The black and blue texts are comments from reviewers and author's responses respectively.

Comments from Reviewer #1,

Chang et al. present work from four small watersheds in northern Taiwan and report stream and precipitation hydrochemistry data over a 3-year period that encompasses 11 typhoons. It is an interesting dataset and I largely think that the methodology is adequate to answer questions related to differences between typhoon and non-typhoon hydrochemistry. There could be issues associated with using the drainage-area ratio method in watersheds with different land-uses, especially during higher flows and for watershed comparisons, but it might not matter too much for the internal hydrochemistry dynamics. The differences between the typhoon and non-typhoon hydrochemistry are striking, but also not unexpected, as storm hydrochemistry often differs from baseflow hydrochemistry. What I am missing, though, is a general discussion WHY these pronounced differences exist (or at least an attempt at an explanation). Because of this the manuscript feels incomplete and I would not recommend publication in its current form. I would suggest the authors alter (or add to) the discussion to include possible explanations for the stark differences in typhoon and non-typhoon hydrochemistry response. Origin and fate of the water constituents should be discussed in more detail (or, for that matter, at all). Pre-typhoon conditions might matter for nutrient mobilization and typhoon runoff ratios (rather than total streamflow) could also help in interpreting the data. Are there precipitation or streamflow thresholds that change the delivery dynamics of nutrients? How might the activation of different flowpathways or water sources contribute to the differences? Please find below some more comments/suggestions.

Reply: We substantially expanded our discussion to include explanations to the observed striking differences between typhoon and non-typhoon periods. Specially, we added the differences in runoff ratio between the two periods in a new Figure 2. The added discussion is listed below.

"Stream discharge originates from three sources, surface runoff, subsurface runoff and groundwater discharge. Among the three sources, groundwater discharge was more important during low than high flow periods, whereas the contribution from surface runoff should be more important during heavy storms than small storms. The contribution from subsurface flow probably dominated the discharge at our study site, especially in F1 and F2 because a study at a natural forest 12 km Southeast from our study site indicated that even during a heavy typhoon storm, with precipitation near 700 mm in two days, there was no observable surface runoff (Lin et al., 2011). The contribution from groundwater and subsurface runoff to total discharge likely resulted in the very high runoff ratios for weeks

with small amount of precipitation. For example, in 28 January 2014, the weekly precipitation and discharge were 1.5 mm and 13 mm, respectively, which led to the highest runoff ratio, 8.7, for the entire study period (Fig. 2).

Groundwater is enriched with ions derived from rock weathering such as K^+, Ca^{2+}, and Mg^{2+} and pre-storm subsurface runoff have a longer contact time with soils that are also rich in these cations and SO_4^{2-}. Thus, the greater contributions from groundwater and subsurface runoff in the non-typhoon period likely contributed to the greater (positive) slopes between discharge and budget of these ions for the non-typhoon period than typhoon period (Figs. 4 and 5). The second possible reason for the greater slopes between discharge and budget of many ions during the non-typhoon period is the differences in ion concentration between typhoon and non-typhoon storms. The day or two days before a typhoon typically has clear sky because the outskirt air masses of the typhoon "blow" away most air pollutants. As a result, precipitation associated with typhoons have low concentrations of ions with terrestrial sources (Lin et al., 2011). In our study, mean concentrations of all ions were lower during typhoon period than non-typhoon period (Table S3) and this diluted precipitation ion concentrations overrode quantity effect and contributed to the smaller increases in budget with increasing discharge in the typhoon period than the non-typhoon period (Figs. 4 and 5)."

