Response to referee #3

We thank the reviewer for careful reading of our manuscript and insightful comments. Following is our response to your comments cited in italics.

In this paper, seasonal variations in nutrients distribution and primary production in the shelf region of the East China Sea are discussed based on the numerical model including physical and biological processes. And, contribution of the nutrients intruded from the Kuroshio subsurface to the primary production is estimated with the comparison of the control case and sensitivity experiments. The seasonal variation found in the model looks to reproduce the distribution usually observed from satellite in general, while they may have some problems about the turbidity and sedimentation. However, observation data are not shown for the horizontal distributions of chlorophyll-a. Some quantitative comparisons should be shown in the manuscript.

Ocean color data observed by satellites are very useful to know horizontal distribution of chlorophyll-a. However, because of high concentration of suspension particle material and colored dissolved organic matter in the East China Sea, Yellow Sea and Bohai Sea, the standard algorithms usually overestimates concentration of chlorophyll-a in our study area. The problems on the turbidity and sedimentation you mentioned were actually caused by the usage of the overestimated satellite data. Therefore, a quantitative comparison is still difficult for the horizontal distribution of chlorophyll-a in the East China Sea, Yellow Sea and Bohai Sea. We know the group of Prof. Ishizaka in Nagoya University is hardly working on this topic and expect to be able compare our model results with their products in the future.

Following your comments on quantitative comparison, we will add some quantitative comparisons with JMA data along PN section in the revised manuscript. We will also add comparison with other nutrient element such as DIP in the revised manuscript.

Contribution of the nutrients from the Kuroshio subsurface to the primary production in the shelf region is important when we consider the biological environment in the area. The authors used a method to compare the results between the case where nutrients are artificially increased and the control one. The result that the supply of oceanic nutrients to the shelf of the ECS contributes to primary production by its element ratio is interesting, considering the role of the oceanic nutrients. The decrease in DIN offshore of the Changjiang estuary due to increase in oceanic nutrients with small N/P ratio is explained in a reasonable sense. On the other hand, for the increase in DIN anomaly is not clearly explained. It should be explained *how the increase in DIN occurs caused by increase in oceanic nutrients in bio-geochemical and physical senses. Is it just caused by dispersion of the higher nutrients?*

The answer is YES but not limited to dispersion since advection also plays an important role. The increase in nutrients in sensitivity experiments was caused by two processes. One is the advection or diffusion of additional oceanic nutrients (= physical sense you mentioned). The other is the decrease in primary production (=bio-geochemical sense you mentioned). Since we did not find any decrease in chlorophyll-a in the sensitivity experiments (Fig.9 in the manuscript), the second possibility should be removed.

In general, appropriate validation of the ecosystem model need to be given in more quantitative senses. And physical and bio-geochemical explanations on the distribution of nutrient and chlorophyll-a anomalies for the additional oceanic nutrients should be given more clearly.

As we replied previously, we will add some quantitative comparison between model results and observed data along PN-line in the revised manuscript. We will also add some sentences to give physical and bio-geochemical explanations on the nutrients and chlorophyll-a anomalies for the additional oceanic nutrients.

Specific comments are as follows.
1. There are two expressions on the layers, that is, the upper layer and the lower layer or the surface layer and the bottom layer. It's better to be defined clearly, concerning the relation to euphotic zone.

Thanks for your remind. We will revise them to make a consistent usage through the manuscript.

2. P1415,L25-p1416, L2: It is better to explain the reason for the seasonal variations, particularly on the three peaks of silicate if it is mentioned.

We will follow your suggestion and add explanations in the revised manuscript. For this purpose, we defined the volume transport of inflow water (Vol_+), the mean concentration (C_+) in the inflow water, the volume transport of outflow water (Vol_-), and the mean concentration (C_-) in the outflow water as follows,

$$Vol_+ = \sum u_+ , \quad C_+ = \frac{\sum u_+ \cdot C}{\sum u_+}, \quad Vol_- = \sum u_- , C_- = \frac{\sum u_- \cdot C}{\sum u_-}.$$

Here, u_+ and u_- denotes inflow and outflow volume at the grids along 200 m isobath, C is concentration. As an example, the inflow and outflow volume transports, the mean concentrations of nitrate and of silicate in the inflow and outflow waters in each month are presented in Figure C1. The inflow volume transport is always larger than the outflow volume transport through a year (Figure C1a). However, the mean nitrate and silicate concentrations in the inflow water are smaller (larger) than those in the outflow water from September to next March (from April to September) (Figure C1b). Therefore, the seasonal variation in onshore nutrient transport is different from that in onshore volume transport.

The difference in the seasonal variations between the onshore fluxes of nitrate and silicate is caused by the concentration specified at south open boundary (Figure C2). The silicate concentration there has three peaks corresponding to the three peaks in the silicate onshore flux across 200 m isobath. The nutrient concentrations at the south boundary were from WOA2005.

3. P1416,L2-: The major variations seem to be seasonal variations. Is it suitable to express with standard variation to show the seasonal variations?

The seasonal variation can be treated as a harmonic function with amplitude and phase. The standard variation of a harmonic function is 0.7 times of its amplitude. For this sense, the standard variation can represent the magnitude of seasonal variations.

In the description given in P1416, L2-, we mixed two comparisons in one paragraph. The first sentence was to confirm the seasonal variation described in previous section. The second sentence and followings were to describe annual mean. In the revision, we will move first sentence to the end of previous section.

