Peter R. Oke & Pavel Sakov

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.

Figure 1

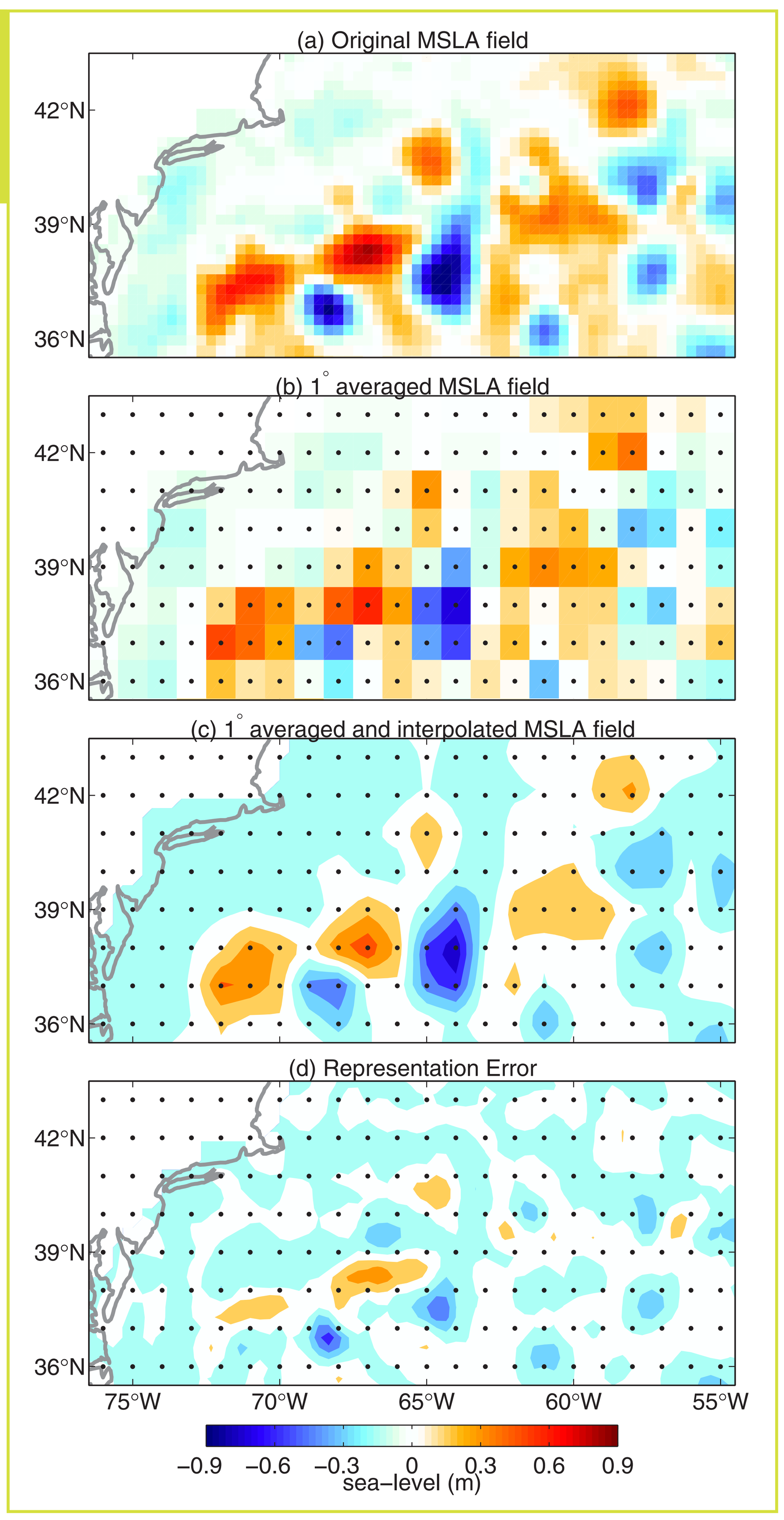

Figure 2

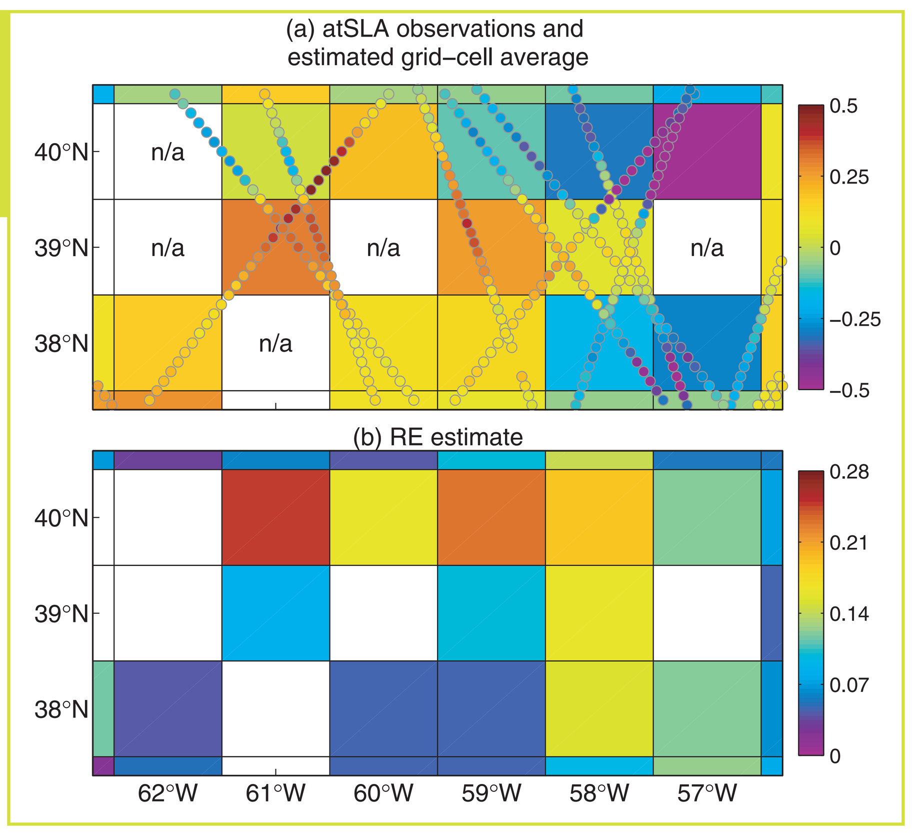

Figure 3

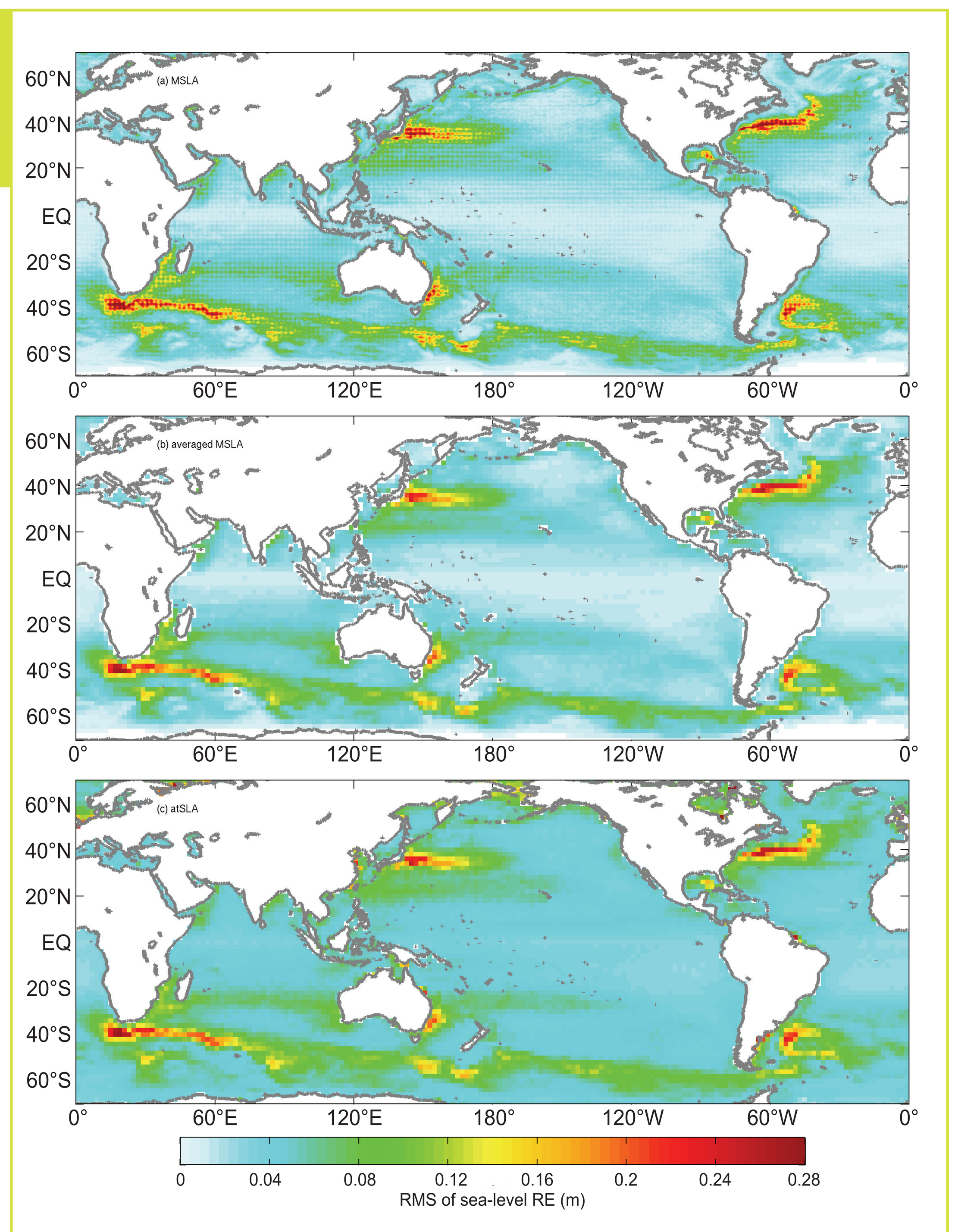

Figure 4

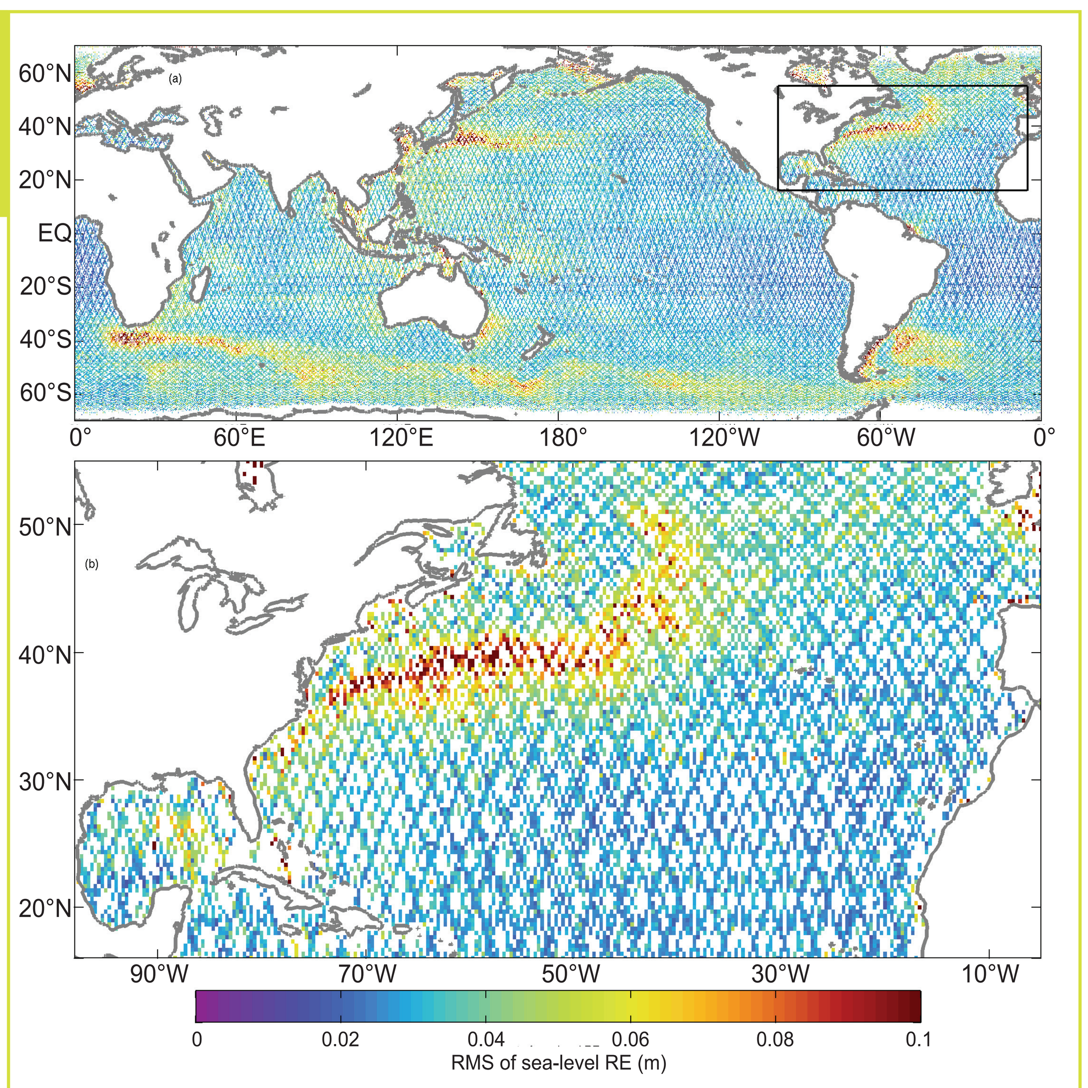

Figure 5

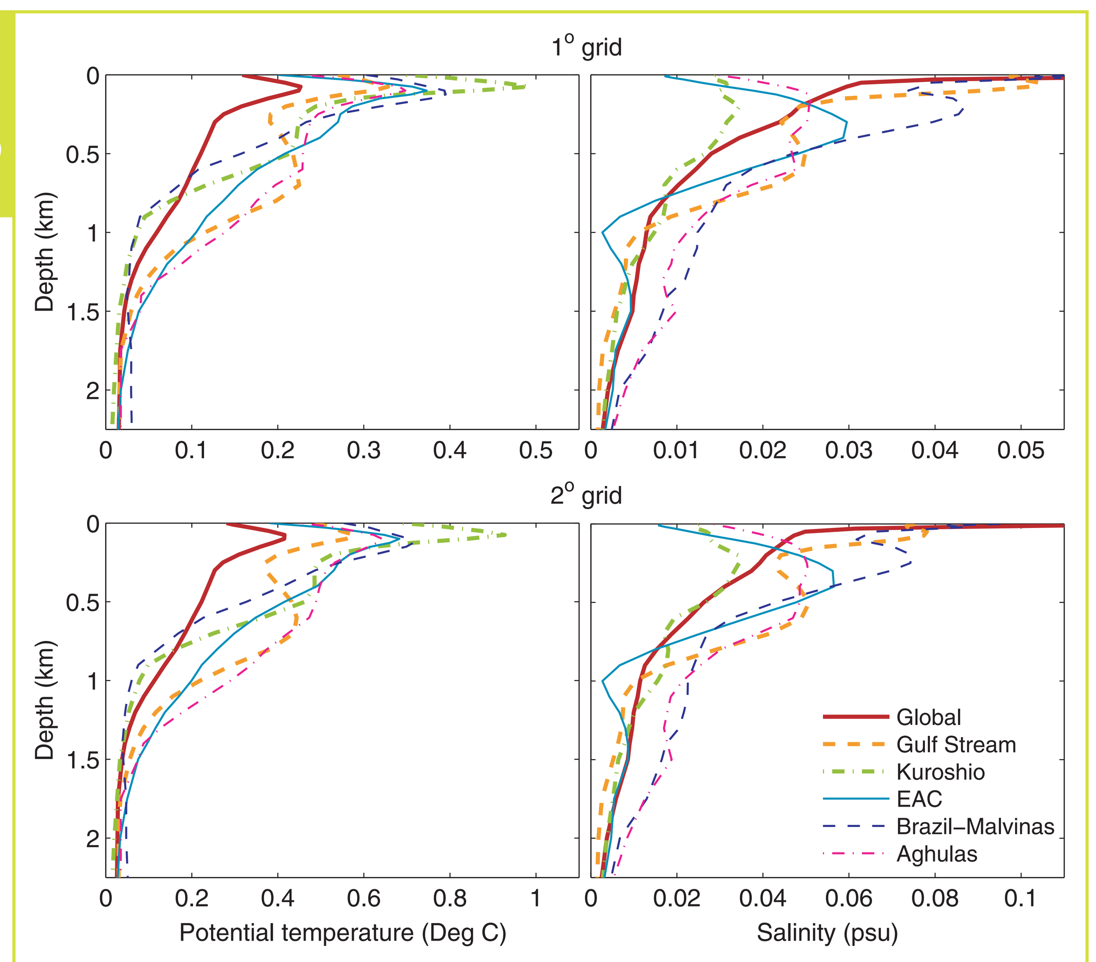

Figure 1: **Example of each step of the MSLA-based method for estimating RE for SL, showing the (a) orginal MSLA