

Ali Ramadhan

SOFTWARE & MACHINE LEARNING ENGINEER
PHYSICIST · CLIMATE SCIENTIST

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SUMMARY

I am a graduate researcher at MIT with 5 years of experience working at the intersection of climate modeling, software engineering, and machine learning.

I write code for next-generation climate models and use machine learning to improve how turbulence is represented. I am looking to apply my skill set to improve weather and climate predictions.

- **Climate scientist** developing next-generation ocean models for climate prediction with 18 peer-reviewed publications.
- **Software engineer** writing user-friendly distributed GPU code with comprehensive test suites and documentation.
- **Applying machine learning** to design, train, and deploy AI powered models of ocean turbulence that improve climate models.

RESEARCH WORK EXPERIENCE

Massachusetts Institute of Technology SEP 2017 –
Department of Earth, Atmospheric, and Planetary Sciences
Graduate Research Assistant

- Developed a fast and flexible ocean model that runs on GPUs from scratch in Julia as part of the **Climate Modeling Alliance**.
- Trained data-driven models of turbulence to learn missing physics in climate models, outperforming operational turbulence models.
- Accelerated research in ocean modeling and Bayesian inference for convection models using GPUs.
- Analyzed terabytes of satellite data to uncover ocean dynamics.

University of Waterloo AUG 2013 - AUG 2017
Department of Physics and Astronomy
Research Assistant

Developed a computational framework for creating movies of chemical reactions using nonlinear optimization and MATLAB. Conducted experiments using X-ray photons at the Canadian Light Source synchrotron. Collaborated with engineers to weld microwires and synthesize graphene oxide gels using lasers.

Tokyo Metropolitan University SEP - DEC 2014
Department of Chemistry
Research Assistant

Developed a method to synthesize and control the end-caps of carbon chains (polyynes) using ultrashort laser pulses. Characterized polyyne samples using liquid chromatography.

Ontario Institute for Cancer Research JAN - APR 2013
Informatics and Bio-Computing Program
Bioinformatics Specialist

Automated the processing and publishing of model organism genomic data sets for use by the cancer research community.

EDUCATION

- 2017– **Massachusetts Institute of Technology**
DOCTOR OF PHILOSOPHY (EXPECTED JUNE 2023)
Earth, Atmospheric, and Planetary Sciences
Computational Science and Engineering
Thesis: Data-driven ocean modeling using neural differential equations
- 2017 **University of Waterloo**
MASTER OF SCIENCE
Physics
Thesis: Molecular movies and geometry reconstruction using Coulomb explosion imaging
- 2016 **University of Waterloo**
BACHELOR OF SCIENCE
Physics with Joint Honours Mathematics
Graduating Dean's Honours List

SKILLS

- LANGUAGES Julia, Python, C, C++, MATLAB, \LaTeX , Mathematica, R, HTML, CSS, Javascript, Bash, Perl, Java
- SOFTWARE CUDA, MPI, Flux.jl, PyTorch, Docker, Google Cloud, DigitalOcean, Buildkite, Django, git, Slurm, Linux, Windows
- Software development, Code review, Automated testing, GPU programming, distributed computing, Data analysis, Performance optimization
- MATH Scientific computing, differential equations, scientific machine learning, Bayesian statistics

SOFTWARE

Oceananigans.jl 📄
Fast and friendly fluid dynamics on CPUs and GPUs with one codebase. Supports GPUs with CUDA and distributed computing with MPI. Comprehensive test suites, robust CI, and extensive documentation.

Atmosfoolery.jl 📄
Atmospheric model running on GPUs built to learn how weather models work with several validation tests.

Project Lovelace 📄
A website with scientific computing themed programming problems with automatic judging of submissions in Python, Javascript, C, and Julia.

