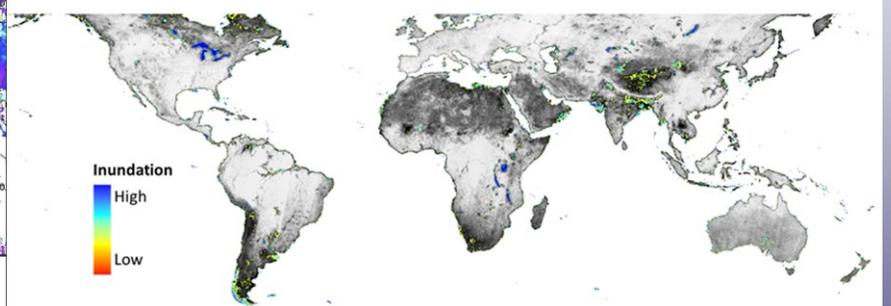
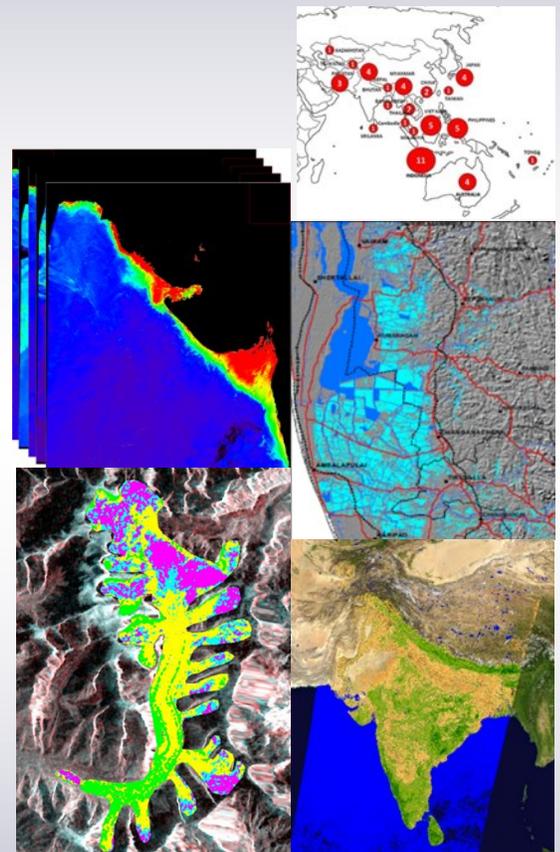
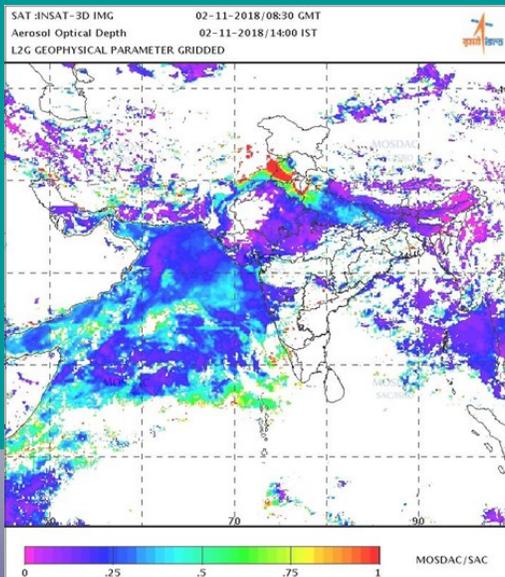


ISG NEWSLETTER

Vol. 24, No.3 & 4

December, 2018

Special issue on Advancements in geospatial technology for societal benefits



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Address for correspondence:

*Indian Society of Geomatics (ISG),
C/o. Room No.6202, Space
Applications Centre (ISRO),
Ahmedabad-380058, Gujarat
Url: www.isgindia.org
Phone: +91-9427010568,
Email: sasharma@sac.isro.gov.in
Fax: +91-79-26916287
Phone: +91-79-26916202*

Editorial Board – ISG Newsletter

Editor: Dr. (Ms.) Arundhati Misra

Members: Dr. (Ms) Alpana Shukla

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Ms. Shweta Sharma

Mr. Ananya Ray

arundhati@sac.isro.gov.in

alpana.botany@gmail.com

rpsingh@sac.isro.gov.in

cpsingh@sac.isro.gov.in

vivekpandey@sac.isro.gov.in

shweta@sac.isro.gov.in

a_roy1660@sac.isro.gov.in

Send your contributions/comments to the Editor at the above e-mail.

Editorial

From the Editor's Desk

Dear Members,

This issue of Indian Society of Geomatics (ISG) is bringing out a special issue of ISG Newsletter on, "Advancements in Geospatial Technology for Societal Benefits" which is being released during the Silver Jubilee Celebration of the Society, on 5th December, 2018, at SAC, Ahmedabad.

For such a special occasion, one cannot start without the nostalgia factor embedded in this event. This motivated us to invite Sri Arup Dasgupta, one of the founder members of this society to jot down the Foreword for this issue. This not only reminds us about the vision and mission of the founding members, but also gives the current generation of the readers a positive direction for the future. I am sure this will augur well with the readers. In this context, I cannot help commenting on some of the issues being brought forth by Sri Dasgupta. The matters of his concern, with respect to some of the burning issues, policies, and high impact progress related articles, and events definitely need emphatic articulation. However, as with any progressive scientific society, the moderation and guiding factors sometimes go well beyond the jurisdiction of the editorial committee members. I feel, that the success story of this chapter, itself is something to be cheerful about, and the ever changing regimes of the members with their own priorities and visions, may make the colours appear a bit faded sometimes.

To mention some of the new fields which have been touched upon since the last few issues of the Newsletter, one must be appreciative of the state of the art technologies which have been dealt with, such as UAV based remote sensing in the far North East of India, or the explorations in the Antarctica, Solar Calculator, which was appreciated by the ministry of power, Desi GPS (NAVIC) utilization in remote sensing applications and calibration etc. Many more State of the Art technologies, which are being included in the current issue, are setting the trend for making the ISG, Newsletter a stronghold of "Geo"!

Now I must delve a little bit into the topics covered in this issue of Newsletter, to keep the readers more engrossed.

We have tried to cover a wide variety of new technologies being developed in India which are judiciously used for societal benefits. Geospatial Technologies for providing Agro-advisories, whereby Web-GIS based pest forewarning systems, weekly crop prospects, dryness assessment for rain-fed farming has been illustrated. E-governance for flood management in North Eastern states of India, Air Quality informatics for alerting the citizens of India, aerosol optical depth retrieval, and monitoring of air quality indices and providing regular products on VEDAS, disaster management support systems using space technology, development of Bhuvan National geo spatial platform, Geomatics applications for Himalayan region, Harnessing Non-Conventional Energy using satellite technology, are a few of our favourite topics.

*Apart from these, advanced technique development leading to the **Multi-temporal Data-cube** of Earth Observation Analysis Ready Data from OCM-2 / RS2 / RS2A, **MOSDAC Live**, a new Web*



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Editorial

GIS based portal that enables users to visualize, analyze and relate the different kinds of satellite data, information products and forecast, Hydrological applications using altimeter and scatterometer data, Forest biomass estimation and Glacial faeces detection using SAR data have been projected. The article on mangrove mapping is also quite informative and gives us insight into the need for remote sensing based routine monitoring, which will be the need of the day for conserving our eco system. The article on Earth Observation Applications in Governance and Development makes very interesting reading indeed.

Finally, we have done a special interview with one of the greatest stalwarts in the field of "Global Greening", none other than, Dr Kartikeya Sarabhai, Director, CEE, Ahmedabad, to make this Newsletter interesting in all aspects.

I thank the contributors and columnists for their cooperation and the editorial team for doing an excellent job. I hereby would like to take the opportunity to thank Ms Neetu Nambiar, Mr Jakesh Mohapatra and the Library for providing the much needed support in bringing out this Special Edition.

Happy reading.



*Arundhati Misra
Editor, ISG Newsletter
(arundhati@sac.isro.gov.in)*

Message from President ISG

Over the decades since sixties, satellite observations have led to rapid and wider imaging and observation coverage over land, oceans and atmosphere. This ability led to greater strides in assessing our climate, environment, agriculture, natural resources and mitigating natural and human-induced hazards. In effect satellite based remote sensing is leading to effective protection of global environment, reduction in disaster losses, and enabling us to move towards sustainable development.



Presently, India is owning one of the world's large constellation of Electro Optical (EO) remote sensing satellites in operation. Microwave Remote Sensing (MRS) programme of ISRO has seen the development of both active (e.g. RISAT, Scatterometer) as well as passive (e.g. MSMR) remote sensing systems for space and airborne remote sensing activities. Future NASA ISRO joint mission, L and S band NISAR is going to provide an unprecedented periodic differential interferometric observation of all solid masses, including cryosphere, for assessing geo hazards and global environmental changes.

As the technology grew, user demands and expectations also increased progressively. Availability of high resolution geospatial maps along with geolocation information in geospatial platform through easily accessible devices, i.e. mobile phones, has changed the perception of common man in terms of its daily uses and improving the quality of life. Now various information/alerts such as weather forecast, disaster, air quality, traffic, rail and aviation services are easily available which could not have been thought of 2-3 decades ago.

Future demands will include requirements of high resolution information in high temporal resolution, leading to earth observation almost in near real time. It will call for innovative and complementary constellation of large number of small satellites, with stronger capabilities built with small size and less power. Building new data architecture, transmission and dissemination techniques is a big challenge in future. If current trends are any indication, data is going to be progressively cheap or free, but information will become costly, as a function of information accuracy and relevance. Technological developments in the field of machine learning and computer vision algorithms need to be pursued with focused approach to address such demands. Predictive modeling and assessment of global changes, without human intervention, is need of the hour.

It gives me immense pleasure to acknowledge the efforts made by the editorial team members of ISG Newsletter to bring out Special issue on "Advancements in Geospatial Technology for Societal Benefits" highlighting nuggets of diverse remote sensing applications. However, in no sense the depiction is complete. As more and more innovations in machine learning capability and artificial intelligence are becoming norm, human ingenuity will lead to much greater strides in bringing satellite remote sensing much closer to daily human needs. I hope this expert team will continue their efforts in updating and communicating recent developments in the field to members, through innovative ideas. I am sure the efforts by editorial team will make ISG newsletter a powerful medium of information dissemination in the field of geospatial technology and its applications.

Ahmedabad

20th November 2018

A handwritten signature in blue ink that reads "Tapan Misra". The signature is written in a cursive, slightly slanted style.

(Tapan Misra)

President, ISG

Foreword

The ISG Newsletter Editorial Board of the Indian Society of Geomatics has given me the honour to write a foreword for the upcoming issue to be released during the Silver Jubilee celebration of the Society. Indeed it is not only an honour but an invitation to reminisce about those heady days in 1993 when 15 of us got together to put together the Society. There were many questions as to why we needed 'another' society. A sub question was why 'Geomatics', why not 'Geoinformatics' or even 'Geospatial'?

ISG was set up to address the need to look beyond Remote Sensing, GIS and Cartography. There was much more to the Science, Technology and Art of collection, storage and analysis of data about the earth, its environs and living objects than was covered by the traditional sciences and technologies like Geodesy and Cartography and even Geography. Remote Sensing and GIS represented the fledgling steps that these traditional sciences were taking towards their modernisation. However, there were many more technologies appearing over the horizon. Location, through Global Navigation Satellite Systems was one such which fell between the stools of remote sensing and cartography. GIS was considered to be a glorified CAD, ignoring its analytical capabilities. In short, ISG was set up to look at the bigger picture which went beyond natural resources and included the impact on society and vice versa.

Why 'Geomatics'? In a lighter vein 'Geospatial' is an adjective and not a noun and Geoinformatics by definition was too restrictive. Geomatics happens to be the ISO term for the Science, Technology and Art mentioned earlier and thus we became ISG.

In 25 years ISG has come a long way. It has captured the imagination of professionals in government, Academia and Industry. It has started a peer reviewed journal which is a success. It has held seminars, workshops, quizzes and opened Chapters in many cities. The question is has it met its original goals? As one of the Founder Members, the first Editor of the Newsletter and the first Webmaster I can say, paraphrasing Pandit Nehru, "not wholly or in full measure, but very substantially". I am happy that we have a better linkage with industry and our coverage goes beyond the RS & GIS fixation of other societies. I do see articles on technology and on the convergence of technologies beyond RS & GIS.

However, I think a professional society needs to go beyond just technology and applications. It needs to address issues that impact the technology and systems, like law, regulations, institutionalisation, privacy and interactivity. A professional society should be an advocate of the technology, its applications and an environment that is enabled to absorb it. I find this missing in ISG and its publications. Momentous events like the Geospatial Information Regulation Bill, the Space Act and the crucial National Spatial Data Policy find no discussion either in the Newsletter or even in the Annual Conferences of the Society.

Another missing area is the fast developments in general areas such as Big Data Analytics, Deep Learning and Blockchain. Each of these are being absorbed into Geomatics and totally disrupting the ways in which we have been using data and data analytics. In this context one should reread the definition of Geographical Information Science as formulated by the UCGIS in 1999:



(Continued on page viii)

Foreword

“Geographic Information Science (GIScience) is the basic research field that seeks to redefine geographic concepts and their use in the context of geographic information systems. GIScience also examines the impacts of GIS on individuals and society, and the influences of society on GIS. GIScience re-examines some of the most fundamental themes in traditional spatially oriented fields such as geography, cartography, and geodesy, while incorporating more recent developments in cognitive and information science. It also overlaps with and draws from more specialised research fields such as computer science, statistics, mathematics, and psychology, and contributes to progress in those fields. It supports research in political science and anthropology, and draws on those fields in studies of geographic information and society.”

A Society is a living system and like all such systems it has a life cycle and if care is not taken, it can become moribund. The aim of the Society should be to reinvent itself so as to be ready to meet the challenges of the future. As ISG enters its next quarter century I would like to exhort all its members to continue to keep the Society at the vanguard of the growth of Geomatics not only academically but in other fora as an advocate of using geomatics and other technologies in a convergent manner for the sustainable development of the earth and of the living beings who call it 'home'. In this century humankind will begin to colonise the Moon and Mars. Is ISG ready to take up these new challenges?



Shri Arup Dasgupta

An Interview with Shri Kartikeya V. Sarabhai



Shri Kartikeya V. Sarabhai is one of the world's leading environmental educators and a dedicated community builder. He was educated in Cambridge (Tripos in Natural Science) and went on to do post graduate work in development communication at the Massachusetts Institute of Technology (MIT). Mr. Sarabhai is the founder director of the Centre for Environment Education headquartered in Ahmedabad, with 40 offices across India. Mr. Sarabhai's primary focus is on the greening of India's formal education system, and initiatives for biodiversity education. He is a Trustee of the Sabarmati Ashram Preservation and Memorial Trust, Mr. Sarabhai is also a member of many committees set up by the Government of India and other organizations. Recipient of 2016 International Brandwein Medal by Brandwein Institute and the IUCN-CEC in recognition of his lifetime work for inspiring new generations to experience,

embrace and love nature first hand. In 2012, the honourable President of India conferred him with Padma Shri, one of India's highest civilian awards. Mr. Sarabhai is the Co-chair of the Earth Charter International Council and the chair-holder of the UNESCO Chair on Education for Sustainable Development and the Human Habitat. He is the Co-chair of the first Priority Action Area – Advancing Policy of the Global Action Programme. As a well known advocate of education for sustainable development, Mr. Sarabhai has actively contributed to the global negotiation processes around the UNDES

ISG: To start with I would like to thank you, Sir, for accepting our invitation to be part of the ISG Newsletter interview session, for the special issue on the Silver Jubilee Celebration for ISG. We would like to know that as Founder Director of CEE, what was the fundamental idea which prompted you into this wonderful endeavor?

Shri K. V. Sarabhai: In the early 80's, the Ministry of Environment was in its formative stage. The stage had been set in 1972 when the first United Nations International Conference on the Human Environment was held in Stockholm, Sweden. The honourable Prime Minister of India had emphasized the close relationship between conserving the environment and development and poverty eradication. India was evolving its governance structure for managing the environmental challenge which was intertwined with the enormous task of development. A Department of Environment had been created in the Department of Science and Technology. At the time there were several NGOs and others institutions of civ-

il society working on various aspects of environment. At the Nehru Foundation for Development (NFD) established by Dr. Vikram Sarabhai in the mid 1960's, work on science, mathematics and environmental education was going on. One of the first environmental education projects involving students measuring pollution levels in the Sabarmati River was carried out through the Community Science Centre. We were conducting innovative programmes in schools including rural schools and observing how transformative such education could be. Through VIKSAT, another organization of the NFD, we were working on looking at urban systems and how our urban environments were changing and what the future entailed. Through Sundarvan we were exploring wildlife education, camping and outdoor education. We strongly advocated that education, communication and public awareness should be an integral part of the Ministry's strategy going for-

wards. The Department of Environment positively looked at the proposal and decided to form Centre for Environment Education (CEE) as a Centre of Excellence of the soon to be formed Ministry of Environment and Forests, Government of India in collaboration with NFD. CEE was constituted in August 1984.

ISG: We, the Geomatics fraternity, know that you have seen how Remote Sensing Application Programmes in India have grown since inception of ISRO in early days. Please share some of your personal experiences with us about the way geomatics have grown primarily fuelled by Indian Space Program?

Shri K. V. Sarabhai: Connecting spatial data with developmental issues is a very critical part of the geomatics revolution. Remote sensing applications really brought about a completely new type of capability. We did have fairly good maps, showing for instance the forest cover, before remote sensing came in. We had maps of rivers and river basins, maps showing catchment areas, we had maps of cities and road maps. But what capabilities came about as a result of remote sensing was that it was photographic and it became a complete game changer. The founding of India's Space programme was based on the role Space could play in a developing nation. Geomatics and remote sensing were an integral part of that core idea. Over the years, the capabilities and skills have tremendously increased. No longer do we just know the contours of a forest area but can make out what group of trees there are in the forest, the botanical group they belong to. We can assess growth rates and estimate carbon sequestration. We at CEE are involved in many coastal programmes, geomatics is essential for this work.

ISG: Sir, looking at India's position on current environmental concerns, in your opinion what should be the priority area towards mitigating them primarily with the technological interventions?

Shri K. V. Sarabhai: There is a long list here of what problems we have to deal with. We have problems of looking at snow cap melting for instance, we have problems of looking at how for-



ests are changing as a result of climate change, as a result of human pressure as a result of other changes which are happening. We also need to see how these patterns are changing. We need to look at our coastal areas, we need to look at the mangroves, we need to look at coastal erosion and that is something which is a priority and concern. Agriculture and changing cropping patterns need to be continuously monitored. ISRO has done wonderful work in all these areas. Take for instance wetlands. Till a few years ago wetlands were not considered as critical. And they were almost seen as wastelands. Areas where you can just do land fill and grow cities. Its only in the last 20 years that we have now realized how important a role wetlands play in the ecological system and how we need to protect them. We need to see how cities are growing. What is the extent of slums and how the housing crises can be met? Where does development happen, where does erosion happens, are there new wastelands emerging. We have monitoring to be done for instance on illegal mining. The scale of some of these things is such that without remote sensing it is difficult to see how such monitoring can be done. So I think there are several applications where the role of remote sensing is critical.

ISG: Being an Environmental Scientist, and with your tie up with several National and International projects what is your comment on the Global Warming, and India's role in it.

Shri K. V. Sarabhai: Global warming is very much to do with lifestyles. This conventional path of development, which is a path western



countries took post the industrial revolution, was based on fossil fuels. A simple mathematics calculation can show you how this path is completely unsustainable. It is something which leads us to an ecological footprint or a carbon footprint way above what this planet can sustain to survive. Why we are not at a crisis stage now is because a large part of the people on this planet are still poor and as long as they are poor, they don't have access to resources the way the rich and rich nations use resources. Now when we go towards all nations rapidly developing and treading on the same path, the total resource consumption reaches levels that we simply don't have. In India we must realize that currently we are the second most populous country in the world. But com-

pared to China we have an extremely different population age profile. The Indian age profile is such that it leads to a population growth rate which is quite different from China's. India is also the fastest growing economy in the world. And it is predicted that in another four years from now, India will become the most populous country in the world. One in every six person in the world is from India. That gives us a certain sense of responsibility. How we choose live will make a difference to the world. We also in some way performing a leadership role *vis-à-vis* other developing countries. While the developed countries are trying to retrofit the model they have, we have an opportunity to make the right choices from the beginning.

India is a country which can show the way. India's role in dealing with the global problem of Climate Change would be to show people how sustainable development can take place. Climate Change needs to be dealt with in terms of both mitigation and adaptation. In both cases, India has a very important role to play.

ISG: Sir, thank you very much for sparing your valuable time for this wonderful discussion on the challenge of SDGs and the role of geomatics for the special issue of ISG Newsletter.

Geomatics Applications for Himalayan Region

Shakil Ahmad Romshoo and Sadaff Altaf

Department of Earth Sciences, University of Kashmir, Srinagar;
E-mail: shakilrom@uok.edu.in

INTRODUCTION

Himalaya provide most of the south Asia fresh water, energy, host huge reserves of ice outside the polar regions, harbor rich biodiversity, are home to a large population and are therefore key to the future of more than a billion people. Yet, poverty, climate change, disaster vulnerability and environmental degradation are threatening the life and infrastructure in the Himalayan mountainous region. By taking care of the Himalaya, we would ensure the long-term security and survival of all that is connected to them, including humans. Therefore, the generation and availability of knowledge about various aspects of the mountain ecosystems has become imperative for environmental protection and conservation, disaster vulnerability assessment, energy and food security, land and water resources management together with the preservation of cultural heritage in the Himalaya (Romshoo et al., 2017, Winiger et al., 2005). Therefore, various disciplines figuring under 'geomatics' like remote sensing, GIS and GPS together with existing records, field studies, laboratory experiments and simulation models provide a useful means to generate very important information about key components of social, economic and environmental conditions in mountains regions like Himalaya for effective characterization, efficient monitoring, and precise diagnosis of the present, past and future situation (Gruen and Murai, 2002). GIS (geographic information systems) and remote sensing tools and methods provide a useful means to investigate key components of social, economic, and environmental conditions through systematic generation of data indicating their present situation and changing status through space and time.

Geomatics in Mountainous Himalaya

The article briefly discusses, in the following subsections, the application of geomatics related to a few of the important applications concerning the mountainous Himalayan region.

Watershed studies

The watershed is considered to be the most appropriate spatial arrangement and functional unit for managing complex environmental problems. Geomatics is widely used in characterization and assessment studies based on watershed approach, prioritization of watersheds, and for assessing the influences of watershed characteristics on hydrological response for flood and soil erosion studies (Altaf et al., 2014; Meraj et al., 2017).

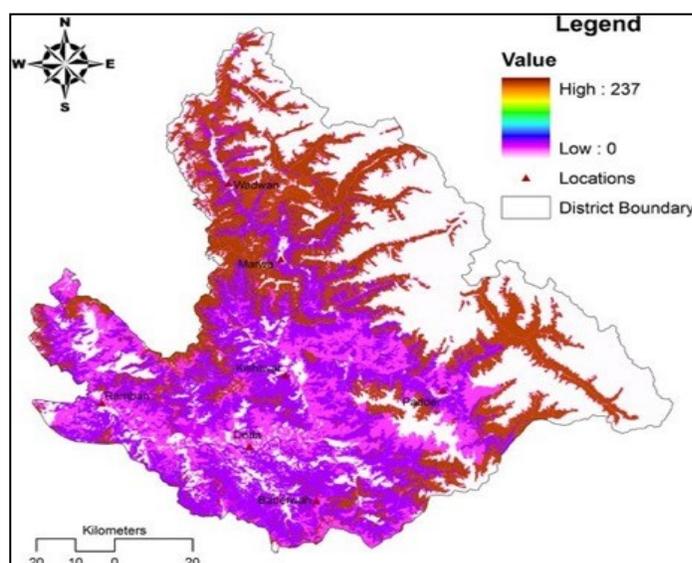


Figure 1: Biological richness map of Doda district

Forest and other natural resources

Geomatics has vast applications in studies related to natural resources. Examples may include biological richness map (Figure 1) showing a very rich biodiversity repository with signs of disturbance where terrain is either complex or where the anthropogenic pressures on forest resources are apparent (Rashid et al., 2013). Paddy crop yield estimation suggests that the simulation modelling coupled with geomatics could simulate regional yield with good accuracy (Muslim et al., 2015). Geomatics is routinely used for Soil Mapping (Khan and Romshoo, 2008).

Cryosphere studies

Geomatics has enormous applications in cryosphere studies as the glacier areas are most often inaccessible. It can be used for studying the dimensional changes in glaciers as shown in Figure 2. There are scores of instances of the use of geomatics in snow and glacier mapping in the Indian Himalayan region. Geomatics has applications in glacial-geomorphic studies as well as shown in the Figure 3. Several studies suggest that the use of geomatics in glacial-geomorphic studies provide vital information to make inferences about the effect of geomorphology on glacial advance and retreat (Dar et al., 2017).

Water resources assessment

To conserve and manage the water resources, it is important to have inventory of lakes, wetlands in the catchment (Panigrahy et al., 2012) The storage capacity of the lakes in the Himalaya has decreased significantly because of the massive siltation from the catchment as can be seen from the Figure 4 (Romshoo et al., 2017). Geomatics is used to study the impacts of anthropogenic activities on water quality, nutrient loading and understanding human-biophysical interactions (Rashid et al., 2016). Glacial lake inventory is another important cryospheric application of geomatics in the mountainous Himalayan region (Li and Sheng, 2012).

Land degradation studies

The steep slopes in the Himalayas along with depleted forest cover, as well as high seismicity have been major factors in soil erosion with the headwaters generating a large volume of water and eroded sediment in Himalaya. The estimation of soil erosion is necessary to initiate land degradation measures at a watershed level (Jain et al., 2001). Geomatics is used for identifying and prioritization of soil conservation measures in the mountainous Himalaya as shown in the Figure 5 (Meraj et al., 2017).

Tourism infrastructure development

Tourism in the mountainous Himalaya is becoming a growing environmental concern due to extreme

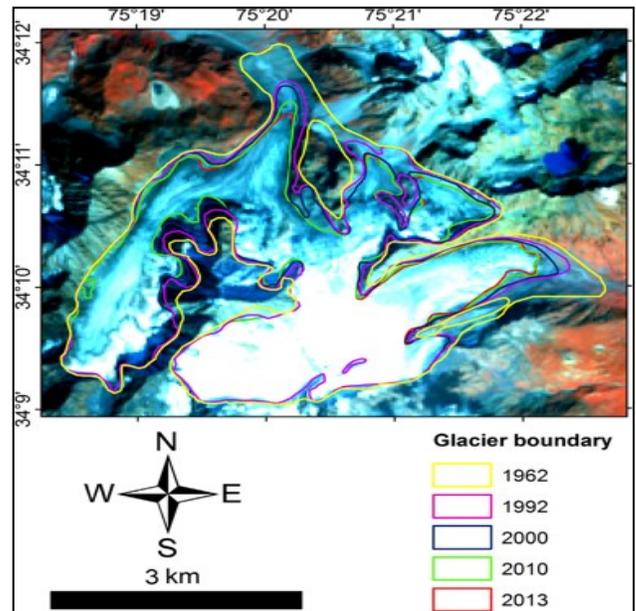


Figure 2: Change in glacier area since 1962

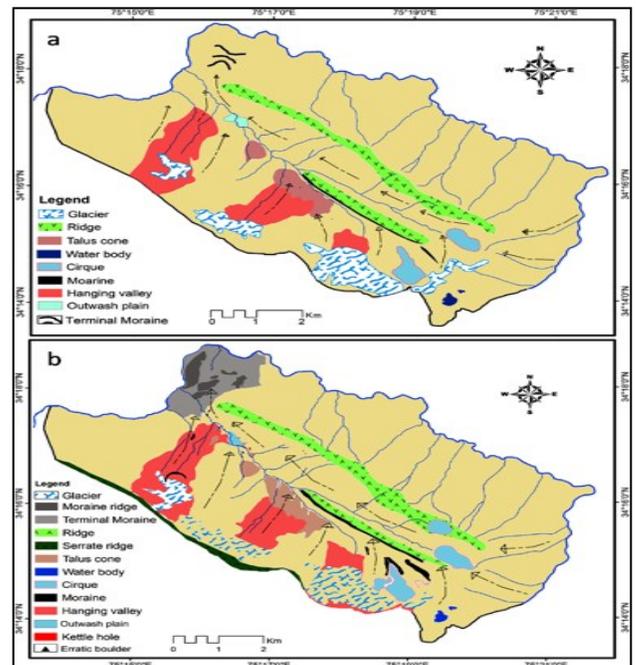


Figure 3: Glacial-geomorphic map of the Thajwas glacial valley digitized from (a) Landsat ETM imagery and (b) Google Earth Imagery. The dotted arrows indicate the palaeo-ice flow directions

seasonality, lack of suitable infrastructures and planning, and interference with ecosystems (Geneletti and Dawa, 2009). Planners are using geomatics technology to find suitable sites for tourism development depending upon the tourist interest and other natural factors (Kanga et al., 2007).

Urban and regional planning studies

Urban development and migration of population from mountain is a global phenomenon. Any small and isolated population centers are rapidly changing into large metropolitan cities and hence the conversion of natural land to urban use is quite obvious as can be seen from Figure 6 (Romshoo et al., 2017). Geomatics is used for identifying suitable sites for urban development in the mountainous Himalaya.

Climate change studies

Geomatics has provided major advances in quantifying the impacts of climate change on land and water resources (Yang et al., 2013). Climate change studies are usually carried out by studying the spatio-temporal variability of indicators like vegetation, streamflow and cryosphere (Rashid et al., 2015; Romshoo et al., 2015) as shown in Figure 7.

Land use and land cover mapping

Land use land cover mapping helps in understanding the landscape dynamics for sustainable management of land resources. Geomatics has become a suitable platform for data analysis, update and retrieval for LULC analysis. Many studies have been carried out in Himalaya to analyze LULC (Meraj et al., 2017, Rawat and Kumar 2015).

Meteorological studies

Understanding weather and climate requires the availability of high resolution and high quality hydro-meteorological data. The complex orography of the Himalayan region poses a serious obstacle to atmospheric monitoring. In order to overcome the problem, remote sensing products are being widely used as satellite-based products show clear relationships with *in-situ* observations (Rashid et al., 2018).

Flood studies

Geomatics has become the key tool for flood monitoring (Figure 8) in recent years and the development in this field has evolved from optical to radar remote sensing. Geomatics is routinely used for the delineation of flood zones and preparation of flood hazard maps for the vulnerable areas in Himalaya (Brivio et al., 2002; Sanyal and Lu, 2004).

Challenges for Geomatics in Mountainous Himalaya

Some remotely sensed products have been developed successfully and have become standard applications

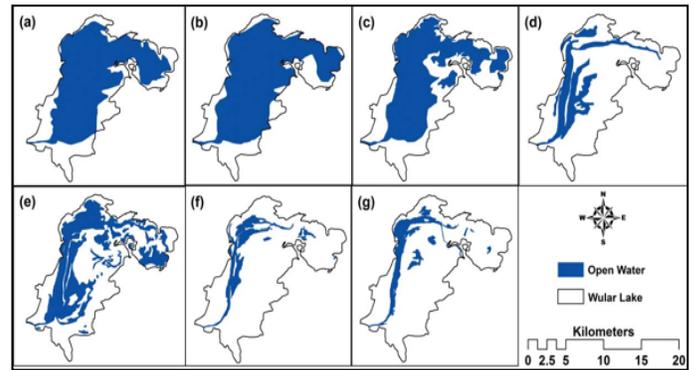


Figure 4: Open water extent of Wular Lake at different points in time: (a) 1911, (b) 1954, (c) 1962, (d) 1979, (e) 1992, (f) 2001 and (g) 2013

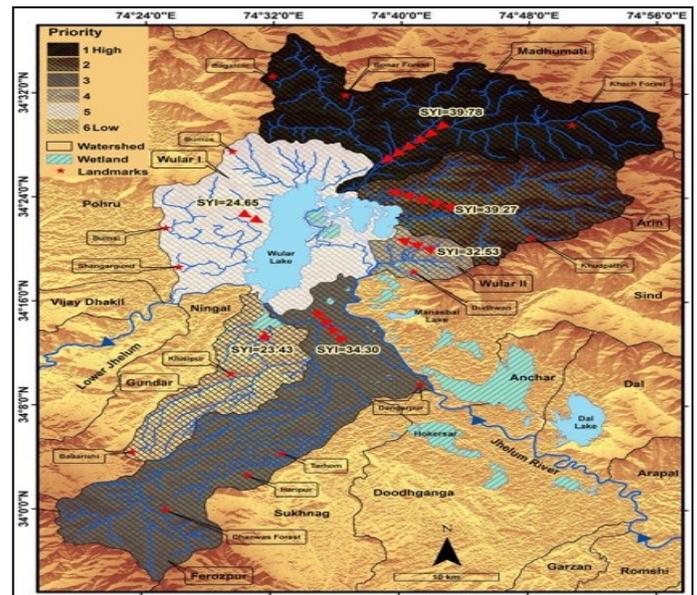


Figure 5: Sediment yield index (SYI) of the six surrounding watersheds of the Wular lake and the final watershed prioritization map. The number of red arrows represents the comparative sediment yield of these watersheds

in Himalaya over the last few decades, an example being land use mapping, terrain mapping, snow and glacier mapping, settlement analysis etc. However, there are significant drawbacks to the application of potential geomatics technologies in mountain regions, e.g. those aiming to take advantage of the latest available techniques such as radar, or laser sensors. Foreshortening, layover and shadows possess a challenge for the use of radar images and is particularly true for mountain regions, where steep terrain complicates image processing. Data pre-processing steps, namely geometric correction is more difficult in steep terrain as there are differences in the distance between ground surface and the receiving sensor. Shadows, in the sense of non-illuminated areas for passive sensors and non-accessible areas for active sensors, hamper the homogeneous interpretation and classification of remotely sensed data. This is even more so for the very high-resolution sensors of the latest satellite generations, due to their lower platform orbits and varying viewing angles (Schneiderbauer et al., 2007). Similarly, a reliable risk monitoring system for mountain hazards such as avalanches or landslides requires daily data, which are often not achievable with existing satellites.

CONCLUSIONS

The application of geomatics technologies to a great variety of issues in the Himalaya clearly demonstrates its usefulness for the characterizing, monitoring, analysis and representation of data about spatio-temporal processes in the mountainous areas. Satellite remote sensing, image processing, aerial photogrammetry, GIS modeling, use of DEM, cartography, visualization and simulation modeling play essential roles in generating valuable and strategic knowledge about key aspects of mountain system that have far reaching influences in the plain areas. Highlighting the applications of Geomatics technologies to various disciplines in the Himalaya in this article presents an interesting mosaic and framework for mountain research community. However, it is likely that several other applications of geomatics in mountainous ecosystems shall be presented in much more details during various thematic sessions of the Geomatics-2018 and would help to draw more attention of the public and policy makers to these fragile regions in the country.

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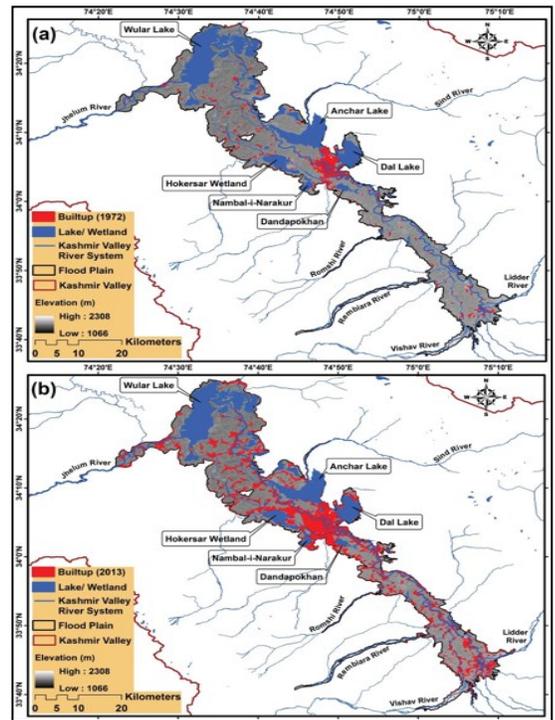


Figure 6: Urbanization in the floodplains of Jhelum (a) 1972 and (b) 2013

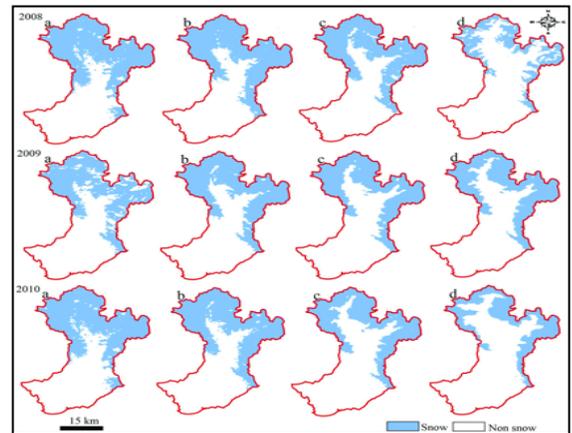


Figure 7: Spatio-temporal distributions of the snow cover in the study area from 2008 to 2010, in (a) February, (b) March, (c) April, and (d) May

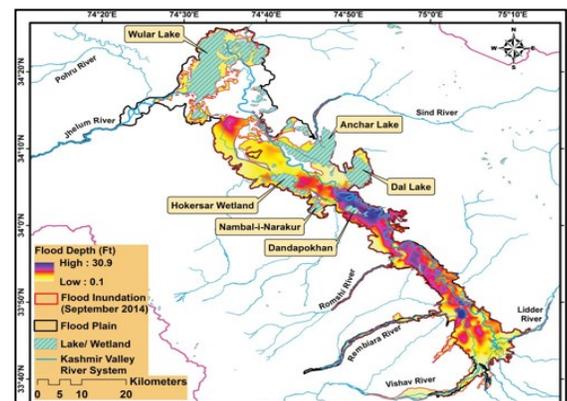


Figure 8: Flood inundation level (depth) in the flood plains of Jhelum basin

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Earth Observation Applications in Governance and Development

Shantanu Bhatawdekar

*Earth observation applications & Disaster management support Programme Office (EDPO),
ISRO Headquarters, Bangalore*

INTRODUCTION

Vision of Indian Space Programme is laid with the aim to “Harness space technology for National Development”. With a humble beginning in 1963 and throughout the five-decade journey, Indian Space Research Organisation has been demonstrating remarkable indigenous capabilities in space technology and unique applications. Space applications have played an important role in enabling solutions to some of the priority areas of national development including key parameters for Governance. These have made some impacts on the quality of life of citizens and enabling societal transformation.

The data and value added services emanating from Earth Observation (EO) satellites, in conjunction with ground based observations, contribute significantly in the domains of food, water & energy security; environment protection; weather forecasting; sustainable development; disaster risk reduction etc. Space derived inputs along with geospatial technologies and field information are adopted in an integrated way by various Central Ministries and State Governments in planning, periodic monitoring, mid-course correction and evaluation of developmental activities under the parlance of governance. The capabilities of satellite communication and navigation, in addition to earth observation, are also exploited in providing an array of application services in the area of education & health, connectivity, location based services and so on. Some of the operational space applications addressing socio-economic transformation and making a difference to the society are highlighted below:

Food Security

India's population has been growing rapidly, which would further result in increasing demand for food grain production to ensure food security to our people. This would necessitate development of rain-fed agricultural areas, wastelands, improvements in cropping system and agricultural practices, greater efforts towards disaster risk reduction and so on.

Satellite data, synchronous with ground data, is being analysed and used with a focus on agro-meteorology and market economics to estimate **crop acreage and production** for 8 major crops viz. Wheat, rice (kharif & rabi), mustard, rabi sorghum, jute, winter potato, sugarcane, cotton in the country. Using the procedures developed by Space Application Center, ISRO, the Mahalanobis National Crop Forecast Centre (**under Ministry of Agriculture & Farmers Welfare**) has been regularly generating crop forecasts at District/State/National level and providing to the Government for planning and decision making.

Satellite remote sensing data has been used for production estimation of 7 **horticultural crops** (Potato, Onion, Tomato, Chili, Mango, Banana and Citrus) for 180 districts in 12 major states. Action plans are generated to identify suitable sites for expansion of horticultural crops in under-utilized areas and planning of infrastructure to minimize losses of fruits & vegetables.

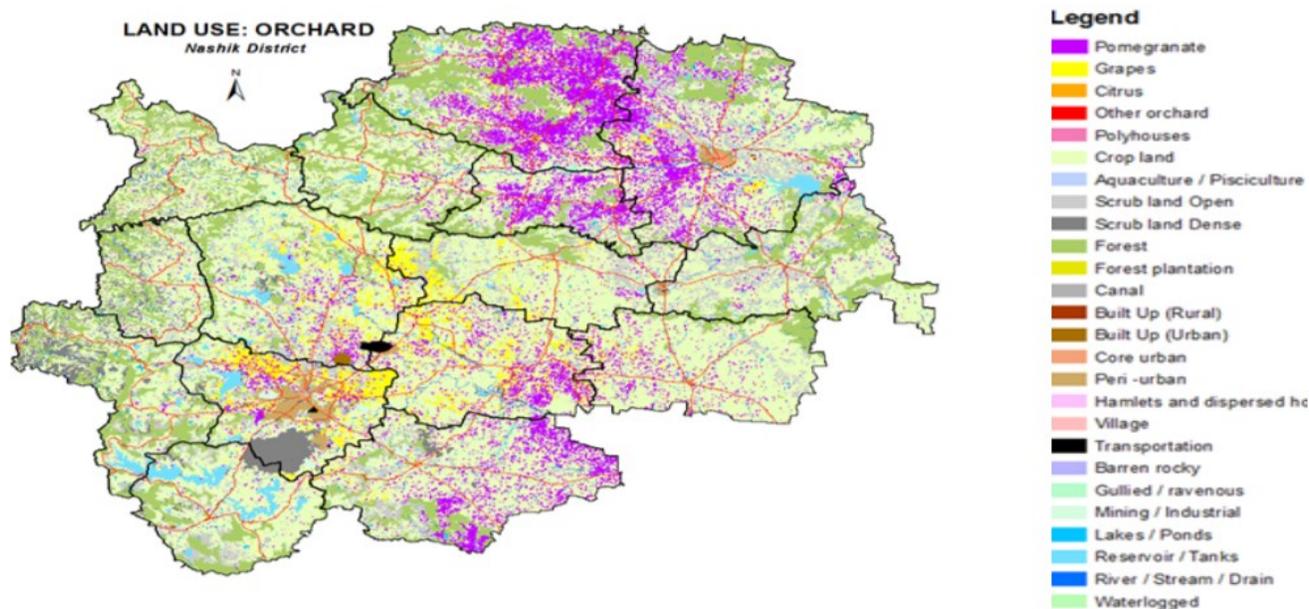


Figure 1: Fruit orchard inventory, Nashik district

The country has been repeatedly provided with the status of wastelands, both culturable and non-culturable, ever since late 1980s. Management of wastelands is crucial for enhancing agricultural production, improving ecology and environmental protection. Remote Sensing based mapping and monitoring of wastelands is done at regular intervals to support **Ministry of Rural Development** for planning and implementation of reclamation measures with the objective of bringing **More Area under Agriculture**.

