वार्षिक रिपोर्ट
ANNUAL REPORT
2024-2025

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

Annual Report
2024-2025

Indian Institute of Remote Sensing
Indian Space Research Organisation
Dept. of Space, Govt. of India
Dehradun

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Highlights of Activities & Achievements of IIRS

Since its establishment in 1966, Indian Institute of Remote Sensing (IIRS), a unit of Indian Space Research Organisation (ISRO), Govt. of India has been a key player for training and capacity building in geospatial technology including Remote Sensing (RS), Geographical Information System (GIS) & its applications through training, education and research in India as well for geospatial scholars/ professionals from other parts of the world. The training, education and capacity building programmes of the Institute are designed to meet the requirements of professionals at working levels, fresh graduates, researchers, academia, and decision makers. As an integral part of capacity building, the Institute undertakes applied research in RS & GIS related science, technology and applications and also participate in various research programmes of ISRO.

The Institute also hosts and conduct 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.

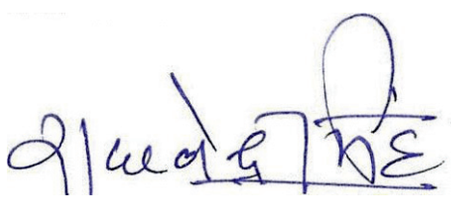
During Financial Year (FY): 2024-25, a total of 1136 participants have benefited from regular training, educational programmes (PG Diploma, M.Sc., sponsored, certificate programme, etc.) and special courses as part of capacity building activities. In addition to regular training programmes, the customized special courses were organized for various target groups.

IIRS distance learning programmes - both Live and Interactive classroom and Online e-learning programme have significantly contributed in the mass capacity building activity of the Institute. Under IIRS outreach programme, several modules of Learning Management Systems (LMS) for various certificate courses in geospatial technology were developed.

IIRS is involved in a number of research projects of ISRO/ DOS such as Earth Observation Application Mission, Disaster Management Support, Climate and Atmospheric Programme (ISRO-GBP) and other Mission Projects. In addition to these ISRO/ DOS projects, IIRS faculty have significantly contributed in the research activity through ongoing TDPs and other in-house research projects. Various research papers were published in peer reviewed international and national journals.

The IIRS Academia Meet (IAM-2025) on theme 'Exploring Himalaya: EO Perspectives and Insights' was also held on March 21, 2025 at IIRS. There were more than 200 participants from various academic institutions, government departments, industries from all over India besides faculty and student participants from IIRS.

I am thankful to Dr. V. Narayanan, Chairman, ISRO for his continuous support and guidance on various initiatives and endeavours of IIRS.



Dr. Raghavendra Pratap Singh

Director, IIRS

IIRS Profile

Indian Institute of Remote Sensing (IIRS) 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:

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 endeavor 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 Department under Central & State governments.

To widen its outreach, IIRS has started live and interactive distance learning programme (DLP) in 2007. Further, graduate and postgraduate students from universities spread across the country have also benefitted through EDUSAT based distance learning programmes being offered by the Institute till date.

Efforts are underway to develop the e-learning content (also in Hindi) for various RS 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 also. 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 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. Currently, microwave, hyperspectral and high-resolution EO data processing and their applications is the main research focus.

Various state-of-the-art laboratories, field-based instrumentations and observatories networks help meeting the research goals and objectives.

Brief summary of Managerial committees and Organisation chart with details about groups, Departments, etc. are also listed from Page 88 onwards. However, for further details please visit IIRS website at https://www.iirs.gov.in

ACADEMIC & CAPACITY BUILDING PROGRAMMES

The Institute organises about 35-40 courses every year and it has trained 15639 professionals (till March, 2025), including 1665 professionals from abroad representing 115 countries mainly from the Asia, Africa and South America. 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 Big Geodata Processing (03), Cloud Computing using GEE for Spatio-Temporal Data Analysis (10), Training for-Middle Management Officers of the Indian Audit and Account Department (19), Geoinformatics for Field Foresters (46), Remote Sensing & GIS for Environmental Studies (87), ISRO- sponsored NNRMS Course on RS & GIS Technology and Applications (55), One-week orientation course for IFS Officers on Application of Technology in Forestry (115), Open Source GIS Technologies (Skill Development programme in Hybrid Mode) (15), High Resolution Data Analysis for Automated Feature Extraction (12), Remote Sensing and GIS for Agriculture Informatics (ITEC) (20), Remote Sensing and GIS Applications in Agricultural Water Management (12), Geospatial Applications for Atmospheric & Oceanic Hazards (09), Remote Sensing-An Overview for Decision Makers (24), UAV Remote Sensing and its Application (11), Structured Training Programme (STP) – 2024 on Advances in satellite Radar imaging (28), Geospatial Technology Applications in Hydrology (ITEC) (Tanzania-25), SAR Remote Sensing Technolo-gies and its Applications (19), Advanced SAR Data Processing for Ground Surface Movement (25), NSSTA sponsored special course on Applications of Remote Sensing for Disaster Management (24) Applications of Remote Sensing for Disaster Management (22), Remote Sensing Data Analytics in Agriculture (17), Applications of Remote Sensing and GIS in DRR (26), Remote Sensing & GIS in Digital Soil Mapping (20), Hyperspectral and Microwave Remote Sensing for Terrestrial and Planetary Geological Studies (25), Advance Remote Sensing & GIS and its Application in Water Resources (20), BigAI for BigGIS (28), Training Course for NASRDA Officials (25), Applications of Remote Sensing and GIS in Disaster Risk Reduction (25), Geospatial Inputs for Enabling Master Plan Formulation under AMRUT 2.0 Sub-scheme(25), Advance Remote Sensing & GIS and its Application in Water Resources (18), Remote Sensing of Geological Hazard (ITEC) (12), Applications of Remote Sensing and GIS in DRR (10), Geospatial Inputs for Enabling Master Plan Formulation under AMRUT 2.0 Sub-scheme (17), DMSP sponsored special course on Remote Sensing of Geological Hazards (18), Short Course on Remote Sensing and Image Analysis (CRS) (17), Applications of Remote Sensing and GIS in Disaster Risk Reduction (16), Advance Remote Sensing (Spatial Analysis using AI/ML/DL) (Bhutan Officials) (16), Spatial Data Analysis and Mobile Based Field Data Collection (Bhutan Officials) (20), Remote Sensing and GIS Applications for Agricultural Resource Mapping (25), etc.

Summarized details are tabulated on the next page.

Students passed-out in the year 2024-25

Year	Regular Programme								Special Programme	Total
	PG Diploma*	NNRMS	M. Tech. **	M. Sc ***	M.Sc. (Agr) (DAIICT)	PGD GI	Decision Maker	Certificate (CRS)		
2024-25	26	55	53 +4$^{\$}$= 57	7	27	7	24	17	916	1136

*Completion batch: * PG Diploma (2023-24) **M.Tech (2022-24) $ M.Tech (2021-23) *** M.Sc (2022-24)*

Summarized-details of the courses organised during the year 2024-25

S.No.	Course Title	Course Duration	Course Period		No. of Participants
			From	To	
1.	Big geodata processing	6 Weeks	04-03-2024	12-04-2024	03
2.	Cloud computing using GEE for Spatio-Temporal data analysis	1 Week	29-04-2024	03-05-2024	10
3.	Training for-Middle Management Officers of the Indian Audit And Account Department	3 Days	06-05-2024	08-05-2024	19
4.	YUva VIgyani KAryakram (ISRO Hqs' registered – Yuvika)	2 Weeks	13-05-2024	24-05-2024	51
5.	Geoinformatics for field foresters	1 Week	10-06-2024	14-06-2024	46
6.	Remote Sensing & GIS for environmental studies	1 Week	10-06-2024	14-06-2024	87
7.	One-week orientation course for IFS officers on 'Application of technology in forestry'	1 Week	08-07-2024	12-07-2024	115
8.	Open-source GIS technologies (Skill development programme in hybrid mode)	2 Weeks	15-07-2024	26-07-2024	15
9.	High resolution data analysis for automated feature extraction	1 Week	22-07-2024	26-07-2024	12
10.	RS and GIS for agriculture informatics (ITEC)	2 Weeks	29-07-2024	23-08-2024	20
11.	RS and GIS applications in Agricultural Water Management	2 Weeks	19-08-2024	30-08-2024	12
12.	Geospatial applications for Atmospheric & Oceanic Hazards	1 Week	09-09-2024	13-09-2024	09
13.	UAV Remote Sensing and its Application	1 Week	23-09-2024	27-09-2024	11
14.	Structured Training Programme (STP) – 2024 on 'Advances in satellite RADAR imaging'	1 Week	23-09-2024	27-09-2024	28
15.	Geospatial technology applications in hydrology (ITEC)	2 Weeks	07-10-2024	18-10-2024	25
16.	SAR Remote Sensing technologies and its applications	3 Weeks	07-10-2024	25-10-2024	19
17.	Advanced SAR Data Processing for Ground Surface Movement	2 Weeks	14-10-2024	25-10-2024	25
18.	Applications of Remote Sensing for Disaster Management (NSSTA sponsored)	1 Week	04-11-2024	08-11-2024	24
19.	Applications of Remote Sensing for Disaster Management (NSSTA sponsored)	1 Week	18-11-2024	22-11-2024	22
20.	Remote Sensing data analytics in agriculture	2 Weeks	18-11-2024	29-11-2024	17
21.	Applications of Remote Sensing and GIS in DRR	2 Days	02-12-2024	03-12-2024	26
22.	Remote Sensing & GIS in digital soil mapping	2 Weeks	02-12-2024	13-12-2024	20
23.	Hyperspectral and microwave Remote Sensing for terrestrial and planetary geological studies	2 Weeks	09-12-2024	20-12-2024	25
24.	Advance RS & GIS and its Application in Water Resources	2 Weeks	09-12-2024	20-12-2024	20
25.	BigAI for BigGIS	1 Week	16-12-2024	20-12-2024	28
26.	Applications of RS and GIS in Disaster Risk Reduction	2 Weeks	06-01-2025	17-01-2025	25
27.	Advances in satellite image analysis & SAR data processing' for NASRDA officials	2 Weeks	06-01-2025	17-01-2025	25
28.	Geospatial Inputs for Enabling Master Plan Formulation under AMRUT 2.0 Sub-scheme	2 Weeks	20-01-2025	31-01-2025	25
29.	Advance RS & GIS and its application in Water Resources	2 Weeks	20-01-2025	31-01-2025	18
30.	Remote Sensing of geological hazard (ITEC)	2 Weeks	03-02-2025	14-02-2025	12
31.	Applications of RS and GIS in DRR	2 Days	10-02-2025	11-02-2025	10
32.	Geospatial inputs for enabling master plan formulation under AMRUT 2.0 Sub-scheme	1 Week	10-02-2025	14-02-2025	17
33.	DMSP sponsored special course on Remote Sensing of Geological Hazards	2 Weeks	03-02-2025	14-02-2025	18
34.	Applications of RS and GIS in Disaster Risk Reduction	2 Weeks	24-02-2025	07-03-2025	16
35.	Advance RS (spatial analysis using AI/ML/DL) (Bhutan Officials)	2 Weeks	03-03-2025	14-03-2025	16
36.	Spatial data analysis and mobile based field data collection (Bhutan Officials)	2 Weeks	17-03-2025	28-03-2025	20
37.	RS and GIS applications for agricultural resource mapping	1 Week	17-03-2025	22-03-2025	25
				Total	916

EDUCATION PROGRAMMES

M.Tech. Programme in (RS & GIS)

M. Tech. in Remote Sensing & Geographical Information Systems (RS & GIS) is a two-year course and this year M.Tech. students from (2023-25) batch are in final stages of completion of their dissertation.

The breakups of the 56 participants across disciplines are as follows: Agriculture & Soils (05), Forest Resources & Ecosystem Analysis (08) Geoinformatics (06), Geosciences (04), Marine and Atmospheric Science (06), Natural Hazards & Disaster Risk Management (08) Satellite Image Analysis & Photogrammetry (07), Urban & Regional Studies (05) and Water Resources (07). Project Topics for the batch of M.Tech 2023-25 may be enlisted as follows.

Project Topics

- Integrated Approach for Analysing Multiparametric EO and in-situ data for detection of early signature of Earthquake precursors in the Himalayan Belt.
- Sensitivity analysis of different land surface models coupled to WRF for the simulation of extreme rainfall events over NWH region.
- Evaluating Effectiveness of Transfer Learning Approach using ML/DL Models for Poppy/Aromatic Crop Mapping.
- Automatic Change Detection on Multi-Sensor Remote Sensing Data through Deep Learning.
- Impact of fire on carbon flux in north-western Himalaya.
- Crop Biomass assessment Using PolSAR and InSAR Technique with Multisource RS (EOS-04 and others
- Assessing influence of environmental variability on spatial patterns of Western Himalayan alpine plant diversity using field inventory and Earth Observation data.
- Simulating Urban Heating Parameters Using Machine Learning.
- Assessment of Coastal Compound Flooding using Coupled Hydrodynamic Modelling Technique.
- Impact assessment of ATMS data assimilation on Tropical Cyclone forecasting using Hybrid 3D-EnVar technique.
- Assessing multi-dimensional functional diversity of subtropical forests using Remote Sensing & Machine Learning.
- Study on the pCO2 and Air-Sea CO2 flux variability over the Tropical Indian Ocean.
- Assessment of debris cover impact on glacier-glacier lake dynamics & glacier hazards in Indian Himalaya.
- Modelling the Impact of Climate Change and Urban Expansion on Water Balance.
- Carbon Chronicles: Unravelling the Spatial and Temporal Dynamics of Son beel Wetland, Assam.
- Large scale mapping, slope stability characterization and predictive modelling of selected most vulnerable landslides of Northeast part of Kerala.
- Building Extraction from Multispectral Images using Deep Learning and Generative AI.
- Estimation of PM2.5 from satellite data using ML.
- Integration of laser derived digital bathymetric elevation model (DBEM) in hydrodynamic model.
- Source Apportionment Study of Criteria Air Pollutants in Agra Airshed.
- Multi-hazard susceptibility spatial decision analysis using Generative AI based Large Language Model (LLM) for disaster prone areas in Uttarakhand.
- Comparitive Analysis of Various Algorithms for Downscaling Rainfall data for Uttarakhand.
- Deep Learning Based Semantic Segmentation of Point Cloud for Historic Building Information Modelling.
- Persistent Scatterer Interferometry SAR-Based Urban Land Subsidence Analysis.

- Geospatial Modeling for Land Suitability Analysis of Medicinal and Horticultural Crops using Machine Learning.
- Development of methodological framework for analyzing polarimetric distortions in EOS-04, ISRO, ASAR data.
- Integration of ML-derived Water Quality Parameters in Hydrodynamic Model for Water Quality Assessment.
- Diurnal and Seasonal variability of SIF, GPP, and VIs in Tropical Forest using CliMA ESM & ML Based Satellite Data Fusion for SIF estimation.
- Synergistic use of Multi-Sensor Data for Damage Detection in Heritage Structures using Deep Leaning Method.
- Forest Disturbance and Biomass Mapping Using Earth Observation Data.
- Simulation of extreme weather events using Urban Morphology Parameters in WRF Model.
- Understanding the effect of basin storage & irrigation on hydrological regime of a river basin.
- Integrating Earth Observation based data for Spatial Urban Biodiversity Assessment.
- A Serverless Approach to a Scalable Geospatial Healthcare Web-based Application.
- Gaseous air pollutants over Northern India: Investigation using in-situ Observations, satellite Data and chemistry transport modelling
- Modelling for soil erosion risk using remote sensing data and machine learning methods.
- Large scale mapping, slope stability characterization and Modelling for soil erosion risk using remote sensing data and machine learning methods.
- Analysis of early Noachian period selected olivine bearing exposures on mars using high resolution data sets and machine learning approach.
- Quantifying Irrigation Water Requirement for Irrigation Decision Support System using Machine Learning Algorithms, Remote Sensing and ET station.
- Mining-Induced Geo-Environmental Hazards in Parts of Raniganj Coal Field Area: A Remote Sensing Based Endeavour.
- Coupled usage of Remote Sensing based mapping, predictive modelling/simulation and analysis of conditioning/triggering mechanisms of landslide initiation in parts of J&K: Lessons learnt and future mitigation.
- Assessment of Quantum algorithms with Classical algorithms for EO data feature extraction.
- Forest canopy parameter monitoring using radiative transfer model and machine learning.
- Modelling and Retrieval of Atmospheric Trace gases in Terahertz frequency.
- Coastal vulnerability assessment and mapping of heavy minerals along selected coastal tracts of Kerala using multi-spectral and hyperspectral data
- Quantifying the Effects of Shifting Cultivation on Forest Carbon Dynamics through Integration of EO Data and Advanced Carbon Accounting in Nagaland.
- Wind fields prediction using ML models with GNSS RO observations.
- Reservoir Inflow Forecasting at Different Temporal Scale and Its Impact on Reservoir Operation.
- Assessing Glacial Lake Bathymetry and potential impact of GLOF using satellite observations and Hydrodynamic modelling.
- InSAR based Infrastructural Health monitoring of Sardar Sarovar Dam, Gujarat.
- Active and Old floodplain delineation using Remote Sensing, Geophysical survey and Modelling approach.
- Assessing potential of high-resolution satellite/UAV data for crop monitoring at field scale.
- Study of Shoreline Change & Sea Level Budget Analysis: A Case Study for the East Coast of India
- Quantification of Dominant hydrological processes in Glaciated and Non-Glaciated watersheds using Remote Sensing and Hydro-glaciological Modeling
- Long-Term Spatio-Temporal Assessment of Thermal Comfort Zonation of India.
- Degradation in Glacial Lake Dynamics.

M.Sc. Agriculture Analytics (Joint program of DA-IICT-IIRS-AAU)

IIRS conducted second semester of joint M. Sc. (Agricultural Analytics) program of Dhirubhai Ambani Institute of Information & Communication Technology (DA-IICT), Gandhinagar, Indian Institute of Remote Sensing (IIRS), Dehradun and Anand Agricultural University (AAU), Anand in partnership mode of education vide MoU dated November 29, 2021 and MoA dated December 23, 2022.The second batch of twenty-seven students joined IIRS in second semester in January 2024 and completed in April 2024. The third batch of twelve students have also joined IIRS on January 06, 2025 and envisaged to complete their second semester in May 05, 2025.

During the study period at IIRS, entire Semester module had a 16 credits course with four core subjects such as Geo-data processing & Python Programing, Machine Learning, Spatial Data modeling and geostatistics and Big-data Analytics supplemented with specialized module of one-week duration on Agriculture Analytics. Finally, the participants underwent rigorous evaluation in form of internal and end-semester examination. They also did a pilot project work in 21 days' time on advanced topics of applications in agriculture analytics. Feedback by students reveals that this course structure will help them in getting job in emerging digital industries and start-up. More than 90% students are satisfied with academic exposure, the hospitality and stay.

Master of Science in Geoinformation Science and Earth Observation

The Master of Science (M.Sc.) in Geoinformation Science and Earth Observation (specialization/ domain: Geoinformatics) is offered within the framework of Joint Education Programme (JEP) of the IIRS and the faculty of Geo-information Science and Earth Observation (ITC) of the University of Twente (UT), The Netherlands. Students follow part of the course at IIRS and another part at the Faculty ITC, The Netherlands. Students undergo research work under joint supervision of IIRS & ITC scientist/faculty. This course is targeted for those who are interested to learn remote sensing and GIS technologies and their applications. Three M. Sc. Students joined for 2024-2026 batch and are undergoing required course work for this programme at IIRS-ITC. Seven M. Sc students of (2023-2025) batch are working on dissertation under IIRS-ITC Joint Education Programme (JEP) as per following:

- Spatio-temporal Dynamics of Soil Attributes and Predictive Mapping in Kuttanad, Kerala Using Random Forest and Remote Sensing Techniques
- Deep Learning Modelling for Aboveground Biomass and Forest Height Retrieval.
- Urban Flood Risk Assessment for Mumbai using Multi-criteria Decision Analysis and Machine Learning techniques
- Multi-Hazard Modelling and Prediction for Periyar Basin, Kerala Using ML Methods and SHAP XAI
- Natural Language Interface for spatial SQL interact with spatial database using large language Model (LLM)
- InSAR Analysis for linear infrastructure deformation: A case study of Medigadda Barrage
- Deep Learning based Detection of Fishing Vessels and Illegal Fishing Monitoring using Nightlight images

TRAINING PROGRAMMES

Post Graduate Diploma programme in (RS & GIS)

Post Graduate Diploma in Remote Sensing and Geographic Information Systems (RS & GIS) is approximately one-year course wherein 26 students completed this year while 56 participants were selected to join the course. The participants across disciplines are as follows: Agriculture & Soils (4), Forest Resources & Ecosystem Analysis (09), Spatial Data Science (06), Geosciences (10), Marine and Atmospheric Science (05) Natural Hazards & Disaster Risk Management (07) Satellite Image Analysis & Photogrammetry (04), Urban & Regional Studies (01) and Water Resources (10). The Orientation programme for the P.G. Diploma batch was organized in August 06, 2024 at IIRS Campus. Semester-I of P.G. Diploma was completed in December, 2024.The thematic classes and final examinations in four subjects will be completed in second semester by mid of April, 2025 and henceforth all students will be pursuing PGD projects in their respective Departments.

Post Graduate Diploma in Geoinformation Science and Earth Observation

Post Graduate Diploma (PGD) in Geoinformation Science and Earth Observation (specialization: Geoinformatics) is offered within the framework of Joint Education Programme a (JEP) of the IIRS and the Faculty of Geo-information Science and Earth Observation (ITC) of the University of Twente (UT), The Netherlands. Students follow the course at IIRS. Upon successful completion of the course, students receive a diploma certificate from UT-ITC. This course is targeted for those who are interested to learn remote sensing & GIS technologies and their applications. Both the working professionals and fresh graduates (including candidates in the final semester/year) can apply for the course. This year seven students from PGD (2023 - 24) successfully completed the course while three students joined for PGD (2024-25) batch.

ISRO sponsored NNRMS faculty development program in Remote Sensing & GIS Technology and Applications

The NNRMS programme of eight weeks duration was attended by 55 officials from different academic institutions and Govt. organizations across length and breadth of country during May 13, 2024 to July 05, 2024. Out of the 55 participants; 44 were from academic institutes and 11 were from scientific institutes. The main objective of this programme was to train the university/ college teachers in RS & GIS technology and applications, so that they can further spread skills & knowledge in their universities/ colleges. The training programme was offered in ten different themes in RS & GIS technology and application domains viz., GIS Technology & Big Data Analytics, Image Analysis & Terrain Modelling, RS & GIS Applications in Agriculture & Soil Studies, RS & GIS Applications in Atmospheric and Ocean Studies, RS & GIS Applications in Earth and Planetary Studies, RS & GIS Applications in Forest and Ecosystem Studies, RS & GIS Applications in Urban & Regional Studies, RS & GIS Applications in Water Resources Studies, Disaster and Climate Change Studies.

Remote Sensing: An overview for Decision Makers

The 'Remote Sensing: An overview for Decision Makers' training program, was organized during September 10-14, 2024.

The course emphasized natural resource management, environmental monitoring, and disaster management, focusing on enhancing the technical skills of participants in these areas. The 24 participants included officials from IAS, IFS, State Civil Services, and senior town planners, along with senior scientists and academicians from various research and academic institutions. The course content was designed to provide a comprehensive overview of RS, GNSS & GIS technologies and their applications in various domains, aligning with the course objectives. IIRS prepared an e-book titled 'Overview of RS&GIS Applications' for distribution to the participants, which included 14 chapters covering geospatial technology, applications, and case studies related to governance and development.

A field visit to Mussoorie was also organized to demonstrate the potential of satellite data and correlation of various features as observed on image and as they exist on ground along with an exercise of geo-data collection using mobile app based crowdsourcing approach. The course concluded on Sep. 14, 2024 with a valedictory function where Sh. V.R. Tiwari, IFS, Director WII, Dehradun was chief guest of the function.

Remote Sensing and GIS for Agriculture Informatics (ITEC)

The prime objective of this special course was to strengthen capacity building of Kenyan official on RS&GIS applications in Agricultural Informatics. Considering the needs of Kenyan government and feasibility of sharing knowledge and practical skills, this course was designed with flavour of both core aspects of remote sensing for agriculture and geodatabase services cum Geo-portals creation. This four-week course was organized during July 29, 2024 till August 23, 2024 with 20 officials. These lectures were mainly delivered in coordination of IIRS & NRSC. Special focus was given on Advanced data analytics, Geo-web services, Google Earth Engine applications and open-source data for agricultural monitoring. During the course study tours cum field visits were also conducted. Participants got opportunity to visit educational & tourism destination in Dehradun like Buddhist temple & FRI besides western Doon valley – Selaqui & Vikasnagar, wherein they were briefed about agricultural practices and crops in Doon valley region. They were also apprised about correlating satellite images with different crop types and demonstrated instruments for measurement of leaf area index and soil moisture. Last week of this course was specifically assigned to execute case study project work for self-learning by participants in group manner to explore RS for agricultural applications. Five groups each of four participants, were made to carry out pilot project.

Geospatial Technology applications in Hydrology (ITEC)

A two weeks course on 'Geospatial technology applications in hydrology' was organized by IIRS during October 07-18, 2024 wherein 25 participants from Tanzania participated in the course. The participants were exposed to basics of Remote Sensing & GIS in the first two days of the course. Subsequently they were taught the application of geospatial technology as a whole in hydrology and water resources. Many of the practicals demonstrated to the participants, emphasized on the data of their own country. Under their cultural and educational tour, the course the participants visited Haridwar and Roorkee, wherein they witnessed the irrigation infrastructure like aqueduct, super-passage, canal syphone and Bhimgauda barrage; and also, they also witnessed the Indian cultural values at 'Har ki Pauri' at Haridwar. The lectures were mostly conducted by the IIRS faculty and one guest lecture from ISRO Hqs was also organized. The course was highly appreciated by the participants.

Remote Sensing of Geological Hazard (ITEC)

The two weeks offline special course for ITEC sponsored candidates titled 'Remote Sensing for Geological Hazards' was organized during Feb. 03, 2025 till Feb. 14, 2025 wherein 12 participants from ITEC countries (2 each from Ghana and Morocco; 4 from Ethiopia; & 1 from Kazakhstan, Nigeria, Ecuador and Myanmar) joined the course. The course content was planned in a way that it provided first overview of remote sensing and image-processing techniques followed by specialized lectures in the field of landslide, earthquake, cryospheric, volcanic and mining induced hazards and other surface deformation.

The first week of the course primarily focused on overview of Earth Observation systems and applications and geological hazards, mapping, monitoring of geological hazard with emphasis on landslides, rainfall threshold and landslide initiation; numerical modeling and simulation, Image interpretation techniques for geological feature extraction and Advanced digital topographical and image segmentation techniques in geological applications, Monitoring volcanic eruptions, Microwave/ Thermal Remote Sensing for surface deformation with emphasis on crustal deformation, mining and land subsidence, Application of geophysical techniques for geological hazards, Application of geophysical and geodetic techniques for crustal deformation and earthquake precursor studies. Two very important and relevant guest lectures were also delivered by Dr. JR Kayal, retried Dy. DG (GSI) on '100 years of seismology in India: Seismic hazards & risk' and Dr. Saibal Ghosh, Dy. DG (GSI) on 'Landslide assessment and Early Warning system (LEWS) inclusive of a brief of how landslides are being tackled in India by GSI'.

Practical and demonstration were conducted in afternoon hours daily for providing hand-on experience on various aspects related to geological hazard. The last week of the course was allocated to carry out pilot project by participants to understand & practice RS&GIS applications in dealing with geological hazards. Six groups, were made to carry out pilot project on various topics.

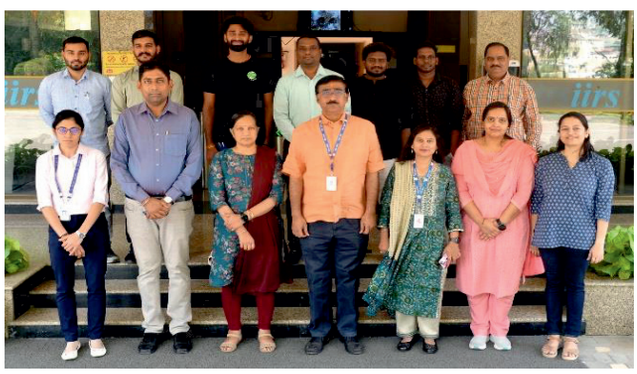
SPECIAL & CUSTOMISED TRAINING PROGRAMMES

Big Geodata Processing

The six weeks course was organized during March 04, 2024 to April 12, 2024 wherein three officials from Tamil Naidu Forest Department comprising of two IFS officers from Chennai and one forester from Villupuram attended the course. Mr. Sourish Kar, ESRI India Technologies Private Limited also delivered a lecture titled 'Advances in big geospatial data handling and future trends' on April 02, 2024.

