IIT Roorkee

Annual Report 2024

ReSim Lab

Reservoir Simulation Laboratory

Department of Water Resources Development and Management

Content

About the Research Lab

The Reservoir Simulation (ReSIM) Lab operates under the Department of Water Resources Development and Management at the Indian Institute of Technology Roorkee, India. The lab is dedicated to tackling research problems in the broader domain of water resources management specifically investigating the dynamics of hydrological processes and their implications across varying spatial and temporal scales.

The lab's research encompasses diverse themes, including improving flood forecasting with uncertainty analysis, creating decision support systems for optimising hydropower generation, assessing reservoir impacts across multiple scales, exploring the water-energy-food nexus, and enhancing hydrological modelling by incorporating innovative machine learning techniques. Another key area of focus is integrating climate change insights, particularly regarding extreme events, into hydrological models. In addition to computational modelling, the lab has actively engaged in developing low-cost instruments for measuring soil moisture and river discharge using sensors and IoT-based mechanisms.

Committed to addressing critical research priorities, the team actively trains skilled researchers. It delivers practical solutions to real-world challenges through collaborative projects with academic institutions and industries both in India and abroad. The lab boasts cutting-edge resources, including high-performance computing systems, real-time simulators, and SCADA (Supervisory Control and Data Acquisition) systems, to support its modelling and simulation efforts.

The ReSIM Lab extends heartfelt gratitude to the Director of IIT Roorkee, the DEAN SRIC, former and current Heads of WRDM, faculty members, and staff for their invaluable support and guidance.

Group Lead

Prof. K.S. Kasiviswanathan currently serves as an Associate Professor at the Department of Water Resources Development and Management and also holds a Joint Faculty position at the Mehta Family School of Data Science and Artificial Intelligence, Indian Institute of Technology Roorkee (IITR), India. His research interests include reservoir operation, flood forecasting, geospatial data analysis, multi-objective optimization, uncertainty, and risk quantification. He pursued his Ph.D. in 'Quantification of uncertainty in hydrological models' from the Indian Institute of Technology Madras in 2014 and a Masters in Water Resources Development from the Indian Institute of Technology Roorkee in 2009. He worked as a Postdoctoral Research Associate at the School of Built Environment, Heriot-Watt University, Edinburgh, United Kingdom, and a Postdoctoral Research Scholar at Schulich School of Engineering, University of Calgary, Calgary, Canada, spending three years. Before joining IIT Roorkee, he served as an Assistant Professor in the School of Engineering, IIT Mandi, India from 2017 to 2019.

Prof. Kasiviswanathan has published more than 40 papers in reputed high-impact factor international journals, including the Water Resources Research, Journal of Hydrology, Hydrological Sciences Journal, Stochastic Environmental Research and Risk Assessment, and many more. He has also presented papers at several National and International conferences. He has been the Guest Editor in reputed journals. He is the recipient of several prestigious awards such as a research grant from DAAD, Germany, the Berkner fellowship from the American Geophysical Union, USA, the Sivapalan Young Scientist award from the International Association of Hydrological Sciences, United Kingdom, the Early Career Research Award, Department of Science and Technology, India, Eyes High Postdoctoral Fellowship, University of Calgary, Canada and the Outstanding Young Faculty Award, IIT Roorkee. He currently holds a research project worth half a million US dollars in collaboration with institutes from India and abroad.

Collaborators

	Collaborator	Designation	Country
	Prof. Adeloye J Adebayo	Professor Emeritus, School of Energy Geoscience, Infrastructure, and Society Heriot-Watt University	United Kingdom - Scotland
	Prof. Jianxun He	Professor Department of Civil Engineering Associate Head of Undergraduate Studies University of Calgary	Canada
	Prof. Claudia Teutschbein	Associate Professor Department of Earth Sciences, Program for Air, Water and Landscape Sciences; Hydrology Uppsala University	Sweden
	Prof. Nicola Fohrer	Director Institute of Nature and Resource Conservation, Department of Hydrology and Water Management, Kiel University	Germany
	Prof. Carsten Montzka	Senior Scientist Institute of Bio- and Geosciences: Agrosphere, Forschungszentrum Jülich GmbH	Germany

