



Zachary L. Moon

Research interests

I am interested in the modeling of air quality, forest canopies, the atmospheric boundary layer, and forest-atmosphere interactions, with an emphasis on in-canopy processes that affect atmospheric chemistry. My PhD work focused on modeling of radiation and photochemistry inside plant canopies using one-dimensional models.


Experience

2022– **Scientific Software Engineer III**, *ERT, Inc. for NOAA ARL*, remote

Part of the Chemical Modeling and Emissions group within NOAA ARL, I work on software for evaluating air quality forecasts and improving NOAA's air quality modeling capability.

Education

2016–2022 **PhD Meteorology & Atmospheric Science**, *Penn State University*, University Park, PA

Thesis: Improving modeled light transfer within plant canopies: scheme comparisons and implications 

Committee: Jose D. Fuentes (advisor), William H. Brune, Miriam A. Freedman, Jerry Y. Harrington

2014–2016 **MS Geological Sciences – Atmospheric Science**, *Indiana University*, Bloomington, IN

Thesis: A modeling study of the impacts of the tropopause height on the structure of intense tropical cyclones






Committee: Chanh Kieu (advisor), Kaj Johnson, Scott Robeson





2010–2014 **BS Chemistry** *summa cum laude*, *Indiana University*, Bloomington, IN

GPA 3.91

Publications






Peer-reviewed journal articles















- 2024 11 Zhu, Q., R. H. Schwantes, M. Coggon, ..., **Z. Moon**, ..., R. C. Cohen, B. C. McDonald, May 2024: A Better Representation of Volatile Organic Compound Chemistry in WRF-Chem and Its Impact on Ozone over Los Angeles, *Atmospheric Chemistry and Physics*,  doi:10.5194/acp-24-5265-2024
- 10 Prein, A. F., Z. Feng, T. Fiolleau, **Z. L. Moon**, ..., Y. Mu, R. M. Rasmussen, April 2024: Km-Scale Simulations of Mesoscale Convective Systems Over South America—A Feature Tracker Intercomparison, *Journal of Geophysical Research: Atmospheres*,  doi:10.1029/2023JD040254
- 9 Dominguez, F., R. Rasmussen, C. Liu, ..., **Z. L. Moon**, ..., L. Xue, T. Schneider, January 2024: Advancing South American Water and Climate Science through Multidecadal Convection-Permitting Modeling, *Bulletin of the American Meteorological Society*,  doi:10.1175/BAMS-D-22-0226.1
- 8 He, J., C. Harkins, K. O'Dell, ..., **Z. Moon**, ..., G. González Abad, B. C. McDonald, January 2024: COVID-19 Perturbation on US Air Quality and Human Health Impact Assessment, *PNAS Nexus*,  doi:10.1093/pnasnexus/pgad483
- 2023 7 Campbell, P. C., W. (Rick) Jiang, **Z. Moon**, S. Zinn, Y. Tang, July 2023: NOAA's Global Forecast System Data in the Cloud for Community Air Quality Modeling, *Atmosphere*,  doi:10.3390/atmos14071110