Cloud Computing Using GEE for Spatio-Temporal Data Analysis

One-week short course was organized during April 29, 2024 to May 03, 2024 wherein ten participants attended the course. The course was targeted at students, faculty, researchers, consultants, policy analysts and working officials of Geoinformatics discipline. The lectures covered varied topics and concepts related to Remote Sensing, Digital Image Processing, overview of geospatial technology, spatial reference systems, GIS databases, data model, file formats, hardware and software requirement of GIS, GIS data creation, querying GIS databases, performing spatial analysis, network analysis, concepts of map making/ visualization, etc. Participants were also introduced to concepts of GIS data quality. The lectures delivered were also supported by videos & demos.



Training for Middle Officers of the Indian Audit and Management Account Department

The development of the capacities, skills and knowledge of officers from the Indian Audit and Accounts Services in spatial technologies, are pre-requisites for the implementation of geospatial technology in this area. Use of GIS & Remote Sensing in Audit could organize and present spatial data in a way that allows effective management of audit planning & other audit processes. With this background, IIRS in collaboration with Centre for Data Management and Analytics, New Delhi proposed to organize a three days exposure training for Middle Management Officers of the Indian Audit and Account Department. The programme was conducted during May 06 -08, 2024 with 19 officers from various states of country. The participants were given an

overview of Geospatial technology and tools covering basic topics like RS & GIS technology, Image analysis and also included a flavour of emerging technologies such as advanced data analytics, Artificial Intelligence in resource monitoring and assessment. The lectures were followed by practical demonstrations and hands on exercises on the few topics. The content also included case examples demonstrating utility of geospatial data and tools for applications in assessing forest and agriculture resources, water resources, environmental pollution, urban land use mapping and change detection and disaster management.

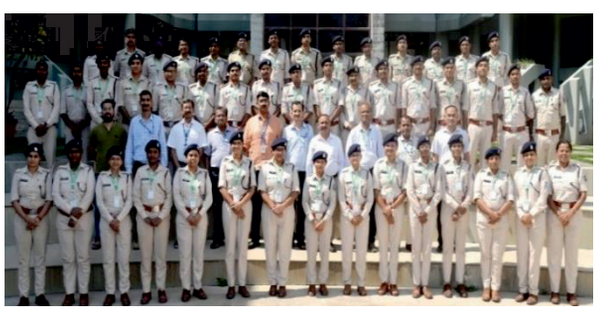
'YUva VIgyani KAryakram', YUVIKA – 2024

IIRS conducted a two-week Yuva Vigyani Karyakram (Yuvika) programme for school children to impart basic knowledge on Space Technology, Space Science and Space Applications during May 13-24, 2024. ISRO has chalked out this programme to ignite the young minds. The programme aims to encourage younger students to pursue career in space science and technology. A total of 352 participants studying in class IX and X were selected for the programme by ISRO out of which 51 students from four states (Delhi, Himachal Pradesh, Uttarakhand and Punjab) and two union territories (Jammu & Kashmir and Ladakh) joined programme at IIRS. The course was simultaneously conducted at seven ISRO centres throughout the country. A two-week exhaustive schedule consisting of lectures, practical sessions were conducted. The programme contents included topics related to Space Science, Indian Space programme, ISRO planetary missions and Applications of space technology and Drone technology. The hands-on experiment sessions included preparation and launch of water rocket, model rocket, seismograph, rubber-band car, wooden DIY kit, sky gazing and wireless rover. Apart from academic activities, extracurricular activities such as Yoga, Outdoor/Indoor sports, swimming, bird watching and cultural activities were also included in the curriculum. To sensitize the participants about geology, ecology, and science, a trek in lower Himalayas and visits to Forest Research Institute and Vigyan Dham were also conducted.

Geoinformatics for Field Foresters

The one-week training course for Range Forest Officer (RFO) trainees of Odisha Forest Rangers' College, Angul on 'Geoinformatics for field foresters' was organised during June 10-14, 2024 wherein 46 RFOs from Chhattisgarh state attended the course. The target of the course was to sensitize the course participants to the basic concepts of RS, GIS, and GNSS technology and how it can be used for the effective management of forests and its resources. Exposure to different satellite data and their sources, creation, and handling of different geospatial data using different software was demonstrated to enable the RFO trainees to harness the potential of geospatial

technology in their field. Twelve (12) lectures on diverse topics including basic of RS, GIS, and GNSSS; Mapping of vegetation type; Sampling design consideration for plant diversity, phytomass, and NTFPs inventory; Forest growing stock, biomass and carbon mapping; Soil and water conservation planning of forest; Forest fire vulnerability, monitoring and impact assessment; Wildlife habitat suitability; Geoportals and database in support of forestry sector schemes were delivered during the training programme. Guest faculty were invited to deliver lectures on special topics during the one-week training. Practical demonstrations were also a core component of the training programme. A total of 13 practical sessions were conducted during the course including Basic GIS operations of vector and raster layers; Digital stratification of forest type and density; Topographical analysis of forested watersheds; Ecological niche modelling of RET species; Multicriteria geospatial modelling for wildlife habitat suitability and forest survey using DGPS.



Remote Sensing & GIS for Environmental Studies

IIRS has been conducting this special course on 'Remote Sensing & GIS for environmental studies' for school students from 10th to 12th standard. The aim of the course is to create an awareness about Space technology & its use for the study of earth and its environment among the school students. This year, the course was organized during June 10 - 14, 2024 wherein 87 students from 45 different schools of Dehradun participated in the course (28 were outstation from other parts of the country). The focus of the course was on the Space technology and its applications for environmental studies. Broad subjects covered in the lectures were: Benefits of Space Science to Mankind, ISRO Launch vehicles and satellites, Physics behind the Rockets and satellites, Gaganyaan, Earth's moon and its exploration, Mars and its exploration, Life beyond Earth, RS & GIS applications in geological studies, hydrology, agriculture, soils, atmosphere, urban and coastal studies. Practical demonstrations were also arranged to familiarize the students with various satellite data portals. There were also demonstrations on Water Rocket, Model Rocket making and Launch, and Assembling the Wireless Rover. A visit to Space Exhibition was also the part of the programme.

Open-Source GIS Technologies

(Skill development programme in Hybrid Mode)

The short course on 'Open-source GIS Technologies (Skill Development programme in Hybrid Mode)' of two weeks' duration was attended by 15 officials during July 15-26, 2024. The skill development program took place online from July 15 to 19, 2024, featuring 15 lecture sessions covering various aspects of open-source GIS. Subsequently, a series of 10 full-day practical sessions were conducted at IIRS from July 22 to 26, 2024.

The primary aim of this two-week training program was to raise awareness among users, researchers, professionals, decision-makers, and academicians regarding geospatial technology in the context of open-source GIS and web GIS environments. Participants gained familiarity with different geo-spatial data processing techniques (both vector and raster) using open-source GIS software. They also learned about Geo-RDBMS concepts, open geodata repositories, and the principles of geo web services necessary for developing generic geo web portals. The course was designed to enable participants to explore GIS customization within an open-source environment through programming concepts. It included both theoretical and hands-on sessions to promote comprehensive learning.

High Resolution Data Analysis for Automated Feature Extraction

The program on High resolution data analysis of one-week duration was organized during July 22 - 26, 2024 with 12 participants wherein nine participants were government sponsored candidates (02-SoI, 03-FSI, 02-TFRI, Jabalpur and 02- cabinet Secretariat) and three self-sponsored candidates. The participants have been given an overview of Geospatial technology and tools, methods for high resolution data analysis like image segmentation etc, UAV data analysis, and HR-3D, DP. The course content and also included a flavor of emerging technologies such as, artificial intelligence in resource monitoring and assessment and satellite imagery analysis with Cloud based tools. The lectures were followed by practical demonstrations and hands on exercises on the topics. The content also included case examples demonstrating utility of high-resolution data for different applications.

Remote Sensing and GIS Applications in Agricultural Water Management

A two-week special course on 'Remote Sensing and GIS Applications in Agricultural Water Management' was conducted during August 19 – 30, 2024. A total 12 participants were selected and joined this course at IIRS. Concept and principles of geospatial technology, fundamentals of Agricultural Water Management, fundamentals of ET and Instrumentations, crop inventory & mapping, RS modeling-based ET estimation, irrigation water requirement, crop water stress assessment and crop yield modeling were covered through theory as well as practical classes. Along this, few special/ guest lectures were also delivered on UAV & advance sensor Technology for agricultural water management and Agromet observations & products for irrigation advisory services. A field campaign was coordinated to give hands-on training

about instrumentation for crop observations and operational handling of instruments. During this field visit, IIRS field-based observatory of eddy covariance tower set-up was illustrated and showed the potential use of this sophisticated instrumentation. With this, a memorable interaction with 'Padam Shri' awardee farmer Dr. Sethpal Singh Ji and our course participants was also much praised by everyone.

Geospatial Applications for Atmospheric & Oceanic Hazards

The special course on 'Geospatial applications for atmospheric and oceanic hazards' was conducted by IIRS during September 09 – 13, 2024 & designed with a view to provide participants an understanding of the scientific concepts and an overview on approaches & pathways of atmospheric and oceanic hazards. There were a total of nine participants from various academic and research institutes of the country. The aim of the course was to sensitize the participants about the use of remote sensing data to understand and analyze various atmospheric and oceanic disasters.

The participants also understand the advantages and limitations of remote sensing observations for preparedness and mitigation during disasters. Broad topics covered in the lectures are: Introduction to Atmospheric and Oceanic Hazards, Applications of Satellite Data for the Study of Extreme Rainfall Events, Gaseous Air Pollutants, Tropical Cyclones, Air Quality Monitoring, and Fog Estimation and Monitoring; Overview of Storm Surge; and Geo-Web Portals for Disaster Management Support and Applications. There were two guest lectures: one on 'EO Satellites and Sensors for Atmospheric and Oceanic Hazards Studies' & another on 'Tsunami Modelling and Coastal Inundation' by Dr. CM Kishtwal, Former OS-scientist, SAC.

UAV Remote Sensing and its Application

A special course on 'UAV Remote Sensing and its Applications' was organized by IIRS during Sept 23-27, 2024 to train working professionals from for the researchers / Scientists/ Ph.D scholars / working level professionals in the field of UAV remote sensing. In this course, total 11 participants joined from all across the country. The course was designed to provide the exposure on basic and advance concepts of UAV Remote Sensing. The course included both theory lectures and hands on practical exercises. The major topics covered in the courses include the Overview of UAV Remote Sensing, UAV Data Collection and Processing, Overview of GNSS for UAV Remote Sensing, UAV Multispectral and Thermal Data processing, Feature extraction using very high-resolution Data (OBIA & ML techniques), Overview of

Aerial LiDAR Remote Sensing and its application, Overview of UAV SAR Remote Sensing, UAV SAR calibration, UAV for Disaster applications, UAV for Urban Applications, & UAV for Water Resources Applications. The Participants were provided hands-on exercises in both COTS and open-source software for processing UAV Remote sensing data for various applications. There is also a field work for UAV flight planning and Data collection.

Structured Training Programme (STP) – 2024 on 'Advances in Satellite Radar Imaging'

STP-2024 was conducted on the topic 'Advances in Satellite Radar Imaging' during 23-27 Sep, 2024 at IIRS, Dehradun. Total 28 participants from various DOS/ISRO centres have participated in STP-2024. Seventeen lectures, three practical sessions on basic & advanced topics along with applications of Radar Remote Sensing were covered. Participants have presented their Case studies in seven teams of four members each. A local field visit was also organized for the participants.

SAR Remote Sensing Technologies and its Applications

A three-week special course titled 'SAR Remote Sensing technologies & its applications' was organized during October 07-25, 2024 for 19 participants. The course was designed for professionals, researchers, and students from both government and private sectors engaged in the evolving field of remote sensing technology and its applications. Nineteen participants from diverse sectors attended the course, which provided a comprehensive overview of SAR remote sensing, its data processing, and practical applications. The curriculum covered essential topics, including the basics of SAR, SAR image interpretation, and advanced data processing techniques. Participants were introduced to SAR Interferometry, Polarimetry, and the applications, which play significant roles in environmental monitoring, urban planning, and agriculture. The program was further enriched by three guest lectures from distinguished experts namely Smt. Nidhi Chaubey from ADRIN, Dr. Anil Kumar from UPES and Mr. Dev Dinesh, consultant at the World Bank In addition to theoretical learning, participants engaged in hands-on fieldwork, where they measured surface roughness and estimated soil moisture using the Theta Probe. This practical component allowed participants to apply theoretical concepts in real-world scenarios. The course concluded with participants presenting case studies on various SAR technologies, encouraging critical thinking and collaboration. The training program successfully equipped participants with a thorough understanding of SAR remote sensing, blending theory with practical expertise, and advancing their capabilities in this crucial technology.

Advanced SAR Data Processing for Ground Surface Movement

Two weeks' special course on 'Advanced SAR data processing for ground surface movement' for researchers / Scientists/ Ph.D. scholars / working level professional working in the field of SAR remote sensing. The course commenced on October 14-25, 2024. Out of 25 participants there were four government sponsored participants, from Govt. Mahila Engineering College Ajmer Nasirabad Road Makhupura Ajmer, National Centre for Earth Science Studies, MoES, Guru Kashi University, Kurukshetra University. The remaining 21 participants joined in self-sponsored category, from various organizations/institutions such as IISc, CSIR (CBRI, CSIO), AMU, University of North Bengal, Amrita Vishwa Vidyapeetham Amritapuri Campus, Indian Institute of IIT (Roorkee), National CAMPA, etc. The training program successfully equipped participants with a thorough understanding of properties & propagation of EM waves, Microwave radiation, RADAR in RS, Polarization & Interference of SAR Signals, Nature of SAR images & acquisition geometries, Backscattering process from natural & artificial scatterers, Airborne and spaceborne SAR systems, SAR interferometry, SAR interferometric processing, Multi-Temporal InSAR techniques, topographic phase removal using various DEMs on LOS deformation and advancing their capabilities in this crucial technology.

Applications of Remote Sensing for Disaster Management

Two programmes each of one-week duration sponsored by NSSTA on 'Applications of Remote Sensing for disaster management' were designed for in-service officers of statistical services, MOSPI, GoI and was attended by officials from NSSTA during Nov 04-08, 2024 with 24 participants and during Nov. 18-22, 2024 with 22 participants. The overall objective of this one-week training programme(s) was to generate awareness among the in-service officers of subordinate statistical service on remote sensing technology and its applications in the field of disaster management. The training program successfully equipped participants with a thorough understanding of Applications of space technology in urban hazards, geospatial technology in atmospheric hazards, CC & glacier retreat, GIS database editing & map generation, Statistical Classification of RS Image, Application of space technology in geological hazards and advancing their capabilities in this crucial technology.

Nov. 18-22, 2024 with 22 participants

Nov 04-08, 2024 with 24 participants

Remote Sensing Data Analytics in Agriculture

Agriculture in India and across the world is facing a twin challenge of enhancing crop productivity and improving efficiency of inputs including irrigation/nutrient/energy. The prime objective of this special course is to impart knowledge and build human resource capacity in field of Remote sensing data analytics and its applications in agriculture for our country's needs of achieving digital and smart agriculture. The course had over-whelming response with seventeen participants from diverse background, region and professional experience ranging from Ph.D. scholars, Teachers, research scientists, analysts & govt professionals of MOA&FW and united insurance company. This course of two weeks duration was organized during Nov. 18-29, 2024 for 17 participants & was executed with mix of lectures, practical, field visit/demonstration and finally mini case study project execution. There were total of 20 lectures and 12 practical and demonstrations conducted during the course. Participants had an opportunity to interact with Remote sensing, agriculture and technology experts of IIRS and guest faculties. All Participants had exposure on field visit /ground truth data collection on Leaf area index (Ceptometer), Soil moisture measurement (Theta probe) and Thermal imaging camera to differentiate crops, interpretation of image & linking measurement to spectral indices.

Applications of Remote Sensing and GIS in DRR

The two days course on 'Applications of Remote Sensing & GIS in DRR' was organized at IIRS during December 02-03, 2024 wherein 26 officials participated in the training program, representing seven states & three UTs (Assam-1, J&K-1, Laddakh-1, Chattisgrah-1, Punjab-2, Chandigarh-2, Himachal Pradesh-2, Jharkahnd2, Karnataka-3, Maharashtra-4 and Goa-7). The course was designed to sensitize and create awareness on the potential application of remote sensing technology for DRR. Lectures were designed in such a manner to have theoretical, use cases and demonstrations for better understanding. The course was executed with mix of nine lectures and practical, etc.

Remote Sensing & GIS in Digital Soil Mapping

A Special Course entitled 'Remote Sensing & GIS in Digital Soil Mapping' of 02 weeks' duration was conducted during December 02 – 13, 2024 by Agriculture and Soils Department, IIRS. 20 candidates representing various research organisations as well as universities across the country attended the course. The course content was designed to give them wide exposure of

application of Remote Sensing and GIS technologies for soil survey and digital soil mapping and comprised of 15 lectures, 07 hands-on practical exercises and 01 field visit for data collection. The major topics covered during lectures were: Introduction to RS, Data Analysis and GIS; Soil-landscape Analysis, Overview of Predictive Soil Mapping, Environmental Covariates, Spectral Indices for soil studies, Application of machine learning/geostatistical techniques for soil mapping, role of spectroscopy for DSM as well as global soil web resources and databases available for soil mapping. Senior scientists from ICFRE, Dehradun, IIT Kharagpur and NRSC Hyderabad delivered invited guest lectures on the topics like statistical measures for sampling and accuracy, proximal soil sensors for digital soil mapping and Spectroscopy in Digital Soil Mapping respectively for the benefit of the participants. Hands-on exercises were carried out on different above-mentioned topics and a one-day field visit was carried out in Bidholi and surrounding area for identification of soils in the field and study of the soil- landscape relationship using RS data and soil sampling. At the end of the course, all participants found the course highly relevant to the current job and very useful in executing their job more efficiently in future.

Applications of Remote Sensing and GIS in DRR

The second batch of the two days course titled 'Applications of Remote Sensing & GIS in DRR' were organized at IIRS during Feb. 10 -11, 2025 with 10 participants representing six states (West Bengal -1, Uttar Pradesh-2, Punjab-2, Chhattisgarh-1, Gujarat-2, New Delhi -2).

Just like the previous course this course was also designed to sensitize and create awareness on the potential application of remote sensing technology for DRR. Lectures were designed in such a manner to have theoretical, use cases and demonstrations for better understanding. The course was executed with mix of nine lectures and practical, etc.

Hyperspectral & Microwave RS for Terrestrial and Planetary Geological Studies

Two-week special course on 'Hyperspectral and Microwave Remote Sensing for Terrestrial and Planetary Geological Studies', was organized by Geosciences Department, IIRS during December 09-20, 2024. The course was targeted for researchers/ working officials and students of the Earth sciences discipline. There were a total of 25 participants. The course was divided into 20 lectures and 18 practicals including four guest lectures. The lectures covered the basics of hyperspectral and microwave remote sensing, Hyperspectral data quality its end-to-end processing, spectral characterization of minerals, and rocks; InSAR and DInSAR for geological applications viz. Glacial velocity, land deformation, and for terrestrial and planetary applications. The persons pioneer

in the field of hyperspectral remote Sensing Dr. Arindam Guha, Scientist, RRSC, Kolkata and Mr. Suresh K. Scientist from SAC Ahmedabad delivered lectures on Hyperspectral Remote Sensing for Critical Minerals and Hyperspectral Data Processing for Planetary Geological Applications respectively. Mr. Ritwik Majumdar Scientist from NRSC, ISRO and Dr. Shriram Saran Bhiravarasu, Scientist from SAC Ahmedabad shared their expertise with the students and delivered the lectures and practical on DInSAR based Glacial Velocity Monitoring and GLOF Studies and Microwave SAR Data Processing for Planetary Geological Studies respectively. The students also used an ASD field Spectro-radiometer during their practical to understand the reflectance spectra of minerals and rocks.

Advance Remote Sensing & GIS and its Application in Water Resources

As per the request received from Rajasthan State Water Informatics Centre, Water Resources Department, Government of Rajasthan to conduct 02 special training course for their 20 officials each under National Hydrology Project during 2024-25. The first course was conducted during Dec 09 – 20, 2024 (20 Nos.) & the second batch was conducted during Jan. 20 - 31, 2025 (18 Nos.); wherein overall 38 participants in both batches attended the course. The course syllabus was designed mutually considering the problems of the Rajasthan State. During the initials two days of the course, the participants were exposed to the basics of RS & GIS through lectures and hands-on exercises. Later, the participants were taught retrieval of rainfall, mapping of water spread area, soil moisture, evapotranspiration using remote sensing data along with role of digital elevation model in water resources. Further, the advance applications of the geospatial technology in water resources management such as river flow modelling, soil erosion, sediment yield modelling using hydrological models. The course participants were exposed to reservoir sedimentation, land degradation, site suitability for water harvesting assessment. Dedicated lectures on urban hydrology were also conducted for the benefit of the participants. Specialized topics namely drought monitoring and assessment; and ground water targeting were also covered. Each day practical exercise on the relevant topics were conducted. The field demonstration of various hydrological instruments was also organized at Asan watershed. A one-day field excursion to Mussoorie was also arranged. The participants provided very high feedback to the course.

BigAI for BigGIS

Recognizing the rapid evolution of BigAI for BigGIS, a one-week course focused on emerging technologies in the BigAI domain was held for Indian nationals from December 16-20, 2024. The course, titled 'BigAI for BigGIS: Quantum Computing (QC),

Generative AI, and Self-Supervised Learning (SSL) approaches for EO' had 28 participants in total, including 12 from industry, eight from government bodies, and seven from academia. Experts from IIRS, Copenhagen, Brown University, IIT-BHU, In-Space, ADRIN, URSC, NRSC, and Development Seed delivered sessions focused on a range of topics, including AI for geospatial applications, BigEO and BigGIS data characteristics, quantum computing for space technology and Earth observation data analysis, generative AI for geospatial queries and human interaction, and BigAI self-supervised learning approaches for foundation model development and application.

Advances in Satellite Image Analysis & SAR Data Processing' for NASRDA Officials

Two-weeks certificate training course for officials from National Space Research and Development Agency (NASRDA), Nigeria titled 'Advances in satellite image analysis & SAR data processing' was organized during Jan 06 - 17, 2025 with 25 participants who were given an overview of geospatial technology & tools, methods for HR-data analysis like image segmentation etc. The second week focused on SAR-DP & included introduction to SAR interferometry and SAR Polarimetry. The lectures were followed by practical demonstrations & hands on exercises on topics.

The participants also did a short assignment based on their interest area incorporating the concepts of the techniques learnt by them during the course. To enhance academic knowledge and cultural understanding two educational field visits - one to Mussoorie and the other in Dehradun- to places of local cultural importance were also organized.

Geospatial Inputs for Enabling Master Plan Formulation *(AMRUT 2.0)*

IIRS organised a two-week training on 'Geospatial inputs for enabling Master Plan formulation under AMRUT sub-scheme 2.0' for 25 town planning officials of Maharashtra during Jan 20 - 31, 2025 (Tier-2). The course was organised based on the request received from the Director, Town Planning and Valuation Department, Government of Maharashtra. The primary aim of the training program is to build capacity among town planning professionals for operational use of geospatial technologies for the generation of a geodatabase as per AMRUT standards and guidelines to enable them to develop GIS-based master plans to guide future growth of cities. The training program comprised 21 lecture sessions and 9 hands-on practical sessions for 25 middle-level nominated participants from the state of Maharashtra. Geospatial technologies play a critical role in modern urban planning by enabling the integration of spatial and non-spatial datasets, facilitating data-driven decision-making, and supporting the creation of dynamic, scalable, & inclusive master plans.

Through tools such use of satellite imagery for land use planning, the use of UAV imagery & processing, network analysis, urban planners are better equipped for efficient decision making. It included both theoretical foundations and practical exercises to provide a balanced learning experience.

DMSP Sponsored Special Course on Remote Sensing of Geological Hazards

The two week special course for DMSP sponsored candidates on 'RS for Geological Hazards' was organized during Feb. 03 - 14, 2025 wherein 18 Indian Participants from State/ UT Govt. departments like Bihar, Odisha, Jammu and Kashmir, WB, U.P, HP, CSIR labs, professionals from Private industry and University academicians, Professors from govt. colleges, representatives from state remote sensing centres, entrepreneurs and research scholars of different Universities across India participated in the course. The course structure comprised of 13 number of lectures, 06 practical sessions & demonstrations, 1-day study tour & a week-long pilot project. The course content was planned in a way that it provided first overview of remote sensing and image-processing techniques followed by specialized lectures in the field of Landslide, Earthquake, cryospheric, volcanic & mining induces hazards and other surface deformation. The first week of the course had primary focus on overview of EO systems and applications and geological hazards, mapping, monitoring of geological hazard with emphasis on landslides, rainfall threshold & landslide initiation; numerical modelling & simulation, Monitoring volcanic eruptions, Microwave/ thermal RS for surface deformation with emphasis on crustal deformation, mining and land subsidence, Application of geophysical techniques for geological hazards, Application of geophysical and geodetic techniques for crustal deformation and earthquake precursor studies.

Remote Sensing & Image Analysis *(CRS)*

A Short Course on Remote Sensing and Image Analysis (CRS) was organized during January 13, 2025 to March 07, 2025 wherein seventeen participants joined in this short course. The primary objective of this course was to enhance the capacity of middle-level professionals in the field of remote sensing with special emphasis on the processing of remotely sensed data using digital image processing techniques. This course of 8-weeks duration was designed in such a way that it offered a blend of the latest technology and conventional techniques. It covered the basic and advanced concepts of RS & DIP. These topics were covered in theory classes followed by practical demonstrations & field visits. There was also a 2-week project in this course, and a total of 13 projects were done by the course participants in groups and individually on different topics.

Applications of RS & GIS in Disaster Risk Reduction

These NDMA sponsored courses were designed for working-level professionals in the Central & State Governments. The course was conducted in 2-batches from Jan. 06-17, 2025 with 25 participants & another from Feb. 24, 2025 to Mar. 07, 2025 with 16 nominated participants including representation from various states (Punjab, Meghalaya, Sikkim, Jammu & Kashmir, Uttarakhand, WB, UP, Odisha, Haryana, HP, Ladakh, Delhi, Karnataka & Kerala.) and Union Territory. The overall objective of this training programme was to generate awareness among working level professionals from states & UTs about RS technology & its applications in disaster risk reduction. The course included theoretical lectures, practical demonstrations & field trip.

Jan 06-17, 2025 with 24 participants

Feb. 24, 2025 to Mar. 07, 2024 with 16 participants

Geospatial Inputs for Enabling Master Plan Formulation *(AMRUT 2.0)*

This AMRUT-2.0 Course (Tier-1 program) for TCPO Officials was organized during Feb. 10-14, 2025 for 17 TCPO officials from various state governments (Govt. of Rajasthan, Govt. of UK, Govt. of Nagaland, Govt. of Sikkim, Govt. of Mizoram, Govt. of WB, Govt. of Kerala). The course comprised of lectures by specialised faculty covering essential topics related to AMRUT program, Government Initiatives, Survey techniques, Navigation Systems, Coordinate systems, Basic principles of Remote sensing, image interpretation, DIP & Mobile mapping for field data collection, GIS and GIS based analysis, GIS data portability across various platforms like Auto CAD to GIS, Base Map preparation as per AMRUT guidelines, Basic concepts of UAV-RS, data acquisition & processing, and its application in urban studies.

Advance Remote Sensing Spatial analysis using AI/ML/DL *(Bhutan officials)*

IIRS and ISRO Hq., in collaboration with Government of Bhutan organized a two-week program for officers from the National Land Commission Secretariat of Government of Bhutan during March 03 - 14, 2025 with 16 participants. The participants have been given an overview of geospatial technology and tools, methods for high resolution data analysis like image segmentation etc. The course content also included a flavour of emerging technologies such as, machine learning and deep learning in resource monitoring and assessment and satellite imagery analysis with Cloud based tools. The second week focused on SAR data processing and included introduction to SAR interferometry and SAR Polarimetry.

Concepts of Hyperspectral data analysis and its practical aspects was also discussed. Case examples specifically for forest and water resources management was also covered. The lectures were followed by practical demonstrations and hands on exercises on the topics. To enhance academic knowledge and cultural understanding an educational field visit - to Rishikesh was also organized.

Spatial Data Analysis and Mobile Based Field Data Collection *(Bhutan officials)*

A two weeks special course for officials of Department of Surveying and Mapping, National Land Commission Secretariat, Bhutan was organized at IIRS during Mar. 17 – 28, 2025 wherein 20 participants attended this programme. The course focused on advanced analysis on spatial data, mobile mapping and Web GIS. Introduction to RS and image processing were also kept to give them basic foundation in the beginning. The participants also got hands-on experience on the topics covered in theory and were also taken to a field visit to Rishikesh for mobile mapping and satellite image interpretation.

The course provided a platform for both the Geoinformatics Department of IIRS and Land Commission Department, Govt. of Bhutan to come together, share knowledge, and explore the possibilities of meeting the requirements of the land commission department.

