Winter ocean heat fluxes under sea ice leads in the Arctic Ocean

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Introduction

Arctic sea ice still declines faster than predicted, mostly due to uncertainties related to:

- Internal climate variability (Jahn et al., 2016)
- Under-resolved ocean mechanisms (Holloway et al., 2007).

Here we focus on one under-resolved mechanism: heat fluxes coming from underlying ocean.

Near surface area averaged winter ocean heat fluxes are usually ~1-2 W/m², but fluxes close to 300 W/m² have been measured locally under ice leads.

Model

We use a high-resolution configuration of the MITgcm with the following properties:

- $\Delta x = \Delta y = \Delta z = 1$ m
- $\Delta t = 1-4$ seconds
- Non-hydrostatic
- Smagorinsky scheme for eddy viscosity
- Realistic T/S profiles of Canadian and Nansen basins
- Sponge layer at the bottom to restore to the profiles
- Ice formation is represented as a salt flux at the surface

Model Tuning

Root mean square of vertical velocities (Wrms) theory predict (Klinger et Marshall, 1995):

$$W_{rms} = (H \times B)^{1/3}$$

Vertical velocities

1. Salt Flux

- Snapshots of vertical velocities for different types of surface fluxes
- Fluxes of momentum yield stronger velocities.
- Effects are non-additive

2. Ekman

3. Ekman + Salt Flux

Heat Fluxes

- In the Canadian Basin heat comes from the Near Surface Temperature Maximum (NSTM)
- In the Nansen Basin, heat fluxes are weaker due to the absence of NSTM
- Heat fluxes are stronger with Ekman alone than combined fluxes

Conclusion

- We studied the effects of two types of surface fluxes occurring over sea ice leads during winter: Ekman pumping and brine rejection.
- Results show that both types of forcing lead to heat fluxes of similar amplitude
- Their combined effects are not additive.

Vertical velocities

4. Ekman + Salt Flux

Objective

The main goal of the research is to understand and model ocean heat fluxes explicitly, without sub-grid scale parameterization.

On a long term, our goals are:

- Compare those heat fluxes to those predicted by large-scale models.
- Improve sub-grid parameterizations for these mechanisms

Four types of simulations:
1. Forced by a uniform buoyancy flux
2. Forced by a buoyancy flux in a lead
3. Forced by shear in the ice-ocean stress across a lead.
4. Forced by both shear and a surface buoyancy flux across a lead.

References