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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/European Space Agency/Committee on Space Research Workshop on Satellite Data Reduction and Analysis Techniques

(Dehra Dun, India, 27-30 November 2000)*[*]

Contents

[*] The present report required preparation by the individual speakers of abstracts of the resentations they had made during the workshop. This process took several weeks, which delayed the submission of the report.

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I. Introduction

A. Background and objectives

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), in particular through its Vienna Declaration on Space and Human Development, recommended that activities of the United Nations Programme on Space Applications should promote collaborative participation among Member States at both the regional and international levels, emphasizing the development of knowledge and skills in developing countries.[1]

2. At its forty-second session, in 1999, the Committee on the Peaceful Uses of Outer Space endorsed the programme of workshops, training courses, symposia and conferences planned for 2000.[2] Subsequently, the General Assembly, in its resolution 54/67 of 6 December 1999, endorsed the United Nations Programme on Space Applications for 2000.

3. Pursuant to resolution 54/67 and in accordance with the recommendation of UNISPACE III, the United Nations/European Space Agency (ESA)/Committee on Space Research (COSPAR) Workshop on Satellite Data Reduction and Analysis Techniques was organized by the United Nations, ESA, COSPAR and the Government of India at the regional Centre for Space Science and Technology Education in Asia and the Pacific and the Indian Institute of Remote Sensing (IIRS), in Dehra Dun, India, from 27 to 30 November 2000. The Indian Space Research Organization (ISRO) acted as host of the workshop on behalf of the Government of India.

4. The main objective of the workshop was to provide a forum for educators and scientists concerned with access, analysis and interpretation of satellite data. While the scientific applications of satellite data may cover a wide range of topics from environmental monitoring to astronomy and from meteorology to remote sensing, the basic techniques of satellite data processing with necessary software would essentially be common to those activities. The workshop considered satellite data reduction and analysis techniques so that the vast banks of such data that existed worldwide could be utilized by a larger member of scientists in developing countries.

5. The workshop provided a platform for interaction between scientists who generated satellite data for various scientific applications and those—in particular in developing countries—who were involved in the access, processing, analysis and interpretation of satellite data for scientific investigations and practical applications in the areas of their expertise. The workshop equipped participants with an expert knowledge of the tools available for access, analysis and interpretation of data obtained by digital data acquisition systems for a variety of educational and scientific purposes. Basic and advanced principles and methods were presented and reinforced with practical examples from everyday data access, analysis and interpretation operations. The workshop also fostered communication between developers and users with a wide range of expertise in the production and use of software packages to pursue data management in remote sensing, satellite meteorology, natural disaster reduction and space science.

6. The workshop also provided an opportunity to start preparations for the next workshop in the series, to be hosted by the Government of the Syrian Arab Republic at the General Organization of Remote Sensing (GORS) in Damascus from 25 to 29 March 2001.

7. The present report has been prepared for submission to the Committee on the Peaceful Uses of Outer Space at its forty-fourth session and to its Scientific and Technical Subcommittee at its thirty-eighth session, in 2001. The participants reported on the knowledge acquired and the work conducted at the workshop to the appropriate authorities of their Governments, universities and research institutions.

B. Organization and programme

8. The workshop was held at the Centre for Space Science and Technology Education in Asia and the Pacific and IIRS, in Dehra Dun, India, from 27 to 30 November 2000. It was attended by 59 researchers and application specialists from the following 21 countries: Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Islamic Republic of Iran, Japan, Republic of Korea, Kyrgyzstan, Lao People’s Democratic Republic, Mongolia, Myanmar, Nepal, Philippines, Spain, Sri Lanka, Syrian Arab Republic, Thailand, Uzbekistan and Viet Nam, as well as from the United Nations and ESA.

9. The United Nations and ESA provided financial support to defray the cost of international air travel and living expenses of 16 participants from developing countries. Room and board and local transportation for the same participants, as well as meeting facilities and equipment for the workshop were provided by ISRO.

10. The programme of the workshop had been developed jointly by the Office for Outer Space Affairs and ISRO. Presentations made at the workshop covered satellite data reduction, analysis and image-processing techniques as used in the fields of remote sensing, meteorology and space science. Information on satellite data access, interpretation and archiving was presented at the workshop along with demonstrations of appropriate software tools.

11. Opening addresses were made by representatives of ISRO (also on behalf of COSPAR), the Office for Outer Space Affairs, ESA, the Centre for Space Science and Technology Education in Asia and the Pacific, IIRS and the National Remote Sensing Agency of India.