Remote Sensing and GIS Applications for Agricultural Resource

A one-week special course on 'Remote Sensing and GIS Applications for Agricultural Resource Mapping' sponsored by Himachal Pradesh agriculture Department was conducted during March 17-22, 2025 wherein twenty-five officials were nominated participants in this course. Various topics were covered during the course & taught including: Fundamentals of RS, sensors & applications in agriculture, over of GIS and GPS, ground truth collection (crowdsourcing & Mobile App development, geotagging), Crop discrimination, crop monitoring, horticulture crop assessment, crop yield modelling, agricultural water management and watershed management and conservation planning were covered through theory as well as practical classes. One guest lecture was also delivered on Advance High Resolution Satellite/ UAV Sensor Technology for Crop Insurance and Agro-hazard Risk Assessment. A field campaign was coordinated to give hands-on training about instrumentation for crop observations and operational handling of instruments.

OUTREACH ACTIVITIES

With the rising trend and increasing popularity of online learning, especially after the emergence of a global pandemic, distance learning – along with new information technology, has been adopted extensively by educational and training institutes. Over the past few years, the government of India through its policy of Digital India, has been promoting such endeavors to popularize digital leaning environment. Distance Learning Programme (DLP) offered by Indian Institute of Remote Sensing (IIRS), Indian Space Research Organisation (ISRO), is an innovative initiative for training students and professionals from academia and user departments in the field of geospatial technology & Earth Observation. IIRS DLP started in the year 2007 with 312 participants from twelve universities in India. Till date, IIRS has successfully conducted 220 outreach programmes through live and interactive classroom mode (also known as EDUSAT programme) benefitted more than 9.7 lakh participants from 3816 network institutions distributed across the country. During financial year 2024-25, around 228988 participants got benefitted by various programmes conducted under IIRS Distance Learning Programme. The present outreach programme is being conducted through following two major modes:

- Live & Interactive Classroom Programmes
- E-learning or Massive Open Online Courses (MOOC).

1. Live and Interactive Classroom Programmes

IIRS uses internet based digital platform for conducting live and interactive online courses to primarily complement the educational programmes of the Indian Universities/Intuitions. In year 2024, IIRS has conducted total 30 online courses/ full-day workshops/ webinar series benefiting 255338 participants from 3035 networked institutions. IIRS has conducted 11 advanced topic courses, 6 basic courses, 7 full day workshops, 3 special customized courses, 1 START course and 2 courses/workshops in Hindi language. A total of 2.55 Lakh participants participated in IIRS online courses in 2024-25. The courses offered were covering a wide range of topics like Exploration of the Solar System, Forest Carbon & Water Cycle Monitoring and modelling, Geospatial Technology in Paleochannel Studies, Geospatial Technology for Modelling of Urban Environment, Space Technology & Applications, Geospatial Technology for Digital Agriculture, Utilities of Sun-Induced Chlorophyll Florescence in Vegetation Studies, Potential of NISAR for Disaster Mitigation and Management, LIDAR Data Processing and Applications, AI/ML for Geodata Analysis, Basics of “Remote Sensing, Geographical Information System and Global Navigation Satellite System, Remote Sensing and Digital Image Analysis, Understanding Cryospheric Hazards, Overview of Global Navigation Satellite System, Overview of Geographical Information System, Space based inputs for Village level crop assessment, Overview of Geo-computation and Geo-web services, RS & GIS Applications in Natural Resource Management, Air pollutants: Implications, Monitoring and Modeling, Deep learning in ecological Studies, Geo-data sharing and Cyber Security, Raman Spectroscopy and its Applications in Earth Observation, Space Science and Technology awareness training, Geodata Processing using Python and

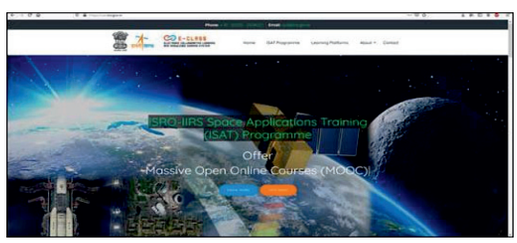
Machine Learning, Remote Sensing of Soils: Mapping, Classification and Evaluation for Agricultural Land Use Planning, Martian Surface, Analogues and Atmosphere, Space Technology for Disaster Risk Reduction. A special course on अंतरिक्ष प्रौद्योगिकी का अवलोकन was also conducted in Hindi language for the benefit of Hindi speaking participants. All the courses of IIRS DLP are made available through in-house developed Electronic Collaborative Learning and Knowledge Sharing System (E-CLASS) platform. The status of total benefiting participants is given in the table below:

Table: Courses conducted in 2024-25

S.No	Course Name	Total Institute	Total Participants
1	Exploration of the Solar System	318	16243
2	Forest carbon & water cycle monitoring and modelling	238	1408
3	Applications of Geospatial Technology in Paleochannel Studies (Course in Hindi)	286	1573
4	Geospatial technology for modelling of Urban Environment	493	2846
5	Space Technology & Applications-For School Teachers	1	1731
6	Geospatial Technology for Digital Agriculture	425	3093
7	Utilities of sun-induced chlorophyll florescence in vegetation studies	265	1304
8	Potential of NISAR for Disaster Mitigation and Management	666	4508
9	LIDAR Data Processing and Applications	1022	10266
10	AI/ML for Geodata Analysis	1798	46587
11	Basics of 'RS, GIS and GNSS'	1398	18231
12	Remote Sensing and Digital Image Analysis	1439	17995
13	Understanding Cryospheric Hazards	542	4930
14	अंतरिक्ष प्रौद्योगिकी का अवलोकन	303	2169
15	Overview of Global Navigation Satellite System	838	8755
16	Overview of Geographical Information System	756	7038
17	Space based inputs for Village level crop assessment	422	3463
18	Overview of Geocomputation and Geo-web services	617	3748
19	RS & GIS Applications in Natural Resource Management	661	3806
20	Air pollutants: Implications, Monitoring and Modelling	529	3237
21	Deep learning in ecological Studies	1002	8822
22	Geo-data sharing and Cyber Security	1270	18045
23	Raman Spectroscopy and its Applications in Earth Observation	485	3435
24	Space Science and Technology awareness training (start)	562	20774
25	अंतरिक्ष प्रौद्योगिकी के अनुप्रयोग	409	2471
26	Geodata Processing using Python and Machine Learning	1226	18115
27	Remote Sensing of Soils: Mapping, Classification and Evaluation for Agricultural Land Use Planning	1026	11453
28	Martian Surface, Analogues and Atmosphere	532	4098
29	Space Technology for Disaster Risk Reduction	603	5194
30	National Workshop on 'Space Science Exploration and Career Opportunities for Students'	01	221
		Total	**255559**

2. E-learning or Massive Open Online Courses (MOOC).

It is essential to create eLearning content that arouses the curiosity of learners and keeps them engaged for the entire duration of the course. At the same time, the content needs to be relatable to the target audience and ensure long-term knowledge recollection. To enhance the outreach of geo-spatial science and technology, IIRS has also developed e-learning contents and Learning Management Systems (LMS) for different certificate courses in Remote Sensing and geo-spatial technology and its applications. E-learning is an active learning platform which provides learner centric online courses to the online learners. It provides a platform where the individual gets a customized package related to key thematic areas, through a computer-guided process. The learning is made available through interactive 2D and 3D animations, audio, video for practical demonstrations, software operations with free and open data sources. The e-learning contents are created as an interactive multimedia application and integrated with customized LMS using open-source Moodle platform. The most attractive part of these online courses are "learning anytime from anywhere". The learners can join these courses any time and can complete the course with self-pace. Currently, more than 29,000 participants have registered for these courses out of which 4178 participants have opted for certificate. The course contents of RS&GIS technology are also available in Hindi language. To expand the scope of E-Learning from technology to application of technology in thematic disciplines, e-Learning content for eight thematic disciplines demonstrating applications of geospatial technology were prepared. The developed thematic contents are being organized in form of e-Learning courses and will be made available to the learners through IIRS e-learning portal. A total of 11 courses on advanced topics are ready and will be soon available to users. IIRS eLearning course "Comprehensive Course on Remote Sensing and GIS" was approved by All India Council for Technical Education (AICTE) as a 04-credit course and made available on SWAYAM portal of MHRD. The course was conducted twice during 2024, one in each academic semester. Two new courses namely अंतरिक्ष प्रौद्योगिकी का अवलोकन and Overview of Space Science got approved by AICTE and were offered to participants through SWAYAM portal. In the year 2024, around 12,000 participants were registered for the course through SWAYAM portal. The examination was conducted by National Testing Agency and around 350 participants successfully completed the first course and received certificate from AICTE. To cater the needs of international participants, IIRS is conducting International Distance learning programme under 'ISRO-IIRS Space Application Training (ISAT)' programme The International Outreach Programme is targeted to impart the training to Student community- Undergraduate, Post graduate and PhD scholars; Scientists and Researchers; and Governmental users from SAARC and Asia Pacific countries wherein 3652 participants registered for the course. IIRS has developed online learning platforms and LMS for ISAT programme and made available to the learners through URL- https://isat.iirs.gov.in. The home page for ISAT LMS are shown in Figure underneath.



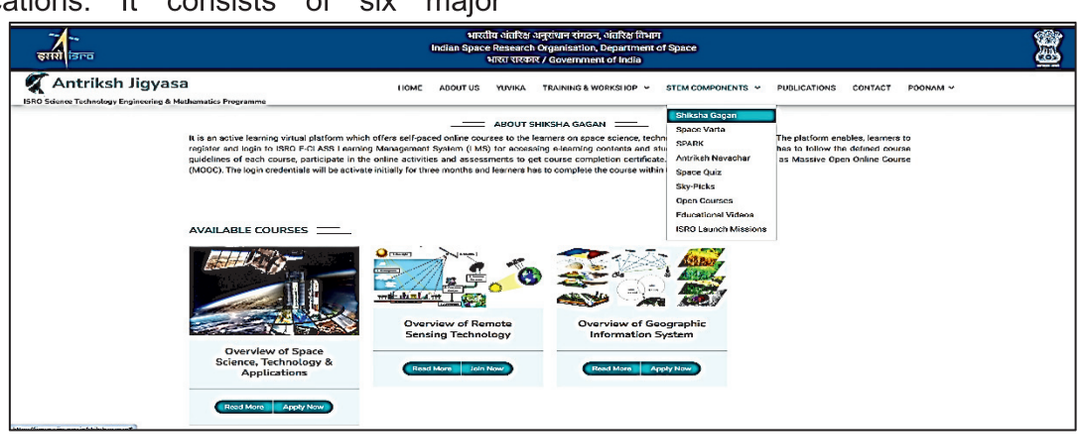
The details of MOOC courses conducted in 2024-25 is given in Table underneath.

Table: MOOC Courses conducted (2024-25)

Course	Overview of Space Exploration-School Students	Earth Observation for Climate Action
Start Date	June 05, 2024	February 10, 2025
End Date	August 04, 2024	February 28, 2025
Total Registration	3652	231
Total Certificate issued	555	26

In the year 2024-25, IIRS conducted ISRO Space science and Technology Awareness Training (START) for the Post-Graduate and Final Year Undergraduate Students in collaboration with Science Programme Office, ISRO Hqs. The programme was conducted during April 24, 2024 – May 10, 2024. A total of 16242 participants registered for the programme and around 4412 participants successfully completed the course and were awarded certificates. 22 number of sessions were conducted by eminent speakers from ISRO and academia. The course included sessions on basic and advanced topics of exploration of Solar System.

IIRS has designed and developed an Online Learning and Knowledge Sharing System 'Antriksh Jigyasa' under ISRO STEM programme. The portal is an active learning virtual platform which offers self-paced online courses to the learners on space science, technology, and its applications. It consists of six major verticals viz. Shiksha Gagan, Space Varta, Sky-Picks, Antariksh Navachar, Space Quiz and Space Park. In the year 2024, the portal was enhanced further for incorporating the automation of various courses and workshop within the portal. It was fully utilized during the ISRO-START, YUVIKA, SSA programmes conducted by ISRO HQ. In the year 2024, four Space Vartas by eminent scientists of space domain have been conducted through this portal namely on Who can become an Astronaut? (Speaker: Gp Capt Angad Pratap, ISRO Astronaut), Space Transportation System - Present and Future (Speaker: Shri S. Sivakumar, PD, NGLV, VSSC), India's Human Space Flight Programme (Speaker: Shri Hanamantray Baluragi, Director, DHSP) and Role of Space Technology in daily lives (Speaker: Dr P Veeramuthuvel, Project Director, Chandrayaan-3, URSC). The home page for Shiksha Gagan is shown in Figure underneath.



CSSTEAP Activities

- Dr. R.P. Singh, Director, CSSTEAP participated in the meeting with the Directors of all Regional Space Science and Technology Education (UN Affiliated) Centers on June 20-21, 2024 in Vienna, Austria. This meeting was organized by UNOOSA for collaborative discussion, sharing of insights and strategic planning to enhance the role and impact of the Regional Centres.
- Ms. Kareff Rafisura, Economic Affairs Officer, Space Applications Section (SAS), Information and Communications Technology and Disaster Risk Reduction Division (IDD), UNESCAP, Bangkok visited CSSTEAP/IIRS, Dehradun during April 02-03, 2024 to discuss further collaborations with CSSTEAP under the Asia-Pacific Plan of Action on Space Applications for Sustainable Development.
- 29th GB meeting was held at Branch Secretariat, New Delhi on December 20, 2024.
- The CSSTEAP Coordination Committee Meeting was held on November 20, 2024 through hybrid mode which was chaired by Shri Shantanu Bhatawdekar, Scientific Secretary, ISRO.
- 15th Advisory Committee meeting of CSSTEAP conducted virtually on October 25, 2024. Dr. Driss El Hadani, Senior Advisor representative of Director, UNOOSA,chaired the Advisory Committee meeting.

CSSTEAP Programmes (2024-25)

ONLINE SHORT COURSES	Start Date	Concluding Date	Participants (with Country)
Short course on 'Forest Carbon Dynamics Assessment Using Earth Observation Data'	02-09-2024	06-09-2024	19 (07)
Short course on 'Solar Physics'	02-09-2024	06-09-2024	68 (6)
Short course on 'Planetary Science'	09-09-2024	13-09-2024	28 (4)
Course on 'Earth's Atmosphere and Climate Change'	21-10-2024	25-10-2024	53 (8)
Course on 'Use of Space Technology for Weather & Climate Studies'	04-10-2024	14-10-2024	33 (11)
OFF-LINE SHORT COURSES	**Start Date**	**Concluding Date**	**Participants (with Country)**
DRR- SAR Remote Sensing for Land Deformation Studies	03-06-2024	14-06-2024	27 (13)
Weather Forecasting using Numerical Weather Prediction Models	22-07-2024	02-08-2024	23 (10)
Satellite Remote Sensing for Ocean Applications	14-10-2024	25-10-2024	16 (7)
Short course on 13th Small Satellite Mission	18-11-2024	29-11-2024	29 (14)
Short courses on Satellite Remote Sensing & Data Acquisition	18-11-2024	29-11-2024	21 (11)
ONGOING PG COURSES	**Start Date**	**Concluding Date**	**Participants (with Country)**
28th PG course in Remote Sensing & Geographic Information System at IIRS, Dehradun	01.07.2024	31.03.2025	20 (10)
14th Satellite Communications Meteorology at SAC, Ahmedabad	01.09.2024	31.05.2025	10 (03)
05th Global Navigation Satellite Systems at SAC, Ahmedabad	01.09.2024	31.05.2025	10 (06)

RESEARCH (R&D) ACTIVITIES

Earth Observation and Applications Mission
1. Retrieval of Geo-Physical Parameters using GNSS/IRNSS Signals
ISRO- Geosphere Biosphere Programme
2. Carbon Dynamics Assessment in Tropical Forests of North East India using Multi-sensor Data
3. Soil & Vegetation Carbon Flux (SVF)
4. Understanding the impact of climate and its Variability on Hydrological Fluxes vis-a-vis Water Availability for Sustainable Development
5. Spatio-Temporal variations of Gases Air Pollutants over the Indian Subcontinent with a Special Emphasis on Foothills of North Western Himalayas
Disaster Management Support Programme
6. IIRS-Advance Studies (AS)
7. IIRS-Advance Building (CB)
In- House R&Ds
8. Automated Detection of Rock Glaciers in Western Himalaya, India
9. Study on Carbon Dynamics over the North Indian Ocean using coupled Numerical Model & Remote Sensing Data
10. Proximal Remote Sensing for Digital Soil mapping of Nutrients and Heavy Metals
11. Detection and Mapping of Forest Lopping Disturbances Using Satellite Data and Deep Learning (TDP)
12. Development of framework Crop-based Irrigation Decision Support System by using Geospatial Technology, Real-time Observations and Weather Forecast
13. Identification and Systematic Characterization of Indian based Martian Analogue Sites with possible traces of Bio-Geological Signatures using Raman Spectroscopy
14. Potential of Terahertz Remote Sensing in Space Applications
15. Machine Learning based Extraction of Urban Canopy Parameters using Cartosat Datasets
16. Multi-satellite Observations-based Assessment of River and Lake Bathymetry for Hydrodynamic Studies
17. Provenance and Process of Formation of highland Anorthosite and Mare Basalt of the Moon from the Study of selected Lunar Analogues in India by Spaceborne and In-Situ Spectral Analysis
18. Assessment of the Impact of Hyperspectral Infrared Sounding Observation Assimilation on regional NWP Model Forecasts
19. Assessment of the Seasonal Water Level Variations Based on Hydrological Sensitivity Analysis of Time-Series SAR Backscattering Coefficients in conjunction with DEM and Gauge Data
20. Raman Spectroscopy to Investigate the Spectral Features of Soil, Vegetation and Water
21. Understanding the Dynamics of Martian Paleo and Present-Day Water Cycle of Mars using Remote Sensing, Modelling Techniques and Earth based Analogue Studies
22. To study impact of Agricultural Practices on Stubble Burning and Green-House Gas Emission through Monitoring and Assessment of Paddy-Wheat Cropping System using Multi-Sensor Data

23. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II)
I. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 1: Geodynamics of Himalaya and Earthquake Precursor Studies
II. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 2: Strengthening Vegetation Phenology-Productivity and Climate Linkages in North-West Himalaya.
III. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 3: Climate and Ecosystem Response Studies through Long Term Ecological Research Stations (LTERS)
IV. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 4: Soil Erosion Estimation Based on Radio Tracer Technique and Soil Quality Assessment in Mountainous Landscape of North-West Himalaya.
V. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 5: Monitoring 2and Modelling of Hydrological Processes in Glaciated and Non-Glaciated Watersheds of North-West Himalaya
VII. Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Sub Theme – 7: Observational and Simulation Study of Extreme Rainfall Over the North-West Himalayan Region
Other Project
24. Geo Ladakh: SDI for UT Ladakh
25. NMHS: Himalayan Alpine Biodiversity Characterization and Information System-Network
26. USDMA funded Satellite Based Mountain Hazard Assessment and Monitoring (MHAM) in Uttarakhand
27. Geo-Ganga: Space Based Mapping & Monitoring of Ganga River (NMCG)
28. ISRO NICES: Remote Sensing and Modelling Approach to Generate the High-Resolution Snow ECV's Products in Himalaya (ISRO NICES)
29. ISRO NICES: Monitoring of River Discharge at Sparsely Gauged Basin Using Integration of Space-Based Water Level and Hydrodynamic Modelling (ISRO NICES)
30. ISRO NICES: Remote Sensing Based Generation of Evapotranspiration using S-SEBI method (ISRO NICES)
31. ISRO NICES: Multi-Satellite Multi-Sensor Approach to Generate the High-Resolution Glacier Related Essential Climate Variables Product in Himalaya (ISRO NICES)
32. JECAM: Joint Experiment for Crop assessment and Monitoring
33. NNRMS: Integrated use of Active and Passive EO and Ground based data for Archaeological Investigations of Heritage Sites
34. Land surface modelling and Remote Sensing based generation of Evapotranspiration Product

Carbon Dynamics Assessment in Tropical Forests of Northeast India using Multi-sensor Data (IGBP)

Forests serve as major carbon sinks and play a pivotal role in regulating both regional and global carbon cycles. However, understanding forest carbon dynamics requires careful consideration of disturbance and regrowth processes, which ultimately influence net carbon flux. In northeast (NE) India, forest landscapes are particularly affected by large-scale deforestation and shifting cultivation—both of which significantly alter land use and contribute to carbon emissions. Hence, to understand these impacts, this project aims to assess forest carbon dynamics under two disturbance scenarios: large-scale deforestation and shifting cultivation. To fulfill the project objectives, the shifting cultivation landscapes of Nagaland have been selected.

Using multi-temporal Landsat satellite data from 1991 to 2024 and advanced time-series analysis, the study assessed spatio-temporal patterns of vegetation disturbance and regrowth in Nagaland. The study area was classified into five land use/land cover (LULC) categories: forest and tree outside forest (TOF), shifting cultivation (SC), agriculture, settlements, and waterbodies. Only forest areas containing SC patches were retained for detailed analysis, excluding non-forested LULC types. Normalized difference moisture index (NDMI) and normalized burn ratio (NBR) were identified as the most appropriate indices for distinguishing between forest, TOF, and SC areas.

Vegetation changes were analyzed using the LandTrendr algorithm, which incorporated nine spectral indices, including NBR, NDMI, normalized difference vegetation index (NDVI), tasseled cap brightness (TCB), tasseled cap greenness (TCG), tasseled cap wetness (TCW), near infrared (NIR), shortwave infrared-1 (SWIR-1) and SWIR-2. Among these, NBR emerged as the most sensitive and reliable indicator of vegetation disturbance and regrowth, especially in moist forest environments. LandTrendr algorithm successfully captured small-scale forest clearings linked to shifting cultivation activities, with the year 1997 recording the highest level of vegetation disturbance across the landscape.

Spatial variations in disturbance and regrowth patterns were evident throughout the study area. In addition, a noticeable shift from traditional jhum practices toward more permanent agricultural systems was observed. Farmers in some regions have transitioned to cultivating long-term commercial crops such as tea, coffee, areca nut, pineapple, and rubber—driven by changing socio-economic conditions and market incentives. The results underscore the changing dynamics of land use in Nagaland and highlight the long-term ecological implications of these transitions. This study contributes valuable insights into forest degradation and recovery processes in shifting cultivation landscapes, offering critical input for sustainable land management and carbon monitoring frameworks.

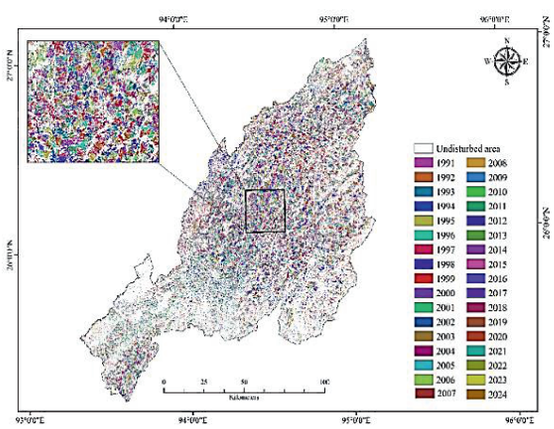


Fig.: Year of detection of greatest disturbance

Soil-Vegetation- Atmosphere-Carbon Flux- Forests & Agriculture (IGBP-CAP) - Inter-disciplinary Project

The project is part of Soil-Vegetation-Atmosphere Carbon Flux (SVAF) under ISRO-Geosphere-Biosphere programme and aims to use state of the art eddy co-variance (EC) flux-towers and remote sensing technique to measure and monitor carbon and water vapor exchange between vegetation systems and atmosphere. The flux towers observations are integrated with satellite observations for generating carbon exchange components and evapotranspiration estimates over large areas. The project is being extended for next 5-years till 2026 with an aim of Understanding Dynamics of Carbon and Water Vapor Fluxes over North-west Himalayan ecosystems. was envisage with objectives (i) Continuity of measurements from eddy covariance-based flux-tower and other meteorological sensors for measuring energy, CO_2 and water vapor exchanges over diverse cropland and natural forest ecosystems (ii)To analyze seasonal and inter-annual variability of carbon and water fluxes of diverse North-western Himalayan ecosystems (iii) Multi-model (LUE based, process-based model and empirical) evaluation for gross primary production estimates of NWH region. Currently project operated in North western Himalayan foot hills with four eddy covariance sites namely Moist Deciduous Sal Forests (Barkot, UK), Mixed Dry Deciduous Plantation (Haldwani, UK), Sugarcane cropland (Saharanpur, UP) and Rice-wheat cropland (Palampur, HP).

The key achievement of the project comprises generation of long-term inter-annual and seasonal carbon balance over natural forests and cropland ecosystems at site and regional scale using flux-tower observations and modeling approaches. The distribution of carbon, water vapour fluxes for Saharanpur flux site (SFS) for years 2020, 2022 and 2023 and Palampur flux site (PFS) from 2019-2023 was analyzed. The illustration of NEE at SFS and PFS is illustrated through the violin plots in Fig. 1. The red dashed line in the graph represents the mean of the fluxes at monthly interval. More negative Net Ecosystem Exchange (NEE) value depicts the carbon sequestration while the positive NEE value depicts the carbon release. The monthly variation in the fluxes clearly depicts the single (sugarcane) cropping system at SFS and double cropping system (rice-wheat) at PFS. At both the study sites and across the crops (rice, wheat, sugarcane), the trend in NEE aligns well with the crop cycle.

Operational Simplified Surface Energy Balance (SSEBop) was used to model ET at the flux sites. SSEBop based evaporative fraction (EF) was incorporated into the LUE model to estimate Gross Primary Productivity (GPP). Machine Learning technique was used to estimate the fluxes particularly during the cloudy conditions using the combination Sentinel-1 based indices and meteorological variables.

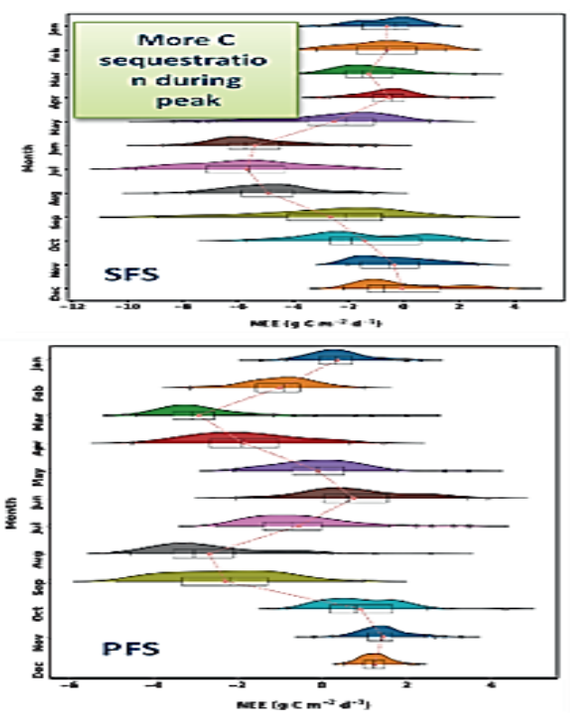


Fig.: Violin plots illustrate daily NEE at SFS and PFS.

Furthermore, interpolation was done to model fluxes at the daily interval. Continuous estimates of carbon and water vapour fluxes are essential for understanding eco-hydrological processes, improving agricultural water management, and informing policy decisions for societal applications. The inclusion of Sentinel-1 data has enhanced the availability of remote sensing data for modelling fluxes particularly during cloudy periods.

A process-based Biome-BGC model implemented with assimilation of time-series Sentinel based LAI data for sugarcane cropping system and rice-wheat cropping system for Nandi-Firozpur and Malan village in Saharanpur and Kangra districts, respectively. The cumulative GPP is illustrated through Fig.

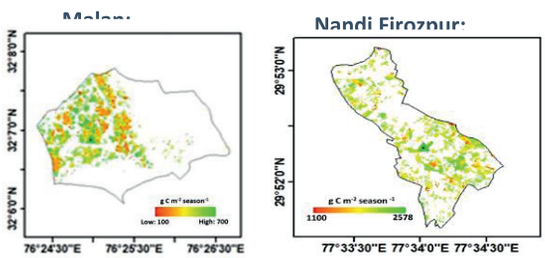


Fig.: Cumulative GPP of Malan and Nandi-Firozpur village in Kangra and Saharanpur districts, respectively

The Biome-BGC model does not perform well for the sugarcane crop with agreement index value below 0.5. It indicated that the Biome-BGC model is not relible to estimated fluxes for the C4 type crop. The impact of 2022 heat wave on NEE using half-hourly eddy covariance measurements from cropland site in Saharanpur was evaluated. NEE decreased during the heat wave period, subsequently increasing the atmospheric carbon dioxide concentration in the atmosphere in comparison to the non-heat wave events. On the similar lines, the impact of heat wave of year 2024 was evaluated on NEE. In late March, we found that the carbon sequestration capacity of the sugarcane system was reduced significantly in comparison to year 2020.

