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An Evolutionary Approach to the Group Analysis of Global Geophysical Data

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An Evolutionary Approach to the Group Analysis of Global Geophysical Data

by

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Michael J. Teague

May 1979

National Space Science Data Center (NSSDC)/
World Data Center A for Rockets and Satellites (WDC-A-R&S)
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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An Evolutionary Approach to the Group Analysis of Global Geophysical Data

J. I. Vette, D. J. Hei, Jr., and M. J. Teague

I. Introduction

In many fields of physics it is possible to test hypotheses by laboratory experiments in which various conditions can be controlled precisely. For example, in nuclear or high-energy-particle physics, a target of known composition can be bombarded by a particle or photon beam of known energy and specific reactions products can be measured as a function of energy and angle. Generally such experiments are dictated by theoretical calculations or are used to obtain the value of parameters of a theory whose validity has been established in a previously measured range of the pertinent variables. For many years in the fields of "hard science" the forms of scientific communication, which we will call standard, have been extremely successful in fostering a steady increase of man's knowledge about the physical laws of nature.

These standard forms of communication consist of: (a) the refereed scientific literature, (b) exchange of preprints, (c) professional meetings where results are presented in various categories as organized by a program committee comprised of scientific peers, (d) symposia and workshops with presentations or discussions organized in a manner similar to (c), (e) visits by a scientist or group of scientists to another institution where formal and informal interactions occur, and (f) informal written or vocal exchange. These time-proven forms of communication are practiced in all forms of science, including geophysics. Geophysics is one of the scientific disciplines rooted in the fundamental physical laws but strongly dependent on the observational techniques applied on a global scale. It is characteristic of geophysics to determine the one or several basic processes that are prevalent at a given place and time to understand the observations. In this sense geophysics is a data-intensive discipline in which the key to understanding is guided very significantly by the character of the measurements. Rocket- and satellite-borne instruments have extended geophysical research to the far reaches of the solar system and particularly to the volume of space within 30 Earth radii of the Earth. In such an arena of human endeavor are there additional forms of scientific communication that can be efficient in advancing our knowledge?

We wish to present in this paper a process, termed coordinated data analysis, that has been developing over the past several years within the International Magnetospheric Study (IMS) that seems to answer the preceding question in the affirmative. By the very nature of geophysical investigations, cooperation among professionals has been a cornerstone of the activity. Gilbert, in verifying his ideas about the nature of the geomagnetic field, employed the use of shipborne magnetometers. Magnetic observatories now abound in the polar, auroral, mid-latitude and equatorial regions to obtain measurements, determine indices, and infer current systems. Airplanes, rockets, and Earth-orbiting satellites have been pressed into service to study the very complex phenomena associated with this vector field. As viewed from the four fundamental forces in nature, geophysics is involved mainly with the gravitational and the electromagnetic interactions, both of which are long-range forces and obey Bose statistics. Perhaps the cooperation of geophysicists as reflected in the establishment of numerous international projects such as the Polar Year, the Geophysical Year, and the Quiet Sun Year demonstrate that they employ some sort of human Bose statistics in achieving the understanding of the complex physical processes.

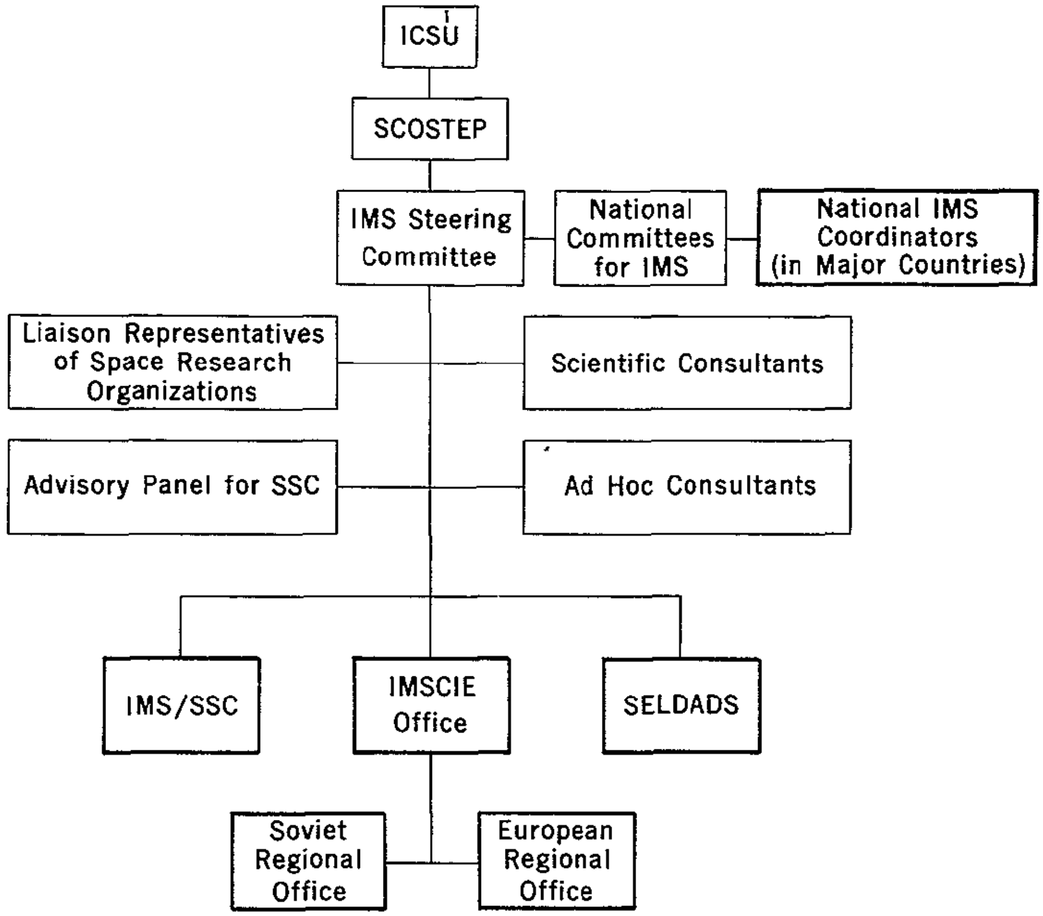
In order to understand and appreciate some aspects of coordinated data analysis -- this new form of scientific communication -- a tracing of its development within the IMS will be given. The most recent milestone in this evolution has been the Coordinated Data Analysis Workshop (CDAW) concept and a first implementation, called CDAW 1.0, that was held in December 1978 at our facility. (The notation provides for series of continuing workshops to be held with the same CDAW 1 data base.) We will summarize the activities that trace the evolution of the concept and will give some indication of the future steps that may be taken.

II. The International Magnetospheric Study

The IMS is a truly international cooperative scientific program involving the resources of some 50 countries to study the plasma environment of near-Earth space. The planning for this program began in 1969 within several organizations of the International Council of Scientific Unions (ICSU), namely the Committee for Space Research (COSPAR), the International Association for Geomagnetism and Aeronomy (IAGA), and the Inter-Union Commission for Solar Terrestrial Physics (IUCSTP), which has become the Scientific Committee for STP (SCOSTEP). Various aspects of the IMS have been described in the literature, particularly at the beginning of the operational phase of the program in January 1976. For example, Roederer (1976) has emphasized that the key element of the IMS is the coordination of the complex system of magnetospheric observations by means of satellites and ground-based, balloon, rocket, and aircraft (GBR) measurements. Manka (1976) has discussed the IMS program planned and implemented by the United States. The use of digital magnetometers for the North American magnetometer network has been described by Lanzerotti et al. (1976). Another major U.S. contribution was the creation of the Satellite Situation Center (SSC) which became a new tool for coordinating simultaneous observations by satellites and GBR methods (Sugiura and Vette, 1976). In addition, the proceedings of the 10th ESLAB Symposium, sponsored by the European Space Agency (ESA) in 1975, were dedicated to the scientific satellite program for the IMS (Knott and Battrick, 1976).

The vigor with which the IMS has been conducted is due in large measure to the energetic scientists participating in the program and the IMS Steering Committee, which has been comprised of working scientists as opposed to scientific senior statesmen that generally occupy the high-level offices of the ICSU organizations. The running documentation of the IMS is provided by a monthly Newsletter that is published by the IMS Central Information Exchange (CIE) Office. A diagram of the organization of the IMS is provided in Figure 1.

It can be seen that the planning, organization, and operation of the IMS has been conducted under the leadership of scientists of international renown within the ICSU framework. The program has been achieving the coordinated data acquisition identified in the planning phase as essential to fulfill the



ICSU - International Council of Scientific Unions - Paris

SCOSTEP - Special Committee for Solar Terrestrial Physics - Washington

IMS - International Magnetospheric Study

IMS/SSC - IMS/Satellite Situation Center - Greenbelt

IMSCIE - IMS Central Information Exchange - Boulder, Moscow, Paris

SELDADS - Space Environment Laboratory Data Acquisition and Display Systems - Boulder

Figure 1. The Organization of the IMS. Operational Elements Shown in Heavy Lined Boxes.

scientific goals mainly because of the following factors, in our view:

1. Guidance of the IMS Steering Committee operating under SCOSTEP;

2. A genuine cooperation between scientists in the various countries;

3. The IMS Newsletter and telex service provided by the IMSCIE Office, which is assisted by the European and Soviet Regional Offices;

4. Extensive use of the IMS/SSC to predict: (a) the special confluences of high-altitude satellites, (b) magnetic conjunctions between various types of satellites that orbit within near-Earth space, (c) magnetic conjunctions between these satellites and certain ground-based stations such as backscatter radars and magnetometer chains, and (d) passage of satellites within a specified range of rocket or balloon launching sites; and

5. The activity of IMS national coordinators in a number of the larger participating countries.

III. Origin of Coordinated Data Analysis within the IMS

With the successful establishment of the operational phase, the IMS Steering Committee and its component parts seriously began considering the conduct of the final phase - the scientific knowledge extraction or data analysis phase. From the beginning it was realized that the need for world-wide, coordinated data acquisition from a variety of measuring platforms meant that coordinated data analysis must be effected. It was generally assumed the usual modes of scientific communication cited in the introduction with emphasis on topical symposia and workshops would be adequate to advance knowledge efficiently in such a complex field.

During the planning phase, agreements were reached between the IMS organizations and scientists with experiments on a number of satellites participating in the program so that summary data from these spaceborne instruments would be available to the scientific community with time delays of only several months. In such a data-intensive research area, the use of data from other probes is essential as a guide to proper analysis of one's own observations.

Following the procurement of the interactive graphics hardware and the development of the software necessary to carry out the functions of the IMS/SSC, some of us at the National Space Science Data Center (NSSDC), which operates the SSC, began thinking seriously about a CDAW concept. This would involve building a common digital base oriented toward a specific problem or series of events with the necessary data from numerous satellite and GBR sensors, placing this data base on-line, and assembling the appropriate experimenters, theoreticians, and modelers at the computer facility so these participants could study the specified problem together employing modern interactive graphics techniques. Although the problem of building a common data base from such a variety of instruments processed on different types of computers around the world was a formidable one, NSSDC had been doing this for many years on a much more extended time frame. Consequently, the expertise assembled to carry out the functions of the NSSDC and the SSC combined to make the demonstration of the envisioned CDAW feasible. The IMS has been uniquely successful in achieving coordinated data acquisition with a variety of spaceborne sensors on a number of different vehicles and with ground-based instruments. To extract the scientific knowledge from such an ensemble of sensors requires a new mode of scientific communication is the belief of many of us associated with the IMS.

The first specific steps for developing new coordinated data analysis methods began in January 1977 at an IMS Steering Committee meeting, when a program committee was established under the chairmanship of Dr. Gordon Rostoker for an IMS Working Conference to be held at the COSPAR meeting in Innsbruck in June 1978. This Working Conference would allow scientists to examine together recently acquired data for some specified time period in an attempt to identify those problems or events for which extensive analysis would appear to be fruitful. By mid-1978 the ESA GEOS 1, ISEE 1, and ISEE 2 satellites, which were the main new spacecraft missions dedicated to the IMS, would have been operating simultaneously long enough to expect that some useful periods could be identified. In August 1977, Rostoker announced that the data collected during the December 1-15, 1977 period should be examined promptly and that interesting occurrences be identified to the IMS Working Conference Program Committee.

At about this same time the SSC had acquired data from three experiments flown on two spacecraft (IMP-H and -J) in order to do some testing and human engineering for the CDAW idea. By the beginning of 1978 an appropriate software development had been completed to organize a time-ordered data base consisting of a number of measured parameters, and NSSDC had acquired some audio/visual equipment believed to be necessary to carry out this activity properly. Graphics terminals have provided the means for an individual to be interactive with a data base for a number of years. However, to allow a group of people to be interactive with each other and with a computerized data base was not an established procedure. As this concept evolved it became clear to us that such a workshop could not be held on an ad-hoc basis at any location because a special expertise was required to build such a diverse data base in a timely fashion and the availability of adequate computer facilities on a one-shot basis was not likely to be found. Consequently, if such a CDAW concept proved viable, it would be necessary to seriously consider the establishment of a Data Analysis Workshop Center (DAWOC) where CDAWs could be accomplished on a regular basis. A detailed presentation of the DAWOC/CDAW concept was given by one of us (JIV) at the March 1978 IMS Steering Committee meeting. It was also at this meeting where recognition of a formal IMS Data Analysis Phase was obtained by the passage of a resolution defining this phase to begin in 1980 and extend through 1985. This is the first case, of which we are aware, that an international cooperative program has created a separate data analysis phase that followed the formal operational phase. Clearly such a vast amount of data requires some continued organizational structure to emphasize coordinated data analysis for knowledge extraction. There has always been a great emphasis on data collection in such programs, in fact too much in our view, relative to this most difficult knowledge extraction phase.

