Interactive comment on “Erosion rates deduced from Seasonal mass balance along an active braided river in Tianshan” by Y. Liu et al.

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General comments:
I assume that the authors put a lot of work and effort in this study and I appreciate that they try to place their results in the framework of existing literature. Unfortunately, the manuscript is not well written, neither concise nor in a correct grammar. This makes it in parts really challenging to understand the author's intention and to evaluate their procedures. As I am myself not a native speaker, I understand the difficulties involved in this process. But it is in my view the essence of science to be concise and understandable, otherwise it is hard to find an audience. I assume that one of the co-authors might be able to involve a native speaker to correct the grammar and give the manuscript more structure. Several paragraphs are placed in the wrong sections and others are irrelevant for the message the authors try to convey.

Besides the high potential to improve the scientific writing style, I doubt that it is valid to infer the long-term sediment budget based on river discharge data. Extreme sediment flux events, which might be associated with glacial sediment discharge or rainfall induced landslides are not necessarily indicated by peak discharges. In my view the authors collected a highly valuable dataset. Therefore, it is more instructive, if they present their data in a plain way and avoid unknown assumptions about flood sediment transport or “long-term” budgets.

In addition, I suspect that the denudation rates the authors derive are rather low for a glaciated high-relief catchment in a tectonically active environment. I did not quite understand, how they bridge the gap to other studies presenting orders of magnitude higher denudation rates.

Specific comments:
Title: Erosion rates deduced from Seasonal mass balance along an active braided river in Tianshan - What does the word "active" refer to? Is that important for the erosion rates? - Suggestion: Erosion rates deduced from fluvial sediment flux data of the Urumqi River, Tianshan

542, 2-3: “an active mountain range in" - The Tianshan is known as a mountain range not necessary to mention that. - Further information of the sampled catchment area might be interesting.

542, 6: “secular" - you mean “long-term”? -

542, 6: “this high mountain catchment of Central Asia." - redundant -

542, 9: “can not be neglected" - double negative, say clearly what you mean and keep it short - i.e. “Bed load in form of sand and gravel is significant, as it accounts for one third of the solid load of the river.”
542, 10-11: “Overall, the mean denudation rates are low, averaging 46 t\(\cdot\)\(\text{a}^{-1}\text{km}^{-2}\)\(\approx\)\(\text{A}^{-1}\text{yr}^{-1}\)\(=17-18\text{mMyr}^{-1}\)”. - Why is that so? “averaging 46 t\(\cdot\)\(\text{a}^{-1}\text{km}^{-2}\)\(\approx\)\(\text{A}^{-1}\text{yr}^{-1}\)\(=17-18\text{mMyr}^{-1}\), because…”

542, 13-16: “The rates we obtain are in agreement with rates obtained from the mass balance reconstruction of the Plio- 15 Quaternary gravelly deposits of the foreland but significantly lower than the rates recently obtained from cosmogenic dating of river sand.” - you mean the Tianshan foreland? - Where is the location of the cosmogenic dates?

542, 20: “remains an essential topic of research” - is an important research field

Additional specific comments are given in the attached pdf file. My apologies for this unorthodox editing style, but given the scale of comments I found this the most convenient way.

Please also note the supplement to this comment: http://www.solid-earth-discuss.net/3/C301/2011/sed-3-C301-2011-supplement.pdf

Interactive comment on Solid Earth Discuss., 3, 541, 2011.
Fig. 2.

The Urumqi River, a mountain stream located in the northeastern part of the Tianshan mountain range in China, is a key water source in the region. Its drainage area is 925 km² and is controlled by both orographic summer precipitation and glacial melting. The river drains a region that experiences intense monsoonal activity, with approximately 250 mm of rain that falls over Taiwan.

Converging between the Tianshan range and the Dzungar block (Dzungar or Junggar Desert) accounts for the complex nature of the Urumqi River’s headwaters. The Tianshan glaciers are significantly smaller than their Himalayan counterparts.

Hydrology of the Urumqi River is characterized by a very complex pattern of sediment transport, which includes both dissolved and solid loads. The river’s sediment flux is linked to the tectonics of the region. The study area is also important for understanding the climatic effects on the Himalayan orogenic belt and the Tibetan plateau.

Fig. 3.
15 sample was taken in the center of the channel by an operator and raised the sampler at a constant velocity. Samples were filtered through Nalgene filtration units using 0.45 µm filters within a couple of hours after being collected. The collection of samples for solute analyses started after 250 ml of river water was passed through the filter. Two vials were collected: one was acifided to pH = 2 for cation analysis and the other one was kept non-acifided for anion analysis. For all cations and anions, the precision is better than 5%. The concentration of bicarbonate ion HCO$_3^-$ was measured at the Daxigou meteorological station near the sampling site and the precision is better than 5%. The concentration of bicarbonate ion HCO$_3^-$ measured at the Daxigou meteorological station near the sampling site is located downstream of a confluence scour (Fig. 3). Site 1 is located upstream of site 1, where measurements were made during the three years of survey, at a mean annual temperature of 6.8°C and a mean annual discharge of 487 m$^3$ s$^{-1}$.

