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## Makoto M. Kelp

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### CONTACT INFORMATION

Pierce Hall G3G  
Harvard University  
Cambridge, Massachusetts, 02138

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*Website:* makotokelp.com

### EDUCATION

**Harvard University, Cambridge, MA** **Sep 2018-May 2023 (expected)**

*Ph.D. Candidate, Atmospheric Chemistry*

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

Advisor: Daniel J. Jacob

**Reed College, Portland, OR**

**Sep 2012-May 2016**

*B.A., Chemistry*

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 L. 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 uncover disparities in air pollution monitoring.

### RESEARCH EXPERIENCE

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

- Characterizing chemical data assimilation routine for NASA's GEOS-CF model
- Developed a machine learning chemical solver for GEOS-Chem chemical transport model
- With Dr. Loretta J. 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](#)

**Research Associate** with Professor Julian D. Marshall **June 2016-Aug 2018**  
*University of Washington Department of Civil and Environmental Engineering*

- Developed a machine-learning neural network solver to emulate the Carbon Bond Mechanism Z gas-phase chemical mechanism
- Analyzed household air pollution from field studies conducted in Koppal, India
- With Professor Timothy V. Larson: analysis of area-wide, mobile source emission factors using absolute principal component scores on mobile campaign in Los Angeles

**Undergraduate Senior Research Thesis** with Professor Juliane L. Fry **Sep 2015-May 2016**  
*Reed College Department of Chemistry*

- Employed GEOS-Chem to implement a new, speciated NO<sub>3</sub>-Terpene VBS scheme to investigate the regional and global distribution of secondary organic aerosols; collaborated with Dr. Havala O.T. Pye (EPA) and Professor Emily V. Fischer (CSU)

**Undergraduate Research Assistant** with Professor Emily V. Fischer **Summer 2015**  
*Colorado State University Department of Atmospheric Science*

- Evaluated importance of monoterpene-derived acetone production to the global acetone budget by employing GEOS-Chem

**Undergraduate Research Assistant** with Professor Juliane L. 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 A. Jaffe (University of Washington)
- Modeled local climate effects of black carbon, PM<sub>2.5</sub>, and other pollutants in SE Portland and their effects on human health using the EPA Environmental Benefits Mapping and Analysis Program (BenMAP)
- 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

**TEACHING  
EXPERIENCE**

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Harvard University Department of Earth and Planetary Sciences*Teaching Fellow***Fall 2019, Fall 2020**

- 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

**PUBLICATIONS** h-index: 7, total citations: 100 (as of Feb 2022, [Google Scholar](#)); as first author (5), as co-author (3)

[7] **Kelp, M.**, Lin, S.\*\*\*, Kutz, J.N., Mickley, L.J. “A new approach for optimal placement of PM<sub>2.5</sub> air quality sensors: case study for the contiguous United States”, *Accepted at Env. Res. Letters*  
\*\*\*undergraduate advisee

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

[5] **Kelp, M.**, Gould, T., Austin, E., Marshall, J.D., Yost, M., Simpson, C., Larson, T., 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., Wang, H., Larson, T., **Kelp, M.**, Zhang, S., Wu, Y., Marshall, J.D., 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.**, Grieshop, A.P., Reynolds, C.O., Baumgartner, J., Jain, G., Sethuramanand, K., Marshall, J.D., 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., Bishop, M., **Kelp, M.**, Keller, C., Ravishankara, A.R., Fischer, E.V., 2017, “A sensitivity analysis of key factors in the modeled global acetone budget”, *J. Geophys. Res.*, 122, doi:10.1002/2016JD025935

[1] Jaffe, D., Putz, J., Hof, G., Hof, G., Hee, J., Lommers-Johnson, D. A., Gabela, F., Fry, J., Ayres, B., **Kelp, M.**, Minsk, M., 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.**, Tessum, C., Marshall, J.D., 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.**, Jacob, D.J., Lin, H., Sulprizio, M.P. “An online-learned neural network chemical solver for stable long-term global simulations of atmospheric chemistry”, *submitted to JAMES*
- Yang, L. H., Hagan, D. H., Rivera-Rios, J. C., **Kelp, M.**, Cross, E. S., Peng C. Y., Kaiser, J., Williams, L. R., Croteau, P. L., Jayne, J. T., Ng., N. L. “Understanding the Sources of Urban Air Pollution Using Low-Cost Air Quality Sensors”, *in review at ES&T*

