AAP China Scholarship Council - CSC 2023

PROJET DE RECHERCHE DOCTORALE (PRD)

Titre du PRD : External inputs of metals to the ocean: coupling observation, experiments and modelling approaches

DIRECTION de THESE

Porteuse ou porteur du projet (***doit être titulaire de l'HDR***) :

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Unité de recherche : Code (ex. UMR xxx) et Intitulé : UMR7093 Laboratoire d'Océanographie de Villefranche (LOV)

Ecole doctorale de rattachement : ED129 - SEIF

Nombre de doctorants actuellement encadrés : 2 co-encadrements

CO-DIRECTION de THESE (HDR) ou CO-ENCADREMENT (Non HDR) :

NOM :

Prénom :

Titre : Sélectionner ou Autre :

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Unité de recherche : Code (ex. UMR xxx) et Intitulé :

Ecole doctorale de rattachement : Sélectionner

Nombre de doctorants actuellement encadrés :

CO-TUTELLE INTERNATIONALE envisagée : ☐ OUI ☒ NON

DESCRIPTIF du PRD :

*Ce texte sera affiché en ligne à destination des candidates et candidats chinois : il ne doit pas excéder **2 pages** doit être rédigé en **ANGLAIS***

In the ocean, trace metals, characterized by their very low concentrations, are at the same time micro-nutrients essential to life (e.g. iron) but are also tracers of the origin of water masses and of external contributions of particulate and dissolved matter to the ocean. Some metals can however become toxic beyond certain concentration thresholds.

Thus, at Laboratoire d'Océanographie de Villefranche, we have shown that atmospheric inputs (see for example the articles of the Special Issue https://bg.copernicus.org/articles/special_issue1040.html of the PEACETIME program (https://campagnes.flotteoceanographique.fr/campagnes/17000300/fr/) (coordinated by C. Guieu) and inputs from shallow hydrothermal sources (Guieu et al., 2018, Tilliette et al., 2022) are sources of "new" chemical elements to the ocean and that they play a key role in oceanic primary production. In the coastal zone, we have also been able to quantify inputs from rivers, especially during exceptional flood events (Monjol-Delphine 2022). Although our studies show causal links between external inputs and marine biological activity (viruses, bacteria, phytoplankton, zooplankton), the spatial and temporal variability of these links remains poorly understood. Moreover, the future trend of these impacts in relation to environmental changes (increase in: stratification &sea surface temperature, decrease in pH) remains uncertain.

If we want to highlight the impact of micronutrients such as metals on the pelagic marine realm in a context of climate change, it appears necessary to couple (1) in situ observation over a long enough period to record extreme events (pyrogenic aerosols from forest fires, desert dust deposition, pollution but also heat waves, storms) to (2) experiments in a controlled environment allowing to vary environmental parameters such as temperature, pH, light and to study very precisely the impact of such phenomena which are process mechanisms strongly amplified by the current climate change.

The objective of this thesis is therefore to (1) better understand how external inputs of metals shape their distribution in the ocean and (2) parameterize the processes involved between external inputs of metals to the ocean and the impact on planktonic communities, today and in the future climate.

The study will be carried out at the Laboratoire d'Océanographie de Villefranche (photo), which has the advantage of having a natural laboratory on its doorstep, the Bay of Villefranche, equipped with services and observation instruments for the continuous monitoring of basic environmental parameters measured weekly (https://www.somlit.fr/parametres-et-protocoles/), to which we will add the measurement of metals in the dissolved and particulate phases of atmospheric deposition, in the seawater column, and in the phytoplankton and zooplankton. The experimental part will be carried out thanks to our clean room laboratory including 9 climate reactors (photo) which showed its relevance for this type of study (Gazeau et al., 2019).

The set of acquired parameters will allow on the one hand to clearly identify the impacts of extreme events that it is very difficult to measure "directly" without this type of natural laboratory and the expertise that our team has acquired regarding experiments in controlled conditions. Once these co-located observation in the atmosphere and ocean and the parametrization from the controlled experiment done, the link with large scale changes will be envisaged. Indeed, improving existing modeling effort with those findings could finally help to understand some specific feature/pattern in the ocean and answer with certainty about the effect of external inputs of metals to the ocean.

Numerical models of ocean biogeochemistry are relied upon to make projections about the impact of climate change on marine resources and test hypotheses regarding the controlling mechanisms of external inputs from ecosystem (Tagliabue et al., 2016). However, they are often struggle to reproduce the observed spatial-temporal pattern for trace metals, because of the limited number of observations in some regions and at some times of the year (e.g., harsh winter) and poor skills in representing intricate cycling processes such as input fluxes, biological consumption, and complex chemical processes (i.e., scavenging and production of iron-binding ligands) (Huang et al., 2022).

One way to circumvent the sparsity of observations and broaden knowledges of controlling mechanisms is to use data-driven statistical models like Machine learning methods (ML) (Chen et al., 2020; Huang et al., 2021; Li & Cassar 2016). ML can upscale the dataset, and infer mechanisms through statistical inferences, which is rapidly gaining interest across the geosciences for their adaptability and ability to capture complex relationships without prior knowledge of underpinning mechanisms (Mattei et al., 2018; Roshan and DeVries, 2017). In this study, we could use the ML-model based on our time-series data of trace metals to explore possible mechanisms governing the distribution from the statistically inferred trace metals' distribution, and also to evaluate other biogeochemical models using our products as a reference. As a result, in conjunction with ML-model products and experiments, we could more accurately catch the picture of trace metals' cycles, and improved model parameterization, validation and projections of future states of the Mediterranean Sea, and possibly to other large oceanic provinces, under various climate scenarios and extreme events.

The candidate must have a strong background in marine biogeochemistry, recognized skills in trace metal chemistry (fieldwork, work in cleanroom (trace metal analysis but also experimental work). Aptitude in modeling is also recommended.

The work will be performed at LOV, within the 'Chemistry-Ocean-Climate' team: https://lov.imev-mer.fr/web/team-choc/

References in the text can be found here: https://urlz.fr/k64q

AVIS de l'Ecole Doctorale :

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Fichier à envoyer par mail simultanément
à l'école doctorale de rattachement et à csc-su@listes.upmc.fr