Responses to the referee 2 s' comments

We thank anonymous referee for their comments.

Referee2 s' comments

1. It seems there is no problem to combined K2 and KNOT data together for the sake of using enough data to clarify the acidification trends in the subarctic western North Pacific Ocean, however, it could be great different with each other In effect because the KNOT time-series station lies in the edge of subarctic front, whereas K2 lies in the Western Subarctic Gyre. It should be obviously different in hydrography. In order to combine the data measured those two different stations, salinity normalized should be applied. i.e. nDIC and nTA are more reasonable, not just use TA and DIC.

➔ KNOT and K2 are both located in the western subarctic gyre. The typical water column structure in this region has a minimum temperature layer at about 26.5σ_θ (~100 m), which is the remnant of the mixed layer from the preceding winter; the maximum temperature layer is at about 27.1σ_θ (~370 m) (e.g., Ueno and Yasuda, 2000, Osafune and Yasuda, 2006).
We did not use observation data if no minimum temperature layer could be identified in our analysis, since station KNOT has occasionally the no minimum temperature water in the water column (~100m) because of the northward migration of subtropical water (Tsurushima et al., 2002). Thus, the combined K2 and KNOT data in this study are not obviously different in hydrography.
To confirm it, we apply salinity-normalized values of DIC and TA (nDIC and nTA) in the minimum temperature layer. A salinity of 33.2 was chosen as the constant and represents mean salinity observed from 1997 to 2011. The rates of oceanic xCO_2 and pH in the winter mixed layer calculated by $nDIC_{win}$ and nTA_{win} are estimated to be 1.3 ± 0.4 ppm yr^{-1} (p < 0.005) and −0.0012 ± 0.0004 yr^{-1} ($p<0.001$), respectively, which are consistent with not salinity-normalized results (Fig. 3). We think that it is no necessary to apply salinity-normalized method in calculated method.

2. The observation data of carbonate system were TA and DIC only, and the other parameters were all calculated by using CO2SYS software. It could be done as that Generally speaking, however, it was limited to used in the stable-state model, and it will be not accurate when it changed in non-stable state situation. For example, it is another story if there is a strong advection transportation there. Authors should make sure this and proof it.

➔ As mentioned above, the combined K2 and KNOT data are not obviously different in hydrography. The subtropical water migrated northward enters the south edge of western subarctic gyre and passes eastward (Ueno and Yasuda, 2000). Because we exclude observed data included no minimum temperature layer as a result of the migration of subtropical water, the combined data does not include the subtropical water. Thus, we think that conditions are in place for the stable-state model to be applicable to our analysis.

3. [Ca^{2+}] were estimated from Salinity by [Ca^{2+}] = 0.01028 * S/35 in this study, however, it is not always true if there is notable carbonate forming biota in the surface and subsurface waters. Cited more biological evidence to prove it if you believe it that there is no such worry about it.

➔ In the western subarctic gyre, the notable carbonate forming biota is coccolithophore and planktonic foraminifera, pteropods which are living in the surface water (0-100m) (Hattori et al, 2004, Sagawa et al., 2012, Fujiki et al., 2010, Steinberg et al., 2008). Because these kinds of planktons are not living below the winter mixed layer (~100m), we think that applying this [Ca^{2+}] estimation below the winter mixed layer is reasonable.

4. To avoid the effect of advection transportation, nDIC should be plotted out to compare with DIC.

➔ nDIC in the winter mixed layer and the 26.9σ_θ surface significantly increased at rate of 1.0 ± 0.2 μmol kg^{-1} yr^{-1} (p < 0.001), and 1.8 ± 0.3 μmol kg^{-1} yr^{-1} (p < 0.001), respectively (Suppl. figure 1). These rates are consistent with not salinity-normalized results (Fig. 3 and 7). In addition, the lack of a ΔS contribution to enhanced acidification on 26.9σ_θ surface was very low (Table 2 and Figure 6). There is no need to use salinity-normalized values of DIC, TA, and nutrients to correct, which indicates that there is no advection transportation. Thus, we think that western subarctic gyre remain the stable-state model during the study period.

5. The Seasonal variations of xCO2, TA and DIC, should be plotted as a sole curve each year, with one curve once a year if possible, in order to compare the annual variations of acidification trends there.

➔ Unfortunately, we cannot plot seasonal variations of xCO_2, TA, and DIC as a sole curve each year, because the duration of sampling at each individual station data was not sufficient. In future, we will investigate the annual variations of acidification trends.

