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A re-analysis of the Lake Suigetsu terrestrial radiocarbon calibration dataset

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ABSTRACT

Lake Suigetsu, Honshu Island, Japan provides an ideal sedimentary sequence from which to derive a wholly terrestrial radiocarbon calibration curve back to the limits of radiocarbon detection (*circa* 60 ka bp). The presence of well-defined, annually-deposited laminae (varves) throughout the entirety of this period provides an independent, high resolution chronometer against which radiocarbon measurements of plant macrofossils from the sediment column can be directly related. However, data from the initial Lake Suigetsu project [1–3] were found to diverge significantly from alternative, marine-based calibration datasets released around the same time (e.g. [4,5]). The main source of this divergence is thought to be the result of inaccuracies in the absolute age profile of the Suigetsu project, caused by both varve counting uncertainties and gaps in the sediment column of unknown duration between successively-drilled core sections.

Here, a re-analysis of the previously-published Lake Suigetsu data is conducted. The most recent developments in Bayesian statistical modelling techniques (OxCal v4.1; [6]) are implemented to fit the Suigetsu data to the latest radiocarbon calibration datasets and thereby estimate the duration of the inter-core section gaps in the Suigetsu data. In this way, the absolute age of the Lake Suigetsu sediment profile is more accurately defined, providing significant information for both radiocarbon calibration and palaeoenvironmental reconstruction purposes.

1. Introduction

There are many useful archives from which radiocarbon (^{14}C) calibration curves can be developed. Tree-ring records provide an important repository of such information since their annual growth bands provide an almost perfect calendar year age, whilst the same material can be directly analysed for their ^{14}C measurements. At present, the limits of the absolute age scale of radiocarbon calibration based upon this dendro-record extends only to 12,593 calendar years bp ([7], an extension of 183 years from that included in IntCal04 [8]), however, and so other sources must be examined to extend radiocarbon calibration further back in time. Chief amongst these alternative archives is the partially varved sedimentary record from the Cariaco Basin [9]. Another such archive is provided by uranium series-dated corals (e.g. [10] working on sites in the Bahamas). Whilst extremely useful, such records provide information on radiocarbon calibration in the oceans, rather than the atmosphere. Although atmospheric ^{14}C concentration ($\Delta^{14}C$) can be approximated from such marine archives, a correction factor for the 'marine reservoir effect' of radiocarbon must necessarily be applied. Since the marine reservoir age is known to vary both temporally and spatially [11], such approximations for atmospheric radiocarbon therefore contain an additional tier of uncertainty.

The annually laminated (varved) sediments of Lake Suigetsu, Honshu Island, central Japan (35°35′N, 135°53′E, 0 m a.s.l.) provide an ideal sequence from which to derive a wholly terrestrial record for radiocarbon calibration through dating of plant macrofossils identified within its sedimentary strata. Such data were presented by Kitagawa and van der Plicht [1–3], however comparison with the aforementioned marine-derived calibration data [4,5] yielded unexplained discrepancies. Fig. 1 demonstrates the divergence of the original Lake Suigetsu data presented by Kitagawa and van der Plicht from the more recent marine-based calibration data of Hughen et al. [9] and Fairbanks et al. [10]. It can be seen that this divergence is particularly pronounced further back in time, especially beyond *circa* 25 cal. ka bp.

2. Main issues to be addressed

It is unlikely that such a systematic divergence between the Lake Suigetsu dataset and the marine-based radiocarbon calibration datasets represents a 'real' offset between these respective archives. The more likely causes of divergence are in

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[1] For full details see: www.suigetsu.org.

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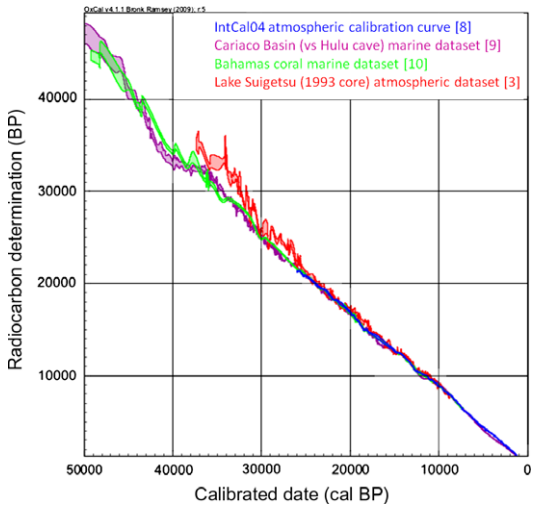

Fig. 1. The Lake Suigetsu radiocarbon calibration dataset of Kitagawa and van der Plicht [3] as compared with the alternative calibration data of IntCal04 [8], Hughen et al. [9], and Fairbanks et al. [10]. All curves are plotted with 1σ uncertainties.

the 'absolute age' of the Lake Suigetsu record: firstly, in the accuracy of the varve counting itself; and secondly, due to the core-drilling methodology applied [12]. The former issue is not due to the nature of the Suigetsu sediments themselves – the sediment profile still provides annual resolution throughout the time period in question – rather, it is a function of the varve counting methodology, which was only based on surface reflectance in the original study. The latter issue meant that since sediment was removed in sections from a single borehole, there was the potential for material to be lost from between core sections, generating gaps in the absolute age profile of the composite core of unknown duration. (Both matters have been remedied in the re-coring of Lake Suigetsu, as undertaken by Suigetsu 2006 Project Members, which should properly resolve the issues mentioned herein.)

