Mixing in the last Arctic epishelf lake

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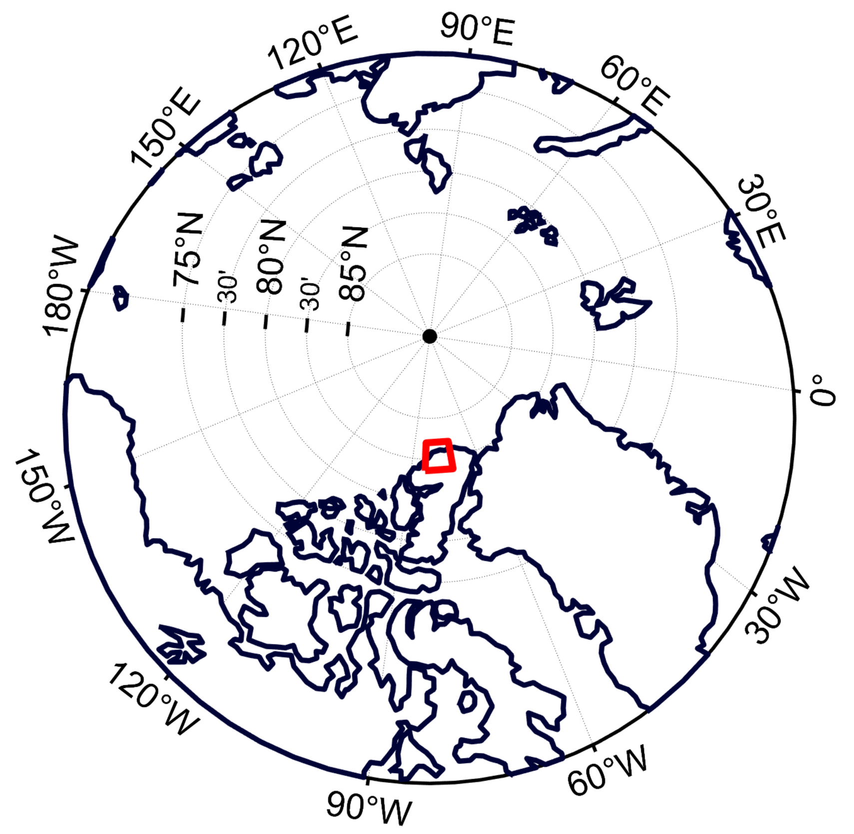
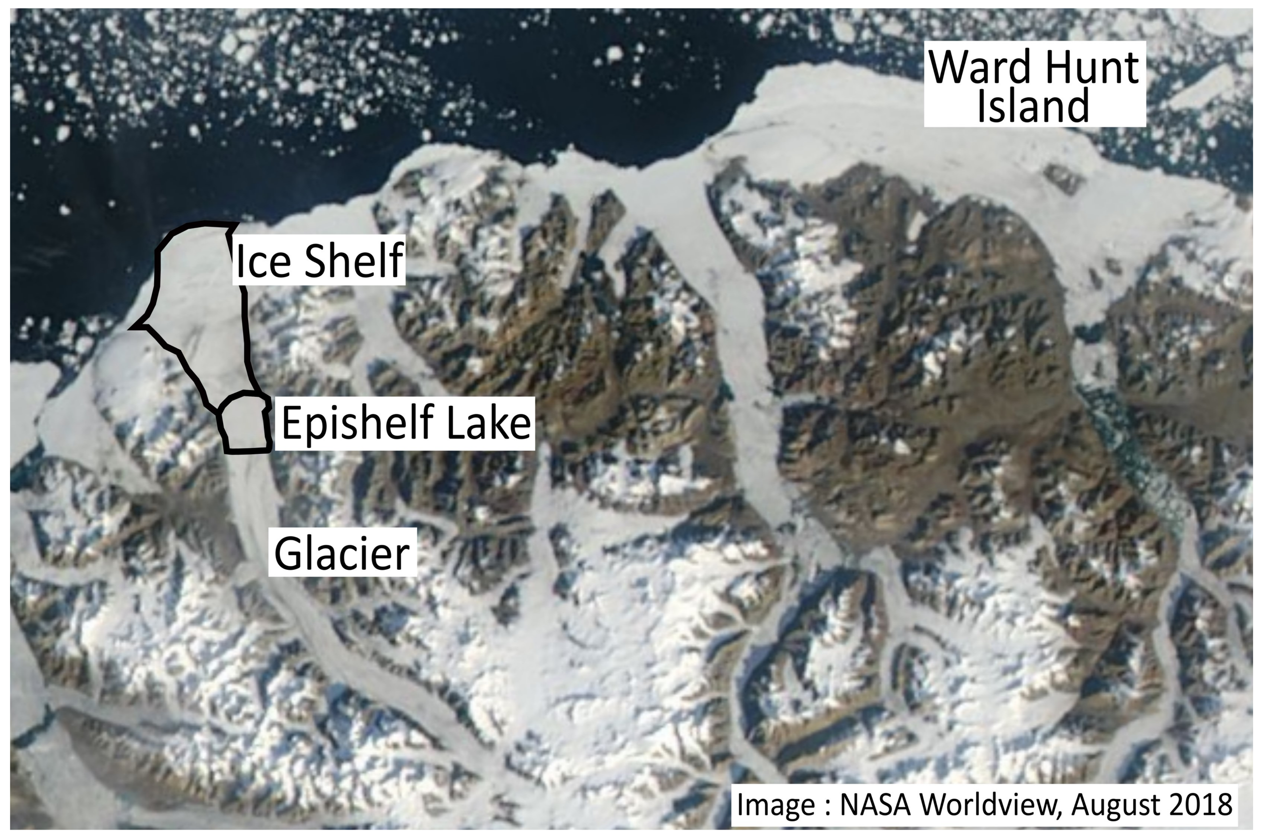
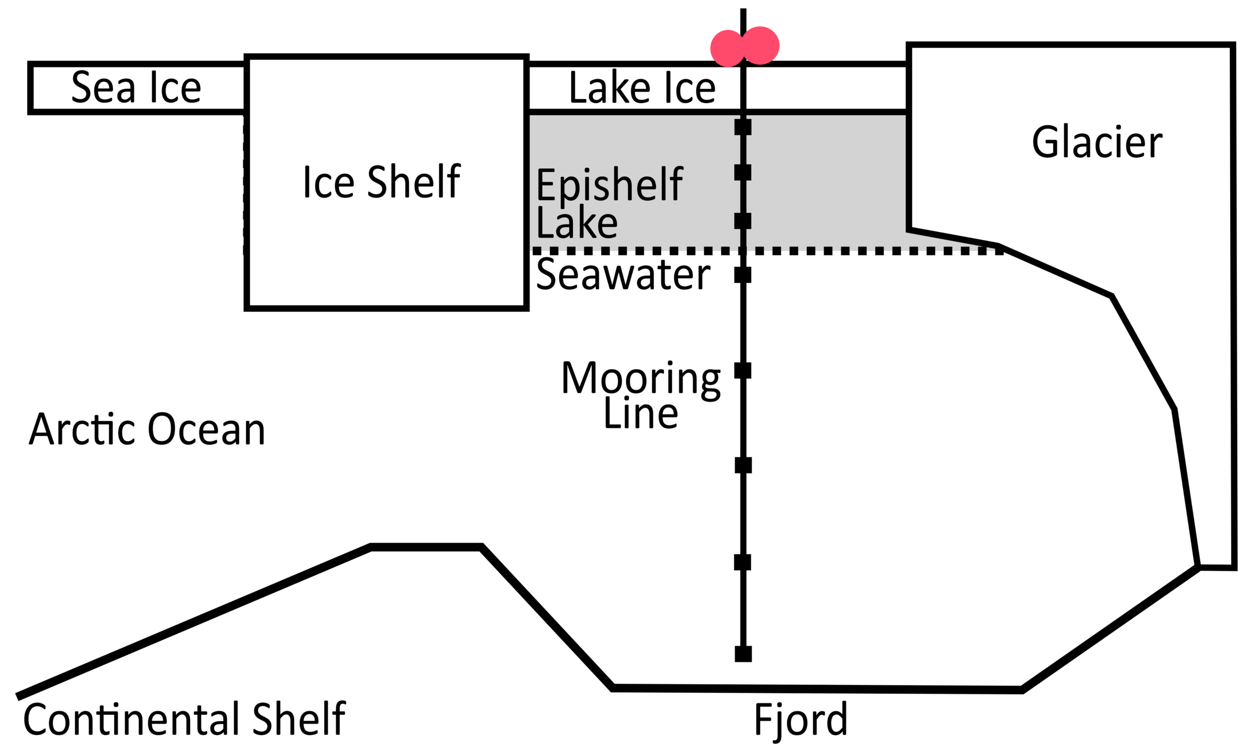