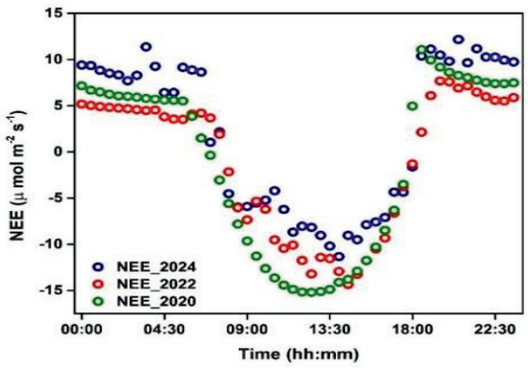


Fig.: Variation in net ecosystem exchange (NEE) during the heat wave periods for year 2020, 2022 and 2024

Over forest sites, eddy covariance flux towers data has been used to generate the long-term carbon exchange of Himalayan deciduous forests and attempt being made to investigate response of net ecosystem carbon exchange of Moist deciduous forest to drought episode.

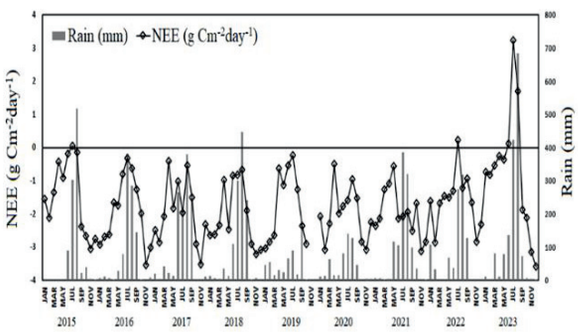


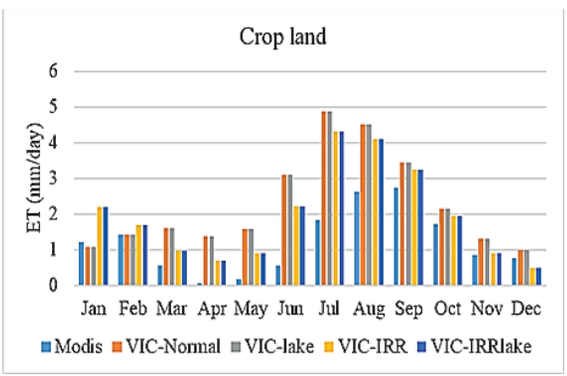
Fig.: Long-term carbon exchange over Moist deciduous Forest

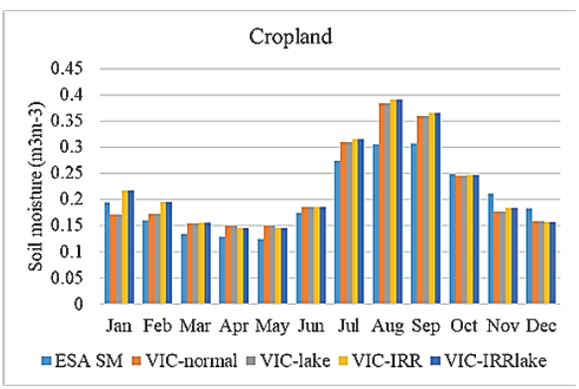
Understanding the impact of climate change & its variability on hydrological fluxes vis-à-vis water availability for sustainable development (IGBP)

The present study is conceptualized with linkage to UN sustainability development goals (SDGs) related to water resources: 13- Climate Action, 15- Life on Land and 6-Clean Water and Sanitation. The impact climate change on hydrological fluxes has been analysed using Land Surface Model (LSM) based modelling approach. In the

present study, the Variable Infiltration Capacity (VIC) LSM has been used for generation of land surface parameters (LSPs). In the previous year, an attempt has been made to improve the accuracy of VIC LSM through assimilating the satellite observed soil moisture and snow cover adapting suitable data assimilation technique. Further, as Ganga Basin has large basin storage and irrigated land, this year an attempt has been made to incorporate these effects to improve the water balance estimation, in turn the hydrology of the basin. Hydrological models aim to simulate water fluxes within a river basin by accounting for various sources and parameters. However, basins are inherently complex systems influenced by additional factors such as irrigation, which can significantly alter evapotranspiration rates and redirect water flows, ultimately impacting basin storage and the overall water balance. Despite this, many hydrological models often overlook the effects of irrigation and storage. This study investigates the impact of incorporating both irrigation and lake storage into the Variable Infiltration Capacity (VIC) model to improve the accuracy of hydrological simulations across a river basin. Four configurations of the model were assessed: the baseline version without additional components (VIC-Normal), a version with lake storage (VIC-Lake), one with irrigation (VIC-IRR), and a configuration that includes both irrigation and lake storage (VIC-IRR Lake).

Among these, the VIC-IRR Lake configuration demonstrated the strongest agreement with observed hydrological data, especially in areas with high agricultural activity. It showed a 3.58% increase in soil moisture over irrigated cropland and achieved a strong correlation (r^2 = 0.89) with ESA CCI soil moisture observations. The evapotranspiration outputs from VIC-IRR Lake also showed improved agreement with MODIS ET data (r^2 = 0.67), compared to the VIC-Normal setup (r2 = 0.46), indicating a more realistic depiction of surface fluxes. The percentage change in discharge, as depicted in the figure below, reflects the difference between streamflow outputs from the VIC-IRR Lake and VIC-Normal model configurations. This increase highlights the significant hydrological impact of including irrigation and surface water storage in the VIC model. Notably, stations like Prayagraj exhibited substantial increases, with discharge rising by over 200% during peak monsoon and post-monsoon months (e.g., 231.6% in September and 271.9% in December). Farakka showed moderate increases, such as 101.1% in August and 93.47% in January. In contrast, upstream stations like Rishikesh displayed minimal or even negative changes, with decreases in several months (e.g., –14.8% in March and –20.4% in November), indicating reduced upstream influence of irrigation and storage.





The VIC-IRR Lake configuration also demonstrated stronger agreement with observed discharge data from the Central Water Commission, with Nash–Sutcliffe Efficiency (NSE) scores of 0.96 at

Rishikesh, 0.65 at Kanpur, 0.96 at Prayagraj, and 0.87 at Farakka. These results underscore the importance of integrating irrigation practices and surface water storage in hydrological models to more accurately capture basin-scale flow dynamics, especially in regions where human interventions significantly alter the natural hydrological cycle.

Spatio-temporal Variation of gaseous Air Pollutants over the Indian Subcontinent with a Special Emphasis in Foothills of North-Western Himalaya

Increasing anthropogenic activities and biomass burning events over Northern Indian region severely affect the pristine environment of North western Himalayas. To investigate their influence in this data sparse region, continuous monitoring of O_3, CO and NO_x are made during January 2018 to December 2019 over Dehradun. Ozone shows daytime broad peak and lower values during nighttime. The maximum daytime ozone is observed in spring with 58.2±2.0 ppbv (56.2±2.7 ppbv) during 2018 (2019). Diurnal variations of CO and NO_x show two distinct peaks, a smaller peak during morning hours during 0800 to 1100 hrs and a much bigger peak in the evening hours during 1700 to 2100 hrs due to vehicular emissions and boundary layer dynamics. Monthly average CO shows maximum value (1274 ± 249 ppbv) during December month and monthly average NO_x shows maximum value (11 ± 2 ppbv) during January month. CO and NO_x are found to be minimum during July month with 327 ± 38 ppbv and 2.5 ±0.6 ppbv mixing ratios respectively. The observational site is also affected from outflow of rabi crop residue burning emissions over Punjab and other adjoining regions during late April and May months which contributes in higher level of ozone precursors at Dehradun and favours for ozone production. MODIS fire counts, Potential Source Contribution Function and Concentration Weighted Trajectory analysis highlight that the concentration of gaseous pollutants over Dehradun are influenced from stubble burning and forest fire emissions during spring season. To quantify the contribution coming from crop residue burning and forest fire emissions, chemistry transport model WRF-chem simulations are performed with and without biomass burning emissions. The analysis reveals that biomass burning over northern Indian region contributed 43 ppbv, 79 ppbv and 1.2 ppbv increase in ozone, CO and NO_x concentrations over Dehradun. The abnormally high surface ozone difference is observed between June 2019 and June 2018 over this location. The analysis reveals two contributing factors for this event. The dust storm event in June 2018 was responsible for excessive loading of dust aerosols, reduced photochemical production of ozone and increased heterogeneous loss of ozone over Dehradun. This resulted in lower surface ozone levels (16.1±9.3 ppbv) over Dehradun in June 2018. In addition, stratosphere troposphere exchange process enhanced tropospheric ozone in June 2019 (53.6±22.3 ppbv). This event contributed in significantly high surface ozone at Dehradun (53.6±22.3 ppbv).

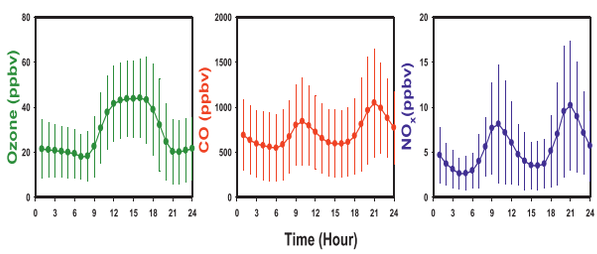


Fig. Typical diurnal variation of ozone, CO and NO_x over Dehradun

Automated detection of rock glaciers in western Himalaya, India

Rock glaciers occurrences is considered as the direct and visible indicators of mountain permafrost and hence are used as indicator for permafrost distribution. The mapped

rock glaciers under the TDP mentioned in the title were compared with the Global Permafrost Zonation Index (PZI) given by Gruber (2012) and by Permafrost distribution map provided by Khan et al. (2021) for Kashmir region, as the region exhibits surface features indicating thermokarst landscape. The occurrence of rock glaciers and thermokarst lakes were compared with permafrost maps for Kashmir region. The permafrost map revealed that the rock glaciers and thermokarst lakes in this region has been formed at locations dominated by discontinuous permafrost followed by continuous permafrost zone. The presence of a number of rock glaciers under continuous and dis continuous permafrost zones in the Kashmir region indicate that rock glaciers can be taken as the primitive indicator for permafrost and their continuous monitoring involving geophysical investigation is crucial under warming scenario.

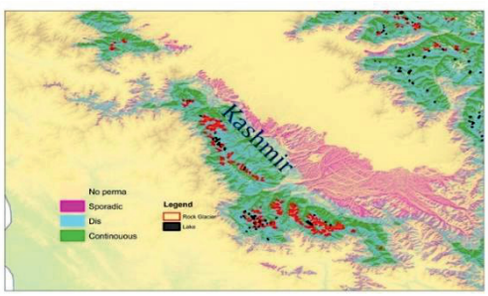


Fig.: The rock glaciers shown on permafrost map

Study on the carbon dynamics over the north Indian Ocean using coupled numerical model and remote sensing data.

In the present study the spatiotemporal distribution of pCO_2 over the north Indian Ocean is investigated using satellite-derived sea surface temperature, sea surface salinity and chlorophyll concentration. The analysis reveals that pCO_2 is high over the north Indian Ocean during April and May due to the warm SST during summer. The pCO_2 is less along the Somali coast during August because of the higher Chl-a concentration due to coastal upwelling as a result of strong monsoon wind. During the southwest monsoon (June-August), upwelling in the Arabian Sea increases surface pCO_2 while riverine inputs in the Bay of Bengal contribute to its seasonal variability. The inter-annual variability of sea surface temperature and pCO_2 is studied over the different sectors of the Indian Ocean. The pCO_2 is showing a positive anomaly after the year 2012 over the Indian Ocean. The tropical Indian Ocean shows a positive trend in SST of 0.0179 °C and the Bay of Bengal leads the highest trend of 0.0219 °C/year. A positive trend in pCO_2 across Indian Ocean is showing evidently with an increment of 0.1514 Pa/year. High positive and negative anomaly of pCO_2 is noticed for the year 2019-2020 and 2023 over the Sumatra and Kerala coast respectively. The results presented in this study are of particular importance as they facilitate the better understanding of the spatial and temporal variability pCO_2 over a highly data sparse region like Indian Ocean, especially under the assumption of climate change-driven global warming.

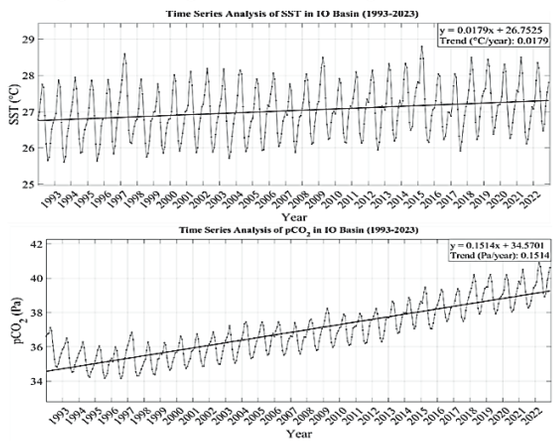


Fig.: Time Series of SST (upper panel) and pCO2 (lower panel) in the Indian Ocean.

Proximal Remote Sensing for Digital Soil Mapping of Nutrients and Heavy Metals

Soil information, including its spatial variability, is crucial for formulating effective soil and land management policies, assessing the environmental impacts of

land-use changes and industrial activities, and supporting sustainable development. Detailed and accurate spatial soil data is also essential for addressing research questions related to earth system modelling, climate change, and ecosystem services. However, conventional soil survey methods and laboratory-based analytical techniques are often labor-intensive, destructive, expensive, and time-consuming. These limitations restrict the number of soil samples that can be practically analyzed. In contrast, proximal soil sensing (PSS) or proximal remote sensing technologies—employing advanced sensors—offer a cost-effective, rapid, and environmentally friendly alternative. These techniques enable the collection of both spatial and temporal soil data with reduced chemical use and less manual effort.

Among the various proximal sensing tools used for the rapid and timely estimation of soil properties, portable X-ray fluorescence (pXRF) spectrometry has seen growing use in recent years for soil analysis and mapping. XRF has primarily been used to assess metal concentrations in contaminated soils, evaluate soil physicochemical properties and fertility, characterize soil morphology and horizon differentiation, estimate calcium content and gypsum requirements, as well as assessing environmental quality—particularly in relation to heavy metal contamination in peri-urban agricultural areas.

However, only very few attempts have been made in India to explore this technique for estimation of various soil parameters. This project aims to develop a methodology and models for prediction of various soil nutrients and heavy metals and their mapping based on advanced sensor based proximal soil sensing approach. Industrial effluents affected croplands adjacent to Hindon river in Saharanpur district and Industrial belt along the Bhagwanpur-Roorkee road, Haridwar District were selected as study areas. A detailed sampling plan was formulated based on literature survey. Transects will be identified at suitable areas, covering both sides of the river for studying the concentration and distribution of heavy metals. 1.5km2 transects on both sides of the river will sampled using a grid sampling approach, with a grid size of 200m, thus resulting in 70 soil samples/ observations per location. Similar transect will be identified and sampled in the unpolluted stretch of river before Saharanpur city too. In addition, ground water and river water samples also will be collected, if possible, to estimate the heavy metal and nutrient concentration. Leaf samples of various crops grown in the area also will be collected for heavy metal analysis and measure the chances of higher upatake. Similar transect based sampling approach will be adopte dint ehinducstrial belt area also, for determining the concentration of nutrients and heavy metals. The measured heavy metal concentrations will be used for mapping and identification of pollution zones using proximal sensing and digital soil mapping techniques.

Detection and Mapping of Forest Lopping Disturbances Using Satellite Data and Deep Learning

Globally, forests are subjected to various drivers of anthropogenic disturbance that vary in magnitude and intensity. Tropical forests, valued for their rich biodiversity and ecosystem services, are particularly affected by both large-scale disturbances (e.g., deforestation, fire, logging) and small-scale but chronic disturbances (e.g., insect outbreaks, tree lopping). Collectively, such disturbances are estimated to contribute over 15% of global CO_2 emissions from various sources.

Tree lopping, undertaken primarily for the extraction of leaf fodder, is a particularly prevalent form of disturbance in forest-adjacent areas of developing countries like

India, where a large livestock population relies on forests and agroforestry systems for feed. This practice, aimed at obtaining foliage for livestock, has led to severe damage and degradation of forests surrounding villages.

While satellite remote sensing has proven highly effective in detecting and monitoring relatively large-scale disturbances, less success has been achieved in detecting and mapping fine-scale disturbances such as forest thinning and lopping. Deep learning techniques have emerged as powerful pattern recognition methods, particularly well-suited for analyzing high-resolution satellite imagery.

In light of this, the present study assessed the potential of high-resolution satellite remote sensing data from WorldView-2 for detecting forest lopped areas within a moist deciduous sal forest in a part of the Doon Valley, Uttarakhand, employing a deep learning (DL) approach. A Convolutional Neural Network (CNN) approach was evaluated using WorldView-2 reflectance bands and spectral indices (namely NDVI, VSI, and GRCI) from images acquired in October and May. Figure presents the RGB image of the study site alongside the DL-classified image, which includes lopped forest as a distinct class.

The overall classification accuracy achieved was 89.0% for the October image and 85.0% for the May image. When the trained models were applied to independent sites, they yielded accuracies of 82.5% and 76.5% for October and May, respectively. The lower accuracy in May is attributed to increased misclassification resulting from the deciduous nature of the sal forests during this period. This study concludes that images acquired in October are more suitable for detecting lopping disturbances and recommends further investigation.

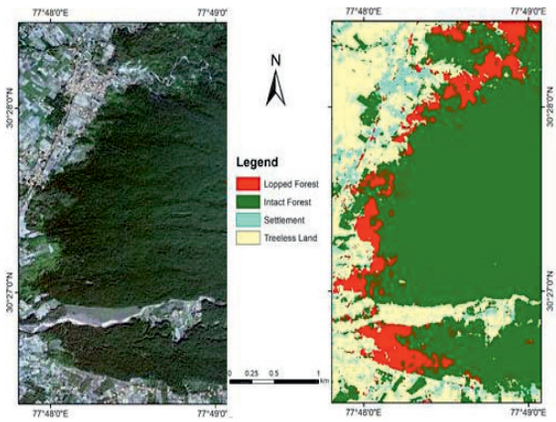


Fig.: WV-2 true colour image of October month and CNN classified image.

Development of framework for Crop-based Irrigation Decision Support System by using Geospatial Technology, Real-time Observations and Weather Forecast

With the key note of 'Per Drop More Crop' from Pradhan Mantri Krishi Sinchayee Yojna (PMKSY), the precise assessment of water requirement and effective utilization of water is the prime mandate in context of recent sustainable agricultural production. The need for an increase in agricultural production, due to the growth of the population, causes the need for improved irrigation water use efficiency. There are various calculation methods for crop water requirements estimation that could be applied by farmers but although crop yield is often related to water use, most producers do not use any methods for determining the water requirements of the crops. Along, the most of the methods (empirical, semi-empirical equations) of calculation require several parameters i.e. weather variables, soil information and crop characteristics for accurate assessment. Many of these methods were designed for areas with localized conditions as specific pedological and climatic conditions and thus their application is very limited.

Thus, a holistic approach is requisite to determine the actual crop water requirement as well as on prediction basis water need for optimal crop production. This integrate the weather observations from ET station, ancillary information and products of geospatial technology, sophisticated instrumentations for crop, soil observations, weather forecast products and time-series analysis based results in the WebGIS based irrigation demand assessment and its user interface. Currently IIRS is working on this project to estimate the crop water requirement in near real time and weekly forecasting scale. In this project, IIRS integrated satellite data, ancillary data, ET station data and satellite derived datasets from 2022 to 2025 for estimation and forecasting of crop water requirement.

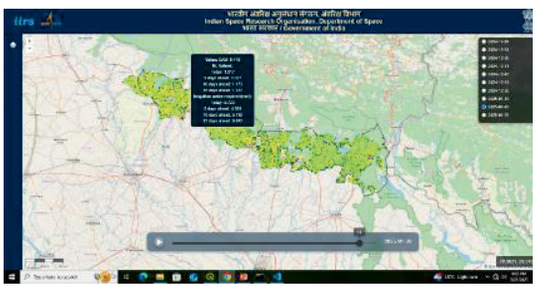


Fig.: Dashboard for Irrigation Demand Assessment for Udham Singh Nagar

Identification and systematic characterization of Indian based Martian analogue sites with possible traces of bio-geological signatures using Raman spectroscopy

Raman spectroscopy of selected potential Indian - based Martian analogue sites having astrobiological significance is being pursued. Some Initial Results of this study aims to investigate and characterize Indian analogue sites that serve as possible tracers of life representing bio-geo-signatures for Mars with Raman spectroscopy and other complementary techniques. To explore the astro-biological potential RAMAN-based investigation is undertaken for the ophiolites from Ladakh (UT) (e.g., Nidar and Spongtong), Andaman Island and Rikhabdev Ultramafic Suite, Udaipur (Rajasthan). Hot springs and saline lakes of Ladakh (Puga, Chumgthang) were selected to study and characterize. Mud-volcanoes of Andaman Island (Bartang and Diglipur) and stromatolites of Jhamarkotra rock phosphate mine, Udaipur were selected for potential organic and biosignature-bearing sedimentary rocks and biostromal structures, respectively. Initially remote-sensing data from multispectral (ASTER-TIR and LANDSAT-8 OLI) and hyperspectral (AVIRIS-NG, PRISMA and EMIT) sensors have been used for spectral characterization of lithology of the study areas. It was followed by field study, sample collection and Laboratory-based spectroscopic study of samples using ASD FieldSpec4 Spectroradiometer (Visible and Near Infrared, VNIR) and Fourier Transform Infrared Spectrometer for reflectance and emissivity, respectively.

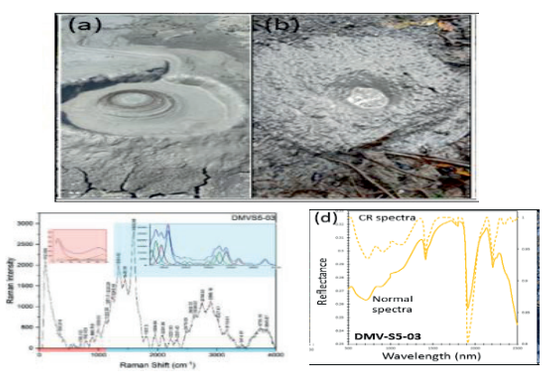


Fig.: Field images of (a) Bartang and (b) Diglipur Mud volcanoes; (c) Peak defined Raman spectrum and deconvolved spectrum presented as an intensity-versus wavelength shift acquired from our recent work on Indian based Martian analogue site samples collected from Diglipur Mud volcano (DMV) (d) Normal and continuum removed reflectance spectra of DMV sample showing the prominent absorption for iron, mafics, and altered minerals.

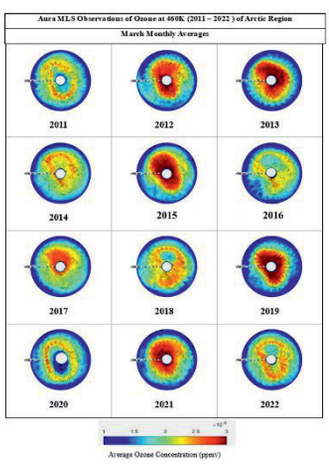
For bulk chemistry samples were sent for geochemical analyses (XRD, XRF, ICPMS) followed by Raman spectroscopy of relevant samples. The Raman measurements were carried out at laser excitation source of 532 nm. The spectra were interpreted after smoothening, baseline correction,

normalization to a selected band followed by defining peaks and curve fitting analysis.

Potential of Terahertz Remote Sensing in Space Applications

Terahertz (THz) remote sensing is an emerging field in atmospheric science and remote sensing that explores the use of terahertz frequencies, typically ranging from 0.1 to 10 THz, to gather information about the Earth's atmosphere and surface. Terahertz waves, which lie between the microwave and infrared regions of the electromagnetic spectrum, have unique properties that make them particularly useful for sensing various atmospheric constituents, including gases, aerosols, and clouds. The Aura Microwave Limb Sounder (MLS) is an instrument aboard NASA's Aura satellite, launched on July 15, 2004, as part of the Earth Observing System (EOS) to study the Earth's atmosphere.

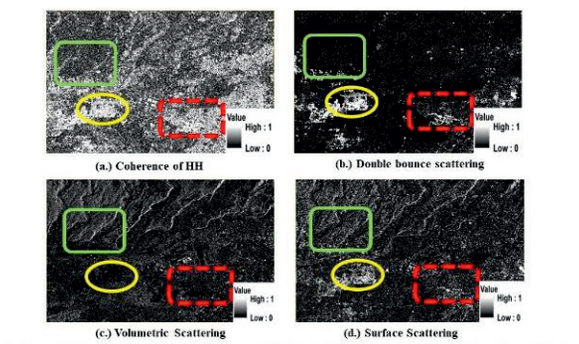
A time series analysis was done on the concentration of ozone gas over the Arctic region from 2010 to 2022 using MLS sensor observations in terahertz frequency. It was observed that unusually prolonged cold stratospheric conditions in 2019/2020 have led to a decrease in the ozone concentrations in the Arctic region. This level was only close to 2010/2011. This behavior resembles that seen in the Antarctic, where an ozone “hole” recurs each winter. The relationship of Chlorine monoxide (ClO) with Ozone loss is also analyzed using MLS sensor observations in terahertz frequency. It was observed that there is a high level of ClO concentrations whenever there is a decrease in ozone concentration in the Arctic region.



Machine Learning based Urban Land Cover Classification using PolInSAR data: A Study with ALOS-2 and RADARSAT-2 Datasets

A substantial variation in the land cover dynamics has been observed as a consequence of increasing urban expansion. Polarimetric synthetic aperture radar (PolSAR) data is widely being used for land cover studies in urban areas as it has all-time and weather imaging capability. However, in dense urban areas, problem arise with buildings having large Azimuth Orientation Angles (AOAs), which are misclassified as vegetation due to depolarization of radar signal leading to volumetric scatting. In this study, it is proposed to use Polarimetric SAR interferometry (PolInSAR) coherence to differentiate urban areas from vegetated areas, Urban areas have high coherence as they are stable scatters in comparison to vegetation which has low coherence due to growth phenology and wind effect. This study evaluates various decomposition and scattering parameters along with PolInSAR coherence derived from L-band (ALOS-2) and C-band (RADARSAT-2). Two machine learning algorithms viz., Random Forest (RF) and Convolutional Neural Network (CNN) were applied for land cover classification. For further improving the classification results, SAR and optical datasets were fused using Gram-schmidt fusion technique, an overall accuracy of 94.50% and kappa statistics of 0.92 were achieved when CNN algorithm was applied on fused optical and C-band RADARSAT-2 dataset. The study concludes that the SAR datasets can provide promising classification outputs and C-band provides the best classification results by using decomposition, scattering, and coherence parameters for LULC classification. The misclassification of urban areas with large Azimuth Orientation Angles has been addressed by using PolInSAR coherence.

The study found that the fusion of optical and SAR parameters gave better results compared to SAR parameters alone. For further research, various other fusion algorithms can be evaluated. Finer optical datasets can be used for fusion and various deep learning architecture and encoders can be evaluated for improving the classification.



Forest Research Institute (FRI) area, Dehradun showing (a) coherence of HH polarization (b) double bounce scattering(c) volumetric scattering and (d) surface scattering of C-band

Multi-satellite observations based assessment of River and Lake Bathymetry for Hydrological Studies

A Technology Development Project has been initiated with the following objectives: Water level, water spread and slope estimation of river/lake using multi-satellite data; River/Lake bathymetry approximation using multi-satellite data and inversion approach; River bathymetry approximation using concurrent observations from SWOT mission and inversion method approach; Evaluation of estimated river/lake bathymetry using in-situ observations and its implications for hydrological studies. This year substantial efforts were made to estimate the glacier lake bathymetry using the remote sensing data. The glacier lakes of Ladakh and Uttarakhand were studied, as these are vulnerable to glacier lake outburst floods. To validate the remote sensing derived bathymetry a comprehensive field-based survey using the echoboat was carried out in both the glacier lakes.

For glacier lake bathymetry retrieval using remote sensing, the slope extrapolation and radiative transfer methods were used. Radiative transfer method (RTM) is a physics-based method used for estimating water depth from multispectral satellite data. This method models how solar radiation interacts with the water column, particularly focusing on the absorption and scattering processes that occur as sunlight penetrates the surface. The degree of attenuation that sunlight undergoes within the water body is dependent on both the inherent optical properties (IOPs) of the water and the wavelength of the incident radiation. The attenuation of light in water follows the Bouguer-Lambert-Beer law, which describes the exponential decrease in light intensity as it travels through an absorbing and scattering medium such as water with increasing depth. This law provides the theoretical foundation for estimating bathymetry in optically shallow waters, where the lake bottom significantly influences the recorded surface reflectance.