TEACHING EXPERIENCE

- 2022 **Staff and speaker**, First-Year Pre-Orientation Program: Discover Earth, Atmospheric, and Planetary Sciences, *MIT*
- 2019 **Kaufman Teaching Certificate Program**, Teaching + Learning Lab, *MIT*
- 2018 **Graduate Teaching Assistant**, Introduction to Weather Forecasting, *MIT*
- 2018 **Lecturer**, Joint Program on the Science & Policy of Global Change, Introduction to Climate Science, *MIT*
- 2016 **Graduate Teaching Assistant**, Thermal Physics, *University of Waterloo*
- 2016 **Drop-in Tutor (4×)**, Calculus II, *University of Waterloo*
- 2015 **Undergraduate Teaching Assistant**, Electricity & Magnetism I, *University of Waterloo*
- 2015 **Undergraduate Teaching Assistant**, Discrete Mathematics, *University of Waterloo*
- 2015 **Drop-in Tutor (2×)**, Electricity & Magnetism I, *University of Waterloo*
- 2014 **Drop-in Tutor**, Linear Algebra I, *University of Waterloo*
- 2014 **Undergraduate Teaching Assistant (2×)**, Physics I: Mechanics, *University of Waterloo*
- 2014 **Undergraduate Teaching Assistant (2×)**, Calculus II, *University of Waterloo*
- 2014 **Undergraduate Teaching Assistant**, Linear Algebra I, *University of Waterloo*
- 2015–17 **Head Tutor and Organizational Team Member**, Mathematics, *Frontier College (now called United for Literacy)*
- 2012–17 **Private Tutor**, Independent and through AccessAbility Services, *University of Waterloo*

PUBLICATIONS

PDF copies are available on my personal website (aliramadhan.me).

- 2023 **Capturing missing physics in climate model parameterizations using neural differential equations**, A. Ramadhan, J. C. Marshall, A. N. Souza, X. K. Lee, U. Piterbarg, A. Hillier, G. L. Wagner, C. Rackauckas, C. Hill, J.-M. Campin, R. Ferrari. Submitted to *Journal of Advances in Modeling Earth Systems*.
- Divergent behavior of hydrothermal plumes in fresh versus salty icy ocean worlds**, S. Bire, T. Mittal, W. Kang, A. Ramadhan, P. Tuckman, C. R. German, A. M. Thurnherr, J. C. Marshall. Submitted to *Journal of Geophysical Research: Planets*.
- 2022 **TOI-1075 b: A Dense, Massive, Ultra-short-period Hot Super-Earth Straddling the Radius Gap**, Z. Essack, A. Shporer, J. A. Burt, et al. (including A. Ramadhan) *The Astronomical Journal* **165**(2), 47.
- Observations of Upwelling and Downwelling Around Antarctica Mediated by Sea Ice**, A. Ramadhan, J. Marshall, G. Meneghello, L. Illari, K. Speer. *Frontiers in Marine Science* **9**, 864808.
- Exploring Ocean Circulation on Icy Moons Heated From Below**, S. Bire, W. Kang, A. Ramadhan, J.-M. Campin, J. Marshall. *Journal of Geophysical Research: Planets* **127**, e2021JE007025.
- 2021 **On the Settling Depth of Meltwater Escaping from beneath Antarctic Ice Shelves**, C. W. Arnscheidt, J. Marshall, P. Dutrieux, C. D. Rye, A. Ramadhan. *Journal of Physical Oceanography* **51**(7), 2257–2270.
- Near-Inertial Waves and Turbulence Driven by the Growth of Swell**, G. L. Wagner, G. P. Chini, A. Ramadhan, B. Gallet, R. Ferrari. *Journal of Physical Oceanography* **51**(5), 1337–1351.
- 2020 **Uncertainty Quantification of Ocean Parameterizations: Application to the K-Profile-Parameterization for Penetrative Convection**, A. N. Souza, G. L. Wagner, A. Ramadhan, B. Allen, V. Churavy, J. Schloss, J. Campin, C. Hill, A. Edelman, J. Marshall, G. Flierl, R. Ferrari. *Journal of Advances in Modeling Earth Systems* **12**, e2020MS002108.
- Oceananigans.jl: Fast and friendly geophysical fluid dynamics on GPUs**, A. Ramadhan, G. L. Wagner, C. Hill, J.-M. Campin, V. Churavy, T. Besard, A. Souza, A. Edelman, R. Ferrari, J. Marshall. *Journal of Open Source Software* **5**(53), 2018.
- Universal Differential Equations for Scientific Machine Learning**, C. Rackauckas, Y. Ma, J. Martensen, C. Warner, K. Zubov, R. Supekar, D. Skinner, A. Ramadhan, A. Edelman. *arXiv:2001.04385v4 [cs.LG]*.

