Argo-based estimates of the ocean heat content variability: impact of the array's geometry

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Introduction

<u>Argo hydrographic array</u>

- Monitor the evolution of the heat content of the global ocean over a wide range of time scales
- The spatial coverage is still inhomogeneous, and some regions remain poorly sampled (Southern Ocean, shallow waters) or not yet observed (deep ocean, ice-covered areas)

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- Monitor the evolution of the heat content of the global ocean over a wide range of time scales
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Objective

- Evaluate the impact of the Argo array's geometry on the estimation of the ocean heat content variability at global scale

Approach

- Use of an ocean/sea-ice global numerical simulation (even spatial and temporal resolution, 3D global coverage)

Outline

I. Numerical simulation

II. Impact of the Argo array's geographical restrictions

Do the geographical restrictions of the Argo array affect the estimations of the seasonal and interannual variabilities of the global ocean heat content?

III. Impact of the Argo array's spatio-temporal subsampling

Does the Argo geometry distorts the distribution of the mixed layer quantities, such as the Mixed Layer Heat Content?

IV. Conclusions and perspectives

I. Numerical simulation

II. Impact of the Argo array's geographical restrictions

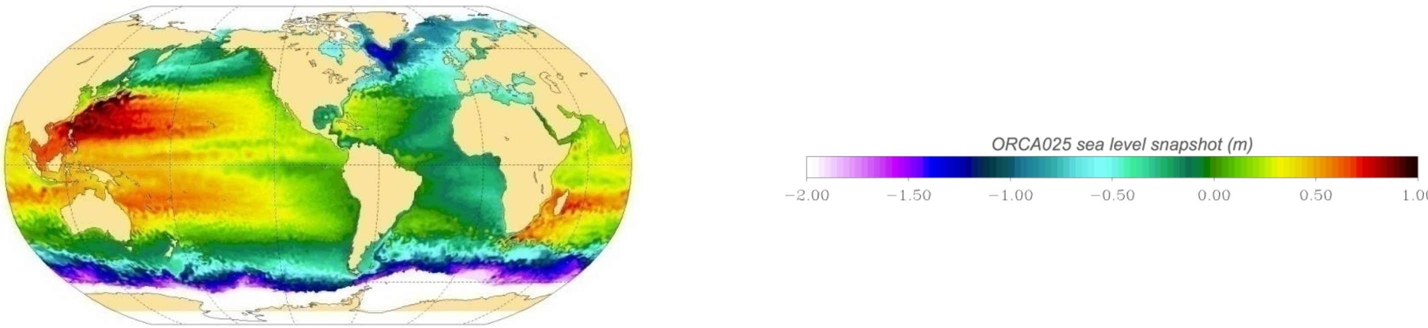
III. Impact of the Argo array's spatio-temporal subsampling

IV. Conclusions and perspectives

I. A model study

<u>DRAKKAR global simulation</u>

- Model configuration at global scale (*DRAKKAR Group*, 2007)



- NEMO code (*Madec*, 2008): ocean model OPA (*Madec et al*., 1998) + sea-ice model LIM2 (*Fichefet and Maqueda*, 1997)
- Resolution: ¼°
- Interannual atmospheric forcing from 1958 to 2009 (*Brodeau et al*., 2010)
  - Turbulent fluxes using atmospheric surface variables from the ERA40 re-analysis
  - Radiative fluxes and precipitations from satellite products
- Archiving: 5-day means (*Crosnier et al*., 2001)
- Largely assessed and used for scientific studies:
  Treguier et al. (2005, 2007), *Barnier et al.* (2006), *Penduff et al.* (2007, 2010), *Lique et al.* (2009), *Lombard et al*. (2009), *Koch-Larrouy et al.* (2010), *Juza* (thesis, 2011)

II. Impact of the Argo array's geographical restrictions

(*Juza et al.*, 2011)

Argo hydrographic array

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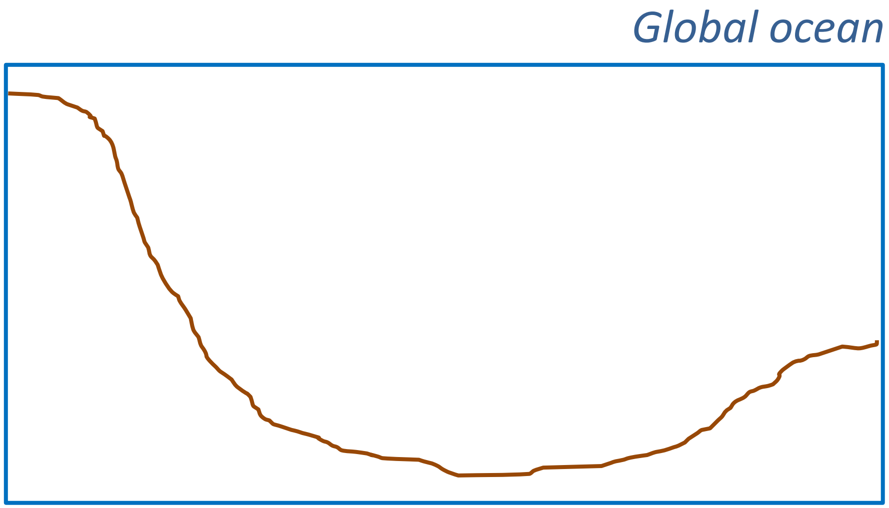

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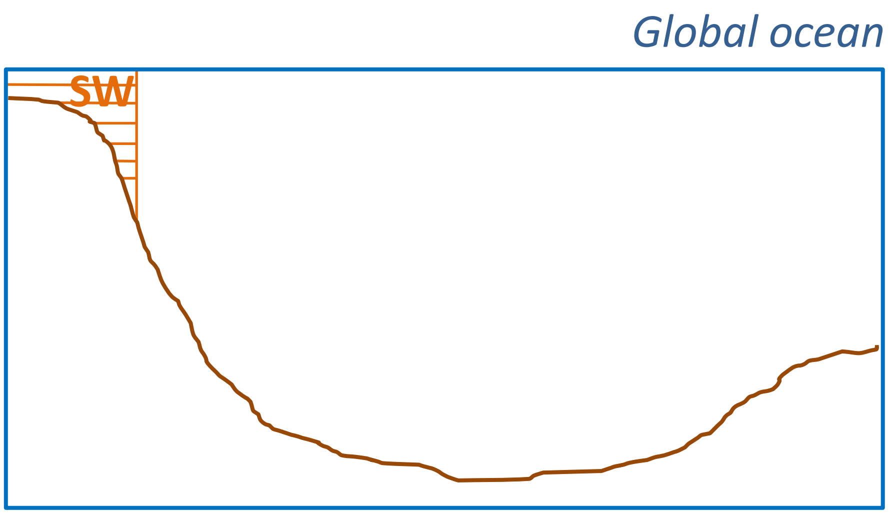

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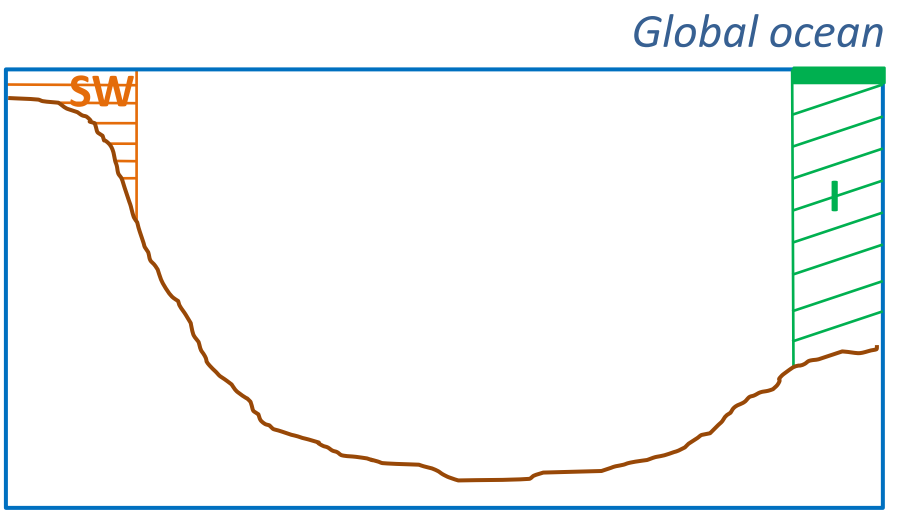

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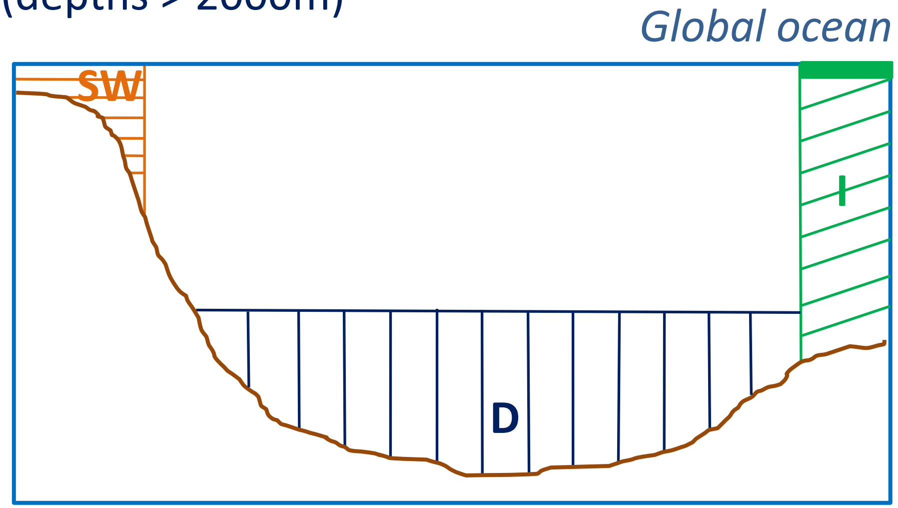

