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Biogeosciences Discussions

Interactive comment on "Measurements of soil respiration and simple models dependent on moisture and temperature for an Amazonian southwest tropical forest" *by* F. B. Zanchi et al.

F. B. Zanchi et al.

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General comments Before replying point-by-point to the reviewers, we appreciate the referees for their comments, corrections and suggestions to improve this paper. And we want to say that, the manuscript will be revised and put in a better structure and we also going to clarify the doubtful points reported by the referees. See the new files attached on this resubmission.

Specific comments of anonymous Referee #1 The manuscript describes soil respiration measurements from tropical forests over nearly a whole year. Data on soil respiration from tropical regions are still relatively scarce (compared to temperate and boreal re-

gions), and publication of these results would be a valuable addition to the literature. However, as a strictly observational study, this work does not carry a strong message, as there is no hypothesis under test. The conclusions drawn are relatively weak, with general trends and the confirmation that soil temperature and moisture alone are insufficient to model soil respiration in tropical settings. There appear to be problems with the data (see comments on Fig. 4 below), which need to be clarified. I may of course be wrong, but there seem to be dramatic shifts in measured soil respiration values which appear unrelated to environmental conditions. If this is caused by a technical problem, the overall magnitude of fluxes reported are doubtful. In my view, there are a number of flaws in the present manuscript, and I think some revision is necessary before it is publishable.

The spatial representation of the study is relatively poor. Soil respiration is measured from 5 points at one site only, and this is taken as a representative setting for forests and soils in this wider region. This is a fairly bold assumption and requires data or literature citations to sustain it. Answer: Indeed, it was small area and not huge amount of replications, because as we know, work in Amazon region is much more difficult then European and Americans Experimental sites, In Brazil all is much more difficult, the weather (moisture and high temperatures), difficult fieldwork access and low research budget. But, previous works (Meir et al, 1996, Sotta et al. 2004, Chambers et al. 2004, Salimon et al 2004) tried to fit models using few hours of measurements of the day, and not using an automatic system which gives 24 hrs of measurements. It sustained in the supposition that they only could see a week seasonal pattern and not a full results details, which could represent a models for Amazon region that has more than a single independent variable to fit as we know from temperate and boreal regions (large temperature ranges). We will change the assumption; Indeed Amazon region is bigger than Europe and has many different soils and biomass and no sense to propose it for whole Amazon region. We still need to do more measurements with others different variables to fit find better models for Amazonia. And not use the Q10 with poor estimations or constant night respiration that still used in the models of plant

functional types (PFTs), Soil-Vegetation-Atmosphere transfers (SVAT) or global atmospheric general circulation models (AGCMs), which is easy to over or underestimate the Carbon cycle in Amazon.

The modelling effort receives most attention in this manuscript, but I did not learn all that much from it. I think for the benefit of the reader, the authors should state more clearly in the introduction what the aim of the study is. The entire focus of the analysis is on soil respiration dependence on soil temperature and soil moisture, but the authors acknowledge themselves that other parameters would be required in order to model the soil respiration dynamics (i.e. autotrophic activity and litterfall are critical). Answer: This has been addressed above. We could not, it is necessary to learn more about other parameters and measure more variables to have a better model fit. The standard models using soil temperature and Moisture is barely accurate for tropical areas compared to a perfect models estimation addressed on these boreal and temperate regions. The tropical regions we noticed that is much more complex than a simple seasonal difference and good model described a century ago that doesn't fit well in the tropics. But, we will change and make clear the manuscript. Thanks for your review.

A major problem for the analysis is the close correlation between soil moisture and soil temperature, which made an independent parameterisation of a model using both moisture and temperature practically impossible. With a temperature depth that is inadequate to resolve diurnal soil temperatur fluctuations (see later comment), the modelling of soil respiration at short time scales (diurnal dynamics) is almost precluded from the start. The fact that longer averaging periods provide better fits is not a surprise, as here only broad seasonal variations in drivers and response variable are considered. The model parameterisation effort uses a very deep soil temperature for reference (15 cm). As a consequence, temperature fluctuations are very modest, and regressions mostly insignificant. The extremely high Q10 results are almost certainly a result of a highly dampened temperature amplitude, which is not relevant to the dynamics of

the soil respiration CO2 flux. Answer: We did change for the soil respiration at 10 cm depth, but for some reason you can check in the data, it did not change substantially and soil temperature at 10 or 15 cm would not change that much to sustaining the better or poor correlation founded on the literatures and in the this analysis, which reiterate that soil respiration do not have a single dependence with soil temperature.

