The reviewer No 1 positively evaluated our work but issued a number of constructive and pertinent comments.

Comment: "Because one of the major objectives of the manuscript is to relate RSM flux and composition to watershed characteristics I strongly suggest including a more detailed description of the watershed characteristics in the region, rather than referring to 4 different references. It would be good to include estimates on biomass or carbon stores in the different regions if available.
Answer: Following this recommendation, we will add the following information in the Supplement of revised manuscript:

Geographical setting of sampled watersheds

Sampling was performed along the latitudinal transect of Western Siberia Lowland (WSL) whose northern part is comprised of taiga zone (Kogalym), forest-tundra (Khanymey and Pangody), and tundra (Tazovsky) biomes. The region is within the watershed of the Ob, Nadym, Pur, and Taz rivers which drain Pleistocene sands and clays and are covered by a 1 to 5 m peat layer**.** Key physio-geographical parameters of studied sites are described in **Table R1** (see the end of this reply).

The rivers (mainly the tributaries of the Ob, Pur, and Taz) drain Pleistocene sands and clays, covered by thick (1 to 3 m) peat and enclose three main zones of the boreal biome, taiga, forest-tundra and tundra. Quaternary clays, sands, and silts ranging in thickness from several meters to 200-250 m have alluvial, lake-alluvial and, rarely, aeolian origin south of 60°N and fluvio-glacial and lake-glacial origin north of 60°N. The annual precipitation increases from 550 mm at the latitude of Tomsk to 650-700 mm at Nojabrsk and further decreases to 600 mm at the lower reaches of the Taz River. The annual river runoff gradually increases northward, from 160-220 mm y^{-1} in the permafrost-free region to 280-320 mm y^{-1} in the Pur and Taz river basins located in the discontinuous to continuous permafrost zone (Nikitin and Zemtsov, 1986). A detailed physio-geographical, hydrology, lithology and soil description can be found in earlier works (Botch et al., 1995; Smith et al., 2004; Frey and Smith, 2005, 2007; Frey et al., 2007a, b; Beilman et al., 2009) and in our recent limnological and pedological studies (Shirokova et al., 2013; Manasypov et al., 2014, 2015; Stepanova et al., 2015).

The peat was actively forming since the beginning of the Holocene until freezing of bogs in sub-Boreal period (9-4.5 thousands y.a.). After that, the rate of peat formation in bog areas has decreased (Peregon et al., 2007; Vasil'chuk et al., 2008; Panova et al., 2010; Ponomareva et al., 2012; Batuev et al., 2015). The main mineral substrates underlying frozen peat layers of the WSL are quaternary clays, sands, and alevrolites. In the sporadic to discontinuous permafrost distribution (Kogalym and Khanymey) the typical substrate is sands of lake alluvium origin with rare layers of alevrolites (Klinova et al., 2012). The older, Paleogene and Neogene, rocks are rarely exposed on the surface and are represented by sands, alevrolites and clays, where carbonate material is present as concretions of individual shells (Geologicheskoe Stroenie, 1958). In discontinuous permafrost zone, the substrate is composed of silts and clays overlaying lake alluvium sands. In continuous permafrost region, the substrate is alluvial sands with alevrolites (Nazarov, 2007). Overall, the mineral substrates are quite similar among all 5 sites of the northern part of WSL and were subjected to strong influence of aeolian processes in the beginning of the Holocene (Velichko et al., 2011).

Climate ranges from moderately humid and cool in summer to cold and snowy in winter in Kogalym to humid and cold in summer to cold and snow-deficient in winter in Tazovsky. Mean annual temperatures are -0.5, –4.0, –5.6, –6.4, and –9.1°C for permafrost-free zone (Tomskaya region), sporadic+isolated permafrost (Kogalym), discontinuous permafrost (Khanymey, Pandogy) and continuous permafrost (Tazovsky), respectively (Trofimova and Balybina, 2014). Permafrost is present at all sites and ranges from discontinuous to sporadic in the south to continuous in the north. Three main micro landscapes are present across the latitudinal gradient: peat mounds, hollows, and permafrost subsidences. The average active layer thickness (ALT) at the time of sampling ranged from 200-300 cm in the south to 65 cm in the north for hollows whereas mounds (hummocks) ranged from 90 cm in the south to 41 cm in the north.

The vegetation of river watershed containing abundant bog types (polygonal, mound, and ridge-hollow) is essentially oligotrophic (poor in nutrients) which indicates ombrotrophic conditions (i.e. lack of groundwater input and lateral surface influx). The mounds and polygons are covered by dwarf shrubs (*Ledum ssp., Betula nana, Andromeda polifolia, Vaccinium ssp., Empetrum nigrum)*, lichens (*Cladonia ssp., Cetraria, Ochrolechia)* and mosses (*Dicranum ssp., Polytrichum ssp., Sphagnum angustifolium, S. lenense*). Depressions and frost cracks contain moss-sedge associates (grasses *Eriophorum russeolum, E. vaginatum, Carex rotundata, C. limosa, Menyanthes trifoliate, Comarum palustre*; mosses *S. balticum, S. majus, S. lindbergii, S. Warnstorfii* and dwarf shrubs *Oxycoccus palustris*). In the most southern site of permafrost development (Kogalym), the pine *Pinus sylvestris* is abundant on ridges, and in the permafrost-free zone (Tomskaya region), the Siberian pine-birch-picea forest is interchanged with bogs and large flood plain zones of the river valleys (Ilina et al., 1985; Peregon et al., 2007, 2009).

