# Parameterization of subgrid-scale ocean mixing by brine rejection in CESM

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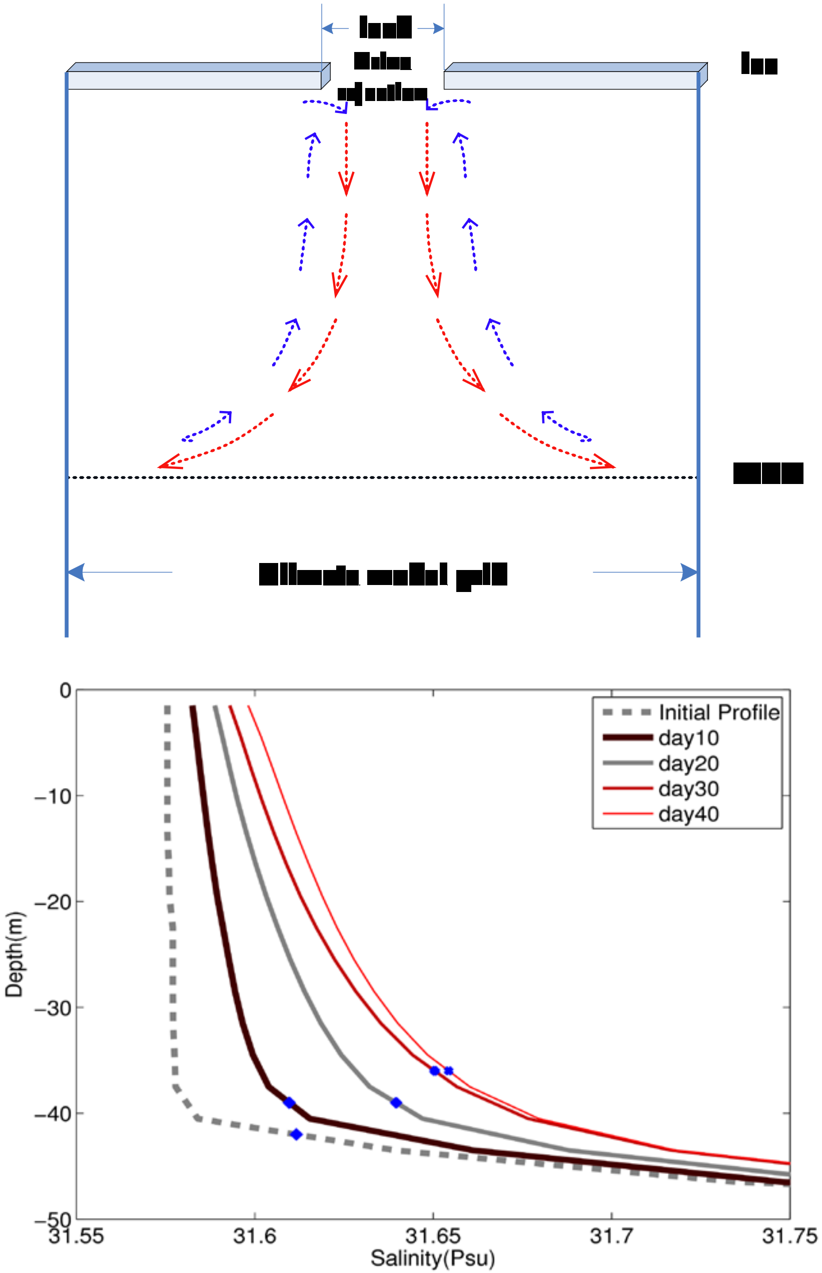
## When lead << climate model grid

