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Interactive comment on "Towards an assessment of riverine dissolved organic carbon in surface waters of the Western Arctic Ocean based on remote sensing and biogeochemical modeling" *by* Vincent Le Fouest et al.

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We gratefully thank referee #1 for her/his constructive comments with respect to our manuscript. In order to improve the manuscript with respect to these comments, we amended the manuscript as suggested by the referee wherever it was possible. Note that, when needed, comments were merged together to bring more clarity in the answer:

1. "Satellite remote sensing obviously can convey information on the directional flow of river plumes carrying DOC, but depth penetration from satellite platforms is modest, so without field sampling, comparison of one set of estimates with another produced by biogeochemical modeling seems like a limited and incomplete outcome."

We agree with that comment in the sense that numerical modeling and remote sensing are not exhaustive approaches. Both are fully dependent from field measurements as their setup (e.g. forcings and differential equations for the model, algorithms for remote sensing) necessarily requires large in-situ databases. In our study, the model was constrained by riverine DOC observations at the boundaries of its numerical domain (see Manizza et al., 2009) while the semi-empirical remote sensing algorithm we used was developed based on field measurements (see Matsuoka et al., 2017). As explicitly mentioned in the manuscript, the modeling and remote sensing approaches combined together provide a relevant insight on the RDOC dynamics over a wide spatial and temporal scale, but limited to the surface coastal waters where RDOC concentrations are the highest.

In order to account for the referee's comment, we modified the end of the abstract (line 33) as follows: "Future studies could apply the combination of model and satellite data extended to the entire AO to quantify, in conjunction with in-situ data, the expected changes in RDOC fluxes and their potential impact on AO biogeochemistry."

2. "Moreover, many of the important areas of concern in the context of climate change revolve around the dynamics of DOC degradation. This process has higher rates in the spring freshet that later in the summer, and the different pools of marine and riverine DOC have different degrees of bioavailabilty. I didn't see this addressed significantly"

According to this comment, we improved the first paragraph of the Perspective section. The text was modified as follows: "In addition, the model involves some limitations mostly due to the biogeochemical processing of RDOC, which is complex to translate into robust mechanistic equations as highly dependent on the availability of in-situ data in Arctic waters. For instance, the RDOC compartment is split in the model into a labile and a non-labile fraction (see Le Fouest et al., 2015). This parameterization strongly constrains the removal of RDOC by bacterioplankton and therefore the RDOC concentrations simulated within surface waters. In natural waters, however, RDOC is made of a complex mixture of compounds that differ by their chemical composition and age (Mann et al., 2016) and so along the seasons (Wickland et al., 2012, Mann et al., 2012). The chemical nature of RDOC impacts its bioavailability estimated to average 6% to 46% of the total RDOC pool with marked disparities amongst the seasons and the rivers (Mann et al., 2012). Nevertheless, the general trend for the six major Arctic rivers (Kolyma, Yukon, Mackenzie, Ob, Yenisey and Lena) is a more labile RDOC pool in winter than in spring and summer (Wickland et al., 2012). Mann et al. (2012) report that, in the Kolyma River, the labile fraction is higher in spring (∼20%) than in summer (<10%) as the exported RDOC is younger during the freshet. Such a pattern is, however, not clearly evidenced in the Mackenzie River (e.g. Wickland et al., 2012). We suggest that a more realistic representation in the model of the nature of the organic matter entering the coastal waters including the riverine flux of both dissolved organic carbon and nitrogen along with an improved C:N stoichiometry for bacterioplankton uptake (see Le Fouest et al., 2015) might improve the RDOC concentrations simulated in surface AO waters."

3. "I didn't see this addressed significantly, including including the extent to which DOC is removed in the river delta or near-shore zone, and after it is accounted for in flux estimates, but before it reaches the open ocean where estimates can be made from satellite platforms."

Line 278 was also modified as follows: "In the model, the seasonal forcing of RDOC was based on RDOC measurements gathered hundreds kilometers upstream the rivers' mouths. This prevented any DOC enrichment of the Mackenzie River water as it flows through the delta (e.g. Emmerton et al., 2008) with, as a consequence, a likely underestimation of RDOC concentrations simulated in nearshore waters. Therefore, the quantification of the RDOC flux from the watersheds to the coastal AO poses

as another key issue to addressing its role in the biogeochemistry of shelf waters."