During the March 1978 Steering Committee Meeting, the specific time periods that would be studied during the IMS Working Conference were established based on inputs from a number of scientists around the world. The periods 1400 (UT) December 1 - 2400 December 3 and 1000 December 10 - 2400 December 12, 1977 were selected for primary study and the September 20-21, 1977 data were set aside for an evening session. The December intervals were broken into three separate segments, with each segment being given a half-day session. Also under consideration was the July 29, 1977 event which had been studied in less formal sessions at the American Geophysical Union Meetings of December 1977 and April 1978. Both of these sessions were organized by R. H. Manka, the U.S. IMS Coordinator, with the help of R. G. Johnson and others. Manka organized another such effort for Innsbruck after the July event was dropped from the Working Conference agenda. In order to allow for direct intercomparison of data, standardized time scales for 5- x 5-cm slides, viewgraphs and analog charts were specified to participants. All of the decisions of the March 1978 meeting concerning the Working Conference were communicated to the community in the IMS Newsletter of April 1978.

In the interim following the March 1978 meeting, the SSC prepared a video tape/motion picture presentation of the CDAW concept demonstrating the equipment believed necessary to carry out such a workshop and defining various phases. This film was shown in Innsbruck. A more lengthy one-hour video tape version, which included an actual mini-workshop held by SSC staff members, was shown privately to those scientists interested in the techniques. The details of the CDAW concept as presented at Innsbruck are given in a later section.

The Working Conference was attended by over 100 scientists. A 16-mm motion picture projector, four 5- x 5-cm slide projectors and three overhead projectors were available for simultaneous projection. Microfiche and microfilm reading equipment were available as well as copying equipment. The diversity of data reported, presented, and discussed at Innsbruck was immense by any measure. The satellite data that was reported on are given in Table 1. Since the satellites traversed large regions of space during the intervals covered in the Working Conference, the data from this ensemble of instruments provided a wide range of complexity. Even more impressive was the array of ground-based measurements that were available for study. This is depicted in Figure 2 where the location of each station used in CDAW 1.0 is shown on a world map with the symbols defined in the legend used to indicate the type of measurement that was made. Additional stations or instruments in Alaska, Antarctica, Finland, Sweden, and the U.S.S.R. were also represented at Innsbruck.

Besides the reports from individual scientists involved with specific measurements, there were data and information available from various service organizations. J. H. Allen of World Data Center-A for Solar Terrestrial Physics provided common scale magnetograms for selected low-altitude, auroral zone, and polar cap stations along with the AE index based on five stations. A. Nishida provided booklets summarizing Japan IMS observations about low latitude responses to the various activity and presented some of the results. The SSC, represented by two of us (JIV and MJT), provided the information shown in Table 2. In the Summary of the IMS Working Conference prepared by G. Rostoker, an Appendix B entitled "Satellite Situation Center Information Products for Workshops and Working Conferences" (22 pages) was included.

Since the Working Conference was an experiment in coordinated data analysis, discussions were held and inputs solicited about the positive and negative features of the meeting format and its implementation. Rostoker's summary of

TABLE 1

Satellite Data Reported at IMS Working Conference

Satellite	Reporter (Experimenter)	Kind of Measurement
ATS 6	Arnoldy	Elec. & Ions 0.05-23 keV
	Masley	Elec. 0.4-1 MeV
		Prot. 0.3-1.2 MeV
DMSP-F2	Candidi (Rothwell)	Elec. 0.05-20 keV
GEOS 1	Amata, Candidi (Mariani)	Magnetometer
	Cornilleau, Jones, Perrault (Gendrin)	VLF Waves
	Etcheto (Petit)	Thermal Plasma Density-Sounder
	Hultqvist	Elec. & Prot. 0.2-20 keV
	Pederson	D.C. Electric Field
	Wrenn, Johnson, Sojka	Elec. & Prot. 0.5-500 eV
GOES 2	Barfield (Williams)	Magnetometer
ISEE 1	Hones (Bame)	Elec. 0.005-20 keV
		Prot. 0.05-40 keV
	Mozer	Double Probe Elec. Field
	Russell	Magnetometer
Prognoz 6	Gombosi (Gringauz)	Elec. 10-300 eV
		Ions 0.01-5.4 keV
	Zhulin (Eroshenko)	Magnetometer
	Zhulin (Pisarenko)	Elec. 0.3-20 MeV
		Prot. 2.1-500 MeV
S3-3	Johnson (Sharp)	Ions 1-32U, 0.07-24 keV
1976-059A	Hones (Higbie)	Elec. 0.03-2 MeV
1977-007A	Hones (Higbie)	Prot. 0.15-150 MeV
		Alphas 1.2-600 MeV

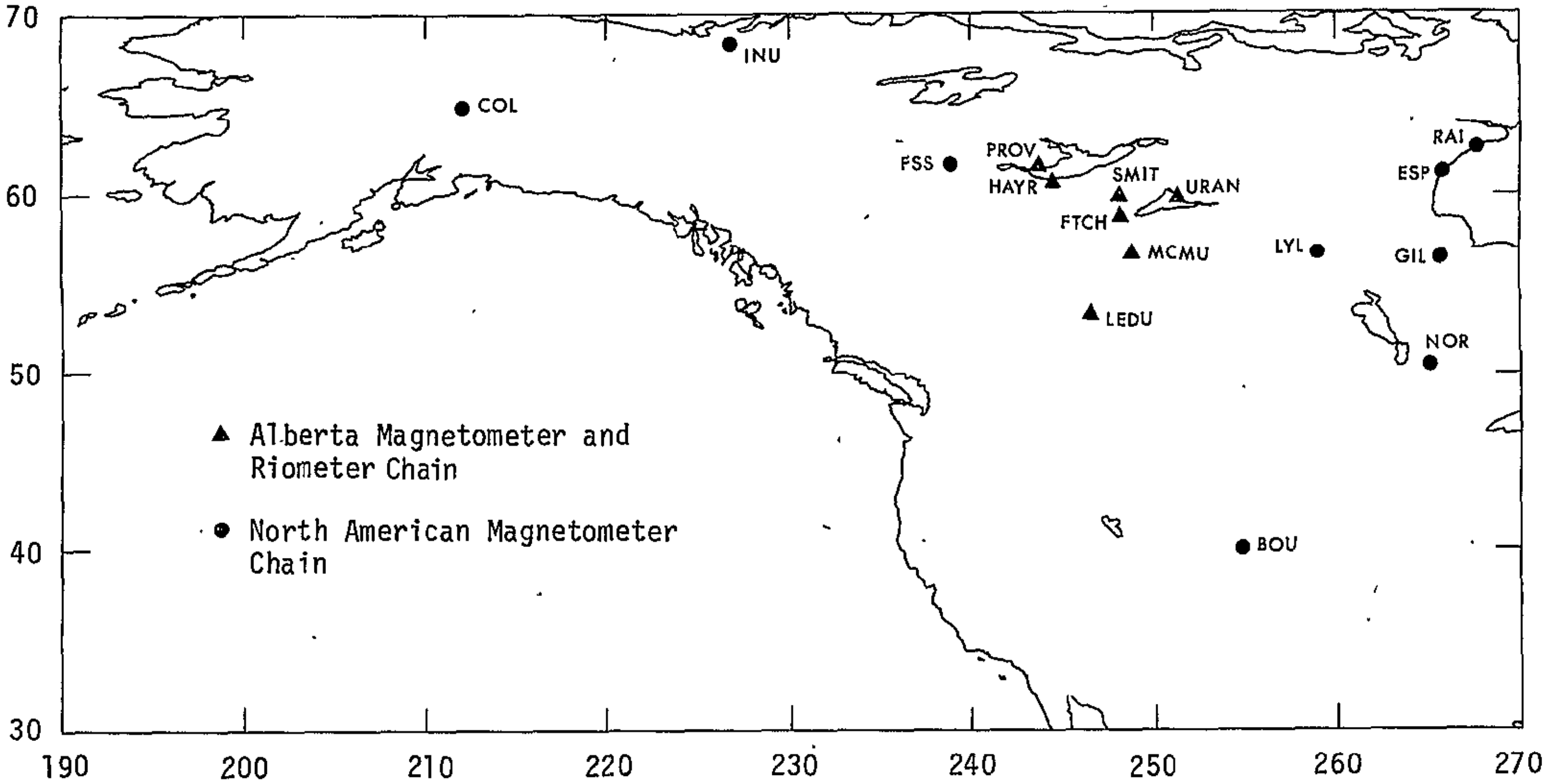


Figure 2. Location of Ground-Based Measurements Used for Study of December 1977 Events. Not Shown are EUS (3.87° S, 321.58° E), SAH (75.27° N, 266.4° E) CAP (70.2° N, 235.3° E), and JOP (72.40° N, 241.7° E).

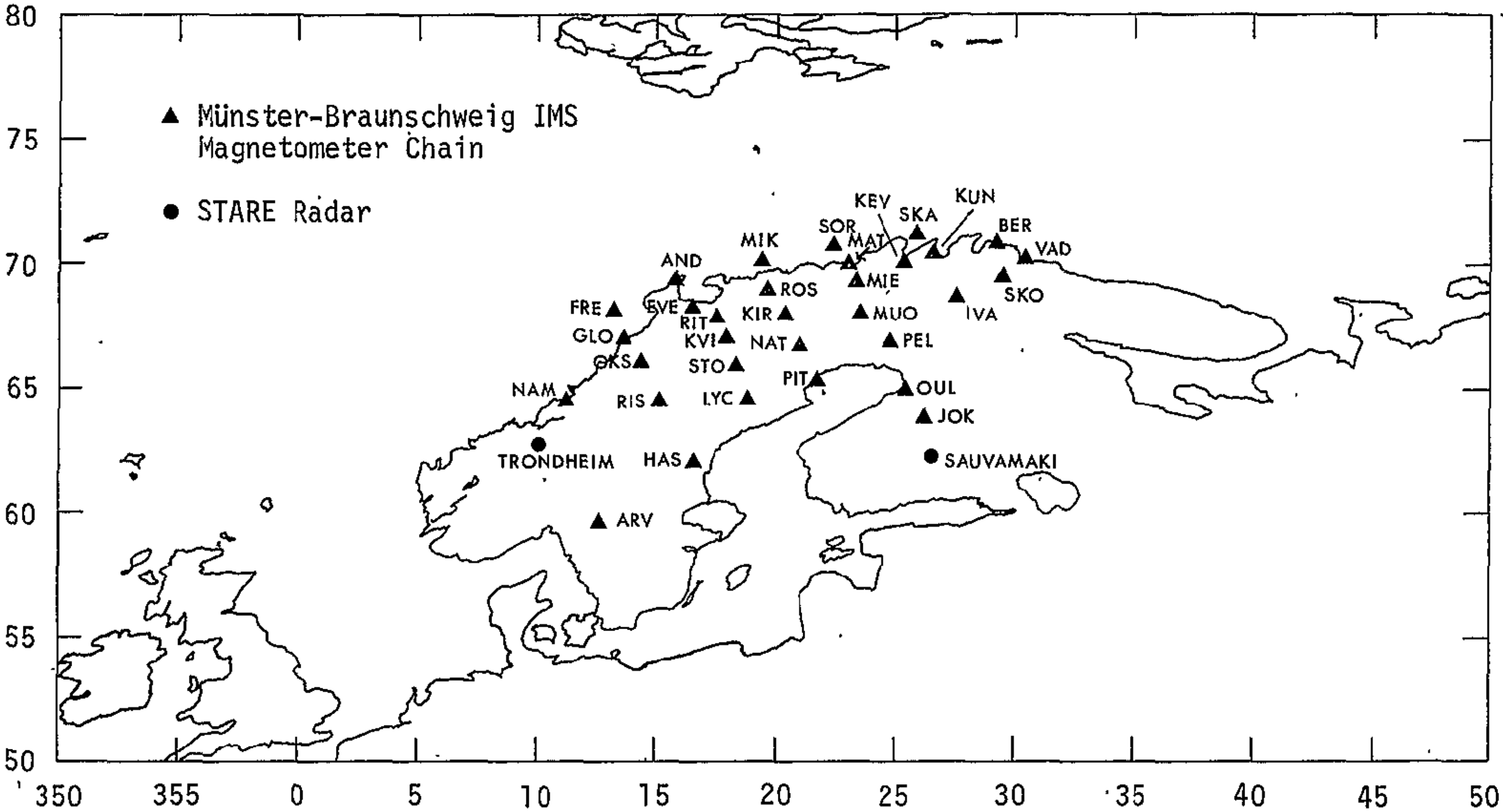


Figure 2 (concluded). Location of Ground-Based Measurements Used for Study of December 1977 Events.

TABLE 2

Satellite Situation Center Data Products in Support of IMS Working Conference

1. Print outs of achieved orbital positions in GSE and SM coordinates (X, Y, Z, LAT, LT, R) for Hawkeye, IMP-H, IMP-J, ISEE 1, Solrad 11B, ATS 6, GEOS 1, GOES 1/2, SMS 2, AE-C, DMSP-F1, DMSP-F2, ISIS 1, ISIS 2, S3-2, S3-3, and TRIAD.