The structure of the text could be improved. The results section is lengthy and covers a fair amount of interpretations that should be moved to the discussion. Answer: In the new review will have a careful attention in this part, thank you for this comment.

The literature used for referincing this work with is relatively dated - granted, there are a few studies from 2008 and 2009, but otherwise virtually nothing published after 2004. The field of soil respiration has developed rapidly over the past 5 years, particularly as far as autotrophic influences on total soil CO2 efflux and heterotrophic decomposition (e.g. priming) are concerned. Similarly, modelling of soil CO2 efflux has developed from 5 years ago, and there is by now a clear realisation in the modelling community that exponential temperature relationships are too simplistic to represent soil respiration. These developments are so far only poorly reflected in this manuscript and should be improved in a revised version. The language is generally good, but for any future revisions the text should be proof-read by a native English speaker to smooth out places where the expression is not quite clear. Answer: Thanks for your comments; we will review on the new manuscript this carefully. And include more recent publications to build a better discussion and conclusions.

Detailed comments 6151, 1: Please clarify, are the 20 mm the monthly rainfall? Answer: It is per month. We missed it, and will be corrected in the new Manuscript.

6152, 3: "units", rather than "unities". Answer: It will be corrected in the new Manuscript.

6152, 11: If the chambers were left open at 45o, would this not prevent rain from falling into at least part of the chamber? Answer: We tested this and it didn't make

any difference because the Chamber has long base, and when it lifted up on 45o didn't block or obstructed the rain, because the rainfall inside of the Rainforest fell in a vertical way, and the wind is not strong enough to change or incline the rain drops in this dense forests areas.

6152, 20: For the calculation of the molar density of CO2 in the soil surface efflux, it would be necessary to use the air temperature, not the soil temperature at 15 cm depth (i.e. the temperature of the air in the chamber). Even though the error is bound to be very small indeed, it should be stated correctly here! Answer: This was wrong in the text, indeed the Mar was calculated using the Air (chamber) temperature. It will be changed in the text.

6153, 16: It is not clear to me why you check for correlations between chambers. What do you do with this information? Answer: We will change it. Is not clear the phrase, the idea is to analyzer the similarities between all chambers, and not the correlation. It will be reviewed in the new manuscript.

6154, 18-27: Move this to the Discussion. Answer: We will move it thanks for your review.

6155, 6-8: This does not seem accurate. According to Fig. 2, there is a rain event in mid-August, but the response in respiration is far weaker compared to the dramatic increase you show in Fig. 4. Answer: We had in the begging of August some rain events which start to change the soil respiration emission. But we saw that this part was not that clear and we worked more in this figures explanation to get a better understand about the results.

6155, 15-21: Move to Discussion. Answer: We will move it thanks for your critical view.

6155, 25: Lloyd and Taylor 1996 is not the correct reference for the Reichstein model! Answer: Indeed is the Reichstein model. Because we are using the model described by Reichstein et al. (2003). This model has also soil temperature and moisture together

and the Lloyd and Taylor does have, they only have the Soil Temperature dependence. In this case we will keep Reichstein model as in the citation instead of the Lloyd and Taylor model.

6156, 12: The variable "REW" is not explained. Answer: This will be corrected to instead of Eo = aREW + bREW * RSWC will be changed to Eo = a + b* RSWC. Because is not necessary the "REW", which is related of the respiration activation energy from water content and It is already addressed from RSWC. It will be take out and clarified on the new review.

6157, 2-5: Or rather, this means that temperature models are not appropriate in these systems! Answer: We could infer this but is necessary to check better the Soil temperature together with some other independent variables, as: Photosynthesis rates, decomposition, soil properties or other ones.

6157, 18/19: "Simple inspection" is fairly arbitrary. The regression curve in Fig. 5b suggests that the maximum soil respiration is at 0.2 m3 m-3. This range also does not match the optimum range you state in the discussion (see comment below). Answer: Thanks for your comments, but the review did not check it properly, was between 0.2 and 0.3 m3 m-3 and not 0.2 m3 m-3. And we corrected to 0.15 and 0.25 m3 m-3.

6157, 25: The soil moisture increments do not match those in the legend of Fig. 6 - please clarify. Answer: Thanks for your correction, the axes will be the same as in the legend it was $0.09 < \theta < 0.25$, will be $0.115 < \theta < 0.25$. I change in the Matlab Script filtering but I forgot to change in the graphic plotting.

6157, 26-6158, 4: Move the comparison with literature results to the discussion. Answer: Thanks, we rephrased this part to be clearer.