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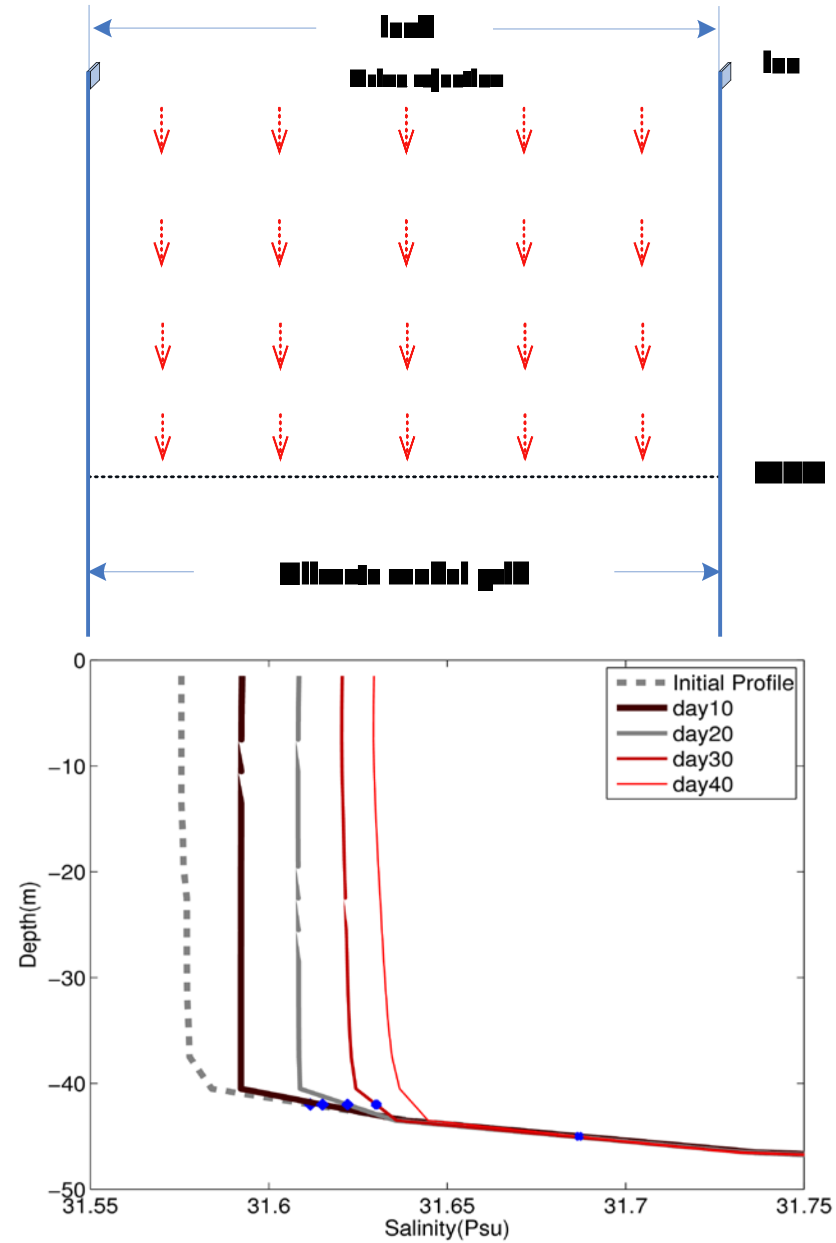
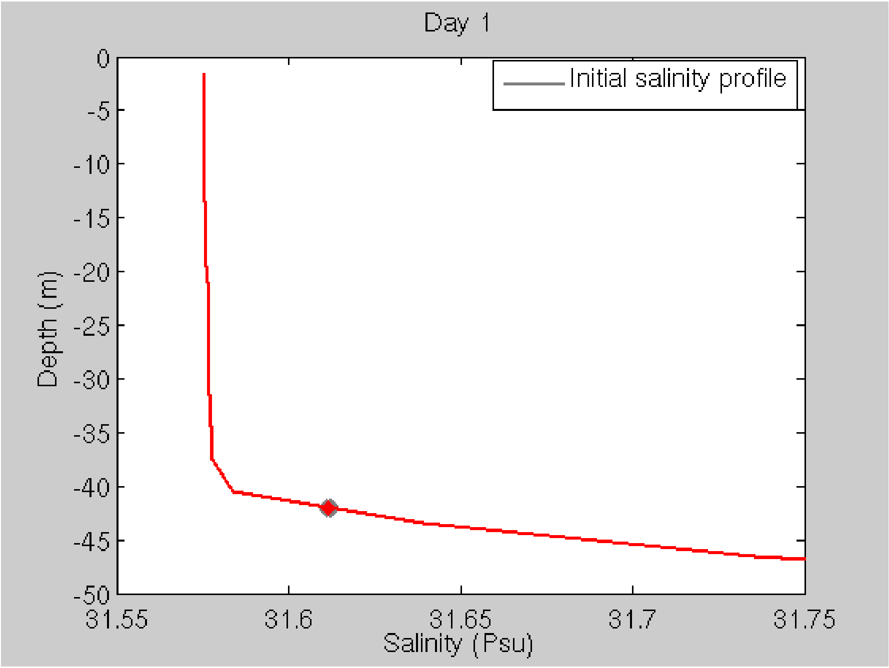
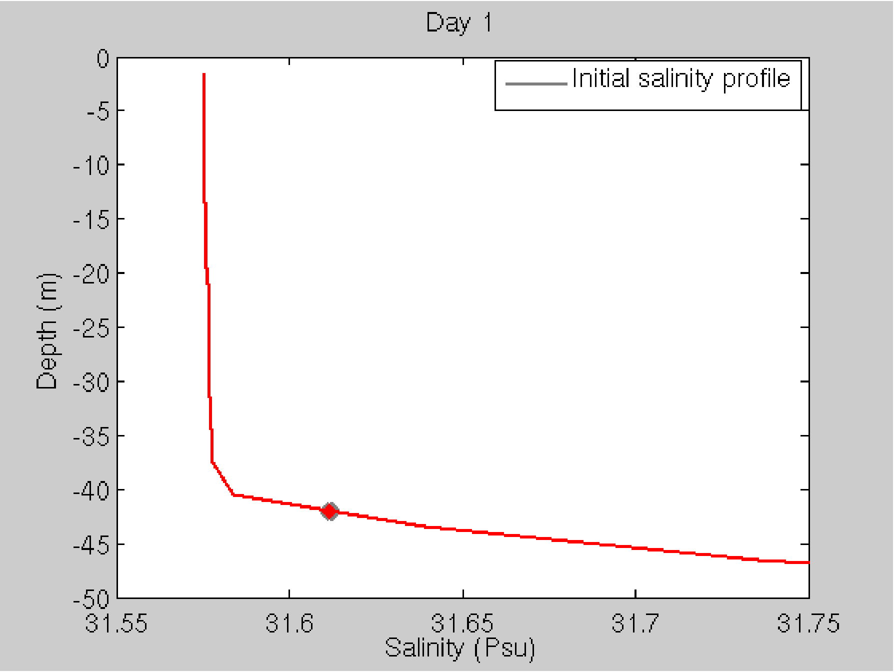




Day 1
Initial salinity profile
Depth (m)
Salinity (Psu)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
31.55
31.6
31.65
31.7
31.75

