 processor. The first of its kind, the system was designed to animate, display, and analyze data from geostationary satellites.

Subsequent executive directors Tom Haig, Fred Mosher, and Bob Fox navigated SSEC through the decades. Major programs included GATE, SESAME, FGGE, TIROS-N, MONEX, VAS, STORM, HIS, AERI, GHIS, IHOP, … (if you know all of these acronyms you have been here a long time).

Partnerships between federal agencies and universities were proving to be advantageous to research endeavors in science, and remote sensing was no different. To further encourage those partnerships, Bill Smith, then a National Environmental Satellite Service (NESS) scientist, moved the NESS Systems Applications Laboratory from Washington DC to Madison in 1976 to work alongside Suomi's growing teams. The formation of the Cooperative Institute for Meteorological Satellite Studies within SSEC followed in 1980. And NASA, NOAA, and the UW agreed to work cooperatively as long as it was mutually beneficial.

It still is. The plaque in the lobby commemorates the building dedication in October 1969 — words as meaningful today as they were then:

"This building, dedicated to the understanding of man's physical environment and its use for the benefit of mankind, was provided by the people of the State of Wisconsin and of the nation through the National Aeronautics and Space Administration and the National Science Foundation."

| W. Paul Menzel and Jean Phillips

Robert Parent (left), Verner Suomi (second from left), and colleagues view ATS photos made possible by the Spin-Scan Cloud Camera. Credit: University of Wisconsin Communications.

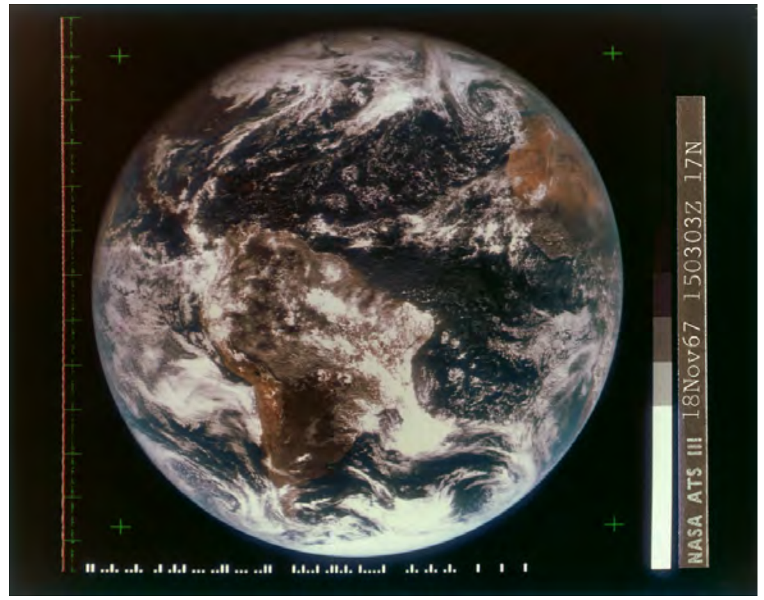
1950s-60s: First images of Earth

The science and technology of meteorology were very much in their infancy in the early 1950s. Verner Suomi, Robert Parent, and their team of scientists and engineers at the University of Wisconsin-Madison were determined to revolutionize the ways in which we looked at the Earth and its atmosphere. Ideas rapidly became concepts, which were transformed into prototypes, which led to successful operational instruments flying on satellites: from their first thermal radiation experiment success on Explorer 7 to increasingly sophisticated sensors on ATS and TIROS. We were no longer bound to observe the Earth from the ground.

In this new era of geostationary satellites, scientists were now able to observe weather systems moving through space and time. SSEC scientists were at the forefront of studying cloud motions and creating the earliest winds products. Indeed, they provided the proof-of-concept. Reacting to images from the Spin-Scan Cloud Camera he and Parent conceived of for the first geostationary satellite, Suomi famously said, “the weather moves, not the satellite.”

Suomi would soon be honored with the title “Father of Satellite Meteorology” for his enduring contributions to the field he helped to establish.

| Leanne Avila



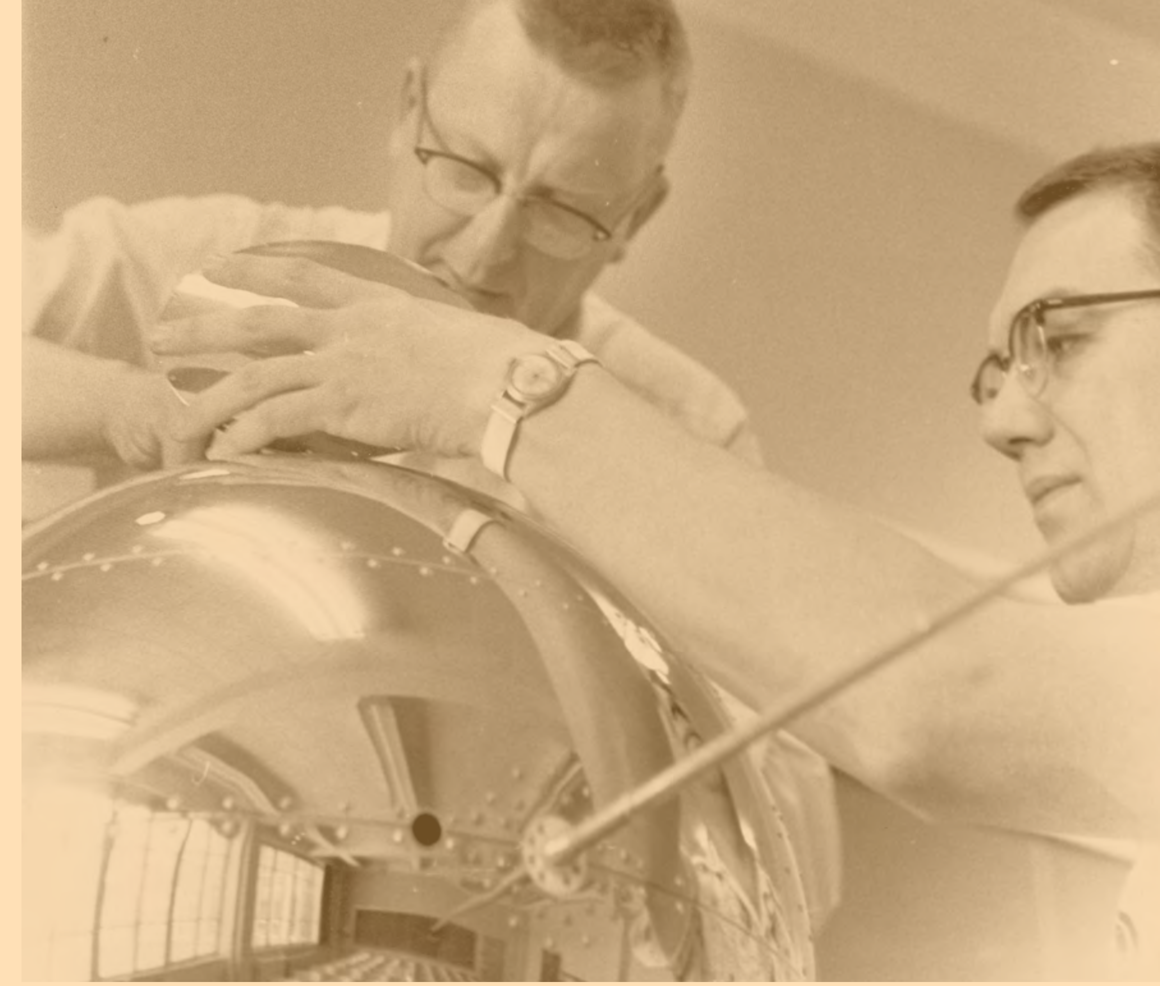
An early image of Earth taken with the Multicolor Spin-Scan Cloud Camera (MSSCC) on ATS III in 1967. Credit: NASA.