6158, 4/5: I agree that the very limited temperature range will have caused the high Q10 estimates. In fact, your Q10 values are more of an artefact than a result, and it should be clearly stated that the Q10 values are not true respiration responses to

temperature. I don't think that anything can actually be deduce from these values in terms of the ecophysiological response of these soils. Answer: Thanks, it is explained in the 6158, line 8, that Q10 is not the real respiration.

6161, 3-5: This is an over-simplification. To my knowledge, there are no models in use at present that attempt to predict regional or global soil CO2 flux on such simplistic responses - the field has moved on a fair deal in the past 10 years, and your references are a little dated. Answer: Thanks, we included new literature on the new manuscript.

6161, 14: In the results, you state a different optimum range - please clarify this! Answer: Thanks, is corrected in the new manuscript.

Fig. 1: Why no error bars for the soil respiration results? Answer: If put the error bar will have a lot of information and will be not ease to distinguish the results.

Fig. 4: The soil respiration dynamics look peculiar. There seem to be two levels of respiration between which the system switches: 0 to 5 umol m-2 s-1, or 12-20 umol m-2 s-1. These do not correlate well with the soil moisture values, and rain events seem to cause either switches up or down-wards. Are these quality checked results, or is there a possibility that the results are caused by failure of individual chambers which affect the average, or possible technical issues? What does the vertical hatched line represent? The shift before and after that line, for example, is not (apparently) related to changes in temperature and moisture. The dates in the legends seem wrong, as the graph shows values between 31st August and 30th September. Also the circles in the graph are not explained. Answer: Thanks, the data past by a new filtering as the referee 1 and 2 suggest. And now seems to have a better estimation and looks more clean the whole data set.

Fig. 5: The temperature dependence is very weak, given the large scatter. Is the regression at all significant? If it is not, you should leave out the regression line. Answer: Is significant of the Figures presentation. That is why we keep it there.

Fig. 6: The soil moisture categories on the axes, in the legend, and in the text don't match! Answer: Thanks, It is corrected in the new manuscript.

Anonymous Referee #2 Received and published: 30 August 2009 The manuscript by Zanchi et al. , Measurements of soil respiration and simple models. . . presents continuous respiration data from the Brazilian Amazon that covers a period of about 10 months. These measurements are still rather sparse for tropical regions, so it is probably useful to try to publish the data set. However, the manuscript still needs substantial work before it is ready for publication. The overall quality of the work would benefit from being placed into a hypothesis testing framework, and from more thorough data quality control. As it stands, the data are reported as observations, some models are fit (poorly) to the data, and the story ends. The manuscript lacks structure which would help guide the reader through the morass of results; if the writing were revised to include paragraphs, rather than pages-long sections with no breaks, it would be a great improvement. Before resubmission the authors need to make sure a native English speaker helps them edit the manuscript. Other shortcomings of the work will be more difficult to address, such as the placement of the soil thermocouples at 10-cm depth rather than a shallower depth, and the lack of ancillary biological measurements (e.g., root biomass and litterfall that coincided with periods of soil respiration measurements). The authors should start with a thorough effort at data cleaning. It is apparent from Fig. 4 that the data are still in very rough shape. Certainly spikes are expected following rain events, but the many large drops to zero must result from diffusion problems, plugged tubing, or some other technical issue. In three places offsets occur that appear to be scale or calibration issues. The vertical dashed line in the top plot is a mystery. Worst of all, the x-axis seems to be erroneous, and the precipitation events in the top plot do not match the changes in soil moisture in the bottom plot, making the reader wonder whether the respiration data actually match the temperature and moisture data in the modeling section. Even if the data cleaning results in the removal of half the data points, any efforts at modeling this dataset are wasted before the errors are fixed. More specific comments are not warranted at this time, although this re-

viewer would prefer to read about soil respiration models that are named consistently after the equation type, which would convey more information than randomly chosen names using improper citations. Answer: Thanks for your comments, will be useful and we worked on the manuscript to correct the failed parts and adjust for these recommendations. All question and remarks from the 2nd referee is addressed in another answers from Referees 1 and 3. Anonymous Referee #3 Received and published: 31 August 2009 In general, I find this manuscript interesting, which tries once again to identify mathematically the main drivers of soil respiration. Their main conclusions are that neither temperature or water content explain (no high correlation) soil respiration immediately. Nevertheless, they find that with monthly averages, these correlations increase, which is what other papers have presented before. My greatest constraint about the manuscript is not methodological, it is about the size of the fragment, which is only 32.5 ha. And there wasn't a single comment on the effect of fragmentation on biophysical properties or structure of the forest. I agree with authors that soil properties must play a major role also on soil respiration and this should be addressed in further research projects. Nevertheless, the topic is very important and the authors address all the issues in a proper manner, so this manuscript, with little revisions is appropriate for publication in this journal. Answer: Thanks for your comments. About the size of the fragment, according to (Laurance, 2008), a climatic change from the edges to inside of the fragment more than 150 meters, does not make such a huge difference concern to the meteorological measurements than it will not affect the measurements that was about 175 meters. And another comments is going to be useful for the new manuscript.

