NAREN VOHRA

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EMPLOYMENT

Postdoctoral research associate, *Los Alamos National Laboratory (LANL).* *2023 – present*
Division: *Applied Mathematics and Plasma Physics (T5).*

EDUCATION

Ph.D. in Mathematics, *Oregon State University (OSU).* *2018 – 2023*
Advisor: Prof. Malgorzata Peszynska. Thesis: *Mathematical Models and Computational Schemes for Thermo-hydro-mechanical Phenomena in Permafrost: Multiple Scales and Robust Solvers.*

Master of Science, Mathematics, *OSU.* *2018 – 2020*

Master of Science, Major in Mathematics, *Indian Institute of Science (IISc),* *2017 – 2018*
Bangalore, India.

Bachelor of Science, Major in Mathematics, *IISc.* *2012 – 2017*

PUBLICATIONS

1 M. Peszynska, Z. Hilliard, N. Vohra, **Coupled flow and energy models with phase change in permafrost from pore- to Darcy scale: modeling and approximation**, *Journal of Computational and Applied Mathematics, 2024*, 115964.

2 N. Vohra and M. Peszynska, **Iteratively Coupled Finite Element Solver for Thermo-hydro-mechanical Modeling of Permafrost Thaw**, *Results in Applied Mathematics, 2024*, 22, 100439.

3 N. Vohra and M. Peszynska, **Robust conservative scheme and nonlinear solver for phase transitions in heterogeneous permafrost**, *Journal of Computational and Applied Mathematics, 2023*, 442, 115719.

4 M. Peszynska, N. Vohra, L. Bigler, **Upscaling an extended heterogeneous Stefan problem from the pore-scale to the Darcy scale in permafrost**, *SIAM Multiscale Modeling and Simulation, 2024*, 22, 10.1137/23M1552000.

5 N. Vohra, K. Lipnikov, S. Tokareva, **Second-order accurate mimetic scheme for solute transport on polygonal meshes**, *Communications on Applied Mathematics and Computation, 2023.*

6 L. Bigler, M. Peszynska, and N. Vohra, **Heterogeneous Stefan Problem and Permafrost Models with P0-P0 Finite Elements and Fully Implicit Monolithic Solver**, *Electronic Research Archive, 2022*, 30 (4), 1477–1531.

7 C. Shin, A. Alhammali, L. Bigler, N. Vohra, and M. Peszynska, **Coupled flow and biomass-nutrient growth at pore-scale with permeable biofilm, adaptive singularity and multiple species**. *Mathematical Biosciences and Engineering, 2021*, 18 (3), 2097-2149.

ARTICLES

N. Vohra, M. Peszynska, **Modeling Permafrost: Soil, Ice, and Some Really Hard Mathematics**, *SIAM News Blog, 7/31/2023, Link: https://sinews.siam.org/Details-Page/modeling-permafrost-soil-ice-and-some-really-hard-mathematics*

AWARDS AND ACHIEVEMENTS

Lightning Talk Award *2022*

Awarded 2^{nd} place/ 63 at the 2022 Student Lightning Talks, Los Alamos National Laboratory, for effectively presenting novel research in less than 10 minutes.

Oregon Lottery Graduate Scholarship *2022*

Awarded by the Graduate School, OSU, for the academic year *2022 - 2023* based on academic success and scholarly potential.

Graduate Student Excellence Award *2022*

Awarded by the department of Mathematics, OSU, for overall excellence in scholarship, including academic performance, research and leadership as a doctoral candidate.

Oberwolfach Leibniz Graduate Students *2022*

Received support from Mathematisches Forschungsinstitut Oberwolfach to attend an Oberwolfach workshop (Id: 2204) in person (Germany).

NSF Mathematical Sciences Graduate Internship *2021*

Internship at Los Alamos National Laboratory funded by Oak Ridge National Laboratory during Summer *2021*.

Outstanding Performance in Coursework Award *2019, 2021*

Awarded by the department of Mathematics, OSU, for exceptional academic success throughout the academic year.

INSPIRE Fellow *2012–2013, 2015–2016*

Awarded the INSPIRE Fellowship from August 2012 - January 2013 and August 2015 - July 2016 after securing admission into IISc through the AIEEE.

All India Rank 506 in AIEEE *2012*

Secured an All India Rank of 506 in the *2012* All India Engineering Entrance Examination, taken by approximately 1.1 million students across the country.

RESEARCH EXPERIENCE

Research Interests: Mathematical and computational modeling of multiphysics multiscale phenomen, Computational fluid dynamics, Heat transfer, Mechanics, Numerical analysis, Finite element and finite volume methods.

