20 YEARS OF ACTIVE LAYER MONITORING IN THE MACKENZIE VALLEY, NORTHWEST TERRITORIES

C. Duchesne[1], S.L. Smith[1], M. Ednie[1], and J. Chartrand[1]

Introduction:

The Mackenzie Valley landscape is characterized by widespread permafrost terrain ranging from continuous on the Beaufort coastal plain to sporadic discontinuous in the south (Fig. 1). Changes in permafrost conditions, including active layer thickness, influence ground stability and drainage which has implications for environmental and infrastructure integrity.

The Geological Survey of Canada has maintained an active layer monitoring network in the Mackenzie Valley and Delta since the early 1990s for determination of annual maximum thaw depth and ground movement. The network currently includes 45 sites established in areas of representative vegetation and surficial material.

Thaw tubes are utilized to determine maximum annual thaw penetration and maximum heave and subsidence of the ground surface (Fig. 2). Most sites are equipped with instruments to measure air and near-surface ground temperature. Some sites also have a thermistor cable installed to measure deeper ground temperatures.

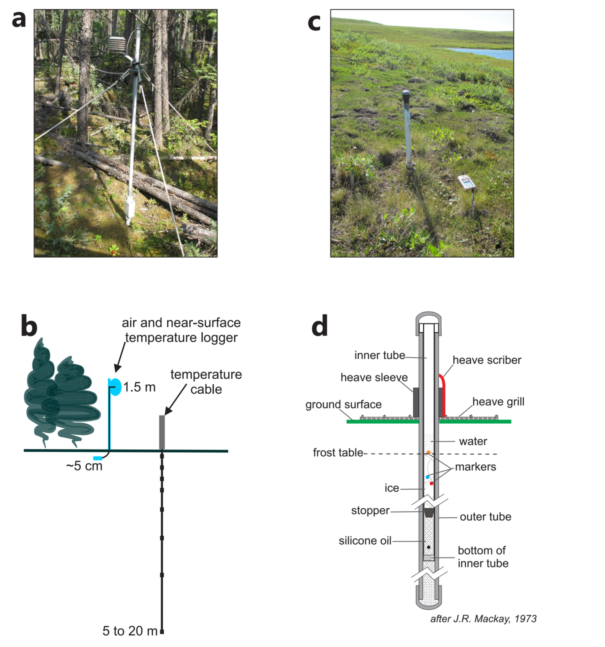

Figure 2: Monitoring installations include multi-channel temperature cable, air and near-surface temperature logger (**a**, **b**). Thaw tube (**c**, **d**) measures maximum thaw penetration and ground heaving during the year.

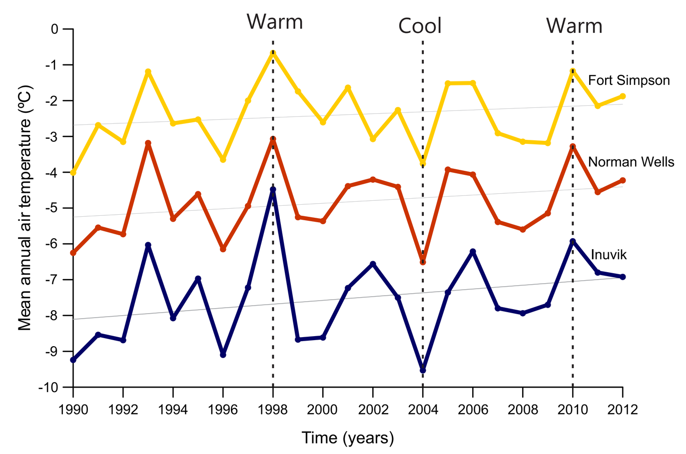

Figure 3: Mean annual air temperature in the Mackenzie Valley (Environment Canada, 2013).

Site description:

The climate of the Mackenzie Valley is characterized by long winters. Air temperatures have increased since 1990 by 0.26 °C/decade and 0.53 °C/decade in the north and south respectively (Fig. 3). Total annual precipitation varies from 248 mm at Inuvik to 369 mm at Fort Simpson of which half falls as snow which may stay on the ground seven to eight months of the year (Environment Canada, 2013).

Vegetation ranges from boreal forest in the south to tundra in the north. Extensive peatlands are found in the southern portion of the region, where organic cover may be several metres thick (Aylsworth and Kettles, 2000). Ice-rich sediments, in particular lacustrine silts and clays, are also common throughout the valley and delta (Aylsworth et al., 2000).

