Benjamin N. Sulman, Ph.D

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Education

Ph.D., Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, 2012

M.S., Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, 2009

B.A., Physics and Astronomy, Oberlin College, 2006

Appointments

Associate R&D Staff: Energy and Environmental Sciences Directorate, Oak Ridge National Laboratory (October 2018-present)

Assistant Project Scientist: Sierra Nevada Research Institute, University of California, Merced (February 2018-October 2018)

Associate Research Scholar: Program in Atmospheric and Oceanic Sciences, Princeton University; Biogeochemistry, Ecosystems, and Climate Group, Geophysical Fluid Dynamics Laboratory (June 2015-March 2018)

Postdoctoral Research Associate: School of Public and Environmental Affairs and Department of Biology, Indiana University (January 2014-May 2015)

Postdoctoral Research Associate: Princeton Environmental Institute, Princeton University (June 2012-December 2013)

Publications

Kimm, H., Guan, K., Gentine, P., Wu, J., Bernacchi, C. J., Sulman, B. N., et al. Redefining droughts for the U.S. Corn Belt: The dominant role of atmospheric vapor pressure deficit over soil moisture in regulating stomatal behavior of Maize and Soybean. *Agricultural and Forest Meteorology*, 287, 107930, 2020. doi:10.1016/j.agrformet.2020.107930

Wieder, W. R., **Sulman, B. N.**, Hartman, M. D., Koven, C. D., and Bradford, M. A. Arctic soil governs whether climate change drives global losses or gains in soil carbon. *Geophys. Res. Lett.* 46, 14486–14495, 2019. doi:10.1029/2019GL085543.

Moore, J. A. M., **Sulman, B. N.**, Mayes, M. A., Patterson, C. M., and Classen, A. T. Plant roots stimulate the decomposition of complex, but not simple, soil carbon. *Funct. Ecol.*, 34, 899-910, 2019. doi:10.1111/1365-2435.13510.

B. N. Sulman, E. Shevliakova, E. R. Brzostek, S. N. Kivlin, S. Malyshev, D. N. L. Menge, and X. Zhang. Diversity in nitrogen acquisition strategies enables enhanced terrestrial carbon storage. *Global Biogeochemical Cycles*, 33(4), 501-523, 2019. doi: 10.1029/2018GB005973

T. A. Ghezzehei, **B. N. Sulman**, C. L. Arnold, N. A. Bogie, and A. A. Berhe. On the role of soil water retention characteristic on aerobic microbial respiration. *Biogeosciences*, 16(6), 1187-1209, 2019. doi: 10.5194/bg-16-1187-2019

B. N. Sulman, J. A. M. Moore, R. Z. Abramoff, C. Averill, S. Kivlin, K. Georgiou, B. Sridhar, M. D. Hartman, G. Wang, W. R. Wieder, M. A. Bradford, Y. Luo, M. A. Mayes, E. Morrison, W. J. Riley, A. Salazar, J. P. Schimel, J. Tang, and A. T. Classen. Multiple models and experiments underscore large uncertainty in soil carbon dynamics. *Biogeochemistry*, 141(2), 109–123, 2018. doi:10.1007/s10533-018-0509-z

W. R. L. Anderegg, A. G. Konings, A. T. Trugman, K. Yu, D. R. Bowling, R. Gabbitas, D. S. Karp, S. Pacala, J. S. Sperry, **B. N. Sulman**, and N. Zenes. Hydraulic diversity of forests regulates ecosystem resilience during drought. *Nature*, 561, 538-541, 2018. doi:10.1038/s41586-018-0539-7

C. E. Hick Pries, **B. N. Sulman**, C. West, C. O'Neill, E. Poppleton, R. C. Porras, C. Castanha, B. Zhu, D. B. Wiedemeier, and M. S. Torn. Root litter decomposition slows with soil depth. *Soil Biology and Biochemistry*, 125, 103-114, 2018. doi:10.1016/j.soilbio.2018.07.002

N. W. Chaney, M. Van Huijgevoort, E. Shevliakova, S. Malyshev, P. C. D. Milly, P. Gauthier, and **B. N. Sulman**. Harnessing big data to rethink land heterogeneity in earth system models. *Hydrology and Earth System Sciences,* 22, 3311-3330, 2018. doi:10.5194/hess-22-3311-2018

A. Salazar, **B. N. Sulman**, and J. S. Dukes. Microbial dormancy promotes microbial biomass and respiration across pulses of drying-wetting stress. *Soil Biology and Biochemistry*, 116, 237-244, 2018. doi:10.1016/j.soilbio.2017.10.017

