SIGNATURES

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Newsletter of the Ahmedabad Chapter of the Indian Society of Remote Sensing

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Ahmedabad Chapter

Executive 1998-2000

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Dear readers

We are happy to place in your hand another issue of SIGNATURES though belatedly. The New Editorial Committee places on record its appreciation of the work done by the earlier editorial committee for providing the material for the current issue of ***Signatures.***

Since the last issue of Signatures, as you are aware, IRS-ID has been launched, further proving the capabilities of Indian scientists in orbiting world class remote sensing satellites.

The cyclone of 9th August 1998 that hit many parts of Gujarat has caused colossal loss of life, caused large-scale devastation and brought untold miseries to the life of the people. I, on behalf of all of you, express deep sense of grief and sorrow and request to contribute in whatever way you can to minimise the sufferings of the people.

I take this opportunity to request all members to co-operate in improving the quality and content of the Newsletter by providing their valuable inputs. I assure you on behalf of the Editorial Committee that we would try to bring out issues of the ***Signatures*** *in time and provide latest update on the developments in the broad area of Remote sensing, GIS and other related aspects. I once again seek your co-operation in this regard.*

- *Editor*

CONTENTS

MITIGATION OF CALAMITIES AND RESTORATION OF HIMALAYAN ECOSYSTEM

Chandi Prasad Bhatt
Dasholi Gram Swarajya Parishad, Chamoli, U.P.

I am delighted to be invited by Indian Society of Remote Sensing-Ahmedabad Chapter (ISRS-AC) to deliver the 9th Laxmi Narayan Calla Memorial Lecture. Over the past few year's I have been watching with keen interest the work done by ISRO scientists and application of space technology for the development of the country. I would not hesitate to say that the contribution made by the satellite technology in the field of natural resource management and environmental studies is remarkable. Satellite technology has been effectively helping in forecasting not only the weather but also providing timely warning of various calamities, such as, cyclone, torrential rain etc.

In the mountainous region such as the Himalayas where I am working for past 4 decades for the restoration of ecological balance, the calamities like landslides, soil erosion, flash floods etc., have become the recurrent phenomena in recent times. One of the major causative factors for these calamities is the large-scale exploitation of forests. This has not only adversely affected the terrain but also the rich biodiversity which is at the verge of extinction. Between the late 50's and early 70's large-scale commercial exploitation of forest was witnessed in the central Himalaya. Silviculturists claimed that the forest exploitation is a scientific process and done according to the guidelines suggested in the working plan. We for the first time challenged the authenticity of the forest working plan in early 70's, through "CHIPKO MOVEMENT" (hugging the trees), as during July 1970 a devastating flood not only swept the Alaknanda basin but also caused large-scale damage in western Utter Pradesh. We could see the relationship of the forest with the flood as the watersheds from where the flood originated were the sites in which 6477 ha of forest was felled between 1959-1969. Never in the historical past the fury of flood was so devastating as seen during 1970. Unfortunately our knowledge gained through experience could not convince the forestry experts. This compelled us to launch the non-violent protest of hugging the trees. Finally the government realised our points and came with the blanket ban on tree felling in the Upper Alaknanda basin which continues till today. Having achieved the protection of forest we realised that it is equally important to re-green the barren slopes through a massive campaign involving the local people. Today after 20 years of our conservation work we have at least been able to rejuvenate the forest in various watersheds. Recent studies conducted by Space Applications Centre, Ahmedabad have shown that there is an overall improvement in the landscape and natural resources status. I would like to emphasise here that for the wellbeing of the nation, the Himalayan ecosystem should be protected with utmost care. The Himalaya, which is not only the storehouse of our natural resources, source of many rivers and abode of spiritual and cultival heritage, gives us identity in the world as a nation with Himalayan pride.

With the advent of satellite technology, I feel that we can definitely provide a new direction in the conservation and eco-restoration strategies. SAC has already done much work in other parts of the country, but Himalayan region is still untouched. I earnestly request the scientist of ISRO and SAC to come forward and provide direction for various conservation and developmental programmes in this region. Calamities are inherent in the Himalayas, but at least we can bring down the fury of such events to a manageable extent, provided we have all the necessary information about the Himalayan ecosystem. Viewing the ruggedness and inaccessibility of the terrain, satellite technology has shown a lot of promise. I hope that very soon we will have the complete blue print for this ecologically fragile region.

Once again I am thankful to ISRS-AC for giving me this opportunity to speak at this occasion. I wish all of you very prosperous future in scientific advancement for the benefit of the nation.