Postdoctoral Research Associate, Los Alamos National Laboratory *10/9/2023 – present*

Currently working with Dr. David Moulton and Dr. Daniil Svyatsky on surface flow and multiphase flow modeling in the Applied Mathematics and Plasma Physics division (T5).

· Designing and implementing robust numerical methods for large scale modeling of surface and subsurface flow, with particular emphasis on finite volume schemes for multiphase flow.

· Simulating novel integrated hydrology scenarios coupled to large storm drain pipe networks for flood mitigation research.

· Contributing to and improving the simulating capabilities and accuracy of the open source flow and reactive transport framework *Amanzi* (C++).

Doctoral Candidate, Oregon State University *2018 – 2023*

Advisor: Prof. Malgorzata Peszynska. Thesis: *Mathematical Models and Computational Schemes for Thermo-hydro-mechanical Phenomena in Permafrost: Multiple Scales and Robust Solvers.*

· Designed, analyzed, and implemented thermo-hydro-mechanical models to simulate energy, flow, and deformation in ice-rich porous media, such as permafrost (MATLAB, Python, C++).

· Researched the use of mixed finite elements for degenerate, non-degenerate parabolic (Stefan problem/permafrost models) and mixed elliptic-parabolic (Biot's poroelasticity) systems, and their subsequent coupling.

· Successfully demonstrated accuracy of new numerical scheme using available in-situ Alaska surface temperature and subsidence data.

Support from NSF Grants DMS-1522734, DMS-1912138, and DMS-2309682 PI: Prof. Malgorzata Peszynska.

Research Intern, Los Alamos National Laboratory *6/21–8/27/2021, 6/20–8/26/2022*

Worked under the guidance of Dr. Svetlana Tokareva and Dr. Konstantin Lipnikov in the Applied Mathematics and Plasma Physics group of Theoretical Division at Los Alamos National Laboratory (LANL), NM, US, as a NSF Mathematical Sciences Graduate Internship participant (*2021*) and as a LANL Graduate Student (*2022*).

· Studied well-balanced, depth-positivity preserving numerical schemes for the shallow water equations on unstructured polygonal meshes and worked on their implementation in the open source framework *Amanzi* (C++).

· Designed and implemented the coupling of surface flow with subsurface flow and solute transport.

Arctic Modeling Intern, Woodwell Climate Research Center *4/18–6/10/2022*

Worked under the guidance of Prof. Malgorzata Peszynska, Dr. Elchin Jafarov, and Dr. Brendan Rogers as an Arctic Subsidence Modeling intern at Woodwell Climate Research Center, MA, US.

· Analyzed the correlation between thaw settlement and the change in the active layer depth by using the void ratio and moisture content of the frozen soil as a random parameter.

· Developed novel open source code to predict subsidence of permafrost and further validated accuracy of results with avaiable in-situ data from Alaska (MATLAB, Python).

Visitor, Technical University of Munich, Germany *1/30–2/4/2022*

Visited Prof. Barbara Wohlmuth's group in the Department of Mathematics at Technical University of Munich.

· Worked on permafrost models and the challenges associated with their numerical implementation, with particular emphasis on introducing visco-elasticity to analyze deformation (C++).

Time Frequency Analysis Trainee at CAOS, Indian Institute of Science *2016–2018*

Worked at Center for Atmospheric and Oceanic Sciences (CAOS) at IISc under the guidance of Prof. Venugopal V. and Dr. Fabrice Papa.

· Conducted analysis of large data sets and successfully identified trends and patterns in Ganges river discharge and Indian Monsoon.

· Developed code for time frequency analysis using the wavelet and Fourier transform (MATLAB).

TEACHING EXPERIENCE

Graduate Teaching Assistant, Oregon State University *2018–2023*

2023: Models and Methods of Applied Mathematics (*Sp*; Grader).

2022: Models and Methods of Applied Mathematics (*Sp*; Grader).

2021: Models and Methods of Applied Mathematics and Probability 2 (*Wi*; Grader), Advanced Calculus and Probability 3 (*Sp*; Grader),

2020: Calculus for Management and Social Science (*Wi*), Integral Calculus (*Su*; Instructor), Differential Calculus (*Fa*).

2019: Differential Calculus (*Wi*), Calculus for Management and Social Science (*Sp*).

2018: Differential Calculus (*Fa*).

Teaching Assistant, Indian Institute of Science *8–12/2017*

Taught and graded for the course *Probability and Statistics* at IISc.