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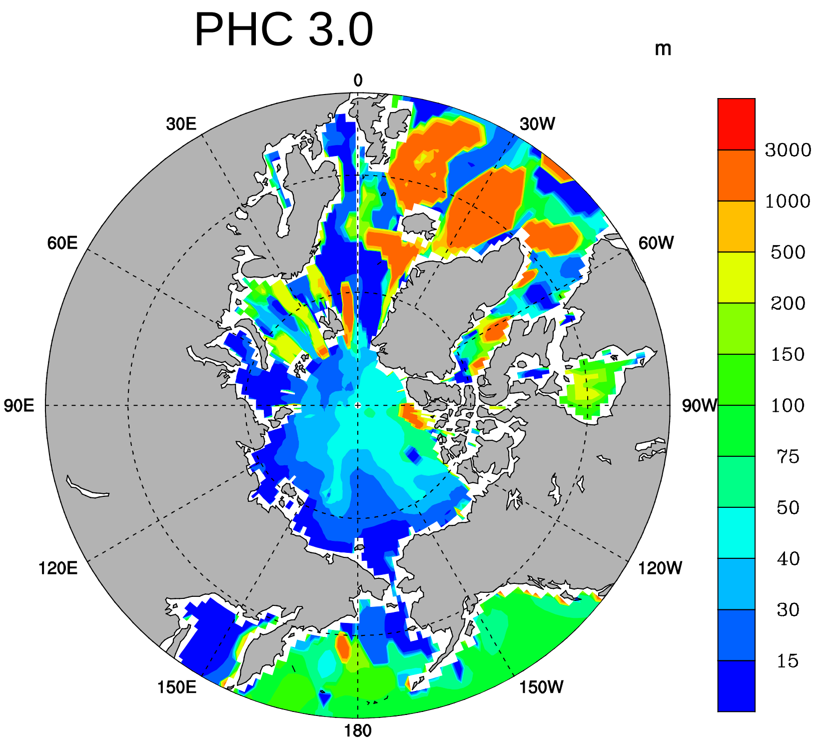
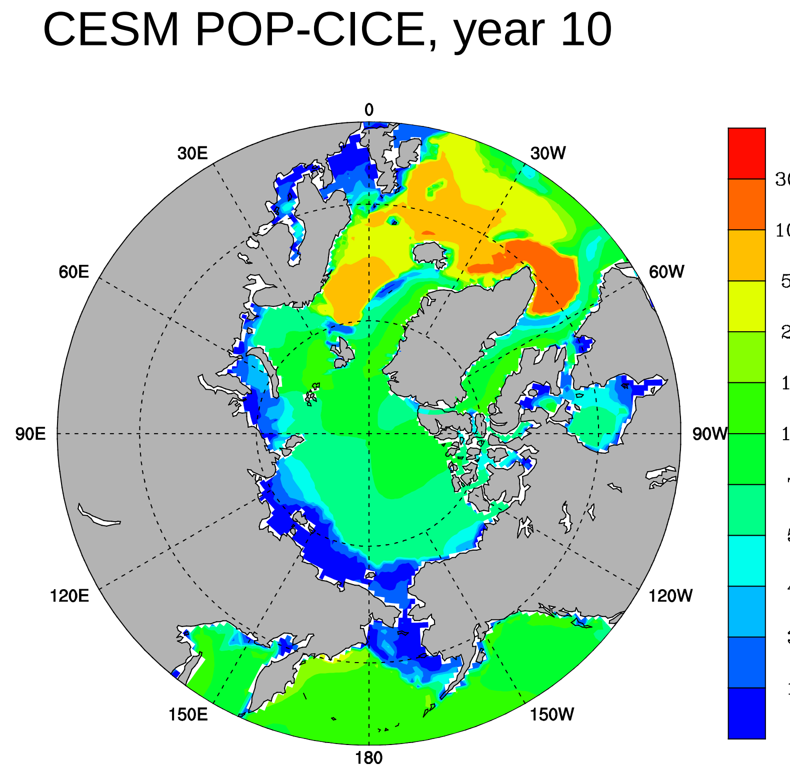
31.75

# HMXL bias in March



Solutions tested:

Multi-column ocean grid (MCOG) in progress:

Passing salt and heat flux in each ice-thickness category from CICE to POP.

Calculate separate mixing coef., and T, S in each column before average.

Parameterization of vertical distribution of brine rejection from lead.

Prescribe a vertical profile depending on the percentage of lead in a grid.

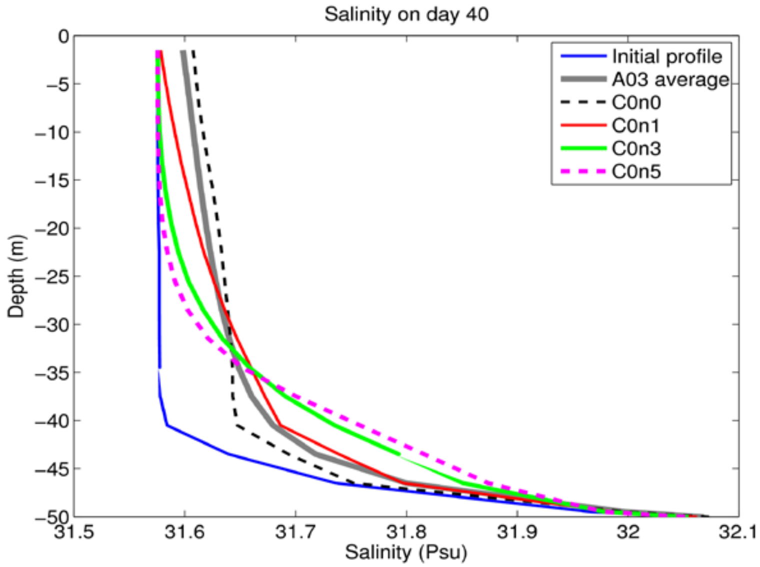
$$\Delta S(z) = Az^n; \qquad \int_0^{MLD} \Delta S dz = Total\ brine\ rejection$$

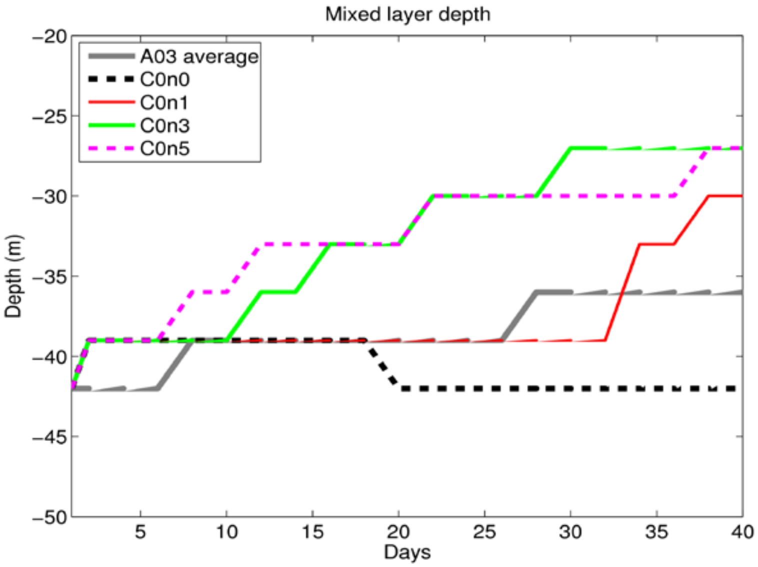
Parameters to determine:

