HEIDI RODENHIZER
Woodwell Climate Research Center
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EDUCATION

Ph.D.	2016-2022	Northern Arizona University, Department of Biology
Certificate	2022	Udemy: Data Analysis with Pandas and Python
Certificate	2018	EO-College: Echoes in Space: Introduction into the principles and applications of radar remote sensing
Graduate Coursework	2015	University of Victoria, Department of Biology
B.S.	2013	Western Washington University, Department of Biology Evolution, ecology and organismal emphasis (Cum Laude, Honors Program)

RESEARCH EXPERIENCE

2022-Present **Postdoctoral Researcher**, Woodwell Climate Research Center
Research on abrupt permafrost thaw and carbon fluxes in permafrost environments using spaceborne spectral remote sensing and eddy covariance methods.

2016-2022 **Research Assistant**, Schuur Laboratory, ECOSS, Northern Arizona University (see my website for more details)
Research using remote sensing (airborne LiDAR, spectral, and SAR), GIS, statistical modeling, and machine learning to investigate the spatial nature of permafrost thaw and the role of climate change on carbon fluxes in tundra ecosystems. Data processing for GPS elevation, eddy covariance carbon flux, chamber-based static CO_2 flux, phenology, and foliar chemistry measurements.

2018 **Intern**, NASA ABoVE, Goddard Space Flight Center
A remote sensing data fusion project with the Arctic Boreal Vulnerability Experiment (ABoVE) to model soil moisture from airborne Synthetic Aperture Radar.

2013 **Student**, The Polaris Project, Woodwell Climate Research Center
A month in the Siberian Arctic implementing an individual research project on the relationship between plant type, microenvironment and carbon fluxes.

2012 **Student**, Research in Reptile Ecology Field Course, Western Washington University
Six weeks of ecological and behavioral reptile research as a part of a class.

SOFTWARE/PROGRAMMING EXPERIENCE

R My preferred program for remote sensing/GIS analysis, data manipulation/visualization, and statistical modeling, and the language I used to write an algorithm to identify thermokarst features (depressions formed in thawing permafrost) from a single elevation raster. Experience parallelizing code and creating packages and shiny apps. I am comfortable with data manipulation in both the tidyverse and data.table and use raster, sf, and sp for spatial data. I have experience with statistical methods using lm (linear models), lme4 (mixed effects models), and various packages for machine learning methods, including gbm (gradient boosted regression trees). I use ggplot2 (go to for all figures and mapping), ggthemes (modifying style), ggpubr (combining multiple figures), plotly (interactive figures), ggmap (interactive maps), DiagrammeR (flowcharts), and magick (gifs) for visualizations most often.

Python I use python for remote sensing/GIS analysis, data manipulation/visualization, and statistical modeling, particularly when I need access to algorithms only implemented in Python or when integration with the Earth Engine Python API is useful. I use rioxarray for raster analysis and pandas, numpy, and seaborn for data analysis and visualization.

Earth Engine I use Earth Engine, both the code editor and Python API, for remote sensing/GIS analysis when access to large amounts of data or extra computational power is necessary.

ArcGIS/QGIS Experience with raster and shapefile analysis, particularly terrain and hydrological analysis.

HPC Extensive use of both Northern Arizona University's and NASA's High Performance Computing clusters for remote sensing and GIS analysis for my research.

Git/Github I use git/github for version control of all my code and have experience collaborating with others on repositories.

DATA VISUALIZATION

Data Visualization Examples

This overview of my PhD research compiles some of the wide variety of figures I created during my PhD. It includes static maps, traditional data figures, a conceptual diagram, a flow chart, and an animated gif, all of which were created for inclusion in peer-reviewed journals. Most of the figures were created in R and Fig. 6 utilized ArcGIS and Photoshop. I created all of the figures independently except Fig. 10, which I created in collaboration with Ted Schuur and Victor Leshyk (artist). I have included the version that I created which Victor Leshyk utilized in adding his artistic embellishments. Creating this figure provided an opportunity to learn how to add ggplot "grobs"

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(entire figures in their own right, packaged up to be added on top of another figure) of pie charts in the place of points. While adding a single grob on top of a figure is quite simple, adding multiple grobs at once in different locations and sizes is not explicitly supported by ggplot2, and was a fun challenge.

Interactive Plots — I create interactive figures in html files to facilitate Schuur Lab discussions of carbon flux data. Plots include the ability to zoom, hover over for information, and turn points off and on through the legend.

Bio698 Visualizing Scientific Results — I completed a scientific visualization class with Victor Leshyk as a part of my PhD coursework.