2. Bar charts for the five high-altitude satellites for each day.

3. Bar charts for the 12 synchronous or low altitude satellites for ten 90-minute intervals during each time interval being studied.

4. Snapshots of three-hours duration for all the time intervals giving projection in the ecliptic plane and height above the plane for Hawkeye, IMP-H, IMP-J, ISEE 1, Solrad 11B, ATS 6, GOES 1/2, SMS 2, and GEOS 1.

5. Table of magnetic conjunction times between GEOS 1 and ISEE 1 as target satellites and eight low-altitude satellites.

6. Magnetic foot tracks for GEOS 1, ISEE 1, ATS 6, GOES 1/2, and SMS 2.

these deliberations are noteworthy and are cited below:

1. The opportunity for participants to see global responses using ground-based magnetometers, riometers, all sky cameras, back-scatter radar, and satellite-borne magnetic and electric field and particle detectors was extremely useful to determine properties of the events.

2. The presentation of the data occurred in a short enough time that many were able to see relationships between various data sets that would have taken much longer under normal circumstances.

3. The use of multiple projector systems was helpful in conveying the many characteristics of the data.

4. All slides and viewgraphs should have clearly readable labels and should conform to a prearranged set of time scales. Times of exciting events should be clearly marked. Many slides and viewgraphs did not conform to these standards. Those that did were extremely useful, those that did not were a waste of time.

5. Too much data were presented; emphasis should have been placed on conveying cardinal features instead of showing complex, hard-to-read slides.

6. More time should have been made available for participants to interact on the conference floor; at least 15% of the agenda time should have been unstructured.

7. One or more people should have been assigned the task of being synthesizers for the data presented; these people should stimulate discussion, call attention to various important results, and present conclusions. Such people should give their overview at the conclusion of each session. (To be effective, we believe these people must have prior exposure to the data presented.)

8. Several theoreticians should be used to stimulate the participants by relating known physical principles to the morphology being displayed.

9. The use of subgroups of participants to study specific items and report to the whole group was felt to be a useful approach that was not attempted.

10. The physical size and layout of the conference room are important to the communication and interaction process. Adjustments in equipment use and positioning of participants were made which proved useful.

IV. The Coordinated Data Analysis Workshop Concept

By the time the Working Conference had been implemented at Innsbruck, the next step in the process, the CDAW concept, had been explicitly presented to the IMS community. The details of this concept are given here by the text that formed the narrative of the film presented by one of us (JIV) at the COSPAR meeting.

"I will discuss a form of scientific communication known as a workshop, which is used by COSPAR, SCOSTEP, and other ICSU bodies. A workshop is very topical and generally relates to the techniques of instrumentation, their operation, calibration, or to data handling. However, workshops have also been organized to focus on specific physical problems or to plan scientific programs."

"I will emphasize and illustrate, using a film, a particular type of workshop I feel has great potential. The concept needs to be explored, refined, and if proven valuable to our science, should be exploited in the near future."

"Let me categorize the various kinds of workshops that have been conducted in the past. The first is one carried out exactly like a scientific symposium related to a theme prescribed by a program committee. A recent Laser Workshop in Athens is one example; a Wave Analysis Workshop to be held at the next URSI meeting is another. A second type of workshop is one carried out by visiting a facility where participants can be trained in some of the latest techniques. Such an example is the two-week-long Workshop on Space Applications of Direct Interest to Developing Countries. This was held in Brazil in 1974 at the Instituto de Pesqisas Espaciais where the facility developed by Dr. Fernando de Mendonca to process Landsat Earth resources data was utilized. A third type can be characterized by the Skylab Workshops held at the National Center for Atmospheric Research in Boulder, Colorado. Each focussed on a specific solar physics problem that could be addressed using the Skylab ATM data, which is mainly photographic. The final category is the Coordinated Data Analysis Workshop (CDAW). This is a computer/interactive graphics-assisted workshop organized to address a selected physical problem in space research utilizing data from satellites, rockets, balloons, aircraft, and ground-based measurements. I cannot cite specific examples of this type, although at some level I am certain one can find similar approaches. The use of a computer with rapid display of a common data base does permit the detailed comparison of various experimental measurements and the testing of theoretical ideas where the esthetics of the display can be altered at will. This kind of workshop, in my view, is one in which COSPAR can play an important role in its development and utilization."

"As I envisage such a workshop, it should involve some 15-30 scientists including theorists and modelers for periods up to two weeks, the appropriate number of data sets, and an adequate computer facility. Since this represents a reasonable amount of resources, it is necessary to examine the rationale for such an activity. To advance our knowledge in many areas of space research, it has become necessary to carry out international cooperative programs involving coordinated data acquisition on a global or near-global scale. Examples of such are the Global Atmospheric Research Program, the International Magnetospheric Study (IMS) and the Study of Traveling Interplanetary Phenomena, which are in the operational phase, and the Middle Atmosphere Program and the

International Solar System Program, which are in the planning phase. With such broad-based data-intensive programs, in addition to existing methods of scientific communication, new mechanisms are needed to achieve coordinated data analysis on a scale consistent with the data acquisition phase. It is the feeling of some of us heavily involved with the IMS that the computer-assisted CDAW concept is one such mechanism. Such a view does not imply that traditional methods of data analysis and informal contacts between individual scientists should be replaced. But rather it says that ability to utilize a larger amount of pertinent data and to interact with more scientific ideas in a problem area should be efficient in obtaining scientific knowledge and this requires a coordination effort similar to that already being accomplished in the operational phase of the IMS. This operational coordination is being achieved mainly through the addition of the Satellite Situation Center, the Newsletter, and some national coordinators to the normal mechanisms utilized by scientists in carrying out international programs."

"There are five phases involved in the CDAW concept and I will briefly describe each to develop the concept more completely. The first is the planning phase which should be completed six months prior to gathering of the participants. An appropriate physical problem must be selected along with experimenters who have the necessary data sets to address the problem. In addition, participating theorists and modelers should be selected to contribute needed ideas and to provide theoretical or model computations to compare with the experimental observations. This phase is not an easy one to accomplish as can be seen from a recent letter announcing that the third Skylab Workshop would be devoted to the problem, The Energy Balance and Physical Conditions in Active Regions, and stating 'The selection of this topic was very difficult and involved a great deal of discussion and correspondence over the past several months.'

"Next is the data entry phase during which the participants would submit fully reduced experimental data, including derived parameters and results from theoretical computations or models. The data would be transferred via the computer to the magnetic disk packs for rapid retrieval during the workshop. However, microfilm plots, photographic displays and additional supporting material are expected to be useful so a microfilm reader capable of producing prints is necessary. Because the submission of magnetic tape requires documentation to describe the format, logical records, and physical records and may require reformatting, the length of this phase could be as long as six months, if results of 20 or more experiments are necessary. In addition, the integrity of the digital data base would have to be verified by each participant prior to the actual workshop."

"The third phase is what I will term the initial workshop phase and is the first gathering of the participants. During this phase, the participants would intercompare data, select various parameters from experiments, compare with theoretical results, present ideas, have discussions and make new uses of the common data base suggested by new ideas. To effectively carry out this phase there is certain equipment we feel should be available. There are: (1) a computer graphics terminal, (2) a unit to produce a paper print of the graphics image, (3) a unit to produce 35-mm film of the image, (4) a unit to record the image on video disk for electronic slides, (5) TV monitors for video display and real time editing, (6) an intercom system to the graphics terminal operator,

(7) a copying machine, (8) a 16/35-mm reader/printer, (9) 35-mm slide projectors, and (10) viewgraph projectors."

"The equipment mentioned here is not very expensive relative to the cost of the basic computer facility. However, their existence adds greatly to the responsiveness that the facility can provide to the participants' needs. On the other hand a large high speed computer is not required to accomplish the essential things that we feel are necessary to achieve the synergism hoped for in this mode of coordinated data analysis."

"The fourth phase, which follows the initial workshop, is the one where each participant is back at his own institution pursuing ideas, making further refinements to his data, theory, or model and preparing for a follow-on workshop. During this fourth phase, the facility hosting the CDAW could supply products from the common disk data base to the various participants upon request."

"The final phase is the follow-on workshop phase in which one or two more gatherings of the participants may be required before the various articles can be written as a result of the coordinated investigations."

"I think some of the roles of COSPAR or SCOSTEP are obvious. The planning phase, for a truly international data analysis workshop, would have to involve the appropriate discipline, technical, steering committees, or working groups. An initial workshop phase might be carried out in association with a Plenary meeting at some facility in the host country, analogous to the workshop in Brazil in 1974."

"Perhaps less obvious, but clearly thoughts for the future are: (1) conduct a workshop in association with a Plenary meeting by utilizing a facility accessible through communication satellites or data transmission lines of adequate speed and bringing the display devices to the site of the meeting, (2) I believe we have reached the point in the conduct of international scientific cooperative programs where the establishment of a permanent International Data Analysis Workshop Center in a neutral country, such as Austria, is not beyond the realm of possibility. Although the funding for such an activity would most likely be through the National Academies of Science of the supporting countries, COSPAR, SCOSTEP or ICSU directly, may well play a central role in such a facility."

V. Preparation for CDAW 1.0

The judgment of the participants of the Working Conference was that certain time periods during the December 1977 events were the most suitable for detailed analysis. These periods were 1500 December 1 - 2400 December 2 and 2100 December 11 - 0730 December 12. If one considers that the original interval December 1-15 consisted of 360 hours of data, the show-and-tell process at the Working Conference reduced the data volume for detailed analysis to a factor of 0.12 times the original amount. A chart showing the important geophysical activity that occurred during these periods that could be discerned from the Working Conference is given in Figure 3.

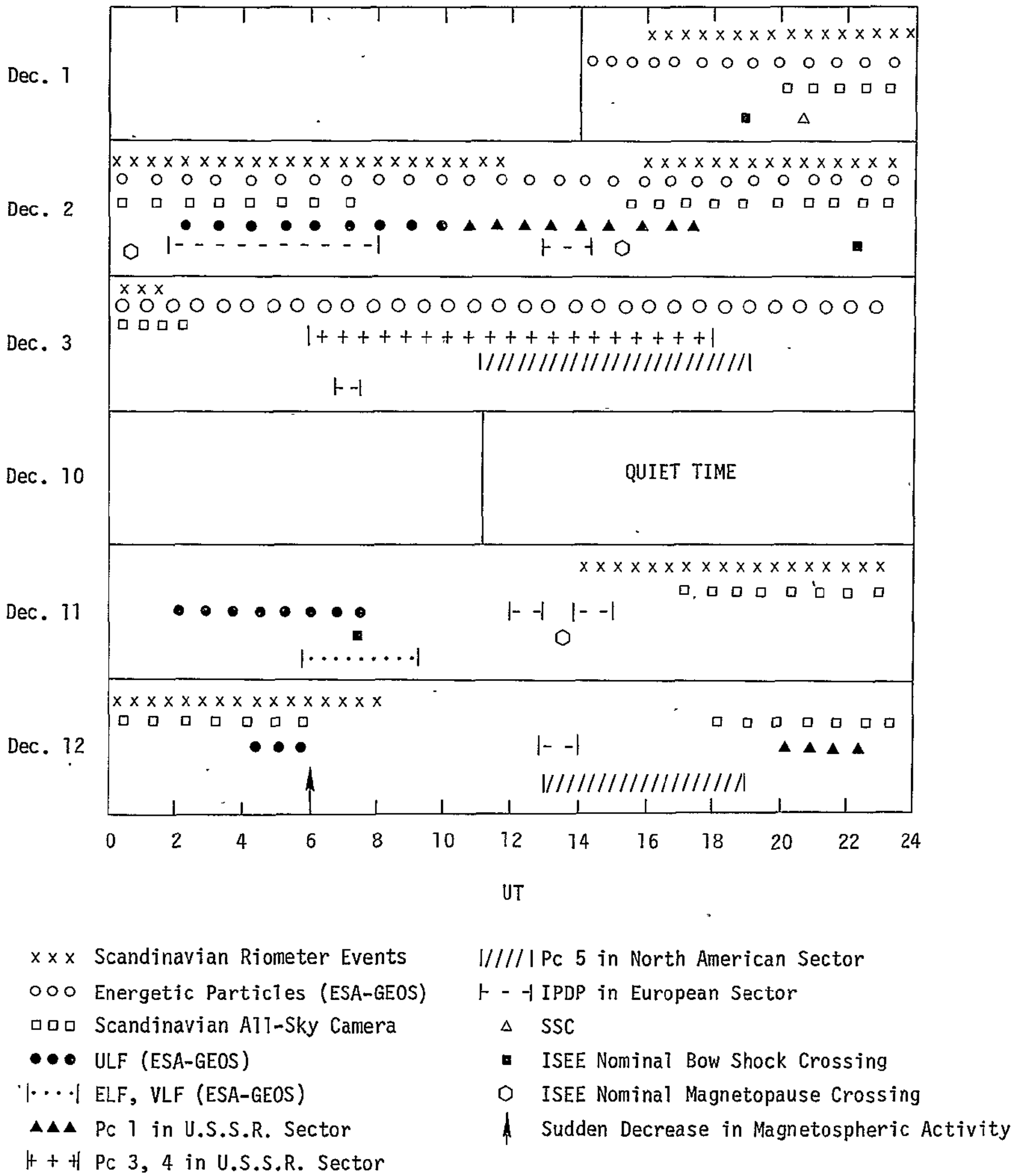


Figure 3. IMS Working Conference December 1977 Events. IPDP = Irregular Pulsations of Diminishing Periods.

