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Scoping the risks associated with accelerated coastal permafrost thaw: lessons from Bykovsky (Sakha Republic, Russian Federation) and Tuktoyaktuk (Northwest Territories, Canada)

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0. Highlights

Permafrost thaw generates risks for Arctic communities that are broad and cross-cutting

Current models of risk under climate change may not be able to address such categories of risk

We propose an initial scoping of existing risk models using field observations.

1. Why is permafrost thaw a challenge?

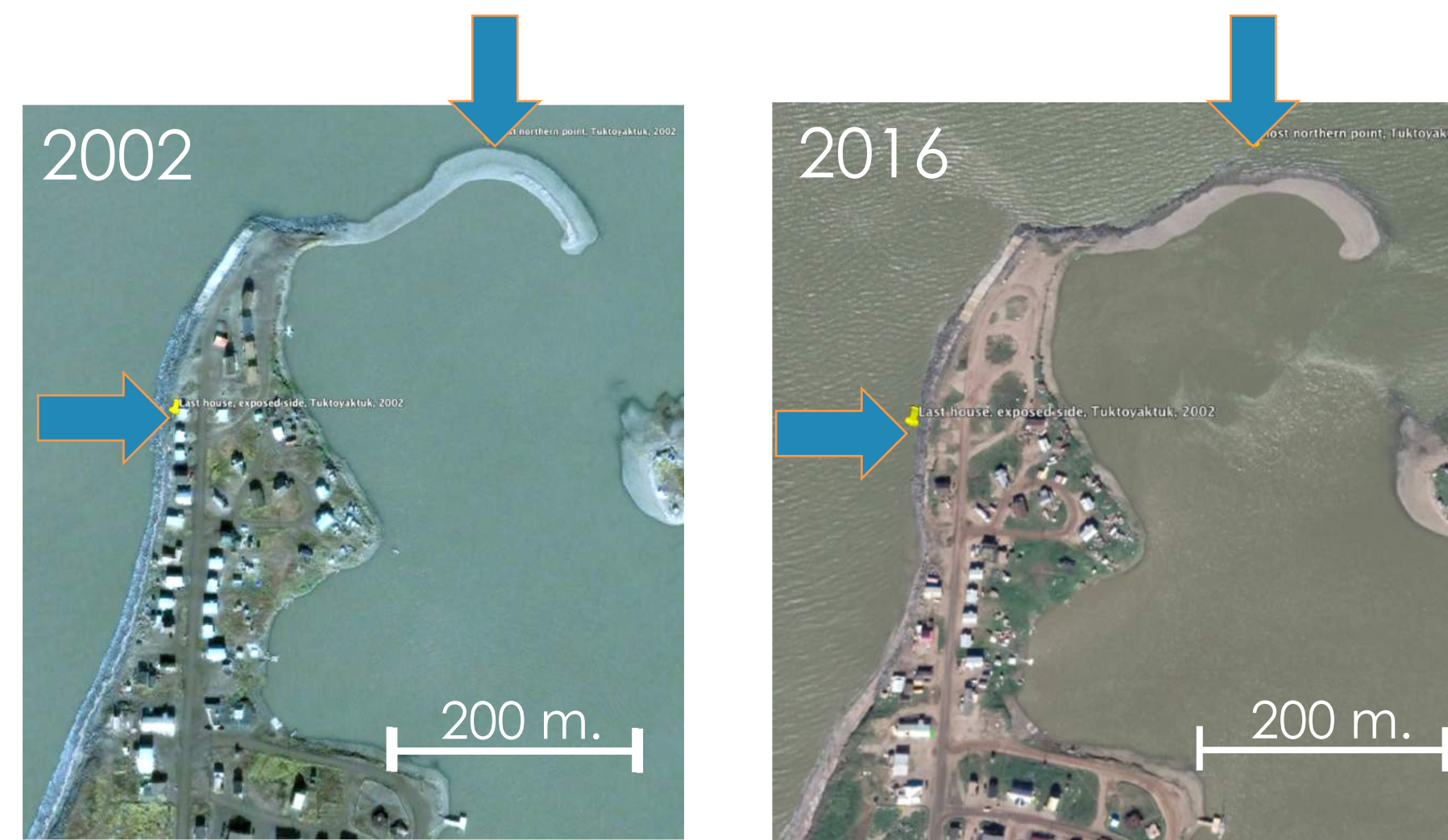
1.a. Climate warming in the Arctic has severe and multidimensional local consequences: and poses a direct threat to: (i) cultural sites and community infrastructure, (ii) marine transportation and subsistence access to terrestrial and marine resources, (iii) food resource species and community food security, (iv) identity, and even (v) worldviews. Permafrost thaw renders the coastline and associated communities more susceptible to these changes and releases nutrients and contaminants to coastal ecosystems.