About the speaker: Shri C. P. Bhatt was born on June 23, 1934 in a small village in Chamoli (UP) and has participated in Sarvodaya movement (1960), working of Dasholi Gram Swarajya Mandal (since 1964) and Chipko Movement (1973). He is recipient of many awards including Padma Shri (1986), Ramon Magasaysay Award (1982), UNEP Global 500 Award (1987) and a number of other awards for the activities of his organisation, the Dasholi Gram Swarajya Mandal.

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Based on the 9th Laxmi Narain Calla Memorial Lecture delivered at ATIRA on December 2, 1996.

HIGH RESOLUTION SPECTROSCOPY FROM SPACE

Prof. J. N. Desai
Physical Research Laboratory, Ahmedabad

I indeed feel highly privileged to have been invited to give this lecture in a series organised in honour of Prof. Pisharoty, the Pioneer of Indian Remote Sensing Programme. We all have always held Prof. Pisharoty in great esteem, not only for his scientific achievements, but also for his wisdom, and humanitarian approach. I regret my inability to quote anything appropriate from Sanskrit at this occasion, and I am extremely thankful to Shri R.M. Pandya to have taken care of that part. I also feel a sense of diffidence, because I myself have not been actively associated with spaceborne programmes. As a consequence, my lecture may be lacking in some aspects. What is lacking in "Specifics", I will try to make up in "Basics".

Title of my talk for today is "High Resolution Spectroscopy from Space". Most of you in the audience have greater interest in "high angular resolution", i.e. sharper imaging, so let me begin by bringing the two on a common platform through basic optical theory. The link connecting the two "high resolutions" is provided by consideration of the "coherence" aspect of the wavefield associated with the radiation received from an object.

Coherence is a measure of average correlation between fluctuations of (complex) field amplitudes ($V(x_1t)$ measured at two different points in space or time. Taking normalised field amplitudes, coherence is then,

$r_{12}(J) \;=\; \langle V_1(t)V^*_2(t+J)\rangle$

Where J is time delay and 1 & 2 signify two points in space.

With $J = 0$, $\;r_{12}(o) = \langle V_1(t)V_2^*(t)\rangle$ measures spatial coherence

$r_{11}(J) = \;(V_1(t)V^*_1(t+J)\rangle$:measures temporal coherence at point 1

Physical measurements of coherence are carried out by observing the interference effects. In the classical Young's double slit experiment, the fringe contrast is a measure of spatial coherence between points in space sampled by location of slits. In Michelson interferometer (division of amplitude by a beam splitter) the fringe contrast measures temporal coherence for a time delay J given by 2D/C where D is the difference in the length of the two interferometric arms.

Now according to the Van Cittert - Zernike theorem, the Spatial Coherence $r_{12}(o)$ gives two-dimensional Fourier transform of intensity distribution across the source. Achieving high angular resolution, i.e., getting sharper image means measuring power in the higher frequency Fourier components, i.e. capacity to measure spatial coherence with the largest possible spatial separation "S". It is now clear why the sharpness of an image is determined by the size of aperture of the image forming system, viz. Resolution δ & $\approx$ S/ . But this also tells us something more. At least in principle, it is the aperture size, and not the optics quality that decides the maximum attainable resolution. This fact has been make use of in achieving diffraction-limited resolution with large telescopes in presence of degradation produced by the atmosphere, through spectral infertorometry and also forms the basics for interferometric imaging methods.

The complementary theorem in temporal domain is the Weigner theorem according to which "Autocorrelation, or temporal Coherence r (J) is the Fourier transform of the source spectrum"

Just as Van Cittert_Zernike theorem provides us basis for high angular resolution, the Weigner theorem provides the basis for high spectral resolution, through what is known as the "Fourier Transform spectroscopy". In past thirty years, this new method of spectroscopy has emerged as a powerful tool and played a crucial role in form of spectrometers flown aboard a number of spacecrafts, both for the earth's atmosphere as well as planetary atmospheres.

It is to be noted that both these developments, high angular resolution and high spectral resolution through measurement of coherence are intimately connected with the great stalwart - A.A. Michelson. First high angular resolution in astronomy was achieved when Michelson measured stellar diameter - that of the star Betalgeise, using fringes obtained with his stellar interferometer in which spatial coherence was measured with a mirror separation of 7 meters. He was also aware of the spectrometric capability of his other device, the Michelson interferometer, but could not use it as a complete Fourier transform spectrometer, due to technological limitations.

