Hydrol. Earth Syst. Sci. Discuss., 10, C3858–C3861, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C3858/2013/

Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Water consumption from hydropower plants – review of published estimates and an assessment of the concept" *by* T. H. Bakken et al.

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Received and published: 7 August 2013

This paper addresses the essential issue of loss of water related to the regulation of river discharge for hydropower or other technical purposes using dams. Water is "lost" due to evapo-transpiration and which is generally expressed in terms of the "water footprint". This paper discusses the various definitions of water footprint used to evaluate the usefulness of hydropower projects and, specifically shows a large variety in results. The authors exemplify for a number of cases available in the literature how the gross and net water consumption as well as the water balance approach is used to calculate the water footprint. The net water consumption and the water balance approach fo-

cus on the change in water consumption associated with the hydropower project rather than the total consumption. Further, the authors stress the importance of setting relevant limitations of the area under consideration as well as the selected time-series used in the analysis. They show for specific cases that the net water consumption is only 12 % to 60 % of the gross water consumption.

A main methodological theme of the paper emanates from Eqns. (1) – (3) reflecting various ways of equating the ratio of water consumption (in cubic meter) to the gain in terms of hydropower production (in Joule or MWh). The authors make an important point in stressing the relevance of using the change in water consumption and the importance of system boundaries for this issue. In my opinion these are important standpoints for assessing the water footprint and would have liked a clearer recommendation on how the change in evapo-transpiration should be assessed and the effects of different approaches. The paper uses the Köppen– Geiger classification of climatic regions and this is obviously a related very important factor for explaining and understanding the water footprint. There also is a brief discussion in the paper e.g. mentioning that "water hungry vegetation" present before the exploitation "will to limited extent change the original evaporation". However, in order to explain the water footprint one would have to consider the change in landtypes resulting from a hydropower project, the shift in area between landtypes even outside the reservoir itself and the associated evapo-transpirations are key to understanding the water footprint. Recent studies for Swedish landscapes show that the actual evapo-transpiration from lakes is nearly equal to the potential evapo-transpiration as well as the precipitation, whereas there are various degree of deviations from these relations for other landtypes (van der Velde et al., 2013).

The consideration of changes in landtypes would naturally involve a second topic discussed by the authors, the selection of area boundaries for the analysis. This problem not only involves the upstream watershed, but also downstream river and water use for irrigation and in cascading hydropower plants (as discussed in the paper). The expressions for the water consumption (Eqns. (1) – (3)) reflect that evapo-transpiration is evaluated for the reservoir (area) alone before and after inundation. Especially in multi-purpose projects, involving e.g. municipal water supply or irrigation, and cascade hydropower the land area of the analysis has to be selected more generally than expressed by the evaluated water consumption expressions. Further, a change in water level in a reservoir has a corresponding effect on adjacent groundwater levels and possibly damming effect in the river system. Thus, since the paper includes a discussion on these methodological problems, it could have specifically included a general expression for or recommendation how to equate the water footprint.

The authors, furthermore, stress the importance of the system boundaries in terms of selection of the duration and frequency of the time-series. This is an essential topic especially in light of the changing environment that tends to introduce drifts in the statistics of river discharge. The uncertainty of e.g. the estimate of the annual mean discharge depends significantly of the auto-correlation (Ballesta, 2004; Zhang, 2005), reflecting that there might be periods in which the data is biased in relation to the mean. Such periods with a significant auto-correlation can extend for decades and an even longer lasting drift has been found in the variance properties (power spectra) of river discharge from landscape with changing agricultural practice (Wörman et al. 2010).

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 8071, 2013.