PIYOOSH JAYSAVAL, PHD

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🏠: San Antonio, TX, USA 🏢: Richland, WA, USA

RESEARCH INTERESTS

Geophysical Methods: Electromagnetic, Electrical, and Seismic — land, marine, borehole, and/or airborne; Numerical Modeling: Finite Difference, Finite Element, Finite Volume, and Integral Equation — Frequency- and Time-domain; Optimization methods: Deterministic, Stochastic and Probabilistic — Conjugate-gradient, L-BFGS, Gauss-Newton, Markov chain Monte Carlo, Simulated Annealing, Genetic Algorithm, and Bayesian approach; Linear System Solvers: Direct, Iterative and Hybrid; Deep Learning/Machine Learning; High Performance Computing: MPI, OpenMP, CUDA; Numerical Linear Algebra.

EDUCATION

University of Oslo, Norway *Jan 2013 - Apr 2016*
PhD in Computational Geophysics GPA: N/A
Thesis: Advances in 3D finite-difference modelling of electromagnetic fields in the conductive earth

Indian Institute of Technology Roorkee, India *Jul 2009 - Jun 2012*
Master of Technology in Geophysics GPA: 9.71/10.0 | US GPA: 4.0/4.0
Thesis: 2D modeling of earth using exponential finite-difference method
Award: Dr. A.N. Khosla Medal for obtaining the highest grade (GPA) in all masters course

University of Delhi, India *Jul 2006 - Jun 2009*
Bachelor of Science (Honors) in Physics Percentage: 91.04 % | US GPA: 4.0/4.0
Award: Gold Medal for obtaining the highest grade in the University of Delhi

CURRENT POSITION

Pacific Northwest National Laboratory, Richland, WA, USA *Feb 2019 - present*
Data Scientist - Geophysics Level 3 *Jan 2022 - present*
Data Scientist - Geophysics Level 2 *Feb 2019 - Dec 2021*

Projects

- **Lead developer of pGEMINI (3D Parallel Geophysical Electromagnetic Modeling and Inversion of Naturally and Induced sources):** This massively parallel unstructured-mesh capability can simulate and invert active-source electromagnetic (EM) data, including controlled-source EM, airborne EM, borehole EM, drone EM, land EM, along with natural-source magnetotelluric data.
- **Lead developer of Geophysics and Inversion Modules in PFLOTRAN – a massively parallel open-source simulation code for flow and transport (https://www.pflotran.org):** These modules facilitate the simulation and inversion of electrical resistivity tomography data as well as the execution of coupled simulations and inversions with flow and transport modules.
- **Core developer of E4D** – I play a vital role in developing new capabilities in E4D, a massively parallel open-source 4D modeling and inversion software for electrical resistivity tomography and seismic tomography (https://www.pnnl.gov/e4d-team).
- **Leading Massively Parallel Joint Inversion Code Development:** I'm leading the development of multi-physics data inversion (including electromagnetic, electric, seismic, and gravity) using deterministic and stochastic optimization approaches.
- **Leading Geophysical Electromagnetic Inversion with Deep Learning:** My role encompasses pioneering the development of geophysical electromagnetic inversion using state-of-the-art deep learning techniques.
- **Co-Leading Drone-Based Electromagnetic Capabilities Development:** I'm spearheading development of drone-based semi-airborne/airborne electromagnetic capabilities for high-resolution shallow (less than 100 m) and deep earth (approximately 4 km) imaging.

- **Leading Real-Time and Autonomous Geophysical Imaging Development:** I'm at the forefront of developing real-time and autonomous geophysical imaging capabilities, utilizing very fast inversion approaches and machine learning schemes.

PREVIOUS WORK EXPERIENCE

University of Texas at Austin, Austin, TX, USA *Aug 2016 - Feb 2019*

Postdoctoral Fellow - Computational Geophysics

Projects

- Developed parallel finite-difference modeling software for both electromagnetic and seismic waves.
- Developed seismic and electromagnetic inversion software using optimization methods such as steepest descent, conjugate gradient, L-BFGS, and Gauss-Newton.
- Designed regularization schemes for optimization, including L-1, L-2, L-p norms, and minimum gradient support.
- Developed joint seismic and electromagnetic inversion software.
- Devolved 2D/3D electrical borehole modeling software.
- Implemented a Very Fast Simulated Annealing (VFSA) optimization scheme for electromagnetic optimization problems.
- Formulated a Bayesian optimization framework for seismic and electromagnetic data inversion analysis.

