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Simulation of model uncertainty using multidimensional Langevin processes in the NOAA Unified Forecast System (UFS)

Jian-Wen Bao[1], Sara Michelson[1,2], Philip Pegion[1], Jeffrey Whitaker[1], Lisa Bengtsson[1,2], and Cecile Penland[1]
[1]NOAA/PSL, Boulder, Colorado, United States of America (jian-wen.bao@noaa.gov)
[2]CIRES – University of Colorado, Boulder, Colorado, United States of America

Numerical weather prediction (NWP) systems nowadays need to be capable of providing not only high-quality deterministic forecasts, but also information about forecast uncertainty. The ensemble forecast technique is commonly used to provide an estimation of forecast uncertainty. Since a great deal of the forecast uncertainty comes from dynamical and physical processes not resolved or explicitly represented numerically, there is a need to correctly quantify and simulate the uncertainty associated with these processes as required by the ensemble forecast technique.

To address this need, we have developed a new stochastic physics scheme for simulating the uncertainty in parameterizations in the NOAA Unified Forecast System (UFS). This scheme 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 scheme. We will show how we have used this scheme to simulate uncertainty at the process level of unresolved dynamics and physics in the UFS. We will also present a preliminary performance comparison of previously-implemented stochastic physics schemes with the newly-developed process-level scheme in the UFS medium-range ensemble prediction