

General comments:

While I can't comment on their statistical techniques, I noticed one major flaw in their approach. In calibrating radiocarbon ages of the shells the authors used the northern hemisphere terrestrial calibration curve - they are marine shells. They should be using the marine calibration curve and related to this would be the effects of marine reservoir corrections - surely this would impact the results and mean a reanalysis is necessary.

The first referee had the same comment, so we relate to the respective reply to Rev. 1. (cp-2018-50-AC1-supplement) on Page 5, comm. 8. Reanalysis with the new data has been done, and the results did not differ significantly.

From a writing perspective, the manuscript would benefit greatly from an improvement to the text. Notably, the descriptions of the indicative meaning of a sea level indicator used to create sea level index points/limiting constraints. I think there is some confusion here or at least it is not made clear. The introduction, in particular, could do with re-writing - there is a lot of unnecessary information and the goals of the paper should be made clearer, earlier on

We improved the text based on the suggestions of the referee and re-write certain parts of the introduction. We improved the description of indicative meaning and clear the confusion between sea-level indicators and sea-level index points. Therein, we followed the recommendations of Shennan et al. (2015, Chap 2). We included all the specific corrections into revised version of the manuscript.

Specific comments:

Page 1

- L. 18 abbreviate here to RSL - you do this later on in the text but it is first used here.

Corrected.

- L. 18-21 Poor English and vague statement. Have a better opening sentence.
Could be written so much better.

We rewrote the opening paragraph and tried to improve English.

- L. 21 Elements??

Corrected term is features.

Page 2

- L. 1 You're describing here features of the indicative meaning of a sea level index point. The SLI is used to establish a sea level index point. Refer to the sea-level handbook of Shennan 2015

We now described the difference between sea-level indicator and sea-level index point based on Shennan et al. (2015, Chap. 2).

“Fossil samples, morphological and archaeological features governed by the paleo sea level are defined as sea-level indicators (Shennan et al. 2015, van De Plassche 1986). Those sea-level indicators that are containing four main attributes: location of the sample on the Earth, deposition age, elevation related to present RSL, ordnance datum and the tendency, are expressed as sea-level index points, abbreviated to SLIPs or SLI (here, we will use SLI) and are commonly used to reconstruct past RSL (Shennan et al 2015). Elevation of the SLI represents “indicative meaning” in relation to the present RSL (van De Plassche 1986). SLI living range with respect to the corresponding shoreline was introduced as indicative meaning by van de Plassche (1986) and contains two parameters: the reference water level and the indicative range. “

- L. 2 Do they? Have any examples?

Here the aim was to point out that in order to differentiate SLIs from predictions and estimates of GIA models, they can be described as observations, while that is not correct term since SLIs have to be processed by e.g. dating methods, correction to GPS measurements or the statistical methods to obtain derivation of one of the 4 attributes (Shennan et al. 2015).

- L. 3 establishing elevation of a SLI.

Note - leveling is a method from which we establish the elevation of SLI. You should use the correct terminology.

Corrected.

- L. 3-4 models? do you mean techniques? i.e. c14 etc

if you are referring to age models they are usually restricted to continuous sequences of sediment, not SLI like shells.

the correct term would be modern analogue.

This sentence now reads as follows: “ In addition to the elevation and age determination for each SLI, the relation to RSL has to be derived from the indicative meaning based on the modern analogue or the deposition conditions of the sample/specimen.”

- L. 3 This term should be introduced above with correct referencing of van de Plassche.

Done.

- L. 4 i don't understand what your point is.
This opening paragraph reads confused,

As mentioned before, opening paragraph of the introduction, along with definitions has been rewritten to improve the understanding and goals of the paper.

- L. 7 Examples?

It is common to use 2σ range to define upper and lower limits. But, since we do not use this confidence interval, we removed this part of the sentence.

- L. 7 Might want to introduction this definition earlier on. Also why start the sentence with "it is important to mention"?

We introduced RSL further up.