Fourier Transform Spectroscopy

Fourier transform spectroscopy being not so familiar, a brief outline is given here. Output

(Based on 2nd Prof. P.R. Pisharoty Lecture delivered on March 26,1997 at PRL Auditorium)

Intensity of a two beam interferometer like Michelson interferometer, for an ideally monochromatic line at wavenumber σ [$\sigma=1/\lambda$] of intensity I_o is given by

$I(\Delta) = 1/2\, I_o\, [1 + \text{Cos}\, (2\pi\sigma\, \Delta)]$; Δ being the path difference introduced interferometor arms.

For a broadband source with spectral distribution characterized by B (σ), this takes the forms

$I(\Delta) = 1/2 \int_0^{\infty} B\, (\sigma)\, [1 + \cos(2\pi\sigma\Delta)]\, d\sigma$

$I(\Delta)$ has a constant part $1/2 \int B(\sigma)\, d\sigma$ and variable part $1/2 \int B(\sigma)\cos(2\pi\sigma\, \Delta\,)d\sigma$

The variable part is called the interferogram and is the cosine transform of the spectrum B (σ). So the inverse transform of the interferogram gives the spectrum. This in short is the method of Fourier transform spectroscopy. The technological difficulties faced earlier were associated with i) Computations and ii) Sampling interferogram [i.e. $I(\Delta)$] at accurately determined Δ. Width of the resolved spectral element "$d\sigma$" in Fourier transform spectroscopy is $\approx 1/\Delta_{max}$; where Δ_{max} is the maximum path difference at which the interferogram is sampled. This corresponds to a temporal delay $J = \Delta_{max}/c$. Again we see that it is the maximum time delay with which one can measure temporal coherence, that decides the resolution achieved. [The same principle can be seen to apply in other spectrometers like grating and prism spectrometers].

Advantages

One may wonder why one should take recourse to such an indirect way of recovering spectrum when one can directly obtain it with devices like grating spectrometers. The answer lies in the so-called "Multiplex Advantage". Different spectrum elements (energy densities at different wave numbers) are modulated through cosine function and a single detector receives the combined intensity. Inverse transforms demodulate the information stored in form of interferogram, to give back the spectrum. So in detector noise limited situations one gains in S/N ratio by a factor $\approx\sqrt{N}$ when N is the number of spectral elements simultaneously recorded. Planetary atmospheres radiate mostly in the thermal infrared and it is in this regime that the vibration rotation spectra of the constituent gases carry information about composition and physical conditions. It is also in this region that one encounters detector noise limited situations. This is why Fourier transform spectrometers have played a pivotal vole in high resolution spectroscopy with space borne instrumentation for planetary spectra.

Throughput

Another qualifying parameter for a spectrometer is the field of view over which it can collect radiation when operating at a given resolution. In general higher the resolution, smaller is this angle. (e.g. slits of a grating spectrometer have to be narrow if higher resolution is desired). Around 50's, Jacquinot carried out pioneering investigations in this direction, comparing various spectrometer systems and concluded that interferometric spectrometers as the most efficient in this respect, followed by grating spectrometers. Prism spectrometers are the least efficient of the three. This large "throughput" or the "light grasp" of interformetric spectrometers, quantified as $R\Omega=2\pi$ is referred to as the "Jacquinot advantage" of interferometric spectrometers. Here R is the resolving power "$\sigma/d\sigma$" and Ω is the corresponding field of view "seen" by the spectrometers. Basically, we have two types of interformetric spectrometers. i) Fabry-Perot based systems which directly give spectrum, and ii) Michelson based systems which work as Fourier transform spectrometers.

Both types of spectrometers have played an important role in space borne high-resolution spectroscopy. Fabry-Perot systems found earlier applications because of their simplicity and capability to directly give spectra, but because of their free spectral range limitations (free spectral range is the range of wavelengths that can be covered by a spectrometer without an overlap of orders) they have found use essentially for high resolution line profile studies. These give valuable kinematic information about atmosphere sounded by the spectral line; viz. temperature and winds, pertaining to the heights from where the radiation is emitted One of the earliest high resolution spectrometer on a space vehicle was a Fabry-Perot spectrometer aboard OGO-6 flown during 69-70. This was designed to give thermospheric night time temperatures through line-widths of oxygen red night airglow at 6300A° which comes from a height of 250-300 km. Subsequently, Fabry-Perot technology has undergone great evolution in terms of servocontrol of parallelism between the Fabry-Perot plates and Piezo electrical scanning; together with efficient 2D detectors like CCD to make full use of capability of Fabry-Parot systems to give imaging spectra. A much more sophisticated Fabry-Perot spectrometer was flown aboard the satellite Dynamics Explorer (early 80s) to observe several emission lines from different layers of the atmosphere. This instrument measured

Doppler shifts to infer winds, in addition to the temperatures inferred from Doppler line widths.