PRESENTATIONS AND CONFERENCES/WORKSHOPS ATTENDED

1 ESS PI Meeting (poster), *ICoM: ESS Modeling of Natural and Engineered Systems in the Coastal Zone, from Ghost Forests to Urban Storm Drains*, David Moulton, Yu Zhang, Daniil Svyatsky, Giacomo Capodagio, Maria Contreras-Vargas, Naren Vohra, *Washington DC, 4/16/2023–4/17/2023.*

2 AGU (poster), *Modeling of Urban Drainage Networks with Integrated Hydrological Models*, Giacomo Capodagio, Daniil Svyatsky, Naren Vohra, David Moulton, *San Francisco, California, 12/13/2023.*

3 NGSolve User Meeting 2023, *Portland State University, 7/8–7/11/2023.*

4 Applied Math and Computational Seminar (oral), *Working with Software Tools for Numerical PDEs*, Naren Vohra, Zachary Hilliard, *OSU, 6/2/2023.*

5 ICIAM (oral, invited), *Towards upscaling and simulation of coupled [THM] systems with applications to permafrost modeling*, Malgorzata Peszynska, Naren Vohra, *Waseda University, Tokyo, 8/2023.*

6 SIAM GS23 (oral, invited), *Mixed Finite Elements for Thermo-Hydro-Mechanical Models with Iterative Coupling*, Naren Vohra, Malgorzata Peszynska, *Bergen, 6/21/2023.*

7 SIAM CSE23 (oral, invited), *Finite Elements for Thermo-Hydro-Mechanical Coupling in Modeling Permafrost Thaw*, Naren Vohra, Malgorzata Peszynska, *Amsterdam, 2/28/2023.*

8 AMS Fall Central Sectional Meeting (oral, invited), *Mixed Finite Elements for Permafrost and Thermo-hydro-mechanical Models*, Naren Vohra, Malgorzata Peszynska, *The University of Texas at El Paso, 9/18/2022.*

9 LANL Lightning Talk (oral), *Well-balanced Discretizations of Shallow Water Systems on Arbitrary Polygonal Meshes*, Naren Vohra, Svetlana Tokareva, Konstantin Lipnikov, *Los Alamos National Laboratory, 8/9/2022.*

10 Woodwell Climate Research Center (oral), *Modeling Subsidence Due To Permafrost Thaw*, Naren Vohra, Malgorzata Peszynska, Elchin Jafarov, Brendan Rogers, *virtual, 6/2/2022.*

11 3^{rd} Biennial Meeting of SIAM Pacific Northwest Section (oral, invited), *Mixed Finite Elements for the Permafrost Model and Steps Towards Thermo-hydro-mechanical Coupling*, Naren Vohra, Malgorzata Peszynska, *Washington State University, Vancouver, 5/21/2022.*

12 The Finite Element Circus, *University of Florida, virtual participant, 4/8–4/9/2022*

13 Applied Math and Computational Seminar (oral), *Mixed Finite Elements for the Heterogeneous Stefan Problem and Application to Multiscale Multiphysics Models of Permafrost*, Naren Vohra, Lisa Bigler, Malgorzata Peszynska, *OSU, 3/11/2022.*

14 Oberwolfach Workshop on "Multiscale Coupled Models for Complex Media: From Analysis to Simulation in Geophysics and Medicine" (Workshop Id: 2204), *Mathematisches Forschungsinstitut Oberwolfach, participant, 1/23–1/29/2022.*

15 The Finite Element Circus, *Penn State University, virtual participant, 11/5–11/6/2021.*

16 NSF-MSGI Presentation (oral), *Well-balanced Discretizations of Shallow Water Systems on Arbitrary Polygonal Meshes*, Naren Vohra, Svetlana Tokareva, Konstantin Lipnikov, *virtual, 8/12/2021.*

17 SIAM GS21 (oral), *Accounting for Mass and Volume Conservation in a Coupled Flow-Deformation-Energy Model at Pore-Scale*, Naren Vohra, Malgorzata Peszynska, *virtual, 6/21–6/24/2021.*

18 SIAM CSE21 (oral), *Coupled Biot and Phase Transition Model at Pore-Scale*, Naren Vohra, Malgorzata Peszynska, *virtual, 3/1–3/5/2021.*

19 Joint Mathematics Meeting, *virtual participant, 1/6–1/9/2021.*

20 InterPore Short Course, *Multiphase Flow in Permeable Media: A Pore-Scale Perspective*, Professor Martin Blunt, Imperial College London, *virtual participant, 12/7–12/10/2020.*

21 Second Joint SIAM/CAIMS Annual Meeting (poster), *Coupling of Flow and Deformation in Porous Media at the Network Scale*, Naren Vohra, Malgorzata Peszynska, *virtual, 7/6–7/17/2020.*

22 Applied Math and Computation Seminar (oral), *A Multiscale Study of the Biot System and the Stefan Problem*, Naren Vohra, Malgorzata Peszynska, *OSU, virtual, 5/29/2020.*

