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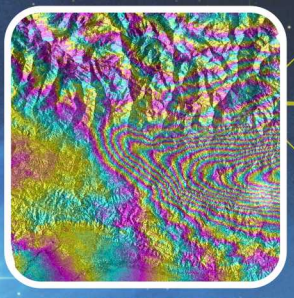
Education · Research · Training · Capacity Building
1966 - 2016
50 iirs
Indian Institute of Remote Sensing
Golden Jubilee

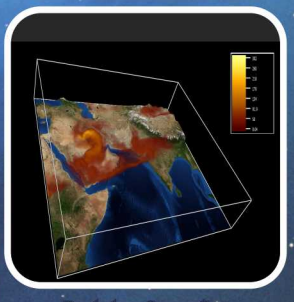
वार्षिक रिपोर्ट
Annual Report

2015-2016

Capacity building for Government's e-governance initiative



Displacement contours of Nepal earthquake



Dust-storm forecasting

Renovated IIRS Main building

भारतीय सुदूर संवेदन संस्थान
Indian Institute of Remote Sensing
देहरादून/ Dehradun

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Contents

HIGHLIGHTS OF ACTIVITIES & ACHIEVEMENTS OF IIRS

The Indian Institute of Remote Sensing (IIRS), a Unit of Indian Space Research Organization (ISRO), Govt. of India is striving continuously for the capacity building in the field of Remote Sensing (RS), Geographical Information System (GIS) and their applications through training, education and research. IIRS is playing a key role since five decades of its establishment in the country and Asian region in capacity building of various target groups, ranging from fresh graduates, engineers and postgraduate students to policy makers. The institute also hosts and conducts the training and educational programmes on RS & GIS offered by the Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations. As an integral part of capacity building, the institute undertakes applied research in Remote Sensing & Geo-information science, technology and applications, and also participates in various research programmes of ISRO.

A. Managerial Activities

Several activities have been taken up during last year in addition to the continuation of ongoing regular capacity building, research and operational programmes.

- IIRS Academic council (AC) and Board of Studies (BoS) have been reconstituted to provide guidance and suggestions to realize the vision,

mission and objectives of the institute. Experienced Scientists/ Engineers of ISRO/ DOS centres and Subject Matter Experts from reputed academic institutions, universities and organizations are included as Members of AC and BoS of the Institute. Dean (A) is Member Secretary of AC and Chairman of BoS.

- The syllabus of M.Tech. (RS & GIS) course has been revised through the sincere efforts of second meeting of re-constituted AC held at IIRS on February 19, 2016 and Second meeting of BoS organised on Septemebr 15, 2015. The revised syllabus will be implemented from the ensuing academic year starting from August, 2016.
- Towards strengthening capacity building and research activities in the field of natural disasters monitoring and management, a new department, 'Disaster Management Sciences' has been established. Another department 'Geoweb Services, IT and Distance Learning' (GIT&DL) has also been formed at IIRS to cater the increasing demand of capacity building in Geoweb Services and Distance Learning.

B. Capacity Building Activities

- During FY: 2015-16, a total of 636 participants have benefited from regular training, educational programmes (PG Diploma, M.Tech., M.Sc., Decision Makers, ITEC sponsored, certificate programme, ISRO-NNRMS sponsored programme for University Faculty, etc.) and special courses as part of capacity building activities.
- In addition to regular training programmes, 18 numbers of customized special courses for various target groups were organized. Around 387 participants have benefited from varoius customized special courses namely "UAV Remote Sensing & Applications", "Geospatial Technologies for Smart City Planning", "RS & GIS for Crop Growth Monitoring and Yield Prediction", "RS & GIS Applications in Carbon Forestry" and "ISPRS sponsored Summer School (In collaboration with University of Reading, UK)" .
- IIRS distance learning programmes - both Live and Interactive classroom (Edusat programme), and Online e-learning programme have significantly contributed in the mass capacity building activity of the institute.
- During the year 2015, 86 new institutions in the country have joined IIRS outreach programme and 8306 participants have been trained in the two courses conducted during the year. The courses are on the topics of "Applications of RS & GIS for Natural Resources" and "Basics of Remote Sensing, GIS and GNSS".
- Under IIRS outreach programme, several modules of Learning Management Systems (LMS) for various certificate courses in geospatial technology were developed. 1800 participants have registered for five courses offered under e-Learning programmes.
- As host institute for CSSTEAP, IIRS has significantly contributed in the capacity building efforts in the Asia-Pacific region. CSSTEAP has conducted a Post Graduate Course in RS & GIS and two special short courses in RS & GIS applications viz., "Disaster Response and Recovery Preparedness" and "Coastal & Marine Disaster Management and Impacts of

Climate Change". 61 participants from 15 Asia-Pacific countries have benefited from PG and short courses.

C. Research Activities

IIRS is involved in a number of research projects of ISRO/ DOS such as Earth Observation Application Mission (EOAM: 9 nos.), Disaster Management Support (DMS: 2 nos.), National Carbon Project (ISRO-GBP: 3 nos.) and other Mission Projects (SARAL-ALTIKA & INSAT INSAT-3D Utilization Projects). In addition to these ISRO/ DOS projects, IIRS faculty have significantly contributed in the research activity through 14 ongoing TDPs and other in-house research projects. As many as 65 research papers were published in peer reviewed international and national journals. Salient findings of some of the selected research projects/ studies are briefly described in following sections -

- **Geodynamics and Seismicity Investigations in Northwest Himalaya (EOAM Project):** Microwave remote sensing data (L-band ALOS-2 PALSAR) DInSAR (Differential Interferrometric SAR) based terrain deformation due to Nepal earthquake showing high relative deformation along the weak structural planes of south west of Mt. Everest was studied using November 24, 2014 and April 27, 2015 temporal data. This terrain deformation map is helpful to understand reasons behind earthquake damages.
- **Analysis and Forecasting of Dust Storm Originated from the Arabian Region (In house Research study):** An attempt has been made to analyse those meteorological conditions which pumped the dust particles towards subcontinent, by means of remotely sensed observations and model simulated datasets. The Weather Research and Forecasting (WRF) model coupled with chemistry (WRF-Chem) and GOCART dust scheme was used to predict the severe dust storm originated from the Arabian Peninsula region. The results obtained from the present work are encouraging and suggest that the WRF forecast may be useful to mitigate the impact of dust storms over the affected regions.
- **Identification and mapping of ice sheet features and glacial landform in Antartica (In house research study):** In this research work, an image album has been made highlighting some of the major ice sheet features and glacier landforms present in Antarctica using Cartosat-2 data. ISRO's microwave satellite data. RISAT-1: FRS-1 and MRS data have been also used to identify additional ice sheet and glacier features which were not detected by optical satellite data.
- **Vulnerability assessment of Forest Ecosystems due to Climate change (EOAM Project):** Ensemble model for forest species prediction for present and future climate change scenarios was developed and forest species distribution model was also established for western Himalaya. It was observed that there was a significant change in the altitude ranges of *Taxus wallichiana* as well as *Abies pindrow* in the western Himalayas.

- **Sustainable Mountain Agriculture (EOAM Project):** GEPIC model simulation for studying impact of future climate change on crop productivity of Himachal Pradesh showed wheat yield decline in 2020s and 2080s, however yield may increase in 2050s as compared to baseline (1960-90) period.
- **Modeling Temporal & Spatial Growth of Cities & Towns in NW Himalaya (EOAM Project):** An Urban Fringe Model (UFM) has been developed for the urban morphology analysis. Using various machine learning algorithms, the future growth scenarios in response to various policy measures were generated for Dehradun and Haldwani planning areas.
- **TRIVIM (In house Research study):** An open source freeware application for 3D model generation has been developed using open source software and made available to public through IIRS website. This application will enable users to generate 3D models using multiple overlapping terrestrial photographs with sub-meter accuracy in planimetry as well as height.
- **3D City Modeling for Harnessing Solar Energy (Inhouse Research study):** A building information model has been developed using Google SketchUp and exported to energy modelling programme in gbXML schema. The semantic characteristics of CityGML model for solar thermal energy potential assessment based on building semantic components was evaluated.
- **3D City Traffic Noise Modeling (Inhouse Research study):** The developed CityGML data model was initially loaded into Post GIS database. A web GIS framework was implemented for traffic noise analysis.

Other Activities

- IIRS in collaboration with Central Govt. Institutes and Nagar Nigam, Dehradun coordinated and participated in 'Joint Swachh Bharat Abhiyaan' activity on October 02, 2015. A unique Swachh Bharat Mobile Application (beta version) using Geospatial technology has been developed by IIRS.
- Fourth IIRS User Interaction Meet (IUIM-2016) on 'Recent Advances in Geospatial Technologies' was held during February 18, 2016 at IIRS. There were more than 200 participants from various academic institutions, government departments, industries, Edusat-users from all over India besides faculty and student participants from IIRS.
- IIRS has been participating in CEOS-WGCapD's annual meetings every year since the inception of the Working Group in 2012. In this meeting, status and progress of various activities were discussed e.g., e-learning programme, data democracy, populating capacity building portal, supporting CEOS in disaster risk management related capacity building activities and future plans.
- The institute provided Biodiversity Information System (BIS) geo-web services to the user community.

- Awards / Honors: In recognition of outstanding contributions in capacity building and research in Honours Geospatial technology and application, IIRS was honoured with several awards like National Award for excellence in Training for 'e-learning initiatives for RS & GIS' and 'Reach the Unreached–EDUSAT Programme' from DoPT & UNDP; and 'Education Leadership Award' from ABP News National Education Award. Three scientists of the institute were also awarded with PR Pisharoty award, Young Scientist award and Eminent Engineers award by ISRS, ISRO and Institution of Engineers, respectively.
- The budgetary allocations under IIRS 'Centre-budget' in RE: 2015-2016 were Rs. 3895 Lakhs and it gives me immense pleasure to inform that actual-expenditure as on March 31, 2016 was Rs.3886.90 Lakhs (99.79%).
- Foundation-stone of Golden Jubilee hostel was laid down by Chairman, ISRO on October 23, 2015. The IIRS master plan has been approved and budget has been allotted to realize the Master plan infrastructure by 2018-19. Other infrastructural improvements include - Vertical extension to GID Building, Additional rooms in Guest House, 30 KWp Grid interactive solar photovoltaic power plant, 2x100 KVA parallel redundant UPS System, etc.
- Several professional days viz. National Remote Sensing Day, Earth Day, Environmental Day, GIS Day and Engineer's Day were celebrated with technical lectures delivered by eminent speakers.
- Hindi Pakhwara was celebrated in the Institute during September 14-28, 2015 wherein various competitions were organized.

I am thankful to Dr. A. S. Kiran Kumar, Chairman, ISRO for his continuous support and guidance on various initiatives and endeavours of IIRS.

I highly appreciate the suggestions and contributions made by the members of Management Council (MC), Academic Council (AC) and the Board of Studies (BoS) and wish to have their support and encouragements in future.

(Dr. A. Senthil Kumar)
Director

IIRS PROFILE

Indian Institute of Remote Sensing (IIRS)- an ISO 9001:2008 institute, is a constituent unit of Indian Space Research Organisation (ISRO), Department of Space, Government of India. Since its establishment in April 1966, IIRS has been a premier institution and key player for capacity building in the field of Remote Sensing and geospatial technology, and its applications through training, education and research. Considering enhanced capacity building needs, IIRS has been given the status of an independent Unit of ISRO with effect from April 30, 2011. Over the years, the institute is playing a major role in **capacity building activities** which can be primarily grouped into the following three domains:

- Training & Education Programmes
- Research Programmes
- Outreach Programmes

Formerly known as Indian Photo-interpretation Institute (IPI), the Institute is the first of its kind in entire South-East Asia. While nurturing its primary endeavour to build capacity amongst the user community by training mid-career professionals, the institute has enhanced its capability and evolved many training and education programmes that are tuned to meet the requirements of various target groups, ranging from fresh graduates to policy makers including academia.

IIRS is also one of the most sought after institute for conducting specially designed courses for the officials of Central and State government ministries and stakeholder departments to make more effective utilization of Earth Observation (EO) data and use of Geographic Information System (GIS) tool. As a follow up of the National Meet held on September 07, 2015. IIRS is also given a special responsibility of Capacity Building needs for effective governance using space technology based tools in Ministries and Departments under Central and State governments.

About 40 courses are conducted every year and more than 10, 000 professionals and students have been trained/ educated since establishment of the institute. About 50 students supervised by IIRS faculty have received PhD degrees till date from different Indian universities. IIRS also received the 'ABP News Education Leadership Award' on July 23, 2015.

To widen its outreach, IIRS has started live and interactive distance learning programme (DLP) through Edusat in 2007. Today, 303 institutions / organizations are networked with IIRS and about 25,000 participants have attended the various basic and advanced courses conducted so far. IIRS has also launched e-learning course on Remote Sensing and Geo-information Science in August, 2014. Efforts are underway to develop the e-learning content (also in Hindi) for various remote sensing and GIS applications.

The Institute campus also houses the headquarters of the Centre for Space Science and Technology Education in Asia and The Pacific (CSSTEAP), affiliated to the United Nations and first of its kind established in the region in November 1995. IIRS, as host institution provides support to conduct all its Remote Sensing and GIS training & education programmes at postgraduate level. The headquarters of Indian Society of Remote Sensing (ISRS), one of the largest non-governmental scientific society in the country, is also located in the Institute's campus.

The institute is involved in teaching and research activities all the year round. Along with providing education to the students in various courses, capacity building in Geoinformatics is also done for numerous organisations on their demands in the form of short courses.

The institute caters to various training requirements and needs of people across India. Its unique blend of programmes is structured to develop strategic thinking and state-of-the-art skills among students and professionals in India and the developing world in RS and GIS. The international relations at IIRS also encompasses a gamut of interests which includes joint research, higher education, faculty and student exchange and other collaborative initiatives.

The Institute has a strong, multi-disciplinary and geospatial solution-oriented research agenda that focuses on developing improved methods/ techniques for processing, visualization and dissemination of EO data & geo-information for various societal applications and better understanding of Earth's system processes. Microwave, hyperspectral and high-resolution EO data processing and their applications is the main research focus, currently. Various state-of-the-art laboratories, field-based instrumentations and observatories networks help meeting the research goals and objectives.

Quality Policy of IIRS

"Promote capacity building through quality training and education in the field of remote sensing and Geoinformatics to comply with requirements and continually improve the effectiveness of the Quality Management System"

Scope of IIRS Quality Management System

"Transfer Technology through training and education in the field of remote sensing and Geoinformatics for sustainable development"

IIRS - GROUPS AND DEPARTMENTS

Programme Planning and Evaluation Group (PPEG)

The Institute receives various requests for conducting training throughout the year. Programme Planning and Evaluation Group (PPEG) under Director's office coordinates the training and capacity building, human resources development, budget, hostel, library, etc. activities of the institute.

PPEG also caters to various demands and requirements of the students. The entrance tests for the admission of M. Tech. and M. Sc. courses are also coordinated by PPEG office. The planning and organisation of various inter-centre assignments are also carried out in close coordination with this Group in interface with other Groups, Departments and facilities of IIRS. It also coordinates the training and research activities of external students carried out under the supervision of IIRS faculty. PPEG also maintains the IIRS alumni database. This Group is also responsible for catalyzing various techno-managerial activities assigned to IIRS and acts as secretariat of IIRS for pertinent correspondence within and outside ISRO/ DOS.

Earth Resources and System Studies Group (ER&SSG)

Agriculture & Soils Department

Agriculture and Soils Department is one of the oldest departments of the institute. The department has carried out many R&D and consultancy projects in the areas of soil surveys, watershed prioritisation, soil and land irrigability assessment, land evaluation, crop resources inventory, agro-meteorology, soil suitability for crops, forestry and plantation, etc. It has also contributed significantly towards various ISRO/DOS Mission projects like Wasteland mapping, Land use/ Land cover mapping, Land degradation mapping, Integrated Mission for Sustainable Development (IMSD), Soil Carbon Pool (SCP) assessment & Soil-Vegetation C flux measurement in National Carbon Project (NCP), etc. This department conducts regular long term academic and special training programs of the institute on the theme of Agriculture & Soils. The capacity building and research activities of the department are-

Capacity Building

- Organization of short courses in- Microwave RS Applications in Agriculture & Soils, Hyperspectral RS Applications in Agriculture & Soils, Satellite Agro-meteorology, Modeling Crop Growth & Productivity, Soil erosion modeling for Watershed management, and
- Organization of special courses as per the requirements of Central and State Government Ministries and Departments (Agriculture, Rural Development & Cooperation, Earth Sciences - IMD).

Research

- Microwave (Active & Passive) and Hyperspectral Remote Sensing in soil and crop resources characterization and inventory,
- Digital soil resources characterization using GPR and geo-statistical methods,
- Process based modeling for soil erosion, sediment loss, soil carbon sequestration and soil carbon dynamics at watershed scale,
- Development of early warning system for drought monitoring by combining climate and crop model and using geospatial techniques,
- Large area fluxes over agro-ecosystem using coarse resolution geostationary satellite, and
- Carbon accounting modeling by integrating flux observation and RS of major agro-ecosystems.

Forestry & Ecology Department

The Forestry and Ecology Department was established in 1966 with the aim of providing training and skill development on the utility of aero-space remote sensing for forest resource inventory, monitoring and management for forest managers in particular and scientific community in general. Nationwide forest cover mapping & nationwide biome level characterization of Indian forests biodiversity at landscape level are the three major projects planned and executed by the department. A few other important research projects carried out by the department are - growing stock and biomass assessment, wildlife habitat modelling, sustainable development planning, national level carbon flux measurement and modelling, national level vegetation carbon pool estimation in India, ecosystem dynamics and hydrological modelling in north-eastern region, wildlife habitat evaluation in Ranikhet and Ranthambore Tiger Reserve, national level biome classification of natural vegetation, grassland mapping and carrying capacity estimation. The capacity building and research activities of the department are-

Capacity Building

- Organization of short courses on RS & GIS applications in Forestry for the line departments, Use of RS & GIS in forest working plan, Impact of climate change in forestry.

- Organization of short courses through IIRS Distance Learning Program on RS & GIS in applications for State forest Departments.
- Organization of special courses following the National Meet and meeting the Ministries' requirements.

Research

- Biodiversity Characterization, Species distribution modeling, plant invasion risk modelling.
- Synergistic use of advanced sensors (hyperspectral, LiDAR, microwave and GPR) for forest biophysical and biochemical parameters retrieval.
- Carbon pool and flux measurement for forest productivity assessment.
- Ecosystem vulnerability assessment, Forest fire risk modelling and Prediction.
- Climate change impact on forests and ecosystems - modelling species loss & changes in plant communities.
- Ecological and wildlife corridor modelling and connectivity analysis.

Marine & Atmospheric Sciences Department

This department established in 1986 offers training & education courses and provides research opportunities in the areas of coastal processes, marine resources, ocean and atmospheric sciences applications. The department has contributed in different research and operational projects of ISRO/DOS, such as Nationwide Land Degradation Mapping on 1:50,000 scale, Oceansat-II data utilization project, National Carbon Project (NCP), SARAL-ALTIKA project, etc. The capacity building and research activities of the department are-

Capacity Building

- Organization of short courses on Microwave RS applications for coastal & ocean sciences, Atmospheric pollution modeling, RS & GIS application in extreme events forecasting & monitoring, fishery forecasting, etc.
- Organization of special courses following the National Meet and meeting the Ministries' (Earth Sciences, Agriculture, Fisheries, etc.) requirements.

Research

- Coastal geomorphology and processes, coastal hazards and their mitigation.
- Ocean color and primary productivity.
- Upper-ocean geophysical parameter retrieval, near shore water quality, aerosol optical depth over ocean.
- Modeling of coastal dynamics, sea level rise and consequent salt water intrusion into coastal aquifers, estuaries and coastal processes.
- Indian summer monsoon studies: Intra-seasonal oscillations, active and break spells etc.
- Retrieval of atmospheric parameters.
- Ozone and its precursors: chemistry and Transport.
- Regional and global Chemistry Transport Modeling.

Water Resources Department

Water Resources Department (WRD) was established in the year 1986 and since then it is engaged in capacity building, research and consultancy services in various fields, such as hydrological modelling, flood risk mapping and zoning, watershed conservation, planning & management, snowmelt runoff modelling, irrigation command area inventory and water management. The department specializes in the areas of flood monitoring and damage assessment, hydrological and hydraulic modelling, impact assessment of climate change in water resources, irrigation water management and drought assessment, snow, glacier studies, soil erosion, sediment yield modelling and reservoir sedimentation, surface and ground water hydrology, watershed assessment and management. The capacity building and research activities of the department are-

Capacity Building

- Organization of courses on Geo-informatics for Water Resources Management, Remote sensing, GPS and GIS for climate change impacts in water resources, Microwave and Hyperspectral RS applications for Water resources, flood disasters risk reduction, hydrological and hydrodynamic modeling.
- Organization of special courses following the National Meet and meeting the Ministries'/ Departments' (Water Resources, CWC, Agriculture–Drought disaster, MHA-Flood disaster) requirements.

Research

- Operationalization of flood early warning system for North Western Himalayan region.
- Development of hill-slope & snow-glacier melt hydrological model for mountainous regions.
- Technique development for retrieval and geophysical product generation of hydrological parameters using Indian EO system and other satellite sensors data.
- Operational technique development for irrigation water management using RS&GIS.
- Technique development for retrieval of water quality parameters & snow properties using hyperspectral remote sensing.
- Climate studies with reference to hydrology.

Urban and Regional Studies Department

Urban and Regional Studies Department (URSD) was established in 1983 in collaboration with ITC, The Netherlands to meet the growing needs and challenges of urban and sustainable regional development. It has developed expertise in the field of urban sprawl and growth modeling, infrastructure planning, urban environment analysis and regional analysis. It works in coordination with Town and County Planning Departments/ Urban Local Bodies and aims to spread the benefits of remote sensing technology at grassroots level. The department has carried out a number of consultancy, operational and research projects. Development planning for the Noida and Greater Noida Authority, Delhi Development Authority (Rohini scheme) and Jaipur Development Authority are some of the landmark consultancy services provided by the department. The capacity building and research activities of the department are-

Capacity Building

- Organization of short courses on Geospatial Technologies for Urban planning through IIRS outreach program and Geospatial technologies for Smart city planning and
- Organization of special courses following the National meet and meeting the Ministries' (Urban Development, Housing & Urban Poverty alleviation, Road, Transport & Highways, Tourism, Culture) requirements.

Research

- Urban Micro Climate Zonation for sustainable smart city planning.
- Modeling Urban air and noise pollutions.
- Urban material detection using hyperspectral RS data.
- Infrastructure mapping through Ground Penetrating Radar (GPR).
- Urban drainage and flooding studies.
- Solar energy harvesting potential assessment for buildings.
- Urban growth dynamic modeling.
- Impact of urban spatial growth dynamics on climate.

Geosciences and Disaster Management Studies Group (G&DMS)

Geosciences and Geohazards Department

Geosciences and Geohazards Department (GSGHD), formerly known as Geosciences Division, was established in 1966 to provide professional training to technical staff of organisations dealing with earth sciences applications such as mineral and oil exploration, engineering geological survey and mapping, geological survey, groundwater exploration, etc. It has successfully executed a number of research, operational and consultancy projects in different fields of geological sciences.

Disaster Management Sciences Depatment

Considering the importance of studying the science behind the incidence and intensity of natural and anthropogenic hazards and adverse environmental impacts, Disaster Management Science Department has been recently (2015) created under the aegis of Geosciences and Disaster Managements Studies Group of the institute. The department is dedicated towards capacity building and research in remote sensing and GIS techniques for assessment, monitoring and modelling of natural and anthropogenic disasters with prime focus on prevention and mitigation measures leading to disaster risk reduction. Currently, this department offers PG Diploma in RS and GIS applications in Natural Hazards and Disaster Management Studies with specialisation in Hydro-meteorological (flood, drought and coastal) and Geological hazards (earthquake, landslides, mining related hazards, glacial lake outburst flood (GLOF), etc.). Over a period of time, the institute has developed expertise in landslide modelling, seismic micro-zonation, active fault mapping, liquefaction modelling, Differential Interferometric Radar (DInSAR) based land surface displacement modelling, flood modelling, drought monitoring, soil erosion modelling, forest fire risk assessment, storm surge modelling, extreme climate induced hazard analysis, multi-hazard vulnerability and risk assessment etc. The capacity building and research activities of the Geosciences and Disaster Management Studies Group are:

Capacity Building

- Organization of short courses on Geo-informatics for disaster risk reduction, Hyperspectral imaging for geological applications, Geo-informatics for mineral, oil exploration and mining, Remote sensing and geophysical investigation for groundwater, and Microwave remote sensing for geological and geo-environmental studies.
- Organization of special courses following the National Meet and meeting the Ministries' (Mines, Coal, Steel, Petroleum & Natural Gas, Atomic Energy and Home Affairs – Geological disaster) requirements.

Research

- Integration of Geophysics (Solid Earth and Shallow Surface) and Earth Observation for Geodynamics, Mineral and Ground water exploration.
- High resolution and temporal hyperspectral image analysis for mineral detection and abundance mapping.
- Microwave and Thermal Remote Sensing and Mining.
- Landslide monitoring, early detection and warning.
- Planetary Geology (Mars and Moon).
- Glaciology and Climate Change.

Remote Sensing and Geoinformatics Group (RS&GG)

Photogrammetry and Remote Sensing Department

Photogrammetry and Remote Sensing Department (PRSD) established in 1966 is imparting professional training in the field of photogrammetry, cartography, remote sensing, and image processing to varied course participants: university teachers, academicians, govt. officials and freshly graduated students. It has successfully executed a number of studies/projects on large-scale surveys and preparation of photo-maps in different parts of the country, generation of national level database on land use/ land-cover, global land-cover mapping using SPOT-4 Vegetation (VGT) data, augmentation of forest cover information in India and Myanmar, generation of land surface parameters for monsoon variability studies using Regional Climate Model etc., to name a few.

The capacity building and research activities of the department are-

Capacity Building

- Organization of short courses on Polarimetric SAR, UAV Remote Sensing & Applications, Close range photogrammetry, LiDAR Remote Sensing & Applications.
- Organization of special courses following the National Meet and meeting the Ministries' requirements.

Research

- LiDAR-RS (Terrestrial Scanner for Cultural, Natural Resource and Landslide monitoring).
- Multi-sensor, multi-platform data integration for extracting terrain feature.
- UAV data Processing for terrain information extraction processing.
- Automated feature extraction and large scale mapping.
- SAR Tomography (Use of space-borne SAR data for single and multi-base line PolinSAR tomography, 3D reconstruction of target & signal compression techniques and tool).
- SAR Calibration (Calibration Constant, PolSAR Calibration and minimization of cross-talks and Faraday rotation).
- Hyperspectral Remote Sensing (Open source tool development for hyperspectral data processing).

Geoinformatics Department

Geoinformatics Department (GID) is one of the technology development department, set-up in 1996 in collaboration with University of Twente, Faculty of Geo-information Science & Earth Observation (ITC), The Netherlands to offer core technological courses in the field of Geo-information Science. The M.Sc. course in Geo-information Science and Earth Observation (specialisation in Geoinformatics) is one of its major programmes offered since 2002 as a part of Joint Education Programme of IIRS and ITC, The Netherlands.

Postgraduate Diploma course in Geoinformatics (as a Joint- Education Programme of IIRS and ITC) is also offered by this department. GID imparts training, education & research in the field of GIS, DBMS, spatial analysis and modelling, Transportation GIS, 3D GIS, Spatial Data Mining, Health GIS and development of open source software tools. Technology development in the areas of GIS, database management, spatial analysis and modelling, development of decision support/ expert systems are its main focus. The capacity building and research activities of departments are :

Capacity Building

- Organization of short courses on 3D GIS, Geospatial data standards, Python for geo-data processing, Geo-tagging & Mobile Apps development, Geostatistics.
- Organization of special courses following the National Meet and meeting the Ministries' requirements.

Research

- Road GIS Components (Network analysis, 3D GIS, Big data analytics, and Transportation GIS).
- Distributed GIS (Web services & Semantic web using Ontologies).
- Health GIS (Data clustering & Outbreak detection).
- 4D GIS (Spatio-temporal modelling and analysis).
- Large scale 3D modelling using High Performance Computing (HPC).
- Improved services of Biodiversity Information System (BIS) using OGC, WPS, WCS.
- Virtual GIS laboratory.

Geoweb Services, Information Technology & Distance Learning Department

Geoweb Services, IT and Distance Learning (GIT&DL) Department is recently formed Department at IIRS to meet the increasing demand of capacity building in Geoweb Services, IT and Distance Learning. The capacity building and research activities of the department are-

A. Geoweb Services:

- Capacity building & R& D activities in Geoweb services and related technologies such as Web GIS, Mobile GIS, Location Based Services (LBS) and cloud GIS, etc.
- Design and development of Geoweb/ Web GIS based solutions for various thematic applications using desktop and mobile platforms.

B. Information Technology (IT)

- Capacity building on advancements in Information Technologies (IT) for Geospatial applications.
- Central data, computing and Information Services.
- IT Infrastructure development, setup and operations for the Institute.

C. Distance Learning (DL)

- Capacity building in Remote Sensing and Geospatial technologies through Distance Learning mode (Live & interactive and e-learning).
- Digital contents creation for Geospatial technologies.
- R&D activities on 2D and 3D Simulations and virtualization for scientific instruments such as DGPS, TLS, spectro-radiometer etc., and practical experiments in RS&GIS.
- R&D activities of methodologies on active learning.

ACADEMIC AND CAPACITY BUILDING PROGRAMMES

Highlights

The institute organises about 40 courses every year and it has trained 10,252 professionals (till March, 2016), including 965 professionals from abroad representing 95 countries mainly from the Asia, Africa and South America. A total of 177 students in M.Sc. and 233 Students in M.Tech. courses have graduated since 2002.

As a follow up of the National Meet held on September 07, 2015, IIRS is also given a responsibility of Capacity Building needs for good governance in Central Ministries and state governments. IIRS provides support to conduct all its remote sensing and GIS training and education programmes at Postgraduate level.

In addition to regular academic programmes, IIRS is one of the most sought after Institute for conducting specially designed courses for the officials of Central & State government ministries and stakeholder departments for the effective utilization of earth observation (EO) data.

Special/ Tailor-made courses were also designed and conducted at IIRS for various user organizations; such as Watershed Management (8), Personnel of the IAF (13), ISPRS Summer School (81), Application of RS & GIS in Water Resources Management for GB Pant institute, Pantnagar (11), NCERT/ ISROs' Training program for PGT in Geography in RS & GIS (40), Course of RS & GIS in Forestry and Wildlife Research for Jammu University (10), Course for Forest Dept. of Bengal on application of GPS & GIS tools of forestry (11), Refresher course for IFS Officers on Forest Working Plan Preparation using RS&GIS Technology (20), Course on RS&GIS for Crop Growth Monitoring & Yield Prediction for IMD Officers (24), Course on application of RS&GIS for Natural Resource Management for ISS Officers (20), Course on UAV RS & applications (23), Smart city planning (34), Course on GIS & GPS applications in forestry (13), Course on Application of RS&GIS in NRM for ISS Officers (46), etc.

To widen its outreach, IIRS has started live and interactive distance learning programme (DLP) in 2007. Further 29,895 graduate and post-graduate students from 368 universities spread across the country have also benefited through EDUSAT-based distance learning programmes being offered by the Institute till date. IIRS has also launched e-learning course on RS&GIS which is running successfully.

The Institute campus also houses headquarters of the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations and first of its kind established in the region in 1995. IIRS provides support to CSSTEAP.

Till date CSSTEAP has conducted 47 PG Courses: 20 in RS&GIS, 9 each in SATCOM, SATMET and SAS. In addition, it has also conducted 41 short courses and workshops in past 20 years. These programmes have benefited some 1544 participants from a total of 34 countries in the Asia-Pacific region and 29 participants from 18 countries outside Asia Pacific region.Till date, 136 PG students (66 in RS&GIS, 35 in SATCOM, 17 in SATMET and 18 in SAS) from 16 different countries have been awarded M.Tech degree.

Student Outputs *(Last two Financial Years)*

Year	Regular Programmes							Special Programmes	Total
	PGD	NNRMS	ITEC	M. Tech.	M.Sc.	DM	Certificate		
2014 - 15	18	61	38	28	6	32	14	223	420
2015 - 16	63	64	34	35	6	36	10	387	635

Major highlights of the Special Courses organised in FY 2015-2016

S. No.	User Department	Course Title	Course Duration	Course Period		No. of participants
				From	to	
1.	WMD, Dehradun	Special course on geospatial technologies in Watershed Mgmt.	1 week	25.05.2015	29.05.2015	8
2.	Indian Air Force	Special Course on Remote Sensing & GIS for Personnel of the Indian Air Force	2 months	08.06.2015	31.07.2015	13
3.	Govt. Departments, Universities & Institutes	Special course on ISPRS Summer School	1 week	06.07.2015	10.07.2015	81
4.	G.B.P.U.A & T, Pantnagar	Special Course on Application of Remote Sensing & GIS in Water Resources Management	2 weeks	13.07.2015	24.07.2015	11
5.	NCERT	Special training program on Capacity Building Program for PGT in Geography in the field of RS & GIS	2 weeks	27.07.2015	7.08.2015	18
6.	University of Jammu	Special course of RS & GIS in Forestry and Wildlife Research	1 month	27.07.2015	21.08.2015	10
7.	Forest Dept. of West Bengal	Special course on application of GPS & GIS tools in forestry	1 week	10.08.2015	14.08.2015	11
8.	MoEF	One week Refresher Training Course for IFS Officers on Forest Working Plan Preparation using Remote Sensing and GIS Technology	1 week	31.08.2015	04.09.2015	20
9.	Indian Meteorological Dept.	Special Course on RS & GIS for Crop Growth Monitoring & Yield Prediction	3 weeks	31.08.2015	18.09.2015	24
10.	Ministry of Statistics & Prog. Implementation	Special Short Course on Applications of Remote Sensing and GIS for Natural Resource Management for ISS Officers	1 week	14.09.2015	18.09.2015	20
11.	Govt. Departments, Universities & Institutes	Special Course on UAV Remote Sensing	1 week	5.10.2015	9.10.2015	23
12.	RSACUP, Lucknow	Special Advance Course on RS and GIS Applications in Forestry	2 weeks	30.11.2015	11.12.2015	12
13.	Forest Dept. of Bangladesh	Special course for Bangladesh Forest Range Officer on RS and GIS Applications in Carbon Forestry	3 weeks	30.11.2016	1.1.2016	6
14.	Town & Country Planning Officials	Special Course on Geospatial Technologies for Smart City Planning	1 week	07.12.2015	11.12.2017	34
15.	NCERT	Special course on Remote Sensing and Geographical Information System for Geography Teachers	2 weeks	04.01.2016	15.01.2016	22
16.	Forest Dept. of West Bengal	Special course on application of GPS & GIS tools in forestry	1 week	29.02.2016	04.03.2016	12
17.	NSSTA (ISS)	Special course on applications of Remote sensing & GIS for Natural Resources management (National Statistical Systems Training Academy)	1 week	14.03.2016	18.03.2016	46
18.	NIELIT	Special Course on Capacity Building Programme in GIS	1 week	21.03.2016	08.04.2016	16
	Total					**387**

EDUCATION PROGRAMMES

M.Tech. Course in Remote Sensing and Geographic Information System

M. Tech. course in Remote Sensing and Geographic Information System is a joint educational program organized by Indian Institute of Remote Sensing (IIRS), Dehradun and Andhra University, Visakhapatnam. The institute offers M.Tech. course in RS & GIS in eight specializations which includes (i) Agriculture & Soils, (ii) Forest Resources & Ecosystem Analysis, (iii) Geosciences, (iv) Marine & Atmospheric Sciences, (v) Urban & Regional Studies, (vi) Water Resources, (vii) Satellite Image Analysis & Photogrammetry, and (viii) Geoinformatics.

