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Hydrology and Earth System Sciences Discussions

Interactive comment on "Development of a river ice jam by a combined heat loss and hydraulic model" *by* J. Eliasson and G. Orri Gröndal

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Development of a river ice jam by a combined heat loss and hydraulic model J. Eliasson and G. Orri Gröndal. Received and published: 23 June 2008

Authors response to reviewers comments

Anonymous Referee #2

Review Report Hessd-2008-0020

General comments: This paper provides a real insight into how the icejam equation works and provides a practical example of how it can be used in the case of a change in slope. This is very useful information as jams often occur there. The formal linkage between ice production and ice jamming is a real contribution. So many articles deal with breakup jams so it is important to see an article deal with a freeze up jam.

Response:This is what we hope to achieve,provide a real insight into how the icejam equation and a formal linkage between ice production and ice jamming.

Questions: * How do dimensionless values (e.g., "a" or "L") differ from dimensionless values used by Beltaos or Ashton? If different, are they similar? How do proposed equations compare with Beltaos or Ashton? * How do results compare with numerical models (e.g., HEC-RAS)?

Response:Parameter “a” has the unit of length-1. “a” relates to “jam strength parameter” “μ” in Beltaos according to (equation provided in a seperate pdf) Thus, for a given strength characterisitc the geometry of the jam is governed by the channel slope and width. This is in agreement with Beltaos. However, Beltaos has shown that overall water depth in breakup jams is related to dimensionelss flow strength. An analogue analysis of the Urriðafoss freezeup jam has not been done yet. Camparison of this theory with numerical models is yet to be done. Comparision with HEC-RAS is cited in section 1.1 (Eliasson and Gröndal (2006)) but not repeated in this paper.

Required clarifications:

* Page 1024: what are the units of C and how is C related to the calculated volume? Response: C is unitless; it represents volume of solid ice pr. volume of water in a river cross section. Clarification added in table of notations after eq. 2.

* What are the units of Volume? Does it include porosity? Response: The units of volume are m3. Bulk volume of the Urriðafoss ice jam is estimated from measurements of elevation of the surface of the jam and measurements of the elevation of the ice free river surface. Bulk volume of the ice jam includes solid ice, liquid water and air in the pores of the jam and water level increase because of backwater effects.

* How is S obtained? Is it from the air/water transfer only (and therefore dependent on C) or is a global value? Does it depend on surface area? What are its units? Based on

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Figure 2, what is the computed air/water transfer coefficient? 17Watts/m2? How does shore fast ice effect the formula? Response: Heat loss from the water column is calculated according to empirical expressions which were adopted from literature, (originally from Carstens, 1970-1 and 2) and confirmed with field measurements of heat loss from open water surfaces carried out in Reykjavík during late 1960ies and early 1970ies (references exist in reports,but in icelandic language only). It is assumed that heat loss is dominated by evaporation, radiation and convection through the air/water interface, and that other effects such as melting of falling or drifting snow, entrainment of cool air in rapids, groundwater inflow and conduction through the river bed are insignificant in comparison and therefore neglected (p. 1025 lines 1 – 15). Input in the heat loss calculations are time series of air temperature, cloud cover, relative humidity, wind speed and average solar radiation; temporal resolution is 1 day. The unit of heat loss is W/m2, and total heat loss depends on the size of the open water area. The size of the open water area is taken as a constant value optained from measurements made during winter conditions when shore fast ice occupies the borders of the river. Effects of shore fast ice are therefore included in the calculation of S (explanation added p. 1025 line 18). The effects of C on heat loss from the water column are neglected; this is justified as C almost never exceeds 0,01 – 0,05 except in the jam itself (which may be an oversimplifycation as C is not equally distributed in the cross section). The air/water transfer coefficient is incorporated into the empirical formulae used, it is not constant as it depends on wind speed and relative humidity.

* Figure 2a: There is no real mention of Q – How was V obtained? Response: Normal water consumption in the hydropower plant at Búrfell just upstream from the actual river section is approximately 300 m3/s (clarification in Fig. 2 caption). Little or no water is bypassing the powerplant during ice events and tributaries are insignificant, therefore discharge can be taken as 300 m3/s. River width and depth is roughly 200 m and 1,5 m respectively.

* Figure 3 : Not sure what solid horizontal blue bars mean Response: Daily observa-

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tions of ice conditions in Thjórsá were made in the winters indicated in the figure. It was noted whether there was frazil or slush ice in the river (horizontal light blue bars) or whether a stable and stationary ice cover had formed on the river (horizontal dark blue bars) Clarification added in fig. 3 caption..

* Missing figure : Please add a definition sketch please for y, h, etc. … or at least refer to a specific definition sketch found in Beltaos or Ashton. Response:Reference to figures in Beltaos and Ashton added p 1026 line 5.

* Figure 4: What do series 3 and 4 refer to? Response: New Fig. 4 with improved legend provided

* Table 2: Hard to follow – What are the columns "x" and "2 jams" referring to? Response:Clarification added page 1033 line 10 – 15

* Equation 3 : Is the first term correct ? * Since the hydraulic radius is half the depth, in equation 7, under root, it should read +2ay and not +4ay. Response: Eq. (3) corrected Indeed, in equation 7 under the root, it should read +2ay. So corrected.

* Similarly in equation 8, to get y, the term should be multiplied by 2(2/5). (The two previous errors are partially off-setting.) Response: So corrected.

* On page 1028, line 19, "So" does appear in y and therefore "hm" is not DIRECTLY linear with "So". Response: Inversely, so corrected

* Page 1030, according to line 15, h = hL at x = 0 whereas according to line 17, h = hL at x = L. The text is a little hard to follow with respect to the value of x in relation to the waterfall from equation 11 and equation 12. Response: Clarification added

* On page 1031, first paragraph, dam should read jam at both locations. Response: So corrected.

Final commant by authors:

We want to thank this referee for providing import antand very helpful comments and

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suggestions. We hope that all necessary corrections and clarifications are now finished and we send a final manuscript to the handling editor.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 1021, 2008.