RE: Following your valuable suggestions, we made major revisions:

(1) Calculate the steric heaight anomaly using in situ GTSPP data, and results are shown in Figure 3.

(2) We removed seasonal cycle of SLA using high-pass filter, and results are shown in Figure 6.

(3) We analyzed the monthly evolution of MLD, and the relationship between MLD and SST among three different zones. Results are shown in Figure 7-8.

(4) We rewrote the Summary and Concluding parts.

(5) We got text check help from text-check Company.

1. General Comments

Data and methods: 1) It is not clear why Argo data are not used to estimate the MLD, especially because the period is from 2003 onwards and because the authors use a fine grid (1/8 resolution). Neglecting Argo data seems improper at this stage. It is also not clear why the steric sea level is estimated only using net heat flux (approximate formula) and there is no attempt to use in-situ data, which are only used for MLD estimation.

RE: Following your valuable suggestions, we made revisions below,

(1)The GTSPP data include profiles float data, and we actually used them in the formal manuscript. We added the 'Argo profiling float data' in Line 100-101.

(2)We compared the steric height anomaly using in situ data, the description and calculations are shown in Section 3.2.1 and Figure 3:

'SSH depends on several ocean processes, including heating and oceanic currents (Stammer, 1997), as shown below:

$$\eta = \eta_s + \frac{1}{g\rho_0} p_b \quad (1),$$

where η_s is the steric height,

We examined the steric height anomaly using two methods: *in situ* GTSPP observations and air-sea heat balance. The anomaly using GTSPP is expressed as:

$$\eta_s(x,y,t) = -\frac{1}{\rho_0}\int_{-H}^{0}[\rho(x,y,z,t) - \rho_m(x,y,z)]dz \quad (2),$$

where $\rho(x,y,z,t)$ is water density, $\rho_m(x,y,z)$ is time mean water density, and ρ_0 is a typical density. The depth H stands for the reference depth taken to be 1000 m.

The anomaly based on air-sea heat balance is:

$$\eta_s(x,y,t) = \frac{\alpha(x,y,t)Q'(x,y,t)}{\rho_0 c_p}\Delta t + \eta_s(x,y,t-1) \quad (3),$$

where time interval Δt was set as 7-day. $\eta_s(x,y,0)$ was given by the satellite SLA on January 1, 2003. The thermal expansion coefficient $\alpha(x,y,t)$ was evaluated from Table A3.1 of Gill (1982), using Levitus's (1982) mean mixed-layer temperatures. The effect of pressure on $\alpha(x,y,t)$ was neglected. c_p is the specific heat of seawater at a constant pressure.

The final term in Equation (1) represents the bottom pressure caused by the fluctuation of barotropic currents, and can be derived from $\eta_b = \eta - \eta_s$.

The variation in SLA, and steric height components calculated from the above two methods are shown in Figure 3. Both SLA and steric height anomaly displayed significant seasonal variation, with negative values in winter and peak values (>15 cm) in mid-summer. The seasonal cycle in SLA was consistent with that of steric height. The amplitude of the steric height anomaly was much larger to the north than that to the south of the SST front. The steric height anomaly calculated from GTSPP data (Equation 2) was considered to represent the true oceanic conditions. That derived from air-sea heat flux roughly displayed the temporal variation in the true steric height. However, some mesostructures to the south of the SST front (within the black boxes of Figure 3a,c) were excluded, possibly due to the coarse resolution of the NCEP/NCAR net heat fluxes or the loss of freshwater flux.

