Response to Anonymous Referee #2

We would first like to thank the anonymous referee for his or her helpful comments. In this response we will try to answer these comments and the indicated changes will be applied in the revised manuscript.

Comment 1: *Abstract: line 5, sentence word order a little scrambled, '(RUSLE) model is due to...' add comma after model, and move 'is' to after 'basis,'*

Answer: Abstract, line 5, sentence "(RUSLE) model is due to its simple structure and empirical basis a frequently used tool" is changed to "(RUSLE) model, due to its simple structure and empirical basis, is a frequently used tool" in the revised manuscript.

Comment 2: *Abstract: line 17, word order, reverse 'in' and 'good'*

Answer: Abstract, line 17, sentence "resulted in values that are in good comparison with high resolution" is changed to "resulted in values that compared well to high resolution" in the revised manuscript.

Comment 3: *Introduction: line 12, biogeochemical components have become increasingly important - add references.*

Answer: We add the following references in the revised manuscript after line 12: Thornton et al. (2007) and Goll et al. (2012)

Here are the full references:

Thornton, P. E., Lamarque, J.-F., Rosenbloom, N. a. and Mahowald, N. M.: Influence of carbon-nitrogen cycle coupling on land model response to CO 2 fertilization and climate variability, Global Biogeochem. Cycles, 21(4), n/a–n/a, doi:10.1029/2006GB002868, 2007.

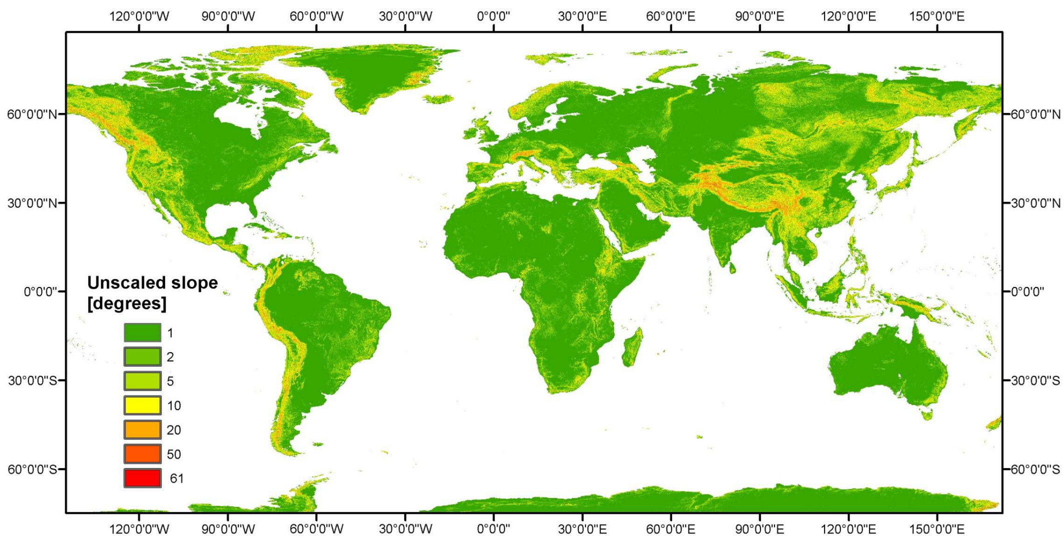
Goll, D. S., Brovkin, V., Parida, B. R., Reick, C. H., Kattge, J., Reich, P. B., van Bodegom, P. M. and Niinemets, Ü.: Nutrient limitation reduces land carbon uptake in simulations with a model of combined carbon, nitrogen and phosphorus cycling, Biogeosciences, 9(9), 3547–3569, doi:10.5194/bg-9-3547-2012, 2012.

