Author’s response to the review

Referee #1 (Piotr Kowalczuk):

<u>The reviewer's comments are in bold.</u>

Ref 1#: Authors have presented a study based on unique data set collected during ship based and ice based expeditions between 2010-2019 in the Lena River delta and Laptev Sea. Based on this data set Authors have established a sound relationship between CDOM absorption coefficient a_{CDOM}(350) and DOC concentration in the Laptev Sea and East Siberian Sea. Using salinity and oxygen isotopes data together with a_{CDOM}(350), they have established water mass balance and calculated the organic carbon budget in the Lena River delta. Authors calculations revealed that ca. 15. TG of carbon is rejected from land fast ice with brine during ice formation, and is exported from Laptev Sea shelf into Transpolar Drift and to the East Siberian Sea shelf waters. Author have also concluded that melt water from mealting land fast ice in the Laptev Sea shelf dilutes the CDOM contained in the Lena River plume. The additional source of fresher water with lower CDOM content explained the mixing anomaly indicated in the CDOM vs. salinity mixing diagram.

The manuscript is very well written, and well edited serving as very important source of information on poorly described and quantified part of the DOM cycle in the Arctic Ocean. I found it very interesting and providing new and very relevant information. In my opinion this study deserved prompt publication after minor revision.

Detailed remarks Hölemann et al, are particularly important in the context of the current questions on the organic carbon flux exported from Arctic Ocean through Fram Strait. For this reason I recommend this paper for prompt publications.

We would like to thank Piotr Kowalczuk for reviewing our paper and for his helpful and constructive comments and remarks. In the revised version of the paper, we address the mentioned criticisms.

Ref.#1: The weak point of the manuscript is within discussion on the land fast ice annual cycle of freeze and thaw. This is especially important in the context of the CDOM. CDOM is not only rejected from the ice with brine but also its composition is significantly altered. I do recommend inclusion of findings presented in papers by Müller at al., 2011 and 2013 (Ann. Glaciol. 52 (57), 233–241; Mar. Chem. 155, 148–157), who studied the composition modification of CDOM contained in the ice during field studies and during controlled experiment. Further modification of CDOM in the ice results from biological activity in spring and summer. Studies by Granskog et al., 2015 (Ann. Glaciol. 56 (69)), Retelleti-Brogi et al., 2018 (Sci. Total Environ. 627, 802–811), and most recent by Zabłocka et al., 2020 (Mar. Chem. 227, 103893), have documented that CDOM produced by sympagic algae leads to overall dominance of the protein-like fractions in the CDOM/FDOM composition.

We have added to the Introduction a more detailed discussion of the changes in the composition of the DOM/CDOM locked in the ice.

Line 85:”*During sea ice growth, DOM is expelled from ice crystals and concentrates in brines, which can then drain into the underlying sea water (Müller et al., 2013). The DOM* *remaining in the ice undergoes significant fractionation. The humic-like DOM fraction is most prone to rejection from the sea ice along with the brine during freezing, while the protein-like fraction is least prone to this process, which shifts the molecular composition of DOM in the ice towards a higher proportion of low molecular weight compounds (Müller et al., 2013; Granskog et al., 2015a; Retelletti-Brogi et al., 2018, Zabłocka et al., 2020).*"

We have also briefly described the effect of the dominance of protein-like substances in sea ice that has a high proportion of marine DOM.

Line 322: *"The high $a_{CDOM}(350)$ coincided with high chlorophyll-a concentrations (K. Abramova, pers comm.). However, CDOM absorption spectra of algae-rich ice samples exhibited no ultraviolet absorption shoulders that indicate mycosporine-like amino acids from sympagic autotrophic organisms (Xie et al., 2014; Granskog et al., 2015b)."*

Ref #1: I also suggest minor correction in the abstract. Specifically, phrase " Laptev (LS) and East Siberian Seas (ESS) receive enormous amounts of tDOM rich" should be rewritten in the sentence containing a approximate quantitative information about riverine discharge.

We have reworded and shortened the abstract to make the aims of this study more apparent. The sentence in question now reads:

"Each year, ~ 7.9 Tg of dissolved organic carbon (DOC) is discharged into the AO via the three largest rivers that flow into the Laptev (LS) and East Siberian Sea (ESS). A significant proportion of this tDOM-rich river water undergoes a freeze-melt cycle in the land-fast ice that forms along the coast of the Laptev and East Siberian Sea in winter".

Ref#1: Except suggested short paragraph in the discussion, on the alteration of the CDOM/FDOM composition due to brine rejection during freeze and biological production during spring, that should be added during revised manuscripts edits, I did not find any weak point in this presentation.

We have included the description of these processes as part of the introduction (line 85, see above).

Referee#2 (anonymous)

<u>The reviewer's comments are in bold.</u>

Ref#2: The authors present an impressive data set collected over a longer period, from a region which importance for the Arctic Ocean is substantial. This data simply needs to be published and the authors are acknoweldged for making the data publicly available.

That said, I found that the manuscript only scratches the surface, and the authors could have done a much thorough job to at least have a closer look at some aspects of the data they present. Admittedly the Siberian shelf system with runoff, sea-ice formation, sea-ice melt, complex circulation pattern is also very complex to understand, and thus also a more thorough examination of the data is warranted.

Salinity-property plots are not well equipped in such a system with multiple source waters, and the oxygen isotope data available to the authors should have been exploited more fully with the DOC and CDOM data. Also a closer look at the S275-295 for evidence of possible photodegradaton should have been done more thoroughly.

It would also be nice to see a more thorough discussion on how this data can help to explain the formation of the Arctic halocline waters.

We thank the referee for the constructive comments and questions. We also thank the anonymous reviewer for the positive comment on the publication of the entire data set. To "fully" analyse this dataset, which spans a 9-year period and multiple summer and winter expeditions, and present the results in this study is beyond the scope of this paper. However, we believe that the results presented in this paper give a key to any further interpretations. The main objective is to show, using measurements and calculation of budgets, that the distribution of DOM concentrations in the Laptev and East Siberian Sea is determined primarily by the mixing of three freshwater "parent water masses" (river water during the freshet, river water after the freshet, and meltwater from the fast ice) with different DOM concentrations and compositions. As far as we understand, this central hypothesis is not challenged by the reviewer. Although this paper addresses only one aspect of the topic of DOM transport and degradation in the Arctic Ocean, we believe it makes an important contribution to the scientific debate. In order to give other scientists the opportunity for further analysis regarding other aspects, we have decided to publish the entire data set in full spectral resolution. In trying to write the paper as concisely as possible, we seem to have inadequately presented important results of our analysis (such as the presentation of the ratio of the river water fraction - O18 data - to CDOM absorption). We hope that the reviewer will nevertheless believe us when we emphasize that we have thoroughly analysed the data set.

A detailed determination of the degradation rates of tDOM on the Siberian shelves is not the central topic of this study. Our data set also indicates that some tDOM is removed in the area of the Siberian shelves. However, it also indicates that degradation of tDOM cannot adequately explain the observed concentration distribution on the shelves. However, we agree with the reviewer that we should better elaborate on the key messages by including figures of river water fraction (O18 data) and CDOM absorption and discussing these data in more detail. We have done this in the revised version of the manuscript and hope that we have address the reviewer's main criticisms. We also discuss the slope values (S275-295) and their significance in more detail. However, the inclusion of these results, which was certainly necessary, does not disprove the central conclusions of this paper but is further evidence of the plausibility of our hypotheses.

The formation of the Arctic halocline is an important and interesting research topic that our group has also been working on for more than 20 years. However, the description of this physical-oceanographic process is not - and cannot be - the subject of this paper. In this context, we refer to the published studies of some of the coauthors: Bauch et al. (2009, JGR), Bauch et al. (2011, Prog in Oceanogr.), Bauch et al. (2014), Janout et al. (2017), and Janout et al. (2020). These papers, which are cited in our paper, provided an important basis for the hypotheses presented in this study.

Detailed answer to Referee #2

Comments and questions from the reviewer are in bold.

Title: "the impact" - perhaps nice to have a title that is descriptive in the way it tells what the assumed impact is

The growth and melting of land-fast ice has several effects on the distribution of DOM. It does not make sense to list them in the title. We suggest the following title: *"The impact of the freeze-melt cycle of land-fast ice on the distribution of dissolved organic matter in the Laptev and East Siberian Seas (Siberian Arctic)"*

Line: 17 / delete "their"

Done

Line: 17-19 / sampling for oxygen isotopes is not described

We have include a sentence explaining that oceanographic data (T,S) were also collected and samples were taken for the determination of oxygen isotopes: "*The dataset, covering different seasons over a 9-year period (2010-2019), was complemented by oceanographic measurements (T, S) and determination of the oxygen isotope composition of the sea water.*"

Line 18: / delete "concentration", and add "(CDOM) absorption" - assuming you measured the absorption of CDOM, not fluoresence? and **Line 19: / You make the assumption that all the DOM is of terrestrial origin, but there must be some marine production, or release from sediments?, thus the more generic term of DOM should be used, unless you have solid evidence this is all terrigenous material...**

We have rephrased the sentence: *"To better understand how growth and melting of land-fast ice affect dissolved organic matter (DOM) dynamics in the LS and ESS, we determined DOC concentrations and the optical properties of colored dissolved organic matter (CDOM) in sea ice, river water and sea water."*

Line 21 / 211 km^3 average over the years?? and Line 22 / 245 km^3 average over the years?? which period exactly (give months).. for both landfast ice melt and river water.

Unfortunately, we have not noticed that a numerical error has crept into the abstract. We have rewritten this part: *"Although removal of tDOM cannot be ruled out, our study suggests that conservative mixing of high-tDOM river water and sea-ice meltwater with low-tDOM sea water is the major factor controlling the distribution of tDOM in the LS and ESS. A case study based on data from winter 2012 and spring 2014 shows that the mixing of about 273 km^3 low-tDOM landfast-ice melt water containing ~ 0.3 Tg DOC with more than 200 km^3 high-tDOM Lena river water discharged during the spring freshet (~ 2.8 Tg DOC yr-1), plays a dominant role in this respect. The mixing of the two low-salinity surface water masses is possible because the meltwater and the river water of the spring freshet flow into the southeastern LS at the same time every year (May-July). In addition, budget calculations indicate that in the course of the growth of land-fast ice in the southeastern LS, ~ 1.2 Tg DOC yr^{-1} (± 0.54 Tg) can be expelled from the growing ice in winter together with brines."*

Line 25 / the shelf is quite shallow, so what do you mean by "near-surface layer", please be more specific, as usually one assumes that the dense brine-rich water would find their way to the bottom on the shelf, no?

We have also rewritten this part of the abstract: *" In addition, budget calculations indicate that in the course of the growth of land-fast ice in the southeastern LS, ~ 1.2 Tg DOC yr^{-1} (± 0.54 Tg) can be expelled from the growing ice in winter together with brines. These DOC-rich brines can then be transported across the shelves into the Arctic halocline and the Transpolar Drift Current flowing from the Siberian Shelf towards Greenland. "*

The entire central and eastern Laptev Sea with its high inputs of river and meltwater has a strong density stratification that persists well into winter. Even in extreme years when the winds transport the river and meltwater plume to the east, the stratification in the central Laptev Sea is not completely eroded until March. Our research group was able to demonstrate this using measurements with oceanographic moorings (Janout, M., Hölemann, J., Smirnov, A., Krumpen, T., Bauch, D., Laukert, G., and Timokhov, L.: On the variability of stratification in the freshwater influenced Laptev Sea region, Front Mar Sci, doi: 10.3389/fmars.2020.543489, 2020.). Additional citations can be found in the Discussion section. Brines that form during the strong growth of fast ice in October to March in the SE Laptev Sea are therefore not transported in bottom waters across the inner and central shelf but in the surface mixed layer (0-10 m) and within the pycnocline (10-25 m). On the outer shelf and in the area of the continental slope, the DOM-rich brines from the SE Laptev Sea can be mixed into greater water depths by the supply of further DOM-poor but denser brines and by mixing processes at the shelf edge (Schulz et al, 2021), but the DOM concentration will be diluted. We tried try to illustrate this better in the discussion (chapter 4.4):

"*A significant proportion of the surface waters (0-20 m) of the LS and western ESS leaves the Siberian shelf north of the New Siberian Islands (Morison and Kwok, 2012) and supplies the Transpolar Drift Stream with tDOM-rich water masses (Charette et al., 2020), while denser bottom waters flow north of the New Siberian Island further to the east and leave the shelf in the western ESS (Anderson et al. 2017). The transport of tDOM in the water masses at the upper halocline is confirmed by investigations in the East Greenland Current where a higher CDOM absorption occurring between 30 and 120 m water depth at salinities between 32 and 33 is explained by a high fraction of brine and river water from the Siberian shelves (Granskog et al., 2012).*

During the northward transport of the brine-enriched water masses across the shelf, an increase in density occurs due to the further influx of brines from ice formation in leads and coastal polynyas of the western LS (Janout et al., 2017). Erosion of the density stratification at the end of winter and mixing with denser water masses from the western shelf of the LS could dilute the tDOM-rich brines from the southeastern LS but at the same time increase the density and bring them to greater water depths where they then flow into the Arctic halocline. The seasonal evolution of the density stratification in the LS is described in more detail in Janout et al. (2020). The water depth at which the brine is transported across the LS shelf and into the Arctic halocline depends mainly on the density structure of the water column in winter, which in turn depends on the position of the ROFI in the previous summer (Bauch et al, 2012). An eastward-directed transport south of the New Siberian Islands towards the ESS at depth greater than ~ 20 m is inhibited by the shallow water depths of the Dmitry Laptev (10 m) and Sannikov Straits (18 m)"

Schulz, K., Janout, M., Lenn, Y.-D., Ruiz-Castillo, E., Polyakov, I., Mohrholz, V., Tippenhauer, S., Reeve, K. A., Hölemann, J., Rabe, B., and Vredenborg, M.: On the Along-Slope Heat Loss of the Boundary Current in the

Eastern Arctic Ocean, Journal of Geophysical Research: Oceans, 126, e2020JC016375, https://doi.org/10.1029/2020JC016375, 2021.

