Sensitivity Analysis of Thawing and Freezing n-factors in Thermal Modeling of Permafrost Regions under a Changing Climate: Initial Probabilistic Results

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1. Introduction

The Arctic landscape is rapidly changing due to climate change which leads to permafrost thaw, the active layer to thicken, and widespread thaw settlement to occur. In order to maintain the stability of permafrost infrastructure, frozen ground conditions must be maintained while designing stable infrastructure depends on a thorough understanding and analysis of current and future climate conditions. Climate data can be used as input for thermal models to predict how permafrost may behave under different climatic conditions. However, there is often uncertainty in thermal modelling parameters, and it is important to understand how those uncertainties affect modelled results.

This study presents a sensitivity analysis of how n-factors affect predictions of active layer thickness using a probabilistic thermal model. The goal of this study is to **probabilistically assess the critical parameters affecting permafrost degradation** in order to optimize data gathered during the investigation.

2. Conceptual Background

Thaw settlement was calculated using the following equation:

$\delta = \varepsilon * \Delta TLD$

δ: thaw settlement

ε: thaw strain

ΔTLD: change in thawed layer depth

3. Framework

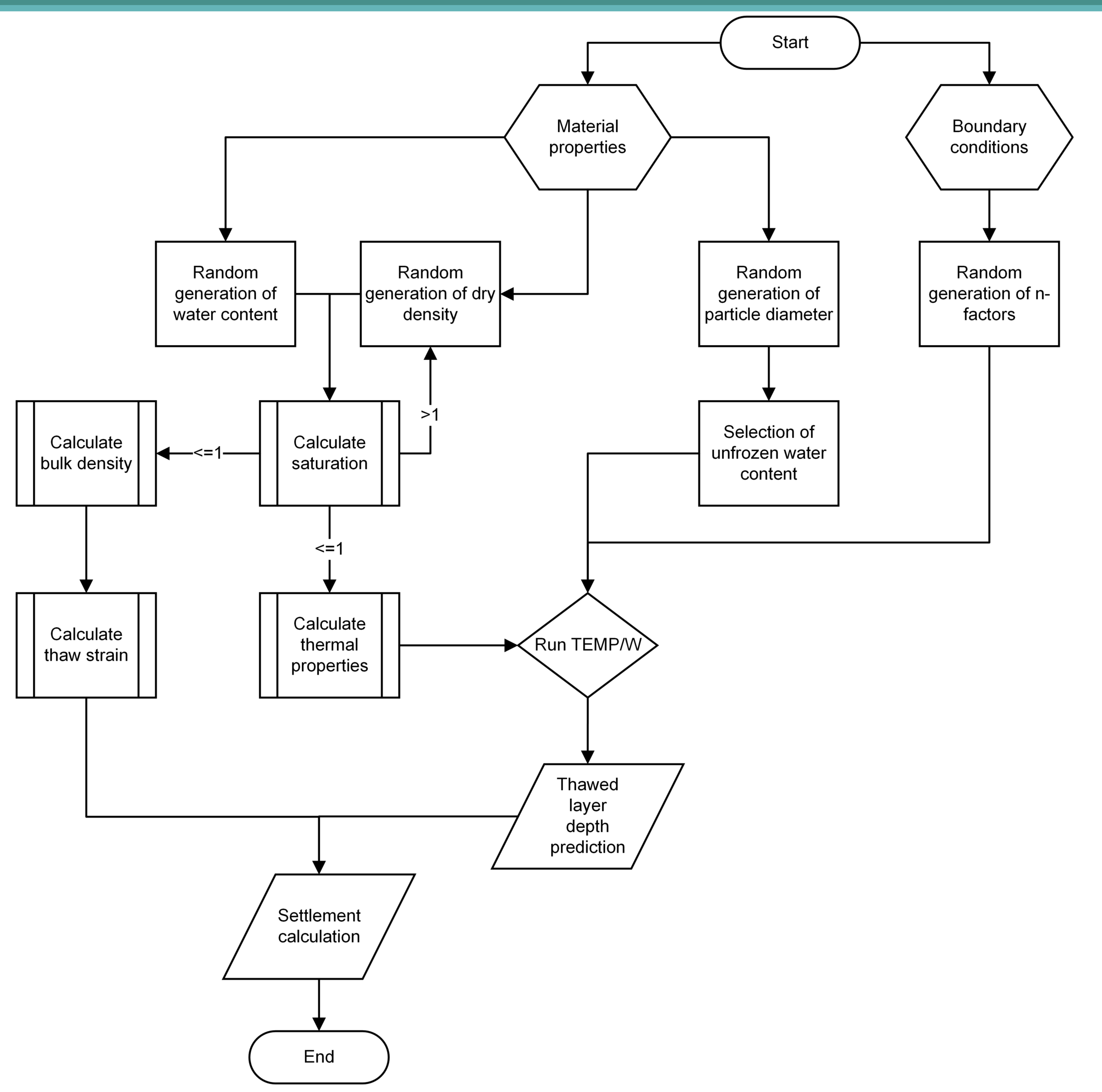

Figure 1: Monte Carlo analysis flow chart.

