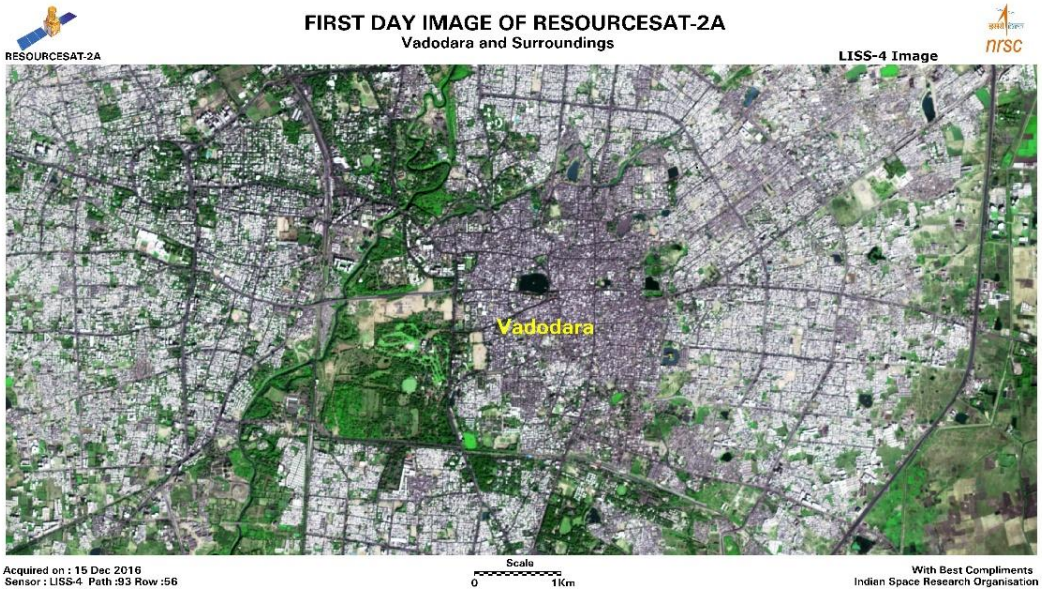
Volume 4 | Issue 1 | December 2016

IEEE Gujarat Section
Geoscience and Remote Sensing Society- Chapter Newsletter

Top Stories



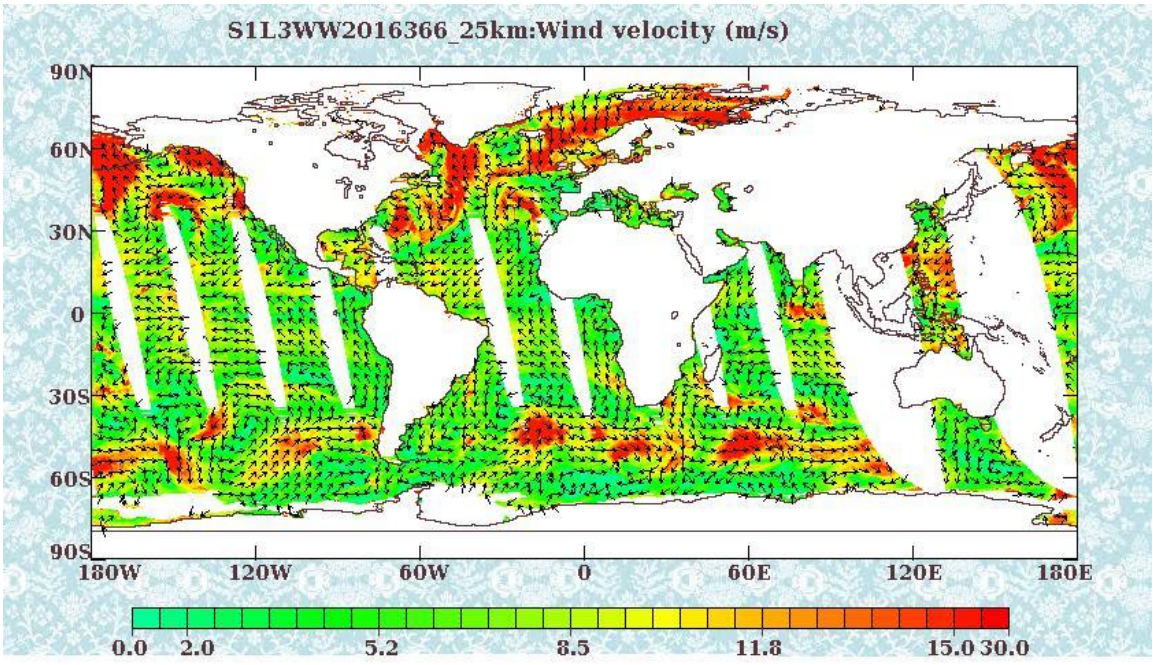
Collaboration is a crucial keyword in space research. This is of fundamental importance for both enabling groundbreaking scientific results and making the definition and implementation of complex missions affordable.

Prof. Lorentz Bruzzone (Fellow IEEE)

Major Remote Sensing Mission of ISRO in 2016-

- *Cartosat-2 Series*
- *Scatsat-1*
- *Resourcesat-2A*

IEEE-Gujarat Section-GRSS Organized Record Breaking Events In The Year 2016



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Editor's Pen

The period that followed the last issue (December 2015) has been spectacular in the area of Remote Sensing in many respects. Closer at home, we had witnessed the launch of an impressive Indian satellite mission Scatsat-1 in September 2016. This has carried a Scatterometer operating in Microwaves. This was preceded by Oceansat-2 (2009) which also carried a Scatterometer. The capability of Scatterometers in measuring surface winds over global oceans make them important tool for societal applications, especially in times of natural hazards like impending cyclones. Oceansat-2 Scatterometer had provided critical information of Typhoon 'Kabayan' near Philippines and Hurricanes 'Irene' and 'Sandy' to the US, besides several cyclones in the Indian Ocean. We are happy to carry a lead article on Scatsat-1 in the present issue.

Frequency of occurrence of natural hazards (eg., Cyclones/Hurricanes/Typhoons, Avalanches, Tsunamis, Landslides, Cloudbursts, Forest Fires, and many others) is seen to increase in recent times. Timely dissemination of the early information of such hazards will go a long way in preventing huge losses of precious human lives and resources. Remote Sensing can undoubtedly play a very important role in this. It will be desirable if a comprehensive article on this is published in one of the future issues of our Newsletter.

The present issue of the Newsletter is carrying an Interview with a leading scientist, associated with IEEE, Prof Lorenzo Bruzzone. He is teaching subjects related to Remote Sensing and Electrical Communications at the University of Trento, Italy. He had been a member of the joint NASA-ESA Science Definition Team for Radar Instruments for Outer Planet Flagship Missions. We are very fortunate to have Prof Bruzzone as our guest interviewee in this issue.

The present Issue also carries a collage of our activities besides several other informative columns in this issue.

Enjoy Reading!

Dr. Abhijit Sarkar
Editor, IEEE GUJARAT SECTION -GRSS CHAPTER

Members Updates

Dr. Ami Desai: Received IEEE Grant of 1750 US dollars for presenting her paper entitled "Modelling of lunar crater ejecta extend for highland and mare using mini-rf data" at IEEE-IGARSS 2016 in Beijing

Cover Page Image: Vadodra Region as seen from optical (Resourcesat-2A) and Global Wind Vector product from Scatsat-1 sensors from space [Image courtesy ISRO and MOSDAC]

Message from the Chairman's Desk

Dr. Shiv Mohan.