Line 27-29 (last sentence of abstract) / Feels like hand waiving, and unless there is something more substantial to support this vague statement, delete it. If you can describe what is potentially changed, it would have more substance.

In the conclusions we have presented this in more detail and hopefully better. We have removed this sentence and replaced it with: *"The study of dissolved organic matter dynamics in the AO is important not only to decipher the Arctic carbon cycle, but also because CDOM regulates physical processes such as radiative forcing in the upper ocean, which has important effects on sea surface temperature, water column stratification, biological productivity, and UV penetration"*

Line 32 / I would find that work by e.g. Stroeve and coworkers is more appropriate citation here.. e.g.

Stroeve, J., & Notz, D. (2018). Changing state of Arctic sea ice across all seasons. Environmental Research Letters, 13(10), 103001. https://doi.org/10.1088/1748-9326/aade56

We agree with the reviewer and have cite the proposed study in the revised version of the paper.

Line 34 / Impressive number in Pg of C, but without context it is useless .. please provide context for this amount of carbon.

Honestly, we don't understand this comment. In our opinion, the context is apparent in the sentences following the citation: *"Due to the accelerated degradation of terrestrial permafrost, an estimated 1035 ±150 Pg of organic carbon stored in the upper three meters of circumpolar permafrost soils (Hugelius et al., 2014) can be either mineralised and mobilized as terrestrial dissolved organic matter (tDOM) into the hydrosphere or released as gaseous emissions into the atmosphere (Plaza et al., 2019). The release of soil carbon into the hydrosphere in combination with an increasing freshwater discharge from Arctic rivers (McClelland et al., 2006, Rawlins et al. 2010; Haine et al., 2015) might thus increase the flux of tDOM into the ocean (Frey and Smith, 2005; Guo et al., 2007; Prokushkin et al., 2011; Tank et al., 2016)."*

Line 40 / replace "in the high" with "at high"

Done.

Line 48 (and paragraph above): What about the ESS - you describe both LS and ESS in the abstract, but here focus on LS only. Aren't there also riverine fluxes of DOM to the ESS as well? How large are they compared to LS/Lena? And what about diffuse input, not carried by the largest rivers? Which fraction of the water shed (area wise) does the larger rivers cover?

We have rewritten the paragraph in question and added the missing information:

„*Currently, the annual riverine input of DOC into the AO is about 25-36 Tg C yr^{-1} (Raymond et al., 2007; Anderson and Amon, 2015), with the six largest Arctic rivers discharging about 18-20 Tg C yr^{-1} (Stedmon et al., 2011; Amon et al., 2012). The three major Siberian river* *systems (Ob, Yenisey and Lena) account for about 14 Tg C yr^{-1} (Holmes et al., 2012) with the Lena River alone discharging 6.8 Tg C yr^{-1} DOC into the Siberian Laptev Sea (LS) (Juhls et al., 2020). The total riverine DOC flux to the LS is about 8.3 Tg C yr^{-1} (Manizza et al., 2009), with the Lena drainage basin (2.61 x 10^6 km²) accounting for about 70 % of the total area of the LS watershed. The LS additionally receives freshwater from the outflow of the Kara Sea (KS), which transports river water from Ob and Yenisey through the Vilkitzky Strait into the northwestern LS (Janout et al., 2015). The combined DOC flux of the two major rivers discharging to the ESS (Kolyma and Indigirka) is ~1.1 Tg DOC yr^{-1} (Opsahl.et al., 1999), which is ~50 % of the total annual riverine DOC flux to the ESS (Manizza et al. 2009). The combined area of the drainage basin of the Rivers Kolyma and Indigarka (1.01 x 10^6 km²) accounts for ~75 % of the total ESS watershed.*

The total terrigenous input (particulate and dissolved) of carbon to the AO from costal erosion is estimated to be 15.4 Tg yr^{-1} (9.2-24.2 Tg yr^{-1} with one standard deviation; Terhaar et al., 2021). However, DOC concentrations measured in Bhuor-Khaya Bay east of the Lena Delta, a region known for the most rapid and extensive coastal erosion of the Siberian Arctic coastline, suggest that direct DOC input from coastal erosion must be small compared to the riverine DOC flux (Alling et al., 2010)."

Line 54-55 / Also Granskog et al. 2012 indicated loss in Fram Strait and **Line: 54-55 / And for Hudson Bay another study on estimating loss of (t)CDOM was also presented in:**

Granskog, M., et al. (2009). Coastal conduit in southwestern Hudson Bay (Canada) in summer: Rapid transit of freshwater and significant loss of colored dissolved organic matter. Journal of Geophysical Research, 114(C8), C08012. https:// doi.org/10.1029/2009JC005270

We added the Fram Strait and the associated citation (Granskog et al., 2012) and the study in Hudson bay (Granskog et al, 2009): *"In contrast, a number of studies indicate significant degradation of tDOM in the Arctic Ocean. (Bélanger et al., 2009, Alling et al., 2010; Stedmon et al., 2011; Letscher et al., 2011; Kaiser et al., 2017a), the Fram Strait (Granskog et al. 2012), and the Hudson Bay (Granskog et al., 2009; Granskog, 2012)."*

Is there differences in the ice season length on Laptev versus Hudson Bay, that could indicate different potential for photochemistry?

Unfortunately, Hudson Bay was not part of our study. It was also not our goal to compare the Laptev Sea and the East Siberian Sea with all Arctic seas. We can only refer to previously published studies and satellite data of ice cover (Univ. Bremen etc.) to answer the question. The ice season in Hudson Bay is only slightly shorter than in the fast ice areas in the eastern Laptev Sea and the western East Siberian Sea. The seasonal period with 50% ice cover is about one month shorter in Hudson Bay. However, in terms of photochemistry, two other factors could make a crucial difference. First, the study area in Hudson Bay (Granskog et al., 2009) is south of the Arctic Circle between 55° N and 61° N, whereas our study area is north of the Arctic Circle between 70° N and 78° N. Since Granskog's study is based on post-summer data (October), we would suggest that the significant differences in solar radiation between the two marine areas could be a major factor. Second, salinities in the eastern Laptev Sea south of 75° N in the surface mixed layer (0-10 m) are below 25 in all years studied with a_{CDOM} (350) above 6 m^{-1}. This leads to strong absorption of solar radiation already in the uppermost 2 m of the water column and could further reduce photochemical processes in the deeper water layers.

Another key difference between the marine areas is also mentioned in Granskog et al (2009): "Clearly, in considering any process related to freshwater in Hudson Bay, both RW (river water) and SIM (sea-ice meltwater) need to be considered. The distribution, location of entry, and timing of these two freshwater sources differ." This is not the case in the SE Laptev Sea. Here, about a third of the annual river discharge and more than 40% of the annual DOC input flows into the SE Laptev Sea where considerable amounts of fast ice are melting at the same time. The description of this process and its impact on the distribution of tDOM is one of the main topics of our study.

In the Granskog study, the river water fraction is at most 25%. In our study from the Laptev Sea it is much higher. The Laptev Sea is a major ice-formation and export shelf sea with an open boundary to the Nansen and Amundsen Basin and thus probably more dynamic. I am sure that there are many other differences that could also explain the different potential for photochemical processes. However, this is not the subject of our paper.

Line 62 / delete "a" before tDOM

Done.

Line 66 / But in fact all the studies you cite here elude towards a loss of tDOM, isn't that consistent? and **Lines 65-71 / Here also refer to work by Belanger et al (2006) and the CDOM losses have been estimated in the FramStrait (Granskog et al 2012), and the work of Manizza and co-workers approached this from a modelling perspective, for completeness also discuss these results in the paragraph lines 65-71.**

Yes, this sentence is not well formulated and misleading. In contrast to the studies on the Arctic marginal seas, all publications cited here postulate a degradation. Whereby the residence time and degradation rates of DOM varies between studies. We decided to delete this paragraph because the publications cited here deal with the residence time of DOM in the AO. However, this is not directly related to our study.

Line 74 / You mean conservative mixing? Why do you not simply say so. This is an awkward way of telling that.

We have tried to avoid using the term "conservative mixing" here because it already implies an interpretation of the observation. Since we do not want to appear awkward, we rephrased the sentence to: *"Considering the high seasonal variability in input and chemical composition of tDOM and a predicted strong degradation of tDOM that is controlled by multiple processes, it appears puzzling that most studies in the LS have observed a conservative mixing of tDOM."*

Line 77 / depends on the what the sea ice melts into..and Line 77 / and here it is more appropriate to say "DOM" since offshore there is also marine DOM in the water column.

That is, of course, correct. We rephrased the sentence: *„On the other hand, melting of CDOM-poor drifting pack ice (Kowalczuk et al., 2017) or immobile land ice (Wegner et al., 2017) is also important because it produces a freshwater source that can dilute higher DOM concentrations in the surrounding sea water (Amon, 2004; Mathis et al., 2005; Granskog et al., 2015b; Logvinova et al., 2016; Tanaka et al. 2016)."*

Line 79 / what do you mean by thin, and does it melt in place or is it mobile?

We are referring here to the drifting pack ice north of the fast ice. We have rewritten this section to make this clear: *"At the end of winter, the LS shelf north of the land-fast ice (Fig. 1) is covered by large areas of open water (polynyas) and thin (< 50 cm) pack ice, which has almost completely retreated by the end of June (Itkin and Krumpen, 2017). The retreat of the pack ice is predominantly controlled by the prevailing atmospheric conditions in April and May (Janout et al., 2016a). Whereas land-fast ice that forms in winter in the LS and ESS between 115° E and 170° E retreats only during the month of July (Selyushenok et al., 2015)."*

Janout, M. A., Hölemann, J., Waite, A. M., Krumpen, T., von Appen, W. J., and Martynov, F.: Sea-ice retreat controls timing of summer plankton blooms in the Eastern Arctic Ocean, Geophys Res Lett, 43, 12493-12501, 10.1002/2016gl071232, 2016a.

Line 81 /There are in fact a number of experimental studies that directly look at the fractionation of DOM during sea ice formation.. and the latter point to a minor preferential retention of DOM in ice vs. salt..

Following also the suggestions of reviewer 1, we have describe the results of these studies in more detail in the Introduction. Line 85 in the resubmitted version"*During sea ice growth, DOM is expelled from ice crystals and concentrates in brines, which can then drain into the underlying sea water (Müller et al., 2013). The DOM remaining in the ice undergoes significant fractionation. The humic-like DOM fraction is most prone to rejection from the sea ice along with the brine during freezing, while the protein-like fraction is least prone to this process, which shifts the molecular composition of DOM in the ice towards a higher proportion of low molecular weight compounds (Müller et al., 2013; Granskog et al., 2015a; Retelletti-Brogi et al., 2018, Zabłocka et al., 2020).*"

Line 82 / replace "also explain" with "may explain" - before you have solid proof it is not another process. and **Line 84 / landfast sea-ice and Or do you mean sea ice in general, or the ice melting in place?** and **Line 87 / replace "studied" with "understood"**

We have rewritten this section of the introduction.

Lines 102-103 / The two sentences could be combined to: "Six ice cores from three different sites (Fig. 1) in March-April 2012 were analysed (Ti12, Table 1).

Yes that sounds better. We have combine the two sentences in the revised version of the paper: *"Six ice cores taken at three different locations (Fig. 1) in March-April 2012 were analysed (Ti12_ice, Table 1)."*

Lines 102-103 / Should the campaign be "Ti12_ice" for the ice cores??

Yes. We chose an extra campaign label for the ice cores because the O18 data from the ice cores, unlike the Ti12 water samples, have not yet been published in PANGAEA.

Figure 1 / where all stations visited every year of sampling?, if not, please somehow indicate in the figure which where visited in which year (or expedition).

No, not all stations were sampled again every year. We can point this out again in the caption. We have tried to mark the individual expeditions with different colors. But this makes the figure completely confusing. However, each record of the different expeditions has a doi at PANGAEA. When one opens the doi, a map of the sample locations appears. One can zoom into this map. If you drag the cursor over the individual stations a pop-up window opens that gives the metadata of that station. We have referred to this possibility in the caption: *"Figure 1. Map of the Laptev (LS) and East Siberian (ESS) Seas and station distribution during the ship-based expeditions in summer (red dots). The border between the LS and the ESS runs along 140° E. The LS was sampled in 2010, 2011, 2013, 2014, 2018, and 2019. Only a few stations could be repeatedly sampled in multiple years. The ESS was sampled in 2019. Maps of the stations of each expedition with a detailed description of the location and date are available under the respective doi of the PANGAEA data publications (Table 1, Hölemann et al., 2020 a-g; Kattner et al., 2010). In addition, samples of land-fast ice (fast ice) and the water column were taken from March to April 2012 (yellow stars). The extent of fast ice describes the situation on May 1, 2011. The grey line between A and B represents the oceanographic transect shown in Figure 6. Bathymetric data were provide by IBCAO V3 (Jakobsson et al., 2012)."*

Figure 1 / Bathymetry perhaps draw e.. the 50 m or 100 m isobath for clarity. And what is the source for the bathymetry?

The bathymetry is based on IBCAO Version 3.0 (we mention this in the caption: "*Bathymetric data were provide by IBCAO V3 (Jakobsson et al., 2012).*". Inserting the 100 m isobath that also marks the shelf edge is a good idea. We have insert the 100 m depth line.

Figure 1 / Does the 245 km^3 also include the ice in the ESS? (all that is shown on the map)? If not, please show where you draw the border between LS and ESS in your budgets. And is this the average over a period of years, please clarify in the caption.

The figure explicitly states that the 245 km^3 refers only to the fast ice in the Laptev Sea. The basis of the calculation is the publication of Selyuzhenok et al. (2015). The volume of fast ice in the East Siberian Sea is subject to strong annual variations. This is explained in more detail in the discussion. It is also described there that we have drawn the boundary (according to the general definitions) between the Laptev and East Siberian Sea at 140°E. We now also explain this in the caption: "*The border between the LS and the ESS runs along 140° E.*"

Table 1: / "Campaign/expedition" rather than "Name"

We have changed the column label in the table to "*Campaign*"

Line 118 / Section 2.2, how were oxygen isotope samples collected, and volume large enough to make robust salinity measurement from same sample?