Comment 4: *Pg 2998, line 14 - why is a 3x3 pixel window chosen? Is it purely because this is the smallest moving window? What is the influence of this choice? Can changing window size in different topographical regions help?*

Answer: As discussed in Zhang et al. (1999), a 3x3 pixel window is chosen mainly because of two reasons. First, it is the smallest moving window, secondly, it is assumed that the fractal coefficient α and fractal dimension D are stable in this 3x3 pixel window. The last assumption is essential here, because the fractal method of scaling slope is mainly based on this assumption. If one would increase the moving window size, the fractal parameters could be less stable, independent of the topographical region. We already see that although we assume that in a 3x3 pixel window the fractal coefficients are stable, they actually change a little bit. This effect would increase with increasing moving window. Also, this effect is more pronounced in topographically complex regions.

Comment 5: *Figure 2: I would find it useful if the original RUSLE estimation was shown as well as a difference. Figure 2: caption 'redisch'*

Answer: We add in the revised manuscript the unscaled global slope in Figure 2A and keep the difference plot in Figure 2B. "Redisch" is corrected by "Reddish" in the revised manuscript.



Comment 6: *Figure 3 and 6: Why is Switzerland presented differently to the other two regions? I would prefer a uniform representation, unless there is a rational for this, in which case it should be presented.*

Answer: We guess you mean not Switzerland but the Ebro basin in Spain that is presented differently. This is due to the fact that we cannot have access to the original erosivity data of the Ebro basin (presented in the study of Angulo-Martinez et al., 2009) and thus cannot make a difference plot such as the figures of the USA and Switzerland. We state this explicitly in the revised manuscript in the description of figure 6.

New description figure 6:

Figure 6. Spatial difference plots showing the difference between the high resolution rainfall erosivity and erosivity calculated with the new regression equations for (A) the USA, (B) Switzerland and (C) the Ebro basin in Spain; In (A) and (B) the blue colours show an underestimation of the calculated erosivity when compared to the high resolution erosivity, while the red colours show an overestimation; the Ebro basin serves here as an independent validation set and it has two graphs, (C1) a spatial plot of erosivity according to the new regression equations, and (C2) the high resolution erosivity from Angulo-Martinez et al. (2009); All values in the graphs are in MJ mm ha^{-1} h^{-1} y^{-1}; The Ebro basin is presented differently here when compared to the USA and Switzerland, due to the lack of the original erosivity data from Angulo-Martinez et al., 2009.

Comment 7: *Figure 4: more explanation of figure in the caption would be useful.*

Answer: We add an additional table (Table 3) with definitions for all climate zones as presented in Peel et al. (2007) in the revised manuscript. The rest of the tables in the manuscript are be renumbered.

Table 3. Description of Köppen climate symbols and defining criteria (from Peel et al., 2007).

1st	2nd	3rd	Description	Criteria*
A			Tropical	T_{cold}>=18
	f		- Rainforest	P_{dry}>=60
	m		- Monsoon	Not (Af) & P_{dry}>=100–MAP/25
	w		- Savannah	Not (Af) & P_{dry}<100–MAP/25
B			Arid	MAP<10×$P_{threshold}$
	W		- Desert	MAP<5×$P_{threshold}$
	S		- Steppe	MAP>=5×$P_{threshold}$
		h	▪ Hot	MAT>=18
		k	▪ Cold	MAT<18
C			Temperate	$T_{hot>}$10&0<T_{cold}<18
	s		- Dry Summer	P_{sdry}<40&P_{sdry}<P_{wwet}/3
	w		- Dry Winter	P_{wdry}<P_{swet}/10
	f		- Without dry season	Not (Cs) or (Cw)
		a	▪ Hot Summer	T_{hot}>=22
		b	▪ Warm Summer	Not (a) & T_{mon10}>=4
		c	▪ Cold Summer	Not (a or b) & 1<=T_{mon10}<4
D			Cold	T_{hot}>10&T_{cold}<=0
	s		- Dry Summer	P_{sdry}<40&P_{sdry}<P_{wwet}/3
	w		- Dry Winter	P_{wdry}<P_{swet}/10
	f		- Without dry season	Not (Ds) or (Dw)
		a	▪ Hot Summer	T_{hot}>=22
		a	▪ Warm Summer	Not (a) & T_{mon10}>=4
		c	▪ Cold Summer	Not (a, b or d)
		d	▪ Very Cold Winter	Not (a or b) & T_{cold}<=-38
E			Polar	T_{hot}<10
	T		- Tundra	T_{hot}>0
	F		- Frost	T_{hot}<-0

