

KELVIN H. BATES, PH.D.

School of Engineering and Applied Science, Harvard University
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EDUCATION

- Ph.D. in Chemistry, California Institute of Technology, Pasadena, CA** 2012 - 17
Thesis: "Isoprene Oxidation and Secondary Organic Aerosol Formation Under HO₂-Dominated Conditions"
Faculty mentors: Professors John Seinfeld, Paul Wennberg, and Brian Stoltz
- B.S., Chemistry and Economics, Davidson College, Davidson, NC** 2008 - 12
Phi Beta Kappa, *Summa cum Laude*
Study abroad: Geneva, Switzerland, fall 2010 (Kent State Univ.); Cádiz, Spain, summer 2010 (Davidson College)

PROFESSIONAL EXPERIENCE

RESEARCH

- Visiting Research Associate** 2020 -
with Professor Tran Nguyen at University of California at Davis, Davis, CA
 - Coordinated a compilation of nationwide laboratory studies in the Index of Chamber Atmospheric Research
 - Performed chamber experiments to quantify organic acid formation and sulfate photochemistry in aerosols
- Postdoctoral Fellow** 2017 -
with Professor Daniel Jacob at Harvard University, Cambridge, MA
NOAA Climate & Global Change / Harvard University Center for the Environment Postdoctoral Fellowships
 - Incorporated detailed isoprene oxidation chemistry into the GEOS-Chem global chemical transport model
 - Developed a new theoretical framework of odd oxygen for examination of tropospheric ozone budgets
 - Led the chemistry subgroup of postdocs and grad students within the Atmos. Chem. Modeling Group
- Postdoctoral Scholar & Graduate Research Assistant** Summer 2017
2012 - 17
with Professors John Seinfeld, Paul Wennberg, and Brian Stoltz at the California Institute of Technology, Pasadena, CA
 - Determined rates and products of reactions in the OH-initiated oxidation of isoprene under low-NO conditions
 - Examined factors affecting formation of organic aerosol from isoprene in an environmental chamber
 - Synthesized chemical standards of isoprene-derived products for use in chamber experiments and calibrations
 - Simulated the effects of isoprene oxidation in the global atmosphere with chemical transport modeling
 - Measured aerosol concentration and composition over coastal CA in two aircraft campaigns (2015 & 2016)
- NASA Student Airborne Research Program** Summer 2012
with Professor Donald Blake at NASA Dryden, Palmdale, CA, and University of California at Irvine, Irvine, CA
 - Operated whole air sampling manifold aboard research flights over LA basin and Central Valley, CA
 - Analyzed volatile organic compounds in collected samples by various GC and GC-MS methods
 - Estimated hydrocarbon emissions from the California oil and gas extraction industry using box modeling
- NOAA Hollings Internship** Summer 2011
with Dr. Charles Brock at NOAA Earth Systems Research Laboratory, Boulder, CO
 - Assembled and programmed a scanning mobility particle sizer (SMPS) to measure aerosol size distributions
 - Tested SMPS against commercial instrument and in ambient conditions; programmed data analysis method
 - Presented findings at Hollings symposium in Washington, DC; won climate division presentation competition

TEACHING

Organic Chemistry I	Ch 41a	Caltech	Teaching Assistant	Fall 2013
Atmospheric Chemistry	Ch/ESE/Ge 171	Caltech	Teaching Assistant	Spring 2015
Fellowship Writing	AGC 298	UC Davis	Guest Lecturer	Fall 2020

AWARDS AND FELLOWSHIPS

- Climate and Global Change Postdoctoral Fellowship National Fellowship, NOAA 2017 - 19
- Center for the Environment Postdoctoral Fellowship Harvard University 2017 - 19
- Selected to participate in ACCESS XIV Brookhaven National Lab Summer 2017

NSF Graduate Research Fellowship	National Fellowship, NSF	2014 - 17
Sharp Fellowship	California Institute of Technology	2012 - 13
David Halbert Howard, Jr. Chemistry Award	Davidson College, Dept. of Chemistry	Spring 2011
ACS Outstanding Scholastic Achievement Award	American Chemical Society, Regional Award	Spring 2011
Goldwater Scholarship Honorable Mention	National Fellowship	Spring 2011
Ernest F. Hollings Undergraduate Scholarship	National Fellowship, NOAA	2010 - 12
POLYED Award for Achievement in Organic Chemistry	Davidson College, Dept. of Chemistry	Spring 2010
Davidson Honor Scholarship	Davidson College	2008 - 12
Presidential Scholar	National Award	Spring 2008