The 12th M.Tech. course in RS and GIS commenced on August 19, 2013. A total of 35 participants joined the course. M.Tech. is a 24 month course and consists of 4 semesters. The Semester-I is of 4 months duration while Semester-II is of 6 months duration divided into 2 modules (Module-II and Module-III) each of 3 months duration. Based on their specializations, the participants joined their respective department for the Module-II of Semester-II. Module-III is a common module on advanced topics and recent trends on RS and GIS. Semester-III and IV is meant for project work of 14 months duration. The project-titles were as follows:

- Object identification approach for hyperspectral and multispectral thermal data
- PolInSAR and TLS data modeling for forest biophysical parameter characterization
- Automatic Extraction of Water Features at Multiple Scales
- Detection of Phenological change over Himalaya region using Decomposition model
- Simulation of Hyper-Spectral Data From Multispectral data Using Spectral Reconstruction Approach
- Machine learning based Regression model for forest above ground Biomass Estimation using RISAT-1 POLSAR and TLS LiDAR data
- Object recognition in Very High Resolution Satellite Imagery using Ontology
- Specific Crop Identification using Kernel based Fuzzy Approach from Temporal Data

- Flood Simulation Using Weather Forecasting & Hydrological Models
- Assimilation of Remote Sensing derived parameters in hydrological model for Ganga Basin.
- Water resource assessment at a basin level using water balance approach and remote Sensing inputs
- Study of Gangotri Glacier Dynamics using Remote Sensing and Geospatial Tools
- Hyderological modelling over Ganga basin with focus on snowmelt runoff.
- CityGML based Interoperability for the Transformation of 3D Data Models
- Web based 3D interactive analysis and visualization services.
- Web based Spatio- Semantic Analysis of Traffic Noise Using 3D Geospatial Information
- Stream Data Clustering for Development of Real Time Disease Outbreak Detection System
- Precipitation Intensity Based Threshold Modelling and Landslide Impact Assessment in Alaknanada Valley
- Land Subsidence modelling using spaceborne geodetic techniques and field based measurements
- Mapping of Alteration mineral zones by combining techniques of RS & Spectroscopy in the parts of SE- Rajasthan
- Identification & Characterization of Active Faults by Space borne ScanSAR Interferometry and Ground Based GPR Techniques in NW Himalayan Foot Hill Region, India
- Assessment of Crustal Deformation along Alaknanda Valley using Campaign mode GNSS observations
- Design of the Digital Control Electronics for a Ground Based Radiometer system and Estimation of Rain Attenuation losses in the Signal Transmission link.
- Spatio-Temporal Variability of Aerosol Optical Properties and their Impact on Aerosol Radiative Forcing Over Indo-Gangetic Plain
- Study of the impact of orography on the amount of rainfall over North-West Himalayan region
- Assessment of seasonal variation in canopy structure and greenness in tropical wet evergreen forests of northeast India
- Predicting hotspots of forest invasive species (FIS) in India using species distribution modeling
- Graph theory based analysis of forest connectivity in Western Himalayas
- Simulating Climate Change Impact on Soil Erosion & Soil Carbon Sequestration
- Crop-Specific Drought Monitoring and yield loss assessment by integrating geospatial, climate and crop modelling.
- Web Based Decision Support Tool for Fertility Management in Agriculture
- Geospatial assessment of shift in Agro-Climatic suitability of food grain and plantation crops in Himachal Pradesh under changing climate
- Spatio-Temporal Modelling of Jammu City Using Remote Sensing and Geographical Information System
- Automatic estimation of Urban Roughness Parameters for Microclimatic Analysis
- Road Alignment and its Impact Assessment on Environs in Himalayan Region Using Geospatial Tools
- Temporal granularity in land surface parameters and gravity anomalies and their relation with land-use/ land-cover and climate over Indian

The students successfully defended their thesis work and the valedictory function was held on August 14, 2015. Besides aforesaid, 27 candidates are pursuing the course of 2014-16 M.Tech. batch which commenced on August 19, 2014. Under M.Tech. (2015-17), 35 candidates joined the course on August 17, 2015 with 32 candidates.

During Golden Jubilee year of IIRS (1966-2016), ISRO has introduced Golden Jubilee Fellowship for the meritorious students in all the long-term courses. Under this scheme, six students of 2015-2017 batch have been awarded with fellowship.

IIRS-ITC JEP: M.Sc. in Geo-Informatics (18 Months)

Master of Science in Geoinformation Science & Earth observation with specialisation in Geoinformatics is a joint educational program organized by Indian Institute of Remote Sensing (IIRS), Dehradun and International Institute for Geo-information Science and Earth Observation (ITC), University of Twente, Enschede, The Netherlands. The course is modular in structure and divided in 23 modules, each module being of 3-week duration. The first 11 modules were taught at IIRS, followed by 4 modules at Faculty ITC of the University of Twente, The Netherlands. In the last 8 modules, each student carried out research on a topic chosen by the student.

The thirteenth M.Sc. course (2014-16) in Geo-Information Science and Earth Observation (specialisation in Geoinformatics) commenced on September 22, 2014 and ended on March 18, 2016. Six students in self-financed category graduated on this day after successfully completing the course work and defending their thesis before Prof. A.A. Vionov as the Chair, ITC Theme Leader, External Examiner, and Supervisors from IIRS & ITC. The project-work of outgoing M.Sc (2015-2016 batch) included following topics:

- Terrestrial Laser Scanning based modelling for forest structure parameter retrieval
- Geoweb Applications for species association with vegetation type and climatic regimes of western Himalaya in Indian Landscape
- Fusion of dual frequency fully polarimetric data and hyperspectral data for enhanced land cover classification
- Polarimetric SAR Tomography for vertical structure estimation of tropical forest
- Non-linear separation of classes using a kernel based Possibilistic c-Means approach
- Exploring measures of similarity/dissimilarity for fuzzy classifier: from data quality to distance quality

The fourteenth M.Sc. course (2015-17) also commenced with six students under self-financed category on September 21, 2015 and will be ending on March 17, 2017. Following lectures were delivered by outside guest -experts during the course :

- Dr. P.S. Acharya, Advisor, DBT
- Prof. Dr. Ir. Alfred Stein, ITC Netherlands delivered lecture through video-conference.
- Dr. Sajjad Anwar, Mapbox, Bangalore

IIRS-ITC JEP: PGD Courses in Geoinformatics

The Joint Education Programme (JEP) between IIRS and ITC also offers Postgraduate Diploma (PGD) in Geo-information Science and Earth Observation with specialization in Geoinformatics, which is a 10 months program. The diploma is awarded jointly by the ITC and IIRS. The thirteenth course which commenced on September 22, 2014 was completed on July 17, 2015 benefitting 10 participants. While fourteenth course commenced on September 21, 2015 and will end on July 15, 2016. There are 10 self-financed students in this ongoing course.

The programme helps participants to develop critical understanding of new methods and techniques in developing tools for acquisition, processing, transformation, analysis, modelling, storage and presentation of spatial data; solving various problems and assist in drafting development policies.

TRAINING PROGRAMMES

IIRS-ITEC Joint Education Programme

The Indian Technical and Economic Cooperation (ITEC) Programme was instituted by a decision of the Indian Cabinet on September 15, 1964 as a bilateral programme of assistance of the Government of India. The ITEC Programme of the Ministry of External Affairs is an earnest attempt by India to share the fruits of its socio-economic development and technological achievement with other developing countries. Under ITEC. two short-courses are conducted as follows:

12th IIRS-ITEC Course on Geoinformatics

The course commenced on September 21, 2015 and concluded on November 13, 2015. The course was attended by 13 candidates nominated by MEA and 5 trainees sponsored by Indian Government. There were 4 participants from India, 3 from Ethiopia, 2 from Mauritius and Nigeria one each from Cuba, Jamaica, Nepal, Niger, Syria, Tajikistan and Uganda. In the eight-week course, the last two weeks dealt with advanced lectures based on demand by students and small case study / projects. A feedback taken at the end indicated that the participants were highly satisfied with the structure and organization and rated the course as excellent. Course was modular in structure and enhanced capacity of participants in understanding various dimensions of Geo-information science and technology for natural resource management and decision making.

16th IIRS-ITEC Course on Remote Sensing with special emphasis on Digital Image Processing

This course commenced on January 04, 2016 and concluded on February 26, 2016. The primary objective of this short course was to enhance the capacity of middle level professionals in the field of remote sensing with special emphasis on processing of remotely sensed data using digital image processing techniques. There were 21 candidates from 18 Countries in this course (three participants were from Uganda, two participants from Estonia, one each from Algeria, Cuba, Ethiopia, Ghana, Indonesia, Kazakhstan, Kenya, Mauritius, Mongolia, Nigeria, Palestine, Poland, Srilanka, Syria, Tanzania and Vietnam). So far about 489 participants from 79 countries representing all continents have been trained under ITEC sponsored courses at IIRS.

This course of 8 weeks duration was designed in such a way that it offers a blend of latest technology and conventional techniques. The topics were covered in theory lecture classes, followed by practical demonstrations and field visits in the nearby areas. An educational and sight seeing tour to Delhi and Agra cities was also organised. In the last two weeks, the trainees were given awareness about applications of RS & GIS in various thematic applications. The trainees carried out a small project/ Case Study topics in the last two weeks.

P.G. Diploma in Remote Sensing in Natural Resources Management

The Post Graduate Diploma in Remote Sensing and Geographic Information System is an important programme of the institute. Presently, eight specializations are offered in PG Diploma course: one in technology area, namely Satellite Image Analysis and Photogrammetry, and six in other application areas such as Agriculture & Soils, Forest Resources and Ecosystem Analysis, Geosciences, Marine and Atmospheric Sciences, Urban & Regional Studies and Water Resources.

The course is designed for the mid-career working professionals, fresh university students with engineering and science background interested in remote sensing and geospatial technology and its applications. The admission to the course is based on the academic record of the candidates particularly in the qualifying examination. It involves regular classes comprising of lectures, practical, hands-on and field visits.

Based on the academic performance of the students, five fellowships are offered to the students since FY: 2015-2016 onwards under the prestigious IIRS Golden Jubilee Fellowship programme.

59th PG Diploma Course in NRM and GIS

The course commenced on August 19, 2014 got completed in June, 2015. A total of 13 participants joined the course out of which 1 was Government sponsored. The participants' distribution across discipline were as follows- Agriculture and Soils (1), Forestry (1), Geosciences and Geohazards (2), Urban & Regional Analysis (2), Marine and Atmospheric Science (2), Satellite Image Analysis and Photogrammetry (2) and Water Resources (3).

Valedictory function for the course was organized on June 19, 2015. The participants received their Post-Graduate Diploma certificates from the chief guest Shri Monish Mullick, Additional Chief Conservator of Forest, Uttarakhand.

Sixty-three participants of 60th PG Diploma Course in NRM and GIS joined on September 21, 2015. This batch will pass-out in August, 2016.

14th PG Diploma in RS & GIS with specialization in Natural Hazards and Disaster Risk Management (NHDRM)

The course commenced on September 22, 2014 and concluded on July, 2015. There were 5 course participants in this batch. The course is modular in structure with 10 course work and one project module, spread over a total of 10 months.

In projects module, students worked on various topics such as: Monitoring and assessment of landslide hazards from Rudraprayag to Agyastmuni, Uttarakhand; Assessment of impact of mining and land degradation in parts of Jharia/ Raniganj coal field; Multispectral-TIR data analysis by split window algorithm for coal fire detection and monitoring; and GNSS data processing and analysis from crustal deformation studies.

ISRO - NNRMS sponsored course on RS&GIS Applications

Optimal management of natural resources is vital to meet human needs especially for the developing countries. The Government of India has set-up the National Natural Resources Management System (NNRMS) in 1983, after

recognizing the need and importance of natural resources management, with Department of Space (DOS) as the nodal department. IIRS conducts ISRO-sponsored NNRMS training programme for university faculty on the recommendations of NNRMS Standing Committee on Training (NNRMS SC-T) since 1994. The training programme is of 8 weeks duration and is offered in eight specializations in technology and application domains.

The prime objective of this programme is to train the University/ P.G. college teachers in RS & GIS technology and applications, so that they can further teach students in their universities and colleges. There are eight seats available in each of the following disciplines:

- GIS Technology and Advances
- RS and GIS in Cartography and Mapping
- RS and GIS in Soils and Land Use Planning
- RS and GIS in Forestry & Ecology
- RS and GIS in Geosciences
- RS and GIS in Water Resources
- RS and GIS in Urban and Regional Planning
- RS & GIS Coastal and Ocean Sciences

Target participants for this course comprises of State/ Central Government-sponsored faculty/ teachers of University/ Colleges/ Govt. affiliated colleges in India. There is no course fee and the candidates, admitted to this course are paid 2nd AC fare by train and DA by the Institute as per Department of Space (DOS) rules. Participants will be provided shared accommodation in IIRS hostel.

22nd NNRMS Course on RS & GIS Applications

This course was conducted during May 05, 2015 to June 26, 2015. A total of 64 participants belonging to 19 states (Maharashtra, Gujarat, Rajasthan, AP, Karnataka, TN, WB, UP, MP, Punjab, Haryana, Delhi, Chattisgarh, Assam, Kerala, Mizoram, Nagaland and Meghalaya) joined the course in this year which is highest since the course started.

The training program was conducted in eight thematic disciplines namely (i) GIS Technology & Advances, (ii) RS and GIS in Water Resources, (iii) Forestry & Ecology, (iv) Urban & Regional Planning, (v) Cartography and Mapping, (vi) Geosciences, (vii) Soils & Land use Planning, and (viii) Coastal and Ocean Sciences.

The course is designed as modular in structure. First two modules were devoted on Geospatial technology dealing with Photogrammetry & RS and Basics of GIS and last two modules focussed on thematic disciplines conducted by eight departments. Each module was of 2 weeks duration. During the course, total 60 lectures, 66 hours of practical and 3 field days were conducted during the first 3 modules in 6 weeks.

The last module has focussed on the pilot-project by the participants using Geospatial technologies in their thematic disciplines. The course participants were honoured by receiving certificates from Dr. S. K. Shivakumar, former Director, ISAC, ISRO.

Remote Sensing: An Overview for Decision Makers

This course offers opportunities to Decision Makers to understand the recent developments in EO data and geospatial technologies. The course provides insights of day to day decision making related to Remote Sensing (RS) data acquisition, utilization, and spatial and non-spatial data handling for Natural Resources Management (NRM).

This training program is of 4 days duration only which is specially designed for senior decision makers from government or private sector.

32nd training course on RS: An Overview for Decision Makers

This year, the course was organized during June 15-18, 2014. The course announcement received overwhelming response as thirty-eight participants representing 22 institutions and more than 14 disciplines attended the programme.

The course participants were from Advanced Data Processing Research Institute (ADRIN), Hyderabad; Bihar Remote Sensing Centre, Patna; Central Marine Fisheries Research Institute (CMFRI), Kochi; Department of Personnel & Training (DoPT), GoI; Disaster Management Authority, Tamilnadu; Gujarat Engineering Research Institute (GERI), Vadodara; Irrigation Management Training Institute (IMTI), Tamilnadu; ISRO Inertial Systems Unit (IISU), Thiruvananthapuram; Krishna Bhagya Jal Nigam, Karnataka; Mines and Geology Dept. and Water Resources Dept. from Goa and Karnataka; National Bank for Agriculture and Rural Development (NABARD); National Environmental Engineering Research Institute (NEERI), Nagpur; Relief and Disaster Management, Manipur; Tata Institute of Fundamental Research (TIFR), Mumbai; Town and Country Planning, Madhya Pradesh; Vikram Sarabhai Space Centre (VSSC), Trivandrum; Wildilfe institute, Dehradun; and Zoological Survey of India (ZSI), Dehradun.

The training programme contained twelve lectures and four demonstration-cum-lectures. These lectures covered applications of geospatial technology in various disciplines ranging from soils and agriculture, forestry, geology, coastal and marine, urban and water resources. Besides these lectures, field visit to Mussoorie and surroundings was also under taken to correlate the natural resources characteristics with their manifestation on satellite data. The topics covered in this course were as follows:

- Current trends in RS & Geospatial technology
- Policies and Institutions of remote sensing, open data and software sources, etc.
- Operational Remote Sensing Applications in Natural Resources Management
- High resolution RS data availability and field scale implementation
- Disaster monitoring and management (Geological, Hydro-meteorological and Environmental)
- Space based Information Support and Decentralized Planning
- Case studies/ Demonstration

Demonstrations on low-cost close-range photogrammetry application developed at IIRS, open source data and software for deriving information about our world and also the GPS were provided. During the valedictory programme on June 18, 2015, the certificates were distributed by Dr. Vikram Desai, Director, DECU and Dr. B. Gopala Krishna, Deputy Director, DPPA&WAA, NRSC, Hyderabad.

SPECIAL & CUSTOMISED TRAINING PROGRAMMES

Geospatial Technologies for Watershed Management

One week short training course on "Geospatial Technologies for Watershed Management" was conducted on the request of Watershed Management Directorate, Dehradun, Uttarakhand for their officials during May 25- 29, 2015. Eight participants attended the course. During the training, fourteen lectures and five practicals were conducted. One day field visit was also conducted in Sitlarao Watershed, Dehradun to demonstrate generation of thematic information for watershed planning. The course was designed keeping in mind the geospatial data requirements and applications in Integrated Watershed Management Programme (IWMP) being executed by State Govt. It has focused on applications of high-resolution satellite data interpretation for watershed characterization, terrain characterization, soil mapping, erosion mapping, GPS concepts, watershed information extraction using Bhuvan services and use of geospatial data in preparing Land & Water Resources Development Plans.

India is an agricultural land where the economy is greatly affected by the country's agriculture. Therefore, this course was planned to make the technologies available for enhancing the participation of tools in Remote Sensing, Geographic Information System and Global Positioning System (GPS) in agriculture.

The course began with Principles of Remote Sensing GIS, GPS and its applications including the Remote Sensing data analysis: Visual and digital analysis and use of Geospatial technologies for Natural Resource Management, etc. Lectures on RS and GIS Applications in Watershed Prioritization for Conservation Planning, surface runoff and Hydrological modelling in water resource development planning, land resource developments planning in watershed and RS in monitoring & impact assessment of watershed development program were also included. Methodology of the programme involved lectures, practical hands-on and field visits.

Image Interpretation and Remote Sensing Application for Indian Airforce Personnel

This second special course commenced on June 08, 2015. Thirteen personnel (6 officers and 7 airmen) from Indian Air Force attended the programme. The course curriculum was designed based on the requirements of the user department with an overall objective to provide awareness about the concept of remote sensing, image interpretation and GIS concepts. The course was designed as modular in structure which provided a blend of theory and hands on practical exercises. It consisted of two modules: Module I was of 5 weeks duration and covered topics on: remote sensing fundamentals (optical, thermal, microwave and hyperspectral), image interpretation, DEM extraction, terrain analysis and visualization, cartography, GPS, digital image processing. Special lectures on SAR data interpretation in snow and glacier areas, disaster management and coastal hazards using geospatial technology and Guest lecture on strategic feature extraction using SAR and

Hyperspectral data by Dr. Abhai Mishra and Dr. Sangeeta Khare, from DEAL; Thermal Imaging for strategic application and feature extraction using LiDAR instrumentation by Mr. HPS Panwar and Mr. Sushil Kumar from IRDE, Dehradun were also organized. Theory lectures were supplemented with two field visits for ground data collection and a facility visit to DEAL, Dehradun. Module II was of 3 weeks duration and covered topics on fundamentals of GIS, GIS database creation, spatial data models, 3D GIS, network analysis and free and open source software for GIS Analysis. At the end of each module, the participants carried out a short project each of one week duration and presented the results. A formal feedback was taken at the end of the course. In general, all the participants rated the course as very good to excellent in terms of objective of course, course program design and implementation. The valedictory function was held on July 31, 2015 and was presided by Dean, IIRS and Group Captain S.K. Mishra from PI school, Airforce HQ.

Applications of Remote Sensing & GIS in Water Resources Management

A special course on application of remote sensing and GIS in water management was organised during July 13 to 24, 2015 benefiting eleven participants from the G.B. Pant University, Pantnagar. Programme overview was to introduce and familiarize the students in the field of Water resources about the basics of remote sensing with especial emphasis on water resources including the role of GIS and GPS to make best use of water resources and avoid water based calamities.

The students of Pantanagar University were taught elaborately on utilization of geospatial technology for planning and management of water resources. Basic contents of the programme incuded the Introduction of Remote sensing, GIS and GPS; Digital image processing; land use and land cover (LULC) mapping using remote sensing data; application of RS & GIS in water resources; rainfall-runoff modelling using RS inputs; soil erosion and watershed modelling; Irrigation water management using remote sensing; Flood mapping and monitoring using remote sensing; online resources and open sources tools for water resources. All the topics were covered through interactive lectures followed by hands-on-exercise during two weeks.

Capacity Building on RS&GIS for Kendriya Vidyalaya Sangathan, Navodaya Vidyalaya Samiti and CBSE affiliated schools

As part of efforts being made towards 'Effective Utilisation of Space Technology Based Tools and Applications in Governance and Development,' an initiative to organise National Level Training Programme in 'Remote Sensing and Geographic Information System' for PG Teachers of Geography in Kendriya Vidyalaya Sangathan (KVS), Navodaya Vidyalaya Samiti (NVS) and CBSE affiliated has been taken up jointly by National Council of Educational Research and Training (NCERT) and Indian Space Research Organisation (ISRO).

The initiative primarily aims at enhancing capacity of teachers so that they can effectively

teach the existing syllabus on Remote Sensing and Geographic Information System (GIS) to students at higher secondary level. It was decided to train 500 teachers in the first phase, representing KVS/ NVS and CBSE affiliated schools across the country as identified by NCERT.

Chairman, ISRO/ Secretary, Department of Space (DOS) approved the financial grant of INR Fifty Lakhs under the National Natural Resources Management System (NNRMS) programme to meet the expenditure towards conducting the first phase of training progamme.

Indian Institute of Remote Sensing (IIRS), ISRO, Dehradun, was identified as the lead Centre for coordinating the training programme with the support of ISRO/DOS Centres, State Remote Sensing Applications Centres (SRSACs) and Academic institutions as identified by NNRMS.

Training courses of two weeks duration were organised in two batches in different time slots and totally 442 teachers have been trained. The training course for first batch was during July 27, 2015 to August 07, 2015 simultaneously at 19 centres across the country and was attended by 292 teachers.

The training course for second batch was organised during January 4-15, 2016 simultaneously at 9 centres and was attended by 150 teachers. The course curriculum was designed jointly by ISRO and NCERT, mainly following the NCERT Geography syllabus of Class XI and XII. The course material developed by IIRS (lecture notes & presentations, practical hand-outs, open source software and data) was used by all training centres to maintain uniformity and the same was also shared with participants in both hard and soft copy format. The participants were also trained on School-Bhuvan, a geoportal developed for school students for hands-on exercises on map/ image visualization, mapping features of interest and attribute data creation.

The feedback indicated that both the courses were well received and the efforts of ISRO and NCERT were appreciated by the participants.

ISPRS Summer School

IIRS hosted ISPRS (International Society for Photogrammety and Remote Sensing) Summer School at Dehradun during July 6-10, 2015 on the following 3 themes:

- Open Source GIS [Focal Point: Indian Institute of Remote Sensing, Dehradun, India]; and
- Online Sharing of Geospatial Data, Algorithm & Model [Focal Point: Wuhan University, China];
- Research and Teaching Methodologies for Master and PhD students [Focal Point: Siberian State University of Geosystems and Technologies, Russia].

The course content was well received in terms of lectures, delivery, hands-on-practice sessions, and facilities. A total of 81 students, researchers and professionals participated in three courses. The main objective and no. of participants of each course is provided below.

	Open Source GIS	Online Sharing of Geospatial Data, Algorithm & Model	Research and Teaching Methodologies for Master and PhD students
Focus of the Course	To provide an overview on various components of geoinformatics like geospatial database creation, management, analysis, visualization and dissemination using Free and Open Source Software for Geoinformatics (FOSS4G)	To provide an overview of the cutting-edge achievements of a geospatial service platform and trained the participants with online tools for geospatial data processing and scientific research through lectures and hands-on-practice sessions	To impart research and teaching skills to the beginners and help improve the quality of their Research and Teaching techniques
No. of Participants	27 (26 from India, 1 from Nepal)	28 (from India)	26 (from India)
Coordinator	Dr. Sameer Saran	Prof. Huayi Wu	Dr. Igor Musikhin




Application of Remote Sensing and GIS in Forestry and Wildlife Research

This special training course was conducted for faculty and research scholars of Institute of Mountain Environment, Bhaderwah campus and Dept. of Life Sciences, University of Jammu, J&K. The course was conducted in Forestry and Ecology Department of IIRS from July 27, 2015 to August 21, 2015. Ten participants attended the course which includes one faculty and five research scholars from Institute of Mountain Environment, Bhaderwah campus and four research scholars from Dept. of Environmental Sciences, University of Jammu. The course comprised of lectures, practical, field visit, demonstration of instrument and institution visit.

There were lectures on basics of remote sensing, GIS and GPS, satellites, sensors and platforms. Lectures and practical on various applications of remote sensing and GIS in forestry and wildlife research, viz., forest cover type mapping and monitoring, prediction modelling, wildlife habitat evaluation, wildlife corridor mapping and monitoring, species distribution modelling, forest fire risk zonation, environmental vulnerability assessment, biodiversity characterization, forest biomass assessment, species invasion assessment, timber-line mapping, etc., were taken.

In addition to that there was a lecture on geospatial technology applications in floods and watershed hydrology and one lecture on Bhuvan. Visit to different institutions like, Forest Research Institute, Forest Survey of India and Wildlife Institute of India was also conducted. In the course feedback, the officer trainees have rated the course as very good and relevant. They felt that the programme objective was achieved to a large extent, course was well to very well structured and organized, course material were highly relevant and the participants were extremely satisfied by interaction with faculty and researchers. Overall impression of the course was excellent.

Application of GPS & GIS tools for Forestry

IIRS provided training to personnel from State Forest Departments. The participants included officer trainees of West Bengal Forest and Biodiversity Conservation Project (WBFBCP), a project funded by Japan International Cooperation Agency (JICA) and executed on behalf of Government of India by WBFD, through the West Bengal Forest and Biodiversity Conservation Society.

The first course benefiting eleven participants for West Bengal Forest Department (WBFD) was organised during August 10-14, 2015 and the second batch benefiting twelve participants was organised during February 29, 2016 to March 04, 2016.

The officer trainees were of the rank of DFOs, ACFs and Range Officers, belonging to different Divisional Management Units (DMUs) of Bankura, Midnapur, Panchet, Rupnarayan, Jhargram and Purulia. The course was designed to emphasize on practical aspects of using GIS and GNSS technologies for their use in Forestry applications. Lectures included Basics of GIS, remote sensing and GNSS, Forestry specific lectures on data sampling, collection and processing and Mobile GIS and location based services. Detailed field exercises were conducted at Forest Research Institute and IIRS. The course material included the open source software, DVD containing software, data & user manuals and printed lecture notes prepared by IIRS faculty. Focus was also kept on using open source and

easily accessible tools in the practical such as QGIS (for GIS based tasks), GEO-ODK (for field data collection), GEOSERVER (for publishing data) and Bhuvan. Valedictory Function of the first batch of officer trainees from West Bengal Forest Department was held on August 14, 2016.

The feedback was very good to excellent. Nearly all the participants found the course to be meeting the objectives, relevant, well-structured and very useful to their current nature of job.

Refresher Training Course for IFS Officers on Forest Working Plan Preparation using Remote Sensing and GIS Technology

One-Week refresher training course for IFS Officers was held during August 3, 2015 to September 04, 2015 sponsored by Ministry of Environment, Forests and Climate Change, New Delhi at IIRS, Dehradun. A total of 45 candidates were initially nominated and subsequently two more officers were nominated to undergo this course. Out of the total 47 candidates, 20 officers joined the course.

Inputs/ feedback from the participants from the previous courses were taken into consideration to develop the course content and appropriate faculty were identified based on experience and expertise. The course syllabus included lectures and hands-on experience on remote sensing & GIS applications for the participants. Eleven lectures were delivered by IIRS faculty and two by guest faculty from Indian Council of Forestry Research & Education (ICFRE), Dehradun & Forest Research Institute (FRI) and Wildlife Institute of India (WII), Dehradun. The hands-on/ practical on the use of remote sensing and GIS were conducted by IIRS faculty. The course participants showed keen interest in remote sensing & GIS applications in working plan preparation. An open source software programme for generation of stand & stock information was also included in the hands-on practice and a copy of the same was provided to the participants.

The course started with introductory lectures on Remote Sensing - An Overview, followed by other lectures i.e. GIS basics and its applications and, remote sensing and GIS in forestry applications. In the second half, the officer trainees were familiarized with the satellite remote sensing data of various resolutions and GIS, which are used in working plan preparation. On the second day, lectures on Working Plan code – 2014, forest cover type and density mapping using visual interpretation, forest cover type and density mapping using digital interpretation were delivered followed by hands-on experience on mapping forest cover type and density.

On the third day, lectures on WPP: wildlife perspective, inventory, sampling techniques and accuracy for working plan preparation, generation of stand and stock map & tables/case studies, recent advances of remote sensing applications in forestry (Microwave, Hyperspectral & LiDAR) which was followed by a hands-on practice on estimation of growing stock/stand assessment & generation of stand and stock map using Open Source software.

On the fourth day, the officer trainees were taken to Mussoorie Forest Division for a first-hand impression of the impacts of various working plan prescriptions in reclamation and conservation in the forests effected by mining activities in the Division. On the final day, lectures on Biodiversity characterization, NTFPs, etc. WP perspective, ISRO Geo - webservices for forestry applications/Edusat & e-learning were organized. This was followed by a panel discussion on the utility of this course to the participants and scope of improvement. This was followed by valedictory function. Dr. Ashwani

Kumar, IFS, Director General, Indian Council of Forestry & Research Education was Chief Guest of the valedictory function. Officers were presented the certificates on successful completion of the course.

Use of RS and GIS for Crop Growth Monitoring and Yield Prediction

IIRS with diversified faculty and expertise supported the capacity building in the field of geospatial technology applications on user-oriented theme for various organization or departments of Central and State government organization. IIRS has been also entrusted with the responsibility of capacity building on agrometeorology theme including crop monitoring, value added agro-advisory and weather–related hazard services by Ministry of Earth Sciences (MoES), Govt. of India. In this regard, IMD under MoES has requested to organize periodically short course for scientists and researcher involved in Gramin Krishi Mausam Seva (GKMS) programme and FASAL Project of IMD and ISRO.

Accordingly, IIRS has organized tailor-made short course on "Application of Remote Sensing and GIS for Crop growth Monitoring and Yield Prediction" during August 31, 2015 to September 18, 2015 and it was entirely sponsored by IMD. There were 24 participants comprising senior scientists and young research scholars from meteorological centres and agromet field unit of state agricultural universities across India. Participants are given certificates on successful completion of course.

The main objectives of the course was to impart training on Remote sensing and GIS for generating satellite based agrometeorological as well as crop related information and their use in improving crop growth monitoring, yield prediction and agro-advisory services. The course structure consists of 30 number of lectures, 14 practical sessions and 2 full day field visits. The first week of the course had focus on basics of satellite remote sensing with lectures and tutorial on Indian space programmes, satellite image processing, GIS & GPS, data integration and spatial analysis.

The second week focussed on aspects of information retrieval from satellite and modelling techniques for crop assessment e.g. crop parameter retrieval from optical and microwave RS, concept and approaches of crop yield modelling, geostationary satellites for agrometeorological applications, soil moisture and evapotranspiration estimation, abiotic and biotic stress assessment, regional yield prediction and early warning.

Participants were also exposed to operational agricultural applications covering crop forecasting, drought assessment and decision support for pest/disease management as well as value added agro-advisory and hazard related services.

The short training course provided forum for agronomist, agrometeorologists,meteorologists, technologists, educators, young researchers and weather related service providers in India to strengthen their horizon of agrometeorological research, and improving operation services to farming community.

Application of Remote Sensing and GIS for Natural Resource Management

Five days, special course sponsored by National Statistical Systems Training Academy (NSSTA), Central Statistics Office, Ministry of Statistics and Programme Implementation is organized for Indian Statistical Service (ISS) Probationers. Every year, course is conducted in two phases/ parts viz. during September 14-18, 2015 for first batch of 20 participants while the second batch of ISS course was for 45 officers and was scheduled during March 14-18, 2016.

The aim of the course is to educate ISS officers about 'Applications of Remote Sensing and GIS for Natural Resource Management'. The course objective takes care about providing awareness of application of geospatial technologies in Ministry of Statistics and Programme Implementation. During the course, the emphasis is given on Geospatial technological aspect as well as its applications in six application streams.

Salient topics covered in this coure were: Overview of Remote Sensing and GIS, Geological Applications including disaster management, Indian Space Programmmes, Remote sensing and GIS Applications in Agriculture & Soils, Geospatial Applications in Urban and Regional Planning, Remote sensing & GIS Application in Water Resources, Remote sensing & GIS Applications in Marine Science.

Course on UAV Remote Sensing

Acquisition of remote sensing data using small unmanned aerial systems (UAV) has seen a significant growth in recent years across the world and in India it is in initial stages. UAVs have significant advantage because of their flexibility, low cost and provides a very high resolution data. It is an emerging technology and there is a need to share the knowledge, theoretical and practical experience in order to utilize the full potential of this technology.

With this in mind, one week special course on UAV remote sensing was designed to create awareness among the remote sensing professionals on the potentials of UAV remote sensing, challenges in data processing and its application. The course commenced on October 05, 2015 with 23 participants from different government departments, universities and private sector joining the course.

The course has a blend of lectures, demonstrations and hands on practice covering various aspects of UAV remote sensing like fundamentals of data capture, processing challenges (feature extraction and DEM generation), legal aspects, GIS analysis and their applications. A demonstration of data acquisition process using a quadcopter was also arranged. The demonstration was given by the students of Delhi Technical University, led by their professor using indigenously developed quadcopter. The lectures were delivered by IIRS

faculty and guest faculty from Delhi Technical University, Indian Air force, IRDE, SASE and Indian Agricultural Research Institute.

A formal feedback was taken wherein participants highly appreciated the course and rated the course as excellent to very good in all aspects. The valedictory function was held on October 09, 2015.

Advanced Course on Remote Sensing and GIS in Forestry Applications

A two-week Advanced Course on Remote Sensing and GIS in Forestry Applications was carried out for the officer trainees from Uttar Pradesh Space Application Centre (UPRSAC), Lucknow (Uttar Pradesh). The course commenced on November 30, 2015 and was concluded on December 11, 2015.

