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Biogeosciences Discussions

Interactive comment on "Amplification and dampening of soil respiration by changes in temperature variability" *by* C. A. Sierra et al.

C. A. Sierra et al.

csierra@bgc-jena.mpg.de

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Response to general comments

We appreciate the comments by this anonymous reviewer who points out some issues in our manuscript. In particular, we appreciate the effort of reviewing the derivatives in Table 1. We reviewed the calculation of derivatives and made changes in the table accordingly (see section on technical comments). In this regard, the reviewer points out that the assumptions in the manuscript lack their basis due to these errors. This is not necessarily true because, after the correction, all derivatives in Table 1 are still positive for the range of temperatures where biological activity takes place. In the Arrhenius equation, the relationship between temperature and respiration is convex

(positive second derivative) if $E > 2\Re T$. At 35°C, the Arrhenius equations is always convex for values of $E > 5.1$ kJ mol^{-1}; and at 0°C, the relationship is convex for all $E > 4.5$ kJ mol^{-1}. These are extremely low values for the activation energy E, which in general is an order of magnitude higher. In a recent study, Craine et al. (2010, Nature Geosci. 3:854-857) report values of activation energy between 51.3 to 139.1 kJ mol^{-1} in a wide range of environmental conditions. Therefore, we believe the basis of this study are still valid because most previous equations used to model respiration are convex functions of temperature.

The reviewer also questions that the residuals of the data after applying the 9-day low-pass filter are white noise. In the Fig.1 below we present histograms of these residuals for the three datasets. These histograms show that the assumption of white noise is reasonable for the three sites. Although this is not a data analysis paper per se, this issue has little influence on the conclusions and the message we attempt to convey.

Another issue raised by the reviewer is the emphasis on convexity in the manuscript. The analytical analysis shows that it is both the convexity of the function and the magnitude of change in variance what would determine the expected changes in respiration. We could simplify and make the analysis more general if the assumption of convexity is replaced by non-linearity. However, by making this change we could only predict that changes in temperature variance lead to changes in average respiration rates. More detailed predictions are obtained if the convexity of the function is included because it allows us to predict the direction of change. If the relationship is convex, an increase in temperature variance causes an increase in average respiration. The interaction of these two factors in emphazised in the Abstract when we mention: *These effects depend on the degree of convexity of the relationship between temperature and respiration and the magnitude of the change in temperature variance*.

Response to technical comments

1. The temperature datasets were not gap-filled. The percentage of missing observation is given simply as additional information about the quality of data. These missing observations are scattered within the datasets and the low-pass filter is able to capture the seasonal behavior without limitations by missing data. For clarity, we removed these statements about missing observations as suggested by the reviewer.

2. These data were aggregated to the daily scale so it is possible to make the comparison with the other datasets. This information was included in the text.

3. Although it seems arbitrary, the 9-day moving average serves two purposes. First, it captures the seasonal behavior of the temperature series at a good degree of resolution. Second, the residuals obtained with this window in the moving average are basically white noise (see Fig. 1 below).

4. These values of s were chosen arbitrarily, with the only requirement that the variance σ_ϵ^2 in the three datasets were inside the range of the values in s^2. For clarification, this sentence was included in the text.

5. Thanks for pointing out this mistake. The change to $T_0 = 10$ was made in the manuscript.

6. Good point. In section 3.3 it is implicitly assumed $I = (-\infty, +\infty)$. This assumption holds for the Van't Hoff, modified Van't Hoff, second order exponential, and the power function models in Table 1. It does not hold for the Arrhenius, Lloyd & Taylor, and Daycent/Century models because of the inflection point. We made a couple of changes in the manuscript to clarify this point. First, we explicitly define the interval in section 3.3. as $I = (-\infty, +\infty)$. Second, a paragraph at the end of section 3.3. was added to point out that a change in convexity within

the interval can lead to different results. This point is addressed in the numerical analysis, therefore the inserted paragraph serves as a transition between the two analyses. This paragraph reads: *Notice that the analysis above only holds for functions that are convex (or concave) in I. When the convexity of the function changes in the interval, different results can be obtained. The numerical example below helps to illustrate the effect of changes in convexity within I.*

7. The correct expression for the second derivative of the Arrhenius equation is $R'' = ae^{(-E_a/\Re T)}\left[\left(\frac{E_a}{\Re T^2}\right)^2 - \frac{2E_a}{\Re T^3}\right]$, and the range of convexity on T is $0 < T < E_a/(2\Re)$ as correctly pointed out by the reviewer.

8. The correct expression for the second derivative of the Lloyd & Taylor equation is $R'' = R_{10}e^{(\frac{E_a}{283.15\Re})(1-\frac{283.15}{T})}\left[\left(\frac{E_a}{\Re T^2}\right)^2 - \frac{2E_a}{\Re T^3}\right]$, and the range of convexity on T is $0 < T < E_a/(2\Re)$ as correctly pointed out by the reviewer.

9. There is no condition on b because it is inside the quadratic term of the second derivative. There is a condition on c that was omitted in the first version. The changed was made in the manuscript.

Interactive comment on Biogeosciences Discuss., 7, 8979, 2010.

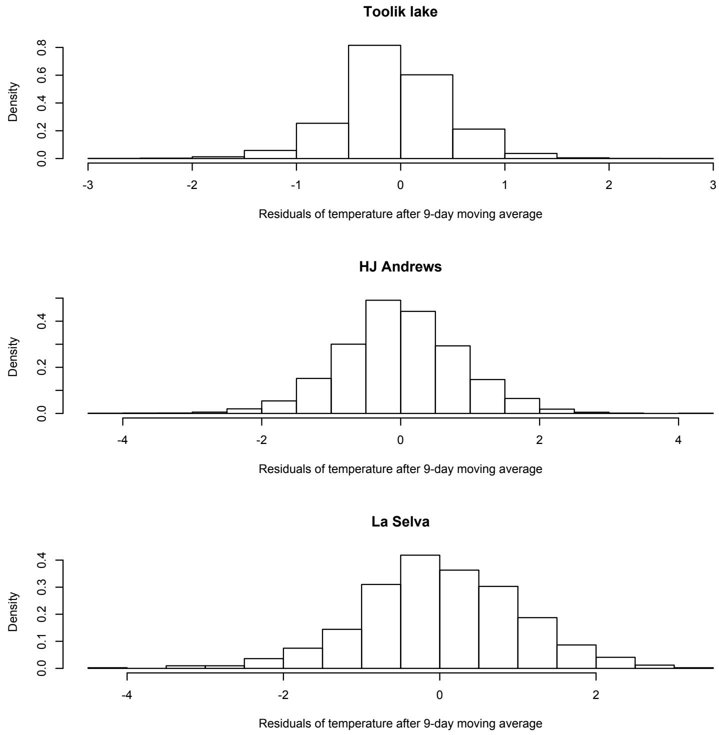

Fig. 1. Residuals of soil temperature data for the three sites after a 9-day moving average