CONTRIBUTION OF THE REGIONS NOT SAMPLED BY ARGO TO THE VARIABILITY OF THE GLOBAL OCEAN HEAT CONTENT

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INTRODUCTION

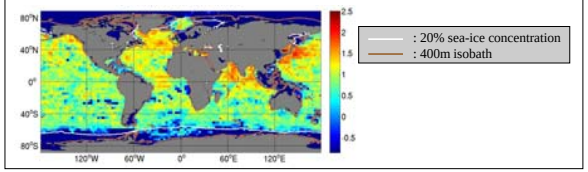
Context

The **Argo** hydrographic array aims at monitoring of the **global Ocean Heat Content** (OHC) over a wide range of scales. However, the array's **spatial coverage** is still **inhomogeneous** and **not entirely global**: some regions remain poorly sampled (shallow-water areas) or not sampled (ice-covered regions, deep ocean). Argo-based global OHC variability estimates may thus be biased by these restrictions.

Geographical restrictions of the Argo array

- Shallow-Water areas (especially shallower than 400m)
- Ice-covered regions (where the annual mean of sea-ice concentration exceeds 20%)
- Deep ocean (>2000m)

Annual mean of number of Argo profiles over 2000-2006 in 3°x3° box (log scale)



Do the geographical limitations of the Argo array affect observational estimates of the seasonal and interannual variabilities of the global OHC? And how?

Toward which of these three unsampled regions should the Argo dataset be extended in priority to better monitor the global OHC variability?

APPROACH

Numerical simulation

We make use of a ¼° eddy-permitting 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 simulation in reproducing the observed mean state and variability of currents and water masses [3][4][5].

Monthly and annual ocean heat content anomalies (2000-2006)

$$OHCA_{m,a}(t) = \rho_0 Cp \iiint_V (T_{m,a} - \overline{T}).dV \quad (J)$$

T_m = monthly climatological temperature, m = [1,12]
T_a = annually-averaged temperature, a = [2000,2006]
$\overline{T}$ = mean temperature over 2000-2006

Methodology

We compare the (detrended) seasonal and interannual variabilities of the simulated global OHC with the observed or extended (to unobserved regions) OHC in terms of phase (correlation) and amplitude (ratio of standard deviations).

Global ocean
"Truth" from the unmasked global simulation

Argo ocean (A)
Global simulation where SW, I and D are masked

Unobserved regions
Shallow Waters (SW)
Ice-covered regions (I)
Deep ocean (D)

Extended Argo ocean
Argo ocean extented to either SW, I or D (A+SW, A+I, A+D)

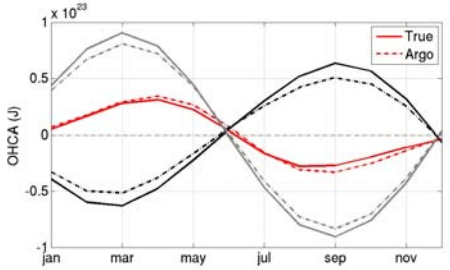
"Strong Hypothesis": ARGO sampling is "perfect" (i.e. matches the 1/4 ° model grid)

RESULTS

SEASONAL VARIABILITY

« TRUE » AND OBSERVABLE OHC VARIABILITY

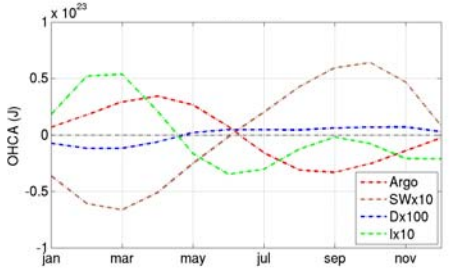
-- Global scale
-- Northern hemisphere (NH)
-- Southern hemisphere (SH)



→ Strong seasonal cycle in the global ocean and both hemispheres (NH and SH).
→ The Global OHCA cycle is in phase with its southern component (greater volume).
→ The « Argo ocean » OHCA is well-correlated with the « true » OHCA, but its amplitude is biased: larger (13%) at global scale, smaller (-9% / -19%) in NH/SH.