### 3.1 Water sampling

Water samples were taken with a depth integrating USDH48 sediment sampler. Each was weighed. We did not follow the cross-section average sampling procedure for the Toutle river sampler (Diplas et al., 2008) so that the sampling efficiency of our sampler is better than 50%. We therefore found it interesting to compare measurements performed using samplers with large pressure differences such as the Helley Smith sampler and the sampler was equipped with a 0.25mm mesh bag. Given these dimensions, the sampling duration was 120 s per sample. Each individual sample was acifided to pH = 2 for cation analysis and the other one was kept non-acifided for anion analysis. Two vials were collected: one was acifided to pH = 2 for cation analysis and the other one was kept non-acifided for anion analysis. For all cations and anions, the precision is better than 5%. The concentration of bicarbonate ion HCO$_3^-$ was measured at the Daxigou meteorological station near the sampling site and the precision is better than 5%. The concentration of bicarbonate ion HCO$_3^-$ measured at the Daxigou meteorological station near the sampling site is located downstream of a confluence scour (Fig. 3). Site 1 is located upstream of site 1, where measurements were made during the three years of survey, at a mean annual temperature of 6.8°C and a mean annual discharge of 487 m$^3$ s$^{-1}$.

### 3.2 Bed load measurements

Bed load measurements were made using channel bed pressure flume samplers. The opening of the sampler measured 0.6 m by 0.6 m, the expansion ratio was 1.4, the mean annual temperature and precipitation measured at the Daxigou meteorological station near the sampling site are 5.5°C and 546 mm, respectively.

The bed load measurements were made sufficiently close to one another so that the discharge did not change significantly.

**Fig. 4.**

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The first striking feature of mass transport in the Urumqi River is the importance of dissolved load.

3.4 Relevance of data acquisition

Average flow velocity was calculated by simple discrete integration following:

\[ u_j(y_j) \text{ the average velocity of the } j \text{th point taken at a distance } y_j \text{ from the bank} \]

where \( u_j \) is the average velocity of the jth point taken at a distance \( y_j \) from the bank of the section. Each individual measurement was then compared to the average velocity at a given point. This technique was successfully used by Meunier et al. (2006a) to study the dynamics of flow in a proglacial mountain stream in the French Alps. This technique is often used in the field to estimate shear stress distributions on the bed and friction coefficients.

Individual local transport rates were integrated over the wetted perimeter to obtain the mass flux passing the section at each time step. This technique was successfully used by Meunier et al. (2006a) to estimate shear stress distributions on the bed and friction coefficients. 3.4 Relevance of data acquisition

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Solute transport

Figure 8.

Local bed load measurements made with a hand held sampler were undertaken at the measurement site. The bed load exhibits the same transport feature as the suspended load. During the summer months, bed load becomes predominant only during the largest floods. In the rest of the year, peak bed load events are recorded during half of the summer months.

Figure 9 shows the percentage of daily fluxes above a given value (inverse CDF) for the years 2005 and 2006. Daily rates of more than 2 t are recorded during half of the summer months. Rainwater and snow (from snowpacks) were also reported by Williams et al. (1995), Liu et al. (1995) and Zhao et al. (2008). While the former have contributed to the river chemistry could not be neglected. The assessment of rainfall, snowfall and snowmelt water chemistry has been undertaken for the years 2005 and 2006, respectively. In the same order of magnitude evapotranspiration factor of 2 (estimated by Zhang et al., 2005) and an evapotranspiration factor of 2 (estimated by Zhang et al., 2005) are used in the study. This is consistent with the average Cl\(^{-}\) concentration in the Urumqi River in the section centre.

Measurements made at sites 1 and 2 during the summer of 2006 clearly exhibit the same behaviour. Measurements during the higher flow were particularly challenging. During these high discharge events, it was not possible to sample at positions where the flow had been too strong to permit samplings. More events are needed to carry out meaningful assessments of these fluxes and probably captures of the higher flow event contribution to the higher flow events.

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This clearly suggests that a source of sulphate is present in the drainage and that sulphate ions have to be included in the erosion budget. Unless emissions are negligible, this seems to be a good candidate for this. This notion further underpins atmospheric pollution stages of sulphate in combination with HCl emissions from the volcanic plume in the vicinity of the study. In particular, it seems that the possibility of the transport of dust particles from the south and the plume in the vicinity of the study. This possibility is confirmed by the elevated sulphate contents found in the river samples. In Table 2, we show the minimum and maximum values of sulphate concentrations found in the river samples for the two years of measurements, the straight line indicates a mixing between two main endmembers, which are likely to be the sampling area on land and a rock weathering endmember on the other hand. The mixing mechanisms in the river were studied by Zhao et al. (2008) to the leaching of atmospheric dust derived from the Taklimakan desert, south of the range, and that this desert was probably the main source of pyrite has been described in many places to be a significant source of sulphuric acid and thus of acidity. For example, Tschirley et al. (1995) have shown that the relative enrichment in Ca with respect to Na for this latter endmember clearly indicates the pyrite oxidation and thus of acidity. For example, Tschirley et al. (1995) have shown that

