

ZANE KARAS MARTIN, PH.D.

NSF Postdoctoral Research Fellow, Colorado State University
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EDUCATION

Columbia University in the City of New York

Ph.D., M.Phil., M.Sc. in Applied Mathematics and Atmospheric Science

New York, NY

May 2020

- Advisors: Prof. Adam Sobel and Dr. Shuguang Wang
- Dissertation: The Interaction of the Madden-Julian Oscillation and the Quasi-biennial Oscillation in Observations and a Hierarchy of Models

Williams College

B.A. with Honors in Mathematics, Magna Cum Laude

Williamstown, MA

Class of 2013

- Undergraduate Thesis Advisor: Prof. Frank Morgan
- Undergraduate Thesis: Perimeter-Minimizing Tiling by Convex and Non-Convex Pentagons

Oxford University, Exeter College

Williams-Exeter Programme at Oxford

Oxford, England

2011-2012 Academic Year

RESEARCH EXPERIENCE

National Science Foundation Post-doctoral Research Fellow in Atmospheric and Geo-space Science

Mentors: Prof. Eric Maloney & Prof. Elizabeth Barnes, Colorado State University

June 2020 - Present

- Using explainable machine learning to study the Madden-Julian oscillation and sub-seasonal predictability in present and future climates using observational data and large-ensemble climate model simulations.

NASA Earth and Space Science Graduate Research Fellow | Graduate Research Assistant

Advisors: Prof. Adam Sobel & Dr. Shuguang Wang, Columbia University

Aug. 2015 - May 2020

- Focus on the Madden-Julian oscillation, with emphasis on (1) interactions between MJO and quasi-biennial oscillation, (2) numerical modeling in a hierarchy of models, (3) MJO indices and Subseasonal climate predictability

SMALL Mathematics Research Experience for Undergraduates

Geometry Group supervised by Professor Frank Morgan, Williams College

Summer 2012 and Summer 2013

- Focus on perimeter-minimizing tilings and related isoperimetric problems

Undergraduate Senior Honors Thesis

Advisor: Prof. Frank Morgan, Williams College

2012-2013 Academic Year

- Focus on perimeter-minimizing pentagonal tilings

ADDITIONAL PROFESSIONAL SKILLS AND EXPERIENCE

Computer Languages/Programs

- Expert in Python, including for machine learning (keras, tensorflow, scikit-learn, etc.), multi-dimensional data analysis and statistics (numpy, scipy, pandas, xarray, etc.), and data visualization (matplotlib, cartopy, seaborn, etc.) using Jupyter
- Extensive experience running and analyzing numerical climate models, including the Weather Research and Forecasting (WRF) model, sub-seasonal forecast models, and coupled global climate models in present and future climates
- Proficient in Matlab, CDO, NCO. Experience with Fortran, Linux, and in high-performance computing environments

Senior Legal Assistant

Sanford Heisler Sharp LLP

August 2013 - August 2015

- Provided administrative support at a plaintiff-side, civil rights law firm. Conducted client intakes; aided in preparation and submission of legal briefs and correspondences; reviewed and summarized case documents; managed case schedules

FELLOWSHIPS, HONORS, AND AWARDS

Fellowships

- NSF Postdoctoral Research Fellowship in Atmospheric and Geospace Science (2020-present)
- Sustainability Leadership Fellow at Colorado State Univ. School of Environmental Sustainability (2020-2021)
- NASA Earth and Space Science Graduate Research Fellowship (2018-2020)
- Alternate: NOAA Climate and Global Change Postdoctoral Fellowship (2020)
- Honorable Mention: NSF Graduate Research Fellowship in Mathematics (2013)

Other Awards

- 1st Place Student Oral Presentation, 2020 AMS 100th Annual Meeting, 8th Symposium on the Madden-Julian Oscillation and Sub-Seasonal Monsoon Variability
- Outstanding Student Presentation Award, 2019 AMS 99th Annual Meeting, 20th Conference on Middle Atmosphere
- Columbia University's EGSC Professional Development Scholarship (Fall 2019)
- Phi Beta Kappa, Sigma Xi (2013)
- Williams College's Olga R. Beaver Memorial Prize in Mathematics (2013)
- Williams College's Jacob C. Stone '14 Scholarship (2009-2012)

PUBLICATIONS & PRESENTATIONS

Submitted or Prepared Publications

The lack of a QBO-MJO connection in climate models with a nudged stratosphere, **Zane Martin**, Isla Simpson, Pu Lin, Clara Orbe, Qi Tang, Julie Caron, Chih-Chieh Chen, Hyemi Kim, L. Ruby Leung, Jadwiga Richter, Shaocheng Xie (in prep for submission to J. Geophys. Res. Atmos.)

