supplement to Comment on "100-year mass changes in the Swiss Alps linked to the Atlantic Multidecadal Oscillation" by Matthias Huss et al., GRL 37, 2010

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We estimate the minimum difference between the reference-surface mass balance and the specific mass balance of the last decade for the glaciers used in the study of Huss et al. [2010]. The mass balance relative to the 1908 glacier surface is calculated using data on glacier length change [Swiss glacier monitoring network, 1881-2009]. Most of the area loss is at the glacier tongue [Paul, 2007] and is thus related to the change of the frontal position of the glacier. Twelve of the 30 glaciers used in the study of Huss et al. [2010] have a length change record covering, most of, the 1908-2008 period (Table 1). The length change ΔL times the width of the glacier tongue W provides a minimum estimate of the area loss $\Delta A = W\Delta L$ (Figure 1). If we assume that ΔA is much smaller than the present-day surface area A_{pd}, the difference between the average mass balance and the average reference-surface mass balance is given by:

$$\Delta b = \frac{\dot{b}\Delta A}{A_{pd}} \qquad (1)$$

where $\dot{b}$ the specific mass balance for the lost ablation area ΔA. We calculate $\dot{b}$ at the altitude of the present day tongue from the average ablation on the tongue of the Swiss Morteratsch glacier of -6 m.w.e. a^{-1} [Oerlemans et al., 2009] and a balance gradient of 0.006 m.w.e a^{-1}m^{-1}. The width of the glacier tongue is measured from Swiss Topo maps, scale 1:25000. For A_{pd} we take the values given by Huss et al. [2010]. If we assign equal weights to large, medium-large and small glaciers as in Huss et al. [2010], the weighted average of Δb, is -0.36 m.w.e a^{-1}. The mean specific mass balance over the last decade is -0.87 m.w.e a^{-1} [Huss et al., 2010]. Thus the minimal estimate of the mean reference-surface mass balance for the last decade is -1.23 m.w.e a^{-1}. Δb only contributes to the negative trend and not to the amplitude of the sinusoid fitted through the mass balance anomaly. Hence, the contribution to the recent glacier wastage of natural variability related by Huss et al. [2010] to the AMO is 33% at most. This is clearly lower than the 50% estimate calculated by Huss et al. [2010].

References

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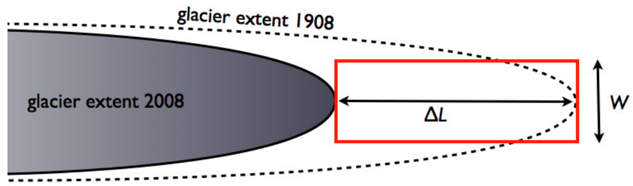

Figure 1: Schematic illustration of the estimated area loss from length change ΔL and glacier width W. Shown are the former glacier extent in 1908 (dashed) and the present day glacier extent (shaded). The red rectangle indicates the minimum estimated area loss.

Table 1: Glaciers used for minimum estimate, their observed length changes, estimated minimum loss of ablation area, present day ablation at the tongue and calculated difference between reference-surface mass balance and specific balance. Following Huss et al. [2010] the glaciers are divided in three groups: large $>$15 km^2 (5), medium 3-15 km^2 (4) and small $<$3 km^2 (3).

glacier	ΔL (period) m	ΔA_{min} km^2	$\dot{b}$ m.w.e. a^{-1}	Δb m.w.e. a^{-1}	
Aletsch	-2430 (1908-2007)	1.51	-9	-0.16	LARGE
Gorner	-1998 (1908-2007)	1.20	-5.5	-0.17	
Unteraar	-1765 (1908-2001)	0.90	-7	-0.28	
Untere Grindelwald	-714 (1908-1983)	0.48	-10	-0.25	
Rhone	-740 (1908-2007)	0.53	-5.5	-0.18	
Allalin	-1190 (1908-2005)	0.47	-3	-0.15	MEDIUM
Gries	-1732 (1908-2006	0.78	-4	-0.15	
Trient	-848 (1908-2007)	0.51	-7	-0.61	
Zinal	-1102 (1908-2007)	0.33	-6	-0.64	
Basodino	-495 (1908-2008)	0.37	-3	-0.51	SMALL
Pizol	-338 (1908-2008)	0.08	-3	-3	
Verstancla	-439 (1926-2008)	0.11	-4	-0.48	