University of Oslo, Norway *Jan 2013 - Apr 2016*

PhD in Computational Geophysics

Projects

- Developed a novel 3D Schur complement-based finite-difference modeling scheme to reduce total computational time in constrained inversions.
- Devised a novel 3D exponential finite-difference modeling method that delivers more accurate results and/or reduces modeling time compared to the standard finite difference method.
- Implemented a fully anisotropic 3D electromagnetic modeling software using a Lebedev grid, capable of handling the general electrical anisotropy of the Earth.
- Developed a geometric multigrid solver that can be utilized as either a standalone iterative solver or a preconditioner.
- Worked on a massively parallel Block Low Rank (BLR) multifrontal sparse direct solver (BLR-MUMPS), aimed at efficiently solving the governing matrix equations in forward modeling.

SCIENTIFIC SERVICES

Grant/Funding Reviewer

- Reviewer for a *Department of Energy - Minority Serving Institutions Partnership Program* (DOE-MSIPP) funding proposal. *Jan 2021*

Journal/Conference Reviewer

- Reviewer for *Geophysics*, *Geophysical Journal International*, *Geophysical Prospecting*, *Interpretation*, *Journal of Applied Geophysics*, and *Computers and Geosciences* journals – **(60+ reviews).** *Ongoing*
- Reviewer for *SEG Annual Meeting* and *Geothermal Rising Conference* – **(10+ reviews).** *Ongoing*
- Served as a Session Judge for a poster session in *Society of Industrial and Applied Mathematics - Computational Science and Engineering 2021 conference.* *March 2021*
- Served as Technical Session Chair for the oral session Electromagnetic Modeling and Imaging Algorithms in *Society of Exploration Geophysicists (SEG) International Exposition and 89th Annual Meeting.* *Sep 2019*

- Served as Technical Session Chair for the poster session Electromagnetic Modeling and Analysis in *SEG International Exposition and 89th Annual Meeting.* *Sep 2019*
- Served as Technical Session Chair for the poster session Spectral Approaches and High-Resolution Techniques in *SEG International Exposition and 87th Annual Meeting.* *Sep 2017*

AWARDS AND SCHOLASTIC ACHIEVEMENTS

- Outstanding Reviewer 2022 Award by *Geophysical Journal International* of the Royal Astronomical Society, UK. *Jan 2023*
- Outstanding Performance Award by the *Pacific Northwest National Laboratory.* *Oct 2022*
- Finalist of Early Career Researcher of The Year Award by the *Pacific Northwest National Laboratory.* *Dec 2021*
- Honorable Mention for Best Paper Presented at *SEG - Annual meeting 2020* as a co-author. *May 2021*
- Dr. A.N. Khosla Medal for obtaining the highest grade (GPA) (out of several hundred students) in all M.Sc. / M.Tech. (Science) courses in IIT Roorkee. *Aug 2012*
- Gold Medal for obtaining the highest grade (out of a few thousand students) in the University of Delhi in B.Sc. (Honors) Physics. *Sep 2010*
- Brijlal Memorial Award for standing first in the college in B.Sc. (Honors) Physics 3rd year. *Feb 2010*
- All India 1st rank (out of tens of thousands students) in *Geophysics* subject in an entrance exam for admission to the Indian Institutes of Technology (IITs). *May 2009*
- AGIP-Scholarship awarded for academic excellence by SEG at the global level. *May 2011*
- Meritorious scholarships in the University of Delhi and Indian Institute of Technology Roorkee for getting first position in the department in every semester. *2006-2012*
- Granted travel grant to present my research paper at 21st Electromagnetic Induction Workshop, Darwin, Australia. *Jun 2012*
- Granted European Association of Geoscientist and Engineers (EAGE) travel grant to present my research paper at Saint Petersburg, Russia. *Apr 2012*
- Participated in Science Conclave Nobel Laureate Meet. *Dec 2008*