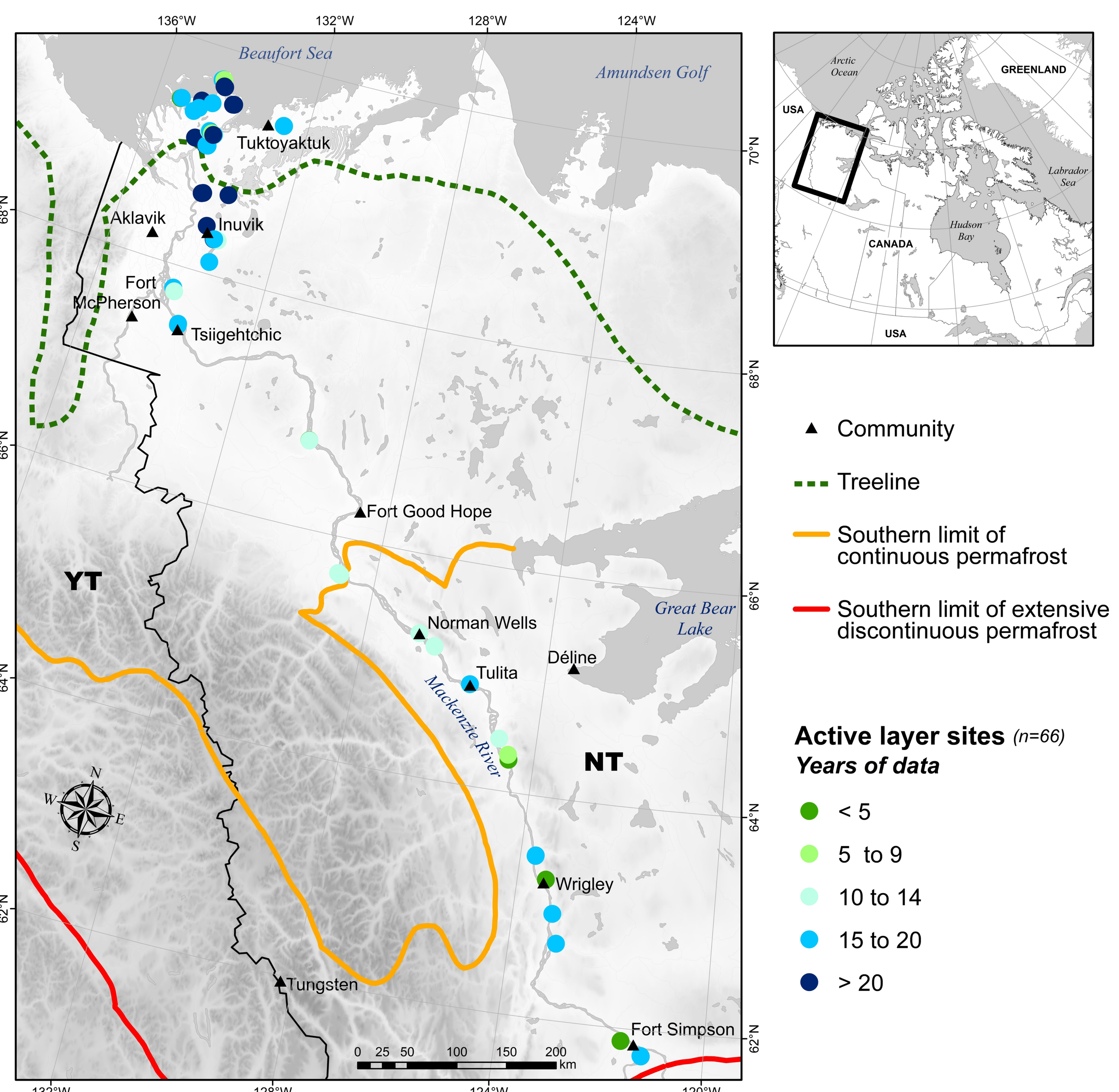

Figure 1: Location map of active layer monitoring sites in the Mackenzie Valley, Northwest Territories.

Active layer and latitude:

Mean active layer thickness in the Mackenzie Valley ranges from less than 50 cm in the north to greater than 100 cm in the south (Fig. 4).

North of treeline, active layers are generally thinner than below treeline with substantial spatial variation (Fig. 4) reflecting the influence of micro-topography, edaphic conditions and ice content. The direct relation between air temperature and active layer is evident with thicker active layer in warmer years (Fig. 5). Also, note changes in the ground surface elevation for ice-rich sites.

South of treeline, greater inter-site variability is observed (Fig. 4) and is a consequence of the insulating effect of the vegetation in summer and variable snow cover in winter. The moderating effect of ground insulation for these sites is apparent with a dampening of the active layer response to variations in air temperature although some of the warmer (1998) and cooler (2004) years are noticeable (Fig. 5).

