Point-by-point response Referee #1

Understanding the role of water and tillage erosion from $^{239+240}$Pu tracer measurements using inverse modelling

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We appreciate that the reviewer acknowledges the study design and supports the publication. The reviewer raised questions with regards to the modelling part of the study. We appreciate the advices and revised the manuscript accordingly. Please see the detailed answers (in italics) to the comments below:

L 82: I don't think parameter space is the term you are looking for here. Consider changing this to "parsimonious parameter set".

Thanks, we follow the suggestion!

Equation 3: This formulation of WaTEM/SEDEM looks a little different to what I usually see (e.g. Tc = Ktc R K (LS-aSIR)). Is this correct?

*Our version of SPEROS is not identical to the WaTEM/SEDEM version of van Rompaey et al. 2001. Our SPEROS version does not include a rill coefficient as for instance used in the SPEROS version by Bouchoms et al. 2017. This was done as (i) rill erosion is not a dominant process in the study area and (ii) the rill/interrill ratio is typically used for longer slopes that cannot be found in the study area. For instance, van Rompaey et al. 2001 use observations from Govers and Poesen 1998 that on a 0.06 m m^{-1} slope after a distance of **65 m** the interrill erosion rate equals the rill erosion rate. To avoid confusion, we remove the reference to WaTEM/SEDEM from the text.*

Equation 5: Is ktil calculated by this equation? I thought it was being sampled from a pre-defined range during the inverse modelling.

Indeed, ktil was not calculated but implemented for a pre-defined range that covers low to extreme tillage erosion rates. The range was defined with respect to literature values and own experiments. As the ktil is one of the three basic parameters of the inverse modelling approach, we would like to provide the formula of the ktil to assist the reader understanding how this

parameter is derived. To avoid confusion, we mention that the ktil formula is just shown for illustration: "(as given for illustration in Eq. 5)" in the implementation section.

Are the raster outputs from equations 3 and 5 summed? A flow-chart explaining the modelling might be helpful to guide the readers. *Yes, the output of the different parameter combinations was summed up and subsequently statistically analysed (e.g. Fig. 5 & 6).*

We had an extensive discussed among the authors if a flow-chart would improve the readability of the manuscript. The result of this discussion was that we probably would need a quite detailed flow chart to substantially add a value for the reader. As the model was already described in detail in earlier papers, we would prefer keeping the focus on the model results rather the model description. So, we would prefer not adding an additional figure. However, if the editor also thinks that a flow-chart would be helpful, we would follow his advice.

L246: Why qualitatively?

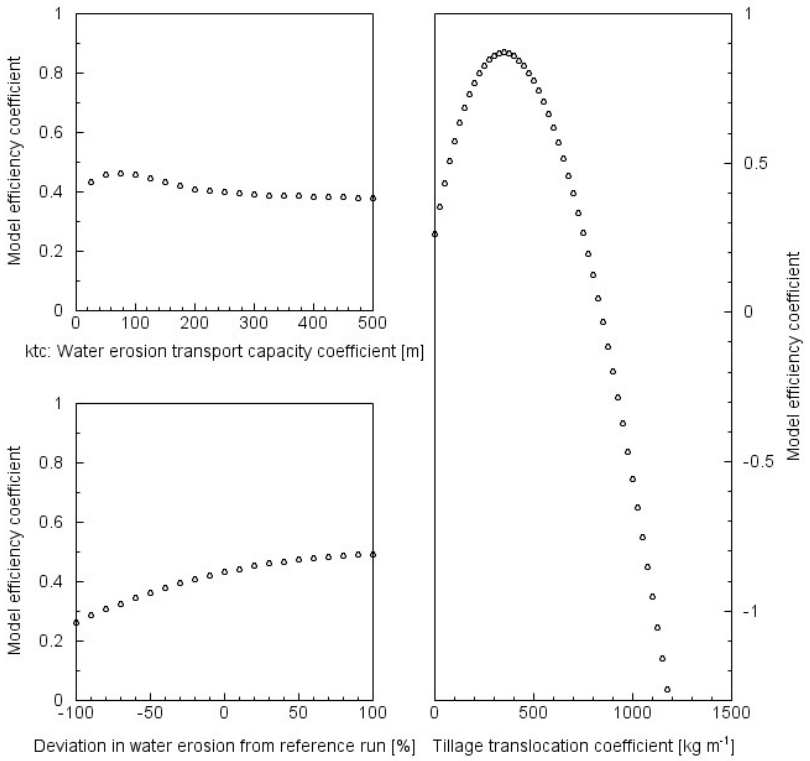
Thank you for pointing at this! We changed the text to "quantitatively"

L247-253: Are these correlations calculated based on the best-fit model realisation? Please inform this in the text.

