Dr. Sathyanarayan Rao

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Compute Stories — Research Scientist & Educator
Indian Institute of Science
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Profile

Interdisciplinary Researcher and Academic with expertise in computational modeling, machine learning, and data analytics. Strong background in scientific computing, high-performance computing, and digital twin simulations, with applications in agriculture, physics, and sustainability. Experienced in academic research, grant writing, and publishing. Passionate about scientific communication, scientific illustration and teaching via Compute Stories YouTube channel.

Education

- **PhD in Engineering Sciences**, UCLouvain, Belgium 2016 – 2020
  Thesis: Computational Modeling of Electrical Signatures of Plant Roots
  Advisor: Prof. Mathieu Javaux
- **MS in Optical Physics**, Alabama A&M University, USA 2013 – 2014
  GPA: 4.0/4.0
- **MS in Electrical Engineering**, University of Alabama in Huntsville, USA 2010 – 2012
  GPA: 3.9/4.0 Advisor: Prof. Nagendra Singh
- **B.Eng in Electronics and Communication**, VTU, India 2006 – 2010
  First Class with Distinction

Research Experience

- **Research Associate**, Indian Institute of Science, Department of Civil Engineering April 2025 – Present
  - Developing hybrid models integrating water cloud models and machine learning techniques for soil moisture prediction from remote sensing data.
  - Analyzing satellite datasets (including Sentinel and upcoming NISAR mission data) for environmental monitoring applications.
  - Designing interactive dashboards for real-time visualization and analysis of field and remote sensing data.
  - Supporting field data collection efforts and model calibration activities for soil moisture retrieval research.
- **Scientific Software Engineer**, Phenorob Project, Forschungszentrum Jülich 2023 – 2025
  - Developed crop model coupling solutions in Fortran, C++, and Python.
  - Created and maintained phenorobdaa.de using Hugo.
  - Created Scientific Animation to illustrate complex processes in soil-plant interface. - Led monthly project meetings and contributed to book chapters.

- **Research Associate**, Indian Institute of Science, Bengaluru 2022 – 2023
  - Developed ML models for soil moisture estimation using LSTM networks.
  - Led field experiments and trained researchers in data collection. - Developed a simple dashboard to showcase field data using vue.js.
- **FNRS Research Fellow**, eRoot Project, UCLouvain, Belgium 2016 – 2020
  - Developed computational models for soil-root electrical interactions (Grant: FNRS T.1088.15).
  - Developed complex finite element meshes for root architecture of Maize plant for FEM simulations - Planned, Handled & Processed Electrical Resistivity Tomography data at field scale for monitoring root activity. - Published multiple journal articles based on research findings.
- **Research Assistant**, University of Paderborn, Germany 2015 – 2016
  - Developed FORTRAN code to simulate excitonic resonances in two-level systems (DFG Grant).
  - Implemented Maxwell-Bloch equations for light-matter interaction modeling.
- **Research Assistant**, Alabama A&M University, USA 2013 – 2014
  - Conducted optical experiments involving lasers and precision optics.
  - Characterized biomolecule deposition using Atomic Force Microscopy. - Taught physics 101 undergrad course as a Teaching assistant.
- **Research Assistant**, University of Alabama in Huntsville, USA 2010 – 2013
  - Worked on NSF-funded computational plasma research (Grant: NSF ATM0647157).
  - Simulated plasma-wave interactions and contributed to publications in Physics of Plasmas.

Teaching & Communication

- **Video Creator — Phenorob Digital Agricultural Avatar, Forschungszentrum Jülich** 2023 – 2024
  - Produced tutorial videos on how to install, configure, and use agricultural models (e.g., AgroModels).
  - Created Docker walkthroughs, terminal-based model execution guides, and troubleshooting guides.
  - Conducted interviews with model developers, explaining the inner workings of various agro-models.
  - Developed video documentation to support researchers and practitioners in digital agriculture.
- **Founder & Content Creator — Compute Stories (YouTube Channel)** 2024 – Present
  - Created engaging educational content on computational physics, Python programming, and mathematical modeling.
  - Produced animated visualizations and scientific storytelling videos to enhance conceptual understanding.
  - Utilized OBS Studio, Final Cut Pro, and audio editing tools for professional-quality educational videos.
  - Built a growing audience interested in **science, coding, and computational methods**.
- **Workshop Instructor — UCLouvain, Belgium** 2018
  - Conducted a MATLAB workshop on inverse parameter fitting for soil hydraulic modeling.
  - Taught non-linear least squares fitting techniques for estimating van Genuchten parameters.
  - Demonstrated soil moisture retention curve fitting using MATLAB's optimization toolbox.
- **Graduate Teaching Assistant — Alabama A&M University, USA** 2013 – 2014
  - Taught Physics 101, covering mechanics, electrostatics, and fundamental physics principles.

