

LARRY WAYNE HOROWITZ

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PROFESSIONAL EXPERIENCE

2008-present **PRINCETON UNIVERSITY**, Princeton, New Jersey
Lecturer, Department of Geosciences, Program in Atmospheric and Oceanic Sciences

2001-present **GEOPHYSICAL FLUID DYNAMICS LABORATORY**, Princeton, New Jersey
Physical Scientist
Leader, Atmospheric Chemistry and Climate Group (2012-2018)
Deputy Leader, Biogeochemistry, Atmospheric Chemistry, and Ecosystems Div. (2018-)

My research focuses on tropospheric trace gases and aerosols. I use global Earth system models to simulate the chemical and dynamical processes affecting atmospheric composition.

1999-2001 **GEOPHYSICAL FLUID DYNAMICS LABORATORY**, Princeton, New Jersey
Visiting Scientist, Atmospheric and Oceanic Sciences Program, Princeton University

My work aimed to improve our understanding of the processes controlling tropospheric trace gas distributions. I used global chemical transport models to study the impact of chemistry and transport on ozone and related chemical species.

1997-1999 **NATIONAL CENTER FOR ATMOSPHERIC RESEARCH**, Boulder, Colorado
Postdoctoral Fellow, Advanced Study Program / Atmospheric Chemistry Division

My research focused on simulating the chemistry of ozone and related species in the troposphere. Using a three-dimensional global model, I studied the dependence of ozone on emissions of precursors from anthropogenic and natural sources.

EDUCATION

1993-1997 **HARVARD UNIVERSITY**, Cambridge, Massachusetts
Ph.D. in Atmospheric Chemistry/Applied Mathematics, Division of Engineering and Applied Sciences, degree received November 1997
Committee: Professors Daniel Jacob (advisor), Michael McElroy, Steven Wofsy

My research focused on the tropospheric photochemistry of ozone, nitrogen oxides, and non-methane hydrocarbons. I developed a photochemical mechanism describing the reactions occurring within the continental boundary layer and the global troposphere, for use in chemical models. Using a three-dimensional chemical transport model, I examined the impact of non-methane hydrocarbon chemistry on the global distributions of ozone and nitrogen oxides. Thesis title: The influence of boundary layer chemistry on global tropospheric ozone and nitrogen oxides.

LARRY WAYNE HOROWITZ

- 1991-1993 **HARVARD UNIVERSITY**, Cambridge, Massachusetts
S.M. in Applied Physics, Division of Applied Sciences

Emphasis on the chemistry and physics of the atmosphere. Additional courses in applied mathematics, including numerical techniques.
- Summer 1990 **WEIZMANN INSTITUTE OF SCIENCE**, Rehovot, Israel

Research on spectroscopy in molecular jets, Department of Chemical Physics, Karyn Kupciner International Science School, funded to attend.
- 1987-1991 **HARVARD COLLEGE**, Cambridge, Massachusetts
A.B. summa cum laude in Chemistry
Advisors: Professors Elias Corey, William Klemperer

HONORS AND AWARDS

- 2017 **Atmospheric Sciences Ascent Award**, American Geophysical Union
2014-2019 **Highly Cited Researcher**, Thomson Reuters / Clarivate Analytics
2012 **Gold Medal**, Department of Commerce
2009 **Outstanding Scientific Paper Award**, National Oceanic and Atmospheric Administration, Office of Oceanic and Atmospheric Research
2009 **Silver Medal**, Department of Commerce
2008 **Administrator's Award**, National Oceanic and Atmospheric Administration
2008 **Editors' Citation** for Excellence in Reviewing, Geophysical Research Letters
2005 **Silver Medal**, Department of Commerce
1993-1996 **NASA Graduate Student Fellowship in Global Change Research**
Provided funding for tuition, stipend, and travel
1991-1993 **Ernst Habicht Fellowship**, Harvard University
Provided funding for tuition and stipend
1991 Elected to **Phi Beta Kappa**
1987-1991 **John Harvard Scholarship**, Harvard College, for academic achievement

