

Space Environment Center 1993–1995

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Environmental Research Laboratories

December 1995





As the Sun sets behind the mountains in Boulder, Colo., our telescope captures an enthusiastic SEC worker in silhouette.

COVER: Space Environment Center's Space Weather Operations are staffed 24-hours a day, the facility is the focal point of solar-terrestrial data flow from around the world.



Space
Environment
Center

A Message from the Director

The fiscal years 1994 and 1995 were filled with change and challenge in the Space Environment Laboratory, now known as the Space Environment Center. We present in these pages a selection of our accomplishments, along with a glimpse of the national space environment community and our role in meeting the needs of that community.

During the last two years the National Space Weather Program (NSWP) has progressed from an idea first presented by the research community to funding agencies in Washington, to being an approved interagency program with a published Strategic Plan and draft Implementation Plan. The NSWP, under the auspices of the Federal Committee for Meteorological Services and Supporting Research, also falls under the jurisdiction of the subcommittee for Natural Disaster Reduction of the National Science and Technology Council (chaired by the President). This federal involvement in U.S. science policy did not exist at the beginning of the period covered in this review. We anticipate that the new structure will enhance interagency cooperation and bring more emphasis to our space weather activities.

Despite our many accomplishments, there are lingering concerns; chief among them is obtaining the resources to adequately serve the Nation's requirements for space weather services and to do the research necessary to improve our services over the long term. The immediate future holds greater promise. There are planned launches of satellites that will provide new data, like ACE and the new Solar X-ray Imager that will fly on GOES-M. SEC will also benefit from its new affiliation with the National Weather Service's National Centers for Environmental Predictions, and we will bring into daily operational use physically based numerical models to nowcast and forecast the state of the magnetosphere. These model developments and transitions have been funded by the USAF. NASA's SOHO mission is also expected to provide new understanding about the Sun and its activity.

Public interest in space weather is high, as evidenced by two popular articles, one in *Discovery* (August '95) and the other in *IEEE Spectrum* (June '95). Your comments about SEC or this report will be welcomed.

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Welcome to Space Environment Center

Who we are and what we do

The Space Environment Center (SEC) occupies a central position in the space weather community. A component of NOAA's Environmental Research Laboratories in Boulder, Colorado, the SEC has also recently become one of the National Centers for Environmental Prediction overseen by NOAA's National Weather Service.

The SEC conducts research in solar-terrestrial physics, develops techniques for forecasting solar and geophysical disturbances, provides real-time monitoring and forecasting of solar and geophysical events to customers, and prepares data to be archived by NOAA's National Geophysical Data Center. It often provides advice on solar-terrestrial phenomena and their adverse effects to government agencies and industry associations. Research scientists at SEC, working toward a better understanding of the Sun-Earth connection, study the Sun's electromagnetic, particle, magnetic-field, and plasma emissions and the processes that affect the space environment around Earth.

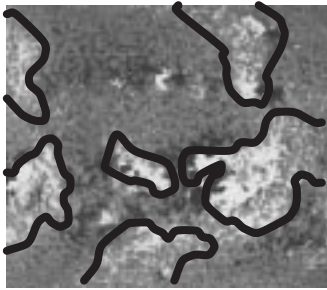
The Space Weather Operations (SWO) group at SEC operates the national and world warning center for disturbances in the space environment that can affect people and electronic equipment. The 50th Weather squadron (formerly the Space Forecast Center) of the U.S. Air Force in Colorado Springs, CO, provides services to U. S. military customers, and works closely with SWO. SWO is jointly operated by NOAA civilians, uniformed NOAA Corps, and U.S. Air Force personnel.

Cooperative ventures also abound in SEC, as graduate students, post-doctoral students, visiting scientists, Cooperative Institute fellows from the University of Colorado, and contractors all contribute to the vibrant atmosphere of the Lab.

Short History

Space weather services grew out of the need to support rapidly expanding radio communications and radar technologies during World War II. SEC's predecessor organization, the Space Disturbances Laboratory of the Environmental Science Services Administration, began routine reporting and forecasting services jointly with the USAF Air Weather Service in 1965. National and international needs for civilian and military space environment services have grown since then, in concert with society's increasing reliance on satellites and other technological systems.

Space Weather



Stormy Regions on the Sun

Earth Weather



Stormy Regions on Earth

By the mid-80's it was recognized that no single agency had the resources, mission, authority, and responsibility to meet all of the national civilian requirements for space weather services.

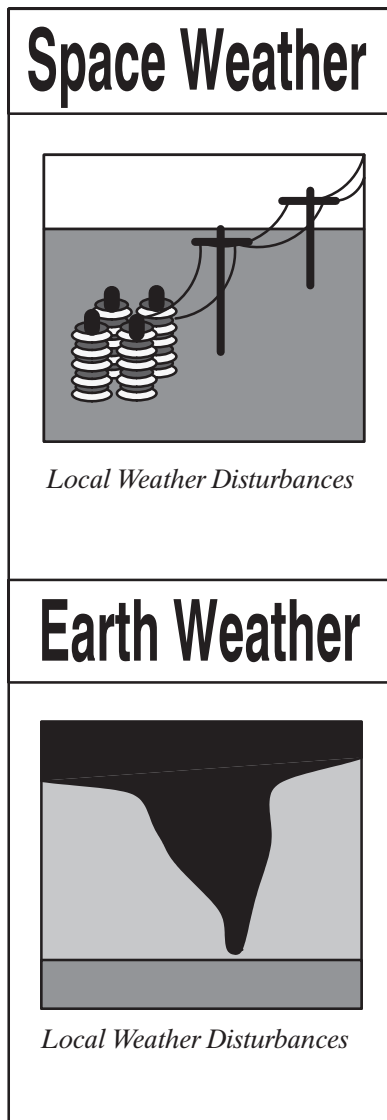
The Office of the Federal Coordinator for Meteorological Services and Supporting Research began to coordinate space weather services, and for more than a decade the roles of each agency have been delineated in consecutive documents: the National Plan for Space Environment Services and Supporting Research for 1983–1987, for 1989–1993 and for 1993–1997.

