Anne Mo Krogh | GEOF338 | University of Bergen – Geophysical Institute

Latent Heat Polynyas and Deep Water Formation in Storfjorden

UNIVERSITY OF BERGEN
Faculty of Science and Technology

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Introduction: The Arctic Ocean includes shallow continental shelves. Deep water form inside polynyas on these shelves and are important for ventilating the deeper ocean.
This poster will explore how a polynya in Storfjorden, Svalbard produce dense brine enriched shelf waters (BSW).

What is a polynya?

Polynyas are open-ocean areas within the pack ice cover [2]. There are two types of polynyas; sensible heat polynyas (thermally driven) and latent heat polynyas (mechanically driven). **Latent-heat polynyas**, the main focus of this poster, develop in regions where persistent offshore winds or divergent ocean currents advect sea ice away from the coastline or from zones of landfast ice [2].

Figure 1: Map showing where Storfjorden, Svalbard is. Source: googlemaps.com

How does a latent heat polynya lead to the production of BSW?

Persistent winds move newly formed ice
↓
Ocean is exposed to cold atmosphere
↓
Heat loss from the ocean to the atmosphere
↓
Frazil ice formation
↓
Salty brine is released to underlying water column
↓
Local water density increases
↓
Dense water masses (BSW) sink down the continental slope and ventilate the deep ocean [1];[2]

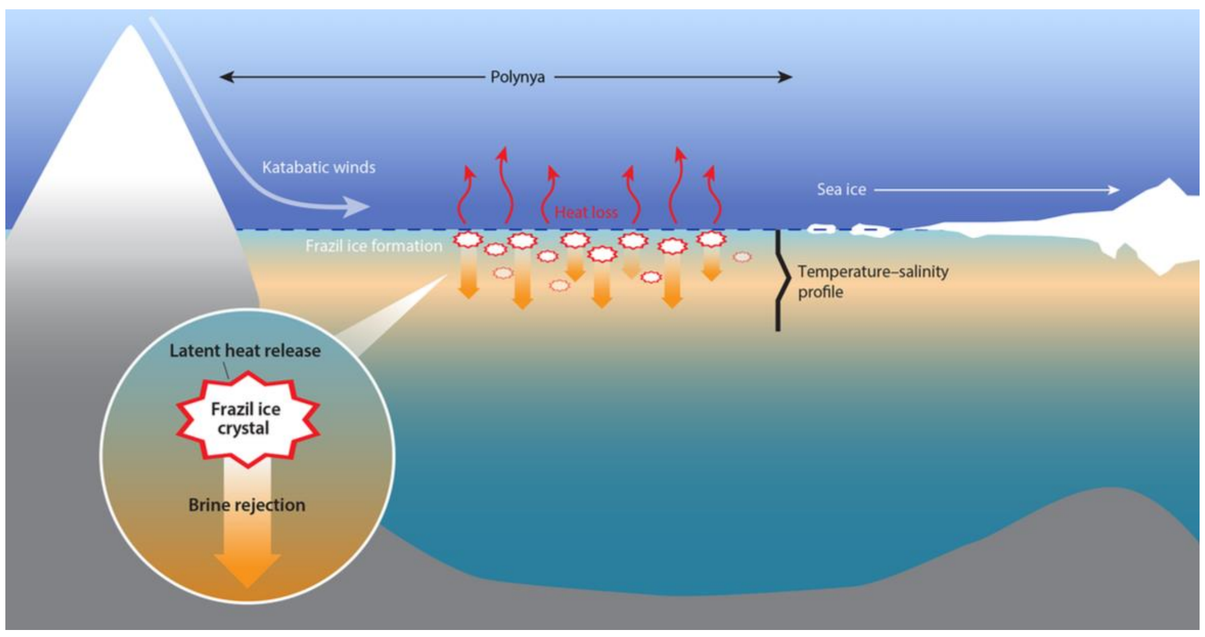

Figure 2: Schemtaic showing how kabatic winds lead to latent heat polynyas. Figure by Thompson et al., 2020.

