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Scale separation in ocean data assimilation systems to better exploit sparse observation networks

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CMEMS assimilation systems encompass a wide range of scales that are difficult to control simultaneously using partial observation networks. All scales are not observable by all observation systems (e.g. along track altimetry, ARGO loats,...) and this is not easily taken into account in current ocean operational systems. The main reason for this situation is that the covariance matrices are usually assumed to be local (e.g. using a localization algorithm to describe the small scales of the system). The consequence is that the large scale patterns are removed from the error statistics.

To better exploit the observational information available for each scale in the ensemble observational update, we investigate a new method to introduce the scale separation in the assimilation scheme. Our method is based on a spectral transformation of the ensemble and observations. The analysis can then be computed in the spectral space with a spectral localization, which allows to investigate and to assimilate each scale separately.

To illustrate our method, we performed a 70-member ensemble simulation with a 1/4° NEMO configuration of the North Atlantic and the Nordic Seas (the CREG4 model configuration obtained from Mercator Ocean). We carried out twin experiments with synthetic altimetry observations (simulating the JASON tracks). Results show that the transformation to the spectral space and the spectral localization provide consistent ensemble estimates of the state of the system (in the spectral space, or after backward transformation to the spatial space). In terms of accuracy, this spectral localization gives better results than the spatial localization to recover the large scale structures until a critical scale, especially for sparse observation networks. Conversely, the spatial localization is still preferable for the small scales.

Finally, we show a combination of these two analysis, according to the critical scale, to keep advantages of these two algorithms. This hybrid scheme, combining spectral localization for the large scales and spatial localization for the small scales, can significantly improve the current use of various ocean observing systems, particularly with regard to the large-scale available information contained in sparse distribution of observations as altimeters or ARGO floats.