# SOURAV DUTTA

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## EXPERIENCE

**The University of Texas at Austin**                    *October 2022 -*
Research Fellow
Computational Hydraulics Group
Oden Institute for Computational Engineering & Sciences

**US Army Engineer Research & Development Center**       *Septermber 2017 - 2022*
ORISE Postdoctoral Fellow
Hydrologic Systems Branch
Coastal & Hydraulics Laboratory

## EDUCATION

**Texas A&M University, College Station**                *August 2010 - 2017*
PhD in Mathematics                                       GPA: 3.89/4.0
Department of Mathematics
Adviser: Dr. Prabir Daripa

**Indian Institute of Technology, Kharagpur**            *July 2005 - 2010*
Integrated B.Sc. & M.Sc. in Mathematics & Computing      GPA: 7.9/10
Department of Mathematics
Adviser: Dr. G.P. Raja Sekhar

## PUBLICATIONS/PREPRINTS

- S. Dutta, P. Rivera-Casillas, B. Styles, M. W. Farthing, "Reduced order modeling using advection-aware autoencoders," *Mathematical and Computational Applications*, 27 (2022) 34. Article
- S. Dutta, P. Rivera-Casillas, O. M. Cecil, M. W. Farthing, "`pyNIROM` - A suite of python modules for non-intrusive reduced order modeling of time-dependent problems", *Software Impacts*, 10 (2021) 100129. Article
- S. Dutta, M. W. Farthing, E. Perracchione, G. Savant, M. Putti, "A greedy non-intrusive reduced order model for shallow water equations", *Journal of Computational Physics*, 439 (2021) 110378. Article
- S. Dutta, P. Rivera-Casillas, O. M. Cecil, M. W. Farthing, E. Perracchione, M. Putti, "Data-driven reduced order modeling of environmental hydrodynamics using deep autoencoders and neural ODEs," *Proceedings of the IXth International Conference on Computational Methods for Coupled Problems in Science and Engineering (COUPLED PROBLEMS 2021)*, 2021. Article
- S. Dutta, P. Rivera-Casillas, M. W. Farthing, "Neural ordinary differential equations for data-driven reduced order modeling of environmental hydrodynamics," *Proceedings of the AAAI 2021 Spring Symposium on Combining AI and ML with Physical Sciences*, 2021. Preprint
- S. Dutta, M. W. Farthing, G. Savant, "Model order reduction of parametric and time-dependent partial differential equations in computational fluid dynamics", *ERDC Technical Report*, (2020)

- P. Daripa, S. Dutta, "On the convergence analysis of a hybrid numerical method for multicomponent transport in porous media", *Applied Numerical Mathematics*, 146 (2019) 199-220. Article
- P. Daripa, S. Dutta, "Modeling and simulation of surfactant-polymer flooding using a new hybrid method", *Journal of Computational Physics*, 335 (2017) 249-282. Article
- J.C. Chrispell, M.W. Farthing, K.R. Fowler, S.E. Howington, E. W. Jenkins, S. Dutta, B. Ji, "Optimization of a managed aquifer recharge network", *Proceedings of the 2014 SC Water Resources Conference*, Columbia Metropolitan Convention Center, October 2014. Preprint

## RESEARCH EXPERIENCE

**Postdoctoral Research,** *U.S. Army ERDC-CHL*                                   Fall 2017 - Summer 2022

*Topic :* Reduced Order Models for Computational Fluid Dynamics

- Proposed a new greedy non-intrusive reduced order model (ROM) using a combination of proper orthogonal decomposition (POD) and radial basis function (RBF) interpolation. Compared the performance of competing ROM strategies like NPOD, POD-DEIM, and greedy RB using Adaptive Hydraulics (AdH) suite as the high-fidelity model for simulating realistic shallow water flow examples. The ROM software was developed in Python.
- Developed data-driven ROM frameworks for applications governed by time-dependent, parametric partial differential equations using techniques like POD-RBF interpolation, Gaussian process regression, dynamic mode decomposition and various machine learning (ML)-based time series models. OpenFOAM and AdH were used to obtain the high-fidelity model solutions.
- Developed a novel physics-guided ML-based methodology to construct efficient and stable ROMs for transport-dominated problems in environmental flows.

