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Hydrology and Earth System Sciences Discussions

Interactive comment on "The nitrate export in subtropical mountainous catchment: implication for land use change impact" *by* J.-C. Huang et al.

J.-C. Huang et al.

riverhuang@ntu.edu.tw

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1. This paper presents a comprehensive 2 year dataset of nitrate concentrations in 16 watersheds (partly nested) of Taiwan. The total loads from each catchment are related to landuse, in particularly to active and in-active farms. The conclusions that the farms in this region severely affect nitrate concentrations of the stream (10 -100 time higher N concentrations than under pristine conditions), most importantly due to very high N fertilizer inputs, and will do so for a long time after the farms have been expropriated are well supported by the date and the performed analyses. These conclusions are not new but deserve to be emphasized because of the unique location of the study area, high up in the mountains with seasonal typhoon events, the ecological richness

of the area and the excessive use of N-fertilizers by farmers. The nitrate dataset of the 16 catchments is really nice and is well suited for publication in HESS. However, the presentation of the data and the performed analyses need to be substantially improved before publication. Many of the sentences do not make sense to me, because of strange words (for example title). In the specific comments I listed a few, but by far not all. Please pay more attention to the text. Also the analyses of nitrate loads could be greatly improved to do justice to the high quality dataset presented (although this would not affect the conclusions because of the very clear observed nitrate load signals).

Reply: As replied above, we changed our title. Below we provide a point-to-point reply. We believed the writing in this revision was improved significantly.

2. For example: At location Y1, discharges were measured (daily?) and nitrate concentrations were measured twice a week and every 3 hours during typhoon events. This is a good dataset that nicely represents the temporal variations in both discharge and nitrate concentrations. This dataset allows for linear interpolation of both discharge and nitrate concentrations to 3 hourly values (smallest sampling interval of N) and to use these interpolated functions to estimate the total nitrate loads for this location as accurately as possible. However, the authors used simulated discharges and binned all the nitrate concentration measurements to calculate an average concentration for the entire period, or an average flow weighted concentration, to estimate the total load. This way they do not take into account the difference in sampling intervals between the measurements and effectively oversample the typhoon events. Although the rating curve method does not have problems with oversampling during typhoon events, a fixed relation between discharge and concentration was nowhere observed. My suggestion would be to calculate as accurately as possible the nitrate load for locations (Y1, k1, with best quality data) based on all measurements via linear interpolation (as described above). Than subsample monthly concentrations from these dataset (like the monthly interval of most other catchments) and see which calculation method performed best if you would only have monthly values. If there is no "best", at least this

will give a better representation of the uncertainties involved in load estimation from monthly values. Even for the monthly concentration values a linear interpolation between monthly values might be most accurate.

Reply: The sampling strategy versus uncertainty issue is another ongoing paper, in which we identify the most "cost-effective" sampling strategy with acceptable uncertainty for different constituents (e.g. DIN and DOC) in subtropical mountainous watersheds. We already realized the effect of oversampling, particularly, on particulate phase material. For dissolved constituents, the difference is less than 20% in terms of annual load. We admitted we did not make clear enough description in our methodology. In fact, hourly typhoon samples were transformed into daily average nitrate concentrations for calculation as reviewer indicated. Hence, oversampling problem didn't exist in our analyses. In this version, we provided more details about rating curve method. We followed reviewer's suggestion bringing two examples, K1 and Y1 stations with twice per week sampling, for discussion. We reduce the sampling interval to daily basis by linearly interpolating and then we conduct random re-sampling to create 5 datasets with fixed intervals of <1 week through 4 weeks. Possible errors (%, compared with "complete" dataset) based on various sampling intervals and methods are shown in Figure 1 below. Generally speaking, error is <20% in all three methods even we lower down the sampling interval to 4 weeks. This is consistent to our previous experience in other watersheds. For test, we applied the monthly sampling scheme of other stations (exactly the same date) onto K1 and Y1, the estimation errors will be the "star symbol" in the Figures below. As expected, stars all fall in the range of possible errors derived from random sampling. The large error in our random sampling practice in rating curve method apparently results from undersmapling at high flow end that transport behavior is distorted. Since we took average from three different estimations (shown in Figure 2), which are varying in a narrow range, the bias caused by single method should be smoothed out. This practice will not be presented in the manuscript to avoid confusing readers.

3. Because the typhoon events are the special feature of these catchments, I would be really interested to know how much of the yearly load is transported during typhoon events. For the detailed datasets of Y1, C2, C7 and K1 this analysis is easily performed. Also here the differences between cultivated and un-cultivated areas are interesting. Reply: A figure panel (Figure 3) will be added into revised version to illustrate the significant contribution from typhoons events.

