Using numerical thermal modelling techniques to support snow management plans along the ITH

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BACKGROUND: Seasonal snow cover has large impact on ground temperatures. During the winter months it acts as an insulator that impedes the flow of heat from the ground. Snow build up along embankments is a concern for the limiting of the effect of infrastructure on the degradation of underlying permafrost. One way to mitigate the effect of snow cover is to manipulated it changing its density and thickness. In this study, numerical models calibrated to a snow manipulation site along the Inuvik-Tuktoyaktuk Highway are being used to investigate the sensitivity to rate of snow manipulation both seasonally and annually.

METHODS

1. Establish 1D ground temperature model in TEMP/W module in GeoSlope developed by GEOSTUDIO INC..
2. Develop Land Climate Interaction (LCI) boundary by obtaining necessary weather information from Environment Canada's historical weather database and TEMP/W built-in functions.
3. Estimate initial soil properties using the Johansen 1975 method.
4. Establish initial ground temperature regime through a spin-up function using weather data from year preceding beginning of model.
5. Compare model output with recorded data with the goal of getting most of the model output within 1°C of the recorded data.
6. Iteratively change soil properties one at a time until model output is deemed sufficient.
7. Apply snow manipulation site data to the model in succession to observe long-term effect of manipulation on ground temperature.

RESULTS

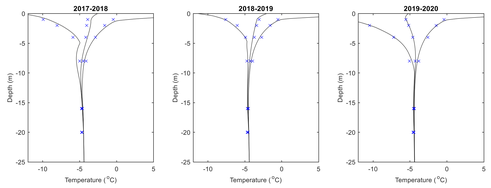

Figure 1: Trumpet curves for a) 2017-2018, b) 2018-2019, c) 2019-2020 showing comparison between model results and thermistor recordings at 1 m, 2 m, 4 m, 8 m, 16 m, and 20 m depths.

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Figure 2: Picture of site undergoing snow manipulation / compaction (Photo: Alice Wilson).

What is the cumulative effect of snow manipulation on ground temperatures using numerical methods?

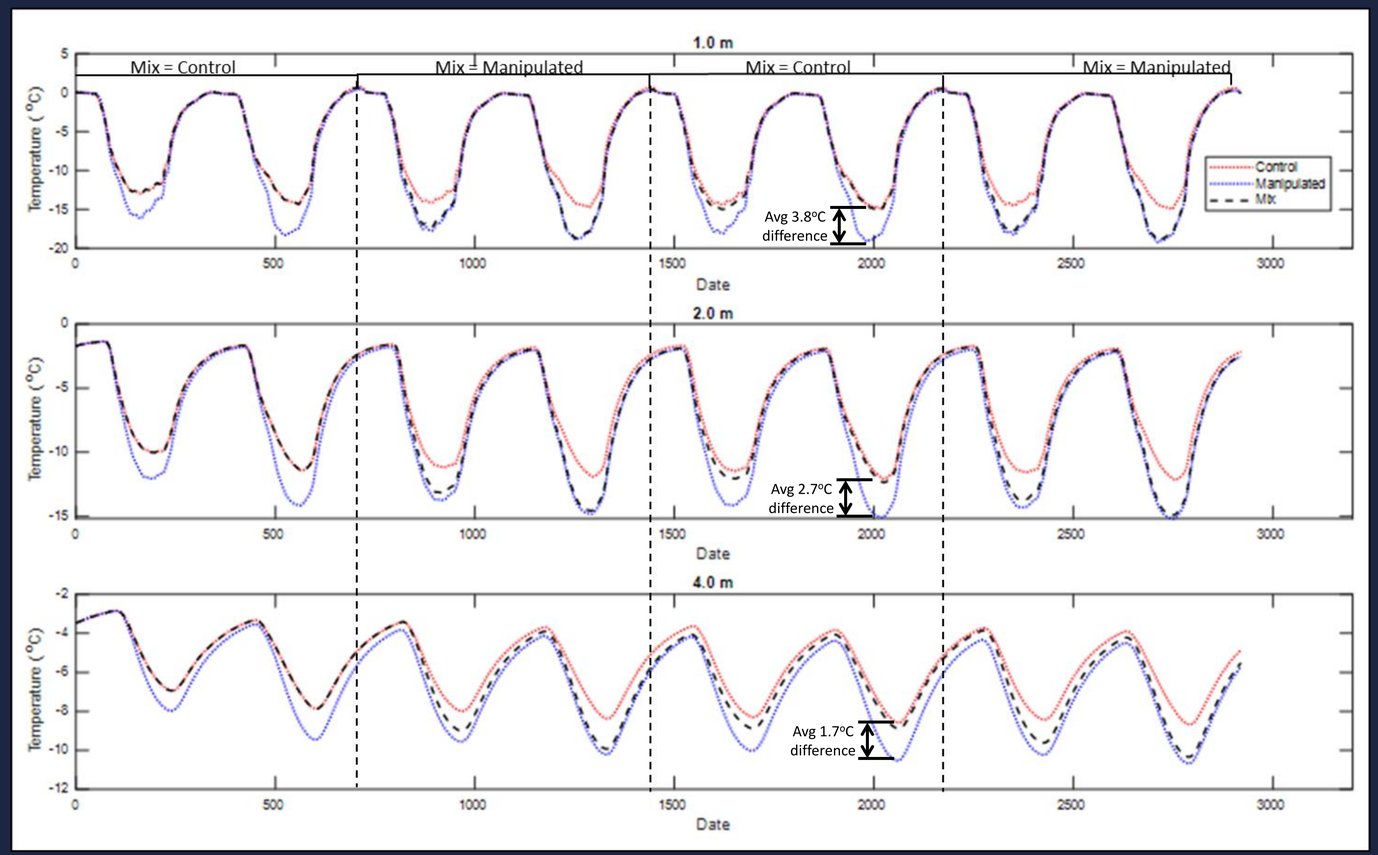

Figure 3: Ground temperature vs time at 1 m, 2 m, and 4 m depths under control, manipulated, and mix of conditions (2 years 'Control' followed by 2 years of 'Manipulated' snow conditions).

The snow manipulation site provided two years of snow cover and density measurements for both a control and manipulated site. Models were developed with the snow information from the control site applied four times in succussion, information from the manipulated site applied four times in succession, and information from the control and manipulated snow conditions applied alternatively. Figure 3 shows the ground temperatures vs time at 1 m, 2 m, and 4 m depth o the models. At 1 m depth the for the 8 modelled years, the average different in annual minimum temperatures between the control and manipulated conditions is 3.8°C. At 2 m depth this difference in annual minimum temperature between the two conditions is 2.7°C and at 4 m depth this difference is 1.7°C.

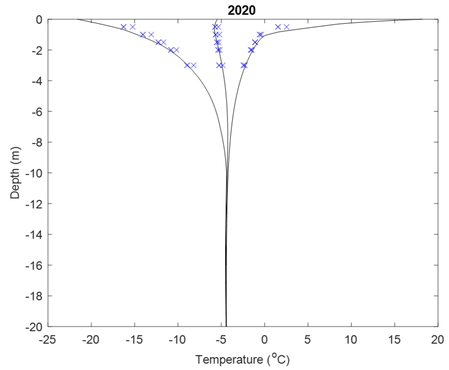

Figure 4: Trumpet curve showing calibration of manipulated site model with thermistor recordings at 0. 5 m, 1.0 m, 1.5 m, 2.0 m, and 3.0 m depths.

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