An ISRS Ahmedabad Chapter Newsletter

Volume 28, Issue 1
March 2021

Special Issue on

Women in Remote Sensing and GIS

Signatures

Inside this issue:

FROM THE EDITORIAL DESK

"Nothing in Life is to be feared. It is only to be understood.

Now is the time to understand more, so that we may fear less" — Dr. Marie Curie

Once again, we are with you!

"*Signatures*" is different this time. It's celebrating the vivacity of women scientists: to inspire, to grow and to empower. Women at large, have contributed significantly in the field of Remote Sensing and GIS. To celebrate and thankfully acknowledge the contributions made by these women scientists in Remote Sensing and GIS from technological advancements, payload (microwave and optical) development, advanced technique development and application demonstration for the societal use, the present issue of *Signatures* has articles contributed by women scientists and engineers. The editorial team appreciatively acknowledges all the contributors who agreed to be part of this special issue. We are sincerely grateful to the library and publishing team for their timely support.

Yet another enthralling feature of this issue is an interview with Shri Nilesh M Desai, Distinguished Scientist and Director, Space Applications Centre, Ahmedabad, who has expressed his views very candidly on many contemporary aspects pertaining to space sector reforms, pandemic, his exciting journey and inspiring message to young scientists and engineers. The team is indeed grateful to him for sparing his valuable time from his busy schedule to share his thoughts.

Signatures, as usual, also brings forth the activities of ISRS-AC, along with the regular information about science breakthroughs, remote sensing news , bits of scientific humour and member contributions.

We hope this edition of *Signatures* will enthuse the readers and they will have a very different flavour. Let's acknowledge and salute all those women who have contributed immensely in scientific endeavours through their sheer dedication, passion and sincerity. So sit back, relax and enjoy the reading.

At last but not the least, the team would be happy to receive feedback/comments/ suggestions, which will help us in improving our future editions.

*Wishing all the lovely women out there, a very **Happy Women's Day 2021** with a shout-out to those who pursue their quest for science.*

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CHAIRMAN'S ADDRESS

SHRI RAJEEV JYOTI

It is heartening to know ISRS chapter is coming out with this special edition of Signatures, celebrating the role of "Women in Remote Sensing and Geographical Information System (GIS)". I would particularly like to congratulate the Editorial team of Signatures who conceptualized and brought out this issue on the occasion of International Women's Day -2021.

Women are doing outstanding work in all branches of medicine, science and engineering. Women scientists are not only empowered by their grit, perseverance and determination, they also inspire awe by their adaptability and resilience. As an elucidation, it was always well documented that the COVID-19 pandemic had significant impact on women scientists, predominantly distressing those at the initial phases of their career, probably flaring the gender inequality in science. Nevertheless, at the same time, the occurrence of the COVID-19 pandemic has evidently established the crucial role of women researchers in multiple stages of the fight against COVID-19, from evolving the knowledge on the virus, to bring forth emergent techniques for testing, and finally to invent the vaccine against the virus.

Against this backdrop, this year's theme of International Women's Day "Choose to challenge" resonates powerfully to reinforce the resilience of women scientists during this tough time. On a similar note, ISRS-AC's initiative towards dissemination of scientific ideas, pledge for equal opportunities promotes knowledge sharing in an unprejudiced structure. This special theme centred on women contributions embodies ISRS-AC's commitment for science and society.

Wishing the editorial team the very best to continue their efforts for the hallmark "Signatures".

Wish you all a healthy, happy and rewarding time ahead.

Rajeev Jyoti
Chairman, ISRS-AC
Deputy Director, MRSA,
SAC-ISRO, Ahmedabad

SECRETARY'S REPORT

DR. D. RAM RAJAK

Let me wish you a Happy International Year of Peace & Trust, 2021!

It is a matter of happiness that this issue of Signatures is a special issue on 'Women in RS & GIS'. When I came to know about it, the words that struck my mind are: Woman, ocean of peace & trust, cradle of sustainable development! And, it is a good co-incidence that this women specific issue of Signatures is being released on International Women's Day 2021 when we are already sailing in International Year of Peace & Trust and in UN Decade of Ocean Sciences for Sustainable Development.

*The previous issue of Signatures was released in December 2020 during the ISRS-ISG National Symposium 2020 (ISRSNS2020) and Annual Convention that was organised by ISRS-AC with Space Applications Centre, ISRO, Ahmedabad. It was the first time that the event was organised in an ONLINE mode. The ISRSNS2020 was scheduled during December 18-19, 2020 and the theme of the symposium was "**Remote Sensing for Environment Monitoring & Climate Change Assessment: Opportunities and Challenges**". The chapter was also involved in the preparations of Silver Jubilee Celebration of IRS-1C Launch organised by ISRS, held on December 28, 2020. We received many messages from various well-wishers all across the country, for very professionally and excellent conducting of the events by ISRS and SAC, DECU teams and our event manager, MMActiv.*

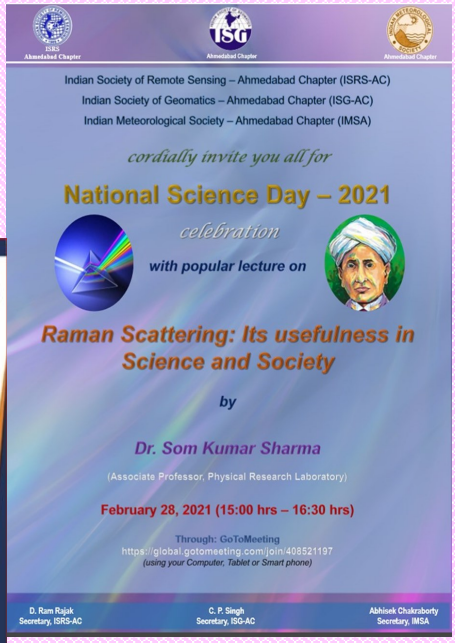
A thanksgiving program was organised on January 4, 2021 at Yashpal Auditorium, SAC, Ahmedabad. President, ISRS (Shri Nilesh M Desai) and Chairman, ISRS-AC (Shri Rajeev Jyoti) gave critical comments and observations made during the ISRSNS2020 and SJIRS1CL events and appreciated the efforts made by the organising committee. They also physically presented the ISRS-2020 awards (already declared during ISRSNS2020) to SAC scientists. We organised a popular lecture (with ISG-AC and IMSA) on 'Raman Scattering' on the occasion of National Science Day 2021 (Feb 28). The lecture was delivered by Dr. Som Kumar Sharma, Associate Professor, PRL, Ahmedabad. The title of the talk was "Raman Scattering: Its usefulness in Science and Society". I am sure with the active support of ISRS-AC members, we will be able to organize many scientific events in the coming days.

Let us come together and give a big hand to the vivacious editorial team of Signatures for bringing out this special issue, full of substance!

D. Ram Rajak
Secretary, ISRS-AC
Scientist, SAC-ISRO, Ahmedabad

ISRS-AC ACTIVITIES

DECEMBER 2020—MARCH 2021



AN EXCLUSIVE INTERVIEW WITH

SHRI NILESH M DESAI

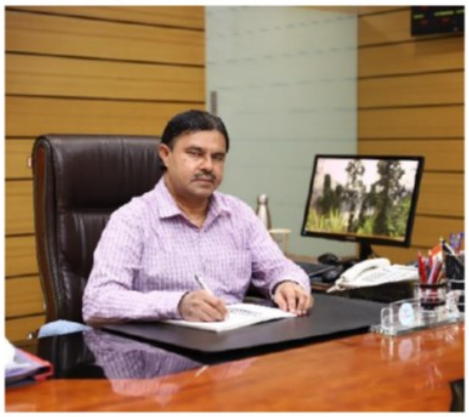
DIRECTOR, SPACE APPLICATIONS CENTRE, ISRO

Signature Team Congratulates

Shri Nilesh Desai (President , ISRS)

For assuming charge of

Director, Space Applications Centre, ISRO



PERSON OF EMINENCE

Shri Nilesh Desai, Distinguished Scientist, assumed charge with effect from 1st January, 2021, as the Director of Space Applications Centre (SAC), Ahmedabad, Born on 1st April, 1964 at Navsari, Gujarat, Shri Nilesh Desai, is a top ranker and gold-medalist of 1985/86 BE (Electronics & Communication) batch of L. D. College of Engineering, Gujarat University, Ahmedabad, India.

Shri Nilesh Desai is a highly accomplished Engineer, who has successfully led the design and development of ISRO's airborne & Spaceborne Microwave Remote Sensing Payloads like RISAT-1 C-Band Synthetic Aperture Radar (SAR), Oceansat-2 and Scatsat-1 Scatterometers, Chandrayaan-2 Orbiter SAR and Lander Altimeter and Hazard Detection & Avoidance Processing System, Airborne SAR for Disaster Management, MiniSAR etc. and associated Signal & Data Processing and Remote Sensing Applications. He was also responsible for the design & development of different types of real time data processing techniques, User Receivers for indigenous NavIC (Navigation with Indian Constellation) satellites and SatCom Hub Earth Stations and user terminals for Mobile, Broadband & High Throughput communication satellites. He has been the main author or co-author of about 175 technical papers presented at various national and international conferences within and outside India. He has also contributed significantly in more than 225 technical reports of SAC/ISRO. He has represented ISRO/India at various International forums at Austria, China, France, Germany, Israel, Russia, Singapore, South Africa and United Kingdom, including delegations at International Committee on Global Navigation Satellite System (ICG) meetings & conferences. Most recently, he organized and presided over the last ICG-14 held in India during Dec.-2019. He is the recipient of ISRO Performance Excellence Award-2018, ISRO Individual Merit Award-2010 and ISRO Team Award for RISAT-1 Payload Design, Realization and Data products for the year-2012.

AN EXCLUSIVE INTERVIEW WITH

SHRI NILESH M DESAI

DIRECTOR, SPACE APPLICATIONS CENTRE, ISRO

Signatures: Sir, you have worked on many state of the art projects of ISRO, Please shed some light over your experiences and the challenges en-route.

Reply : At the outset, let me extend my warm greetings to the Signatures Editorial team for their creativity and efforts in bringing out this special issue, celebrating the pivotal role that women are playing in science and technology.

