Diomede Crossroads

Saving the Arctic sea ice? Thoughts on plausibility

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Motivation

Concerning three facts: present melting, additional future temperature rise under thermal climate inertia and continued global greenhouse gas emissions, and possibly sped up by many positive feedbacks, conventional mitigation efforts, however ambitious, will fail to prevent the complete disappearance of Arctic summer sea ice – most likely on a timescale of no more than decades.

Why 'accepting losing the North Pole'?

Complete melting of the Arctic sea ice cap would be a great loss. Ecologically and, why not mention, emotionally. Moreover, resulting negative climate effects will be felt world wide, through a process known as Arctic Amplification. For instance through the albedo feedback Arctic melting is already increasing temperature rises on the northern hemisphere. And melting in the permafrost zone will further amplify global warming through methane emissions.

Concerning not only what is at stake, but also the immense efforts that are required to slow down global warming, illustrated by the United Nations negotiations on the climate treaty, warrants a search for additional options to help stabilise the Arctic and, in doing so, the wider global climate system. From an Earth system, an ecological and a human perspective, the loss of the ice cap over the Arctic Ocean is simply put unacceptable. That should be the starting point.

Bering Strait, key to the Arctic?

Now as a thinking experiment for a local climate engineering approach aimed at stabilising Arctic sea ice, what would be the effects (detrimental and beneficial) of artificial closure of the Bering Strait? One thing that seems sure is, it will have big effects, as it will close off most interchange between Pacific and Arctic waters, influencing the three most relevant factors:

Ice factors

1. Temperature
2. Dynamics
3. Salinity

For all three factors a decrease is desirable. However, simply (and fully) closing off the Bering Strait may lead to the actual increase of one (salinity). As quantifying absolute influence or determining relative significance would of course require further study, at this stage, from a climate perspective, intervention can only be advocated if all three factors would be decreased – as that would guarantee a net climate stabilising influence.

Fortunately, by adjusting the plan, this seems quite possible. To point out the expected influences on the three factors (temperature, dynamics, salinity) three different options will be analysed, differentiating a plan A, B and C: the Diomede Dam, the Diomede Threshold and the St. Lawrence Dam.

Plan A: the Diomede Dam

Definition:
Fully closing off the Bering Strait by placing a dam at its narrowest point, connecting the Diomede Islands to the mainland of Alaska and Siberia.

Effects

1. Temperature
Plan A will lead to a decrease of temperatures in the Chuckchi Sea: Halting all movement of water, be it northward or southward, can only improve temperature isolation of the Arctic, leading to colder waters. Presently a dominant water current carries Pacific waters through the Bering Strait, deep1 into the Arctic Ocean, bringing relatively high temperatures and probably being the most important factor in the pattern of early spring melt in the Chuckchi.

2. Dynamics
Plan A will lead to a decrease in water and ice dynamics, locally as well as, perhaps, on a larger scale; thereby favouring stability and permanence of the Arctic sea ice, that will be less likely to disintegrate by forces such as the Beaufort Gyre. A dam will not only stop water currents, it will also decrease storm fetch, locally. This favours a stable ice cap over the Chuckchi. Moreover, as the inflow of water from the Pacific is stopped, a slight decrease of the outflow of sea ice to the Atlantic, typically and annually occurring along Greenland's east coast, can, theoretically, be expected.

3. Salinity
A decrease in salinity favours sea ice formation and slows down ice melting. Quite contrary to what one would expect, the inflow of Pacific waters is, according to NOAA, a major source of freshwater in the Arctic. This is because the northward current along Alaska's coast picks up the water of the Yukon, that mouths just 100 km south of the Bering Strait, and then carries it through the strait into the Arctic Ocean. Plan A will stop this inflow, thereby possibly leading to an undesired increase of salinity in the Chuckchi, promoting ice melt.