1) MLD: by density gradient or other scheme
2) n

# Using density gradient as a criteria to determine MLD

Comparison of S profiles and MLD using different n

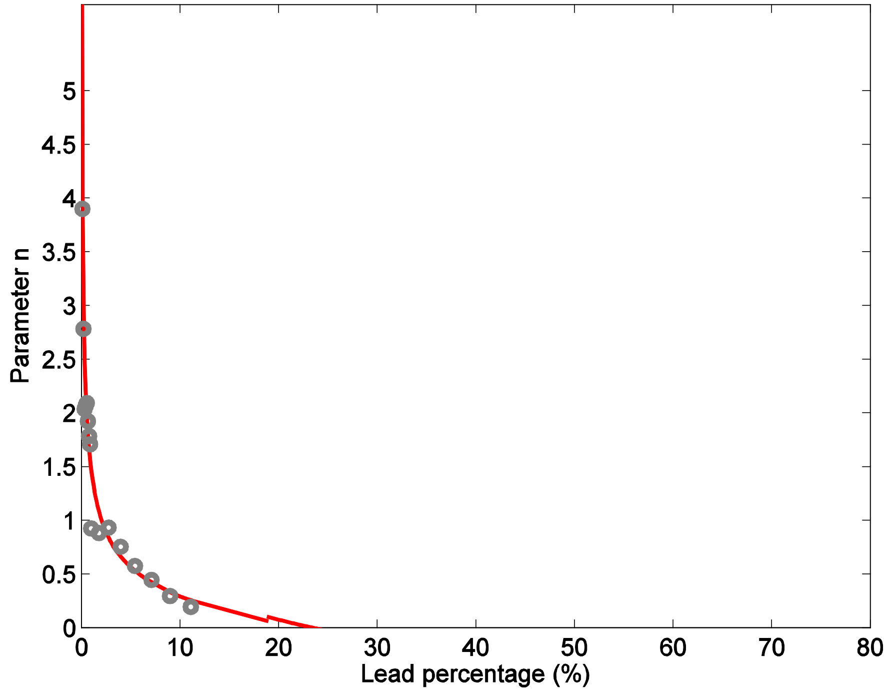


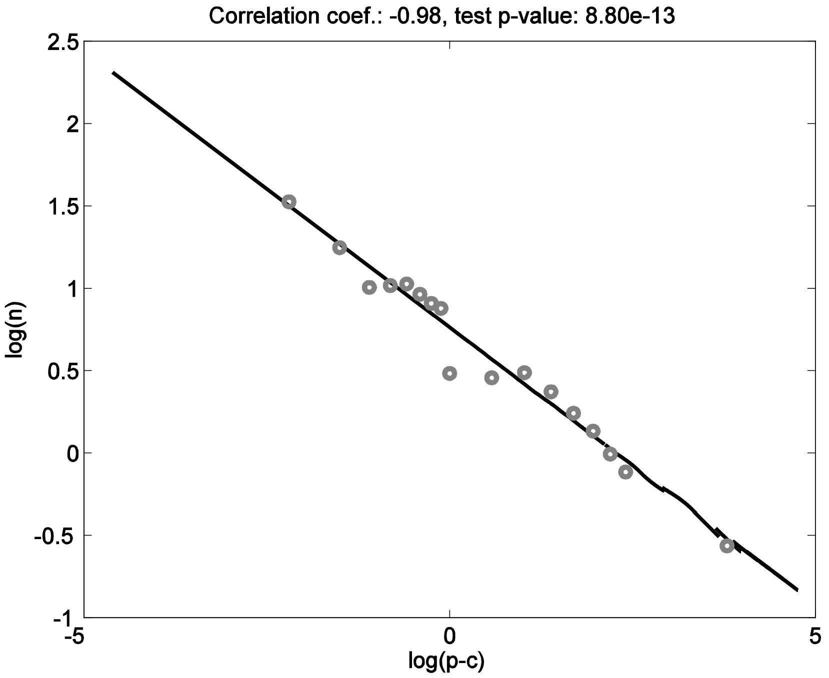



**Using interpolated depth of max buoyance difference with surface density as a criteria to determine MLD (same as used in KPP)**

