

EVIATAR BACH

Lecturer (Assistant Professor) in Mathematics of Environmental Data Science, University of Reading, Reading, UK

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Professional Appointments

- 2024– **Lecturer (Assistant Professor) in Mathematics of Environmental Data Science**
Department of Meteorology & Department of Mathematics and Statistics, University of Reading
Reading, UK
- Member of the Data Assimilation Research Centre (DARC) and member of the steering committee of the Centre for Mathematics of Planet Earth (CMPE). Outreach Officer for the Centre for Doctoral Training in Mathematics for Our Future Climate.
- 2022–2024 **Postdoctoral Research Fellow**
Department of Environmental Science and Engineering & Department of Computing and Mathematical Sciences, Caltech
Pasadena, California, USA
- Stanback Postdoctoral Fellow in Global Environmental Science under the supervision of Tapio Schneider and Andrew Stuart. Part of the Science and Engineering Team at the Climate Modeling Alliance (CliMA).
- 2021–2022 **Postdoctoral Research Fellow**
Laboratoire de Météorologie Dynamique, École Normale Supérieure
Paris, France
- Make Our Planet Great Again Postdoctoral Fellow under the supervision of Michael Ghil.

Education

- 2017–2021 **PhD in Atmospheric and Oceanic Science**
University of Maryland, College Park
College Park, Maryland, USA
Supervisors: Eugenia Kalnay (primary) and Safa Motte (secondary).
- 2012–2017 **BSc in Physics and Computer Science (Honours), Minor in Mathematics**
University of British Columbia
Vancouver, British Columbia, Canada

Publications

Preprints and workshop papers

19. **Bach, Eviatar**, Dan Crisan, and Michael Ghil (2024). *Forecast Error Growth: A Dynamic-Stochastic Model*. arXiv: 2411.06623
18. **Bach, Eviatar**, Ricardo Baptista, Daniel Sanz-Alonso, and Andrew Stuart (2024). *Inverse Problems and Data Assimilation: A Machine Learning Approach*. arXiv: 2410.10523 [cs, math, stat]

17. Luk, Enoch, **Eviatar Bach**, Ricardo Baptista, and Andrew Stuart (2024). “Learning Optimal Filters Using Variational Inference”. In: arXiv: 2406.18066 [cs, math]

Spotlight talk at Machine Learning for Earth System Modeling (ML4ESM) Workshop at ICML 2024.

Published (see Google Scholar)

16. Vishny, David, Matthias Morzfeld, Kyle Gwartz, **Eviatar Bach**, Oliver R. A. Dunbar, and Daniel Hodyss (2024). “High-Dimensional Covariance Estimation From a Small Number of Samples”. In: *Journal of Advances in Modeling Earth Systems* 16.9, e2024MS004417. DOI: 10.1029/2024MS004417
15. Manta, Gaston, **Eviatar Bach**, Stefanie Talento, Marcelo Barreiro, Sabrina Speich, and Michael Ghil (2024). “The South Atlantic Dipole via Multichannel Singular Spectrum Analysis”. In: *Scientific Reports* 14.1, p. 15534. DOI: 10.1038/s41598-024-62089-w
14. **Bach, Eviatar**, V. Krishnamurthy, Safa Mote, Jagadish Shukla, A. Surjalal Sharma, Eugenia Kalnay, and Michael Ghil (2024). “Improved Subseasonal Prediction of South Asian Monsoon Rainfall Using Data-Driven Forecasts of Oscillatory Modes”. In: *Proceedings of the National Academy of Sciences* 121.15, e2312573121. DOI: 10.1073/pnas.2312573121
13. **Bach, Eviatar**, Tim Colonius, Isabel Scherl, and Andrew Stuart (2024). “Filtering Dynamical Systems Using Observations of Statistics”. In: *Chaos: An Interdisciplinary Journal of Nonlinear Science* 34.3, p. 033119. DOI: 10.1063/5.0171827

