THE UNIVERSITY OF CHICAGO

Computational and Applied Mathematics
&
Statistics Student Seminar

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Data Assimilation in Data-Driven Weather Forecasting: Pairing FourCastNet with the Auto-Differentiable Ensemble Kalman Filter

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ABSTRACT

This project explores machine learning-based weather forecasting models in a data assimilation framework to achieve two goals: (1) provide a high-resolution reconstruction of the atmosphere for a given time frame using sparse, potentially irregular, observations and (2) improve the data-driven neural network-based weather prediction model FourCastNet using this sparse data as it is observed sequentially. We propose to learn this model correction to FourCastNet using a recently developed method in data assimilation called the Auto-differentiable Ensemble Kalman Filter (AD-EnKF).

Compared to traditional weather prediction models, which are expressed as large-scale partial differential equations, FourCastNet allows for computationally cheap uncertainty quantification, which provides a large advantage for use in ensemble-based methods like EnKF. However, FourCastNet's prediction quality degrades after roughly a two-week prediction horizon compared to the partial differential equation solutions. Moreover, because FourCastNet was trained only on the ECMWF's ERA5 reanalysis data, this performance may further degrade when evaluated on an independently produced dataset. To improve this model's generalization, we plan to utilize NASA's MERRA-2 reanalysis dataset to sequentially update FourCastNet. By utilizing reanalysis data in this way, we can evaluate the update to FourCastNet using AD-EnKF in a realistic setting in the presence of model and resolution mismatch. We additionally present some considerations for utilizing AD-EnKF on large scale data, particularly global weather data.

This is joint work with professors Rebecca Willett and Daniel Sanz-Alonso.