

Makoto M. Kelp

CONTACT INFORMATION Pierce Hall G3G
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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 system 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 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: 127 (as of August 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

- Editor’s Highlight in *JAMES*, 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.*, 56, 11, 7063–7073, DOI: 10.1021/acs.est.1c07005

- Special Issue on “Urban Air Pollution and Human Health”

[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

[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

** Note: authors who are students I mentored are double starred

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.

PUBLICATIONS IN-PREP, IN-REVIEW

- **Kelp, M.**, T. Liu, and L.J. Mickley. Sensitivity of population-weighted smoke exposure to wildfires in the western United States: implications for prescribed burning at the state level and in rural environmental justice communities, (In-prep)
- **Kelp, M.**, T. C. Fargiano, S. Lin, T. Liu, J. N. Kutz, and L.J. Mickley. Data-driven placement of PM_{2.5} air quality sensors in the United States: an approach to target urban environmental injustice, (In-prep)

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- **Kelp, M.**, C. A. Keller, K. Wargan, B.M. Karpowicz, and D. J. Jacob. Tropospheric ozone data assimilation in the NASA GEOS Composition Forecast Modeling System GEOS-CF v2.0 including direct assimilation of thermal infra-red radiances, (In-prep)

- INVITED TALKS**
- [5] Atmospheric Chemical Mechanisms Conference, Dec 7-9, 2022
 - [4] ECMWF Machine Learning Workshop, Mar 29, 2022
 - [3] University of Illinois at Urbana-Champaign Advanced Env. Engineering Seminar, Feb 11, 2022
 - [2] EPA Model Applications Team Meeting, Jan 12, 2022
 - [1] AGU Virtual Fall Meeting, Dec 7, 2020

- SELECT CONFERENCE PRESENTATIONS**
- [10] **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*
 - [9] **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*
 - [8] **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*, Virtual, December 7, 2020 *Invited 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 in the US• 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 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

TECHNICAL SKILLS

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