Comment: RSM transport is strongly linked to hydrological conditions, however, the current manuscript includes no metric to relate hydrology/discharge to RSM transport. This needs to be addressed before other controlling factors for RSM transport can be identified with any degree of certainty.

Answer: The reviewer has made an important point here. In the revised version, we will include thorough hydrological analysis and we will present the open water-period fluxes of C, N and P in WSL rivers. This analysis takes into account the spatial and temporal variability of river discharge, performed using various hydrological approaches as described in previous works of our group on the dissolved (< 0.45 µm) fraction of the river water (Pokrovsky et al., 2015, 2016 Biogeosciences). The seasonal fluxes of C, N, P and RSM export by WSL rivers were calculated separately for spring (May and June), summer (July, August and September) and autumn period (September-October) for each 2° -wide latitudinal belt of the full WSL territory, following the approach developed for C and major and trace elements in the river water (Pokrovsky et al., 2015 BGD; Pokrovsky et al., 2016 BGD).

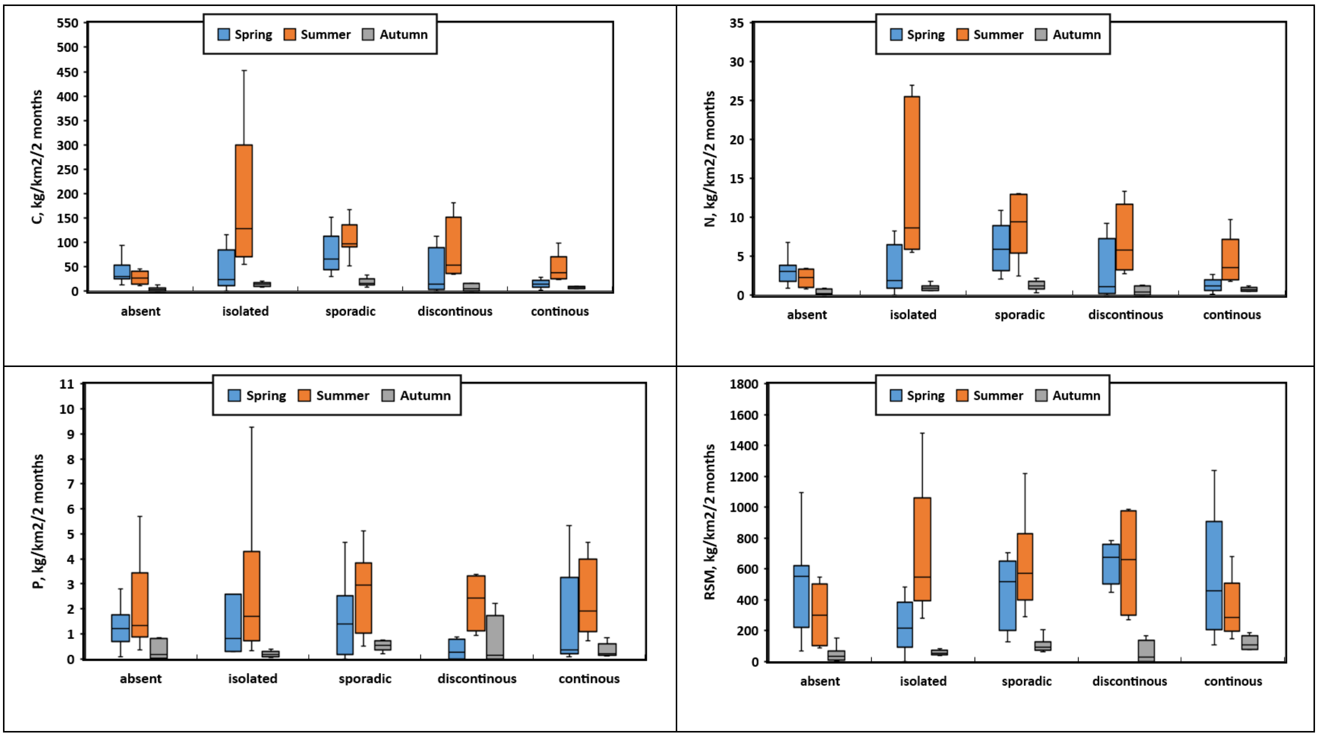

Fig. R1. Seasonally-resolved export fluxes of particulate C, N, P and RSM from WSL rivers during spring (May and June), summer (July and August) and autumn (September and October) for permafrost-free and 4 distinct permafrost zones. This 3 seasons of open-water period represent by far the largest contribution to overall annual element and RSM yield, following the results for other Artic rivers (MacClelland et al., 2016).

Based on results of 3 main seasons, an open-water period export fluxes of C, N, P and RSM were calculated as shown in **Fig. R2** below.

