Dr. Joseph H. Kennedy

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Research Software Engineer

I specialize in multi-institution open-source software development, cloud and high-performance computing, and verification and validation of scientific models. I have extensive experience with end-to-end data science projects incorporating machine learning and statistical analysis of Big Data using the scientific python ecosystem.

Research Highlights

Developed LIVVkit, an ice-sheet model verification and validation toolkit, to provide a wide range of validation analysis covering atmosphere-ice and land-ice interactions as well as ice sheet dynamics. These analysis incorporate everything from point measurements (e.g., weather stations and ablation stakes) to airborne radar altimetry (e.g., NASA IceBridge) and satellite observations (e.g., RADARSAT, NASA GRACE). These analyses exercise the entire data science pipeline, from data wrangling and cleaning to reporting.

Developed EVV, a python package to evaluate the climate statistics of an Earth system model test ensemble against that of a baseline ensemble, by using several modern non-parametric (distribution-free) two-sample statistical tests (e.g., K-S test) for multivariate data to determine the equality of distributions. The critical value for rejecting the null hypothesis is determined by using bootstrap resampling.

Developed a statistical model of ice-crystalline fabric evolution and (two-way) coupled it to a ice sheet flow model by using a Principle Component Analysis (PCA) of the fabric distribution to determine an ice-flow enhancement factor in situ.

Professional Experience

Alaska Satellite Facility, Fairbanks, Alaska, USA
Research Software Engineer
Geophysical Institute, University of Alaska Fairbanks **September 2019 – present**

Develop and maintain ASF's open-source scientific tools and services, including On Demand SAR processing through HyP3, OpenSARlab, and ASF's SAR toolboxes. Transform internally and externally developed science (algorithm and processing) prototypes into Cloud and HPC production services, and execute global-scale processing campaigns.

Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
Computational Scientist in Glaciology
Climate Change Science Institute **December 2016 – September 2019**

Perform research tasks using DOE's Earth system model E3SM and ice sheet models (e.g., MPAS-LI, BISICLES, PISM, CISM); coordinate the verification and validation of E3SM, MPAS-LI, and BISICLES simulations; development of the Land Ice Verification and Validation toolkit (LIVVkit), a python-based toolkit for robust evaluation of ice-sheet models; and develop an extended V&V evaluation tool (EVE) for climate reproducibility testing of ESMs.

Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
Postdoctoral Research Associate
Climate Change Science Institute **January 2015 – November 2016**

Perform research tasks using the Community Ice Sheet Model (CISM) and coordinate the development of the Land Ice Verification and Validation toolkit (LIVVkit) — a python-based toolkit for robust evaluation of ice-sheet models.
Advisor: Dr. Katherine J. Evans

Education

University of Alaska Fairbanks, Department of Physics, Fairbanks, Alaska, USA
Ph.D., 2015, Dissertation Topic:
"Linking climate history and ice crystalline fabric evolution in polar ice sheets."
Advisor: Dr. Erin C. Pettit

Western Washington University, Department of Physics, Bellingham, Washington, USA
B.S., 2008, Physics
Minors: Astronomy, The Study of Religion

Selected Publications

Evans, K.J., *J.H. Kennedy*, D. Lu, M.M. Forrester, S. Price, J. Fyke, A.R. Bennett, M. Hoffman, I. Tezaur, C.S. Zender, and M. Vizcaino. (2019). LIVVkit 2.1: Automated and extensible ice sheet model validation. Geoscientific Model Development, 12, 1067–1086.
DOI:10.5194/gmd-12-1067-2019

Mahajan, S., K.J. Evans, *J.H. Kennedy*, M. Xu, M.R. Norman, M.L. Branstetter (2019) Ongoing solution reproducibility of Earth system models as they progress towards exascale computing. Special Issue for Computational Reproducibility at Exascale Workshop 2017, Super Computing 2017, Int. J. High Perf. Comp. Apps..
DOI:10.1177/1094342019837341

