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Development and validation of the control variable transformation operators using the cubed-sphere grid system to represent a background error covariance

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A background error covariance matrix is essential in a data assimilation system in terms of its spreading out dynamically balanced increments to the horizontal model grid points and the vertical levels. The full representation of the matrix is impossible because of its huge size, the matrix is therefore constructed implicitly by means of a control variable transformation. It is assumed that the forecast errors in the control variables are statistically independent. We utilized two approaches to dividing the unbalanced and the balanced parts; a method is using balance operators derived based on numerical discretization of partial differential equations, and the other is a regression-based approach. We used the spectral element method accompanying the cubed-sphere grid system, which guarantees a scalable performance in the configuration of using multiple CPUs. To model the background error covariance matrix, horizontal wind was decomposed into a rotational component and a divergent component by introducing stream function and velocity potential as control variables. The dynamical constraint of a balance between mass and wind was imposed by applying the linear balance operator and the nonlinear balance operator including cyclonic wind terms. The unbalanced velocity potential and the unbalanced mass variable is defined by using regression coefficients. The experimental background error statistics has been calculated by exploiting the ensemble samples of the Community Atmosphere Model (CAM) - Local Ensemble Transform Kalman Filter (LETKF). In order to understand the structure of the background error covariance, we performed single observation experiments using a three-dimensional variational data assimilation system on the cubed-sphere grid with the spectral transformation that was developed by Korea Institute of Atmospheric Prediction Systems(KIAPS) of which results will be presented.