Discussion on the 3rd Anonymous Referee review

Referee comment on "Particulate organic matter in the Lena River and its Delta: From the permafrost catchment to the Arctic Ocean" by Olga Ogneva et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-183-RC3, 2022

Comment types: Authors' Response: "AR", Referee Comment: "RC"
Comment colors: Authors Response: "blue", Referee Comment: "black"
Comment fonts: When it was possible, we highlighted changed text by the **bold font**, the text from the manuscript copied to this review was taped *cursive*

RC: The manuscript presents and discusses the data on quantity and quality of suspended matter, including its organic fraction, in the Lena River main channel in its middle and lower sections, and in the deltaic section. The manuscript has logical structure, is clearly written, presents novel data and adds to the discussion on the fate of particulate organic matter at the interface between the river and the sea. Two major points arise from the endmember modeling of the POC isotopic signatures : an important contribution from phytoplancton in both riverine and deltaic sections, and a noticeable input from the Ice Complex deposits in the Lena Delta region. The manuscript text needs to be more focused on these two findings, and if the authors think I have omitted any other important aspects, these aspects also need to be clearly framed and put forward. Notably, the 'Discussion' section of the manuscript needs to be centered around these major findings ; it is vague and uninspiring in its present form. Certain sections of this Discussion section, i.e. subsections 4.1.1 and 4.1.2, are quite detached from hydrologic reality. The comparison with ArcticGRO data makes a large part of discussion, while the discussion is usually self-sufficient and mostly relies on the newly presented data. I would suggest a separate section named 'Comparison with previously published datasets' for this discussion rather than spreading them across different sections.

Overall, I recommend a moderate revision of this manuscript with re-review. The revision might affect, first and foremost, the Discusson section, in what is related to regional hydrology, and better framing the major conclusions. By-line comments are available in the attached pdf.

Please also note the supplement to this comment: https://bg.copernicus.org/preprints/bg-2022-183/bg-2022-183-RC3-supplement.pdf

AR: Thank you for your review of our manuscript, we highly appreciate your time and work. We have answered all your comments (including those from the supplemental pdf, which now are transferred into this document with the specific line number) below and revised the manuscript accordingly. As requested by Biogeosciences, the revised manuscript will be uploaded at a later stage after responding to all reviewer comments. There will be a track

change version of the manuscript, as well as a clean version including all modifications following your and the 2 other reviewers' suggestions. All the line numbers refer to this clean revised version.

Thank you for your comments on our discussion. We respectfully disagree with the need to change the structure of the discussion part for a number of reasons we would like to explain. Our aim was to characterize, as fully as possible, the POM in the Lena River and its Delta, as well as to compare them. We are convinced that the current sequence of discourse and observation is the most straightforward way for our aims to provide the entire picture of research.
We agree with you on the two main findings, which are now more clearly described in the abstract and conclusion parts. Specific comments and edits were revised accordingly and are listed below.
L24-26: "*Dual-carbon ($\Delta^{14}C$ and $\delta^{13}C$) isotope mixing model analyses* ***indicated a significant phytoplankton contribution to deltaic POC (~68 ±6 %) and suggested an additional input of permafrost-derived OM into deltaic waters (~18 ±4 % of deltaic POC originates from Pleistocene deposits vs ~5 ±4% in the river main stem)***.

RC: L19-20: In the Abstract, you mostly present the results concerning the river-sea interface, and as early as in the Abstract the question arises what results were obtained from the transect itself. The Abstratc is uninformative in this regard.
AR: Thank you. We rearranged the abstract and edited L19-20 as suggested: *"Here, we studied* ***particulate organic carbon (POC) dynamics in the Lena Delta and compared it with POC dynamic in the Lena River main stem*** *along a ~1600 km transect long from Yakutsk downstream to the delta. We measured* ***POC****…"*

RC: L20: "Disembogue" is rather used as a verb, i.e. 'to disembogue', than as a noun according to Collins Dictionary.
AR: We changed this sentence and removed the word "disembogue"(L20).

RC:L28: I wonder if there is any difference between 'the Pleistocene deposits' in the delta area and 'the Yedoma' in the Lena R. catchment? This phrase creates an enormous confusion, comparable to 'Late Pleistocene Yedoma' from certain Canadian authors. It is either this or that, or Ice Complex deposits
AR: Thank you, changed accordingly at L28: *"****Yedoma*** *deposits in deltaic waters was almost twice as large as POC of Yedoma origin…"*

RC: L45: Lotsar~~y~~ – i
AR: Thank you very much for your attentiveness! We changed this as suggested to "*Lotsari*" (L45)

RC: L49: Correct me if I'm wrong but delayed active layer freeze-up was not in the scope of

(Fuchs et al., 2020) paper on Sobo-Sise cliff, but rather fluvial thermal erosion and abrasion were.