- L. 11-13 You introduced indicative meaning term above
is all this info really needed in the introduction or paper at all? You could have one or two sentences max defining the indicative meaning, RSL etc with relevant references instead of the 2/3 paragraphs.

This paragraph was reduced and we explained indicative meaning together with SLIs.

- L. 25 I understand what you are saying but it is not written very well.
Also note again - SLI are used to produce sea level index points. The SLIPs can be used to validate/tune GIA models.

We are abbreviating sea-level index points as SLIs.

- L. 25-35 This paragraph is too long and should be split in two. You talk about databases, GIA, stat methods. Break it up.

Done.

- L. 25 Such a vague statement. If you're going to say such things back it up with some references.

This sentence was meant to introduce part that follows and describes different methods, and based on suggestion of the referee, that will be a new paragraph.

L. 26 You already abbreviated to RSL so why use in full. This is a simple thing to do.

Done.

L. 27 This should be a new paragraph.

Done.

L. 34 is respected the appropriate word??

We use this word as synonym to considered, concerned and we believe it is appropriate in this sense.

Page 3

Fig 1. Low quality figure

We submitted better quality image.

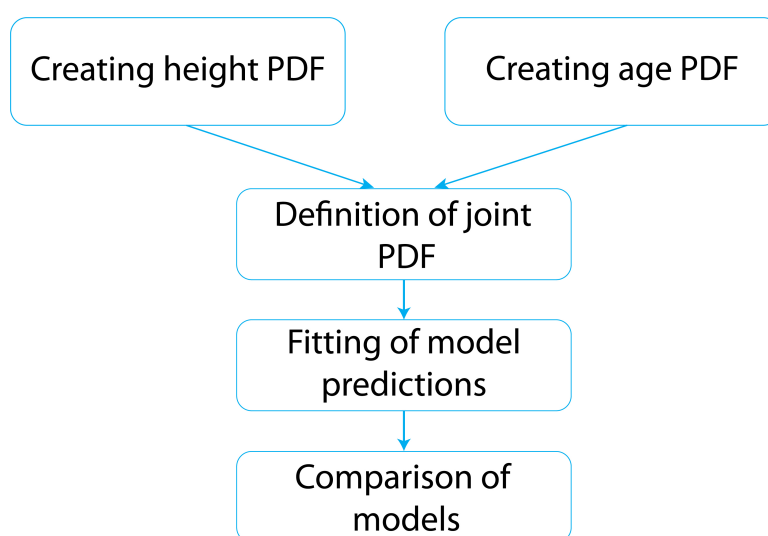


Figure 1. Flowchart of model workflow.

L. 1 Hudson Bay, Canada....

Corrected.

L. 3 This is more suited to section below. Or remove completely.

This paragraph is placed in the section below.

L. 7 At last. This should be made clear in your introduction. What the aims of the paper are.

This part is shifted to the introduction.

- L. 11 Is there a reference or web address for this data?

There is no reference for the data from GFZ database.

- L. 15 Ref?

Data from Art Dyke is unpublished so there is no reference, we now placed “personal correspondence” next to it.

- L. 16 I would prefer to see PDF not abbreviated in the headings.

We agree and corrected.

- L. 17 Elevation

Corrected

Page 4

- L. 4 What about other errors in height/elevation? like measurement or datum uncertainties?

The elevation of the SLIs is referenced to mean sea level. It was measured or it was taken from topographic maps; accordingly it is quite heterogeneous. Considered measurement errors in elevation from selected SLIs and OBIS data are explained in the Equations 5. and 6. We applied a uniform error of 1 m for OBIS data and 5 m for SLIs. Geographical positioning errors are not relevant for this study, therefore we do not consider them.

- L. 13 Italics?

Set to italics letters.

- L. 13 SO where do they typically live? what are their depth ranges? The reader is unlikely going to find this info from OBIS. Better to state.

Depth ranges of the selected shells are visible in the Figure 4. But we agree with the comment, and it is stated in the manuscript along with the information regarding their typical environment

Page 5

RSL at 800m??

