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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Identifying the controls of soil loss in agricultural catchments using ex situ turbidity-based suspended sediment monitoring" *by* S. C. Sherriff et al.

Anonymous Referee #2

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Review of manuscript "Identifying the controls of soil loss in agricultural catchments using ex situ turbidity-based suspended sediment monitoring" by Sherriff et al. for Hydrology and Earth System Sciences (Discussions).

This manuscript describes (1) a comparison of estimates of suspended sediment concentrations and yields from turbidity deployed in a stream channel and located in a stream-side kiosk where water and sediment samples are pumped from the stream for analysis and (2) differences in suspended sediment yields from agricultural catchments in Ireland of different soil drainage classes and agricultural land uses. This manuscript fits within the scope of Hydrology and Earth System Sciences and there is certainly

merit in the data that was collected. There are aspects of the methodology and analyses that are missing that would allow for a complete evaluation of the quality of the data collected. The paper is generally well-written and easy to follow. However, this manuscript does not present a substantial scientific contribution in its current form and I recommend rejection unless major revisions can rectify these issues.

This manuscript was written for landscape managers interested in sediment management in agricultural catchments in Ireland. As a case in point, why should I as a scientist care whether these streams exceeded the repealed EU Freshwater Fish Directive mean annual suspended sediment concentration threshold of 25 mg/L? This is referred to throughout the paper as well as several statements most valuable for landscape managers not scientists – a reason why this manuscript is well suited to an applied or management journal. As a scientific contribution, it is valuable that this manuscript provides some insight into general landscape characteristics that correspond to higher or lower sediment yields, but I found the study location and discussion section lacking as far as linking higher or lower sediment yields to more specific characteristics of arable or grazed land for generation of sediment (e.g., I would have like to know how many cattle or sheep per acre were grazing, what happens to arable land growing winter crops in other seasons, what specific characteristics of the landscapes do the authors think are responsible for such "low" sediment generation – complex fields that the authors only first mention in the discussion). Additionally, the presentation and discussion of the time series of SSC from turbidity could lead to further scientific insight from these catchments.

I mention my major comments here first and then provide detailed manuscript, table, and figure comments below.

(1). Study location - There is a lot of information in this section on the specific types of soils, which if necessary would be best put in table 1 (i.e., Gleys, Podzols, etc.). Including this information in the text is a bit distracting and takes away from highlighting the most relevant catchment features: soil drainage class and land use. The amount

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of text on soil type versus the land use is unbalanced. I would like to know more about how intensive the agricultural practices are on each catchment. Can you quantify this by saying approximately how many cattle or sheep per acre are grazing in each catchment? This is really the key variable that will allow the reader to understand why sediment yield from these grazed catchments are “low” in terms of grazing intensity compared to other catchments in other parts of the world. On a related note from looking at table 1, what happens to the land used for growing winter (or spring) crops in the other seasons? Does it lay bare or is there some type of cover crop that would reduce soil erosion potential? This type of information on land use would be very valuable for better understanding the specific mechanisms governing sediment yield from these catchments rather than the general characteristics listed.

(2). More information on the methodology and channel characteristics at the measurement sites is warranted to better assess the quality of the data collected. One aspect that would help, is listing the width of the channel at the measuring sections and possibly range of depths (within this context where exactly were the intakes/sensors located? Approximately X m above the bed and Y m from the bank). How do you know if your turbidity and suspended-sediment measurements are representative of the cross-section average values? You mention that you collected SSC across the cross-section but do not say anything about what you found regarding the cross-section variability. Typically to obtain truly representative samples, SSC or turbidity samples collected at one point in the river are corrected for how representative that point is of the cross-section averaged SSC at various flows (see Edwards and Glysson, 1999). There is not enough information in your methodology to assess whether these best practices for reducing the error in SSC measurement were followed. Also there is almost no information on your discharge measurements besides saying you installed a weir and measured stage. Did you collect discharge measurements to verify your rating curve?

