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Historical Reconstruction of Anthropogenic Carbon and Excess Heat Content in the Subtropical North Atlantic Ocean

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The oceans have mitigated global warming by the absorption of 90% of the excess heat resulting from anthropogenic radiative forcing and of 1/3 of the anthropogenic carbon (Cant). There are still major uncertainties concerning their regional rates of uptake (or loss), transport and storage by the oceans, knowledge of which is key to the heat and carbon balances, and essential to reduce the uncertainties in global warming prediction. Here, we used tracers observations (transient and passive CFC-11, CFC-12, SF_6, natural C14, the conservative PO_4* and NO_3*, salinity and temperature) and a maximum entropy inverse method to compute Green's functions (G), which contain intrinsically information on ocean dynamics and transit times from the source regions. From G, we propagated surface history of temperature and Cant to reconstruct their fields in the ocean for the industrial era and to quantify their source regions. We present reconstructions of Cant and excess heat (taken as the temperature anomaly from 1850) along the 24°N trans-Atlantic section, at the crossroads of the main contributors of the AMOC and an hot spot of heat and carbon storage, from 5 repeats spanning 1992 to 2015. We show that Cant reconstructions, dominated by the strong increase of Cant in the atmosphere, compare well with a previous global historical reconstruction as well as Cant estimates in the water masses at 24°N. The excess heat reconstructions are tempered by the natural variability that can exceed the anthropogenic trend. They show a net invasion and warming of the top 800m from the 1920's (0.01°C/y). The trend slightly weakens in the late 1970's followed by an acceleration from the 2000's (0.02°C/y). For the well–ventilated deeper waters of the DWBC around 1500m, after a notable cooling period, a weak warming departs in the 1950's with a trend of 0.001°C/y up to the 2000's and of 0.006°C/y afterwards. The waters below 2000m suggest a continuous warming from the 1930's, with a more pronounced trend centered at 3000m of 0.001°C/y up to the 2000's and of 0.003°C/y afterwards. This excess heat evolution in the DWBC contrasts with the Cant evolution which shows continuous increase in Cant content in the upper NADW. Our results highlight the difference of drowning up of Cant ant heat into the deeper ocean, reflecting their different surface histories in the formation regions.