General Responses:

We thank the three reviewers for their comments, and those who provided community comments too. We will respond to all comments individually but there are some general points mentioned in multiple comments that we would like to address, here labelled as General Responses 1 to 3 (GR-1 - GR-3).

GR-1: There is some confusion as to the purpose of this work; this work is an addition to the Varved Sediments Database (VARDA) as opposed to a data compilation exercise using the database. This was not made clear within the text and in the revised manuscript we now explicitly state that this data is a new addition to VARDA (Lines 15, 18, 60, 74).

GR-2: The Kernel Density Estimate plots are not meant to be a comprehensive overview of all known findings of the tephra layers, instead they are intended for use as a statistical and schematic diagram to highlight the future potential to better synchronise varve chronologies using tephra layers. We hope that further clarification in the caption of Figure 4 addresses this issue.

GR-3: The inclusion of tephra data into VARDA is not intended to be used as a new database for tephrochronologists; we aim that the inclusion of tephra data enables varve chronologists to better synchronise varve chronologies to an absolute timescale using tephra as an isochronous marker horizon.

Reply to Reviewer #2 (://doi.org/10.5194/essd-2023-154-RC1)

We are very grateful to Reviewer #2 for the constructive and thorough review that has helped us to improve the manuscript. We copied all comments below, numbered them in order of appearance (RC1-1 to RC1-15) and provided a response accordingly.

General comments:

RC1 - 1: In the present form, it is not clear if this contribution reports on a novel modification/extension of the existing database VARDA or if the presented results are a summary of a VARDA database query. Comparing the structure of VARDA presented in Ramisch et al., 2020 with the actual database website and with the information given about data collection within the manuscripts, some fields (geochemistry) may have been added. However in the manuscripts it is also stated, that this is beyond the scope of this paper. Therefore, I strongly suggest to stress clearly, what is a new or has been modified and what is just a summary of a database query.

Authors' response: We thank the reviewer for this comment, we have rephrased parts of the manuscript to better reflect the nature of this work as an update to the Varved Sediments Database (Lines 15, 18, 60, 74). Please also see our response to general comment GR-1.

RC1 - 2: It is stated that the project focuses on varved records, but for the integrity of a robust tephra-dataset it is extremely important to consider also data of non-varved records. Important information about the age and glass geochemical composition, which are needed for correct correlations and precise chronologies, may come from such non-varved records and thus would be not considered otherwise. The authors already have partially identified this issue, including data from Lake Ohrid/Prespa, although their non-varved character is not consequently reported (see also community comment, as this seems to be the case for other records). However, the approach stills appears incomplete. As the manuscript is reported to be the initial phase, setting the basis for an overarching project, this needs to be considered in depth for the overall long-term project aim to construct global frameworks.

Authors' response: We are adding tephra chemistry to the database to serve a chronological purpose (i.e., using the combined strengths of varve records and tephra markers), not to build an additional tephra database. Therefore, we have clarified that this is an update to VARDA in GR-1, which should now provide clarity on this, and we refer back to our response to CC1-2 for inclusion of non-varved sites. An initial phase is used in the sense that we aim to add other varve records that contain tephra from other locations and from an extended chronological range. This is not going to produce the much sought after tephra geochemistry database from a tephrochronologists point-of-view; rather it will help the varve chronologists better understand how to use tephrochronologies.

RC1 - 3: With regard to the compiled dataset of tephra layers, there is no discussion about the quality of the data collected (quality of geochemical analyses, ages). Even if the authors state that the best age of a tephra/eruption may be a subjective feature, the general quality of available ages could be addressed, as in the end for the application of tephrochronology a single age is needed to unify and align chronologies and their records (and it was done in Figure 4).

Authors' response: We do agree with this comment that data quality should be considered when using tephra layers for the purpose of synchronising records, however, we do not propose in this paper to provide an evaluation of the quality of the data. This is partially a product of no consistent standards on data production through time which limits our ability to provide an assessment of data quality given the standard practices for data publishing have changed through the last few decades. We do provide details of different microprobes used

and the operating conditions and a step further would be to include the analytical totals of secondary standards and going forward there is scope to amend this along the lines of community guidelines set out in Wallace et al. (2022). Trace element analysis for MFM is included but as this is the only dataset of this type for the sites identified in the article, it is less of a focus of the paper but is something that will be developed in time as trace element analysis becomes more widely used.

Age estimates are quoted from the original paper but do not include any recent updates or remodelled ages that have been included and we make this point clear on line 98. Users querying the VARDA database need to be aware that the ages need to be reconsidered and we suggest that where applicable, ages could be recalibrated using the latest IntCal curve (Line 99-100).

Specific comments:

RC1 - 4: *Title:* Consider rephrasing as with the focus set to European volcanism and varved lakes, the dataset collection rather reports on a regional than a global tephra framework. Also, there is no discussion about existing ages, so that chronologies were not improved yet.

Authors' response: *As has been addressed in GR-1, we have further clarified that this paper represents an update to VARDA which has an overarching aim to build towards a global inventory of varve records with robust chronologies. We therefore feel with these in text adjustments (and a minor tweak to the title), that the title remains unchanged.*

Abstract:

RC1 - 5: Consider rephrasing with regard to point out if this contribution represents modification or a query of the VARDA database.

