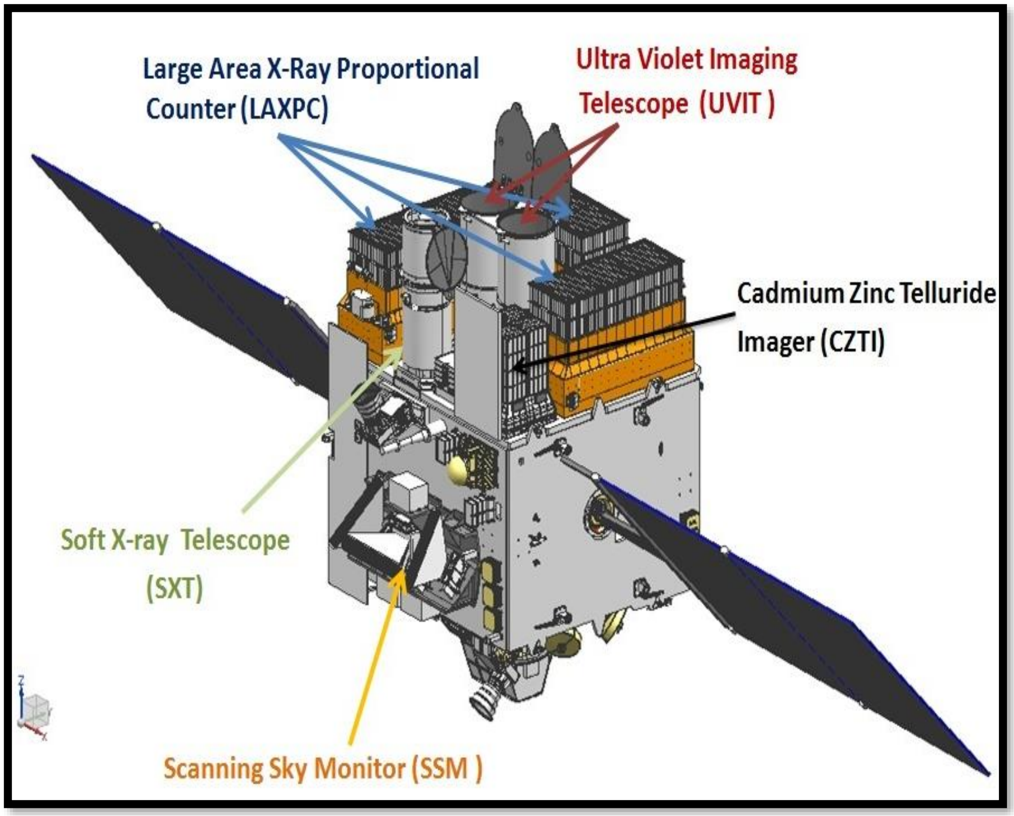
IEEE Gujarat Section
Geoscience and Remote Sensing Society Chapter

Newsletter

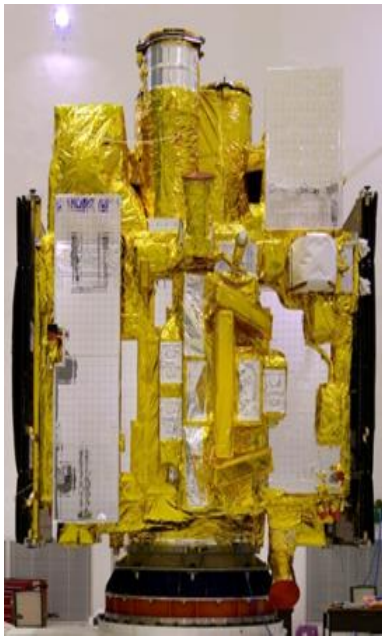
Volume 3 | Issue 1 | December 2015



Inside This Issue

Developers of the future must look on the international constellation as a collective system, not relying on any one sensor that may not be available. This will require that more systems follow the model of free and open data.

Dr. Paul Rosen



About Newsletter

The IEEE Gujarat Section Geoscience and Remote Sensing Society - Chapter Newsletter is intended as an information resource for members of the GRS Society, the IEEE community at large and the global community of individuals interested in the science and engineering of remote sensing of the Earth's land, oceans, and atmosphere. Current scenario and future of Remote sensing is taken up. Various events and lectures have been covered.

IEEE Gujarat Section GRSS Chapter Wishes all Members & their Families A Happy, Healthy and Prosperous New Year 2016

EXECUTIVE COMMITTEE

Chairman
Dr. Shiv Mohan
Vice Chairman
Dr. Aishwarya Narain
Secretary
Prof. Parul Patel
Treasurer
Dr. Anup Das
Chapter Co-ordinator
Prof. Anjana Vyas
Members Development Officer
Prof. Alpana Shukla
IT and Website Expert
Mrs. Suchit Purohit
Editor, e-Newsletter
Dr. Abhijit Sarkar
Co-Editor, e-Newsletter & Website Manager
Ms. Maneesha Gupta
Student Representatives
Dr. Sriram Saran
Mr. Ankit Patel
Industry Representative
Mr. Nirzar Lakhia
Convener, WIE (Women in Engineering)
Prof. G. Sandhya Kiran
Convener,Women Scientist Outreach program
Prof. Parul Patel
Member,Women Scientist Outreach program
Dr. Dipanwita Haldar
Mrs. Suchit Purohit
Dr. Maneesha Gupta
Dr. Ami Desai

EDITORIAL COMMITTEE

Dr. Abhijit Sarkar, Editor
Ms. Maneesha Gupta, Co-Editor
Dr. Anup Das, Member
Mrs. Suchit Purohit, Member
Dr. Sriram Saran, Member

IEEE- Gujarat Section GRSS Chapter Members' Meet at Aashray Restaurant, Ahmedabad on 10th October 2015

EDITOR'S COLUMN

The journey since we published the last issue of GRSS Newsletter (January 2015) was quite an eventful one for our members. Indian space centres are abuzz with activities associated with design, development and building earth observation satellites of Cartosat, Resourcesat, Oceansat and INSAT series. Besides, Indian space science programme has also embarked upon equally ambitious projects with Astrosat (the first dedicated multi-wavelength space observatory; aimed at studying the distant celestial sources), Aditya-1 (a scientific mission for solar studies carrying five scientific payloads including a Coronagraph) and Chadrayaan-2.

