DR. THOMAS

SPACE ENVIRONMENT LABORATORY

Environmental Research Laboratories

ANNUAL REPORT FY 1979

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SPACE ENVIRONMENT LABORATORY

ANNUAL REPORT - FY 1979

PREFACE

This is the annual report of the activities of the Space Environment Laboratory--one of the NOAA Environmental Research Laboratories. This report contains:

- Highlights of activities for FY 1979.
- Plans for FY 1980.
- The organizational structure of the Laboratory.
- The Laboratory's resources.
- A list of Publications by the Laboratory Staff in FY 1979.
- A list of Talks by the Laboratory Staff in FY 1979.
- A listing of the SEL personnel.

INTRODUCTION

The Space Environment Laboratory conducts research in solar-terrestrial (ST) physics; develops techniques for forecasting solar disturbances and provides real-time environment monitoring and forecasting services.

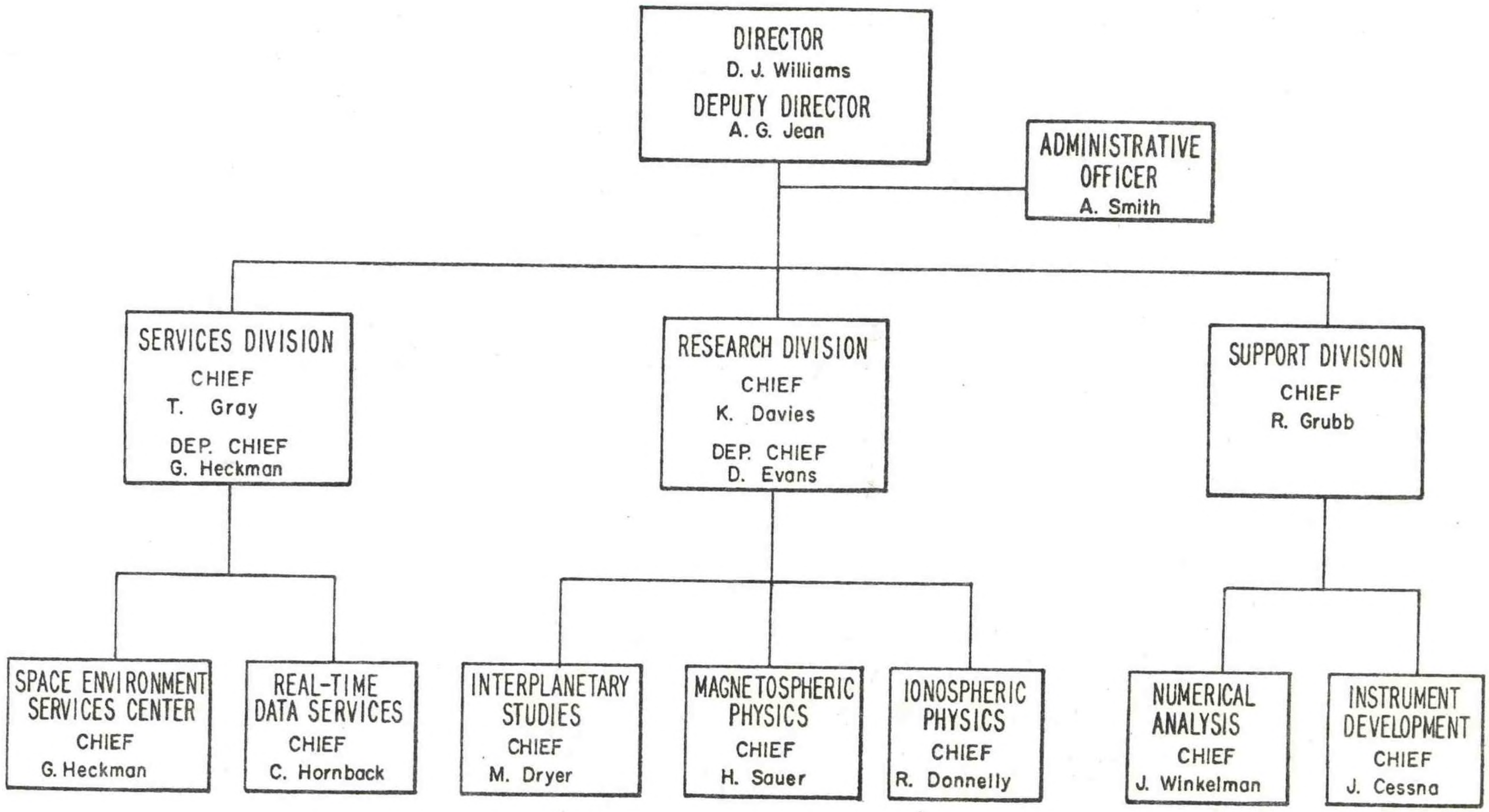
The SEL is the contemporary component of the DOC which has provided ST services for more than three decades. NOAA and its predecessor organizations have provided such services since 1942 when military operations required ionospheric radio propagation predictions for communications purposes. Since then, the increased reliance of society on sophisticated technological systems, which are sensitive to perturbations in the solar-terrestrial environment, has created a growing need for an understanding of ST relationships and technically advanced solar-terrestrial services.

In recent years there has been increasing interest in the solar-terrestrial relationships as evidenced by the number of position papers and proposals by government agencies and scientific study groups. The National Academy of Sciences is conducting a survey of Solar Terrestrial Research for the 1980's. A recommendation was made by the World Meteorological Organization, Eight Congress, in 1979, for a coordinated. solar-terrestrial physics meteorology (STP-M) Research and Monitoring project. In response, the Committee on Atmosphere and Oceans Policy Review Group established a Solar Terrestrial Task Group to define the needs, opportunities and conduct of a nationally-coordinated program to study the solar-terrestrial environment. This Task Group, chaired by Dr. D. J. Williams, and composed of representatives from NOAA, NASA, NSF, DOD, DOE, DOI, and DOT, submitted a report, "On the Need for a Nationally-Coordinated Solar Terrestrial Program in the 1980's," October 1979. The Task Group concluded that a nationally-coordinated, United States solar-terrestrial program is needed; effective national coordination can significantly enhance the overall U.S. effort; the coordination should be based mainly on existing agency programs; and the mechanism for coordination be established in 1980 and extend at least one solar cycle to 1991.

The focal point for the nation's present solar-terrestrial services is in the SEL at Boulder, where, with the cooperation of the Air Weather Service, the monitoring and forecasting services are carried out to meet a wide variety of civilian, military, commercial and federal agency requirements. The scope of the services ranges from the real-time collection of solar-terrestrial data to issuance of forecasts, alerts and warnings of adverse solar-terrestrial conditions, to the archiving and processing of solar-terrestrial data from all over the world, to the development of an understanding of the behavior of the solar-terrestrial environment to yield significant service improvements.

The SEL program studies the solar-terrestrial environment (the Sun-Earth system) as a set of several subsystems with strong interactions that produce significant environmental effects. For instance, at Earth's surface induced currents accompanying geomagnetic storms produce adverse effects on electric power distribution systems and telephone lines at high latitudes. In the atmosphere there appears to be a relationship

SPACE ENVIRONMENT LABORATORY
Organizational Chart



between solar activity and weather. Recent findings also indicate that the ozone layer which protects the Earth from solar ultraviolet radiation may be affected by protons from solar flares. In the ionosphere, there are undesirable effects on high frequency radio communications, on very high frequency radio communications from Earth to satellites, on radar systems, and on navigation aids at very low and at high radio frequencies.

Theoretical and experimental research studies are conducted on the fundamental physical processes responsible for the observed energy release in the form of electromagnetic and particle radiation from solar flares; the propagation of this energy through the interplanetary medium to the near-Earth environment; the transfer of this energy from the near-Earth interplanetary medium into the Earth's magnetic field, the magnetosphere; and the behavior and subsequent effects on this energy within the magnetosphere, the ionosphere, and upper atmospheric regions. Knowledge gathered from these studies is used to develop prediction techniques that can, with the extensive real-time data service maintained by the Laboratory, forecast solar events and their ground-based effects. Early-warning and real-time information concerning the solar-terrestrial environment, especially the near-Earth environment, is provided to a variety of users.

ORGANIZATION

During the last part of Fiscal Year 1979, the laboratory was reorganized into three main parts; namely, the Research Division, the Support Division, and the Services Division, to centralize management of the three main activities in the laboratory. The present organizational arrangement is shown in the accompanying chart. Note that the Services Division consists of the Space Environment Services Center (SESC) and the Real Time Data Service (RTDS); the Research Division consists of the Interplanetary, Magnetospheric and the Ionospheric groups; and the Support Division consists of the Numerical Analysis and the Instrument Development groups.

Functionally, there is constant cooperation and interchange between staff in the three divisions and their branches to accomplish the goals of relatively short-term projects as well as the long-term goals of the Laboratory.

RESOURCES

Trends in resources, indicated by man-year effort and funding from 1973 through 1979 indicate the following:

- The total Laboratory program decreased from 128 to 90 man-years.

  Other agency funded man-years decreased from 38 to 7.

  NOAA man-years decreased from 82 to 75.

  NOAA FTP staff decreased from 75 to 69.

- The use of NOAA funds for labor has increased. In 1979, 86% of the NOAA allocation paid 92% of the total laboratory labor.

- Despite a decrease of 7 man-years of NOAA labor, labor costs increased approximately one million dollars. The ratio of labor costs to man-years increased from $25 K per man-year to $44 K per man-year.

The above figures reflect steadily increasing cost of living, with a steadily decreasing laboratory program, and less reliance on other agency funds for labor. No budget initiatives were approved during this period. It is evident that the ongoing Laboratory programs have been under tight resource restrictions. Programs which have particularly suffered are in-house experimental and developmental programs and the service functions, the latter because the service demands have steadily increased with time. This situation will be helped if the pending budget initiative for FY 1981 is approved.

RESEARCH DIVISION

K. DAVIES

The aim of the new Research Division is to conduct fundamental long-term research into those factors that affect the solar-terrestrial environment. This involves an understanding of emission processes on the sun, the propagation of magnetohydrodynamic waves through the solar wind, the interaction of the solar wind with the earth's magnetosphere and the coupling of energy from the magnetosphere into the ionosphere and the neutral upper atmosphere.

ACCOMPLISHMENTS FY 79

Arrangements were made during the year for the new Research Division which was officially formed on October 1, 1979. The Division contains three Branches in the areas of Interplanetary, Magnetospheric and Ionospheric Physics.

PLANS FY 80

Two new digital ionospheric sounders will be directly available to the Ionospheric Branch. One of these is at the newly completed field station near Brighton, Colorado, the other near Fairbanks, Alaska. These sounders are two of six that enable participation in major national and international ionospheric research campaigns.

The results of the International Solar-Terrestrial Predictions Workshop will be disseminated to insure their practical applications.

A new solar ultra-violet program is anticipated as part of the NOAA Climate Initiative.

The Magnetospheric Branch expects to initiate a major new program as part of the Origin of Plasmas in the Earth's Neighborhood (OPEN).

New emphasis will be placed on energy coupling between the (neutral) atmosphere, ionosphere and magnetosphere (AIM). Progress in this work is discussed separately below.

Interplanetary studies will be advanced by the use of a new three-dimensional model of wave propagation and by participation in the Solar Polar Mission and the Solar Maximum Year.

INTERPLANETARY BRANCH

M. DRYER

The principal activity of the Interplanetary Physics Research Group is the development and testing (using spacecraft and ground-based observations) of models of the flow of plasma mass, momentum and energy from solar flares and coronal holes to the near-earth environment.

