The impact of Mackenzie River colored dissolved organic matter (CDOM) on coastal Arctic Ocean carbon cycling

Clément Bertin[1], Vincent Le Fouest[2], Dustin Carroll[3,1], Stephanie Dutkiewicz[4], Dimitris Menemenlis[1], Atsushi Matsuoka[5], Manfrredi Manizza[6], Charles Miller[1]

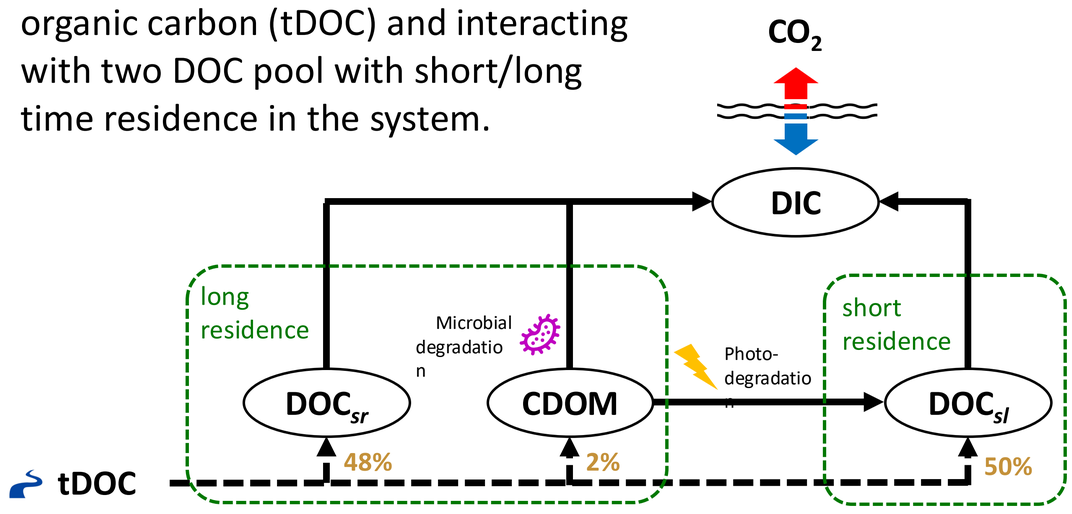
PREPRINT

Background.

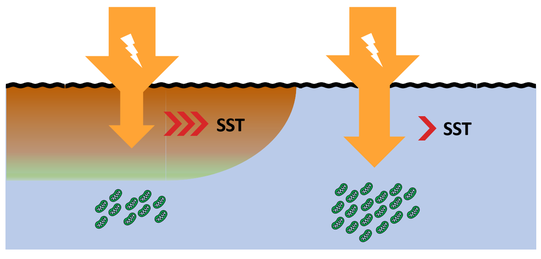
Rivers flowing into the Arctic Ocean (AO) drain an area exceeding 12 million km^2. As the Arctic is warming four time faster than the global average, freshwater export from Arctic rivers is increasing and their associated land-to-ocean flux of dissolved organic matter is changing in both quantity and chemical composition. The response of the coastal AO to climate-driven variability in biogeochemical river runoff remains highly uncertain, as observations in these remote, high-latitude regions remain sparse. Here we aim to better understand how terrestrial dissolved organic matter and its associated optical properties impact coastal-ocean biogeochemistry and air-sea CO_2 flux. We use a regional set-up of the ECCO-Darwin ocean/sea-ice/biogeochemistry model to explore and quantify the effect of terrestrial colored dissolved organic matter (CDOM) on coastal Beaufort Sea carbon cycling. We developed a novel parameterization for riverine CDOM light absorption (from UV to visible light wavelengths) as this signal transitions across the Land-Ocean-Aquatic-Continuum (LOAC).