6. Fig. 2 is too small, should to be adjusted.

➔ I agreed. I will enlarge the figure 2, as follows.

Reference

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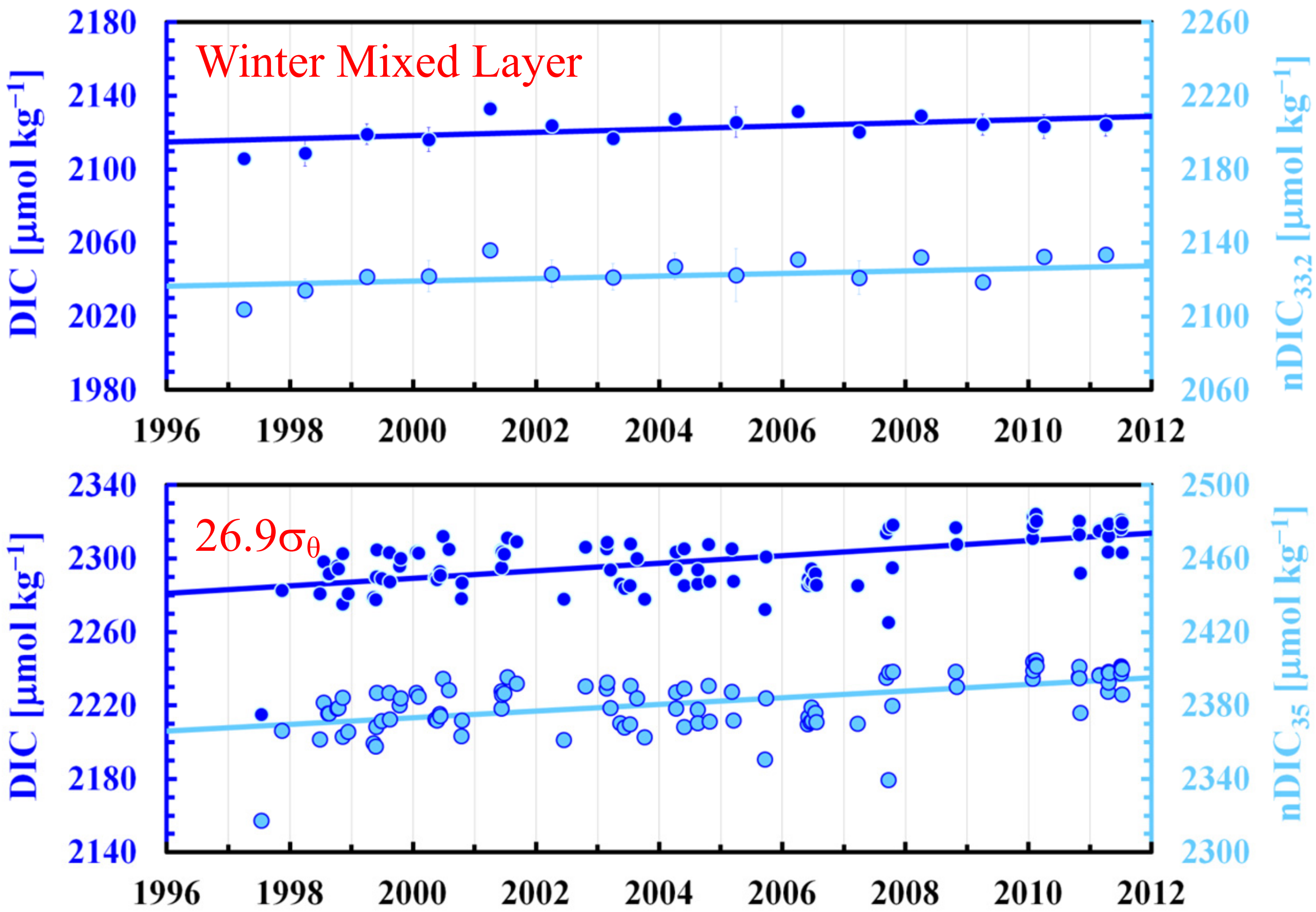
Ueno, H., and I. Yasuda, 2000, Distribution and formation of the mesothermal structure (temperature inversions) in the North Pacific subarctic region, *J. Geophys. Res*., **105(C7)**, 16,885–16,897.



