

# DANIEL A. ROTHENBERG

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## RESEARCH INTERESTS

My research focuses on the multi-faceted role of aerosols in the climate system, particularly their influences on clouds and indirect effects on climate. I am also interested in climate variability, air quality, policy, and “big data” issues in the geosciences including the design and construction of open source software and tools to support novel applications of machine learning and data science to the modeling and analysis of atmospheric and climatic phenomena.

## EDUCATION

**Massachusetts Institute of Technology, Cambridge, MA**  
Ph.D., Atmospheric Science, Dept. of Earth, Atmospheric and Planetary Sciences 2016  
*Committee:* Chien Wang, Dan Czizco, Paul O’Gorman, Steve Ghan  
*Dissertation Title:* Fundamental Aerosol Interactions and the Aerosol Indirect Effect on Climate

**Cornell University, Ithaca, NY**  
B.S., Atmospheric Science, *magna cum laude*, Honors in Research 2010  
*Thesis Advisor:* Natalie Mahowald  
*Thesis Title:* Volcano Impacts on Climate and Biogeochemistry

## HONORS AND AWARDS

Outstanding Student Presentation Award (†), AMS 2015  
National Science Foundation Graduate Research Fellowship, NSF 2012  
National Defense Science And Engineering Fellowship, ASEE (*declined*) 2012  
Father James B. Macelwane Award in Meteorology, AMS 2011  
Klein Fellowship, MIT-EAPS 2011  
Charney Prize, MIT-EAPS 2011  
Academic Excellence Award - Atmospheric Science, Cornell/CALS 2011  
Richard and Helen Hagermeyer Scholarship, AMS 2010

## RESEARCH EXPERIENCE

**Center for Global Change Science, MIT, Cambridge, MA**  
*Postdoctoral Associate* DEC 2016-SEP 2017  
Studied interactions between air quality, climate variability and climate change funded through an EPA Air Quality, Climate, and Energy Center grant, supervised by Noelle Selin and Susan Solomon  
Analyzed large ensemble of IGSM/GEOS-Chem simulations to understand state-dependence of climate penalty calculations  
Studied potential short-term policy impacts on air quality, health and the economy using a novel integrated assessment framework

**Program in Atmospheres, Oceans, and Climate, MIT, Cambridge, MA**  
*Research Assistant* 2011-2016  
Used novel uncertainty quantification techniques to develop emulator of droplet activation for parameterization in global models  
Developed an open-source, modular parcel modeling framework for studying droplet activation from diverse aerosol populations and for evaluating activation schemes  
Used global climate models (CESM, CMIP5 archive, AEROCOM Indirect Effects Experiment) to study aerosol indirect effects and aerosol-cloud interactions  
Participated in Fifth Ice Nucleation Workshop Part 2 in Karlsruhe, Germany; assisted with the operation of the Spectrometer for Ice Nucleation (SPIN) and developed software for automating the instrument and designing experiment setups

**Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, NY***Undergraduate Research Assistant*

2008-2011

Studied biogeochemical/climate processes and interactions with a coupled carbon-climate model  
 Performed and analyzed fully-coupled model simulations studying transient climate change in the 20th century

**Center for Multiscale Modeling of Atmospheric Processes, Colorado State University,**

Fort Collins, CO

*Summer Intern*

SUMMER 2010

Implemented and evaluated a baroclinic instability test case on a very high resolution global atmospheric dynamical core, identifying numerical problems  
 Developed novel visualization tools for analyzing model data on geodesic computational meshes

