UNITED
NATIONS

A

General Assembly

Distr.
GENERAL

A/AC.105/277
11 September 1980

ORIGINAL: ENGLISH

COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

PROGRESS OF SPACE RESEARCH 1979-1980

Report submitted by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU)

Note by the Secretariat

This report is submitted by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) in accordance with the request of the Scientific and Technical Sub-Committee for the submission of annual reports by COSPAR on scientific and technological developments in the exploration and practical uses of outer space, first made by the Sub-Committee at its twelfth session in 1975 (A/AC.105/150, para.73) and reconfirmed at its subsequent session.

80-21620

CONTENTS

Chapter I Earth Observations

1. Earth Observing Program

Operational and experimental meteorological satellites in polar and geostationary orbits have provided high-resolution images of ocean surface thermal features for the study of ocean processes such as up-welling, ocean fronts, large meanders in the western boundary currents, genesis of cold and warm core eddies, and large temperature anomalies. Such observations will continue. They were supplemented for a few months by specially designed quantitative observations from Seasat 1, and continually by observations from Nimbus. Earlier observations from Skylab and Geosat also contributed to the evolution of a new era for oceanographers where unique observations from satellites complement in situ observations from ships and various in-place instrumental systems. The latest results were reviewed at the COSPAR/SCOR/IUCRM Symposium on Oceanography from Space, Venice, Italy, 26-30 May. Oceanographers and remote sensing specialists met to assess the first quantitative results from Seasat and Nimbus, to discuss the interpretation of the satellite signals, and to speculate on the future of space-based oceanographic observations.

Sea-surface temperatures obtained from infrared (IR) soundings are contaminated by the presence of water vapor, aerosols, and undetected clouds. The total noise can reach several degrees K. Data comparison efforts yielded better results. It is anticipated that rms errors can be reduced to about 1.5°K. Temperature detectors may continue to have noise of the order of 2-2.5°K, since the entire data stream must be used in near-real time operations and only limited quality control procedures can be applied. Use of microwave control channels near 3.7 micrometers and split channel observations at 11 micrometers might result in 1°K accuracy. In view of the difficulty in comparing ship observations with satellite radiation temperatures, the best results in the future will arise from implementation of composite systems using advanced satellite sounders that combine atmospheric pressure and window channels with improved ship systems and the more widespread use of buoys.

Water color measurements with the Nimbus 7 Coastal Zone Color Scanner (CZCS) appear capable of chlorophyll determination to about a factor of 2 in waters where plankton dominates the suspended matter content. Thermal channels were shown to be valuable in association with the color images to study surface mixing processes near fronts. The CZCS red band proved useful in identifying the existence of aerosols, needed to make corrections and also in connection with the study of other radiation processes.

Interpretation of spectral signatures of organic and inorganic material is difficult as a result of the non-uniqueness of the signals, interference from other signals, atmospheric problems, and the lack of useful models or interpretation algorithms. The radiation properties of organic surface features of the Earth and inorganic material must be considered in designing observing systems to study surface features of the Earth such as biomass and vegetation types and state of health, geological features, water and other hydrological features, soil properties, and snow and ice. New interpretative methods need to be tried. For example, the use of heat capacity measurements (e.g., differences of day-night temperatures) is proving useful to identify certain types of geological features, whereas the design of the Heat Capacity Mapping Mission had been instigated to meet quite different requirements.

A continuing dialogue between specialists in the many disciplines involved in Earth studies including remote sensing and radiation experts is needed to stimulate continued research on the nature of spectral signatures and their interpretations. A symposium on research in spectral signatures is planned for the next meeting of COSPAR in 1982.

The Side Looking Radar (SAR) on Seasat revealed surface manifestations of internal waves, current boundaries, and tidal flow patterns in shallow water, as well as direct surface features such as waves and slicks. Data processing remains a problem owing to the large data rate, and difficulties of interpretation arise from lack of direct comparison data sets. However, the SAR holds promise on continued evolution for future systems.

The Seasat Radar Scatterometer provided wind data over a greater range of speeds than had been anticipated, and several extensive comparisons showed that winds are obtained with accuracies of about $\pm$ 2 m/s and $\pm$ 25° in azimuth. However, unique interpretation of the "surface" winds requires more investigation since the scatterometer and the ship anemometers measure quite different winds.

The Seasat Altimeter yielded very high precision data of about 7-8 cm accuracy. This was more accurate than the orbital altitude determined by standard techniques, hence accurate observations of the sea height were possible only in local regions where the orbital position was better known. Comparisons made over the JASIN area in the North Sea showed excellent resolution of geoidal and undersea topography. Surface wave height measurements gave an accuracy that appears to have exceeded that of direct observations (which are subjective in some cases and hard to interpret in others).

Passive microwave observations of ice cover indicate a capability for a future monitoring of ice type, possible thickness, and the study of ice dynamics. It appears that active and passive systems together will serve in the future to meet many requirements. Temperature inferences from microwave observations are useful in regions where clouds prevent the use of IR, but accuracies are not quite as high as for the best cases of IR retrievals. In addition, there is interference from some man-made radio signals and there are other technical problems to be solved. Water vapor determinations have proven useful for their own value and for estimating path attentuation and distance corrections for the scatterometer and altimeter, respectively.

Possibilities are opening up for the oceanographic interpretation of larger features of the ocean surface and of near surface features. Interpretation of satellite observations requires the use of comparison data sets and theoretical study.

In the early days of planning for Earth-observing satellites, it was generally agreed that one of the least likely applications was geology. However, through the active participation of many geologists and their organizations, some of the most remarkable results have been in geological studies including mineral exploration. The extensive linear features still being discovered give important clues for tectonic processes. Curvilinear structures have been recognized. Some of these are considered to be Precambrian remnants of impact events of such a magnitude that tectonic and mineralization processes were strongly influenced. These findings open up new possibilities for mineral exploration. Magnetic field and gravity anomaly maps produced from satellite data are being used in conjunction with land observations as further aids to the understanding of geologic processes and mineral exploration. An extensive space geology symposium is planned for the 1982 COSPAR meeting to deal with geology of the Earth during this period of the International Geological Cooperative Programs.

A major change has been announced in the United States Program for Earth Observations. It has been decided, under a Presidential directive, that the Earth Observing Program shall become operational, and that the National Environmental Satellite Service (NESS) of NOAA shall be the cognizant U.S. civilian agency responsible for the on-going operational Earth monitoring satellite program. It is expected that the change-over from the research program supported by NASA to the NOAA operational program will take place circa 1983 with Landsat D prime.

2. First GARP Global Experiment (FGGE) Results

The FGGE temperature profiles were made available on a real-time basis during the experiment, which terminated at the end of November 1979. They proved very useful to the operational analyses in the data-sparse regions of the Southern Hemisphere. In the Northern Hemisphere, particularly in the continental regions well covered by radiosonde networks, the impact of the satellite observations is less notable. This is due partly to radiosonde higher resolution in the vertical, and partly because of the mix of synoptic land-based in situ data and asynoptic remote data which are not handled as yet optimally by the numerical models. Development is underway to improve the merging of the two kinds of observations and their use in models.

