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Reconstruction of the Gulf Stream since 1900 and correlation with the North Atlantic Oscillation

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Prevailing winds over the North Atlantic (NA) have a direct influence on the location and intensity of the Gulf Stream (GS) by the transfer of momentum between atmosphere and ocean. Therefore, the study of interannual variability of the GS requires the identification of sources of variability within the atmospheric circulation.

Various studies have highlighted the impact of the North Atlantic Oscillation (NAO) on the variability of the GS transport. However, there is still no scientific consensus thereupon. On the one hand, several scientific papers (Sato & Rossby, 1995; Curry & McCartney, 2001; deCoëtlogon et al., 2006) exhibit a decrease of the GS transport during low NAO periods, as well as a higher transport during high NAO phases. On the second hand, studies of Gangopadhyay et al. (1992), Baringer & Larsen (2001) and DiNezio et al. (2009) suggest a lower transport during positive phases of the NAO. Finally, Chaudhuri et al. (2011) obtained a more complex conclusion, whereby the influence of the NAO is different upstream and downstream of Cape Hatteras.

This currently limited understanding of the links between the NAO and the GS in NA, impels us to further analyze the spatial and temporal distribution of the GS. Our main purpose in this study is to reconstruct a spatially continuous field of ocean (sub)surface circulation in the NA from in situ time series of discrete steps, in order to accurately quantify the position and intensity of the GS since 1900. From there, we will be able to examine the correlation of this current with the NAO.

To this end, we used the DIVA (Data-Interpolating Variational Analysis) tool, which is a numerical implementation of the variational inverse method (VIM) using the finite elements method to reconstruct continuous fields from discrete measurements. These measurements of temperature, salinity and currents since the beginning of the last century originate from several data bases, such as WOD (World Ocean Database, NOAA), SeaDataNet, ICES (International Council for the Exploration of the Sea), Hydrobase3 and ARGO buoys but also from the Norwegian Marine Data centre (NMD) of the Institute of Marine Research.

The exact duplicates have been removed from these data sets, while the near duplicates (considering space and time) have been subjected to a specific algorithm removing the vast majority of them. The type of instrument (CTD, XBT,...) was also taken into account when attributing the relative weights to observations, following the accuracy of these ones. The signal-to-noise ratio as well as the correlation length have been optimized for each vertical level (15 layers, from 0 to 3000 m depth) and filtered vertically to avoid unrealistic discontinuity. Then, a reference field has been created with DIVA for the whole period (1900-2013) in order to work with anomalies with respect to this averaged field. After the handling of Arctic sea ice, the analyzes of temperature and salinity gives us high-resolution gridded fields for every month since 1900, which allow us to reconstruct in 4D the speed and direction of the GS thanks to the geostrophic approximation.