Yes. Oxygen isotope samples were collected in 100ml glass bottles. About 80ml of the volume was taken for salinity measurements. Accordingly analysis with an AutoSal 8400A salinometer (Fa. Guildline) were made with a precision of ± 0.003 and an accuracy greater than ± 0.005. This is already stated within the manuscript.

Line 124 / "containers" rather than "boxes"?

We now use the term "*containers*"

Line 126-127 / -what samples were drawn from the ice cores, DOC, CDOM, O18, salinity?

Samples were taken from the ice cores for salinity, DOC, CDOM, nutrients, chlorophyll a, particulate matter and O18. Only salinity, DOC, CDOM and O18 were "open" to be used in this study. The O18 samples belong to Dorothea Bauch. It was her advice not to use the O18 data from the land-fast ice. The reason for this is explained in the manuscript. Line 450 in the resubmitted manuscript: *"When interpreting the data, it is important to note that calculated sea ice meltwater fractions do not include meltwater from ice formed from river water (Bauch et al., 2010). Also, because fast ice includes a high and variable proportion of river water,* $\delta^{18}O$ *measurements of land-fast ice from the LS cannot be used directly as an end member for sea ice meltwater."*

Line 127 / Which unit of salinity is used for the data in this paper?

Our measurements are based on conductivity, temperature and pressure. We used the practical salinity scale to describe salinity (PSS 78). Line 129 in the resubmitted manuscript: *"In this study we used the practical salinity scale to describe salinity (PSS-78)."*

Line 150 / what is the effect of microbial degradation on this slope? and also Granskog (2012) indicated that slopes of shorter wavelengths are sensitive to removal.

We expanded the description and describe the effect of microbial degradation on the slope as well. To comply with the reviewer's request, we will also include the citation from Granskog (2012): *"The spectral slope of the absorption spectra in the wavelength range between 275-295 nm* ($S_{275\text{-}295}$) *and between 300-600 nm* ($S_{300\text{-}600}$)*was calculated by fitting with an exponential function* $a_{CDOM}(\lambda) = a_{CDOM}(\lambda 0)\cdot e^{-S(\lambda-\lambda 0)}$*. The usefulness of* $S_{275\text{-}295}$ *and other spectral slopes at shorter wavelengths for determining the origin and diagenesis of CDOM was demonstrated in the studies by Granskog (2012) and Fichot and Benner (2012). Based on the relationship between* $S_{275\text{-}295}$ *and DOC-normalised lignin yield, Fichot and Benner (2012) showed that* $S_{275\text{-}295}$ *is lower than 20* μm^{-1} *when the proportion of terrestrial DOC is higher than 50%. Steeper spectral slopes (i.e. higher* $S_{275\text{-}295}$*) are typically associated with a higher proportion of marine CDOM. Steeper* $S_{275\text{-}295}$ *slopes have also been associated with photochemically induced shifts in molecular weights (Helms et al. 2008). The spectral region between 275 nm and 295 nm lies at the short-wavelength edge of the natural solar spectrum. Solar ultraviolet radiation shows significant degradation for CDOM in natural aquatic ecosystems. In contrast to 295 nm, almost no photons are present at 275 nm in the lower atmosphere. It is therefore assumed that solar radiation absorbed by CDOM would always lead to a greater change in* $a_{CDOM}(295)$ *than in* $a_{CDOM}(275)$ *and consequently to an increase in* $S_{275\text{-}295}$*, so that increased slope values are a good indicator of photodegradation, while microbial degradation should have the opposite effect (Helms et al., 2008). However, in marine systems such as the LS and ESS, which are characterized by a high riverine input of terrestrial CDOM, non-terrestrial sources and non-photochemical processes only become visible once the absorption of terrestrial CDOM has been removed to a high degree (Granskog, 2012."*

"Line 160 / Since the choice of end-member is probably quite important in such a system, what are the uncertainties in the fraction calculated using this mass-balance equation?

The answer has already been published in several publications by Dorothea Bauch and repeated in this study in the Methods section. Line 210 in the revised version of the manuscript: *"The analytical errors from $\delta^{18}O$ and salinity measurements add up to approximately ±0.3 % for each of the fractions. The additional systematic error depends on the exact choice of end-member values. When end-member values are varied within the estimated uncertainties (Bauch et al., 2013), both fractions are shifted by up to ~1 % in absolute values, but results are qualitatively always conserved even when extreme variations in end-member values are tested (Bauch et al., 2011).*

The endmembers are well known for the study area (Bauch et al., 2010, 2013). The only exception is the sea-ice endmember that is based on an assumption on the signature of the source water, since sea ice and underlying water can move independently from each other. Within the direct vicinity of the Lena River, the summer surface layer is strongly influenced by summer discharge of the Lena River, so the low $\delta^{18}O$ summer surface signature in this area is not a useful end-member for the sea ice formed during winter. Therefore, the average surface value from the winter polynya region of −7 in $\delta^{18}O$ is applied as source water for sea ice formation to all stations with a surface $\delta^{18}O$ lower than −7‰. Differences in calculated sea-ice meltwater and river water fractions in the southern LS, when a constant polynya value is used instead of each station's surface signature, are generally small (for a detailed discussion see Bauch et al., 2010) and calculated fractions remain stable relative to each other."

Line 168 / Please elaborate on the choice of end-members, since the resulting fractions are sensitive to the choice of end-member, especially in such a region with clearly several different end members. and **Do you have a measured sea ice end-member value for the landfast sea ice?**

The endmembers are important, but well known for the study area (see Bauch et al., 2010, 2013). The only exception is the sea-ice endmember that is based on an assumption on the signature of the source water, since sea ice and underlying water can move independently from each other. The choice of endmember for sea-ice meltwater is discussed in detail in Bauch et al., 2010: "Within the direct vicinity of the Lena River, the summer surface layer is strongly influenced by summer discharge of the Lena River, so the low $\delta^{18}O$ summer surface signature in this area is not a useful end-member for the sea ice formed during winter. Therefore, the average surface value from the winter polynya region of −7 in $\delta^{18}O$ is applied as source water for sea ice formation to all stations with a surface d18O lower than −7‰. The differences in calculated sea ice meltwater and river water fractions in the southern Laptev Sea, when a constant polynya value is used instead of each station's surface signature, are generally small (see Fig. 6 within Bauch et al., 2010), and calculated fractions remain stable relative to each other". We do have measurements of land-fast ice, but these measurements cannot be used directly as endmember for sea-ice meltwater as they represent a mixture of sea-water and river water contained within the ice.

Line 173/ month/date? Do you have the hydrograph of the Lena River, to indicate when you sampled relative to the freshet in 2014?

We will specified the month and date of the freshet in more detail. Line 254 in the new version: *" The dominant feature of the hydrological cycle of the Lena is the spring freshet in May and June. We sampled this event in the central part of the Lena Delta from 21 May to 19 June 2014 (Lena 2014). The discharge data measured ~200 km upstream at Kyusyur were provided by ArcticGRO (Shiklomanov et al., 2020). In their study based on ArcticGRO discharge data, Juhls et al. (2020) give a more detailed description of the annual variability* *of the tDOM input of the Lena River during the spring freshet and throughout the year."*. The hydrograph is shown in figure 3(a) in chapter 3.2. The citation from Juhls et al. (2020) cited in Chapter 3.2 describes in great detail the evolution of the hydrograph of the Lena River and the variability in the timing of the freshet over the past decades.

Juhls, B., Stedmon, C. A., Morgenstern, A., Meyer, H., Hölemann, J., Heim, B., Povazhnyi, V., and Overduin, P. P.: Identifying Drivers of Seasonality in Lena River Biogeochemistry and Dissolved Organic Matter Fluxes, Frontiers in Environmental Science, 8, 10.3389/fenvs.2020.00053, 2020.

Line 176–177 / 50 ug/L at salinity of 20? Seems quite low at such low salinity. Sea-ice melt?

Please note: All DOC data are presented as µmol L^{-1} **NOT** µg L^{-1}! The lowest values (50 µmol L^{-1}) were measured in the Atlantic Intermediate Water (continental slope at 300 m water depth), which has a river water fraction ($f_{rw;\ Fr\ in\ Fig.\ A}$) of less than 2 percent. Our data do not show a significant input of sea-ice meltwater (positive fi in Figure A) at f_{rw} below 5 %. We show only the CDOM values in our manuscript because DOC was not measured in all samples and the DOC data only show information that does not provide additional information related to our hypotheses (see Fig. A). A figure showing the ratio of $a_{CDOM}(350)$ to river water fraction and $S_{275-295}$ will be included in the manuscript (Fig. 4b in the revised version).

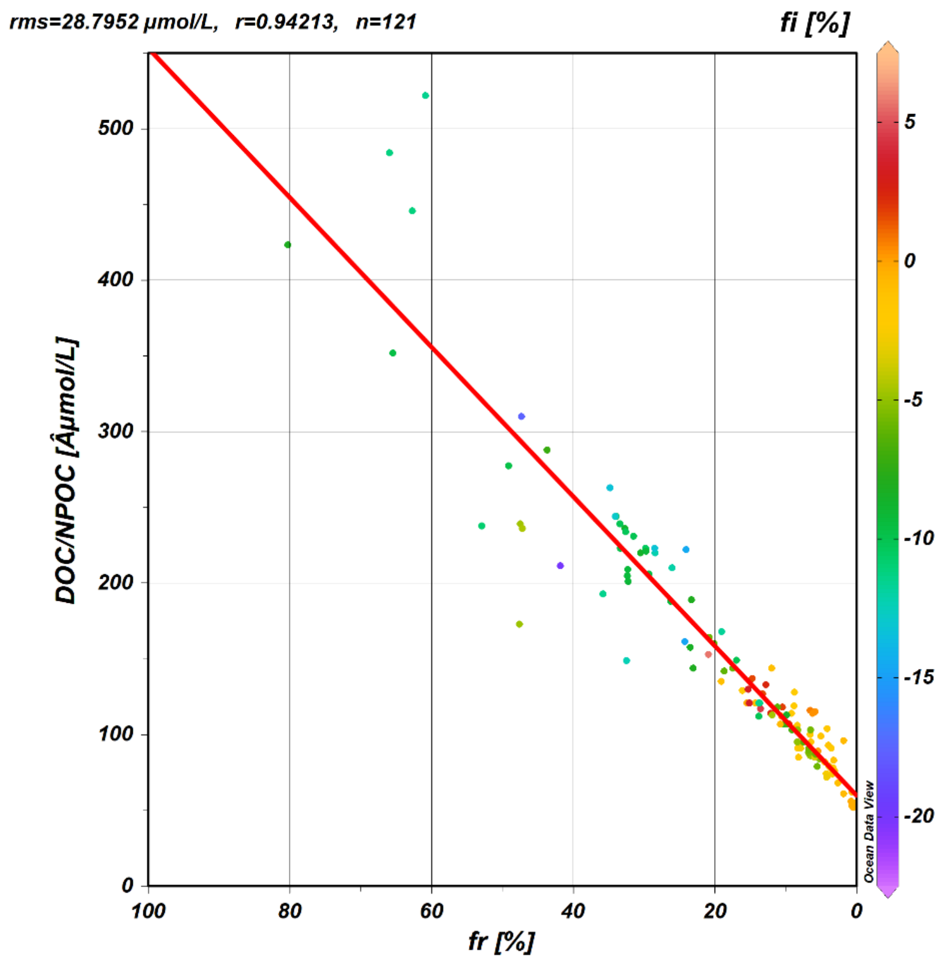


Fig A: DOC (µmol L^{-1}), river water fraction (fr), and **sea-ice** meltwater fraction (fi = fsim in the manuscript).

Please note: Fi does not represent the whole land-fast ice meltwater fraction because the land-fast ice contains a high proportion of river water!. Fitted curve =least square line. ODV. Data set from the published doi's (Table 1 in the manuscript)

Line 179 / How well does the methods applied by Fichot and Benner - and - Goncalves-Araujo et al apply: Fichot, C. G., & Benner, R. (2011). A novel method to estimate DOC concentrations from CDOM absorption coefficients in coastal waters. Geophysical Research Letters, 38, L03610. https://doi.org/10.1029/2010GL046152

Gonçalves-Araujo, R., et al. (2020). A decade of annual Arctic DOC export with Polar Surface Water in the East Greenland Current. Geophysical Research Letters, 47, e2020GL089686. https://doi.org/10.1029/2020GL089686 and Line 181 / impressive R2, but what about RMSE, especially at lower DOC concentrations.

This study does not focus on using CDOM as a parameter to predict DOC concentration (also shown by the fact that we use DOC as x and CDOM as y). Here, we simply describe their relationship. Due to that reason, we initially did not include more statistical parameters for the performance of the non-linear fit model. However, we agree that an absolute error parameter is helpful. We will include the RMSE (= 0.80 m^{-1}) into the figure (Figure 2a in the revised version).

The use of other CDOM parameters (e.g. S275-295) and fit models (amongst many others Fichot and Benner - and - Goncalves-Araujo et al. (2020) to predict DOC is not the scope of this paper. In Juhls et al., 2019 it is reported that $S_{275\text{-}295}$ results in slightly weaker relationships to DOC, compared to a single a_{CDOM} wavelength.

Lines 181-186 / What was the DOC and CDOM in the water that the ice grew into, i.e. what was the "fractionation" at freezing .. the same as for salinity? Are salinity normalized values the same for ice and water?