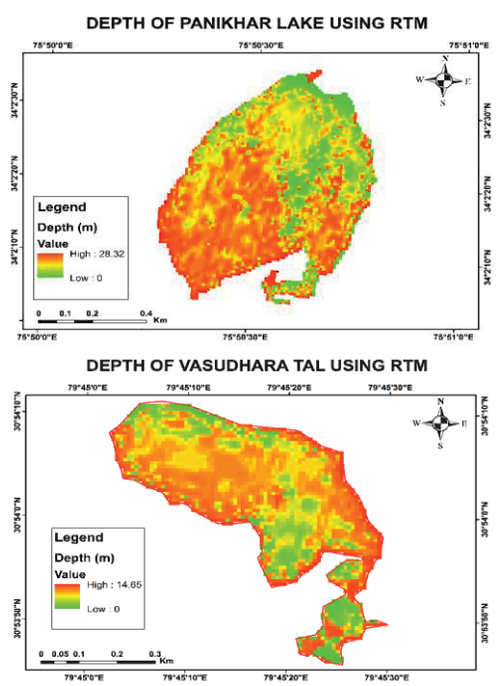


Fig. The retrieved bathymetry of Panikhar and Vasudhara Tal Glacier Lakes using RTM

In this study, RTM is applied to estimate water depth of Panikhar Lake and Vasudhara Tal, both of which are high-altitude glacial lakes in the North-western

Himalayas. Panikhar Lake lies in the Suru basin of Ladakh, while Vasudhara Lake is situated in Dhauliganga basin of Uttarakhand. This law describes the exponential attenuation of light as it passes through an absorbing and scattering medium, such as water. To ensure accurate depth estimation, precise surface reflectance data is required. Therefore, Sentinel-2 Level-1C data for surface reflectance is used.

Provenance & process of formation of highland anorthosite and mare basalt of the Moon from the study of selected lunar analogues in India by spaceborne and in situ spectral analysis

The lunar crust primarily comprises mare basalts and highland anorthosites. The Archean anorthosite complexes of Sittampundi serve as analogs to lunar highland anorthosites, while the Moon's mare regions resemble terrestrial basaltic terrains, found in India's Deccan Traps.

The aim of this project is to spectrally characterize Earth's mafic lithology through a Remote Sensing/Earth Observation (RS/EO)-based methodology. The accompanying figure depicts the False Color Composite (FCC) derived from AVIRIS hyperspectral data acquired over the Sittampundi Anorthositic Complex (SAC).

The SAC is predominantly characterized by relatively pure calcic anorthite (An_{80-100}) and contains less than 10% mafic minerals (Ashwal 2000). Significant absorption features identified in the AVIRIS image spectra are located approximately at 820 nm, indicative of Fe^{2+} and Fe^{3+} presence. Additionally, a low-calcium pyroxene absorption is observed near 1000 nm, and Al-OH and Mg-OH absorptions are evident at 2200.

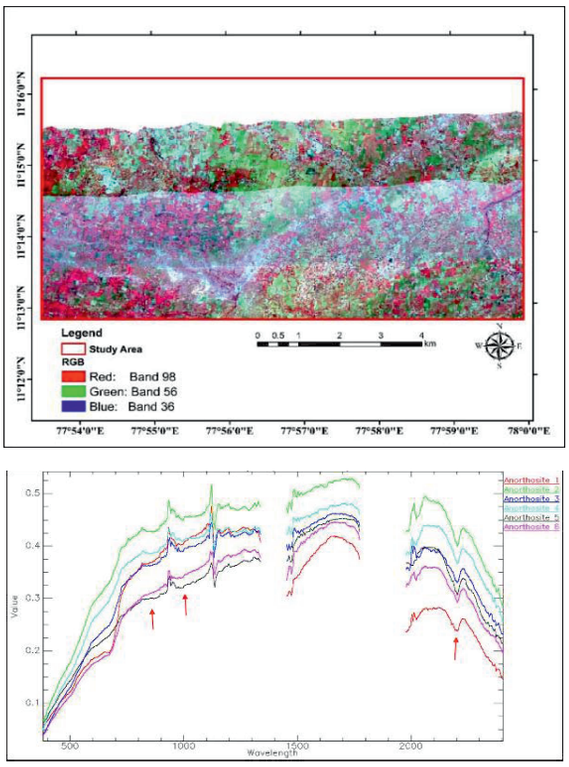


Fig.: FCC of AVIRIS Data Sittampundi Anorthosite Complex and spectra collected from it

Impact of Hyperspectral Infrared sounding observation assimilation on regional NWP model forecasts

Hyperspectral sounders provide information through advanced atmospheric instruments that measure radiation across many narrow, contiguous spectral bands. This information offers in-depth insights into the atmospheric vertical structure, which is essential for weather forecasting. Hyperspectral sounders provide detailed vertical profiles of temperature, humidity, and other atmospheric variables with fine resolution. The use of such observations can significantly improve forecasts from numerical weather prediction (NWP) models. In the present study, two sets of experiments were conducted: the control experiment, which involved only conventional observations (referred to as Control-Run), and the CrIS experiment, which incorporated both conventional observations and hyperspectral data from

the Cross-track Infrared Sounder (CrIS) instrument (denoted as CrIS-Run). Both experiments utilized the WRF model and employed a Gridpoint Statistical Interpolation (GSI) analysis system based on a three-dimensional variational (3D-Var) scheme. The experiments are carried out over the study region from 50°E-100° E and 0°N-40° N for the entire month of June 2023.

The Day-3 temperature forecast at 850 hPa pressure levels, averaged over 30 days, is compared with fifth-generation ECMWF reanalysis (ERA5) data. It is noted that the correlation values of CrIS-Run forecast has improved as compared to Control-Run (Figure-(a-b)). The low correlation observed in the Control-Run over certain oceanic regions has significantly improved, ranging from 0.33 to 0.77, in the CrIS-Run. Furthermore, an improvement in correlation is also observed in temperature forecast over the land regions in the CrIS-Run.

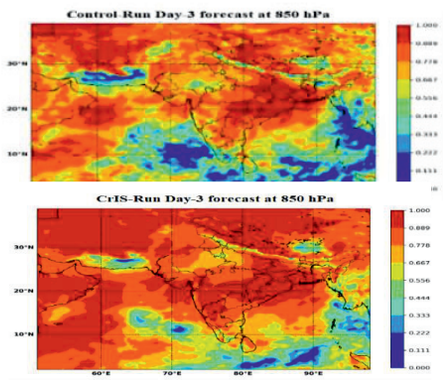


Fig.: Spatial plots showing the 30-day averaged correlation of temperature forecasts with ERA5 reanalysis data at the 850 hPa pressure level for Day-3: (a) Control-Run and (b) CrIS-Run.

Raman Spectroscopy to investigate the spectral features of soil, vegetation, and water

Analysis for the suitability of dual-laser Raman spectroscopy: Raman spectroscopy for environmental samples such as plants, water, and soil has been increasingly applied because of its molecular specificity and non-destructive nature. The selection of the excitation laser, most commonly 532 nm or 785 nm, plays a great role in the quality of the spectrum, especially in fluorescence interference and Raman scattering efficiency itself.

The excitation laser selection greatly influences the quality of Raman spectra from vegetation leaves, which normally contain compounds like lignin, carotenoids and chlorophyll. Due to the high pigment content in leaves, the 532 nm laser frequently has strong fluorescence, but it also has a high Raman scattering efficiency and improves signals from pigments like carotenoids (~1520 cm^{-1}).

Fluorescence from vegetation can often be intense under 532 nm laser excitation and may subsequently mask the Raman signal. In such situations, 785 nm lasers are generally preferred since they fluorescence much less but come at a cost of lower Raman intensity, i.e. weaker Raman signals. With slightly less intensity, the 785 nm laser dramatically lowers fluorescence, making it possible to detect cell wall components like cellulose (~1095 cm^{-1}) and lignin (~1600–1630 cm^{-1}) more clearly. The spectral coverage and dependability of identifying pigment and structural biomolecules in vegetation leaves are enhanced when both lasers are used in a complementary manner. Raman spectroscopy also offers the distinct advantages in characterise the water quality.

For soil samples that are predominantly mineral, the use of a 532 nm laser is advantageous as it gives higher intensity of Raman scattering. Raman spectroscopy combined with classification techniques has demonstrated significant potential in distinguishing various soil types. The dual-laser approach enables optimized spectral acquisition across diverse environmental matrices, improving detection reliability in field applications.

Understanding the dynamics of Martian paleo and present-day water cycle of Mars using remote sensing, modeling techniques and Earth based analogue studies

Martian paleo and present-day water cycle study of Mars using Earth based analogues are studied & as part of the project, one of the Earth based Analog sites has been chosen as Jaisalmer, which is currently arid desert region with historical presence of paleo channels and oceans, which are similar to what are found on present day Mars.

The Khaba fort site was chosen as Mars-Earth Analog site near Jaisalmer, due to our hypothesis that this location represents the upper edge of paleo Saraswati River, where inland water navigation was done during historical times. The geological features and their interpretations can give us clue about present day Mars specially the open question of paleo river channel and Northern Ocean of Mars.

A detailed geophysical investigation was conducted during 1st week of May 2024 at one of the selected Mars-Earth Analog sites, near Khaba fort, Jaisalmer, Rajasthan, India using *Electrical* Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR). The ERT survey profile length was 300m and profile was kept at the intersection of paleo channel with paleo bankline.

The pseudo section was data was acquired in two configurations (Pole-Dipole, fig (A) and Dipole-Dipole, figure (B) using 4-point LIPPMANN IP resistivity meter instrument and Geotest acquisition software. Both the acquired configuration data were inverted using RES2DINV modelling software. The inverted sections (fig A & B) infers a three-layer model with near Khaba fort with top layer indicating low resistivity (10-ohm m to 5-ohm m), intermediate layer showing medium resistivity (20-ohm m to 100-ohm m) which may indicate presence of paleo-channel with *presence* of clay mixed with sand and other long-term deposition of various sediment material as part of Aeolian process along with loading and compaction over the last 5000 years. Last layer with low resistivity (6-ohm m and less) indicating presence of saline water.

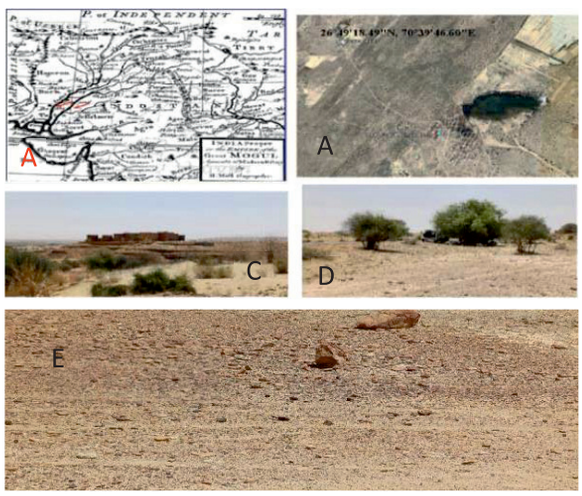


Fig.: *Dutch map – 1746 representing two parallel rivers Indus and Sarasvati River.* ***1-B****. Khaba fort near the lake and start location with a white marker.* ***1-C.*** *Khaba fort now.* ***1-D.*** *Survey point starting from the big tree where the vehicles are standing and ERT survey.* ***1-E*** *Field photographs of Mars-Earth Analog site location.*

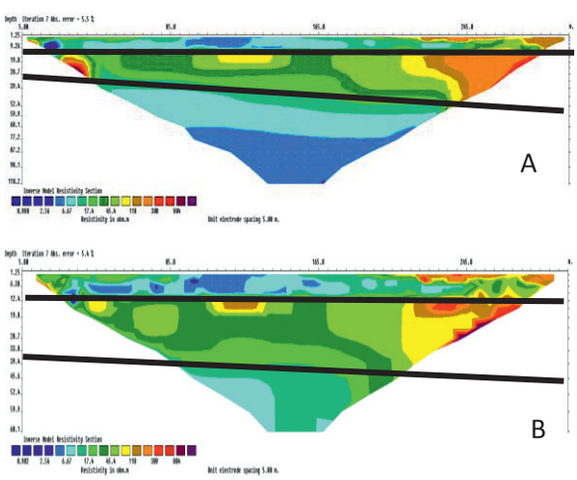


Fig.: Inverted resistivity section in Pole-Dipole configuration and Inverted resistivity section in Dipole-Dipole configuration.

Mountain Ecosystem EOAM – Ph II ST-1: Crustal deformation and active tectonics study in the Northwest Himalaya

The Himalaya is an active tectonic zone continuously experiencing deformation and upliftment, with high seismic hazards and exhumation patterns. To obtain information about the present-day tectonic processes in this area, it is essential to know that crustal deformation which is a physical modification of the Earth's crust caused by tectonic forces.

These forces build up over time, affecting fault geometry, regional strain budget, stress accumulation, prevailing fault slip rates, and the formation of seismogenic structures that can result in earthquakes. The monitoring of active faults is necessary for seismic hazard evaluation, especially in highly populated or infrastructure important regions.

This entails the recognition and examination of the characteristics and behaviour of faults that are currently active in terms of tectonic activity. To measure the rate of strain accumulation and evaluate seismic hazard potential in the Northwest Himalaya, surface deformation is being tracked by a network of 138 GNSS stations. These stations are deployed by IIRS, SOI, NGRI, WIHG, and IIT Kanpur at various epochs from the Gangetic Plains to the Higher Himalaya. An integrated method that involves space-based measurements (GNSS and SAR) together with geophysical techniques can greatly improve the analysis of the regional strain budget, seismic hazards, and possible earthquake precursors.

As the Himalayan region is situated in high seismic risk areas (Zones IV and V), an overall understanding of the active tectonic system of the Northwest Himalayan foothills is critical. Such knowledge can guide and enhance seismic-resistant construction guidelines, especially in regions with a history of high seismic activity.

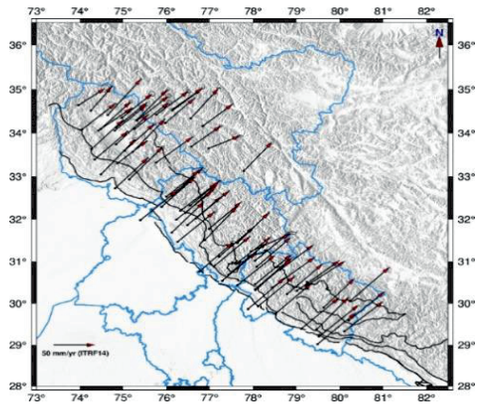


Fig.: Tectonic deformation in the Northwest Himalaya from GPS measurements at GNSS stations installed by IIRS, SOI, NGRI, WIHG and IITK. Site velocity is depicting in ITRF2014 reference frame, along with major faults. The velocity field represents the crustal deformation from 2014-2024.

Impact cratering is the most ubiquitous process that shapes planetary terrains. It creates and overturns lunar regolith and thus profoundly affects the physical characteristics of lunar surface materials at all spatial scales. The process of impact cratering involves three main stages: Contact and Compression, Excavation and Modification. High shock pressures and temperatures cause ejection of shocked melt, vapour and solid spall fragments of varying sizes. Various studies describe the process as involving a conical ejecta curtain wherein the fastest ejected materials are deposited farthest. A ballastic emplacement mechanism involving projectile motion of ejected fragments is also theorised to be responsible for secondary craters and rays. Investigation into the velocity and fragment size of these impactors, emplacement mechanism, particle size and depth of the deposit for the radially straited/ridged ejecta material.

Mountain Ecosystem EOAM – Ph II ST-2: Mountain Ecosystem Project-Strengthening Vegetation Phenology-Productivity and Climate Linkages in North West Himalaya

The northwest Himalayan (NWH) region is characterized by diverse topography and climate, making it ecologically and

climatically significant. Its rich biodiversity, high species endemism, and crucial ecosystem services to the surrounding plains make it a vital focus for climate research. This study aims to understand vegetation phenology, functional traits, productivity, and climate change impacts in Himalayan forests. The objectives include: (i) assessing phenophase transitions using satellite and phenocam data and identifying drivers of change; (ii) developing a plant traits database, mapping functional types, and simulating productivity trends; and (iii) examining alpine vegetation responses to experimental warming.

Sap flow patterns were studied in seven tree species representing various seral stages of forest succession, each with different water requirements. Sensors were installed to monitor diurnal and seasonal variations in sap flow for *Lagerstroemia speciosa*, *Butea monosperma*, *Shorea robusta*, *Mallotus philippensis*, *Acacia catechu*, *Dalbergia sissoo*, and *Holoptelea integrifolia*. The data provided valuable insights into species-specific water-use strategies across different growth stages. These findings help understand how trees adapt their water usage during forest development, contributing to better management of water resources and understanding of forest ecosystem functioning under varying environmental conditions.

The Himalayan forests are increasingly affected by environmental stressors such as dry winters, droughts, fires, insect outbreaks, and climate warming. Carotenoid pigments, essential for plant photoprotection, serve as early indicators of such stress but are difficult to detect remotely due to the dominant reflectance of chlorophyll in healthy vegetation. This study evaluates the use of PRISMA hyperspectral satellite imagery to estimate and map canopy carotenoid content (Ccar) in two key Himalayan tree species: *Shorea robusta* (sal) and *Pinus roxburghii* (chir pine). Using a genetic algorithm-based partial least squares regression (GA-PLSR) model, the study identified optimal wavebands and indices sensitive to carotenoids. Carotenoid absorption was strongest in the blue and green regions (441–571 nm). The Carotenoid Reflectance Index (CRI550) proved most effective, with R^2 values of 0.73 for sal and 0.63 for chir pine. However, GA-PLSR models based on selected reflectance bands showed even higher accuracy (R^2 > 0.8). Chir pine showed higher carotenoid content than sal, indicating a greater ability to withstand environmental stress. These finding offering a promising approach for large-scale forest health monitoring and early stress detection in the Himalayan region.

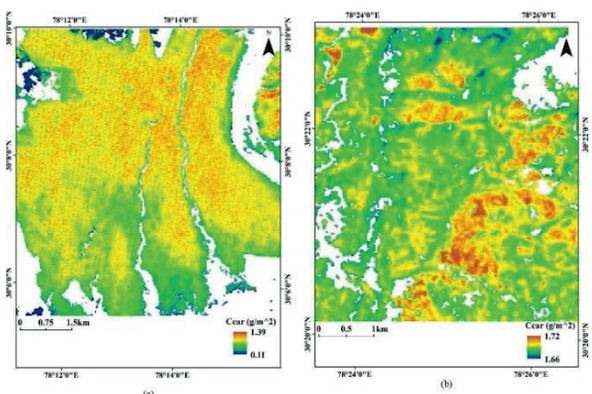


Fig.: Spatial patterns of canopy carotenoids in Subtropical moist deciduous sal forest (left) and Chir Pine forests (right)

Mountain Ecosystem EOAM – Ph II ST-3: Climate and Ecosystem Response Studies through Long Term Ecological Research Stations (LTERS)

Some of the major outcomes this year has been establishment of reduction in ecological niche of important endemic plant species which have potential of local level extinction. The Model outcomes also indicate significant changes in species and loss of species' diversity. It has also been established that the forest fire vulnerability is directly linked to weather patterns climate regimes, and eastern part of Indian Western

Himalaya specially in mid altitude of Himalaya of Uttarakhand are becoming major hotspots of forest fires. The plant functional type map of western Himalaya has been modelled which provides understanding of impact of climate regimes on distribution of plants in this region. Furthermore, long term studies over Hindukush Himalaya have shown that most of the Indian Himalaya are 'greening' specially in lower elevation due to increase in precipitation and temperature.

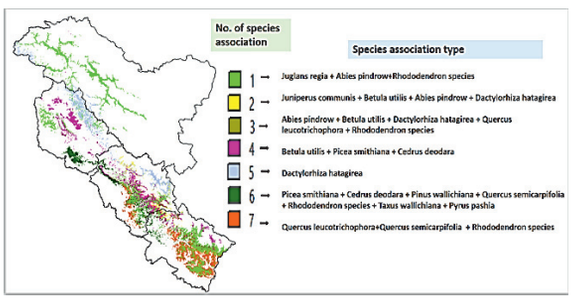


Fig. Predicted Species Association under Climate Change Scenario (RCP 4.5)

Mountain Ecosystem EOAM – Phase II ST-4: Soil Erosion Estimation based on Radio Tracer Technique and Soil Quality Assessment in Mountainous Landscape of North- West Himalaya

The Himalayan hills and mountains are very fragile and being threatened by land degradation due to soil erosion by water, poses serious challenges to the soil ecosystem services and sustainability of natural resources. Reliable estimate of long-term soil erosion rate in various land use/land cover types and slopes are necessitated to suggest suitable conservation measures for managing the natural resources. The rugged terrain, inaccessibility, remoteness, and extreme weather events restrains in adopting conventional methods of soil erosion measurements. Fallout Radionuclides (FRNs) ^{137}Cs provide a unique potential for reliable measurement of long-term soil erosion rate in the hilly and mountainous landscapes. This relies on underlying assumptions of uniform spatial distribution, strong binding to soil particles, negligble plant uptake, minimal leaching by water, no chemical migration as well as movement solely through physical processes and appropriate soil sampling designs. FRN based erosion measurements may compliment to the erosion models as well as serves as exclusive method for erosion estimation in the landscape. In this context, the study aimed to assess soil erosion rate and risk at pixel level using RUSLE model and to validate results with radiotracer technique. The study also aimed to establish depth distribution of ^{137}Cs (FRN) for Himalayan Soils and also estimate long term erosion rate (60 Years) at various hillslope positions and land use / land cover types. Soil quality was also assessed based on environmental variables derived from remote sensing and climate data employing machine learning based predictive techniques.

The measured ^{137}Cs reference inventory in the Tehri dam catchment ranged from 1408.6 to 2246.7 Bq m^{-2} with a mean value of 1834.9 ± 232.9 Bq m^{-2}. Among the different LULC types, forest observed lowest mean soil erosion rate of 5.9 t ha-1 yr-1 followed by grass land (7.8 t ha^{-1} yr-1), scrubland (15. 5 t ha^{-1} yr^{-1}), and agriculture (18.9 t ha^{-1} yr^{-1}). Barrenland observed highest soil erosion rate of 43.2 t ha^{-1} yr^{-1}, among the different LULC types. The average soil erosion rate of the Tehri catchment was estimated to be 18.3 t ha^{-1} yr^{-1}.

Soil erosion rates under different forest types were also estimated. The oak and mixed forest exhibited lowest mean soil erosion rate of 3.7 and 3.8 t ha^{-1} yr^{-1} respectively. Estimated soil erosion rate of Deodar Forest was 6.0 t ha^{-1} yr^{-1}. The highest soil erosion rate was observed in Pine Forest with 7.1 t ha^{-1} yr^{-1}.

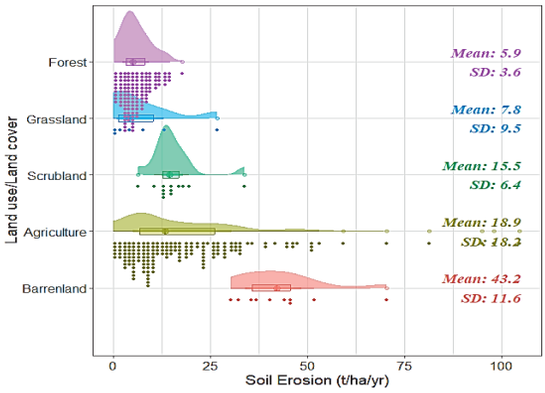


Fig.: Soil erosion rates under various LULC types

Among different hillslope positons, the highest soil erosion rate was observed in lower hillslope position (24.4 t ha^{-1} yr^{-1}), followed by upper (16.0 t ha^{-1} yr^{-1}) and middle (15.7 t ha^{-1} yr^{-1}) positions, whereas the ridge (9.3 t ha^{-1} yr^{-1}) observed lowest soil erosion rate. Contrarily, valley hillslope position observed deposition of sediments at rate of 17.6 t ha^{-1} yr^{-1}. These results establish the role of middle and lower hillslope positions as the most critical source areas with higher soil erosion rates.

Spatial distribution of potential soil erosion rates in the area was also mapped by integrating different geospatial based inputs parameters employing RUSLE model. The model-based outputs were validated with point scale, soil-landscape unit and land use/land cover-based soil erosion rates by FRN technique. The analysis revealed a moderate positive correlation (0.58) between the outcomes.

Spatial prediction models for soil quality mapping in the area employing different ML Techniques such as random forest regression, artificial neural network and support vector machine were developed. Long-term soil and vegetation based spectral indices and terrain parameters were computed by processing of temporal RS data using google earth engine platform and used as predictor variables. The validated models were used for mapping the spatial distribution of soil aggregate stability (SAS) with considerable accuracies with R^2 values ranging from 0.45 to 0.60. The predicted SAS values varied from 0.239 to 0.884, with higher and lower values observed in the valley and Ridge areas respectively. Among the different LULC types, highest SAS was found in valley scrub followed by shoulder forest (North aspect), whereas lowest values were found in ridge agriculture followed by back toe slope agriculture.

Effects of hillslope position and soil properties on micronutrient availability in steep terraced croplands in the study area were also assessed. The different hillslope positions were found to significantly influence the distribution of various micronutrients. Soil pH, organic matter (OM), and clay content were found to be the critical factors affecting micronutrient availability. Whereas, the conversion of natural ecosystems to agriculture was found to reduce micronutrient concentrations, emphasizing the need for nutrient management in altered landscapes

Mountain Ecosystem EOAM – Phase II ST-7: Observational and simulation study of extreme rainfall over the North-West Himalayan region

Extreme Rainfall Events (EREs) over the North West Himalayan (NWH) region of India have been examined for the monsoon season using the latest IMERG V07B rainfall data of 0.1◦x0.1◦ resolution for recent two decades (2000–2022). A strong correlation of 0.95 was noted between IMERG and ground-based IMD data. Intensity corresponding to the EREs for the 95th, 98th, 99th, 99.5th, and 99.99th percentile is found to be 17.43 mm/day, 34.47 mm/ day, 50.52 mm/day, 68.66 mm/day and 197.75 mm/day respectively. In all the classes of intensity, the magnitude is highest along the southwest foothills (1000

m – 3000 m) of NWH with the highest intensity over Dharamshala and Mandi regions (HP) along with southeast region of UK. Statistically robust Mann-Kendall (MK) test revealed a significant decreasing trend (95 % confidence level) in rainfall intensity corresponding to the 99th percentile and above over Dharamshala and Mandi. A late arrival of the 1-day maxima rainfall is observed in Dehradun, Mandi, and Leh regions whereas a contrasting behaviour is unveiled over Pithoragarh, Munsiyari, and Chamoli regions. For the NWH region as a whole, both frequency and intensity are significantly decreasing for the 99.99th percentile, though Ladakh region witnesses a significant increasing trend in frequency and intensity for all the categories barring the 95th percentile.

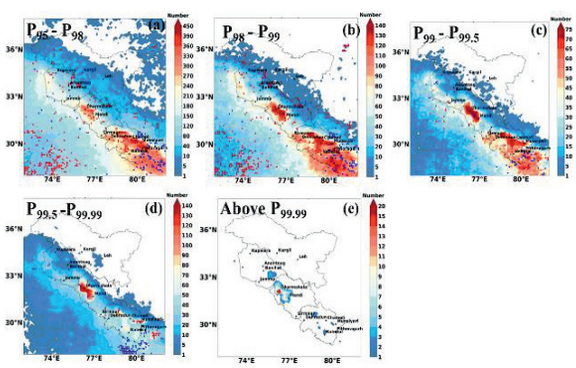


Fig: Spatial distribution of the number of EREs associated with P95-P98 (17.43 mm/day<x< 34.47 mm/day), P98-P99 (34-47 mm/day<x<50.52 mm/day), P99-P99.5 (50.52 mm/day < x < 68.66 mm/day), P99.5-P99.99 (68.66 mm/day < x < 197.75 mm/day), and >P99.99 (>197.75 mm/day), where 'x' is the intensity.

An elevation-wise study of the distribution of frequency and intensity of EREs highlights two major breakpoints (~ 850–1000 m and ~3500–4000 m). The highest percentage of EREs (except 99.99th percentile) are concentrated within 1000 m –2000 m (< 1000 m). The study revealed that intense EREs of magnitude 300 mm/day have the shortest revisit period of 30–45 years in Dharamshala and Mandi. The present study would prove to be useful for policymakers for mitigation strategy and infrastructure development planning in mountainous regions of India and provide a framework for analysing EREs across the global mountain regions.

Geo-Ganga: Space Based Mapping and Monitoring of River Ganga (NMCG)

A geo-portal 'Geo-Ganga' was developed using the Arc Enterprise platform. The satellite and re-analysis based long term (2000 – 2024) hydro-meteorological parameters for entire Ganga basin including transboundary namely evapotranspiration, precipitation, temperature, etc. were uploaded on the portal. Apart from these, the thematic layers such as land use land cover, Elevation, Soil Texture along with administrative and sub-basin boundaries were also incorporated in the portal for better visualization.

To meet the project objectives, the stretch from Kanpur to Varanasi of Ganga River is selected for satellite-based water quality monitoring. The satellite derived indices like Normalised Difference Turbidity Index (NDTI) and Normalised Difference Chlorophyll Index (NDCI) were generated at fortnightly interval from April 2024 – March 2025. The derived water quality indices are also uploaded on the portal. Along with it, the location of NMCG supplied water quality monitoring stations, sewage treatment plants are available on the portal. Further, the Water Quality simulation at higher temporal and spatial scale is attempted using the hydrodynamic modelling approach.