In the time period from June 10, following the completion of the Innsbruck Working Conference, and July 31, 1978 an intensive planning effort to implement the CDAW concept occurred. During this period the Program Committee given in Table 3 was formed using the Working Conference Program Committee as a nucleus. This committee, operating mainly by telephone, with some telex and letter communication established a date for the CDAW, determined an agenda and selected three types of invitees - participants, analysis consultants, and observers. Participants were experimentalists who would contribute digital data for the on-line data base. Analysis consultants were theoreticians or experimentalists with specific knowledge and expertise who did not have data available for the December 1977 event periods chosen. Observers were selected from four different categories: (a) members of funding agencies for space research in various countries, (b) members of administrative and service organizations associated with the IMS, (c) experimentalists who provided data for the common data base but could not be invited as regular participants because of facility limitations, (d) scientists participating as program committee members on other CDAWs that might be conducted.

It is necessary at this point to explain that for logistic reasons the total attendance at CDAW 1.0 had to be limited. For a standard scientific meeting the following facilities and equipment are generally necessary:

1. 5- x 5-cm projectors (35-mm slides)

2. Overhead projectors (viewgraphs)

3. Chalkboards

4. Suitably sized rooms for lectures with microphones and audio amplification equipment.

For the CDAW the following additional facilities were necessary:

5. A computer with disk drives and suitable software to handle data base management, data manipulation, and graphics display

6. Computer graphics terminals

7. A video system and hardcopy capability to display graphics outputs and produce desired hardcopy for all attendees

8. An audio system to communicate between conference room, graphics terminals, and computer room

9. A software capability to build a common data base from digital tapes produced on various types of computers employed by space scientists around the world.

The requirements 5-9 listed above, as could be provided by NSSDC, placed the fundamental limitation on the total member of attendees in each of the above named categories. These limitations set the total attendance at about 40 with no more than 21 participants and no more than 11 people as analysis consultants

TABLE 3

Program Committee for CDAW 1.0

Dr. Gordon Rostoker	U. of Alberta	Chairman
Dr. Arne Pederson	SSD-ESTEC	
Dr. Donald Williams	SEL/NOAA	
Dr. Igor Zhulin	IZMIRAN	

The above were members of the IMS Working Conference Program Committee. The additional NASA and ESA people were added to provide a balanced representation for these agencies and the GEOS 1, ISEE 1, and ISEE 2 experiments that would contribute a major portion of the data base.

Dr. Karl Knott	ESA	Project Scientist
Dr. Keith Ogilvie	ISEE 1	Project Scientist
Dr. Edgar Page	SSD-ESTEC	
Dr. Erwin Schmerling	NASA Hdqs	

Workshop Coordinator:	
Dr. James I. Vette	NSSDC
Ex Officio:	
Prof. Juan Roederer	Geophysical Institute, Alaska

or observers in category c. In the mode of operation called the subgroup mode the analysis consultants and some of the category c observers could be accommodated at the tables. In extending invitations to participants, the opportunity of naming an alternate was allowed in recognition of the inability of the principal to attend because of other commitments or extenuating circumstances.

Since most scientific meetings are open to all those wishing to attend, the Program Committee had a difficult task in limiting the number of invitees for the CDAW as dictated by the facility constraint. The final attendance list by category is given in Table 4. Initial letters of invitation were sent by July 31 along with guidelines for the submission of digital data on magnetic tape and the deadline for this submission by September 22. It was recognized that the data entry phase of the concept was being shortened from six months down to four months and that this would cut deeply into the data verification. One might legitimately ask what was the hurry to have the CDAW so soon after Innsbruck. The major motivation was to put such a concept to the test and scrutiny of the IMS community in time to allow for the establishment of one or more DAWOCs for the IMS Data Analysis Phase (DAP), if the concept proved viable. Since the end of the IMS is December 31, 1979, except for data analysis, the momentum of the operational program was deemed necessary to make such establishment possible and some direct contribution to the DAP by such DAWOCs must be visible by mid-1981 or any association with the IMS would, most likely, be lost. Since other international programs in solar-terrestrial or solar-system physics will follow the IMS, such as the Middle Atmosphere Program (MAP), that can also profit by the use of DAWOC's, it seemed in the best interests of international science to press on with the testing of this latest step in the evolution of coordinated data analysis. The next possible time to hold a CDAW would have been late May 1979 based on other standard scheduled meetings and availability of the necessary participants.

It was the hope of the Program Committee and those at the host facility (NSSDC) that the preparation of data for the Innsbruck meeting would result in timely submission of digital data for the CDAW. Unfortunately, only six data sets were submitted by the deadline. Three data sets were received in August, seven in September, 24 in October, eight in November, and one participant showed up on December 11 with tape in hand. Naturally complete data verification prior to the CDAW was impossible. Those who provided data sets by late October were mailed graphical and/or tabular outputs to effect data verifications by November 17. In spite of the late delivery of much of the data, all data submitted was placed on-line before completion of the workshop and essentially all problems with the data sets were corrected.

It was recognized that it would be difficult for the attendees to prepare properly for this new type of meeting. To help educate the attendees, a copy of the one-hour video tape presented privately in Innsbruck was provided to each invitee who requested it and a final written description of the capabilities of the computer-display system, the agenda, and procedures were mailed to all attendees by November 15.

The on-line data base that was constructed was impressive by any standards. It consisted of 415 parameters obtained from 38 experiments flown on 10 different satellites and 171 parameters obtained from 67 instruments comprising 5 different

TABLE 4

Attendees of CDAW 1.0

Name	Affiliation	Attendance Category
K. L. Ackerson	U. of Iowa	Participant
S.-I. Akasofu	Geophysical Institute, Alaska	Analysis Consultant
J. H. Allen	IMSCIE Office	Observer (b)
E. Amata	Laboratorio Plasma Spazio (LPS)	Observer (c)
R. L. Arnoldy	U. of New Hampshire	Participant
A. Bahnsen	Danish Space Research Institute	Participant
W. Baumjohann	Institut für Geophysik Münster	Participant
D. P. Cauffman	NASA Hdqs. - Solar Terrestrial Programs (ST)	Observer (a)
E. R. Dyer, Jr.	SCOSTEP	Observer (b)
J. Etcheto	Centre National d'Etudes des Telecommunication (CNET)	Participant
C.-G. Fälthammar	The Royal Institute of Technology, Stockholm	Analysis Consultant
T. A. Fritz	Space Environment Laboratory	Participant
R. E. Gendrin	CNET	Participant
H. Glaser	NASA Hdqs. - ST	Observer (a)
R. A. Greenwald	Max-Planck-Institut (MPI) für Aeronomie	Participant
A. J. Grobecker	National Science Foundation (NSF)	Observer (a)
D. A. Gurnett	U. of Iowa	Participant
(1) J. A. Heppner	Goddard Space Flight Center (GSFC)	Analysis Consultant
B. K. G. Hultqvist	Kiruna Geophysical Institute	Participant
E. W. Hones, Jr.	Los Alamos Scientific Laboratory	Participant
J. F. E. Johnson	University College of London	Participant
R. G. Johnson	Lockheed Palo Alto	Observer (d)
E. Keppler	MPI für Aeronomie	Observer (c)
K. Knott	ESA European Space Technology Centre	Observer (b, c)
A. Korth	MPI für Aeronomie	Observer (c)
(2) R. P. Lepping	GSFC	Participant
R. H. Manka	US IMS Coordinator	Observer (b)
F. Mariani	LPS	Observer (c)
F. S. Mozer	U. of California, Berkeley	Partcipant
A. Nishida	Japanese IMS Committee	Observer (b)/Analysis Consultant
(3) K. W. Ogilvie	GSFC	Participant
J. V. Olson	U. of Alberta	Participant
W. P. Olson	McDonnell-Douglas, Huntington Beach	Observer (d)
J. Ortner	Austrian Solar and Space Agency	Observer (b)
G. Paschmann	MPI für Extraterrestrische Physik	Participant
D. S. Peacock	NSF	Observer (a)
T. A. Potemra	Applied Physics Lab	Participant
G. Rostoker	U. of Alberta	Chairman/CDAW

TABLE 4 (Concl.)

Attendees of CDAW 1.0

Name	Affiliation	Attendance Category
H. Singer	U. of California, Los Angeles	Participant
D. P. Stern	GSFC	Analysis Consultant
V. Vasyliunas	MPI für Aeronomie	Analysis Consultant
B. Wilken	MPI für Aeronomie	Participant
D. T. Young	U. of Berne	Participant

(1) Represented by N. C. Maynard or M. Sugiura at some sessions.
(2) Represented by D. H. Fairfield or J. H. King at some sessions.
(3) Represented by J. D. Scudder at some sessions.

ground-based networks. The details are shown in Tables 5 and 6. For the GOES 2 magnetometer three parameters were quiet time measurements used to subtract from disturbed times to obtain disturbance values. The same is true for the seven magnetometers of the Alberta chain. Three experiments on GEOS 1, one on IMP-H, one on IMP-J, and the STARE backscatter measurements required a decommutation parameter which will be explained below. The total on-line data volume was 161 M bytes at the completion of CDAW 1.0 although the amount reached a peak value of 165 M bytes during the workshop because of modifications made to the data base during the workshop. GEOS 1 data used 57 M bytes, ISEE 1 and 2 used 72 M bytes, other satellites accounted for 18 M bytes and the ground-based observations occupied 14 M bytes.

The limitations of the data base management software for CDAW 1.0 dictated that the data base must be constructed with a parameter value as a function of universal time. Consequently, the data could only be plotted in an on-line mode with time as the abscissa. Several data sets were submitted in such a format that they had to be decommutated before being plotted. This required developing software that could perform this decommutation and it became necessary to construct a parameter upon which selection criteria could be coded on-line to produce a physically meaning plot with the supplied data. The symbol D in tables 5 and 6 denotes such parameters. These parameters were not physical measurements but were an encoded word of several independent variables associated with the measurement. For example, in an ion composition experiment where the accumulated counts were obtained within a given mass, energy, and pitch angle value, the appropriate counts could be extracted from the digital bit stream for plotting. The parameter for decommutation consisted of the mass, energy, and pitch angle and the criteria for these variables was coded on request. Such on-line coding was called a logicon. During the course of data submission it became clear, in contact with several invitees, that the development of algorithms to operate on parameters of the data base before plotting was very desirable. Consequently modifications of the software were made that allowed the development of user-specified code to be generated in real time before plotting. Typical examples of this were to convert the three vector parameters submitted in cartesian coordinates to polar coordinates before plotting or to combine the vector measurements from two different experiments (e.g., solar wind velocity and magnetic field measurements) into a vector product before producing a plot.

Besides the intensive software development and data entry, there was a parallel effort to obtain or construct the necessary elements of the audio/visual system deemed necessary to carry out CDAW 1.0 in an effective manner. These basic elements consisted of 7. and 8. listed earlier in this section with the appropriate cabling and a flexible central control console that could switch audio and video signals to desired output devices located in the conference room where the Workshop would take place. The details of this effort are not important to elaborate here, only to note that a considerable effort was expended to achieve the required system. The important thing was to insure that a truly group-interactive environment was created for the Workshop and could be maintained, recognizing hardware elements might fail and work-around procedures would be required. In addition, the usual logistics associated with conducting a meeting of some 40 attendees had to be provided.

