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Biogeosciences
Discussions

Interactive comment on "Particulate organic matter composition and organic carbon flux in Arctic valley glaciers: examples from the Bayelva River and adjacent Kongsfjorden" *by* Z.-Y. Zhu et al.

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We go through the comments of referee #2, and find that the review's major comments include several points. In this reply, we reply to the major comments point by point, and ended by a reply to the specific comments (minor comments) all together. We appreciate the reviewer's help.

Major comments:

Point 1: is the DOC, POC and TSM correlated with discharge?

Regression analyses of water discharge versus TSM gave correlations over long time period but the fitted curve slopes are different from year to year (Bogen and Bønsnes, 2003). With respect to relationship between POC/DOC and discharge, no previous report can be found for Svalbard glacier meltwaters.

In this study, the instrumental recorded water discharge at NVE station in whole August, 2012 ranged from 0.12 m3/s to 9.66 m3/s, averaging 2.56 m3/s (on an hourly measurement base). Based on our chemical measurement at NVE station, however, no relations can be found, between DOC/POC/TSM and the daily nor hourly discharge. The statistical results are shown as following table (Table R2):

Table R2. (due to format reason, please refere to supplement pdf file for this tableR2)

Point 2: how do you calculate the flux and error? And the discussion regarding with representativeness of the Bayelva river in Svalbard

For the Bayelva river OC flux and error:

Based on the data in Table 1, we calculate the mean and standard deviation of POC, DOC and TSM. The discharge is calculated based on the instrumental discharge monitoring data set in 2012. In 2012 the discharge was 29 $\times$106 m3 (or exactly 29847888 m3). So the river flux is estimated as mean concentration multiplied by discharge. The error is estimated as half of the standard deviation multiplied by discharge.

For the whole Svalbard OC flux and error:

According to the Bayelva River monitoring result (Table1), we obtained the POC in percentage as 0.35% $\pm$ 0.106%, and the published total TSM flux of the whole Svalbard is 16 $\times$ 106 t/yr (Hasholt et al., 2006). So the whole POC flux for Svalbard is 0.35% $\times$ 16 $\times$ 106 t/yr = 0.056 $\times$ 106 t/yr, and the error is 0.106%$\times$16 $\times$ 106 t/yr = 0.02$\times$ 106 t/yr.

Similarly, the DOC concentration in the Bayelva river was used to calculate for the total DOC flux for whole Svalbard. According to Table 1, the DOC concentration was 73 $\pm$

30 μM and the glacier meltwater runoff is 25 km3/year (Hagen et al., 2003). So the total DOC flux is 73 μM multiplied by 25 km3 and the error is derived from 30 μM multiplied by 25 km3.

In the revised version, we will further add discharge-weighted flux:

The discharge-weighted flux will be calculated as the total OC flux divided by the glacier area. The glacier area in Svalbard is cited from literature (Hagen et al., 2003), which is 36600 km2.

It should be noted that the above calculation for flux is only estimate and for sure it comes with uncertainties. The uncertainties are largely due to our own data set (only three weeks were covered, and no further more other rivers data), and are also partly due to other data source concerned (e.g., uncertainties in the total TSM flux and total runoff for whole Svalbard). Most of the Svalbard islands have an extensive cover of glaciers and there are many rivers/creeks coming out from them, supplying sediments to the ocean. There is limited OC study in Svalbard glacier meltwaters. As for dissolved organic carbon (DOC), as was wrote in the manuscript, previous work in neighboring drainage basins suggests that DOC concentration in Svalbard glacial meltwater is maintained at high levels (250–426 μM in glaciated basins and 165–204 μM in non-glaciated basins) between mid June and early September (Tye and Heaton, 2007). A study to a southern glacier in Spitsbergen (Werenskioldbreen) showed that DOC in the runoff is 283 μM (Stibal et al., 2008). POC study in Svalbard is more limited and a previous study to Bayelva river reported the POC content to be $\sim$0.5% (Kuliński et al., 2014). As Bayelva river is derived from glacier meltwater, so another uncertainty comes from the Non-glacier Rivers in Svalbard, but the non-glacier river is in minority in Svalbard. Previous investigation to non-glacier rivers (e.g., NyLondon river in the biggest island in Kongsfjorden) indicates its POC% is higher, namely $\sim$2.5% (Kuliński et al., 2014). Other glacier meltwater river with unusual POC content include the river that flows through birds colony, the POC% of which can be over 9% (Kuliński et al., 2014). However, these rivers are not common in Svalbard. So, compared with

other common glacier meltwater OC values, our DOC and POC value are comparable to other glacier meltwater OC values, and somewhat lower (in our study for Bayelva river, DOC: 20 âĂŢ 167 μM, POC%: 0.16% âĂŢ 0.48%). The value we used for whole Svalbard OC flux estimate is DOC 73 μM, POC 0.35%, and accordingly, our whole Svalbard OC flux estimate may be lower, but still within the same order, if compared with flux estimated via other glacier meltwater OC values.

