CSSTEAP
Newsletter

CSSTEAP

Centre for Space Science & Technology Education in Asia & the Pacific

(CSSTEAP)

(Affiliated to the United Nations)

on a mission of capacity building, the initiative of the United nations, for Asia and the Pacific Region in Space Science and Technologym through Excellence in Education, Training and Research.

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Director's Message

The Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) has been contributing significantly in empowering scientists and engineers in Asia Pacific countries in the frontier areas of Space Science and Technology and their Applications since its inception in 1995. In particular, its contributions have been focused on PG Courses in Remote Sensing and Geographic Information Systems, Satellite Communications & Global Positioning Systems, Satellite Meteorology & Global Climate, Space & Atmospheric Science and Global Navigation Satellite System, which are well recognized by UNOOSA as potential subjects for societal benefit applications. The Centre also conducts short courses on different themes of Remote Sensing and GIS applications, Small Satellite Missions and Navigation and Satellite Positioning system on regular basis. The Centre also organizes short courses& awareness programmes from time to time based on the request of user departments.

During the Year 2016 the centre has conducted three PG courses and five short courses in which total 164 participants from 21 different countries are benefitted.

As the main purpose of the courses is to empower the participants in respective disciplines, it is important that at the end of the 9-month long program, participants should have hands-on experience to apply the methods learnt in the class rooms.I am happy to note that the course participants of PG courses have taken up challenge to carry out a pilot project as part of the course curriculum. This certainly builds up confidence among participants to apply the methods studied to undertake future projects in their home country for their nationaldevelopment. This Newsletter consists of summary of pilot projects carried out by the participants, besides other relevant information on different activities of CSSTEAP.

Dr. A. Senthil Kumar
Director

About **CSSTEAP**

Considering the importance and use of space science, technology and applications in promoting social and economic development, the United Nations, through its Office for Outer Space Affairs (UN-OOSA), facilitated the establishment and operation of the Regional Centres for Space Science and Technology Education. In its resolution 45/72 of December 11, 1990, the United Nations General Assembly (UN-GA) endorsed the recommendation of the Committee on the Peaceful Uses of Outer Space (COPUOS) to establish Regional Centres for Space Science and Technology in developing countries. Under the auspices of the United Nations, through its Office for Outer Space Affairs (UN-OOSA), six Regional Centres for Space Science and Technology Education have been established in the regions that correspond to the United Nations Economic Commissions for Asia and the Pacific (India and China), Africa (Morocco, Nigeria) and Latin America and the Caribbean (with offices in Brazil and Mexico) and Jordan for the West Asia region. The Centres are affiliated to the United Nations through UN-OOSA. Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) is the first Centre and was established on November 1, 1995 in India and has been Centre for Space Science and Technology Education in Asia and the Pacific imparting education/training in the areas of RS&GIS, Satellite Communications, Satellite Meteorology and Global Climate, Space and Atmospheric Science, Navigation and Satellite Positioning System and Small Satellite Missions using modern infrastructure, technology and training tools and practices. The Centre has a announced a new Post Graduate course on Global Navigation Satellite Systems (GNSS) from 2015 and is hosted by Space Applications Centre, ISRO Ahmedabad.

The Centre's headquarter is located in Dehradun, India, and its programmes are executed by faculty of the Department of Space (DOS) at campuses in Dehradun, Ahmedabad and Bengaluru. The Centre has arrangements with Indian Institute of Remote Sensing (IIRS), Dehradun for RS & GIS course; with Space Applications Centre (SAC), Ahmedabad for Satellite Communication (SATCOM), Satellite Meteorology and Global Climate (SATMET) and Global Navigation Satellite System (GNSS) and Navigation and Satellite Positioning Systems (NAVSAT) short courses; with Physical Research Laboratory (PRL), Ahmedabad for Space & Atmospheric Science course and ISRO Satellite Centre (ISAC), Bengaluru for short course on Small Satellite Missions. The Centre also has agreement with the Government of India by which it has been accorded specific privileges and international status to the centre, similar to the privileges enjoyed by UN specialized agencies. Under the agreement the Centre also has access to facilities, infrastructure and expertise of DOS/ISRO institutions, including IIRS, SAC, PRL, NRSC and ISAC. The Centre has a Governing Board consisting of signatories from 16 countries from Asia-Pacific region and two observers, (UN-OOSA & ITC, The Netherlands). The Centre has formal UN affiliation with UN-OOSA for developing the CSSTEAP model and extending support in terms of expert advice, technical assistance, relevant documentation and future directions. The countries have agreed to the goals and objectives of the Centre by endorsing a cooperation agreement through which the Centre was established. The technical activities of the Centre are guided by an International Advisory Committee (AC) consisting of subject experts that critically reviews the curricula, technical facilities, expertise in terms of faculty, etc.

The course curricula developed by the Centre and endorsed by the United Nations are adapted for the educational programmes. The educational programmes of the centre are oriented towards the dissemination of knowledge in relevant aspects of space science and technology. The centre offers Post Graduate level courses in these five areas. The model of the PG courses is designed as to emphasize university educators, researchers and application scientists on the development and enhancement of knowledge and skills coupled with a application project with a small component (3 months) in India and major one (one year) in their home country with a view to transfer the technology in their home organization. This gives an opportunity to the scholar to apply their knowledge and training received to deal with a 'real life' problem, where inputs from space technology can be used. Besides the Post Graduate level courses, the Centre also conducts short courses, workshops, awareness programmes on specific themes in the four areas, highlighting how space-based information can be used for national development. These educational programmes have benefited many scientists/engineers who will be the future policy & decision makers in several countries.

CSSTEAP conducts all of its educational programmes in close collaboration with one of the DOS institutions and thus has direct access to their physical facilities and intellectual capabilities. In addition to providing facilities,infrastructure and skilled manpower, the Government of India, through the Department of Space provides most of the funding. Funding grants for international travel of participants, subject experts, tuition fees and scholarships of students and the management of the centre are mainly provided by Department of Space on behalf of Host country. UN-OOSA also provides funding for travel of the participants. Other agencies financially contribute include are UNAgencies like UNSPIDER, Beijing, China; UN-ESCAP in Bangkok, Thailand, UNESCO and UNDP.

Educational Programmes

The Centre offers post-graduate (PG) level training in five areas of specialization namely:

1) Remote Sensing and Geographic Information Systems (RS & GIS),
2) Satellite Communication (SATCOM),
3) Satellite Meteorology and Global Climate (SATMET)
4) Space and Atmospheric Science (SAS), and
5) Global Navigation Satellite Systems (GNSS)

Apart from these, Centre conducts short courses on different themes of Remote Sensing and GIS, Small Satellite Missions and Navigation and Satellite Positioning system on regular basis. The Centre also organizes workshops & awareness programmes from time to time Till date the Centre has been conducted 49 PG Courses: 20 in RS&GIS, 10 in SATCOM, 09 in each SATMET and SAS and 01 in Global Navigation Satellite System. Three courses are presently ongoing namely RS&GIS, SATMET and SAS. In addition, the Centre has conducted 48 short courses and workshops in the past 21 years. These programmes have benefited some 1726 participants from a total of 35 countries in the Asia-Pacific region and 29 participants from 18 countries outside Asia Pacific region have also benefited from these educational programmes.

EVENTS

20ᵗʰ Post Graduate Course on Remote Sensing & Geographic Information System (RS&GIS)

RS&GIS

The twentieth PG course on RS&GIS of CSSTEAP commenced on July 1, 2015 ended on March 31, 2016 at Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, one of the host institutions of CSSTEAP. Total 24 participants from 15 countries of Asia-Pacific Region viz. three participants from Mongolia, two each from Bangladesh, DPR Korea, India, Kazakhstan, Kyrgyzstan, Nepal, Sri Lanka and one participant each from Fiji, Indonesia, Myanmar, Tajikistan, Thailand, Uzbekistan and Viet Nam attended the course.

The entire period of 9 months was divided into two semesters. Semester-I was further divided into two modules, Module-1A and 1B were of three and one month duration, respectively. Similarly, Semester-II also has two modules Module-II and Module-III of two and three months, respectively. Due to personal reasons one of the participant from Fiji had to leave the course in between after completing four months of the course.

Technical visits are a part of the course curricula. During technical visits, participants had opportunity to visit cultural & natural landscape in Visakhapatnam, Delhi, Hyderabad, Agra during December 24, 2015 to January 3, 2016. At Andhra University, they attended lectures on specialized topics &also their documents were verified for findingM.Tech. eligibility. Participants also visited Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS) a state-of-art multi-mission ground segment processing enterprise for earth observation satellites and witnessed real time acquisition of EO data at Shadnagar, Hyderabad. The course participants learnt a great deal with respect to practical and technical aspects of RS & GIS technologies and their applications during the three months of pilot project carried out in Module-III. This module is basically designed to carry out pilot project work by the course participants. Course participants developed and finalized pilot project in consultation

Dr. George Joseph, Chief Guest alongwith Dr. Senthil Kumar, Director IIRS & CSSTEAP awarding certificates to graduating students

with organization in their home country and supervisor of IIRS.

The broad topics of the pilot projects under taken by the course participants were:

(1) Crop inventory & soil moisture estimation using temporal RISAT-1 SAR data; (2) Evaluation of S-SEBI & SEBS algorithms in the estimation of crop evapotranspiration; (3) Drought risk assessment using RS & GIS; (4) Forest degradation assessment combining optical & SAR data and in-situ measurements; (5) Forest canopy density mapping & modelling with terrestrial Laser scanner data for upscaling forest carbon estimation; (6) Mineral

Top three rank holders & meritorious participants with CSSTEAP Excellence medals

mapping using EO-1 Hyperion data; (7) Geophysical investigation & Debris flow modelling for Landslide characterization; (8) Landslides susceptibility mapping & risk analysis; (9) Landsat-8 for retrieval of chlorophyll & sediment concentration in Lampung Bay, Indonesia; (10) Salt water intrusion into coastal Aquifer; (11) Modelling the impact of urban parameterization on climatic variables in a urban area; (12) Assessment of Ecotourism potential for sustainable development; (13) Study of Education facilities on surrounding of LULC of the part of Dehradun city; (14) Estimation of water balance components on Beas river basin in current & future climate scenarios; (15) Modelling of surface water & ground water interaction using SWAT & MODFLOW; (16) Hydrological aspects of site suitability selection for hydro power project using geospatial technology; (17) GIS based network analysis for emergency services- A case study of Bishkek city; (18) Spatial data quality parameters checking & automation using Python; (19) Identification Sea Ice of Korean Western sea using Fuzzy classification; (20) Hybrid & Quad Pol data processing for scattering pattern identification; (22) Synergistic use of optical & SAR data for open cast mine boundary detection;(23) Mineral mapping using simulated Hyperspectral data from Multispectral data; Land cover mapping using integration of SAR & optical remote sensing datasets

The valedictory function of 20th RS & GIS course was organized on March 23, 2016. Dr. George Joseph, Former Director, SAC & CSSTEAP was the Chief Guest of the Valedictory function. On the occasion, Memoirs comprising of messages from GB, AC members, eminent persons, course report and pilot project abstracts of students was released by Chief Guest. Dr. George Josephdelivered the valedictory address and awarded Post Graduate Diploma certificates to all the successful participants.

Eleven participants passed with Distinction, ten in First class and two participants passed as Pass grade. Three meritorious participants, Mr. ShesKanta Bhandari from Nepal, Ms. MedisettiBhavana from India and Mr. Manh Van Nguyen from Viet Nam were awarded Merit Certificates for 1st, 2nd and 3rd positions respectively. CSSTEAP Excellence medals alongwithmerit certificates were awarded by the Chief Guest to the meritorious students.

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20th PG Course participants along with dignitaries during valedictory function

21st Post Graduate Course on Remote Sensing & Geographic Information System (RS&GIS)

RS&GIS

21stPost Graduate Course on Remote Sensing and Geographic Information System of CSSTEAP commenced on July 1, 2016. A total of 20 participants from 11 countries of Asia and the Pacific Region have joined the course. Of the 20 participants, 3 each were from Kazakhstan and Sri Lanka, 2 each from Mongolia, India, Nepal, Uzbekistan and Myanmar and one candidate each from Fiji, Tajikistan, Kyrgyzstan and Thailand.

The course had been designed tohelp the participants at learning and skill development in geospatial technologies, as well as their applications in monitoring and conservation of the natural resources, tackling the challenges of climate change, natural disaster and their mitigation. The participants were from varied backgrounds like Hydrology, watershed management, Ecology, Meteorology, Urban and Regional planning, Geoinformatics, Surveying, cartography and disaster response.

The course has two phases. The Phase-I involved 9 months teaching at the IIRS and culminates today with the award of PG Diploma. Phase-II study which will be carried out in their home country on a dissertation research work of one year will lead to the award of M.Tech. Degree by Andhra University after its successful completion. The course structure is based on UN Curricula of UN-OOSA, with minor modifications as suggested by the International Advisory Committee and internal Board of Studies (BOS) committee. The entire period of 9 months of Phase 1 was divided into two semesters with 2 modules each.

The course started with an 'Induction week' where the participants were exposed to geographic perspective of India, social systems, customs and festivals of India, overview of space science, technology and applications, etc. Module-1A covered basically the fundamentals of RS&GIS with theory, practical and tutorials.The participants had several field excursions for ground truth collection and for interpretation and analysis of satellite data. Module-1B of Semester-I, of one month duration was on recent trends and advances in RS & GIS and environmental analysis & management including climate change.

21st PG Course participants along with dignitaries during valedictory function

In semester-II, the course participants choose one of the eight electives i.e. Agriculture & soils, Forestry& Ecology, Geosciences & geo-hazards, Marine & Atmospheric Science, Water Resources, Urban & regional planning, Satellite image analysis & photogrammetry and Geo-informatics. Based on their academic qualification, technical requirement of their parent organization and their professional experience, 5participants each had opted Geoinformatics and Satellite image analysis & photogrammetry; 3 each for Urban & Regional Planning and Water Resources; 2 for Forestry & Ecology, two for Marine & Atmospheric Science. Again considering their interest they were assisted to choose specific topics in Module III- i.e. Pilot project.

The major components of course syllabus were covered by the faculty of IIRS and additional lectures by guest faculty on specialized topics was also arranged for the academic benefit of the course participants. The subject experts were invited from various Indian Organizationssuch as India Meteorological Department (IMD); Wildlife Institute of India, Dehradun, Indian Institute of Technology (IIT),Roorkee, National Remote Sensing Centre (NRSC), Hyderabad; Aryabhatta Research Institute of Observational Research (ARIES), Nainital; Space Applications Centre (SAC), Ahmedabad, Andhra University, Visakhapatnam etc. to deliver specialized lectures.

The academic activities like theory, guest lectures, practical, etc. were organized in smart-class rooms. Lecture notes in the form of printed books and supplementary reading materials were distributed well in advance to all the course participants to help easy assimilation of the subject in the class and also for future reading. Academic performance of the course participants was evaluated in each semester through periodic internal and external examinations in the form of written and practical examinations; class test, tutorials, seminar etc.

The pilot project of 3 months which has been designed to help the participants to apply the

knowledge they have gained to carry out a project work on their own. Good quality project work has been carried out by the participants which have been evaluated by a panel of experts. Some of the notable areas of the pilot project carried out were:3D Close Range Photogrammetry, Ecosystem services Assessment, Space based solutions for extreme rainfall events, Seasonal Variation of Chlorophyll-a with Suspended Sediments Concentration, Polarimetric and Interferometric Modelling For Vegetation Height Estimation, Impact of Climate Change on Runoff Response, Evaluation of Open Spatial Data for Topographic Mapping and Analysis of Open Green Spaces to name a few.

The participants of the course also participated in the ISRS-ISG National Seminar in December 2016 and user Interaction Meet during February 2017 at IIRS Dehradun. Technical and educational visits to Andhra University, Visakhapatnamand National Remote Sensing Centre, Hyderabad were undertaken during October 2016. The participants hadopportunity to visit the Integrated Multi-mission Ground Segment for Earth Observation Satellites (IMGEOS) and watched the real time acquisition of EO data at Shadnagar, Hyderabad.At Andhra University, the educational records of all participants were scrutinized for assessing their M.Tech. eligibility. Here the participants also attended lectures on specialized topics on environmental analysis & management, marine, weather forecasting, etc. On the social front, the participants had glimpses of Indian festivities by their active participation in various festivals such as Dussehra, Diwali, Id-ul-Fitr, Christmas, New Year, Holi, etc.

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10th Post Graduate Diploma Course in Satellite Communications (SATCOM-10) and First Post Graduate Diploma Course in Global Navigation Satellite Systems (GNSS-1) of CSSTEAP.

The tenth Post Graduate Diploma Course in Satellite Communications (SATCOM-10) and first Post Graduate Diploma Course in Global Navigation Satellite Systems of CSSTEAP started on August 01, 2015 and concluded on 30 April, 2016 at SAC Ahmedabad. Sixteen participants from four countries of Asia Pacific region, namely Bangladesh, India, Mongolia and Nepal, attended the SATCOM-10 course and nine participants from four countries of Asia Pacific region, namely Bangladesh, India, Kazakhstan and Mongolia, attended the GNSS-1 course. The Joint Valedictory function was held on 25 April 2016 at Bopal Campus, SAC.