TABLE 5

CDAW 1.0 Satellite Data Base

Satellite	No. of Expts	No. of Parameters
AE-C	5	9
ATS	1	32
DMSP-F2	1	18
GOES 2	1	6 (3Bkg)+
GEOS 1	9	92 (3D)*
IMP-H	2	32 (1D)*
IMP-J	3	41 (1D)*
ISEE 1	9	115
ISEE 2	6	67
TRIAD	1	3
TOTALS	38	415

+ 3 parameters are background values
* D represents a decommutation parameter (see text)

TABLE 6

CDAW 1.0 Ground-Based Data Base

Network	No. of Instruments	No. of Parameters
AE Indices Magnetometers	5	9
Alberta Magnetometer Chain	7	14 (7B)+
Alberta Riometer Chain	7	7
IMS Magnetometer Münster-Braunschweig Chain	33	99
North American Magnetometer Chain	13	39
STARE Backscatter Radars	2	3 (1D)*
TOTALS	67	171

+ 7 parameters are background values
* 1 parameter is a decommutation parameter (see text)

VI. The Conduct of CDAW 1.0

The general format of the meeting consisted of the following elements:

1. A half-day session devoted to opening remarks and training/orientation lectures for the workshop;

2. A half-day session devoted to 10 minute papers presented by each participant to provide the group with the main features of the available data;

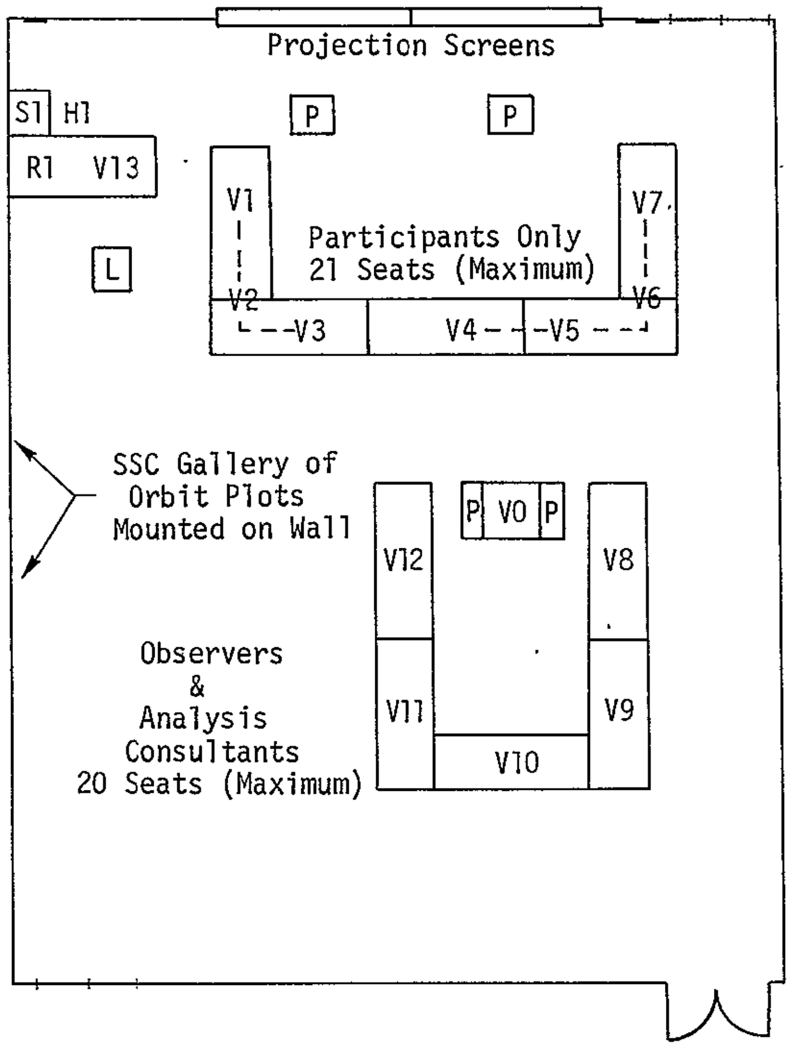
3. Three full days of interacting with the data base either in a group or subgroup mode. The conference room layout for the two modes are given in Figures 4 and 5; a more detailed explanation of the operation will be given shortly;

4. A final half-day session for a critique of the CDAW concept and its initial implementation; determination of the ground rules for the continued use of the on-line data base; and future plans.

We will discuss briefly in this section the results of 1. and 2. above and give a description of the operation in 3. The scientific problems studied in 3. and the results of the discussions in 4. will be given in the next section.

The welcoming remarks by Dr. Robert S. Cooper, Director of Goddard Space Flight Center, included some insight from his experience where the incorporation of too much data of different precisions resulted in a reduction of accuracy of the final information product. Consequently, any experiment relating to the ability to utilize effectively large data bases is of great interest. Dr. David P. Cauffman of the Space Plasma Physics Office, Solar Terrestrial Programs made the remarks for NASA. He noted the international representation at the Workshop reflected the character of the IMS and he was pleased to see this participation in an experiment to develop new techniques to solve the problems in solar-terrestrial physics. In his view, the CDAW 1.0 represented a new, untried problem-oriented approach, in a scientific sense, that hopefully could cope with those problems that were beyond the scope of individual efforts and he was gratified that such efforts were being pioneered as part of the IMS. The Workshop was also a sociological experiment to learn more about the interplay among the human brain, the increasing capabilities of the computer to manipulate and display data, and the interactive problem solving abilities of a group of people. He emphasized that CDAW 1.0 was a pilot workshop and was the first effort to make such an extensive data base available through a single computer where group manipulation and interaction were possible. He encouraged the group to provide constructive comments at the conclusion so that future workshops could profit and be made even better.

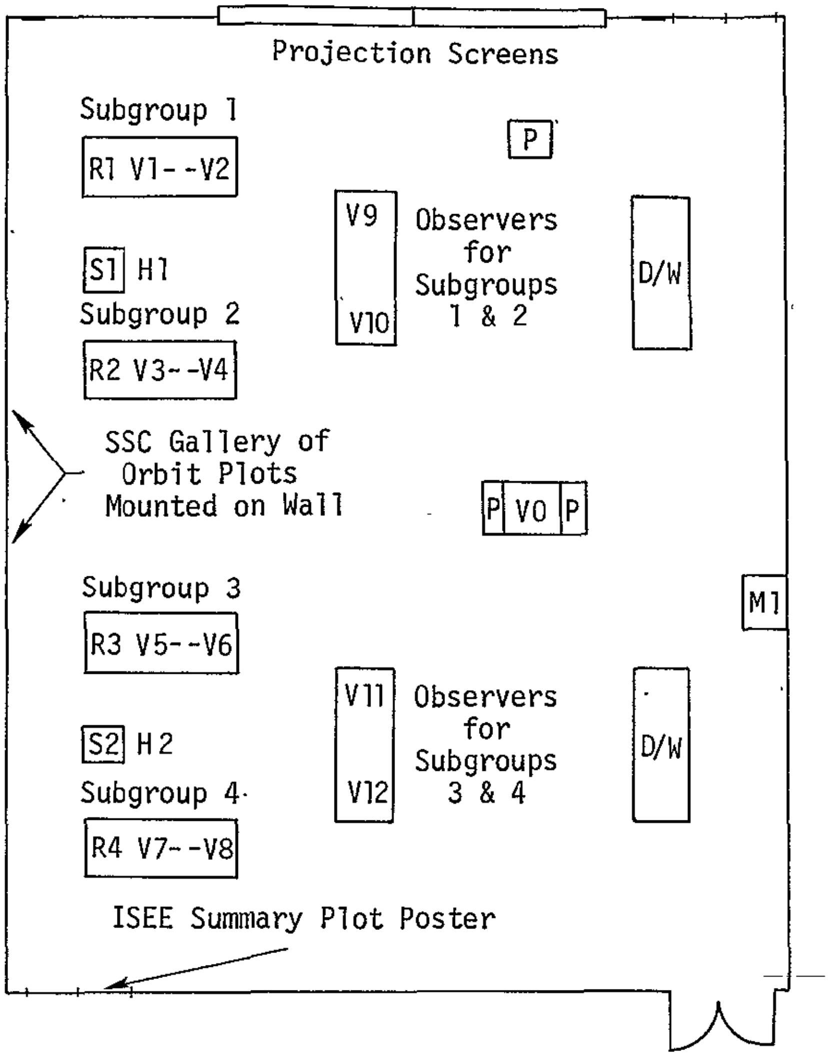
Dr. Karl Knott, GEOS 1 Project Scientist, made the remarks for ESA. He told the audience that ESA was very interested in making the data exploitation phase of the IMS a success and was committed to supporting conferences and workshops to effect this goal. The complete success of the IMS is necessary to pave the way for new international cooperative programs, which are essential for scientific progress in many fields. He related the formal cooperative nature of



H1 = Headset
L = Lectern
P = Projector
R1 = Arvin Echo Video Discassette Recorder VDR-1RA

S1 = SSC Analysis Coordinator
V0 = Large Projection TV
V1-V13 = 9-inch TV Monitors

Figure 4. CDAW 1.0 Conference Room Group Mode Layout.



D/W = Discussion/Work Tables
H1, H2 = Headsets
M1 = Microfilm/Microfiche Reader/Printer
P = Projector

R1-R4 = Arvin Echo Video Discassette Recorders VDR-1RA
S1, S2 = SSC Analysis Coordinators
VO = Large Projection TV
V1-V12 = 9-inch TV Monitors

Figure 5. CDAW 1.0 Conference Room Subgroup Mode Layout.

the GEOS 1 program between ESA and NASA which resulted from the need to have NASA obtain data from the Western apogee passes of that satellite during the first 6 months following launch. The ESA cooperation was to be demonstrated by holding joint workshops with NASA; the first such effort was the IMS Working Conference in Innsbruck and CDAW 1.0 represented the next step. He pointed out that ESA intends to support future workshops and hopes that the scientific community itself will take the initiative in organizing future ones instead of the space agencies and IMS coordinating bodies.

Dr. Vette outlined the effort and organization involved in bringing about CDAW 1.0. Besides the Program Committee given in Table 3, there were five internal committees set up within NSSDC. These were (a) Software Development chaired by Dr. Michael J. Teague, (b) Workshop operations chaired by Dr. Michael J. Teague, (c) Audio and Video System Development (Hardware) chaired by Dr. Donald J. Hei, Jr., (d) Logistics Support chaired by James Riordan, and (e) Social Activities chaired by Dr. Robert H. Hilberg. The latter was also cited for leading the sizable procurement effort that was necessary to have the appropriate equipment available to conduct the Workshop. It was through this recognition that the diligent efforts of some 25 members of the NSSDC staff were acknowledged.

Although documentation on the capabilities of the CDAW software systems had been sent to all invitees and demonstration of the various equipment given in Table 7 and Figures 4 and 5 had been effected through a video tape, Dr. Teague gave an orientation lecture on the workshop procedures and explained the CDAW 1.0 Data Catalog. This catalog contains (a) the identification of the 38 satellite and five ground-based data sets given in Tables 5 and 6 including the mnemonic name assigned basic time resolution and physical units, (b) the identification and mnemonic of the parameters given in Tables 5 and 6, (c) the algorithm documentation and mnemonic for specific parameters, which had been specified and requested by invitees prior to the Workshop, and (d) the logicon documentation and mnemonics for (1) GEOS 1 Hultqvist - 24, (2) GEOS 1 Wilken - 15, (3) GEOS 1 Young - 26, (4) IMP-H Williams - 4, (5) IMP-J Williams - 6, (6) STARE Greenwald - 28. In addition forms were included to allow the participants to specify time period, time resolution, type of ordinate axis and scaling, labeling, and necessary manipulation by algorithm for the parameter that he desired to have plotted. Plots were available with one, two, or three panels per frame (plot) with one or two parameters per panel.

In the subgroup mode layout shown in Figure 5, each subgroup had to share the output of one of the 4014 graphics terminals given in Table 7 with another subgroup. The plot request forms were given to an analysis coordinator, S1 or S2, who in turn communicated with the 4014 terminal operator through a headset (H1 or H2). The coordinators were personnel with scientific expertise in solar-terrestrial physics and were intimate with the CDAW software system. The output of the graphics terminal appeared on the 611 slave display unit which was viewed by a high resolution (~ 1000 lines/horizontal) vidicon camera. The video output from the camera was routed through central control to the appropriate subgroup video discassette recorder. The invitees could then record and play back these recorded images for display on their 9" TV monitors. Hardcopy for individual frames was available on request and viewgraph transparencies could be made from these. In the group mode any of the 21 participants could request

TABLE 7

Equipment in the IMS/SSC Terminal Room

2 - Tektronix Graphics Terminals 4014-1 (operated at 9600 baud)

2 - Tektronix Display Monitor 611

2 - Diamond High Resolution Video Camera

2 - Tektronix Hardcopy Units 4631

2 - TV Monitors - 9 inch

2 - Tektronix Alphanumeric Terminals 4023 (operated at 2400 baud)

1 - Tektronix 8 x 10 Digitizing Tablet

outputs which would be displayed on all the TV monitors in the room and could be recorded. Following Dr. Teague's lecture and an extensive question and answer period, the invitees were prepared for the next three days of the CDAW.

The SSC Gallery consisted of two sets of orbit plots for all the possible satellites of interest, including the ten satellites used in CDAW 1.0 data base, which were pasted on the wall of the conference room as shown in Figure 4. Each set consisted of the daily high-altitude satellite bar charts for the four days being investigated, the 90-minute low- and medium-altitude satellite bar charts for the whole time period under study, and the projection of the high- and medium-altitude satellites projected on the solar ecliptic plane in three-hour snapshots. The height above the solar ecliptic plane was denoted for the beginning and end of each time interval on these latter plots. The details of the SSC Gallery were discussed by Dr. Vette with the invitees during a coffee break in order to maintain the agenda time table.

The final lecture of the first half-day session was given by Dr. Rostoker, as Chairman of CDAW 1.0. He arrived one day early for the expressed purpose of becoming indoctrinated about the CDAW system and preparing some material from the data base to use in his orientation summary of the important facts known about the events selected for study. Consequently, his lecture served two purposes; to focus on some aspects of scientific interest and to provide additional education on how to use the common data base. The conclusions cited earlier about the IMS Working Conference were summarized by Rostoker. He then singled out three intervals which he felt might be of extreme interest to some of the participants:

Interval 1 -

12/1	2028	Onset of substorm with geographically localized micropulsations that were seen in a number of areas around the globe.

Interval 2 -

12/2	0225	Interplanetary shock wave triggered much magnetic activity
	0413	GEOS 1 (Hultqvist) saw particle dropouts
	0840	Negative bay in horizontal magnetic field component
	1200-1300	Intensification
	1520	STARE growth of electric field; quenching of North American micropulsations
	1620	Strong asymmetric ring current; electrojet in Europe exploded toward equator
	1900-1940	ATS 6 was in magnetosheath
	2106	Major substorm onset in Scandinavia
	2141	Major substorm onset in Scandinavia

Interval 3 -

12/12	0216	Abrupt change in solar wind plasma velocity - interplanetary shock and ISEE's & IMP's were in good positions
	0458	Substorms triggered
	0555	Magnetic activity terminated rapidly

In addition to pointing to these interesting periods, Rostoker pointed out several things he had learned about using the data base. He cautioned that one should not request long periods of times be plotted with high time resolution data sets since this would require an inordinate amount of time. He noted one should be aware of periods of missing data from an experiment that might be caused by saturation rather than an actual data gap such as he had noted with the IMP-J magnetometer data at 1910 UT on December 2. He also cautioned that plotting of data where lines are drawn between successive points can cause some confusion when some data points are missing from the data base.

