THE UNIVERSITY OF CHICAGO | THE COMMITTEE ON COMPUTATIONAL AND APPLIED MATHEMATICS

Dissertation Presentation and Defense

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Atmospheric Extremes Through the Lens of Transition Path Theory

FRIDAY, May 13, at 1:00 PM (Central Daylight Time (CDT))
Jones 303, 5747 S. Ellis Ave. Chicago, IL 60637
and via Zoom

Zoom information included in email announcement.

ABSTRACT

Extreme weather events have large consequences, dominating the impact of climate on society, but are inherently difficult to characterize statistically. A rare event with a 100-year return period appears only once, on average, in 100 years of simulation or observations, and longer simulations come at the cost of higher bias due to lower resolution. An archetypal example is sudden stratospheric warming (SSW): a rapid breakdown of the stratospheric polar vortex, often bringing extreme storms and cold air outbreaks to midlatitude regions. SSW defies long-term prediction and has disputed mechanisms. Calculating such low probabilities, and finding dynamical precursors in the chaotic atmosphere, is a primary challenge for climate science generally.

In this talk, I will address these challenges using ideas borrowed from the molecular dynamics community. Transition path theory (TPT) is a formalism to describe rare events as a statistical ensemble, relating short-term ("weather") forecasts to long-term ("climate") statistics of stochastic dynamical systems. This connection allows us to leverage high-fidelity, but short, weather forecast ensembles for a new purpose: calculating the occurrence rate and seasonal distribution of SSW events. Using data generated over 21 years, we calculate SSW probabilities as rare as once in 500 years. TPT also reveals interesting features of an idealized SSW model, including two distinct phases of evolution: a long, slow, "preconditioning" phase of heat flux, followed by a precipitous drop in wind strength. Regression analysis helps identify an optimal observable for monitoring the onset of an SSW event.

With this demonstration, I hope to convey the considerable potential of this new method, and to inspire the climate modeling community to use it for analyzing many other kinds of atmospheric extremes.