Lipscomb, W.H., S.F. Price, M.J. Hoffman, G.R. Leguy, A.R. Bennett, S.L. Bradley, K.J. Evans, J.G. Fyke, *J.H. Kennedy*, M. Perego, D.M. Ranken, W.J. Sacks, A.G. Salinger, L.J. Vargo, and Patrick H. Worley. (2019). Description and evaluation of the community ice sheet model (CISM) v2.1. Geoscientific Model Development, 12, 387–424.
DOI:10.5194/gmd-12-387-2019

Goelzer, H., S. Nowicki, T. Edwards, M. Beckley, A. Abe-Ouchi, A. Aschwanden, R. Calov, O. Gagliardini, F. Gillet-Chaulet, N. Golledge, J. Gregory, R. Greve, A. Humbert, P. Huybrechts, *J.H. Kennedy*, E. Larour, W. Lipscomb, S. Le clec'h, V. Lee, M. Morlighem, F. Pattyn, T. Payne, C. Rodehacke, M. Ruckamp, F. Saito, N. Schlegel, H. Seroussi, A. Shepherd, S. Sun, R. van de Wal, F. Ziemen. (2018). Design and results of the ice sheet model initialization experiments initMIP-Greenland: An ISMIP6 intercomparison. The Cryosphere, 12, 1433–1460.
DOI:10.5194/tc-12-1433-2018

Kennedy, J.H., A.R. Bennett, Evans, K.J., S. Price, M. Hoffman, W.H. Lipscomb, J. Fyke, L. Vargo, A. Boghozian, M. Norman, P.H. Worley. (2017). LIVVkit: An extensible, python-based, land ice verification and validation toolkit for ice sheet models. Journal of Advances in Modeling Earth Systems, 9(2), 854–869.
DOI:10.1002/2017MS000916

Price, S., M. Hoffman, J. Bonin, T. Neumann, I. Howat, J. Saba, J. Guerber, D. Chambers, K.J. Evans, *J.H. Kennedy*, J. Lenaerts, W.H. Lipscomb, M. Perego, A. Salinger, R. Tuminaro, M. van den Broeke, and S.M.J. Nowicki. (2017). An ice sheet model validation framework for the Greenland ice sheet. Geoscientific Model Development, 10, 255–270.
DOI:10.5194/gmd-10-255-2017

Kennedy, J.H., and E.C. Pettit (2015). The response of climate induced fabric variations to simple shear and migration recrystallization. Journal of Glaciology, 61(227), 537–550.
DOI:10.3189/2015JoG14J156.

Kennedy, J.H., E.C. Pettit, and C.L. Di Prinzio (2013). The evolution of crystal fabric in ice sheets and its link to climate history. Journal of Glaciology, 59(214), 357–373.
DOI:10.3189/2013JoG12J159.

Gusmeroli, A., E.C. Pettit, *J.H. Kennedy*, and C. Ritz (2012). The crystal fabric of ice from full-waveform borehole sonic logging. J. Geophys. Res., 117, F03021.
DOI:10.1029/2012JF002343.

Funded Grant Proposals

NASA Advancing Collaborative Connections for Earth System Science (ACCESS) Program (2020)
Co-I: *Training Data for Stream Flow Estimation*
$447K total; $273K over 3 years to UAF

NASA Advancing Collaborative Connections for Earth System Science (ACCESS) Program (2020)
Co-I: *Enabling Cloud-based InSAR Science for an exploding NASA InSAR data archive*
$1.02M total; $316K over 2 years to UAF

DOE E3SM phase II project (2018)
Co-I: *The energy exascale Earth system modeling project scientific focus area renewal*
$4.5M over 5 years to ORNL

DOE BER next-gen development project (2018)
Co-I: *Climate reproducibility tests for E3SM model components and stand-alone kernels*
$1.44M over 3 years to ORNL

DOE BER/ASCR sea-level projections (2017)
Co-I and V&V task lead: *Probabilistic sea-level projections from ice sheet and Earth system models*
$1.33M over 5 years to ORNL

DOE BER ACME-SM project (2016)
Co-I: *A Global climate model software modernization surge*
$1.35M over 3 years to ORNL