- 2021 6 Núñez Ocasio, K. M., A. Brammer, J. L. Evans, G. S. Young, **Z. L. Moon**, September 2021: Favorable Monsoon Environment over Eastern Africa for Subsequent Tropical Cyclogenesis of African Easterly Waves, *Journal of the Atmospheric Sciences*,  doi:10.1175/JAS-D-20-0339.1
- 2020 5 **Moon, Z.**, J. D. Fuentes, R. M. Staebler, September 2020: Impacts of Spectrally Resolved Irradiance on Photolysis Frequency Calculations within a Forest Canopy, *Agricultural and Forest Meteorology*,  doi:10.1016/j.agrformet.2020.108012
- 2017 4 **Moon, Z.**, C. Kieu, July 2017: Impacts of the Lower Stratosphere on the Development of Intense Tropical Cyclones, *Atmosphere*,  doi:10.3390/atmos8070128
- 3 Ferrara, M., F. Groff, **Z. Moon**, ..., S. M. Robeson, C. Kieu, May 2017: Large-scale Control of the Lower Stratosphere on Variability of Tropical Cyclone Intensity, *Geophysical Research Letters*,  doi:10.1002/2017GL073327
- 2016 2 Kieu, C., V. Tallapragada, D.-L. Zhang, **Z. Moon**, July 2016: On the Development of Double Warm-Core Structures in Intense Tropical Cyclones, *Journal of the Atmospheric Sciences*,  doi:10.1175/JAS-D-16-0015.1
- 1 Kieu, C. Q., **Z. Moon**, April 2016: Hurricane Intensity Predictability, *Bulletin of the American Meteorological Society*,  doi:10.1175/BAMS-D-15-00168.1
- Forthcoming**
- Núñez Ocasio, K. M., C. A. Davis, Z. L. Moon, Q. A. Lawton: Moisture Dependence of an African Easterly Wave within the West African Monsoon System, *JAMES*. [in-revision]
 - Moon, Z., J. D. Fuentes: Evaluating numerical methods to investigate spectral solar radiative transfer in plant canopies, *JAMES*. [in-revision]
 - Núñez Ocasio, K. M., Z. Moon: TAMS: A Tracking, Classifying, and Variable-Assigning Algorithm for Mesoscale Convective Systems in Simulated and Satellite-Derived Datasets, *GMD*,  doi:10.5194/egusphere-2024-259 [submitted]
 - Hung, W.-T., P. C. Campbell, Z. Moon, R. Saylor, J. Kochendorfer, T. R. Lee, W. Massman: Evaluation of an In-Canopy Wind and Wind Adjustment Factor Model for Wildfire Spread and Air Quality Forecasting Applications, *JAMES*. [submitted]

Presentations

Conference

- 2024 31 Núñez Ocasio, K. M., C. Davis, **Z. Moon**, Q. A. Lawton: Moisture Sensitivity of the African Easterly Wave-African Easterly Jet and Convection Systems, *AMS 36th Conference on Hurricanes and Tropical Meteorology*, Long Beach, CA, May 2024 [talk] 
- 30 Feng, Z., R. Leung, ..., **Z. Moon**, ...: Mesoscale Convective Systems in DYAMOND Models: A Feature Tracking Intercomparison, *EGU General Assembly 2024*, Vienna, Austria, March 2024 [talk] 
- 29 Campbell, P. C., **Z. Moon**, W.-T. Hung, ..., R. Saylor: Development of Canopy-App for Atmospheric Composition Modeling Across Scales, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 28 Ortiz Rosario, S. M., K. M. Núñez Ocasio, **Z. Moon**, C. Davis: Environmental Moisture Influence on African Mesoscale Convective Systems, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 27 Ortiz Rosario, S. M., K. M. Núñez Ocasio, **Z. Moon**, C. Davis: Environmental Moisture Influence on African Mesoscale Convective Systems (MCSs), *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 

