Response to comments by reviewer#1

We would like to thank the reviewer for the very constructive and helpful review which provided great support for the improvement of the paper. We have addressed all issues indicated in the review report. Please find detailed responses to the reviewers' suggestions and comments below.

The paper describes a case study of a very detailed investigation of groundwater discharge patterns to a lake. The authors used a range of methods and took a large number of measurements with the goal to derive relationships between parameters that are easy to obtain (e.g. topographic indices) and groundwater discharge patterns. They found that groundwater discharge was higher closer to the lake shore. They also found correlations between topography and large-scale groundwater inflow patterns, and between small-scale groundwater inflow patterns and sediment grain size distributions. The paper does not really present anything new. The methods are well established and the outcomes confirm the general assumptions made about groundwater discharge to lakes, including that it is usually very heterogeneous. The only surprise was that hydraulic conductivity did not seem to correlate with groundwater discharge. However, the investigation was well designed, the methods are nicely described and the paper is overall very well written. I think it therefore merits publication and it will be a very useful reference for other researchers working on similar subjects.

I only have a few minor comments that should be addressed before publication:

There is no information on the motivation for this study. Was it a purely science-driven study and the lake was selected for convenience reasons, or was there a problem that drove the initiation of the project, such as lake water quality issues which may result from groundwater discharge?

At Lake Hinnensee significant lake level fluctuation were observed in the last 30 years, but processes and mechanisms driving these fluctuations and the role of lacustrine groundwater discharge (LGD) within the water balance of the lake were only poorly understood.
We will include the background of the study within the introduction (in subsection 1.3 Objectives) on P3L21 as follows:
"To study these research questions we chose Lake Hinnensee, a typical post-glacial lake located in the intensively monitored TERENO observatory in the lowland landscape of northeast Germany. At this lake strong water level fluctuations were observed in the last decades, but processes and mechanisms causing these lake level fluctuations are yet not well understood. "

How does the selection of the lake impact on the transferability of the findings?

We assume that our findings are transferable to other lakes in similar landscapes, which means humid lowland landscapes. We assume that the main important restriction of the transferability of our findings is the occurrence of complex hydrogeological settings overriding the topographical signal, for example discontinuities in the aquifers. We will address this question in the conclusion of the revised manuscript.

P9L26: Groundwater levels were measured "regularly": What does that mean? "Regular" can be once every year…please specify.

Thank you for this advice. Groundwater levels were measured approximately bimonthly. We will change the sentence as follows:
"Groundwater levels were measured ~~regularly~~ roughly bimonthly (intervals of 7-9 weeks) from 2012 to 2014 using an electric contact meter (SEBA Hydrometrie, electric contact meter type KLL, accuracy: ± 1 cm)."

P15L20: You give transpiration as a possible reason for a near-shore depression in groundwater levels. Is there a type or density of vegetation at this location that potentially transpires more than at other locations at the lake shore, i.e. is there a reason to believe transpiration could be the cause?

The type and density of vegetation does not significantly differ from other locations, but this lake section is characterized by low groundwater gradients. Transpiration could reduce groundwater gradients (Winter et al., 1998) and if groundwater gradients are already very low, transpiration could even cause a reversal of groundwater gradients. Thus, we assume the reversal results from the combination of transpiration and the occurrence of low groundwater gradients.
We will make this clearer by changing the paragraph as follows:
"Even though the interpolated groundwater surface showed groundwater flow towards Lake Hinnensee from all directions (Figure 10), we measured negative LGD rates at one small subsection of the lake (Figure 2). Reasons for this flow reversal are unclear. However, this lake section is characterized by low groundwater gradients (Figure 10). While transpiration is likely to cause diurnal fluctuations in groundwater levels all around the lake, it can result in a local inversion of the groundwater – lake gradients at locations where these gradients are very low (Winter et al., 1998)."

Conclusion: My main question is: so what? Your main recommendation seems to be to take topographic indices combined with a few sediment cores as a first step, and then do more investigations at areas of interest. But which ones are most useful and give you most value for money?

The value of using topographic indices or sediment cores to predict LGD patterns depends on the focus of the study. From our results, we assume that topographic indices can help to predict large scale LGD patterns and sampling sediment cores could help to get a picture of small scale variability in LGD patterns. This will be added in the conclusion as follows:
P18 L23-25 ", as topographic gradients could help to get information on large scale patterns and sediment cores could be used as indicator for small scale patterns."

We will clarify the outcome of our study by including a short discussion on the employed methods and by providing a recipe for designing a study on LGD variability. In this part we would emphasize the advantages of using a needle for measuring sediment temperatures, because this instrument allows precise sediment temperature measurements without disturbing the sediment and the flow. Furthermore, we will evaluate the use of temperature measurements from one single sediment depth (instead of the entire profile) to get a fast impression of LGD patterns and will therefore present correlations between LGD rates estimated from VTPs and sediment temperatures from different depths of the of the profile. Sediment temperatures from the top of the sediment down to a depth of 10 cm were not well correlated with LGD rates, but strong correlations were found between LGD rates and sediment temperatures measured 20 cm below surface and deeper (absolute correlation coefficients ranged between 0.46 and 0.96, see Figure below). Measuring sediment temperatures only in one sediment depth instead of complete VTPS would save a lot of time in the field. A discussion of these points will be included in the revised manuscript.

