
Makoto M. Kelp

CONTACT INFORMATION

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EDUCATION

Harvard University, Cambridge, MA

Ph.D. Candidate, Atmospheric Chemistry

May 2023 (expected)

S.M., Environmental Science and Engineering

March 2022

Thesis: Expanding the capabilities of atmospheric chemistry models using machine learning

Advisor: Daniel Jacob

Reed College, Portland, OR

B.A., Chemistry

May 2016

Thesis: Tropospheric particle formation in forests: global modeling of secondary organic aerosol production from reaction of NO₃ radical with speciated monoterpenes

Advisor: Juliane Fry

RESEARCH INTERESTS

My research blends the domains of atmospheric chemistry, air quality engineering, and machine learning/data science to lift barriers in atmospheric chemistry modeling and to address disparities in air pollution monitoring.

RESEARCH EXPERIENCE

Graduate Research Assistant with Professor Daniel Jacob

Sep 2018-Present

Harvard University Department of Earth and Planetary Sciences

- Characterizing chemical data assimilation for NASA's GEOS-CF model
- Developed a machine learning chemical solver for GEOS-Chem chemical transport model
- With Dr. Loretta Mickley: Created method to identify the optimal placement of air pollution sensors
- Machine learning and data science subgroup co-leader within the [Atmos. Chem. Modeling Group](#)

Jr. Research Scientist with Professor Julian Marshall

June 2016-Aug 2018

University of Washington Department of Civil and Environmental Engineering

- Developed a machine-learning neural network solver to emulate the CBM-Z chemical mechanism
- Analyzed household air pollution from field studies conducted in Koppal, India
- With Professor Timothy Larson: analysis of area-wide, vehicle emission factors on mobile campaign in Los Angeles

Undergraduate Senior Research Thesis with Professor Juliane Fry

Sep 2015-May 2016

Reed College Department of Chemistry

- Employed GEOS-Chem to implement a speciated NO₃-Terpene VBS scheme to investigate the regional and global distribution of secondary organic aerosols; collaborated with Dr. Havala Pye (EPA) and Professor Emily Fischer (CSU)

Undergraduate Research Assistant with Professor Emily Fischer

Summer 2015

Colorado State University Department of Atmospheric Science

- Evaluated importance of monoterpene-derived acetone production in GEOS-Chem

Undergraduate Research Assistant with Professor Juliane Fry

Summer 2014-May 2015

Reed College Department of Chemistry

- Analyzed effects of black carbon from coal trains in the Columbia River Gorge; collaborated on field campaign with Professor Dan Jaffe (University of Washington)
- Maintained Reed College and Brooklyn Rail Yard monitoring sites; modeled ambient air pollution in SE Portland with data from field sites in conjunction with Oregon DEQ

PUBLICATIONS

h-index: 7, total citations: 115 (as of May 2022, [Google Scholar](#)); as first author (6), as co-author (4)

[9] **Kelp, M.**, D.J. Jacob, H. Lin, and M.P. Sulprizio (2022). An online-learned neural network chemical solver for stable long-term global simulations of atmospheric chemistry. *JAMES*, 14, e2021MS002926, DOI: 10.1029/2021MS002926 *Special Collection on “Machine learning application to Earth system modeling”

[8] Yang, L. H., D.H. Hagan, J.C. Rivera-Rios, **M. Kelp**, E.S. Cross, C.Y. Peng, J. Kaiser, L.R. Williams, P. L. Croteau, J.T. Jayne, N.L. Ng (2022). Investigating the sources of urban air pollution using low-cost air quality sensors at an urban Atlanta site. *Environ. Sci. Technol.*,
*Special Issue on “Urban Air Pollution and Human Health” DOI: 10.1021/acs.est.1c07005

[7] **Kelp, M.**, S. Lin**, J.N. Kutz, and L.J. Mickley (2022). A new approach for optimal placement of PM_{2.5} air quality sensors: case study for the contiguous United States. *Env. Res. Letters*, 17, 034034, DOI: 10.1088/1748-9326/ac548f **undergraduate advisee

[6] **Kelp, M.**, D.J. Jacob, J.N. Kutz, J.D. Marshall, and C. Tessum (2020). Toward stable, general machine-learned models of the atmospheric chemical system. *JGR: Atmospheres*, 125, e2020JD032759, DOI: 10.1029/2020JD032759

[5] **Kelp, M.**, T. Gould, E. Austin, J.D. Marshall, M. Yost, C. Simpson, and T. Larson (2020). Sensitivity analysis of area-wide, mobile source emission factors to high-emitter vehicles in Los Angeles. *Atmospheric Environment*, 223, 117212, DOI: 10.1016/j.atmosenv.2019.117212

[4] Wen, Y., H. Wang, T. Larson, **M. Kelp**, S. Zhang, Y. Wu, and J.D. Marshall (2019). On-highway vehicle emission factors, and spatial patterns, based on mobile monitoring and absolute principal component score. *Science of The Total Environment*, 676, 242-251, DOI: 10.1016/j.scitotenv.2019.04.185