The first afternoon session consisted of 10-minute papers being presented in the following order: J. H. King (for R. P. Lepping), H. Singer, G. Paschmann, E. W. Hones, Jr., J. D. Scudder (for K. W. Ogilvie), F. S. Mozer, D. A. Gurnett, K. L. Ackerson, T. A. Fritz, R. L. Arnoldy, D. T. Young, B. K. G. Hultqvist, B. Wilken, R. E. Gendrin, A. Bahnsen, K. Knott, J. F. E. Johnson, E. Amata, T. A. Potemra, J. V. Olson, W. Baumjohann, R. A. Greenwald, and J. Etcheto. The last paper was out of logical sequence due to the late arrival of the presenter. In the process of the afternoon, first, Dr. Gendrin and then Prof. Mozer requested via submission of forms that electronic slides be prepared from the data base to support their presentations. Their forms were processed and the frames were recorded on the video cassette recorder for display during the session. This was a perfect demonstration of how responsive the CDAW system could be and paved the way for the following days' activities.

VII. The Use of the CDAW 1.0 Data Base by the Invitees

We chose to discuss the major part of the Workshop, namely the activities of December 12-14, 1978, separately from the other sections. This was the part of the agenda that was entirely new and deserves its own treatment. As we had envisioned the purpose of the group mode, it would serve as the platform by which intercomparisons of various kinds, such as plasma data from several instruments, energetic particle data from several instruments, parameters derived from several measurements checked against the equivalently measured values, e.g. $\vec{E} = \vec{V} \times \vec{B}$ could be compared. Such comparisons viewed in the group mode would make attendees aware of the strengths, shortcomings, and problems of each of the measured parameters as they then settled into subgroups to attack, in more detail, the problems that could be studied with such an extensive data base. With an abbreviated data entry phase, data base verification was far from complete when the invitees convened at NSSDC, as we have pointed out earlier. Consequently, there was a great desire to abort the use of the group mode entirely.

Dr. Rostoker, as Chairman, convened an afterwork session on the first day to discuss the desires of all so that the next three days would be the most productive. Since the spirit of the Workshop was interactive, the Program Committee had the foresight to build in an interactive agenda. A vigorous discussion by all attendees, led by Rostoker, resulted in the decision to begin the second day in the subgroup mode. Four subgroups were organized that evening with the following structure: (1) ISEE 1 and ISEE 2 experimenters formed a subgroup to look at features of the boundary layers of the magnetosphere; this consisted of Ackerson, Hones, Lepping, Gurnett, Singer, Vasyliunas, and Heppner,

(2) A second subgroup from ISEE was formed concerning plasma parameter comparisons, and electric field consistency, comprised of Mozer, Ogilvie, Etcheto, Paschmann, and Fälthammar; (3) The third subgroup consisted of ground-based experimenters plus the low-altitude satellites represented by Potemra and consisted of Akasofu, Amata, Baumjohann, Greenwald, Olson, J., and Potemra; (4) Most of the GEOS 1 experimenters along with the geostationary ATS 6 and GOES 2 experimenters, formed a subgroup consisting of Arnoldy, Bahnsen, Fritz, Gendrin, Hultqvist, Johnson, Knott, Korth, Stern, Wilken, and Young. The organization of the subgroups varied slightly during the course of the Workshop, but many key personnel remained in the same subgroups throughout the three days of computer graphics activity. The group mode was never used, although this room arrangement was used during the first day. Upon seeing the initial organization of the subgroups on the second day, Dr. Cauffman remarked that the interactions fostered by the subgroups should have been accomplished prior to the Workshop. However, it was pointed out that the existing methods of communications had not permitted such interactions and the Workshop environment should be viewed as one which permitted this to be realized.

In order to view CDAW 1.0 in an overall perspective, it is useful at this time to present a statistical overview of the use of the data base. After this, a more detailed look at the specific problems pursued will be instructive. During the course of the Workshop, a total of 354 frames of catalogued plots were generated. This comprised a total of 982 panels of data that displayed 1507 parameters of which 287 were derived using algorithms and 112 involved logicons directly. The average number of panels per plot (frame) was 2.77, and the average number of parameters per plot was 4.25. Seventy-two algorithms were constructed during the Workshop. Of this number, 38 used parameters exclusively from the ISEE spacecraft while 22 used parameters exclusively from GEOS 1. Twenty-one algorithms used parameters from more than one data set. There were 31 algorithms specified prior to the Workshop by the participants. In regards to logicons, 57 were entered prior to CDAW 1.0 and 44 were entered during the Workshop. Approximately half of the initial 57 were deleted during the course of activity. The usage of data sets and the amount of disk space each set required are displayed in Table 8. This is useful to study in order to learn about data base construction for future workshops. Since there were some alterations of the data base during the workshop, the actual size varied up to 165 Mbytes but Table 8 gives the final values. A usage index has been displayed in the far right hand column that was obtained by dividing the number of times a parameter from a data set was used for plotting by the total number of Mbytes the data set occupied on the disks. The detailed identification of each data set, denoted by mnemonic, is not necessary here. However, AEC refers to AE-C, A6 to ATS 6, GO2 to GOES 2, G1 to GEOS 1, IE to ISEE 1, IE2 to ISEE 2, IH to IMP-H, IJ to IMP-J, and TR to TRIAD. The association of the mnemonic with the ground-based data is also fairly obvious. A study of Table 8 reveals that the five most frequently requested data sets had usage indexes above 34 and consisted of data volume approximately 2.5 Mbytes or less. The scatter plot of usage versus data set volume (Figure 6) shows this clearly. The very large data sets were used infrequently. Four data sets from ISEE were the most frequently used and six data sets from GEOS 1 and the one from DMSP-F2 formed the next set of high usage. Since the majority of the attendees represented ISEE (10) and GEOS 1 (11), the statistics are not surprising.

TABLE 8

CDAW 1.0 Data Base Size and Usage

Data Set Mnemonic	Disk Storage Space (MBytes)	Usage* (No. times plotted)	Usage Index No. times/MBytes
AECP1-8	0.55	0	0
A6A	5.89	47	7.98
DF2B	2.46	49	19.92
GO2B	2.39	19	7.95
G1A	12.53	59	4.71
G1E	0.37	16	43.24
G1G	13.94	35	2.51
G1H	5.10	29	5.69
G1J	1.54	39	25.32
G1P	0.12	68	566.67
G1U	5.96	56	9.40
G1W	6.08	50	8.22
G1Y	11.00	48	4.36
IEA	0.92	44	47.83
IEB	17.20	12	0.70
IEG	20.90	26	1.24
IEH	1.17	33	28.20
IEO	1.84	81	44.02
IEP	2.21	76	34.39
IES	0.24	42	175.00
IET	2.15	75	34.88
IEW	0.49	28	57.14
IE2A	0.92	4	4.35
IE26	19.66	4	0.20
IE2H	0.55	13	23.64
IE2P	2.40	23	9.58
IE25	1.47	78	53.06
IE2W	0.25	0	0
IHA	0.98	13	13.26
IHW	1.60	0	0
IJA	0.98	12	12.24
IJL	1.23	17	13.82
IJW	1.04	5	4.81
TRP	0.55	3	5.45
ZAE	0.55	29	52.73
Z+3 character str name (N. Am.)	2.09	6	2.87
Z+3 character str name (Scand.)	6.39	32	5.01
Z+4 character str name (AL)	4.30	20	4.65
ZSTG	0.55	29	52.73
	160.56	1220	

*Not including algorithm plots

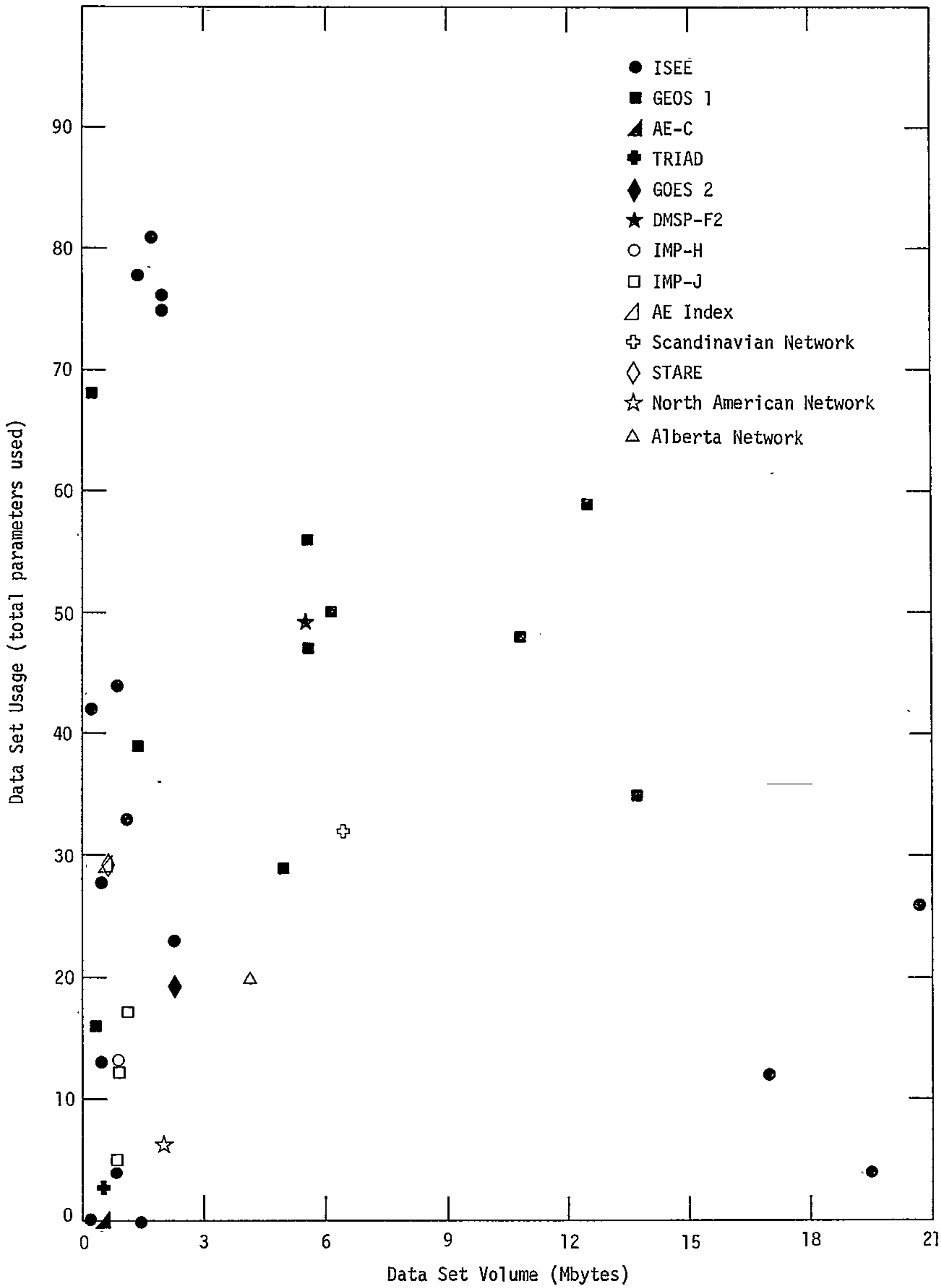


Figure 6. Size and Usage of CDAW 1.0 Data Base.

The problems addressed by the various subgroups are of interest not only from a discipline standpoint but from the nature of the work itself. There were three periods during the CDAW when the various subgroups reported to the whole group with short summaries of the work being done. The first reporting period occurred on the afternoon of the third day. This was followed by one in the late morning and one in the late afternoon of the fourth day. Following each reporting period the chairman encouraged subgroup members to shift to different tables and take up new studies.

VIII. Summary of First Reporting Period

Subgroup 1: Reporter - E. W. Hones, Jr.

These workers were concerned with the features of the boundary layers by studying the plasma parameters, magnetic fields, energetic electrons, and electrostatic noise obtained by ISEE 1 and ISEE 2 experiments. The IMP-J magnetometer data was also used. Interesting correlations between enhanced electrostatic noise and passage through the boundary surfaces or just outside them was being studied. Magnetospheric currents were also being investigated. No conclusions could be made at that time but it was hoped some clarification could be reported later.

Subgroup 2: Reporter - F. S. Mozer

This subgroup was checking the consistency between the parameters obtained from three ISEE plasma experiments and with the ISEE electric and magnetic experiments. The density measurements obtained by the wave and plasma particle experiments agreed very well but the flow vectors did not. The differences between the electric field obtained from $\vec{V} \times \vec{B}$ and direct measurement in the solar wind agreed in many cases but some discrepancies of the order 0.1 to 1 mV/m were observed. Heat flow away from the magnetopause based on electron measurements was 50-100 W/km^2 but the dot product $\vec{E}\cdot\vec{J}$ based on obtaining $\vec{J}$ from $d\vec{B}/dt$ indicated higher values. The flow velocity was toward magnetopause on both sides of this boundary. This was in agreement with the electric field measurement but some discrepancies arose when detailed comparisons were made.