L. M. Jacobs, **B. N. Sulman**, E. R. Brzostek, J. J. Feighery, and R. P. Phillips. Interactions during decomposition between root litter, leaf litter, and SOM affect soil C dynamics. *Journal of Ecology,* 106, 502-513, 2018. doi: 10.1111/1365-2745.12921

C. A. Pugh, D. E. Reed, A. R. Desai, and **B. N. Sulman**. Wetland flux controls: How does interacting water tables and temperature influence carbon dioxide and methane fluxes in northern Wisconsin? *Biogeochemistry*, 137, 15-25, 2018. doi: 10.1007/s10533-017-0414-x

V. Bailey, B. Bond-Lamberty, K. DeAngelis, A. S. Grandy, C. V. Hawkes, K. Heckman, K. Lajtha, R. P. Phillips, **B. N. Sulman**, K. E. O. Todd-Brown, and M. D. Wallenstein. Effective proxies for key soil processes and properties inform predictions of climate change. *Global Change Biology*, 24, 895-905, 2018. doi:10.1111/gcb.13926

W. R. Wieder, M. D. Hartman, **B. N. Sulman**, Y.-P. Wang, C. D. Koven, and G. B. Bonan. Carbon cycle confidence and uncertainty: exploring variation among soil biogeochemical models. *Global Change Biology*, 24, 1563-1579, 2018. doi:10.1111/gcb.13979

B. N. Sulman, E. R. Brzostek, C. Medici, E. Shevliakova, D. N. L. Menge, and R. P. Phillips. Feedbacks between plant N demand and rhizosphere priming depend on type of mycorrhizal association. *Ecology Letters*, 20, 1043-1053, 2017. doi:10.1111/ele.12802

B. N. Sulman, D. T. Roman, K. Yi, L. Wang, R. P. Phillips, and K. A. Novick. High atmospheric demand for water can limit forest carbon uptake and transpiration as severely as dry soil. *Geophysical Research Letters*, 43, 9686-9695, 2016. doi:10.1002/2016GL069416

K. A. Novick, D. Ficklin, P. C. Stoy, C. A. Williams, G. Bohrer, A. C. Oishi, S. A. Papuga, P. D. Blanken, A. Noormets, **B. N. Sulman**, R. L. Scott, L. Wang, and R. P. Phillips. The increasing importance of atmospheric demand for ecosystem water and carbon fluxes. *Nature Climate Change*, 6, 1023-1027, 2016. doi:10.1038/nclimate3114

B. N. Sulman, D. T. Roman, T. M. Scanlon, L. Wang, and K. A. Novick. Comparing methods for partitioning a decade of carbon dioxide and water vapor fluxes in a temperate forest, *Agricultural and Forest Meteorology*, 226-227, 229–245, 2016. doi:10.1016/j.agrformet.2016.06.002

W. Wieder, S. Allison, E. Davidson, K. Georgiou, O. Hararuk, Y. He, F. Hopkins, Y. Luo, M Smith, **B. N. Sulman**, K. Todd-Brown, Y.-P. Wang, J. Xia, and X. Xu. Explicitly representing soil microbial processes in earth system models. *Global Biogeochemical Cycles*, 29, 1782-1800, 2015. doi:10.1002/2015GB005188

B. N. Sulman, A. C. Oishi, R. P. Phillips, E. Shevliakova, and S. Pacala. Microbe-driven turnover offsets mineral-mediated storage of soil carbon under elevated CO_2. *Nature Climate Change*, 4, 1099-1102, 2014. doi:10.1038/nclimate2436

B. N. Sulman, A. R. Desai, and D. J. Mladenoff. Modeling soil and biomass carbon responses to declining water table in a wetland-rich landscape. *Ecosystems*, 16, 491-507, 2013. doi:10.1007/s10021-012-9624-1

R. F. Grant, A. R. Desai, and **B. N. Sulman**. Modelling contrasting responses of wetland productivity to changes in water table depth. *Biogeosciences*, 9, 4215-4231, 2012. doi:10.5194/bg-9-4215-2012

B. N. Sulman, A. R. Desai, N. M. Schroeder, D. Ricciuto, A. Barr, A. D. Richardson, L. B. Flanagan, et al. Impact of hydrological variations on modeling of peatland CO_2 fluxes: results from the North American Carbon Program site synthesis. *Journal of Geophysical Research*, 117, G01031, 2012. doi:10.1029/2011JG001862