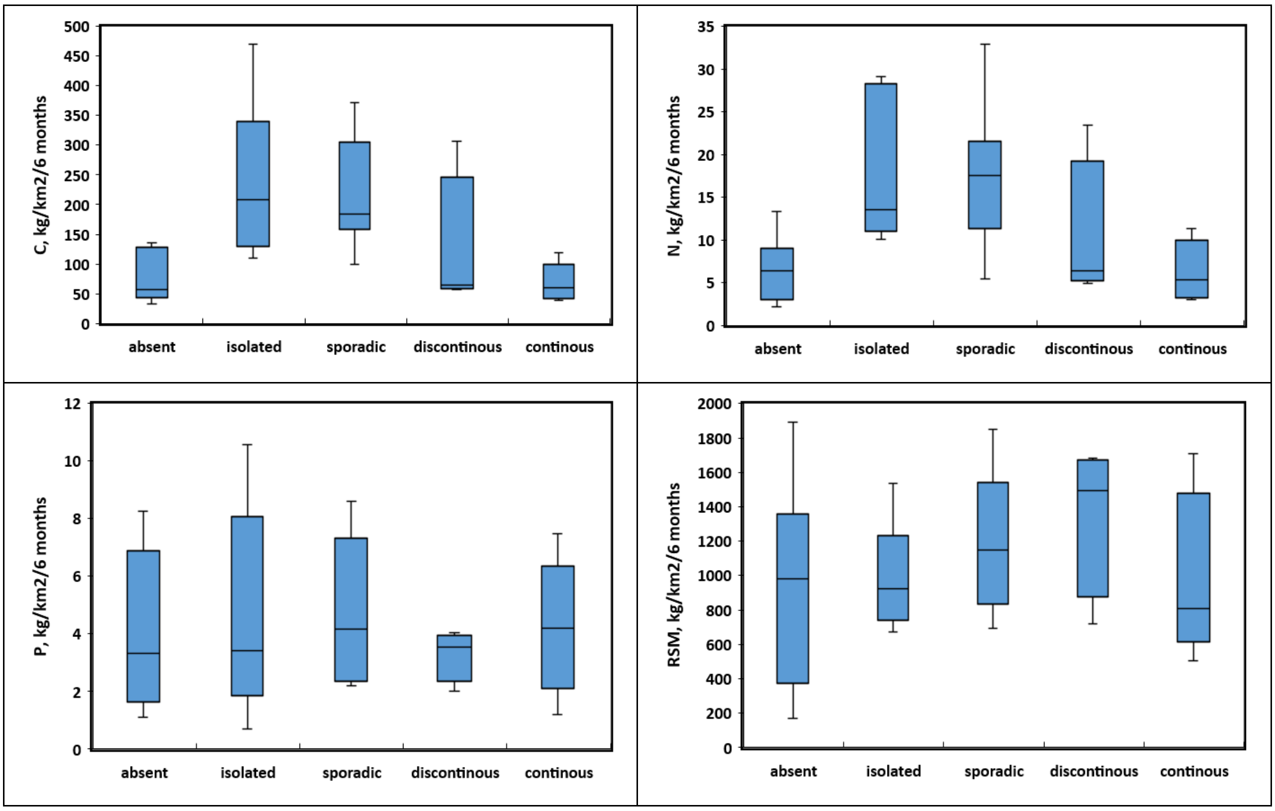

Fig. R2. Total open-water seasons fluxes of particulate C, N, P and suspended matter in 5 permafrost-free and 4 distinct permafrost zones of WSL. There is a clear maximum of C and N export at the beginning of permafrost appearance, in isolated to sporadic permafrost zone.

The obtained fluxes are in fair agreement with values assessed for terminal gauging station of the Ob River by PARTNERS (ArcticGRO) program (MacClelland et al., 2016).

Comment: The authors identified a relationship of carbon concentrations to the watershed size, how much of this relationship is caused by the fact that smaller watersheds have a faster flow than larger rivers, which allow for settlement of RSM? Could it be a matter of different sedimentation rates?
Answer: No, we do not believe that there is a sedimentation in large rivers compared to small rivers. First, due to extremely flat context of the WSL and the runoff which is between 100 and 250 mm y^{-1}, the flow rate of small rivers is not sizably different from that of the large rivers; moreover the small rivers have lower water velocity than the large ones, which is opposite to what is known from mineral soils and mountainous region of the other regions of Arctic.
Second, the large rivers are strongly enriched in mineral particles (lower in C and N than the small ones, see Fig 2A of the manuscript). Because mineral particles are heavier, they settle faster than the organic particles. This clearly indicates that there is no impact of sedimentation rates on C concentration in WSL rivers particulate loads.

Comment: The authors describe a process by which particles are transported within the soil (supra permafrost). This process is not commonly known, and should be described in more detail in the new "study site description section".
Answer: The main factor controlling elemental behavior during accelerating thaw in permafrost and release of soil carbon and metals to surrounding aquatic landscapes is the connectivity between soils and rivers or lakes, which occurs via water and solute transport along the permafrost table ("supra-permafrost flow"). The supra-permafrost (shallow subsurface) water occurs in the active layer, typically at the border between the thawed and frozen part of the soil profile (Woo, 2012). In the permafrost regions having no groundwater discharge, this water represents a major source of solutes,

and, possibly, particles, to rivers or lakes from surrounding soils. In the frozen peatbogs of WSL, the active (unfrozen) layer thickens (ALT) is maximal at the end of seasons, which is typically end of September - beginning of October (Raudina et al., 2018).

Woo, M.-K., 2012. Permafrost Hydrology, Springer, Heidelberg Dordrecht London N.Y., doi 10.1007/978-3-642-23462-0.