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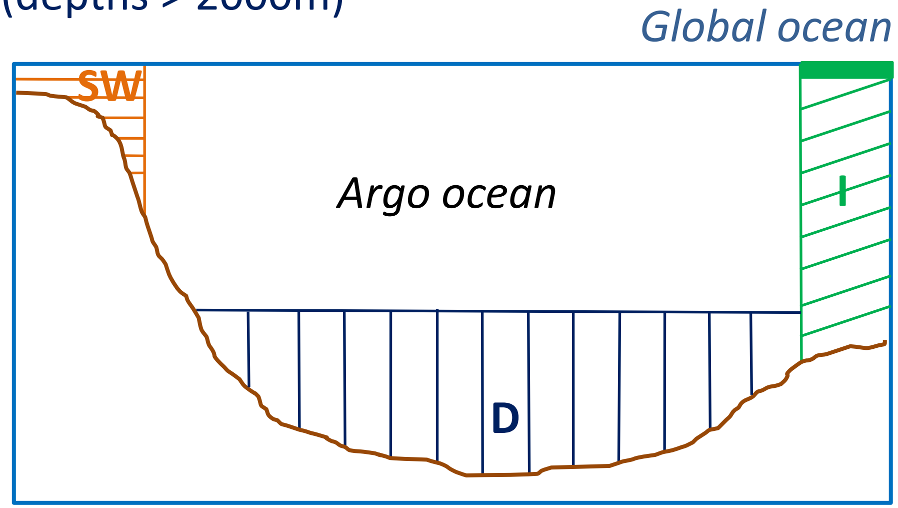

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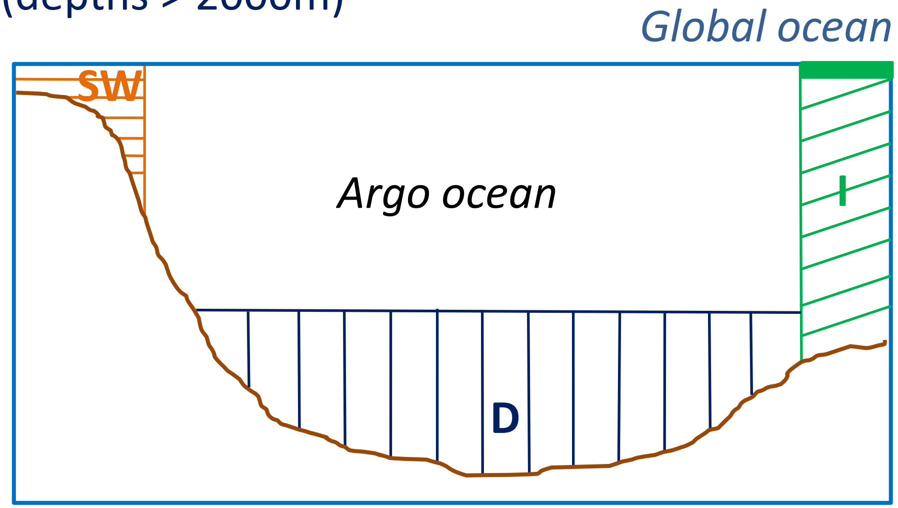


➢ Do the geographical restrictions of the Argo array affect the estimations of the seasonal and interannual variabilities of the global ocean heat content?

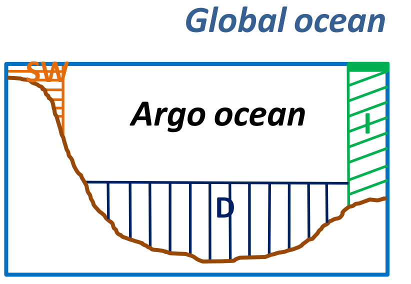
➢ Toward which region(s) should be beneficial to complete the actual array to better represent the variability of the global ocean heat content?

II. Impact of the Argo array's geographical restrictions

(*Juza et al.*, 2011)

Method

- Global ¼° simulation over 2000-2006
- Comparison of heat content seasonal and interannual variabilities of the simulated « global » and « Argo » oceans (phase and amplitude)



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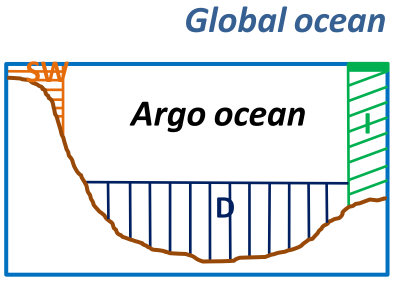
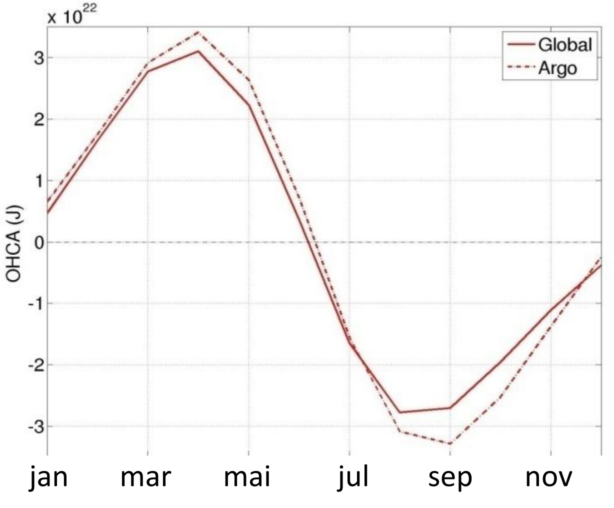


Seasonal cycle of heat content anomalies



→ Deducing the OHC seasonal variability from «Argo ocean» yields an overestimation

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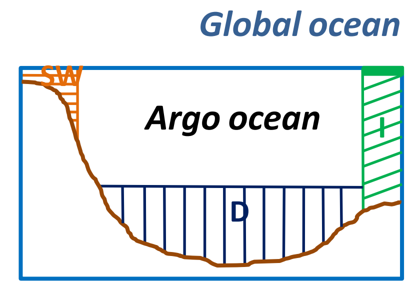

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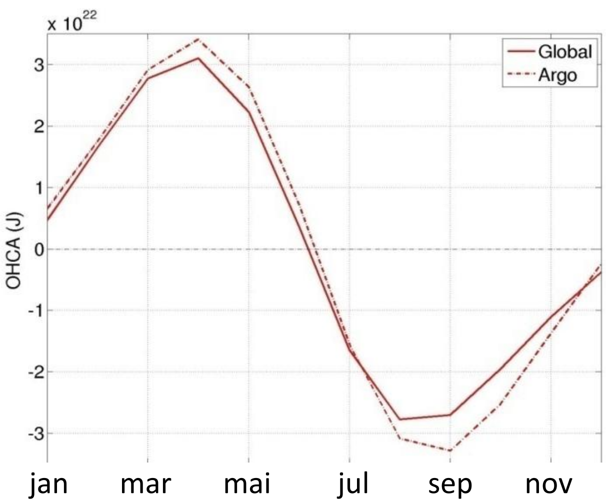
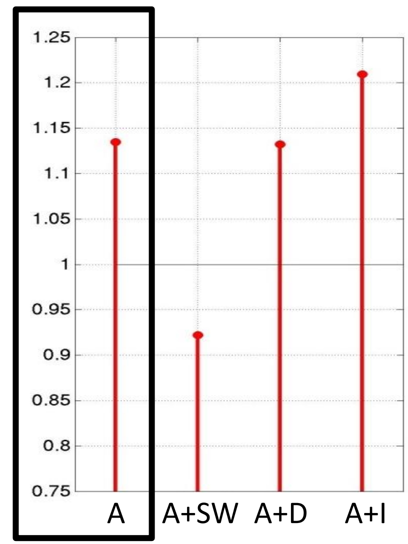


Ratio of amplitudes
Argo / Global

A = Argo



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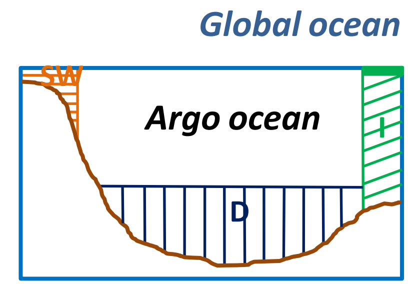