1. I do not understand the title, please rephrase Reply: Please see the reply above.

2. Abstract: Be consistent throughout the paper: Use kg-N/km2/yr everywhere. Even in abstract you used many forms. Reply: We made the unit consistent in the revision.

3. You often use the word "baseline" throughout the paper, which to me is confusing Reply: We rephrased the word "baseline" in the Abstract and Conclusions: "This is an important reference for comparisons with other climate areas." In the Introduction: "This study can not only advance the understanding of the nitrate export in subtropical zone, which is important for the nitrogen budget study in regional and global scale, but also provide the useful guidelines for land management."

4. P9295,Line 13: I do not understand what Dumont pointed out: Intensive agriculture in low latitude areas, or Intensive agriculture and low latitude areas (what do you mean by "and")? Reply: We added "both" to clarify the sentence.

5. P9295, Line 28: it is recognized by whom? Ref. And how does the amount of rainfall affect vulnerability of ecosystems? Reply: See reply above.

6. P9296, line 3: what do you mean by delineation of protected areas, delineation into what? Reply: "Delineation" is often used in GIS software. However, we modified our sentence to avoid confusing readers. "From the past two decades, the government made great efforts to rehabilitate the environment, such as creating national park and expropriation of agricultural land."

7. P9296, line 7: attempted to investigate ! investigated Reply: Corrected.

8. Line 13, baseline for land management? Reply: See reply above.

9. Line 25: rephrase Reply: Corrected as "The mean daily discharges averaged within the total study period are 7.94 m3/s for Chi-Chia-Wan and 2.41 m3/s for You-Sheng Creek, and those averaged within the wet season are 11.80m3/s and 4.07m3/s respectively."

10. I find the subdivision in active and inactive vegetation confusing: Better to use active and inactive farms: Reply: Corrected.

11. P9297,line 17: rephrase Reply: The sentence was rephrased as "All sampling sites are located at the outlet of subwatersheds (Figure 1)."

12. Line 19: delineation of subwatershed: probably you mean: delineation into subwatersheds, but this kind of errors makes the reader confused. Reply: Corrected.

13. First paragraph Section 2.2 is confusing, regular versus two weekly/ monthly, please rewrite Reply: We rewrote this paragraph as following: "Biweekly (at C1, Y1, and K1) and monthly (other 13 stations) sampling schemes were conducted since 2007. Additional intensive (3 hour) typhoon sampling (Sepat, 8/16∼8/19/2007) and (Krosa, 10/4∼10/7/2007) were executed at C2, C7, Y1, and K1."

14. Section 2.3: report discharge measurement frequency, model timestep. Also: how did you apply the parameter sets for C1 and Y1 to the other catchments. Is landuse a parameter of the model, or is it just by area? Reply: We mentioned "daily" specifically for discharge measurement frequency and model timestep.

We added a few sentences in paragraph associated with ungauged discharge. "Landuse type was assumed to have no influences on water discharge since forest is predominating in the watershed (90%). Due to lithology difference in catchments above C1 and Y1 (Huang et al., 2008), we apply discharge model separately onto C1 and Y1, within each catchment parameters were assume to be homogenous."

15. Eq 4. I would include sample interval, to prevent oversampling of typhoon values.

Better yet I would prefer linear interpolation of nitrate measurements. Reply: See reply above.

16. Eq 6. In the conclusions you state that the large rainfall amounts during the typhoon season, makes this catchment special. Although average concentrations are not larger than elsewhere, the total load is large because of high discharge volumes. In this equation to distinguish between 2007 and 2008 I would also expect the total discharge of the corresponding year (k expressed in Kg/m3/Km2/yr) Not every year has the same amount of discharge and thus the same load. Why or why not? Reply: This is a very constructive comment. Our answer is yes, the k factor may change as discharge changes. However, the variability is limited. As replied above, we added a new figure showing the correlation between cumulative runoff depth (instead of discharge) and cumulative load. From this figure (Fig. 4), we know that annual N load and thus k value (yield factor) is controlled by annual runoff depth. In our case, the difference in annual runoff between 2007 and 2008 is ∼6%. According to historical record from Central Weather Bureau, the 50-year mean annual precipitation is 3400+600mm for mountainous areas. This long-term mean annual rainfall and variability indirectly provides an uncertainty of ∼15% to our yield factor.

17. P9302, Line 2: the trial and error method! a trial. Reply: correted.

18. P9303, Line 2: K1 revealed an opposite pattern: Please better explain the "opposite" . I see extremely elevated concentrations in K1 during Typhoon, Much stronger than in Y1, but concentrations in K1 during typhoon still do not reach the lowest levels of Y1. Reply: This sentence is improper and we removed it. Now the sentence is changed to "At K1, which was regarded as a relatively pristine catchment (depending on the land use pattern; see Figure 1 or Table 2), the nitrate concentration was around 0.1 $\sim$ 0.4 mg/L showing significant seasonal variation yet with smaller magnitude when comparing with that observed at Y1.".