FGGE experience has been very helpful in improving in global temperature derivations needed to fully utilize this powerful satellite technique. For example, independent measurements of the height and location of the tropopause and, if possible, of the inversion in the boundary layer will improve the soundings dramatically. Limb soundings offer the possibility of the tropopause measurements. Improvements are needed in the statistical regression formulations as well as the data bases from which they are derived. It is important to have independent measurements of surface pressure and temperature to aid in forcing closure of the temperature derivations. Satellite observations are becoming accurate enough to satisfy this requirement over the oceans. Buoys in ocean regions where there are few ships of opportunity also provide needed surface observations. In the future, it will be useful to increase the spectral resolution of the sounders so that the vertical resolution of the derived profiles can be increased. Increased spatial resolution will lessen the contamination of the desired signals from clouds. Improved moisture observations will permit better corrections for water vapor contamination. Aerosol observations will make it possible to detect contamination from this source; if the observations are quantitative, corrections will also be possible.

Cloud tracking using images from geostationary satellites provided critical information on the wind fields at low latitudes, and over ocean areas even in mid-latitudes. The most important problem to be solved in the future is an independent and reliable determination of the heights of the tracked elements. Stereo analysis of the overlapping portions of the images from geostationary satellites proved that accurate heights can be obtained in this way. However, there are several important problems here. One is that the three major organizations operating geostationary satellites have not been able to coordinate operations sufficiently to provide synchronous scans. This matter needs international discussion. Current spacecraft design and operation modes may not permit complete synchronization, but the situation can be improved. There is also an important gap over the Indian Ocean which may not be filled for some time. If stereo processing is the only or best way to get cloud heights, more than five satellites will be needed to provide the needed coverage over sparse areas.

For the future, it would be useful to incorporate water vapor channels on more satellites. The water vapor channel on Meteosat provided wind fields in its area of coverage for regions where there are no suitable cloud tracers. The water vapor channels can also provide observations in a wide range of altitudes.

A space-borne laser system is being studied to provide a global wind system. Doppler analysis of the return signals from laser pulses scattered from atmospheric constituents will provide information on the velocity fields. Technological implementation problems are: large power is required; the laser elements currently available have limited number of pulses available; and the system will have to be flown at relatively low altitude to minimize power requirements. Nevertheless, laboratory and simulation tests are underway, and airborne tests of small systems have been carried out to demonstrate the feasibility of the technique. Plans are underway for an in-orbit test using the Space Shuttle in the mid-1980's.

Several hundred inexpensive buoys were deployed for FGGE in the Southern Hemisphere at mid- and high latitudes. The buoys were the results of tests in several countries. Canadian scientists took the lead in designing the electronics systems. The space-borne tracking and data relay system was developed in France, which provided units to the U.S.A. for inclusion in the TIROS-N operational series of meteorological satellites. Deployment was carried out in cooperation with the various countries that maintain Antarctic research bases; additional deployment was carried out with oceanographic and other ships, and with aircraft. The average lifetimes of most of the buoys (discounting those damaged on deployment, or infantile failure) approached one year. Sensor failure was not large. Data recovery was excellent. Aerial coverage was excellent. The observations were extremely valuable operationally, and will contribute significantly to the value of the FGGE data set. For example, the storm centers in the southern oceans are far more intense, numerous, and longer-lived than previously supposed. This has significant impact on our understanding of atmospheric circulation energetics in the Southern Hemisphere.

The total FGGE data set is a valuable reference source for future studies. In particular, the cloud data can be used to develop statistics on horizontal and vertical cloud distributions. These can be used in connection with analysis of Earth radiation budget measurements. A small group of cloud experts is designing an internationally coordinated program to utilize the FGGE data, along with data collected in 1980, as the basis for an international cloud statistics atlas for climate research. FGGE was the first time that an essentially global and homogenous data set was obtained on cloud coverage.

Analysis of FGGE data is in the first stages. The satellite data are already known to be critical to extended forecasts. For example, at the European Center for Medium Range Weather Forecasting, Reading, U.K., several case studies have shown that deletion of satellite data degrades forecasts in the 5-to 8-day range and shortens their useful life by 2-3 days. Deletion of any of the special observations (i.e., aircraft data relayed by satellite, buoy, or constant-level balloon data; Southern Hemisphere data for cross-equatorial flow which occurs frequently; stratospheric data; etc.) cannot be omitted without degradation of the forecasts.

3. Climate and Solar Variability

In 1976, a rocket experiment was conducted in which several "absolute" cavity radiometers were flown on the same rocket. The agreement among the several instruments was such that a good spot value of the solar irradiance was obtained. The experiment was repeated in 1978, and the results were analyzed and reported in 1979. In brief, there was a change of several tenths of a percent in the observed irradiance.

In this similar time period, observations have been obtained from the cavity radiometer on Nimbus 7. Short-term variations of the flux are such that two random measurements taken a year or two apart cannot be used to fix any trend of increase or decrease. There are also some notable sharp drops in irradiance, as seen in August 1979. Such sharp drops are not accounted for satisfactorily by current solar theory.

These results indicate the necessity of instituting a carefully planned program to monitor the solar output with good time resolution. The information is critical to understanding the solar behavior, and for input to climate modeling and studies of variability. The Solar Maximum Mission discussed in Chapter V carries a three-cavity radiometer for monitoring the total solar output.

Chapter II Planetary Magnetospheres

Major advances in space plasma physics in the 1979-80 period have been made possible by the arrival at the planet Saturn of Pioneer 11; by the more detailed study of Jupiter by two Voyager spacecraft; by Pioneer Venus, Venera 11 and 12 measurements at Venus; and in the vicinity of our own planet by the highly sophisticated measurements obtained with the ISEE 1, 2, and 3, ESA-GEOS 1 and 2 spacecraft.

1. Saturn

Pioneer 11 reached Saturn in early September 1979, 6 years and 5 months after launch and 4 years and 10 months after its flyby of Jupiter. On its way, measurements out of the ecliptic plane helped establish the idea that magnetic sector boundaries are not really boundaries perpendicular to the ecliptic plane, but are due to a current sheet lying near the ecliptic plane. Although this idea has been around for several years, it has only recently found general acceptance.

There has not yet been much time to study the data returned from Saturn and only a limited amount has been published. It is already apparent that the measurements provided important new findings. We know that Saturn has its own magnetic field which, at the planet surface (radius being 60,000 km), is comparable with the intensity of the magnetic field at the Earth's surface (0.5 Gauss). An important difference as compared with Earth is that the magnetic dipole axis and rotation axis are closely aligned. Since, in addition, at Saturn's position of 10 AU the solar wind pressure is 100 times smaller than at Earth, Saturn's magnetosphere is large and well ordered, with the simple dipole approximation remaining valid throughout a very large cavity. This cavity, although larger than the Earth's magnetosphere, is still smaller than that of Jupiter.