1.b. Arctic communities are not homogeneous, they differ in their: (i) cultural, (ii) economic, and (iii) governance contexts.

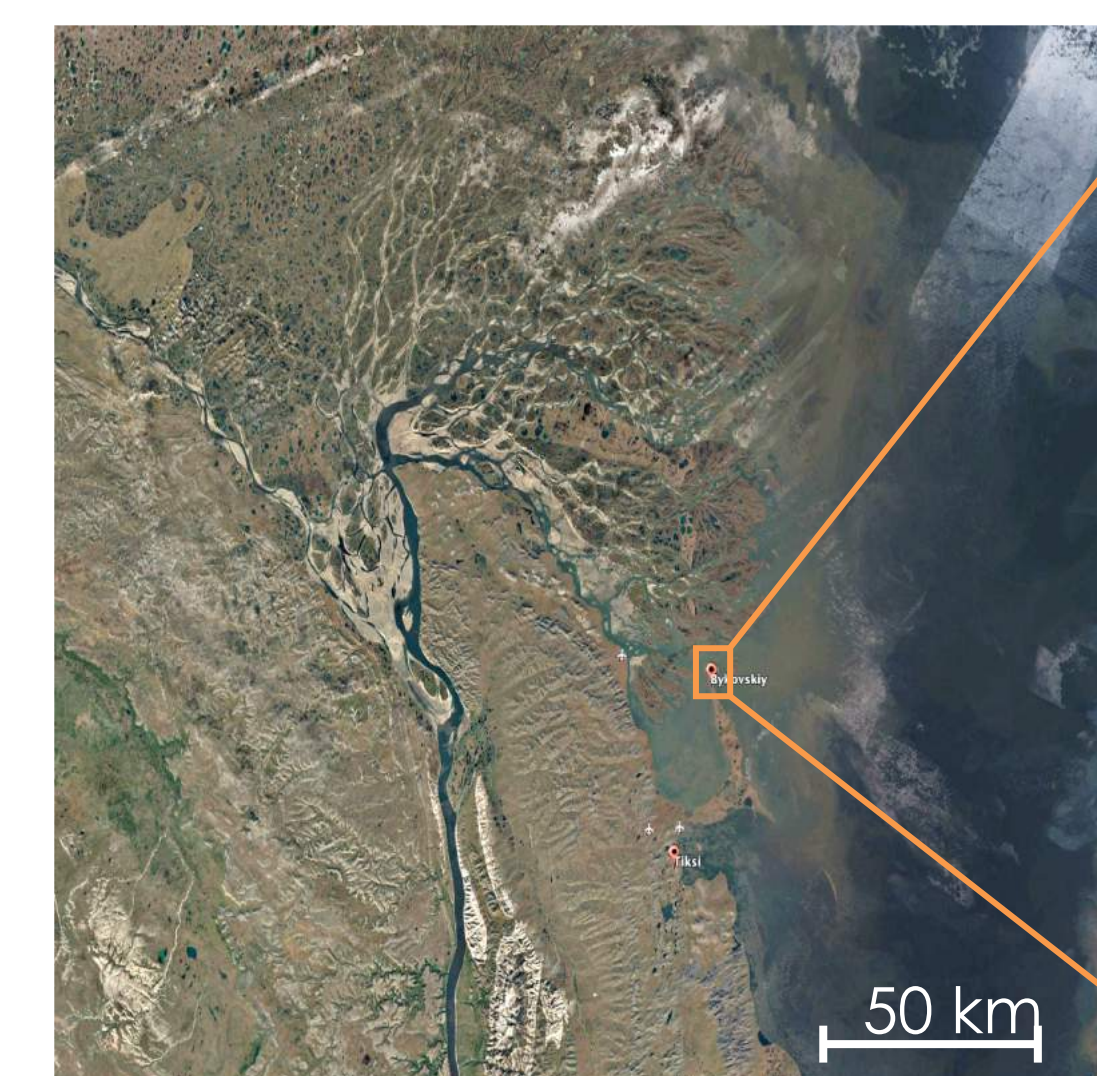
II. Two study sites



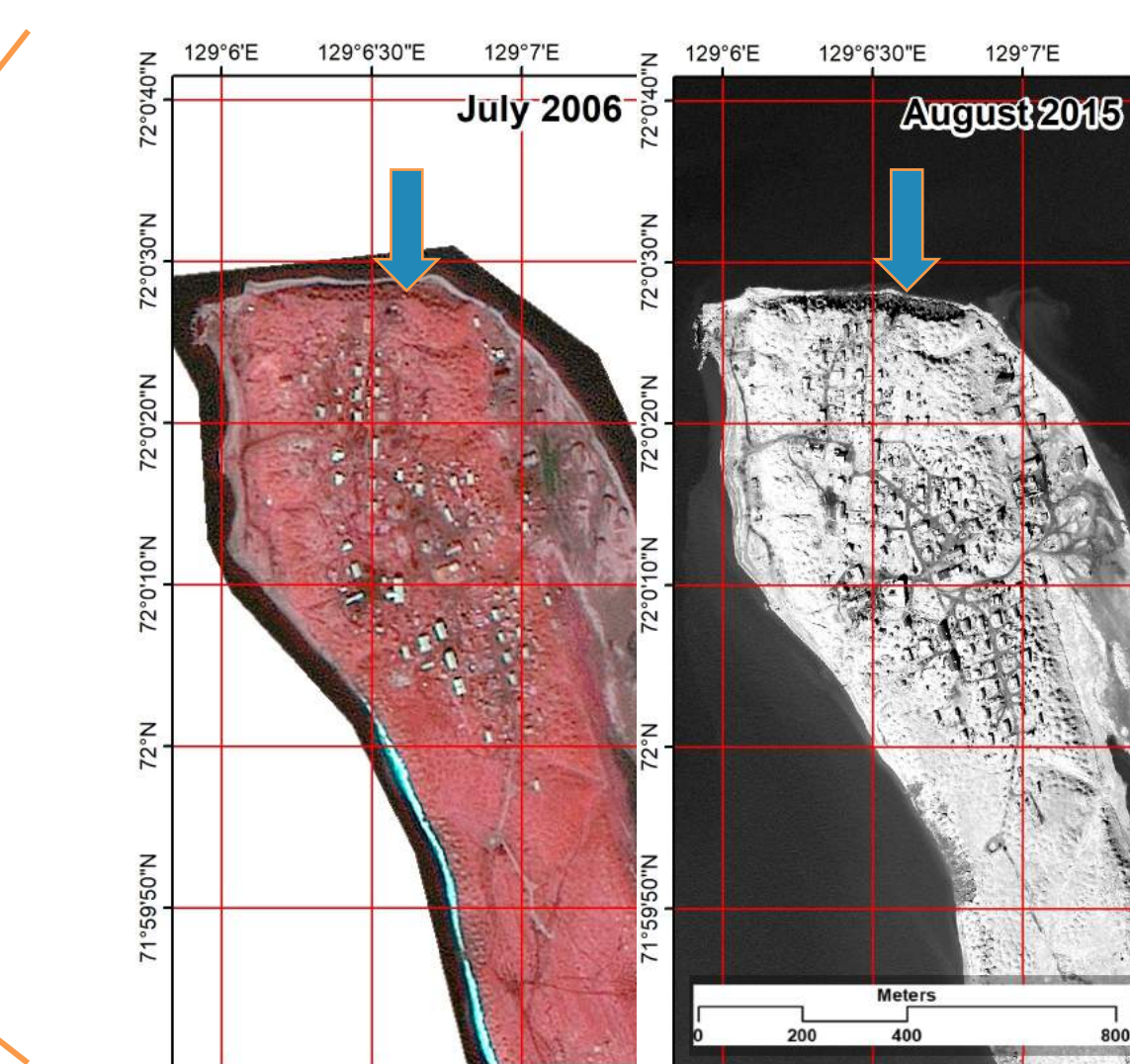
(A) Locating the two sites



(B) Northern tip of Tuktoyaktuk, 2002 and 2016



(C) Bykovsky



(D) Cape Bykovsky, 2006 and 2015

(A) Locating our two sites; (B) illustrating coastal retreat in Tuktoyaktuk, note the removal of buildings; (C) illustrating the remoteness of Bykovsky; (D) illustrating moving erosion front in Bykovsky

