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Interactive comment on "Application of isotopes and water balance on Lake Duluti–groundwater interaction, Arusha, Tanzania" *by* N. P. Mduma et al.

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Response to Anonymous Reviewers

Please refer to the interactive comments of anonymous reviewers for a manuscript entitled "Application of isotopes and water balance on Lake Duluti–groundwater interaction, Arusha, Tanzania" by N. P. Mduma et al. We thank the reviews of valuable comments, and suggested areas for improvement. We will use the critical comments to improve and strengthen the analysis of our manuscript. We agree with the reviewers that the paper needs to be strengthened. Given another opportunity to improve the manuscript, the introduction section will be re-written to include current scientific understanding in the field (rigorous literature review on lake water balance, lake-groundwater interaction), define clearly the problem (knowledge gap), and objectives. We will revisit all the assumptions made in formulating all equations and all errors made and unnecessary equations such as equation 7 will be rectified using well-developed approaches. This applies to the first two comments of the first reviewer shown below. Also because comments from the four reviewers are similar response to the comments from the first reviewer general covers for the others. We will do our level best to ensure that there are no grammatical and typographic errors.

1. Lacking scientific background The scientific background disregards existing work in the field, is much too general and not to the point of the actual study. It only contains local investigations (many of them also in grey literature) and most of them in groundwater. There is virtually no study on a lake water balance or on lake-groundwater exchange included that would proves that the authors are aware of the actual methodology to be used. Starting with the pioneering works of Joel Gat there are many examples in the literature that used environmental isotopes to characterize lake water balances and also the exchange with surrounding groundwater.

Comments 2.Wrong assumptions in the isotopic mass balance As a consequence of a missing scientific background there are major shortcomings in the applied methods that produce totally wrong results. The most alarming mistake is included in equation 7: It is simply wrong that the isotopic composition of lake water can be derived by simply adding isotopic concentrations of inflow, precipitation and evaporation. It is known from literature that the isotopic enrichment of an evaporating water body is a complex process and depends on various factors. The fundamental equations are given in various scientific papers, with Gat & Browser (1991) being only one example. And even if a traditional mixing approach was applicable (this could eventually be for other tracers, e.g. major ions), tracer concentrations would have to be weighted by the amounts of the different components.

Comments 3. Uncertain laboratory procedures for major ions It is acknowledged that the authors are from a developing country with limited laboratory resources. However, the applied methods are only briefly described and no estimation on the error of the procedures is possible. Which “multi-parameter meter” was used for the onsite field measurements? Why were some major ions measured by a multi-parameter spectrometer (K, No3, So4) and others by tritration (Ca, Mg, CO3, Cl) and Na by a flame photometer? Authors’ response It is indeed true that laboratory resources are often limited in the developing south. We have a used a range of methods to overcome some of these challenges. For in-situ measurement we used HANNA Multi-Parameter instrument. We will improve on the description of the methods applied. Methodology Comment from Reviewer 1 4. Non-necessary freezing of isotope samples Samples for stable water isotopes are stable for many years if they are filled without headspace and kept in tight bottles. Why were the samples for isotopes frozen in glass bottles? How was breakage prevented during freezing? How was tightness guaranteed during freezing and volume expansion? In the freezer a leakage will cause sublimation and additional fractionation. If studies like this are published, other researchers will perhaps freeze their samples too which causes non-necessary problems for them.

Response: Samples were not frozen but rather were stored in a refrigerator. This was a typing error as the samples were stored in a refrigerator and not freezer. Thanks you for pointing us to this statement, we will modify accordingly. 5. Violated assumption of complete mixing of the lake water body The authors admit themselves that mixing inside the lake was poor, because concentrations varied between different locations and different depths. Nevertheless they assume complete mixing and used single mean values for the lake water balance. For this they form averages of various samples collected in the dry and wet season. But fractionation by evaporation is higher at the lake surface and groundwater inflow occurs at certain depths only. In addition, no exact sampling dates are given, it seems that samples were averaged arbitrarily, when is a wet season sample a wet season sample?

Northern Tanzania is characterized by two main rain seasons (bimodal rainfall) namely the long rains and the short rains, which are associated with the northward and southward migration of the Inter-Tropical Convergence Zone (ITCZ), respectively (Kabanda and Jury, 1999; Zorita and Tilya, 2002; Kijazi and Reason 2009). The long rains begin in the mid of March and end at the end of May, while the short rains begin in the middle of October and continues to early December. Fieldwork for the dry season was conducted between January and February 2015, while that of wet season was conducted between the months of March and April, 2015. Dates of sampling will be provided in revised version of the manuscript. Assumptions made about mixing in the lake will be reviewed as we did contradict ourselves.

6. Poor interpretation of tracer data The interpretation of the measured major ion chemistry is not convincing. Only for some ions it is argued that concentration in the lake is higher than in groundwaters due to evaporation, but this is principally true for all ions. Also anthropogenic inputs are only related to high SO4 not to other ions. A positive correlation of So4 with NO3 is no indication for oxidation of organic matter, there may be many other factors playing a role here, primary production inside the lake is only one. But also the isotopic data interpretation of figure 6 is limited: First of all a straight line through all sampled data does not make sense, because different types are mixed. Second, the "local meteoric water line" stems from samples virtually sampled at many different locations across Tanzania. They produce a very large scatter and cannot be related to the samples of the present study.

We highly acknowledge for pointing out weaknesses in interpretation of our data. We will re-analyze our data and provide a comprehensive data interpretation. Availability of data to reconstruct a local meteoric water line for Arusha region only is not available and our idea was to construct a local meteoric water line for Tanzania by utilizing isotope data available at the GNIP website, actual measurements of precipitation for samples collected during this study and other reported data elsewhere, and then compare it with the results of the present study.

References Kabanda, T.A. and. Jury, M.R., 1999. Inter-annual variability of short rains over northern Tanzania. Climate Research 13, 231–241. Kijazi, A.L. and Reason,

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Discussion paper

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