ACCOMPLISHMENTS FY 79

Models of these kinds are essential for the understanding and future operational use of forecasts of terrestrial magnetic storms and potential climate and weather effects (c.f., the first venture into this field is in Wu et al., in Solar-Terr. Infl. on Weather and Climate, 1979) associated with solar variations. A more realistic quasi-three-dimensional (3D) model of the coronal response to a solar flare has been developed and reported for the first time (Wu et al. Bull. Amer. Astron. Soc., 11, 410, 1979) in June 1979. This model permits the study of transverse MHD wave propagation into the solar wind in addition to the fast and slow wave modes studied in previous years. This previous work (time-dependent, two-dimensional model) is still a main tool for comparison with spacecraft and ground-based observations. Summaries of this work are given in the proceedings of several NASA workshops (Dryer et al., in A Close-Up of the Sun, 1978; Rust et al., 1979) and international symposia (Dryer, in Solar Wind IV, 1979; Maxwell and Dryer, 1980; and Steinolfson et al., 1979). Details are published in refereed journals (Steinolfson et al., 1978; Dryer et al., 1979; and Dryer and Maxwell, 1979). One important aspect of this work is the evaluation of the energy output budget of solar flares. Figure 1, for example, shows the simulated energy output (above the pre-existing background levels) for one of the Skylab-observed flares; the net output shown in the figure, multiplied by an estimate of the flare's depth in the plane-of-sky, gives about 2×10^{32} ergs. An overall comparison of the initial X-ray energy release ($\sim 10^{31}$ ergs) with interplanetary (spacecraft) observations is given by Tanaka et al. (1980).

The two-dimensional, one-fluid, time-dependent magnetohydrodynamic (MHD) solar wind model (Wu et al., Planet. Space Sci., 27, 255, 1979) simulates the propagation of multiple, staccato-like solar flares and their mutually-interacting dynamic processes enroute, as it were, to the earth's magnetosphere. An encouraging preliminary comparison of the temporal and spatial simulation, based on the August 1972 flares, has been made with the observations (at earth) of the widely-separated U.S. and USSR spacecraft: Pioneer 9 (47° east of earth st 0.78 AU) and Prognoz 1 and Prognoz 2. The concept is illustrated in Figure 2 from D'Uston et al., (1979) which shows isodensity contours in the ecliptic plane between the sun and 1 A.U. at a time of 36 hours after a solar flare. This flare, assumed to have produced an interplanetary shock which had a velocity of 2000 km sec^{-1} close to the sun, is a simulation of the first of the four major flares in August 1972. The earth was located at 35°W of the flare's central meridional direction. Propagation of the entire structure, including a forward MHD shock (labeled F.S.) and reverse shock (R.S.) with a more limited longitudinal extent, is clearly simulated.

The simpler one-dimensional solar wind model has been used to consider the detailed structures of interplanetary shock-bounded corotating stream interaction regions that buffeted Jupiter during several periods in 1973 and 1974 when Pioneer 10 and Pioneer 11, (respectively)

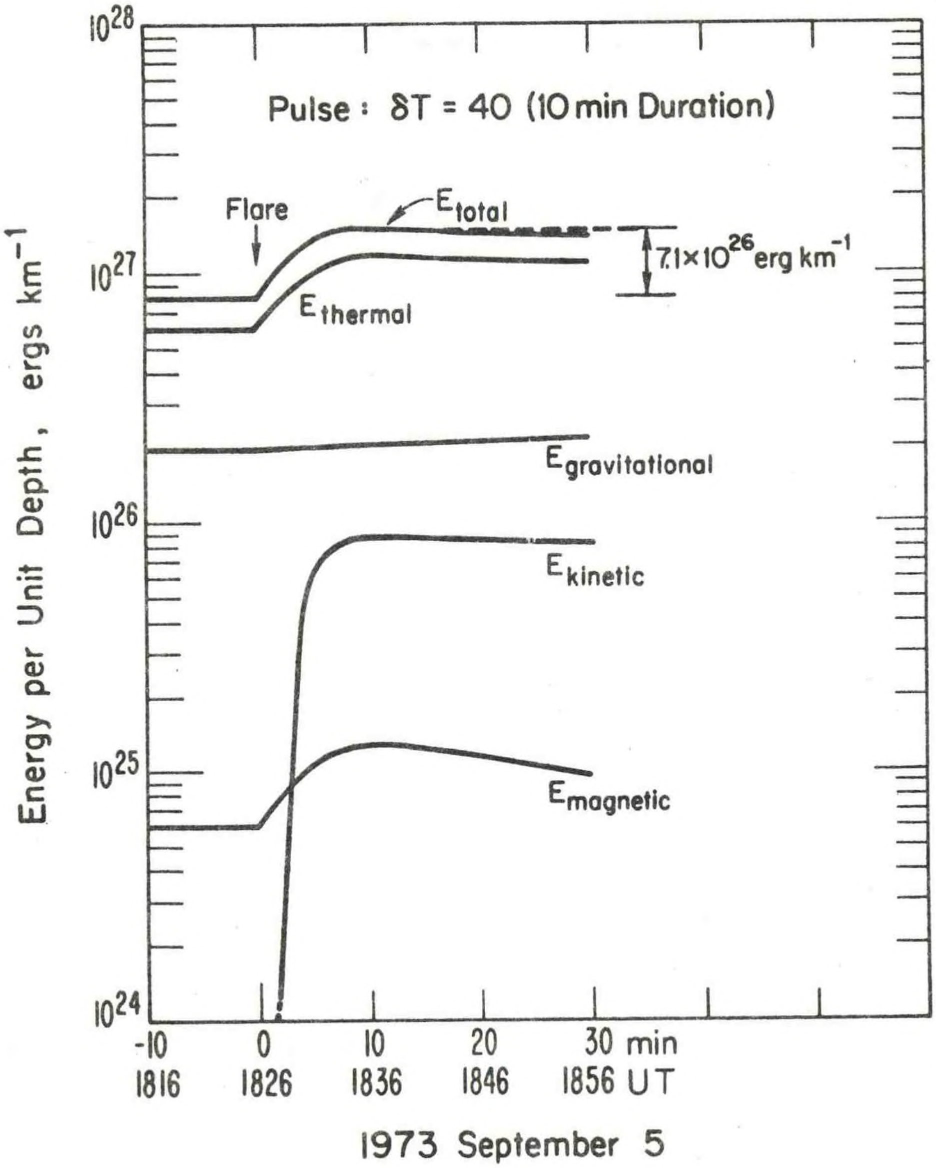


Fig. 1 Simulated energy budget for one of the Skylab-observed solar flares. The initial energy (thermal, gravitational, and magnetic) within the two-dimensional half-plane-of-the-sky is followed by the time-dependent response to a flare. The flare is simulated by a square wave thermal pulse having a 10 min duration. The radial extent of the analyzed coronal motion is 10 solar radii. When the net energy addition (due to the "flare") per unit depth into the plane-of-sky is multiplied by typical average values, the total energy release—exclusive of EM energy—is about 2×10^{32} ergs. Available estimates for the coronagraph-observed gravitational and kinetic energies corroborate this theoretical result. (Dryer and Maxwell, 1979).

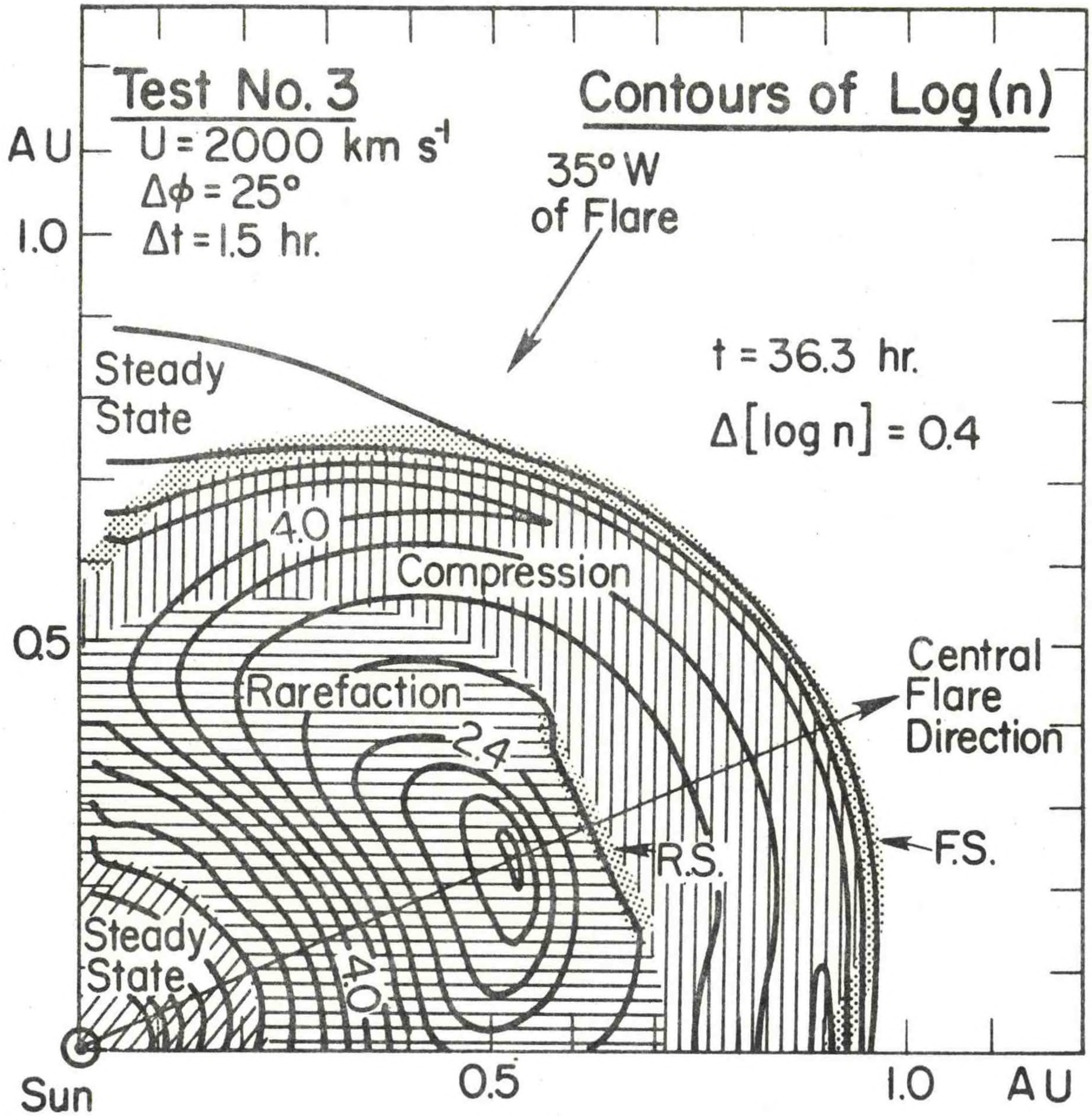


Fig. 2 Isodensity solar wind contours in the ecliptic plane between the sun and one astronomical unit following a solar-flare-generated interplanetary forward (F.S.) and reverse (R.S.) shock wave. MHD simulations such as these (plus additional superimposed staccato-like flare effects) must be checked with multi-spacecraft observations such as those during the multiple August 1972 flare events. (D'Uston et al., 1979).

approached, flew within the massive Jovian magnetosphere, then receded from this planet. It was confirmed that the variable solar wind pressure was responsible for the alternate compression and expansion of the magnetosphere. This process alternately exposed each spacecraft to the solar wind before allowing it to be engulfed again by the magnetosphere. This demonstrated support for the idea that exposure to high energy Jovian electrons and protons is strongly modulated by the variable momentum flux within solar wind structures.

Also completed (Grib et al., 1979) is a related, detailed quasi-time-dependent study of the interaction of interplanetary shock waves with the bow shock and magnetopause of planetary magnetospheres. This process is basic to the initiation of magnetic storms at earth and even for the variability of the ionospheric interaction of Venus with the solar wind including the formation of its nightside ionosphere.

