Response to Reviewer2's comments (RC2) about the paper: "A practical approach to lake water density from electrical conductivity and temperature"

by S. Moreira, M. Schultze, K. Rahn and B. Boehrer

MS No.: hess-2016-36

Additional Discussion items that would be useful:

1. *Given that the approach developed in this paper does require considerable water quality information, it would be useful to provide a suggestion on how to use the results of this paper to estimate the coefficients in other water bodies that do not have this detailed information.*

This approach only requires the concentration of the major ions. This information is available in most limnologically studied water bodies. However, if not, the first option is taking a water sample and getting a reasonable idea of the water chemistry – This is not expensive. If no chemical data are included, density contributions of solutes are very badly represented. With a small effort, you can reduce the error by a factor 5 to 10. Even an analysis of limited accuracy will yield a much better density relation than UNESCO or Chen& Millero.

2. *The main benefit of this new approach appears to be an improvement in the absolute estimate of density. It would be helpful to discuss the absolute improvement in the density estimated versus the relative improvement. In other words, does this approach primarily shift the curves in Fig. 1 (first column) up and down? If this is the main improvement, it will not significantly change the results that have been obtained in most modeling exercises. I think that this discussion should be included.*

We agree with the reviewer that it is important to represent density DIFFERENCES (gradients) accurately. Of course, we also improve the absolute value of density ("shifting up and down" in left column). However, our approach is especially designed to represent density gradients due to solute gradients, which are so badly represented in the standard approaches.

In detail: Two water parcels of the same temperature (e.g. 15°C) but different solute concentration (0 and Lake Constance conc.) have different densities. Now looking at Fig. 1, right column, Lake Constance: the density difference between those water parcels is underestimated by about 6% using our lambda approach but by 45% using Chen&Millero. The lambda approach is better by a factor of 8.

If solute concentrations are only part of the difference of 0 to Lake Constance conc., this scales down roughly linearly. The relative inaccuracies remain roughly the same, and hence also the advantage of the lambda approach over Chen&Millero.

In conclusion, yes, this lambda approach significantly improves the calculation of density stratification, if gradients of solute concentrations are involved.

General comments:

1. *Most people refer to Mono as Mono Lake and not Lake Mono.*

2. *In your comparison of methods, why is the most common approach the UNESCO approach not used for Rappbode, Geneva, and Constance. Even if it provides similar results to another mention, it should be at least mentioned.*

1. We accept the correction of the reviewer and we will modify all the references the text from "Lake Mono" to "Mono Lake".

2. UNESCO is only valid above a salinity of 2psu. For the case below 2psu, Chen & Millero replaced the UNESCO formula by their slightly different approach, trying to remove some short comings of ocean salinity at very low values. – do not expect any better results from the Unesco formula. We are aware that most numerical models use UNESCO for freshwater, despite the fact that it is not recommended. However, using UNESCO in this critical comparison would mean using and blaming the formula for conditions it is not made for. We wanted to avoid this.

Specific Comments:

Page 1: Modify the title to say: "approach to estimating lake water density"

This is not guessing. We present an approach for accurate calculation of density in limnic waters and we even provide the detailed assessment of its accuracy. We retain our title.

Page 1, line 14: consider adding "absolute" in front of the word "accuracy".

Considered but we do not see the implication of the word. What feature is the absoluteness of accuracy? Hence, not included.

Page 1, line 21: remove the words "by far".

Done.

Page 2, line 6: wouldn't it make sense to add seasonality as your main example?

Sure, one can investigate this, but a seasonality of the lambda coefficients can only be expected for extreme cases, where the composition of the solutes changes dramatically. We do not have such a lake in our focus.

Page 2, line 12: Add the word "do" between that and not.

Done.

Page 3, line 5: I would delete this sentence.

We eliminated those lines and rephrased the paragraph.

Page 3, line 7: Why not include this sentence in the paragraph before this?

Done.

Page 3, line 33: Considering adding (and lake specific variables describing the effects of differences in the chemical composition of the water) to the end of the sentence.

Sorry, we do not understand

Page 4, line 3: change the word "deliver" to "provide".

Done.

Table 1, consider cutting back on the number of significant digits, unless they are real.

We have reduced the number of significant digits in the calculated conductivity, but we will keep them in the measured variables of the table. Three decimal digits have been kept in all density values. Due to the small differences

between the Practical Salinity, Absolute Salinity and Corrected Salinity, the decimals have been kept too.

Table 2. There is no discussion of the starred lambdas in the table. If it is important it should be included in the paper, if not it should be deleted. Consider cutting back on the number of significant digits, unless they are real.

A small paragraph about starred lambdas has been added.
Accepted; we show two significant digits of all lambdas. The starred values are the empirical values from density measurements. Both, starred and non-starred values are shown in figure 2 to demonstrate the accuracy quantitatively.

NOTE: All the corrections concerning the text previously mentioned will be included in the final version of the manuscript.