**Optimize n as a function of lead fraction in one grid**

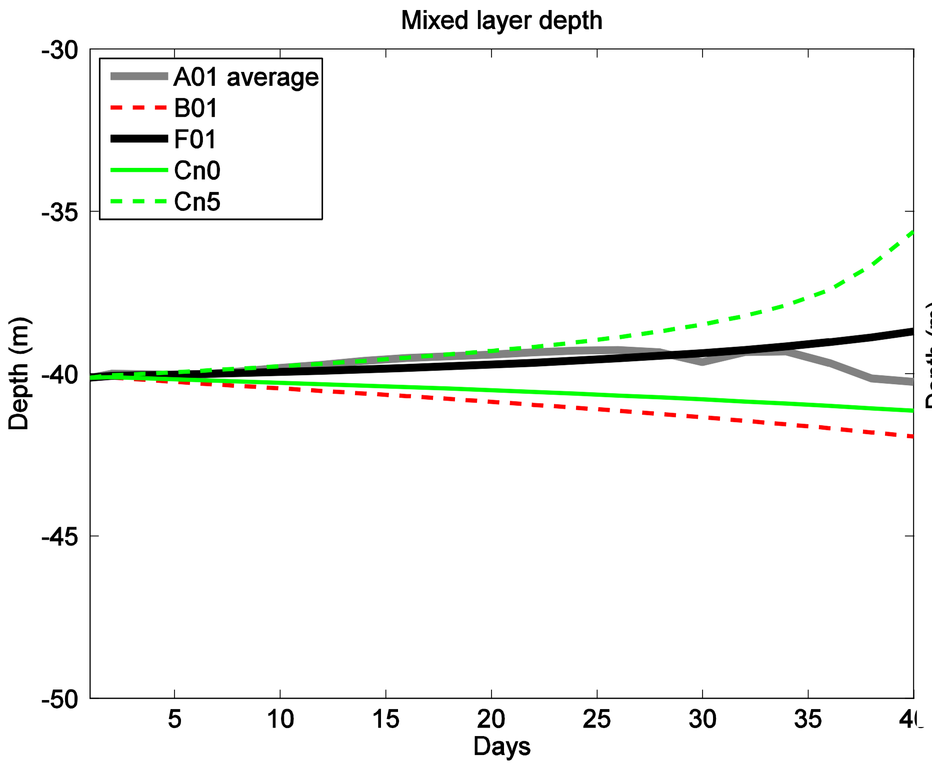
$$n = a \cdot p^{b} + c$$

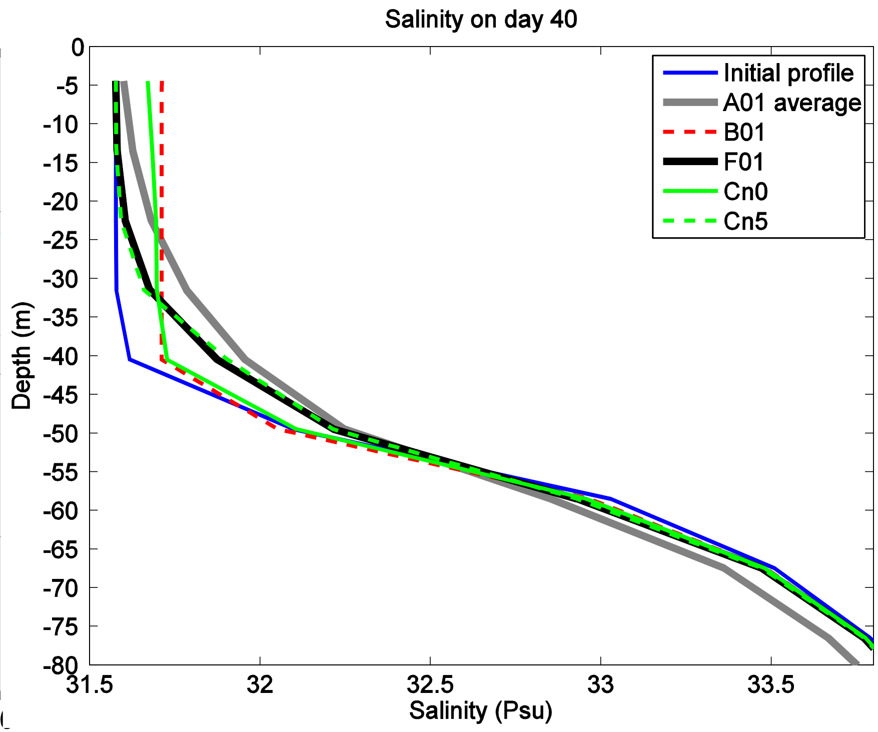


**Using interpolated depth of max buoyance difference with surface density as a criteria to determine MLD**

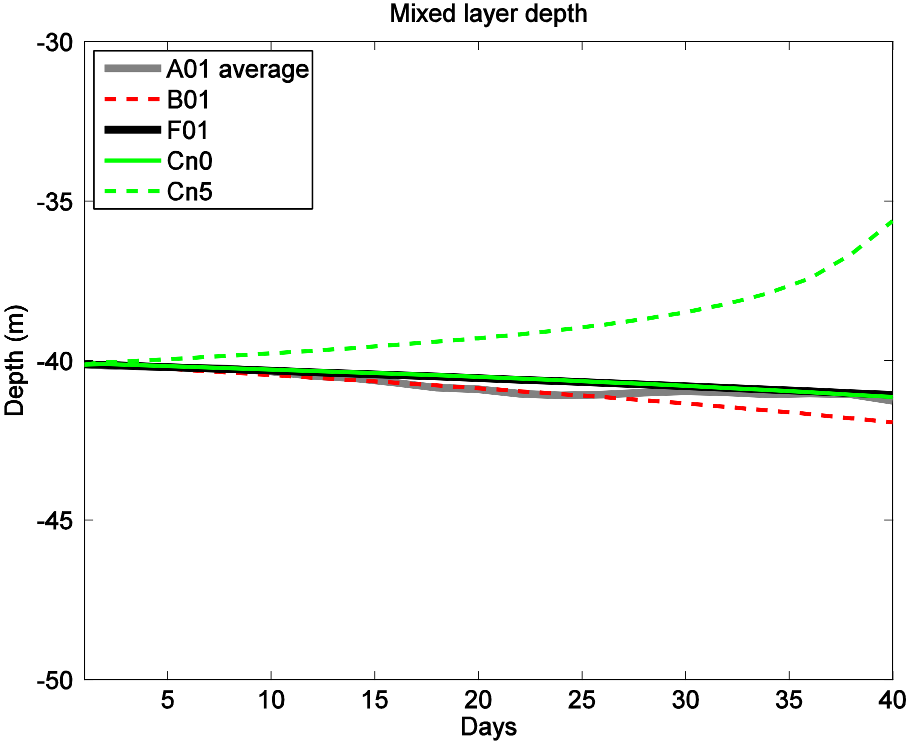
**When lead fraction =0.11% in one grid**