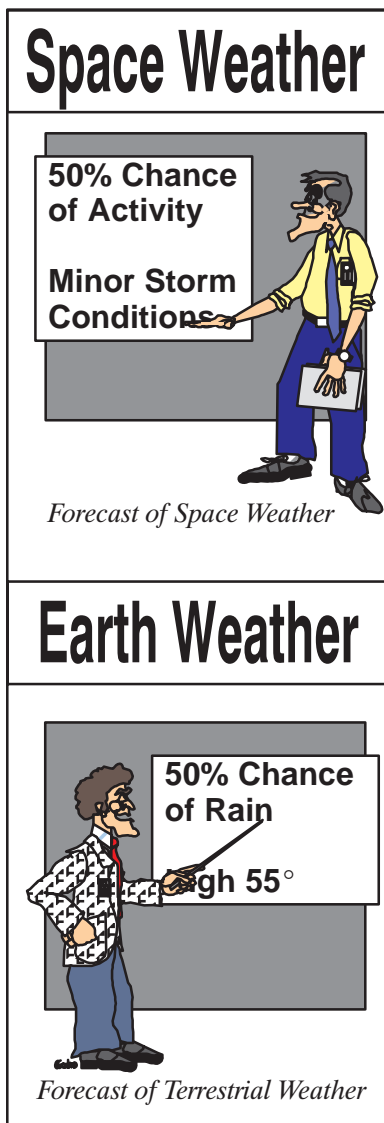
Space Weather Program

We have now entered a new era—the era of the National Space Weather Program (NSWP). Chartered on August 4, 1995, the NSWP draws on the talent, resources, and priorities of six agencies: the Department of Commerce, the Department of Defense, the Department of Energy, the Department of the Interior, the National Aeronautics and Space Administration, and the National Science Foundation. The NSWP is guided by the National Space Weather Program Council, under the Federal Committee for Meteorological Services and Supporting Research. The Council has approved the NSWP Strategic Plan, and the Implementation Plan is scheduled for completion in early 1996.

The NSWP acknowledges and affirms the National Plan, which states that the Department of Commerce, specifically the Space Environment Center, is the provider of civilian space weather services. These services include the following:

- Procuring and operating solar and space environment monitors
- Ingesting solar and geophysical data from NOAA sources and other national and international agencies, and interpreting and analyzing these data
- Providing data and indices to interested users
- Alerting users to existing extreme and (or) hazardous conditions, and warning them of expected hazardous conditions
- Preparing and disseminating summaries and forecasts of space environment conditions
- Conducting research into the causes and consequences of fluctuations in the space environment
- Translating research into operational algorithms and guidelines
- Educating users and the general public about the consequences of fluctuations in the space environment





- Archiving and distributing solar and space environment data
- Advising federal agencies and industry groups about the space environment and its adverse effects on technological systems

Our nation-wide dependence on electric power and satellite communications for personal and economic well-being makes all of us vulnerable to extreme space weather conditions. It is now recognized that some of the Nation's power distribution grid might collapse under the influence of a severe geomagnetic storm, requiring days of effort to restore service even if no equipment were permanently disabled. Estimated economic loss, if the northeast United States experienced a blackout, runs into billions of dollars. Early warning of geomagnetic storms would allow electric utilities to take steps to protect equipment and maintain service, satellite operators could increase staff to deal with anomalies, communicators might forego transmissions or choose to alternate frequencies, and radio navigators would be aware of possibly degraded signals.

The Plan for Natural Disaster Reduction, written by the Subcommittee on Natural Disaster Reduction under the National Science and Technology Council's Committee on the Environment and Natural Resources, includes consideration of widespread power blackouts caused by severe space weather.

SEC's Mission

To serve the Nation's need to reduce adverse effects of solar-terrestrial disturbances on human activities, Space Environment Center will

- acquire, interpret, and disseminate monitoring information;
- prepare and disseminate forecasts and alerts of conditions in the space environment;
- conduct research and development in solar-terrestrial physics and in techniques to improve monitoring and forecasting;
- prepare high-quality data for national archives; and
- use its expertise to advise and educate those affected by variations in the space environment.

Service Improvements

The most improvements in SEC services in over a decade occurred in the years 1994 and 1995.

New or improved products were created:

- Energetic electron alerts
- A standard daily description of solar wind conditions
- Energetic electron flux (given a much wider distribution)
- Radiation assessments for the satellite environment
- An alert for magnetopause crossings, for use by satellite operators having trouble with orientation problems

New data were incorporated into operations:

- GOES-8 and GOES-9 Space Environment Monitor data
- Solar wind data from the WIND satellite orbiting upstream from Earth
- Improved access to the growing U.S. Geological Survey's INTERMAGNET data

Special analyses and support were provided to national programs:

- GOES-8 anomaly resolution (commercial and Department of Defense satellites as well)
- FAA GPS studies
- Loran/Omega system vulnerabilities

Data systems were improved:

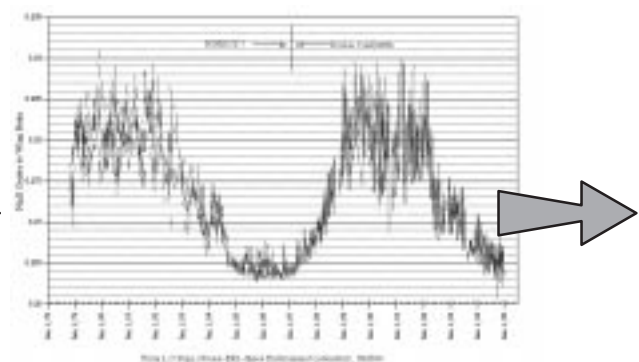
- The first set of processes was moved from the old, central computer to newer decentralized networked processors
- Outside users' access to SEC products and data was revamped
- World Wide Web (WWW) is now a mainstream data channel for SEC products
- The GOES Ground System that receives data was overhauled
- Table Mountain Observatory was automated and is now running unstaffed
- International data exchange moved from Teletype to the WWW or "Internet"

The future of USAF's Solar Optical Observatory Network (SOON) was discussed, and an agreement with the USAF was achieved (see below); new support arrangements for the Shuttle Program and the Space Station were made to save NASA money.

Several other projects achieved important goals over the last two years. Here is a brief description of some of them.

SELRAS—The Research division has placed historical NOAA/TIROS and GOES space environment data on line through SELRAS (the Space Environment Laboratory (Center) Retrieval and Analysis System). SELRAS has greatly increased the ability of forecasters and the research staff to use NOAA/TIROS and GOES observations in, for instance, the analyses of the causes of spacecraft anomalies. When anomalies occur, the environmental data taken near the time and location of the anomaly can be used to determine whether conditions were unusually stressful around the spacecraft. This technique was used in recent analyses of anomalies encountered in the operation of the Space Telescope,

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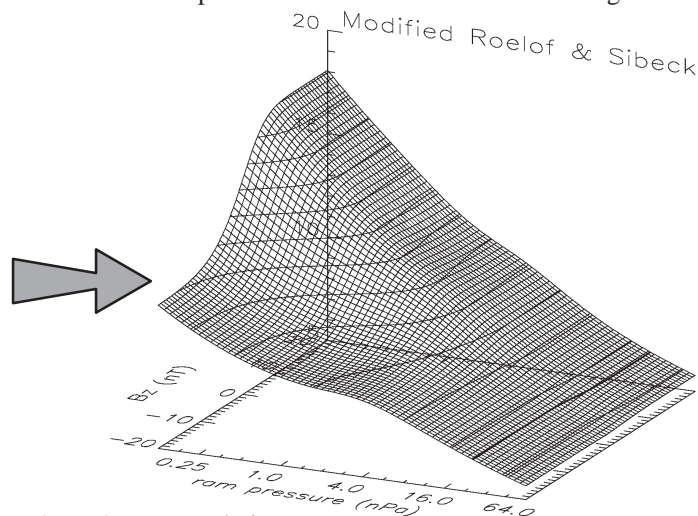
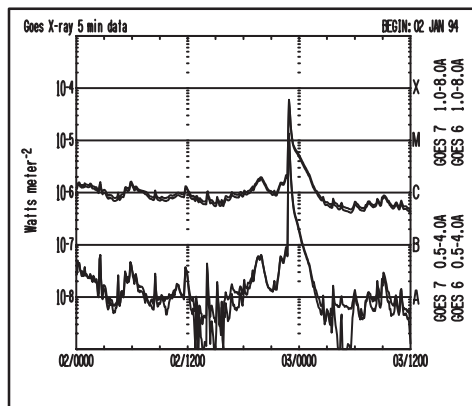
A model is based on one-dimensional data streams, plotted in two dimensions ...