Sea Surface Temperature and Chlorophyll retrieved from satellites are used for providing **Potential Fishing Zone advisories** to the fishing community to reduce the time and effort in fishing. Such advisories have been helping them in improved fish catch and reduction in search time and improving their livelihood options. Indian National Centre for Ocean Information Services under **Ministry of Earth Sciences** provides these advisories on a daily basis.

Water Security

EO based applications are employed to assess the availability of water resources, efficient storage of rain water, monitoring of irrigation infrastructure, estimation of reservoir storage capacity and improving the management of water resources.

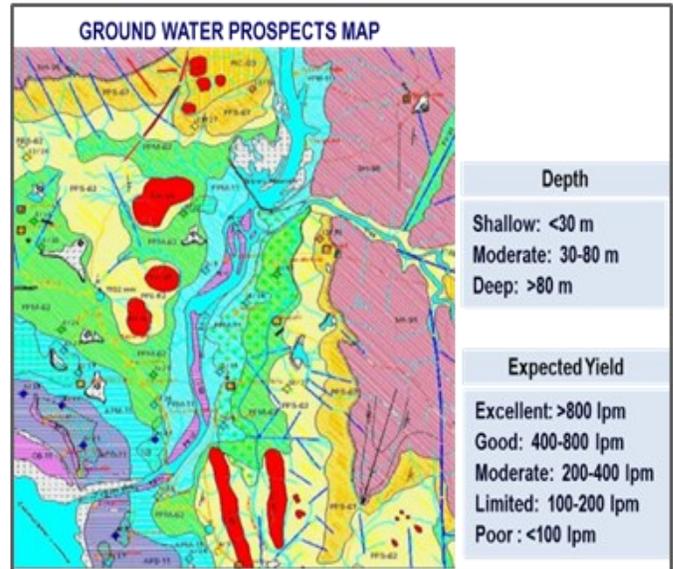
Using multi-temporal satellite images, National level **surface waterbody maps** depicting water spread and its availability are prepared on a fortnightly basis and posted on the Bhuvan web geoportal for use. Ground-water prospects maps have been prepared for the entire country, by integrating multi-thematic information derived using remote sensing data and field observations. These maps provide information on **ground water sources** in terms of depth and yield and help in narrowing down to the areas for selection of suitable sites for bore-well/tube-well and also for constructing recharge structures.

These maps (also hosted as *Bhuvan Bhujal on the web geoportal*) have been extensively used by various state governments for drilling wells, with good success rate. National Remote Sensing Center, ISRO, responded positively and carried out ground water prospects mapping at 1:10,000 scale in dry areas during serious drought conditions in the past few years. In addition, necessary collaborative efforts are also taken up in 8 selected states based on the requirements proposed by the **Ministry of Drinking Water & Sanitation**.

High-resolution satellite data is operationally used by **Central Water Commission (CWC)** for monitoring the irrigation Infrastructure to assess the physical progress and identify the **gaps between irrigation potential**

created and its utilization on the ground. Systematic Assessment of sedimentation is also made to plan reservoir operation for optimum utilization of water. The water spread areas at different water levels in different month of the year are computed from satellite images.

India-WRIS (www.india-wris.nrsc.gov.in) deployed, jointly by ISRO and CWC has been providing important information on water resources for effectively management at national level. Recently, initiatives have been taken up at State level, viz., Telangana and Andhra Pradesh to comprehensively address water resources management, including facilitating the irrigation water management and others. These initiatives have started helping the concerned States in the water sector.



Energy Security

Space technology is useful for assessing the potential of renewable energy resources and to plan power generation and distribution. Solar Calculator Mobile App to estimate solar energy potential and Digital atlas for Solar, Wind and Wave energy has been deployed in VEDAS portal (www.vedas.sac.gov.in) which are used by M/o New & Renewable Energy as well. Remote sensing data integrated with geospatial data provide valuable information on various parameters viz. geological, environmental, terrain, availability of suitable geological materials, proximity to procurement hubs etc. to identify suitable sites for Hydropower plants.

Sustaining the Environment & Eco-System

Remote Sensing data has been of significant help in monitoring our forest cover, assessment of trees outside forest and planning for sustainable use of forest. Forest Survey of India makes regular assessment of forest cover at national level, on a two-year cycle, to plan for conservation measures of bio resources. New initiatives have been recently taken up by ISRO to process time series satellite images to enable semi-automated forest cover change locations, on an annual basis for entire country. These products have been made available to the Ministry of Environment, Forest & Climate Change as an effective measure to monitor forests in the country. Also, MOEF&CC has effectively used ENVIS services, Desertification & Land Degradation Maps.

The satellite data has helped in deriving the spatial distribution of different vegetation communities in Eastern & Western Himalayas, Shivaliks, Vindhyas, Eastern & Western Ghats and Coastal areas. The database provides vital input planning conservation and prioritization.

Integrated watershed development programme is one of the major initiatives in the country towards conservation of soil and water resources in the rain fed area. Remote Sensing based database on natural resources integrated with field data and traditional wisdom are used to prepare



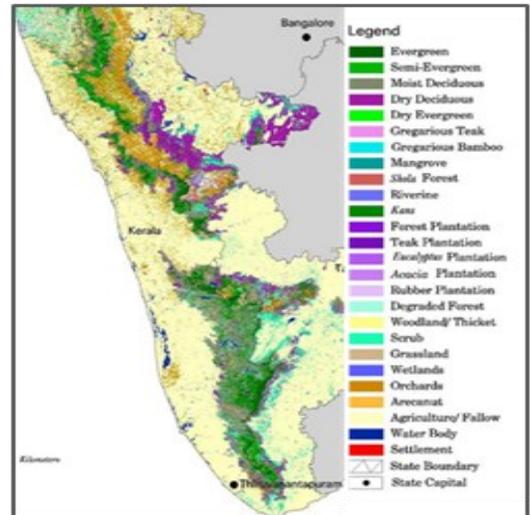
locale-specific action plans for land & water management to enable sustainable planning at grass root level. Such action plans are used to suggest optimal land use practices for better returns and livelihood.

Disaster Risk Reduction

The synergistic use of the space and airborne systems, in conjunction with conventional technologies, play a key role in all spheres of disaster management from preparedness to recovery. It facilitates near-real time data acquisition, generation of value-added information and its dissemination in shortest possible time.

For disaster preparedness, flood hazard and landslide hazard zonation maps have been generated using historical data on occurrence of such disasters. Initiatives have been taken for assessing vulnerability of agricultural drought and preparation of risk maps. Flood Early Warning System (FLEWS), operational in all districts of Assam, provides actionable product and flood alerts for effective management of floods. The data & geophysical products derived from Indian meteorological satellites are assimilated in the Numerical Weather Models of India Meteorological Department for prediction (24 to 72 hours in advance) of cyclone track, intensity & landfall. The accurate early warning during cyclones viz. Hudhud, Phailin, Vardha has immensely helped in saving the lives of people.

EO satellites data are used for near-real time monitoring of disasters and in deriving value-added products for damage assessment to support during disaster response and rehabilitation. Citizens also participate in providing information on the damages caused during disasters through Bhuvan. Satellite phones and transportable satellite terminals are used to establish critical emergency communication between inaccessible areas.

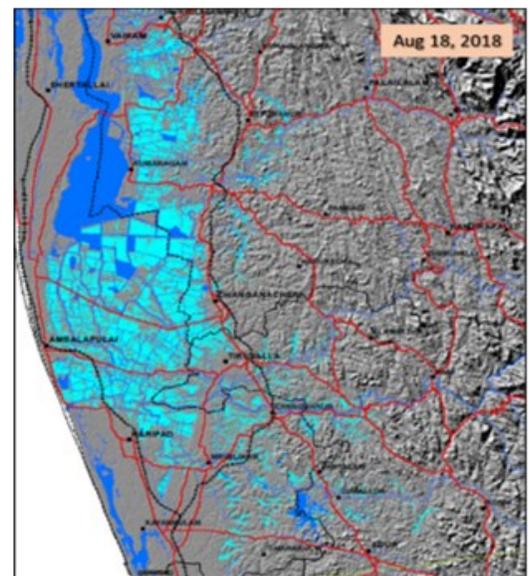


The Turning Point

National Meet, a unique initiative by the Prime Minister himself, was organized on 7th September 2015 with a goal of maximizing the use of Space Technology in Governance and Development across Central Ministries and State Governments. The event witnessed participation of more than 1500 officials deliberating the significance of Space Applications in agriculture, energy & environment, infrastructure planning, water resources, technology diffusion, developmental planning, communication and navigation, weather and disaster management, health and education. The Prime Minister of India, in his address, emphasised the significance of space technology and called upon Central Ministries and State Governments to formulate space application initiatives in all possible areas of governance and development.

This effort forked more than 150 projects across varied disciplines and development of host of web & mobile applications, specifically towards enabling e-governance and ease of doing business. Some of these initiatives are elucidated below:

- At the behest of **Ministry of Rural Development**, Mobile App (DRISHTI) and Web Applications (SRISHTI) are deployed for online monitoring and evaluation of about 86,000 micro-watersheds in the country. SRISHTI enables hierarchical visualization of watersheds by administrative units; along with



natural resources' database while DRISHTI helps reporting field accomplishments as Geotags. Nearly 9.45 lakh geo tagged field interventions are uploaded on to SRISHTI from state nodal agency teams.

- Remote sensing Images in conjunction with geospatial tools are being used for **urban planning** by enabling Urban Local Bodies for master plan preparation for 500 cities/towns under AMRUT programme of **Ministry of Urban Affairs**. Urban geospatial database generation for AMRUT towns on 1:4,000 scale and GIS based Master Plan preparation are being carried out.
- At the behest of **Ministry of Culture**, inventory has been completed for all notified 3658 archaeological heritage sites in the country by demarcating site management zones viz. Prohibited, Protected & Regulated zones. Towards Ease of doing business, a customized mobile application is developed for online processing of Citizen Requests for No Objection Certificate.
- Under MGNREGA, satellite derived location based services are being utilized for monitoring of assets created annually. More than 3 crore assets have already been geotagged and hosted on Bhuvan-MGNREGA Geoportal for **Ministry of Rural Development**.
- A National Health Resources Repository (having 7000+ attributes) is being built to spatially map the government & private health care resources to enable health census.
- The initiative 'Space based Information Support for Decentralized Planning' plays a key role in empowering the panchayats to prepare developmental plans at grass root level in collaboration with **Ministry of Panchayati Raj**.
- To monitor the progress of the beneficiary houses at five different stages under Pradhan Mantri Awas Yojana (PMAY) a Bhuvan-MoHUA Web Geoportal has been developed. The construction activity is monitored based on the stage of construction such as Not Started, Foundation, Lintel, Roof and Completed, to track the activity against the schedule. 31 Lakh houses geotagged.



Summary

Space technology applications have spread its wings in addressing various national developmental needs and the impact of these applications, in making a difference to the society, have been successfully demonstrated. Besides ensuring continuity of data and services for operational applications, the future agenda is drawn towards augmenting the space systems and catalyzing development of innovative applications to give further impetus to space based applications in governance and development.

Space Technology in Disaster Management Support

V Bhanumurthy and P V N Rao

National Remote Sensing Centre, ISRO, Dept. of Space, Balanagar, Hyderabad - 500 018; E-mail: bhanumurthy_v@nrsc.gov.in; rao_pvn@nrsc.gov.in

INTRODUCTION

India with its long coastline and diversity in terrain and weather conditions is severely prone to natural disasters such as floods, cyclones, earth quakes, forest fires and droughts. Combined with varying degrees of socio-economic conditions of people across the country, the impact of a natural disaster is seriously felt in terms of loss of life, shelter and property. In addition, anthropogenic disasters such as oil spill, increased air pollution due to ever increasing vehicular traffic in urban areas and agriculture residue burning has been a serious cause of concern in recent years from the perspective of public health and global climate change. Disaster risk assessment in the country shows 12% of land area (40 Mha) is flood prone, 8% of land area along the coast is cyclone prone, over 65% of land under cultivation is drought prone, around 25% land (under Seismic zones IV-V) area is Earthquake prone and Himalayan and Western Ghats regions are Landslide prone. Average annual direct loss is estimated in terms of 4350 lives, 1.42 Mha of affected crop area, 2.36 M damaged houses resulting in loss of 2% of the GDP. The indirect losses include expenses on emergency response and relief, diversion of developmental funds, and the socio-psychological losses that cannot be quantified.

In the light of above scenario, identifying disaster vulnerability areas and risk assessment, setting up of ground and space based monitoring systems, developing early warning systems for prevention and mitigation of loss of life and property as well as for timely relief measures and damage assessment assumes importance. Government of India, in recognition of the importance of Disaster Management as a national priority, on 23 December 2005 enacted the Disaster Management Act, which envisaged the creation of National Disaster Management Authority (NDMA), headed by the Prime Minister, and State Disaster Management Authorities (SDMAs) headed by respective Chief Ministers, to spearhead and implement a holistic and integrated approach to Disaster Management in India. NDMA is striving to realise its vision "to build a safer and disaster resilient India by a holistic, pro-active, technology driven and sustainable development strategy that involves all stakeholders and fosters a culture of prevention, preparedness and mitigation" with multi-institutional participation.

Role of Space Technology

Space technology with its three components of remote sensing, navigation and communication satellite systems combined with the data processing and analytical expertise in the respective subject domains has a big role to play by providing near real time spatial inputs on natural disasters and their monitoring for damage assessment in space and time at regional to local scales and disseminate the information to the policy/decision makers and the relief departments for timely action. Space-borne remote sensing sensors have the advantage of frequent large area coverage at desired intervals of time and spatial resolution, and access to humanly impossible remote areas. True to the saying "a picture is worth a thousand words", remote sensing brings reality on the ground to the decision makers for quick action resulting in efficient governance and transparency. In addi-

tion to bringing near real time information products in map form, remote sensing provides invaluable data to generate databases on land use land cover, water resources, annual net sown area, urban sprawl etc., to use along with the disaster time data for damage assessment. Additionally, remote sensing provides much needed information for generating high resolution Digital Elevation Models and on weather parameters on regular basis for developing models for early warning. In recent times, using locational services through navigational satellites and internet services through communication satellites, crowd sourcing has assumed greater significance in bringing in-situ conditions by way of location (lat/long) and field photographs through MobileApps, which in turn is strengthening the information derived by remote sensing.

Disaster Management Support Programme (DMSP) in ISRO

DMSP, conceived and implemented during the 10th Five Year Plan by ISRO, adopted a comprehensive approach with its major components of (i) Earth observation (EO) satellites for thematic inputs, (ii) weather inputs from meteorological satellites, (iii) communication support through communication satellites, (iv) a single window EO information dissemination service through the Decision Support Centre (DSC) at National Remote Sensing Centre (NRSC), a GIS based National Database for Emergency Management (NDEM) at NRSC, Bhuvan Geoportal for visualisation, data access and geospatial support, disaster management support at global level through international charter, Sentinel Asia, UN-SPIDER and UNESCAP, aerial support for high resolution terrain data and R&D for early warning using space inputs. Figure 1 shows ISRO-DMS programme at a glance with the information and support services, institutional participation and the stakeholders. Following sections focus on DSC and NDEM being executed at NRSC as covering all aspects of DMSP is out of scope of this article.

ISRO-DMS Programme at a Glance



Figure 1: ISRO-DMSP

Disaster Management Support Centre (DSC)

It is established at NRSC as a single delivery point for space and aerial enabled inputs for disaster management with major activities being (i) near real time monitoring of disasters (floods, cyclones, forest fires, landslides, earthquakes), (ii) generation of vulnerability and hazard zonation maps and provide information for planning disaster mitigation measures, (iii) provide comprehensive disaster specific multi-scale database to NDEM, (iv) inputs to MHA, NDMA, CWC, IMD, Central & state DMA, (v) Disaster Early Warning, (vi) Capacity Building and (vii) Sentinel Asia and Charter activities (Figure 2).

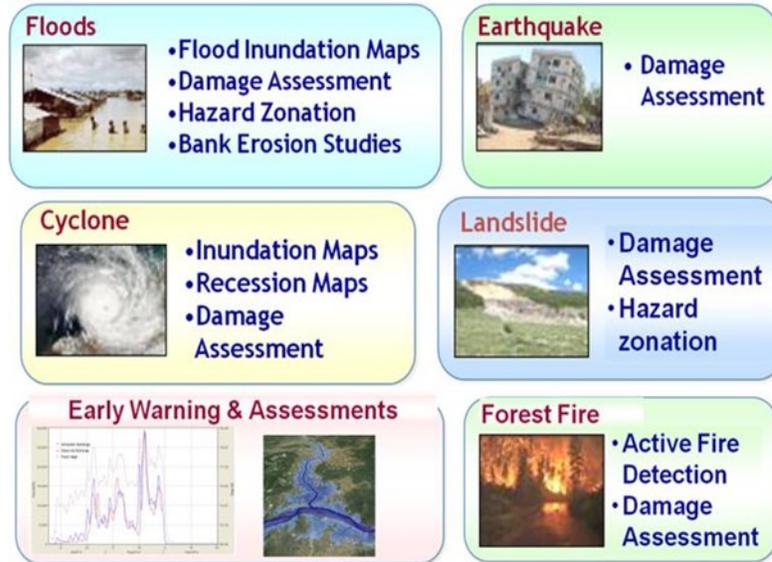


Figure 2: Major activities of Disaster Management Support Centre at NRSC

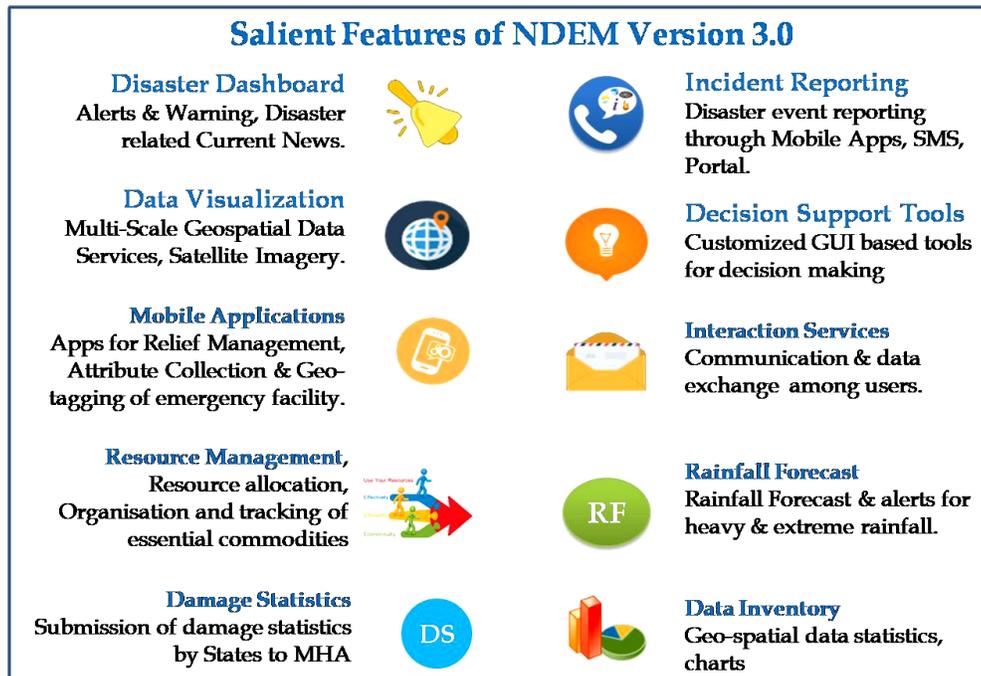


Figure 3: Functionalities of NDEM Version 3.0

National Database for Emergency Management (NDEM)

Implemented at NRSC as the lead agency on the behest of Ministry of Home Affairs (MHA) with multi-institutional participation, NDEM is a GIS based repository of data to support disaster/ emergency management for the entire country with a set of Decision Support System tools. Fully operational since 2013, the NDEM Version3.0 is populated with multi-scale geospatial database for entire country at 1:50,000 scale, for 350 Multi-hazard prone districts at 1:10,000 scale and for 5 Mega-cities at 1:2,000 scale, and supported by the necessary computer infrastructure to facilitate network connectivity, data ingest, validation, GIS databases organization, data dissemination and services hosting. The database consists of 45 layers of base, thematic, infrastructure, disaster specific information and raster data in addition to more than 3 million points of interest with location & attribute information for use in emergency situation. Major functionalities of NDEM are

shown in Figure 3 and the portal can be accessed from <https://ndem.nrsc.gov.in/>

Support to International Community

ISRO is an active partner in international initiatives to share the experiences, exchange the information and best practices towards global disaster management. DMS programme of ISRO is responding to the International Charter on “Space and Major Disasters” and Sentinel Asia project for supporting disaster management activities in the Asia-Pacific region and the initiatives of UNOOSA, UNESCAP and BIMSTEC. NRSC /ISRO is actively involved in Sentinel Asia (SA) program, a voluntary initiative led by Asia-Pacific Regional Space Agency Forum, and supports the Emergency Observation Requests (EOR’s) with IRS series of satellite datasets comprising of Resourcesat-1/2 (AWiFS , LISS III and LISS IV), Cartosat-1/2, RISAT-1 etc. on voluntary basis. In this regard, about 67 Emergency observation requests were supported with more than 144 satellite datasets during 2011- 2016 and some of the major disasters supported include Nepal Landslides 2015, Taiwan Typhoon 2015, Philippines Typhoon “BOPHA” 2012, Japan Tsunami, 2011. Figure 4 shows the distribution of the events covered.

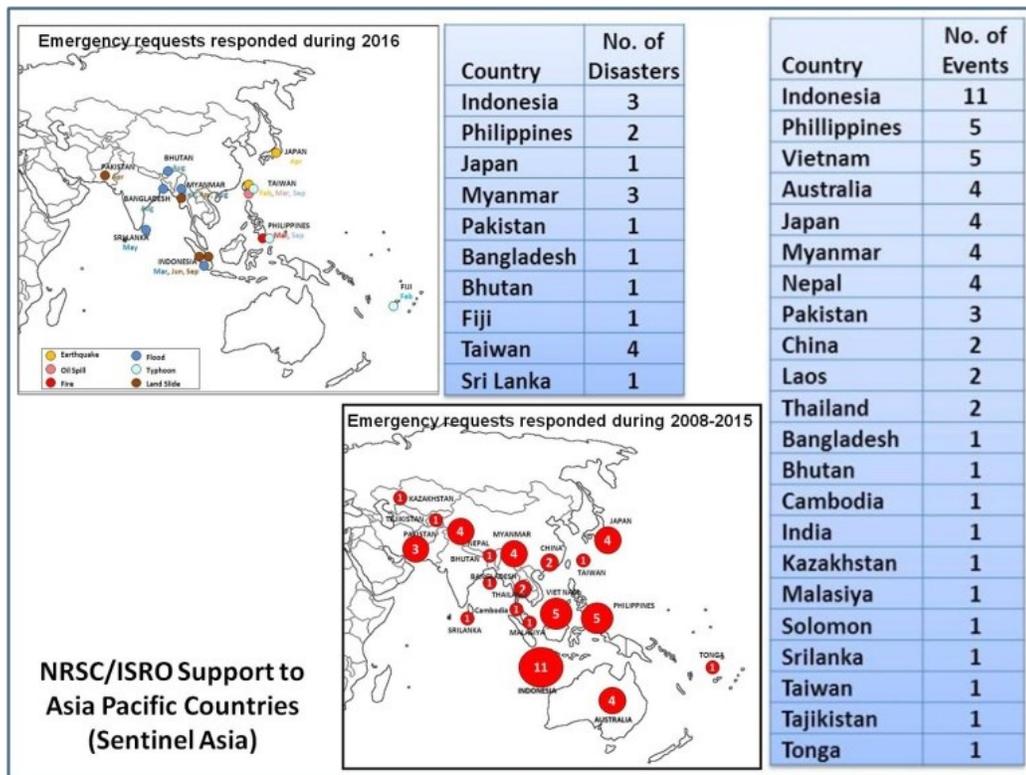


Figure 4: NRSC/ISRO in Sentinel Asia

CONCLUSIONS

Space technology through its components of remote sensing, location and communication services is providing vital inputs to all four stages of disaster management cycle consisting of mitigation, preparedness, response and recovery. Availability of much needed real time remote sensing data, weather models and early warning systems combined with capacity building with necessary infrastructure and skilled manpower is making disaster management support programme effective and efficient in minimising the loss of life and property for sustainable development.

Acknowledgements

Authors are greatly indebted to our colleagues involved in Disaster Management Support activities including NDEM and gratefully thank them profusely for their support and inputs in bringing out this article.

SAFAR : Air Quality Informatics to Citizens (SAFAR: System of Air Quality and Weather Forecasting & Research)

Gufran Beig*, Saroj K Sahu** and Rajnikant Shinde*

**Indian Institute of Tropical Meteorology, Pune; **Utkal University, Bhubaneswar;
E-mail: beig@tropmet.res.in*

INTRODUCTION

Ministry of Earth Sciences (MoES), Govt. of India, has introduced a major national initiative, “**System of Air Quality and Weather Forecasting and Research**” known as “**SAFAR**” for greater metropolitan cities of India to provide location specific information on air quality in near real time and its forecast 1-3 days in advance for the first time in India. It has been combined with the early warning system on weather parameters. The SAFAR system is developed by Indian Institute of Tropical Meteorology, Pune along with ESSO partner institutions namely India Meteorological Department (IMD) and National Centre for Medium Range Weather Forecasting (NCMRWF). The implementation of SAFAR is made possible with an active collaboration with local municipal corporations and various local educational institutions and governmental agencies in that Metro city.

Air pollution is one of the major growing problems all over the world. Many different sources such as factories, power plants, automobiles and even from natural causes such as wind-blown dust, smoke from bush fires and volcanic eruptions are responsible for pollution. The air quality can get affected in many ways due to the pollutants emitted from these sources. The deterioration of air quality thus results into a corresponding increase in health problems, eventually inducing the monitoring of air quality and its prediction in advance as a prime necessity in day-to-day life. There is a growing awareness of the linkages between human health, weather and climate.

Timely air quality information even a day in advance can assist general public in coping with health problems caused by its constituents *viz.* ground-level ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, particulate matter and other pollutants. Air quality advisories or alerts issued when pre-determined pollutant threshold exceeds should result in actions to reduce pollution levels and encourage people to avoid polluted areas thereby alleviating adverse effects on health. Briefly, in response to the air quality advisories people can try to take actions against the increased pollution themselves like use public transportation and polling together, stagger work hours or even stay indoors and industry and regulatory agencies may decide on temporary shutdown of polluting factories, thermal power plants. Similarly, the traffic controlling authorities can reroute the flow of traffic to avoid hot spot areas.

Apart from these air pollutants resulting from human activities, there are other parameters which affect human health and harm the environment as well. For example, the pollen season that is reasonably well-known to people who are allergic to it. The presence of pollen, its density and trajectory, as well as the possibility of being removed from the atmosphere by showers, all depend on the day-to-day weather. Also, the amount of UV radiation which not only leads to increase in skin diseases and eye cataracts in humans but also affect plants, aquatic organisms and other natural systems depends on the day-to-day weather conditions. These radiations also play an important role in modulating the level of air pollutants.

The SAFAR system, first of this kind in the country, is successfully developed with indigenous capabilities for 4 cities namely DELHI (2010), PUNE (2013), MUMBAI (2015) and AHMEDABAD (2017) and dedicated to citizens as an operational service. The early warning system for air quality and weather developed under the project proved as a useful machinery to reduce the first-hand impact of deteriorated air quality on human health. The successful implementation of SAFAR in both operational and research mode is recognized by the global scientific communities and Global Atmospheric Watch (GAW), Global Urban Research Meteorology and Environment (GURME) project of United Nation's "World Meteorological Organization (WMO)" appreciated and recognized it as its pilot project and also recommended to replicate and implementing it in other metropolis for the citizens of India which is likely to set an example for Developing countries.

System Components

Observational network

Under the project dense observational network of Air Quality Monitoring Stations (AQMS) and Automatic Weather Stations (AWS) has been established (50 × 50 km domain of metropolitan region) by selecting representative sites of different micro-environments including industrial, residential, background/ cleaner, urban complex, agricultural zones etc.

Air Quality indicators monitored at about 3 m from the ground includes Particulate Matter (PM10, PM2.5), Black Carbon (BC), Ozone (O3), Carbon Monoxide (CO), Carbon Dioxide (CO2), Oxides of Nitrogen (NO, NO2, NOx), Volatile Organic Compounds (VOC's) and Mercury (Hg). In addition to this temperature, rainfall, humidity, wind speed, wind direction, and solar radiation are monitored along with Ultraviolet radiation flux in terms of erythemal UV dose using AWS and UV-E radiometer. Calibrations of the online analyzers is performed at appropriate time interval using inbuilt calibrators for some pollutants or with external calibration cylinders with multipoint calibration techniques for other elements.



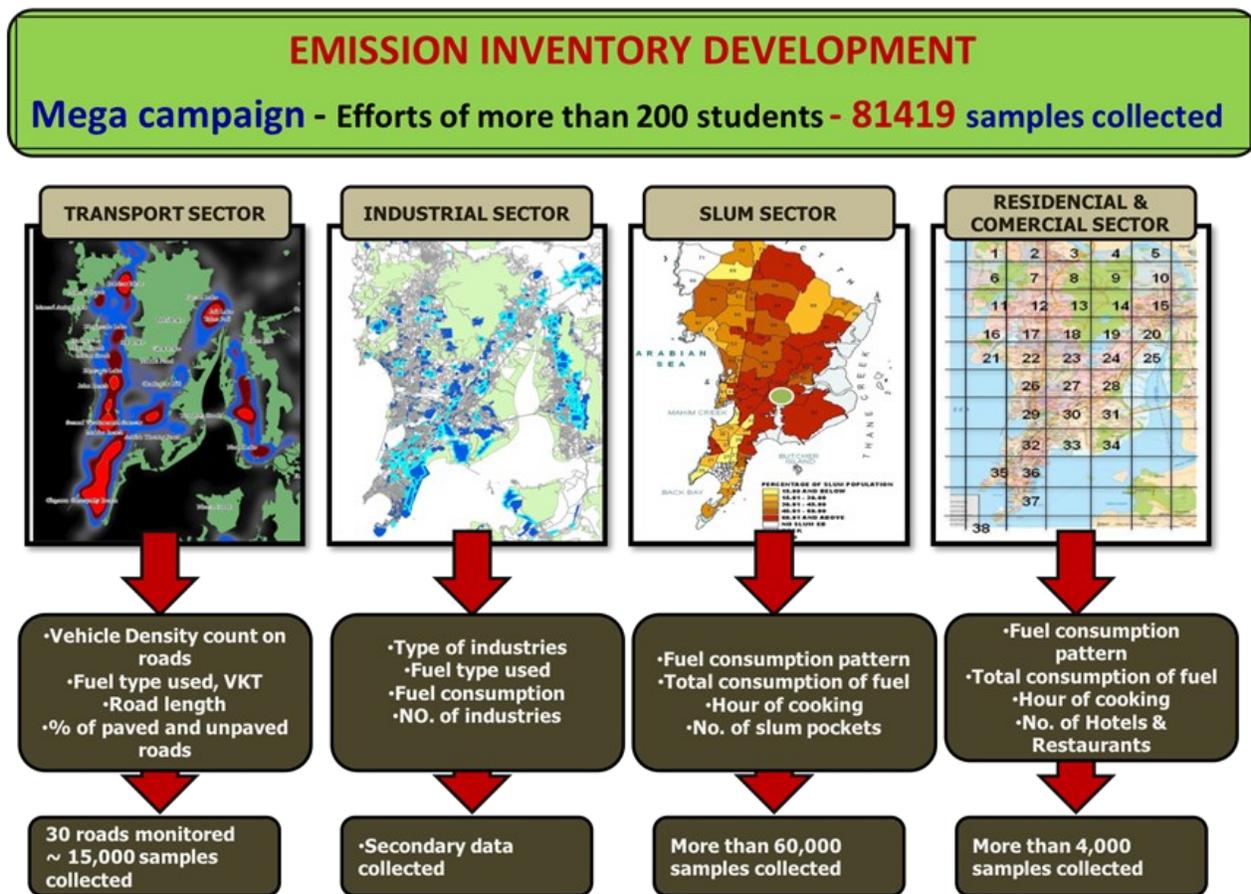
Air quality monitoring station (AQMS) along with Automatic Weather Stations (AWS)

Development of emission inventory

Emission of various air pollutants as a consequence of burning of fossil fuel and bio-fuel in our day to day life for industrial activity, transportation, cooking, power generation, agricultural production, waste disposal and so on is important phenomenon which alters the normal composition of air. In any urban settlement, these are the most potential air pollution sources but their contribution and intensity varies with geographical and socio-

economical factors. To identify the major air pollution sources in the region and their region specific spatial distribution, scientific approach has to be adopted. **Emissions Inventory** is the most effective scientific tool for the same. This is the most critical input to the 3-D atmospheric chemistry transport models along with meteorological input to forecast the air quality, the quality of forecast depends on the accuracy of emission inventories. It helps to implement effective air quality management program & formulate environmental policy.

Under the project SAFAR a high-resolution (1 km x 1km) emission inventory has been developed by **IITM** for all these 4 cities by using bottom-up approach. Development of Emission inventory is a complex process and required huge amount of activity data and knowledge of fundamental scientific processes. The accuracy and reliability of emission inventory has been maintained by collecting unique region specific activity data during the extensive field survey for several months involving more than 200 students of various educational organizations and proper country specific emission factors has been selected to estimate the total emissions of above pollutants from transport, industries, residential, slum sector. The particulate emissions from untouched source, paved and unpaved roads, are also estimated. The spatial distribution of pollutants has been studied by using GIS (Geographical Information System) based statistical model.

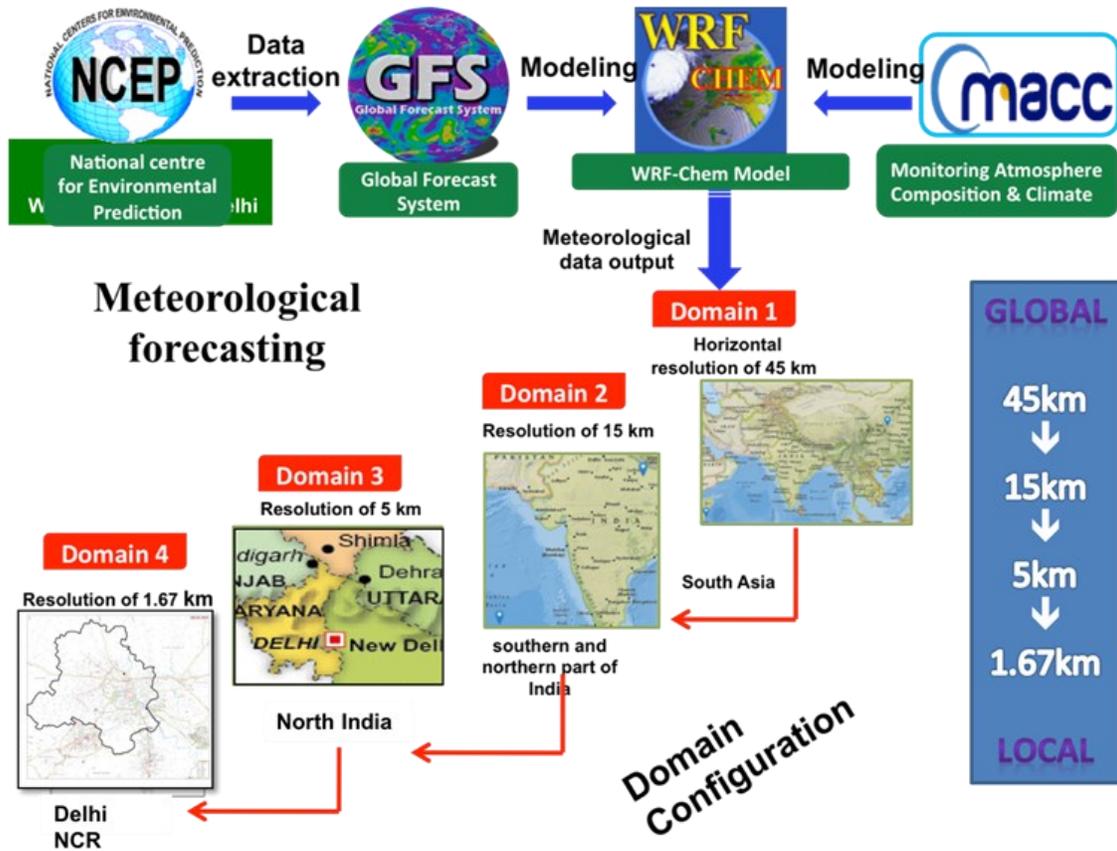


Development of Air Quality and Weather Forecasting Model

The air quality forecasting is a highly-specialized area and requires huge computational power on regular. Atmospheric chemistry transport model is used for Air Quality forecasting. To forecast the air quality of various pollutants along with weather parameters, IITM uses four nested domains starting from near global to the local city level. The inner domain has a resolution of 1.67 km x 1.67 km. All these 4 domains run interactively and feedback of meteorology to chemistry and vice-versa has been accounted. This model requires several key inputs for accurate forecasting. Major among them are- emission inventory of pollutants from various sources, weather parameter, topographical data, land use-land cover data, initial and lateral

boundary conditions, etc.

MODELLING FRAMEWORK FOR CITY LEVEL FORECAST



Data to Information

Under the project measurements of air quality indicators and weather parameters have been made round the clock and the data is recorded and stored at every five minutes interval for quality checks and scientific analysis. This near real time online raw data is then converted in the public friendly format like **Air Quality Index (AQI) or UV-Index** at SAFAR-Control room after rigorous quality control and quality check by expert scientific team. Air Quality Index (AQI) is a rating scale used for reporting the quality of air we breathe in and the associated health effects. The UV Index is a measure of the amount of skin damaging UV radiation expected to reach the earth's surface at the time when the sun is highest in the sky (around midday).

System Products

The SAFAR system provides information on current and 1-2 days advance forecast for air quality and weather, harmful radiation and emission scenario over the city area in a very simple and user friendly format. The systems location specific products include **Air Quality- Now, Air Quality-Tomorrow, Weather-Now, Weather-Tomorrow, UV Index –Skin Advisory, AQI – Health Advisory and City Pollution Maps**. To disseminate the information to maximum stakeholder's user friendly platforms has been developed where one can access our products easily including MobileApp- "SAFAR-Air", **dynamic professional web portal (<http://safar.tropmet.res.in/>)**, **LED- Digital Display Board System (DDS)**, **Integrated Voice Response Service (IVRS) (Toll free No: +91- 1800 1801 717)**. The information will be updated at each hour to notice the variability and to know most current air quality and weather conditions. Public may subscribe to the Alert Network through the website to receive direct **E-mail Alerts or SMS Alerts** for extreme weather

condition or air pollution event. All these facilities are available in English, Hindi and regional language. Those interested in information on e-mail, can also contact- safar@tropmet.res.in.

Data processing and dissemination

The near real time online raw data measured at various AQMS and AWS is transferred to **AQMS server** located in SAFAR Control Room at IITM, Pashan, Pune, through GPRS network. The raw data is then converted to **Air Quality Index (AQI) or UV-Index**, etc. **FTP Master Control Server** receives current Air quality data, weather data, AQI and UVI each hour from AQMS server through wired connectivity whereas the air quality and weather forecasting data for the next day from HPC facility of IITM and IMD. The FTP master control server will have responsibility to channel the data to **Display Server, WEB server of SAFAR-Pune and IVRS** from where the system products mentioned in previous section disseminated through LED boards via 3G communication network, dynamic website and toll free number.

SAFAR - India
System of Air Quality & Weather Forecasting And Research
Proud to be India's First Air Quality Forecasting System...

SAFAR - Products

- AIR QUALITY TODAY City Locations
- AIR QUALITY 3-day Forecast
- AIR QUALITY Health Advisory & Precautions
- EXTREMES Pollution & Weather Alerts
- EMISSION MAP Sources of Pollution (1km*1km)
- UV-INDEX Harmful Radiation & Skin Advisory

REACHING TO SOCIETY

METRO AIR QUALITY INFORMATION & ADVISORY SERVICE

Good | Satisfactory | Moderate | Poor | Very Poor | Severe

50 | 100 | 200 | 300 | 400 | 500

<http://safar.tropmet.res.in> |
 safar@tropmet.res.in |
 +91-20-24904261

Mobile-App
Safar-Air

Dynamic Website
Safar.tropmet.res.in

Big Display
(USNos.)

