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Discussions

Interactive comment on "Modern silicon dynamics of a small high-latitude subarctic lake" *by* Petra Zahajská et al.

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We thank Referee 2 for constructive comments on our manuscript. We followed these suggestions carefully for the revision. We enclose a full account of our responses (normal font) to the comments and suggestions of the reviewer (*in italics*), including references to all changes in the manuscript.

The manuscript by Zahajská et al. presents a interesting point describing the silicon dynamics in a high-latitude lake. The authors quantified the groundwater and river inputs by using Si isotope and 222Rn mass balances through the years. Groundwater contributed 3 times higher than the rivers. The methods could be used for other water bodies. In general, It is a nice piece of work to be published in Biogeosciences.

However, the current manuscript version does not reach the level of Biogeosciences. Especially the interpretation of the raw data and the discussion focus too much on the mass balance for the whole lake.
We would like to emphasize that the mass balance is the main principle of the manuscript. Therefore, we have clarified the aim of the study in the introduction L 47: "Here, we investigate the diatom-rich sediment formation in Lake 850 through water and silicon mass balances." Thus, the study does not aim to constrain the seasonal diatom production, the factors driving the seasonal changes in diatom production or the in-lake processes. The study focuses on the impact of changes in external sources of Si on the lake Si cycling.

Considering 79% of DSi input is consumed by diatoms. I would like to see more interpretation about the changes of DSi and BSi concentration, for example the DSi concentration decrease in the beginning of the growing season, however the DSi consumed by diatoms and BSi flux to sediment increased.
The changes in DSi consumed by diatoms and BSi flux to sediment in the beginning of the growing season are modelled based on measured lake DSi and based on a dated sediment core, which do not have the temporal resolution required for seasonal studies. In addition, we do not have data from sediment traps or any other measurements of seasonal diatom production.

To my knowledge, the temperature involved the process.
Although we do not have water temperature data for the entire year, lake water temperature is expected to be stable over the year, as suggested by the air temperature stability shown by Bigler and Hall, 2003 (DOI:10.1016/S0031-0182(02)00638-7). For this reason, we do not think that annual changes in water temperature are a main factor driving the diatom production and accumulation in Lake 850 and we have not included this in the discussion.

We point out in Lines 485-486 that further studies are needed for the entire biogeochemical Si cycle in high-latitude lakes. Further, these studies would require additional

data collection and systematic monitoring to understand the inter-annual factors on BSi accumulation.

Suggested theoretical issues:

1. *The authors claimed the mechanisms responsible for the diatom-rich sediment formation in the lake, I only see the results and discussion based on water/silicon isotope/ Radon mass balances. I would like to see more discussion about the water-sediment interaction. How the temperature involved the primary production of diatom and dissolution of detritus, especially during the growing season.*
   The objective of this paper was to investigate the diatom-rich sediment formation in Lake 850 through water and silicon mass balances (Line 47). For that reason, water-sediment interactions are out of the scope of this paper. This type of study would require annual lake monitoring using sediment traps, primary production measurements and Si utilization measurements, which has not been done here. Thus, our data do not allow us to conclude more about the sediment development than the information provided by the mass balances and age-depth model from the sediment core.

2. *Considering the residence time of the lake is around 2 months during the growing seasons and most of the biogeochemical processes happened during the same period, water samples from streams and lakes were collected from June to September 2019, while the Si isotope mass balance based on an age depth model. To me there is a huge uncertainty.*
   We did construct a model on a monthly basis, however the study aimed to investigate the silicon dynamics on an annual basis. The monthly resolution was chosen to obtain basic knowledge of the system's functioning, rather than to explain the lake processes on a monthly basis. We do use the monthly resolution to constrain all possible factors throughout the year, which may be further applicable on longer-timescales with lower resolution.