The observed solar cycle variation of the atmospheric albedo of Neptune and Titan led to a study (Lockwood et al., 1980) of recent solar variability in its UV and solar wind output. It was shown that the albedo is controlled by solar EUV irradiance below 1600 A and/or by energetic particle precipitation which is modulated by solar-wind-stream structures and that solar UV emissions are unimportant. A model for the variation of the Hermaean magnetosphere in response to variable solar wind pressure was also developed (Suess and Goldstein, 1979).

A review article on solar wind flows and their associations with various diagnostics of coronal holes (Suess, Space Sci. Rev., 23, 159, 1979; also Suess, J. Geophys. Res., 84, 3306, 1979) as well as a paper on the anomalous solar activity during the Maunder Minimum were also published. Work was also initiated on a two-dimensional, time-relaxation MHD coronal model which asymptotically simulates the development of diverging flows from coronal holes.

PLANS FY 80

As a Guest Investigator with NASA's Solar Maximum Mission (to be launched in January 1980) it is planned to test two-dimensional MHD coronal model with observations of coronal transient mass and shock motions triggered by solar flares and prominence eruptions. A new major thrust is the model which incorporates plasma and magnetic field components which are perpendicular to the analysis plane (i.e., a quasi-three-dimensional capability).

The quasi-3D MHD model will be applied to the interplanetary medium an assessment will be made (with either the new model or the existing 1-D and 2-D MHD models) of the temporal and spatial variations of the meridional component of the interplanetary magnetic field. These variations, coupled with solar wind velocity, have been explicitly correlated with geomagnetic substorm commencement, termination and magnitude.

Collaboration with other groups will start with a completely new analysis of solar wind dynamics through the additional use of higher moments of the solar wind velocity distribution function for the heat flux and excess (or deficiency) of particles in the tail of the distribution function.

As a Co-Investigator with NASA's Solar Polar Mission to be launched in the mid-1980s, SEL will develop a time-relaxation computer-code for the investigation of the development of coronal holes and streamers and their continuation into the interplanetary medium.

A magnetospheric magnetic field code which is designed to study some general aspects of merging sometimes called magnetic reconnection on the geometry and dynamics of planetary magnetospheres will be completed.

Participation will continue in national and international projects such as the National Academy of Sciences' 1979-80 Study on National Goals for Solar-Terrestrial Research in the 1980s; SCOSTEP's projects on the Study of Travelling Interplanetary Phenomena (STIP) and Solar Maximum Year (c.f., Dryer and Shea, 1979); organization of STIP Symposia in Australia, Czechoslovakia and Peoples Republic of China; the editing of the proceedings of the IAU Symposium 91 on Solar and Interplanetary Dynamics; and the organization of a number of bilateral Indo-U.S. projects on various topics in solar and interplanetary physics (c.f., Dryer, in Proc. Indo-U.S. Workshop on Solar-Terrestrial Physics (A. Bhatnagar et al., Eds.), p. 61, 1979).

MAGNETOSPHERIC PHYSICS BRANCH — H. SAUER

The Magnetospheric Physics Program Area conducts experimental and theoretical investigations of magnetospheric physics comprising the study of the geomagnetic field and the several particle populations within it, and the dynamics of the complex electromagnetic processes by which the particles interact. Emphasis is placed on the analysis of satellite instrumentation data sets, obtained from both research and operational satellite series.

ACCOMPLISHMENTS FY 79

Major emphasis was placed on the technical aspects of the data reduction of the output from the Medium Energy Particles Experiment aboard the ISEE A and B spacecraft launched October 22, 1977. These data sets comprise complete three-dimensional scans of the particle distributions encountered over a broad range of energy for both electrons and ions; full scans being obtained every 36 seconds from the ISEE A instrument. Important scientific conclusions have already been obtained through the analyses of these high quality data.

The motion of the magnetopause and its distance from the spacecraft has been determined from the ISEE A particle distributions near magnetopause crossings. Charged particles spiral around field lines in their motions with a radius called the gyroradius. If an absorbing boundary exists with one gyroradius (dependent on energy), one would expect that the 90° particles would be depleted over some azimuth range from which, through simple geometric modelling, the direction and distance to that boundary can be calculated. Such azimuthal depletions, indicated by D in Figure 3 are seen in the observations (Williams, 1979). Three-dimensional scans of the 24-44.5 kev protons near the magnetopause, the solid line denotes the direction 90° from the local magnetic field direction, the dashed lines indicate directions ± 45° from the field direction. The ability to clearly define the magnetopause boundary on the basis of a simple model, for particles at least, is remarkable in its implications with respect to the integrity of that boundary. Figure 4 from Williams et al. (1979) shows the distance of the magnetopause from the ISEE-A satellite during a succession of magnetopause excursions past the satellite. It is seen that the boundary is in constant motion on several time scales. Studies of the occurrence of wave structures on the magnetopause boundary show the existence of coherent wave structures which will be examined in the light of the relevant boundary dynamics.

Multi-satellite study of particle and field data continue to be made, addressing questions of the injection and acceleration processes in the near earth plasma sheet and outer radiation zones.

A self-consistent model of the generation of magnetic field-aligned electric fields in the auroral zone has been developed (Lyons, 1979). The model is based only on the existence of gradients in the convection velocity over the polar caps. These gradients establish a field-aligned potential which agrees with the potentials inferred from the observation of the so called inverted V's in the auroral particle energy distributions.

Further theoretical study has been directed toward the physics of loss processes in the radiation belts and their ionospheric consequences. This work attempts to establish preliminary prediction schemes based on causal interrelations rather than statistical correlations. While order of magnitude predictions of the disturbed period following magnetic storms are possible, further study of plasmaspheric whistler mode wave turbulence is required to develop more precise quantitative forecasts. Such predictions of ionospheric density enhancements may be important for very low to medium frequency ionospheric radio wave propagation forecasts.

Two further experiments were run at the large vacuum chamber of the NASA Johnson Space Center, in order to define the characteristics and scaling laws of the beam plasma discharge previously observed in experiments concerning the interaction of an electron beam with a

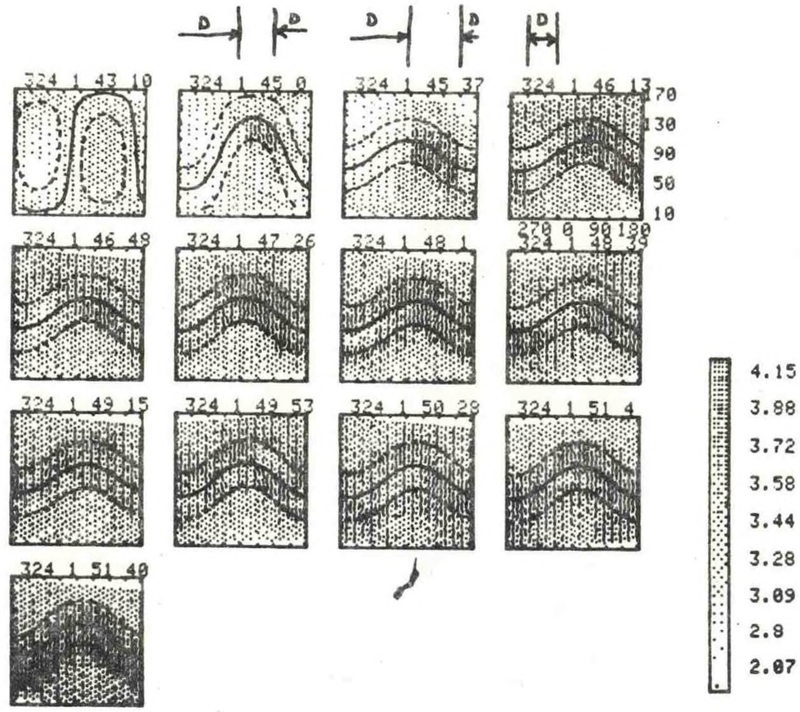


FIGURE 3 ISEE-A 3-D 22-44.5 KeV PROTON DISTRIBUTIONS

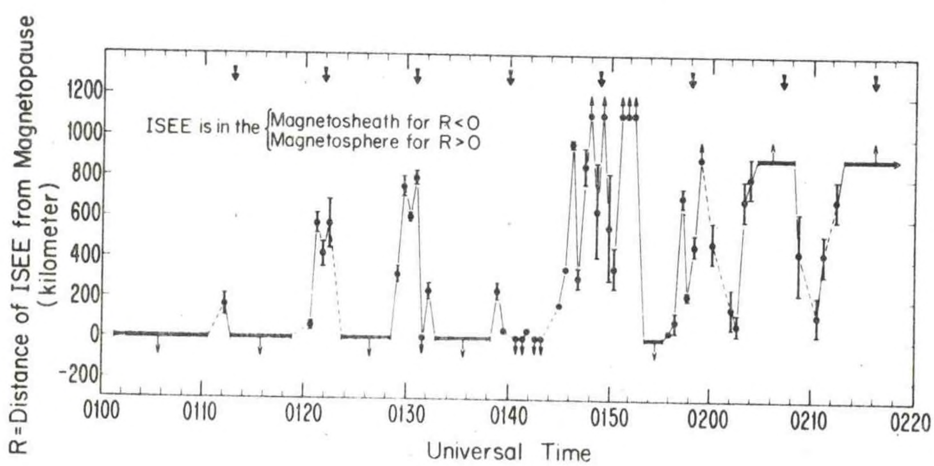


FIGURE 4 MAGNETOPAUSE DISTANCES INFERRED FROM ISEE-A

local ambient plasma under conditions simulating that of the low to middle auroral ionosphere. With low currents, the beam is found to be interpretable in terms of single particle properties, but at a critical value of the current density the so-called beam plasma discharge occurs, signaling the "explosive" onset of collective interactions of the beam with the ambient plasma leading to a concomitant dramatic increase of the ambient plasma density and optical emission. The discharge is observed as in Figure 5. At the bottom of the figure the beam is still defined, but most of the upward path is characterized by a non-structured intense ion column. The dependence of the beam current necessary to establish the discharge, on properties of the ambient magnetic field and plasma have been reduced to approximate scaling laws so that the results may be scaled to ionospheric conditions and comparisons of photometric observations with plasma probe data for these two experiments have been made. These data show that plasma diffusion across magnetic field lines occurs at rates much higher than expected from collisional diffusion processes and suggests the importance of plasma turbulence to the observed diffusion rates.

The role of ions heavier than hydrogen in the magnetosphere and specifically their contribution to the dynamics of the ring current continue to be investigated, both theoretically and through multiple satellite observations of trapped particle composition measurements, during both magnetospherically quiet and disturbed periods. These studies directed toward questions of particle source and energization mechanisms. Theoretical studies (Spjeldvik, 1979) have shown that the charged state of an ion which has traveled to the inner magnetosphere is essentially independent of its initial charge state at an assumed source distance of 6.6 R_e. Figure 6 shows the results of calculation for Oxygen ions with charge of 1 and 6, respectively. It can be seen that at low L values (the inner magnetosphere), the distributions of the charge states, indicated by the numbered curves, are indistinguishable from each other.

PLANS FY 80

The ISEE A and B data sets will be enthusiastically exploited. Specific studies are directed toward questions of: non-thermal plasma occurrences in the tail region and their sources, changes in particle distribution functions across magnetospheric boundary regions and their dynamical bases, and the definition of magnetopause characteristics well away from the subsolar point in local time. The group may be involved in the forthcoming OPEN (Origin of Plasmas in the Earth's Neighborhood) and Galileo programs. OPEN is a proposed four satellite program to critically investigate the energy transfer dynamics of the solar wind-magnetosphere-ionosphere system, while the Galileo payload will orbit Jupiter and study its magnetosphere.