The Flood hazard tab of the portal contains the layers related to the historical flood, Flood prone zone, and water level retrieved from the satellite data. Additionally, attempts are on for mapping the DO, BOD, TSS and Coliform using AI/ML based techniques. The aim of the project is to provide single point solution for the Ganga Basin. Apart

from these regular activities, the water quality changes during the Maha Kumbh was also monitored under the project.

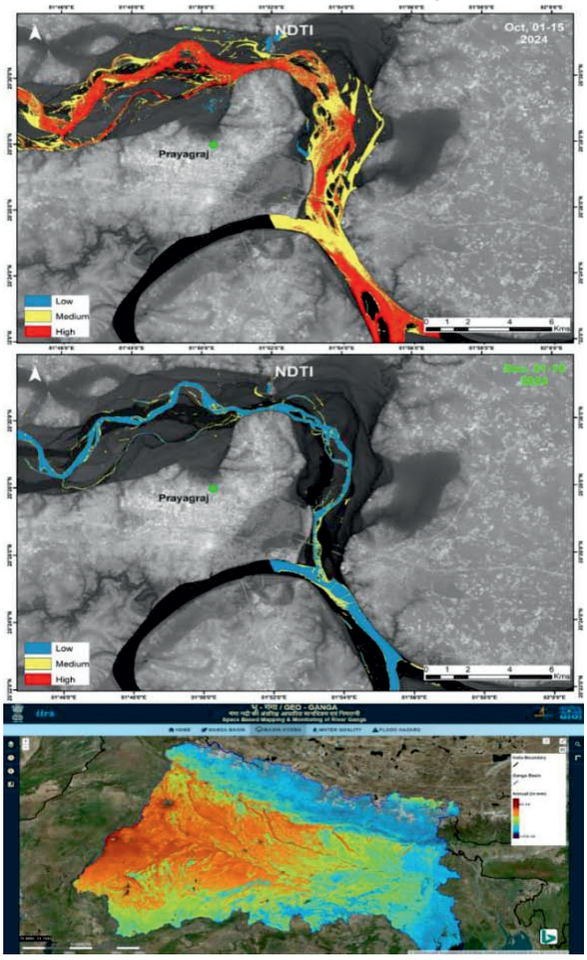


Fig. Mapped Water Quality at Prayagraj, UP and Snapshot of the Portal

Remote Sensing and Modelling Approach to Generate the High-Resolution Snow ECV's Products in Himalaya (ISRO NICES)

Satellite-Based Observations for Snow Cover in the Northwest Himalaya (NWH) undergoes pronounced seasonal variations in snow cover, which play a critical role in regulating water availability, climate, and ecological balance across the region. Daily mean Snow-Covered Area (SCA) data was generated from 2000 to 2024 using MODIS and IMS satellite datasets. Recent satellite observations from November 2023 to May 2025 reveal a distinct seasonal pattern. Snow cover steadily expanded during early winter, peaked between late February and early March, and then gradually receded with rising temperatures (Fig.(g)). Specifically, on Nov. 01, 2024, snow covered 20.9% of the NWH (Fig.(a)), marking the onset of winter. By Dec. 10, 2024, SCA increased to 29.5% (Fig (b)) due to early accumulation, rising further to 40.3% by Jan.01, 2025 (Fig (c)), indicating intensified snowfall. The snow cover reached its seasonal peak at 58.2% on Mar. 07, 2025 (Fig (d)), reflecting persistent late-winter snowfall. Subsequently, the snow covers gradually declined to 49.1% by Apr. 01, 2025 and 43.1% by April 30, 2025 & upto 38.9% by May 12. 2025.

Compared to the long-term average (2000–2025), the SCA from Dec. 2024 to April 2025 remained above normal. Despite this overall increase, snowfall events were interspersed with significant dry spells. Major snowfall events were recorded during Dec. 7–11, Dec. 21–24, Dec. 27–28, January 3, Jan. 15–22, Feb. 1–5, and Feb. 28 to Mar. 3, 2025. These were separated by dry spells lasting approximately 5 to 15 days.

According to the India Meteorological Department (IMD), cumulative precipitation data from January 1 to March 11, 2025, revealed regional disparities. Jammu & Kashmir experienced a snowfall deficit of -59% to -20%, whereas Ladakh recorded large excess snowfall, exceeding 60%. Himachal Pradesh received above-normal precipitation (+20% to +59%), and Uttarakhand observed a large excess, with precipitation surpassing 60%. Earlier in the season, all regions faced significant rainfall deficits; however, heavy snowfall between early January and early March shifted the trend toward excessive precipitation. Periods of above-average snowfall led to sharp SCA increases, while prolonged dry spells caused sustained melting. Monitoring snow cover variability is crucial for understanding regional water resource

availability, climate interactions, and hazard management. Excessive snowfall increases avalanche risk, exemplified by the Mana snow avalanche on February 28, 2025. In contrast, early snowmelt can disrupt river flows, adversely impacting downstream agriculture and hydropower production. The observed strong winter snowfall suggests potentially enhanced water availability in the coming months. Therefore, continuous satellite-based snow monitoring remains essential for assessing these dynamic patterns and informing water resource management and climate adaptation strategies in the region.

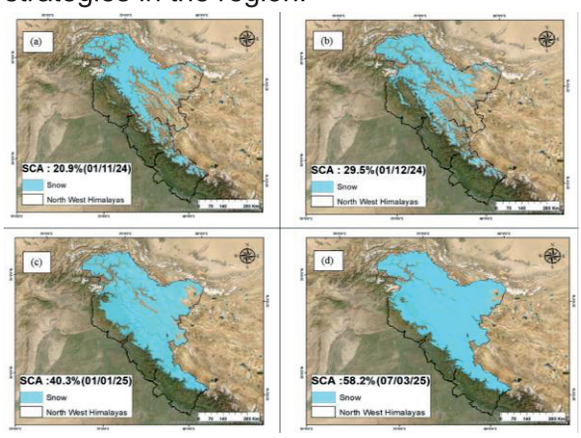


Fig. (a) Snow cover Area on 01/11/24, (b) Snow cover Area on 01/12/24, (c) Snow cover Area on 01/01/25, (d) Snow cover Area on 07/03/25

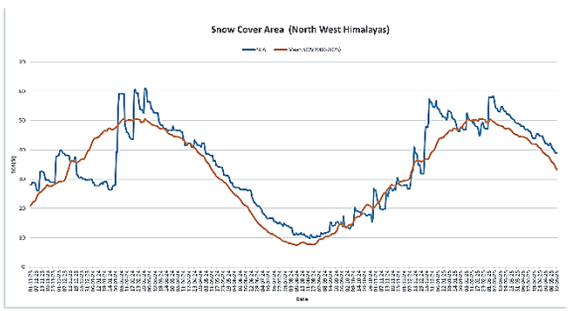


Fig.: Nov. 2023-May 2025 SCA map with long term SCA analysis graph

Monitoring of river discharge at sparsely gauged basin using integration of space-based water level and hydrodynamic modelling (ISRO NICES)

Monitoring and assessment of water resources within the watershed play a crucial role in meeting human requirements and influencing socio-economic practices in industrial and agricultural activities. The hydrological and hydrodynamic models used for various applications (e.g. hydrological forecasting, impact of climate change on water resources, flood risk assessment) typically depends on water level and discharge to test the reliability of the simulated outputs. However, gauging stations in many parts of the world are either unavailable or sparsely available and decreasing due to the high economical and temporal efforts required for their maintenance. Remote sensing data provides an opportunity to monitor water level of transboundary river basins at fixed temporal resolution. The challenge remains how to convert satellite observed water level into river discharge.

The limited availability of in-situ data has drawn attention towards using remote sensing techniques to monitor river discharge. Radar altimetry data has been used to generate stage-discharge rating curves through power-law relations and empirical methods. However, evaluating hydrodynamic models for rating curve generation using multi-mission altimetry data in data-scarce regions is lacking. We used altimetry data (Jason 2, Jason 3, SARAL/AltiKa, Sentinel 3A, and Sentinel 3B) over the Mahanadi River to evaluate rating curves at virtual stations (Fig.). The HEC-RAS hydrodynamic model was set up, identifying seven virtual stations along the Mahanadi River from Boudh to Mundali Barrage. Statistical evaluation of 'water level' (RMSE 0.27-0.88 m) and 'discharge' (KGE 0.52 to 0.88) components of the generated rating curves showed significant agreement with radar altimetry data. The availability of rating curves at virtual stations allows the expansion of the gauging network along the sparsely gauged river basin (Fig.). This approach provides the low-cost uniform monitoring of river flow in remote areas. For

further information, kindly refer to published work Dhote et al., 2024.

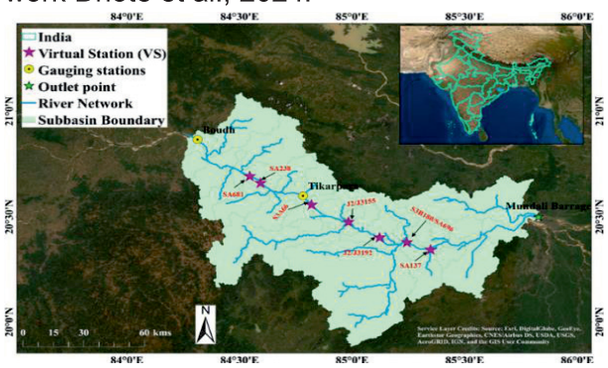


Fig.: Mahanadi River stretch (Boudh to Mundal Barrage) considered in the study along with locations of gauging stations, outlet and identified virtual stations (VSs) from multi-mission altimetry data. Red colour label corresponding to each virtual station represents altimeter data type (Jason 2 (J2), Jason 3(J3), SARAL/AltiKa (SA), Sentinel 3A (S3A) and Sentinel 3B (S3B)) and its track number.

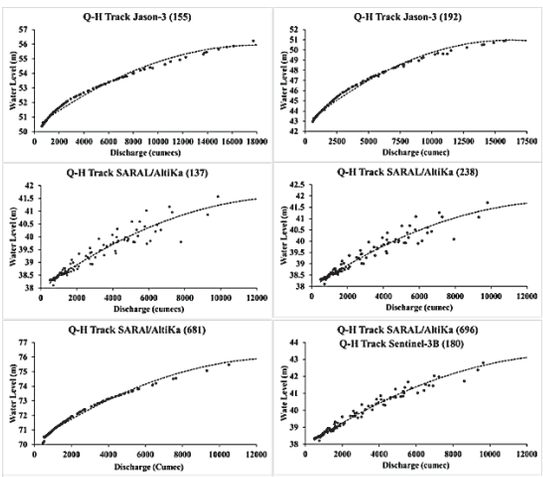


Fig.: Stage-discharge rating curves generated at virtual stations

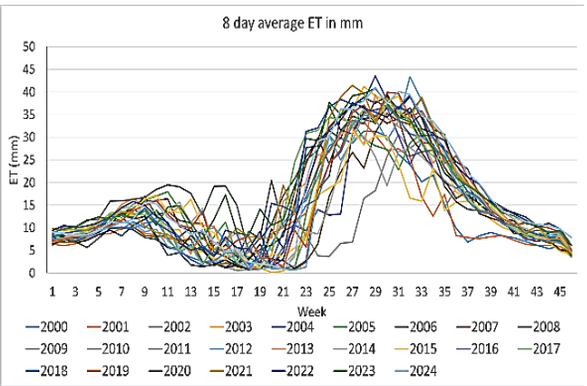
Remote Sensing Based Generation of Evapotranspiration using S-SEBI method (ISRO NICES)

The redistribution of moisture and heat in soil and atmosphere occur due to the energy exchange processes at the land surface. The land surface connects the radiation, energy and water balances of the soil and atmosphere. Estimation and spatio-temporal monitoring of evapotranspiration (ET) or consumptive water use over large-area holds the key to irrigation management plans and regional drought preparedness.

The prime objective of this study was to analyse the variations in ET by applying the simplified-surface energy balance index (S-SEBI) model proposed by Roenrink et al., 2000 for the period of 24 years between 2000 - 2024 in Northwest Himalaya using MODIS satellite data. An average ETc was estimated around 14 mm per 8-day for different watersheds/basins in the study region. Further, the statistical analysis of change in ET was done with the change in soil moisture and land surface temperature for the same period of 24 years between 2000–2024 to improve the understanding to impact of changing climate over the water availability and requirement. The study showed that evapotranspiration has been increased during study duration and the water requirements have increased significantly in some parts of the study region in 25 years.

The evapotranspiration from the hilly terrain of NWH can also be estimated using Remote sensing-based energy balance (RS-EB) model (corrected or parameterised for the hilly terrain) or many other methods like: S-SEBI, SEBAL, METRIC, PT, ALEXI/DISALEXI, etc. The optical and thermal remote sensing data (Landsat 8/9, MODIS, etc.) will be used along with the field observed meteorological and energy fluxes observations. The models will be parameterised for hilly terrain and the results will be validated using observed energy fluxes observed from existing flux towers installed in the region or in the near surrounding by IIRS, NRSC, SAC or any other organisation. The data from micro-met towers proposed in the project will also be used for parameterisation and validation of applied technique. The ET derived from the models will be time integrated using suitable interpolation technique to generate seamless daily, weekly and monthly evapotranspiration product (ECV). The Remote sensing derived ET will be used to cross-validate the ET product of land

surface model. The advantage of land surface model over remote sensing derived ET is the availability of products under complete cloudy condition as well. The land surface model can also provide us the partitioning of evaporation from land and snow/glacier covered areas and transpiration from vegetation cover from the area.



Multi-Satellite Multi-Sensor Approach to Generate the High-Resolution Glacier Related Essential Climate Variables Product in Himalaya (ISRO NICES)

A project with objective to derive glacier related essential climate variables products for North West Himalaya (NWH) using remote sensing data and modelling approach such as: Glacier area, Accumulation/Ablation zones, Glacier mass change, Glacier elevation change and Glacier surface velocity is being conducted under National Information system for Climate and Environment Studies (NICES), a program established by ISRO to monitor climate variability and climate change from space.

The glacier area at decadal scale will be updated using both optical and synthetic aperture radar (SAR) datasets. The high spatial resolution remote sensing data will be used to update the glacier boundary. Using the cloud free optical and thermal remote sensing images of end of ablation season, the accumulation and ablation zones will be identified, either through visual interpretation or band ratio techniques. However, using the SAR data, coherence will be studied for mapping the glacier boundary. Thermal data is required for mapping the debris covered glacier region. In many cases getting cloud free optical data of end of ablation period is difficult due to micro-climatic conditions of the NWH region. For glacier in such areas and time periods, the radar zone mapping approach using different season SAR data will be used to map glacier area and identification of the accumulation and ablation zones at annual scale. The digital elevation model (DEM) based approaches may also be explored to identify the equilibrium line altitude. Adapting these approaches, the glacier boundaries and zones will be updated.

The glacier mass balance will be done using the Accumulation Area Ratio method. Taking the two-time DEMs and co-registering them the change in glacier elevation would be attempted at decadal scale. The Feature Tracking approach using annual time period optical remote sensing data, the glacier surface velocity will be estimated. During the project duration, the geodetic GNSS receivers will be installed to validate the remote sensing-based estimation of glacier velocity and elevation change. Apart from geodetic mass balance, the attempt will also be made for selected/important glaciers to setup suitable hydrological model to estimate their glacier melt over the time and use this information for hydrological glacier mass balance. Along with Feature Tracking, the Offset Tracking and DInSAR approach using SAR data will be attempted for estimation of glacier surface velocity of selected glaciers. The best estimated annual glacier surface velocity will be provided as the glacier surface velocity product at annual time scale. This approach will be tested and implemented for NWH in 1st 3 years of project and in the last two years, attempt will

be made to implement established approach to cover other parts of Himalaya. At present the methodologies are tested on the glaciers in the Bhagirathi Basin. The initial results with respect to SAR composite and coherence of the glaciers in the basin are shown in below figure along with the estimated glacier surface velocity of Gangotri Glacier, the major glacier in the basin.

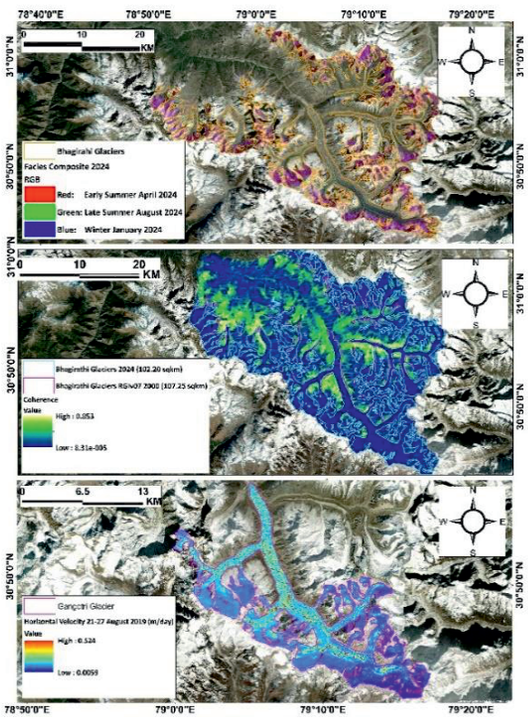


Fig. SAR composite for glacier radar zone mapping, SAR coherence map, and estimated glacier surface velocity

JECAM: Joint Experiment for Crop assessment and Monitoring

Orchard mapping at Siyana, Bulandshahar by pixel-based methods and object-based classification was demonstrated, to prove better clusting of orchards using the later. SAR parameters and optical data derived Vegetation indices based annual temporal profile used to identify the sensitive phenological stages of mango orchards. Mango orchard phenology characterization was done using the EOS-4 RISAT-1A during 2022 - 2024. During 2024 FRS-quad-pol high resolution data were evaluated towards orchard signatures and categorization age-group wise. This data was indicative of the orchard biophysical parameters for young, medium and old category. Age based categorization is being validated from the above dataset. NISAR datasets will be explored to understand the higher wavelength signatures beyond C-band.

Integrated use of Active and Passive EO and Ground based data for Archaeological Investigations of Heritage Sites (NNRMS)

A Remote sensing technologies are increasingly becoming useful tools for monitoring and preservation of cultural heritage and to constantly update the condition report of a monument or site. Documentation for monitoring of archaeological/ heritage sites requires the data collection both at close range level and at synoptic level because of the following reasons:

- Recording micro details of artifacts/architecture/subsurface features etc needs high resolution data and ground-based perspective.
- The sites are normally complex and large in spatial spread, requiring synoptic perspective to effectively study context and interpret associations.

As a consequence of above reason, it is proposed to acquire the data with ranging and imaging devices (both active and passive) at various viewing levels. Therefore, the data acquisition is being done using multiplatform sensors which would enable surface and subsurface documentation of the object of interest.

Data acquisition was carried out at different heritage sites in Uttarakhand, Dholavira, Lothal, Nalanda, Rajgir and Mahabalipuram. The data has also been

taken with ground and UAV based platforms. The integration of multisource data (LiDAR + stereo photos, GPR) is in progress. The underneath figure depicts the external coverage of monument (Lakhamandal Shiv Temple, Uttarakhand) providing a ground photograph view of monument by laser scanning.

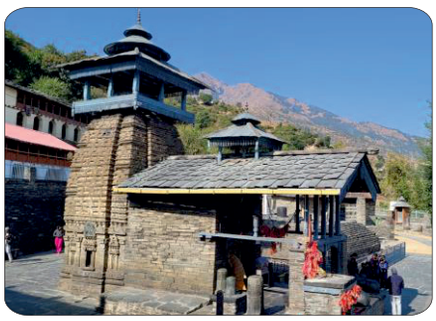


Fig.: Lakhamandal Shiv Temple

The underneath figure demonstrates the 3D model of artifacts at Lothal Archaeological site (Gujrat) by ultra-dense laser scanning.

Fig.: 3D Documentation – Eastern Reservoir, Dholavira, Gujrat

The underneath figure shows ground photograph and Lidar point cloud of Eastern Reservoir in Dholavira, Gujrat

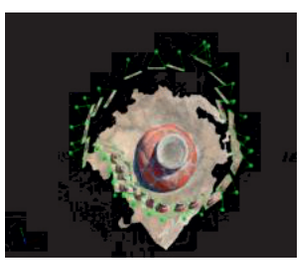


Fig.: LiDAR Data for 3D Modelling - Lothal Gujrat

ADDITIONAL R&D ACTIVITIES

Floor fractured and Impact Craters: An overview

A Copernican crater represents the most pristine and unaltered lunar impact crater available for research. It has associated with itself distinct types of impact ejecta material which can readily be classified into distinct ejecta facies. Radar datasets show a continuous ejecta blanket which is radar bright followed by a radar dark halo. Optical low sun angle/ high phase angle datasets offer an opportunity to map radially striated ejecta facies by being sensitive to variations in regolith topography. Investigation into wavelength dependency of the diameter of the radar dark halo and Circular Polarisation Ratio, Backscatter Coefficient, Rock abundance and other parameters variation for different ejecta facies deposits.

Floor fractured craters (FFC) represent a synergy of volcanic, tectonic and impact cratering processes on the Moon. Pyroclastic deposits are a potential resource and provide information about composition of the mantle. Fissure eruption from fractures, lineaments or rilles are seen. Source Vents are also found to be residing on these features. For FFCs located on or near the Maria, it is important to distinguish the Mare basalt from the pyroclastic deposits since Mare basalt with a high TiO_2 content can also be radar dark. Pyroclastic deposits are typically fine-grained rock poor deposits and presence of TiO_2 modulates the bulk loss tangent of the regolith. Investigation into the relationship between the backscatter coefficient and the Titanium/Iron content, Circular Polarisation Ratios, Rock abundance quantitative variation.

Impact cratering is the most ubiquitous process that shapes planetary terrains. It creates and overturns lunar regolith and thus profoundly affects the physical characteristics of lunar surface materials at all spatial scales. The process of impact cratering involves three main stages: Contact and Compression, Excavation and Modification. High shock pressures and temperatures cause ejection of shocked melt, vapour and solid spall fragments of varying sizes.

Various studies describe the process as involving a conical ejecta curtain wherein the fastest ejected materials are deposited farthest. A ballistic emplacement mechanism involving projectile motion of ejected fragments is also theorised to be responsible for secondary craters and rays. Investigation into the velocity and fragment size of these impactors, emplacement mechanism, particle size and depth of the deposit for the radially straited/ridged ejecta material.

Mineralogy of Tsiolkovsky Crater, Moon from Chandrayaan 1-M^3 and Chandrayaan-2 IIRS data

Tsiolkovisky crater, a ~185 km diameter crater, located at 20ºS, 129º E on the far side of the Moon provides an excellent example of post-impact volcanism on the crater floor and a central peak that excavated fresh subsurface material. Previous studies indicated the presence of pure anorthosite and troctolite-bearing exposures at the central peak (CP) of the crater. However, the spatial distribution of different lithological boundaries throughout the crater is not yet fully understood. The study investigated the detailed mineralogical abundances and compositional diversity at the Central peak and floor of the crater using hyperspectral data from Chandrayaan-1 and 2 mission. The

methodology included capture and delineation of different volcanic units based on Integrated Band Depth approach, followed by spectral analysis, band parameter estimation for mineralogical abundances of the various basaltic floor units and comparison with laboratory spectra. Beside mineralogy, LRO-WAC and Diviner data have been used to determine age of the various geological units to understand their spatial distribution & stratigraphic relation and map Christiansen feature to derive CF variations across the units at Tsiolkovsky Crater.

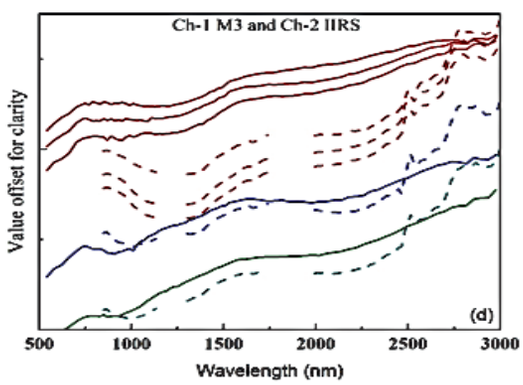


Fig.: Mineral diversity captured from the central peak of Tsiolkovsky crater from Chandrayaan-1 M^3 and Chandrayaan-2 IIRS data

Post-Facto Physical based numerical modelling and Factor of Safety of Chooramala Landslide, Wayand, Kerala

The Chooramala landslide in Wayanad district exemplifies a high-risk slope failure driven by the interplay of lithological weaknesses, steep topography, and intense monsoonal rainfall. To investigate both the failure mechanisms and the potential downstream impacts, two advanced numerical modelling approaches were employed: slope stability analysis using the Finite Element Method (FEM) in RS2 and debris flow simulation using RAMMS. The RS2 model, run under saturated conditions, incorporated geotechnical inputs from field observations, VES surveys, and standard material values, yielding a Factor of Safety (FoS) of 0.742. This low FoS indicates a critically unstable slope, particularly during heavy rainfall when pore pressure rises and material strength decreases. The simulated failure surface aligned well with the observed scarp and followed lithological discontinuities, underscoring the role of geological structures in slope instability. Complementing this, RAMMS was used to simulate the post-failure debris flow using a 2.5 m Cartosat DEM and calibrated field parameters. The model predicted flow heights exceeding 12 meters, peak velocities of around 35 m/s, maximum pressures over 2400 kPa, and momentum nearing 1600 kNs. The debris was channelled through a narrow valley before spreading into a depositional fan, matching the observed runout of approximately 7 kilometres. Together, the FEM and RAMMS simulations provide an integrated understanding of the Chooramala landslide—from failure initiation to runout—highlighting the urgent need for targeted slope stabilization measures and early warning systems in similar geomorphic settings across the Western Ghats.

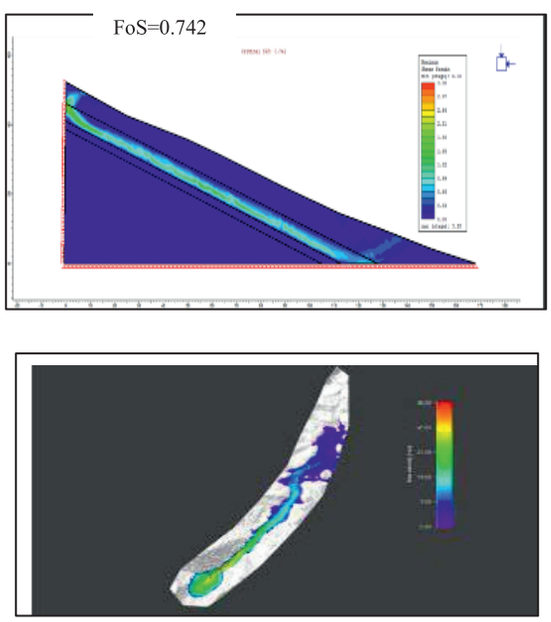


Fig.: FEM and RAMMS simulation outputs for the Chooramala landslide. (a) RS2-derived Factor of Safety (FoS = 0.742) indicating instability. (b) RAMMS outputs showing flow velocity, highlighting dynamic behaviour

Cloud reflectivity and hydrometeors profile characterization over the North-West Himalayan region based on decade-long GPM-GMI and DPR observations

Present study aims to provide a comprehensive understanding about the cloud microphysical parameters and its association with the Indian Summer Monsoon rainfall over the North West Himalayan (NWH) region using decade-long remotely sensed observations from GPM-GMI and DPR. This study unfolds that clouds with an echo-top height of about 14 km develop over the NWH region during the summer monsoon along with melting layer located at 6 km altitude. Vertical profile of Dual Frequency Ratio broadly indicates that three classes of hydrometeors, namely water phase, mixed phase and ice phase hydrometeors constitute the monsoon clouds over this region. Maximum concentration as well as larger-sized hydrometeors are mostly present in the melting layer band. Although the larger-sized hydrometeors are mostly available for convective rain, contrastingly concentration of hydrometeors is more for stratiform rain. Spatial pattern of cloud microphysical parameters characterizes a dual band structure over Uttarakhand and a single band over Himachal Pradesh and Jammu & Kashmir at monthly and seasonal scales, barring Cloud Liquid Water (CLW). However, no such bands for any of the ECMWF microphysical variables are observed over Ladakh region.

Furthermore, it is noted that convective rainfall predominantly occurs at elevations of less than 2000 m, but stratiform rainfall is observed up to 4000 m height. Presence of rainfall as well as other microphysical parameters become insignificant beyond 4000 m elevation. Statistically robust tests revealed that microphysical parameters are significantly correlated with the amount of rainfall and undergo substantial changes in their characteristics during contrasting monsoon conditions. Present study is the first-ever comprehensive attempt to examine cloud reflectivity and microphysical parameters over the complex mountainous topography of the North Western Himalayan region using space borne observations. The outcomes of this study would have implications to identify suitable microphysics parameterization for improved weather forecast over topographically complex North-west Himalayan region.