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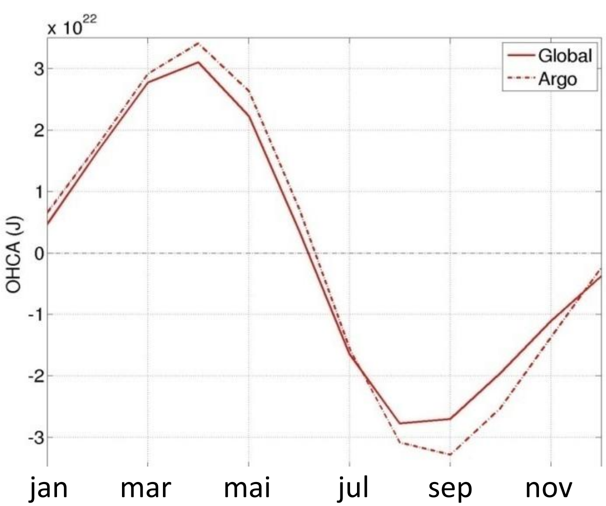
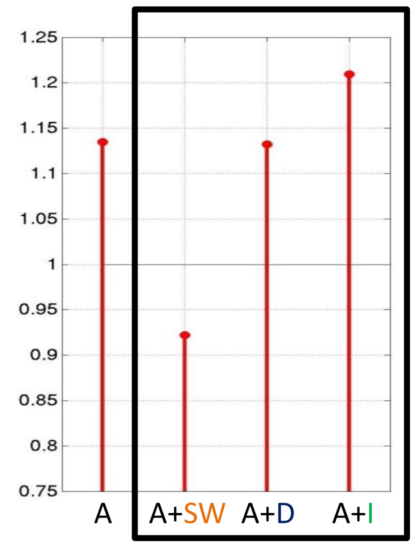


Ratio of amplitudes
Extended Argo / Global

A + SW = Argo + shallow waters
A + D = Argo + deep ocean
A + I = Argo + ice-covered regions



→ Deducing the OHC seasonal variability from «Argo ocean» yields an overestimation (13%)

→ The most beneficial extension: complete the Argo array in the shallow waters at seasonal and interannual scales

I. Numerical simulation

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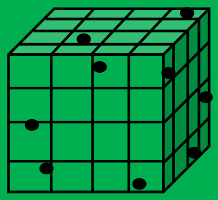
IV. Conclusions and perspectives

III. Impact of the Argo array's spatio-temporal subsampling



ENACT-ENSEMBLES

(ARGO, XBT, CTD, buoys)

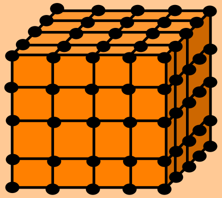
T,S(x,y,z,t) profiles (~10.10^6)

Global. 1956-present

MODEL

T,S(x,y,z,t)

Global. 1958-2009



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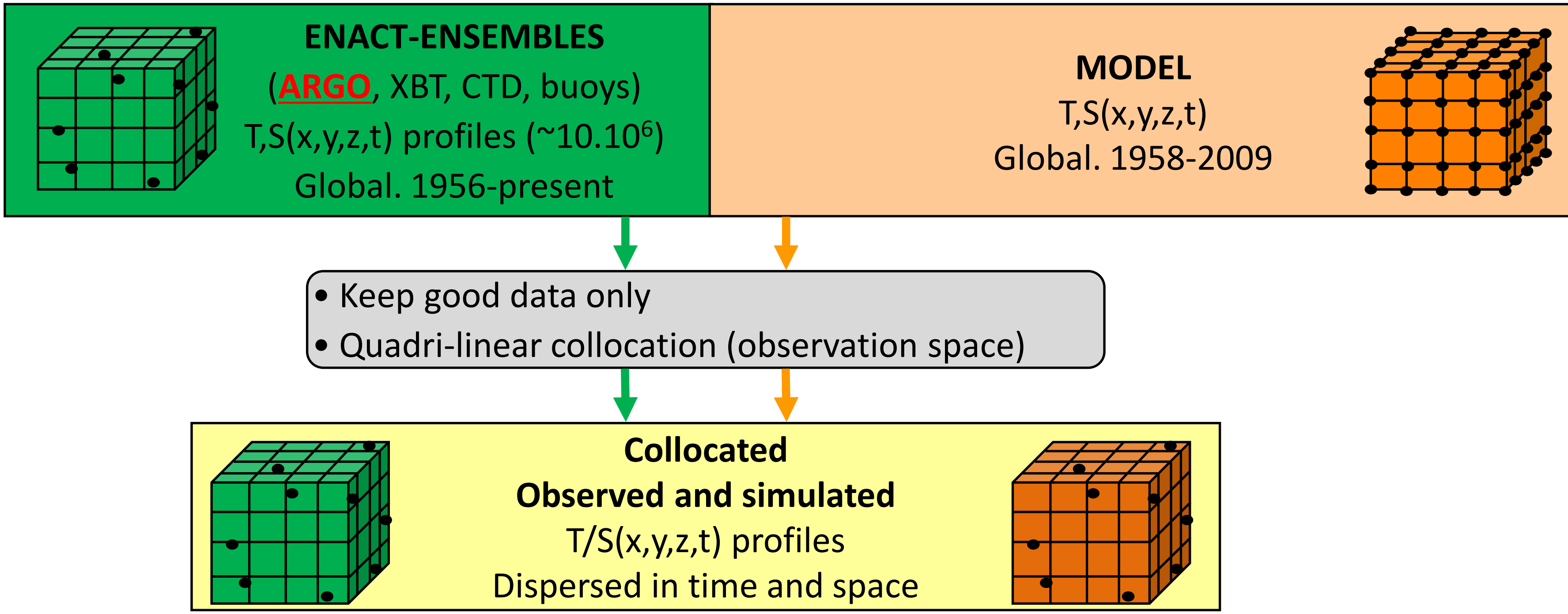

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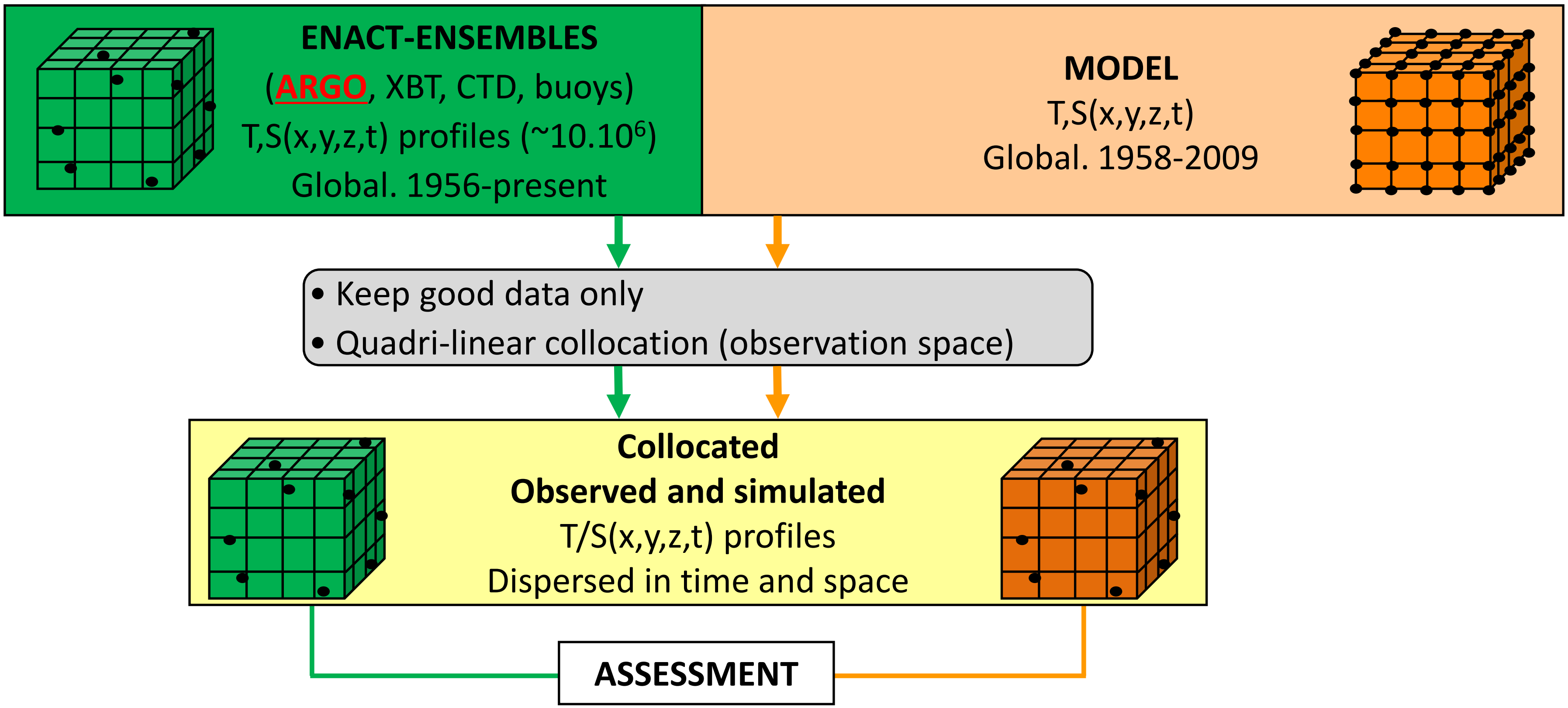