PUBLICATIONS

28. Wells, K. C., Millet, D. B., Payne, V. H., Deventer, M. J., **Bates, K. H.**, de Gouw, J. A., Graus, M., Warneke, C., Wisthaler, A., and Fuentes, J. D. Global measurements of isoprene from space: Constraints on emissions and atmospheric oxidation over source regions. *Nature*, 585, 225-233, DOI: 10.1038/s41586-020-2664-3, 2020.
27. Wang, S., Apel, E., Schwantes, R. H., **Bates, K. H.**, Fischer, E., Hornbrook, R., Hills, A., Emmons, L., Tilmes, S., Lamarque, J.-F., Yang, M., Marandino, C., Saltzman, E., de Bruyn, W., Kameyama, S., Tanimoto, H., Omori, Y., Hall, S., Ullmann, K., Ryerson, T., Daube, B., Commane, R., McKain, K., Sweeney, C., Thames, A., Miller, D., Brune, W., Diskin, G., DiCanci, J., and Wofsy, S. Global atmospheric budget of acetone: air-sea exchange and the contribution to the hydroxyl radicals. *J. Geophys. Res. – Atmos.*, 125 (15). DOI: 10.1029/2020JD032553, 2020.
26. Link, M., Nguyen, T. B., **Bates, K. H.**, Müller, J.-F., and Farmer, D. Can isoprene oxidation explain high concentrations of atmospheric formic and acetic acid over forests? *ACS Earth Space Chem.*, 4 (5), 730-740, DOI: 10.1021/acsearthspacechem.0c00010, 2020.
25. Schulze, B. C., Charan, S. M., Kenseth, C. M., Kong, W., **Bates, K. H.**, Williams, W., Metcalf, A. R., Jonsson, H. H., Woods, R., Sorooshian, A., Flagan, R. C., and Seinfeld, J. H. Characterization of aerosol hygroscopicity over the Northeast Pacific Ocean: Impacts on prediction of CCN and stratocumulus cloud droplet number concentrations. *Earth Space Sci.*, 7, e2020EA001098, DOI: 10.1029/2020EA001098, 2020.
24. **Bates, K. H.** and Jacob, D. J. An expanded definition of the odd oxygen family for tropospheric ozone budgets: Implications for ozone lifetime and stratospheric influence. *Geophys. Res. Lett.*, 47, e2019GL084486, DOI: 10.1029/2019GL084486, 2020.
23. Møller, K. H., Kurtén, T., **Bates, K. H.**, Thornton, J. A., and Kjaergaard, H. G. Thermalized epoxide formation in the Atmosphere. *J. Phys. Chem. A*, 123 (49), 10620-10630, DOI: 10.1021/acs.jpca.9b09364, 2019.
22. Dovrou, E., Rivera-Rios, J. C., **Bates, K. H.** and Keutsch, F. N. Sulfate formation via cloud processing from isoprene hydroxyl hydroperoxides (ISOPOOH). *Environ. Sci. Technol.*, 53 (21), 12476-12484, DOI: 10.1021/acs.est.9b04645, 2019.
21. Li, K., Jacob, D. J., Liao, H., Zhu, J., Shah, V., Shen, L., **Bates, K. H.**, Zhang, Q., and Zhai, S. A two-pollutant strategy for improving ozone and particulate air quality in China. *Nature Geosci.* 12, 906-910, DOI: 10.1038/s41561-019-0464-x, 2019.
20. **Bates, K. H.** and Jacob, D. J. A new model mechanism for atmospheric oxidation of isoprene: Global effects on oxidants, nitrogen oxides, organic products, and secondary organic aerosol. *Atmos. Chem. Phys.* 19, 9613-9640, DOI: 10.5194/acp-19-9613-2019, 2019.
19. Rooney, B., Zhao, R., Wang, Y., **Bates, K. H.**, Pillarisetti, A., Sharma, S., Kundu, S., Bond, T. C., Lam, N., Ozultun, B., Xu, L., Fleming, L. T., Weltman, R., Meinardi, S., Blake, D. R., Nizkorodov, S. A., Edwards, R. D., Yadav, A., Arora, N. K., Smith, K. R., and Seinfeld, J. H. Impacts of household sources on air pollution at village and regional scales in India. *Atmos. Chem. Phys.*, 19, 7719-7742. DOI: 10.5194/acp-19-7719-2019, 2019.
18. Schwantes, R. H., Charan, S. M., **Bates, K. H.**, Huang, Y., Nguyen, T. B., Mai, H., Kong, W., Flagan, R. C., and Seinfeld, J. H. Low-volatility compounds contribute significantly to isoprene sSOA under high-NO conditions. *Atmos. Chem. Phys.*, 19, 7255-7278. DOI: 10.5194/acp-19-7255-2019, 2019.
17. Møller, K. H., **Bates, K. H.**, and Kjaergaard, H. G. The importance of hydrogen shift reactions in atmospheric isoprene oxidation. *J. Phys. Chem. A.*, 123 (4), 920-932. DOI: 10.1021/acs.jpca.8b10432, 2019.
16. Li, K., Jacob, D. J., Liao, H., Shen, L., Zhang, Q., and **Bates, K. H.** Anthropogenic drivers of 2013-2017 trends in summer surface ozone in China. *Proc. Nat'l Acad. Sci.*, 116 (2), 422-427, DOI: 10.1073/pnas.1812168116, 2019.

