

ANDREW BENNETT

CONTACT

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EDUCATION

University of Washington **Sept. 2016 - Mar. 2021**
Ph.D. - Department of Civil and Environmental Engineering
Hydrology and hydrodynamics, Advisor: Bart Nijssen
Dissertation: Applications of information theory and machine learning for hydrologic modeling

University of Wisconsin, La Crosse **Sept. 2008 - May 2013**
Bachelor of Science - Physics and Mathematics

PROFESSIONAL EXPERIENCE

University of Arizona **Sept. 2021 - Present**
Postdoctoral Research Associate - Department of Hydrology and Atmospheric Sciences

University of Washington **Apr. 2021 - Sept. 2021**
Research Scientist - Department of Civil and Environmental Engineering

Oak Ridge National Laboratory **Oct. 2013 to Aug. 2016**
Research Associate - Computer Science and Mathematics Division

University of Wisconsin, La Crosse **Jan. 2012 to May 2013.**
Physics Tutor

STUDENT MENTORING

Peter Sumner JISAO Summer Intern **Summer 2017**
Project: Google Earth Analysis of Soil Moisture
and Landslide Risk in the Pacific Northwest

Tushar Khurana Undergraduate Research Assistant **Fall 2018**
Project: Information Theoretic Analysis of Hydrological Land Surface Models

Adi Stein Undergraduate Research Assistant **Spring 2019- Summer 2021**
Project: Developing spatially-consistent and process-aware
bias-correction methods for streamflow simulations

TEACHING

Instructor University of Arizona HWRS 401/501 **Fall 2022**
Tools for Data Handling and Analysis in Water, Weather, & Climate

Guest lecturer University of Saskatchewan GEOG 825 **Winter 2022**
Process Based Modeling

Guest lecturer University of Saskatchewan GEOG 825 **Fall 2020**
Meteorologic Forcing Data

Excercise development CUAHSI Virtual Snow Modeling **Fall 2019**
Snow modeling with SUMMA

SEMINARS

Workshop speaker Knowledge Guided Machine Learning Workshop **Summer 2021**
Embedding neural networks to simulate turbulent heat

fluxes in a process-based hydrologic modeling framework

Seminar University of Arizona TRIPODS Seminar
Embedding neural networks into physics-based hydrologic models

Spring 2021

Seminar University of Washington Data Science Seminar
Embedding neural networks into large Earth systems models

Winter 2020

Public speaker Puget Sound Programming Python Meetup
Algorithms, information and the environment

Winter 2019

Workshop instructor WaterHackWeek
MetSim: A python library for meteorological data simulation

Spring 2019

AWARDS & HONORS

AGU Outstanding Student Presentation Award 2020
EGU Outstanding Student Poster and Pico Award 2019
COMAP Mathematical Contest in Modeling Honorable Mention 2013

SERVICE

Session Convener June 2022
Frontiers in Hydrology Meeting: "Emphasizing F, I and R in FAIR hydrology:
Bottlenecks and solutions to making hydrologic science more reproducible"

Poster Judge March 2022
University of Arizona - El Dia de la Agua y la Atmosfera

Travel Grant Committee March 2022
Pennsylvania State University - HydroML Symposium

Reviewer

- Earth and Space Science
- Geophysical Research Letters
- Hydrologic Processes
- Hydrologic & Earth Systems Science
- Journal of Hydrology
- Journal of Advances in Modeling Earth Systems
- Journal of Open Source Software
- Stochastic Environmental Research and Risk Assessment
- Water Resources Resources

SOFTWARE & TECHNICAL SKILLS

Programming Languages:
Bash, C, Fortran, Python, Java, Javascript, Julia, R, LaTeX

Technologies:
git, NetCDF, HPC systems, Python packaging (pypi, conda), automake, pytorch, tensorflow

Open Source Development Experience:

- **SUMMA**: <https://github.com/NCAR/summa>
- **pysumma**: <https://github.com/UW-Hydro/pysumma>
- **bmorph**: <https://github.com/UW-Hydro/bmorph>
- **MetSim**: <https://github.com/UW-Hydro/MetSim>
- **ParFlow**: <https://github.com/parflow/parflow>
- **LIVVkit**: <https://github.com/LIVVkit/LIVVkit>
- **Eclipse ICE**: <https://gitlab.eclipse.org/eclipse/ice/ice>

ESIP - Machine Learning Tutorial

August 2022

Lead PI: High resolution predictions of global snow using recurrent neural networks
Total award: \$5,000

in review* **NOAA Weather Prediction Office

November 2022

PI: Advancing UFS Forecast Model Evaluation and Improvement for S2S Hydrometeorological Prediction in the Western States
Total award: \$989,000

BOOK CHAPTERS
& MONOGRAPHS

Bennett, Andrew. “AI for Physics-inspired Hydrology Modeling”. *Earth Science Artificial Intelligence*, edited by Ziheng Sun, Nicoleta Cristea, and Pablo Rivas, Accepted, Elsevier, 2022, chapter 12.