II. Summary of presentations

A. Space and atmospheric science

1. Fourier and wavelet analysis techniques

12. It was reported that Fourier and wavelet analysis were mathematical tools used for audio de-noising, signal compression, object detection, image de-noising, image enhancement, image recognition and time series analysis as applied in remote sensing, meteorology, communications and space science. The Fourier transform works like a mathematical prism, breaking up a function into the frequencies that composed it, much as a prism breaks up light into colours. It transformed a function

that varies in time (or in space) into a new function that is frequency-dependent. While the Fourier transform turned a signal with one variable (time or space) into another function with one variable (frequency), the wavelet transform produced a transform with two variables, time and frequency. The goal of both transforms was to convert the information in a signal into coefficients that can be manipulated, stored, transmitted, analysed, compressed or used to reconstruct the original signal. Astrophysical data and software, available on the World Wide Web, had been used to demonstrate the application of Fourier and wavelet transforms for time series analysis.

2. Retrieval of ozone from satellite data sets

13. The importance of atmospheric ozone in absorbing the lethal ultraviolet (UV) radiation from the Sun and in atmospheric chemical reactions was reported to be well known. Its role as a greenhouse gas was also being realized. Observation of extensive ozone depletion in the Antarctic region during the spring had been a remarkable discovery. Even though the use of chlorofluorocarbons was almost curtailed, they would remain in the atmosphere for a long time. In addition, concentrations of many greenhouse gases (such as carbon dioxide, nitrous oxide, methane and so on) were increasing, causing concern related to climate change. There was a need to monitor ozone and other gases in the atmosphere to understand its changing chemistry and effects on the environment.

14. Satellite techniques were the best suited for long-term global monitoring of ozone and related gases. Remote measurements of atmospheric gases employed absorption and/or emission features of those gases. While ozone has absorption bands in the UV, visible and infrared (IR) wavelength, most of the other trace gases had those features in the IR and microwave regions. Extensive measurements of the total column of ozone had been made over a very long period by the total ozone mapping spectrometer (TOMS), which had been launched on various satellites to ensure continuous observations. The upper atmosphere research satellite (UARS) had provided useful data sets. Japan, the United States of America and ESA had plans to launch satellites with multiple instruments to measure a host of trace gases along with ozone. The basic techniques of satellite measurements and data retrieval were discussed during the presentation.

3. The extraction of timing data of X-ray sources from the Indian X-ray Astronomy Experiment on-board the IRS-P3 satellite

15. It was reported that the Indian X-ray Astronomy Experiment (IXAE) consisted of a set of three collimated proportional counters that are used to study the properties of cosmic X-ray sources, namely, neutron stars and black holes. IXAE had been launched aboard the Indian IRS-P3 satellite on 21 March 1996 and had been operating since then. In the last four and a half years, about 60 pointed observations had been made with IXAE in which about 40 galactic point X-ray sources had been observed. Some very interesting and important results revealing various properties of those compact objects and their interaction with their environments had been obtained. The instruments and the results obtained so far were described at the workshop and details of the various analysis techniques used for achieving those results were discussed. Other interesting scientific data that

could be extracted from the existing observations with IXAE were also presented along with the data analysis techniques.

4. Retrieval and analysis of ultraviolet spectra of stars from International Ultraviolet Explorer data

16. ESA reported that its Science Programme had been very successful with unique space science missions, which had created large data collections in various areas of basic space science. As a consequence of the special nature of space missions as compared with ground-based observatories (such as stability of instruments, large data-gathering capability and so on), the data collections of those projects had strongly driven the concept of archives as major research tools for scientists. The past decade had seen significant efforts to make the data and results of those missions directly available to the scientific community. For ESA such archives were associated with the following science missions:

International Ultraviolet Explorer	UV spectra of astronomical objects
Infrared Space Observatory	IR spectra and images of astronomical objects
Hipparcos	Proper motion and parallaxes of astronomical objects
Hubble space telescope	UV, optical and IR images and spectra of astronomical objects
Solar and Heliospheric Observatory	UV and X-ray images of the Sun and its corona
Ulysses	Hydro-magnetic and particle mapping of the heliosphere

17. Owing to the different nature of the study area of the missions, each of the archives had its own structure and domain of application. The importance of the limitations in the archive products was discussed and it was clarified that archival preparations had other requirements than normal data reduction because of the large quantity of data available. It was stressed that the stability of archives was an essential aspect for end-users, since only then could scientists concentrate their efforts on interpretation of results rather than on data processing. Stable archives were also the essential foundations on which initiatives such as virtual observatories could be built successfully. Clarification was given as to why the use of archives from previous and ongoing missions represented an exceptionally efficient approach to communities that were only now beginning to have access to the benefits to be gained from space science activities. In the education of young scientists, the use of the archives presented an important stimulus and efficient means to prepare a scientific and technically literate community. This was essential in order to begin to reap the benefits of space activities on a global scale. The use of space archives in developing countries was an important step on the road to sharing in the space benefits in many areas of society.