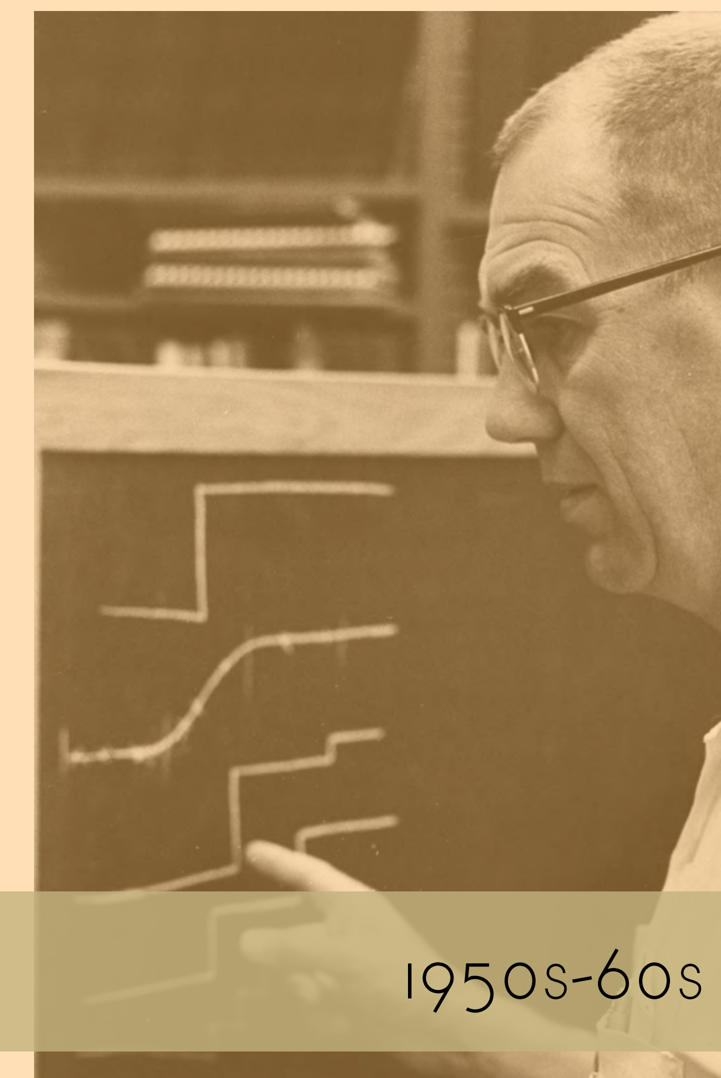
From left to right: Robert Shaw, Victor Starr (kneeling), H. C. S. Thom, Verner Suomi, and W. H. Pierre examine instruments to measure heat, moisture, and wind in the microclimate of a cornfield in Ames, Iowa, in 1947. Credit: Iowa State College Experiment Station.

Top right: Verner Suomi and Robert Parent examine the Vanguard satellite in 1959. Credit: University of Wisconsin Archives.

Bottom right: Robert Parent. Credit: University of Wisconsin Archives.

Bottom left: Verner Suomi (left) and Herman LeGow (right) examine the Explorer VII satellite prior to its launch into orbit from Cape Canaveral, Florida, in 1959. Credit: NASA.





The Pioneer Venus net flux radiometer instrument team. Last row, from left: Evan Richards, Gene Buchholz, Bob Herbsleb, Wanda Lerum, Jerry Sitzman, Hank Revercomb. First row, from left: Doyle Ford, Tony Wendricks, Ralph Dedecker, Verner Suomi, Larry Srmovosky, Bob Sutton. Credit: SSEC.

1970s: Revolutions in imaging

The geostationary imaging of weather systems first made possible in the 1960s set yet another revolution in motion: the need for a robust, computer-based method to generate winds from tracking cloud motions and tools to animate and analyze these images. SSEC developed a prototype system known as Windco that would evolve into the Man-computer Interactive Data Access System (McIDAS). The latest generation of McIDAS continues to provide users with a powerful way to display, analyze, interpret, acquire, and manage geophysical data.

Observations and data are crucial to scientific advances – the more data the better. With this in mind, SSEC scientists sought to establish global scientific collaborations through which they would share data, culminating in several of the largest field experiments to date, the GARP Atlantic Tropical Experiment (GATE) and the First GARP Global Experiment (FGGE), with key planning and participation from SSEC scientists. A testament to our growing data management expertise, SSEC was selected to become the national archive for geostationary satellite data.

As our knowledge about Earth grew, Suomi and his fellow investigators at SSEC began to look beyond our planet to other planets in our solar system. They measured winds from cloud motions on Venus to learn about the planet's circulation patterns and built small probe net flux radiometers for the Pioneer Venus mission to study its atmospheric radiative properties and climatology. The planetary meteorology group at SSEC, led by Suomi, also participated on science teams for Voyager 1 and 2, which had set their sights on observing Jupiter and Saturn. These missions offered an opportunity for scientists to compare and contrast these new planetary observations with what we already knew of Earth's atmosphere and climate.