AR: Your are right, so we removed this misplaced reference (L47-48):

"*In addition, the delayed active layer freeze-up increases winter river runoff (Walvoord & Kurylyk, 2016; Lamontagne-Hallé et al., 2018; Wang et al., 2021a).*"

RC: L49 "enchances/Enchanced" – repetitive

AR: Thank you! See comment above: the first sentence was modified, thus the word "Enchanced" at the L49 is not repetitive anymore.

RC: L86-87: No data from official sources are available for the Lena R. at Kyusyur after 2013.

RC: L114-115: This is highly dubious, since Wang et al. 2021b paper and conclusions can not be traced to verifiable data; also, the mean annual Lena River discharge/runoff for years 2014-2020 can not be accessed because of incomplete officially published Roshydromet data from Kyusyur gauging station. The most recent data-supported trend estimate is 15.6% (1936-2013) from Tananaev et al., 2016 GRL.

RC: L188-189: Official data are incomplete for the Kyusyur g/s for 2019, therefore I wonder if the data are correct, and what is the actual source of these data; the following material suggests that no, not entirely, e.g. see below data on peak discharge.

AR: We would like to combine these three comments associated with the same issue and to provide one detailed answer for all of them. The discharge data for the Lena River collected by Roshydromet as well as for several other large Arctic rivers were published on the base of ArcticGRO project (Shiklomanov et al., 2021). These data could be accessed and used from this source: https://arcticgreatrivers.org/data/. At the moment of writing this response (November 2022) it is available for Kyusyur station until 29 May 2022. Moreover, there are a number of studies that use Lena River discharge data from ArcticGRO after the year 2013. We invite you to browse a good collection of them here: https://arcticgreatrivers.org/publications/ .

To make this clear we adjusted L199-202: "T*he discharge data are provided by the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet,* ***published by Shiklomanov et al., 2021b****) for the Lena River at Kyusyur (70.68°N, 127.39°E, see Figure 1a).*"

We also updated the reference list accordingly:

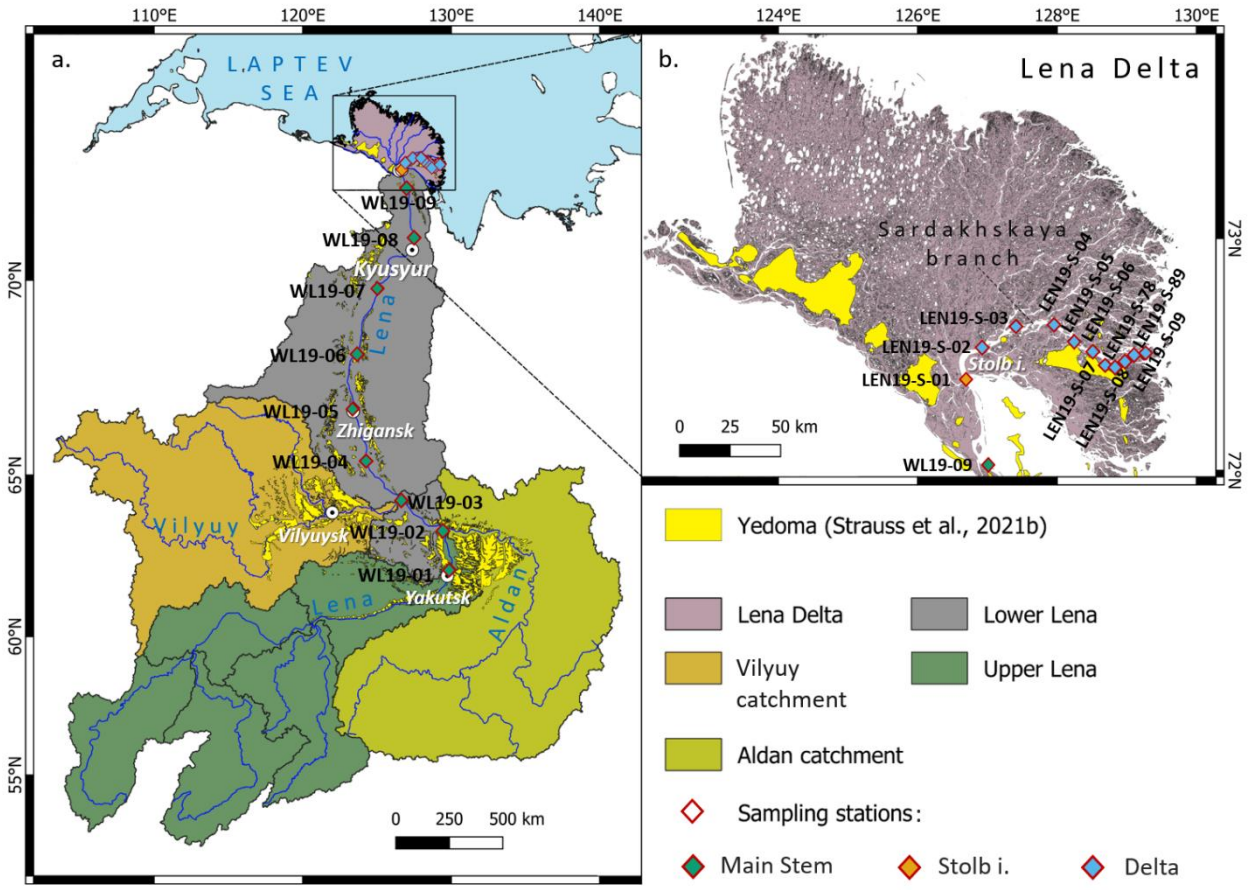
Shiklomanov, A., Déry, S., Tretiakov, M., Yang, D., Magritsky, D., Georgiadi A., Tang W.: River Freshwater Flux to the Arctic Ocean. In: Yang, D., Kane, D.L. (eds) Arctic Hydrology, Permafrost and Ecosystems. Springer, Cham., https://doi.org/10.1007/978-3-030-50930-9_24, 2021**a**

