

# ANDREW BENNETT

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## CONTACT

e-mail: [bennett.andr@gmail.com](mailto:bennett.andr@gmail.com)  
mobile: +1 920 973 6379  
web: [arbennett.github.io](http://arbennett.github.io)

## 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

<b>Workshop speaker</b> Knowledge Guided Machine Learning Workshop Embedding neural networks to simulate turbulent heat fluxes in a process-based hydrologic modeling framework	<b>Summer 2021</b>
<b>Seminar</b> University of Arizona TRIPODS Seminar Embedding neural networks into physics-based hydrologic models	<b>Spring 2021</b>
<b>Seminar</b> University of Washington Data Science Seminar Embedding neural networks into large Earth systems models	<b>Winter 2020</b>
<b>Public speaker</b> Puget Sound Programming Python Meetup Algorithms, information and the environment	<b>Winter 2019</b>
<b>Workshop instructor</b> WaterHackWeek MetSim: A python library for meteorological data simulation	<b>Spring 2019</b>

## AWARDS & HONORS

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

## SERVICE

<b>Session Convener</b> Frontiers in Hydrology Meeting: "Emphasizing F, I and R in FAIR hydrology: Bottlenecks and solutions to making hydrologic science more reproducible"	<b>June 2022</b>
<b>Poster Judge</b> University of Arizona - El Dia de la Agua y la Atmosfera	<b>March 2022</b>
<b>Travel Grant Committee</b> Pennsylvania State University - HydroML Symposium	<b>March 2022</b>

### 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>

#### EXTERNAL FUNDING

##### **ESIP - Machine Learning Tutorial**

**August 2022**

\$5,000

Lead PI: High resolution predictions of global snow using recurrent neural networks

#### BOOK CHAPTERS & MONOGRAPHS

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

#### PEER-REVIEWED PUBLICATIONS

Knoben, Wouter Johannes Maria, Martyn P. Clark, Jerad Bales, **Bennett, Andrew**, 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. in revision, 2021.

**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*, 2021, in revision.

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/10.1029/2020WR028993>, <https://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.