18. Two of the ESA archives were discussed in detail in order to illustrate the differences in structure and the consequences for their usage and maintenance. This demonstrated the importance of a well-designed archive as a tool by which

developing countries could participate in activities in space sciences and applications. The two archives in question were the International Ultraviolet Explorer Newly Extracted Spectra (INES) system from the International Ultraviolet Explorer, and the archive from the Infrared Space Observatory. The two examples were discussed in detail to demonstrate the different approaches and the consequences for end-users as well as for the long-term support needs for the archives. Access to both archives was fully driven by the Internet and the associated World Wide Web technology. The INES archive for the International Ultraviolet Explorer was an example of a fully distributed archive with only two primary centres in Canada and Spain, serving a worldwide system of national hosts in 22 countries and providing access to end-users. The archive of the Infrared Space Observatory was a highly centralized archive with two primary centres, in Spain and the United States, in which the upgrading of the output products was a driving tool. The consequences of the different structures in the two approaches were discussed in detail.

B. Remote sensing and meteorology

1. Activities of the Asian Centre for Research on Remote Sensing in receiving, automatic processing and distribution of data

19. The Asian Institute of Technology (AIT), established in Thailand in 1959, had been playing an important role as a graduate school in providing high-level human resources in various fields of technology to the Asian region. The Space Technology, Applications and Research (STAR) programme was a unit that provided education, training and research opportunities in the field of space technology, specifically remote sensing, geographic information systems (GIS) and the use of global navigation satellite systems.

20. Observing the expansion of application fields of space technology, STAR had redefined its role in two aspects in 1999 for more effective promotion of space technology in the region. One aspect concerned the programme’s role as technology developer and the other as a technology partner. As a technology developer, STAR trained students who had capabilities in developing applicable technology in their field of speciality. It had also promoted research activities by establishing its research centre. As a technology partner, it had established an institute-wide GIS and remote sensing laboratory providing education and research opportunity to the entire AIT. STAR also provided expertise to the region through training, research and consulting activities.

21. STAR consisted of three components, education, training and research, to fulfil the role defined above. Those three components shared human resources, equipment and research experience to maximize their combined efficiency.

22. Education, which was a primary function of STAR, comprised master and doctoral programmes. The master course programme was a 20-month programme of five terms. The first three terms consisted of course work to build up basic to advanced knowledge. The last two terms were for completing a master’s thesis, during which students were encouraged to contribute to the development of applicable technology. The doctoral programme was 36 months long and students devoted their time to research work.

23. As regards training, STAR had established the GIS Application Centre to feed back its expertise to users. Five courses supported by the National Space Development Agency of Japan were the main activity of the Centre. Three courses, in watershed management, coastal zone management and synthetic aperture radar were conducted at AIT. These were advanced courses targeting integration of remote sensing and GIS. The other two courses were so-called “caravan” courses, which were conducted outside Thailand to provide training opportunities to more end-users in the region. The Centre had also started a new type of course by adding a one- to two-month mini-project programme after the usual intensive course. This new course increased the efficiency of the intensive course.

24. STAR established a research centre, the Asian Centre for Research on Remote Sensing, in cooperation with the Asian Association on Remote Sensing (AARS), to promote research activities and to provide technical support to the region. The Centre organized research projects and provided research opportunities, accepting visiting researchers. The Centre received advanced very high resolution radiometer (AVHRR) data from the National Oceanic and Atmospheric Administration (NOAA) of the United States and produced 10-day normalized difference vegetation index (NDVI) cloud-free composite images operationally, and distributed data over the Internet to promote near real-time applications. It is expected to establish a moderate resolution imaging spectroradiometer (MODIS) receiving station by March 2001.

25. STAR would like to establish a data application centre to provide more data with technical support to users in the region. This would contribute to the practical application of remote sensing data as well as to the upgrading of research in the region.