Shri K.S. Parikh, DD, SNAA welcomed the participants and invitees to the function and said that the entire function will be memorable and wished great success. Dr. Sarnam Singh, Programme Coordinator, CSSTEAP said in his address that there was a big competition in 1995 to organise these courses and finally India won the bid to organise these prestigious courses. He said that, now the focus is on disaster management and the SATCOM, GNSS technologies will help us in this direction. He further described about the ongoing courses in CSSTEAP and concluded his speech with future courses in CSSTEAP. Shri D.K. Das, DD, SNPA motivated the participants and described the learning process and how 100% learning can be achieved by various factors in the learning cycle. Dr. Raghunadh K Bhattar, Course Director, SATCOM-10

& GNSS-1 presented the course report. Many course participants came forward to express their views about the course and gave their valuable feedback. They said that the course structure was very well designed and they have very much benefitted from the course. They also expressed that repetitions in some topics might have been avoided. The Chief Guest of the function, Dr. Anup K. Singh, Director General, Nirma University was kind enough to present the PG Diploma certificates to SATCOM-10 and GNSS-1 participants. Later, in his address to the audience, he said that ISRO is one of the finest organisations and it is a matter of pride to graduate from here. He emphasised on the team management skills and said that learning is individual but execution is team work. The medals were given to rank holders in both SATCOM-10 and GNSS-1 courses. Finally, Dr. Raghunadh K Bhattar, proposed the vote of thanks and thanked all the focal persons, faculty, all departments of SAC and PRO team for their support in successful completion of the course.

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Participants of SATCOM-10 Course with dignitaries

Participants of SATCOM-10 Course with dignitaries

10ʰ Post Graduate course in Satellite Meteorology and Global Climate

The Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations, is imparting training in various disciplines including "Satellite Meteorology and Global Climate (SATMET)". The Tenth Post Graduate Courses on Satellite Meteorology and Global Climate has commenced at Space Applications Centre (Bopal Campus), Ahmedabad, on August 1, 2016. Up till now we have trained 150 students from ASIA Pacific countries.

Thirteen participants representing seven countries of the Asia Pacific region are attending the Courses, viz. Bangaladesh-2, India-2, Nepal-1, Kyrgyzstan-3, Malaysia-1, Mongolia-3, Thailand-1.

SATMET-10 course has 2 semesters spread in 3-modules. The 1st module covers the fundamentals of Satellite Meteorology and Global climate, and 2nd module deals with Advance Concept of Satellite Meteorology, e.g., Geophysical Parameter Retrieval and Satellite Products and their application in NWP etc. The 3rd module, called Pilot project module (duration: 3 months) the participants have to do project on a topic relevant to their own country under the guidance of an expert scientists from Space Applications Centre, Ahmedabad

Faculty members for this course were drawn mostly from AOSG and SAC, Ahmedabad. There were also lectures from experts from PRL, IMD and Andhra University. In addition to class room lectures during the morning hours, practical using satellite data were conducted in the afternoon sessions. Weather discussion and climate seminar was also conducted during the course. Tours were conducted to Northern India and Southern India covering various institutes like IMD New Delhi, DWR-Chennai, INCOIS& NRSC Hyderabad, IMD, Andhra University Vishakhapatnam, SDSC-SHAR, and also the important monuments of India.

The pilot projects have already commenced from February, 2017. The broad Themes of the pilot project include:

- Assimilation of satellite data and impact studies of severe weather using WRF model
- Sounding products - INSAT-3D / AIRS and MODIS data - validation/Applications.
- Cryosphere (assessment of change)/ over Kyrgyzstan.
- Mesoscale convective studies using satellite data.
- Radio Occultation and Application.
- Structural analysis of Tropical cyclone using high resolution scatter-meter data.
- Now-casting using satellite data.
- Climate modelling Applications.
- Rainfall estimation
- Validation of SAPHIR data from Megha Tropiques.

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SHORT COURSES

10ʰ Post Graduate course in Space and Atmospheric Science

The Tenth PG course in Space and Atmospheric Science (SAS-10) is being conducted by Physical Research Laboratory (PRL), Ahmedabad at its Bopal Campus from August 1, 2016 under a programme by The Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations. The course will end on April 30, 2017.

The course has 3 modules spead over two semesters. Subjects covered in the 1st module were Atmosphere, Ionosphere, Ground Based Techniques, Space Instrumentation and Space Exploration wheras the 2nd module covered topics on Magnetosphere, and Astronomy (Solar, Radio and Stellar). Faculty members included eminent Scientists/Engineers from PRL and other Institutions in India. Each subject was taught in 40 one-hour lectures during the morning hours. Relevant practicals were conducted in the afternoon sessions. For each of these subjects, there were tests, assignments and short seminars which were graded and used for internal assessment of the students.

As a part of the programme, the students were taken on a scientific tour to Udaipur Solar Observatory and the infra-red observatory at Mt Abu.

The 3rd module, called Pilot project, has started from February 2017. Each student chooses a topic of her/his research interest and pursues the research under the guidance of a faculty of PRL. The pilot project topics are as follows:

Instrument demonstration

1. Temperature and soil moisture change over Ulaanbaatar, Mongolia

2. Ozone and its precursors in Ahmedabad : Features of diurnal and day-to-day variations

3. Study of waves and oscillations in the Earth's atmosphere

4. Investigation of Atmospheric Greenhouse gases over India

5. Determination of aerosol optical depth by using sun photometer

6. Study of Aerosol Black Carbon

7. Enhancing spectropolarimetry of CZT Imager, AstroSAT

8. CCD Photometry of AGNs

9. Study of stealth CME and ICME

10. Study of halo CME in interplanetary medium during 2011

11. Study of Proton Flare Characteristics and Their Relation to CME Dynamics

12. Looking at the coronal loop dynamics using numerical simulations

Classroom at Bopal campus SAC, Ahmedabad

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Short Courses

Advances in Geospatial Tools in Forestry and Ecology Application

The loss of the forest cover as a result of deforestation and constant increase in the ecological foot print of the humanity is resulting in degradation of the ecological services. It has resulted in unsustainable extraction of the ecosystem goods and services and also impacting Earth's atmosphere. Furthermore the impact of various anthropogenic and climate change induced disasters are attributed to global climate change and will have profound impact on the different ecosystems on the earth. The loss of biological diversity reduces the ecosystems ability to adapt to the change. Biologically diverse ecosystems apart from providing the basic ecosystem services like climatic stabilization and carbon sinks is also a vital resource for technological development in agriculture, bioprospecting, pharmaceuticals and other technological innovations for societal benefits. The need of the hour is a systematic spatial and temporal monitoring of the natural resource and the intensity of the anthropogenic pressure on the resources.

Earth Observation and Geographical Information System technologies have opened new vistas for natural resource management. Remote Sensing provides an important tool for extraction of information in near real-time and in spatial and temporal domains. Advances in RS and GIS include improvement in the spectral and spatial resolutions like Hyperspectral remote sensing, microwave remote sensing and LIDAR remote sensing and high resolution multispectral remote sensing for forestry and ecological applications. These advances have been useful in improving the accuracy of mapping, ecological characterization, management perspectives, REDD+, etc. Geoinformatics provides a

Group Photograph of the participants and faculty

Group Photograph of the participants and faculty

framework for measurement, monitoring, modeling, planning, decision-making and management of our environment and natural resources. With introduction of GIS the ecological modeling has reached a totally new dimension as the impact of anthropogenic pressure and climate change can be modeled in time and space. This training aimed to familiarize the users/researchers/ professionals / decision makers/ academicians in the recent advances in the RS and GIS applications in forestry and ecology.

Considering the need the training course was organized by Centre for Space Science and Technology Education in Asia and Pacific (CSSTEAP) and conducted by the faculty of Indian Institute of remote Sensing, ISRO Dehradun, India from 23rd May to 21st June, 2016. The participants were familiarized to use of various kinds of remote sensing data and geoinformation science starting from assessment of the forest resources, ecological studies, quantification of biomass and carbon, ecological damage and risk assessment, and geospatial modeling and also modern trends of research on climate change, invasive species mapping and modeling, use of Terrestrial laser Scanner, Hemiview, etc. The course was attended by 20 participants from 09 countries of Asia and Pacific region. Lectures and practical were conducted mostly by IIRS faculty members and with few special lectures by prominent speakers of former faculty of IIRS.

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SHORT COURSES

Short Course on Space Weather

Space weather is a branch of Physics and Aeronomy. Its study includes time varying activities on the Sun e.g., solar flares, filament eruptions, coronal mass ejections, which cause massive energy and mass flow through interplanetary medium and affect the entire Solar System. The space surrounding the Earth undergoes drastic changes: magnetosphere, ionosphere and thermosphere suffer large-scale changes. Today there are space vehicles and space missions stationed and/or passing through the interplanetary space. Some of these may be manned. The solar wind and radiation affect human health in space. These solar energetic events can cause disruption of electronics and communications systems on-board and also those on Earth. Global Positioning System receivers and cell phones react to some solar emissions, degrading service during such events. Space weather plays a very important role in life on Earth including humans. It affects almost all aspects of modern society. A clear understanding of space weather has thus become a necessity for modern civilization. With this view in mind, the Centre for Space Science and Technology Education in Asia and Pacific region (CSSTEAP) organized a short course on "Space Weather" conducted at Physical Research Laboratory (PRL), Ahmedabad for the participants from Asia-Pacific region.

The inaugural ceremony was held at PRL on 9th May, 2016. It was a cosmic coincidence that Mercury was passing across the Sun that very day! The course had a duration of one month. Thirteen members from six countries participated. A total of forty one-hour lectures were delivered by PRL's expert faculty on primary solar sources of space weather, propagation of the electromagnetic radiation and charged particles through the interplanetary space, dynamics of Earth's

Valedictory function of the short course on Space Weather

magnetosphere, ionosphere and thermosphere, short and long term consequences of Sun's activity on other planetary systems, and now-cast and forecast of space weather events. For a better understanding of the theory, there were practical sessions on identifying Fraunhofer lines in the solar spectrum, calculating Full width at half maximum (FWHM) of H-alpha line, estimating rotation rate of the Sun and speed of a coronal mass ejection, measurement of interplanetary magnetic field, radio sounding of ionosphere and measurements of TEC over Ahmedabad, and optical techniques for space weather studies.

At the end of May, the students were taken to Udaipur and Mt Abu for a short scientific tour. They visited the site of Global Oscillation Network Group (GONG) at Udaipur Solar Observatory (USO). The GONG site is part of a global network to make continuous observations of the Sun and provides rich information about solar activity. The students got exposure regarding the working of the GONG instrument and the data products from the GONG. They also visited the multi-application solar telescope (MAST) installed on the island in Lake fatehsagar. MAST is a state-of-the-art modern 50 cm aperture telescope to observe the photospheric and chromospheric layers of the sun. The working principle and design of the main telescope and the instruments for imaging were explained to the students. An introduction to the adaptive optics system developed for compensating atmospheric seeing was also given. Live solar images were shown to the participants and various features and their properties were described. At Mt. Abu Observatory, the students got a glimpse of the functioning of 1.2m infrared telescope and the back-end instrumentation.

At both Udaipur and Mt Abu the students were taken on sightseeing tours which they thoroughly enjoyed. The short course ended on June 8 with a colourful valediction ceremony. Feedback from the students was very positive. Dr. George Joseph, Padma Bhushan, graced the occasion as the Chief Guest.

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5ᵗʰ Short course on Small Satellite Missions

The Fifth CSSTEAP International Training Course on Small Satellite Missions (SSM-2016) was conducted in ISRO's training Centre cum Guest House at Devanahalli, Bangalore. The Course was jointly conducted by CSSTEAP and ISRO Satellite Centre (ISAC) from November 21 to December 2, 2016 with an objective:

- To create an awareness of the potential of space technology and its opportunities
- To create an awareness of the potential of small satellites
- To update on the on-going activities small satellites in ISRO
- To create an awareness the technology involved in small satellites
- To prompt researchers and professionals in design, develop, launch and utilizing the benefits of small satellites.

The course commenced on 21ˢᵗ November with 25 participants from Asia-Pacific countries (9 countries: India, Kazakhstan, Kyrgyzstan, Vietnam, Nepal, Mongolia, Srilanka, Tajikistan, Indonesia) and 12 officials from ASEAN (7 countries, i.e. Brunei, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, and Vietnam) joined the course. The Course was inaugurated on 21ˢᵗ November by Dr. T. K. Alex, Member Space Commission, Govtof India andpresided by Director of ISRO Satellite Centre, Dr. M. Annaduraiand Dr. A. Senthil Kumar, Director CSSTEAP/Director IIRS.

The syllabus covered various aspects ranging from benefits of space technology, India's space capabilities, technology involved in small satellites,

applications of small satellites and management of small satellites. The lectures were delivered by the faculty from ISAC, ISTRAC and ANTRIX Corporation. The course was a blend of theory lectures, video sessions, interactive sessions and demonstration with exhibits. There was also an exclusive visual space station tracking with details from open source and local communication and participants were also taken to different ISRO centers like ISRO Satellite Integration & Test Establishment (ISITE) and ISRO Telemetry, Tracking & Command Network (ISTRAC) for facility visit.

As a part of the course, participants also carried out a small project where the participants were divided into four heterogeneous groups. The Projects included making of models of Lunar Lander, Lunar Rover, twins for space rendezvous and docking and amedium sized satellite with payloads for green-house gases and pollution measurements. At the end of the course a formal feed was taken and all the participants expressed an overall satisfaction and appreciated the quality of the presentations and the content delivered.

The Valedictory function was held on 2ⁿᵈ December and was presided by Dr. M. Nageswara Rao, Associate Director, ISRO Satellite Centre. The Certificates were given away by Associate Director ISAC.

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Weather Forecasting using Numerical Weather Prediction Models

Numerical Weather Prediction (NWP) is the quantitative forecast of weather or climate based on a model or a set of models derived from our "best" understanding of the physical processes that govern the atmosphere or the climate. A NWP model is basically a set of partial differential equations (PDEs) that describe the dynamic and thermodynamic processes in the earth's environment. The NWP models require initial and boundary conditions that are integrated forward in time to represent and predict the weather. During past four decades, the Numerical Weather Prediction is now a well recognized discipline of operational sciences that encompasses the elements from various other disciplines such as the computer science, satellite remote sensing, satellite communication, etc. Even though NWP forecasts is significantly superior and unmatchable to the manual forecasts. However, the science of NWP is constantly evolving with innovations in computer technology, improvements in our understanding of physical processes, and the availability of new observations from terrestrial, airborne and space-based platforms. One of the present day challenges of NWP is to understand the nature of biases and errors in the modeling of physical processes as well as in the observations from various sources, and to obtain the most accurate assessment of the state of the present and future weather or climate.

One of the important roles of weather forecasting is to help society about rare and extreme events, such as tropical cyclones, heavy rainfall, high winds, that can cause severe damage and losses of human lives and property. However, accurate weather forecasting and continuous monitoring of cyclones like HudHud, Phailin, etc. in Bay of Bengal have

reduced the loss of human lives to less than a dozen in Eastern Coast of India. Therefore, numerical models have now become essential tools in environmental science, particularly in weather forecasting and climate prediction. Numerical Weather Prediction (NWP) uses the power of computers to make a forecast. Currently, 90% of the total data used in the operational NWP models comes from space-borne observing systems. The increase in the quality and range of satellite observations together with advanced data assimilation techniques and enhanced computational resources has led to significant forecast improvements. Currently, due to the lack of proper training and expertise, space based observations are under-utilized by NWP community, particularly in Asia Pacific region. Therefore, well trained weather forecasters are needed to utilize the vast amount of satellite data in the NWP models for improved prediction of extreme weather events.

Therefore, overall objectives of this training course was to generate awareness amongst users/ researchers/professionals/academicians on fundamentals of numerical weather prediction and data assimilation. The participants were familiarized with the use of numerical weather prediction models, particularly the world's most widely used model for weather prediction, the Weather Research and Forecasting (WRF). The Mesoscale and Microscale Meteorology (MMM) Division of National Center for Atmospheric Research (NCAR) supports the WRF system to the user community. In addition to this, participants will be made aware of assimilation techniques to make best use of conventional and satellite observations in prediction of extreme weather events. The course was organized 4th April to 17th May, 2016 by the CSSTEAP and conducted by IIRS. This course was attended by 23 participants from 07 countries of Asia and Pacific region were benefitted. The subject experts from IIRS, SAC, IIT Delhi, CMMACS Bangalore, NCMRWF, Noida etc. delivered lectures. The practical exercise were conducted HPC facility at IIRS.

Group Photograph of the participants of NWP Course

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Disaster Damage and Loss Assessment using Satellite Data in Natural and Cultural Heritage Sites using Geospatial Techniques

The natural and cultural heritage sites have outstanding universal value from the point of view science, history or art. The cultural heritage sites include monuments which depict the architectural works, monumental sculptures, paintings, inscriptions, cave dwellings, architecturally important groups of buildings, sites of archaeological importance having historical, aesthetic, ethnological or anthropological importance, etc. Cultural and Natural heritage conservation in Asia and the Pacific region has been facing many challenges in recent decades as a result of extreme pressure exerted on these sites and ecosystems. UNESCO (2012) in its second cycle of Periodic Reporting (2012) on World Heritage Centre on the State of Conservation of World Heritage properties in Asia and the Pacific, has emphasized capacity building for World Heritage conservation and management. Most of the countries are aware of such requirement but due to lack of technical and scientific expertise, awareness at local level, finance, social unrest and law and order issues these sites are deteriorating or vanishing over the time.

