A new method for computing horizontally anisotropic background error covariance matrices for data assimilation in ocean models.

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Current operational ocean modelling systems often use variational data assimilation (DA) to improve the skill of the ocean predictions by combining the numerical model with observational data. Many modern methods are derivatives of objective (optimal) interpolation techniques developed by L. S. Gandin in the 1950s, which requires computation of the background error covariance matrix (BECM), and much research has been devoted into overcoming the difficulties surrounding its calculation and improving its accuracy. In practice, due to time and memory constraints, the BECM is never fully computed. Instead, a simplified model is used, where the correlation at each point is modelled using a simple function while the variance and length scales are computed using error estimation methods such as the Hollingsworth-Lonnberg or the NMC (National Meteorological Centre). Usually, the correlation is assumed to be horizontally isotropic, or to have a predefined anisotropy based on latitude. However, observations indicate that horizontal diffusion is sometimes anisotropic, hence this has to be propagated into BECM. It is suggested that including these anisotropies would improve the accuracy of the model predictions.

We present a new method to compute the BECM which allows to extract horizontal anisotropic components from observational data. Our method, unlike current techniques, is fundamentally multidimensional and can be applied to 2D or 3D sets of un-binned data. It also works better than other methods when observations are sparse, so there is no penalty when trying to extract the additional anisotropic components from the data.

Data Assimilation tools like NEMOVar use a matrix decomposition technique for the BECM in order to minimise the cost function. Our method is well suited to work with this type of decomposition, producing the different components of the decomposition which can be readily used by NEMOVar.

We have been able to show the spatial stability of our method to quantify anisotropy in areas of sparse observations. While also demonstrating the importance of including anisotropic representation within the background error. Using the coastal regions of the Arabian Sea, it is possible to analyse where improvements to diffusion can be included. Further extensions of this method could lead to a fully anisotropic diffusion operator for the calculation of BECM in NEMOVar. However further testing and optimization are needed to correctly implement this into
operational assimilation systems.