Subgroup 3: Reporters - R. A. Greenwald and W. Baumjohann

An investigation of the oscillations observed during the period December 2 0650-0730 was being made. Micropulsations were observed on the ground; the STARE backscatter radar detected oscillations in the electric field and the GEOS 1 electric and magnetic field detectors revealed oscillations; all data showed periods around 5 minutes. The magnetometer on ISEE also detected these events. Electric field polarization in the ionosphere was obtained. The GEOS 1 magnetometer obtained the same polarization. It was concluded the results showed the presence of an electric field along the magnetic vector. Greenwald requested the particle experimenters to check for particle flows along the magnetic field vector during this time period. A second effort of this subgroup was to study the effects of the large interplanetary shock that struck the magnetosphere on December 2 at 1906 UT. A large shift of the westward electrojet to the south was observed by the Scandinavian magnetometer chain. The auroral oval was detected moving southward at this time using

DMSP-F2 data. ISEE observed that the bow shock was pushed in by 2 Earth radii and the magnetosheath was moved into the orbit of ATS 6.

Subgroup 4: Reporter - B. K. G. Hultqvist

A detailed look at most of the GEOS 1 sensors during ion flow reversals made the determination of the region in which the spacecraft was traversing a difficult one. The variable magnetic field data and the presence of alpha particles suggested the spacecraft was in the magnetosheath. However, the ions normally seen in this region were not present. The ion flows reversed direction after a short time. There were some rapid drop outs of the particle data. The density of cold plasma was large while the density of hot plasma was low. It appeared that this was a special boundary layer region of the magnetosphere with the magnetic field lines connected from GEOS 1 to the ionosphere. The streaming of particles along the field line placed the source of the particles somewhere between the ionosphere and the 20° latitude that the spacecraft was at during these times. The periods that GEOS 1 was in this special region on December 2 occurred at approximately 0300, 0419-0426, 0540-0600, and again around 1620. There was ATS 6 data at 12 hours difference in local time that indicated similar behavior.

XI. Summary of Reporting Sessions on Last Day of Data Base Use

Some of these reports were involved with the work of only two or three people and as such do not constitute full subgroup reports.

Subgroup 1: Reporter - V. Vasyliunas, R. A. Greenwald, and E. W. Hones, Jr.

Some work done during the very first session but not reported earlier was concerned with looking at the ISEE magnetic and plasma wave experiments during the period on December 12 where Hones, on the first day, had reported a rotating plasma blob. ISEE was near dawn at a local time of 5H at a distance of 8Re. The magnetic field described a rotation about the mean value of magnetic vector with a period of 8 minutes. The magnetic vector could be traced for two or three cycles of this rotation. The flow velocity and the magnetic vector were observed to be 90° out of phase and in the same plane. The plasma radiation was observed to drop at the time the particle flow was tailward and the magnetic field was duskward, then the plasma waves increased throughout the rotation and fell again. There was a slight ground effect, that being that a maximum occurred in the horizontal magnetic field as measured by the Scandinavian stations.

The tracing of the flow direction in the ionosphere and near the equator by using the hot plasma experiment of Frank (Ackerson) and the STARE radar results during the time period 0145-0245 on December 12 was undertaken. Both instruments indicated a sunward flow. However, there was some discrepancy in the flow direction based on a study of two components; the third ISEE component was being investigated at the reporting time.

The two magnetopause crossings around 0200 and 0300 December 2 were studied using both ISEE 1 and ISEE 2 data. This revealed that fluctuations both in the plasma data and electrostatic waves were observed on both spacecraft. Consequently, if the source of these disturbances was at the boundary, these disturbances must have been traveling upstream. It should be interesting to see if this feature is prevalent on all such crossings.

Subgroup 2: Reporters - G. Paschmann and V. Vasyliunas

Some ISEE experimenters attempted to study the bow shock crossings encountered on December 2. However, they found the plasma data was not yet in suitable shape to do this very well. Good solar-wind ion data had not been provided for the data base. In addition, the electron data upstream of the shock had not been processed adequately yet to account for spacecraft potential and other factors. The efforts of the subgroup were again being turned to comparing flow velocity from the plasma experiments with the electric field experiment. Paschmann made an attempt to study the GEOS 1 Ion Composition Experiment data during the vortex or rotating plasma event observed by Hones. Unfortunately, GEOS 1 was not being tracked at that time.

Also the ISEE magnetopause crossings around 0200 and 0300 were studied in this subgroup. The time difference between crossing times of the two spacecraft was typically eight minutes. The pattern of the temperature profile was such that one could see there was no change in spatial structure during the passage through the region by each spacecraft. There was a heating of the plasma just ahead of the magnetopause within a region of 30 km thickness. The heat flux increased a factor of 2 over this distance.

Subgroup 3: Reporters - G. Rostoker and W. Baumjohann

The study of the effects of the interplanetary shock wave that impacted the magnetosphere around 1906 UT on December 2 and produced several bow shock crossing by the ISEE spacecraft during the period 1906-2030 UT was continued. The subgroup was beginning to have difficulty coping with the great diversity of data in terms of assimilating the information and drawing conclusions. The IMP-J magnetometer data in the tail region became saturated during the period of interest but the delay time of the response of the tail to the shock wave could be determined. The satellite data was probed during the period 2055-2106 UT on December 2 to see if any effects of the substorm seen over Russia by the Scandinavian magnetometer could be seen. There was no observable effects seen by IMP-J in the magnetotail, nor by the low energy electrons on ATS 6 near local noon, nor by ISEE, which was in the interplanetary medium.

Subgroup 4: Reporters - R. L. Arnoldy and K. Knott

A series of electron injections (or a spatially structured distribution) was observed by ATS 6 on December 2 around 0240 UT when the spacecraft was at a local time of 1800 hours. The GEOS 1 electric field showed spikes at this time when it was in the dawn portion of the magnetosphere. The electric field data in the sheath obtained both by ISEE and IMP-J did not show any of the spikiness seen on GEOS 1. A large electric field impressed on the magnetosphere might have been responsible for local acceleration of electrons.

The events called strange flow patterns were studied extensively by GEOS 1 experimenters and occurred near the magnetopause. The three periods of major interest were 0300, 0419-0426, 0540-0600. These were analyzed as far as possible with existing data and further work would continue after the Workshop with higher time resolution data. It appeared during the first two intervals listed, the spacecraft was inside the magnetosphere and was outside for the latter one. The events were preceded by short impulsive DC electric fields, increase in cold plasma density, and an asymmetric particle pitch angle distribution characteristic of particles coming from higher latitudes in the near hemisphere. There were generally strange patterns of DC magnetic fields and strong noise in the ULF spectrum. The detailed reports for these events will be given at Alpach, Austria in June 1979.

The fourth event of detailed study was done in conjunction with Subgroup 3 and was the pulsation event of 0650-0730 UT on December 2. This event seemed to have been generated by a poloidal mode of the magnetosphere with a period of five minutes.

X. Critique and Evaluation of the CDAW Concept

The critique of the Workshop was held on the final day for approximately 90 minutes; an additional 90 minutes was given to establishing the ground rules for future use of the CDAW-1 data base. Besides this direct input there were numerous letters written to us by the attendees offering praise, comments, and suggestions for improvements. In addition, there were a number of suggestions and observations from the CDAW staff that merit inclusion. It is from this body of material that the evaluation of the concept can be made.

Based on all the inputs received there can be no doubt that the concept was regarded as a significant milestone in the methodology of analyzing data. With the ability to place many coordinated probes throughout near-Earth space completely demonstrated during the IMS and now to be able to perform complicated correlations utilizing inputs from a variety of experiments, solar-terrestrial research appears to be on the threshold of a new era. The reduction in the time required to provide the data to answer a specific question afforded by the CDAW approach is considered revolutionary and it now appears to be practical for investigators to address much more complex problems. To the best of our knowledge, every subgroup was planning some publication based on their findings and further analyses of the projects begun at CDAW 1.0.

Another significant accomplishment of CDAW 1.0 was the agreement by the participants that the data base would be open to anyone who desired to use it. If this precedent is continued, it opens up entirely new vistas for coordinated analysis on a much broader scale. It was agreed the outputs from the data base supplied by NSSDC to any requester would also be sent to the original participant. In that manner, any communication the principal investigator deems necessary to have with the requester could be initiated with the knowledge of the materials that have been supplied. There was some discussion on proposing a new citation in journal articles for those who furnish validated data that would be subordinate to the authors, more formal than an acknowledgement, and should be recognized by funding agencies as a measure of scientific accomplishment to be taken into account during the evaluation of proposals.

Although the CDAW can be judged as an extremely successful introduction to coordinated data analysis techniques, it is important to realize that there is much to be done and much for the scientific community to learn if, indeed, the concept is to realize its full potential.

It is worthwhile to discuss these factors here. A number of the participants recognized that their preparation for the Workshop had been inadequate. It is most important to have the problems defined before coming to the facility and to have the subgroups organized and working prior to the Workshop itself. If this lesson is not learned, then the community may waste vital resources and time. The time for coordinated data analysis cannot replace the time required for creative thinking; workshops must be used at the appropriate time to enhance the analysis process by the synergism of several knowledgeable minds with rapid access to a large data base. The expenditure for such an activity as a CDAW will be discussed later; clearly it is a resource that must be used wisely or its contribution to the advancement of knowledge will not be cost effective. In addition, to be efficient at a CDAW, a participant should read the preliminary information made available prior to the Workshop. Clearly, many CDAW 1.0 attendees had not assimilated this type of material adequately. In proper fairness, it was difficult to prepare for something that one had not yet experienced and some admitted that prior to the Workshop, they were skeptical that the planned Workshop process would prove useful. We believe the scientific community is capable of making proper preparation and using these techniques at the appropriate time in the analysis cycle.

Because one is attempting to account for many more measurements than previously to reach an understanding of the various phenomena, it may require the development of new, concise presentations. There were several who suggested that a time-line chart in which interesting times could be noted would have been a useful thing. Clearly some work needs to be done to develop this type of presentation. The variety of events represented by the CDAW 1.0 data base is not likely to be the theme of all such workshops; consequently each type of study may require its own type of new presentation development. As an analogous example, we have found the use of the bar chart for multi-satellite position display to be extremely efficient in conveying the extensive amount of information required for 10-12 satellites.

The majority of suggestions for improvements fall into four categories: (a) participant preparation, (b) software, (c) equipment, and (d) procedures. Those suggestions which are within the bounds of the DAWOC that is planned to exist at NSSDC are listed in Tables 9-12. More ambitious suggestions have not been included in the tables. For example, there was some expression of the desirability of being able to manipulate the common data base from remote terminals at the participants' home institutions. This would require obtaining a large computer with the appropriate communications hardware. Since this section is concerned with refining the CDAW concept within the minimum facilities we felt were necessary to have a viable DAWOC, the larger-scale activities will be treated in the next section.

In reflecting on the experiences of CDAW 1.0, we would now advocate moving the third phase of the CDAW concept, the initial Workshop outlined in section IV, to the final phase. It is believed that utilization of the data base by participants requesting outputs (original phase 4) will lead to the appropriate

TABLE 9

Participant Preparation Improvements

1. Participants should read and be familiar with any documentation about the system, procedures, or the data base parameters prior to attending a workshop or using the data base. This will prevent improper requests which consume much interactive time.

2. Participants should organize problems to be investigated prior to attending a workshop and should obtain outputs from the system to help define these. This will also insure that appropriate data parameters with proper resolution are part of the Workshop Data Base.

3. Participants should organize subgroups prior to workshop based on problem interests.

4. Participants should document their data sets fully, and submit data plots for each physical parameter for several time intervals to serve as verification intervals. Timely submission of data along with proper documentation should reduce data entry costs.

5. Working with members of the DAWOC staff, summary plots, time-line charts, or other useful material should be prepared prior to any workshop and distributed to the participants.

TABLE 10

Software Improvements

1. Algorithms. This capability is vitally important. It is very desirable to expand this capability to include:

   (a) ability to have calling arguments
   (b) ability to have algorithms call other algorithms
   (c) ability to operate simultaneously on data from different time periods
   (d) editing of on-line algorithm construction
   (e) larger storage arrays
   (f) better readability of verification display

2. Data Base Management. It is very desirable to improve this software to:

   (a) reduce granule size to avoid wasted storage
   (b) store data more efficiently
   (c) provide for rapid averaging or decimation of parameters
   (d) provide for time lag retrieval

3. Display. It is very desirable to expand capability to include:

   (a) ability to plot one or two parameters as a function of another parameter, where any of the parameters may be derived, rather than original parameters
   (b) ability to add new capabilities in future
   (c) simple, flexible operator interface
   (d) ability to show data gaps for all line types

4. Data Catalog. This should be enhanced to provide rapid documentation and distribution for changes in data base quantities, logicons, and algorithms. The ability to use an alias for a mnemonic would be very useful to ease the filling of forms by participants.

TABLE 11

Equipment Improvements

1. TV projection system did not work well - This system not necessary in future workshops.

2. With existing resolution on TV display system, no more than two people should be assigned one TV monitor.

3. Units should be available to produce hardcopy on demand.

4. Intercommunication equipment needs some modifications for operator comfort and ease of use.

TABLE 12

Procedures Improvements

1. The complete SSC Gallery of orbit plots could not be seen clearly from all positions in the room. Hardcopies of these plots should be available for each table. Opera glasses would be appropriate for future wall displays.

