The influence of snow cover thickness on the thermal regime of Tête Rousse Glacier (Mont Blanc range, 3200 m a.s.l.): Consequences for outburst flood hazards and glacier response to climate change

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[1] Tête Rousse Glacier (French Alps) was responsible for an outburst flood in 1892 that devastated the village of St Gervais-Le Fayet close to Chamonix, causing 175 fatalities. Changes in the hydrothermal configuration of the glacier are suspected to be the cause of this catastrophic outburst flood. In 2010, geophysical surveys of this glacier revealed a subglacial lake that was subsequently drained artificially. The processes controlling the thermal regime of the glacier have been investigated on the basis of measurements and snow/ice cover and heat flow models using meteorological data covering the last 200 years. Temperature measurements show a polythermal structure with subglacial water trapped by the cold lowest part of the glacier ($-2^\circ$C). The modeling approach shows that the polythermal structure is due to temporal changes in the depth of the snow/ice cover at the glacier surface. Paradoxically, periods with negative mass balances, associated with warmer air temperature, tend to cool the glacier, whereas years with colder temperatures, associated with positive mass balances, tend to increase the glacier temperature by increasing the firnpack depth and extent. The thermal effect of the subglacial lake is evaluated and shows that the lake was formed around 1980. According to future climate scenarios, modeling shows that the glacier may cool again in the future. This study provides insights into the thermal processes responsible for water storage inside a small almost static glacier, which can lead to catastrophic outburst floods such as the 1892 event or potentially dangerous situations as in 2010.


1. Introduction

[2] In all mountainous glaciated area, polythermal structures can be observed on glaciers. Many studies have described this kind of glacier in the Alps [Eisen et al., 2009], Greenland [Loewe, 1966], Alaska [Rabus and Echelmeyer, 2002; Harrison et al., 1975], the Rockies [Paterson, 1972; Clarke and Goodman, 1975], the Himalayas [Maohuan, 1990; Gulley et al., 2009], the Peri-Antarctic Islands

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