On the estimation of representation error for ocean data assimilation

Background
Optimal data assimilation requires accurate estimation of both background and observation errors. A significant source of observation error is representation error.

Representation error (RE) is the error that results from the inability of grid-cell averaged values in models to represent point measurements. More generally, one can attribute RE to any error that results from features that cannot be represented by the given model, because of either geometric or physical limitations of the model.

Even a perfect observation must be assigned an error because the model cannot perfectly represent it.

Methods
We propose two methods for estimating the RE for sea-level (SL); one based on mapped sea-level anomalies (MSLA), described in the caption of Figure 1, and one based on along-track sea-level anomalies (atSLA), described in the caption of Figure 2. Both methods use observation-based products as the truth and estimates of grid-cell averaged fields as the best possible model estimate. The difference of these is here regarded as the RE.

Results
Using the methods described by Figures 1 and 2, we compute weekly estimates of RE for SL for a 2° global grid, using altimetry for the period 1993-2005. We then compute the root-mean square (RMS) of these estimates (Figure 3) that show large errors in the boundary currents and along the path of the Antarctic Circumpolar Current (ACC).

RE estimates for SL are presented for a 1/3° model in Figure 4 using the atSLA-based method, indicating that even away from the eddy-rich regions, RE for SL is comparable to instrument error.

Consistent estimates of temperature (T) and salinity (S) can also be derived from the RE estimates for SL using a vertical projection technique (Cooper and Haines 1996). These fields are summarised in Figure 5 showing area averaged profiles of different regions around the world.

Conclusions
We present two methods for obtaining consistent estimates of RE for SL, T and S. We find that RE for oceanic observations are very inhomogeneous and may be much larger than instrument error, depending on the model grid. We argue that our simple methods are a step towards more accurate estimates of the observation errors that are needed for data assimilation.