Dr. Anil Kumar

Ph.D. in Computational Geophysics

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Research Bio

Dr. Anil Kumar is a computational geophysicist with strong expertise in integrating machine learning and numerical modeling to address complex geoscientific and environmental problems. He earned his Ph.D. through a joint doctoral program between Indian Institute of Technology Bombay, India and Monash University, Australia. His research spans geophysics, hydrology, and applied artificial intelligence, with significant contributions to topics such as inverse problems, reduced-order modeling and operational flood forecasting. Dr. Kumar has published extensively in leading peer-reviewed journals, reflecting both methodological rigor and real-world impact. He has substantial experience working in interdisciplinary and international research environments, enabling effective collaboration across engineering, earth sciences, and data science domains.

Currently, Dr. Kumar serves as Principal Project Scientist in the Department of Civil Engineering, Indian Institute of Technology Delhi, where he leads the development of reduced-order and surrogate models for real-time urban flood prediction, supporting operational decision-making and disaster risk reduction.

Research Interests

Geophysical Inversion, Reduced Order Modeling, Surrogate Modeling, Bayesian Analysis, AI/ML applications in Geoscience.

Experience

Aug'2023 – Present **Principal Project Scientist**, *Indian Institute of Technology Delhi*, Department of Civil Engineering.

Apr'2023 – Jul'2023 **Senior Project Scientist**, *Indian Institute of Technology Delhi*, Department of Civil Engineering.

Dec'2022 – Feb'2023 **Senior Project Scientist**, *Indian Institute of Technology Delhi*, Department of Civil Engineering.

Aug'2015 – Apr'2016 **Junior Research Fellow**, *Indian Institute of Technology Bombay*, Department of Earth Sciences.

Education

2016 – 2022 **Ph.D. in Computational Geophysics**, *Dept. of Civil Engg. at Monash University, Australia and Dept. of Earth Sciences at the Indian Institute of Technology Bombay, India*, *CPI – 8.88/10*.

2013 – 2015 **M.Tech in Petroleum Geoscience**, *Dept. of Earth Sciences at the Indian Institute of Technology Bombay, India*, *CPI – 8.75/10*.

2008 – 2013 **Integrated M.Tech in Geophysical Technology**, *Dept. of Earth Sciences at the Indian Institute of Technology Roorkee*, Roorkee, India, *Percentage – 61.40%*.

Ph.D. Thesis

Thesis ***Statistical and Machine Learning Models for the Evaluation of Geophysical and Geomechanical Data***

Supervisors Professor Kumar Hemant Singh, Professor Mohan Yellishetty & Professor Trilok Nath Singh

Description My PhD research focused on the development of a reduced-order model (ROM) for rapid prediction of long-term slope stability, extending predictive capabilities up to 50 years. A significant focus of this work was on enhancing geomechanical assessments by identifying potential instability zones to support proactive risk mitigation efforts. Crucially, I implemented Proper Orthogonal Decomposition (POD) to effectively simulate hydromechanical processes and identify dominant modes. This technique significantly reduced the computational load, enabling the representation of complex dynamics involving approximately 2 million Degrees of Freedom (DOFs) with just 10-15 POD modes. One of the most impactful outcomes of this model was its ability to reduce simulation times from several days to just a few minutes, greatly accelerating computational processes while maintaining high accuracy in the modeling results. This rapid prediction capability is essential for timely decision-making in geotechnical engineering applications.

Bachelor's Thesis

Thesis ***Development of a Monte Carlo Inversion Technique for MASW Data***

Supervisors Professor R.G.S. Sastry (Dept. of Earth Sciences) & Professor R.S. Jakka (Dept. of Earthquake Engineering)

Description In this work, titled "Development of a Monte Carlo Inversion Technique for MASW Data," I developed a simulated annealing and the Nelder-Mead simplex algorithm based inversion code to enhance the inversion of Multichannel Analysis of Surface Waves (MASW) data. This research aimed at delineating the near subsurface characteristics, a critical aspect in geophysical surveys. The innovative approach not only improved the accuracy of subsurface profiles but also streamlined the computational process, setting a new standard in geophysical data analysis. This work exemplified my capability to integrate complex mathematical techniques with practical geophysical applications, demonstrating a significant advancement in the field of geotechnical engineering.