Chaos Editor’s Pick

12. Xu, Zhengjie, Yan Li, Yingzuo Qin, and **Eviatar Bach** (2024). “A Global Assessment of the Effects of Solar Farms on Albedo, Vegetation, and Land Surface Temperature Using Remote Sensing”. In: *Solar Energy* 268, p. 112198. DOI: 10.1016/j.solener.2023.112198
11. **Bach, Eviatar** and Michael Ghil (2023). “A Multi-Model Ensemble Kalman Filter for Data Assimilation and Forecasting”. In: *Journal of Advances in Modeling Earth Systems* 15.1, e2022MS003123. DOI: 10.1029/2022MS003123
10. Chattopadhyay, Ashesh, Ebrahim Nabizadeh, **Eviatar Bach**, and Pedram Hassanzadeh (2023). “Deep Learning-Enhanced Ensemble-Based Data Assimilation for High-Dimensional Nonlinear Dynamical Systems”. In: *Journal of Computational Physics* 477, p. 111918. DOI: 10.1016/j.jcp.2023.111918

Featured in *SIAM News Blog*.

9. Dunbar, Oliver R. A., Ignacio Lopez-Gomez, Alfredo Garbuno-Iñigo, Daniel Zhengyu Huang, **Eviatar Bach**, and Jin-long Wu (2022). “EnsembleKalmanProcesses.Jl: Derivative-free Ensemble-Based Model Calibration”. In: *Journal of Open Source Software* 7.80, p. 4869. DOI: 10.21105/joss.04869
8. Chattopadhyay, Ashesh, Mustafa Mustafa, Pedram Hassanzadeh, **Eviatar Bach**, and Karthik Kashinath (2022). “Towards Physics-Inspired Data-Driven Weather Forecasting: Integrating Data Assimilation with a Deep Spatial-Transformer-Based U-NET in a Case Study with ERA5”. In: *Geoscientific Model Development* 15.5, pp. 2221–2237. DOI: 10.5194/gmd-15-2221-2022

7. Qin, Yingzuo, Yan Li, Ru Xu, Chengcheng Hou, Alona Armstrong, **Eviatar Bach**, Yang Wang, and Bojie Fu (2022). “Impacts of 319 Wind Farms on Surface Temperature and Vegetation in the United States”. In: *Environmental Research Letters* 17.2, p. 024026. doi: 10.1088/1748-9326/ac49ba
6. **Bach, Eviatar**, Safa Mote, V. Krishnamurthy, A. Surjalal Sharma, Michael Ghil, and Eugenia Kalnay (2021). “Ensemble Oscillation Correction (EnOC): Leveraging Oscillatory Modes to Improve Forecasts of Chaotic Systems”. In: *Journal of Climate* 34.14, pp. 5673–5686. doi: 10.1175/JCLI-D-20-0624.1
5. **Bach, Eviatar** (2021). “Parasweep: A Template-Based Utility for Generating, Dispatching, and Post-Processing of Parameter Sweeps”. In: *SoftwareX* 13, p. 100631. doi: 10.1016/j.softx.2020.100631
4. **Bach, Eviatar**, Safa Motescharrei, Eugenia Kalnay, and Alfredo Ruiz-Barradas (2019). “Local Atmosphere–Ocean Predictability: Dynamical Origins, Lead Times, and Seasonality”. In: *Journal of Climate* 32.21, pp. 7507–7519. doi: 10.1175/JCLI-D-18-0817.1

3rd most read article in the *Journal of Climate* in the period 5 June 2019 – 5 June 2020.

