The use of multidimensional Langevin processes for stochastic uncertainty quantification in the NOAA Unified Forecast System (UFS)

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Modern numerical weather prediction (NWP) model forecasts for various applications require not only high-quality deterministic forecasts, but also information about forecast uncertainty. An ensemble forecast is commonly used to provide an estimation of forecast uncertainty. Since a great deal of the forecast uncertainty comes from dynamical processes not resolved or explicitly represented by NWP models, there is a need to correctly quantify and simulate NWP model uncertainty for an ensemble forecast to be useful and reliable.

We present an overview of a theoretical framework for simulating the uncertainty in unresolved physics in the NOAA Unified Forecast System (UFS). This framework is derived from the connection in mathematical physics between the Mori-Zwanzig formalism and multidimensional Langevin processes. It follows the correspondence principle, a philosophical guideline for new theory development, such that it can be shown that the previously implemented stochastic uncertainty quantification schemes in the UFS are particular cases of this framework. We will show an example of how we have used this framework to develop a new process-level stochastic uncertainty quantification scheme in the UFS. We will also present a preliminary performance comparison of these previously-implemented schemes with the newly-developed process-level scheme in the UFS ensemble predictions on short, medium and sub-seasonal time scales.