Toll Free Number
1800 220 161

E-Governance for Flood Management in North Eastern Region of India –FLEWS, An Example of Space Technology Initiative

Diganta Barman and P L N Raju

NE-SAC, ISRO; E-mail: Diganta_isro1@yahoo.co.in , plnraju@gmail.com

The North Eastern Region (NER) of India is the richest water resources portion of the country. With highest average annual rainfall, this region comprising of six hilly and two plain states has its fare share of flooding and associated problems and sufferings. While the states of Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Nagaland & Sikkim are pre-dominantly hill topographies, the states of Assam and Tripura are having flat terrains. Majority of the rivers in this region are parts of two major river systems namely Brahmaputra and Barak, which eventually join the bay of Bengal in Bangladesh. The accumulated overall discharge of the river systems of all the states of NER finally enters these two relatively narrow river valleys of Brahmaputra and Barak that flows across the territory of Assam. While the Brahmaputra with its large number of tributaries covers 30 districts of Assam, the remaining three districts of southern Assam come under the Barak valley. The Brahmaputra flows for 670 km through Assam where it receives 103 major tributaries - 65 on the right (north) bank and 38 on the left (south) bank along the valley. The Barak river mainly receives upstream discharges from Manipur and Mizoram hills. Along with their various tributaries these rivers cause havoc in the state of Assam. Along with chronic flooding, river bank erosion has also become a dominant problem for NER in general and Assam in particular. The mitigation measures against these two interconnected problems of Flood and Erosion can be divided in to two major categories of structural and non-structural measures. While structural measures are mostly physical interventions for preventions of flood and river bank erosion, the non-structural measures are mostly focused towards damage reduction, empowerment flood affected communities towards resilience , implementation of preventive rules & regulations etc. While construction of embankment, spurs, porcupine screenings, guide bund etc. are basically the structural measures, the non structural measures comprise of Flood forecasting, flood hazard zonation, flood plain regulation etc. Both central government and state government agencies are associated with flood management and associated activities. While state government entities are mostly associated with structural measures, the central government entities are mostly regulatory in nature and are inclined more towards non-structural measures of flood mitigations. Academia and research organizations are also in recent times more inclined towards non-structural measures as well as the design aspects of structural measures. Application of e-governance in combination with space technologies are presently playing pivotal role for flood management across the globe and NER is also not an exception in this context.

Conventional flood forecasting systems, covering only major river channels, based on monitoring of river level fluctuations in real time has not been found to be adequate enough to effectively mitigate the flood damage. This is because, adequate lead time of warning cannot be achieved with this present system. Although floods are anticipated in the state almost every monsoon season, it is difficult to predict the intensity, scale, duration and spatial extent of the flood event. Rainfall-runoff modeling at the spatial and temporal scale for a basin is generally obtained by direct in-situ discharge measurements or indirect techniques involving rational, lumped (conceptual), semi or quasi-distributed, and distributed hydrologic models. As the conventional method at times faces constraints with scale and other hydrologic variables, quasi-distributed/physically distributed rainfall-runoff modeling techniques is generally adopted for computing flood runoff discharges, and serves as

the backbone of the **FLEWS flood forecasting system** as developed by NESAC for Brahmaputra and Barak valley at the request from state governments. Forecasted precipitation dataset using numerical prediction based Weather Research and Forecasting (WRF) model in combination with a GIS based quasi-distributed hydrological model for computation of flood discharges is in the core of FLEWS.

Weather Research and Forecasting (WRF) Model is a next-generation mesoscale NWP system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. With the WRF model, it is possible to mix and match the dynamical cores and physics packages of different models to optimize performance since each model has strengths and weaknesses in different areas.

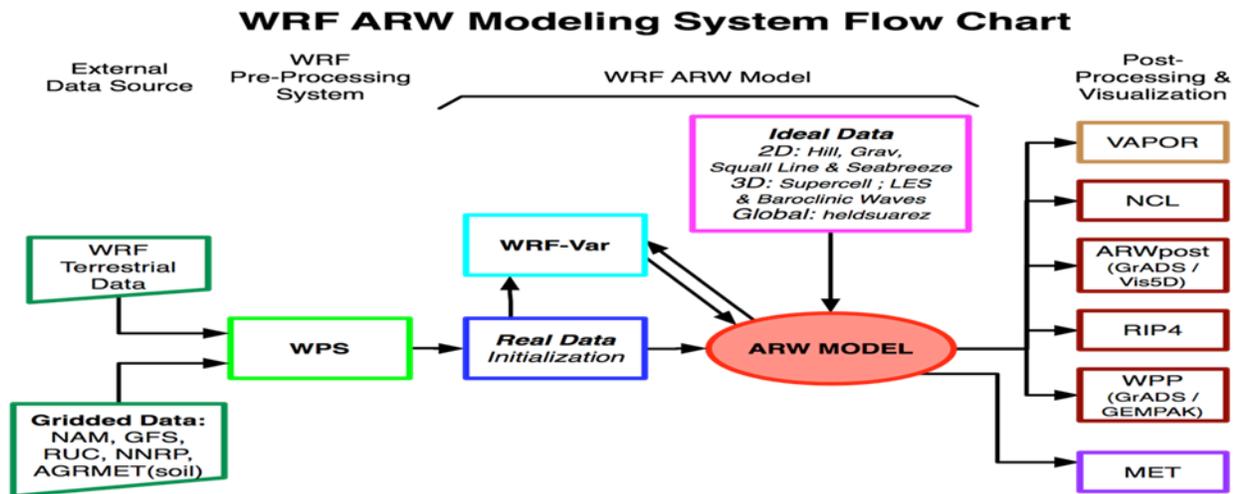


Figure 1: The Met model

In the **Hydrologic Modeling System (HEC-HMS)**, although a host of components for precipitation-runoff-routing simulation is present, the primary components used in FLEWS include:

- Loss models which can estimate the volume of run-off, given the precipitation and properties of the watershed.
- Direct Runoff models that can account for overland flow, storage and energy losses as water runs off a watershed and into the stream channels.
- Hydrologic routing models that accounts for storage and energy flux as water moves through stream channels.
- Models of naturally occurring confluences and bifurcations
- Models of water control measures using diversions and storage facilities.
- Links to database management system including input and analysis. HEC-DSSVue has been used extensively for the process.

The accurate prediction of probable flood is the most complex mechanism in the whole warning system as it necessitates expertise to find probability of flood from analysis of various meteorological and hydrological outputs. Also the alert has to be issued **with sufficient lead time** so that the end user can take proper response measures. The next step after decision making is dissemination of the alert to concerned authorities so that they can take timely mitigation measures to avert the effect of the probable disaster. The alert dissemination is done in the form of mobile sms and emails. The mobile sms is sent to the State Control Room, District Project Officers (DPOs), DCs so that immediate actions can be taken. Also, detailed alert in the form of emails to concerned departments is issued. The detailed alert also contain catchment map of the river where probability

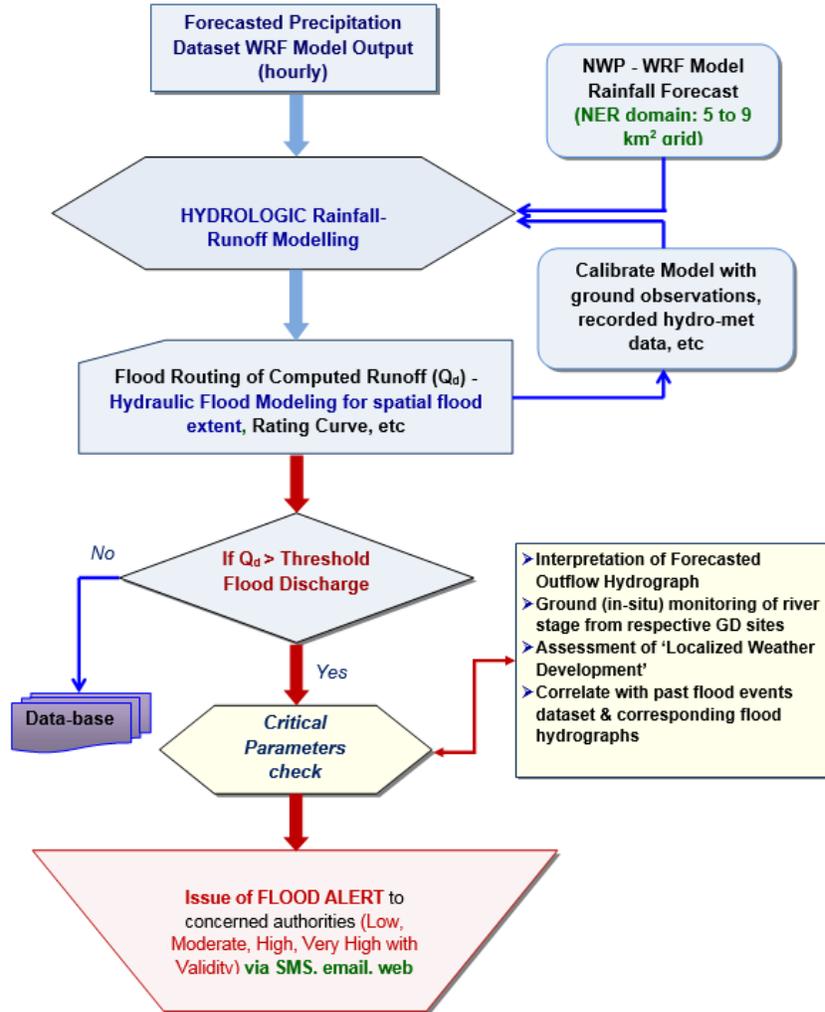


Figure 2: The hydro model

11000014 Gmail - Low to Moderate Flood Alert for Dhemaji District

FLEWS ASSAM <flews.nesac@gmail.com>

Low to Moderate Flood Alert for Dhemaji District

FLEWS ASSAM <flews.nesac@gmail.com> Mon, Aug 18, 2014 at 4:47 PM

To: ***** ALL CONCERNED**

FLOOD EARLY WARNING SYSTEMS (FLEWS) NORTH EASTERN SPACE APPLICATIONS CENTRE
Low to Moderate Flood Alert for Dhemaji District

Dated : 18 August 2014 (1655 hrs)

Respective All Concerned,

FLEWS Hydrological & Meteorological Analysis (with forecasted dataset) indicates a probable **Low to Moderate FLOOD situation** with the details specified as under:

District(s) : **DHEMAJI**

Rivers/Catchments: Jadhoh, Kumatia, Sisi, Gainadi with SubTributaries

Revenue Circles/Blocks likely to be affected : Gogamukh, Dhemaji, SisiBargaon,

Validity : 24-48 hours

Pl refer to the attached Alert Maps for more spatial information.

This alert has the approval of Director, NESAC.

Regards,
FLEWS TEAM
 North Eastern Space Applications Centre
 Department of Space, Government of India
 Unniam - 793 103, Asshalyaya (India)
 ngrometz@gmail.com, rs.ngangbam@nesac.gov.in

Disclaimer: The above information/advisory is based on Hydro - Met Analysis and not to be used for any legal purpose.

Figure 3: Sample flood alert to authorities

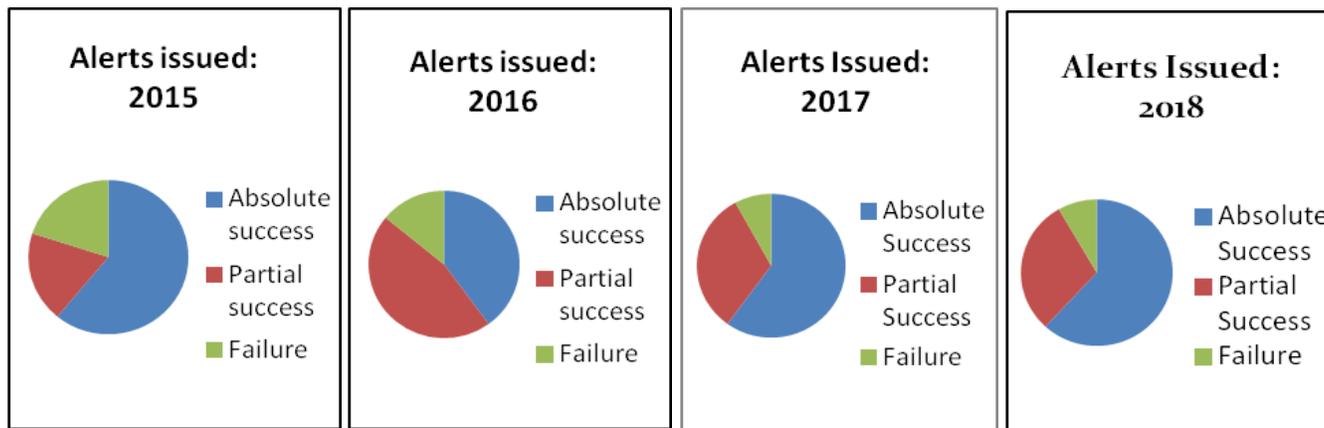


Figure 4: FLEWS performance

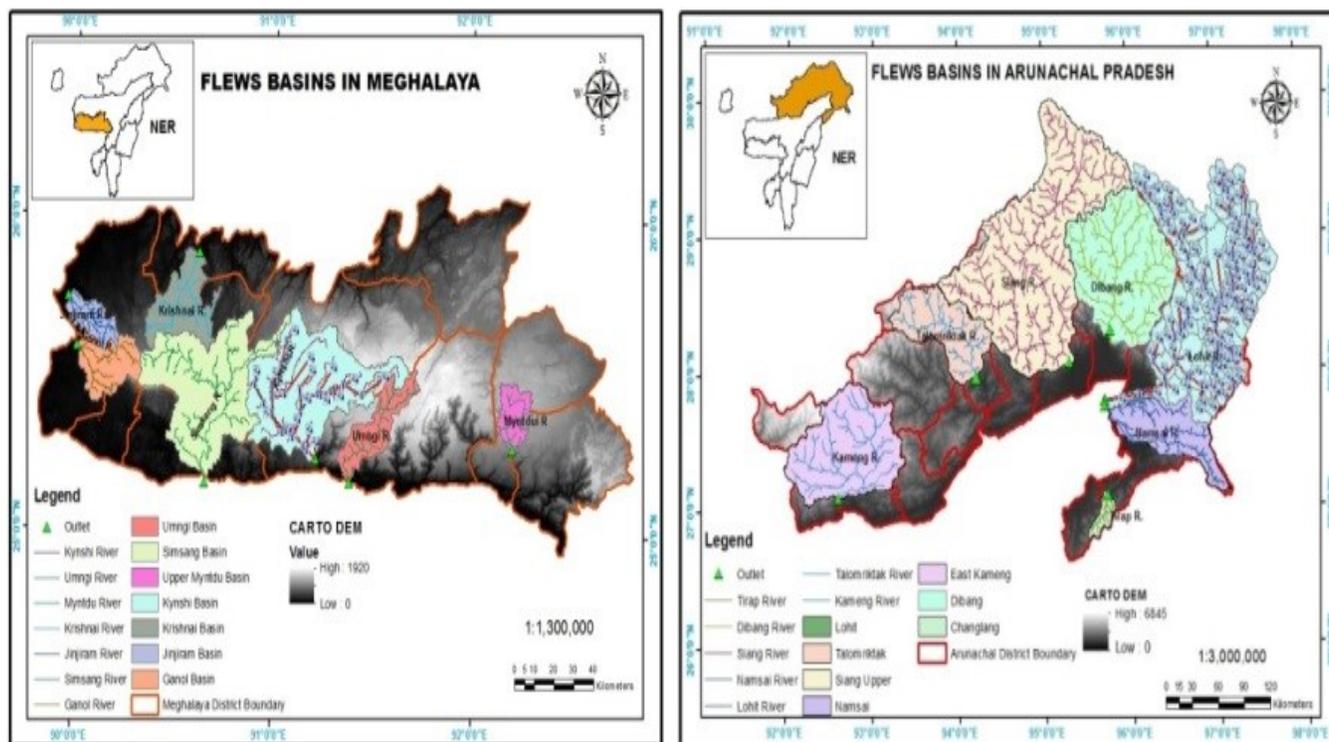


Figure 5: FLEWS models built for Meghalaya & Arunachal Pradesh

of flooding is alerted.

FLEWS, which got started as a pilot project for Lakhimpur district in 2009 extended to all major flood prone districts of Assam by 2015. The proper validation of the success and failure of FLEWS is a challenging task as the validation of floods necessitates robust ground monitoring and data availability in near real time in the event of the disaster. Hence, resources from satellite imageries to local news, state DMS centre information, etc. is taken into account.

This exercise is one of the first of its kind in the country where, Numerical Rainfall Prediction coupled with GIS based quasi distributed hydrological model has been used for operational flood forecasting. The entire state of Assam has been covered with 40 FLEWS models which in total have taken around 130 major and minor tributaries of Brahmaputra & Barak. With its astounding success in Assam and on the advice of ISRO headquarter, this flood forecasting service is presently planned also for other flood prone states of NER.

Around 28 FLEWS models (Meghalaya – 8 nos, Arunachal Pradesh – 7 nos, Tripura – 5 nos, Nagaland – 3 nos, Manipur – 2 nos, Mizoram – 2 nos & Sikkim – 1 no) have been built. These models are expected to be trained and tested with in situ surface observations once the ground sensors are installed in these states under the National Hydrology Project (NHP) sponsored by the World Bank. This exercise also has both national and regional level recognition such as Professional best practice declaration by the union ministry of Public Grievances & Pensions, Govt. of India as well as E-North East award for E-Governance & Citizen Service delivery. NESAC-ISRO has been regularly answering good number parliament questions both from LOK SABHA & RAJYA SABHA every year ever since FLEWS has been operationalized in 2012 in Assam. Most importantly FLEWS implementation, has given popularity to a new paradigm of modern approaches of GIS based flood management among all stake holder agencies (both central and state) working in the North Eastern region. All stake holders now have a collective consensus about the usefulness of space technology based hydro-met approaches for flood management. As a result NESAC in recent times, has a good number of willful collaborators such as Central Water Commission (NPMU, NHP), Brahmaputra Board, Assam Water Research & Management Institute Society, North Eastern Electric Power Corporation, Flood & River Erosion Management Agency etc. for various joint endeavours for development of useful services of flood and river bank erosion management in NER.

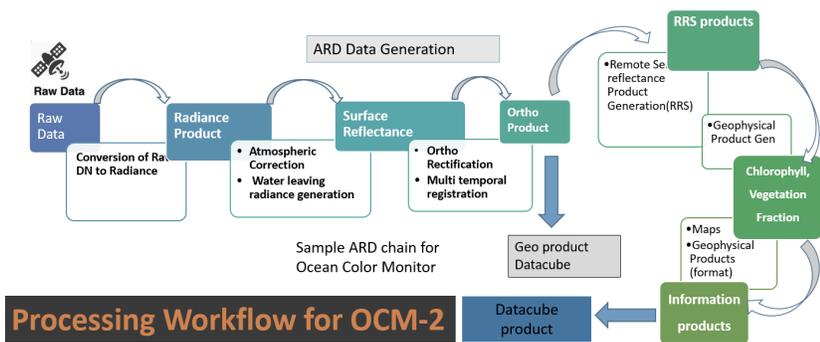
Multi-Temporal Datacube of Earth Observation Analysis Ready Data from OCM-2 / RS2 / RS2A

Tushar Shukla, Ravikamal Choudhary, Nitesh Kaushik, Ghansham Sangar, Sampa Roy and Debajyoti Dhar

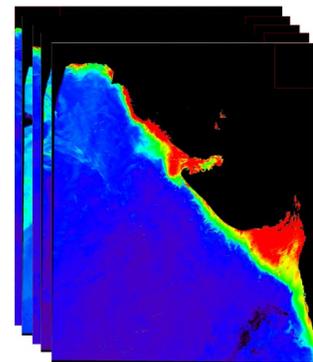
ODPD, SAC-ISRO

INTRODUCTION

Extraction and formulation of spatio-temporal relationship has always been the very core of resource planning and management. Remotely sensed Earth Observation (EO) data is the prominent input for deriving such relations due to the multi-temporal nature of satellite data. OCM-2 and Resourcesat-2/2A satellites are two major satellite series for Ocean and Land resource monitoring launched by ISRO since 2009. The available long term data archive of these satellites can help to study long term changes of Geophysical parameters. Multi-temporal data generated from Ocean Colour Monitor (OCM) sensor of Oceansat-2 and LISS-3 from RS2/RS2A (Goa and Gujarat) will deliver a large amount of information in the context of temporal behavior of geophysical components.



(i) ARD DP chain (OCM-2)

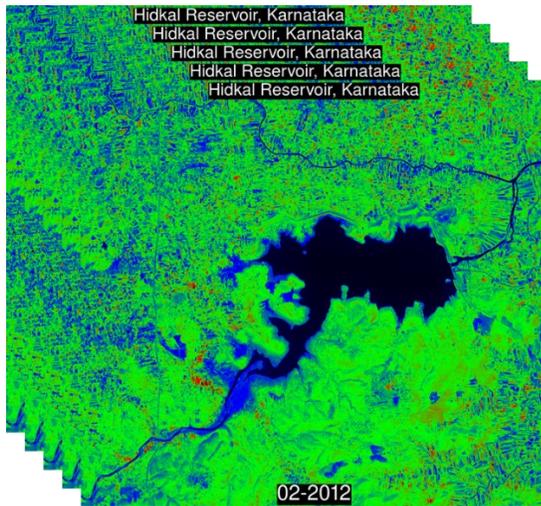


(ii) Chlorophyll-a Time-series cube (OCM2)

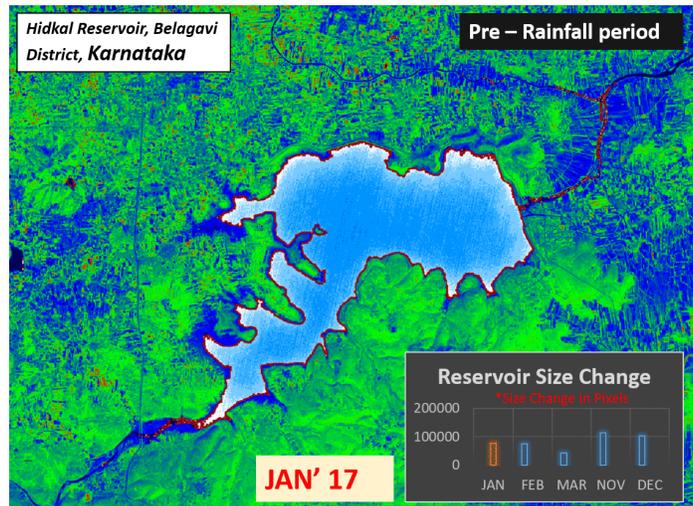
The multi-temporal Datacube of Geophysical parameters derived from available LTA of OCM-2 and RS2/2A data reduces the complexity by eliminating the need of advanced processing systems at user-level, by directly providing ARD (Analysis-Ready Data) for application needs.

What is a EO Datacube?

A EO datacube can be described as a massive multi-dimensional array of ‘raster’ or ‘gridded’ data whose size is significantly beyond the main memory resources of server hardware. The Data values, all of same



(iii) LISS-3 data stack (RS2A)



iv) Dam boundary and temporal change of reservoir content

data type, sit at a regular grid points as defined by n-axes of n-dimensional cube. Coordinates along these axes allow addressing data values unambiguously.

Computing performance

The available OCM-2 & RS2/2A data had total cumulative size of more than 30 TeraBytes (TB) and as such high computing performance became one the major requirement of generating the datacube structure. This was achieved by developing efficient python and c++ codes for geophysical parameter generation, multi-temporal image registration, indexing and ingestion; to efficiently utilize multi-processing environment. Both data and task-level parallelism techniques were employed to process data within a meaningful time duration. Further, adaptive data tiling and partitioning method was developed and integrated for optimized storage and faster data retrieval times when accessing large datasets.

Major Challenges and Milestones Achieved

The entire activity was divided into smaller goals for building this huge Datacube: development of scripts for

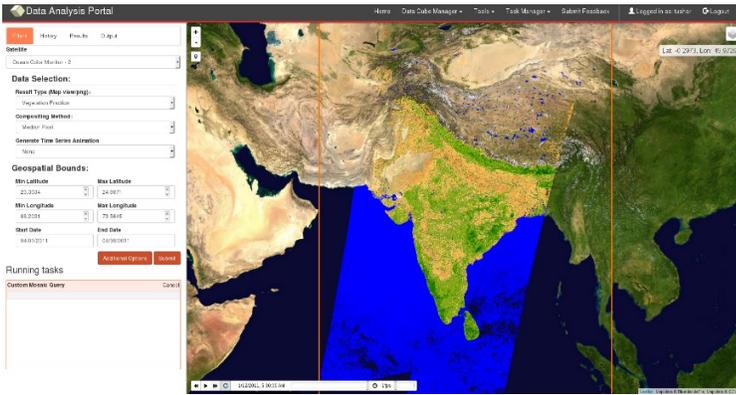
- (a) Large data handling and reducing redundancy;
- (b) Efficient storage and categorization of radiance,
- (c) Reflectance and geophysical data for rapid access;
- (d) Reference generation and multi-temporal image registration via Improved SIFT
- (e) Development of geo-spatial web user interface.

Geo-spatial Web User Interface

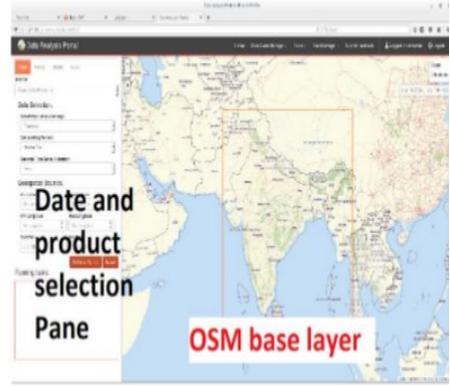
Developing multi-temporal data analysis portal which will help users in visualization and analysis of pre-processed data. It utilizes the strength of the underlying On-Line Processing of ARD temporal data-stacks of same geospatial regions. Platform provides freedom to develop and integrate pluggable applications for various algorithms which in turn can help users to process data online and get results instead of downloading input data and setting up environment for applications to run for the same this in turn saves lot of user's time.

Following are some key highlights about developed Datacube UI Portal:

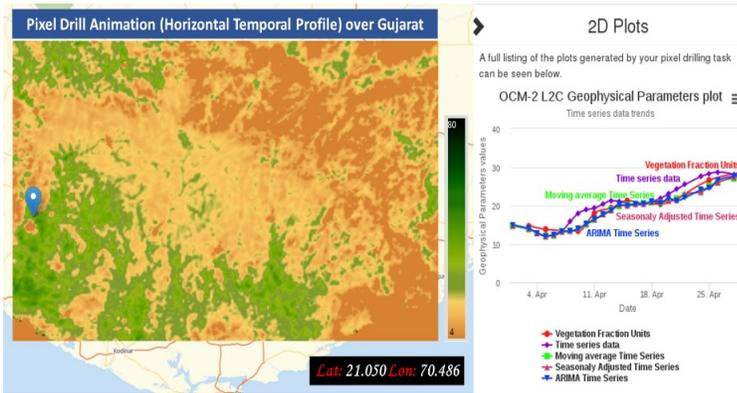
- **Geoserver – Datacube** used with Django framework for High Performance Visualization and



(1)



(2)

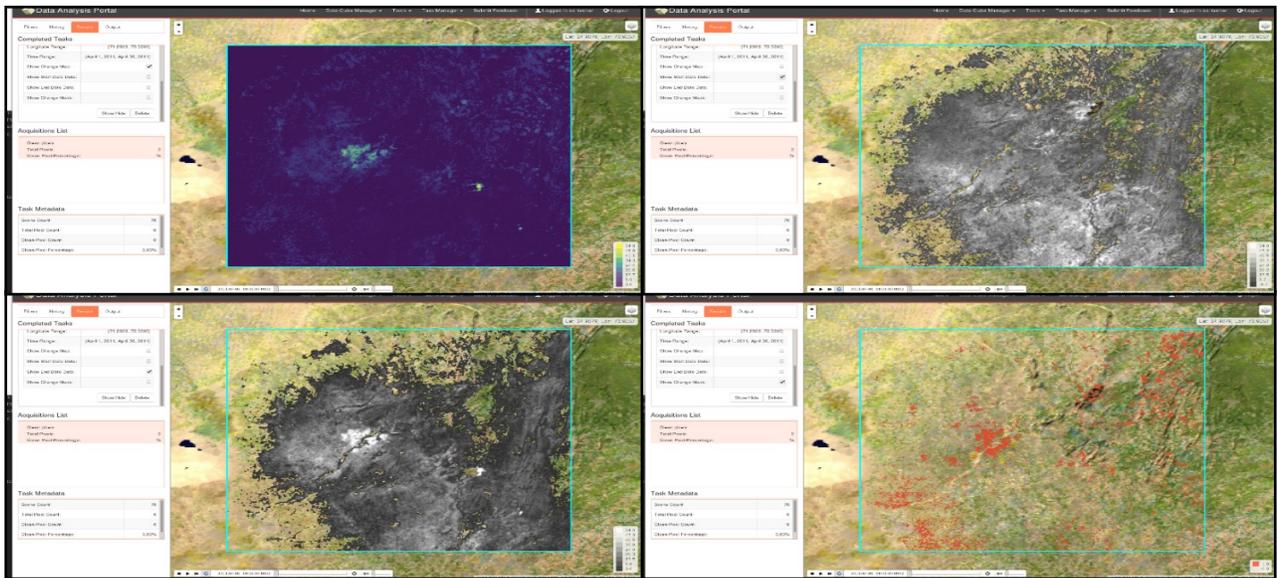


(3)

Ingested Product list

Product Name	Date	Status
OCM-2 L2C Geophysical Parameters	2018-04-04	Completed
OCM-2 L2C Geophysical Parameters	2018-04-11	Completed
OCM-2 L2C Geophysical Parameters	2018-04-18	Completed
OCM-2 L2C Geophysical Parameters	2018-04-25	Completed

(4)



(5)

Images (Top to bottom) – 1. UI look for Time series Data Analysis Portal. 2. Base layer visualization customization 3. Product overlay (Composite file generate via Date and Location selection panel) and Time series profile for the selected Latitude and Longitude. 4. Data product list. 5. Integrated change Detection Application computes changes based on Image Differencing Algorithm. Results are available for user download in GeoTiff, NetCDF and PNG file formats.

Analysis Platform.

- Online available Analysis Ready Data (includes **Multi-Temporal Registration correction**).
- On-the-fly post-processing of ARD data (ingested in datacube framework) to generate custom mosaic for different Bio-geophysical products such as vegetation fraction, chlorophyll-a concentration.
- Online Application for **Change Detection** between selected dates (includes PCA, Image Differencing etc.)
- Tool for ROI based on-the-fly **pixel drilling** query over available geophysical products.
- Online **Time series Trend analysis** algorithms such ARIMA.

Role of Geospatial Technologies in Agro - Advisories

Rahul Nigam and Bimal K Bhattacharya

Space Applications Centre (ISRO), Ahmedabad

Decision making in agricultural production system is a complex process in which many threats need to be considered for a constructive decision to be made. Extreme climatic events such as severe drought, flood, cyclonic systems or temperature and wind disturbances strongly impede sustainable agricultural development in terms of quantity and quality (Sivakumar and Motha, 2007). The day-to-day weather variations play major role on the decision process of farmers for various farm operations to minimize crop losses and cost of farm operations. India Meteorological Department (IMD) has network of 130 Agro-Met Field Units (AMFUs) in whole India which issued bi-weekly advisories to farming communities solely-based on medium-range and extended weather forecasts under Gramin Krishi Mausam Seva (GKMS). An economic impact assessment showed that the agro-met advisories issued from India Meteorological Department through present framework, data quality and reliability could reduce 5-10% cost of farming operations (Rathore and Maini, 2008) on an average and increase in crop yield varying from 10-25%. However, it was felt that there is a need to augment current agro-advisory system using new advanced techniques at district to block level. This opens up a new opportunity to use space data to generate near real-time agro-met and value-added products that will help to develop decision support system for GKMS services for better agricultural management. Agriculture remains no longer profitable without judicious use of fertilizers, water and plant protection measures. Moreover, moisture stress along with pests and diseases are major causes of reduction in crop yield. Timely remedial measures may reduce the yield loss. The availability of crop and agrometeorological parameters retrieved through space-borne remote sensing and forewarning of stresses provide an opportunity to assess real-time crop condition assessment for better farm management both in rainfed and irrigated agricultural systems. In this regard, Space Applications Centre (ISRO), Ahmedabad has taken an initiative to develop models for geo-spatial forewarning of candidate crop pests and diseases, weekly crop prospect and dryness index from INSAT-based agro-met product to add value to GKMS advisories for the farming community of India.

Web-GIS Based Pest Forewarning

The severity of infestation of pests and diseases differs between seasons, regions and crop types and crop stage within a region. In the absence of stable, desirable and diverse sources of resistance to the biotic menaces, chemical pesticides remain the primary effective means to manage them. Since these biotic menaces are weather-dependent, weather-based prediction models could be developed to manage these menaces. However, such models do not exist in general. In India, there are 127 agro-ecological zones, which would require weather data recording at least at ~1200 observatories apart from multi-year observations on pest epidemics / epizootics in those many locations. Such exercise would be time-consuming, labour - intensive in the country with difficult terrain and other constraints. Therefore, limitation of forewarning models for specific geographic locations could be overcome by use of twenty-four hours' short range weather forecast data. In India, first time a pest forewarning model for mustard aphid has been developed at spatial scale. The model is developed using twelve years (2004-2016) of systematic *in situ* mustard aphid population data, high resolution short range weather forecast, satellite derived mustard crop mask and phenology over all mustard growing

grids of Rajasthan State. The developed forewarning model provides crop age (in days) at first appearance of aphid pests (Y1), crop age (in days) at peak population/severity of aphid pests (Y2), maximum aphid pest population (pests count) (Y3) at all mustard grids from January 01 to first fortnight of February on standard Meteorological Week (SMW) basis. The aphid forewarning model provides first forecast on January 1, i.e. 15-20 days in advance for first appearance of aphid at all mustard grids (5 km × 5 km) of Rajasthan state. Web-enabled system for forewarning important pests of Mustard crop based on developed model are using three-tier architecture viz. input datasets, model execution and spatial presentation of model input. This approach brings numerous benefits including increased maintainability, scalability, reusability, reliability and most importantly flexibility. The pest forewarning information are divided into three categories (low, medium and high) represented by different colours which are obtained through objective analysis of aphid data based on historical records. For each category, various advisories are generated as per the view of subject expertise. These advisories were also stored into the database. The advisory is put on web portal. The forewarning model output is updated at each week from January 01 to second fortnight of February. The developed model is now operational and information is disseminated through VEDAS geo-portal (vedas.sac.gov.in) with weekly updated as per the standard Meteorological Week (SMW) as shown in Figure 1. The forewarning model is validated in two districts of Rajasthan state at multiple sites showed 8 to 10% difference in days for crop age at first appearance and 5 to 6% in days for crop age at peak population during crop season with 15-20% difference in maximum aphid population.

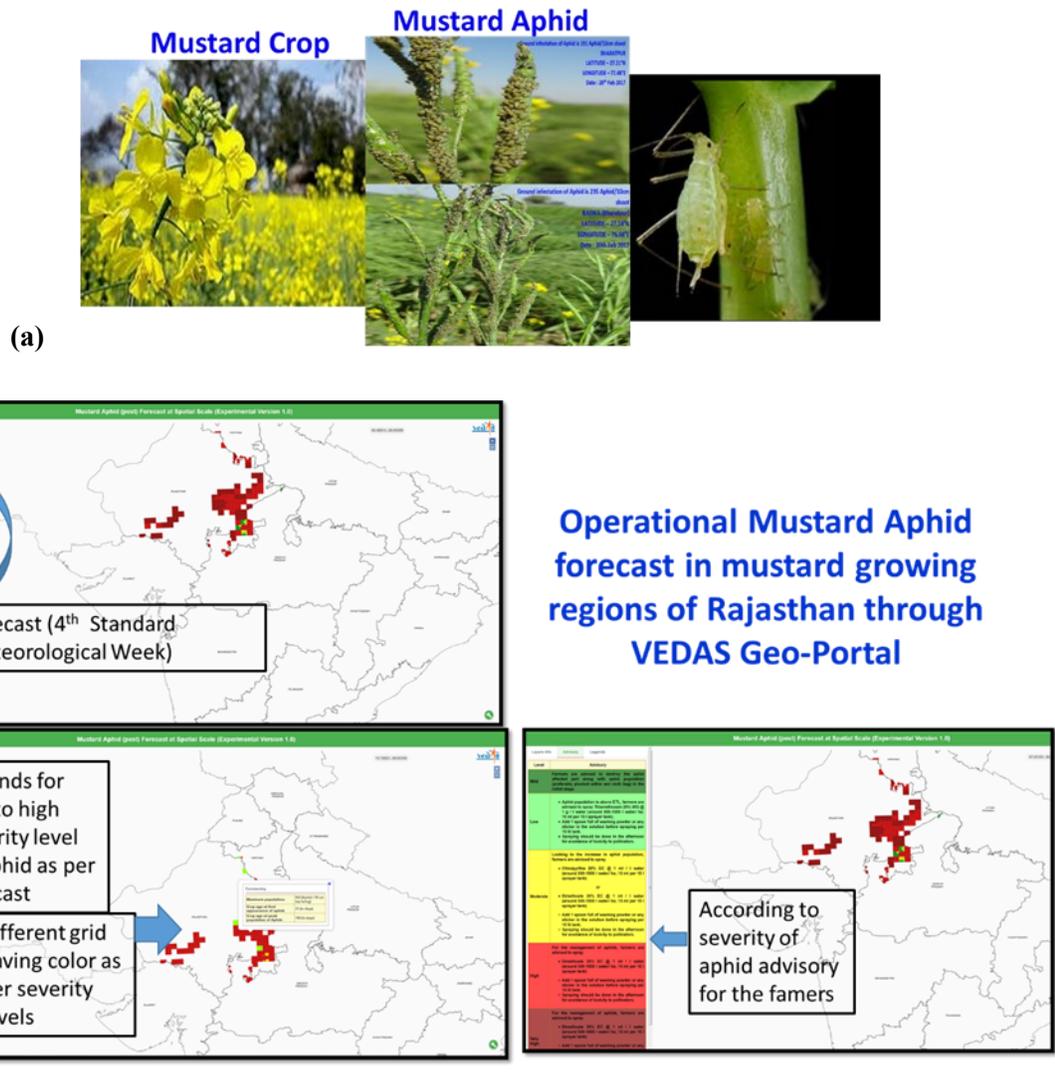


Figure 1: Web based dissemination of mustard aphid forecasting from VEDAS geo-portal

Weekly Crop Prospect from Space-Based Remote Sensing Products

The soil water deficit due to rainfall scarcity in early part of south-west monsoon period affects sowing / transplanting schedule of farming community specially in rainfed agriculture. The occurrence and persistence of rainfall deficit also affect the water management decisions in irrigated agriculture as well. As a result, uncertainty appears in harnessing potential crop acreage and productivity that influences gross domestic product. Frequent occurrences of early, mid and late-season water deficit *vis-a-vis* drought during last few years pose threats to secured and sustainable food production in India due to delayed onset and erratic distribution of south-west monsoon rainfall. Assessment of early-season water deficit and country-scale crop prospect are required for issuing advisories at the early part of Kharif season. The daily large-scale surface soil moisture (SSM) data from passive microwave radiometer observations of AMSR-2 in 10.65 GHz or SMAP L-band (1.41 GHz) in combination with weekly composites of vegetation Index (NDVI) are used to assess crop prospect. Impact on inter-seasonal variability of progress of crop acreage of standing crops and sowing or transplanting suitability were quantified on weekly time-scale using combination of pre-determined thresholds of SSM and NDVI over potential agricultural land use (Nigam et al., 2016).

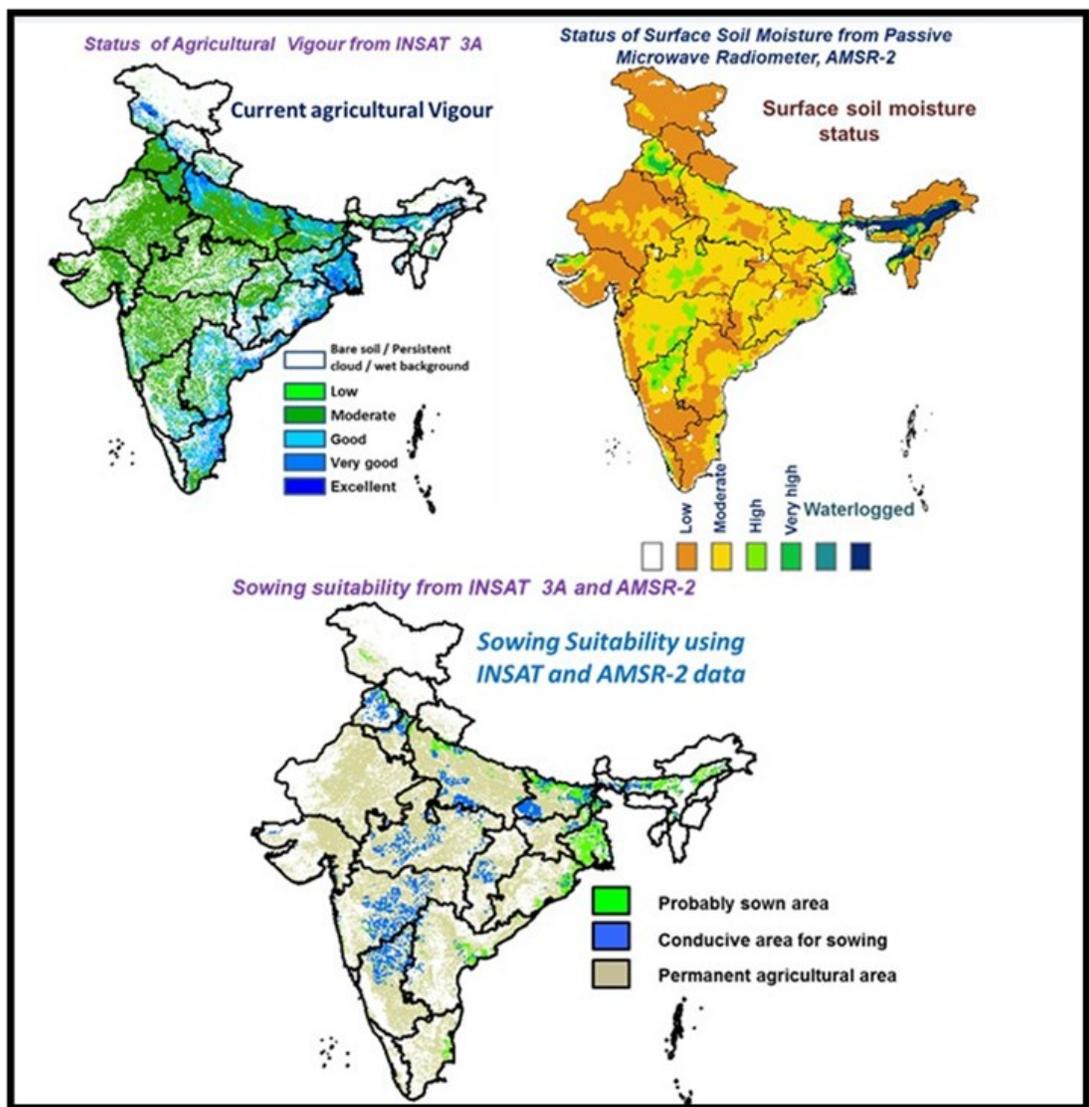


Figure 2: Example of crop prospect assessment during kharif season

The fusion of soil moisture and vegetation index was found to have the potential to assess early-season crop prospect at country-scale and hence adopted in bi-weekly agromet advisory issued by IMD Pune during *kharif* season as shown in Figure 2.