Satellites which were launched in the last one and half year are GSAT-16 (December 2014) carries 48 communication transponders, IRNSS-1D (March 2015), GSAT-6 (August 2015), Astrosat (September 2015), GSAT-15 (November 2015), IRNSS-1E (January 2016), IRNSS-1E (March 2016) and IRNSS-1G (April 2016). Towards preparedness of forthcoming satellite missions – a record number of 22 satellites are scheduled for launch this year. Along with Cartosat 2C, 21 other satellites will be launched onboard PSLV C34. The upcoming ISRO mission will include LAPAN A3 of Indonesia, BIROS of Germany, SKYSAT GEN 2-1 of the US and MVV of Germany. An immensely encouraging fact is participation of academic institutions in proposing their own satellites. This year alone, at least three such satellites (Chennai's Sathyabama University, Pune University and Nurul Islam University of Kanyakumari) will find their berths on PSLV. Now that the complete IRNSS constellation is in place, the ground segment, monitoring stations and user segments have to gear up for realisation of end applications.

Scatsat-1 is being developed as a microsatellite to substitute Oceansat-2's scatterometer system for tracking and predicting cyclonic systems and facilitating weather predictions. Its data is expected to be used by meteorological and oceanographic community world over including NASA, EUMETSAT and NOAA.

This obviously kept the scientists and engineers on their toes and resulted in sliding of the publication of this issue by a couple of quarters. The Editor takes the responsibility for this huge slippage. The lessons learnt are that the preparation of the Newsletter has to be a continuous process. Work on the December 2016 issue must begin as soon as we complete the present one. The Editorial Committee solicits your contributions for our columns.

Dr. Abhijit Sarkar

Cover Page Images: *Source: www.isro.gov.in*

Centre: Payloads of AstroSat, India's first dedicated astronomy mission launched on 28 Sep 2015

Bottom Left: AstroSat Satellite in clean room before its integration with PSLV-C30

Message from the Chairman's Desk

The IEEE Geoscience and Remote Sensing Society (IEEE- GRSS) Gujarat Chapter was initiated by a group of renowned Scientists and professional of Gujarat region in the month of June 2013. Since then, Society is bringing out its newsletter on regular basis consistently with articles and interviews from experts in their respective field. The society has brought its volunteer on a common platform for the purpose of sharing knowledge and expertise through various outreach program. We have also attempted to bring many well known global experts to share and update the knowledge on current scientific issues and challenges. The society represents volunteers from various institutes like Space Applications Centre (SAC/ISRO), Physical Research Laboratory, CEPT University, NIRMA University, Gujarat University, MS University, Corporate sector and freelancer providing educational services in Geoscience and remote sensing applications. During the current year, society has served the purpose of bringing out professionals from International and National institutes at a common platform by organizing the events like Workshop, training course and lectures from global experts.

In addition, chapter has established its own website and News letter during first year of its operation. Chapter has also contributed towards working as a technical sponsor for International Conference. Thus, chapter has established its presence at National and International level which has built a confidence not only to our members but also brought up laurel from International and National professionals. All this is feasible by team effort of our members who have worked hard as IEEE volunteer of the society. Like earlier years, our editorial team has brought out the new issue with important items. I congratulate Editorial team for their outstanding contribution in bringing out the third issue of the New Letter in a professional manner.

Dr. Shiv Mohan
Chairman
Geoscience and Remote Sensing Society Chapter
IEEE Gujarat Section
e-mail : shivmohan.isro@gmail.com

Event Reports

FELICITATION OF DIRECTOR, SAC, Shri TAPAN MISRA (20 February 2015)

IEEE GRSS- Gujarat Chapter along with Indian Society of Geomatics (ISG), Ahmedabad Chapter felicitated the new director of Space Applications Centre (SAC) Shri Tapan Misra on his assumption of office in February 2015. On this occasion Dr. Shiv Mohan, Chairman IEEE-GRSS Gujarat presented flower bouquet to Shri Tapan Misra and briefed him about the activities of the society. Director SAC showed keen interest in the activities of the society and wished the society all the success in its future endeavors.

NATIONAL SCIENCE DAY CELEBRATION (28 February 2015)

IEEE GRSS- Gujarat Chapter in association with the Department of Physics & Electronics, St Xaviers College, Ahmedabad organized popular lectures on National Science Day on 28th Feb 2015. There were two lectures, one on ‘Optical Remote Sensing and Applications’ delivered by Dr Ajai, Professor, Space Applications Centre, Ahmedabad and the other on ‘Introduction to Microwave Remote Sensing’ delivered by Dr Shiv Mohan, Chair, IEEE GRSS Gujarat, on the occasion. These lectures were designed for the students and research scholars with little or no idea about remote sensing technology and received overwhelming response from the student’s community. Most of the 250 participants, who attended the lectures, were students and young researchers from various institutes of Ahmedabad.

Lecture being delivered by Dr. Ajai

Dr. Shiv Mohan addressing the participants

Participants during the lectures

Members of IEEE GRSS- Gujarat Chapter participated in the event

TRAINING WORKSHOP ON INTRODUCTION TO REMOTE SENSING, GIS AND APPLICATIONS (23 May 2015)

IEEE-GRSS Gujarat in collaboration with eInfochips Training & Research Academy (eiTRA), Ahmedabad organized a one-day training workshop on 'Introduction to Remote sensing, GIS and Applications' on 23 May 2015 at eiTRA. Eminent faculties selected form the Space Applications Centre (ISRO), Physical Research Laboratory (PRL) and IEEE-GRSS Gujarat delivered lectures and practical demonstrations in the workshop. In the workshop several applications of satellite remote sensing and GIS including basics to advanced techniques in optical and microwave remote sensing, GIS and their applications in land, ocean and atmospheric studies were presented. The participants were also exposed to satellite data processing techniques by expert team. The workshop was highly appreciated by the participants.

In total 19 professionals, mostly teaching faculty and research scholars from institutions like Gujarat Central University - Gandhinagar, SAC - Ahmedabad, Gujarat University, Ahmedabad University, SVNIT Surat, ISTAR-Ahmedabad, Vallabh Vidyanagar-Anand, Institute of Seismological Research- Gandhinagar, HNG University - Patan and Government Science College – Valod, participated in the Workshop. Participation certificates were distributed to all the participants at the end of the workshop.

The participants expressed their interest for similar training workshops in future involving more applications using the technology.