Landsat, TOPEX, and NOAA's polar and GOES satellites. New analysis routines will be incorporated into SELRAS to allow the researcher to easily perform boolean operations, power spectra, and filtering.

Auroral Activity Estimates—The Hemispheric Power Index (HPI) of auroral and geomagnetic activity is generated directly from SEM observations obtained with NOAA polar-orbiting satellites. Maps of the estimated location and intensity of auroral activity are available in near real time, by cross referencing the HPI with statistical patterns of auroral energy input to the atmosphere.

Thermospheric Model—In collaboration with the Air Force Phillips Laboratory, efforts to transition a physically based thermospheric model to operational use are proceeding. The objective is to provide a predictive (12 hours in the future) model of upper atmospheric properties that out-performs current empirical models. The new model's ability to predict atmospheric density has been tested for a specific time period; in initial testing it performed slightly better than current empirical models. The goal is to break the 20-year-old ~15% density standard deviation barrier and approach ~5% density specification.

GOES Next—The National Environmental Satellite, Data, and Information Service has initiated a multi-phase process to define NOAA's needs for observations from geosynchronous orbiting platforms to meet data and service requirements in the years 2005–2015. Part of the preparation for this program, called GOES–Next, involves solar and magnetospheric teams at SEC examining future SEM specifications. SEC will seek input from the user community to help focus concept studies of instruments and spacecraft configurations by asking the question what data will be needed to drive future models of the space environment?



... combined with other data sets, and results in a three-dimensional plot.

Geospace Environment Modeling—Participation in the National Science Foundation GEM (Geospace Environment Modeling) program by SEC has an ultimate goal of constructing a Geospace General Circulation Model that will predict how the near-Earth environment reacts to solar wind inputs. SEC has collaborated on science studies that are focused on the development of new models; we hosted a GEM Workshop that emphasized applied aspects of the GEM program that concentrated on space weather issues, the National Space Weather Program, and forecaster needs and concerns. These efforts are important in bringing together scientists, modelers, and the people who ultimately interface with the space environment user community.

Other space weather model development is being supported by the Air Force for use at the U.S. Air Force 50th Weather Squadron in Colorado Springs, CO. SEC coordinates forecasting activities with the Air Force, and has contributed to the development of interplanetary shock propagation models (STOA and ISPM) and the thermospheric forecast model (TFM) referred to in the left-hand column.

Nitric Oxide Varies with X-ray Flux—A revision of the measured values of soft x-ray fluxes now suffices to explain nitric oxide (NO) peak concentrations in the mesosphere and lower thermosphere, as well as their variation over the solar cycle. The solar cycle induced changes of auroral energy influx at high latitudes do not faithfully follow geomagnetic indices, and changes in polar NO are also not explained by auroral energy influx variability. It now appears that high latitude, solar cycle variability of NO is a consequence of the change in the soft x-ray flux, due to the damped extension of the equatorial process. Short-term fluctuations at high latitude

are, however, most likely controlled by the auroral and energetic particle input.

Solar Imaging Analysis—Images of the Sun arrive at SEC every day from a variety of locations around the world. Each is unique, and they vary in size, shape and intensity. During the last year we have developed a process to normalize all Solar Optical Observing Network images into a standard format. Each image is sized, centered, and corrected for limb darkening. Linear and circular brightness gradients are also removed, intensities and their deviations are set to standard values, and areas above the limb are enhanced to better display faint prominences. The processed images can be used directly by the staff of the operations center in their analyses.

WIND real-time products—Real-time solar-wind data, currently received from the WIND satellite a few hours per day, give warning of impending intense geomagnetic activity; several product enhancements are being developed from the original data. One product, in alpha testing this year, is known as VBs. This product is a measure of the driver of the electric field across Earth's polar caps, and its value is as an indicator of the level of geomagnetic activity expected about an hour after it is measured at the satellite. The data are processed in such a way that the possibility of false alarms are minimized. Additional real-time products are being developed from the data we are receiving at this time.

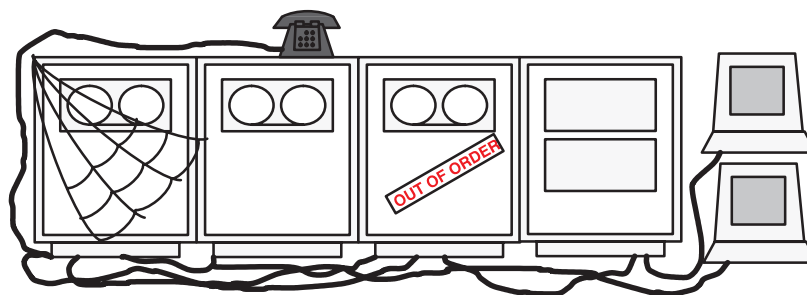
Improved Solar Particle predictor—Two recent studies have indicated a strong link between features of solar x-ray observations and the occurrence of solar energetic particle events (a radiation hazard for anything flying above the atmosphere of Earth). One study indicates that solar flares with higher peak temperatures have increased likelihoods of being followed by solar particle

events at Earth. This correlation offers improvement to the currently used algorithm for predicting the arrival time and the size of energetic particle events.

The other research looked at a special property of the hard x-rays emitted during a solar flare. When the 50–100 keV x-rays exhibit spectral hardening, there is a very high probability that energetic solar particles will subsequently arrive at Earth. The correlation between the solar x-ray hardening and the particle events is so strong that it brings into question some of the current concepts regarding how these particles are accelerated and escape from the Sun. We plan to develop this into an improved operational algorithm.

Satellite Woes—The most pressing space weather problem for satellite operators during late phases of the solar cycle, is the frequent appearance of extremely large fluxes of energetic electrons in the near-Earth environment. These electrons can penetrate deep into the electronics of a satellite and build up a charge there. If the charge builds up more rapidly than it can bleed away, it can reach critical levels, suddenly discharge, and damage electronic components of the satellite. An example of this phenomenon was the failure of the Anik satellite, which led to a major disruption in the Canadian communications service. The problem became especially relevant to NOAA when the effect appeared on GOES-8. Though the effect is not new, the need to reduce the high cost of spacecraft may lead to designs that leave some spacecraft particularly vulnerable to large energetic electron fluxes and the resultant deep dielectric and surface charging.