Natural as well as man-made disasters cause immense damage to cultural and natural heritage structures. Each country is required to identify and list such property of the cultural and natural heritage sites threatened by serious and specific dangers, such as the threat of disappearance caused by accelerated deterioration, large-scale public or private projects or rapid urban or tourist development projects; destruction caused by changes in the use or ownership of the land; major alterations due to unknown causes; abandonment for any reason whatsoever; the outbreak or the

threat of an armed conflict; calamities and cataclysms; serious fires, earthquakes, landslides; volcanic eruptions; changes in water level, floods and tidal waves. Therefore, capacity building through educational and information programmes, to strengthen appreciation and respect towards the cultural and natural heritage using modern tools and technologies to identify, protect, conserve, manage and rehabilitate these areas is of paramount importance.

RS, GIS and GPS have immense potential to assess the damage and loss due to disasters. Very High resolution satellite and/or aerial remote sensing data is being used to map and monitor the heritage sites. Terrestrial Laser Scanning (TLS) and 3-D visualization techniques have opened new vistas for database creation of such monuments. These techniques can play an important role in recording, rehabilitation and reconstruction of the heritage sites. This course was first on this important theme and attempted to address some of these issues. Considering the urgent need the present course was jointly organized by CSSTEAP and UNESCO C2C and conducted jointly by the faculty of IIRS and Wildlife Institute of India with objectives (a) Contribute to the strengthening of capacities in the management of Natural World Heritage in the region; (b) Contribute to achieving a more balanced representation of properties from Asia and the Pacific on the World Heritage List; (c) Raise awareness among the general public and the youth in particular of the importance of Natural World Heritage and the need to protect it; and (d) Foster international cooperation on Natural World Heritage initiatives. The course was conducted 13th to 30th September, 2016. The course was attended by 24 participants from 11 countries of Asia and Pacific region. Expert subject faculty were drawn from IIRS, Dehradun and WII, Dehradun and with few special lectures by prominent speakers from UNESCO, UNEP, World Bank, UNESCAP, LBSNAA, MHRD, ASI, KNP etc. and International speaker from IUCN, Nepal. The participants visited cultural sites in and around Delhi, Agra and Fatehpuri Sikri and natural heritage site of Keoladev National Park, Bharatpur Rajasthan.

Course participants during field visit to cultural heritage site in Delhi

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PILOT PROJECT ABSTRACTS

Project Abstracts of 20th Post Graduate Course on Remote Sensing & Geographic Information System

Creating Python Scripts for Geodatabase Analysis and Data Updating by Mobile Mapping

In any GIS project, data capturing and processing task take most of the time. In data processing Geo-processing tasks can be time intensive since they are often performed on a number of different datasets or on large datasets with numerous records. Data quality is the major thing which must be known to make use of geospatial data. In case of geospatial data some of the quality parameters are positional accuracy, attribute accuracy, completeness, logical consistency, metadata, topology etc. Any GIS software has capability to check some of the data quality parameters. But using programming language like Python, all parameters can be addressed and process can be made automatic based on some rules. Scripting is an efficient method of automating Geo-processing tasks. Scripts are reusable and data nonspecific. The aim of this project is creating python scripts for geo-processing in ArcGIS 10.0 environment. Data used for this project is 3D vector data

digitized from aerial photograph with 0.5 meter spatial resolution. Data is analyzed using ArcGIS software to identify the problem and rules (topological rules, quality parameters). The Python script is developed to rectify identified problems for Geodatabase.

Mobile mapping technology is wireless communication combined with Remote Sensing, GIS, GPS are used for acquiring new information or updating the existing information. Mobile mapping not only helps to update the information at faster compared to traditional method but also it is cost effective method.
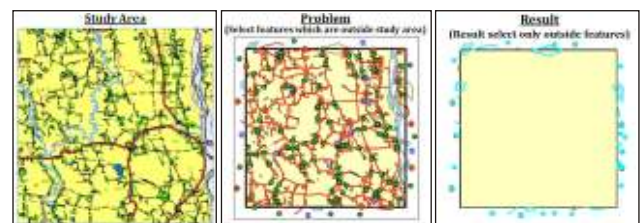
Estimation of Crop evapotranspiration using Landsat 8 images data and S-SEBI algorithm in Western U.P

Evapotranspiration (ET) is an important part of the environmental applications, such as optimizing irrigation water use, irrigation system performance, crop water deficit, drought mitigation strategies, and accurate initialization of climate prediction models. Especially, crop evapotranspiration rate is highly important for identification of crop stress due to crop disease, water deficiency, and insect infestation. The gist of the remote sensing approach for estimating ET is to accurately quantify radiation and turbulent heat fluxes using radiometric measurements from satellite sensors. The gist of the remote sensing approach for estimating ET is to accurately quantify radiation and turbulent heat fluxes using radiometric measurements from satellite sensors. The more advanced and successful of these are based on the thermal infrared signals that contain information on the spatial distribution of the land surface temperature (Wang et al., 2006).The more advanced and successful of these are based on the thermal infrared signals that contain information on the spatial distribution of the land surface temperature (Wang et al., 2006). The major advantages of this particular technique over other remote sensing flux algorithms are stated as follows.

- No additional meteorological data is needed to calculate the fluxes if the surface hydrological extremes are present.
- The extreme temperatures for the wet and dry conditions vary with changing reflectance values, where the other methods try to determine a fixed temperature for wet and dry conditions for the whole image or for each land use class.

Unlike other algorithms procedure in S-SEBI algorithm the sensible flux and latent flux are not calculated as separate, but as the evaporative fraction() a term which has been explained earlier.

The purpose of this project is to estimate actual evapotranspiration of agricultural region using Landsat 8 images and S-SEBI algorithm in the western Uttra Pradesh of India. First, the parameters of the surface energy balance system was be estimated from Landsat 8 images data for ETc.

Finally, the daily Evapotranspiration of agricultural region during kariff season and rabi season of the period from May, 2014 to June, 2015 was be estimated. The results obtained based on S-SEBI algorithm was be compared with Scintillometer data.
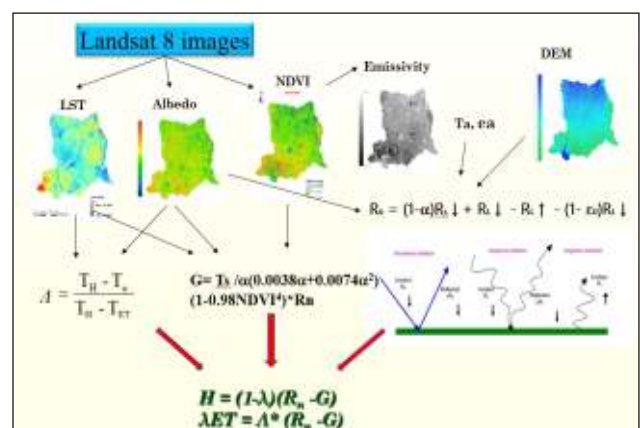
ETcresult of the day 12th Feb 2015

Evaluation of Low and High Incidence Angle RISAT-1 Hybrid Polarimetric SAR Data for Crop Discrimination

Crop discrimination is the first step for many agricultural related applications using remote sensing data. Optical and infrared sensors have already proved their potential in this field. But under cloud cover conditions operational capabilities of optical and infrared sensors are very limited. Synthetic Aperture Radar (SAR) offers an opportunity to address this important issue due to its all-weather capabilities. All weather capability of SAR when coupled with its other unique capabilities like sensitivity towards physical, geometrical and di-electrical properties of the target under consideration makes it a right choice for agricultural applications and crop discrimination. Although role of SAR data in agricultural applications including crop discrimination has been well understood and well documented but use of hybrid polarimetric SAR data in this field has been grossly under explored and under reported. Launch of RISAT-1, the Indian indigenous SAR satellite makes multi-incidence angle multi-temporal hybrid polarimetric SAR data available for remote sensing community. In this study an attempt has been made to evaluate low and high incidence angle hybrid polarimetric RISAT-1 SAR data for crop discrimination. For this study, two hybrid polarimetric RISAT-1 SAR dataset were acquired dated on 16 August 2015 at 32 and 17 August 2015, at 14 incidence angle over parts of Haridwar District, India. To achieve the objective, backscatter (RH & RV) and mspace decomposition polarimetric parameters

in terms of even bounce, odd bounce and volume componentwere generated from both the datasets to know the scattering mechanism for different agricultural crops and other land cover classes. All the generated backscatter (RH &RV) and m polarimetric decomposition parameters images were geo-referenced and stacked in single file to use following seven different combinations for crop discrimination:

1. RH-RV of high incidence angle
2. RH-RV of low incidence angle
3. Even-volume-odd component of high incidence angle
4. Even-volume-odd component of low incidence angle
5. RH-RV of high and low incidence angle
6. Even-volume-odd component of high and low incidence angle
7. RH-RV of high and low incidence angle and even-volume-odd component of high and low incidence angle

All seven images were used for supervised classification based on the ground truth information. The studyindicated that polarimetric decomposition parameter is very useful for detection and detailed study of different crops compare to backscatter parameters. It was also observed that high incidence angle data is more sensitive for crop discrimination. However, classification accuracy further enhances by the combination of low and high incidence angle hybrid polarimetric RISAT-1 SAR data.

Identification Sea Ice in Korean Western Seaby using Fuzzy Classification

In winter season, it is important to forecast the situation of sea ice accurately for navigation and fishery. Sea ice is formed in Korean Western Sea during winter. Until now almost scientists have studied about multiyear ice in the Arctic and the Antarctic for assessing the effect of ice to global climate using MODIS and SAR data.

Generally NDSI (Normalised Difference Snow Index) is applied for detecting sea ice from remotely sensed data. After calculating NDSI, the pixels which meet the threshold are classified as snow and sea ice.

There are several kinds of objects such as not only sea water but also soil (islands), snow and sedimentin this study area, and consequently the sea ice of Korean Western Sea has properties different from them of the Arctic and the Antarctic.So the methods used in former literatures couldn't be applied to this study for accurately classifying sea ice as mentioned methods.

In this study, Landsat8 OLI data has been utilised. Samples of several types of sea ice and other objects were collected, their spectral features were analysedand processed by applying PCM (possibilistic c-Means) classification with 12 measures of similarity and dissimilarity. PCM is a modified form of FCM clustering technique that assigns representative feature points the highest possible membership, while unrepresentative points get low memberships.

All results were analysed according to several types of sea ice and different measures and chose the thresholds in that pixels of processed images were classified as sea ice. The processed images were converted to binary images based upon thresholds and integrated into one image according to different measures.The areas of sea ice were calculated corresponding to measures, compared and analysed which measure and why gave the best output.Caberra measure gave the best classification output at the lowest threshold. In other words, the measures besides Canberra misclassified other objects as sea ice when the thresholds decrease below values further less than threshold of Caberra.

After then, temporal landsat8 OLI data were processed by PCM with Canberra measure and variation in sea ice was observed. The deficiency of Caberra-measure is to misclassify water of river estuary as sea ice in case sea ice involves some sediments and the brightness values of the pixels are low.

Sea Ice of Korean Western Sea

Climate Oriented Urban Classification using Earth Observation data

Urban areas constitute about 23% of Earth's surface and contains about half of world's population is accountable for 75% of the GHG emissions thereby altering the climatic patterns. Considerable progress was recently made in the determination of urban morphologies from different Earth Observation (EO) datasets. Though globally available LULC takes urban entity as a single unit. Urban area is heterogeneous in nature, due to its heterogeneity it produces distinct micro-climates. Urbanization is taking place at a faster rate in India .Urbanization negatively impacts the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere and the covering of the soil structure. One of the best known effects of urbanization is the Urban Heat Island (UHI). Urban climate is affected by its permeability, geometry, urban fabric and anthropogenic heat. The new "local climate zone (LCZ)" classification system provides a research framework for urban heat island studies and standardizes the worldwide exchange of urban temperature observations (Stewart & Oke). The main objective of the study is to classify urban areas using different EO datasets and further comparing the results of the identified methods. Delhi which is the 3rd largest urban area in the world located on the banks of the river Yamuna is taken as study area due to its typical

monsoon influenced semi arid climate. BesidesDelhi has acquired as characteristics of variety of development patterns in the process of becoming a metro city. For this study Bechtel et al, 2012 (WWW.WUDAPT.org) method and nDSM based method have been identified.B ectel method is based on random forest classifier and LCDM data for generation of Local Climate Zonation. In nDSM based method, Very High Resolution(VHR) nDSM from Pleiades data and LULC has been used for generation of Local Climate Zonation Map. The results of this study is vey accurate. This considerable accuracy potential provides some evidence that LCZ can be derived from the EO datasets. The output of this study is directly used as an input of NWP. Figure 1 & 2 represents Local Climate Zonation Scheme which is proposed by Stewert and Oke, Figure 3 represents the final output of the Bectel method and figure 4 represents area of the respected LCZ.
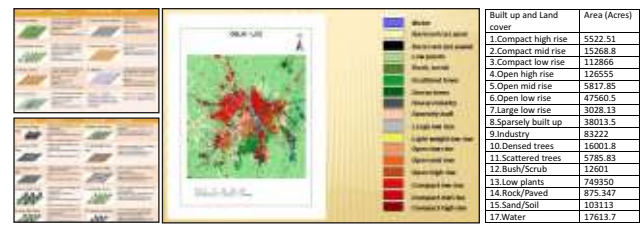

Built up and Land cover	Area (Acres)
1.Compact high rise	5522.51
2.Compact mid rise	15268.8
3.Compact low rise	112866
4.Open high rise	126555
5.Open mid rise	5817.85
6.Open low rise	47560.5
7.Large low rise	3028.13
8.Sparsely built up	38013.5
9.Industry	83222
10.Densed trees	16001.8
11.Scattered trees	5785.83
12.Bush/Scrub	12601
13.Low plants	749350
14.Rock/Paved	875.347
15.Sand/Soil	103113
17.Water	17613.7

*Fig. 1 & 2: Local Climate Zonation Scheme*   *Fig. 3: LCZ Output*   *Fig. 4: Area of LCZ*

Hybrid and Quad-pol data processing for identifying scattering patterns

The present study aims at expounding the paramount importance of PolSAR calibration and decomposition modelling of hybrid-pol and quad-pol data for scattering information retrieval and to study the effect of polarisation orientation angle shift on different scattering elements. A part of Dehradun covering Haridwar, Rishikesh and Barkot forest has been chosen for the study. Here, RISAT-1 FRS-1 hybrid-pol mode and FRS-2 quad-pol mode acquired in c-band were used to conduct a study on the quad-pol data generated from the hybrid-pol data of RISAT-1. The hybrid-pol data has an advantage of self-calibration while the quad-pol data was calibrated manually for the real and imaginary part of each polarisation mode (HH, HV, VH, and VV). The remarkable feature of this project would be to investigate and explore completely the potential of quad-pol data derived from partially polarised hybrid pol data for the purpose of understanding the effect of polarisation orientation angle shift in quad-pol RISAT-1 data and to make a comparative analysis of the scattering pattern information retrieved from hybrid-pol, quad-pol data of RISAT-1 and POA shift compensated data after applying certain methods of POA compensation and also using decomposition modelling techniques like m-α, m-δ, m-χ for hybrid polarimetric data; van-zyl and yamaguchi decompositions for quad-pol data.The methodology was

implemented by generating stokes parameter for the hybrid-pol data, then decomposition techniques: m-delta, m-chi and m-alpha were generated by implementing the respective formulae in ENVI band math function. 100 sample points were chosen from each region of interest like river, urban, forest and dry river bed and graphs were plotted in excel separately for each feature to make a comparative analysis of the scattering elements retrieved from each of these three decompositions. It has been observed that m-alpha decomposition technique shows better scattering response from different features. Urban feature shows prominent double-bounce scattering in pink/red and river shows surface scattering in blue colour and forest in green. There is equal weightage to the respective scattering pattern from every feature in m-alpha decomposition without any overestimation which was found in m-chi and m-delta decompositions.
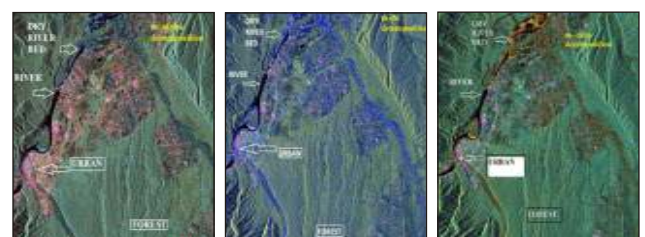
Retrieval of Chlorophyll-A and Suspended Sediment Concentration Using Landsat 8 OLI in Lampung Bay, Indonesia

Phytoplankton biomass and Suspended Sediment Concentrations are responsible for changing the spectral composition of ocean water. The color of the ocean in coastal area can be detectedby satellite remote sensing such as Landsat 8 OLI. The objectives of this study are retrieval of chlorophyll-a (Chla) and suspended sediment concentration (SSC) in Lampung Bay using Landsat 8 OLI bands. In this study subsurface reflectance of Landsat 8 OLI bands and field measurement from insitu radiometer (TriOS RAMSES) are used for evaluation of existing algorithms and development of site specific algorithms for retrieval of Chla and SSC and to generate Chla and SSC maps from Landsat-8 OLI data. The existing algorithms such as ocean Color OC2 and OC3 along with some algorithms based on band ratio with linear and multiple regressionanalysis are applied for retrieval Chla in Lampung Bay. Similarly, for retrieval of SSC, the existing algorithms based on single band, various band combinations with band ratio are applied and their statistical analyses have been carried out. The meanof reflectance spectra corresponding to three types of dinoflagellates (*Pyrodinmium Bahamense, Gymnodinium and Cochlodinium Polykrikoides*) and one diatom (*Chaetoceros* Sp.) have been analyzed. Since, the existing algorithms failed to provide better result, an attempt has been made to generate site specificnew coefficients for the established existing algorithms using the available in situ field observations. The algorithms with new coefficients have been applied to the Landsat-8 OLI data to generate chlorophyll and suspended sediment concentration maps in the Lampung Bay. The satellite estimated and in situ measured Chla and SSC are compared and the statistical analysis have been presented. The distribution of Chlavaluesin Lampung Bayis between 0.025 to 9.85 µg/L with an average value of 0.774 µg/L. While the distribution of SSC in Lampung Bay is between 22.45 to 280.52 mg/L with an average value of 148.61 mg/L. The analysis indicates that the Lampung Bay coastal waters are turbid in nature due high sedimentation near the coast. The spatial and statistical analysis indicates that the Chlain Lampung Bay is little bitinfluenced by suspended sediment concentration.
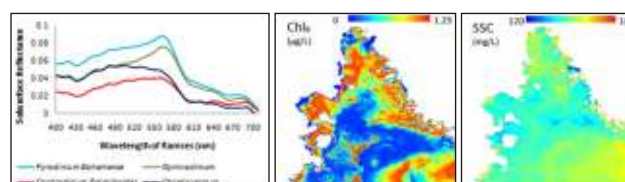

Synergistic use of optical and SAR data for opencast mine boundary detection

Opencast coal mining has a number of adverse effectson the Earth's surface environment which could jeopardize the human communities as well as flora and fauna nearby the mining site. Thus, a constant monitoring of opencast mines is a necessity to prevent these effects caused by the mining activity. Taking into account the environmental concerns related to opencast coal mining, this project aims to suggest a remote sensing solution for opencast mines boundary detection. With the advantages of covering large area, providing continuum data from the satellites in operation as well as archive remote sensing data, remote sensing techniques can be used efficiently in the monitoring of opencast mines. This information can be used in various activities related to the mines such as monitoring, pollution control, reclamation etc.