***** MAP = mean annual precipitation, MAT = mean annual temperature, T_{hot} = temperature of the hottest month, T_{cold} = temperature of the coldest month, T_{mon10} = number of months where the temperature is above 10, P_{dry} = precipitation of the driest month, P_{sdry} = precipitation of the driest month in summer, P_{wdry} = precipitation of the driest month in winter, P_{swet} = precipitation of the wettest month in summer, P_{wwet} = precipitation of the wettest month in winter, $P_{threshold}$ = varies according to the following rules (if 70% of MAP occurs in winter then $P_{threshold}$ = 2 x MAT, if 70% of MAP occurs in summer then $P_{threshold}$ = 2 x MAT + 28, otherwise $P_{threshold}$ = 2 x MAT + 14). Summer (winter) is defined as the warmer (cooler) six month period of ONDJFM and AMJJAS.

Comment 8: *Pg 3004, line 5, how is this evaluated? Using the r squared? In how many cases are the Renard Freimund R factors kept?*

Answer: Yes, we mainly used the r squared combined with the residual standard error to evaluate if the improvement of the R factor was significant. If the r squared value of the regression method was significantly different from the method of Renard and Freimund, then the regression method was preferred. In case there was not much difference in the r squared values between the methods, we looked at the differences in the residual standard error. In case of the E climates, the r squared was low for both methods, so we also compared the mean R values of these climates to the observed ones to see if there was improvement. The Renard and Freimund R factors are first of all kept for climate zones where we had no or too less high resolution data. From the climate zones where we had high resolution data, the Renard and Freimund R factors were kept for the BWh and Csa climates. These are just 2 climate zones out of 17. Although the Renard and Freimund method performed badly for the Csa climate, no improvement was found with the multiple regression approach. For the BWh the Renard and Freimund method performed slightly better than for the Csa climate, and the multiple regression approach did not change this result significantly.

We will highlight this in the revised manuscript, on Pg 3004 in the last paragraph of subsection 3.2.

Comment 9: *Climate zones - I struggled to find a definition of the climate zones to begin with, but I see there's a description of some of he zones in Table 5. Signposting the reader to the definitions earlier in the text would be helpful, and providing definitions for all the climate zone codes would also be useful.*

Answer: See answer to comment 7. We also refer to the new table with definitions for the climate zones on Pg 3002, line 27, in the revised manuscript.

Comment 10: *Pg 3004, line 22, should this be Table 5 rather than 3?*

Answer: We can see the point you are making here. Both Table 3 and 5 in the manuscript show that the f climate zones can be explained by the total yearly precipitation and the SDII. Table 3 shows which the significant parameters are for the f climate zones, while table 5 shows that for these climate zones the regression performs well when compared to high resolution erosivity for the USA. We refer to both tables in the revised manuscript.

Comment 11: *Figures 5 needs to be improved. The layout and sizing of the plots needs to be consistent. I would find it easier to evaluate the results if the plots were given equal axes such that the one-to-one line always lies on the 45 degree diagonal, and the axes were the same between 1 and 2. Units should be mentioned.*

Answer: The sizing of figures 5 is improved to be more consistent in the revised manuscript. It was for us difficult to give all the plots equal axes, due to the fact that the correlation becomes much less visible. Also one is not able to see anymore how the data is spread, and in which way the different methods overestimate or underestimate the observed R values. In these plots it is most important to see how the observed R values correlate with the modelled ones from the different methods for a specific climate zone. In some cases the modelled R values are much larger than the observed ones, which make it difficult to use equal axes and equal spacing between the axis ticks. Finally, one needs to keep in mind that the red line always lays on the 45 degree diagonal. In the description of figure 5 in the revised manuscript we add the units and explicitly mention that the red line always lies on the 45 degree diagonal. New caption figure 5:

Figure 5. Comparison of high resolution erosivity data and predicted erosivity from (1) the Renard and Freimund method and (2) the new regression equations, for various climate zones; the red line is the 1 tot 1 line that always lies on the 45 degrees diagonal, and does not appear in some graphs because predicted erosivity is strongly overestimated; All values in the graphs are in MJ mm ha^{-1} h^{-1} y^{-1}

Comment 12: *Figure 6 and text that refers to it, care should be taken to highlight that Switzerland is no longer a truly independent test given that this data has been used in the regressions. This doesn't invalidate the work, the improvements for Spain are impressive, but it should be discussed.*

Answer: We mention in the revised manuscript about the fact that Switzerland is not an independent case study anymore after the regression. We also mention that in the Ebro basin in Spain the E climate zones, for which the R factor was adjusted in Switzerland, also occur. And there the improvement is also clearly visible.

The addition text, Pg 3005, in line 11: "…of the observed *R*. It should be noted that Switzerland is not an independent case study anymore for the E climate zones. However, the Ebro basin case study confirms that the improvement for the E climate zones, which also occur here, is significant (Fig. 6C). For the…"

Comment 13: *Section 4.2: I think it's important to provide mapped results for the erosion models as this is the end point for the work. Means do not tell the whole story and mapped output would help illustrate the discussion.*

Answer: We did not present a global map of soil erosion rates, due to the fact that the other RUSLE factors (K, C and P) are not adjusted to the coarse resolution for global scale application as the S and R factors. We wanted to stress the improvements made by adjusting the S and R factors, rather than focusing on the final soil erosion rates. However, we agree that providing global maps of erosion rates can help making the statistics in table 7 point out the improvements made in this study in a clearer way. So, additional to table 7 (of the original manuscript), we include in the revised version of this article 4 maps of global soil erosion rates (see below). One map showing the erosion rates for the fully adjusted RUSLE model (Fig. 8A). The second map will show a difference plot between the fully adjusted and unadjusted RUSLE model (Fig. 8B). The third map will show a difference plot between the RUSLE model with only adjusted S factor and the unadjusted RUSLE model (Fig. 8C). And finally the last map will show a difference plot between the RUSLE model with only adjusted R factor and the unadjusted RUSLE model (Fig. 8D). These maps should highlight the different contributions of the adjusted S and R factors on erosion rates for the global scale. In section 4.2, we change the text between line 409 and 411 as following: "From the global map showing the difference between the erosion rates of the S adjusted RUSLE and the unadjusted RUSLE versions (Fig. 8C) one can see that erosion rates are in general increased and mostly pronounced in mountainous regions. This feature is 'dampened' by adjusting the R factor. Looking at the global map showing the difference between the R adjusted RUSLE and unadjusted RUSLE versions (Fig. 8D), one can see that the erosion rates are overall decreased in regions where the adjustments are made. When combining both adjustments of the RUSLE model in the fully adjusted RUSLE version and subtract the unadjusted RUSLE erosion rates (Fig. 8B), one can see that the erosion rates are slightly decreased in areas where the R factor is adjusted. However, in the tropics for example there is an increase in erosion rates by the fully adjusted RUSLE due to the lack of adjusting the R factor there. This indicates that these two factors balance each other, and that it is important to have a correct representation of all the RUSLE factors on a global scale in order to predict reliable erosion rates“

On page 3007, line 24, we add after ” 7tha^{-1}yr^{-1} “ (Fig. 8A)