By developing products that characterize this environment, SEC helps spacecraft designers and operators remain aware of the harmful effect of these electrons on their hardware. The SEC staff used SEC products and



SELDADS II, 1981–1996

Old and costly
Failure prone
Unique operating system
Non-portable software

data in the diagnosis of these effects on GOES-8; this means that there can be appropriate improvements in future spacecraft design. This information is routinely provided to other satellite operators and designers, and SEC staff provides training and expertise to people within the space industry. The current solar activity cycle is expected to end in late 1996, and the energetic electron events are expected to decline in importance after this time. They will become a significant hazard again, however, in the near-minima phase of every solar cycle that follows.

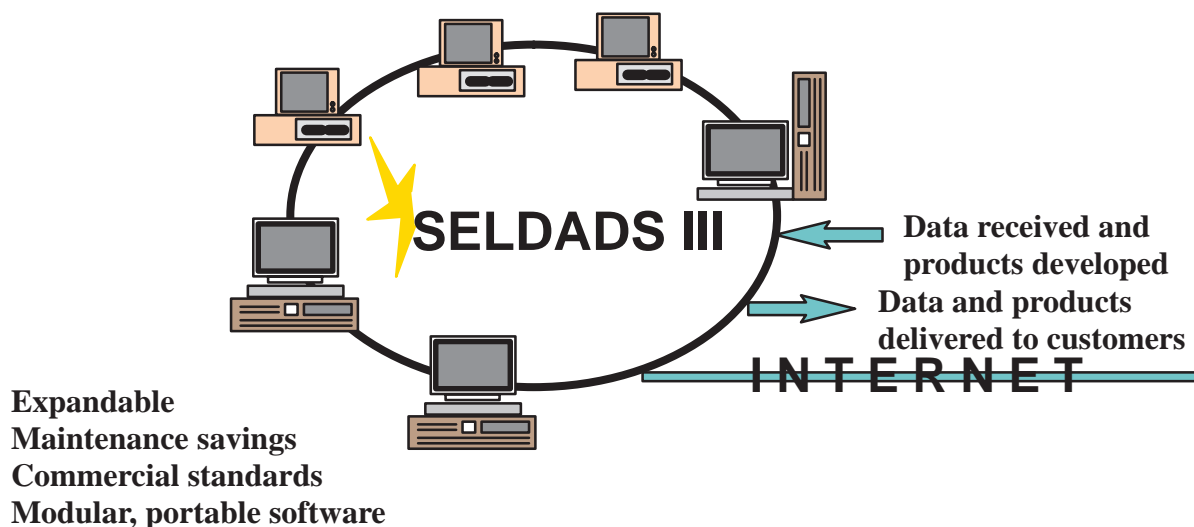
New Computer System—The core of the SEC data collection and analysis system is a minicomputer, now 14 years old, and a series of data-collecting microcomputers. New hardware and software to replace this aging system have long been needed, but initiatives to implement a replacement system (included in the NOAA budget requests each of the last several years) have yet to be funded. The current system has little capability to handle modern data transfer protocols, and it is increasingly vulnerable to failures. A replacement system has been designed and will replace the old processor with state-of-the-art multi-processors, networks, and operating systems; it will utilize off-the-shelf hardware wherever possible. The new system will provide a POSIX-compliant network of pre-processors to handle the immense amounts of data that flow into and out of SEC daily. Though new hardware is needed, by far the greater cost of switching to a new computer system will be the labor to port to new platforms the mountain of code written for the old computer's unique operating system.

The additional forecaster interfaces, data access and display software, and the management of all the processes that are necessary to maintain operations are gradually being moved from the old computer to a new

distributed system, built around structured data bases. This part of the new system uses a dedicated processor to serve outside users, primarily over the Internet and with World-Wide-Web-accessible home pages for displaying data and products. The outside user system replaces a previous system of multiple dial-up modems, direct connections to the SELDADS, a bulletin board system, and teletype data exchange. SEC is committed to "pull the plug" on the old minicomputer at the end of FY96, but without additional resources we will not have the capability to run numerical models to provide guidance to our forecasters.

Solar Electronic Observing Network—For the past 2 years, the USAF and NOAA have been studying the future of the real-time ground-based solar patrol network called Solar Electronic Observing Network (SEON). Basic stipulations for space environment services require that such a system be available. The USAF has agreed to maintain operation of the current system, with certain upgrades, while NOAA seeks to establish a continuous solar patrol using the Solar X-ray Imagers on future GOES spacecraft.

Astronaut Protection—The increasing time that American astronauts spend in space as the Space Station moves closer to reality strengthens the requirement that SEC maintain a lookout for solar energetic radiation events in the space environment. NASA maintained this vigilance in the past, making extensive use of data from SEC. This year, NASA agreed that SEC, which maintains such vigilance for all its users, will feed information more directly to NASA mission control operators and notify them when potentially dangerous conditions arise or are expected. NASA radiation support staff will therefore be able to stand down during large portions (the quiet times) of missions, thereby saving costs.



New Data Sources

SEC was originally chartered to use diverse space environment data, collected by various government agencies and public institutions, and integrate it into coherent space weather services. The products SEC provided included forecasts, alerts, and specification of conditions in the space environment. These products were provided to data contributors as well as to others who had a need for them.

SEC has continued to pursue this original mandate. As money for research and development in the space and environment sectors becomes increasingly tight, however, it becomes vital that efficient use be made of the data currently available. SEC is in a unique position to provide this national capability. The data acquired by SEC come from a variety of sources including the Department of Commerce, the Department of Defense, the Department of the Interior, NASA, the National Science Foundation, numerous universities, and over 100 foreign countries. Almost all these data are eventually archived by NOAA's National Geophysical Data Center (NGDC).

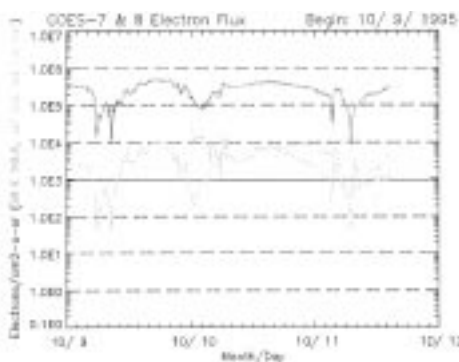
As scientific understanding of solar-terrestrial relationships improves, several critical data gaps have emerged as potential roadblocks to better space weather services. Recognizing this problem, SEC commenced several new sets of observations in 1995 that significantly improve current services, or lay the groundwork for improvements in the future.