Saturn, Jupiter, and Earth magnetospheres should make possible many interesting intercomparisons in the years to come. As at Earth and Jupiter, magnetospheric boundaries have been observed at Saturn and multiple crossings of the magnetopause have been observed. Saturn has trapped radiation belts and, as at Jupiter, these belts are strongly affected by the presence of moons and planetary rings. A diffuse G ring has been seen at 10-15 planetary radii, much outside the previously known rings, and the position of this ring is clearly seen also as a decrease in trapped charged particle intensity. Closer to Saturn at 2.5 radii a short, sharp, and very large decrease in particles, observed together with a distortion of the magnetic field, has been interpreted as evidence for the existence of a "new" moon with important magnetic properties. The charged particles around Saturn do not reach the high energies seen around Jupiter and consequently Saturn is not an interesting source of radio emission.

2. Jupiter

The Voyager experiments were more sophisticated than those carried by the earlier Pioneers and as a result interesting new discoveries have been made at Jupiter. Bow shock and magnetopause features were again encountered several times on each pass and for the first time wave measurements were made at these discontinuities. Plasma waves have been detected upstream from the shock and ion acoustic waves at the shock showing behavior similar to that seen at the Earth's bow shock. At the magnetopause, a new type of broadband electric field turbulence was detected extending up to 2 kHz. This is very similar to the electric field turbulence recently discovered at the Earth's magnetopause by the ISEE 1 and 2 spacecraft and it may play an important role in the diffusion and transport of particles across the magnetopause boundary layer.

Evidence for the presence of a Jovian boundary layer has been found both in the plasma and magnetic field data. Inside the Jovian magnetosphere, the low energy plasma is observed to be corotating at a speed of approximately 200 km/s, but rigid corotation holds only as far as about 10 Jovian radii. The magnetospheric plasma was found to be mainly heavy ions, and H^+, O^{2+}, S^{3+}, O^+, S^{2+}, Na^+, and S^+ have been identified together with ionized molecules (probably sulphur compounds) with mass to charge ratios of 64, 104, and 160. Sulphuric compounds are probably injected into the Jovian magnetosphere by the volcanoes discovered on the satellite Io.

A magnetohydrodynamic interaction between the corotating plasma and the satellite Ganymede has been observed in both the particle and magnetic field data. Since the plasma corotation flow is submagnetosonic, there is no shock around Ganymede but the interaction resembles that between the solar wind and the Earth's moon with the formation of a wake behind Ganymede. Problems arise, however, in explaining the nature of the observed perturbations. The magnetic field changes intensity but not direction and the position of this "weak" interaction is surprisingly distant from Ganymede (up to 60 Ganymede radii).

Both magnetic and plasma data agree in describing Jupiter's equatorial current sheet as lying in the magnetic equator at distances up to 40 Jovian radii and being rather tilted toward the rotational equator for larger distances. The existence of a Jovian magnetotail has been clearly established. Tail length is probably between 1 and 2 AU and tail diameter 300 to 400 Jovian radii (1 Jovian radii = 71,000 km). From the size of the magnetotail and the field strength there, it has been estimated that the Jupiter auroral oval bounds a region about 10° wide and somewhat displaced from the dipole axis. Evidence for auroral activity has been found. Like the Earth's auroral zone, Jupiter also emits a strong kilometric radiation which, as seen by the spacecraft, displays a 10-hour periodicity corresponding to strong latitude variations as the planet rotates.

3. Venus

The Pioneer Venus mission has provided very interesting results on the solar wind/magnetosphere/ionosphere interactions. Bow shock and ionopause signatures have been observed by several experiments on more than 100 passes. The variation of the bow shock and ionopause positions with solar wind parameters indicate a much closer link between the solar wind and the ionosphere than is the case with the Earth's. In fact, one of the main conclusions about the Venus ionosphere is that its high ion and electron temperature cannot be explained by photo-ionization and excitation. A heat source caused by sheath-ionopause interactions may be responsible for this heat input. Wave activity observed in this region indicates that this may be the case.

While Venus does not appear to have an intrinsic magnetic field, it does have an interesting magnetosphere which at times is much the inverse of the terrestrial magnetosphere. The Pioneer Venus mission shows that the Venus ionosphere is usually magnetic field free. The magnetic field in the magnetosheath piles up outside the ionosphere, putting a magnetic cap on the ionosphere and shielding it from the solar wind flow. However, at times the magnetosheath field penetrates deep into the ionosphere, giving Venus an "induced" magnetosphere. A most intriguing phenomenon of the Venus ionosphere is the appearance of flux ropes or twisted bundles of magnetic flux treading the otherwise field-free ionosphere in much the manner of magnetic ropes in the solar atmosphere.

4. Earth

Sophisticated experiments and spacecraft recently have made possible detailed measurements of electric fields and plasma composition and motion in ways not possible earlier. The electrostatic cleanliness of the ESA-GEOS 1 and 2 spacecraft, together with the high data rates provided, has made available excellent electric field measurements out to the geostationary position. For example, it has been possible to measure DC electric fields with accuracies of a fraction of a millivolt per meter depending on the local plasma environment.

ISEE 1 and 2, also electrostatically clean and providing high time resolution data, operated as a pair to sort out space and time variations. For the first time, the dual measurements have made it possible to determine with certainty parameters such as magnetopause thickness and velocity.

Perhaps the most significant results appearing in 1979-80 were those giving direct evidence of magnetic reconnection. Such a process was theoretically predicted many years ago, but the only experimental evidence was based on the global magnetospheric response; i.e., it was shown that magnetic flux was taken from the front (dayside) of the magnetosphere and carried back to form a magnetic tail behind the Earth. Details have been published recently of a number of observations which seem to show magnetic merging in progress. In one case, the magnetic field geometry viewed by ISEE 1 and 2 evolved in such a way that, indeed, the interplanetary field appeared to join the terrestrial magnetic field. In another case, the magnetic field configuration defined the likely position of reconnection in progress, and plasma jetting away from this location was indeed measured as predicted by theory. Other observations have shown that the electric field and current flow are oriented at the magnetopause to give power dissipation consistent with reconnection taking place.

The first reliable measurements of quasi-stationary electric fields have been reported from the GEOS and ISEE 1 satellites. The field is much more variable than that expected by many people and it has been found that geomagnetic pulsations (recorded at the ground) are associated with large amplitude (up to 7 millivolts per meter) electric field variations measured at the spacecraft. It has been seen, too, that geomagnetic storms and substorms are associated with increased DC components of the electric field (up to 20 millivolts per meter).

A year ago, excellent ion composition measurements from GEOS and ISEE were reported. During 1979 the first results on the composition of the plasma mantle appeared in the data from Prognoz 7. These show, among other things, that the ionospheric ions O^+ and He^+ constitute a significant part of the mantle plasma, that the high latitude magnetopause is a fairly solid boundary for ionospheric ions, and that the electrons and ions in the mantle are more energetic than those in the magnetosheath.

The plasma wave measurements on ISEE and GEOS, together with the advent of time varying three dimensional plasma distribution functions, permitted for the first time comparisons of theoretical calculations of plasma instabilities with observations.