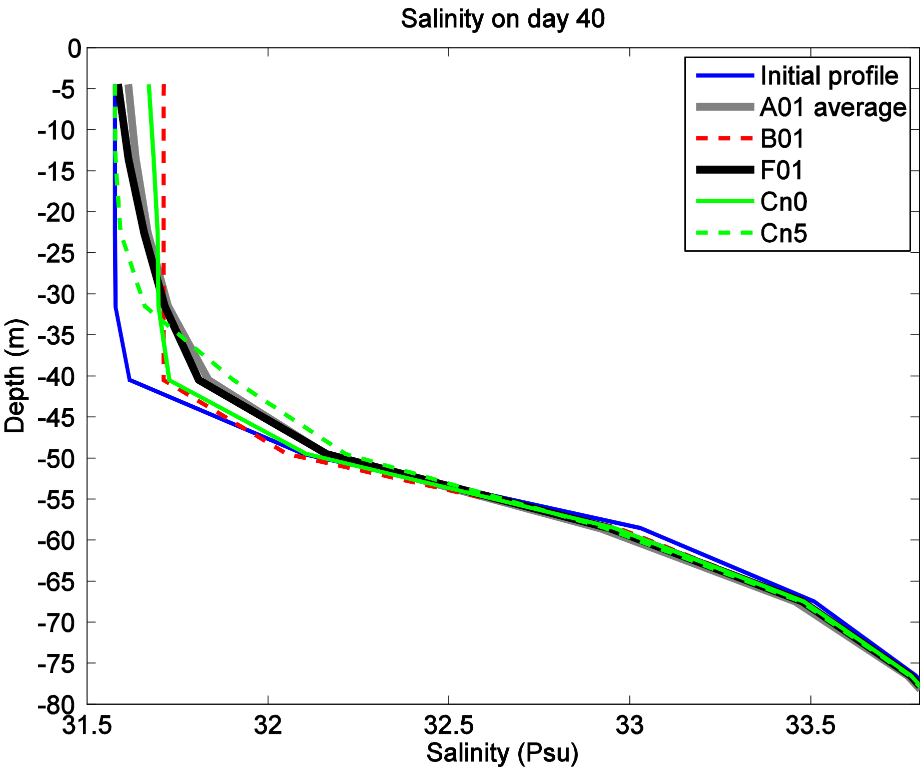


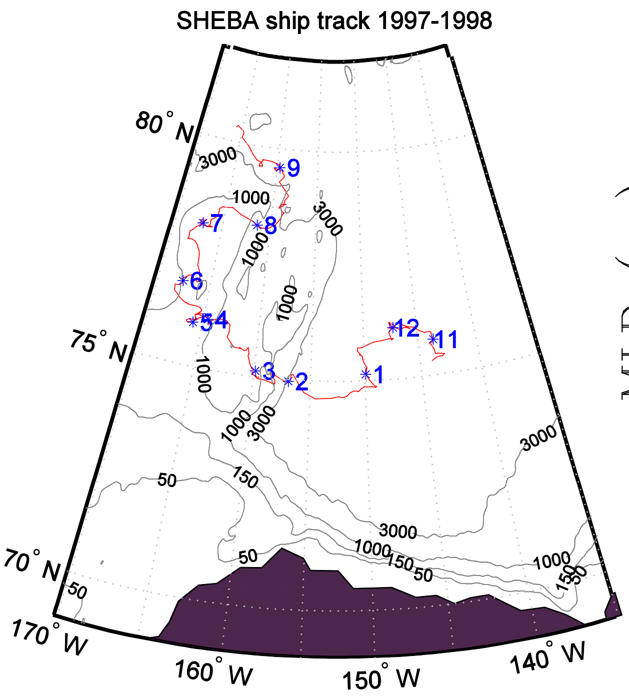
# Using interpolated depth of max buoyance difference with surface density as a criteria to determine MLD