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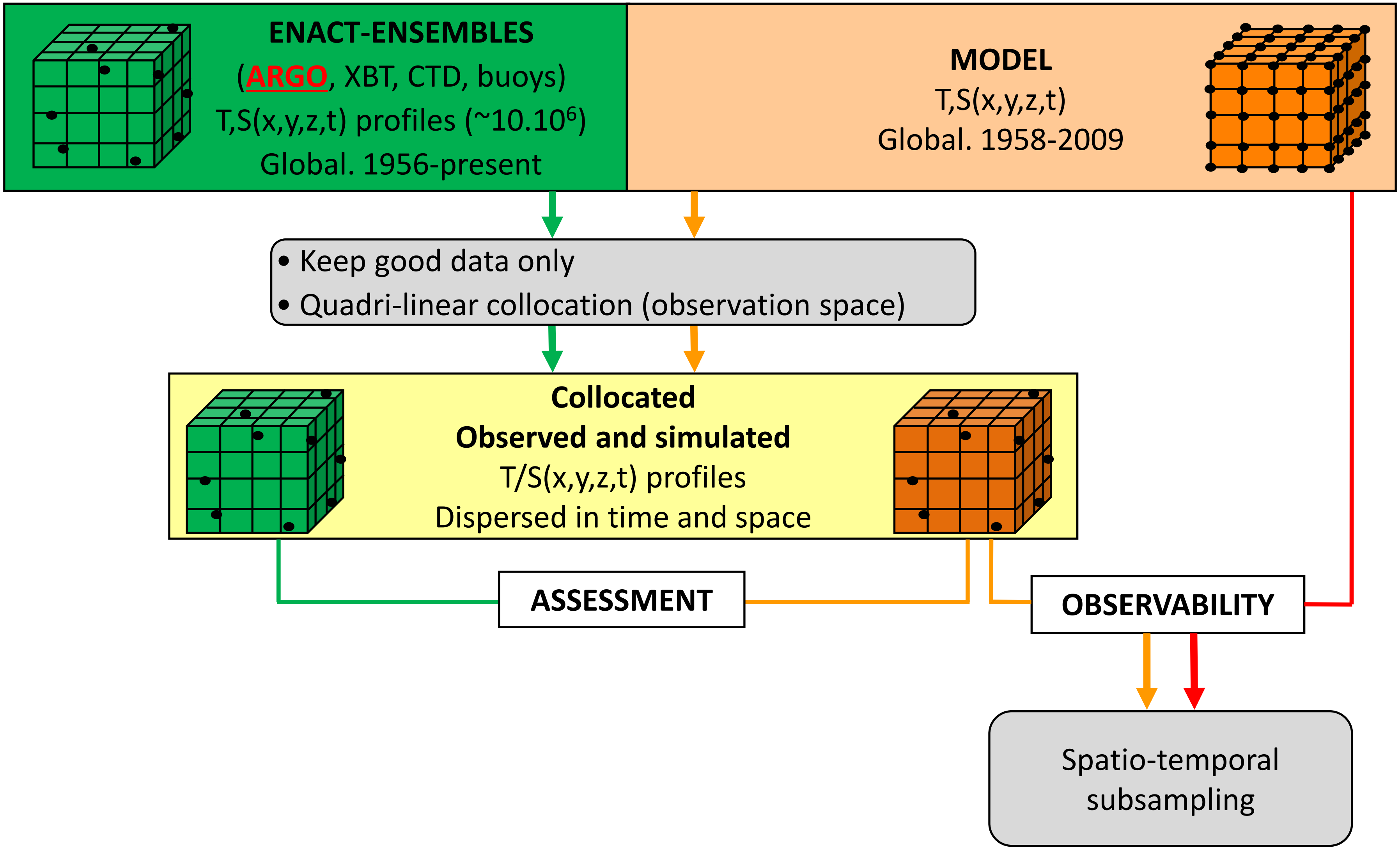

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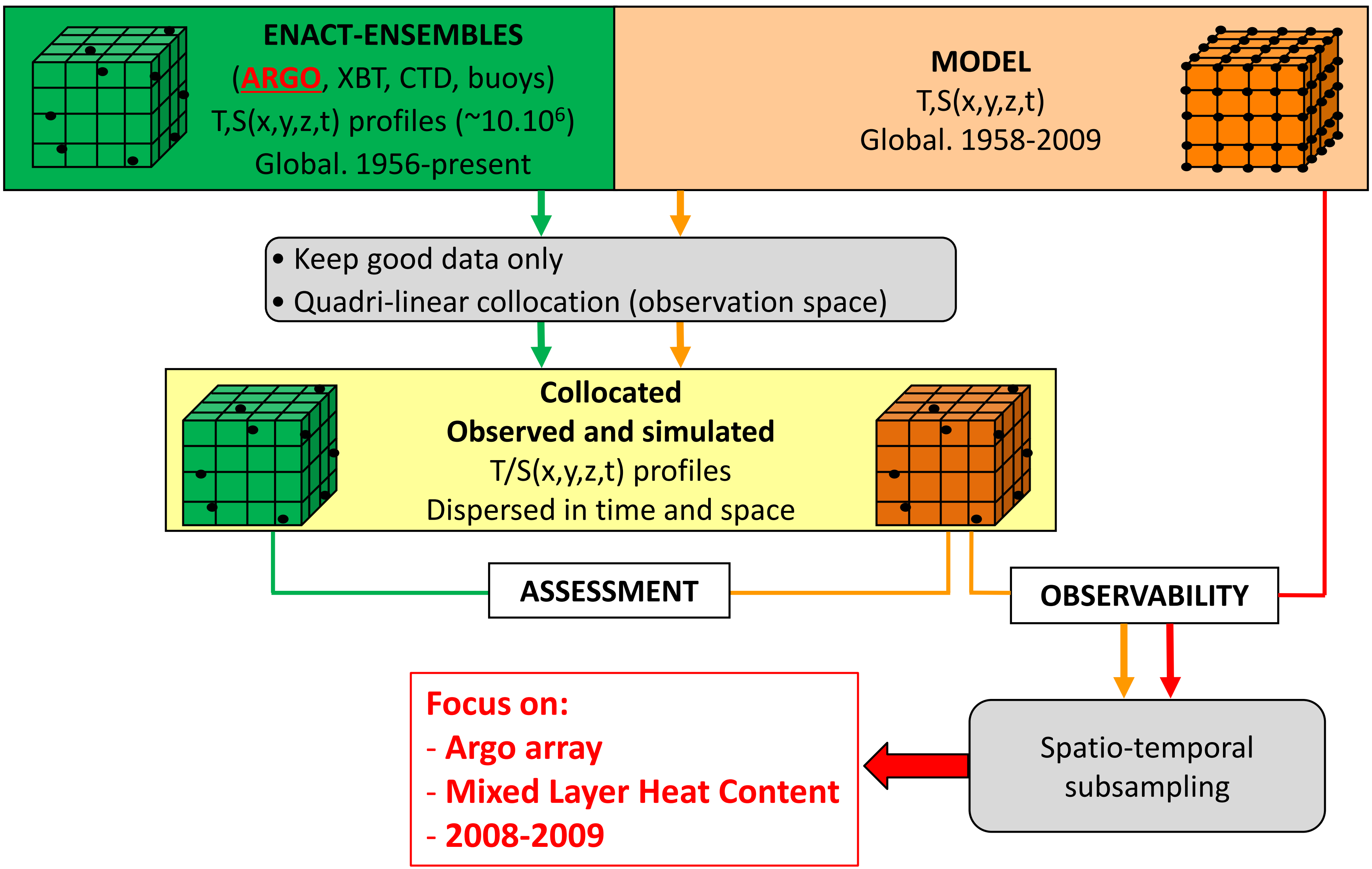


