Responses to Raphael Gromig, Grigory Fedorov, Bernd Wagner, Volker Wennrich, and Martin Melles

Dear colleagues,

We very much appreciate the extra effort you have shown with your helpful community comment. Your feedback ensures that we can provide and maintain a high quality publication.

In the attached .pdf response file (supplement), we provide detailed replies to each individual comment and provide our proposed changes and adjustments to the manuscript that we will carry out and show within the revised manuscript version. We have therefore highlighted your comments in black and *italics* and highlighted our responses in blue.

Thank you once again for taking the time to provide feedback on our manuscript.

On behalf of all the authors,

Gregor Pfalz

(i) Data reference, availability and usage

The origin of the data used in the third case study in most cases is not visible directly from the manuscript but has to be investigated via a "Code and Data availability" spreadsheet, which can be accessed by an attached GitHub link. This spreadsheet in 41 cases provides links to the open and free data repository PANGAEA or original publications, which not always contain the original data and descriptions of age model developments (see below), and in 33 cases the reader is asked to request unpublished data. Once access to the data is accomplished, it is not clear from the manuscript in its present form, which of the existing age data eventually became used in the third case study (see example below).

In our mind the relevant original publications existing have to be cited in the manuscript directly and included in the reference list, the data used in the third case study has to be clarified, and the unpublished data used has to be presented in a table in this paper or at least made freely accessible via an open database.

Thank you for the valuable comment. We agree that it is relevant for the reader to be aware of the underlying data used for our calculations. Fortunately, since the submission of the manuscript, several unpublished datasets have become available in journals. We found only seven unpublished datasets that we would exclude from the revised version. In addition, for all of our sediment cores, we shall refer to the publications with the originally published data and age-depth model. We also qualitatively compared the LANDO model results with the original published age-depth model version and adjusted our LANDO model where needed, for example in the cases listed below.

Following your suggestion, we shall add a table on data availability within the manuscript containing six columns: "CoreID", "PaleoLake Database ID", "Age-Depth Model Available", "Repository", "Accessible", and "Paper Reference". Furthermore, we shall include the references given in this table in the main references of the publication. We will remove the spreadsheet from the GitHub repository. Instead, we shall also add a table with all dating points from the references in the supporting material to make it easier for the reader to follow the data.

(ii) Missing geological context

The LANDO-derived sedimentation rates displayed for 39 sediment cores in Figures 5 and S1 suggest continuous sedimentation up to 21 cal ka BP with variable rates. Some of these sedimentation rates are obviously wrong, due to missing consideration of geological evidence. Two examples are given below.

It is true that some of the sedimentation rates do not reflect the actual sedimentation rates compared to age-depth models derived using geological evidence. For this reason, we already wrote on Page 21, Lines 527-528 "*Even though LANDO can produce age-depth models for multiple sediment cores ("Multiple cores" – CS3), we must assume limitations in the geoscientific validity for some of the results.*" Since our approach is purely data-driven, i.e., without geological interpretation, we are aware that "*[…] the results from our combined model might over- or underestimate the true sedimentation rate[s]*" (Page 21, Lines 531-532). Our overall purpose was to make LANDO user-friendly enough to allow users to analyze multiple sediment cores without special customizations.

Thanks to your comment, we see that we need to give LANDO users more flexibility. In the revised version, we will mention in the manuscript that LANDO works best in multi-core mode when users have continuous dating series, i.e., only cores without hiatus. We are already planning another paper / technical note to update LANDO for purposes other than lake sediments. Our goal in the next paper is to accommodate user customizations for single sediment cores (such as hiatus or special calibration curves) within a multi-core collection.

First, the sedimentation rates derived for core Co1309 from Ladoga Lake are based on age data, which according to the "Code and Data availability" spreadsheet originate from Andreev et al. (2019) and Savelieva et al. (2019). However, Andreev et al. (2019) only present OSL ages between 118 and 80 ka BP, substantially exceeding the age range of interest here. Savelieva et al. (2019) present the radiocarbon and OSL ages available from the postglacial part of the record, but mention that the age-depth model used originates from Gromig et al. (2019, in Boreas, 48: 330-348), a paper not cited in the manuscript. Gromig et al. (2019) excluded some of the radiocarbon and OSL ages and, on the other hand, added additional age control from varve chronology and correlation with a radiocarbon-dated record close by. Hence, from the references provided it is unclear, which data finally became used for the LANDO calculations presented. Moreover, both Andreev et al. (2019) and Savelieva et al. (2019) mention that the record contains an obvious hiatus, which spans ca. 14-80 ka BP and is described in detail by Gromig et al. (2019). This hiatus is ignored by the LANDO calculations presented, leading to false data at least for the period 21 - 14 ka BP.