Comment: "The current manuscript does not make use of the source information contained in the elemental composition of RSM. C/N ratios have the potential to constrain different sources of RSM. For example if DOM coagulation or flocculation is an important source of RSM in this system the C/N ratio should be quite high (typically >40), however, the C/N ratios reported in the study are all between 10 and 23, more common for soil derived organic matter or microbial derived organic matter. The authors should use the C/N ratio to discuss sources in the manuscript.

Answer: We thank the reviewer for this valuable comment and added a new box plot (**Fig. R3**) of C : N ratio versus permafrost type, as requested.

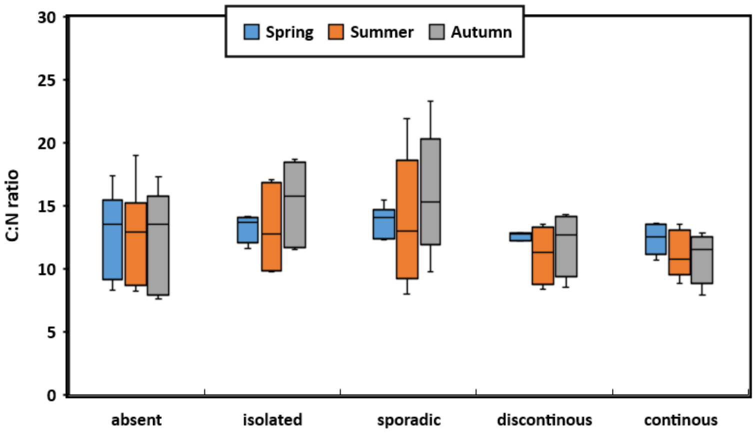

Fig. R3. A plot of C:N ratio in particulate matter of WSL rivers for three seasons, as a function of type of permafrost distribution.

As it is stated in the Abstract, « The C:N ratio in the RSM reflected the source from deep rather than surface soil horizon, similar to that of other Arctic rivers." We did perform the detailed analysis and pertinent discussion of C:N parameter. The C:N ratio of RSM was independent on the watershed size in spring but decreased 2-3 times with $S_{watershed}$ increase ($R^2 = 0.4$) in summer and autumn (Fig. 2D of the manuscript).

The decrease of C:N in the RSM from small to large rivers likely reflected a shift in main origin of suspended matter, from peat in small rivers to more lithogenic (deep soil) in large rivers. This was mostly visible in summer and autumn; in spring the rivers exhibit a very homogeneous C:N signature which may be linked to a dominant source of RSM from bank abrasion and sediment transport as well as deposition within the riparian zone. In fact, the flood plain of the Ob river and other rivers of the WSL extend more than 10 times the width of the main channel (Vorobyev et al., 2015). Note that the C:N ratio in large rivers (>100,000 km²) approach that of average sedimentary rocks (8.1; Houlton et al., 2018). In this regard, highly homogeneous C:N ratios in particulate load of Arctic rivers (7 to 18 for Mackenzie, Yukon, Kolyma, Lena, Yenisey and Ob regardless of season; McClelland et al., 2016) are interpreted as the mixture of deep soil sources where C:N < 10 (Schädel et al., 2014) and upper organic-rich horizons of soils with elevated C:N (Gentsch et al., 2015). The Ob River demonstrates the youngest POC of all Arctic Rivers (-203 to -220 ‰ $\Delta^{14}C$; McClelland et al., 2016) which certainly indicates a relatively fresh (ca. 1,000-2,000 years old) origin of particulate carbon that is presumably from intermediate peat horizons.

We believe that the variation in C:N in RSM may reflect different sources of organic material feeding the river depending on seasons and latitudes. A compilation of C:N ratios in peat and mineral horizons as well as in thermokarst lake sediments for four main sites of latitudinal transect considered in this study is given in Fig. S4 of Supplement of the manuscript (see below). The range of C:N values in

RSM rivers (10 to 20) is closer to that in sediments of thermokarst lakes (20 to 30). Note that the resuspension of sediments may be an important source of water column POC (Yang et al., 2016). The minerotrophic bogs, which are mostly linked to rivers via hydrological networks, have a C:N ratio in upper peat horizons ranging from 24 to 28. In mineral soils of the region, the C:N range is between 10 and 15 regardless of latitude, from the tundra situated Taz River riparian zone to the taiga situated middle channel of the Ob River. For upper organic horizons the C:N is always higher than the bottom mineral horizons. The old alluvial deposits of the Pyakopur River (discontinuous permafrost zone) had only 0.2% of POC with C:N equal to 6. Overall, there is an enrichment in N relative to C in the course of water transport of organic and organo-mineral solid particles from soils and riparian deposits to the river water.

Comment: The conclusion section is way too speculative. The presented data do not support such wide reaching conclusions. A closer look at the C/N ratios might help with this. Can the increased C and N concentrations in the sporadic permafrost region be explained by differences in the vegetation or biomass? “

Answer: Note that the increase in C:N ratio in the sporadic permafrost zone is also observed but it is less significant than that of C and N concentration (Fig. 3 of the manuscript) and fluxes (see **Fig. R2**). The most complete, ground-calibrated vegetation and ecosystem map of western Siberia (Frey and Smith, 2007) does not allow to attribute any specific characteristics, capable to explain the C, N pattern, to the sporadic permafrost zone. Three major parameters changing along the permafrost transect are illustrated in **Fig. R4** graphs taken from Frey and Smith (2007) below.