Using simple, explainable neural networks to predict the Madden-Julian oscillation, **Zane Martin**, Elizabeth Barnes, Eric Maloney (under review at JAMES; preprint at <https://www.essoar.org/doi/10.1002/essoar.10507439.3>)

Published

- [16] *The influence of the quasi-biennial oscillation on the Madden-Julian oscillation*, **Zane Martin**, Seok-Woo Son, Amy Butler, Harry Hendon, Hyemi Kim, Adam Sobel, Shigeo Yoden, Chidong Zhang, 2021, Nature Reviews Earth & Environment, <https://doi.org/10.1038/s43017-021-00173-9>
- [15] *Large-scale state and evolution of the atmosphere and ocean during PISTON 2018*, Adam Sobel, Janet Sprintall, Eric Maloney, **Zane Martin**, Shuguang Wang, Simon de Szoeke, Benjamin Trabling, and Steven Rutledge, 2021, J. Clim., <https://doi.org/10.1175/JCLI-D-20-0517.1>
- [14] *The MJO-QBO relationship in a GCM with stratospheric nudging*, **Zane Martin**, Clara Orbe, Shuguang Wang, and Adam Sobel, 2021, J. Clim., <https://doi.org/10.1175/JCLI-D-20-0636.1>
- [13] *Identifying Opportunities for Skillful Weather Prediction with Interpretable Neural Networks*, Elizabeth A. Barnes, Kirsten Mayer, Benjamin Toms, **Zane Martin**, and Emily Gordon, 2020, arXiv, <https://arxiv.org/abs/2012.07830> (from the AI for Earth Sciences Workshop at NeurIPS, 2020)
- [12] *Variability in QBO Temperature Anomalies on Annual and Decadal Timescales*, **Zane Martin**, Adam Sobel, Amy Butler, and Shuguang Wang, 2020, J. Clim., <https://doi.org/10.1175/JCLI-D-20-0287.1>
- [11] *Clouds and convective self-aggregation in a multi-model ensemble of radiative-convective equilibrium simulations*, Allison Wing, et al. (incl. **Zane Martin**), 2020, JAMES, <https://doi.org/10.1029/2020MS002138>
 o Conducted modeling experiments for the RCEMIP project (<http://myweb.fsu.edu/awing/rcemip.html>)
- [10] *The impact of the stratosphere on the MJO in a forecast model*, **Zane Martin**, Frederic Vitart, Shuguang Wang, Adam H. Sobel, 2020, J. Geophys. Res. Atmos., 125, <https://doi.org/10.1029/2019JD032106>
- [9] *Insignificant QBO-MJO prediction skill relationship in the SubX and S2S sub-seasonal reforecasts*, Hyemi Kim, Jadwiga H. Richter, **Zane Martin**, 2019, J. Geophys. Res. Atmos., 124, <https://doi.org/10.1029/2019JD031416>
 o Selected for EOS Editor Highlight (<https://eos.org/editor-highlights/emerging-controversy-in-madden-julian-oscillation-prediction>)
- [8] *Impact of the QBO on prediction and predictability of the MJO convection*, Shuguang Wang, Michael K. Tippett, Adam H. Sobel, **Zane Martin**, Frederic Vitart, 2019, J. Geophys. Res. Atmos., 124, <https://doi.org/10.1029/2019JD030575>
- [7] *The impact of the QBO on MJO convection in cloud-resolving simulations*. **Zane Martin**, Shuguang Wang, Ji Nie, Adam Sobel, 2019, J. Atmos. Sci., 76, 669–688, <https://doi.org/10.1175/JAS-D-18-0179.1>
- [6] *The convex body isoperimetric conjecture in the plane*, John Berry, Eliot Bongiovanni, Wyatt Boyer, Bryan Brown, Paul Gallagher, David Hu, Alyssa Loving, **Zane Martin**, Maggie Miller, Byron Perpetua, Sarah Tammen, 2017, RHIT Undergrad. Math. J. Vol. 18, No. 2, (<https://scholar.rose-hulman.edu/rhumj/vol18/iss2/2/>)
- [5] *Perimeter-Minimizing Tilings by Convex and Non-Convex Pentagons*, Whan Ghang, **Zane Martin**, Steven Waruhui, 2015, RHIT Undergrad. Math. J., Vol. 16, No. 1, 24-56 (<https://scholar.rose-hulman.edu/rhumj/vol16/iss1/2/>)