The remainder of this paper provides a statistical modelling approach to demonstrate both the likely sources of error in the original Lake Suigetsu study, and the enduring usefulness of the information (over 280 radiocarbon determinations) pertaining to the extension of the ^{14}C calibration curve beyond the tree-ring limits that is nevertheless represented by the Kitagawa and van der Plicht dataset.

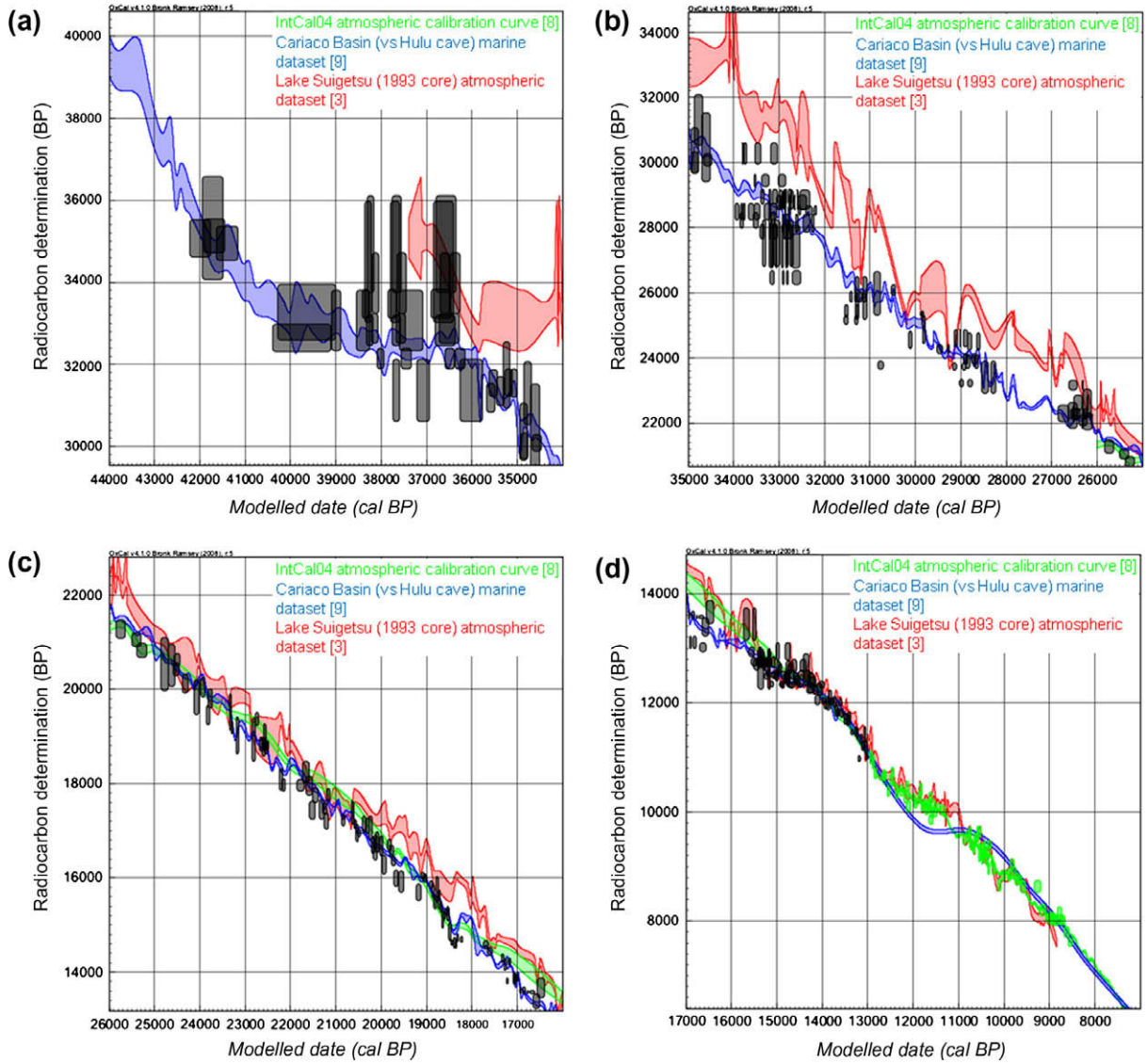

Fig. 2. The re-modelled data of Kitagawa and van der Plicht [3] as calibrated against IntCal04 [8] (Suigetsu core sections SG13 to SG17) and the Cariaco Basin record [9] (Suigetsu core sections SG18 to SG34) shown for: (a) 34–44 cal. ka bp; (b) 25–35 cal. ka bp; (c) 16–26 cal. ka bp; and (d) 7–17 cal. ka bp. The data are plotted with 1σ uncertainties shown, as are the original, unaltered Kitagawa and van der Plicht data (i.e. without intervals inserted between core sections).