It is correct that we used dating points derived from Andreev et al. (2019) and Savelieva et al. (2019) for Co1309 (Lake Ladoga). **Table 1** represents the input data of Co1309 to LANDO in our original version of the manuscript and **Figure 1** shows the resulting output.

Table 1 *– Input data of Co1309 based on Andreev et al. (2019) and Savelieva et al. (2019). LANDO input parameters "Lab-Location", "Weight", "Pretreatment", "Reservoir Age", and "Reservoir Error" not included in this table for readability.*

MeasurementID	Thickness (cm)	LabID	Category	Material	Uncali-brated Age (yr BP)	Uncali-brated Age Error (+/- yr)
Co1309 35	1	Col4057	14C terrestrial fossil	organic macro remains	2470	54
Co1309 126.8	1	Col4061.1.1	14C terrestrial fossil	organic macro remains	6681	58
Co1309 130	10	C-L3832	other	quartz silt fraction	7000	300
Co1309 131.8	1	Col4065.1.1	14C terrestrial fossil	organic macro remains	10921	68
Co1309 152.8	1	Col4062.1.1	14C terrestrial fossil	organic macro remains	12214	69
Co1309 533	10	C-L3835	other	quartz silt fraction	14000	900
Co1309 743	10	C-L3836	other	quartz silt fraction	17300	800
Co1309 960	10	C-L3837	other	quartz silt fraction	21800	1100
Co1309 1166	10	C-L3838	other	quartz silt fraction	23400	1400
Co1309 1403	10	C-L3839	other	quartz silt fraction	82200	7800
Co1309 1775	10	C-L3841	other	quartz silt fraction	90300	5300
Co1309 1977	10	C-L3842	other	quartz silt fraction	112800	4900
Co1309 2160	10	C-L3843	other	quartz silt fraction	117600	12600