There were total twelve participants registered for the course. The course consisted of twenty-three lectures, each of one hour duration and seven practical exercises to apprise the participants on the specific requirement of the forestry and remote sensing technology. Various topics covered in the lectures included Role of RS/GIS in forest working plan preparation, Biomass and productivity estimation, Wildlife habitat mapping and modelling, Biodiversity characterization at landscape level, Image Enhancement and Digital classification. Introductory lectures on the advanced remote sensing viz. Hyperspectral, LiDAR, Microwave remote sensing, applications of UAV in forestry and 3D visualization tools were also delivered during the course. Participants were also made aware of the Biodiversity information System and BHUVAN Portals developed by ISRO. Lecture notes and presentation handouts were provided to the participants for reference. Course feedback was taken at the end of the course. Overall the course was rated very well in meeting the current and future requirement of the participants and appreciated for the excellent exposure on the advanced techniques in forestry by the experienced faculty members.

RS and GIS Applications in Carbon Forestry

Forests are one of the important components of our ecosystems which provide immense service to the humanity. This natural resources need to be managed for the benefit of citizens in the country. The mapping of forest resources quality, variability and quantity is important for their proper management. Bangladesh is a coastal country with very high population diversity and a predominantly agrarian economy. This country has extensive low lying land and one of the best known mangrove ecosystems in this world. Since, most of the forested areas in Bangladesh are low-lying, are also threatened with inundation as a result of global warming induced sea level rise. Furthermore, due to population pressure there has been extensive degradation of the forests in the country. As part of World Bank initiatives there has been active participation of the forest department and for assessment of the forest resources and afforestation in appropriate regions of the country.

A one-month long special course on 'Remote Sensing and GIS Applications in Carbon Forestry'

was organized at Forestry and Ecology Department (FED), IIRS for the six Forest Range Officers from Bangladesh Forest Department during November 30, 2015 to January 01, 2016. Bangladesh Forest Department through an ongoing World Bank project on the Climate Resilient Participatory Afforestation and Reforestation Project (CRPARP) in Bangladesh, sponsored the course. The course programme was specially designed in view of the role of RS and GIS in execution of CRPARP activities in Bangladesh. The key topics of interests were basics of Remote Sensing, GIS and GPS, pre-processing and enhancement of satellite data, mapping and monitoring of afforestation/ reforestation activities, planning field sampling design for biomass inventory, spatial prediction and quantification of biomass and carbon stock. Hands-on-exercises in advanced image processing and GIS software and demonstrations on forest mensuration instruments were also organized. Field excursions to Mussoorie Hills, Thano Reserve Forest and Rajaji National Park were organized. Participants carried out a team project on 'Estimation of carbon stock of Thano Reserve Forest, Doon Valley using RS and GIS'.

Participants also visited Forest Research Institute, Dehradun and cultural heritage sites in Delhi and Agra. On the way to Mussoorie hills, Participants were familiarized with ground truth collection.

Geospatial Technologies for Smart City Planning

This course was organized at IIRS, Dehradun during December 7-11, 2015. Thirty-four participants working in Town and Country Planning Department (TCPD) or Urban Local Bodies (ULB) namely, Aizawl Municipal Corporation; Andhra Pradesh Capital Region Development Authority, Vijayawada; Andhra Pradesh Industrial Infrastructure Corporation Ltd.; Bhubaneswar Development Authority; Dept. of Urban Planning, Chandigarh; Development Authority, Dimapur; Mumbai Metropolitan Development Authority (MMRDA); Municipal Corporation, Jaipur; Navi Mumbai Municipal Corporation; NDMC, New Delhi; NWCMC, Nanded; Regional Center for Urban & Environment Studies, Lucknow; State Institute for Urban Development (SIUD); Surat Municipal Corporation; Telengana State IIC; TCPD, Haryana; TCPD, Himachal Pradesh; TCPD, Rajasthan and TCPD, Dehradun have attended the programme.

The five-day training programme consisted of 15 lectures, 2 practical sessions and three demonstrations namely, Smart City Planning: Concepts and Some Examples, Smart City: Challenges and the Role of TCPDs/ULBs, Introduction to GPS/ DGPS/ MMU, Remote Sensing Overview and Earth Observation Data for Smart City Planning, Smart City Geo database Creation and Organization, Remote Sensing Image Analysis and Interpretation, Urban Land use/ Land Cover Classification, Smart City Planning (Urban Growth Modeling, Suitability Analysis, Plan Monitoring and CAD Data Transformation), Urban Information System (NUIS and Bhuvan-NUIS), Smart Urban Environment (Solid Waste Management, Urban Pollution, Urban Heat Island and Urban Green Spaces), G-Governance for Smart City Planning (Property Taxation and Municipal Information System, Cadastral Mapping and Electricity Information System), 3D City Modeling for Urban

Planning, Urban Hazards (Seismic, Industrial and ,Hydrological/ Flood Hazard Assessment), Sustainable and Energy Efficient Cities (Solar, Wind, Hydropower), Smart Urban Infrastructure and Planning, Automated Mapping/ Facility Mapping (AM/FM) and Location based Services (LBS), Crowd-sourcing and Mobile Apps for Citizen-centric services, etc.

On the first day, Dr. Sudhir Krishna, former Secretary, Ministry of Urban Development (MoUD) inaugurated the programme and delivered a memorable presentation on the Roadmap for Planning and Developing Smart, Sustainable & Inclusive Cities. He spoke of 11 challenges in upscaling the services in the context of Smart City Planning e.g., housing, Multiplicity of authorities, Smart Drainage Planning, Smart Water, solid waste and sewage Management, etc.

Dr. Mahavir, Professor, Planning, SPA, New Delhi deliberated on Smart City Planning: Concepts and Some Examples. Shri K. K. Joadder, Chief Planner, and Shri S. Surendra, Town Planner, TCPO, MoUD, New Delhi enlightened the participants with the Smart City Mission Guidelines: Opportunities and Challenges for the TCPDs/ULBs. Later, the participants received the certificate from Shri K.K. Joadder, Chief Guest of the valedictory programme.

Summer School on 'Usefulness of Remote Sensing & GIS for Environmental Studies'

Since last four years, IIRS is conducting a special course on "Usefulness of Remote Sensing & GIS for Environmental Studies" for school students. The aim of the course is to create awareness about remote sensing technology and its use for the study of mother planet earth and its environment among the school students. This year, the course was organized during June 22-26, 2015. A total of 46 students from 22 different schools had applied for the course, however, 33 students from 17 schools finally participated. Broad subjects covered in the lectures were Indian space programme, basics of remote sensing, basics of GIS, fundamentals of satellite meteorology, tropical cyclones, Tsunami, coastal processes and climate change in addition to RS & GIS applications in geological studies, watershed hydrology, agriculture and urban studies. Practical demonstrations were also arranged to familiarize them with satellite images and GPS technique. Students also visited the various departments of IIRS to get an exposure on the use of remote sensing in various fields. The students were also taken to Edusat studio to explain the role of IIRS for distance education in RS and GIS. Videos on Indian space programme including Chandrayaan mission, Mars mission and Space Capsule Recovery Experiment were also shown to the students.

IIRS DISTANCE LEARNING PROGRAMMES

IIRS distance learning program was initiated in 2007 with the participation of twelve universities in India. Till December 2015, IIRS has successfully conducted 15 programs through live and interactive classrooms (also known as EDUSAT programme) and also launched five online courses under e-learning programme. The connectivity with user segment was extended by using Internet and broadband technologies and linking more professional and user departments and ministries in the country to develop their skills in geospatial technologies. Currently, IIRS distance learning programme is conducted through following modes:

1. Live and Interactive classroom sessions
2. E-learning based online courses.

Live and Interactive classroom

The live and interactive mode of distance learning is enabled through Internet and A-view software platform developed by Amrita e-learning Lab in collaboration with Ministry of Human Resource Development (MHRD). Under this programme, 303 Universities/ Institutions/ Departments were networked till December 2015. During the last eight years, 24,831 participants have benefited under this programme. In the year 2015, two courses i.e. 14th course on "Applications of RS & GIS for Natural Resources" and 15th course on "Basics of Remote Sensing, GIS and GNSS" were conducted. From 240 networked institutions in the country, 8306 participants were trained in the above mentioned two courses. Eighty-six new institutions have joined IIRS outreach programme first time in the year 2015.

15th Programme on Basics of RS, GIS & GNSS

15th Outreach programme was conducted during August 10, 2015 to November 27, 2015. Ninety-one new universities/ institutions have joined this programme first time. Around 5,809 participants from 140 universities/ institutions and 212 individual participants registered in this programme. The course consisted of four modules on Basics of Remote Sensing, Global Navigation Satellite System (GNSS), Geographical Information System (GIS), and Applications of Geospatial technologies. Also 54 lectures and 11 practical demonstrations were conducted during the programme. The course was inaugurated by Dr. A. Senthil Kumar, Director, IIRS on August 10, 2015 who also delivered the inaugural lecture on "Glimpses of Geospatial technology." In addition to the above lectures and practical demonstrations, offline practical sessions were also conducted by various universities/ institutions at their end with the technical support of IIRS.

At the end of each module, an online examination was conducted through IIRS e-learning portal. The attendance cut-off to appear in the exam was 80% and 4,150 participants appeared in the examination conducted in different time slots. The online feedback session was conducted with the participants and the coordinators which was analysed and presented during IUIM-2016. In addition, one live feedback and interaction session was conducted on December 1, 2015. Overall feedback of the programme is very positive. The University coordinators and participants have expressed their interest to participate in similar programme for various thematic applications, such as urban planning, water resource, biological and environmental studies, disaster and emergency management, agriculture and soil studies, etc.

e-LEARNING PROGRAMMES ON GEOSPATIAL TECHNOLOGIES

To expand the outreach of geospatial science and technology, IIRS has developed e-learning contents and Learning Management Systems (LMS) for various certificate courses in Remote Sensing and other geospatial technologies. The e-learning courses are interactive, learner centric are self-paced. The course content is designed to include the latest developments and trends in geospatial science and technologies with specific focus on Indian case studies for geospatial applications. The learning is made available through interactive 2D and 3D animations, audio and video for lecture and practical demonstrations.

The e-learning contents are created as interactive multimedia application and integrated with customized LMS based on Moodle. IIRS e-learning initiatives targets professionals, academia and research community to enhance their knowledge in Remote Sensing and Geospatial technology. The learners are spending 32 to 102 learning hours per course including participation in online activities like quiz, assessments, projects and online practical exercises. The expert faculty are also available for live interaction with participants. The most attractive part of these online courses are "learning anytime from anywhere". The learners can join the course any time and can complete the course at their own pace. Total 1800 participants have registered for five courses wherein 456 participants have opted for certificate till December, 2015.

e-learning hours for available courses under IIRS e-learning programme.

Subject	e-learning hours	
	Theory	Practical
Image Statistics	3	2
Basic Remote Sensing	19	3
Photogrammetry and Cartography	12	2
Digital Image Processing	14	7
Geographical Information System	19	7
Global Navigation Satellite System	4	2
Customization of Geospatial Tools	3	5
Applications of Geospatial Technologies-Theory	4	-

IIRS SUPPORT TO UN - CSSTEAP

IIRS Support to CSSTEAP

Centre for Space Science & Technology Education in Asia and the Pacific (CSSTEAP) is the first Regional Centre established by UNOOSA in November, 1995 with the infrastructure, facilities and faculty support from Department of Space with its headquarter at IIRS, Dehradun. Under the host country agreement, Department of Space and Government of India has made available appropriate facility and expertise to the Centre through the Indian Institute of Remote Sensing (IIRS), Dehradun, Space Applications Centre (SAC), Physical Research Laboratory (PRL), Ahmedabad and ISRO Satellite Centre (ISAC), Bengaluru. The institute helps the centre to organize special short courses for UN-SPIDER, UN-ESCAP, UNDP, WHO, etc. and facilitates students to continue advance research leading to M.Tech. and PhD towards the use of space science, technology & applications. The Centre is affiliated to the United Nations and its educational programmes are recognized by Andhra University, India for the Master of Technology (M.Tech.) degree. Being the first Centre, CSSTEAP played major and important role in the development of curricula of four courses, which are currently being followed by all CSSTEs and later, endorsed by the United Nations. Since the inception of CSSTEAP, IIRS has conducted 20 Post Graduate courses and 26 short-term courses in RS & GIS discipline benefiting 402 and 495 professionals respectively from 35 countries of Asia-Pacific, region. While doing advanced research, 65 participants from 16 countries of the region have been awarded Master of Technology degree in RS & GIS also.

CSSTEAP Hqrs., Dehradun

Space Applications Centre, Ahmedabad

ISRO Satellite Centre, Bengaluru

Physical Research Laboratory, Ahmedabad

Research Activities- CSSTEAP

Remote Sensing and GIS:

Advanced RS & data analysis (High resolution, microwave, Hyper-spectral, LiDAR and Planetary science mission data analysis & processing), Natural Disaster Monitoring and Management (Landslide risk analysis, Soil erosion modeling & nutrient loss, Forest fire risk zonation & flood modeling, etc.), Modeling Earth processes (LULC change prediction, Crop & forest productivity, Ecological Niche, Hydrological & hydro-dynamic, Debris flow, Ground water balancing, etc.), Advanced GIS (3D GIS Creation, Storage and Visualisation, Spatial Data Quality and Uncertainty, Geoweb, Location Based Services and SDI, etc.).

Space and Atmospheric Sciences:

Oceanography, Atmospheric science, Solar physics, Astronomy, SST, aerosols, ozone, ionospheric irregularities, solar wind, solar radiation, comets, Novae & Globular clusters, etc.

Satellite Communications:

Communication Techniques (Modulation and Coding, Communication link design, Satellite data network, etc.), Earth Station Technologies (Terminal development, Receiver technologies, etc.), Signal Processing-Compression techniques, Antenna Systems (Design mechanism and realization techniques), Satellite Meteorology and Global Climate, Meteorology (Extra Tropical, Weather Systems, Tropical Weather Systems, Monsoon, etc.), Image processing and interpretation, Advanced concepts in Satellite meteorology (Geophysical parameter retrieval, Application of satellite derived parameters, Satellite data assimilation in NWP, etc.), Global Climate Environment: Short term climate variability, long term climate change, etc.

Satellite Meteorology and Global Climate

Meteorology, Extra tropical weather systems, Tropical Weather Systems, Monsoon, etc.; Image processing and interpretation; Advanced concepts in Satellite meteorology: Geophysical parameter retrieval, Application of satellite derived parameters, Satellite data assimilation in NWP, etc.; Global climate environment, Short term climate variability, long term climate change, etc.

Training and Capacity Building for CSSTEAP

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

This course commenced on July 1, 2015 and ended on March 31, 2016 and 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 joined 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 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. Module-1A covered the fundamentals of RS&GIS including the Principles of RS, Photogrammetry (Analytical as well as Digital), Module-1B Semester-I was on recent trends in RS & GIS and environmental analysis & management. In semester-II, the course participants choose one of the eight optical electives considering his/her academic qualification, professional experience, and technical requirement of their parent organization. Image Analysis (included both visual and digital techniques), concepts of GIS and GPS. During technical visits, participants had opportunity to visit cultural & natural landscape in Visakhapatnam, Delhi, Hyderabad, Agra, etc. At Andhra University, they attended lectures on specialized topics. 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. 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 this occasion, Memoirs comprising of messages from GB, AC members, eminent persons, course report and pilot project abstracts of students was released by the Chief Guest. Later, the chief guest awarded the Post Graduate Diploma certificates to all the successful participants.

4th Short course on Small Satellite Mission

Small satellites have already created a niche in developing communication infrastructure and tools for natural resource management, infrastructure development, environmental monitoring, sustainable development, etc. The increasing capability of small satellites and their use in building space infrastructure for disaster monitoring and resource managements have encouraged the small and developing countries to envisage for building such capabilities within. UNOOSA under BSTI initiative is also encouraging the capacity building programmes for small satellites with an objective to create awareness among the decision/policy-makers/planners and technologists who are involved in space programme of these developing countries. Under this initiative, 4th short course of 2 weeks duration on Small Satellite Missions was organized by CSSTEAP during November 16–27, 2015, jointly by IIRS and ISRO Satellite Centre (ISAC) at IIRS, Dehradun to create an awareness of the potential of space technology, small satellites and its opportunities. The course commenced on November 16, 2015 and had 20 participants from 08 countries (Bhutan-2, India-4, Indonesia-1, Kazakhstan-3, Kyrgyzstan-1, Mongolia-5, Nepal-1, Vietnam-3). The syllabus covered various applications of space technology, small satellites, different orbits suitable for small satellites, details of subsystems of the satellites like structure, thermal, mechanism, power, RF systems, onboard computers, launch vehicle interface, data quality aspects, applications, etc. Lectures were delivered by faculty from ISAC, ISTRAC, SAC and IIRS. The course was a blend of theory lectures, video sessions, interactive sessions and demonstration with exhibits. As a part of the course, participants also carried out assignments on various aspects related to designing of small satellites and presented their nature of work in the space related fields and the benefit of this course. A formal feedback was taken at the end of the course. In general, all the participants expressed their satisfaction and appreciated the course. The valedictory function was held on November 27, 2015.

Research Activities and Achievements

Research is an integral part of IIRS capacity building activities. IIRS is significantly contributing towards research and operational programmes of ISRO, and in the process, has maintained an interface with other ISRO Centres. IIRS is recognised as a Research Centre for carrying out Ph.D. level research by several universities, viz. IIT Roorkee, Pune University, FRI (Deemed) University, Dehradun, HNB Garhwal University, Gurukul Kangri University and Kumaun University. The major ISRO's research programmes / projects in which IIRS have participated and initiated major research projects are discussed in this section.

Ongoing Research Projects

National Mission Projects

- IBIN (Indian Bio-Resource Information Network)
- ISRO-GEO Portal: Biodiversity OGC WMS services
- Contributions in development of ISRO Geo-portal & Bhuvan

ISRO – GBP Project

- National Carbon Project (NCP) [Soil Carbon Project (SCP)] as nodal point for Uttarakhand

EOAM Projects

- Monitoring and Assessment of Ecosystem Processes in North- Western Himalaya
- Mapping, Modeling and Impact Assessment of Land Subsidence in North India
- RS based hydro-meteorological Data Assimilation in the Hydrological and WRF Models
- Precise Terrain Parameter extraction using Low Altitude Platforms data
- Reflectance spectroscopy for mineral exploration – parts of Rajasthan & Odisha
- Evaluation of Pol-InSAR data for forest biophysical parameter retrieval
- Optimizing parameters from multiple sensors for vegetation biomass estimation
- Multi-sensors EO data for Automatic Retrieval of water, vegetation & built up

DMS Project

- Landslide assessment – rainfall threshold DInSAR based modelling in Uttarakhand
- Flood early warning, concepts, issues & implementation in North West Himalaya

Other Projects

- SARAL - ALTIKA UP: Applications for Inland Waters & Glaciers;
- INSAT-3D UP: Development of retrieval algorithms for 3D Sounder observation.

List of Ongoing In-house research (TDPs)

A. Agriculture & Soils

- Crop and soil studies using space borne hyperspectral & SAR data

B. Forestry & Ecology

- Applications of GPR in assessing root biomass of poplar (*Populus deltoides*) in agro-forestry system in Northern India

C. Geosciences & Geohazards

- Risk Assessment, simulation/ modelling

& characterization of geotechnical properties of vulnerable slopes and landslides in Garhwal Himalayas
- Study of stress & strain distribution using GNSS and correlation with seismic activity in Uttarakhand & Himachal Pradesh

D. Marine & Atmospheric Sciences

- Diagnostic study of Indian summer Monsoon Season using satellite data
- Study of trace gases over Dehradun: role of chemical and dynamical processes on the distribution of Ozone and its precursors.

E. Urban & Regional System Studies

- Evaluation of 3D modeling techniques for urban applications
- Development of methodology for linking built environment and urban climate to identify the adaptation strategies
- A solar intensive approach for a smart city planning
- Urban air quality assessment using geospatial techniques

F. Water Resources

- Retrieval of geophysical parameter related to water resources using hyper-spectral remote sensing
- Development of relationship among vegetation indices (VI) and influencing parameters adopting soft computing approach
- Modelling of soil moisture regime in irrigated and rainfed agricultural using process based model framework and geospatial data assimilation techniques
- Hillslope hydrologic response studies in northwest Himalayan ecosystem

G. Geoinformatics

- Real time road traffic monitoring and analysis of Dehradun city using wireless sensor network
- Study the effects of temporal granularity in climatic forcing, vegetation Index and gravity data over India
- Real time spatio-cluster detection on public-health data stream
- Multibaseline Polinsar tomography for urban and forest structures

H. Photogrammetry & Remote Sensing

- Aerosol Optical Depth Estimation Studies over Land Using Indian Satellite Datasets

Agriculture & Soils Applications

Climate change impact on productivity of food grains & plantation crops *(EOAM Project Sub-theme 3A - Monitoring and assessment of Mountain ecosystem processes in North-West Himalaya)*

Climate change has become reality and affecting strongly the plant growth processes and productivity in tropics. Understanding climate change effects on crop productivity of food and plantation crops in highly vulnerable mountainous ecosystem is indispensable for achieving resilience and sustainability of mountain's agriculture.

Objectives

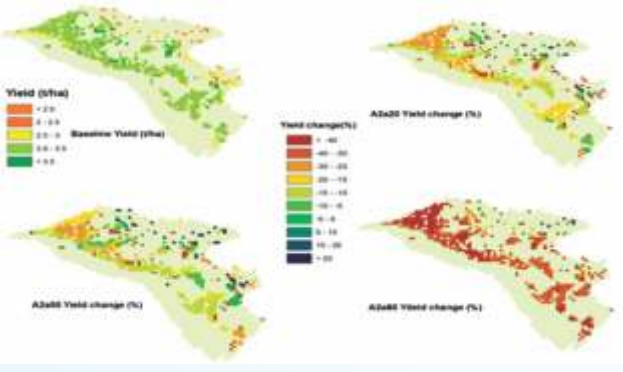
- Assessing the current and future climate change impacts on crop yield and production of major food crops in western Himalaya.
- Development of multi-variate models for predicting productivity of fruits and vegetable crops under future climate change.
- Identifying the potential shift in cultivating areas of major crops and their land suitability

Progress and Achievements

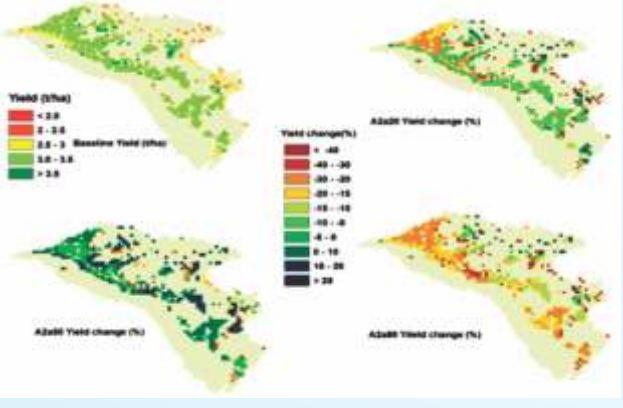
- Simulation of high resolution (1km grid) productivity of Maize, rice and wheat under current and future climate scenario using GEPIC model was carried out.
- Down-scaling of GCM (ECHAM) model by

RegCM 4.0 captured inter-annual variability of climatic parameters (2001-2025) and has shown reasonably good agreement for rainfall and temperature simulation with CRU data.

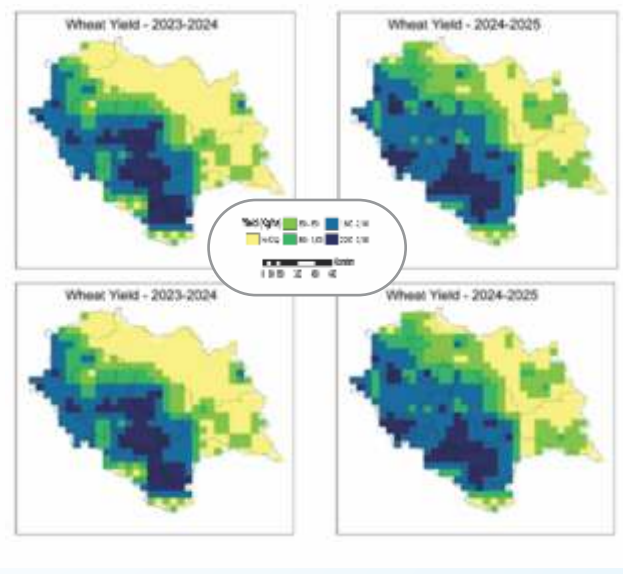
- Grid based simulations of wheat and Maize yield using DSSAT and GEPIC Crop models were completed.
- Land suitability changes under future climate scenario in Himachal Pradesh (HP) using multi-criteria AHP were analysed.
- Climate change impact on crop productivity:
  - Model simulation using GEPIC revealed decline in crop yields (%) in 2080s without CO_2 fertilization for Maize, Rice and Wheat in order of 14%, 20 and 40%, respectively in Doon Valley. However, magnitude of reduction in crop yields are lower down in CO_2 fertilization scenario. Wheat appeared to be more sensitive to climate change and showing 10-15% decline in crop yield in 2020s for both with and without CO_2 fertilization scenarios.
  - GEPIC model simulation for Himachal Pradesh showed wheat yield decline in 2020s and 2080s, however yield may increase in 2050s as compared to baseline (1960-90) period decline in 2020s and 2080s by 9% and 11%, respectively .
  - Down-scaling of GCM (ECHAM) model by



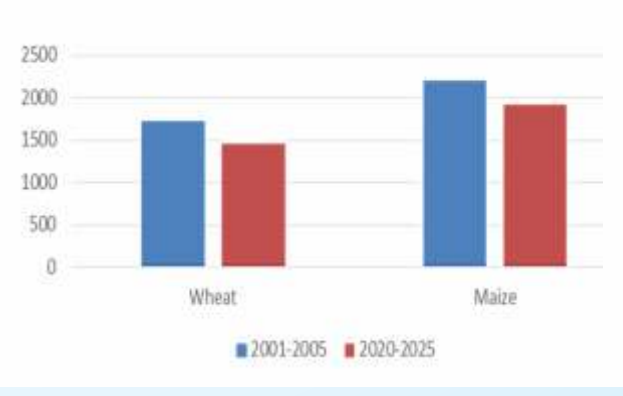
Climate change impact on productivity of wheat crop in Doon Valley (A2a Scenario without CO_2 fertilization)



Climate change impact on productivity of rice crop in Doon Valley (A2a Scenario without CO_2 fertilization)



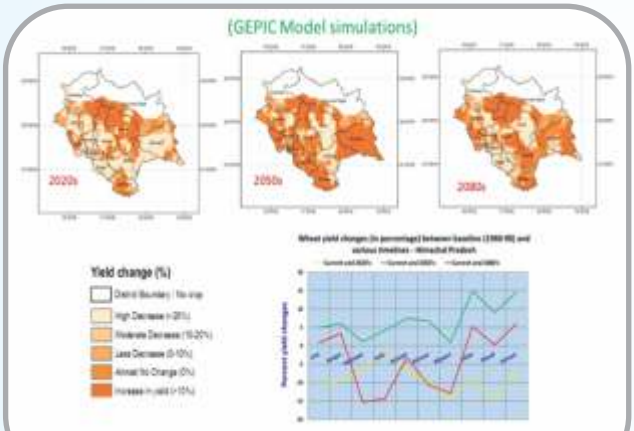
Simulated yield of wheat and Maize in HP under future climate using DSSAT



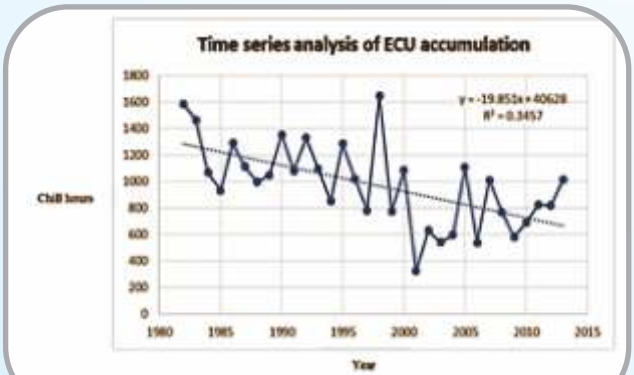
Yield change between 2001 - 2005 and 2021 – 2025 for Wheat and Maize in HP.

RegCM 4.0 captured inter-annual variability of climatic parameters (2001-2025) and has shown reasonably good agreement for rainfall and temperature simulation with CRU data.

- Model simulation with CERES-Wheat and CERES-Maize models within DSSAT reveals that wheat and maize yield in Himachal Pradesh had reasonably good agreement with observed yield at district level. Overall agreement index for simulated maize and wheat yield is 0.67 and 0.72, respectively.
- In near future (2021-2025), climate change is appeared to have marginally reduced the crop yield of Maize (13%) and Wheat (15.7%) in Himachal Pradesh as compared to 2001-2005.



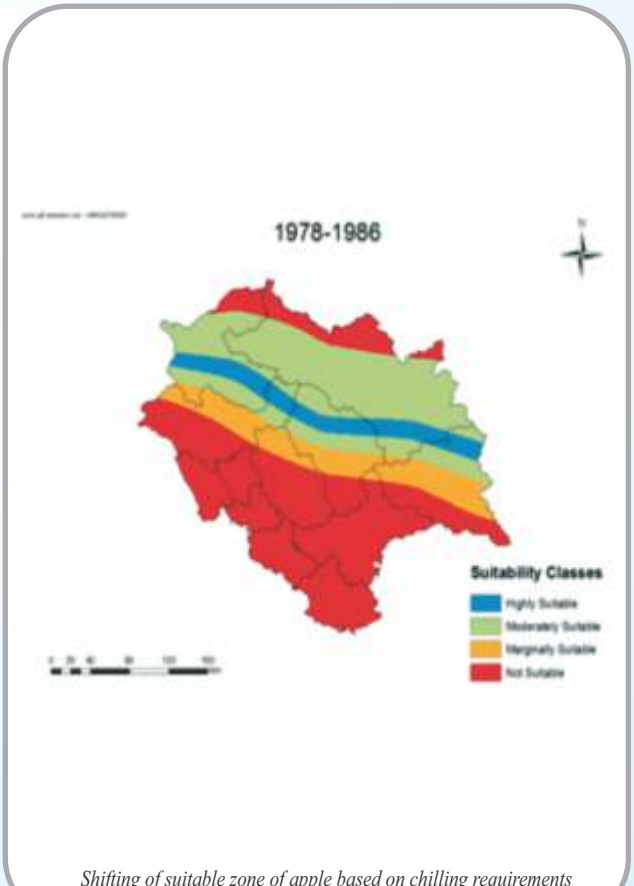
Climate change impact on wheat yield under climate change scenarios



Chill unit accumulation vs. year.

Climate change impact on land suitability of crops

- Chill unit accumulation has decreased significantly from 1997 to 2013 and this decreasing trend is continued to affect apple cultivation. Suitable areas for apple cultivation shifting towards high-altitude in Himachal Pradesh.
- Areas under adequate length of growing period (period in terms of water availability for crop production) showed declining trend from 1971 to 2007. The decreasing trend may seriously affect land suitability zones for food grain crops.
- Multi-criteria analysis done for identifying suitability of land for maize and wheat crop in baseline (1960-90) and future scenarios (2020s, 2050s and 2080s)



Shifting of suitable zone of apple based on chilling requirements

Assessing Soil Erosion and Nutrient Loss and its impact on Soil Quality and Crop Productivity *(EOAM Project - Sub Theme – 3B: Mountain Ecosystem Processes and Services in North Western Himalaya)*

Understanding of process based models and simulation of the model for soil erosion, nutrient loss and crop productivity required for better understanding of soil erosion processes and its impact on soil quality in Mountain agro-ecosystem.

Objectives

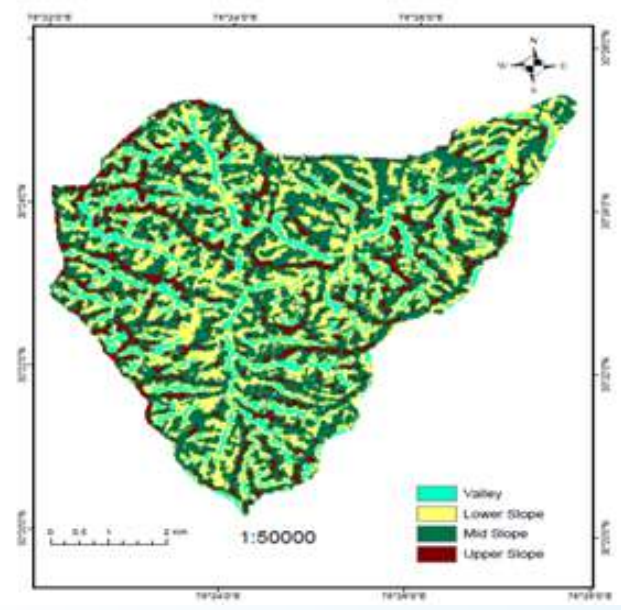
- To characterize and model surface runoff, sediment and soil nutrient losses (TC, N, P) at watershed scale.
- Developing model parameters for assessment of soil and nutrient loss. Modeling to assess impact of climate change on soil erosion and nutrient loss.
- Developing Land Quality Index (LQI) model in assessing soil resilience and sustainability for hilly farming system.

Progress and Achievements

- Instrumented field site for measurement of soil erosion and nutrient loss at mid – Himalaya watershed scale established and data was collected for the year 2015-16.
- Soil and terrain characterization of the watershed completed.
- Soil and land quality indices developed.
- Climate change impact on soil quality (soil organic carbon) and soil erosion investigated in Mid-Himalaya.
- One watershed in Palampur (HP) has been characterized for soil and terrain parameters.

Landform wise, Soil Quality Index (SQI) and Land Quality Index (LQI)

On the basis of this index it is interpreted that SQI for valley is 0.71, for lower slope is 0.68, for middle slope is 0.67 and for upper slope is 0.65. Soil quality of valley is best among all followed by SQI of lower slope, mid slope and upper slope. LQI of valley is 0.74, of lower slope is 0.71, for mid slope 0.66 and for upper slope is 0.63. Hence, land quality of valley is best followed by lower slope, mid slope and upper slope.

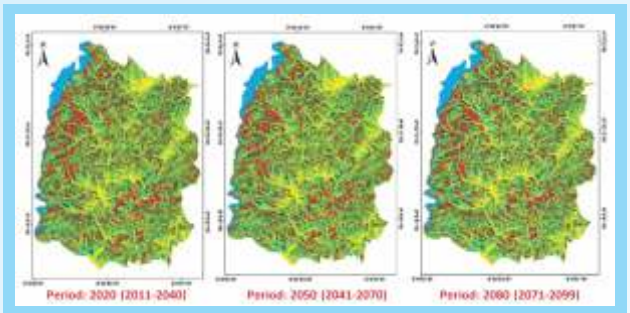


Landform elements based on Carto DEM

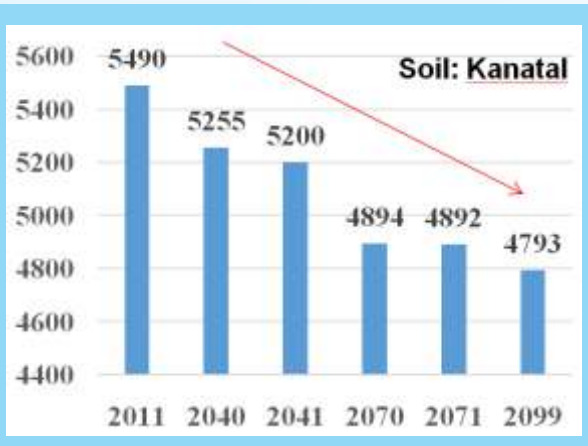
S. No.	*Landform elements*	*SQI*	*LQI*
1	*Valley(n=10)*	*0.71*	*0.78*
2	*Lower slope(n=20)*	*0.68*	*0.71*
3	*Mid slope(n=9)*	*0.67*	*0.66*
4	*Upper slope(n=6)*	*0.65*	*0.63*

Climate change impacts in Mid Himalaya

Soil erosion was predicted for future periods and the results revealed that the average annual soil loss may increase by 28.38, 25.64 and 20.33 percent in 2020s, 2050s and 2080s, respectively under A2 scenario. Similarly, average annual soil loss may increase by 27.06, 25.31 and 23.38 percent in 2020s, 2050s and 2080s, respectively under B2 scenario from the base period (1985-2013).