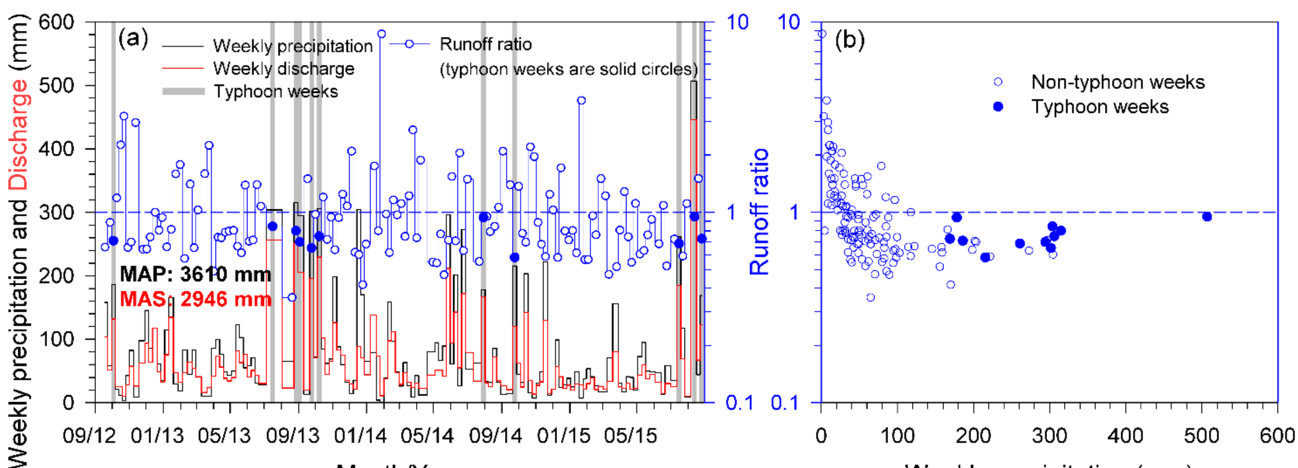


Figure 2: Mean weekly precipitation, discharge and runoff (a), and the relationship between mean weekly precipitation and mean runoff ratio (b) of the four studied watersheds combined. MAP: Mean annual precipitation, MAS: mean annual stream discharge.

Table S3. The mean (one standard deviation) concentrations of ions (mg/l) in precipitation during non-typhoon (Non_Ty) and typhoon periods

	H^+	Na^+	K^{2+}	Ca^{2+}	Mg^{2+}	NH_4^+	Cl^-	NO_3^-	SO_4^{2-}	PO_4^{3-}
A1										
Non_Ty	0.06 (0.06)	4.15 (8.35)	0.64 (1.36)	0.84 (1.36)	0.59 (1.04)	0.85 (1.35)	9.43 (22.9)	3.97 (6.27)	5.18 (7.26)	0.04 (0.15)
Typhoon	0.02 (0.02)	3.78 (3.51)	0.43 (0.45)	0.48 (0.36)	0.51 (0.41)	0.12 (0.14)	6.05 (5.21)	0.40 (0.70)	1.54 (1.57)	0.01 (0.02)
F2										
Non_Ty	0.04 (0.06)	3.37 (8.17)	0.61 (1.66)	0.84 (1.91)	0.55 (1.08)	0.55 (1.18)	7.96 (23.9)	2.56 (9.10)	4.84 (10.2)	0.01 (0.05)
Typhoon	0.01 (0.02)	3.36 (2.75)	0.37 (0.39)	0.32 (0.23)	0.46 (0.36)	0.14 (0.17)	5.03 (3.96)	0.39 (0.53)	2.11 (2.80)	0.002 (0.003)