15. Allen, H. M., Teng, A. P., **Bates, K. H.**, Crouse, J. D., Thayer, M., Rivera-Rios, J., Keutsch, F., St. Clair, J. M., and Wennberg, P. O. Kinetics and product yields of the OH driven oxidation of hydroxymethyl hydroperoxide. *J. Phys. Chem. A*, 122 (30), 6292-6302, DOI: 10.1021/acs.jpca.8b04577, 2018.
14. Kalashnikova, O. V., Garay, M. J., Xu, F., **Bates, K. H.**, Kong, S., Kenseth, C., Cappa, C., Siedel, F., Yorks, J., Diner, D. J., Jonsson, H. H., and Seinfeld, J. H. Photopolarimetric sensitivity to black carbon content of wildfire smoke: Results from the 2016 IMPACT-PM field campaign. *J. Geophys. Res. – Atmos.*, 123 (10), 5376-5396, DOI: 10.1029/2017JD028032, 2018.
13. Wennberg, P. O., **Bates, K. H.**, Crouse, J. D., Dodson, L. G., McVay, R. C., Mertens, L. A., Nguyen, T. B., Praske, E., Schwantes, R. H., Smarte, M. D., St. Clair, J. M., Teng, A. P., Zhang, X., and Seinfeld, J. The gas-phase oxidation of isoprene and its first-generation products. *Chem. Rev.*, 118 (7), 3337-3390, DOI: 10.1021/acs.chemrev.7b00439, 2018.
12. Sorooshian, A., MacDonald, A. B., Dadashazar, H., **Bates, K. H.**, Coggon, M. M., Craven, J. S., Crosbie, E., Hersey, S. P., Hodas, N., Lin, J. J., Negrón Marty, A., Maudlin, L. C., Metcalf, A. R., Murphy, S. M., Prabhakar, G., Rissman, T. A., Shingler, T., Varutbangkul, T., Wang, Z., Woods, R. K., Chuang, P. Y., Nenes, A., Jonsson, H. H., Flagan, R. C., and Seinfeld, J. H. A multi-year data set on aerosol-cloud-precipitation-meteorology interactions for marine stratocumulus clouds. *Scientific Data*, 5, 180026, DOI: 10.1038/sdata.2018.26, 2018.
11. **Bates, K. H.**, Nguyen, T. B., Teng, A. P., Crouse, J. D., Kjaergaard, H. G., Stoltz, B. M., Seinfeld, J. H., and Wennberg, P. O. Production and fate of C₄ dihydroxycarbonyl compounds from isoprene oxidation. *J. Phys. Chem. A*, 120 (1), 106-117, DOI: 10.1021/acs.jpca.5b10335, 2016.
10. Wang, Z., Ramirez, M. M., Dadashazar, H., MacDonald, A., Crosbie, E., **Bates, K. H.**, Coggon, M. M., Craven, J. S., Lynch, P., Campbell, J. R., Aghdam, M. A., Woods, R. K., Jonsson, H., Flagan, R. C., Seinfeld, J. H., and Sorooshian, A. Contrasting cloud composition between coupled and decoupled marine boundary layer clouds. *J. Geophys. Res. – Atmos.*, 121 (19), 11679-11691, DOI: 10.1002/2016JD025695, 2016.
9. Nguyen, T. B., Crouse, J. D., Teng, A. P., Coggon, M. M., Schwantes, R. H., **Bates, K. H.**, Zhang, L., Feiner, P., Miller, D. C., Skog, K., Rivera, J., Olson, K., Koss, A., Goldstein, A. H., de Gouw, J., Tyndall, G., Brun, W. H., Keutsch, F. N., Seinfeld, J. H., and Wennberg, P. O. Atmospheric fates of Criegee intermediates in the ozonolysis of isoprene. *Phys. Chem. Chem. Phys.*, 18, 10241-10254, DOI: 10.1039/C6CP00053C, 2016.