**INVITED TALKS**

- [3] **M. Kelp**, D.J. Jacob, H. Lin., M.P. Sulprizio An online-learned neural network chemical solver for stable long-term global simulations of atmospheric chemistry, *ECMWF Machine Learning Workshop*, Virtual, (upcoming)
- [2] **M. Kelp**, S. Lin, J.N. Kutz, L.J. Mickley. A new approach for determining optimal placement of PM<sub>2.5</sub> air quality sensors,
- *EPA Model Applications Team Meeting*, Virtual, January 12, 2022
  - *University of Illinois at Urbana-Champaign Advanced Environmental Engineering Seminar*, Virtual, February 11, 2022
- [1] **M. Kelp**, J. N. Kutz, J.D. Marshall, 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, 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**, 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**, 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, C.W. 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, 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, 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**, 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 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

<b>WORKSHOPS</b>	Deep Learning for Science School, Lawrence Berkeley National Laboratory, CA	<b>July 2019</b>
<b>MENTORING</b>	<p><i>Margaret Schultz</i>, Harvard University, January 2022 - present</p> <ul style="list-style-type: none"> <li>• Project: Real-time high-resolution downscaling of fine particulate matter (PM<sub>2.5</sub>) air quality in the United States using machine learning</li> <li>• Harvard ESE senior research thesis (co-mentor with Drew Pendergrass and Dr. Loretta Mickley)</li> </ul> <p><i>Samuel Lin</i>, Harvard University, Summer 2021-Fall 2021</p> <ul style="list-style-type: none"> <li>• Project: Optimal air quality sensor placement in the United States</li> <li>• HUCE Summer Undergraduate Research Program (co-mentor with Dr. Loretta Mickley)</li> </ul> <p><i>Marie Panday</i>, University of Maryland, Summer 2021</p> <ul style="list-style-type: none"> <li>• Project: Trends in and Reconstruction of Smoke Days across the United States</li> <li>• OEB REU (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley)</li> </ul> <p><i>Kent Toshima</i>, Harvard University, Summer 2020 - Summer 2021</p> <ul style="list-style-type: none"> <li>• Project: Application of Deep Learning to Detection of Wildfire Smoke in HMS over North America</li> <li>• HUCE Summer Undergraduate Research Program (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley)</li> </ul> <p><i>Miah Caine</i>, Harvard University, Summer 2020 - Spring 2021</p> <ul style="list-style-type: none"> <li>• Project: Agreement between the HMS Product and Ground-Level Smoke in the Pacific Northwest</li> <li>• HUCE Summer Undergraduate Research Program (co-mentor with Tina Liu, Drew Pendergrass, and Dr. Loretta Mickley)</li> </ul>	
<b>HONORS AND AWARDS</b>	<p>Bok Center Certificate of Distinction in Teaching Fall 2019, Harvard University</p> <p>AGU Outstanding Student Presentation Award</p> <p>Deep Learning for Science School Travel Grant</p> <p>National Science Foundation STEM Scholar, Reed College</p> <p>Commendation for Academic Excellence, Reed College</p> <p>F. W. Erickson Scholarship, Reed College</p> <p>Department of Chemistry Summer Research Grant, Reed College</p> <p>Ann W. Shepard Memorial Scholarship, Reed College</p> <p>National Advanced Placement Scholar Award</p>	<p><b>April 2020</b></p> <p><b>January 2020</b></p> <p><b>July 2019</b></p> <p><b>2013-2016</b></p> <p><b>2012-2013, 2015-2016</b></p> <p><b>2014-2016</b></p> <p><b>Summer 2014</b></p> <p><b>2013-2014</b></p> <p><b>2012</b></p>
<b>LEADERSHIP AND OUTREACH</b>	<p>Machine learning and data science subgroup co-leader in ACMG</p> <p>Harvard EPS Department G2 Quads Buddy Committee</p> <p>Harvard EPS Department Visiting Scholar Lecture Series Committee</p> <p>Science-A-Thon Participant</p> <p>Oregon Museum of Science and Industry (OMSI) Chemistry Lab Teacher</p>	<p><b>2021-Present</b></p> <p><b>2020-2021</b></p> <p><b>2018-2019</b></p> <p><b>October 2018, 2019</b></p> <p><b>2012-2013</b></p>
<b>COMMUNITY ENGAGEMENT</b>	<p>Harvard University Monday Jazz Band</p> <p>Dudley Graduate Student Jazz Band</p> <p>NPR Philosophy Talk Guest Jazz Musician</p> <p>Reed College Jazz Ensemble and Conference Musician</p> <p>Jazz Band and Music Department Assistant</p>	<p><b>2019-Present</b></p> <p><b>2018-2019</b></p> <p><b>Aired Nov 29 2015</b></p> <p><b>2012-2016</b></p> <p><b>2015-2016</b></p>

**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](#)

**TECHNOLOGY  
SKILLS**

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