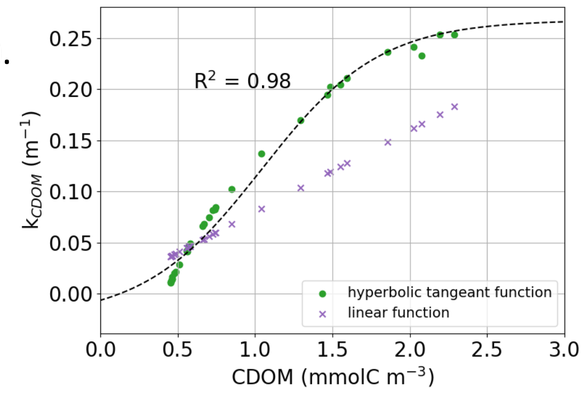
I. SIMULATING COASTAL CDOM

ECCO-Darwin regional simulation, including an explicit CDOM tracer (mmolC m^{-3}) forced by riverine dissolved organic carbon (tDOC) and interacting with two DOC pool with short/long time residence in the system.

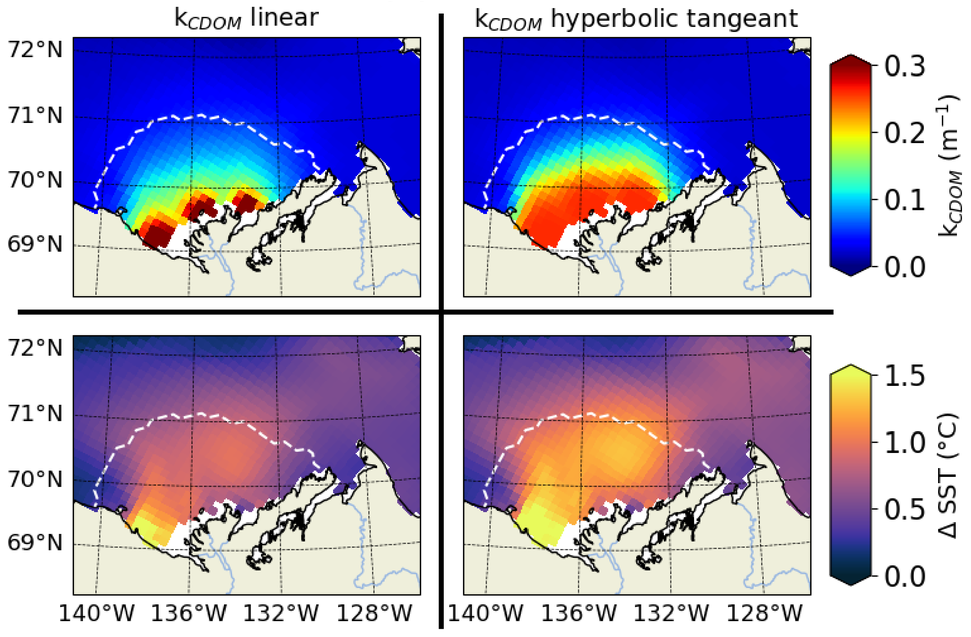


CDOM light attenuation (k_{CDOM}) as a hyperbolic tangent function of CDOM calculated from *in-situ* measurements on the Mackenzie Shelf (see preprint paper for more details on the method). CDOM impacts phytoplankton growth through PAR attenuation and seawater temperature through total light attenuation (including UV-A).