23 7^{th} Annual Cascade RAIN Meeting (oral), *Coupling of Flow and Deformation in Porous Media at Network Scale*, Naren Vohra, Malgorzata Peszynska, *virtual, 4/4/2020.*

24 2^{nd} Biennial Meeting of SIAM Pacific Northwest Section, *Seattle University, participant, 10/18–10/20/2019.*

25 Mathematical Problems in Industry Workshop, "Construction of the PDF of fiber size and distribution using finite samples" (project sponsored by Gore Technologies), *New Jersey Institute of Technology, participant, 6/17–6/21/2019.*

26 Graduate Student Mathematical Modeling Camp, "Modeling flow and fouling in elastic membrane filters", *University of Delaware, participant, 6/12–6/15/2019.*

27 OpenFOAM Workshop, *OSU, participant, 6/3–6/4/2019.*

28 6^{th} Annual Cascade RAIN Meeting, *University of Washington, Bothell, participant, 4/13/2019.*

PROGRAMMING LANGUAGES, FRAMEWORKS, AND LIBRARIES

MATLAB (expert), C++ (advanced), Python (advanced), Amanzi (*Multiphysics flow and transport framework*; contributor), deal.II (*Finite element library*), ParaView, Git, Blender, OpenFOAM, OpenMP, MPI.

SOFTWARE

This is a list of the open source software that I have contributed to/developed and used in my research.

1. Poroelasticity code capsule

• Developed one-dimensional poroelasticity solver to simulate flow and deformation in porous media using quasi-static Biot's system with documentation.

• MATLAB implementation: https://github.com/nvohra0016/Biot1D-MATLAB (Documentation with examples included)

• Python implementation: https://github.com/nvohra0016/Biot1D-Python

Developers: Naren Vohra, Prof. Malgorzata Peszynska. Implemented as part of `MPower` (http://sites.science.oregonstate.edu/ mpesz/mpower/)

2. Amanzi

Amanzi is a flow and reactive transport simulation framework: https://github.com/amanzi/amanzi

• Designed and implemented numerical schemes for hyperbolic and parabolic systems: shallow water equations, urban storm drains, subsurface flow, multiphase flow, and solute transport.

TRAVEL AWARDS

OSU College of Science Student Travel Award; travel support to attend SIAM CSE23, *2023.*

OSU Graduate School Scholarly Presentation Award; registration support for SIAM CSE23, *2023.*

SIAM travel award; Conference on Computational Science and Engineering (CSE23), *2023.*

AMS travel award; Fall Central Sectional Meeting, *2022.*

SIAM travel award; 3^{rd} Biennial Meeting of SIAM Pacific Northwest Section (PNW21), *2022.*

SIAM travel award; Conference on Mathematical & Computational Issues in the Geosciences (GS21), *2021.*

SIAM travel award; Conference on Computational Science and Engineering (CSE21), *2021.*

OSU Graduate Student Professional Development Award; registration support for Joint Mathematics Meeting (JMM), *2021.*

Mathematical Problems in Industry, New Jersey Institute of Technology; full support, *2019.*

Graduate Student Mathematical Modeling Camp, University of Delaware; full support, *2019.*

Annual Cascade RAIN Meeting, University of Washington; travel support, *2019.*

SELECTED COURSEWORK

OSU (*2018–Present*)
Partial Differential Equations (PDE)
Finite Elements for PDE
Numerical Analysis
Finite Volume and Discontinuous Galerkin Methods
Structural Mechanics
Uncertainty Quantification
Computational Mathematics Foundations of Multiphysics

IISc (*2012–2018*)
Functional Analysis
Homogenization of PDE
Fourier Analysis
Digital Image Processing
Linear and Nonlinear Optimization
Probability Models

SERVICE

OSU Student Chapter SIAM *2019 – 2023*

President (elected), *2021 – 2022*.

Organized multiple talks and discussions with alumni for the chapter members along with programming tutorials.

Helped increase number of members by at least 10 during the 2021-2022 academic year.

Mathematics Ad Hoc Review Committee (OSU) *5/2022 – 3/2023*

Member (invited) of the ad hoc committee to review the effectiveness of the PhD qualifying requirements in the department of mathematics.

Reviewed the qualifying exam requirements at peer institutions, and successfully reported on the strengths and weaknesses of different possible requirements.

Advanced Computational Geosciences Initiative (ACGI) *11/2023 – present*

Committee member of ACGI, formed to advance mathematical modeling, simulation and other computational aspects of geosciences.

Involved in organizing talks and inviting speakers for conference.

(https://organizations.lanl.gov/acgi/)