Shri Shashikant Sharma, Scientist, SAC, delivering lecture on Applications of GIS

Dr. Markand Oza, Scientist, SAC, delivering lecture on Image processing techniques

Dr. P. K. Pal, Deputy Director, SAC, delivering lecture on Remote Sensing studies of the Atmosphere

THE IEEE DISTINGUISHED LECTURE PROGRAM (DLP) (30 November 2015)

IEEE Geoscience and Remote Sensing Society (GRSS) – Gujarat organized IEEE distinguished lecture program (DLP) on "Earth Science Informatics: An Overview" by Dr. Hampapuram Kasturi Ramapriyan, (Senior Member, IEEE) Chief Science Research Advisor, Science Systems and Applications, Inc. USA, on 30 Nov 2015 at CEPT University, Ahmedabad

With a brief introduction on IEEE GRSS, Dr Ramapriyan introduced the audience to the field of informatics management with reference to Geoscience and Remote Sensing data. His talk presented an overview of current efforts in Earth Science Informatics (ESI), the role members of IEEE GRSS play and discuss recent developments in data preservation and provenance. His emphasis was mostly on the national and international research and infrastructure projects in ESI such as the Global Earth Observation System of Systems (GEOSS), the European Commission's INSPIRE, the U.S. NSDI and Geospatial One-Stop, the NASA EOSDIS, and the NSF DataONE, EarthCube and Cyber infrastructure for Geoinformatics. Dr. Ramapriyan elaborated on available global open source data and products for research in geosciences.

Dr. H. K. Ramapriyan

About 25 professionals including students, faculty and scientists attended the lecture. The lecture generated lot of interest among the students and researchers as evidenced by enthusiastic audience interacting with the speaker during question-answer session. The lecture ended with vote of thanks to the distinguished speaker and to IEEE GRSS for providing financial support and ISRO for providing infrastructure facility.

Dr. Shiv Mohan welcoming Dr. Ramapriyan during the inaugural session

Dr. Ramapriyan delivering the lecture

INTERVIEW SECTION

An Interview with Dr. Paul Rosen

Dr. Paul Rosen is well known to the international space science fraternity. We will restrict to only a brief outline of his brilliant career. Dr. Rosen is presently the Manager of the Radar Science and Engineering Section of JPL, comprising a large number of scientists and engineers involved in defining, designing and building state-of-the–art radar instruments for NASA's Earth and planetary science missions. His assignments at JPL have centered on scientific and engineering research and development in methods and applications of Synthetic Aperture Radar (SAR) and interferometric SAR (InSAR). He had earlier been the supervisor of the Interferometric SAR and System Analysis Group at JPL. Dr. Rosen has developed and promoted scientific applications of differential interferometry, including crustal deformation mapping and hazard assessment, and has led several proposals for surface deformation satellite missions. This was preceded by his contribution to the Shuttle Radar Topography Missions (SRTM) as Project Element Manager for Algorithm Development and Verification. Dr. Rosen is also a visiting faculty member and lecturer at the Division of Geological and Planetary Sciences at the California Institute of Technology, and has authored or co-authored over 30 journal articles and two book chapters. Dr. Rosen was recently named as a Project Scientist for the NASA-ISRO Synthetic Aperture Radar (NISAR) mission.

Several members of IEEE GRSS Gujarat Chapter actively participated in the meetings/workshops on ISRO SAR Missions. One huge spin-off for us was the opportunity to interact with Dr. Paul Rosen during one such event. What started as informal discussions during short tea-breaks grew into closer and enlightening interactions. Those indeed are great moments of pride for our Chapter. The members of the Editorial Committee managed to get the text of the Interview, which is being reproduced below.

Q1: Current decade is witnessing several operational & research Synthetic Aperture Radars. Do you foresee significant increase in number of SAR missions in the years following this decade?

PR: There are a number of major missions using SAR instruments that are currently being planned, including Sentinel 1 A/B and their continuity missions, RISAT-2, NISAR, SAOCOM A/B, TANDEM-L, BIOMASS, Radarsat Constellation Mission, COSMO-SkyMed Next Generation, and commercially sold versions of TerraSAR-X and CSK. In addition to these missions, there are a number of new ventures that intend to create smallsat SAR constellations for rapid repeat focused imaging. So yes, I believe there will be many more SAR systems, with more countries developing or purchasing their own systems.

Q2: Please throw some light on 'selection of frequency bands and other system parameters' of present generation SARs /InSARs.

PR: The selection of frequency band is basically driven by the required bandwidth, and by the sensitivity of a given frequency to the surface scale sizes of interest. Cost is also a factor. Generally, the higher the frequency, the larger the available bandwidth, both in an absolute sense, and sometimes in a relative sense (relative to the center frequency). At L-band (1215-1300 MHz), the total bandwidth available is 85 MHz, with a 7% relative bandwidth. At S-band (2100-2300 MHz), the total bandwidth available is 200 MHz, with a relative bandwidth of 9%, and so on. Objects scatter most strongly when they are of the size of the wavelength of the radar signal or larger, So when the radar frequency is high, everything looks bright and it is difficult to differentiate different sized objects. When the frequency is lower, there is lower sensitivity to smaller objects, and greater penetration into volumes (forests, ice, dry sand), so lower frequency images generally have greater contrast. Lower frequency radars are useful for broad area geophysical mapping, while higher frequency radars are often used for fine resolution mapping of hard targets like buildings and infrastructure. Higher frequency radars are more compact, and therefore would be cheaper for similar capabilities.

Q3: Readers of our Newsletter and other Researchers will be interested developments in new algorithms. Please provide some examples.

PR: There is exciting work going on in many areas: Polarimetric Interferometry, Tomography, time-series analysis, non-local means filtering, sparsity algorithms for teasing out multiple scatterers in a pixel, machine learning for product assessment, cloud computing for large SAR data sets, GPU algorithm development for the SAR workflow. There's a lot going on.

Q4: A few joint missions between ISRO & NASA are taking shape. Please tell us in brief!

PR: The NASA-ISRO SAR Mission, or NISAR, is a joint mission for Earth science and applications. The objectives are quite ambitious, to understand fundamental processes of the Earth's crust, the ice sheets and sea ice, and carbon exchange in global forests. All of these relate in one way or another to measuring Earth change for understanding climate or the nature and severity of hazards. The mission has two radars, one at L-band provided by NASA that has global coverage, and another at S-band provided by ISRO that will focus on India, polar regions, and select regions around the world. To achieve unprecedented accuracies, the sampling strategy is nothing short of full global coverage of Earth's land and ice surfaces, at L-band ascending and descending every 12 days. This will produce an unprecedented amount of data to process and interpret. In addition, NASA and ISRO are exploring a joint scatterometer ocean winds mission to replace NASA's QuickScat and ISRO's OceanSat. Another possibility is a hyperspectral imager, for which an airborne campaign was recently conducted, flying a NASA hysperpectral instrument on one of ISRO's aircraft at 57 sites in India. Other ideas are also being explored.