Recognizing the promise of geostationary imaging and sounding capabilities, SSEC played a significant role in developing the Visible/Infrared Spin-Scan Radiometer (VISSR) Atmospheric Sounder (VAS) for the early Geostationary Operational Environmental Satellites (GOES). With an eye toward developing processing techniques for VAS data, as well as future sounding improvements, Suomi and David S. Johnson, head of the National Environmental Satellite Service, moved Bill Smith's group of NOAA scientists to Madison to work side-by-side with university scientists. In 1980, VAS would demonstrate, for the first time, an atmospheric sounding capability from geosynchronous orbit and would influence future generations of sensors.

| Leanne Avila

Left: Verner Suomi writing on a blackboard in 1973. Credit: University of Wisconsin Archives.

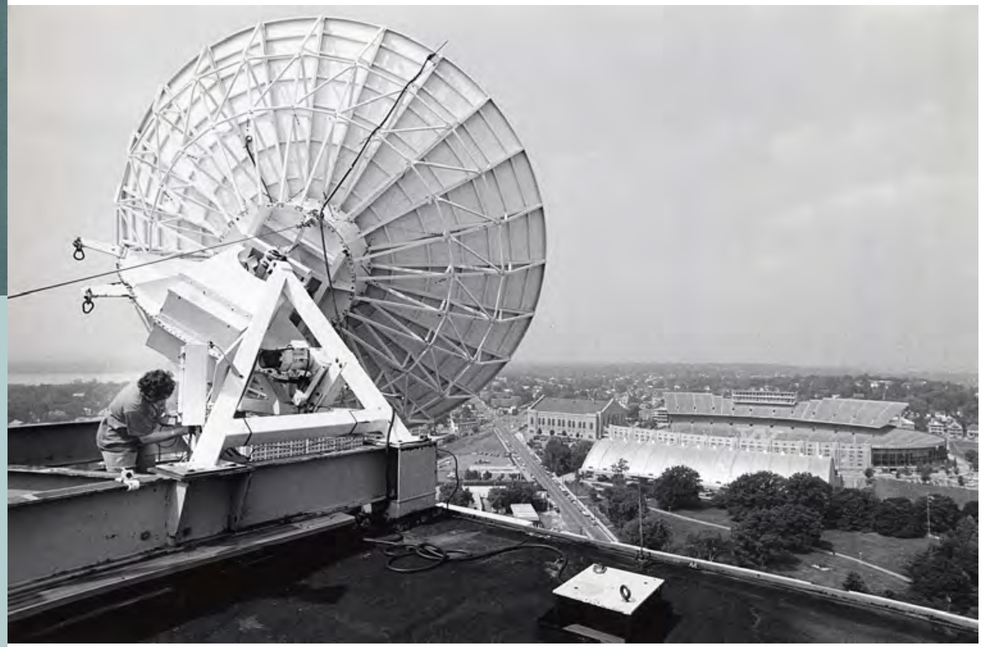
Center: A technician installs an early antenna on the roof of the AOSS building. Credit: University of Wisconsin Archives.

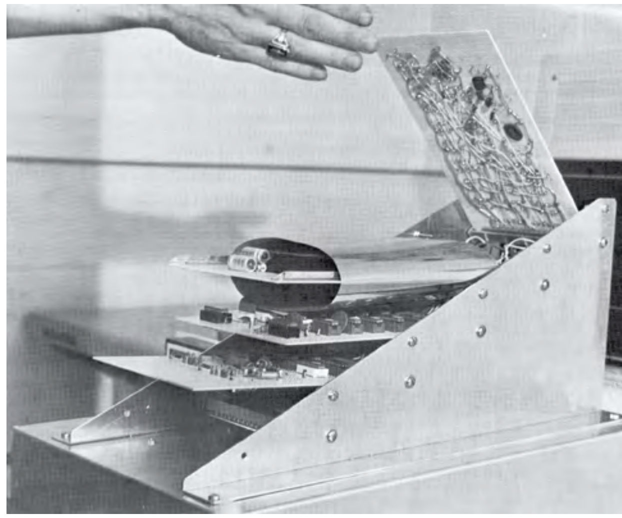
Top right: Jim Maynard and Joanne Banks test computer parts for the McIDAS system. Credit: University of Wisconsin Office of Information Services.

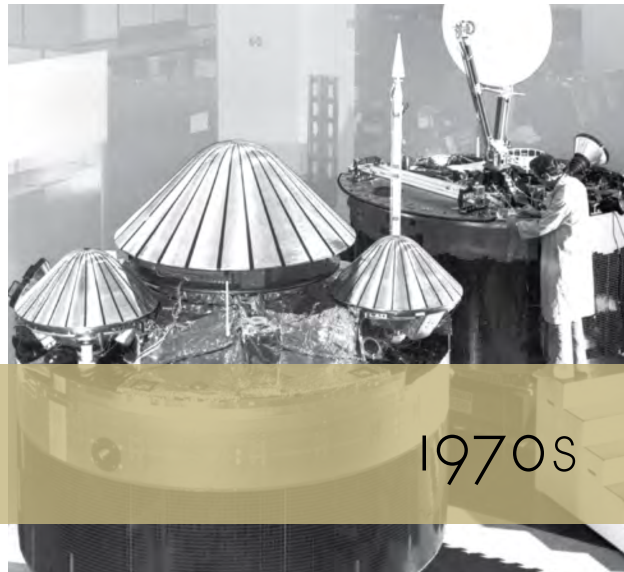
Middle right: Breadboard electronics for the McIDAS display system. Credit: SSEC.

Bottom right: A technician works on the Pioneer Venus orbiter in 1978. Credit: University of Wisconsin Archives.

Bottom left: Tom Haig (left) and Verner Suomi next to an early interactive meteorological processing and display system in 1973. Credit: Edwin Stein, Wisconsin State Journal.







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

1980s: Legendary partnerships

Collaborations established in the 1970s were strengthened, particularly with the National Oceanic and Atmospheric Administration (NOAA). This mutually beneficial partnership resulted in the formation of the Cooperative Institute for Meteorological Satellite Studies (CIMSS) within SSEC in 1980; the partnership would expand to include the National Aeronautics and Space Administration (NASA) in 1989. CIMSS remains dedicated to conducting remote sensing research for meteorological and surface-based applications.

Building on its engineering expertise, SSEC continued its contributions to spaceflight hardware design with a net flux radiometer for the Galileo mission to study Jupiter, broadening the exploration of planetary atmospheres.

