The annual heat balance of Lake Untersee in Dronning Maud Land

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Lake Untersee is a perennial ice-covered (~ 3 m thickness) lake and one of the largest and the deepest freshwater lakes in Dronning Maud Land, East Antarctica (Wand *et al*. 1997; Fig. 1, shown in the next page). Some studies from hydrological, biological and geological perspectives, have mentioned that lake Untersee has several notable features. First, Lake Untersee has two basins (Wand *et al*. 1997). One, located in the northern part of the lake, is an oxic and deepest basin which is in contact with Anuchin Glacier and is cooled by the glacier, being well mixed through most of the lake. The water temperature of the main part is constant at about 0.5 ℃. The other, located in the southern part of the lake, is a stratified and shallower basin because this basin is isolated from main convection part of the lake due to geographic barrier, and this basin is anoxic below 80 m. Second, the water of the main part of the lake is ultra-oligotrophic. So, there are little phytoplankton in the main part of the lake. On the other hand, the anoxic basin has more phytoplankton because the water is relatively nutrient-rich due to physical diffusion from the bottom of the lake. Third, the anoxic basin has an unusual thermal profile. The water temperature is stable at 4 ℃ below 50 m depth, but is kept at 5 ℃ between 70 m and 80 m depth, and declines to 3.7 ℃ at 100 m lake bottom. The water column stratified below 4 ℃ water body is higher density than the upper layer, then does not mix with oxic water. The reason why the water between 70 m and 80 m is heated to 5 ℃ is that the absorption of energy input from solar radiation occurs as a result of biomass increasing the opacity of the water (Bevington *et al*. 2018). These studies reach conclusions from observations and data only at Austal summer. So it's unclear whether this thermal profile and/or the distribution of phytoplankton are sustained throughout the years. If this thermal profile does not fluctuate throughout the years, what is the mechanism that keeps water condition? To understand these questions, we investigated the annual heat balance of Lake Untersee. We constructed an automated weather station to measure hourly solar radiation, temperature, wind speed and direction at the shore of Lake Untersee. And we constructed underwater measuring devices of the mooring system to measure hourly photosynthetically active radiation (PAR), water temperature, and Chlorophyll *a* fluorescence at both oxic basin and anoxic basin. In the oxic basin, we measused PAR at 7 m, 40 m and 120 m, water temperature at 10 m, 40 m, 120 m and 160 m, and Chlorophyll *a* at 120 m (Fig. 2). In the anoxic basin, we measused PAR at 7 m, 40 m, 70 m and 80 m, water temperature at 10 m, 40 m, 70 m, 80 m, 90 m and 100 m, and Chlorophyll *a* at 70 m (Fig. 2). We recovered each dataset from December 2014 to November 2015. As a result, the thermal profiles of either oxic basion or anoxic basin were sustained throughout the year, albeit with slight changes in water temperature (Fig. 3). The relationship between weather conditions and the underwater environment is now under consideration. Detailed results and the mechanism maintaining this thermal profile will be reported in the poster presentation.

References

Bevington, J., McKay, C. P., Davila, A., Hawes, I., Tanabe, Y., & Andersen, D. T. (2018). The thermal structure of the anoxic trough in Lake Untersee, Antarctica. *Antarctic Science, 30*(6), 333–344.

Wand, U., Schwarz, G., Bruggemann, E., & Brauer, K. (1997). Evidence for physical and chemical stratification in Lake Untersee (central Dronning Maud Land, East Antarctica), *Antarctic Science, 9*(1), 43–45.