Q5: Extending discussions on NISAR – Science & Applications this month at Ahmedabad, do you foresee participation by countries other than India and the US?

PR: NISAR data are planned to be free and open science data. As such anyone in the world will have access to the data, and many other countries' researchers will undoubtedly use the data. However, it is not likely that other countries will participate in developing the mission. NASA is planning for extended calibration and validation teams that will involve international collaborations, and ISRO may do the same. This will be a good way to engage other countries.

Q6: Many users prefer continuity of Applications after having familiarised with the System. Please throw some light on this issue.

PR: Data continuity is indeed a major issue with any mission. For reliable applications, the developer and user needs to know data will be there. Given that only Sentinel has a commitment beyond a decade, I would expect that developers of the future must look on the international constellation as a collective system, not relying on any one sensor that may not be available. This will require that more systems follow the model of free and open data. I believe this will happen as the SAR providers realize that the value added products are more valuable than the SAR data themselves.

Q7: On NISAR mission again. One of the major benefits of NISAR type mission is to provide information on Natural Disasters or Hazards. There are proposals to have an effective platform for conveying this to the society at large in a near real time mode (eg., a 24 X 7 TV Channel on Natural Hazards). Please respond..

PR: NISAR is not an operational SAR mission- it is a science mission. It is not well suited by itself to a 24/7 channel because the satellite may not come over a disaster site until a number of days after the event. However, as more SAR systems come on line and make their data available for disasters, one could definitely imagine a communication vehicle for such data. At NASA we are prototyping a data system called the Advanced Rapid Imaging and Analysis (ARIA) system designed to use data from any SAR system and GPS, and automatically download and process data on trigger immediately after the data are available. It has a web portal for instant dissemination of results. ARIA has responded to a number of natural disasters successfully, and I expect many such systems will come on line in the near future.

ARTICLE CORNER

REMOTE SENSING OF OCEANS: A CROSS-SECTION VIEW

Dr. Abhijit Sarkar, formerly with Space Applications Centre (ISRO), Ahmedabad- 380015
e-mail: sarkar.abhi@gmail.com

1.0 INTRODUCTION:

Remote sensing of Earth from space occupies an important place among the themes of contemporary research and societal applications. It is primarily because of its synoptic nature, its capability of repetivity and versatility. Versatility is possible because remote sensing techniques allow observations of diverse type of targets- land surface (bare or vegetation covered), water bodies (like lakes, estuaries or oceans), ice or snow, and their meaningful classification. The present day sensors are capable of yielding much more details than merely the target types. Observations and measurements from a vantage point in space are most suited for oceans because of limitations of conventional measurements due to its vastness, turbulent nature and inaccessibility of many regions of oceans. This uniqueness of Remote Sensing of oceans has resulted in its integration in Ocean Science. It will be appropriate here to mention the example of Oceanic Eddies. Several types of Eddies are known to exist now. But the Spiral Eddies were first detected by observations of ocean from space by astronauts during Apollo Missions in 1968. Renowned Ocean scientist Walter Munk refers to this discovery of sub-mesoscale oceanic features from space (**Figure 1**) as “virtually impossible to recognise from shipboard and too large to be encompassed from aircraft”. Remote Sensing of oceans is now a well-structured discipline and has entered the curriculum in both undergraduate and postgraduate textbooks.

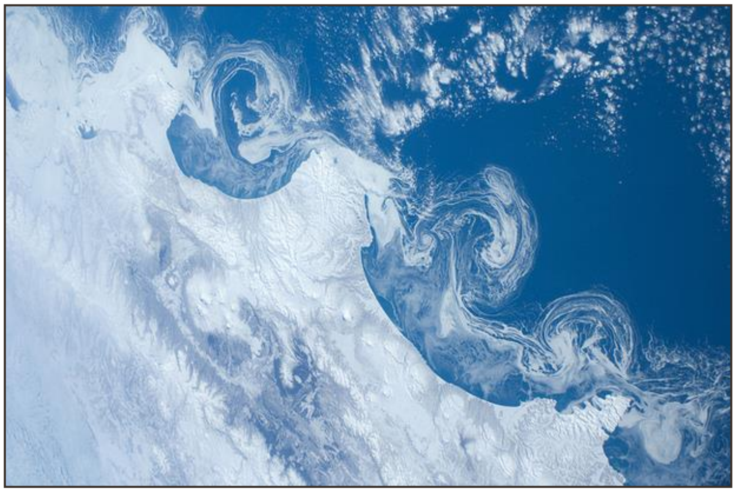


Fig.1: Astronauts on board the International Space Station took this photo of ice floes along the south-eastern coastline of Russia Kamchatka Peninsula. The irregular coastline creates large circular eddies that are very dangerous to navigate by boat, meaning that the vantage point of space is our best opportunity for seeing and studying these floes. At the picture's bottom centre, a patch of ground appears darker than the surrounding areas. That is the Karymsky Volcano, and, based on this picture, scientists believe it likely produced an ash plume in the days before this picture was taken, darkening or melting the snow around it.

2.0 REMOTE SENSING OF OCEANS:

The remote sensing technology makes use of several regions of Electromagnetic Spectrum ranging from optical region (with wavelengths 0.4 µm and higher) to microwaves (~meters and shorter). The present write up will highlight a few examples from optical remote sensing and those using the microwaves.

The prime objective of remote sensing of oceans using **OPTICAL BANDS** (popularly referred to as 'ocean colour remote sensing') is quantitative estimation of the constituents of ocean water from the spectrum of the solar reflected/scattered radiation from the ocean. As is known, only the Visible-Near IR part of the incident solar radiation penetrates into water. This radiation, after entering into water undergoes multiple scattering and absorption by water molecules and other ocean water constituents. A small fraction of this radiation is scattered out of ocean surface, which is detected by the remote sensing sensors in space (**Figure 2**). From this radiance (called water-leaving radiance), detected in selected set of wave bands, the concentrations of water constituents are estimated through an exclusive algorithm (called retrieval algorithm). Among the important ocean products retrievable from ocean colour sensors are chlorophyll-a (a photosynthetically active pigment contained in phytoplankton) concentration and total suspended matter.

