AAP de Recherche Doctorale Partenariats internationaux 2023

Title: Role of physical and biogeochemical fluxes of organic matter on the dynamics of deoxygenation in the Humboldt system

Titre: Rôle des flux physiques et biogéochimiques de matière organique sur la dynamique de désoxygénation dans le système de Humboldt

Keywords:

OMZ, coupled model, biogeochemistry, fine scale transport, Humboldt system, oxygen, nitrogen

Beware! short deadline: before June 14th

Context

Global changes caused by anthropogenic forcing will severely impact all components of the biosphere both at regional and local scales, as well as their related ecosystem services and dependent socio-economic systems. It has become critical to develop a stronger capacity to understand and predict these impacts, in order to identify robust strategies for socio-economic adaptation and climate change mitigation.

Despite improvements brought to global Earth System Models in recent years (Seferian et al., 2020), some areas of the world oceans remain stubbornly biased, which has precluded a realistic simulation of the evolution of essential variables such as oxygen and primary production in a warmer climate. Among such areas is the Oxygen Minimum Zone (OMZ) off Chile, spreading from the coastal to the open-ocean, where many uncertainties remain amongst state-of-the-art models in terms of its long-term trend (Kwiatkowski et al., 2020). Recently, important effort were made to detail the different physical fluxes on the OMZ formation and variability (Montes et al., 2014; Vergara et al., 2016; Pizarro-Koch et al., 2019, 2023), but **the analysis of the biogeochemical fluxes and of the coupling of biogeochemical processes, as well as the small scale physical transport on those terms remain to be investigated**. Further, the Humboldt OMZ system is under the combined influence of offshore and coastal, natural and anthropogenic pressures, which result in a spatio-temporal variability of the quality of the organic matter and of observed phytoplanktonic populations. And beyond the pure academic interest, this system presents critical ecosystem services such as the provision of fish stocks and landing, aquaculture production, tourism and recreation.

The present PhD project contributes to the COPAS-Coastal[1] mission and takes place within the CLAP[2] project, whose objectives are:

Specific Objective 1: Monitoring and analyzing past and current trends. Generate and analyze customized regional observational datasets, to deliver an empirical understanding of the state, variability, and trends of the ocean and coastal service pressures.

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[1] https://copas-coastal.cl/

[2] https://oceandecade.org/actions/research-program-for-climate-action-planning/

Specific Objective 2: Modeling coupled ocean-biogeochemical processes. Deliver downscaled simulations of oceanic response to climate change at regional to coastal scales.

Objectives of the PhD project

The goal of the PhD project is to gain a clear understanding of the biogeochemical dynamics in the deoxygenated (Paulmier et al., 2006; Fuenzalida et al., 2008) and productive (Daneri et al., 2000, Montero et al., 2007, Testa et al., 2018) Humboldt system. This entails a better description of the drivers of oxygen (O_2) fluxes with, in particular, a better comprehension of sources and sink terms that are coupled to the nitrogen (N) cycle and to the dynamics of organic matter. The low and rather stable O_2 stocks commonly observed in the OMZ core may falsely reflect an apparent homogeneity of the system, which may as well result from a strong ventilation (strong physical O_2 inputs) coupled with high respiration rates, or from weak O_2 inputs and low O_2 consumption. This project will particularly focus on the sources of organic matter as the main biogeochemical forcing mechanism. A challenge therefore lies in the adequate representation of biogeochemical fluxes, and in particular O_2. The extreme physical-biogeochemical gradients, high temporal variability and advection (Farías et al., 2021) will require fine simulation scales to be properly accounted for.

The project will benefit from a large variety of data to parameterize the model, such as in-situ, temporal monitoring at two sites (Tongoy Bay in Coquimbo, 30°S, including a mooring, and Concepción/Station 18 at 36°S), the Tara Ocean dataset (http://taraoceans.sb-roscoff.fr/EukDiv/) and the Argo-Float/O_2 data network. Data from SEPICAF 1 et 2 deployments for instance, will be coupled with a Lagrangian analysis to provide a description of fine scale transport. The two sites are productive, upwelling areas but with contrasted situations: while Tongoy Bay is more in the core and under the influence of atmospheric depositions from the desert, the 36°S station 18 time series at Concepción is closer to the margin of the OMZ and receives the riverine inputs from the Biobio River. The anthropic pressure is also more pronounced at the Concepción station.