8. Liu, Y., Brito, J., Dorris, M., Rivera-Rios, J. C., Seco, R., **Bates, K. H.**, Artaxo, P., Duvoisin, S., Keutsch, F. N., Kim, S., Goldstein, A. H., Guenther, A., Manzi, A.-O., de Souza, R., Springston, S. R., Watson, T. B., McKinney, K. A., and Martin, S. T. Isoprene photochemistry over the Amazon rain forest. *Proc. Nat'l. Acad. Sci.*, 113 (22), 6125-6130, DOI: 10.1073/pnas.1524136113, 2016.
7. Zhang, X., Dalleska, N. F., Huang, D. D., **Bates, K. H.**, Sorooshian, A., Flagan, R. C., and Seinfeld, J. H. Time-resolved molecular characterization of water-soluble organic aerosols by PILS + UPLC/ESI-ToF/MS. *Atmos. Env.*, 130, 180-189, DOI: 10.1016/j.atmosenv.2015.08.049, 2016.
6. St. Clair, J. M., Rivera-Rios, J. C., Crouse, J. D., Knap, H. C., **Bates, K. H.**, Teng, A. P., Jørgensen, S., Kjaergaard, H. G., Keutsch, F. N., and Wennberg, P. O. Kinetics and products for the reaction of the first-generation isoprene hydroxy hydroperoxide (ISOPOOH) with OH. *J. Phys. Chem. A*, 120 (9), 1441-1451, DOI: 10.1021/acs.jpca.5b06532, 2016.
5. Nguyen, T. B., **Bates, K. H.**, Crouse, J. D., Schwantes, R. H., Zhang, X., Kjaergaard, H. G., Surratt, J. D., Lin, P., Laskin, A., Seinfeld, J. H., and Wennberg, P. O. Mechanism of the hydroxyl radical oxidation of methacryloyl peroxy nitrate (MPAN) and its pathway toward secondary organic aerosol formation in the atmosphere. *Phys. Chem. Chem. Phys.*, 17, 17914-17926, DOI: 10.1039/C5CP02001H, 2015.
4. Praske, E., Crouse, J. D., **Bates, K. H.**, Kurtén, T., Kjaergaard, H. G., Wennberg, P. O. (2015) Atmospheric fate of methyl vinyl ketone: peroxy radical reactions with NO and HO₂. *J. Phys. Chem. A*, 119 (19), 4562-4572, DOI: 10.1021/jp5107058, 2015.
3. **Bates, K. H.**, Crouse, J. D., St. Clair, J. M., Bennett, N. B., Nguyen, T. B., Seinfeld, J. H., Stoltz, B. M., Wennberg, P. O. Gas phase production and loss of isoprene epoxydiols. *J. Phys. Chem. A*, 118 (7), 1237-1246, DOI: 10.1021/jp4107958, 2014.
2. Nguyen, T. B., Crouse, J. D., Schwantes, R. H., Teng, A. P., **Bates, K. H.**, Zhang, X., St. Clair, J. M., Brune, W. H., Tyndall, G. S., Keutsch, F. N., Seinfeld, J. H., Wennberg, P. O. Overview of the Focused Isoprene eXperiments at California Institute of Technology (FIXCIT): mechanistic chamber studies on the oxidation of biogenic compounds. *Atmos. Chem. Phys.*, 14, 13531-13549, DOI: 10.5194/acp-14-13531-2014, 2014.
1. Nguyen, T. B., Coggon, M. M., **Bates, K. H.**, Zhang, X., Schwantes, R. H., Schilling, K. A., Loza, C. L., Flagan, R. C., Wennberg, P. O., Seinfeld, J. H. Organic aerosol formation from the reactive uptake of isoprene epoxydiols (IEPOX) onto non-acidified inorganic seeds. *Atmos. Chem. Phys.*, 14, 3497-3510, DOI: 10.5194/acp-14-3497-2014, 2014.