SSEC engineers also developed their first aircraft instrument, the High-resolution Interferometer Sounder (HIS), and with it demonstrated the utility of high spectral resolution soundings of the atmosphere – measuring infrared spectra with unprecedented accuracy. The HIS ultimately became a workhorse for numerous field campaigns across the atmospheric sciences due to its value as a calibration and validation standard for aircraft and satellite observations.

With ever increasing amounts of data to process and analyze, SSEC focused efforts on improving McIDAS, to meet the growing demands of users across the country and around the globe. As McIDAS emerges onto the world scene, many international organizations and agencies select it as their primary visualization tool.

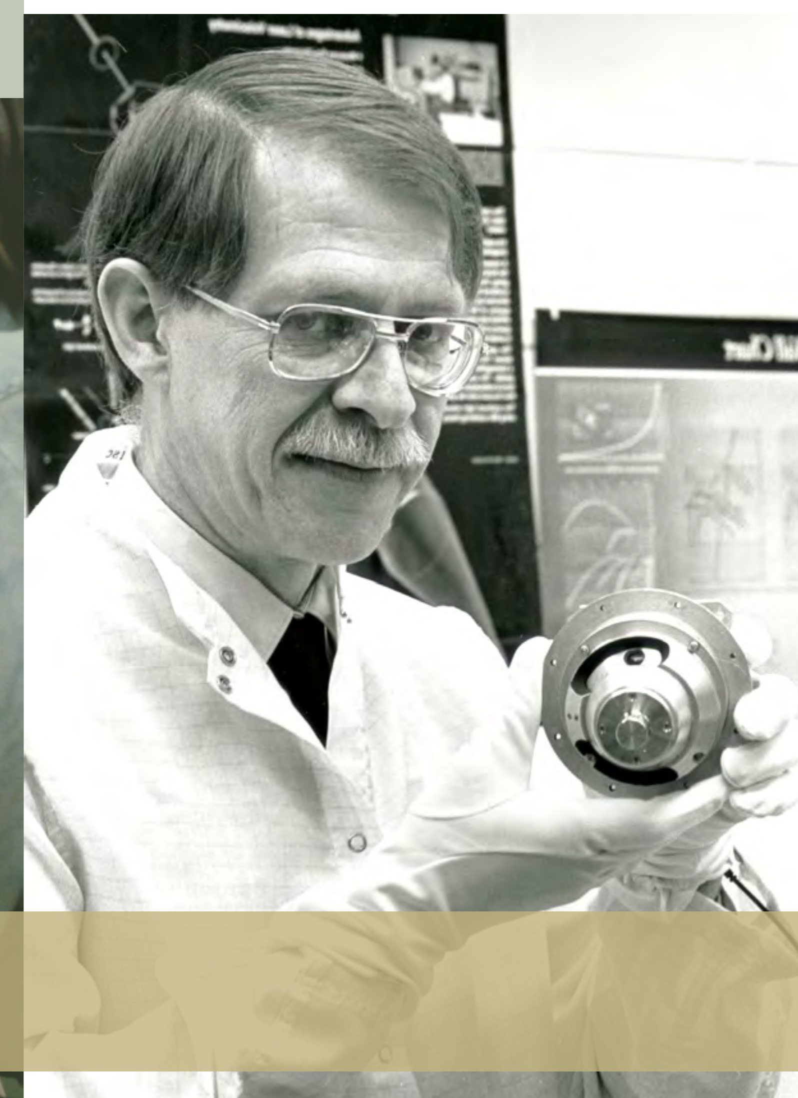
Toward the end of the decade, Suomi retired as SSEC director and Francis Bretherton replaced him in that role. Bretherton's leadership was central to defining the NASA Earth Observing System (EOS) science plan that laid the groundwork for coordination among all aspects of earth science – land surface, oceans, and atmosphere – to improve our understanding of global climate.

| Leanne Avila

Above, from left to right: Bob Herbsleb, Fred Best, Bill Zmek, and John Short with the High-resolution Interferometer Sounder (HIS) at an airfield. Credit: University of Wisconsin Photo Media.

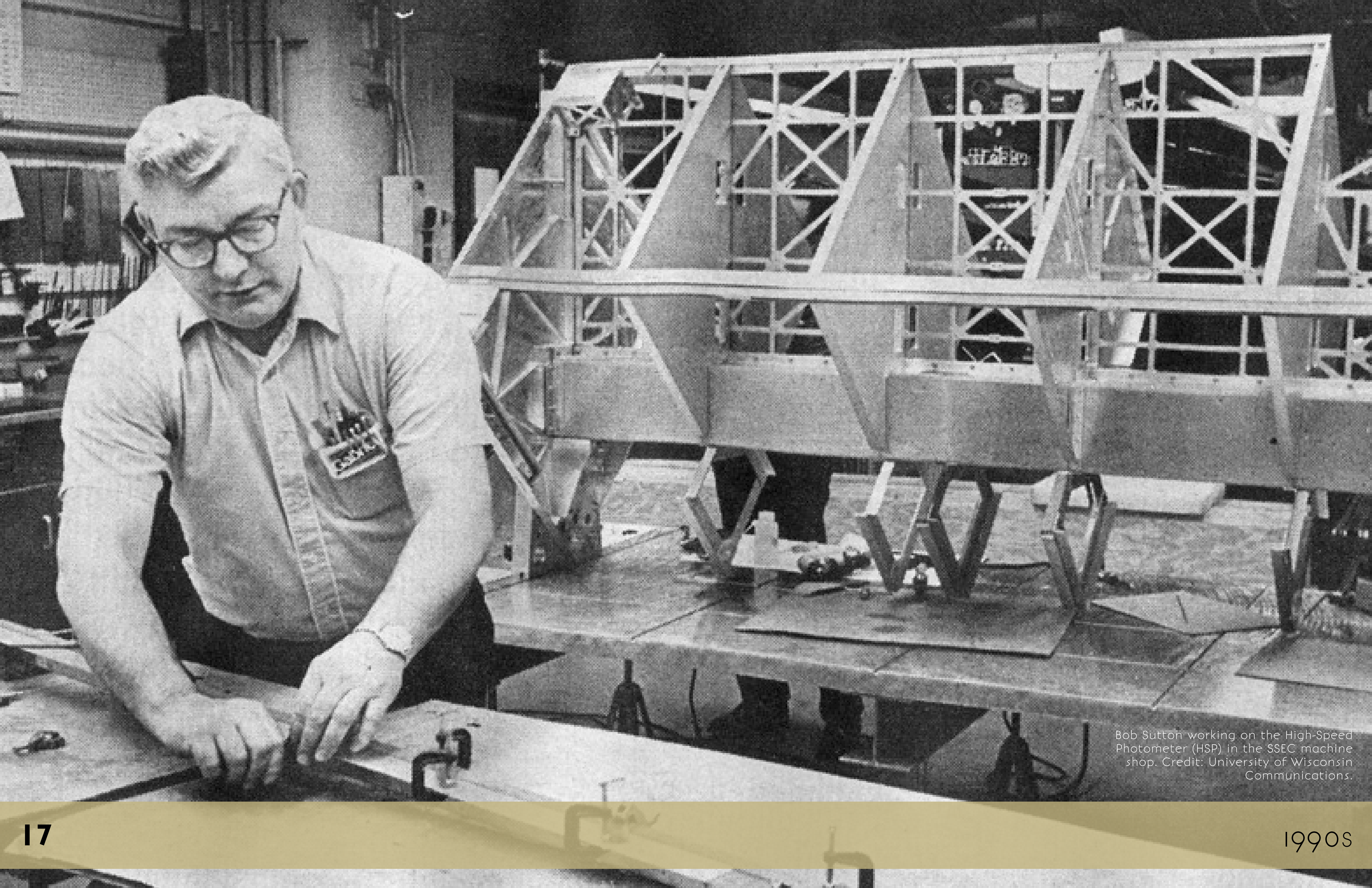
Top right: Verner Suomi (left, UW Meteorology), Jerry Normberg (center, Astronautics Corp), and William Birkmeier (right, UW Electrical Engineering) examine the wind profiler in 1987. Credit: University of Wisconsin Archives.