	Prof. Sandhya Patidar	Associate Professor, School of Energy, Geoscience, Infrastructure and Society Heriot-Watt University	United Kingdom - Scotland
	Prof. Mohanasundaram	Assistant Professor Water Engineering and Management Asian Institute of Technology	Thailand

Research Team

Post Doctoral Researchers

Dr. Suresh Devaraj

Ph.D. - Microwave Remote Sensing

Research Expertise:

Remote Sensing and GIS

Doctoral Researchers

Mr. Koustav Nath

Research Expertise:

Modeling of Soil Moisture Dynamics

Ms. Abhinanda Roy

Research Expertise:

Hydrological Modeling, Flood Forecasting, Uncertainty Quantification

Mr. Pattabiraman B

Research Expertise:

Reservoir Operation & Optimization, Prediction in Ungauged Basin

Mr. Vageshvar Yadav

Research Expertise:

ML models for Hydropower Management, IOT and Automation

Ms. Sruthakeerthi P

Research Expertise:

Hydrological Modeling, Reservoir Operation

Mr. Siddig Mohammed Ali Berama

Research Expertise:

Flood Mitigation and Management

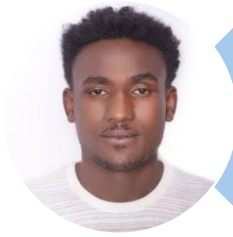## Mr. Bhabesh Das

Research Expertise:

Water-Food-Energy Nexus

Ms. Aiswarya S.L

Research Expertise:

Hydrological Modeling, Machine Learning, Remote Sensing

Post Graduates

Mr. Surafel Shimels

Research Expertise:

Machine Learning Models in Streamflow Forecasting

Mr. Surat Bahadur Sunar

Research Expertise: Pumped Storage Based Hydropower Assessment Under Climate Change

Mr. Kassian Gervas Mtitu

Research Expertise:

Energy Saving Analysis for Effective Management of Water Pumping Networks

Mr. Sagar Pokhrel

Research Expertise:

Reservoir Optimization

Mr. Mlondolozi Thulebona Nxumalo

Research Expertise:

Remote Sensing, Deep learning techniques

Mr. Yub Raj Yonghang

Research Expertise:

Reservoir Sedimentation using Remote Sensing and GIS

Project Fellow

Mr. Vijaya Lakshmanan S
Research Expertise:
IoT and Automated System

Courses Offered and Outreach Activities

Courses Instructed

The courses offered to the master's and Ph.D. students include:

- WRN 597 ML Models in Water Resources Planning and Management
- WRN-532 Hydropower System Planning (HSP)
- WRN-505 Preparation of Water Resources Project Report
- WRN-503 Water Resources Planning and Management

Outreach Activities

Delivered a lecture on 'Introduction to Artificial Intelligence (AI) and Machine Learning (ML) in Water Resources Engineering' in the Training Program on Capacity Building of Civil Engineers of Minor Irrigation (MI) Organization, on 2nd February 2024.