Awards

2016 IITB-Monash PhD Fellowship

2012 Graduate Aptitude Test in Engineering (GATE Fellowship) in the Geology and Geophysics (GG) Paper

Textbook(s)

2024 **Dr. Anil Kumar** and Dr. Manabendra Saharia. ***Python for Water and Environment***, Textbook for undergratuate and postgraduate students, computational hydrologists, geophysicists and water professionals, Published by Springer Nature, 2024. ISBN : 978-981-99-9408-3. DOI: 10.1007/978-981-99-9408-3

Journal Publications

2025 Gourab Panda, Vipul K. Singh, **Anil Kumar**, Manabendra Saharia, Sandeep Kumar. ***Graph Machine Learning Framework for Gravimetry Data Analysis and Cavity Detection***. IEEE Transactions on Artificial Intelligence, 2025. [Accepted]

2024 **Anil Kumar**, Manabendra Saharia, Pierre Kirstetter. ***Mapping a novel metric for Flash Flood Recovery using Interpretable Machine Learning***. Journal of Hydrometeorology, 2024. DOI: 10.1175/JHM-D-23-0196.1

2024 Roger Hu, **Anil Kumar**, Mohan Yellishetty, Stuart DC Walsh. ***A bootstrap strategy to train, validate and test reduced order models of coupled geomechanical processes***. Computers and Geotechnics, volume 167, page 106094, 2024. DOI: 10.1016/j.compgeo.2024.106094

2023 Ritesh Mohan Joshi, **Anil Kumar**, Kumar Hemant Singh. ***A simulation and data informed approach to porosity partitioning***. Geoenergy Science and Engineering, volume 229, page 212044, 2023. DOI: 10.1016/j.geoen.2023.212044

2021 **Anil Kumar**, Roger Hu, Stuart DC Walsh. ***Development of Reduced Order Hydro-mechanical Models of Fractured Media***. Rock Mechanics and Rock Engineering, volume 55, page 235, 2021. DOI: 10.1007/s00603-021-02668-9

2020 Pradeep Kumar Gautam, Rishab Dwivedi, Akshay Kumar, **Anil Kumar**, Amit Kumar Verma, Kumar Hemant Singh, Trilok Nath Singh. ***Damage Characteristics of Jalore Granitic Rocks After Thermal Cycling Effect for Nuclear Waste Repository***. Rock Mechanics and Rock Engineering, volume 54, page 235, 2020. DOI: 10.1007/s00603-020-02260-7

2020 **Anil Kumar**, Rohit Kumar Shrivastava, Kumar Hemant Singh. ***Bayesian inference of material properties in disordered media using sound characteristics***. EPL (Europhysics Letters), volume 129, page 24001, 2020. DOI: 10.1209/0295-5075/129/24001

2019 Ashutosh Tripathy, **Anil Kumar**, Vinoth Srinivasan, KH Singh, TN Singh. ***Fractal analysis and spatial disposition of porosity in major indian gas shales using low-pressure nitrogen adsorption and advanced image segmentation***. Journal of Natural Gas Science and Engineering, volume 72, page 103009, 2019. DOI: 10.1016/j.jngse.2019.103009

2018 Piyush Sarkar, **Anil Kumar**, Kumar Hemant Singh, Ranjana Ghosh, Trilok Nath Singh. ***Pore system, microstructure and porosity characterization of Gondwana shale of Eastern India using laboratory experiment and watershed image segmentation algorithm***. Marine and Petroleum Geology, volume 94, page 246, 2018. DOI: 10.1016/j.marpetgeo.2018.04.006

Book Chapters

2020 Kumar Hemant Singh, **Anil Kumar**, Sanjay Pandit, Ashok Soni. ***Partitioning of porosity for carbonate reservoirs using Differential Effective Medium models***. Petro-physics and Rock Physics of Carbonate Reservoirs, volume 1, pages 129-145, 2020. DOI: 10.1007/978-981-13-1211-3_10

2020 Monesh Sharma, Kumar Hemant Singh, Sanjay Pandit, **Anil Kumar**, Ashok Soni. ***Petrophysical Modelling of Carbonate Reservoir from Bombay Offshore Basin***. Petro-physics and Rock Physics of Carbonate Reservoirs, volume 1, pages 55-73, 2020. DOI: 10.1007/978-981-13-1211-3_5

Conference Proceedings

2022 Anup Kumar Shahi, **Anil Kumar**, Kumar Hemant Singh, PG Ranjith. ***Understanding the Significance of Microporosity in Pore-Scale Fluid Flow Modelling Within Carbonate Reservoirs Using Multiscale Pore Networks***. AGU Fall Meeting Abstracts, volume 2022, pages H45M-1543, 2022.

