Understanding and scaling change in lowland permafrost: Cross-scale feedbacks to hydrology and carbon

Merritt R. Turetsky
University of Guelph
Permafrost is both climate- and ecosystem-driven.
Permafrost is both climate- and ecosystem-driven.
Permafrost is both climate- and ecosystem-driven.
Abrupt thaw typically involves local subsidence and wetting
See work by Bill Quinton, Kevin Devito, Mike Waddington
Increasing runoff & basin drainage

Recurring theme: reorganization of hydrology

<table>
<thead>
<tr>
<th></th>
<th>Avg. Runoff (mm)</th>
<th>Avg. Precip (mm)</th>
<th>Runoff Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976-85</td>
<td>87.2</td>
<td>364.5</td>
<td>0.24</td>
</tr>
<tr>
<td>2006-15</td>
<td>193.4</td>
<td>402.3</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Quinton et al. papers
Cross-scale threshold change

Regional wetting?

Basin drying

Local flooding
Wetting AND drying through time

Life Cycle of Thaw Lakes: Subsidence and Wetting -> Drainage -> Permafrost Recovery
For each generalized thaw trajectory, we synthesized data on:

- spatial extent of early and late thaw states
- transition rates between states
- carbon fluxes for each state
Permafrost Plateau

Thermokarst Lake

Young Fen

Old Fen

Old Bog

Young Bog (< 100 yr old)

Young Lacustrine Fen
Thermokarst C losses dominated by upland environments

Simulated Thermokarst C Loss (Pg C)
How important is CH$_4$ to permafrost C losses?

- CH$_4$-C contributed little to total C release in a synthesis of year long incubations of permafrost soils (Schadel et al. 2016)
- However, CH$_4$ became significant in a 7+ year incubation (Knoblauch et al. 2018)
Oxic environments lost the most C with thaw, but radiative forcing of CH$_4$ was high across all landscape settings.
Known Unknown #1
Fate of erosional material
Known Unknown #2

Emissions during zero curtain

Zona et al. 2016
Known Unknown #3
Methane seeps can transform the landscape

- Geologic sources of CH₄ (cf. Walter Anthony et al. 2012)
- Enhanced CO₂ uptake in Arctic ocean seep exceeded GWP of emitted CH₄ (Pohlman et al. 2017)
Recurring theme: Heterogeneity
*Occurs in Time and Space*

Permafrost thaw

**Hot spot** process:
- 20% of land at risk
- <5% is an active feature

Abrupt thaw

**Hot moment** process:
- <5% of bubble trap measurements responsible for >95% of old C release

Methane ebullition
Public Engagement
We all have stories to share. They are more powerful together so we have a unique opportunity for science engagement.

At lunch today, please join me to explore this and other outreach opportunities!
Thank you

mrt@uoguelph.ca

@queenofpeat
Principles for effective communication and public engagement on climate change

A Handbook for IPCC authors

1. Be a confident communicator
2. Talk about the real world, not abstract ideas
3. Connect with what matters to your audience
4. Tell a human story
5. Lead with what you know
6. Use the most effective visual communication
Mineral lowland terrain: thaw lakes

Organic lowland terrain: thaw wetlands

Hillslope terrain: thaw slumps/slides
Simulated change in areas in lowland organic terrain
Simulated change in net ecosystem carbon balance
Case study: Peel Plateau megaslumps
Gas hydrate breakdown unlikely to cause massive greenhouse gas release
What about permafrost peatlands?

*permafrost = topography!*

Sniderhan and Baltzer 2016