Supli. Figure 2-1. Time-series of DIC (blue circles) and salinity-normalized DIC (nDIC; aqua blue circles) in the winter mixed layer (upper panel) and the 26.9σ_θ surface (lower panel). We choose a salinity of 33.2 for in the winter mixed layer and 35 for the 26.9σ_θ surface as the constant. Regression lines for 1997 to 2011 are shown for DIC (blue line, winter mixed layer: 0.9 ± 0.2 μmol kg^{-1} yr^{-1}, $p < 0.001$, 26.9σ_θ: 2.0 ± 0.3 μmol kg^{-1} yr^{-1}, $p < 0.001$), and nDIC (aqua blue line, winter mixed layer: 1.0 ± 0.2 μmol kg^{-1} yr^{-1}, $p < 0.001$, 26.9σ_θ: 1.8 ± 0.3 μmol kg^{-1} yr^{-1}, $p < 0.001$).

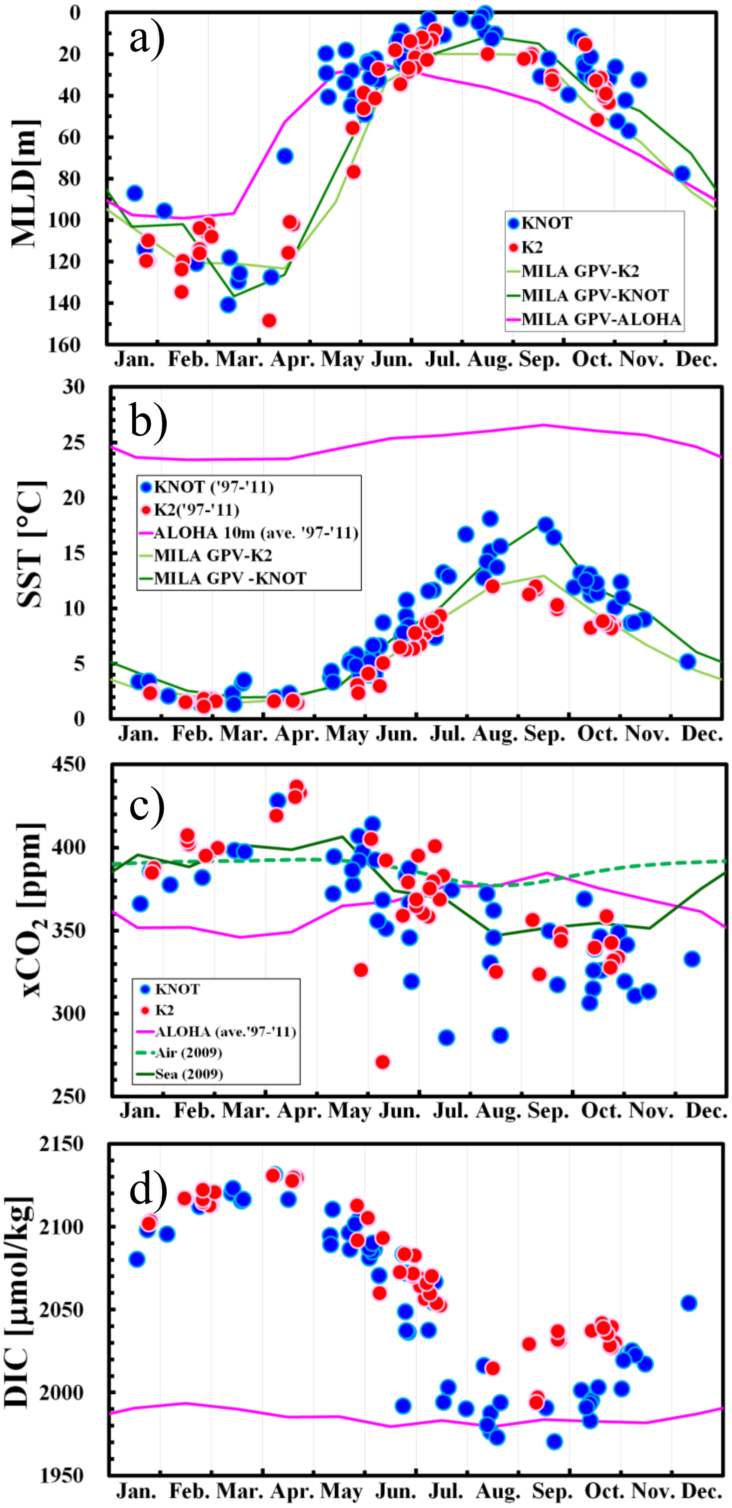


Figure 2. Seasonal variations of (a) the maximum mixed layer depth (MLD), (b) sea surface temperature (SST), (c) oceanic and atmospheric xCO_2, (d) DIC, (e) TA, (f) phosphate, (g) pH (total scale) at the in situ temperature ($pH_T^{in\ situ}$), and (h) $CaCO_3$ saturation states (Ω) with respect to aragonite and calcite in the surface mixed layer at KNOT (blue circles) and K2 (red circles). These figures were plotted using all data from