Larry Sromovsky, Sanjay Limaye, and Bob Krauss examine interplanetary photographs at SSEC in 1986. Credit: Norman Lenburg, University of Wisconsin Archives.



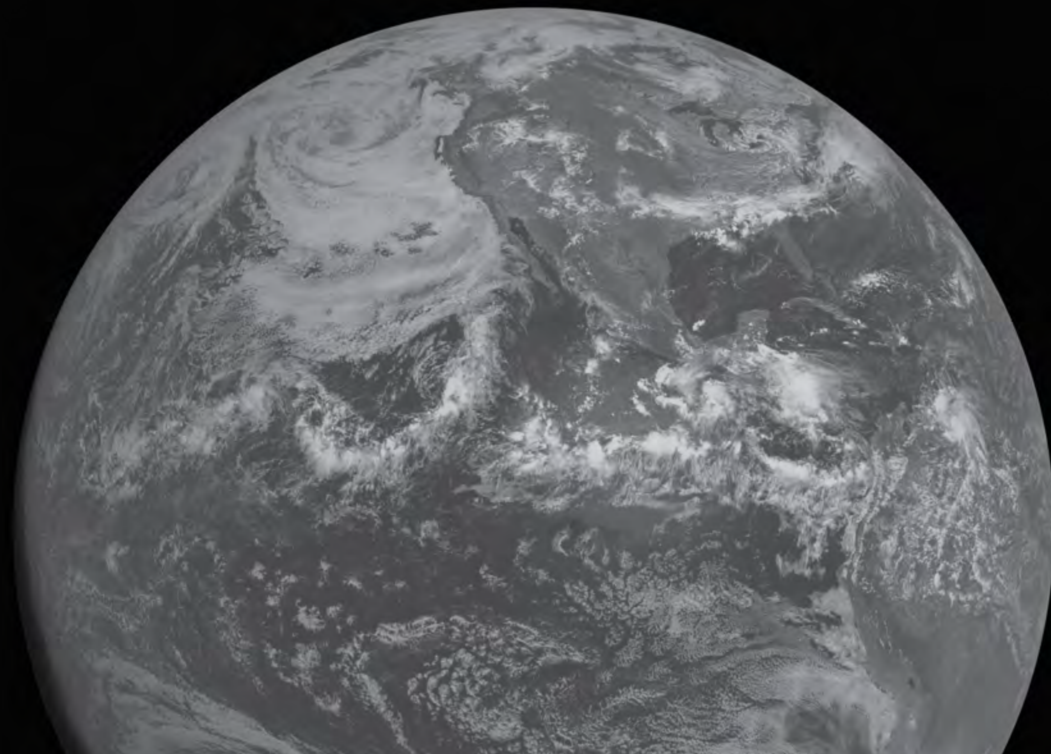
Bottom right: Verner Suomi and Robert Fox in 1986. Credit: Norman Lenburg, University of Wisconsin Archives.

Bottom left: Larry Sromovsky holding the net flux radiometer in 1989. Credit: SSEC.



Bob Sutton working on the High-Speed Photometer (HSP) in the SSEC machine shop. Credit: University of Wisconsin Communications.

1990s: Space-age technology



GOES-7 visible image from August 7, 1993. Credit: CIMSS.

SSEC's engineering expertise in spaceflight hardware continued to be in demand, achieving a number of high-profile successes: from the High Speed Photometer (HSP) flown on the Hubble Space Telescope, to the Diffuse X-ray Spectrometer (DXS) flown on a space shuttle mission, to the Adiabatic Demagnetization Refrigerator (ADR) flown on the Astro-E satellite, a joint Japanese-NASA X-ray astronomy project.

Closer to home, SSEC's participation in scientific field campaigns soared in the 1990s. From the Arctic to the Antarctic and the Atlantic to the Pacific, our scientists traveled the globe to participate in studies of hurricanes, atmospheric water vapor and radiation, tropical atmospheres, and Arctic, cirrus, and winter clouds – and many more.