New Data from GOES and NOAA satellites—The most significant new observations, in terms of better service for users, have been those from the modernized Space Environment Monitors on the GOES-8 and GOES-9 satellites. The range of measurements of the

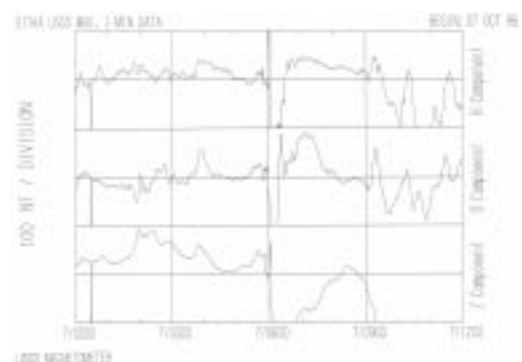
energetic electrons, protons, and ions in the geosynchronous environment have been expanded. Energetic electron fluxes are now measured at three energies, rather than the old, single measurement at >2 MeV. Knowing the strength of the fluxes of these electrons is important to maintain reliable, efficient operation of defense, navigation, and communication satellites. The expanded range of proton and ion measurements provides more reliable assessments of radiation doses to crews and passengers of very high flying aircraft and the space shuttles. The new x-ray sensors now give forecasters and solar technicians the ability to assess the peak energy of some of the most intense solar flares. The previous GOES sensors became saturated during very bright solar events, leaving SEC without useful measurements.

A new series of Space Environment Monitors (SEM-2), with improved energy coverage and a greater number of data channels has been developed, and the first one will be flown on NOAA-K (scheduled for launch in mid-1996). Continuous monitoring on board NOAA satellites well into the next century is insured by procuring sufficient instruments now. These instruments may also fly on the European series of polar orbiting satellites (EPOP). SEC is working closely with the 50th Weather Squadron of the Air Force—our Department of Defense counterpart for space weather services—in formulating the joint requirements for near-Earth space-environment monitoring within the National Polar Orbiting Environmental Satellite System. This combined civilian-military satellite program will replace the individual NOAA, Department of Defense, and some NASA programs by 2010.

Solar Wind Observations—Newly available in 1995 to geomagnetic users of SEC services, are solar wind observations from the NASA WIND satellite, and improved access to terrestrial magnetometer data from the U.S. Geological Survey's magnetometer network. The



Electron plots of 3 intensities



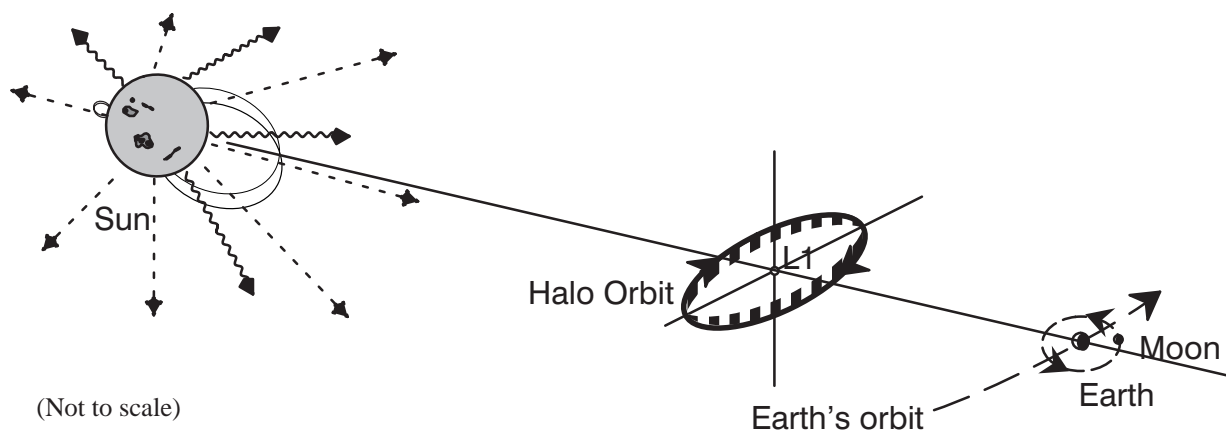
Magnetometer data from U.S. Geological Survey

WIND satellite, orbiting between Earth and Sun, provides an advanced look at the solar-wind-induced conditions that are about to affect Earth. Changes in the solar wind at the satellite location are telemetered to Earth, so that forecasters have advance warning of geomagnetic storms and their associated effects, a half an hour to one hour before the driver arrives at Earth. The WIND satellite observations are also useful in evaluating the propagation effects upon solar disturbances transiting to Earth. WIND's temporal coverage is incomplete, reducing the short-term forecasting capability to a few hours per day, but the operational experience gained with WIND data is providing the basis for improved forecasting capability in the future when continuous observations will become available. Access to the real-time solar wind data from WIND is a cooperative effort of SEC, NASA, and the U.S. Air Force.

Complementary to the real-time solar wind data from WIND is the data provided by the NASA ACE satellite that will soon be available to SEC. NOAA has funded a slight modification of the spacecraft that will allow data from three instruments to be broadcast almost continuously from ACE. Using ground stations operated by the USAF, as well as those provided by international partners, the data will be available 24 hours per day. SEC will be responsible for developing the software for processing the raw data into usable products for distribution. The ACE spacecraft is nearing completion, and is expected to be launched in August 1997, just in time for the beginning of the next solar cycle.

Magnetometer data—Using data from the International Real Time Magnetic Observatory Network (INTERMAGNET) in cooperation with the U.S. Geological Survey, space environment forecasters and technicians now have available magnetometer data of improved reliability and time-resolution. Forecasters and technicians issuing forecasts and alerts of geomagnetic activity are critically dependent on the data from two dozen U.S. and international stations that are collected by the Geological Survey and relayed to SEC with delays of only a few minutes. We plan to continue our collaboration with INTERMAGNET data providers, in hopes of developing maps of activity that will assist in nowcasting.

Solar X-ray Imager (SXI)—NASA, with major support provided by the USAF, is in the final stages of building the first Solar X-ray Imager (SXI) designed to fly on GOES satellites. SEC staff are involved in every phase of the instrument design and fabrication. The telescope will deliver full disk images of the Sun every few minutes, 24 hours per day. The current GOES x-ray sensor gives whole disk measurements, in two wavelengths, integrated every few seconds, so SXI represents a significant improvement. Various parts of the instrument have undergone final testing during the last year, and they are ready to be placed into the final instrument configuration. The instrument will be completed and delivered by the end of FY96 for integration into the GOES-M satellite.



Customer Service Throughout SEC



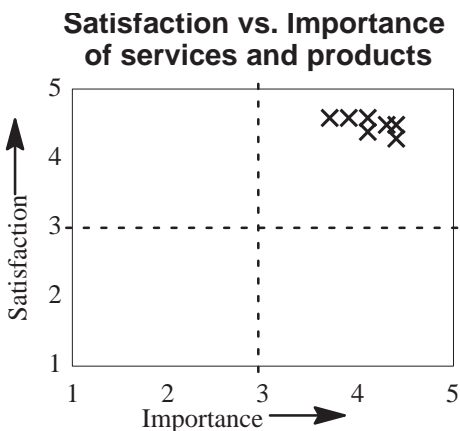
Commerce Prize for Customer Service—SEC is very proud to have earned the Secretary of Commerce’s *Customer Service Excellence Award* for “Putting Customers First.” This award was received from Secretary Brown in Washington on November 22, 1994, and each member of the staff received a certificate like the one to the left. We will endeavor to continue to provide service excellence.