19. P9305, Line 9. I do not understand why a dilution effect would point to leaching of

nitrate towards groundwater. Reply: Reviewer is right. The inference is not solid. We removed this sentence.

20. Line 17: as flooding? Please rewrite Reply: “We could infer that the specific NO3-N flux would exceed 100 kg/day/km2 while flood occurred.”

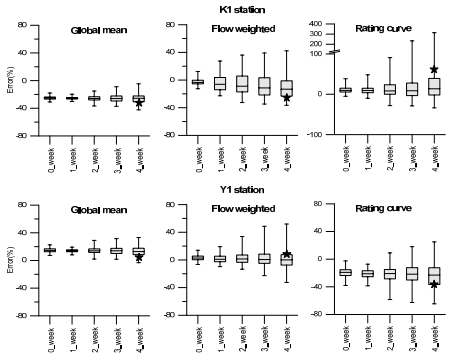
21. Page 9306, line 4 Please rewrite Reply: “Although nitrate concentration level is similar to those in other catchments around the world, much larger rainfall/runoff depth (5-8 times higher) in Taiwan results in a high nitrate yield.”

22. You completely repeat table 7 in text 23. Page 9308,line 25 MO3->NO3 24. Page 9313, Table 1: Average slopes of 76 degrees are only suited for rock climbing. Probably you mean % Reply: corrected.

25. Page 9318 Table 6: Boyer et al., 2002 is not in reference list. The paper of Boyer et al, 1997, which is in the ref. list, does not contain any Nitrate data. Reply: We changed to Mayer et al. (2002).

Mayer, B., Boyer, E.W., Goodale, C., Jaworski, N.A., Van Breemen, N., Howarth, R.W., Seitzinger, S., Billen, G., Lajtha, L.J., Nosal, M. and Paustian, K.: Sources of nitrate in rivers draining sixteen watersheds in the northeastern US: Isotopic constraints, Biogeochemistry, 57(1), 171-197, 2002.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 9293, 2010.



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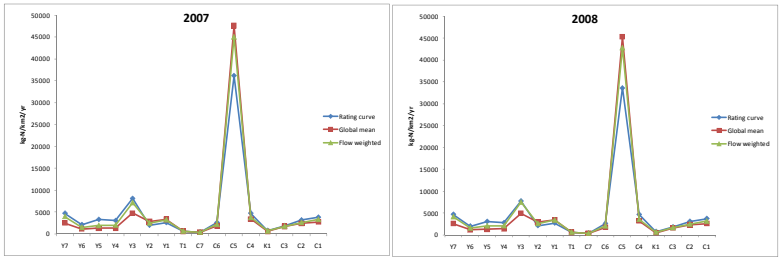

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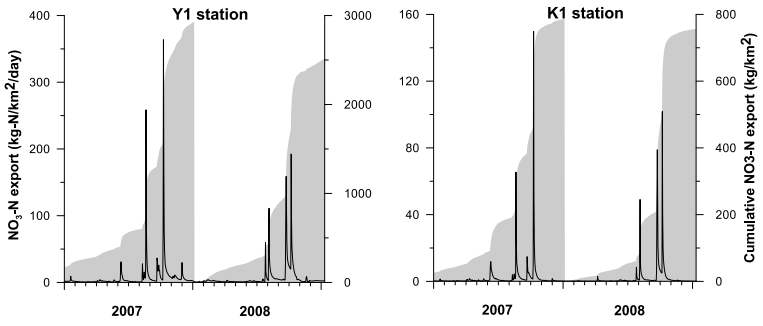

Figure 6. The cumulative nitrate export in Y1 and K1 during 2007 and 2008

Fig. 3. The cumulative nitrate export in Y1 and K1 during 2007 and 2008

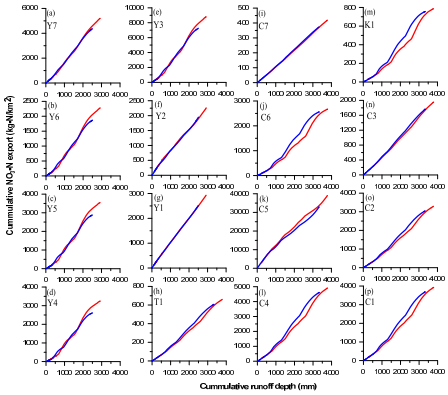

Figure 2. The Cumulative runoff depth and nitrate export for the all 16 sites. The red and blue curves represent the export during 2007 and 2008, respectively.

Fig. 4. The Cumulative runoff depth and nitrate export for the all 16 sites. The red and blue curves represent the export during 2007 and 2008, respectively.