PRESENTATIONS AND POSTERS

INVITED TALKS

- 2020 Bates, K. H., *et al.* Organic hydroperoxides and the catalytic role of formaldehyde in atmospheric sulfate formation. *American Chemical Society Fall Meeting*, August, San Francisco, CA (virtual).
- 2020 Bates, K. H., *et al.* An expanded definition of the odd oxygen family for tropospheric ozone budgets: Implications for ozone lifetime, stratospheric influence, and source tagging. *American Meteorological Society*, January, Boston, MA.
- 2019 Bates, K. H., Global implications of a new model mechanism for atmospheric oxidation of isoprene. *Massachusetts Institute of Technology*, April, Cambridge, MA.
- 2019 Bates, K. H., Redefining odd oxygen: a new budget diagnostic for tropospheric ozone. *National Center for Atmospheric Research*, March, Boulder, CO.
- 2018 Bates, K. H., The influence of isoprene on global atmospheric oxidant budgets. *University of Washington*, April, Seattle, WA.
- 2018 Bates, K. H., Atmospheric isoprene oxidation and smog formation in remote environments. *Københavns Universitet*, March, Copenhagen, Denmark.

CONFERENCE TALKS

- 2020 Bates, K. H., *et al.* Intercomparison and optimization of aromatic oxidation mechanisms. *Atmospheric Chemical Mechanisms*, November, Davis, CA (virtual).
- 2019 Bates, K. H., *et al.* Modeling the effects of an updated isoprene oxidation mechanism on organic aerosol, reactive nitrogen, and sulfate budgets. *American Association for Aerosol Research*, October, Portland, OR.
- 2019 Bates, K. H., *et al.* Redefining odd oxygen: a new budget diagnostic for tropospheric ozone. *International GEOS-Chem Conference*, May, Cambridge, MA.
- 2019 Bates, K. H., *et al.* An expanded definition of odd oxygen for improved tropospheric ozone accounting. *American Meteorological Society Annual Meeting*, January, Phoenix, AZ.
- 2017 Bates, K. H., *et al.* Isoprene oxidation mechanisms and secondary organic aerosol formation under HO₂-dominated conditions. *ACCESS XIV*, July, Brookhaven, NY.
- 2017 Bates, K. H., *et al.* Updated isoprene chemistry in GEOS-Chem: mechanisms and impacts. *International GEOS-Chem Conference*, May, Cambridge, MA.
- 2016 Bates, K. H., *et al.* Incorporating recent advances in isoprene photooxidation into GEOS-Chem: Effects on oxidant, NO_x, and VOC budgets. *American Geophysical Union Fall Meeting*, December, San Francisco, CA.
- 2016 Bates, K. H., *et al.* Determinants of isoprene SOA yields from recent comprehensive chamber studies. *American Association for Aerosol Research*, October, Portland, OR.
- 2015 Bates, K. H., *et al.* Secondary organic aerosol yields from isoprene oxidation under low-NO conditions. *American Association for Aerosol Research*, October, Minneapolis, MN.