In this study, synergistic use of optical and SAR images can act as an effective tool for detecting opencast mine boundaries. Use of high spatial resolution optical data can help for detecting opencast mine boundaries in terms of shape and size. To detect opencast mine boundaries, Histogram Based Segmentation (HBS) and Watershed Transform Segmentation (WTS) were performed on the Digital Elevation Model (DEM) obtained from InSAR of ALOS PALSAR data and on the DEM from Cartosat stereo-pair. The HBSalgorithm partitions the image into different regions which are same according to some predefined criteria. From all the pixels in the images a histogram is computed, the clusters in the image are then located by using the peaks and valleys in the histogram. WTS is applied on the gray scale image for solving various segmentation problems as gray scale images can be considered as topographic surfaces. Here the intensity of a pixel is regarded as the height of the pixel. Opencast mines boundary detection using watershed transform segmentation has shown better results in comparison with Histogram Based Segmentation technique.

A :   Cartosat DEM   HBS   WTS

B :   ALOS DEM   HBS   WTS
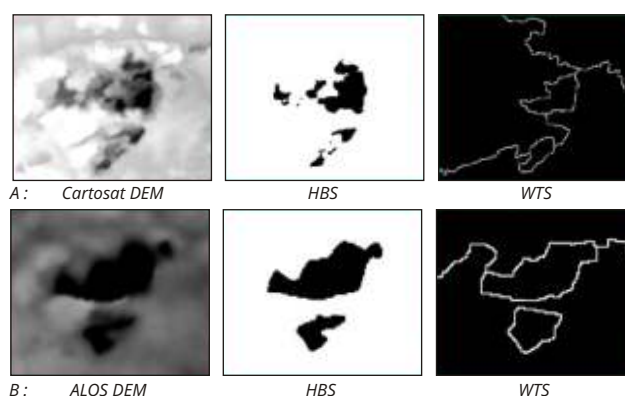
Opencast mines boundary detection using (A) Cartosat DEM and (B) ALOS PALSAR DEM

RS&GIS

RS&GIS

Estimation of Water Balance Components on Beas River Basin in Current and Future Climate Scenarios

Water resources are important to both society and ecosystems. Climate change will affect water resources through its impact on the quantity, variability, timing, form, and intensity of precipitation. To evaluate impact of climate change on water balance components of study area, hydrological modelling was done by using Variable Infiltration Capacity (VIC).

VIC has vital roles, when combined to GCM, of both a hydrologic model and land surface scheme. Within a grid cell, both the water and surface energy budgets are balanced by this semi-distributed macroscale hydrological model (VIC). Variations in the sub-grid are statistically captured by the VIC model. VIC model has some distinguished characteristics namely, LULC subgrid variability and soil moisture retaining capacity, nonlinear base flow, includes orographic precipitation and temperature lapse rates in mountainous regions. This gives a more realistic hydrology. Post processing of the VIC outputs with linear based transfer function independent routing model is necessary in order to stimulate the stream flow.

At a basin scale, the distributed hydrological model gives more accurate estimate of Water balance components. Assimilation of accurate data in the hydrologic model helps to produce better results. Remote sensing has potentials to measure spatial as well as temporal variation of climatic parameters and variables. These parameters play a vital role in hydrology. Hence integrating remote sensing data into hydrologic model will help generating valid outputs.

Land Use Land Cover (LULC) data from ISRO-GBP project (1:50 000 scale), Cartosat-1 DEM with 30 m resolution, soil data from NBSS&LUP (1:250 000), meteorological data from NCEP for period 1996-2006, future climate scenario data from IPCC-5 (RCP 4.5) for period 2006-2098 were used to generate input files for running VIC model. Throughrunning VIC model, water balance components like precipitation, runoff, snowmelt, snow depth and baseflow were generated. Then using VIC routing model simulation, which transports grid cell surface runoff and baseflow within each grid cell to the outlet of that cell into the river system, was generated to quantify discharge in m^3/sec. Observed discharge data from Bhakra Beas Management Board for period 1994-2014 were used to calibrate and validate model. Modelling was done with grid size 1x1 km using NCEP data and at 5x5 km grid for RCP4.5 downscaled climate scenario data of RegSIM. This study shown that in future, mean discharge varies from 396.7 to952.3 m^3/s.
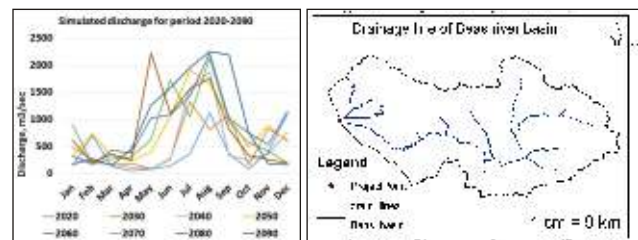

GIS Based Network Analysis For Emergency Services: A Case Study of Bishkek City, Kyrgyzstan

The population in cities, in Bishkek city as well, is increasing very rapidly and hence the accidents on the roads are increasing day by day. So, there is need to search closest facilities from the accidents spots in a emergency situation. The Closest Facility Analysis is concerned with finding the minimum travel cost (Distance or time) from a random accident spot to the closest hospital or police station or vice versa. In this project, the Geographical Information System (GIS) was usedfor finding out the feasible solution of Closest Facility Analysis. In terms of minimizing travel cost and getting closest facilities according to the requirements. Was performed the service area of each existing facility in the study area (Bishkek city, Kyrgyzstan). Main Objectivesof this project: To create the Digital Database of road transportation network for the solution of Closest Facility (CF) & Service Area (SA) Analysis for Emergency Purpose; To perform the closest facility (CF) and Service Area (SA) analysis for emergency situation. Sub Objectives of this project was: To create the Network Dataset with proper attribute for CF and SA analysis; To find out the minimized travel cost in term of distance and time impedance factors. Expected results: Digital GIS database for the solution of closest facility and service area analysis for the Bishkek City; Closest Facility analysis for emergency services; Service area analysis for all the existing facilities in the study area; Map generation with proper direction of movement for the user.

This study carried out for GIS based solution of Closest Facility and Service area analysis for emergency services in the study area and finally results are highlighted in Map layout Form in GIS environment.This will be useful for any accident and other emergency situation for finding out the closest hospital or police station. This is also useful for assigning the service area of each existing facility in the study area. The accuracy assessment had be done theoretically. The analysis will be very useful friendly and can be applied for any emergency service.
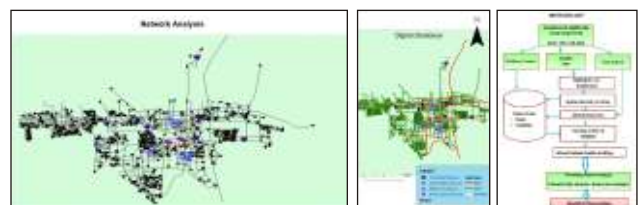
Assessment of Tourism Potential for Sustainable Development: A Case Study of Rishikesh

Tourism is a popular leisure activity and can be important in maintaining social harmony, reconciling conflicts and may part in enhancing excellence in community skills. Rishikesh at the confluence of the Chandrabhaga and Ganga is known for Ashrams, Dharmshala's often claimed as 'Yoga Capital of the World'. Rishikesh has a considerable floating population as millions of tourists/ pilgrims flock from India and abroad every year for spiritual reasons and adventure tourism. As per statistics issued by tourism department of Uttarakhand, estimated average duration of stay of tourist in Rishikesh is around 6.3 days as comparted to Uttarakhand average of 3.95 days. The peak seasons of tourist influx the last seven years are 513419 (2009), 1045932 (2010), 1186529 (2011), 809770 (2012), 374409 9(2013), 332988 (2014), 437756 (2015). However the actual density of Rishikesh is 260,343 as per census data of 2011.

In this regard, much tourism development without proper planning to adopt themselves with large number of visitors, at the same time showed evidence that tourism can destroy the social and physical environment. In the present study, remote sensing data along with ancillary information have been used to assess the tourism carrying capacity of Rishikesh town. Merged satellite imagery of Cartosat 1 + IRS P6 Liss-IV, Cartosat DEM of 10 m resolution, Ward map, land use map, topographical map and Guide map of Rishikesh have been used in the present study. Questionnaire survey carried out to determine the benefits of tourism to establishments in Rishikesh and Tourist statistics of 7 years of these area, allowed us to find generally.

Network analysis has been done to make routing of tourist destination such as religious and adventure tourism places around Rishikesh town. Tourism carrying capacity assessment has been done based on number of domestic and foreign tourist in peak season, residential population, area of Rishikesh municipal boundary, average number of days of tourists' stay in Rishikesh town, number of days in peak season, URDPFI Density and Normalizing Density.
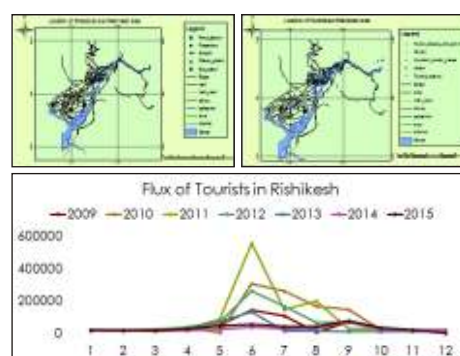

In result we defined a Carrying capacity, and found the Main of Users of Rishikesh area are Indian Tourists, and active type of ecotourism are foreigners.

Agriculture drought risk assessment using Remote sensing and GIS

Drought is a period of below average precipitation in a given region, resulting in prolonged shortages its waters supply, whether atmospheric, surface or ground water. Drought risk assessment described steel may be formed by reducing the risk of drought impacts and help to develop a better management plan. Earth observation satellite data are often necessary for the provision of synoptic, wide area coverage and frequent information for monitoring of drought condition. In this study an attempt has been made to apply RS and GIS techniques for drought detection in the Western Uttar Pradesh, Haryana and near surroundings at block/district level region of India. Agricultural drought risk areas were identified based on Vegetation condition index (VCI) by using vegetation data with 500m resolution from MODIS satellite during 2001-2015. Anomaly of the VCI from the mean values was classified to determine the agricultural drought risk. Meteorological drought was determined based on Standardized Precipitation Index (SPI). SPI values were interpolated to determine the spatial pattern of meteorological drought and threshold value for different types of drought. The drought risk maps were prepared by calculating the classes frequency of droughts. Finally, a resultant risk map was obtained by integrating agriculture and meteorological drought risk maps.

Resultant risk map obtained by integrating agriculture and meteorological drought risk map indicates the areas facing a combined hazard. It also represents the frequency of years a particular area faced the hazard. It was evident from the study that South and western parts of study area more prone to drought either agricultural or meteorological. The research shows motivating results that can be used in taking corrective measures timely to minimize the reduction in agricultural production in drought prone areas. The results obtained provide objective information on prevalence, severity level and persistence of drought conditions, which will be helpful to the resource managers in optimally allocating scarce resources.

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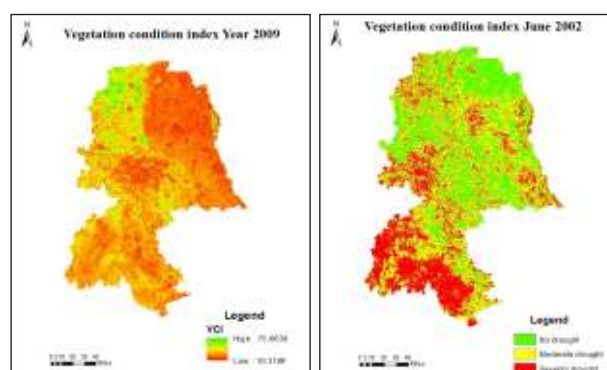
Mineral Mapping Using EO-1 Hyperion Data
## (Dungapur-Banswara region, Rajasthan, India)

The main objective of the present study is to identify minerals using the Hyperspectral data. Hyperion dataset and to evaluate its potential application in mineral exploration in the selected areas.

To achieve this objective EO-1 Hyperion data, covering Southwestpart of the Rajasthanwas used. Geological setup of study area reveals the Archaean basement rocks, consisting Mangalwar complex and Hindoli group, which are followed by Delwara and Debari groups, belonging to Aravalli super group. As far as rock types are concerned, Mangalwar complex mostly consist of metamorphic rocks i.e. Amphibolites quartzite, marble, carbon phyllite, etc. While Hindoli group is made up of Phyllite and greywacke with metavolcanics. Delwara group consisting basic volcanics, quartzite and dolomite. Debari group contain rock types i.e; Conglomerate, arkoses, carbon phyllite and the most significant Pb-Zn bearing dolomite.

The need for reliable spectral information possessboth challenges and opportunities for Hyperspectral remote sensing in mapping and exploration of earth's natural resources. Hyperion sensor is a Hyperspectral imager on-board of EO-1 satellite, was launched on November 21, 2001 by NASA. Radiometrically corrected and geometrically corrected products are freely available by USGS.

Earth's atmosphere affects the spectral characteristics of materials present at the surface therefore, atmospheric correction is required before proceeding to further processing. Here FLAASH atmospheric correction model has been applied to normalize the atmospheric effects in the EO-1 Hyperion image. The atmospherically corrected image was further processed using data reduction techniques Minimum Noise Fraction (MNF) & Pixel Purity Index (PPI) to find the purest pixels present in the area, Through above mentioned processing finally nine mineral end members were identified successfully i.e. Dolomite, Talc, Calcite, lizardite, etc. End members have been identified by matching with USGS spectral library using Spectral Analyst tool in ENVI. A classified mineral map of study area has been generated using Spectral Angle Mapper (SAM) method, for the identified end members. The figure shows the map generated by SAM and the spectra of mineral identified.
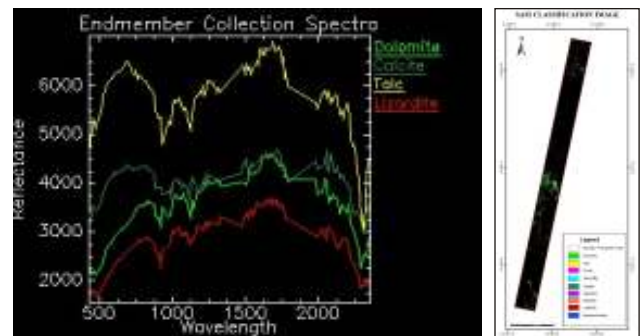
Salt Water Intrusion into Coastal Aquifer: A Case from Gulf of Cambay, Gujarat, India

Water is the important component to human for survival after the oxygen. Three-fourth part of earth is being surrounded by water although a little portion of ground water is used for drinking purpose. Ground water is the most important source of drinking water in India. It plays a vital role in the development and public health of the population in arid and semi-arid zones. Problems related to sea water intrusion have a significant rise over the last decades.Gujarat,a satesituated at the western coast of India, has the longest coastline of about 1800 km. However, environmental problems especially in the coastal areas have multiplied over the years because of rapid industrialization and excessive use of the natural resources. There has been an intensive use of ground water resources by various stockholders for their individual benefit. In the absence of any concreted management plan, ground water quality has therefore seen a drastic deterioration in the recent years. Coastal regions, especially in the low laying areas are more prone to sea water intrusion problems, as is the case of the study area. In this study, GALDIT method has been used to assess the vulnerability of sea water intrusion in coastal aquifers using hydrogeological data in pre and post-monsoon seasons. Also, the number of population effected by the high salinity content of drinking water has also been assessed. Satellite Remote Sensing data have been also used to assess the effect of soil salinity on vegetation of this study area. It shows that the groundwater salinity in this area and chlorine content in groundwater has increased considerably from 1983 onwards
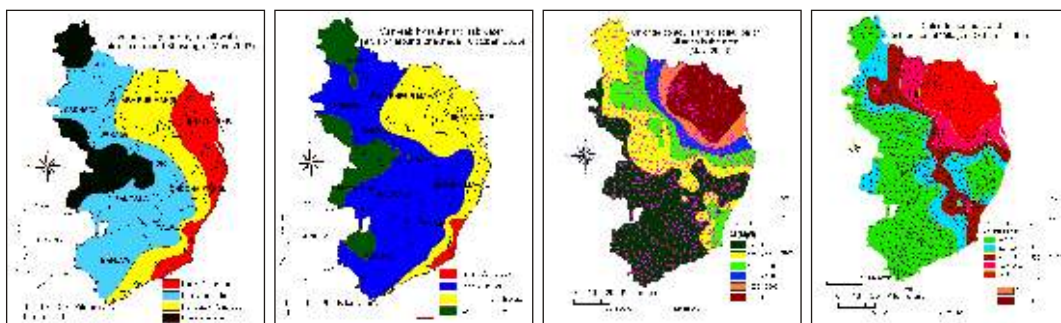
Surface Water and Ground Water Interaction Study using SWAT and MODFLOW

Ground water is the primary source of the fresh water for most of the people over the world and also important source for irrigation in agriculture. Interaction between surface water and ground water is a complex and not fully explored phenomenon till date. Therefore, there is a need explore the interaction mechanism between surface and ground water so that the resources can be well planned for the conjunctive use. Remote sensing and Geographical information system (GIS) can be used in combination with hydrological model to understand ground water system. In the present study, Surface water and Ground water modelling has been done using SWAT and MODFLOW models for Rajim Watershed, Raipur district. Area of the watershedis about 3176.679 km^2 in the Dhamtari & Raipur District of Chhattisgarh State. The study area lies between Latitudes 81°45'to 82°28' N and Longitudes 19°52' to 20°58' E.

