DOES THE ARGO ARRAY ACCURATELY SAMPLE THE THERMAL VARIABILITY OF THE GLOBAL OCEAN?

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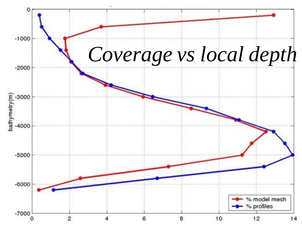
INTRODUCTION

Context

The **Argo** hydrographic array aims at monitoring the evolution of the **global ocean heat content** (OHC) over a wide range of timescales. However, the **spatial coverage** of the Argo floats is **inhomogeneous**, and some regions remain poorly sampled (e.g. Southern ocean, coastal areas) or not sampled (deep ocean, ice-covered regions).

Argo sampling of the global ocean: horizontal and vertical restrictions

• Argo does not sample (adequately):
- the deep ocean (> 2000m)
- the shallow water regions (especially shallower than 400m)
- the ice-covered regions



Q1: How do the geographical limitations of the Argo array may affect observational estimates of the seasonal and interannual variabilities of the global heat content?

• Argo profiles are dispersed in time and space

Q2: Does the Argo geometry distort the distribution of the mixed layer quantities, such as the Mixed Layer Heat Content (MLHC)

OCEAN HEAT CONTENT

[m = monthly field ; a = annual field]

Local heat content (J/m²): $HC_{m,a}(x,y,t) = \rho_0 Cp \int_{z2}^{z1} T_{m,a}(x,y,z,t)dz$

Global heat content anomaly (J): $HCA_{m,a}(t) = a^2 \rho_0 Cp \int_{\lambda1}^{\lambda2}\int_{\phi1}^{\phi2}\int_{z1}^{z2}(T_{m,a} - \overline{T})\cos\phi dz d\phi d\lambda$

APPROACH

Numerical simulation

We make use of a ¼° global ocean/sea-ice simulation performed by the DRAKKAR Group [1] driven by a realistic daily interannual atmospheric forcing function [2] over 1958-2007. Several studies have shown the skill of this simuation in reproducing the observed mean state and variability of currents and water masses [3][4].

Methodology

Q1: We compare the (detrended) seasonal and interannual variabilities of the simulated global OHC with and without masking of deep, ice-covered and coastal oceans.

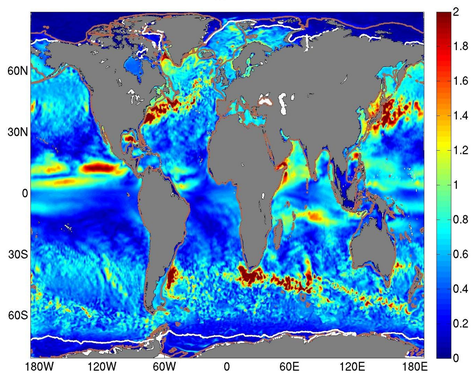
Q2: The model simulation is sub-sampled in time and space like the actual Argo floats. The MLHC estimations from the model-derived Argo profiles are then compared to their full-model counterparts to estimate how the Argo array has distorted the PDFs of MLHC in monthly regional bins.

Q1. VARIABILITY OF THE OHC IN THE TOTAL AND OBSERVABLE OCEANS

Seasonal variability of HC

Standard deviation of the monthly HC[0-bottom]

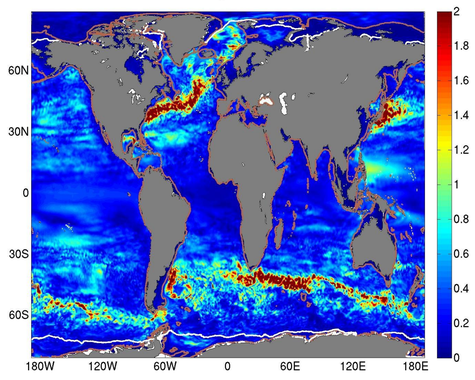
$\sigma_{HC_m}[0-bottom]$



Interannual variability of HC

Standard deviation of the annual HC[0-bottom]

