INTERFACE: UNDERSTANDING EARTH SYSTEM CHANGE ACROSS ARCTIC COASTAL ENVIRONMENTS

While representing just a small fraction of Earth's surface, arctic coastal environments are among the most complex and dynamic systems on the planet. These narrow bands—where terrestrial, marine, atmospheric, and human processes interact—modulate the input of heat, freshwater, and organic matter into the ocean in ways that have the potential to generate globally significant impacts.

These include ecological and economic consequences for humans living and working in the Arctic.

Two key factors make modeling and understanding arctic coastal systems an urgent and challenging scientific priority:

- The loss of perennial sea ice, permafrost thaw, and other cryospheric change represents the largest physical transition of any region on Earth over the past several decades.
- Arctic coastal zones are at great risk for environmental hazards, coastal flooding and erosion, loss of permafrost, and increased uncertainty of sea ice extent. These can impact settlements, resource development, and national security.

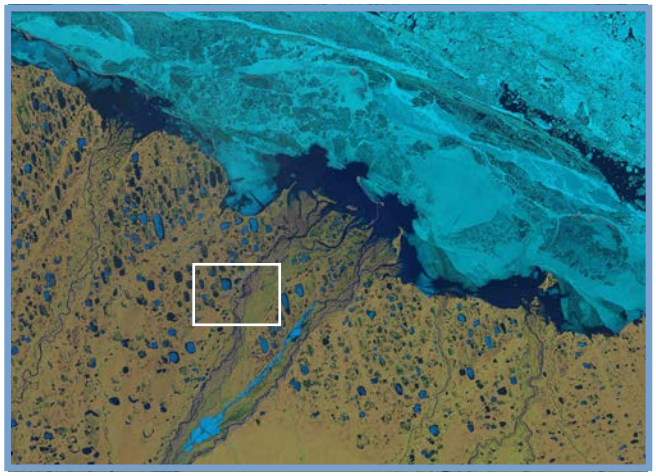
A CHANGING REGION

Observed arctic changes have not occurred in isolation. Changes to land, ocean, sea ice, and atmospheric processes will require the adaption or wholesale transformation of human systems. The fact that existing models for addressing the economic, societal, and earth system dynamics of coastal regions have focused on low-latitudes further complicates our ability to develop a predictive understanding of changes in Arctic coastal regions.

Limited modeling capability is worsened by sparse modeling data sets. Improving understanding of change magnitude, rates, and geographic variability of natural arctic change will help researchers evaluate feedbacks with human systems, such as transportation networks, resource development, and coastal communities.

INTRODUCING INTERFACE

Integrating leading expertise and data resources across the U.S. Department of Energy (DOE) complex, a new research project—the Interdisciplinary Research for Arctic Coastal Environments (InteRFACE)—is designed to improve fundamental understanding of change in arctic coastal systems.



Sentinel 2 satellite image acquired on June 6, 2018 of the north slope of Alaska. The white box highlights the Prudhoe Bay region on the banks of the Sagavanirktok River.

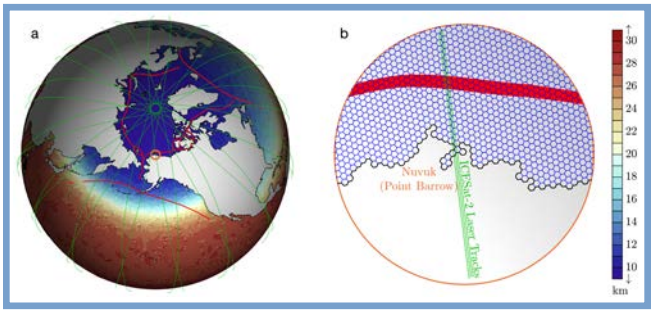
The project spans DOE's modeling (Regional and Global Model Analysis, Earth System Model Development, and Multisector Dynamics) and Data Management programs. InteRFACE is a partnership between Los Alamos National Laboratory, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratories, and researchers at the University of Alaska-Fairbanks.

Through inter-agency collaborations and workshops, InteRFACE will help integrate ongoing and proposed research investments in arctic marine biogeochemistry, shipping, and coastal change.

SCIENCE QUESTIONS

InteRFACE seeks to address the following overarching science questions:

- How will reductions in sea ice thickness and extent alter maritime shipping, resource extraction, and communities along the northern Alaskan coast and across the Arctic,



E3SM Arctic regional mesh refinement similar to InteRFACE's planned grid: a) Horizontal resolution of the E3SM unstructured grid (shaded), with a transition from 30km in mid-latitudes to 10km in the Arctic Ocean. Frame (b) is an enlarged area of the orange-circled region in the center of frame (a) surrounding Nuvuk, indicating the E3SM coastline topology. The green lines highlight an ICESat-2 overflight path and the redline shows an approximate shipping route.

and how will these changes affect local, regional, and global communities and economies?

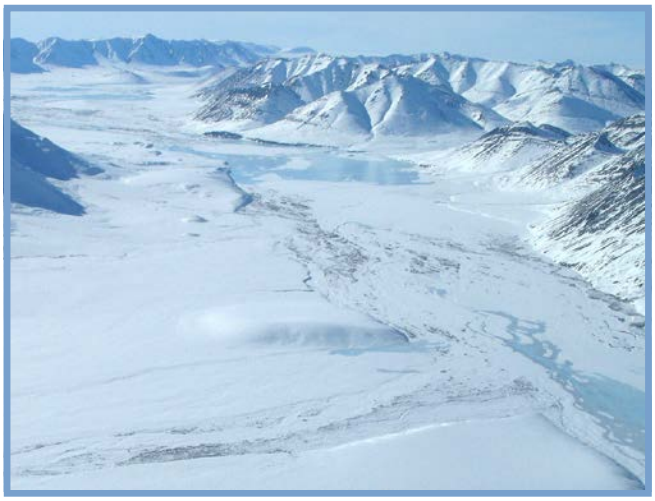
- How will riverine fluxes change, and how will these changes alter feedbacks between sea ice, ocean circulation, and marine biogeochemistry that may affect the sustainability and economies of coastal communities in northern Alaska?
- How will the vulnerability of the northern Alaska coast to erosion and flooding influence the economics of maintaining, relocating, and expanding coastal communities and infrastructure associated with resource utilization under regional and global economic drivers?

SUPPORTING EARTH SYSTEM MODEL DEVELOPMENT AND ANALYSIS

Over the next three years, researchers plan to implement several key developments for the Energy Exascale Earth System Model (E3SM). These will be tested and benchmarked on a regionally refined oceanic mesh designed to inform navigability for Arctic shipping, and better represent coastal biogeochemistry and river outflow.

InteRFACE researchers will also introduce to E3SM landfast sea ice, wave-sea ice coupling, higher-order-closure-type oceanic mixing, benthic biogeochemistry, and a nested permafrost hydrology model.

Multi-scale modeling and analysis will focus on understanding the drivers and patterns of coastal change and how potential change may interact with settlements and economic development in northern Alaska. Model development, analysis, and testing will be backed by a simulation campaign focused on quantifying the spread



Snow covered watershed on the north slope of Alaska.

of moderately-sized ensembles, presenting the potential of significant improvements to the polar physics and biogeochemistry of E3SM.

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