PhD position in marine biogeochemical modelling

Primary production in the subpolar North Atlantic: from historical variability to future projections

Applications are invited for a PhD position at Institut Pierre Simon Laplace, Laboratoire des Sciences du Climat et de l'Environnement (IPSL/LSCE), Gif-sur-Yvette, France. The research will be carried out in close collaboration with French-Canadian research teams and in the framework of the project "*Improved accounting of the Arctic Ocean's carbon sink through a combination of observations and model*" funded by the France Canada Research Fund. The thesis will be hosted by the French partner and will involve extended stays at the Canadian partner institution (Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada).

Rationale & Objective:

Deep winter convection is a conspicuous feature of North Atlantic subpolar gyre ocean dynamics. Deep convection injects atmosphere-born tracers (e.g. oxygen, anthropogenic tracers) to the ocean interior and mixes nutrients up to the productive surface ocean. While the link between deep convection and the ocean carbon cycle has been an area of intense research, much less attention has been paid to impacts on the regional nutrient budget and productivity. Deep winter mixing replenishes the mixed layer with nutrients and allows the development of a vigorous, diatom dominated spring bloom. Diatoms are large silicifying phytoplankton with a unique requirement of dissolved silica. They are at the base of a productive food chain with copepods as their main grazers and link to higher trophic levels. A recent study by Hatun et al. (2017, doi: 10.1038/s41598-017-14837-4) reports a decrease in mixed layer dissolved silica concentrations, a limiting nutrient for diatoms, at the onset of spring stratification across the subpolar North Atlantic. Such a reduction would have consequences on the intensity, composition and duration of the spring bloom, which will ultimately impact ecosystem productivity. Hatun et al. (2017) attributes the observed decrease in dissolved silica to natural subpolar gyre variability and, in particular, to less vigorous deep convection in the Labrador Sea. A causal link between shallower deep convection and decreases in productivity is similarly found in twenty-first century climate change projections. In a future warm climate, intensified freshwater fluxes from Greenland ice sheet melt and melting arctic sea ice are projected to increase stratification, decrease deep convection, nutrient levels in the mixed layer, and ultimately productivity. Despite the consistency of projected changes, major uncertainties still exist in particular with respect to the role of biotic processes in shaping future levels of productivity, as well as to the interaction between shallower mixed layer depths and light limitation. *The interactions between natural modes of subpolar gyre variability and climate change in setting future North Atlantic nutrient and productivity levels remain open questions.* The **objectives** of the thesis are twofold: 1. Assess the link between natural variability of deep convection, nutrient levels and marine productivity at the scale of the subpolar North Atlantic ocean over the past 60 years; 2. Evaluate future changes in subpolar gyre dynamics and explore their impact on nutrient levels and productivity.

The **candidate** should have a strong interest in one or more of the following: physical and/or biogeochemical oceanography, plankton ecology and numerical modelling (Earth system/biogeochemical ocean modelling). Prior knowledge and experience in UNIX computer programming or languages such as Fortran, Python, Matlab, NCL and/or R will by an asset.

Applicants are invited to submit a letter of motivation, their CV, a description of the academic curriculum and details of two referees to M. Gehlen (marion.gehlen@lsce.ipsl.fr) and D. Wallace (Douglas.Wallace@Dal.Ca).