**PhD Dissertation,** *Texas A&M University*                                   Spring 2012 - Summer 2017

*Topic :* Mathematical Models and Numerical Methods for Porous Media Flows Arising in Chemical Enhanced Oil Recovery

- Proposed a new global pressure function for incompressible, two-phase, multicomponent porous media flows arising in the context of chemical enhanced oil recovery. The model includes capillary and dispersion effects. Developed a new and efficient hybrid numerical method combining a discontinuous FEM and a characteristics-based FDM. Code was developed in MATLAB.

**Master Thesis,** *IIT Kharagpur*                                   Spring 2009 - Spring 2010

*Topic :* Driven Lid Partially Filled Porous Cavity - Single Domain Approach

- Developed a single domain model for incompressible, viscous flows in a partially porous lid-driven cavity. The system was transformed into velocity-streamfunction form and numerical simulations were carried out to study the effects of various parameters. Coded in MATLAB and C.

## TALKS

- "**Deep learning methods for reduced order modeling of advection-dominated problems**", SIAM Annual Meeting 2022 (Pittsburgh, July 2022)
- "**Physics-aware machine learning model for predicting coastal hydrodynamics**", SIAM Annual Meeting 2022 (Pittsburgh, July 2022)
- "**Deep learning methods for reduced order modeling of convection-dominated environmental hydrodynamics**", CMWR 2022 (Virtual, June 2022)

- "**Data-driven reduced order modeling for applications in computational hydrology**", Applied Math Seminar, Texas A&M University-Corpus Christi (Virtual, February 2022)

- "**Data-driven reduced order modeling for applications in computational hydrology**", Nonlinear Mechanics Seminar, University of Texas at Rio Grande Valley (Virtual, November 2021)

- "**Non-intrusive reduced order modeling for simulation of ship dynamics in complex environments**", Mechanistic Machine Learning & Digital Twins 2021 (Hybrid, September 2021)

- "**Data-driven reduced order modeling of environmental hydrodynamics**", Dolomites Workshop on Constructive Approximations and Applications 2021 (Virtual, September 2021)

- "**Data-driven reduced order modeling of environmental hydrodynamics using deep autoencoders and neural ODEs**", Coupled Problems 2021 (Virtual, June 2021)

- "**Kernel-based approximation methods for reduced order modeling applications in hydrology**", OSNA$^2$ 2021 (Virtual, April 2021)

- "**Neural ordinary differential equatons for data-driven reduced order modeling of environmental hydrodynamics**", AAAI MLPS 2021 (Virtual, March 2021)

- "**Non-intrusive reduced order models for applications in hydrology**", SIAM CSE 2021 (Virtual, March 2021)

- "**Data-driven approaches for reduced order modeling of shallow water equations**", CMWR 2020 (Virtual, December 2020)

- "**Data-driven approaches for reduced order modeling of free surface flows**", ERDC RD20 Symposium (Virtual, October 2020)

- "**Data-driven reduced order modeling in hydrology**", ERDC Data Science Workshop 2020 (Virtual, August 2020)

- "**Computational models for coastal and hydraulic applications in the U.S. Army Corps of Engineers**", Applied Math Seminar, United States Naval Academy (Annapolis, January 2020)

- "**An optimal RBF-kernel based non-intrusive reduced order model for the shallow water equations**", ICIAM 2019 (Valencia, July 2019)

- "**An Efficient Non-intrusive Reduced Order Model for Approximation of Shallow Water Flows**", Coupled Problems 2019 (Sitges, June 2019)

- "**An Efficient Non-intrusive Reduced Order Model for Approximation of Shallow Water Flows**", SIAM Geosciences Meeting 2019 (Houston, March 2019)

- "**Reduced Order Modeling for Coastal and Hydraulic Applications in the Corps of Engineers**",Industrial and Applied Math Seminar(Texas A&M, November 2018)

- "**Effective model reduction for shallow water flows**", 7th European Conference on Fluid Dynamics (Glasgow, Scotland, June 2018)