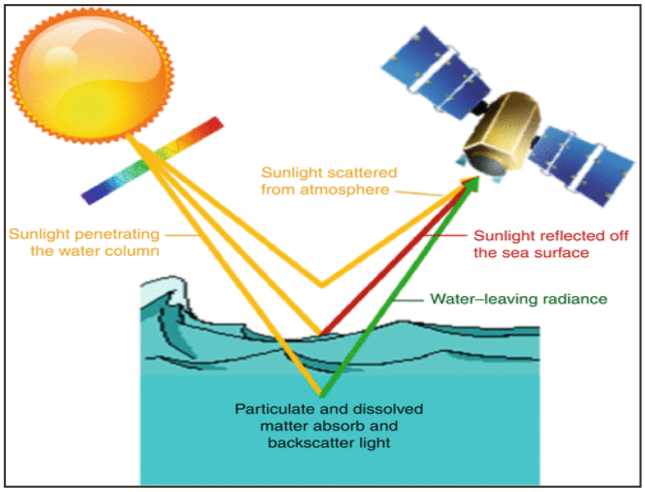


Fig.2: Detection of radiation (comprising of Sunlight scattered from atmosphere, sunlight reflected off the sea surface and water leaving radiance) by a space-borne sensor - a schematic.

Chlorophyll-a is a strong absorber of blue region of spectrum (~0.443 µm), and a weak absorber near the green portion (~0.535 µm). This explains why oceans rich in phytoplankton appear green, while those with low phytoplankton appear blue in sunlight. As the turbidity increases, the upward radiance peak shifts towards red, and that is why one sees muddy water as brown (a common site near the coasts). Satellite-borne ocean colour sensors thus are widely used for detection, mapping and monitoring of phytoplankton blooms, an essential ingredient of oceanic food web. Algal blooms being indicators of health of marine ecosystems, their monitoring is a key component of effective management of coastal and oceanic resources. The need for more effective environmental monitoring of the open and coastal ocean has recently led to notable advances in satellite ocean colour technology and research.

OCEAN COLOUR SENSORS :

AQUA-MODIS and ENVISAT-MERIS are two commonly used ocean colour sensors in sun-synchronous orbits. The OCEAN COLOUR MONITOR (OCM) was carried onboard Indian satellite Oceansat-2 (launch - September 2009) to provide in-orbit replacement to Oceansat-1 (which was launched in May 1999, and had carried an almost similar Ocean Colour Monitor). OCM is an 8-band multi-spectral camera operating in the visible and near-IR spectral range with the capability of instantaneous geometric field of view of 360 m and a swath of about 1400 km. The OCMs played an important role in ocean colour research and applications along with other global sensors. One of the major applications of Ocean Colour sensors is for fisheries. Identification of potential fishing zone is achieved by combining physical, biological and environmental parameters, such as Sea Surface Temperature (derived from space-borne sensors like radiometers) and ocean biology as manifested by chlorophyll-a concentrations (derived from space-borne ocean colour sensors). For complete information for development of an application model, one would require additional parameters such as currents, mixed layer depth, internal waves, winds, salinity, etc.

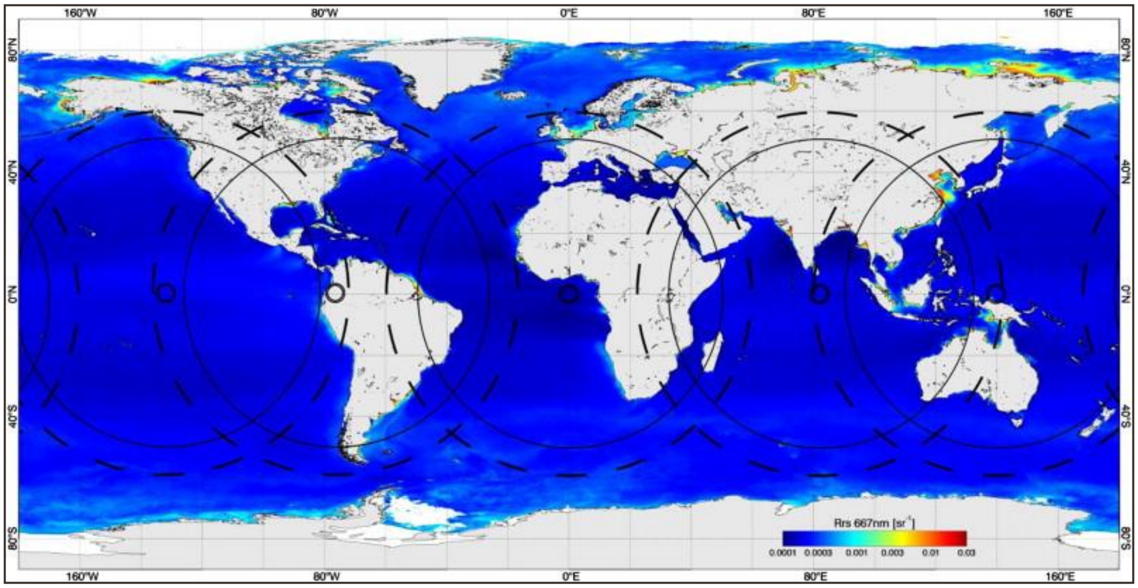


Fig.3: Approximate ground visibility from five geostationary satellites, located above the equator as shown by small black circles. The dashed and solid line ellipses are bounded by sensor zenith angle of 60° and 70° respectively. The background image shows remote sensing reflectance at 667 nm from MODIS as a composite for the period of 1 July 2002 to 30 July 2012. The limiting sensor zenith angle for ocean colour SSO sensors is a key question for researchers and will depend on various factors (desired product accuracy, sun zenith angle, turbidity of water, atmospheric correction algorithm, etc.).

In addition, there are growing numbers of Ocean Colour Sensing satellites with improved capabilities for sampling the optical spectrum with increased spectral and spatial resolutions for regional and global data collection. One such sensor is GOCI (Geostationary Ocean Colour Imager). Launched in June 2010, it is the first dedicated ocean colour sensor in geostationary orbit. This orbit (~36000 km) provides continuous coverage of locations within the area covered. However, in contrast to sun-synchronous orbits, the optimum coverage of the earth's surface is limited to less than 60° latitude. The unprecedented capability of hourly images of GOCI permitting observations of sub-diurnal movements of suspended sediment and chlorophyll-a concentrations is indeed a breakthrough. **Figure 3** illustrates the possible global coverage with 5 satellites in geostationary orbits. The limitation of high latitudes is critical and, a key challenge for the exploitation of geostationary satellites for ocean colour is to develop better sensors and atmospheric correction algorithms that will push the satellite oceanography in this decade.

