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Re-thickening Arctic Sea Ice

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Regional Application of Arctic Ice Thickening

Arctic sea ice is essential for Arctic peoples and ecosystems whilst also keeping the Earth cool by reflecting vast quantities of solar radiation. As sea ice melts it exposes dark open ocean which absorbs more solar radiation, warming the planet and melting more ice in a feedback loop known as *Arctic Amplification*. Arctic ice thickening aims to slow or even reverse the current trend of melting by thickening sea ice, so it survives longer during the summer months and reverses the feedback loop of *Arctic Amplification,* cooling the Arctic and the planet.

Targeted Ice Arch Strengthening

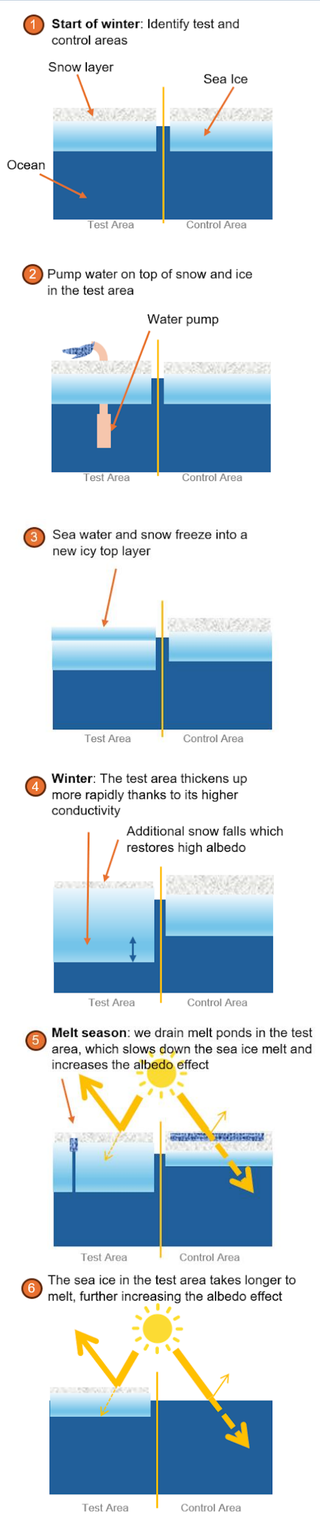
Sea ice is exported from the Arctic ocean via a few key routes. Ice arches typically form as a barrier that block the export of ice, but these have been forming less frequently and breaking up more easily (Moore, G. W. K. et al., 2023). Hence, it may be beneficial to thicken the relatively small ice arches so that they are stronger and more resistant to the pressure of the sea ice behind them. Delaying the breakup of the ice arches would contain the sea ice within the cold Arctic ocean where it is less susceptible to melting and can reflect the most solar radiation back into space, keeping the Arctic and the planet cooler.

During the Arctic winter, existing sea ice acts as an insulator between the cooling on the surface and the seawater that is freezing at its base. Any snow on the ice is even more insulating and further slows the rate of sea ice growth. Under investigation are two techniques for increasing the rate of sea ice growth:

- *Surface Thickening*: Pumping seawater to the surface of snow-free ice. This bypasses the insulating effect of the existing sea ice as the seawater is directly exposed to cooling. Therefore, it freezes faster and thickens the sea ice from its top surface (Desch et al., 2017).
- *Snow Flooding:* Flooding snow on the ice's surface to consolidate it into solid ice that is less insulating. Alongside the increase of ice thickness on the top surface it also increases the rate of natural freezing on the base of the ice for the rest of the winter (Pauling & Bitz, 2021).

In early Arctic summer solar radiation melts the ice/snow surface which forms ponds of dark meltwater on top of the sea ice. These absorb much more solar radiation than the reflective snow/ice, warming up and therefore increasing the melt rate. A summer intervention is therefore considered to slow the melt rate of either existing or thickened ice:

- *Melt Pond Draining*: Drilling small holes through the ice in the centre of melt ponds so that the melt water drains from them back into the ocean, maintaining the highly reflective snow/ice surface so that the rate of melting is reduced.



Satellite Analysis

Applying ice thickening across the whole Arctic is impractical. Therefore, satellite analysis will be used to help identify areas where ice thickening could have the maximum benefit, e.g. ice arches or regions where the ice can be prevented from melting fully during the Arctic summer.

Small-Scale Ice Modelling & Lab Experiments

The flooding of ice that is either covered in snow or just bare has not been thoroughly researched. A variety of modelling techniques and lab experiments will be used to assess the impact of ice thickening on various properties of the ice such as ice thickness, temperature, salinity and strength along with how seawater flows through snow. These are important for capturing the details which can be represented in larger-scale models and may be difficult to measure in the field.

Arctic/Global Scale Modelling

The impacts of ice thickening/arch strengthening must be assessed at the Arctic/global scale. In particular the large-scale modelling will inform the overall global impact of the techniques and when/where implementation could be most beneficial. Both Arctic-scale and Earth system models will be used to model ice thickening and arch strengthening to investigate their impacts at large scale and over long time periods.

Impact upon Arctic Albedo

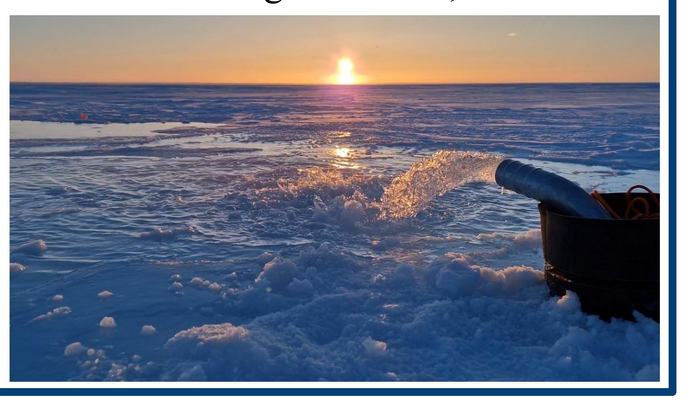
There are benefits of increased ice cover (both spatially and temporally) for people and ecosystems in the Arctic but a key driver behind the project is increasing the Arctic (and Earth's) albedo. Coinciding with the regional/global scale modelling, the impact of ice thickening on albedo both directly (e.g. consolidating snow into ice) and indirectly (e.g. ice surviving for longer) will be a particular focus throughout.

Field Experiments

Field experiments have already provided valuable insights and are essential to develop our understanding of the processes governing ice thickening. These are ongoing in various Arctic locations, increasing in scale and in measurement detail to feed into all aspects of the project. We will continue to be led by local Inuit partners in the field work throughout the entirety of the project.

Conclusions

The aim of the project is to investigate ice thickening techniques for two purposes. The first is the preservation of sea ice where it would have otherwise melted for the primary purpose of reflecting more solar radiation back into space. The second is thickening ice arches, which slow ice export from the Arctic ocean, to strengthen them and delay export of ice into warmer waters where it will melt. Again, with the purpose of maintaining ice cover to cool the Arctic and thereby the planet.



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