ORNL/NOAA performance project (2016)
Co-I: *Performance analysis of climate workflows*
$336K over 1 year to ORNL

Significant Reports and White Papers

Kennedy, J.H., B.W. Mayer, K.J. Evans, J. Durachta (2017). Performance analysis of large scale HPC worflows for Earth system models. ORNL Technical Memo, ORNL/TM-2017/540.
doi:10.2172/1439154

Allen, M.R., H.M.A. Aziz, M.A. Coletti, *J.H. Kennedy*, S.S. Nair, and O.A. Omitaomu (2017). Workshop on human activity at scale in Earth system models. ORNL Technical Memo, ORNL/TM-2017/24.
doi:10.2172/1343540

Kennedy, J.H., B. Debusschere, K. Sargsyan, F.M. Hoffman, K.J. Evans (2016). Full-system evaluation of Earth system models. Ideas paper 51 in E. Ng, K.J. Evans, et al. (Authors), Advancing Cross-Cutting Ideas for Computational Climate Science, Workshop Report, Rockville, MD, September 12-13, 2016. ORNL/TM-2016/717.
doi:10.2172/1341564.

Law, K., R. Archibald, *J.H. Kennedy* (2016). Data assimilation for ice-sheet models. Ideas paper 22 in E. Ng, K.J. Evans, et al. (Authors), Advancing Cross-Cutting Ideas for Computational Climate Science, Workshop Report, Rockville, MD, September 12-13, 2016. ORNL/TM-2016/717.
doi:10.2172/1341564.

Software

Developer of the Alaska Satellite Facility's Hybrid Pluggable Processing Pipeline (HyP3; pronounced "hype"). HyP3 consists of:

- *The platform*: An AWS-based job orchestration engine with a friendly, OpenAPI and Swagger based, API.
- *Science plugins*: Container-based science algorithms and processing software. When invoked, they marshal input data, generate an output product, and upload the product to the cloud. Plugins can be used independently of the platform.
- *Science products*: The data our users are after – typically GeoTIFF and netCDF based data, with associated metadata, documentation, and usage guides.
- *Tools*: ArcGIS plugins, python packages for working with the HyP3 API and HyP3 products, and other packages useful for HyP3 development.
- *Documentation*: How we help our users, and ourselves. This includes product/software/tool documentation, examples and guides, and everything that goes into making documentation usable and look great.

The entire HyP3 ecosystem is open-source and developed within the ASFHyP3 organization on GitHub.

Contributor to open-source software projects

- Conda-forge recipe maintainer for:
  - ASF Tools
  - EVV
  - HyP3lib
  - HyP3 Metadata
  - HyP3 SDK
  - ILAMB
  - JSON tricks
  - LIVVkit
  - MPAS-Analysis
  - MPAS-Tools
  - TempestRemap
- PR48 to tox-conda leading to release of v0.4.0 with support for `conda-spec.txt` and `conda-env.yml` files.
- PR19 and PR27 to sphinx-js leading to release of (bugfix) v2.0.1 and contributing to v2.2.
- PR10 to ILAMB helping the python 2 to 3 conversion and allowing an editable install with pip.

Past:

Technical and visionary lead of the Land Ice Verification and Validation toolkit (LIVVkit); a python-based, extensible verification and validation suite for land-ice models.
https://github.com/LIVVkit/LIVVkit

Creator of the ISMIP6 Atlas submission validation tool; an extension to LIVVkit which checks submissions to ISMIP6 experiments for correct file names, paths, metadata, etc. and produces a large variety of diagnostic plot. https://github.com/LIVVkit/Atlas

E3SM (Energy Exascale Earth System Model) core developer (infrastructure group) for phase 2; DOE's E3SM is a state-of-the-science Earth system model development and simulation project to investigate energy-relevant science using code optimized for DOE's advanced computers.
https://e3sm.org/

Developer on DOE's E3SM ecosystem projects

- MPAS-Analysis: Analysis for simulations produced with Model for Prediction Across Scales (MPAS) components and DOE's E3SM.
  https://github.com/MPAS-Dev/MPAS-Analysis
- A-Prime: Python based scripts to generate coupled priority metrics for DOE's E3SM.
  https://github.com/ACME-Climate/a-prime
- EVV: Extended verification and validation for Earth system models.
  https://github.com/LIVVkit/evv4esm