SEA SURFACE TEMPERATURE (SST) :

As mentioned earlier, Sea Surface Temperature (SST) is one of the essential parameters for applications in fisheries. In fact, SST Is a key climate and weather parameter, as it is directly related to and often dictates the exchanges of heat, momentum and gases between the oceans and the atmosphere. Therefore, there is a long history of measurements of SST by in-situ techniques. Bucket method, Engine inlet pipe injection method, hull- (or buoy-) mounted thermistors, etc are all examples of in-situ SST measurements, referred as bulk estimates. They are known to suffer from different types of 'noise' (or contaminations).

SST is currently derived from a variety of space-borne infrared (IR) sensors, such as the Advanced Very High Resolution Radiometer (AVHRR) on NOAA platforms, the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua platforms, and microwave sensors such as the Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) on Aqua.

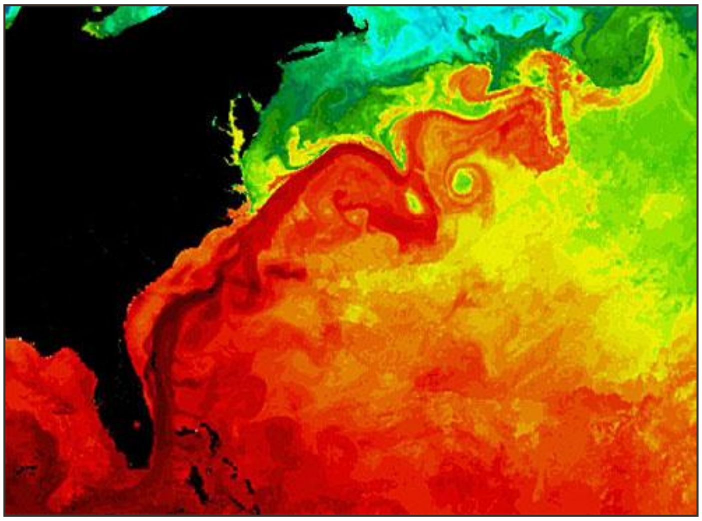


Fig.4: Satellites can measure ocean surface temperatures shown in computer-generated colors. Blue and green represent colder water while red and yellow represent warm water. This image shows the Gulf Stream, a warm ocean current that moves north along the coast of Florida, turning eastward off North Carolina and flowing to the northeast across the Atlantic. It is one of the strongest currents in the ocean. In the process several eddies are formed.

IR sensors generally have higher resolution (~1 km), but cannot see through cloud cover and are attenuated by atmospheric water vapour. Microwave sensors offer coarser resolution (~25 km) but are capable of all-weather viewing. IR instruments sense radiation emitted by the 10-µ thin skin of the ocean, while passive microwave emissions include the upper few millimetres of the ocean. The international Group for High Resolution SST (GHRSST) has been successful in integrating global SST efforts from both types of sensors in a common format and using common grid coordinates. The standardization and interoperability of these products allow for maximum usage across a broad range of applications and institutions. An example of application of synoptic SST observations in ocean currents and eddies is illustrated in **Figure 4**. The present and the next decade will see availability of SST measurements from the Visible/Infrared Imager Radiometer Suite (VIIRS) and Microwave Imager/Sounder (MIRS) instruments on the National Polar-orbiting Operational Environmental Satellite System (NPOESS), continuing the climate data records established by AVHRR, MODIS, and AMSR-E. Passive microwave measurements by AMSRE onboard the Japanese mission – Global Change Observation Mission – Water (GCOM-W). Multi year-derived SST measurements at 1-2 km spatial resolution would yield new insight into the behaviour of the interannual and decadal signals in critical coastal areas. Scientific breakthroughs explaining how coastal upwelling and eddy variability are associated with interannual and decadal signals would yield new insight into how these important areas are affected by climate (**Figure 5**).

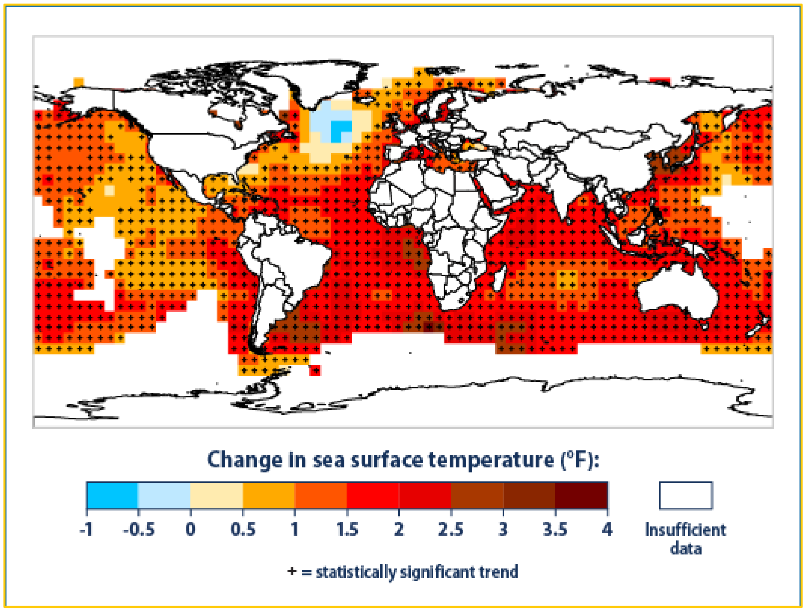
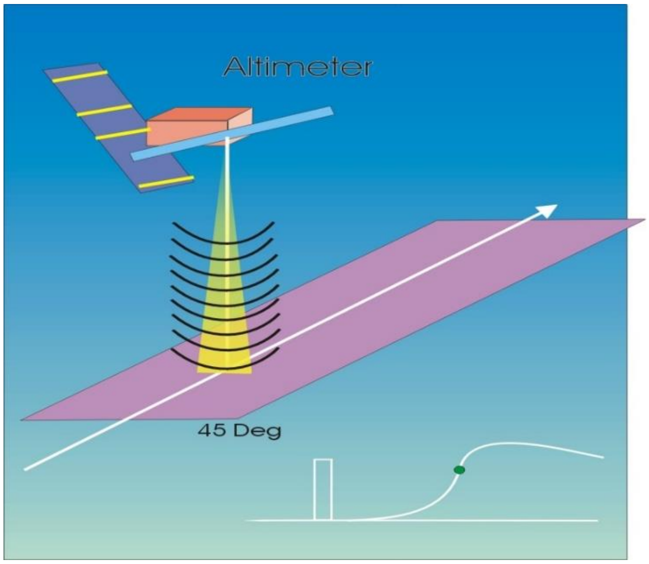


