Marine Ecosystem Evolution in a Changing Environment: MEECE project

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Aims of this project and methods:
In this project, we investigated the potential impact of climate change in the Benguela Upwelling System (BUS), within an oxygen minimum zone, using coupled physical/biogeochemical modeling (ROMS/BioEBUS), in situ and satellite data. First, the model performances were evaluated for the present period (1980-2000) as well as for a climatological situation as compared with in situ and satellite data (climatology, cruises). Then, the potential changes for the future period (2080-2100) were analyzed in the Benguela area and compared with other oceanic areas (Baltic sea, Black sea, North Sea,…) as well as the global ocean within the MEECE project.

Main results:
The performance of the coupled model (ROMS/BioEBUS) using the two embedded grids (1/4° and 1/12°) is reasonably good within the Benguela upwelling system especially for oxygen for the climatological situation due to a detailed description of the nitrification/denitrification/anammox processes. The O_2 level over the entire area of the Benguela Upwelling System is controlled by the combined effects of the O_2 poor-water advected by the Angola current (poleward slope current), consumption by nitrification and O_2 input by mixing (Le Vu et al., in prep.).

Within the MEECE project, we used outputs of global climate simulations from the IPSL-CM4 model. A downscaling of the wind using the methodology of Goubanova et al. (2011) was needed to capture the very energetic dynamics of the BUS, both for the physics and biogeochemistry (Machu et al., 2014).

We investigated the impact of different drivers on production and biomass in the BUS under future potential climate change (scenario A1B2: A1B (2080-2100)) compared to present period (PD (1980-2000)) with downscaled wind forcing. In the BUS, this forcing corresponds to a mean SST increase of 1.4°C over the whole domain (Fig.1a) and is associated with a decrease of alongshore winds magnitude (-10% in its northern part) and of oxygen concentrations (-20-30 mmolO_2.m^-3 in its
These climate drivers influence the ecosystem of the BUS with a subsequent decrease of primary production (Fig. 1b) (-0.12; fractional change = \([ (A1B_{2080-2100}) \) / \(PD_{1980-2000} )\) -1]; (-1 to 0: decrease, positive values: increase)), phytoplankton (-0.148) and zooplankton (Fig 1c) (-0.126) biomasses over the whole domain. However, an unexpected ecological niche with increased production and plankton biomass (Fig. 1b and 1c) could develop in the Northern part of the BUS and along the coast, associated with the increase of temperature, stratification and decrease of the winds (Dadou et al., 2013.; in prep.).

Compared to other regional areas investigated in the MEECE project, simulations suggest negative amplification is the dominant response across 47% of the ocean surface and prevails in the tropical oceans including the BUS; whilst positive trophic amplification prevails in the Arctic and Antarctic oceans and trophic attenuation is projected in temperate seas. This suggests negative amplification of climate driven modifications of trophic level biomass through bottom-up control, leading to a reduced capacity of oceans to regulate climate through the biological carbon pump (Chust et al., 2014).

**Fig.1:** Mean difference (climate – present) for: (a) SST (°C), (b) Net Primary Production (mgC.m\(^{-2}.d^{-1}\)), (c) Integrated zooplankton biomass (mgC.m\(^{-2}\)). All the simulations are with downscaled winds.

**Publications:**