2. Development of geometric correction methods of multi-temporal resolution satellite images

26. It was reported that in recent times, a large volume of natural and synthetic image and grid data had been generated and were becoming available, for example, data from current-image satellites, the European Remote Sensing (ERS) satellite, the Land Remote Sending Satellite (Landsat), RADARSAT and the Satellite pour l’observation de la Terre (SPOT). There were plans to launch more than 100 Earth observing satellites by the year 2005. Digital orthophoto mapping was another field in which a major financial investment was being made and in which a large volume of raster data was being produced. Obviously, there were many opportunities if different types of data could be integrated into a database. The development of such a database system would allow effective use of such data for purposes like environmental monitoring of the Earth.

27. Research had focused on two methods to construct database systems to manage a very large number of geo-coded satellite images and raster data. Those methods are described below.

28. For high accuracy geometric correction, ground control points (GCP) were indispensable, but it was not always easy to find GCPs clearly in one scene for image coordinate registration. In addition, geometric correction using GCPs was very labour-intensive and traditional geometric correction methods could be used without good GCPs in a scene. It was therefore necessary to correct geometrically

all the satellite images to be used automatically at the same time. A method to identify GCPs and tie-points in an automated manner and to adjust geometric errors over all images based on the idea of block adjustment used in photogrammetry had been proposed. That method helped to improve the efficiency and to reduce the total amount of GCPs required for geometric correction.

29. Firstly, the shapes of the footprints of pixels were represented on a given coordinate system. By projecting pixel boundaries or four corners on the image plane onto the ground coordinate system where the grid cells were generated, the relationship between pixel and grid could be exactly and explicitly represented. The process was "computational-heavy", but the projected pixel boundary could be used repeatedly as long as grid cells were defined on the same coordinate system. The second step consisted of representing the footprints of pixel boundaries by a combination of linear features. Pixel boundaries and line boundaries could be approximated by line segments with the same intervals. This enabled processing very fast computation of intersection points with grid cell boundaries.

3. Natural resource management using satellite remote sensing

30. It was reported that adopting sustainable development strategies was no more an option, but an imperative necessity for achieving economic and food security for humanity. This was been the central theme of Agenda 21, adopted by the United Nations Conference on Environment and Development in 1992. Scientific and technological knowledge had to contribute to achieving sustainable development strategies. While the spectacular developments in space technology during the last four decades had revealed very forcefully the concept and nature of the single fragile global village, the survival of Earth as a whole was dependent on promoting a reasonable quality of life in harmony with nature and the environment. This included the monitoring and management of available natural resources and their conservation. Satellite remote sensing combined with geographical information systems played a crucial role in determining, enhancing and monitoring the overall carrying capacity. It also assisted in the drawing up of appropriate action plans for sustainable development.

31. Apart from direct benefits, space technology had clearly demonstrated the interconnectivity of both natural and anthropogenic phenomena occurring anywhere on Earth, through weather, climate, geosphere and biosphere, inextricably linking the fate of each country with that of the world as a whole. Examples presented were of forest cover, wasteland mapping, agricultural crop estimation, yield estimation and their monitoring. An example of integrated resource management for sustainable development was shown in which a site-specific action plan was developed. Emphasis was also placed on environmental analysis tools using geoinformatics and natural disaster damage reduction using satellite remote sensing data examples. The results focused, however, on the need to institutionalize the technology and to develop mechanisms, capacity-building and data-sharing among developing countries. Unless resource management and development strategies based on space remote sensing and other information technology inputs consistent with societal demands and cultural practices were adopted on a worldwide scale, it would not be possible to ensure environmental security in the coming decades.

4. Fundamentals and details of satellite imagery and image processing

32. The significance of the different remote sensing images obtained in the different band frequencies of the electromagnetic spectrum lay in the interaction mechanism between the electromagnetic radiation and the material being imaged. Each image depicted an array of numbers that indicated discrete brightness levels (pixels). Image processing started with radiometric and geometric correction to the image, which could then be registered with a system of map coordinates so that other spatial data could be added. For better interpretation and analysis, an image was further enhanced and classified into various categories of object. Various enhancement techniques and classification tools were discussed and examples were provided.

5. Satellite imagery and radiometric data reduction for meteorological applications

33. It was reported that weather forecasting was carried out on three major time scales, short, medium and long. It was basically an initial value problem at short and medium ranges, requiring prescription of accurate initial conditions. With their synoptic and high-repetitive coverage, satellites could give a global picture of winds at four levels, in addition to temperature and humidity profiles in the troposphere. Those parameters were used in prognostic numerical weather prediction models to forecast weather and rainfall. One of the most important boundary parameters obtained from satellites was sea surface temperature.