Plan B: the Diomede Threshold

Definition:
Partially closing off the Bering Strait by building a threshold, on the same location as the dam of plan A, limiting water inflow to a certain depth.

Effects

1. Temperature
Similar to plan A a decrease of temperature in the Chuckchi can be expected, although the effect is likely to be far less pronounced. Partially sealing off the Bering Strait will allow for some heath exchange between the Pacific and the Arctic to remain. Also noteworthy: a close off of for example 80 percent is unlikely to leave just 20 percent of the Pacific inflow remaining as, most likely, it will lead to an increase in flow velocity.

2. Dynamics
As for temperature plan B seems unlikely to have big effects on dynamics, as there will be no dam above the water line to lessen wind fetch. Since a small decrease of the Pacific inflow remains to be expected, on a larger scale plan B could, theoretically, contribute to a (very slight) decrease in sea ice outflow towards the Atlantic.

3. Salinity
The big reason to opt for plan B is of course that it will allow for freshwater inflow from the Yukon to remain. What's more, at a cleverly adjusted altitude plan B can actually help decrease salinity in the Chuckchi, making use of the salinity gradient of the water that increases with depth, as saltier water is heavier. Under the present conditions in the Bering Strait the Yukon freshwater indeed seems to flow on top of the saltier Pacific seawater. It seems plausible therefore that a threshold in the Bering Strait could decrease salinity of the inflowing water, without decreasing discharge too much, to the extent that a decrease of salinity in the Chuckchi can also be expected, favouring sea ice conditions.

Plan C: the St Lawrence Dam

Definition:
1. Fully closing off Pacific waters from the Arctic by building a dam not at the very Bering Strait, the narrowest point, but instead further south in the Bering Sea, on the shallow plain of the continental shelf, connecting St Lawrence island to the mainland of Alaska and Siberia.
2. Optional, to increase benefits: diverting part of the lower Kuskokwim river flow, by digging an approximately 100 kilometer long canal, connecting this 9th largest river of the United States to the lower Yukon.

Effects

1. Temperature
Plan C will lead to a decrease in temperature in the Chuckchi (and the entire Arctic) similar to plan A, but perhaps even slightly greater, due to increased spring and autumn albedo benefits on and around the northern Bering Sea, that in turn increase temperature insulation.

2. Dynamics
Plan C will lead to a decrease in dynamics in the Chuckchi (and the entire Arctic) similar to plan A, with the difference that this effect will reach further south.

3. Salinity
Plan C will lead to a decrease in salinity in the Chuckchi (and the entire Arctic), because the only net water flow northward through the Bering Strait will originate in fluvial input, whereas all salt, oceanic inflow is blocked.
Plan C will also lead to the formation of a small basin in between the St Lawrence dam and the Bering Strait. Most likely the waters of this basin will become significantly less salty over time, as it will be more or less 'flushed' by Yukon waters. It is therefore also likely this basin will easily freeze during winter months, and stay frozen to some point much further in spring than the present early unset of Bering and Chuckchi melting, creating the above mentioned albedo benefit. Although this effect will be local and small it does add dimension, literally, to the temperature border between the Pacific waters and the Chuckchi Sea.

Conclusion
Based upon the comparison of likely effects on three dominant factors influencing Arctic ice conditions plan C seems most potent.

Concerns

Any plan acting on a large scale may also possibly have large-scale negative side effects. One can never advocate execution of these plans before they are thoroughly researched. So far, however, concerning the St Lawrence Dam, it is still likely that for all relevant climate criteria benefits may outweigh costs.

1. Ecology

Any dam disconnecting Pacific and Arctic waters would create an ecological barrier between the two. This is of course highly undesirable. However, concerning this plan the ecological 'cost of inaction ' seems much bigger , as complete melting of Arctic sea ice leads to a collapse of the Arctic marine ecosystem and its many interdependent organisms . The Bering Strait does not seem to serve the role of a crucial migration route to Arctic whales, like the beluga and the bowhead.

