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The Cryosphere Discussions

Interactive comment on "Surface mass budget and meltwater discharge from the Kangerlussuaq sector of the Greenland ice sheet during record-warm year 2010" *by* D. van As et al.

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This section compares predicted runoff, calculated using a surface energy balance model, with observed discharge in the proglacial river, which was measured in Kangerlussuaq, approximately 25 km from the ice sheet margin. There is reasonable agreement between the two records, although there is some mismatch which is explained by uncertainty about the size of the catchment area.

The authors observe that there is a lag between peaks in calculated runoff production and peaks in observed discharge in both 2009 and 2010, and argue that this reflects the time taken for meltwater to move through the glacier drainage system. It is then

stated that the lag between meltwater production and observed runoff decreases over the course of each summer melt season.

The authors state that the late summer decrease in this lag is explained by an evolving subglacial drainage system, which becomes more efficient in response to inputs of meltwater from the ice sheet surface, allowing meltwater to be transported to the ice margin more quickly.

I agree that seasonal development in the structure of the subglacial drainage system occurs in this section of the Greenland Ice Sheet margin. This has been indicated by a number of ice dynamics studies (e.g. Van de Wal et al., 2008, Bartholomew et al., 2010, Sundal et al., 2011, Bartholomew et al., 2011a), the preliminary borehole work which is referred to (Harper et al., 2011) as well as a detailed hydrological study at Leverett Glacier (which is within the catchment in this paper) from 2009 (Bartholomew et al., 2011b).

I do not think, however, that the data presented in this study can be used to support these studies. Firstly, the change in lag between peak meltwater production and runoff is only addressed qualitatively and is not clear to me from visual inspection of figure 7. Secondly, any change in lag between these two records must also reflect changing supraglacial conditions (such as snowpack removal), englacial drainage conditions, distance which meltwater has to travel (as melt occurs at higher elevations), and transport in the proglacial river. It is difficult, therefore, to ascribe these observations to changes in the subglacial drainage system alone.

It is stated that "the smeared-out freshwater discharge" which is observed at Kangerlussuaq is "regulated in a funnel-like fashion by the drainage system of the ice sheet". In a study at Leverett Glacier in 2009, however, we found significant short-term variations in runoff at a location <2km from the glacier snout that are not evident in figure 7a (compare with figure 2 in Bartholomew et al., 2011b). This suggests that a lot of the "smearing out" also happens in the proglacial stream and that it is difficult to make in-

ferences about the ice sheet drainage system using hydrological observations at such a large distance (>25km) from the ice sheet margin.

Overall, this section seems to be a bit of an afterthought: the data are not thoroughly investigated and it is not particularly clearly written. The data do not provide any new insights into subglacial drainage system development and, for the reasons outlined above, I do not think that they can be used to support existing hypotheses.

Specific comments:

p2333/19: It would be useful to see the catchment delineated on a map (e.g. in Figure 1) p2333/21-22: "There are no fair-sized streams near the ice margin". What is meant by 'fair-sized streams'? We have seen streams carrying 1-2 cumecs within 8 km from the margin near Leverett Glacier and much larger streams within 35 km of the margin. p2333/23: "virtually the entire ablation zone, efficiently draining meltwater". Do you mean the entire Greenland Ice Sheet ablation zone? This is quite a large area for such observations. It also seems likely that the efficiency of englacial transport is spatially and temporally variable. p2334/20-29: again, it is important to actually see the extent of the catchment. p2335/10-11: Please refer to the recent hydrological study of Leverett Glacier in 2009 (Bartholome et al., 2011b) which investigates drainage system development in this section of the ice sheet. p2335/11: "continuously increases its capacity" - it also increases in size over the course of a melt season, with upglacier extension of efficient drainage at the expense of a distributed system. Again, see Bartholomew et al., 2011b.

References not currently in the manuscript:

Bartholomew, I., P. Nienow, A. Sole, D. Mair, T. Cowton, S. Palmer, and M. King (2011a), Seasonal variations in Greenland Ice Sheet motion: inland extent and behaviour at higher elevations, Earth and Planetary Science Letters, 307, 271–278, doi:10.1016/j.epsl.2011.04.014.

Bartholomew, I., P. Nienow, A. Sole, D. Mair, T. Cowton, S. Palmer, and J. Wadham (2011b), Supraglacial forcing of subglacial hydrology in the ablation zone of the Greenland Ice Sheet, Geophysical Research Letters, 38, L08502, doi:10.1029/2011GL047063.

Van de Wal, R., W. Boot, M. Van den Broeke, C. Smeets, C. Reijmer, J. Donker, and J. Oerlemans (2008), Large and rapid melt-induced velocity changes in the ablation zone of the Greenland Ice Sheet, Science, 321 (5885).

Interactive comment on The Cryosphere Discuss., 5, 2319, 2011.