Coming to the specific question, let me tell you that I have worked with dedicated and talented individuals, many of them women, who have found innovative solutions to the challenges posed and this made my journey easier. My first tryst with digital technology at SAC, was the development of Quick Look Display for X-Band Side Looking Airborne Radar (SLAR). This was followed by my maiden research experience with the then new and emerging field of microwave remote sensing in SAC & ISRO, which involved Radar Signal Processing and other radar technologies. To begin with, I designed Real Time Range & Azimuth Signal Processor system for C-Band Airborne Synthetic Aperture Radar (ASAR) and that challenging effort was very well appreciated. Thereafter, I got exposure to various facets of Radar technologies while working on ISRO's Microwave Remote sensing Programme, involving both Active and passive microwave radar systems and associated Payload developments and radar signal Processing Systems. Each challenge was an opportunity to learn, explore and improvise, which had been my "mantra" all along. Every mission brought its own set of challenges and complexities, be it RISAT-1 & follow-on missions, Oceansat-1 MSMR, Oceansat-2 and ScatSat-1 Scatterometer and Megha Tropiques missions. Meanwhile, I also worked on various Technology Development Programmes (TDPs), which fed into various payload development activities like Chandrayaan-2 Orbiter SAR, Lander Radar Altimeter and S-band SweepSAR for NISAR. Thereafter, I was made to change the course and I worked on SatCom and SatNav Applications involving VSAT and MSS Technologies and NavIC Receivers to meet various user Applications. I can only say that it was God's grace and my luck that I could gain wide experience and exposure in diverse fields of Remote Sensing and ComNav Payload development and associated Applications, thereby covering all gamut of activities being carried out in a multi-disciplinary centre like SAC. And all throughout, I got the cooperation and support of my team members and these team efforts have only brought out the best results.

Signatures : Sir, what are your views regarding the recent liberalization of policies governing the acquisition and production of geo-spatial data and how it will boost the economy and impact the space sector ?

Reply : Geospatial Policy liberalization will pave its way for a wide range of location based applications and provide impetus to established ventures as well as startups in the fields of navigation services, area specific applications, etc. and will also create an unprecedented user demands and development in the country. This will have a potential impact of boosting the Indian economy hit hard by recent Covid-19 pandemic. Space in particular, will club up with a myriad of avenues and support a wide range of activities in the fields of transportation, agriculture, healthcare, disaster mitigation etc.

AN EXCLUSIVE INTERVIEW WITH

SHRI NILESH M DESAI

DIRECTOR, SPACE APPLICATIONS CENTRE, ISRO

Signatures : Sir, In the dual capacity as Centre Director and President ISRS, what are the goals you aim at and how do you view the confluence of the two entities for societal benefits?

Reply: I consider my roles as Centre director and as president of a prolific and eminent scientific and remote sensing society not to be disjoint but very intricately woven together. ISRS has a wide network of outreach amongst students, academia, researchers and industries. The ISRS activities provide the necessary feedback to various system studies, technological advancements and societal applications, which govern the prime and basic objectives of a multi-disciplinary Centre like Space Applications Centre, which has a unique place among various ISRO entities.

Signatures : Sir, what will be the new face of remote sensing in the making of आत्मनिर्भर भारत?

Reply: Remote Sensing has ample potential to be a stepping stone towards आत्मनिर्भर भारत Bharat, with the opening up of Space sector. The new Geospatial guidelines will lead to liberal National Geospatial policy (NGP-2021), which along with our own Indian NavIC (Navigation with Indian Constellation) and Indigenous Web Services and Portals like ISRO's Bhuwan, MOSDAC and VEDAS, help turn India into a self-reliant nation in the field of remote sensing technology and its applications. The new age coronation of indigenous development in remote sensing, will bring it from outer space to every nook and corner, right into the life space of a common man. This new face of Remote sensing will unveil the true potential of space applications and fulfill the dream of Dr. Vikram Sarabhai of using space technologies for societal benefits.

Signatures : In the current times, COVID-19 has threatened the lives and livelihoods of mankind. In such situations how can we, as space scientists, utilize science and technology to empower our society to face such challenges?

Reply: COVID-19 has really impacted all spheres of our lives and livelihoods. However, it has also taught us to adapt to challenges. As a space science and technology organization, with a significant role in remote sensing and GIS applications, ISRO can significantly contribute to provide latest satellite data based GIS maps with upto date geotagged information on hospitals, vaccinations centres, active hotspots zones, pathways for ambulances, pharmacies, pathologists and testing centres, in order to make the availability of medical facilities quickly and easily at any location. Of-course our technology acumens can be and are being effectively utilized to develop various innovative and cost-effective products like protective face-shields and masks, automatic sanitizer dispenser, ventilators, sanitized air flow tent /cabin, contact tracing geospatial solutions, ultraviolet (UV) sanitizer & disinfecting system, contactless temperature mapping, Thermal Camera, AI based chest radiography etc. We can carry out technology transfer of some of the innovative products & technologies to the industries and thereby, contribute to Atma Nirbhar Bharat.

AN EXCLUSIVE INTERVIEW WITH

SHRI NILESH M DESAI

DIRECTOR, SPACE APPLICATIONS CENTRE, ISRO

Signatures : Sir, you have always encouraged Science and Technology outreach activities, please share your learnings and teachings from the same.

Reply: Our scientists and technologists have gained lot of knowledge and experience in the field of space science and technology through their relentless and dedicated efforts spread over many years. Science and Technology Outreach activities are very important for minimizing the gap between the space enthusiasts and the veterans and also for encouraging the budding talents with innovative minds to join the Indian science fraternity, in general and space program, in particular in coming days. This is not a one way process, we also learn from the students and researchers, who through their innocuous and inquisitive queries and interactive discussions, make us think and ponder on new and challenging topics. As it is rightly said, 'Knowledge multiplies on sharing'. In summary, these S &T outreach activities have helped improve the overall scientific temperament of the country, as was evident from the enthusiasm and curiosity shown by citizens during missions like Chandrayaan-1, 2 and MangalYaan, and now Gaganyaan is evincing keen interest from student and researcher community.

Signatures : Sir, you have been an inspiring role model for many of our young Scientists & Engineers. What are the future directions in space science investigations and technology development which the younger generation should pursue and explore?

Reply: Current scenario calls for out of box thinking for addressing issues like climate change, deforestation, Pandemics, food insecurity, fossil fuel depletion, etc. that are key areas to address for a sustainable development of the country and mankind. We need to identify the problem areas, plan scientific and sustainable solutions and then look for developing suitable technology. The next generation strategies essentially involve meeting the varied user demands with cutting edge technologies, artificial intelligence and smart adaptations.

WOMEN IN EDUCATION: A REMOTE SENSING PERSPECTIVE

ALPANA SHUKLA, HEAD, BOTANY DEPARTMENT
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Let us look at the role of women as reflected from our ancient mythology. In her highest form she is "Shakti"- a source of energy. She is also described as "Jagaddhatri", the fosterer of the world. In Vedas and Hindu philosophy, the Supreme Power, Brahman, manifests itself in Shakti; the feminine principle in divine form. We have Durga triumphing over evil; we have Lakshmi to bring prosperity and Saraswati to remove ignorance. These deities are significant pointing to the need of the feminine principle – Shakti, to solve our problems. If we have a bird's eye view over the entire history of the evolution and achievements of mankind, we clearly see the role of women, in every era, to protect the society to solve the problem of evil and to bring and establish peace. Women in the present days, in the age of science and technology are also performing the same as depicted in ancient mythology. The form may be different but the essence is the same.

Necessity of Higher Education For Women

I refer a statement of philosopher-president and noted educationist Dr. S. Radhakrishnan (1948). He says "*there cannot be educated people without educated women. If general education has to be limited to men or women, the opportunity should be given to women. From them it would most surely be passed on to the next generation*."

Almost half of the population in India is occupied by women. They are the half of the human resources. For the socio-economic development of our country, we must accept the fact that education is the fundamental agent. Access to education is an instrument for women's equality and empowerment that raises their self-confidence and develops the aptitude/ abilities leadership qualities, thus leading to their increased participation in decision making.

'When girls are educated, their countries become stronger and more prosperous' – Michelle Obama

Today, as India is poised to becoming a superpower, women education in India has become a need of the hour, as education is the foundation for the empowerment of women enabling them to respond to the challenges, to confront their traditional role and change their life as well as the status of the country as far as Leadership is concerned. Our social and cultural progress is only through education of women at higher levels.

As Dr Vikram Sarabhai, Father of Indian Space science said, "We must be second to none in the application of advanced technologies to the problems of man and society"... Today, Women are ahead in all walks of life, contributing their best for country's development. Both, the government and civil society in India have a preoccupation in women education as educated women can play a very important role in the development of the country.

The commission on the higher education for women, University of Madras in 1979 rightly observed: for women and men college education is necessary for character formation, ability to earn, creative self expression and personal development. Over the past four decades, the number of higher education students has increased globally, and an eye catching feature of this development has been the increasing rate of women's participation in higher education. The contribution of women in the areas of technology, politics, human welfare and most importantly, education has been phenomenal. Female educators across the globe have educated,

WOMEN IN EDUCATION: A REMOTE SENSING PERSPECTIVE (CONTD.)

uplifted and influenced millions of souls.

Who are these women in the education sector?

Our country has a great number of people who are selflessly doing something in their capacity for the betterment of the society. They are never in the limelight, never invited for inaugural functions; they just keep working towards their goals. Illiteracy is still a serious problem in India and some women have taken it upon themselves to change that. Women in science from being a minority are now occupying the most important positions, in realms once thought were unachievable before. From winning Nobel Prizes to heading NASA, women scientists have etched their names in history. Although science and tech remains a male-dominated field, women like Ritu Karidhal, Chandrima Saha and others have taken on leading roles in organisations like ISRO and INSA, initiated new projects with far-reaching results. It was Dr. Purnima Sinha who broke the ceiling for women in Physics research, imparting scientific temper to ordinary people in West Bengal and her mastery in the Arts leaves her in a league of her own. Her life is testimony to the notion that anything is indeed possible.

Women in Science and Remote Sensing

Given the requisite qualifications and opportunities the women in science and technology in India can be achievers. Apart from Sunitha Wiliams and Kalpana Chawla, many women contribute silently to India's space program. Malathy Chandra Mohan, an engineer from ISRO, was one among six finally selected from thousand candidates for the American space shuttle challenger in 1987. Kamakshi Sivaramakrishnan technology is onboard NASA's New Horizon mission, which is probing Pluto.

Tessy Thomas, the 'Missile Woman' of India is the Director General of Aeronautical Systems, Muthayya Vanitha, the Project Director of Chandrayaan-2 and the first woman to lead the interplanetary mission at ISRO; Gagandeep Kang, a virologist and scientist, known for her interdisciplinary research in transmission, development, and prevention of enteric infections in children; Mangala Mani, the 'polar woman of ISRO', is ISRO's first woman scientist to spend more than a year in the icy landscape of

WOMEN IN EDUCATION: A REMOTE SENSING PERSPECTIVE (CONTD.)