Delivered an invited lecture in the Statistical Tools for Modelling Big Data in Hydro-climatology (STAMBH) workshop organized by the Department of Hydrology, IIT Roorkee, under the KARYASHALA Scheme.
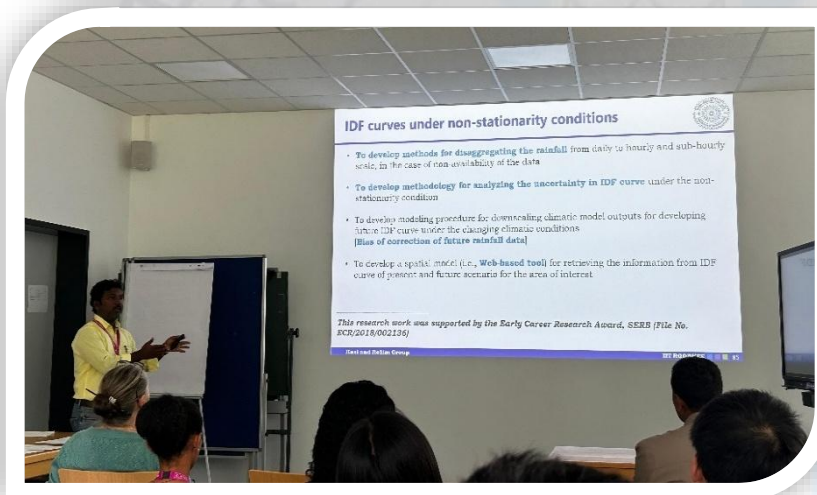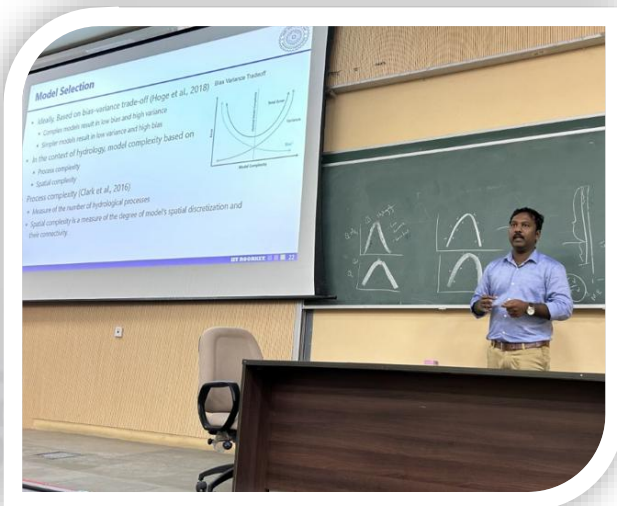
Delivered a lecture on 'Applications of Machine Learning in Hydrological Modeling' at Kiel University, Germany.

Delivered a lecture on 'Applications of Machine Learning in Hydro-Climate Modelling' in the 'Decoding Climate Change: From Modelling to Machine Learning' workshop conducted at the Institute of Climate Change Studies (ICCS) Kottayam.

Lecture at ICCS Kottayam

Organised and participated in the first alumni meeting conducted by the Department of WRDM on 8th November 2024. As a part of the programme, sessions were arranged in which students could benefit from interacting with the Alumni members about the field knowledge/job market/industry exposure etc.

Alumni meet at the Department of WRDM

Research Projects

New Research Projects

| Sponsoring Agency	Title of Project	Amount of Grant (Lakhs, INR)
Department of Science and Technology	Restructuring and Enhancing Strategies with a Transformative AppRoach for InTegrated Water Disaster Management in India and the Netherlands - RESTARTIN	300

Ongoing Research Projects

Sponsoring Agency	Title of Project	Amount of Grant (Lakhs, INR)
GISE Hub, IIT Bombay, DST	Development of Low-Cost Sensor-based Real-Time River Flow Monitoring System	22.11
DST, STAR	Development of Adaptive Machine Learning-Based Approach for Robust Calibration of Hydrological Models in collaboration with IISc Bangalore	96.94
Swedish Research Council - Sustainability and Resilience funding	Impacts of Recent El-Niño Southern Oscillation (ENSO) on the Water-Food-Energy Nexus in India in collaboration with Uppsala University, Sweden and Amrita Vishwa Vidyapeetham, India	59.20

Completed Research Projects

Sponsoring Agency	Title of Project	Amount of Grant (Lakhs, INR)
Tehri Hydro Development Corporation Limited (THDC) India Ltd	Development of Decision Support System for Integrated Operation of Tehri Hydropower Complex	56.59