Simulating Soil Loss for A2 Scenario



Soil Carbon Sequestration (2011-2099) for A2 scenario (Climate Change Impact on Soil Quality: CENTURY Model Mid Himalaya (Chamba, Tehri Garhwal)

The study revealed that the amount of organic carbon in Bhaitan, Kanatal , Kotdwar, Malas, Pata and Thangdhar sites in Mid Himalaya watershed may reduce by 11.6, 15.8, 17.19, 13.54, 19.2 and 12.7 percent, respectively for A2 scenario and by 9.62, 15.6, 15.72, 11.45, 16.96 and 13.36 percent for B2 scenario up to 2099.

Monitoring of Crop Growth and Soil Moisture using RiSAT-1 Hybrid Polarimetric SAR data *(EOAM Project)*

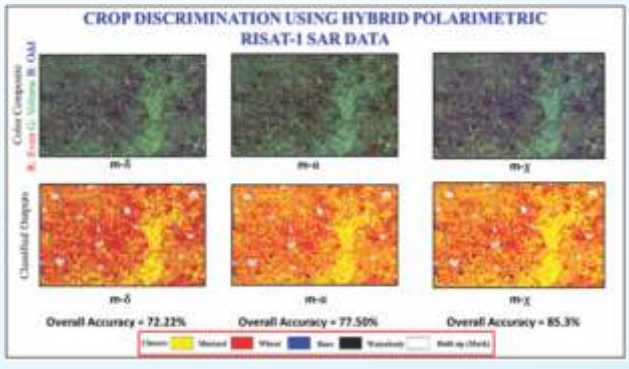
Hybrid Polarimetry data is capable of providing large number of polarimetric parameters that can be explored to exploit its potential for monitoring of crop growth and soil moisture for bare soil conditions as well as under crop covered conditions.

Objectives

- To study the sensitivity of Polarimetric Parameters generated using various decomposition techniques towards crop biophysical parameters and soil moisture.
- Retrieval of biophysical parameters of crop using RISAT-1 hybrid polarimetric SAR data.
- Retrieval of soil moisture using RISAT-1 hybrid polarimetric SAR data for bare as well as crop covered agricultural fields.

Progress and Achievements

- Potential of RISAT-1 hybrid polarimetric SAR data for crop discrimination using m-δ, m-α and m-χ space decomposition techniques has been explored.
- Sensitivity of hybrid polarimetric parameters generated from RISAT-1 hybrid polarimetric SAR data towards bio-physical parameters of the paddy crop has been done.
- Soil moisture retrieval under wheat crop has been attempted.
- Crop discrimination & bio-physical paramers retrieval: m-χ space decomposition has been identified as suitable technique for crop discrimination due to the change in magnitude & phase of the received horizontal and vertical polarized signals. It is observed that the polarimetric parameters (even bounce, odd bounce and volume component) are more sensitive towards biophysical parameters of the paddy crop than the backscattering coefficients (σ˚RH, σ˚RV).



Crop discrimination using hybrid polarimetric RISAT-1 SAR data

Hybrid Polarimetric RISAT-1 SAR Parameters used for Paddy Biophysical Parameters Retrieval			n	Correlation Coefficient (r) Plant Parameters				
				LAI	Wet Biomass	Height	Dry Biomass	Plant Volume
σ^0_{RH}	σ^0_{RV}		35	0.79	0.8	0.5	0.8	0.66
m-δ_Even bounce	m-δ_Odd bounce	m-δ_Volume	35	0.86	0.83	0.5	0.9	0.77
m-γ_Even bounce	m-γ_Odd bounce	m-γ_Volume	35	0.86	0.83	0.51	0.83	0.76
m-σ_Even bounce	m-σ_Odd bounce	m-σ_Volume	35	0.87	0.85	0.57	0.82	0.75
m-ψ_Even bounce	m-ψ_Odd bounce	m-ψ_Volume	35	0.89	0.83	0.68	0.82	0.76

Crop biophysical parameters retrieval of paddy using hybrid polSAR RISAT-1 data

- Soil moisture estimation: Volume component generated by decomposing target vector is found to be more sensitive for soil moisture as compared to circular polarized RISAT-1 SAR backscatter.

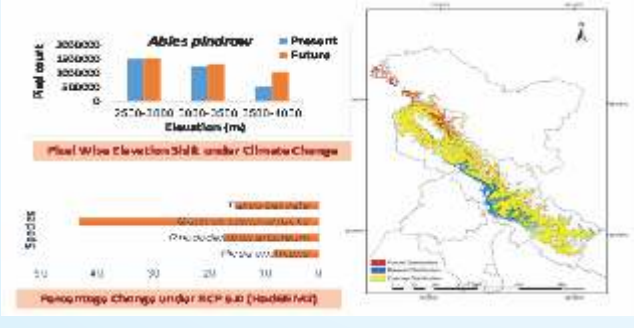
Forestry and Ecological Applications

Vulnerability Assessment of Mountain Ecosystems due to Climate change: Ecosystem Structure and Functioning *(EOAM Project - Sub-theme-2: Monitoring and assessment of Mountain ecosystem processes in North-West Himalaya)*

Climate change in twenty first century is bringing serious impacts on the structure and functioning of Himalayan ecosystems. Changes in the overall distribution of species include one of the earliest indicators of these impacts. Some of the preliminary field studies suggests that warming has contributed to geographical upward range shifts in endemic plant species in the Himalayan region.

Objectives

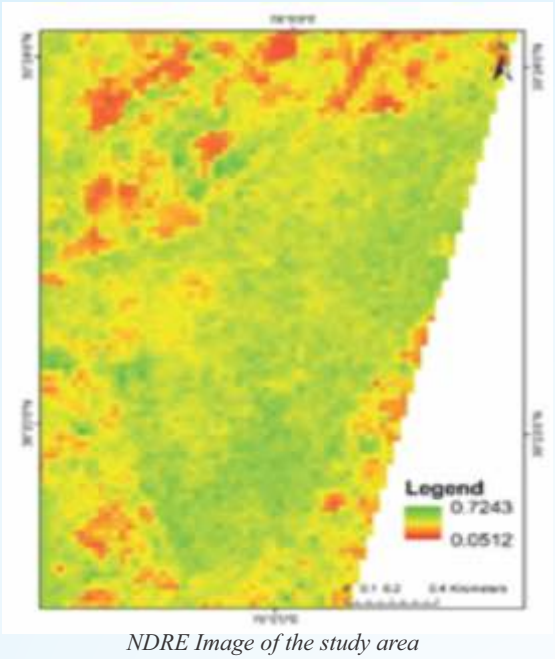
The main objective of the project is to assess the vulnerability of the fragile mountain ecosystems in terms of ecosystem structure (Biodiversity, vegetation types, contiguity) and functioning (nutrient dynamics, carbon stock and flow, phenology) due to global change. The project has the following sub-areas: (i) Impact of Global Change on Species Composition in Himalayas; (ii) Quantification of Ecosystem Processes: Nitrogen dynamics in Mountain ecosystem structure and functioning; and (iii) Impact of Global Change on tree line ecotone of Himalayan region



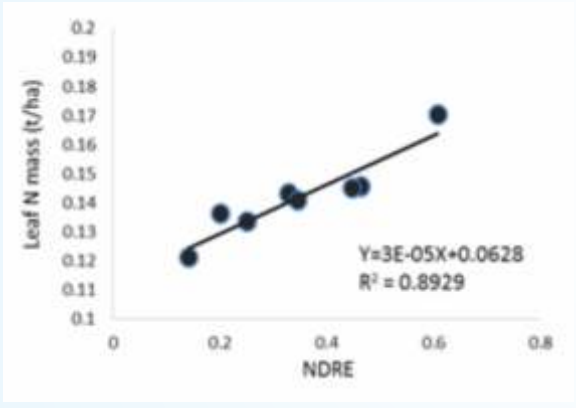
Probable range shift in Quercus semicarpifolia under climate change scenario

Progress and Achievements

- **Modelling Range Shifts In Some Temperate and Sub Alpine Forestry Species under Climate Change In Western Himalayas**
  - The modeling results exhibit species response towards predicted climate change in terms of considerable advancement in the tree line to higher elevations.
  - Shrink in current range distributions in temperate species eg. *Quercus semecarpifolia, Taxus wallichiana, Picea smithiana and Rhododendron arboreum*.
  - Sub-alpine species like Betula utilis, Abies pindrow and Juniperus recurva showed trend difference from temperate species with expansion in their range areas under climate change.
  - Emergence of Trans Himalayas and Tibetan plateau as a refuge to Himalayan species under projected climate change.
- **Quantification of Forest canopy Nitrogen using Narrow-band Spectral Indices**
  - Normalized Difference Red Edge (NDRE) Index has been applied to EO-1 Hyperion data and validated with field observations to map Sal (*Shorea robusta*) forest canopy nitrogen in the Malsi reserve forest, Dehradun. The relation between NDRE and leaf nitrogen mass was found as R2=0.89. The study highlights importance of red-edge spectral region in assessing health of forested canopies.



NDRE Image of the study area



Relation between NDRE and leaf N mass

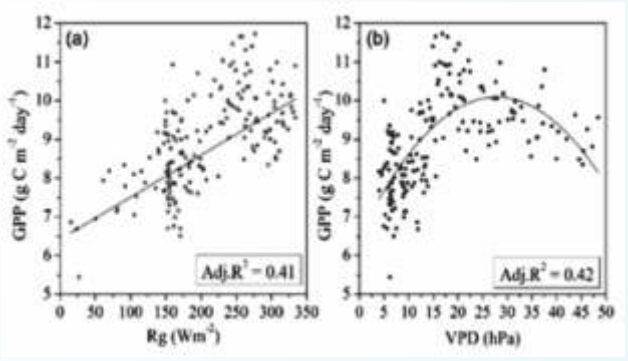
Soil, Vegetation-Atmosphere Carbon Flux Modelling (IGBP: National Carbon Project)

Objectives

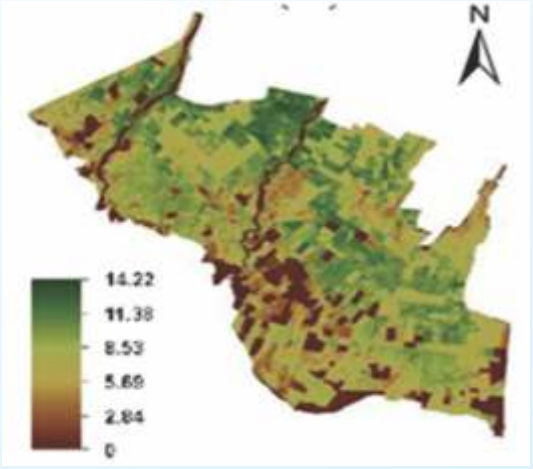
The project on Soil-Vegetation-Atmosphere Carbon Flux (SVF) is part of National Carbon Project (NCP) under ISRO-Geosphere Biosphere Program. This project aims at long-term monitoring of CO_2 and H_2O fluxes using advanced Eddy Covariance (EC) technique and upscaling it to national level with integration of RS & GIS and modelling technique. Under this program, IIRS is responsible for operation, maintenance, data retrieval and data analysis of two flux towers sites located in Moist Deciduous Sal Forest at Barkot and Young Mixed Forest Plantation at Haldwani, Uttarakhand.

Progress and Achievements

One of the main advantage of using EC is that it allows us to measure the carbon fluxes from half-hourly to years, providing an opportunity to study the seasonal carbon dynamics and how it is regulated by the bio-climatic variables. The relationship between Gross Primary Productivity (GPP), incoming solar radiation and vapour pressure deficit (VPD) observed at Barkot flux site suggested in findings that higher rate of GPP is observed at moderate VPD level prevail during September and October months. While GPP derived using Light Use Efficiency (LUE) model parametrized with EC observations for Haldwani forest site finding, reveals that 11-year old mixed forest plantation at Haldwani site is strong sink of carbon with an Avg.-rate of 3.081 g Cm^2/day.



Relationship between GPP, incoming solar radiation and VPD at Barkot forest site



Upscaled GPP over Haldwani forest site

Optimizing parameters from multi-sensors for biomass estimation (EOAM Project)

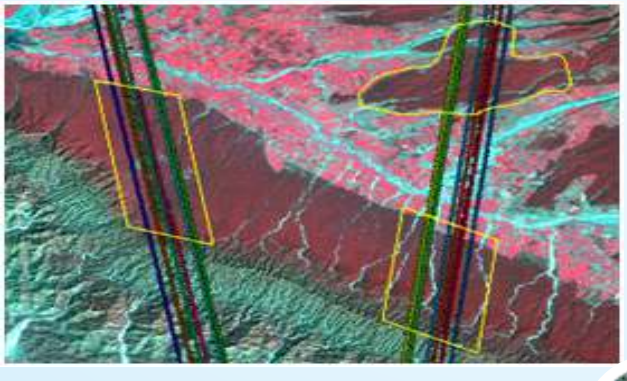
Forests store large amount of carbon and play a significant role in the regional and global carbon cycle. Hence, the accurate estimation of the forest biomass is extremely crucial to determine its precise role in global carbon cycle.

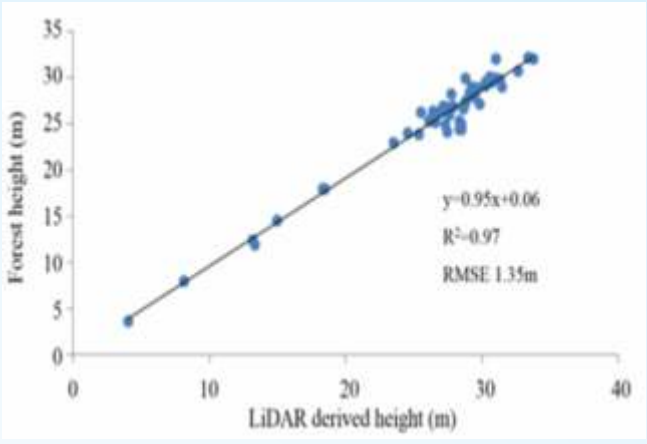
Objectives

- To optimize the multi-sensor parameters for biomass assessment.
- Comparing the accuracies of biomass assessment derived from different multiple regression algorithms, for example, Support Vector Machine, Random Forest and Multi-Layer Perceptron algorithms.
- To explore a relationship between height metrics derived from ICESat waveform and RADAR derived parameters.

Progress and Achievements

- Estimation of aboveground biomass (AGB) at ICESat/GLAS footprint level was done by integrating data from multi-sensors using three regression algorithms, viz., Random Forest (RF), Support Vector Machine (SVM) and Multi-Layer Perceptron (MLP) algorithms. The study was conducted in the Tropical Moist Deciduous forests of western Doon valley, Uttarakhand.
- The forest height was predicted with an RMSE of 1.35 m.The study showed that a combination of LiDAR, spectral and textural parameters provide better biomass estimation accuracies as compared to those obtained by using single sensor parameters.





LiDAR derived height vs field measured forest height

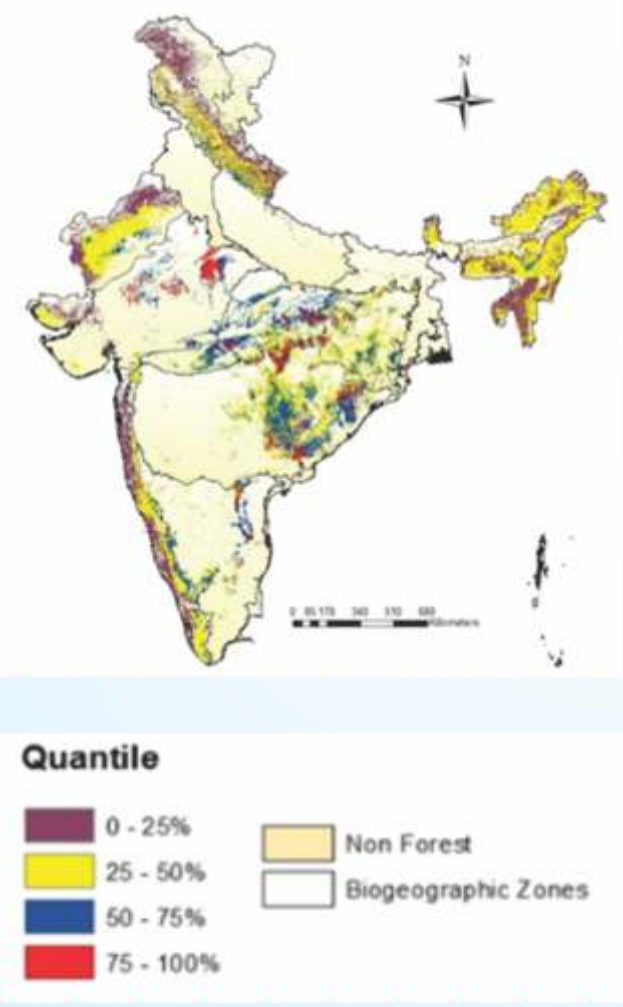
- It showed that 6 most important parameters, viz., wdistance, wextent, Correlation2, nir2max, irgvi2max and H75 were able to explain 78.7% (adjusted) variation of the observed biomass with an RMSE of 13.9 Mgha-1. ICESat waveform parameters like wdistance, and wextent correlated well with a combination of Freeman 3 decomposition parameters derived from ALOS PALSAR quadpol data.
- Therefore, a combined equation for areas outside LiDAR footprints was developed which resulted in a validation RMSE of 14.69 Mgha-1. The study conclusively established that sensor integration approach is much better than single sensor approach in predicting the AGB. The study also demonstrated the potency of RF, SVM and MLP algorithms in variable selection for biomass estimation.

Assessment of Alien Plant Species Invasion Risk on Indian Forests

- Identification of hotspots of invasion that support multiple invasive alien species is a pre-requisite for surveillance, pre-emptive response, control and management of invasive.
- In this study, the bio-gragraphic zones in the country supporting potential habitats of 105 most noxious alien forest invasive species have been predicted with the field

inventoried distribution records and environmental covariates (e.g. climate, soil, vegetation type, canopy cover and topography) following maximum entropy modelling approach.

- The study shows different risk categories namely very high (75-100%), high (50-75%), medium (25-50%) and low (<20%) risk. The prime wildlife habitats of central Indian landscape and foothills of Himalaya and Western Ghats are the most prone to alien plant species invasion.

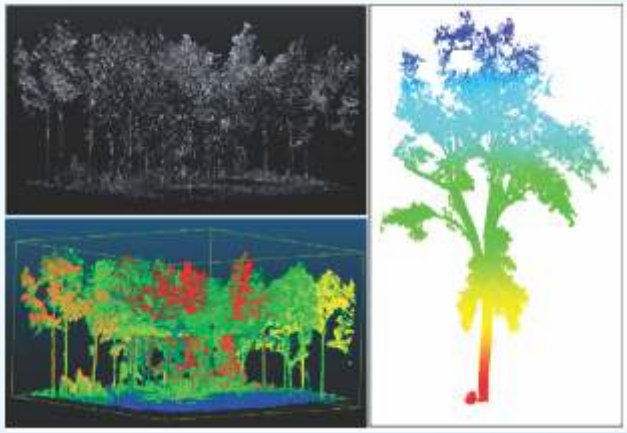


Hotspots of invasion of alien invasive species in Indian Forests

Retrieval of Forest Inventory Variables with Terrestrial Laser Scanning

- Assessment of three-dimensional (3D) forest structure is very crucial as it impacts the microclimate and regulates several physical and biological processes. LiDAR operating from space-borne, airborne or terrestrial platforms, can be used to model forest structure. Terrestrial laser scanning (TLS), also known as terrestrial LiDAR, has limited spatial coverage as compared to space-borne and airborne LiDAR, but has the potential to reduce uncertainty of field-based measurements. It is a non-destructive ground-based method that can retrieve the 3D vegetation structure at plot level with high accuracy. In the present study.

- TLS data were acquired with RIEGL VZ-400 terrestrial laser scanner. From TLS-3D point cloud data, individual trees were extracted. The tree parameters, like diameter at breast height (dbh) and height were derived from the extracted single trees. Stem diameter and tree height were retrieved from TLS data with RMSE of 2.34 cm and 2.01 m respectively. The retrieved parameters can be used to assess aboveground biomass and carbon stock of forest. Recent advances in terrestrial LiDAR technology have made LiDAR data widely available to study vegetation structure characteristics & forest biomass.



a) TLS point cloud data, b) 3D visualization of point cloud data and c) Individual tree extraction.

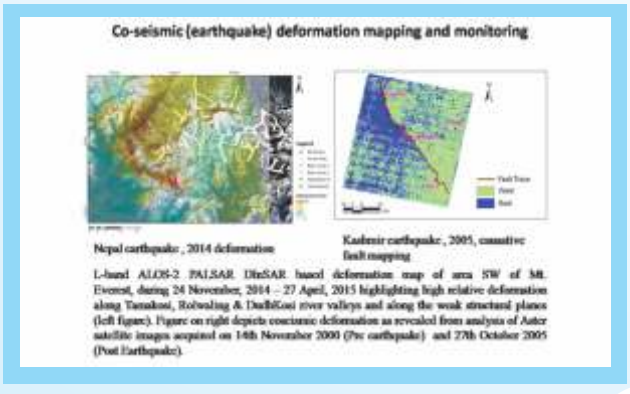
Geosciences and Geo-hazards Applications

Geodynamics and Seismicity Investigations in Northwest Himalaya (EOAM Project: Sub-theme 3A - Monitoring and assessment of Mountain ecosystem processes in North-West Himalaya)

Himalayan region is one of the most seismically active regions of the world due to continuous northward movement of Indian plate at a rate of 40 mm per year (approx.) that has resulted in three major fault systems (MCT, MBT, HFT) and numerous other faults. Several earthquakes in the recent past have occurred in the region - 6.8 Mw Uttarkashi earthquake in 1991, 6.6 Mw Chamoli earthquake in 1999, 7.6 Mw Kashmir earthquake in 2005 and most recently 6.9 Mw Sikkim earthquake in 2011, Nepal and Pakistan earthquake in 2015. Two mega events in the past: 1905 Kangra earthquake and 1934 Bihar-Nepal earthquake are stark reminders of the fact that crustal dynamics and associated devastating earthquakes need to be studied in a comprehensive manner. Therefore, a collaborative study has been undertaken by IIRS and Wadia Institute of Himalayan Geology (DST), Dehradun on geodynamics and seismicity.

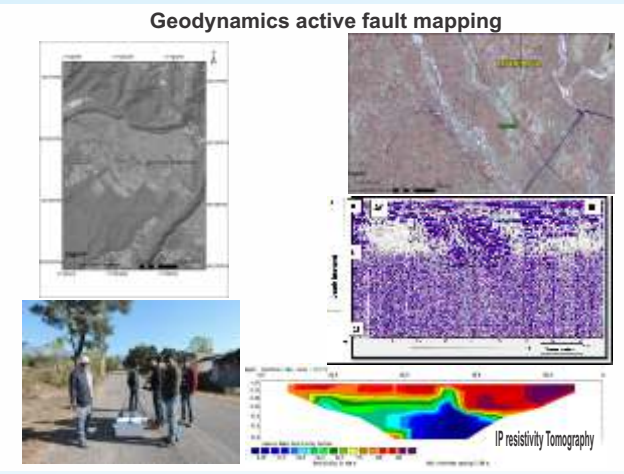
Objectives:

- Deformation measurement and strain modelling using DGPS, DInSAR and ScanSAR. Earthquake precursor studies (TEC, Seismic):
- Acquisition of Total Electron Content (TEC) data and assessment of EO data for earthquake precursors study using inospheric anomalies with reference to significant earthquakes in Himalaya and surrounding region.
- Active fault mapping using high resolution EO data and geophysical investigation in selected sectors around major fault systems (HFT, MBT, MCT).



Progress and Achievements

- **Deformation monitoring using CORS/ DGPS data:** Three CORS stations have been installed at Dehradun, Mandal and Pantnagar that are providing GNSS data continuously since their date of installation during 2014-2015. Four set campaign mode GNSS receivers have been purchased and first round of campaign mode survey at 15 locations have been completed and the data is being compared with SOI data for crustal deformation between 2005 and 2015. Such observations are to be repeated bi-annually.
- **Total Electron Content (TEC) data analysis:** TEC data from 2 CORS stations were processed for Pipalkoti and Nepal earthquakes in 2015 and anomalies have been observed. Additionally, TEC data from other CORS maintained by other departments/organizations have been analysed. However, study is under progress to cross-check such anomalies due to solar flare and magnetic anomalies.
- **Active fault mapping:** This study has been carried out in Doon valley and surrounding regions from HR satellite data followed by GPR and IPR based confirmation. At selected location, a trench has been opened up (at Bhauwala) for confirmation and samples have been collected for dating. Morphotectonic studies have been carried out for Bhagirathi and Alkananda basin and results are under finalization. Evolution of river basin and Himalayan mountain front (in Mohand sector) has been analyzed.

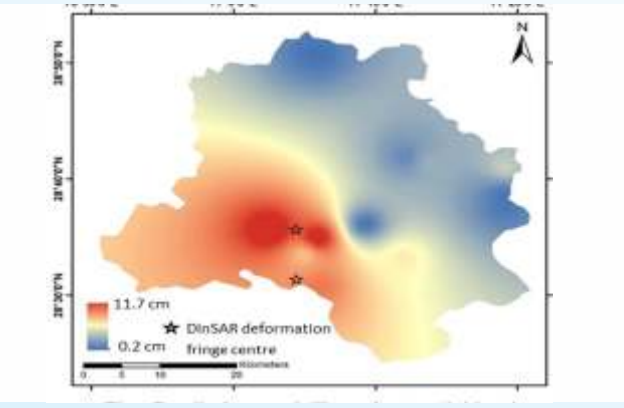


Land Subsidence Mapping

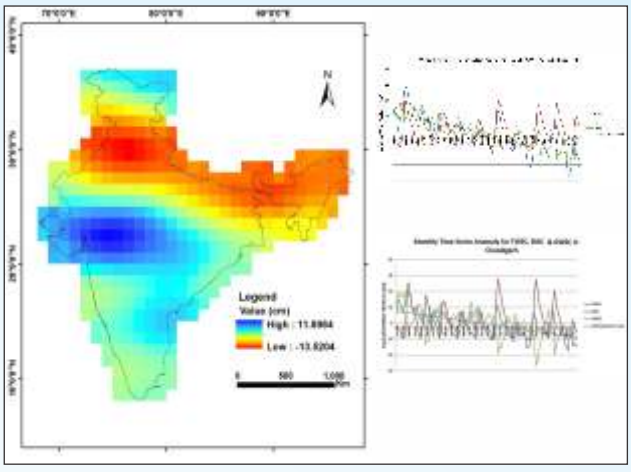
- There is an urgent need for systematic spaceborne approach in India for detection, mapping and predictive modelling of groundwater-induced land subsidence scenario at regional scale.

Objectives

- In this EOA project, a collaborative effort along with Central Ground Water Board and Geodetic & Research Branch (Survey of India) has been made to address several objectives: (a) Detection, mapping and modelling of land subsidence in selected cities (groundwater depletion hotspot locations) of Northern India, (b) To decipher the relation between land subsidence groundwater extraction, (c) Predictive modelling of aquifer system compaction due to groundwater depletion for assessing the spatial extent and magnitude of potential land subsidence,



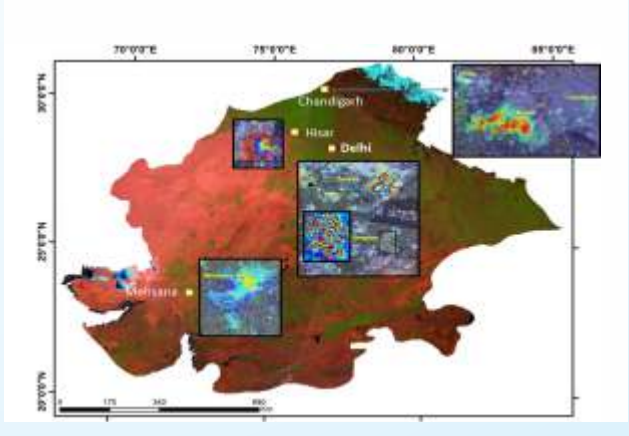
Mapping, Modelling and Impact Assessment of Land Subsidence in Northern India (EOAM Project)



Spaceborne Grace gravity anomaly and groundwater depletion scenario in Delhi and Chandigarh during 2003-2012.

(d) Inter-comparison of land subsidence, groundwater depletion and gravity anomaly (say, mass deficit in terrestrial water storage) on regional scale.

- Several techniques are adopted to achieve the objectives of the project: (a) Spaceborne DInSAR and ScanSAR Interferometric SAR aided by other spaceborne & terrestrial geodetic techniques such as GNSS observation & digital levelling, (b) Predictive modelling of groundwater induced land subsidence aided by ground-based layer compression measurements by subsurface instrumentation, (c) Hydrological modelling and inter-comparison of space borne gravity based terrestrial water storage change (TWSC), groundwater depletion & land subsidence scenario.



Rainfall threshold for initiation of landslides and decoupling of spatial variations in precipitation, erosion, tectonics in Garhwal Himalaya (DMSP Project)

This project was taken up under Disaster Management Support Programme (DMSP) of Indian Space Research Organisation (ISRO)

Objectives

- The objectives are establishing Automated Weather Stations (AWS) along important road sectors for acquiring hourly rainfall data, assessment of spatio-temporal variation of precipitation (ground and satellite based) and its relation with initiation of landslide, spatio-temporal modeling and establishment of precipitation threshold (PT) index for initiation of landslides in different areas and assessment of tectonics and climate control on landslides and mass wasting.
- Preliminary precipitation thresholds (PT) based on 72-hours precipitation and previous 15-days precipitation as a measure of antecedent moisture were established for different storm events using historical data sets. These threshold equations were applied to precipitation data obtained from AWS and were correlated with landslide events.
- Further to this study to generate an early warning system for landslide prediction, an attempt was made to establish an intensity-duration based rainfall relationship for predicting initiation of landslides in Alaknanda valley, Garhwal Himalaya.
- ***Intensity–Duration Thresholding for landslide initiation:*** The log-log plot of maximum intensity (I in mm/hours) to total duration (D in hours) of rainfall events which resulted in landslides have been used to derive the I-D equation. The equation can be used to determine the probable duration of events which can initiate slope failures. A set of 112 landslide events, from the year 2009 to 2014 were used for calculation of the intensity-duration equation.
- **Logistic regression based modeling:** A landslide probability model using logistic regression was developed for two prime locations along NH-58 using both Climate Prediction Center (CPC-RFE V2.0) as well as Tropical Rainfall Measuring Mission (TRMM 3B42-daily data) rainfall data. Major storm events were identified near the above mentioned locations and corresponding landslides were taken from the BRO records for the year 2009 to 2013. For these days of the landslide incidences, the T6 (of 72 hrs and 15-days precipitation) and its derivative's values were used to generate the logistic regression based equation.

Overall Accuracy of Prediction

Total No of Days	No of Landslide Days		No of non-landslide Days	
	True	False	True	False
737	98 (87.5%)	14 (12.5%)	566 (90.56%)	59 (9.44%)

Total No. of Days	No. of Landslide Days (120)		No. of Non-landslide Days (368)	
	True	False	True	False
488	108 (90%)	12 (10%)	271 (73.6%)	97 (26.4%)

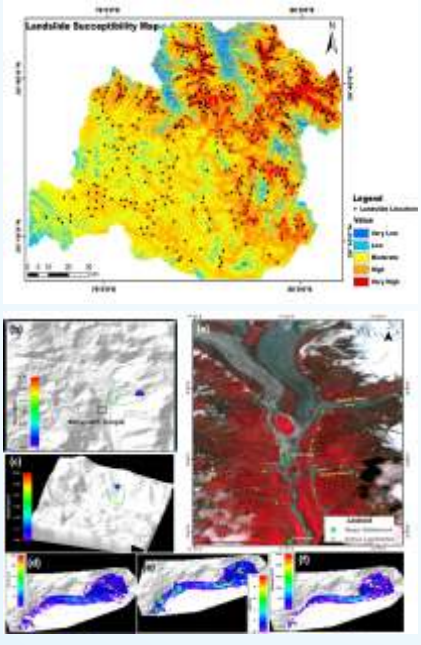
Risk Assessment, Simulation/modeling and Characterization of Geotechnical properties of vulnerable slopes and landslides in Garhwal Himalaya (TDP Project)

Debris flows has globally been attempted to model taking cues from satellite derived and ancillary data. Garhwal Himalaya in the present decade has emerged as a hot spot for landslide occurrences in this tectonically fragile zone affecting life and property. Lanslides/ debris flows associated with Kedarnath, Ukhimath, Uttarkashi, Lambagarh, Kaliyasaur are few among the major ones to name.

Objectives:

- The main objective of the project is modeling of potential flows/slides, characterization of engineering properties of rock and soil and thereby, establish the risk of unstable slope/slide to facilitate mitigation.

- The major outcomes of the project include post Keadrntah (2013) disaster landslide hazards zonation/risk maps prepared at 1:40000 to 1:50000 scale for Kedarnath to Rudraprayag along Mandakini basin, upper reaches of Yamunotri valley and parts of Alaknanda valley. Simultaneously, modeling of important debris flows by numerical simulation include Kedarnath, Ukhimath, Uttrakashi, Kaliyasaur (Srinagar), Maithana (Pipalkoti) etc. Simulation techniques were also tested in different litho-tectono-structural regimes in peninsular India to test the procedural adaptability and objectivity.
- A state-of-the-art geotechnical/ engineering geological lab has been set up. The output in terms of spatial variation of physical parameters, quantitative assessment of which is of critical importance in mitigation measures is to be generated.