Now the specific comments: pg 6152, line 22 - one of the abreviations is Mar, where in the equation it is written Ma (without the r); Answer: We corrected in the new manuscript. pg 6154, ln21 - exchange the word "prejudiced" to "jeopardized" (actually I am also brazillian, so I don't know of a better word, but prejudiced does not sound right to me); Answer: We corrected in the new manuscript. pg 6154, ln24- change "dept" to "depth" Answer: We corrected in the new manuscript.

pg 6155, ln1- change "noticed" to "observed" Answer: We corrected in the new manuscript. pg 6156, ln3 - change "others" to "other" Answer: We corrected in the new manuscript.

pg 6157 ln6 - change "derivate" to "derived" Answer: We corrected in the new manuscript.

pg 6158 ln28 - change "to be possible to understand better" to "in order to better understand" Answer: We corrected in the new manuscript.

pg 6160 ln13 - the authors use the term "dry spell", which I haven't read in academic or scientific papers... maybe they could change that Answer: We corrected in the new manuscript.

pg6160 lns14-17. This whole sequence is confusing. Authors should re-write the whole sentences so we can understand clearly what they are trying to say. Answer: We corrected in the new manuscript.

pg 6160 ln27 - change "make" to "makes" and "smooth" to "smoothly" Answer: We corrected in the new manuscript.

pg6161, ln2 - change "temperature" to "temperate"; Answer: We corrected in the new manuscript.

pg6161, ln9 - change "satisfactorlly" to "satisfactory" Answer: We corrected in the new manuscript.

pg6161, ln25 - change "prejudiced" to "jeopardized" Answer: We corrected in the new manuscript.

pg6162, lns 4-5 - I agree that species composition interfeers in ecosystem properties, such as soil respiration, but I find it hard to relate an emergent property of the ecosystem with individual tree species or decomposer species. I think this comment could be made somewhere else, but not on the last line of the whole manuscript. Answer: We

corrected in the new manuscript.

pg6170 graph1 - where is "rain dry period" in the graph, authors forgot to include it. Other thing Rs is equal to Rsoil? Answer: We changed all Rsoil to Rs which is equal. And we include a new figure cleaning the rain events

pg 6172 graph 3 - in the inner graph, authors present a scatter plot with 6 sets of data, while in the larger graph there are 13 sets of data for both litterfall and soil respiration. Why didn't they use all 13 sets of data for the regression present in the inner graph? Answer: We used only the amount of Data set belongs to Soils respiration and Litter fall data available. Which means 7 months, where we had for both measurements?

pg 6174, graph 5 - third line of legend "two models dependence..." this is confusing. Shouldn't it be "model dependent on..." I think the phrase must be re-written. Answer: We corrected in the new manuscript.

T. Baisden t.baisden@gns.cri.nz Received and published: 24 August 2009 I have noticed relatively few non-referee contributors to BGD, and would like to take this opportunity to make a very brief and I hope helpful contribution to this work as a short comment. Assuming no instrumental biases (concern expressed by referee 1) exist, it would be valuable to consider whether the concerns of Kirschbaum (2004) may apply to this work, particularly the efforts to assess the appropriateness of models taking the moisture content of soil into account. Briefly, the concern Kirschbaum (2004) expresses is that heterotrophic respiration may reflect temporal changes in the size of a labile soil organic matter pool, that in turn reflect seasonal variation in supply superimposed onto the decomposition dynamics. The result is potentially biased parameters for temperature sensitivity (and possibly moisture sensitivity also). Where heterotrophic and autotrophic respiration are considered in total soil respiration, seasonal dynamics in the autotrophic supply of photosynthate to soil respiration (Hogberg et al., 2001) may also correlate with soil temperature and moisture, and cause further biases if not considered. In a worse case, these differences could lead to the conclusions that C

dynamics respond in fundamentally different ways in different ecosystems, even when the same underlying relationships hold. Answer: Thanks. It clarifies some of our goals in this manuscript. Indeed we will adjust more the manuscript to elucidate better the ideas.