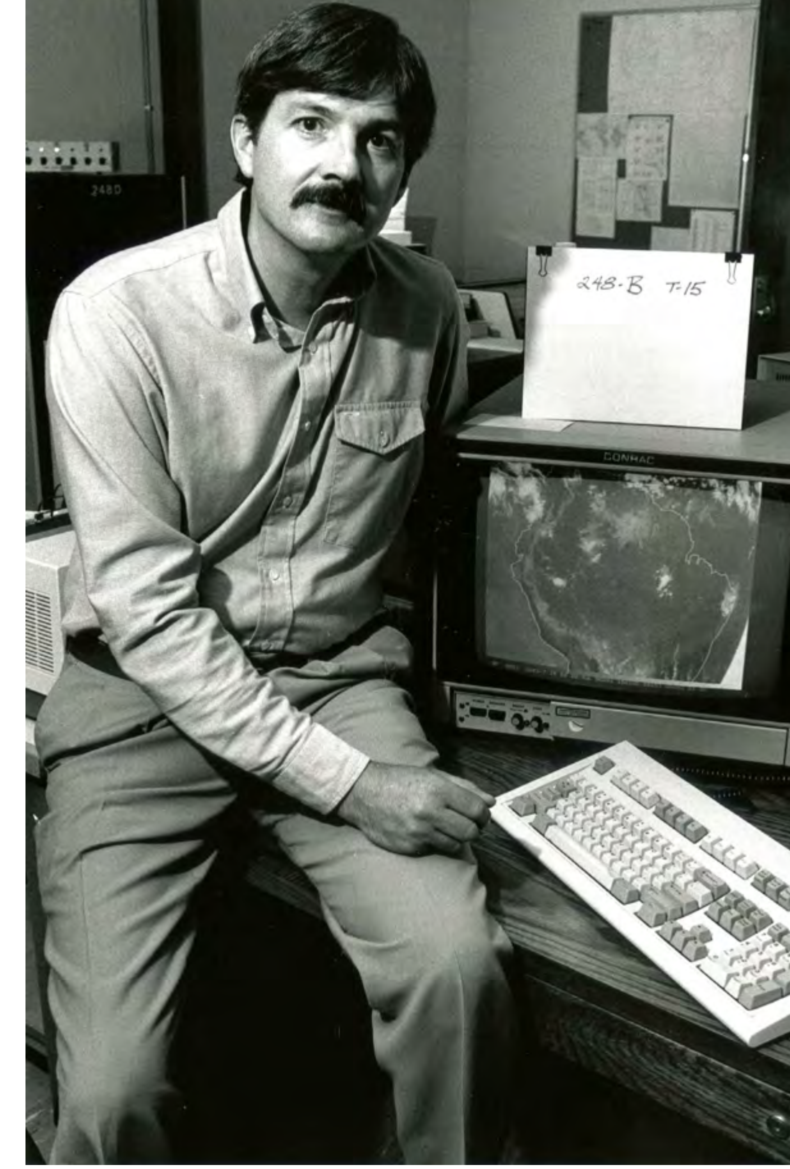
In addition to flying the HIS, SSEC engineers developed and built a more advanced version known as the Scanning HIS (S-HIS). The S-HIS proved its worth, delivering hyperspectral infrared radiances with very high accuracy and low noise, setting the stage for more sophisticated hyperspectral sounder development and testing.

To augment the data collected from its aircraft instruments, SSEC designed and fabricated its first ground-based instrument, the Atmospheric Emitted Radiance Interferometer (AERI) — in principle, a HIS instrument turned upside down. Measuring temperature and water vapor profiles, as well as trace gases, the AERI became a critical component to establishing a long-term climate record for the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program. SSEC would go on to build a Marine AERI system for measuring ocean temperature and emissivity.

The decade would push the boundaries of new satellite instrument development, advanced sounding capabilities, and data acquisition, all of which remained cornerstones of SSEC's research endeavors.

SSEC scientists continued to influence the evolution of instruments developed for NASA's EOS missions, especially the Atmospheric Infrared Sounder (AIRS) and the Moderate Resolution Imaging Spectroradiometer (MODIS). At the same time, SSEC, with industrial partners, designed an advanced sounder for NOAA operations that would ultimately be realized in the Cross-track Infrared Sounder (CrIS) carried on the Suomi National Polar-orbiting Partnership (NPP) satellite.