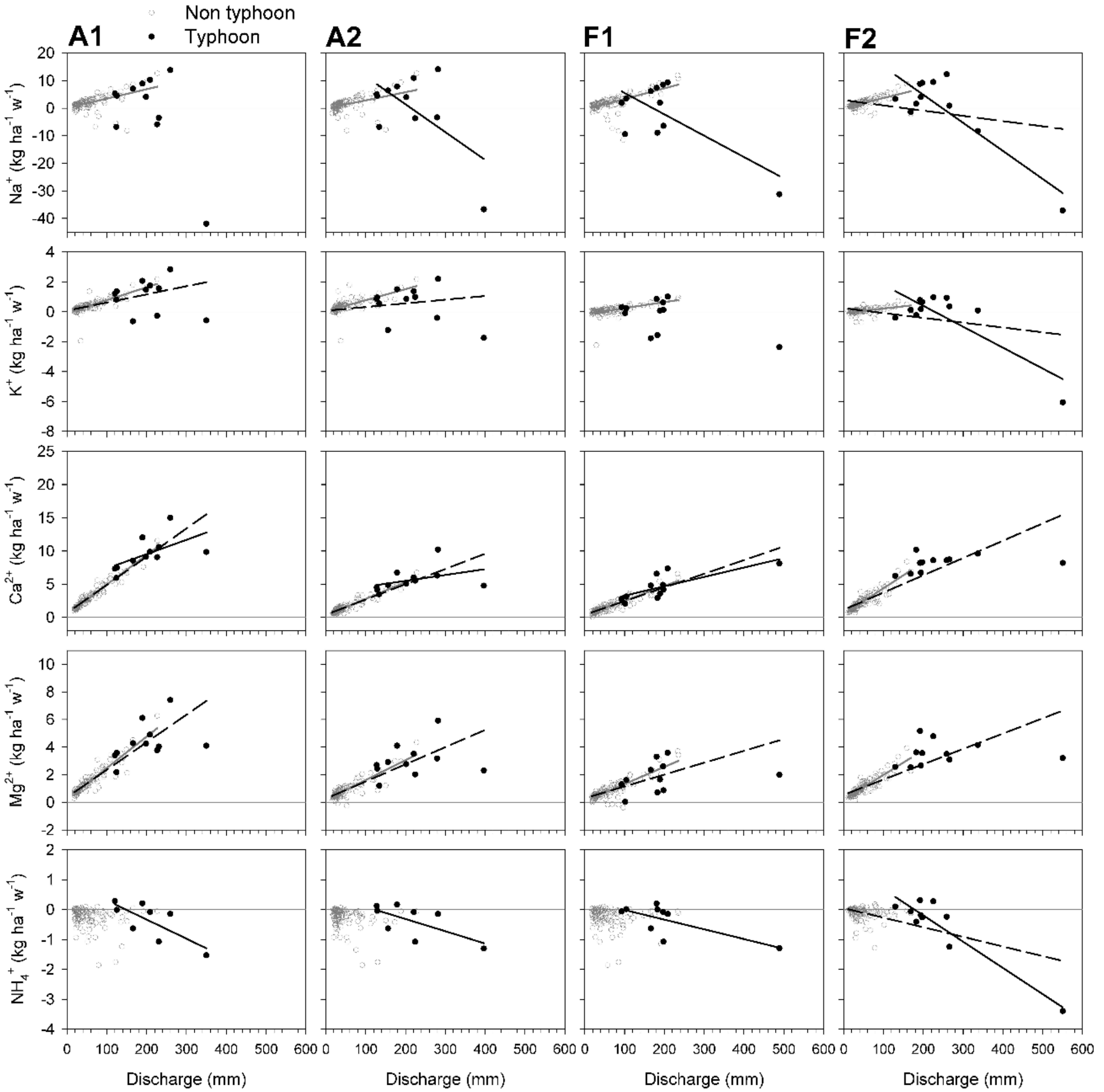


Figure 4: Relationship between stream discharge and nutrient budget (stream output – precipitation input) of cations (Na^+, K^+, Ca^{2+}, Mg^{2+}, and NH_4^+). The gray, black, and dash lines indicate significant linear regressions between discharge and ions budgets for non-typhoon, typhoon and all data, respectively. Please refer to Table S2 for the regression models and R^2s.

