# FINAL REPORT PROGRAM LEFE

| Program LEFE/ CYBER | Project Title<br>Oceanic Flux Mapping of Key Atmospheric Chemistry gazes at Global Scale<br>Cartographie des Flux Océaniques de Réactifs de la Chimie Atmosphérique à l'Echelle Globale (FORCAGE) | Years 2015 – 2016 |
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| SZOPA Sophie<br>LSCE | Contribution to H2020 CRESCENDO project, the international GEIA (a joint IGAC / iLEAPS / AIMES initiative of the IGBP) and SOLAS initiatives.<br>Other funding sources (obtained after the LEFE project) a PhD fellowship from CEA (~90k€), H2020 CRESCENDO~5k€ |

**CONTEXT** : In addition to their major role in the distribution of carbon in the ocean, planktonic organisms also play a key role in volatile organic coupounds production. In the superficial layers of the oceans (the euphotic zone) planktonic biomass leads, more or less directly (via photosynthesis or photolysis of organic matter), to the production of a multitude of organic compounds. Many of them are sufficiently volatile to be released to the atmosphere and to act on different physicochemical equilibria.

**Objective :** Modelling of oceanic concentrations of gaseous compounds of interest for atmospheric chemistry (CO, isoprene, halogenated)

Quantifying the interannual and regional variability of ocean to atmosphere fluxes and their impact on atmospheric budgets.

1. measurement campaign in the Arctic in the 2015 summer
2. summary of measures available in the literature
3. modeling in PISCES (marine biogeochemistry model)

=> availability of observed concentration maps (via CYBER and SOLAS database) and emission maps modeled for the atmospheric chemistry community (via GEIA)

**Main results**

Firstly, we gathered the existing measurements of oceanic carbon monoxide (CO) concentrations: The synthesis includes 29 profiles representing the synthesis of 159 individual profiles (carried out since the 1970s) and 21 campaigns of CO measurements at the surface. This database is used to evaluate the biogeochemical model below (but is too fragmented to really constrain processes in the model).

Secondly, as part of a collaboration with the Alfred-Wegener-Institute and the LEFE-FORCAGE project, 2 LSCE people were able to participate in the TRANSSIZ campaign in the 2015 spring aboard the German ship Polarstern to document the horizontal and vertical variations of the carbon monoxide (CO) and a selection of volatile organic compounds (VOCs) in the Arctic Ocean. In this context, a system for extracting dissolved compounds was developed and coupled to two analyzers (chromatograph for CO measurement and PTRMS for VOC measurement). The measurement by PTRMS has notably documented isoprene and DMS, 2 compounds emitted by phytoplankton but also, and to our knowledge for the first time, methane thiol (CH3SH). During the transect of the Bremerhaven boat north of Spitsbergen (57°N-81°N), CO and VOC concentrations were measured continuously in surface water (~6m). Then, at the different ice measurement stations, vertical profiles (0-100 m) of the compounds in the ocean were measured. In parallel, chlorophyll measurements and different phytoplankton species were carried out by AWI colleagues. Low values of isoprene have been measured which could be explained by the predominance of diatoms of cold waters with low emissions in this area (see FIg 1). On the other hand, ocean measurements of CO show particularly high values in this zone which can exceed 20nmol.L-1 for surface seawaters.

Thirdly, we improved the representation of CO and isoprene production and loss processes in the PISCES model. This work has been a little delayed compared with the initial project while waiting for a PhD student. It is currently in full swing with Ludivine CONTE's thesis (2016-2019). Through these developments, we provide the first estimate based on a model of oceanic CO emissions (see Fig 2) that will soon be available for use in current atmospheric models. The mechanistic model has helped to better understand the

processes influencing the concentrations of CO in seawater and to determine the global flux of CO in the atmosphere, such as the importance of the term bacterial consumption. Such a dynamic model allowed us to predict that CO fluxes could increase slightly in a future scenario given a sharp increase in atmospheric $CO_2$ concentration. The same approach will be used to study other short-lived gases such as volatile organic compounds.

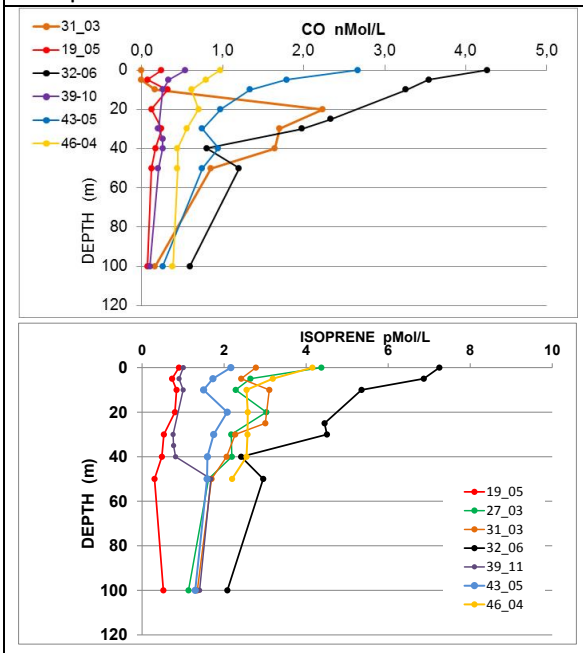


Fig 1: Profiles of CO and Isoprene measured during the TRANSSIZ campaign

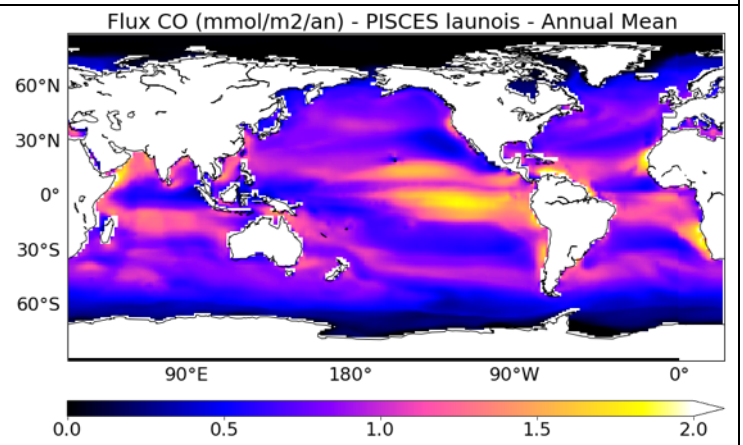


Fig 2 : CO flux in mmol/m2/yr - Annual average simulated by the PISCES marine biogeochemistry model (Conte et al. In prep)

*Future of the project : The emission module will be extended to the representation of halogenated compounds. New measurements should be done in the international framework of the MOSAIC program (if funded)* (http://www.mosaicobservatory.org/)

The measurement results are currently being interpreted and will be published (Gros et al.). They were presented at the conference "Arctic Frontier" (Jan. 2017) and in the internal workshops of the TRANSSIZ project.

The modelling work was presented by a poster at the GEIA international workshop (workshop on emissions for atmospheric chemistry). 1 thesis (Ludivine Conte) is in progress and 1 publication on carbon monoxide is in preparation (and one is planned for isoprene next year)