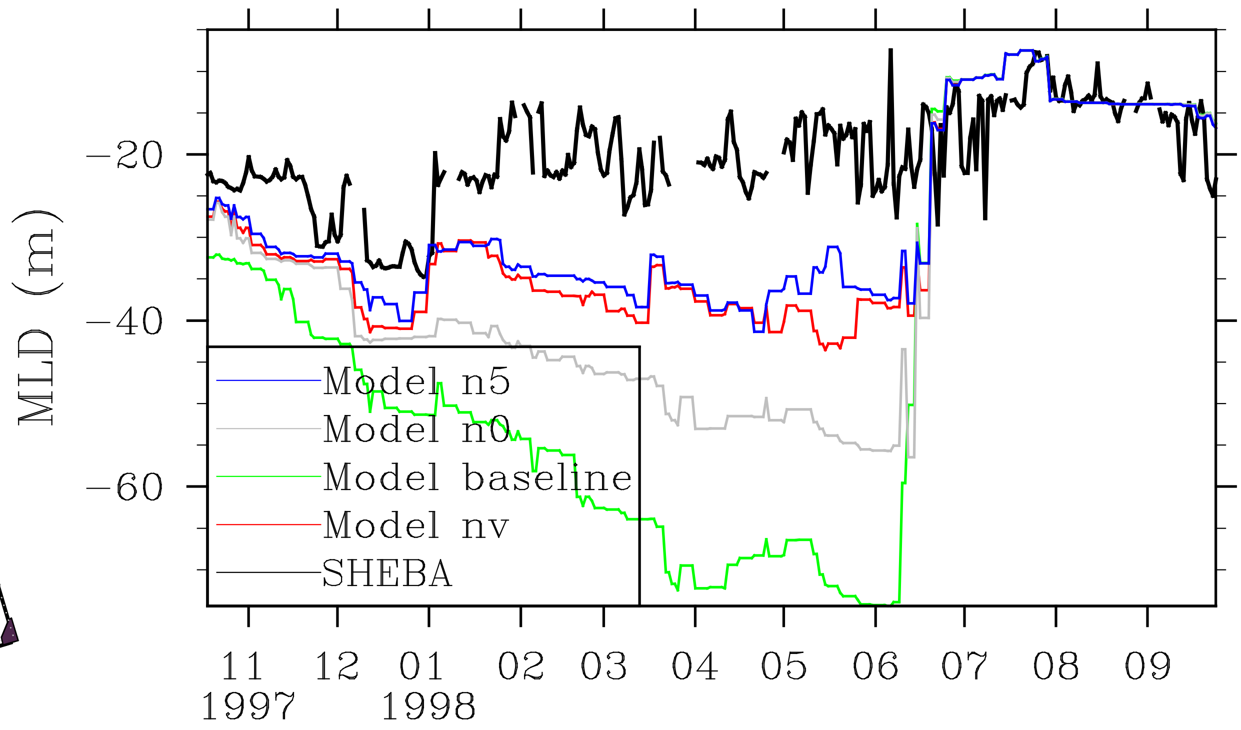
**When lead fraction =1% in one grid**



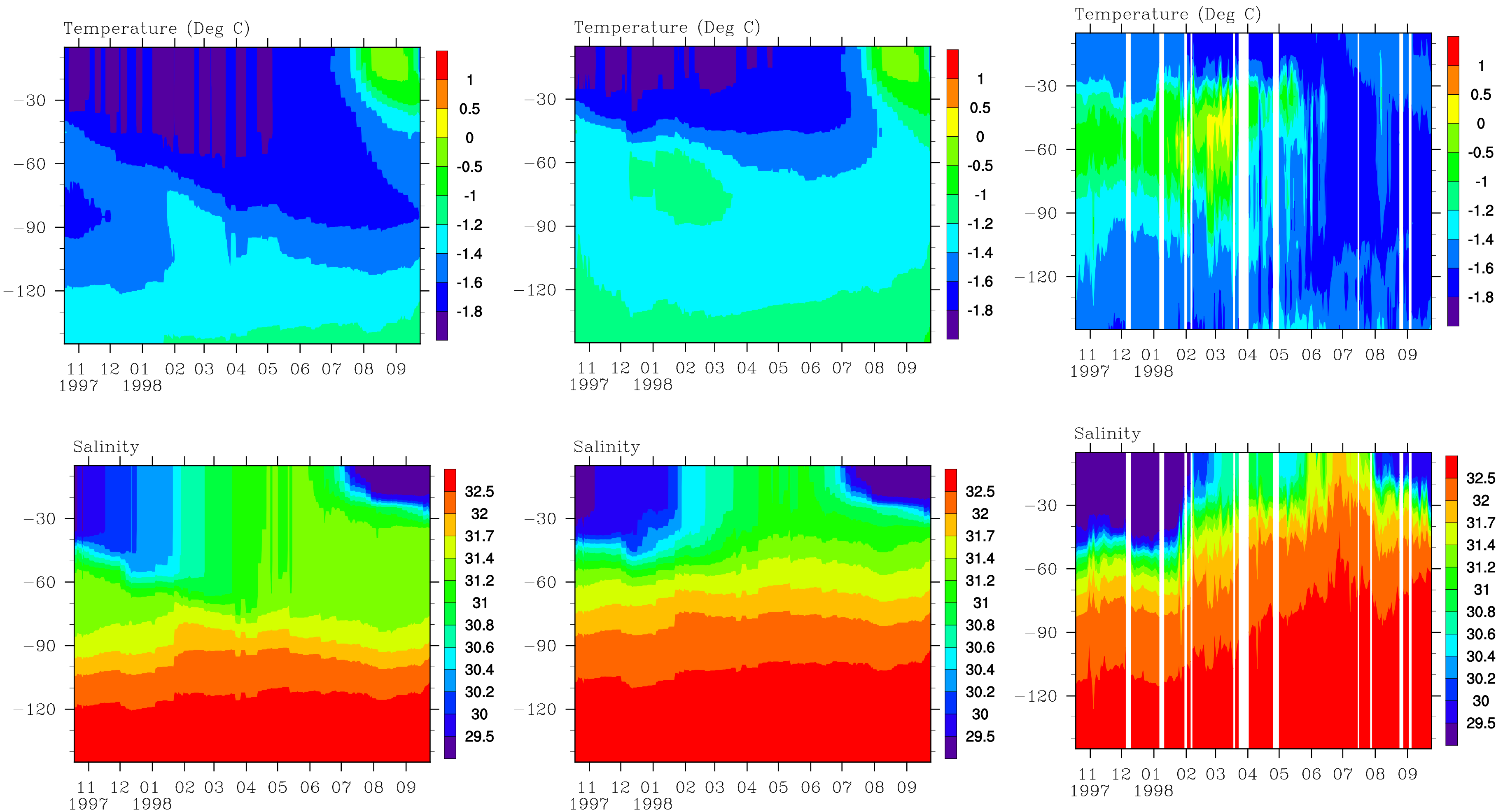
# Application of parameterization in global CESM ice-ocean model
# Comparison with SHEBA data 1997-1998



Comparison of modeled T, S with the SHEBA data along the track.

IO IONV Observation



Sea ice thickness distribution

Modeled ice thickness is too thin, and too large lead fraction.

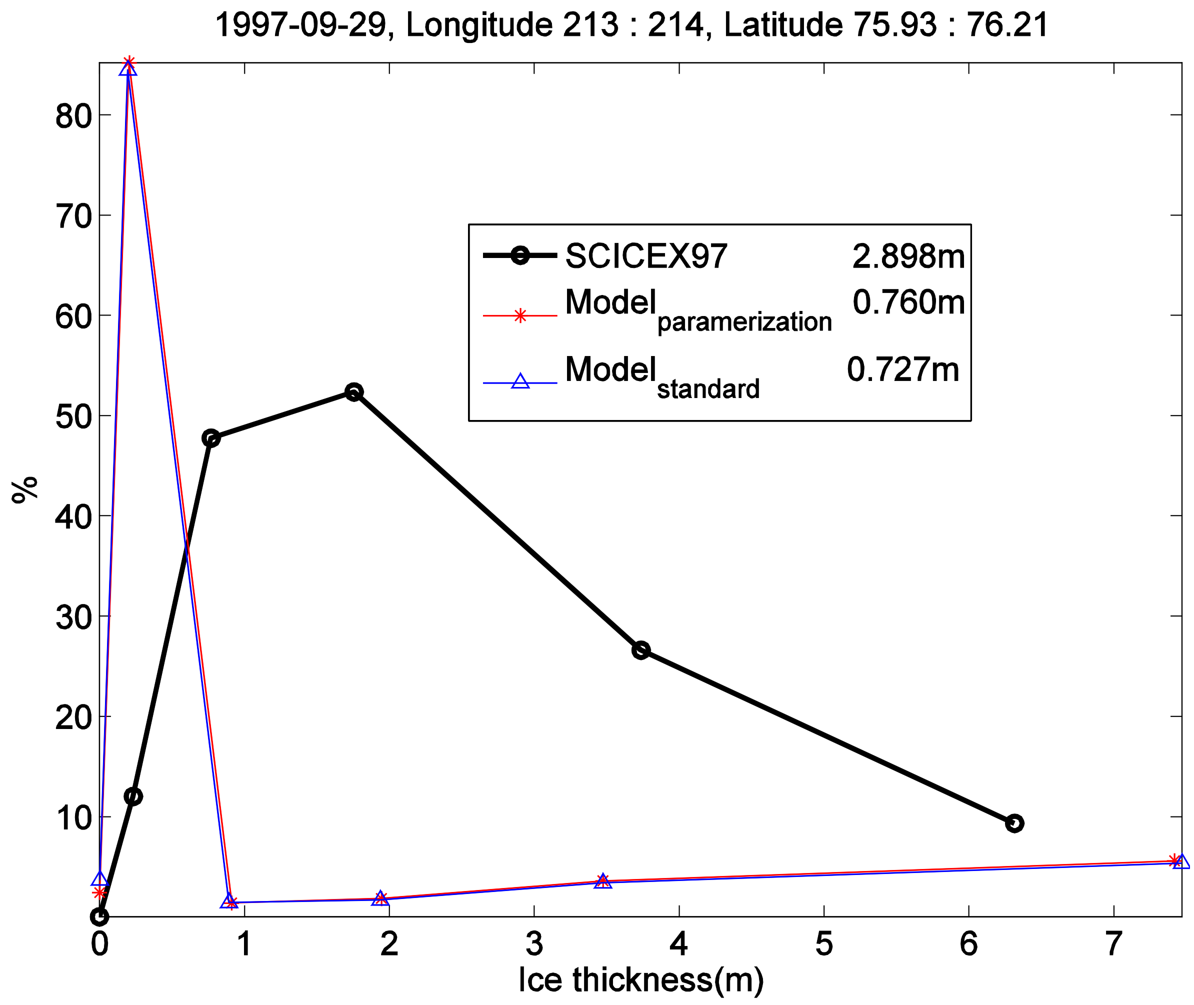
The parameterization corrected both errors but not signigicantly.