TEACHING EXPERIENCE

- 2003-present **Princeton University Visiting Lecturer**, Atmospheric and Oceanic Sciences Program
Atmospheric Chemistry, graduate-level class
- 1992-1997 **Harvard University Teaching Fellow**, Department of Earth and Planetary Sciences
Environmental Sciences, Professors Brian Farrell and Michael McElroy
Chemical Oceanography, Professor Heinrich Holland, graduate-level class
Atmospheric Chemistry, Professor Daniel Jacob
Environmental Pollution, Professors Raymond Siever and Daniel Jacob
- Fall 1993 **Harvard University Teaching Fellow**, Undergraduate Core Curriculum Program
The Atmosphere, Professors Michael McElroy and Daniel Jacob

LARRY WAYNE HOROWITZ

1990-1991 **Harvard University Course Assistant**, Department of Mathematics
Linear Algebra and Differential Equations, Professor Shlomo Sternberg
Multivariable Calculus, Professor David Kazhdan

PROFESSIONAL SERVICE AND AFFILIATIONS

2017-present **Earth System Working Group**, GFDL Model Development Team, co-Chair
2016-2018 **Fourth National Climate Assessment**, Air Quality Chapter, Author
2016-present **GFDL High-Performance Computing Advisory Group**, Member
2013-present **GFDL Diagnostics and Evaluation Team**, co-Chair (2013-2019)
2013-2018 **Graduate Work Committee**, Atmospheric and Oceanic Sciences, Princeton University
2007-2016 **Personnel Management Advisory Committee (PMAC IV)**, GFDL, Member
(Chair since 2012)
2002-present **Science**, Reviewer
2001-present **Atmospheric Chemistry and Physics**, Reviewer
2001-present **Geophysical Research Letters**, Reviewer
1999-present **Atmospheric Environment**, Reviewer
1999-present **Journal of Atmospheric Chemistry**, Reviewer
1999-present **National Science Foundation, Division of Atmospheric Sciences**, Reviewer
1998-present **Journal of Geophysical Research - Atmospheres**, Reviewer
1998-present **NASA Office of Earth Science, Atmospheric Chemistry Modeling and Analysis Program**, Reviewer
1996-present **American Geophysical Union**, Member

PUBLICATIONS

Held, I.M., H. Guo, A. Adcroft, J.P. Dunne, L.W. Horowitz, J. Krasting, E. Shevliakova, M. Winton, M. Zhao, M. Bushuk, A.T. Wittenberg, B. Wyman, B. Xiang, R. Zhang, W. Anderson, V. Balaji, L. Donner, K. Dunne, J. Durachta, P.P.G. Gauthier, P. Ginoux, J.-C. Golaz, S.M. Griffies, R. Hallberg, L. Harris, M. Harrison, W. Hurlin, J. John, P. Lin, S.-J. Lin, S. Malyshev, R. Menzel, P.C.D. Milly, Y. Ming, V. Naik, D. Paynter, F. Paulot, V. Ramawsamy, B. Reichl, T. Robinson, A. Rosati, C. Seman, L.G. Silvers, S. Underwood, and N. Zadeh, Structure and performance of GFDL's CM4.0 climate model, *J. Adv. Model. Earth Syst.*, *11*, <https://doi.org/10.1029/2019MS001829>, 2019.

Irvine, P., K. Emanuel, J. He, L.W. Horowitz, G. Vecchi, and D. Keith, Halving warming with idealized solar geoengineering moderates key climate hazards, *Nature Clim. Change*, *9*, 295-299, doi:10.1038/s41558-019-0398-8, 2019.

Lin, M., S. Malyshev, E. Shevliakova, F. Paulot, L.W. Horowitz, S. Fares, T.N. Mikkelsen, and L. Zhang, Sensitivity of ozone dry deposition to ecosystem-atmosphere interactions: A critical appraisal of observations and simulations, *Global Biogeochem. Cycles*, *33*, 1264-1288, <https://doi.org/10.1029/2018GB006157>, 2019

Qin, Y., Y. Fang, X. Li, V. Naik, L.W. Horowitz, J. Liu, N. Scovronick, and D.L. Mauzerall, Source attribution of black carbon affecting regional air quality, premature mortality and glacial deposition in 2000, *Atmos. Environ.*, *206*, 144-155, doi:10.1016/j.atmosenv.2019.02.048, 2019.