Frey, K. E. and Smith, L. C.: How well do we know northern land cover? Comparison of four global vegetation and wetland products with a new ground-truth database for West Siberia, Global Biogeochem. Cy., 21, GB1016, doi:10.1029/2006GB002706, 2007.

1) permafrost-free (south of 61°N), 2) isolated (61 to 63.5°N); 3) sporadic (63.5 to 65°N); 4) discontinuous (65 to 66°N), and 5) continuous permafrost zones (north of 66°N).

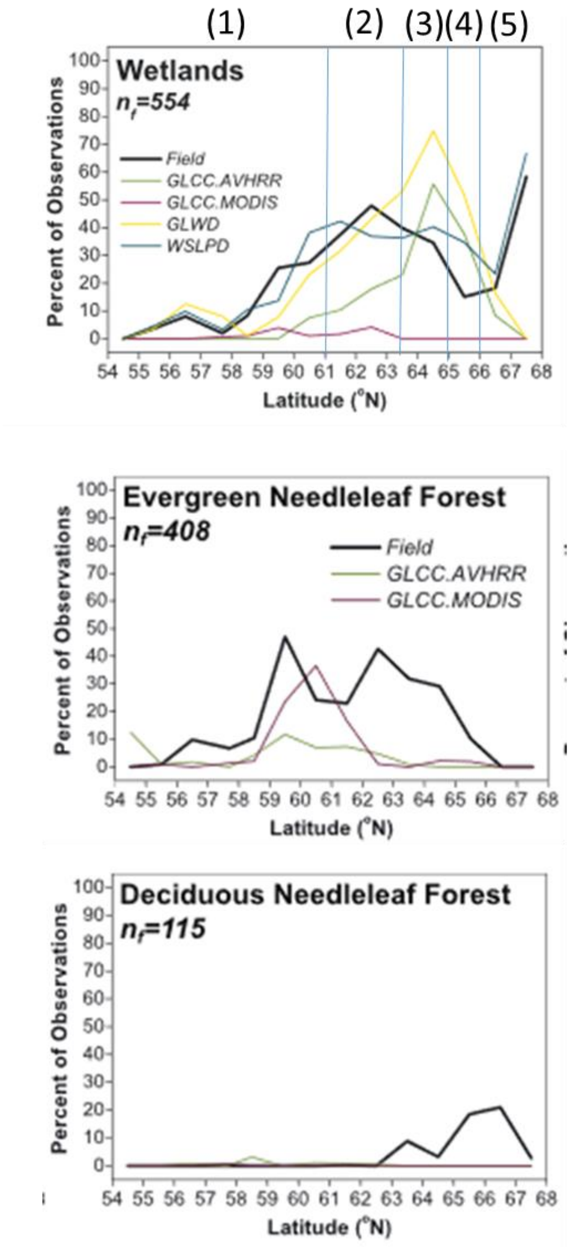

Fig R4. Percentages of wetland, evergreen needleaf forest and deciduous needleleaf forest of the ground-truth sites (binned by latitude) identified in Frey and Smith (2007) and calculate dusing various remote sensing models. There is no particular feature of main vegetation distribution at the thawing front (sporadic to isolated permafrost zone) identified in the present study as the site of maximal mobilization of nutrients from the soil to the river.

Comment: The conclusions also state that climate change will lead to the drainage of lakes and bogs. This also needs to be explained, why do we expect the bogs to drain in the future?

Answer: The lakes drainage and bogs colonization by forest is very common scenario of landscape evolution in Western Siberia under on-going climate warming (Kirpotin et al., 2009; 2011). Scenarios of thermokarst lake evolution under climate warming and permafrost thaw in western Siberia include 1) draining of large thermokarst lakes into hydrological network, which is especially pronounced in discontinuous permafrost zone (Smith et al., 2005; Polishchuk et al., 2014) and 2) appearance of new depressions, subsidences and small thaw ponds (< 100-1000 m^2), which is evidenced across all permafrost zones of this region (Shirokova et al., 2013; Bryksina and Polishchuk, 2015).

There are two main scenarios of climate warming impact on western Siberian peatlands. According to the first scenario, the area of hollows and subsidences will increase and the coverage of palsa by mounds and polygons will be decreasing (Moskalenko, 2012; Pastukhov and Kaverin, 2016; Pastukhov et al., 2016). The decade to century period are reported to be needed for reorganization of vegetation, water storage, and flow paths in the permafrost landscapes in peaty-silt lowlands (Jorgenson et al., 2013).

Bryksina, N. A.; Polishchuk, Y. M. Analysis of changes in the number of thermokarst lakes in permafrost of Western Siberia on the basis of satellite images. Kriosfera Zemli (Earth's Cryosphere) 2015, 19 (2), 100–105. (in Russian).

Jorgenson, M.T., Harden, J., Kanevskiy, M., O'Donnell, J., Wickland, K., Ewing, S., Manies, K., Zhuang Q., Shur Y., Striegl R., Koch J., 2013. Reorganization of vegetation, hydrology and soil carbon after permafrost degradation across heterogeneous boreal landscapes. Environ. Res. Lett. 8, 035017. doi:10.1088/1748-9326/8/3/035017.

Kirpotin, S.N., Berezin A., Bazanov V. et al. (2009) Western Siberia wetlands as indicator and regulator of climate change on the global scale. Internat. J. Environ. Stud. 66(4), 409-421. DOI: 10.1080/00207230902753056

Kirpotin S., Polishchuk Y., Bryksina N., et al. (2011) West Siberian palsa peatlands: distribution, typology, hydrology, cyclic development, present-day climate-driven changes and impact on CO2 cycle. Internat J Environ Stud, 68(5), 603-623, doi: 10.1080/00207233.2011.593901.