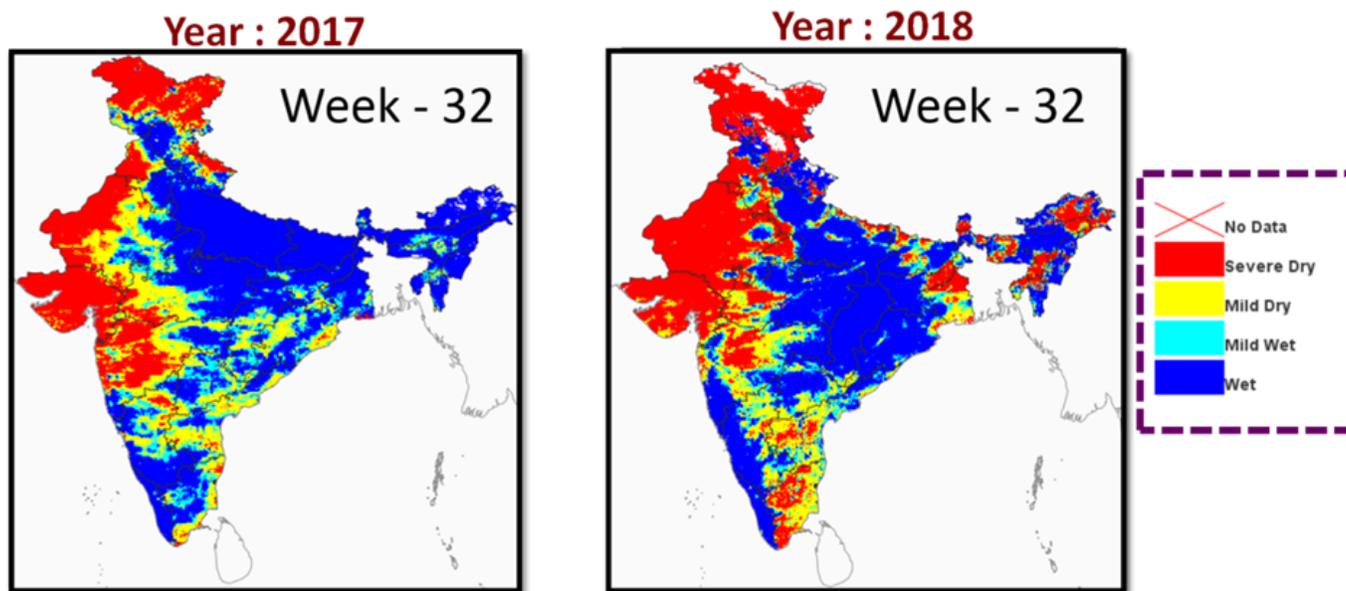


Figure 3: Weekly dryness Index from INSAT 3D derived reference evapotranspiration and rainfall products at VEDAS geo-portal

Web-GIS Based Weekly Dryness Assessment for Rainfed Farming

Rainfed farming management and decisions depend on weekly dryness index and its persistence. Daily reference evapotranspiration and rainfall (HEM) products generated from INSAT 3D at MOSDAC portal have been used to derive weekly dryness indicator which has made operational at VEDAS geo-portal (vedas.sac.gov.in) since June 2018 and weekly updated as shown in Figure 3. The portal also provides different online tools to user for comparison of (weekly and past year) dryness index of a particular place so that advisory can be fixed accordingly.

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Hydrology using Altimeter and Scatterometer

P K Gupta, R P Singh, Dr. Arundhati Misra and Dr. R K Sharma
 Space Applications Centre (ISRO), Ahmedabad

BACKGROUND

Altimetry and Scatterometry are two satellite based remote sensing techniques, which are mainly designed for the Ocean applications. Altimeters designed for the retrieval of ocean wave height and wind speed whereas scatterometers for the wind direction and speed in oceans. Nevertheless, of late these sensors have been used for the land hydrological applications, especially altimeters for the retrieval of river/reservoir water levels with high precision. Scatterometers are being utilized for the catchment scale dynamic processes such as wetness due to coarser spatial but higher temporal resolutions.

ALTIMETRY

Altimeter is a ranging system to estimate the height of the target with respect to a certain datum. Altimeter system consists of transmitter, receiver, antenna, radiometer, DORIS (Doppler Orbitography and Radio positioning Integrated by Satellite), laser retro reflector array (LRA). DORIS and LRA used for the precise orbit determination of the satellite. Altimeter transmits pulses of a very short duration of the order of two Nano seconds and measures the two way travel time from its transmission to interaction with the target and return to receiver using atomic clock having sensitivity of Peko seconds. Additionally, return signals amplitudes are received over the 128 bins (Altika) or range gates to get the waveform data and information about the surface (Figure 1). Altimeter has the potential to monitoring major inland water bodies such as river, reservoirs, ponds, lakes etc. at the global scales. Poor knowledge of spatial and temporal dynamics of surface water level, discharge and storage, also insufficient in situ measurements with inadequate global coverage was the driving force behind the application of satellite altimetry for inland water bodies. Three measurements are essential for the monitoring (1) water surface elevation (h) (2) temporal change in water surface elevation $\partial h/\partial t$ and (3) water surface slope $\partial h/\partial x$.

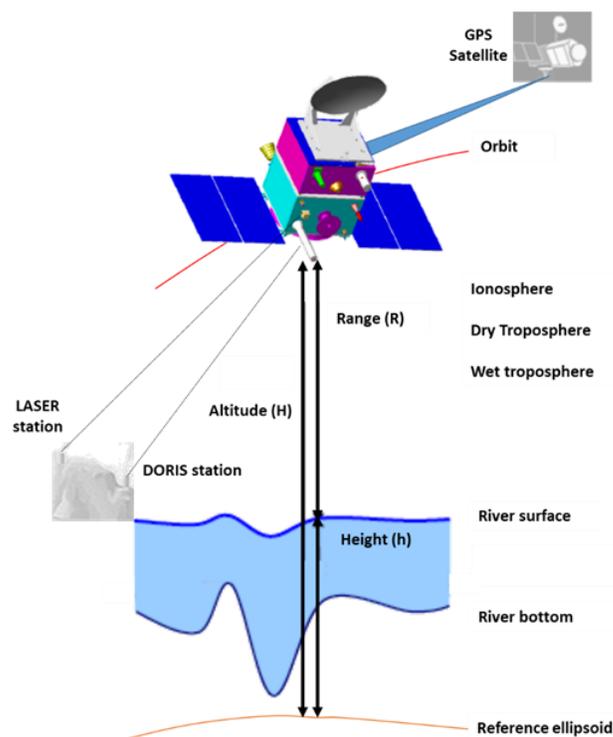


Figure 1: Altimeter principle of ranging

Table 1: Details of satellite altimeter missions

Altimeter	Launch date	Altitude (km)	Beam width (deg)	Frequency (GHz)	PRF (Hz)	No. of gates	Tracking gate	Sampling time (ns)
Seasat	27/06/1978	800	1.6	13.5	1020	60	30.5	3.125
Geosat	12/03/1985	800	2.1	13.5	1020	60	30.5	3.125
ERS-1	17/07/1991	784	1.3	13.8	1020	64	32.5	3.03
TOPEX	10/08/1992	1334	1.0	13.6	4500	128	32.5	3.125
POSEIDON	10/08/1992	1334	1.1	13.65	1700	60	29.5	3.125
ERS-2	21/04/1995	784	1.3	13.8	1020	64	32.5	3.03
GFO	10/02/1998	800	1.6	13.5	1020	128	32.5	3.125
Jason-	07/12/2001	1334	1.3	13.6	1800	104	32.5	3.125
Envisat	01/03/2002	784	1.3	13.6	1800	128	43.0	3.125
ICESat	01/01/2003	600	0.029	laser	40	1000	500	5.0
CryoSat-2	08/04/2010	717	1.08	13.6	1970	128	63.0	3.125
HY-2A	15/08/2011	971	41.0	13.58, 5.25	2000	128	32.5	3.125, 6.25
Altika	25/02/2013	800	0.6	35.75	3800	128	52.0	2.073
Sentinel-3	16/02/2016	814	1.3	13.57	1900	128		3.125

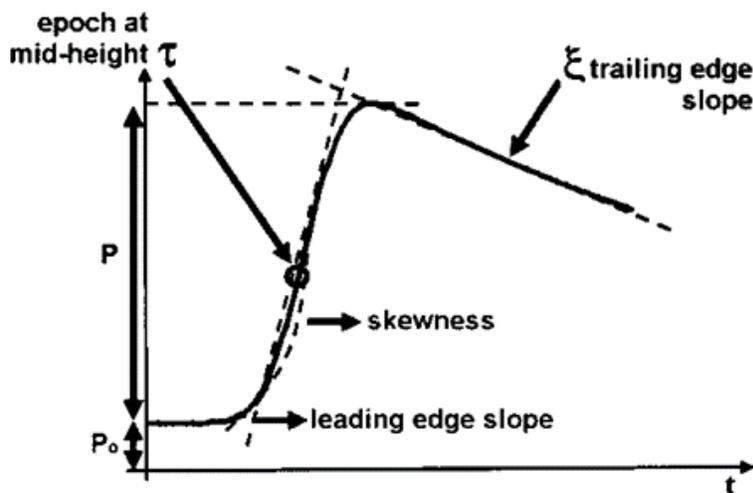


Figure 2: Power waveform from altimeter measurements

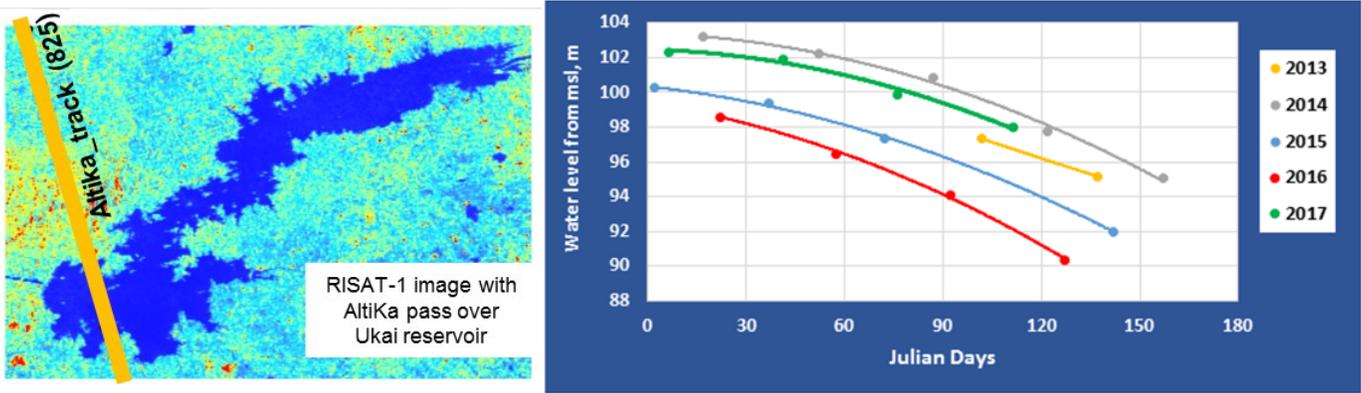


Figure 3: Ukai reservoir with Altika track and Altika retrieved reservoir water levels

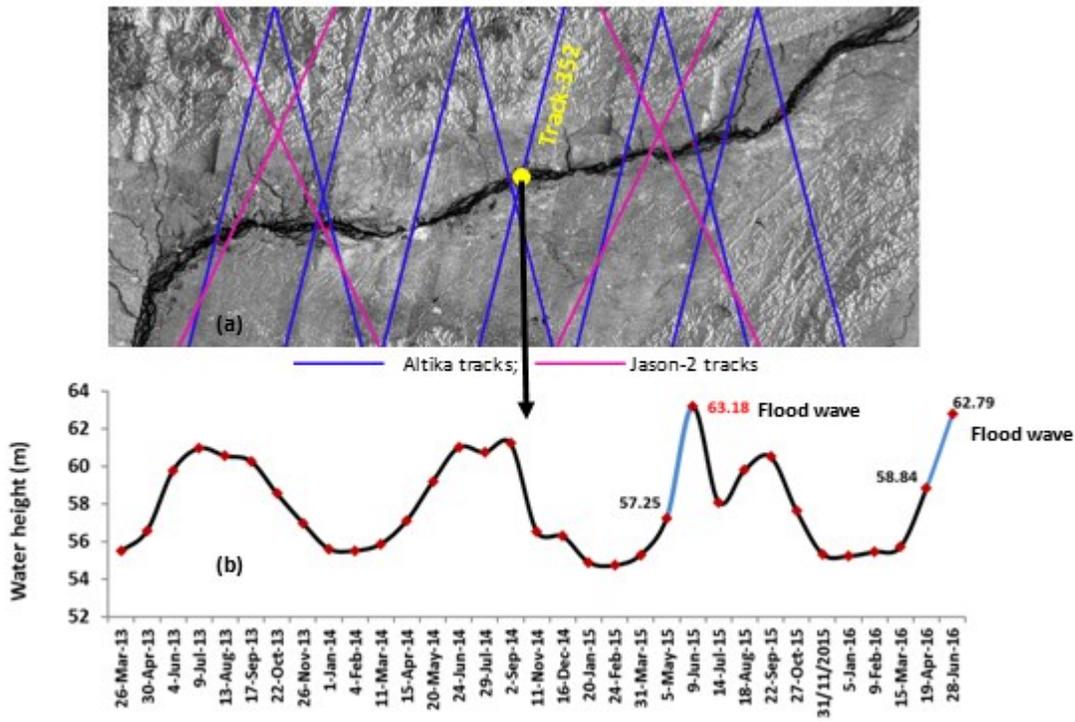


Figure 4: Altika and Jason-2 tracks over Brahmaputra with Altika retrieved water level for track-352 over Brahmaputra river

Altimetry started with the launch of Seasat (1978) and subsequently mission arranged in the chronological order Viz. Geosat (1985), ERS (1991), Topex (1992), GFO (1998), Jason (2001), Envisat (2002), Cryosat (2010), Hy-2 (2011), SARAL/Altika (2013), Sentinel (2014) and future missions include Jason-CS, Sentinel-3C, SWOT etc. (2020).

The mean returned power waveform is presented in the Figure 2. This waveform contains various information 1) thermal noise (imposes a constant power level to the return waveform) due to instrument electronics 2) leading edge and 3) trailing edge.

Leading edge is the main part of the waveform, which contains the maximum return power from the scattering surfaces. The range between the satellite altimeter and the target surface at the nadir can be extracted from the midpoint of the leading edge through retracking process, which is about correcting the range estimated by the on-board tracker along with geophysical corrections such as dry and wet troposphere, ionosphere, solid tides etc. As the return power from the scattering surface decays, the trailing edge of waveform is constructed,

Table 2: Satellite platform based scatterometer details

Scatterometer	Period in service	Spatial resolution (km)	Frequency (GHz)	Scanning geometry
SeaSat-A	1978	100	14.6	Two sided double swath
ERS	1991-2011	50	5.3	One sided single swath
NSCAT	1996-1997	50	13.9	Two sided double swath
Quickscat	1999-2009	25	13.4	Conical scan one wide swath
ADEOS-II	2002-2003	25	13.4	Conical scan one wide swath
ASCAT	2006-present	25	5.25	Two sided double swath
OCEANSAT-2	2009-2014	50	13.5	Conical scan one wide swath
HY-2	2011-present	25	13.25	Conical scan one wide swath
SCATSAT-1	2016-present	25	13.5	Conical scan one wide swath
FY-3E		25	C and Ku	Conical scan one wide swath
METOP-C		50	C	Two sided double swath
OCEANSAT-3		25	Ku	Conical scan one wide swath
CFOSAT		25	Ku	Conical scan one wide swath

whose slope depends on the altimeter antenna pattern and the off-nadir angle. Various retracking algorithm for example beta parameter (Martin et al., 1983), off centre of gravity (Wingham et al. 1986), threshold (Davis, 1995), adaptive etc. are used for the retrieval of river and reservoir water heights. Figure 3 and 4 presents altimeter retrieved reservoir and river water levels, respectively.

Satellite altimetry for inland water applications has evolved from investigation of water height retrieval to monitoring and discharge estimations since last two decades (Birkett and Doorn, 2004, Coe 2000, Berry et al., 2005, Calmant et al., 2008). Recent research focuses on integrating altimetry with other remote sensing techniques and hydraulic models (Schumann et al., 2009) to deal with key inland water resources problems such as flood (discharge, water spread and volume), rating curve generation for remote locations, reservoir operations, estimation of river cross sections, calibration of river/lake models etc.

SCATTEROMETER

A Scatterometer is incoherent radar that measures reflectivity and collects normalized radar backscatter measurements using Ku (13.5 GHz) and C (5.3 GHz) band frequency over a set of different azimuth angles of the earth objects. Conical scanning systems have two-pencil beam radars that uses a single paraboloid reflector to emanate two beams at horizontal and vertical polarizations and at two different look angles, respectively (Figure 5a). This translates from a nominal altitude of 700-800 km to an inner swath of order of 1400 km (horizontal) and outer V-polarized beam with 1800 km (OSCAT-2). It covers the 90% of the globe on daily basis (Misra et al., 2014). A pencil-beam scatterometer has several key advantages over aft-beam scatterometer; it has a higher signal-to-noise ratio, it is smaller in size, and it provides superior coverage. Ground footprint measurements are sliced into different slices (Figure 5b). Due to scanning geometry there are multiple acquisitions of the target this helps to develop scatterometer image reconstruction (SIR) products for

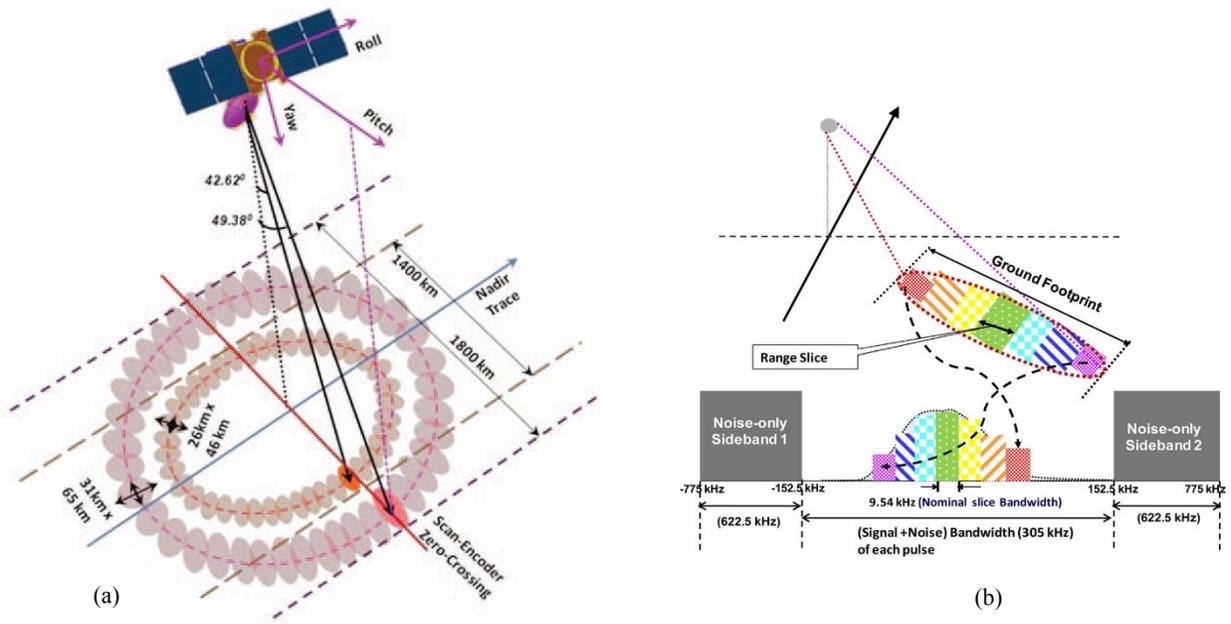


Figure 5: (a) Scanning geometry of OCEANSAT-2 and (b) partitioning of receiving bandwidth (source: Misra and Kumar, 2015; Misra et al., 2014)

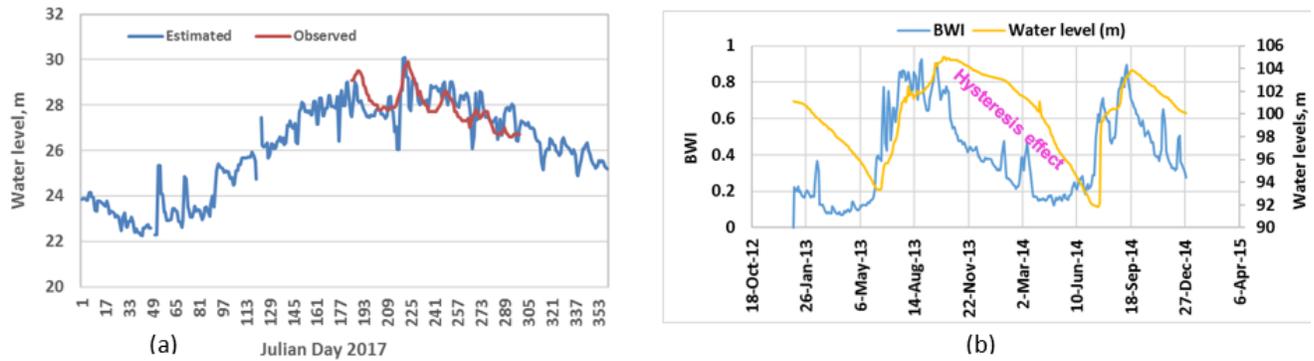


Figure 6: (a) Brahmaputra river (Dhubri) and (b) Reservoir (Ukai) water levels retrieved using Scatterometer datasets

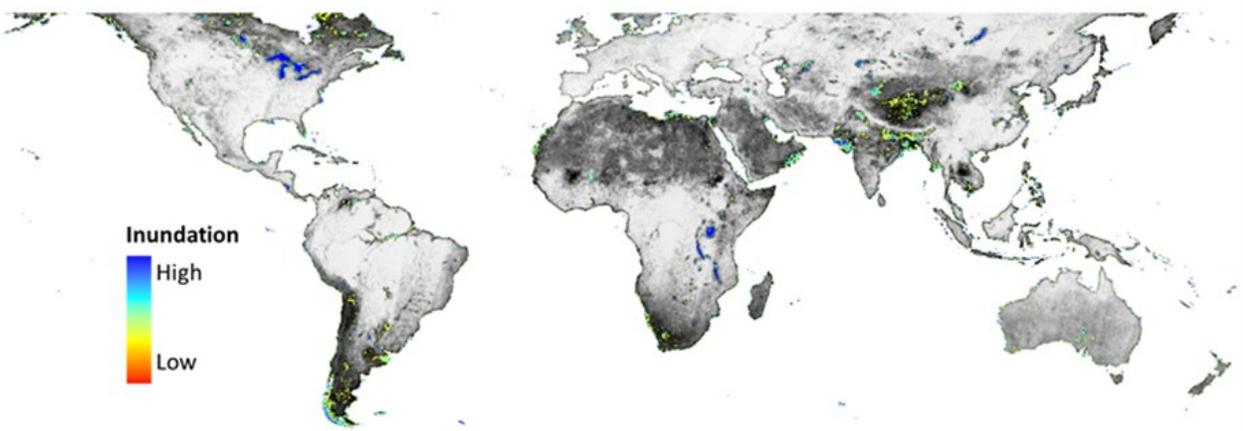


Figure 7: Inundation area over the globe

much higher spatial resolution of the order of 2 km (Long et al., 1993).

Originally designed to estimate wind speed and direction over the ocean, scatterometers have also been utilized for various land applications using SIR sigma0 and brightness temperature products such as estimation of soil moisture (Wagner et al., 1999;), detection of flood and polar sea ice extent (Andersen et al., 2005), tracking icebergs (Stuart and Long 2011), monitoring global vegetation (Stephen and Long 2002) and estimating river water levels (Scipal et al., 2009).

Advantage of scatterometer observations is high temporal repetivity as compared to SAR data and offers monitoring of soil wetness and associated hydrological processes. Coarser spatial resolutions limits its use for the catchmentment scale processes such as runoff, major floods etc. Scatterometer data was used to estimate a basin water index (BWI) which gives relative wetness and this index was used to estimate the river/reservoir water levels. River water levels found to have a power function with BWI (Figure 6a). Unlike river systems, reservoirs/natural lakes do not show power law relation between BWI and water level. In fact, it gives hysteresis effect due to different decaying pattern of BWI and water levels (Figure 6b). Rising trends of water levels are correlated with the BWI but recession pattern are opposite and hence create a hysteresis effect.

Scatterometer ground footprint consists of two noise only sidebands, which received in passive mode for the calibration purposes. These noise data are used for the estimation of brightness temperatures (BT). Both sigma0 and BT observations are useful for the detection and monitoring of major floods in the river flood plains. One such example for inundation areas with levels for the entire globe is shown in Figure 7.

DISCUSSION

The advent of spaceborne scatterometers has opened the door to more accurate weather forecasting, scientific studies related to global climate change phenomena, and monitoring of large-scale human interaction.

A profiling instrument such as altimeter would miss ~30% of rivers and ~70% of lakes (16-day cycle). Impractical to measure discharge from space LeFavour and Alsdorf (2005) used Manning's equation to estimate discharge from SRTM data. Data assimilation of remotely sensed hydraulic measurements (h , $\partial h/\partial t$, $\partial h/\partial x$) into a hydrodynamics model, to indirectly estimate discharge. Ka band allows larger beam width which gives better vertical resolution of 0.3m instead of 0.5 m in Ku-band. Also in Ka band there is strong attenuation in the trailing edge due to small antenna aperture, this greatly reduce the contamination of land gates into river water gates in the land-river transition areas.

Some of the Sources for the Surface Water Altimetry Data

- U.S. Department of Agriculture–NASA–University of Maryland www.pecad.fas.usda.gov/cropexplorer/global_reservoir/index.cfm
- ESA River and Lake Program earth.esa.int/riverandlake
- LEGOS-CNES Program www.legos.obs-mip.fr/soa/hydrologie/hydroweb/

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Forest Biomass from Microwave Remote Sensing

Anup Kumar Das and C. Patnaik

Space Applications Centre (ISRO), Ahmedabad

INTRODUCTION

Accurate measurement of forest vegetation biomass and monitoring the changes in biomass is important for forest conservation and assessment of carbon stock and carbon fluxes from the forest ecosystems. In India, periodic estimation of forest above-ground biomass (AGB) in regional to national level has been a long standing requirement as the country is gearing up for implementation of UN's REDD+ programme. There have been efforts to estimate forest AGB at local to regional levels by many using satellite remote sensing technology. However, estimation of forest AGB at state level or national level and production of forest aboveground biomass maps of India are yet to achieve maturity. Synthetic Aperture Radar (SAR) data has shown great potential in retrieval of forest AGB due to the capability of SAR to provide more dynamic range for vegetation growth variables as compared to optical data. SAR signals in longer wavelength (such as L and P-band) have ability to penetrate deeper inside the vegetation canopy and produce more sensitivity to the biomass of higher densities, hence are widely used for retrieval of forest AGB. Several methodologies for biomass estimation have been reported in recent literatures but no method has been projected to be robust for national level biomass estimation, especially for India where forest vegetation has high diversity due to varied climatic conditions, physiography and topography. There is also no clear view on how carbon pools and their fluxes should be reported and what the accuracy and uncertainty of biomass monitoring might be. Therefore, biomass mapping has become an urgent need to assess and produce data on forest carbon stocks and the change in these stocks at a national level. The article presents possible methods and suitable data along with their sources for establishing an operational methodology for forest AGB estimation over Indian region.

Approach

Selection of suitable data and suitable method is vital for accurate estimation of forest AGB. In India, SAR data acquired during dry season (leaf-off period) provide higher backscatter dynamic ranges within the forest vegetation compared to the data acquired during wet season (leaf-on period) and produce better estimation of above-ground vegetation biomass (Das and Patnaik, 2017). Various algorithms are reported in literature, for estimation of forest AGB using SAR data, however, all the studies have followed a generalized methodology as shown in the figure 1. . The important components of this approach are: selection of proper SAR data; external DEM for topographic correction of SAR data; forest inventory data for ground measured forest biomass; biomass inversion models; and reliable forest mask.

SAR Data

While SAR data collected in L-band or P-band is suitable for estimating biomass of higher densities (such as 50 – 200 tons/hectare or t/ha), C-band SAR data has been found to be more sensitive to biomass of lower densities (< 50 t/ha). Hence a combination of C-band and L or P band SAR data is more suitable for retrieval of forest AGB of wide range of densities. Currently, L-band dual-pol (HH+HV) SAR data of ALOS-

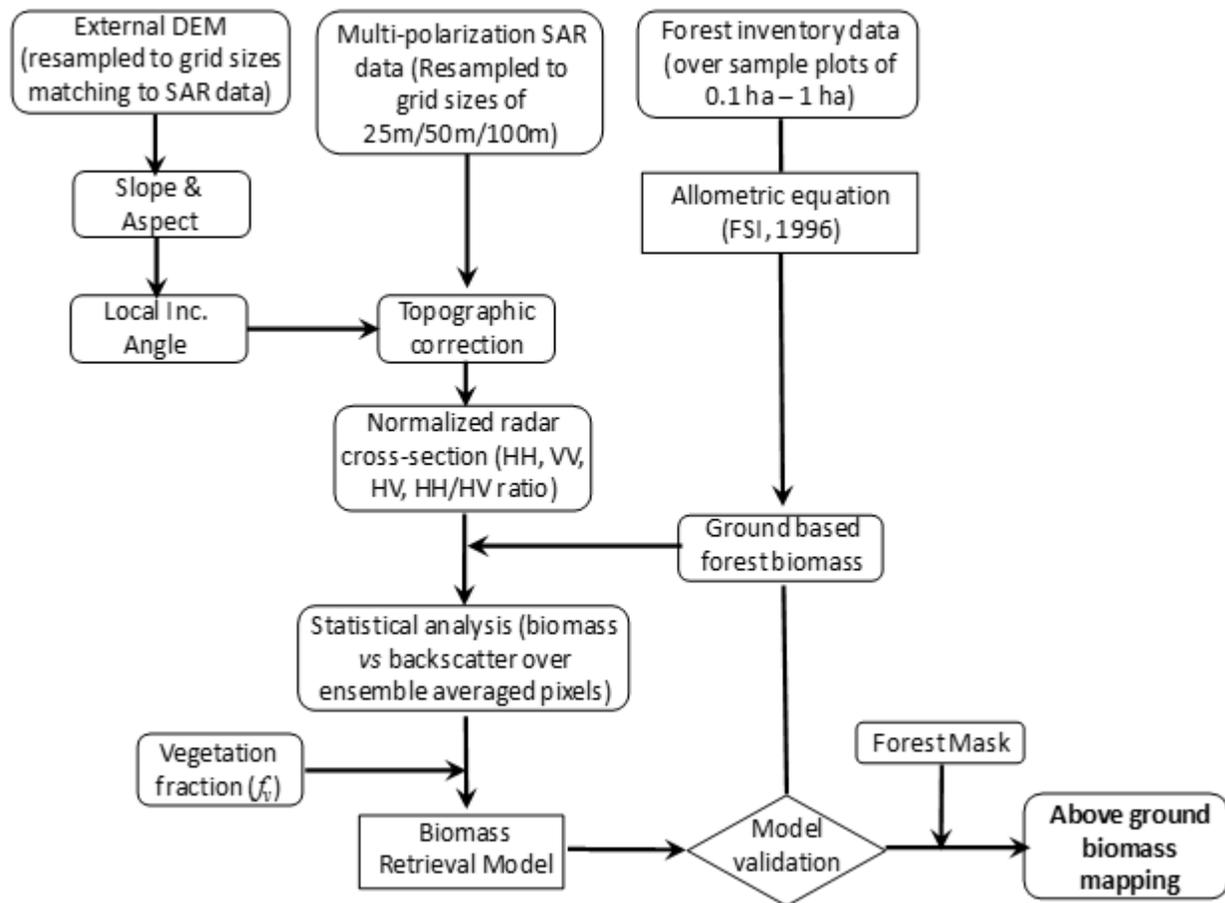


Figure 1: Methodology of biomass estimation

PALSAR-1 & 2 and C-band dual-pol (VV+VH) SAR data of ESA's Sentinel-1 are the most valuable data freely available for forest AGB estimation. JAXA's global mosaics of ALOS PALSAR HH and HV polarization data generated at 25m and 50m spatial resolution for the years 2007-2010 (ALOS-PALSAR-1) and 2015-2017 (ALOS-PALSAR-2) is freely available at: https://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/data (Shimada et al., 2014). Similarly, C-band Sentinel data at various resolutions are available at: <https://scihub.copernicus.eu/>. Sentinel-1 data is mostly available in VV+VH polarizations over Indian region. Apart from that, C-band SAR data Indian RISAT-1 acquired in Medium Resolution ScanSAR mode (MRS) in HH+HV polarization at 18m spatial resolution from is also available over Indian region for the years 2012-2016 at a nominal cost from National Data Centre (NDC), NRSC (<http://www.nrsc.gov.in/>). In future, space borne SAR missions such as Argentinian L-band SAOCOM, German's L-band TerraSAR, NASA-ISRO L & S band NISAR and ESA's P-band BIOMASS will provide valuable data for forest above-ground biomass estimation.

Digital Elevation Model Data

Topographic correction of SAR data using Digital Elevation Model (DEM) is very essential for calibration of SAR backscatter and development of coefficients for biomass inversion models (Shimada et. al., 2010; Das et. al., 2014). Currently freely available DEM data posted at 30m (1 arc second) pixel spacing such as SRTM (http://www.srtm.csi.cgiar.org/srtm_v4/); ASTER (<http://www.gdem.aster.ersdac.or.jp/>); ALOS World3D-30m (<https://www.eorc.jaxa.jp/cgi-bin/ALOS/aw3d30/en>); and Carto DEM (<http://www.bhuvan.nrsc.gov.in/data/>) are most valuable DEM data over Indian region, which can be used for

SAR topographic correction. While SRTM DEM is generated from C & X band SAR data, DEM from ASTER, ALOS and Cartosat are generated from optical stereo image data. High resolution DEM data (10 m or higher) from Indian Cartosat satellite and German TerraSAR satellite can be obtained through purchase from the respective agencies.

Forest Inventory Data

Information about vegetation allometric parameters over fixed dimension sampled plots over forest vegetation is important for accurate estimation of ground based vegetation AGB, which is used to train an inversion model to predict AGB over unknown areas. There are various methods for selection of sample inventory plots depending on type of vegetation concerned. Size of forest inventory plots as reported by various researchers varies from 0.1 Ha to 1.0 Ha of circular, rectangular or square shaped plots. There are few useful documents and manuals that provide details of methods and instructions for forest inventory data collection (FSI,2002; Tewari, 2016; Condit, R., 2008; FAO, 1981; Kauffman and Donato, 2012; Marthews et. al., 2012). During forest inventory, vegetation allometric parameters such as tree height, stem diameter, vegetation canopy density, leaf-area index etc. are measured corresponding to each tree within an inventory plot and species of the tree are noted. Subsequently, using tree species specific volumetric equations developed for forests of different physiographic regions in India and species specific wood specific gravity, above-ground dry biomass over the inventory plot is estimated. The AGB is expressed in tons/ha. The volumetric equations of trees in Indian region are available in various literature. One of the most extensive compilations can be found in FSI, 1996.

Biomass Inversion Model

Development of biomass inversion models are based on the predominant scattering contributions from forest vegetation, which can be represented by the following equation:

$$\sigma_{pq}(b) = f_{veg} A_{pq} (1 - e^{-B_{pq}b}) + f_{veg} C_{pq} b^{\alpha_{pq}} e^{-B_{pq}b} + (1 - f_{veg}) \sigma_{pq}^{bare} \quad (1)$$

Where f_{veg} is the vegetation fraction of a pixel. $f_{veg} = 1$ for pixels fully covered by vegetation, p and q are the H and V polarization, α_{pq} is the biomass power factor which depends on polarization. b is the aboveground live biomass (AGB) expressed in tons/ha, finally, A_{pq} , B_{pq} , C_{pq} are the calibration coefficients which are calibrated for specific ecoregions and/or forest types. Here, the first term denotes the volume scattering from the forest vegetation, second term represents multiple scattering from ground-vegetation and the third term corresponds to the scattering from ground, which has dependence on soil moisture and surface roughness. From this relation, various biomass inversion models are developed for estimation of AGB. SAR cross-polar backscatter (HV or VH polarization) shows higher sensitivity to vegetation biomass, hence considered as the most preferred parameter in biomass inversion models.

Forest Mask and Vegetation Fraction Data

Forest / non-forest mask is important for generation of forest AGB maps. Many of the forest biomass retrieval models use forest vegetation fraction information as percentage of vegetation within image resolution cell (pixel) for estimation of AGB. Forest Survey of India (FSI) generates biannually the forest cover map of India at 24m pixel spacing using optical satellite data by the (<http://.fsi.nic.in/>) (figure 3.). The soft copy (in IMG and TIFF format) of the data can be purchased from FSI. This data serves as the most authentic forest cover mask of India. FSI forest cover presents forest cover with vegetation fraction as 0-10% (scrub), 10-40% (open forest), 40-70% (moderately dense forest) and 70-100% (very dense forest). Global forest cover for the year 2000 and forest cover gain and loss maps up to the years 2012 & 2017, respectively have been generated by University of Maryland using Landsat data at 30m pixel spacing (Hansen et. al., 2013). The data can be freely downloaded from <http://earthenginepartners.appspot.com/science-2013-global-forest/>). The data provides

forest vegetation fraction in the range of 1% - 100%. Forest cover map of India can also be obtained from global forest/non-forest product generated for ALOS-PALSAR dual-polarization data at 25m pixel spacing and can be freely downloaded from https://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/data (Shimada, et al., 2014). However, The data doesn't provide information on vegetation fraction within the forests.

Estimation of Forest AGB over Gujarat and Karnataka States

Using the above approach forest AGB has been estimated over two Indian states (viz. Gujarat and Karnataka) using space-borne dual-polarization SAR data in C-band and L-band, together (Figure 2). Here different model coefficients have been generated over different vegetation types in Gujarat and Karnataka.

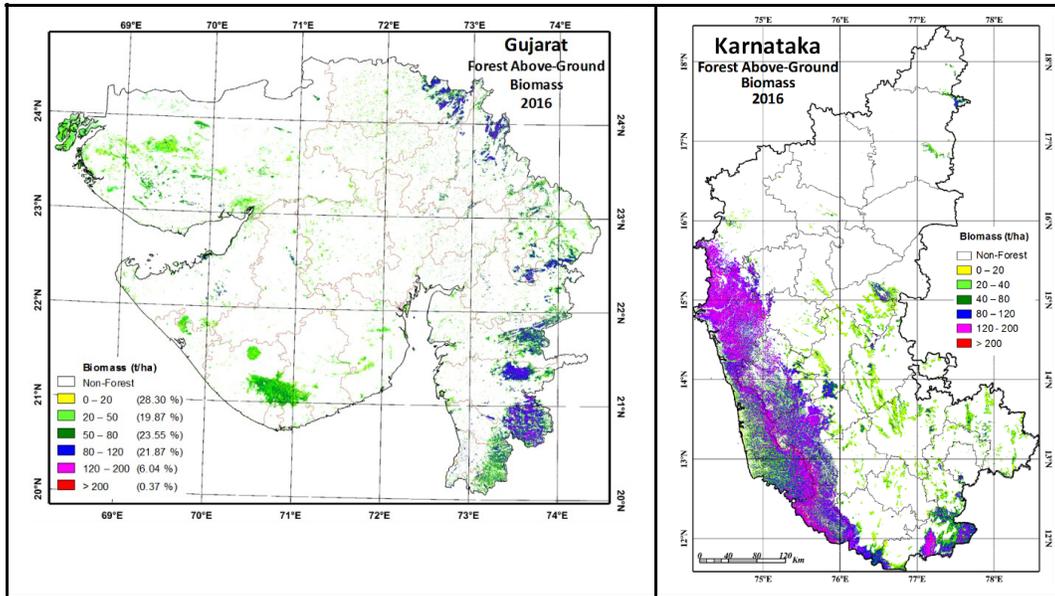


Figure 2: Forest above ground biomass (expressed in t/ha) map of Gujarat and Karnataka states derived from combination of C-band (RISAT-1) and L-band (ALOS PALSAR-2) SAR data acquired during 2016

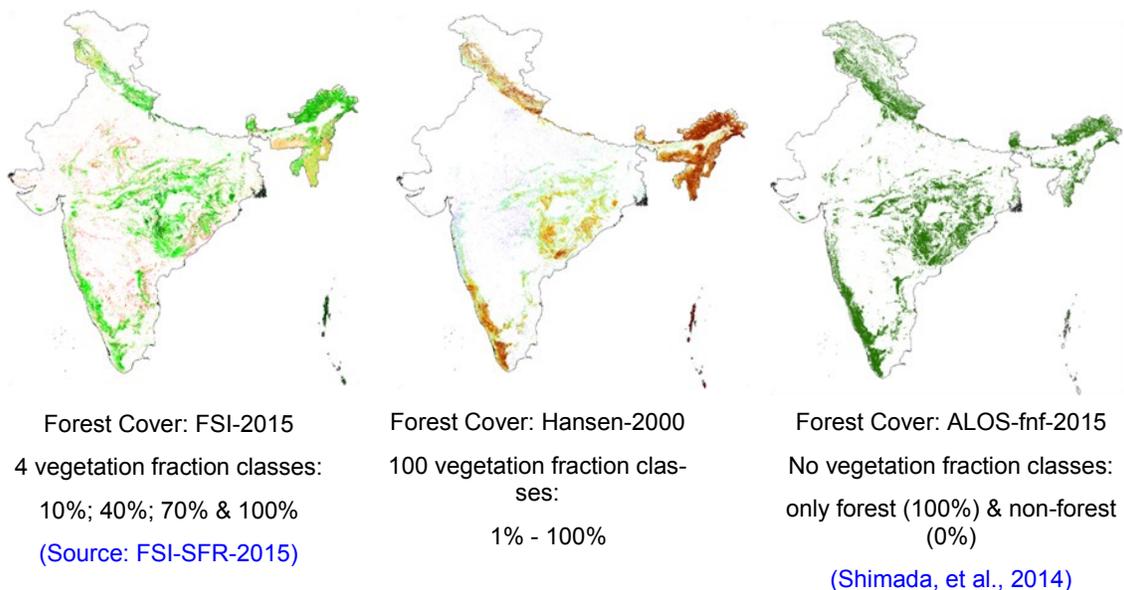


Figure 3: Available forest cover maps over Indian region

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AOD Estimation from Satellite Data and its Potential

Manoj K Mishra

Space Applications Centre (ISRO), Ahmedabad; E-mail: manoj8187@sac.isro.gov.in

Increasing interests in understanding the role of aerosol in radiative forcing, climate change and air quality requires accurate measurements of aerosol concentration and aerosol properties. Aerosol affect Earth's radiation budget directly by changing the radiation reflected from the earth surface as well as by changing incoming solar radiation. They can also affect Earth's budget indirectly by changing the cloud properties. Since aerosol plays major role as nuclei for cloud condensation therefore also shows impact on precipitation. Number of networks such as Aerosol Robotic Network (AERONET), ISRO Geosphere-Biosphere Programme (ISRO-GBP) acquires continues ground observation of aerosol concentration and aerosol properties around the world at very high temporal resolution. However, since aerosols are very dynamic spatially as well as temporally, therefore point observations from these networks do not represent real spatial distribution of aerosols. In Indian standpoint, recent reports about severely elevated air pollution in metropolitan cites, especially located in Indo-Gangatic plane led to an urgency of synoptic measurement of aerosols over Indian region at high temporal resolution to understand the possible causes such as transportation of aerosol from other places, anthropogenic activities and to identify hot spots of aerosol sources. The satellite derived aerosol optical depth (AOD) defined as the integrated extinction of solar light over a vertical column of atmosphere of unit cross-section due to particles in atmosphere, is an excellent source for monitoring spatial distribution of air pollution. AOD in general is directly correlated to the concentration of particulate matter suspended in atmosphere. Therefore, AOD can potentially be useful for air pollution monitoring including other applications such as impact of aerosols on cloud formation and on Earth's radiation budget i.e., on climate change. The aerosol retrievals from polar orbiting satellites provides valuable information about aerosols at poor temporal (once a day) therefore polar orbiting satellite may not be perfect for monitoring the aerosol motion. On the other hand, geostationary satellites such as Indian weather satellite INSAT-3D (INSAT-3D) provide better prospects to derive aerosol information over a fixed area on Earth at high temporal resolution (at 15-30 minutes interval during sun light time) and thus enable us to monitor the aerosol transportation. Recently, research team at space applications Centre, ISRO, have developed and operationalized an algorithm for aerosol optical depth retrieval from INSAT-3D on Meteorological & Oceanographic Satellite Data Archival Centre (MOSDAC) and Visualization of Earth Observation Data and Archival System (VEDAS) web portal. The daily near real time aerosol state at temporal resolution of 30 minutes can be visualized and analyzed from air-quality portal of VEDAS/ISRO website (www.vedas.sac.gov.in), while AOD data is freely downloadable from MOSDAC/ISRO website (www.mosdac.gov.in). The study on retrieval uncertainty and validation of INAT-3D AOD (Mishra, M. K. (2018). shows that the INSAT-3D aerosol product can be used for monitoring aerosols and can be calibrated with MODIS aqua/terra aerosol product to generate combined aerosol product at high temporal resolution (30-minute) over Asian landmass and adjoining ocean. The Centre Pollution Control Board (CPCB), Delhi, an Indian government agency is using the INSAT-3D AOD product on VEDAS air-quality portal to monitor air pollution from space (figure 1). Similarly, another government agency, the Indian Meteorological Department (IMD), Delhi is also using the INSAT-3D AOD data product (Figure 2).