Upstream particle beams and ULF waves were studied intensely by many groups with the ISEE spacecraft. The particle beams were found to be of two types, one narrow in energy and one broad in energy. The beams were found to decelerate and deflect the solar wind and to generate ULF waves.

Some measurements of the Earth's ring current were reported during 1979. However, the papers which seemed to gain most attention were those which demonstrated how little is still known about the ring current, although its existence was postulated long before the space era. Detailed plans were laid, however, for space missions which would include investigation of why the ring current is set up, what type of particle and source contributes, and why and how it disappears again.

It might reasonably be concluded that the year was of significant scientific achievements. Saturn, Jupiter, and Venus were further explored. Some physical processes long suspected to be operating in the Earth's magnetosphere were "caught in the act." Plans were made for coordinated future programs.

Chapter III Planetary Bodies

The exploration of the planetary system by spacecraft, and the analysis of results and samples from previous missions, continued to progress.

1. Jupiter and Its Satellites

The exploration of Jupiter and its satelltes by the spacecraft Voyager 1 and 2 has yielded a rich harvest of scientific results.

The high-resolution images of the planet, taken at regular intervals during the encounter phase, have shown turbulent and systematic motions down to the finest scale observed. The well known Red Spot in the southern hemisphere is in rapid rotation. It is a region of rising and diverging material. Nonetheless, its observed temperature is lower than that of its surroundings. There is a range of similar phenomena, from a group of white ovals at more southerly latitudes which have been observed from Earth for decades, to transient eddies which formed and disappeared during the observation period. The complex series of bands and zones in differential rotation around the planet was observed in detail. The overall heat balance of Jupiter can now be calculated more precisely. Various models have been put forth to account for this, but there is no agreement as yet.

Two phenomena observed for the first time, on the dark side of Jupiter, are auroral displays in polar regions, and lightning. The intensity and distribution of the aurora seem consistent with models which relate them to the planet's magnetic phenomena, as on Earth. The lightning displays are of a remarkable intensity.

An unexpected discovery by the Voyager 1 spacecraft, studied in better detail by Voyager 2, is a planetary ring about 6000 km wide. Its sharp outer edge is defined by a newly discovered satellite, 1979JI. The inner edge is more diffuse, and apparently some particles can be found within it down to the top of Jupiter's atmosphere. A second small satellite, 1979J2, also has been discovered inside the zone of the Galilean satellites.

Images of Amalthea, which is an irregularly shaped inner satellite about 250 km in diameter, and the Galilean satellites have been published in many places. Voyager 1 observed Io, Callisto, and Ganymede at close range. Voyager 2 completed the observations of Europa, and provided further data on the other three. The most shaking discovery was that of active volcanism on the innermost Galilean satellite, Io. At least seven active volcanoes have been seen. The emissions from Io control the composition of the Jovian magnetosphere in the inner zone. Large current flows have been observed.

Europa appears to have an ice crust with linear features and exceptionally low relief. Callisto and Ganymede present complex surfaces dominated by impact features. These surfaces must be very old. More accurate densities have been obtained, better defining the composition of these bodies.

2. Saturn

The Pioneer 11 spacecraft launched in 1973 encountered Saturn during this period. Two small satellites were discovered. The most interesting observations were those of the rings, from angles inaccessible to observation from Earth. From behind, the dense rings are dark, while diffuse rings appear bright from forward scattered light. It is possible to define better the various zones and gaps, and to obtain new information on the mass and character of the ring particles. Subdued surface markings were observed on the planet. Magnetic observations showed phenomena somewhat similar to those seen on Jupiter, but on a smaller scale.

3. Venus

Analysis of data from the Venera and Pioneer-Venus missions continues. Data on the composition of the atmosphere continue to be refined. The low content of H_2O observed in the Venera near-infrared experiment seems now generally accepted. The ratio $^{36}Ar/^{40}Ar$, on the order of unity is confirmed. At the same time, radar observations from Earth are giving much new information on the topography of the planetary surface. Both internally-generated and impact features are apparently observed.

4. Mars

Observations of Mars by the Viking spacecraft are substantially complete. Analysis of images and other data are continuing.

Analysis of older data, and especially of lunar samples obtained earlier by U.S. and Soviet missions by scientists in many countries continued to yield important results.

Chapter IV Planetary Atmospheres

1. 1979 Solar Eclipse

Substantial information is beginning to become available from rocket flights made during the February 27, 1979 solar eclipse in southern Canada. Analysis of the data was complicated by the fact that a strong particle event took place simultaneously with the solar eclipse, and the ionization by solar X rays and extreme ultraviolet was much less than that produced by the particle flux at altitudes below 95 km. Even above 95 km, particle effects were important. As a result, electron-density distributions measured below 100 km show essentially no eclipse effects. For example, electron densities at about 75 km were a factor of 30 greater than expected. Above 110 km, the expected eclipse effects were observed in the electron-density distribution.

Ion composition measurements also were affectd by the dominance of particle precipitation below 100 km. Hydrated ions were dominant below 78 km. This suggested a 3 ppm mixing ratio of water vapor. Nitric oxide was deduced as 5×10^6 cm^{-3} at 85 km and 10^9 at 105 km. Negative ions seen included hydrates of CO_3^-, HCO_3^-, and NO_3^-, together with $CO_3^-$and Cl^-. Below 90 km, a significant number of heavy negative ions (greater than 60 amu) were seen.

Aerosol conductivity measurements using flash lamps showed enhanced conductivity with UV illumination above 80 km in totality. This indicated a possible significant role for aerosols in the ion chemistry.

2. International Reference Ionosphere (IRI)

Detailed comparisons are now being made of the COSPAR/URSI International Reference Ionosphere with rocket, satellite, and ground-based data. Since the IRI deals only with the mid-latitude ionosphere, comparisons have been limited so far to that region. Results of 25 rocket flights at Volgograd in the 100-to 200-km height region have been compared as have been partial reflection and VLF-propagation measurements in the U.S.S.R. for the altitude region below 100 km. Several workers using medium- and high-frequency absorption data have identified a discrepancy in the diurnal variation of absorption from that predicted by the IRI. Results from Intercosmos 19 have been compared for electron concentrations and electron temperatures in the F region. An extension of the IRI to high and low latitudes is being considered.

3. Energy Sources in the Upper Atmosphere

Results from several satellite and rocket missions have been used to explore the significance of various sources of energy in the upper atmosphere. Atmosphere Explorer-C and ESRO 4 data have been used to compare electron and proton particle energy disposition and Joule heating in the cusp region and the resulting atmospheric perturbations. UV inputs were investigated using the Atmosphere Explorer-E satellite, and composition changes resulting from changing solar activity by using the AEROS satellite. Detailed measurements of auroral emissions resulting from proton and electron precipitation were studied using the Cosmos 900 satellite.