TEACHING/WORK EXPERIENCE

August 2016-May 2022	Research Assistant, Schuur Laboratory, Northern Arizona University (interspersed with TA-ships)
January-May 2022	Microbiology Laboratory Teaching Assistant, Northern Arizona University
February-March 2021	Designed and taught a workshop on coding best practices in science for the Schuur Laboratory
August 2017-May 2020	Writing in Microbiology Teaching Assistant, Northern Arizona University
August-December 2016	Unity of Life: Life of the Cell Laboratory Teaching Assistant, Northern Arizona University
January-April 2015	Biology of Land Plants Laboratory Teaching Assistant, University of Victoria

PUBLICATIONS

Google Scholar Profile

Schuur, EA, Abbott, BW, Commane, R, Ernakovich, J, Euskirchen, E, Hugelius, G, Grosse, G, Jones, M, Koven, C, Leshyk, V, …, **Rodenhizer, HG**, et al., 2022. Permafrost and Climate Change: Carbon Cycle Feedbacks from the Warming Arctic. *Annual Review of Environment and Resources*, *47*, pp.343-371.

Rodenhizer, HG, Belshe, F, Celis, G, Ledman, J, Mauritz, M, Goetz, S, Sankey, T and Schuur, EA, 2022. Abrupt permafrost thaw accelerates carbon dioxide and methane release at a tussock tundra site. *Arctic, Antarctic, and Alpine Research*, *54*(1), pp.443-464.

Collins, CG, Elmendorf, SC, Hollister, RD, Henry, GH, Clark, K, Bjorkman, AD, Myers-Smith, IH, Prevéy, JS, Ashton, IW, Assmann, JJ, …, **Rodenhizer, HG**, et al., 2021. Experimental warming differentially affects vegetative and reproductive phenology of tundra plants. *Nature communications*, *12*(1), pp.1-12.

Prevéy, J, Elmendorf, S, Bjorkman, A, Alatalo, J, Ashton, I, Assmann, J, Björk, RG, Björkman, MP, Cannone, N, Carbognani, M,..., **Rodenhizer, HG**, et al., 2021. The tundra phenology database: More than two decades of tundra phenology responses to climate change. *Arctic Science*, (ja).

Schuur, T, Bracho, R, Celis, G, Belshe, F, Ebert, C, Ledman, J, Mauritz, M, Pegoraro, E, Plaza, C, **Rodenhizer, Heidi G**, and Romanovsky, V, 2021. Tundra underlain by thawing permafrost persistently emits carbon to the atmosphere over fifteen years of measurements. *Journal of Geophysical Research: Biogeosciences*, pp.e2020JG006044.

Rodenhizer, HG, Ledman, J, Mauritz, M, Natali, SM, Pegoraro, E, Plaza, C, Romano, E, Schädel, C, Taylor, M and Schuur, E, 2020. Carbon Thaw Rate Doubles When Accounting for Subsidence in a Permafrost Warming Experiment. *Journal of Geophysical Research: Biogeosciences*, *125*(6), pp.e2019JG005528.

Schädel, C; Koven, CD; Lawrence, DM; Celis, G; Garnello, AJ; Hutchings, J; Mauritz, M; Natali, SM; Pegoraro, E; **Rodenhizer, HG**; et al. 2018. Divergent patterns of experimental and model-derived permafrost ecosystem carbon dynamics in response to Arctic warming. *Environmental Research Letters. 13(10)*, pp.105002.

PRESENTATIONS/POSTERS

Rodenhizer, Heidi G, Belshe, F, Celis, G, Ledman, J, Mauritz, M, Goetz, Mack, M, S, Sankey, T and Schuur, E, 2021. Carbon Release Accelerated by Abrupt Thaw at Eight Mile Lake, AK. Presented at the American Geophysical Union Fall Meeting, New Orleans, LA.

Rodenhizer, Heidi G, Belshe, F, Celis, G, Ledman, J, Mauritz, M, Goetz, Mack, M, S, Sankey, T and Schuur, E, 2021. The Thermokarst Detection Algorithm: A Case Study at Eight Mile Lake, AK. Poster presented at the Regional Conference on Permafrost, online.

Rodenhizer, Heidi G, Ledman, J, Mauritz, M, Natali, SM, Pegoraro, E, Plaza, C, Romano, E, Schädel, C, Taylor, M and Schuur, E, 2020. Accounting for Subsidence Reveals 50% Deeper Permafrost Thaw and Double the Rate of Carbon Thaw in a Permafrost Warming Experiment (Invited). Presented at the American Geophysical Union Fall Meeting, online.