2022 Anup Shahi, **Anil Kumar**, Kumar Hemant Singh, Ranjith Pathegama Gamage. ***Improved Upscaling Methods for Carbonate Rock Image Data***. ARMA – 56th U.S. Rock Mechanics/Geomechanics Symposium, Santa Fe, New Mexico, USA, 2022. DOI: 10.56952/ARMA-2022-2204

2022 Anup Shahi, **Anil Kumar**, Kumar Hemant Singh, Ranjith Pathegama. ***An optimization-based method for upscaling carbonate volumetric image data***. InterPore 2022.

2020 **Anil Kumar**, Rohit Kumar Shrivastava, Kumar Hemant Singh. ***Bayesian modelling for determining material properties***. 2018 International Conference on Recent Innovations in Electrical, Electronics & Communication Engineering (ICRIEECE), Bhubaneswar, India, pages. 1557-1563, 2018. DOI: 10.1109/ICRIEECE44171.2018.9009196

Invited Talks

Oct' 2025 Delivered invited guest lecture titled *"Clarity, Structure, Impact: Writing Scientific Reports That Work"* to students of the M.Sc. Artificial Intelligence and Machine Learning programme at VIT Vellore, 16 October 2025 (57 participants).

Jul' 2025 Delivered an invited short talk titled *"GPU-Enabled Flood Forecasting System for Chennai"* to Ph.D. students and researchers at the School of Artificial Intelligence (ScAI), IIT Delhi (13 participants).

Teaching Experience

Sept'2025 – Till Date **Teaching Faculty**, **AI & ML for Industry, Batch-06**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: In my capacity as a teaching faculty, I am delivering a detailed content on selected AI and ML topics. The course aims to furnish participants with the comprehensive knowledge and practical skills required to deploy AI and ML technologies effectively across various sectors and domains.

Aug'2025 – Till Date **Teaching Faculty**, **AI & ML for Industry, Batch-05**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: In my capacity as a teaching faculty, I am delivering a detailed content on selected AI and ML topics. The course aims to furnish participants with the comprehensive knowledge and practical skills required to deploy AI and ML technologies effectively across various sectors and domains.

Jan'2025 – June'2025 **Teaching Assistant & co-taught**, CVL736, Soft Computing Techniques in Water Resources, Civil Engineering, IIT Delhi: In this course I cover a range of advanced topics in Artificial Intelligence and Machine Learning, including Artificial Neural Networks, Expert Systems, Genetic Algorithms, Fuzzy Logic Systems, Support vector machines, Probabilistic modeling etc. with a strong emphasis on their application in hydrology. My expertise particularly extends to the relevance of these techniques for spatial and temporal data analysis, crucial for addressing complex challenges in water resources.

Dec'2024 – July'2025 **Teaching Faculty**, **AI & ML for Industry, Batch-04**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: In my capacity as a teaching faculty, I deliver a detailed content on selected AI and ML topics. The course aims to furnish participants with the comprehensive knowledge and practical skills required to deploy AI and ML technologies effectively across various sectors and domains.

Oct'2024 – Apr'2025 **Teaching Faculty**, **AI & ML for Industry, Batch-03**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: As a teaching faculty, my job is to guide participants through an intensive curriculum covering both foundational and advanced concepts in AI and ML. The course includes hands-on sessions in machine learning principles, neural networks, and deep learning architectures, along with practical applications in data processing, optimization, data fitting and generative models. Through this program, participants would gain a thorough understanding and practical skills in implementing AI and ML solutions in their respective industries.

Aug'2024 – Nov'2024 **Teaching Assistant & co-taught**, CVP484, Computational Aspects in Water Resources, Civil Engineering, IIT Delhi: Students were taught practical data analysis techniques using Python, gaining skills in analyzing diverse water systems and environmental interactions. Additionally, they applied statistical and numerical modeling methods, equipping them to address complex real-world challenges in water resources.

