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Interactive comment on “Modeling radiocarbon dynamics in soils: SoilR version 1.1” *by* C. A. Sierra et al.

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We would like to than the anonymous reviewer for her/his helpful comments. The main comments from the review are provided below in italics, with our reply in normal font.

General comments:

- *My major concern is the lack of illustration/discussion of relation among the three major topics: “General radiocarbon model” (Section 2.1), “Mean transit time” (Section 2.3), and “Atmospheric radiocarbon datasets” (Section 2.4.2).*

  We agree with the reviewer in that we do not discuss the relations between these different sections and how these different components of our modeling framework can be used in combination to answer more specific scientific questions. We

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added a Discussion section that addresses these relations.

- *I did not see the necessity to include radiocarbon modeling for the estimation of mean transit time*

  The estimations of mean transit times are indeed independent from the modeling of radiocarbon. However, the topics are related and there is a general perception that radiocarbon measurements help to estimate the residence time of carbon in soils or ecosystems. We think this is an important aspect to address and added this topic to the new Discussion section.

- *In addition, the feedback from atmospheric radiocarbon to soil radiocarbon through plant absorption of CO2 was not fully elucidated*

  Yes, we forgot to add a discussion about the time-lag of radiocarbon in vegetation before it is incorporated in the soil. The argument `inputFc` of the function `GeneralModel_14` includes the option to specify the time-lag radiocarbon spends in the vegetation before it enters the soil system. In addition, one can use a simple pool structure to more specifically introduce this time-lag of radiocarbon in vegetation. We discuss these ideas with more detail in the new version of the manuscript.

Technical comments:

- *Page 3169, the following statement confused me, "the transit time density distribution* $\psi(T)\ldots$ *is identical to the output O (T) observed at time T . . . ?.* $\psi(T)$ *is a PDF (probability density function), while O(T) is "the cumulative output" (see your definition on page 3168) , I could not understand why they could be identical to each other?*

  We understand this argument may be confusing, but it is actually an important result in reservoir theory. The derivation of this result is presented in Nir and

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Lewis (1975), and it wouldn't be within the scope of this manuscript to rewrite the long-derivation presented there. We tried however to explain this better in the new version.

- *Eq. 15, please further explain Sr(I/I, 0, T)? Does it mean that "Sr" is a function of I/I with the period from t = 0 to t = T? How to construct this function? Please give an example if possible.*

  The term S_r is a function that represents the numerical solution of the output flux that takes as initial conditions an impulsive input. We reworded this paragraph for clarity.

- *Page 3175, the authors reported the results for the mean residence time (MRT). However, it's unclear how to practically compute the MRT since the PDF for residence time (T) was not clearly defined in section 2.3.*

  This was a mistake in the text. Instead of mean residence time we meant mean transit time, which is explicitly defined in section 2.3. We made this correction in the text.

- *Page 3170, please explain the meaning of the non-zero eigenvalues of the matrix A.*

  The non-zero eigenvalues was part of the original definition of τ_{cycle} given by Lasaga (1980). From the work of Bolker et al. (1998), it is clear that linear decomposition models do not show zero eigenvalues, only decay functions with eigenvalues with real negative part. For this reason we removed the reference to non-zero eigenvalues from the text and just define λ_i as the eigenvalues of the matrix A.

- *Page 3171: lambda, the "-" sign for the parameter value is not necessary since the "-" sign has been indicated in Eq. 4.*

  Good point. The negative sign was removed.

- *Page 3172: what's the difference between datasets "IntCal09" and "IntCal13"? temporal resolution? It seems that the latter one has a finer temporal resolution than the former one. Can we generate "IntCal09" from "IntCal13"? Is it necessary to keep both?*

  IntCal13 is simply an updated and revised version of IntCal09 that includes additional data, finer temporal resolution, and improved the calculation of uncertainties. They both are internationally-ratified curves by the geochronology community. The reason we included both curves in SoilR is that we can replicate previous analysis performed before the availability of the new curve. This information was introduced in the new version of the manuscript.

- *Page 3172: what are the "uncertainty values" for datasets "IntCal09" and "IntCal13"?*

  The calibration curves are created using a Bayesian procedure that takes the observed radiocarbon values at each point in time and adjust a state-space model producing a posterior distribution for each time point. These uncertainties reported are the standard deviation of the posterior distribution at each time point. This is described with detail in Niu et al (2013) and Reimer et al. (2013)

- *Fig.5: based on the values for k1, k2, and k3, i.e., negative values, I presume these are log-transformed values, which was not indicated in the fig caption.*

  The parameter values for k_1, k_2, and k_3 were not log-transformed. They were erroneously plotted as negative values, but we corrected this in the new version.

- *Fig. 6: what are the "prediction intervals"? standard deviations or 95% (90%?) confidence intervals?*

  They are 80 and 95% confidence intervals. This information was added to the figure caption.

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Technical corrections:

- *Page 3166: 13C $->$ 14C*

  This is indeed 13C fractionation. This is a correction typically given by radiocarbon labs to account for possible mass fraction effects on a sample. For details see ref. Mook and van der Plicht (1999).

- *Page 3179, Line 5, "in or calculations" $->$ "in our calculations"*

  Done.

- *Fig. 5, "p3$->$k4"$->$"p3$->$k3"*

  Done.

References

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Mook, W. and J. Van Der Plicht. (1999). Reporting ^{14}C activities and concentrations. *Radiocarbon*, 41(3):227–239.

Nir, A. and Lewis, S. (1975). On tracer theory in geophysical systems in the steady and non-steady state. Part I. *Tellus*, 27(4):372–383.

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Interactive comment on Geosci. Model Dev. Discuss., 7, 3161, 2014.