Supplement of

Improving age–depth relationships by using the LANDO ("Linked age and depth modeling") model ensemble

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Figure S1 – Optimized models for 33 published sediment cores displayed for each modeling system as weighted average median sedimentation rate (in centimeter per year, cm/yr – y-axis) binned into 1000-year bins (in calibrated years Before Present, cal. yr BP, i.e. before 1950 CE – x-axis) for the last 21,000 years. Bold lines indicate the weighted average median sedimentation rate for all models, while shaded areas are their respective one-sigma and two-sigma ranges in the same colors with different opacities. Each grid cell contains the unique core identifier of each involved sediment core. In seven cases, the letters below each number give the name of the independent proxy used for optimization process.
Figure S2—Boxplot representing the overall two-sigma ranges (in years) for each model within our data collection of 55 sediment cores. We examined the modeling results over the entire length of each individual sediment core.

Figure S3—Boxplot representing the two-sigma ranges (in years) of each model around 11 700 yr BP for our data collection of 55 sediment cores. We examined the period from 11 600 to 11 800 yr BP to enable a comparison with the 100-year-binned model results.
Figure S4 – Color vision deficiency plot for sediment core EN18208 (OSL and 14C data from Vyse et al., 2020) generated by LANDO. Equivalent to panel (a) of Figure 3 in the main publication, the left plot shows the age-depth models for EN18208, whereas the right plot displays the results from the sedimentation rate calculation for each modeling system. The difference to Figure 3 is that each modeling system has received a different line style and shading to help differentiate between the models. Instead of representing the median age and median sedimentation rate of all models by solid lines, the various line styles shall support the interpretation of age-depth models for people with color vision deficiency. Furthermore, each shading characterizes both one-sigma and two-sigma ranges for the individual models with decreasing opacities, respectively.
Table S1 – Overview of the screening results for whether modeling systems were able to use age determination data to create an age-depth model. Label “CHECK” refers to a successful modeling process, while label “FAIL” indicates an unsuccessful process.

| CoreID             | Undatable | Bchron | hamstr | Bacon | clam |
|--------------------|-----------|--------|--------|-------|------|
| T6-KP-04-L.19      | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| BC2008             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| BL02-2007          | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| BN2016-1           | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Chupa-5            | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Co1209             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| Co1242             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| CON01-603-5        | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Dolgoe2012         | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| EN18208            | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| EN18218            | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| ESM-1              | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| KAS-1              | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Korzhino2010       | FAIL      | CHECK  | CHECK  | CHECK | CHECK|
| LENDERY180-4       | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| LENDERY192         | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| LENDERY200-1       | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| LENDERY203-3       | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| LOT83-7            | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| LS-9               | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Maloye-1           | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| MC2006             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Muan2018           | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| Okun2018           | FAIL      | CHECK  | CHECK  | CHECK | CHECK|
| OSIN               | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PER3               | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1111             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1205             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1214             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1228             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1238             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1341             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1351             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1437             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1746             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1755             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1756             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1858             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1890             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1972             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG1975             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG1984             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG2023             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| PG2133             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG2201             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| PG2288             | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| Tel2006            | CHECK     | CHECK  | CHECK  | CHECK | FAIL |
| Teriberka17        | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| TKT-3              | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| TL-1-1             | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
| TULOMA27           | FAIL      | CHECK  | CHECK  | CHECK | CHECK|
| UKhau2015          | CHECK     | CHECK  | CHECK  | CHECK | CHECK|
Table S2 – Runtime for each model for case study CS1 (“Continuously deposited sequence”) and CS2 (“Inconsistent sequence”) split into their individual steps. Both case studies ran ten times in our test setup. The presented values are the mean value and their standard deviation. Note: a) Within our test setup, we let Bacon adjust the default values automatically. For the “Continuously deposited sequence” case study (CS1), Bacon changed the accumulation rate prior mean (acc.mean) to 50 yr/cm and the thickness to 4. In the “Inconsistent sequence” case study (CS2), Bacon adjusted the acc.mean to the same value (50 yr/cm), but increased the thickness to 10 to account for the length of the sediment core, which resulted in a reduction of runtime. b) For both case studies, we used our “best fit” option within clam. For the “Inconsistent sequence” case study, LANDO could not find a best fit with the clam models, hence, our program skipped both “Aggregation” and “Sedimentation Rate Calculation” (SRC) step.

| Case Study   | “Continuously deposited sequence” – CS1 | “Inconsistent sequence” – CS2 |
|--------------|-----------------------------------------|-------------------------------|
| Length of selected sediment cores [m] | 6.53                                      | 10.76                         |
| **Execution time [s]**                |                                          |                               |
| Reservoir correction                  | 39.87 ± 0.39                             | 45.39 ± 0.55                  |
| Undatable                              |                                          |                               |
| Preparation                            | 0.40 ± 0.01                              | 0.40 ± 0.02                   |
| Execution                              | 8.58 ± 0.16                              | 10.39 ± 0.43                  |
| Aggregation                            | 0.36 ± 0.01                              | 0.55 ± 0.01                   |
| SRC                                     | 18.35 ± 0.18                             | 34.62 ± 0.12                  |
| Bchron                                  |                                          |                               |
| Preparation                            | 0.10 ± 0.00                              | 0.10 ± 0.00                   |
| Execution                              | 166.89 ± 0.55                            | 193.42 ± 1.94                 |
| Aggregation                            | 1.86 ± 0.02                              | 3.07 ± 0.10                   |
| SRC                                     | 18.82 ± 0.13                             | 35.77 ± 0.95                  |
| hamstr                                  |                                          |                               |
| Preparation                            | 0.10 ± 0.01                              | 0.10 ± 0.01                   |
| Execution                              | 93.37 ± 0.58                             | 118.90 ± 1.90                 |
| Aggregation                            | 2.93 ± 0.02                              | 4.21 ± 0.01                   |
| SRC                                     | 18.70 ± 0.08                             | 35.48 ± 0.66                  |
| Bacon                                   |                                          |                               |
| Preparation                            | 0.10 ± 0.01                              | 0.11 ± 0.01                   |
| Execution                              | 1220.62 ± 4.08                           | 657.46 ± 3.48                 |
| Aggregation                            | 2.99 ± 0.01                              | 4.25 ± 0.03                   |
| SRC                                     | 18.71 ± 0.14                             | 36.07 ± 0.91                  |
| clam                                    |                                          |                               |
| Preparation                            | 0.05 ± 0.01                              | 0.05 ± 0.01                   |
| Execution                              | 193.72 ± 2.88                            | 217.64 ± 4.43                 |
| Aggregation                            | 1.96 ± 0.06                              | 0.04 ± 0.00                   |
| SRC                                     | 19.39 ± 0.40                             | 0.04 ± 0.00                   |
| **Overall execution time [min]**       | 30.46 ± 0.16                             | 23.30 ± 0.26                  |