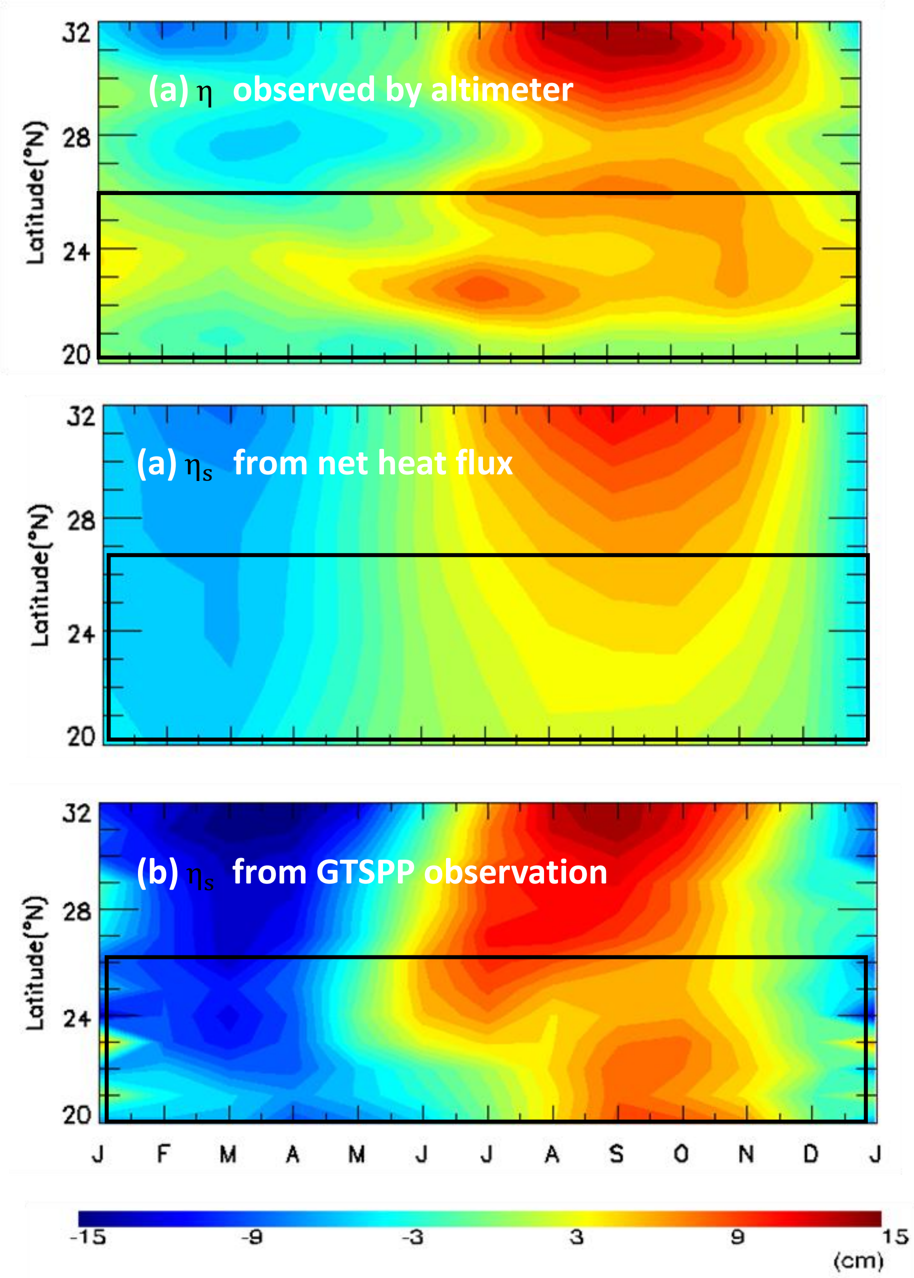


Figure 3 Qiu et al., 2014

2. Section 3.1 looks much too an enumeration. Once would expect to understand why the front location has different variability depending whether it is on the western, central or eastern part of the area study.

RE: Thanks for your valuable suggestions. We added sentences in Line 115-123, 'In different locations, the frontal position had different variations. The frontal position showed significant seasonal variation in the western part (130 – 135 °E), was stable throughout the year in the central region (135 – 150 °E), and shifted seasonally in the eastern part (150 -160 °E). Subtropical waters are influenced by the path of Kuroshio Current, and in some years, the Kuroshio mean path entered the western and eastern parts of our study area (Figure 2 of Sugimoto and Hanawa, 2014). Therefore, the different patterns of seasonality of the frontal position may have been induced by movement of this current's path. '

3. Results presented in 3.2.1 seem not commented /explained. Actually they are quite obvious: the EOFs analysis that uses monthly or sub-monthly data will certain provide the seasonal cycle as principal component / first mode. It is very intuitive that the variability of SLA and SST follows a meridional gradient and its dominant component is the seasonal one.