UNOBSERVED OHC VARIABILITY (Global scale)

-- Argo ocean (A)
-- Shallow Water areas (SW)
-- Deep ocean (D)
-- Ice-covered regions (I)



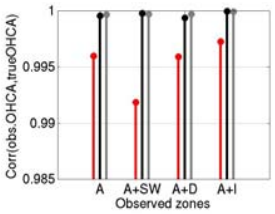
→ Smaller seasonal and interannual variabilities in unobserved regions (SW, I, D) than in « Argo ocean ».
→ The Shallow Waters (SW) are anticorrelated/well-correlated with the « Argo ocean » at seasonal/interannual timescales.

POTENTIAL BENEFITS OF REGIONAL EXTENSIONS ON ARGO'S OHC VARIABILITY ESTIMATES

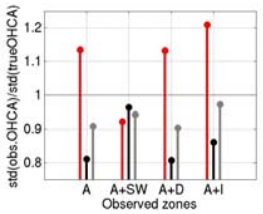
Argo ocean (A)
Argo ocean extended to SW (A+SW)
Argo ocean extended to D (A+D)
Argo ocean extended to I (A+I)

-- Global scale
-- Northern hemisphere (NH)
-- Southern hemisphere (SH)

Phase

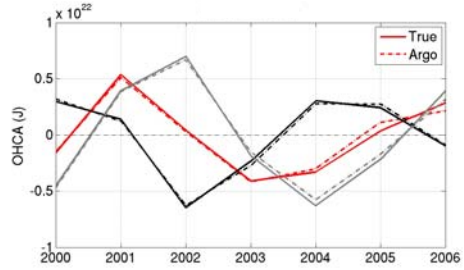


Amplitude

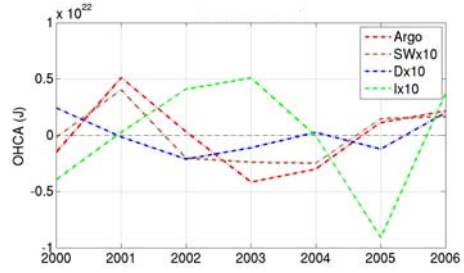


→ A vs A+SW: extending observable regions to the Shallow-Water (SW) areas decreases the amplitude biases at both seasonal and interannual timescales.
→ A vs A+I, A vs A+D: extending observable regions to Ice-covered regions (I) and Deep ocean (D) do not compensate the biases at global scale. However, adding the Ice-covered areas (I) improves the representation of the variability in the southern hemisphere.

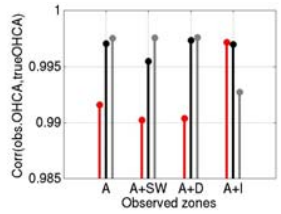
INTERANNUAL VARIABILITY



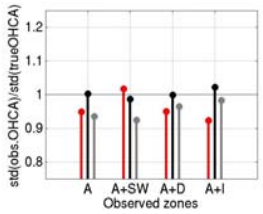
→ Substantial interannual variability, but O(10) smaller than at seasonal scale.
→ The « Argo ocean » OHCA is well-correlated with the « true » OHCA, but it reveals a bias in amplitude: smaller (-5%) than the « true » at global scale because of the bias in the southern hemisphere (-7%).



Phase



Amplitude



CONCLUSIONS

➢ The seasonal/interannual variabilities of Ocean Heat Content are 10-100 times smaller in unobserved (Shallow-Water, Ice-covered and Deep) regions than in the observed « Argo ocean » (A), but their phases are quite different.

➢ Consequently, estimates of the « global » OHC variability amplitudes based on Argo data may be biased by +13% (overestimated seasonal cycle) and -5% (underestimated interannual variability).

➢ Extending the existing Argo collection of temperature profiles to waters shallower than 400m may be most beneficial (compared to Ice-covered or Deep regions) for improving in-situ estimates of seasonal and interannual Ocean Heat Content variabilities.

PERSPECTIVES

➢ This study is being complemented by an assessment of sampling biases due to the Argo array's sparsity in the observable « Argo ocean » (relaxation of the "*Strong Hypothesis*").

➢ A similar approach might be applied to assess the observability of other signals (e.g. ocean temperature trends).

This work is reported in Juza, M., T. Penduff, and B. Barnier, 2011: « How should the Argo array be extended to better monitor the Global Ocean Heat Content variability? », Mercator Ocean Quaterly Newsletter, *in press*.

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