Authors' response: *We have taken this on board and updated our abstract and text to make this distinction (Line 14, 18).*

RC1 - 6: Please check the given numbers about records and tephra layers. Not all 19 records represent varved records, further Figure 3 shows more than 49 tephra layers…

Authors' response: *As has been identified, we are aware that not all sites presented here contain varve sediments, however we now make clear in our figures which records are not varved. Additionally, in the results section (L.117-119), we refer to the sites only as lakes or lake archives and therefore incorporate generally all data collated for the database in this instance. We would like to confirm that there are exactly 49 tephra layers displayed on Figure*

3, but have clarified in the text that these represent the tephra layers that have been correlated to a known tephra layer, and does not include the tephra layers in the dataset which are uncorrelated (Line 129 and Line 132).

Introduction:

RC1 - 7: Figure 1 is not crucially needed with respect to the dataset compiled.

Authors' response: *We feel that this figure provides a good visual representation of the increasing interest in combining varve chronologies with tephra layers and explains the wider community need for adding tephra data to structured databases.*

Methods:

RC1 - 8: It appears that only records registered within VARDA were considered, which may be insufficient to present a full list of (varved) records. Using only data given in VARDA strongly depends on data quality, maintenance and update of this database. This is not discussed within the manuscript. For example, for the Lake Ohrid tephra data the latest results 2019-2023 are not included in VARDA (and were potentially also missed by the google scholar search). Therefore, to provide a reasonable and critical review of existing data to compile a dataset about tephra layers of the LGIT, there should be not only one database considered, but also additional non-database listed references included to ensure completeness and quality of the presented data.

Authors' response: *We thank the reviewer for this comment as the Ohrid dataset had indeed been missed. As the database is routinely being updated, this data can be added in the next phase of data compilation. We would further confirm that as this was an addition to the existing VARDA Database, as clarified in GR-1, we are only collating data that would add to the available datasets on VARDA.*

RC1 - 9: I would suggest rephrasing of the data collection paragraph in order to point out, how VARDA was modified (see general comment).

Authors' response: *We would like to refer here to GR-1 clarifying that this is an addition of a dataset to VARDA.*

RC1 - 10: For the new data fields, there are some fields listed in the supplementary data (such as data_availability, datset, lake, geochemistry_availability), which are not given in the tables of the manuscript. There are also only major element data fields (Table 1), whereas also trace element data is given in the attached dataset. For Table 2: What about adding a field for

importing uncalibrated radiocarbon ages in order to simplify recalibration of radiocarbon ages using the same IntCal curve. Please consider adding the information based on which calibration curve the age was calibrated.

Authors' response: Thank you for this important comment. We agree that there was an inconsistency between the tables in the manuscript and the supplementary data, which we have rectified. Additionally, the intention at the start of the project was to include trace element data but published trace element data was only available for one site, therefore it became less of the focus of the project (but is still valuable information to include). Metadata field "Calibration curve" was added to table 2 in the manuscript and, where possible, to the "Tephra_Major_Elements" sheet in the supplemented dataset, accordingly.

RC1 - 11: Further, for the tables presented I would consider avoiding colour coding of mandatory and optional fields in order to make figures accessible to readers with colour-blindness.

Authors' response: This is an important point and we replaced the colour coding in table 2 with symbology where "M" stands for mandatory and "O" for optional fields in the manuscript and the published dataset.

Results:

RC1 - 12: Referring to the community comment, I also welcome the provided original references of the compiled individual datasets. Please check if your list of references (p.6) is complete and includes latest references (and the consequences for Figure 3).

Authors response: We appreciate the need to accurately cite original references, and have made these changes accordingly (Lines 159 - 167).

RC1 - 13: Based on the tephra correlations presented in Figure 3, eight of them are reported within the focussed time-interval. Consider if it is applicable to report on the different geochemical results of these eight (everywhere the same composition, variations?) and about their potential ages, findings may also be picked up in the implications section.

RC1 - 14: Figure 3: Is it necessary to report tephra layers well beyond this interval? Otherwise, I would suggest highlighting the focussed time-interval.

Authors response: RC1-13 is is an interesting point raised by reviewer #2, which highlights the utility of the dataset that has been added to VARDA and the potential to explore variation in geochemical composition spatially. However, as we have now clarified the intent of the

paper as an update to VARDA, we feel that to properly investigate the spatial differences in tephra composition would require incorporating more geochemical data from non-varved records for a more accurate representation of that tephra layer and we feel that discussing this point would detract from the main focus of the paper. In regard to RC1-14, the addition of tephra layers beyond the time interval is addressed on Line 125 - 127.

Implications:

RC1 - 15: I like the idea of comparing the known distribution of an ash cloud with the location of available records to identify potential new targets for (crypto)-tephra investigations. Please specify how the list of (7) new locations was compiled. Maybe it is worthwhile to consider a function for VARDA to report also non-successful cryptotephra investigations, which did not yield any (crypto-)tephra findings. Also these (negative) findings may help to improve knowledge about ash distribution, but also avoid unnecessary investigations by others.

Authors response: *We have clarified within the text that the additional potential tephra sites were identified using a simple query on VARDA for sites within Europe and within the appropriate age span (Line 163). We agree that negative findings in a "lessons-learned" database can avoid unnecessary double work for researchers. Negative results are not yet commonly reported in the literature and correct acknowledgement of data ownership for unpublished data and curation of changing those require a more comprehensive data management infrastructure, which is not included at this stage of development.*