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Recent glacier retreat over Kerguelen archipelago (49°S, 69°E) derived from field data, satellite imagery and modelling

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Situated in the Indian Ocean at 49° S, 69° E, Kerguelen archipelago represents a unique sub-polar observational site. Located at low altitude and on islands, the glaciers are particularly sensitive to oceanic and atmospheric variations (e.g. Poggi, 1977a,b; Vallon, 1987). The cryosphere on Kerguelen showed important fluctuations during the last 2 centuries (Frenot et al., 1993). After a small stable period until 1961, the ice cap showed a huge and extremely quick retreat, losing 20% of its surface during the last 40 years (Berthier et al., 2009). Relating directly this acceleration with the fluctuations of temperature and precipitation inferred from direct meteorological measurements is attractive and was generally performed (e.g. Frenot et al., 1993, 1997; Berthier et al., 2009). However, it was recently discovered that the drastic temperature change may be mainly due to changes in meteorological station characteristics in 1973 (Météo France, personal communication), challenging previous interpretation.

The analysis of field data collected on Ampere glacier since 2010 presented here provides a first approach in our aim to understand the recent rapid retreat of its cryosphere. In this area, short term mass balance data from previous studies (Vallon 1977a,b, 1987) were compared to recent mass balance measurements. The analysis revealed that the spatial distribution of SMB significantly changed in 40 years. Collecting spatially distributed data of the surface characteristics and ablation was crucial to better interpret our field data. Recent variations (from 2000 to 2012) of the equilibrium line altitude (ELA) of Cook ice cap derived from MODIS imagery confirmed that the ELA rose about 100m since 2000. Additionally, we analysed meteorological and reanalysis data over Kerguelen from 1950 to 2012, in order to assess the causes and processes involved in the retreat of the ice cap, and present additional SMB and ELA estimates from a simple positive degree-day model. We concluded that the parameter with the largest variation was precipitation, which was associated to a decrease in cloud cover. The direct impact of these changes was a rise of the 0°C level that led to a reduction of the occurrence of solid precipitation at low elevation. These retroactions demonstrate that Kerguelen's glaciers are extremely sensitive to small climatic changes.

These results on glaciological processes of Ampere glacier are an important base to constrain modelling approaches to assess past, present and future ice cap variations. In this framework, regional scale simulations of mass balance processes over Kerguelen archipelago have been initiated with a downscaling scheme (SMHiL) and with the regional climate model MAR (Modèle Atmosphérique Régional).