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Mass Balance of Campbell Glacier (Northern Victoria Land, Antarctica): Preliminary Analysis

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INTRODUCTION

This study aims to estimate the mass balance of Campbell Glacier (northern Victoria Land, East Antarctica) by integrating ice-core data with remote sensing data. The estimate of mass balance has been addressed through a component approach (surface mass balance minus ice discharge at grounding line). Snow accumulation estimates, based on firn cores, were integrated with remote sensing data in order to determine the net surface mass-balance distribution. Ice discharge was assessed at the grounding lines by defining surface velocities (through the analysis of multitemporal imagery) and determining the vertical sections (RES) of glacier (Frezzotti et al., 2000).

Campbell Glacier (164°22'E 74°25'S), about 125 km long, drains a mountainous coastal zone of Victoria Land (Transantarctic Mountains); it originates near the South end of Mesa Range and drains South-East between the Deep Freeze Range and Mt. Melbourne. It flows into northern Terra Nova Bay, forming a Glacier Tongue about 17 km long that tends to remain constant over the time (Frezzotti, 1993). Many glaciers from the Deep Freeze Range (to the western side) flow into the Campbell Glacier (Raney, Recoil, Harper, Rebuff, Capsize and Bates Glaciers), whereas only the Styx Glacier flows into the Campbell basin from the east side, draining the Southern Cross Mountains.

The snow deposition process is very complicated on the Transantarctic Mountains where katabatic winds are strong and snowstorms severe. Converging katabatic winds in Terra Nova Bay greatly influence the environmental conditions in Victoria Land. The primary route for katabatic winds into Terra Nova Bay is the Reeves Glacier valley, but an important secondary source is provided by airflow down the David and Priestley Glaciers (Bromwich et al., 1990).

Wind-field data derived from surface aeolian morphologies (snow drift, sastrugi, windscoop and drift plume) show that katabatic winds from the West and SW cross Eisenhower Range and Priestley valley, and affect the Deep Freeze Range and the leeward area (hydrographic right) of Campbell Glacier (Frezzotti, 1998; Zibordi & Frezzotti, 1996), where they are responsible for the extensive formation of blue-ice areas. In the eastern part of the Campbell Glacier valley (hydrographic left) the effect of winds strongly diminishes. Automatic Weather Station 7356 on Tourmaline Plateau (74°11'S, 163°29'E, 1700 m; Baroni, 1996) shows that prevailing winds blow mainly from the West and SW. Winds can reach speeds of over 40 kts, and speeds greater than 7 kts persist for more than 50% of the year. Measurements at Vostok Station show that snow transportation by saltation starts at wind speeds of about 9 kts. Several authors (Watanabe, 1978; Pettré et al., 1986; Frezzotti et al., 2002) have highlighted the influence of katabatic winds on snow accumulation. The extensive presence of blue-ice area and glazed surfaces caused by long-term hiatuses in accumulation, with nil or negative accumulation rates (mainly due to sublimation and wind scouring), has a significant impact on the surface mass balance of a wide area of the western Campbell Glacier. Firn and ice albedos generally decrease from the visible to the near infrared wavelengths (*e.g.* Warren, 1982), whereas the spectral reflectance of glazed surfaces is intermediate to that of snow and ice (Frezzotti et al., 2002). Different spectral properties of snow, ice and glazed surfaces allow these features to be easily identified in satellite images.

DISCUSSION

The surface mass balance rate is the difference between gross accumulation (from precipitation, drifting snow deposition, condensation, vapour-to-solid sublimation, and superimposed ice) and the gross ablation rate (deflation of snow, evaporation, sublimation, and surface melt runoff). In most of Victoria Land there is no melting at the surface, and percolation of summer melt into the underlying layers accumulated in previous years is generally limited to areas below altitudes of 600 m (Frezzotti, 1997). The statistical relationship between accumulation and elevation has been investigated by a number of researchers (*i.e.*, Fortuin & Oerlemans, 1990). Many accumulation/ablation rates measured in different areas of northern Victoria Land are used to elaborate snow accumulation/ablation models which take into account variations in altitude (Baroni et al., 1995; Bintanja, 1999 and references therein; Folco et al., 2002; Stenni et al., 2000 and references therein). Accumulation/ablation rates and elevation show a very good negative correlation. Cores collected from the western side of Campbell Glacier are an exception; they show a very low correlation due to the intensity of wind scouring. Remote sensing data (Landsat MSS, TM, ETM+ and Spot) was used to characterize surface conditions in order to distinguish positive accumulation zones from nil (wind glazed surfaces, rock outcrops) or negative ones (blue-ice areas). These types of surfaces are mostly located on the western side of the basin.