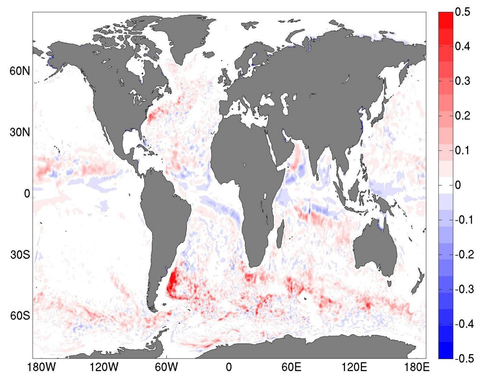
$\sigma_{HC_a}[0-bottom]$



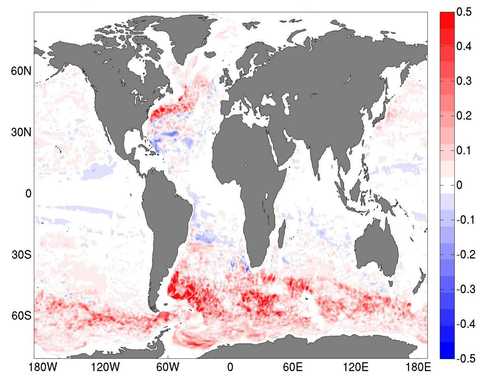
Large seasonal and interannual variabilities of local HC(x,y) within [0-bottom] in turbulent regions. Variability reaches larger local values at interannual time scales.

Ignoring the variability in the [2000m-bottom] layer

$\sigma_{HC_m}[0-bottom] - \sigma_{HC_m}[0-2000m]$



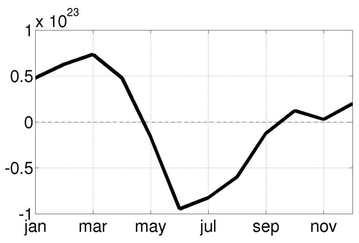
$\sigma_{HC_a}[0-bottom] - \sigma_{HC_a}[0-2000m]$



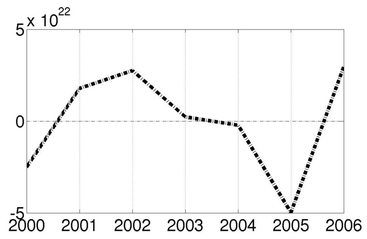
The confinement of ARGO above 2000m underestimates local HC variability in eddying regions, especially at the interannual time scale.

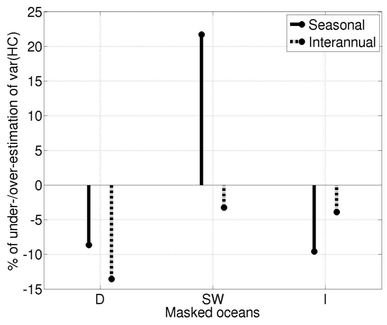
Variability of the global ocean heat content

Monthly HCA(t) within [0-bottom]



Annual HCA(t) within [0-bottom]





Ignoring the …

Deep ocean => seasonal variability (~-9%); interannual variability (~-13%)

Shallow Water regions => seasonal variability (~+22%); interannual variability (~-3%)

Ice-covered regions => seasonal variability (~-10%); interannual variability (~-4%)

(D = deep ocean, SW = shallow waters, I = ice-covered regions)

Under-estimation ⇔ positive correlation between the ignored region and the rest of the ocean

Over-estimation ⇔ negative correlation between the ignored region and the rest of the ocean

Q2. IMPACT OF THE SPACE-TIME SUBSAMPLING OF ARGO FLOATS ON THE REGIONAL MLHC

Approach

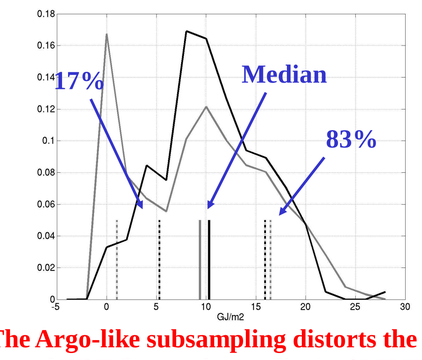
- Collocate model outputs on the space-time positions of Argo profiles [5].
- Calculate Mixed Layer Heat Content (MLHC).
- Compare statistics from fully sampled and subsampled (Argo-like) MLHCs.

MLHC = $HC_m(x,y,t)$ integrated within the mixed layer

-- fully sampled model
-- subsampled model

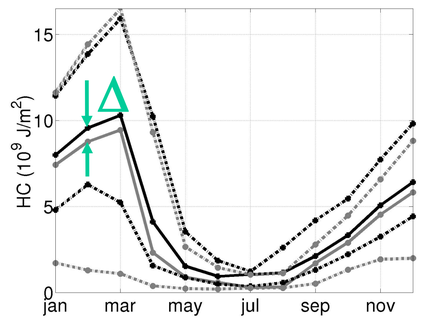
A. Regional and monthly PDF of MLHC

Ex: Northwest Atlantic in March 2002-2006.



The Argo-like subsampling distorts the actual PDF (hence the median) of MLHC.