TECHNICAL SKILLS

Programming	FORTRAN, C/C++, MATLAB, Octave, Python and Julia
Parallel Libraries	MPI, PETSc, OpenMP and CUDA (GPU)
Deep Learning Libraries	TensorFlow, Keras, and PyTorch
Version Control Systems	Git, Mercurial and Apache subversion
Compilers	GNU and Intel

FUNDING AND GRANTS

Funded proposals

US Department of Energy - ARPA-E *April 2024 - March 2027*

Subsurface intelligence for undergrounding operations: rapid Ai-based geophysical imaging and advanced visualization

Amount: $3,750,000

Investigators: Day-Lewis, F., **Jaysaval, P. (Co-PI)**, Johnson, T., Slater, L., Simon, B., Witonis, M., Suard, J., Robinson, R., and Schaef, H.

US Department of Energy *March 2023 - Feb 2025*

Drone-Based Geophysical Surveying and Real-Time AI/ML Analysis for Sustainable Production of Critical Minerals

Amount: $1,200,000

Investigators: Day-Lewis, F., **Jaysaval, P. (Co-PI)**, Mangel, A., Johnson, T., Taubman, M., and Schaef, H.

PNNL – Laboratory Directed Research & Development *Oct 2021 - Sep 2022*
Deep learning at depth: Estimating subsurface governing parameters from multimodal geophysical monitoring data
Amount: $75,000
Investigators: Chojnicki, K., **Jaysaval, P. (Co-PI)**, Johnson, T., Hammond, G., Mudunuru, M., Byler, E., and Hodas, N.

Electric Power Research Institute *July 2021 - Sep 2023*
Geophysical Groundwater Research at Coal Combustion Product Sites in Tennessee Valley
Amount: $241,000
Investigators: Kreuzer, R., **Jaysaval, P. (Co-PI)**, Day-Lewis, F., and Johnson, T.

PNNL – Laboratory Directed Research & Development *Jan 2021 - Sep 2023*
IN**duced **S**pectral **I**maging **T**echnology for **E**nvironment – **INSITE
Amount: $4,000,000
Investigators: Johnson, T., Rosso, K., Taubman, M., Hammond, G., Myjak, M., and **Jaysaval, P. (Co-PI)**

US Department of Energy *Oct 2020 - Sep 2023*
Understanding a Stratigraphic Hydrothermal Resource – Geophysical Imaging at Steptoe Valley, Nevada
Amount: $1,500,000

Investigators: Schwering, P., Norbeck, J., Hinz, N., Knox, H., **Jaysaval, P. (Co-PI)**, Siler, D., Fauld, J., Ayling, B., and Hardwick, C.

US Department of Energy *July 2020 - Sep 2023*
Demonstrating near real-time joint inversion of ERT and seismic data for actionable wellsite intelligence
Amount: $1,150,000
Investigators: Schaef, H., Johnson, T., **Jaysaval, P. (Co-PI)**, Sprinkle, P., Strickland, C., and Knox, H.

Not funded proposals

US Department of Energy *Jan 2021 - Dec 2023*
Advanced Resource Characterization (ARC): Revealing undiscovered heat sources in the Washington Cascade Volcanic Arc
Amount: $2,738,135
Investigators: Bonneville, A., Steely, A., Vasco, D., Schoenball, M., Nayak, A., Kolker, A., Sprinkle, P., **Jaysaval, P. (Co-PI)**, Schultz, A., Hou, J., Friedel, M., and Canfield, C.

*PI: Principal Investigator | Co-PI: Co-Principal Investigator

ADVISOR TO FOLLOWING POSTDOC RESEARCHER(S)

1. **Esteban Bowles-Martinez**, PhD Geophysics, Oregon State University. (July 2023 – present)

ADVISOR TO FOLLOWING INTERN STUDENTS

2. **Evan D. Shapiro**, PhD Student in Computational Mathematics and Statistics, University of Colorado Denver, *Real-time Deep-learning Inversion of Drone-based Electromagnetic Data.* (May 2023 – present)
1. **Trang L. Huynh**, MS Student in Computer Science, University of Houston, *Deep Learning based Geophysical Electromagnetic Inversion.* (Sep 2021 – March 2022)

PUBLICATIONS

Peer Reviewed Journals

15. **Jaysaval, P.** and Johnson, T.C., pGEMINI: Parallel geophysical electromagnetic modeling and inversion for natural and induced sources — 3D Forward modeling for active source: *Computational Geosciences - under revision.* (2024)

