Reply to comments from Referee #2

Dear Referee #2,

many thanks for your helpful comments on our manuscript. We were able to incorporate the majority of your suggestions during the review. Your questions and remarks really helped to improve the paper. Please, find below our detailed answer to your comments. We hope that you find your comments sufficiently considered and would once again thank you for your time and support in improving this paper.

Yours sincerely

A.Y. Bossa and B. Diekkrüger

General Comments and recommendation

The manuscript reports a long term study of soil CO2 efflux and associated environmental variables (soil temperature and humidity) in a Norway spruce-dominated forest ecosystem in Germany. The work seems to attempt to address issues inherent in spatial-temporal variability of soil CO2 efflux under different environmental conditions. Even though several studies have been published in this issue at different ecosystems, the information brought up by the authors is significant to improve our knowledge in spatial-temporal variability of soil CO2 efflux. In general the authors have done a lot of work and collected a significant quantity of data; however, I consider that the manuscript has some shortcomings necessary to deal with before any possible acceptation.

The introduction section presents a poor literature research concern to “the stare of art” in spatial-temporal variability issues and modeling, there are good quantity of studies done in this subject that have not been taken in account is this section.

Answer:
We considered more references as displayed below and the introduction has been improved as follows:

Page 2, lines 73 to 75: In a study in a temperate forest Sitka spruce stand, Saiz et al. (2007) have shown that soil temperature is the dominating factor but soil moisture is more variable and had an overall negative effect on soil respiration.

Pages 2 to 3, lines 101 to 116: While applying Hydrus1d for the simulation of soil respiration in an agricultural field, Buchner et al. (2008) have shown that Hydrus1d is well suited for modeling and that CO2 efflux strongly depends on soil hydrological properties which determine matter transformation as well as transport rates within the soil.
The spatio-temporal variability of soil respiration is analyzed in a number of studies ranging from global to local scales. Reichstein et al. (2003) analyzed 17 sites in Europe and North America with different site properties. Within the EUROFLUX project Morales et al. (2005) applied different models for a number of sites spread over Europe to determine model applicability to this data set. From this study, not too much can be learned concerning the effect of site conditions on soil respiration. Kang et al. (2003) studied the effect of local topographic and climatic conditions on soil respiration in Korea. They compared six slopes with different aspect, elevation, as well as rainfall and found again temperature is the most important driver. Pacific et al. (2009) investigated how large the effect of local scale topography is on soil respiration. They analyzed two different position along a transect from the riparian zone of a river to the drier hill slope for two short periods (less than 3 months) in a wet and a dry year. They found a strong influence of the hill slope position on soil respiration which is further modified by climate conditions. Because the measurement

periods were rather short and they did not attempt to model the data, the findings cannot be transferred directly to other sites.

Buchner, J. S., Šimůnek, J., Lee, J., Rolston, D. E., Hopmans, J. W., King, A. P. and Six, J.: Evaluation of CO2 fluxes from an agricultural field using a process-based numerical model, J. Hydrol., 361(1-2), 131–143, doi:10.1016/j.jhydrol.2008.07.035, 2008.

Kang, S., Doh, S. and Lee, D.: Topographic and climatic controls on soil respiration in six temperate mixed-hardwood forest slopes, Korea, Glob. Chang. Biol., 9, 1427–1437, doi:10.1046/j.1365-2486.2003.00668, 2003.

Morales, P., Sykes, M. T., Prentice, I. C., Smith, P., Smith, B., Bugmann, H., Zierl, B., Friedlingstein, P., Viovy, N., Sabate, S., Sanchez, A., Pla, E., Gracia, C. a., Sitch, S., Arneth, A. and Ogee, J.: Comparing and evaluating process-based ecosystem model predictions of carbon and water fluxes in major European forest biomes, Glob. Chang. Biol., 11(12), 2211–2233, doi:10.1111/j.1365-2486.2005.01036.x, 2005.

Pacific, V. J., McGlynn, B. L., Riveros-Iregui, D. a., Epstein, H. E. and Welsch, D. L.: Differential soil respiration responses to changing hydrologic regimes, Water Resour. Res., 45(7), W07201, doi:10.1029/2009WR007721, 2009.

Reichstein, M., Rey, A., Freibauer, A., Tenhunen, J., Valentini, R., Banza, J., Casals, P., Cheng, Y., Gru, J. M., Irvine, J., Joffre, R., Law, B. E., Loustau, D., Miglietta, F., Oechel, W., Ourcival, J., Pereira, J. S., Peressotti, A., Ponti, F., Qi, Y., Rambal, S., Rayment, M., Romanya, J. and Rossi, F.: Modeling temporal and large-scale spatial variability of soil respiration from soil water availability , temperature and vegetation productivity indices, Global Biogeochem. Cycles, 17(4), doi:10.1029/2003GB002035, 2003.