Internship Opportunities

During the summer 2024, Mr. Praavin Kumar, B.Tech. 3rd year, Department of Computer Sciences, SRM Institute of Science and Technology, Chennai, was offered an internship to work in the lab for researching on 'Flood Zoning Using Deep Learning Models'
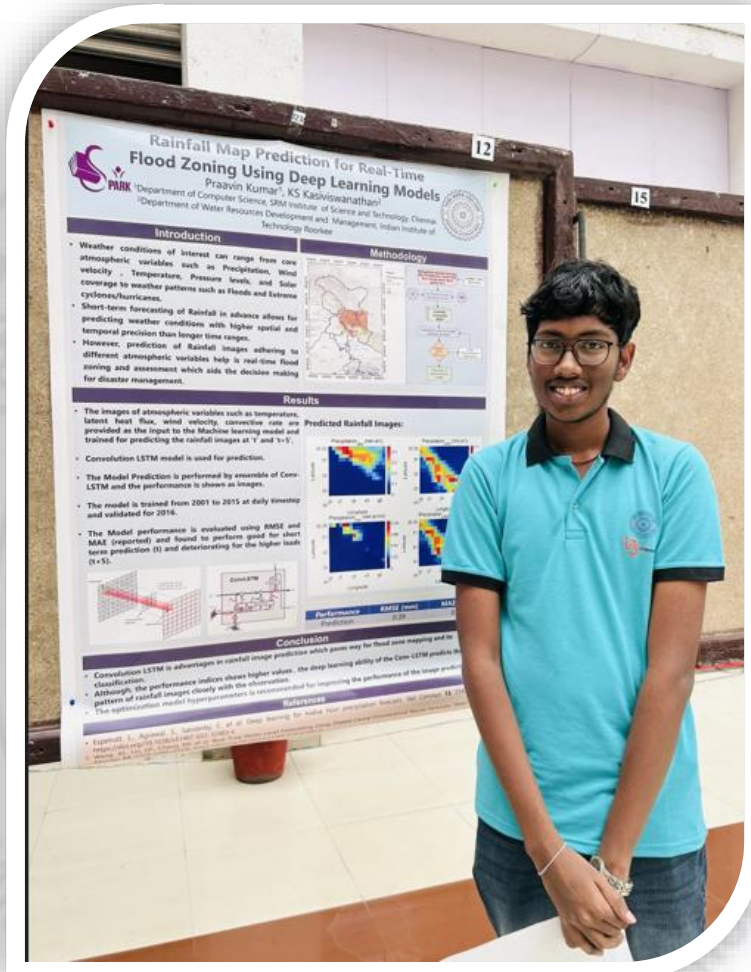
Research Publications

Journal Publications

Chandni Thakur**,** Claudia Teuschbein, KS Kasiviswanathan, Bankaru- Swamy Soundharajan (2024). Mitigating El Niño Impacts on Hydro-energy Vulnerability through Identifying Resilient Run-of-river Small Hydropower Sites. Journal of Hydrology: Regional Studies. doi:10.1016/j.wre.2022.100198

Chandni Thakur**,** KS Kasiviswanathan, Claudia Teuschbein, Bankaru- Swamy Soundharajan, MM Diwan Mohaideen, Venkatesh Budamala. Assessment of Hydrological Changes in Godavari River Basin Under the Impacts of El Niño. Proc. IAHS. https://doi.org/10.5194/piahs-385-203- 2024

Nath, K., Nayak, P. C., & Kasiviswanathan, K. S. (2024). Soil volumetric water content prediction using unique hybrid deep learning algorithm. *Neural Computing and Applications*, *6*. https://doi.org/10.1007/s00521-024-09991-6

Roy, A. and Kasiviswanathan, K.S (2024), Quantifying Streamflow Prediction Uncertainty Through Process-Aware Data-Driven Models. Hydrological Processes, 38: e15310. https://doi.org/10.1002/hyp.15310

Yadav N, Pattabiraman B, Tummuru NR, Soundharajan BS, KS Kasiviswanathan et al (2024) Toward improving Water-Energy-Food Nexus through Dynamic Energy Management of Solar Powered Automated Irrigation System. Heliyon. DOI: https://doi.org/10.1016/j.heliyon.2024.e25359.

Conferences

Devaraj S, Kasiviswanathan KS, Exploring the Potential of Run-of-River Small Hydropower to Reduce El Niño-induced Risks for Energy Production in the Godavari River Basin, India, AOGS, South Korea (2024).