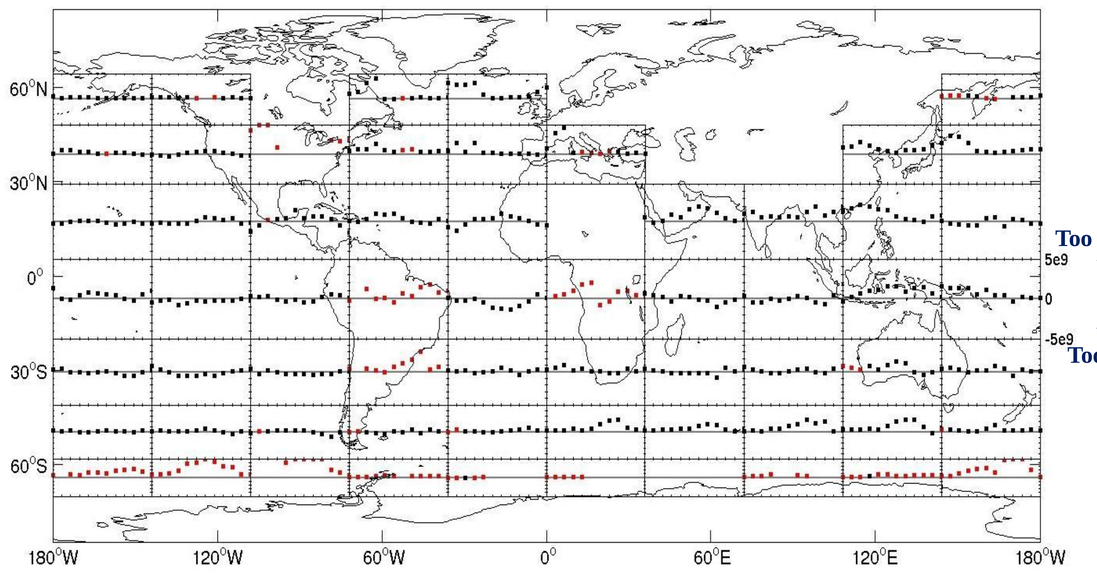
B. Monthly cycle of MLHC



The Argo array correctly samples the seasonal cycle of MLHC, despite a persistant over-estimation of its median in this region.

C. Monthly cycle of regional sampling distorsion of the MLHC at global scale (J/m²)

Sampling distorsion is characterized by the difference of medians between the full and subsampled medians: Δ



Number of profiles > 11 (■) or 50 (■) per monthly regional bin

The Argo sampling tends to distort MLHC PDFs mostly in winter, up to about ~5.10⁹ J/m². The positive bias seems to be due to an over-sampling of deep winter Mixed Layer areas.

CONCLUSIONS

Q1: Impact of Argo's geographical restrictions on global ocean heat content (OHC) variability estimates

- Restriction on the upper 2000 ➔ ~10% underestimation of seasonal and interannual OHC variabilities.
- Restriction to areas deeper than ~400m ➔ ~20% overestimation of seasonal OHC variability.
- Restriction to ice-free areas ➔ ~10-4% underestimation of seasonal and interannual OHC variabilities.

Q2: Argo-induced distorsion of Mixed Layer Heat Content PDFs in the "observable" ocean

Dispersion in time & space of Argo floats ➔ regional sampling distorsions of the seasonal mixed layer properties [6]

This unassimilated approach

- Does not tell how Argo data constrains assimilated simulations (unlike traditional OSSEs).
- Does help comparing actual & sub-sampled quantities. May be a useful preliminary to OSSEs.
- Such exercises may also help improve mapping techniques, and the design of observation systems.

REFERENCES

[1] Drakkar Group, 2007: « Eddy-permitting ocean circulation hindcasts of past decades », *Clivar Exchanges*, *No 42* (vol 12 No 3), 8-10.
[2] Brodeau, L., B. Barnier, T. Penduff, A.-M. Treguier, and S. Gulev, 2010: « An ERA-40 based atmospheric forcing for global ocean circulation models », *Ocean Modelling*, *31*, 3-4, 88-104.
[3] Koch-Larrouy, A., R. Morrow, T. Penduff, M. Juza, 2010: « Origin and mechanism of Sub Antarctic Mode Water formation and transformation in the Southern Indian Ocean », *Journal of Physical Oceanography*, doi:10.1007/s10236-010-0276-4.
[4] Penduff, P., M. Juza, L. Brodeau, G.C. Smith, B. Barnier, J.-M. Molines, A.-M. Treguier and G. Madec, 2010: « Impact of global ocean model resolution on sea-level variability with emphasis on interannual time scales », *Ocean Science*, *6*, 269-284.
[5] Ingleby, B., and M. Huddleston, 2007: « Quality control of ocean temperature and salinty profiles – historical and real-time data », *Journal of Marine System*, *65*, 158-175.
[6] Juza, M., T. Penduff, J.-M. Brankart, and B. Barnier, 2010: « Estimating the distorsion of the mixed layer property distributions induced by the Argo sampling », *in revision*.