Since elevation is an important parameter controlling snow precipitation and ablation, data were combined with a Digital Terrain Model to obtain the distribution of areas according to elevation. On the basis of the distribution of surfaces (rock outcrops, blue ice, *etc.*), ice core data, basin morphology and wind directions, the Campbell Glacier basin was divided into two parts (Fig.1). All elements playing an important role in the process of snow accumulation were input in a Geographical Information System (GIS) for calculating the net mass balance of the glacier.

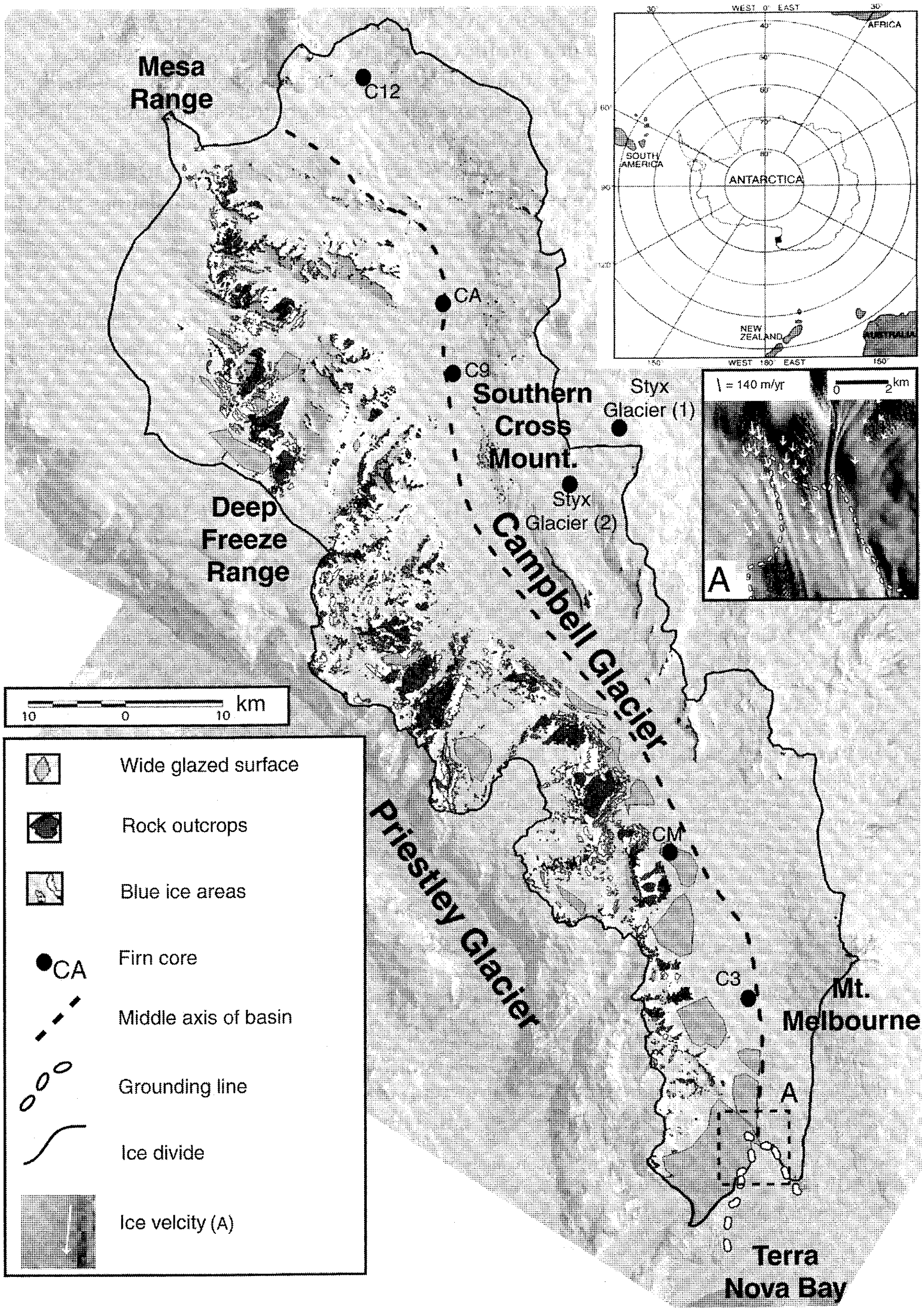

Fig. 1 – Satellite image of Campbell Glacier.

Airborne radar surveys were conducted over Campbell Glacier to determine ice thickness and bed morphology along longitudinal profiles of the grounded and floating segments. A new analysis of Landsat TM satellite images using a tracking technique enabled the measurement of ice velocities at grounding lines and along ice tongues. The integration of radar and satellite data helped locate the grounding lines and calculate the ice discharge.

The calculated discharge of ice was compared to the net surface balance determined by integrating ice core and remote sensing data. Preliminary mass balance calculations show that equilibrium conditions prevail at Campbell Glacier.

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