LARRY WAYNE HOROWITZ

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- Yang, W., G. Vecchi, S. Fueglistaler, L.W. Horowitz, D.J. Luet, Á.G. Muñoz, D. Paynter, and S. Underwood, Climate impacts from large volcanic eruptions in a high-resolution climate model: The importance of forcing structure, *Geophys. Res. Lett.*, 46, 7690-7699, <https://doi.org/10.1029/2019GL082367>, 2019.
- Conley, A.J., D.M. Westervelt, J.F. Lamarque, A.M. Fiore, D. Shindell, G. Correa, G. Faluvegi, and L.W. Horowitz, Multimodel surface temperature responses to removal of U.S. sulfur dioxide emissions, *J. Geophys. Res. Atmos.*, 123, 2773-2796, <https://doi.org/10.1002/2017JD027411>, 2018.
- Dhomse, S., D. Kinnison, M.P. Chipperfield, I. Cionni, M. Hegglin, N.L. Abraham, H. Akiyoshi, A.T. Archibald, E.M. Bednarz, S. Bekki, P. Braesicke, N. Butchart, M. Dameris, M. Deushi, S. Frith, S.C. Hardiman, B. Hassler, L.W. Horowitz, R.-M. Hu, P. Jöckel, B. Josse, O. Kirner, S. Kremser, U. Langematz, J. Lewis, M. Marchand, M. Lin, E. Mancini, V. Marécal, M. Michou, O. Morgenstern, F.M. O'Connor, L. Oman, G. Pitari, D.A. Plummer, J.A. Pyle, L.E. Revell, E. Rozanov, R. Schofield, A. Stenke, K. Stone, K. Sudo, S. Tilmes, D. Visioni, Y. Yamashita, and G. Zeng, Estimates of ozone return dates from Chemistry-Climate Model Initiative simulations, *Atmos. Chem. Phys.*, 18, 8409-8438, <https://doi.org/10.5194/acp-18-8409-2018>, 2018.
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- Li, J., J. Mao, A.M. Fiore, R.C. Cohen, J.D. Crouse, A.P. Teng, P.O. Wennberg, B.H. Lee, F.-D. Lopez-Hilfiker, J.A. Thornton, J. Peischl, I.B. Pollack, T.B. Ryerson, P. Veres, J.M. Roberts, J.A. Neuman, J.B. Nowak, G.M. Wolfe, T.F. Hanisco, A. Fried, H.B. Singh, J. Dibb, F. Paulot, and L.W. Horowitz, Decadal changes in summertime reactive oxidized nitrogen and surface ozone over the Southeast United States, *Atmos. Chem. Phys.*, 18, 2341-2361, doi:10.5194/acp-18-2341-2018, 2018.
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LARRY WAYNE HOROWITZ

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- Schnell, J. L., V. Naik, L.W. Horowitz, F. Paulot, J. Mao, P. Ginoux, M. Zhao, and K. Ram, Exploring the relationship between surface PM_{2.5} and meteorology in Northern India, *Atmos. Chem. Phys.*, *18*, 10157-10175, <https://doi.org/10.5194/acp-18-10157-2018>, 2018.
- Turner, A.J., I. Fung, V. Naik, L.W. Horowitz, and R.C. Cohen, Modulation of hydroxyl variability by ENSO in the absence of external forcing, *Proc. Natl. Acad. Sci.*, *115*, 8931-8936, doi:10.1073/pnas.1807532115, 2018.
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- Zhao, M., J.-C. Golaz, I.M. Held, H. Guo, V. Balaji, R. Benson, J.-H. Chen, X. Chen, L.J. Donner, J.P. Dunne, K. Dunne, J. Durachta, S.-M. Fan, S.M. Freidenreich, S.T. Garner, P. Ginoux, L.M. Harris, L.W. Horowitz, J.P. Krasting, A.R. Langenhorst, Z. Liang, P. Lin, S.-J. Lin, S.L. Malyshev, E. Mason, P.C.D. Milly, Y. Ming, V. Naik, F. Paulot, D. Paynter, P. Phillipps, A. Radhakrishnan, V. Ramaswamy, T. Robinson, D. Schwarzkopf, C.J. Seman, E. Shevliakova, Z. Shen, H. Shin, L.G. Silvers, J.R. Wilson, M. Winton, A.T. Wittenberg, B. Wyman, B. Xiang, The GFDL global atmosphere and land model AM4.0/LM4.0: 1. Simulation characteristics with prescribed SSTs, *J. Adv. Model. Earth Syst.*, *10*, <https://doi.org/10.1002/2017MS001208>, 2018.
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LARRY WAYNE HOROWITZ