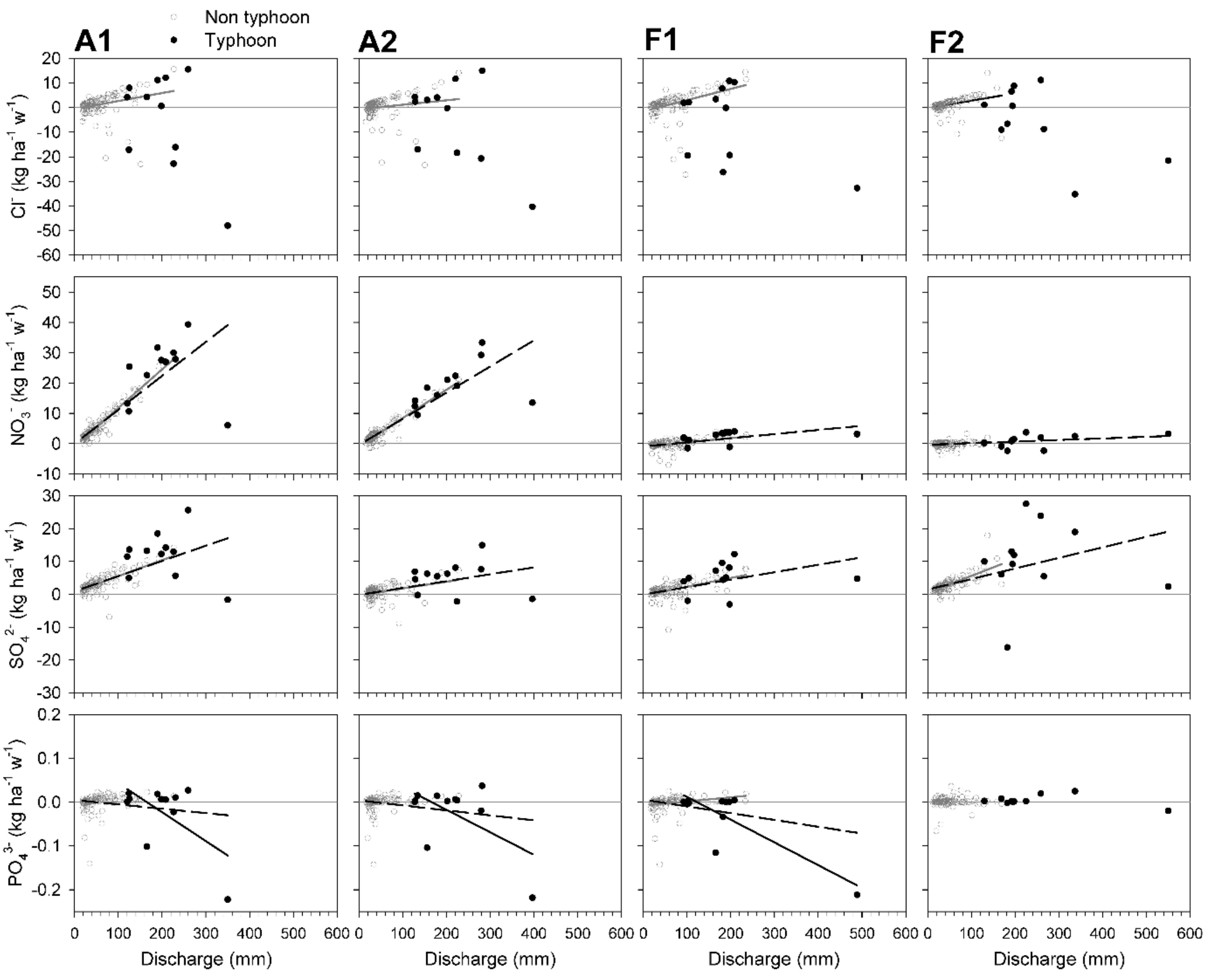


Figure 5: Relationship between stream discharge and nutrient budget (stream output – precipitation input) of anions (Cl^-, NO_3^-, SO_4^{2-}, and PO_4^{3-}). The gray, black, and dash lines indicate significant linear regressions between discharge and ions budgets for non-typhoon, typhoon and all data, respectively. Please refer to Table S2 for the regression models and R^2s.

1. P3 L5: Based on size, it would make sense that F1 is a 1st or 2nd order stream. However, the drainage network in Figure 1 suggests it might be a 3rd order stream.

Reply: Watershed F1 is indeed a 3rd order stream. It is not uncommon to have 3rd order streams with an area smaller than 100 km^2 in Taiwan due to the abundant precipitation and rough topography (so that many upstream watersheds are small).