III. Impact of the Argo array’s spatio-temporal subsampling

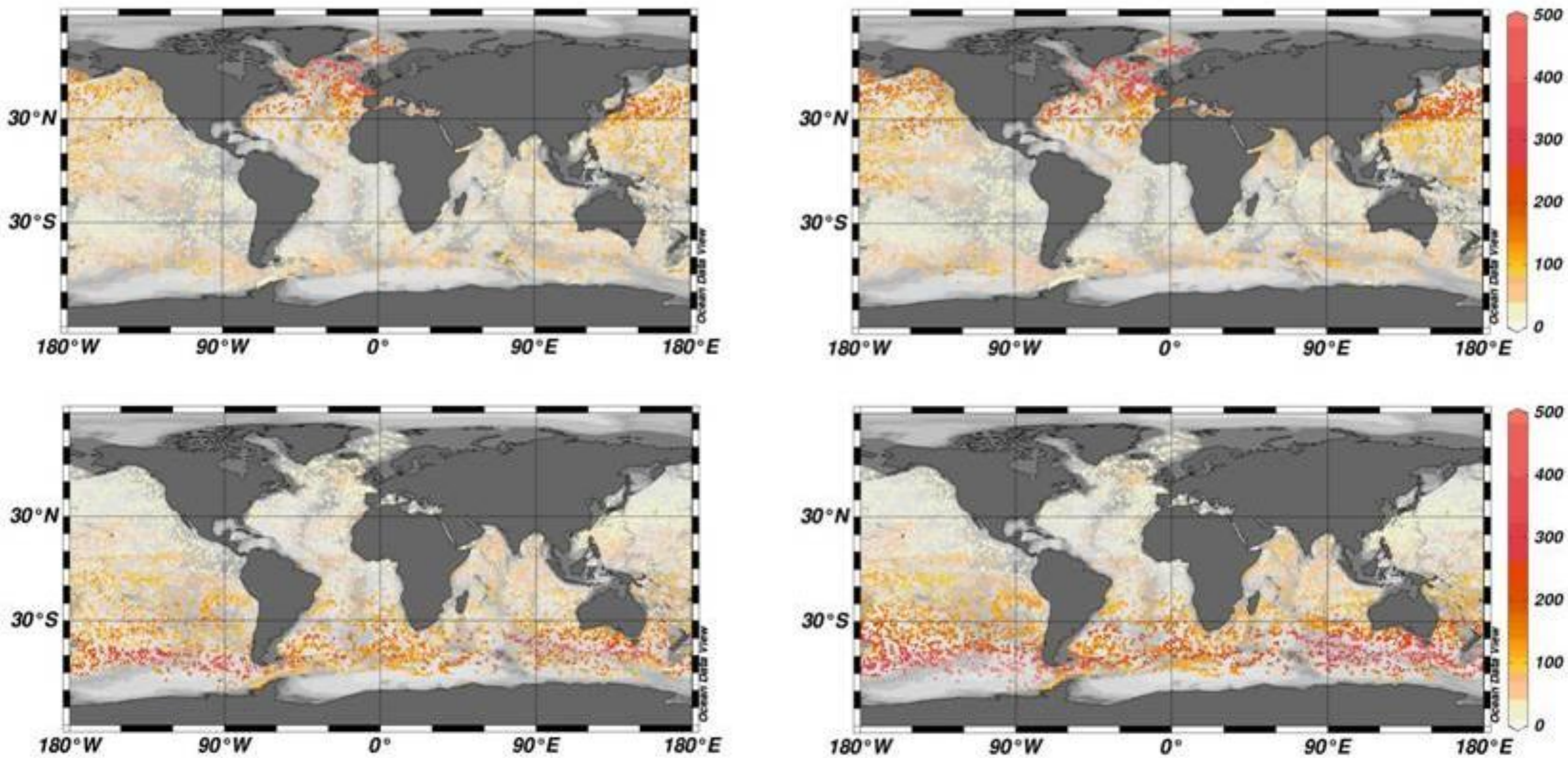
(*Juza et al.*, 2012)

<u>Mixed Layer Depths at global scale</u> (m): 2008-2009

Observations (Argo) | Subsampled ¼° simulation

February

August



→ Inhomogeneity of the spatio-temporal distribution of the Argo array

→ Realism of simulated and observed MLD distribution and magnitude

III. Impact of the Argo array's spatio-temporal subsampling

(*Juza et al.*, 2012)

$$MLHC = \rho_0 Cp \int_{MLD}^{surface} T(z)\,dz$$ (GJ/m^2)

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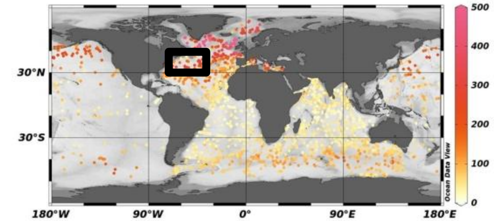
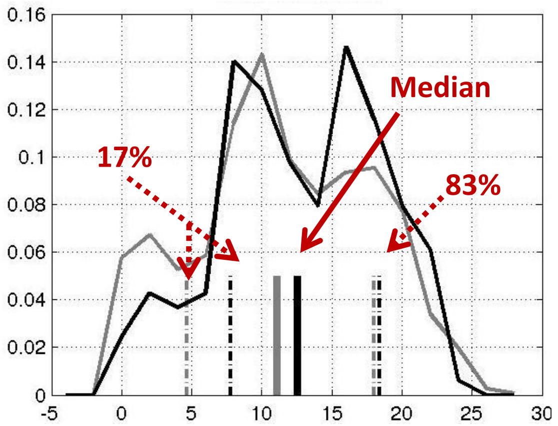


(1) Regional distribution of MLHC: median, 17%, 83%

Ex: NW Atlantic in March 2008-2009



-- fully sampled model

-- subsampled model (like Argo)

→ The Argo subsampling distorts the MLHC distribution

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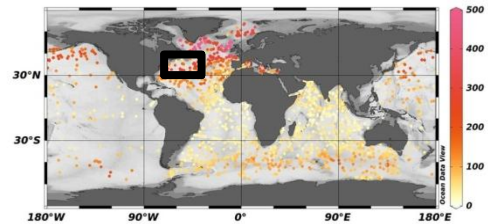

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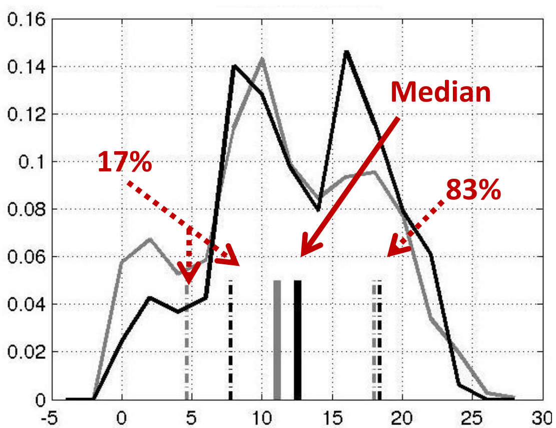

→ The Argo subsampling distorts the MLHC distribution

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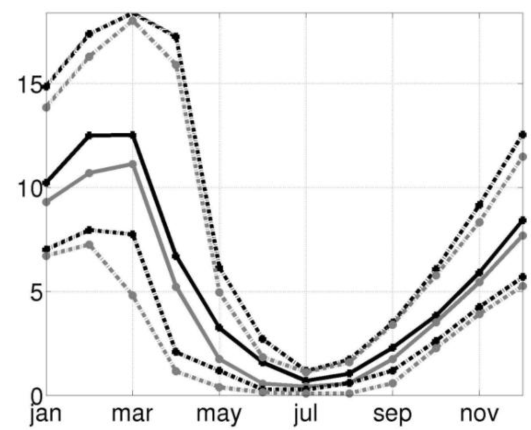
Median and percentiles (17%, 83%) for all months →

(2) Monthly cycle of MLHC

(Solid line=median; Dashed line=17%, 83%)



→ The Argo array observes correctly the seasonal cycle of MLHC. However, a strong sampling error is found in winter

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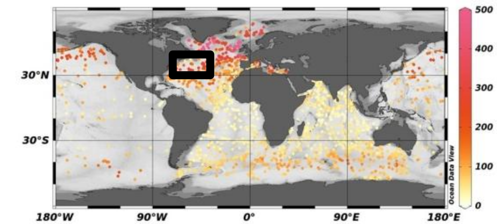

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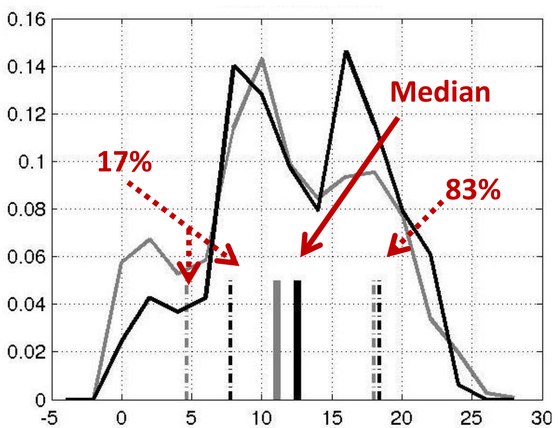

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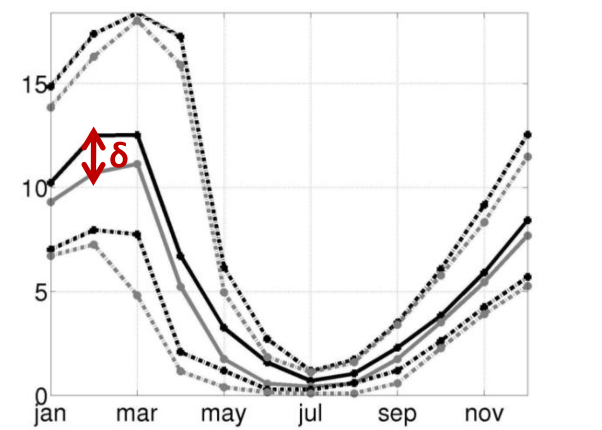

→ The Argo subsampling distorts the MLHC distribution

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(3) Sampling median bias:

