EARTH OBSERVATION

Monitoring the regional heat content change over the Atlantic Ocean with the space geodetic approach: the 4DATLANTIC-OHC project

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Given the major role of the Atlantic Ocean in the climate system, it is essential to characterize the temporal and spatial variations of its heat content. The 4DATLANTIC-OHC Project (2021-2023) aims at developing and testing space geodetic methods to estimate the regional **ocean heat content (OHC)** change over the Atlantic Ocean from satellite altimetry and gravimetry. The strategy developed in the frame of the ESA MOHeaCAN Project is extended at regional scale both for the data generation and the uncertainty estimate.

The space geodetic approach

OHC change time series may be inferred by different methods (Meyssignac et al., 2019). An indirect approach is the space geodetic approach which relies on the **sea level budget** equation. The ESA-funded project MOHeaCAN acted as a proof-of-concept, describing the application of the space geodetic approach on a global scale (Marti et al., 2022). The space geodetic approach aims at measuring the thermosteric sea level change due to seawater density change induced by temperature based on differences between the **total sea level** change derived from satellite altimetry measurements and the **barystatic sea level** change from satellite gravity measurements. **Halosteric sea level** variations due to saline contraction are estimated from in situ data and removed from the total sea level variations (Figure 1).

Figure 1: Deriving thermal expansion of the ocean

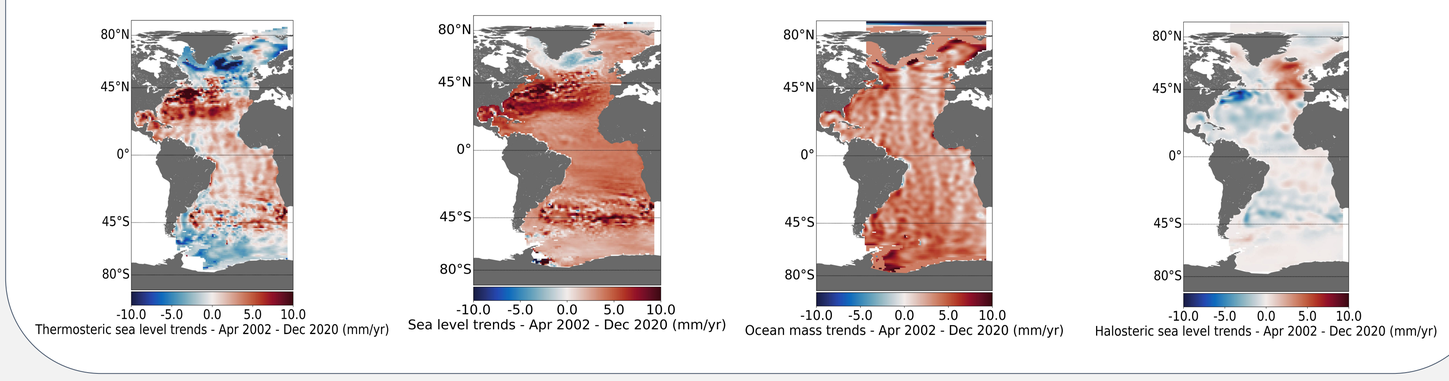
From the sea level budget equation, **thermosteric sea level change** is calculated:

$\Delta SL_{thermosteric} = \Delta SL_{total} - \Delta SL_{mass} - \Delta SL_{halosteric}$

Space altimetry from Copernicus Climate Change Service

Space gravimetry from GRACE(-FO), update of Blazquez et al. 2018

In situ based, from Argo, combination of ISAS20 (0-2000m) and EN4.2.2.l09 (below 2000m)



The OHC change is computed at regional scales (Figure 3) by dividing the thermosteric sea level change with the **Integrated Expansion Efficiency of Heat** (IEEH) coefficient: it expresses the change in ocean density due to heat uptake (Figure 2) and it is estimated from in situ temperature and salinity measurements.
OHC change uncertainties are estimated by uncertainty propagation from input data until OHC change.

