Consiglio Nazionale delle Ricerche
ISMAR - Istituto di Scienze Marine
Sede Secondaria di Roma
Via Fosso del Cavaliere 100
00133 Roma, Italy
Tel +39 06 45488634 Fax +39 06 45488291
direzione@ismar.cnr.it
C.F. 80054330586 - P.IVA 02118311006

Climate shift of the Atlantic Meridional Overturning Circulation (AMOC) in Reanalyses (ORAS5): possible causes, and sources of uncertainty

Vincenzo de Toma[1,2,3] Chunxue Yang[3], and Vincenzo Artale[2]

[1]Università di Roma Tor Vergata, Dipartimento di Fisica, 00133 Rome, Italy
[2]ENEA C.R. Frascati, Climate and Modelling Laboratory, 00044 Frascati (RM), Italy
[3]Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine (CNR-ISMAR), 00133 Rome, Italy

Abstract

We present preliminary results and insights from the analysis of the Atlantic Meridional Overturning Circulation (AMOC) in the ensemble of Oceanic Reanalysis System 5 (ORAS5), produced by the European Center for Medium-Range Weather Forecast (ECMWF), which reconstruct ocean's past history from 1979 to 2018, with monthly means temporal and spatial resolution of 0.25˚ and 75 vertical levels. Considered as one of the main drivers of the Earth's Climate System, we observed that the AMOC strength at 26.5˚ N presents a shift in the mean of about 5 Sverdrup in the period 1995-2000 which can be considered as a climate tipping point. We aim to investigate the causes of this reduction and propose three mechanisms responsible for the observed AMOC volume transport reduction: the Gulf Stream Separation path, changes of the Mediterranean Outflow Water (MOW) and the North Atlantic Deep Water (NADW) formation processes in the Labrador Sea respectively. The Gulf Stream Separation path is investigated by visualizing the barotropic stream function averaged over two periods, before and after the 1995-2000. Shifts are present in the direction of the barotropic currents, enhanced by seasonal climatology analysis. In the first period (greater volume transport), patterns are more intense, and the Gulf Stream reach higher latitudes, allowing for a more vigorous deep water formation in the Labrador Sea than in the second period. Moreover, we connect this shift to a reduction in the heat fluxes over the Labrador Sea, which then has a cascade effect on horizontal averages for temperature, salinity, and potential density profiles, manifestations of less deep water production in the Labrador Sea, buoyancy-driven AMOC weakening. It is well known that the warming of the Mediterranean Sea of the last years induce a large variability in the hydrological characteristics of the MOW, more likely one concurring factor driving the AMOC variability observed in ORAS5. The larger ensemble spread in both the temperature and salinity climatological profiles at 40 ˚N, i.e.; in correspondence of the Gibraltar Strait and Gulf of Cadiz, highlights the high sensitivity of the MOW to perturbations producing the different ensemble members of ORAS5. In conclusion, our preliminary results brought out the relevance of the deep water formation process in the Labrador Sea, the MOW and the Gulf Stream path as the main sources of the AMOC variability and stability. Besides, our analysis points out the need for further studies.