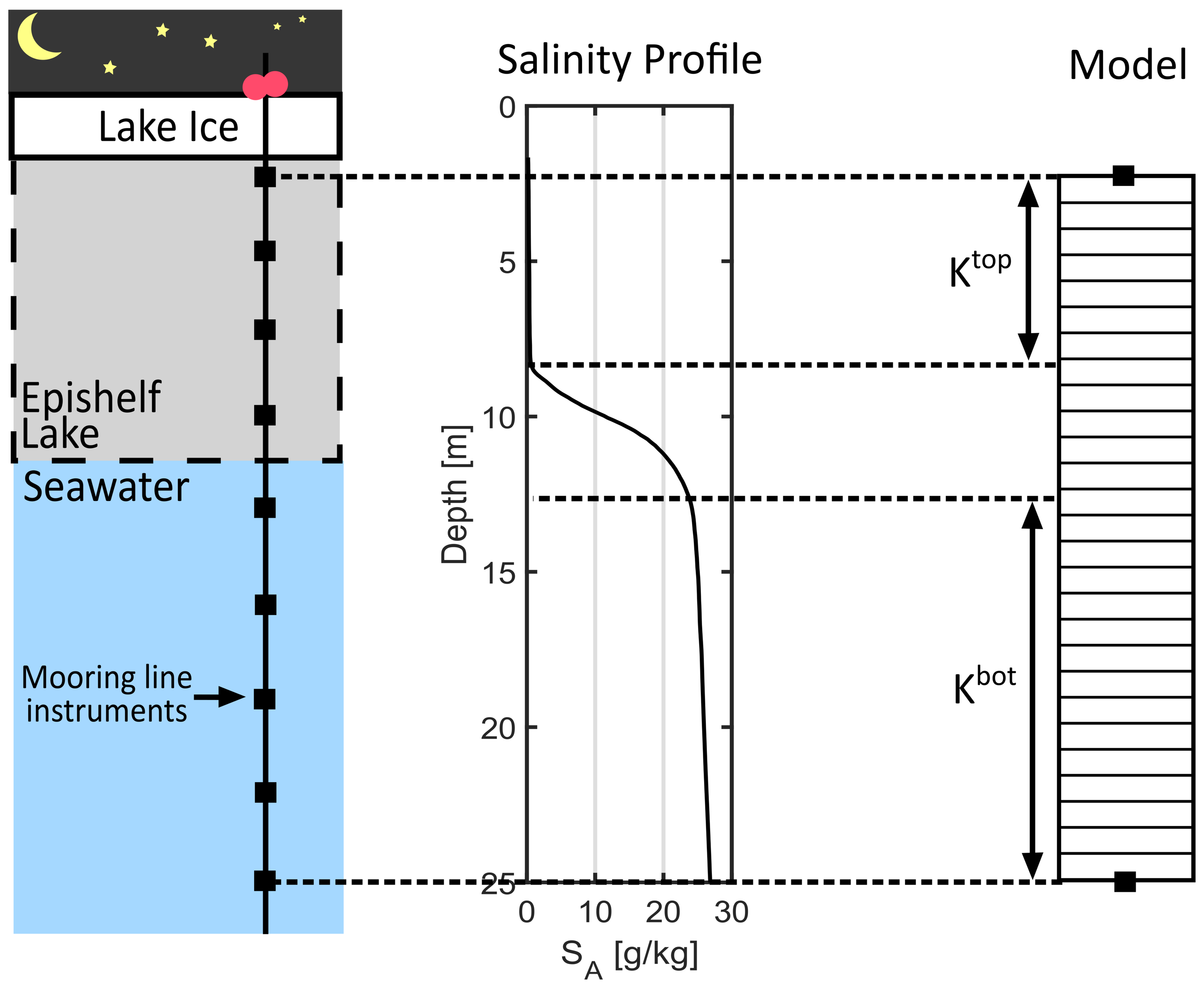


Milne Ice Shelf is the last intact ice shelf on Ellesmere Island. Located at the mouth of Milne Fiord, this floating ice dam prevents fresh meltwater in the fjord from flowing to the ocean, thereby creating a unique system called an "epishelf" lake [1]. Once numerous in the Arctic [2], warming and ice shelf break-up over the last several decades has caused many epishelf lakes to drain. Because of the strong coupling of epishelf lakes to their environment, a good understanding and monitoring of epishelf lakes can provide significant information on the state of surrounding ice shelves and glaciers. The winter data from a mooring installed in the Milne Fiord epishelf lake (2011-2019) was analysed in the framework of a one dimensional model in order to study the mixing at the top of the water column.



