Circumpolar Active Layer Monitoring
CALM program:
Long-term monitoring of the active layer/upper permafrost system.

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CALM OBJECTIVES

1. Develop and maintain programs of long-term, active layer observations;

2. Develop standardized active-layer data sets for use in validating hydrologic, ecosystem, permafrost, and climate models;

CALM HISTORY

1989: International Symposium on Geocryological Studies in Arctic Regions, Yamburg, Russia
1991-1997: Initial CALM program launched and managed in association with the International Tundra Experiment (ITEX) program
1995-1998: NSF Arctic Flux Program in northern Alaska
1998-2003: CALM I (OPP-9732051)
2002: First CALM Workshop, Lewes, DE
2004-2009: CALM II (OPP-0352958)
2008: Second CALM Workshop, Fairbanks, AK
2009-2014: CALM III (ARC-1002119)
2014-2019: CALM IV (PLR-1304555)
Three methods are used to determine the thickness of the active layer:

Spatial Measurements: A) Mechanical probing using a graduated metal rod; Conducted on regular grids of sampling points ranging from $10 \times 10$ m to $1000 \times 1000$ m.

Point Measurements: B) Temperature measurements;  C) Frost/thaw tubes.
SPATIAL ACTIVE LAYER MEASUREMENTS

Grids are established at undisturbed locations, characteristic of dominant environmental conditions.

Size of grids varies depending on site geometry, and the level of natural variability of surface and subsurface conditions.

In general, 10×10m to 100×100m size grids are established within relatively homogeneous landscape units. Several sites contain a number of grids representing various landscape units within the area.

The 100×100m to 1000×1000m grids usually encompass several characteristic landscapes within the area.
The CALM network incorporates 234 sites in Arctic and mountainous regions.

About 115 continuously report data.

About 70% of the sites are located in Arctic and Subarctic lowlands underlain by continuous permafrost.

The distribution of sites is not uniform, a circumstance attributable to historical circumstances and logistical constraints.

Data available at www.gwu.edu/~calm

NSF AON CALM (PLR-1304555): 82 Active sites (33 USA (AK); 50 RU)
Long-term active-layer change in six different Arctic regions as observed within the Circumpolar Active Layer Monitoring (CALM) project. The data are presented as annual percentage deviations from the mean value for the period of observations.
ALT TRENDS (1995-2014)

ALT Trend (cm/y)
-0.15 - 0.00
0.00 - 0.15
0.15 - 0.30
0.30 - 0.45
>0.45

Barrow, CRREL Plots

Alaska North Slope
(20 sites)

% of Change

1995-2014 mean
0.47 m

LONG-TERM ALT AVERAGES

ALT (cm)
- Green: 30 - 40
- Yellow: 41 - 50
- Orange: 51 - 60
- Red: 61 - 70

Map showing altitude averages with various color codes indicating different ranges.
LANDSCAPES SPECIFIC VALUES OF ALT

<table>
<thead>
<tr>
<th>Landcover categories</th>
<th>Coastal Plain</th>
<th>Foothills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moist nonacidic tundra</td>
<td>40.0</td>
<td>56.4</td>
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<tr>
<td>Moist acidic tundra</td>
<td>40.5</td>
<td></td>
</tr>
<tr>
<td>Moist low shrub tundra</td>
<td>43.0</td>
<td></td>
</tr>
<tr>
<td>Wet graminoid tundra</td>
<td>62.9</td>
<td>49.1</td>
</tr>
</tbody>
</table>

**Coastal Plain**

**Foothills**

**Thaw depth (cm)**

**Alt (cm)**

**WET**

**MNT**

**MAT**

**SHR**

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\sqrt{DDT}
\]
GROUND SURFACE TEMPERATURE MONITORING
### Summer Season Temperature Difference and N-Factors

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>D</th>
<th>E</th>
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</thead>
<tbody>
<tr>
<td><strong>ΔT°</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barrens</td>
<td>-0.07</td>
<td></td>
<td>-0.41</td>
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<tr>
<td>Moist Nonacidic Tundra</td>
<td>1.51</td>
<td>2.23</td>
<td>3.31</td>
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<tr>
<td>Moist Acidic Tundra</td>
<td></td>
<td></td>
<td>3.64</td>
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<tr>
<td>Shrublands</td>
<td></td>
<td></td>
<td>4.30</td>
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<tr>
<td>Wet Tundra</td>
<td>0.77</td>
<td>3.16</td>
<td>2.58</td>
</tr>
<tr>
<td>Cold Acidic Tundra</td>
<td>0.73</td>
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</table>

<table>
<thead>
<tr>
<th><strong>N-Factor</strong></th>
<th>C</th>
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<th>E</th>
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<tbody>
<tr>
<td>Barrens</td>
<td>1.14</td>
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<td>1.11</td>
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<td>Moist Nonacidic Tundra</td>
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<td>0.67</td>
<td>0.67</td>
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<tr>
<td>Moist Acidic Tundra</td>
<td></td>
<td></td>
<td>0.61</td>
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<tr>
<td>Shrublands</td>
<td></td>
<td></td>
<td>0.59</td>
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<tr>
<td>Wet Tundra</td>
<td>0.75</td>
<td>0.62</td>
<td>0.71</td>
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<tr>
<td>Cold Acidic Tundra</td>
<td>0.90</td>
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</table>
Long-term changes in summer N-Factors and temperature differences between the air and soil surface indicate the increase in the thermal insulating properties of vegetation.

Changes in the insulating properties of vegetation can be attributed to long-term climate-induced changes in biomass. However further investigations are needed.
Frost heave and thaw subsidence are important drivers of geomorphological processes in permafrost and periglacial areas.

Upward movement of the ground surface can be attributed to migration of water to the freezing front and development of segregation ice.

Downward movement occurs due to thawing of sub-surface permafrost during summer months.

ISOTROPIC THAW SUBSIDENCE: Landscape-scale, thaw-induced subsidence that lacks the topographic contrasts associated with thermokarst terrain.
• Entire natural landscapes underlain by ice-rich permafrost are subsiding slowly in response to warming of atmospheric climate, without initiation by localized anthropogenic or geomorphic disturbances.

• The annual contemporary rate of subsidence for the study period, as inferred from the study sites is about 1.0 cm/year in the Coastal Plain and 1.7 cm/year in the Foothills.
GTN-P: Global Terrestrial Network On Permafrost

Global Climate Observing System (GCOS)

GCOS global networks

Global Atmosphere Watch (GAW)
Global Ocean Observing System (GOOS)
Global Terrestrial Observing System (GTOS)

Global Terrestrial Networks

Ecology (GTN-E)
Hydrology (GTN-H)
Glaciers (GTN-G)
Permafrost (GTN-P)

GTN-P: Active-layer monitoring

GTN-P: Thermal State of Permafrost
The new database of the Global Terrestrial Network for Permafrost (GTN-P)

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GTN-P data are featured in:

- State of the Climate Report (BAMS)
- Arctic Report Card (NOAA)
- Roshydromet Annual Report
- IPCC, SWIPA, ACIA, UNEP

http://gtnpdatabase.org/