Development of a method for Arctic ice restoration using high-albedo reflective materials for localized surface treatments

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Abstract

Context: A Focus on Arctic Ice Restoration Arctic ice loss has been linked to global climatic changes including droughts and wildfires and extreme winter weather. Since 1979 the Arctic has lost 75% of its ice volume, resulting in a loss of albedo that contributes significantly to global warming. Ice911's mission is to develop and test methods to preserve and ultimately restore ice using a thin coating of high-albedo reflective materials applied to strategic areas of low-albedo ice in the Arctic, in order to reduce climate change impacts. Methods: Arctic Field Testing and Laboratory Safety Testing At Ice911's Arctic lake test site in Ukpeagvik (Barrow), Alaska, working with UIC for science logistics and permits, a section of the winter ice was treated with 15,000 m2 of reflective hollow glass microsphere materials, using an agricultural spreader. Monitoring instrumentation included albedo and temperature measurement and cameras mounted on buoys. The treated area was observed and compared to control areas throughout the 2018 melt. Data was transmitted wirelessly and combined with on-site aerial drone footage. Laboratory safety testing and field evaluation of the fate of the materials continued, as part of the "first do no harm" obligation of the work. Results The data collection and wireless communication worked reliably in the field. Video footage taken during the melt was run through an image processing algorithm to compare albedo differential and results show higher reflectivity in areas with material applied, despite variable stream flows during the melt. The flotation for both the custom Ice911-built buoys and a purchased buoy were compromised by the variable stresses exerted during the ice melt in the lake, and improvements are being made to the Ice911 buoy design. Laboratory safety testing shows no deleterious impacts from the materials. At the field test site, after the melt the sand-like materials were blown to shore and joined the surrounding mud. Conclusion Field work, permitting, climate modeling and laboratory testing are ongoing to confirm material safety and performance and to improve deployment and monitoring, with the goal of readying the technology for a potential targeted deployment within a few years of a 10,000-100,000 km2 on sea ice at a location chosen to have a significant positive climate impact.

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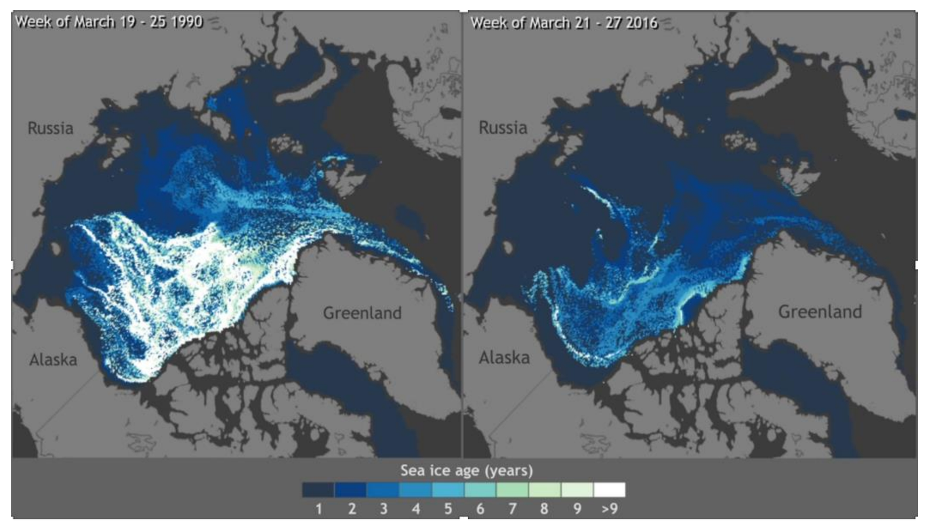
75% of Arctic Ice Lost Since 1979

Over the last several decades, the Arctic has lost 3/4 of its bright reflective ice, accelerated due to a positive feedback loop known as the Ice-Albedo Feedback Effect. Approximately 1/3 of global temperature rise comes from this loss of reflectivity in the Arctic.



Why High-Albedo Arctic Ice Loss Matters

Ice melt has been a result of global warming, but now it is acting as a lever on further climate change effects, due to its own effects on global temperature rise, destabilization of the jet stream, and changes in behavior of the polar vortex. Effects that are being felt all over the world include droughts, wildfires, floods, sea level rise, and greater severity of storms.