Shiklomanov, A.I., R.M. Holmes, J.W. McClelland, S.E. Tank, and R.G.M. Spencer. Arctic Great Rivers Observatory. Discharge Dataset, Version YYYYMMDD.

https://www.arcticrivers.org/data, 2021b

RC: Figure 1: Vilyuy

AR: We changed Figure 1 accordingly:



The name of the river was changed within the entire manuscript text accordingly as well: (see L104, 281, 324, 328, 341)

RC: L129-130: Is it correct that the sample volume for TSM analysis was less than 1L ? Though these samples evidently can not be retaken, it is assumed that a sample of at least 1L is needed to assure correct TSM measurement (in mg L-1). Sample freezing before filtration is also a questionable practice, since we have numerous times observed organic matter coagulation in (presumably) ferro-organic colloidal complexes upon freezing which would normally not be included in TSM if not frozen.

AR: In 2012, the "optimal filtration volume" for TSM analyses was established by Neukermans et al., (2012). They stated that an optimal sample volume is dependent on the amount of particles retained on the filter and must contain enough TSM to be sufficiently and precisely measured. Therefore, if enough particles are present in a volume less than 1 L, this is the optimal sample volume. Neukermans has also shown that it is possible to use a lower or higher volume of water as well and TSM concentration stays stable.

Additionally, it was further shown by Röttgers et al (2014) that the volume of the sample does not have a significant impact on TSM concentration variation (water samples from Elbe

estuary of volumes from 100 ml to several Liters were studied). Thus, it is appropriate to use an aliquot of less than 1 L for TSM measurement, when this water was taken from the river/estuary. The protocols you are referring to are often originating from the marine community sampling in clear oceanic waters with very low matter concentrations, which is definitively not applicable for Lena River and Delta water.