CONFERENCE POSTERS

- 2019 Bates, K. H., *et al.* Combined volatility-based partitioning and reactive-uptake parameterizations of SOA formation in GEOS-Chem: Application to isoprene. *European Aerosol Conference*, August, Gothenburg, Sweden.
- 2019 Bates, K. H., *et al.* An expanded definition of the odd oxygen family for tropospheric ozone budgets. *Gordon Research Conference on Atmospheric Chemistry*, July, Newry, ME.
- 2018 Bates, K. H., *et al.* Modeling the effects of isoprene oxidation and hydrogen shift reactions on HO_x, NO_x, and ozone. *American Geophysical Union Fall Meeting*, December, Washington, DC.
- 2018 Bates, K. H., *et al.* Coupled gas and particle phase modeling of isoprene SOA formation. *American Association for Aerosol Research*, September, St. Louis, MO.
- 2018 Bates, K. H., *et al.* New constraints on budgets of oxidized volatile organic compounds in the remote troposphere. *iCACGP-IGAC*, September, Takamatsu, Kagawa, Japan.

- 2017 Bates, K. H., *et al.* Modeling the formation of secondary organic aerosol precursors from isoprene. *American Association for Aerosol Research*, October, Raleigh, NC.
- 2017 Bates, K. H., *et al.* A new explicit model of isoprene oxidation. *Gordon Research Conference on Atmospheric Chemistry*, August, Newry, ME.
- 2015 Bates, K. H., *et al.* AMS observations over coastal California from the Biological and Oceanic Atmospheric Study (BOAS). *American Geophysical Union Fall Meeting*, December, San Francisco, CA.
- 2015 Bates, K. H., *et al.* Recent revisions to isoprene photochemistry based on Caltech chamber and field data. *International GEOS-Chem Conference*, May, Cambridge, MA.
- 2014 Bates, K. H., *et al.* Photooxidation products of isoprene epoxydiol (IEPOX) and IEPOX-derived secondary organic aerosol. *American Geophysical Union Fall Meeting*, December, San Francisco, CA.
- 2014 Bates, K. H., *et al.* Photooxidation of isoprene epoxydiol (IEPOX)-derived secondary organic aerosol. *American Association for Aerosol Research*, October, Orlando, FL. (student poster competition winner)
- 2013 Bates, K. H., *et al.* Gas-phase production and loss of isoprene epoxydiols. *American Geophysical Union Fall Meeting*, December, San Francisco, CA.
- 2012 Bates, K. H., *et al.* Signature alkane ratios and hydrocarbon emission estimates for western Kern County oilfields. *American Geophysical Union Fall Meeting*, December, San Francisco, CA.

AFFILIATIONS

American Geophysical Union (AGU)	member	2012 -
American Association for Aerosol Research (AAAR)	member	2014 -
American Meteorological Society	member	2018 -
American Chemical Society	member	2019 -

TECHNICAL SKILLS

Computer proficiency: GEOS-Chem (chemical transport modeling); IGOR Pro (data analysis); MatLab, Mathematica, MathCad (mathematical programming); Spartan (molecular modeling); LaTeX; LabVIEW (visual programming interface); IDL, Fortran 77/90, Python, R, html (programming).

Atmospheric & analytical chemistry instrumentation: proficient with aerosol mass spectrometry, scanning mobility particle sizer, differential mobility analyzer, condensation particle counter, chemical ionization mass spectrometry, gas chromatography, HPLC, NMR spectroscopy, FT-IR and UV/Vis spectroscopy; some experience with nephelometer, single particle soot photometer, wideband integrated bioaerosol sampler.

Reviewer: proposals: NASA ACMAP, NOAA AC4; journals: *Proc. Nat'l. Acad. Sci.*, *Atmos. Chem. Phys.*, *J. Geophys. Res. - Atmos.*, *ACS Earth & Space Chem.*, *Geosci. Model Dev.*, *Beilstein J. Org. Chem.*, *Atmos. Environ.*, *Environ. Sci. & Technol.*, *Geophys. Res. Lett.*

Languages: fluent in English, proficient in Spanish, conversant in French

LEADERSHIP

Chemistry subgroup leader, Atmospheric Chemistry Modeling Group, Harvard	2018 -
Coordinator, Atmospheric & Environmental Chemistry Seminar Series, Harvard	2018 - 2019
Resident Associate, Page House, Caltech	2014 - 2017
Communications Officer, Science and Engineering Policy at Caltech (SEPAC)	2015 - 2017
Caltech PRISM (LGBTQ alliance)	
President	2014 - 2015
Treasurer	2013 - 2014 & 2015 - 2016