III. Comparing Tuktoyaktuk and Bykovsky

III. a. What do Tuktoyaktuk and Bykovsky have in common?

-> The mechanisms and impacts of permafrost thaw



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Observed impacts	Consequences	Governance challenges
Foundation shifting	Building abandonment/relocation.	<ul style="list-style-type: none"> As permafrost thaw and erosion are widespread and variable, foundation suitability and longevity of relocation sites need careful consideration. Other amenities such as shore access are important. Space is limited and retreat may entail more distant redevelopment (e.g new Tuktoyaktuk suburb) Cemetery or other places of cultural significance may not be relocated
Coastline erosion	Abandonment/relocation of buildings and other infrastructure; erosion of island a concern for harbour maintenance.	
Changes in landscape and weather	Loss of sense of place, reliability of traditional knowledge, changing ice conditions risk to hunters	<ul style="list-style-type: none"> Indigenous culture is adaptable, but changing environment challenges customary practices and traditional knowledge, with negative impacts on the well-being of northern residents.
Ecosystem changes and food resources	Loss of access to traditional resources	<ul style="list-style-type: none"> These changes affect the subsistence economy, health (food security and quality), and cultural identity. Finding alternate sources of income is not necessarily a satisfactory solution.
Transport infrastructure destabilized	Shortened ice-road season; increased costs, need for capital investment	<ul style="list-style-type: none"> Alternate infrastructure (permanent roads, bridges, harbour facilities) are expensive (e.g. newly opened Inuvik-Tuktoyaktuk Highway).
Contaminant release	Impaired safety of water and country food and related health risks.	<ul style="list-style-type: none"> While this pertains directly to physical health, related concern and stress can have direct impacts on mental health and thus community well-being.

III. b. Where do Tuktoyaktuk and Bykovsky differ? -> Mostly in their institutional contexts

Tuktoyaktuk	Bykovsky
Its status has been stabilized under the Inuvialuit Final Agreement (IFA 1984)	Economic uncertainty of Perestroika following collapse of the Soviet Union has changed demographic and economic base.
Increasing northern autonomy, economic capacity, and research leadership under the auspices of the Inuvialuit Regional Corporation.	Current rapid institutional changes both at the Sakha Republic level and at the federal level.
Has seen major investment to address some key challenges (e.g., building of Inuvik-Tuktoyaktuk all-weather road); provides shallow-draft NWT harbour.	Has not seen significant development; potential development as access point for Lena River and nature reserve and proximity to regional center (Tiksi).
Growing potential for a relatively diversified economy.	Current economic base is limited to whitefish fishery, sensitive to environmental changes.
Sees the institutional future as relatively predictable	Institutional future creating a level of perceived uncertainty.

Result We need a risk model that takes into the account the breadth of the impacts of permafrost thaw, including the cultural dimension, as well as the economic and institutional contexts as a critical source of uncertainty and isolation as a fundamental challenge.

IV. Assessing current risk models against the specifics of permafrost thaw?

Model	Pro	Con
Source Pathway Receptor Consequence (SPRC) model (Narayan et al. 2014)	Clarifies options in terms of structural solutions.	May impose a simplistic external worldview on communities
Inverted SPRC deliberative model (Kane et al. 2014)	Allows for structured deliberation about the dynamics at work	Difficult to implement, does not allow for defective institutions.
Event, vulnerability, exposure model (IPCC 2014)	Explicit in the difference between exposure and vulnerability	In the case of permafrost thaw "event" and "exposure" are intertwined.
Integrated risk perception model (Renn 2008, Vanderlinden et al. 2017)	Takes into account cultural dimensions as a central feature, acknowledges the importance of local values.	Core of argument on perceptions, need to clarify the role for facts.
System centered resilience models (Wardekker et al. 2010, Vanderlinden et al. 2015)	System thinking, consideration of institutions and governance.	Centrality of the concept of events as singular occurrences

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Conclusion

Current models of risk are not yet attuned to the specific risks of permafrost thaw, more integration work is needed.