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Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Estimating deformations of random processes for correlation modelling in variational data assimilation

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Data assimilation makes an extensive use of covariance models in order to describe the statistical structure of errors that are present in the observations, in short term forecasts, and in the numerical model. Building on work in the computer vision community, we introduce the shape from texture approach for the modelling of covariances and correlations in data assimilation with large dimensions. In this framework, the covariance model is obtained as the deformation (coordinate transform) of a stationary covariance model. Contrary to some coordinate changes already proposed in the literature, here the deformation is objectively estimated from the data.

The energy of the deformed process is measured at different scales and orientations by a continuous wavelet analysis. The scalogram is shown to obey a Texture Gradient Equation that relates its derivatives to local metric changes. The deformation gradient can be estimated from a single realization of the deformed process, and integrated to recover the deformation. Estimating the inverse of the deformation allows to spatially stationarize the process. These steps define linear interpolating operators for the direct, adjoint and approximate inverse deformation, which can be used in the control variable transform in variational data assimilation schemes.

We also highlight that the representation of spatially deformed background error covariances is in agreement with the propagation equation of the Kalman filter when advection is a leading phenomenon in the model, and when the analysis error covariance matrix is more homogeneous and isotropic than the background error covariance matrix, which is the case when the observing network is dense. We show that this modelling of the correlations has interesting properties such as it does not require accurate re-normalization of the variances, it allows geographical variability of the correlations and it is computationally feasible. The algorithm is applied to the modelling of background error covariances in a convective scale model and is compared to other approaches such as the recursive filters and the diagonal assumption in a wavelet basis.