

# Makoto M. Kelp

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**CONTACT INFORMATION** Pierce Hall G3G  
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## **EDUCATION** Harvard University, Cambridge, MA

*Ph.D. Candidate*, Earth and Planetary Sciences May 2023 (expected)  
*S.M.*, Environmental Science and Engineering March 2022  
*Thesis*: Expanding the Capabilities of Atmospheric Chemistry Models and Datasets Using Machine Learning and Data-Driven Methods  
*Advisors*: Daniel Jacob and Loretta Mickley

## **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 NO<sub>3</sub> 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 and exposures.

## **RESEARCH EXPERIENCE**

**Graduate Research Assistant** with Professor Daniel Jacob **Sep 2018-Present**  
*Harvard University Department of Earth and Planetary Sciences*

- With Dr. Christoph Keller at NASA GSFC: Chemical data assimilation system in 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 NO<sub>3</sub>-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: 149 (as of March 2023, [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<sub>2.5</sub> 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 NO<sub>3</sub> radical with speciated monoterpenes”, Reed College.

## PUBLICATIONS IN-PREP, IN-REVIEW

- **Kelp, M.**, M. Carroll, T. Liu, R.M. Yantosca, H.E. Hockenberry, and L.J. Mickley. Prescribed burns as a tool to mitigate future wildfire smoke exposure: Lessons for states and environmental justice communities, (In review at *Earth’s Future*)
- **Kelp, M.**, T. C. Fargiano\*\*, S. Lin\*\*, T. Liu, J.R. Turner, J. N. Kutz, and L.J. Mickley. Data-driven placement of PM<sub>2.5</sub> air quality sensors in the United States: an approach to target urban environmental injustice, (Submitted to *Science Advances*)

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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**
- [12] AGU/AMS GeoHealth Showcase, March 9, 2023
  - [11] MIT Atmospheric Chemistry Colloquium, Feb 7, 2023
  - [10] Stanford University, Jan 24, 2023
  - [9] Royal Meteorological Society Atmospheric Chemistry Special Interest Conference, Dec 8, 2022
  - [8] Atmospheric Chemical Mechanisms Conference, Dec 7-9, 2022
  - [7] Pennsylvania Dept. of Env. Protection Air Monitoring Committee Workshop, Dec 6, 2022
  - [6] Karlsruhe Institute of Technology, Nov 7, 2022
  - [5] University of Washington, July 8, 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**
- [12] **M. Kelp**, 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. *AMS Annual Meeting*, Denver, CO, January 12, 2023 *Talk*
  - [11] **M. Kelp**, 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. *AGU Fall Meeting*, Chicago, IL, December 14, 2022 *Talk*
  - [10] **M. Kelp**, T. C. Fargiano, S. Lin, T. Liu, J. N. Kutz, and L.J. Mickley. Data-driven placement of PM<sub>2.5</sub> air quality sensors in the United States: an approach to target urban environmental injustice. *AGU Fall Meeting*, Chicago, IL, December 12, 2022 *Talk*
  - [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**, 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*
  - [6] **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*
  - [5] **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

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[4] **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

[3] **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

[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 NO<sub>3</sub> 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

Teaching Certificate, Harvard University, Derek Bok Center for Education & Learning, 2023

Harvard University Department of Earth and Planetary Sciences

*Teaching Fellow*

**Fall 2019, Fall 2020, Fall 2022**

*Guest Lecturer*

**Fall 2022**

- EPS 200: Graduate-level Atmospheric Chemistry and Physics

Reed College Department of Chemistry

*Laboratory Teaching Assistant*

**2015-2016**

- Chem 101: Molecular Structure and Properties
- Chem 102: Chemical Reactivity

*Tutor, Grader*

**2013-2016**

- Chem 101: Molecular Structure and Properties
- Chem 102: Chemical Reactivity
- Chem 230: Environmental Chemistry

## MENTORING

*Timothy Fargiano*, Harvard University, Summer 2022 - Fall 2022

- Project: Optimal placement of PM<sub>2.5</sub> air quality sensors in the US: An approach to target environmental injustice
- HUCE Summer Undergraduate Research Program (co-mentor with Dr. Loretta Mickley)

*Margaret Schultz*, Harvard University, January 2022 - December 2022

- Project: Real-time high-resolution downscaling of fine particulate matter (PM<sub>2.5</sub>) air quality in the United States using machine learning
- Harvard ESE senior research thesis (co-mentor with Drew Pendergrass and Dr. Loretta Mickley)

*Sanjna Kedia*, Harvard University, Summer 2022

- Project: Machine learning for automated detection of wildfire smoke in the US
- HUCE Summer Undergraduate Research Program (co-mentor with Drew Pendergrass and Dr. Loretta Mickley)

*Samuel Lin*, Harvard University, Summer 2021-Fall 2021

- Project: Optimal air quality sensor placement in the United States
- HUCE Summer Undergraduate Research Program (co-mentor with Dr. Loretta Mickley)

*Marie Panday*, University of Maryland, Summer 2021

- Project: Trends in and Reconstruction of Smoke Days across the United States

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- OEB REU (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley)

*Kent Toshima*, Harvard University, Summer 2020 - Summer 2021

- 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)

*Miah Caine*, Harvard University, Summer 2020 - Spring 2021

- 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	<b>April 2020</b>
AGU Outstanding Student Presentation Award		<b>January 2020</b>
Deep Learning for Science School Travel Grant		<b>July 2019</b>
National Science Foundation STEM Scholar	Reed College	<b>2013-2016</b>
Commendation for Academic Excellence	Reed College	<b>2012-2013, 2015-2016</b>
F. W. Erickson Scholarship	Reed College	<b>2014-2016</b>
Department of Chemistry Summer Research Grant	Reed College	<b>Summer 2014</b>
Ann W. Shepard Memorial Scholarship	Reed College	<b>2013-2014</b>

#### PROFESSIONAL SERVICE AND AFFILIATIONS

- **Peer reviewer** for *Atmos. Chem. and Phys.*, *Env. Res. Comm.*, *Atmospheric Pollution Research*, *Geoscientific Model Development*, *Env. Res. Letters*, *JAMES*, *GeoHealth*, *Environ. Sci. Technol.*
- **Proposal review panelist** for *NASA Earth Science ROSES Program* (Nov 2022)
- **Co-leader** of Statistical Learning in Atmos. Chem. (SLAC) group (Oct 2022 – Present)
- **Memberships:** AGU, AAAR, AMS
- 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		<b>2019-Present</b>
Dudley Graduate Student Jazz Band		<b>2018-2019</b>
NPR Philosophy Talk Guest Jazz Musician		<b>Aired Nov 29 2015</b>
Reed College Jazz Ensemble and Conference Musician		<b>2012-2016</b>

#### TECHNICAL SKILLS

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