These calculations are based on the best model fit realisation of the ktil and the reference for water erosion. We did not explicitly stress this in the text as the correlation results are only affected by changes in the ktc value (ktil and RUSLE product do not influence spatial soil redistribution patterns) that follow the reference parameterisation. To avoid confusion, we reformulate the sentence: "The spatial correlation between the $^{239+240}$Pu derived patterns and the modelled best knowledge soil redistribution, including both water and tillage erosion, is only moderate (R^2: 0.45) on a raster by raster comparison (n: 1699, 5 m x 5 m grid points; Fig. 5a)."

L256-257: By looking at figure 6c I wouldn't say the predictions showed "hardly any sensitivity to erosion strength". The MEF ranges to -0.2 to 0.6, with higher values clearly associated to the positive deviations in water erosion from reference run. Of course, the effect of the tillage parameter is much more pronounced. Nevertheless, it would be a good idea to show univariate dotty plots of the sampled parameter space with their associated goodness-of-fit measure.

We agree, there is minor sensitivity that, however, does not lead to any indication of an optimal parameterisation. The requested dotty plots underlines that statement (see below), however, we think the 3D plot nicely shows the interplay between the parameterisations. Hence, we would prefer to stay with the 3D Figure.



L260: I think it would be nice to look at the parameter space which produced acceptable model realizations (for instance, within the kriging variance or above a given MEF threshold), instead of focusing on the best-fit. That would make your approach more robust. There are multiple solutions to an inverse problem, and perhaps that should be more explicitly recognized. I mean, if you consider the error in the observed data (interpolated Pu map), there might acceptable model realizations produced with the contribution of the water erosion component. This also relates to the discussion in lines 307-310.

In general, we agree that there are multiple solutions for an inverse modelling and this might result in a substantial equifinality problem. However, as we did only vary three parameters where the parameter for the tillage erosion clearly dominates soil redistribution processes, there is no typical equifinality problem resulting from our approach. We follow the idea to provide a range of the ktil parameterisation that achieves a MEF better than 0.8 and demonstrate the limited sensitivity of the water erosion parameterisation on the best-fit model run. The following was added to the text: "A MEF better than 0.8 and RMSE below 6.5 Bq m^{-2} were found for a k_{til} range from 225 to 475 kg m^{-1}, while the best model fit was found for a k_{til} of 350 kg m^{-1} achieving a MEF of 0.87 and a corresponding RMSE of 5.2 Bq m^{-2}. The best model fit was found without the contribution of water erosion. The highest impact on the best-fit model run was a 0.31 MEF-reduction by an extreme water erosion parameterisation (k_{tc} = 500, water erosion strength = 200%)."

L309-310: Not sure I understand this. If none of the sampled parameter values produced adequate system representations, why would we need to assume the reference parameterisation is the most appropriate?

Thanks for pointing at this. As the inverse modelling did not indicate any optimal value for the water erosion parameterisation, we follow the input data recommendations that has been officially published by the administration of the state Brandenburg, Germany. We changed this in the text: "Therefore, we assume the reference parameterisation for the region given by the state of Brandenburg as the most appropriate (ktc: 150 m and RUSLE parameters according to Tab. 1)."

Technical corrections:

L209: "Results" is repeated.

Thanks, we changed the text as follows: "[…]raster map against the results calculated by the inverse modelling approach."

L307-308: "Inverse modelling" is repetitive at the end of the sentence.

Thanks, we changed the text as follows: "This sediment delivery into the kettle hole cannot be explained by the inverse modelling of water erosion applying a reasonable parameter range."