Adrienne Hoarfrost

NASA Ames Research Center
Space Biosciences Division
Moffett Field, CA, USA

adrienne.l.hoarfrost@nasa.gov
adrienne.l.hoarfrost@gmail.com
503.753.3207

Education

PhD in Marine Sciences, University of North Carolina at Chapel Hill. Advisor: Carol Arnosti ….....2018

MS in Marine Sciences, University of North Carolina at Chapel Hill. Advisor: Carol Arnosti……2015

AB in Biological Sciences (Geobiology concentration), Dartmouth College……..2011

Employment

NASA Postdoctoral Fellow, Space Biology, NASA Ames Research Center.....2021 - present

Scientific Advisor and Co-founder, BlueCarbon *(early stage ocean-tech startup)*.....2021 - present

Faculty, ML Lead, Frontier Development Lab 2021 Astronaut Health Challenge.....2021

Researcher, Frontier Development Lab 2020 Astronaut Health Challenge.....2020

NASA Postdoctoral Fellow, Astrobiology, Rutgers University.....2019 - 2021

PhD student, University of North Carolina at Chapel Hill.....2012 - 2018

Lab Technician, Harvard University. PI: Peter Girguis.....2011 - 2012

Publications

Hoarfrost, A., Aptekmann, A., Farfanuk, G. & Bromberg, Y. (*accepted in Nature Communications*), Shedding Light on Microbial Dark Matter with A Universal Language of Life. *Preprint on bioRxiv*: doi:10.1101/2020.12.23.424215.

Sanders, L., Yang, J., Scott, R. T... **Hoarfrost**, A., et al. Beyond Low Earth Orbit: Biological Research, Artificial Intelligence, and Self-Driving Labs. *Invited review in submission at Nature Machine Intelligence. Preprint: arXiv:2112.12582.*

Scott, R. T., Antonsen, E., Sanders, L... **Hoarfrost**, A., et al. Beyond Low Earth Orbit: Precision Space Health, Monitoring, Artificial Intelligence, and Modeling. *Invited review in submission at Nature Machine Intelligence. Preprint: arXiv:2112.12554.*

O'Donoghue, O.*, Duckworth*, P.*, Scheibenreif, L.*, Ughi, G.*, Khezeli, K., **Hoarfrost, A.**, Budd, S., Chia, N., Foley, P., Mackintosh, G., Kalantari, J., Soboczenski, F., Sanders, L. Invariant Risk Minimisation for Cross-Organism Inference: Substituting Mouse Data for Human Data in Human Risk Factor Discovery*. Machine Learning 4 Health at NeurIPS 2021, arXiv:2111.07348 (* indicates equal contribution of the authors)*

O'Donoghue, O.*, Duckworth*, P.*, Scheibenreif, L.*, Ughi, G.*, Khezeli, K., **Hoarfrost, A.**, Budd, S., Chia, N., Foley, P., Mackintosh, G., Kalantari, J., Soboczenski, F., Sanders, L. (*in submission),* Leveraging Invariance in non-i.i.d. Federated Learning.

Budd, S.*, Blaas, A.*, **Hoarfrost, A.***, Khezeli, K.*, D'Silva, K., Soboczenski, F., Mackintosh, G., Chia, N., Kalantari, J. Prototyping CRISP: A Causal Relation and Inference Search Platform. *IEEE LifeTech Proc., 2021,* pp. 517-521. doi: 10.1109/LifeTech52111.2021.9391819.

ElAbd, H., Bromberg, Y., **Hoarfrost, A.**, Lenz, T.L., Franke, A., Wendorff, M. (2020), Amino Acid Encoding for Deep Learning Applications. *BMC Bioinf. 21:235*, *doi: 10.1186/s12859-020-03546-x.*

LaRowe, D., Arndt, S., Bradley, J., Estes, E., **Hoarfrost, A.**, Lang, S., Lloyd, K., Mahmoudi, N., Orsi, W., Shah Walter, S., Steen, A., Zhao, L. (2020), The fate of organic carbon in marine sediments – new insights from recent data and analysis. *Ear. Sci. Rev. doi:10.1016/j.earscirev.2020.103146.*

Hoarfrost, A., Nayfach, S., Ladau, J., Yooseph, S., Arnosti, C., Dupont, C. L., Pollard, K. S. (2020), Global ecotypes in the ubiquitous marine SAR86 clade. *ISME Journal. 14:178-188, doi: 10.1038/s41396-019-0516-7.*

Hoarfrost, A., Brown, N., Brown, C.T., Arnosti, C. (2019), Sequencing data discovery with MetaSeek. *Bioinformatics*, *btz499*, *doi:10.1093/bioinformatics/btz499*. Live at http://www.metaseek.cloud/.

