

Education

- Princeton University**, Princeton, NJ
Ph.D., Atmospheric and Oceanic Sciences Sept. 2019
 Advisor: Yi Ming
- Princeton University**, Princeton, NJ
M.A., Atmospheric and Oceanic Sciences Sept. 2016
- Cornell University**, Ithaca, NY
B.S., Engineering Physics; Honors in Research; magna cum laude May 2014
 Thesis Advisor: Natalie Mahowald

Experience

- Allen Institute for Artificial Intelligence**, Princeton, NJ
Research Scientist Sept. 2021 - Present
- Applying corrective ML parameterization via coarse graining to improve the coarse-resolution simulation of land precipitation and surface temperature in multi-year simulations in multiple climates.
- Vulcan Inc.**, Princeton, NJ
Software Engineer for Climate Model Development Aug. 2019 - Aug. 2021
- Supported Vulcan Climate Modeling's efforts as a member of both VCM's ML team and GFDL's SHIELD model development team.
 - Contributed code to GFDL's SHIELD model to enable online coarse-graining of diagnostics and model restart files in physically consistent ways. Ran multiple global 3-km resolution simulations with outputs coarse-grained online to 25-km resolution to produce 50+ TB datasets with high frequency output for machine learning training and testing.
 - Helped build and use infrastructure to run a Python-wrapped version of NOAA's FV3GFS model for machine learning experiments, in which output from the 3-km runs was used to train ML models to improve coarse-resolution simulations.
- Princeton University, Program in Atmospheric and Oceanic Sciences**, Princeton, NJ
Research Assistant Sept. 2014 - Aug. 2019
- Characterized the role of water vapor in the ITCZ response to hemispherically asymmetric perturbations.
 - Demonstrated that South Asian monsoon low pressure systems can be simulated in an idealized moist GCM, and that the storms exhibit some properties consistent with moisture vortex instability theory, as well as some properties that deviate from it.
 - Studied the sensitivity of equatorial wave variability in an idealized moist GCM to various forms of heating perturbations.
- Cornell University, Department of Earth and Atmospheric Sciences**, Ithaca, NY
Research Assistant Jan. 2011 - Mar. 2017
- Characterized the episodicity of forest and grass fires and developed 7 new prescribed emissions cases to test the impact of fire episodicity on fire's aerosol direct and indirect radiative forcings.
 - Implemented 8 GCM lightning parameterizations in CAM5, compared their results to LIS/OTD observations, and studied their future projections.

Selected Honors and Awards

- Arnold Guyot Teaching Award, *Princeton University Department of Geosciences* 2018
- NDSEG Fellowship, *American Society for Engineering Education* 2016-2019
- Dorothy and Fred Chau Award (Excellence in Undergraduate Research), *Cornell AEP* May 2014
- Rawlings Cornell Presidential Research Scholar, *Cornell* 2010-2014

Publications

Submitted

2022 Kwa, A., **Clark, S. K.**, Henn, B., Brenowitz, N. D., McGibbon, J., Watt-Meyer, O., Perkins, W. A., Harris, L., and Bretherton, C. S. Machine-learned climate model corrections from a global storm-resolving model: Performance across the annual cycle. *Submitted to Journal of Advances in Modeling Earth Systems*, September 2022. doi: [10.1002/essoar.10512393.1](https://doi.org/10.1002/essoar.10512393.1)

Harris, L., Zhou, L., Kaltenbaugh, A. D., **Clark, S. K.**, Cheng, K.-Y., and Bretherton, C. S. A Global Survey of Rotating Convective Updrafts in the GFDL X-SHiELD 2021 Global Storm Resolving Model. *Submitted to Journal of Geophysical Research: Atmospheres*, September 2022. doi: [10.1002/essoar.10512351.1](https://doi.org/10.1002/essoar.10512351.1)

Refereed

2022 **Clark, S. K.**, Brenowitz, N. D., Henn, B., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., Bretherton, C. S., and Harris, L. M. Correcting a 200 km Resolution Climate Model in Multiple Climates by Machine Learning From 25 km Resolution Simulations. *Journal of Advances in Modeling Earth Systems*, 14(9):e2022MS003219, 2022. ISSN 1942-2466. doi: [10.1029/2022MS003219](https://doi.org/10.1029/2022MS003219)

Cheng, K.-Y., Harris, L., Bretherton, C., Merlis, T. M., Bolot, M., Zhou, L., Kaltenbaugh, A., **Clark, S.**, and Fueglistaler, S. Impact of Warmer Sea Surface Temperature on the Global Pattern of Intense Convection: Insights From a Global Storm Resolving Model. *Geophysical Research Letters*, 49(16):e2022GL099796, 2022. ISSN 1944-8007. doi: [10.1029/2022GL099796](https://doi.org/10.1029/2022GL099796)

