

EGU24-6791, updated on 02 Nov 2024

<https://doi.org/10.5194/egusphere-egu24-6791>

EGU General Assembly 2024

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## A Foray of Dynamics into the Realm of Statistics: A Review of Ensemble Forecasting

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Uncertain quantities are often described through statistical samples. Can samples for numerical weather forecasts be generated dynamically? At a great expense, they can. With statistically constrained perturbations, a cloud of initial states are created and then integrated forward in time. By now, this technique has become ubiquitous in weather and climate research and operations. Ensembles are widely used, with demonstrated value.

The atmosphere evolves in a multidimensional phase space. Does a cloud of ensemble solutions encompass the evolution of the real atmosphere? Theoretically, random perturbations in high dimensional spaces have negligible projection on any direction, including the error in the best estimate, therefore consistently degrading it. As the bulk of the perturbation variance lies in the null-space of error, samples in multidimensional space do not contain reality.

An evaluation suggests that initial and short-range forecast error and ensemble perturbations are random draws from a high dimensional domain we call the subspace of possible error. Error in any initial condition is a result of stochastic observational and assimilation noise, while perturbations explore other, mostly independent directions from the subspace of possible error that may have resulted from other configurations of stochastic noise. What benefits may arise from the deterministic projection of such noise?