Nath, K., Nayak, P.C., and Kasiviswanathan, K.S., Predicting Soil Volumetric Water Content with a Novel Hybrid Deep Learning Algorithm, AGU fall Meeting Abstracts 2024, Online, 8-13 December (2024)

Pattabiraman B, Kasiviswanathan KS, Deriving dynamic reservoir operating policy under the changing precipitation and inflow patterns in snow-dominated Himalayan regions, EGU General Assembly 2024, Vienna, Austria, (2024)

Roy, A. and Kasiviswanathan, K.S (2024), Towards minimizing prediction uncertainty of hydrological models through Physics-aware machine learning models, AGU Fall Meeting 2024, Washington D.C., USA, 09-13 Dec 2024, 508217

Roy, A., Kasiviswanathan, K. S., and Patidar, S. (2024), A novel two-stage multi-step dynamic error correction model for improving streamflow forecast accuracy, EGU General Assembly 2024, Vienna, Austria, 14–19 Apr 2024, EGU24-315, https://doi.org/10.5194/egusphere-egu24-315, 2024

Thakur C, Kasiviswanathan KS, An Integrated Hydrological Modeling Framework for Enhancing Water- Energy Nexus during El Niño Events in the Godavari River Basin, India, EGU General Assembly 2024, Vienna, Austria (2024)

Thakur C, Kasiviswanathan KS, Evaluating the snowmelt dynamics and runoff in the Himalayan Region, AOGS, South Korea, (2024)

Field Surveys Conducted

Godavari River Basin

A field survey was conducted in the Godavari River Basin as part of the project titled "Impacts of Recent El-Nino Southern Oscillation (ENSO) on the Water-Food-Energy Nexus (WFEN) in India by the ReSim Lab members Pattabiraman B, Bhabesh Das, Vijay Lakshmanan S under the guidance of Prof. KS Kasiviswanathan and Prof B.S Soundharajan (Amrita Vishwa Vidyapeetham). This survey took place from September 13 to September 18, 2024, and aimed to analyse the effect of ENSO events on agricultural yield and water availability, two critical components of WFEN.

The survey was divided into four main components: a questionnaire survey, real-time agricultural land mapping, investigation of water storage structures, and soil sample collection. It covered around 15 villages in the upper, middle, and lower Godavari sub-basins including interaction with farmers for collecting primary data. The questionnaire focussed on diverse agricultural practises, crop management, irrigational techniques and management measures at the local scale. Soil sample collection involved gathering 43 disturbed soil samples from grasslands to assess the grassland health. The investigation of substantial water storage structures such as Sripada Yellampalli Project and the Sri Ram Sagar Project, was also conducted to get the details regarding the operational status, capacity and purpose. As part of agricultural land mapping, real-time cropland mapping was conducted using Distance and Land Area Measure (DLM) mobile application.
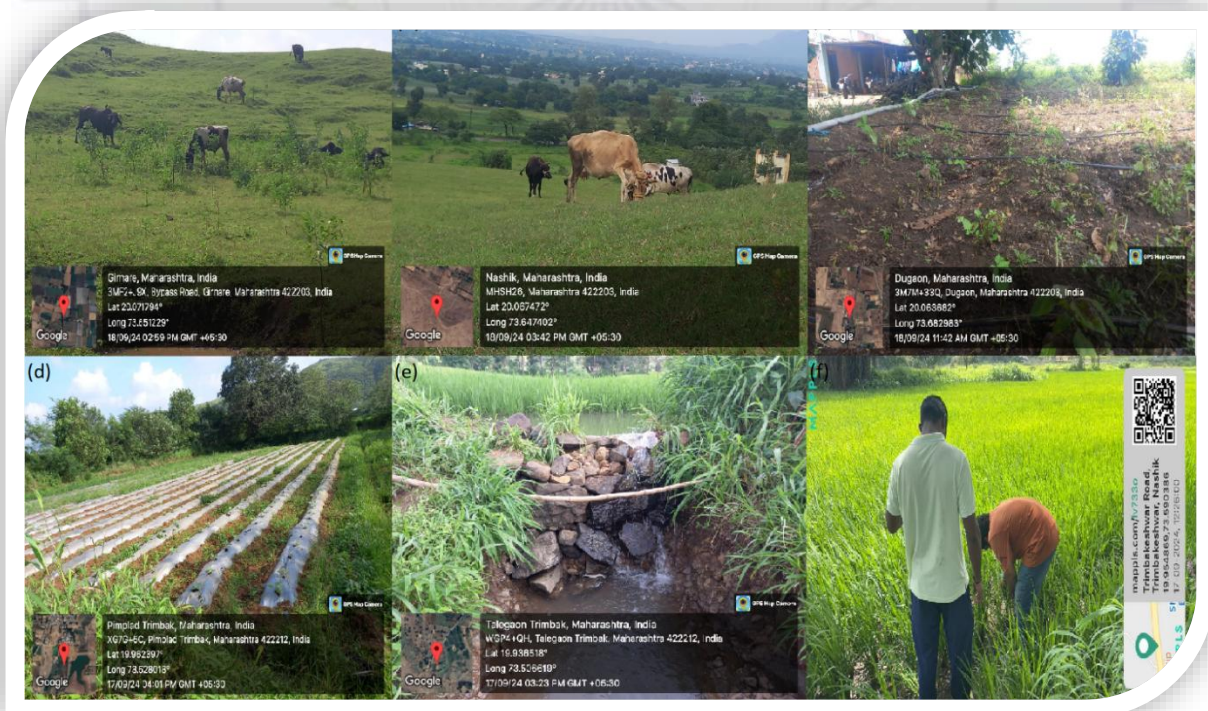
Glimpses from the Godavari field survey