4. Middle Atmosphere Program

Planning continues for the Middle Atmosphere Program (MAP) scheduled to take place during the period 1982-1985, and COSPAR sponsored an International Symposium on Middle Atmosphere Dynamics and Transport in July 1980 at Urbana. Spacecraft for middle atmosphere studies which will fly during the MAP period include the Solar Mesosphere Explorer (SME) from the United States and the EXOS-C satellite from Japan. It now appears that the Upper Atmosphere Research Satellite (UARS), proposed but not yet started by the United States, will not fly until 1986, so an extension of the MAP period is being considered to allow cooperative observations involving that satellite and its very comprehensive middle-atmosphere monitoring instruments. The first campaigns for MAP have now been approved, including the MAP/WINE (Winter in Northern Europe) proposal and the Globus proposal for coordinated sampling of the stratosphere using balloons. Other proposals will be developed and approved during the next year.

Chapter V Space Astrophysics

1. Optical, Ultraviolet, and Infrared Astronomy

The International Ultraviolet Explorer (IUE), a joint U.S./ESA/U.K. program, was placed into orbit in January 1978, and continues to work well. It is operated two-thirds time from the NASA Control Center at the Goddard Space Flight Center, and one-third time from the ESA tracking station at Villafranca, Spain. The observational objectives are to measure spectra of stars and galaxies to about 10^m_o with a 45-cm Cassegrain telescope with 0.05 Å resolution over the 2200-3000 Å range. These data provide information on the physical characteristics of stellar atmospheres, the interstellar medium, mass outflows from stars, and the distribution and chemical composition of material in the Galaxy. Objectives of the extragalactic work are to determine properties of active galaxies such as Seyferts and of QSOs. Of particular importance is the extensive Guest Investigator program which allows scientists from all nations to participate in the IUE.

The Space Telescope and its instrumentation are now under construction in the U.S. for launch in 1984. This program also has about a 15% contribution from ESA, which includes providing one of the five focal-plane instruments.

Details of the 2.2-m diffraction-limited telescope and its instrument complement have been described in the COSPAR report to the UN for 1979. The telescope will be operated by a science institute now being constituted in the U.S. with a related European operation. Following the initial operation, where time is committed to the investigators who have constructed the instruments, extensive observational time will be available to the international community.

The U.S. spacecraft Copernicus, a component of the Orbiting Astronomical Observatory Program, has provided thousands of observations on the spectra of bright stars and galaxies since its launch in 1971, and is about to be retired from active operations.

The joint U.S./Netherlands Infrared Astronomical Spacecraft (IRAS) is about to go into prelaunch qualification for launch in early 1982. There have been extensive and costly technical problems associated with the helium-cooled telescope and detector system being constructed in the U.S. This survey instrument operates in the 10- to 1000-μm range, with sensitivities 10^6 better than previously obtained, and will provide a catalog of perhaps 10^5 sources. These data will also be available to the world-wide scientific community, and will provide many opportunities for further investigations.

Also being planned in the U.S. for infrared observations are a cooled telescope (SIRTF) for the Spacelab/Space Shuttle. This is intended for detailed observations of specific sources, rather than for a survey. A Cosmic Background Explorer (COBE) to study the spectrum and isotropy of the 3°K relic radiation believed left over from the "big bang" which initiated the Universe, and an Extreme-Ultraviolet Explorer (EUVE) are both scheduled for construction in the U.S.

Many additional optical, IR, and UV instruments selected for the joint U.S./ESA Spacelab program have been delayed because of the technical problems in the U.S. Space Shuttle project.

The European Space Agency has made a major decision to proceed with a space astronomy satellite, Hipparcos. This will provide important information for astronomers in the form of accurate measurement of the trigonometic parallaxes, proper motions, and positions of 100,000 stars brighter than 10^m to an expected accuracy of 0.002 arc-second. Many members of the European Astronomical Community are participating in this project.

ESA also has under study several additional missions for space astronomy.

2. High Energy Astrophysics

The U.S. High Energy Astronomical Observatory (HEAO) program was completed with the launch of the last of the three spacecraft in the series on September 20, 1979. This spacecraft (HEAO-3) contains two cosmic-ray instruments and one gamma-ray spectrometer. The cosmic-ray instruments are designed to determine spectra, charge, and isotopic composition over the range $3 < Z < 110$. One of the instruments is from the U.S., while the second was provided by a French/Danish consortium. The U.S. gamma-ray spectrometer is designed to search for nuclear gamma-ray lines expected from a variety of astrophysical processes, in the $50 \text{ keV} < E < 10 \text{ MeV}$ range, to sensitivities of about 10^{-4} ph/cm -sec. Preliminary results indicate that all instruments are operating as expected.

Data analysis from the HEAO-1, which operated between August 1977 and February 1979, is nearly complete. The HEAO-2, which contains a 0.6-m grazing-incidence X-ray telescope with a number of focal plane instruments operating over the 0.15-to 2.5-keV range, has continued to operate well since its launch in November 1978. Scientifically, this has been an outstanding success, and has provided much new data on stellar objects, supernovae remnants, distant galaxies and clusters, and many other sources. The HEAO-2 has an extensive guest investigator program which includes international participation.

The interplanetary gamma-ray burst network, which consists of U.S., French, and U.S.S.R. instruments on a large number of U.S. and U.S.S.R. spacecraft, continues to operate and provide detections of the remarkably brief (1-30 sec), intense gamma-ray bursts which occur in the 10-keV to 3-MeV range. The large number of events now catalogued has permitted notable progress in categorizing the phenomena, and guiding theoretical interpretation. Of particular interest has been the unique event of March 5, 1979, which was located (by interplanetary triangulation) to a precision of 10 arc-seconds. This position coincides with a supernova remnant in the Large Magellanic Cloud.

The gamma-ray observatory COS-B, built and operated by a European consortium, is now in its fifth year of operation. The Indian spacecraft, Bashara was launched in June 1979. Although designed primarily for remote sensing of the earth, it contains a soft X-ray proportional counter useful for astronomical observations.

Many instruments and spacecraft designed to provide new observational data in the field of high-energy astrophysics are now under construction, in a definition phase, or being studied. The European EXOSAT is expected to be launched in 1981. The U.S.S.R./French Gamma-1 is under construction for an early launch opportunity on a U.S.S.R. mission. Important instruments for solar gamma-ray and cosmic gamma-ray burst studies are on the joint U.S./ESA solar-polar missions, now delayed until 1985. The U.S. Gamma-Ray Observatory (GRO), the next major U.S. mission in high-energy astrophysics, is about to complete its definition phase. Both ESA and the U.S. are considering missions to measure fast-and slow-time variations of bright X-ray sources, both galactic and extragalactic, as well as to survey for transient sources. Several U.S. and European instruments have been selected for the Spacelab program. In the U.S., a follow-on to the HEAO-2, the 1.2-m Advanced X-Ray Telescope Facility (AXTAF) is under intense study.

