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Interactive Comment

Interactive comment on "The mass distribution of coarse particulate organic matter exported from an alpine headwater stream" *by* J. M. Turowski et al.

B.J. MacVicar (Referee)

bmacvicar@uwaterloo.ca

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Turowski et al (2013) present an interesting study on the relative frequency of wood pieces of different sizes in alpine river systems. Their key conclusion is that the size distribution follows a scaling law over many orders of magnitude. The methods and the datasets are of good quality. This study is valuable because it has teased out general trends from what can appear to be an unpredictable process. However, the conclusion that the slope of the scaling law is constant across a wide range of drainage basins is not sufficiently supported, as is discussed in some detail below. A reanalysis of one data set is used to show that the exponent may be sensitive to channel bed slope. This

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Interactive Discussion

Discussion Paper

item is suited to a discussion rather than a correction by the original authors. A few minor points are also noted that can be corrected prior to the publication of the final version of this manuscript, but otherwise I feel that this paper is ready for publication.

In the discussion of their paper, Turowski et al (2013) make a connection with the results from the Ain River of MacVicar and Piegay (2012). Turowski et al (2013) estimated the relative frequency of floating wood pieces by mass using a technique that digitized length data from the earlier study and used a correlation found in the Erlenbach system to relate the wood piece length to mass. This relation (from Figure 8) had a fairly low correlation coefficient, which calls into question the accuracy of the results (shown in Figure 9). A better method is to calculate the volume of wood pieces from raw data rather than relying on a weak correlation between mass and length from a river system that is smaller (drainage area of 0.7 km2 versus 3630 km2 for the Ain River) and much steeper (channel bed slope of 18

The calculation of wood volume from the video analysis procedure was possible because diameter measurements were also made for each piece at the time of the original analysis. Wood volume was calculated for each piece by approximation the shape of each wood piece as a cylinder. As a note, only wood pieces with lengths greater than 1 m and diameters greater than 0.10 m were included due to the video resolution limitations and in keeping with the objectives in MacVicar and Piegay (2012), which were to detect and measure the quantity of large wood that was exported during flood events.

When the relative fraction of wood pieces is plotted versus wood piece volume, the distribution does plot on a straight line in log-log space for all three floods (Figure 1). Assuming that mass is related to the volume of wood by a constant wood density, this figure thus supports the conclusion that the relative fraction (C) of the respective particle mass (M) can be described using a power function of the form C = $kM^{-\alpha}$. The coefficients (k and α) also appear to be constant for all three floods, which again confirms a significant conclusion of Turowski et al. (2013). The most significant difference between the results shown here and those as presented in Figure 9 by Turowski et al.

is the magnitude of the scaling exponent (α). Where the video procedure results in a fairly mild slope of α = 0.8, Turowski et al found a higher value (α = 1.62) using the correlation between mass and length found at the Erlenbach. The higher value was used as evidence of a universal scaling law because it corresponded with values obtained from basket samples and bedload traps of much smaller wood pieces (α = 1.41 to 2.26), wood pieces locked in jams in ten Swiss mountain streams (α = 1.39 to 1.75) and for all wood pieces in those same streams (α = 1.78 to 2.04).

Ultimately it may be easier to work from wood piece length data rather than volume data. The relative frequency of wood piece lengths has also been plotted on Figure 2 for comparison. Similar to the volume data, the distribution of wood pieces by length also follows a power law that is independent of the flood event being considered, showing that it also agrees with two of the major trends identified by Turowski et al. (2013). The exponent for the length (α = 1.9) than that of the slope. These observations provide further justification for the definition of piece length categories defined on a log base 2 (ÏŢ) scale as recommended by MacVicar and Piegay (2012). Volume data is difficult to work with because it is difficult to measure unless wood pieces can be analyzed in a laboratory situation. Using two different methods to obtain the volume distributions, widely different exponents were obtained. While the analysis from the raw data presented here is felt to be more reliable than the correlation between piece mass and length for material from the Erlenbach system, it nevertheless relies on an assumption that wood pieces are cylindrical, which may not be accurate in many cases.

The current analysis of the raw data shows a much lower slope exponent than those found by Turowski et al (2013) in headwater alpine systems, and it is possible that this difference reflects real variability between the field sites. Turowski et al (2013) noted that the distribution of wood exported from a system is not likely to match the distribution of wood inputs to the river channel. A large portion of the wood mass is thought to enter the river as part of whole trees, meaning that the exponent α would be lower close to the input source or that a bimodal distribution would be found. The change

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in the river, characterized as an increase in alpha and/or a lower variability around a scaling law, is thought to be related to wood breakdown. Wood breakdown occurs as a result of stresses during transport and decay during the inter-flood periods. We should thus expect that the exponent α will reflect distance from a source or different breakdown rates. In systems where rapid breakdown occurs, larger wood pieces should be relatively rare and smaller pieces more common. In the alpine systems, wood transport is mixed with bedload, which is why it can be measured in a bedload trap, and it will be frequently submitted to large localized forces that could lead to breakage. In the Ain River, a bedload trap would yield little information about wood transport because it floats at the water surface, which is why it can be measured using a streamside video camera. Wood and bedload are clearly separated in the Ain and wood transport is likely to be much more benign.