Mar'2024 – Sept'2024 **Teaching Faculty**, **AI & ML for Industry, Batch-02**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: As a teaching faculty, I guided participants through an intensive curriculum covering both foundational and advanced concepts in AI and ML. The course included hands-on sessions in machine learning principles, neural networks, and deep learning architectures, along with practical applications in data processing, optimization, data fitting and building generative models. Through this program, participants gained a thorough understanding and practical skills in implementing AI and ML solutions in their respective industries.

Jan'2024 – May'2024 **Teaching Assistant & co-taught**, CVP731, Simulation Lab I, Civil Engineering, IIT Delhi: I taught data analysis using Python helping the students gain deeper insights from their hydrometeorological datasets.

Apr'2023 – Sept'2023 **Teaching Faculty**, **AI & ML for Industry, Batch-01**, Certificate course through Continuing Education Program (CEP) e-Vidya, IIT Delhi: I guided the participants through a rigorous curriculum covering both foundational and advanced topics in AI and ML. The course emphasized practical, hands-on learning with sessions on machine learning fundamentals, neural networks, and deep learning architectures, alongside applications in data processing, optimization and generative modeling. This program provided participants with the knowledge and skills to effectively implement AI and ML solutions.

Jul'2023 – Nov'2023 **Teaching Assistant & co-taught**, CVL736, Soft Computing Techniques in Water Resources, Civil Engineering, IIT Delhi: Starting with the basics of Python programming, I taught the students the foundations of soft-computing and data fitting. This helped the students do a comprehensive analysis on their hydrometeorological datasets.

Jan'2022 – Jun'2023 **Teaching Assistant & co-taught**, CVP731, Simulation Lab I, Civil Engineering, IIT Delhi: I taught the foundations of Python programming followed by the spatial and temporal analysis of hydrometeorological datasets.

Aug'2022 – Nov'2022 **Teaching Assistant**, GS535, Statistical Methods in Geosciences, Earth Sciences, IIT Bombay

Mar'2020 – Jul'2020 **Teaching Assistant**, RSE3020, Resource Estimation, Civil Engineering, Monash University

R&D Projects

Mar'2022 – Aug'2022 **Design and validation of shallow subsurface void detection algorithms using seismic techniques**: The project focused on devising an advanced Rayleigh wave inversion code for prompt identification of shallow subsurface voids. To address limited data challenges, we integrated machine learning into the inversion framework. Utilizing Generative Adversarial Networks (GANs), we generated realistic subsurface scenarios. Additionally, we tested dimensionality reduction algorithms to capture 3D subsurface data efficiently. The result was an innovative approach that melded traditional geophysical techniques with modern computational methods.

Defence Research and Development Organisation (DRDO), India

Aug'2021 – Feb'2022 **Development of a Software for Multivariate Biomarker Analysis**: In this research endeavor, our primary objective was to devise an Alternating Least Squares (ALS) based multivariate analytical software tailored for pinpointing source rock signatures. A laboratory biomarker evaluation of in-situ oil specimens was conducted to secure a definitive concentration matrix. Subsequently, a sophisticated Python algorithm was developed to deconvolute the complex crude oil amalgamations. This innovative tool, leveraging the derived concentration matrix, proficiently yielded both the fractional contribution and the corresponding end-member matrices, providing crucial insights into the oil's provenance.

- Oil India Limited (OIL), India

Jul'2016 – Dec'2021 **Data-driven rock physics model for carbonates**: The project aimed to map the carbonate pore networks to their acoustic signatures. Carbonate rocks exhibit heterogeneity at all scales. It was found that predicting the pore networks was an ill-posed problem and required sophisticated machine learning techniques. To meet the objectives, a forward model for acoustic wave simulation was first realized using a finite difference technique. This helped generate acoustic responses of various rock core samples. After investigating several deep learning architectures, a U-Net based deep learning model was developed, modified and trained to predict the pore network from their acoustic responses. Prediction accuracy of 94% was achieved for the test set.

- Oil and Natural Gas Corporation (ONGC), India

Computer skills

Intermediate C++, FORTRAN, LaTeX

Advanced Python, MATLAB

Personal Interests

- Mentoring AI/ML Projects
- Bullet Chess
- Electronics projects enthusiast