Soil temperature and thaw depth differences associated with tundra vegetation types at Trail Valley Creek, NWT, Canada

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Study site

Data from Walker et al. (2005)

Trail Valley Creek

- 68.74°N, 133.50°E
- North-West Canada
- Low Arctic, tree line
- Annual temperature: −7.9 °C
- Active layer depth: 25 cm to 100 cm
- Permafrost depth: 100 m to 150 m

Marsh et al. (2008)
Trend of the annual mean temperature: 1.1 °C/decade

Strongest trend in May: 2.8 °C/decade
Vegetation types

Tree
Tall shrub
Riparian shrub
Dwarf shrub
Tussock
Lichen
Water
Vegetation types

- Tree
- Tall shrub
- Riparian shrub
- Dwarf shrub
- Tussock
- Lichen
- Water
Vegetation – radiation relationship

- Lowest albedo at water logged conditions
- Tall vegetation shades the soil and reduces the albedo
Radiation – active layer relationship

- Apparently no connection
Field measurements

- 68 iButton temperature sensors just below the soil/lichen/moss surface
- Below different vegetation within a 600 m radius
- August 2016 to August 2018
- Snow depth measurements April 2017, active layer depth August 2018
Top soil temperature

Soil temperature (°C)

08/2016 12/2016 04/2017 08/2017 12/2017 04/2018

Lichen
Tussock
Dwarf shrub
Tall shrub
Top soil temperature and snow

- Tall shrubs trap snow: warm soil in winter and cold top soil in spring
- Lichen and dwarf shrub tundra are similar in winter
Top soil temperature and snow

Tall shrubs trap snow: warm soil in winter and cold top soil in spring

Lichen and dwarf shrub tundra are similar in winter
Top soil temperature and snow

- Tall shrubs trap snow: warm soil in winter and cold top soil in spring
- Lichen and dwarf shrub tundra are similar in winter
Top soil temperature and snow

- Date of snow melt is strongly related to snow depth
- Top soil temperatures in March and April are related to snow depth
Statistical model for snow depth

Snow depth ~ End date of thawing + T range March + T range April

\[ R^2 = 0.82, 0.72 \]

Mean absolute error: 11.3 cm, 12.5 cm
Top soil temperature and active layer

- June temperatures are similar for all types
- August temperatures are cooler below shrubs
- Tall shrubs reduce the active layer depth

<table>
<thead>
<tr>
<th>Median temperature (°C)</th>
<th>Soil temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lichen</td>
<td>Tussock</td>
</tr>
<tr>
<td>Dwarf shrub</td>
<td>Tall shrub</td>
</tr>
</tbody>
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- June temperatures are similar for all types
Top soil temperature and active layer

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![Median temperature (°C)]

- Lichen
- Tussock
- Dwarf shrub
- Tall shrub

![Soil temperature (°C)]

- 01/08 04/08 07/08
- 0 5 10 15
Top soil temperature and active layer

- June temperatures are similar for all types
- August temperatures are cooler below shrubs
- Tall shrubs reduce the active layer depth
Top soil temperature and active layer

Snow melt date influences end of season active layer depth

Weak relationship with the range of temperatures in April
Active layer depth ~ End date of thawing + Median T January
+ T range May

\[ R^2 = 0.68, 0.49 \]

Mean absolute error: 8.1 cm, 8.1 cm
Take home messages

- Uncertainty due to irregular soil surface
- Top soil temperatures indicate the spatial snow depth variability
- Top soil temperatures after snow melt have no connection with active layer development
- Vegetation has an influence but cannot be used as main indicator
Thank you — Questions?
Literature


Vegetation map of Trail Valley Creek

- Published LiDAR dataset of 2016:
  - Mean and maximum vegetation height
  - DTM: slope, aspect, roughness, topographic index, topographic position index
- Canadian aerial imagery
- Resolution 10 m
- 87% accuracy at validation data set
- User and producer accuracy of all classes >75%
Vegetation map of Trail Valley Creek
Vegetation map of Trail Valley Creek