- 26 Marvin, M., B. Baker, P. C. Campbell, **Z. Moon**, W.-T. Hung: Parameterization of Leaf-Scale Biogenic Emissions for Application to Air Quality Models, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 25 Baker, B., **Z. Moon**, W.-T. Hung, ...: Development of a Data-Driven Machine-Learning Based Aeolian Threshold Friction Velocity with Applications to the NOAA FENGSHA Dust Emission Model in the Rapid Refresh Forecast System with Smoke and Dust (RRFS-SD) and the National Air Quality Forecast Capability (NAQFC), *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 24 Tang, B., B. Baker, P. C. Campbell, **Z. Moon**, ..., W.-T. Hung: Development of Multi-Layer Dry Deposition Mechanisms in Canopy-App, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 23 Hung, W.-T., P. C. Campbell, **Z. Moon**, ...: Development of a Global 1-km Vegetative Canopy Dataset Using Multi-platform Satellite Measurements, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 22 Li, W., B. Tang, ..., **Z. Moon**, ...: Upgrade the Chemistry Component of the Next Generation Regional Air Quality Forecast System: UFS-AQM, *AMS 104th Annual Meeting*, Baltimore, MD, January 2024 [talk] 
- 2023 21 Feng, Z., R. L. Leung, ..., **Z. Moon**: How Well do Global Convection-Permitting Models Simulate Mesoscale Convective Systems?, *AGU Fall Meeting 2023*, San Francisco, CA, December 2023 [talk] 
- 20 Zhu, Q., R. Schwantes, ..., B. Baker, **Z. Moon**: Improved WRF-Chem representation of VOC chemistry from VCP and cooking emissions, *AGU Fall Meeting 2023*, San Francisco, CA, December 2023 [talk] 
- 19 He, J., L. Zhang, B. Baker, ..., **Z. Moon**, ...: Development of Configurable ATmospheric Chemistry (CATChem) component within NOAA's Unified Forecasting System (UFS), *AGU Fall Meeting 2023*, San Francisco, CA, December 2023 [talk] 
- 18 Hung, W.-T., B. Baker, P. C. Campbell, ..., G.-R. Jeong, **Z. Moon**: Development and Evaluation of a Machine Learning Based Wildfire Spread Prediction Model for Regional Air Quality Forecasting, *AMS 14th Fire and Forest Meteorology Symposium*, Minneapolis, MN, 2023-05-04 [talk] 
- 17 **Moon, Z.**, P. C. Campbell, W.-T. Hung, B. Baker: A Model for Forest Canopy Effects on Weather and Atmospheric Composition in the NOAA Unified Forecast System, *AMS 35th Conference on Agricultural and Forest Meteorology and Sixth Conference on Atmospheric Biogeosciences*, Minneapolis, MN, 2023-05-02 [talk] 
- 16 Campbell, P. C., P. Makar, B. Baker, ..., W.-T. Hung, **Z. Moon**: Beyond the Big-Leaf Model for NOAA's Unified Air Quality Forecasting Capabilities, *AMS 14th Fire and Forest Meteorology Symposium*, Minneapolis, MN, 2023-05-02 [poster] 
- 15 Núñez Ocasio, K., **Z. Moon**: TAMS: A Tracking, Classifying, and Precipitation-Assigning Algorithm for Mesoscale Convective Systems in Simulated and Satellite-Derived Datasets, *University of Oxford Cloud Tracking Workshop*, Oxford, UK, 2023-04-18 [talk]
- 14 Baker, B., **Z. Moon**, W.-T. Hung, P. C. Campbell, R. Montuoro: Development of a Data-Driven Machine-Learning Based Aeolian Threshold Friction Velocity using a Soil Database, Reanalysis, and Observed Dust Point sources, *AMS 103rd Annual Meeting*, Denver, CO, January 2023 [poster] 
- 2022 13 Schwantes, R., L. K. Emmons, B. Baker, **Z. Moon**, ..., B. C. McDonald, G. J. Frost: MELODIES MONET – A New Community Diagnostic Tool for Evaluating Air Quality and Atmospheric Chemistry Models Against Observations, *AGU Fall Meeting 2022*, Chicago, IL, December 2022 [talk] 
- 12 **Moon, Z.**, P. C. Campbell, B. Baker: Canopy Radiative Transfer Spectral Resolution and Implications for In-Canopy Photolysis, *AGU Fall Meeting 2022*, Chicago, IL, December 2022 [talk] 