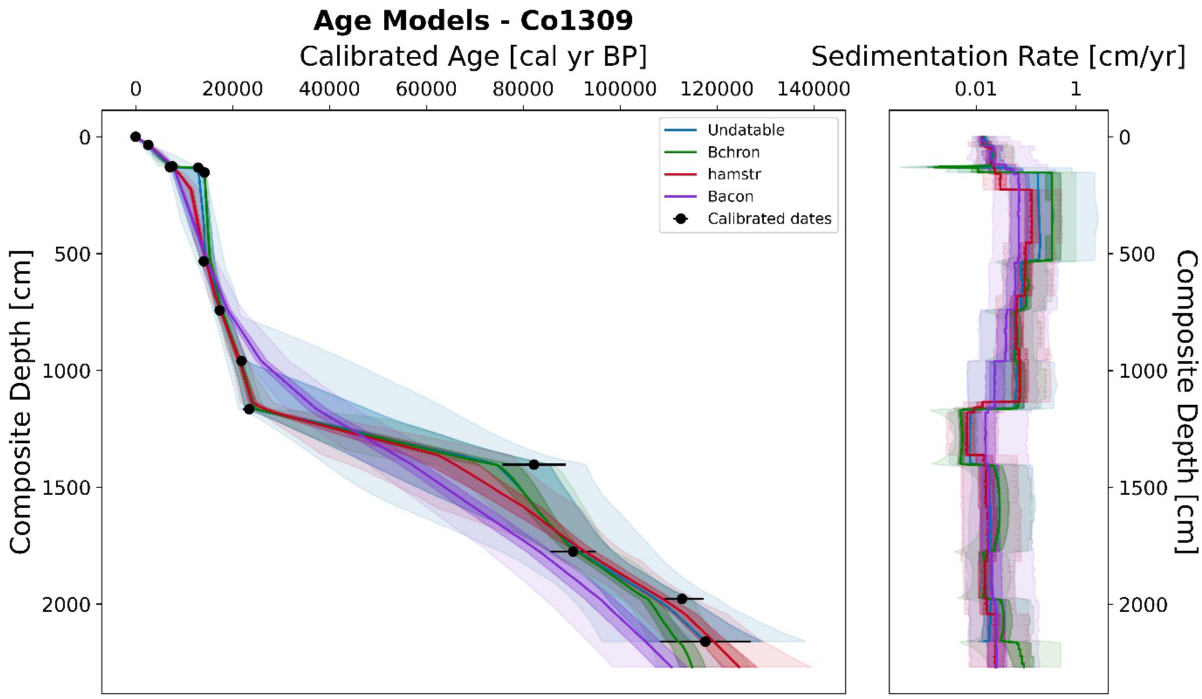

***Figure 1** – Previous (first submission version) LANDO age-depth model from Co1309 based on input data by Andreev et al. (2019) and Savelieva et al. (2019)*

We apologize for not including the absolute years of the varve count and the radiocarbon date from Lake Pastorskoye (Subetto et al., 2002), used as an anchor point, published by Gromig et al. (2019) in our original version of the manuscript. As we have decided to streamline our data availability section, i.e., one publication per sediment core, we will now only include data reported by Gromig et al. (2019). Gromig et al. (2019) was the only one out of the three publications that provided a complete age-depth model. However, to allow for a comparison between LANDO and the published age-depth model, instead of modeling the entire core length of 22.7 m, we will also stop at the last varve point at 13.23 m. This avoids the problem of extrapolation.

Table 2 shows all dating points published by Gromig et al. (2019), which used for the new age-depth model of Co1309. By including the new 30 age controls LANDO generates the output in **Figure 2.**

***Table 2** – Input data of Co1309 based on Gromig et al. (2019). LANDO input parameters "Lab-Location", "Weight", "Pretreatment", "Reservoir Age", and "Reservoir Error" not included in this table for readability.*

MeasurementID	Thickness (cm)	LabID	Category	Material	Uncali-brated Age (yr BP)	Uncali-brated Age Error (+/- yr)
Co1309 35	1	Col4057	14C terrestrial fossil	organic macro remains	2470	54

Co1309 126.8	1	Col4061.1.1	14C terrestrial fossil	organic macro remains	6681	58
Co1309 130	10	C-L3832	other	quartz silt fraction	7000	300
Co1309 131.8	1	Col4065.1.1	14C terrestrial fossil	organic macro remains	10921	68
Co1309 152.8	1	Col4062.1.1	14C terrestrial fossil	organic macro remains	12214	69
Co1309 202.7	1	Varve1	other	varve	11380	140
Co1309 231.1	1	Varve2	other	varve	11480	140
Co1309 268.8	1	Varve3	other	varve	11580	140
Co1309 310.7	1	Varve4	other	varve	11680	140
Co1309 351.4	1	Varve5	other	varve	11780	140
Co1309 386.6	1	Varve6	other	varve	11980	140
Co1309 426.9	1	Varve7	other	varve	12080	140
Co1309 449.5	1	Varve8	other	varve	12180	140
Co1309 472.2	1	Varve9	other	varve	12280	140
Co1309 489.3	1	Varve10	other	varve	12380	140
Co1309 506	1	Varve11	other	varve	12480	140
Co1309 533	10	C-L3835	other	quartz silt fraction	14000	900
Co1309 538.6	1	Varve12	other	varve	12580	140
Co1309 575.9	1	Varve13	other	varve	12680	140
Co1309 581	2	Ua-14803	14C terrestrial fossil	Mosses from Lake Pastorskoye	10745	95
Co1309 616.5	1	Varve14	other	varve	12780	140
Co1309 651.7	1	Varve15	other	varve	12880	140
Co1309 684.6	1	Varve16	other	varve	12980	140
Co1309 724.6	1	Varve17	other	varve	13080	140
Co1309 743	10	C-L3836	other	quartz silt fraction	17300	800
Co1309 763.6	1	Varve18	other	varve	13180	140
Co1309 798.5	1	Varve19	other	varve	13280	140
Co1309 846.2	1	Varve20	other	varve	13380	140
Co1309 897.4	1	Varve21	other	varve	13480	140
Co1309 958.5	1	Varve22	other	varve	13580	140
Co1309 960	10	C-L3837	other	quartz silt fraction	21800	1100