3. Penny, Stephen G., **Eviatar Bach**, Kriti Bhargava, Chu-Chun Chang, Cheng Da, Luyu Sun, and Takuma Yoshida (2019). “Strongly Coupled Data Assimilation in Multiscale Media: Experiments Using a Quasi-Geostrophic Coupled Model”. In: *Journal of Advances in Modeling Earth Systems* 11.6, pp. 1803–1829. doi: 10.1029/2019MS001652
2. Li, Yan, Eugenia Kalnay, Safa Motescharrei, Jorge Rivas, Fred Kucharski, Daniel Kirk-Davidoff, **Eviatar Bach**, and Ning Zeng (2018). “Climate Model Shows Large-Scale Wind and Solar Farms in the Sahara Increase Rain and Vegetation”. In: *Science* 361.6406, pp. 1019–1022. doi: 10.1126/science.aar5629
 - 14th top Earth science article on Altmetric in 2018, 79th of all articles in 2018, most-blogged about article of September 2018.
 - 10th most featured climate paper in the media in 2018, according to Carbon Brief.
 - Cited in IPCC Special Report on Climate Change and Land.
 - Written about by the BBC, *Los Angeles Times*, *Popular Science*, and other international media.
1. **Bach, Eviatar**, Valentina Radić, and Christian Schoof (2018). “How Sensitive Are Mountain Glaciers to Climate Change? Insights from a Block Model”. In: *Journal of Glaciology* 64.244, pp. 247–258. doi: 10.1017/jog.2018.15
 - Shortlisted for 2020 IACS-IGS Graham Cogley Award, for papers published by early career scientists in the *Journal of Glaciology* or *Annals of Glaciology*.
 - Selected glaciology article for the period 2015–2019, Canadian National Committee for the International Union of Geodesy and Geophysics.

Non-refereed

- **Bach, Eviatar** and Oliver Dunbar (2023). *How Do We Estimate Climate Parameters? An Introduction to Ensemble Kalman Inversion*. Climate Modeling Alliance Blog. URL: <https://clima.caltech.edu/2023/06/12/how-do-we-estimate-climate-parameters-an-introduction-to-ensemble-kalman-inversion/>

- Chattopadhyay, Ashesh, Ebrahim Nabizadeh, **Eviatar Bach**, and Pedram Hassanzadeh (2021). “Deep Learning-Augmented Data Assimilation for Next-Generation Predictive Models”. In: *SIAM News Blog*. URL: <https://sinews.siam.org/Details-Page/deep-learning-augmented-data-assimilation-for-next-generation-predictive-models>
- Pentakota, Sreenivas, Sagar V. Gade, Suryachandra A. Rao, Cheng Da, Kriti Bhargava, Chu-Chun Chang, **Eviatar Bach**, Eugenia Kalnay, and Travis Sluka (2020). “Advances in Coupled Data Assimilation, Ensemble Forecasting, and Assimilation of Altimeter Observations”. In: *CLIVAR Exchanges* 79, pp. 27–30. DOI: 10.36071/clivar.79.2020

Honors and Awards

2022–2024	Foster and Coco Stanback Postdoctoral Fellowship in Global Environmental Science Division of Geological and Planetary Sciences, Caltech, Pasadena, California, USA
2021–2022	Make Our Planet Great Again Postdoctoral Fellow Campus France, République Française
2020	Eugene Rasmusson Fellowship Department of Atmospheric and Oceanic Science, University of Maryland, College Park, USA
2020–2021	Ann G. Wylie Dissertation Fellowship University of Maryland, College Park, USA
2017–2021	Flagship Fellowship University of Maryland, College Park, USA

Presentations

Invited talks

2024	Dynamics Days Europe 2024 (July 29 – August 2) Minisymposium on Stability, long term behaviour, and data assimilation in infinite dimensional stochastic systems for weather, climate, and ocean Bremen, Germany
2024	AMS-UMI International Joint Meeting (July 23–26) Special session on Analysis, control and inverse problems in climate sciences Unione Matematica Italiana and American Mathematical Society Palermo, Italy
2024	Chaos, Computation, Analysis and Optimization (CaCAO) Days (April 15) Scripps Institution of Oceanography La Jolla, California, USA
2024	Department of Applied Mathematics (April 8) University of California, Santa Cruz, California, USA

