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Biogeosciences Discussions

Interactive comment on "Soil respiration at mean annual temperature predicts annual total across vegetation types and biomes" *by* M. Bahn et al.

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Ref #2: 'The analysis done in the current manuscript (regression across sites) is incorrect for the question asked. A cross-site regression assesses if a relationship holds between the two variables across sites, not how good the relationship is at any individual site. Lots of cross site predictions work across sites, but not for an individual site (for example, Gower et al., 1996; Litton et al., 2007). Some reasons for this lack of utility for an individual site include (1) the gradient across sites obscures important within-site variability and (2) the cross-site relationship has a different response than that of the population of organisms at an individual site. In this case, the proposed method is being promoted exactly for such a site–specific use.'

Reply: Ref #2 is making an important point, to which we fully agree. The approach

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suggested in our ms is not primarily targeted towards obtaining precise estimates for single sites, but for making progress with accounting for the considerable variability of soil respiration (SR) across landscapes and regions. In contrast to earlier attempts to obtain such estimates from either coarse proxies such as air temperature and precipitation or highly elaborate productivity indices, we here suggest an approach inferring annual SR from directly measured SR at mean annual temperature, which is based on a clearly defined theoretical framework. Estimates of annual SR based on our suggested approach will obviously be much less accurate than when based on a complete annual SR dataset, but nevertheless may be of value when the spatial variability of SR at larger scales needs to be assessed. We also agree that the limitations of the approach for assessing within-site variability need to tested and outlined more carefully, as discussed further below in our response to a later comment. The issues raised by Ref#2 have been more strongly emphasized in the revised manuscript, and references to earlier such discussions by Gower et al. (1996) and Litton et al. (2007) have been included.

Ref #2: I'm not a statistician, but I believe that the correct analysis would be a paired t-test between predicted and observed, perhaps stratified by two or three flux levels. This analysis would generate a mean difference between modeled and observed together with an uncertainty for that mean difference. I would also want to know the range in absolute and relative error for estimating an annual flux this way before I decided to use it. The more accurate the method could be shown for an individual site, the more likely it will be used.

Reply: We carried out a number of further analyses to back up our results and conclusions, and to provide an uncertainty estimate for predicted SRannual. To assess the robustness of our analysis related to Fig. 4 we first re-calculated the regression for SRMAT versus SRannual for the 35 non-water limited sites leaving out one site at a time (cross-validation approach). The probability density function (pdf) for the 35 sites is as shown below and is not significantly different from a normal distribution (using

BGD

6, C4803–C4809, 2010

a One-Sample Kolmogorov-Smirnov Test). The line in the chart represents a normal distribution.

Then we calculated the related bias for these new estimations. The mean of all the sites is 1.01 $\pm$ 0.159 (s.d.; minimum = 0.69; maximum = 1.4). The site that is underestimated is ITex-(1998); and the site that is overestimated is Cow Park (UK). The results are practically the same as the ones that we showed in the original version giving that the mean of the prediction is 1.01 at each particular site when that site is excluded. Therefore this new approach is consistent with our previous results and does not change our conclusions. The 95% confidence interval of the predictions made with the reported regressions ranges from 1.01 – 1.96*SD to 1.01 + 1.96*SD; i.e. between 70% and 132% of the correct annual total. We included this in the revised manuscript.

Next we tested the model output against the observed values using a paired t-test. First, we only used the 35 non-droughted sites with the predicted values from the regression without each one of the sites. There were no significant differences between observed values and predicted (t=-0.032, P = 0.974), even when these values were calculated with a regression excluding each one of the respective sites. Then we calculated the changes in the P/PET correction factor excluding case by case and recalculating the equation. Finally, the predicted annual total SR was recalculated accounting for both changes in the P/PET correction factor and the overall relationship of SRMAT and SRannual occurring when each of the sites is left out at a time. Again, a paired t-test did not yield any significant differences between measured and predicted values.

Finally, we estimated the prediction uncertainty for the overall dataset by calculating the root mean squared error (RMSE). For the whole dataset RSME was 625 g C m-2 y-1 for non-droughted sites, 404 g C m-2 y-1 for sites for which an P/PET correction factor was applied, and 618 g C m-2 y-1 for all sites. Stratified by four flux levels RSME was 203 g C m-2 y-1 (SRannual = 0-500 g C m-2 y-1), 191 g C m-2 y-1 (SRannual = 500-1000 g C m-2 y-1), 300 g C m-2 y-1 (SRannual = 1000-1500 g C m-2 y-1) and 262 g C m-2 y-1 (SRannual =1500-2000 g C m-2 y-1), corresponding to a relative error of 51, 27, 24 and 14%, respectively. In comparison, within-site uncertainty estimates of annual SR have been reported to be in the range of 9-25 %, in some instances even up to 40-90% of SRannual (Bahn et al. 2008).

Ref #2: 'I could not understand how the model for the Monte Carlo simulation worked, but seeing such a biased pattern (all of the variability on the high side of the relationship) suggests something not quite correct is happening.'