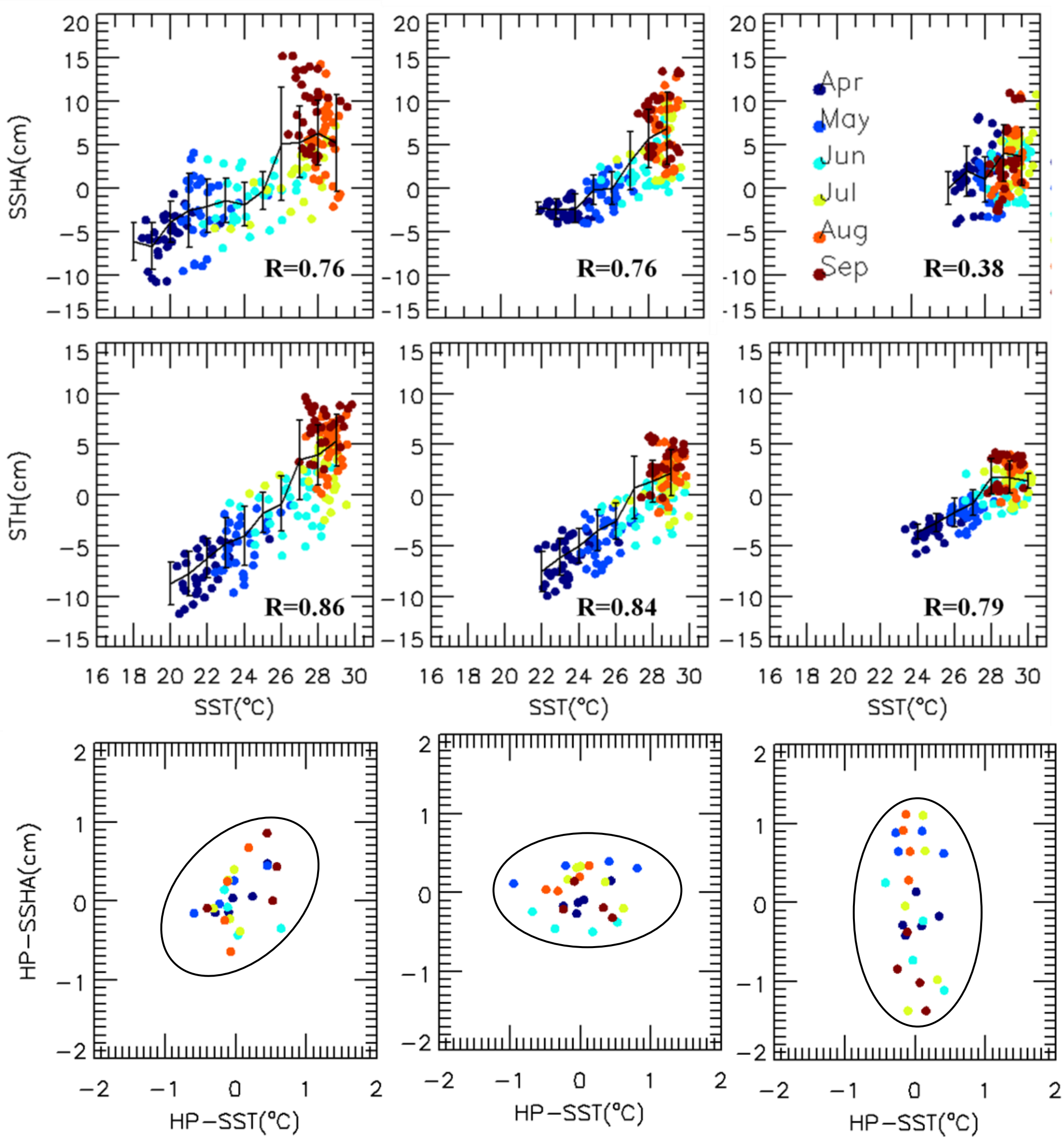
RE:

(1)We changed the order of section 3.2.1 and 3.2.2. We corresponding sentences were added in L180-L183,

' One would expect the EOFs analysis using weekly data to provide the seasonal cycle as the principal component /first mode, and it is intuitive that the variabilities in SLA and SST follow a meridional gradient and their dominant component was seasonal.'