Moskalenko, N.G., 2012. Cryogenic landscape changes in the West Siberian northern taiga in the conditions of climate change and human-induced disturbances. Earth's Cryosphere. 16 (2), 38–42.

Pastukhov, A.V., Marchenko-Vagapova, T.I., Kaverin, D.A., Goncharova, N.N., 2016. Genesis and evolution of peat plateuas in the sporadic permafrost area in the European North-East (middle basin of the Kosyu river). Earth's Cryosphere. XX (1), 3–13.

Pastukhov, A.V., Kaverin, D.A., 2016. Ecological state of peat plateaus in northeastern European Russia. Russian J. Ecology. 47 (2), 125–132. doi:10.1134/S1067413616010100.

Polishchuk, Y.; et al. Remote study of thermokarst lakes dynamics in West-Siberian permafrost. In *Permafrost: Distribution, Composition and Impacts on Infrastructure and Ecosystems*; Pokrovsky, O.S., Ed.; Nova Science Publishers: New York 2014; pp 173–204.

Shirokova, L. S.; Pokrovsky, O. S.; Kirpotin, S. N.; Desmukh, C.; Pokrovsky, B. G.; Audry, S.; Viers, J. Biogeochemistry of organic carbon, CO2, CH4, and trace elements in thermokarst water bodies in discontinuous permafrost zones of Western Siberia. Biogeochemistry 2013, 113, 573–593.

Smith, L.; Sheng, Y.; Macdonald, G.; Hinzman, L. Disappearing Arctic lakes. *Science* **2005**, *308*, 1429.

Specific comments

Line 37 should say "...the Western Siberian Lowland ..." Answer: Fixed

Line 56: Why are high latitude rivers most vulnerable to a changing particulate nutrient regime? What are you trying to say?
Answer: We intended to say "High-latitude rivers are most to on-going climate change via altering their hydrological regime (Bring et al., 2016) and widespread permafrost thaw that stimulates nutrient release (Vonk et al., 2015)", fixed accordingly

Line 72-74. Awkward wording, change the sentence.
Answer: We simplified as "Further, potentially increased transport of P and N may significantly change primary productivity in riverine ecosystems (Wrona et al. 2016; McClelland et al. 2007), thereby impeding rigorous predictions of climate change impact on Arctic terrestrial-aquatic ecosystems."

Line 108: should say "..on the permafrost-bearing zone"
Answer: Yes, corrected accordingly.

Line 116: "mechanisms to predict change in..."?
Answer: Yes, corrected accordingly.

Line 138-140: Why is the late autumn the time when the soils are best connected to the rivers, this needs to be explained in the "study site description section"
Answer: Good point. The late autumn (October) is the time of maximal altered layer thickness, which provides the maximal connection of soils to the rivers via suprapermafrst flow. Explained in details in our response to the suprapermafrost flow.

Line 146: "... temperature was 4 and 2.7 degrees higher..."
Answer: Fixed

Line 202: What do you mean by "RSM did not depend on the open water season..."
Answer: "Mean bulk RSM concentration in the WSL river waters did not depend on the season of open-water period of the year"

Line 240:" ... in the watershed.." - Fixed.

Line 260-262: Reword to clarify what you mean here.
Answer: We modified as: "The share of particulate phosphorus versus total ranged from 10 to 90%. It did not demonstrate any link to size of river watershed…"

Line 266: ... nutrients... is not the best term for this title line.
Answer: Changed to "Concentrations of C, N and P in the RSM and impact of the watershed size"

Line 354: "...was also found in the isolated and sporadic..." - Fixed.

Figure 3: Include C/N ratios to highlight potential shifts in organic matter sources.
Answer: We did so, see in our response above, Fig R1.