Luo, Y, Lu, X, Schuur, E, Mauritz, M, Taylor, M, **Rodenhizer, Heidi G**, Schädel, C, Ebert, C, Garnello, A, Pegoraro, E and Ma, S, 2019. Significant C source driven by elevated water table but sink by increasing thaw depth in Alaska tundra under experimental warming: A data assimilation study. Poster presented at the American Geophysical Union Fall Meeting, San Francisco, CA.

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Rodenhizer, Heidi G, Mauritz, M., Taylor, M. and Schuur, E., 2018. Using the Relationship Between Active Layer Thickness and Subsidence to Constrain Permafrost Thaw. Poster presented at the American Geophysical Union Fall Meeting, Washington, D.C.

Rodenhizer, Heidi G, Hoy E**.** 2018. Detecting Soil Moisture with L-band SAR and LiDAR. Poster presented at the NASA Goddard Intern Poster Session, Greenbelt, MD.

Rodenhizer, Heidi G, Mauritz M, Natali S, Romano E, Pegoraro E, Taylor M, Sankey T, Schuur E. 2018. Quantification of Surface Subsidence Using Real Time Kinematic GPS in Experimentally Warmed Permafrost. Poster presented at the ABoVE Science Team Meeting, Seattle, WA.

Rodenhizer, Heidi G, Mauritz M, Natali S, Romano E, Pegoraro E, Taylor M, Sankey T, Schuur E. 2017. Quantification of Surface Subsidence Using Real Time Kinematic GPS in Experimentally Warmed Permafrost. Poster presented at the American Geophysical Union Fall Meeting, New Orleans, LA.

Squires, Ellen; **Rodenhizer, Heidi G**; Natali, Susan M; Mann, Paul; Bunn, Andrew. 2013. Plant-Environment Interactions of Arctic Vegetation and Implications for CO2 Flux. Poster presented at the American Geophysical Union Fall Meeting, San Francisco, CA.

DATASETS

Rodenhizer, Heidi G, Celis, G, Bracho, R, Schuur, E. 2021. AmeriFlux US-EML Eight Mile Lake Permafrost thaw gradient, Healy Alaska., Ver. 4-5, AmeriFlux AMP, (Dataset). https://doi.org/10.17190/AMF/1418678

Rodenhizer, Heidi G; Mauritz, Marguerite; Taylor, Meghan A.; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G. 2020. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): GPS Elevation, 2009-2020* , Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:729, http://www.lter.uaf.edu/data/data-detail/id/729. 10.6073/pasta/18922ce3170dc2abf1dcc78585302f45

Rodenhizer, Heidi G; Mauritz, Marguerite; Taylor, Meghan A.; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): GPS Elevation, 2009-2019* , Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:729, http://www.lter.uaf.edu/data/data-detail/id/729. doi:10.6073/pasta/9b181a01b52f254a9cdbcba007c0a165

Rodenhizer, Heidi G; Mauritz, Marguerite; Taylor, Meghan A.; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): GPS Plot Locations*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:730, http://www.lter.uaf.edu/data/data-detail/id/730. doi:10.6073/pasta/73e1738968a42877a37b4e0c80e07ef0

Rodenhizer, Heidi G; Mauritz, Marguerite; Taylor, Meghan A.; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): GPS Plot Locations*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:731, http://www.lter.uaf.edu/data/data-detail/id/731. doi:10.6073/pasta/8c263d69877876c5a3d6c7f47814cf3d

Rodenhizer, Heidi G; Celis, Gerardo; Ledman, Justin; Schuur, Edward A.G. 2019. *Eight Mile Lake Research Watershed, Thaw Gradient: GPS Plot Locations*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:732, http://www.lter.uaf.edu/data/data-detail/id/732. doi:10.6073/pasta/7f9ffc13d7c9b77e283ebd475033597a

Rodenhizer, Heidi G; Mauritz, Marguerite; Taylor, Meghan A.; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): Half-hourly growing season, chamber-based, CO2 flux data, 2009-2019*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:481, http://www.lter.uaf.edu/data/data-detail/id/481. doi:10.6073/pasta/49590d6e1c6093f5d47f8190dbc70b79

Rodenhizer, Heidi G; Mauritz, Marguerite; Ledman, Justin; Natali, Susan M.N.; Schuur, Edward A.G.; Taylor, Meghan A. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): Growing season, chamber-based, CO2 flux data, 2009-2019* , Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:495, http://www.lter.uaf.edu/data/data-detail/id/495. doi:10.6073/pasta/c227846909916e442b916eed334dd3cb