Bretherton, C. S., Henn, B., Kwa, A., Brenowitz, N. D., Watt-Meyer, O., McGibbon, J., Perkins, W. A., **Clark, S. K.**, and Harris, L. Correcting Coarse-Grid Weather and Climate Models by Machine Learning From Global Storm-Resolving Simulations. *Journal of Advances in Modeling Earth Systems*, 14(2):e2021MS002794, 2022. ISSN 1942-2466. doi: [10.1029/2021MS002794](https://doi.org/10.1029/2021MS002794)

Xiang, B., Harris, L., Delworth, T. L., Wang, B., Chen, G., Chen, J.-H., **Clark, S. K.**, Cooke, W. F., Gao, K., Huff, J. J., Jia, L., Johnson, N. C., Kapnick, S. B., Lu, F., McHugh, C., Sun, Y., Tong, M., Yang, X., Zeng, F., Zhao, M., Zhou, L., and Zhou, X. S2S Prediction in GFDL SPEAR: MJO Diversity and Teleconnections. *Bulletin of the American Meteorological Society*, 103(2):E463–E484, February 2022. ISSN 0003-0007, 1520-0477. doi: [10.1175/BAMS-D-21-0124.1](https://doi.org/10.1175/BAMS-D-21-0124.1)

2021 McGibbon, J., Brenowitz, N. D., Cheeseman, M., **Clark, S. K.**, Dahm, J. P. S., Davis, E. C., Elbert, O. D., George, R. C., Harris, L. M., Henn, B., Kwa, A., Perkins, W. A., Watt-Meyer, O., Wicky, T. F., Bretherton, C. S., and Fuhrer, O. Fv3gfs-wrapper: A Python wrapper of the FV3GFS atmospheric model. *Geoscientific Model Development*, 14(7):4401–4409, July 2021. ISSN 1991-959X. doi: [10.5194/gmd-14-4401-2021](https://doi.org/10.5194/gmd-14-4401-2021)

Watt-Meyer, O., Brenowitz, N. D., **Clark, S. K.**, Henn, B., Kwa, A., McGibbon, J., Perkins, W. A., and Bretherton, C. S. Correcting Weather and Climate Models by Machine Learning Nudged Historical Simulations. *Geophysical Research Letters*, 48(15):e2021GL092555, 2021. ISSN 1944-8007. doi: [10.1029/2021GL092555](https://doi.org/10.1029/2021GL092555)

2020 Harris, L., Zhou, L., Lin, S.-J., Chen, J.-H., Chen, X., Gao, K., Morin, M., Rees, S., Sun, Y., Tong, M., Xiang, B., Bender, M., Benson, R., Cheng, K.-Y., **Clark, S.**, Elbert, O. D., Hazelton, A., Huff, J. J., Kaltenbaugh, A., Liang, Z., Marchok, T., Shin, H. H., and Stern, W. GFDL SHiELD: A Unified System for Weather-to-Seasonal Prediction. *Journal of Advances in Modeling Earth Systems*, 12(10):e2020MS002223, 2020. ISSN 1942-2466. doi: [10.1029/2020MS002223](https://doi.org/10.1029/2020MS002223)

Brenowitz, N. D., Henn, B., **Clark, S.**, Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., and Bretherton, C. S. Machine Learning Climate Model Dynamics: Offline versus Online Performance. In *Climate Change AI*. Climate Change AI, December 2020

Narinesingh, V., Booth, J. F., **Clark, S. K.**, and Ming, Y. Atmospheric blocking in an aquaplanet and the impact of orography. *Weather and Climate Dynamics*, 1(2):293–311, July 2020. ISSN -. doi: [10.5194/wcd-1-293-2020](https://doi.org/10.5194/wcd-1-293-2020)

Clark, S. K., Ming, Y., and Adames, Á. F. Monsoon Low Pressure System–Like Variability in an Idealized Moist Model. *Journal of Climate*, 33(6):2051–2074, March 2020. ISSN 0894-8755, 1520-0442. doi: [10.1175/JCLI-D-19-0289.1](https://doi.org/10.1175/JCLI-D-19-0289.1)