Figure 2: IEEH mean value

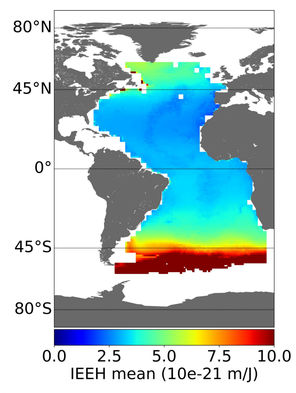
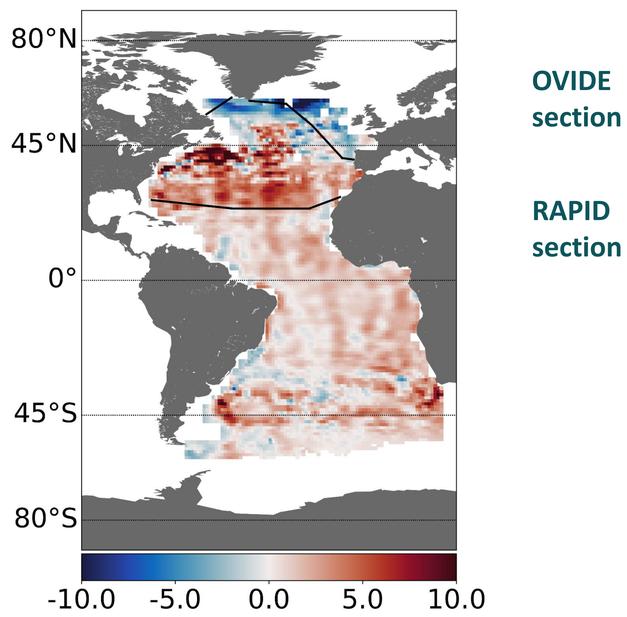


Figure 3: Ocean Heat Content trends



The 4DAtlantic OHC product in a nutshell:

- Ocean heat content change and associated uncertainties
- Representative of the full water column - spatial resolution: 1°x1°
- Study period: 2002-2020

Validation of the product

Validation activities were carried out over the Subtropical North Atlantic (SPNA) region (Figure 4) and in the Subpolar North Atlantic (SNA) region (Figure 5) against Argo dataset.

Figure 4: Validation over the SPNA region

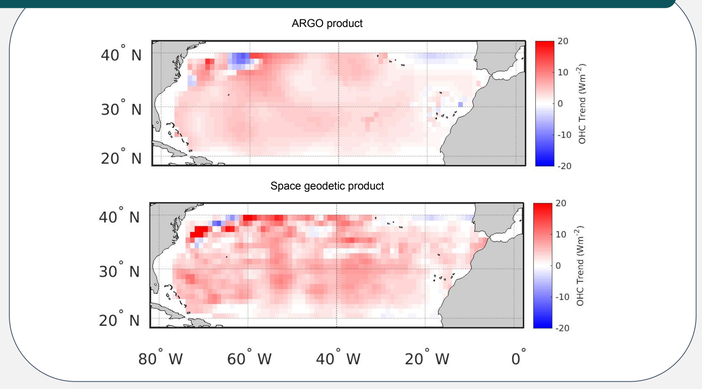
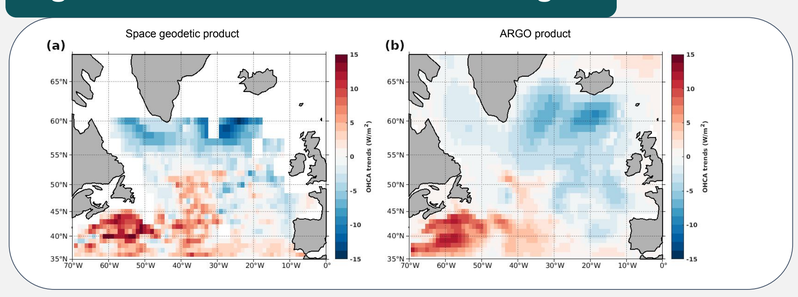


Figure 5: Validation over the SNA region



Furthermore, the use of data from RAPID and A25-OVIDE mooring sections highlights a good consistency in OHC trends with the space geodetic product.

Upcoming science use case

- Estimate the Meridional Heat Transport (MHT) in the North Atlantic with a regional ocean heat budget approach
- Validate it against in-situ data (RAPID & OSNAP)
- Analyse the variability of the MHT and its cause in the North Atlantic

Early adopters

Several use case studies will be realised such as:

- The improvement of the operational decadal predictions (BSC),
- The contribution to the Copernicus Marine Service ocean reporting activities (MOi),
- The evaluation for use as part of MetOffice climate indicators dashboard (MetOffice)

Dissemination & perspectives

The **4DAtlantic-OHC product** is available to the scientific community on the **ODATIS/AVISO portal**:
https://doi.org/10.24400/527896/A01-2022.012

Perspectives

- To extend the progress made to other ocean basins
- To improve our knowledge on the global energy budget
- To transfer the results to a sustainable Essential Climate Variable (ECV)

References

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ESA MOHeaCAN project: https://eo4society.esa.int/projects/moheacan/

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