- 2017 **Molecular movies and geometry reconstruction using Coulomb explosion imaging**, A. Ramadhan. *Master's thesis*, University of Waterloo.
- X-Ray Dosimetry During Low-Intensity Femtosecond Laser Ablation of Molybdenum in Ambient Conditions**, M. J. Wesolowski, C. C. Scott, B. Wales, A. Ramadhan, S. Al-Tuairqi, S. N. Wanasundara, K. S. Karim, J. H. Sanderson, C. A. Wesolowski, P. S. Babyn. *IEEE Transactions on Nuclear Science* **64**(9), 2519–2522.
- Synthesis of hydrogen- and methyl-capped long-chain polyynes by intense ultrashort laser pulse irradiation of toluene**, A. Ramadhan, M. Wesolowski, T. Wakabayashi, H. Shiromaru, T. Fujino, T. Kodama, W. Duley, J. Sanderson *Carbon* **118**, 680–685.
- 2016 **Ultrafast molecular dynamics of dissociative ionization in OCS probed by soft X-ray synchrotron radiation**, A. Ramadhan, B. Wales, I. Gauthier, R. Karimi, M. MacDonald, L. Zuin, J. Sanderson *Journal of Physics B: Atomic, Molecular, and Optical Physics* **49**, 215602.
- A Novel Femtosecond Laser-Assisted Method for the Synthesis of Reduced Graphene Oxide Gels and Thin Films with Tunable Properties**, K. Ibrahim, M. Irannejad, M. Hajialamdari, A. Ramadhan, K. Musselman, J. Sanderson, M. Yavuz *Advanced Materials Interfaces* **3**, 1500864.
- 2014 **Ultrafast Light Interaction with Graphene Oxide Aqueous Solution**, K. Ibrahim, M. Irannejad, A. Ramadhan, W. Alayak, J. Sanderson, B. Cui, A. Brzezinski, M. Yavuz. *Proceedings of the 14th IEEE International Conference on Nanotechnology* 830–831.
- Welding of Au Microwires by Femtosecond Laser Irradiation**, N. Ly, M. Mayer, A. Ramadhan, and J. Sanderson. *Proceedings of the 14th IEEE International Conference on Nanotechnology* 146–149.
- Coulomb imaging of the concerted and stepwise break up processes of OCS ions in intense femtosecond laser radiation**, B. Wales, É. Bisson, R. Karimi, S. Beaulieu, A. Ramadhan, M. Giguère, Z. Long, W. Liu, J. Kieffer, F. Légaré, J. Sanderson. *Journal of Electron Spectroscopy and Related Phenomena* **195**, 332–336.

PRESENTATIONS

- 2023 **Capturing missing physics in climate model parameterizations using neural differential equations**, *NASA-GISS Workshop on Climate Modeling using Machine Learning*, New York City, NY. (Oral)
- 2022 **Capturing missing physics in oceanic boundary layer turbulence using neural differential equations**, *2022 Ocean Sciences Meeting*, Virtual. (Oral)
- Capturing missing physics in climate models using neural differential equations**, *Society for Industrial and Applied Mathematics Seminar*, MIT, Cambridge, MA. (Oral)
- 2020 **Oceananigans.jl: Improving Climate Model Accuracy with Fast and Friendly Geophysical Fluid Dynamics on GPUs**, *International Conference for High Performance Computing, Networking, Storage and Analysis (SC2020)*, Virtual. (Poster)
- 2019 **Mathematical diseases in climate models and how to cure them**, *36th Chaos Communication Congress (36C3)*, Leipzig, Germany. (Oral)
- Oceananigans.jl: Fast and friendly high-resolution ocean process modeling for long-range climate prediction**, *13th Graduate Climate Conference*, Woods Hole, MA. (Treasurer, session chair, and poster)
- Constraining the Position of the Antarctic Divergence and Ascertaining its Effects on Antarctic Land Ice Loss Using Observations**, *27th International Union of Geodesy and Geophysics (IUGG) General Assembly*, Montréal, QC, Canada. (Oral)
- Reducing the error bars on climate and ocean predictions**, *MIT Stephen A. Schwarzman College of Computing Launch*, Cambridge, MA. (Poster)
- 2018 **Reducing the error bars on climate predictions**, *Society for Industrial and Applied Mathematics Seminar*, MIT, Cambridge, MA. (Oral)