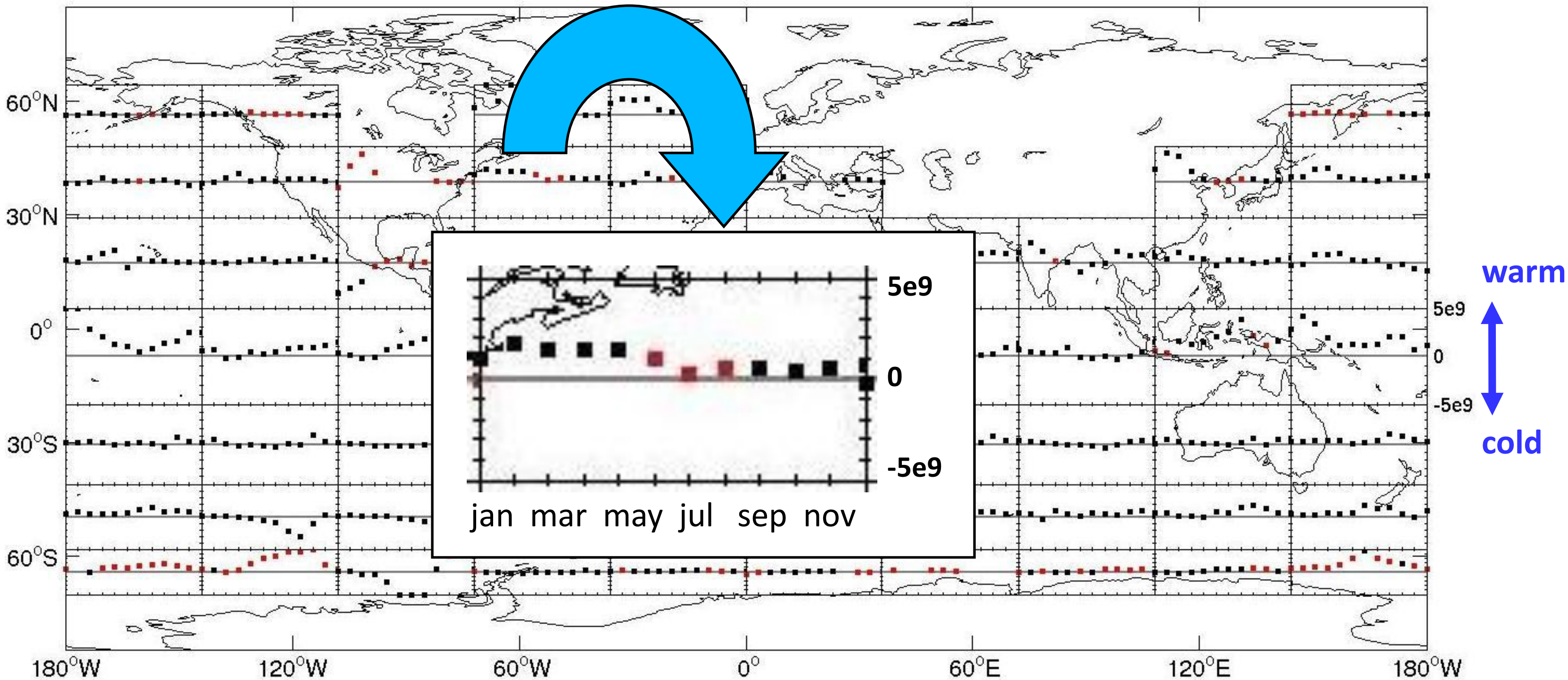
δ = median(subsampled model) – median(fully sampled model)

III. Impact of the Argo array's spatio-temporal subsampling

(*Juza et al.*, 2012)

<u>Assessment of the Argo array over 2008-2009</u>

Seasonal cycle of regional sampling median biases of MLHC (J/m^2)



Bin = 30° x 30° x 1 month (2008-2009)

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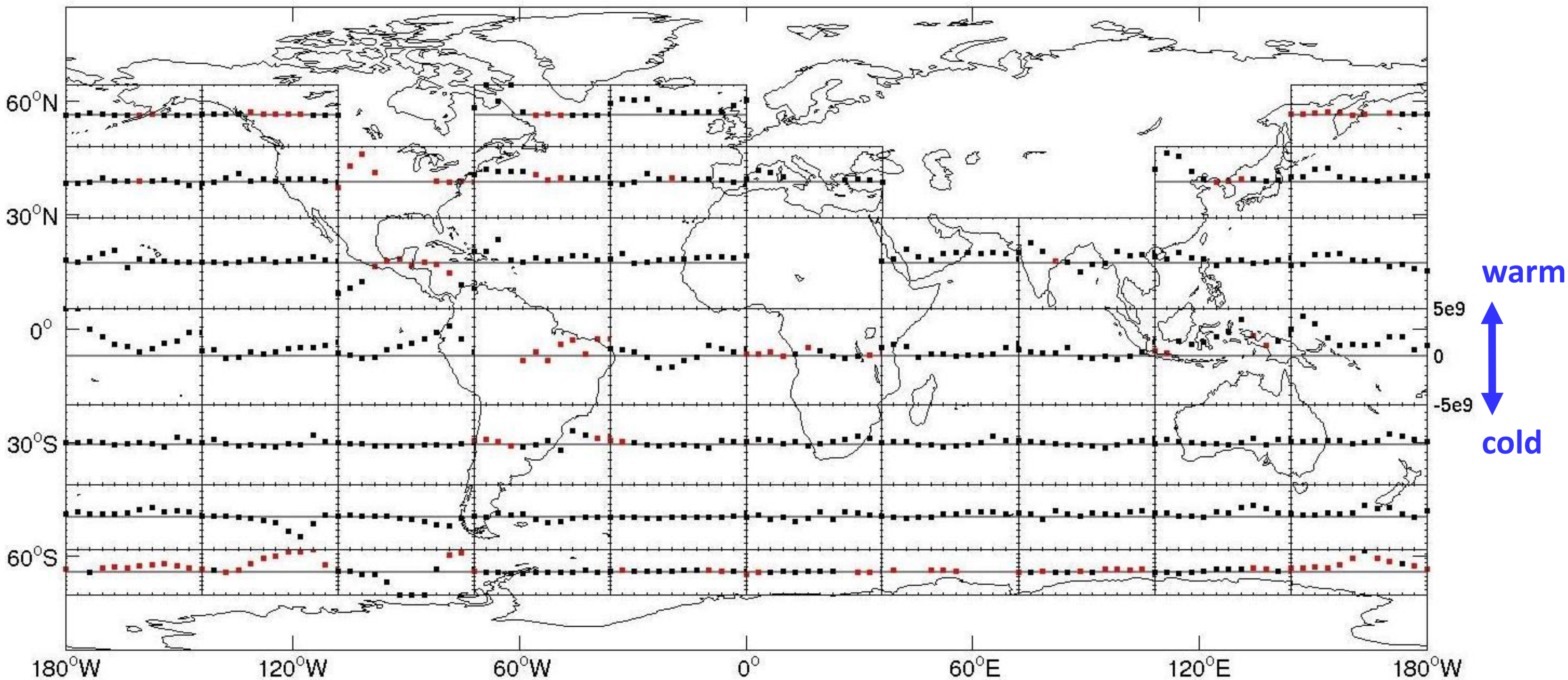

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→ Argo subsampling → overestimation of MLHC (max 5 *GJ/m²*)

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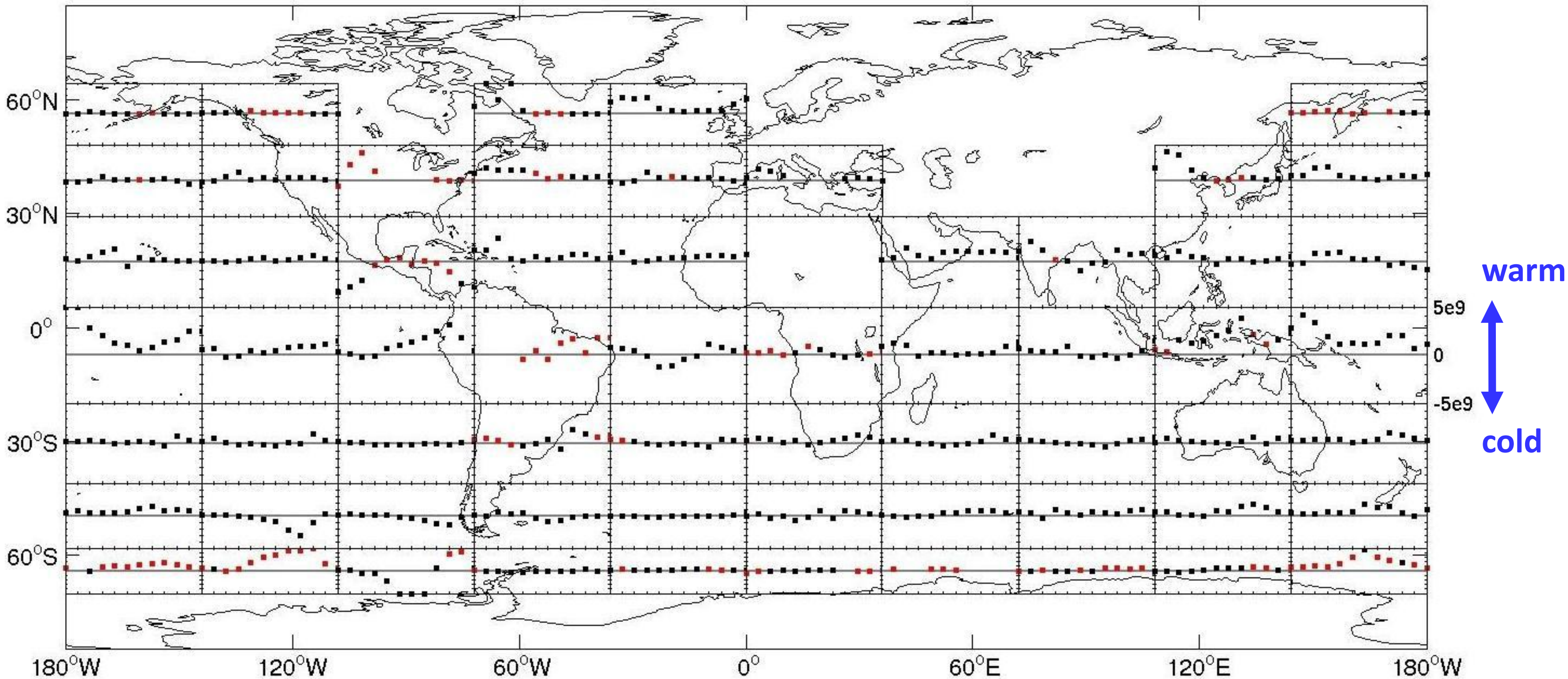