In conclusion, the exponent α of the power law between relative frequency and wood size may be sensitive to the channel bedslope. While Figure 7 in Turowski et al (2013) shows no relation between bed slope and α, all of the sampled streams were mountain streams with a minimum gradient over 5

Specific Comments

6/21 – Why was an assumption of 5000 L/s made? Is there any justification for this assumption? What is the sensitivity of your results to this assumption?

5/6 - In many rivers wood will float at the water surface and thus not be mixed in with the bedload at the bed surface. At an 18

8/20 – why were the data from the two extreme events not included?

10/4 – bimodal assumption seems uncertain. Branches are more likely to break off than whole trees. Scaling would then be affected by distance from source.

Conclusions – interesting to note that there is a possible similarity with other breakdown processes. Most familiar to me is the -5/3 slope on Kolmogorov's (1941, "Dissipation of

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energy in locally isotropic turbulence in an incompressible viscous liquid", Dokl. Akad. Nauk SSSR, 30, 299-303.) scaling law for turbulence as part of the energy cascade. Big turbulent structures beget smaller turbulent structures. The energy cascade used a reversed axis in comparison with the current work (smaller turbulent structures were to the right) and was measuring the amount of energy in each scale rather than the frequency. Paiement-Paradis et al.(2003, "Scalings for large turbulent flow structures in gravel-bed rivers", Geophysical Research Letters, 30(14), 1773) used conditional sampling to look for the frequency of events of different durations and plotted them in log-log space. They found similar scaling laws with exponents between α = 1.44 to 1.82 for these type of events.

Figure 2 – Should the relative count not add up to 1.0? How is the relative count determined if not by normalizing by the total number of wood pieces?

Minor

1/24 – leaves

1/24 – wood fragments over twigs – incorrect use of word ‘over’, meaning not clear

7/21 – ‘borne’ is past tense of ‘to bear’.

Figure 8 – Piece length

Figure 9 – I don’t think the values on the x-axis can be correct. See the figure included in this discussion for appropriate wood volumes. The caption says mass, so it is possible, in fact likely that the x-axis is mislabeled rather than the values.

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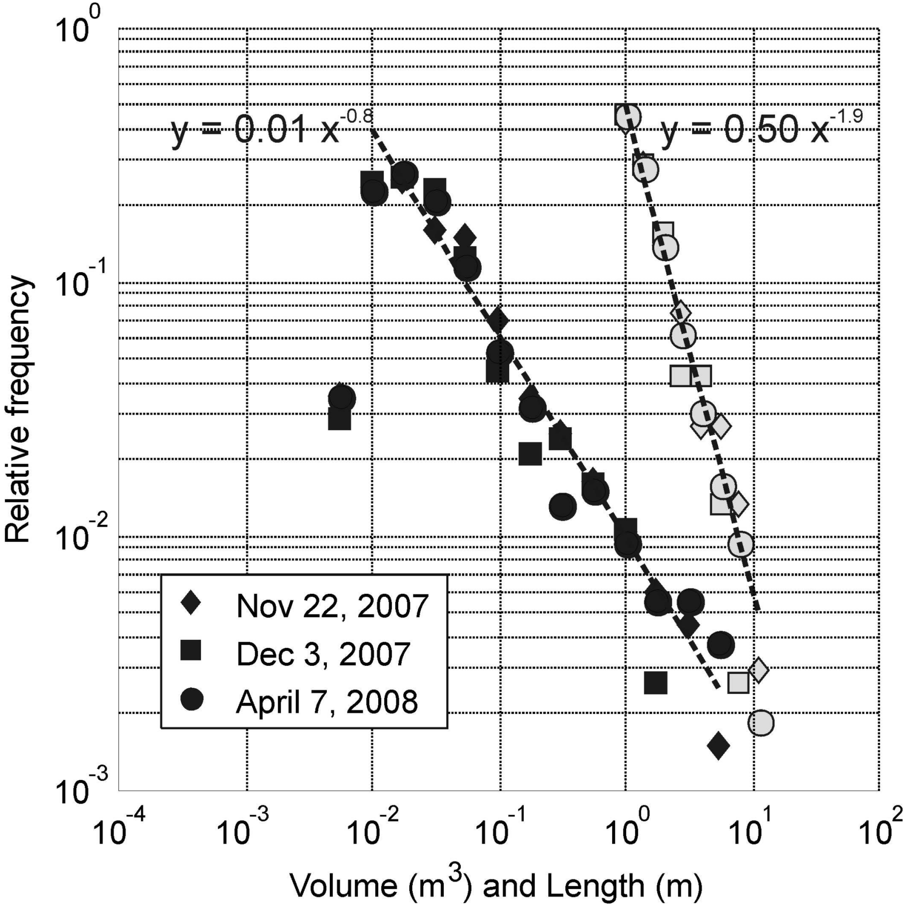

Fig. 1. Relative frequency of wood for three floods as described in MacVicar and Piegay (2012). Solid black symbols are used for wood piece volume and outlined grey symbols are used for wood piece length

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