An alternative approach that may be more robust (by avoiding correlation of substrate supply with temperature and moisture) is to assess soil respiration responses to moisture and temperature using controlled experiments (presumably in the laboratory), and then to impose the laboratory relationships onto the field data. I have been involved in a recent study (Brown et al., 2009), which undertook such an approach, and believe that consideration of the modified Lloyd and Taylor relationship and parameters obtained may be of some use here, despite the differences in ecosystems studied. Answer: Thank you for this comment, but indeed the ecosystem are different and the temperature fluctuation from your pasture is higher than inside forest, certainly Lloyd and Taylor relationship would be better in a pasture because of this larger temperature difference the soil behaves more about temperature fluctuation and another variables are not that much important. And laboratory treatment would be a good test, which would gave us the temperature sensitivity for this soils and then would be checked if some another variable could be taking account to soil respiration, but we could not do this type of experiment here, low budget for science.

Brown M, Whitehead D, Hunt JE, Clough TJ, Arnold GC, Baisden WT, Sherlock RR. 2009. Regulation of soil surface respiration in a grazed pasture in New Zealand. Agricultural and Forest Meteorology 149(2):205-213. Hogberg P, Nordgren A, Buchmann N, Taylor AFS, Ekblad A, Hogberg MN, Nyberg G, Ottosson-Lofvenius M, Read DJ. 2001. Large-scale forest girdling shows that current photosynthesis drives soil respiration. Nature 411(6839):789-792. Kirschbaum MUF. 2004. Soil respiration under prolonged soil warming: are rate reductions caused by acclimation or substrate loss? Global Change Biology 10(11):1870- 1877.

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P. Meir, J. Grace, A. Miranda, and J. Lloyd. Soil respiration in a rainforest in Amazonia and in cerrado in Central Brazil. In J. H. C. Gash, C. A. Nobre, J. M. Roberts, and R. L. Victoria, editors, Amazonian Deforestation and Climate, pages 319–329. John Wiley and Sons, Chichester, UK, 1996.

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C. I. Salimon, E. A. Davidson, R. L. Victoria, and A. W. F. Melo. CO2 flux from soil in pastures and forests in southwestern Amazonia. Global Change Biology, 10(5):833–843, April 2004. doi: 10.1111/j.1529-8817.2003.00776.x.

E. D. Sotta, P. Meir, Y. Malhi, A. D. Nobre, M. G. Hodnett, and J. Grace. Soil CO2 efflux in a tropical forest in the Central Amazon. Global Change Biology, 10(5):601–617, May 2004. doi: 10.1111/j. 1529-8817.2003.00761.x.

William F. Laurance, Theory meets reality: How habitat fragmentation research has transcended island biogeographic theory, Biological Conservation, Volume 141, Issue 7, July 2008, Pages 1731-1744, ISSN 0006-3207, DOI: 10.1016/j.biocon.2008.05.011.

Please also note the Supplement to this comment.

Interactive comment on Biogeosciences Discuss., 6, 6147, 2009.

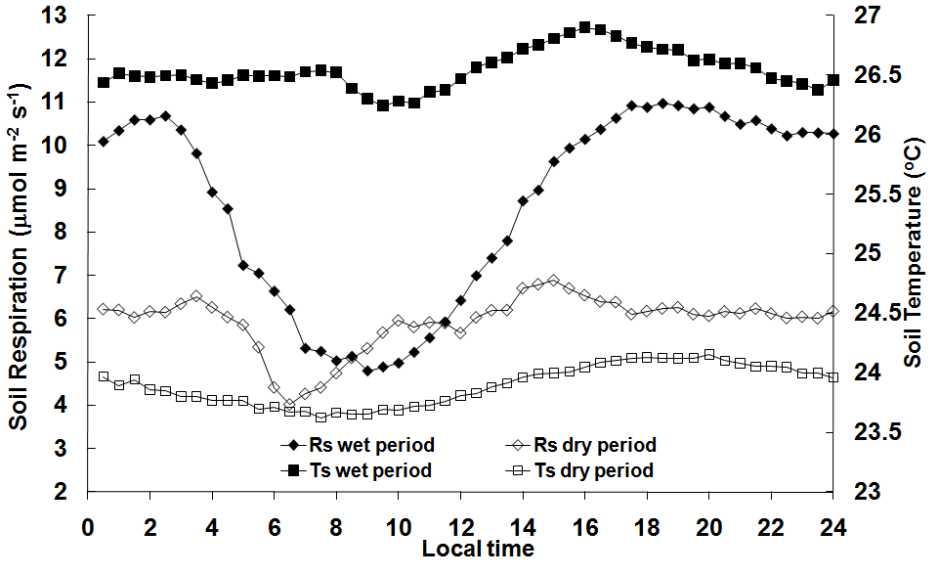
Soil Respiration (µmol m-2 s-1)
Soil Temperature (°C)
Local time
Rs wet period
Rs dry period
Ts wet period
Ts dry period

Fig. 1.