Although a Fabry-Perot has a high luminosity, for faint emission one may need to increase it further. This means we must have $R\ \Omega > 2\pi$. The field of view Ω, as dictated by the relation $R\ \Omega = 2\pi$ can be further increased by a large factor, particularly for Michelson type interferometers by using principle of "field widening". [In field widened michelson, essentially the geometrical image of reflecting mirror in one interferometer arm is made to superpose on the mirror in the other arm by using a dispersive element in one arm. Optical path difference remains finite. This permits much wider field of view at a given resolution].

A device of this type designed by G.Shepherd and his colleagues has been flown recently aboard Upper Atmosphere Research Satellite (UARS). Here it is the visibility of the fringes for an observed emission line that gives Doppler widths and hence the temperature; the winds are obtained through Doppler shifts observed as "phase of the fringes". Capacity to obtain high S/N ratio for weak emission lines is the special advantage of this type of field widened spectrometers.

As earlier mentioned, Fabry-Perot based systems, although comparatively simpler, have the limitation of use for line-profile measurements of isolated emission lines. When it is desired to observe complete rotation - vibration spectra over large spectral range (as for example in the study of planetary atmospheres, both for constituents and physical conditions) Fabry-Perot systems are grossly inadequate. It is here that Fourier transform spectrometers - named IRIS (infrared interferometric spectrometers) flown aboard several space vehicles have proved very useful. IRIS spectrometers aboard Nimbus Satellite have proved very valuable in obtaining temperature - height profiles for earth's atmosphere through the high resolution CO_2 spectra. IRIS spectrometers have also been flown aboard Mariner and Voyager satellite for obtaining high resolution spectra in the thermal infrared for studying the atmospheres of outer planets and their satellites. These spectra have revealed a number of minor constituents like methane, ethane, ethylene, benzene, phosphene, germane and several others in these atmospheres.

Towards the end of my talk let me return to the high angular resolution. One knows that a large aperture telescope on ground cannot directly produce image sharper than ≈ 1" of an arc. However, as already mentioned earlier, images taken with large apertures do contain information at Fourier frequencies ≈ Aperture diameter/λ. In mid 70^s a way was discovered to retrieve images upto these frequencies - which were the method of speckle interferometry developed by Labeyric. Within a short time, the technique of adoptive optics was also developed which corrects the image forming wavefront by a flexible mirror. A Hartmann-Shack Screen senses distortions produced by atmospheric turbulence and this information is used to appropriately distort a correcting mirror in a servo mode to get back a sharp image. However, nothing so good as direct pictures from beyond the atmosphere. These have been provided by Hubble space telescope with an aperture of 2.4 meters. As everybody knows Hubble landed in a trouble. One of the most exciting space activity was to remove the spherical aberration of Hubble by a device known as COSTAR (Corrective Optics for Space Telescope Axial Replacement). However, even prior to that, the images produced by Hubble could be deconvolved with its (aborted) point spread function, which was 1″, and images could be considerably improved. It is interesting to compare, i) Hubble pictures prior to COSTAR, ii) Processed pictures prior to COSTAR, iii) Pictures after COSTAR, iv) Ground based pictures of same objects obtained with adoptive optics with ESO's new technology telescope at Chile.

Since size of aperture on a space borne telescope has a limitation, final answer in achieving highest angular resolution may be from an interferometric array on moon!

BIO-DATA OF Prof. J.N. DESAI: Prof. J.N. Desai, who recently retired as a senior-Professor from Physical Research Laboratory, is internationally known for his work on Solar Corona using Febry-Perot methods. He has about 80 research publications in reputed journals. He is a fellow of National Academy of Sciences, Allahabad and also Gujarat Science Academy and a life member of number of learned societies.

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STUDIES ON GUJARAT CYCLONE

The damage caused by the Gujarat Cyclone of 9th June 1998 was assessed using satellite data of LISS-III, PAN, WiFS on-board IRS-1C and IRS-1D. Both visual and digital data of pre and post cyclone were used to assess the area and extent of inundation, effects on salt pans, flora and fauna along the coast, agricultural and horticultural crops and structural damages etc. Details of the study are available with Dr S. R. Nayak, Head, MWRD, RESA, Space Applications Centre, Ahmedabad.

