# Empirical Inverse Transform Function for Ensemble Forecast Member Selection

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## Key Findings

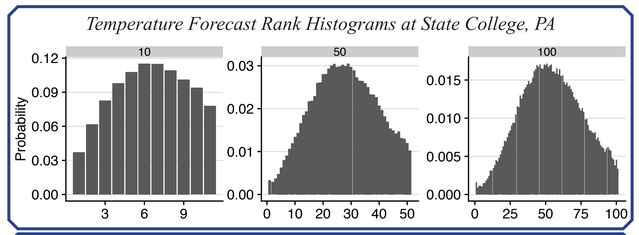
- The addition of forecast ensemble members does not necessarily improve forecast accuracy.
- Increasing ensemble members might not be the solution to histogram mis-calibration.
- Historical forecast distributions can be used to improve operational forecast ensembles.
- The Empirical Inverse Transform (EITrans) function improves ensemble reliability and sharpness.

## Introduction

Ensemble modeling and probabilistic forecasts tackle challenging tasks, such as weather model uncertainty estimation and global climate projections, with the use of high-performance computing. High resolution model simulations were once deemed impossible to complete within a reasonable amount of time, but many models are now run as an ensemble to better characterize model uncertainty.

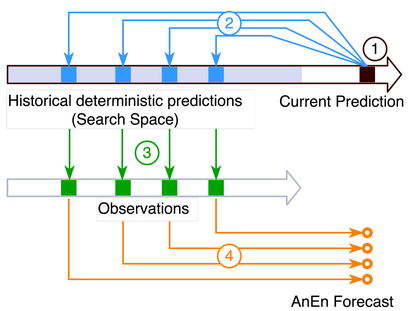
As forecast ensembles became widespread, important questions were raised with respect to their proper interpretation and verification. Forecast ensembles are usually more accurate than a deterministic prediction, but more ensemble members do not guarantee a better quality prediction. One such example is histogram mis-calibration, as shown to the right. A flat rank histogram indicates perfect calibration, but the shape of the rank histogram barely changes when the number of ensemble members changes.

This work proposes EITrans to improve ensemble calibration and quality. EITrans relies on statistical analysis using historical model performance. It is able to reduce forecast uncertainty while maintaining the accuracy of the forecast ensemble.




## Methods

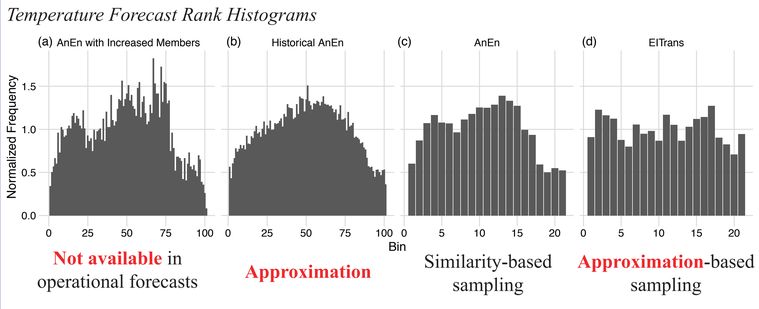
### Analog Ensemble




Analog Ensemble (AnEn) generates forecast ensembles from deterministic predictions. It relies on historical forecasts and corresponding observations. The AnEn technique is highly efficient and scalable.

*https://weiming-hu.github.io/AnalogsEnsemble/*

### Empirical Inverse Transform Function

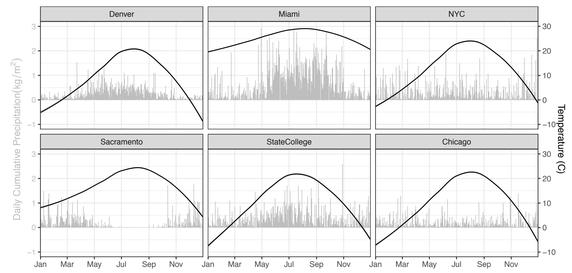



EITrans is a sampling technique inspired by the inverse transformation method on distributions. In operational forecasts, real-time verification is not available since future observations are unknown (Fig a). Therefore, EITrans evaluates ensemble members and performs the sampling technique based on historical forecast performance (Fig b). Fig c and d show results with and without EITrans.