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→ overestimation of MLD (max 100m)

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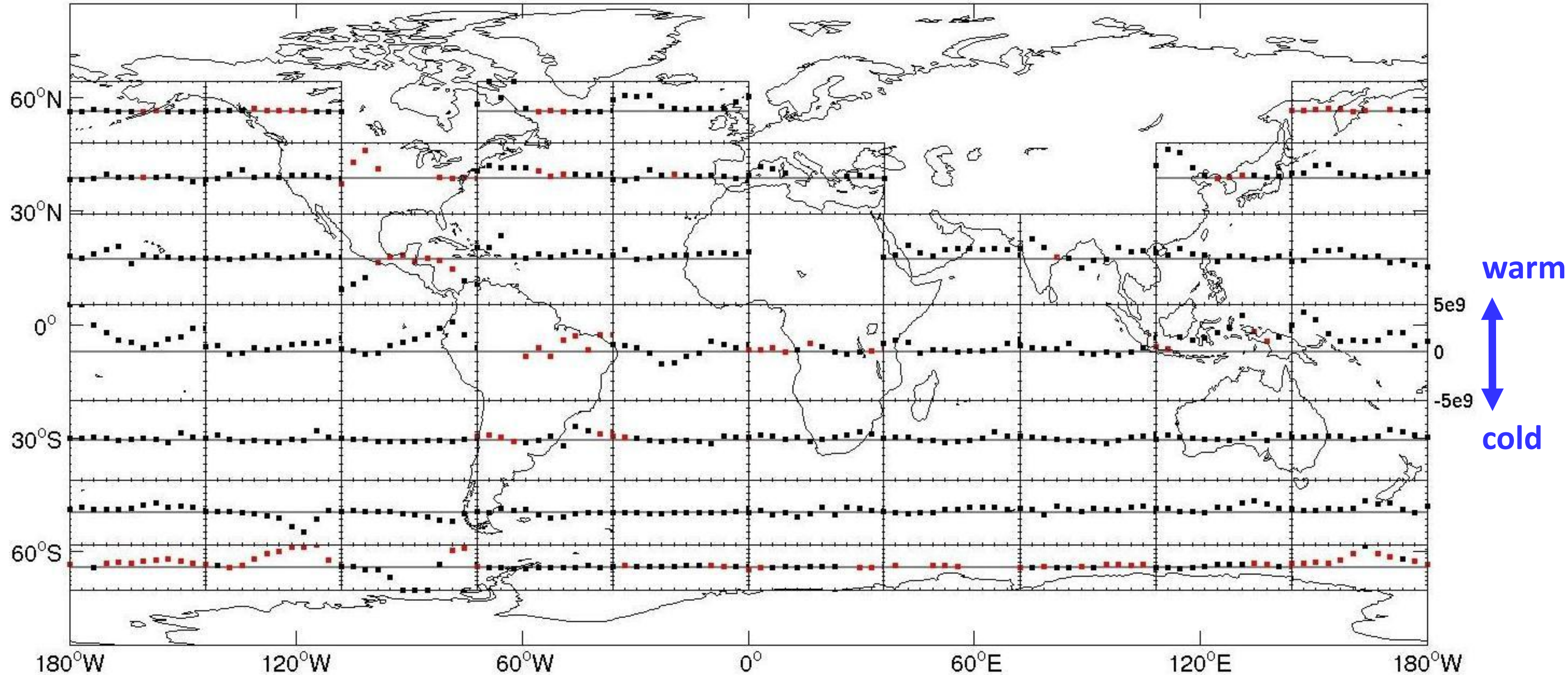

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→ Argo subsampling → overestimation of MLHC (max 5 *GJ/m²*)

→ overestimation of MLD (max 100*m*)

→ 2004-2005 vs 2006-2007 vs 2008-2009: improvement since the Argo array is mature

I. Numerical simulation

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Objective

- Assessment of the Argo observational array with respect to simulations

Main results

- The thermal variability of the global ocean is mostly captured by the array.
- Non-observed ocean: errors induced by the geographical restrictions
  - the global OHC seasonal variability is over-estimated by 13%
  - the global OHC interannual variability is under-estimated by 5%
- Observed ocean: errors induced by the spatio-temporal dispersion of the Argo array
  - MLD (max +/-100*m*), MLT (max +/-5*°C*), MLHC (+/- 5 GJ/m^2).
- Subsampling and geographical restrictions of the Argo array induce errors on the estimations of the heat content of the global ocean:
  - In deep and intermediate water formation sites
  - In boundary circulations (Western/Eastern currents)
  - In coastal areas
  - In marginal seas

IV. Conclusions and perspectives

Perspectives

- Combine others observations with the Argo floats
  - Gliders could be deployed to sample most of regions cited before
  - SOCIB-IMEDEA: gliders in the Western Mediterranean Sea = « miniature » ocean (coastal regions, strong boundary current, deep convection areas, channels, …)

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  → Estimation of the error due to the subsampling of array in the mapping method.
  → Optimisation of future deployments of observational systems.

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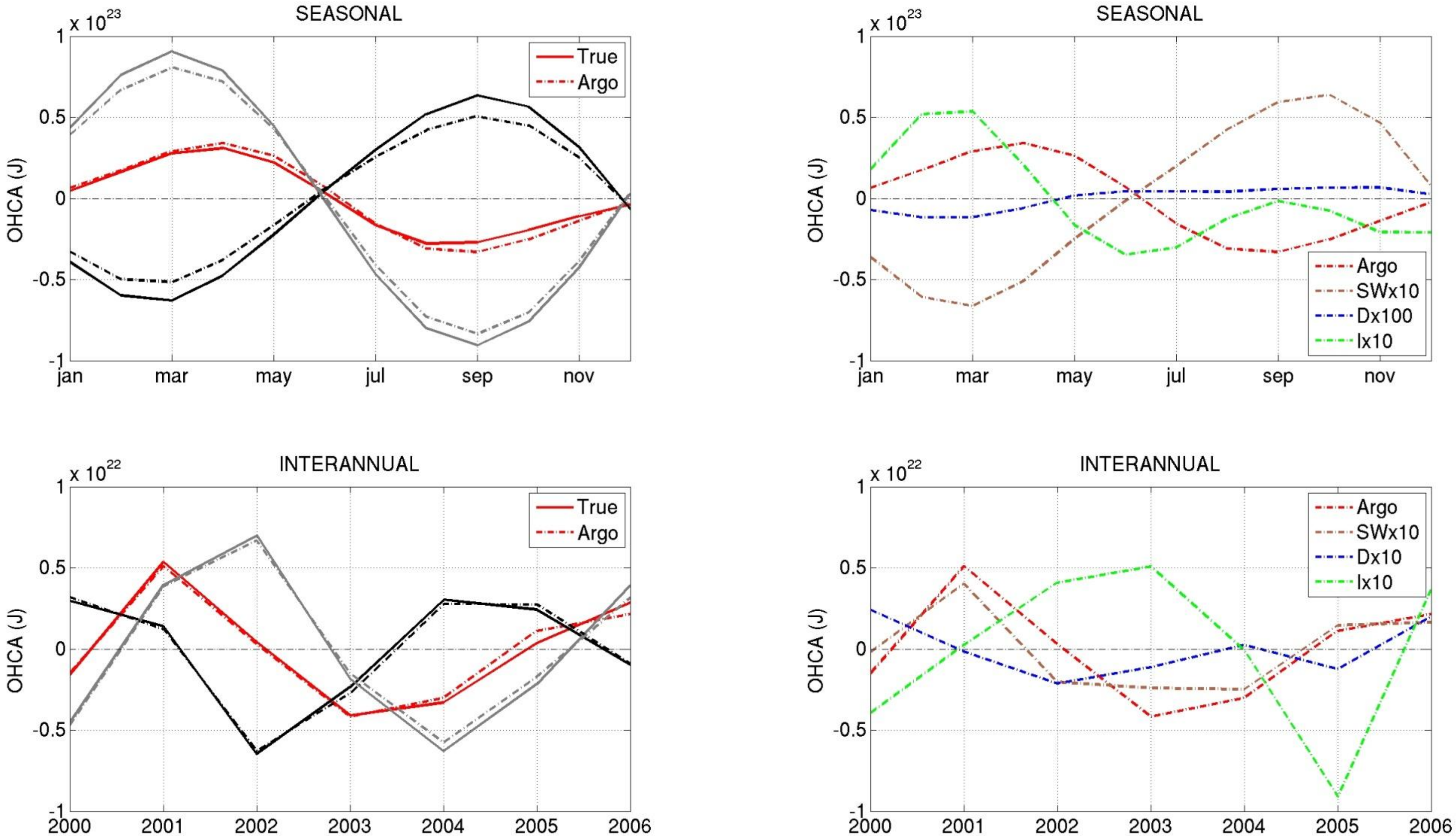
Thanks for your attention …
Questions?