3. Solar Physics

The Solar Maximum Mission was launched by NASA in February 1980. This satellite contains a set of imaging and spectrographic experiments covering wavelengths from the visible range out to gamma radiation. All experiments are working well, and the program objective of operating the spacecraft as an observatory with well-coordinated programs is proceeding smoothly. Ground-based research in the form of an international Solar Maximum Year (SMY) plays an essential role in extending the observational capabilities as well as in broadening the analytical and interpretative base of the program. This program will deal with the problems of solar activity, especially the explosive energy release in solar flares. The Japanese solar observatory, ASTRO-A, will be launched in February 1981 and will further contribute to understanding solar activity.

The joint ESA/NASA International Solar Polar Mission is a two-spacecraft mission which explores for the first time the out-of-the-ecliptic part of the solar corona and solar wind. It will pass over the solar poles directly at perihelion. The instruments will study the local solar wind, solar and galactic cosmic rays, and X rays, and will return the first images of the solar corona from this new perspective.

NASA also plans a program of solar observations from Spacelab, of which the main instrument will be a 1.25-m diffraction-limited Solar Optical Telescope (SOT). SOT will obtain visible and ultraviolet images, with no image degradation due to the Earth's atmosphere, down to spatial scales corresponding to a scale height in the solar atmosphere.

Chapter VI Life Sciences and Space Research

1. Organic Molecules in Space

Over 50 molecules are now known in the interstellar medium. These include organic, and inorganic species, and contain H, N, C, O, Si, and S, ranging in complexity from 2 to 11 atoms. The radiation from these molecules has provided a unique means of determining physical conditions in dense interstellar clouds (20° to 70°K; densities 10^3 to 10^7 cm^3 by number) and of elucidating how these clouds evolve stars. Detection of certain key interstellar molecular ions, previously unknown in the laboratory, has confirmed the role of ion-molecule reactions for at least the small species. These chemical models have also successfully explained the high deuterium abundances observed in some interstellar molecules. Conversely, the long-chain polycyanoacetylenes recently observed in interstellar space may form only on grain surfaces. Well over 100 unidentified microwave lines are currently seen from interstellar clouds, and systematic work on identifying these lines, involving laboratory collaboration, is under way. The discovery of several organic molecules in the interstellar medium, particularly hydrogen cyanide, ammonia, formaldehyde and cyanoacetylene, call to mind their key role in prebiotic synthesis. It is now established that cyanides and aldehydes play an important role in the synthesis of amino acids, while hydrogen cyanide is also an efficient precursor of purines. Formaldehyde gives rise to sugars, cyanoacetylene and urea to pyrimidines.

"New" comets have a size distribution consistent with the accretion of planetesimals, and the H, C, N, O elemental ratios to Si suggest that they are closer to solar abundances than the C 1 chondrites. The traditional picture of a condensation equilibrium in the solar nebula seems to work for comets as well as meteorites, but it implies that the range of physical and chemical conditions of the early nebula be narrowed to the extreme. It has been estimated that, during its early history, the Earth captured a mass of cometary material of the order of 10^{23} grams. Carbon is presumed to be at least three times more abundant in comets than in carbonaceous chondrites (3.5% C in C 1 chondrites), hence it can be deduced that about 10^{22} grams of carbon (as compounds) was added by comets to the surface of the prebiotic Earth. Since, in addition to carbon, comets contain substantial amounts of water and other hydrogen bearing compounds, the capture of comets by the Earth would have contributed to aqueous and reducing environmental conditions necessary for organic synthetic processes. Thus, terrestrial capture of cometary material and related meteoritic matter may well be fundamental for the generation and early evolution of terrestrial life. Certain organic compounds in carbonaceous chondrites are indigenous and the result of an abiotic, chemical synthesis. Several investigations have established the presence of amino acids and precursors, mono- and dicarboxylic acids, N-heterocycles, and hydrocarbons as well as other compounds. For example, studies of the Murchison and Murray meteorites have revealed the presence of at least 40 amino acids with nearly equal abundances of D and L isomers. The population consists of both protein and nonprotein amino acids including a wide variety of linear, cyclic, and poly-functional types. Such findings provide support for the theory of chemical evolution and offer natural evidence for the protobiological subset of molecules from which life on Earth may have arisen.

Studies of the atmospheres of the outer planets and Titan by means of infrared and ultraviolet spectroscopy have also revealed the presence of a variety of simple carbon compounds. This work has just received a powerful impetus from the assistance of the IUE satellite and the NASA Voyager spacecraft.

Decades ago Bernal postulated that clays may have served to concentrate organic molecules from the "primordial soup." Clays may be visualized as inorganic analogs of enzymes that could have catalyzed condensation reactions leading to the abiogenic origin of life. The properties that clays share with enzymes are their large surface area and the regular arrangement of charges which imply a template or specific absorption characteristics. Many enzymes are associated with ions, as are clays. In general, bentonites are found to bind nulceotides better than kaolinites. Zn^{++} substituted bentonite and kaolinite bind better than those with Na^{+} or Mg^{++}. The effect of concentration on binding of nucleotides by clays may be a step towards elucidating the mechanism of clay-catalyzed nucleotide oligomerization. Transition-metal homoionic bentonites have been shown to absorb both nucleotides and amino acids from aqueous solution readily. The results of several studies have demonstrated the potential of clays as prebiotic catalysts. Using repeated heating-wetting-drying cycles to simulate a prebiotic tidal environment, oligomerization of non-activated amino acids in aqueous solution has been achieved without the use of exotic condensing agents.

2. Biological Evolution

A group of diverse bacteria have been identified whose members are autotrophic, heterotophic, aerobic, anaerobic, acidophilic, thermophilic, extremely halophilic, and/or mesophilic, and chemically and biochemically different from other microorganisms. Because the first of these organisms identified was from extreme environments reminiscent of the Archean ecology, the term "archaebacteria" has been coined to characterize them. These archaebacteria contain at least three characteristic molecular markers (16SrRNA homologues, absence of cell wall muramic acid, and isoprenyl glyceryl ether lipids) that provide a phyletic basis for grouping them under the same classification but separate from that of other microorganisms. The distribution of isoprenold hydrocarbons in the archaebacteria resembles that of isoprenoids isolated from ancient sediments and petroleum. Therefore, these findings may have major implications for biological and biogeochemical evolution.

The first autotrophs, possibly chemosynthetic methanogenic bacteria, probably evolved in response to a decreasing supply of abiotically synthesized fermentable organic compounds. They could have exploited the chemical energy of the mixture of carbon dioxide and hydrogen supplied to the atmosphere by volcanoes. Only when this source of energy became inadequate to meet the needs of an expanding biota did a stimulus exist for the origin of photoautotrophy. The present high O_2 concentration in the terrestrial atmosphere is believed to be due to photosynthesis, presumed to have arisen 2 to 3 billion years ago. However, the atmosphere 3 to 4 billion years ago most likely contained traces of O_2 resulting from UV dissociation of water. Early biological evolution must have occurred in this "microaerobic" environment, and some oxygen-utilizing biochemical systems probably became operational under these conditions. The distinction between prokaryotic vs. eukaryotic, and photorophic vs. chemo-and organo-trophic fossil microorganisms rests entirely on morphological comparisons with recent counterparts. The residual nature of the microbial fossil record prompts the suggestion that it must be based on (a) the most abundant organisms, (b) those inhabiting environments with high preservation potential, e.g., stromatolites, and (c) those most resistant to degradation. These criteria support Cyanophytes as likely candidates for most Precambrian microbial fossils.

