Geophysical Research Abstracts, Vol. 8, 08452, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08452

Energy balance of N-Vatnajökull, Iceland, during extreme glacial river floods

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We describe the energy balance and melting of the Brúarjökull outlet glacier of the Vatnajökull ice cap and the exceptional circumstances leading to three extreme floods in the main river Jökla draining the outlet, two of which occurred in August 2004 and one in July 2005. A typical July and August mean river discharge is around 400 $m^3\ s^{-1}$, but daily average flow of 700 - 800 $m^3\ s^{-1}$ where observed during the flood events. Flood prediction is crucial because the river is presently being dammed for production of hydropower. One to three automatic weather stations, providing the full energy balance, have been operated on the glacier outlet during the summers since 1996. The meteorological data, along with mass balance observation at stakes and satellite optical images, where used to produce energy balance maps for the entire outlet glacier. Runoff calculated from the energy balance data satisfactorily agree with the measured river discharge. The results show that the first flood was related to intensive rain, but the second and third to glacial melting maintained by exceptionally warm and sunny weather accompanied by unusually low glacier surface albedo. During the second and third floods, up to 40% of the net energy supplied for melting could be explained by high turbulent heat fluxes driven by the warm air advecting over the glacier. The main contribution to the glacial melting was from high net radiation maintained by the clear solar radiation and the low albedo. Circumstances leading to the low albedo during the second flood in August 2004 were days with high turbulent heat fluxes driven by strong southerly winds at the end of July and heat supplied by rain in August, all speeding up the removal of snow in the ablation area. The low albedo during the third flood was mainly due to sand and dust blown over the glacier in July 2005. Our analyses of the processes providing the floodwater are used to evaluate how frequent extreme flood events may be related to both weather- and glacier surface conditions that can be expected on the ice cap.