**PROFESSIONAL  
ACTIVITIES****Rossbypalooza, Climate/Statistics Summer School, University of Chicago, Chicago, IL** SUMMER 2016**NSPG, STEM on the Hill Congressional Visits Day, Washington, DC** SPRING 2015**AMS, Weather Water and Climate Day, Washington, DC** JUNE 2015**AMS, 7th Annual Geosciences Congressional Visits Day, Washington, DC** SEPTEMBER 2014**AMS, Summer Policy Colloquium, Washington, DC** SUMMER 2014**MIT/SPI, ASTE Science/Engineering Congressional Visits Day, Washington, DC** SPRING 2012/2014**CMMAP/NCAR/NCEP, Summer School on Atmospheric Modeling, Boulder, CO** SUMMER 2010**TEACHING  
EXPERIENCE***Graduate***Global Warming Science (12.340x)**

SPRING 2016

MIT-EdX and MIT, Department of Earth, Atmospheric and Planetary Sciences  
 Teaching Assistant

**Atmospheric Physics and Chemistry (12.806/12.306)**

SPRING 2014-2015

MIT, Department of Earth, Atmospheric, and Planetary Sciences  
 Teaching Assistant

**"Climate Change Science" IAP Seminar**

WINTER 2011-2013

MIT, Joint Program on the Science and Policy of Global Change  
 Lecturer

*Undergraduate***Object-Oriented Programming and Data Structures (CS 2110)**

2009-2010

Cornell University, Department of Computer Science  
 Course Consultant, Teaching Assistant

**LEADERSHIP  
AND  
SERVICE****American Meteorological Society**

Annual Meeting Oversight Committee

Member

2017-PRESENT

Student Conference Planning Committee

Co-Chair

2015-2016

Session Chair

2011-2014

AMS Committee on Environmental Information Processing Technologies

Member, Python Symposium Committee

2018-PRESENT

Session Chair, *Teaching, Training, Outreach, and Building Communities around Python* 2018  
 Panelist, *Status of AI [in the Atmospheric Sciences]* 2019  
 Session Co-organizer, *Scalable Operational Artificial Intelligence Applications with Python* 2019

#### Reviewer

Journal of Geophysical Research - Atmospheres  
 Journal of Climate  
 Atmospheric Chemistry and Physics  
 The Journal of Open Source Education  
 IBM World Community Grid

#### Pangeo-data

Founding Member and Developer 2016-PRESENT  
 Lead, Data Management Technical Working Group 2018-PRESENT

#### Graduate Climate Conference Executive Committee

MIT/Woods Hole Oceanographic Institution/University of Washington  
 Co-Chair 2013  
 Steering Committee Member 2015  
 Advisor; Fundraising Chair 2015

#### Atmospheric Sciences Seminar Committee

MIT Department of Earth, Atmospheric, and Planetary Sciences  
 Member 2012-2014  
 Chair 2014-2015

#### Science Policy Initiative Executive Committee

Massachusetts Institute of Technology 2013-2016

#### Climate Voices

Speaker 2016-2018

#### /r/science Moderator

Reddit (volunteer) 2010-2011, 2016

#### WORK EXPERIENCE

#### ClimaCell

Chief Scientist SEP 2018-PRESENT

Director of Meteorology AUG 2017-SEP 2018

Oversaw the research, development, and implementation of a real-time, global, high-resolution precipitation observation system using commercial cellular microwave links

Created and managed a long-term research and development roadmap aligned with emerging company business opportunities

Managed a team of physical scientists conducting research and product development to support company business initiatives

Established professional forecasting services unit within the company to broaden product portfolio in support of improving client satisfaction and retention

Developed and implemented a quantitative, precipitation nowcasting system optimized for performance on the cloud

Developed and prototyped cloud-optimized, tera-scale geoscientific data archival system

#### Google / Ravenbrook Software

2011

Contract Developer

Ported a high-performance algorithm used in surface temperature analysis at the National Climatic Data Center from Fortran to Python

Developed extensive documentation and test suite for algorithm  
 Identified and corrected numerous numerical and programming bugs and validated algorithm against synthetic datasets

### Orion Network Services

2006-2007

#### Software Developer

Developed an online river flooding visualization tool for NOAA using ArcGIS and other scripting tools