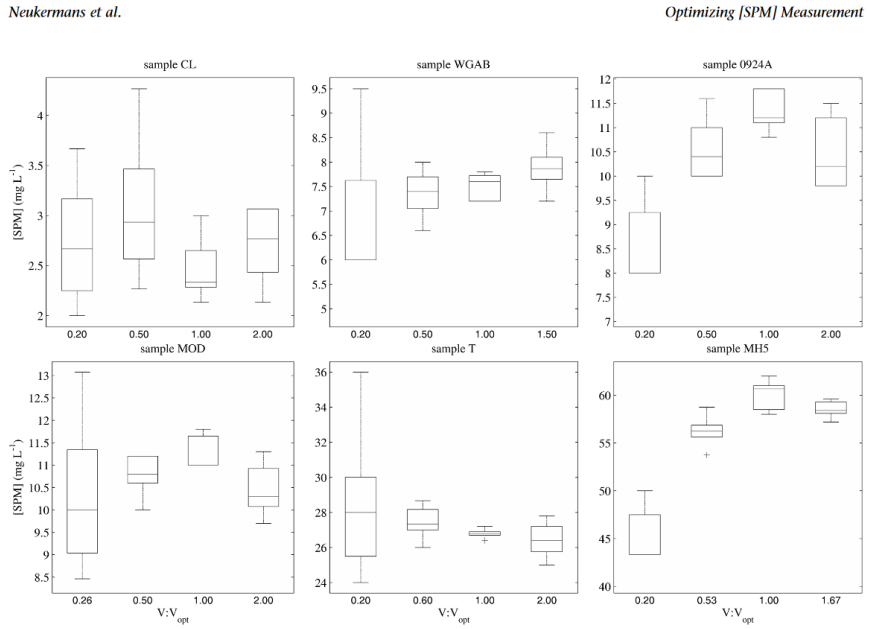


Fig. 8. Boxplot of [SPM] obtained through filtration of different volumes of sampled seawater at six different stations.

Figure 8 from Neukermans et al (2014).

Concerning your question on freezing the samples: In our work we avoided sample freezing when it was possible and filtrations could be done immediately. However, this could not always be realized. Thus we used immediate sample freezing for the water preservation. It was shown by Nachimuthu et al., (2020) that freezing of unfiltered water samples leads to variable DOC results, but is an appropriate treatment in case of total organic carbon determination.

RC: L186: TSM, SSC, SPM there are too many acronyms here, please reduce to one
Thank you, changed accordingly. L197: "..*spring – early summer ice breakup (maximum water and **TSM** discharge)"*

RC: L195: 'Discussion' if has important implications, otherwise in methods description. Also important whether a cross-section profiles were done at
AR: Since it is known that water profile of the river and estuary may be stratified (for example Geyer and Ralston, 2012), we suggest this result (the absence of stratification in the Lena Delta) is very important to be mentioned in the "Results" part of the paper. Cross-section profiles were not done. We sampled along a transect. This information is described in the methodology part (2.2. Sampling).

RC: L222-223 Georgiadi et al. 2019 ?
AR: We decided against referring to the mentioned work in that part of our paper because L

222-223 belongs to the result part of the paper. Here we would like to keep describing our own results and comparing them with ArcGRO dataset. Additionally, the manuscript mentioned does not include information regarding the TSM.

RC: L235: Georgiadi et al. 2019 ?
AR: Unfortunately, despite the huge interest of our group in the great work of A. Georgiadi , N. Tananaev and L. Dukhova and even an attempt to combine our datasets, we cannot directly compare our POC data with the data provided by this publication due to methodological differences. POC reported by Georgiadi at al. was determined as the loss of ignition using the theoretical calculation of C as 45% of OM lost during ignition and without pre-acidifying the filter, whereas we determined POC directly after getting rid of inorganic C by acidifying the filter.

RC: L275: The dataset is not a research subject but the TSM and POC are. So, not 'the dataset displayed', but 'the concentrations displayed'.
AR: Changed accordingly with editing (L288): "*Our TSM and POC concentrations measured in 2019 displayed generally higher and more variable values…*"

RC: L276: This preliminary suggests that further discussion will evolve around explanations why the TSM/POC concentrations are more variable in the Lena R. than in the delta. But is this accurate?
AR: This paragraph is an introduction for the detailed part of the discussion on the TSM/POC concentrations, which follows this paragraph as separate chapters (4.1.1 and 4.1.2).
A reference to Figure 2, which demonstrates that OC content in TSM is higher in the Lena Delta than in the Lena main stem was added.
L289: "*…while the OC content of TSM was higher in the Lena Delta* ***(Figure 2c)***."

RC: L285: 111,000 m3 s-1 according to official Roshydromet data; also provide values for Tabaga g/s since the transect starts there. A hydrogram will be useful to better relate the survey to actual hydrological conditions.
AR: Discharge data for the Lena River collected by Roshydromet as well as for several other large Arctic rivers were published on the base of ArcticGRO project, which we were happy to find and use here: https://arcticgreatrivers.org/data/.