The changing pattern of global teleconnection and the seasonal precipitation in the High Mountain Asia region

Using fifth-generation ECMWF Atmospheric Reanalysis (ERA-5) we investigate the topical changes in global teleconnection with seasonal precipitation dynamics in the backdrop of climate change particularly for the recent 20 years (L20:2002 to 2021) with respect to the previous 20 years (F20: 1982–2001). It unveils a considerable decrease in both monsoon and pre-monsoon precipitation over the Northwest Himalaya (NWH) in the Indian region and a decline in winter precipitation over the Tibetan Plateau (TP). Statistically robust K-S test shows notable changes (5% significance level) in the regional distribution of the atmospheric parameters in parts of the High Mountain Asia (HMA) region in recent decades (L20). Further, a weakening of the North Atlantic Oscillation (NAO) and El-Nino Southern Oscillation (ENSO) influence on precipitation pattern is noted in the L20 (2002–2021) compared to the F20 (1982–2001) years over parts of the HMA region. A regional heterogeneity is perceptible among different parts of HMA i.e. NWH in the Indian region and the TP. The NWH precipitation shows a diametrically opposite relation with the NAO index for winter precipitation in L20 (correlation coefficient R= -0.18, sample size: 240) compared to a positive correlation in F20 (correlation coefficient R = 0.15, sample size: 240) which is significant at 5% significance

level. The plausible reasons for such a diametrical change in the relationship during winter are addressed by examining the changing signature of the subtropical jet stream and its relationship with NAO and ENSO. Sea surface temperature shows cooling of the tropical Pacific and the resulting weakening in El-Nino signatures in recent years. Our results point to the noteworthy changes in the atmospheric circulation pattern over the HMA region in recent decades which is attributed to the alteration in the global teleconnection patterns and subsequent their association with the precipitation distribution over the HMA region. This study would be useful for an improved understanding of the precipitation dynamics over the HMA region and global teleconnections in the future.

Evaluation of the characteristics of Indian summer monsoon simulated by CMIP6 models

The present research is aimed at evaluating the climate coupled models with respect to the observational datasets for the investigation of the characteristics of the Indian summer monsoon (ISM). The monthly averaged historical simulations from 12 coupled climate models that participated in Coupled Model Intercomparison Project Phase 6 (CMIP6) are compared with the ground based observational data, satellite and reanalysis datasets for the study period of 1980–2014. This study uses these high-resolution models to investigate monsoon features, onset and withdrawal dates, primarily focusing on individual model performances rather than highly documented multi-model mean performance. Performance evaluation of the models suggests that sea surface temperature (SST) simulations by the models are in better agreement for the Arabian Sea than the Bay of Bengal with respect to the ERA5 reanalysis data sets. Further, inter-model differences amongst the CMIP6 models in estimating the spatial distribution of various monsoon system variables during pre-monsoon and monsoon seasons are noted which may be attributed to the different model components and varying physics configuration, nonetheless, models like NESM3 and INM-CN5 are able to reproduce ISM pattern reasonably well. The annual precipitation cycle demonstrates a good agreement between most climate models and IMD data. Evolution of tropospheric temperature gradient (ΔTT) estimated from the CMIP6 models mimics the temporal pattern of the annual rainfall and therefore, is used to estimate the onset and withdrawal dates from CMIP6 models; however, high variability is noted amongst the CMIP6 models in retrieving the onset and withdrawal dates when compared with the IMD observations. Most of the models show a shorter rainy season except NorESM2-MM. Overall our results suggest that the CMIP6 models can be used for the seasonal mean evaluation of monsoon system parameters and process-based studies to improve our present understanding of the ISM system.

Scrutinizing Diurnal Scale Rainfall Variability Over Himachal Pradesh Using High Resolution Satellite-Based GPM-IMERG Product

The pattern of monsoon rainfall has been explored at diurnal scale level using the precipitation dataset GPM-3IMERGHH-06 over the state of Himachal Pradesh from 2004 to 2020. The present study identified the spatio-temporal pattern of rainfall peaks and found the trend of rainfall peaks (5% significance level) during different times over selected locations. One-sample student's t-test has been employed to find the significance of the trend. Intense rainfall peaks (0.7–1 mm/hour) are found at late night (0200 IST to 0230 IST) as well as morning (0600 IST TO 0630 IST) hours over the mountain foot regions and less intense peaks (0.4–0.6 mm/hour) are found during afternoon or evening time (1430 IST to 1700 IST) over

southern parts of the state. Late-night peaks of rainfall show a significant increasing trend over the regions Kullu, Mandi, and Sirmaur, while morning peaks of rainfall show a decreasing trend over the same regions. Significant increasing trends have been found over Hamirpur and Mandi during evening hours. The state is characterized by undulating terrain and is prone to extreme rainfall events during the monsoon season. Diurnal pattern of rainfall gives a glimpse into the physical mechanism behind such sudden unexpected events. Trend analysis helps to understand the future risk over different regions which is important for implementing any kind of mitigative actions.

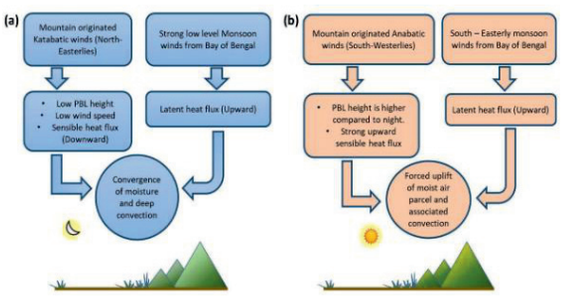


Fig: Schematic diagram which shows (a) Mechanism behind the late night - early morning precipitation peaks (b) Mechanism behind the day time peaks

Progression of marine heat wave events over the tropical Indian Ocean and its underlying mechanisms

Marine Heat Waves (MHW) are devastating extreme oceanic events that have severe and destructive effects on the marine and coastal ecosystems. In the present study, the generation and advancement of MHW events during the last four decades over the tropical Indian Ocean (IO) and its primary regulating factors are investigated. Multiple MHW events have been detected over the tropical IO in the past decade. It was found that between 2011 and 2021, the tropical Indian Ocean observed a significant increase in both the mean annual number of MHW days and the frequency of MHW occurrences. This coincided with a substantial rise in sea surface temperatures (SST) in the region during the same period. Long-running events were detected for the years 2015 over the Somali coast, 2016 over the Java-Sumatra Coast, and for 2019, and 2020 over the Seychelles Dome. Event-specific analysis revealed that a decline in wind speed was observed during the second phase of the 2015 MHW event along the Somali coast which resulted in the subsidence of upwelling, similar observations were also made around the Java-Sumatra coast. Subsequently, the role of planetary waves in the sustenance of the long-running MHW events is analysed. Positive sea level anomaly values were observed around Somali and Sumatra for 2015 and 2016, which in turn signify the presence of downwelling planetary waves. These planetary waves play an important role in oceanic surface and sub-surface warming and mixing by deepening thermocline and consequentially inhibiting the upwelling and entrainment. An analysis of the mixed layer heat budget terms over the active regions of MHW events in 2015, 2016, 2019, and 2020 shows that the primary contributor influencing these MHW events is net heat flux over the majority of the affected areas which is followed by the dominant role of vertical advection over the Somali region.

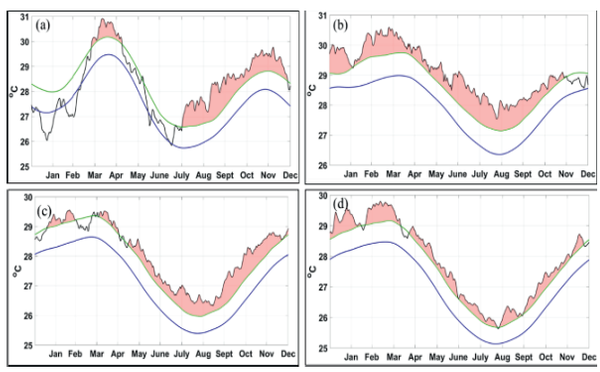


Fig.: *MHWs duration showing the significant events during (a) 2015 (5oS-7.5oN, 39-55oE), (b) 2016 (6-14oS, 100-120oE), (c) 2019 (6-18oS, 62-80oE), and (d) 2020 (8-18oS, 57-87oE) averaged over the boxes mentioned for the respective years. The pink filled area represents the MHWs conditions. SST climatology from OISST for the detection of MHWs (blue line), 90th percentile MHW threshold (green line), SST time series (black line).*

RISAT-1A utilization of data

RISAT 1A MRS data (temporal) for Agra, Punjab and Palampur site analysed. RISAT FRS-1 and 2(compact-polarized/ full-pol) data preliminary analysis completed. Different transplantation date signature could be extracted from multitemporal RISAT-1A data. For the Agra site, KVK was visited during October 2023 to collect the yield data. Crop cutting for crop biomass estimation was done. RISAT-1A based analysis carried out in the current year for both Agra site on pearl millet and JECAM site for orchards. Pearl millet crops in mature stage (standing crop) is seen as green- high volume scattering, cyan and bluish fields ready for harvest (combination of surface and volume scattering) and dark blue/black as already harvested crop (dominance of surface scattering).

Also, the high-resolution data (FRS) based analysis showed significant correlation with the crop scattering and biophysical parameters. These signatures were extracted for tea plantations too. The important cultural operations viz. picking, regrowth, picking and pruning could be depicted in the RISAT 1A derived temporal backscatter.

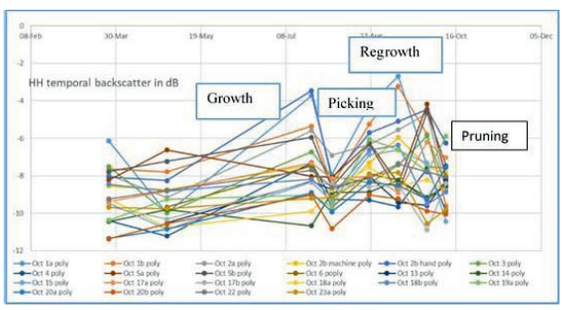


Fig. HH temporal backscatter Signature of various Stages at the plantation

In addition, temporal compact polarised data from September 2024 to March 2025 has been utilised to understand the increase in scattering and decay in relation to crop phenology. This will provide compact-pol signatures for phenological stages of sugarcane and biomass estimation. Paddy crop signatures in peak and mature stages were also analysed to understand the differences in few basmati sites. Sentinel-2 data was also utilised to corroborate the understanding in scattering.

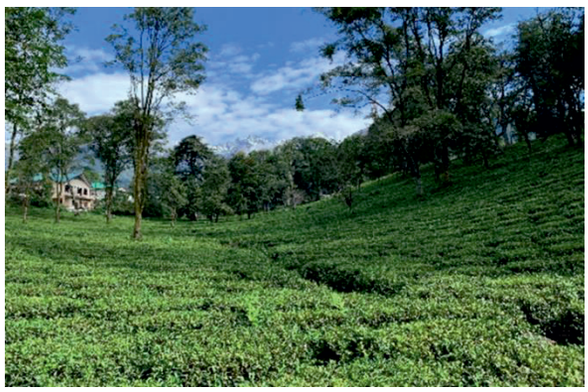


Fig.: field photograph of the tea garden (Palampur) in picking stage

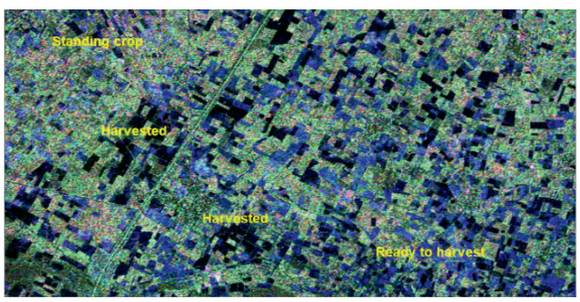


Fig.: Dominant scattering mechanisms in fields of the pearl millet in harvesting stage as depicted by high resolution EOS-4 data.

Enhancing spatial resolution of Landsat derived land surface temperature

The study presents an approach for downscaling Landsat retrieved land surface temperature (LST) from 30 m spatial resolution to 10 m using an extreme learning machine (ELM) algorithm. The LST was retrieved from Landsat thermal data using a split window algorithm. For LST downscaling, seven vegetation indices were calculated from Dove satellite data. ELM was utilized to establish a causal relationship between LST and the downscaling variables. The mean absolute error (MAE) achieved during the training and testing of ELM was 0.48 and 0.51, respectively. Since ELM finds the hyperparameters analytically, it led to reduced training time and better

generalization. Assuming the causal relationship between LST and variables to be scale-invariant, the LST was downscaled from 30 to 10 m resolution. The downscaled LST at 10 m was validated using LST values collected by ground survey, and the MAE between the downscaled and validation LST data was found to be 1.3°C. The downscaled results were also spatially compared with the land cover map of the study area. It was found that the maximum effect of LST downscaling was observed over heterogeneous built-up areas, where the LST spatial variability became more pronounced after downscaling, compared to other land covers.

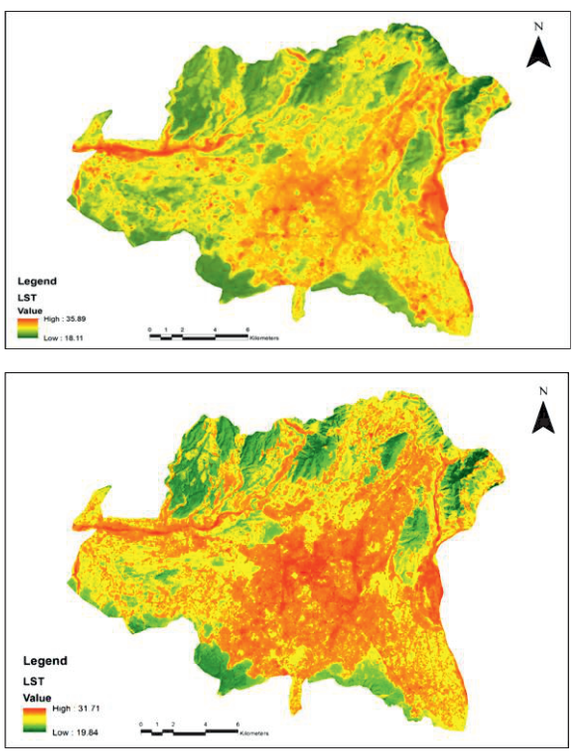


Fig.: Downscaled LST at 10 m (LandsatLST10)

Participation in India Arctic (Winter) Expedition – 2025

One Scientist/ Engineer from IIRS was deputed to the Indian Arctic (Winter) Expedition - 2025 during March 03-28, 2025 and visited Kartverkets Geodetic Observatory that monitors the Earth's position and orientation in space and makes it possible to operate various satellites (Navigation, Communication, and Earth Observation) in orbit around the Earth. The Gurvebadet Atmospheric Lab was also visited wherein Indian institutions and organisations are carrying out the atmospheric observations – such as aerosols, black carbon, cosmic rays, etc. He joined NCPOR Marine Biology team for water sampling from the Kongsfjorden, as well. The ground truth measurements were collected of the snow pack characteristics such as snow wetness and density using the snow fork instrument from Austre and Vestre Brøggerbreen Glaciers.

Fig.: LST retrieved at 30 m (LandsatLST30)

Preparedness for NISAR towards Agriculture- from Ecosystem perspective

Finalisation of validation sites (tentatively three in north India) for NISAR products is under finalisation; wherein the ongoing activities include crop area mapping with the available datasets. Scientist/ Engineers from IIRS are also contributing as team-member in the evaluation committee of this product.

List of Publications (FY: 2024-25)

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- A. Rasray, R.Khuroo, S.Lone, K.Hussain, T. Islam, S.A. Wani, F.A. Dar, I.D. Rai, H.Padalia and AA Khuroo, Cushtions serve as conservation refuges for the Himalayan Alpine Plant Diversity:Implications for natur-based environmental management. Journal of Environmental Management, 359, 120995. April 2024.
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- Saha, M., and Charu Singh (2024). Evaluation of characteristics of Indian summer monsoon simulated by CMIP6 models. International Journal of Climatology, 1–19. https://doi.org/10.1002/joc.8484. (Impact Factor: 3.9).
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- Published IIRS Reference Handbook on 'Earth Observation for Soil Resource Assessment' (authored by Dr. Suresh Kumar & Justin George K.), 2024, IIRS.
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- Dharanya Thulasiraman & Dipanwita Haldar Comparison of RISAT-1A hybrid polarimetry based crop biomass retrieval vis-à-vis fully polarimetric spaceborne SAR data. Session: TU1.R6: Estimating crop leaf & canopy parameters,

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- T J Anurose , Shweta Bhati, Kshama Gupta, A Jayalumar, Saji Mohandas, 2024, Impact of Urban Morphology and high-resolution Land Use Land Cover for city scale modeling, Joint annual R&D workshop and 6th momentum partnership convective scale workshop, Bureau of Meteorology, Australia, September 9-13, 2024.
- Abstract - "Mapping of field scale ET over sugarcane crop in semi-arid region using combination of Landsat OLI and Sentinel observation" by N R Patel et al. is presented in International Science Workshop on 'High-Resolution Thermal Earth Observation', scheduled during 19-21 Nov 2024, at SAC, Ahmedabad.
- Abstract titled "Estimation of evapotranspiration and soil moisture by integrated use of optical and thermal Infrared observations from MODIS" by N R Patel et al. is presented in International Science Workshop on 'High-Resolution Thermal Earth Observation', scheduled during 19-21 Nov 2024, at SAC, Ahmedabad
- Abstract - 'Multi-tier surface energy balance mapping for the water-energy nexus using geospatial technology: Insights and Foresight for the TRISHNA Mission" by Abhishek Danodia et al accepted for oral presentation in International Science Workshop on 'High-Resolution Thermal Earth Observation', during Nov19-22, 2024, at SAC.
- Abstract – 'Spatial soil quality assessment using machine-learning techniques in a hilly Watershed of Himalayan' by Nilkamal Konra et al presented in poster session during Global Soils Conference, during Nov19-22, 2024, at N. Delhi.
- Abstract -'Digital soil mapping approach for studying spatial variability of soil properties & delineation of Mgmt zones' by Arunima et al presented in poster session during Global Soils Conference, during Nov19-22, 2024, at New Delhi.
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- Mamta Chauhan, Aakansha S. Borkar, Giorgio Antonino Licciardi, Patrizia Sacco and Deodato Tapete, Ladakh Ophiolites: Martian Analogue site mapped for degree of serpentinization using PRISMA hyperspectral satellite Imagary. Submitted joint abstract with ASI (Italian Space Agency) for ESA-Live Planet Symposium 2025 (23-27 June, Vienna).
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- Manu Mehta, Mehak Sharma, Anusha Arora, Aditi Mehta, Nishtha, Shivani, Ranu Gadi, 2024. On variability of PM2.5 & heat index for 2 locations in India during El Niño, URSI-RCRS 2024, ARIES/GEHU, Bhimtal, 22-25 Oct, 2024 (Poster)
- Vishal Soni and Manu Mehta, Aerosol Optical Depth estimation using Mars Color Camera on board Mars Orbiter Mission, URSI-RCRS 2024, ARIES/GEHU, Bhimtal, India, 22 - 25 October, 2024 (Oral).
- Manu Mehta, Shivani and Somya Garg, 'Variability of Air Pollution and Heat Stress over Kolkata', IASTA 2024
- Apoorva Sharma and Manu Mehta, 'Trends in Aerosol Optical Depth over Uttarakhand during the Last Twenty Years', IASTA 2024
- Padmavati Shrivastava1, Manu Mehta, et al., 'Machine Learning Approaches for Air Quality Index Prediction: A Comparative Performance Study', IASTA 2024.
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- Soumyadeep Roy and Charu Singh, 2024. Atmospheric Rivers and Cloudburst Events over North-West Himalaya: A Case Study. InGARSS-2024, Dec 2-5, 2024, NIT Goa India.
- Manali Saha and Charu Singh, 2024. Characteristics of 2021 cloudburst events based on INSAT data. InGARSS-2024, Dec 2-5, 2024, NIT Goa India.
- Saurabh Verma, Charu Singh and Soumyadeep Roy, 2024. Assessment of renewable energy parameters and identification of micro-climatic zones over UT-Ladakh. InGARSS-2024, Dec 2-5, 2024, NIT Goa India.
- A research paper on "Heat wave characterization and its impact on carbon fluxes over sugarcane agroecosystem" is adjudged as best paper in J. of Agrometeorology by Association of Agrometeorologists.
- Best poster award to Justin George et al. for the paper titled 'Soil quality parameter estimation using sensor based soil colour measurement and development of a smartphone based application' during XVII Agricultural Science Congress, held during 20-22 February, 2025 at GBPUAT, Pantnagar.
- Singh P. Kumar V., and Kumar S. 'Mare Vaporum Ferrous Oxide Mapping Using Chandrayaan-1 M3 Datasets', 2024 IEEE India Geoscience and Remote Sensing Symposium (InGARSS), Goa, India, 2024,
- Gaur H., Garg S. and Kumar V., 'Comparison of deep learning models for crater detection using OHRC Dataset of Chandrayaan-2', 2024 IEEE India Geoscience and Remote Sensing Symposium (InGARSS), Goa, India, 2024,
- Uniyal A. and Kumar V., "Evaluation of EOS-04 PolSAR Data For Land Cover Classification Using Machine Learning Approach," 2024 IEEE India Geoscience and Remote Sensing Symposium (InGARSS), Goa, India, 2024, pp. 1-4, doi: 10.1109/InGARSS59135.2023.10490347
- Manu Mehta, Shivani and Somya Garg, 2024."Variability of Air Pollution and Heat Stress over Kolkata", IASTA 2024, Conference of Indian Aerosol Science and Technology Association, Theme: Aerosol Impacts to Air Quality, Human Health & Climate Change, December 17-20, 2024, Doon University, Dehradun.
- Apoorva Sharma and Manu Mehta, 2024. "Trends in Aerosol Optical Depth over Uttarakhand during the Last Twenty Years", IASTA 2024, , Conference of Indian Aerosol Science and Technology Association, Theme: Aerosol Impacts to Air Quality, Human Health & Climate Change, December 17-20, 2024, Doon University, Dehradun.
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- Chakraborty, A., Saharia, M., Chakma, S., Pandey, D.K., Kumar, K.N., Thakur, P.K., Kumar, S. and Getirana, A. (2024). Improved soil moisture estimation and detection of irrigation signal by incorporating SMAP soil moisture into the Indian Land Data Assimilation System (ILDAS). Journal of Hydrology, 638, 131581, 15 pages, https://doi.org/10.1016/j.jhydrol.2024.131581.
- Dwivedi, S.K., Thakur, P.K., Dhote, P.R., et al. (2024) Unravelling flash flood dynamics of Song watershed, Doon Valley: key insights for floodplain management, Geomatics, Natural Hazards and Risk, 15:1, 2378979, DOI: 10.1080/19475705.2024.2378979.

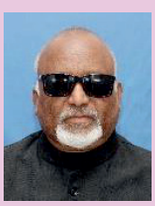
Award(s)

- Dr. R. P. Singh, Director, Indian Institute of Remote Sensing was awarded the 'Fellow of the ISRS Society-2024' during ISRS Annual Convention and National Symposium organised at Dr. A.P.J. Abdul Kalam Technical University, Lucknow during Dec. 11-13, 2024.
- Dr. Suresh Kumar, GD, AFEG/IIRS received 'IASWC fellow (for the year 2022)' award during National Conference on 'Living with Nature: Soil, Water & Society in Ecosystem Conservation' during June 20-22, 2024 at IISWC, Dehradun.
- Dr. Pramod Kumar, Dean (Academics), IIRS & GD, URSD was awarded with Space Gold Medal - 2022 by the Astronautical Society of India (ASI) on April 17, 2024.
- Sh. Ashish Joshi, Scientist/ Engineer- SF was awarded with Space Gold Medal- 2022 by the Astronautical Society of India (ASI) on April 17, 2024.
- Team IIRS GeoCrop Mappers comprising of Scientist/ Engineer (Dr. Anil Kumar), JRF (Mrs Sonakshi Mehrotra) & M.Tech students (Ms Anamika S. & Suhas M.) was awarded first rank in 'Kritagya DA & FW Hackathon' organized by M/o Agriculture and Farmer welfare, DA & FW on theme Digital Crop Survey, on May 15, 2024 at Krishi Bhawan, New Delhi.

Foreign Deputation(s)

- Mr. Abhishek Danodia, Scientist/Engineer- 'SD', Mr. Justin George Kalambukattu, Scientist/ Engineer- 'SE', and Dr. Kamal Pandey, Scientist/Engineer-SE, were deputed to Bangkok, Thailand during 30.03.2024 to 07.04.2024 (including travel time) for conducting short course titled 'Crop classification and inventory' jointly organized by CSSTEAP & GISTDA.
- Dr. Arijit Roy, Scientist/Engineer- 'SG' & Dr. H.C. Karnatak, Scientist/Engineer- 'SG' were deputed to Guadalajara, Mexico for conducting joint workshop on EO based Forest Fire Management during August 24, 2024 - Sept. 02, 2024.
- Dr P.K. Thakur, Scientist/Engineer- 'SG' made an official research visit to Laboratoire d'Informatique, Systèmes, Traitement de l'Information et de la Connaissance (LISTIC), a Research unit (UR) of the Université Savoie Mont Blanc (USMB), Annecy, France during Sep. 13, 2024 – Oct. 14, 2024 on official invitation & funding from Prof. Emmanuel Trouvé, Director of LISTIC on the theme of 'Surging Glaciers of Karakoram'.
- Dr. Vaibhav Garg was deputed to Indian Arctic Expedition (winter) 2025 during Mar 03- 31, 2025 and he also visited Kartverkets Geodetic Observatory & Gurvebadet Atmospheric Lab.

Transfers/ Deputation/ Superannuation/ New-joining



Shri Ram Naresh Arun, Sci./Engr- SD, GI01427 superannuated on 31.07.2024 (AN).

Shri Prashant Kumar Parashar, Administrative Officer, GI03062 joined IIRS w.e.f 24.09.2024 (FN).

Shri Prasad Kaduru, Administrative Officer, SH15573 transferred to SDSC-SHAR and relieved from IIRS on 30.09.2024 (AN).

Shri Niraj Verma, Junior Translation Officer, GI03060 transferred to SDSC-SHAR and relieved from IIRS on 26.11.2024 (AN).

Shri Sunil Chauhan M, Purchase and Stores Officer, AC08356 transferred to SAC, Ahmedabad and relieved from IIRS on 28.11.2024 (AN).

Major Events

Deputations of IIRS personnel for ECI (Election) duties

Based upon orders received from Election Commission of India, various IIRS officials participated in trainings & performed duties for General Election, 2024 (Ph-1 on April 19, 2024).

Chairman, IN-SPACE, visit to IIRS

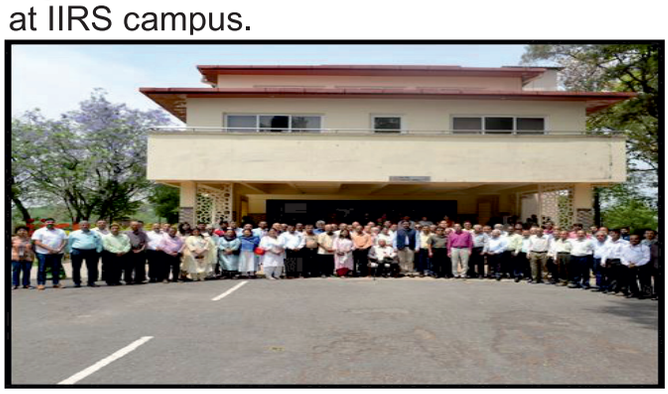
Dr. Pawan Goenka, Chairman, IN-SPACe visited to IIRS on April 22, 2024 and reviewed training, academic & research activities. Director, IIRS, Director NRSC, Dean (A), Group Directors, GHs & HoDs were also present.

Ambedkar Jayanti Celebrations

IIRS celebrated 'Ambedkar Jayanti' to honour birth anniversary of Dr B.R. Ambedkar ji, wherein an official lunch was offered to all employees of IIRS, CSSTEAP & CISF along with JRFs/ SRFs on April 26, 2024

IIRS Foundation-day celebration

IIRS Foundation-day celebration was organised on April 23, 2024 wherein all retired personnel of IIRS were invited for felicitation & official lunch was also organized for them & senior functionaries at IIRS campus.



Awareness lecture on 'Cervical cancer'

Dr. Chitra Joshi, HoD, Obstetrics & Gynaecology, Doon Medical College, Dehradun delivered lecture titled 'Awareness on Cervical Cancer' on May 03, 2024 at IIRS Auditorium and was attended by IIRS staff, students & CISF personnel wherein over 100 attendees were present.

Eye check-up camp

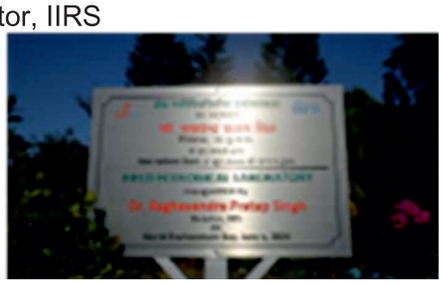
Drishti Eye Institute, Dehradun, conducted an eye check-up camp at IIRS on June 15, 2024,. This camp took place at the Golden Jubilee Hostel, 3rd Floor of IIRS. Various eye examinations were conducted in this camp, such as vision check, glaucoma screening, eye pressure check, retina examination, cataract screening, diabetic retinopathy examination, etc. Employees, students, and CISF personnel of the Indian Institute of Remote Sensing benefitted from these examinations. The programme commenced at 10:00 AM and continued until 01:30 PM. A total of 101 participants attended this camp and received the facility for eye examinations and consultation for eye problems.