It gives me immense pleasure to see the growth and performance of IEEE GRSS Gujarat Society, established in June 2013 by a group of renowned scientists and professionals of Gujarat region. The Society represents members working on applications of Geosciences, representing various institutes like Space Applications Centre (SAC, ISRO), Physical Research Laboratory,CEPT University, NIRMA University, Gujarat University, MS University, Corporate sectors, and freelancers working towards science and educational services. During the year 2016, Society organized a very large number of events in the basic training and advancement in the area of remote sensing and applications. The Society thus has served the purpose of bringing the professionals from International and National institutes on a common platform by organizing the events such as Workshop, Training Courses and Lectures by specialists. In addition, our Chapter has established its own website, which is updated regularly. The Chapter has also contributed towards working as a technical sponsor for an International Conference. Thus, the Chapter has established its presence at National and International level which has imparted confidence not only to our members, but also received appreciation from International and National professionals. All this was feasible because of team effort of our members who have worked hard as IEEE volunteers of the Society. After overwhelming response on preceding issues of our Newsletter, our editorial team has brought out December 2016 issue. At this moment, I congratulate IEEE GRSS members for their outstanding contribution in bringing out this issue of the Newsletter.

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

IEEE- Gujarat Section GRSS Chapter Members' Meet at Aashray Restaurant, Ahmedabad on July 2016

Event Reports

OUT- REACH PROGRAM FOR STUDENTS ON NATIONAL SCIENCE DAY (FEBRUARY 2016)

IEEE-GRSS Gujarat celebrated 'National Science Day' on February 29, 2016 by organizing popular lectures for graduate and post-graduate students by eminent scientists at St Xavier's College, Ahmedabad. The event was commemorated with popular lecture on 'Remote Sensing for Societal Benefits' delivered by Dr. Ajai, Professor Emeritus, followed by talk on 'Indian Mars Mission – Early Results' by Dr. A.S. Arya, Head of the Planetary Science division in Space Applications Centre, ISRO, Ahmedabad. The speakers vividly brought out the prospects and potential of remote sensing technology for the use of the common man and the opportunities the Indian Mars mission brought towards the study of planets and natural satellites.

Students at the popular lecture

The event was attended by over 100 students and faculty members from various colleges in Ahmedabad, who interacted with the experts during the lectures.

Invited speakers with the college faculty and IEEE-GRSS members

WORKSHOP ON HYPER-SPECTRAL REMOTE SENSING (March 2016)

Faculty of Technology, in collaboration with IEEE Gujarat Section Geoscience and Remote Sensing Society (GRSS) and Indian Society of Geomatics (ISG) - Ahmedabad Chapter organized a workshop on Hyperspectral Remote Sensing on 01 March 2016 at CEPT University.

The workshop invited distinguished faculty Prof. Melba M Crawford from Purdue University, Indiana, USA for the lead talk. Eminent scientists from the Space Applications Centre (SAC), ISRO and the Physical Research Laboratory (PRL), Ahmedabad were also invited to deliver talks on related topics in the workshop. The workshop was participated by over 60 students, faculty members and scientists from IIT-Gandhinagar, NIRMA University, CEPT University, MG Science College, SAC and PRL. The participants showed keen interest on the recent developments in hyper spectral imaging techniques and applications.

There were six lectures delivered in the workshop. The first two lectures were delivered by Prof. Crawford, who presented the basics of Hyper-Spectral Remote Sensing'' and the 'Advanced Classification Methods for Hyper-Spectral Data'. Prof. Crawford elaborated on the opportunities and

Prof. Melba M Crawford delivering a talk

Participants listening to the speaker at the workshop

challenges of hyper spectral data with various case studies and also emphasized on the critical issues of atmospheric corrections, data dimensionality reduction, spectral un-mixing and classifications of hyper spectral data, in her lectures. Following her lectures Mr. Manish Mittal of SAC, Ahmedabad deliberated on the 'Development of Hyper-Spectral Remote Sensors in ISRO' for past and future terrestrial and planetary missions. Following to that Dr. Bimal Bhattacharya of SAC, Ahmedabad presented on the status of 'Hyper spectral Remote Sensing in India' and the ongoing 'AVIRIS-NG Airborne Campaign over India'. He informed the audience that the airborne AVIRIS-NG successfully completed the first phase of its campaign over India and the mission will survey more than 60 study sites in India proposed for various land, atmospheric and oceanic applications. Dr. Debabrata Banerjee of PLANEX, PRL delivered talk on 'Remote Sensing for Planetary Explorations', while Dr. Neeraj Srivastava of PLANEX, PRL presented interesting results obtained from the hyper spectral sensors of Indian Chandrayaan-1 mission and Mars Orbiter Mission during his talk on 'Hyper spectral Remote Sensing of Moon and Mars', in the workshop.

Participants with Prof. Crawford and other IEEE-GRSS and ISG members at the workshop

IEEE Distinguished Lecture Program (DLP) (March 2016)

IEEE-GRSS Gujarat in association with the Indian Society of Geomatics and CEPT University organized IEEE lecture by Prof. Melba M Crawford of Purdue University (USA) on March 01, 2016 at CEPT University, Ahmedadad under the IEEE Distinguished Lecture Program (DLP). Prof. Crawford delivered lecture on "Active Learning Strategies for Classification of Hyper spectral Data" and discussed about advanced methods in machine learning, including active learning, for analysis of hyperspectral data. Prof. Crawford started the lecture with brief introduction of IEEE-GRSS and its activities and appealed the audience for larger participation in the development of remote sensing technology for advances in geosciences and encouraged for IEEE-GRSS membership. Her lecture was highly

Prof. Melba M Crawford at the lecture

acclaimed by the audience where she brought out the key issues of classifications of hyper spectral data using examples from airborne and space-borne imagery.

The lecture was attended by many professionals comprising members of the IEEE-GRSS, ISG, students and academic faculties of various institutions of Ahmedabad and Gandhinagar and scientists from SAC and PRL.

Audience interacting with Prof. Crawford during the lecture

Special Workshop session on Hyper spectral remote sensing (March, 2016)

Workshop on Hyperspectral Remote Sensing was organized jointly by the Indian Society of Geomatics (ISG), IEEE Geoscience & Remote Sensing Society (Gujarat Section), Society of Geomatics (Vadodara chapter) & Indian Science Congress Association (Baroda branch). The event took place in Maharaja Sayajirao University (MSU) of Baroda on March 02, 2016 and witnessed about 100 participants. The guiding theme was for Hyperspectral Remote Sensing and its applications in land cover mapping, 'Going to Basics'

The workshop began with a prayer and university song. Prof G. Sandhya Kiran, Head of the Department of Botany, and Convenor of ISG and ISCA Chapter and gave a warm welcome in her welcome address to Dr. Shiv Mohan, Scientist from PRL and Chapter convener IEEE GRSS Gujarat Section, Prof. Melba Crawford and Prof A.C. Sharma, Dean Faculty of Science, The Maharaja Sayajirao University of Baroda, and all other learned audience.

