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Physically motivated covariance models for two-dimensional wind fields.

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One of the main problems in data assimilation is the adequate representation of the forecast errors of numerical weather prediction systems. This goal can be reached using parametric covariance models that include physical relations of various atmospheric variables of the assimilating system. This is particularly promising as it establishes physical consistency via the assimilation process.

Here we consider a stochastic process for atmospheric variables that are connected by differential relations. These variables are the stream function, the velocity potential, the associated wind field and its curl and divergence. We start by introducing a bivariate Matérn covariance model for stream function and vector potential.
Using the differential relations that connect the potential functions (stream function and velocity potential) to the other variables we derive a stochastic process describing the joint dynamics of all of the variables. This allows us to easily
implement constraints such as non-divergence or geostrophy. We describe the estimation of model parameters and explain how estimates of their uncertainty can be computed. We exemplify our methods by applying them to forecasts of the COSMO-DE ensemble prediction system, and explain the meaning of the obtained results.