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Interactive comment on "Uncertainties, sensitivities and robustness of simulated water erosion in an EPIC-based global-gridded crop model" *by* Tony W. Carr et al.

Anonymous Referee #3

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Review of

Uncertainties, sensitivities and robustness of simulated water erosion in an EPIC-based global-gridded crop model

By T. W. Carr et al.

This manuscript describes a study to characterize global soil erosion rates on cropland using the exploration of a large parameter space of driver data and erosion models. Starting with global information on climate, soils, agricultural practices, and field properties, the authors calculate representative erosion rates. In a series of experiments, they show the sensitivity of the model to driving inputs and parameter assumptions.

They evaluate the model results against a large dataset of observed soil erosion data. The authors conclude that the model results are very sensitive to assumptions about management strategy, and the accuracy of the model is limited by a lack of field observations for calibration and evaluation.

In general this manuscript is well written and simple enough to understand. However some key information is lacking in the main text of the manuscript, and some of the results seem rather suspicious, possibly because of artifacts in the input data. In particular, the headline numbers for global soil erosion, and the mapped model output, appear to be strongly influenced by erosion in mountainous areas, where in reality land use for agriculture may be much more limited than the model assumes. These issues need to be addressed in a revision before the manuscript is ready for publication.

Looking at the model results in Figure 2a, what stands out immediately is that very high rates of erosion are plotted in many regions of the world where I would not be sure that there is any significant amount of agriculture, including the central highlands of Borneo, the Himalaya, eastern Madagascar, South Korea, and parts of the Alps. These are indeed high-rainfall/high slope regions and in some of the area agriculture is practiced. But where there is cropland, it almost certainly must be limited to valley bottoms or other low-slope areas, or only performed with substantial investment in erosion mitigation measures, such as terracing. Digging deep into the manuscript supplementary materials, I discovered that the actual crop distribution data used in this study (5') comes from Portmann et al. (2010). This citation, and explanation for how the crop areas were determined, must be moved to the main body of the text. It appears that Portmann et al. (2010) do not use slope or any other topographic characteristics in determining the spatial allocation of cropland in their crop area maps. Furthermore, 5' resolution is probably too coarse even in the authors' own admission to accurately determine appropriate mean slope classes for their soil erosion calculations.

These limitations mean that the headline numbers for erosion (e.g., lines 25-26 of the abstract), and much of the results are likely to be skewed by calculations that are not

realistic, because they are biased by high-slope/high-precipitation areas where in reality, agriculture is not practiced at all, or only in very limited and specialized forms, e.g., agroforestry, and perennial crops such as tea and orchards. This source of uncertainty needs to be addressed more thoroughly and the methods presented more transparently before this manuscript is suitable for publication.

Finally, it would be interesting if the authors performed a "reality check" on their erosion numbers. With some of the extreme values that they calculated, could agriculture be sustainable at all? How long would it take before most soil is completely eroded away?

Lines 122-123

What is the justification for choosing the "most common slope"? At the very least, wouldn't it make more sense to choose the lowest slope class in each 5' gridcell? At least until all of the area in the slope class is filled by agricultural land use before moving to the next steeper class? If not, the authors' choice of modal slope class should be justified with citations.

Lines 184-187

Again, where is the evidence that steeper slopes are actually cultivated, and on what basis are these P-factors selected? Were the parameters selected using empirical evidence, or a citation?

Lines 352-355 What is the evidence that any of these "cultivation areas with slopes steeper than 8

Lines 377-379

"...a significant share of the estimated 379 soil removal of 7 Gt a-1 originates from small wheat and maize fields on steep slopes with strong annual precipitation". So here the authors admit that the global numbers are skewed by extreme levels of simulated erosion. But more evidence that these fields actually exist needs to be provided.

Lines 391-392

How were the countries where "conservation agriculture... is likely" selected? What evidence is there for this?

Lines 423-425

That "... many older measurements are poorly accessible as they are not available online" seems to be a bit of a weak argument for not collecting more measurements on soil erosion. Can the authors elaborate a bit more in what kind of data are out there and precisely what it would take to utilize them for future studies?

Lines 466-467

Yes it seems clear that increased resolution would be important. Several datasets are already available however, including 100m agricultural cover fraction data (Buchhorn et al., 2019) and 90m topography from a range of different datasets, such as MERIT-Hydro (Yamazaki et al., 2019). Global climate and soils data are available at at least 1km resolution and could be downscaled (Fick Hijmans, 2017; Hengl et al., 2017). Some more explanation as to why the authors were limited to 5' and more concrete recommendations for future research would be valuable.

Lines 473-474

As the high erosion "areas represent only a small fraction of global cropland 474 for wheat and maize", why not show median values as the headline results instead of means?

Lines 684-689; Figure 2

I would like to see the map and statistics separated out into two, one figure set each for maize and wheat. As the growing areas are different and only partially overlapping, it would be very helpful to see these individually in the main body of the manuscript.

Lines 706-709; Figure 7

I am quite suspicious that there is any substantial amount agriculture at all in the purple areas marked on the map, e.g., Borneo highlands, northern Laos, Himalayan front, western Madagascar, Korea, Japan. If there is, agriculture must be limited to valley bottoms that are not detected at 5' resolution or done with extreme terracing.

Lines 691-693; Figures 3 and 4

Would also be useful to see how much uncertainty is caused by the assumption of what slopes are being farmed, e.g., always lowest slopes first, mean slope, median slope, etc.

List of References

Buchhorn, M., Smets, B., Bertels, L., Lesiv, M., N.-E., T., Herold, M., Fritz, S. (2019). Copernicus Global Land Service: Land Cover 100m, epoch 2015, Globe (Version V2.0.2).

Fick, S. E., Hijmans, R. J. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. Int J Climatol, 37(12), 4302-4315. doi:10.1002/joc.5086

Hengl, T., Mendes de Jesus, J., Heuvelink, G. B., Ruiperez Gonzalez, M., Kilibarda, M., Blagotic, A., Shangguan, W., Wright, M. N., Geng, X., Bauer-Marschallinger, B., Guevara, M. A., Vargas, R., MacMillan, R. A., Batjes, N. H., Leenaars, J. G., Ribeiro, E., Wheeler, I., Mantel, S., Kempen, B. (2017). SoilGrids250m: Global gridded soil information based on machine learning. Plos One, 12(2), e0169748. doi:10.1371/journal.pone.0169748

Portmann, F. T., Siebert, S., Döll, P. (2010). MIRCA2000-Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling. Global Biogeochem Cy, 24(1), n/a-n/a. doi:10.1029/2008gb003435

Yamazaki, D., Ikeshima, D., Sosa, J., Bates, P. D., Allen, G., Pavelsky, T. (2019). MERIT Hydro: A high-resolution global hydrography map based on latest topography

datasets. Water Resour Res. doi:10.1029/2019wr024873

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