METHODS

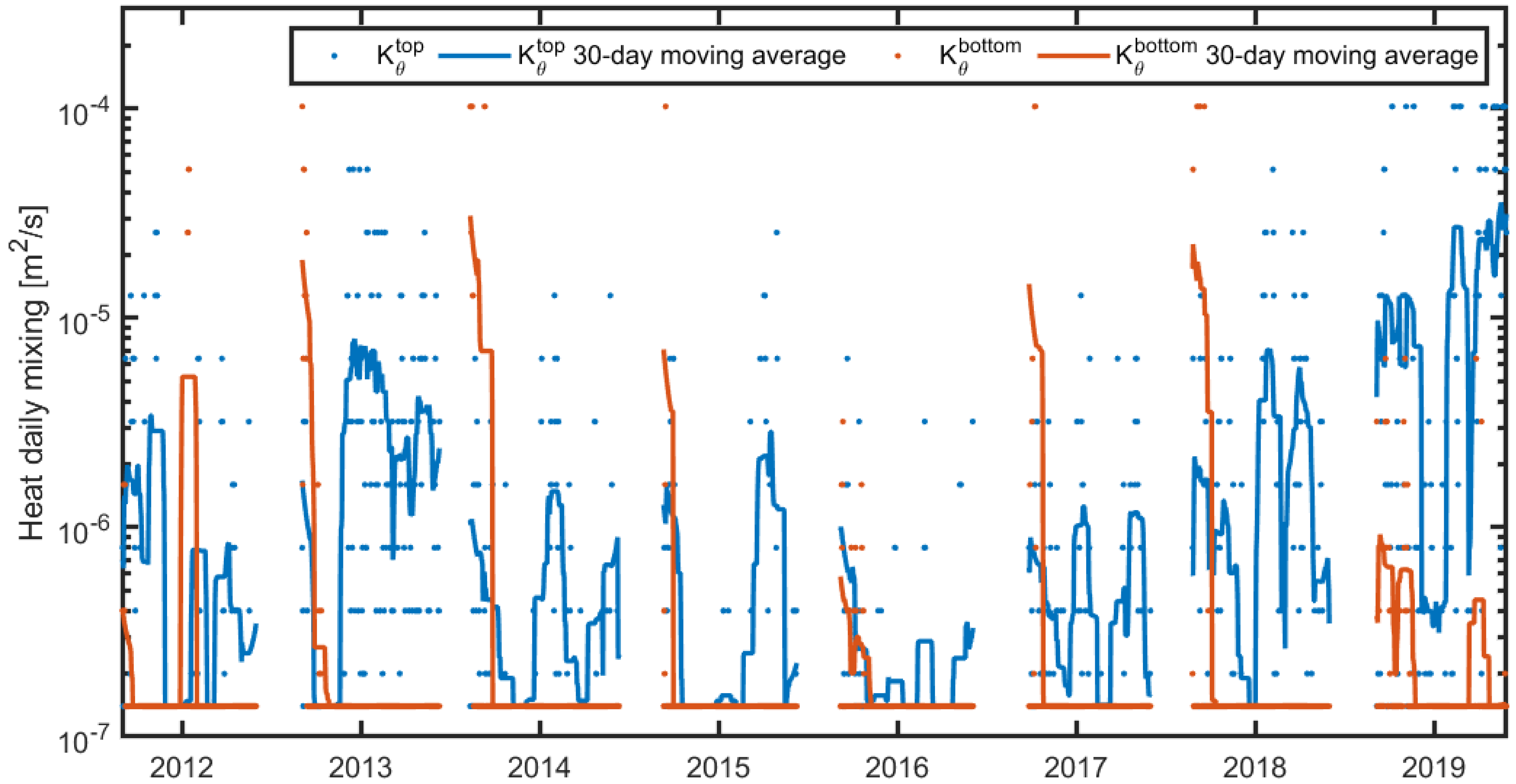
A 1D diffusion equation was solved on a 0.1m x 0.5hour finite difference grid and the mixing coefficients were determined by iterative process using the mooring data. The model finds the mixing coefficients (K) that return the best fit for every day outside of the melt season, from July 2011 to July 2019. Mixing is assumed molecular at the halocline. Both heat (temperature, Θ) and salinity (S_A) are modeled. The top and 25 m thermistors were used to define boundary conditions for heat and no flux boundary conditions were used for salinity.



$$\frac{\partial \bar{\theta}}{\partial t} = K_\theta \frac{\partial^2 \bar{\theta}}{\partial z^2}$$

$$\frac{\partial \bar{S_A}}{\partial t} = K_S \frac{\partial^2 \bar{S_A}}{\partial z^2}$$

RESULTS



***Heat mixing coefficient timeseries**. Daily (dots) and 30-day (solid lines) vertical mixing coefficients for the epishelf lake (blue) and the seawater underneath (red). The mixing coefficients are returned by the model for every day outside of the melt season.*

PRINCIPAL FINDINGS

- There is vertical mixing in both the epishelf lake (K^{top}) and the seawater below (K^{bot}) just after the melt season but it occurs only in the lake following that in most years.
- There is more mixing in the epishelf lake than in the seawater below. This is surprising because the lake is isolated from external forcing by its ice cover above and strong stratification below.
- Mixing in the epishelf lake is correlated with higher temperature variance suggesting an internal wave process is linked to the enhanced mixing in the top layer.

CONCLUSION

The analysis of the Milne Fiord mooring data using a 1D model shows that mixing rates are higher in the epishelf lake than in the seawater below during winter. Further investigation is needed in order to identify more precisely the mechanisms causing this mixing. Subsequent versions of the model should include additional processes (inflows, radiative convection, enhanced advective fluxes) in order to describe the system during the melt season (not considered here).

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