## PUBLICATIONS

### *In Prep / Review*

1. Koecorius, S., **et al**: [New particle formation and its effect on CCN abundance in the summer Arctic: a case study during PS106 cruise](#), Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2019-600, 2019. (*in review*)
2. **Rothenberg, D.**: Parameterization of sub-grid scale aerosol-cloud processes for climate models using auto-machine learning, (*in prep*)
3. **Rothenberg, D.**, Eastham, S., Monier, E., Garcia-Menendez, F., Solomon, S., and Selin, N.: Quantifying the “time of emergence” of air quality climate penalties (*in prep*)
4. Garimella, S., **Rothenberg, D.**, Wolf, M. J., Zawadowicz, M. A., Froyd, K. D., Murphy, D. M., Wang, C., and Czizco, D. J.: A previously unrealized climate and health co-benefit from reduced coal fly ash emissions (*in prep*)

### *Refereed / Peer-Reviewed*

1. Dimanchev, E. G., Paltesev, S., Yuan, M., **Rothenberg, D.**, Tessum, C. W., Marshall, J. D., and Selin, N. E.: [Health co-benefits of sub-national renewable energy policy in the US](#), Environ. Res. Lett. 14, 085012, doi:10.1088/1748-9326/ab31d9, 2019.
2. **Rothenberg, D.**, Wang, C., and Avramov, A.: [On the representation of aerosol activation and its influence on model-derived estimates of the aerosol indirect effect](#), Atmos. Chem. Phys., doi:10.5194/acp-18-7961-2018, 2018.
3. Demott, P. J., **et al**: [The Fifth International Workshop on Ice Nucleation phase 2 \(FIN-02\): Laboratory intercomparison of ice nucleation measurements](#), Atmos. Meas. Tech., 11, 6231-6257, doi:10.5194/amt-11-6231-2018, 2018.
4. Jin, Q., Grandey, B. S., **Rothenberg, D.**, Avramov, A., Wang, C.: [Impacts of Ship Emission Regulations, DMS Emissions, and Aerosol Mixing States on Cloud Radiative Effects of International Shipping Emissions](#), Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2018-416, 2018
5. Tong, C. H. M., Yim, S., **Rothenberg, D.**, Wang, C., Lin, C-Y, Chen, Y., Lau, N-C: [Projecting the impacts of atmospheric conditions under climate change on air quality over the Pearl River Delta region](#), Atmos. Environ., doi:10.1016/j.atmosenv.2018.08.053, 2018
6. Tong, C. H. M., Yim, S., Chen, Y., Lau, N-C, **Rothenberg, D.**: [Assessing the Impacts of Seasonal Atmospheric Conditions on Air Quality over the Pearl River Delta Region](#), Atmos. Environ., doi:10.1016/j.atmosenv.2018.08.053, 2018
7. Grandey, B. S., **Rothenberg, D.**, Avramov, A., Jin, Q., Lee, H., Wang, C.: [Effective radiative forcing in the aerosol—climate model CAM5.3-MARC-ARG compared to default CAM5.3](#), Atmos. Chem. Phys., 18, 15783-15810, doi:10.5194/acp-18-15783-2018, 2018
8. Garimella, S., **Rothenberg, D.**, Wang, C., Czizco, D. J.: [How uncertainty in field measurements of ice nucleating particles influences modeled cloud forcing](#), J. Atmos. Sci., doi:10.1175/JAS-D-17-0089.1, 2017
9. Garimella, S., **Rothenberg, D. A.**, Wolf, M. J., David, R. O., Kanji, Z. A., Wang, C., Roesch, M., and Czizco, D. J.: [Uncertainty in counting ice nucleating particles with continuous diffusion flow chambers](#), Atmos. Chem. Phys., 17, 10855-10864, doi:10.5194/acp-17-10855-2017, 2017.