2. P3 L9-10: Were the samples also analyzed within 24 hours of sample collection?

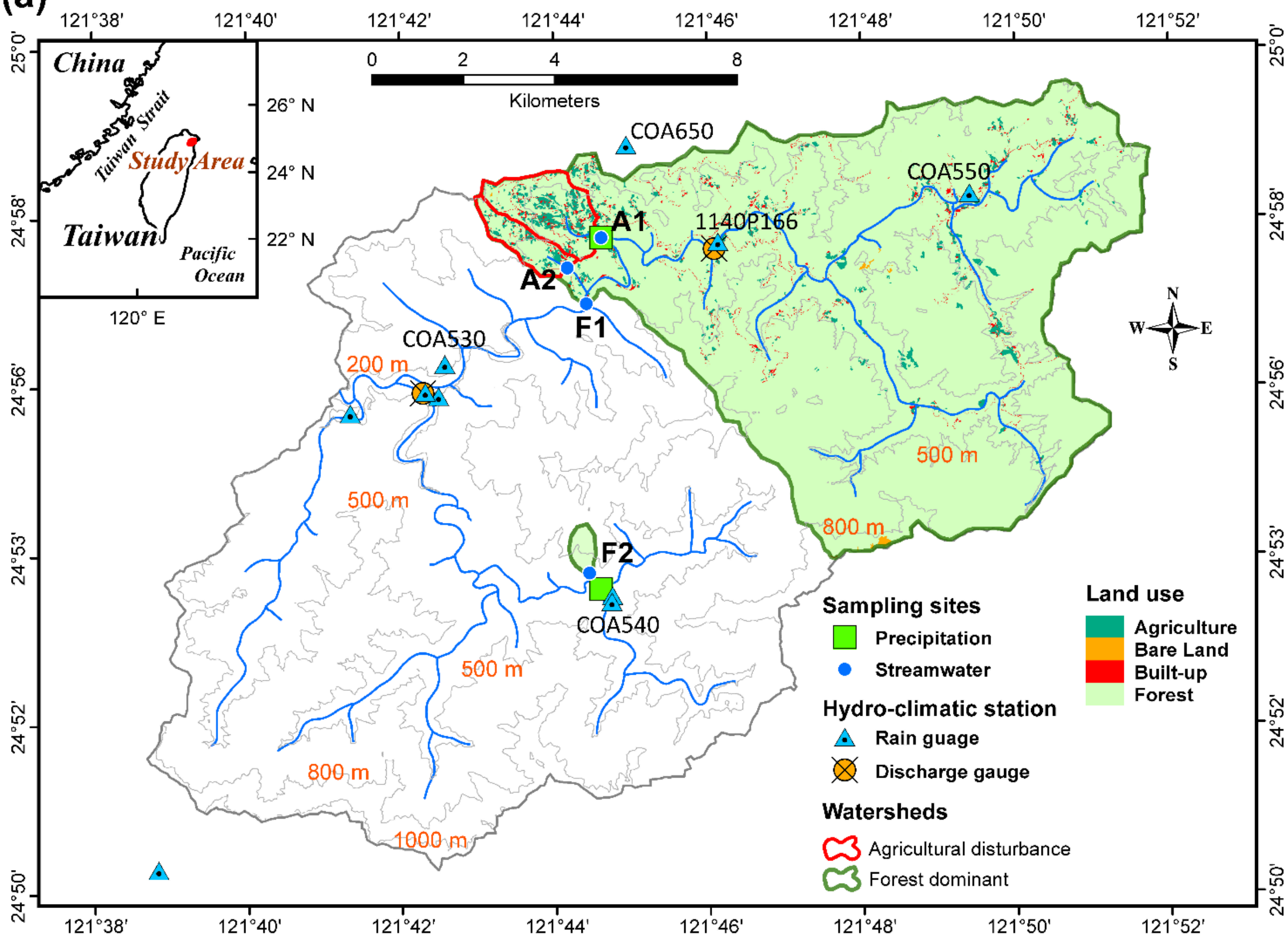
Reply: We filtered the samples the same day of collection and the chemical analysis were mostly completed within two weeks. We added one sentence to deliver this information. *"After the measurement of pH and conductivity, samples were filtered (0.45 μm filter paper) mostly within eight hours of sample collection."*

3. P3 L15: What is the topographic relief in the F1 watershed? Is it large enough that orographic precipitation differences should be considered?