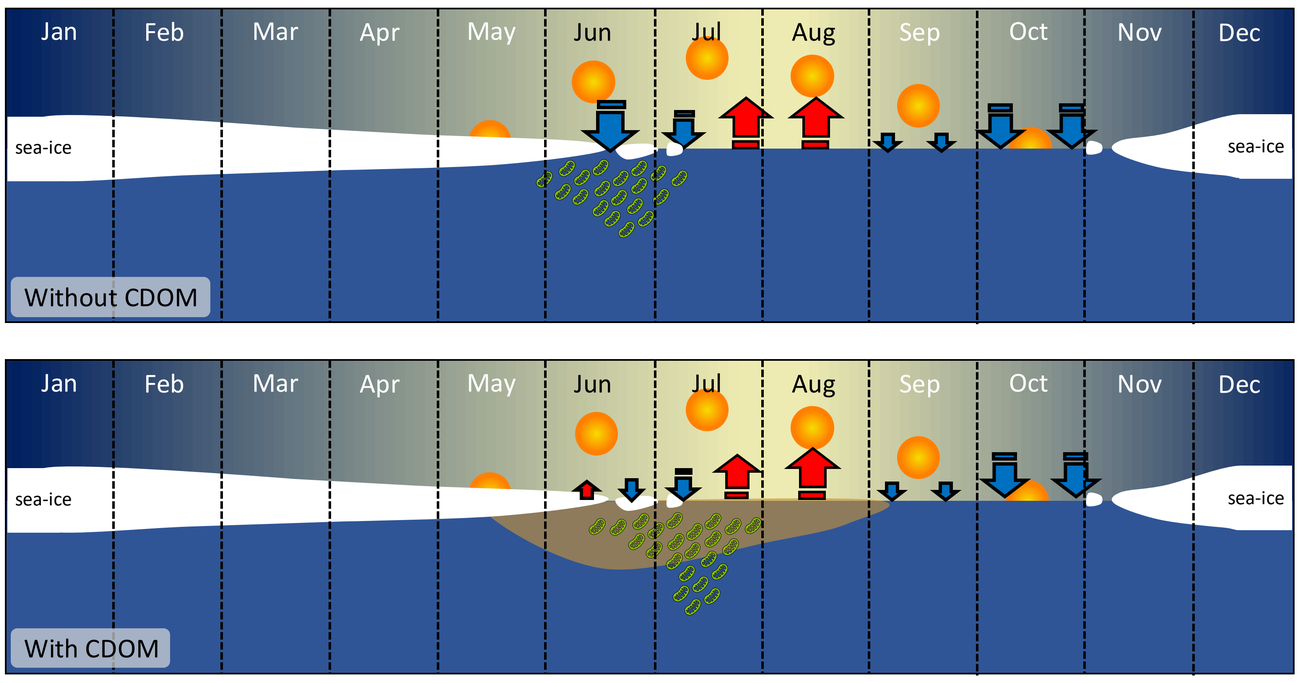


July 2012



II. EFECT OF RIVERINE CDOM ON PHYSICAL PROPERTIES

- Using light attenuation as a hyperbolic tangent function of CDOM limits over-attenuation effects in high CDOM concentration regions, allowing for CDOM absorption to more evenly spread along the nearshore region
- CDOM heating effect is 36% higher with the hyperbolic tangent function *vs* classic linear relationship, with an increase the local SST due to terrestrial CDOM peaking at 1.7°C.



III. CHANGES IN SEASONAL PHENOLOGY

- CDOM light attenuation triggers a shorter but stronger the phytoplankton bloom, delayed by 2 weeks.
- Combined with the increase in SST in July, the Mackenzie River plume region is simulated as a net source of CO_2 for the atmosphere of 7.35 GgC yr^{-1}

TAKE HOME MESSAGES.

- We developed a regional setup of ECCO-Darwin including a CDOM tracer interacting with fast/long residence carbon pool
- CDOM light attenuation is parameterized as a hyperbolic tangent function of CDOM content
- Our new parameterization better represent light attenuation in regions with high CDOM concentration such as river plumes.
- A combine increase in SST and a delay in the phytoplankton bloom due to CDOM light interaction, results in a Mackenzie River plume region simulated as a net source CO_2 of 7.35 GgC yr^{-1}

Contact information. clement.maxime.bertin@jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology

[1]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2]LIttoral ENvironnement et Sociétés (UMR 7266), La Rochelle Université, La Rochelle, France
[3]Moss Landing Marine Laboratories, San José State University, Moss Landing, CA, USA
[4]Department of Earth Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA
[5]Institute for the Study of Earth, Oceans, and Space, University of New Hampshire, Durham, USA
[6]Geosciences Research Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, California, USA