10. **Rothenberg, Daniel** and Chien Wang: [An aerosol activation metamodel of v1.2.0 of the pyrcel cloud parcel model: development and offline assessment for use in an aerosol–climate model](#), *Geosci. Model Dev.*, 10, 1817–1833, doi:10.5194/gmd-10-1817-2017, 2017.
11. Garimella, S., Kristensen, T. B., Ignatius, K., Welti, A., Voigtländer, J., Kulkarni, G. R., Sagan, F., Kok, G. L., Dorsey, J., Nichman, L., **Rothenberg, D.**, Rösch, M., Kirchgäßner, A., Ladkin, R., Wex, H., Wilson, T. W., Ladino, L. A., Abbatt, J. P. D., Stetzer, O., Lohmann, U., Stratmann, F., and Cziczo, D. J.: [The SPectrometer for Ice Nuclei \(SPIN\): An instrument to investigate ice nucleation](#), *Atmos. Meas. Tech.*, doi:10.5194/amt-9-2781-2016, 2016.
12. **Rothenberg, Daniel** and Chien Wang: [Metamodeling of Droplet Activation for Global Climate Models](#), *J. Atmos. Sci.*, 73, 1255–1272. doi:10.1175/JAS-D-15-0223.1, 2016
13. **Rothenberg, D.**, Mahowald, N., Lindsay, K., Doney, S. C., Moore, J. K., and Thornton, P.: [Volcano impacts on climate and biogeochemistry in a coupled carbon–climate model](#), *Earth Syst. Dynam.*, 3, 121–136, doi:10.5194/esd-3-121-2012, 2012.
14. Mahowald, N., Lindsay, K., **Rothenberg, D.**, Doney, S. C., Moore, J. K., Thornton, P., Randerson, J. T., and Jones, C. D.: [Desert dust and anthropogenic aerosol interactions in the Community Climate System Model coupled-carbon-climate model](#), *Biogeosciences*, 8, 387–414, doi:10.5194/bg-8-387-2011, 2011.
15. Mahowald, N. M., Kloster, S., Engelstaedter, S., Moore, J. K., Mukhopadhyay, S., McConnell, J. R., Albani, S., Doney, S. C., Bhattacharya, A., Curran, M. A. J., Flanner, M. G., Hoffman, F. M., Lawrence, D. M., Lindsay, K., Mayewski, P. A., Neff, J., **Rothenberg, D.**, Thomas, E., Thornton, P. E., and Zender, C. S.: [Observed 20th century desert dust variability: impact on climate and biogeochemistry](#), *Atmos. Chem. Phys.*, 10, 10875–10893, doi:10.5194/acp-10-10875-2010, 2010.

#### *Other*

1. **Rothenberg, Daniel**: [Seeing through the haze to learn how clouds shape climate](#). *Physics Today*, doi:10.1063/PT.5.4027. February 2, 2017.

#### *Software*

1. **MARC: Model for Research of Aerosols and Climate**. doi:10.5281/zenodo.1117370. Last Updated: v1.0.4, December, 2017
2. **xbpch: xarray interface for bpch files**. doi:10.5281/zenodo.584153. Last Updated: vo.3.0, May, 2017.
3. **pyrcel: cloud parcel model**. doi: 10.5281/zenodo.163265. Last Updated: v1.3.0, October, 2016.
4. **py-mie: Python wrapper for Mie subroutines**. doi: Last Updated: vo.4.0, December, 2016
5. **experiment: high-performance, distributed processing of large-scale geophysical modeling experiment output (*in prep*)**
6. Contributor/collaborator: **GCPy, xarray, pangeo-data**

#### **PRESENTATIONS AND TALKS**

##### *Invited Talks*

**Rothenberg, D.**, Avramov, A., Wang, C., Garimella, S., Wolf, M., and Cziczo, D. Understanding Fundamental Aerosol-Cloud Interactions and their Contributions to the Aerosol Indirect Effect. NOAA Geophysical Fluid Dynamics Laboratory. Princeton, NJ. 2016

##### *Conference Talks*

**Rothenberg, Daniel**. [Rapidly Prototyping High-performance Meteorological Data Systems Using Xarray and Numba](#). Ninth symposium on Advances in Modeling and Analysis Using Python. Phoenix, AZ, 2019.