We thank reviewer # 1 for his/her valuable comments

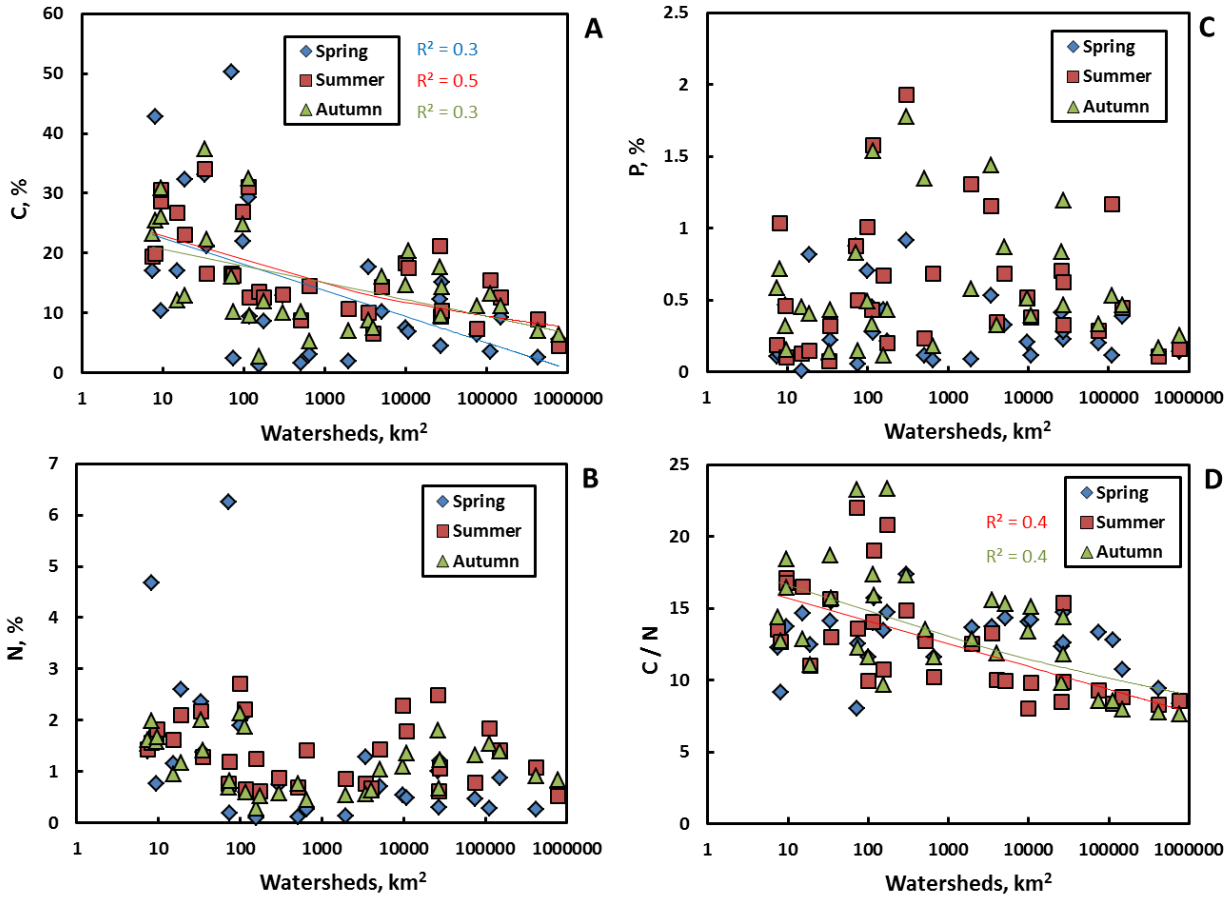

Fig. 2. Particulate (> 0.45 µm) C (**A**), N (**B**), P (**C**) concentration in the RMS (%) and C: N ratio (D) in RSM as a function of river watershed size.

