In this paper, we reexamine sublimation of buried ice deposits in the Dry Valleys. As a point of departure from earlier theoretical work, we gather site-specific field data and consider models that incorporate the effects of textural facies in supraglacial tills and measured (non-linear) temperature variations with depth (e.g., Schorghofer, 2005, 2007; Kowalewski et al., 2006). Our study focuses on Mullins till, a thin and dry supraglacial till (Bockheim et al., 2007) that rests directly on buried ice from Mullins Glacier, purportedly one of the oldest alpine glaciers in the world (Bidle et al., 2007; Marchant et al., 2007).

Our results indicate that buried ice is sublimating, but at an extremely slow rate; <0.09 mm a^{-1} near the glacier terminus. Our sensitivity tests suggest that a stable ice surface (e.g., with sublimation rates of 0.00 mm a^{-1}) is possible with only modest changes to present atmospheric conditions, e.g., consistent with an overall increase in summertime cloud cover.

2. Regional setting and background

The McMurdo Dry Valleys (MDV; 78°S. latitude) occupy 4000 km^2 of predominantly ice-free terrain between the western Ross Sea and the East Antarctic polar plateau (Fig. 1). The land surface rises in a series of steps that at ~100 km from the coast reaches a maximum elevation of 2900 m at Mount Feather (Fig. 1). Deep, east–west trending valleys cut across the mountains and provide considerable local relief. Given the strong covariance between summertime air temperature and bedrock elevation in the MDV (Doran et al., 2002), environmental conditions vary widely but predictably (Marchant and Denton, 1996). On the basis of measured changes in summertime atmospheric temperature, relative humidity, soil temperature, and soil moisture, Marchant and Head (2007) divided the region into three microclimate zones, each fostering a unique suite of endemic landforms: a coastal thaw zone, an inland-mixed zone, and a stable upland zone. Mullins Glacier lies within the stable upland zone (Fig. 1), a region with extremely cold atmospheric temperatures (mean summertime temperature ~−11 °C and mean annual temperature of −23 °C) and dry conditions (Doran et al., 2002; Kowalewski et al., 2006; Vieira et al., 2010). Such conditions ensure that ablation is entirely via sublimation, with no observable melt at the surface of buried glacier ice.

2.1. Mullins Glacier

Mullins Glacier is a small, debris-covered alpine glacier that descends from bedrock slopes incised in Ferrar dolerite, Beacon Heights orthoquartzite, and Arena sandstone at the head of Mullins Valley (77.874° S., 160.537° E.) (Fig. 2). It is ~8 km long, between 0.5 and 0.7 km wide, and up to ~150 m at its thickest measured point (Shean et al., 2007; Shean and Marchant, 2010). It is sourced from a

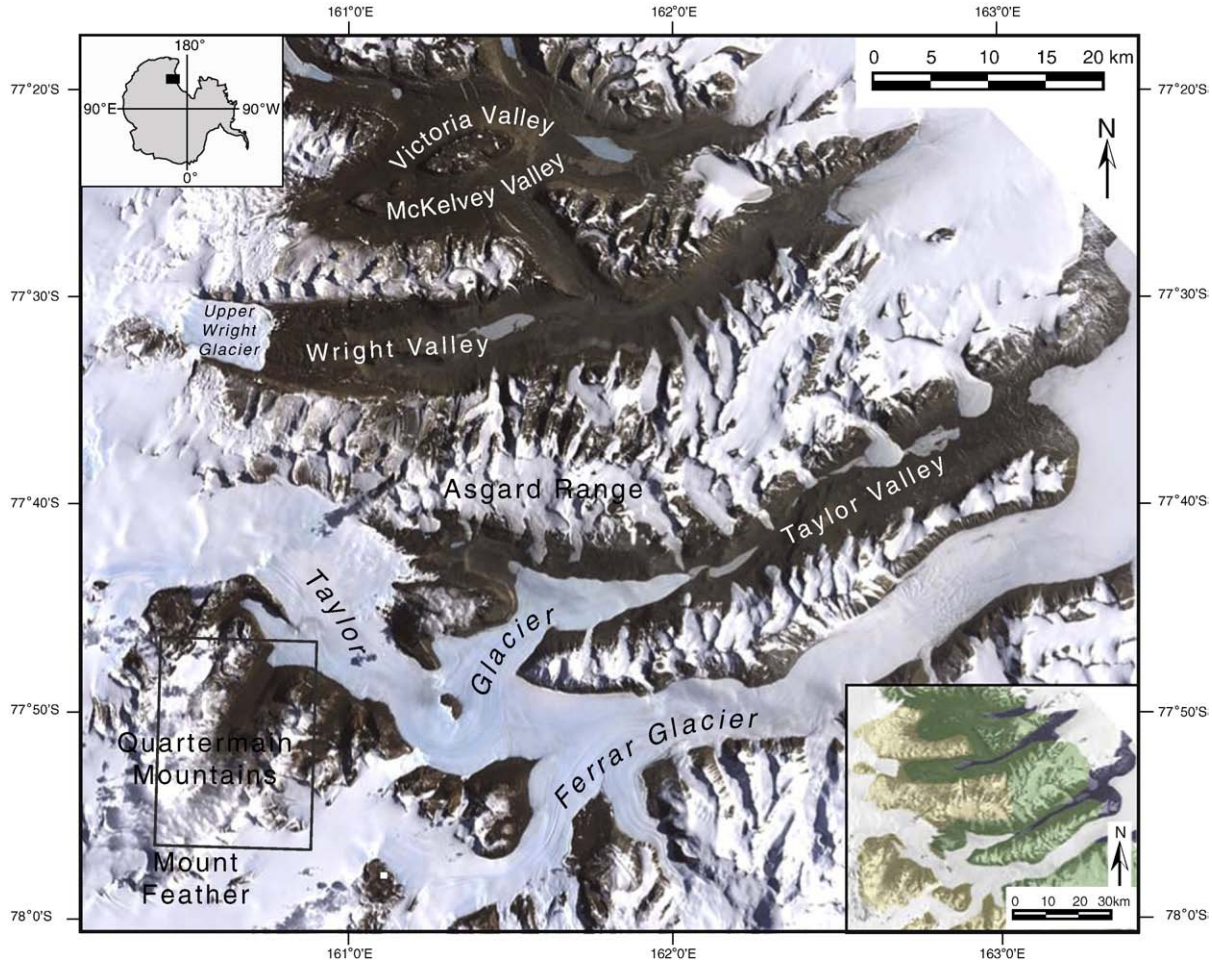

Fig. 1. Satellite image of the McMurdo Dry Valleys. Centered at ~77°35′ S., the region encompasses ~4000 km^2 of predominantly ice-free terrain between the western Ross Sea (off image to the right) and the East Antarctic polar plateau (off image to the left); top left inset shows location of the MDV on the sketch of the Antarctic continent. Lower right inset shows geomorphic zones for the MDV as defined by Marchant and Denton (1996) and Marchant and Head (2007); dark blue is the coastal thaw zone (CTZ); green is the inland-mixed zone (IMZ); and tan is the stable upland zone (SUZ) (see text for details). The box in the Quartermain Mountains, SUZ, outlines Beacon Valley and merging tributaries, including the Mullins Valley tributary (see Fig. 2 for details).