International Day of Yoga

International Day of Yoga was celebrated in IIRS on June 21, 2024 with active participation by IIRS employees, students, research scholars and CISF staff wherein 'Common Yoga Protocol' practices were performed under guidance of Yoga Instructor.

World Environmental Day

World Environmental Day was celebrated in IIRS on June 05, 2024 wherein the 'Tree planting' event was organised and Dr. V.P. Uniyal, Prof., Graphic Era University delivered a lecture titled 'Bio Indicators for Monitoring Ecosystem Health & Climate Change.' Field Ecological Laboratory was inaugurated by Director, IIRS



हिन्दी गतिविधियां / OLIC Activities

राजभाषा विभाग, ग्रह मंत्रालय, भारत सरकार द्वारा जारी वार्षिक कार्यक्रम के आदेशानुसार इस कार्यक्रम मे सभी अधिकारियों/ कर्मचारियों के सरकारी कामकाज हिन्दी मे सुगमतापूर्वक करने के लिए एक दिवसीय हिन्दी कार्यशाला का आयोजन 07 जून, 2024 को भा.सु.सं.सं. में किया गया जिसमें वक्ता डॉ. महेश्वर घंघोट उपनिदेशक, इसरो मुख्यालय गया ने "राजभाषा कार्यान्वयन मे वरिष्ठ प्रबंधन की भूमिका" विषय पर व्याख्यान प्रस्तुत किया। भारतीय सुदूर संवेदन संस्थान में हिंदी दिवस/ पखवाड़ा का आयोजन: सरकारी कामकाज में राजभाषा हिंदी के प्रति जागरूकता तथा उसके उत्तरोत्तर प्रयोग में गति लाने के उद्देश्य से केंद्र सरकार के कार्यालयों में प्रति वर्ष हिंदी दिवस/पखवाड़ा का आयोजन किया जाता है। प्रत्येक वर्ष की भांति इस वर्ष भी भारतीय सुदूर संवेदन संस्थान में समारोह 13 से 27 सितंबर 2024 के बीच आयोजित किया गया । संस्थान के कार्मिकों तथा उनके परिवार के सदस्यों ने दिनांक13 से 27 सितंबर 2024 के दौरान विभिन्न प्रतियोगिताओं जैसे निबंध लेखन, हिंदी टंकण (यूनिकोड में), हिंदी टिप्पण व आलेखन, हिंदी भाषा/ व्याकरण ज्ञान, राजभाषा प्रश्नोत्तरी, वाद-विवाद, आशुभाषण, देशभक्ति गीत आदि प्रतियोगिताओं में भाग लिया। समापन समारोह में विभिन्न प्रतियोगिताओं के विजेताओं को 30 सितंबर, 2024 को पुरस्कार वितरित किए गए।

Independence Day

78th Independence Day was celebrated at IIRS on August 15, 2024 with full zeal, enthusiasm wherein various programmes were arranged on the occasion for staff, students & family members. The program started with the greeting and Guard of Honor by CISF, followed by the hoisting of the National Flag & address by Director IIRS to the employees & family members. The sweets were distributed at the end of program.

'Adrash Champawat - Geospatial Dashboard' Launched

Geospatial dashboard for Champawat District: Hon. Chief Minister of Uttarakhand Shri Pushkar Singh Dhami launched the 'Adrash Champawat geospatial dashboard' developed by IIRS, ISRO on Sept 15, 2024 at CM Camp office, Dehradun *(URL- https://maps.iirs.gov.in/champawat).*

'Swachhta Pakhwada - 2025'

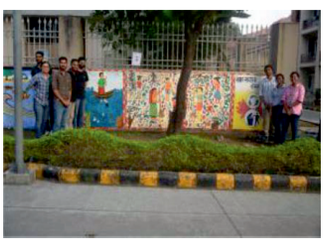
'Swachhta Pakhwada - 2025' was organized during Feb. 01-15, 2025 in IIRS with full zeal wherein various events/ lectures were organised for families of IIRS, CSSTEAP, CISF, contractual employees including pledge, quiz-competitions, health-checks, wall-paintings, waste-to-art competition, etc. Closing ceremony was organised with distribution of prizes & certificates to winners & participants of various competitions on Feb. 20, 2025 in presence of Director, IIRS & Chief guest Mr. Anoop Nautiyal, founder of Social Development Communities Foundation.

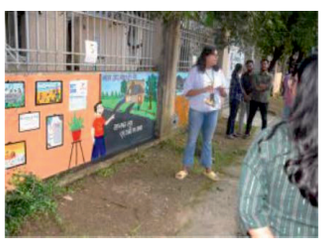
National Space Day (NSpD) Celebrations – 2024

NSpD-2024 was celebrated at IIRS campus on Aug. 09, 2024 wherein various programmes/ activities were carried out like competitions (quiz & oration), demonstrations, screening of documentaries released by Hqs (ISP, NaVIC & Chandrayan-3, MoM, etc.) wherein 30 students each from three Universities of Dehradun (DITU, GEU & UPES) & 60 students from five schools of Dehradun participated. Prof. A. S. Raghubanshi, Director, IESD, BHU graced the event as Chief Guest and delivered lecture titled 'man and environment - a historical perspective'. Director IIRS alongwith team participated in NSpD celebrations at Bharat Mandapam, Delhi on Aug 23, 2024. Besides aforesaid, individual Sc/ Engrs of IIRS were also deputed to deliver lectures, participation & supporting facilitations for NSpD celebrations in various Institutions/ Universities/ Ministries as per respective invitations received namely UCOST, Uttarakhand; UPES, Dehradun; Doordarshan Kendra, Dehradun; MPCOST, Bhopal (Kalidasa Sanskrit Academy, Madhav Govt. Science PG College, Ujjain wherein event was open for entire city [~500 Nos] & Holkar Govt. Science PG College, Indore [~100 Nos]); CWC, Roorkee; MoEF&CC, N.Delhi; SoI, Dehradun; FSI, Dehradun; UPSW, M/oJS, Lucknow; NCSCM, Chennai;, etc. during Aug. 20-23, 2024.

Gandhi Jayanti & Shastri Jayanti

Birth anniversary of Shri. Mahatma Gandhi ji & Shri. Lal Bahadur Shastri ji, was celebrated wherein mass pledge and a cleanliness drive was organized in IIRS campus on October 02, 2024 in IIRS. Daily activities were planned & executed under Special Campaign 3.0- Institutionalizing Swachhta during October 02 - 31, 2024 wherein a mass-pledge was administered by all the officials of IIRS, CSSTEAP & CISF staff and other contractual manpower with a resolution to maintain cleanliness through hygiene and sanitation practices in the workplace and residence. Besides aforesaid several other activities were organized like cleaning of rainwater drains, water bodies, water fountains, GLRs, and OHTs to ensure clean water. A cleaning drive was also organized near the auditorium, main-building wherein single-use plastics and other garbage waste were collected, segregated, and handed over to Nagar Nigam vehicle of door-to-door garbage collection. A fumigation drive in office buildings, and hostel buildings was organized to curb the mosquitos and larvae and remove harmful micro-organisms. A cleaning drive for cleaning of storm water drains was conducted by outsourced staff in the housing colony for cleaning and uprooting of rank vegetation, grass.





National voluntary 'Blood-donation' Day

Pledge was taken by IIRS employees under 'National Voluntary Blood Donation Day' on Oct. 03, 2024.

National Unity Day

National Unity Day was celebrated in IIRS on October 31, 2024. Under this, the oath of unity was taken by all employees.

World Space Week

'World Space Week' was celebrated during Oct. 04-10, 2024 at IIRS. Total 600 (approx.) students along with faculties from various colleges/ institutes/ schools/ universities visited IIRS for the educational visit. During the visit, students had visited IIRS Exhibition, various Instrument sites at IIRS Campus, & were shown documentaries on IIRS & ISRO programmes, followed by Interactive session at IIRS Auditorium. An Elocution Competition was also conducted for IIRS Students/ Research Scholars. An event of "Gazing of Night Sky (Stars, Moon, Planets etc.) through Telescope" was organized on October 09, 2024 for students, IIRS staff & their family members.

Karmayogi Saptah

Karmayogi Saptah - National Learning Week' was observed during Oct. 19-25, 2024 at IIRS and masterclass webinars of Dr. S. Somanath on 'Aiming for the stars: India's Journey in Space' on Oct. 25, 2024 (17:30-18:30 Hrs) was broadcasted at IIRS auditorium & main conference hall.

Vigilance Awareness Week 2024'

Vigilance awareness week 2024' was observed at IIRS during Oct. 28, 2024 to Nov. 03, 2024 on theme titled 'Culture of integrity for Nation's prosperity' including participating in the e-pledge.

Innovation in Science & Technology

Team of Scientist/ Engineers from IIRS participated in the Youth Festival-2024 exhibition to showcase the IIRS & ISRO activities in the event 'Innovation in Science & Technology' during November 10-14, 2024 organised by Ministry of Youth, Govt. of India and Youth Welfare Department & Govt. of Uttarakhand at Dehradun.

One-day workshop on 'Data Privacy & Authenticity in Cyber Space'

Team of Scientist/ Engineers from IIRS participated in the Youth Festival-2024 exhibition to showcase the IIRS & ISRO activities in the event 'Innovation in Science & Technology' during November 10-14, 2024 organised by Ministry of Youth, Govt. of India and Youth Welfare Department & Govt. of Uttarakhand at Dehradun.

Samvidhan Divas celebrations

'Samvidhan Divas' was observed on Nov 26, 2024 wherein preamble was read in IIRS auditorium foyer.

25th Anniversary of GIS Day

IIRS organized 25th anniversary of GIS Day on Nov. 20, 2024 at IIRS Campus wherein students' teams participated in mapathon organized with theme of 'Mapping Minds, Shaping the World' during Nov. 18-19, 2024. Dr. Pradeep Singh, Dy. Surveyor General delivered lecture titled 'Mapping with improvised technology in village areas'

Children's park in IIRS residential Colony

A children's park has been established in IIRS for providing recreational facilities to the children of IIRS staff in the residential colony which was formally inaugurated by Director, IIRS on June 05, 2024.

Former Chairman, ISRO visit to IIRS

Dr. S. Somanath, Former Secretary, DoS & Chairman, ISRO visited IIRS on Jan. 21 2025 and addressed the faculty, staff and students of IIRS with his encouraging words.

Chairman, ISRO & Secretary, DOS visit

Chairman, ISRO and Secretary, DOS visited IIRS campus on March 03-04, 2025. He had a technical discussion with all senior dignitaries of IIRS on evening of March 03, 2025 where he reviewed IIRS activities and addressed the faculty, staff & students of IIRS on March 04, 2025.

IIRS Academia Meet (IAM) - 2025

The IAM-2025 on theme 'Exploring Himalaya: EO Perspectives and Insights' was held on March 21, 2025 at IIRS.

Dr. A.S. Kiran Kumar, Member, Space Comm. & Chairman, PRL Governing Council was the Chief Guest; while Dr. M.K. Goel, Director, NIH and Prof. S.P. Singh, former VC, Garhwal Univ. participated as Guest of Honour. Various publications were released like 'Placement brochure for 2025', 'IIRS inhouse Newsletter- Contact', 'IIRS compendium of publications', 'Quick reference guide for exploration of RS&GIS applications in Urban environment studies', EO for natural Disasters & their Mgmt.' & 'EO for soil Resource Assessment' and also the exhibition was inaugurated wherein posters on student research & departmental activities were displayed.

The IAM comprised of three sessions- inaugural ceremony, a plenary session & a panel discussion wherein besides registered participants, the event was attended by Sc/ Engrs, JRFs/ SRFs, staff, students of IIRS.

National workshop on 'Space science exploration & career opportunities' was conducted on Mar 20, 2025 wherein 43 faculty members from various academic Institution across country, 161 students & 17 scientists of ISRO/DOS attended events. Apart from this 111 Institutions across country also attended in virtual mode.

National Safety week - 2025

'National Safety Week-2025' was organized during March 04-10, 2025 in IIRS with full zeal wherein various events were organised including pledge, quiz-competitions, etc.

Guest Lecture Series at IIRS

- Dr. Amlanjyoti Kar, Consultant, Asian Development Bank & Former Regional Director, Central Ground Water Board (CGWB), Ministry of Jalshakti delivered lecture titled' Looming crisis of water resources in India with special reference to Eastern Mainland vs Islands of the country' on April 24, 2024

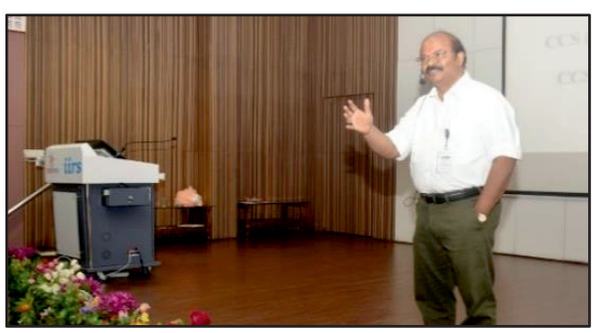
- Prof. Dev Niyogi, Professor, University of Texas, Austin, USA visited Indian Institute of Remote Sensing (IIRS), Dehradun on June 13, 2024. He delivered a special talk jointly organized by IIRS and Indian Society of Remote Sensing-Dehradun Chapter (ISRS-DC) on "Localizing decisions using digital twins form climatic extremes"

- Guest lecture titled 'Measuring glacier dynamics by optical & SAR satellite image time series' was delivered at IIRS auditorium by Prof. Emmanuel Trouve, Director and lecture titled 'Spatially constrained source separation' by Prof. Argheesh Bhanot from LISTIC, Savoie Mont Blanc University, Annecy, France, on Nov 21, 2024.

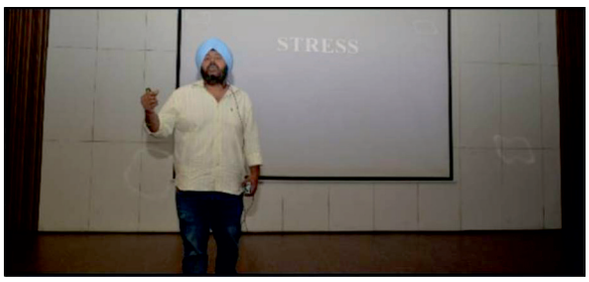
- Dr. Ramesh P. Singh, Professor, School of Earth and Environmental Sciences, Chapman University, USA is visited IIRS during July 22-26, 2024 under the ISRO-NASA Professional engineers & scientist exchange programme (PESEP) and held various meetings. He also delivered an invited talk for IIRS scientist/ engineers, students and researchers on 'Emerging challenges due to climate change along the Himalayan region'.

- 'Himalaya day' was celebrated at IIRS on Sep. 09, 2024 wherein lecture titled 'Himalayan resources & opportunities and way forward' was delivered by Dr. Kalachand Sain, (former Director, WIHG, Dehradun) and a talk on 'Echoes from the Himalaya: A journey through time & terrain' by Dr. George Phillip, EE, JISRS (former Sr. Scientist, WIHG) besides conduction of various programs/ competitions like slogan, painting, quiz, etc. for scientists & students of IIRS.

- A workshop on 'CCS (Conduct Rules), CCS (CCA) Rules' was organised wherein presentation was made by Shri K.V. Lakshmana Kumar, OSD, DOS on Sep. 13, 2024 for Scientist/Engineer working in IIRS.



- A lecture on 'Stress Mgmt.' was delivered by Dr. A. Singh, Doon Hospital, Dehradun on Sep. 20, 2024.



- Shri Dinesh Kumar, Purchase & Stores Officer, Indian Institute of Petroleum (IIP), Dehradun delivered lecture on 'Procurements in Scientific Institutions' on October 18, 2024.

- A lecture on 'Gender sensitivity & provisions of sexual harassment of women at workplace (prevention, prohibition & redressal) Act 2013' was delivered by Sh. M. Sahai, Ex-Controller/Admn, CSIR on Sep 06, 2024.

- A health-talk was delivered on topic 'Make your campus healthy campaign' by Dr. Punit Chaturvedi. Assistant Professor, National Institute of Ayurveda (NIA), Jaipur on Jan. 27, 2025.

- Shri H. Ramakrishnan, Controller LPSC delivered lecture titled 'Purchase, stores & procurement guidelines' & 'Case-studies on procurement' on April 08, 2025 at IIRS auditorium for IIRS staff.

Shri P.L.N. Raju, Special Secretary, Govt. of Assam & former Director, NESAC, Meghalaya delivered a lecture on 'Space technology for governance & development- perspective of North-East' on Sep. 19, 2024.

Participation in S2:STEP2025 & 6th IPSC-2025 at Roorkee

Director, IIRS alongwith team from IIRS participated in 'International Conference on Space for Sustainability: Science, Technology, Education & Policy (S2:STEP2025); 6th Indian Planetary Science Conference (6th IPSC-2025) at IIT, Roorkee; and also in the 'Viksit Bharat Viksit Uttarakhand-2025' during Mar 04-06, 2025. at Roorkee wherein ISRO exhibition stall received best stall award for showcasing space science activities

OTHER INFRASTRUCTURAL IMPROVEMENTS

Land reclamation was done opposite to GID building and got around 0.5 acre land. Children Park was established for residents of Housing Colony. Extensive maintenance works were carried out in Hostel B & C blocks. RRM wall was constructed as part of slope protection measures. New Academic Block is almost completed. Establishing the New Sewage Treatment Plant (STP) is in progress.

Land Reclamation opposite to GID building

Hostel 'B' and 'C' Block

Children Park

RRM Wall in NE Slopes

FINANCIAL PERFORMANCE DURING FY: 2024-25

Following are the major accomplishments with respect to IIRS Budget in FY: 2024-25 (Zero Based Budgeting), wherein detailed justification for the fund requirement was prepared and projected for approval by ISRO HQ/DOS.

- The major activities carried out involved budget formulation, expenditure monitoring and control, preparation of quarterly plan of expenditure and ensuring optimal allocation of budgetary resources to various projects, programmes, activities, etc.
- The budget proposals were entered and presented through Budget Management Software (BMS) made operational by ISRO HQ. The ISRO Council approved, IIRS Budget was made operational in COINS/COWAA finance module.
- The budget analysis was completed timely w.r.t. RE:2024-25 & BE:2025-26 and data was uploaded in BMS software. The COINS/COWAA document was released after successful completion of the RE/BE data entry.
- Based on the input submitted to HQ, and review by JS & FA the IIRS budget was revised & expenditure status for RE:2024-25 and BE: 2025-26 was also updated.
- Expenditure/commitments targets were timely submitted to ISRO HQ for IIRS Budget for FY: 2024-25; wherein expenditure to the tune of Rs. 60.86 Crores was met in the financial year of 2024-25 as against the RRE approved figure of Rs. 61.82 Crores (98.44%).
- The IIRS budget approved by the ISRO Council for BE 2025-26 is Rs. 70.64 Crores.
- Summary of major programmatic allocations and expenditure details may be summarised as follows:

(INR in Lakhs)

S. No.	Activity/	BE 2024-25	Final Allocation (RRE) 2024-25	Actuals 2024-25	% of utilisation w.r.t. RRE	BE 2025-26
1	Technical Facilities & Infrastructure *(TFI)*	6.75	5.35	5.35	100 %	764.50
2	Pay and Allowances *(Salary, PRIS, rewards, etc)*	28.15	26.08	26.06	99.92 %	2906.50
3	Technology Development Programme *(TDP/ R&D)*	4.50	1.34	0.91	67.91 %	200.00
4	Administrative Expenses	23.15	21.96	21.82	99.36 %	2200.00
5	Facility Operations & Maintenance *(O&M)*	4.50	2.46	2.14	86.99 %	417.00
6	Motor Vehicles	0.59	0.18	0.13	72.22 %	25.00
	Sub-Total (A)	***67.64***	***57.37***	***56.41***	***98.33 %***	***6513.00***
7	Major Works *(MCW)*	5.01	4.45	4.45	100 %	550.00
8	Housing	0.01	0.00	0.00	0 %	01.00
	Sub-Total (B)	***5.02***	***4.45***	***4.45***	***99.81 %***	***551.00***
	Total	**72.66**	**61.82**	**60.86**	**98.45 %**	**70.64**

Organisation Structure

CHAIRMAN, ISRO

Director, IIRS & Director CSSTEAP
Dr. Raghavendra Pratap Singh, Sci./Eng. - G

Director's Office	
Ms. Meena Jethi	PS to Director, CSSTEAP
Mr. Paramjeet Singh Nagpal	PPS to Director, IIRS

- IIRS MANAGEMENT COUNCIL
- Academic Council
- Board of Studies

Budget Planning and Monitoring Department (BPMD)
Dr. Puneet Swaroop, Sci./Eng. - SG & Head, BPMD

Mr. Aniruddha Ajay Deshmukh	Scientific Officer-C

Research Project Monitoring Department (RPMD)
Dr. Ashutosh Bharadwaj, Sci./Eng. - SF & Head, RPMD

Dr. Swati Swaroop	Sci./Eng. – SE
Mr. Javed Akram	Senior Assistant

Central Library
Mr. Arun Kumar Sardar, Sci./Eng. - SF & I/C Library

Mr. I. Srinivasa Raju	Library officer-D

Programme Planning & Evaluation Group (PPEG)
Dr. Hari Shanker, Sci./Eng. - SG & Group Head, PPEG

Ms. Swarn Lata	PPS

Construction and Maintenance Division (CMD)
Mr. Ganesh Kumar Kota, Sci./Eng. - SE & Dy. Head CMD

Ms. Mamta Sah	Sci./Eng. - SE
Mr. Ramesh Chand Meena	Sci./Eng. - SD
Mr. Pankaj Kumar	Sci./Eng. - SD
Mr. Md Sarwar Alam	Technician G
Mr. Mohammad Faheem Akther Ansari	Technician G
Mr. Bhanu Bushan Bijalwan	Technician F
Mr. Ankit Dhiman	Technician B

Geospatial Technology & Outreach Program Group (GTOPG)
Ms. Shefali Agrawal, Sci./Eng. – G & Group Director, GTOPG

Photogrammetry and Remote Sensing Department (PRSD)
Dr. Anil Kumar, Sci./Eng.- SG & Head, PRSD

Dr. Hina Pande	Sci./Eng. - SG
Dr. Shashi Kumar	Sci./Eng. - SF
Mr. Ashish Joshi	Sci./Eng. - SF
Dr. Manu Mehta	Sci./Eng. - SF
Mr. Vinay Kumar	Sci./Eng. - SF

Geoinformatics Department (GID)
Dr. Vandita Srivastava, Sci./Eng. - SG & Head, GID

Mr. Kapil Oberai	Sci./Eng. - SF
Mr. Ashutosh Kumar Jha	Sci./Eng. - SF
Mr. Prasun Kumar Gupta	Sci./Eng. - SF
Dr. Ashutosh Srivastava	Sci./Eng. - SF
Mr. Prabhakar Alok Verma	Sci./Eng. - SE
Ms. Shobha Devi	Senior Project Attendant

Geoweb Services, IT and Distance Learning Department (GITDL)
Dr. Harish Chandra Karnatak, Sci./Eng. - SG & Head, GITDL

Dr. Poonam Seth Tiwari	Sci./Eng. - SG
Mr. Dharmendra Kumar	Sci./Eng. - SF
Mr. Ravi Bhandari	Sci./Eng. - SF
Dr. Kamal Pandey	Sci./Eng. - SE
Mr. Ashok Gildiyal	Technical Officer - D
Mr. Janardan Vishwakarma	Technical Officer - D
Mr. Manghea Ram	Technical Officer - C
Mr. Md. Sajid Ansari	Technician - F

Dean (Academics)
Dr. Pramod Kumar, Sci./Eng. - G & Dean (Academics)

Ms. Sangeeta Chachara	Personal Assistant

Smt. Minakshi Kumar, Sci./Eng. - SG & Head Academics

Mr. Vikas	Technician-F

Personnel & General Administration
Shri. Rathin Sengupta, Head, Personnel & General Administration/Head, Accounts, IFA & CPIO

Sec I, II, III (VDLS, CHSS, Estt., OL)
Mr. Anshuman Misra, Administrative Officer (GA)

Shri Om Prakash	Senior Assistant
Ms. Nirjara Jain	Senior Assistant
Shri Bhaskar Prasad	Senior Assistant (adhoc)

Sec IV, V (PR & R&R)
Mr. Prashant Kumar Parashar, Administrative Officer (PR)

Mr. Ajay Kumar Malik	Senior Assistant
Mr. Manoj Kumar	Senior Assistant
Mr. Harbhajan Singh	Sr. Project L V D-C
Mr. Rajender Kumar	L V D-B

Pay & Account Section
Mr. Rajender Singh Katariya, Accounts Officer

Mr. Naveen Kumar	Senior Assistant

Purchase and Stores Section
Mr. Somnath Shukla, Purchase & Store Officer (adhoc)

Mr. Vivek Ashish	Senior Assistant
Ms. Priyanka Das	Senior Assistant (adhoc)

Agriculture, Forestry & Ecology Group (AFEG)
Dr. Suresh Kumar, Sci./Eng. - G & Group Director, AFEG

AGRICULTURE & SOIL DEPARTMENT (ASD)
Dr. N. R. Patel, Sci./Eng. - SG & Head, ASD

Dr. Dipanwita Haldar	Sci./Eng. - SF
Mr. Justin George K	Sci./Eng. - SE
Mr. Abhishek Danodia	Sci./Eng. - SD
Mr. Dinesh Amola	Technical Officer- C

FORESTRY & ECOLOGY DEPARTMENT (FED)
Dr. Hitendra Padalia, Sci./Eng. - SG & Head, FED

Dr. Subrata Nandy	Sci./Eng. - SF
Dr. Ishwari Datt Rai	Sci./Eng. - SE
Dr. Taibanganba Watham	Sci./Eng. - SE
Mr. Ashish Bisht	Sci./Eng. - SD

Geosciences & Disaster Management Group (GDMG)
Dr. R. S. Chatterjee, Sci./Eng.-G, Head GSD & Group Director, GDMG

Geosciences Department (GSD)

Dr. Shovan Lal Chattoraj	Sci./Eng. - SF
Dr. Pratima Pandey	Sci./Eng. - SF
Ms. Richa Upadhyay	Sci./Eng. - SE
Dr. Suresh Kannaujiya	Sci./Eng. - SE
Dr. Mamta Chauhan	Sci./Eng. - SE
Mrs. Jappji Mehar	Sci./Eng. - SC
Mr. Amit Shrivastava	Senior Scientific Assistant

Disaster Management Studies Department (DMSD)
Dr. Arijit Roy, Sci./Eng. - SG & Head, DMSD

Mr. C M Bhatt	Sci./Eng. - SG
Mr. Hari Shankar	Sci./Eng. - SF
Mr. Yateesh Ketholia	Sci./Eng. - SD

Hydrology & Urban Studies Group (HUSG)
Dr. Pramod Kumar, Sci./Eng. - G & Group Director, HUSG

Urban and Regional Studies Department (URSD)
Dr. Sandeep Maithani , Sci./Eng. - SG & Head, URSD

Dr. Kshama Gupta	Sci./Eng. - SF
Dr. Asfa Siddiqui	Sci./Eng. - SE
Dr. Surendra Kumar Sharma	Sci./Eng. - SD

Water Resources Department (WRD)
Dr. Praveen K. Thakur, Sci./Eng. - SG & Head, WRD

Dr. Vaibhav Garg	Sci./Eng. - SF
Dr. Arpit Chouksey	Sci./Eng. - SE
Mr. Pankaj Ramji Dhote	Sci./Eng. - SE

Marine & Atmospheric Sciences Group (MASG)
Dr. D. Mitra, Sci./Eng. - G, Head MSD & Group Director, MASG

Marine Sciences Department (MSD)

Dr. Sachiko Mohanty	Sci./Eng. - SE

Atmospheric Sciences Department (AtSD)
Dr. Yogesh Kant, Sci./Eng. – SG & Head, AtSD

Dr. Shuchita Srivastava	Sci./Eng. - SF
Dr. Charu Singh	Sci./Eng. - SF
Ms. Pooja Jindal	Sci./Eng. - SE
Dr. Sanjeev Kumar Singh	Sci./Eng. - SE

Staff strength at end of FY 2024-25 *(as on 31.03.2025)*

S.N.	Category	Group-A		Group-B		Group-C		Group-D	
		M	F	M	F	M	F	M	F
1.	Scientist/ Engineer	49	19	NA	NA	NA	NA	NA	NA
2.	Technical Support Staff	6	0	6	0	1	0	0	0
3.	P&GA / F&A/ P&S Officers / Asst.& Secretarial	4	0	8	4	1	1	0	0
4.	Administrative Staff (Drivers / Attendants)	0	0	1	0	2	1	0	0
	TOTAL	59	19	15	4	4	2	0	0

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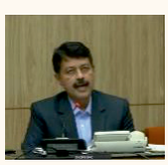

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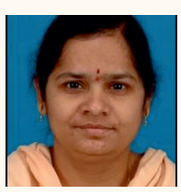

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