Antarctica. She will soon be featured in a BBC series about women in science. In a newspaper article, she is quoted as saying, "Women are venturing into every field. Women just need to be willing, ready and take that opportunity when it comes. With the knowledge explosion, the sky is not the limit, there is much more beyond."

At the ***Department of Space***, India, there are 1163 women employees belonging to Scientific and Technical categories and 1259 women employees belonging to administrative categories, representing 17.64 percent of personnel in DOS. Many women with high qualifications and experience have reached the top.

DOS has many women Leaders: Recent statistics show more women scientists and engineers join and continue in service. They are taking leadership roles and surging ahead:

Several scientists have reached significant positions, several have received awards and presented papers at national and international conferences. This is a testament to the congenial and gender-neutral environment that is fostered in the scientific institutions like ISRO. We can expect a woman to be one of the two astronauts in ISRO's first manned mission after a decade. Institutes like IIRS, SAC, IISc, ISRO, etc. play a major role in empowering women through Remote sensing Education and Earth Observation courses. As a college Botany Teacher and a researcher in remote sensing applications, I am truly honoured to work with a team of incredibly dedicated female colleagues. Some of the best teachers in the whole world are women, and here's why:

- *They are caring and nurturing: essential characteristics when teaching and helping children and young adults*.
- *They are efficient and incredibly organised.*
- *They are passionate.*
- *They are truly dedicated to the profession They are just great teachers, period!*

All teachers, male or female, are heroes and heroines

We inspire the next generation with our tireless efforts to educate, sustain, help and care for our learners.

Remember: it is important to develop trusting relationships with students and emphasize the importance of literacy, work out a unique way of 'raising the bar' each time without making the learner realise.

So what do we take from this article on a daily basis? That's easy – smile, don't be too serious and have energy: we shall learn better because of it!

ELECTRO-OPTICAL PAYLOADS FOR REMOTE SENSING AND GIS APPLICATIONS: INDIAN ODYSSEY

NILIMA K MANGALWEDHEKAR
SEDA, SPACE APPLICATIONS CENTRE (ISRO), AHMEDABAD 380015. Email: nilimakm@sac.isro.gov.in

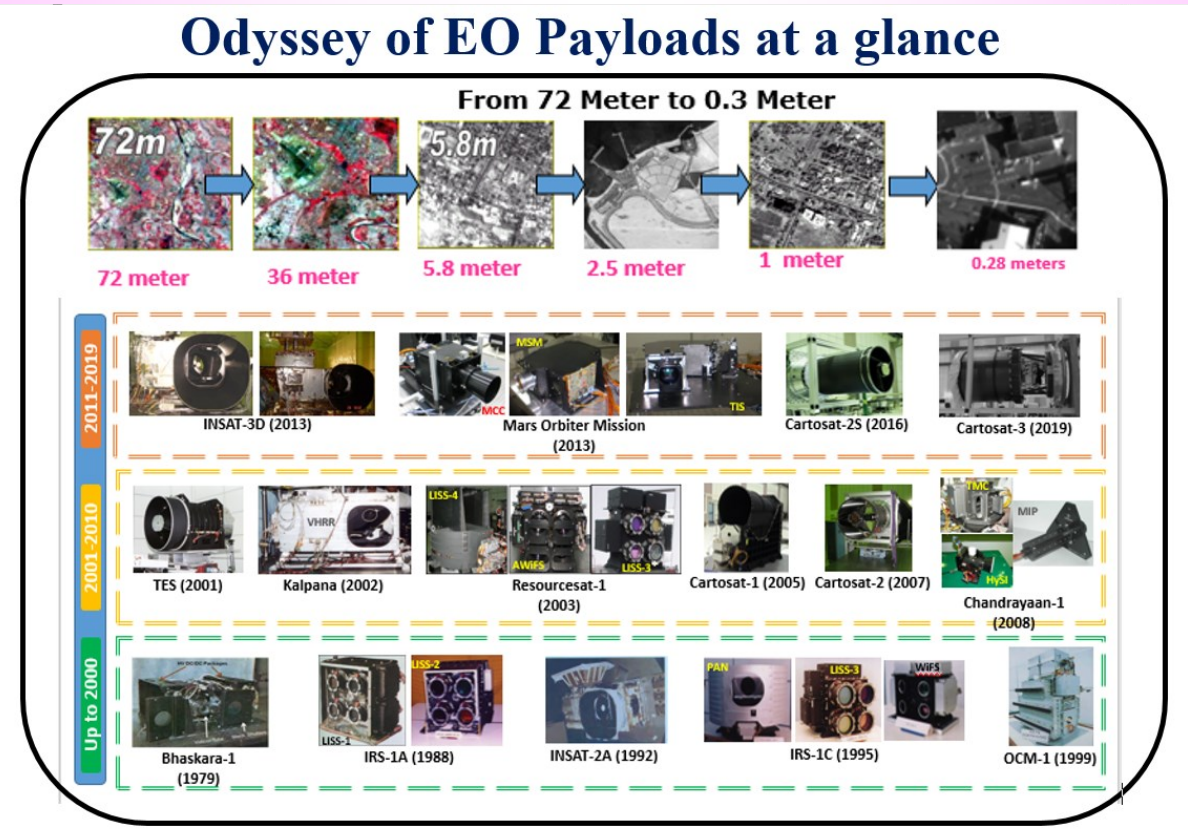
Space borne electro-optical (EO) sensors have emerged as a vital tool for variety of remote sensing applications including resource management, agriculture, forestry, GIS, town planning, disaster management, fisheries, meteorological applications, weather forecasting, atmospheric sounding and many more by virtue of earth, atmosphere, ocean, space/ interplanetary and solar observations (Basic Earth, Air, Water, Space and Fire…Panch Mahabhuta observations). State of the Art , Panchromatic, Multispectral and Hyper spectral imaging EO payloads have been developed by implementing latest technologies in the field of Optics, Electronics, Detectors, Material Science, Metrology, System integration, System calibration and Characterization for Leo, Geo and interplanetary missions.

EO payload design is initiated once the specific user requirements for the remote sensing applications like Earth, Ocean, Atmospheric observations etc. is received. Based on this, the system parameters are defined and subsequently specifications of the components for the imaging chain like optics, filters, detectors (Focal Plane Arrays) and electronics are derived. Some of the parameters studied for trade-off are focal length, aperture, field of view, pixel size, no of pixel, quantum efficiency, optical efficiency, no. of spectral bands etc. These lead to achieving desired system performance in terms of signal to noise ratio (SNR), spatial resolution, Modulation Transfer Function (MTF) for integrated system at the pre-defined orbital height. Subsequently, each sub-system is designed and developed to achieve the desired performance. Each payload development is a challenging task and requires technical skills in optics, mechanical and electronic fields.

Size of the EO payloads developed varies from a giant to button size depending upon the applications. Miniaturization i.e. achieving Small Weight and Power (SWaP) without compromising on the performance is the requirement and key feature in evolution of EO systems. Payloads for Nano and Microsatellite have an advantage of short development time, cheaper to launch and can go as a piggyback with other satellites. High functionality commercial components suitably ruggedized are used to meet the short time mission goals. IMS-1 and Mars Orbiter missions used COTS components for payload realization to meet the tight time schedule. Microsat-2A (ready for launch) is developed with metal optics and will be providing high-resolution images in MWIR & LWIR bands catering to agricultural disaster management services from an inclined orbit. Refractive, reflective, diffractive, grating based optical systems have been realized for varying applications. Currently, metal mirrors are emerging as a suitable candidate for replacing glass mirrors especially in IR range to get the benefit of lightweight, lower cost and more stability. Pure metal optics mirrors minimizes distortion of the reflected image and offers a very hard, scratch-resistant surface with low thermal distortion as angstrom level surface finish can be achieved. Indigenously fabricated metal mirrors are used in GSAT-29 communication payloads and Microsat series of satellites.

Establishment of In-house fabrication and testing facilities and close interaction with Indian industries for development of optical, mechanical and electronic components is the current trend making India self-reliant in space sector. There is vast advancement in detector technology too

ELECTRO-OPTICAL PAYLOADS FOR REMOTE SENSING AND GIS APPLICATIONS (CONTD.)



wherein state of the art detectors are designed and fabricated within the country. Indigenously developed detector was used for Methane sensor of Mars Mission. Hyperspectral Imagin Satellite (HySIS) mission was first of its kind wherein every component including detectors were developed indigenously within SAC and ISRO centres. With this dedicated launch, ISRO forayed in hyper spectral imaging sensors for land/ ocean and atmospheric applications in 2018.

Odyssey of the EO payload development at SAC

Launch of IRS-1A in 1988 laid the foundation of IRS programs. Under the IRS flagship missions, ISRO designed, developed and operationalized LISS, WiFS/AWiFS and PAN class of EO imaging sensors on-board various IRS missions namely IRS-1A, 1B, 1E, P2, P3. For fulfilling the combined requirement of higher resolution, medium resolution and larger swath with Panchromatic, multispectral and hyperspectral imaging and with high repeativity, various payloads were developed. Each payload was developed based on the knowledge and expertise gained from the previous missions with enhanced performances by implementing latest technologies and unique concepts. IRS-1C/1D payloads are the example of a unique three-tire imaging concept. OCM-1 and OCM-2 were developed for ocean and coastal area mapping. In near future OCM-3 sensor with 13 bands is envisaged for providing better spectral and radiometric performance.

ELECTRO-OPTICAL PAYLOADS FOR REMOTE SENSING AND GIS APPLICATIONS (CONTD.)

High resolution images as captured by Cartosat-2 and Cartosat-3 sensors

Dedicated stereo mission, Cartosat-1 significantly helped remote sensing and GIS applications by providing high-resolution digital elevation model (DEM) for the country on operational basis. Technology Experimental Satellite, TES with 1 m class resolution provided the knowledge and expertise for developing high-resolution Cartosat-2 payload. This sub-meter class imaging mission for GIS applications offers 0.8m Ground Sample Distance (GSD) with improved revisit time. Subsequently, four payloads in Cartosat-2S series with GSD of 0.65m in PAN band were developed and phased by 90 degree in orbit for providing daily revisit. It used a novel technique of optical butting of five TDI devices to achieve the required swath with improved signal collection. Further enhancement in spatial resolution was achieved with Cartosat-3 satellite providing 0.28m and 1.1m GSD in PAN and Multispectral imageries respectively. Indigenously fabricated large 1.2m diameter, light-weighted mirror was used in the telescope. EO Payloads have been developed for multiple applications for planetary missions also. Chandryaan-1&2, Mars mission payloads have accomplished their objectives and have provided excellent science data. Limb View Hyperspectral Imager (LiVHySi/Youthsat) was developed for Airglow measurements. INSAT-3D was the first Indian satellite from geostationary orbit with atmospheric sounding capability providing valuable information over India and surrounding oceanic region, which proves to be pivotal for numerical weather predictions. Geo Imaging satellite (GISAT-1 and 2), INSAT-3DS, payloads for Chandrayaan-3 are envisaged with better imaging capabilities. Interferometric measurement based HySI sensors, LIDARs for terrain and atmospheric mapping, polarization sensors, small satellite constellations, thermal imagers, high-resolution sensors, etc. are new technology elements envisaged for future satellites.