- [4] *Isoperimetry in the Plane with Density $e^{-1/r}$* , Paul Gallagher, David Hu, **Zane Martin**, Maggie Miller, Byron Perpetua, 2014, RHIT Undergrad. Math. J., Vol. 15, No. 2, 100-114 (<https://scholar.rose-hulman.edu/rhumj/vol15/iss2/7/>)
- [3] *Surface-Area-Minimizing n-Hedral Tiles*, Paul Gallagher, Whan Ghang, David Hu, **Zane Martin**, Maggie Miller, Byron Perpetua, Steven Waruhiu, 2014, RHIT Undergrad. Math. J., Vol. 15, No. 1, 209-236 (<https://scholar.rose-hulman.edu/rhumj/vol15/iss1/13/>)
- [2] *The sharp log-Sobolev inequality on a compact interval*, Whan Ghang, **Zane Martin**, Steven Waruhiu, 2014, Involve, a Journal of Mathematics 7-2, 181-186. DOI 10.2140/involve.2014.7.181 (<http://msp.org/involve/2014/7-2/p05.xhtml>)
- [1] *Perimeter-Minimizing Tiling by Convex and Non-Convex Pentagons*, **Zane Martin**, 2013, Williams College Senior Thesis (https://docs.wixstatic.com/ugd/65e897_d3e9c1df46e84ee29a21d0be37652fe8.pdf).

Presentations, Poster, Talks, and Conference Papers

Conference Papers & Technical Reports:

- “Machine learning to extend and understand the sources and limits of water cycle predictability on subseasonal-to-decadal timescales in the Earth system” Katherine Dagon et al., incl. **Zane Martin** (Department of Energy Earth and Environmental Systems Science Division White Paper on AI for Earth System Predictability (AI4ESP), <https://doi.org/10.2172/1769744>)
- “Identifying Opportunities for Skillful Weather Prediction with Interpretable Neural Networks”, Elizabeth Barnes, Kirsten Mayer, Benjamin Toms, **Zane Martin**, and Emily Gordon (AI for Earth Sciences Workshop at the 34th Conference on Neural Information Processing Systems (NeurIPS 2020); October 2020)

Invited Presentations:

- “Predicting the Madden-Julian oscillation using interpretable machine learning models”
- Florida State University Meteorology Seminar, March 2021
 - University of Florida Department of Geography Seminar, March 2021
 - NCAR ASP Workshop S2S Science and Predictions, August 2021
- “The QBO influence on the MJO, Its Teleconnections, and Predictability”
- 9th MJO Symposium, AMS Annual Meeting, January 2021
- “The relationship between the Madden-Julian oscillation and the quasi-biennial oscillation: Observations and global climate models”
- NASA Goddard Institute for Space Studies Seminar, October 2020
 - NCAR Climate and Global Dynamics Seminar, September 2020
 - National Autonomous University of Mexico Seminar, June 2020
 - Harvard University ClimaTea Seminar, October 2019
- “The MJO-QBO relationship and S2S predictions: Challenges and opportunities”
- US CLIVAR Process Study and Model Improvement (PSMI) Panel Summer Meeting, August 2020

Additional Presentations: 30+ additional scientific presentations nationally and internationally, including recently:

- “Using simple, explainable neural networks to predict the Madden-Julian oscillation”
- 2nd Workshop on Knowledge Guided Machine Learning, August 2021
 - 3rd NOAA Workshop on Leveraging AI in Environmental Sciences, September 2021
- “Predicting the MJO using interpretable machine learning models”
- Colorado State University Atmospheric Dynamics “Supergroup” Meeting, March 2021
 - AMS Annual Meeting January 2021
 - AGU Annual Meeting, December 2020; see poster at <https://doi.org/10.1002/essoar.10506356.1>
- “Examining the MJO-QBO relationship in a global climate model with a nudged stratosphere”
- SPARC Workshop on Stratosphere-Troposphere Dynamical Coupling in the Tropics, Kyoto, Japan, February 2020
 - AMS Annual Meeting, January 2020
 - AGU Annual Meeting, December 2019

