TOWARDS QUANTIFYING THE RELATIVE INFORMATION CONTENT OF SEA SURFACE DATA RELATIVE TO INTERIOR DATA IN CONSTRAINING OCEAN STATE ESTIMATES

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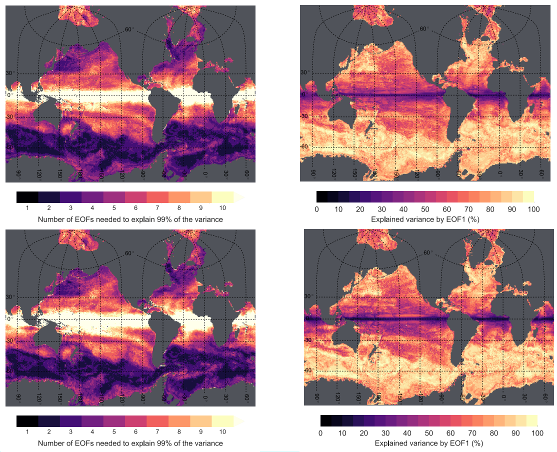
SUMMARY

Current ocean state estimates rely on optimally combining surface observations (SSH, SST, sea surface colour) with interior observations (such as ARGO Floats). The relative information content of each types of data in constraining the ocean interior circulation is not well understood, and depends on the Data Assimilation scheme and geographical location. The main purpose of the proposed OSTST project is to make theoretical progress towards quantifying the relative information content of surface observations using theory, models and observations. This works focuses on: 1) How complex is the vertical structure of ocean internal variability? 2) What is the evidence for the existence of vertical modes? 3) Can we use temporal filtering to tease out information from sea surface height?

HOW COMPLEX IS THE PROBLEM?

Perhaps the first question to address when trying to use surface information to constrain the ocean interior is what are the number of degrees of freedom required to describe ocean interior variability? Using a 20 years long high-resolution (1/12) model simulations using NEMO, the following figures show the minimum number of vertical modes (using EOFs) to describe 99% of the variance (left panels, top for zonal velocity, bottom for meridional velocity), and the variance explained by the first EOF (right panels). Equatorial regions are a priori considerably more complex to reconstruct than ACC or western boundary regions.



CAN TEMPORAL FILTERING SEPARATE VERTICAL MODES?

The theoretical basis for projecting surface information on the interior relies on assuming that the pressure can be written as a sum of N vertical modes, where an indication for the number N needed depends on the geographical location, as evidenced by the above diagnostics.

$$p(x,y,z,t) \approx \sum_{N} p_i(x,y,t)F_i(z)$$

Now, knowledge of sea surface height yields the following constraint:

$$p(x,y,0,t) = \rho_s g SSH(x,y,t) = \sum_{N} p_i(x,y,t)F_i(0)$$

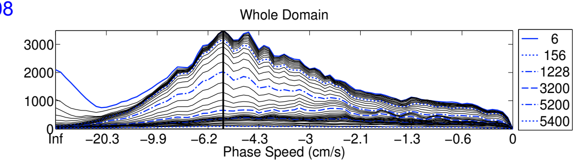
Now, if N>1, that is not enough to constrain the ocean interior. The key theoretical issue for answering the question of to what extent can SSH alone constrain the ocean interior depends on the possibility to construct temperature or spatial filters that can tease out information about the functions p_i(x,y,t) as follows:

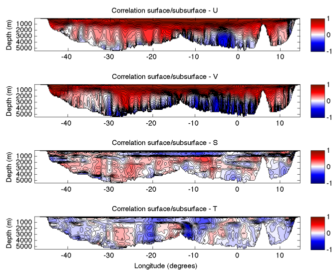
$$\rho_s g \Im_i\left(SSH\right) \approx p_i(x,y,t)F_i(0)$$

So far, the main approach to construct filters has relied on Fourier transforms in space. In this work, we investigate the possibility to use temporal filters to tease out information from SSH.

WHAT IS THE EVIDENCE FOR VERTICAL MODES?

A key assumption for projecting surface information on the vertical is the existence of vertical modes. What is the evidence for it? From Hunt, Hirschi and Tailleux (2012) Applying the Radon transform on meridional velocity anomalies at different depths in 1/6 degree CLIPPER model simulations suggest that the assumption of Rossby wave theory that Rossby waves are vertically coherent is valid, in contrast to Lecointre et al. 2008

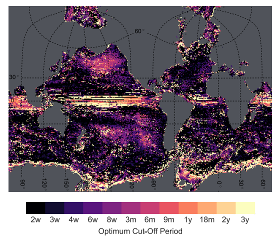


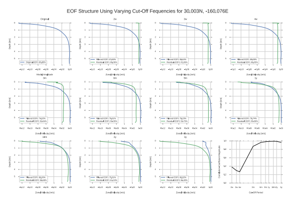


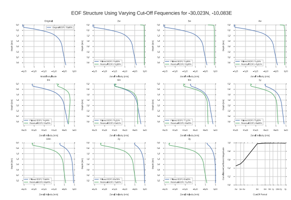
Pearson correlation coefficient between interior and surface values suggest that velocity anomalies may have simple modal structures, but that is not so for temperature/salinity anomalies, presumably because the latter are strongly affected by mean T/S gradients

OPTIMAL CUT-OFF FREQUENCY FOR TEMPORAL FILTERS

A Butterworth temporal filter is used at each point to separate the temporal signal into a low frequency and high frequency for any given cut-off frequency. The leading EOF is computed for the low-pass and high-pass signals. The top panel shows the cut-off frequency maximising the decorrelation between the low-pass and high-pass EOFs. The optimal cut-off frequency is in general close to a few weeks. The lowest two panels show the two leading EOFs for the high-pass and low-pass parts of the signal as a function of the cut-off frequency at two particular locations in the ocean. Although temporal filtering is found capable of isolating different vertical structures for different temporal scales, it does not appear very efficient at teasing out the different functions p_i(x,y,t).







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Hunt, F., R. Tailleux and J.M. Hirschi 2012: The vertical structure of oceanic Rossby waves: a comparison of high-resolution model data to theoretical phase speeds. *Ocean Sci.* **8**, 19.

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CONCLUSIONS Evidence of vertical coherence and good agreement of observed vertical structures with theoretical ones, provided that spatial scales are taken into consideration. Relative Information content of sea surface height appears to be much higher in ACC or western boundary currents than in equatorial regions. Temporal filtering is only moderately useful to tease out information about vertical structures from sea surface height, suggesting that spatial filtering might be more promising.