Milestones

- ➢ Prof. K.S. Kasiviswanathan received the Outstanding Young Faculty Award 2024, with an Institute Research Fellowship (IRF) for three years by IIT Roorkee. This is a highly competitive award to recognise faculty members who have carried out excellent research work.
- ➢ PhD degrees awarded to research scholars Mr. Wasu Manawko Tefera, Mr. Rahmatullah Dost and Ms. Chandni.

Abroad Visits and Awards

Prof. K.S. Kasiviswanathan visited Kiel University, Germany under the DAAD fellowship for carrying out research for 3 months from 20th May to 15th August 2024.

SWAMP Summer School and Workshop

Mr. Pattabiraman B and Mr. Vijaya Lakshmanan attended the 'Sustainable Water Management under Pressure in Ethiopia (SWAMP)' summer school and workshop funded by DAAD, at Kiel University from 30th July to 8th August 2024.

Prof. K.S. Kasiviswanathan, Mr. Pattabiraman B and Mr. Vijaya Lakshmanan conducted a field visit to the UNESCO identified demonstration site for ecohydrological modelling. During the visit, they collected water quality data by
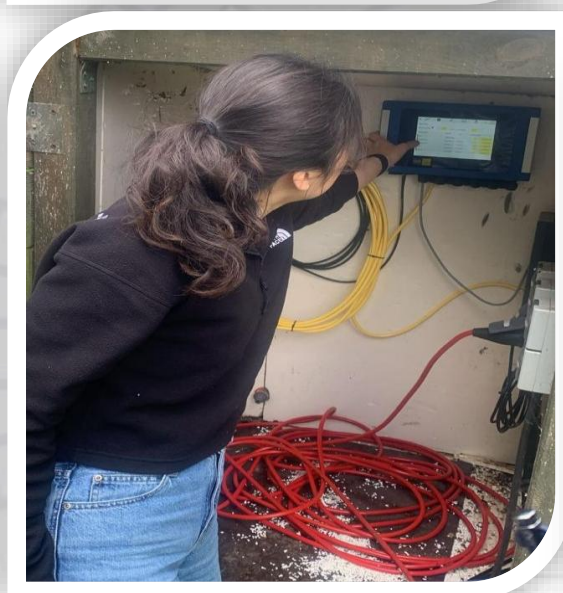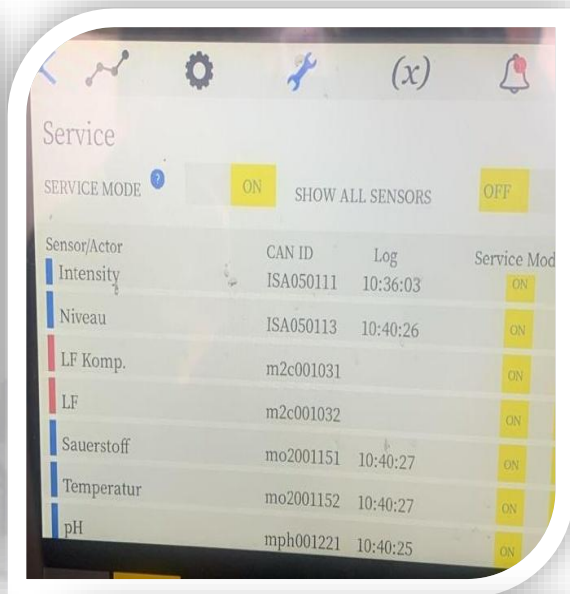
conducting experiments at the catchment outlet, and hydrometeorological data from the Moorau station.

