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Detection of Supra-Glacial Lakes on the Greenland Ice Sheet Using MODIS Images

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During melt season, supra-glacial lakes form on the margins of the Greenland ice sheet. Because of their size exceeding several kilometers, and their concentration, they affect surface albedo leading to an amplification of the regional melt. Furthermore, they foster hydro-fracturing that propagate liquid water to the bedrock and therefore enhance the basal lubrication which may affect the ice motion. It is known that Greenland ice sheet has strongly responded to recent global warming. As air temperature increases, melt duration and melt intensity increase and surface melt area extends further inland. These recent changes may play an important role in the mass balance of the Greenland ice sheet. In this context, it is essential to better monitor and understand supra-glacial spatio-temporal dynamics in order to better assess future sea level rise. In this study MODIS (Moderate Resolution Imaging Spectroradiometer) images have been used to detect supra-glacial lakes. The observation site is located on the West margin of the ice sheet, between 65°N and 70°N where the concentration of lake is maximum. The detection is performed by a fully automatic algorithm using images processing techniques introduced by Liang et al. (2012) which can be summarized in three steps: the selection of usable MODIS images, mainly we exclude images with too many clouds. The detection of lake and the automatic correction of false detections. This algorithm is capable to tag each individual lake allowing a survey of all lake geometrical properties over the entire melt season. We observed a large population of supra-glacial lakes over 14 melt seasons, from 2000 to 2013 on an extended area of 70.000 km^2. In average, lakes are observed from June 9 $\pm$ 8.7 days to September 13 $\pm$ 13.9 days, and reach a maximum total area of 699 km^2 $\pm$ 146 km^2. As the melt season progresses, lakes form higher in altitude up to 1800 m above sea level. Results show a very strong inter-annual variability in term of date of melt and freeze up onset, melt season duration, maximum total surface area and number of lakes. As it has already been noticed, we observed a strong spatial persistence. Lakes tend to form at the same place for several years, probably because of the ice sheet surface topography. In order to investigate possible links with climatic parameters we calculated positive degree day (PDD). The main result of this comparison is a strong correlation between melt intensity and the altitude of lakes. During warmer summer, lakes form higher in altitude and consequently the extent of melting increase. Recent studies showed this trend is likely to continue and to increase in the years to come.