14. **Jaysaval, P.**, Kreuzer, R.L., Thomle, J.N., Day-Lewis, F.D., and Hensel, B., Characterization of impoundments of coal combustion products using towed waterborne and ground-based time domain electromagnetics: *Frontiers in Earth Science - drafted.* (2024)

13. Zhu, Y., **Jaysaval, P.**, Johnson, T.C., and Zhang, Z., Parallel joint inversion of three-dimensional DC resistivity and seismic travel-time data with cross-gradient constraints: *Computers and Geosciences - under revision.* (2024)

12. Mishra, P., Arnulf, A., Sen, M.K., Zhang, Z., and **Jaysaval, P.**, Probabilistic joint-inversion of seismic first-arrival traveltime and CSEM data with fuzzy coupling: *Geophysics - under revision.* (2024)

11. Robinson, J., Johnson, T., Thomle, J., Cambeiro, J., Peta, K., **Jaysaval, P.**, and Mackley, R., Interpretation of large-scale, long-term electrical geophysical monitoring guided by a process simulation: *Vadose Zone Journal.* https://doi.org/10.1002/vzj2.20303 (2024)

10. **Jaysaval, P.**, Hammond, G., and Johnson, T.C., Massively parallel modeling and inversion of electrical resistivity tomography data using PFLOTRAN: *Geoscientific Model Developments.* https://doi.org/10.5194/gmd-16-961-2023 (2023)

9. Robinson, J., St. Clair, J., Thomle, J., **Jaysaval, P.**, Cambeiro, J., Peta, K., Day-Lewis, F., and Mackley, R.D., Using multiple geophysical methods to refine and provide an alternative stratigraphic conceptual site model at a nuclear waste site: *Environmental Processes.* https://doi.org/10.1007/s40710-023-00622-1 (2023)

8. Schwering, P., Winn, C., **Jaysaval, P.**, Knox, H., Siler, D., Hardwick, C., Ayling, B., Faulds J., Mlwasky, E., McConville, E., Norbeck, J., Hinz, N., Matson, and Queen, J., Advancing geophysical techniques to image a stratigraphic hydrothermal resource: *GRC Transactions.* https://doi.org/10.5281/zenodo.7080206 (2022)

7. Mangel, A.R., Linneman, D.C., Sprinkle, D.P., **Jaysaval, P.**, Thomle, J.N., and Strickland, C.E., Multifrequency Electromagnetic Geophysical Tools for Evaluating the Hydrologic Conditions and Performance of Evapotranspiration Barriers: *Journal of Environmental Management.* https://doi.org/10.1016/j.jenvman.2021.114123 (2022)

6. **Jaysaval, P.**, Robinson, J.L., and Johsnon, T.C., Stratigraphic identification with airborne electromagnetic at the Hanford Site, Washington: *Journal of Applied Geophysics.* https://doi.org/10.1016/j.jappgeo.2021.104398 (2021)

5. Datta, D., **Jaysaval, P.**, Sen, M.K., and Arnulf, A., Fast full waveform inversion using a Schur complement based frequency-domain finite-difference modeling: *Geophysics.* https://doi.org/10.1190/segam2017-17678493.1 (2019)

4. Shantsev, D., **Jaysaval, P.**, de la Kethulle de Ryhove, S., Amestoy, P. R., Buttari, A., LExcellent, J.-Y., and Mary, T., Large scale 3D frequency-domain EM modeling with a Block Low-Rank multifrontal sparse direct solver: *Geophysical Journal International.* https://doi.org/10.1093/gji/ggx106 (2017)

3. **Jaysaval, P.**, Shantsev, D., de la Kethulle de Ryhove, S., and Bratteland, T., Fully anisotropic 3-D EM modelling on a Lebedev grid with a multigrid preconditioner: *Geophysical Journal International.* https://doi.org/10.1093/gji/ggw352 (2016)

2. **Jaysaval, P.**, Shantsev, D., and de la Kethulle de Ryhove, S., Efficient 3D controlled-source electromagnetic modelling using an exponential finite-difference method: *Geophysical Journal International.* https://doi.org/10.1093/gji/ggv377 (2015)

