

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.

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- 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
2014-2022 **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

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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 2012-2016)
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 and Atmospheric Composition: Campaign Data Analysis and Modeling**, Reviewer
1996-present **American Geophysical Union**, Member

PUBLICATIONS

Bowman, H., S. Turnock, S.E. Bauer, K. Tsigaridis, M. Deushi, N. Oshima, F.M. O'Connor, L. Horowitz, T. Wu, J. Zhang, D. Kubistin, and D.D. Parrish, Changes in anthropogenic precursor emissions drive shifts in the ozone seasonal cycle throughout the northern midlatitude troposphere, *Atmos. Chem. Phys.*, 22, 3507-3524, <https://doi.org/10.5194/acp-22-3507-2022>, 2022.

Paulot, F., V. Naik, and L. Horowitz, Reduction in near-surface wind speeds with increasing CO₂ may worsen winter air quality in the Indo-Gangetic Plain, *Geophys. Res. Lett.*, in press, 2022.

Xie, Y., M. Lin, B. Decharme, C. Delire, L.W. Horowitz, D.M. Lawrence, F. Li, and R. Séférian, Tripling of western US particulate pollution from wildfires in a warming climate, *Proc. Natl. Acad. Sci.*, 119(14), e2111372119, doi:10.1073/pnas.2111372119, 2022.

Zanis, P., D. Akritidis, S. Turnock, V. Naik, S. Szopa, A.K. Georgoulas, S.E. Bauer, M. Deushi, L.W. Horowitz, J. Keeble, P. Le Sager, F.M. O'Connor, N. Oshima, K. Tsigaridis, and T. van Noije, Climate change penalty and benefit on surface ozone: a global perspective based on CMIP6 earth system models, *Environ. Res. Lett.*, 17, 024014, 2022.

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- Zeng, G., O. Morgenstern, J.H.T. Williams, F.M. O'Connor, P.T. Griffiths, J. Keeble, M. Deushi, L.W. Horowitz, V. Naik, L.K. Emmons, N.L. Abraham, A.T. Archibald, S.E. Bauer, B. Hassler, M. Michou, M.J. Mills, L.T. Murray, N. Oshima, L.T. Sentman, S. Tilmes, K. Tsigaridis, and P.J. Young, Attribution of stratospheric and tropospheric ozone changes between 1850 and 2014 in CMIP6 models, *J. Geophys. Res. Atmos.*, *127*, e2022JD036452, <https://doi.org/10.1029/2022JD036452>, 2022.
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- Derwent, R.G., D.D. Parrish, A.T. Archibald, M. Deushi, S.E. Bauer, K. Tsigaridis, D. Shindell, L.W. Horowitz, M.A.H. Khan, D.E. Shallcross, Intercomparison of the representations of the atmospheric chemistry of pre-industrial methane and ozone in earth system and other global chemistry-transport models, *Atmos. Environ.*, *248*, 118248, <https://doi.org/10.1016/j.atmosenv.2021.118248>, 2021.
- Griffiths, P.T., L.T. Murray, G. Zeng, Y.M. Shin, N.L. Abraham, A.T. Archibald, M. Deushi, L.K. Emmons, I.E. Galbally, B. Hassler, L.W. Horowitz, J. Keeble, J. Liu, O. Moeini, V. Naik, F.M. O'Connor, N. Oshima, D. Tarasick, S. Tilmes, S.T. Turnock, O. Wild, P.J. Young, and P. Zanis, Tropospheric ozone in CMIP6 simulations, *Atmos. Chem. Phys.*, *21*, 4187-4218, <https://doi.org/10.5194/acp-21-4187-2021>, 2021.
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- Keeble, J., B. Hassler, A. Banerjee, R. Checa-Garcia, G. Chiodo, S. Davis, V. Eyring, P.T. Griffiths, O. Morgenstern, P. Nowack, G. Zeng, J. Zhang, G. Bodeker, S. Burrows, P. Cameron-Smith, D. Cugnet, C. Danek, M. Deushi, L.W. Horowitz, A. Kubin, L. Li, G. Lohmann, M. Michou, M.J. Mills, P. Nabat, D. Olivié, S. Park, Ø. Seland, J. Stoll, K.-H. Wieners, and T. Wu, Evaluating stratospheric ozone and water vapor changes in CMIP6 models from 1850 to 2100, *Atmos. Chem. Phys.*, *21*, 5015-5061, <https://doi.org/10.5194/acp-21-5015-2021>, 2021.
- Ming, Y., N.G. Loeb, P. Lin, Z. Shen, V. Naik, C.E. Singer, R.X. Ward, F. Paulot, Z. Zhang, N. Bellouin, L.W. Horowitz, P.A. Ginoux, and V. Ramaswamy, Assessing the influence of COVID-19 on the shortwave radiative fluxes over the East Asian marginal seas, *Geophys. Res. Lett.*, *48*, e2020GL091699, <https://doi.org/10.1029/2020GL091699>, 2021.
- Murray, L.T., A.M. Fiore, D.T. Shindell, V. Naik, and L.W. Horowitz, Large uncertainties in global hydroxyl projections tied to fate of reactive nitrogen and carbon, *Proc. Natl. Acad. Sci.*, *118*, e2115204118, doi:10.1073/pnas.2115204118, 2021.
- Paulot, F., D. Paynter, V. Naik, S. Malyshev, R. Menzel, and L.W. Horowitz, Global modeling of hydrogen using GFDL-AM4.1: Sensitivity of soil removal and radiative forcing, *Int. J. Hydrog. Energy*, <https://doi.org/10.1016/j.ijhydene.2021.01.088>, *46*(24), 13,446-13,460, 2021.