Prof. Melba Crawford on the Dias

Prof. A.C. Sharma Dean Faculty of Science, MSU addressing the gathering

Dr. Dharmendra Shah gave a brief introduction about the Department of Botany and Dr. C.S. Buch introduced ISG and ISCA chapters giving a summary of the activities carried out by these chapters. Dr. Shiv Mohan introduced the keynote speaker Prof. Melba Crawford who is the Purdue Professor of Excellence in Earth Observation, the Director of the Laboratory for Applications of Remote Sensing. The keynote speaker Prof. Melba Crawford, in her opening address gave an overall view of IEEE-GRSS. She explained different activities carried out by the society and the benefits provided to the members and encouraged the audience to join this society. Later, she defined the word 'Hyperspectral Remote sensing in a wide variety of terms. She also briefed on data processing, its applications and its future opportunities and challenges. Hyperspectral and Multispectral Perspectives, Statistical Classification Methods, Digital Image Processing, Statistical Analysis of Spatial/Temporal Processes, Analysis of Remotely Sensed Data, was also explained. Prof, A.C. Sharma Dean Faculty of Science, gave his presidential address and interacted with the speaker regarding different hyperspectral data issues. The program concluded with a vote of thanks by Dr. Suryanarayan, Associate Professor from Civil Engineering Department followed by National Anthem.

Dr. Shiv Mohan, welcoming the speakers

A section of the audience at MSU paying attention to the speaker during the workshop

Prof. G. Sandhya Kiran, Convenor of ISG and ISCA addressing the gathering

Dignitaries on the dais

Training Workshop on Microwave Remote Sensing (May, 2016)

IEEE-GRSS Gujarat in association with the Indian Society of Geomatics (ISG) organized one-week training workshop for the research scholars and faculty members of engineering colleges on 'Microwave Remote Sensing Applications' at the Centre for Continuing Education (CCE), Nirma University, Ahmedabad during May 23-28, 2016. The training program was attended by 16 participants with diverse fields of interests, representing different institutions across India. This training covered topics related to the basics and advanced techniques in microwave remote sensing, SAR data processing and analysis techniques and it's applications in agriculture, urban planning, ocean, atmosphere and disaster management. Hands on training on SAR data processing with various space-borne SAR data was incorporated in the training.

Dignitaries at the inaugural function

Mr. Deepak Putrevu of SAC-ISRO providing overview of Indian Microwave Remote Sensing Programme

The resource persons for this training program were selected from reputed institutions such as Space Application Centre (SAC), ISRO - Ahmedabad, Indian Institute of Technology (IIT)-Bombay, Institute of Technology of Nirma University - Ahmedabad and Gujarat Institute of Disaster Management (GIDM) - Gandhinagar based on their rich scientific and practical experiences in microwave remote sensing. The workshop started with lecture on 'Overview of Indian Microwave Remote Sensing Programme and RISAT-1' by Shri. Deepak Putrevu from SAC, ISRO. Following to that Dr. Shiv Mohan, former scientist SAC, ISRO & Physical Research Laboratory (PRL) and Chair, IEEE-GRSS Gujarat conducted two lectures on 'Basics of Microwave Remote Sensing and Synthetic Aperture Radar (SAR)' and 'SAR Image Interpretation and Analysis'.

Ms Rutu Parekh, member IEEE-GRSS conducting hands-on training with the participants

Dr. Shiv Mohan, delivering lecture on fundamentals of Microwave Remote Sensing

Prof. Y.S. Rao from CSRE, IIT-Bombay delivered lectures and conducted practical sessions on 'SAR Interferometry Principles, Differential InSAR and PSInSAR Techniques' and 'Principles and Applications of SAR Polarimetric Techniques'. Prof. P.R. Patel, Civil Engineering department of Nirma University delivered lecture

on 'Ground Survey of subsidence area using GPS' followed by lectures on 'SAR applications in Soil Moisture Retrieval' by Dr. Shiv Mohan and 'SAR Applications in Agriculture' by Dr. Bindi Dave from GIDM. On the final day Dr. Aiswarya Narain (Former Scientist of SAC-ISRO) delivered lecture on 'SAR Applications in Disaster Management' and Dr. Abhijit Sarkar (Former Scientist of SAC-ISRO) delivered lecture on 'SAR Applications in Oceanography'.

The hands on tutorials were conducted by IEEE-GRSS members Dr. Sriram Saran and Ms. Rutu Parekh, with various space-borne SAR data from Indian and foreign sensors, using different open-source and indigenously developed software. Feedback from the participants were collected and participation certificates were provided to the participants after completion of the training program.

Participants paying attention to a demonstration of indigenously developed SAR data analysis software

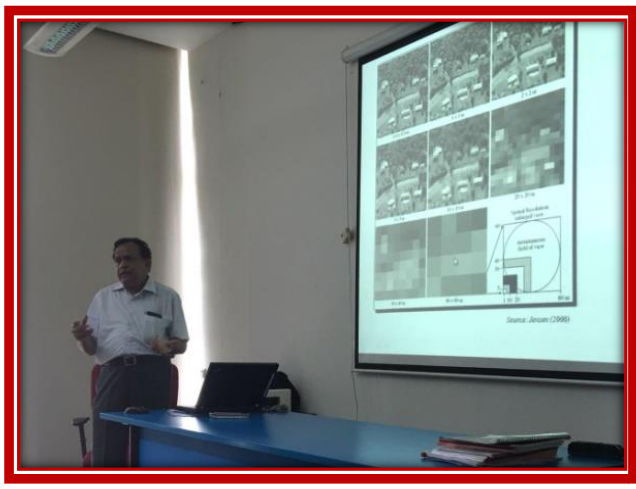
Participants listening to Prof. Y.S. Rao from IIT-Bombay delivering lecture on SAR Interferometry

A section of the participants with faculty members

A participant receiving certificate on completion of the training workshop

One Day workshop on basics of Remote sensing, Applications (August, 2016)

IEEE-GRSS Gujarat in association with Gujarat Institute of Disaster Management (GIDM) organized one-day training workshop on 'Basics of Remote Sensing, GIS and its Applications' at GIDM, Gandhinagar on August 30, 2016. The program was mainly for the beginners of the remote sensing technology. Course content of the training workshop included basics of remote sensing and its applications in various disciplines of geosciences and planetary sciences. For delivering lectures, scientists and faculty members from reputed institutes like SAC/ISRO, PRL and GIDM were invited. About 60 PG students from various institutions in Ahmedabad and Gandhinagar, participated in the workshop.



Dr. Shiv Mohan delivering lecture at the workshop

Participants paying attention to a lecture

Participants during a lecture at the workshop

Dr. Bindi Dave and Dr. Sriram Saran delivering lecture at the workshop

The faculties who delivered lectures in the workshop included Dr. Shiv Mohan, former scientist & head, SAC-ISRO and Chair, IEEE-GRSS Gujarat Section, Dr. Aishwarya Narain, former scientist & head, SAC-ISRO and vice-chair, IEEE-GRSS Gujarat, Dr. Sriram Saran, Research Associate, SAC-ISRO, Dr. Ami Desai, Assistant Professor, GIDM, Ms. Shaily Gandhi, Research scholar, CEPT university, Dr. Madhumita Tripathy, Research Scientist., GIDM and Dr. Bindi Dave, Research Associate, GIDM.

National Seminar on Remote sensing – Enabling our (October, 2016)

IEEE-GRSS Gujarat Section along with the Indian Society of Geomatics (ISG) - Vadodara Chapter conducted National seminar on "Remote Sensing - Enabling Our Future" at The Maharaja Sayajirao University (MSU) of Baroda, during October 7-8, 2016.

