ARCTIC LAND-OCEAN INTERACTIONS

ISTAS workshop session:

Permafrost land-ocean interactions in the Arctic: from coastal to submarine permafrost including gas hydrates

Authors

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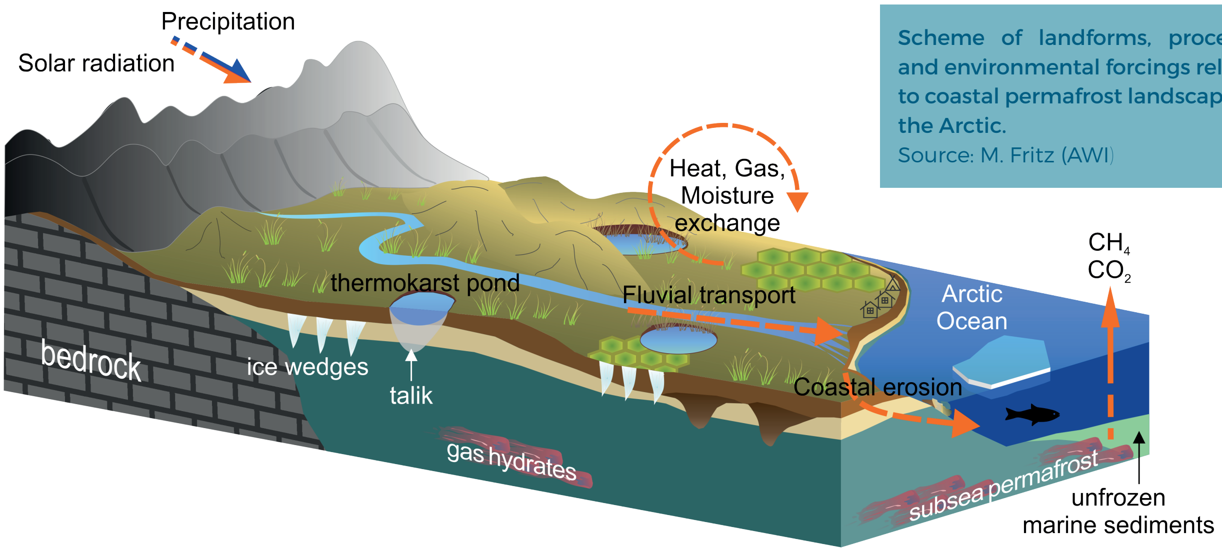
Overview

Most Arctic coasts are permafrost coasts. There is regional evidence in northern Alaska and the Laptev Sea area for recent acceleration in the rate of coastal erosion. This is related in part to more open water and higher wave energy due to reduced sea ice coverage, rising sea level, and more rapid thermal abrasion along coasts with high volumes of ground ice. Nearshore zones are a sensitive source and temporary storage for terrigenous matter inputs onto the shelves via coastal erosion, river discharge, and sea ice. Recent flux estimates of sediment and organic carbon from coastal erosion into the Arctic Ocean are around 430 Tg (Tg = 10^{12} gram) sediment per year and 4.9-14.0 Tg organic carbon per year. However, the fate of the terrestrial material, the contribution to greenhouse gas emissions and ocean acidification, and the impact on nearshore ecosystems is poorly constrained.



Scheme of landforms, processes and environmental forcings related to coastal permafrost landscapes in the Arctic.
Source: M. Fritz (AWI)

As sea levels in the Arctic continue to rise, warming ocean water and seawater intrusion enhance the degradation of submarine permafrost. Submarine permafrost is thought to act as a barrier to rising gases from depth, thus, as permafrost degrades, it allows the release of methane gas from dissociating gas hydrates into the water column. Because the Arctic coastal waters are very shallow, escaping greenhouse gases may pass through the water column, and enter the atmosphere directly.

Apart from regional to global consequences of a changing environment along Arctic coasts, immediate local implications for coastal communities and indigenous peoples are becoming more apparent. Nearshore ecosystems located in traditional hunting and fishing grounds might be impacted by high loads of sediments and nutrients released from eroding coasts. Coastal retreat leads to a loss of natural habitat for flora and fauna and of cultural heritage from the early explorers and indigenous peoples. In the Arctic coastal zone, the impacts of environmental change on local communities, on ecosystem services, and socioeconomic dynamics have not been quantified yet.