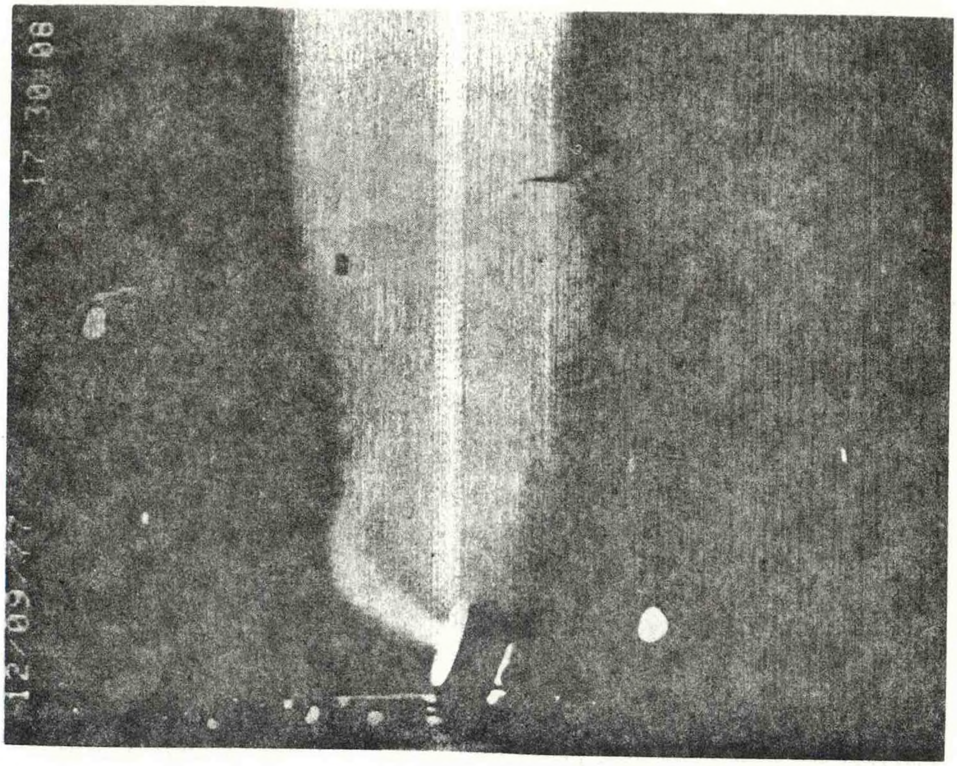


FIGURE 5 BEAM-PLASMA DISCHARGE

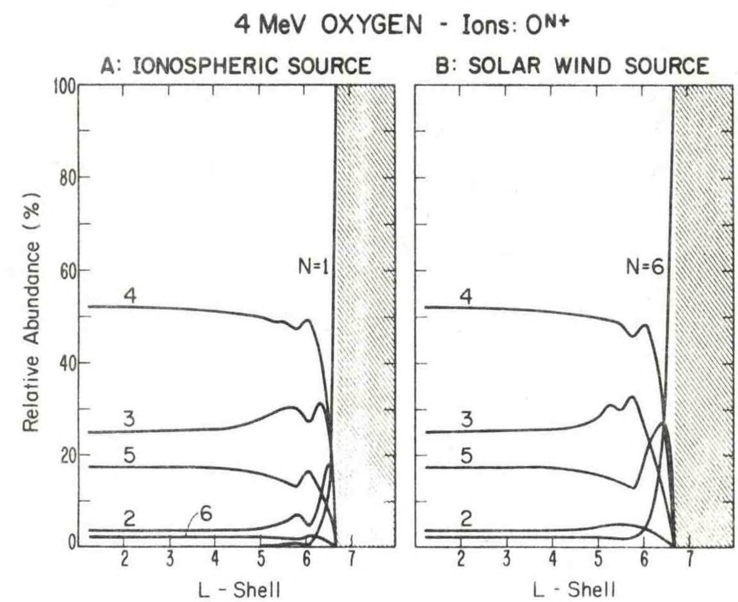


FIGURE 6 RADIAL DISTRIBUTION OF 4 MeV OXYGEN CHARGE STATES

In spite of its success, the laboratory beam plasma experiments will be discontinued in response to necessary management priority decisions in the face of imposed fiscal and personnel restraints under which the laboratory must operate. Further analysis of the past experimental data will continue for some months to make final the best assessment of the responsible mechanisms for the discharge process and find correspondence with flight accelerator results that might be available.

IONOSPHERIC PHYSICS BRANCH — R. DONNELLY

The Ionospheric Branch conducts theoretical and experimental research of the physical processes that govern the ionosphere, including the production, loss and movement of the ionized plasma and the influence of the underlying neutral atmosphere and the overlying magnetosphere. The theoretical research involves computer modeling based on our current knowledge of ionospheric physics. Such modeling is an essential complement to the experimental studies. Modeling is used to analyze the experimental observations to account for the known physics in order to study the portion that is not adequately understood. The experimental research includes measurements by digital ionosondes, transionosphere observations of satellite radio beacon transmissions, and satellite measurements of solar radiation.

ACCOMPLISHMENTS FY 79

THEORETICAL MODELING

The motion of depleted plasma regions in the equatorial ionospheric F region has been theoretically studied to determine the ambient conditions under which they propagate. The resulting calculations show that the vertical bubble velocity, as a function of time, depends critically on the background ionospheric electric field and that this dependence extends to much greater heights than was previously thought. Bubbles which are initiated at 350 km altitude at 1900 LT with a 5% depletion in electron content attain an upward velocity of 200 m/sec at 1920 LT when the background electric field is 0.6 mV/m. In the absence of an ambient electric field, one hour is required for the vertical bubble velocity to reach 200 m/sec. Small scale irregularities are produced in the wake of a rising bubble which cause severe radio scintillations that disturb communications via satellites.

A theoretical investigation of the composition of the nighttime ionospheric F1 region near the magnetic equator was carried out to explain satellite and rocket measurements which show that NO^+ is often the dominant ion up to altitudes of 250 to 300 km. Solving the coupled, time-dependent, non-linear ion continuity equations (NO^+, O_2^+ and O^+) and incorporating a realistic vertical $\overline{E}x\overline{B}$ drift model, produces NO^+, O_2^+ and O^+ density profiles which are consistent with the observations. The chemical reaction $O_2^+ + N(^4S) \rightarrow NO^+ + O$ is important and acts as a sink for O_2^+ ions and a source of NO^+ as the F layer moves upward under the action of $\overline{E}x\overline{B}$ drift. Both the observations and calculations show that where NO^+ is the dominant ion, the electron and ion densities are nearly constant in altitude, i.e., the plasma scale height becomes very large. This has important implications for the growth of large scale irregularities.

In a joint study with the Centre de Recherches en Physique de l'Environnement in France, models have been developed of the changes in thermospheric wind patterns caused by auroral heating in a magnetic storm, the generation of ionospheric electric fields and currents as winds move the conducting air through the geomagnetic field. It is found that the electric fields so generated are comparable in magnitude to observed fields on magnetically quiet days, but tend to be directed oppositely to the quiet-day fields at low latitudes. Consequently, the movement of the ionospheric plasma by electric fields at low latitudes tends to be inhibited in the recovery phase of magnetic storms, in agreement with observations.

A cooperative program with the University of Alabama was successfully completed on the subject "A Model of the Mid- and low-Latitude F-Region Ionosphere and the Plasmasphere." O^+ and H^+ ions and interhemispheric transport of electrons were considered. The model was applied to the study of the ATS6 total electron content measurements at Ootacamund, India, and used to determine the probable drift velocities.

DIGITAL IONOSONDE

The Boot Lake Field Site near Brighton, Colorado was developed. Field tests of the new digital ionosonde commenced. The layout of the field site is shown in the center of Figure 7. Note that the dimensions are quite large. The ionosonde equipment is shown in the lower right and some of the data displays are illustrated in the upper left of Figure 7.

Five new digital ionosondes have been completed and the sixth instrument is nearly completed (see section on Instrumentation Services). The ionosonde owned by the National Science Foundation (NSF) is currently operating at the NOAA Boot Lake Field Site. A field site for the NSF ionosonde was developed near Poker Flat, Alaska, in cooperation with the University of Alaska, Utah State University, and NSF. The ionosonde owned by Utah State University is now operating at Logan, Utah. The Max Planck Institute and White Sands Missile Range now have their ionosondes. The British Antarctic Survey is operating their ionosonde near Cambridge, England. The NOAA ionosonde is the sixth instrument. Two high-power (100KW) fixed-frequency transmitters and the associated hardware and