- "**Comparison of intrusive and non-intrusive projection-based model reduction for approximation of free surface flows**", Computational Methods in Water Resources XXII (Saint-Malo, France, June 2018)

- "**Dispersive effects on multicomponent transport through porous media**", 70th APS DFD Meeting 2017 (Denver, November 2017)

- "**Modeling and simulation of multicomponent, multiphase porous media flows using a new hybrid method**", SIAM Annual Meeting 2017 (Pittsburgh, July 2017)

- "**Theory and computation of multiphase, multicomponent flows in porous media**" West Texas Applied Math Graduate Minisymposium (Texas Tech University, Lubbock, TX, April 28, 2017)

- "**The mathematics of chemical enhanced oil recovery**", Mathematics Graduate Student Organization Seminar (Texas A&M, April 2017)

- "**A modern hybrid method for multiphase, multicomponent flow and transport in porous media**", Texas Differential Equations Conference (College Station, March 4-5, 2017)

- "**A numerical study of immiscible two-phase multicomponent flows in highly heterogeneous porous media**", Joint Mathematics Meeting 2017 (Atlanta, January 2017)

- "**Modeling and simulation of multicomponent, multiphase porous media flows using a new hybrid method**", Texas A&M Conference on Energy 2016 (Texas A&M, September 2016)

- "**Numerical analysis of a hybrid method and large scale simulation results of SP-Flooding**", SIAM Annual Meeting 2016 (Boston, July 2016)

- "**Modeling and simulation of multiphase porous media flows using a new hybrid method**", Student Research Week 2016 (Texas A&M, March 2016)

- "**Optimization and analysis of a managed aquifer recharge network**", SAMSI Industrial Math/Stat Modeling Workshop 2013 (Raleigh, July 2013)

- "**An efficient numerical method for ASP flooding in tertiary oil recovery**", SIAM Geosciences Meeting 2013 (Padova, Italy, June 2013)

- "**An efficient numerical method for enhanced oil recovery**", SIAM Annual Meeting 2012 (Minneapolis, July 2012)

## AWARDS AND HONORS

**L.F. Guseman Award**, Texas A&M University, 2017. Given each spring semester to a graduate student in math with high scholastic achievement and who has demonstrated outstanding performance in teaching, research or service.

**OGAPS Graduate Research and Presentation Travel Award**, Texas A&M University, 2017.

**Student Travel Award**, SIAM Annual Meeting, 2016 & 2017.

**Awarded $2^{nd}$ place** for Oral Presentation in "Math, Statistics and Computer Science" subject category at the Student Research Week, 2016, Texas A&M University.

**Selected** for the SAMSI Industrial Math/Stat Modeling Workshop, June 2013.

**Research Assistant**, Fall 2010 - Spring 2011, Qatar National Research Foundation (QNRF).

**Regent's Fellowship**, Fall 2010, Texas A&M University.

**Full scholarship** to study with Dr. Michael Böhm at Zentrum für Technomathematik, Universität Bremen during Summer 2009.

**Regional Mathematics Olympiad**, Eastern India, 2003.

## WORKSHOP EXPERIENCE

**SAMSI Industrial Math/Stat Modeling Workshop**        July 2013
*Advisers: Dr. E.W. Jenkins, Dr. M.W. Farthing*

*Topic :* Pajaro Valley Water Management

- Worked with elevation maps, topographical tools, rainfall data and an overland hydrologic model (CASC-2D) to design a network of recharge basins along drainage lines that can use previously

uncaptured storm water runoff. Constructed an appropriate cost function using land costs, infiltration rates and conductivity to obtain an optimum network under associated known physical constraints.

- Coordinated with a team of 5 students to complete the project within 10 days.

## TEACHING EXPERIENCE

### Instructor of Record

· **MATH 166** – *Topics in Contemporary Math II.*                                        *Fall 2015*
Class-size: 63 students.
Course Webpage: http://www.math.tamu.edu/~sdutta/math166/m166f2015.html
Responsibilities included preparing and delivering lectures, writing assessments (exams, quizzes etc.) and managing a grader. Earned excellent student evaluations.