1. **Jaysaval, P.**, Shantsev, D., and de la Kethulle de Ryhove, S., Fast multimodel finite-difference controlled-source electromagnetic simulations based on a Schur complement approach: *Geophysics*. https://doi.org/10.1190/geo2014-0043.1 (2014)

Conferences

25. Robinson J.L., Johnson, T.C., Thomle, J.N., Cambeiro, J., Peta, K.A., **Jaysaval, P.**, and Mackley, R.D., Monitoring Subsurface Plumes in the Vadose Zone at the Hanford Site Using Time-Lapse Surface Electrical Resistivity: *Waste Management Symposia, Phoenix, Arizona*. (2024)

24. **Jaysaval, P.**, Kreuzer, R.L., Thomle, J.N., Day-Lewis, F.D., and Hensel, B., Characterization of impoundments of coal combustion products using towed waterborne and ground-based time domain electromagnetics.: *35th Symposium on the Application of Geophysics to Engineering and Environmental Problems*. (2023)

23. Thomle, J.N., Werkema, D., **Jaysaval, P.**, Day-Lewis, F.D., and Mochon-Collura, T., An Investigation of the subsurface freshwater/saltwater distribution in AN estuarine environment using towed time domain electromagnetic method: *35th Symposium on the Application of Geophysics to Engineering and Environmental Problems*. (2023)

22. Robinson, J., St. Clair, J., Thomle, J., **Jaysaval, P.**, Cambeiro, J., Peta, K., and Mackley, R.D., Investigating Preferential Groundwater Pathways Using Multiple Geophysical Methods on the Hanford Site to Support Remedial Decisions: *Waste Management Symposia*. (2023)

21. **Jaysaval, P.**, Knox, H., Chojnicki, K., Schwering, P., Winn, C., Hardwick, C., Norbeck, J., Hinz, N., Matson, G., Mlwasky, E., and Faulds J., Feasibility study of magnetotelluric and controlled-source electromagnetic methods for geothermal exploration at Steptoe Valley, NV: *Geothermal Rising Conference*. https://doi.org/10.5281/zenodo.6326589 (2021)

20. Schwering, P., Winn, C., Knox, H., **Jaysaval, P.**, Chojnicki, K., Hardwick, C., Norbeck, J., Hinz, N., Matson, G., Mlwasky, E., and Faulds J., Advancing Geophysical Techniques to Image a Stratigraphic Hydrothermal Resource: *Geothermal Rising Conference*. (2021)

19. **Jaysaval, P.**, Robinson, J.L., and Johnson, T.C., Airborne electromagnetic imaging of stratigraphy at the Hanford Site, Washington: *AGU Annual Meeting*. (2020)

18. Zhu, Y., **Jaysaval, P.**, Johnson, T.C., and Zhang, Z., Parallel joint inversion of three-dimensional DC resistivity and seismic travel-time data with cross-gradient constraints: *AGU Annual Meeting*. (2020)

17. Biswas, R., Arnulf, A., Sen, M., Datta, D., **Jaysaval, P.**, Two-step velocity inversion using trans-dimensional tomography and elastic FWI: *SEG Annual Meeting*. https://doi.org/10.1190/segam2020-3407268.1 (2020)

16. Miller, Q., Schaef, T., Nune, S., Jung, K., Burghardt, J., Martin, P., Prowant, M., Denslow, K., Strickland, C., Prasad, M., Pohl, M., **Jaysaval, P.**, and McGrail, B., Geophysical monitoring of seismic metamaterial contrast agents: *URTeC SEG Annual Conference*. https://doi.org/10.15530/urtec-2019-1123 (2019)

15. **Jaysaval, P.**, Datta, D., Sen, M., Arnulf, A., Bertrand, D., and Williamson, P., 2.5D controlled-source electromagnetic inversion using very fast simulated annealing: *SEG Annual Meeting*. https://doi.org/10.1190/segam2019-3211567.1 (2019)

14. **Jaysaval, P.**, Datta, D., Sen, M., and Arnulf, A., 2.5D controlled-source electromagnetic inversion using very fast simulated annealing: *AGU Annual Meeting*. (2018)