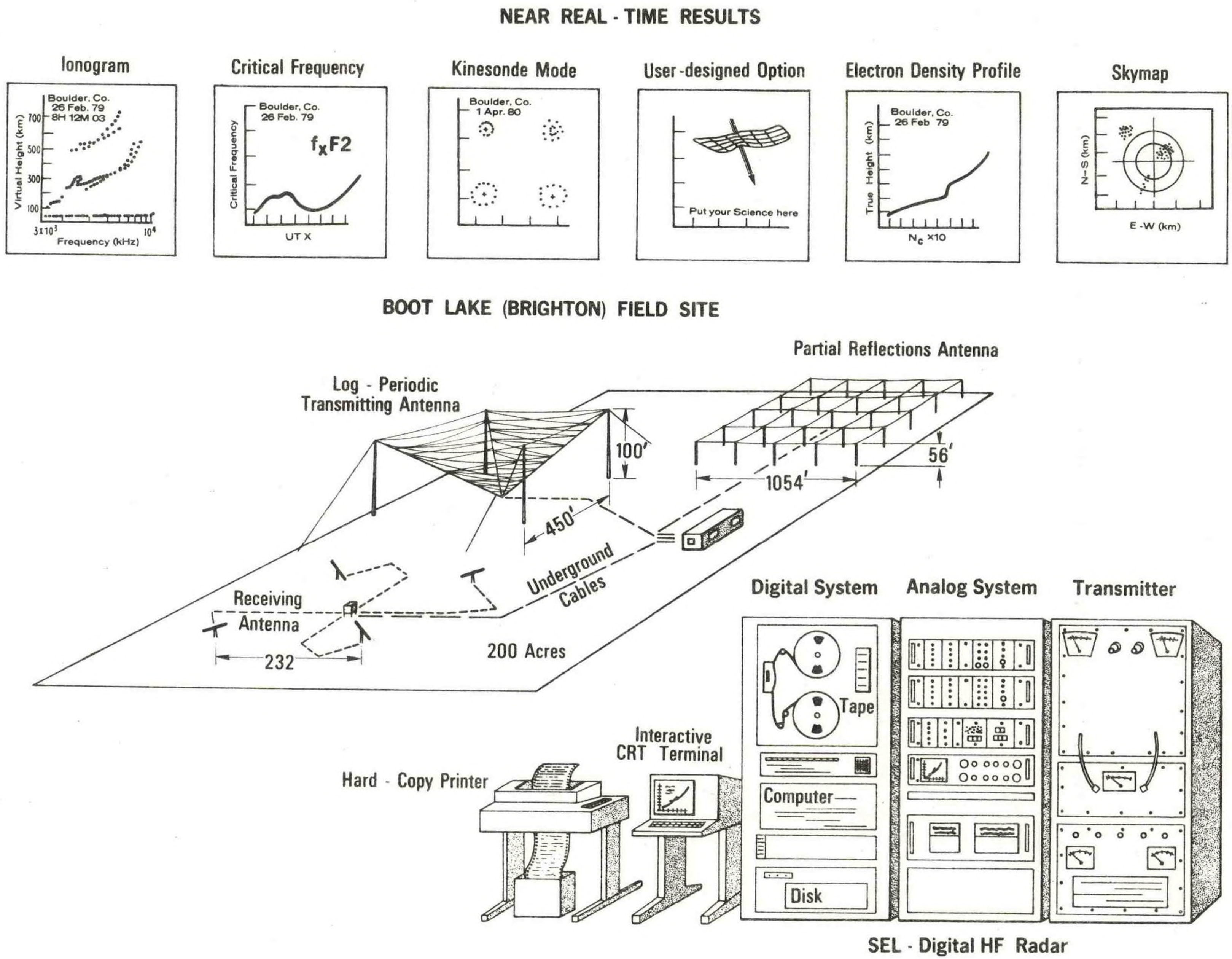


Fig. 7 The Boot Lake Field Site near Brighton, Colorado

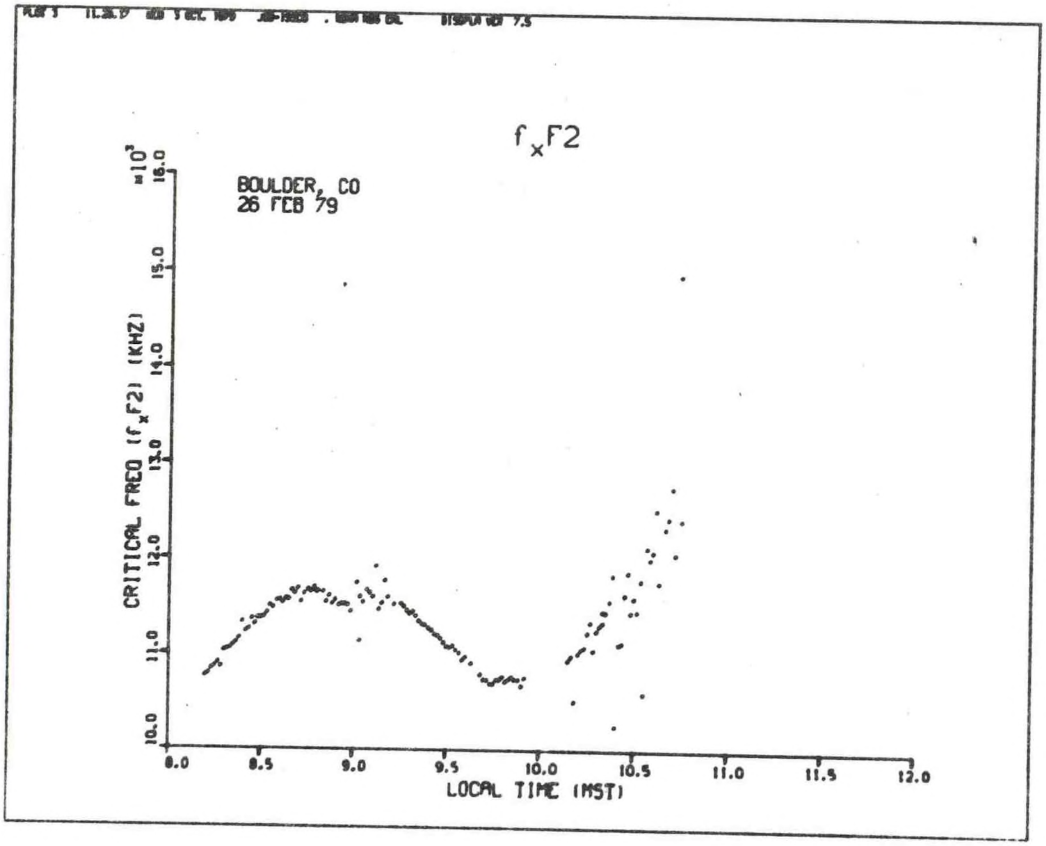


Fig. 8 Computer-processed observations during the solar eclipse on February 26, 1979, showing a marked depletion in f_xF2 near 10 MST.

software are being built now so that the HF Radar can operate as a partial reflection sounder. An 80-dipole array (see Fig. 7) is in place at Boot Lake, Colorado, and a second array has been started at Poker Flat, Alaska.

As an example of some of the early results, the new digital ionosonde was operated while still in the construction laboratory to make measurements at low power (200 watts pulse power) during the solar eclipse on February 26, 1979. Digital ionograms were recorded in one minute intervals for a period of approximately 2-1/2 hours centered around the time of maximum occultation at 0923 MST. The large number of ionograms obtained during this event provided an opportunity to test a new procedure for computing the critical frequency of the F-layer directly from the digital data recorded on tape, instead of using the classical approach of displaying an ionogram and extrapolating visually for the critical frequency. Figure 8 shows the early results on the day of the eclipse.

TABLE 1 Data Processing Programs for Digital Ionosonde Data

Frequency-Dependent Processing		Functions
Program		
DSNDPLT	I,B	Plot ionograms; print data; plot skymap (see Fig. 1) gonionogram, amplionogram; O,X; extract traces.
AUTONH	I,B	Compute time-dependent N(h,t) profiles
Time-Dependent Processing		
PHAMPLT	K	Plot time series of Amplitude, phase, group-path; print data.
ARRIVAL	K	Compute and plot time-series and skymap of echolocation or group path vector, with temporarily controlled smoothing.
VISTA	K	Compute and plot Fourier transforms of amplitude, phase, or complex amplitude time series, auto and crosscorrelograms; fit Gaussian Space-time 'correloid' for moving pattern velocities.

I = Swept-Frequency Ionosonde Mode. K = time-series Kinesonde Mode.

B = Basic Measurement Mode (variations with frequency, time and antenna elements).

A main emphasis in the ionosonde project is the development of scientific software for the new digital ionosondes. The development of software for general data analysis has benefited from existing software for earlier ionosondes, namely the Kinesonde for time-series studies and the Dynasonde for swept-frequency studies. Much effort was devoted during the year to the modernization and further development of these existing programs listed in Table 1 for analysis of digital, tape-recorded, ionospheric sounding data.

Figure 9 shows an ionogram segment (2-7 MHz, 220-270 km) recorded by the Dynasonde and processed by the TRACE feature.

ATS6 RADIO BEACON

The analysis of measurements at Ootacamund, India, was published (Bouwer et al., 1979). The diurnal variation of total electron content N_T was successfully modelled (Tan, 1978) using a theoretical model of the F region. N_T and the shape factor of the electron-density altitude profile, were modelled (Donnelly, 1979) using electron density-height profiles from Jicamarca, Peru. The day-to-day variations in electron content at Ootacamund were found to be smaller relative to the monthly median values than at Hawaii and at midlatitudes. The deep predawn dip in the shape factor is caused by the downward drift of the peak of the F layer to low altitudes where high loss rates cause a large reduction in ionization below 300 km and a very flat $N_e(h)$ profile.

A cooperative program with the University of Electro-Communications, Tokyo, Japan, was successfully completed (Okuzawa and Davies, 1979). The ATS6 radio signals received at Boulder reveal small-amplitude, quasi-sinusoidal fluctuations with periods in the range of 10 to 50 sec. Spectral analyses by the maximum entropy technique were conducted on sample ATS6 records and simultaneous geomagnetic-field variations recorded at the ground near Boulder. The principal results are: (1) The occurrence rate of the events is higher on magnetically disturbed days than on quiet days. (2) The maximum likelihood of occurrence is around 21 UT (14 LT). (3) The dominant spectrum peaks of the radio fluctuations and geomagnetic field on the ground generally coincide. Also, cases were found in which the temporal characteristics of the spectra are similar. These results indicate a close association of the radio fluctuations with the Pc 3-4 type pulsations of the geomagnetic field.

Measurements of radio beacon transmissions at Boulder during Phase III of the ATS6 project when the satellite was located at 140° West were completed. The data analysis to date has concentrated on examining the effects of changes in the satellite pointing and in testing the self-consistency of the data. One main goal is to determine the diurnal variation of the plasmaspheric electron content at high levels of solar activity.

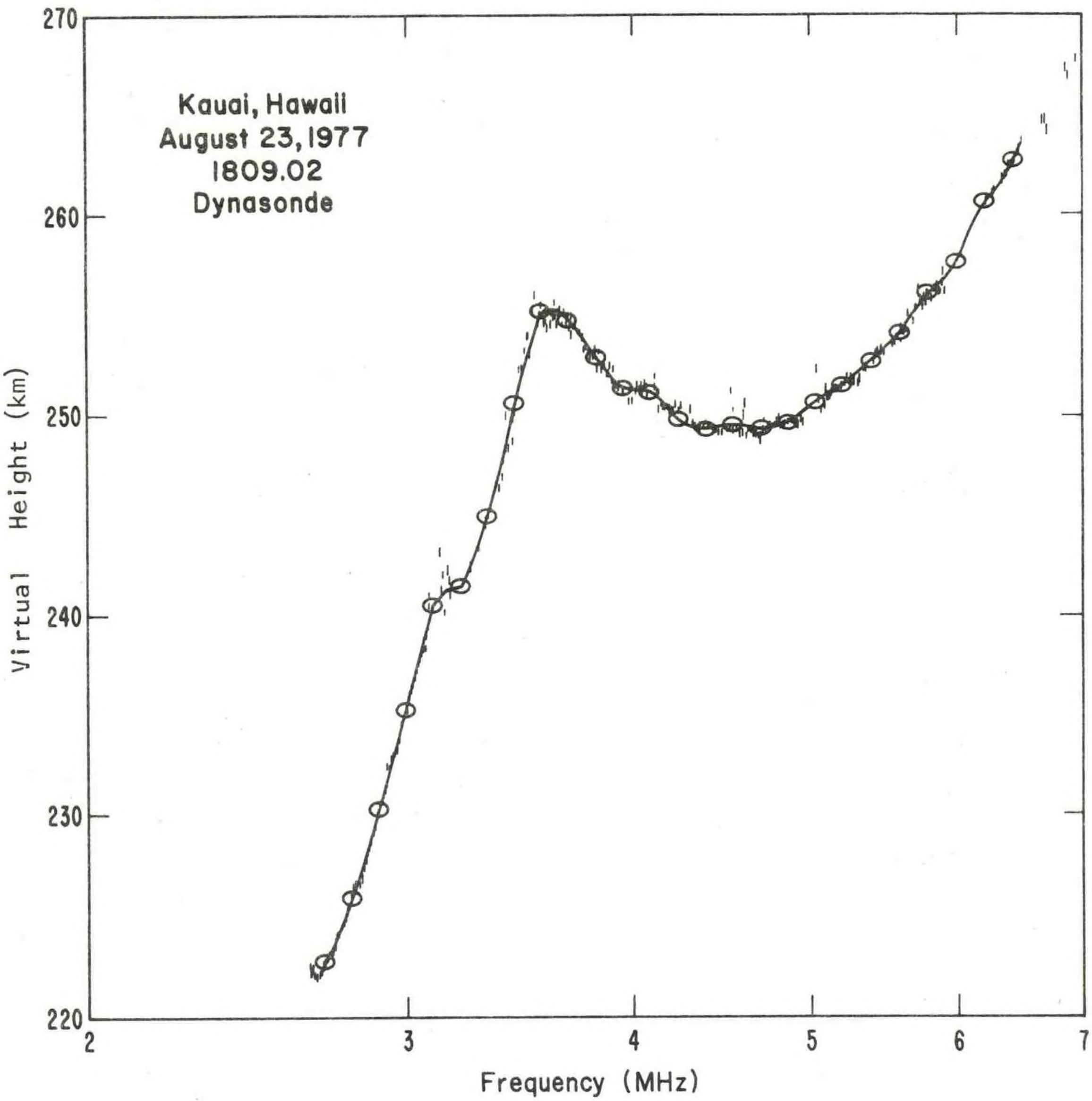


FIGURE 9 Computer-processed Dynasonde measurements recorded at Kauai, Hawaii, on August 23, 1977.