RC: L301-302: No, unless you present data from spring freshet period, which comprises about 80 to 90% of suspended sediment runoff.
AR: Thank you. This sentence was removed following also the suggestion from the first anonymous referee.

RC: L315-316: This is incorrect. The Upper Lena R. is upstream Vitim, the Middle Lena is from Vitim to the Vilyuy R. mouth, and Lower Lena R. downstream the Viliyuy R. The discussion

that follows should be better aligned with hydrological reality of the catchment.

AR: Here, we define the Lower and Upper Lena River by the area of subcatchments of the Lena River. We did not subdivide Middle Lena as well as for example Kutscher et al., 2017 and Liu et al., 2005.

To define these subcatchments we used the most recent data that is available: https://www.hydrosheds.org/products/hydrobasins. As a result, while the Upper Lena River includes the catchment upstream of the Aldan junction, the lower Lena River consists of the catchment area downstream of the Aldan junction excluding the catchments of Aldan and Vilyuy.

To avoid any misunderstanding regarding the definition of the Upper and Lower Lena we added this essential clarification into our manuscript and to edit our previous description:

L99-105: *"The Lena River watershed was subdivided into the Upper and the Lower Lena, which contribute differently to the TSM and water discharge into the Lena River and are characterised by distinct morphologies.* ***Here, we define the Upper and Lower Lena River by the area of subcatchments of the Lena River (https://www.hydrosheds.org/products/hydrobasins). The separation between the Upper and Lower Lena was made approximately 150 km downstream from Yakutsk (Figure 1a). The Upper Lena includes the southern limits of the river and the catchment upstream of the Aldan junction, its watershed covers an extensive area between Lake Baikal and Yakutsk and includes dozens of tributaries including creeks and small rivers. The Lower Lena consists of the catchment area downstream of the Aldan junction excluding the catchments of Aldan and Vilyuy (Figure 1a). It flows from downstream of Yakutsk into the Laptev Sea and receives waters from catchments including the Verkchoyansk Range****."*

RC: L318-320: No

AR: Please take a look at our response to the previous comment. There, we explained our approach regarding the Lena River watershed subdivision.

RC: L333-334: The Lena River is not fed from the Central Siberian Plateau, except minor tributaries of the Vilyuy R. which is not, in any case, make part of the Upper lena River basin as declared here. The Aldan R. catchment never was 'relatively flat', and is flanked by the mountains all along the right-bank side, and the Aldan River itself originates from the mountainous region.

AR: To avoid misunderstandings we removed this sentence from the manuscript.

RC: L342: Vilyuy

AR: Yes, following your advice we replaced Vilyuy accordingly here and the rest of the manuscript: L104, 281, 324, 328, 341.

RC: L346: Kyusyur

AR: replaced accordingly and multiply along the entire manuscript (L126, 200, 324, 344, 345,

346, 400, 561) and at Figure 1 and 2.

RC: L351: Transport~~ing~~ ed
AR: Changed accordingly (L349).

RC: L347-348: If it is known, please reference.
AR: Changed accordingly in L345-347: "*It is also known that the majority of TSM brought by the Lena River from the water catchment is deposited before the Lena reaches the stream north of Kyusyur, which is known as the "Lenskaya Truba" (which means "Lena pipe")* ***(Antonov, 1960)***."
Reference list update:
Antonov, V.S.: The Lena River Delta.- Works of oceanographic committee of the Acad. Sci. USSR Vol. VI: 25-34, 1960 (in Russian)

RC: L442: ~~9~~ nine
AR: Edited accordingly (L441)

RC: L475-477: Any satellite imagery available for the survey dates to track river turbidity at sampling locations, and/or ChlA quantity ?
AR: Tracking river turbidity and/or chlorophyll-a in Arctic rivers using remote sensing is not a straightforward task. Thus, available products often lead to a misinterpretation of real conditions.
For instance, backscattering of phytoplankton in surface waters can result in stronger backscattering that could be misinterpreted as higher sediment particle load.
The Lena River as all Arctic rivers and Arctic coastal waters are optically complex waters. Optically, the water is dominated by the absorption of organic matter and existing algorithms currently fail to retrieve chl-a and sediment/turbidity load (IOCCG, 2015).