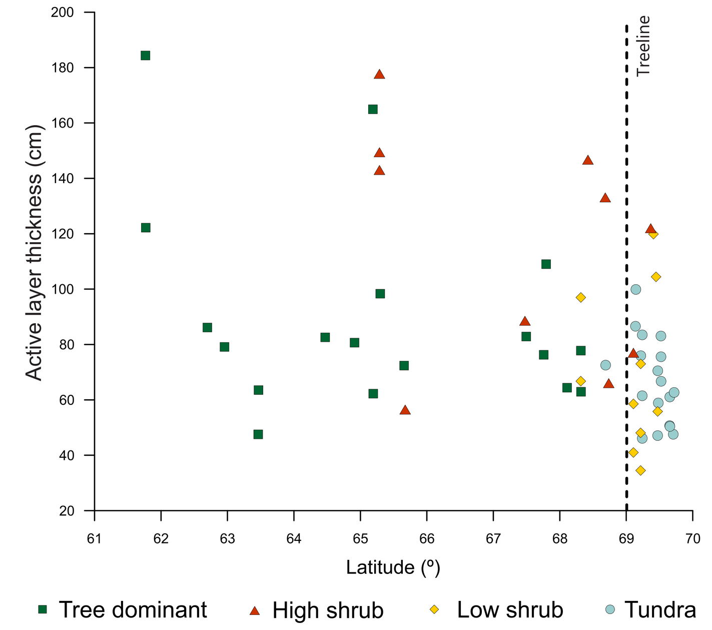

Figure 4: Mean active layer thickness for all years for 57 active layer sites classified by dominant vegetation type.