Saiz, G., Black, K., Reidy, B., Lopez, S. and Farrell, E. P.: Assessment of soil CO2 efflux and its components using a process-based model in a young temperate forest site, Geoderma, 139, 79–89, doi:10.1016/j.geoderma.2006.12.005, 2007.

In M&M section it is necessary to be more precise with methodology and approach, there still some gaps in the information concerning soil CO2 measurements. For example: how many plots/positions where measured at each site, how long and in which intervals the measurements where done, etc.

Answer:
As mentioned in page 697, lines 20 to 24), 80 single points along two different transects across the investigated catchment river and at a grid setup in the southern part of the catchment were weekly monitored from 2006 to 2012 (cf. Dwersteg (2012) for more details). In this present study, significant differences of various factors such as the topography, soil type and proximity to the river are accounted for by considering ten of the investigation sites. These information are now better formulated in the text.

The Results and Discussion section: The authors have collected a large amount of data to address the problem and applied a multivariate analysis in order to identify clusters and that addressed the aims, but the manuscript focuses on the statistical analyses performed, where the focus should properly be more on the biology and physics of the processes influencing the soil CO2 efflux spatial- temporal variability.

Answer:
Since we are analyzing the pattern of soil respiration we agree with you that in our work, statistics were considerably used. Nevertheless, we also made sure that all major and relevant biophysical processes are also captured in the non-linear model we suggested. Your last comment suggested deleting some statistical aspects and we did so.

Specific comments:

In M&M, the first part of the measurements section (2.2)-(P696, L20-26, P697 L1-9) bellows to introduction not to M&M.

Answer:
It is considered.

The authors stated that soil temperature at 5 cm depth was measured but it seems to me that was not taken into account during analysis and only soil temperature at 11 cm depth is presented in the results. It is well know that soil temperature at 10 cm depth is not good enough for determination of soil CO2 efflux sensitivity to temperature due to that majority of soil activity is in the upper part of the soil. Moreover, it presents very low daily dynamic in comparison to soil temperature at 5 cm depth, which fix much better the response of soil CO2 efflux to temperature (mainly in Norway spruce forest ecosystems). Have the authors done any analysis about the best fitted soil temperature depth to their soil CO2 efflux?

Answer:
Unfortunately, only measurements in the depth of 11 cm were available for the whole measurement period. Soil temperature measurements in 5 cm depth are limited to the period 2008-2010. In her PhD thesis, Dwersteg (2012) analyzed the differences in correlation between 5 and 11 cm using an Arrhenius relationships. She found that the coefficient of determination slightly reduces from 0.9 to 0.85 when data are used from 11 cm depth instead of 5 cm. Because of the variability in the thickness of the litter layer, Dwersteg decided to use 11 cm depth to be always in the mineral soil. This is similar to the approach of Saiz et al. (2007) who compared soil temperature measurements in 2 and 10 cm soil.

Table 1. Each investigated site should be presented alone with its variables rather than as a group.
Fig. 1. More information about individual site characteristics should be added (plant vegetation cover, Soil Temp., Soil moisture, Bulk density, etc).

Answer:
We now provided more information on the time-independent variables in a table below Fig. 1 (as follows).Concerning vegetation cover, we already mentioned that the study was carried out in a spruce-dominated environment with a cover rate of 90%.

Site	Soil type	Slope (%)	Elevation (m)	Bulk density [g cm^{-3}]	Root biomass [g m^{-2}]	Organic matter [g m^{-2}]	Litter thickness [m]
WA1	S-B: Gleyic Cambisol	8.84	600	0.82	131.25	10029.67	0.02
WA6	S-G: Stagnic Eutric Gleysol	5.59	598	0.91	73.20	12272.50	0.02
WA7	S-G: Stagnic Eutric Gleysol	5	598	0.90	73.20	12272.50	0.02
WA10	B-S: Cambisol	5.3	597	0.67	177.73	10029.67	0.04
WA11	B-S: Cambisol	7.29	598	0.70	177.73	10029.67	0.02
WA15	S-B: Gleyic Cambisol	12.87	601	0.70	131.25	10029.67	0.02
WB3	S-B: Gleyic Cambisol	12.75	604	0.82	131.25	12511.83	0.03
WB4	S-B: Gleyic Cambisol	14.25	605	0.76	131.25	12511.83	0.02
M1	S-B: Gleyic Cambisol	7.29	616	0.76	28.58	11019.17	0.04
M8	S-B: Gleyic Cambisol	7.29	617	0.84	52.40	7330.17	0.08

Figs. 3, 6 and 8. Can be deleted, they are not necessary.

Answer:
It’s done and the results and discussion section is accordingly revised.