Co1309 1023.6	1	Varve23	other	varve	13680	140
Co1309 1107.1	1	Varve24	other	varve	13780	140
Co1309 1166	10	C-L3838	other	quartz silt fraction	23400	1400
Co1309 1191	1	Varve25	other	varve	13880	140
Co1309 1283.5	1	Varve26	other	varve	13980	140
Co1309 1301.3	1	Varve27	other	varve	13894	140
Co1309 1315.7	1	Varve28	other	varve	13905	140
Co1309 1322.4	1	Varve29	other	varve	13910	140

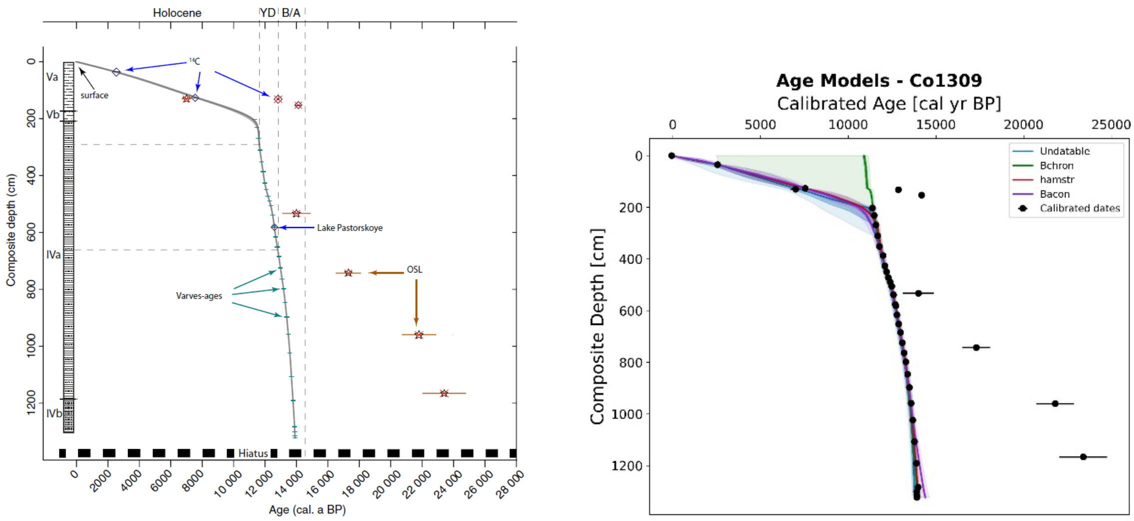

Figure 4 *– Comparison of age-depth model from Co1309 – Left: original published age-depth model by Gromig et al. (2019), Right: Corrected LANDO output for Co1309 to include in the revised version.*

Figure 2 shows that LANDO can reproduce the overall age-depth model by Gromig et al. (2019) without removing dating points.

Second, the sedimentation rates presented for core PG1205 from Basalt Lake in East Greenland are based on radiocarbon ages originally published by Wagner et al. (2000 in Palaeo3, 160: 45-68), although reference is made to the PhD thesis of Wagner (2000). The LANDO calculations suggest continuous and relatively constant sedimentation since at least 21 cal. ka BP. However, both Wagner et al. (2000) and Wagner (2000) state that the lake record consists of a till at its base, which in all likelyhood was deposited during the Milne Land stade 11.30 - 11.15 cal. ka BP, overlaid by ca. 6.4 m of glaciolacustrine sediments deposited with high sedimentation rates during deglaciation and ca. 2.6 m of hemipelagic sediments deposited with much lower rates during the past ca. 10 ka BP. Hence, the calculations conducted by Pfalz et al. obviously neglect the regional glacial history presented and discussed by Wagner et al. (2000) and Wagner (2000) as well as many papers published before and afterwards, giving the wrong impression that this part of East Greenland became deglaciated already prior to 21 cal. ka BP.

