INFRAHAZARD

Geomorphic sensitivity of the Arctic region: geohazards and infrastructure

Jan Hjort
Department of Geography, University of Oulu, Finland

Miska Luoto
Department of Geosciences and Geography, University of Helsinki, Finland

Juha Aalto
Department of Geosciences and Geography, University of Helsinki, Finland
Finnish Meteorological Institute, Helsinki, Finland

INTRODUCTION

Deeper understanding of the impacts of climate change on geomorphic earth surface systems is fundamental for science and society (Knight & Harrison 2013; Fig. 1). This is highly relevant in the Arctic, where geomorphic processes control landscape dynamics and ecosystem processes. Changes in the geomorphic systems impact on land-surface stability, and can lead to increased frequency and magnitude of natural hazards, including permafrost thaw, landslides and related ground instabilities (Nelson et al. 2001, 2002). These hazards could severely impact infrastructure, and socio-economic and cultural activities in the Arctic (ACIA 2005; AMAP 2011).

Infrastructure forms the basis for regional economic growth and sustainable development in the Arctic. Infrastructures of the Arctic land areas are highly depended on the physical conditions of upper soils. The increase in permafrost temperatures may change physical properties of soil that can have drastic negative effects on infrastructure and land use (Fig. 1). Due to the increasing economic and environmental relevance of the Arctic, it is of a vital importance to gain new knowledge on the potential threat areas of Arctic infrastructure at applicable scales (ACIA 2005; AMAP 2011).