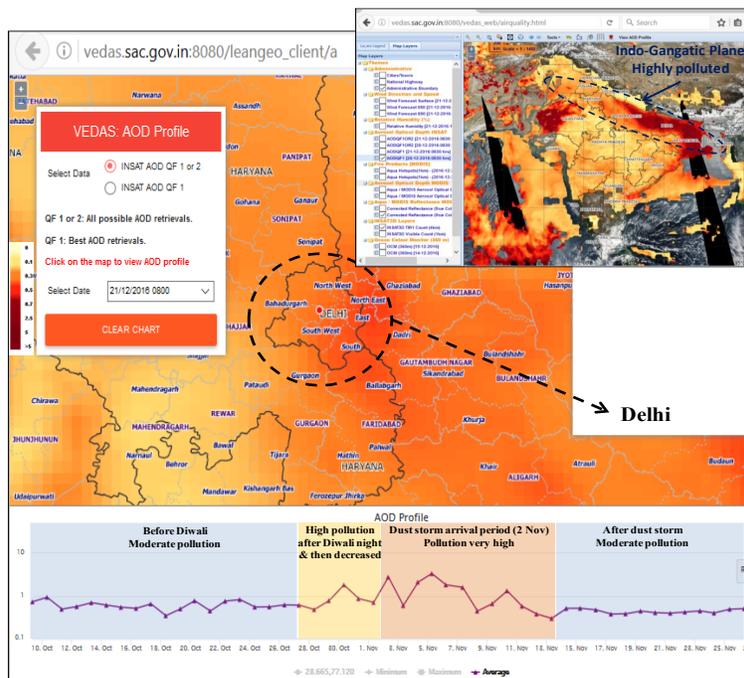


Figure 1: Snap shot of ISRO-VEDAS air quality web portal showing aerosol optical depth over Indian region. The temporal profile (at bottom) over Delhi region shows elevated air pollution due to the use of firecrackers for Diwali celebration (just after 28 October 2016)

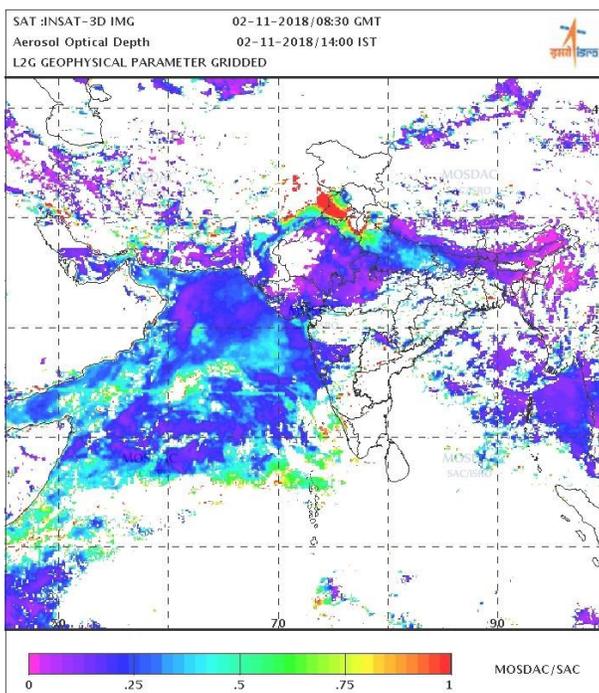


Figure 2: INSAT-3D AOD product from MOSDAC/SAC, ISRO.

Reference

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Himalayan Glacial Facies Detection and Monitoring using SAR Data

Sanchayita Das^{1,3}, Sanid C², Manab Chakraborty³ and Arundhati Misra²

¹*Nirma University, Ahmedabad; E-mail: sanchayita_kundu02@yahoo.com*

²*SAC-ISRO, Ahmedabad ; E-mail: sanid@sac.isro.gov.in, arundhati@sac.isro.gov.in*

³*Formerly with SAC-ISRO*

The Himalayan glaciatic region accompanying the other neighboring glaciated regions, like, Karakoram, Hindukush and Central Asian mountain range, forms the largest glaciated region outside the poles. The major agricultural regions of Asia depend upon the perennial rivers originated from snow-melt runoff of this glaciated region. Therefore, health of the Himalayan and other neighboring glaciated regions are of major concern. Regular monitoring is necessary to understand the impact of climate change over these regions. In last few decades, advancement of remote sensing techniques, facilitate the glaciological studies which are, otherwise, a tedious job due to harsh environment and climatic conditions.

As determined by the physical characteristics, a glacier can be divided into five zones, namely the dry snow zone (DSZ), the frozen percolation zone (FPZ), the wet percolation snow zone (WSZ), the superimposed ice zone (SIZ), and the bare ice zone (BIZ) (Benson, 1962). To monitor the Himalayan glacial zones and their temporal changes, regular data analysis and output derivation are necessary. The yearly monitoring will help to develop data inventories. It also helps to predict glacial mass balance, changes in climate and its impact on glacial mass. SAR data have been used as primary input to get information of glaciers' transient zones and their metamorphosis over the time unobstructed by atmospheric conditions. Use of SAR data increases opportunity of collecting information of the glaciers without affected by cloud cover or solar illumination. The variation in backscattering of the radar signal is subjected to system parameters, like, signal frequency, polarization and target parameters, like, surface roughness, target's dielectric constant, orientation to the radar beam (Partington, 1998). Sensitivity of radar signal to liquid water allows detecting wet snow precisely. Penetration capability of radar signal (some particular frequencies for some particular depth) also aids to study sub-surface properties of glaciers, mostly at accumulation region. To monitor the Himalayan glaciers, regular data analysis and output derivation are necessary. The purpose of the work was to develop a classification method as a tool to analyze multi-temporal SAR data over multiple glaciers with more objective way.

Initially, two glaciers, Ganotri and Mana glaciers were identified for SAR backscattering study.

Later other glaciers, namely, Chhota Shigri, Zemu, Durung Drung glacier are included in the study. Model is also applied over western Himalaya and eastern Himalayan glaciated zones. Radar Imaging SATellite-1 (RISAT-1) Medium Resolution SAR (MRS) data are used for this study. Multi-temporal SAR data from the year 2012 to 2015 are analyzed. The calibrated filtered data of each date contains two image files (in .tif format), i.e., HH and HV polarization images. The other data which are required for classification is Digital Elevation Model (DEM) of the study area (in .tif format). The glacier boundary is considered as AOI and provided in .shp format for the classification process. The data are in Universal Transvers Mercator (UTM) projection.

Temporal data were analyzed to develop signatures of different zones. The two dimensional SAR backscattering signatures (HH and HV polarizations) of the glaciers zones define the linear decision rules of classification (Kundu and Chakraborty, 2015). To minimize the error due to overlap of signatures, altitude thresholds are employed to segregate the mixed classes.

The decision rule classification module is integrated under Microwave Data Analysis Software (MIDAS). MIDAS, in-house software, is developed in Space Applications Centre, ISRO for analyzing microwave data and polarimetric signatures. The core module is written in C/C++, whereas, the Graphical User Interface (GUI) is written in TCL/TK (Figure 1). The module requires calibrated ortho-rectified sigma naught dual-pol SAR imagery in Geotiff (.tif) format. The glaciated area should be provided as shape file (.shp) format which will generate Area of Interest (AOI). A Digital Elevation Model (DEM) file is required for altitude threshold. The output classes are saved in separate files with Boolean values. The classification module is tested over the Himalayan region from west to east. The universal backscattering based classification result of level 1 is fully automatic. In level 2, altitude threshold is variable since formation of glacial zones depends up on the

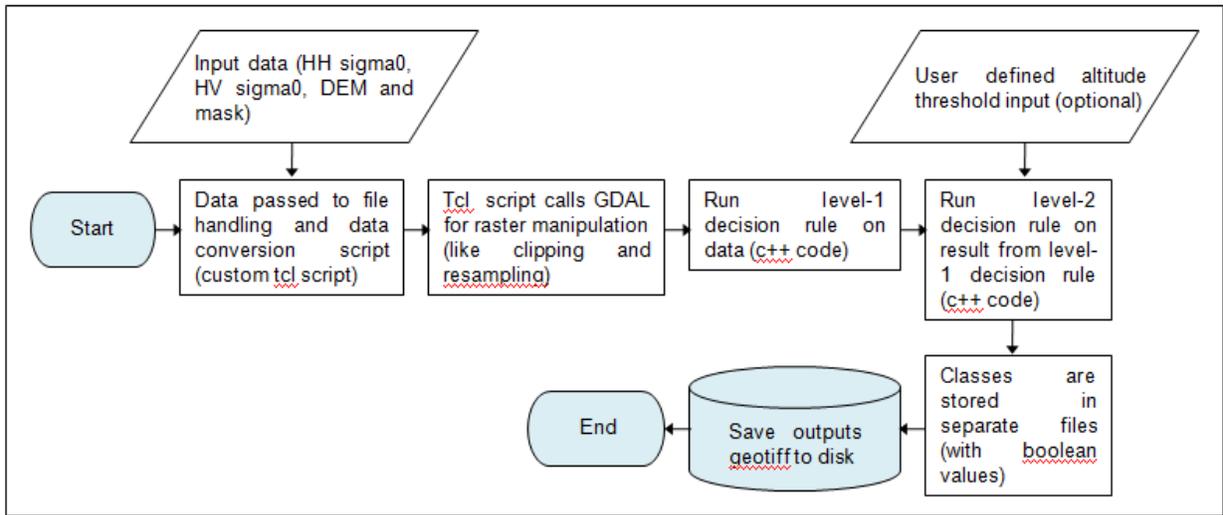


Figure 1: Conceptual diagram of classification module integrated in MIDAS software

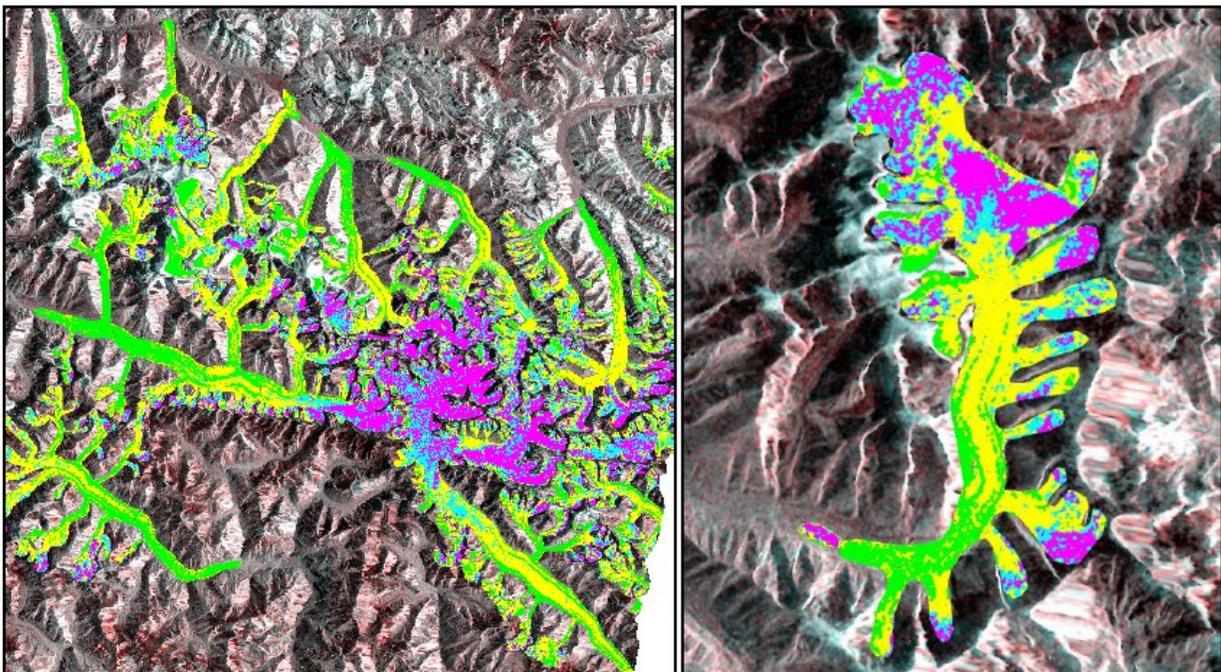


Figure 2: Left: Glaciated region at Shyok valley of Indus basin; Right: Glacier of eastern Himalaya near Arunachal Pradesh, India. The glacial zones are represented by colour as follows, green: Debris Covered Ice Zone (DCIZ), yellow: Bare Ice Zone (BIZ), cyan: Super-imposed Ice zone (SIZ), magenta: Wet Snow Zone (WSZ). Water in glacial lake is represented by magenta colour

prevailing weather, which is highly variable from western to eastern Himalaya.

The classification results were generated over many glaciers throughout the Himalaya (Figure 2). The outer boundary of wet snow zone (WSZ represented in magenta colour) provides existence of snowline at a particular altitude on that date. The glacial lakes were classified by the classification module. The subsurface characteristics of the glacier zones were identified from winter season data. As SAR can penetrate through dry and fresh fine grained snow, it interacts with subsurface layers. The firn zones were identified from winter season data which develops under the freshly accumulated winter snow. From this study, it has been observed that snowline altitudes of the Himalayan glaciers are varied from 4800 m asl to almost 6000 m asl from western Himalaya of Kashmir to eastern Himalaya of Arunachal Pradesh. The classification algorithm can be applied over any glaciated region; however, the classification module is currently spatially limited over 'Hindukush-Karakoram-Himalaya' (H-K-H) region and used for regular monitoring of glacial facies over the Himalayan region.

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Bhuvan National Geo-Spatial Platform

Vinod Bhothale
NRSC, ISRO, Hyderabad

ADVANCEMENTS IN GEOSPATIAL TECHNOLOGY FOR SOCIETAL BENEFITS

Bhuvan (<http://bhuvan.nrsc.gov.in>) is a Geo-Platform of ISRO, a web-GIS solution that hosts a variety of GIS applications, data products and map services for world-wide users. Bhuvan was launched on 12 August 2009 as a simple visualization platform for displaying GIS data. Over the years, Bhuvan has grown rapidly using open source tools providing 2D/3D applications, free satellite and satellite derived data products, thematic services, online mapping tools, project monitoring tools and disaster support. Bhuvan currently hosts 120 web applications in collaboration with various ministries, state and central departments. More than 7000 map services are hosted on Bhuvan and available to public as WMS/WMTS services. Some of the major developments in Bhuvan are discussed below.

Bhuvan currently hosts various national level geospatial governance applications. Some of the examples include: Asset mapping in MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act), Integrated Watershed Management Program (IWMP), Housing for All, Crop Insurance, Soil-Health Card for inventory & Advisory, Mapping of Postal Services, Mapping of Banks (Reserve Bank of India), Inland water fisheries, PMKSY (Pradhana Mantri Krishi Sanchai Yojana), Crop Intensification under National Food Security Mission, RKVY (Rashtriya Krishi Vikas Yojana) etc. High resolution satellite data is one of the major requirements for such applications to provide better decision support services. Bhuvan currently hosts two layers of 1m resolution satellite data for entire India for the years 2016 & 2017 and 5m resolution satellite data for the year 2017. The satellite data service is available for public as WMS service and can be overlaid on user applications using various open source or commercial GIS software. Apart from satellite data Bhuvan also hosts administrative & infrastructure data, rich thematic data containing Land Use Land Cover, Waste land, Geomorphology, Urban Land Use, Lineaments, Water Bodies, etc. Bhuvan also provides rich diverse data like Hydrological Boundaries, Climate and Environment, Disaster, Forestry, Tourism, Water, Urban, Agriculture etc. More than 40 Million point of interest data is currently available on Bhuvan. Bhuvan also provides free data downloads. This includes, 23 m resolution LISS-III (Linear Imaging and Self Scanning Sensor) data, 56 m AWiFS (Advanced Wide Field Sensor) data, CartoSat Digital Elevation Model data and more than 50 products under NICES (National Information System for Climate and Environment Studies) Program including Cryospheric products, terrestrial sciences products, Ocean sciences products and Atmosphere and Climate sciences products. Downloadable datasets are also enabled with quick view, technical document describing the process and metadata in NSDI 2.0 standard.

This vast magnitude of data can be used for research projects, governance projects, citizen centric applications etc.

Bhuvan provides various GIS tools to enable users to upload or overlay user's datasets, generate choropleth maps, online mapping tools to enable users to draw points, lines, polygons etc. Tools for navigation between two locations and proximity based point of interest search are also available for general public.

Recently, BHUVAN – SUVIDHA (<http://bhuvan-suvidha.nrsc.gov.in/>), a web portal using Open Source GeoNode, that has the capability of sharing and managing the datasets option and easy-to use interface allowing non-specialized users to share data and create interactive maps is developed and released. Using this portal, with few quick steps users can upload, edit, create, style, share spatial data online and create maps using existing layers and their own data. This portal also facilitates user full control on his/her uploaded datasets like who can view, edit (data, metadata), style and share. This will enable a completely new dimension to present Bhuvan Geo portal and enables Bhuvan partners/stakeholders and non-GIS experts to quickly publish, verify,



Figure 1

manage and share data. Thus minimizes the technology knowhow for creation, styling and hosting map services over internet resulting in better, efficient and faster map services.

Additionally, Bhuvan hosts **School Bhuvan** portal for students. This e-learning portal of students provides map based learning to bring awareness among the students about country's natural resources, environment and their role in sustainable development besides teaching aid for teachers.

Some of the major applications that are released recently are given below.

MGNREGA:

Bhuvan–MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act), Geo-portal for DoRD facilitating platform for Visualization of Moderation of Geotagged Assets is developed and released. MGNREGA aims to enhance livelihood security of rural people by guaranteeing 100 days of wages in a financial year for adults willing to take up unskilled manual work. Assets created under this project, across the country under the rural job scheme, which involves water harvesting, drought relief and flood control as preferred activities are geo-tagged in Bhuvan-MGNREGA portal. More than 3 Crores of assets are uploaded under this project in Bhuvan.

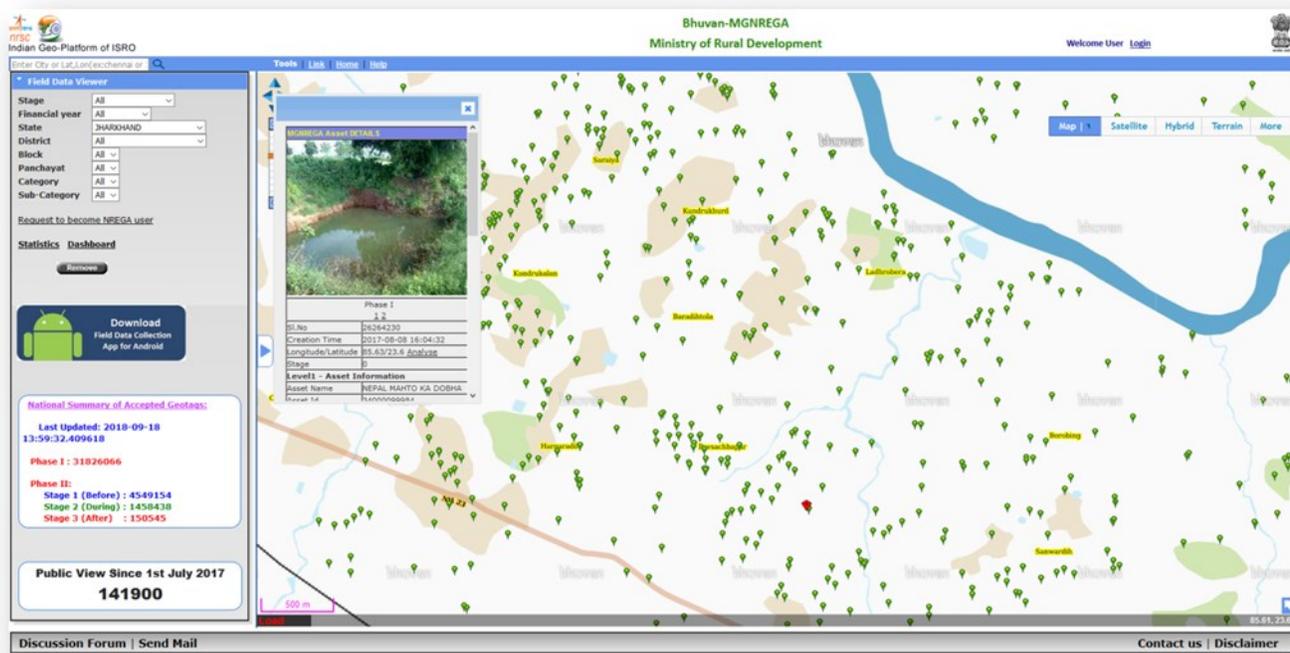


Figure 2: Geo-tagged Asset visualisation in MGNREGA

International Day of Yoga

International Yoga day is celebrated country-wide on 21-06-2018. Mass yoga demonstrations are carried out widely across various locations. In order to capture these demonstrations, NRSC/ISRO in co-ordination with Ministry of Aayush, has come out with Android based Mobile app for image collection with location information. The data thus captured is made available on Bhuvan portal for visualization.

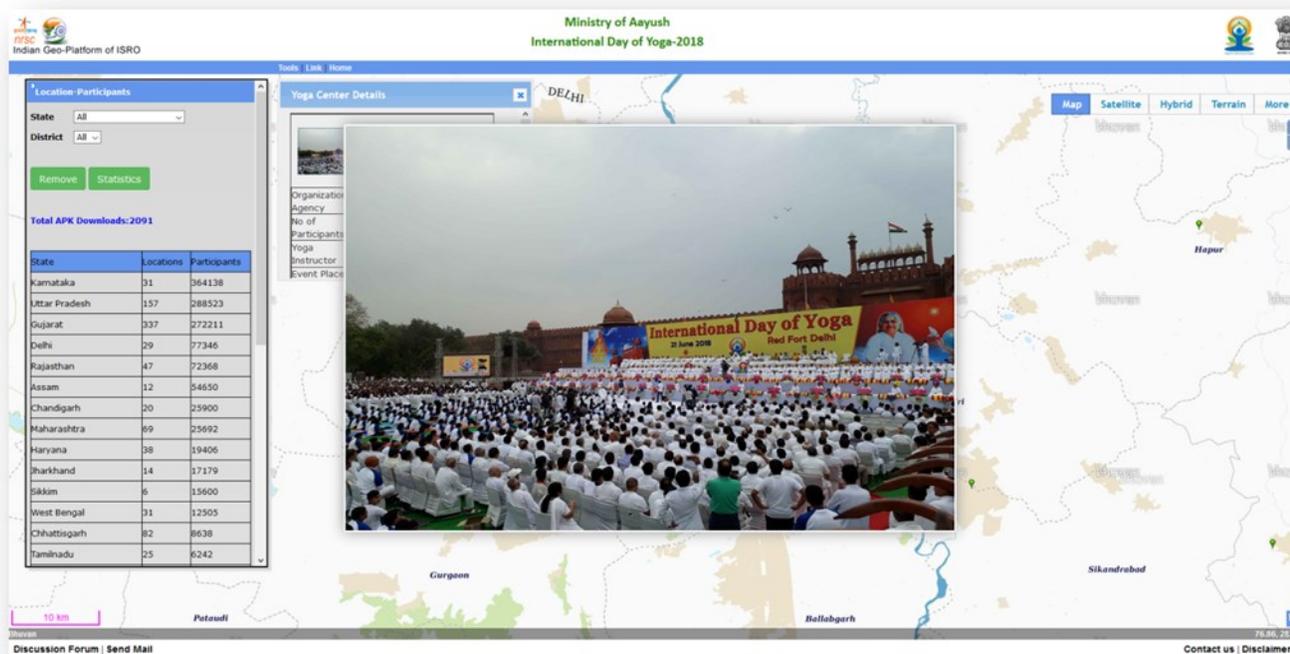


Figure 3: Yoga day at Red Fort, New Delhi

Data collected is made available as dynamic web map service for visualization in portal, graphical views as

charts on various administrative hierarchy like country, state and district levels. This responsive progressive dashboard with intuitive interface provides the analytical information like no of participants, cumulative numbers in the state, districts etc. Total 2066 APK downloads from 992 different locations with 12.7 Lakh participants are recorded.

Housing for All

Pradhan Mantri Awas Yojana (PMAY)- ‘Housing for All’ (urban) (HFA) mission for urban areas will be implemented during 2015-2022 and the mission will provide central assistance to implementing agencies through State / UTs for providing houses to all eligible families/ beneficiaries by 2021. All 4041 statutory towns as per Census 2011, with a focus on 500 Class I cities will be covered in three phases under this scheme. The mechanism of release of Central assistance to the States/UTs will be made based on the urban population and estimated slum population and other criteria as may be decided by Ministry of Housing and Urban Poverty Alleviation (MoHUPA). As per the guidelines, the progress of individual houses should be tracked through geo-tagged photographs, so that each house can be monitored effectively. For this purpose, a mobile application is released to collect and report geo-tagged information and monitor different stages of the houses construction for which are under “Housing for All” scheme. The information such as location captured from, photographs captured from, project name, type of construction, type of the house, stage of construction, etc. or any other related description about the location can be collected using this mobile application. The geo-tagged information is moderated and accepted before they are made available to public in Bhuvan web application.

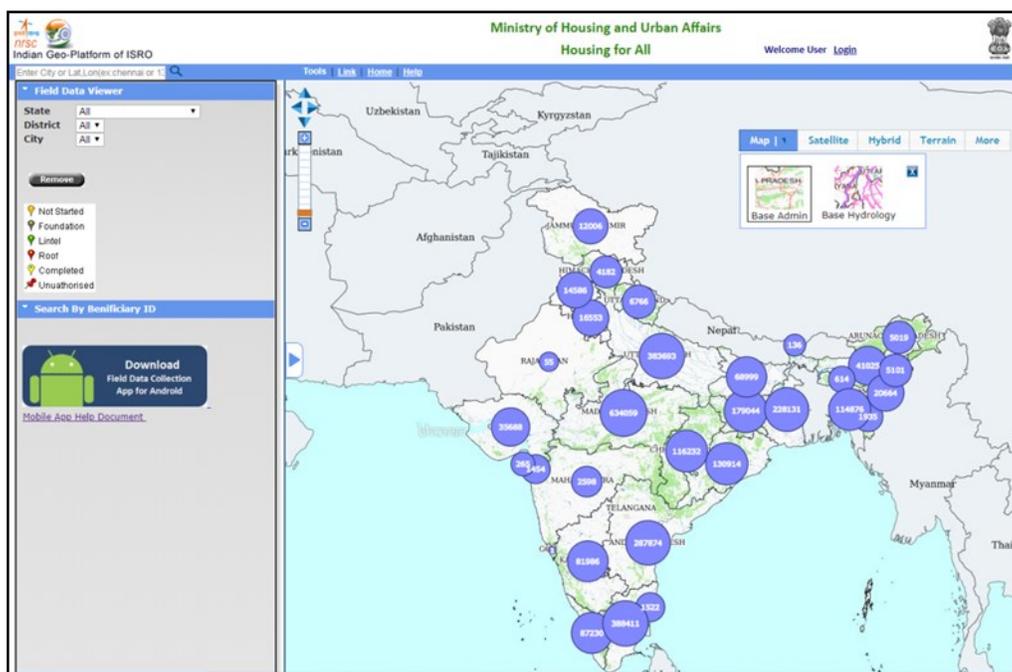


Figure 4: Housing for all

Reserve Bank of India

The aim of this project is to geo-tag bank branches of RBI in India using Bhuvan. As part of this project, second version of mobile application is released. Major features of this application are providing mobile app to user for uploading images with attribute information, collection of data at server level, handling the functionality of Image compression on both mobile and server side, provision of editing registration request by the user, provision of online dashboard to the user etc.

NABARD

Monitoring of NABARD (National Bank for Agriculture and Rural Development) Watershed Projects using Geospatial Technology is one of the projects taken up by Bhuvan. NABARD, as part of developmental and promotional interventions under farm sector, is implementing participatory watershed projects in 19 drought affected states. Major objectives of the program are conservation of soil and water; employment generation, poverty alleviation and increased agriculture production and productivity through judicious use of the resources conserved and developed in such project areas. To address climate change issues, NABARD is also implementing Climate Proofing interventions in completed watershed projects. Using this application, watershed activity can be monitored by Geotagging activities from the field using mobile app. This data can be visualized on Bhuvan web application.

With all these applications, datasets and GIS tools and much more, Bhuvan continuously strives to improve its applications and build solutions for planners, decision makers, social groups, village communities and individuals for societal benefits. Bhuvan website is currently accessed by over 30,000 users everyday and more than 1.5 lakh products are downloaded every year. Bhuvan expects that these tools and data sets will be used by more and more researchers and decision makers nation-wide for building their own applications.

Role of Satellite Technology in Harnessing Non-Conventional Energy for the Societal Benefits

Dr. Raj Kumar

Earth, Ocean, Atmosphere, Planetary Sciences and Applications Area (EPSA), SAC-ISRO, Ahmedabad; E-mail: rksharma@sac.isro.gov.in

Global warming over millennial time scales is caused due to anthropogenic greenhouse gas emissions produced by several human activities. This, in turn, influences all the human beings and other creatures on the Earth in the form of sea level rise, extreme rainfall events (floods or droughts), extreme heat, cold, storms and crop failures. With the exhaustion of fossil fuels and increasing awareness on these environmental issues, harnessing energy from available natural resources has become a prime focus in the developing countries. Many countries have realized that the exploitation of new and renewable energy resources is the only solution to suffice the ever-growing demand for electricity.

India ranks third largest power generation capacity in the world with about 345.5 GW and third largest consumer of electricity. During the financial year 2017-18, the gross electricity generated in India was more than 1000 TWh, whereas the gross electricity consumption was more than 1000 kWh per capita. With the launch of “Make in India” campaigns by the Government of India, there will be increase in manufacturing in India and possibility of increase in power demand in future.

India was the first country in the world to have “Ministry of Non-Conventional Energy Resources”, now named as Ministry of New and Renewable Energy (MNRE), which is primarily responsible for R & D, international cooperation, promotion, and coordination in renewable energy sources for supplementing the energy requirements of India. The renewable energy contributes 20.4% (70.6 GW) that include solar (23 GW), onshore wind power (34.3 GW), biomass (8.7 GW), small hydro (4.5 GW) and waste to energy (0.1 GW). The government has setup an ambitious target of renewable energy capacity to 175 GW by end of 2022, committed to Clean and Green Energy and is driving efforts to achieve 40% power installed capacity from non-conventional energy resources and reducing emissions by 33- 35% of its GDP by 2030. This target includes 100 GW of solar power (including 40 GW of grid-connected rooftop solar installations), 60 GW from wind power (including onshore and offshore wind farms), 10 GW from biomass power and 5 GW from small hydropower.

The *International Solar Alliance (ISA)* initiated by India in November 2015 has active co-operation of more than 121 sunshine countries situated between the Tropic of Cancer and the Tropic of Capricorn. The primary objective of the alliance is to work for efficient exploitation of solar energy to reduce dependence on fossil fuels. India stands third largest installed capacity of concentrated solar power (CSP) in the world. With approximate 300 clear sunny days a year, India has approximately 5000 trillion kWh/m² incident solar energy, which is more than the possible energy output of all fossil fuel energy reserves in India. On the other hand, the country has the fourth largest installed onshore wind power capacity in the world. Among the renewable resources, wind power is a very large energy source, with proven commercial technology and very low or negligible CO₂ emissions. Wind power is accounted for 8.5% of India's total installed power capacity, and 2.5% of the country's power output. The presence of strong and persistent winds all throughout year, many regions along the coast of India are suitable for good potential of wind energy. There are no offshore wind farms installed in the country as on today. The *National Offshore Wind Energy Policy 2015* boosts the development of offshore wind farms within the Indian Exclusive Economic Zone (EEZ). The First Offshore

Wind Project of India (FOWPI) with the capacity of 1 GW has been initiated in the coastal waters off Gujarat. The International Energy Agency estimates India will add between 600 GW to 1,200 GW of additional new power generation capacity before 2050. This added new capacity would be equivalent to the 740 GW of total power generation capacity of the European Union (EU-27) in 2005.

Assessing such resources requires accurate long-term measurements, which is lacking due to limited network of Automatic Weather Stations (AWS) and offshore meteorological buoys as such observations are highly expensive. Hence, satellite remote sensing could provide an alternative rich source of synoptic data, covering larger areas continuously for longer periods. The use of remote-sensing observations from geostationary satellite sensors with high temporal sampling frequency is ideal to capture the diurnal variability of atmospheric constituents such as water vapour, ozone, aerosols, and clouds, and thereby surface insolation on a spatial scale. The data from geo-stationary satellites could be used to estimate the solar energy over the entire country. On the other hand, wind and waves can be monitored using space-borne microwave radars like scatterometers (ScatSat-1, OSCAT, QuikSCAT, ASCAT etc.) and altimeters (SARAL AltiKa, Jason series etc.) respectively in the polar orbits. Wave-power generation is not currently a widely used technology. As scatterometer derived winds are not available over the land, analyses from Numerical Weather Prediction Models (NWP) like Weather Research and Forecasting Model (WRF) derived winds are generally used to estimate wind energy and the same model can be used to forecast winds and solar energy also.

At Space Applications Centre (SAC), ISRO, a large volume of satellite datasets from several Indian and foreign satellite have been used synergistically to generate potential energy resources of insolation, offshore winds, and ocean waves. In addition, some experimental forecasts are being generated and disseminated through MOSDAC (<https://www.mosdac.gov.in>) on the above parameters using state-of-art models in combination with satellite data. The details of different renewable energies like insolation, wind and wave can be accessed through VEDAS web portal (<https://www.vedas.sac.gov.in>) and also through Android mobile applications to get the energy potential details of any position within and surrounding the Indian region. This information on non-conventional energy resources would highly benefit the policy makers to take decisions on installing wind and solar farms precisely with good confidence for the benefit of the society.

VEDAS: Opening New Vistas for Online User's Applications

Shashikant A Sharma and Markand P Oza

VEDAS Research Group, EPSA, SAC, ISRO, Ahmedabad;

<https://vedas.sac.gov.in>

Importance of Geospatial information in effective data based decision making and planning is well recognised. The prime motivation for formulating VEDAS (Visualisation of Earth observation Data and Archival System) is to play a meaningful role for acceptance of Earth Observation (EO) products in various developmental plans for the country. The main objective of VEDAS is to develop in-house custom crafted EO application using predominantly Indian EO data / products and disseminate the information through a website. VEDAS can be accessed on internet at <https://vedas.sac.gov.in>.

This geo-portal offers a unified web-platform as a repository of variety of scientific products on various themes of earth resources. The themes include inventory for Earth observation (Desertification, wetland, coastal environment, coral reef, shoreline change, snow and glacier, wasteland and alpine treeline), Polar science (sea ice trend, elevation, ice melt products), Planetary science (Moon and Mars), Hydrological science (Altimeter and Scatterometer) and some special products (Horticulture, Mangrove, Fodder, Air borne hyperspectral and L&S band, sea salinity, surface dryness products). This geoportal provides unique visualisation and access to variety of data products pertaining to status of earth resources as derived using India's Space Infrastructure. Some unique and important applications developed at VEDAS include

- Web-GIS based Vegetation Monitoring System;
- Renewable Energy (Solar & Wind) Potential;
- Urban Sprawl Information System (USIS);
- Air Quality Monitoring portal.

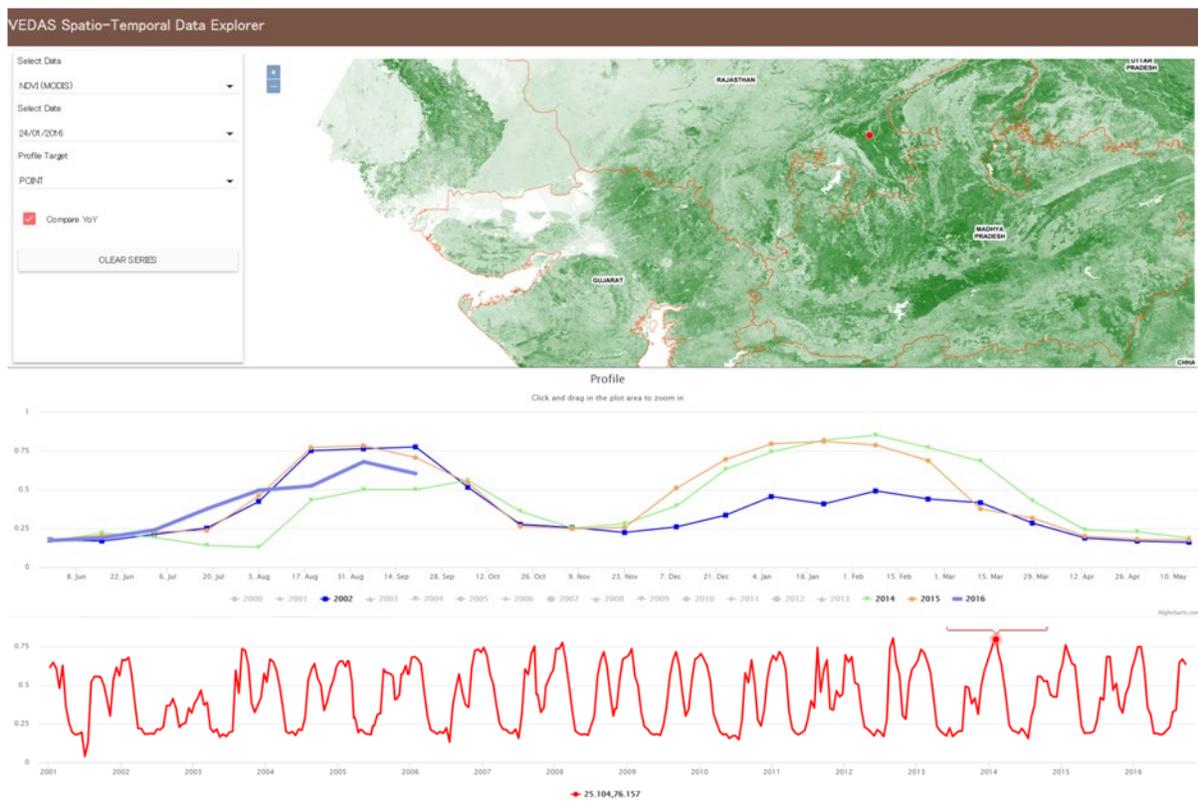
Salient features and demonstrated utility of these web based system are briefly described here below. Real value of the functionality provided offered can be appreciated by visiting this website.