The fast ice grows throughout the winter, but the thermodynamic growth should be strongest in October, November, and December, when the fast ice is still thin. The measurements in the water under the ice made during the Ti12 winter campaign in March and April 2014 therefore represent rather the sea water that will mix with the meltwater (0-10 m, Mean Salinity 20, Mean DOC 308 µmol l^{-1}, SD 104 µmol l^{-1}, Mean $a_{CDOM}(350)$ 5.5 m^{-1}, SD 1.6 $^{m-1}$, n=19). Since the Siberian Laptev Sea is closed to navigation from mid-October to July and measurement campaigns with helicopters are only possible from March onwards, there are absolutely no oceanographic and marine chemical measurements from these areas during this period. Therefore, for the estimation of DOC concentrations from which the fast ice grows (line 384), we took the average salinity (9) and the average DOC concentration (475 µmol l^{-1}) of the surface mixed layer (0-5 m) from the SE Laptev Sea. These values were recorded during our measurement campaigns in August/September. New first paragraph in chapter 4.4: *"We used fast ice and sea water data from the southeastern LS to estimate how much DOC might be expelled along with brine from growing land-fast ice in the LS. The observed average DOC concentration in surface waters (0-5 m) east of the Lena Delta (south of 73.4° N and east of 125.0° E) was 475 µmol L^{-1} (SD ±165 µmol L^{-1}) Thus, with a median DOC concentration in the land-fast ice of 96.2 µmol L^{-1}, 379 µmol L^{-1} have been removed during ice growth. This value was multiplied by the total volume of fast ice (273 km³; Kotchetov et al., 1994; Barreis and Görgen, 2005; Selyuzhenok et al., 2005)"*

We did not calculate the fractionation due to lack of continuous measurements in the water body. For the calculation of the budgets the observed concentrations from the fast ice and the water of the SE Laptev Sea were taken. This is certainly only a first approximation, but in our opinion a plausible assumption.

Figure 2 / The fit is made for the DOC range that is "huge" when marine environments are considered, and despite the high R, are the deviations from this at low DOC significant? What is the RMSE, as it is an absolute measure of the goodness of fit, rather than R? Add a "zoom in" for the range 0-200 ug/L DOC, or perhaps 0-400 to include the ice samples.

Please note: DOC concentrations are presented as µmol l^{-1}.

In the revised version we have now include the zoom inset and the RMSE into the figure (Figure B)

We also used the model developed by Stedmon and Markager (2001) to differentiate between marine and terrestrial organic matter (Figure 2b). The model that suggests a dominance of tDOM in the LS and ESS is based on the relationship between the spectral slope coefficient (300-600 nm) and CDOM absorption at 375 nm. In the LS and ESS most data points show high $S_{300-600}$ values (> 17 µm^{-1}) that stay relatively constant as a_{CDOM}(375) decreases. The results of these investigations are discussed in more detail in chapter 4.1.

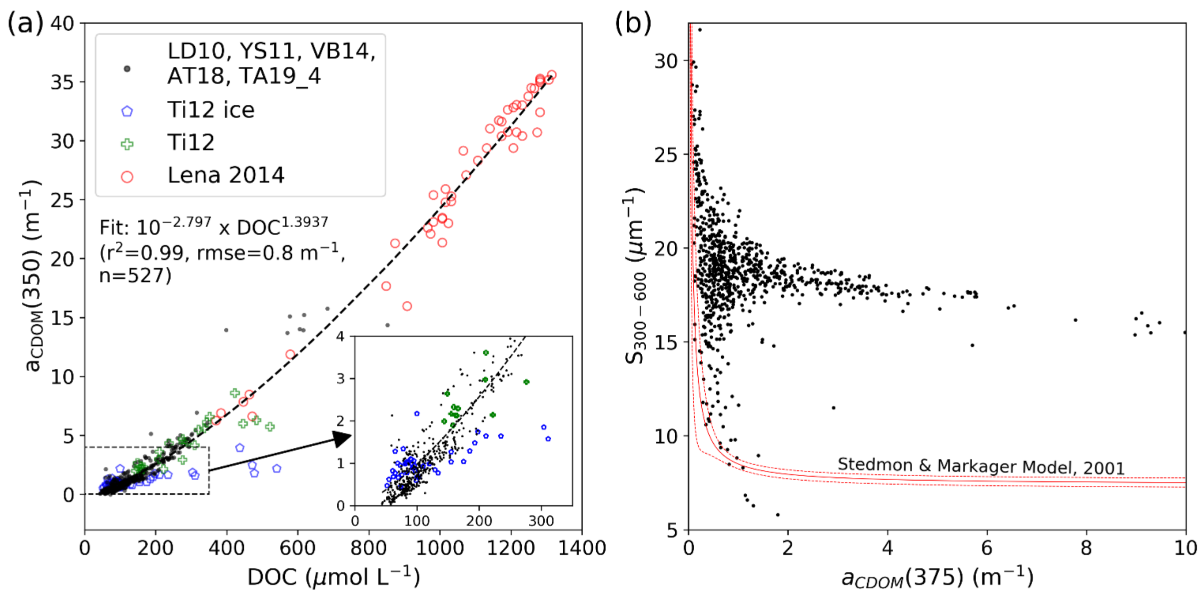


Figure B

Figure 2. (a) The relationship between DOC and **aCDOM**(350) for Lena River water, ice samples and seawater samples from the LS and ESS. The regression and r**2** was calculated only on the basis of river and seawater samples. (b) Shows the model developed by Stedmon and Markager (2001) to differentiate between marine and terrestrial organic matter. Data points from the LS and ESS that lie within the model boundaries of the Stedmon and Markager (2001) model (dotted red lines) are defined as marine CDOM, while the rest are terrestrial in origin.

Figure 3. / Add a panel for S275-295, does this change with season/freshet..

We added a panel for $S_{275\text{-}295}$. An added in the text: *"$S_{275\text{-}295}$ values in river water are above 16 µm^{-1} before the onset of the spring freshet and drop to values below 14 µm^{-1} during the spring freshet (Fig. 3b), indicating a seasonally different composition of tDOM in the river water of the Lena (Juhls et al., 2020)."*

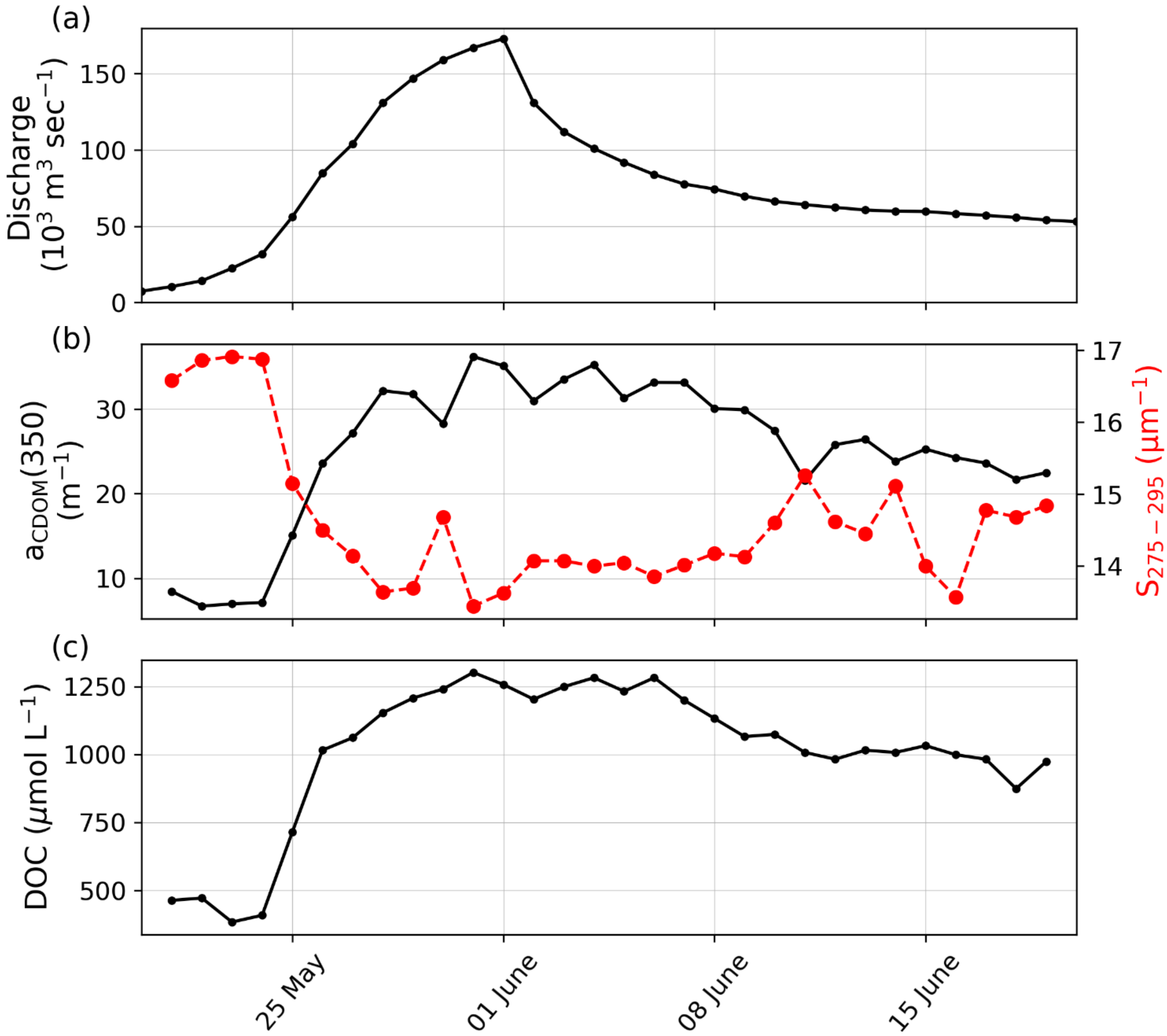


Figure 3. (a) Corrected daily Lena River discharge data (10³ m³ sec^{-1}), (b) a$_{CDOM}$(350) and $S_{275\text{-}295}$, and (c) DOC concentration (µmol L^{-1}) measured near Samoylov Island in the Lena Delta during the spring freshet in May/June 2014.

For a detailed description of $S_{275\text{-}295}$ and its full seasonal variability in the Lena River, we refer to the publication by one of the co-authors of this study: Juhls et al. (2020).

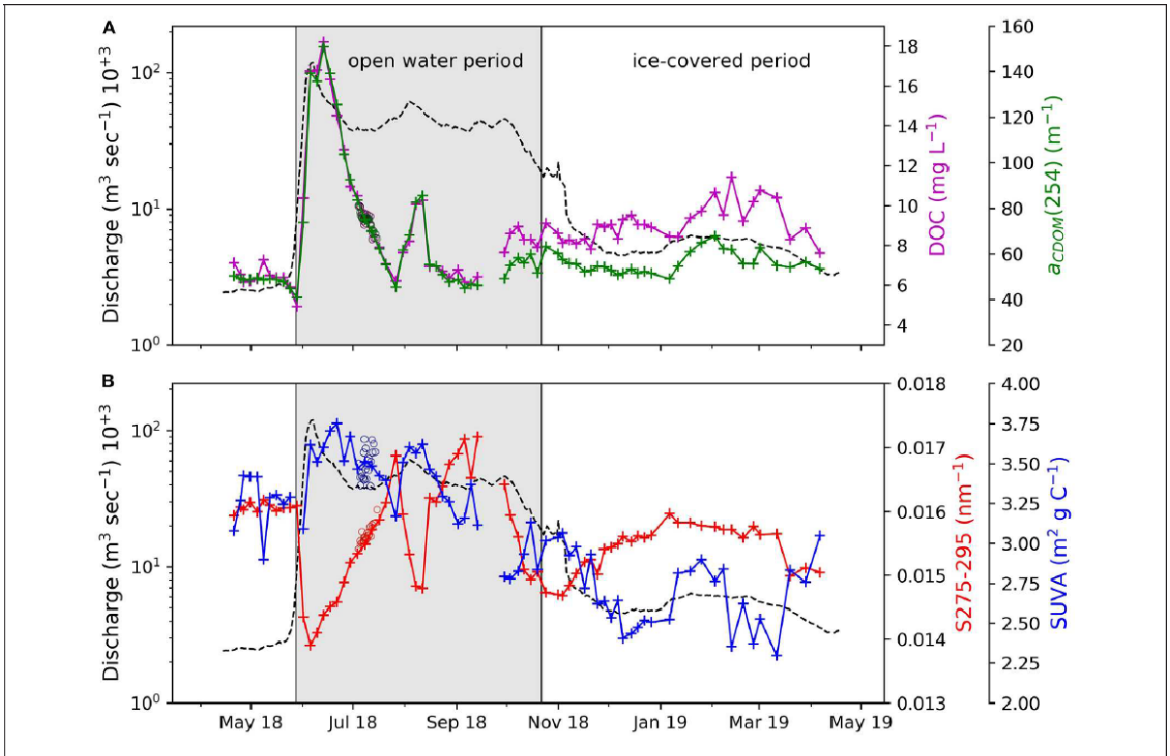
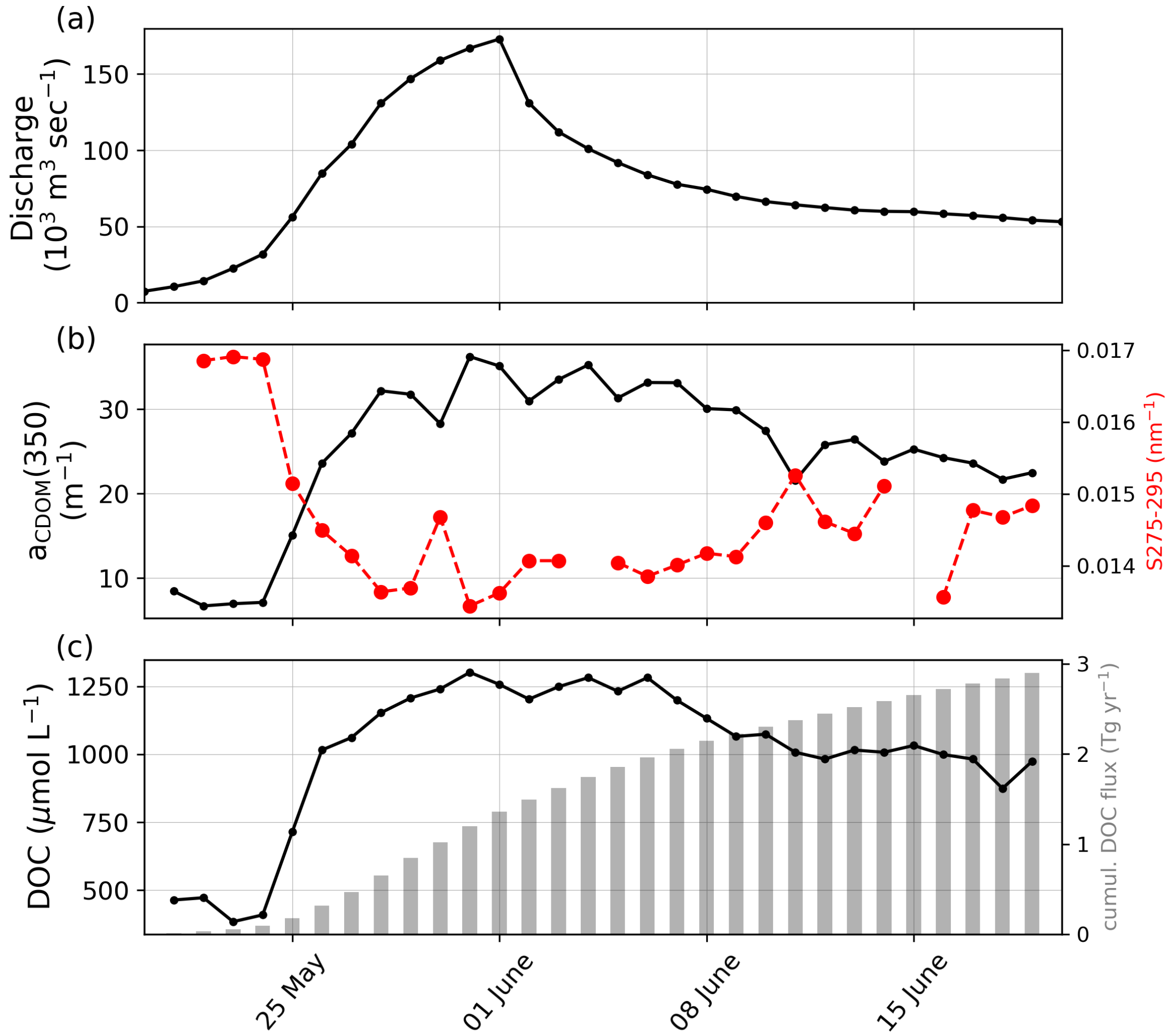


FIGURE 5 | Seasonal variation of DOC and $a_{CDOM}(254)$ **(A)** and S275-295 and SUVA **(B)**. Black dashed line shows the discharge. Circles in respective colors show high frequency measurements from July 2018.