13. Biswas, R., Arnulf, A., Sen, M., Datta, D., and **Jaysaval, P.**, Ray-based tomography and acoustic full waveform inversion with reversible jump Markov chain Monte Carlo algorithm: *AGU Annual Meeting*. (2018)

12. **Jaysaval, P.**, Datta, D., Sen, M., and Arnulf, A., Fast frequency-domain 2D elastic wave modeling using a Schur complement based finite-difference method: *SEG Annual Meeting*. https://doi.org/10.1190/segam2018-2997447.1 (2018)

11. **Jaysaval, P.**, Datta, D., Sen, M., and Arnulf, A., Fast finite-difference simulations of DC borehole measurements using a Schur complement approach: *SEG Annual Meeting*. https://doi.org/10.1190/segam2018-2997037.1 (2018)

10. **Jaysaval, P.**, Sen, M., Arnulf, A., and Denel, B., Fast 2.5D controlled-source electromagnetic inversion using a Schur complement based finite-difference modeling: *SEG Annual Meeting*. https://doi.org/10.1190/segam2017-17468148.1 (2017)

9. **Jaysaval, P.**, Datta, D., Sen, M., and Arnulf, A., A Schur complement based fast 2D finite-difference multimodel modeling of acoustic wavefield in the frequency domain: *SEG Annual Meeting*. https://doi.org/10.1190/segam2017-17655352.1 (2017)

8. Datta, D., **Jaysaval, P.**, Sen, M., and Arnulf, A., Fast full waveform inversion using a Schur complement based frequency-domain finite-difference modeling: *SEG Annual Meeting*. https://doi.org/10.1190/segam2017-17678493.1 (2017)

7. de la Kethulle de Ryhove, S., **Jaysaval, P.**, and Shantsev, D., Large scale 3D controlled-source EM modeling with a Block Low-Rank MUMPS solver: *MUMPS Users Day*. (2017)

6. **Jaysaval, P.**, Shantsev, D., de la Kethulle de Ryhove, S., and Bratteland, T., 3D electromagnetic modelling of a TTI medium and TTI effects in inversion: *EGU General Assembly*. (2016)

5. **Jaysaval, P.**, Shantsev, D., and de la Kethulle de Ryhove, S., Efficient 3D frequency-domain modeling of CSEM data using an exponential finite-difference method: *MARELEC*. (2015)

4. **Jaysaval, P.**, Shantsev, D., and de la Kethulle de Ryhove, S., Schur complement based fast multimodel finite-difference CSEM simulations: *EM Induction Workshop*. (2014)

3. **Jaysaval, P.**, Gupta, P. K.., Khatri, V., Efficient computation of 2D MT Response using Exponential Finite Difference Method: *EM Induction Workshop*. (2012)

2. **Jaysaval, P.**, Ray, S., and Gupta, P. K., Exponential finite difference method for simulation of EM response of layered earth: *9th Biennial International Conference & Exposition on Petroleum Geophysics*. (2012)

1. **Jaysaval, P.**, and Gupta, P. K., Exponential finite difference method for simulation of EM response of layered Earth: *Saint Petersburg International Conference and Exhibitions, EAGE*. (2012)

Technical Reports

3. Warren, I., Friedel, M.J., Wallin, E., Lautze, N., Hou, Z.J., Vasco, D.W., Glubokovskikh, S., Gritto, R., Jarpe, S., Martel, S.J., **Jaysaval, P.**, Ren, H., Bonneville, A., Pauling, H., Kolker, A., and Rhodes, G., Innovative subsurface learning and Hawaiian exploration using advanced tomography (ISLAND HEAT) Phase 1 (Final Report). National Renewable Energy Laboratory (NREL), Golden, CO (United States). https://doi.org/10.2172/2005568. (2023)

2. Robinson, J.L., Mackley, R.D., Rockhold, M.L., Johnson, T.C., Thomle, J.N., Johnson, C.D., and **Jaysaval, P.**, Geophysical methods for stratigraphic identification Rev 1.0: *Pacific Northwest National Laboratory*. https://doi.org/10.2172/1810384 (2020)

1. Robinson, J.L., Mackley, R.D., Rockhold, M.L., Johnson, T.C., and **Jaysaval., P.**, Geophysical Methods for Stratigraphic Identification. *Pacific Northwest National Laboratory*. https://doi.org/10.2172/1684643 (2019)