3. Non-Human Space Flight Activities

Soyuz-Salyut cooperative experiments included study of weightlessness as a factor in fruiting of the mushroom Polyporus, structure and genetics of the alga Chlorella, and membrane organization of the bacterium Proteus vulgaris. Cosmos 936 experiments included development and genetics of tobacco, and effects of stress on the biochemistry of the rat digestive tract. Radiation studies included effects of the gamma radiation-weightlessness interaction on growth, development, and cytogenetics of plants (Progress-Salyut 6-Soyuz) and HZE effects in Bacillus subtilis (Apollo-Soyuz). High altitude (balloon, alpine) experimental results with tobacco, fruit flies, and T4B bacteriophage were consistent with orbital radiation studies.

The third in a series of Cosmos biological satellites was launched September 25, 1979, from the Soviet Union. The satellite, which contained mammals, plants, insects, and radiation dosimeter, remained in orbit for 18.5 days. Scientists from the U.S., U.S.S.R., France, Czechoslovakia, and other countries participated in experiments directed at understanding how the stresses of space flight, principally hypogravity, affect the growth, development, physiology, and biochemistry of a variety of species. Seeds and seedlings were flown to determine if normal growth and development occurred in the virtual absence of terrestrial gravity. Fruit flies were exposed to a gravity gradient using a unique centrifuge developed by Soviet specialists to determine if the insects displayed a gravity preference during orbital flight. Also flown was a mammalian tissue culture experiment designed to detect histological and biochemical changes induced by space flight. Joint U.S./U.S.S.R. and France/U.S.S.R. radiation physics experiments were designed to measure the radiation environment inside and outside the orbiting spacecraft and also to detect potential cosmic radiation damage in a variety of biological tissues. Rats from the Czechoslovak Academy of Sciences were included for a variety of experiments to determine the effects of space flight on behavior, biorhythms, physiology, and morphology. In addition, an experiment was flown to determine if, during flight, rats would breed, generate normal fetuses, and postflight, bear normal young. The embryonic development of Japanese quail was also studied. Analyses of the specimens are underway and are being compared to specimens obtained from ground control groups. Future primate flights are planned.

4. <u>Human Space Flight Activities</u>

A joint study to investigate physiological changes in humans resulting from simulated weightlessness was completed at the Insitute of Biomedical Problems, Moscow, U.S.S.R., and at NASA's Ames Research Center. Both American and Soviet scientists have used extended bed rest to simulate the effects of weightlessness. The usefulness of the results of such studies can be enhanced by standardized procedures. In the past, during Soviet bed rest studies, the subjects' heads remained lowered 6° from the horizontal, while in the U.S., the subjects remained horizontal. Two years ago, the joint U.S./U.S.S.R. Working Group on Space Biology and Medicine agreed to conduct a joint study comparing the two methods. In addition, it was agreed that all procedures, including physiological tests, would be as similar as possible to facilitate comparisons. Ten subjects were tested at the Institute of Biomedical Problems in Moscow in May 1979. Five subjects were tested in the horizontal position, and five in the 6° head-down position. Two months later, an identical study was performed at Ames Research Center. Insofar as possible, identical physiological measurements were made at both locations. The scientific teams met in October 1979 to discuss the results of this study and to work out details for a joint publication.

Human body immersion into a liquid environment is thought to simulate the physiological effects of weightlessness. A ground-based application of the method allows an integral assessment of the mechanisms of regulation responsible for the functional rearrangement of the human body under reduced gravity conditions. Manned experiments carried out during 3-and 7-day dry support-free immersion included study of various parameters of external respiration, cardiovascular function, and fluid electrolyte balance. Blood and urine samples were taken for further biochemical analysis. These studies showed that the acute stage of adaptation of man to water immersion is accompanied by phasic changes, reflecting intersystemic relations typical of those occurring is space flight.

Long-term experiments with rabbits have been conducted to evaluate the human hazard from heavy ions during prolonged periods in space. Experiments with 400 Mev/nucleon Ne ions and 530 Mev/nucleon Ar ions have revealed that true late effects of a degenerative nature are manifested only years after irradiation. At the appropriate dose (the high end of the experimental dose range), the magnitudes of the late effects are comparable with those encountered in human patients given radiation therapy with neutrons. Such comparisons show that the rabbit experiments are applicable to man. Results from the low end of the experimental dose range lead to the conclusion that astronauts subjected to the radiation fluxes anticipated during flights of the above duration could experience late radiation effects one or more decades after exposure. Late degenerative changes will occur mainly in tissues of the central nervous system, terminally differentiating systems, and stem cell populations. Individual tissues may be "prematurely aged" by radiation in the sense that the "life spans" of those tissues can be decreased without the appearance of malignancies.

With increasing duration and crew size of future space missions, the need for recycling major metabolic products becomes obligatory. Since the realization of stable self-regenerative systems for man is expected to require long lead times (10 to 20 years), NASA has initiated a program for conducting studies in Controlled Ecological and Life Support Systems (CELSS). Research priorities include human nutrition and closure of the food chain loop using biological and/or chemical processes. Problems of ecological and energetic inter-relationships between the biological components of CELSS place special emphasis on modeling studies.

Chapter VII Material Sciences in Space

1. Recent Studies

The United States Spar 6 rocket flight in November 1979 carried investigations for single- and three-axis acoustic levitation systems involving heated gallia-calcia glass spheres in the former and 2 cm diameter water droplets in the latter. A directional solidification experiment using the magnetically interesting manganese-bismuth (Mn-Bi) alloys was performed. Liquid phase epitaxial growth in gallium arsenide using an isothermal furnace was studied.

A major part of the U.S.S.R. Salyut 6 flight was devoted to microgravity experimentation in the "Crystal" and "Splav" furnace systems. Here, comparison between ground-based and microgravity in antimony single crystals confirmed expected homogenous electrical properties and improved structural characteristics. Similarly, germanium grown by directional solidification reconfirmed similar findings on Skylab using a slightly different technique on the improvement in structural perfection and chemical homogeneity. An experiment devoted to the crystallization of mercurous bromide from molten solution with mercuric bromide displayed significant differences from expected ideal shapes, as well as new characteristics related to components with directional dependence of bonds in the crystal lattice and with a high index of refraction.

The German Texus II Rocket flight program had the following results. The role of the wetting angle in a liquid/solid dispersion was demonstrated by the experiment "Stability of Multicomponent Mixtures" in which several samples with differing compositions were remelted in space. Strong dependence of separation on contact angle was discussed.

In another experiment involving melting and solidification of alloys of the Mn-Bi system, in the absence of sedimentation and buoyancy, other forces promoting segregation such as surface tension gradients did not become effective. However, in comparison with the original materials, there was a distinct increase in the proportion of ferromagnetic MnBi. In addition, the MnBi phase was present in the flight specimens in uniform distribution and in the form of relatively small particles. The latter was obviously responsible for the good magnetic properties of the flight samples compared with the 1-g samples.

