Using Argo and altimetry to assess the quasi stationary circulation in the North Atlantic

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Summary

The goal of the present study is to produce and improve the estimates of the circulation for the North Atlantic based on the available data from Argo (Array for Real-Time Geostrophic Oceanography) profiling buoys and satellite altimetry provided by Aviso for the years 2005 and 2006 and the Inverse Finite Element Ocean Model (IFEOM). The model solves for temperature (T) and salinity (S) fields that are close to data, and respect quasi-stationary tracer balances, and simultaneously produces estimates of the circulation with a surface elevation close to the observed dynamic topography. The data on T and S include Gouretsky and Koltermann climatology (GKC) and Argo buoy data (ARGOdata) for the corresponding year. Altimetry data (ALTdata) is taken from Aviso. The absolute Dynamic Topography, the sum of sea level anomaly (SLA) and mean dynamic topography (MDT, Rio05) is used. Four model experiments are performed, the assimilation of : (i) GKC (Gur), (ii) GKC + ALTdata (Alt), (iii) GKC + ARGOdata (Argo) and (iv) GKC + ALTdata + ARGOdata (AltArgo).

We show, that including altimetry (AltArgo) improves the circulation pattern, while using only ARGOdata (Argo) has limited success. This can be explained by the poor spatial sampling of ARGOdata in comparison to ALTdata.

Model and Data

The success of altimetry data assimilation is shown in histogram of sea surface elevation misfit (Fig. 5, left panel). The frequencies of small differences are clearly increased (Alt compared to Gur). The shift of peaks of the two curves is dynamically irrelevant due to the fact that the model circulation is driven by the spatial gradient of the dynamic topography and the presence of an arbitrary constant in it does not affect the model circulation. The locations of the remaining differences are depicted in Fig. 5, right panel. They are mainly in regions of higher variability. The same is true for temperature differences. Fig. 6, left panel, shows that the model takes into account the information from ARGOdata (Argo compared to Gur). The remaining differences are still present in regions of higher spatial and temporal variability (Fig. 6, right panel). Remaining data misfits in both, Alt and Argo can be explained by transient processes imprinted in the data which do not project onto the stationary estimate.

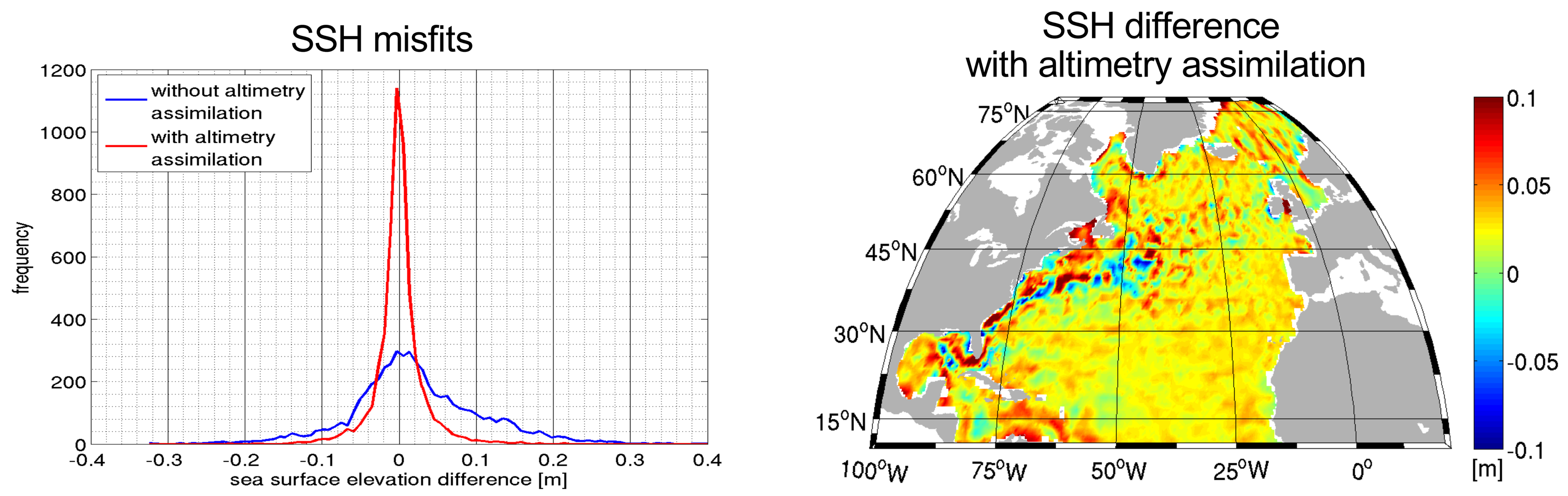

Figure 5: left: histogram of sea surface elevation misfit (Gur-ALTdata(blue); Alt-ALTdata(red)); right: sea surface elevation difference (Alt-ALTdata)

