Modeling and assessing impact of artificially enhancing the Arctic Sea Ice Albedo

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Abstract

Summer ice in the Arctic is diminishing at an alarming rate. Increase in radiative forcing due to the loss of sea ice is contributing to global warming. Artificially enhancing the sea ice albedo could be a possible lever to restoring and rebuilding the Arctic sea ice. Using reflective hollow glass spheres with low environmental impact, Field et al (2018) reported that such a technology could be promising towards restoring Arctic Sea Ice. Here we present the preliminary climate modeling and impact assessment of such a technology both regionally and globally. We seek to answer the scientific question of whether an enhanced sea ice albedo over the whole of Arctic sea ice provides a large enough perturbation to the climate in the Arctic and if so what is its likely impact over the rest of the globe. The study shows that the climate impact of such a method results in more than 1.5°C cooler temperatures over a large part of the Arctic and about 3°C reduction over regions north of Barents and Kara Seas. We also see notable increases in sea ice thickness (20–50 cm Arctic wide) and (>15–20%) increases in sea ice concentration across large parts of the central Arctic. These preliminary results suggest that such a technology may be a viable instrument for restoring Arctic ice. However, practicality dictates that a localized targeted deployment of the technology may be more desirable. We are extending this work to evaluate targeted deployment of materials in key areas and will present the climate modeling results on efficiency of targeted deployment for at least one such targeted area. Reference: Field, L., Ivanova, D., Bhattacharyya, S., Mlaker, V., Sholtz, A., Decca, R., et al.(2018). Increasing Arctic sea ice albedo using localized reversible geoengineering. Earth's Future, 6. https://doi.org/10.1029/2018EF000820

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Poster
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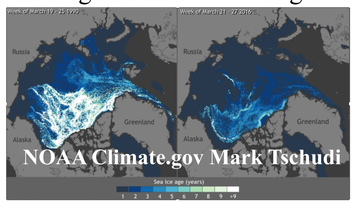
Why High-Albedo Arctic Ice Loss Matters

The highest rate of change in climate is observed in the Arctic where the summer ice is diminishing at an accelerated rate. The loss of Arctic sea ice increases radiative forcing and contributes to global warming.



Ice911 Technology can Restore Arctic Ice

Restoring reflectivity of Arctic ice could be a powerful lever to help in the effort to limit global warming to 1.5°C or less. Ice911's novel method to locally increase ice albedo is to spread a thin layer of highly reflective materials like hollow glass spheres materials on top of the ice.

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.

Arctic Restoration Methodology

Climate Modeling

Objective: **To investigate the regional and large scale climate impact of local changes in the Arctic sea ice albedo.**

We study how the changes in sea ice albedo impact:

- Sea ice concentration
- Sea ice area
- Sea ice volume
- Sea ice thickness
- Sea ice export
- Arctic temperature
- Global temperature

Modeling & Simulation: Simulate the effect of Ice911 material by perturbing the sea ice albedo in key Arctic regions using climate model.

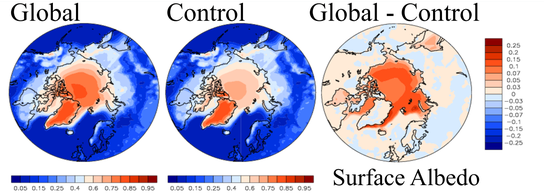
We use the NCAR Community Earth System Model (CESM) - fully coupled climate model which consists of atmospheric, ocean, land and sea ice components interacting and exchanging water and energy fluxes via coupler.

Numerical Experiments:

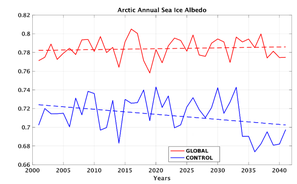
1. Control – Current Day Climate
2. Sensitivity Experiment 1 – Arctic-Wide Sea Ice Albedo Changes (Global)
3. Sensitivity Experiment 2 – Fram Strait Sea Ice Albedo Changes (Fram)