B. N. Sulman, A. R. Desai, N. Z. Saliendra, P. M. Lafleur, L. B. Flanagan, O. Sonnentag, D. S. Mackay, A. G. Barr, and G. van der Kamp. CO_2 fluxes at northern fens and bogs have opposite responses to inter-annual fluctuations in water table. **Geophysical Research Letters**, 37, L19702, 2010. doi:10.1029/2010GL044018

B. N. Sulman, A. R. Desai, B. D. Cook, N. Saliendra, and D. S. Mackay. The impact of a declining water table on observed carbon fluxes at a northern temperate wetland. *Biogeosciences*, 6, 1115-1126, 2009. doi:10.5194/bg-6-1115-2009

Book chapters and non-peer-reviewed publications

A. Sengupta, B. Sulman, Z. Brown, and M. Ruix-Urigüen. Caregiver awards support early-career researchers. *EOS*, 100, 2019. doi:10.1029/2019EO121825

F. Santos, R. Abney, M. Barnes, L. Jin, K. Moreland, N. Bogie, **B. N. Sulman**, T. A. Ghezzehei, and A. A. Berhe. The role of soil physical properties for determining biogeochemical responses to soil warming. *In:* Ecosystem Consequences of Soil Warming: Microbes, Vegetation, Fauna, and Soil Biogeochemistry. Editor: J. Mohan. 2019.

Research Funding

Simulating estuarine wetland function: Nitrogen removal, carbon sequestration, and greenhouse gas fluxes at the river-land-ocean interface, DOE Earth and Environmental Systems Modeling, Early Career Award Program, 2020-2024 (PI). Total cost: $2,500,890

Modelling Microbes to Predict Post-fire Carbon Cycling in the Boreal Forest across Burn Severities, DOE Terrestrial Ecosystem Science Program, 2020-2022 (co-PI). PI: T. Whitman. Total cost: $299,972

Using FACE experiments and models to investigate decadal scale processes that govern terrestrial ecosystem responses to CO_2, DOE Terrestrial Ecosystem Science Program, 2020-2022 (co-I). PI: Anthony Walker. Total cost: $1,050,000.

Testing mechanisms of how mycorrhizal associations affect forest soil carbon and nitrogen cycling, DOE Terrestrial Ecosystem Science program, 2019-2022 (Co-PI). PI: C. Hicks Pries. Total cost: $999,995.

Identifying key process uncertainties in soil carbon dynamics using multiple models and observational meta-analysis, RCN mini-workshop grant, 2017 (PI). Total cost: $8,000.

Benchmarking and improving microbial-explicit soil biogeochemistry models, DOE Environmental System Science Program, 2015-2017 (Co-I). PI: W. Wieder. Total cost: $497,780.

Constraining and testing treatment of disturbance, succession, and biogeochemistry in a forest landscape model, NSF BART IGERT fellowship, 2009-2011 (Fellow). Total cost: $63,000.

Awards

DOE Early Career Award program, 2020

AGU Editors Citation for Excellence in Refereeing, 2018.

DOE GREF fellowship, Honorable Mention, 2009.

UW Atmospheric and Oceanic Sciences Department award for excellent performance in first year graduate studies, 2008.

John Frederick Oberlin Scholarship, Oberlin College, 2002-2006.

Selected invited seminars

Putting Biology, Geology, and Chemistry into biogeochemical models. American Geophysical Union Fall Meeting, San Francisco, CA, 2019.

Linking biogeochemistry and physics in soil models: Challenges and opportunities. Soil Science Society of America meeting, San Diego, CA, 2019.

Water, carbon dioxide, and nitrogen: Understanding plant and soil responses to global change. Cary Institute of Ecosystem Studies, Millbrook, NY, 2017.

Plant nitrogen acquisition and soil microbial activity in the GFDL land model. Nutrient limitation on land: how accurate are our global land models? Yangling, Shaanxi, China, 2016.

Microbes, minerals, and roots: Next-generation soil carbon in the GFDL land model. Geophysical Fluid Dynamics Laboratory, Princeton, NJ, 2016.

Microbes, minerals, and roots in a soil organic matter model at local to global scales. INTERFACE RCN 2016 workshop: Integrating models and experiments to explore climate feedbacks in a managed and warming world. St. Pete, FL, 2016.

Controls on vertical soil carbon distributions in the continental United States: Applications for model evaluation. American Geophysical Union Fall Meeting, San Francisco, CA, 2015.

Incorporating roots, microbes, and minerals into soil carbon models at ecosystem and global scales. Lawrence Berkeley National Laboratory, Berkeley, CA, 2015.

