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Birth and demise of lakes on the Greenland Ice Sheet

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The stability of ice sheets are a major concern under the ongoing climate change. Drainage of supra-glacial lakes has been shown to be an important mechanism for enhanced basal sliding and also for increased speed of the ice sheet. We have investigated the initiation, evolution, disappearance and location of these lakes on the Greenland ice sheet to obtain better understanding for the spatio-temporal variations in lake distribution.

For this task we have used Moderate Resolution Imaging Spectroradiometer (MODIS) images from 2007 and 2008 situated over part of the western Greenland Ice Sheet. The images were collected every 5 days during the entire ablation season. We have used manual delineation of lake extent to generate a temporally dense set of lake observations. The lakes in each image were linked together in such a way that the lake evolution could be followed. Lakes where then divided into transient lakes (available only in one image) and sustained lakes (available in multiple images).

Using air temperature data from Kangerlussuaq and by applying a lapse rate approach we have been able to link initiation and termination of lakes in relation to the estimated time and elevation dependent temperature field. Our results quantitatively show that lake formation is closely coupled to a threshold in energy input for melting; lakes disappear due to two processes, draining during the summer season and freeze-over at the end of the ablation season. Some lakes also drain only to re-appear later during the season. The positive degree days needed to initiate lakes are; 38.2˚C days for 2007 and 42.4˚C days for 2008 and the mean life time expectancy were for 2007 22 days and in 2008 19.1 days. Given the error margins associated with the PDD method the two years exhibit a marked similarity in energy input required for lake initiation.

Lakes initiate at lower elevations ($<$1000 m a.s.l.) early in the melt season in response to the seasonal rise in temperature. These lakes have a similar life time expectancy and size as the lakes at higher elevations ($>$1500 m a.s.l.). This is probably related to the steeper slopes at lower elevations limiting lake basin extent and at higher elevations the available amount of energy is likely to be the constraining factor for the evolution of these lakes, due to the less numerous PDD at these elevations.