Ali Ramadhan

Climate Scientist
Software & Machine Learning Engineer

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Summary

I am a graduate researcher at MIT at the intersection of climate science, software engineering, and machine learning.

I am excited to apply my unique skill set to tackle challenges in weather forecasting and climate prediction.

- **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 train and deploy AI-powered models of ocean turbulence to improve the accuracy of climate models.

Research Work Experience

Sep 2017 – Present

Massachusetts Institute of Technology (MIT)

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 large satellite datasets to uncover ocean dynamics.

Aug 2013 - Aug 2017

University of Waterloo

Department of Physics and Astronomy
Research Assistant

Formulated a computational framework for creating movies of chemical reactions. 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.

Sep - Dec 2014

Tokyo Metropolitan University

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.

Jan - Apr 2013

Ontario Institute for Cancer Research

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
Math	Scientific computing, differential equations, scientific machine learning, Bayesian statistics

Projects

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.

Project Lovelace
A website with scientific programming problems with automatic judging of submissions.

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 Colloqium*, Osaka, Japan. (Invited seminar)

Imaging of Structure in the OCS^{6+} molecule using intense variable pulse length 7–200 fs laser pulses, *Photonics North 2014*, Montréal, QC, Canada. (Oral)

2013 **Coulomb Explosion Imaging of CO_2 and OCS in Intense Femtosecond Laser Radiation**, *Canadian Undergraduate Physics Conference 2013*, Hamilton, ON, Canada. (Oral)

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