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Supplementary Material

For

MET-IRSL used to track pre-depositional sediment transport history

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This file contains additional procedures, observations, discussion and references to support the above publication.

Analysis of MET-IRSL results – additional notes

Fitting of growth curves was undertaken manually as individual grains within the same sample group often require different fitting approaches; automated fitting was observed to omit results for some grains, and provide sub-optimal dose estimates for others. Summary data files for each temperature (ANR files) were made, and subsequently opened, and the position and grain number, the equivalent dose, De uncertainty and net sensitivity were transferred for each MET-IRSL measurement temperature into a single spreadsheet. Results for each grain were aligned so that De estimates made at different temperatures were presented on the same row. An initial manual search was conducted through the values for each grain identifying De estimates that might represent a single bleaching event considering their uncertainties. That is, we were seeking De values where the one sigma uncertainty value overlapped with that from another De estimate for the same grain.

In practice, we find that it is easier to convert De estimates into age using the mean dose rate for grains of this grainsize range (either 180-212 or 125-180μm) before identifying and rigorously estimating plateau ages; we note that this may slightly increase operator bias, and so we are particularly careful to be systematic in the treatment of data. The lower values for ages when expressed in ka in comparison to De values in seconds make it easier for the operator, in our experience. It also helps the operator to assimilate patterns within the age structure of the results that might be explored further at a later stage of analysis.

Dose recovery determination

Dose recovery determinations were carried out using conventional multiple grains discs following extended white light bleaching using either a 6000K LED light source or natural daylight; residual signals observed following bleaching were subtracted from dose recovery signals. In other respects the protocol used was as similar as possible to that used in the dating determinations for the glacial delta samples from Chinley, Derbyshire, and for the assessment of past exposure and transport history for the samples from Ilkely Moor, Yorkshire, and Twigmoor Woods, Lincolnshire, UK. Figure S1 displays the dose recovery results, showing the administered dose of around 13.8 Gy by a dashed line. Despite no treatment between the main IRSL measurements (Lx) and the test dose (Lamothe et al., 2018), reasonable recycling is observed for most samples, and no systematic departures are observed for one group of samples.

Palaeophotochronometry

When a sample comprises a collection of grains each bleached at a different date over an extended period, for example by extensive episodes of reworking, there exists the potential to assess whether there were variations in the degree of bleaching through time by constructing a record at each apparent plateau age using a simple bleaching index (see main text for details). We have constructed such a record for sample TW20-04 (Shfd 20159) presented in Figure 5 (main text). Here, we display these results along-side a record of ice rafted debris (IRD) from the North Atlantic compiled by Bond et al. (2001), and presented by Smith et al. (2016), to allow readers to consider possible causes of the observed variation (Figure S2). The possibility exists that these are meaningless, random variations in bleaching. Although we cannot fully dismiss this possibility, it appears to us that the apparent change that aligns with the Younger Dryas climate event, a period of extensive dune formation in this part of Lincolnshire (Bateman et al., 1999), and the spacing of peaks in the Holocene part of the record that to us appear reminiscent of the climate cycles identified by Bond et al. (2001), tend to support the hypothesis that a meaningful environmental signal may be present. We consider that the timing of peaks and troughs may be have some error associated with them, particularly considering that grains may have previously been part of different sediment bodies with somewhat different dose rates.

Additional references

Lamothe, M., Brisson, L. F., Hardy, F. (2018). Dose recovery performance in double IRSL/pIRIR SAR protocols. Radiation Measurements, 120, 120-123.

Smith, A.C., Wynn, P.M., Barker, P.A., Leng, M.J., Noble, S.R., Tych, W. (2016). North Atlantic forcing of moisture delivery to Europe throughout the Holocene. Scientific Reports 6, 24745, DOI: 10.1038/srep24745