(2)We also used a high-pass filter to smooth out the seasonal variations of SLA, and showed the results in the bottom row of Figure 6. The descriptions are in Line198-214:

'We further examined the relationships between SLA and SST after removing the seasonal cycle, using a high-pass filter, and called the resulting values HP-SLA and HP-SST. They are shown in Figure 6 g-i. In the cold zone, HP-SLA and HP-SST displayed a weak linear relationship with a correlation of 0.4. In the front zone, the variation in HP-SSH was smaller than that in the cold and warm zones, but the variation in HP-SST was larger. In the warm zone, the relationship between HP-SLA and HP-SST was opposite to that in the front zone, indicating that the disturbances in SLA did not result from those in SST. The warm zone located in the area of subtropical countercurrent field reported by Kobashi and Kawamura (2001) contained three branches of geostrophic current. These suggest the possible significant influence of oceanic currents on SLA in the warm zone. In the cold and front zones, SLA cycles were dominated by steric height, which was induced by air-sea heat balances. But in the warm zone, SLA cycles were not related to the steric height anomaly, and were possibly induced by oceanic currents. A strong subtropical countercurrent occupied the warm zone (Kobashi and Kawamura, 2001; Qiu and Kawamura, 2012), which further suggests that variation in SLA is induce by the oceanic current in the warm zones.'



4. By introducing Section 2, the salinity effect on steric sea level is neglected. The authors should at least discuss this issue

RE:As mentioned in question 1, we used in situ density observations to estimate the steric height. Therefore, the salinity effects were included in these calculations.

5) There is a lack of explanation, discussion and interpretation of results. For instance, no attempt in explaining (Figure 5) the different steric/SSHA cycles in the three zones. The reader does not understand e.g. if it comes from an approximation in the steric sea level, or it responds to a variation in the barystatic term of sea level.

RE: See question 3. We input some interpretations in Line 205-214:

'The warm zone located in the area of subtropical countercurrent field reported by Kobashi and Kawamura (2001) contained three branches of geostrophic current. These suggests the possible significant influence of oceanic currents on SLA in the warm zone. In the cold and front zones, SLA cycles were dominated by steric height, which was induced by air-sea heat balances. But in the warm zone, SLA cycles were not related to the steric height anomaly, and were possibly induced by oceanic currents. A strong subtropical countercurrent occupied the warm zone (Kobashi and Kawamura, 2001; Qiu and Kawamura, 2012), which further suggests that variation in SLA is induce by the oceanic current in the warm zones.'

6) Again, the high correlation SSH-SST and SSL-SST is quite obvious because it is dominated by the seasonal cycle. This applies to most ocean regions, and also to the global mean sea level. There is no clear implication on the weakening of the subtropical front.

RE: Following your suggestions, we added sentences in Line 193-197:

'We found the SLA cycles were different in the three zones. From April to September, the SLA sharply increased due strong heating in the cold zone, but it no evident variation in the warm zone. Finally, the SLA displayed a similar value ~8 cm, across the entire study area in September. The balance in SLA across the cold and warm zones occurred in reaction to the weakening of the SST front.'

Specific Comments

Pacific Ocean is never mentioned in the Abstract,

Corrected.

Figure 1 is never mentioned in the text.

Corrected in Line 75.

P85L27: AMSRE data are available from 2002

Corrected in Line 82.

A discussion/reference on the use of 0.6 degC as MLD temperature criterion is required, since it appears relatively large. The resolution of the grid used for analysing the data (1/8) seems much finer that the signal provided by altimetry and in situ data. The authors should discuss/justify this choice, as it would be more obvious interpolating all the data to a coarser grid

Because our interest is the monthly evolution of MLD, its temporal variation is more important than itself. We once compared three definitions in Qiu et al.(2014), finding that the definitions of MLD not important for the mechanisms of the SST front.

Typo

P84L4: investigate instead of investigated; sea level anomaly (without "the")

Corrected.

P84L25 use "exchanges"; also the sentence is not complete, eg "sea surface height VARIATIONS", and needs a full stop.

Corrected.

P85L4 : geostrophic

Corrected.

P85L14: deepening instead of enlarge

Corrected.

P85L14 induces

Corrected.

P85L16 "We need to check..." this sentence sounds weird and needs rephrasing

Corrected.

P86L2: data processing DESCRIBED

Corrected.

P86L3: The sentence “AMSRE has no seasonal variation” does not make sense. Perhaps

“AMSRE has no data gaps and therefore is suitable for investigating seasonal variability”

Corrected.

P86L14 summing, not summarized

Corrected.

P87L4 and many other occurrences: please use the simple present and not the past

Corrected.

C3

P87L8: “locations” instead of part

Corrected.

P87L25 “relatively” instead of relative

Corrected.

P88L3: indicates instead of represent

Corrected.

Equation 1: it is better to consider than anomalies and state clearly in the text that the three components are anomalies wrt to the mean state

Corrected.

P88L15 “cp” is described here but introduced later in Equation 2

Corrected.