Soil and Water Assessment Tools (SWAT) model is used to incorporate the effect of LULC over runoff of and to compute the ground water recharge on the study area. Soil map, DEM (SRTM 30m), LULC is used to calculate CN in NRCS-CN method which is further used for estimating runoff. SWAT divides whole study

area into different HRU's. Which are the unique combinations of land use, soil type and slope type in watershed.

Hydrological modelling by SWAT estimates the ground water recharge values that are used as input for the MODFLOW simulation. The ground water mainly occurs in phreatic condition for the study area and weathered thickness varies from 5 to 20m. Hence, type of aquifer given as unconfined. Discritized domain consist of 362 columns and 596 rows having each cell size as 200 x 200m. No flow boundary condition is given along the polyline representing water ridges and specified variable head boundary along river. The upper boundary of the model is devided into different zones according to HRU's created by SWAT. Groundewater recharge values are given to the each zone representing HRU estimated by SWAT. Both the models were simulated for the period 2003-2007 and each year analysis has been done corrosponding to pre monsoon, monsoon and post monsoon. Analysis of Surface water and Ground water interaction is done over different HRU's. Outputsare hydraulic head, draw down contour maps and zonal water budgets. Results will be a basis for decision making regarding conjuctive use surface water and groundwater sources.
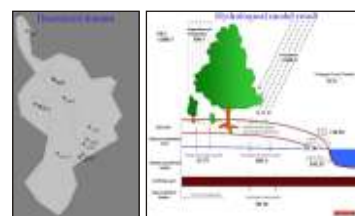
Forest degradation assessment combining optical and sar remote sensing in Lachhiwala Forest Range

Forest degradation can be generally defined as: the reduction of the capacity of a forest to provide goods and services (FAO, 2010a). Forest Degradation may involve opening of the canopy, modification of the vertical structure or change of other attributes. Remote sensing and GIS technology are very useful and important for monitoring changes. The subtle structural changes taking place in forest canopy due to anthropogenic disturbance are difficult to detect using optical remote sensing alone. SAR possess high sensitivity to canopy structure and thereby also to the changes.This research intended to assess the fractional cover, difference in normalized burnt area index, Yamaguchi decomposition and radar fraction degradation Index for mapping degradation in Lachhiwala Forest range, Dehradun forest division, Uttarakhand, India. Landsat seriesimages from 2007 to 2015 and SAR images 2010 and 2015 were used for quantifying the changes. Ground observation and field data were used for validation. The forests for the study area are affected by recurrent incidences of forest fire, lopping of trees for fodder, illicit felling's and conversion of land. Spectral unmixing provide the information about fractional cover of the vegetation. Fig. 1 shows the fractional cover of the study area generated from Landsat OLC for the year 2015. The areas under green shade represents...while blue color represents the non-

photosynthetic vegetation and red color represents bare soil substrate.

Results showed that fire is one of the causative disturbance factors of forest. The combination of optical and SAR gives more accurate method of mapping forest degradation. Forest is being degraded by each year. The result showed that 4.49% is under disturbance and 0.27% is deforested. More research has to be done on other mode of polarization like circular and optimal derived coherences for better understanding.
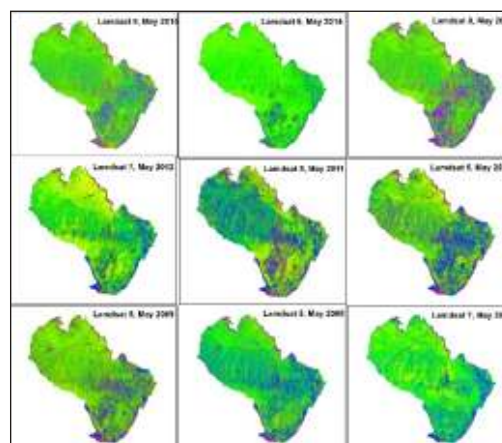

Fig. 1: *Fractional Cover from 2007 to 2015*

Forest Canopy Density Mapping and Modelling with Terrestrial Laser Scanner Data for Upscaling Forest Carbon Estimation

Growing interest in global carbon cycle demands estimating above ground biomass and carbon with sufficient accuracy to establish the increment or decrements of carbon stored in forests. There are several variables to indirectly estimate the biomass and carbon of a forest. Forest canopy density (FCD) is one of these variables which facilitates the rapid estimation of biomass and carbon. On the other hand, Terrestrial Laser Scanning (TLS) is one of the emerging field of remote sensing for precise estimation of forest biomass and carbon. Therefore, this study is proposed to assess forest canopy density by using FCD Mapper and to develop a model between FCD classes and biomass/carbon based on TLS data from Barkot-Rishikesh Forest Range of Uttarakhand, India. The Landsat-8 OLI data was used to generate FCD classes by using FCD Mapper which was

validated with the FCD values collected from ground by using Spherical Densiometer. The diameter and height of each tree of each plot was estimated from TLS point cloud data which was validated with diameter (tape) and height (range finder) measured from the ground. The point cloud data were registered by using RiSCAN PRO V1.8.1. Then the plots and individual tree were extracted by using cross section tool in Cloud Compare v2.6.3. The *dbh* and height of each tree was measured in 3D Forest. The volume, biomass and carbon were estimated from the validated dbh and height. The correlation between FCD map and field measurement is 0.83. The correlation between TLS and Tape measured dbh is 0.996 with RMSE 3.07cm and the correlation between TLS and Range finder's height is 0.974 with RMSE 1.84m.The estimated biomass and carbon is 341.19 and 160.36 t/ha.

Integration of Satellite Remote Sensing and Geophysical Methods for Landslide Characterization at Kalimath, Garhwal Himalaya, India

During the extreme precipitation event of 15th-17th June 2013 in Garhwal Himalaya, Glacial Lake Outburst Flooding (GLOF) accompanied by numerous landslides and flash flood events caused wide spread death and destruction. Apart from the most immediate catastrophic effect, the event had an adverse impact on stability of hill slopes and steep riverbanks. Quick survey aided by satellite image analysis identified many such vulnerable slopes marked by subsidence, ground rupture, fractures and scarp development. One such spectacular scarp of approximately 685 m had developed in river Kali Ganga valley close to Kalimath (Fig 1). In order to assess the landslide risk, the depth of failure plane, zone of accumulation of water/ moisture zone, a highly cost effective and faster non-invasive geophysical technique, two-dimensional electrical resistivity tomography (ERT) and ground penetrating radar (GPR) were used. By using 2D ERT profiles across the developed scarp obtained by pole-dipole configuration of 40 electrodes at an interval of 5m, weighted average depth of the slip surface was estimated. One GPR profile was obtained by using 100MHz antenna across the scarp but in specifically small

area due to difficulty of implementing the survey in extremely rugged and complex terrain.

The slip surface has been interpreted to be at weighted average depth of 18m approximately (Fig. 3). High resolution GPR radargramprofile (Fig. 2) which was carried out location marked on the ERT profile (Fig. 3), has clearly identified the slip surface at the depth of 6.5m. The average depth to slip surface obtained in same location from ERT profile is same as the depth obtained from GPR radargarm. Therefore presence of slip surface also confirmedby the high resolution GPR radargram profile. Studies on relationship between landslideevent, 3 day cumulative and 15 day antecedent rainfall data revealed that the high precipitation event of 15th - 17th of June 2013 acted as the main triggeringfactor for formation of the scarp andinitiation of the landslide. This study hasestablished that earth observation toolsin integration with faster and cost effective geophysical techniques can establish the subsurface characterization of the potential landslide,which isan essential information requiredfor landslide disaster risk management
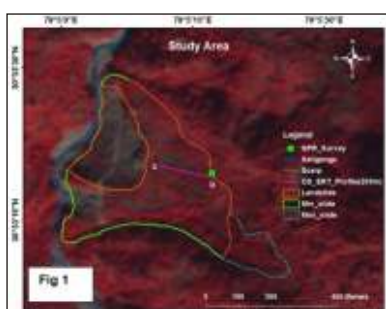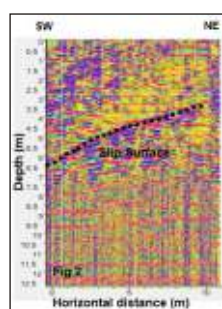

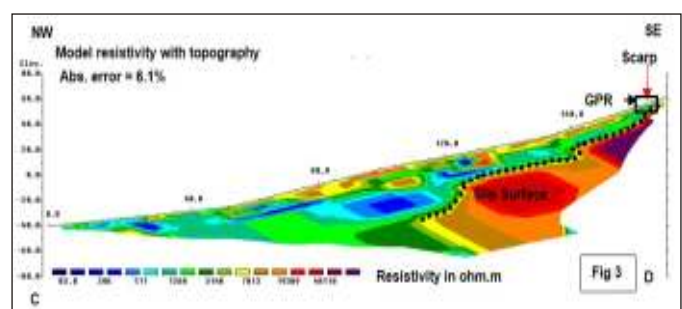**Fig. 1:** *Study Area*   **Fig. 2:** *GPR Profile*

Fig. 3: *Resistivity Profile*

Landslide Susceptibility Mapping and Debris Flow Modelling in a part of Tons Valley, Uttarakhand, India

Landslides are the most occurring geological hazards in the world, these causes injuries, loss of life, damage to the property as well as infrastructures and affect large number of resources. Asia undergoes the maximum damage due to landslides and the south Asian nations, in particular, are the worst sufferers. Furthermore, among the south Asian countries, India is one of the mostaffected countries by landslides. Himalayan terrain is highly prone to landslide hazards as compared to other physiographic divisions of India. There are many factors that cause the instability of slopes, but the main controlling factors are rainfall, seismic activities and human activities. Landslide susceptibility assessment is necessary for developmental planning and disaster management activities. In the present study, bivariate statistical analysis in the form of information value method (IVM) was used to produce a landslide susceptibility map for part of Tons valley, Uttarakhand. The IVM has the advantage of assessing landslide susceptibility in an objective way. The method allows for the quantified prediction of susceptibility by means of a score even on terrain units not yet affected by landslide occurrence. Landslide inventory having information more than 300 landslideswere prepared by using IRS LISS

IV satellite imagery. For susceptibility mapping different causative factors viz., geology, geomorphology, land use and land cover, relative height, slope, aspect, distance to linear features (stream, lineament and fault) and NDVI were considered. Subsequentlythematic layers wereintegrated in GIS to delineate landslide susceptibility zones based on IVM. The resulting susceptibility map identified five zones of susceptibility of landslide hazard, very high (14.3%), high (27.7%), moderate (33.2%), low (17.2%), very low (7.6%) and 90% of the landslide pixels in the area fall in very high and high hazard zones. Field observations and groundvalidation on landslides were used to prepare final map. Furthermore, prominent debris flow located at Ichari was modelled using numerical simulation technique. This model was used to infer the variation of geophysical parameters along the entrainment path.
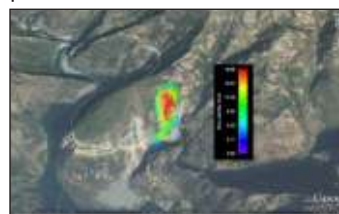

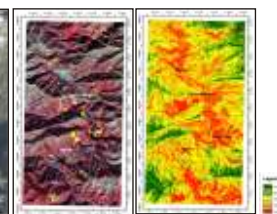**Fig.1:** *spatial variation of velocity of the modelled flow*

Fig. 2: *Landslide inventory (Left), Landslide Hazard Zonation Map (Right)*

Hydrological aspects of site suitability selection for Hydro Power project using geospatial technology

The first stage in development and design of Hydropower Plants (HP) is finding the optimum location. This project presents a methodology for preliminary site selection of HP with the help of geospatial data analysis (techniques) in a Geographic Information System (GIS) environment. The conventional method of HP site selection has certain limitations and is not cost and time effective. The volume of data and the criteria for the site selection of HP causes a lot of difficulties for decision making. However, with the help of GIS as an information technology and with its analytical ability for decision making optimization, we can overcome these difficulties.

Present work examines site suitability selection for Hydro Power and source of variability in snowmelt runoff as a means of identifying methods that could help for site selection in Gori Ganga basin. The large-scale GIS based hydrological model, variable infiltration model (VIC) was chosen in orderto cover the various snowmelt routines in energy balancemode. VIC model require remote sensing data based land use land cover, meteorological forcing files and topographical information for simulating hydrological processes. VIC was used to find the

dependable flow at main river basin outlet as well as at various sub-watersheds. After we estimate the HP potential for propose site, then by above analysis suitable site selection for HP generation can be chosen. In this studytotal basin area was subdivided into 7 sub-basins and dependable flow at 75% was estimated for calculating HP project power potential along with use of carto-version 3.1 Digital Elevation Model (DEM) for head estimation. Few sites selected on the basis of discharge and head basis are shown in figure below.

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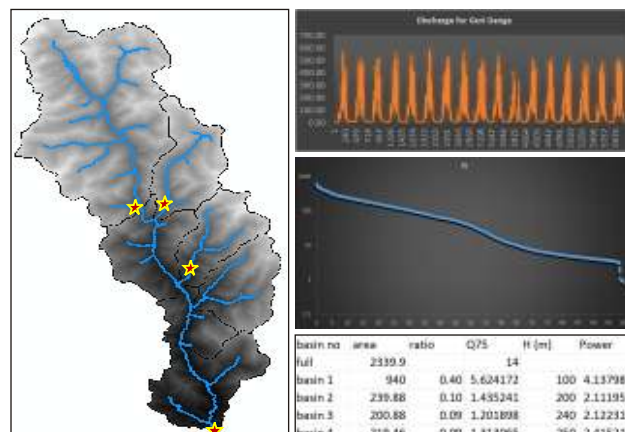
Changing spatial form of Rishikesh city

Indian cities are growing at a very rapid pace, which besides resulting in encroachment of contiguous agricultural areas is also disturbing the various hydrological and ecological cycles. In order to ensure a sustainable urban development it is essential to develop predictive models of urban spatial growth, as these models not only provide a understanding of the urban growth process but also help in visualizing the various urban growth scenarios in response to various policy measures.

To present study aims to study the changing spatial form of Rishikesh city and its environs. Rishikesh is a famous tourist place located in hilly state of Uttarakhand, on the banks of river Ganga. The city is not only a famous tourist place but also serves as a major service and administrative centre for the hilly areas of Garhwal region. As a consequence the city is witnessing a rapid outward spatial growth in the last few decades. Initially the growth of the city occurred around the city core, but slowly the city has expanded beyond the municipal limits on to the surrounding agricultural lands. The growth has been influenced by the existing road network with most of the urban expansion being radial in nature. With time the densification of the existing scattered linear development has also started taking place. Most of the development has been concentrated in the southern part of the study area, which has good road network, flat terrain and also houses employment centers. The growth in north has been constrained by the presence of reserved forests. The development in North-east of the study area is mainly driven by ashrams and other tourist related activities.

In order have a better understanding of growth dynamics of Rishikesh city, the present study aims to develop a Cellular Automata (CA) based predictive model of urban growth. CA models are spatial in nature and can capture the nonlinear behavior of complex phenomena like urban growth. Temporal LISS IV imageries were used to generate urban growth map of period 2008-2014. Various GIS layers corresponding to causative factors driving urban growth were generated (i.e., distance from road network map, location of schools, transportation nodes, banks) using the remote sensing data and secondary data sets. Future areal estimates of Rishikesh urban area was done using Markov chain process. The CA model was then utilized for spatial allocation of the future estimated urban areas. Different scenarios were generated to simulate the growth of the city in response to various policy measures. The CA-Markov model not only serves as a 'what-if' tool for the urban planners, but also provides a rational basis for taking future decisions

Imagery of 2008 year   *Imagery of 2014 year*

Map of Urban growth   *Map of Road Network*
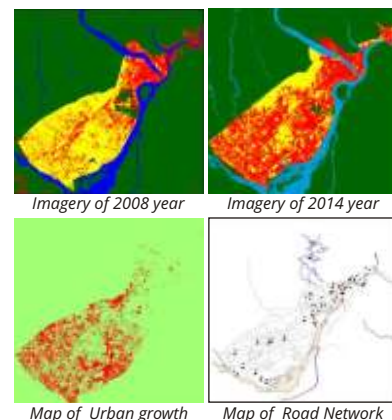
Mineral Mapping Using Simulated Hyperspectral Data from Multispectral Data

Data acquired from Hyperspectral Remote Sensing (HRS) sensors are contiguous and spectrally rich and enables identification of the features which are spectrally similar, whereas Multispectral Remote Sensing (MRS) data fails to do so because of coarser spectral resolution. Hyperspectral data which normally ranges from visible to Short Wave Infrared (SWIR) of the Electro Magnetic Spectrum (EMS) with narrow bandwidth. It is also used as one of the effective tool for mineral mapping and identification, due to its capability of identifying peculiar absorption features. In spite of various applications of HRS data very few number of space borne hyperspectral sensors are available. These hyperspectral sensors require sensitive detectors, high speed data processors and large data storage capability. Due to its high end usage for various applications and limited availability of hyperspectral sensors it is required to simulate hyperspectral datasets from available multispectral datasets.