- Guo, Y., J. Liu, D.L. Mauzerall, X. Li, L.W. Horowitz, W. Tao, and S. Tao, Long-lived species enhance summertime attribution of North American ozone to upwind sources, *Environ. Sci. Technol.*, *51*, doi:10.1021/acs.est.6b05664, 2017.
- Li, Z., J. Liu, D.L. Mauzerall, X. Li, S. Fan, L.W. Horowitz, C. He, K. Yi, and S. Tao, A potential large and persistent black carbon forcing over Northern Pacific inferred from satellite observations, *Sci. Rep.*, *7*, 43429, doi:10.1038/srep43429, 2017.
- Lin, M., L.W. Horowitz, R. Payton, A.M. Fiore, and G. Tonnesen, US surface ozone trends and extremes from 1980-2014: Quantifying the roles of rising Asian emissions, domestic controls, wildfires, and climate, *Atmos. Chem. Phys.*, doi:10.5194/acp-17-2943-2017, 2017.
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- Morgenstern, O., M.I. Hegglin, E. Rozanov, F.M. O'Connor, N.L. Abraham, H. Akiyoshi, A.T. Archibald, S. Bekki, N. Butchart, M.P. Chipperfield, M. Deushi, S.S. Dhomse, R.R. Garcia, S.C. Hardiman, L.W. Horowitz, P. Jöckel, B. Josse, D. Kinnison, M. Lin, E. Mancini, M.E. Manyin, M. Marchand, V. Marécal, M. Michou, L.D. Oman, G. Pitari, D.A. Plummer, L.E. Revell, D. Saint-Martin, R. Schofield, A. Stenke, K. Stone, K. Sudo, T.Y. Tanaka, S. Tilmes, Y. Yamashita K. Yoshida, and G. Zeng, Review of the global models used within phase 1 of the Chemistry-Climate Model Initiative (CCMI), *Geosci. Model Dev.*, *10*, 639-671, doi:10.5194/gmd-10-639-2017, 2017.
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- Silva, R.A., J.J. West, J.-F. Lamarque, D.T. Shindell, W.J. Collins, G. Faluvegi, G.A. Folberth, L.W. Horowitz, T. Nagashima, V. Naik, S.T. Rumbold, K. Sudo, T. Takemura, D. Bergmann, P. Cameron-Smith, R.M. Doherty, B. Josse, I.A. MacKenzie, D.S. Stevenson, and G. Zeng, Future global mortality from changes in air pollution attributable to climate change, *Nature Clim. Change*, doi:10.1038/nclimate3354, 2017.

LARRY WAYNE HOROWITZ

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LARRY WAYNE HOROWITZ

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PRESENTATIONS

- Climate Change, Fifth Grade Class, Millstone River School, Plainsboro, NJ, March 2019.
- Historical evolution of climate, air quality, and aerosol effective radiative forcing in GFDL's CM4 and ESM4 coupled models, AGU Fall Meeting, Washington, DC, December 2018.