In the last three decades, ISRO has taken major technological leap in the field of EO sensor design, development and operationalization for remote sensing and GIS applications. EO images/data and GIS are so interwoven that without EO images/ data ,GIS solutions are difficult and in reverse, GIS

ELECTRO-OPTICAL PAYLOADS FOR REMOTE SENSING AND GIS APPLICATIONS (CONTD.)

usage is demanding EO data with innovative technologies, on-board intelligences to enable faster and user ready image delivery to wide range of users for unleashing variety of commercial applications. The trend is for IMAGES ANYTIME ANYWHERE with real-time geo-rectification, seaming, organising and making available images as they stream or within 24-48 hours of image acquisition. Major challenge lies in image data analysis.

Sensor development area at SAC is geared up to take new challenges and have already embarked on various technological development programs and R&D activities with more emphasis on innovative imaging strategies, state-of-the-art components/subsystem design & development, techniques, on-board processing capabilities, integration, testing and calibration activities. This will make ISRO fully '*Atmanirbhar*'.

In the odyssey of EO payload developments, many woman scientists and engineers have put in their extra-ordinary efforts in design, development, testing and characterization of optical systems, detectors and focal plane systems, mechanical systems, electronics systems and integrated payloads. By virtue of their technical knowledge, management capabilities and dedication to projects, women have achieved greater heights in position and received global recognition, which is an inspirational for young women scientists and science students. In coming years, they will have a major role to play in realization of the high-tech imaging sensors for remote sensing and GIS applications. '*Sky is not the limit for women!*'

Interesting Space Facts

The radio signal that a spacecraft uses to contact Earth has no more power than a refrigerator light bulb

The average temperature on Venus is more than 480 degrees Celsius — hotter than a oven

The microgravity environment of space causes premature aging in astronauts

American astronauts at the International Space Station (ISS) get most of their water by recycling and recovering the water lost through sweat and urine or while brushing or making coffee using the Water Recovery System, which NASA introduced in 2009

You can see 20 quadrillion miles on a clear night

FRONTIER TECHNOLOGIES IN MICROWAVE REMOTE SENSING: EYEING THE FUTURE

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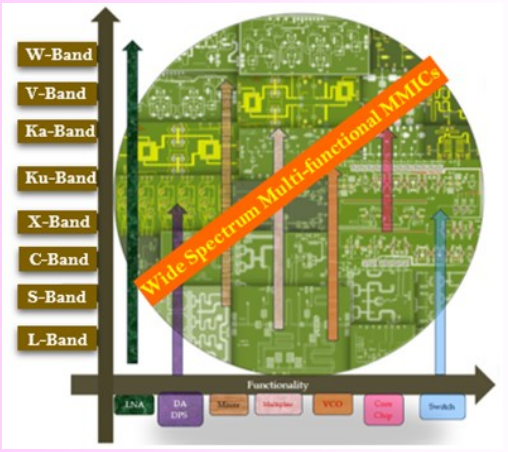
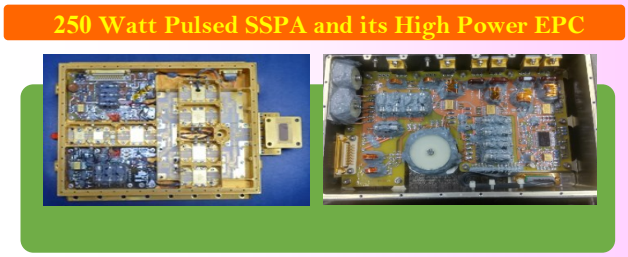
Introduction

Microwave Remote Sensing, encompassing both active and passive sensing techniques, is a very dynamic field driven by advancements of microwave sensor technology elements ranging from RF and digital electronics to processing techniques and data retrieval algorithms. Because of their long wavelengths, compared to the visible and infrared, microwaves have ability to see through cloud cover, haze, dust and heavy rainfall, making them vital for all-weather and day-and-night imaging for weather and climate monitoring. Microwave sensors are extremely valuable as they cater to diverse applications like, agriculture, forestry, geology, hydrology, disaster-monitoring, oceanography, cryosphere, archaeology, strategic-applications, etc. This article highlights the frontier technologies in microwave remote sensing payloads of Microwave Remote Sensors Area (MRSA), Space Applications Centre.

Advancements in RF/Microwave Technology

ISRO embarked upon its journey of microwave remote sensing for earth observation with Bhaskara-I satellite in 1979, which had a passive microwave radiometer 'SAMIR' operating at 19.35 GHz and 22.235 GHz for studies of ocean state, atmospheric water vapour and cloud liquid water content. With the focus on indigenization, ISRO's microwave remote sensing journey has taken a giant technology leap since its inception, with state-of-the-art technological advancements viz. Gallium Arsenide (GaAs) and Gallium Nitride (GaN) Monolithic Microwave Integrated Circuits (MMICs), Low Temperature Co-Fired Ceramic (LTCC) based T/R Modules, high power GaN based solid state power amplifiers (SSPAs) and associated high power EPCs. ISRO's first active array SAR Radar Imaging Satellite-1 (RISAT-1), launched in April 2012, the only C-band SAR in the world capable of giving 1 m resolution over 10 km x 100 km spot, had the entire set of technologies associated with the payload indigenously built. It consisted of more than 1000 sub-systems working in symphony, out of which 576 were Transmit Receive Modules (T/R Modules) having thousands of multi-functional GaAs Monolithic Microwave Integrated Circuits (MMICs), which were packaged and qualified for





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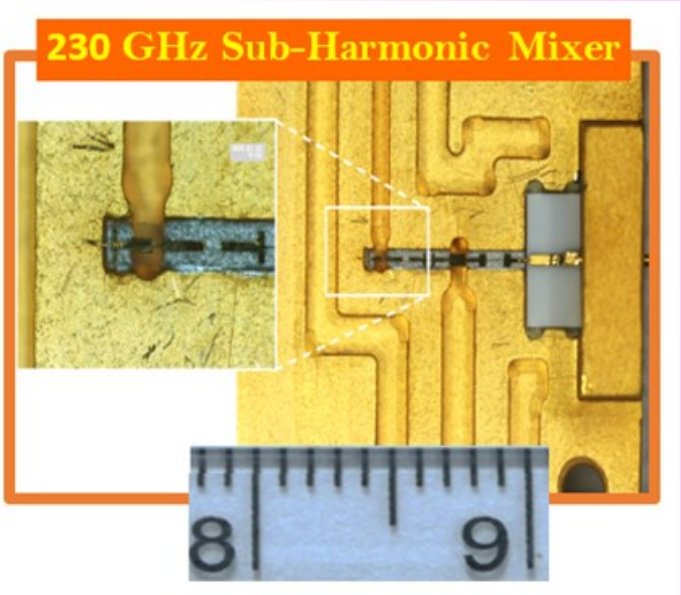
space use.

RF designers in MRSA took the first step towards proud leap of multi-functional custom-designed GaAs and GaN MMICs for microwave remote sensing payloads, which were fabricated using space-qualified foundries, and then successfully qualified for space use. Ka Band Radar Altimeter on-board the Chandrayaan-2 Lander mission became the first payload where in-house designed GaAs MMICs were extensively used. On-going microwave payloads of ISRO like RISAT-1A and 1B, NISAR (NASA-ISRO SAR), Chandrayaan-3, and RISAT-2A are being realized with thousands of these custom-built state-of-the-art MMICs.

Along with devices and circuits, packaging technology is also crucial to accommodate these densely packed chip functionalities efficiently, in addition to meeting the hermeticity requirements for MMIC packaging. One such development is LTCC based T/R Modules. ISRO's indigenous space qualified Low Temperature Co-Fired Ceramic (LTCC) fabrication facility has been successfully used for realization of more than 375 flight model of miniaturized LTCC based T/R Modules for ongoing microwave remote sensing payloads like RISAT 1A, RISAT 1B and NISAR. NISAR Mission, a joint collaboration between ISRO and NASA for development of a dual-band L and S-Band SAR payload, proves ISRO's technological prowess amongst space faring nations.

Further, 50 & 45 Watt GaN HEMT based L&S-Band SSPAs have been successfully developed and space-qualified for dual-frequency SAR of Chandrayaan-2 Orbiter. 250 Watt GaN based X-Band pulsed SSPA and its high power EPC with overall efficiency greater than 83% has also been successfully realized and flown on-board RISAT-2B satellite series.



Advancements in Millimeter/Sub-mm wave Technology

mm-wave technology finds enormous applications in radiometers, sounders, imaging systems and radars, as it offers multitude of benefits viz. miniaturized systems, large bandwidths associated with high frequencies, interesting propagation characteristics. However, for true exploitation of mm-wave region, the key requirement involves development of mm-wave MMIC based RF front-ends and associated LOs, which was demonstrated in engineering model of 50-60 GHz temperature sounder and 183±16GHz Humidity Sounder with in-house development of almost all the required critical technologies for realizing the mm-wave circuits and sub-systems.

Continuing the thrust for building and indigenizing state-of-the-art technologies and benchmarking the design expertise up to mm-wave, ISRO has

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Glimpse of Digital Subsystems

ventured into the sub mm-wave and THz domain with the vision to bridge the "Terahertz Gap" in technology that exists between microwave and IR/optical/UV wavelengths and the mission of indigenous development of the "country's first sub-millimeter wave Telescope". The major technological challenge at sub-mm wave frequencies is to develop high sensitivity cryogenically cooled sub-mm wave receivers in order to detect the faint molecular lines having intensities of the order of few Jansky/Ω. Ongoing sub-mm wave technology developments include 40K cooled, sub-harmonically pumped, Schottky Barrier Diode (SBD) mixer based receiver front-ends at 220-230GHz and 330-345GHz along with associated MMIC based LO sources at 112.8GHz and 169.2GHz.