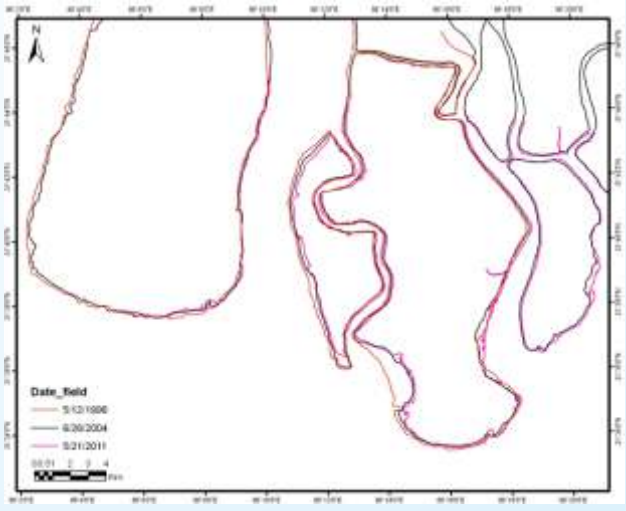


Susceptibility map of Alaknanada Valley and Satellite image showing location of major landslides and debris flows; ***(b-c)*** *Location of source area and area of influence (green boundary) of debris flow on Cartosat-1 DEM in 2D and 3D, respectively;* ***(d-f)*** *Spatial variation of simulated velocity, height and momentum respectively for debris flow. Data Source: Merged data product of Resourcesat-2 LISS-IV and Cartosat -1 image acquired on 21 June, 2013, displayed with RGB-321 band combination.*

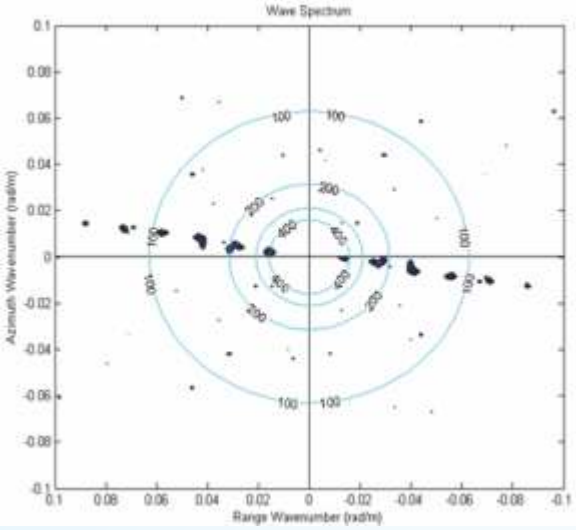
Marine and Atmospheric Sciences Applications

Coastal Dynamics Study of Bay of Bengal around Sunderban using Space-borne InSAR and PolSAR Data (TDP project)

- This research is focused mainly on the application of interferometric and fully polarimetric data in oceanographic parameter retrieval and the capability of numerical simulation technique in studying and predicting coastal change dynamics.
- Interferometric coherence came out to be a useful parameter to identify the land-ocean boundary as a large gradient in coherence values exists across the interface.
- Polarimetric coherency matrix diagonal element T33 ($4\langle|S_{HV}|^2\rangle$) has proved to be most effective as it represents volume scattering which is the dominant scattering mechanism at land, hence discriminating between land and specularly reflecting water surface.
- Full polarimetric data has been used to compute complete directional wave spectra information without the need to solve for a complex hydrodynamic modulation transfer function and it removes the directional ambiguity as well. The wave-length, wave-direction and significant wave height can be retrieved.



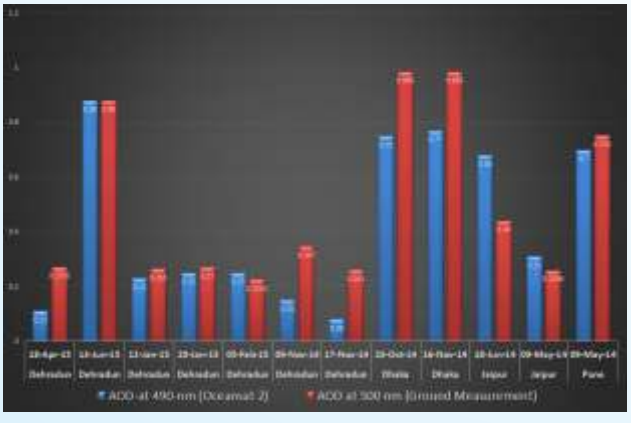
Change analysis of shoreline from InSAR and PolSAR



Wave Spectra generated from RADARSAT II

Retrieval of Aerosol Optical Depth Over Land from Oceansat-2 data (Oceansat II Project)

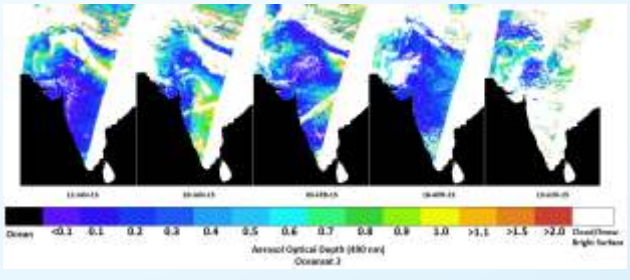
- Studies of aerosol properties are important to study climate change, including investigations of anthropogenic influences on climate (forcing), and the air quality. Satellites are increasingly used to obtain information on aerosol properties (e.g., the aerosol optical depth (AOD), the columnar concentration of particles, their sizes).
- The aim of the present work is to implement an appropriate method to retrieve aerosol optical depth (AOD) from Ocean Colour Monitor (OCM) sensor on board Oceansat-2.



Comparison of Microtop II sunphotometer, Aeronet measured aerosol optical at 500 nm and Oceansat-2 retrieved AOD at 490 nm

The retrieval of AOD over land surface from remotely sensed top of atmosphere radiance requires knowledge about ground reflectance which is again a variable quantity both spatially and temporally. However, in the SW region <0.67m (except of snow and desert ground) the spectral surface reflectance has values in the range of 0.05 and lower, decreasing with shorter wavelength. Thus, a retrieval of aerosol properties over land requires separation techniques to consider the variable contribution of the surface reflectance.

- In the present work, the study area (68° E - 92° E Longitude and 11° N to 38° N Latitude) is comprised of chain of snow clad Himalayan mountains in the north, the Great Indian Desert in the north-west, Indo-Gangetic plains in the middle and the triangular peninsular land mass in the south.
- The aerosol loading in this region is mainly influenced by Indian monsoon and the regional geography. In the present work, a hybrid approach is implemented to retrieve aerosol optical depth (AOD) from Ocean Colour Monitor (OCM) sensor on board Oceansat-2. The retrieved AOD has been validated with ground observations made at different locations of the study area by AERONET sites and hand held sun photometer. The Oceasat-2 retrieved AOD is also being compared with the MODIS Terra and Aqua retrieved AOD. It is observed that Oceansat-2 retrieved AOD is in good agreement with ground observed AOD.

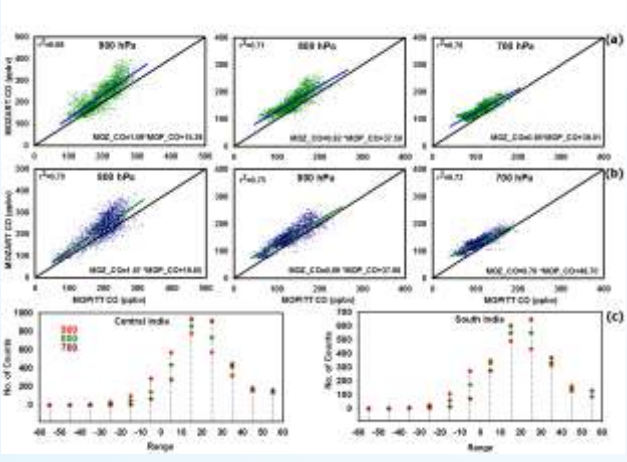


The AOD at 490 nm from Oceansat-2 from May 2014 to June 2015

Variability of lower tropospheric carbon monoxide inferred from observations and model simulation over Indian sub-continent (IGBP ATCTM)

Objectives

- Installation and validation of chemistry transport model MOZART, and also the Investigation of source regions of air pollutants using MOZART tagged tracer run.
- Chemistry transport model MOZART (Model for Ozone and Related chemical Tracers-Version-4) has been successfully implemented. MOZART simulation has been made from 2003 to 2007 and compared with satellite observations with a specific focus on Indian subcontinent to illustrate the capabilities of MOZART model. The model values are compared systematically with latest version (version-6) of MOPITT (Measurement Of Pollution In The Troposphere) satellite carbon monoxide (CO) retrievals.



Scatter plots for MOPIIT CO mixing ratios and their corresponding MOZART-4 mixing ratios over (a) Central India and (b) for South India in the lower troposphere (900 hPa, 800 hPa and 700 hPa). The black line shows the 100% correlation line and the linear fit of data pairs used for comparison is depicted by color line. The histogram of corresponding percentage difference between observed and modeled mixing ratios are also shown (c)

- Model reproduces major spatial features present in satellite observations. However, model overestimates CO over the entire Indian region in the lower troposphere. The frequency distribution of all data points with respect to MOZART error shows similar distribution of gridded data points for all the pressure levels with maximum in the error range of 10-20 %. Over total Indian landmass, the percentage of gridded CO data that are being overestimated in the range of 0-30% at 900 hPa, 800 hPa and 700 hPa are 58 %, 62 % and 66 %, respectively. The study reflects very good correlation between two datasets over Central India (CI) and South India (SI). The correlation (r^2) values over CI are found to be 0.68-0.78 whereas 0.70-0.78 over the SI. The correlation is week over North India (NI) with slope values of 0.2-0.4 and r^2 values of 0.1-0.3.

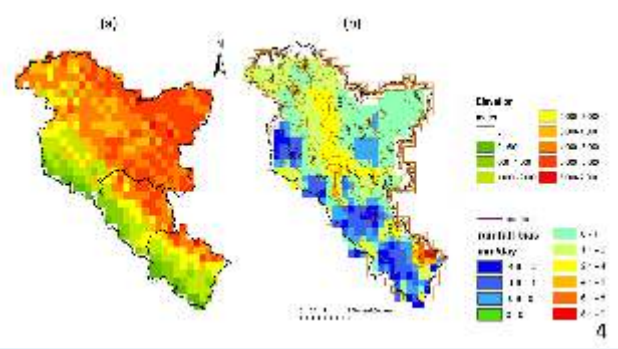
Rainfall retrieval using remotely sensed data and study of extreme rainfall events over the North-West Himalayan region (Sub-theme - 6: EOAM Monitoring and assessment of Mountain ecosystem processes in North-West Himalaya)

Objectives

- A systematic documentation of the fine-scale spatio-temporal variability of rainfall,
- An analysis of extreme events over the topographically rich Northwest Himalayan region.
- Long-term analysis of the rainfall data set and trends investigation. Modification/ comparative analysis of merged rainfall products for example TRMM 3B42, 3B43 and IMSRA with respect to IMD rainfall data (ground based observation) over NWH region
- Rainfall retrieval algorithm from microwave, remotely sensed data.

Progress and Achievements

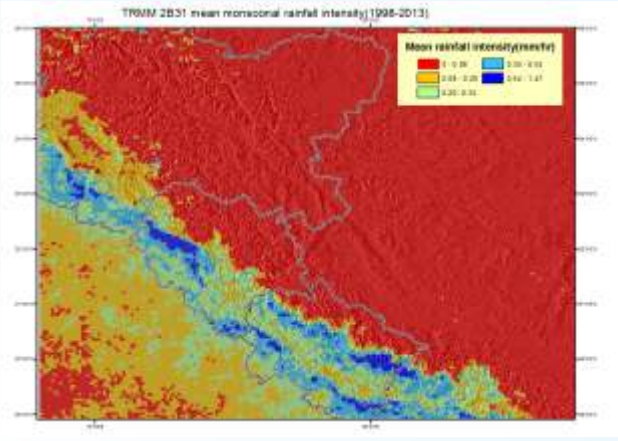
- During the South–West monsoon season, the North–West Himalayan regions receives maximum rainfall in the month of August. However, the maximum contribution to the



(a) Elevation map of NWH generated using resampled SRTM DEM (b)Rainfall bias map generated for NWH region with contours depicting elevation ranges in meter.

seasonal total rainfall comes from the month of August, but the long term (1901 to 2004) trend of the rainfall suggests a significant decrease (significant at 6% significance level) in the amount of the rainfall in the recent years.

- Using remotely sensed TRMM 3B42 version 7 precipitation data a thorough investigation of extreme rainfall events during the monsoon season has been conducted over the Northwest Himalaya for the period of 1998 - 2013. The strong positive correlation from 0.88 was found between the TRMM data and ground based IMD gridded rainfall data supporting the use of TRMM satellite data for the study of rainfall over Northwest Himalaya region. However, satellite underestimates precipitation over high mountains of >3000 m elevation and overestimates precipitation over < 3000 m elevation regions.
- In order to identify the extreme rainfall index three percentiles 98th, 99th and 99.99th of rainfall distribution over the region have been analyzed. It has been shown that the rainevents exceeding the 99.99th percentile of the region's statistical distribution can be defined as the cloudburst events as the frequency of events decreases steadily with the increasing rainfall intensity. Both Kedarnath (June 2013) and Leh (August 2010) events received rainfall >99.99th percentile of the rainfall distribution of the respective regions.
- Further to this, the total mean rainfall intensity has been calculated to develop a fine scale spatial map based on the long term data of principal monsoon season of India over the topographically rich mountainous region. The map reveals a dual band structure of rainfall in Uttarakhand, characterized by two step topography and a single elongated band of high rainfall intensity in Himachal Pradesh characterized by one-step topography.



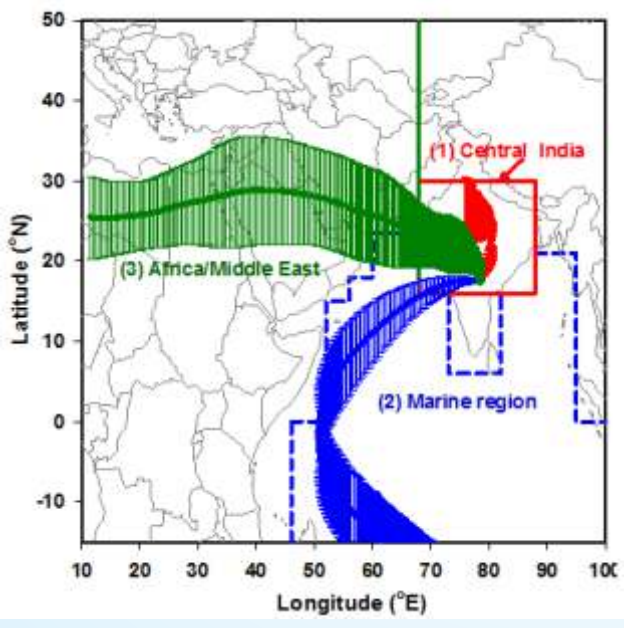
Total mean rainfall intensity map over Jammu and Kashmir, Himachal Pradesh and Uttarakhand during monsoon developed from processed high resolution [5x5 km] TRMM 2B31 data set by averaging from 1998-2013 for monsoon months. There is a dual rainfall band over Uttarakhand and a clustered region of high rainfall in Himachal Pradesh.

Influences of regional pollution and long range transport over Hyderabad using ozone from MOZAIC (In house research study)

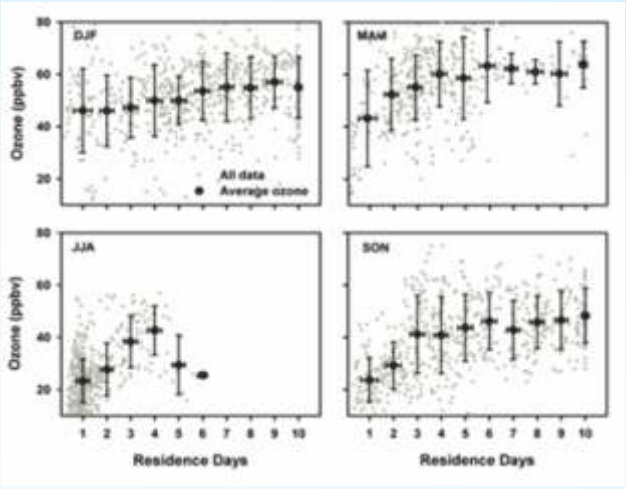
- Long-term (2005-2011) MOZAIC ozone data have been investigated over Hyderabad (17.37° N, 78.47°E, 489 m amsl), India using back-air trajectories and contribution from regional pollution and long-range transport are assessed.
- Ozone data are grouped and analysed according to the air-mass residence time over the central India, marine region and Africa/Middle East regions. Ozone shows a linear dependence on air-mass residence time over the central India region for about

six days. Rate of ozone increase is maximum during summer and minimum during winter.

- The background ozone is estimated by extrapolating the linear regression line to zeroth residence day and is found to be significantly lower during summer/monsoon (~15.8±2.4 ppbv) within the boundary layer due to influence of marine air-mass.
- Seasonal variation of the boundary layer ozone shows a distinct peak during March-April months. The ozone in regionally polluted air masses influenced by the central Indian region is found to be higher than average ozone by 6-15% within the boundary layer and by 5-9% in the lower troposphere during different seasons. The marine air shows a lower ozone levels by 7 to 28 ppbv throughout the year within the boundary layer. Role of long-range transport is found to be significant in the lower troposphere and shows 4.4 ppbv and 9 ppbv higher ozone mixing ratio during summer and autumn, respectively.



The spatial coverage of 10 days back-air trajectories originated from the (1) Central India region,(2) marine region, & (3) Africa / Middle East region and reaching Hyderabad. The vertical bar represent +- 1 sigma

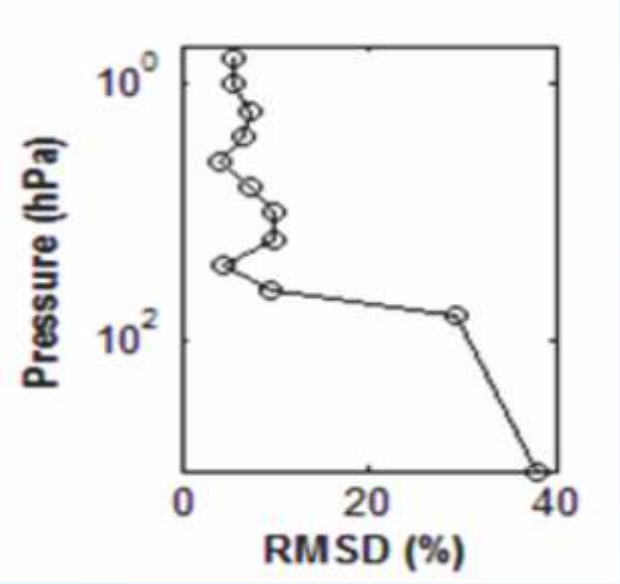


Variation in ozone mixing with residence days in the boundary layer during winter (DIF), spring (MAM), summer / monsoon (JJA) and autum (SON) over regionally polluted sector

Development of retrieval algorithms for ozone profile using geostationary IR sounder observations (INSAT-3D UP)

Objectives

- To develop algorithms for retrieval for total ozone and its profile using various techniques like regression, Principal Component Analysis, and (ii) To validate the retrieved ozone using ground truth.
- Based on Principal Component analysis, a novel methodology for retrieving ozone profiles over the region 45˚S to 45˚N using geostationary IR sounder (e.g. INSAT-3D sounder, GOES sounder) observations has been proposed.
- A comparison of the RMSE of ozone estimate with standard deviation of the data set have shown that the skill of the retrieval algorithm is very good from about 200 hPa to about 5.0 hPa where the RMSE of retrievals is significantly below the natural variance of the ozone.
- The figure shows that the %RMSD between INSAT-3D retrieved and SBUV/2 ozone profiles are within 10% in stratosphere with values as low as about 4% at 4 hPa. However the %RMSD values are higher in troposphere.



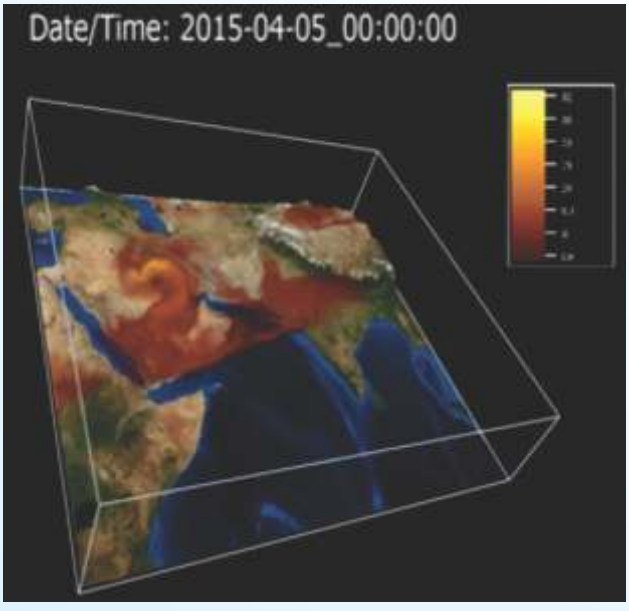
% RMSD between INSAT-3D retrieved ozone profile and SBUV/2 ozone profiles for December 2013.

Analysis and Forecasting of Dust Storm Originated from the Arabian Region

Dust is one of the most important source of the suspended particles in the atmosphere. Of late, attention has been paid to understand the effects of natural aerosols such as dust aerosols on regional and global climate. Impact of dust on global climate may be categorized as direct and indirect effects. The dust directly absorbs and reflects the solar radiation, and therefore modifies the Earth radiation budget whereas, the indirect effect encompasses the changes in cloud properties, droplet size, cloud lifetime, precipitation efficiency and cloud cover attributed to the presence of mineral dust. Recently, a major dust outbreak over the Arabian Peninsula region on April 2, 2015 invited the attention of meteorologists and common man worldwide and grabbed an extensive coverage in both print and digital media. This dust storm was so severe, that it swept the Arabian Sea region and entered into the Indian subcontinent region (specifically, the Mumbai) in a time span of about 4 days.

In this study, an attempt was made to first analyse those meteorological conditions, which pumped the dust particles towards the Indian subcontinent, by means of remotely sensed observations and model simulated datasets. Further to this, we also explored the forecasting skills of the Weather Research and Forecasting (WRF) model coupled with chemistry (WRF-Chem) and GOCART dust scheme to predict the severe dust storm originated from the Arabian Peninsula region. The analysis of dust storm activity has been performed using INSAT-3D visible imagery, newly generated aerosol product (AOD at 550 nm; generated at IIRS by assimilating model, satellite and in-situ observations) and NCEP re-analysis winds, etc. INSAT-3D visible imagery illustrates a well-defined dust patch across the breadth of the Arabian Sea region on April 4 and 5, 2015. Spatial pattern of the newly generated aerosol product indicates substantial aerosol loading over the Arabian Peninsula on April 2, 2015. It is revealed from the analysis that wind changes its direction and strength noticeably over the Arabian Peninsula and the Arabian Sea regions during the course of the dust storm event. It also appears that the significant change in the wind direction over the Arabian Sea region was responsible for pumping the dust particles towards the lower latitudes (e.g. Mumbai) of the Indian subcontinent. Substantial amount of dust loading is witnessed over the West Coast of India. Based on the climatological features and anomalies of the daily winds and total AOD, it is observed that the wind speed was enormously high during the dust storm event of April 2015. The anomalously high wind pattern and substantial aerosol loading in the first week of April, 2015 is distinctly preserved in the daily anomaly plots, suggesting that the dust outbreak over the Arabian Peninsula was one of the never seen before events. For the purpose to analyse the dynamical process of the dust emission and to test the potential of the NWP model, 144 hours forecast from the WRF coupled with chemistry and GOCART dust scheme has been generated from 00 UTC of March 31, 2015. WRF simulations in the present study suggest that the turbulent pattern associated with the enormously high wind speed has triggered the dust outbreak on

April 2, 2015 over the Arabian region which was further transported towards the Indian subcontinent region after sweeping the Arabian Sea region across its breadth. The dust storm initiation process, thus unveiled from the model simulations, is in concurrence with the previous studies. Forecasted wind fields and mixing ratio of dust particles are able to capture the spatial and temporal pattern in close agreement with the NCEP analysis winds and the new aerosol product, respectively. The transitions of the wind direction, speed and dust transportation from Arabian Peninsula to the Indian subcontinent (specifically the West Coast i.e. Mumbai) are remarkably simulated by WRF. Statistical analysis reveals high significant correlation between the forecasted winds and the NCEP analysis winds over the entire study domain. Based on the WRF forecast, low visibility observed over the Mumbai city on April 5 and 6, 2015 may be attributed to the piling up of the dust particles of 0.5 to 4.5 µm effective radii from surface to up to 800-700 hPa levels (approximately 2 to 3 km). Vertical distribution of dust aerosols are also supported by the CALIPSO measurements. It has also been observed that the dust particles corresponding to 1.4 and 2.4 µm effective radii contributed more towards the substantial dust loading over the Mumbai city. As per the NOAA (2002) report, generally the fine dust particles of size less than 50 µm are observed in the dust storms originated in the Arabian region. However, it contains larger particles also but they rarely reach up to a height of 10 to 15 meters. Results obtained from the WRF forecasts also suggest the abundance of the fine dust particles over the Mumbai city. In addition to this, dust health impacts have also been assessed in the present work. A dust storm contribution of about 2 µg/m^3 PM10 leads to 2,058 respiratory mortality and 580 cardiovascular mortality per year.



Dust forecast based on WRF simulations. Spatial pattern of the 120 h forecast of dust mass mixing ratio (integrated for all size ranges) valid for 00 UTC on April 5, 2015. Colour bar indicates dust mass mixing ratio in µg/kg-dry air

Present study reveals that the WRF coupled with chemistry is able to forecast the dust storm and dust transportation from the source region well in advance. Therefore, suitably configured WRF may be utilised in future to generate a short to medium range forecasts of dust storms. Results obtained from the present work are encouraging and suggest that the WRF forecast may be useful to mitigate the impact of dust storms over the affected regions.

Urban and Regional Studies

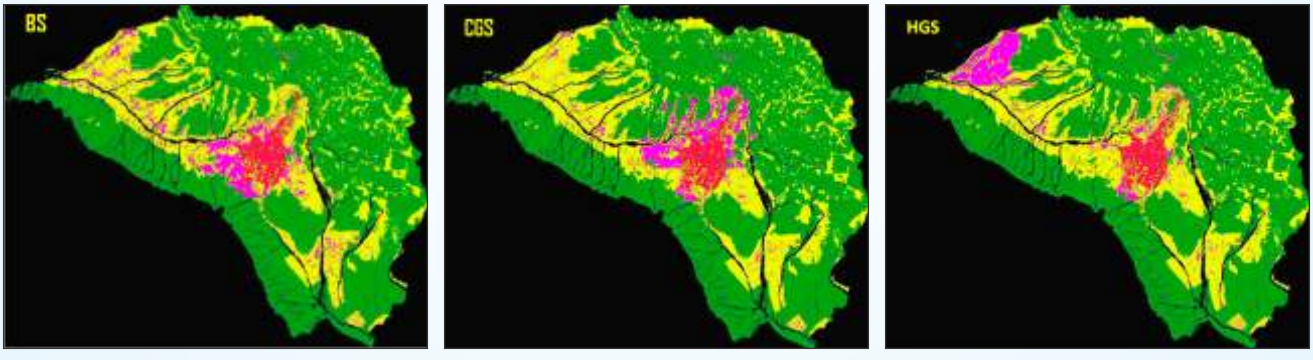
Modeling temporal and spatial growth of NWH cities (Sub-theme - 5: EOAM monitoring and assessment of Mountain ecosystem processes in NWH)

- The North-west Himalaya (NWH) states since their inception have been experiencing a rapid urban growth. However, this urban growth has been concentrated to a few cities only. The reason for this concentrated growth is mainly due to the geographical location and better infrastructural facilities available in these cities. Therefore, these cities are experiencing a rapid unplanned urban growth, which is not only leading to loss of rich contiguous agricultural lands but is also affecting the environment and other ecological systems as land is being converted in an irreversible manner into built-up form.

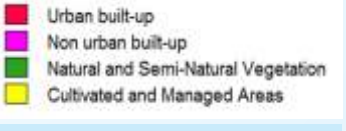
- Thus, in order to scientifically manage the growth of these cities and to ensure a sustainable development, there is a urgent need to develop predictive models of urban growth ("What-If " tools). This will also aid in making the urban growth process inclusive and resilient to disasters.
- The main objective of the present research is to develop a predictive model for urban spatial growth modelling. The research is aimed at demonstration of techniques like Artificial Neural Network (ANN) in modelling complex urban systems and effectiveness of remote sensing and GIS in such studies as spatial data providers and spatial data handlers, respectively.
- The present study is aiming to propose steps for making the NWH cities climate resilient and reducing urban vulnerability to climate induced hazards. The urban growth at the city edges, is the most dynamic zone where the non-urban land is always under foreshadow of being converted to built-up. The uncontrolled and aimless overspill of the city makes it difficult for the city administration to plan in advance and provide basic services to all these areas. The proposed model will help in predicting the trend of urban growth in cities of NWH, thus helping to take stock of the future urban growth and avoid ill effects, if any, through planning measures.

Semi-automatic 3D model extraction of parts of Delhi using high resolution satellite data

- Laser scanning based methods considered most suitable for urban surface modeling. However, in few cases availability of LiDAR with desired density is not feasible and besides, working on LiDAR data requires significant editing and computing power, which makes it more expensive. On the other hand, availability of very high-resolution stereo data opens a field where these data sets can be processed to generate the 3D city models using photogrammetric methods.

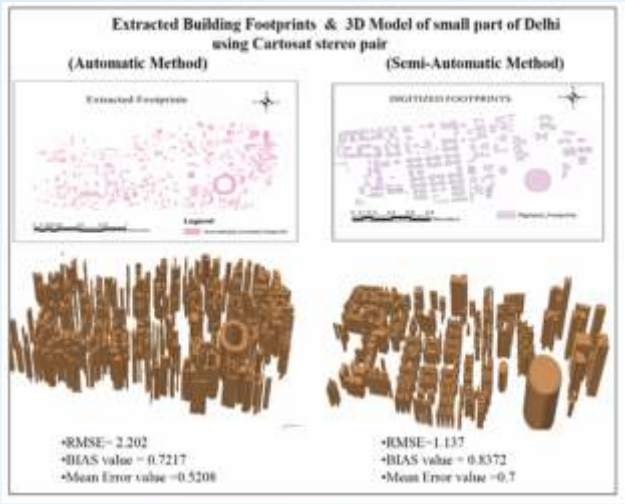


	Cultivated and managed vegetation class PCM	Urban built-up class PCM	Non urban built-up class	Overall PCM
Model calibration for year 2005	98%	95.52%	93.07%	98%
Model validation for year 2009	85.43%	81.3 %	62.85 %	81%



- Base line scenario (BS) predicts urban growth under "business as usual" scenario. No development is allowed within a user defined buffer zone of river channels.
- Compact growth scenario (CGS) simulates urban growth if a policy of high density nucleated growth is pursued. Future development will occur in the west and south direction of existing development.
- Hierarchical growth scenario (HGS) simulates urban growth process if a multi-nucleated growth is promoted, this will result in a hierarchy of urban settlements with the most prominent urban centre coming up in west of the study area.

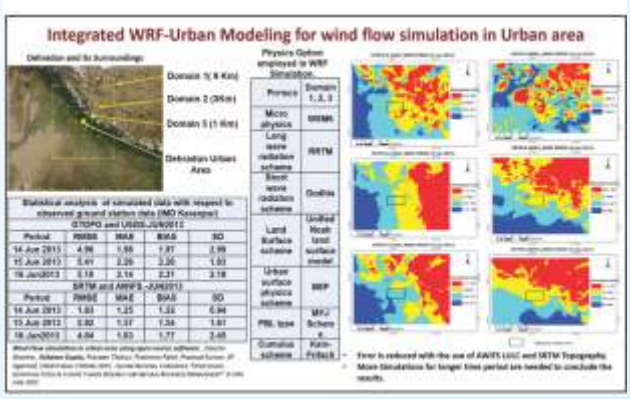
Simulated land cover for 2021 under various scenarios using ANN based predictive model



- 3D models of part of Delhi was generated using automatic and semiautomatic approaches. The Root Mean Square Error (RMSE) of height measurements was computed with respect to ground measurements for both the methods which was found to be 1.14 m for semi-automatic method and 2.20 m with automatic extraction.
- Cartosat -1 data was found to have good potential for semi-automatic extraction of 3D models of urban areas in low to moderately dense urban areas consisting of large to medium size structures. However, the automatic methods yielded less accuracy of building footprint extraction and building height measurements.
- This project was taken up to derive applications of very high resolution satellite data for 3D city modeling. This project can be linked to the ongoing and future air and space based very high resolution/ LiDAR data mission of ISRO or other space agencies.

Wind flow simulation in urban area using WRF-community model (TDP Project)

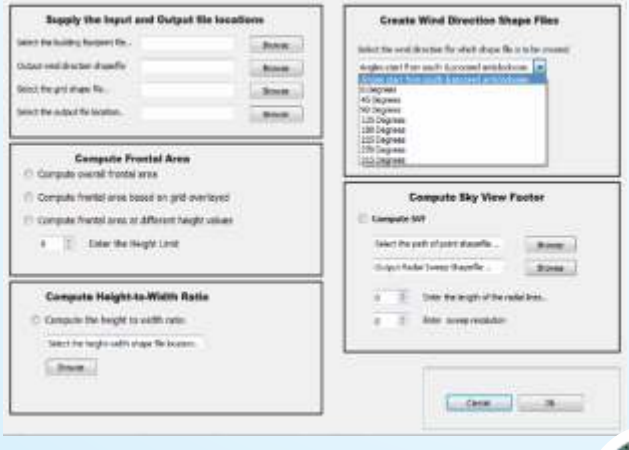
- Research is being carried out for zoning of urban areas based on urban climate characterization. This involves development of methodologies for generation of urban database, urban parameterization in numerical weather models and understanding the urban climate phenomenon. Currently, the emphasis is given to development of urban parameterization and it will be further extended to the simulation of urban growth vis-à-vis urban climate.
- Anthropogenic developments such as construction of buildings, highways, parking lots, driveways and streets are the major cause of population and urbanization. This emergence has led to drastic change in the urban roughness that in turn affects the urban climate and urban wind flow patterns.
- In this study, the open source numerical weather prediction model- WRF (weather research forecasting) integrated with urban physics parameterization has been used for downscaling the National Centre for Environmental Prediction (NCEP) data (1°x1°) to urban scale (~1km) grid. Two sets of simulation were examined for Dehradun & its surrounding using GTOPO (1 km) and USGS (1 km) as first data set and SRTM (90 m) and AWiFS (56 m) as second data set, both of them are open source data sets. The results were analyzed with respect to ground observation (Automatic Weather station ID ISRO989_15F3DD IMD Karanpur, Dehradun) for the period June 14 to June 16, 2013.
- The resultant RMSE values are 4.96, 5.41 and 5.10 using GTOPO and USGS and 1.83, 2.92 and 4.04 using SRTM & AWiFS data sets. It



clearly shows that RMSE values has been reduced with the use of SRTM and AWiFS data sets. Thus, the study concludes that AWiFS & SRTM being a high resolution land use and topography can give better results for climatic parameter.