The program was attended by undergraduate & Post graduate students, research scholars as well as the faculties of the M.S University (MSU). Many dignitaries from various discipline shared the knowledge on various aspect of remote sensing techniques and applications. Among the dignitaries were Prof. G. Sandhya Kiran, Head of the Department of Botany, MSU, Chairperson of ISG, ISCA and IWSA (Vadodara Chapters), Chief Guest of the function Dr. D.K. Das, Associate Director, SAC-ISRO, Ahmedabad, Dr. Ajai, Emeritus Scientist &

Former Group Director SAC- ISRO Ahmadabad, Dr. Shiv Mohan, Chair, IEEE GRSS Gujarat, Dr. A. Narain, Vice Chair, IEEE GRSS Gujarat, Dr. C.B.S. Dutt, Ex- Deputy Director, Earth and Climate Sciences, NRSC, Hyderabad, Dr. A. S. Rajawat, Head, Geo Science Division, SAC-ISRO and Prof. A.C. Sharma, Dean, Faculty of Science, MSU.

Delegates on the dais during inaugural function

Participants listening to a lecture

Award given by Dr A. Narain for best oral presentation

Group photo of invited dignitaries

On the first of the seminar, technical sessions were conducted in which, many scientists were invited for talks to share their knowledge and experience. On the second day also, few technical sessions were conducted with invited lectures of scientists from Indian Agricultural Research institute (IARI) and ISRO. Concurrently oral presentations of research works conducted by scholars from MSU and other universities were held in the technical sessions on both the days, which grabbed much attention. Total 11 papers were presented. The invited talks and the oral papers during Seminar were highly appreciable.

The seminar ended with panel discussion by eminent scientist from ISRO/PRL along with ISG/IEEE executive members who brought out a future road map for development of research interests in remote sensing technology among the undergraduate and post graduate level students through teaching, training, workshops and other outreach programs.

INTERVIEW SECTION

An Interview with Prof. Lorenzo Bruzzone

The Editorial Committee is fortunate to have Dr Lorenzo Bruzzone for our Interview Column. He is the Head of the Remote Sensing Laboratory in the Department of Information Engineering and Computer Science, University of Trento. Professor Bruzzone teaches Pattern Recognition, Radar, and Electrical Communications, besides Remote Sensing. He has been associated with the Editorial Committees of IEEE Geoscience and Remote Sensing, IEEE Geosciences and Remote Sensing Letters, IEEE TGRS, Canadian Journal of Remote Sensing and IEEE Geoscience and Remote Sensing Newsletter. He has made significant contribution to NASA/ESA Science Definition Team for Radar Instruments for Outer Planet Flagship Missions. The Editorial Committee of IEEE Gujarat Section's GRSS Chapter Newsletter are grateful to Prof Bruzzone for giving this Interview.

Q: 1 You had extensively worked on the design of Radar Sounder for exploring subsurface layers of ice moons of Jupiter. What are the prospects of Radar Sounders in other planetary missions, undertaken by different space agencies?

A: 1 Radar sounders for the analysis of the subsurface of planets and their moons have been currently used in a very limited number of missions at Mars and the Moon. Currently the Radar for Icy Moon Exploration (RIME) is under development in the framework of the JUpiter ICy moon Explorer (JUICE) mission of the European Space Agency (ESA). RIME science objectives are related to the analysis of the Jupiter icy moons Europa, Ganymede and Callisto. Also NASA is working to a mission to Europa that includes a radar sounder. However, there are many others interesting targets for which there are currently studies for possible missions with radar sounders on board, including Venus, Titan, Enceladus, asteroids and comets. Moreover, there are studies for the development of an Earth Observation satellite mission with a radar sounder for subsurface analysis.

Q: 2 India at present is actively engaged in missions aimed at exploration of Mars and Moons. Your suggestions for new generation of sensor types?

India has all the required skills to play a primary role at international level

India is currently deeply involved in space with both Earth Observation and Planetary Exploration missions. I think the technical expertise and the know-how available in this country will push for new and always more challenging developments in the space exploration. It is difficult to provide specific suggestions for new generation sensors from space, but of course having reliable, miniaturized and robust technology is a driving factor for playing a primary role in the field. Here India has all the required skills to play a primary role at international level.

Q: 3 In view of the fact that different space agencies are launching satellites with near-identical specs. What is their scope in applying multi-temporal remote sensing? What are the gains and limitations?

There are missions that share the same target (e.g., Mars) but often have complementary payload on board. Sometime the same kind of instrument is considered but with different resolution or with the capability to acquire complementary data. In other cases, as in Earth Observation, there are also constellation of satellites with the same payload so that the revisit time is improved and thus result in an efficient temporal monitoring of the Earth surface. This is crucial for applications related to change detection connected for example with emergency management and damage assessment in natural disasters. More in general the cooperation among different agencies is crucial to have the capability to fully exploit in a synergistic way different data that can result in enhanced scientific results when combined.

Q: 4 What are the areas where there is scope of close collaboration in research of radar design for scientific space missions?

Collaboration is a crucial keyword in space research. This is of fundamental importance for both enabling groundbreaking scientific results and making the definition and implementation of complex missions affordable. Planetary missions, and to a less extent also Earth Observation satellites, are complex and expensive and often difficult to implement at the level of a single agency. This is an important factor that pushes in the direction of international cooperation. There are many examples of missions with instruments on board developed through the cooperation of different agencies. This is also the case of radar instruments, where for example RIME for the JUICE mission is developed under the leadership of Italian Space Agency with contributions from NASA in the framework of an ESA mission. There are many other examples that also include ISRO that is cooperating with NASA JPL for an Earth Observation SAR mission.

ISRO is cooperating with JPL-NASA for an Earth Observation SAR mission- NISAR

Q: 5 As you are aware the Himalayan regions of our country are frequently affected by natural hazards such as Landslides and Avalanches. Can you suggest some necessary research work using Remote sensing techniques which can help to obtain early information on these occurrences?

Earth Observation has the capability to monitor many different natural hazards. Landslides can be studied and monitored by using SAR data in the framework of interferometry, differential interferometry, and the related developments. Under proper assumptions this technology makes it possible to estimate the velocity of displacement. It is also possible to identify avalanches, but under specific conditions on the size of the avalanches and the related characteristics. For sure in these areas further research is required for improving our current capabilities, also integrating remote sensing with other ground based or UAV technologies. More in general the large number of remote sensing data available from satellites and the reduced revisit time of the most recent systems (e.g., the Sentinel family of satellites of ESA developed under the Copernicus program) offer many possibilities for monitoring different kinds of natural hazards.

Q: 6 Many young scientists and students here would like to get their work published in IEEE Journals/Magazines. They will be happy to read a few encouraging words from you.

India is strengthening its position in the international remote sensing community and there are many Indian scientists who regularly publish their research results in IEEE journals. I encourage young scientists and students to develop their research and then to submit their paper to IEEE journals. It is very important when doing this to take properly into account the different targets of different IEEE journals dealing with geoscience and remote sensing published by the IEEE Geoscience and Remote Sensing Society. We have: i) the IEEE Transactions on Geoscience and Remote Sensing (TGRS), which target is to publish full papers with relevant novel methodological contributions; ii) the IEEE Geoscience and Remote Sensing Letters (GRSL), which target is the fast publication of novel contributions not fully mature or not deep enough for a full paper; iii) the IEEE Journal on Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS), which publishes novel contributions on applied remote sensing; iv) and the IEEE Geoscience and Remote Sensing Magazine (GRSM), which publishes tutorial papers, survey contributions and high quality technical papers without requiring methodological novelty. I would like to take advantage of this opportunity for pointing out that currently there is an open call for papers for a special issue of IEEE JSTARS which is focused on remote sensing in India. I strongly encourage the readers to submit their work to this special issue.