The RSL as a correction term due to GIA is the difference between geoid displacement and radial surface displacement (Farell & Clark, 1976). Extended over land areas, it is dominated

here by the radial surface displacement due to the former ice load. Furthermore, we now show the distribution at 8 ka BP.

Page 7

Fig 5. This is straight out of the OxCal software. At least make some effort to edit it yourself.

We generated new figure from the OxCal output. Considering the much smoother curve due to applying marine curve, we stay in using the PDF directly, as we aim to extend this method to terrestrial samples where the characteristics of the PDF will become more irregular.

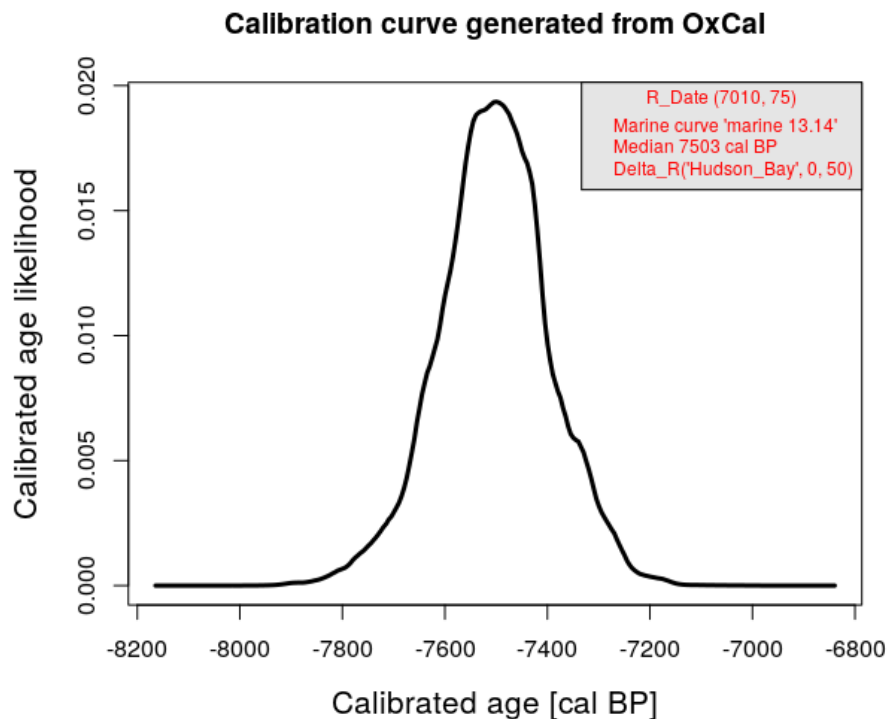


Figure 5. Calibration curve generated from OxCal output with measured radiocarbon determination of 7010 ± 75 BP (Ramsey, 2017). Marine curve “marine 13.14” was used in the calibration, with reservoir age correction (Delta_R) of 416 ± 50 yr.

L. 2 You have to reference such statements - did you come up with this??

This paragraph has been rewritten with appropriate references.

“Radiocarbon technique has been used for dating of archaeological and geological records since its invention in the 1940s (Libby 1952, Reimer et al 2013). But ^{14}C ages according to the decay of the radio nuclid do not represent directly calendar years due to the variable production rate of ^{14}C in the upper atmosphere (Reimer et al 2103.). Determination of ^{14}C age

is calculated by ratio of $^{14}\text{C}/^{12}\text{C}$, which depends on ^{14}C production and the conversion of ^{14}C age to calendar years is done with calibration curves (Törnquist et al 2015). Here we used marine curve “Marine13” (Reimer et al. 2013) and calibration software OxCal (Ramsay, 2017) to calibrate ages of considered SLIs. Since they are marine samples we had to take into account “reservoir effects”. The CO_2 exchange between atmosphere and the ocean leads to a delayed uptake in the surface waters (e.g. Törnquist et al 2015). Due to this effect, called reservoir effect, marine samples will have lower concentration of ^{14}C than the terrestrial samples, having as a global average deviation of 400 ^{14}C years (Törnquist et al 2015). “

Furthermore, in reply to Rev 1., we considered a spatial variability of this correction (see P. 1, comm. 1).