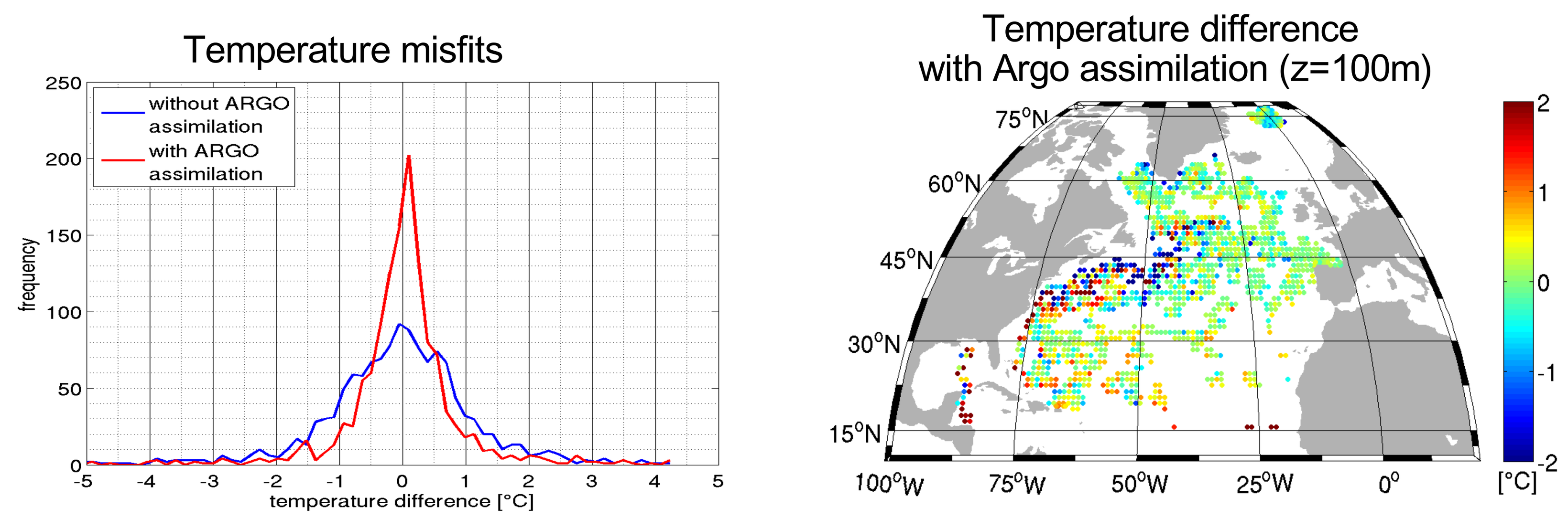

Figure 6: left: histogram of temperature misfits (Gur-ARGOdata(blue); Argo-ARGOdata(red)) ; right: temperature difference (Argo-ARGOdata)

Model fields

Model solutions AltArgo obtained for 2005 reproduce the circulation in the North Atlantic with a degree of realism similar to that of other models of same (1deg) resolution as shown in the plots below. Fig. 1 displays the model dynamic topography, which agrees with the ALTdata. Fig.2 shows the model T field at 100m depth, with the ARGOdata (marked as dots) put on it. This proves that the model is capable to account for the sparse buoys data. Fig. 3 and Fig. 4 depict the barotropic and meridional overturning stream functions, respectively. They give the estimates within the ranges provided by other studies.