- **Web-GIS based Vegetation Monitoring System**

An effective monitoring system require quick access and easy visualisation of the current status as well as knowledge of their performance in the past. Agriculture is controlled by environmental condition such as soil moisture and temperature. The response of the vegetation to the environmental condition and management practices can be studied by spectral response of vegetation. Vegetation Monitoring System integrates NDVI, temperature, Precipitation and soil moisture data from different sources and from different formats for Vegetation monitoring. The spatial database includes satellite Remote Sensing images (NDVI from OCM, AWiFS, MODIS, PROBA and Soil moisture from AMSR2 and SMAP). With the help of this application, it is possible to know that in which district / taluka / village and which duration the crop is deviating from the average along with weather (e.g. temperature, rainfall and moisture) condition.

The developed application of web map service is on 3-tier architecture of client server computing environment

where a map server is working as middle ware and JavaScript and HTML is working as client and spatial database is used for data creation, storage, transaction and management. User can send their request through web browser and they can get response in the form of maps, chart and tables. The developed web-GIS application helps the user to budget not only an overall picture of the country with regard to condition of vegetation over the cropping season and thus assess the impact of drought and other severe conditions. This web based system facilitates users to browse maps and profiles of parameters viz. NDVI, Temperature, Soil Wetness Index, Soil Moisture and rainfall. Developed web based GIS application also provides basic GIS functionalities viz. Pan, Zoom-In, Zoom-Out, Full-Extent, Measurement and Identify etc. The profiles can be viewed in a year-over-year mode. To facilitate improved and user defined visualisation and analysis, daily as well as composited NDVI, temporal NDVI colour composite, on the fly image differencing, range analysis to confirm persistence of certain conditions, temporal PCA and temporal classification are provided.



This Web-GIS based vegetation monitoring system is a friendly, flexible, dynamic and responsive tool that supports planning especially related to agriculture and vegetation.

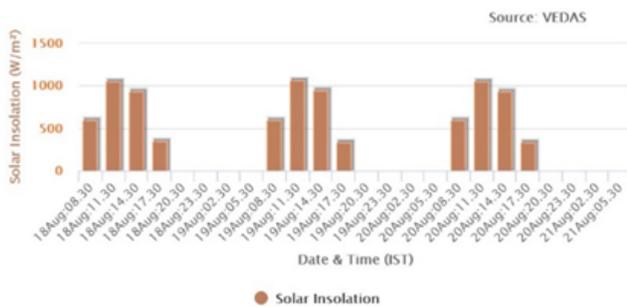
- **Renewable Energy (Solar & Wind) Potential**

A web-based application is developed which provides information on monthly and yearly potential solar, wind and wave energy at a given location. Such information is required for locating potential sites for extracting / tapping Renewable Energy resources. The power output of a photovoltaic cell is directly proportional to incident solar irradiation on the cell. The higher the solar irradiation, the higher the power output of a photovoltaic cell. The global (total) horizontal insolation (GHI), combining direct as well diffuse component of incident solar energy, is obtained from the half-hourly observations at 8 km spatial resolution in optical and thermal infrared bands from the Indian geostationary satellite KALPANA-1 Very High Resolution Radiometer (VHRR) and at 4 km spatial resolution from INSAT 3D. The data is available on MOSDAC (www.mosdac.gov.in) web portal of ISRO. The VEDAS web-portal provides information on monthly and yearly potential solar along with monthly minimum and maximum temperature, annual sun path and daily solar

hours. Wind energy is the second fastest growing source of electricity in the world. Harnessing energy from wind and converting into electricity has several advantages. It has considerably reduced the usage of non-renewable energy sources. Thus to exploit wind energy from vast coastline of India which cover 7600 km and land, the VEDAS web-portal provides information on monthly wind energy potential. The interface is designed to assess monthly average wind speed, wind power density and power generation at a different heights provided by the users. Wind forecast for next 72 hours at 3-hour interval generated from Weather Research Forecast (WRF) model is also available in developed application.



72 hrs Forecast of Solar Insolation (with 3 hrs Interval) from 18-08-2017



One very useful example of utility of solar energy is roof top solar power availability at various locations of India. The application provides the technical solar energy potential, peak power generation potential, built-up area, temperature profile and optimum tilt-angle of solar panels for 98 proposed Smart cities and 60 Solar cities and 98 smart cities of India. It shows the monthly average solar insolation and air temperature, annual sun path and daily solar hours for each of these cities as well as at any given location in India.

An android app has been developed for computation of solar energy potential at mobile user's location. Solar insolation is obtained using Indian Geostationary satellite data. It is a very useful tool for installation of PV Solar panels for tapping solar energy. It provides monthly / yearly solar potential (kWh/m²) and min/max temperature at any location. It also displays location on image and provides azimuth / elevations angles as well as day length over different time periods in a year. Obstruction of sunlight due to terrain is also computed using DEM. This app can be downloaded from <https://vedas.sac.gov.in>.

- **Urban Sprawl Information System (USIS)**

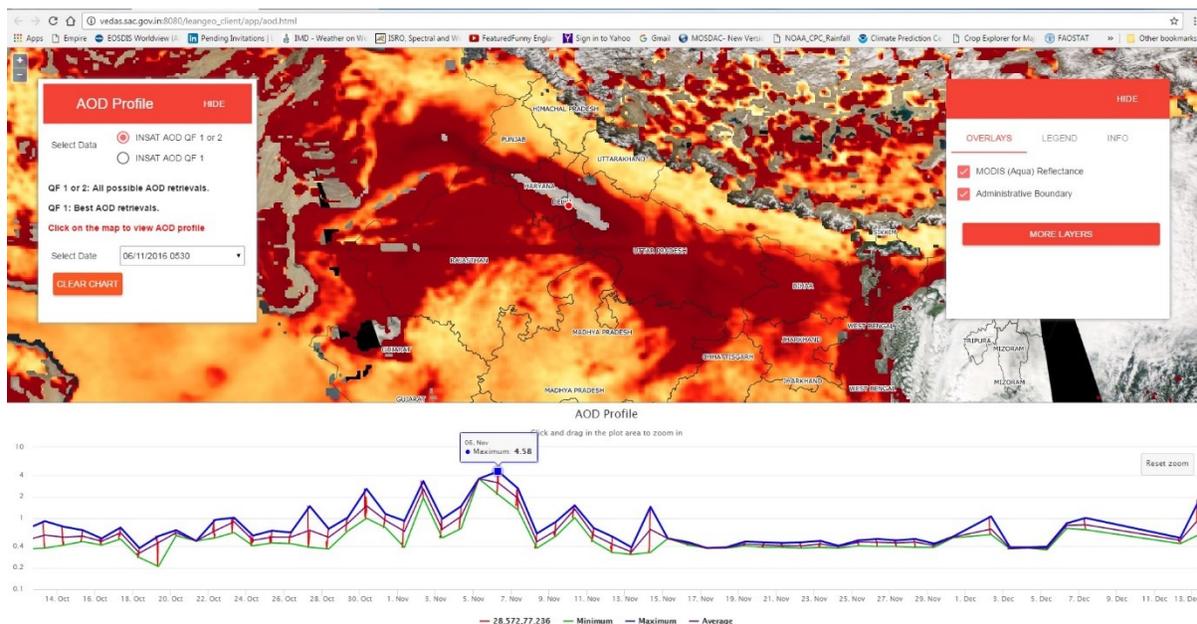
Design and development of web-based Urban Sprawl Information System (USIS) for visualising urban sprawl, new development, multi-date satellite images and simulated urban growth of nine cities. Temporal trends of urban indicators such as growth rate, scattered development, net population density, annual rate of change of density, compactness of urban core, proportion of leapfrog development are provided.

- **Air Quality Monitoring portal**

An interactive online application for monitoring air quality parameters over Indian region has been developed for dissemination of remote-sensing data and sensor data relevant to monitoring air-quality. It has tools to view trends in air-quality and associated parameters. For visualization, animation of archived satellite images is facilitated. It provides opportunity of overlaying wind and dust forecast values over the satellite images to understand the causes and effects of likely ground situation. It also serves as a resource of historical data for analysis purpose.

User can access following information on the portal.

1. **Aerosol Optical Depth:** It is a measure of atmospheric opacity. It is linked to the abundance of particles that hamper visibility and are one of the indirect indicators of poor air quality. Interactive charts of AOD values are also available
2. **CPCB Sensor data:** Data regarding particulate matter (PM 2.5 and PM 10) is automatically fetched from CPCB sensors for display in interactive charts. Each individual station data can be accessed individually and can also be compared with other station data
3. **Other Data:** OCM Imagery, MODIS Imagery, Fire Hotspots, Wind Direction and Speed, Relative Humidity, INSAT-3D TIR & Visible images and Administrative Boundaries



Capacity Building

The available Indian EO data volume is huge. It is increasing at a very fast pace. There is paradigm shift in the perception data sharing and use. The global emphasis has changed from data to information to data derived / driven process understanding and knowledge discovery. A limited set of analysts cannot do justice to the value

of ever increasing EO data on hand. There are large talent pool of researchers looking for data to understand the earth eco-system processes. To kindle their curiosity and to incubate their fresh and novel ideas on Indian EO data sets, a capacity building facility was envisaged, created and developed wherein infrastructure such as hardware, software, data and mentoring is provided to the interested researchers to exploit their skill set and develop useful applications. In last two years, 22 training programs of 4 – 10 days have been completed wherein about 480 trainees from 125 institutes have participated. As far as research programme is concerned, 75 researchers have completed their project work spanning 2 to 12 months. VEDAS provides opportunity of handshake between data generators potential analysts for utilisation of satellite-derived information to develop custom crafted geo-spatial applications which can feed into or support decision making system.

Summary and Concluding Remarks

To sum up, VEDAS provides infrastructure and environment for popularising Indian EO data and end-products of EO Applications. The aim is to expand societal benefits of ISRO's investment in Earth science research. This is done by (i) Dissemination of EO data and products as well as sharing webmap services; (ii) Developing customized WebGIS based Apps; and (iii) Providing a platform (data, infrastructure and guidance). In this article, an attempt is made to introduce and give flavour of some of the developed applications. But the real value of the functionality provided offered can be appreciated by visiting this website.

MOSDAC: Frontier in Geo-Spatial Technology for Meteorological and Ocean Applications

Amod Aggarwal, Darshan K Patel and Nitant Dube
SAC-ISRO, Ahmedabad

Abstract

Advancements in Geo-spatial technology is helping in development of advanced visualization and analysis applications in the field of meteorology and oceanography. Web-GIS based portal for scientific data visualization is one such technical advancement that has contributed significantly. These portals helps in saving the life and property from the natural disasters and extreme events such as heat waves, cyclone, cloud burst and heavy rains. GIS based mashups help the decision makers in taking necessary actions before and after the occurrence of the events by visualizing multiple source of geo-referenced data on a single map. Satellite data visualization helps in better understanding and real-time monitoring of large scale and local events. This paper describes the capability and features of different meteorological and ocean geo-spatial web applications hosted by MOSDAC.

Keywords: MOSDAC Live, WISDOM, Rip Current Forecast, Ocean Eye, Eddy Currents, Soil Moisture/Soil Wetness Index

INTRODUCTION

Meteorological and Oceanographic Satellite Data Archival Center (MOSDAC) is Indian Space Research Organisation (ISRO) data center for dissemination of data, value added products and satellite derived information products related to meteorology and oceanography. It maintains archival of different Indian meteorological and ocean data products. Advancements in Geo-spatial technology is helping in development of advanced visualization and analysis applications [1, 2, 3]. A lot of MOSDAC geospatial web applications has been developed for data and information visualization, analysis and their dissemination.

The long term satellite data maintained in the archival provides researchers with a wealth of information that allows them to use various ocean and weather parameters for their studies. Assimilation of satellite data in forecast models has leads to generation localized forecasts and has seen increased usage of this data for societal applications [4]. The information generated from these model runs is in the form of text or scientific data formats such as HDF, Netcdf, and Geotiff. For making this information more meaningful to end users, it is necessary to represent these information and data in easy to interpret format. Visual representation integrated in a geospatial platform makes data and information very easy to understand and interpret [5].

Geo-spatial Data Analysis and Visualization

MOSDAC Live

This is a Web GIS based portal that enables users to visualize, analyze and relate the different kinds of satellite

data, information products and forecast. This is an effort towards narrowing the gap between data and analysis. Moreover, this portal is also of great benefit to researchers and scientists as it allows them to visually explore the data, find the data of their interest, and then download.

Geo-spatial capabilities of MOSDAC Live include

Visualisation

- Multiple Standard and Geo-physical Parameters, in-situ data and weather forecast information layers along with different Base-Maps and Vector Layers on a map
- Capability to control opacity, enhancements, applying different pseudo LUTS and provision of legend.
- Accessible on all latest browsers.
- Provides capability to animate different layers as a function of time.
- Capability to switch between GMT and local time zone
- Location search on map based on name, address or coordinate information
- Configurable date, time, parameter and elevation of each added layer
- Automatic Update of most recent data
- Quick access to forecast alerts such as cloudburst, heavy rainfall, predicted cyclone track, rip current forecast information

Analysis

- User defined Contours,
- Time series profiles
- Point probing
- Calculation of area and distance
- Contour Generation
- Thermodynamic diagrams (Tephigram)

MOSDAC Live provides capabilities and features to interact with the satellite data and weather information. It has capability for real-time as well as past date 2D/3D visualization of multi-mission satellite data along with forecast, climatology and in-situ data. It provides visualization of SCATSAT-1 Analyzed winds, Upwelling index, Sigma Naught, Brightness Temperature, INSAT-3D & INSAT-3DR Standard and Geo-physical products, Forecast & climatology. Latest events/forecast information from Cyclone (cyclone track), Nowcast [6] (All India Heavy Rainfall and Cloudburst in regions of Himachal Pradesh and Uttarakhand), Automatic Weather Station (AWS) data visualization, RIP current forecast (GOA beaches), MOSDAC Live also provides data analysis capability in terms of point probing for the selected point, thermodynamic diagrams (Tephigram) from INSAT-3D sounder & WRF model data and temporal profiles. Date, time and parameter of each added layer on the map are configurable. User can also customize the data display (contrast and color coding) based on the selection of the palette and data range. Other features of LIVE are location search capability, contour generation, time based animation of the frames, distance and area measurement etc. This portal can be accessed via URL '<https://live.mosdac.gov.in/>'. All of the information in this portal is updated in automated mode without any human intervention.

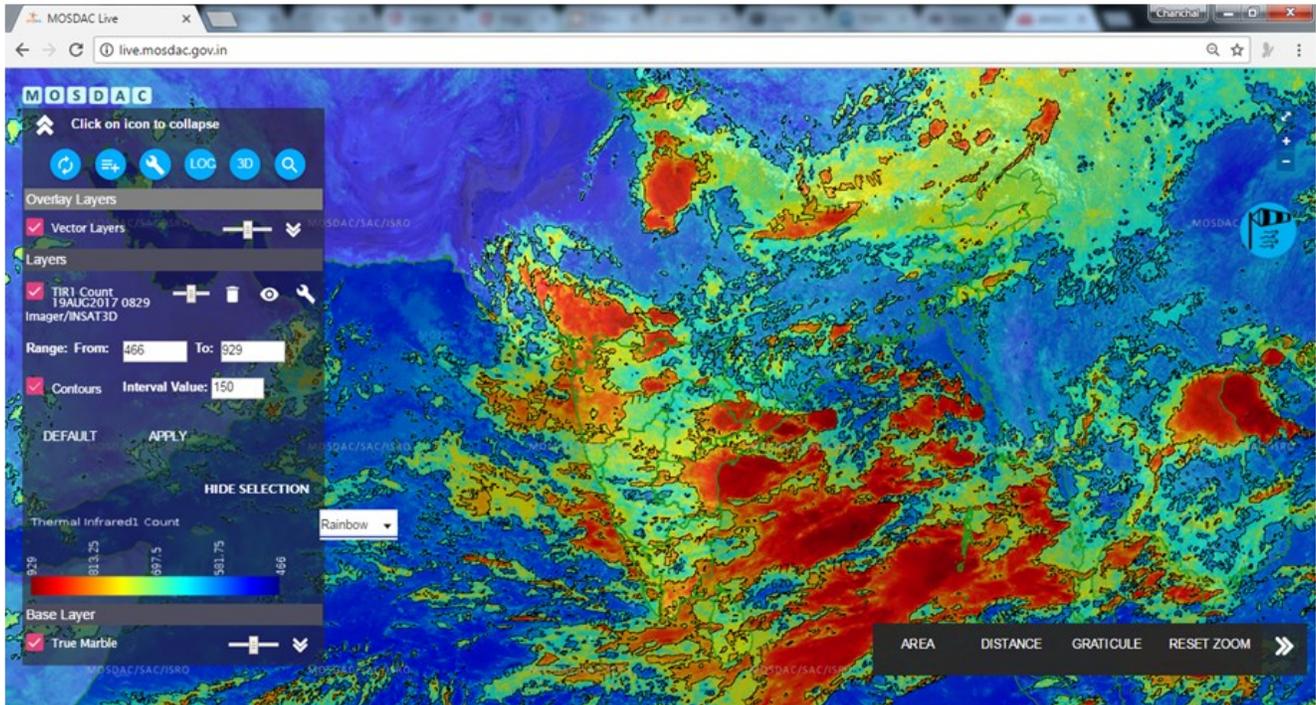


Figure 1: Interface for Earth Observation Data Visualization with style selected as rainbow for the selected satellite data layer

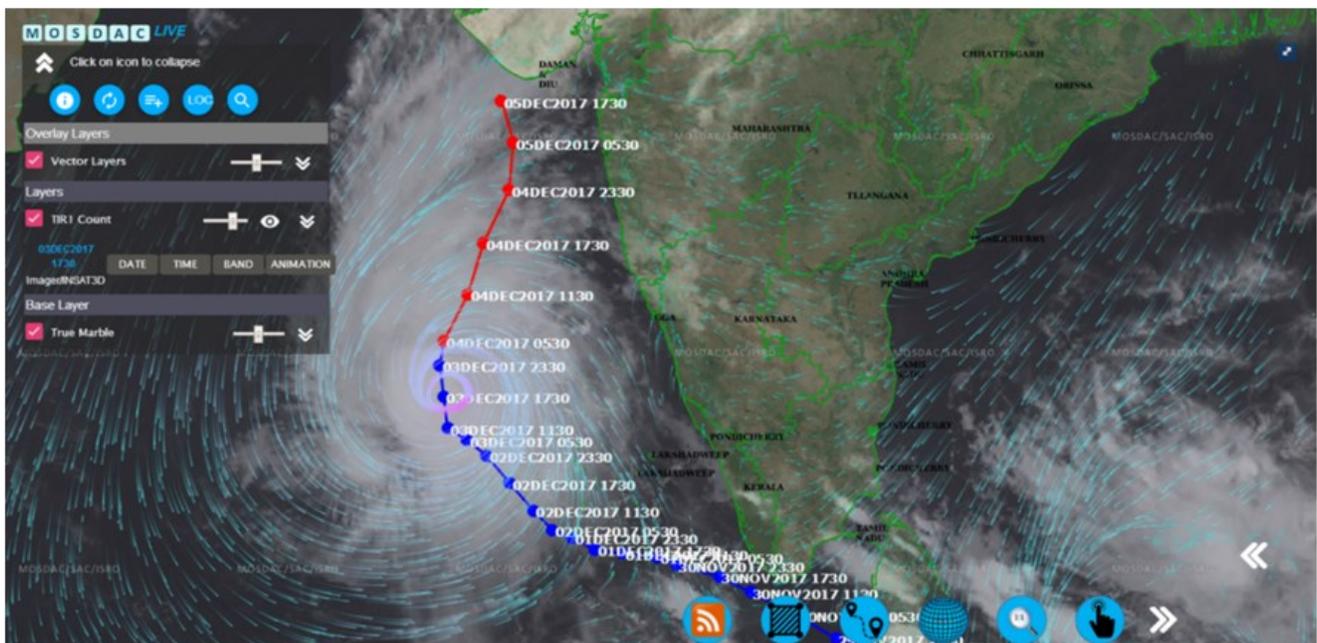


Figure 2: Ockhi cyclone track

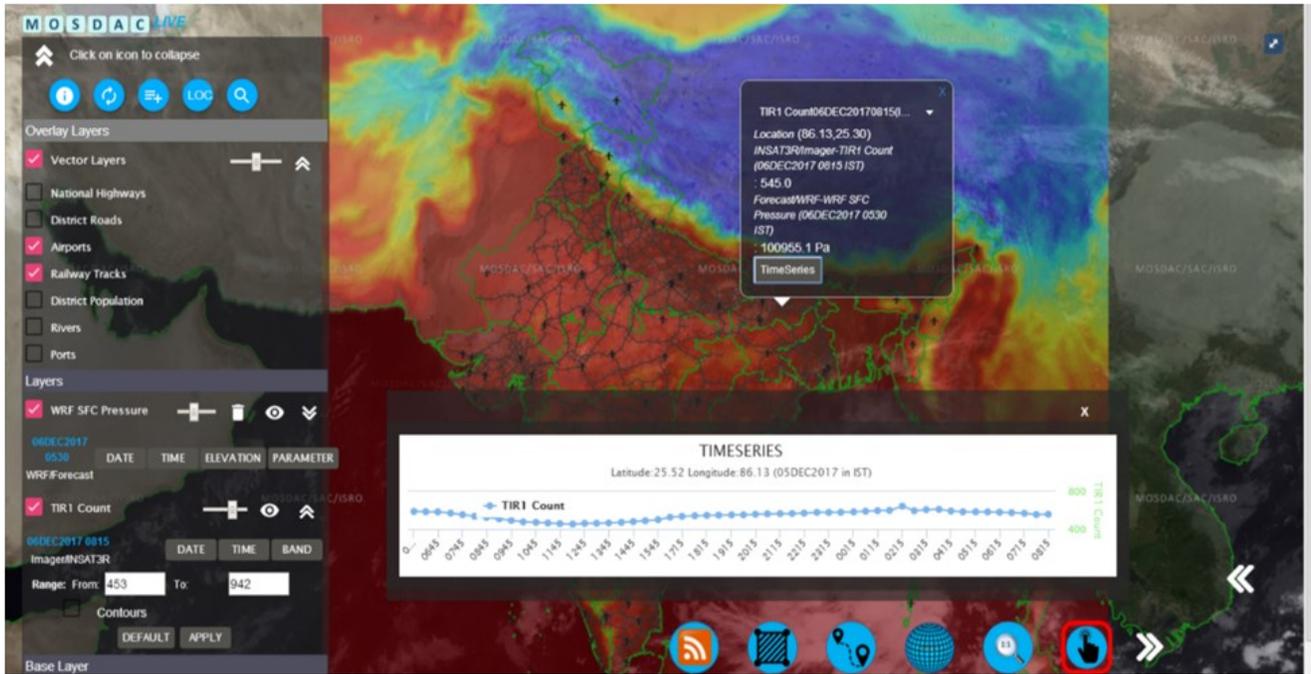


Figure 3: Temporal profile for the selected layer and point probe for all the layers overlaid on the map

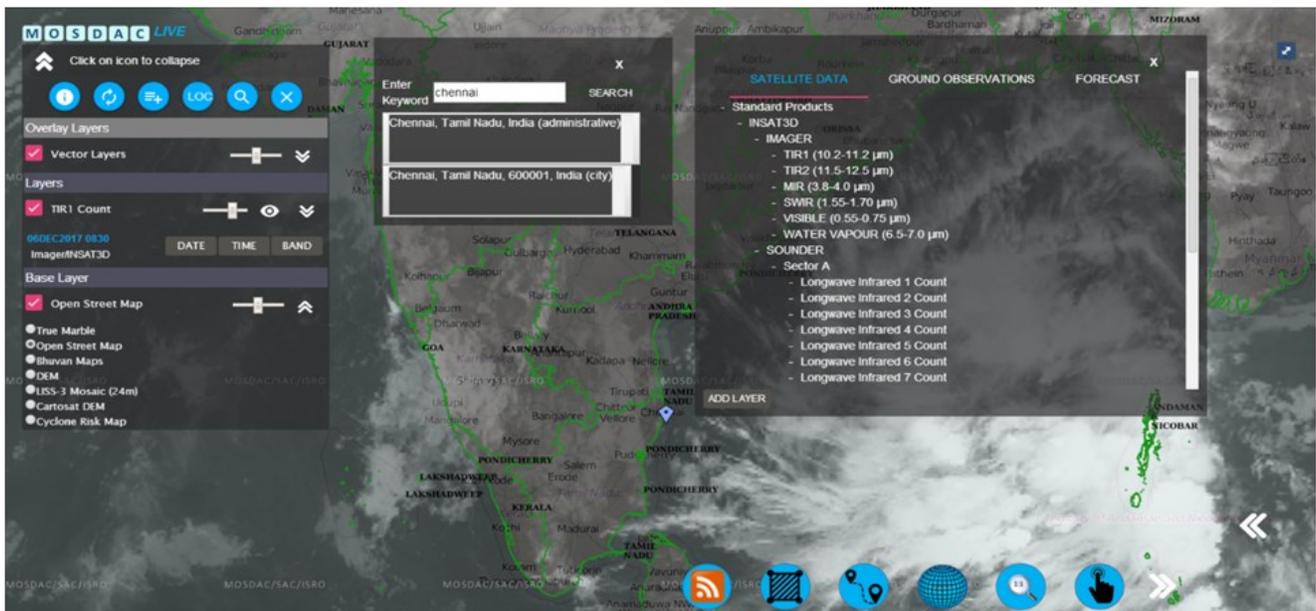


Figure 4: Selection list for the data layer to be added on the map; Marker shows the searched location on the map

Meteorological Geo-spatial Applications

Disaster management and support

Weather Information Services and Decision support for Oceanography and Meteorology (WISDOM) (http://mosdac.gov.in/weather_forecast/) is another web portal that is dedicated only to the weather information services. This portal also enables users to view the forecast of previous dates which is important for validation

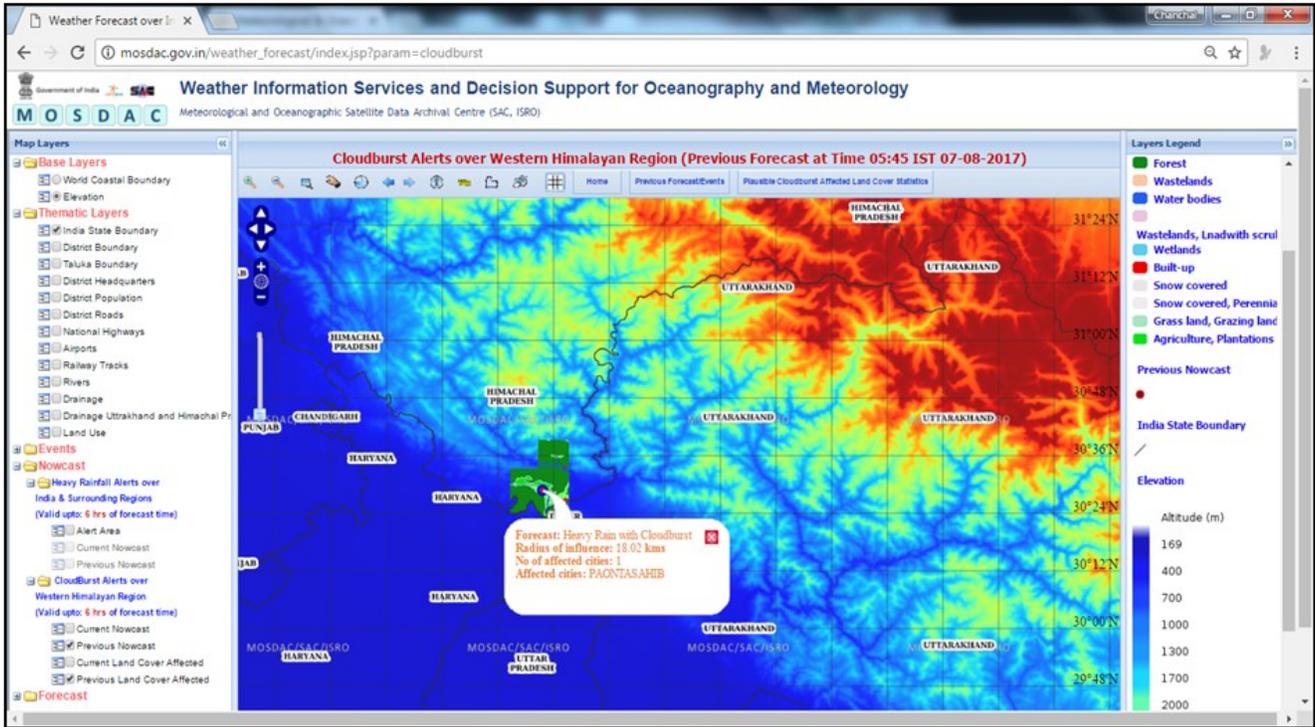


Figure 5: Probable affected land cover due to cloudburst event

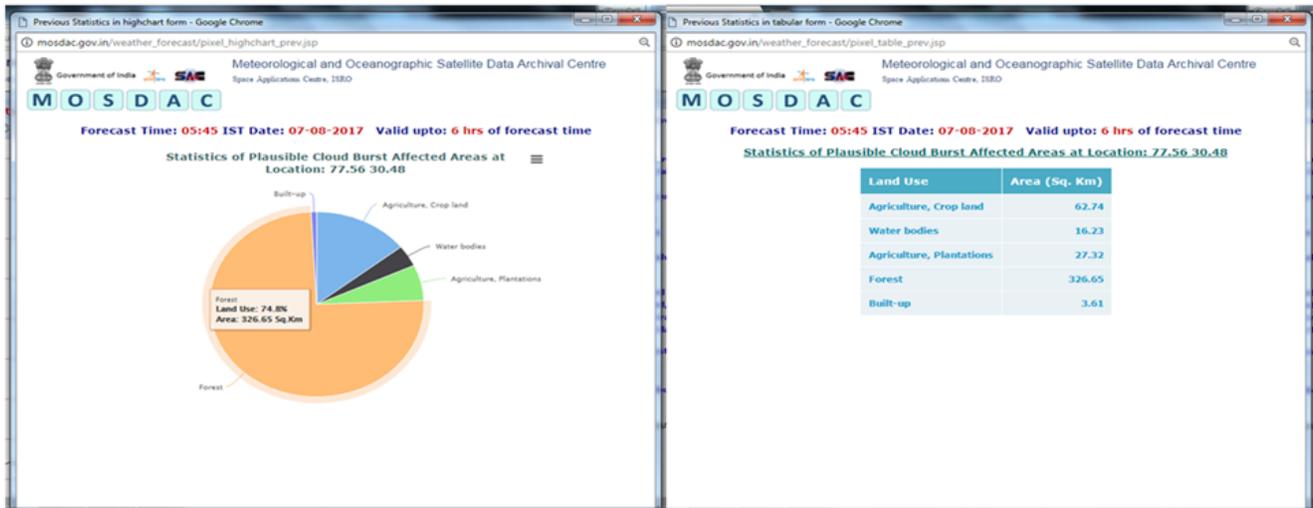


Figure 6: Statistics of affected land cover due to cloudburst event

purposes. It allows users to get land use/ land cover impact assessment [7] in terms of visualization and get the statistics of land use/ land cover.

Agro meteorology

The Soil Moisture and Soil Wetness Index portal provides latest maps of Soil Moisture and Soil Wetness. It also enables users to get the time series of both the parameters for the selected time period on the single chart. Data on this portal is updated on daily basis.

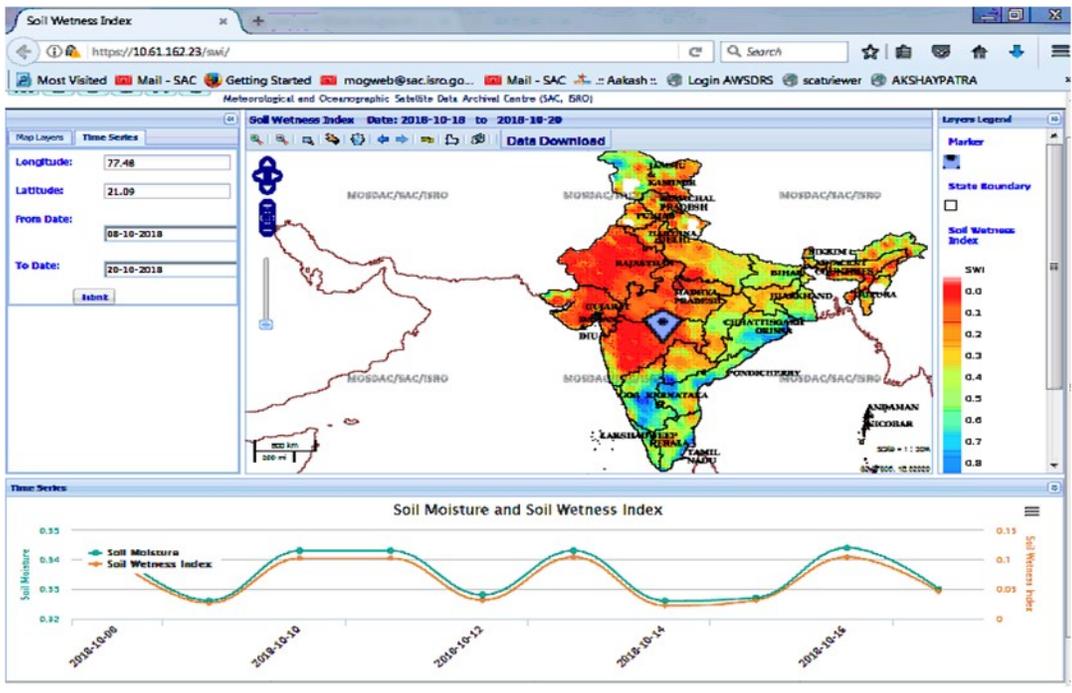


Figure 7: Soil Wetness Index map and time series of the Soil Moisture and Soil Wetness Index for the selected time period

Ocean Geo-spatial Applications

Rip current forecast

This portal provides information about the rip current risk level for the different zones of the Goa coastal area. Zones are color coded according to the severity level of rip currents. This information is provided for the Goa beaches in current scenario, but will be extended to other beaches in the near future. This information is of vital importance to tourists and swimmers. It also provides detailed beach forecast in terms of sea state forecast and tide forecast.

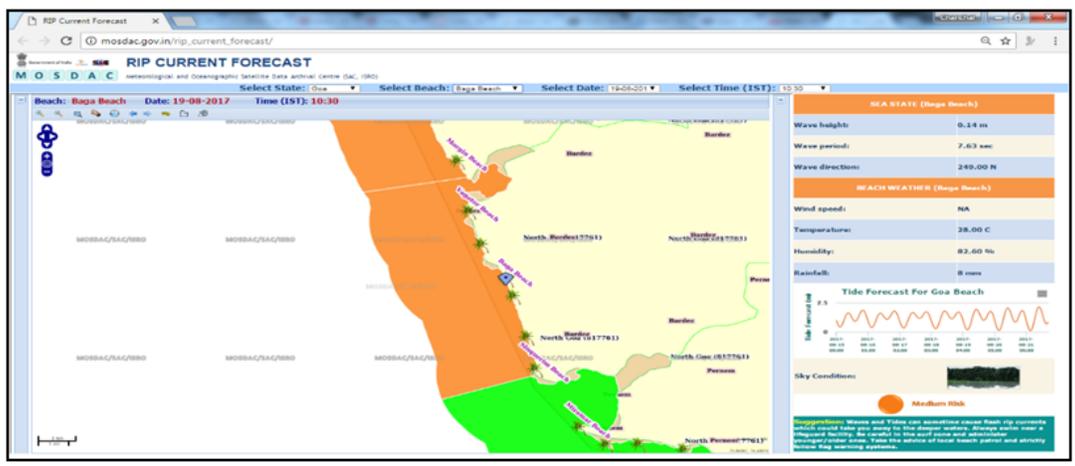


Figure 8: Web interface for Rip Current forecast portal

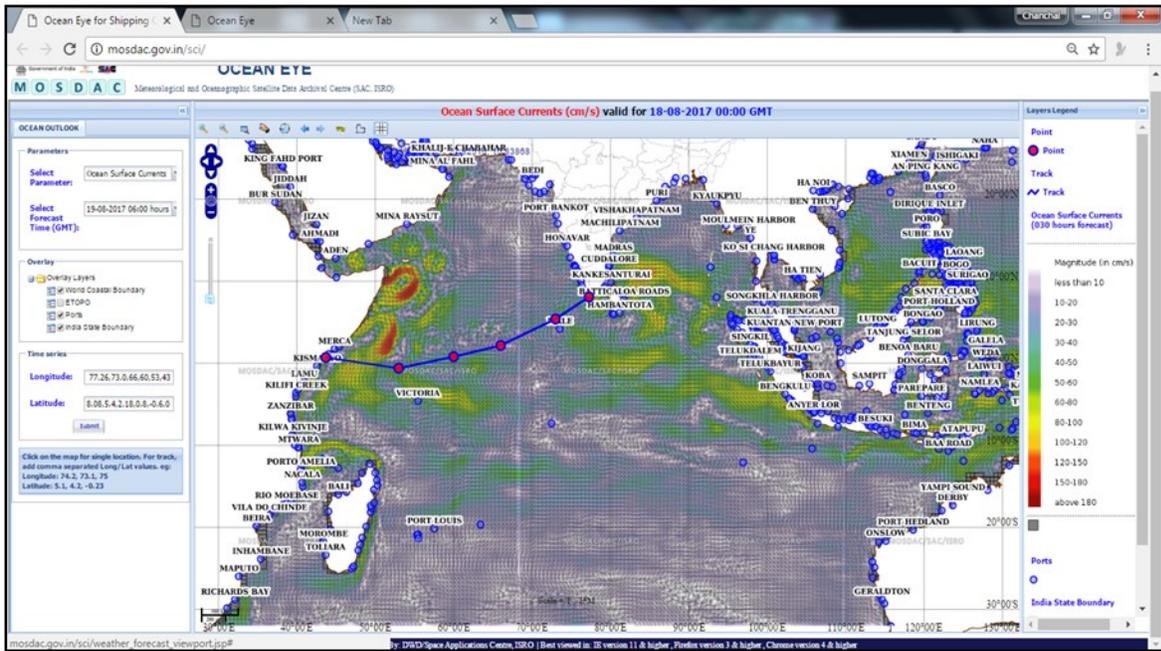


Figure 9: User Interface of Ocean Eye showing Ocean Surface Currents overlaid with user added track

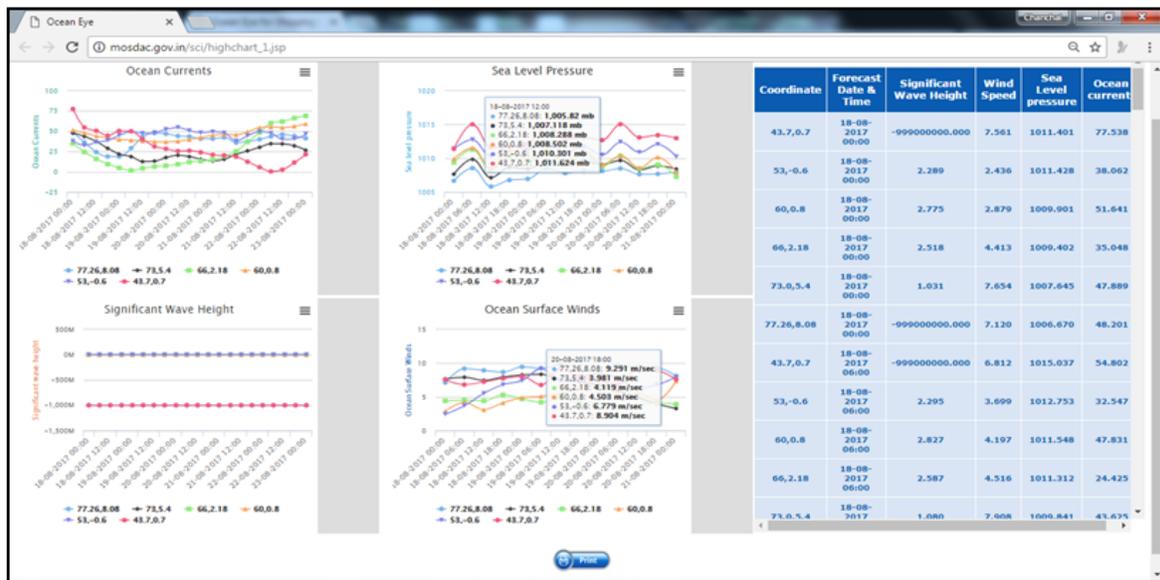


Figure 10: Reports of the ocean forecast information for different parameters along the generated track

Ocean Eye

Sea State forecast information is of importance for applications such as ship routing. Sea State information includes parameter such as ocean surface currents, sea level pressure, surface winds and wave height. 'Ocean Eye' application provides these parameter and time based visualization of the forecasted data for the above mentioned parameters on the map along with the capability to overlay user provided ship track. Ship track can be visualized over the map as a vector layer based on user's input of the locations. Reports can be generated

for the forecasted parameters of the selected track in tabular and graphical form for comparative analysis.

Conclusion and Future Perspective

MOSDAC is able to enhance its visualization and analysis capabilities by using the advance geo-spatial tools and techniques. Weather and ocean information services and satellite data visualization portals are being used for applications such as disaster monitoring and management, ship routing, tourism and agriculture. Many new data products from the upcoming satellite missions and RADAR data will also be available for visualization and analysis through these portals in the future using semantics and ontology based data and information retrieval [8]. The key areas of focus during the next few years will be 3D/4D data visualization, performance improvement for online visualization of spatiotemporal data and online data analysis.