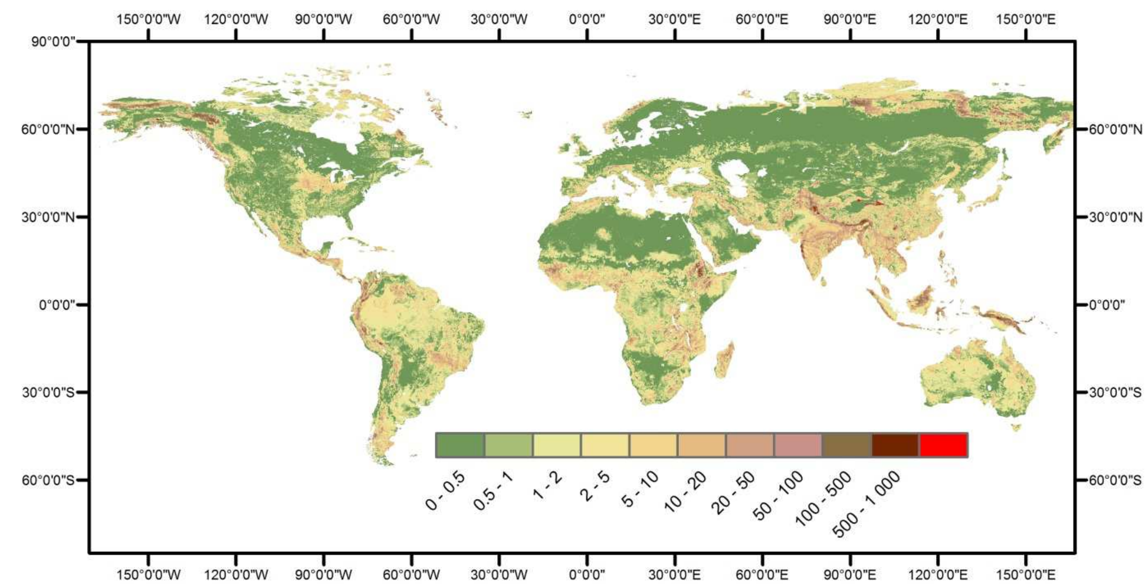


Figure 8A: Global average erosion rates for the current period from the “fully adjusted RUSLE model” in t ha^{-1} yr^{-1}.

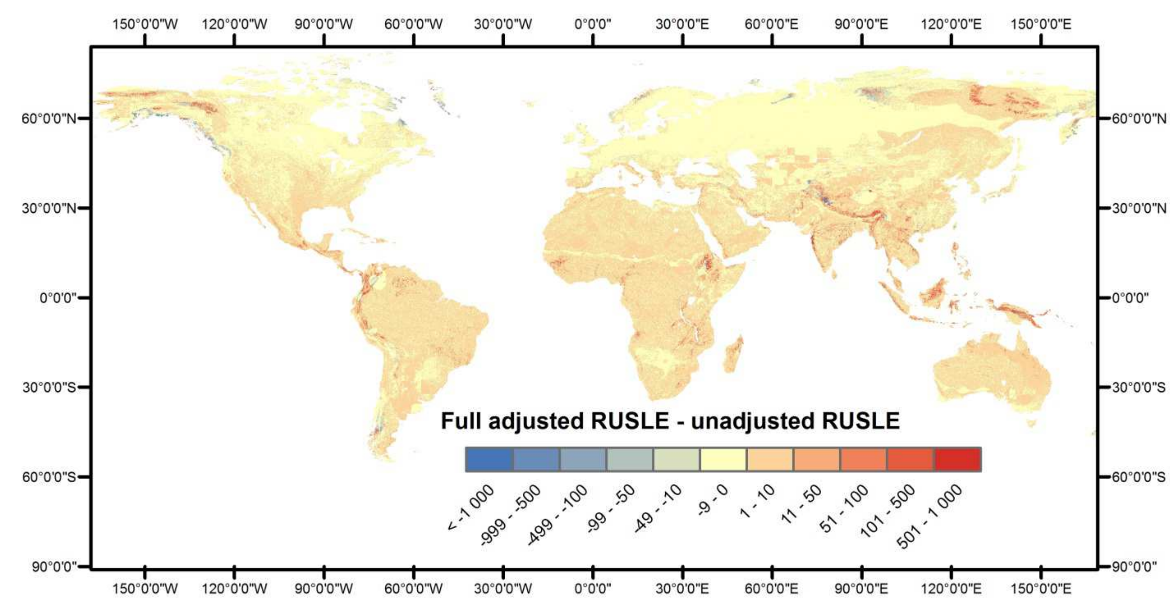


Figure 8B: Difference plot between global average erosion from the "fully adjusted RUSLE model" and the "unadjusted RUSLE model" in t ha^{-1} yr^{-1}. Reddish colors show an overestimation by the "fully adjusted RUSLE model" and yellow to bluish colors show an underestimation.