Developer and integrator for the joint DOE/NSF Community Ice Sheet Model (CISM); an open-source, next-generation ice sheet model used for predicting ice sheet evolution and sea level rise in a changing climate. https://github.com/ESCOMP/cism

Allocation Proposals

Energy Research Computing Allocations Process (ERCAP) for NERSC (2016)
Co-I, accepted, *Predicting ice sheet and climate evolution at extreme scales*, 10M hours on Edison

OLCF Director's Discretion Allocation (2015)
Co-I, accepted, *Earth system modeling collaborative*, 10M hours on Titan

Awards

2016 CCSI Professional Development Award, $100,000
Co-I: *Understanding the links between neighbourhood level human activity and global climate change by developing an integrative methodology using data analytics, agent-based modelling and Earth system modelling.* Project PI: Dr. Melissa R. Allen.
Climate Change Science Institute, Oak Ridge National Laboratory

2013–2014 Thesis Completion Fellowship, $15,000 + tuition
University of Alaska Fairbanks Graduate School

2011–2012 CASE GK-12 Fellow, $45,000
NSF Graduate STEM Fellow in K-12 Education, Changing Alaska Science Education

Synergistic Activities

2021–present	Serve on the NASES ESDS Cloud Analytics Reference Architecture Working Group.
2018	Organized a minisymposium on computational methodologies for next-generation climate models at the European Seminar on Computing (ESCO) 2018 conference in Pilzen, Czech Republic.
2017	Organized an international workshop on human activity at scale in Earth system models at Oak Ridge National Laboratory.
2016–present	Referee for the Australian Antarctic Division, the Geophysical Journal International, Journal of Geophysical Research, Journal of Mountain Science, and Polish Polar Research.

Teaching Experience

Oak Ridge Institute for Continued Learning at Roane State Community College, Oak Ridge, Tennessee, USA

Co-lecturer with Dr. Melissa R. Allen (ORNL)

Climate Change Science **June 2016**

We presented four lectures, one and a quarter hours in length, on the topics: 1) global warming and the carbon cycle, 2) indicators of climate change, 3) impacts of climate change on human life and 4) global and regional climate modeling and uncertainty.

University of Alaska Fairbanks, Fairbanks, Alaska, USA

Graduate Teaching Assistant

Geology & Geophysics Department **August 2014 – December 2014**

I taught the computational portion of the graduate level geophysics course Foundations of Geophysics and was responsible for lectures, homework assignments, and grades. Further duties included holding weekly office hours.

- GEOS 631/431 – Foundations of Geophysics, Fall 2014

Guest Lecturer

GEOS 631/431 — Foundations of Geophysics (Oct. 25 and Oct. 30, 2012): I gave two lectures, one and a half hours in length, on general conservation laws, conservation of energy, and heat transfer. The first lecture started with the general form of the conservation laws, derived the conservation of momentum equation the students were familiar with, and then discussed the definition and forms of energy. The lecture concluded with a discussion on the first law of thermodynamics as well as a derivation of the conservation of energy equation. The second lecture discussed Fourier's law and solved practical heat flow problems; some of which were taken from Chapter 4 of Turcotte and Schubert's Geodynamics textbook.

Guest Lecturer

GEOS 636/436 — Beyond the Mouse: Computer Programming and Automation for Geosciences (Sept. 11 and Nov. 15, 2012): The September lecture was 1 hour in length and focused on an introduction to variables and data types. We discussed what a computer is, how a computer thinks, what a program is, and what a programming language is. The students were then taught how to create variables and store different types of data. The November lecture was a demonstration of live programming and was 2 hours in length. I demonstrated how to use common command line tools, a scripting language, and good file structure to create a manuscript preparation work-flow. I developed scripts to help create a LaTeX document and introduced tools such as a distributed version control system to keep track of changes and share work with collaborators.