| Leanne Avila

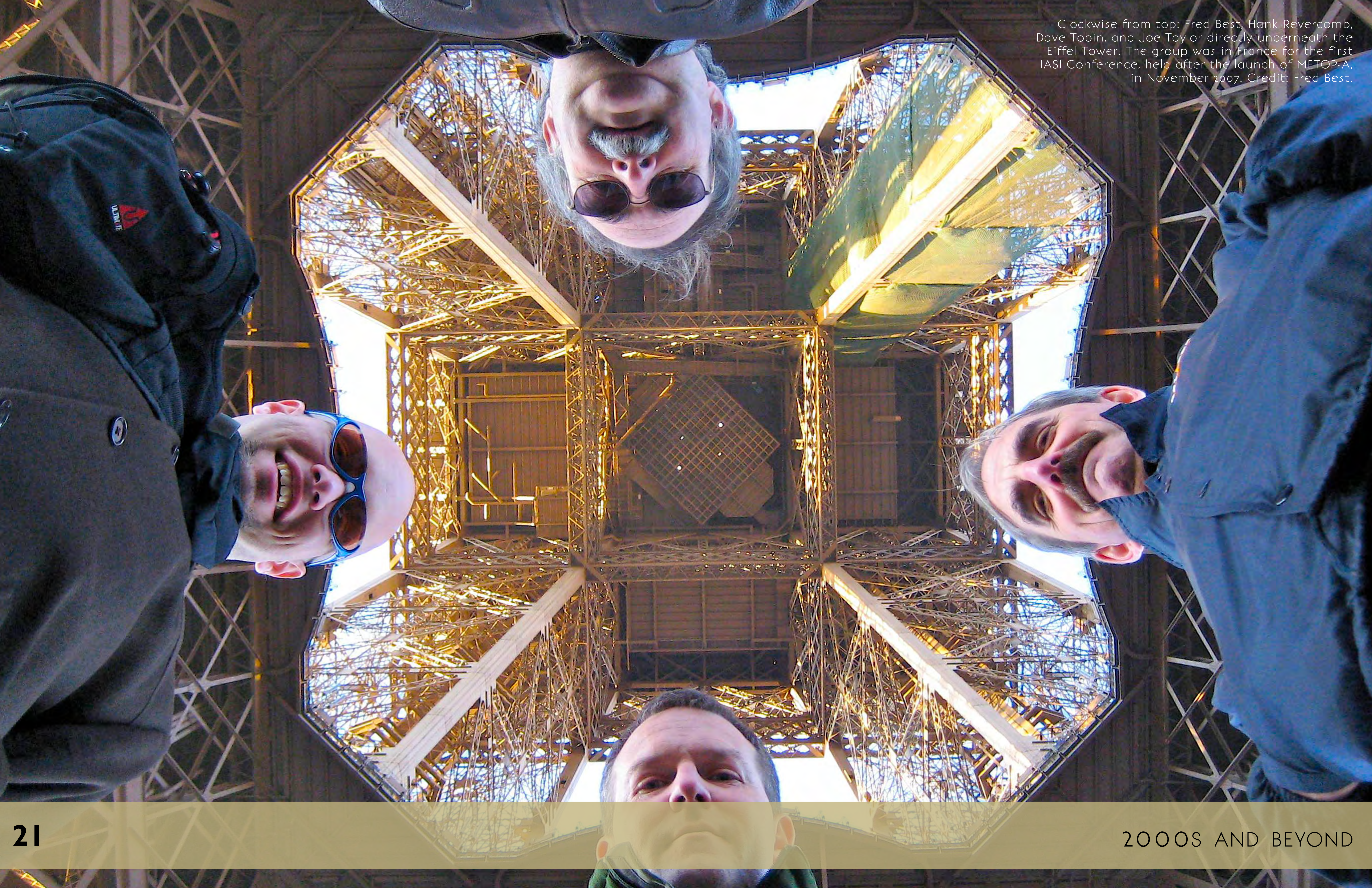


Top left: Verner Suomi with a group of university students on the roof of the AOSS building in 1991. Credit: On Wisconsin magazine.

Center: Verner Suomi with the Skin-layer Ocean Heat Flux Instrument (SOFHI). Credit: University of Wisconsin Archives.

Top right: W. Paul Menzel monitors biomass burning in the Amazon from a computer terminal at SSEC. Credit: University News Service.

Bottom left: Dan LaPorte with the S-HIS. Credit: SSEC.



Clockwise from top: Fred Best, Hank Revercomb, Dave Tobin, and Joe Taylor directly underneath the Eiffel Tower. The group was in France for the first IASI Conference, held after the launch of METOP-A, in November 2007. Credit: Fred Best.

2000s: Leading innovation

With the turn of the century, preparations for new polar-orbiting satellite missions through NASA's EOS program intensified. SSEC scientists participated through science teams, algorithm development, and calibration/validation activities. This work and the lessons learned would inform the development of future instruments.

Launched in 2011, the National Polar-orbiting Partnership satellite was renamed Suomi NPP to honor Suomi's vision and enduring contributions to the field of satellite meteorology. First light data from two of its key instruments, CrIS and VIIRS, were generated at SSEC. These were important milestones for SSEC, and our scientists continue to advance data analysis and processing techniques.

On the geostationary side, SSEC scientists have a long history of contributing operational algorithms to the Geostationary Operational Environmental Satellite (GOES) program, leading to a significant participation on risk reduction and algorithm development teams for the next generation GOES satellite (GOES-R) set to launch in 2016.

In an effort to advance the state of satellite technology, SSEC worked with federal and university partners to design and develop an advanced imaging spectrometer that would observe atmospheric conditions over large areas of the planet over extended time periods. While the instrument has not been realized in the United States, a version is moving ahead in Europe and China.

SSEC engineers forged ahead on other satellite instrument technologies: new and improved blackbodies and phase change cells for absolute temperature calibration. Both have been integrated into a prototype Absolute Radiance Interferometer (ARI), part of the future Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission that will extend the climate record.

In addition to developing instruments to observe the atmosphere, SSEC engineers, partnering with the National Science Foundation, were investigating ways to drill into ice in harsh conditions, from a hot water drill to pave the way for the IceCube neutrino telescope in Antarctica to specialized drills designed to extract ice cores to study ancient climates.

With our past research endeavors serving as a foundation for the future, our scientists, engineers, and leaders are poised to continue to grow an organization with an international reputation for excellence.

| Leanne Avila

Antarctic Meteorological Research Center (AMRC) scientists Matthew Lazzara (left) and Charles Bentley (right) service the Kominko-Slade Automatic Weather Station (AWS) in 2010. Credit: AMRC.

Tom Achtor displays hailstones precipitated during the IHOP field experiment in 2002. Credit: Wayne Feltz.

Top left: The SSEC Data Center's "rising Earth" display in 2014. Credit: Bill Bellon.

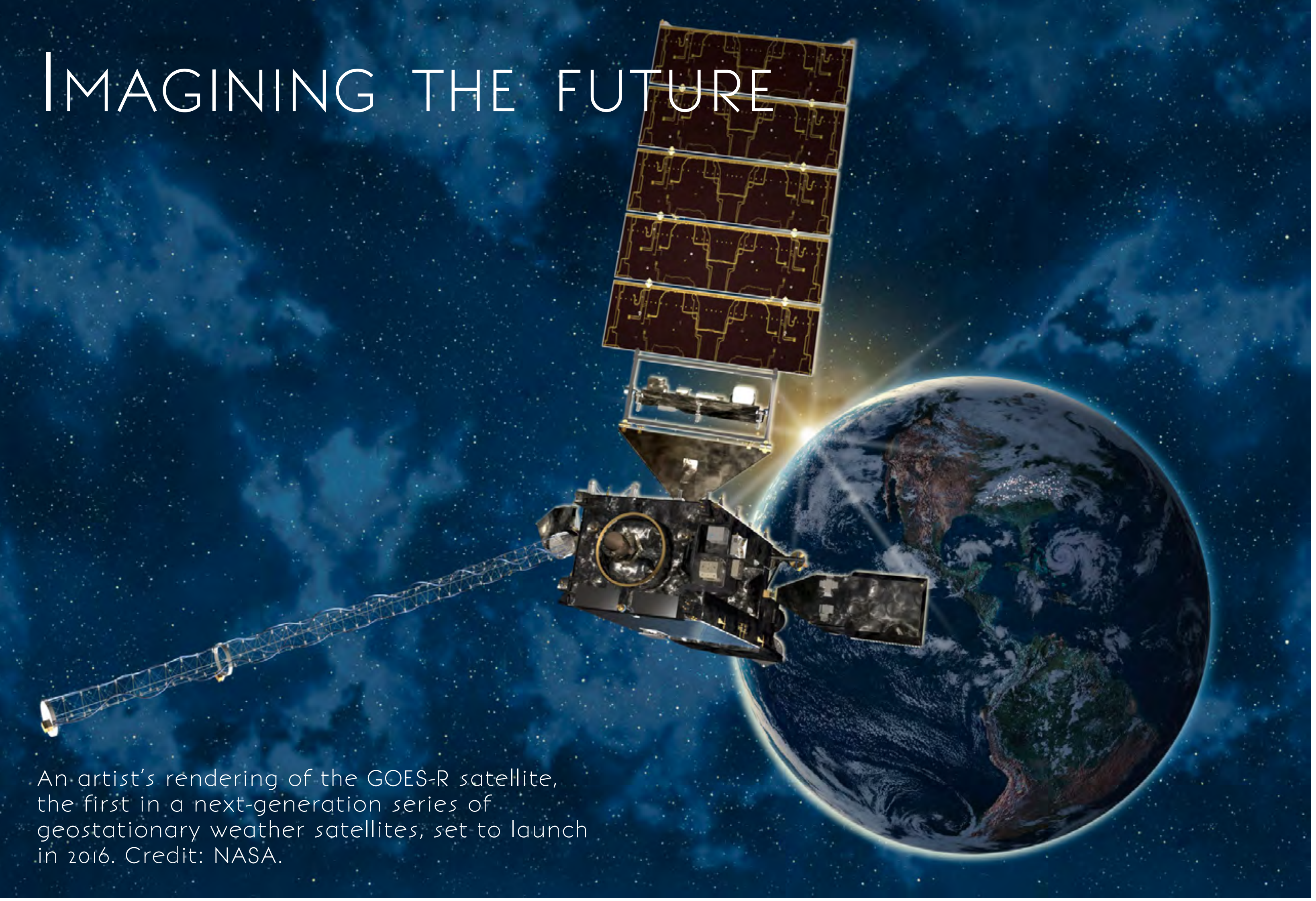
Top center: Science Expeditions attendees tour the AOSS rooftop in 2011. Credit: Jeff Miller, University of Wisconsin Communications.

