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Interactive comment on "Modelling long-term, large-scale sediment storage using a simple sediment budget approach" *by* V. Naipal et al.

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We would first like to thank Bertrand Guenet for his constructive comments. In this response we provide an answer to all the comments and the indicated changes will be applied in the revised manuscript.

Comment 1:"You used a modified version of the RUSLE equations without the support practice factor and then conclude that land use change is a driving factor of erosion. I think that you should discuss carefully how their conclusions would be impacted by the use of the support practice factor. In particular, how it could change the trends after the 1950's and during the middle age when animal traction was more and more used to plough."

Answer: The exclusion of the support practice factor, which represents the effect of

contouring, terracing, and subsurface drainage areas on erosion (Renard et al., 1997), may indeed impact the effect of land use change on erosion and the resulting sediment fluxes in regions with a long agricultural history, such as the Rhine catchment. However, our assumption that the factor equals unity in our study is consistent with a detailed assessment at the European scale where the average P factor for 2012 was estimated at 0.97 (Panagos et al., 2015). Furthermore, the study of Doetterl et al. (2012) showed that the S, R, C and K factors explain approximately 78% of the total erosion rates on cropland in the USA. This indicates that on cropland the L and P factors, which are related to agriculture and land management, contribute only for 22 % to the observed variability in erosion rates. Thus, although we neglect these factors in agricultural regions where they may play an important role, we expect that this does not affect the overall results of our study, such as that land use change is the driving factor of erosion. We will comment on the exclusion of L and P in the discussion.

Changes in the manuscript: Line 557: "... in cropland. Neglecting these factors in agricultural regions, where they may play an important role, results in an overestimation of the increases of soil erosion esp. during the 1950's, but we expect that this does not affect the overall trends. This assumption is supported by Doetterl et al. (2012), who shows that the L and P factors explain only up to 22% of the variability in water erosion rates on cropland in the USA."

Comment 2:"You used a modified version of RUSLE on non-croplands areas whereas this equation has been developed on croplands areas. I missed few sentences to justify that the use of RUSLE makes sense also for forest and grassland."

Answer: Indeed the original USLE model, the predecessor of RUSLE, was originally developed for cropland. However, as the model name already indicates, it is universal and can also be applied to forested and grassland areas. Model parameters for these land uses have been estimated using observational data and the model has been applied on a regular basis for the estimation of erosion in nature conservation areas, mine sites, forested areas and range- and grasslands (Dissmeyer, 1981; Millward and

Mersey, 1999; Lu et al., 2004). We will include this short explanation in the methods section of the revised manuscript.

Changes in the manuscript: Line 174: "... global scale. Although, RUSLE was originally developed for cropland, model parameters for other land cover types such as forest and grassland have also been estimated using observational data (Dissmeyer, 1981; Millward and Mersey, 1999; Lu et al., 2004).

Comment 3:" It would have been quite interesting to know the sensitivity of your approach to the inputs coming from the MPI-ESM using simulations coming from other ESMs. I am aware that this is asking a lot of additional work to redo everything using other ESMs outputs therefore adding just few elements in the discussion will be enough but at least it is important to mention it and to discuss how the uncertainties from the ESMs results might impact your conclusions."

Answer: Indeed, the sensitivity of our model to input data can be tested using data from other ESMs. We expect that the input data from other ESMs may significantly alter the trends in erosion rates and sediment fluxes for the last millennium. This is due to the fact that ESMs simulate climate and land cover in different ways.

Changes in the manuscript: Line 539: "... R factor remain. It is therefore also important to test the sensitivity of the sediment budget model with input data on precipitation and land cover from other ESMs."

Comment 4:"The discussion refers several times to the land use history but without enough references. Please document better this part."

Answer: We will add in the revised manuscript references to the studies of Hoffmann et al. (2007), Dix et al. (2005) and Kalis et al. (2003), who describe the long land use history of the Rhine catchment in more detail.

Minor comments: "L 133: You implicitly assume that movement of water during the flooding events do not induce erosion? If I understood well it should be clearly stated."

Answer: We only focus on rill and interrill erosion (which is indicated in the paper line 165), and not gully erosion or stream bank erosion that are the more extreme forms of erosion and related to flooding.

Changes in the manuscript: None

"L 151: I am not sure to fully understand what at and bt mean physically. Please clarify."

Answer: a_τ and b_τ in equation 3 are the adjustment parameters of our model relating the residence time to the flow-accumulation or catchment area. We will make this more clear in the revised manuscript.

Changes in the manuscript: Line 151: "...constants relating the residence time to the flow-accumulation or catchment area. Flowacc is the flow-accumulation and is defined as the number of grid cells...."

"L 355: Does it means that you use the same climate each year without inter-annual variability or do you repeat the sequence between 850 and 950 AD?"

Answer: We use the same yearly mean precipitation, temperature and the R factor, averaged over the 100-year period of 850-950AD (no inter-annual variability). In our study we calculated the R factor as an average over 100 year timeperiods starting from 850 AD and over a 50 year time period between 1950 and 2000.

"Fig. 4: Since it is scatter plot, you should fix the intercept to zero to have a better idea on how close to the 1:1 line the model is."

Answer: We will include the 1:1 line in the figure in the revised manuscript.

"Supplementary material l 44: If I understood well these parameters are fixed during the simulations? Why not use the stock of organic C predicted by the MPI ESM?"

Answer: Yes, the parameters to calculate the K factor, and the K factor itself are fixed during the simulations. We didn't use the C predicted by MPI-ESM because it is a very uncertain parameter of the model and it is therefore better to use the data from

GSCE. Also we assume that in the timeperiod of the last millennium the K factor will not change drastically in a way that it can change the erosion rates significantly.

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