Lead fraction

Observation: 0.02%

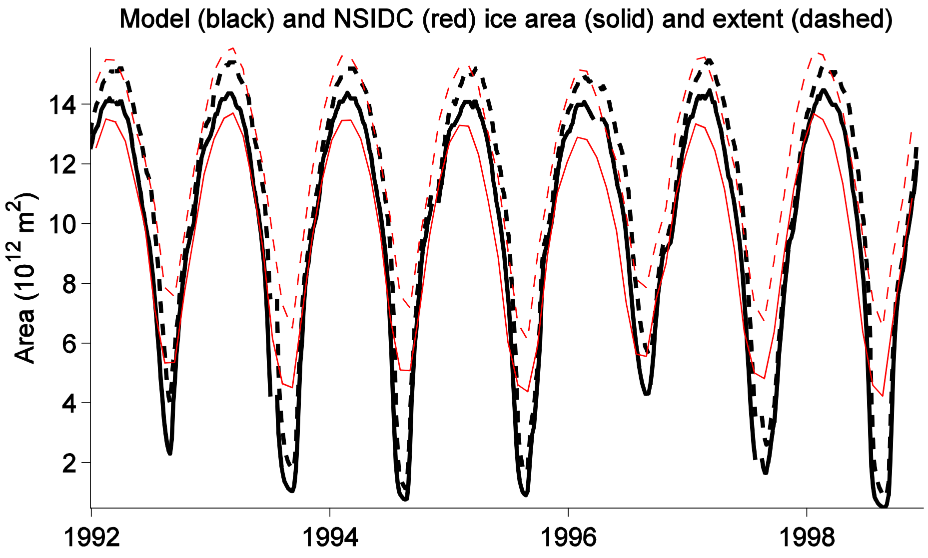
Standard CESM: 3.6%

With paramerization: 2.4%

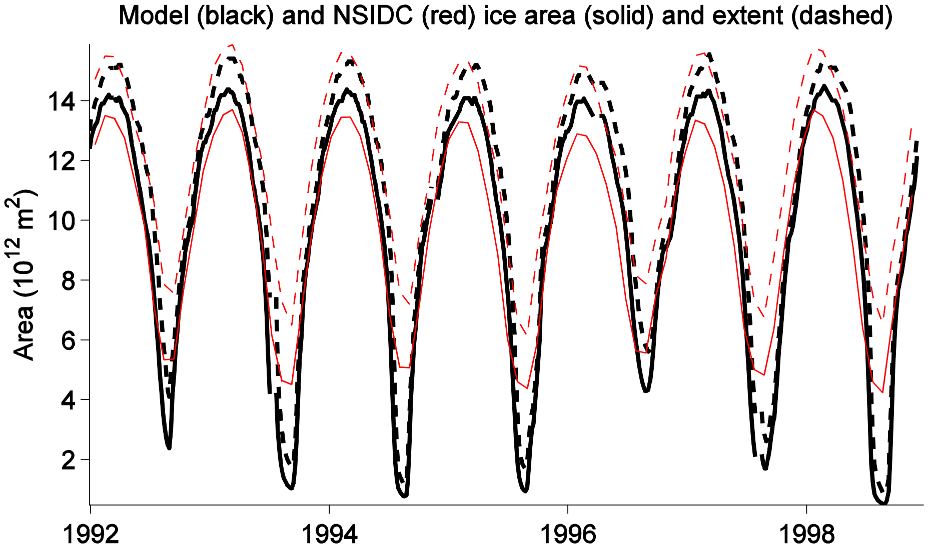


Sea ice area and extent of the NH
Too less ice area in the summer.

With paramerization




Default
CESM CICE-POP



## 9. Summary and outlook

•When lead is relatively small and unresolved in a model grid, both vertical salinity profile and MLD show systematic errors with saltier sea surface and deeper MLD.

•The parameter n determined as a function of lead percentage in a model grid cell is proved to improve modeled salinity profile and MLD under various sea ice conditions. It is also tested for different horizontal and vertical model grid resolutions.

•Parameterization in the CESM CICE-POP runs were found to improve the overall model comparison with upper mixed layer T, S observations and MLD in the Arctic Oceans.

•The effects of the parameterization is weakly positive on the sea ice results. But the large bias in simulated ice thickness might caused large errors in surface ocean mixing.

**Acknowledgments.**

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