CHAPTER II

SITE DESCRIPTION

To develop a method of using SAR to track the ELA, a study area must be selected. Four factors are required for a good study site. First, to examine dry snow conditions, to quantify SAR penetration, the glaciers must be polar glaciers. Second, a variety of glaciers must be in a close proximity to compare different glaciological features and topographic characteristics relative to the SAR position. Third, access to the study site must be available to support the investigation. Fourth, the surface travel over the glaciers must be accessible by foot; too many crevasses and icefalls would preclude surface travel and therefore this experiment. The glaciers in Taylor Valley, Antarctica meets all the requirements for this research.

Taylor Valley is about 35 km long and 12 km wide, extending from McMurdo Sound to the east and to the Taylor Glacier (an outlet glacier of the East Antarctic Ice Sheet) in the west (Figure 1.1). The Asgard Range bounds the Taylor Valley to the north and the Kurki Hills to the south, both rising 2,000 m.

The mean annual air temperature of Taylor Valley is -18° C, with summer (December and January) temperatures reaching 0° C and winter temperatures dropping as low as -40° C (Clow et al., 1988). Average monthly wind speeds range from 2-4 m s^{-1} in Taylor Valley. In 1995 the mean annual wind speeds ranged from 2.7-3.9 m s^{-1} with peak averages 11-15 m s^{-1} (*ibid*). Testifying to the high winds of the valley, ventifacts are found throughout the valley (Fountain et al., 1998). Precipitation in the valleys is less than 10 cm water equivalent yr^{-1}; however it is mostly lost to sublimation and does not accumulate (Keys, 1980).

The winter climate is strongly influenced by episodic katabatic winds. The katabatic winds begin on the Polar Plateau with intense radiative cooling of the ground and subsequent downslope movement of cold near-surface air under the influence of gravity (Parish and Bromwich, 1987). As the air descends, it heats adiabatically and its relative humidity drops. These winds exhibit speeds up to 20 m s^{-1} and persist for an average of six hours (Clow et al., 1988). At Lake Hoare, adjacent to Canada Glacier, katabatic winds greater than 5 m s^{-1} occur 33% of the time during the winter; air temperatures increase 20-30˚ C; to approximately -12˚ C, and the relative humidity drops by 20-30% (*ibid*).

Meltwater streams originate from all glaciers in the valleys indicating surface melt during the austral summer (Fountain et al., 1998). Stream flow is dependent on melting ice and is determined, in part, by air temperature (Conovitz et al., 1998). This melt water is the primary limiting condition for life in the valley: during the short summer, the glacial meltwater transports water and the nutrients that the biologic community depends on (Conovitz et al., 1998; Moorhead and Priscu, 1998).

Snow has a very high albedo (the reflectivity of a surface) from 0.7-0.9 reflecting most of solar radiation, whereas ice has a much lower albedo, 0.2-0.4, absorbing more energy and melting more readily (Patterson, 1994). Because of this, even a thin snow cover greatly influences glacial melt. A summer snowstorm covering the glacier ice stops almost all melt for weeks (Fountain et al., 1998).

Many glaciers in Taylor Valley have steep termini that form near-vertical cliffs (Fountain et al., 1998). Most of the glaciers are small (3-5 km^2) alpine glaciers that descend from altitudes of about 1000 m to the valley floor about 50 m above sea level. Net snow accumulation is only 0.1 m water equivalent (weq) averaged over the accumulation zone. Similarly the annual mass loss in the ablation zone is on the order of 0.1 m weq. The glaciers vary in roughness from smooth (roughness less than 1 cm) to extremely rough (10 m or more). The movements of the glaciers are slow, roughly 4 m yr^{-1} (Fountain, unpublished). The equilibrium line altitude (ELA) of the glaciers rises from about 200 m near McMurdo Sound to about 900 m at the western end of the valley (Fountain et al., 1999). The rise in the ELA results from a strong climatic gradient in the valley: snowfall decreases and windiness increases away from the coast. Since glaciological observations began in Taylor Valley, the snow in the accumulation zones has been dry, although thin ice layers in the snow indicates slight melting (Fountain et al., 1998). Melting is mostly limited to the exposed ice region near the lower margin of the glaciers (*ibid*). The mass changes of Taylor Valley glaciers are small: 10-30 cm of snow collecting in the accumulation zone and 6-15 cm of ice lost in the ablation zone (Fountain et al., 1999). The primary components of ablation in Taylor Valley are sublimation, evaporation, and melting. Surface energy calculations on Canada Glacier indicate that evaporation and sublimation accounts for up to 70-90% of the summer ablation, and melting 15-30% (calving accounts for 1-3%) (Lewis et al., 1995).

McMurdo Dry Valleys Long Term Ecological Research (LTER).

The National Science Foundation funded, McMurdo Dry Valleys Long Term Ecological Research (MCM-LTER) project, has studied the Taylor Valley ecosystem since 1993 (Fountain et al., 1999; Harris, 1998). The project is one of twenty-one sites representing diverse and unique ecosystems, ranging from the dry valleys in Antarctica, to a tropical rainforest in Puerto Rico (*ibid.*). Taylor Valley is relatively pristine, with a relatively sparse ecosystem (dominated by microbiota) with short food chains, and lacks all high plant and animal life (Moorhead and Priscu, 1998). The valley presents an opportunity for study of basic ecological processes without complications of higher organisms. The environment is very sensitive to physical changes and offers an opportunity for measuring response of the ecosystem to subtle climatic variation (Harris, 1998; Moorhead and Priscu, 1998). The life that exists in this polar desert is approaching the environmental limits of life on Earth (Moorhead and Priscu, 1998). It is an "end member" in the spectrum of environments studied by the LTER network (*ibid*).

The glaciological research of the MCM-LTER project helps to define the controls on water flow variation in the valley that animates the biotic community. The project has produced a rich body of data that are useful for interpreting SAR data. The glaciological investigations in the valleys include mass balance measurements, surface energy balance calculations on the Canada Glacier, ice velocity measurements, and ice depth. These studies are focused on four glaciers: Canada, Commonwealth, Howard, and Taylor glaciers. Glacier mass balance data are collected twice a year, once in the spring (November) and once in late summer (January), to provide winter and summer mass changes (Fountain et al., 1998). The measurements are based on a 130-stake network spread across the four glaciers. The main questions being answered by these measurements are (1) whether the glaciers are in balance with the current climate, (2) how surface slope and aspect affect ablation, and (3) methods for predicting glacial melt. The measurements at each stake include surface height change, snow density, and stratigraphic characteristics of the snow (including snow crystal size and form). From surface height change and density, mass change is calculated.

Nine meteorological stations are located in the dry valleys with eight in Taylor Valley (Doran et al., 1995). All stations measure air temperature, humidity, ice (or soil) temperature, wind speed/direction, snowfall, and incoming and outgoing solar flux. Stations located on Glaciers also measure longwave radiation and barometric pressure is measured at two stations (Lake Hoare and Canada Glacier). The sensors are queried every 30 seconds and store data every 15 minutes.