Reply: F1 has a mean slope steepness of 38.7% so that there could be some orographic precipitation differences. In response to this comment, we used 10 rainfall stations (instead of two in the original manuscript) to simulate the discharges of the four sites via the Hydrologiska Byråns Vattenbalansavdelning (HBV) model. The site map has been changed to include the locations of the stations. The areal rainfall from Thiessen polygon was applied, and thus the rainfall spatial heterogeneity has been considered partially. For orographic precipitation differences in F1, we conducted pair comparisons among the three rainfall stations (C0A550, 1140P166, and C0A650 outside the F1). The result showed that the slopes were close to 1.0 and the R^2 values were greater than 0.65. Based on the result, the differences among the three stations are less than 10% on a weekly basis. This demonstrated that the orographic effect exists and the differences in weekly precipitation among stations could be as large as 100 mm. However, the high correlations indicated that using Thiessen polygon interpolation is valid for representing the rainfall amount in F1. We added the following to the revision.

"Precipitation in mountainous area is quite dynamic due to the interaction between orography and circulation. Following Huang et al. (2011), we used 10 rainfall stations to simulate the discharges of the four sites via Hydrologiska Byråns Vattenbalansavdelning (HBV) model. The areal rainfall from Thiessen polygon was applied, and thus the rainfall spatial heterogeneity has been considered partially. Precipitation of each of the four watersheds was then obtained from the spatial distribution of precipitation."

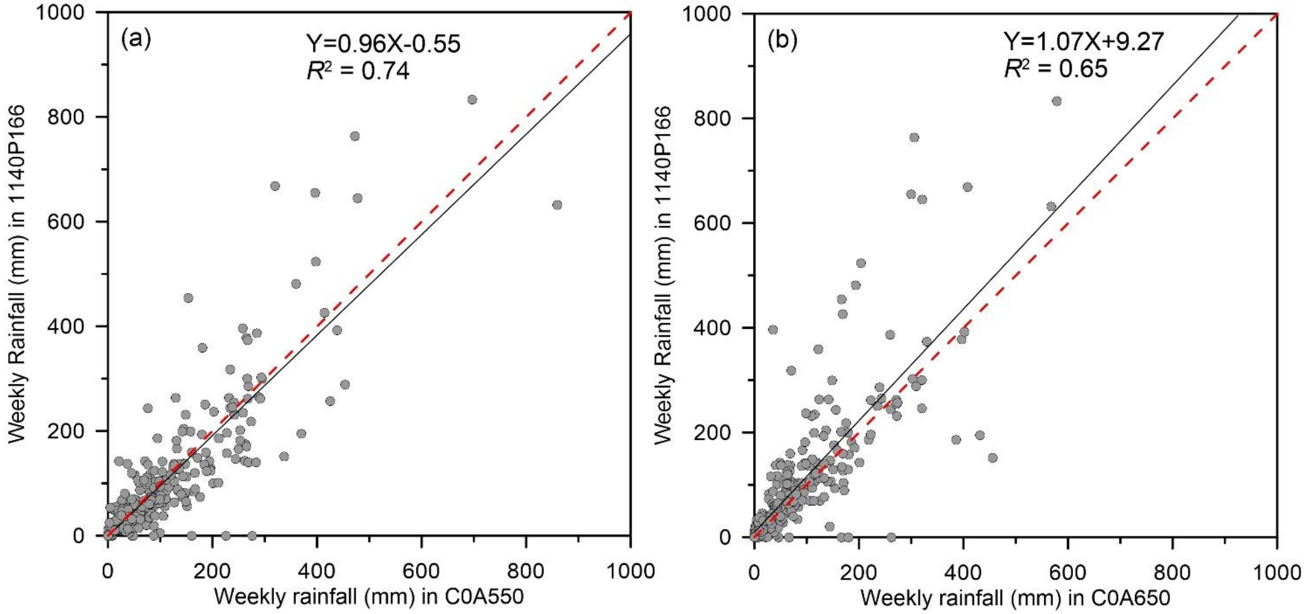
(a)



(b)

Watersheds	Area (km^2)	Slope (%)	Land use (%)					
			Natural Forest	Agriculture	Road	Building	Water body	Others
A1	2.92	39.3	68.0	22.1	3.61	1.54	0.69	4.11
A2	1.36	34.8	75.5	17.1	2.96	1.31	0.19	2.96
F1	86.04	38.7	93.5	2.87	0.77	0.35	1.12	1.44
F2	0.67	48.1	99.2	0.38	0.00	0.00	0.00	0.38

Figure 1: Location and land uses of the studied watersheds at the Feitsui Reservoir Watershed (a) and the basic information of four watersheds (b).