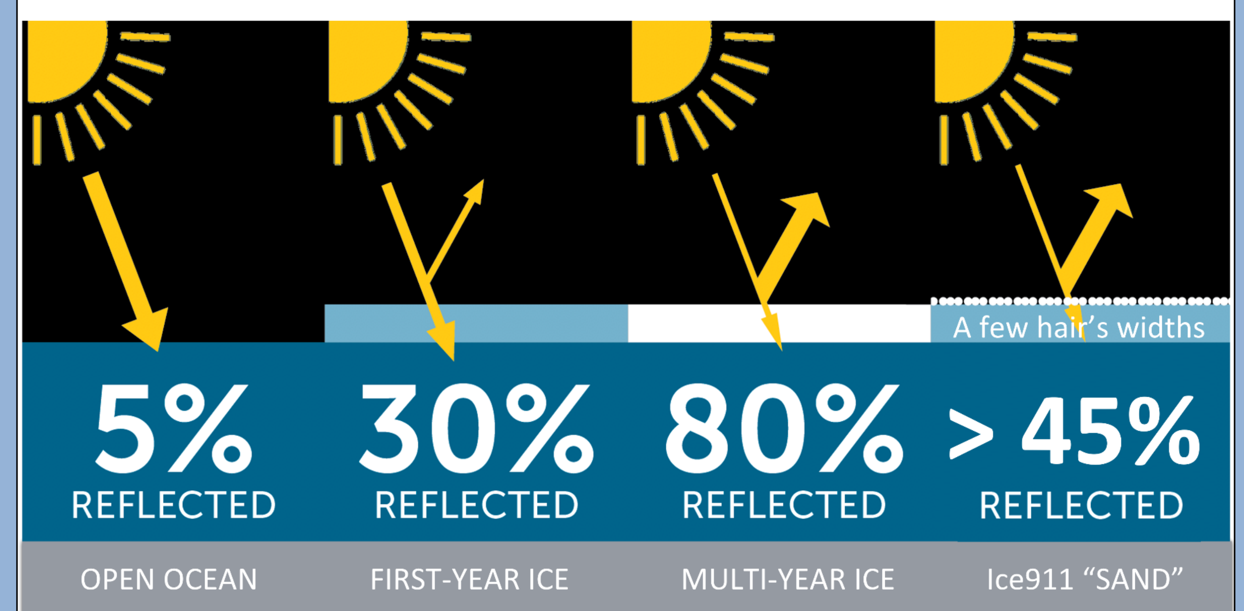
The Need to Restore Arctic Ice

Restoring reflective Arctic ice could be a powerful lever to help in the effort to limit global temperature rise to 1.5°C or less, and to reduce the risk of a number of potential impacts of further ice melt such as accelerating the melt of Greenland's ice sheets, and increasing release of methane from melting permafrost.

Surface Albedo Modification to Restore Arctic Ice

Young thin first-year ice is still formed every winter over much of the Arctic ocean, but it melts quickly in the summer sun.

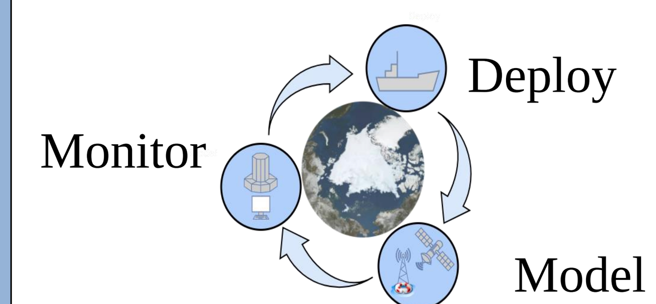
Ice911 proposes to locally increase ice albedo by spreading a thin layer of benign and highly reflective materials like hollow glass spheres materials on top of the young, thin, first-year ice, causing it to act more like highly reflective multi-year ice.

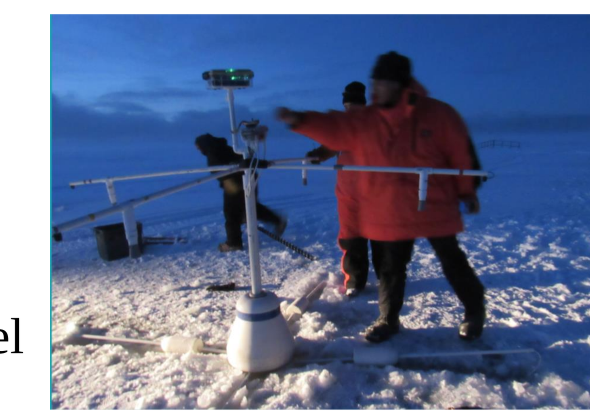


The hollow glass spheres are fundamentally like floating sand, which is silica surrounding a gas core, so that it floats. Silica is ubiquitous in terrestrial and oceanic ecosystems, and is a benign material in the presence of which the earth's ecosystems and life forms evolved.

Arctic Restoration Methodology

Ice911 uses an iterative process in its research and development efforts, in which first of all the appropriate permits are obtained for the contemplated testing in the field; the effects of the ice albedo treatment are modeled using laboratory and field-measured inputs as parameters to climate modeling; the materials are deployed in the field, and the results of the deployment are monitored and evaluated using a customized suite of instrumentation on buoys in the treated test and untreated control areas.