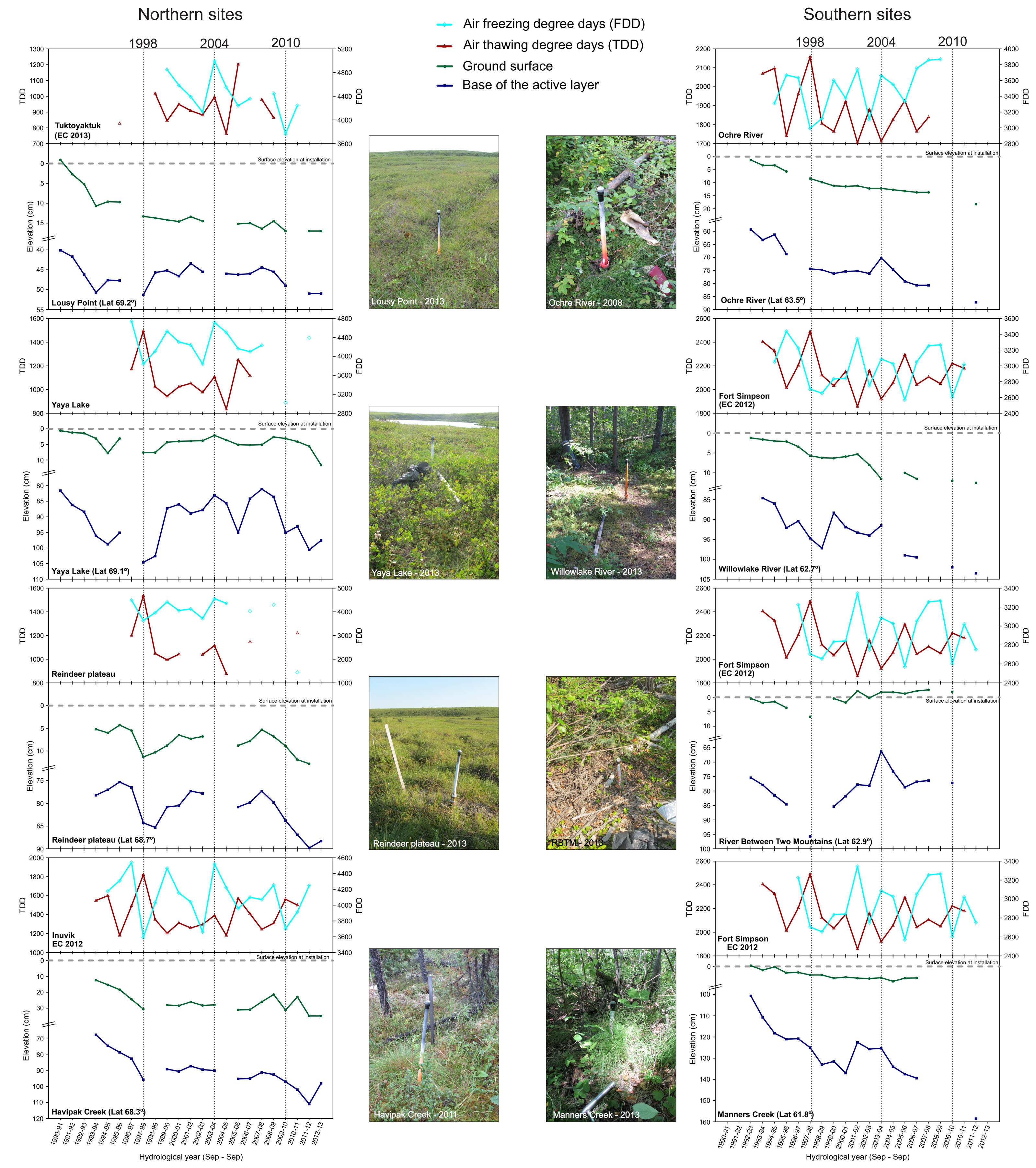

Figure 5: Air thawing and freezing degree days using site data or, where unavailable\sporadic, the closest Environment Canada (EC) weather station data. Maximum thaw penetration and ground surface elevation between 1990 and 2013.