INTERNATIONAL SOLAR-TERRESTRIAL PREDICTIONS PROCEEDINGS AND WORKSHOP PROGRAM

In order to improve predictions of solar activity and their terrestrial effects, a three-part program was conducted that included (1) an exchange of preprints about predictions among working group members (October 1978-March 1979), (2) a workshop, The International Solar-Terrestrial Predictions Workshop held April 23-27, 1979, and (3) a four-volume proceedings. The goals were to determine current practice at forecast centers throughout the world, applications of predictions, future needs for predictions, and suggestions for new prediction schemes. The workshop was attended by nearly 200 scientists and forecasters from 18 countries. Representatives from 19 forecast centers attended, including solar physicists from Yunnan Observatory, Peking Observatory and Purple Mountain Observatory, China. It was the largest gathering of solar terrestrial forecasters to date.

The fourteen working groups listed in Table 2 participated in the program. Most workshop sessions involved joint sessions of several groups discussing topics of mutual interest. Workshop participants were asked to read the pertinent preprints before arriving at the workshop.

The results of the program are being published in the Solar-Terrestrial Predictions Proceedings, which consist of four volumes:

Volume I.	Prediction Group Reports
Volume II.	Working Group Reports and Reviews
Volume III.	Solar Activity Predictions
Volume IV.	Prediction of Terrestrial Effects of Solar Activity

Volume I reviews the current practice in solar-terrestrial predictions. Volume II presents the recommendations and reports developed by the working groups atthe workshop held in Boulder, April 23-27, 1979. Topical reviews and papers on the current and future needs for predictions are also included. Volume II reports the results of discussions of questions such as: What predictions are needed? Where are current predictions inadequate? What recent results from solar-terrestrial research should be applied to improve solar-terrestrial predictions? Volumes III and IV present individual suggestions for particular prediction schemes. Volume I was sent to the publisher on August 23, 1979, and will soon be available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, USA (Superintendent of Documents No. 003-023-00041-9). Volumes II, III and IV are still being prepared for publication.

TABLE 2 Working Groups and Group Leaders

Long-Term Solar Activity Predictions: P. S. McIntosh, NOAA, ERL, SEL, Boulder, Colorado 80303, USA

Short-Term Solar Activity Predictions: P. Simon, Observatory Meudon, France

Solar Wind and Magnetosphere Interactions: C. T. Russell, Space Science Center, Institute of Geophysics and Planetary Physics, Univ. of California, Los Angeles, California 90024, USA

Geomagnetic Storms: S. I. Akasofu, Geophysical Institute, Univ. of Alaska, Fairbanks, Alaska 99701, USA

Energetic Particle Disturbances: G. A. Paulikas, Aerospace Corp., Los Angeles, California 99701, USA

Magnetosphere-Ionosphere Interactions: R. R. Vondrak, Radio Physics Lab., SRI International, Menlo Park, California 94025, USA

High-Latitude E- and F-Region Ionospheric Predictions: R. D. Hunsucker, Geophysical Institute, Univ. of Alaska, College, Alaska 99701, USA

Midlatitude and Equatorial E- and F-Region Ionospheric Predictions: C. M. Rush, Institute of Telecommunications Sciences, National Telecommunications and Information Administration, Boulder, Colo., 80303, USA

D-Region Ionospheric Predictions: E. Thrane, Norwegian Defense Research Establishment, Division for Electronics, P. O. Boks 25, Kjeller, Norway.

Solar-Weather Predictions: K. H. Schatten, Department of Astronomy, Boston Univ., 725 Commonwealth Ave., Boston, Mass. 02215, USA

Communications Predictions: A. P. Mitra, Radio Science Division, National Physical Lab., Hillside Road, New Delhi - 110012, India

Subsection on Ionosphere-Reflected Propagation: B. M. Reddy, Radio Science Division, National Physical Lab., Hillside Road, New Delhi - 110012, India

Subsection on Trans-Ionosphere Propagation: J. A. Klobuchar, AFGL-PHP, Hanscom Air Force Base, Bedford, Mass. 01731, USA

Geomagnetic Applications: W. H. Campbell, USGS Box 25046, Denver Federal Center MS 964, Denver, Colorado 80225, USA

Space-Craft Environment and Manned Space Flight Applications: A. L. Vampola, The Aerospace Corp., P. O. Box 92957, Los Angeles, Calif., 9009 USA

Some highlights of the major conclusions and recommendations of the program include:

1. Increased realization of the great importance and need for improving long-term solar-activity predictions (5-20 years).

2. Movement toward real-time use of ISEE-3 satellite measurements of the solar wind and interplanetary magnetic field between the sun and Earth to provide 90 minute predictions of geomagnetic disturbances.

3. One major result of the Working Group on Geomagnetic Applications was the formation of a permanent association of those concerned with the effects of geomagnetic variations upon human enterprise, e.g., the geomagnetic disturbances on longline electric power networks, long pipe-lines, and geomagnetic surveys. Work on geomagnetically induced currents is becoming an increasingly important area of applied geophysics.

PLANS FY 80

THEORETICAL MODELING

Theoretical studies of the semiannual effect observed by Doty-ATS6 measurements of total electron content will be made using the ionosphere-plasmasphere density model. A cooperative study with NCAR will be made to study the low and midlatitude diurnal variation in O^+, H^+, T_i and T_e by solving the coupled, time-dependent plasma (O^+ and H^+) continuity and heat conduction equations. By modifying equations, the effects on the ionosphere of the HEAO-C launch will be studied.

The dynamic coupling between neutral and plasma motions in the low latitude ionosphere will be modelled to see how this coupling affects the generation of electric fields and large-scale irregularities. Data from the ionosonde and other instruments will be used to study wave motions in the thermosphere and mesosphere.

DIGITAL IONOSONDE

The NSF ionosonde will be moved to Poker Flat, Alaska, for measurements in cooperation with NSF, Utah State University and the University of Alaska. The White Sands Missile Range will build antennas for their ionosonde. The Utah State University and Stanford University will move their ionosonde to Roberval, Canada, in the spring of 1980, and then to Siple, Antarctica in the summer of 1980.

The Max-Planck Institute will conduct ionosonde measurements in conjunction with the European ionospheric heating experiment. The British Antarctic Survey will move their ionosonde to Halley Bay, Antarctica. The NOAA staff will be involved in cooperative studies with these other instruments and groups from time to time because of common interests.

The NOAA ionosonde will be operated at the Boot Lake Field Site near Brighton, Colorado. Current plans are to build several permanent antenna facilities around the world for multiple usage as needed. Sites under consideration for particular scientific campaigns include Cape Parry, NWT, Canada, (in cooperation with the Univ. of Alaska), Jicamarca, Peru, and Arecibo, Puerto Rico.

An iteration process for separating overlapping ordinary and extraordinary echos will be developed and tested. Further testing will result in complete separation of echo traces. This will be an important step toward automatic calculation of electron density profiles with better accuracy.

The specific antenna-frequency switching sequence implemented at the Brighton Field Site should yield the Doppler frequency for each echo set (Doppler profile): first results are promising.

Testing of data will be continued to make sure that the system is working properly before data processing methods can be finalized.

<u>Solar-Terrestrial Predictions Proceedings</u>

Editing, publication and distribution of Volumes II, III and IV of the <u>Solar-Terrestrial Predictions Proceedings</u> will be completed.

<u>Solar UV Radiation Program</u>

As part of the NOAA Climate Program, a new program on Solar UV Radiation Research will commence. The major goal is to determine the temporal variations of solar UV flux in the 1000-4000 Å range. Some of the guiding principles being considered in the design of the program is to avoid duplication with existing UV radiation programs and to include cooperative programs with NASA, NBS, and university research groups.

ATMOSPHERIC-IONOSPHERIC-MAGNETOSPHERIC COUPLING — D. EVANS

It is important to view the neutral atmosphere, the ionosphere and the magnetosphere a single interactive system in which each element is acted upon and reacts on the other elements. For example the aurora are manifestations of the coupling between a magnetospheric "dynamo" and an ionospheric "load" which leads to the production of large electrical potential differences which, in turn, enhance the energy flow into the neutral atmosphere by energetic particle precipitation and by electrical current (Joule) heating.

ACCOMPLISHMENTS FY 79

The concepts underlying the AIM coupling are being formulated on a quantitative basis. Data from the TIROS-N satellites (particle precipitation) are being accumulated in a systematic manner. These data demonstrate the importance of the energy input on the behavior of the upper atmosphere. Figure 10 gives an idea of the global energy input from this source on April 25, 1979 which was a moderately geomagnetically active day. The maximum power inputs into each hemisphere approaches $2x10^{11}$ watts during magnetic substorms which exceeds the power input by direct solar radiation and exceeds the power generating capacity of the USA. Many disturbances in the upper atmosphere, in middle and low latitudes, can be traced to enhanced energy input into the auroral ionosphere by these coupling processes. During the past year it was shown that a major (sometimes a dominant) portion of the energetic electrons found in the distant plasma sheet originates in the earth's upper atmosphere, dispelling the idea that all magnetospheric electrons came from the sun, and illustrates the necessity to view the system as a unit. The latter is supported by recent confirmation that much of the ion-population in the "ring current" is composed of heavy ions (helium and oxygen) rather than protons which points directly to the ionosphere as a source. These observations show that ionospheric positive ions are accelerated upwards into the magnetosphere by the same electric fields that accelerate electrons downward into the ionosphere to produce aurora.

PLANS FY 80

A program for research in AIM coupling has been formulated and includes: (1) numerical modeling of the various electromagnetic and mechanical processes which govern the interactions between the atmosphere, the ionosphere and the magnetosphere and (2) an experimental program to validate the proposed processes. The first part requires individuals with experience in theory and modelling. Part (2) will be accomplished by involvement in auroral research and in chemical release experiments, designed to study the dynamics of the coupled system. It is hoped that, as part of this program, the data from TIROS-N will be achieved and used to determine the impact on the neutral atmosphere of the energy input.