- 11 Campbell, P. C., W. (Rick) Jiang, S. Zinn, **Z. Moon**: Use of NOAA's Global Forecast System Data in the Cloud for Community Air Quality Modeling, *2022 CMAS Conference*, Chapel Hill, NC, October 2022 [talk] 
 - 2021 10 **Moon, Z.**, J. D. Fuentes, G. G. Katul: Sensitivity of Modeled Canopy Energy Balance and Convective Boundary Layer Development to Canopy Spectral Radiative Transfer, *AMS 34th Conference on Agricultural and Forest Meteorology*, virtual, June 2021 [talk] 
 - 9 Fuentes, J. D., **Z. Moon**, V. Saptoka, C. E. Forest, A. Mejia: Afforestation Versus Reforestation: Climate and Air Quality Interactions and Implications, *AMS 34th Conference on Agricultural and Forest Meteorology*, virtual, June 2021 [talk] 
 - 2020 8 **Moon, Z.**, J. D. Fuentes: Sensitivity of Modeled Leaf Temperature to Canopy Radiative Transfer Formulations, *AMS 100th Annual Meeting – 20th Symposium on Meteorological Observation and Instrumentation*, Boston, MA, January 2020 [talk] 
 - 7 Salinger, M. J., J. D. Fuentes, M. E. Mann, **Z. Moon**: Afforestation versus Reforestation in New Zealand: Effects on Regional Climate, *AMS 100th Annual Meeting – 33rd Conference on Climate Variability and Change*, Boston, MA, January 2020 [talk] 
 - 6 **Moon, Z.**, D. Wei, J. D. Fuentes, ..., W. H. Brune, J. J. Orlando: Oxidation of Isoprene and Monoterpenes as a Function of Nitrogen Oxides in the Amazon Rain Forest, *AMS 100th Annual Meeting – 22nd Conference on Atmospheric Chemistry*, Boston, MA, January 2020 [talk] 
 - 2018 5 **Moon, Z.**, J. D. Fuentes: Modeling the disposition of spectral actinic flux in a mixed deciduous forest canopy, *AMS Fourth Conference on Biogeosciences*, Boise, ID, May 2018 [talk]
 - 4 **Moon, Z.**, J. D. Fuentes: Modeling the disposition of spectral actinic flux in a mixed deciduous forest canopy, *NOAA Ninth Biennial EPP Forum*, Washington, D.C., March 2018 [talk]
 - 2016 3 **Moon, Z.**, C. Kieu: On the Role of the Tropopause Height in the Development of a Double Warm Core Structure in Intense Tropical Cyclones, *AMS 32nd Conference on Hurricanes and Tropical Meteorology*, San Juan, PR, April 2016 [talk]
 - 2 Kieu, C., **Z. Moon**: Upper Bound on Hurricane Intensity Forecast Errors, *AMS 32nd Conference on Hurricanes and Tropical Meteorology*, San Juan, PR, April 2016 [talk]
 - 1 Ferrara, M., F. Groff, **Z. Moon**, ..., S. M. Robeson, C. Kieu: Understanding the Climatological Connection of Tropical Cyclone Intensity and the Tropopause Variability, *AMS 32nd Conference on Hurricanes and Tropical Meteorology*, San Juan, PR, April 2016 [talk]
- [At Penn State](#)
- 2021 8 **Moon, Z.**: Modeling the Light Spectrum within Plant Canopies, *PhD Thesis Defense seminar*, University Park, PA, December 2021 [talk] 
 - 2019 7 **Moon, Z.**: Spectrally resolved canopy radiative transfer, *Frank Talk seminar series*, University Park, PA, December 2019 [talk]
 - 6 **Moon, Z.**: Photochemistry in plant canopies, *ESSC Brown Bag seminar series*, University Park, PA, December 2019 [talk]
 - 5 **Moon, Z.**: Understanding the role of in-canopy oxidation of biogenic emissions by advancing 1-D modeling capabilities, *PhD Comprehensive Exam seminar*, University Park, PA, November 2019 [talk]
 - 4 **Moon, Z.**: Photochemical loss of gases within plant canopies, *Frank Talk seminar series*, University Park, PA, April 2019 [talk]
 - 2018 3 **Moon, Z.**, J. D. Fuentes: Impact of spectral resolution and canopy radiative transfer scheme on photolysis calculations within a forest canopy, *PhD Candidacy Exam seminar*, University Park, PA, May 2018 [talk]