Automatic estimation of roughness parameters to understand urban wind dynamics

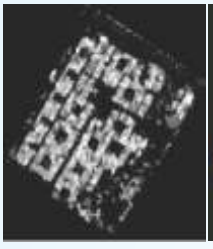
- Urban roughness is of major importance for understanding the wind dynamics and microclimate in an urban area. Morphometric methods are ideally suited for estimation of urban roughness in an urban environment due to increasing availability of 3D urban database, remote sensing and GIS. Frontal area is one of the key morphometric parameter required to compute roughness length (z_0) and zero plane displacement height (z_d). However, the estimation of these morphometric parameters, in a large area is computation intensive and complex. The advent of GIS and open source computer technologies has eased the complexity of computation of these parameters.
- The present study illustrates development of such an open source application, Urban Morphology Extractor (UME) and its deployment on a sample data. UME is a standalone application developed using open source programming language Python and requires open source shapefile (.shp) data format for inputs and outputs. UME is a comprehensive application and is one of its kind, its capabilities include criteria based computation of frontal area, computation of height-to-width ratio and generate shapefiles for eight different wind directions at user specified windline resolution.
- UME was tested over a sample dataset and overall accuracy of 92.5% and 90.3% were estimated when compared with manual computation for two different wind directions.



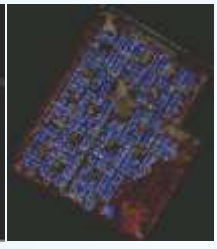
A solar intensive approach for smart city planning

- We are today in a 'new phase' of sustainable planning, with an aim to build smart cities: cities capable of survival, with an ability to perform efficiently. The world's energy problem and the huge scarcity of sources producing energy, drifts our attention towards renewable energy sources. The energy influx from solar radiation is widely regarded as sufficient to meet the present primary energy needs of the world (Brower, 1992). Useable solar influx is limited by diurnal variation, geographic variation and weather conditions (Rogner, 2000). Solar urban Planning at city level is capable of addressing this issue to a large extent. Geospatial technologies have wide applications in identifying suitable locations for placing the solar panel and harness maximum radiation to produce maximum energy.
- Two major inputs required in this context are: High resolution Digital Surface Model (DSM) and Building Footprints. DSM was generated using high resolution Worldview-2 data for the study area Gandhinagar using LPS extension of ERDAS Imagine. DSM quality is affected by the two parameters, the quality of the stereo image orientation and the matching strategy. The assessed accuracy gave a mean error of 0.42 m and 0.35 m in urban areas and open areas, respectively.

- Building footprints were extracted from the fused (PAN+MSS) image using Object Based Image Analysis (OBIA) technique of image segmentation and image classification giving 92% accuracy. Total, Direct and Diffused Insolation were computed on the built-up areas based on method from hemispherical view shed algorithm (Rich 1990, Rich et al., 1994) and further developed by Fu and Rich (2000, 2002). The results showed abundant insolation over built up areas during months ranging from April to October.



DSM (2.5x2.5) of study area



Extracted Building Footprint

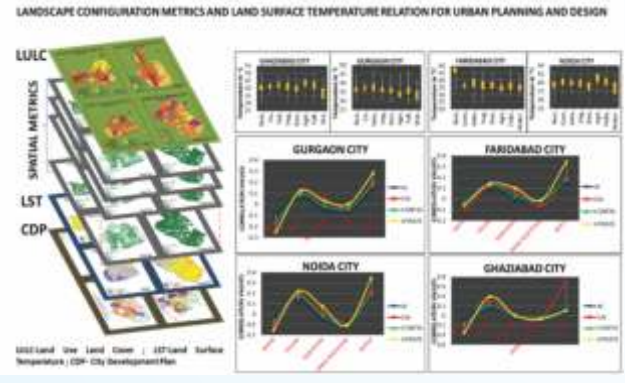
Global Radiation in WH/m2

Landscape configuration and thermal environment study for urban planning

- Cities are like complex adaptive systems maintained by the most intense form of human-nature interaction and modifying the environmental setup. Understanding the effects of changing landscape pattern and ecology with spurious anthropogenic growth gives a reasonable perspective for environmental issues like urban heat island. Urban conurbations has resulted in receding green buffer zone area around nodal centre and the ring towns tend to face a greater risk of intense heat problems.
- This research work is an attempt at quantifying the urban landscape spatial configuration by using spatial metrics and its collation with the thermal conditions of the selected towns in Central National Capital Region (CNCR) region. The study area comprises of Ghaziabad, Noida, Faridabad and Gurgaon, which are the major satellite towns lying in the CNCR (Central National Capital Region) belt around NCT-Delhi. Due to the fast rate of urbanisation and receding green buffer, this region has been consistently reported for rising summer temperatures and discomfort of the urban residents.
- Data used for the research was derive from satellite images of RESOURCESAT-2 LISS-IV and Landsat-8 data of May 2013 along-with City Development Plans. The quantification of urban form was based on four aspects: Area and Edge, Shape, Core Area, and Aggregation. Indices for each aspect measurement were Area Weighted Radius of Gyration, Mean Contiguity, Mean Core Area Index and Aggregation Index, respectively. Metric computation was done by moving window analysis on the land cover image that gives an output as a new grid for each specified index. LST data were retrieved from two thermal bands of TIRS with the application of split window algorithm model. Pixel based correlation was employed to investigate the relationship between LST and the spatial pattern of land cover configuration represented via metrics.
- The correlation found in the region was gentle ranging from -0.3 for water bodies and 0.4 for built up land cover as built-up contributes towards the propagation of surface temperature. Among the four indices, Area Weighted Radius of Gyration exhibited highest correlation with the thermal conditions followed by Mean Core Area Index, Mean Contiguity and Aggregation Index. Patch size has a greater influence on the variation in correlation values, for example, with increasing patch size of built up, the correlation values will be highly positive and reverse scenario for natural land covers. Thus, vegetation does not show significant negative correlation as its mean patch area is 5-8 times smaller than built-up

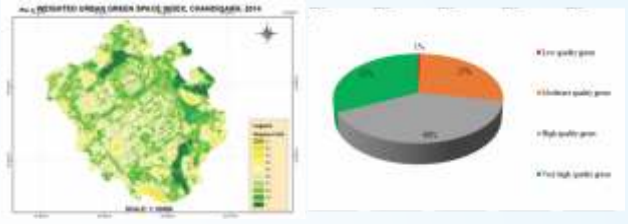
class wherein the average patch size values for vegetation are ranging from 0.10 to 0.14 and for built-up 1.31 to 3.99. Thus, small patch of dense vegetation cover shows meagre contribution in mitigating the LST.

- Among the cities, Gurgaon depicts highest fragmentation and heterogeneity in configuration of patches and thus least maximum temperature. The trend of heterogeneity decreases from Gurgaon to Faridabad, Noida and Ghaziabad and the temperature ranges are seen to be higher. This interlinking of urban climate and urban setting are found to be having applicability in urban ecological planning and design. Future policy efforts may focus on encouraging strategies to introduce higher heterogeneity in geometry of urban landscapes to reduce urban heat island.



Development of an index for assessment of urban green space

- Urban green spaces (UGS) are one of the indispensable elements for design and development of cities. UGS are considered as "lung" of cities as well as are one of the elements reflecting the quality of life.
- The aim of this research is to develop an index for assessment of city wide UGS based on multi-criteria analysis of Chandigarh city. The percentage of green, type of green and proximity to green are selected as parameters to study weighted urban green space index. All these parameters were derived using IRS-P6 LISS-IV data and IRS-P6 LISS-4 + Cartosat-1 fused product. NDVI and Object based classification method was used to derive different layers and then analyzed using multi-criteria analysis to derive the modified green index.
- The final result showed the distribution of green space in study area consisted of very high quality green, high quality green, moderate quality green and low quality green. The assessment of UGS was carried out sector wise which is useful for planning considerations.



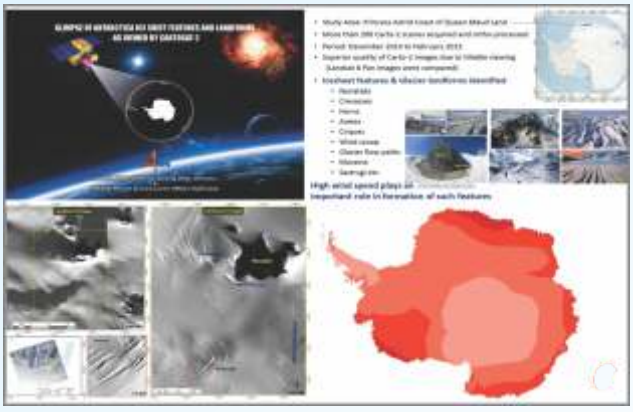
Percentage of quality green in Chandigarh, 2014

Water Resources Applications

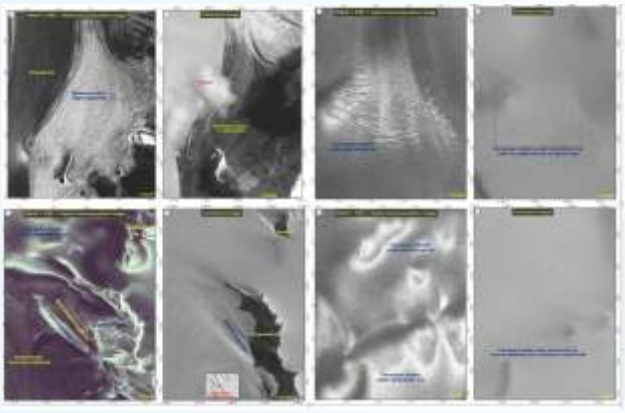
Identification and mapping of ice sheet features and glacial landform in Antarctic

- The current study has been done to identify and map the various ice sheet features and glacier landform in parts of Antarctica using high resolution optical cartosat-2 and RISAT-1 FRS-1 datasets. In first part of this work, an image album has been made highlighting, some of the major ice sheet features and glacier landforms present at Antarctica using ISRO's high resolution satellite Cartosat-2. In second part, RISAT-1 FRS-1 and some MRS-data has been used to identify additional ice sheet and glacier features which were not detected by optical data.
- The main identified features are the Aretes, Cirques, Nunataks, Wind scoop, Glacier flow paths, Moraine, Horn, Sastrugi, outcrop, Crevasses etc. These features are formed due

to geological and also due to the meteorological processes such as movement of ice sheets, glaciers and high wind speed found in this part of Antarctic.



Antarctic ice sheet features and glacier landforms as viewed by Cartosat-2

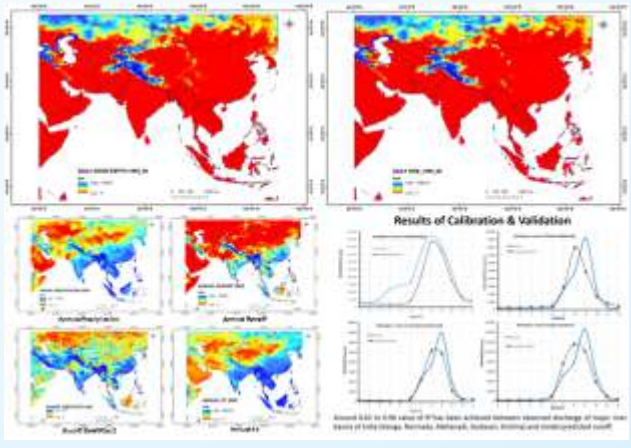


RISAT-1 FRS-1 and Cartosat-2 based ice sheet and glacier features

Land surface modeling and parameters estimation for Indian monsoon region

Objectives

- To generate high resolution land surface parameter dataset for the Indian Monsoon region using energy balance based land and surface model and hydrological modelling over Indian Monsoon Region using Variable Infiltration Capacity Model and high resolution land surface parameters. The main objective of this work was to generate high resolution land surface parameters using VIC model.
- This study has been done using Meteorological Forcing from NCEP for Daily Rainfall, Daily Temp (Max, Min), Daily Wind Speed, Vegetation Parameters from Land Use Land Cover Map (GLCF, 2000) and Vegetation Parameters (GLDAS), Soil Parameters from Soil Texture (FAO) and Topographical Parameters from GTOPO (30 arc sec/Hydro 1k). These were used in VIC land surface model to generate various land surface parameters.
- Land Surface Parameters Outputs: Runoff, Evapotranspiration, Bare Soil Evaporation, Transpiration from Vegetative surface , Soil Moisture of top soil layer (0-30 cm), Soil Moisture of middle soil layer (30 ~ 100 cm), Soil Moisture of bottom soil layer, Fractional area of Snow Cover, Snow depth (mm), Snow Water Equivalent (SWE), Change in SWE, Bare Soil Temperature, Average radiative surface temperature, Emitted long wave radiation from earth surface, Rainfall- Snowfall amounts, Canopy Interception Storage, Average surface albedo, Snow pack albedo, Net heat flux into ground, Net upward latent heat flux, Incoming longwave at ground surface (under veg), Energy of fusion, melting) in snowpack, Net downward longwave flux, Net downward shortwave flux, Net downward radiation flux, Net upward sensible heat flux, Energy budget error, Water budget error.



- Various land surafce parameters such as Runoff, Evapotranspiration, Soil Moisture of top soil layer (0-30 cm), middle soil layer (30 ~ 100 cm) and bottom soil layer, Fractional area of Snow Cover, Snow depth (mm), Snow Water Equivalent (SWE), Change in SWE, Net downward longwave flux, shortwave flux, radiation flux and Net upward sensible heat flux has been generated at 0.25 deg from 1977-2006.

ISRO-GBP: Land-use and land-cover dynamics and impact of human dimensions in Indian river basins: Hydrological modeling

Objectives

- To study the impact of human dimensions on LULC dynamics.
- To project the future LULC scenario using appropriate model(s).
- To analyze and project the impact of LULC on hydrological cycle.
- Around 0.62 to 0.96 value of R^2 has been achieved between observed discharge of major river basins of India (Ganges, Narmada, Godavari and Krishna) and hydrological model predicted runoff

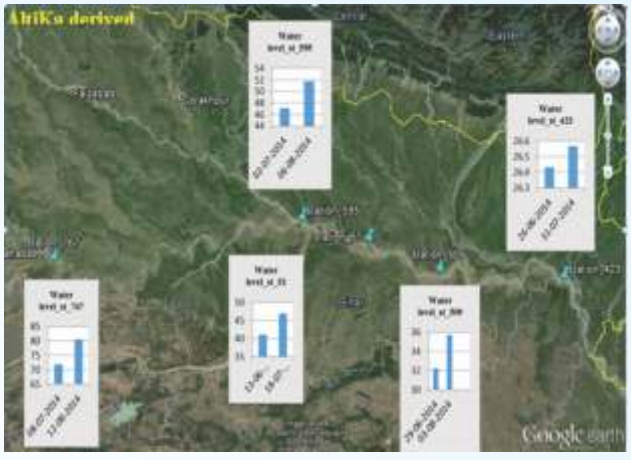
Project on SARAL ALTIKA applications for Inland Waters, Glaciers and Sunderban Deltas

Objectives

- Inland Water Level, Discharge using ALTIKA based radar altimeter.

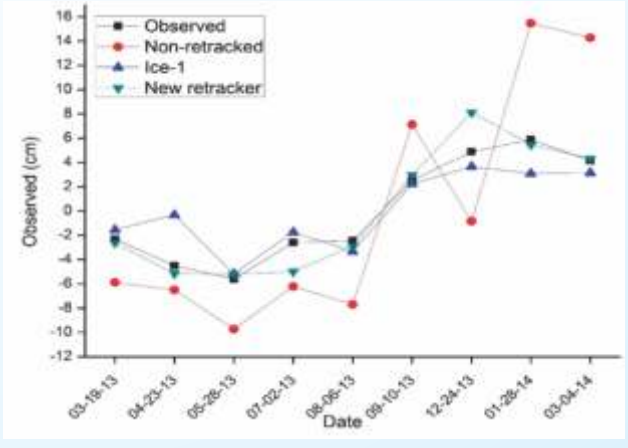
Progress and Achievements

- AltiKa payload includes a highly innovative Ka-band altimeter (35.5-36 GHz) and a dual-frequency radiometer (23.8/36.8 GHz) having better horizontal and vertical resolutions. The method for dry and wet troposphere corrections is being used for inland areas of rivers, reservoirs and lakes.



Ganga River water level during Monsoon, 2014

- In-situ observations of River Discharge and river/lake water level of major river gauging sites of Ganga and Mahanadi river basin. The Long-term tide gauge data of Sunderban delta, Vs Altika GDRs for assessment of the SARAL-AltiKa data along with the other altimetric data of ENVISAT-RA2, ERS altimeter and TOPEX.



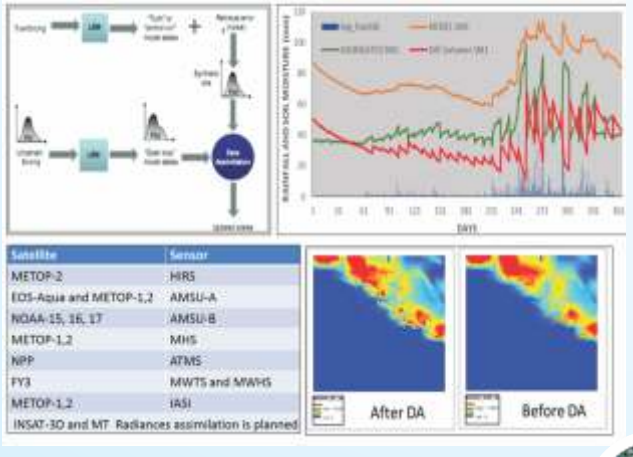
Comparison between direct estimation of water level from altimetry and using retracked waveform data.

Remote Sensing based Hydro-Meteorological Data Assimilation in the Hydrological and Weather Forecasting Models (EOAM Project)

Objectives

The main research objective of this project is to incorporate remote sensing based hydro-meteorological data using appropriate data assimilation techniques to improve the simulation accuracy of hydrological and weather research forecasting models.

- Variable Infiltration Model (VIC) with model state mode and DA module is being used for hydrological data assimilation. Weather Research and Forecasting (WRF) model with DA module is used for meteorological and land surface data assimilation using 3Dvar and 4Dvar methods. Mike 11 data assimilation with ensemble Kalman method is being used for water level data assimilation in 1-D hydrodynamic model. Both the model will use approach shown in figure below for testing DA runs.
- Satellite radiance data assimilated in WRF model using Hybrid DA scheme, which uses a combination of 3D-Var static error covariance and ensemble estimated error covariance to incorporate a flow-dependent estimate of the background error statistics is adopted.
- Soil Moisture products of AMSR-E has been assimilated in top soil layer of LSM (VIC) using Ensemble Kalman Filter (EnKF) on ten daily basis for entire Ganga Basin.

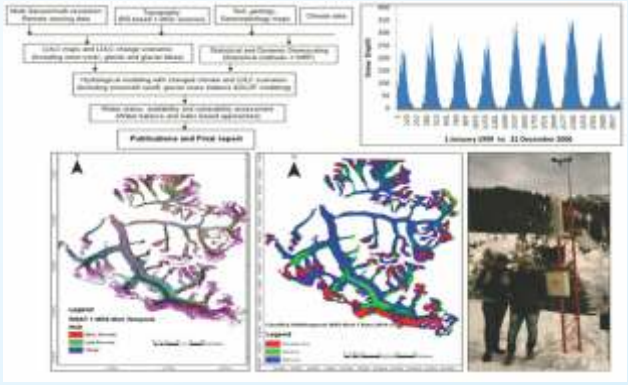


Satellite	Sensor
METOP-2	HIRS
EOS-Aqua and METOP-1,2	AMSU-A
NOAA-15, 16, 17	AMSU-B
METOP-1,2	MHS
NPP	ATMS
FY3	MWTS and MWHS
METOP-1,2	IASI
INSAT-3D and MT Radiances assimilation is planned	

Water resources status and availability EOA Project (Sub theme – 4: Monitoring and Assessment of Ecosystem Processes & Services in North-Western Himalaya)

Objectives

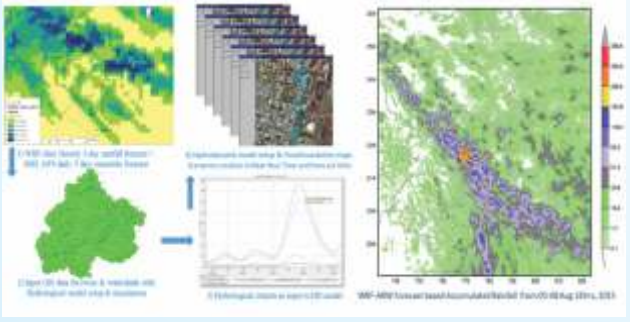
- i) To improve assessment of surface water, snow cover area and snow parameters, debris covered glacier ice and crevasses in NWH glaciers using RS-GIS under normal and changed climate and LULC scenarios, ii) Climate and Land Use Land Cover (LULC) change scenario modeling and hydrological modeling to quantify its effect on water availability.
- Estimated glacier ice depth and zones for Gangotri and Satopanth glacier. Estimated snowmelt runoff for Beas and Ganga basin using energy balance models. IIRS has already procured 26 numbers of AWS, which are planned to be installed in Himachal Pradesh (HP) and Uttarakhand (UK) in already identified and selected sites.
- AWS data being received at every 5mins from field stations, will be very critical for flood forecasting and early warning simulations. The AWS in snow bound areas are being upgraded with snow depth gauge, SWE gauge and one full snow pack analyzer at Manali.



Remote Sensing, Ground Observations and Integrated Modeling based Early Warning System for Climatic Extremes of North West Himalayan region (DMSP Project)

Objectives

- Use of hydrological and weather parameters derived from remote sensing and ground data in early warning modelling systems.
- Early warning system modelling (basin to watershed scale, with coupling of weather forecasting and hydrological models) at various test basins and watersheds of North west Himalayas.
- Calibration and validation of early warning results with ground data.
- High resolution pre and post floods Cartosat-1 and LISS-IV FMX data for base line database preparation. In house high resolution WRF-ARW 3 day rainfall forecast along with IMD forecast. DEM for hydrological and river HD parameters extraction.
- Setup and weather forecasting, hydrological and hydrodynamic (HD) models for upper Ganga basin upto Haridwar. Full Near Real Time (NRT) and Short term simulations for 30 events in 2015, 6 events in 2014, and 6 simulations were done in (June, 2013 to August, 2012) time to capture the Kedarnath and Uttarkashi floods. SCS and kinematic wave based rainfall-runoff models are used to estimate surface runoff and temperature index based method in HEC-HMS model were used for snowmelt runoff estimation. Validation of WRF results with IMD, TRMM data. Uncoupled hydrological and HD modelling of 2014 (few events) and 2015 monsoon (every 3 days). Validation with INSAT-3D rainfall and ensemble of hydro-models and calibration/validation CWC based river discharge.



Geophysical Parameter Retrieval using Hyper Spectral Remote Sensing Data

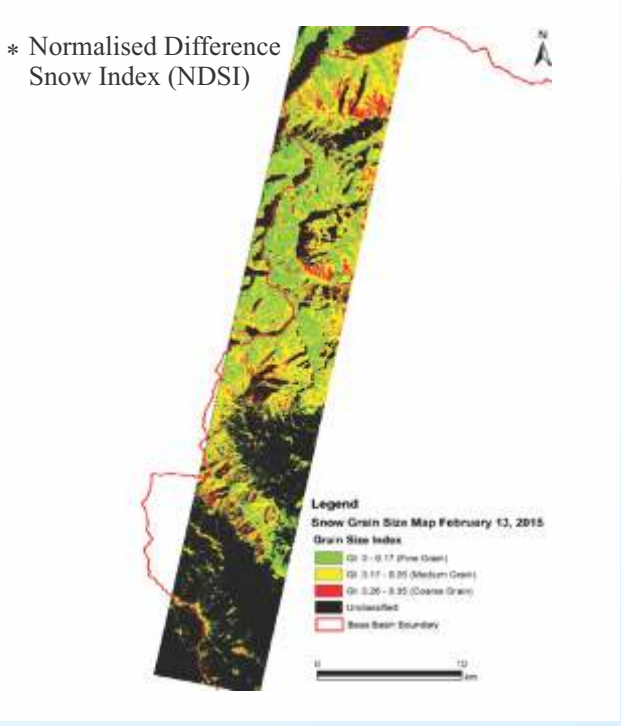
Objectives

- Retrieval of water quality parameters (mainly water supply lakes) and Mapping of different snow types and snow grain size
- Snow Cover Area (SCA) is estimated using Normalised Difference Snow Index (NDSI)-

$$NDSI = \frac{\text{Reflectance (Green)} - \text{Reflectance (SWIR)}}{\text{Reflectance (Green)} + \text{Reflectance (SWIR)}}$$

- Grain Size Index (GI): The snow grain size map was generated using the GI method proposed by Negi et al. (2010) based on the field collected hyperspectral reflectance data.

$$GI = \frac{\text{Reflectance (590nm)} - \text{Reflectance (1050nm)}}{\text{Reflectance (590nm)} + \text{Reflectance (1050)}}$$

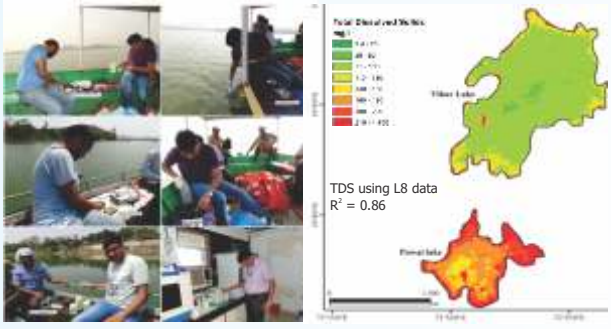


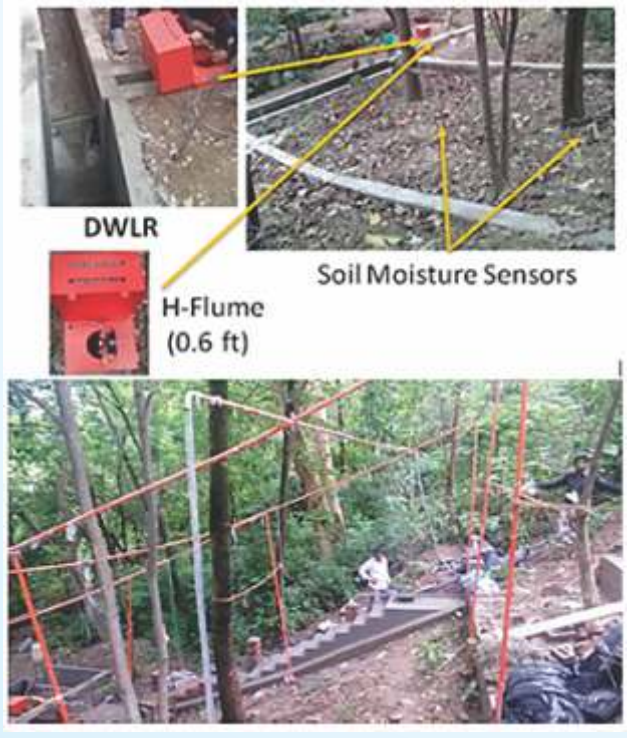
Snow Grain Size Mapping in Part of H.P. using GI

Hillslope hydrologic response studies in Northwest Himalayan Ecosystem

Objectives

- To study the runoff generation over different hillslopes (experimental plots) by variable intensity rainfall generation.
- To derive the relationship between rainfall intensity, its duration, rainfall amount and runoff response at hill slopes.
- Development and establishment of Hillslope Hydrologic Model.
- RS data assimilation and calibration and validation of developed model at the watershed/catchment/basin scale.



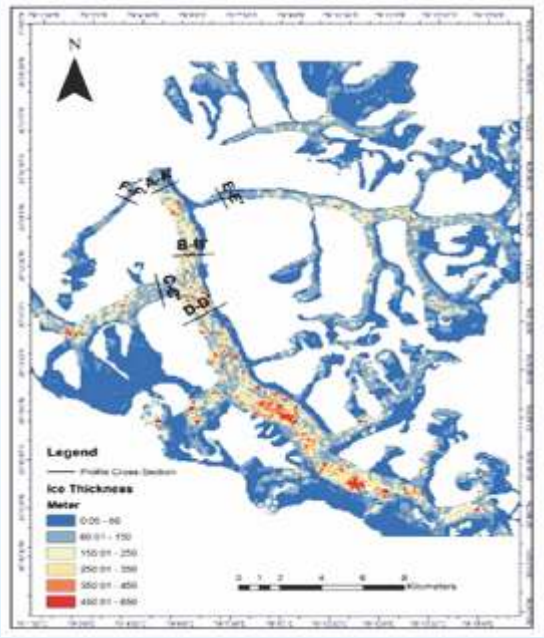


Rainfall Simulator and soil moisture sensors installed

Study of Gangotri Glacier Dynamics using Remote Sensing and Geospatial Tools

Objectives

- i) To estimate the glacier movement using Optical feature-tracking method; ii)To estimate subsurface depth and basal movement using modelling techniques; iii) To estimate glacier classes for the observed period using optical methods.
- The average velocity of Gangotri glacier for the period of observation from 9 September 1998 to 21 September 2014 was calculated to be 0.02 m $day^{-1}$for whole glacier. This observation when limited to upper areas of the observation yielded an average movement of 0.041 m day^{-1}.
- The major conclusion of the ice depth profile analysis have shown that the variation in Laminar flow model is very huge with variations from 20m to 400m. Also the depth at snout was found to be ~60 m and the maximum depth was found at accumulation zone at ~650 m. Uncertainty in the volume estimation of the Gangotri Glacier which is reported to be 11.4% for the current study. Ice thickness was validated by TLS measurement at snout for 9 Points at snout of Galcier with accuracy of 80%.

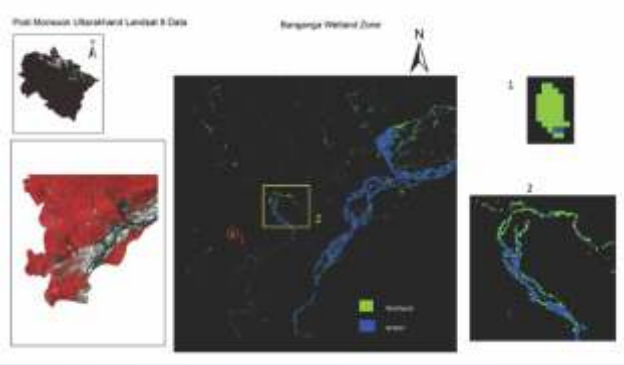


Digital Photogrammetry and Satellite Image Analysis

Synergistic utilization of earth observation data for Automatic Retrieval system and monitoring of water, vegetation and built up area at variable scales (EOAM Project)

Objectives

- Development of Automatic retrieval system for water, vegetation and built up area using multi-sensor data at global, regional and scene specific scales. Multi scale feature extraction based on low-level image processing followed by hierarchical learning. Analysis of water regions, vegetation cover and built up limits through a multi-scale approach to study and monitor dynamic changes. To build a fundamental framework for unsupervised/supervised learning, focusing on feature of interest.
- The water and non water areas were delineated using optimization of spectral indices. An overall classification accuracy of more than 85% was achieved for all water classes. The accuracy of extraction was estimated and was found to be 89%.
- Land surface temperature and night time light data was used to differentiate urban and rural patches. An effect of seasonal variability was tested on medium resolution RS data for water feature extraction. The data for February, May, September and November months were processed for water body extraction. It was found that though the ground extent of water is changing in different seasons, however the accuracy of classification is not effected.
- Automatic extraction of drainage network was also attempted for a sample area. The edges pertaining to feature of interest were extracted and the noise was filtered out. The edge linking and feature refinement was carried out, to generate the drainage network. The accuracy analysis indicated that the methodology can be extended to regional level on medium resolution data (completeness-79.2%, correctness-74.7%, quality-76.1%).



Differentiated water and non water features

Precise Terrain Parameter Estimation from Low Altitude Platforms (EOAM Project)

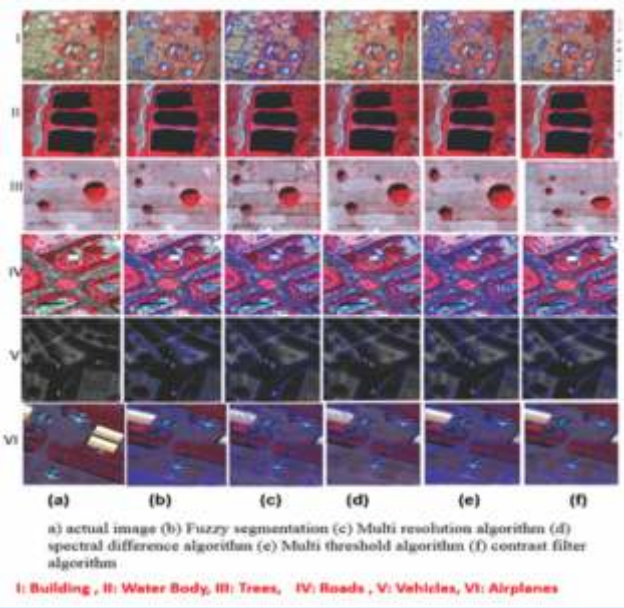
Objectives

- Extraction of geo-referenced terrain parameters using GNSS, IMU and establishing facility for capacity building in this domain.
- Exploration of available software packages for processing UAV data and identifying the possible improvements/loop-holes and action has been initiated to address these gap areas for developing necessary packages/tools.
- UAV photogrammetric data processing framework is developed to integrate the overlapping photographs, IMU, GPS data. Sample datasets available in various formats for terrain with varying features and different categories of UAV (fixed wing, Quadcopter etc.) were processed using the available software and generated DEM/dense points/mosaics. The accuracy of 0.12m, 0.013m, and 0.33m is obtained in DEM in Northing, Easting and Elevation, respectively.
- Organized a special course on UAV remote sensing to create an awareness about the potential application for natural resource management.

Developing a Fuzzy Similarity System based on Image Transforms and Textures for feature Identification

Objectives

- The project aims at evaluating colour space transformations, indices and textural features for segmenting high resolution images and to develop a fuzzy based similarity system for image segmentation.
- Image transforms and GLCM texture parameters used for segmentation and its performance was evaluated. It was observed that GLCM textures, when used in conjunction with high resolution image improves the segmentation accuracy for urban features.
- Performance analysis indicates that inclusion of fuzzy membership in the segmentation process improves the results. Improvement is more significant for natural features. Performance analysis of segmentation algorithms carried out over urban scenario.



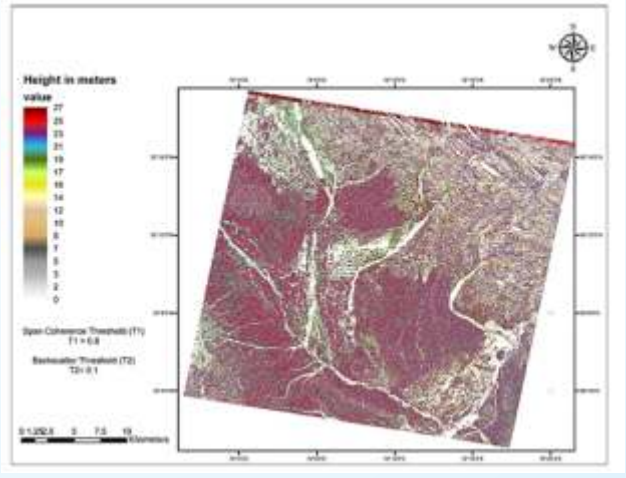
a) actual image (b) Fuzzy segmentation (c) Multi resolution algorithm (d) spectral difference algorithm (e) Multi threshold algorithm (f) contrast filter algorithm

I: Building , II: Water Body, III: Trees, IV: Roads , V: Vehicles, VI: Airplanes

Multi-baseline PolInSAR Tomography for Forest Vegetation and Urban Structures (TDP project)

Objectives

- Prime focus of the study is three-dimensional imaging and scattering mechanism estimation over urban scenes and forest structures using multi-baseline PolInSAR tomography technique.
- Three-stage inversion process is applied to the PolInSAR data using the derived coherences in various polarization basis. The height of the forest stand is estimated and the height map is shown below. This technique utilizes the complex coherences computed for different polarization basis. The complex coherences are plotted on complex plane and using the technique described in the forest stand height is estimated for each resolution cell. The estimated tree height ranges from 0 – 27m. The different colors in figure denote the height range.