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Mangrove Mapping in India using Remote Sensing Technique

Sugata Hazra¹, Anirban Mukhopadhyay¹, Jyoti Prakash Hati¹, Nilima Rani Chaube² and Arundhati Misra²

¹*School of Oceanographic Studies, Jadavpur University, Kolkata, West Bengal;*

²*Space Application Centre, Ahmedabad, Gujrat*

Why do we map mangroves? Mangroves are the unique halophytic, mostly evergreen forests that thrive under extreme harsh condition along the intertidal region of the coasts and estuaries braving high salinity, extreme wind and tides, high sedimentation, high temperatures and muddy anaerobic soils (Giri et al., 2011) yet offer unique ecosystem services like biodiversity conservation, carbon sequestration, protection against storm and erosion, and provisioning food fodder and fuel wood for the mankind. Distribution of mangrove forests are restricted within tropical and subtropical regions between 30°N and 30°S latitude (Giri et al., 2011), controlled by ocean currents and the 20°C isotherm of seawater in winter (Alongi, 2009). They thrive in river deltas, lagoons and estuarine complexes (Thom, 1984) as well as on shorelines and islands in sheltered coastal areas (Lugo & Snedaker, 1974). About 75% of mangroves are localised in just 15 countries within Asia accounting for the largest area under mangrove forests (42%), followed by Africa (20%), North and Central America (15%), Oceania (12%) and South America (11%). The mangroves of Sundarbans, Mekong Delta, Amazon, Madagascar, Papua New Guinea, and Southeast Asia are some of the best developed mangroves of the world. The Indo-Malaysian region accounts for 48 mangrove species (Duke et al., 1998), the highest species diversity found anywhere in the world. It is a matter of concern that we are destroying such unique resource worldwide. Around 26% of mangrove forests are degraded worldwide due to over-utilization of fuel wood and timber production (Valiela et al., 2001; Polidoro et al., 2010). Shrimp culture contributes to 38% of the comprehensive loss of mangroves (Ellison, 2008; Polidoro et al., 2010). Although biodiversity of mangroves is highest in the Indo-Malay Philippine Archipelago, it is the same region that records highest loss of mangrove area [30% reduction since 1980 (FAO, 2007)] followed by the Caribbean region, with approximately 24% loss of mangroves over the past quarter-century. Although human settlement, water pollution, and aquaculture, have affected some areas (Pagliosa, 2004; Lamparelli et al., 1997) there has been very little mangrove area loss in Brazil since 1980 (ibid). According to the present estimate, the total area of global mangroves ranges from 110,000 to 240,000 km² (Wilkie and Fortune, 2003; FAO, 2007; Giri et al., 2011). Globally mangrove forests have been reduced to more than half of what it was before 1960s (Spalding et al., 1997; Spiers, 1999) and much of the vestiges are in a degraded condition (Giri et al., 2011). This necessitates accurate mapping of mangrove forests, its change in area, health and species composition, so that appropriate measures can be taken up to recover the loss and secure the forests for the generations to come. Such views are strengthened by Ramsar Convention on Wetlands or the Kyoto protocol which urge for protection and conservation measures to prevent further loss of mangrove ecosystem.

Mangroves in India

India, the world's third richest country in term of mangrove species diversity, supports 46 true mangrove species which belongs to 14 families and 22 genera (Ragavan and Mandal, 2018). The country has 4921 km² mangrove forest (3.3% of global mangrove vegetation) which spreads over nine coastal states and four union territories (FSI, 2017) (Figure 1).

The east coast mangroves of India are deltaic in nature, whereas in the west coast estuarine and backwater mangroves are found. Mangroves of Andaman and Nicobar Islands are classified as insular mangroves



Figure 1: Mangrove locations of India

(Ragavan et al., 2016). The east coast, west coast and insular mangroves have 58%, 29% and 13% share of the total mangrove vegetation respectively (ibid). The mangrove forest in the country is under stress due to natural (i.e. climate change, coastal erosion, salinity increase etc.) and anthropogenic activities which lead to the change in mangrove area coverage and species assemblage (Ragavan and Mandal, 2018). Some endangered species are on the verge of extirpation regionally (i.e. *Heritiera littoralis*, *Bruguiera cylindrica*, *Sonneratia caseolaris*, *Xylocarpus granatum*, etc. in the west coast) (Chavan, 2013; Ragavan and Mandal, 2018; Upadhyay et al., 2002). Despite this stress, the mangrove area in India has increased in the last decade (Ragavan and Mandal, 2018) which is a result of rigorous mangrove plantation by the Forest Survey of India (FSI). According to FSI, during 1987 to 2017, the mangrove forest area in the country has increased 875 km² of which 181 km² has increased from 2015 to 2017 only (FSI, 2017).

Mapping of Mangroves

It is difficult if not impossible to map the extent, composition and changes in mangroves using conventional field techniques. Intertidal habitat of mangroves with varying degree of submergence, inaccessibility often aggravated by wild life (Tiger in Sundarbans or Crocodile in Bhitarkanika) restricts such conventional approaches. With the advent of airborne and space borne remote sensing, both spatial and temporal quality of mapping has increased manifold. Continuous improvement of satellite and sensors enhancing spatial and spectral resolutions contributed to better understanding of species composition, health or changes in the mangrove ecosystem. Keeping pace with advancement of sensors and satellite data products, different methodologies for information extraction, classification and mapping techniques evolved rapidly. New possibilities for ecosystem based assessment, species discrimination in mixed assemblage, productivity or biomass estimation, providing management support to fisheries, forestry or coastal engineering emerged in tandem.

Untawale et al. (1982) demonstrated the distribution of mangroves in Goa using aerial photos. Aerial photographs were particularly useful for mapping narrow stretches of mangroves. Temporal analysis of them provides information about cleared or newly forested areas.

Roy (1989) from multispectral images of MKF-6 camera of Salyut 7 space station classified threatened and newly generated mangroves of Bhitarkanika in Odisha by visual interpretation techniques. With the availability of medium resolution multispectral LISS-III data from Indian Remote Sensing Satellite 1C and ID, mangrove mapping got a boost in India. At every region (Figure 2), mangrove forests were mapped with considerable details.

Using onscreen visual interpretation, unsupervised and supervised classification of IRS 1D data, Nandy et al. (2011) could identify four mangroves and eight non mangrove classes in Sundarbans. At Bhitarkanika, with the help of field survey data (2004-2006) and remote sensing data (IRS P6 LISS III), mangrove community zonation map was produced by Pattanaik et al. (2008). The ISODATA clustering algorithm together with unsupervised classification yielded a primary zonation map of mangroves. Then the maximum likelihood classifier algorithm was implemented using ground verification data to finalize the mangrove community zonation map. From the IRS 1C LISS III data, land use map of mangrove forest and surroundings were generated for Coringa Wildlife Sanctuary (Satyanarayana et al., 2001). Between 1986 and 2001, the dynamical changes in Godavari estuary mangroves were detected by Ramasubramanian et al. (2006). Changes in the spatial distribution of mangroves in Godavari delta with special emphasis on Coringa Wildlife Sanctuary were also accomplished (Reddy & Roy, 2008). During the first decade of the study period of 30 years, approximately 24.6 km² mangrove area was lost. After the restoration programme, an increase of 7.6 km² of mangrove from 1977 to 2005 was also observed in Coringa Wildlife Sanctuary. Effect of mangrove restoration in Pichamvaram wetlands of Tamilnadu was demonstrated using temporal remote sensing data (Selvam et al., 2003). From the analysis of 1986 LANDSAT TM data and 2002 LISS III data, 90% increase in mangrove canopy cover was observed. At Goa, Land use land cover change, mangrove mapping and classification over Terekhol, Chapora, Mandovi, Zuary, Sal, Talpona, Galgibag estuary and Cumbarjua canal was performed using LISS II and LISS III data, to analyze the changes from 1990 to 2001 (Singh et al., 2004). An increase of 9.02 in the total mangrove vegetation area was found between the years 1994 and 2001. Overall increase in mangrove forest from 14.61 km² was observed as a result of protection and regeneration programme.

Shah et al., (2005) mapped the mangroves of Marine National Park, Gujarat which constitutes six mangrove species (11,000 ha) using LISS III data. Mangroves were classified in six different classes by supervised classification with 92% accuracy. Bhatt et al. (2009) mapped the density and diversity of mangrove of Purna estuary, South Gujarat using LISS III data of the year 2003 and extensive field work for two years. 387 ha of mostly dense mangrove forests were found to be generated in the estuarine area, previously occupied by terrestrial vegetation only. With the help of maximum likelihood classifier, seven mangrove species, nine mangrove associates and six species of salt marsh could be identified there.

In Andamans, the mega earthquake and subsequent tsunami in 2004 was observed to have a devastating impact on mangroves of Nicobar (with 70% loss) and south Andaman islands (Nehru & Balasubramanian, 2016). However, after 5 years of the tsunami, regeneration of several mangrove species was confirmed (Sachithanandam et al., 2014) although south Andaman experienced more damage than north Andaman. Among the 36 islands in Lakshadweep, mangroves could only be found in Minicoy Island (Ragavan et al., 2016; Reddy et al., 1997). From Lakshadweep, 8 species were reported which belong to 5 genera and 3 families (Mandal and Naskar, 2008). In all such efforts, separation of mangroves from non mangroves and discrimination between different genus/ species level remained problematic. Through different applications with medium resolution multispectral satellite data, supervised maximum likelihood classifier (MLC) found to be most effective in classifying mangroves. Incorporation bands derived from Principal component analysis of Landsat bands, classification accuracy was reported to increase manifold. Application of different vegetation indexes like NDVI in the pre-classification stage could separate mangroves from non mangroves with considerable accuracy. However, in case of mixed mangrove assemblages like Sundarbans, where the size of the single species assemblage seldom exceeds the pixel size of LISS III image, the

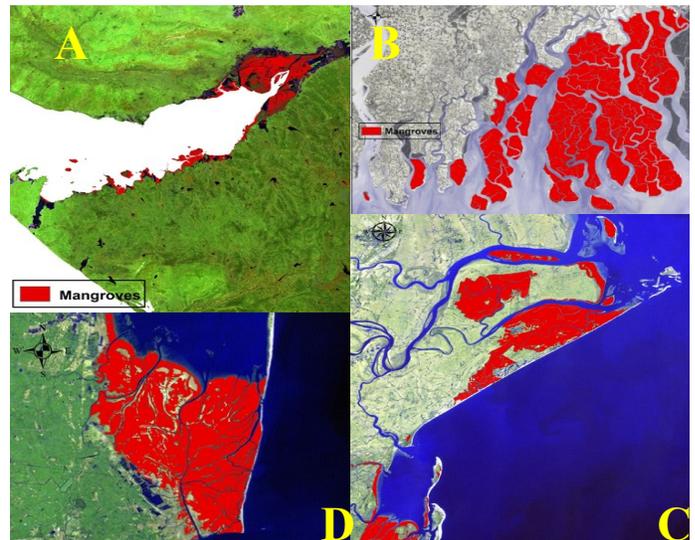


Figure 2: Mangrove covers of (A) Kutch, (B) Sundarbans, (C) Kakinada and (D) Bhitarkanika

classification accuracy remained ambiguous. Recently Gupta et al. (2018) developed an improved index which incorporates Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) to develop a new index called Combined Mangrove Recognition Index (CMRI) to discriminate mangroves from non mangroves. This index was successfully applied to map mangroves in Sundarbans, Bhitarkanika and Andamans with better accuracy than indexes like NDVI.

Till date, very few attempts of characterizing the Indian mangrove biomass by means of remote sensing tools are reported. Patil et al. (2015) estimated the carbon stocks of *Avicennia marina* stands in the Thane creek of Mumbai by combining ground based sampling and remote sensing techniques. Normalized differential vegetation index (NDVI), Light use efficiency (LUE) and Photo-synthetically Active Radiation (PAR) were estimated from remotely sensed imageries. Landsat Thematic Mapper (TM) images were used by them. They also computed the gross primary productivity of the mangrove stands from the product of LUE and PAR. Earlier Manna et al. (2014) quantified the biomass of a five year old *Avicennia marina* plantation situated in Indian Sundarbans using LISS IV satellite data. Vegetation indices, namely normalized difference vegetation index (NDVI), optimized soil adjusted vegetation index (OSAVI), and transformed difference vegetation index (TDVI) were computed for biomass estimation.

In India, because of their prohibitive costs, multispectral data with high spatial resolution could not be tested much for mangrove mapping. Though PAN sharpened false colour composite of IKONOS data can supply quality information capable of discrimination between species level in high spatial resolution through visual interpretation only, it demands rigorous field information which restricts its application to mixed mangroves of comparatively inaccessible terrains.

New scope of mangrove mapping came with availability of space borne hyperspectral data in 400-2500 nm range with 10 nm band width and spatial resolution of 30 meter. Several specialised application like species identification, leaf water content and chemistry, environmental changes and stress detection in mangrove became possible.

Padma and Sanjeevi (2014) integrated the two approaches of Spectral Angle Mapper (SAM) and Jeffries-Matusita (JM) distance to make a novel hyperspectral matching algorithm (JM-SAM) for distinguishing mangrove community. They have implemented this algorithm for mapping Pichamvaram, Muthupet and Bhitarkanika mangrove community and for every location JM-SAM achieved higher classification accuracy than SAM and JM separately.

In Pichavaram Wetland, mapping of different mangrove species using EO-1 Hyperion data (2003) was accomplished (Salghuna & Pillutla, 2017) with the help of reference spectra obtained from literature. After several processing using Maximum Noise Fraction (MNF) and Pixel Purity Index (PPI), n-dimensional visualisation and end member extraction, the final spectra was utilized in SVM classification and Spectral Feature Fitting (SFF) for identification and spatial discrimination of mangroves using Linear Spectral Unmixing (LSU) approach.

However, the medium range spatial resolution of space borne hyper-spectral data and availability of location and species specific spectral signatures remained constraints for such studies in a remote terrain with mixed mangroves.

The next possible breakthrough in mangrove mapping comes with availability of AVIRIS-NG airborne hyper-spectral imaging of mangrove terrains of India through the initiative of SAC and NASA. Hyper-spectral data with a large number of very narrow bands (<10 nm) in the 380–2500 nm range and high spatial resolution enables high quality detailed mapping of mangroves. However it also comes with new challenges of time consuming image processing of large number of bands.

Space borne and airborne RADAR data are least explored for mangroves but useful by virtue of their all-weather character. Useful information like mangrove extent, structural parameters, inundation after storm surges, deforestation and health status and biomass can be derived in conjunction with high resolution optical data. However, in India, investigations with RADAR data for mangroves have been initiated

recently. Efficacy of RISAT 1 SAR data fused with LISS-IV optical data was tested on mangroves of Jamnagar (Kumar et al., 2017), Gujarat and found to be useful in separating mangroves and other land cover classes with considerable accuracy. Earlier, Cornforth et al (2013) studied the impact of cyclone Sidr and coastal erosion on mangroves of Sundarbans (India, Bangladesh) using L band data of ALOS PALSAR data. The analysis reported degradation of health of mangroves after the high intensity event and continuing coastal retreat in forested islands.

In recent time, importance of mangroves has been reaffirmed from studies on Climate Change and associated impact. Mapping of mangroves, change detection and modelling for future prediction of species assemblages are of immense importance for climate change adaptation.

In one such study (Mukhopadhyay et al., 2018) it was observed that with the changing climate and progressive aquatic salinization, mangrove migration is inevitable which will affect the ecosystem as a whole and will have a potential impact on their ecosystem services. Salt tolerant mangrove species may show dominance in the near future due to lack of freshwater in some regions of Sundarbans by 2050.

Payo et al., (2016) observed potential impacts of climate change like sea level rise on mangroves of Sundarbans (Bangladesh). Using Sea Level Affecting Marshes Model (SLAMM) it was predicted that about 81 to 1393 km² of mangrove area of Bangladesh can be submerged under different sea level rise scenarios within 2100.

In future, such studies will be of immense help to understand the vulnerability and resilience of mangroves and their ecosystem services in India in the face of climate change and would provide the required impetus for improved mapping techniques using optical, hyper-spectral, SAR and wherever possible, LIDAR data.

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News and Snippets

ISRO has set deadline of December 2021 for launch of the human spaceflight programme

Source: epaperbeta.timesofindia.com (30/08/2018)

Indian Space Research Organisation (ISRO) Chairman Sivan K, on Wednesday said that the space agency has set itself a target of December 2021 for the launch of the human spaceflight programme (HSP), which is more ambitious than the 2022 deadline set by Prime Minister Narendra Modi. Before this, ISRO will have to carry out a series of critical tests, including two unmanned missions—in December 2020 and June 2021—inflight abort test of the crew module among others. The agency will also have to develop other technologies like crew support systems, the service module and even the orbital module for the project. Conceding to these, Sivan also said that no decision pertaining to the number of astronauts (Gaganauts), or the number of days they will spend in space had been taken by the space agency so far. Three Indians who will be chosen for the country's first human space flight programme will reach space within 16 minutes of the launch from the Sriharikota spaceport. They will spend five to seven days in the low-earth orbit before the crew module makes a splashdown in the Arabian Sea off the Gujarat coast, ISRO Chairman K Sivan said.



India using remote-sensing tech developed by NASA to find rare earth elements

Source: <https://www.hindustantimes.com> (21/09/2018)

An advanced remote-sensing technology developed by US space agency NASA to map minerals on the moon and Mars is being used in India for the first time to prospect for gold, diamonds, platinum and rare earth elements. “In its pursuit for minerals, the GSI is going to use ultra-modern remote sensing technology to find lead, zinc, copper, gold, diamond and platinum, among others. This will be used for the first time in India,” Dinesh Gupta, director general, Geological Survey of India (GSI). “Rare earth metals such as lanthanum, cerium, holmium and lutetium among others are a group of 17 elements, which have chemical similarities.



Called Advanced Visible Infra-Red Imaging Spectrometer-Next Generation (AVIRIS-NG), the sensor-based technology that will now be used in India has been proved effective for mapping surface mineralogy on earth, the moon and Mars. “AVIRIS-NG is being used by Australia, USA, Canada and South Africa,” said Gupta. The AVIRIS-NG sensor was mounted on an ISRO aircraft to get hyperspectral images of 14 mineralised blocks across India, including in Jhagadia in Gujarat, Udaipur in Rajasthan, Chhatarpur in Madhya Pradesh and Kuhi-Khobna in Maharashtra, among others. GSI signed a MoU with the National Remote Sensing Centre (NRSC), a wing of the Indian Space Research Organization (ISRO), on September 5, to analyse data to trace the minerals from the hyperspectral images taken by ISRO in three phases – October to November 2015, January to February 2016, and April to May 2018. “Over the next three years, scientists from the GSI and NRSC-ISRO will analyse the airborne hyper-spectral data to look for surface signatures of mineralization in those 14 promising areas,” he said.

Environment ministry setting up expert group to look at air pollution warning system

Source: <https://www.hindustantimes.com> (25/06/2018)

The ministry is gearing up for a spike in air pollution levels during winters that impacts Delhi-NCR and the northern plains. The environment ministry is gearing up for a spike in air pollution levels during winters that impacts Delhi-NCR and northern plains. The environment ministry will be setting up an expert group to provide recommendations about an early warning system for air pollution, an official said. The ministry of earth sciences through its SAFAR (System of Air Quality and Weather Forecasting and Research) programme does provide air quality forecasts for four cities: Delhi, Mumbai, Pune and Ahmedabad. The ministry, through the Central Pollution Control Board, the apex pollution regulator, has already started work on using satellite data from Indian Space Research Organisation (ISRO) to estimate ground-level PM 2.5 concentrations (particulate matter that is 2.5 microns or less in diameter), as reported by HT. The ministry is gearing up for a spike in air pollution levels during winters that impacts Delhi-NCR and the northern plains. In November 2017, barring three days, air quality in Delhi-NCR was in the “very poor” or “severe” categories throughout. To tackle winter pollution, the department of science and technology (DST) within the ministry of science and technology is assessing technological solutions so that pilots can be launched in the coming three months. The meeting, chaired by environment secretary CK Mishra, had representatives from ISRO’s Space Applications Centre, DST, IIT Delhi, IIT Mumbai, National Environmental Engineering Research Institute, and Indian Meteorological Department.



ISRO maps out 12 eco-corridors to link sloth bear habitats

Source: <http://dnai.in> (19/07/2018)

These corridors connect 5 major protected areas & unprotected bear habitats A study on sloth bears in Gujarat, funded by the Indian Space Research Organisation (ISRO),



has identified 12 ecological corridors that will help connect fragmented habitats of the animal in the state. These corridors connect five major protected areas and unprotected bear habitats. ISRO funded the project and this is the first instance of application of space science geospatial technology being used for wildlife conservation in Gujarat. The corridors, if developed, can lead to the bears moving towards villages, which can be a potential conflict point. Potential conflict zones have also been identified, so that the forest department can take preemptive action. The project was jointly carried out by a team of Nishith Dharaiya, a member of the state wildlife board and associate professor of Hemchandracharya

North Gujarat University, and CP Singh, a scientist with Space Application Centre. The research, titled 'Habitat Suitability & Corridor Analysis for Sloth Bear in Gujarat using Remote Sensing and Ecological Modelling', found that 1.45 per cent of the forest area, where sloth bears are found, can be developed as potential corridors. It should be noted that 20 per cent of the forest land, out of the total forest cover present in Gujarat, is designated as sloth bear landscape. "Given the fact that sloth bears continue to be in the vulnerable category, it is imperative that we manage the isolated habitats of the animals, which in Gujarat remain highly fragmented," said Dharaiya, who chairs the IUCN sloth bear expert team.

Geospatial tech to monitor water, soil and air quality

Source: <http://www.tribuneindia.com> (18/07/2018)

The Punjab Remote Sensing Centre (PRSC), Ludhiana, has signed a Memorandum of Understanding (MoU) with the Central University (CU), Bathinda, for use of geospatial technology in natural resource management, including monitoring of water, soil and air quality. The scope of MoU also involves sharing of expertise, domain knowledge and available facilities, research outcomes and patents of results at national and international platforms and exchange of scientists for research programmes. The expertise of the PRSC in geospatial technology and modeling and the CU in environment and chemical technologies will be optimally used for monitoring of air, soil and water quality in Punjab and India.

In a first, 5 ISRO satellites used to rescue marooned in Kerala

Source: <https://www.dailypioneer.com> (27/08/2018)

The Centre and State Government's disaster management teams have managed to rescue thousands of marooned victims of Kerala flood with the help of five earth-based satellites of the Indian Space Research Organisation (ISRO).



The satellites are Resourcesat-2, Oceansat-2, INSAT 3DR, Cartosat-2 and Cartosat-2A. This is the first time that the Government agencies have used satellite technology to rescue victims during floods in the country. Top sources said the satellites were consistently providing information and images on real-time weather situations, weather forecasts, regional conditions and other crucial updates on the flooded areas of the State to the control

centre. The data and images provided by the satellites helped the agencies and disaster management teams to stay consistently and carry out rescue operations effectively in every corner of the State. "Each satellite is assigned to provide data on different parameters that will help analyse the situation better. All these data are relayed to the Decision Support Centre (DSC) at the National Remote Sensing Centre (NRSC), ISRO, Hyderabad, where necessary analyses and report generation are done.

Society Activities –2017-2018

Indian Society of Geomatics –Ahmedabad Chapter (ISG-AC) Activities

Dr. C. P. Singh

(Secretary, ISG-AC: Term 2017-20)

July 22, 2017

Outreach Programme at M.N. SCIENCE College, Patan

As part of outreach activity, the programme entitled ‘**Geomatics: An instructional tool**’ was conducted at Patan on July 22, 2017, which involved around 70 college students. On this occasion, lectures were delivered by Dr. Prakash Chauhan, Dr. Alpana Shukla and Dr. C.P. Singh. For the benefit of students, the lectures were especially delivered in Hindi and Gujrati language. Students were highly benefitted by the lectures and interactions covering future avenues in the field of Geomatics education.



August 12, 2017

Popular Lecture at MG Science Institute, Ahmedabad

On the occasion of Dr Vikram Sarabhai’s birthday, eminent Space Scientist Prof. Narendra Bhandari was invited for a popular talk on “Falling Stones & Secrets of the Universe” on August 12, 2017. The event arranged at GIDC Bhavan, was well-attended by professionals and more than 150 students. Dr Bhandari shared his research experiences, which was highly motivational for the youngsters .



September 02, 2017

National Remote Sensing (NRS) Day Celebration in CEPT University, Ahmedabad

Remote sensing day was celebrated at CEPT University on Sept 2, 2017. The event received overwhelming response from nearly 250 Under Graduate & Post Graduate students from Gujarat University, MG Science Institute and CEPT University. A full day event included activities like Origami, quiz and visit to VSSE. Dr. Raj Kumar, Deputy Director, EPSA, SAC, ISRO gave valedictory remarks followed by prize distribution to the winners.



September 09, 2017

World Ozone Day Celebration– at GMIS, Ahmedabad

Every year, 3rd Saturday in the month of September is globally celebrated as World Ozone day. However, the program was organised by ISG-AC at Global Mission International School at Sanskar Dham (Bopal-Godhavi road) on September 09, 2017 due to their academic schedule. Dr Mehul Pandya (SAC) was invited to deliver a talk on “Role of Space Science in Ozone and Earth Observation. It was attended by 450 students from class 6 to 12. Many ISG-AC members also participated and answered to the queries of students.



September 16, 2017

One-day workshop on “Introduction to Remote Sensing and GIS for Civil Engineering Applications” at L.D. College of Engineering, Ahmedabad

One-day workshop on “Introduction to Remote Sensing and GIS for Civil Engineering Applications” was organised in collaboration with L.D. College of Engineering and IEEE Geoscience and Remote Sensing Society Gujarat Chapter during September 16, 2017 with various lectures by eminent speakers from PRL and ISRO. The lectures covered, Basics of remote sensing and Applications, Basics of microwave remote sensing and applications, Basics of GIS and applications, Satellite based surveying techniques and Applications of Satellite data in Hydrological Modeling. Around 50 professionals, mostly faculty and research scholars from various institutions in Gujarat participated in the Workshop. Participation certificates were distributed to all the participants at the end of the workshop. The workshop was highly appreciated by the participants. The participants expressed their interest for similar training workshops in future involving more applications using the technology.



September 22, 2017

National Seminar at Gujarat University, Ahmedabad

One-day seminar on Applications of Geospatial Technology for Sustainable Development was organised in collaboration with Department of Geography, Geology and Geoinformatics of Gujarat University during September 22, 2017. More than 150 participants from various universities and colleges gathered for the seminar. The seminar provided an excellent platform and opportunity to the students, researchers, practitioners and entrepreneurs to update their knowledge on Geospatial Technology, research ideas and Applications of such technology in achieving sustainable development goals.



November 10, 2017

Popular Lecture on “Semantics Enabled Framework for Mining Large Remote Sensing Data Archives” at SAC, Ahmedabad

A Popular Lecture on “Semantics Enabled Framework for Mining Large Remote Sensing Data Archives” by Dr. Surya Durbha, Associate Professor, CSRE, IIT Bombay, Powai, Mumbai was organised by ISG-AC during November 10, 2017 at SAC and it was well received by ISG members and scientists at SAC. It was attended by around 80 participants.



November 11, 2017

GIS Day and GIS Week Celebration

GIS Day was organised by Geomatics Programme, Faculty of Technology, CEPT University, Ahmedabad in Collaboration with Indian Society of Geomatics, Ahmedabad Chapter during November 11, 2017, followed by GIS Week (till November 15, 2017) during which series of expert lectures were organised. Events like story maps, spatial thinker, memory game, treasure hunt, geo quiz, debate, puzzle (jigsaw), pin it, find me if you can, map design contest and 3D map modeling were also organised. It was 10th Anniversary of GIS Day at CEPT University as they have been celebrating GIS Day since 2007. A webpage (<http://cept.ac.in/events/international-gis-day>) was made operational for this event.

Dr. R. Nandakumar Ex-Senior Scientist, SAC, ISRO and active ISG member contributed in the GIS Day celebration along with Prof. Anjana Vyas, Adjunct Professor, Faculty of Technology & Executive Director, CEPT and Ms. Shubhangi Mane, Senior Technical support executive, ESRI India. Dr Nandakumar delivered a lecture on “Software Quality with Geospatial Examples”. Ms. Mane delivered her talk on “New trends in GIS”. More than 7 colleges and 2 schools participated, making a total of 95 participants, of which 75 were students, 15 alumni of CEPT University and 5 researchers. These include H K Arts College, Adani University,



Parul College, Anant University, EDI, RSAC (U.P.), Gujarat University, Udgam and Anand Niketan schools respectively.

Poster competition based on the basic understanding of GIS were the participants were given freedom to draw and explain their understanding of GIS. In this competition both school and college students made hand drawn posters explaining their view of GIS. In total 40 students took part in the competition. Debate competition participants were divided in to teams and were given topics on which they speak for or against the topic. For this each team made of four students from which two spoke for and two spoke against the topics given on current trends in GIS like “GIS: New Science or Old Wine”. four teams participated in the event. A period of five minutes was given to think upon the topic. In total five minutes was given to each team to speak for and

against the topic. The medium of communication was Hindi, English or Gujarati. The participants were judged on the choice of points, confidence, pronunciation & enunciation, grammar, choice of words and body language.

In the treasure hunt game, the goal was to educate the students about GPS and space. GIS based treasure was planned in which the participants were exposed to the GPS technology to find the treasure hidden in the CEPT campus with the help of geographical clues. Four teams participated in the event with 6 participants in each team having both school and college students. One of the team reached the treasure by cracking all the hints.

Pictionary was also organised which is a word game wherein the participants are grouped in the group of two. One of the participant is given a word related to Geospatial Technology which had to be explained to the other participant of the team by drawing it to the board within 15 seconds. The game was played in two levels; easy, and hard. In total 14 teams participated. The words chosen for the event were all related to remote sensing, space and earth sciences. Teams were judged based on the time individually. Students Ideas and Innovations on implementing GIS in SMART City applications were also presented. The winners of poster and debate competition were given trophies and certificates toward end of the day. Prof Anjana Vyas, Prof. Bindi Dave, and Prof. Darshana Rawal from Geomatics Group handed over the trophies and certificate to winning participants. The event was also featured in local newspaper.

December 28, 2017

Popular lecture at GIDC Bhawan, Ahmedabad

ISG-AC organised a popular lecture on "Exploiting Petabyte Scale EO Data: A Data Cube Approach" by **Shri T. T. Medhavy, Director EO Science at Geoscience Australia** during December 28, 2017 at GIDC Bhawan, Besides M.G. Sci. Institute, Ahmedabad which was well received by the students and ISG-AC members. Around 80 students took part in this event.



December 26-31, 2017

Teachers' Training Programs at M.G. Science Institute

Dr. Alpana Shukla, Head, Botany Department, M. G. Science Institute and Vice-Chairperson, ISG-AC, successfully organized TWO week-long Teachers' Training Programs, in December 2017 and during April, 2018. These trainings were sponsored by ISRO Headquarters and supported by SAC-ISRO as well as ISG-AC. Twenty teachers took part in the first one and 21 teachers from Physics, Botany, Environmental Science, etc., representing various universities of Gujarat like Gujarat University, Hemchandracharya North Gujarat University, Veer Narmad South Gujarat University and Kutch University, participated in the second training. The trainings included theoretical as well as practical aspects of basics of remote sensing and GIS. The Program content included fundamentals of remote

sensing, applications of space technology in recent times, especially in Ecosystem management, visual interpretation of satellite images, digital image processing, basics of GIS and its applications in various domains, applications of GPS and opportunities in Geomatics and geoinformatics. Hands on training sessions were conducted for participants, which included introduction to web portals like BHUVAN and VEDAS, satellite data downloading, opening images of various formats in advance software like ENVI and QGIS, classification of various features by supervised and unsupervised methods and overlying shape files and boundaries on the image files. All the theory and hands on training sessions were carried out by expert scientists from ISG, SAC, MGScience and senior most faculties from different institutes and research fellows. Visit to VSSE was the highlight of these training programs.

February 3-4, 2018

Educational Excursion at Mundra Port

An environmental educational excursion to Mundra Port was jointly organised by ISG-AC and IMSA for its members during 03 – 04 February, 2018 (Saturday-Sunday). Total 72 members from ISG-AC and IMSA participated. Upon reaching Ahmedabad to Mundra port (351 km) members were received and felicitated by Adani officials and Video show on Adani group was followed by visit to Adani Port & SEZ, Adani Wilmar Ltd., Shantinath Mahadev Aarti and cultural programme / activities by members and their family members.

Next day visit to West Port and Adani Power Ltd. was conducted and thereafter departed by Bus for Ahmedabad. The educational excursion was highly appreciated by all the members. Members were presented with a memoir (wooden key ring) having logo of both the society.



June 05, 2018

World Environment Day (WED) Lecture at SAC, Ahmedabad

Indian Society of Geomatics – Ahmedabad Chapter in collaboration with Indian Society of Remote Sensing – Ahmedabad Chapter organised a lecture on the occasion of World Environment Day (WED) – 5 June, 2018. Dr. H.G. Sadhu, Scientist, MD (Gen Med), AFIH from ICMR -National Institute of Occupational Health, Ahmedabad delivered his lecture on “Challenges for Occupational and Environmental Health in India”. The lecture was organised at Vikram Hall, Space Applications Centre, Ahmedabad on 5th June, 2018 (15:30 hrs) and around 80 members attended the lecture.



June 24, 2018

19th Annual General Body Meeting (AGM) of ISG-AC

The 19th AGM was held on July 24, 2018 at SAC Ahmedabad. More than 46 members attended the meeting & actively participated in the deliberations. AGM started with welcome remarks by Shri N. S. Mehta, Chairman, ISG-AC. He mentioned that year 2017-18 was very eventful and ISG-AC could conduct around 12 activities in less than one-year time. He also appreciated the association of M. G. Science Institute, CEPT University and NIRMA University with ISG-AC. After the opening remarks by the Chairman, items as per the Agenda were taken up. Dr CP Singh, Secretary, ISG – AC presented the minutes of the meeting (MoM) of 18th AGM. House discussed the MoM and after certain clarifications the house passed the minutes by voice-vote. Secretary, ISG – AC presented annual report of activities carried out during the year 2017-18. It was appreciated by all members and passed by voice - vote. Future plan of activities including updates on preparations of National Symposium – 2018 was also presented. Dr Nikhil Lele, Treasurer, ISG-AC presented audited account report and house passed the audited account report by voice-vote. House also agreed on to continue with the current CA for 2018-19. Various activities for coming year were proposed by members and note of it was made. Vote of thanks was proposed by Vice-Chairperson, Dr. Alpana Shukla. This was followed by high tea and further interactions.



August 11, 2018

Popular Lecture on the eve of Vikram Sarabhai Birth anniversary and to celebrate International Youth Day

On the eve of birth anniversary of Dr. Vikram Sarabhai “Father of Space Science in India” & to mark the United Nations International Youth Day 2018 with the theme “Safe Spaces for Youth” Indian Society of Geomatics – Ahmedabad Chapter with Indian Society of Remote Sensing – Ahmedabad Chapter & M.G. Science Institute, Ahmedabad organised a popular lecture on “Role of Youth towards a Sustainable Future” by Shri Kartikeya V. Sarabhai (Founder Director of Centre for Environment Education (CEE)) on August 11, 2018 (Saturday) in M. G. Science Institute, Ahmedabad. The program also included welcome address by Dr B.K. Jain, Principal, MG Sci. Inst. followed by brief on ISG society and its activities



by Shri NS Mehta, Chairman, ISG-AC, brief on ISRS by Dr Raj Kumar, Chairman, ISRS-AC and brief on International Youth Day & Introduction of the speaker by Dr C.P. Singh The lecture was well received by around 200 students and ISG members.

August 12, 2018

NRS Day Celebration

National Remote Sensing Day (Birth Day of Prof. Vikram Sarabhai) on August 12, 2018 was organised Jointly by ISG-AC, ISRS-AC and VSSE (SAC, ISRO) at Vikram Sarabhai Space Exhibition. The program included events like, garlanding of bust of Vikram Sarabhai to commemorate his 99th Birth-Day, Drawing and Painting Competition, Debate Competition, Visit to Exhibition and interaction with Scientists/Engineers. Total 59 students from 17 schools participated in these competitions.



August 16-17, 2018

Hands-on workshop on “Free and Open Source Geospatial (FOSS4G) Tools” at SAFRONY

A Hands-on workshop on “Free and Open Source Geospatial (FOSS4G) Tools” was organised with technical support of ISG-AC during August 16th-17th, 2018 at Saffrony Institute of Technology, Mehsana, Gujarat. Various lectures were delivered by ISG-AC members like, Remote sensing and its applications by Shri. R. P. Dubey, new Geospatial Applications using FOSS4G for the Entrepreneur in You by Dr. R. Nandakumar, Geomatics and careers options in Geomatics field by Dr. Alpana Shukla, Global Navigation Satellite System Understanding Components of GPS and IRNSS by Dr. Parul Patel. Around 50 students were benefitted from this program.



September 15, 2018

Outreach program at Divan Ballu Bhai School

An outreach program was conducted for students of class 10 to 12 with their faculty in Divan Ballu Bhai School, Kankaria, Ahmedabad. Lecture on Geomatics and its Applications was delivered by Dr CP Singh followed by Lecture on Career guidance in the field of Geomatics by Dr Alpna Shukla and Interaction with students by Dr Mehul Pandya and Dr PS Thakker. Around 150 students attended the program.



November 03, 2018

GIS Day celebration

International GIS day was celebrated at CEPT University with the support of ISG-AC. Lectures by Dr AS Rajawat and Dr RP Singh and various competitions related to GIS technologies were conducted during the event.

A poster for International GIS Day at CEPT University. The text reads: "CEPT UNIVERSITY INTERNATIONAL GIS DAY 3RD NOVEMBER' 2018". Below this is a quote: "The application of GIS is limited only by the imagination of those who use it." -Jack Dangermond. Underneath the quote is a list of "EVENTS": "EXPERT LECTURES", "THEMATIC ACTIVITY", "TREASURE HUNT", "DEBATE", and "QUIZ". At the bottom of the poster is a graphic of a globe with a network of lines connecting various points on its surface.

CEPT UNIVERSITY **INTERNATIONAL GIS DAY**
3RD NOVEMBER' 2018

“ The application of GIS is limited only by the imagination of those who use it. ”
-Jack Dangermond

EVENTS
EXPERT LECTURES
THEMATIC ACTIVITY
TREASURE HUNT
DEBATE
QUIZ

Indian Society of Geomatics –Ludhiana Chapter Activities

Dr. Anil Sood
(Secretary)

November 15, 2017

International GIS Day

International GIS day was celebrated at Punjab Remote Sensing Centre, Ludhiana, organized by Indian Society of Geomatics-Ludhiana Chapter & Punjab Remote Sensing Centre with the aim to expose the school Children to GIS related activities through fun filled games, skits, quiz, lectures etc. In all Ten schools and 90 research scholars attended the event. A Lecture on “GIS in Day to Day Life” was Delivered by Mr. C.M. Adhikari, ESRI India Ltd.

February 21-23, 2018

National Conference on Role of Geospatial Technologies to Bridge the Rural and Urban Divide

The conference was organized in collaboration with Punjab Remote Sensing Centre, Ludhiana (21st Feb-Tutorials; 22nd & 23rd Feb-Conference) with the objectives to sensitize the researchers, academicians planners and about the role of geospatial technologies in day to day life and to provide a platform to share their respective knowledge expertise and experiences in geospatial sciences. Around 20 participant across the Country attended the Pre Conference tutorials where lectures were delivered by Scientist from ISRO and PRSC. Participants were also exposed to the Geospatial Technologies through Hands on practise. Total 300 participants (including invitee, dignitaries, experts, guests etc.) attended the conference. The dignitaries present at the dice at Inaugural ceremony were, Chief Guest of the Event S. Navjot Singh Sidhu, Hon’ble Cabinet Minister, Local Govt., Tourism & Cultural Affairs and Archives & Museum, Govt. of Punjab; Guest of Honour Dr. A. Senthil Kumar, Director IIRS, Dehradun; Special Guest of Honour Dr. Sandeep Tripathi (IFS), Principal Chief Conservator of Forest (Wild Life) cum CEO, ORSAC, Bhubaneswar; Presidential Address Dr. Shasikant A. Sharma, Scientist SG, SAC on Behalf of President ISG (Dr. Tapan Misra), Director SAC, Ahmedabad; Chairman ISG Ludhiana Chapter, Dr. Brijendra Pateriya, Director, PRSC; and Secretary, ISG Ludhiana Chapter, Dr. Anil Sood, Scientist, PRSC.

June 05, 2018

Environment Day

World Environment day, celebrated by Punjab Remote Sensing Centre (PRSC) in collaboration with Indian Society of Remote Sensing (ISRS) and Indian Society of Geomatics (ISG)-Ludhiana Chapters. The young and budding scientists demonstrated the drone and robotics usages on the occasion. Dr Brijendra Pateriya, Director, PRSC while addressing the participants urged them to think about how we are part of nature as we ultimately depend on it. Prof S S Kukal, Dean, College of Agriculture, Punjab Agricultural University welcomed the participants and gave a detailed account of environmental degradation in the region and encouraged the participants to protect our environment. A lecture on precision farming and air quality monitoring using drone was given by Mr. Aryaman Verma, a student of class 8th in Sat Paul Mittal School. Mr Amarinder Singh, a progressive farmer from Nabha (Patiala) presented successful and sustainable agriculture by enhancing crop production using climate smart agriculture techniques. The students of WhiZRobo-A Robatic Institute in Ludhiana demonstrated the use of Robotics to destroy the mines under water. A plantation drive was conducted in PRSC Campus.

June 21, 2018

World Yoga Day Celebrated at PRSC

Attended and practice Yoga by Staff from PRSC under the guidance of Dr. H S Sur (Yoga Expert), Ex Director, PAU Research Station for Kandi Area, Balowal Saunkhri.

July 10, 2018

Online Workshop

One day online workshop titled “Geospatial Technologies and Sendai framework for Disaster Risk Reduction”, was conducted at PRSC for ISG-ISRS members and faculty & students from local Institutes (PAU, GNEC, GCG etc.).

July 25, 2018

Guest Lecture by Dr. B K Handique Scientist, NESAC, Shillong on topic, “Geospatial Activities in the NESAC”.

Knowledge sharing between the two institutes- Attended by research Scholars from Punjab Remote Sensing Centre, ISG-ISRS Members and faculty/students from Punjab Agricultural University, Ludhiana.

November 15, 2018

International GIS Day

International GIS day was celebrated.

Indian Society of Geomatics –Shillong Chapter Activities

Shri P. L. N. Raju
(Secretary)

October 23, 2017

ISG-EC Meeting at New Delhi

Secretary and Treasurer, ISG-Shillong Chapter attended the ISG-EC meeting held at Hotel Ashok, New Delhi. Shri PLN Raju, Director, NESAC, Secretary, ISG-Shillong Chapter and Dr. B.K. Handique, Treasurer, ISG-Shillong Chapter attended the ISG-EC meeting in the sideline of the Asian Conference on Remote Sensing and proposed to host the ISG National Symposium at Shillong during 2020.