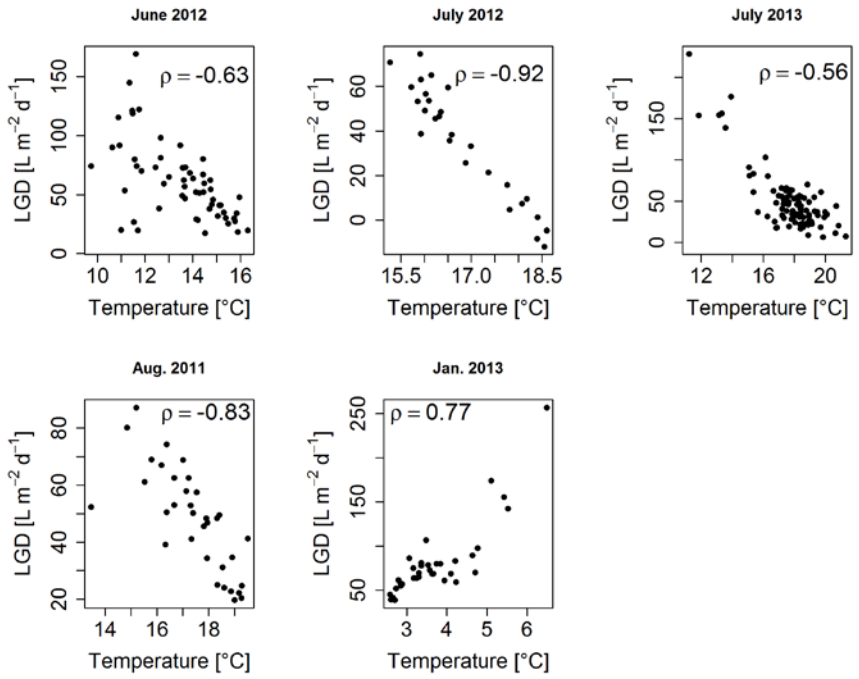

Figure 1: Sediment temperature measured 30 cm below the sediment lake interface measured during different VTP surveys are plotted against LGD rates estimated from VTPs.

Are the findings transferable to other lake settings?

As mentioned above, we assume that our findings are transferable to other lakes in similar landscapes, which means humid lowland landscapes in which the groundwater tables likely follow the topography. We assume that the main important restriction of the transferability of our findings is the occurrence of complex hydrogeological settings overriding the topographical signal, for example discontinuities in the aquifers. We will address this point in the recipe for an experimental designs focusing on LGD variability.

I am also wondering how such an investigation would help remediation planning. How important is it to know the spatial distribution or local hot spots of groundwater discharge to a lake? What could you do about those hot spots, or would you use them to trace back a contamination source?

In general, knowing LGD variability, especially identifying LGD hotspots, is important from two perspectives: for water quantity issues and water quality issues. Missing hotspots of LGD could lead to a wrong estimation of LGD and hotspots could be of great importance, as these hotspots could carry larger loads of contaminations, especially if LGD hotspots meet contamination hotspots. You could thus indeed use this to trace back contamination sources. This will briefly be mentioned in the beginning of the conclusion as follows:
P15 L2: “Quantifying LGD rates and determining LGD patterns can be essential for a sustainable lake management if LGD significantly contribute to a lake water budgets or significantly influence lake water quality by transporting large loads of nutrients or contaminants (Meinikmann et al., 2013; Lewandowski et al., 2015).”

References: P10L11-13: the two references are missing in the reference list
Thank you for this advice. We will include these references in the reference list.

Language/typos:

Readability could be improved by using more hyphens, e.g.: Large-scale patterns, Small-scale variability, High-precision thermometer, Near-surface sediments, Far-field conditions, Climate-driven processes and similar constructions throughout the manuscript. “Grain size” should be two words

P1L27: groundwater-lake exchange

P7L22/23: “purged for 3.5 at least hours” should be “purged for at least 3.5 hours”

P8L4 and 6: I think internationally the term “screen” is preferred to “filter”

P8L27: mean was or means were

P9L1: goodness-of-fit

P10L4: “resolution of 1 m that” should be “so that”

P11L1: “norther” should be “northern”

P11L31: “measurements in2 minute intervals” should be “measurements in 2-minute intervals”

P1L28: “a slight negative, but spastically” should be “a slightly negative, but statistically”

P15L31/32: ksat should be ksat (subscript)

P16L5: remove comma after structure

Figures:

Figure 2: The use of (a) (b) and (c) in the caption is a bit confusing

Figure 7: kf should be ksat in the caption

Figure 10: (e) is missing in the caption

Thank you for these specific and valuable advices. We will include these suggestions in the revised manuscript.