*https://weiming-hu.github.io/EITrans/*

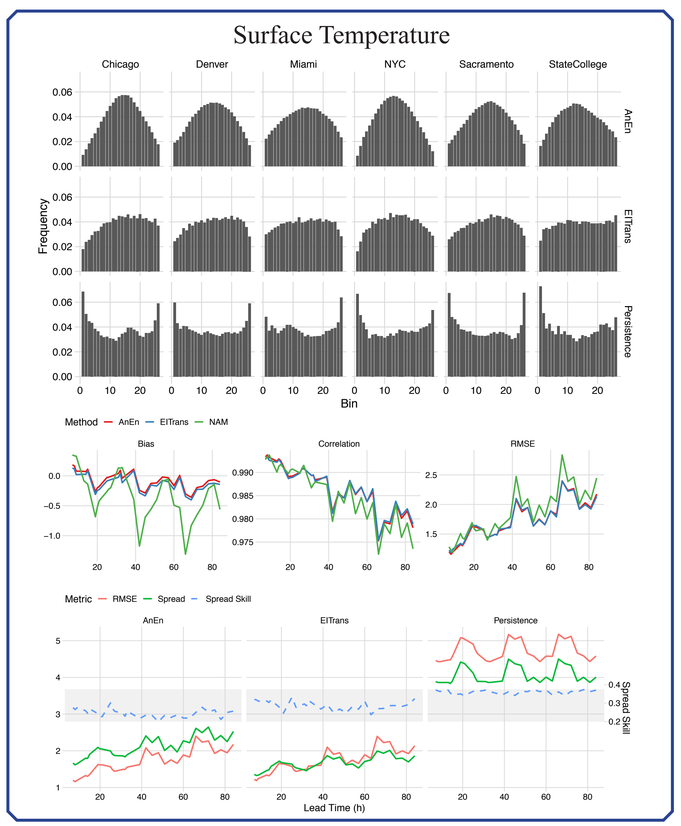
## Data

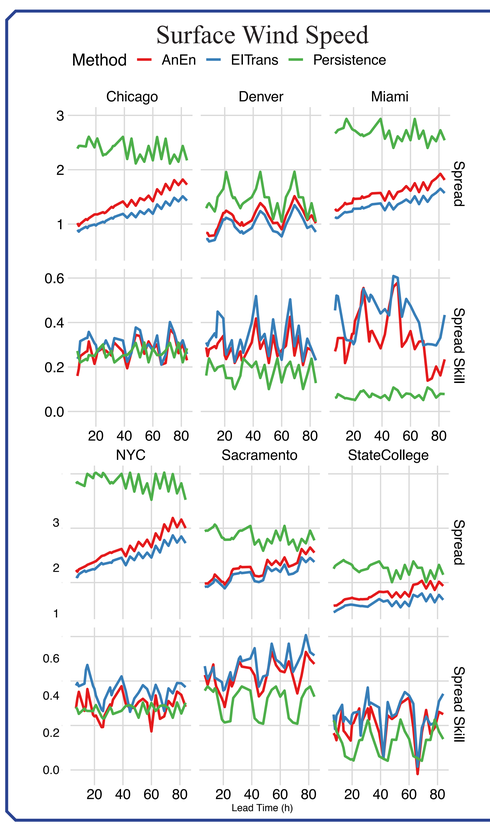

- Forecast: North American Mesoscale (NAM) model
- Locations: Six cities in the Continental US
- Historical Period: 1 Jan 2009 to 31 Jul 2017
- Test Period: 1 Aug 2017 to 31 Jul 2018




Six cities are chosen to represent different climate zones. The ten-year data repository of the entire spatial domain exceeds 8 TB.

## Ensemble Calibration




## Conclusions

EITrans improves ensemble reliability, as demonstrated by the rank histograms, and the method generates sharper forecasts in comparison to AnEn in ensemble spread and spread-skill correlation. EITrans successfully demonstrates a real-time solution for ensemble calibration using historical forecast distribution and weather analogs.

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