Hoarfrost, A., Balmonte, J.P., Ghobrial, S., Ziervogel, K., Bane, J., Gawarkiewicz G., Arnosti, C. (2019), Gulf Stream ring water intrusion on the Mid-Atlantic Bight continental shelf break affects microbially driven carbon cycling. *Front. Mar. Sci. 6(394), doi:10.3389/fmars.2019.00394.*

Balmonte, J.P., Buckley, A., **Hoarfrost, A.**, Ghobrial, S., Ziervogel, K., Teske, A., Arnosti, C. (2018), Community structural differences shape microbial responses to high molecular weight organic matter. *Environ. Microbiol. 21 (2), 557-571. doi:10.1111/1462-2920.14485.*

Hoarfrost, A., and Arnosti, C. (2017), Heterotrophic extracellular enzymatic activities in the Atlantic Ocean follow patterns across spatial and depth regimes, *Front. Mar. Sci*., 4, 200, *doi:10.3389/fmars.2017.00200.*

Hoarfrost, A., Snider, R., Arnosti, C. (2017), Improved measurement of extracellular enzymatic activities in subsurface sediments using competitive desorption treatment, *Front. Earth Sci., 5(13)*, 13. *doi:10.3389/feart.2017.00013.*

Adams, M. M., **Hoarfrost, A.**, Bose, A., Joye, S. B., Girguis P. R. (2013), Anaerobic oxidation of short-chain alkanes in hydrothermal sediments: potential influences on sulfur cycling and microbial diversity, *Front. Microbiol., 4(110), doi:10.3389/fmicb.2013.00110.*

External Funding

Active funding

NASA Postdoctoral Fellowship 2019

Project Title: *Linking Life and Earth with Deep Transfer Learning*
Amount Awarded: $275,869
Role: lead PI

Past Funding

Microsoft AI For Earth Grant 2020

Project Title: *The Universal Language of Life – Leveraging Deep Transfer Learning to Model the Biogeosphere*
Amount Awarded: $5000
Role: sole PI

Royster Society of Fellows Dissertation Completion Fellowship 2018
Project Title: *Linking Environmental and Microbial Processes from Community to Global Scales*
Amount Awarded: $21,000
Role: lead PI

Deep Carbon Observatory Deep Life Modeling and Visualization Graduate Fellowship 2016
Project Title: *Using Machine Learning to Predict Global-Scale Patterns in Microbial Communities and Carbon-Cycling Activities*
Amount Awarded: $27,000
Role: lead PI

Center for Dark Energy Biosphere Investigations Graduate Fellowship 2014
Project Title: *Investigating Microbial Activities Driving Organic Matter Transformations in the Deep Subsurface*
Amount Awarded: $65,000
Role: lead PI

Awards & Recognition

1st place Regional, 3rd place Global winner, Mondial de Mer Ocean Hackathon	2021
IEEE LifeTech 2021 Outstanding Paper Award	2021
International Union of Crystallography Travel Award	2018
UNC Graduate Student Mentor Award	2016
UNC Graduate and Professional Student Federation Travel Award	2013
Richter Memorial Fund Recipient for Independent Research	2010
Barr 1968 Memorial Scholarship for accomplishment in the sciences and performing arts	2009