Advancements in Digital Technology

Last two decades have witnessed design and development of powerful digital sub systems for various microwave remote sensing payloads of ISRO. With the evolution of ultra-high speed Digitizers, Digital to Analog Converters, all programmable FPGAs with large logic resources, ASICs etc., the complex on-board processing (Digital Beam forming, Digital Filtering, On-board processing for Computer Vision based autonomous landing, wideband signal synthesis), payload and active antenna control (Command, co-ordination and status monitoring of various subsystems of the payload and active antenna) tasks have been implemented across various digital subsystems like Data Acquisition and Beam Former Subsystem (DABF), Chirp Generator-Data Acquisition and Compression Subsystem (CGDACS), Digital Processing Unit (DPU), Payload Controller (PLC), Tile Control Unit (TCU) and T/R Controller (TRC). A great deal of hardware optimization and innovation has been done in subsystems like Digital Subsystem for Ka-band Radar Altimeter to meet the severe constraints of Chandrayaan-3 mission. Complex signal processing tasks like digital filtering, Digital beam forming, synchronization of multiple channels prior to digital beam forming among many other features has been successfully implemented in DABF subsystem for NISAR mission. Due to these advancements, the effective output data rate from the payload has reduced by a large factor (~60%) in addition to substantial

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reduction in mass, power and volume requirements.

In order to leverage the benefits of on-board processing for SAR missions with minimum turnaround time, the first and foremost requirement is the ability to generate precise SAR images on-board the spacecraft. This futuristic capability is particularly essential for various planetary missions wherein downlink rates and earth visibility time are at a premium. As a precursor to on-board SAR processor development, various real time SAR processing systems based on multiple-DSP processors, GPGPU's and multi FPGA's have been developed at MRSA/SAC. Currently, design activities related to hardware realization of on-board SAR processor as well as implementation of algorithm is under progress. Various indigenous RHBD on-board controller ASICs has been developed based on 180nm CMOS process of SCL. Advanced Radar controller ASICs are currently under development in MRSA for future microwave missions.

Conclusion

WE, team MRSA, acknowledge the progress we have made so far, nonetheless we are on a magnificent journey of technological advancements and IT's A LONG WAY TO GO, AS WE DREAM FOREVER MORE…

Recognition of Women Space Scientist of SAC by Delhi Commission for Women during IWD-2021

Delhi commission for women (DCW) felicitated seven women scientists of the team Chandrayaan-2 from ISRO, namely Smt. Vanitha M (URSC), Smt. Kalpana K (URSC), Smt. Kalpana Aravind (URSC), Smt. Ritu Karidhal (URSC), Smt. G. Padmanabhan (VSSC), Smt. K. P. Lilly (IISU), Smt. Priyanka (SAC) with International women's day award 2021 in a ceremony held at Delhi on the 8th March 2021. Honorable Chief Minister of Delhi graced the occasion. Some of other prominent people awarded at the ceremony included Captain Tanya Shergill, the first woman in the country who became parade adjutant for Republic Day; CRPF's Daredevil biker squad led by inspector Seema Nag; Shikha Pandey, a member of the Indian cricket team and an air force jawan; the Head constable of Delhi police, Seema Dhaka, and many other police officers who have saved lives while on duty.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING IN REMOTE SENSING

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Introduction

There is an increasing interest in using artificial intelligence (AI) and machine learning to automatically analyse remote sensing data and increase our understanding of complex environmental systems. The remote sensing scientists find its application in identifying vegetation crops, simulating urban growth models, weather forecasting, flood and drought prediction, mapping land cover and image enhancement etc. With the availability of high computational power and large amounts of remote sensing data including satellite data, LIDAR, very high-resolution drones and unmanned aerial vehicles (UAVs), it is considered as an area of "Big Data". Artificial intelligence is useful in merging information acquired from these sources for generating faster and optimal solutions for societal benefit.

Broadly, AI refers to the ability of computers to perform a task that typically involves some level of human intelligence. Machine learning is one type of AI engine that has the capability to learn and improve from data and experience without being specifically programmed. Many studies have found that these methods tend to produce higher accuracy compared to traditional parametric methods, especially for high-dimensional complex feature space (Ghimire et al. 2012). One type of machine learning that has recently emerged useful in the remote sensing domain is Deep learning. Deep learning uses computer-generated neural networks (more than two layers), which are inspired by the human brain, to solve problems and make predictions. It exploits feature representations learned from data, instead of hand-crafting features. For instance, convolutional neural networks (CNNs) have proven to be good at extracting mid- and high-level abstract features from images. Typical architecture of CNN is shown in Figure 1. Studies indicate that the feature representations learned by CNNs are greatly effective in large-scale object detection (Girshick et al. 2016), image recognition (He et al. 2016), and semantic segmentation (Rastogi et al. 2020).

Benefits of Machine learning and AI in remote sensing field

AI in combination with remote sensing can help to improve experts' understanding of land, ocean

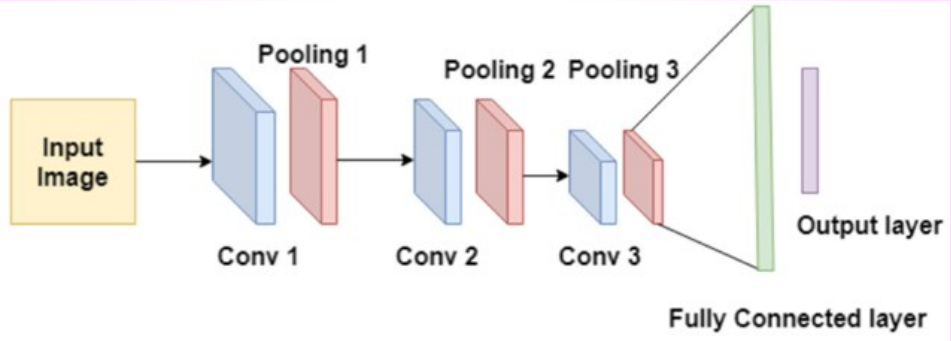

Figure 1: Typical architecture of Convolutional Neural Network, integrating multi-layer feature maps

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and atmosphere systems. This can lead to benefits, including improved predictions about the behaviour of such environmental systems, automation of data analysis, better resources management, and the discovery of new insights from complex data sets. Few of them are discussed below.

Improved environmental predictions - An ongoing objective in long-term climate modelling is reducing uncertainties and improving predictions. AI has been used to reduce uncertainties about the role of climate variables by combining multiple climate models and projections into an atmospheric map. This enables the system to learn strengths and weaknesses of individual models, leading to more realistic projections.

Automating and improving image classification - The classification of remote sensing images for environmental systems relates to the identification of features or objects in the digital image. Deep learning algorithms have advanced the automation of image classification, using more of the available data, saving on time and reducing errors introduced by human analysts.

Improving resource management- Information for managing vital natural resources such as water and soil, minerals (for farming and other land uses) can be generated using AI techniques. AI is used to convert global satellite soil moisture data and vegetation index, an indicator of soil health and vegetation vigour respectively, into more accurate estimates at the regional and local levels.

Improving mitigation and response- Flood and drought requires mitigation and quick response at the time of occurrence. Water resource management, rainfall forecasting and advances in climate modelling all feed into flooding and drought predictions and for developing mitigation and response plans. Satellite and drone capabilities are being combined with machine learning for detection, mitigation, alerts, emergency response and recovery efforts at the time of disaster events.

Challenges

While there are many benefits of using AI in environmental remote sensing, there are also some barriers to its use. The effectiveness of a model is dependent on having an accurate and well-developed training dataset. However, generating large training data is time-consuming task but once correctly built it can be used for multiple models and validation purposes. Accessibility of an adequate amount of training data can be eased by using higher resolution remote sensing datasets, such as UAVs, aerial imagery and local field data that are validated as per specifics of the applications.

Conclusion

Currently, data analysis methods play a central role in geosciences and remote sensing. The availability of large amount of remotely sensed data ranging from satellite images to very high-resolution drones has notable effects both on predictive analytics, knowledge extraction and interpretation tools. Evidently, AI makes processing of these large datasets more feasible

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and helps in extracting data and drive patterns that might otherwise be too complex or time consuming for human analysts.

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Some Inspirational quotes for women's day

"If you want something said, ask a man. If you want something done, ask a woman." –Margaret Thatcher

"A strong woman stands up for herself. A stronger woman stands up for everyone else."

"Her soul is fierce, her heart is brave, her mind is strong."

VIGILANT EYES FROM SKY OVER TROPICAL CYCLONES

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Tropical cyclones (TCs) are the most devastating natural hazards that adversely affect coastal regions due to intense winds, heavy rainfall, thunderstorms, storm surges and extremely high waves formed in the ocean. TCs are low-pressure systems that form in open oceans during the presence of favourable environmental conditions like warm SST (>27^{o}C), low to moderate atmospheric wind shear, high humidity and vertical instability. The advance prediction of development of TCs is very important for planning, evacuation and decision-making to save life and property.

TCs get its primary source of energy from the ocean surface. It interacts through heat, momentum and moisture flux exchanges at the air-sea interface. Thus, the atmospheric (air-temperature, pressure, humidity, winds, rainfall etc.) and oceanic (sea surface temperature, ocean heat content, surface waves, eddies etc.) both parameters are investigated for their monitoring and prediction. The advanced algorithms are developed to retrieve such atmospheric and oceanic parameters from satellite data. These parameters are used to study the characteristics of tropical cyclones and assimilated in numerical models by the researchers and operational forecasters to simulate cyclone forecasts. For accurate simulations of cyclone track, intensity, rainfall, storm surge and wave height, it is important to represent the reasonably well air-sea interaction process in the numerical weather prediction models.

