Fire and Permafrost

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FAIRBANKS, ALASKA, 1930-2011
Mean annual ground temperatures

Depth:
- 0.08 m (red)
- 0.3 m (green)
- 0.5 m (cyan)
- 1 m (blue)

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The effects of forest fire on the frozen soil thermal state

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Figure 0.1. Climatological data from the Fairbanks International Airport station: (A) mean annual air temperature in °C and (B) seasonal averaged snow depth in meters.
Figure 0.3. Simulations of the active layer thickness for (A) Upland and (B) Floodplain boreal forest sites for different warming scenarios with no fire disturbances. Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run.
Figure 0.4. Simulations of the permafrost table depth for (A) Upland and (B) Floodplain boreal forest sites for different fire severities during stable climate (mean annual air temperatures $-2^\circ$C). Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run, where 0 is year of a fire ignition.
Figure 0.2. The rates of (A) moss, (B) fibrous, and (C) amorphous organic soil layers post-fire dynamics simulated by DOSTEM model during the equilibrium run.
Figure 0.5. Simulations of the permafrost table depth for (A) Upland and (B) Floodplain boreal forest sites for different fire severities during stable climate (mean annual air temperatures $-2^\circ C$) using dynamic organic soils recovery rates. Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run, where 0 is year of a fire ignition.
Figure 0.6. Simulated permafrost table dynamics with and without changes in the soil moisture content within 10 years after fire for (A) upland (B) lowland sites during stable climate (mean annual air temperatures −2°C) using dynamic organic soils recovery rates generated by the Dynamic Organic Soil Terrestrial Ecosystem Model. Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run, where 0 is year of a fire ignition.
Figure 0.7. Simulated permafrost table dynamics after (A) 50 % burn for the upland and (B) 100 % burn for the lowland boreal forest permafrost sites during different climate warming scenarios using dynamic organic soils recovery rates and changes in soil moisture content. Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run, where 0 is year of a fire ignition.
Figure 0.8. Simulated permafrost table dynamics after 100% organic layer burn for the upland boreal forest permafrost sites during different climate warming scenarios using dynamic organic soils recovery rates and changes in soil moisture content. Time interval [-10,0] corresponds to the equilibrium run, and [0,120] time interval corresponds to the transient run, where 0 is year of a fire ignition.
Detecting Spatial Variability in the Ground Temperatures in a Discontinuous Permafrost Region and Attributing it to the Physical and Biological Parameters
Air Temperature
-6 to -2 °C

Snow Surface Temperature
Close to Air Temperature

Ground Surface Temperature
0 to +3 °C

Permafrost Table Temperature
0 to -1.5 °C

AIR

SNOW COVER

MOSS LAYER

ORGANIC LAYER (PEAT)

ACTIVE LAYER

PERMAFROST

MINERAL SOIL
Air Temperature 2009

-1.4°C  GS2
-1.6°C  GS3
-4.6°C  GS4
-4.0°C  GS9

Distance, km

Elevation, km a.s.l.
Air Temperature 2010

+0.6 C

+0.4 C

-3.1 C

-1.2 C

-2.2 C
Air Temperature 2011

-0.6°C
-0.8°C
-4.1°C
-2.2°C
-3.0°C
Surface Temperature 2010-2011
Surface Temperature 2010-2011

Elevation, km a.s.l.

Distance, km

GS1, GS2, GS3, GS4, GS5, GS6, GS7, GS8, GS9, Las_V, P Creek

Surface temperature values shown in the diagram:
- GS1: 0.6
- GS2: 0.0
- GS3: 2.1
- GS4: 1.7
- GS5: 0.4
- GS6: -0.2
- GS7: 0.7
- GS8: 0.3
- GS9: -1.7
- Las_V: 0.4
- P Creek: -2.6

Temperature range: 0.0 to 3.6
Temperature at 1.2 m
2010-2011
Temperature at 1.2 m

2010-2011

Elevation, m.a.s.l.

Distance, km
GS#4: Permafrost
GS#2: No Permafrost
GS#7: No Permafrost ???

![Graph showing temperature changes over time for depths of 0.5 m, 1 m, and 1.17 m](image-url)

- **Temp, 0.5 m**
- **Temp, 1 m**
- **Temp, 1.17 m**

Date range: 9/18/08 to 9/18/11
Temperature at 1.2 m
2010-2011
Conclusions

• At any given climate sub-zone, there is a wide variety of permafrost conditions governed by local topography, vegetation, soil and hydrology

• Future changes in climate will have a very different effect on permafrost in different environmental settings

• Future changes in vegetation and hydrology that partly will be governed by changes in permafrost will add even more complexity in the response of permafrost to changing climate