Top right: Kristina Slawny (left) and Jay Johnson (right) stand next to the Deep Ice Sheet Coring Drill, designed by the Ice Drilling Design and Operations group. Credit: Jay Johnson.

Bottom right: Patrick Rowley demonstrating the Science On a Sphere (SOS) globe. Credit: Jeff Miller, University of Wisconsin Communications.

Bottom left: Dave Jones, SSEC building manager and electronics technician, inspects the Moderate Resolution Imaging Spectroradiometer (MODIS) antenna in 2005. Credit: Jeff Miller, University of Wisconsin Communications.

Imagining the future



An artist's rendering of the GOES-R satellite, the first in a next-generation series of geostationary weather satellites, set to launch in 2016. Credit: NASA.

The Space Science and Engineering Center occupies a unique place in the field of satellite meteorology. Indeed, the field has its earliest roots at the University of Wisconsin-Madison. As we imagine the future, SSEC scientists will continue to help define the direction of this field, along with our national and international partners, as envisioned by Verner Suomi some fifty years ago.

And as we imagine that future, we begin with the research questions that are foremost in our minds. What are the scientific advances and observations needed to improve weather forecasting on weekly and seasonal time scales? What advancements and observations are needed to improve the prediction of extreme weather events?

As we seek to address these questions through satellite remote sensing, we must also think about "The Three W's" – the where, when, and wavelength issues linked to those measurements.

Beginning with where and when, ideally, we would have observations that cover the Earth in its entirety – 24/7. And of course we want that coverage at higher spatial and temporal resolutions. Geostationary observations will meet the ever-increasing temporal resolution demands of the future. Looking to GOES-R, for example, we can see 1-minute sampling and its applications very much in the near-term. We need this type of sampling from global geostationary satellites in order for our observations to be meaningful. Our polar-orbiting satellites are also on track to provide near-continuous observing capabilities at the poles. This coverage and the increased resolutions are critical to future forecast improvements.

When we think of wavelength improvements, we often think of higher spectral resolution measurements. SSEC paved the way for high spectral resolution measurements with the development of the High-resolution Interferometer Sounder (HIS). It flew on the ER-2 in the 1980s, providing prototype measurements. In the decades since, these measurements have been realized on polar-orbiting satellites and have been used to retrieve temperature, moisture, and trace gas concentrations of the atmosphere. SSEC scientists are involved not only in current satellite missions that make use of these observations, but are designing future instruments as well.

Active remote sensing from a satellite is also in our future. Combining satellite measurements with radar and lidar observations will help to achieve a comprehensive global measurement of cloud microphysical properties in order to further refine and constrain weather and climate models.

Demands for better and higher resolution imagery along with demands for increased imaging frequency will drive future space-based measurements for temperature and moisture profiles. Some of these demands can be met with constellation systems in combination with geosynchronous platforms. GEO-based sounders, small-sat, and CubeSat versions of these measurement technologies are promising areas of research for our scientists. With the ever-increasing costs of large satellite missions, small and Cubesat missions will provide a cost-effective way to maintain the continuous observations of Earth necessary for weather and climate studies.

Some of these new capabilities will be made possible by our long-time international collaborators, such as EUMETSAT, the Japan Meteorological Agency (JMA), and the China Meteorological Administration (CMA).

This leads us to a fourth W that must be added to ensure future success: working together. Historically, our best collaboration occurs when government, industry, universities, and international organizations work together – the model established in the earliest years of SSEC and solidified with the founding of CIMSS in 1980. While the primary mission of each of these entities is different, each is critical to the overall success of the remote sensing community.

The primary duty of government is to serve and protect its citizens; modern satellites yield societal benefits through improved weather forecasting, including warning of the hazardous weather associated with thunderstorms, hurricanes, and winter cyclones. Universities benefit the public in another but equally important way, by generating knowledge in the form of research that can directly support the operational mandates of the federal government. This is the Wisconsin Idea in action.

Maintaining a healthy investment in research and application activities is crucial not only to the continued collaboration between these key partners but also to their continued progress and breakthroughs that have tangible, real-world results in the form of lives and property saved.

Working together also includes participation in the World Meteorological Organization coordinated global observing system where our international partners are advancing technology, applications, and data collection at an unprecedented rate.

The public is working with us and becoming more engaged through citizen science opportunities — helping to categorize hurricanes and make observations that can be used to validate satellite- and ground-based observations. We need to continue to engage the public in our science; new technologies, like mobile devices, will make that easier and more scientifically productive. This fusion of data from new technologies and citizen scientists with models will improve decision-making.

Looking back, each decade has called for increased resources to support emerging scientific and societal needs. The challenges of the past continue to be the challenges of the future; the call to expand our understanding of our environment is familiar, worthy, and urgent. It is a challenge SSEC scientists embrace and lead.

| Steve Ackerman and Jean Phillips

The Atmospheric, Oceanic, and Space Sciences building at dusk in 2004. Credit: Jeff Miller, University of Wisconsin Communications.

Black Marble: The most detailed image of Earth from space to date, as seen by the Suomi NPP satellite in 2012. Credit: NASA/NOAA.

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

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