4. Parameter Distribution

Table 1: N-factors distribution characteristics.

Variable	Distribution type	Range
Thawing n-factor	Uniform	0.73 - 2.00
Freezing n-factor	Uniform	0.25 - 1.00

5. Thawing and Freezing n-factor Effects on Thawed Layer Depth

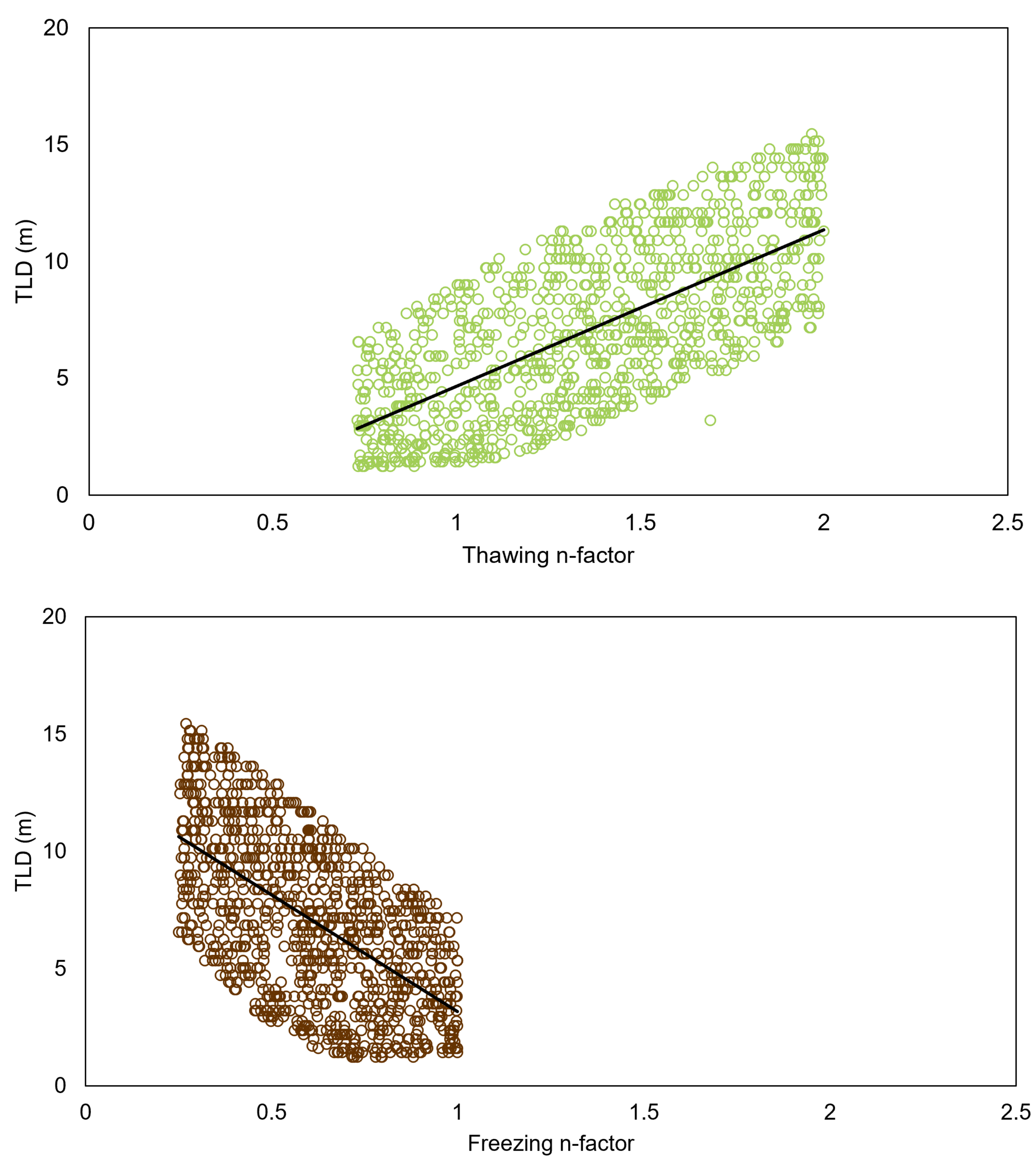

Figure 2: TLD and settlement in a. thawing and b. freezing n-factor sensitivity analysis at 2100