- Conducted laboratory sessions and assisted undergraduate students with hands-on experiments.
- Graded assignments, prepared course materials, and provided academic support to students.

Fellowships

- **Research Fellowships:**
  - FNRS Fellowship, UCLouvain 2016 – 2020
  - KAUST Postdoctoral Fellowship (Offered, not accepted) 2022
  - Hebrew University Postdoctoral Fellowship (Offered, not accepted) 2022
  - NSF Fellowship, University of Alabama 2011 – 2012
- **Research Grants:**
  - DFG Research Grant, University of Paderborn 2015 – 2016
  - NSF-Funded Research, University of Alabama 2011 – 2012

Publications

Journal Articles

1. Rao, S., et al. (in preparation). When Does Random Forest Soil-Specific Calibration Improve SAR-Based Soil Moisture Estimates? A Comparative Study. *Remote Sensing Letters*, to be submitted.
2. Rao, S., et al. (under review). Process-Based Modeling and Model Coupling for Agricultural Digital Twins: A Comprehensive Review. *In Silico Plants*, submitted.
3. Rao, S., et al. (2020). Imaging plant responses to water deficit using electrical resistivity tomography. *Plant and Soil*, 29 citations.
4. Rao, S., et al. (2020). Sensing the electrical properties of roots: A review. *Vadose Zone Journal*, 19(1), 71 citations.
5. Rao, S., et al. (2019). Impact of maize roots on soil–root electrical conductivity: A simulation study. *Vadose Zone Journal*, 18(1), 35 citations.
6. Singh, N., Rao, S., et al. (2013). Waves generated in the plasma plume of helicon magnetic nozzle. *Physics of Plasmas*, 20(3), 27 citations.
7. Rao, S., Singh, N. (2012). Numerical simulation of current-free double layers created in a helicon plasma device. *Physics of Plasmas*, 19(9), 39 citations.
8. Singh, N., Rao, S. (2012). Plasma turbulence driven by transversely large-scale standing shear Alfvén waves. *Physics of Plasmas*, 19(12), 3 citations.

Book Chapters

1. Rao, S., Ranganath, P. (2025). Climate-Resilient Agriculture: Leveraging Language Models for Mitigation and Adaptation. In *Mitigation and Adaptation Strategies Against Climate Change in Natural Environments*.

2. Rao, S., Ranganath, P. (2025). Unmanned Aerial Vehicles (UAVs) as Sensor-Driven Data Feeders for Agricultural Digital Twins *Book Chapter submitted to Taylor Francis for publication.*

3. Rao, S. (2025). Quantum Machine Learning in Climate Change using IoT Devices. In *Quantum Computing, Sensing and Communications for IoT*. Springer Studies in Computational Intelligence Series. (Accepted, manuscript due June 2025).

Conference Presentations

1. Rao, S., et al. (2019). Investigation of Electrical anisotropy as a root phenotyping parameter: Numerical study with root water uptake. *Geophysical Research Abstracts*, 21.

2. Rao, S., et al. (2019). Relationship between electrical anisotropy of soil-root continuum and geometrical architecture of root system. *National Symposium for Applied Biological Sciences.*

3. Rao, S., et al. (2017). A forward model for electrical conduction in soil-root continuum: a virtual rhizotron study. *4th International Workshop on Geoelectrical Monitoring.*

4. Rao, S., et al. (2017). Characterizing root system characteristics with Electrical resistivity Tomography: a virtual rhizotron simulation. *EGU General Assembly Conference Abstracts.*

Peer Review & Professional Service

- Reviewer for *Nordic Machine Intelligence*
- Reviewer for *Plants in Silico*
- Reviewer for *PeerJ Computer Science*
- Reviewer for *Plant and Soil*
- Reviewer for *Vadose Zone Journal*
- Grant proposal reviewer

Volunteer Experience

Blog Committee Member — Young Hydrologic Society (YHS) April 2025 – Present

- Selected to contribute to the YHS Blog Committee, creating educational content for early career hydrologists.
- Develop blog posts on topics related to computational hydrology, digital twins, and environmental modeling.
- Support the YHS mission of promoting participation of early career researchers in the hydrologic science community.

My Online Learning

- **Introduction to Linux (LFS101x)**, EdX, LinuxFoundationX August 15, 2014
  Issued by The Linux Foundation, verified by: Certificate
  Training Program Director: Jerry Cooperstein, Ph.D.
  General Manager, Training: Clyde Seepersad
- **Greatest Unsolved Mysteries of the Universe (ANU-ASTRO1x)**, EdX, ANUx June 20, 2014

Issued by Australian National University, verified by: Certificate
Deputy Vice-Chancellor (Academic): Marnie Hughes-Warrington
ANU Online Lead: Richard Robinson
Professor: Brian Schmidt, Paul Francis

- **Solving Complex Problems (TPM1x)**, DelftX, Delft University of Technology January 6, 2015
Issued by EdX, verification link: Certificate