SEASONAL
x 10^23
OHCA (J)
True
Argo
jan
mar
may
jul
sep
nov
SEASONAL
x 10^23
OHCA (J)
Argo
SWx10
Dx100
Ix10
jan
mar
may
jul
sep
nov
INTERANNUAL
x 10^22
OHCA (J)
True
Argo
2000
2001
2002
2003
2004
2005
2006
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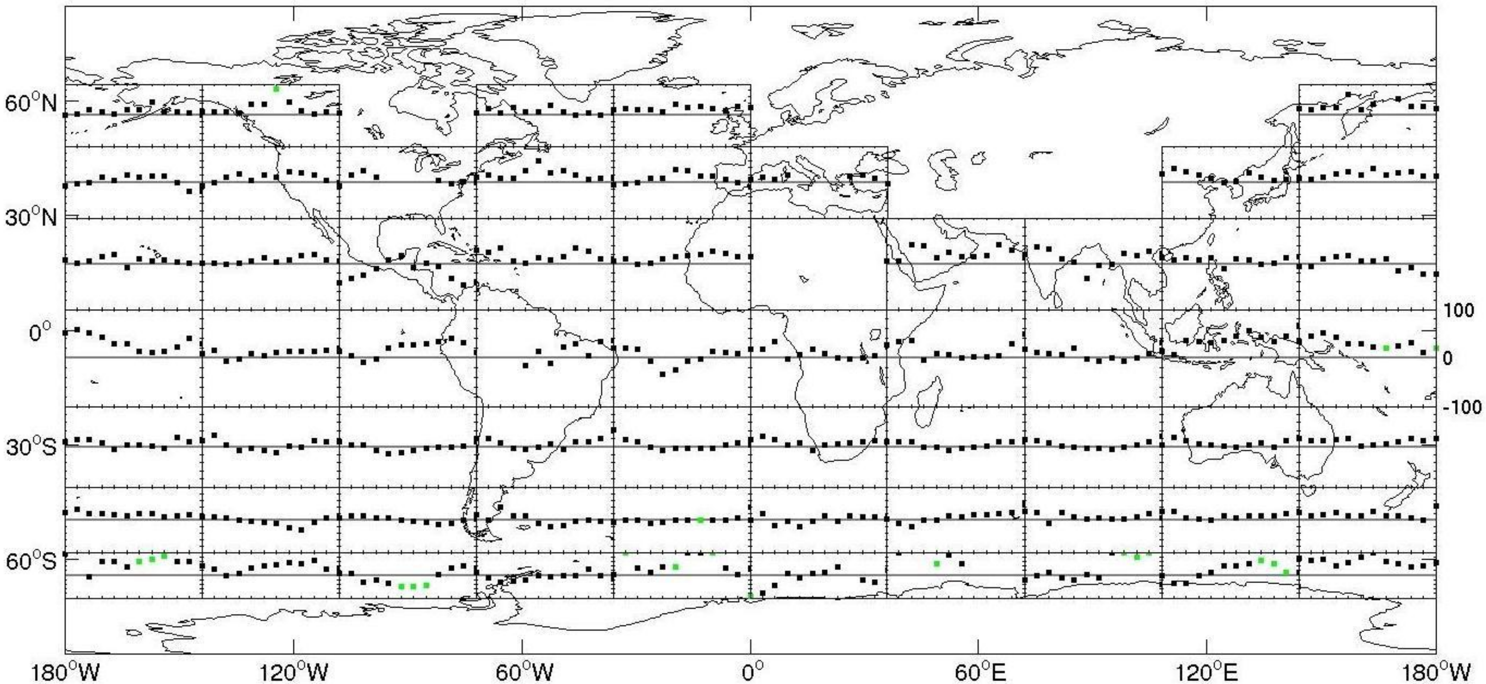
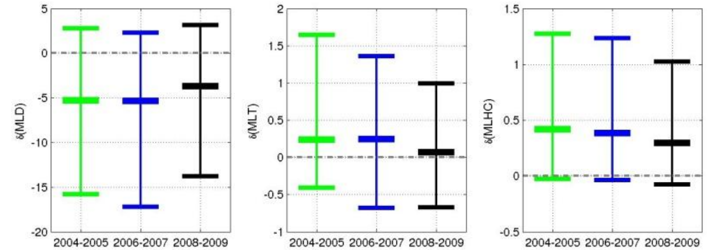
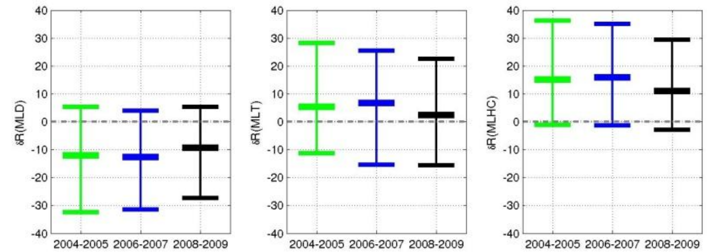
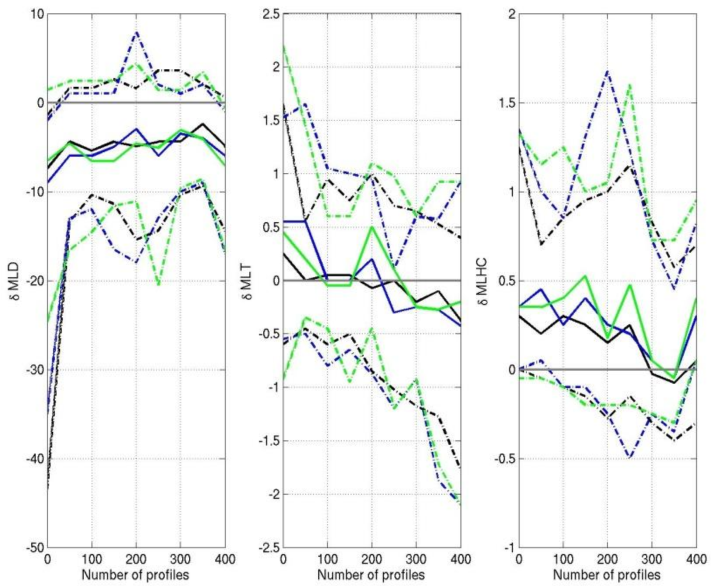
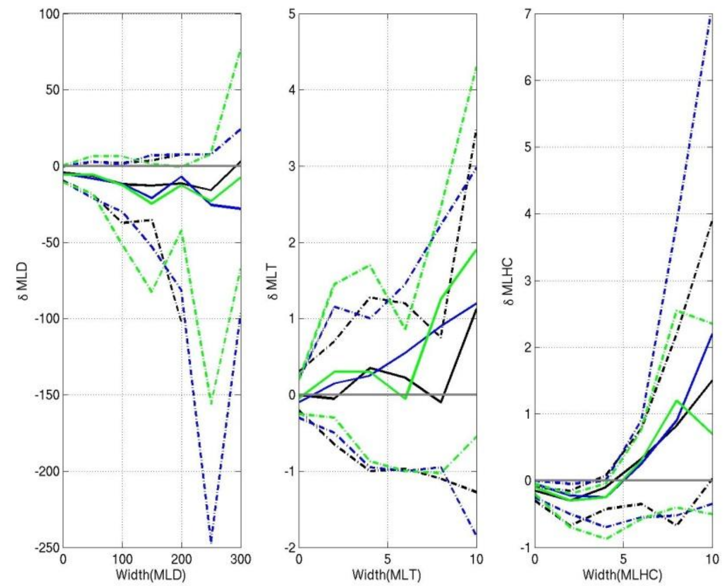


60°N
30°N
0°
30°S
60°S
100
0
-100
180°W
120°W
60°W
0°
60°E
120°E
180°W


δ(MLD)
δ(MLT)
δ(MLHC)
2004-2005
2006-2007
2008-2009


δR(MLD)
δR(MLT)
δR(MLHC)
2004-2005
2006-2007
2008-2009


δ MLD
δ MLT
δ MLHC
Number of profiles


δ MLD
δ MLT
δ MLHC
Width(MLD)
Width(MLT)
Width(MLHC)