INTRODUCTION

Widespread and systematic changes in the thickness of the active layer (the seasonally thawed ground above permafrost), if accompanied by penetration of their tree lines, could have profound effects on the flora and fauna that inhabit terrestrial ecosystems in cold regions and on landscape processes. It is therefore critical that observational and analytical procedures be conducted over extended periods to assess trends and detect cumulative changes in active-layer dynamics over long periods. Establishment of long-term sites of active-layer measurements at fixed locations and across diverse landscapes and regions is required to identify scales of spatial variation, detect temporal trends, and validate models.

Northern Hemisphere sites in the CALM III program operate as part of the Arctic Observing Network (AON) supported by NSF. CALM III is integrated closely with the TSP (Thermal State of Permafrost) program, and considerable emphasis is being placed on making borehole and active-layer observations in close proximity.

CALM is among the international permafrost community’s first large-scale efforts to construct a coordinated monitoring program capable of producing data sets suitable for evaluating the effects of climate change. Together with the International Permafrost Association’s Thematic State of Permafrost program, CALM compiles GTP-F, the Global Terrestrial Network for Permafrost. CALM is currently administered through the Geography Department of George Washington University and the University of Delaware. Data are distributed through the AON’s data program, through CALM’s web site, and through data products produced by the Freezal Ground Data Center at the University of Colorado.

DISTRIBUTION OF ARCTIC SITES

The distribution of CALM observational sites in the Northern Hemisphere is shown in Figure 1. The CALM network incorporates 185 sites in Arctic, sub-Arctic, Antarctic, and mountainous regions. Recent sites constitute longitudinal and latitudinal transects across northeastern North America, Europe and the Nordic region, and northeastern and southwestern Russia. Sites in Europe, China, Mongolia, and Kazakhstan provide high-latitude locations. About 75% of the sites are located in Arctic and Subarctic lowlands intermixed by continuous permafrost. Discontinuous and nonpermafrost sites cover respectively, 25% and 15% of the sites. The distribution of sites is not uniform, a circumstance attributable to historical circumstances and logistical constraints. The sites were established in regions of extant economic activity and/or in areas of long-term climatic, permafrost, and ecosystem research. This logistical driven approach to site selection was intended to ensure regularity and periodicity of measurements.

MONITORING PROCEDURES

In 86 of the sites, the active layer is measured by mechanical probing on regular grids of sampling points ranging from 10 to 30 m in 2000 to 1000 m in (Figure 3). The time of probing varies from mid-August to the end of September, i.e., when thaw depth is at or near the maximum. More frequent measurements are made in some sites and in some years. The grid sampling design allows for analysis of transect and inter-site spatial variability and yields sufficient data for examining interrelations between physical and biological parameters.

As of the sites, active layer thickness is determined exclusively by interpretation of ground temperature measurements, obtained by an array of thermistors distributed vertically from the ground surface downward into the permafrost. Liquid- or soil-filled bore tubes are employed at 11 Canadian and 3 Alaska sites.

TRANSPARENT LAYER

The transition layer serves as a buffer between the active layer and permafrost (Figures 6, 8). Significant ice segregation can occur within this layer during "wet" years, due predominantly to freezing from below during the winter and melting during most "dry" years (for "wet" years, the transitional layer is filled with ice and snow throughout the summer). For "dry" years, the transitional layer can be composed primarily of organic material. The thickness of the transition layer is determined exclusively by interpretation of ground temperature measurements, obtained by an array of thermistors distributed vertically from the ground surface downward into the permafrost.

REGIONAL ACTIVE-LAYER CHARACTERIZATION

Several regions with large assemblages of sites and representative of high-latitude climatic landscape gradients are suitable for spatial data integration. As present, the CALM database contains two regional trend scales: active-layer maps compiled from data sampled from multiple sites. The first is a 10-year series of maps (1 km resolution) depicting annual active layer thickness (Figure 5A) and the probability of the active layer exceeding certain thickness thresholds (Figure 5B). The second regional compilation is a detailed digital landscape and active-layer map of the Western Hemisphere (Figure 5B). The map was compiled in cooperation with the Earth System Research Institute (ESRI) and depicts data sets of land use, land cover, landscape units, organic layer thickness, morphology, and the landscape-specific characteristic values of active-layer thickness.

Field investigations involve using differential GPS (Figure 9) and traditional surveying to track transect features to monitor seasonal and interannual thawing and freezing/thawing. Sites are visited by scientific personnel in summer on foot, by boat or helicopter, and by small aircraft. The site teams are composed of scientists from different universities and affiliated organizations. Site teams are coordinated through the National Coordination Office (NCO) for Permafrost.

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