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- Clifton, O.E., D.L. Lombardozzi, A.M. Fiore, F. Paulot, and L.W. Horowitz, Stomatal conductance influences interannual variability and long-term changes in regional cumulative plant uptake of ozone, *Environ. Res. Lett.*, *15*, 114059, 2020.
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- Horowitz, L.W., V. Naik, F. Paulot, P.A. Ginoux, J.P. Dunne, J. Mao, J. Schnell, X. Chen, J. He, J.G. John, M. Lin, P. Lin, S. Malyshev, D. Paynter, E. Shevliakova, M. Zhao, The GFDL Global Atmospheric Chemistry-Climate Model AM4.1: Model Description and Simulation Characteristics, *J. Adv. Model. Earth Syst.*, *12*, e2019MS002032, <https://doi.org/10.1029/2019MS002032>, 2020.

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- Paulot, F., D. Paynter, M. Winton, P. Ginoux, M. Zhao, and L.W. Horowitz, Revisiting the impact of sea salt on climate sensitivity, *Geophys. Res. Lett.*, 47, e2019GL085601, <https://doi.org/10.1029/2019GL085601>, 2020.
- Paulot, F., C. Stock, J.G. John, N. Zadeh, and L.W. Horowitz, Ocean ammonia outgassing: Modulation by CO₂ and anthropogenic nitrogen deposition, *J. Adv. Model. Earth Syst.*, 12, e2019MS002026, <https://doi.org/10.1029/2019MS002026>, 2020.
- Schnell, J.L., V. Naik, L.W. Horowitz, F. Paulot, P. Ginoux, M. Zhao, and D.E. Horton, Corrigendum to “Air quality impacts from the electrification of light-duty passenger vehicles in the United States” [Atmos. Environ. 208 (2019) 95–102], *Atmos. Environ.*, 229, 117487, <https://doi.org/10.1016/j.atmosenv.2020.117487>, 2020.
- Skeie, R.B., G. Myhre, Ø. Hodnebrog, P.J. Cameron-Smith, M. Deushi, M.I. Hegglin, L.W. Horowitz, R.J. Kramer, M. Michou, M.J. Mills, D.J.L. Olivié, F.M. O'Connor, D. Paynter, B.H. Samset, A. Sellar, D. Shindell, T. Takemura, S. Tilmes, and T. Wu, Historical total ozone radiative forcing derived from CMIP6 simulations, *npj Clim. Atmos. Sci.*, 3, 32, <https://doi.org/10.1038/s41612-020-00131-0>, 2020.
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PRESENTATIONS

- Climate Science Workshop, Princeton Learning Cooperative, Princeton, NJ, May 2022.
- Sensitivity of ozone dry deposition to ecosystem-atmosphere interactions: A critical appraisal of observations and simulations, AGU Fall Meeting, San Francisco, CA, December 2019.
- 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.
- 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.

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- 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.
- Global simulation of tropospheric ozone using MOZART-2, NCAR/ASP Research Report, Boulder, CO, October 1999.
- Current status of MOZART-2, MOZART Workshop, NCAR, Boulder, CO, September 1999.
- Tropical tropospheric ozone: The role of biomass burning and lightning, NCAR/ACD Research Report, Boulder, CO, July 1999
- 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.
- 2-D and 3-D chemical transport modelling: Preliminary results and future plans for the MOZART-2 model, NCAR/ASP Research Report, Boulder, CO, October 1998.
- 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.

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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.