Liaisons with various industries—SEC staff members attend conferences and meetings of industries interested in the space environment, such as the Institute of Navigation’s 50th annual meeting in Colorado Springs from June 6–8, 1994. This conference was attended by interest groups ranging from commercial airlines to farmers. SEC representatives also attended the biennial Hughes Commercial Satellite Owner/Operators’ Conference to hear about problems the owners and (or) operators may have had with their satellites, and to present new products or technologies being developed at Hughes.

At every such meeting, SEC gains new information about our customers, and we are able to deliver information about space weather services to industrial users.

Users Conference—The most recent SEL Users Conference was held in Boulder in May 1995. Those who attended were mainly from the satellite community, radio communications or the navigation fields. This gave the conference a different feel from the 1990 Conference, when a greater range of interests was represented. Interest groups at the 1994 Conference were more focused on the problems occurring in the later phase of the current solar cycle. The next User Conference will be held during the ascending phase of Solar Cycle 23; we expect that violent space weather events prior to the Conference will ensure large and enthusiastic attendance.

Bureau of Census survey results—As part of the National Performance Review, a survey by the U.S. Census Bureau on behalf of the Department of Commerce was sent to a selection of our users.



Ninety-six percent of the 78 respondents reported being satisfied or very satisfied with SEC’s information services and data products. All aspects of products and services that were deemed important by the respondents were given ratings that were above “satisfied.” The graph to the left, taken from the Census Bureau report, illustrates these results. SEC will strive to keep its customers satisfied, as we deliver our important services more efficiently and effectively.

Internet at the core of interactions with customers



On the Web:
www.sec.noaa.gov
gopher.sec.noaa.gov
ftp.sec.noaa.gov

Outside User System and the World Wide Web—Our electronic communications **gopher** and **ftp** services have grown at a tremendous rate. The vast majority of users who access our data remotely have moved to the new systems. Many bulletin board users have also switched, and we have many new customers using the **gopher** and **ftp** servers. In August 1995, the World Wide Web (WWW) server transferred 189,000 files to nearly 4,000 sites around the world. This is an average of 6,000 files a day. SEC continuously strives to improve products; we have continued to enhance our WWW pages, for example, with displays that automatically update every 5 minutes and five redesigned special-interest pages for major SEC customer groups.

WebShop '95 Best WWW Page—SEC received the award for the best WWW page in OAR, SEC's parent organization, at the NOAA World Wide Web Workshop that was held in Silver Spring, MD, from June 13-14, 1995. The workshop brought together managers and technical staff from throughout NOAA to share information about how the agency is using the Internet today, and to raise issues concerning how this medium should be used in the future.

Coordination of Observing Campaigns—Scientists have prompt, reliable, easy-to-access information on SEC's WWW pages to coordinate important ground-based observing support for major worldwide observing campaigns. SEC has made use of both passive and active data distribution to support the InterAgency Consultative Group, made up of NASA, the Russian Space Agency, the Japanese Space Agency, and the European Space Agency, in studying the Sun and down-stream influences on the space environment. The campaign coordination page at SEC's WWW website will be especially useful after the launch of NASA's SOHO spacecraft, as numerous campaigns are already planned to take advantage of the new capability.

New products—New SEC products, such as the alert for magnetopause crossings, are available on our WWW page. Crossings occur when the ram pressure of the solar wind is large enough to push the magnetopause below geosynchronous altitude. Some spacecraft at that altitude have experienced orientation problems in the past when the ambient magnetospheric field conditions suddenly changed from the normal terrestrial situation to that of the interplanetary solar wind.

Forecast verification statistics for six products are published in our weekly *Preliminary Report and Forecast of Solar Geophysical Data* publication. A verification page on the WWW, updated quarterly, also has a few key overview statistics for the last calendar quarter, and a summary diagram relating to a specific aspect of forecast quality. There are links from this page to more detailed verification information as well.

Education and In-house Services



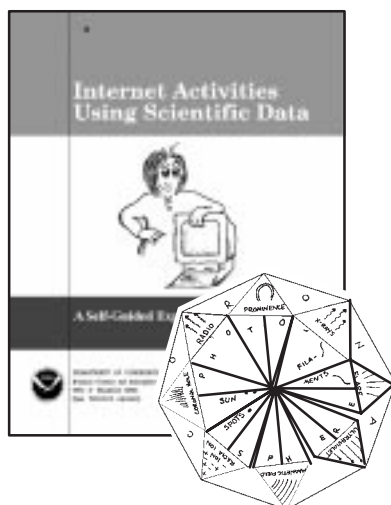
Publications—A powerful and important tool for interacting with our customers is the written material we send out to subscribers and other customers. SEC serves both old and new customers through its publications:

- *SEC User Notes* comes out in January, April, July, and October and contains information about SEC and our customers.
- *Primer on the Space Environment* is a good introduction to our science that is useful to everyone from students to new space-environment workers.
- Topics papers are good overview papers. Currently we have papers on *Navigation* and *Radio Wave Propagation*, completed in the last 2 years. Additional topics papers are in the works.
- Several technical papers are available about events, new products, and forecast verification.

Education—We view education in two ways at SEC. First, the individuals who work at customer sites are continually changing. Though some have been dealing with the space environment and its effects for 30 years, we are faced with novices to the field every year. These newcomers constitute one target for educational materials.

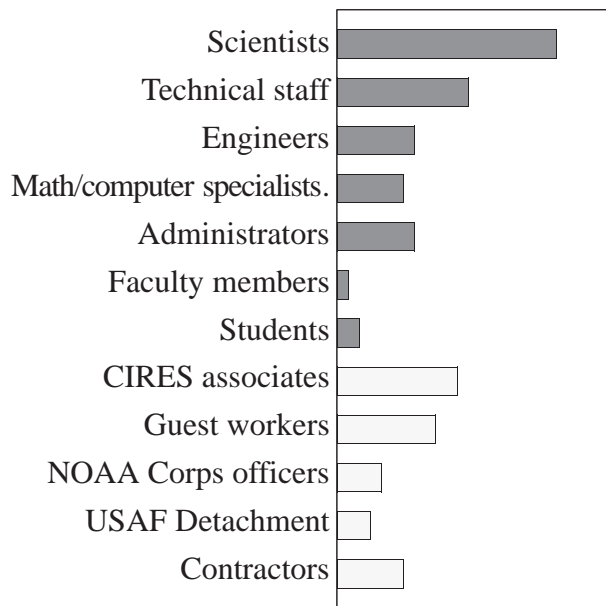
Second, we believe that educating the public, and especially young people, is of vital interest to us and to the Nation. SEC has therefore tried to target students and teachers in our educational materials. Happily, these two requirements for educational materials often coincide nicely. Here are some examples of our materials developed over the last 2 years:

- *Solar Physics and Terrestrial Effects* is a comprehensive short text and series of activities aimed at high school and college students.
- *Internet Activities Using Scientific Data* is a “self-guided exploration” of the Internet, using interesting and educational Internet sites in the government and other institutions. Plans are underway to revise, reprint, and disseminate this publication more widely.
- The Solar Origami project, Solar Fun Books, and a series of photos that allow students to calculate the rotation rate of the Sun are a few of the other enticing handouts we use for schools.