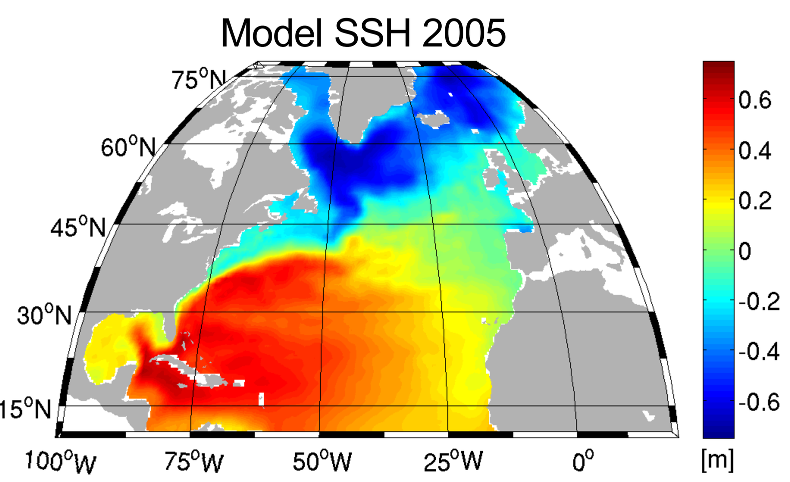

Figure 1: Sea surface height (SSH) of AltArgo experiment

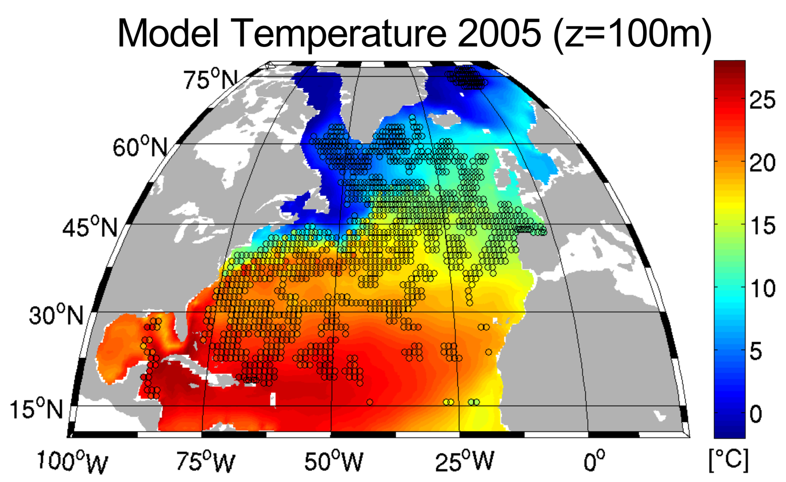

Figure 2: Model temperature of AltArgo experiment

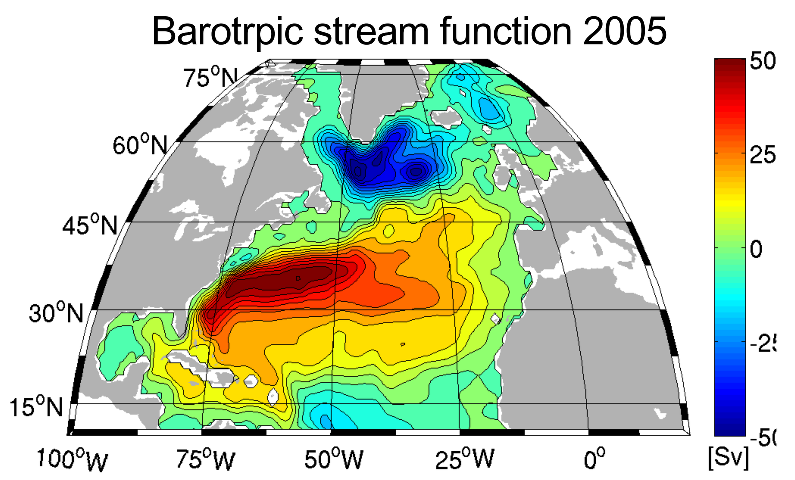

Figure 3: Barotropic stream function of AltArgo experiment

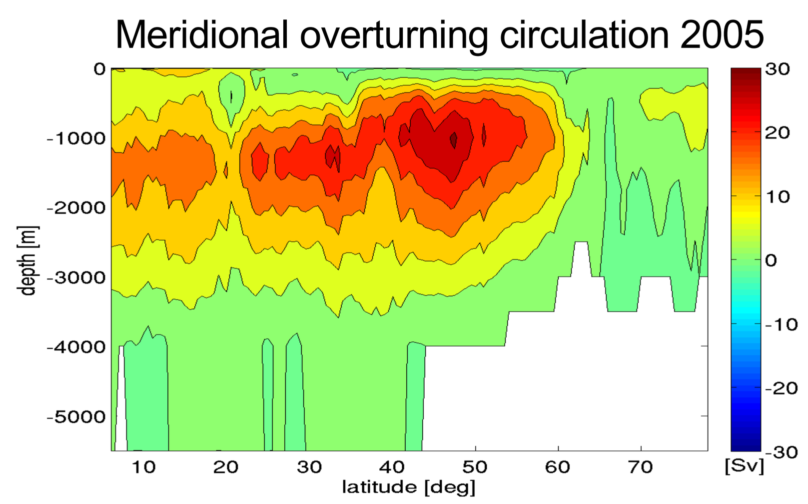

Figure 4: Meridional overturning circulation of AltArgo experiment

Data influence

The assimilation of altimetry changes the model topography on large scales. Fig. 7, left panel, shows the difference between Alt and Gur experiments. This difference