Ph.D. Positions at UChicago (for Spring/Fall 2024):

The University of Chicago's new Climate Extremes Theory and Data (C*e*TD) research group (PI: Pedram Hassanzadeh) has multiple positions for Ph.D. students interested in working on multidisciplinary projects in the following general areas (and at their intersections):

1) Extreme weather events and climate change (with a focus on dynamics and the extratropical atmospheric circulation),

2) Scientific deep learning for multi-scale nonlinear dynamical systems (with a focus on developing general, rigorous frameworks),

3) Applications of deep learning to improve analysis, modeling, and prediction of climate variability, weather extremes, and geophysical turbulence (with a focus on subgrid-scale modeling and spatio-temporal forecast/emulation).

Full financial support for these projects is available through funding from NSF, ONR, Schmidt Futures, and UChicago. The topic of each project is flexible but is expected to be aligned with our current interests and future directions, which are as follows.

Regarding (1), we are especially interested in studying *persistent extratropical circulation* patterns, such as blocking events, wavy jet streams, and annular modes, using a combination of theory, hierarchical modeling, and observational data analysis. Developing better eddy-mean flow interaction theories for blocks, constraining changes in their key characteristics with climate change, and understanding the implications for future extreme events (e.g., heat waves), are of particular interest. See, for example, this paper and news release. As for the annular modes, our work is focused on a new reduced-order model for extratropical circulation, the recently discovered intrinsic 150-day periodicity of the Southern Annular Mode, and the implications for climate model evaluation and development (e.g., see this paper and Editor Highlight).

Regarding (2), we are mainly focused on developing rigorous frameworks for applications of deep neural networks to multi-scale, nonlinear PDEs such as those governing the climate and turbulent systems. Explainability, stable spatio-temporal integration, generalizability, learning extreme events and high frequencies, and uncertainty quantification are of particular interest. We aim to combine fundamental concepts and tools from nonlinear dynamics, numerical analysis, and theoretical deep learning to address these challenges. For example, see this paper on the Fourier-wavelet analysis framework and this one on stable integrations.

Regarding (3), we aim to leverage the outcomes of (1)-(2) and employ physics-informed deep learning to improve analysis, modeling, and prediction of climate variability, weather extremes, and turbulence. Of particular interest are developing i) data-driven subgrid-scale parameterizations, and ii) data-driven spatio-temporal forecast models. As for (i), we are focused on using deep learning and equation-discovery methods applied to canonical geophysical turbulent flows, atmospheric gravity waves, and the quasi-biennial oscillation and polar vortex variability as a part of the Schmidt Futures-supported DataWave and NSF-supported GW-CSSI projects. For example, see this paper and this one. Note that DataWave and GW-CSSI involve a number of other institutions (NYU, Stanford U, NWRA, UK Met Office, MPI Hamburg, U Frankfurt, ENS Paris) and the former is also a part of Schmidt Futures Virtual Earth Systems Research Institutes. There are many opportunities for inter-institutional collaborations and visits for those involved in these projects. As for (ii), we are mainly interested in the short- and long-term stability and accuracy of such forecast models, with a focus on rare, extreme events. See, e.g., this paper and this one.

All Ph.D. students will benefit from our group's involvement in multi-institutional, international collaborative projects such as the Schmidt Futures-supported DataWave and NSF-supported GW-CSSI. They will also benefit from UChicago's thriving and expanding programs in Climate Science, AI+Science, Computational and Applied Math, Data Science, and Climate Systems Engineering.

Qualifications: We are looking for highly motivated applicants with undergraduate or master's degrees in Earth and climate sciences, applied mathematics, physics, statistics, engineering, or a related field. The ideal students are proficient in applied mathematics and programming, and have a strong background in at least one of the following areas: i) atmospheric and climate sciences, ii) fluid dynamics (especially turbulence), iii) mathematical modeling and/or scientific computing, and iv) machine learning.

Applications: Depending on an applicant's research interests and educational background, they can apply to the Ph.D. programs in Geophysical Sciences (https://geosci.uchicago.edu/academics/graduate-program-and-admissions/), Computational and Applied Mathematics (https://cam.uchicago.edu/academics/graduate-programs/), or other disciplines in UChicago's Physical Sciences Division (https://physicalsciences.uchicago.edu/academics/academic-departments/#PhD).

We encourage those interested to contact us as soon as possible to discuss the programs and research opportunities. Please send a brief description of your plans and research interests (in the context of research areas 1-3 listed above), and a complete CV that includes details of your education, past research experience, publications and presentations (if any), and skills in programming, scientific computing, and/or machine learnoing to Prof. Pedram Hassanzadeh, pedramh@uchicago.edu (use "Ph.D. Position" as the email's subject).

Equal Employment Opportunity Statement:

All University departments and institutes are charged with building a faculty from a diversity of backgrounds and with diverse viewpoints; with cultivating an inclusive community that values freedom of expression; and with welcoming and supporting all their members.

We seek a diverse pool of applicants who wish to join an academic community that places the highest value on rigorous inquiry and encourages diverse perspectives, experiences, groups of individuals, and ideas to inform and stimulate intellectual challenge, engagement, and

exchange. The University’s Statements on Diversity are at
https://provost.uchicago.edu/statements-diversity

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Job seekers in need of a reasonable accommodation to complete the application process should call 773-834-3988 or email equalopportunity@uchicago.edu with their request.