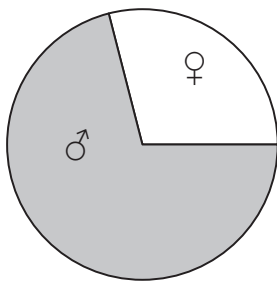


In-house services (*Sol Source*)—SEC also recognizes the need to have good “customer service” within our organization, and we pursue this through an in-house newsletter, *Sol Source*, that has come out weekly for two years. It records management news, calendar items, space weather events, and personal news that is of interest to all staff members.

Staff and Organization

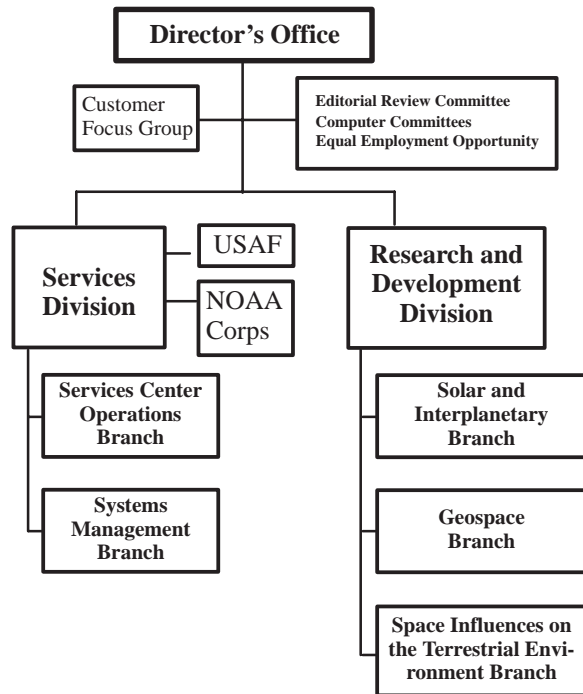


The darker bars constitute the SEC positions that make up the 54.6 Full Time Equivalents at the close of FY95; 61 FTE's were authorized.



The Center is committed to EEO and employs a wide variety of technical people.

Center Organization—Most of SEC's employees work in one of two functional areas: service operations or research. Each area cooperates with, and contributes to, the goals of the other. The Center Director and his immediate staff provide leadership and administrative support to these efforts.

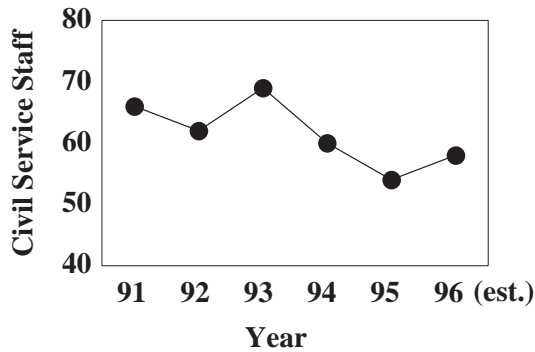


Space Environment Center organization

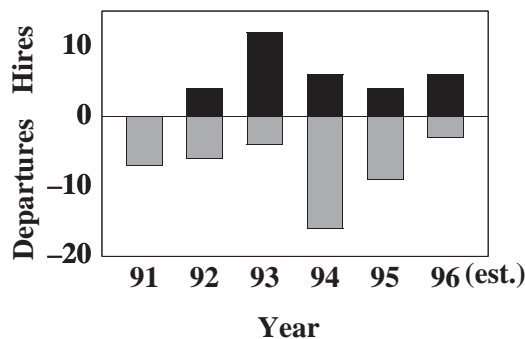
Committee memberships, review boards, planning groups—SEC staff members play an important role in the space environment community as leaders of scientific organizations, interest groups, and members of scientific organizing committees of meetings too numerous to mention. A few examples follow:

- JoAnn Joselyn serves as Secretary-General of the International Association of Geomagnetism and Aeronomy.
- Ron Zwickl is Chairman of the National Meetings Committee of the American Geophysical Union.
- Howard Singer is one of the founders of the Geospace Environment Modeling effort.
- Ernie Hildner is on the National Solar Observatory Users' Committee; is Chairman of Committee on Space Environment Forecasting, and is on the Executive Committee of the Colorado Space Business Roundtable.
- Gary Heckman is Secretary of the IUWDS, the international data collection and dissemination service for space weather.

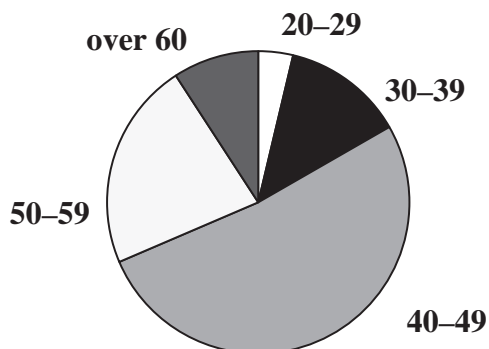
Changes in Staffing



Civil Service Staff Size



Turnover in Civil Service Staff



Age Distribution of Civil Service Staff, 1995

Declining Staff Size—Over the past 5 years, Space Environment Center has experienced an 18% decline in staff size. In 1991 SEC employed 66 civil servants; that number dropped to 54 at the end of FY95. This change reflects voluntary retirements and a mandated reduction in force. A Congressional increase in funding for SEC is unlikely to occur in FY96, and the prospect for the next few years is probably no better than level funding, with a few losses of staff. We are prioritizing our work and looking for ways to streamline or re-direct activities. Two areas under review are the Solar Technician (Sol-Tech) and Solar Forecaster positions.

SolTechs and Forecaster Duty Changes—The core duties of the SolTech are currently to monitor our computer systems, check the flow of data in and out of the Forecast Center and interface with our customers by responding to their questions and concerns. In the future we will expect each SolTech to not only understand the effects of the Sun-Earth environment on various customers, but also to develop a working knowledge of electronic networks, telecommunications, various computer systems and software packages and diagnostics. By defining such a diverse position and hiring and training to fill it, we will be better staffed to effectively meet the needs of changing priorities within SEC.