Reply: As correctly observed by Ref #2, a combination of high temperature variability (Tsd) and high Q10 values leads to exceptionally high ratios of SRannual/SRMAT in ca. 10 out of 1000 model runs. However, this does not reflect a bias but is fully consistent with what is theoretically to be expected, because of the non-linearity of the respiration response to temperature (cf. p. 11506 l. 21 – 11507 l. 3 and Fig. 1 in the BGD paper).

Ref #2: There are several sites in the data set where a site-specific multi-year analysis could be conducted, and such an analysis would strengthen the paper.

Reply: The available multi-year data for four sites have been included in Fig. 4 and will also be incorporated in Table 1 of the revised manuscript. As Fig. 4 shows, any of the years included would have yielded estimates of SRannual that are close to the observed values. (within substantially less than the overall uncertainty – cf. above). We took up the idea to carry out a separate multi-year analysis of these sites and found that for the two sites with more than three years worth of data the relationship between SRMAT and SRannual differs significantly from the overall relationship including all sites (while it was similar for the two sites with only three site-years each). From this we conclude that while the approach suggested by this study is well suitable for estimating SRannual across sites, it is associated with higher uncertainties when being applied for estimating interannual variability. This notion has been included in the revised manuscript.

Ref #2: I'm also wondering how the paper would suggest dealing with diurnal variability.

Reply: Diurnal variability is an issue that has normally not been accounted for in most studies estimating total annual SR, however, emerging datasets based on automated systems indicate that its consideration will likely improve not only the accuracy of the annual estimates of SR, but also the importance of underlying processes and their contribution over time (e.g. Savage et al. 2008, 2009, Vargas et al. 2010). Most SR datasets synthesized in this study are based on daytime measurements of SR, thus, consistently, we would suggest that daytime measurements of SR at soil temperatures approximating MAT suffice for estimating related SRannual. Once more continuous datasets become available it should be possible to elaborate systematically on possible related errors. In any case, it should be stressed again that the approach presented in this ms is targeted towards minimizing errors related to the spatial rather than the temporal variability of SR.

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BGD

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BGD

6, C4803–C4809, 2010

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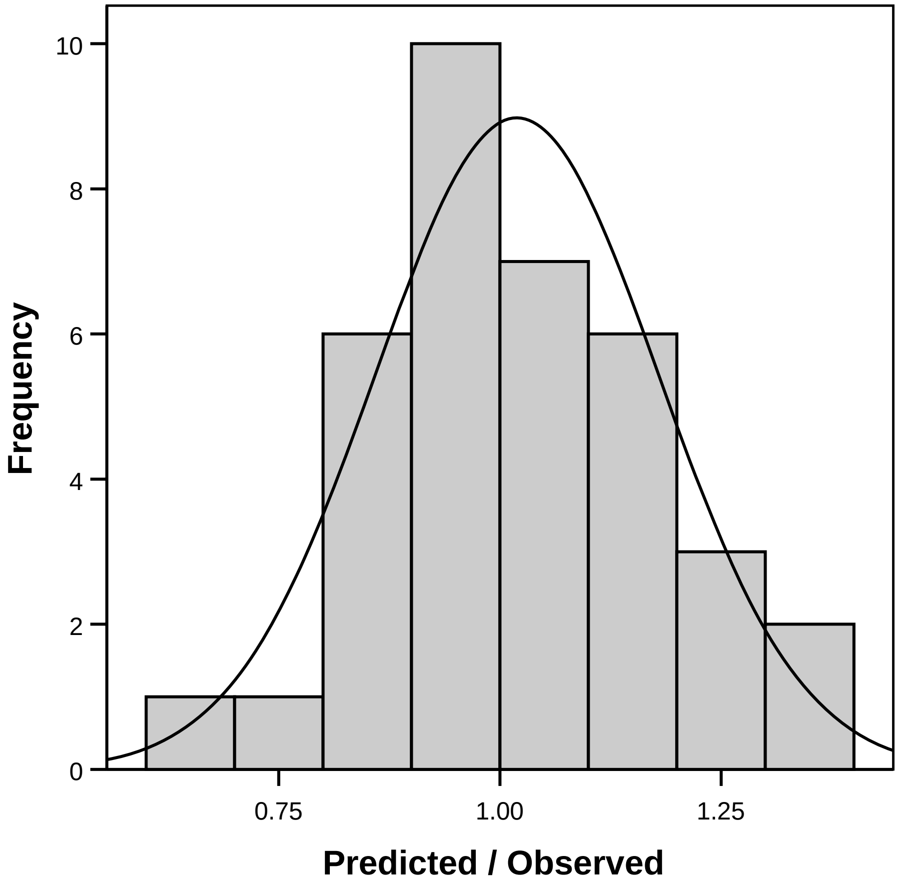

Fig. 1. Histogram and probability density function (pdf) of predicted/observed annual soil respiration for the 35 non-water limited sites, as obtained from a cross-validation approach (see text).