field (i.e., the *truth*); (b) MSLA field that has been averaged onto a 1° grid; (c) the field in (b), interpolated back to the original grid (the *best possible model estimate*); and (d) the difference between (a) and (c), providing an estimate of the RE for SL.**

Figure 2: **Example of each step of the atSLA-based method for estimating RE for SL, showing (a) atSLA observations (coloured circles, showing every second; the *truth*) and the grid-cell average (the *best possible model estimate*); and (b) the standard deviation of the difference between the *truth* and the *best possible model estimate* for each grid cell, providing an estimate of the RE for SL.**

Figure 3: **RMS of the RE for SL on a 2° global grid using (a) the MSLA-based method; (b) the grid-cell average of (a); and (c) the atSLA-based method based on MSLA fields and atSLA observations for the period 1992-2005.**

Figure 4: **RMS of the RE for SL using the atSLA-based method for a 1/3° global grid. Panel (a) shows the entire globe, while panel (b) shows the North Atlantic.**

Figure 5: **Area-averaged RMS of the RE for T (left) and S (right) for a 1° (top) and 2° (bottom) grid for various regions using the MSLA-based estimates of the RE for SL.**

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Peter.Oke@csiro.au
Pavel.Sakov@csiro.au
CSIRO Marine and Atmospheric Research