Specific question: How do organic matter and its fine scale transport affect the OMZ dynamics (stability/ intensity, and variability)?

Working Hypothesis: The origin, nature and spatial distribution of the organic matter affect the biogeochemistry specific to the OMZ, and O_2 sinks in particular

Proposed methodology: The PhD fellow will implement a coupled, physical-biogeochemical ocean model at fine resolution. The starting point could be the CROCO (https://www.croco-ocean.org/) physical model, coupled to the biogeochemical model BioEBUS. The latter has already successfully described the Eastern Tropical Pacific OMZ at a 1/9° resolution (Montes et al., 2014), as well as the Namibian upwelling (Gutknecht et al., 2013a), Benguela upwelling (Gutknecht et al., 2013b) and the OMZ off Peru (Vergara et al., 2016) and off Chile (Pizarro-Koch et al., 2019, 2023) at an eddy-resolving resolution (1/12°). Simulation grids of the physical environment at 1/12°, 1/36° and 1/108° (~1 km) will allow exploring the influence of fine, local physical processes on the dynamics of biogeochemistry. Such resolutions are necessary to account for the distinct origins (terrestrial or oceanic) of the organic matter and to provide accurate descriptions of O_2 fluxes. In a first, theoretical approach, localized sources of organic matter with different quality can be applied to observe how these evolve in the system while exploring the model sensitivity to the parameters space. In a second step, more realistic simulations could be performed to more specifically describe and characterize the two contrasted sites and explore how sensitive the OMZ is to anthropic pressure. The project will benefit from outcomes of the H2020 FutureMares consisting of simulations of a regional biogeochemical model at different resolutions (1/12°, 1/36°) with climate change scenarios for the Peru/Chile coastal region. These will be used to explore the sensitivity of the OMZ to climate change.

This project is highly original, with very moderate risks as the project team possesses all the required expertise and access to adequate data to successfully mentor the PhD fellow.

Outcomes

Model simulations will provide an **original description of the OMZ dynamics at an unprecedented resolution**, including the characterization of fine scale transport within and at the limits of the Chilean OMZ. Outcomes of the project will also provide an identification of the sources of particulate and dissolved organic matter that feed the OMZ, discriminating between phyto– and zooplankton communities and the external sources (oceanic beyond the OMZ, coastal, possibly riverine, atmospheric and anthropogenic). The coupled approach will also provide a precise description of the impact of origin and transport of the organic matter on all the simulated, biogeochemical processes, including primary and secondary production, on which fisheries largely rely. Last, **the approach will quantify the contribution of fine scale transport to the O_2 budget in the OMZ, deconvoluting the physical and biogeochemical contributions to the O_2 fluxes and stocks under present and future conditions**.

This project will contribute to strengthening the ties that both LOMIC and IRD separately had so far with Chilean institutions, and further represents a new, structuring initiative between these teams. This training-through-research project also strongly contributes to the Flagship 4 EU+ European University Alliance. In particular, results will provide a better understanding of the OMZ dynamics as well as **forecasts of the possible ocean deoxygenation consequent to climate change. These will also be crucial to guide decision-making in regard to the management of the coastal ocean and fisheries.**

Host team

The PhD fellow will join a multidisciplinary project-team with expertise in physical oceanography, biogeochemical oceanography and phytoplankton ecophysiology. One adviser (D. Narvaez) is located at the University of Concepción, Chile and the other (S. Rabouille) at the Oceanological Observatory of Banyuls, France. The PhD fellow will work in tight collaboration with all the team members, which include B. Dewitte (expert in physical oceanography, PI of the CLAP project), V. Garçon (expert in biogeochemical modeling), A. Paulmier (marine biogeochemist with expertise in ocean oxygenation).

Profile

Candidates should have a Master degree in Oceanography or biogeochemistry or marine sciences with strong competences in modeling. Desire to work in a multidisciplinary, international team. The project involves long stays in both France and Chili. A good knowledge of English (both spoken and written) will be necessary to interact with mentors and project partners.

Application:

Please send a motivation letter, CV, list of grades and ranks (if possible per course) for all years of the Bachelor and Master degree, as well as the names, email and phone number of up to 3 possible referents, to:

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