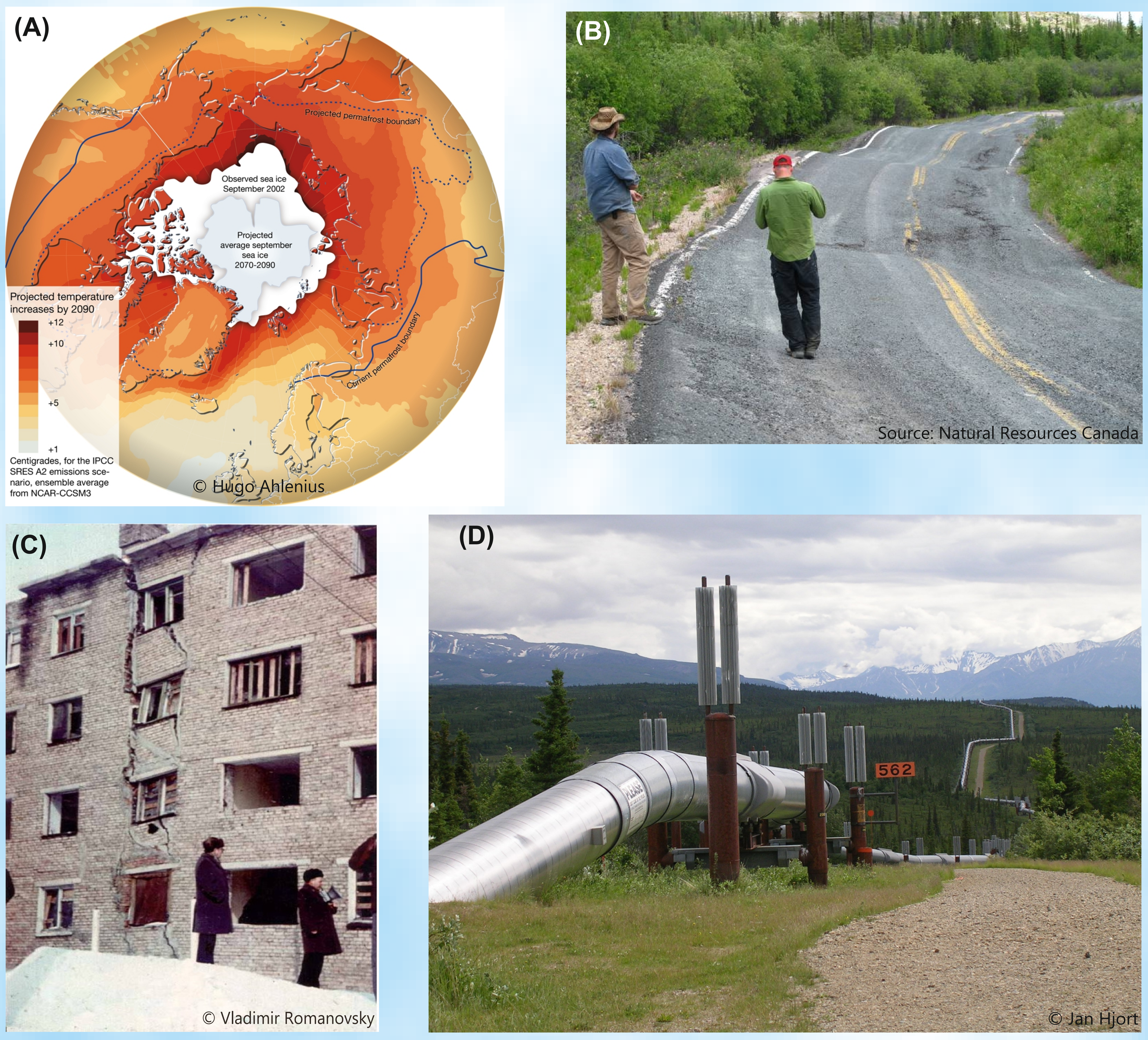

Figure 1. (A) Air temperature, permafrost and sea ice projections for 2090 (ACIA 2005). (B) Abandoned section of NWT highway 4 (east of Yellowknife) damaged by permafrost thaw. (C) A building buckled due to thawing permafrost. (D) The trans-Alaska oil pipeline.

OBJECTIVES

The INFRAHAZARD project focuses on the modelling of Arctic earth surface systems in a changing climate and production of geographic information system (GIS) based infrastructure risk maps for decision making and land use planning (Fig. 2). The specific aims are:

(i) Construction and evaluation of geomorphic distribution models across scales in the Arctic,

(ii) Assessment of the climate sensitivity of geomorphic systems throughout the 21st Century,

(iii) Exploration of the occurrence of permafrost and related geomorphic processes under warmer climates in the past, and

(iv) Production of Arctic infrastructure risk map based on the climate sensitivity outputs and compiled infrastructure database.

For the first time the sensitivities of geomorphic systems and their relation to human activity is explored across the Arctic region (cf. ACIA 2005; AMAP 2011).

DATA AND METHODS

The innovative approach is to apply complementary research data and methods to assess the impact of the climate change on the Arctic geomorphic systems and infrastructure (Fig. 2). The research is based on comprehensive GIS and remote sensing data at global, regional and local scales, and novel modelling methodology (Hjort & Luoto 2013; Aalto et al. 2014).The research consortium promotes close interaction between geography, geology and geoinformatics. Participating national and international research groups are the leading earth surface system research teams, and represent recognized expertise in the fields of permafrost science, climate change impact analyses, geoengineering and numerical modelling.

