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Geoscientific Model Development Discussions

Interactive comment on "SEAMUS (v1.0): a $\triangle^{14}$C-enabled, single-specimen sediment accumulation simulator" *by* Bryan C. Lougheed

Anonymous Referee #1

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General comments.

Lougheed et al present a stochastic simulation model that tracks the position of individual particles (e.g. Foraminifera) in an accumulating sediment as they are deposited and subsequently mixed by bioturbation (SEAMUS). A radiocarbon activity and geochemical proxy climate signal value can be attached to these particles so that the effects of mixing can be investigated on both age-depth models and proxy climate reconstructions from hypothetical sediment cores.

As SEAMUS explicitly tracks individuals, sediment accumulation rates, bioturbation depths, species flux rates and 14C reservoir ages can all be allowed to vary dynamically over time and the time integrated effects of these changes will be correctly modelled.

A similar analysis of age heterogeneity could be achieved using the existing sediment proxy forward modelling software "Sedproxy", by treating the 14C calibration curve as the input climate signal; however, sedproxy does not explicitly track individuals and relies on sampling from the theoretical age distribution of individuals in a given slice of sediment. To do this it has to assume that bioturbation depth and sedimentation rate are constant in the time period around the sample, although these can be different for different downcore samples. This approximation can lead to artefacts at the transition from periods of high to low sedimentation rate. Additionally, SEAMUS allows for the effects of changes in the absolute flux rates of Foraminifera to be investigated, whereas only relative changes in flux rate can be modelled using sedproxy. Furthermore, SEAMUS keeps track of the number of bioturbation cycles each individual has experienced before it finally settles in the buried layers – this information is important for estimating the additional bias that can appear due to disintegration of the oldest specimens in a layer – and is not available from sedproxy.

Therefore, SEAMUS can be used to test/model scenarios that cannot by addressed without explicit modelling of the history of individuals. This comes at a cost of computing time, so it may not be the most appropriate tool in all situations, but it does represent a significant increase in realism and flexibility over existing software.

The effects of bioturbation on sediment proxy records, in particular the heterogeneity in age that adds noise to the signal and hidden uncertainty to the age model, are in general underappreciated, or if appreciated they are difficult to deal with. SEAMUS will provide a useful tool to check the possible size of these effects when interpreting data from a core, or planning a new sampling scheme.

Specific comments.

Although written for MATLAB, some of the SEAMUS code runs correctly on the open source GNU Octave language.

seamus_run required only minor alterations of the code to do with loading and saving

of files.

seamus_pick threw more errors but perhaps these are easy to fix for someone more familiar with Octave/MATLAB

If SEAMUS can be made compatible across MATLAB and Octave this would increase its availability.

Technical comments.

The manuscript was well written and I found only minor text errors:

Line 9 – “record” to “recorded”

Line 322 – “and expected” to “an expected”

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