IP3 progress at Scotty Creek

Joint Annual Workshop of the IP3 & WC2N Networks, Lake Louise, Alberta, Canada, 14-17 October, 2009
Scotty Creek, Northwest Territories

Study Area

0 50
kilometres

Fort Simpson
Mackenzie River

Lake
Isolated bog
Fen
Connected bog
Peat plateau (43%)

L.S.A. Canada

Goose Lake

1 km
Hillslope Runoff

unsaturated zone

water table

open water

frost table

permafrost

organic mineral

active layer

mineral

organic

(saturated)

active layer

unsaturated zone
Shifting Boundaries
Warming Active Layer
Permafrost Melt 1947 - 2000

Mean annual air temp. (°C)

Annual precip. (mm)

1947

2000
Quantifying errors in permafrost plateau change from historic remote sensing data
Quantifying errors in permafrost plateau change from historic remote sensing data

Based on linear permafrost loss of ~ 1% per year, and a pixel resolution of 1 m or less, 26 years are required between images to confidently show change (approx. same amount of time between 1970 and 2008 images).
Change in permafrost cover

1947 = 72%
1970 = 60%
1977 = 59%
2000 = 52%
2008 = 40%
Change in permafrost cover
Basin Runoff Related to Cover Type

Four River Basins (150-1300 km²)
- Scotty Creek
- Birch River
- Blackstone River
- Jean-Marie River

Different percentage of land-cover types
- bogs (storage)
- fens (routing)
Will basin runoff respond to permafrost melt?

Annual runoff (mm)

Runoff / precip.
Examining CO₂ Gas Flux in Permafrost Terrain (Scotty Creek, NWT)

<table>
<thead>
<tr>
<th>Season</th>
<th>Dates</th>
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</thead>
<tbody>
<tr>
<td>Snowmelt</td>
<td>April 26 – April 30</td>
</tr>
<tr>
<td>Pre-Green</td>
<td>May 1 – May 10</td>
</tr>
<tr>
<td>Green</td>
<td>May 11 – June 6</td>
</tr>
<tr>
<td>Late-Green</td>
<td>August 23</td>
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</tbody>
</table>
Conceptual Model of Permafrost Melt

- **Yellow**: unsaturated, thawed peat
- **Green**: saturated, thawed peat
- **Gray**: saturated, frozen peat

1. **Peat plateau**
2. **Thaw depression**
3. **New isolated flat bog**
Linear Wetlands

linear disturbance
(permafrost-free corridors)

unsaturated, thawed peat
saturated, thawed peat
saturated, frozen peat

kilometres
Electrical Resistivity Imaging of Permafrost
Electrical Resistivity Imaging of Permafrost

Line 1

Bog
Permafrost
Peat
Clay

10 m resistivity

>10^4 m

Line 2
Permafrost ~10 m thick

50-yr old winter road
Active layer ~2.5 m deep
Active layer and permafrost thaw:
Examining the influence of pore size and geometry on peat hydraulic properties using 3-D CT analysis

The large reduction of $K_{\text{unsat}}$ with depth, under a constant pressure head, is controlled by air-filled pore hydraulic radius, tortuosity, air-filled pore density and the fractal dimension due to decomposition and compression of the organic matter.
On-going work:

1) Identify the key factors controlling the rates and patterns of preferential thaw leading to permafrost degradation,

2) Develop a new model that simulates the permafrost response to climate warming and human disturbance,

3) Develop conceptual & mathematical models of key hydrological processes, and

4) Couple the hydrological and permafrost models to predict the spatial distribution of permafrost, and the river flow regime under scenarios of climate warming and human disturbance.
Cumulative daytime canopy shadows within permafrost plateau and peat bog in summer and late autumn.

Ground surface energetics and subsurface thermal regime of permafrost plateau and a peat bog.

![Graph showing cumulative Qg (MJ m\(^{-2}\)) over time from April 26 to August 30, 2005. The graph compares plateau and bog frost-free conditions.]

- **Plateau**: Black line
- **Bog**: Gray line

**X-axis**: 2005 (month/day)

**Y-axis**: Cumulative Qg (MJ m\(^{-2}\))

**Legend**:
- plateau
- bog frost-free

Maps showing
- June, 2005
- November, 2005