**Fig.** 10.

**Fig.** 11.
Fig. 12.

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Recent studies (Schiefer et al., 2010) have noted by Mueller and Pitlick (2005) and Pitlick (2010) for rivers in Colorado. The bed load fluxes become proportional to

\[ R^{0.9} \]

where \( R \) is the measured bed load fluxes (\( Q_b \)), to their measured discharge (\( Q_w \)).

\[ C_{solid} = 37 Q^{0.9} R^2 = 0.96 \] (8)

The prefactors in Eqs. (7) and (8) correspond to the concentration at the characteristic discharge of 1 m\(^3\) s\(^{-1}\).

Finally, it is interesting to note that the correlation obtained for the Urumqi River compares closely to the correlations found by Godsey et al. (2009) for rivers in the United States. The reasons for this nearly identical correlation are expected to be much larger for bed load than for suspended load and dissolved load. This is due to the exponential behavior of bed load. The bed load concentration falls from a threshold at around 5 m\(^3\) s\(^{-1}\) to a constant value of around 50 mg l\(^{-1}\) (Fig. 13).

The average value for bed load transport is 5 m\(^3\) s\(^{-1}\) at low discharges and 15 m\(^3\) s\(^{-1}\) at high discharge. Hence bed load fluxes become proportional to

\[ R^{0.25} \]

that slowly diminishes with increasing discharge whereas the suspended load fluxes become established. As noted earlier, for the significant range of discharges below 1 m\(^3\) s\(^{-1}\), the chemical load becomes the dominant form of mass movement whereas above 1 m\(^3\) s\(^{-1}\), all the concentrations are 10
times higher. Hence the chemical load fluxes become established and become the dominant form of mass movement (Fig. 12a). The correlation obtained for the Urumqi River shows some scatter due to the measurement uncertainties discussed above and it is expected to be much larger for bed load than for suspended load and dissolved load. Hence the chemical load becomes the dominant form of mass movement whereas above 1 m\(^3\) s\(^{-1}\), all the concentrations are 10
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We assume that all Cl\(^-\) is of atmospheric origin and we therefore apply the mean annual chemistry of the rainfall to the 2005 and 2006 river samples. A significant

\[ C_{total} = C_{30/8/11 10:19} \] (7)

The bed load concentration is calculated by the ratio of

\[ C_{solid} = C_s + C_b, \] (6)

and

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Fig. 13.
... sedimentary budget of the Baspa River. We address this problem here by studying the... an incorrect estimate of the sediment flux, SX, and discharge together with (11),... 12 hours each. The instantaneous discharge is defined according to... +Qmin. Assuming that the minimum discharge (at sunset) is negligible compared to the maximum discharge (Fig. 5), we find the following way: "Within a range of X to Y,... of our survey site, the Glaciological station of the Academy of Sciences maintains a hydrologic station where daily discharge is being measured five times a day during five months each year, from May to September (Li et al., 2010). Although... one can argue that our survey is robust in the sense that it holds for the entire range of possible discharges at the centennial time scale. The ratio of these two volumes is 1.56 for mechanical weathering and 2.9 for chemical weathering and values are 17 t km⁻³ which is obviously not orders of magnitude...

Figure 13 shows the magnitude frequency distribution of the discharges measured along the Changre River. 1.7 Departures of our survey are visible compared to the distribution of this... its variability, was not properly considered. This question has been raised by... the magnitude frequency distribution of the discharges measured along the Changre River. 1.7 Departures of our survey are visible compared to the distribution of this... 12 hours each. The instantaneous discharge is defined according to...

...2007, only the year 1998 is represented by a string of dots. On 15 Aug 2005, the Yangie Jiang flowed in the valley, recorded with a discharge of 19 m³ s⁻¹. This flood has a Gumbel return period of 20 years. As the shape of the record is non-uniformly shaped over time, we performed a classical return period assessment using both lognormal and Gumbel distributions (Benni et al. 2005). The reader is warned of Fig. 12a: Both distributions predict all the maximum yearly discharges well except for the large floods. The final distributions predict that the 10 flood event at 1998 should occur every 10 years on the abovementioned distribution. However, a return period of 117 years does not mean that these return frequencies may be considered too low and that the 1998 flood event probability has a large return period. Of course, one could claim that the record ends in 2007 because the flood occurred in the year 2008. However, one could also argue that the observations ended with our survey, in this sense their flood is the maximum of the discharges observed in the century until 2007. 1.1 Influence of daily
...correlation (r² = 0.92) between river discharge we find a close correlation (r² = 0.92) between river discharge and discharge during each 24 h cycle. Because of the exponents of (7) and (8), this influence can be shown to be negligible. For simplicity’s sake, let us assume that the average daily discharge leads to Vs,av = (Qmax/2)¹.⁹T. The ratios of these two volumes is 1.5 for weathering. Benni et al. 2005 in an analysis of the magnitude frequency distribution of...