Relationship of weekly precipitation among three gauge stations of the study site.

Huang, J. C., Kao, S. J., Lin, C. Y., Chang, P. L., Lee, T. Y., and Li, M. H.: Effect of subsampling tropical cyclone rainfall on flood hydrograph response in a subtropical mountainous catchment, J. Hydrol., 409, 248–261, doi:10.1016/j.jhydrol.2011.08.037, 2011.

4. P3 L17: The drainage-area ration method assumes similar watershed characteristics and runoff generation mechanisms. Considering that A1 and A2 have a considerable amount of agricultural area, runoff generation mechanisms are likely different, which would call into the question the comparability of streamflow volumes.

Reply: Following this comment and the general comment, we re-calculated stream discharge using the Hydrologiska Byråns Vattenbalansavdelning (HBV) model. The following detail is added to the Materials and Methods.

"Stream discharge of the four ungauged watersheds was also simulated by the HBV model processed through TUWmodel (ver. 0.1-8) (Parajka et al., 2013). Five daily rain gauges, maintained by Water Resource Agency (WRA), and five metrological stations, maintained by the Central Weather Bureau of Taiwan (CWB) with hourly observed rainfall, temperature, wind speed, and solar radiation were used to estimate daily rainfall and potential evapotranspiration. The daily evapotranspiration is also observed by Taipei Feitsui Reservoir Administration (TFRA, Taiwan) at the Feitsui meteorological station. The

observed rainfall, temperature and evapotranspiration were applied into 20 sub-catchments with Thiessen polygon method. Daily discharge was monitored in three main tributaries of Baishi Creek by TFRA. In the calibration against the observed values, parameters were generated by the package DEoptim (ver. 2.2-4) (Mullen et al., 2011). Three objective functions, Nash Efficient Coefficient (NSE), its power of 2 and log scale, were used to adjust the model to suit normal, extreme, and low flow conditions. The validation gauge is located in the inflow of dam of reservoir. The modelled daily discharge was aggregated into weekly discharge." We updated all the figures and tables based on the new calculations. The basic patterns do not change but some details are different. The cited references are listed below.

Parajka, J., Viglone, A., Salinas, R. M., Sviapalan, M., and Blöschl, G.: Comparative assessment of predictions in ungauged basins - Part 1: Runoff-hydrograph studies, Hydrol. Earth Sys. Sci., 17, 1783–1795, doi:10.5194/hess-17-1783-2013, 2013.

Mullen, K. M., Ardia, D., Gil, D. L., Windover, D., and Cline, J.: "DEoptim: An R Package for Global Optimization by Differential Evolution, J. Stat. Softw., 40, 1–26, doi: 10.18637/jss.v040.i06, 2011.

Table 1: I am not sure I understand the difference between the accumulated and total precipitation (and streamflow) values. The accumulated values are the values for just the typhoon days, while the total values are the values for the entire typhoon week? That means precipitation was measured at sub-weekly intervals and later aggregated to weekly values? This is not immediately clear from paragraph 2.3.

Reply: We agree that the current expression is a bit confusing. We changed *"Accumulated prec. of specific typhoon" to "Prec. between the first and last typhoon warnings" and changed "Accumulated discharge of specific typhoon"" to "Discharge between the first and last typhoon warnings". We think this should make it clear that the numbers in the two columns represent precipitation contributed by the typhoon that occurred in the week and the total precipitation of the week, respectively. This should make it clear what we meant in the next column C = A/B, the contribution of typhoon precipitation to the weekly precipitation. We also added notation that "Precipitation was recorded at a 5-min interval at the two rain gauge stations and aggregated to weekly and typhoon precipitation."* Note that this table is now moved to supplementary information as Table S1.

Table S1. The basic information of the typhoon affected weeks.