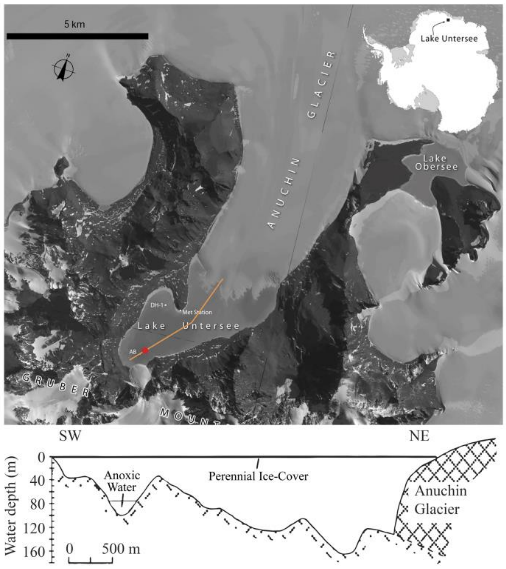

Figure 1. The location of Lake Untersee and its satellite imagery and the cross-section of Lake Untersee at the orange line of the satellite imagery (from Bevington *et al*. 2018).

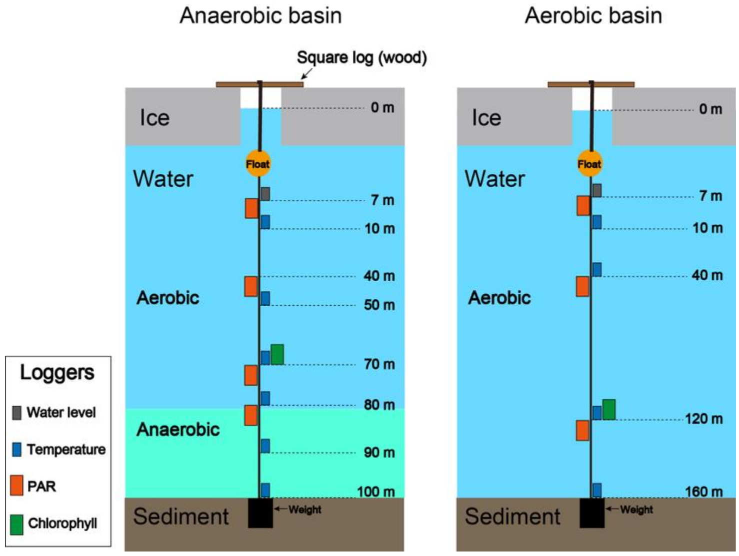

Figure 2. Underwater measuring devices of the mooring system. The left system was set at the anoxic basin. The right system was set at the oxic basin. We constructed data loggers at each depth as shown in this figure.

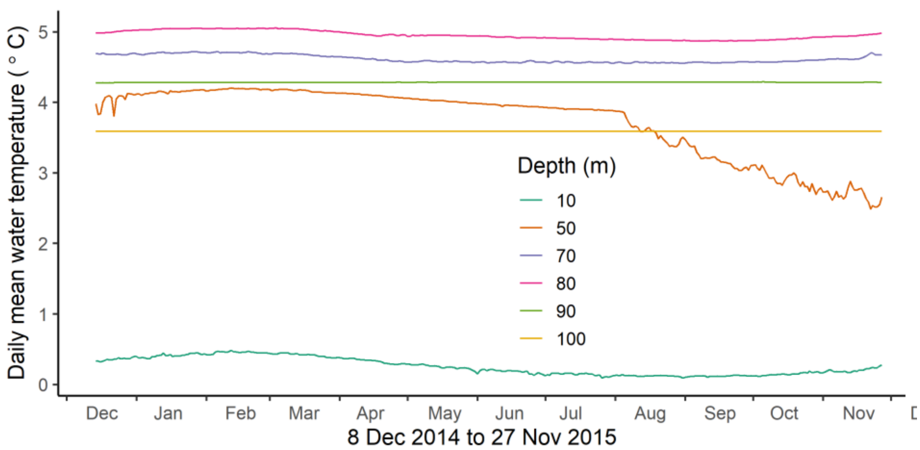

Figure 3. The result of daily mean water temperature in the anoxic basin. Each color indicates each depth as shown in this figure. The temperature at both 90 and 100 m were stable throughout the year. At other depths except 50 m, the temperature slightly changed seasonally with changes in solar radiation. At 50 m depth, the temperature dropped from the end of the polar night, indicating changes in the convection layer thickness and/or change in the thermocline depth.