Geophysical Research Abstracts
Vol. 21, EGU2019-7978, 2019
EGU General Assembly 2019

Eigenmode-based perturbation of stochastic parameters for optimal ensemble construction in atmospheric models

Annika Vogel (1,2) and Hendrik Elbern (1,2)

(1) Rheinish Institute for Environmental Research (RIU), University of Cologne, Cologne, Germany (av@eurad.uni-koeln.de),
(2) Institute for Energy and Climate Research (IEK-8), Research Center Jülich, Jülich, Germany

Efficient and reliable uncertainty quantification for numerical weather forecasts has become increasingly important for interpreting the results. However, current algorithms for estimating parameter uncertainties in atmospheric models do not account for intrinsic correlations within this high-dimensional system. Using correlations of model parameters, an eigenmode-based approach for efficient perturbation of uncertain parameters is developed. This approach is based on the Karhunen-Loève extension of a stochastic quantity. Although this extension is well established in mathematics, this study is the first application to ensemble generation in atmospheric models. Given covariances of the stochastic quantities, stochastic sampling for ensemble generation is substituted into an uncorrelated parameter subspace. Through this reduction of the sampling space, the degrees of freedom of the problem can be lowered significantly. This renders the algorithm suitable for ensemble forecasts of high-dimensional atmospheric models, for which computational costs are a limiting factor.

Generally, the presented approach can be efficiently applied to various types of uncertain yet correlated parameters in numerical weather prediction systems (NWPs) as well as chemical transport models (CTMs). Here, a first application to biogenic emissions and deposition velocities in the EURAD-IM (EURopean Air pollution Dispersion - Inverse Model) model is presented. Estimates of these highly variable quantities are controlled by a large number of processes inducing high sensitivity to various input uncertainties. Required covariances of the stochastic quantities are estimated from a sensitivity analysis of these input uncertainties. Preliminary results for a case-study show high spatial correlations as well as cross-correlations between biogenic gases. Considering these large correlations, the leading uncertainties are described by a few principal directions. Within the reduced sampling space provided by the Karhunen-Loève expansion, local stochastic fields of these quantities can easily by covered by $O(10)$ samples.

Furthermore, future applications of the presented ensemble generation approach are discussed. The discussion focuses on the perturbation of various quantities within parameterizations of regional NWPs. Additionally, possible advantages in efficient combination of stochastic perturbations within different parts of the modeling system are investigated.