- 2019 Adames, Á. F., Kim, D., **Clark, S. K.**, Ming, Y., and Inoue, K. Scale Analysis of Moist Thermodynamics in a Simple Model and the Relationship between Moisture Modes and Gravity Waves. *Journal of the Atmospheric Sciences*, 76(12):3863–3881, December 2019. ISSN 0022-4928, 1520-0469. doi: [10.1175/JAS-D-19-0121.1](https://doi.org/10.1175/JAS-D-19-0121.1)
- 2018 **Clark, S. K.**, Ming, Y., Held, I. M., and Philipps, P. J. The Role of the Water Vapor Feedback in the ITCZ Response to Hemispherically Asymmetric Forcings. *Journal of Climate*, 31(9):3659–3678, February 2018. ISSN 0894-8755. doi: [10.1175/JCLI-D-17-0723.1](https://doi.org/10.1175/JCLI-D-17-0723.1)
- 2017 **Clark, S. K.**, Ward, D. S., and Mahowald, N. M. Parameterization-based uncertainty in future lightning flash density. *Geophysical Research Letters*, 44(6):2017GL073017, March 2017. ISSN 1944-8007. doi: [10.1002/2017GL073017](https://doi.org/10.1002/2017GL073017)
- 2015 **Clark, S. K.**, Ward, D. S., and Mahowald, N. M. The sensitivity of global climate to the episodicity of fire aerosol emissions. *Journal of Geophysical Research: Atmospheres*, 120(22):2015JD024068, November 2015. ISSN 2169-8996. doi: [10.1002/2015JD024068](https://doi.org/10.1002/2015JD024068)


Presentations

- 2022 **Clark, S. K.**, Brenowitz, N., Henn, B. M., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., Bretherton, C.S., and Harris, Lucas M. “Correcting Coarse-Grid Weather and Climate Models by Machine Learning From Global Storm-Resolving Simulations.” Physics Dynamics Coupling Workshop, Princeton, NJ, June 2022. Oral presentation.
- 2021 **Clark, S. K.**, Brenowitz, N., Henn, B. M., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., and Bretherton, C.S. “Applying machine learning parameterization through coarse graining to improve the skill in simulating multiple climates in a full complexity GCM.” AGU Fall Meeting, December 2021. Virtual Poster Presentation.
- Clark, S. K.**, Brenowitz, N., Henn, B. M., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., and Bretherton, C.S. “Applying machine learning parameterization through coarse graining to improve the skill in simulating multiple climates in a full complexity GCM.” NOAA Artificial Intelligence Workshop, September 2021. Virtual Oral Presentation.
- 2020 **Clark, S. K.**, Brenowitz, N., Bretherton, C. S., Henn, B. M., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., Chen, X., Harris, L., Zhou, L. “Using nudging to investigate biases in a global 3 km resolution simulation with GFDL’s X-SHIELD model.” AGU Fall Meeting 2020, December 2020. Virtual Poster Presentation.
- Clark, S. K.**, Brenowitz, N., Henn, B. M., Kwa, A., McGibbon, J., Perkins, W. A., Watt-Meyer, O., Harris, L., Bretherton, C.S. “Challenges associated with training a machine-learning based moist physics parameterization by coarse-graining in a model with topography.” NOAA Artificial Intelligence Workshop, December 2020. Virtual Oral Presentation.
- 2018 **Clark, S. K.**, Ming, Y., Adames, Á. F. “An idealized framework for simulating monsoon low pressure systems and their potential sensitivity to the mean state.” AGU Fall Meeting 2018, Washington D.C., December 2018. Poster Presentation.

- 2017 **Clark, S. K.**, Ming, Y. "Investigating synoptic-scale monsoonal disturbances in an idealized moist model." AGU Fall Meeting 2017, New Orleans, LA, December 2017. Poster Presentation.
- Clark, S. K.**, Ming, Y., Held, I. M., and Philipps, P. J. "The role of water vapor in the ITCZ response to hemispherically asymmetric forcings." Dynamics seminar series, Princeton University, Princeton, NJ, November 2017. Oral Presentation.
- 2016 **Clark, S. K.**, Ming, Y., and Held, I. M. "The role of water vapor in the ITCZ response to hemispherically asymmetric forcings." AGU Fall Meeting, San Francisco, CA, December 2016. Poster Presentation.
- Hill, S. A., **Clark, S. K.** "The other 'aospy': automated climate data analysis and management." AOSPy Workshop at Columbia University, New York, NY, November 2016. Oral Presentation.
- Clark, S. K.**, Ming, Y., and Held, I. M. "The role of water vapor in the ITCZ response to hemispherically asymmetric forcings." WCRP Model Hierarchies Workshop, Princeton, NJ, November 2016. Poster Presentation.
- Clark, S. K.**, Ming, Y., and Held, I. M. "The role of water vapor in the ITCZ response to hemispherically asymmetric forcings." Dynamical Core Model Intercomparison Project, Boulder, CO, June 2016. Poster Presentation.
- 2015 **Clark, S. K.**, Ming, Y., and Held, I. M. "Climate Impacts of Inter-hemispherically Asymmetric Radiative Forcing." AGU Fall Meeting, San Francisco, CA, December 2015. Poster Presentation.
- Clark, S. K.**, Ming, Y., and Held, I. M. "Climate Impacts of Inter-hemispherically Asymmetric Radiative Forcing." Gordon Research Conference, Lewiston, ME, July 2015. Poster Presentation.
- 2014 **Clark, S. K.**, Ward, D. S., and Mahowald, N. M. "The implementation and evaluation of five lightning parameterizations in a global climate model." Cornell Applied and Engineering Physics Honors Thesis Presentation, Ithaca, NY, May 2014.
- 2013 **Clark, S. K.**, Ward, D. S., and Mahowald, N. M. "The sensitivity of global climate to the episodicity of fire aerosol emissions." SESSA Spring Research Symposium, Ithaca, NY, May 2013. Poster Presentation.
- 2012 **Clark, S. K.**, Ward, D. S., and Mahowald, N. M. "Climate Model Responses to Increased Episodicity in Prescribed Fire Aerosol Emissions." CESM Workshop, Breckenridge, CO, June 2012. Poster Presentation.
- Clark, S. K.**, Ward, D. S., and Mahowald, N. M. "Climate Model Responses to Increased Episodicity in Prescribed Fire Aerosol Emissions." SESSA Spring Research Symposium, Ithaca, NY, May 2012. Poster Presentation.