2. Thermohaline circulation

The big risk of interfering with Arctic currents is a disturbance of the worldwide thermohaline circulation. However, the stability of the entire worldwide thermohaline circulation is served by sustained cold in the Arctic, as the low temperatures allow for crucial formation of so called deep water (in the North Atlantic-Arctic bordering area). Therefore this plan seems much likelier to increase thermohaline stability, than to decrease it. It should be noted that thermohaline stability also increases with salinity. This plan indeed aims to lower salinity, by increasing fluvial influence. However this effect will most likely be local, in the Chuckchi and around the Arctic coasts of Alaska and eastern Siberia and not in the Greenland Sea, the zone of deepwater formation. The only real risk of significantly decreasing water salinity in the Greenland Sea would be melting of sea ice and an increased inflow of melt water from Greenland. Through albedo effects, this plan may even help decrease Greenland melting and decrease the inflow of Greenland melt water, again favouring thermohaline stability (although that effect is likely to be small as the geographical distance between most of the Greenland ice sheet and the Chuckchi Sea, central focus point of this plan, is rather big – over 4.500 km).

3. Increased Atlantic influence

Apart from thermohaline concerns, building the St Lawrence dam would decrease the discharge of the Bering Strait inflow. This means the present point of 'collision' of inflowing Pacific and Atlantic waters, the ' crossroads', on the edge of the Chukchi plateau and the Amerasian Basin, will disappear. Perhaps this will decrease friction of the Atlantic current that is thereby enabled to extent its flow and influences, mainly the transportation of warmer water, into the Arctic. As the Pacific inflow is already comparably small, and the Amerasian Basin very voluminous, it seems unlikely this will have significant impacts.

4. Overshooting

This plan should help preserve the Arctic climate, not create the onset of global cooling. If it would prove effective to theoretical extremes, feedbacks like the albedo effect could lead to undesired sea ice formation, beyond the original extents of the polar ice cap. This seems very unlikely. If however calculations should prove inadequate to remove this concern, many engineering options are at hand to prevent overshooting and regulate the process.

5. Practicalities

Building the St Lawrence dam would require thorough scientific research, international cooperation and of course a large financial investment. On the other hand, from an engineering angle, it does seem feasible. As the length of St Lawrence Island will make up a significant part of the dam, its dimensions can be reduced to a length of some 300 kilometres. Presuming the local Bering sea has an average depth of some 50 meters, and the dam would need to be twice as wide as high, around 1.5 billion m3 of rock would be required. How do these financial costs compare to the carbon credits of prevented permafrost emissions? (Plan B, the Diomede Threshold, would of course have far smaller material requirements.)

Final Thoughts

Building the St Lawrence Dam could be part of an ultimate effort to save the North Pole sea ice, the Arctic marine and tundra ecosystems, and prevent or slow down positive feedbacks influencing global warming, like the northern hemisphere albedo effect and possible future methane emissions.

If the St Lawrence Dam would prove capable of truly halting permafrost thawing it is not unthinkable its mitigation effect, expressed in prevented methane emissions, is of a similar scale as the combined reduction efforts under the Kyoto Protocol. (If only one thing is to be concluded from that, it should be the necessity of increased collective ambition for future climate treaties, especially the forthcoming Copenhagen Protocol.)

Clearly and unmistakably, what the world needs is massive investments in renewable energy, energy efficiency and other clean technologies, collective lifestyle changes, halting deforestation, carbon taxation and ETS. But apart from that, in an effort to stay below truly dangerous CO_2 (-equivalent) levels we may need to look for additional measures, especially ones that are focused on preventing emissions from positive carbon feedbacks. If for instance the St Lawrence Dam proves capable of preventing a part of permafrost thawing and methane emissions, it should be considered as such, and hopefully promote further thinking along similar lines – in order to actually preserve the all-important Arctic sea ice cap.

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