**Glimpses of field visit to Kielstau catchment**

Collection of meteorological data at Moorau station

Collection of water quality data at the catchment outlet

Prof. K.S. Kasiviswanathan, Mr. Pattabiraman B and Ms. Abhinanda Roy presented their research works at the esteemed European Geosciences Union (EGU) General Assembly 2024 held in Vienna, Austria from 14th to 19th April 2024. Ms. Abhinanda was funded with the Early Career Scientist's Travel Support (ECSTS), financed by the European Geosciences Union, to attend the assembly.
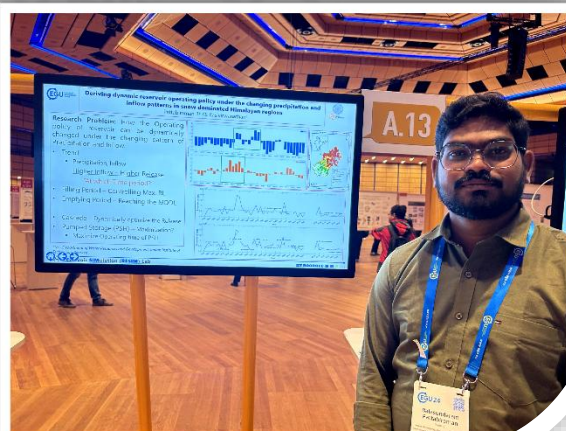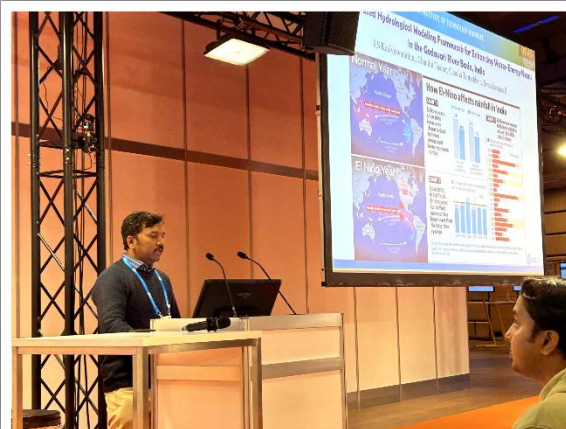
ReSim Laboratory at EGU General Assembly 2024

Ms. Chandni, research scholar, was awarded International Travel Support by the Department of Science and Technology, Government of India, and a Student Fee Waiver Award to attend the 21st Annual Meeting of the Asia Oceania Geosciences Society (AOGS2024) in Pyeongchang, Gangwon-do, South Korea, 23-28 June 2024.

Ms. Abhinanda Roy, research scholar, received the prestigious Commonwealth Split Site Scholarship 2023, funded by the UK Commonwealth Scholarship Commission and tenured at Heriot-Watt University, Edinburgh, United Kingdom (08th Jan 2024 – 07th Jan 2025).

Ms. Abhinanda Roy presented her work titled 'Towards minimizing prediction uncertainty of hydrological models through Physics-aware machine learning models' at the American Geophysical Union (AGU) Fall Meeting conducted in Washington D.C., USA from December 9th to December 13th, 2024.
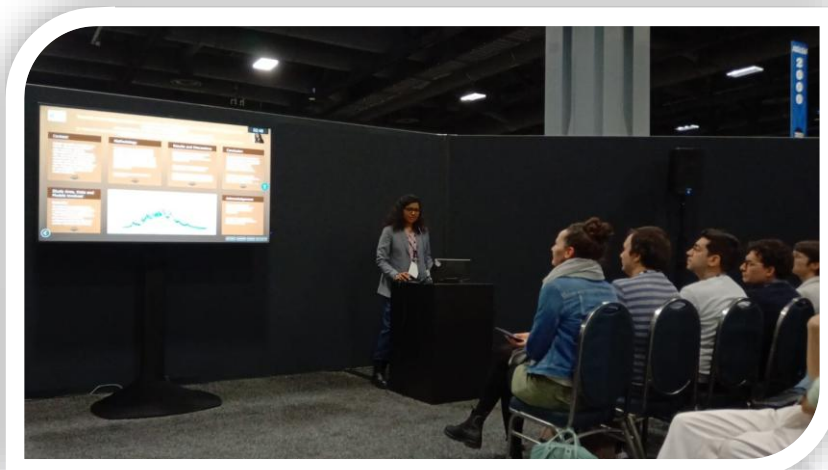
Ms. Abhinanda at AGU 2024