In the same vein, the duties of the forecaster also will become more diverse, and the forecaster will become more involved in other duties. The duty forecaster is primarily responsible for providing the nation's real-time space weather analysis, specification, and predictions. In addition to preparing space weather products and services, each forecaster recently has been given responsibility for improving the quality of service in a specific segment of the space environment: solar, geomagnetic, and energetic particles. In the assigned area, each forecaster is responsible for the following:

- preparing educational materials for customers affected by space weather;
- developing new products and services to meet customer needs;
- assisting in the implementation of new space weather data;
- developing requirements for new research and forecasting software/hardware;
- identifying areas where improvements are needed;
- and working with researchers to transition research results into operations.

Funding

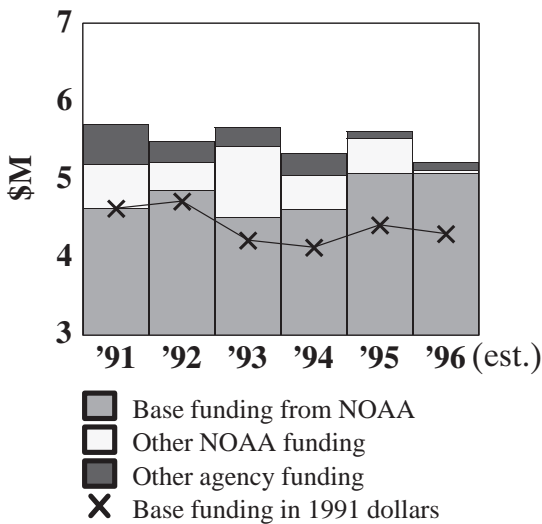
The major funding for SEC is by Congressional appropriation, with other-agency projects and other NOAA programs providing a small additional amount.

In this volatile time of shrinking government resources, SEC suffered when its SELDADS III initiative—an anticipated \$1.5 M increase to our base funds in FY96—was not funded. Although the loss is a severe setback, we are looking at ways to restructure and redesign our systems to take advantage of new technologies.

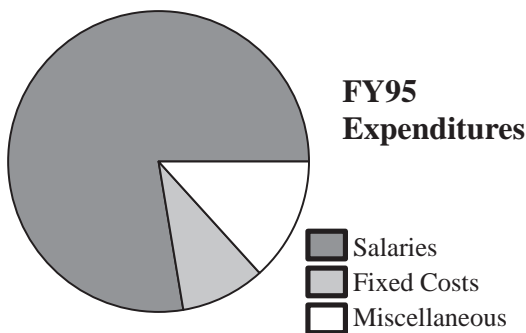
Some of the other NOAA programs in which SEC has participated in the past, ESDIM and Climate and Global Change also are facing uncertainty in the near future because of the current budget climate.

Most of the work we do with agencies other than NOAA is based on cooperative agreements or memoranda of understanding reflecting shared information or resources, where real dollars don't change hands. Funded other agency work has diminished substantially over the past couple of years. Our current other-agency projects are as follows:

Budgets over the last 5 years



- The collection, analysis, and provision of GOES magnetic-field and energetic-particle data (for NASA).
- The development of Space Environment Monitors (for NASA, which manages the procurement for NOAA), for the TIROS satellites.
- The development of a fast running neutral thermosphere forecast model capable of accepting both empirical and first-principles ionospheric specifications. (for U.S. Air Force).



Our income profile for the past 5 years, and how we spent our funds in FY95.

Our staffing level is down and our funding seems to be declining, due to inflation, but our high-quality staff is determined to maintain and improve the high level of solar-terrestrial research and products we provide and continue to give our customers excellent service.

Space Environment Center Staff and Associates

(Phone extensions listed below can be used by dialing (303) 497 – extension.)

Services

Abeyta, Jim 5827
 Balch, Chris 5693
 Barrett, Bill 6872
 Cohen, Norm 7824
 Combs, Larry 5299
 Cruickshank, Cheryl 3930
 Curtiss, Candice 3204
 DeFoor, Tom 7575
 Doggett, Kent 3317
 Finelli, Dave 7409
 Heckman, Gary, Chief 5687
 Hill, Fred 7832
 Hirman, Joe 568
 Ito, Dave 3994
 Jones, Sallie 7720
 Kunches, Joe 5275
 Lewis, Dave 3170
 Masten, Bob 5716
 Miller, Warren 3749
 Nelson, Gayle 3990
 Raben, Vi Hill 5691
 Raben, Vern 5711
 Real, Dan 3409
 Recely, Frank 3204
 Sayler, Steve 3959
 Seegrist, Larry 5045
 Speich, Dave 3316
 Sutton, Doug 5153
 Taylor, John 5712
 Wolf, Carol 5828

NOAA CORPS

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 Herlihy, Dan Maj. 6498,
 Steward, LTJG Graham 6498
 Taggart, Kelly Aust.

U.S. AIR FORCE

Gehred, Capt. Paul 5999
 Schmeiser, TSgt. Mike 5694
 Tegnell, Ken, MSgt 5692

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 Coop. Ins. Res. Env. Sci.
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 Packard, Paul
 Satellite Data Systems
 Retallack, Bill
 Satellite Data Systems
 Sargent, Tad
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 Satellite Data Systems

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 Bornmann, Patricia 3532
 Bushnell, Bob 3966
 Cook, David 3113
 Detman, Tom 5394
 Evans, Dave 3269
 Garcia, Howard 3916
 Greer, Sue 5418
 Joselyn, Jo Ann 5147
 Matheson, Lorne 3164
 Newman, Ann 5100
 Puga, Larry 5763
 Sahm, Susan 5884
 Singer, Howard 6959
 Smith, Zdenka 3473
 Speiser, Ted 3824
 Trolinger, Joanna 3980
 Winkelman Jim 3283
 Zwickl, Ron, Chief 3029

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 Coop. Ins. Res. Env. Sci.

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 Coop. Ins. Res. Env. Sci.
 Dryer, Murray 3978
 Coop. Ins. Res. Env. Sci
 Dusenbery, Paul 3824
 University of Colorado
 Fuller–Rowell, Tim 5764
 Coop. Ins. Res. Env. Sci.
 Huynh, Minh 3608
 Satellite Data Systems
 Kiplinger, Alan 5892
 University of Colorado
 Kutiev, Ivan 3616
 National Research Council
 Millward, George 7754
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 Neupert, Werner 3274
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 Pizzo, Victor 6608
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 Sauer, Herb 3681
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 Berkeley Research Inst.
 Speiser, Ted 3824
 University of Colorado
 Watari, Shin 7394
 Comm. Research Lab.

Administration

Conlon, Kathy, Admin. 3313
 Grubb, Dick 3284
 Hildner, Ernie, Director 3311
 Garcia, Nancy, 3314
 Poppe, Barbara 3992
 Rivera, Susie 3311

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Davies, Ken 5401
 NOAA

SEC Publications, FY 1994 and 1995

(SEC employees' names are capitalized in this list)

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