SPACE NEWS

* NASA proposes a New Generation Space Telescope (NGST), a follow-on programme to the Hubble Space Telescope. NGST (with an aperture greater than 4 m) will have observing capabilities far better than the existing ground and space-based telescopes, providing the opportunity for the first time to look back through eons of time to the very first stars and galaxies in the Universe.

* In a rare celestial spectacle, two comets have been observed plunging into the Sun's atmosphere in close succession, on June 1 and 2. The observations of the comets were made by the LASCO coronagraph on ESA's Solar and Helioscopic Observatory (SOHO) spacecraft.

* Higher resolution of 3 meters is planned for the third and fourth China-Brazil Earth Resources Satellites.

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ISRS-AC ACTIVITIES

Presented below is the ISRS-AC Secretary's **Annual report (April '97 - March '98)**.

MEMBERSHIP

The membership of the Chapter as on 31/3/97 is –

Life –237; Annual – 27; Sustaining – 8; Patron –3.

As many as 10 life members, 5 annual members and one sustaining member were added during the year. The Ahmedabad Chapter continues to be the largest chapter.

WORLD ENVIRONMENT DAY CELEBRATION

To observe world environment day on June 5, 1997, two popular lectures were organised jointly with IMS - Ahmedabad Chapter. First lecture was delivered on "Impact of environmental activism in pollution control" by Prof. P.P. Oza, member APPELLATE authority to pollution acts and second lecture was given by Dr. P.C. Pandey, Advisor, ASC, Goa on "Monitoring environment through space". The lectures were well attended by members of both the societies. In addition on the occasion of Van-Mahotsava, about 2000 sapling, provided by Forests Dept. Gujarat, were distributed to the members of ISRS-AC.

NATIONAL REMOTE SENSING DAY CELEBRATION

A popular lecture on "Launch Vehicles for Remote Sensing Satellites" by Shri E. Janardhana, Group Director, Launch Vehicle Design Group, VSSC, was delivered on 12th August (Dr. Vikram Sarabhai's birthday) at Vikram Hall, SAC. Enthusiastic response was received from the audience from the various sections at SAC and society members.

SHRI L.N. CALLA MEMORIAL LECTURE

10th lecture in this series was delivered by Prof. K.S. Valdiya, Prof. Emeritus, JLN Centre for Advanced Scientific Research, Bangalore on "Impact of neotectonics on Himalayan Environment" on December 10, 1997 at Vikram Hall, SAC.

EDUCATIONAL EXCURSION

ISRS-AC organised one day educational excursion to "Sardar Sarovar Narmada Dam Site" on September 27, 1997. More than 150 members with their families participated in the programme and made it a memorable one. This scientific field excursion helped all of us to understand and appreciate the importance of such large scale gigantic project, which is considered to be a life line of Gujarat state

NATIONAL SCIENCE DAY CELEBRATION

ISRS-AC in collaboration with other three societies of SAC i.e. IMSA, SSME and ISG, celebrated the National Science Day on March 1, 1998 at Vikram Hall, SAC. Essay competition, Cartoon competition and a popular lecture by Dr. Sitaram, Director, CSC were the highlights of the day. Members and their families of above mentioned societies participated in the programme.

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FORTHCOMING SYMPOSIA

INTERNATIONAL SYMPOSIA

1. 35th Annual Symposium and Map Curators Group Workshop, 10-13, September, 1998 University of Keele, UK.

Contact: David Fairbairn, BCS Programme Committee Chairman, Dept. of Geometrics, University of Newcastle, Newcastle, NEI 7 RU, UK

2.Fifth International Conference on Remote Sensing for Marine and coastal Environments.5-7, October, 1998 San Diego Princess Convention Centre, San Diego, California.

Contact: Nancy Wallman, ERIM, Box 134001, Ann Arbor MI 48113-4001 USA.

3. International Symposium on Information Technology in Oceanography, 12-16, October 1998. National Institute of Oceanography, Dona Paula, Goa - 403 004, India

Contact : Organising Secretary, ITO-98, National Institute of Oceanography, Dona Paula, Goa - 403 004, India.