Graduate Teaching Assistant

Geology & Geophysics Department **August 2012 – December 2012**

I taught the computational portion of graduate level geophysics courses and was responsible for lectures, homework assignments, and grades. Further duties included holding weekly office hours.

- GEOS 631/431 — Foundations of Geophysics, Fall 2012
- GEOS 636/436 — Beyond the Mouse: Computer Programming and Automation for Geosciences, Fall 2012

NSF GK-12 Fellow

Denali Elementary School **May 2011 – May 2012**

I taught 4 science lessons a week in two first grade classrooms of 30 students (10 contact hours per week). We covered a variety of subjects, including: the scientific method, the five senses, plants, birds of prey, migratory birds, caribou, weather, glaciers, heat transfer, food science, rockets, pressure-volume-temperature, volcanoes and how to design a testable question. I primarily designed the lesson plans, homework, and experiments for the students. At the end of the year, the classes worked on a joint science fair project in which the students designed and conducted the entire experiment. The classes won a first place ribbon and a $50.00 prize for *Exceptional Women in Science* at the Fairbanks Northstar Borough School District Science Fair.

Graduate Teaching Assistant
Physics Department **August 2008 – May 2009**
I taught the laboratory portion of introductory physics courses and was responsible for lectures, homework assignments, and grades. Further duties included holding weekly office hours and staffing the homework help office.

- ◇ PHYS 103 – College Physics I, Fall 2008, 2 sections
- ◇ PHYS 104 – College Physics II, Spring 2009
- ◇ PHYS 115 – Physical Science I, Spring 2009

Western Washington University, Bellingham, Washington, USA
Undergraduate Teaching Assistant **September 2006 – June 2008**
I taught the laboratory portion of the introductory physics courses and was responsible for lectures, homework assignments and grades.

- ◇ PHYS 131 — Physics with Calculus I Lab, Fall 2006, 2007
- ◇ PHYS 132 — Physics with Calculus II Lab, Winter 2007, 2008
- ◇ PHYS 133 — Electricity and Magnetism Lab, Spring 2007, 2008

Invited Talks (last 5 yrs)

Kennedy, J.H.
ASF HyP3 for SAR Data Processing
Mini-Workshop for Community Capabilities and Best Practices on Large-scale and Automated Processing of SAR and Optical Data Products, August 27, 2020

(Plenary) Mahajan, S., K.J. Evans, *J.H. Kennedy*, M. Norman, M. Xu
A Multivariate Approach to Ensure Statistical Reproducibility of Climate Model Simulations
Platform for Advanced Scientific Computing (PASC) Conference, ETH Zurich, Switzerland, June 13, 2019

Kennedy, J.H., K.J. Evans
Reproducible verification and validation testing with LIVVkit 2.0+
Climate, People and the Environment Seminar, University of Wisconsin–Madison, April 3, 2018

Kennedy, J.H., K.J. Evans, A.R. Bennett, P. Worley, S. Price, M. Hoffman
Evaluating the performance of ice sheet models using LIVVkit
Minisymposium on numerical methods towards next generation ice sheet models SIAM Conference on Mathematical and Computational Issues in the Geosciences Erlangen, Germany, Sept. 11, 2017

Kennedy, J.H.
Climate change today: An overview of the science, the observations, and a look toward the future
TENS: The Executive Network of Seattle, Seattle, Washington, January 16, 2017

Kennedy, J.H., M.R. Allen
Climate change overview
League of Women Voters of Oak Ridge, Oak Ridge, Tennessee, February 16, 2016

Conference Presentations (last 5 yrs)

Kennedy, J.H., et al.
Get HyP3! SAR processing for everyone
AGU Fall Meeting, Abstract IN001-0003, December 7, 2020

Kennedy, J.H., et al.
Automated verification of Earth system models with EVV
SIAM conference on Mathematical and Computational Issues in the Geosciences, March 14, 2019

Kennedy, J.H., et al.
LIVVkit: Now and into the future
CESM land-Ice working Group Meeting, February 4, 2019