Gilford, D., Solomon, S., Emanuel, K., and **Rothenberg, D.** [Seasonal Cycles in North Atlantic and Western Pacific Tropical Cyclone Maximum Intensity](#). AMS Annual Meeting. Phoenix, AZ, 2019.

- Rothenberg, D.**, Garcia-Menendez, F., Solomon, S., and Selin, N. Regional Variation in the Time of Emergence of Air Quality Climate Penalties Under Climate Change Mitigation Scenarios. AMS Annual Meeting. Austin, 2018.
- Rothenberg, D.**, Wang, C., and Avramov, A. [Contributions of Uncertainty in Droplet Nucleation to the Indirect Effect in Global Models](#). AGU Fall Meeting. San Francisco, 2016. | [PPTX](#)
- Rothenberg, Daniel**. [A Python-based Parcel Model Framework for Studying Aerosol-Cloud Processes](#). Sixth Symposium on Advances in Modeling and Analysis Using Python. New Orleans, 2016. | [PDF](#)
- Rothenberg, D.**, Wang, C., and Avramov, A. [On the Sensitivity of Model-derived Estimates of Aerosol Indirect Effects and Forcings to Activation Schemes](#). 96th Annual Meeting of the American Meteorological Society, Eighth Symposium on Aerosol-Cloud-Climate Interactions. New Orleans, LA. 2016.
- † **Rothenberg, Daniel**, Chien Wang and Alexander Avramov. [Evaluating Advanced Aerosol Activation Treatments in a Coupled Climate/Mixing-State Resolving Aerosol Model](#). 95th Annual Meeting of the American Meteorological Society, 7th Symposium on Aerosol-Cloud-Climate Interactions. Phoenix, AZ. 2015. | [PDF](#)
- Rothenberg, Daniel** and Chien Wang. Evaluating the Role of Aerosol Mixing State in Cloud Droplet Nucleation using a New Activation Parameterization. American Geophysical Union Fall Meeting, (A34D-03). 2013.
- Rothenberg, Daniel** and Chien Wang. [Cloud and Climate Impacts in a Hazy World Simulation](#). 93rd Annual Meeting of the American Meteorological Society, 5th Symposium on Aerosol-Cloud-Climate Interactions. Austin, TX. 2014.
- Rothenberg, Daniel** and Nick Barnes. [Lessons From Deploying the USHCN Pairwise Homogenization Algorithm in Python](#). 92nd Annual Meeting of the American Meteorological Society, Second Symposium on Advances in Modeling and Analysis Using Python. New Orleans, LA. 2012

#### *Conference Posters*

- Rothenberg, Daniel** and Chien Wang. [Assessing Regional Differences in Aerosol-Cloud Interactions and their Contribution to the Global Indirect Effect](#). 97th Annual Meeting of the American Meteorological Society, Ninth Symposium on Aerosol-Cloud-Climate Interactions. Seattle, WA. 2017. | [PDF](#)
- Garimella, S., **Rothenberg, D.**, Wolf, M., Zawadowicz, M., Christopoulos, C., Froyd, K. D., Huang, Y.-w., Murphy, D., Wang, C., and Cziczo, C. Climate implications of coal fly ash particles due to ice cloud formation. 35th Annual Conference, American Association for Aerosol Research. Portland, OR. 2016.
- Rothenberg, D.**, Wang, C. and Avramov, A. Impacts of Droplet Activation on Fast and Slow Responses in a Coupled Aerosol-Climate Model. Gordon Research Seminar/Conference. Bates College, ME. 2015 | [PDF](#)
- Rothenberg, Daniel** and Chien Wang. Assessing the sensitivity of global aerosol indirect effects to activation treatment. Graduate Climate Conference, University of Washington. Seattle, WA. 2014
- Rothenberg, Daniel** and Chien Wang. [A Novel Parameterization of Droplet Activation Suitable for Global Climate Models](#). 14th Conference on Cloud Physics, American Meteorological Society. Boston, MA. 2014 | [PDF](#)
- Rothenberg, Daniel** and Chien Wang. [A Novel Parameterization of Droplet Activation Suitable for Global Climate Models](#). CENSAM Workshop. Singapore. 2014
- Rothenberg, Daniel** and Chien Wang. [Evaluating the Role of Aerosol Mixing State in Cloud Droplet Nucleation using a New Activation Parameterization](#). 94th Annual Meeting of the American Meteorological Society, Sixth Symposium on Aerosol-Cloud-Climate Interactions. Atlanta, GA. 2013. | [PDF](#)
- Rothenberg, Daniel** and Chien Wang. Global Climate Response to Enhanced Anthropogenic Aerosol Emissions in a “hazy world” Experiment with the CESM. 6th Graduate Climate Conference. 2013.