PEER-REVIEWED
PUBLICATIONS

Maghami, I., A. van Beusekom, Hay L., Li Z., **Bennett, A.**, Y. Choi, Nijssen B., D. Tarboten, and Goodall J.L. “Building Cyberinfrastructure for the Reuse and Reproducibility of Complex Hydrologic Modeling Studies”. *Environmental Modelling & Software*, 2022, in review.

Hull, R., E. Leonarduzzi, L. De La Fuente, H. V. Tran, **Bennett, A.**, P. Melchior, R. M. Maxwell, and L. E. Condon. “Using simulation-based inference to determine the parameters of an integrated hydrologic model: a case study from the upper Colorado River basin”. *Hydrology and Earth System Sciences Discussions*, 2022, pp. 1–38. <https://doi.org/10.5194/hess-2022-345>.

Bennett, Andrew and Bart Nijssen. “Explainable AI uncovers how neural networks learn to regionalize in simulations of turbulent heat fluxes at FluxNet sites”. *Water Resources Research*, 2022, in revision.

Knoben, W. J. M., M. P. Clark, J. Bales, **Bennett, A.**, S. Gharari, et al. “Community Workflows to Advance Reproducibility in Hydrologic Modeling: Separating model-agnostic and model-specific configuration steps in applications of large-domain hydrologic models”. *Water Resources Research*, vol. n/a, n/a, e2021WR031753 2021WR031753, e2021WR031753. <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2021https://doi.org/https://doi.org/10.1029/2021WR031753>.

Cristea, Nicoleta C., **Bennett, Andrew**, Bart Nijssen, and Jessica D. Lundquist. “When and where are multiple snow layers important for simulations of snow accumulation and melt?” *Water Resources Research*, vol. n/a, n/a, e2020WR028993. <https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2020WR028993https://doi.org/https://doi.org/10.1029/2020WR028993>.

Lumbrazo, Cassie, **Andrew Bennett**, William Currier, Bart Nijssen, and Jessica Lundquist. “Evaluating Multiple Canopy-Snow Unloading Parameterizations in SUMMA With Time-Lapse Photography Characterized by Citizen Scientists”. *Water Resources Research*, vol. 58, no. 6, 2022, e2021WR030852. <https://doi.org/https://doi.org/10.1029/2021WR030852>.

Bennett, Andrew, Adi Stein, Yifan Cheng, Bart Nijssen, and Marketa McGuire. “A process-conditioned and spatially consistent method for reducing systematic biases in modeled streamflow”. *Journal of Hydrometeorology*, 2022. <https://doi.org/10.1175/JHM-D-21-0174.1>.

Beusekom, Ashley E. Van, Lauren E. Hay, **Andrew R. Bennett**, Young-Don Choi, Martyn P. Clark, Jon L. Goodall, Zhiyu Li, Iman Maghami, Bart Nijssen, and Andrew W. Wood. “Hydrologic Model Sensitivity to Temporal Aggregation of Meteorological Forcing Data: a Case Study for the Contiguous USA”. *Journal of Hydrometeorology*, 2021. <https://doi.org/10.1175/JHM-D-21-0111.1>.

Bennett, Andrew and Bart Nijssen. “Deep Learned Process Parameterizations Provide Better Representations of Turbulent Heat Fluxes in Hydrologic Models”. *Water Resources Research*, vol. 57, no. 5, 2021. <https://doi.org/https://doi.org/10.1029/2020WR029328>.

Clark, Martyn P., Reza Zolfaghari, Kevin R. Green, Sean Trim, Wouter J. M. Knoben, **Andrew Bennett**, Bart Nijssen, Andrew Ireson, and Raymond J. Spiteri. “The numerical implementation of land models: Problem formulation and laugh tests”. *Journal of Hydrometeorology*, 2021. <https://doi.org/10.1175/JHM-D-20-0175.1>.

Choi, Young-Don, Jonathan L. Goodall, Jeffrey M. Sadler, Anthony M. Castronova, **Andrew Bennett**, et al. “Toward Open and Reproducible Environmental Modeling by Integrating Online Data Repositories, Computational Environments, and Model Application Programming Interfaces”. *Environmental Modelling & Software*, 2020.

Nearing, Grey S, Benjamin L Ruddell, **Andrew R Bennett**, Cristina Prieto, and Hoshin V Gupta. “Does Information Theory Provide a New Paradigm for Earth Science? Hypothesis Testing”. *Water Resources Research*, vol. 56, no. 2, 2020.

Bennett, Andrew R., Joseph J. Hamman, and Bart Nijssen. “MetSim: A Python package for estimation and disaggregation of meteorological data”. *Journal of Open Source Software*, vol. 5, no. 47, 2020. <https://doi.org/10.21105/joss.02042>.