Figure from From: Juhls, B., Stedmon, C. A., Morgenstern, A., Meyer, H., Hölemann, J., Heim, B., Povazhnyi, V., and Overduin, P. P.: Identifying Drivers of Seasonality in Lena River Biogeochemistry and Dissolved Organic Matter Fluxes, Frontiers in Environmental Science, 8, 10.3389/fenvs.2020.00053, 2020.

Figure 3. / Also, a second y-axis with accumulated flux could be added to each panel (except S275-295)..

The accumulated fluxes are given in the text. Another illustration would not give any further information (Figure D).



Example: Figure with cumulative flux added

When recalculating the DOC flux during the observational period in 2014 (2.35 Tg DOC), we found that we made a calculation error, which was very difficult for the reviewers to detect and was therefore not objected. The actual discharge in the observation period is 2.83 Tg DOC. However, the flow-weighted value of $a_{CDOM}(350)$, which is the basis for our calculation of mixing with meltwater, is correct. In the revised version of the paper we will change all text that refers to the DOC flux.

Line 199 / 211 km3: But this must vary from year to year, and this data is available from Arctic GRO for the years with observations, consider at least reporting these values.

The discharge measurements of the Lena River (Kyusur) were provided through ArcticGRO. The citation for ArcticGro discharge data – according to their homepage - is (Shiklomanov et al., 2020). The annual variation of the Lena River discharge is presented in the publications of Janout et al. (2020) and Juhls et al. (2020) and many other studies. The variability in the discharge and timing of the freshet are discussed in detail in Juhls et al. (2020). We took the year 2014 in which we made our measurements as a case study. Just as in the study by Juhls et al. (2020), several measurements were taken during the freshet each week. These measurements in the Lena delta are currently being continued and form a time series that gives a much better temporal resolution than the rather sporadic DOM measurements taken in the middle reaches of the Lena River by ArcticGro. However, the time series from the Lena Delta are subject to future studies and are not part of this publication.

Line 202 / where is the value of 14 m^{-1} taken from?

This value is an average of all July, August, and September data from the Lena Delta (Polar Station Samoylov) derived from the data DOI cited in Juhls et al. (2020) (Data DOI https://doi.org/10.1594/PANGAEA.913196). This is cited in line 264 (Actually: 14.4 m^{-1} with a standard deviation of 3.4 m^{-1}). We will also include the citation in the text in line 202.

If we take the data published at ArcticGro (July to October) from the middle course of the Lena we get a mean value of aCDOM(350) 13 m^{-1}. We decided to take the value of the high resolution time series near the mouth of the river Lena.

We have removed this sentence here and use it instead in chapter 3.3: *"The data points in the LS are well below the theoretical mixing line resulting from a conservative mixing between the Lena river water discharged after the spring freshet (Summer in Fig. 4), which has an average $a_{CDOM}(350)$ of 14.4 m^{-1} (standard deviation 3.4 m^{-1}, n = 26; Juhls at al., 2020), and the tDOM-poor sea water (salinity > 34) of the Nansen Basin."*

Line 203 / how far does the "full freshet" extend, and by how much (%) would the water and CDOM/DOC fluxes increase?

The reviewer's question has led us to delete the text part "…indicate that the observation period did not cover the entire spring freshet. Taking into account the whole period of the spring freshet would lead to an even higher tDOM flux, as reported in Juhls et al. (2020).".

With an outflow of 50,000 m^3 sec^{-1} at the end of the observation period, the Lena has reached a value that is within the range of discharges observed in July to November (ArcticGro). The $a_{CDOM}(350)$ absorption is still higher than the average value for the summer months, but is within the seasonal variability of CDOM absorption measured in 2018 (values for $a_{CDOM}(350)$ are published in PANGAEA and cited in Juhls et al. 2020). Therefore, specifying a date for the end of the freshet in 2014 that is after June 19 would be somehow arbitrary.

Line 206-7 / Using an a350 end-member of 14 m^{-1} seems low, when you show in Figure 3 values of 26 m-1 for the period of observations in Lena River, no?

In the text it is always described that the value of 14 m^{-1} is the absorption of the river water after the freshet in (post-freshet July, August and September). We will emphasize this again in the text with the term "post-freshet": *"The data points in the LS are well below the theoretical mixing line resulting from a conservative mixing between the Lena river water discharged after the spring freshet (Summer in Fig. 4), which has an average $a_{CDOM}(350)$ of 14.4 m^{-1} (standard deviation 3.4 m^{-1}, n = 26; Juhls at al., 2020), and the tDOM-poor sea water (salinity > 34) of the Nansen Basin."*

We now also show and describe the flow-weighted annual value: *„Looking at the theoretical conservative mixing line of the flow-weighted annual river input of CDOM (Annual in Fig. 4) that includes the spring freshet (Apr 2018 to Apr 2019, $a_{CDOM}(370)$ 18.7 m^{-1}, calculated from data published by Juhls et al. 2020)"*

Figure 4 / In this system you also have another mixing line, with sea-ice melt as end-member, right? This should also be indicated with at least with apparent location, low S (2-5?) and 5-fold lower CDOM than the parent water (at most 14/5?). And: That said, you have a system where salinity alone cannot be used to deduce the exact behavior or cause of the deviations. I would expect to add a panel to this figure where "salinity" is replaced with "fraction of river water(meteoric)".

The reviewer is right. We have now merged the chapters to better present the results. We have also added a figure showing CDOM vs. river water fraction.

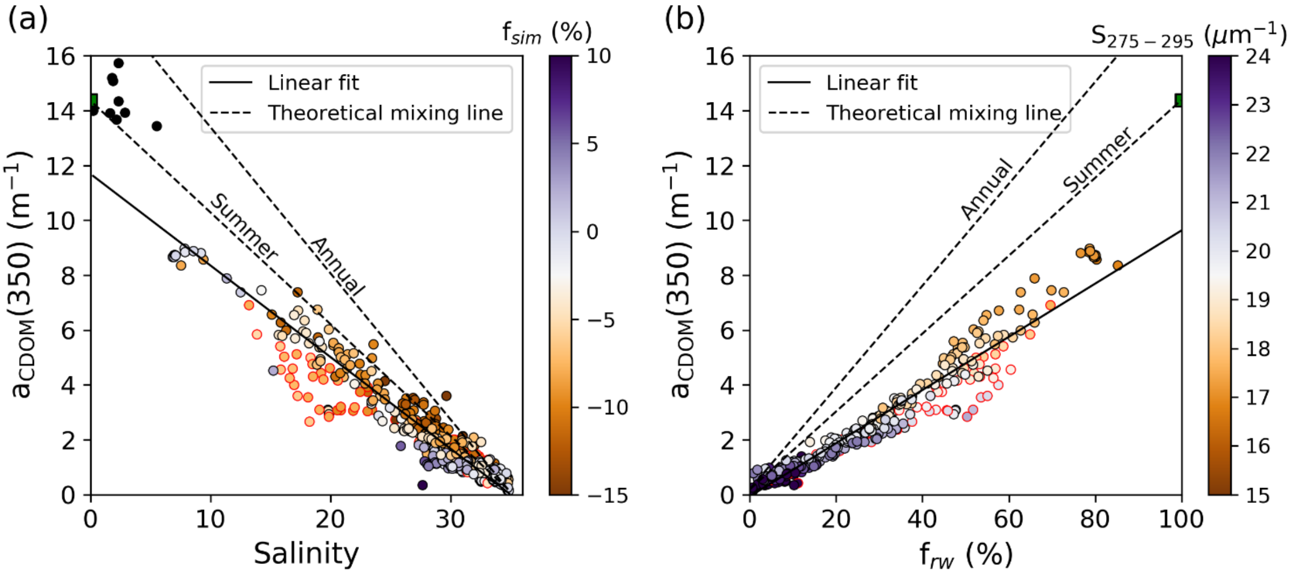


Figure 4. (a) Salinity, $a_{CDOM}(350)$, and the percentage of sea-ice meltwater fraction (f_{sim}%) measured in the LS in summer (NE10, LD10, YS11, VB13, VB14, AT18, and TA19_4) and (b) Percentage of river water (Frw), $a_{CDOM}(350)$, and $S_{275-295}$. The solid black line represents the linear regression fit to the data in the LS. The black dashed lines show the theoretical conservative mixing line between Lena River water after spring freshet (Summer, $a_{CDOM}(350)$ 14.4 m^{-1} calculated from Juhls et al., 2020) and the marine endmember (Nansen Basin (NB) seawater), as well as the theoretical conservative mixing line of year-round flow-weighted average CDOM absorption of the Lena River (Annual, $a_{CDOM}(350)$ 18.7 m^{-1} based on year-round measurements in the Lena Delta, Apr 2018 - Apr 2019, , Juhls et al. 2020) and the marine endmember. Red outlined dots are water samples from the surface layer (< 20 m) taken north and east of the Lena Delta in September 2011. Black dots in (a) represent samples on which stable oxygen isotope analysis was not performed (LD10).

We show in our study that the landfast-ice melt water in the LS mixes with river water, while the melt water in the ESS tends to mix with sea water in 2019 (see discussion). We have therefore redesigned the figure and inserted the two mixing paths as arrows.

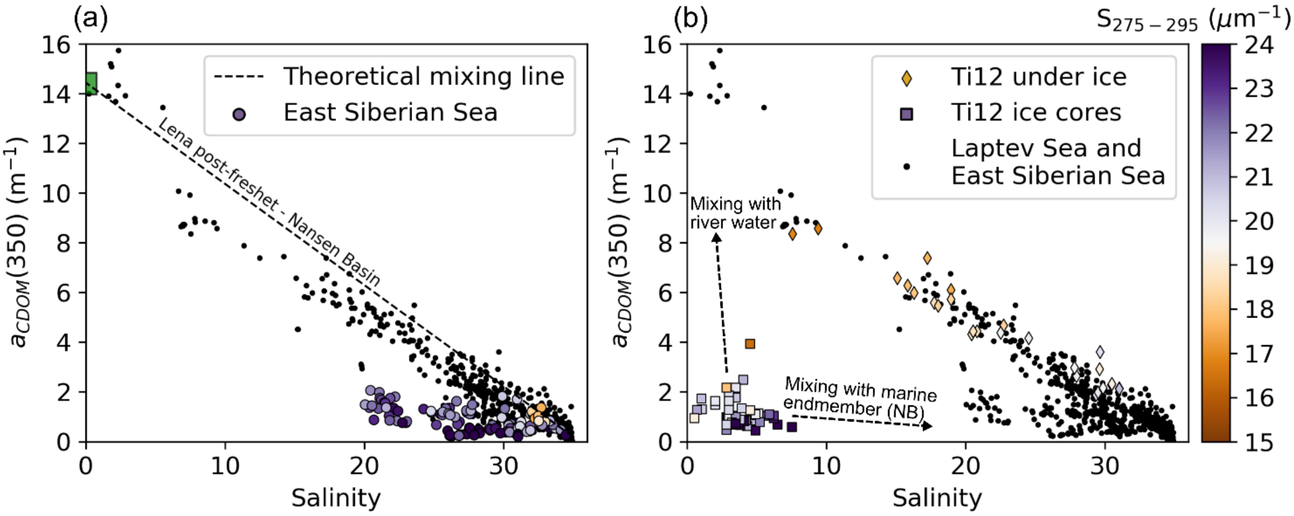


Figure 5. (a) Salinity and $a_{CDOM}(350)$, in the ESS (August and September 2019, colored dots) and LS (black dots). The broken line shows the theoretical conservative mixing line between the Lena River water that enters the LS after the spring freshet (post-freshet) and the marine end-member (Nansen Basin sea water, NB). The colour of the dots shows the slope of the absorption spectra in the range between 275 and 295 nm ($S_{275-295}$). (b) Salinity, $a_{CDOM}(350)$ and $S_{275-295}$ in land-fast ice (squares) and sub-ice water samples (diamonds) in the LS collected in (March/April 2012). The arrows indicate the direction of theoretical conservative mixing lines between the landfast-ice melt water and the Lena river water, as well as between the melt water and the marine endmember. The black dots represent the samples from the LS and ESS (2010-2019).