- 2024 **SIAM UQ24** (March 1)
Probabilistic Approaches to Uncertainty Quantification in Dynamical Systems session
Society for Industrial and Applied Mathematics
Trieste, Italy
- 2023 **ICIAM 2023** (August 24)
Combining Machine Learning and Stochastic Methods for Modeling and Forecasting Complex Systems session
International Council for Industrial and Applied Mathematics
Tokyo, Japan
- 2023 **SIAM Conference on Mathematical & Computational Issues in the Geosciences 2023** (June 19)
Computational Aspects of Ensemble Design and Interpretation in Climate Science and Modelling session
Society for Industrial and Applied Mathematics
Bergen, Norway
- 2023 **Energy and Machine Learning Seminar** (April 25)
Pacific Northwest National Laboratory, Richland, Washington, USA (online)
- 2023 **Atmosphere Ocean Science Colloquium** (March 29)
Courant Institute for Mathematical Sciences, New York University, New York City, USA
- 2023 **Department of Scientific Computing Seminar** (March 1)
Florida State University, Tallahassee, USA
- 2022 **Applied Math Seminar** (October 14)
Florida International University, Miami, USA (online)
- 2022 **Applied Math Seminar** (October 6)
Hunter College, City University of New York, New York City, USA (online)
- 2022 **Forecast Verification and Data Assimilation in intermediate and large scale models of geophysical fluid dynamics** (September 23)
Isaac Newton Institute for Mathematical Sciences
Reading, England
- 2022 **Department of Atmospheric, Oceanic & Earth Sciences Seminar** (May 11)
George Mason University, Fairfax, Virginia, USA (online)
- 2022 **AI for Climate Seminar** (January 26)
Sorbonne University, Paris, France
- 2020 **Climate Modeling Alliance Seminar** (October 21)
Caltech, Pasadena, California, USA (online)
- 2020 **PrExDA: Predicting Extremes by Data-Driven Analytics** (October 1)
National Science Foundation Convergence Accelerator (online)
- 2020 **Department of Atmospheric, Oceanic & Earth Sciences Seminar** (April 29)
George Mason University, Fairfax, Virginia, USA (online)

Contributed talks

- 2024 **International Symposium on Data Assimilation 2024** (October 21–25)
Kobe, Japan
- 2024 **Oxford Workshop on Model Uncertainty** (September 25)
Oxford University, Oxford, UK
- 2024 **Machine Learning for Earth System Modeling workshop** (July 26)
International Conference on Machine Learning (ICML)
Vienna, Austria (online talk, joint with Enoch Luk)
- 2024 **RMetS Annual Weather and Climate Conference** (July 9)
Royal Meteorological Society
Reading, England
- 2024 **Toward Minimizing Early Model Biases and Errors in S2S Predictions** (June 7)
National Oceanographic and Atmospheric Administration
Boulder, Colorado, USA (online talk)
- 2024 **Conference on Hurricanes and Tropical Meteorology** (May 10)
American Meteorological Society
Long Beach, California, USA
- 2024 **ESA–ECMWF Workshop on Machine Learning for Earth System Observation and Prediction** (May 10)
European Space Agency and the European Centre for Medium-Range Weather Forecasts
Frascati, Italy (online talk)
- 2024 **International Symposium on Data Assimilation – Predictability** (May 3)
Online
- 2024 **International Symposium on Data Assimilation – Advancements in Ensemble Data Assimilation** (March 8)
Online
- 2023 **2023 AGU Fall Meeting** (December 9–13)
American Geophysical Union
San Francisco, California, USA
- 2023 **EGU General Assembly 2023** (April 28)
European Geosciences Union
Vienna, Austria (online talk)
- 2022 **2022 Model Hierarchies Workshop** (August 30)
Stanford University, Stanford, California, USA
- 2022 **SIAM Conference on Mathematics of Planet Earth 2022** (July 14)
Society for Industrial and Applied Mathematics
Pittsburgh, Pennsylvania, USA (online talk)
- 2022 **International Symposium on Data Assimilation 2022** (June 7)
Colorado State University, Fort Collins, Colorado, USA

- 2022 **EGU General Assembly 2022** (May 25)
European Geosciences Union
Vienna, Austria (online talk)
- 2020 **2nd NOAA Workshop on Leveraging AI in Environmental Sciences** (September 10)
Online
- 2020 **PSU-UMD Data Assimilation Workshop** (August 21)
Pennsylvania State University and University of Maryland (online)
- 2019 **CISESS Science Meeting** (November 12–14)
Cooperative Institute for Satellites Earth System Studies (CISESS), College Park, Maryland, USA
- 2019 **2019 AGU Fall Meeting** (December 9–13)
American Geophysical Union
San Francisco, California, USA

Teaching

- 2024 **ACM270: Inverse Problems and Data Assimilation, a Machine Learning Approach** (Spring semester)
Department of Computing and Mathematical Sciences
California Institute of Technology, Pasadena, California, USA
Creating curriculum and co-teaching graduate-level, special topics course with Andrew Stuart.
- 2019, 2018 **Snakes on a Satellite workshops at AGU Fall Meetings**
American Geophysical Union
Co-taught interactive workshops on the scientific Python ecosystem and its use for Earth science data processing and analysis. Attended by over 70 participants in 2019.
- 2019, 2018 **Snakes on a Satellite workshops at NOAA**
NOAA Center for Weather and Climate Prediction, College Park, Maryland, USA
Co-taught interactive workshops on the scientific Python ecosystem. Attended by over 100 NOAA scientists.