India is strengthening its position in the international remote sensing community and there are many Indian scientists who regularly publish their research results in IEEE journals. I encourage young scientists and students to develop their research and then to submit their paper to IEEE journals

ARTICLE CORNER

Scatsat-1 ISRO's Eye in Space for Ocean Wind Vector

Maneesha Gupta, Suchandra Bhowmick
Space Applications Centre, ISRO, Ahmedabad
e-mail: maneesha.nano@gmail.com; maneesha@sac.isro.gov.in; suchandra@sac.isro.gov.in

1.0 Introduction

SCATSAT-1 is a continuity mission of OSCAT, carrying a dual polarized pencil beam Scatterometer launched by PSLV C-35 on 26th September 2016. The payload is operating at a Ku band frequency of 13.5 GHz by conically scanning the earth; covering a swath of 1800 Km from an altitude of 720 Km in a Polar Sun synchronous orbit. The repeativity of entire globe is two days. Like OSCAT, it is a miniature satellite for providing measurements of wind velocity over the ocean surface as a key objective. Other major objectives of SCATSAT-1 is weather forecasting, cyclone prediction along with ocean state monitoring and prediction. It is currently catering towards weather and climate sector, naval and shipping operations, renewable energy sector along with tracking services to India as well as to the world. *This payload is efficient to its ancestral Oceansat-2 scatterometer in terms of better resolution over the globe*. In comparison to earlier OSCAT mission this mission undergoes various challenges in terms of payload hardware, number of modes of data acquisitions, resolution, data processing and products quality etc. The mission specifications are described in table 1.

Table 1. Mission Specification SCATSAT-1 (*MOSDAC Site)

Launch date	September 26, 2016
Launch site	SDSC (Satish Dhawan Space Centre), Sriharikota.
Launch vehicle	PSLV - C35
Orbit	Sun Synchronous, dawn-dusk orbit
Altitude	720 km
Inclination	97.4°
Local Time on Ascending Node	6:00 hours
Repetitively	2 days
Payloads	Scatterometer
Mass at lift off	310 Kg
Power	15 Sq.m Solar panels generating 1360W, Two 24 Ah Ni-Cd Battries
Mission Life	5 years

2.0 SCATSAT-1 Payload and its Objectives

The winds over the oceans play a significant role in deciding global atmosphere. It is important to have knowledge of ocean winds at global scale at a good temporal resolution to predict future weather. Historically, the measurements of winds have been provided by Ocean buoys and ships. The buoys are accurate but are sparse geographically. The ships cannot provide measurements at regular time interval. The satellites can provide wind measurements covering entire world at regular time interval. Hence, satellites carrying various fan-beam as well as pencil-beam Scatterometer have been launched by various countries for serving this purpose in both C band and Ku band frequency. The Ku-band has advantage of better sensitivity to capillary waves at all wind speeds and ability to provide higher resolution with a smaller antenna. The Scatterometer on board Oceansat-2 (OSCAT) was a pencil beam Scatterometer operating on Ku band

frequency. The sigma0 and wind vectors generated by the Oceansat-2-Scatterometer have been used and appreciated by international organizations such as NASA, NOAA, KNMI and EUMETSAT. After discontinuation of service by OSCAT, the SCAT-2 was designed as continuity mission of OSCAT and was flown onboard SCATSAT-1 satellite by ISRO. The experience of OSCAT, gives a challenge to ISRO scientist to improve its hardware to provide flexibility and better performance. The payload will have two modes, normal mode and enhanced mode. The normal mode is designed to work similar to OSCAT. The enhanced mode will provide additional features in terms of Higher precision of sample and noise data, Post deramping FFT with or without windowing and programmable features like processing and noise bandwidths, start binning position for S+N samples and noise samples, number of bins per slice for S+N samples and overlapped binning for S+N samples. Also, Information about I/Q reversal of reference chirp, and the higher volume of data resulting from larger processing bandwidth or finer range resolution of slices. Similar to OSCAT, the Scatsat-1 system has a 1-metre parabolic dish antenna and a dual feed assembly to generate two pencil beams and is scanned at a rate of 20.5 rpm to cover the entire swath. The Ku-band pencil beam scatterometer is an active microwave radar operating at 13.515 GHz providing a ground resolution cell of size 25 x 25 km. The parabolic dish antenna of 1 meter diameter is offset mounted with a cant angle of about 46 degree with respect to earth viewing axis. This antenna is continuously rotated at 20.5 rpm using a scan mechanism with the scan axis along the +ve Yaw axis. By using two offset feeds at the focal plane of the antenna, two beams are generated which will conically scan the ground surface. The back scattered power in each beam from the ocean surface is measured to derive wind vector. The inner beam makes an incidence angle of 48.900 and the outer beam makes an incidence angle of 57.600 on the ground. It covers a continuous swath of 1400 km for inner beam and 1840 km for outer beam respectively. The inner and outer beams are configured in horizontal and vertical polarization respectively for both transmit and receive modes. The aim is to provide global ocean coverage and wind vector retrieval with a revisit time of 2 days.

Table 2. SCATSAT-1 payload specifications

Parameter	Inner beam	Outer beam
Orbital altitude	720 km	
Instrument frequency	13.515 GHz (Ku-band)	
Wind speed range	3-30 m/s, accuracy of 1.8 m/s (rms) or 10%	
Wind direction	00 to 3600, accuracy of 200 rms	
Wind vector cell size (resolution)	25 km x 25 km grid	
Polarization	HH	VV
Swath width	1400 km	1840 km
Scanning circle radius	700 km	920 km
Scanning rate	20.5 rpm	

3.0 Data Product Overview

Scatsat-1 data provides wind vector at a cell size or resolution of 25km x 25km. This data is well calibrated and is given to various agencies. NASA, NOAA, EUMETSAT, KNMI etc. are the potential users of this data. The turnaround time for the product generation is significant in such missions to predict the near real time ocean phenomenons. Data from Scatsat-1 comprises of four levels i.e. scan mode Level-1B, grid mode Level-2, Global grid Level-3 and High Resolution Level-4 products. Table 3 describes the data products from Scatsat-1. The data processing of Scatsat-1 mission is operational at National Remote Sensing Centre of ISRO and is disseminated from the SAGAR webportal (). Also, the Value added products i.e. Level-4 products having high resolution winds is available for users at MOSDAC webportal (details discussed in table 3). User can access the product by login to MOSDAC (www.mosdac.gov.in)and NRSC SAGAR (www.sagar.nrsc.gov.in) webportal.