3. *I am confused by the DSi consumed by diatoms in Figure 6 B, is it constant? Can you also add the monthly temperature in the figure?*
   The DSi consumed by diatoms is calculated from the BSi flux data, which have a resolution of 12 ± 6 years. Thus, the resolution is not enough to specify fluxes on a monthly basis. For this reason, we constructed 3 scenarios with 3 different lengths of time of BSi flux to the sediment, which influences the DSi consumed by diatoms. However, those are only 3 scenarios among many, and the lake system is more complex and variable between years. As our study does not aim to describe the processes on a high-resolution scale, such as intra-annual changes, we do not think that including a monthly temperature figure is needed. We focus on constraining the more general functioning of the lake Si cycle based on one year of data.

4. *Considering the high accumulation of BSi, any idea to include the legacy assessment based on your data set? I did'n see this in the discussion.*
   Unfortunately, we do not understand the question. We are willing to provide an answer if the question is clarified.

5. *I am interested in the BSi flux in Figure 4. Can you explain the change for the period 1803-2019? Maybe you can get some clue from DOI:10.1038/ncomms1128 or mainly because of the sedimentation rate?*
   The relative changes in MAR are more pronounced than changes in BSi, thus the BSi flux is strongly influenced by the MAR. For this reason, we do use mean SR, MAR and BSi wt% in our models. As this is a pristine lake, we do not expect any watershed process to influence BSi accumulation, only the MAR. There is no agriculture in the watershed nor anthropogenic disturbance, hence we do not consider the Nature Communications paper to be relevant here.

   Specific comments:
   L 10-11 Switch section 3 And 4. Maybe considering combining to one section.
   Sections 3 was kept as the theoretical approach, which aims to introduce the

reasoning for why different samplings were conducted. The sampling schemes are then described in section 4.

L 58 the temperature in 2018-2019 should be 10.1
The temperature has been corrected (L 58).

L 70 Compress this section by move more details to SI.
We have modified the text according to the reviewer's comment. This section has been removed.

L244-245 The text read like out of place.
Part of the sentence was moved to the Study Area section in Lines 59-60, and the text in former Lines 244-245 was adjusted accordingly to: During the ice-free period direct surface precipitation results in $0.65l.s^{-1}$, which represents only 1.4% of the lake volume, and similar or higher discharges are observed in the stream inlets from July to August (new Lines 253-254).

L248 Can you add the rough flow velocity of the Lake during the growing season? I am curious the net sedimentation rate of BSi in the lake. More interpretation about how the residence time impact the BSi accumulation.
Unfortunately, we do not understand what flow velocities the reviewer is interested in. We do not have measurements of flow velocities in the lake. We do not have net sedimentation rates of BSi, as the study does not focus on diatom seasonal production and sedimentation. We use the net accumulation rate of BSi, which is based on the sedimentary data.

The relative retention of DSi as BSi in lakes was shown to be related to the residence time and weakly correlated with the ratio of lake to catchment area (Frings et al., 2014, DOI: 10.1007/s10533-013-9944-z). Results of our model show that Lake 850 accumulates above the expectation, based on data from Frings et al. 2014.

We have added the following sentence into the discussion: Based on the positive

correlation between water residence time and the relative retention of DSi in lakes (Frings et al., 2014), Lake 850 with its DSi retention of $35 \pm 17\%$ of the total DSi inlet and residence time ranging from 0.15 to 1 year, accumulates more DSi as BSi than expected. (Lines 384-386)

L254-257 Based on this part, discuss how does BSi and temperature involved in the seasonal change of DSi in the below discussion part.
Unfortunately, we do not have the water temperature data for each season. Moreover, based on the air temperature stability shown by Bigler and Hall, 2003, we expect the lake water temperature to be stable over the year. Further, we look only on sedimentary BSi, thus we cannot assess the effect of temperature on diatom production. Thus, this question is out of scope the study's objectives as we defined it in the Introduction section (L 47).

L478 fine-grain should be fine-grained.
The text has been corrected according to the reviewer's comment (L 412).

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