34. There were two classes of meteorological satellites, the geostationary (providing repetitive coverage over a particular part of the globe) and the orbiting (providing global coverage about two times a day). The types of instrument on board the satellites were passive (for example, imagers—IR and microwave radiometers—and sounders—vertical and limb) and active (radar—altimeter, scatterometer, synthetic aperture, lidar and so on).

35. The Indian National Satellite (INSAT) series of geostationary satellites and the NOAA series of polar Sun-synchronous satellites had been the workhorses for nearly two decades in the study of the main weather systems of India, including the tropical cyclones, the south-west monsoon and the western disturbances. Products available from INSAT were cloud motion winds, the precipitation index and outgoing long-wave radiation (OLR) and from NOAA the sea surface temperature. Demonstrations were made of how those products were derived.

36. India had recently launched the Oceansat–1 satellite, with the multi-channel scanning microwave radiometer (MSMR) to measure the marine atmospheric and ocean surface parameters.

6. Satellite information retrieval from raw data to derivation of useful parameters

37. The inverse problem aspect of thematic classification of remote sensing images was brought out to emphasize that unique solutions were not feasible and one method to solve such an ill-posed problem was to introduce constraint of maximum likelihood (MLH). With the help of a case study, it was demonstrated that MLH could provide classification accuracy of about 72 per cent. The ground enumeration-based GIS overlay describing different classes for the given image was used to redefine the a priori probability (as the ratio of the area under a given thematic class to the total area of the image) and MLH classification was run in

iterative mode until accuracy improvement was within 3 per cent accuracy with regard to GIS overlay. Even using this method, a classification accuracy of only 87 per cent could be achieved with five iterations. The reasons for such a limitation were explained with the help of histograms and scatterograms between different bands.

38. As agriculture, soil systems and meteorology could be taken as homogeneous over 10 m and 100 km scales, respectively, and these were inter-modulating processes, the geometric mean of 10 m and 100 km, that is, 1 km, could be the scale of space-based observations for agrometeorological applications. The 98 per cent confidence-level relationship, over the district scale, between the temporal profile of the AVHRR data-based NDVI and growing degree days—the conventional agrometeorological growth indicator—was demonstrated. The problems of variation of emissivity and change in the relative area exposure of soil and crop over the crop growth cycle were handled by estimating the temperature (T_s) of the pixel under two extreme assumptions of fully soil (T_g) and fully covered with vegetation (T_v) by using the respective emissivity value in AVHRR bands 4 (10.3-11.3 µm) and 5 (11.5-12.5 µm); the $NDVI_g$ and $NDVI_v$ values for the situations describing the emissivities used for computing T_g and T_v were available from the literature. The T_s was estimated by using $T_s = T_g(1 - NDVI_n) + T_v * NDVI_n$ where $NDVI_n = (NDVI - NDVI_g)/(NDVI_v - NDVI_g)$. Here, NDVI is the observed NDVI for the pixel having temperature T_s.

7. Application of remote sensing at the General Department of Land Administration of Viet Nam

39. It was reported that the Remote Sensing Centre was a unit of the General Department of Land Administration of Viet Nam that had been established in 1985, based on the Remote Sensing Division in operation since 1980. In the Remote Sensing Centre, applications of remote sensing focused on image processing to supply users with satellite data at different levels of processing, including level 3, and to update topographic maps. Another activity of the Centre was to create thematic maps such as land use maps of different scales. So far all applications had been based on optical data such as SPOT, Landsat and images from various Russian satellites. For future development, the project on application of remote sensing technology for coastal zone management carried out by the Centre with technical assistance from the Department of Economic and Social Affairs, Office for Outer Space Affairs and ESA would constitute a new impulse. It is aimed at capacity-building in the application of remote sensing technology to the Centre's operational mapping activities, specifically as they relate to the coastal zone of Viet Nam, and to implementing a major microwave remote sensing component. The first results of the ongoing project were presented.

8. Radar data processing for ocean applications

40. The presentation covered both an introduction to radar techniques (real aperture and synthetic aperture radars and interferometry) and a discussion of the importance of space-borne radar instruments for oceanographic applications.

