CLIMATE CHANGE INDICATORS - PERMAFROST

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Almost half the land mass of Canada is underlain by permafrost, a large proportion of which is at temperatures of a few degrees below 0°C (Smith et al. 2001a). Temperature variations in the near-surface permafrost (20-200m depth) can be used as a sensitive indicator of the inter-annual and decade-to-century climatic variability and long-term changes in the surface energy balance (eg. Lachenbruch and Marshall, 1986; Beltrami and Taylor, 1994). Seasonal thaw depths may also increase in response to climate warming resulting in subsidence of the ground surface where surficial materials are ice-rich. The response of the permafrost environment to changes in air temperature is modulated by variations in many local seasonal factors and site characteristics such as snow cover, vegetation, surficial material, moisture content and drainage.

Evidence of change in the southern extent of the discontinuous permafrost zone in the last century has been recorded. In North America, the southern boundary of the discontinuous permafrost zone has migrated northward in response to warming after the Little Ice Age, and continues to do so today (Thie, 1974; Vitt et al., 1994; Halsey et al., 1995; Laberge and Payette, 1995; French and Egorov, 1998). Long-term monitoring of shallow permafrost began in earnest in the last few decades. Recent analyses of trends in shallow permafrost temperatures indicate that permafrost is currently warming in many regions of the earth (eg. Sharkhuu, 1998, Vonder Mühll et al., 1998; Romanovsky and Osterkamp, 1999) but the onset, magnitude and rate of warming varies regionally (Osterkamp and Romanovsky, 1999). In the western Arctic, recent warming of permafrost has been observed in Alaska (Fig. 1) and thaw depths (Fig. 2) in the Mackenzie valley and Delta have increased (Osterkamp and Romanovsky, 1999; Wolfe et al., 2000, Smith et al., 2001b). In the central Yukon however, this warming signal has not been observed (Burn, 1998). In the Canadian High Arctic (Fig. 3), warming of a smaller magnitude in shallow permafrost has been observed in the late 1990s (Smith et al. 2001c). There is also evidence of permafrost cooling from the late 1980s to the mid-1990s in the eastern Canadian Arctic (Fig. 4) (Allard et al., 1995) but recent evidence suggests warming of permafrost in the latter part of the 1990s (Allard, 2001).

There are however regional data gaps, such as in the central and high Arctic and large areas of the discontinuous zone, and we are not yet able to fully evaluate the temporal and spatial changes in permafrost conditions in North America in the last few decades. A new international permafrost monitoring network, the Global Terrestrial Network for Permafrost (GTN-P) has been developed to help address these gaps and document the spatial and temporal variability in permafrost conditions across the permafrost zone (Burgess et al., 2000). This program consists of two components: (i) monitoring of active layer through the circumpolar Active Layer Monitoring (CALM) program established in 1990; (ii) a new program for long-term monitoring of the thermal state of permafrost in a network of boreholes.

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