is imprinted in the corresponding change in barotropic stream function (Fig. 7, right panel). The major changes are in the Gulf Stream region, the subpolar gyre and the Nordic Seas. Fig. 8 repeats Fig. 7 but for Argo and Gur experiments. The changes done by ARGOdata assimilation are comparable to those in Alt experiment mainly in the Gulf Stream region, which is explained by good ARGOdata coverage there.

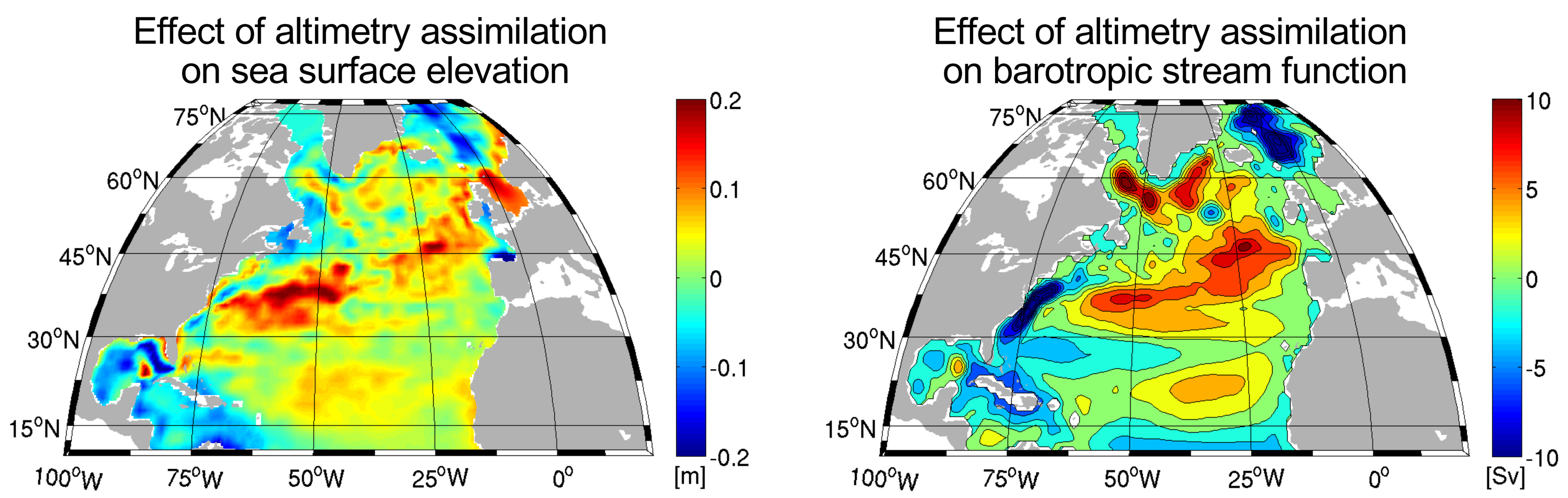

Figure 7: left: sea surface elevation change; right: change in barotropic stream function caused by altimetry assimilation (Alt)