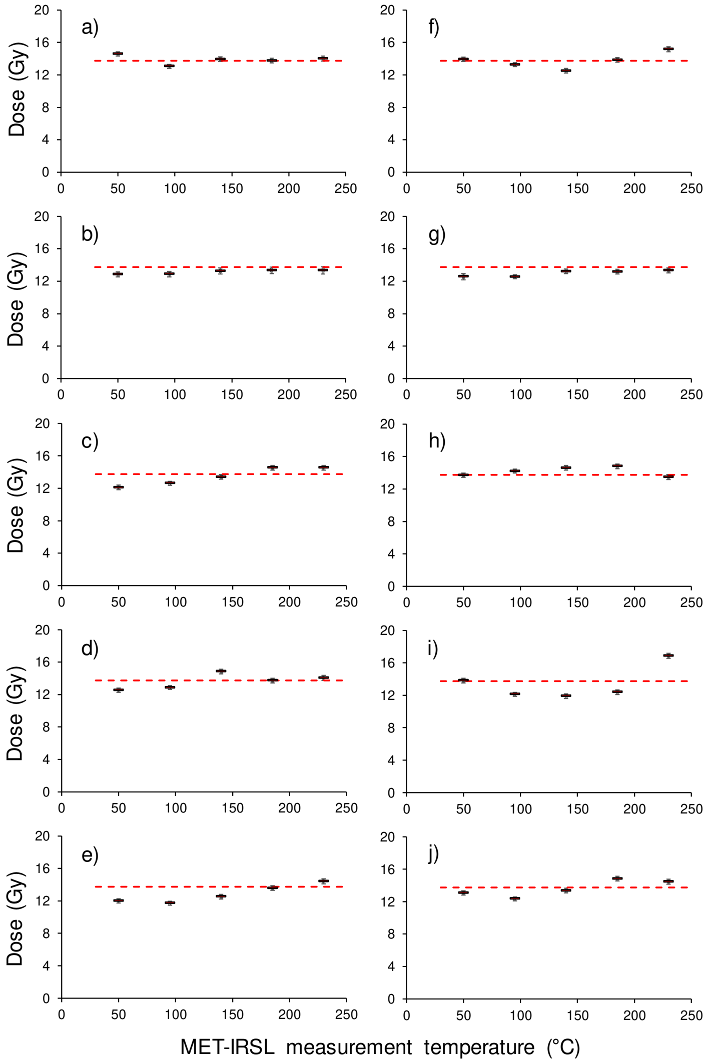

Figure S1. Dose recovery determinations using conventional multiple grain aliquots for samples within this study. The dashed line represents the administered dose of 13.8 Gy. Data represent average of two aliquots, with residual signal after bleaching subtracted. Samples are as follows (field code: laboratory code): a) TW20-03: 20158, b) TW20-04: 20159, c) BS16-01: 16132, d) BS16-02: 16133, e) BS16-03: 16134, f) IM19-05: 20128, g) IM19-06: 20129, h) IM19-01: 20040, i) IM19-02: 20041, j) IM19-03: 20042.

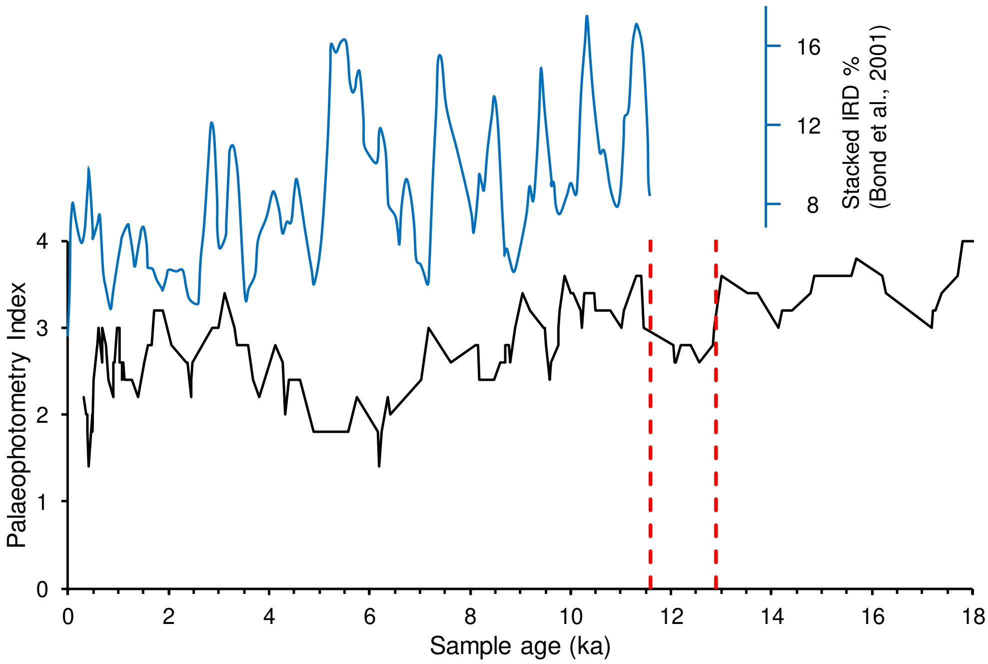

Figure S2. A partially smoothed palaeophotometry proxy signal based on the running mean of 5 bleaching index values from different single grain plateau age estimates of sample TW20-04, laboratory code Shfd 20159, ranging from 18,000 years ago until a few hundred years ago identical to that in Figure 5 (main text). We have added a record of ice rafted debris (IRD) from the North Atlantic constructed by Bond et al. (2001). We note a similarity in the pacing of peaks between the two records of about 1.5ka, particularly between 12 and 7 ka and 5 to 2 ka, which may suggest similar climate pacing of the two records; possibly representing Dansgaard-Oeschger cycles. Note our caveats regarding interpretation of these data in the main and supplementary text.