PROFESSIONAL ENGAGEMENT

- Member, World Meteorological Organization MJO Task Force (January 2021-present)
- Member, American Meteorological Society Committee on the Middle Atmosphere (January 2020-present)
- Co-chair, 10th MJO Symposium, (AMS Annual Meeting, 2022)
- Session Co-chair, 9th MJO Symposium, AMS Annual Meeting, 2021
- Session Co-chair, Joint Session on Variability and Predictability of Climate on Subseasonal-to-Seasonal Timescales, 100th AMS Annual Meeting
- Reviewer for Bulletin of the American Meteorological Society, Journal of Atmospheric Science, Geophysical Research Letters, Climate Dynamics, Journal of Climate, Quarterly Journal of the Royal Meteorological Society, AI for Earth Sciences Workshop at the NeurIPS 2020 Conference, Journal of the Meteorological Society of Japan
- Lamont Doherty Earth Observatory Open House (public outreach event; 2018, 2019)

SUMMER SCHOOLS, WORKSHOPS, AND INTERNATIONAL COLLABORATION

Artificial Intelligence for Earth System Science (AI4ESS) Summer School, NCAR/UCAR (June 2020)

Usable Climate Science and the Uses of History, Yale University (November 2019)

2nd ICTP Summer School on Theory, Mechanisms and Hierarchical Modelling of Climate Dynamics: Convective Organization and Climate Sensitivity (July 2019)

European Centre for Medium-Range Weather Forecasting (July 2018; 2-weeks as a visitor at the Centre to collaborate with Dr. Frederic Vitart)

University of Chicago Rossbypalooza Summer School (June 2018; Advisor: Tiffany Shaw)

NCAR/UCAR CMIP Analysis Platform Tutorial (August 2016)

OTREC Field Campaign (September 2019; Costa Rica. Supervisors: Prof. Ben Lintner, Prof. David Raymond, and Prof. Zeljka Fuchs)

PISTON Field Campaign (August-September 2018; West Pacific aboard R/V Thomas G. Thompson. Supervisors: Prof. Jim Moum, Prof. Janet Sprintall)

PROFESSIONAL MEMBERSHIPS

American Geophysical Union, American Meteorological Society, Mathematics and Climate Research Network, Society for Industrial and Applied Mathematics

TEACHING & MENTORING EXPERIENCE

Mentor, Colorado State University REU Site in Earth System Science

Colorado State University

Summer 2021

- Primary mentor for a 10-week undergraduate project combining atmospheric science and machine learning
- Developed project, met at least 2x weekly with mentee to assist in research, share code, discuss results, prepare results for presentation, and discuss graduate school plans and career opportunities

Teaching Assistant

Columbia University

Fall 2015, Spring 2016, Spring 2018

- Multivariable Calculus (APMAE 2001): *Weekly recitation lectures for 3 sections; wrote and graded quizzes; held office hours and exam review sessions; aided in writing and grading exams*
- Functions of a Complex Variable (APMAE 4204), Introduction to Applied Mathematics (APMAE 2101): *Weekly office hours; graded homework*

Williams College

Spring 2011, Fall 2012, Winter 2013, Spring 2013

- Multivariable Calculus (MATH 105), Real Analysis (MATH 301), Introduction to Cryptography (MATH 10), Measure Theory & Probability (MATH 402); *Weekly office hours; graded homework; held exam review sessions*

Guest Lecturer

Columbia University

Spring 2019

- Tropical Meteorology (EESC 6928); *focus on quasi-biennial oscillation in observations, models, and theory*

Other Experiences

- Columbia University Applied Math Dept. Student Mentor (2019-2020)
- Columbia University Applied Math Dept. Student Co-Coordinator of Social Events (2016-2019)
- Williams College Dean's Tutor (2010-2013)
- Williams College Math-Science Resource Center Tutor (2010-2013)