Rodenhizer, Heidi G; Schuur, Edward A.G.; Greyson-Gaito, Christopher J.; Mauritz, Marguerite. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): Phenology of Dominant Plant Species I - Bud burst and Senescence 2013-2018*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:570, http://www.lter.uaf.edu/data/data-detail/id/570. doi:10.6073/pasta/df1b08285422add4f9387ccf1ebd22ec

Rodenhizer, Heidi G; Schuur, Edward A.G.; Greyson-Gaito, Christopher J.; Mauritz, Marguerite**.** 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): Phenology of Dominant Plant Species II - Berry Production 2013-2018*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:580, http://www.lter.uaf.edu/data/data-detail/id/580. doi:10.6073/pasta/218e76b8f5e3fb4bfaebd3443d26627c

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Rodenhizer, Heidi G; Natali, Susan M.N.; Schuur, Edward A.G.; Greyson-Gaito, Christopher J.; Mauritz, Marguerite. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): Phenology of Dominant Plant Species I - Bud burst and Senescence 2013-2018*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:571, http://www.lter.uaf.edu/data/data-detail/id/571. doi:10.6073/pasta/f5f36fa71cbbcd6b1eba17ad0bc1afb6

Rodenhizer, Heidi G; Natali, Susan M.N.; Schuur, Edward A.G.; Greyson-Gaito, Christopher J.; Mauritz, Marguerite**.** 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): Phenology of Dominant Plant Species II - Berry Production 2013-2018*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:582, http://www.lter.uaf.edu/data/data-detail/id/582. doi:10.6073/pasta/9f0841213d7087ec746b3c0d288c389d

Rodenhizer, Heidi G; Natali, Susan M.N.; Schuur, Edward A.G.; Greyson-Gaito, Christopher J.; Mauritz, Marguerite. 2019. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): Phenology of Dominant Plant Species III - Flowering Date 2013-2018*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:583, http://www.lter.uaf.edu/data/data-detail/id/583. doi:10.6073/pasta/2eb020103df4d213a26b0abc66868380

Rodenhizer, Heidi G; Schuur, Edward A.G. 2018. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): leaf C, N, delta-13C, delta-15N at peak biomass; 2009-2016*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:499, http://www.lter.uaf.edu/data/data-detail/id/499. doi:10.6073/pasta/13054b36e37b925361d70258d367e286

Rodenhizer, Heidi G; Natali, Susan M.N.; Schuur, Edward A.G.; Mauritz, Marguerite. 2018. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating and Drying Research (DryPEHR): leaf C, N, delta-13-C, delta-N-15 2011-2016*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:628, http://www.lter.uaf.edu/data/data-detail/id/628. doi:10.6073/pasta/8f11ed993adfc4c10e686b247bd1f354

Rodenhizer, Heidi G; Schuur, Edward A.G. 2017. *Eight Mile Lake Research Watershed, Carbon in Permafrost Experimental Heating Research (CiPEHR): C, N, delta-13C, delta-15N from senescent leaves, 2009-2015*, Bonanza Creek LTER - University of Alaska Fairbanks. BNZ:500, http://www.lter.uaf.edu/data/data-detail/id/500. doi:10.6073/pasta/d116a9a76f648acbb4917d8dfd883ea5

AWARDS

2021 Dr. Oliver W Johnson Scholarship in Biology
2021 ARCS Scholar
2018 Center for Ecosystem Science and Society Travel and Research Awards Program Recipient for the AGU Fall Meeting
2018 ABoVE Science Team Meeting Student Travel Grant
2017 United States Permafrost Association Andrew Slater Memorial Scholarship
2012 Western Washington University President's List Fall, Winter and Spring Quarters
2010 2-yr President's Scholarship
2009 First Green of WA Scholarship

REVIEW ACTIVITY

Publons Profile
Journals/Publishers: Biogeosciences, Polar Geography, Oxford University Press, Journal of Geophysical Research: Earth Surface

OUTREACH/VOLUNTEER EXPERIENCE

2021 NAU Upward Bound Math & Science presentation to High School students
2018-2019 Scientists in the Classroom in-class visits to Sinagua Middle School science class
2015 Siberian plant identification sessions with Barry Wendling of Western Washington University
2008-2009 Citizen Wildlife Monitoring Project winter tracking volunteer for I-90 wildlife bridges
2007 Seattle Aquarium Citizen Scientist

PROFESSIONAL AFFILIATIONS

American Geophysical Union (AGU), United States Permafrost Association (USPA)

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LANGUAGES

English, German (conversational)