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PhD opportunity

Fate in Arctic coastal waters of terrigenous organic carbon mobilized by thawing Arctic permafrost: A high-resolution physical-biogeochemical modeling approach

Laboratories involved:
UMR 7266 LIENSs La Rochelle Université – CNRS (France)
UMI Takuvik CNRS – Université Laval (Canada)
ARGANS (France)
NASA Jet Propulsion Laboratory (JPL), California Institute of Technology (USA)
Scripps Institution of Oceanography (USA)

Background

About one-third of the world's coastline is permanently frozen soil (permafrost, Lantuit et al., 2012). Permafrost was formed several thousand years ago in the Arctic watersheds. More than half of the planet's organic carbon stock is stored there (Tarnocai et al., 2009). Permafrost is the largest reservoir of continental carbon well before fossil reserves of oil, gas, and coal.

The melting and release of frozen organic carbon stored within permafrost and its subsequent recycling into greenhouse gases carbon dioxide (CO_2) could push global warming above the 1.5 °C target of the recent COP21 Paris Agreement (Schuur et al., 2015). A key question today is to know whether the Arctic Ocean (AO) will evolve either as a sink or a source of CO_2 to the atmosphere, with the consequences that this would imply for climate in the future.

Over the past 30 years, the Arctic hydrological cycle has intensified resulting in a steady increase in river runoff (Holmes et al., 2015). Combined with melting permafrost, the flux of terrestrial dissolved organic carbon (tDOC) to coastal waters would then increase (Tank et al., 2016). This is also the case for the Mackenzie River (Beaufort Sea, western AO), where the change into terrestrial DOC (tDOC) flux increased by 40 % (Tank et al., 2016). Marine bacteria consume tDOC (Colatriano et al., 2018), recycle it into nutrients and respire some of it into CO_2. Although the role played by these marine bacteria in the CO_2 oceanic cycling might be significant, it is still poorly understood in large river plumes where tDOC concentrations are the largest. As the bacterial activity might be greatly enhanced by the warming of the oceans, their contribution to the AO carbon cycle must be estimated.

Objectives

By combining numerical modeling and remote sensing tools, the PhD project aims to investigate the fate of tDOC within the Arctic coastal waters and to quantify the bacterial contribution to the CO_2 oceanic outgassing. Ocean biogeochemical models need to represent in a realistic way the riverine tDOC fluxes into the AO. Mean climatological tDOC fluxes (e.g., Le Fouest et al., 2018) does not include the strong interannual variability of the processes that govern the observed land-sea fluxes. On the other hand, tDOC fluxes simulated by Arctic watersheds models suffer from uncertainties on the mechanistic representation of the complex processes involved (Kicklighter et al., 2013). As a result, the potential effects of global warming on the Arctic tDOC land-to-sea flux cannot be predicted by coupled ocean-sea ice-biogeochemical Arctic models as they do not account for these processes.

In collaboration with the UMI Takuvik (French CNRS/U Laval, Canada) and the ARGANS company, the PhD candidate will propose an alternative method to compute tDOC fluxes by using new ocean color products from space remote sensing. tDOC concentrations derived from Sentinel-2A/MSI and Landsat8/OLI high-resolution sensor data in the mouth of the Mackenzie River (Matsuoka et al., 2017) will be used. These satellite data will be associated with the Canadian Water Office's daily river discharge data to build up year-specific time series of tDOC fluxes. These tDOC time series will be implemented as forcings within the coupled ocean-sea ice-biogeochemical MITgcm model (Manizza et al., 2019, Le Fouest et al., 2018; Menemenlis et al., 2005). The three-dimensional Arctic model will simulate at high horizontal resolution freshwater and tDOC dynamics in the coastal waters at the synoptic to seasonal time scales. Satellite data from the space SMOS/MIRAS sensor will be used to discriminate and validate the freshwater input from the rivers to the coastal waters simulated by the model. SMOS/MIRAS sensor data were successfully applied in the study area (Matsuoka et al., 2016). The tDOC fields simulated by the Arctic model will be validated using tDOC data derived from high-resolution (Sentinel-2A/MSI and Landsat8/OLI) and medium resolution sensors (Sentinel-3A/OLI, GCOM-C/SGLI (JAXA), ENVISAT/MERIS, NPP/VIIRS, Aqua and Terra/MODIS, Orbview-2/SeaWiFS).

In collaboration with the NASA Jet Propulsion Laboratory (JPL), California Institute of Technology (USA) and Scripps Institution of Oceanography (USA), the PhD candidate will set up the high-resolution configuration of the Arctic MITgcm model (see Menemenlis et al., 2005) for the Beaufort Sea, Western AO. She/he will work on a very new model parameterization of the freshwater discharge and tDOC fluxes by the Mackenzie River (see above) so as to predict CO_2 air-sea fluxes within the river plume. For that, she/he will couple the physical-biogeochemical model ECCO-Darwin (Manizza et al., 2019) to the MITgcm high-resolution model and work on adding bacteria/tDOC processes (Le Fouest et al., 2015) in the ECCO-Darwin model to simulate the bacterial contribution to the CO_2 fluxes.

This PhD project is part of the European Horizon 2020 Arctic project NUNATARYUK (2017-2022). The candidate will hence interact with the research scientists of the EU project. In addition, we foresee mobilities to the US and Canada for the modeling work.

Applicants must be self-motivated and hard working, with good written and verbal communication skills. A strong background in numerical modeling, oceanography, and data analysis is required.

Applications are due on April 15, 2019. Expected start date October 2019.

Applicants are asked to send a *curriculum vitae*, a statement of research experience and interests, publications to Vincent Le Fouest (vincent.le_fouest@univ-lr.fr) and Antoine Mangin (Antoine.Mangin@acri-st.fr).

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