In this study hyperspectral datasets are simulated from multispectral data using spectral reconstruction approach which is a sensor independent technique. This

technique makes use of information of atmospherically corrected MRS data and normalized ground spectra for simulation of HRS data. In this study EO-1 ALI dataset was used for simulation of HRS data to discover Udaipur region's unique minerals. Total 61 spectral bands with 10 nm bandwidth were simulated. The simulated HRS data were validated using visual interpretation, statistical and classification approaches. Simulated HRS data from EO-1 ALI has shown high correlation with EO-1 Hyperion data. Spectral Angle Mapper (SAM) classification was also performed on simulated hyperspectral data for mineral mapping. It was observed that simulated hyperspectral data have shown comparable results with Hyperion and better than their corresponding multispectral datasets.
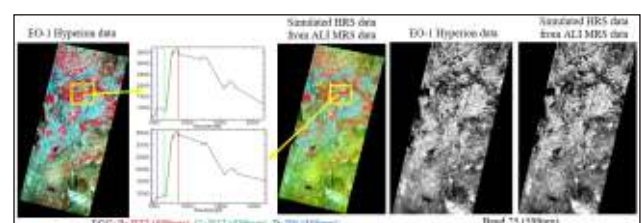
Land cover mapping using Integration of SAR and Optical remotely sensed datasets

Land cover classification mapping from remotely sensed datasets is of great interest since they allow every country to monitor deforestation, water resources reduction as well as urban growth. Maintaining up-to-date, Land-cover information is both costly and time consuming using traditional field and air photo methods.Applicability of remote sensing data has been proven by several researchers in last decades. Most of the researchers performedland cover mappingusing Optical satellite sensors which usually detect reflected solar radiation in the visible and infrared part of the electromagnetic spectrum with spatial resolution ranging from 1 meter to 30 meters. At present, Synthetic Aperture Radar (SAR) has become a key remote sensing technique due to its all weather capability, independence of daylight and its cloud penetration capability.

Prime focus of this project isto explore the potential and find out suitable fusion methods using Synthetic Aperture Radar (SAR) and Optical datasets. Both the data

(Sentinel 1A and Sentinel 2)used in this study were provided by European Space Agency (ESA). Processing of the data includes several steps and few of them are multilooking, radiometric calibration, speckle filtering etc. Firstly, Gammap map and Frost is selected to reduce speckle noise of SAR image. Then, two popular methods, including PC and IHSbased on fusion techniques is used for classification. Finally, this proposed approach is compared with the classified image generated from Optical dataset.
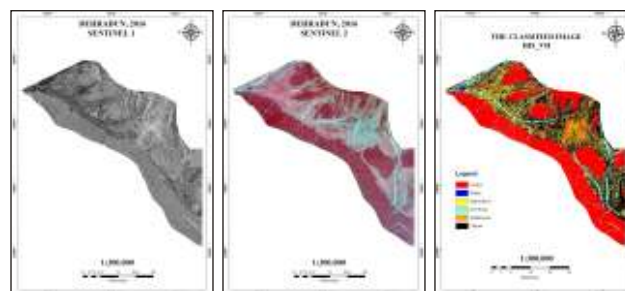
Project Abstracts of 1ˢᵗ GNSS Courses

Study and Position Determination Using GPS and IRNSS Satellite Signals for Achieve Better Accuracy Compare to Using Single (GPS) Constellation for Bangladesh Perspective

Survey of Bangladesh is the national surveying and mapping organization of Bangladesh and I work one of its section i.e. Geodetic Detachment. This unit is responsible for establishing national horizontal and vertical datum throughout the country. Horizontal and vertical datum's are the part and parcel for making maps. Geodesy doesn't compromise with accuracy. My aim how can I get more accurate position for my organization. So, I choose this topic as a project work.

At present we are using GPS for navigate position and also some latest application to found better accurate position using GPS. But from this running GNSS-1 course I came to know that GPS has its own 10-20 meter error (main reason we are fallen into equatorial reason) in position and India is going to be fulfill its IRNSS constellation by March, 2016. Very good wishes for all the members who are involve for IRNSS constellation. Bangladesh falls into IRNSS primary service area. For equatorial reason IRNSS system may be very effective. India is the first country who is going to established RNSS system near equator. Also they are going to introduce most effective model for equatorial reason and that is "Grid based model". GPS used "Klobuchar model" that is not good enough for equatorial reason. There are other advantage and disadvantage of GPS and IRNSS. But GPS is a system that contributes globally.

Study and Real-Time Kinematic (RTK) Positioning Its Challenges and Applications in Surveying and Mapping

Real time kinematic (RTK) refers to a stop-and-go method where the coordinates of points are available in real time. In this method, a radio communication link is maintained between the base receiver and the rover, and the base receiver supplies the pseudo-range and carrier phase measurements to the rover which in turn computes its position and display the coordinates.

RTK technique is most accurate method today. It can be determinate position within few centimeters or millimeter at a moment. Now a days CORS (continuously operating reference station) is used as the reference station of Network-based RTK. In this method, Radios, phones or internet can be used to transmit RTK data directly from the receivers.High-accuracy real-time kinematic (RTK) positioning with global positioning system (GPS) is one of the most widely used surveying and mapping techniques.

Survey of Bangladesh, the national mapping organization is preparing Digital topographical and thematic maps of different scales by using aerial photograph and satellite imagery.In every step of producing the new digital maps there is an involvement of GPS. Our organizations purchased few precise RTK GPS receiver and also establish RTK based six permanent GNSS-CORS station in six divisional cities. In future permanent GNSS-CORS station will be increases. So skilled manpower is needed for proper uses this RTK Receiver. My project work will be converged towards that direction. The knowledge of the pilot project will help me to identify the problems of the positioning techniques of my organization.

Navigation Signal Simulator for Performance Analysis of GNSS Signals

Interoperability and compatibility is the main goal for current GNSS systems. A concept of Global Navigation Satellite System (GNSS) is to use all navigation system together to provide better capabilities compared with those that would be achieved relying solely on one service or signal. Compatibility, on the other hand, assures that existing GNSS signal is not degrading each other below certain threshold. GNSS provider is concerned about their own signal as well as other signals from different service provider for co-existence. For this reason interference analysis of current GNSS signal is the most needed requirement in current scenario. India is developing its own regional navigation systems named as Indian Regional Navigation Satellite System (IRNSS). An in-house tool is developed with suitable Graphic User Interface (GUI) which provides static analysis of different type of interference parameters and indicates its compatibility with already existing signals. Using the tool, this paper analyzes the degradation in IRNSS signal performance due to various navigation signals in different bands via consideration of parameters such as Power Spectral Density, Root Mean Square (RMS) Bandwidth and Rectangular Bandwidth.

GNSS

Analysis & Comparison of GPS & Gagan Data using by carrying out field trials on Aircraft

Air navigation requirement can be divided into various phases such as enroute/terminal navigation, taxing, approach, landing and departure. Further approach/landing can be divided into precision (CAT I, II, III landing) or non precision approach. GPS system which has become backbone of navigation for the last two decades cannot alone satisfy the requirement of safety critical applications such as aircraft landing in terms of accuracy, integrity and availability. GAGAN (GPS aided geostationary augmented navigation) is an implementation of regional satellite based augmentation system by the Indian government with the help of Indian Space Research Organisation technology and space support. GAGAN is formulated to enhance the capability of GPS by providing error corrections and integrity information through geostationary satellite for precision approach of aircrafts. Services for navigation provided by GAGAN (RNP and APV) for enroute and approach has been checked and verified. Comparison of field accuracy of GPS and GAGAN has been discussed,however no comprehensive field study and trials has been carried out

on aircraft especially in India to compare and establish the authencity and accuracy of data obtained by the above mentioned navigation systems.

The aim of my MTECH research will be pertaining to study and analyse the performance of GPS and GAGAN with the aid of an 'INDRA-DHANUSH' receiver. This study and analysis will be implemented by accessing the performance of both the systems during various phases of aircraft flying such as enroute operations consisting of cross country trips both above land and sea and also during short circuit flying where aircraft coordinates along X,Y and Z axis changes very rapidly. Performance assessment will be under taken at various Indian Air Force bases located at different geographical locations in India in order to collect more realistic data and analyse the same for better assessment. Data from various field trials will be collected by positioning an 'INDRADHANUSH' receiver inside the aircraft Data (Latitude, Longitude and Altitude) will be converted to KML format using a Matlabprogram.

Study and Various PN Sequences for GNSS, There Implementation and Comparison

Codes are a fundamental element in any CDMA system like navigation system because these codes are the tools that enable a GNSS receiver to distinguish one satellite from another. PRN codes have a spectrum similar to random sequence of bits but are deterministically generated. Codes are either memory based or generated through shift register. When GPS was designed for the first time the memory chips were not as cheap as they are today and thus the shift register approach was easiest to implement in terms of memory. With the years the memory capacities of microprocessors have improved

leading to feasibility of implementation of memory based Codes

There are different families of PRN codes available with different properties. The code to be used must be carefully chosen to minimize interference between each satellite signal. This project aims at studying various types of code families available for GNSS and compare them in terms of their properties mainly correlation properties. Phase I would cover the study aspect and phase II would involve their comparison, post implementation in MATLAB.

IRNSS and GPS Signal Generation and its Acquisition in MATLAB

The GPS and IRNSS are satellite based navigation systems and they transmit signals in L1 and L5&S frequencies respectively besides the signals at other frequency. The signals transmitted in GPS and IRNSS are CDMA signals with spreading code and navigation data on it.

In order to design a GPS and IRNSS receiver it is necessary to know the characteristics of the transmitted

signals and data from the GPS and IRNSS Satellites. The modulation technique, spreading codes and data-encoding of these signals will be studied prior to its implementation. The signal generation will be implemented in MATLAB. The generated signal will also be coarsely verified and by implementation of acquisition algorithm in MATLAB.

GNSS

Study of Ionospheric Scintillation Over the Indian Subcontinent and its Impact on the Performance of IRNSS user receiver

Ionospheric scintillations are rapid fluctuations in signal phase and powercreated by diffraction of GNSS waves as they pass through a medium of irregular structures with variable refraction indexes. The scattering and recombination of radio waves can be constructive or destructive. The depth of scintillation is controlled by the irregularity amplitude, background electron density and its distribution in the ionosphere. Amplitude scintillations generate deep fades in the received signal power that can cause the signal to drop below the lock threshold. During phase scintillation a receiver's phase lock loop has difficulty in tracking the quickly varying carrier phase which would result in cycle slips or even complete loss of lock reducing the availability of carrier phase measurements. The navigation processor would then be unable to produce a useful positioning solution. The pilot project involves the

analysis of occurrence of ionospheric scintillations in the IRNSS signals with carrier frequency of 1176.45 MHz over the Indian subcontinent. The characterestics of ionospheric scintillation in the signal would be studied in which the probability distribution function of the scintillation process would be analysed to define a goodness of fit with standard probability distribution functions. The frequency spectrum of the scintillation process would be defined using appropriate Fourier transform. The autocorrelation of the scintillation process would be analysed to define the temporal characterestics of the ionospheric scintillation and its decorrelation time. These characterestics would be analysed forgoodness of fit with an appropriate filter response for obtaining a discrete time simulation Using MATLAB.

Development of On-Board Orbit Determination System for Low Earth Orbit Satellite Using Global NavigationSatellite System Receiver

In order to make the orbit control system autonomous, and reduce the need for ground intervention there is a need for an on-board availability of continuous and accurate knowledge of the satellite orbit. In the pilot project, we propose to use on-board Global Navigation Satellite System (GNSS) receiver to compute the orbit of Low Earth Orbit satellite. There are six orbital elements defined for a satellite, which are to be specified to define the satellite orbit. With the help of four GPS satellites in the GNSS constellation, on-board GNSS receiver collects the navigation data and calculates its own position. The position information in the GNSS contains the GNSS data in the form of Pseudo-ranges with respect to time. From this information, position and velocity vector is calculated

as a function of time. Orbital elements of the current position are calculated using the position and velocity vectors. Comparing theses orbital elements with the reference orbit, one can get the errors out of that and correct it further. Measurement noise and process noise models will be selected for simulating actual scenario. For orbit estimation, Extended Kalman filter method will be used. Software for orbit integration will be developed in MATLAB.

The main purpose of this Pilot Project to study a rather simple but still fairly accurate algorithm to determine the artificial satellite orbit, in its real time and with low computational burden, by using raw navigation solution provided by GPS receiver.

Study and GNSS Applications and GPS receiver use Cadastral Surveying

The Global Navigation Satellite Systems (GNSS) involves satellites, ground stations and user equipment all around the world.

In today's scenario the Global Positioning System (GPS) of the United States of America and the Russian Global Navigation Satellite System (GLONASS) are the fully operational global navigation satellite systems. Other countries with their regional satellite systems like China's COMPASS and Beidou, European navigation satellite system GALILEO, IRNSS of Indian, QZSS of Japan are under development and they would be joining the GNSS soon.

Global Navigation Satellite System (GNSS) plays a

significant role in high precision navigation, positioning, timing, and scientific questions related to precise positioning.

Cadastral surveying is concerned with the process of gathering evidence in the form of position information that is used to define the location of objects or land boundaries for the purposes of identifying ownership and/or the value of land parcels. The advent of Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS), has revolutionised the way 3-dimensional positions are determined and GPS surveying techniques, particularly Real Time Kinematic (RTK), are increasingly being adopted by cadastral surveyors.

GNSS

Project Abstracts of 10th SATCOM Courses

Synthetic Aperture Radar (SAR) Image Segmentation

Synthetic aperture radars (SAR), the Modern airborne and spaceborne imaging radars, are capable of producing high quality pictures of earth's surface while avoiding some of the shortcomings of certain other forms of remote imaging systems. Radar overcomes the nighttime limitations of optical cameras and cloud cover limitations of both optical and infrared imagers. The most recent version of imaging radar, the spotlight mode SAR, the radar beam is focused on one patch of ground as the aircraft flies from point A to point B. Returned signals are collected continuously to create a high-resolution image integrated over a very large aperture. SAR can provide a relative high resolution in azimuth compared to other radars, which is an important advantage to other radars. This high range resolution can be achieved by pulse compression techniques. The solid theoretical basis of this procedure allows designing a guided search of the best parameters according to the desired solution, avoiding a tedious trial-and-error process. Although the

used images have different characteristics, results prove that similar sets of parameters can be used, showing some degree of robustness with respect to the image, for a given sensor and image acquisition mode.This paper documents is a description of a graphic user interface (GUI) for Image Segmentation of SAR Images. Image Segmentation is a process of dividing an image into different regions based on certain attributes e.g intensity, texture, color, etc. The GUI and associated MATLAB toolbox has now been extended to include several other capabilities and has grown into a toolkit that can be used in an introductory course in SAR image processing. The GUI and toolbox now include additional teaching and research capabilities, to include additional types of filters and image compression capability. Apart from this one can choose different algorithms that help to extract the single look image from the raw SAR data that are going to implemented in MATLAB, because of its wide availability, and "self documenting" capability.

Comparative Study of OFDM and CDMA in Prospective of GEO Satellite Communication

Both Code division multiple access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) techniques are well established in terrestrial mobile networks but have not found up to now significant use in the space application. Here in this article effort will be on to explore the feasibility of these techniques for the satellite communication in computer simulated environment especially for GEO communication satellite and try to present the comparative study between both technique CDMA and OFDM. For this study two

transceivers will be simulated in MATLAB for both the technique. In order to provide a framework for a comparison we have to consider common parameters for both schemes, including identical channel bandwidth, coding/decoding algorithms and similar net data rate and evaluate them in Additive white Gaussian noise channel. The physical layer performance on the basis of Bit Error Rate (BER), signal to noise ratio (SNR) spectral efficiency and capacity performance is to be calculated and compared.

Study and design of Automatic Modulation Classification

Automatic modulation classification (AMC) was first motivated by its application in military scenarios where electronic warfare, surveillance and threat analysis requires the recognition of signal modulations in order to identify adversary transmitting units, to prepare jamming signals and to recover the intercept signal. In modern civilian applications, unlike in much earlier communication systems, multiple modulation types can be employed by a signal transmitter to control the data rate, to control the bandwidth usage and to guarantee the integrity of the message. Though the pool of modulation

types is known both to transmitting and receiving ends, the selection of modulation type is adaptive and may not be known at the receiving end. Therefore, AMC is required for the receiving end to select the correct demodulation approach in order to guarantee that the message can be successfully recovered.

The main goal of this thesis is design and implementation of Automatic Modulation Classification. This project will incur the study of latest modulation schemes, Vector Signal Analysis, different types and features of modulation classifiers and their performances.

