



Supplement of

Large-eddy simulations of the ice-shelf–ocean boundary layer near the ice front of Nansen Ice Shelf, Antarctica

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Supplementary material



Figure S1. Vertical profiles of velocity, potential temperature, salinity in strong turbulence case. (Coarse resolution $-216 \times 216 \times 108$, Moderate resolution $-288 \times 288 \times 144$, Fine resolution $-432 \times 432 \times 216$). In terms of velocity magnitude, magnitude and scale of overturning cells and thermohaline properties, LES results in moderate resolution is similar with those in fine resolution.



Figure S2. xy distribution of meridional velocity at 3 m depth to estimate baloclinic eddy and Rossby radius of deformation by Coriolis force. Calculation for Rossby radius of deformation is based on depth-averaged buoyancy frequency and depth (scale) between the sea surface and IOBL bottom.



Figure S3. Zonal distribution of turbulence intensity in cases with weak and strong turbulence. Flow from inlet boundary has transition regime to form a fully developed flow. In this study, we conclude that the flow from inlet boundary change to fully developed flow after 312, 336 m, respectively.



Figure S4. Vertical profile of buoyancy flux which is calculated by potential density fluctuation and vertical velocity fluctuation to examine the PISW depth and destabilizing region by turbulence.



Figure S5. xz contours of vertical velocity in the cases with weak turbulence (n=3) and strong turbulence (n=7). These contours show PISW upwelling, downwelling at local salinity maximum and the existence of inner overturning cell clearly.



Figure S6. xz contours of z-direction, relative vorticity in the cases with weak turbulence (n=3) and strong turbulence (n=7). Positive values represent the region for the symmetric instability (vertical shear), whereas negative values represent the region for the centrifugal instability (lateral shear) in well-stratified fluid ($N^2 > 0$). Gravitational instability occur at the region of concentrated salt flux by sea ice formation ($N^2 < 0$). PISW upwelling right after the ice front can be classified to gravitational instability (inset profile of Figure S7a).



Figure S7. (a) Vertical profiles of angle of balanced Richardson number to identify the type of possible instability in the whole ocean region. Inset figure in (a) is for that in the frontal region from the ice front to 24 m. Vertical profiles of (b) buoyancy and (c) flow shear terms of Richardson number in the cases with weak turbulence (n=3) and strong turbulence (n=7).