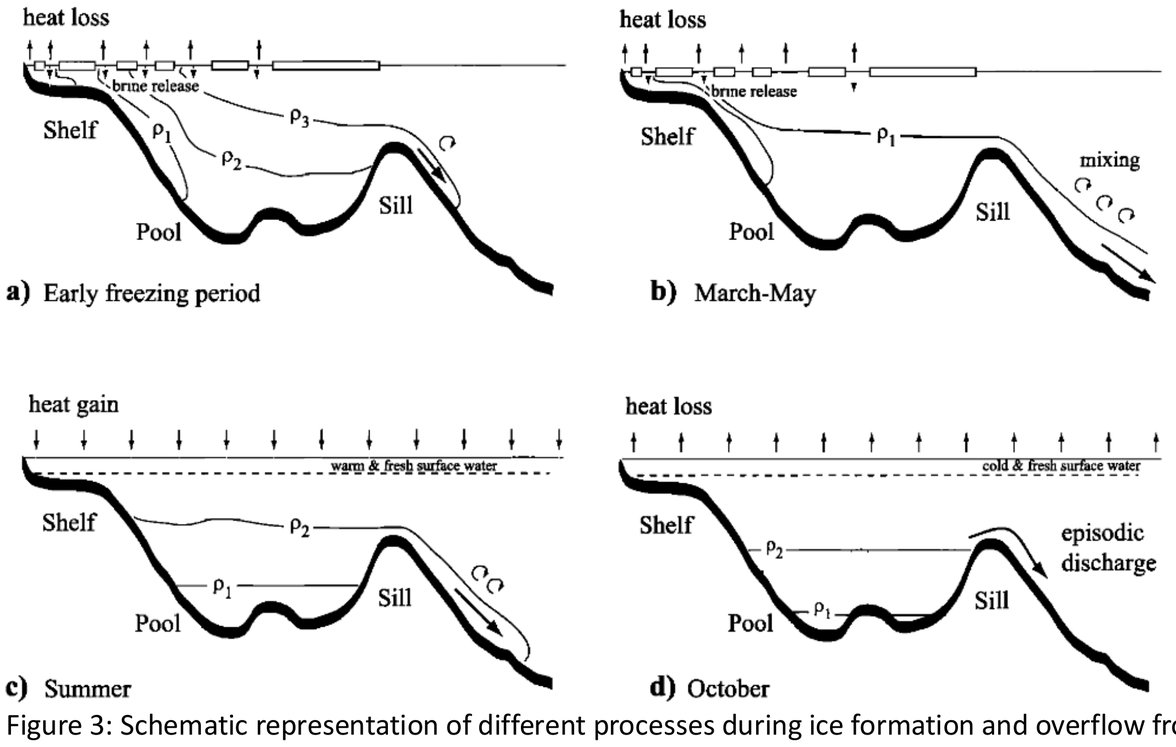

Figure 3: Schematic representation of different processes during ice formation and overflow from Storfjorden during (a) the early freezing period, (b) March-May, (c) summer, and (d) October. Isopycnals are arbitrary, with $\rho_1 > \rho_2 > \rho_3$. Figure by Skogseth et al., 2005b.

The importance of Storfjorden

Storfjorden, Svalbard is a sill-fjord where there is a reoccurring wind driven polynya [4]. This polynya forms **brine-enriched shelf waters** (BSW) [6]. The deepest part of Storfjorden is about 190 m deep, and the fjord has a **120 m deep sill** [8]. The dense water masses accumulate in the fjord basin, and can eventually **overflow the sill**, and flow down into the deeper parts of the Arctic Ocean [6].

Key observations

Polynya width: **~30 km** (max 130 km) [5]
Ice volume produced: **~40 km^3** (57 % formed in open ice area) [5]
BSW salinity range: 34.8-35.8 psu [6]
BSW production: 0.06-0.07 Sv (freezing period average), **0.03-0.05 Sv** (annual average) [7]
Overflow: ~0.06 Sv [3]
$1\ Sv = 10^6\ m^3/s$

Conclusion: The Storfjorden latent heat polynya produces approximately 0.06 Sv of BSW during the freezing season, ventilating the fjord's deep basin through brine-driven convection. As BSW accumulates and rises above the 120 m sill, it cascades into the Barents Sea, contributing to Arctic intermediate water renewal and thermohaline circulation.

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