### Teaching Assistant

· *Recitations & Lab sessions:*
**MATH 151** – *Engineering Mathematics I*                          *Fall 2011, Spring 2014*
**MATH 152** – *Engineering Mathematics II*                                  *Spring 2015*
Responsibilities included conducting recitations, writing and grading weekly quizzes, grading exams and MATLAB assignments.

· *Lab sessions:*
**MATH 417** – *Numerical Analysis I*                                        *Spring 2012*
Responsibilities included preparing and grading lab assignments and grading home assignments.

· *Grading:* (Undergraduate – U, Graduate – G)
**MATH 311**(U) – *Matrix Algebra and Vector Analysis*                       *Summer I 2012*
**MATH 641**(G) – *Analysis of Applications I*                                   *Fall 2012*
**MATH 602**(G) – *Methods and Applications of Partial Differential Equations*     *Summer II 2013*
**MATH 141**(U) – *Business Mathematics I*                                  *Summer I 2014*
**MATH 412**(U) – *Theory of Partial Differential Equations*                       *Fall 2014*
**MATH 601**(G) – *Methods of Applied Mathematics I*              *Summer I 2015, Summer I 2016*
**MATH 401**(U) – *Advanced Engineering Mathematics*                           *Spring 2016*
**MATH 617**(G) – *Theory of Functions of a Complex Variable I*                     *Fall 2016*

· *Help Sessions:*
**MATH 308** – *Differential Equations*                          *Summer II 2012, Summer I 2013*

### Mentoring                                                                *Summer 2014*
· Led a preparatory course for graduate students appearing in the Complex Analysis Qualifying Exam.

## PROFESSIONAL EXPERIENCE

### Reviewer
· Journal of Applied Water Engineering & Research, Dolomites Research Notes on Approximation, IEEE Transactions on Neural Networks and Information Systems, Proceedings of the AAAI MLPS 2021 Symposium.

### Co-organizer, *Minisymposium*
· *SIAM MDS 2022*: Two sessions on "Machine Learning and Data-Driven Methods for Forward and Inverse Problems" with Dr. Dhruv Patel and Dr. Matthew Farthing.

· *SIAM CSE 2021*: Two sessions on "Physics-Guided Machine Learning and Data-Driven Methods in Computational Geoscience" with Dr. Matthew Farthing and Dr. Jonghyun Lee.
· *SIAM Geosciences 2013*: Three sessions on "Theory and Computation of Porous Media Flows" with Dr. Prabir Daripa.

**Co-organizer,** *Texas A&M University*                                                             Spring 2016
· Initiated and co-organized the **Industrial and Applied Math Seminar** with Dr. Peter Howard.
· Co-organized a **workshop** on "Scientific Computing with MATLAB at Texas A&M" (April 25, 2016) to mark the maiden visit of Dr. Cleve Moler (Founder of MathWorks) to Texas A&M.

**Panelist,** *Texas A&M University*                                                     Fall '14, '15 & Summer '15
· Discussion on *PhD Qualifying Exams* in the First Year Graduate Student Seminar.
· Discussion on *Applying for Grad School* in the Summer REU program.

## LEADERSHIP/EXTRA CURRICULAR

- **President** & **Founding Member**: TAMU Student Chapter of SIAM ['15]
  Organized social and professional development events, and research seminars. Organized a campus tour, a workshop and a public lecture to commemorate Dr. Cleve Moler's visit to Texas A&M. Authored an **article** in SIAM News. Awarded the SIAM Student Chapter **Certificate of Recognition**.
- **Department Delegate**: Graduate and Professional Student Council (GPSC) ['14, '15, '16]
- **Programming** Committee & **Outreach** Committee : GPSC ['14, '16]
- **Counselor**: Grad Camp ['15] - Sole representative of the College of Science in the organizing team.
- Volunteer: **Big Event** (*Largest one day community service project in USA*) ['12, '13]
- Volunteer: " Pi-Day of the Century" event ['15] - Judge of the Pi digit memorization contest and also coordinated with a team of volunteers to make the event a success.

## COMPUTER SKILLS

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|---|---|
| **Programming Languages** | Python, MATLAB, C |
| **Software & Tools** | AdH, OpenFOAM, pyMOR, GMSH, Docker, LaTeX, Office |