Table 3. SCATSAT-1 Data Product specifications [source: MOSDAC, SAC, ISRO Ahmedabad]

Level	Description	Parameter	Spatial Resolution	Format	NumProdsPerDay
Level 1B	Scan mode	Sigma0	~6kmx30km	HDF5	2*14.4
Level 2A	Swath grid	Sigma0	25kmx25km and 50kmx50km	HDF5	(P*R) 2*2=4*14.4
Level 2B		Wind velocity		HDF5	(P*R) 2*2=4*14.4
Level 3S	Global grid	Sigma0	0.5°x0.5° and 0.25°x0.25°	HDF5	4
Level 3W		Wind velocity		HDF5	2
Level 4 (INDIA, NPOLAR,SPOLAR)	Image form	Sigma0	2kmx2km	GEOTIFF	6 + 4 + 4
		Gamma0		GEOTIFF	6 + 4 + 4
		BT	6.25km x 6.25km	GEOTIFF	6 + 4 + 4
Level 4 (FULL GLOBE)	Image form	Sigma0	2kmx2km	GEOTIFF	6
		Gamma0		GEOTIFF	6
		BT	6.25km x 6.25km	GEOTIFF	6
Level 4 (Analyzed Winds)	Gridded wind	Wind Vectors	25kmx25km	NETCDF	1
Level 4 (High Resolution Winds)	Swath grid	Wind Vectors	6.25kmx6.25km	NETCDF	2*14.4

Table 4- Level-4 Product Details [source: MOSDAC, SAC, ISRO Ahmedabad]

Category	Sub-category	Spatial Extent	
		Lat. Range	Lon. Range
India	VVDES, VVASC, VVBOTH, HHDES, HHASC, HHBOTH	[6:40]	[64:100]
FullGlobe	VVDES, VVASC, VVBOTH, HHDES, HHASC, HHBOTH	[-90:90]	[-180:180]
NorthPolar24	VVDES, HHDES	[60:90]	[-180:180]
NorthPolar72	VVBOTH, HHBOTH	[60:90]	[-180:180]
SouthPolar24	VVBOTH, HHBOTH	[-90:-50]	[-180:180]
SouthPolar72	VVASC, HHASC	[-90:-50]	[-180:180]

Category	Product Generation for all sub-categories
India	Generated once every day using L1B products of last 48 hours, so 6 products per day per parameter
FullGlobe	Generated once every day using L1B products of last 48 hours, so 6 products per day per parameter
NorthPolar24	Generated once every day using L1B products of last 24 hours, so 2 products per day per parameter
NorthPolar72	Generated once every day using L1B products of last 72 hours, so 2 products per day per parameter
SouthPolar24	Generated once every day using L1B products of last 24 hours, so 2 products per day per parameter
SouthPolar72	Generated once every day using L1B products of last 72 hours, so 2 products per day per parameter

4.0 SCATSAT-1 from user's perspective

Wind vector observation over data sparse ocean is the primary objective of scatterometer instruments. It is also one of the major players for study of polar ice and tropical vegetation. Scatterometer also have a proven history of being useful for mapping the sea ice extent right from time of NASA's NSCAT. The SCATSAT data too is in the similar line, have several such applications. The major applications panned under the SCATSAT utilization program of ISRO, includes the forecast of the meteorological hazards like cyclones and storms, ocean state forecasts, monitoring of crop and vegetation, polar ice sheet monitoring, soil moisture mapping etc. Success of all these applications depends on the accuracy of measured backscattering coefficient (σ^0). Hence an ideal application program begins with the in-flight calibration of a satellite scatterometer, (as this is not guaranteed by its pre-launch absolute calibration tests), a rigorous retrieval chain for extracting wind from σ^0 using a geophysical model function (GMF). This is followed by validation of the retrieved wind along with the user specific applications of wind and backscatter.

Post launch calibration of σ^0 and validation of the correspondingly retrieved wind with respect to the in-situ observation /other contemporary scatterometer instruments, is one of the required activity under the application theme which is followed by all other applications mentioned above. The calibration essentially assesses time evolution of the accuracy of measured σ^0 by the scatterometer. It points out at any sudden change in the attitude of the space borne instrument that may cause any spurious anomaly in the measured σ^0. In case of scatterometer this is performed using relative calibration over land targets with trivial spatio-temporal variation of σ^0. Over such targets one can access the consistency of near-simultaneous

measurements from fore and aft looks and biases between the ascending and descending passes of the scatterometer. A few such targets are Amazon, Greenland, Antarctica etc. that are historically used for calibrating scatterometers. Similar type of calibration is performed in case of the SCATSAT-1. Following the calibration chain, validation of the retrieved wind product with the available observations from other sources determines the manifestation of the calibration error in the ultimate product of wind. This essential chain of validation in case of SCATSAT-1 would contain comparisons with in-situ observations, other satellite derived winds and NWP models. Left panel of the Figure -1 shows the variation of the sigma-0 in each of the slices of outer and inner beam of SCATSAT in 2days of L1B data over the entire globe. The right panel shows look biases over the slices of each beam.

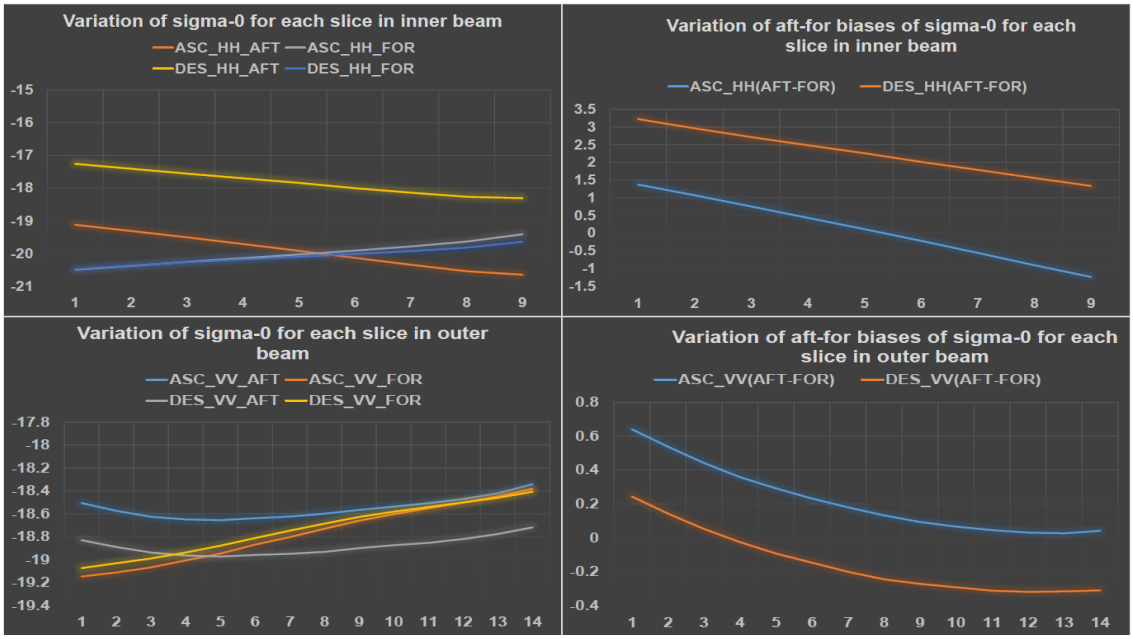


Figure-1. The variation of the a) sigma-0 b) Look biases with the slices for inner and outer beam over the entire globe (computed using two days of L1B data.

Very clearly at slice level variation of look biases over the entire globe is around 2.5 dB for HH which is 0.6 db for VV this shows a good slice balancing. The look biases over the calibration targets like amazon is shown in figure -2 for descending pass of HH and VV. It shows the variation between ±0.25dB over isotropic target of the calibration site confirming the excellent quality of measurement from SCATSAT-1.