The latest advances in technology such as satellites radars and automated weather stations has provided invaluable observational network for tropical cyclones which support the continuous monitoring of the horizontal and vertical structure of the atmosphere. As these systems form in the open oceans where in-situ observational network are sparse the vigilant eye from the sky i.e. remote

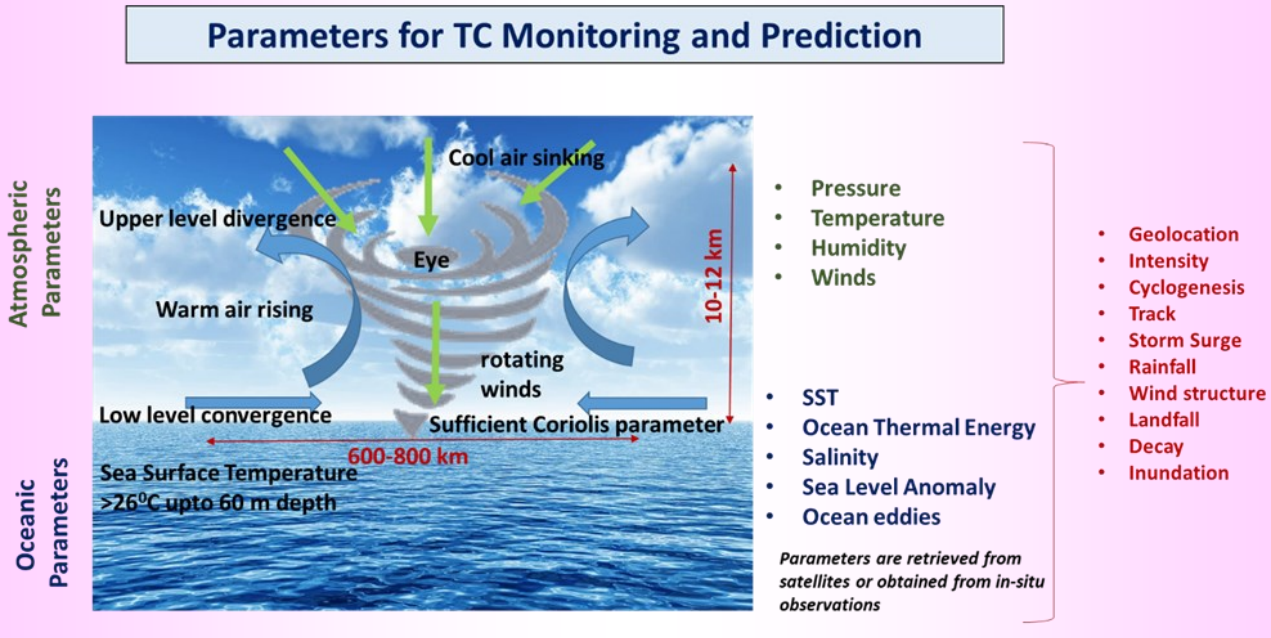

Figure 1: Schematics showing parameters required for tropical cyclone monitoring and Prediction

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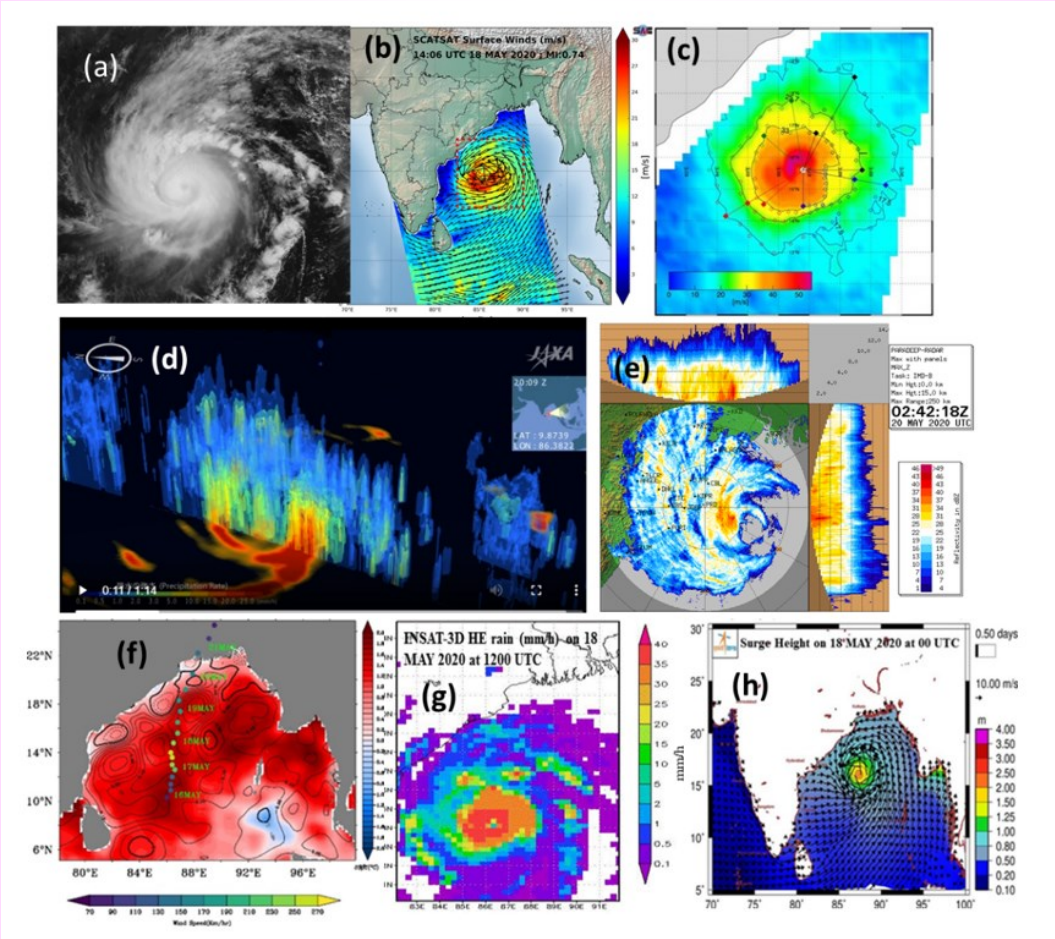

Figure 2: Super cyclone AMPHAN viewed by different satellite sensors (a) INSAT 3D Visible channel (b) Ocean Surface wind vectors from SCATSAT-1 (c) Ocean surface wind speed from SMAP (d) 3d Precipitation from GMI Precipitation Radar; e) Reflectivity measured by coastal radar at Paradeep during landfall of cyclone (f) Background OISST anomaly (shaded) overlaid with sea level anomalies (black contours) averaged for the period May 01-16, 2020, Color dots represent cyclone wind intensity (Km/hr) over the track g) Rainfall estimated using INSAT-3D and h) Strom Surge prediction using ADCIRC Model.

sensing observations obtained from different infrared and microwave instruments on-board geostationary and polar satellites are highly useful for their monitoring and prediction.

The continuous acquisition of images from thermal -infrared and visible channels of geo-stationary satellites (like INSAT-3D and INSAT-3DR) provides the top view of clouds which are the key indicators of storm development. Such images are used by all operational agencies for storm tracking and intensity estimation using Advanced Dvorak Technique. The microwave satellite data have a capability to penetrate within the cloud and thus it provides unique observations during cyclonic conditions. The data from satellite microwave

VIGILANT EYES FROM SKY OVER TROPICAL CYCLONES (CONTD.)

radiometers, scatterometers, altimeters, synthetic aperture radar (SARs), microwave sounders, rain radar, cloud profiling radar, as well as coastal radars, airborne radars have all contributed significantly to tropical cyclone research and forecasting. The advanced techniques have been developed to retrieve the surface wind information from the data provided by microwave sensors on board polar orbiting satellites (like SCATSAT-1, SMAP, ASCAT, CYGNSS). These observations are highly useful in estimating storm surface wind structure like maximum sustained winds (Vmax), radius of maximum winds (Rmax), asymmetric wind radii (R27, R34, R50, R64) etc. These parameters are used as an input in the numerical models to define the cyclone vortex and assimilated to improve the model initial conditions.

The SAR onboard satellites like Sentinel, Radarsat, RISAT etc. provides cyclone wind structure with high spatial resolution (~ 1 km). These advanced high-resolution observations are also highly useful in the damage assessment due to disaster like TCs. Tropical cyclone heat potential (TCHP) is important ocean parameters influencing the frequency and intensity of tropical cyclones. In addition to in-situ measurements, the satellite based TCHP products are generated using sea surface height anomalies (SSHA) observations.

For more advanced cyclone research, it is highly important to understand cyclone dynamics, which needs high spatial and temporal resolution information within the storm 3-D structure providing the vertical structure of storm winds and temperature.

A string of books with female Protagonists

- *Six Wakes* by Mur Lafferty
- *Fool's War* by Sarah Zettel
- *Trail of Lightning* by Rebecca Roanhorse
- *Gods, Monsters, and the Lucky Peach* by Kelly Robson
- *Blackout* by Connie Willis
- *Defy the Stars* by Claudia Gray
- *Feed* by M. T. Anderson
- *A Wrinkle in Time* by Madeleine L'Engle
- *Station Eleven* by Emily St. John Mandel

EXPLORING SPACE-BASED AGRICULTURE WITH RESPECT TO CLIMATE RESILIENCE

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It is evident that agriculture can be considered as the "vertebral column" of the human life and has considerable control on economy. The satellite RS with its high repeativity, synoptic coverage in real time and digital format, allows for qualitative and quantitative analysis of the agricultural inventory. In the last three decades, Earth observation data acquired from polar and geostationary platforms embedded in various sensors (MODIS, ASTER, Landsat, RISAT-1, INSAT series, SCATSAT-1, Sentinel, RADARSAT, ENVISAT, EO-1 Hyperion and airborne AVIRIS-NG hyperspectral data etc.) generated enormous information on agriculture. The thrust areas are crop monitoring and condition assessment, acreage and production estimation, precision agriculture, detection of biotic and abiotic stresses, estimation of agricultural water productivity and water demand, agricultural risk assessment, monitoring of extreme climatic events etc. The intermingling of satellite-derived information on crop, land surface as well as meteorological parameters can enhance agricultural monitoring while addressing food and water security with respect to climate resilience.

Agricultural sector is the largest water user amongst all the economic sectors. In view of water scarcity in agricultural sector with a goal of sustainable agricultural development, the best applicable strategy for water use optimization can be achieved through estimation of spatially-explicit agricultural water productivity (AWP) and agricultural water demand (AWD) at regional scale for ensuring food and water security (Choudhury and Bhattacharya, 2018; 2021). The UN-specified Sustainable development goals (SDGs) stipulate that agricultural productivity should be doubled by 2030 (SDG 2.3) and that water use efficiency must substantially be increased (SDG6.4) (UN, 2016). Therefore, there is a need to measure the water use efficiency in agricultural sector in

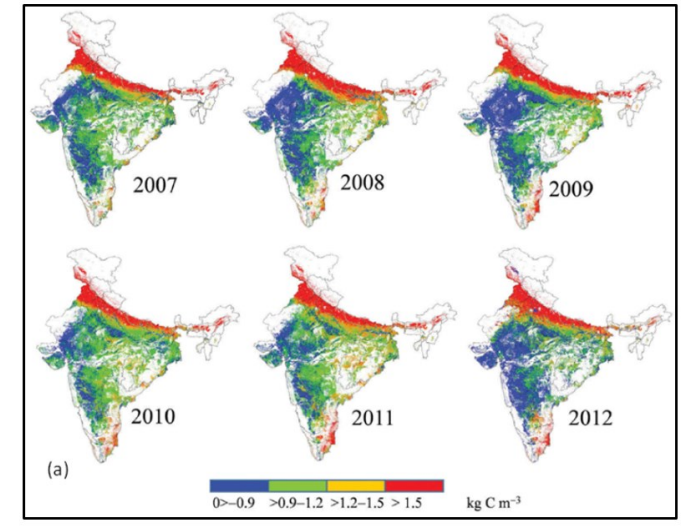

Figure 1: Spatiotemporal variation of AWP over Indian region

EXPLORING SPACE-BASED AGRICULTURE (CONTD.)