Results show increasing albedo

Global Control Global - Control



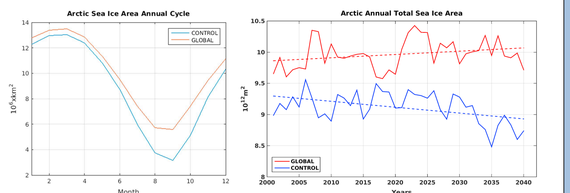
Surface Albedo



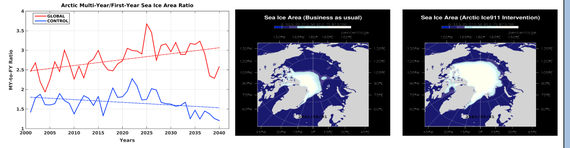
Increasing trend in annual sea ice albedo

Enhancing Albedo Increases Ice metrics

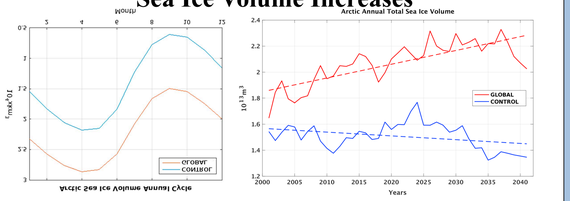
Sea Ice Area Increases

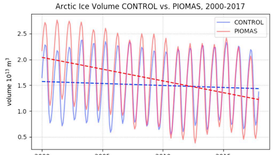


Multi-Year Ice Summer Ice



Sea Ice Volume Increases

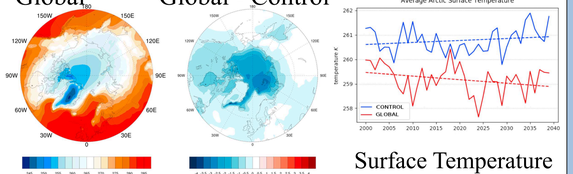




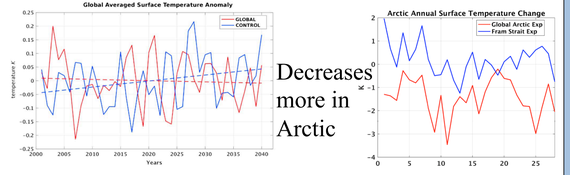
Pan Arctic Ice Ocean Modeling & Assimilation System, Reanalysis Data 2000-2017

Lowers Surface Temperatures

Global Global - Control

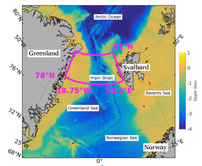


Surface Temperature



Decreases more in Arctic

Targeted Strategic Deployment



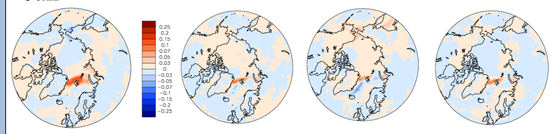
Strategic treatment area in Fram Strait

Questions we seek to answer

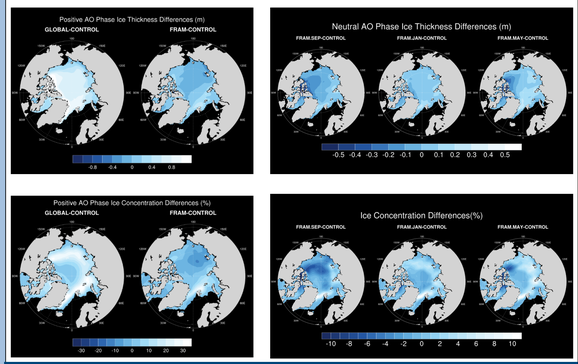
1. Selecting a strategic location
2. When to deploy? Seasonality
3. Arctic Oscillation Phase
4. Comparing Arctic-Wide vs strategic deployment
5. Size to deploy

Surface Albedo increase over Fram (Fram-Control)

positive phase Jan neutral phase Jan May Sep



Increase in Ice Thickness & Ice Concentrations



In Conclusion

- Arctic ice regrowth is an effective lever on global climate
- Albedo modification of sea ice is an effective method of ice preservation
- Albedo enhancements increase the sea ice area and volume and decrease the surface temperature

Further studies underway to evaluate impacts of targeted deployment. **Ref: Field et al. 2018, *Earth's Future*, 6, 10.1029/2018EF000820**