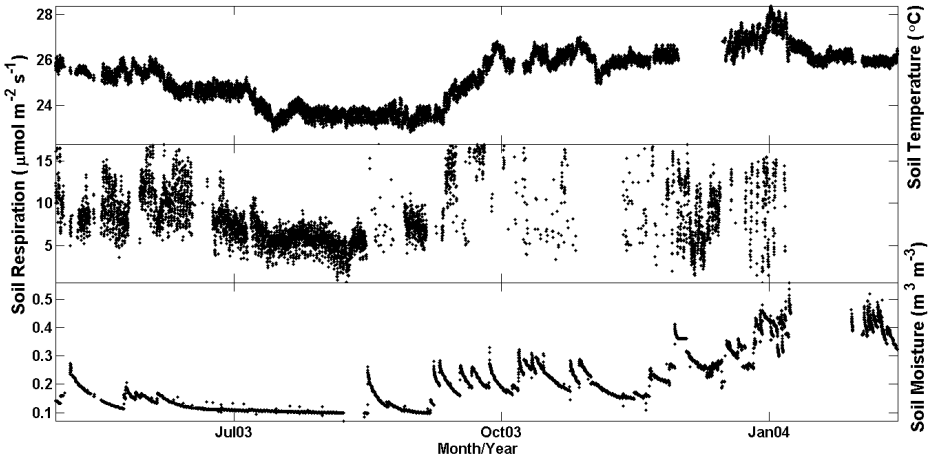
Soil Respiration (µmol m-2 s-1)
Soil Temperature (°C)
Soil Moisture (m3 m-3)
Jul03
Oct03
Jan04
Month/Year

Fig. 2.

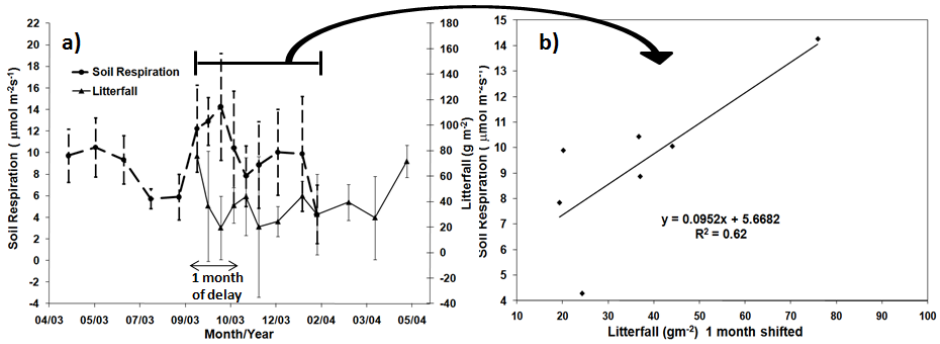
a)
Soil Respiration
Litterfall
1 month
of delay
Soil Respiration (µmol m-2s-1)
Litterfall (g m-2)
Month/Year
04/03
05/03
07/03
09/03
10/03
12/03
02/04
03/04
05/04
b)
y = 0.0952x + 5.6682
R² = 0.62
Soil Respiration (µmol m-2s-1)
Litterfall (gm-2) 1 month shifted

Fig. 3.