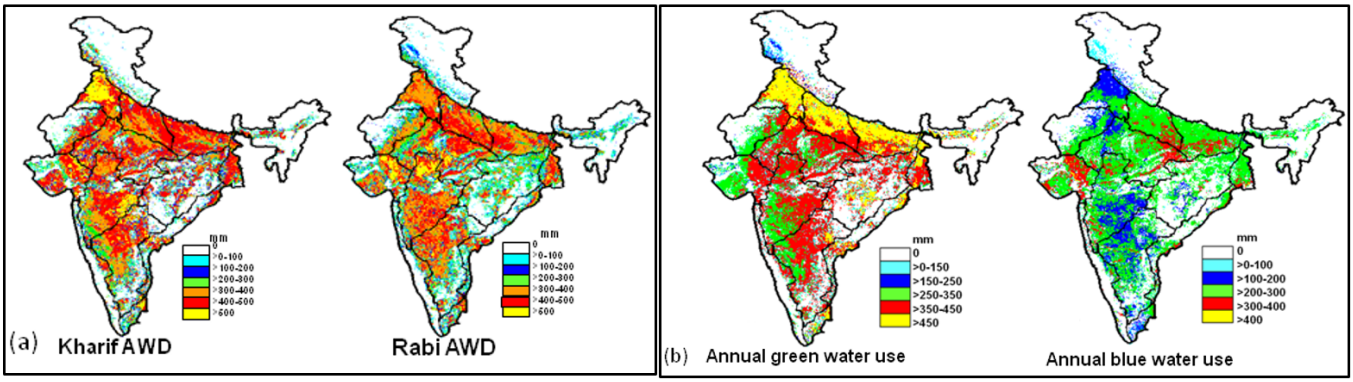

Figure 2: Spatiotemporal variation of a) seasonal distribution of AWD and b) annual green and blue water use over Indian region

conjunction with productivity and water consumed that estimates agricultural (crop) productivity per unit of consumptive water use (CWU), an indicator to analyse the inter-relationship between water use and crop production. The CWU refers to the total evaporative use of a crop during the crop growth period, often termed as "evapo-transpiration (ET)". Satellite-based ET estimation at daily, monthly and seasonal scale has opened frontiers in agricultural water use management over large area and diverse landscapes. Real time information on ET components i.e. reference ET, crop ET and actual ET at spatiotemporal scales are essential for deciphering rainfall distribution pattern, estimation of CWU and AWD, drought assessment, water accounting etc., which are required for planning and management of agricultural water resources, quantifying crop water requirements to plan optimum water allocation, analysis of crop-water stress etc. AWP refers to the agricultural production (biomass) per unit of water consumed (both rainfall and irrigation) as defined by Eta. As rainfall and agriculture are highly blended together, therefore, a combined estimation and assessment of AWP at spatiotemporal scale over an agricultural area (Figure 1) can help to determine the existing water availability and water usage with possible "hotspots" of highest or lowest WP areas within and between fields (Choudhury and Bhattacharya, 2018). This opens up an opportunity to study the causes of differences in water use to produce unit of grain and to locate 'hotspots' where these differences occur, and thereby, strategize approaches to increase WP. In addition, AWD is an important input to identify the trade-offs and synergies between strategies to achieve food security (SDG-2) and water security (SDG-6). The important inputs required for the satellite-based estimation of AWD are the seasonal sum of ETc over a particular crop-growing season. The regional-scale satellite-based estimation of ET0 summed over a month within growing season and the corresponding composite crop-coefficient (Kccomp) can be used to generate regional-scale ETc at monthly scale (Choudhury and Bhattacharya, 2021). The spatiotemporal analysis of AWD (Figure 2) at regional scale can bring out clearly the "hot-spot" zones of high and low water demand in agricultural sector with an opportunity to optimize AWD for designing improved crop and water management practices. This can lead to reduce regional water scarcity risks. Besides, partitioning of CWUs (seasonal sum of ETa) into

green (CWUg i.e. ETa streaming from rainfall) and blue water (CWUb i.e. ETa streaming from irrigation water e.g. surface and ground water) in spatiotemporal domain enables to understand and quantify the geographic distribution of CWU's from rainfall and irrigation sources. The satellite-based estimation of AWD, effective rainfall and CWU are the three major inputs required for the estimation of regional scale CWUg and CWUb (Choudhury et al., 2019). This is an important input to prioritize the proportion of green and blue water allocation in agroecosystem with a scope for improving water management resources in agricultural sector. Therefore, the regional-scale estimation of agriculture water requirements, agricultural water demand and consumptives water uses enable to enumerate agricultural water use efficiency both quantitatively and qualitatively that can allow the prediction of future trends in agricultural production and trade. Therefore, in areas where water resources are scarce and becoming increasingly scarcer, it is imperative that relevant authorities should optimize water management processes by developing water-saving technologies and adjusting crop-planting patterns. While looking at the future water shortage and existing erratic monsoon rainfall pattern, the establishment of an optimal water allocation plan to improve water use efficiency may ease the contradiction between water supply and its requirement. This would definitely help for the development of sustainable agricultural water management plan to achieve food and water security with respect to climate resilience. In future, with the availability of finer-scale resolution satellite data, the spatial variability of satellite-based estimation of the above mentioned products will definitely be high, which will help in better assessment at district as well farmer's field level.

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THE RECENT FLASH FLOODS IN UTTARAKHAND: REMOTE SENSING PERSPECTIVE

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Almost 8 years after the flash floods of 2013, Uttarakhand was again engulfed in a calamity on 07 February 2021 when a sudden surge of water in Rishiganga river in Chamoli district led to a dam being obliterated. The flash flood also had an impact on a hydro project owned by NTPC.

We attempted to understand the probable causes of this event using multi-sensor satellite data and derived products around Raini village, Uttarakhand as discussed in the following text:

- Snow cover areal extent was estimated using IRS AWiFS image of 06 February 2021 and LISS-III image of 08 February 2021 based on Normalized Difference Snow Index approach for the watershed covering region around Rishiganga. Snow cover was observed to reduce from 2777 sq km to 1995 sq km, showing a drastic reduction of almost 800 sq km. WRF model predictions of snow (mm) also suggested that snowfall activities had reduced significantly after 05 February 2021 over the selected location (Personal communication- ASD/AOSG/EPSA). However, sudden conversion of this 32% loss in snow cover into melt discharge may not be possible as no such rise in temperature was noticed during this time frame.
- The analysis of recent and past optical images of IRS LISS-III, Landsat-8 and Sentinel-2 did not show the presence of any temporary or permanent pro-glacial lake, hence ruling out the possibility of the occurrence of Glacier Lake Outburst Flood (GLOF).
- Satellite images showed evidence of a rock failure in the shadowed region of Trishuli in the Nanda Devi Mountain as shown in figure 1. A scar is visible in the slope of this mountain in the satellite image of 08 February 2021, thus confirming that chunks of rocks broke off from this peak due to rock failure.

Based on these observations, it can be inferred that this event started from the rock failure in Trishuli. Due to freezing, thawing and temperature variations in the past, this rock mass was structurally weakened and it collapsed. As it moved down the valley along the slope, it took along materials such as snow, debris including boulders etc on the way. It slowed down near the base of the valley, where Raunthi Gadhera stream flows, blocking water of the stream and probably creating a temporary dam-like situation. The reduction in snow cover prior to the disaster may have also contributed in increasing the storage capacity of this temporary damming. Finally, this whole mass of water, boulders and rocks came crashing down with force towards Rishiganga dam site. This washed away the hydropower project on Rishi Ganga river and caused massive damage to the under-construction Tapovan hydel power project.

While it is important to ascertain the cause of this disaster, it is equally important to have mitigation measures in place so that such disasters can be avoided in future. Recent floods have raised the issue of disaster management, particularly in the light of climate change impacts. Potential zones can be identified and their regular monitoring can be done. There should be efficient early warning mechanisms for glacial lake outbursts and flash floods in the Himalayan region. Analysis of near real-time satellite data, precise mapping capabilities using remote sensing and GIS, developing efficient hydrological and meteorological models, increasing forecasting capabilities, establishing an efficient and robust

THE RECENT FLASH FLOODS IN UTTARAKHAND: REMOTE SENSING PERSPECTIVE

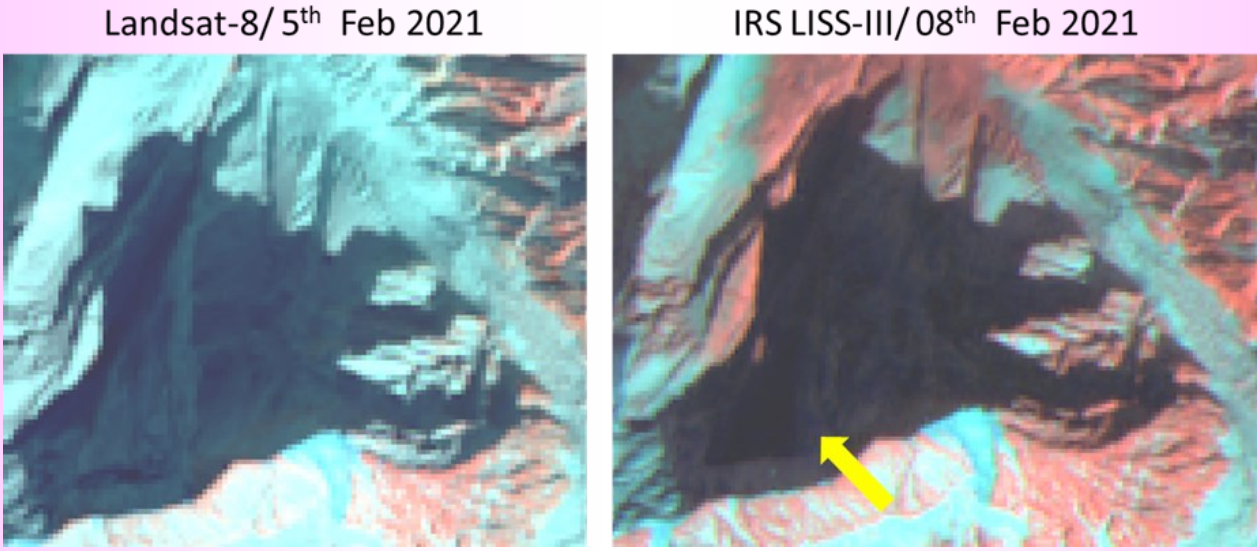

Figure 1: Rock failure in Trishuli region, Nanda Devi mountain

communication system and ensuring effective dissemination of information to the concerned stakeholders are some crucial steps that can be implemented in order to mitigate the effects of such calamities.

