EGU24-2404, updated on 03 Nov 2024
https://doi.org/10.5194/egusphere-egu24-2404
EGU General Assembly 2024

Data Assimilation with Biases & Random Errors

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Assimilating dynamic models and observations, along with their errors using Bayesian estimation method are challenged when the model has both aleatoric and epistemic errors. We devised a diffusion map technique that can filter an observational data stream, stripping it of components that are near statistically stationary, leaving behind what we denote the tendency of the time series. The tendency of the time series can be thought of as an executive summary of the time series. A model constructed on known physical principles may not be able to capture the tendency with fidelity and thus one can identify, from an estimation process on aleatoric fields, the epistemic error. Using machine learning strategies a surrogate model for the epistemic error can be inferred from a comparison of the physics model and the tendency. The surrogate model is thus incorporated into the model dynamics to enhance the fidelity in predictions. The assimilation of the enhanced model and the observations can now be carried out over the aleatoric Bayesian framework. To meet the challenge of the resulting highly nonlinear and non-Gaussian data assimilation we employ a newly developed Stein sampler we call the particle flow filter. In this talk we will describe and demonstrate this assimilation strategy.