4. "It is also significant that much of the spring freshet flows over and under coastal sea ice from the Mackenzie River, but there is little inference about how that is accounted for."

In the model, the river flow and RDOC concentrations spread under coastal sea ice. By contrast, there were no RDOC data where sea ice above the sea surface was present in the remote sensing dataset. Therefore, only the grid points where both simulated an remotely sensed RDOC coincided were analyzed.

5. "Comparisons are made to primary production, and it is stated that DOC from rivers represents 10-19% of the carbon fixed by primary production in the Arctic Ocean as a whole and up to 34% of primary production in the coastal Beaufort Sea, but the labile nature of organic carbon that is formed by marine production is quite different from most of the organic carbon in RDOC. "

The reviewer's comment is relevant in the sense that most of RDOC is refractory to biological use while biogenic carbon formed by primary producers can flow more easily within the food webs when it does not sink out of the euphotic zone (∼10%; Buesseler, 1998). However, the purpose of our sentence was primarily to scale a bulk comparison between these two main sources of organic carbon that fuel the upper water column, irrespective to their nature and fate. We hence modified the sentence as follows: "Irrespective to their distinct nature and fate, both the carbon contained in RDOC and that formed by primary producers can be considered as new carbon fueling annually the upper AO. For comparison, RDOC would amount ∼10% to 19% of the carbon formed by phytoplankton in the whole AO (Stein and Macdonald, 2004; Bélanger et al., 2013), a proportion that would reach ∼34% in the oligotrophic Beaufort Sea (S. Bélanger, pers. comm.)"

6. "It should be mentioned that the authors acknowledge some of these limitations in a general sense, including seasonal challenges to gathering satellite data, and the

complex nature of RDOC in the Perspectives section, although those limitations are not reflected in the abstract of the study, which reads more optimistically."

The limitations pointed out be the reviewer were developed in our detailed answers to comments 2 and 3. We also modified the beginning of the third paragraph of the Perspective section (line 288) to develop on some aspects of the remote sensing: "In our study, the RDOC concentrations remotely sensed in shelf waters provide the advantage of already integrating the effect of the watersheds processes such as mobilization, transformation and transport at the seasonal and synoptic time scales. However, we acknowledge that the temporal coverage of the remote sensing data is restricted to spring and summer and that we miss the cloudy and ice-dominated winter season, when RDOC is the most labile (e.g. Wickland et al., 2012) and likely subject to degradation within surface waters. In the Mackenzie River, the winter season is responsible for $\sim$25% of the annual load of labile RDOC (Wickland et al., 2012). Despite this limitation, and in regard to the model-satellite data comparison, the assimilation of remotely sensed RDOC data into Arctic models would still offer an interesting perspective as it might result in more realistic simulated fields of RDOC in spring-summer, when the river discharge and RDOC export is the highest."

"The manuscript could be improved by light editing by a Native English language writer."

The English will be improved.

"Data supporting the study are available on-line, but no metadata or "read-me file" explaining use of the on-line files is provided."

A read-me file will be provided with the data.

"I see no reason the manuscript couldn't be improved and accepted for publication, but I am skeptical of its potential for providing a more transformative understanding of dissolved organic carbon cycling in the Arctic."

To our knowledge, this study is the first to compare cutting-edge RDOC data derived

from remote sensing datasets and outputs from a predictive Arctic model. We show that the two approaches compare favorably in terms of RDOC concentrations and lateral fluxes and that they could be associated to overcome, at least partially, their own limitations. The study also attempts to shed light on the potential to further develop the two approaches to contribute for a better understanding of the RDOC dynamics and fate within AO waters in past and future decades, and so along with the increasing sampling effort done in the Arctic. To that respect, we think this study could be relevant for publication.

New cited references Buesseler K. O.: The decoupling of production and particulate export in the surface ocean, Global Biogeochem. Cycles, 12, 297–310, 1998.

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