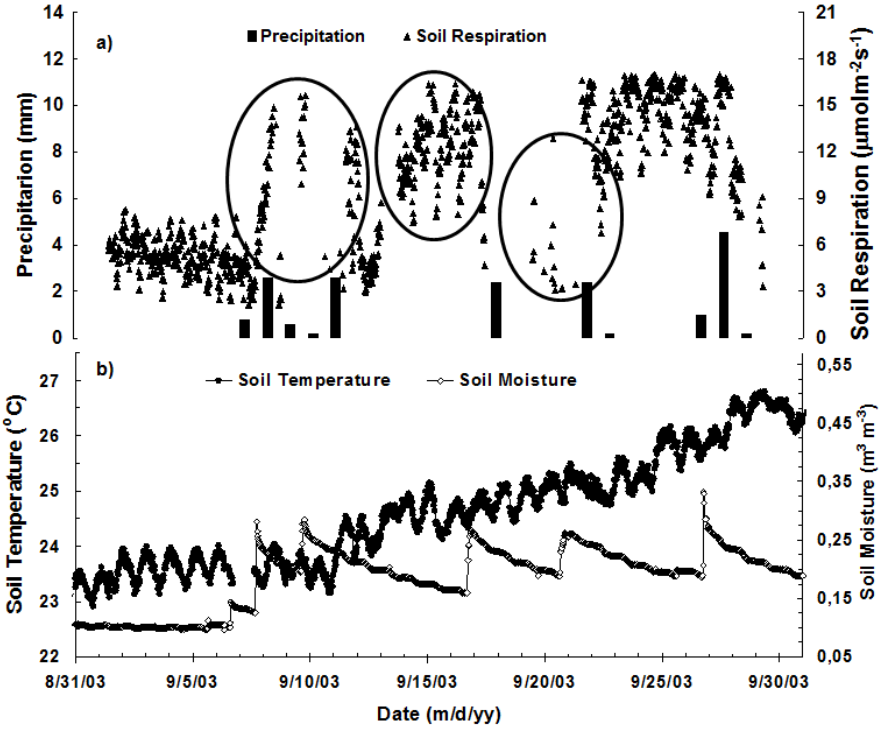
a)
Precipitation
Soil Respiration
Precipitarion (mm)
Soil Respiration (µmolm-2s-1)
b)
Soil Temperature
Soil Moisture
Soil Temperature (°C)
Soil Moisture (m3 m-3)
8/31/03
9/5/03
9/10/03
9/15/03
9/20/03
9/25/03
9/30/03
Date (m/d/yy)

Fig. 4.

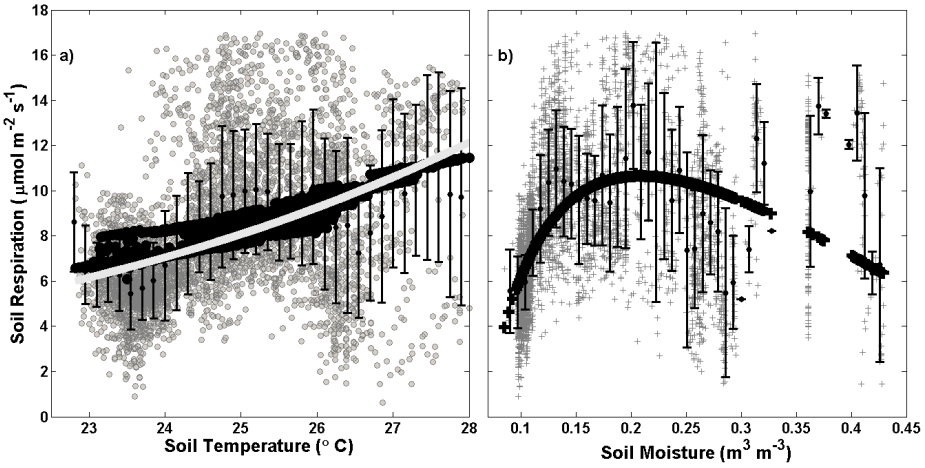
a)
b)
Soil Respiration (μmol m-2 s-1)
Soil Temperature (° C)
Soil Moisture (m3 m-3)

Fig. 5.

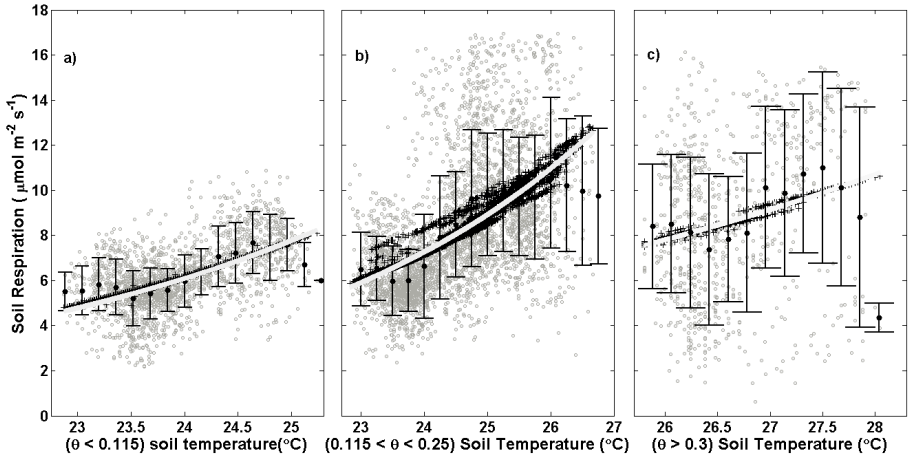
a)
b)
c)
Soil Respiration (μmol m-2 s-1)
(θ < 0.115) soil temperature(°C)
(0.115 < θ < 0.25) Soil Temperature (°C)
(θ > 0.3) Soil Temperature (°C)

Fig. 6.