LARRY WAYNE HOROWITZ

- Effective radiative forcing and climate response from aerosols and ozone in GFDL-CM3 coupled chemistry-climate model, AGU Fall Meeting, New Orleans, LA, December 2017.
- Quality controlling CMIP datasets at GFDL, AGU Fall Meeting, New Orleans, LA, December 2017.
- Impacts of ozone changes on climate in GFDL-CM3, Ozone-climate workshop, Massachusetts Institute of Technology, June 2016.
- The influence of short-lived air pollutants on climate, Princeton University, Science, Technology and Environmental Policy program seminar, December 2012.
- Historical and Future Climate Change Simulated by GFDL's CM3 Coupled Model, NOAA Geophysical Fluid Dynamics Laboratory, seminar, May 2012.
- Tropospheric chemistry and climate, Geosciences Department, Princeton University, seminar, April 2008.
- Observational constraints on the chemistry of isoprene nitrates over the eastern United States, Department of Environmental Sciences, Rutgers University, seminar, April 2007.
- Impact of meteorology and emissions on methane trends, 1990-2004, AGU Joint Assembly, Baltimore, MD, May 2006.
- MOZART Photochemistry and Transport Modeling for ICARTT, ICARTT Data Analysis Workshop, Durham, NH, August 2005.
- Tropospheric ozone and aerosols, GFDL/Hadley Centre Meeting, Princeton, NJ, November 2003.
- Tropospheric chemistry and aerosol modeling in AM2, NCAR-GFDL Model Development Meeting, Princeton, NJ, October 2003.
- MOZART-2 modeling in ITCT 2K2 and 2K4, Planning Meeting for Summer 2004 Atmospheric Research Campaigns, Durham, NH, April 2003.
- Trans-Pacific transport of pollution during ITCT 2K2, ITCT 2K2 Data Workshop, Boulder, CO, March 2003.
- Chemical weather forecasts using the MOZART-2 global model in ITCT 2K2, AGU Fall Meeting, San Francisco, CA, December 2002.
- Ozone and aerosol modeling: Radiative forcing and air quality, GFDL-NOAA Meeting, Princeton, NJ, November 2002.
- Ozone and aerosol modeling: Radiative forcing and air quality, NOAA/OAR Senior Research Council Meeting, Princeton, NJ, November 2002.
- Ozone and aerosol modeling: Radiative forcing and air quality, NCAR/GFDL Joint Atmospheric Model Development Workshop, November 2002.
- Chemical transport models and applications, NOAA/OAR Aerosol-Tropospheric Ozone Research Workshop, Boulder, CO, October 2002.
- Budget of tropospheric ozone in MOZART-2, Max Planck Institute for Meteorology, Hamburg, Germany, June 2002.
- Overview of MOZART-2, ITCT 2K2 Planning Meeting, Boulder, CO, November 2001.
- Status of MOZART-2, MOZART Workshop, Boulder, CO, November 2001.
- Global simulation of tropospheric ozone and related tracers: Description and evaluation of MOZART, version 2, AGU Spring Meeting, Boston, MA, May 2001.
- A global simulation of tropospheric ozone and related tracers: Description and evaluation of MOZART, version 2, MOZART Workshop, NCAR, Boulder, CO, April 2001.
- MOZART-2: Recent updates and comparison with observations, MOZART Workshop, UIUC, Urbana-Champaign, IL, September 2000.
- MOZART-2: Model evaluation and recent updates, MOZART Workshop, Nederland, CO, May 2000.
- MOZART-2: Model description and evaluation, MOZART Workshop, Max Planck Institute for Meteorology, Hamburg, Germany, January 2000.
- Update on model development at NCAR and status of IPCC effort, NCAR/LLNL Model Symposium, NCAR, Boulder, CO, October 1999.

LARRY WAYNE HOROWITZ

Global simulation of tropospheric ozone using MOZART-2, NCAR/ASP Research Report, Boulder, CO, October 1999.

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Model Simulation of Tropical Tropospheric Ozone, and Its Dependence on Biomass Burning, Lightning, and Convection, AGU Spring Meeting, Boston, MA, June 1999.

Tropospheric ozone in the tropics: The role of biomass burning and lightning, NCAR/ASP Presentation, Boulder, CO, May 1999.

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Tropospheric ozone in the tropics: The role of convection, NCAR/ASP Research Report, Boulder, CO, May 1998.

Update on recent work on the MOZART model, NCAR/ACD Presentation, Boulder, CO, March 1998.

The impact of fossil fuel combustion on the global distributions of tropospheric nitrogen oxides and ozone, AGU Fall Meeting, San Francisco, CA, December 1997.

The effect of non-methane hydrocarbons on the export of reactive nitrogen from North America during summertime, AGU Fall Meeting, San Francisco, CA, December 1996.