Lipscomb, William H, Stephen F Price, Matthew J Hoffman, Gunter R Leguy, **Andrew R Bennett**, Sarah L Bradley, Katherine J Evans, Jeremy G Fyke, Joseph H Kennedy, Mauro Perego, et al. “Description and evaluation of the Community Ice Sheet Model (CISM) v2. 1”. *Geoscientific Model Development*, vol. 12, no. 1, 2019.

Bennett, Andrew, Bart Nijssen, Gengxin Ou, Martyn Clark, and Grey Nearing. “Quantifying Process Connectivity With Transfer Entropy in Hydrologic Models”. *Water Resources Research*, vol. 55, no. 6, 2019. <https://doi.org/10.1029/2018WR024555>.

Evans, Katherine J, Joseph H Kennedy, Dan Lu, Mary M Forrester, Stephen Price, Jeremy Fyke, **Andrew R Bennett**, Matthew J Hoffman, Irina Tezaur, Charles S Zender, et al. “LIVVkit 2.1: automated and extensible ice sheet model validation”. *Geoscientific Model Development*, vol. 12, no. 3, 2019.

Billings, Jay Jay, **Andrew R Bennett**, Jordan Deyton, Kasper Gammeltoft, Jonah Graham, Dasha Gorin, Hari Krishnan, Menghan Li, Alexander J McCaskey, Taylor Patterson, et al. “The eclipse integrated computational environment”. *SoftwareX*, vol. 7, 2018.

Kennedy, Joseph H, **Andrew R Bennett**, Katherine J Evans, Stephen Price, Matthew Hoffman, William H Lipscomb, Jeremy Fyke, Lauren Vargo, Adrianna Boghozian, Matthew Norman, et al. “LIVVkit: An extensible, python-based, land ice verification and validation toolkit for ice sheet models”. *Journal of Advances in Modeling Earth Systems*, vol. 9, no. 2, 2017.

SELECTED
CONFERENCE
PRESENTATIONS

Bennett, A., B. Horowitz, E. Leonarduzzi, H. Tran, L. Condon, P. Melchior, and R. Maxwell. “Surrogate modeling of the hydrologic cycle to advance on-demand seasonal prediction capabilities across the Continental United States”. *AGU Frontiers in Hydrology Meeting*. 2022.

Bennett, A. and B. Nijssen. “Informing Machine Learning Models with Hydrologic Theory: A Case Study in Land-Atmosphere Interactions”. *AGU Fall Meeting*. 2021.

Bennett, A., M. Bassiouni, and B. Nijssen. “Searching for new physics: Using explainable AI to understand deep learned parameterizations of turbulent heat fluxes”. *AGU Fall Meeting*. 2021.

Bennett, A. and B. Nijssen. “Searching for new physics: Using explainable AI to understand deep learned parameterizations of turbulent heat fluxes”. *EGU General Assembly*. 2021, <https://doi.org/https://doi.org/10.5194/egusphere-egu21-3516>.

Bennett, A. and B. Nijssen. “A coupled approach to incorporating deep learning into process-based hydrologic modeling”. *AGU Fall Meeting 2020*. 2020, <https://doi.org/https://doi.org/10.1002/essoar.10504849.1>.

Bennett, A. and B. Nijssen. “Hard to measure, hard to model: Using information theory to understand turbulent heat fluxes (invited)”. *EGU General Assembly 2020*. 2020, <https://doi.org/https://doi.org/10.5194/egusphere-egu2020-5957>.

Bennett, A., B. Nijssen, Y. Cheng, A. Stein, and M. McGuire. “Post-processing Hydrologic Model Output for Water Resources Studies: A Spatially-consistent, Process-based Correction Method”. *EGU General Assembly 2020*. 2020, <https://doi.org/https://doi.org/10.5194/egusphere-egu2020-6036>.

Bennett, A., J. Lundquist, J. Hamman, and B. Nijssen. “Leveraging Open Source Platforms to Foster Computational Thinking”. *University of Washington Teaching and Learning Symposium*. 2020.

Bennett, Andrew, B. Nijssen, and G.S. Nearing. “Dynamic process connectivity for model diagnostics, evaluation, and intercomparison”. *AGU Fall Meeting*. 2019.

Bennett, A., B. Nijssen, G.S. Nearing, and M.P. Clark. “A process network based approach to model intercomparison using SUMMA ensembles”. *EGU General Assembly*. 2019.

Bennett, A., B. Nijssen, G.S. Nearing, and M.P. Clark. “Information theoretic fingerprinting of hydrologic Models”. *AGU Fall Meeting*. 2018.

Bennett, A., B. Nijssen, and M.P. Clark. “Fingerprinting hydrologic models by identifying coupling structures”. *SIAM Mathematics of Planet Earth*. Invited talk, 2018, Invited talk.

Bennett, A., B. Nijssen, O. Chegwiddden, A. Wood, and M.P. Clark. “What Makes Hydrologic Models Differ? Using SUMMA to Systematically Explore Model Uncertainty and Error”. *AGU Fall Meeting*. 2017.