**Rothenberg, Daniel** and Ross Heikes. [A baroclinic instability test case on an anelastic dynamical core](#). 91st Annual Meeting of the American Meteorological Society, 24th Conference on Weather and Forecasting/20th Conference on Numerical Weather Prediction. Seattle, WA. 2012.

#### *Technical and Programming Talks*

**Rothenberg, Daniel**. Tutorial: Moving from Single Jobs to Many Nodes: Dask, X-Array, and Pangeo. 99th Annual Meeting of the American Meteorological Society, Ninth Symposium on Advances in Modeling and Analysis Using Python. Phoenix, AZ. 2019

**Rothenberg, Daniel**. Climate Data Science: A Framework for Improving Computational Climate Analysis. 98th Annual Meeting of the American Meteorological Society, Eighth Symposium on Advances in Modeling and Analysis Using Python. Austin, TX. 2018

**Rothenberg, Daniel**. [Basic Pandas](#). 97th Annual Meeting of the American Meteorological Society, Seventh Symposium on Advances in Modeling and Analysis Using Python. Seattle, WA. 2017

#### *Public Talks and Engagement*

Climate Chords. WUOL, WFPL, and SONICBernheim. Louisville, KY, August 2018

[What's the Deal with Climate Change?](#) Esplanade Association Lecture Series. Boston, MA. 2017

Additional talks to churches, community organizations, and classrooms through [Climate Voices](#).

*Note: annotations (†, etc) correspond to "Honors and Awards" section.*

#### PROFESSIONAL AFFILIATIONS

American Meteorological Society	2010-PRESENT
American Physical Society	2011-PRESENT
American Geophysical Union	2013-PRESENT
Association for Computing Machinery	2011-2012

#### TECHNICAL SKILLS

*Note: Please visit my [Github](#) page for examples of projects implementing these skills*

**Data Science** - Python (*expert*), Spark/dask/MPI, Matlab, Java, d3.js, git/hg/svn, R (*familiar*)

**Numerical Modeling** - Python/NumPy/Cython/Numba, Julia, legacy/modern Fortran, C/C++/CUDA (*familiar*); emphasis on scientific software design and application of software engineering to numerical codes/tools, as well as the development of high-performance, distributed analysis systems for tera/peta-scale data.

**Atmospheric/Climate Models** - [pyrcel](#), GEOS-Chem/GCHP, CESM, MIT-CRM, WRF (*familiar*)

**High-Performance Computing** - Google Cloud Platform/Amazon Elastic Compute Cloud; Multi-user clusters; NCAR supercomputers (bluefire/yellowstone/cheyenne); previously worked on NERSC and Oak Ridge systems

**Web Design** - Django, ghost, HTML/CSS

#### PERSONAL INTERESTS

Violin performance - classical (21 years), Winter sports, Backpacking/hiking, Software development/engineering, Meteorology education/forecasting, Debate and rhetoric, Science/Innovation policy

*Last Updated: August 12, 2019*