2. The analysis coordinators were extremely useful and helpful. It would be desirable if there could be one for each subgroup.

3. More explicit guidelines should be sent to Participants to insure that they will know how to document their data sets properly. These guidelines should point out things that could be done to simplify data entry and unification such as:

   (a) time order data
   (b) maintain an integral number of logical records per physical record
   (c) keep each physical record autonomous so it can be processed independently

4. Arrangements to support one subgroup per graphic terminal is highly desirable. This might be accomplished by limiting size of attendance at given workshop or staggering use of terminals to allow for think or discussion sessions.

5. With a proper time interval for data entry and verification phase, good documentation should be provided to participant to familiarize him with the data base parameters, how they were constructed, and their limitations.

organization of subgroups. This would be followed by these various subgroups planning and conducting on-site workshops (original phase 5) which would be followed by a final group level workshop (original phase 3) where complete exchange of ideas could occur. It will be interesting to see how this concept develops within the scientific community.

It is necessary to give an estimate of the cost of the CDAW activity so that one can determine the cost effectiveness of this mode of data analysis. In addition, an appreciation of the cost factors will permit the scientific community to determine how to use such a resource properly. The cost breakout is given in Table 13. These are operational costs and do not reflect development or equipment costs. The senior staff is comprised of scientifically trained people knowledgeable both in computers and the scientific disciplines. Programmers are at the junior to mid range-level and technicians cover the data, computer, and electronic equipment fields. Clerical/logistics also covers publication and graphic arts.

One can see that a reasonable effort goes into the planning of a data base since it requires interfacing with a CDAW Program Committee issuing instructions and documentation, making phone calls, and attending meetings. The allocation of on-line disk storage space for each data set is an important factor and the general constraints of the facility have to be invoked on the Program Committee at various times. The Workshop planning involves the usual logistics associated with any meeting and, as well as the room arrangement, it includes equipment placement, cabling, and internal operations. A new data set is one that has not been submitted to any prior data base. For CDAW 1.0, all data sets except the IMP-J magnetometer data were new (Lepping had provided this data for use in the development of the CDAW system). As can be seen from Table 13, the handling of a new data set is a factor of 6.5 greater than that of an old data set, i.e., one previously entered into a CDAW data base. As long as the data structure and format of a submitted digital tape remains the same for building future coordinated data bases, the data set can be considered an old data set; the time resolution can be different and the parameters that must be taken from the supplied tape can be changed without additional expense.

With the unit resources given in Table 13, it is useful to put into context the cost of a CDAW (on a participant basis) relative to the annual amount of funds received by a participant to carry out his data analysis. As a typical example we will consider: (1) there are 28 participants involved in a CDAW, involving 42 new data sets, or an average of 1.5 data sets per participant. (2) Each participant will attend one group size Workshop and one subgroup size Workshop, each of three days duration, (3) each participant will request 50 frames of output during the lifetime of the data base to be sent to him at his institution, and (4) the responsive lifetime of the data base is one year. Travel costs are $1K assuming $500 as the average cost of a four-day trip. This results in a cost per participant of about $4.5K per year. If the data set submitted is an old data set then the cost drops to $2.8K. It is our understanding the average annual NASA grant or contract for an investigator is $55K. Consequently, the total costs of the assumed CDAW on a participant basis represents somewhere between 5.1% and 8.2% of his annual funding. These cost breakouts are summarized in Table 14. Averaging these two numbers, gives 6.7% as a good rule of thumb. We believe it is on this basis that the cost benefit of

TABLE 13

Unit Resources for DAWOC

Activity	Clerical/Logistics (Hours)	Technician (Hours)	Programmer (Hours)	Senior Staff (Hours)	Terminal (Hours)	CPU (Min.)	Total Cost ($)
Planning A Data Base (40 Data Sets)	8			80			1470
Arrangement for Submission of New Data Set	8			8			195
Analysis/Programming - New Data Set			52	20	21	72	900
Documentation - New Data Set	10		6	2	1	3	160
Data Set Entry			1	1	1	21	50
Data Set Verification	1		1.5	1	1.5	18	55
Total New Data Set	19		60.5	32.0	24.5	114	1360
Arrangement for Submission of Old Data Set	2			2			50
Documentation - Old Data Set	1		1				15
Data Set Entry			5.5	1	1	21	90
Data Set Verification	1		1.5	1	1.5	18	55
	4		8.0	4	2.5	39	210

TABLE 13 (Concl.)

Unit Resources for DAWOC

Activity	Clerical/Logistics (Hours)	Technician (Hours)	Programmer (Hours)	Senior Staff (Hours)	Terminal (Hours)	CPU (Min.)	Total Cost ($)
Planning & Logistics For Subgroup Workshop (7 People)	14	24		82			1705
Daily Operation of Subgroup Workshop	8	16	8	24	12	150	820
Planning & Logistics For Group Workshop (30 People)	50	96		270			5755
Daily Operation of Group Workshop	16	24	16	48	24	450	1690
Servicing of Data Base Per Frame Request (Based on 25 Requests/Week)	0.17	0.62		0.11	0.5	3	10.50

TABLE 14

Cost per Participant for Idealized CDAW

Activity	Cost	Cost/Participant
Planning Data Base	$ 1,470.	$ 52.50
Planning/Subgroup	5,115.	182.68
Subgroup Workshops	9,840.	351.43
Planning/Group	5,755	205.54
Group Workshop	5,070	181.07
Data Base Requests	14,700.	525.00
Travel	28,000.	1,000.00
Subtotal	69,950.	2,498.21
New Data Set Entry	57,120.	2,040.00
Total (NEW)	127,070.	4,538.21
Old Data Set Entry	8,820.	315.00
Total (OLD)	78,770.	2,813.21

the CDAW concept should be judged by funding agencies and by the investigators themselves. It can be seen the cost for new data set submission and entry is a significant factor as is travel. The former cost can be reduced as the participants learn to document their data correctly and exert good quality control.

A study of the total OSS data analysis budgets, believed by us to be accurate to within 20%, has shown that a total of about $55M is spent annually. Neglecting the travel costs, the cost of the idealized CDAW-type activity outlined represents about 5%. If this figure is applied to all OSS scientific disciplines, instead of just to solar-terrestrial physics, this would indicate a $2.75M per year operation would be adequate to provide the indicated level of CDAW activity. Of course in the true spirit of the CDAW, data from NOAA, DOD, NSF activities, as well as those from the space research of foreign countries are vital for coordinated analysis and their research programs also would benefit, assuming such analysis methodology is judged cost effective.

XI. Future Scenarios for the CDAW Concept

In this final section we feel it is worthwhile to note the future activities that are relatively firm, those which may come into being, and some other possibilities that we have envisioned. In the NSSDC funding for FY80 a proposal for additional resources has been submitted to allow for the establishment of a DAWOC capable of building and servicing two to four data bases similar to CDAW 1.0, annually. The number of data bases would depend on the number of workshops held with each and the use of the data base. It is likely that this proposal will be approved. During the remainder of FY79, two new CDAWs are in the firm planning stage at this time. The first will involve the ISEE experimenters to study selected bow shock and magnetopause crossing and will be held in July 1979 at the level of about 15 data sets with about 30 attendees. The second is a full-scale CDAW involving about 42 data sets concerning the July 29, 1977 events that is presently planned for the week of September 24, 1979. This will involve data from about 6 ground-based networks and 11 satellites including GEOS 1. Besides the group size workshop, a subgroup workshop involving six to eight attendees will occur on May 24-25, 1979. This CDAW will be supported by NASA, ESA, NOAA, and NSF.

Within the present NSSDC resources, a new CDAW software system incorporating the improvements listed in Table 10 is being developed. This will be completed by January 1980 and require about 3.2 man years of effort. The present system (used for CDAW 1.0) must be operated until that time so there will not be a gradual increase in capability. This is not likely to have an impact on any CDAWs that will be planned for FY80 if the DAWOC proposal mentioned earlier is approved.

As discussed in sections IV and V, within the IMS there has been interest in establishing an IMS/DAWOC to support the data analysis phase of that program. The IMS Steering Committee is in the process of discussing this matter with ICSU, various space research funding agencies throughout the world, and the International Institute for Applied System Analysis (IIASA) located in Laxenburg, Austria, a suburb of Vienna. A very similar concept to that of CDAW has been developed by three IIASA scientists which they term International Team Research

(Dubrov et al, 1978). When such an activity is assisted by a computer, they term this Computer Assisted International Team Research and the initial implementations of their concept has been carried out at IIASA and documented (Rauch and Randolph, 1978). It is believed the decision on the establishment of an IMS/DAWOC will be made by the fall of 1979.

Dr. D. P. Cauffman, an observer of CDAW 1.0, queried what the possibilities were for providing a 24-hour-turn-around time for requests from CDAW data bases by some 25 groups in solar-terrestrial research supported by NASA. Requests would be limited to two frames per day per group. After some investigation, we responded that transmission of the plots via facsimile was the most feasible. The transmissions costs are approximately $.50 per frame. However, the 24-hour-turn-around increases the unit cost by a factor of about 2.5 from that quoted in Table 13, since an additional 3 hours of NSSDC computer operation per day would be required under full loading of 2600 frames/year.

Both from NASA Headquarters, following our above response, and from letters by several participants of CDAW 1.0, there was interest in being able to manipulate a CDAW data base by remote terminals and receiving outputs in real time at the participant's facility. With the present computer facility at NSSDC this is not feasible for the following reasons. The MODCOMP IV computer at NSSDC has 512 Kbytes of memory, the maximum this computer can have. The operating system requires 128 Kbytes and the CDAW on-line software requires an additional 128 Kbytes. Since the CDAW system is not a re-entrant program (and cannot be made one on the MODCOMP IV) it would not be possible to allow a number of remote users to use this system. In looking at the present utilization of the NSSDC computer facility in carrying out the Satellite Situation Center and the classical NSSDC tasks, there is the possibility of allowing a single remote user to use the CDAW system at selected hours during the normal operating day, which consists of operations from 8 am to 7 pm Eastern Local Time on Mondays through Saturdays. There is an additional limitation that exists for a remote user. The output from the plotting program used in the CDAW System is only compatible with driving a Tektronix graphical terminal. Such a pilot user is in the process of being selected.

In our view, the next level of activity would be to acquire a "super" minicomputer, which is presently on the market. Such a facility would be able to handle approximately 50 remote users simultaneously, and have a physical memory of about 5 Mbytes.

A crude estimate of the resources necessary to acquire such equipment would be $0.8M and software development of $0.5M to carry out CDAW activities at this elevated level. The annual operating costs at full capacity would be approximately $0.9M per year, which is about 1/3 of the total NASA/OSS CDAW system indicated in section X, assuming 5% of data analysis would be conducted in this manner. We are investigating possibilities for such a system; however, the ultimate decisions for the future depend on the judgment of the scientific community and NASA Headquarters as to the value of coordinated data analysis in the general framework of scientific progress.

An even larger scenario would be to have all of the processing and analysis for NASA/OSS data be done in a centralized facility with only the terminals and output devices at the investigator's institution. Among other things, this would permit CDAW activity in any size, at any time, and in which each participant could input his data from his storage into that of an advanced CDAW software system. This type of facility would have to be about 60 times the size of the previous one and has been given the name, Space Science Data Service (SSDS). It is clear that this approach is too large to take now in one step even if everyone agreed it was the most cost effective solution to data analysis. A much more reasonable approach is the previously discussed one which at a level of three times that activity we might term the OSS/DAWOC. Through such an approach a logical development of a total data analysis system could evolve in which the scientific community NASA supports could determine its characteristics and operational philosophy. Such an evolving facility could be utilized for coordinated data analysis in all space science disciplines. A facility with a capital investment of approximately $10M would allow for the total processing of about 25% of the OSS Missions and might be termed a pilot SSDS. By adopting a modular growth approach which modern computer technology and data communications allows, a complete SSDC could be completed in about 10 years.

It will be interesting to see how the process of data analysis systems proceeds as one gains more experience with the group approach to analysis of global data. Clearly we have outlined only a few of the possible approaches.

References

Dubrov, G.M., R.H. Randolph, and W.D. Rauch, Information Networks for International Team Research, Telecommunication Policy, 282, December 1978.

Knott, K., and B. Battrick, eds., The Scientific Satellite Programme during the International Magnetospheric Study, D. Reidel, Dordrecht-Holland, 1976.

Lanzerotti, L.J., R.D. Regan, M. Sugiura, and D.J. Williams, Magnetometer Networks during the International Magnetospheric Study, EOS Trans. AGU, 57, 442, 1976.

Manka, R.H., U.S. Program for the IMS, EOS Trans. AGU, 57, 63, 1976.

Rauch, W.D., and R.H. Randolph, Computer Assisted Panel Sessions (CAPS): Review of an Experiment in Accelerated International Teleconferencing, IIASA Research Memorandum RM-78-49, September 1978.

Roederer, J.G., IMS 1976-1979: New Concepts in International Scientific Cooperation, EOS Trans. AGU, 57, 6, 1976.

Sugiura, M., and J.I. Vette, The IMS Satellite Situation Center, EOS Trans. AGU, 58, 70, 1977.

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