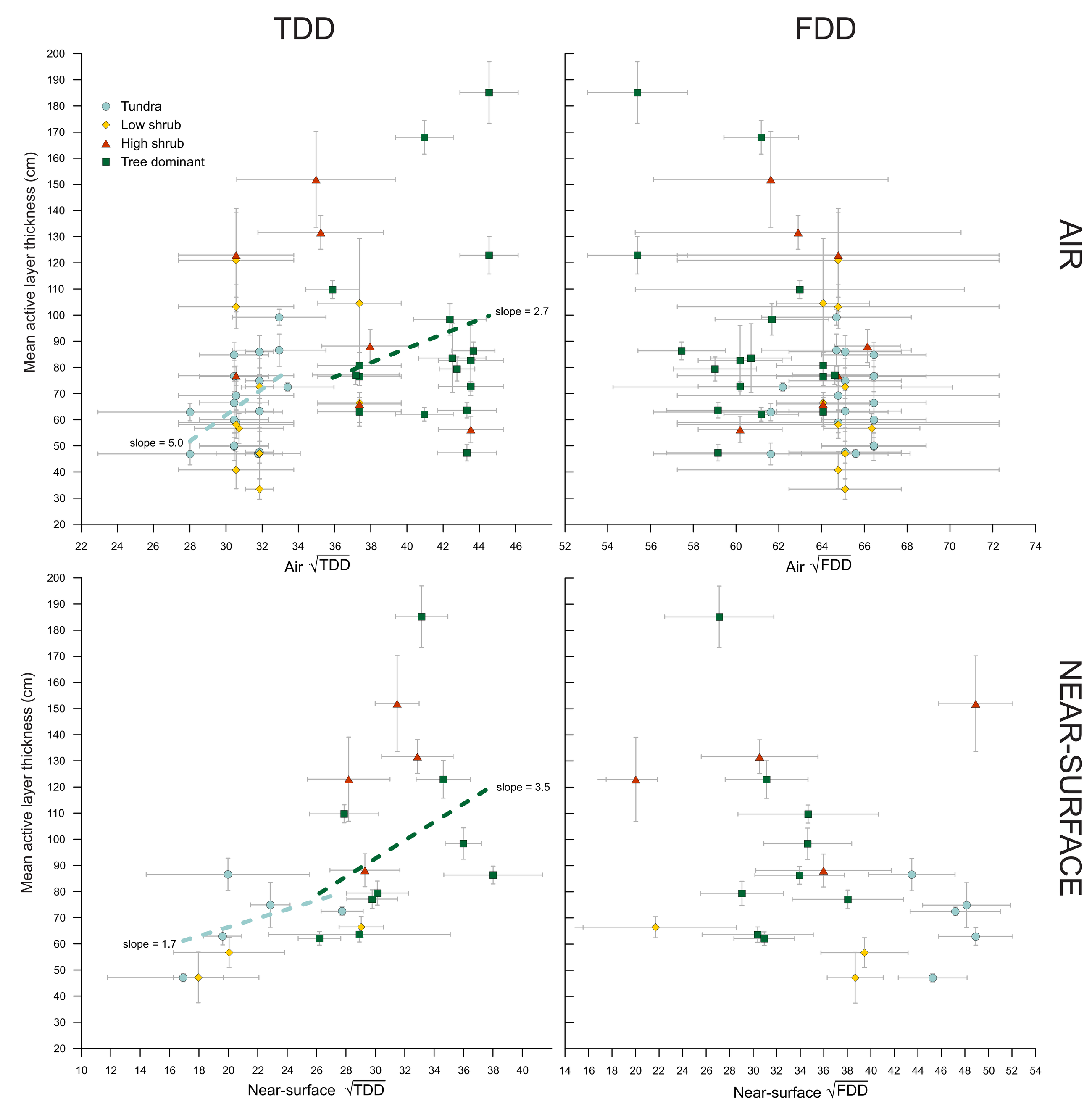

Figure 6: Mean active layer thickness versus air and near-surface freezing and thawing indices. The error bars represent +/- 1 standard deviation from the mean. Linear fit is shown for both tundra and tree dominant TDD.

Influence of TDD and FDD:

The modulating effect of vegetation on active layer development is shown in figure 6 where near-surface TDD display a better relation with active layer than air TDD. Also this effect is seen with the steeper slope of air TDD which tends to be greater when sites have less insulation.

Summer air temperatures have a greater influence on active layer development in the tundra where surface insulation is less. There is also greater temporal variability in winter air temperature, indicating that FDD may be an important factor influencing the long term variability of active layer thickness.

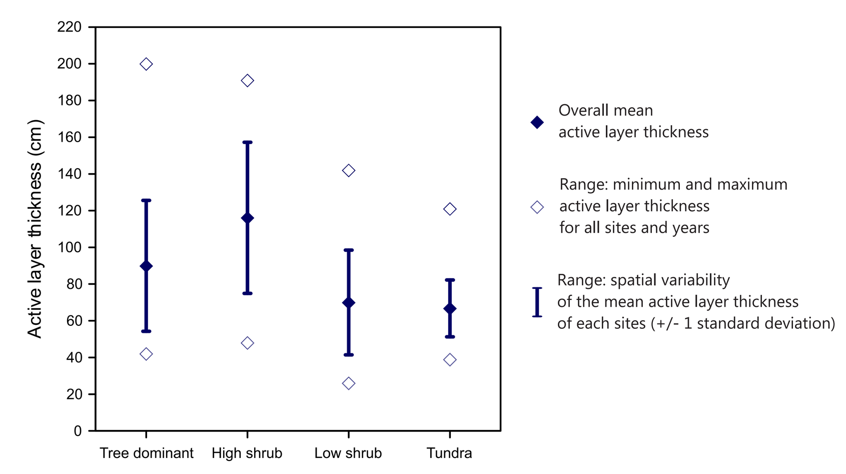

Figure 7: Mean and ranges in active layer thickness by dominant vegetation type. The overall mean active layer is for all years and all sites.

Summary:

Greater spatial and temporal variability in active layer thickness (Fig. 7) is observed for the tree dominant sites. The thickest active layer generally occurs at sites with high shrubs.

Active layer thickness increased between 1991 and 1998 (Fig. 8). The maximum in 1998 was followed by a thinning of active layers to 2005, with increasing thickness to 2012.

The monitoring network provides baseline information that is helpful in understanding the impacts of a changing climate on a permafrost environment.

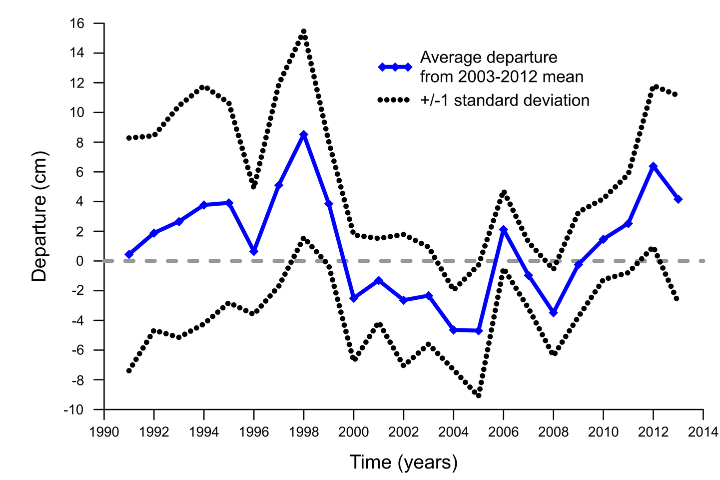

Figure 8: Average active layer departures from 2003-2012 mean for all sites.

Reference:

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[1] Geological Survey of Canada, Natural Resources Canada, 601 Booth Street, Ottawa, Ontario

For more information, please contact C. Duchesne (Caroline.Duchesne@NRCan-RNCan.gc.ca).

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