To address these issues, we require year-round and multinational access to research stations and vessels; improved and continuous satellite observation; transparent national licensing procedures; application of emerging technologies; transdisciplinary international cooperation; and improved communication among all interested parties. This framework should be sustained through the provision of adequate resources, including research funding.

The ISTAS interdisciplinary and international workshop (Integrating spatial and temporal scales in the changing Arctic System: towards future research priorities) was organized in October 2014 by the Arctic in Rapid Transition (ART) network at the IUEM in Plouzané, France. The overarching objective of the workshop was to bring together Arctic scientists of different areas of expertise and experience level in order to discuss future research priorities for the Arctic Ocean and adjacent coasts from an early and mid career researchers' perspective. This set of priority sheets summarizing the workshop's discussions is one of the contributions of the ART network to the 3rd International Conference on Arctic Research Planning (ICARP III) in Japan.

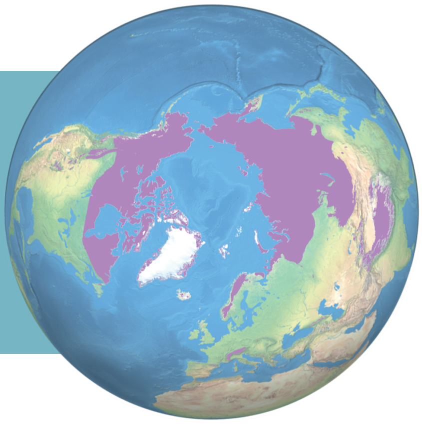
LAND-OCEAN INTERACTIONS

RESEARCH PRIORITIES

APPROACHES AND RECOMMENDATIONS

▶ Address past, modern and future dynamics of Arctic coastal erosion, and the related biogeochemical fluxes and implications for climate change.

- Conduct operational monitoring of the Arctic coasts with remote sensing.
- Improve prediction and projection of future coastal erosion and associated lateral material fluxes.
- Develop a conceptual model of coastal retreat since the last ice age with the help of paleoenvironmental data; especially from marine sediment records.
- Take into account the lateral material fluxes in Earth system models.



Permafrost distribution in the Northern Hemisphere. 24% of the land mass is in the permafrost zone (pink). Source: IPA

▶ Develop an understanding of submarine permafrost dynamics on the Arctic continental shelves regarding aggradation and degradation in the past, present and future.

- Investigate the controls on permafrost evolution and degradation.
- Improve numerical modelling of submarine permafrost.
- Apply deep drilling and improve techniques to prevent drilling hazards.
- Develop and apply suitable geophysical detection techniques to subsea permafrost.
- Include paleoenvironmental data on regression and transgression history, and on ice sheet growth and decay.

▶ Track the linkages between the Arctic Ocean and the terrestrial hydrological cycle with special emphasis on lateral water and material fluxes.

- Reconstruct temporal changes in ice sheet configuration, paleohydrology, catchment size, freshwater budget and subsurface hydrogeological conditions.
- Develop and test a terrestrial-based organic geochemical proxy for paleohydrology.
- Link paleoclimate modelling with paleoproxy data (see also ART priorities 'Proxy Calibration and Evaluation').
- Compare terrestrial archives with marine sediment records (see also ART priorities 'Paleoceanographic Times Series').

▶ Quantify the impacts of environmental change on Arctic local communities, on ecosystem services, and socioeconomic dynamics.

- Conduct community-based research.
- Assess and quantify the hazard potential for (i) thaw subsidence and thermokarst, (ii) coastal erosion, (iii) the loss of natural habitat, municipal infrastructure, and cultural heritage.

Summary

- Most Arctic coasts are permafrost coasts.
- Coastal erosion is already accelerating in some places due to climate warming.
- Gas hydrates are an additional source of greenhouse gas emissions from the Arctic when submarine permafrost degrades.
- Lateral fluxes of sediment, organic matter and nutrients will impact nearshore ecosystems and traditional hunting/fishing grounds.
- Ecosystem services in the Arctic coastal zone have not been quantified yet. This is, however, crucial to assess the socioeconomic implications of a changing Arctic.

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