[3] **Kelp, M.**, A.P. Grieshop, C.O. Reynolds, J. Baumgartner, G. Jain, K. Sethuramanand, and J.D. Marshall (2018). Real-time indoor measurement of health and climate-relevant air pollution concentrations during a carbon-finance-approved cookstove intervention in rural India. *Development Engineering*, 3, 125-132, DOI: 10.1016/j.deveng.2018.05.001

[2] Brewer, J. F., M. Bishop, **M. Kelp**, C. Keller, A.R. Ravishankara, and E.V. Fischer (2017). A sensitivity analysis of key factors in the modeled global acetone budget. *J. Geophys. Res.*, 122, DOI: 10.1002/2016JD025935

[1] Jaffe, D., J. Putz, G. Hof, G. Hof, J. Hee, D.A. Lommers-Johnson, F. Gabela, J. Fry, B. Ayres, **M. Kelp**, and M. Minsk (2015). Diesel particulate matter and coal dust from trains in the Columbia River Gorge, Washington state, USA. *Atmospheric Pollution Research*, 6, 946-952, DOI: 10.1016/j.apr.2015.04.004

OTHER PUBLICATIONS

[2] **Kelp, M.**, C. Tessum, and J.D. Marshall (2018). Orders-of-magnitude speedup in atmospheric chemistry modeling through neural network-based emulation. arXiv:1808.03874

[1] **Kelp, M.**, 2016. “Tropospheric particle formation in forests: global modeling of secondary organic aerosol production from reaction of NO₃ radical with speciated monoterpenes”, Reed College.

INVITED TALKS

- [3] **M. Kelp**, D.J. Jacob, H. Lin., and M.P. Sulprizio. An online-learned neural network chemical solver for stable long-term global simulations of atmospheric chemistry. *ECMWF Machine Learning Workshop*, Virtual, March 29, 2022
- [2] **M. Kelp**, S. Lin, J.N. Kutz, and L.J. Mickley. A new approach for determining optimal placement of PM_{2.5} air quality sensors,
• *University of Illinois at Urbana-Champaign Advanced Environmental Engineering Seminar*, Virtual, February 11, 2022
• *EPA Model Applications Team Meeting*, Virtual, January 12, 2022
- [1] **M. Kelp**, J. N. Kutz, J.D. Marshall, and C.W. Tessum. Toward stable, general machine-learned models of the atmospheric chemical system. *AGU Virtual Fall Meeting*, December 7, 2020

CONFERENCE PRESENTATIONS

- [9] **M. Kelp**, D.J. Jacob, and H. Lin. An Online-Learned Neural Network Chemical Solver for Stable and Long-Term Global Simulations of Atmospheric Chemistry in S2S Applications. *AMS Annual Meeting*, January 26, 2022 *Talk*
- [8] **M. Kelp** and D.J. Jacob. A recursive neural network chemical solver for fast long-term global simulations of atmospheric composition. *AMS Annual Meeting*, Virtual, January 13, 2021 *Talk*
- [7] **M. Kelp** and D.J. Jacob. A recursive neural network chemical solver for fast long-term global simulations of atmospheric composition. *Atmospheric Chemical Mechanisms Conference*, Virtual, November 18, 2020 *Lightning talk*
- [6] **M. Kelp**, J. N. Kutz, J.D. Marshall, and C. Tessum. Deep Learning Emulation and Compression of an Atmospheric Chemical System using a Chained Training Regime. *AGU Fall Meeting*, San Francisco, CA, December 13, 2019
- [5] **M. Kelp**, C.W. Tessum, and J.D. Marshall. Orders-of-Magnitude Speedup in Atmospheric Chemistry Modeling through Neural Network-Based Emulation. *AGU Fall Meeting*, Washington D.C, December 12, 2018
- [4] **M. Kelp**, A.P. Grieshop, C.O. Reynolds, J. Baumgartner, G. Jain, K. Sethuramanand, and J.D. Marshall. Investigating Health-Relevant Air Pollution Concentration Linkages Across Multiple Seasons During Indoor Cookstove Campaign in Rural India. *ISES-ISEE Joint Annual Meeting*, Ottawa, CA, August 25, 2018
- [3] T.W. Aung, A.P. Grieshop, **M. Kelp**, and J.D. Marshall. Emission and Concentration Linkages from a Cookstove Intervention Trial in India. *International Society of Exposure Science (ISES) Annual Meeting*, Research Triangle Park, NC, October 15-19, 2017
- [2] **M. Kelp**, H.O.T. Pye, E.V. Fischer, J. Brewer, and J. Fry. Global Modeling of Secondary Organic Aerosol Production from Reaction of NO₃ Radical with Speciated Monoterpenes. *AAAR Annual Conference*, Portland, OR, October 18, 2016
- [1] **M. Kelp**, J. Brewer, C. Keller, and E.V. Fischer. Evaluating the Potential Importance of Monoterpene Degradation for Global Acetone Production. *AGU Fall Meeting*, San Francisco, CA, December 16, 2015