For PG1205 two datasets exist on Pangaea – one dataset (https://doi.pangaea.de/10.1594/PANGAEA.734962) referencing the publication of Wagner et al. (2000) in Palaeo3, one dataset (https://doi.pangaea.de/10.1594/PANGAEA.385643) referencing the modified version of the PhD thesis of Wagner (2000) published in Reports on Polar Research ("Berichte zur Polarforschung"). Both datasets on Pangaea are identical in content. We referenced the dataset from the publication in Reports on Polar Research (https://epic.awi.de/id/eprint/26538/) because this publication was freely available and allowed us to review the content, while the publication in Palaeo3 (https://doi.org/10.1016/S0031-0182(00)00046-8) was initially behind a paywall and therefore not immediately accessible.

To ensure that we do not include grey literature in the references, we now use Wagner et al., (2000) as reference for the core PG1205. For this 9.85 m-long core we list all the publicly available dating points in **Table 3**, which produced the output in **Figure 3**.

Table 3 *– Input data of PG1205 based on Wagner et al. (2000). LANDO input parameters "Lab-Location", "Weight", "Pretreatment", "Reservoir Age", and "Reservoir Error" not included in this table for readability.*

MeasurementID	Thickness (cm)	LabID	Category	Material	Uncali-brated Age (yr BP)	Uncalibrated Age Error (+/- yr)
PG1205 33	2	OxA-7253	14C terrestrial fossil	twigs	845	40
PG1205 41	2	OxA-7286	14C terrestrial fossil	twigs	985	50
PG1205 89	2	UtC-8453	14C terrestrial fossil	leaves, twigs	3050	80
PG1205 124	1	OxA-7254	14C terrestrial fossil	mosses	4175	50
PG1205 149	2	UtC-8222	14C terrestrial fossil	leaves, twigs	5433	35
PG1205 181	2	OxA-7287	14C terrestrial fossil	leaves, twigs	6455	70
PG1205 241	2	UtC-8454	14C terrestrial fossil	leaves, twigs	8960	160

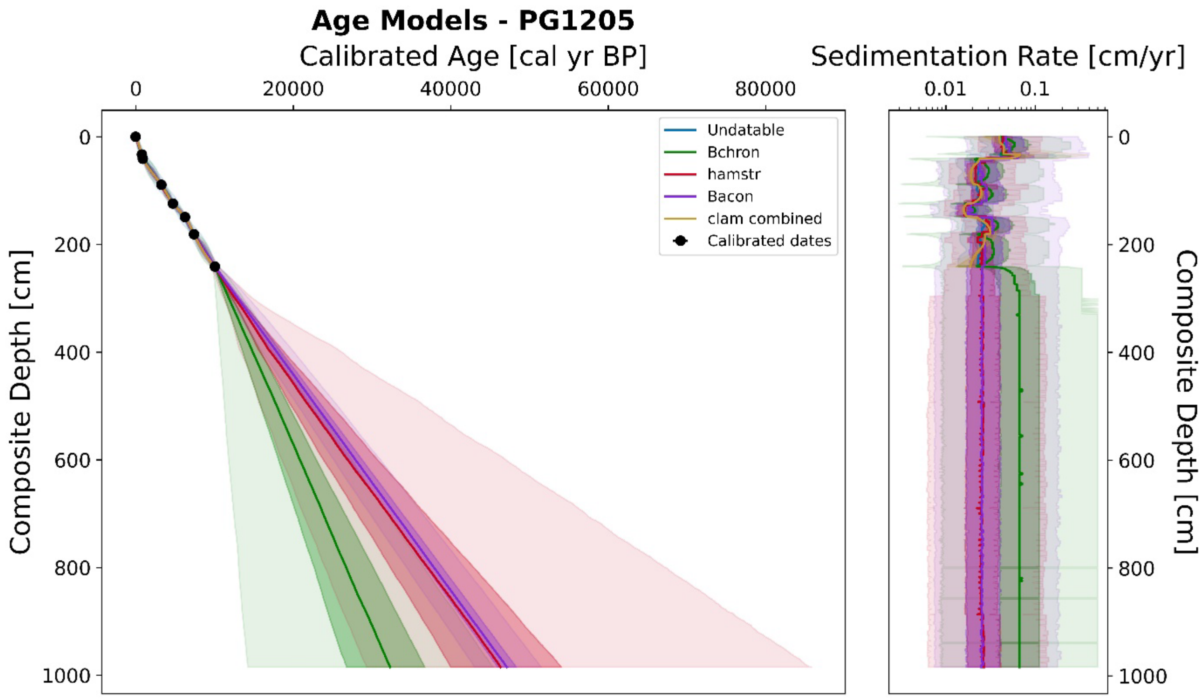

Figure 3 *– Previous (first submission version) LANDO age-depth model from PG1205 based on input data by Wagner et al. (2000)*