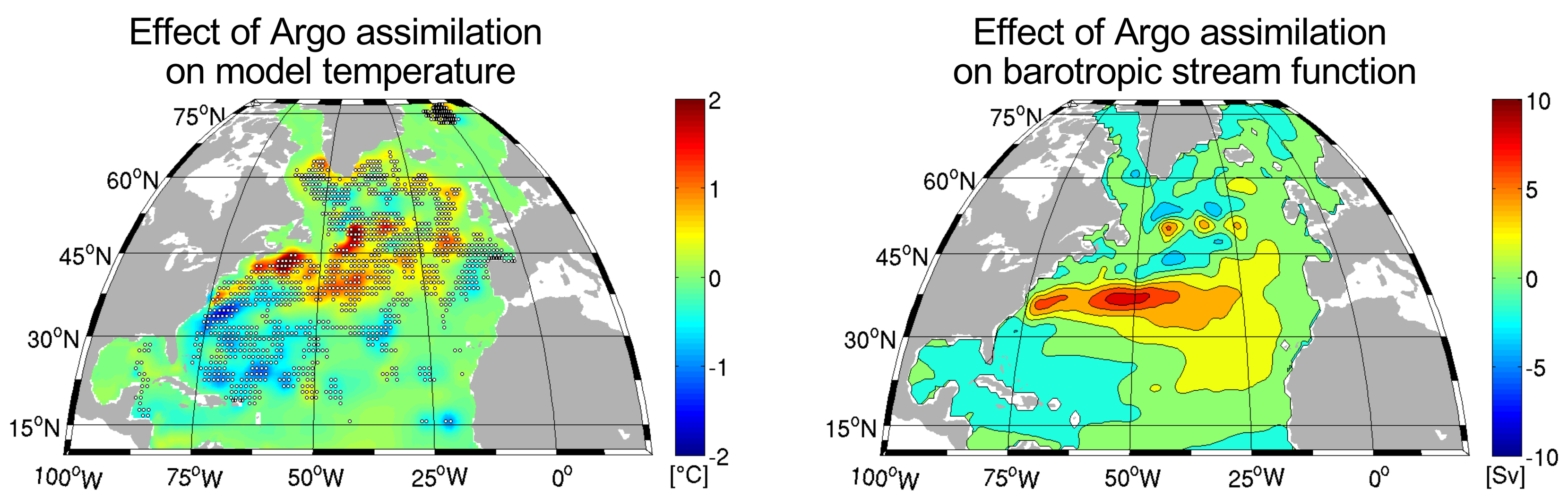

Figure 8: left: temperature change; right: change in barotropic stream function caused by ARGOdata assimilation (Argo) (circles indicate ARGOdata positions)

Interannual variability

The variability between 2005 and 2006 is illustrated by the change in the dynamic topography. Fig. 8, left panel, shows the sea level change derived from altimetry data directly, middle panel displays the same for Argo experiment and the right panel corresponds to AltArgo results. All show the sea level rise of about 4cm in Nordic seas and a small drop in the sub-tropics while the region of Gulf Stream and its extension are characterized by large eddy activities with the contribution in the estimated interannual differences of about 20cm.

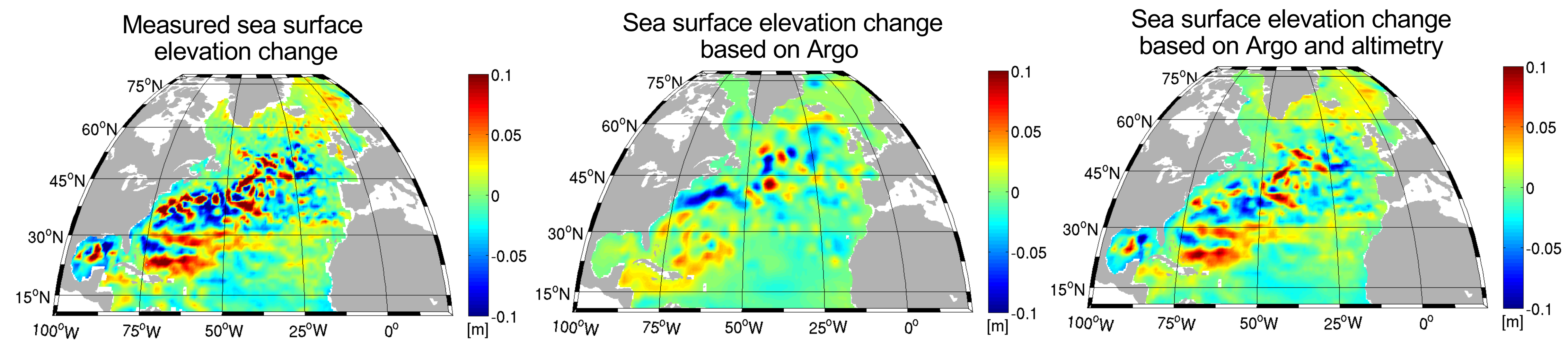

Figure 9: left: inter-annual change (2006-2005) of sea surface elevation in: ALTdata (left) ; Argo (middle) and AltArgo (right)

The discrepancies between Alt and Argo results can be explained by poor spatial sampling of ARGOdata in comparison to ALTdata. The variability provided by AltArgo solution (right panel) is similar to that derived from ALTdata (left panel). The data difference is characterized by the presence of small scale features which is not taken into account by the model. Still, a significant part of variability contained in the data is represented by the model.

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