- 2016 **Comparing Coulomb explosion dynamics of multiply charged OCS after ionization by soft X-rays and few cycle femtosecond laser pulses**, *Photonics North 2016*, Québec City, QC, Canada. (Oral)
- 2015 **Reconstructing Molecular Geometries of Small Molecules using Coulomb Explosion Imaging**, *Compute Ontario Research Day*, Kitchener, ON, Canada. (Oral)
- Dissociative ionization dynamics of the OCS molecule induced by soft X-rays**, *Canadian Light Source 18th Annual Users' Meeting*, Saskatoon, SK, Canada. (Poster)
- 2014 **Coulomb Explosion Imaging and Polyyne Production in Toluene using Femtosecond Laser Pulses**, *Kindai University Physical Chemistry Colloquium*, Osaka, Japan. (Invited seminar)
- Imaging of Structure in the OCS⁶⁺ molecule using intense variable pulse length 7–200 fs laser pulses**, *Photonics North 2014*, Montréal, QC, Canada. (Oral)
- 2013 **Coulomb Explosion Imaging of CO₂ and OCS in Intense Femtosecond Laser Radiation**, *Canadian Undergraduate Physics Conference 2013*, Hamilton, ON, Canada. (Oral)

ACTIVITIES

Graduate Climate Conference

2019

Treasurer

- Secured conference funding from several institutional sources. Co-chaired the oceanography session.
- Distributed travel funding to attendees in need and processed local and international reimbursements.

Frontier College (now United for Literacy)

2015 – 2017

Head Tutor, Organizational Team Member

- Worked with local schools to develop new educational math programs and games for students in grades 4–8.
- Tutored middle and high-school students one-on-one in math, science, and English for two nights a week.

University of Waterloo Science Endowment Fund

2014 – 2016

Physics Representative

- Represented and advocated for the Physics Department at council meetings to ensure funding of equipment.
- Voted on funding requests taking endowment fund policies and undergraduate interests into consideration.

University of Waterloo Cooking Club

2012 – 2016

Founder, President (5×)

- Founded a club for students who enjoy cooking to meet and to teach other students how to cook.
- Led a team of 12–25 executive members as president to plan events, recruit members, and ensure smooth club operation.
- Planned and hosted cooking classes, competitions, potlucks, bake sales, BBQ's, restaurant outings, and field trips. Many events were highly attended (50–100) and members consistently rated our classes highly.

AWARDS

- 2017 **Praecis Presidential Graduate Fellowship**, Massachusetts Institute of Technology
Jule Charney Prize, Program in Atmospheres, Oceans, & Climate, MIT
- 2016 **Alexander Graham Bell Graduate Scholarship**, Natural Sciences and Engineering Research Council of Canada
President's Graduate Scholarship, University of Waterloo
Marie Curie Award, Department of Physics and Astronomy, University of Waterloo
Dean's Honours List (7×), Faculty of Science, University of Waterloo
- 2015 **Undergraduate Student Research Award**, Natural Sciences and Engineering Research Council of Canada
- 2014 **Xerox Research Centre of Canada Award for Excellence in Oral Communication**, University of Waterloo
- 2013 **Undergraduate Student Research Award**, Natural Sciences and Engineering Research Council of Canada
- 2011 **Merit Scholarship**, University of Waterloo