- 2017 2 **Moon, Z.**, J. D. Fuentes: Comparing four approaches to modeling vertical profiles of spectral actinic flux in a mixed deciduous forest canopy, *Graduate Technical English Exam talk*, University Park, PA, December 2017 [talk]
- 1 **Moon, Z.**, J. D. Fuentes: Modeling Profiles of Spectral Irradiance in the Borden Forest, *First-Year Graduate Student Symposium*, University Park, PA, August 2017 [talk]
- [Other](#)
- 2019 2 **Moon, Z.**, J. D. Fuentes, R. Saylor: Modeling radiative transfer in a forest canopy and its importance in a 1-D air chemistry model, *NOAA NCAS-M ProjectFest*, College Park, MD, September 2019 [poster]
- 2018 1 **Moon, Z.**, R. Saylor: Modeling radiative transfer in a forest canopy and its importance in a 1-D air chemistry model, *NOAA ARL/ATDD seminar*, Oak Ridge, TN, August 2018 [talk]

Teaching & Mentoring

[Penn State](#)

Teaching Assistant

- Fall 2020 Application of Computers to Meteorology (METEO 473)
Assisted students with Python and the Scientific Python stack during class and office hours, online via Zoom.
- Spring 2020 Atmospheric Thermodynamics (METEO 431)
Graded and corrected homework assignments and held office hours.
- Fall 2019 Application of Computers to Meteorology (METEO 473)
Assisted students with Python and the Scientific Python stack during class and office hours.
- Spring 2019 Mesoscale Meteorology (METEO 414)
Graded and corrected homework assignments.
- Spring 2017 Applications of Computers in Meteorology (METEO 473)
Prepared and gave several lectures.
- Fall 2016 Climate Dynamics (METEO 470)
Gave two lectures, one of which I prepared in full.

Mentoring

- Summer 2020 Penn State Climate Science REU – Elana Cope – “Data Acquisition Software for Tracking Foraging Patterns of Bees With Radar”
I provided feedback and assistance to Elana, who developed some Python code to visualize and analyze the motions of bees detected by radar.

[Indiana University](#)

Teaching Assistant

- Spring 2015 Fate of Environmental Pollutants (SPEA-E 564)
- Fall 2014 Intro. to Environmental Science (SPEA-E 272)
- Spring 2014 Intro. to Programming I (CSC-A 201)

[Other](#)

- July 2020 Howard University PBL Workshop
Created and presented a Python tutorial (github.com/zmoon/hu-pbl-workshop-2020) demonstrating xarray, Jupyter, Binder, and Matplotlib.

Mentoring

- Summer 2023 NCAR Earth System Science Internship (NESSI) – Stephanie Ortiz Rosaio, undergrad at UPRM
I was a “code mentor”, helping Stephanie with Python, Jupyter, and using TAMS and helping the other mentors with project design and providing feedback.
- April 2024 NCAR Student Visitor – Giselle Martinez, grad student at UW-Madison
Helped develop code for analysis of CPEX-CV, including using TAMS (Python).

————— Honors, Awards, & Fellowships

- 2021 Hans Neuberger Teaching Assistant Award, *Penn State Dept. of Meteorology & Atmospheric Science*
- Sp17–Fa18 NCAS-M Graduate Fellowship, *NOAA Center for Atmospheric Science and Meteorology*
- 2016 FEGR 1st-year graduate fellowship, *Penn State Graduate School*
- 2014 College of Arts & Sciences Graduate Fellowship, *Indiana University*
- 2013 Phi Beta Kappa Honor Society inductee
- 2009 National Merit Scholar

————— Professional activities

- 2015–2021 Student Member, *American Meteorological Society (AMS)*
- 2022– Full Member, *American Geophysical Union (AGU)*

————— Other employment

- 2015–2021 RA/TA, *Indiana University and Penn State University*
- 2011–2015 Starbucks Shift Supervisor, *The Indiana Memorial Union, Bloomington, IN*

————— Computer skills

OS	macOS, Windows, Linux	office suites	Microsoft Office, LibreOffice
programming	Python, Fortran	numerical	MATLAB, R
shell	Bash	misc	HTML/CSS, Git, GitHub, GrADS
some exp.	Julia, JavaScript, NCL, Lua, Jekyll/SASS, Ruby, (t)csh, C, Rust, Haskell, SQL		

————— Languages

English	mother tongue	Spanish	basic
French	basic (studied in high school)	Latin	basic (studied in undergrad)

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