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Machine to Machine Communication Using Satcom

The expansion of IP networks around the world has made machine to machine communication quicker and easier. In modern times the communication is often via the Internet of Things (IoT). The Internet Protocol Version 6 (IPv6), with its large address space, can completely accommodate all of the sensors and machine-readable identifiers that IoT would require. Machine to Machine (M2M) is a special category of IoT with emphasis on remote access and control of a system or an entity without human intervention. Remote monitoring and control of SCADA (Supervisory Control and Data Acquisition) systems over large geographical areas (often without cellular connectivity) necessitated the need for M2M communications using alternative backhaul media such as satellites. However, there are not many standards/ protocols laid down for M2M communications using satellites.

The aim of this project is to carry out a study of M2M communications over satellite with special focus on SCADA (Supervisory Control and Data Acquistion) control over satellite links and prepare a working model incorporating the study results by demonstrating a real life M2M scenario. The pilot phase of this project would include a study of SCADA communication for M2M communications and the satellite link budgets for M2M communications using NS2 simulation and LabView for hardware design and configuration. The subsequent stages would include configuration, simulation, integration and testing of a working model which addresses a real time case scenario of M2M communications over a satellite link followed by findings, recommendations and conclusion.

To Study The Satellite Earth Station Automation and Develop a SMS Notification Alarm for Faulty System and Automatic Storage of Received RF Data from Satellite

The traditional satellite earth station consists of a building full of specialized hardware and a large stationary antenna operated by a group of onsite personnel. Reduced budgets have forced project managers to re-evaluate this concept in search of ways to save money along with greater functionality and consistency. A lot has been done to this end, automation of satellite earth station using PC-based systems have been developed that reduce hardware costs and the number of machines and personnel necessary to perform station tasks.

The purpose of this project is to study the automation of satellite earth station and to accomplish a system using

hardware and software which sends a SMS notification alarm in case of fault in any equipment. Also it is envisaged to develop a system to store the RF data in digitized form at receiving end to be analyzed later in case of any fault in baseband equipment.

The development of SMS notification alarm system will help to early notice the failure of any equipment in satellite earth station so that necessary corrective measures can be taken fast without much damage. Moreover, it also helps in reducing manpower as no continuous supervision is required to check the system. RF storage will help to reduce the possibility of data loss in case any fault arises in baseband system.

Cognitive Satellite Communication Systems

The demand for precious radio spectrum is continuously increasing while the available radio frequency resource has become scarce due to spectrum segmentation and the dedicated frequency allocation of standardized wireless systems. This scarcity has led to the concept of cognitive radio communication which comprises a variety of techniques capable of allowing the coexistence of licensed and unlicensed systems over the same spectrum. Cognitive satellite communications, which is a rather unexplored area in the literature despite its significant benefits to both satellite and terrestrial operators. This concept has been motivated due to the limited availability of the satellite spectrum as well as the

continuously increasing demand of broadband multimedia, broadcast and interactive satellite services.

In this context, The focus is on interweave and underlay cognitive radio paradigms which are widely considered as important enablers for realising cognitive radio technology. In the interweave paradigm, an unlicensed user explores the spectral holes by means of some spectrum awareness methods and utilizes the available spectral availabilities opportunistically while in the underlay paradigm, an unlicensed user is allowed to coexist with the licensed user only if sufficient protection to the licensed user can be guaranteed.

Synthetic Aperture Radar (SAR) Image Segmentation

Automatic Identification System (AIS) is short-range coastal tracking system currently being used on ships. It was developed to provide identification and position information to both vessels and shore stations. The AIS signals have a horizontal range of about 40 nautical miles. The modulation used by AIS is GMSK (Gaussian Minimum Shift Keying) with 9600 bps (bits per second) data rate and 0.4 BT (Bandwidth Time). The channel access scheme is SOTDMA (Self Organised Time Division Multiple Access) based. The size AIS message packet is 256 bits which consists of Ramp up sequence, Training sequence, Start flag, Data, FCS, End flag and buffer. AIS communication takes place using two VHF frequencies, 161.975 MHz and 162.025 MHz, using a bandwidth of 25 kHz. There is an increasing interest in detecting and tracking ships at distances from coastlines that are larger than those that

can be accomplished by normal terrestrial AIS. This is for better handling of hazardous cargo, improved security and countering illegal operations. A satellite-based AIS system is a way of obtaining the aforementioned objectives. A satellite system calls for several technical issues and operational challenges. An LEO constellation of satellites will be apt for global coverage, with an altitude ranging from 600 to 1000 km. From such an altitude and with the beam width typical of on-board VHF antennas, the satellite field of view (FoV) spans over a few thousands of nautical miles. Various technical challenges like, message collisions, path delay, low SNR and Doppler effect needs to be taken into account for design and development of an AIS receiver. In this project, I will be doing a MATLAB simulation for implementation of standard AIS system over satellite.

Comparative Study of OFDM and CDMA in Prospective of GEO Satellite Communication

This project aims at developing the software package for characterisation of in-orbit satellite antenna. This software will have a unique feature of comparison by superimposing composite ground coverage pattern of measured values of satellite antenna during ground antenna testing and measured values during in-orbit testing after launching the satellite. The development of this software incur the study of different latest interpolation algorithms, developing interpolation algorithm, multithreading parallel processor programming along with memory management and various dB level contour mapping for ground measurement and in-orbit measurement on maps with associated features along with their comparison.

Software package will help parent organization in terms of satellite communication links margins in the critical battle fields, analysing and characterising the in-orbit antenna for the intended purpose. For the pilot project, the study of different latest interpolation algorithms, multithreading parallel processor programming along with memory management for preparing inputs for the contour mapping will be undertaken. Software will prepare maps for ground measurement, simulates the orbits for satellites at GEO, GSO, MEO and LEO with the individual satellite parameter selection, analysing the composite coverage of number of satellites and in-orbit measurement on graph will be aimed at for final MTech Thesis submission.

Design of Integrated Terrestrial and Satellite Network for Disaster Management in Mongolia

This project work will provide necessary interface between the Information communications network company (national backbone optic network company in Mongolia, known as Netcom) and a satellite network resulting in better and faster communications for deployments of disaster events. This project work also considers possible network topology integrating both terrestrial and satellite network including technical characteristic, medium impairments, modulations multiple access techniques and some problems related

to path loss due to usage of higher frequency bands, rain attenuation (for Mongolian region) and adjacent earth station interferences etc. At last the link budget will be finalized for integrated design using both terrestrial and satellite network and selection of satcom equipment and their implementations.

The integrated network design of this nature is targeted to provide last mile connectivity to deal with disasters and provide necessary rescue aids.

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Design and Implementation of the Transceiver for Cube Satellite

Cube Satellite systems engineering can be divided into several widely disparate fields, that is, the design of the Structures, Communication, On board computer, Power, Solar Panel, Antenna, Launch adapter, Development setup and support equipment, Camera, Kits and buses, Ground station, Training simulator, Propulsion and pressurization, Attitude Determination Control System (ADCS), Sun and Attitude sensing board. It is impossible for cube satellite system engineering can be skilled in all these difficult subjects but, at the same time, it is necessary for those who to appreciate the compromises among conflecting elements.

The communication systems composed from the transceiver module is very flexible that works at S-band frequencies of 2100 MHz to 2500 MHz and supports the

BPSK, and GMSK modulation schemes. It has capacity to provide downlink data rates up to 100 kbps, while featuring low power consumption.

The low cost of Cube sat has enabled unprecedented access to space for smaller institutions and units. How ever, for most Cube Satellite forms the range of accessible power is limited in 2W approximately, and in terms of communications antenna, a single helical antenna or four monopole antennae are deployed by a spring-loaded mechanism.

Within the topic of research it is aimed to design and implementation of RF Transceiver module in accordance with the radio communication's standards and technical requirements.

Study of Small Satellite Network for Voice and Data Services

Small satellites or Smallsats are satellites of low mass and size, usually under 500 kg (1,100 lb). In 2014, 107 commercial microsatellites (1-50 kg) were launched and thousands of commercial small satellites (101-500 kg) are planned for launch over the next fifteen years. Recent multi-million and multi-billion dollar investments in various ventures confirm the commercial sector's continued interest in the Nano/microsatellite and small satellite industries. These modern small satellites are designed and built with a different philosophy to that used for conventional satellites and offer.

The 640 communication satellites will operate in circular LEO / 1200 km altitude, transmitting and receiving in the Ku band of the radio frequency spectrum. Earlier small size satellites were used to provide few applications, short space life, low power transmission and low communication. Present day small satellites can provide data and voice service. Small satellite constellation can provide coverage footprint distant area by low cost and communication services. In the first phase main aim of my pilot project is a detailed study of design, basic techniques, parameters and characteristics of small satellites.

Study and Simulation of Ka-band Propagation Model for VSAT applications in Mongolia

Satellites are an essential part of our daily life, and they have a very large usage ranging from Search and Rescue Operations to Environmental Monitoring. The widest use of satellites is, however, in communication systems. Satellites can cover vast areas of the world; therefore, they are the nodes where all communication links pass through in a communications network involving satellite. Many users can access such a network simultaneously while they are widely separated geographically. The purpose of this project work is to model and analyze propagation models for a geostationary satellite communication system for VSATs networks in Mongolia.

The envisaged system is to be examined in Ka band also. The simulation results will be obtained for each different ITU models. The performance of the system is to be evaluated in terms of atmospheric attenuation due to gases, cloud, fog, rain and ice affecting VSAT communications in Mongolia. In the first phase, a detailed study will be carried out on available ITU models applicable for VSAT communication network considering its applicability in Mongolia In the second phase, the aim of the project is to carry out further simulation and customization of ITU propagation models for applications in Mongolia for VSAT communications in Ku and Ka bands.

Study, Simulation and Implementation of LDPC Codes for DVB-S2 Standard

In order to have a reliable communication with low power consumption over noisy channel, error correcting codes need to be used. As one of the most powerful error correcting codes, Low Density Parity Check (LDPC) codes are recently emerged in digital communications. Because of the superior performance of LDPC codes are dubbed as Shannon limit error correcting codes. It is based on the low complexity iterative decoding and are used in many upcoming standards.

LDPC codes are been used in new Digital Video Broadcasting Satellite Second Generation (DVB-S2) standard. To provide flexibility, 11 different code rates ranging from (R=1/4 up 9/10) are specified with a codeword length up to 64800bits.

In this project, the LDPC code used in DVB-S2 standard are to be studied, simulated and will be implemented. The performance of the LDPC codes will be evaluated.

To Enhance Availability and Reliability of GSM Network in Nepal Using Ka-Band Future VSAT Network

Nepal is a country in the midst of rapid economic and social change with the use of cellular technology rising dramatically over the years. These networks have evolved drastically from being unreliable or non-existent to being available in many rural areas of Nepal. However, since terrestrial networks usually demand Line of Sight(LOS), there still exists "availability and reliability" issue of Wireless Networks in Nepal whose geographically difficult terrain make such kind of communication difficult or even impossible. Slow point-to-point cellular backhaul via satellite urgently needs to be replaced as ever increasing rural customer base demands for higher speed. As demand for high-speed connectivity escalates, Nepalese mobile operators are under increasing pressure to provide ubiquitous high-speed services where traditional means of using fiber, copper or even microwave to connect cell sites in remote cannot be

easily/cost effectively accomplished. This project shall attempt to find an effective plus efficient solution for mobile operators in Nepal trying to cover "hard-to-serve" areas. It aims to do so by demonstrating optimized satellite network that is able to meet demand while not unnecessarily burdening service-providers as the use of expensive satellite backhaul connections can generate much less revenue per unit bandwidth than traditional traffic if not carefully planned. Under efficient design, this project aims to improve availability and reliability of GSM Network in Nepal using Ka-Band future Network.

The project shall comprise Ka-Band network design for "hard-to-serve" area with derivation of area-specific ka-band fade-mitigation technique, network analysis plus simulation study along with budget and financial analysis.

Study and Design of VSAT Terminal for Cellular Communication to Remote Villages of Nepal

Nepal is a landlocked and mountainous country with a diverse topography located on the southern part of Asia. Nepal is divided into three regions as: Himalayan region, Hilly region and Terai region which are running parallely from east-to-west. Nepal has a population of 28 million of whom 82 percent reside in rural areas, only 18 percent living in urban areas. There is a significant disparity in cellular communication between the high coverage levels in the cities and the no coverage available in the underdeveloped rural regions. Wire line networks are often not an economic option due to high initial investment and low financial returns, especially in small communities and isolated locations. The purpose of this work is to investigate and define efficient ways to provide

economic cellular communication service to rural communities of Nepal by means of a communications satellite. Cellular communication can be achieved with a VSAT terminal, which has ubiquitous presence under the satellite's footprint. For that reason satellites are being considered as a backbone for cellular communication to those regions. In first phase - Capacity planning for Cellular network, Bandwidth requirements, and Link budget will be completed. In Second phase - Selection of Telecom hardware, VSAT Systems for remote locations as per the traffic requirements, Demonstration and Implementation of the proposed system at one of the site will be completed.

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Study and Design of Ultra VSAT Terminal in Ka Band for Voice and Data

The modern development in Satellite's Field of Region has played a vital role to spread the communication system in every corner of the world effectively for its prosperity. It is very difficult to connect the hilly and mountainous terrain through the terrestrial and optical fibre communication for basic communication services. The satellite communication is inevitable to the country like Nepal having difficult geography to spread the communication to every part of the country and to lessen the existing digital divide between the remote and urban part of country.

Although Ku-Band systems are deployed extensively throughout the orbital arc, the number of Ka band system is increasing rapidly due to many advantages. Wi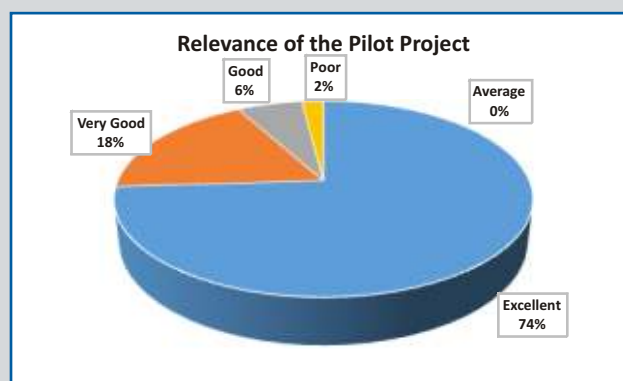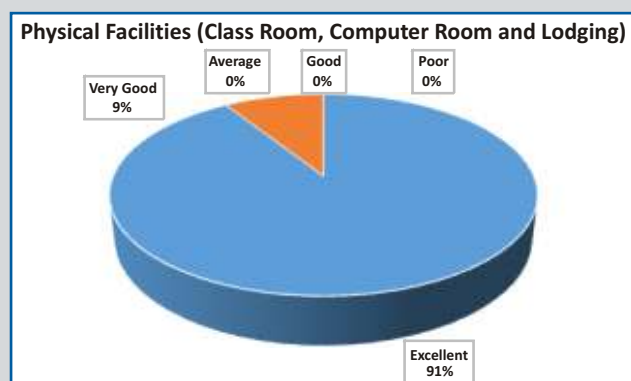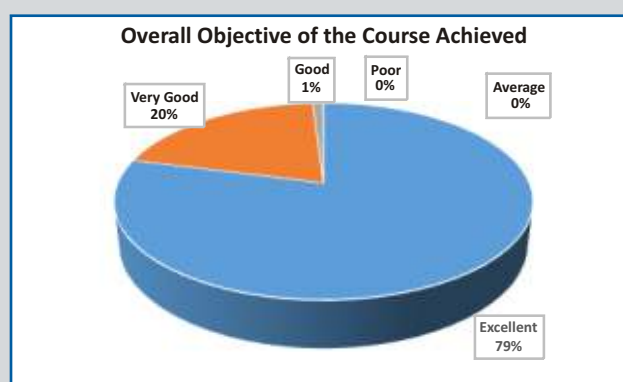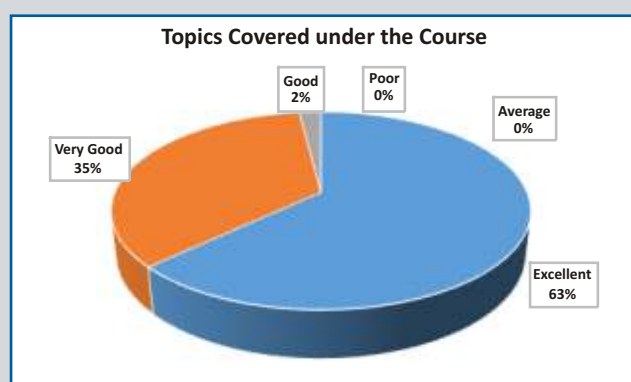th more orbital slots available to accommodate new Ka-Band payloads, the Ka-band coverage will be accelerated in all over the world in future. Also since the antenna directivity varies inversely as the square of the RF wavelength, the G/T of spacecraft and Earth Station in Ka-band is higher than for the same size of Ku-band. In this context, the study and design of USAT in Ka band will play a vital role to implement Ka band VSAT system in my country for the voice and data. During the first phase of my pilot project, I will carry out thorough feasibility study of Ka band system, the implementation aspects like available space segment specification and the design of VSAT Network including Hub and Remote stations with specification. In second phase, the design of baseband integration will be carried.