Figure 4 / Are the samples with S<5 also included in the fit? And the "drop" of values from S<5 to S>5, how is that explained?

Yes they are included. We do not want to go too much into the interpretation of the data when presenting the measurements. We cannot see a "drop" in the sample cluster because the sample with the lowest salinity does not show the highest value. A possible reason for this sample cluster is discussed in the discussion section 4.1 *" Because $a_{CDOM}(350)$ in river water may show intra-seasonal fluctuations between 10 m^{-1} and 22 m^{-1} in the post-freshet season (Juhls et al., 2020), the relatively high $a_{CDOM}(350)$ of 13.6-16 m^{-1} at salinities < 6 observed in the river plume near the Lena Delta in summer 2010 (Fig. 4a) were likely caused by short-term fluctuations of $a_{CDOM}(350)$ in the river."*

Figure 4 Legend / Instead of "Theoretical mixing line" - this is the River:Marine mixing line. Since there are more than 2 end-members here (+processes we cannot account for in such a salinity-property plot).

We added a river-water fraction vs. CDOM figure and insert there the theoretical mixing line between the post-freshet river water and the sea water. We call it "theoretical" because it is clear from the data shown that there is more than one freshwater component (i.e. post-freshet, freshet, fast-ice meltwater). For this reason, we do not call our regression line that was created based on the measurements a mixing line but "only" a linear fit. This fit cannot be an "actual" mixing line because we prove that there are three dominant freshwater sources with different DOM characteristics. This examined examined in more detail in the discussion section.

Figure 4: / Especially the end-member at 0 salinity might vary a lot from campaign to campaign (which you only show in Fig 8!)... thus I think one should indicate this uncertainty in the mixing line(s) and also here show the zero salinity values now only shown in Fig 8.

The uncertainties of the different "mixing lines" are given in the text (Results and Discussion). The variability of the flux endmember during the pos-tfreshet period is described in the text. We believe that the figure shows the 0 salinity values. "Exact" values are given in Figure7 (Discussion). They are also mentioned in the text. We also do not want to overload the figures with too much information.

"Samples from the LS showed a significant negative linear relationship between salinity and $a_{CDOM}(350)$ ($r^2 = 0.90$, $n = 659$, $p < 0.01$) (Fig. 4 a) and between the fraction of river (meteoric) water (f_{rw}) and $a_{CDOM}(350)$ ($r^2 = 0.94$, $n = 465$, $p < 0.01$) (Fig. 4b). The data points in the LS are well below the theoretical mixing line resulting from a conservative mixing between the Lena river water discharged after the spring freshet (post-freshet, Summer in Fig. 4), which has an average $a_{CDOM}(350)$ of 14.4 m^{-1} (standard deviation 3.4 m^{-1}, n = 26; Juhls at al., 2020), and the tDOM-poor sea water (salinity > 34) of the Nansen Basin. Looking at the theoretical conservative mixing line of the flow-weighted annual river input of CDOM (Annual in Fig. 4) that includes the spring freshet (Apr 2018 to Apr 2019, $a_{CDOM}(370)$ 18.7 m^{-1}, calculated from data published by Juhls et al. 2020) and the sea water, the discrepancy becomes even more apparent. The freshwater endmember calculated from the data in the LS on the basis of salinity has an $a_{CDOM}(350)$ of 11.7 m^{-1} (interception of linear fit in Fig. 4a). The $a_{CDOM}(350)$ of the river water endmember calculated from f_{rw} (interception of linear fit in Fig. 4b) is ~10 m^{-1}, which is about 50 % lower than the annual flow-weighted average $a_{CDOM}(350)$ of the river water."

Fig 4 / And I believe the Fsim fraction could be shown better with a different colormap. E.g. in matplotlib a colormap type Diverging (coolwarm), see https://matplotlib.org/3.1.0/tutorials/colors/colormaps.html#diverging . Would perhaps be better, than the "rainbow" type used now.

We have changed the colour scales of all the illustrations according to the reviewer's suggestion.

Line 214/ insert. .. fit "to the data in the Laptev Sea" (solid line). ?

Done (see Fig. 4).

Figure 5 / Again, make certain what the mixing line is for (See comment on fig 4). Also here, indicate the plausible marine to sea-ice melt mixing line.

The reviewer's suggestions were taken into account in the new figures 4 and 5. In Figure 5, the representation of the "linear fit" has been deleted.

Figure 5 / Consider that you show the station in ESS in Fig 1. with their own color, and then use same color in this plot for ESS data points.

We believe that it will be clear to the reader that the samples we indicate as coming from the East Siberian Sea actually come from the East Siberian Sea (see also Tabel 1). The station details (meta data) can be found in the map shown under the associated PANGAEA data doi.

We have also described in Figure 1 where the boundary between the Laptev and East Siberian Sea is. In the new Figure 5a, the data from the ESS are no longer shown in a uniform red colour. They now show the $S_{275-295}$ slope.

Figure 5 / What are the different sizes of the back dots representing? Or are they clusters of samples?

This is an error in the illustration. The black dots should all be the same size. They are not clusters. We have corrected this.

Generic comment / Results Section. I would have expected a salinity-DOC plot, just out of curiosity to see also how DOC relates to salinity. Same also for Fr-DOC if there is enough data available. And colored with e.g. Fsim

We again point out that the entire data set is published and thus the reader can satisfy his curiosity. The desired illustration would not provide any additional information with regard to the central hypotheses of our article.

Figure 4, 5, 6 / Figure 4, 5, 6 should be merged into one figure with multiple panels, also including plots Fr-property. And add S/Fr-DOC plots as well.

We do this in Figure 7 in the discussion section. A fr-property plot was inserted in the results section (Fig. 4b). We have now merged the chapters that originally contained figures 4, 5, 6. In the process, the figures have been combined into 2 new figures, supplemented and redesigned (Fig. 4 and 5). We hope that we have largely followed the reviewer's suggestion.

Line 235-236 / Here you have the data to also indicate the potential sea-ice end member in Figs 4 and 5. And mixingline from marine to sea-ice melt. What was the DOC concentration in the sea ice?

We added: *"The median of the DOC concentration in the ice was 96.2 µmol L^{-1}."*

Line 235-236 / Also, the comparison to a350 at same salinity is valid in terms of the effect as end-members. But the ice was likely grown into water with a salinity of >20?

No, the ice has probably not grown in water with a salinity of > 20. The ice is formed from surface water with salinities well below 20. For example: In October 1995, the hydrography of the LS was observed during the onset of sea ice formation (the only existing measurements from this important period, however, without DOM measurements). Salinities in the SE Laptev Sea at this time were well below 15 (see also Janout et al. (2020), Figure 13).

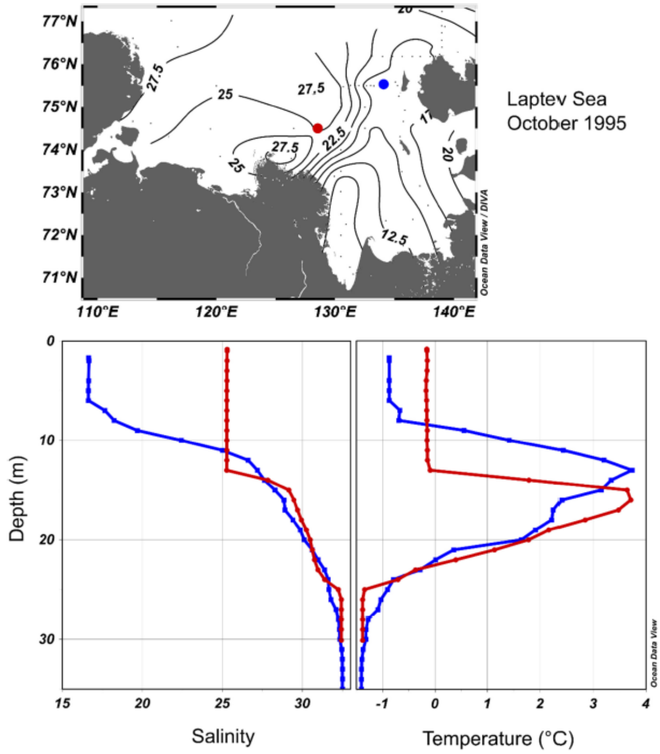


Figure 13 from Janout et al. 2020.

Figure 6 / Your sea ice data in Fig 6 shows what you could use as a mixing line for sea-ice melt in the Figures 4&5, thus I would introduce the sea ice a350 data already in Figure 4, and use this to add the mixing line. This in turn explains (potentially) the data from the ESS. At least I would show them in the same figure, but different panels, this would make it much easier to compare and review.

We now show the data from the fast ice and from the ESS in the same figure (Fig. 5 a and b). We have also marked the possible mixing paths for the landfast-ice meltwater in this figure.

Line 244-45 / this was also shown to indicate CDOM loss (Granskog, 2012).

This sentence is now part of chapter 2. We have added the citation there. "*Steeper $S_{275-295}$ slopes have also been associated with photochemically induced shifts in molecular weights (Helms et al. 2008; Granskog, 2012).*"

Line 261 / But with salinity alone, you cannot really say this, because you have evident contributions from sea-ice melt (or brine) which could also alter the situation, and thus change your salinity-property mixing line. Thus as suggested above also including the Fr-property plots would allow to make full use of the isotope data collected (cf. Granskog, 2012, analysis in Hudson Bay).

We added a plot a f_{rw} vs. property plot (Fig. 4b). We have also changed the text in the discussion, which now reads: *"To describe the tDOM dynamics in the Siberian shelf seas we analysed the optical properties of DOM along the salinity gradient in the LS, the ESS and the adjacent continental slope. In water samples from the LS, we found a statistically robust negative correlation between $a_{CDOM}(350)$ and salinity ($r^2 = 0.90$, $n = 659$, $p < 0.01$) (Fig. 4 a) and between $a_{CDOM}(350)$ and the fraction of river (meteoric) water (f_{rw}) and ($r^2 = 0.94$, $n =$*

465, $p < 0.01$) (Fig. 4b). The strong linear relationship suggests that tDOM mixes conservatively with seawater during the transit of river water across the shelf. The calculated $a_{CDOM}(350)$ concentration of the river water endmember of ≈ 10 m^{-1} (Fig. 5, linear fit of samples from the LS) is approximately 30 % below the mean $a_{CDOM}(350)$ absorption measured in the Lena River after the spring freshet (July – September, 14.4 m^{-1} with a standard deviation of 3.4 m^{-1}, Juhls et al. 2020), and nearly 50 % below the flow-weighted annual average $a_{CDOM}(350)$ of the Lena River of 18.7 m^{-1} that also includes the spring freshet (observed in 2018/19, data from Juhls et al., 2020). Because $a_{CDOM}(350)$ in river water may show intra-seasonal fluctuations between 10 m^{-1} and 22 m^{-1} in the post-freshet season (Juhls et al., 2020), the relatively high $a_{CDOM}(350)$ of 13.6-16 m^{-1} at salinities < 6 observed in the river plume near the Lena Delta in summer 2010 (Fig. 4a) were likely caused by short-term fluctuations of $a_{CDOM}(350)$ in the river."

Line 261 / Why is the situation in the Hudson Bay so different? (Granskog, 2012), with evident loss of CDOM?

This has hopefully already been clarified, at least to some extent, by answering the reviewer's question regarding lines 54-55 of the original manuscript (see above).

Line 268 / This apparent conservative mixing is indicated in the (deleted)

We will delete the reference to conservative mixing because the sentence is misleading and rephrased the sentence: *"The dominance of riverine input of terrestrial DOM and the resulting close relationship between salinity and $a_{CDOM}(350)$ is also evident from a hydrographic transect across the LS shelf observed in September 2010 (Fig. 6; the area of the transect is indicated in Fig. 1), The oceanographic transect runs from the mouth of the Lena River in the southeastern LS (A, Fig. 6) to the Taymyr Peninsula in the northwestern LS (B, Fig. 6). While the southeastern LS is dominated by the tDOM-rich river water plume of the Lena River, the northwestern LS is mainly affected by the inflow of tDOM-poor sea water from the Nansen Basin (Janout et al., 2013)."*

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Figure 7 / Since you have at least CDOM data, add a panel with S275-295 into this figure. and **What are the black bars at two of the station on the top of figure?**

The relationship between $a_{CDOM}(350)$, $S_{275-295}$ and f_{rw} is shown in Figure 4b. A supplemental profile with the slope values really does not contain any additional information that would support or contradict the hypotheses of our study.

The black bars indicate changes in the direction of the transect (Figure 1). We will explain this in the caption. "*The black bars at the top of the panel indicate bends in the transect (see Figure 1)".* This indication helps the reader to interpret the data and is probably more common in illustrations of geological profiles.

Line 280-282 / could this also be explained rapid loss at very early stages of the more labile material during freshet?

This is a quote from Alling et al. (2010). We have reworded the sentence to avoid misunderstandings: *"Alling et al. (2010) suggested that the absence of tDOM-rich waters from the freshet on the LS shelf in 2008 was caused by a rapid wind-driven eastward* *transport into the adjacent ESS. But, this is not consistent with the observation that when winds are predominantly easterly, as they were in the summer of 2008, the ROFI in the LS extends far north to the outer shelf of the LS (Janout et al, 2020). The same atmospheric forcing as in 2008 was also observed in 2011, when strong southeasterly summer winds, coincided with mixed layer salinities below 16 ~ 300 km north of the Lena delta (Janout et al., 2020). The northern part of the ROFI should thus contain a significant amount of tDOM-rich freshwater from the spring freshet. But, this is not evident from the data (data from YS11, Table 1)."*

Line 289 / do you mean microbial degradation is a plausible loss term?