Forest Stand Height estimated using Improved Three-stage inversion process

Aerosol Optical Depth Estimation Studies Over Land from Indian Satellite Datasets (TDP project)

Objective

- Estimation of AOD from satellite data using radiative transfer modeling approach.
- Implementation of a physically based approximate model SMART (Simple Model for Atmospheric Radiative Transfer) in Multiple scattering approximation
- Sensitivity w.r.t. land surface albedo, asymmetry parameter and single scattering albedo
- Algorithm development for image based AOD retrieval

TRIVIM: An open source freeware application for 3D Model Generation

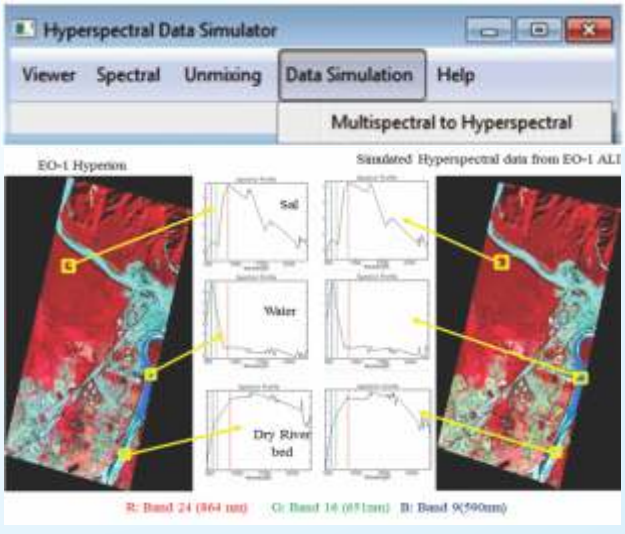
Objectives

- Development of an open source, low cost solution for generating geo-referenced textured 3D models by integrating navigational position data and overlapping photographs.
- An open source freeware application, made available to public through IIRS website. Enables utilization of any camera type, including smart phones as a measurement device even by non- experts in geospatial technology. Capable of onsite direct camera calibration, Georeferenced point cloud generation, Creation of user defined database, Sub meter level accurate 3D Model Database query,3D Visualization.
- ***End Use:*** 3D database creation and query system, Emergency Management, Disaster loss estimation, Property Management, Potential tax estimation for an urban area, Urban governance, Augmented reality, Spatial data infrastructure.

Simulation of Hyperspectral Data from Multispectral Data Using Spectral Reconstruction Approach

Objectives

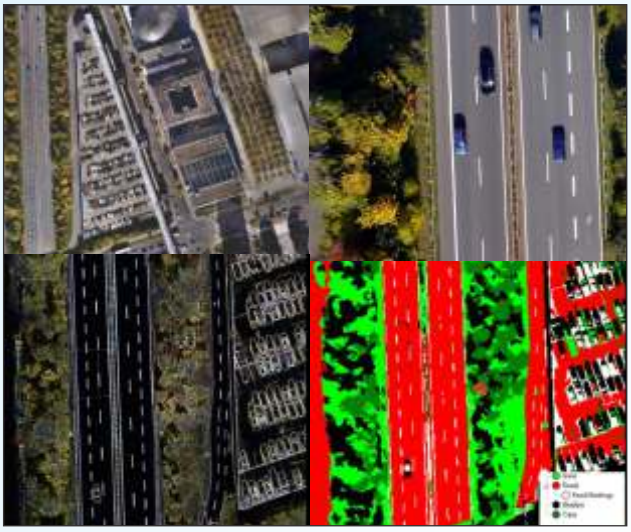
- i) It simulate hyperspectral data from multispectral data using Spectral Reconstruction Approach; ii) In Development of open source tool for the simulation of HRS data from MRS data.
- Hyperspectral bands are simulated from EO-1 ALI multispectral data using spectral reconstruction approach which is a sensor independent technique and the simulated hyperspectral bands have shown very high correlation with the EO-1 Hyperion bands.
- An open source tool for Hyperspectral Data Simulation (HyDAS) is developed to simulate hyperspectral data from multispectral data.



Ultra High Resolution Image Processing and Classification

Objective

- Feature Extraction from ultra-high resolution UAV Images



Feature Extraction through Integrated Textures and Object based Analysis

Vehicle Crush Measurement using Terrestrial Photogrammetry (In house research study)

Objectives

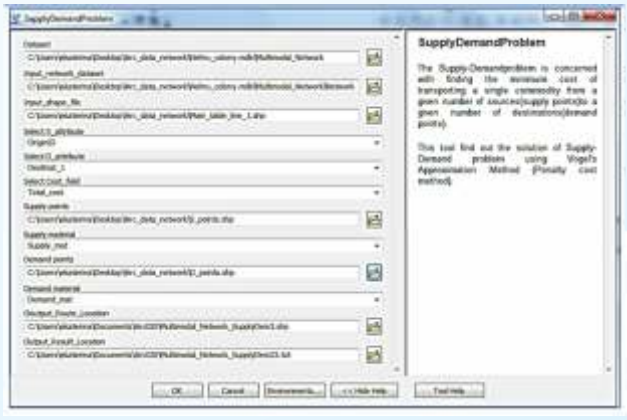
- Assessing the capability of digital close range photogrammetry for damage assessment due to road accidents.
- Results indicate that the technology can be utilized for damage assessment due to road accidents.
- Various camera types – calibrated DSLR, point and shoot cameras and camera sensors on mobile phones can be used as data capture devices.

Increasing level of detail with greater complexities

GIS Technology and Applications

Development of GIS Tool for the Solution of Supply-Demand Problem using Vogel's Approximation Method

- The population in cities is increasing very rapidly and hence demand of utility commodities is also increasing day by day. There is need to deliver goods / material from supply points to demand points. Supply-Demand Problem is a network optimization problem to minimize the total transportation cost (distances or time) in the delivery of goods / material from a set of supply points to a set of demand points. GIS tool development plays a crucial role in solving the road transportation network related problems and has a wide range of potential.
- In this study, a new customized GIS tool in python scripting was developed for the solution of Supply-Demand problem using Vogel's Approximation Method. A digital database of a part of Dehradun city was created in GIS environment along with all necessary attribute information required for the solution of supply-demand problem, and this GIS tool was linked with the digital database and used for performing network analysis of the said problem.
- The results obtained by developed GIS tool are very much satisfactory and minimizes the total transportation cost for the delivery of products available at main supply locations.



GIS Tool for S-D Problem

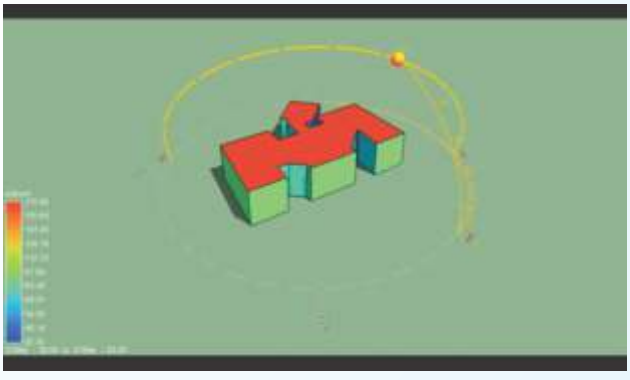
The performance assessment of GIS tool was done based on theoretical and results obtained by the tools on the same network.

- The performance of developed tool is assessed practically and theoretically by means of a live example of distribution of Pepsi product. The main advantage of the developed tool is, it requires minimum number of input information like total good/material available at supply locations and total required good/material at different demand locations.

Result of S-D Problem

3D City Modeling for harnessing Solar Energy

- The exponential growth of cities in India due to urbanization resulted in increased use of non-renewable energy resources to meet the essential power requirements of urban built environment. It is essential for urban planners to provide innovative solutions in context of urban energy simulation based on virtual 3D city models. The recent 3D geoinformation science studies are insufficient in providing optimal solutions because of lack of emerging concepts and integrated software. Presently, 3D GIS data can be generated into various LODs (Levels of Detail) depending upon the application requirement and input data used.
- There are various 3D GIS software like Google SketchUp, ESRI CityEngine etc., which are being used mostly for data creation especially for boundary representation for geometry abstraction without semantic information. The 3D GIS data conversion from native format into City Geography Markup Language (CityGML) enhances it by providing information both at geometric and at semantic level in interoperable format.
- A building information model of Geoinformatics department building in IIRS campus is created using Google SketchUp and exported to energy modelling program in gbXML schema. The present investigation explores the semantic characteristics of developed CityGML model for solar thermal and photovoltaic energy production potential assessment based on building semantic components. The amount of solar irradiation incident on bounding features and also illumination obtained through openings of building is quantized using SunCast and RadianceIES application of IESVE Software, respectively. The simulated energy data are integrated with building semantic features and stored in open source PostGIS RDBMS to address basic semantic queries.



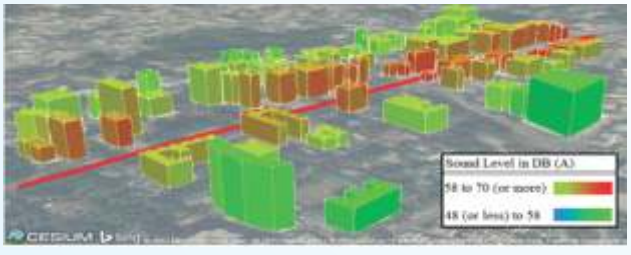
Solar Mapping on LoD2 model

Traffic Noise Modeling

- 3D GIS technologies have been adapted in various disciplines of engineering such as urban energy demand, facility management and city planning for decision making. Indian population is growing very fast and traffic noise is one of the environmental risk raised with increase in Indian population. The traffic noise is the primitive contributor to the overall noise pollution in urban environment.
- An attempt has been made to develop a web enabled application for spatio-temporal

semantic analysis of traffic noise of one of the urban road segment in India. Initially, a traffic noise modeling was proposed for the study area based on the Calixto model. It was identified that, the traffic noise issue can be addressed very efficiently with a realistic simulation of its effects in a virtual 3D environment.

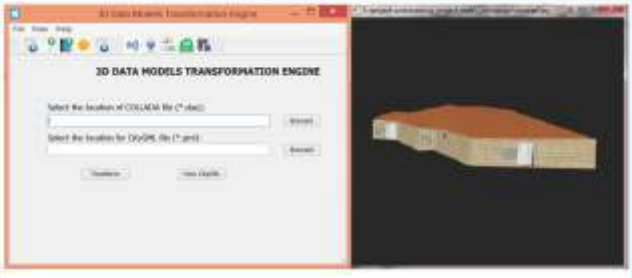
- A City Geographic Markup Language (CityGML) which is OGC encoding standard for 3D data representation, fits all these requirement and was utilized for this purpose. The developed CityGML data model was initially loaded into PostGIS database. A web GIS framework was implemented for analysis of traffic noise pollution and simulation of noise level mapped on building walls using the data from PostGIS.
- Finally spatio-temporal semantic analysis to quantify the effects in terms of threshold noise level, number of walls and roofs affected from start to the end of the day, was performed. The presented research work is an open source initiative for analysis of 3D City Models and it can be utilized by urban planners for making effective decisions before implementing the plan.



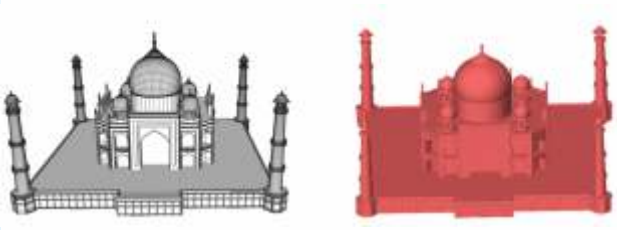
Traffic Noise Map generated using the LoD2 CityGML Semantic Model

CityGML based Interoperability for the transformation of 3D Data Models (In house research study)

- A large number of 3D data models have been developed for the visualization, storage and exchange of 3D data; all differing with respect to geometry, semantics, levels of detail, schema etc., making Interoperability a crucial issue in 3D geodata integration.
- The research work presents the study for the development of Interoperability model for 3D data models with CityGML 2.0.0, addressing the issues of data heterogeneity in conceptual modelling at three levels: syntactic, semantic and schematic. The focus is on the transformation of 3D information from Visualization models (COLLADA) to 3D GIS domain (CityGML). Since COLLADA and CityGML differ widely, it is necessary to identify the classes modelling buildings in both the models.
- The matching of schema is helpful in enlisting the analogous entities an attributes. The applications of CityGML have opened gateways for better exchange and use of geodata but its visualization over web can be time-consuming because of complex structures and large size of CityGML files.
- Subsequently, several 3D standards including VRML, X3D, and KML/COLLADA have been developed. For visualization, the CityGML model is converted to X3D for rendering over browser using X3DOM and also to KML 2.2 and viewed over Google Earth with COLLADA integration with CityGML attributes included as extended data in the KML.



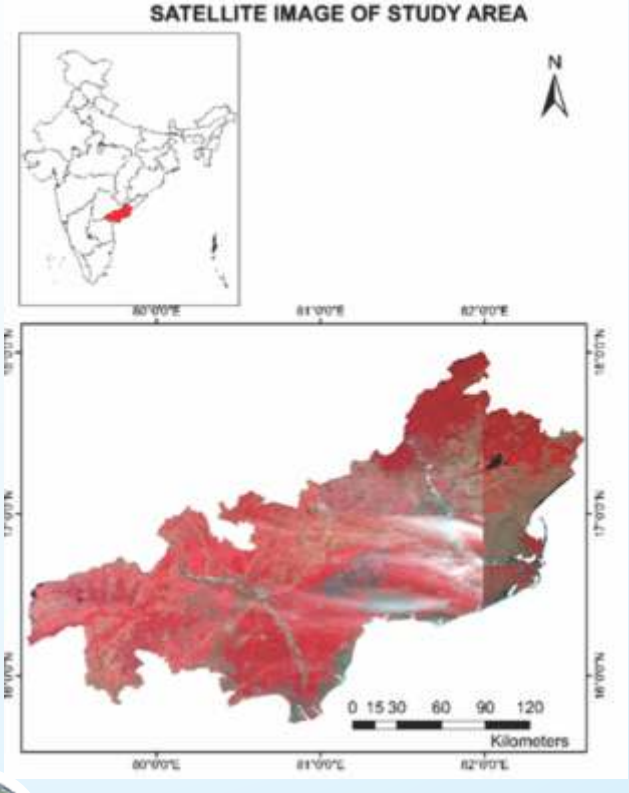
Graphical User Interface (GUI) and COLLADA Viewer

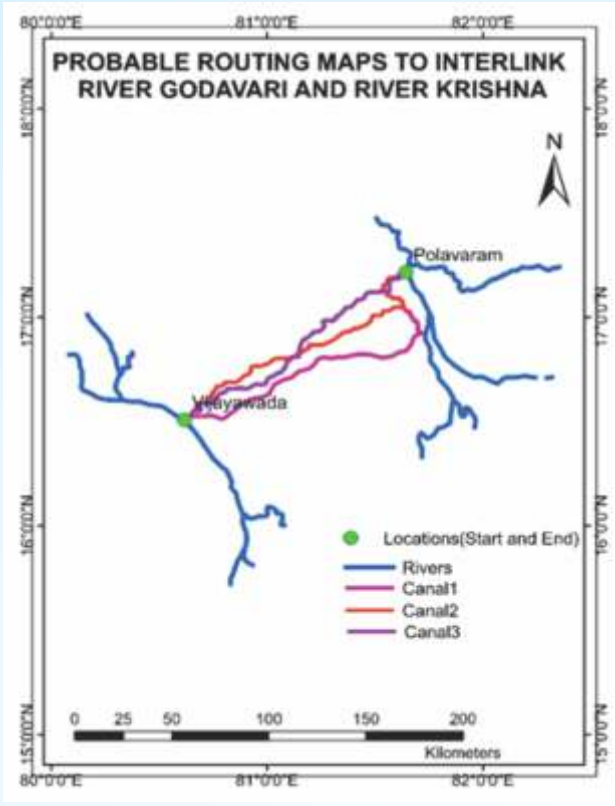


Taj Mahal COLLADA and CityGML model

Spatial Decision Modelling for Interlinking of Godavari (Polavaram link) and Krishna (Vijayawada link) Rivers in Andhra Pradesh, India

- India is a land of rich natural resources, water being one of the most vital of all. Interlinking of rivers can be the best epitome for transferring the surplus flood waters to deficit/drought prone areas. Geospatial modelling provides a holistic approach to generate probable interlinking routes of rivers based on existing geoinformatics tools and technologies. This mechanism involves the integration of multi-disciplinary data related to geomorphology, agriculture, environment, and also to the socio-economic aspect to develop an optimal routing map.
- In the present study, Carto-DEM and AWiFS satellite imagery datasets coupled with Land Use/Land Cover, Geomorphology map, Soil map, and ground water table data have been used to identify the potential routes in geospatial domain for interlinking of Godavari and Krishna Rivers. Flow Direction, Flow Accumulation, Slope map, and watershed boundaries have been delineated using Digital Elevation Model of Cartosat-1. The road, railway, drainage networks and drought prone areas have been delineated using the Satellites data. The ortho-rectified AWiFS data has been used to prepare the Normalized Difference Water Index (NDWI) map which helps in identifying the surface water bodies. Inundation map has been prepared using microwave data of RISAT-1.
- Majority Rule Based (MRB) aggregation technique is performed to optimize the resolution in order to retain the spatial variability of the classes. Analytical Hierarchy Process (AHP) based on Multi-Criteria Decision Making (MCDM) is performed to obtain the prioritization of parameters like Geomorphology, Soil, DEM, Slope, and Land Use/Land Cover. AHP is also performed on different Soil types, Geomorphologic features, Land Use/Land Cover classes, Slope map to obtain the priority vectors.
- A likelihood grid has been generated and all the thematic layers are overlaid to identify the potential grids for routing optimization and also for the construction of water harvesting structures. Impedance map has been generated and several constraints including cost constraints along with rainfall data and discharge data of India-WRIS is considered to give a better routing map. The ground control points (coordinates) collected from field data and Inundation map prepared from microwave data of CRS mode acquired by RISAT-1 are used for validation purposes.
- Comparative studies for the CartoSAT-1 DEM and ASTER DEM were done and it was identified that CartoDEM has given the most beneficial results. Certain feasibility studies were carried out for the model and it was observed that implementation of canal system in some areas where there are settlements and roads needs additional cost.
- Thus, the proposed routing map will emphasize on transferring the surplus waters to drought prone areas and also to provide adequate storage capacity in order to

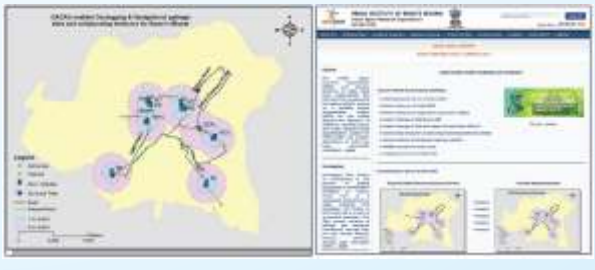




solve the problem of water scarcity and to properly utilize the flood waters for irrigational purposes. The developed spatial decision model is not restricted to Godavari and Krishna Rivers but the similar methodology can be adopted in other interlinking of river systems.

Joint Swachh Bharat Abhiyaan (A Multi-institutional activity carried out in Dehradun on October 2, 2015)

- The Government of India has declared October 2 - as Swachh Bharat Day. With the motive to clean our city. IIRS has taken initiative for making collaborative efforts with all the Central Government organizations to join Joint Swachh Bharat Abhiyaan (JSBA) using geoinformatics tools and technologies. IIRS has carried out the reconnaissance survey using GAGAN receiver (Parisudh model) to identify the authorized and unauthorized garbage dumping sites covering major areas of Dehradun city.
- IIRS coordinated with Central Government institutes to implement the proposed GIS based plan. This initiative was supported by Nagar Nigam, Dehradun (local authorities). GIS techniques such as geo-fencing using proximity analysis (buffering, spatial & attribute queries), geo-tagging etc. were used to develop an optimum implementation plan. A map was made representing service area of each institute considering time constraints and resource allocation. Five routes were identified to cover different parts of the city.
- The details of this event is available online at *www.iirs.gov.in/SBA.html*. In all, 9 Central Government Institutes and Nagar Nigam (State Govt. authority) have participated in JSBA and a total of 22 identified sites and roadsides were cleaned. A total of 514 (471 Central Government volunteers and 43 Nagar Nigam volunteers) people have voluntarily worked for cleanliness.
- One of the unique results of this novel multi-institutional initiative is the conceptualisation of crowdsourcing tool to identify, map and monitor the dumping sites. This novel initiative by IIRS has been published in ISRO website under Geospatial Technology for Swatchh Bharat Abhiyaan' (http://www.isro.gov.in/geo-spatial-technology-swachh-bharat-abhiyaan) as "Story of the Week" on January 11, 2016 and English newspapers. A unique Swachh Bharat Mobile Application (beta version) is being developed by IIRS in collaboration with IIT, BHU. Thus, the crowd-sourcing for swachh bharat will be soon realized and implemented with the help of Academic Institutions as a regular exercise for the cleanliness of the city.



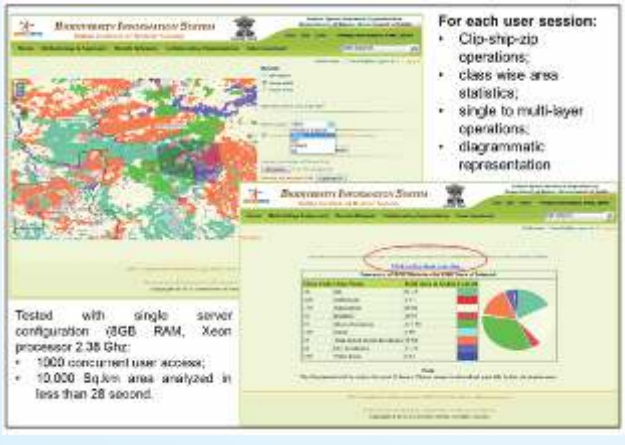
QGIS-LITE (BETA) (In house R&D)

- The QGIS software (formerly called Quantum GIS) is a popular free and open source GIS software which is cross platform i.e., it runs on Linux, Mac OSX, Windows and Android. QGIS is growing in its use as a viable alternative to commercial GIS and the case studies published on its website (ww.qgis.org), highlights the practical application of the GIS software. As per the study conducted in December 2011, QGIS has been estimated to have 100,000 unique users worldwide.
- QGIS is preferred choice of GIS software for all the special courses and training programs conducted at IIRS. The importance of QGIS can be judged from the fact that the National Council of Educational Research and Training (NCERT), a body identified to assist and advise the central and state governments on academic matters related to school education, has mandated teaching of QGIS in secondary and higher secondary schools.
- The current beta release of QGIS-Lite is fully open source and easy to learn & use. The customized software has been tested on Ubuntu (versions Trusty Tahr (14) and Precise Pangolin (14)) and Windows 8 operating system.
- The additional benefits of QGIS-Lite is that users have the flexibility to adapt and install in on any Linux & Windows based operating system. The basic QGIS install has limited functionality in the important domain of GIS Network analysis. The customized QGIS-Lite has new built in modules for finding service areas and doing closest facility analysis. The built in module for shortest path analysis (also called road graph plugin) has been enhanced by adding additional criteria for Length, Cost Impedance and Time as input parameters. Shortest path analysis can be done using new algorithms such as Dijkstra and Floyd-Warshall.
- Two new modules on raster reclassification and spatial data mining (using decision tree classifier, adaboost classifier and random forest classifier) have also been included. The benefit of customizable interfaces and all basic GIS tools (such as Geo-referencing, Projection, Database Creation, Linking of Spatial & Non-spatial data, Spatial and Attribute Queries, Spatial Analysis (Vector & Raster) and Map Composition) are also inbuilt into QGIS-Lite.
- For future reference and ease of use, detailed documentation on installation and troubleshooting has made available from IIRS including step-by-step user guide / instruction manual with sample datasets based on Dehradun city data.

Biodiversity Information System and Spatial Landscape Modelling

- National Biodiversity Characterization at Landscape Level, a project jointly sponsored by Department of Biotechnology and Department of Space, was implemented to identify and map the potential biodiversity rich areas in India. This project has generated spatial information at three levels viz. Satellite based primary information (Vegetation Type map, spatial locations of road & village, Fire occurrence); geospatially derived or modeled information (Disturbance Index, Fragmentation, Biological Richness) and geospatially referenced field samples plots
- Spatial data generated during the study is organized as central data repository in Geo-RDBMS environment using PostgreSQL and POSTGIS.

- The WMS and WFS based system allows geo-visualization, online query and map outputs generation based on user request and response. This is a typical mashup architecture based geo-information system which allows access to remote web services like ISRO Bhuvan, Openstreet map, Google map etc., with overlay on Biodiversity data for effective study on Bio-resources. The complete system is hosted at IIRS through *http://bis.iirs.gov.in* for public access.
- The spatial queries and analysis with vector data is achieved through SQL queries on POSTGIS and WFS-T operations. But the most important challenge is to develop a system for online raster based geospatial analysis and processing based on user defined Area of Interest (AOI) for large raster data sets.
- The map data of this study contains approximately 20 GB of size for each data layer which are five in number.
- The raster operations like clip-zip-ship, class wise area statistics, single to multi-layer operations, diagrammatic representation and other geo-statistical analysis are performed. This is an indigenous geospatial data processing engine developed using Open system architecture for spatial analysis of Biodiversity data sets in Internet GIS environment.



Indian Bio-resource Information Network (IBIN)

It is a de-centralized bio-resource database based on distributed architecture. It works on the principle of spatial data infrastructure wherein distributed databases available across the country are accessed through one single window gateway. Presently, IBIN consist of two core nodes namely, IIRS and UAS, Benguluru and there are 5 BRICs (Bioresource Information Centre's) namely ATREE, FRLHT, NEHU, IHBT & Calcutta University window gateway. Recent developments in IBIN includes:

- IBIN portal (www.ibin.gov.in) is hosted and maintained from IIRS.
- Development of IBIN standard on Biodiversity is submitted to DBT.
- Development of Policy document on IBIN is submitted to DBT.
- Design and development of Android based IBIN Mobile App which enables an end user to submit datasets on species through crowdsourcing approach.

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Major Events

IIRS Users Interaction Meet-2016

Fourth IIRS User Interaction Meet (IUIM-2016) on 'Geospatial Technologies and its role in Good Governance' was held on February 18, 2016 at IIRS. There were more than 200 participants with following breakup- Academia (35), Edusat/e-learning (47), Central Govt. (42), Industry (2), State Govt (19), Students (37) and Ex-employees (9); besides Scientists/ Engineers and student participants from IIRS. Programme commenced with the inaugural session. Director, IIRS gave the introductory remarks during inaugural session of the Meet, which was followed by addresses of chief-guest Dr. H.S. Dhami, Vice Chancellor, Kumaon University, Nainital and Guest of Honour, Dr. Savita, IFS and Director, FRI and Vice Chancellor, FRI University, Dehradun.

Besides inaugural a technical-plenary and three parallel-sessions (including Edusat and Hindi) were also arranged, wherein eminent speakers delivered talks & shared their experiences. The themes of various technical sessions were as follows:

- Plenary Session on 'Recent Advances in Geospatial Technologies and Capacity Building Requirements'
- First Parallel technical-session on 'Capacity Building for National Development'
- Second parallel session was in Hindi titled – 'भू–सूचना प्रौद्योगिकी का निर्माण एवं क्षमता संवर्धन की आवश्यकता'
- Third Parallel session was on 'IIRS Outreach Programme'

Later, the interactive-sessions and panel-discussions were also held with the users/ participants to dwell upon the future activities of institute on enhancing capacity-building activities and aligning developmental-programmes for diversified country needs. Outreach feedback session was organised as part of IUIM-2016, recommending significance of webinars on specialized-topics and availability of self-learning practical materials.

IIRS has organized three User Interaction Meets during 2013, 2014 and 2015 prior to this Meet. Representatives from Central/State government departments, autonomous organizations, NGOs, academia including institutions associated with distance learning programmes of IIRS, and industry participated in these Meets and shared their experiences and expectations. The deliberations have been highly fruitful, and have made all the events very successful. IIRS Alumni Meets were also organized during these events.

The meet is organised every year to have a constant dialogue with the users/stakeholders as the feedback is essential to understand the issues in capacity building in Geospatial technologies and their applications for resources management. Considering this, 4th IIRS User Interaction Meet (IUIM-2016) focussed on Capacity Building and its Role in Governance with following main objectives:

- Appraise the user ministries/stakeholder departments and geospatial community on the role of geospatial technologies in governance vis-à-vis IIRS role in capacity building and research,
- Understand and explore new opportunities with user organizations in government, non-government and private sectors on the capacity building requirements,
- Interact with partners of IIRS distance learning programme for further improvement,
- Interface with geospatial industry on the current and future requirements and explore the placement opportunities for IIRS students.

The Meet provided a platform to share the experiences by user ministries/stakeholders, geospatial community, IIRS faculty and explore the potential areas for capacity building and joint research. The industry had an opportunity to understand present and future requirements,

and also an opportunity to interact with students. IUIM is an important forum for all the stakeholders to get the feedback on overall training and education programmes of IIRS, which will be an important input for designing future courses and taking up research in newer areas relevant to the user community. The industry has an opportunity to understand present and future requirements, and also an opportunity to interact with students. It also provides unique opportunity for interaction on entire gamut of geospatial capacity building requirements in the country and formulating appropriate strategy to address such requirements.

A digital-exhibition was also organized during the IUIM-2016 for the benefit of academia, user and industry highlighting training and education opportunities, research initiatives of IIRS faculty, research outputs of students, on-going national projects, products, services and infrastructure available at IIRS. It also showcased the major initiatives of ISRO in terms of Earth and Planetary Observation missions, flagship application projects and programmes undertaken in partnership with Central and State government departments/ ministries, and various space-based products and services made available to society. Finally, an interactive session and a panel discussion was also organised in the valedictory session. The meet concluded with a cultural programme by the students of St. Kabeer Academy, Dehradun.

FOSS4G India – 2015 Conference

The Second National Conference on 'Free and Open Source Software for Geospatial' (FOSS4G-India 2015) was organized at IIRS, Dehradun during June 9-10, 2015. FOSS4G-India is held biennially with a mission to foster the development and promote the widespread use of Open Source Geospatial Technologies including support for software development and publicly available Geo-data. The theme of the conference was 'Open Source Geospatial Tools in Climate Change Research and Natural Resource Management.' It was organized by Open Source Geospatial Foundation of India (OSGeo-India) in collaboration with Survey of India (SOI), Wadia Institute of Himalayan Geology (WIHG) and Indian Meteorological Society - Dehradun Chapter. Department of Science & Technology (Govt. of India), Ministry of Earth Sciences (Govt. of India), Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP, affiliated to the United Nations), Mapbox and Kaiinos Geospatial Technologies Pvt. Limited supported the event. Pre-conference Workshops on 'Becoming QGIS Power User' (by Mr. Ujaval Gandhi from Google) and 'Geospatial Processing' were also organized on June 8, 2015. While 17 participants from 11 organisations attended the QGIS Workshop, 23 participants from 10 organisations attended the R Workshop.

The conference was inaugurated by Prof. P.K. Garg, Vice Chancellor, Uttarakhand Technical University and while Dr. Anmol Kumar, Director General, Forest Survey of India, Dehradun was the Guest of Honour. Total 108 delegates representing 27 organisations across the country participated in the conference. Besides three Plenary/Popular talks and a panel discussion at the end, 45 papers were presented during the conference in 12 technical sessions covering a variety of themes viz., Food Security & Agriculture Applications, Water Resource Management & Climate Studies, Development of WebGIS Applications, LULC Research & Village GIS, Open Standards and Open Source

Databases, Forestry & Social Mapping, Smart City and Urban Mapping, Disaster Mapping & Solutions, Capacity Building & Strategic Applications, and Open Source Technology Development. The conference emphasized the relevance of FOSS4G, especially the adoption of open data standards, development of open source tools, and localization of open GIS tools in Indian languages, for national development.

Workshop: Australia-India Council

The second workshop of collaborative project between Indian Institute of Remote Sensing and University of Technology, Sydney (UTS) under Australia-India Council (AIC) was organised at IIRS on April 16, 2015 with the participation of Dr. Alfredo Huete and Dr. Rakhesh Devadas from the UTS and scientists/researchers from centres of ISRO (IIRS, NRSC, SAC) and Indian Agricultural Research Institute. The topic of the workshop was "Remote Sensing of Agricultural productivity: New Possibilities for Managed Agricultural Regions in India and Australia" Presentations and discussion were held in a brain storming sessions to explore possibilities of using chlorophyll fluorescence imaging for productivity estimation and establishing agro-supersites in north-western Indo-Gangetic Plains. There were 20 participants including Professors/Scientists, Research Scholars and PhD students who have attended the workshop and actively participated in the discussion. Various approaches aimed at improved crop monitoring (chlorophyll fluorescence imaging, radiation efficiency and process-based crop modelling) and deployment of instruments at sites was discussed and implementing full-fledged project under Australia-India Council. A special lecture by Dr. Alfredo Huete on "Seasonal cycles shape ecosystem responses to environmental change and extreme climates" was also organised for the benefit of scientific fraternity and students of IIRS.

SAARC Conference

Considering the potentials of Space-based technology tools and services for overall socio-economic development of South Asian Association for Regional Cooperation (SAARC) region, the Hon'ble Prime Minister of India desires India to dedicate a satellite for the SAARC region and made an announcement at the 18th SAARC Summit at Kathmandu in November 2014, that India will host a Conference for all South Asian, Partners in 2015 to build capacity in applications of Space Technology in development and governance. Accordingly, ISRO with active support from Ministry of External Affairs, Government of India hosted a conference on "Satellite for the SAARC region and Space Technology Applications" on June 22, 2015 at New Delhi, India. The conference was inaugurated by Shri S. Srinivasan, Member (Finance), Space Commission, Atomic Energy Commission and Earth Science Commission. Dr. M. Annadurai, Director of ISRO Satellite Centre, made a presentation on "Indian Space Programme". Dr. A.M. Gondane, Joint Secretary

(SAARC & BC), MEA briefed on the "Satellite for the SAARC region" initiative. Dr. Y.V.N. Krishna Murthy, Scientific Secretary, ISRO welcomed the delegates and provided an overview about the conference and Shri S. Kumaraswamy, Joint Secretary, DOS provided vote of thanks in the inaugural session. Representatives from all member countries of SAARC (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka), SAARC Secretariat and senior officials of Government of India have participated in this conference with the participation of more than 90 delegates.