Ice/Snow Preservation Field Work

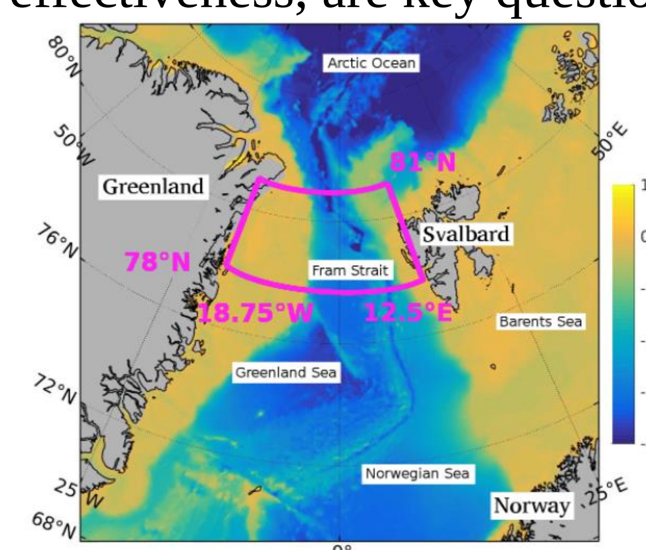
Ice911's technology was tested using an array of monitoring instrumentation on sections of small ponds located in California's Sierra Nevada Range, Alberta, Canada, Minnesota, and the BEO area in Barrow, AK.

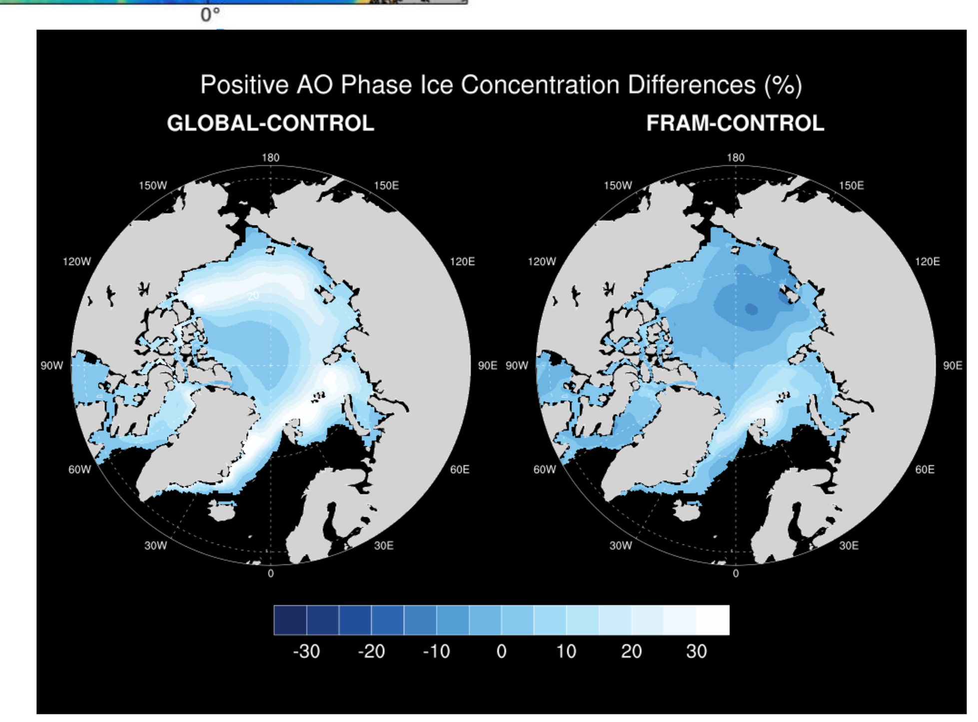
A delay in ice melt was observed beyond that seen in surrounding untreated control areas. For small areas of shallow ponds, influenced by untreated sections of the pond, surrounding shores and pond bottoms, this delay is a significant result. This merits detailed climate modeling and impact assessment of Ice911's technology, before large scale testing/deployment.

Ref: Field et al. 2018, *Earth's Future*, 6, 10.1029/2018EF000820

Climate Modeling for Strategic Leveraged Deployment

Working with expert climate modelers, one of Ice911's key questions is how much positive impact can result from a relatively small deployment in a key area of leveraged impact. The Fram Strait is one such area, predicted to be important because of the large amount of ice exported in that relatively narrow area. To identify such areas, as well as what sizes of deployment, and seasonality of maximum effectiveness, are key questions.





In Conclusion

Field testing reveals that albedo modification can be effective in preserving Arctic ice, and climate modeling reveals that the Fram Strait does indeed allow for a leveraged climate impact, and that deployment at certain times of year and certain phases of the Arctic Oscillation can be especially effective in this regard.