May 10-11, 2018

Seminar on Advances in Remote Sensing and GIS Applications

A national level seminar was organised jointly by ISG-Shillong Chapter in association with ISRS-Shillong Chapter and Dept of Geography, North Eastern Hill University (NEHU) at NESAC, Umiam. The Seminar was preceded by a Preconference Tutorial on UAV Remote Sensing on May 9, 2018. The Seminar focused on Optical, Microwave, LIDAR and Hyper spectral remote sensing including high resolution data processing with special emphasis on issues and challenges of North Eastern Region. Secretary and Treasurer, ISG-Shillong Chapter attended the ISG-EC meeting held at Hotel Ashok, New

Delhi. Shri PLN Raju, Director, NESAC, Secretary, ISG-Shillong Chapter and Dr. B.K. Handique, Treasurer, ISG-Shillong Chapter attended the ISG-EC meeting in the sideline of the Asian Conference on Remote Sensing on October 23, 2017 and proposed to host the ISG National Symposium at Shillong during 2020. Hon'ble Governor of Meghalaya Shri Ganga Prasad was the Chief guest of the Inauguration programme. Shri C.H. Kharshing, Planning Adviser, North Eastern Council (NEC), attended the programme as the Guest of Honour. Dr. Prakash Chouhan, Director, Indian Institute of Remote Sensing (IIRS), Dehradun, Shri S. Hamilton, Regional Director, Atomic Minerals Directorate, Shillong & President, ISRS-Shillong Chapter, Shri P L N Raju, Director, NESAC & Chairman of the Organising Committee and Prof. B. S. Mipun, NEHU & President, ISG-Shillong Chapter were the other dignitaries who graced the inauguration function. An abstract volume of the selected papers were brought out and was released by Hon'ble Governor during the inaugural function. About 250 participants from across the country participated in the seminar, who deliberated on different areas of space technology applications grouped in 2 Plenary Sessions and 10 technical sessions. A cultural programme was also organized on the first day of the Seminar showcasing the rich and diverse culture of the region.



July 25, 2018

Invited Talk

Dr Bijoy K. Handique, Treasurer, ISG-Shillong Chapter was invited to deliver talk on Space Technology applications in north eastern region of India at Punjab Remote Sensing Centre (PRSC), Ludhiana. Director, scientists, research scholars and project trainees from PRSC were present during the presentation. Director, PRSC appreciated the effort of NESAC in taking up various projects in NE region and sought the support of NESAC in initiating the UAV remote Sensing in the Centre.



Indian Society of Geomatics –Hisar Chapter Activities

Dr. Anup Kumar
(Secretary)

March 21-22, 2017

Golden Jubilee Celebrations and Regional Conference

ISG Hisar Chapter organized Golden Jubilee Celebrations and Regional Conference on “Space Technology for Sustainable Development” at Haryana Space Applications Centre (HARSAC), Hisar. About 300 delegates from various parts of the country participated and more than 100 papers were presented in different technical sessions. Exhibition stalls were also put in the conference. The life members and executive members of the ISG Hisar Chapter promoted space technology among school students by delivering lectures during their visits at Haryana Space Applications Centre (HARSAC), Hisar.

April 28, 2018

Talk on “Geo-informatics for Sustainable Development”

Dr. R.S. Hooda, Chairman, ISG Hisar Chapter delivered the talk at RPS College, Mahendergarh. About 90 BA and MA students of Geography and faculty of the college attended the talk.

October 27, 2018

A lecture on “Role of Remote Sensing in Urban Planning”

Dr. R.S. Hooda, Chairman, ISG Hisar Chapter delivered the lecture at Hindu College of Architecture, Sonapat. About 35 B.Arch./ M.Arch students and faculty of the college attended the talk.

October 30, 2018

Lab Visit and Lecture

Students of Geoinformatics Assistant Trade of Govt. Industrial Training Institute (ITI), Panchkula visited Lab. at Front Office of HARSAC, Panchkula. Dr. Anup Kumar, Senior Scientist-SG (Geology/ Geomorphology), HARSAC demonstrated the satellite and launch vehicle models to the students. He delivered a lecture on “Job Opportunities in Geospatial Technology”.

November 02, 2018

Essay Writing

Essay writing assignment on the title “Advantages and Disadvantages of Space Technology” was given to the students of the Geoinformatics Assistant Trade of Govt. Industrial Training Institute (ITI), Panchkula .

Indian Society of Geomatics –Kashmir Chapter Activities

Prof. Shakil A. Romshoo
(Chairman)

May 4-5, 2018

Workshop on GIS for Tourism Development

Workshop was organised in collaboration with the Department of Earth Sciences, University of Kashmir (KU). It was organized to bring awareness about the Geomatics among the senior officers heading various Tourist Development Authorities in the State of Jammu and Kashmir. 60 officers including Director of Tourism, Kashmir, Director, JKTDC, Director, RSGC, J&K CEO's of all the Tourist Development Authorities of Jammu, Kashmir and Ladakh regions attended the workshop. It comprised of Lectures from the ISG-KC members, hands-on exercises about the use of GIS for mapping tourist facilities and other resources and a poster session where the various members had displayed their research related to the use of GIS for tourism and other related sectors. About 65 members of the Kashmir chapter of the society attended various sessions of the 2-day Workshop. The Inaugural function of the workshop was followed by a keynote lecture by the Chairman of the Chapter, Prof. Shakil A. Romshoo (HoD, Earth Sciences) titled "Geoinformatics for sustainable Tourism development in the J&K state". Dr. Irfan Rashid (Assistant Prof.), Dr. Sumaira Zaz (Assistant Professor), Ms. Sadaff Altaf, all EC Members of the chapter delivered lectures on GPS and GIS applications in Tourism. The second day of the Workshop comprised of a series of lectures by Prof. Shakil A. Romshoo, Dr. Irfan Rashid, Dr. Khalid Omer Murtaza (Assistant Professor) and Ms. Sadaff Altaf, all Chapter members discussing the Geomatics concepts and their applications for tourism carrying capacity, importance of remote sensing and GIS for EIA in tourism, GPS mapping and web-based GIS. Lastly, hands-on training about basic GIS operation and the use of GPS data for mapping



tourist facilities and infrastructure was given to the participants in the three Labs of the Remote sensing, GIS and digital image processing at Earth Sciences Department, University of Kashmir. The workshop was concluded a brief valedictory followed by the distribution of certificates and study material to the participants.

October 26, 2018

Seminar on Climate Change Vulnerability of J&K

ISG and the Indian Meteorological Society (IMS) in collaboration with the Department of Earth Sciences, University of Kashmir hosted a seminar on ‘Climate Change Vulnerability of J&K’. It was organized in the backdrop of the recent IPCC Special Report on the impacts of global warming. More than 250 people attended the seminar including the people from government sector, civil society, industrial sector, faculty and students of various departments from University of Kashmir, SKUAST and Central University of Kashmir. Prof. Talat Ahmad, Vice Chancellor, University of Kashmir presided over the Inaugural function. Prof. Nilofer Khan, Registrar of the Kashmir University was the chief Guest at the Inaugural. The function was attended by a galaxy of distinguished participants from government, civil society, academia and industry. Prof. Romshoo delivered a keynote talk about the climate change vulnerability of various sectors in the J&K state. Various aspects of the climate change were explained with special focus on the vulnerability of various sectors like water resources, glaciers and agriculture. Climate change scenarios and behavior of different climatic zones in J&K were highlighted. Prof. Nilofer Khan (Registrar), who was the guest of honor, deliberated upon the need to sensitize the young generation towards the environmental issues at the school level so that they may come forward and contribute towards spreading awareness in the society. The Prof. Talat Ahmad (Vice Chancellor), talked about the issue of rising global temperature as a concern at global level and its repercussions in future in the mountainous state of J&K. Prof. Talat appreciated the efforts of the Kashmir Chapter of the ISG. The lectures were followed by a poster session where members of the society presented their work related to role of GIS and remote sensing in climate change studies and had interaction with the participants.



Indian Society of Geomatics –Surat Chapter Activities

Dr. Chetan R Patel
(Chairman)

2017-2018

Expert Talk

Experts talk on “Geospatial Techniques and Today’s Smart World “by Dr Chetan R Patel, Chairman ISG Surat local Chapter at Civil Engineering Department, SVNIT, Surat.

2017-2018

Brainstorming Session

Brainstorming Session on “Geospatial opportunity in India” at Civil Engineering Society to B. Tech Students, SVNIT.

2017-2018

Training

Hands on Training on DGPS and Total Station to M. Tech (Urban Planning) students of SVNIT.

2017-2018

Training

Hands on Training on Arc GIS to M. Tech (Urban Planning) Students of SVNIT.

February 02, 2017

Seminar

As Knowledge Partners in one-day seminar on “Urban Plans: Procedures & Challenges” organised by PG Centre in Town & Country Planning, Faculty of Civil Engineering, SCET.

March 25-26, 2017

Seminar

As Knowledge Partners in National Conference on “NEW HORIZONS IN CIVIL ENGINEERING” NHCE – 2017 organized By Faculty of Civil Engineering Sarvajanic College of Engineering & Technology, Surat, Gujarat.

Indian Society of Geomatics –Vadodara Chapter Activities

July 24-30, 2017

National Workshop

National workshop on “Current Facets of Botany” was organized by ISG Vadodara Chapter in association with Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Indian Science Congress Association (Baroda Chapter) & Indian Women Scientists’ Association (Baroda Branch) and IEEE Geoscience and Remote Sensing Society (Gujarat Chapter).



September 29, 2017

World Space Week Celebration

ISG Vadodara Chapter along with Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara and RRSC-W, NRSC/ISRO, Jodhpur organized a School Level Space Quiz & Painting Competition on 29th September, 2017. The topic was based on Exploring New Worlds in Space with focus on astrobiology.



Indian Society of Geomatics –Pune Chapter Activities

September 15, 2017

Workshop

During the last one year ISG Pune Chapter has conducted one day workshop “GEOVISION 2017” on Watershed and Development.

Indian Society of Geomatics –Vishakhapatnam Chapter Activities

February 28, 2017

National Science Day

National Science Day celebrations were conducted in association with Dept. of Geo-Engineering, Andhra University. Dr. Sumiko Kubo, Professor of Waseda University, Tokyo, Japan and the Chief Guest of the function has delivered a speech on “Contribution of Science for Disaster Management in Japan” which was well attended by about 100 members including teachers, research fellows and students.



April 22, 2017

Earth Day Celebrations

Conducted Earth Day Celebrations in collaboration with the Department of Geo-Engineering, under the banner GEOLATRY (Earth Worship). This was a week-long programme during which a number of sports, quiz, and elocution contests were conducted for the students and prizes were distributed to the winners of various events on behalf of the Chapter in the final celebrations meeting. The speakers highlighted the importance of geospatial technologies in understanding the issues and challenges the Earth is facing at global, regional and local levels.



July 17, 2017

Workshop on Geospatial Technologies – Present and Future Trends

The Chapter joined hands with the Department of Geo-Engineering in conducting a One-Day Workshop on Geospatial Technologies – Present and Future Trends.



September 15, 2017

Engineer’s Day Celebrations

Activities to the student level from various colleges in and around Visakhapatnam has been conducted in Dadi Institute of Engineering and Technology (DIET), Visakhapatnam District.



November 15, 2017

GIS Day

Conducted the GIS Day at Andhra University.

Indian Society of Geomatics –Ajmer Chapter Activities

January 11 2017

Seminars/Workshops

Workshop on Empowerment Panchayat Raj institute Spatially (EPRIS) – Target groups Gram Panchayat and Panchayat samiti, Sanganer at Panchayat Samiti , Sanganer district Jaipur, Rajasthan.

January 30, 2017

Seminars/Workshops

Workshop on Empowerment Panchayat Raj institute Spatially (EPRIS) – Target groups Gram Panchayat and Panchayat samiti, Sanganer at Panchayat Samiti.

February 28, 2017

Science Day Celebrations

Celebrated Science Day on 28 February, 2017. Delivered lecture on Disaster Management : Role of Remote Sensing at Govt Women’s Engineering College , Civil Engineering Department, Ajmer.

August 12, 2017

Remote Sensing Day Celebrations

Delivered lectures on Basics of Remote Sensing at local selected schools of Ajmer city and pamphlets were distributed to students for awareness Of Remote Sensing and Geoinformatics among school children.

August 14, 2017

Lectures

Delivered two lectures by Chairman ISG and ISRS Ajmer Chapter in Refresher courses on the topic “ Role of Remote Sensing and GIS for Renewable Resources” at Academic Staff College, M.D.S. University, Ajmer .

September 09, 2017

Lectures

Delivered two lectures by Chairman ISG and ISRS Ajmer Chapter in Orientation courses on the topic “ Role of Remote Sensing and GIS for Disaster Management ” at Academic Staff College, M.D.S. University, Ajmer .

From ISG Secretariat

ISG NEW LIFE MEMBERS

S.No.	Membership No.	Name	Name & address
1	ISG-L-1846	Prof. H.B. Raghavendra	Director, School of Technology, PDPU, Gandhinagar, Gujarat
2	ISG-L-1847	Seerat Megray	Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
3	ISG-L-1848	Midhat Fayaz Shalla	Lecturer, Department of Earth Sciences, Srinagar, Jammu & Kashmir
4	ISG-L-1849	Dr Rakesh Chandra	Sr. Assistant Professor, Department of Earth Sciences, Srinagar, Jammu & Kashmir
5	ISG-L-1850	Dr Farooq Ahmad Dar	Assistant Professor, Department of Earth Sciences, Srinagar, Jammu & Kashmir
6	ISG-L-1851	Omar Jaan	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
7	ISG-L-1852	Aamina Sultan	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
8	ISG-L-1853	Jhokar Subiaya Bashir Bashir	M.Sc. Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
9	ISG-L-1854	Jasia Bashir	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
10	ISG-L-1855	Aneaus Shakil	M.Sc. Student, Department of Earth Sciences, Srinagar, J & K
11	ISG-L-1856	Anjum Shafi Zsani	Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
12	ISG-L-1857	Govinda Rajul K.	Sci./Engr.'SF', SAC, ISRO, Ahmedabad, Gujarat
13	ISG-L-1858	Sr. Tejaskumar P. Thaker	Assistant Professor, Pandit Deendayal Petroleum University, Vadodara, Gujarat
14	ISG-L-1859	Shahid Gulzar	Associate Professor, COWI India Ltd., Delhi
15	ISG-L-1860	Sarah	DST-Inspire Faculty, University of Kashmir, Srinagar, J & K
16	ISG-L-1861	Bilal Ahmad Wani	Student, Department of Earth Sciences, KU, J & K
17	ISG-L-1862	Ubair	M Sc. Student , Geoinformatics , HARSAC, HISAR, Haryana
18	ISG-L-1863	D. Hariprasad	Associate Professor, College of Engineering, Hyderabad
19	ISG-L-1864	Debabrata Nandi	Lecturer, North Orissa University, Takatpur, Orissa
20	ISG-L-1865	Dr. Kakoli Saha	Assistant Professor, SPA, Bhopal, Bhopal, MP
21	ISG-L-1866	Abhishek Anand	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
22	ISG-L-1867	Inderpret Kaur Grewal	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
23	ISG-L-1868	Arvind Kumar	Research Fellow, Punjab Remote Sensing Centre, Ludhiana, Punjab
24	ISG-L-1869	Gurpreet Kaur	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
25	ISG-L-1870	Harleen Kaur Vohra	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
26	ISG-L-1871	Richa Sharma	JRF (Chemical Analyst), Punjab Remote Sensing Centre, Ludhiana, Punjab
27	ISG-L-1872	Reenu Sharma	Scientist, Punjab Remote Sensing Centre, Ludhiana, Punjab
28	ISG-L-1873	Lakhvir Singh	Research Associate, Punjab Remote Sensing Centre, Ludhiana, Punjab

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
29	ISG-L-1874	Shivani Singh	Research Associate, Punjab Remote Sensing Centre, Ludhiana, Punjab
30	ISG-L-1875	Anchal Kumar Jain	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
31	ISG-L-1876	Rajni Sharma	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
32	ISG-L-1877	Dr. Harmeet Singh	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
33	ISG-L-1878	Anand R.	Assistant Professor, Easwari Engineering College,
34	ISG-L-1879	Dr. Ramesh Indirani	Assistant Prof., Tamilnadu Agri. Univ., Madurai, Tamil Nadu
35	ISG-L-1880	Ms. Arti Sarkar	Sci./Engr.'SG', SAC, ISRO, Ahmedabad, Gujarat
36	ISG-L-1881	D. K. Das	Associate Director, SAC, ISRO, Ahmedabad, Gujarat
37	ISG-L-1882	Dr. Plya Kesava Rao	Assistant Professor, NIRD & Panchayati raj, Rajendranagar, Hyderabad, Telangana
38	ISG-L-1883	Sejal S. Bhagat	Assistant Professor, SCET, Surat, Gujarat
39	ISG-L-1884	Bhasker Vijaykumar Bhatt	PG Incharge & Asst. Professor, CED, SCET, Surat, Gujarat
40	ISG-L-1885	Jamakuwala Daisy	Adhoc Assistant Professor, College of Engineering & Technology, Surat, Gujarat
41	ISG-L-1886	Riddhi Dalal	M. Tech Student (Urban Planning), SUNIT, Surat, Gujarat
42	ISG-L-1887	Upasana Nitin Panchal	B.E. Student (Civil), ICEA, Surat, Gujarat
43	ISG-L-1888	Zarana Hitesh Gandhi	Adhoc Assistant Professor, SCET, Surat, Gujarat
44	ISG-L-1889	K. Venkateswaran	Assistant Professor, Kongu Engineering College, Perunderai
45	ISG-L-1890	Dr. N. Kasthuri	Professor, Kongu Engg. College, Perunderai, Tamil Nadu
46	ISG-L-1891	Venkata Ramana Murthy B.	Assistant Professor, BITS-VIFAG, Visakapatunam, Andhra Pradesh
47	ISG-L-1892	Dr. S.Jayakumar	Assistant Professor, Pondicherry University, Pondicherry, Tamil Nadu
48	ISG-L-1893	Dr. Suja P. Devipriya	Assistant Professor, Pondicherry University, Pondicherry
49	ISG-L-1894	Dr. R. Arun Prasath	Assistant Professor, Pondicherry University, Pondicherry
50	ISG-L-1895	Dr. K. N. Kusuma	Assistant Professor, Pondicherry University, Pondicherry
51	ISG-L-1896	Dr. Selvalakshmi S.	Professor, Pondicherry University, Pondicherry
52	ISG-L-1897	Dr. Ramaya K.	Professor, Pondicherry University, Pondicherry
53	ISG-L-1898	Satyam Verma	Professor, Pondicherry University, Pondicherry
54	ISG-L-1899	Kuimi T. Vashum	Ph. D. Scholar, Pondicherry University, Pondicherry
55	ISG-L-1900	Ajeet Kumar Singh	Ph. D. Scholar, Pondicherry University, Pondicherry
56	ISG-L-1901	Sathya M.	Ph. D. Scholar, Pondicherry University, Pondicherry
57	ISG-L-1902	Swapna Sarika Khadenga	Ph. D., Pondicherry University, Pondicherry
58	ISG-L-1903	Dr. Jayamohan J	Professor, Civil Engg. Dept., LBSITIN, Trivendrum
59	ISG-L-1904	Mohammed Ali Feroze Khan	Senior Survey Engineer, AECOM, Doha, Qatar
60	ISG-L-1905	Dr. P. Jambulingam	Director, ICMR, Puducherry

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
61	ISG-L-1906	Dr. S. Sabesan	Scientist, VCRC (ICMR), Puducherry
62	ISG-L-1907	Dr. S. Subramanian	Scientist, ICMR, Puducherry
63	ISG-L-1908	Mrs. A. Srividya	Scientist, ICMR, Puducherry
64	ISG-L-1909	Dr. K. Hari Kishan Raju	T.A., VCRC (ICMR), Puducherry
65	ISG-L-1910	Chirag Shailesh Shastri	Executive Director, CHDI, Ahmedabad, Gujarat
66	ISG-L-1911	Sneha Susai John	GIS System Analyst, Puducherry Water Resources Organisation, Puducherry
67	ISG-L-1912	Dr (Mrs) Phibankhamti Ryngnga	Asst. Professor, North Eastern Hill University, Shillong
68	ISG-L-1913	D. Naresh	Asst. Professor, S. T. Martin's Engg. College, Hyderabad
69	ISG-L-1914	Alajangi Simhachalam	Faculty, NIRD&PR, Assam
70	ISG-L-1915	Subitha.L	Asst. Professor, Department of PSM, JIPMER, Puducherry
71	ISG-L-1916	Mahalakshmy T	Assistant Professor, Department of PSM, JIPMER, Puducherry
72	ISG-L-1917	Dr. Kollipara Padma Kumari	Professor, Jawaharlal Nehru Technological University, Kakinada, Andhra Pradesh
73	ISG-L-1918	Rana Amitkumar Venilal	Assistant Professor, BMCARP, Surat, Surat, Gujarat
74	ISG-L-1919	Patel Chetankumar Ramanlal	Assistant Professor, S.V.N.I.T, Surat, Surat, Gujarat
75	ISG-L-1920	Tailor Ravin Maheshkumar	Assistant Professor, S.V.N.I.T, Surat, Surat, Gujarat
76	ISG-L-1921	Parikh Hina Jaydeep	Town Planner, Design Ican, Surat, Surat, Gujarat
77	ISG-L-1922	L Balaji	CMD, Geomatics AERO Technologies Pvt. Ltd., Tamil Nadu
78	ISG-L-1923	Dr G Muthu Sankar	Head of GIS, French Institute of Pondicherry, Pondicherry
79	ISG-L-1924	Parmar Manish	Sci./Engr. 'SD', SAC, ISRO, Ahmedabad, Gujarat
80	ISG-L-1925	Shirke Sunil Suresh	Director, Shirke Consultants, Pune, Maharashtra
81	ISG-L-1926	Dr Tripathi Shashank	Project Scientist, Remote Sensing Applications Centre - UP, Lucknow
82	ISG-L-1927	Duvvuru Rajesh	Research Scholar, Andhra University College of Engineering, Andhra Pradesh
83	ISG-L-1928	Pandey Neha	JRF, BISR, Jaipur, Rajasthan
84	ISG-L-1929	Babu Neela Victor	Professor & Principal , Baba Institute of Technology and Sciences, Visakhapatnam
85	ISG-L-1930	Nathani Beena H.	JRF, Vadodara, Gujarat
86	ISG-L-1931	Pal Subhasree	Student, Symbiosis Institute of Geoinformatics, West Bengal
87	ISG-L-1933	Dr Kuttippurath Jayanarayanan	Assistant Professor, IIT, Kharagpur, Kharagpur, W.B.
88	ISG-L-1934	Das Pulakesh	Ph. D. Research Scholar, IIT, Kharagpur, West Bengal
89	ISG-L-1935	Jana Amit Kumar	Research Scholar, University of North Bengal, West Bengal
90	ISG-L-1936	Vekaria Girish L	Assistant Professor, Sir P.T. Science College, Modasa
91	ISG-L-1937	Sengar Sandeep Singh	Associate Professor, JKLU, Jaipur, Jaipur

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
92	ISG-L-1938	Pandey Arvind Chandra	Professor, Central University of Jharkhand, Jharkhand
93	ISG-L-1939	Tiwari Sharad	Scientist 'SF', Institute of Forest Productivity, Jharkhand
94	ISG-L-1940	Thakur Brahmanand Singh	Scientist-D, CGWB, Jharkhand
95	ISG-L-1941	Arvind Kumar	Director, Geological Society of India, Jharkhand
96	ISG-L-1942	Amit Kumar	Assistant Professor, Central University of Jharkhand, Jharkhand
97	ISG-L-1943	Jalem Kiran	Assistant Professor, Central University of Jharkhand, Jharkhand
98	ISG-L-1944	Parida Bikash Ranjan	Assistant Professor, Central University of Jharkhand, Jharkhand
99	ISG-L-1945	Saikia Purabi	Assistant Professor, Central University of Jharkhand, Jharkhand
100	ISG-L-1946	Parmar Kavita	DST-Young Scientist, Central University of Jharkhand, Jharkhand
101	ISG-L-1947	Binita Kumari	Research Scholar, Central University of Jharkhand, Jharkhand
102	ISG-L-1948	Gupta Saurabh Kumar	Junior Research Fellow, Central University of Jharkhand, Jharkhand
103	ISG-L-1949	Ahmad Tauseef	Junior Research Fellow, Central University of Jharkhand, Jharkhand
104	ISG-L-1950	Chaudhary Satendra Kumar	Research Scholar, Central University of Jharkhand, Jharkhand
105	ISG-L-1951	Stuti	Research Scholar, Central University of Jharkhand, Jharkhand
106	ISG-L-1952	Basheer Ahammed KK	Research Scholar, Central University of Jharkhand, Jharkhand
107	ISG-L-1953	Diksha	Research Scholar, Central University of Jharkhand, Jharkhand
108	ISG-L-1954	Tripathi Gaurav	Research Scholar, Central University of Jharkhand, Jharkhand
109	ISG-L-1955	Vashishat Nisha	Assistant Ornithologist, Ludhiana
110	ISG-L-1956	Singh Sukhdeep	JRF, PRSC, Ludhiana, Ludhiana
111	ISG-L-1957	Baskey Tapati	JRF, PRSC, Ludhiana, Ludhiana
112	ISG-L-1958	Kaur Amanjot	JRF, ACM Division, PRSC, Ludhiana, Ludhiana
113	ISG-L-1959	Manish Kumar	JRF, ACM Division, PRSC, Ludhiana, Ludhiana
114	ISG-L-1960	Kanhaiya Lal	Asst. Professor, Central University of Jharkhand, Jharkhand
115	ISG-L-1961	S Balaselvakumar	Assistant Professor, Dept. of Geography, Periyar EVR College, Tiruchirappalli
116	ISG-L-1962	Tikader Sribash	Assistant Professor, Dept. of Geography, Micheal Madhusudan Memorial College, W.B.
117	ISG-L-1963	Joshi Veena	Professor and Head, Department of Geography, Pune
118	ISG-L-1964	M. Chinnamuthu	Research Scholar, Centre for Geoinformatics and Planetary Studies, Salem
119	ISG-L-1965	Pinank Rajendrakumar Patel	Assistant Professor , SSAIET, Navsari, Surat

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
120	ISG-L-1966	Uday Kumar	Ranchi University
121	ISG-L-1967	Ajeet Singh	HARSAC, HISAR
122	ISG-L-1968	Jogender	HARSAC, HISAR
123	ISG-L-1969	Ch. Kannan Naidu	Aditya Institute of Technology and Management (AITAM)
124	ISG-L-1970	Sachin Sagar	MyWay Educational Charitable Trust Khurja
125	ISG-L-1971	Manoj Chavan	C-DAC, Pune
126	ISG-L-1972	Hiren Prabhatsinh Rathod	Stesalit Systems Ltd.
127	ISG-L-1973	Priya	
128	ISG-L-1974	Bharath H. Aithal	Indian Institute of Technology, Kharagpur
129	ISG-L-1975	Pankaj Bodani	ISRO
130	ISG-L-1976	Kriti Rastogi	SAC, ISRO
131	ISG-L-1977	Ujjwal Kumar Gupta	SAC, ISRO
132	ISG-L-1978	Karshanbhai Chaudhari	SAC, ISRO
133	ISG-L-1979	Bindi Satyam Dave	CEPT University
134	ISG-L-1980	Mini Raman	SAC, ISRO
135	ISG-L-1981	P Sridhar	Shri Vishnu Engineering College for Women
136	ISG-L-1982	S Shravya	Shri Vishnu Engineering College for Women
137	ISG-L-1983	Krishnendra Singh Nama	Carrier Point University, KOTA
138	ISG-L-1984	Gravitas Kaushik	DOIT&C
139	ISG-L-1985	R P Singh	SAC, ISRO
140	ISG-L-1986	Duraiswami Raymond	SPPU, Geology Department
141	ISG-L-1987	Bhumika Narendrabhai Vaghela	Gujarat University
142	ISG-L-1988	Sapna Godiya	
143	ISG-L-1989	Dedeepya Rachakonda	
144	ISG-L-1990	Mona Govindbhai Parmar	Climate Change Impacts Management
145	ISG-L-1991	Padam Jee Omar	IIT-BHU, Varanasi
146	ISG-L-1992	V.V. Arun Kumar Surisetty	SAC, ISRO
147	ISG-L-1993	A Jothibasu	Periyar University
148	ISG-L-1994	Y Pari	Geospatial Technologies, Digital , Divisional L&T Construction, Corporate, Chennai
149	ISG-L-1995	A Vivekananth	L&T ECC, Chennai
150	ISG-L-1996	Kalpana R Malvat	Nalini Arvind & T.V. Patel Arts College, Vallabh Vidhyanagar
151	ISG-L-1997	Ratheesh Ramakrishnan	SAC, ISRO
152	ISG-L-1998	R.V.G. Anjaneyulu	NRSC, Balanagar, Hyderabad

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
153	ISG-L-1999	Varun Singh	MNNIT, Allahabad
154	ISG-L-2000	Pankaj Jayantilal Gandhi	
155	ISG-L-2001	R K Setia	Punjab Remote Sensing Centre
156	ISG-L-2002	Yashmeet Kaur	Punjab Remote Sensing Centre
157	ISG-L-2003	Mohd. Abdul Kalam	Sreyas Institute of Engg & Technology
158	ISG-L-2004	K Shunmugapriya	Dept. of Civil Eng., Dhanalakshmi Srinivasan Engi. College, Thuraiyur Road, Perambalur, TamilNadu
159	ISG-L-2005	R Uma Maheswara Rao	CDM Smith International
160	ISG-L-2006	Ajith Kumar S	IRS, Anna University, Chennai
161	ISG-L-2007	Rajesh Shriramsa Gujar	Pandit Deendayal Petroleum University
162	ISG-L-2008	Kailash Chandra Tiwari	Delhi Technological University
163	ISG-L-2009	Parikshit Parasher	SAC, ISRO
164	ISG-L-2010	Samneet Thakur	SAC, ISRO
165	ISG-L-2011	Mukesh Kumar Mishra	SAC, ISRO
166	ISG-L-2012	Shubham Gupta	SAC, ISRO
167	ISG-L-2013	Jitendra Kumar Chaudhary	Gurukula Kangri Vishwavidhyalaya, Haridwar
168	ISG-L-2014	Samir Jayprakash Patel	SVNIT, Surat
169	ISG-L-2015	Bhavesh Narendra Dhonde	SVNIT, Surat
170	ISG-L-2016	Raviraj Nigambhai Dave	CEPT University
171	ISG-L-2017	Shrawani Sable	CEPT University
172	ISG-L-2018	Kshitija Shrimani Survawanshi	CEPT University
173	ISG-L-2019	Priyanka Machya	CEPT University
174	ISG-L-2020	Hitesh Dhanjibhai Rathod	CEPT University
175	ISG-L-2021	Urvi Shroff	CEPT University
176	ISG-L-2022	Jayachandra Ravi	CEPT University
177	ISG-L-2023	Akshay Premanand Kumar	CEPT University
178	ISG-L-2024	Vijaya Lakshmi Thatiparthi	JNTU, Hyderabad
179	ISG-L-2025	A Somasundaram	Department of Higher Education (TN)
180	ISG-L-2026	Ishan Trivedi	B/52, Satellite Apartment
181	ISG-L-2027	Sujatha S Judes	University college of Engineering
182	ISG-L-2028	Prafulla Kumar Panda	Centurion University of Technology & Management

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
183	ISG-L-2029	Atri Jayeshkumar Dave	M.S. University of Baroda
184	ISG-L-2030	Raghavendra K Venkata	NRSC, ISRO
185	ISG-L-2031	RVN Srinivas	PPEG, NRSC
186	ISG-L-2032	Mehali Jigesh Mehta	Sarvajanik College of Hydraulics, IWWA
187	ISG-L-2033	Manisha Pranav Vashi	Sarvajanik College of Engineering & Technology
188	ISG-L-2034	Khushbu Shashikant Gandhi	Sarvajanik College of Engineering & Technology
189	ISG-L-2035	Dhruvi A Shukla	Khyati Institute of Science
190	ISG-L-2036	Bagale Shankar Sidramappa	WIPRO LTD
191	ISG-L-2037	Rahul Nigam	SAC, ISRO
192	ISG-L-2038	Prathishta Narain	ISR, Gandhinagar
193	ISG-L-2039	Bankim Chandra Yadav	IIT, Roorkee
194	ISG-L-2040	Barot Sumarth H	
195	ISG-L-2041	Mehul Maisereri	CEPT University
196	ISG-L-2042	Joshua Ranjit E	
197	ISG-L-2043	Arvind Kumar Singh	SAC, ISRO
198	ISG-L-2044	Maneesha Gupta	SAC, ISRO
199	ISG-L-2045	Hemang Dalwadi	NIRMA University
200	ISG-L-2046	Dhwanilnath Gharekhan	NIRMA University
201	ISG-L-2047	Dipen D Sahajramani	CEPT University
202	ISG-L-2048	Kanwar Deepak	DAU College, Jalandhar
203	ISG-L-2049	Navneet Kaur	PAU, Ludhiana
204	ISG-L-2050	Vivek Kumar Mishra	PIXEL SOFTEK Pvt. Ltd.
205	ISG-L-2051	Krunal Bhanubhai Suthar	ISTAR
206	ISG-L-2052	Mohitgiri A Goswami	St Xaviers College
207	ISG-L-2053	Monika Sharma	Jiwaji University, Gwalior
208	ISG-L-2054	Nupur Adarsh	Banasthali Vidyapith
209	ISG-L-2055	Madhu S Trivedi	
210	ISG-L-2056	Kinjal Arunkumar Dave	CEPT University
211	ISG-L-2057	A P Goswami	M V M Sci.& Home Sci. College
212	ISG-L-2058	Krishna Kumar Soni	Gujarat University
213	ISG-L-2059	Jayaprakash Alajangi	NIRDPR, Hyderabad
214	ISG-L-2060	Radhika A Chipade	SAC, ISRO
215	ISG-L-2061	Ajaz Ahmad Parray	University of Kashmir

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
216	ISG-L-2062	Basharat Nabi	University of Kashmir
217	ISG-L-2063	Waheed Shah	University of Kashmir
218	ISG-L-2064	Ain us Saba Qazi	University of Kashmir
219	ISG-L-2065	Ovaaid Javed	University of Kashmir
220	ISG-L-2066	Sumaira Lateef	University of Kashmir
221	ISG-L-2067	Sarish Mukhtar	University of Kashmir
222	ISG-L-2068	Sameer Ahmad Sheikh	University of Kashmir
223	ISG-L-2069	Nuzhat Nissa	University of Kashmir
224	ISG-L-2070	Aurooj Shafi	University of Kashmir
225	ISG-L-2071	Salim Lateef	University of Kashmir
226	ISG-L-2072	Tajamul Islam	University of Kashmir
227	ISG-L-2073	Mustafa Hameed Bhat	University of Kashmir
228	ISG-L-2074	Ummer Ameen	University of Kashmir
229	ISG-L-2075	Rasiq Ahmad Mir	University of Kashmir
230	ISG-L-2076	Darakshan Ayub Bhat	University of Kashmir
231	ISG-L-2077	Azra Jan	University of Kashmir
232	ISG-L-2078	Shaheena Gulam	University of Kashmir
233	ISG-L-2079	Saish Sarikonda	CEPT University
234	ISG-L-2080	Kunal Shah	CEPT University
235	ISG-L-2081	Jay Prajapati	CEPT University
236	ISG-L-2082	Aagam Shah	CEPT University
237	ISG-L-2083	Nikunj M Pithva	CEPT University
238	ISG-L-2084	Prathvi G Bhatti	CEPT University
239	ISG-L-2085	Manveen Ahluwalia	CEPT University
240	ISG-L-2086	Mehreen Khan	CEPT University
241	ISG-L-2087	Vaishnavi Vikas Purnanik	CEPT University
242	ISG-L-2088	Malik Roma Ratnakar	CEPT University
243	ISG-L-2089	Rana Divyeshkumar Dineshchandra	CEPT University
244	ISG-L-2090	Yashraj Jain	CEPT University
245	ISG-L-2091	Devendra Kumar Saini	
246	ISG-L-2092	Shubham Vinod Raut	
247	ISG-L-2093	Vrutti Bhatt	CEPT University
248	ISG-L-2094	Smit Patel	CEPT University
249	ISG-L-2095	Sanyukta Gautam	CEPT University
250	ISG-L-2096	Prakhar Mishra	CEPT University
251	ISG-L-2097	Nilraj Chhasatiya	CEPT University
252	ISG-L-2098	Shah Kirtan Samirbhai	CEPT University

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
253	ISG-L-2099	Jenish Patel	CEPT University
254	ISG-L-2100	Neha Sharma	CEPT University
255	ISG-L-2101	Jesal Zala	CEPT University
256	ISG-L-2102	Shivani Kharra	CEPT University
257	ISG-L-2103	C Mahesh	SAC, ISRO
258	ISG-L-2104	Deepak Putrevu	SAC, ISRO
259	ISG-L-2105	Sushil Kumar Singh	SAC, ISRO
260	ISG-L-2106	Rasmi Sharma	SAC, ISRO
261	ISG-L-2107	Sasmita Chaurasia	SAC, ISRO
262	ISG-L-2108	Pradeep Kumar Thapliyal	SAC, ISRO
263	ISG-L-2109	Nitant Dubey	SAC, ISRO
264	ISG-L-2110	Bimal Kumar Bhattacharya	SAC, ISRO
265	ISG-L-2111	Saroj Maity	SAC, ISRO
266	ISG-L-2112	Ranjit Kumar Sarangi	SAC, ISRO
267	ISG-L-2113	Sanjib Deb	SAC, ISRO
268	ISG-L-2114	V Manavala Ramanujam	SAC, ISRO
269	ISG-L-2115	Abhineet Shyam	SAC, ISRO
270	ISG-L-2116	Tathagata Chakraborty	SAC, ISRO
271	ISG-L-2117	Rosly Boy Lyngdoh	SAC, ISRO
272	ISG-L-2118	Sanid C	SAC, ISRO
273	ISG-L-2119	Touseef Ahmad	SAC, ISRO
274	ISG-L-2120	Shivani Tyagi	SAC, ISRO
275	ISG-L-2121	Pradyumnan Singh Rathod	SAC, ISRO
276	ISG-L-2122	Anand S S	SAC, ISRO
277	ISG-L-2123	Raghav Mehra	SAC, ISRO
278	ISG-L-2124	Pragya Arora	SAC, ISRO
279	ISG-L-2125	Tarun Maganti	SAC, ISRO
280	ISG-L-2126	Purvee Joshi	SAC, ISRO
281	ISG-L-2127	Naveen Thripathi	SAC, ISRO
282	ISG-L-2128	Ashwin Gujarati	SAC, ISRO
283	ISG-L-2129	Sreejith K. M	SAC, ISRO
284	ISG-L-2130	Arvind Sahay	SAC, ISRO
285	ISG-L-2131	Saurabh Tripathi	SAC, ISRO
286	ISG-L-2132	Ayan Das	SAC, ISRO
287	ISG-L-2133	Shard Chander	SAC, ISRO

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
288	ISG-L-2134	Syed Moosa Ali	SAC, ISRO
289	ISG-L-2135	Amit Kumar Dubey	SAC, ISRO
290	ISG-L-2136	Nilima Rani Chaube	SAC, ISRO
291	ISG-L-2137	Dharmendra Kumar Pandey	SAC, ISRO
292	ISG-L-2138	Manoj Mishra	SAC, ISRO
293	ISG-L-2139	Phani Rajshekhar	SAC, ISRO
294	ISG-L-2140	Debojyoti Ganguli	SAC, ISRO
295	ISG-L-2141	Aswati Vijaya Krishna	SAC, ISRO
296	ISG-L-2142	Sugali Sekhar Naik	SAC, ISRO
297	ISG-L-2143	Abhilash Narayan Patil	SAC, ISRO
298	ISG-L-2144	Ramdayal Singh	SAC, ISRO
299	ISG-L-2145	Dr. Ch Ramesh Naidu	GVP College of Eng. Vishakhapatnam
300	ISG-L-2146	Suma Dawn	Jaypee IIT, Noida
301	ISG-L-2147	Golla Bhakta Thukaram	HEXOCT Geospatial Technologies
302	ISG-L-2148	Sudhanshu Raghubanshi	SAC, ISRO
303	ISG-L-2149	Mukesh Kumar	SAC, ISRO
304	ISG-L-2150	Preeti Rajput	SAC, ISRO
305	ISG-L-2151	Aswathy Vijaya Krishna	SAC, ISRO
306	ISG-L-2152	Rohit Pradhan	SAC, ISRO
307	ISG-L-2153	Nimisha Singh	SAC, ISRO
308	ISG-L-2154	K. N. Babu	SAC, ISRO
309	ISG-L-2155	Satadru Bhattacharya	SAC, ISRO
310	ISG-L-2156	Nandini Ray Chaudhury	SAC, ISRO



Indian Society of Geomatics

To,
The Secretary, Indian Society of Geomatics
6202, Space Applications Centre (ISRO)
AHMEDABAD – 380 058. INDIA

Sir,
I want to become a Member/ Life Member/ Sustaining Member/ Patron Member/ Foreign Member/ Student Member of the Indian Society of Geomatics, Ahmedabad for the year _____. Membership fee of Rs. _____ is being sent to you by Cash/ DD/ Cheque/Online. (In case of DD/ Cheque/ Transaction No. _____ dated _____ drawn on Bank _____). I agree to abide by the Constitution of the Society.

Date: _____

Place: _____

Signature

Name: Mr/Ms/Mrs/Dr _____

Address: _____

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Phone: _____ Mobile: _____ Email: _____

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Mailing Address: _____

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Proposed by:

(Member's Name and No)

Signature of Proposer

For Office Use: A/P/L Member No.		Receipt No.		Date:	
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Indian Society of Geomatics (ISG), Room No. 6202 Space Applications Centre (ISRO), Ahmedabad-380058, Gujarat. Url: www.isgindia.org Phone: +91-79 26916202 Email: secretary@isgindia.org or sasharma@sac.isro.gov.in Fax +91-79-26916287

MEMBERSHIP FEES

S.No.	Membership	Life/Patron Membership fees		Annual Subscription
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2.	Life Member			
	a) Admitted below 45 years of age	2500	250	
	b) Admitted after 45 years of age	2000	200	
3.	Sustaining Member	---	---	2000
4.	Patron Member	50000	3000	---
5.	Student Member	10	---	100

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Bank: State Bank of India. **Branch:** Jodhpur Tekra, Ahmedabad

IFS Code: SBIN0003967 **Account No:**10327867093

Financial year of the Society is from April 1 to March 31.

For further details, contact Secretary, Indian Society of Geomatics at the address given above.

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Journal of the Society will be sent to Life Members by softcopy only.

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