Name of typhoons	Date	Prec. between the first and last typhoon warnings (mm, A)	Total Prec. of the typhoon week (mm, B)	C = A/B (%)	Discharge between the first and last typhoon warnings (mm, D)	Total discharge of the typhoon week (mm, E)	F = D/E (%)
Jelawat	26-29 Sep. 2012	181	184	98	106	132	80
Soulik	12-14 Jul. 2013	334	345	97	212	256	83
Trami	20-22 Aug. 2013	296	321	92	230	252	91
Kong-Rey	28-30 Aug. 2013	258	286	90	187	205	91
Usagi	20-22 Sep. 2013	265	304	87	159	195	82
Fitow	5-7 Oct. 2013	305	324	94	191	229	83
Matmo	22-23 Jul. 2014	170	184	92	145	167	87
Fung-Wong	20-23 Sep. 2014	180	187	96	112	120	93
Chan-Hom	9-11 Jul. 2015	243	252	96	157	185	85
Soudelor	7-9 Aug. 2015	470	507	95	380	445	85
Goni	21-24 Aug. 2015	160	168	95	112	122	92
Average		260	278	94	181	210	86

1. The accumulated precipitation of typhoons were summed from first and last typhoon warnings issued and the total precipitation (mm) of typhoon week is the average value of two rain gauges (COA530 and COA540) during the week of typhoon influenced, and same as the discharge (the average value of four watersheds, A1, A2, F1, and F2). Precipitation was recorded at a 5-min interval at the two rain gauge stations and aggregated to weekly and typhoon precipitation.

5. P4 L4-18: It would be important to have more basic hydrologic data in this paragraph. For starters, I am missing streamflow hydrographs for the study periods. For a better overview of the general hydrologic conditions. This paragraph and Table 1 contain data to calculate typhoon runoff ratios (the amount of precipitation that becomes runoff over a period of time: streamflow/precipitation), but it would also be interesting to see annual runoff ratios for the watersheds with and without the typhoon periods. Assessing pre-typhoon conditions might also be helpful for interpreting the different response between typhoon and non-typhoon periods but also the variability within the typhoon responses.

Reply: We added hydrograph for the study periods and added the following sentence to describe it. "*During the sampling period, weekly precipitation ranged from 1 mm to 470 mm while weekly streamflow ranged from 10 mm to 446 mm (Fig. 2)*". We also calculated weekly runoff ratio and the mean runoff ratio for the typhoon and non-typhoon periods. In the Results section, we added "*The weekly runoff ratio was negatively related to precipitation quantity and was highly variable during the non-typhoon period but varied much less during the typhoon period (Fig. 2)*". In the Discussion section, we added "*Stream discharge originates from three sources, surface runoff, subsurface runoff and groundwater discharge. Among the three sources, groundwater discharge was more important during low than high flow periods, whereas the contribution from surface runoff should be more important during heavy storms than small storms. The contribution from subsurface flow probably dominated the discharge at our study site, especially in F1 and F2 because a study at a natural forest 12 km Southeast from our study site indicated that even during a heavy typhoon storm, with precipitation near 700 mm in two days, there was no observable surface runoff (Lin et al., 2011). The contribution from groundwater and subsurface runoff to total discharge likely resulted in the very high runoff ratios for weeks with small amount of precipitation. For example, in 28 January 2014, the weekly precipitation and discharge were 1.5 mm and 13 mm, respectively, which led to the highest runoff ratio, 8.7, for entire study period (Fig. 2).* " The new Figure 2 is presented in our reply to the general comment.

6. P4 L17 and Figure 2: Record over what time? What are the "5, 8, 9, and 9 typhoon weeks" and how are they shown in Figure 2? What do the dashed lines in Figure 2 represent?

Reply: We rephrased/corrected the sentence to clarify what we meant to say. The new sentence is now "*Among the 10 highest hourly, 6-hr, 12-hr and 24-hr precipitation events, 5, 8, 9, and 9 of them occurred during weeks associated with typhoon storms.*"

7. P4 L14-18: This whole paragraph is about hourly intensities, not precipitation totals.

Reply: Yes, indeed this paragraph is about how intense typhoon storms were. The information about precipitation totals is given in the paragraph before this paragraph.

Because hydrological processes may be different between intense storms and regular storms, we thought it is important to describe how intense the typhoon storms were.

8. Table 2: It's good to list the regression models but this could be supplemental information in my opinion

Reply: Table 2 is now moved to supplemental information.