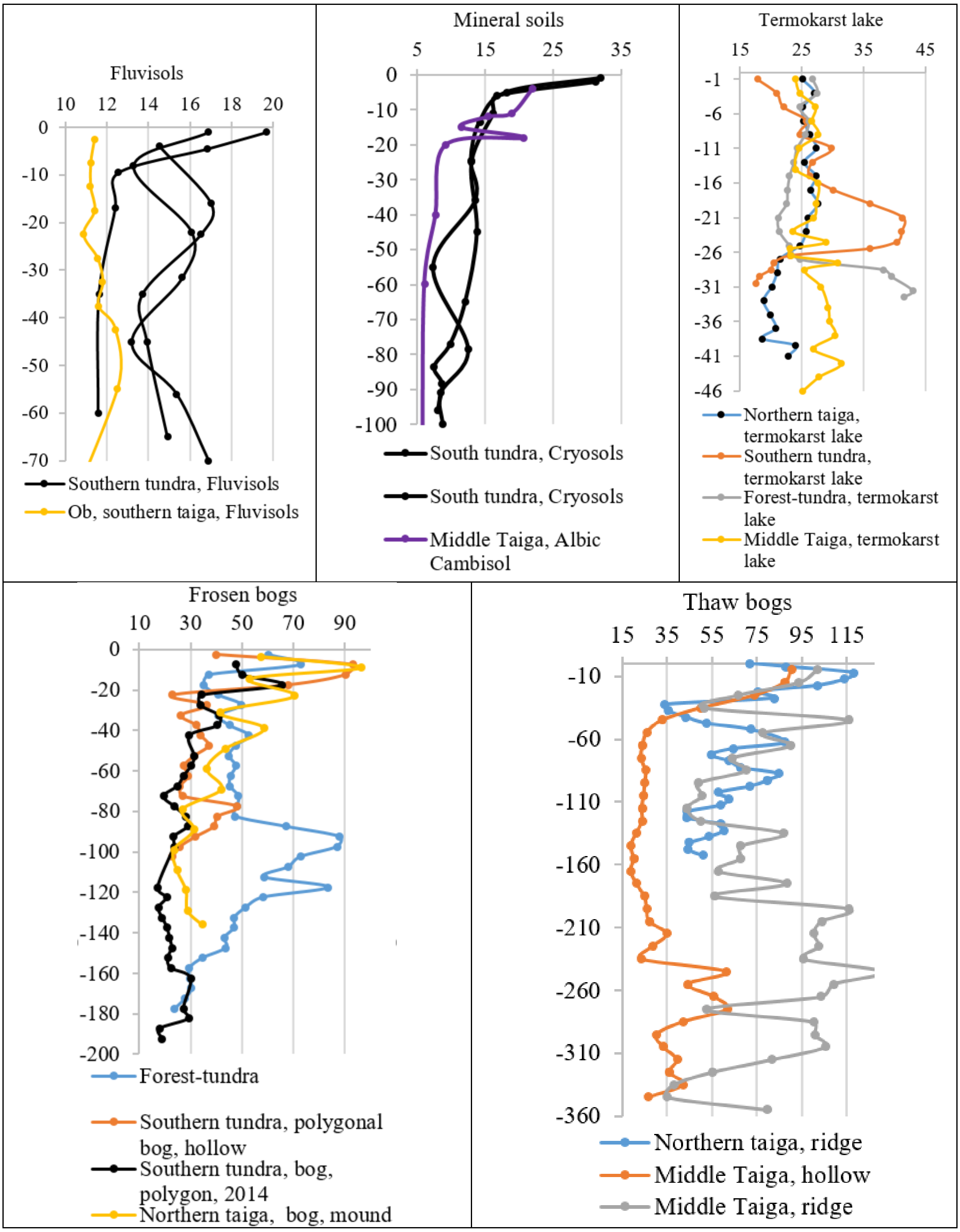

Fig. S4. C:N in peat profile across the latitudinal transect of WSL, corresponding to four main regions (permafrost-free region of Ob, southern taiga; isolated/sporadic permafrost at Kogalym; discontinuous permafrost at Khanymey and continuous permafros at Tazovsky). Authors' unpublished data.

Table S4. Mean C:N values in presented profiles.

Site	Mean ± SD
Cryosols in Tazovsky, south tundra, mineral soils	14.0±7.0
Cryic Histosols, polygonal southern tundra in Tazovsky, (CкTz15)	24.3±5.7
Cryic Histosols, polygonal southern tundra in Tazovsky (CкTz14-2)	28.4±10.7
Cryic Histosols, depression over permafrost, southern tundra (CкTz14-3)	39.5±20.1
Soil of recently drained lakes, south tundra, Tazovsky, 2016	22.4±3.0
Sediments of thermokarst lake in Tazovsky, continuous permafrost	27.3±8.1
Fluvisols in Taz River flood zone, south tundra, continuous permafrost	14.9±2.2
Cryic Histosols, frozen mound in Pangody, forest-tundra (CкP15)	50.0±16.3
Thermokarst lake sediment Pangody, August 2015	27.7±7.3
Cryic Histosols, frozen mound in northern taiga Khanymey (X17-9)	43.6±19.6
Cryic Histosols, frozen mound in northern taiga Khanymey (X14-4)	57.1±16.8
Albic Alisol, light color soil, Khanymey, northern taiga Khanymey	13.0±6.4
Thermokarst lake sediment Khanymey, August 2015	24.0±3.0
Histosols, bog, ridge, northern taiga, Kogalym , sporadic perm. (Kg16-1)	65.4±21.1
Thermokarst lake sediment Kogalym, August 2015	26.8±2.5
Histosols, bog, depression, middle taiga (Stepanova et al., 2015)	36.3±18.8
Histosols, bog, ridge, middle taiga (Stepanova et al., 2015)	79.4±25.5
Fluvisols in floodzone of the Ob River, southern taiga, Kaibasovo, 2017	11.0±1.4

Table R1. Physico-geographical and landscape characteristics of 5 study sites, corresponding to sporadic to continuous permafrost zone of the WSL.

Site	Mean annual temp., °C	Mean annual precipit., mm	Mineral substrate	Micro-landscapes	share of micro-landscape, %	Peat thickness, m	Seasonal thaw depth, cm	Soil type (WRB, 2014)
Tazovsky, (Tz) 67.4°N 78.7°E	–9.1°C	363	Clay loam and loam	polygon	65	2.0–4.0	41	Dystric Hemic Epicryic Histosols (Hyperorganic); Dystric Murshic Hemic Epicryic Histosols (Hyperorganic)
				permafrost subsidences	7		55	Dystric Epifibric Hemic Cryic Histosols (Hyperorganic)
				frost crack	13		44	Dystric Epifibric Cryic Histosols (Hyperorganic)
				hollows	16	0.2–1.5	65	Dystric Fibric Cryic Histosols; Histic Reductaquic Cryosols (Clayic)
Pangody, (Pg) 65.9°N 75.0°E	–6.4°C	484	Loam	peat mounds	53	0.2–1.3	49	Dystric Hemic Epicryic Histosols; Histic Cryosols (Loamic); Histic Oxyaquic Turbic Cryosols (Loamic)
				permafrost subsidences	10	0.6–1.1	74	Dystric Hemic Endocryic Histosols
				hollows	37	0.3–1.0	82	Dystric Epifibric Endocryic Histosols; Histic Reductaquic Turbic Cryosols (Loamic); Dystric Fibric Histosols (Gelic)
Khanymey, (Kh) 63.8°N 75.6°E	–5.6°C	540	Sand	peat mounds	49	0.1–1.4	90	Dystric Hemic Cryic Histosols; Spodic Histic Turbic Cryosols (Albic, Arenic); Histic Turbic Cryosols (Albic, Arenic)
				permafrost subsidences	30	0.7–1.1	165	Dystric Hemic Histosols (Gelic)
				hollows	21	0.4–1.1	215	Dystric Epifibric Histosols; Spodic Histic Turbic Cryosols (Arenic); Gleyic Histic Entic Podzols (Turbic)
Kogalym, (Kg) 62.3°N; 74.2°E	–4.0°C	594	Sand	ridge	61	1.7–2.3	–	Dystric Ombric Fibric Histosols (Hyperorganic)