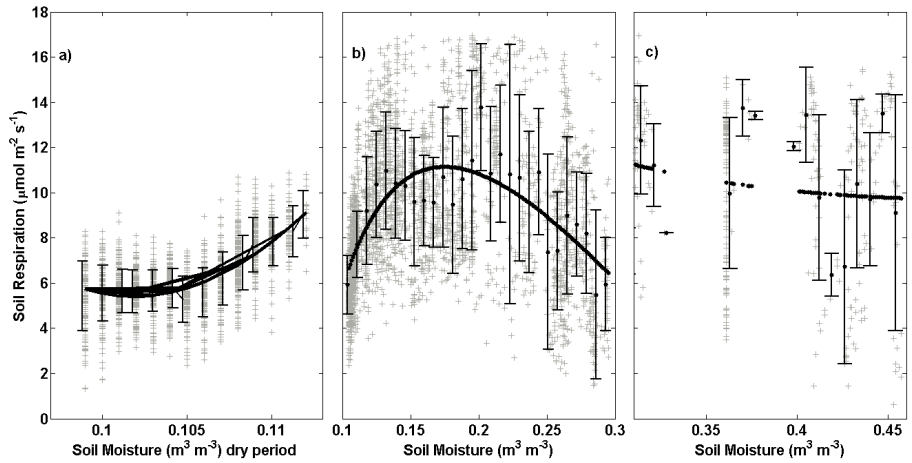
a)
b)
c)
Soil Respiration (μmol m-2 s-1)
Soil Moisture (m3 m-3) dry period
Soil Moisture (m3 m-3)
Soil Moisture (m3 m-3)

Fig. 7.

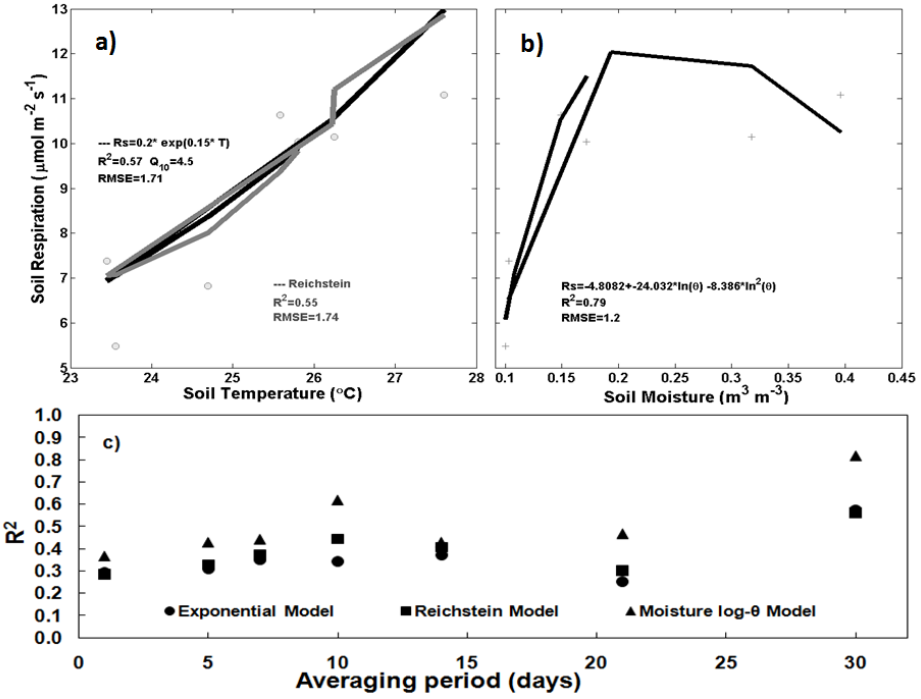
a)
--- Rs=0.2* exp(0.15* T)
R2=0.57 Q10=4.5
RMSE=1.71
--- Reichstein
R2=0.55
RMSE=1.74
Soil Respiration (μmol m-2 s-1)
Soil Temperature (°C)
b)
Rs=-4.8082+-24.032*ln(θ) -8.386*ln2(θ)
R2=0.79
RMSE=1.2
Soil Moisture (m3 m-3)
c)
R2
Exponential Model
Reichstein Model
Moisture log-θ Model
Averaging period (days)

Fig. 8.