Contribution ID: **12** Type: **Invited talk**

Data-driven reduced modeling of chaotic, turbulent, and stochastic systems via population dynamics

Tuesday, March 3, 2026 9:15 AM (45 minutes)

Learning models of time-dependent processes that generalize across initial conditions and parameter regimes is a key challenge in machine learning and the computational sciences. For chaotic, turbulent, and stochastic systems, modeling the dynamics of individual trajectories can be exceedingly challenging because trajectories can be erratic and irregular, and in stochastic settings may even be nowhere differentiable. Instead, we focus on learning population dynamics, which model how the distribution of the system states evolves over time. By learning population dynamics, we deliberately discard trajectory-specific information to obtain dynamics that are smoother and more well behaved than the underlying sample trajectories. We argue that this loss of information is an acceptable, principled form of reduced modeling because population-level statistics are maintained, and these are often the quantities that are of interest in scientific and engineering settings.

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