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The Cryosphere Discussions

Interactive comment on "Simulating the growth of supra-glacial lakes at the western margin of the Greenland ice sheet" *by* A. A. Leeson et al.

Anonymous Referee #3

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Overview: This paper presents an attempt to model the location and growth of supra-glacial lakes across a catchment in the SW of the Greenland Ice Sheet based upon the routing and storage of modelled runoff across a DEM of the ice sheet surface. Supraglacial lakes have been the focus of much recent research owing to their importance as potential points of connection between the supra-glacial and subglacial drainage systems, particularly across high elevation regions of the Greenland ice sheet. Their distribution, size, volume, and drainage mechanism have formed an important component of recent field and remote sensing based studies to determine their significance to the issue of melt-induced dynamic acceleration. This paper focusses on modeling their distribution and growth, an area of study that has been less well explored. The model is run for a DEM with spatial resolution of 100 m based upon the InSAR derived work of Palmer et al (2011) with melt input from the MAR regional cli-

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Interactive Discussion

Discussion Paper

mate model with 25 km spatial resolution. The model benefits from being conceptually simple. Output is assessed by making comparisons against MODIS derived estimates of the distribution and growth of supraglacial lakes. Statistical tests of the model performance in being able to predict the location of lakes are undertaken and conclude that the method achieves a good degree of success in this regard. Sensitivity of the model to temporal resolution of melt delivery and to runoff magnitudes are explored and discussed. Reasons are provided for mismatch between the model output and observations including limitations of observational sampling and caused by simple physical process representation within the model. The fact that the model does better in the region between 1000m and 1600m elevation is a good result as this is the region where lakes may be the principal agents in the process of transfering melt-water through thick cold ice. If hydrological and ice flow models are to be successfully coupled then models may have to account for the role of supraglacial lakes. This paper tackles this challenge and explores the potential of one approach that may inform future modelling strategies. As such it makes a useful contribution to the topic.

General points: The main point of concern I have that has not been mentioned by previous reviewers is in the statistical methods used to determine the success or otherwise of the lake location forecasts. The authors use two scores, the Odds Ratio (OR) and the Peirce Skill Score (PSS). The OR gives a result that sounds impressive but should probably not be used since it is so heavily skewed by the overwhelming number of correct non-event forecasts (type d forecasts in a 2 by 2 contingency table). The Peirce Skill Score does better, but again the large number of type d forecasts renders the numbers produced less meaningful. Other tests could be applied that would not give such apparently good results: the Heidke Skill Score (HSS) is similar to the PSS but because of the bias in the data towards over prediction of lakes it comes out with a lower score of about 0.34. The Threat score is considered better for forecasting of rare events, i.e. when type d forecasts are very numerous, and may be more applicable here. It, and the related Gilbert Skill Score (GSS), give lower scores of 0.23 and 0.21 respectively. Perhaps some more sophistocated test which incorporates a spatial dimension would be the best. I would recommend the authors discuss their data with a statistician with expertise in this type of problem.

The paper would also benefit from a much clearer statement about the rationale for this type of modelling. The abstract ends with a statement about the authors optimism that their work will be developed further but there is little in the paper itself which gives a clear statement of what the next steps in this development should be. This is an opportunity that they should take. If the long-term objective is to be a step towards coupled melt and ice flow models then perhaps this should be stated. Large scale ice sheets models are unlikely to run at the spatial resolution of the DEM used here and so some analyses of the model sensitivity to a coarser spatial resolution of DEM would be useful.

Other points:

Little said about sensitivity of the model to uncertainty in the vertical resolution of the DEM. Radar backscatter from the ice sheet surface varies across different ice sheet snow facies. At the the large scale of the ice sheet this is a small error but, what effect would an uncertainty of 1-2 m in identifying the surface have on the area and volume of supraglacial lakes given that they are typically quite shallow features?

The assumption is made that the DEM from 1996 is a valid basis for lake prediction a decade or more later. This may be questionable but is probably unavoidable, however this uncertainty should be considered consistently throughout the paper. It is probably not strictly defensible to claim that the error in the input DEM is the reason for the forecasting of near misses (p1321 lines 14-16) but implicitly assume that it works well when predicting a "hit".

p1317 ln5, p1317 ln14-16 p1324 Ln6: It's not obvious early on whether the PSS scores relate to the whole study area or just the area between 1000 m and 1600 m elevation. Need to clarify this.

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p1318 ln15: Some might think that an overestimation of 51 percent does not mean the model has performed "well" in predicting cumulative lake area. Rephrase this?

p1324 ln24 to 1322 ln 6: this is an example of a section that is very repetitive of earlier sections and there is scope for reducing the length. This general point has been made by other reviewers.

Interactive comment on The Cryosphere Discuss., 6, 1307, 2012.

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