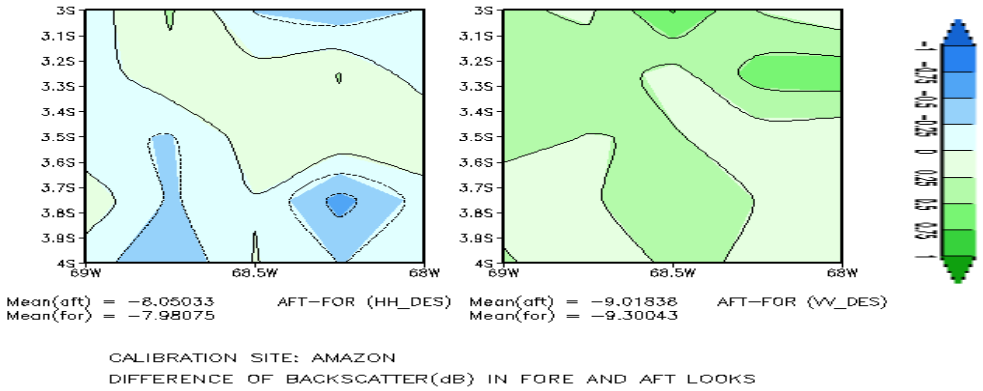


Figure-2. The look bias (differences of sigma-0 in aft and fore look) over calibration site at Amazon for month of April -2017

The overall quality of the retrieved wind is evident from the comparison of the SCATSAT wind speed and direction with that of ASCAT (figure-3).

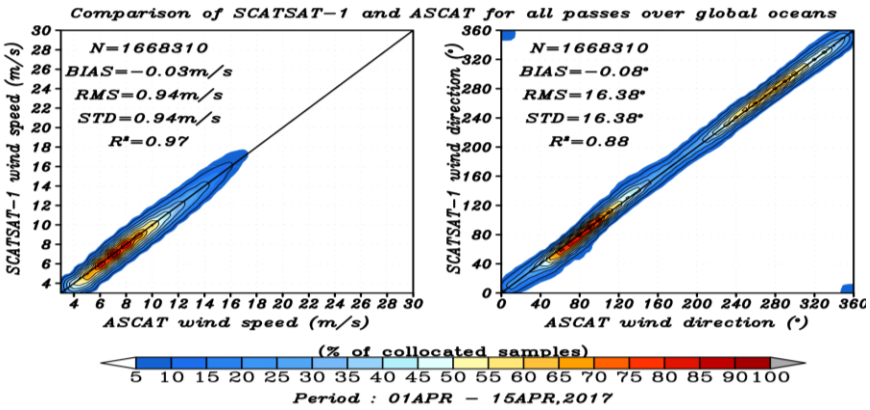


Figure-3. The inter-comparison of SCATSAT-1 wind speed and direction with that of ASCAT scatterometer.

Clearly the RMSE is less than 1m/s in speed and around 16° in direction which imply a **high quality of retrieved wind from SCATSAT**. Few of the most important applications that were initiated using the scatsat-1 wind data includes the study of the cyclogenesis as shown in figure 4 in case of cyclone Mathew. The analyzed wind is also prepared using the SCATSAT data for making it fit for forcing the numerical models which requires a continuous wind field.

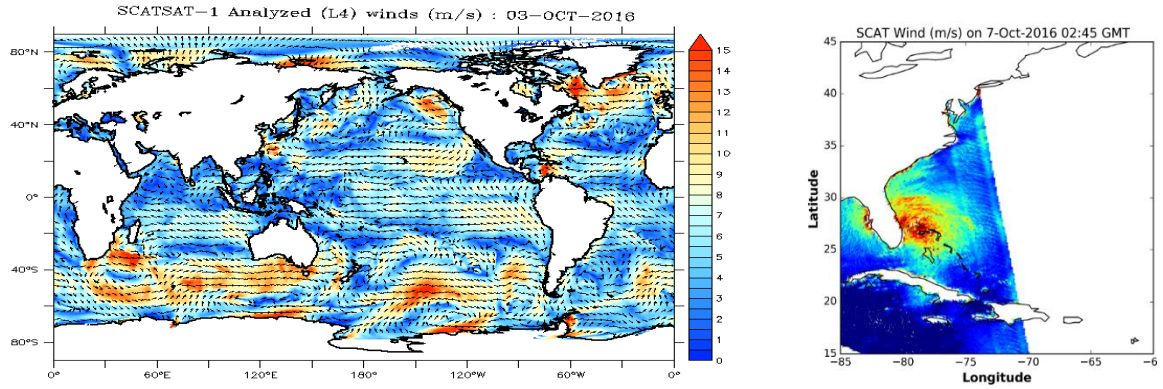


Figure-4. a) SCATSAT-1 analyzed wind speed and direction and b) SCATSAT-1 observed wind speed over cyclone Mathew at instant of landfall.

5.0 Conclusion

Over all the SCATSAT data is of very high quality and is extremely suitable for a dozens of application. It is currently operational and providing high quality wind products. User can login to MOSDAC and NRSC webportal for continuous accessing of data.

6.0 References

- Suchandra Aich Bhowmick, Raj Kumar, and A. S. Kiran Kumar , Cross Calibration of the OceanSAT -2 Scatterometer With QuikSCAT Scatterometer Using Natural Terrestrial Targets- IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 52, NO. 6, JUNE 2014
- Raj Kumar, Suchandra Aich Bhowmick, K. N. Babu, Rahul Nigam, and Abhijit Sarkar, Relative Calibration Using Natural Terrestrial Targets: A Preparation Towards Oceansat-2 Scatterometer, IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 49, NO. 6, JUNE 2011

Events for the Year 2017

1. Meeting of IEEE-GRSS Gujarat Section members	Feb, 2017
2. popular lecture on Remote Sensing for Undergraduate Botany students by Dr Shiv Mohan, Chair, IEEE GRSS, Gujarat, M G Science Institute	Feb, 2017
3. Distinguish lecture on Hyperspectral Image Analysis with applications of UAVs for precision agriculture by Dr Lori M Bruce, Mississipissi State University, USA venue: CEPT University, Ahmedabad.	March, 2017.
4. Distinguish lecture on Hyperspectral Remote sensing and applications by Dr Lori M Bruce, Mississipissi State University, USA venue: L D Engineering College, Ahmedabad.	March, 2017.
5. Special lecture on . Advancing Careers in Science & Engineering by Dr Lori M Bruce Mississipissi State University, USA venue: L D Engineering College, Ahmedabad.	March, 2017.
6. One day workshop on remote sensing , NIDM, Gandhinagar, Ahmedabad	Aug, 2017
7. Workshop on recent advances in microwave remote sensing.	Nov 2017
8. Two day training workshop on SAR polarimetry by Prof Eric Pottier	Dec 2017

