Research Highlight: How does weather forecast work mathematically?

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Contemporary weather forecast often involves models with more than a million prediction variables. Finite ensemble Kalman filters (EnKF) have been developed by geoscientists. They are successful indispensable tools in science and engineering, because they allow for computationally cheap low ensemble state approximation for extremely large dimensional turbulent dynamical systems. The practical finite ensemble filter like EnKF necessarily involve modifications such as covariance inflation and localization, and it is a genuine mystery why they perform so well with small ensemble sizes in large dimensions. This paper provides the first rigorous stochastic analysis of the accuracy and covariance fidelity of finite EnKF in the practical regime where the ensemble size is much smaller than the large ambient dimension for finite EnKFs with random coefficients. A challenging issue overcome here is that finite EnKF in huge dimensions introduces unavoidable bias and model errors which need to be controlled and estimated.

Reference:

Performance of Ensemble Kalman filters in large dimensions (with A.J. Majda) Comm. Pure Appl. Math., 71(5), 892-937, (2018)