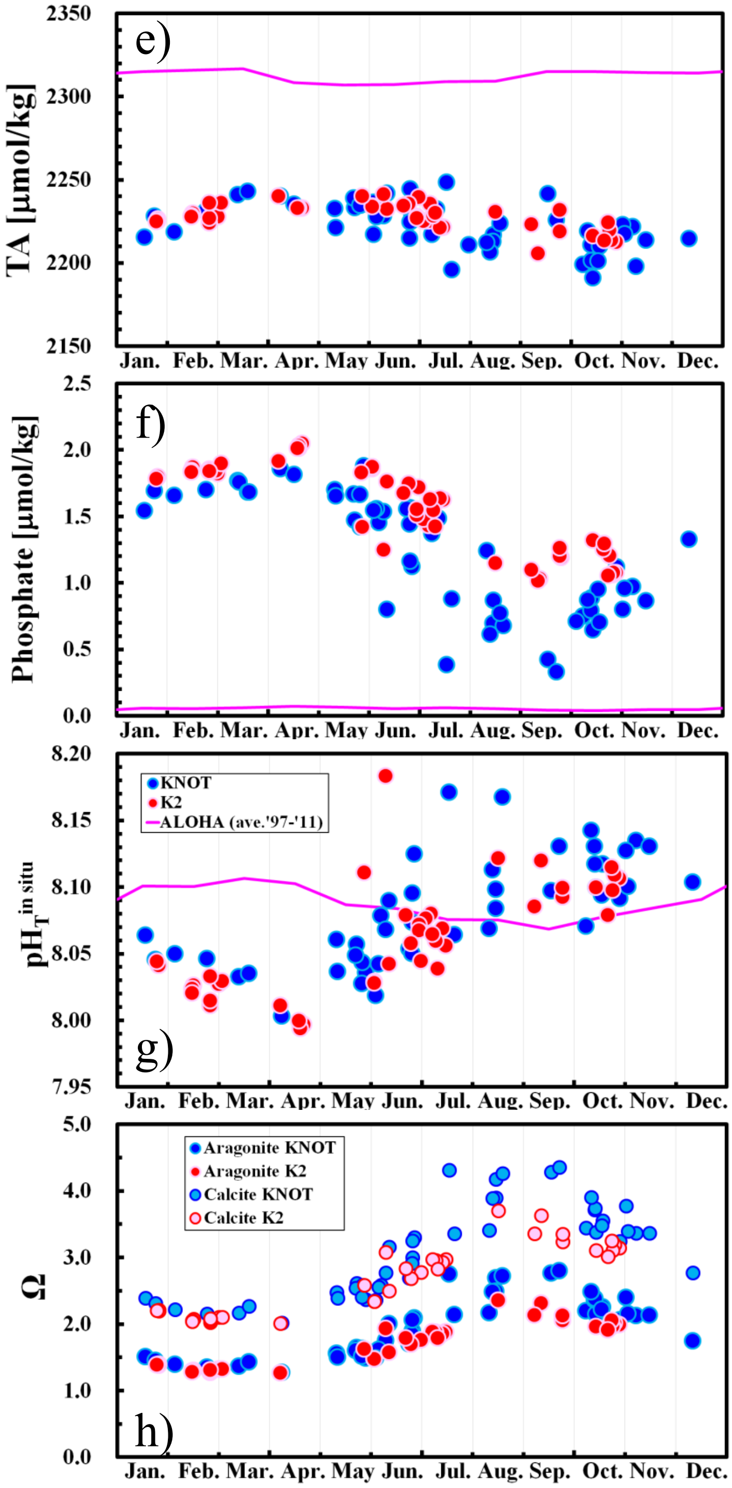


Figure. 2 continued

1997 to 2011 in order to examine typical seasonal variations and for comparison with the climatological monthly means of MIxed Layer data set of Argo, Grid Point Value (MILA GPV) (Hosoda et al., 2010) (a, b), data from Station ALOHA (Dore et al., 2010) (b–g), and Takahashi et al., (2009) (c). Values of oceanic xCO_2 (c), $pH_T^{in\ situ}$ (g) and Ω (h) were calculated from TA and DIC. The density criterion in the surface mixed layer was smaller than 0.125 kg m^{-3} (de Boyer Montégut et al., 2004).