Yes. Theoretically. This is only discussed here as a further explanatory hypothesis. To avoid misunderstandings, we have rephrased the sentence: *"Another explanation for the absence of freshet-related high $a_{CDOM}(350)$ values within the ROFI could be the removal of tDOM, i.e., nonconservative mixing. This would imply that ~50 % of the tDOM discharged into the southeastern LS in May and June had already been removed prior to the August and September sampling period. In this context, photochemical processes, flocculation of tDOM or rapid microbial degradation could play a major role."*

Line 290-291 / How does this relate to what was observed by Belanger et al.? and**: What does the $S_{275-290}$ data tell you? You show it above, but do not fully explore what the data tells in terms of signs of photodegradation. I would have expected some discussion on the Slope data since it is shown in the Results part.**

Belanger et a.l (2006) studied the degradation of tDOM in the Mackenzie River plume to describe the influence of a seasonally steadily decreasing sea ice cover. During the study period, the sea area was ice-free in large areas. Quote from Belanger: "Consequently, the plume was exposed to UV radiation for longer periods of time thus allowing more tDOC to be photochemically mineralized." *We are explicitly talking about the freshet of the Lena River at this point. Here, the extremely CDOM-rich (and therefore not very transparent) river plume flows beneath the 2-m-thick, snow-covered, completely closed ice sheet of the fast ice. How can there be significant photochemical degradation of the tDOM? Unfortunately, we have no DOM samples taken under the fast ice during the freshet. However, we changed the text to: "A previous study in the Mackenzie River, showed that photodegradation of tDOM was highest after spring freshet (Osburn et al., 2009). On the other hand, Belanger et al. (2006) noted that under a closed ice cover, photochemical reactions of tDOM carried by the Mackenzie River into the Beaufort Sea do not play a significant role in the degradation of tDOM. In the turbid nearshore waters of southeastern Hudson Bay, which have a high proportion of river water (f_{rw} > 25 %), self-shading could additionally slow photochemical-reactions (photobleaching) of tDOM (Granskog, 2012)"The "initial" $S_{275-295}$ signal coming out of the river during the year is already extremely variable (Juhls et al., 2020). Most studies do not take this into account. Therefore, it is extremely difficult to attribute changes in $S_{275-295}$ to processes/degradation on the shelves unless we "normalize" it to the river signal. Most photodegradation likely occurs when organic matter is still on land surfaces before it is transported to lakes and rivers and finally to the ocean. We have also described the method and its limitations in detail in the methodology section, so that the reader is able to evaluate the $S_{275-295}$ data: "The spectral slope of the absorption spectra in the wavelength range between 275-295 nm ($S_{275-295}$) and between 300-600 nm ($S_{300-600}$)was calculated by fitting with an exponential function $a_{CDOM}(\lambda) = a_{CDOM}(\lambda 0) \cdot e^{-S(\lambda - \lambda 0)}$. The usefulness of $S_{275-295}$ and other spectral slopes at shorter wavelengths for determining the origin and diagenesis of CDOM was demonstrated in the studies by Granskog (2012) and Fichot and Benner (2012).*

Based on the relationship between $S_{275-295}$ and DOC-normalised lignin yield, Fichot and Benner (2012) showed that $S_{275-295}$ is lower than 20 µm^{-1} when the proportion of terrestrial DOC is higher than 50%. Steeper spectral slopes (i.e. higher $S_{275-295}$) are typically associated with a higher proportion of marine CDOM. Steeper $S_{275-295}$ slopes have also been associated with photochemically induced shifts in molecular weights (Helms et al. 2008; Granskog, 2012). The spectral region between 275 nm and 295 nm lies at the short-wavelength edge of the natural solar spectrum. Solar ultraviolet radiation shows significant degradation for CDOM in natural aquatic ecosystems. In contrast to 295 nm, almost no photons are present at 275 nm in the lower atmosphere. It is therefore assumed that solar radiation absorbed by CDOM would always lead to a greater change in $a_{CDOM}(295)$ than in $a_{CDOM}(275)$ and consequently to an increase in $S_{275-295}$, so that increased slope values are a good indicator of photodegradation, while microbial degradation should have the opposite effect (Helms et al., 2008). However, in marine systems such as the LS and ESS, which are characterized by a high riverine input of terrestrial CDOM, non-terrestrial sources and non-photochemical processes only become visible once the absorption of terrestrial CDOM has been removed to a high degree (Granskog, 2012)."

We have described the $S_{275-295}$ data from the LS in chapter 3.3: *"In the LS, $S_{275-295}$ showed an inverse relationship with frw (Fig. 4b), indicating on the one hand a fluvial source of CDOM and on the other hand a more intense photobleaching of CDOM in the water masses on the outer shelf and continental margin. When interpreting the slope data, however, it must be kept in mind that in marine systems characterised by a high input of terrestrial CDOM, non-terrestrial sources and non-photochemical processes only become visible when the absorption of terrestrial CDOM has been removed to a high degree (Granskog, 2012)."*

The slope data observed in the ice are now also discussed in chapter 4.2 (Line 411): *"We assume that the transformation processes of the DOM during ice growth, which shifts the molecular composition of DOM in the ice towards a higher proportion of low molecular weight compounds (Müller et al., 2013; Granskog et al., 2015a; Retelletti-Brogi et al., 2018, Zabłocka et al., 2020) are also responsible for the high $S_{275-290}$ values (> 19 µm^{-1}) of CDOM in the ice (Figure 5b)."*

The slope data from the 2011 Expedition to the LS and in the ESS are now shorty discussed in chapter 3.2. (Line 475)*"High SSTs caused by solar warming, support the assumption that photodegradation could be the major factor leading to tDOM loss and a $S_{275-295}$ > 20 µm^{-1} (Fig. 4b). An alternative explanation to the removal of tDOM in 2011 could be a change in the relative proportion of one of the freshwater endmembers or a change in concentration in one of the tDOM sources."* And (Line 498) *"Alling et al., (2010) assumed that due to the long residence time of the water of the Lena River on the ESS shelf, degradation of tDOM may be more advanced, leading to generally low tDOM concentrations in the western ESS, as observed in August and September 2008. This assumption is supported by the generally high $S_{275-295}$ values (Figure 5a), which indicate that the CDOM in the ESS has already been strongly transformed (e.g. by photochemical processes)."*

Section 4.2. / Please split this one up in a few paragraphs.

We have divided the sections describing the influence of melting and ice formation into three short paragraphs. The authors of this study do not see why these short paragraphs should be further subdivided in any meaningful way. To avoid misunderstandings, we have changed the title of chapter 4.2 to: *"4.2 The importance of land-fast ice meltwater for the distribution of tDOM in the LS"*

line 299 / "during sea ice formation" added.

Done (Line 400): *"DOM is expelled from the ice matrix during sea ice growth and is enriched in the brine (Giannelli et al., 2001; Müller et al., 2013)."*

line 308 / cross-out

Accepted.

line 314 / "landfast" added

Done: "*Our budget calculations reveal that the mixing product (MIX) of landfast-ice meltwater and the river water from the spring freshet has an $a_{CDOM}(350)$ of 12.6 m^{-1} (Figure 7).*"

Figure 8 / again, since this is a multiple source system, I think adding the sea-ice melt mixing line is also valuable to show. You also have some data to indicate that end-member.

And as before indicate the uncertainty in the mixing lines with e.g. shading. I would drop the Linear fit, since it is a fit to the data, that might include factors affecting the CDOM, and as such is not "the" mixing line but a "results" of processes acting on the CDOM on the shelf.

We added the direction of the theoretical mixing lines in Figure 5b. That there are uncertainties in the mixing lines due to the variable concentrations that are described in the text. This figure (now Figure 7) no longer shows the "linear fit" line. The figure has been fundamentally revised:

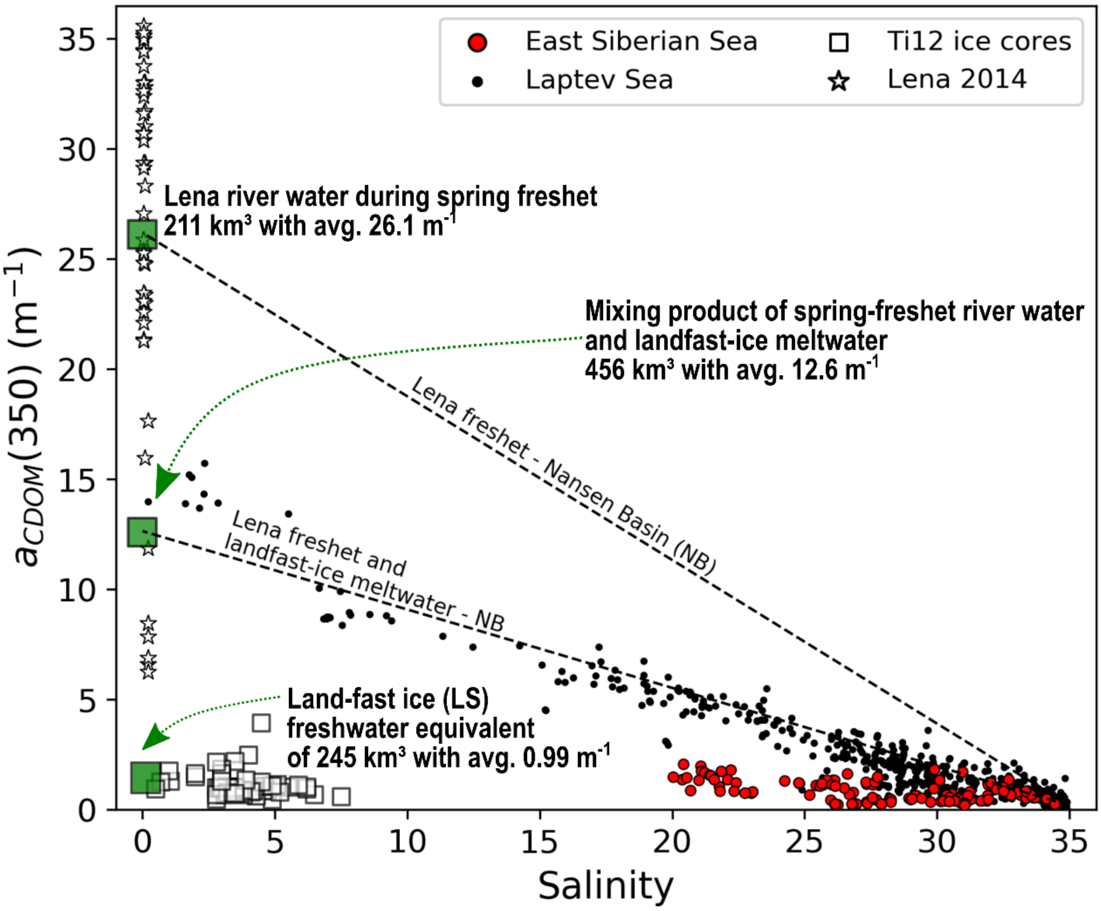

Figure 7. Salinity and a_{cdom}350 measured in land-fast ice from the LS (squares), Lena river water during the spring freshet in May/June 2014 (stars), and marine waters from the LS (black dots) and ESS (red dots). The dashed lines represent the theoretical conservative mixing lines between the spring-freshet river water (flow-weighted CDOM absorption) and the Nansen Basin (NB) sea water, as well as between the mixing product of the spring-freshet river water with the land ice melt water (MIX) and the sea water. The green squares indicate a_{cdom}350 endmember values of the spring-freshet river water and land-fast ice meltwater (freshwater equivalent), as well as the calculated endmember value for the mixing product of the two sources.

Line 333-334 / I thought the landfast ice start growing early, so it is fairly thick after the winter? You mention 2.0 m thick landfast ice, so I am bit confused here. Please clarify.

At this point we describe the relatively young drifting pack ice north of the fast ice that covers most of the Laptev Sea north of the 20 m depth contour (middle and outer shelf). We will present this more clearly in the text. We will include the citation of the study by Itkin and Krumpen (2017) that describes why this is so. The sentence was expanded: *"Because of the high sea ice export, relatively young and thin drifting pack ice (< 50 cm) covers most of the LS north of the land-fast ice at the end of winter (Itkin and Krumpen, 2017)."*

Lines 334-337: Given the complexity of the system the simple property-property plots (figs 4-5,8) are hardly able to explain the situation. Here the approach should rather be on individual profiles, where the "parent" water mass (i.e. end-members) for each one can be more reliably determined, and such the relative contribution of e.g. ice melt can be deduced. E.g. the approach by Granskog et al. (2009) in Hudson Bay was based on

"individual" end-members since these vary much in space in such coastal systems with sea ice. and**: Are there data for the isotopic values of the landfast sea ice?**

Diese Textpassage bezieht sich auf ein bereits veröffentlichtes Ergebnis. However, we presented and discussed the O18 data in more detail and used a plots of the river water fraction (Abbildung 4b) to explain the situation: *"The proportions of meltwater and brine visible in the oxygen isotope data from the LS at salinities > 25 are not clearly pronounced at salinities < 25 (Fig. 4a). However, the observation that the oxygen isotope data from the shelf water with salinities < 25 shows no dilution with meltwater, but even indicates increased amounts of brine, does not mean that no meltwater was added. This seemingly contradictory conclusion can be explained by the high export of sea ice in winter (Itkin and Krumpen, 2017). Part of the brine formed in winter is still present in the LS the following summer (Schlosser et al., 1994; Bauch et al., 2009a), while the newly-formed sea ice from which the brine originates is continuously exported to the central AO. Because of the high sea ice export, relatively young and thin drifting pack ice (< 50 cm) covers most of the LS north of the land-fast ice at the end of winter (Itkin and Krumpen, 2017). The melting of this thin pack-ice cover and the land-fast ice leads to a weakening of the isotopic brine signal (Bauch et al. 2013), but the isotopic composition nevertheless remains dominated by the brine-enriched winter water. Hence, the stable oxygen isotope signal of the sea-ice meltwater fraction is masked by the high brine signal from the winter. When interpreting the isotope data, it is important to note that the calculated sea ice meltwater fractions do not include the meltwater resulting from the high and variable proportion of frozen river water that was part of the land-fast ice (Bauch et al., 2010). Thus $\delta^{18}O$ measurements of land-fast ice from the LS cannot be used directly as an end member for sea ice meltwater."*

In contrast to meltwater from land-fast ice, the sea-ice meltwater in Hudson Bay comes from ice in western Hudson Bay that has formed at salinities between 32.3 - 33.2. It is therefore "actually" fsim. The meltwater from the fast ice with its high river water content is not identical to fsim. Frozen river water does not give an isotope signal. Moreover, the seawater content in the melt water of the fast ice is masked by the high brine values (a relict of ice formation and the strong export of ice in winter) in the LS. Furthermore, in contrast to Granskog et al (2009), the spring freshet of the Lena and the melting of the fast ice occur at the same time and place.