If there were no images from orbiting satellites, it would have been difficult to ascertain the causes and events of this disaster. Thanks to remote sensing.

Acknowledgments

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AN INSIGHT INTO RESPOND @ SAC

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Indian Space Research Organisation (ISRO) carries out research and development in space science, technology and applications. ISRO initiated RESPOND programme in the 1970s with the (main objective to develop strong links with academia through quality research with focused output of relevance to ISRO programmes at large. The RESPOND programme intent to provide necessary financial and technical support to academic institutions in India for conducting research and development activities related to Space Science, Space Technology and Space Applications for meeting the needs and aspirations for national development.

In order to involve academia in specific research areas pertaining to payload development, data processing and applications in the areas of Satcom, Satnav and Earth Observation the programme is implemented at SAC. Various reputed Central and State institutions and universities like IITs, NITs, BITS, NIAS, Nirma, CEPT etc. have actively participated in RESPOND programme at SAC. All the participating institutions and universities have contributed in many ways in space research and has developed much greater potential for contribution.

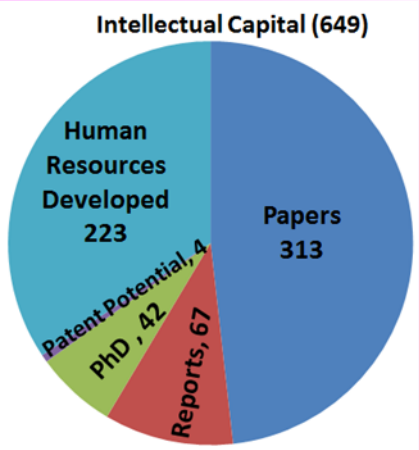
At SAC, RESPOND has adopted very proactive approach of bridging the gap between academia and Space research in the country. A number of initiative like organizing Interest Exploration Meetings, bringing our 'Research Areas of SAC' and 'RESPOND Basket of SAC' documents, dedicated SAC RESPOND Website (https://www.sac.gov.in/respond/), active participation of SAC scientist/ engineers, guidance from SAC senior management, organizing progress review meetings and assessment of outcome of completed project etc. are few of the firm steps taken towards fulfilling RESPOND objectives as describe below:

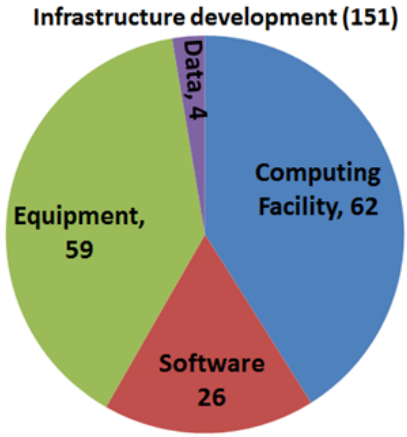
Interest Exploration meetings are organized in various geographical clusters among the country. These meets provide opportunity to academia for direct interaction, wherein different universities and academic institutions are invited for participation. Research areas offered to academia for conducting research related to SAC are presented and RESPOND mechanism is explained to the academia so that the programme can get utmost recognition. Research Areas of SAC and RESPOND Basket of SAC documents are published at regular interval, which provides an explorative view of research areas relevant to SAC and offering state of the art research topics to academia. These documents are also sent in advance to the concerned Universities/ Institutions located in the State where the IEM is to be organized for generating interest in RESPOND research areas. RESPOND Website broadcast latest updates including necessary formats, submission procedures, terms and conditions etc. Respond Review Committee reviews and monitors progress of the projects at regular interval throughout the year. At the same time, Annual RESPOND Review of SAC projects is organized every year to take a stalk of progress and provide specific directives to academia for focused research efforts for their concerned projects.

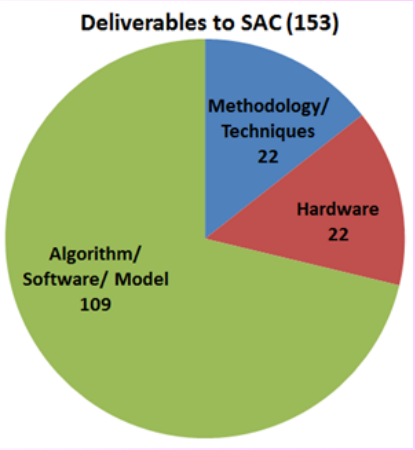
The proactive approach also includes assessing the outcome in terms of intellectual capital, Infrastructure development at academia for space research and deliverables received at SAC.

With the above listed proactive approaches, SAC has developed its own mechanism for

AN INSIGHT INTO RESPOND @ SAC (CONTD.)







management of RESPOND programme. In order to understand effectiveness of RESPOND programme, quantitative outcome parameters in terms of intellectual capital, Infrastructure development at academia for space research and deliverables received at SAC were analysed for the 68 completed projects during last five years. The pie charts depicting the same provides an insight in to RESPOND programme in fulfilling its goal. The effectiveness of the proactive approach is reflected in terms of 649 intellectual capital development of 68 completed project with 42 PhD, and 313 research papers published in national/ international conference, symposium, journals and 223 human resource development. As a result of quality research conducted by academia under the guidance of SAC scientists/Engineers, RESPOND review committee and senior management, the quality of 4 outcome were worth potential for patent.

Infrastructure development at Academia is also another important aspect in terms of country's preparedness towards space research. RESPOND@SAC has contributed in the same by means of lab development at academia. Infrastructure development at Academia of 68 completed project with 59 of equipment/Hardware, 62 of computing facility and 26 specific software for Space research has created opportunity for students and researchers at academia to carry out space research even after completion of RESPOND project.

Besides one of major feature of RESPOND programme is that the academia is encouraged to take up state of the art space research of relevance to ISRO. With active involvement of scientists/Engineers, Review committee and senior management at SAC, review mechanism has resulted in focused research by academia with 153 deliverables to SAC of 68 completed project comprising of 109 algorithms/ software/ model is delivered, 22 methodology/ techniques developed, 22 hardware delivered to SAC of these 68 completed projects.

The Intellectual capital, Space research infrastructure development at academia and deliverables received by SAC as outcome of RESPOND research carried out by academia for the 68 projects completed during last five years in terms of parameters of interest provides an insight in to effectiveness of the implementation of RESPOND programme at SAC.

REMOTE SENSING NEWS

INDIA'S NEW REMOTE SENSING DATA POLICY (RSDP)

The Indian government has adopted a comprehensive Remote Sensing Data Policy (RSDP) for the acquisition and distribution of remote sensing satellite data, from Indian and foreign satellites, for civilian use in the country. The policy also covers guidelines for licensing the IRS capacities to other countries. Department of Space (DOS) will be nodal agency for implementing this policy. The RSDP is envisaged to be a step towards making transparent procedures for satellite data distribution. National Remote Sensing Centre (NRSC) is authorized to acquire and disseminate all remote sensing satellite data in India, from both Indian and foreign satellites.

NASA'S 'PERSEVERANCE' LANDS ON MARS

NASA's 'Perseverance' rover successfully landed on Mars Feb. 18 after completing a journey of nearly seven-months from Earth. The rover returned images from hazard cameras, or hazcams, on the front and rear of it. The cameras allowed the mission team to determine the orientation of the rover. Most of the payload will be devoted to studies of the landing site and surrounding region, looking for evidence of past Martian life. Scientists will also use the rover's instruments to characterize the planet's geology and climate. One payload on the rover, called MOXIE, will test the ability to convert carbon dioxide in the atmosphere into oxygen for life support and propellant. The rover will also deploy a small helicopter, called Ingenuity, that will attempt the first powered flight in the Martian atmosphere. Such vehicles could serve as scouts for astronauts on future missions.

ISRO SUCCESSFULLY LAUNCHES 19 SATELLITES

ISRO launches Amazonia-1, the first Brazilian satellite along with 18 other co-passenger satellites. One of the co-passenger satellites is engraved with a picture of Prime Minister of India Shri Narendra Modi and also carries Bhagavad Gita.

REMOTE SENSING NEWS

AFTER PIXXEL, SATSURE AIMS FOR REMOTE SENSING SATELLITE FLEET

From 2022, SatSure is planning to launch a fleet of remote sensing micro satellites to meet the growing need of high-resolution satellite imagery in various fields. The satellites will be powered by Bellatrix Aerospace, a startup incubated at the Indian Institute of Science.

AGRICULTURAL MINISTRY GETS DGCA APPROVAL FOR DRONE-BASED CROP IMAGING

The agriculture ministry has got approval from aviation regulator DGCA for flying drones over rice and wheat fields in 100 districts to assess crop yields at gram panchayat level under the Pradhan Mantri Fasal Bima Yojana (PMFBY). Apart from drone-based images, high spatial resolution satellite data, biophysical models, smart sampling and artificial intelligence will also be used in the large scale pilot study. It is believed that use of UAV data in the scheme will bring new dimensions to ensure timely settlement of claims in the scheme as well as for crop area estimation, losses due to localized calamities and to resolve yield dispute between different stakeholders under the scheme.

GIANT ICEBERG BREAKS OFF IN ANTARCTICA

A giant iceberg approximately broke off from the northern section of Antarctica's Brunt Ice Shelf. Radar images by Sentinel-1 mission showed the 1,270-square-kilometer iceberg breaking free and moving away rapidly from the floating ice shelf. Recent ice-surface velocity data derived from Sentinel-1 indicated the region north of the new crack to be the most unstable, moving approximately 5 meters per day. Then the newer crack widened rapidly before finally breaking free from the rest of the floating ice shelf.

UPCOMING CONFERENCES

(March—December 2021)

- *52nd Lunar and Planetary Science Conference (LPSC) will be held virtually on March 15–19, 2021.*
- *8th International Conference on Remote Sensing and Geoinformation of Environment, March 16 – 18, 2021, Paphos, Cyprus.*
- *International Geoinformatics Conference 2021, Riyadh Saudi Arabia, 29-31 Mar 2021.*
- *ISPRS TC-V, Second International Conference on Unmanned Aerial Systems in Geomatics-2021 (UASG-2021) , Greater Noida India, April 02-04, 2021.*
- *9th World Climate Congress & Expo, Thailand (online), April 06 - 07, 2021 Webinar. Recent innovations and Emerging trends in climate change.*
- *GISTAM-2021,The International Conference on Geographical Information Systems Theory, Applications and Management. Conference Date: April 23 - 25, 2021.*
- *IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2021), Brussels, Belgium, July 11 - 16, 2021.*
- *SPIE Remote Sensing 2021, Spain. Webinar. IFEMA, Madrid, Spain, September 13 – 16, 2021.*
- *5th World Conference on Disaster Management 2021, New Delhi, November 24-27, 2021.*

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