Fig.5: Change in Sea Surface Temperature, 1901-2014. This map shows how average sea surface temperatures around the world changed between 1901 and 2014. It is based on a combination of direct measurements and satellite measurements. A black "+" symbol in the middle of a square on the map means the trend shown is statistically significant and white areas did not have enough information.

MICROWAVE SENSORS :

As far as sensing of oceans exclusively by **MICROWAVE SENSORS** is concerned, Radar Altimeters are by all means the most sought after sensors. Interestingly, the basic concept of satellite altimetry is deceptively straightforward. The principal objective is to measure range from the satellite to the sea surface from the round-trip time of the microwave pulse transmitted by the altimeter towards the sea surface at nadir. There are however a lot of corrections (various components of atmospheric refraction, EM scattering at the roughened sea surface, satellite orbit related corrections, etc). The range estimates along the sub-satellite track after all processing provides the sea-surface topography. Ocean surface (topography) is known to be highly dynamic. The changes in topography can be measured by subtracting sea surface height from one traverse of the ground track from height measured on a later traverse. The geoid being constant in time, the subtraction removes the geoid, revealing changes due to changing currents such as mesoscale eddies (assuming tides and such factors are removed by certain techniques). From the measurements of surface topography, slope of the surface and in turn the surface geostrophic currents can be calculated. A large volume of work in geophysics and satellite oceanography has been carried out on sea surface heights, oceanic currents, gyres and eddies exploiting satellite altimetry. **Figure 6** illustrates the overall concept of Satellite Altimetry.



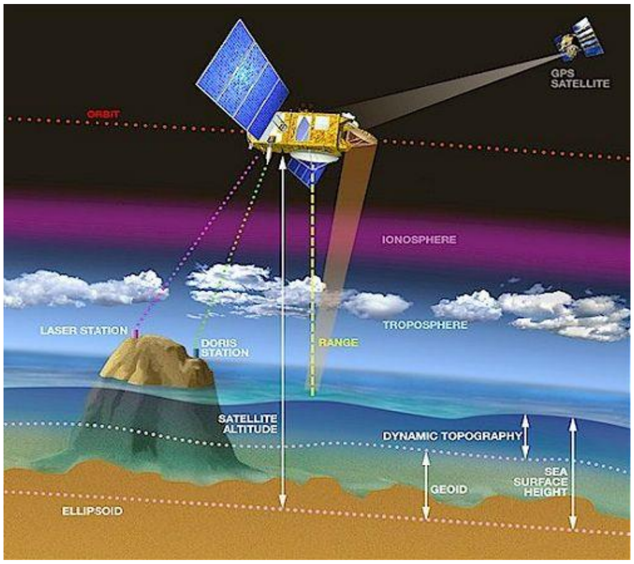


Fig.6: From the round-trip travel time measured by radar altimeter pulse, distance to sea surface is measured. From this (and additional information), Dynamic Sea surface Topography can be obtained.

Even with the early space-based altimeter missions (Seasat and Geosat launched in 1978 and 1985 respectively), although not as accurate as oceanographers had desired, it was possible to demonstrate the capability of altimeter data for studying ocean dynamics. These two missions were followed by a host of altimetry missions facilitating unprecedented gapless images of circulation of global oceans. According to renowned Altimetry expert Lee Fu - the new observations with precision missions like TOPEX-POSEIDON and its follow-ons have motivated the advancement in ocean modelling and data assimilation leading to the development of ocean state estimation for a variety of applications. The decade-long data record provides the first global view of the decadal change in ocean circulation and its geographic variability. The capability of detecting the rate of global mean sea level change at a level of uncertainty less than 1mm/year represents the state-of-the-art of precision altimetry (**Figure 7**).

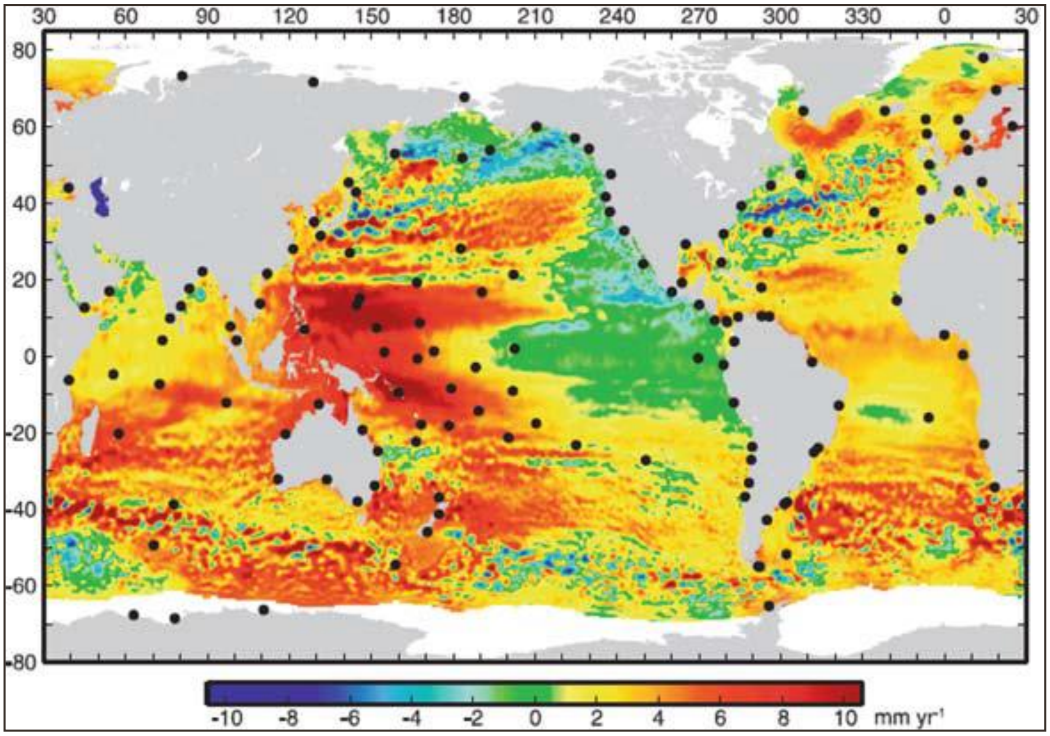


Fig.7: Sea level trends (1993-2007) from multi-mission gridded sea level anomalies. The black dots are locations of well-surveyed tide gauges