Due to the fact that sampling in the Laptev Sea is practically impossible in the period between mid-October and mid-March and between the beginning of June and the last week of July, and due to the complex oceanographic processes, we do not consider the approach of defining different end-members on the basis of individual profiles to be helpful for our study

(Please note also the our answer for line 168). We do have measurements of the land fast "sea-ice", but these measurements cannot be used directly as endmember ("parent" water mass) for sea-ice meltwater as they represent a mixture of sea-water and river water contained within the ice. In addition to the analysis of the oxygen isotope data, our approach is therefore based on direct measurements of the DOM properties in the land ice and the calculation of the volumes and processes leading to the mixing of the different water masses (fresh, post-fresh and melt water of the fast ice).

Lines 342-344 / Again, it would have been helpful if there was data on Fr and the deviation from the river water mixing line could be deduced, salinity alone makes it rather difficult to discern what actually causes this deviation.

We now show the f_{rw} in Figure 4b. We no longer discuss salinity but instead take frw. This hint from the reviewers was extremely helpful: *"This cluster represents water samples from the upper water column (< 20 m) north of the Lena Delta that has a f_{rw} of 40-60 % (Figure 4b). $a_{CDOM}(350)$ in the low-$a_{CDOM}(350)$ cluster was up to 50 % lower than in samples with the same f_{rw} percentage lying on the mixing line of river water (post-freshet; Summer) and seawater."*

Line 361 / What about sea ice conditions during this expedition? (pack ice gone long before cruise?).

Good point. The sea ice condition should be described here too. We added: *"The entire ESS shelf had salinities above 20 and $a_{CDOM}(350)$ being about 50 % lower than in LS samples having the same salinity (Fig. 5a colored dots and 7 red dots). During sampling in the last week of September 2019, the ESS was ice-free. However, during the first week of July 2019, the ESS was almost completely covered with land-fast ice and drifting pack ice that did not completely melt until the last week of July (data from www.meereisportal.de; Spreen et al., 2008)."*

Line 376 / is it all landfast ice, or could it also be drift (Pack) ice that is melting in the region? and **Line 383 / must if be landfast ice, or in cases further offshore also pack ice? The pack ice could have even lower CDOM than the landfast ice? E.g. see Kowalczuk et al. Kowalczuk, P., et al. (2017). Bio-optical properties of Arctic drift ice and surface waters north of Svalbard from winter to spring. Journal of Geophysical Research: Oceans, 122(6), 4634–4660. https:// doi.org/10.1002/2016JC012589**

Yes, it can be both. We will change this in the text accordingly: *"But as in the LS, the addition of large amounts of DOM-poor meltwater from the land-fast ice and meltwater from the pack ice, which may show even lower CDOM absorptions (Kowalczuk et al., 2017), should result in a strong dilution of the riverine tDOM. The ESS west of 170° E is characterized by an extensive land-fast ice belt that varies in extent from 130,000 km² to 200,000 km². The land-fast ice, which contains a freshwater equivalent of 230-360 km³, usually melts back in the first two weeks of July, and drifting fields of decaying ice might persist until August. We assume that the absence of the Lena ROFI in the western ESS, the generally low river runoff and the resulting higher fraction of low-tDOM sea-ice meltwater in the ESS led to the comparatively low tDOM concentrations in the western ESS observed in 2008 and 2019."*

Lines 384-386 / Do not quite follow how you derive the amount of DOC "removed" from sea ice, or rather moved with the brine. Please elaborate.

We agree with the reviewer. Chapter 4.4 now begins with the following paragraph: *"We used fast ice and sea water data from the southeastern LS to estimate how much DOC might be expelled along with brine from growing land-fast ice in the LS. The observed average DOC concentration in surface waters (0-5 m) east of the Lena Delta (south of 73.4° N and east of 125.0° E) was 475 µmol L^{-1} (SD ±165 µmol L^{-1}). Thus, the observed median DOC concentration in the land-fast ice of 96.2 µmol L^{-1} indicates that 379 µmol L^{-1} have been removed during ice growth. This resulting value was multiplied by the total volume of fast ice*

(273 km³; Kotchetov et al., 1994; Barreis and Görgen, 2005; Selyuzhenok et al., 2005). Assuming that the DOC is removed from the ice together with the brines, about 1.2 Tg yr^{-1} (± 0.54 Tg) DOC would thus be expelled from the growing land-fast ice. The process of brine release is reflected in the water samples from the polynya at the northern land-fast ice edge in the southeastern LS, which show high brine fractions with simultaneously increased a_{CDOM}(350) (Ti12, winter 2012). This budget calculation, however, does not take into account that the tDOM in the brines has a higher bioavailability (Jørgensen et al., 2015). Thus, rapid removal of the salt-derived tDOM could also play an important role."

Line 388-389 / what do the actual studies of Giannelli and Müller tell about the change in DOM composition at ice growth?

We now describe this in more detail in the first paragraph of chapter 4.2: *"DOM is expelled from the ice matrix during sea ice growth and is enriched in the brine (Giannelli et al., 2001; Müller et al., 2013). Only about 10 to 40 % of the original DOM and other impurities remain in the sea ice (Petrich and Eicken, 2010). Furthermore, Müller et al. (2013) were able to show that a relatively higher proportion of DOM is incorporated into the sea ice in relation to the dissolved inorganic substances. Most of the DOM then flows off into the underlying water column along with the saline brine (Amon, 2004; Anderson and Macdonald, 2015. This explains the observed low a_{CDOM}(350) of 0.99 m^{-1} (median) and DOC concentration of 96.2 µmol L^{-1} (median) in the LS land-fast ice that forms from tDOM-rich surface waters sourced by the Lena river (Figure 5b). Helms et al. (2008) showed that as a result of this process, the molecular weights of DOM in the ice and brine also decrease. Jørgensen et al., (2015) further suggest that the transformations of DOM during sea ice formation also increase its bioavailability. We assume that the transformation processes of the DOM during ice growth, which shifts the molecular composition of DOM in the ice towards a higher proportion of low molecular weight compounds (Müller et al., 2013; Granskog et al., 2015a; Retelletti-Brogi et al., 2018, Zabłocka et al., 2020) are also responsible for the high $S_{275-290}$ values (> 19 µm^{-1}) of CDOM in the ice (Figure 5b)."*

Lines 390-395 / at what salinity are these brine-rich waters on the shelf? From an oceanographic point of view, these do not then contribute to the formation of Arctic halocline in the Nansen or Amundsen basin?

The seasonal development of density stratification in the Laptev Sea is described in more detail in Janout et al. (2020). Due to the erosion of the density stratification at the end of winter and the mixing with denser water masses (from the western shelf) in the area of the shelf edge, the tDOM-rich brines from the southeastern Laptev Sea are probably diluted and mixed down to greater water depths and can thus contribute to the formation of the Arctic halocline. That this takes place is very plausible but has not been observed so far.

We explain this now in more detail in chapter 4.4: *"A significant proportion of the surface waters (0-20 m)of the LS and western ESS leaves the Siberian shelf north of the New Siberian Islands (Morison and Kwok, 2012) and supplies the Transpolar Drift Stream with tDOM-rich water masses (Charette et al., 2020), while denser bottom waters flow north of the New Siberian Island further to the east and leave the shelf in the western ESS (Anderson et al. 2017). The transport of tDOM in the water masses at the upper halocline is confirmed by investigations in the East Greenland Current where a higher CDOM absorption occurring between 30 and 120 m water depth at salinities between 32 and 33 is explained by a high fraction of brine and river water from the Siberian shelves (Granskog et al., 2012).*

During the northward transport of the brine-enriched water masses across the shelf, an increase in density occurs due to the further influx of brines from ice formation in leads and coastal polynyas of the western LS (Janout et al., 2017). Erosion of the density stratification at the end of winter and mixing with denser water masses from the western shelf of the LS could dilute the tDOM-rich brines from the southeastern LS but at the same time increase the density and bring them to greater water depths where they then flow into the Arctic halocline. The seasonal evolution of the density stratification in the LS is described in more detail in Janout et al. (2020). The water depth at which the brine is transported across the LS shelf and into the Arctic halocline depends mainly on the density structure of the water column in winter, which in turn depends on the position of the ROFI in the previous summer (Bauch et al, 2012). An eastward-directed transport south of the New Siberian Islands towards the ESS at depth greater than ~ 20 m is inhibited by the shallow water depths of the Dmitry Laptev (10 m) and Sannikov Straits (18 m)."

Lines 407-8 / at what depth? Do they feed to the halocline observed all the way in Fram Strait? And could CDOM be used to indicate where the brine-rich waters originate from?

Due to the possible erosion of the density stratification at the end of winter in the mid-shelf region (water depth > 40 m; Janout et al. 2020) and the mixing of the water column at the shelf edge, the CDOM-rich brines transported northward during winter from the inner shelf of the eastern LS could leave the shelf at depths of up to 100 m (shelf break) (see also the answer above). The actual water depth depends on the strength of stratification, which in turn is controlled by the position of the Lena River plume and the intensity of ice formation on the shelf. Whether brine and tDOM enriched water masses are then also dense enough in the eastern LS to sink further (like the brine-enriched bottom waters observed in the western Laptev Sea, Janout et al. 2017) could not yet be substantiated with observations.

The formation of the Arctic halocline is an important and interesting research topic that our group has also been working on for more than 20 years. In this context, we refer to the published studies (and studies cited in this study) by Bauch et al. (2009, JGR), Bauch et al. (2011; Prog in Oceanogr.), Bauch et al (2014), Janout et al. (2017) and Janout et al (2018). In addition, the publications of Igor Dmitrenko and Thomas Krumpen who were members of our working group for a long time are also of interest. These papers provided an important basis for the hypotheses presented in this study. In this context, we are surprised that a reviewer who repeatedly points out that the degradation of tDOM is an important process proposes to use tDOM like a conservative tracer for water mass formation (Arctic Halocline) on the Siberian shelves. We believe that this is a very difficult and challenging approach that would require a much better availability of data from the Siberian Arctic (especially winter data).

Line 413 / outer shelf?

No. The large polynyas of the western Laptev Sea run along the entire coast of the Taymyr Peninsula (from the inner to the outer shelf) and the northern edge of the fast ice approximately along the 20-meter depth contour. There are also large polynyas off the Severnaya Zemlya archipelago. However, the dense water formed there drains directly into the oceanic basins.

Lines 418-420 / Does this mean the winter brine formation never reaches the bottom on the shelf?

Never? We would definitely not say that. We just haven't observed it. The seasonal development of density stratification in the Laptev Sea is described in more detail in Janout et al. (2020). However, the bottom water (> 40 m water depth) of the Laptev Sea has salinities above 33. The CDOM maximum in Fram Strait described in Granskog et al. (2012) shows salinities between 32 and 33 which is interpreted in Granskog et al. (2012) as an indication of formation on the Siberian shelves. Thus, our observations are consistent with the measurements in Fram Strait. This is mentioned in chapter 4.4: *"The transport of tDOM in the water masses at the upper halocline is confirmed by investigations in the East Greenland Current where a higher CDOM absorption occurring between 30 and 120 m water depth at salinities between 32 and 33 is explained by a high fraction of brine and river water from the Siberian shelves (Granskog et al., 2012)."*

Line 428 / and these multiple sources are? and **Line 431-433 / are all these changes relative to 1940s? Please be specific which period the rates of change are given for in each case.** and **Line 437 / But arguably you also first need a source of brine, thus sea ice formation in the future must also play an integral role? IF there is stratification sea ice can more easily form - but will it ever penetrate the stratification?**

We have rewritten the entire Conclusions chapter and taken into account the reviewer's comments:

5. Conclusions

The eastern LS and western ESS together represent a region where much of the freshwater-influenced waters of the Siberian shelves discharge into the transpolar drift current and the Arctic halocline, which carries the shelf waters towards Greenland and the Nordic Seas (Morison et al., 2012; Timmermans and Marshall, 2020). This region is thus a key region for a better understanding of the Arctic marine carbon cycle. Analysis of the extensive data set in this study, spanning several years and different seasons, illustrates that the distribution of tDOM in the LS and ESS is mainly determined by the physical mixing of river water, sea-ice meltwater, and sea water. Our study highlights that the formation and melting of land-fast ice in the Laptev and East Siberian Sea significantly shapes the concentration distribution of tDOM in the area of the Siberian shelf seas. In this context, the observed concentration distribution on the shelves indicates a conservative mixing behaviour of tDOM introduced by the river rather than a removal or an additional DOM supply from other sources. The reason for this could be the short residence time of the river water on the Siberian shelves as well as a reduced photochemical degradation of the tDOM due to the ice cover of the southern shelves lasting until July. The extremely high CDOM absorption and suspended matter concentrations within the ROFI (Juhls et al., 2019; Heim et al., 2014), which lead to a self-shadowing effect, may also inhibit photodegradation. The results of the study also illustrate that the growth of fast ice and the associated formation of CDOM-rich brines have an important role in the transport pathways of tDOM across the Siberian shelves and the AO.

The duration of the landfast-ice season in the LS is reduced by 2.8 days per year (observational period 1999 to 2013; Seyushenok et al., 2015), while in the second decade of the 21st century the onset of the spring freshet of the Lena River happens about 6 days earlier than at the beginning of the observational period in 1940 (Shiklomanov et al., 2020). Further changes of the ice regime and the timing of spring freshet will certainly have an impact on the dynamics of tDOM in the AO. In addition, the decline of Arctic sea ice and the associated longer ice-free season will lead to changes in wind forcing in the shelf systems of the Arctic and to an increased input of solar radiation into the water column. This will significantly *change freshwater transport pathways, the heat content of the water column and stratification in the LS and ESS. The heat content in turn influences the formation of new ice and thus also the production of DOM-rich brines. Because density stratification also controls where and at which depth the DOM-rich brine leaves the shelf, changes in stratification also impact the future transport pathways of tDOM in the AO. Studying these processes is important not only to decipher the Arctic carbon cycle, but also because it regulates physical processes such as radiative forcing in the upper ocean, which has important effects on, for example, sea surface temperature, water column stratification and UV penetration (Gnanadeskian et al. 2019; Soppa et al., 2019).”*