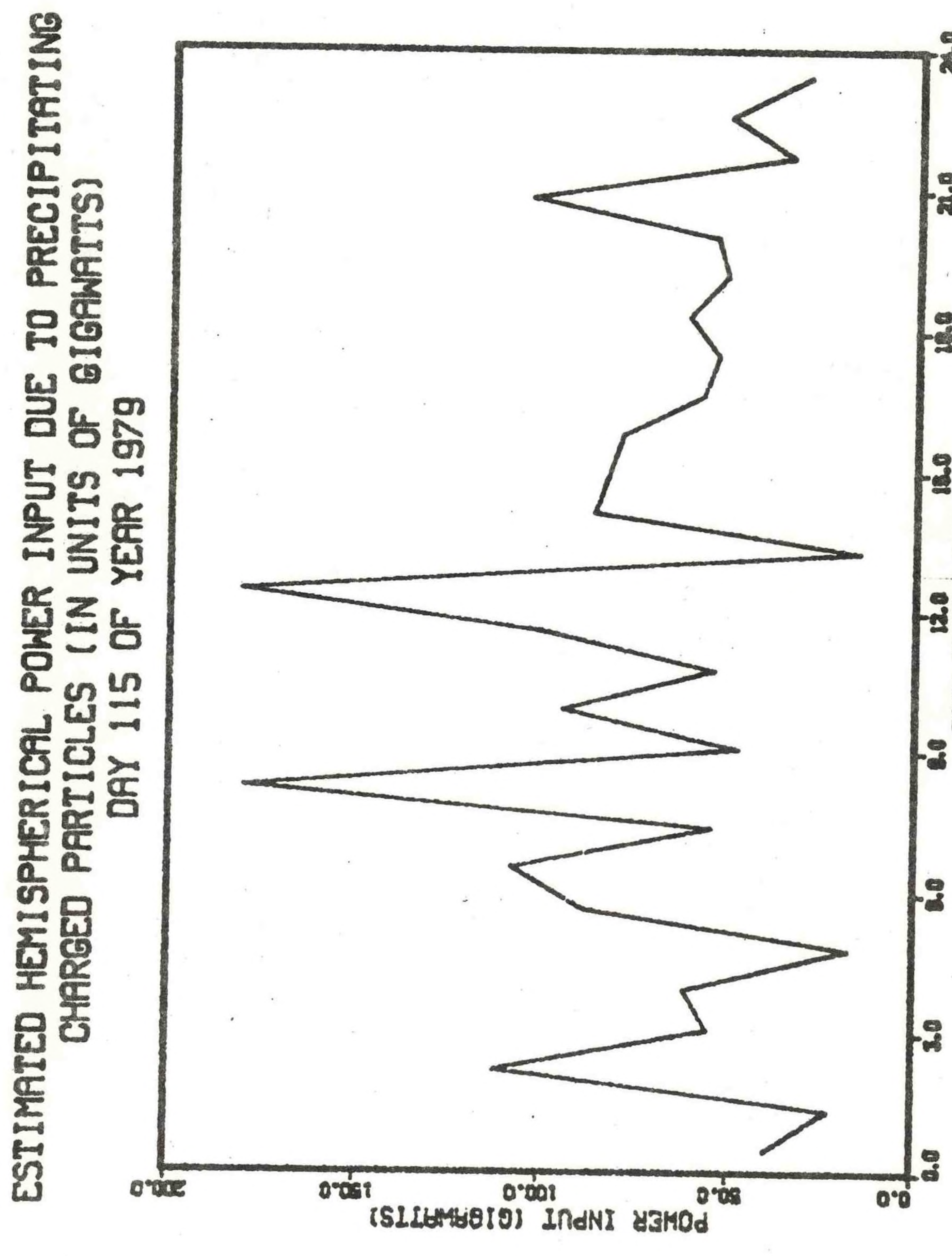

ESTIMATED HEMISPHERICAL POWER INPUT DUE TO PRECIPITATING
CHARGED PARTICLES (IN UNITS OF GIGAWATTS)
DAY 115 OF YEAR 1979
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
TIME OF DAY (UT)
0.0
50.0
100.0
150.0
200.0
POWER INPUT (GIGAWATTS)

Figure 10

SUPPORT DIVISION — R. GRUBB

The Support Division provides assistance to all Laboratory projects; in the use of computers for the acquisition and analysis of data through the Analysis Branch; and in the development of instrument hardware, engineering software and data systems design, through the Instrument Development Branch.

Typical contributions to the Laboratory research and services are the development of ground-based and satellite instrumentation for experimental and observational data collection and in the analysis of data used in research publications.

ANALYSIS BRANCH — J. WINKELMAN

The Analysis Branch of the Support Division provides support to all Laboratory projects requiring assistance or advice in the use of computers. It provides continuing processing of satellite data tapes and maintains a library comprising more than 17,000 reels of magnetic tape from satellite and ground-based experiments.

ACCOMPLISHMENTS FY 1979

Consolidation of gains made last year was the major thrust this year. The two largest projects, the International Sun Earth Explorer (ISEE) and the High Frequency Radar (HF Radar), have been refined to run better and more consistently.

The ISEE data reduction consists of merging several experiments on two satellites into a single Master Science File (MSF) tape. The experiments produce data interspersed on the input tape, with no experiment synchronous with another. Production has continued through the year with programming done to enhance the quality of the data written to the MSF. Emphasis has been on being able to process tapes with many errors on them (the normal condition) and when some of the experiments are not working. Several subroutines have been rewritten so that ten days of data can be processed in a week. The first full year of data has been processed including the reprocessing of several time periods for which the newer programs were necessary to retrieve the data.

The HF Radar, also known as the digital HF sounder or ionosonde, has been delivered to four installations. The programs and documentation were completed in time for a training session for potential users in April. The software has been modified since then to provide better operation and new features requested by the users. New diagnostics and test programs were written to aid in testing and verifying the operation of the equipment.

Production processing of SMS-GOES data tapes is now up to date. All recovery of bad data tapes has been done.

Three support programs (OUTFOL, a file management utility; COMPOS, a compositor for documentation; and CONCORD, a program to make concordance listings of whole programs) have been modified to run under both Standard FORTRAN and the new FORTRAN-77. These programs are widely used outside this organization.

Processing on the IMP, OGO, and ATS satellites is finished. The programs to process the TIROS-N data to archive format have been defined and programming has started. Software planning for the GALILEO Jupiter orbiter is continuing.

Programs to transfer selected data from ISEE-MSF tapes to 4051 cartridges have been done. These cartridges allow the researchers to study their data using the 4051s and to define plotting formats which will display the data most usefully. Many of these plot formats have then been written for the central computer and large numbers of plots are now routinely produced as each new MSF tape is written. The central computer facility recently acquired a new FR-80 microfilm plotter. The Analysis Branch was heavily involved in the plotter specifications and has written the system software needed to use the FR-80 on the 6600. This software was written under contract to the Central Computer Facility and allows use of the FR-80 without change to current programs. The new plotter has greatly improved resolution and clarity.

PLANS FY 1980

All the FY-79 projects except OGO will continue during FY-80. ISEE should finish production on the ISEE-1 satellite (the experiment stopped working recently) and may catch up with the production on ISEE-2. A whole new set of plots is being defined by the ISEE researchers. These plots will be programmed and run for all MSF tapes.

New display and sounding modes are being written for the HF Radar. The operating system is being modified so that it can swap between routine soundings and stand-alone computer operation automatically. The Front End Processor (FEP) will be reprogrammed to do more processing of the pulses. This will remove some of the load on the central processor and allow faster soundings.

INSTRUMENT DEVELOPMENT BRANCH

J. R. CESSNA

The Instrument Development Branch (IDB) provides general support to the Laboratory in the areas of instrument hardware, engineering software, and data system design. The group provides laboratory facilities for the scientific staff, engineering design services, and contractor technical supervision and management.

ACCOMPLISHMENTS FY 1979

Operational Space Environment Monitors. The IDB continues to serve as the focal point within SEL for the identification of operational requirements for space environment monitors (SEM) as well as to provide the technical support and contract monitoring required for SEM instruments flown on NOAA/NESS satellites (i.e., TIROS, GOES).

The TIROS-N SEM was activated on October 19, 1978, without major anomalies. Satisfactory operation is continuing at this time.

NOAA-6 SEM was activated on June 12, 1979, with no anomalies. Satisfactory operation is continuing at this time.

FM-3 and FM-4 were completed and delivered on October 31, 1978.

FM-5 was completed and delivered on January 12, 1979.

FM-6 and FM-7 were completed and delivered on April 26, 1979.

FM-5, -6, and -7 HEPADS were delivered to Panametrics Corporation for integration into the GOES D, E, and F EPS systems.

The EM for the GOES D, E, and F SEM was completed and satisfactorily passed the qualification test phase.

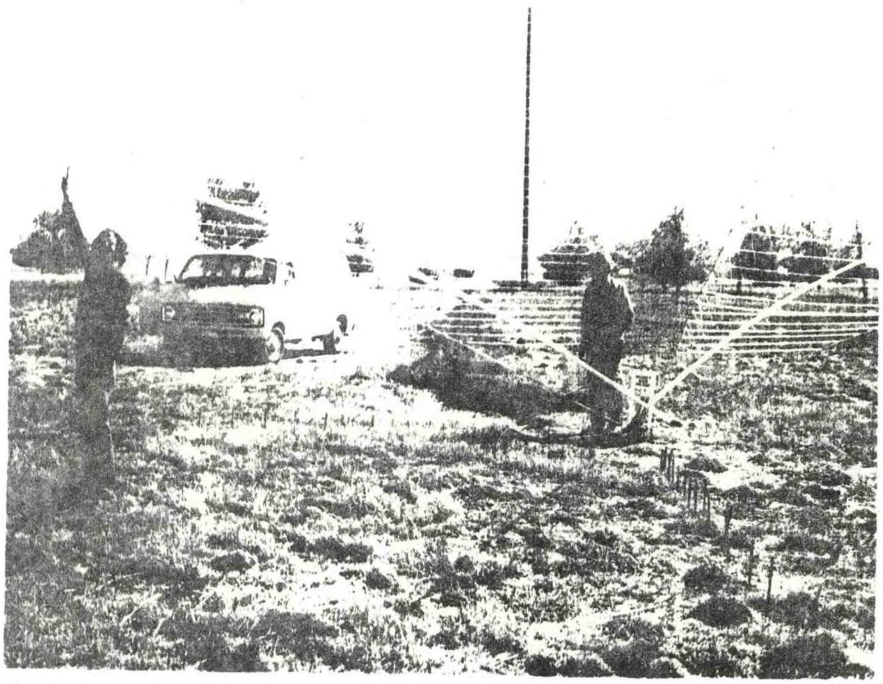
HF Radar. A new generation of computer based HF Radar sounder has been developed by the IDB. Construction of the receivers and transmitter controllers for the six sounders has been completed. The NSF, White Sands, BAS, Utah, and MPI systems are operational, while the NOAA system requires calibration and testing.

Eight sets of printed circuit boards for the FEP/TSG (Front End Processor/Timing Sequence Generator) were produced, assembled, and debugged. Four of these sets have been installed as part of the integration of the 4 radar systems completed in this period. Of the remaining four sets, two will be installed and two will be used as spares.

The ROM (read only memory) version of the TSG control program was developed and installed.

The Bootlake (Brighton) field site of SEL (see Figure 11) was opened in September, with the NSF unit undergoing its first actual field test. Its location, 23 km south of the Platteville heating transmitter, will allow joint experiments to be planned using both facilities. A log periodic antenna for this site was designed, built, and tested. Although the design was compromised by

Figure 11. Boot Lake (Brighton) Field Site



limitations in space and tower height, it performs adequately through the range of 1-30 MHz.

ATS-6 Beacon. The ATS-6 Beacon receiver was operated at Table Mountain until August, 1979, when recording was terminated due to termination of satellite attitude control. The receiving system was dismantled and parts are being used in other programs.

P-N Code Beacon. A feasibility study is underway for a P-N Code modulated radio beacon transmitter proposed for future (System 80 N) geostationary satellites. A requirement of this beacon, intended for measuring total electron content, is that it can be received by very simple and inexpensive ground stations.

A single channel 140 MHz receiver and transmitter simulator were built. The simulator generates a 1024 bit M-sequence which phase modulates the 140 MHz carrier. The signal is demodulated by an identical code generator in the receiver, which is synchronized by a microprocessor controlled correlation peak detector.

Solar X-Ray Imager. A proposal was prepared for NOAA/NESS for a hardware feasibility demonstration of a Solar X-Ray Imager suitable for future (System 80 N) geostationary satellites. This program was approved and work is underway to develop the electronics to process x-ray images from a CCD silicon image array, including electronic image despinning. A component of this work is being carried out at MSFC, Huntsville, where the mirror/optics part of the system are being produced.

Galileo Energetic Particles Detector (EPD). The IDB is providing the program management and a portion of the design for the EPD, part of the NASA project Galileo, an international program to send an orbiter and surface probe to the planet Jupiter to gather scientific information in the second half of the next decade. The EPD is being developed in collaboration with The Johns Hopkins University, Applied Physics Laboratory and the Max-Planck Institute for Aeronomy in West Germany.

During FY 79, the EPD team has been developing the Engineering Model circuits and has begun fabrication of some of the Engineering Model subsystems. All the flight unit parts have been ordered except for some mask programmed read only memory chips that are awaiting development of masks.

PLANS FY 1980

Integration support for the TIROS-N SEM program will continue. GOES D S/C will be launched in the third quarter of FY 80 and will be supported with continuing technical monitoring both before and post launch.