TEACHING EXPERIENCE	Harvard University Department of Earth and Planetary Sciences	
	<i>Teaching Fellow</i>	Fall 2019, Fall 2020
	<ul style="list-style-type: none"> • EPS 200: Graduate-level Atmospheric Chemistry and Physics 	
	Reed College Department of Chemistry	
	<i>Laboratory Teaching Assistant</i>	2015-2016
	<ul style="list-style-type: none"> • Chem 101: Molecular Structure and Properties • Chem 102: Chemical Reactivity 	
	<i>Tutor, Grader</i>	2013-2016
	<ul style="list-style-type: none"> • Chem 101: Molecular Structure and Properties • Chem 102: Chemical Reactivity • Chem 230: Environmental Chemistry 	
MENTORING	<i>Sanjna Kedia</i> , Harvard University, Summer 2022	
	<ul style="list-style-type: none"> • Project: Machine learning for automated detection of wildfire smoke America • HUCE Summer Undergraduate Research Program (co-mentor with Drew Pendergrass, Tina Liu, and Dr. Loretta Mickley) 	
	<i>Timothy Fargiano</i> , Harvard University, Summer 2022	
	<ul style="list-style-type: none"> • Project: Optimal placement of PM_{2.5} air quality sensors in the US: An approach to target environmental injustice • HUCE Summer Undergraduate Research Program (co-mentor with Dr. Loretta Mickley) 	
	<i>Margaret Schultz</i> , Harvard University, January 2022 - present	
	<ul style="list-style-type: none"> • Project: Real-time high-resolution downscaling of fine particulate matter (PM_{2.5}) air quality in the United States using machine learning • Harvard ESE senior research thesis (co-mentor with Drew Pendergrass and Dr. Loretta Mickley) 	
	<i>Samuel Lin</i> , Harvard University, Summer 2021-Fall 2021	
	<ul style="list-style-type: none"> • Project: Optimal air quality sensor placement in the United States • HUCE Summer Undergraduate Research Program (co-mentor with Dr. Loretta Mickley) 	
	<i>Marie Panday</i> , University of Maryland, Summer 2021	
	<ul style="list-style-type: none"> • Project: Trends in and Reconstruction of Smoke Days across the United States • OEB REU (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley) 	
	<i>Kent Toshima</i> , Harvard University, Summer 2020 - Summer 2021	
	<ul style="list-style-type: none"> • Project: Application of deep learning to detection of wildfire smoke in HMS over North America • HUCE Summer Undergraduate Research Program (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley) 	
	<i>Miah Caine</i> , Harvard University, Summer 2020 - Spring 2021	
	<ul style="list-style-type: none"> • Project: Agreement between the HMS Product and Ground-Level Smoke in the Pacific Northwest • HUCE Summer Undergraduate Research Program (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley) 	
HONORS AND AWARDS	Bok Center Certificate of Distinction in Teaching Fall 2019, Harvard University	April 2020
	AGU Outstanding Student Presentation Award	January 2020
	Deep Learning for Science School Travel Grant	July 2019
	National Science Foundation STEM Scholar, Reed College	2013-2016
	Commendation for Academic Excellence, Reed College	2012-2013, 2015-2016
	F. W. Erickson Scholarship, Reed College	2014-2016
	Department of Chemistry Summer Research Grant, Reed College	Summer 2014
	Ann W. Shepard Memorial Scholarship, Reed College	2013-2014

**PROFESSIONAL
SERVICE AND
AFFILIATIONS**

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- **Peer reviewer** for *Atmos. Chem. and Phys.*, *Env. Res. Comm.*, *Atmospheric Pollution Research*, *Geoscientific Model Development*, *Env. Res. Letters*, *JAMES*, *GeoHealth*
 - **Memberships:** American Geophysical Union, American Association for Aerosol Research, American Meteorological Society
 - Air Quality Sample Assistant (Fall 2015) at Oregon DEQ: installed and collected BGI filters and maintained an [EPA validated method sampling site](#) and helped create [statewide attention](#) towards arsenic and cadmium concentrations in SE Portland, which resulted in the Bullseye Glass Co. [suspending its use of chromium](#)

**COMMUNITY
ENGAGEMENT**

Harvard University Monday Jazz Band	2019-Present
Dudley Graduate Student Jazz Band	2018-2019
NPR Philosophy Talk Guest Jazz Musician	Aired Nov 29 2015
Reed College Jazz Ensemble and Conference Musician	2012-2016
Jazz Band and Music Department Assistant	2015-2016

**TECHNICAL
SKILLS**

Languages: Fortran 90, IDL, R, Go, Python, Matlab, Unix environments
Software: GEOS-Chem, TensorFlow, LaTeX, RStudio
Operating Systems: Linux, Mac OS X