Permafrost Remote Sensing Through Airborne Electromagnetic Geophysics and Thermal Anomalies

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Goldstream Valley Watershed
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B) FREQUENCY-DOMAIN EM METHOD

F = 100 Hz

Primary Field at Receiver
EMF in Conductor = (\(\mu\) \(\delta_{ip/\delta l}\))
Secondary Field at Receiver

Decomposition into
In-Phase Component
Quadrature Component
90° Phase Lag

C) TIME-DOMAIN EM METHOD

Transmitter Current
Off-time
On-time
Decaying EM Fields with time

Receiver Output Voltage
On-time
Off-time

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Pilgrim Hot Springs
Pilgrim Hot Springs resistivity model

Jonathan Glen
Mosaic Image Visual Interpretation

Christian Haselwimmer

Arvind Chittambakkam
Spring thermal and optical imagery

04/2011, daytime airborne FLIR, 1.2m

04/2011, optical, 20cm
Goldstream Valley DEM and AEM lines
Apparent resistivity maps

140KHz

3300KHz

40KHz

1800KHz

8200KHz

400KHz
Goldstream Valley resistivity model 0-5m

Model created with EM1dfm
Goldstream Valley resistivity model 10-30m

Model created with EM1dfm
Auxiliary data
Péwé 1958 geologic map
Péwé 1958 geologic map and resistivity
Wells with silt
Wells with gravel
Wells with schist
Wells with frozen ground
- The winter air temperature inversion makes the valley bottom mean annual air temperature 3.6°C lower than the ridge crest.

- Ground surface and ground temperatures at 1.2 m generally follow the air temperatures.

- There is definitely no permafrost on the northern ridge crest above the valley.

- There is no near-surface permafrost in the upper part of Ballaine hill.

- However, there may still be permafrost present at depth >3m.
Modeled ground temperature

-1°C mean annual air temperature and groundwater flow into the valley.
Modeled ground temperature

-1°C mean annual air temperature around sinusoidal annual distribution. Summer and winter n-factor correction for vegetation.
Modeled ground temperature

Same as before after 300 years.

Near equilibrium permafrost depth of 36 meters. Without groundwater flow deeper.
Bottom of permafrost?

2 ½ D inversion with Workbench

Legend

goldenmean_5_10_res_web.grd

(VALUE)

- 0 - 10
51 - 150
151 - 300
301 - 1,000
1,001 - 8,736

Legend

goldenmean_10_20_res_web.grd

(VALUE)

- 0 - 50
51 - 100
101 - 300
301 - 1,000
1,001 - 10,324

Legend

goldenmean_20_50_res_web.grd

(VALUE)

- 0 - 30
51 - 100
101 - 300
301 - 1,000
1,001 - 90,450

Legend

goldenmean_20_100_res_web.grd

(VALUE)

- 0 - 50
51 - 100
101 - 300
301 - 1,000
1,001 - 90,114

5m

20m

50m

100m
Vertical gradient of resistivity

5-10m

10-20m

20-50m

50-100m
Silt layer (a first attempt)
Things to do

• Develop geological model in 3D GoCad environment
• Cross-reference the well data with resistivity to establish range of resistivities connected with frozen/unfrozen silt, gravel, and schist
• Thermal modeling
• Generate 3D permafrost model
Thank you

Questions?