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Dr. Abhijit Sarkar
Editor, IEEE Gujarat Section, GRSS-Gujarat 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-Gujarat Chapter
Building 47 A, Room No. 4702, IAQD/SPDCG/SIPA
Space Applications Centre, ISRO
Jodhpur Tekra, Anbawadi, Ahmedabad, 380015
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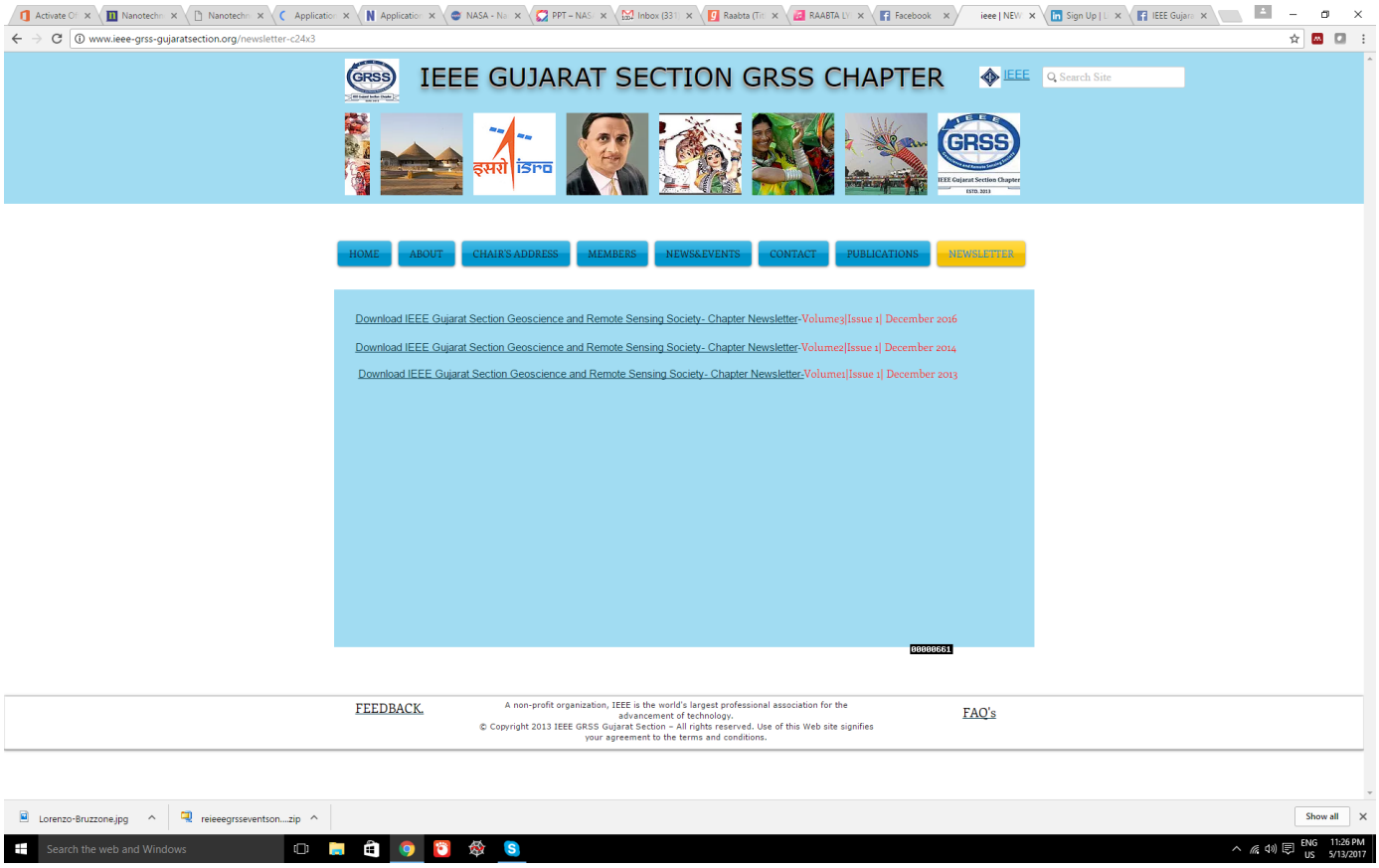
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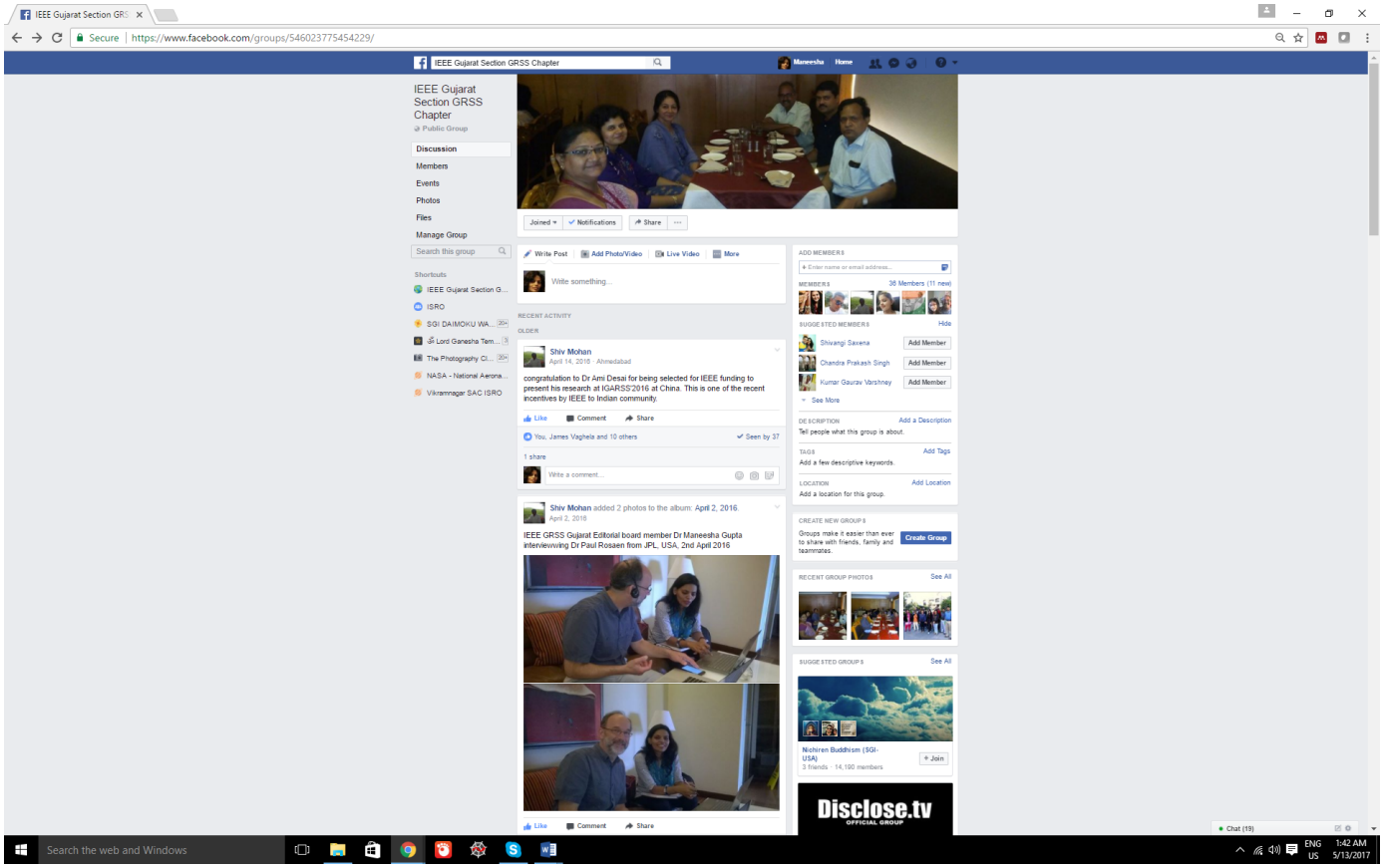
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