Modeling root exudation, priming, and protection from ecosystem to global scales. American Geophysical Union Fall Meeting, San Francisco, CA, 2014.

Simulating priming, protected carbon, and root exudation in the GFDL Land Model. RCN FORECAST Workshop: Representing soil carbon dynamics in global land models to improve future IPCC assessments, Breckenridge, CO, 2014.

Selected invited workshops and working groups

DRI-MEE: Drying and Rewetting, Integrating Modelling and Empirical Environments, University of Lund, Lund, Sweden, 2019

LTER:SOM Synthesis working group, NCEAS, Santa Barbara, CA, 2018.

Nutrient limitation on land: how accurate are our global land models?, Yangling, Shaanxi, China, 2016.

Frontiers in terrestrial climate feedbacks workshop, INTERFACE RCN, St. Pete, FL, 2016.

International Decade of Soils workshop, Boulder, CO, 2016.

Representing soil carbon dynamics in global land models to improve future IPCC assessments, FORECAST RCN, Breckenridge, CO, 2014.

DISsertations initiative for the advancement of Climate Change ReSearch (DISCCRS) Symposium, Colorado Springs, CO, 2013.

Other workshops and programs

Summer school on atmospheric modeling, Geophysical Fluid Dynamics Laboratory, Princeton, NJ (2012)

4th Annual Summer Course in Flux Measurements and Advanced Modeling, University of Colorado Mountain Research Station (2011)

Biosphere Atmosphere Research and Training (BART) short course on biosphere-atmosphere interactions, University of Michigan Biological Station (2009)

Teaching and mentoring experience

Led ecosystem modeling discussion group for graduate students and postdocs, University of California, Merced, January 2018-2019.

Soil science outreach booth, community science fair, Patterson, CA, 2018.

Mentored two undergraduate students in an independent research project: "Measuring leaf and root decomposition and associated priming effects across a mycorrhizal gradient", February 2014 – June 2015.

Co-led outreach programs for high school students and university classes at the Morgan Monroe State Forest Ameriflux site, 2014.

Invited classroom lectures:

- Fundamentals of Soil Sciences, Department of Earth System Science, University of California, Merced (2018). *Soil organisms.*
- Topics in Environmental Systems, Department of Earth System Science, University of California, Merced (2016). *Soil organic matter.*
- Applied Math in the Environmental Sciences, School of Public and Environmental Affairs, Indiana University (2015). *Limits and derivatives.*
- Ecology, Department of Biology, Indiana University (2014). *Ecosystem modeling.*

Tutor, Physics and Astronomy, Oberlin College, 2003-2006.

Service

American Geophysical Union Biogeosciences Section Executive Committee Early Career Representative, 2018-2019.

American Geophysical Union Biogeosciences Section Early Career Committee, 2017-2019.

Grant review panel member, DOE, 2014 and NASA, 2013; External review contributor for NSF Earth Sciences program.

Manuscript reviews: *Nature Geoscience, New Phytologist, Biogeochemistry, EOS, PLoS ONE, Wetlands, Biogeosciences, JGR, Agricultural and Forest Meteorology, Soil Biology and Biochemistry, Global Change Biology*

Technical skills and languages

Languages: English (Native speaker); Portuguese (Basic proficiency)

Technical languages: Python, Matlab, R, IDL, C, C#, Fortran, LaTeX

Conference presentations

Refining ELM simulations of NGEE Arctic field sites using vegetation community and biomass measurements. American Geophysical Union Fall Meeting, San Francisco, CA, 2019.

Improving large-scale model representations of Arctic soil biogeochemistry. Soil Science Society of America meeting, San Antonio, TX, 2019.

Linking biogeochemistry and physics in soil models: Challenges and opportunities. Soil Science Society of America meeting, San Diego, CA, 2019.

Modeling Microbe Munchers: Trophic interactions control temperature response of soil carbon stocks. American Geophysical Union Fall Meeting, Washington, DC, Dec 2018.

Incorporating microbe-mineral interactions into biogeochemical models. Ecological Society of America meeting, New Orleans, LA Aug 2018.

Diversity in nitrogen acquisition strategies enables enhanced terrestrial C storage under elevated CO_2. American Geophysical Union Fall Meeting, New Orleans, LA, Dec 2017.

N acquisition strategies determine ecosystem responses to elevated CO_2 in the GFDL global land model. 5th iLEAPS Science Conference, Oxford, United Kingdom, Sept 2017.

Modeling the role of mycorrhizae in C and N cycling and ecosystem and global scales. Ecological Society of America Annual Meeting, Portland, OR, Aug 2017.