(3). I would have liked to see discharge, turbidity (or SSC derived from turbidity), and SSC measurements plotted as a time series (if not for all sites then a few; and

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with data gaps shown where data gaps were encountered) to judge how well those individual measurements captured the range of flows/SSC for the year. You mention that your turbidity sensor was not working for certain periods of the year (either ISCO intake blocked or turbidity sensor saturated). When the turbidity sensor saturates (for your T_in) this is a problem because you are not capturing the SSC during the largest flows, which you point out are responsible for the largest sediment loads. How did you account for missing turbidity data in your estimate of SSY for each year? By showing your "raw" data it is easier for the reader to better understand how representative your measurements were in capturing, or not, all of the SSC variability throughout the year.

Detailed manuscript comments (Page, P; Line, L):

Title: This paper does not really identify the controls of soil loss but instead describes differences in suspended sediment yields from catchments of different soil drainage classes and agricultural land uses in Ireland.

P 2710, L 17: "Brown Earths" and "Podzols" are capitalized here but not at P 2712, L 8. Suggest consistency of writing soil types here and throughout the manuscript.

P 2710, L 19: How do soils contribute sediment through sub-surface pathways? Is fine sediment really moving through soil pore spaces? Or do you mean sediment entering sub-surface drain tiles? Or do you mean through bedrock fissures and karst? Please be more specific.

P 2712, L 5: Why were these 5 catchments chosen?

P 2712, L 5: Reference table 1 here?

P 2712, L 14: How intensive? Can you say how many cattle per acre of land?

P 2713, L 1: Grassland C is listed as being located in "north-central Ireland" whereas Arable B is listed as being located in "east-central Ireland." From the dots on the map of Ireland in figure 1, these catchments both appear to be located in the same region, maybe north-east Ireland. I suggest changing the description of these two catchment

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locations so they are consistent.

P 2713, L 17: Beef (or dairy for that matter) does not use the grassland. The grassland is used by cattle that are raised for beef. Suggest changing “beef” to “cattle”.

P 2713, L 28: Why should the reader care whether land is used by cattle for beef or dairy? Is there something about their grazing habits that is different for cattle raised for beef than cattle raised for dairy? Also can you say whether cattle or sheep on a landscape would generally contribute to more sediment erosion based on their grazing practices?

P 2714, L 12: Can you provide more information on how you obtained and verified your discharge data? Did you collect flow measurements at the weir to verify the stage-discharge relationship?

P 2714, L 16: What exactly was regular about the “regular low-flow samples”? And what is intensive and discrete about samples collected at the “intensive, discrete, high magnitude flow events” that was not intensive and discrete about the low-flow samples?

P 2714, L 21: Define what you mean by “turbidity-stratified sampling programme.” Something like . . .turbidity-stratified sampling programme, where X volume samples were collected every Y minutes when the turbidity reading exceeded Z, thus circumventing. . .

P 2715, L 6: I do not understand why this comparison necessitated deploying a second ISCO sampler next to the in situ turbidimeter? From my understanding of this comparison you have two ISCO samplers (which are really both deployed ex situ, it is just that the one is used to obtain sediment to compare to the in situ turbidimeter) a turbidimeter (ex situ) deployed in an instrument kiosk on the bank next to the ISCO sampler and another turbidimeter (in situ) deployed within the stream near the ISCO_in intake. Why did you not just deploy the in situ turbidimeter near the intake of the ISCO_out and use those sediment samples to calibrate both turbidimeters? The only real usefulness that

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I can see for having the two ISCO samplers is to see if the length of the intake tube affects the measurements.

P 2715, L 7: What was the approximate distance specifically? 10 cm? 1 m?

P 2715, L 15: You collected 225 depth-integrated samples but I do not see 225 depth-integrated points in Figure 2. Did you composite the samples somehow? Figure 2 says the samples were averaged, in what way exactly?

P 2715, L 16: What about during non-flood events, such as at low flows?

P 2715, L 22: How wide are the channels I wonder (please add to study site or table 1)? For (2): How much coarser, please specify at least a rough measure, 1m? Were the samples from (2) depth-integrated? You mention the samples in (2) are taken from multiple depth positions; are these at-a-point samples? If so at what depths? 0.2, 0.6, and 0.8 depth? If at-a-point how do you collect samples at multiple depths with a depth-integrating sampler? You must have used a different sampler? The U.S. Geological Survey has conducted substantial research on how most accurately to measure SSC using physical samplers, I am trying to determine by reading your methods how consistent your methods are with established best practices for reducing measurement error as described in Edwards and Glysson (1999).