Editorial

- 2023–2024 **Special Issue Editor, *Earth System Dynamics***
Co-editor of special issue “Theoretical and computational aspects of ensemble design, implementation, and interpretation in climate science”, with David Stainforth, Christian Franzke, Irina Tezaur, and Francisco de Melo Virissimo.
Joint issue between *Earth System Dynamics*, *Nonlinear Processes in Geophysics*, and *Geoscientific Model Development*.

Sessions Co-Chaired

- 2024 **SIAM UQ24** (February 27)
Advances at the intersection of probabilistic machine learning, inverse problems and data assimilation mini-symposium
Society for Industrial and Applied Mathematics
Trieste, Italy
- 2023 **SIAM Conference on Mathematical & Computational Issues in the Geosciences 2023** (June 21–22)
Theoretical Aspects of Ensemble Design and Interpretation in Climate Science and Modelling session
Society for Industrial and Applied Mathematics
Bergen, Norway
- 2022 **2022 Model Hierarchies Workshop** (August 30)
Model Hierarchies for the Ocean 2 session
Stanford, California, USA
- 2022 **SIAM Conference on Mathematics of Planet Earth 2022** (July 14)
Data Science session
Pittsburgh, Pennsylvania, USA

Advising

- 2024– **Enoch Luk** (Caltech, undergrad)
Advising a research project on using variational inference to learn optimal filters for data assimilation.
- 2024 **Kota Okuda** (Tohoku University, undergrad)
Co-advised (with Oliver Dunbar) a Summer Undergraduate Research Fellowship (SURF) on accelerated Markov chain Monte Carlo methods for emulators.
- 2022, 2024 **Anagha Satish** (Caltech)
Co-advised (with Oliver Dunbar) a SURF on the impact of time-step size on ensemble Kalman inversion, and advised a research project on combining numerical and machine learning models for data assimilation.
- 2023 **Sydney Vernon** (Caltech)
Co-advised (with Oliver Dunbar) a SURF on accelerating the convergence of ensemble Kalman inversion using momentum methods.
- 2019–2020 **Greta Easthom** (University of Maryland, College Park undergrad)
Co-advised (with Safa Mote) an undergraduate thesis on mathematical modelling of population dynamics.

Visiting Positions

- 2022 **Residential Programme participant, Isaac Newton Institute Satellite Programme on Geophysical Fluid Dynamics** (September 10–25)
Reading, England
- 2018 **Visiting Researcher, Indian Institute of Tropical Meteorology** (November 18 – December 8)
Pune, Maharashtra, India

Service

- Journal reviews (over 40):

General interest: *Science*; *Proceedings of the National Academy of Sciences*; *PLOS ONE*; *Journal of Open Source Software*

Earth science: *Geophysical Research Letters*; *Journal of Advances in Modeling Earth Systems*; *Journal of Climate*; *Monthly Weather Review*; *Communications Earth & Environment*; *Climate Dynamics*; *Quarterly Journal of the Royal Meteorological Society*; *Nonlinear Processes in Geophysics*; *International Journal of Climatology*; *The Cryosphere*; *Earth's Future*; *Journal of Applied Meteorology and Climatology*; *Earth and Space Science*; *Geografiska Annaler: Series A, Physical Geography*; *Journal of Glaciology*.

Physics: *Chaos: An Interdisciplinary Journal of Nonlinear Science*; *Physics of Fluids*

Other: *Information Fusion*

- Reviewed a book manuscript on data analysis for Earth science for Wiley.
- Grant reviewer for National Research, Development and Innovation Office, Hungary (2022).