Key process uncertainties in soil carbon dynamics: Comparing multiple model structures and observational meta-analysis. American Geophysical Union 2016 Fall Meeting, San Francisco, CA, Dec 2016.

Plant nitrogen acquisition and soil microbial activity in the GFDL land model (**invited presentation**). Nutrient limitation on land: how accurate are our global land models? Yangling, Shaanxi, China, June 2016.

Microbes, minerals, and roots in a soil organic matter model at local to global scales (**invited presentation**). INTERFACE RCN 2016 workshop: Integrating models and experiments to explore climate feedbacks in a managed and warming world, St. Pete Beach, FL, Jan 2016.

Controls on vertical soil carbon distributions in the continental United States: Applications for model evaluation (**invited presentation**). American Geophysical Union 2015 Fall Meeting, San Francisco, CA, Dec 2015.

Modeling plant N acquisition and soil biogeochemical feedbacks in a temperate forest. Ecological Society of America Annual Meeting, Baltimore, MD, Aug 2015.

Responses of evaporation and transpiration to drought in a temperate forest. Ameriflux PI meeting, Washington, DC, Jan 2015.

Root exudation, priming, and protection: Advanced soil carbon processes in a global model. North American Carbon Program PI meeting, Washington, DC, Jan 2015.

Modeling root exudation, priming, and protection from ecosystem to global scales (**invited presentation**). American Geophysical Union 2014 Fall Meeting, San Francisco, CA, Dec 2014.

Responses of evaporation and transpiration to drought in a temperate forest. American Geophysical Union 2014 Fall Meeting, San Francisco, CA, Dec 2014.

Simulating priming, protected carbon, and root exudation in the GFDL Land Model. RCN FORECAST Workshop: Representing soil carbon dynamics in global land models to improve future IPCC assessments, Breckenridge, CO, June, 2014.

Microbial priming and protected carbon responses to elevated CO_2 at local to global scales: A new modeling approach. American Geophysical Union 2013 Fall Meeting, San Francisco, CA, Dec 2013.

Simulating priming and protected carbon in an earth system model. International Union of Soil Scientists Soil Carbon Conference, Madison, WI, June 2013.

How disturbances are (or are not) represented in CMIP5 Earth System Models. North American Carbon Program All-Investigators Meeting, Albuquerque, NM, February 2013.

Peatland carbon cycle responses to long-term hydrological change. American Meteorological Society 30th conference on Agricultural and Forest Meteorology/First Conference on Atmospheric Biogeosciences, Boston, MA, May 2012.

Ecosystem model performance at wetlands: Results from the North American Carbon Program site synthesis. American Geophysical Union 2011 Fall Meeting, San Francisco, CA, Dec 2011.

Challenges for wetland carbon cycle modeling. Ameriflux Science Meeting and 3rd Annual North American Carbon Program All-investigators Meeting, New Orleans, LA, Feb. 2011.

Sensitivity of regional forest carbon budgets to continuous and stochastic climate change pressures. American Geophysical Union 2010 Fall Meeting, San Francisco, CA, Dec. 2010.

Is temperature change or disturbance more important? Modeling the future of northern Great Lakes forest carbon cycling. American Meteorological Society 29th Conference on Agricultural and Forest Meteorology, Keystone, CO, Aug. 2010.

Carbon cycling in northern Michigan forests. LANDIS-II Users Meeting, Madison, WI, January, 2010.

How well do we model wetlands?. NACP Interim Synthesis, Oak Ridge, TN, Nov. 2009:

Forests, wetlands, and lakes: comparing drivers of carbon cycling in heterogeneous northern landscapes. Ameriflux meeting, Washington, DC, Sept. 2009.

Water, biology, and climate in northern Wisconsin: Carbon dioxide fluxes at a drying wetland. University of Wisconsin-Madison Department of Atmospheric and Oceanic Sciences department seminar, Madison, WI, April, 2009.

Observed carbon-water interactions in three north-temperate wetlands. Ameriflux meeting, Boulder, CO, Oct 2008.

Carbon and water cycle interactions in a temperate wetland: Modeling and measuring the impact of a declining water table on regional biogeochemistry. 11th Annual ChEAS Meeting, University of Notre Dame Research Center – East, Land O Lakes, WI, August, 2008.

Interactions of carbon and water cycles in north temperate wetlands: modeling and observing the impact of a declining water table trend on regional biogeochemistry. Am. Meteorol. Society 18th Conference on Atmospheric Biogeosciences, Orlando, FL, April 2008.