Kennedy, J.H., et al.
Efforts toward evaluation and reproducibility for ice sheet modeling
SIAM Conference on Mathematics of Planet Earth, September 14, 2018

Kennedy, J.H., et al.
A Look at the challenges of, and some solutions to, evaluating next-generation Earth system models
6th European Seminar on Computing (ESCO), June 6, 2018

Kennedy, J.H., et al.
A tour of ORNL's Earth system model assessment tools
ORNL Software Expo, May 16, 2018

Kennedy, J.H., et al.
Exploring the validity of modeled surface mass balance Over Greenland With LIVVkit 2.1
AGU Fall Meeting, Abstract C14B-02, December 11, 2017

Kennedy, J.H., et al.
Evaluating the performance of ice sheet models using LIVVkit
SIAM Conference on Mathematical and Computational Issues in the Geosciences, September 12, 2017

Kennedy, J.H., et al.
Using the LIVVkit 2.0+ validation infrastructure
22nd Annual CESM Workshop, June 19, 2017

Kennedy, J.H., et al.
Climate reproducibility testing with EVE
ACME all-hands meeting, June 5, 2017

Kennedy, J.H., et al.
PISM-FEvoR: a multi-scale ice flow model incorporating fabric evolution with recrystallization
SIAM Conference on Computational Science and Engineering, MS243, March 2, 2017

Kennedy, J.H., et al.
LIVVkit 2: A robust and extensible python package for ice-sheet model verification and validation
AMS Annual Meeting, Seventh Symposium on Advances in Modeling and Analysis Using Python, January 24, 2017

Kennedy, J.H., et al.
LIVVkit 2: An extensible land ice verification and validation toolkit for comparing observations and models
AGU Fall Meeting, Abstract GC21A-1051, December 13, 2016

Kennedy, J.H., et al.
Full-system evaluation of Earth system models
Advancing X-cutting Ideas for Computational Climate Science, September 12, 2016

Kennedy, J.H., et al.
Building LIVVkit
CCSI Earth System Modeling Workshop, August 16, 2016

Kennedy, J.H., et al.
Developing LIVVkit
Oak Ridge Postdoc Association Research Symposium, August 8, 2016

Kennedy, J.H., et al.
An introduction to LIVVkit 2.0
21st Annual CESM Workshop, June 22, 2016

Kennedy, J.H., et al.
LIVVkit now and into the future: A discussion
Land Ice Working Group Meeting, February 10, 2016

Field Work

Dome C, East Antarctica. Deploying a sonic probe down the Dome C ice core borehole and prepping ice core samples. 3 weeks.
Valdez, AK, USA. Deploying sea temperature moorings. 3 days.
Yakutat Glacier, AK, USA. Taking GPS measurements, ablation stake measurements, and deploying time laps cameras. 5 days.
Icy Bay, AK, USA. Deploying hydro-acoustic mooring, taking CDT casts, and hydro-acoustic recordings. 5 days.

Affiliations

AGU	American Geophysical Union
APS	American Physical Society
IGS	International Glaciological Society
SIAM	Society for Industrial and Applied Mathematics

Technical Skills

Languages:	Python, R, C++, FORTRAN, SQL, Bash, LaTeX
Operating Systems:	Unix/Linux (desktop and HPCs), Windows, OSX
Math/Science Packages:	Anaconda, Scikit-learn, Pandas, Xarray, Numpy, Scipy, MATLAB
Climate/GIS Tools:	QGIS, NetCDF, NCO, NCL, PyNIO/PyNGL, CF-conventions
Web Development:	Javascript, HTML, CSS, PHP, Drupal, Jekyll
Data Science:	PCA, multivariate testing, regression analysis
Frameworks/Skills:	Agile software development, test-driven development, verification and validation, unit and integration testing, continuous integration, version control systems

Other Skills and Activities

- ◇ Wilderness experience including a continuous 700 mile, 33 day, canoe trip down the Yukon River
- ◇ Extensive boat experience: sailing, canoeing, power-boating, etc.
- ◇ Enjoy outdoor recreation: biking, hiking, backpacking, camping, etc.
- ◇ Trained in bear safety