L. 4 Not relevant

We removed this sentence.

L. 7 Why are you using this calibration?! They're marine shells. Also related are marine reservoir effects - did you not consider this? This would effect the ages and your results

See the answer to the comment Page 7, L. 2.

Page 9

L 2. tense

Corrected

Page 11

L. 1 lithosphere

Corrected.

L . 4-6 Sentence doesn't read properly.

The sentence has been rewritten.

“In Table 2 , we present results of different studies that are estimating mantle viscosity for Hudson Bay region compiled in Wolf et al. (2006) together with one further study and two global estimates. “

Page 14

L 2.-4 Awkward opening line.

Opening sentence is changed.

L. 8 You have used the wrong calibration curve. It should be marine.

[See the answer to the comment Page 7, L. 2.](#)

L. 10 no where in the paper did you say this until the conclusion...

[This is corrected and added into the section 2.1 of the manuscript.](#)

L. 15 First real mention of this. How would tidal range change effect your results? Moreover, how are the shells related to tides anyway??

[Some shells are living in intertidal zone and can be effected by tides, but the tidal range for the Hudson Bay at present varies between 0 and 4 m \(Webb 2013\), and produces accordingly an offset depending on the living conditions with respect to the tidal range. We decided not to add this aspect as well as not to consider the relation of some samples to “storm-beaches” \(see comment to Rev. 1. \(cp-2018-50-AC1-supplement\) P. 3, comm. 3\)](#)

Literature

Butzin, Martin; Köhler, Peter; Lohmann, Gerrit (2017): Marine radiocarbon reservoir ages for the past 50,000 years, links to model results in NetCDF format. PANGAEA, <https://doi.org/10.1594/PANGAEA.876733>, Supplement to: Butzin, M et al. (2017): Marine radiocarbon reservoir age simulations for the past 50,000 years. Geophysical Research Letters, 44(16), 8473-8480, <https://doi.org/10.1002/2017GL074688>

Farrell, W. E. and Clark, J. A. (1976), On Postglacial Sea Level. Geophysical Journal of the Royal Astronomical Society, 46: 647-667. doi:[10.1111/j.1365-246X.1976.tb01252.x](https://doi.org/10.1111/j.1365-246X.1976.tb01252.x)

Libby, W.F. (1952) Radiocarbon Dating, University of Chicago Press, Chicago

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Grootes, P. M., Guilderson, T. P., Hafliðason, H., Hajdas, I., Hatt, C., Heaton, T. J., Hoffmann, D. L., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Staff, R. A., Turney, C. S. M., , and van der Plicht, J.: IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP, Radiocarbon, 55, 1869–1887, https://doi.org/10.2458/azu_js_rc.55.16947, 2013

Shennan, I., Long, A. J., and Horton, B. P., eds.: Handbook of Sea-Level Research, Wiley, Blackwell, Chapter 2, 2015.

Törnqvist, T. E., Rosenheim, B. E., Hu, P. and Fernandez, A. B. (2015). Radiocarbon dating and calibration. In Handbook of Sea-Level Research (eds I. Shennan, A. J. Long and B. P. Horton). doi:[10.1002/9781118452547.ch23](https://doi.org/10.1002/9781118452547.ch23)

van de Plassche, O., ed.: *Sea-level Research: A Manual for the Collection and Evaluation of Data*, Norwich, Geo Books, Norwich, <https://doi.org/10.1007/978-94-009-4215-8>, 1986

Webb, D. J.: On the tides and resonances of Hudson Bay and Hudson Strait, *Ocean Sci.*, 10, 411-426, <https://doi.org/10.5194/os-10-411-2014>, 2014.