4. XIXth congress of the International Society for Photogrammetry and Remote Sensing (ISPRS) – Geoinformation for All, Amsterdam, The Netherlands, 16-23 July, 2000. Important Dates : Call for Papers – Jan,1999; Deadline for Abstracts – Sep,1999, Deadline for manuscripts – Mar,2000.

Contact: Saskia Tempolman, Secretary, Local Organising Committee, ITC, P.O.Box 6, 7500 AA ENSCHEDE, The Netherlands, E-mail: ISPRS@ITC.NL, WWW: http://www.itc.nl/~isprs

NATIONAL SEMINAR / SYMPOSIA

1. National seminar on Frontiers of Research and its Application in Coastal Agriculture at Navsari September 1998. Organised by Indian Society of Coastal Agricultural Research, CSSRI, Regional Research Station Canning Town, and Gujarat Society of Agronomy and Soil Science, GAU - Navsari Campus.

Contact: Sect., Indian Society of Coastal Agricultural Research, Central Soil Salinity Research Institute., P.O. Canning Town, 24 – Praganas, West Bengal, 743329.

2. Regional Workshop on Inputs from Remote Sensing for Natural Hazard Mitigation, October 24-26, 1998, at Aligarh Muslim University, Aligarh.

Contact: The Indian Geological Congress, Department of Earth Sciences, University of Roorkee, Roorkee-247 667, India.

3. GEOINFORMATICS'98 : National Seminar on Geoinformatics, at Indian Institute of Remote Sensing, Dehra Dun, India on 26-27, October, 1998, Organised by Indian Institute of Remote Sensing (NRSA), Dehradun and International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, The Netherlands.

Contact: Prof. M. D. Shedha, Organising Secretary, GEOINFORMATICS'98 Seminar, Indian Institute of Remote Sensing (NRSA), Dehra Dun – 248 001, India. E-mail: dean@del2.vsnl.net.in

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ABOUT ISRS-AC MEMBERS

***Signatures** joins all ISRS-AC family in congratulating our illustrious members. We request you to bring to our notice all such recent accomplishments, which will be covered in the next issue.*

Dr. P. C. Pandey has been elected fellow of the Indian Academy of Sciences. He has joined DOD as advisor and will be Executive Director for Centre of Antarctic Research being set up at Goa.

JOINED

Dr. Shiv Mohan, SAC - as Chief Scientist Haryana Remote Sensing Applications Centre, Hisar.

Dr. A. Narain - as Director Remote Sensing Applications Centre, Uttar Pradesh, Lucknow

Shri T.P.Singh, SAC - as Director Remote Sensing and Communication Centre (RESECO), Gandhinagar, Gujarat.

Shri R.L. Mehta and Shri Sandeep Oza, Scientists SAC joined RESECO, Gandhinagar, Gujarat as senior scientists.

AWARDED

Dr. Ajai, Group Director FLPG, Space Applications Centre (ISRO), Ahmedabad has been bestowed Indian National Remote Sensing Award for 1997, for his pioneering contribution in the field of remote sensing applications to crop stress detection, condition assessment, evapotranspiration and yield estimation.

A REQUEST

Readers are requested to send articles/anecdotes and other useful information they wish to share with other ISRS-AC members for making the NewsLetter regular. Articles should not exceed 2-3 typed pages, preferably in MS Word, supported by 1 or 2 good quality line diagrams, if necessary, in Indian Black ink.

A DECADE OF IRS SATELLITES

IRS 1A	**17-03-1988**
IRS 1B	**29-08-1991**
IRS 1E	**20-09-1993**
IRS P2	**15-10-1994**
IRS 1C	**28-12-1995**
IRS P3	**21-03-1996**
IRS 1D	**29-09-1997**

Maiden Bhaskara Award instituted by the Indian Society of Remote Sensing will be conferred on Dr. George Joseph, Director Space Applications Centre (ISRO), Ahmedabad in recognition of his lifetime and outstanding contribution in the field of electro-optical sensors conceptualisation, design and development. These sensors have been flown successfully on-board IRS series of satellites. Indian Society of Remote Sensing – Ahmedabad Chapter congratulates Dr. George Joseph for this achievement. ISRS - AC also wishes a very long, active and happy life to Dr. George Joseph, Director SAC and Ex-President ISRS, on his sixtieth birthday, which falls on August 4, 1998.

BOOK POST

If undelivered please return to :

Secretary, ISRS-Ahmedabad Chapter,
C/o Remote Sensing Applications Area (RESA),
Space Applications Centre (ISRO),
Ahmedabad 380 053.