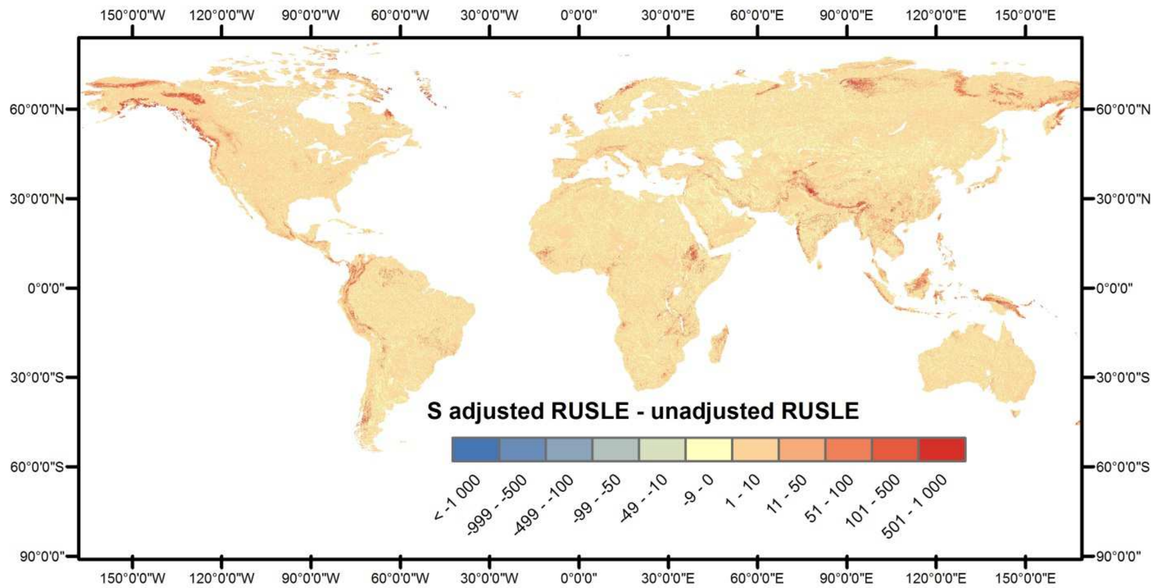


Figure 8C: Difference plot between global average erosion from the "S adjusted RUSLE model" and the "unadjusted RUSLE model" in t ha^{-1} yr^{-1}. Reddish colors show an overestimation by the "S adjusted RUSLE model" and yellow to bluish colors show an underestimation.