RC: L553-554: No need to explain what you show on the Figure - there is a figure caption for this. Figures are illustrative to your ideas - rather present ideas than figures.
AR: Changed accordingly (L559-562): "***The*** *estimated contributions of different OM sources to the actual average POC concentration measured for the Lena main stem and delta (Figure 5) showed that POC derived from Holocene soils decreased from 0.44 to 0.05 mg* L^{-1} *due to sedimentation, which takes place in the Lower Lena, particularly downstream from Kyusyur station, and in the delta itself as explained in section 4.1.2."*

RC: Figure 5: y-axis units ?
AR: Thank you very much! The y-axis units were lost and now they were reintroduced , and the figure was adjusted.

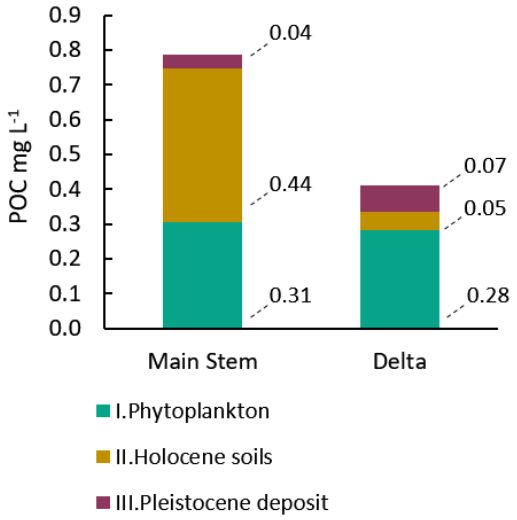


Figure 5. Contributions of different OM sources to the POC measured in the Lena River main stem and the Lena Delta along the transect in 2019.

RC: L592-593: Usually the data are made available prior to submission which is particularly reasonable for open access journals with open review.

AR: We agree with this statement and submitted our data to the PANGEA several months before submitting the manuscript. Unfortunately, due to the current load of PANGEA, our data is still not published yet.

The authors would like to thank AR for their work, time, editing and contribution to our manuscript and wish them all the best!

References used in this response:

Georgiadi, A.G., Tananaev, N.I. & Dukhova, L.A. Hydrochemical Conditions at the Lena River in August 2018. *Oceanology* **59**, 797–800, https://doi.org/10.1134/S0001437019050072, 2019

Geyer, W. R., and D. K. Ralston. 2012. The Dynamics of Strongly Stratified Estuaries. Treatise on Estuarine and Coastal Science. Vol. 2. Elsevier Inc. https://doi.org/10.1016/B978-0-12-374711-2.00206-0

IOCCG (2015). Ocean Colour Remote Sensing in Polar Seas. Babin, M., Arrigo, K., Bélanger, S. and Forget, M-H. (eds.), IOCCG Report Series, No. 16, International Ocean Colour Coordinating Group, Dartmouth, Canada.

Kutscher, L., Mörth, C.-M., Porcelli, D., Hirst, C., Maximov, T. C., Petrov, R. E., and Andersson, P. S.: Spatial variation in concentration and sources of organic carbon in the Lena River, Siberia, J. Geophys. Res. Biogeosci., 122, 1999– 2016, https://doi:10.1002/2017JG003858, 2017

Liu, B., Yang, D., Ye, B., Berezovskaya, S.: Long-term open-water season stream temperature variations and changes over Lena River Basin in Siberia, Global and Planetary

Change, Volume 48, Issues 1–3 (pp 96-111), https://doi.org/10.1016/j.gloplacha.2004.12.007, 2005

Nachimuthu, G., Watkins, M. D., Hulugalle, N., & Finlay, L. A.: Storage and initial processing of water samples for organic carbon analysis in runoff. MethodsX, 7, 101012. https://doi.org/10.1016/j.mex.2020.101012, 2020

Neukermans, G, Ruddick, K., Loisel, H., Roose, P.: Optimization and quality control of suspended particulate matter concentration measurement using turbidity measurements, Limnol. Oceanogr. Methods, 10, doi:10.4319/lom.2012.10.1011, 2012

Röttgers, R., Heymann, K., Krasemann, H.: Suspended matter concentrations in coastal waters: Methodological improvements to quantify individual measurement uncertainty, Estuarine, Coastal and Shelf Science, Volume 151 (pp 148-155), https://doi.org/10.1016/j.ecss.2014.10.010, 2014

Shiklomanov, A.I., R.M. Holmes, J.W. McClelland, S.E. Tank, and R.G.M. Spencer. Arctic Great Rivers Observatory. Discharge Dataset, Version YYYYMMDD. https://www.arcticrivers.org/data, 2021