Selected Professional Development, Service & Outreach Activities

Challenge Owner, Mondial de Mer Ocean Hackathon, San Francisco, USA	2021
Subject Matter Expert & moderator, NASA AI for Space Biology Workshop	2021
Subject Matter Expert, NASA Space Apps COVID-19 Challenge	2020
Census of Deep Life Metadata Standards Working Group	2017 - 2018
Next-Generation Sequencing Analysis Workshop, Augusta, MI	2015
Science Advisor for the children's book *Where the Wild Microbes Grow*	2015
President, Graduate Action Group, UNC-Chapel Hill Dept. of Marine Sciences	2014 - 2015
Deep Carbon Observatory Summer School, Big Sky, MT	2014
Science Judge, Blue Heron Bowl, Raleigh, NC	2014
Senator and Finance Committee member, Graduate and Professional Student Federation Senate, UNC-Chapel Hill	2013 - 2014

Teaching & Mentorship

Mentor to 4 interns (NASA), 4 undergraduates (Rutgers & UNC)	2013 – present
Graduate Teaching Assistant (UNC): Energy Flow in the Environment and Society	2013
Graduate Teaching Assistant (UNC): Marine Physiological Ecology	2013
Graduate Teaching Assistant (UNC): The Marine Environment	2012
Mentor to two high school interns, Harvard University	2011 - 2012
Undergraduate Lab Teaching Assistant (Dartmouth): Genetics	2009

Field Experience

R/V *Endeavor*, North Atlantic. Effects of organic carbon source on carbon cycling activities.	2016
R/V *Endeavor*, Mid Atlantic Bight. Impacts of ring water intrusions on microbial enzymatic activities.	2015
R/V *Knorr*, South Atlantic. Latitudinal and depth-driven patterns in heterotrophic functional capacities.	2013
R/V *Atlantis*, Juan de Fuca Ridge. Expedition with the Alvin submarine to study microbial hydrocarbon and sulfur cycling in hydrothermal vent ecosystems.	2010

Invited Talks

Empowering AI-Driven Insights into Biological Complexity. University of Georgia Athens, Virtual, Feb 2022.

Empowering AI-Driven Insights into Biological Complexity. Rutgers University, Virtual, Sep 2021.

Learning the Biological 'Language of Life': Capturing High Complexity with Limited Data. NASA Artificial Intelligence and Modeling for Space Biology Workshop, Virtual, June 2021.

Empowering Data-Intensive Discovery and Deep Learning-Driven Insights to Capture Biological Complexity in the Biogeosphere. Woods Hole Oceanographic Institution, Virtual, April 2021.

Empowering AI-Driven Insights of Biological Complexity and Open Science for Space Biology. NASA Ames, Virtual, March 2021.

Capturing the complexity of the bio-geosphere with deep transfer learning. NASA Postdoctoral Program Site Visit, Virtual, July 2020.

Capturing the complexity of the bio-geosphere with deep transfer learning. ENIGMA Symposium, Virtual, June 2020.

Modeling the complexity of the bio-geosphere with deep transfer learning. ENIGMA Symposium, New Brunswick, NJ, May 2019.

Linking environmental and microbial processes from community to global scales. Royster Fellow Interdisciplinary Seminar, Chapel Hill, NC, Oct 2018.

From data discovery to data-driven discovery: leveraging sequencing data integration for insights into global microbial biogeography. Rutgers University, New Brunswick, NJ, May 2018.

Data discovery => data-driven discovery. Deep Life Modeling and Visualization Workshop, Tempe, AZ, Mar 2018.

Opportunities and challenges facing deep learning for subsurface microbiology in the era of data-intensive bioinformatics. Microorganisms and Organic Carbon in the Marine Subsurface Workshop, Knoxville, TN, Mar 2018.

Sequence data discovery with MetaSeek. University of California Davis, Davis, CA, July 2017.

Sequence data discovery with MetaSeek. Deep Carbon Observatory Deep Life Community Meeting, Edinburgh, Scotland, Mar 2017.

Global-scale patterns in microbial communities and functions using machine learning. Deep Life Modeling and Visualization Workshop, Ascona, Switzerland, Mar 2016.

Contributed Presentations

Hoarfrost, A., Aptekmann, A., Farfanuk, G., Falkowski, P., Bromberg, Y. *Illuminating the Microbial Dark Matter Driving Energy Transformations in the Environment with a Universal Language of Life*. Goldschmidt Annual Conference, Virtual, July 2021.