The Altimetry System is being transitioned from research to operations. With data merged from two altimeters, the decade-long data set that has made great strides in advancing our knowledge of ocean circulation has a spatial resolution that prevents observation of the important sub-mesoscale processes at scales shorter than 100 km. A way to advance the capability of future altimetry is the use of radar interferometry for making high resolution wide-swath altimetry measurement. The SWOT Mission is taking on this challenge by developing a Ka-band radar interferometry system for flight in the late 2010s (now shifted to late 2020s). **Figure 8** illustrates the configuration of SWOT measurement system. SWOT measurement will significantly advance both oceanography and land hydrology and address two key aspects of climate change: improving the prediction of the rate of warming through improved understanding of the oceanic submesoscale processes, and improving the capability of monitoring and managing the shifting water resources caused by warming climate. By providing wide-swath coverage, a single mission like SWOT is equivalent to more than 10 conventional nadir-looking altimeters.

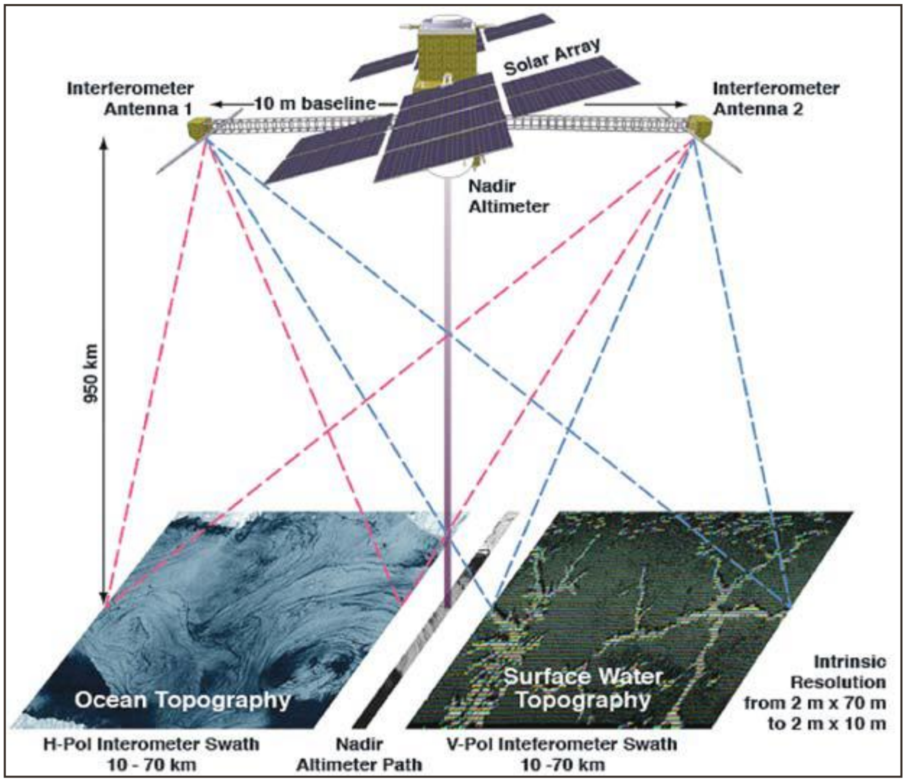


Fig.8: The configuration of the SWOT measurement system

CONCLUDING REMARKS:

It was in 2012, a Work Plan of the intergovernmental Group on Earth Observations - GEO (Oceans & Society: Blue Planet) was formally introduced. The new task seeks to coordinate the marine work under GEO and develop synergies between its various components, with a view to generation of information for societal benefit. A related goal is to raise awareness of the societal importance of observing the ocean, both in situ as well by remote sensing.

Illustrations sources:

1& 2 earthobservatory.nasa.gov

3 Ruddick et al., Remote Sensing of Environment, 146, 63-76, 2014

4 Centre for Innovation in Engineering & Science Education, New Jersey

5 US Environment Protection Agency Web Update, June 2015

6 Rosmorduc et al.,Radar Altimetry Tutorial, ESA & CNES, http://www.altimetry.info

7 Merrifield et al., 2009, J Climate, 22:5772-5781

8 JPL, NASA (E Rodriguez) in Earth science & applications from space, National Research Council, Washington, 2007

Upcoming Events

- Outreach program for students at St Xavier's College, Ahmedabad with expert lectures from eminent Scientists — 29th Feb 2016
- DLP by Prof M Crawford at CEPT University: Workshop on hyper-spectral remote sensing — March 1, 2016
- Special Workshop session on Hyper spectral remote sensing at M S University, Baroda — March 2, 2016
- One week Training Program on Microwave remote sensing applications at NIRMA University, Ahmedabad — 23-28 May 2016
- One Day workshop on basics of remote sensing, Applications, At Gujarat Institute of Disaster Management, Gandhinagar — 30th Aug 2016
- National Seminar on "Remote Sensing: Enabling our future" At MS University, Baroda — 07-08 Oct 2016

Contact for Feedback & Queries

Dr. Abhijit Sarkar
Editor, IEEE Gujarat Section, GRSS Chapter
54-2 Bimanagar Society, Satellite Road,
Ahmedabad, 380015
Ph: +91-79-26731255; Mobile: 0-9426301523
e-mail: sarkar.abhi@gmail.com

Dr. Maneesha Gupta
Co-editor and Website Manager, IEEE Gujarat Section, GRSS Chapter
Building 47 A, Room No. 4702, IAQD/SIPG
Space Applications Centre, ISRO
Jodhpur Tekra, Anbawadi, Ahmedabad, 380015
Ph: 079-2691-4796/4702 (O); Mobile: +91-9375031959
e-mail: maneesha@sac.isro.gov.in; maneesha.nano@gmail.com

We are on the Web @ www.ieee-grss-gujaratsection.org