Software Development

- xarray, A widely-used Python library providing N-dimensional labeled array data structures 
Contributor and Core Developer Feb. 2017 - Present
- Led an effort to add first-class support of non-standard calendar types frequently used in climate science.
 - Responsible for taking part in carefully reviewing new contributions, fixing bugs, adding requested features, and answering user/developer questions.
- cftime, A Python library providing datetime instances for non-standard calendars 
Contributor Feb. 2018 - Present
- Enabled exact numerical decoding and encoding of datetimes.
 - Proposed strategy that led to speeding up fundamental operations, e.g. datetime construction and timedelta arithmetic, by 200 to 400x.

nc-time-axis, A Python library providing the ability to plot cftime datetimes in matplotlib 

Contributor and Core Developer

Jan. 2019 - Present

- Enabled plotting `cftime.datetime` objects directly in matplotlib, instead of requiring a wrapped version of a `cftime.datetime` object.
- Added infrastructure for documentation and basic documentation content.

fv3gfs-fortran, AI2's fork of NOAA's FV3GFS weather forecast model 

Contributor and Core Developer

Aug. 2019 - Present


- Implemented the ability to output coarsened diagnostics and restart files with a variety of coarse-graining methods.
- Implemented the ability to override the surface radiative flux inputs used by the land-surface model with those set externally, allowing us to set those using values predicted by machine learning models.

fv3net, AI2's code for running and analyzing results GCM simulations coupled to ML parameterizations 

Contributor and Core Developer


Aug. 2019 - Present

- Implemented Python equivalents of the coarse-graining methods I implemented in the fortran model.
- Added the ability to train machine learning models on simulations from multiple climates.

faceted, A Python package that makes it easier to create matplotlib figures with precise control over the overall width, plot aspect ratio, between-plot spacing, and colorbar dimensions. 

Primary author

Nov. 2017 - Present

xpartition, A Python package for distributed xarray computations on HPC or cloud computing platforms that leverages dask in a creative way. 

Primary author

Dec. 2020 - Present


Teaching Experience

Princeton University, Princeton Environmental Institute, Princeton, NJ

Modeling the Earth System (ENV367)

Fall 2017

Assistant in Instruction

- Adapted an existing compact Earth System Model  for use as a teaching tool. Wrote comprehensive web-based documentation for the model.
- Authored lab exercises to help students learn about the features and limitations of the model, and illustrate Earth system modeling concepts.

Cornell University, Department of Applied and Engineering Physics, Ithaca, NY

Mathematical Physics II (AEP 4220)

Spring 2014

Grader

- Held weekly office hours, wrote official solutions, and graded homework and exam problems.


Professional Experiences

Participant, *Columbia AOSPy Workshop, founding meeting of the Pangeo Data initiative* 

Nov. 2016

Organizer, *Princeton AOS Workshop on Tropical Dynamics*

2016

Participant, *Dynamical Core Model Intercomparison Project Workshop* 

June 2016

Service

Assistant mentor to NOAA Hollings Scholar Bridgette Befort (2017).

Reviewing

Peer-reviewed manuscripts for *Nature*, *Nature Climate Change*, *Journal of Geophysical Research* –

Atmospheres, Journal of Climate, Quarterly Journal of the Royal Meteorological Society, and GFDL internal manuscript review.

Activities

Varsity Tennis, Cornell University

Sept. 2010 - May 2014