P 2715, L 24: How long did it take you to measure SSC on these streams and how fast were conditions changing?

P 2716, L 15: I did not see the results from this comparison analysis of the two curve fits to the data. In addition I did not see the parameters that were actually fit to the data or the form of the equations shown in Figure 2 or for estimating the final SSC and SSY for all catchments. Please mention the rating curves that were selected, the parameters of the curve, and the quality of the fit.

P 2717, L 16: Here you allude to sub-weekly maintenance of the turbidity sensors. The specifics of what you do during this maintenance should be mentioned in the methods

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section. Specifically, I am curious what you do to ensure the turbidity sensor does not experience biological fouling, do you stop data collection, do you clean the sensor, do you switch the sensor out for a different instrument?

P 2717, L 25: Here is why knowing more about the distance between ISCO intakes and cross-section variability of SSC are important! Are the sampling intakes far enough apart that cross-sections and cross-section variability of SSC between these two intake sites are different? I understand that the difference is not statistically significant but you mention that this difference is a bias between instruments that should be explained somehow.

P 2718, L 5: I do not doubt that the percentages of sand in suspension measured by ISCO_in versus ISCO_out would be that much different. The comparison you are making here misses the point of Horowitz (2008) that you bring up. Horowitz mentions that ISCO samplers tend to over sample sand compared to conventional depth-integrating samples (such as the DH-48 that you use). Thus you should be comparing the concentration of sand measured by the ISCO samplers to the concentration of sand measured by the depth-integrated sampler.

P 2718, L 9: The statement here that "the hypothesis that inadequate sample collection using either method [both ISCO sampling methods] could affect SSC is unlikely" is not justified by the comparisons made. You need to compare SSC measured by the ISCO sampling method to SSC measured using the depth-integrating sampler or non-ISCO pumped samples.

P 2718, L 11: This is interesting! You are saying that you collect a smaller proportion of sand in SSC as discharge increases. I would like to see you expanded on this finding in the results/discussion. I would like to see this data in a figure and have you discuss whether you think this is because that is how the landscape behaves or because there is an issue with how the ISCO collected sand (did the depth-integrated samples show this?) or because the cross section variability of sand changes with

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discharge? This should be further discussed because it is not consistent with most studies or understanding.

P 2718, L 15: I think this is the only place that the results of the pump length comparison test is discussed. How much different were the 1m versus the 7m tube lengths for SSC? I understand the difference is not significant but is there a bias that might help explain the also insignificant bias of measured SSCs between ISCO samples?

P 2718, L 16: "It is possible. . ." why not state based on data whether this is the case or not? You measured SSC every 20 cm along the channel correct? So you have a measure of how variable SSC is throughout the cross section at various flows.

P 2719, L 12: Fig. 3 does not provide any information on the (short) duration of high magnitude SSC events. You cannot tell from this plot whether there were 10 high magnitude events of relatively short duration or 2 high magnitude events of relatively long duration that contribute to the small fraction of total time exceeding a given concentration. This figure only shows the percentage of time high magnitude SSC occurred. That is, Fig. 3 shows that high magnitude events are infrequent. Throughout this paragraph you refer to shorter duration or shorter periods when what the figures show are frequency of occurrence or percentage of time.

P 2719, L 17: Roughly 25-40% of the time, not 50%!

P 2719, L 19: More like 5-8%, or you could say "were limited to less than 10% of the monitoring period."

P 2719, L 26: What is it about these catchments that make them "predominantly improved"? This is the necessary insight as to why your grassland study catchments have "low" sediment yields. Do these "improved" catchments have fewer animals grazing, where there other measures taken that reduce sediment yields? Please mention what the factors are for these two catchments and whether your grassland catchments have the same factors. You mention later in this sentence the soil drainage class for

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these catchments but are these the “improvements” that you are referring to?

P 2720, L 14: This sentence contains valuable information I would have liked to read earlier on in the section on study catchments. Can you show an aerial photo of these irregularly shaped fields so the reader can obtain a better sense of this? This is a very important statement for helping other landscape managers control sediment in their catchments in other parts of the world. Helping translate this in an image would help landscape managers understand what it might take for their agricultural landscapes to have lower sediment yields. An image would also be valuable to better translate what you mean by “complexity of landscape features” and how they are laid out spatially.