The conference deliberated on the potential applications of space technology including that of "Satellite for the SAARC region". Experience of space technology applications in the areas like education, healthcare, disaster response, natural resource management, weather forecasting and communication were discussed. A Panel Discussion, chaired by Dr. Y.V.N. Krishna Murthy, Scientific Secretary, ISRO was held at the end, wherein all participants have shared their views on this initiative. All member countries of SAARC region appreciated this new initiative by Government of India.

Besides Dr. A. Senthil Kumar, Director, IIRS; Scientist/ Engineers from IIRS namely, Dr. Sarnam Singh and Dr. Puneet Swaroop were identified as LOC members. IIRS actively participated in organizing this event. Director, IIRS also delivered presentation on Capacity Building activities.

Uttarakhand State Meet

The Uttarakhand state meet on 'Promoting Space Technology Based Tools & Applications in Governance and Development' was organised on Feburary 27, 2016 by USAC in collaboration with IIRS at IIRS campus. It was attended by more than 250 participants from 52 departments and other Government organisations.

The meet was inaugurated by Chief Secretary, followed by presentation from 40 departments in 8 technical sessions, namely Agriculture, Environment and Energy, Infrastructure and Planning, Water Resources, Health and Education, Weather and Disaster Management, Developmental Planning, and Technology Diffusion, Communication and Navigation.

The Plenary session was addressed by Shri Harish Rawat, Hon'ble Chief Minister and Shri A. S. Kiran Kumar Chairman, ISRO and they highlighted the role of space technology in Uttarakhand particularly for disaster management and development in remote areas.

In response to inputs from departments, USAC will finally work out the details of projects to be carried out/strengthened.

Independence Day Celebrations

The 69th Independence Day was celebrated on August 15, 2015 with full fervor and gaiety. Faculty, staff and their family members, contract staff, students of various courses of IIRS and CSSTEAP participated in the event. Dr. A. Senthil Kumar, Director, Indian Institute of Remote Sensing unfurled the National Flag and the Flag Salutation was followed by the National Anthem. Director, IIRS addressed the gathering on this occasion. He sumptuously highlighted the achievements of ISRO and IIRS in the last one year and called for greater efforts in meeting the targets set for training and capacity building as a follow-up to National Meet held on September 7, 2015. This was followed by distribution of balloons and sweets to all the children and others present on the occasion.

On this occasion, the Recreation Club of IIRS organized games for different groups of children, students, staff and their family members. Two games on Yoga principles namely, Duck Race for children and Vraksha Aasan for all the students were also organised. Though tough, participants did excellent in both events beyond expectations. Fancy dress competition for young children was most exciting and was a trying times for the parents. Musical chair competition for ladies was enjoyed by all. The prizes to the winners of different games were distributed by Director, IIRS. At the end, a movie on 'Walking with Dinosaurs' was screened.

Foundation laying ceremony of Golden Jubilee Hostel

Foundation Stone Laying Ceremony of Golden Jubilee Hostel Building was done by Shri A.S. Kiran Kumar, Chairman, ISRO and Secretary, Dept. of Space on October 23, 2015. Shri A.S. Kiran Kumar, Chairman, ISRO & Secretary, Dept. of Space visited IIRS during October 22-23, 2015 and had an interaction with staff and Scientist/ Engineers of IIRS, alongwith students from IIRS and CSSTEAP.

IIRS Celebrates Golden Jubilee of ITEC

The Indian Technical and Economic Cooperation (ITEC) Programme was instituted by a decision of the Indian Cabinet on 15 September 1964 as a bilateral programme of assistance of the Government of India. It has completed 50 years of its existence. Ministry of External Affairs, Govt. of India has requested the collaborating institutes to celebrate ITEC day as a part of Golden Jubilee ceremony. Indian Institute of Remote Sensing celebrated the ITEC Day on October 9, 2015 and was attended by all IIRS employees and ITEC course participants of the ongoing course.

IIRS organizes two training programmes every year in the category of Technical Course under ITEC and Special Commonwealth African Assistance Programme (SCAAP). The courses are of 8 weeks duration with 20 seats per course. The two courses are: (a) Short course in Remote Sensing with emphasis on Digital Image Processing (SRS), and (b) Short course in Geoinfomatics (SGI).

The primary objective of the short courses is to enhance the capacity of middle level professionals in the field of Remote Sensing with special emphasis on processing of remotely sensed data using digital image processing techniques and in understanding the various dimensions of Geo-information science and technology for natural resource management and decision making. Out of 161 partner countries, IIRS has hosted participants from 79 countries. A total of 468 candidates from 79 countries (out of 161 member countries) have benefited so far in these courses. The largest participation has been from Uzbekistan (38), followed by Vietnam (24) and Algeria (23), Sri Lanka (21) and Syria (21) and other countries.

The celebration programme began with the welcome address and the messages received from Shri Arun Kumar Sahu, Joint Secretary, MEA highlighting the Institute's contribution towards ITEC Capacity building programme. The feedbacks received from ITEC-IIRS alumni were also read out, which was followed by the feedback from the ongoing Short course on Geoinformatics course participants. The contributions of ITEC and IIRS were applauded by the alumni and course participants. Dr. A. Senthil Kumar, Director, IIRS then addressed the distinguished gathering emphasizing the capacity building initiatives of IIRS. The programme concluded with formal vote of thanks.

Visit of Chinese delegation for the cooperation on Education and Training between IIRS/ ISRO and Beihang University/ CNSA

As a follow-up of the memorandum of understanding (MoU) on '2015-2020 Space Cooperation' signed between Indian Space Research Organisation (ISRO), Government of India and Chinese National Space Administration (CNSA) on May 15, 2015, a delegation from CNSA and Beihang University China, visited Indian Institute of Remote Sensing (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 between IIRS and Beihang University for capacity building initiative taken up by ISRO and CNSA in space science and technology. During two days meeting, detailed presentations were made on various long and short term courses with sharing the experience including feedback. This was followed by discussions on different aspects of expertise and cooperation such as sharing of experience for capacity building between two premier reputed organizations; training and exchange of experts in the field of space sciences, space technology and applications and enhancing the communication on the curriculum of different programmes organized by both sides.

The points agreed upon after the discussions for the future collaboration between IIRS, ISRO and Beihang University included Resources Sharing, Course curriculum sharing, Publicity of e-learning and DLP programmes through websites, Exchange of students and Faculty/Scientists. Besides aforesaid, it was also agreed to share the virtual models, course-

announcements, newsletters, text-books, etc. regularly among the Centres and institutions. To start with, short-duration exchange programmes for students on mutually agreed areas will be taken up initially.

Foreign delegation included Ms. Jiang Hui, Director, International Space Cooperation, CNSA; Ms. Wang Fang, Department of System Engineering, CNSA; Mr. Weng Jingnong, Dean International School Beihang University, Executive Director of RCSSTEAP and Director APSCO, Education and Training Centre, China; Mr. Gao Guozhu, Attorney Law, The Law School of Beihang University and legal Expert for RCSSTEAP, China; and Ms. Guo Yuanyuan, Program Director of RCSSTEAP, International School of Beihang, University and Deputy Director APSCO, Education and Training Centre, China.

Cooperation on Education and Training between India and Australia

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. Before the meeting they were shown a few labs and infrastructure facilities such as High Computing Facility, Computer lab of Photogrammentry and Remote Sensing Department, EDUSAT and Distance learning programme (DLP) facility. They also interacted with course participants of Indian Technical and Economic Cooperation (ITEC) and CSSTEAP course participants.

Mr. Sean Kelly, Australian Consul-General gave his opening remarks and highlighted about the objectives of the visit. He was very pleased to interact with course participants from different countries. He also briefed about the Australian Space Programme and mentioned that Australia is among the leading countries in the world in Space 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 and Faculty/Scientists. To start with initially, the Fellowships under New Colombo Plan, 2016 need to be availed and encouraged in mutually agreed areas.

Women's Day

Each year International Women's Day (IWD) is celebrated on March 8, 2015. International Women's Day represents an opportunity to celebrate the achievements of women. It celebrates womanhood and pays tribute to the indomitable spirit of women across the globe. The IWD was celebrated in the IIRS campus with the participation of women scientists and staff.

National Safety Week

National Safety Week was observed in the campus on March 04, 2015 in which all faculty, staff and students participated actively. Shri V.K. Srivastava, DGM Safety, SDSC-SHAR delivered an excellent talk on Safety parameters.

Earth Day

IIRS celebrated "Earth Day" at IIRS on April 22, 2015 to demonstrate the support for environmental protection. The events begun with organization of a painting competition in the forenoon on theme- "It is our turn to protect the environment" for school children. Nine students from five schools of the Dehradun city participated in the programme. Ms. Kartiki Malik, from KV, FRI; Ms. Khusbhoo, from KV, Salawala; Mr. Aman, from Govt. Intercollege, Dobhalwala won 1st, 2nd and 3rd prizes, respectively. Consolation prizes went to Ms. Anchal Rawat from KV, FRI and Ms. Ambika Bisht from SGRR. In the afternoon, a debate was organized on topic- 'Smart cities are environmental friendly: Myth or reality' for the students of IIRS/CSSTEAP and faculty/ staff of IIRS and later a quiz competition was conducted on environmental Issues. Following the quiz, a popular talk on 'Widespread Environmental changes, the drivers and interconnections in the Atmosphere' was delivered by Dr. S.P. Singh, Ex- Vice Chancellor, Garhwal Unversity. The programme ended with distribution of prizes to winners of different events by the Director, IIRS.

World Environment Day

World Enviornment Day is an annual event, celebrated on June 05, 2016 every year. The event is celebrated so as to make people aware of their environment and keep our surrounding environment green and planting trees that will lessen pollution. This day is celebrated to raise global awareness to take positive environmental action and to protect nature and the planet earth. On this occasion, Director, IIRS and staff from IIRS and CSSTEAP, planted trees in the campus. Director, IIRS opined that these might be small steps but when we do it together, one can definitely see the results.

International Yoga Day

IIRS celebrated the International Day of Yoga by organizing the Yoga practice/ demonstration on June 21, 2015 . The instructional booklet and DVD of Common Protocol of Yoga Asanas has been circulated through email to all employees and trainees. A Yoga Trainer was invited for conducting the Yoga practice/ demonstration. Around 56 people including employees, trainees and their family members participated voluntarily. The International Day of Yoga was very successful.

National Remote Sensing Day

The National Remote Sensing Day was celebrated on August 12, 2016 to commemorate the birth anniversary of Dr. Vikram Sarabhai, a renowned scientist and educationist of our country and the 'Father of Indian Space Programme'. The celebration began with a popular talk on theme 'Indian Space Programme' for the benefit of children, delivered at Welham Girls School, Dehradun. At IIRS campus, the quiz programme on Remote Sensing was conducted for students and staff of IIRS and CSSTEAP. In the afternoon, Dr. Savita, IFS & Director, Forest Research Institute, Dehradun delivered a popular talk to the gathering of students, scientists and staff of IIRS and CSSTEAP on the important theme 'National Mission for Clean Ganga: Challenges' at IIRS auditorium.

Sadbhawana Diwas

Communal Harmony Fortnight was observed during August 20 – September 03, 2015, in which all faculty, staff and students participated actively. On August 20, 2015, Sadbhawana Diwas pledge was taken by all the employees.

Viswakarma Puja

Vishwakarma Day also known as Vishwakarma Jayanti or Vishwakarma Puja is a day of celebration for Vishwakarma, a Hindu god, the divine architect, and celebrated this year on September 17, 2015. The technical staff of the institute worshiped their instruments and tools which they use in their profession and sought blessings from Lord Vishwakarma.

GIS Day Celebration

GIS Day was celebrated at IIRS on November 19, 2015 with full enthusiasm and passion. The programme was attended by more than 100 people which included students, faculty and researchers. The main highlights of the GIS day were:

- GIS Quiz Competition
- Debate Competition on the topic '*Role of Geospatial Technology in Smart Cities Planning*'.

Director, IIRS welcomed the participants and briefed about relevance of geospatial technology for the development of the country. He emphasized the role of students to develop innovative methods for various applications. The debate competition was also organised on the occasion which highlighted the relevance of geospatial technology towards smart city development. The deliberation by the students gave new insights to understand the relevance of geospatial technology for smart city plan.

Sports meet

Every year sports meet for all ISRO centres is organized at one centre wherein employees from all centres participate. For the year 2015, sports meet was organised at SCL, Mohali in the month of November with the games like Cricket, Football, Ball Badminton (Men/Women), Tennikoit (Women), Hockey, Volleyball, Basket Ball, Kabadi, Tennis organised in two phases.

Other Important Activites

Visit of Delegation from Bangladesh: Hon'ble begum Ismat Ara Sadique, State Minister of Public Administration, Govt. of Bangladesh and her accompanying delegation including Dr. Abdul Hamid, Deputy Secretary, Ministry of Public Administration; Mr. Md. Shahriar Kader

Siddiky, Deputy Secretary, PS to Hon'ble Minister of State, Ministry of Public Administration; and Md. Abdul Halim, Additional Secretary, Rajesh Kumar Shekhawat, Director, Geotechnical Engg. Directorate (research) visited IIRS campus and interacted with with Scientist/ Engineers of IIRS

Kathak Dance Concert: The Recreation club, IIRS organised a Kathak Dance concert by Gauri Diwakar with the help of SPIC MACAY.

Prominent Guest Lectures & Visits

Foreign:

- Dr. D.G. Rossiter, Associate Adjunct Professor, Cornell University, USA (Ex-Faculty at Faculty of Geo-information Science and Earth Observation (ITC), University of Twente) delivered lecture on titled 'Advanced concepts in geostatistical analysis'.
- Dr. David G. Rossiter, Adjunct Professor, from Cornell University, USA delivered a lecture on 'Tata-Cornell Agric. & Nutrition Initiative (TCI): Soil Health Component'.
- Dr. Alexey Voinov, Professor in Department of Geo-information Processing, Faculty of Geoinformation Science and Earth Observation (ITC) at the University of Twente delivered lecture on 'System Sustainability in space and time' .
- Prof. Alfredo Huete from University of Technology Sydney, Australia delivered lecture on 'Seasonal cycles shape ecosystem response to environmental changes and climate extremes'.
- Dr. Valentyn A. Tolpekin, Assistant Professor, Department of Earth Observation Science, ITC, University of Twente delivered lecture on 'Super-resolution Mapping of Satellite Imageries'.

Indian:

- Shri Sajjad Anwar from Mapbox Inc, Bengaluru, delivered lecture on 'Participatory Mapping and Open Street Maps'.
- Dr. SK Shivkumar, Vikram Sarabhai Distinguished Professor, ISITE, Bengaluru visited IIRS in June, 2015.
- Dr. S. K. Jain from Central Ground Water Board NW, REGION Chandigarh delivered lecture on 'Groundwater Budgeting & Hydrological system Analysis with Emphasis on Aquifer Mapping'.
- Prof. Mohammed Latif Khan, Department of Botany, Dr. Hari Singh Gour, Central University delivered lecture on 'Structure and quality of thesis'.
- Dr. Sanjay Kumar from Banaras Hindu University (BHU) Varanasi delivered lecture on 'Structured Technical Writing & Technical Writing and Argumentation'.
- Dr. Prakash C Tiwari from Kumaon University, Nainital delivered lecture on 'Urban Growth in Himalayas: Understanding the Process and Options for Sustainable Management under Climate Change'.
- Wg. Cdr. Deepak Vats from Indian Air Force delivered lecture on 'Challenges and issues on UAV operations in India for RS applications'.
- Prof. Rajiv Sinha, Head, Dept. of Earth Sciences, IIT Kanpur delivered lecture on 'Application of UAVs for river system studies'.
- Dr. Snehmani Deputy Director, Snow & Avalanche Study Estt. (SASE), Research & Development Center (RDC) delivered lecture on 'UAV applications for Cryosphere'.

- Dr. R.N. Sahoo, Senior Scientist, IARI, New Delhi delivered lecture on 'UAV applications for Agriculture'.
- Prof. S.P. Singh, former V.C. of HNB Garhwal University and former Emeritus Professor, FRI University, Dehradun delivered lecture on 'Widespread environmental changes'.
- Dr. Venkitakrishnan P.V., Dy. Director, MME/ VSSC delivered lecture on 'Rocket Manufacturing'.
- Mrs. PV Jayasri, from NRSC, Hyderabad delivered lecture on 'SAR Calibration'.
- Mr. Anil Kumar from UPES, Dehradun delivered lecture on 'Overview of computational model for Whole Slide Imaging 3D Visualization'.
- Dr Diganta Burman, Scientist from NESAC, Shilong delivered lecture on 'Flood modeling and flood early warning in NE region'.
- Shri R. Sriniwas from TCPO delivered lecture on 'Smart Cities Mission: Guidelines and the Role of ULBs'.
- Dr. R.R. Navalgund, Vikram Sarabhai Distinguished Professor, delivered lecture on 'Climate Change and Space Technology'.
- Dr. Som Sapkota, Dy. Director, Geol. Survey of Nepal and CSSTEAP alumnus visited IIRS and made a presentation on 'Earthquake Geology/Seismicity in Nepal'.
- Dr. Sudhir Krishna, former secretary, Ministry of Urban Development, GoI delivered lecture on 'Smart Cities Mission: Challenges and the Role of TCPDs/ULBs'.
- Dr. Mahavir, Professor, SPA, New Delhi from SPA, New Delhi delivered lecture on 'Smart Cities: Concepts and some examples from India and abroad'.
- Shri S. Surendra, Town Planner and Head, URIS, TCPO, New Delhi from MoUD, GoI delivered lecture on 'Govt. of India Initiative on Geospatial Technology in Spatial Planning with special reference to Sub-Scheme on GIS based Master Plan for 500 Amrut Cities.'
- Shri K.K. Joadder, Chief Planner, TCPO, New Delhi from MoUD, GoI delivered lecture on 'Smart Cities Initiative of Govt. of India: Convergence with other Government Schemes'.

Foreign Deputation

S. N.	Officials	Duration	Purpose	Country
1	Dr. Harish Chandra Karnatak	01.06.2015 to 05.06.2015	East Asia Summit (EAS) workshop on Application of Space information technology in major natural disaster monitoring and assessment at National Disaster Reduction Centre of China	China
2	Dr. Hitendra Padalia	08.06.2015 to 07.08.2015	To participate in Space Studies Programme 2015 at Ohio University, Athens, USA	Athens, USA
3	Mr. Shashi Kumar	04.07.2015 to 23.07.2015	Participation in task group on Synthetic Aperture Radar (SAR) LiDAR models for measuring and mapping forest carbon under the partnership for land use science technical assistant in USA.	USA
4	Mr. P.L.N. Raju	08.07.2015 to 11.07.2015	Participation in joint meeting of technical commission presidents with ISPRS Council at Prague	Prague
5	Dr. Sarnam Singh	14.09.2015 to 16.09.2015	To participate in United Nations International Conference on Space-based technologies for Disaster Management at Beijing, China	Beijing, China
6	Dr. Shiv Prasad Aggarwal	17.10.2015 to 24.10.2015	AARS General conference & 36th ACRS at Crowne Plaza, Manila Galleria, Manila	Manila, Philippines
7	Dr. Vandita Srivastav	17.09.2015 to 22.09.2015	To participate in United Nations International Conference on Space-based technologies for Disaster Management at Beijing, China	Beijing, China
8	Dr. A. Senthil Kumar	27.03.2016 to 04.04.2016	Participation as Vice-chair during CEOS WGCap-D Annual Meeting	USA
9	Dr. B.R. Nikam	08.01.2016 to 02.05.2016	For participation in the Short Term Faculty Secondment program of Government of India at Bangkok, Thailand	Bangkok, Thailand

AWARDS AND HONOURS

IIRS e-learning initiatives are well appreciated by user community. Department of Personnel & Training (DoPT), Government of India and United Nations Development Programme (UNDP) has conferred a national award for excellence in training for the year 2015 to IIRS e-learning initiatives for innovative training contents & delivery.

IIRS has also received the National Awards for Excellence in Training for year 2015 by Department of Personal and Training (DoPT), Government of India and UNDP, for the live and interactive Outreach Programme.

Various awards received by the institute and faculty members are listed in following table:

S. No.	Name of the Award (s)	Date & Month	Remarks
1.	Education Leadership Award	July 23, 2015	Awarded to Institute (IIRS) in recognition of leadership, development, marketing, and Institute industry interface by ABP News National Awards
2.	National Award for Excellence in Training	April 11, 2015	Awarded to Institute (IIRS) for E-learning initiative for Remote Sensing and Geoinformation Science by DoPT
3.	National Award for Excellence in Training	April 11, 2015	Awarded to Institute (IIRS) for "Reach the Outreached- EDUSAT Programme by DoPT
4.	Young Scientist Merit Award	August, 2015	Awarded to Dr. P.K. Thakur for exhibiting performance excellence by ISRO
5.	Eminent Engineers Award	September 15, 2015	Awarded to Dr. S.P. Aggarwal for RS&GIS applications in Water Resources by Institution of Engineers
6.	PR Pisharoty Award	December 16, 2015	Awarded to Dr. Anil Kumar by ISRS

IIRS also received the 'Education Leadership Award' from ABP News National Education Awards on July 23, 2015 at Mumbai. The award is in recognition of leadership, development, marketing, and institute and industry interface. The institute promises to achieve greater heights of excellence and innovation in Education. IIRS family rejoices the glorious achievement with pride and commitment to training and capacity building in geospatial technologies.

राजभाषा गतिविधियाँ -2015

भारत सरकार की राजभाषा नीति के अंतर्गत सरकारी कामकाज में राजभाषा हिन्दी के प्रति जागरूकता तथा उसके उत्तरोत्तर प्रयोग में गति लाने के उद्देश्य से केन्द्र सरकार के प्रत्येक कार्यालय में प्रति वर्ष हिन्दी दिवस/पखवाड़ा का आयोजन किया जाता है। तदनुसार, भारतीय सुदूर संवेदन संस्थान, देहरादून में इस वर्ष भी हिन्दी पखवाड़ा समारोह का आयोजन किया गया। यह समारोह निदेशक, भारतीय सुदूर संवेदन संस्थान की अध्यक्षता में दिनांक 14-28 सितंबर 2015 तक मनाया गया। उक्त समारोह के आयोजन से संबन्धित जानकारी परिपत्र, ईमेल व बैनरों के माध्यम से प्रचारित की गई तथा इस आशय की सूचना संस्थान के महत्वपूर्ण स्थानों पर उपलब्ध सूचना पट्टों पर भी प्रदर्शित की गई। हिन्दी दिवस/पखवाड़ा के उदघाटन समारोह में माननीय गृह मंत्री, भारत सरकार के संदेश का अनुवाचन किया गया। उक्त समारोह के अंतर्गत विभिन्न प्रतियोगिताओं का आयोजन किया गया, यथा: श्रुतलेखन प्रतियोगिता, अनुवाद प्रतियोगिता, टिप्पण एवं आलेखन प्रतियोगिता, हिन्दी भाषा/व्याकरण ज्ञान प्रतियोगिता, अंन्ताक्षरी प्रतियोगिता, आशुभाषण प्रतियोगिता, राजभाषा प्रश्नोत्तरी, कार्मिकों के बच्चों हेतु श्रुतलेखन व सुलेख प्रतियोगिता तथा कविता पाठ प्रतियोगिता। प्रतियोगिताओं में नकद पुरस्कार प्राप्त करने वाले प्रतिभागियों के प्रोत्साहन एवं उनकी उपलब्धि को मान्यता/पहचान प्रदान करने हेतु विजेता प्रतिभागियों को प्रमाण-पत्र प्रदान किया गया। भारत सरकार, अंतरिक्ष विभाग के का0 ज्ञा0 सं0 8/3/14/2012 (वा0।।) दिनांक 10 अगस्त 2012 के अनुसरण में संस्थान के कार्मिकों/स्टाफ के ऐसे बच्चों को हिन्दी दिवस के उपलक्ष्य पर पुरस्कृत किया गया, जिन्होंने शैक्षणिक वर्ष 2014-15 में दसवीं तथा बारहवीं कक्षा की बोर्ड परीक्षा में हिन्दी विषय में अत्यधिक अंक प्राप्त किए थे।

वार्षिक हिन्दी निरीक्षण

भारतीय सुदूर संवेदन संस्थान में वर्ष 2014-15 हेतु हिन्दी के प्रगामी प्रयोग से संबन्धित वार्षिक निरीक्षण दिनांक 16 व 17 दिसंबर 2015 को किया गया। अन्तरिक्ष विभाग के आदेशानुसार उक्त निरीक्षण विक्रम साराभाई अन्तरिक्ष केन्द्र के वरिष्ठ प्रधान, कार्मिक एवं सामान्य प्रशासन, श्री एम0 पलवेसम द्वारा किया गया।

Infrastructure Improvements

The Master Plan of IIRS is evolved to find an optimized solution to meet infrastructural demands of the IIRS Campus i.e. Shortage of Hostels, shortage of workspace, large capacity lecture hall and computer labs, lack of unified character among the various buildings, need for vehicle parking, interactive spaces and covered connecting pathways. Larger demands for capacity building in the areas of RS&GIS have emerged from the 'National meet' for which IIRS has to play a major role. This has further increased the demand for additional physical infrastructure to be built up in the campus. Master plan was prepared with the following provisions

- Construction of new Academic block
- Construction of new 40 room hostel
- Construction of new 60 room hostel
- Vertical extension of Library Building
- Central Dining & Recreational Facility
- Connecting Corridors between Tech. buildings and Hostels

ISRO/DOS management has approved this master plan and allotted the budget to realize the Master plan infrastructure by 2018-19.

The Vertical extension to GID Building construction project was executed to cater the increased workspace demand for Outreach program of IIRS by providing a state-of-art EDUSAT studio along with other facilities. A total of 252 sq./m of area is added by construction of one more floor over the existing GID building. The state-of-art EDUSAT studio has attached control room, content development lab and addition seating space and conference hall.

Adequate accommodation facilities are essential for any training and research institute. Therefore, keeping in mind the requirements, the facilities in Visiting Scientist Hostel (VSH) at IIRS has been enhanced. Additional capacity of 4 rooms and 5 deluxe rooms have been added thereby increasing the occupancy to a total of 14 rooms including 2 deluxe rooms and 2 VIP suites.

Solar Power Plant

ISRO is encouraging its centres and units to use the non-conventional energy sources for meeting the energy demand at their premises. IIRS has already taken initiative towards green energy generation by installing 80 KWp Solar Power Plant on the roof of main building. This year IIRS has established 30 KWp Grid interactive solar photovoltaic power plant on the roof top of Auditorium building.

This power plant contains 102 numbers of 300 Wp solar panels spread across 300 sq.m area. This system has only one string inverter of 30 KW rating and the supply is synchronized with IIRS internal grid. This plant generates on an average 120 to 130 units/day which saves Rs. 2.5 Lakhs in the electricity bill, annually. The project has a cost of Rs. 24 Lakhs with the payback period of 10 years and the minimum life of the plant is 25 years.

The institute has a 60 KVA UPS for general usage and 2x10 KVA UPS for IRNSS. With the increase in demand, IIRS has procured 2x100 KVA parallel redundant UPS System. As the UPS systems are located in different buildings, it is very difficult to perform the operations and maintenance. In view of this, centralized UPS facility was established in substation building by placing all UPS systems in this building. This gives easy operation & maintenance facility of all UPS Systems and also yields recurring savings.

Access Control & Video Surveillance

An Integrated Access Control and Video Surveillance system based on the guidelines issued by DOS inter centre standing committee on Biometric based access control system and security gadgets is under installation in the campus. The seamless integration is also planned with the main building and other pertinent locations which will be integrated with a common server and control room. The Integrated Access Control and Video Surveillance system has the following features.

- Central alarm management & Monitoring
- 3 levels access control (Security, Building & Lab level)
- Online visitor request & approval etc.
- IP Cameras with online backup
- Photo Flashing
- Photo/video clip recording during entry/exit
- Tracking of a person based on his access
- Graphical location maps
- Can be integrated with Fire Alarm & PA Systems
- Tail Gating alert/alarm.

The first phase of this project is expected to be getting completed by June, 2016.

State-of-the-art Studio

IIRS is in process of setting up a state-of-art education studio to meet the growing requirements of online training and capacity

building in the country. At present 300+ academic institutions in India are connected to receive live and interactive classrooms from IIRS. The existing studio facility was setup in year 2007 with bare minimum infrastructure on experimental basis.

The existing studio is capable to generate digital education contents and transmission of live and interactive classroom session in low bit rates using analogue technology. The proposed studio will be based on digital technology which will facilitate to generate high quality digital contents and transmission of online education materials to the participants. The new studio will have advanced technologies like robotic controlled HD Cameras, Chroma Background feature, sensitive microphones and Optical Disc-Based Data Archive System, etc. With sustained growth and demand for the outreach program, IIRS is in the process of establishing new start-of-the-art studio cum classroom which will serve for the following purposes:

- Conducting theme specific customised courses for user departments and ministries
- Addressing students of IIRS as well as outreach program participants, simultaneously,
- Broadcasting popular talks from eminent persons and received across many centres,
- Developing the Digital Content Materials for students and other working professionals.

IIRS Management Council

Chairman	Director, National Remote Sensing Centre (NRSC), ISRO, Hyderabad.
Alternate Chairman	Director, Space Applications Centre (SAC), ISRO Ahmedabad.
Members	Additional Secretary, Department of Space, ISRO Headquarters, Bangalore.
	Director, Indian Institute of Space Science and Technology (IIST) , Department of Space, Thiruvananthapuram.
	Scientific Secretary, ISRO, Bangalore.
	Director, Earth Observation System (EOS) Programme Office, ISRO Headquarters, Bangalore.
Member-Secretary	Director, Indian Institute of Remote Sensing, ISRO, Dehradun

IIRS Academic Council

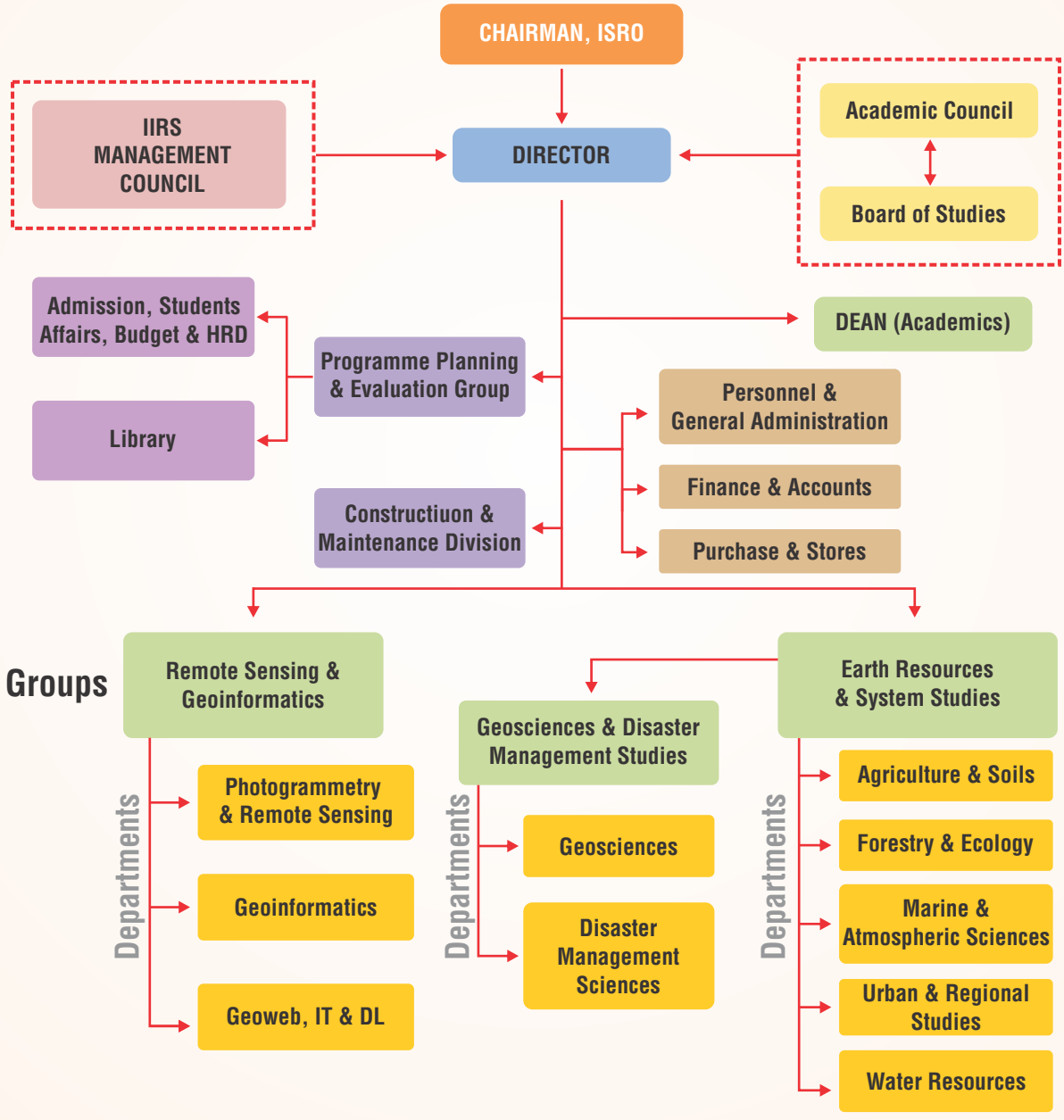
Chairman	Director, IIRS
Members	Shri V.Raghu Venkataraman, ANTRIX, ISRO HQ, Bangalore
	Dr. M.V.R. Sesha Sai, NRSC, ISRO, Hyderabad
	Dr. J. Krishnamurthy, ISRO HQ, Bangalore
	Dr. A. Chandrasekhar, IIST, Thiruvananthapuram
	Shri D. Dhar, SAC, ISRO, Ahmedabad.
	Vice Chancellor, Andhra University, Visakhapatnam
Special Invitees	Dr. I.V. Muralikrishna, Distinguished Fellow, DRDO
	Dr. P.K. Garg, Uttarakhand Technical University, Dehradun
	Dr. S. Sanjeevi, Anna University, Chennai
	Dr. Subashis Dutta, IIT, Guwahati
Member-Secretary	Dean (Academics), IIRS, ISRO, Dehradun.

IIRS Board of Studies

Chairman	Dean (Academics) IIRS, ISRO, Dehradun
Members	Prof. S.K. Ghosh, Indian Institute of Technology, Kharagpur
	Dr. S. S. Sarkar, Space Applications Centre, ISRO, Ahmedabad
	Dr. S. Natarajan, PES University, Bangalore
	Chairman, BoS, Geo-Engineering Department, AU, Vishakapatnam
	Dr. Rama Rao,IIST, Thiruvananthapuram
	Dr. P.V.Radha Devi, ADRIN, Hyderabad
	Dr. K.Venugopala Rao, NRSC, Hyderabad
	Dr. C.Jaganathan, BITS, Ranchi
	Group Head, PPEG, IIRS
Member-Secretary	Course Director (M.Tech), Indian Institute of Remote Sensing, ISRO, Dehradun

IIRS Organisational Set-up

The broad setup and the organization of the IIRS may be pictorially represented as follows:



Vision

"Achieve excellence and remain in the forefront for capacity building in Remote Sensing & Geoinformatics and their applications"

Mission

"Transfer technology through capacity building and research in the field of Remote Sensing and Geoinformatics for sustainable development"

iirs

Indian Institute of Remote Sensing

Indian Space Research Organisation

Department of Space, Govt. of India

Dehradun

www.iirs.gov.in