Review

The mass distribution of coarse particulate organic matter exported from an alpine headwater stream

J. M. Turowski, A. Badoux, K. Bunte, C. Rickli, N. Federspiel, and M. Jochner

General Comments:

This is an interesting topic which has received little attention in the geomorphological and sedimentary literature. The real strength of the paper is that it examines a wide range of CPOM components over a variety of sites and attempt to define a single scaling relationship. This is very commendable and based on the available data is generally done well. The context/introduction to this work is clear and overall the paper is well written. The content illustrates nicely the wide range of potential interactions between CPOM and stream processes over a wide range of scales. The basic aim to use dry mass as a descriptor in the scaling relation connecting all CPOM sizes from leaves to logs is interesting, and to some extent pioneering.

However, there are aspects of the paper that warrant further clarification / discussion and some specific issues that need to be addressed before the paper is finalised.

Specific Comments

The broad definition of Coarse Particulate Organic Matter (CPOM) is any material greater than 1 mm and includes wood and non-woody material. This is derived from Cummins (1974) [*Structure and function of stream ecosystems, BioScience 24, 631-641*]. It is interesting that CPOM in this paper is defined by dry mass (> 0.1 g) but in the introduction it is defined by size (> 1 mm). Also the smallest traps (bed load traps)had a bag mesh size of greater than 6mm hence CPOM here is defined as the fraction > 6mm? However, it does not appear a rigorous criterion for the smallest fraction has been consistently applied. The statement: '*all pieces of organic matter heavier than about 1 g were individually weighed and measured. In samples taken at lower discharges with the bed load samplers, all pieces heavier than 0.1 g or 0.01 g were individually weighed, depending on the total number of pieces*.' seems vague. The use of bed load traps of 0.2 x 0.3 m opening is bound to be problematic in this system where much of the CPOM will exceed these dimensions and either be not captured in the traps or block the openings and reduce the catch yields. During extended periods of deployment (up to 7 hours) such effects must have an impact on yield? Although it is acknowledged in the paper that the different sampling methods capture different fractions of the CPOM load and some components are 'missed' there is very little said about the different sampling efficiencies of the various methods? This is an important and needs to be accounted for when deriving the scaling relationships.

Because of the relatively low density of CPOM and its strong shape characteristics (twigs and logs) then rating relationships derived from a characteristic length scale (e.g. particle diameter) and discharge might be expected to be weaker than in classic alluvial systems. These relations will vary with the nature of the CPOM (organic particles – leaves – twigs – logs – whole trees (LWD)) so sampling efficiencies and transport behaviours will differ across the full 'particle' size range. For example the definition of large woody debris outlined in the introduction has an aspect ratio of 10:1. Fine CPOM will tend to 'drift' through the stream showing a weak relation with discharge whereas LWD may have a very high threshold discharge before it is entrained. Given these characteristics it is perhaps surprising that there is such a clear dependence on discharge. I would like to see greater discussion of the significance of shape in the CPOM components and an evaluation of its potential significance in affecting transport relations.

Another key element in explaining the CPOM dynamics in any stream system is defining the 'residence times' of the different fractions of the CPOM. We can probably assume the residence times of small fractions e.g. leaves and small twigs is very short but for larger logs these may form semi-permanent features of the channel. Furthermore, is there any bias introduced by sampling during mainly snowmelt events? The supply of CPOM to the channel will vary seasonal so sampling will reflect the seasonal flux to the channel.

In the final paragraph of Section 5.2, there is the bold statement that 'CPOM export for all size fractions can be estimated from [is] the volumes of LWD exported in a large event, … ' However, there is no indication of the error or uncertainty associated with such a procedure.

In section 5.3 it would be interesting to produce a Figure which shows the relation between wood mass (kg), frequency of delivery and flow. A 3 kg mass is an arbitrary definition of hazardous wood as in different situations a different mass would be significant. Also the hazard is not only related to the mass (impact potential) but also frequency, as high frequencies of woody debris can lead to blockage and damming e.g. culverts.

At the start of section 5.4 it is argued that the scaling component (P12, L16-20) is characteristic of catchment and channel characteristics. However, the discussion of Table 1 and Figure 7 provides little evidence to support this hypothesis and it is stated 'The scaling exponents do not show a strong correlation with any of the tested predictor variables mean elevation above sea level, drainage area, channel bed slope, channel width, forested area, and percent forested area ' (P13, L3-5). Thus there is some uncertainty of what the range in the exponent is telling us about the catchment and instream processes. Much more could be said about the difference between the exponents for transported CPOM and the CPOM locked in the bed material / bed structure. CPOM exponents for material that is 'locked-in' should be more clearly explained in terms of the physical processes that produce the difference. Furthermore, it is noted (P14, L9-10) that 'in general piece mass scales as a declining power law with scaling exponents in a narrow range between about 1.4 and 2.0' but what justification can be given that this is a 'narrow' range when the value of the scaling exponent cannot be correlated with catchment or channel characteristics?

Finally, it would be neat to compare thee scaling relationship for the components of a whole tree (possibly through tree allometry) with those that are transported in the stream system as this might reveal some interesting features of the breakdown of woody debris and transfer by fluvial processes?

Technical corrections:

Jackson and Sturm (2002) is missing from the reference list.
P2, L24 the sentence ' … from leave and wood fragments over twigs and branches to logs and complete trees.' should be rewritten ' … from leaf and wood fragments through twigs and branches to logs and complete trees.'
P4, L26 – 'annual' rather than 'yearly'
P3, L91 – Better expressed in $m^3 s^{-1}$ than l s-1 e.g. 50 year return frequency is 11.1 $m^3 s^{-1}$.
P6, L21-22 – It is not clear to me from the description provided how the representative discharge values were determined for the larger events. The methods seem prone to large uncertainty. Why was a value of 5000 $l s^{-1}$ chosen?

P7, L14 – Better to talk about ‘limb’ than ‘branch’ – confusing in the context of CPOM.
P7, L21 – it is ‘borne’ not ‘born’.
P9, L4 – Change to ‘In nine log jams …’.
Table 1 – Why is the scaling exponent for the Erlenbach not shown in the table? Add to caption explanation why two values (a/b) are given in the ‘#data points used for fit’ column.
Fig 1. – Detail of the Erlenbach catchment is not well shown in the annotated aerial photograph. Also could the other catchments used in Table 1 be added to main Swiss map?
Fig 2. - A threshold value of 2 kg for the retention basin samples appears to be a better value.
Fig 5. - When describing Figure 5 on P9, L6 – you talk about particle mass but the figure shows piece volume.
Fig 8. – X axis ‘Piece Length’
Fig 9. – Contradiction between the caption which states x axis is mass and the graph which shows it as volume. Given values I guess this is probably mass - a 2000 m3 piece of wood is very large!