P 2720, L 20: On average here being the 4-year average correct? Compared to the 1-year averages mentioned at line 25? If Cooper et al. (2008) suggests “annual target and threshold investigation SSY values” then why compare the 4-year averages and not just the 1-year averages?

P 2721, L 6: What do you mean by sediment delivered through sub-surface pathways? Is it that fine sediment is moving from the surface of the fields through pores in soil? Or is this related to sub-surface tile drainage? Or is this through bedrock pores or karst?

P 2721, L 11: Table 3 says poorly-drained for soil drainage class for Grassland C, not moderate- to poorly-drained as the text here states.

P 2721, L 15: Did you normalize for differences in rainfall from catchment to catchment from year to year for your comparisons? It appears from table 3 that there are moderate variations from year to year in magnitude of change in rainfall when comparing the yearly changes between catchments.

P 2721, L 25: A very important statement for management.

P 2721, L 28: What is CV%? Coefficient of variation? Please define.

P 2722, L 13-24: Good points! Very important for managers.

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P 2722, L 24: Time lag of what?

P 2724, L 9: “Equivalent catchments and landscape settings”? The only discerning factors are catchment size and country in Figure 4.

P 2724, L 9: Spelling, “settings” not “settlings”?

P 2724, L 12: Should be “was [generally] higher.” It is important to clarify this as a general statement because this is not so for all study catchments with poorly-drained soils.

P 2724, L 16: Where/how is this shown exactly in the paper? How do we know the timing of when the soils were bare in comparison to extreme climatic conditions?

P 2724, L 25: Why do “key questions still remain regarding the magnitude and frequency characteristics of sediment transfer at shorter timescales”? You have the continuous turbidity and thus continuous SSC data. With this data why do you not say something about the magnitude and frequency characteristics of sediment transfers at shorter timescales?

Table comments (Table, T):

T 2: T_in saturated at 1000 NTU, can you translate this to SSC at these sites so the reader can be aware of how frequent this sensor was being saturated? Did you do any corrections to the data to account for when the turbidity sensor was saturated and thus unable to provide an accurate measurement? Furthermore, how could you report accurate total loads/yields and mean concentrations if your T_in sensor does not provide information on the highest concentrations, which contribute the most sediment to the total loads? What is more bothersome is why this is not mentioned in the text.

Figure comments (Figure, F):

F 1: It would be nice to see a scale on the Ireland map. Otherwise it is hard to tell how large these catchments are compared to Ireland. Also the text in this figure is too small

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to read, I can only see which catchments are which by zooming in really far into this figure. I would instead suggest labeling the zoomed in catchments (with large text size) rather than on the Ireland map so then it is easiest to quickly see which catchments are which. The dotted line then connects the location of the catchment to the location in Ireland for the reader. The names of the catchments are also followed by what appears to be the nearest city/town name. I suggest identifying this additional information as in fact nearby cities in at least the caption if not also the text. I am unable to find Corduff, Ireland at the location pointed out on the map if these names are in fact cities. Corduff appears to be a suburb of Dublin. What is it that Corduff describes?

F 2: Again text is too small to read easily. Can you report the equations used to fit the data?

F 3: (a) y-axis should be something like, "Percentage of time SSC exceeded" (b) y-axis should be something like, "Cumulative distribution of the percentage of total SSY contributed by a given SSC"

F 4: I would put the black filled circles and black unfilled squares on top of the gray filled triangles so more of the data can be easily seen. I see a lot of squares hiding behind the triangles.

F 5: Why not put actual values on the x-axis – 100% grassland to 100% arable? You have the numbers. Is this diagram truly conceptual or is it based on the data? The values on the contours and the fact that you have data suggest that this figure was based on the data. How were the contours determined and what values were used to place the points (the 4-year averages)?

References:

Edwards, T.K., and G.D. Glysson (1999), Field methods for measurement of fluvial sediment, in Techniques of Water-Resources Investigations of the U.S. Geological Survey: Book 3, Application of Hydraulics, Chapter C2, Reston, VA, 89 p. (available at

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http://pubs.usgs.gov/twri/twri3-c2/pdf/TWRI_3-C2.pdf).

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