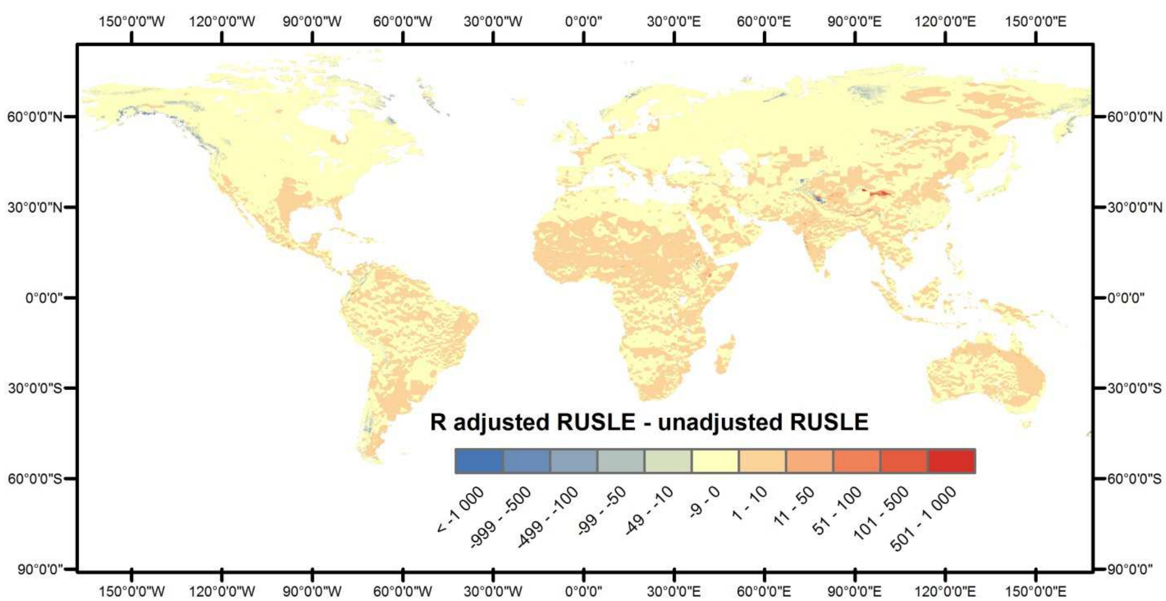


Figure 8D: Difference plot between global average erosion from the "R adjusted RUSLE model" and the "unadjusted RUSLE model" in t ha^{-1} yr^{-1}. Reddish colors show an overestimation by the "R adjusted RUSLE model" and yellow to bluish colors show an underestimation.

Comment 14: *Pg 3008, line 19, What's happened in the north west of the US with the adjusted model? Perhaps the authors can comment.*

Answer: In the revised manuscript we add the following on Pg 3008, line 18: "…local overestimations. For example, the north west of the US shows a slightly worse performance in the adjusted model most probably because in this region the estimation of the R factor could not be improved, while the S factor is increased. This gives an overall increase in soil erosion rates. In this region of the USA, the Csb climate prevails, for which the R factor is still difficult to estimate in a correct way (see table 3, r squared for Csb climate). So for this climate there are some outliers in the R factor in this specific region."

Comment 15: *Perhaps the authors can comment on using the RUSLE which gives a erosion rate for an average annual climate and then comparing that*

Answer: We are sorry, but unfortunately we do not understand, what the referee means here.

Comment 16: *Pg 3009 Can you say something more definitive here? You can see where the model is overestimating, and you know the K and C factors for these areas - are there trends here, i.e. is it systematically overestimating in regions dominated by arable land covers?*

Answer: We shortly took a look at how the adjusted RUSLE model performs for different land cover types in the USA and Europe and didn't see a clear signal where the RUSLE performs worse and where better. The global maps on erosion rates from the new figures can provide some insight here as they can make the analysis spatially explicit. In general, we see that the adjusted RUSLE model still overestimates erosion rates for most land cover types. However, when taking a more accurate look the largest biases are found for shrubs, and the least for grassland. A lot of factors play a role here, for example it is important to consider where the land use is allocated. On steep hillslopes the effect on erosion would be different than in flat areas. So a more explicit analysis is needed here to find out how we can improve the contribution of land cover and land use to erosion rates in the RUSLE model.

In the revised manuscript we add the following (Pg 3009, after line 5 in the original manuscript): "…of the global scale. From figures 8, which provide global erosion rates, no clear signal can be found for which land cover types the RUSLE performs worse or better. In general, we can see that the adjusted RUSLE model still overestimated erosion rates for most land cover types. A short analysis for Europe showed that the largest biases are found for shrubs, and the least for grassland. However, a more explicit analysis is needed here to find out how we can improve the contribution of land cover and land use to erosion rates in the RUSLE model. For example looking at the location of land use in a certain grid cell could make a difference in the resulting erosion rates. If the land use in a grid cell is located…."

Comment 17: Pg 3011, line 21 spelling: performs

Answer: Pg 3011, line 21 "performes" is changed to "performs" in the revised manuscript.