Hoarfrost, A., Blaas, A., Budd, S., Khezeli, K., Chia, N., D'Silva, K., Gal, Y., Mackintosh, G., Soboczenski, F., Kalantari, J. *Prototyping CRISP: A Causal Research and Inference Search Platform.* 2021 NASA Human Research Program Investigators' Workshop, Virtual, Feb 2021.

Hoarfrost, A., Bromberg, Y. *The universal language of life – leveraging deep transfer learning to model the biogeosphere.* Goldschmidt Annual Conference, Virtual, June 2020.

Hoarfrost, A., Brown, N., Brown, C.T., Arnosti, C., Bromberg, Y. *Data discovery, integration, and deep learning for the bio-geosphere.* Astrobiology Science Conference, Bellevue, WA, June 2019.

Hoarfrost, A., Brown, N., Brown, C.T., Arnosti, C. *Sequencing data discovery and integration with MetaSeek: enabling data-driven discovery linking the biosphere and geosphere*. Earth in 4D: Deep-time Data Driven Discovery and the Evolution of Earth Workshop, Washington, DC, June 2018.

Hoarfrost, A., Nayfach, S., Ladau, J., Arnosti, C., Yooseph, S., Dupont, C., Pollard, K. *Predicting global functional and phylogenetic distributions of SAR86*. Ocean Sciences Meeting, Portland, OR, Feb 2018.

Hoarfrost, A., Brown, N., Brown, C.T., Arnosti, C. *Discovery and integration of ocean sequencing data with MetaSeek*. Ocean Sciences Meeting, Portland, OR, Feb 2018.

Hoarfrost, A., Brown, N., Arnosti, C. *Sequencing data discovery and integration for Earth system science with MetaSeek*. American Geophysical Union Annual Meeting, New Orleans, LA, Dec 2017.

Hoarfrost, A., Brown, N., Brown, C. T., Arnosti, C. *MetaSeek: A sequencing data discovery platform*. Deep Carbon Observatory International Meeting, Edinburgh, Scotland, Mar 2017.

Hoarfrost, A., Balmonte, J.P., Ziervogel, K., Ghobrial, S., Gawarkiewicz, G., Arnosti, C. *Strong effects of a shelfbreak jet on microbial enzyme activities*. Ocean Sciences Meeting, New Orleans, LA, Feb 2016.

Hoarfrost, A., Snider, R., Arnosti, C. *Microbial degradation of organic carbon in the diverse sediments of Guaymas Basin*. American Geophysical Union Annual Meeting, San Francisco, CA, Dec 2015.

Hoarfrost, A., Arnosti, C. *Patterns in heterotrophic extracellular enzymatic activity across geospatial regimes*. Gordon Research Conference on Chemical Oceanography, Holderness, NH, July 2015.

Hoarfrost, A., Arnosti, C. *Microbial extracellular enzymatic hydrolysis of organic carbon along depth and latitudinal gradients in the South Atlantic*. Association for the Sciences of Limnology and Oceanography Annual Meeting, Barcelona, Spain, Feb 2015.

Hoarfrost, A., Couper, L., Arnosti, C. *Pour some sugar on me: extracellular enzymatic hydrolysis of high-molecular-weight polysaccharides in sapropelic and non-sapropelic subsurface sediments*. American Geophysical Union Annual Meeting, San Francisco, CA, Dec 2014.

Hoarfrost, A., Couper, L., Arnosti, C. *Extracellular enzymatic hydrolysis of high-molecular-weight organic carbon in sapropelic and non-sapropelic subsurface sediments*. Center for Dark Energy Biosphere Investigations Annual Meeting, Marina, CA, Oct 2014.

Hoarfrost, A., Couper, L., Arnosti, C. *Investigating microbial activities driving organic matter transformations in the deep subsurface*. Deep Carbon Observatory Summer School, Big Sky, MT, July 2014.

Hoarfrost, A., Arnosti, C. *Investigating microbial activities driving organic matter transformations in the deep subsurface*. Center for Dark Energy Biosphere Investigations Annual Meeting, Marina, CA, Oct 2013.