SATCOM

Performance Report of CSSTEAP

(2010-2015)

The Centre has been conducting Post Graduate (PG) and Short course in various disciplines of space science and technology. During the past 19 years, 49 Post Graduate educational courses have been successfully conducted. During period of assessment, the number is showing increasing trend and it is observed that the RS&GIS, SATCOM, SATMET PG courses have good student participation and performance (100%, 82%, 78%, respectively). CSSTEAP has been organizing short courses on recent and advanced technological applications. In the last 6 years, 22 short courses/workshops on various themes have been conducted. There has been tremendous jump and interest from the professional, Governing Board member countries, organization, especially UN-ESCAP, UNSPIDER, SAARC and IWMI in organizing themes and demand specific short courses. Among the short courses, there is good students participation and performance is good. The feedback provided by participants indicate that overall course objectives were achieved with high level of satisfaction. Following figure indicate the detailed feedback.

Topics Covered under the Course
- Good 2%
- Poor 0%
- Average 0%
- Very Good 35%
- Excellent 63%

Overall Objective of the Course Achieved
- Good 1%
- Poor 0%
- Average 0%
- Very Good 20%
- Excellent 79%

Physical Facilities (Class Room, Computer Room and Lodging)
- Average 0%
- Good 0%
- Poor 0%
- Very Good 9%
- Excellent 91%

Relevance of the Pilot Project
- Good 6%
- Poor 2%
- Average 0%
- Very Good 18%
- Excellent 74%

Was Reading Material Useful
- Poor 5%
- Average 0%
- Good 9%
- Very Good 26%
- Excellent 60%

IRNSS-1E : IRNSS-1E is the fifth navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B, 1C and 1D were launched by PSLV-C22, PSLV-C24, PSLV-C26 and PSLV-C27 in July 2013, April 2014, October 2014 and March 2015 respectively. IRNSS-1E has a lift-off mass of 1425 kg. The configuration of IRNSS-1E is similar to that of IRNSS-1A, 1B, 1C and 1D. IRNSS-1E carries two types of payloads navigation payload and ranging payload. The navigation payload of IRNSS-1E transmits navigation service signals to the users. This payload is operating in L5-band and S-band. A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1E consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1E also carries Corner Cube Retro Reflectors for laser ranging. PSLV-C31 Successfully launched IRNSS-1E on January 20, 2016 at 09:31 Hrs (IST) from SatishDhawan Space Centre SHAR (SDSC SHAR), Sriharikota, the spaceport of India.

IRNSS-1F : Polar Satellite Launch Vehicle, in its thirty fourth flight (PSLV-C32), launched IRNSS-1F, the sixth satellite of the Indian Regional Navigational Satellite System (IRNSS). The launch took place from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota.

IRNSS-1G : IRNSS-1G is the seventh navigation satellite of the seven satellites constituting the IRNSS space segment. Like all other IRNSS satellites, IRNSS-1G also has a lift-off mass of 1425 kg. The configuration of IRNSS-1G too is the same as IRNSS-1A, 1B, 1C, 1D, 1E and 1F. IRNSS-1G was launched by PSLV-C33 into a sub Geosynchronous Transfer Orbit (sub GTO) on April 28, 2016 at 12:50 hrs (IST) from SatishDhawan Space Centre (SDSC) SHAR, Sriharikota.

CARTOSAT-2 C : The Cartosat-2 series satellite is the primary satellite carried by PSLV-C34. This satellite is similar to the earlier Cartosat-2, 2A and 2B. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C34, the satellite was brought to operational configuration following which it will begin providing regular remote sensing services using Panchromatic and Multi-spectral cameras.

The imagery of Cartosat-2 series satellite will be useful cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, precision study, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications. Launch of PSLV-C34/Cartosat-2 Series Satellite Mission took place on June 22, 2016 at 09:26 hrs (IST) from SDSC SHAR, Sriharikota.

INSAT-3DR : INSAT-3DR similar to INSAT-3D, is an advanced meteorological satellite of India configured with an imaging System and an Atmospheric Sounder. The significant improvements incorporated in INSAT-3DR are:

- Imaging in Middle Infrared band to provide night time pictures of low clouds and fog
- Imaging in two Thermal Infrared bands for estimation of Sea Surface Temperature (SST) with better accuracy
- Higher Spatial Resolution in the Visible and Thermal Infrared bands

SCATSAT-1 : India's Polar Satellite Launch Vehicle, in its thirty-seventh flight (PSLV-C35), launches the 371 kg SCATSAT-1 for weather related studies and seven co-passenger satellites into polar Sun Synchronous Orbit (SSO). Co-passenger satellites are ALSAT-1B, ALSAT-2B, ALSAT-1N from Algeria, NLS-19 from Canada and Pathfinder-1 from USA as well as two satellites PRATHAM from IIT Bombay and PISAT from PES University, Bengaluru.SCATSAT-1 was placed into a 720 km Polar SSO whereas; the two Universities / Academic Institute Satellites and the five foreign satellites will be placed into a 670 km polar orbit. This is the first mission of PSLV in which payloads were launched into two different orbits.PSLV-C35 was launched from the First Launch Pad (FLP) of SatishDhawan Space Centre (SDSC) SHAR, Sriharikota on Monday morning at 9:12 hrs (IST) on September 26, 2016.

Indian Regional Navigation Satellite System (IRNSS)

IRNSS is an independent regional navigation satellite system developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area. An Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 300 South to 500 North, Longitude 300 East to 1300 East.

IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorized users. The IRNSS System is expected to provide a position accuracy of better than 20 meter in the primary service area.

The IRNSS has a operational name of **NavIC** , which etymologically mean "sailor" or "navigator" in Sanskrit, Hindi and many other Indian languages, which also stands for 'Navigation' with Indian Constellation.

Some applications of IRNSS are:

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers

The IRNSS Signal-in-Space Interface Control Document (ICD) for Standard Positioning Service (SPS) is released to the public to provide the essential information on the IRNSS signal-in-space, to facilitate research & development and aid the commercial use of the IRNSS signals for navigation-based applications.

The space segment consists of the IRNSS constellation of seven satellites with the prefix "IRNSS-1". Three satellites are located in suitable orbital slots in the geostationary orbit and the remaining four are located in geosynchronous orbits with the required inclination and equatorial crossings in two different planes. All the satellites of the constellation are configured identically. IRNSS-1A, the first of the seven satellites, was launched on 1 July 2013 while the seventh satellite ,IRNSS-1G was launched on 28 April 2016.

The ground segment consists of the satellite navigation center within the campus of ISRO Deep Space Network (DSN) at Byalalu, in Karnataka . A network of 21 ranging stations located across the country will provide data for the orbital determination of the satellites and monitoring of the navigation signal.

Major Highlights of the IRNSS program

- An indigenous, independent regional navigation satellite system for providing location and time information.
- Service Area Indian landmass and surrounding 1500 km
- Location accuracy better than 20 m
- Navigation Services : Standard Positioning Service (open to all users), Restricted Service (to authorized users only)
- IRNSS space segment : 4GSO (Geo-synchronous) +3GEO (Geo-stationary) satellites
- Navigation Payload: L5 & S
- Ranging Payload: C x C
- Atomic Clocks: RAFS

IRNSS Concept   IRNSS Antenna   IRNSS GUI

IRNSS
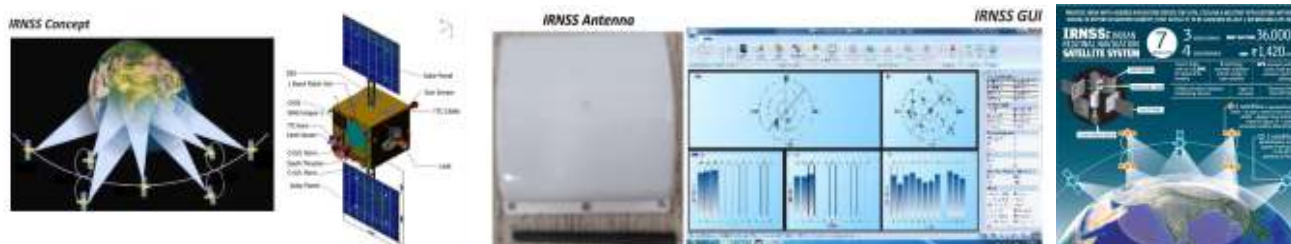
Meeting of CSSTEAP Governing Board

The 21st meeting of CSSTEAP Governing Board (GB) was held at New Delhi on December 19, 2016. The meeting was chaired by Mr. A.S Kiran Kumar, Chairman CSSTEAP GB and Secretary, Department of Space, Govt. of India and was participated by all the GB member and invited participants. The GB members included Mr. Afif Budiyono, Mr. Hojat Mousazadeh, Prof. A.A. Abdykakovich, President, Mr. Ulugbeg Begaliev, Mr. Om Prakash Joshi, Mr. Hong Pong Gi, H.E. Ms. Ma Teresita C. Daza, Mr. S. Panawennage, and Dr. A. Senthil Kumar. Others who participated included Mr. Tapan Kumar Misra, Director, Dr. Shantanu Bhatawdekar, Mrs. ShankariMurali, Mr. Vivek Singh, Dr. D.Gowrisankar, Dr. Sarnam Singh, Dr. S.K. Saha, Dr. S.P. Aggarwal, Dr. J. Banerjee, Dr. Raghunadh K. Bhattar, Dr. Arijit Roy, Dr. PuneetSwaroop, Dr. Vaibhav Garg, Mr. Rajender Katariya, Mr. D.D. Nagpal.

Dr. A. Senthil Kumar, Director, CSSTEAP welcomed the members and special invitees to the 21st meeting of the CSSTEAP-GB. Mr. A.S. Kiran Kumar, Chairman, CSSTEAP-GB/ Secretary, DOS welcomed all the GB members, observers and special invitees. He expressed his extreme gratification that the Centre has completed 21 glorious years of commendable service of capacity building in Asia Pacific region. The chairman also commended the center for the different short and long term courses in the different fields of space sciences.

The GB members were apprised of efforts being made by the CSSTEAP Secretariat to bring more countries onboard as members of Governing Board. Out of the eight countries to whom request was made, CSSTEAP has received positive response from Azerbaijan, Fiji, Maldives, Vietnam and Bangladesh. A briefing of delegation from Chinese National Space Administration (CNSA) and Beihang University China, visited Indian Institute of Remote Sensing (IIRS) and CSSTEAP as a follow-up of the Memorandum of Understanding (MoU) on "Space Cooperation" signed between ISRO and CNSA. Also, a two-member delegation from the office of Australian Consulate General, Chennai visited IIRS and CSSTEAP to discuss and identify the potential areas of mutual cooperation for capacity building and research in the areas of space science and technology. Chairman, CSSTEAP-GB highlighted the significant achievements of Indian Space Programme and missions since last GB meeting.

As Host country commitment, Department of Space continues to provide necessary support in terms of man-power, infrastructure and finance for smooth functioning of the Centre with some contribution from UNOOSA. Over the years, the Centre is able to sustain its excellent performance with active participation of member countries and due to guidance and direction provided by the Governing Board. He urged all the learned members to look into the possibility of furthering their support by providing financial contribution, fellowship & travel grant to the participants, organizing short training programs of regional interest.

Dr. Simonetta D. Pippo, Director, United Nations Office for Outer Space Affairs presented her remarks through SKYPE. She expressed her pleasure to address the Governing Board and acknowledged the participation of all governing board members in the 21st Meeting of the Governing Board. She had a great satisfaction that CSSTEAP is in the able hands of the Indian Space Research Organisation, an organisation that is leading an ambitious space programme for the benefit of humanity. She thanked Mr. A S Kiran Kumar, Chairman of ISRO and Chair of this Governing Board, for his mentorship to the CSSTEP.

Dr. Shirish Ravan from UNOOSA has proposed that CSSTEAP may support a course on Post Disaster (Earthquake) Rapid Damage Assessment to be held at Myanmar. Chairman GB appreciated the proposal and GB has approved the Proposal.

The agenda for the 21st meeting of the GB, which was circulated to the members, was adopted unanimously. Dr. A. Senthil Kumar, Director CSSTEAP briefed GB on the status of the action items emerged out of the 20th GB meeting. Director, CSSTEAP also presented report highlighting programmes, activities, host country support, etc. and reiterated that Centre would be involved in capacity building in space science & technology and applications in five assigned areas and also special theme-based short courses. He also apprised the dignitaries about the successful completion of the various courses.

Director, CSSTEAP apprised about the future plans to continue the present P.G Diploma & short courses in disciplines on space science technology & applications and to continue to support M.Tech research scholarship and need based for PhD. Research on a specific request from AP countries. He also emphasized that EDUSAT like distance education programmes should be taken up by CSSTEAP and GB member countries. Necessary support and infrastructure need to be made available by the respective country. He also added that CSSTEAP will develop international linkages with institutions like GEO, GEOSS, WMO, UNEP, etc; and also stressed on the need to have an monitoring mechanism and understanding need of the respective country in capacity building in Space applications. To achieve this, a National advisory council is proposed. He suggested that each country may set up a National Advisory Council (NAC) for CSSTEAP.

The meeting was closed by Chairman, CSSTEAP-GB who thanked all the GB members for their active participation and involvement in improving the overall activities of CSSTEAP. He mentioned that CSSTEAP is doing excellent service in Asia-Pacific region and all the countries are actively participating and sending their scholars / professionals/ students.

Visit of Australian Consul-General

Two member delegation consisting of Mr. Sean Kelly, Consul-General to Southern India and Ms. Sophie Anne Craig, Consul from the office of Australian Consulate General, Chennai visited Indian Institute of Remote Sensing (IIRS), Indian Space Research Organisation (ISRO) and Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) on February 23, 2016. The objective of the visit was to discuss and identify the potential areas of mutual cooperation for capacity building and research initiatives between ISRO, Government of India and Government of Australia in the areas of space science and technology. Dr. A. Senthil Kumar, Director, IIRS & CSSTEAP highlighted about the Capacity Building activities of IIRS and CSSTEAP in Space Science and Technology. He also mentioned that ISRO has used Australian field data for calibration of RISAT-1 data and are aware of crop productivity and florescence studies being done in Australia.

Mr. Sean Kelly, Australian Consul-General interacted with course participants of RSGIS from different countries. He briefed about the Australian Space Programme and mentioned that Australia is among the leading countries in the world in Space Programme and stressed about issues of Space Security, Space debris and collision between satellites, environmental monitoring, etc. He also informed about the New Colombo Plan for the students of member countries, particularly Australia and India. He informed that Australian Space Scientist Prof. Brian Schmidt who was 2011 Nobel Laureate in Physics is now the Vice Chancellor of Australian National University. He also mentioned about the supersonic and super-computing facilities in Queensland University. He also informed that Australian Prime Minister's has announced National Innovation and Science Agenda and informed about the International Science Congress in Adelaide in 2017 for partnerships with industry and space agencies to set up space science industry to study solar systems. He said these programmes will help India and Australia to science exchange programmes under New Colombo plan. He informed that Ms. Sophie Anne Craig, Consul will be the lead in space cooperation programme. The points agreed upon after the discussions for the future collaboration included Resources Sharing, Conducting Joint research programme, Publicity of e-learning and DLP programmes through websites, study-tours, and Exchange of Students, Faculty/Scientists.

Visit of delegation from Beihang University/CNSA

A delegation from CNSA and Beihang University China, visited IIRS during January 4-5, 2016. The visit was part of the Theme 4: Cooperation on Education and Training of the said MoU and to discuss on the potential cooperation between IIRS and Beihang University. The objective of the meeting was to discuss and identify the areas of mutual cooperation on Capacity Building between IIRS and Beihang University which includes Exchange of Students, faculty, Resouce sharing and elearning programmes.

Alumni meet at Colombo, Srilanka

An Alumni meet with the students of CSSTEAP from Sri Lanka was organized on October 20, 2016. at Colombo, Sri Lanka. Dr. Sanath Panawennage, Director, General and CEO of Arthur C Clarke Institute for Modern Technologies, Sri Lanka and GB member from Sri Lanka also attended the Alumni meet. Dr. A. Senthil Kumar Director, CSSTEAP interacted with CSSTEAP alumni members and asked for their views on future requirements of courses in the region. The outcome of the meeting includes a recommendation of short course on Planetary Mission, Lidar Applications and Unmanned Aerial system should be organized. Also a refresher course for the alumni may be organized through Distance Learning Programme.

Glimpses of student activities at CSSTEAP

Students during laboratory exercises

International hostel for course participants at IIRS Dehradun

Students participating in cultural programme

Participants celebrating Deepawali festival

Student at Gymnaism

Educational Visit to Qutub Minar, Delhi

Students at Practical Sessions

Mussoorie Visit

Taj Mahal Visit

Students playing Billiards

CSSTEAP Students participating in Tug-of-war at IIRS

Ongoing Courses

21nd RS & GIS PG Course	9 Months	1st July 2016 to 31st March 2017
10th Post Graduate course on Satellite Meteorology and Global Climate	9 Months	1st August 2016 to 30th April 2017
10th Post Graduate course in Space and Atmospheric Science	9 Months	1st August 2016 to 30th April 2017

Future Courses

Lidar Remote Sensing and its Application	2 Weeks	15th May to 26th May 2017
UAV Remote Sensing and its Application	2 Weeks	12th June to 23rd June 2017
Weather forecasting using NWP models	2 Weeks	3rd July to 14th July 2017
Small Satellite Mission	2 Weeks	20th Nov to 1st Dec 2017
22nd RS & GIS PG Course	9 Months	1st July 2017 to 31st March 2018
11th SATCOM PG Course	9 Months	1st August 2017 to 30th April 2018
2nd GNSS PG Course	9 Months	1st August 2017 to 30th April 2018
User demand courses	2-4 weeks	TBD

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