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Brine rejection and cascades in the Arctic

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The formation of sea ice is accompanied by brine rejection, where the ice releases much of its salt into the underlying water. This causes densification of the seawater which consequently sinks. On the continental shelf the dense plume may reach all the way to the sea bed. If the horizontal density gradient is sufficient, a dense water cascade can occur, transporting the brine down the continental slope and ultimately into the deep ocean. The fate of this brine is poorly represented in ocean models because (1) the coarse horizontal resolution does not capture the small scale over which brine release occurs and (2) the coarse vertical resolution cannot resolve the dense water cascades that transport the dense brine from the continental shelf into the deep ocean. This work focuses on exploring ways of altering the vertical grid of an ocean model in order to allow the transport of brine from the Arctic Shelf to Arctic Basin via dense cascades. We present results from a 7 km and 18km resolution pan-Arctic ocean/sea ice model (NEMO SHELF – LIM2). Idealised model experiments indicate that using a hybrid vertical grid enables the model to resolve dense water flows down and along the Arctic continental slope. The hybrid coordinates include stretching the vertical grid to align with the seabed topography in shallow shelf waters (sigma coordinates) and allowing it to be horizontal when the water depth is greater (z coordinates). It also involves limiting how steep the grid cells can slope when there is steep topography. A passive tracer that tracks the salt introduced to the ocean when ice forms and brine is rejected was included in the model. Initial pan-Arctic experiments using realistic forcing and initial conditions suggest that with the improved vertical grid the brine tracer crosses the shelf break but the locations where the tracer enters the deep Arctic Basin are limited. As the Arctic moves towards being seasonally ice covered, brine transport pathways are likely to change. Understanding how this occurs is important because in addition to transporting salt, the dense water cascades also transport nutrients and dissolved gases from the surface ocean to depth.