The whole Svalbard glacier coverage is 55% (Lang et al., 2015) to 60% (Nuth et al., 2010), while the glacier coverage in Bayelva river basin is almost the same, namely 55% (Bogen and Bønsnes, 2003). The whole Svalbard annual TSM flux was estimated via the sediment yield rate of 586 t/km2/year (Hasholt et al., 2006), which was obtained from the Bayelva river basin. Also, Bayelva river is the earliest river that started in the long-term monitoring program of water discharge and sediment transport (by Norwegian Water Resource and Energy Directorate), which started in 1989 (Bogen and Bønsnes, 2003). So, though Bayelva River alone cannot stand for the whole Svalbard rivers in a 100% manner, but we think Bayelva river is a very important and typical one among all the glacier meltwaters in Svalbard. The above comparison also indicates that the OC values between Bayelva river and other Svalbard glacier meltwaters are in the same order and hence our estimates should not deviate too much from the true value. As was stated in the manuscript, temporally and spatially expanded OC investigations for glacier meltwater rivers in the future is absolutely necessary for a more comprehensive Svalbard OC flux estimate and our flux value so far is preliminary and tentative.

Point 3. Discussion of THPAA contribution to PN

In section 4.1, we discussed about the POM composition and its controls. First we began with the assimilation discussion in 4.1.1, mainly based on bulk parameters of OC, like total amino acids concentration, POC, PN, and other environmental properties (Chla, nutrients), and then in 4.1.2 we further discussed the composition based on detailed amino acids enantiomers, like D-Ala, D-Glx.

Under this frame, in section 4.1.1, a bulk-parameter-based approach was used to estimate various sources contribution of amino acids nitrogen. For the bacterial amino acids nitrogen calculation, the bulk-parameter approach is based on the fact that: 1. Bacterial POC is 20% in Kongsfjorden (Rokkan Iversen and Seuthe, 2011), 2. Within the cell, marine bacterial carbon and its amino acids nitrogen ratio is 7.46 (calcualted from Table 3 and Table 5 in Simon and Azam, 1989). So based on the fjord surface POC concentration (in μM), a bulk-parameter-based bacteria amino acids nitrogen contribution to PN was calculated (24% $\pm$ 9%) and further compared to the total PN pool in section 4.1.1. The reviewer suggests that we use D-ala approach only (this approach was carried out in section 4.1.2), which gave a bacteria amino acids nitrogen contribution to PN of 36% $\pm$ 18% (see Table 4 in manuscript). We agree with this idea and then in section 4.1.1 the phytoplankton and bacteria THPAA nitrogen together contributed 51% of total PN, with the rest 27% of THPAA nitrogen contribution unaccounted for, which is likely due to uncertainties in the calculation, presence of zooplankton, and also the non-living AA, as was suggested by the reviewer.

The reviewer further suggest to use DI to evaluating contribution of non-living AA to PN. DI is an index which indicates the integrated organic matter degradation status and in the discussion of contribution to PN section (i.e., section 4.1), only the surface fjord samples are focused. For those stations with elevated THPAA nitrogen contribution to PN, namely stations mainly at the fjord mouth, the DI values for these samples ranged from 0.5 to 0.8, indicating these samples are under strong influence of fresh organic matter. A further comparison of DI value with phyto-, or bacterial THPAA nitrogen contributions to PN also gave no statistical significance.

Point 4. Adding a new table.

Fine. We can revise the table 1, expand it, and add the organic matter parameters for both river and fjord waters.

Specific comments:

Basically this work is mainly focusing on surface waters. Bottom samples were also collected whenever possible (i.e., the stations that observed via R/V Tiesten), the depth of which was usually 10-20m above the seabed. For station 14# (depth: 74m), 4 layers of samples were collected (namely at 0m, 10m, 40m and 70m).

For Page 15660 line 16, yes, it should be ‘filtered’, instead of ‘cleaned’. This is a mistake in writing. Thanks.

About tryptophan, yes, the acid-hydrolysis method is unfriendly to tryptophan. Indeed this amino acids is zero in amount in our data set. We will remove this amino acid.

About the DI calculation, we use the factor score coefficients reported in Vandewiele et al., (2009), so that the calculated DI value remains comparable to previous work.

For Page 15666 lines 14-25, the estimate contribution of phytoplankton THPAA to PN is based on the fact that: 1. Phytoplankton amino acids nitrogen is around 70% of the total algal nitrogen (Dortch et al., 1984); 2. In Svalbard, phytoplankton carbon: Chla ratio is 50 (Hop et al., 2002); 3. Phytoplankton carbon: nitrogen = 6.6, namely Redfield ratio (Redfield et al., 1963). So based on the chlorophyll a concentration, we calculated the phytoplankton THPAA nitrogen.

The estimate contribution of bacterial THPAA to PN: see above reply to major comments point 3. Phytoplankton/bacterial contribution to POC was not estimated here in this paragraph.

In latter section 4.1.2, bacteria contribution to POC and PN was estimated via D-ala approach (in brief, convert D-ala into carbon or nitrogen amount via conversion factor in the literature that has been obtained by culture marine/freshwater bacteria).

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Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C7949/2015/bgd-12-C7949-2015-supplement.pdf

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