41. The first part of the presentation covered real aperture radars and in particular the differences in image representation between optical and radar images. The concept of slant range projection was introduced and compared with the classical

optical image projection. That part was then completed with a definition of range and azimuth resolution. As the ERS scatterometer was in essence a real aperture radar, some concepts of scatterometry were introduced. Strategies for improving the range resolution and the azimuth resolution (for SARs) were discussed and followed by an explanation on the role of the Doppler effect in radar imaging. Some indications about the characteristics of SAR images were given, in particular effects due to surface roughness, incidence angle, dielectric characteristics of the target, which was linked to the penetration depth and the polarization of the incident radiation. The overall discussion of radar imaging was concluded with a discussion of an image of Dehra Dun.

42. The second theme was interferometry, for which the main equations were briefly explained. An interferogram of Dehra Dun as well as its coherence image were used to illustrate some of the main interferometric applications (topography, slope map generation, land use classification, change detection, ice motion and application related to earthquakes and volcanoes).

43. The role of space-borne radar instruments for oceanographic applications was of major importance because the ocean had a key role in many aspects of life, not only in the geophysical but also in the socio-economic context. One of the primary elements of the parameters to be measured over the ocean was the wind and the scatterometer was a very useful tool to provide global coverage with reasonable time resolution to help meteorologists and oceanographers to understand better the relations between the ocean and the atmosphere. Radars measured the ocean’s roughness. The derivation of the wind speed and direction from the ocean surface roughness, which was directly related to the wind blowing at the sea surface, was described.

44. The radar altimeter already had a long history. The first radar altimeter had been flown on Skylab in 1973, followed by a series of other instruments of increasing precision. The various applications of that type of instrument depended not only on the accuracy of the time measurement on-board but also on the coverage, the various characteristics of the instruments, the characteristics of the mission and the various geophysical corrections to be applied. The main oceanographical applications of the radar altimeter included currents, mean sea level, El Niño, sea level topography and tides. However, many other applications existed, in particular for the monitoring of inland water (e.g. the evolution of Lake Chad or the Caspian Sea) or land ice sheet topography.

9. Designing and building a small ground station (direct readout) and computer network for receiving, processing and distributing S-VISSR images from the GMS-5 geo-weather satellite

45. This presentation described a system that had been developed at the Institute of Physics of the National Centre for Natural Science and Technology of Viet Nam for receiving, processing and distributing S-VISSR images from the GMS-5 satellite, the operational Japanese geo-synchronous weather satellite in operation since June 1995. GMS-5 was stationed over the Equator at 140˚ E at a distance of about 35,800 km from the Earth. The system was based on a local area network of personal computers and both hardware and software were user-friendly. The equipment of the system consisted of an antenna, a low-noise amplifier, a down-converter/receiver, a bit/frame synchronizer and a personal computer ingestor card.

One personal computer of the local area network had been established in order to service the whole process. The system contained several image-processing functions that could be divided into four main modules: image receiving, image pre-processing and displaying, conventional data image processing and application. The application functions were available to address any specific questions that users might have. The system's open file architecture allowed users to read and analyse virtually any type of image and share the data with other software users.

46. The system described above could receive signals from the FY-2 series of Chinese geo-meteorological satellites. A new satellite in the series, FY-2B, had been launched on 25 June 2000 and its first images had been received by the system in September 2000.

C. Demonstrations in remote sensing and geographic information systems

47. A fundamental requirement of Agenda 21 is to support sustainable development while safeguarding the Earth's environment. This requires optimal management of natural resources, which in turn depends on the availability of reliable and timely information at the national and regional levels. Remotely sensed data play an increasingly important role as a source of reliable and timely information needed for sustainable management of natural resources and for environmental protection. Through GIS, remote sensing data can be integrated with data from other sources to facilitate the efforts of resource managers, planners and decision makers in obtaining the relevant information they need. In order to facilitate such sustainable resource management in developing countries, the Centre for Space Science and Technology Education in Asia and the Pacific conducts a postgraduate course in remote sensing and GIS as applied to various Earth resource disciplines. The venue of the course, IIRS, is a premier training institution in the region that has trained individuals from India and elsewhere over the last three decades. The Institute is well equipped with state-of-the-art computing facilities such as personal computers and workstations with modern peripherals and software. It also has laboratories for ground truth equipment and technology understanding. Participants at the workshop had an opportunity to familiarize themselves with the available computer hardware and software at the Institute and the Centre for Space Science and Technology Education in Asia and the Pacific during demonstration sessions for satellite data reduction, processing and analysis and applications.

Notes

[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)*, chap. I, resolution 1, part I, sect. 1 (e) (ii), and chap. II, para. 409 (d) (i).

[2] *Official Records of the General Assembly, Fifty-fourth Session, Supplement No. 20* (A/54/20), para. 52.