The behavior of Al_2O_3 particles at the solidification front of molten metals was studied in an experiment with an aluminum-copper (Al-Cu) alloy. In this case, no distinct effect of the suspended particles on structure, arrangement, and size of the eutectic cells in the resolidified material could be established.

In the French experiment program, seven experiments were carried on Salyut 6 between March and May. The main objectives of the experiments included the following: Germanium and vanadium oxide were grown in vapor phase which is of fundamental interest in understanding transport and deposition processes and defect formation. For germanium, growth on glassy and oriented substrates was to be compared. Vanadium oxide was sought for fundamental studies on the conducting-nonconducting transition state at 150°K.

Suspended growing of semiconductor materials (whose purpose was to melt and resolidify boules of several materials suspended from quartz wires in an ampoule) was to verify if this simple way to position melted material successfully avoids contact with the walls.

Growing of gallium arsenide and gallium-indium phosphide was concerned with solution growth on an oriented substrate, and was designed to demonstrate how the absence of gravity-driven convection reduces defects in crystals with potential benefit to conventional ground-base procedures.

Modification of cellular or dendritic structures in Al-Cu and strontium-lead alloys was to study interfacial destabilization of the solid-liquid interface generating nonplanar growth and consequently cellular or dendritic structures.

Magnetic materials were processed, such as neodymium-cobalt structures with acceptable coercibility and quality, which are difficult to obtain. Uncontrolled nucleations are suspected of causing opposite orientations of the magnetic domains which the convectionless conditions and lower interaction with container walls prevailing in space could reduce. Also, cerium-manganese alloys should theoretically have good magnetic properties if the miscibility gap does not hinder their corresponding phase structure as it does on the ground. It has been suggested that microgravity could create this new phase structure.

Ground-based studies continued to reaffirm that the virtual absence of gravity available for prolonged periods during free space flight has a significant impact on a number of phenomena involving fluids. In a growing number of cases, these studies have already involved space experiments. The areas of interest are concentrated in solidification and crystallization with continuing significant interest in biological separations, vacuum utilization, and some basic examinations into the nature of fluid flow and into microgravity effects near critical stability regions.

2. Future Activities

A significant number of scientists world-wide appear to have committed themselves to the necessarily long-term involvement. In the United States, 50 projects in some 40 primarily academic institutions are involved. Primary emphasis is on the preparation of equipment and experiments for the Shuttle/Spacelab flights presently scheduled for 1982, supplemented by the U.S. Spar Rocket program and the German Texus Rocket program, and appropriate ground-based research. While no immediate commercial applications have been identified, attention is also being given to encouragement of the industrial sector in early participation. Comparably strong involvement is visible in the German and French programs. In the U.S.S.R., a major portion of Salyut 6 was devoted to space processing with significant participation from the Polish and Czech scientific community. Thus, the program has emerged from its early speculative phase into a time of significant present and near-term space-borne experimentation with an appropriate ground-based "control" program.

Chapter VIII Activities of Technical Panels

1. Potentially Environmentally Detrimental Activities in Space (PEDAS)

These activities and their effect have been addressed in a report submitted to COSPAR in Budapest which covers the following subjects: (causes) Strong Laser/Lidar Beams, Chemical Releases, Releases from Spacecraft, High-Power Beams, Debris of Spacecraft, Re-entry Burnout, Plasma Depletion by Release, (effects) Optical Astronomy, Fast Transient Phenomena, IR Astronomy, Radio Astronomy, Exobiology, and Ozone. Active experiments will be written following the Budapest Symposium. Two other subjects, Balloons and Technical Aspects of Debris Removal, are missing from the report. Some information from this report will be used in the UN Outer Space Affairs Division report on "Relevance of Space Activities to Earth Resource Management and to the Environment."

2. Technical Problems Related to Scientific Ballooning

Activities have been concerned with establishing communications concerning balloon technology and operations related to scientific experimentation in the regions of space that are inaccessible to rockets, satellites, and space probes. A symposium was held in Budapest to discuss balloon instrumentation and experiments, construction and stress/thermal analysis, and long-duration operations. The need for international launching facilities in the Southern Hemisphere will be discussed in a workshop near the end of 1980 in Buenos Aires. Developing countries have an interest in this form of vehicle for instrumentation.

3. Dynamics of Artificial Satellites and Space Probes

Recent work has been concerned with the effects of non-gravitational forces such as atmospheric drag and solar pressure. In addition, the resonance effects associated with the longitudinally dependent variations (tesseral harmonics) of the gravity field have been described and analyzed. The effects are studied with satellites whose period is such that the forces act for long intervals of time in a cumulative fashion.

The increasing availability of data from laser tracking stations has resulted in an accuracy of orbit determination that requires numerical integration techniques rather than analytical ones.

ACRONYMS

AEROS	Aeronomy Satellite
AMU	atomic mass unit
AU	astronomical units
AXTAF	Advanced X-Ray Telescope Facility
CELSS	Controlled Ecological and Life Support Systems
COBE	Cosmic Background Explorer
COS	Celestial Observation Satellite
COSPAR	Committee on Space Research
CZCS	Coastal Zone Color Scanner
DC	direct current
ESA	European Space Agency
ESRO	European Space Research Organization (now ESA)
EUVE	Extreme-Ultraviolet Explorer
EXOS	Exospheric Satellite
FGGE	First GARP Global Experiment
FRG	Federal Republic of Germany
GARP	Global Atmospheric Research Program
GEOS	Geostationary Earth Orbiting Satellite
GRO	Gamma-Ray Observatory
HEAO	High Energy Astronomical Observatory
ICSU	International Council of Scientific Unions
IR	infrared
IRAS	Infrared Astronomical Spacecraft
IRI	International Reference Ionosphere
ISEE	International Sun-Earth Explorer
IUCRM	Inter-Union Commission on Radio Meteorology
IUE	International Ultraviolet Explorer
JASIN	Joint Air Sea Interaction Experiment
MAP	Middle Atmosphere Program
NASA	National Aeronautics and Space Administration (USA)
NESS	National Environmental Satellite Service (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
PEDAS	Potentially Environmentally Detrimental Activities in Space
QSO	Quasi-Stellar Object
SAR	Side Looking Radar
SCOR	Scientific Committee on Oceanic Research
SIRTF	Shuttle Infrared Telescope Facility
SME	Solar Mesosphere Explorer
SMY	Solar Maximum Year
SOT	Solar Optical Telescope
TIROS	Television and Infrared Observations Satellite
UARS	Upper Atmosphere Research Satellite
U.K.	United Kingdom
ULF	ultra-low frequency
UN	United Nations
URSI	Union Radio Scientifique Internationale
U.S.	United States
U.S.A	United States of America
U.S.S.R	Union of Soviet Socialist Republics
UV	ultraviolet
VLF	very low frequency
WINE	Winter in Northern Europe