General support, as required, for the existing 6 HF Radar systems will continue. In addition, supplementary fixed frequency high power transmitters will be constructed for the NSF and SEL systems. A software development system will be assembled in the lab for continuing software development while the 6 systems are in the field. Two systems remain to be integrated with the updated FEP/TSG hardware. The TSG software will be modified to allow alternate scenarios to be downloaded on operator request. An FEP assembler should be completed to allow much easier generation of new FEP software. The receiver and transmitter controller for the NOAA sounder will be tested and calibrated before transfer to Brighton. The receiver will be modified by the installation of a second crystal filter in the IF amplifier, so that wide or narrow bandwidth operation can be selected.

The P-N Code beacon system will be expanded to two channels at 40 and 360 MHz, using the surplus ATS-6 hardware. Additional hardware and software will be developed for measuring simulated group delay between the two channels.

After completing assembly and integration of the Solar X-Ray Imager electronics and optics "brassboard," a test of the system is planned using the MSFC x-ray facility. A full proposal to NOAA HQ/NESS FOR "System 80 N" Solar X-Ray Imager requirements will be prepared by SEL, and the IDB will provide the technical section based in part on the results of this study.

In FY 80, the Galileo EPD team plans to complete fabrication of the Engineering Model, begin fabrication of the flight unit, and perform beam calibrations of the Engineering Model.

SERVICES DIVISION

T. GRAY

The Services Division provides a variety of services to a growing national and international community of users who are concerned with the effects of solar activity on the environment. The Real-Time Data Services Branch and the Space Environment Services Center which comprise the Services Division jointly constitute the major activity of the United States in the area of solar-terrestrial monitoring, forecasting, and real-time data collection and dissemination. Many of the services activities are joint activities of NOAA and the USAF.

SPACE ENVIRONMENT SERVICES CENTER

G. HECKMAN

The Space Environment Services Center (a joint operation of NOAA and the USAF Air Weather Service) continued to provide a schedule of predictions, alerts and data for a variety of users whose systems are affected by disturbances in the space environment or who are conducting scientific experiments dedicated to improved understanding of that environment. Predictions and summaries of activity are distributed daily to users throughout the U.S. and the world. Customers making use of the services include the DOD, NASA, DOE, FAA and NSF federal agencies, universities and research foundations and industrial and commercial users.

ACCOMPLISHMENTS FY 1979

One hundred sixty-four special alerts were issued for solar flares, proton events, magnetic storms and radio bursts that were sufficiently large to disrupt terrestrial systems. Weekly summaries are published in the "Preliminary Report and Forecast of Solar Geophysical Activity," received by 1,350 users in the U.S. and 42 foreign countries.

Some examples of the uses of the service in satellite operations illustrate the range of applications in one industry. As the Pioneer II spacecraft neared the planet Saturn in September, the sun became particularly active. Three different types of solar radiation, originating over a two-week period, arrived simultaneously at Saturn along with the Pioneer 11 spacecraft. Predictions and alerts from SESC were used by the Pioneer operators and scientists to minimize data losses from the experiments on the spacecraft. In addition, the Naval Astronautics Group came to Boulder to review their eight years of experience in using SESC predictions in generating the real-time positional ephemeris data carried onboard the TRANSIT navigation satellites. During the last few weeks of the life of Skylab, NASA and the USAF used high-time resolution SESC predictions of solar activity, made 27 days in advance, to predict the well-publicized Skylab re-entry date. Long-term prediction of sunspot numbers were made by the SESC in 1977, and brought an early awareness of re-entry problems associated with the Skylab problem; the SESC medium range predictions are now used for determining satellite orbital parameters for 6-10 low-orbiting satellites. Other satellite users, both commercial and scientific, used SESC alerts to change operating modes and to protect vulnerable instruments during the solar proton events that marked the rising proportion of the new eleven-year solar cycle. A brief review of the SESC in a communication industry publication at the end of the year has brought in several prospective new satellite customers.

In moves to handle increasing data volumes and workloads with fixed numbers of personnel, new uses were devised for the SELDADS (Space Environment Laboratory Data Acquisition and Display System). One set of routines developed by RTDS personnel is being used to manage the customer alert lists in an effort to effect the distribution of the alerts in a more timely manner. Another set of routines is being used to compile, combine and edit incoming reports of solar flares and energetic events. In addition to its use by the forecast center operation, the SELDADS is used by a number of customers who wish to look directly at the observational data.

New data from the U.S.A.F. Solar Optical Observing Network (SOON) and Radio Solar Telescope Network (RSTN) came on line during the year, but, additional, higher data rate streams are expected in the coming year. After delays due to lack of equipment, the joint American-Australian SOON/RSTN Observatory at Learmonth, in Western Australia, moved to become operational and the first NOAA Commissioned Corps Officer arrived as the SESC observer. A NOAA Corps Officer also serves as U.S. representative and observer at the Culgoora Observatory in Eastern Australia. The two Southern Hemisphere observatories are intended to remove some of the long gaps in solar observations that have been a continuing problem in the Northern Hemisphere winter.

Particle data from the TIROS-N satellite were used to extend the spatial and spectral coverage of the energetic particle sensors on the GOES satellites. Real-time displays of the TIROS-N data are not yet on line, but off-line data were used during periods of high proton flux during the year to confirm the extent of the event.

Data from the International Magnetospheric Study North American Chains have been continuously collected in the SELDADS system and the plots from the 25 magnetometers are available to the SESC in near real-time. The data have been used to compile and publish a continuous near real-time magnetospheric substorm catalog. This catalog is the only continuous list of geomagnetic disturbances that contains information on the geographical variation of the intensity of these disturbances.

The Communications Center has finished filling several vacancies. With a workload of eleven thousand scheduled messages and about two thousand special messages in the past year, error rates in data handling increased to three times nominal values while new personnel were trained. The rate has been lowered to about 2-1/2 times nominal and is expected to decrease further as the new operators become more experienced.

An international cooperative program devoted to the study of solar flares, the Solar Maximum Year (SMY) began in 1979. It is built around the joint participation of observatories and scientific satellites from several countries. In its role of World Warning Agency for the International Ursigram and World Days Service, SESC will circulate each day's observing program to all participating organizations. A key part of the

SMY is the Solar Maximum Mission (SMM) Satellite. The support will include summaries of solar activity and predictions of flare intensities for each solar active region. The predictions will be used to select one active region each day to be observed by the narrow-field-of-view instruments on the SMM and at the cooperating observatories.

To support technique development work of specific interest to SESC, modest sums of money were obtained from the Air Force Geophysics Laboratory. The funds were used to begin a study (by the National Bureau of Standards) of the use of a set of flare prediction parameters that have been collected over the past two years and to support a preliminary study of the usefulness of Kitt Peak solar velocity field observations for solar flare predictions.

An old, but neglected field of study, the association of geomagnetic disturbances with the eruption of dark filaments on the sun, was revived in work done by the members of the SESC staff. It appears that solar flares, solar coronal holes and erupting solar prominences each produce about equal numbers of disturbances varying according to the phase of the eleven-year cycle. Members of the SESC staff also provided the primary list of specifications for a proposed solar x-ray imager that would be flown as part of the NOAA System 85 environmental monitoring satellites.

PLANS FY 1980

Major new real-time data streams are expected to begin arriving in the SELDADS in FY 1980. Included are data from the ISEE-3 interplanetary satellite and from the SOON/RSTN telescopes. The ISEE-3 data will permit the observaton of solar flare shocks 15 to 30 minutes before they impact the earth. If the system works as expected, a highly accurate alert of the beginning of major magnetic storms can be distributed to customers 15 to 30 minutes before the storm begins. A primary objective for SESC personnel will be the design of new data displays that will allow full integration of these new data sets into the real-time service operation. These new displays, especially those for the SOON/RSTN data, will be prototypical of new data displays to be designed for the new generation equipment that is expected to replace the current SELDADS.

Technique development will continue to the limited extent that time and funds permit. In-house work will continue on the study of the association of filament activity and geomagnetic activity, on the use of large-scale solar maps for activity prediction and on heuristic models for very short-term (30 minutes) flare predictions and medium range (days to months) predictions of the day-to-day variations of solar radiation levels.

REAL-TIME DATA SERVICES

C. HORNBACK

The Real-Time Data Services (RTDS) operates systems which provide data from various solar and geophysical sensors for supporting the Space Environment Services Center (SESC) forecast operations. There are three operational components in the RTDS: (1) the High-Latitude Monitoring Station (HLMS) at Anchorage, Alaska; (2) the Table Mountain Observatory (TMO) at Table Mountain, 10 miles north of Boulder, Colorado, and (3) the Data Display Systems (DDS) in the NOAA-NBS Radio Building at Boulder, Colorado. Systems at the three sites operate 24 hours per day, 7 days per week. The sites are manned during normal working hours and personnel are on call for taking care of problems outside of normal working hours.

Operational requirements continue to strain the RTDS resources. The old equipments have performed remarkably well this past year. Some critical repair parts have been purchased and should help improve the 24-hour per day service. More operational manpower is required if the operations are to be appreciably improved.

ACCOMPLSHMENTS FY 1979

High-Latitude Monitoring Station (HLMS)

The HLMS is operated jointly with the Air Force Air Weather Service with a complement of one RTDS and two AWS personnel.

Except for the usual kinds of maintenance problems, the HLMS equipments performed remarkably well. Some changes were made in the XDS 920 software to improve the system performance and to provide more data required by the Air Force AWS.

This was the year for the Air Force to rotate their personnel at the site. The new people have been indoctrinated.

Table Mountain Observatory (TMO)

The TMO facility is operated by three RTDS personnel.

The TMO systems have performed well during the past year. Several pieces of equipment have been decommissioned in order to reduce the workload on the site personnel. This was necessary since we were not allowed to replace an electronic technician who retired.

Software on the XDS-930 has been modified to reflect the changes in the decommissioned equipments. Preparations have been made for processing the ISEE-3 data in the XDS-930.

There are three complete S-band receiving systems (16-foot dish antennas, receiver, and bit synchronizer) available for taking the SEM data from the two operational GOES satellites.

Data-Display Systems (DDS)

The DDS facility is operated with seven (including a clerk-typist, a NOAA Corps officer, and a contract programmer) RTDS personnel. Part-time student help is used as it is available.

The systems which made up the Space Environment Laboratory's Data Acquisition and Display System (SELDADS) and the SESC forecast displays have performed well. There are some fifty registered users for the SELDADS data. The system is heavily loaded and will be hard pressed to adequately support the users until a new system is made operational in 1985.

Considerable software has been developed for supporting the SESC and AWS operations. The software for processing IMS magnetometer data has been completed. Some software for the TIROS-N/NOAA-6 space environment monitor data has been developed.

Preparations have been made for acquiring and processing solar-wind, magnetometer, solar hard X-ray, and electric field data from the ISEE-3 satellite.

PLANS FY 1980

Efforts will continue for making the systems more reliable.

Software for processing and displaying the TIROS-N/NOAA-6 and ISEE-3 SEM data will be completed.

IMS

J. JOSELYN

The International Magnetospheric Study (IMS) involves approximately 55 countries and a large number of cooperating satellites along with an array of coordinated ground-based programs. One key element of the U.S. involvement in IMS is the planning, development, deployment and operation of the North American IMS magnetometer network. The core of the network is composed of 25 Satellite-Transmission-Relay (STR) Observatories which telemeter information to SEL via the NOAA GOES satellites. NESS receives the data via the GOES data collection system, then telemeters the data to SEL, where it is processed, stored, and disseminated using the Space Environment Laboratory's Data Acquisition and Display System (SELDADS).

The IMS-STR magnetometer network became operational late in 1977. Programs have been completed for routinely recording and processing the data. Data are routinely sent to the EDIS for dissemination. Real-time displays must still be programmed. Daily data plots are made for generating a comprehensive catalog of magnetic disturbances.

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