Ms. Abhinanda Roy attended the Scottish International Scholars Event 2024 at Playfairs Library, University of Edinburgh, Scotland. It was organized by the 'Study UK Campaign' to celebrate the class of 2023-24 international scholars holding GREAT, Chevening, Commonwealth, and the Marshall Scholarships.

Ms. Chandni was offered a post-doctoral fellowship at the School of Geography, Earth and Environmental Sciences, University of Birmingham, UK. She joined the position on 16 January 2025 on a fixed-term contract of two years, working under the supervision of Dr. Martin Widmann, Senior Lecturer in Climate Science. Currently, she is working on a project funded by the UK Met Office under the WCSSP-India program, titled "Heavy Precipitation Forecast Postprocessing for India with Machine Learning (HEPPI-ML)." The project focuses on applying machine learning

techniques for postprocessing numerical ensemble precipitation forecasts over India, with the goal of improving their predictive skill, particularly for extreme rainfall events. HEPPI-ML aims to comprehensively assess forecast performance before and after ML postprocessing, including evaluations across different weather conditions. The outcomes of this research will support improved decision-making related to heavy precipitation and flood risk management in India.

Group Activities and Recognitions

Research scholars Mr. Pattabiraman B., Mr. Bhabesh Das, Ms. Sruthakeerthi P, and Ms. Aiswarya S.L. participated in and completed a 5-day workshop on 'Ecohydrological Modelling' organized by the Department of Civil Engineering, NIT Warangal, under the Global Initiative of Academic Networks (GIAN) scheme.

GIAN Course at NIT Warangal

Mr. Siddig Mohammed Ali Berama participated online in the 6th Workshop on Water Resources in Developing Countries: Hydroclimate Modeling, Information Tools and Simulation Techniques organized by the International Centre for Theoretical Physics and presented a poster on 'Impact of Climate Change and LULC Change on the Water Availability in the Blue Nile Basin.'

Ms. Sruthakeerthi P a poster titled "Urban Precipitation Anomaly in Major Indian Cities – A Nation Scale Study" at the International Conference on Water and Agricultural Sustainability Under Changing Climate - WASCC 2024, held at Tamil Nadu Agricultural University, Coimbatore, and won the second position for the best poster presentation.

A visit to Pathri hydropower plant, Haridwar

Mr. Pattabiraman B and Mr. Bhabesh Das conducted a site visit for the preliminary examination on the structural stability of Asan barrage, Dehradun and the wetlands conservation practices followed.

Ms. Chandni was offered the guest faculty position at the Department of Civil Engineering, NIT Hamirpur, and served from August 2024 to October 2024.

2024 Highlights

- ➤ Five research papers were published in high-impact peer-reviewed journals, including Journal of Hydrology: Regional Studies and Hydrological Processes.
- ➤ Completion of a project:
    - o Development of Decision Support System for Integrated Operation of Tehri Hydropower Complex
- ➤ Three PhD degrees were awarded – Mr Wasu Manawko Tefera, Mr Rahmatullah Dost and Ms Chandni.
- ➤ Visit of Prof. Kasiviswanathan KS to Germany for 3 months, supported by the DAAD fellowship
- ➤ Prestigious Institute Research Fellowship received by Prof. Kasiviswanathan KS and the recognition as Outstanding Young Faculty

Acknowledgements

Contact Us

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URL: https://www.iitr.ac.in/~WR/K___S___Kasiviswanathan

Report Edited by: Ms. Sruthakeerthi P and Ms. Aiswarya S.L.

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