6. Vegetation Cover VS Sand and Gravel Surface Material

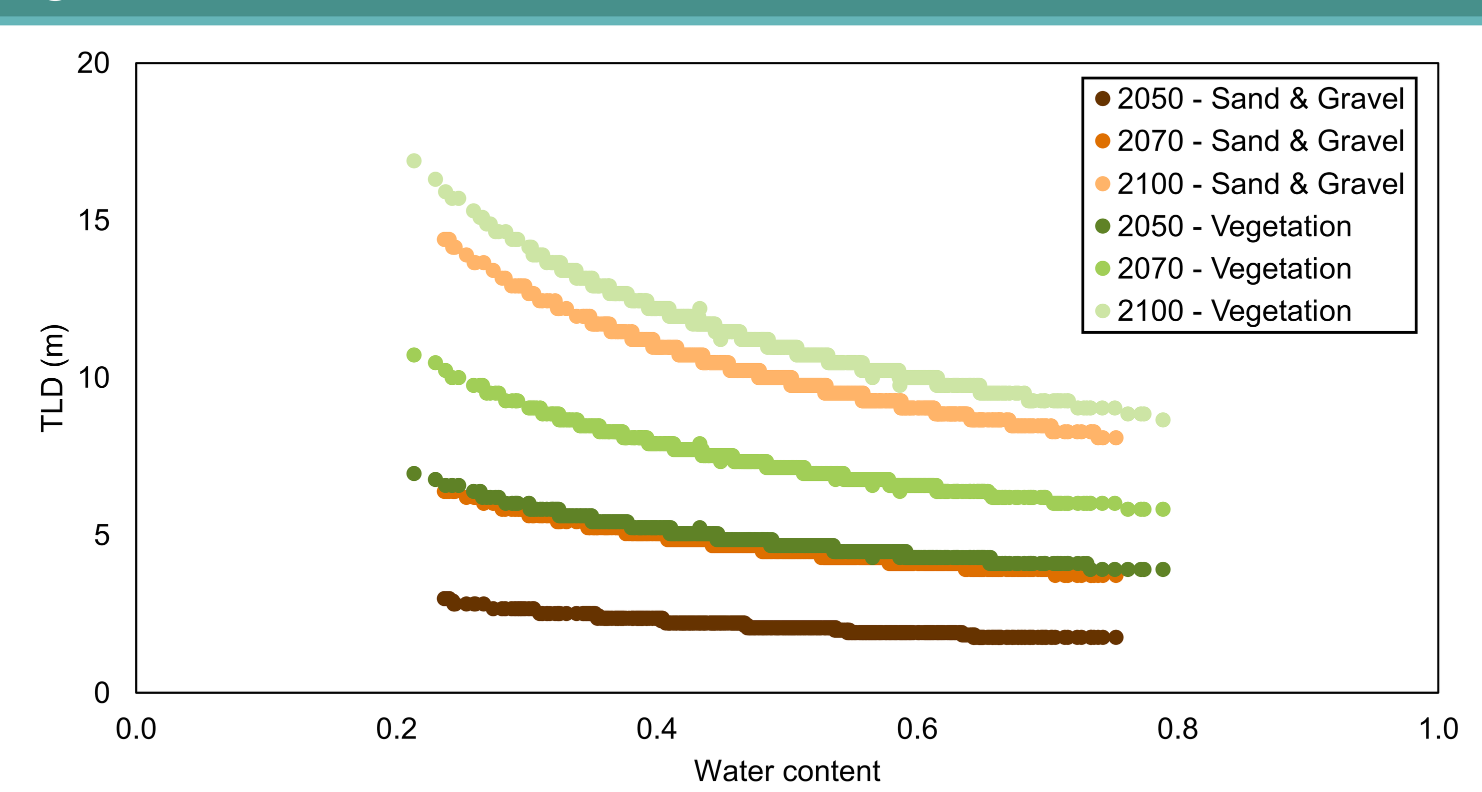

Figure 3: TLD for 2050, 2070 and 2100 in water content sensitivity analysis for both surface materials.

7. Conclusion

This study investigated the effect of thawing and freezing n-factors parameters on thawed layer depth changes in permafrost regions. Based on the findings of this study:

- Changing freezing n-factor causes bigger changes in the thawed layer depth in comparison to changing thawing n-factor indicating warmer winters are more critical than cooler summers in predicting the thermal regime of permafrost regions.
- A higher thawed layer depth was observed in varying the surface material from sand and gravel to vegetation cover in water content sensitivity analysis. Vegetation cover has a complex impact on the thermal regime of permafrost yet, it causes more heat flux absorption from atmosphere to the ground and eventually, thawing of permafrost.

8. Acknowledgement

We are grateful to NSERC PermafrostNet for providing funding for this research.

PermafrostNet
NSERC | CRSNG

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