Figure 3 shows why LANDO produces an output that is inconsistent with geological evidence. Since dating points are only available for the first 2.5 meters, LANDO has to extrapolate the remaining seven meters to cover the entire sediment core, which is an extreme case compared to other sediment cores. In the manuscript on Page 24, Lines 645-648 we stated that "*[e]xtrapolating the age-depth models beyond age determination points always bares the risk that the extrapolated dates do not reflect the actual age. The implemented modeling systems account for this circumstance by increasing the uncertainty for these undated regions (Blaauw, 2010). While we are aware of this potential issue, we wanted to allow users to take advantage of the full age-depth coverage for their sediment core.*" Similar to the Lake Ladoga sediment core Co1309, we changed the length of the sediment core to the last dating point to avoid strong extrapolation in the new version (Figure 4). We shall include an additional paragraph in the revised version addressing these extrapolation/hiatus issues of LANDO, as well as listing the CoreIDs where we had to adjust our models, so that readers can track our adjustments.

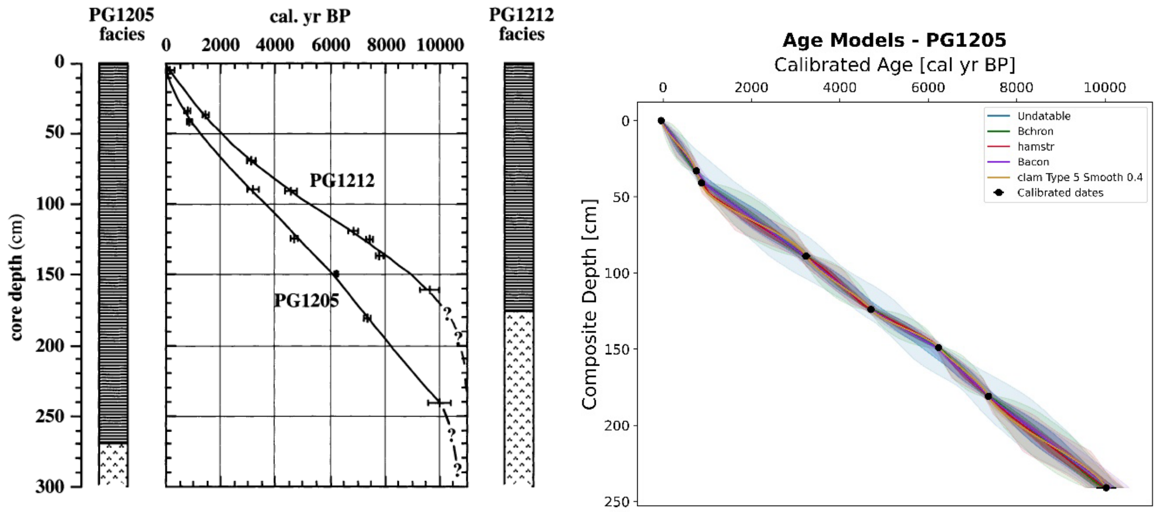

Figure 4 *– Comparison of age-depth model from PG1205 – Left: original published age-depth model by Wagner et al. (2000), Right: Corrected LANDO output for PG1205 to include in the revised version.*

These two examples illustrate that neglecting geological evidence for hiatuses or large changes in the rates of deposition can create much larger errors in age-depth models and resulting sedimentation rates than the employment of an age-depth modelling system that may not be ideal for the record investigated. From the two examples it becomes evident to us that the literature existing for all sediment records used in the third case study, not only Co1309 and PG1205, needs to be (re)studied and discussed to assure that the geological evidence provided is considered in the sedimentation rates calculated.

Thank you for bringing this important matter to our attention. We agree and have re-examined all the sediment records closely by comparing the originally published age-depth models and the LANDO outputs. In addition to the two cases you mentioned, we found two other case, where we had to adjust the output. In all four cases discovered, we will discuss this issue in the revised version of the manuscript with reference to the original publication.