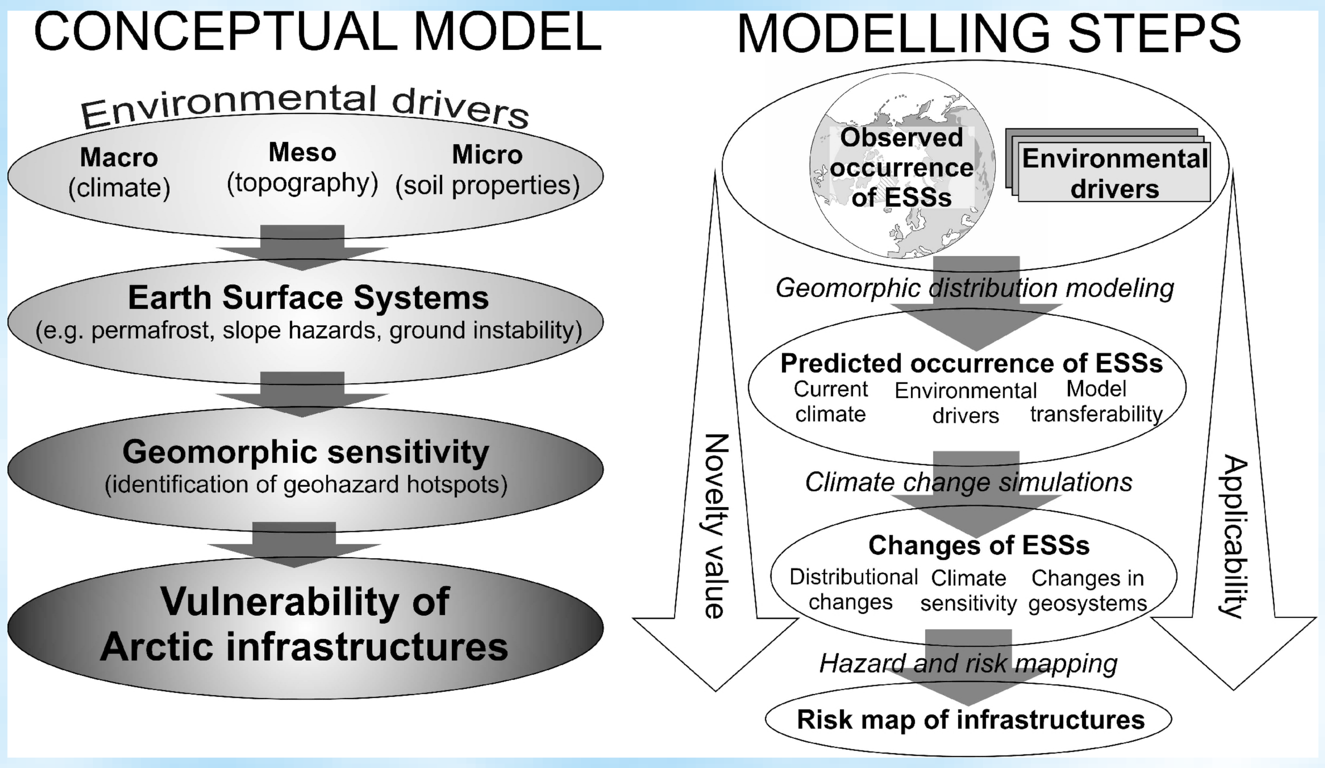

Figure 2. A conceptual model and modelling steps of the INFRAHAZARD consortium (macro, meso and micro refers to the scales of environmental drivers; ESS = earth surface system).

EXPECTED RESULTS

The expected research results have both theoretical and applied implications. The results will advance geoscientific global change research beyond the state-of-the-art in three ways. First, we improve our understanding of the geomorphic earth surface systems in the Arctic. More precisely, we gain new knowledge on the recent distributions of the key geomorphic processes. Spatial knowledge on earth surface systems is crucial in exploring Arctic landscape dynamics and ecosystem processes (e.g. productivity and biogeochemical cycles). Second, we model the consequences of climate change on geomorphic systems. For example, we gain new understanding on the sensitivity of permafrost in the Arctic. Third, we develop methodology to identify threat spots of Arctic infrastructures in the face of climate warming. More precisely, we will compile a spatial database and thematic maps about the vulnerability of Arctic infrastructure under current and warmer climates. Due to the use of full range of environmental variables our Arctic infrastructure risk maps will be more detailed than any previous presentations (Fig. 3).

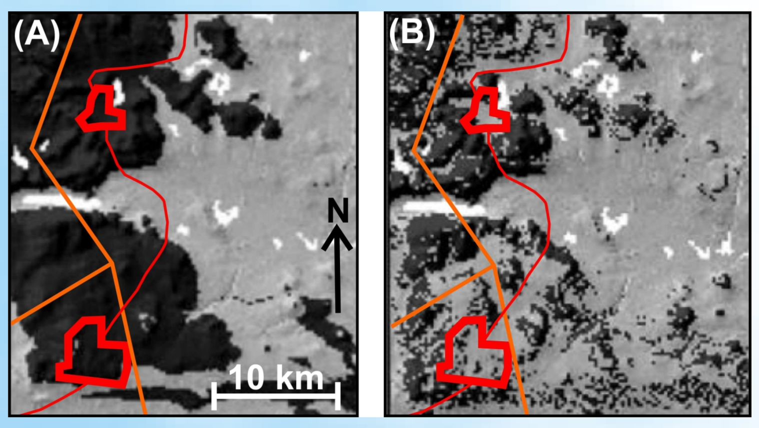

Figure 3. Fine-tuning infrastructure risk maps using local environmental determinants. This hypothetical example show high risk areas (light gray; thaw of ice-rich permafrost) and low risk areas (dark gray) based on (A) climate-only models (comparable to previous mappings) and (B) models based on full range of environmental determinants (INFRAHAZARD approach). New high risk areas appear when also local determinants are used in the analyses (red = settlements and roads, orange = pipelines).

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Professor Jan Hjort
Department of Geography
P.O. Box 3000
FI-90014 University of Oulu
Finland

email: jan.hjort@oulu.fi

Professor Miska Luoto
Department of Geosciences and Geography
P.O. Box 64
FI-00014 University of Helsinki
Finland

email: miska.luoto@helsinki.fi

Dr. Juha Aalto
Department of Geosciences and Geography
P.O. Box 64
FI-00014 University of Helsinki
Finland

email: juha.aalto@helsinki.fi

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