4. P1416,L19-24: Although the volume transport of the intrusion from the section northeast of Taiwan is about ten times of that through the section southwest of Kyushu, the difference of nutrient transport is about three times. What is the reason for the small ratio for the nutrients?

A short answer to your question is because the nutrient concentrations in the inflow and outflow waters are different in two regions. As shown in Figure C1, the net nutrient flux does not always follows the net water flux in a system with large exchange water flux because the concentration of nutrients can be different in the inflow and outflow waters.

Here we use nitrate as an example to demonstrate this process. Table C1 presents monthly volume transports of inflow and outflow and monthly nitrate concentrations in the inflow and outflow waters at regions northeast of Taiwan and southwest of Kyushu. The monthly nitrate concentrations in the inflow and outflow waters were calculated in a similar way as those in Figure C1. Apparently, the nitrate concentration in the inflow water is lower (higher) than that in the outflow water at the region northwest of Taiwan (southwest of Kyushu) through a year. On the other hand, the volume transport of inflow is much larger (a little larger) than that of outflow at the region northwest of Taiwan (southwest of Kyushu). Consequently, at the area northeast of Taiwan, only the difference in the volume transport of inflow and outflow contributes to the onshore flux of nutrients; the difference in the nutrient concentration of inflow and outflow waters has a negative effect on the onshore flux of nutrients. At the area southwest of Kyushu, both the difference in the volume transport of inflow and outflow and that in the nutrient concentration of inflow and outflow waters have a positive contribution to onshore flux of nutrients.

As additional information, we like to note that the annual mean onshore nutrient transport across 200 m isobath calculated from Table C1 is 19.43 kmol s^{-1} for the area northeast of Taiwan and 7.56 kmol s^{-1} for the area southwest of Kyushu, respectively. The annual mean onshore water volume transport is 5.43 Sv for the area northeast of Taiwan and 0.48 Sv for the area southwest of Kyushu, respectively. As you mentioned, the ratio of total onshore volume transports between two areas is > 10 but that of total nutrient transport is < 3.

5. P1417,L4-6: Does it mean that nutrients intruded into the shelf region from the Kuroshio subsurface would not be lifted up to the euphotic zone during the period carried to Tsushima Strait?

Yes, it is possible that a part of the Kuroshio subsurface water across 200m isobath does not contribute to the primary production over the shelf of the East China Sea. Because of this possibility, some researchers argued that the Kuroshio subsurface water is not important to the primary production in the East China Sea. One of our purposes in this study is to clarify this point, that is, to confirm the possible contribution of Kuroshio subsurface water to the primary production over the shelf.

6. P1419,1st para.: As the annual mean transport, the region around PN section is located to offshore transport as shown in Fig.8. Is it suitable to discuss the onshore intrusion of nutrients using PN section?

We chose PN section is because this section is a well-known place to the researchers who are interested in the East China Sea. The PN section is actually located at offshore transport region from the viewpoint of the flux across 200 m isobath. However, this does not mean that the section cannot represent the onshore intrusion of nutrients because the nutrients at the area shallower than 200 m can be supplied by onshore intrusion of nutrients northeast of Taiwan. The water generally flows northeastward over the shelf between 100 m depth and 200 m depth. Therefore, the onshore intruded nutrients northeast of Taiwan can be transported to the PN section.

7. Fig.9 and 11: In Fig.9 nutrient anomaly looks to exceed 0.5 in winter in the mid shelf, while it seems to be around 0.2 in the surface layer along the PN section. Is it consistent?

The left point of section PN in Figure 11 is 124.5 E. The concentration in winter (e.g. January) exceeds 0.5 and is less than 0.2 in summer. The concentration in Figure 9 at the same place is also over 0.5 in winter and less than 0.2 in summer. They are consistent.

8. Fig. 11 and 12: It is better use another color for euphotic depth. And it is hard to see the numerals on contours.

We agree with you and will change it in our revision. we will enlarge numbers inside the contours in these figures.

9. P1420,L19: in model the calculation » in the model calculation

It is our careless miss. We will correct it.

Table C1. Monthly mean nitrate concentration and volume transport of inflow and outflow across 200 m isobath at the areas northeast of Taiwan(NOT) and southwest of Kyushu(SOK). Positive values denotes onshore transport.

mean nitrate concentration (mmol m^{-3})					volume transport (Sv)			
	outflow water		inflow water		outflow		inflow	
	NOT	SOK	NOT	SOK	NOT	SOK	NOT	SOK
1	6.45	9.55	5.70	9.63	-4.54	-3.44	9.20	3.64
2	5.24	8.86	4.52	9.28	-4.53	-3.65	9.52	3.87
3	4.27	8.51	3.68	9.12	-4.75	-3.67	9.83	3.96
4	4.74	7.96	4.29	9.07	-4.86	-3.58	10.45	3.68
5	4.57	7.42	4.19	9.22	-4.98	-3.52	10.68	3.59
6	4.06	8.24	3.86	10.20	-4.89	-3.71	10.50	3.79
7	3.94	8.54	3.82	10.42	-5.23	-3.98	11.25	4.14
8	4.48	8.86	4.23	10.06	-5.22	-3.50	10.84	3.97
9	4.27	10.23	3.77	10.06	-5.21	-2.51	10.44	3.63
10	4.50	9.83	3.81	9.95	-5.11	-2.68	10.73	3.93
11	5.11	9.28	4.26	10.03	-4.91	-3.36	10.68	4.36
12	5.15	9.55	4.30	10.02	-4.79	-3.51	10.09	4.25

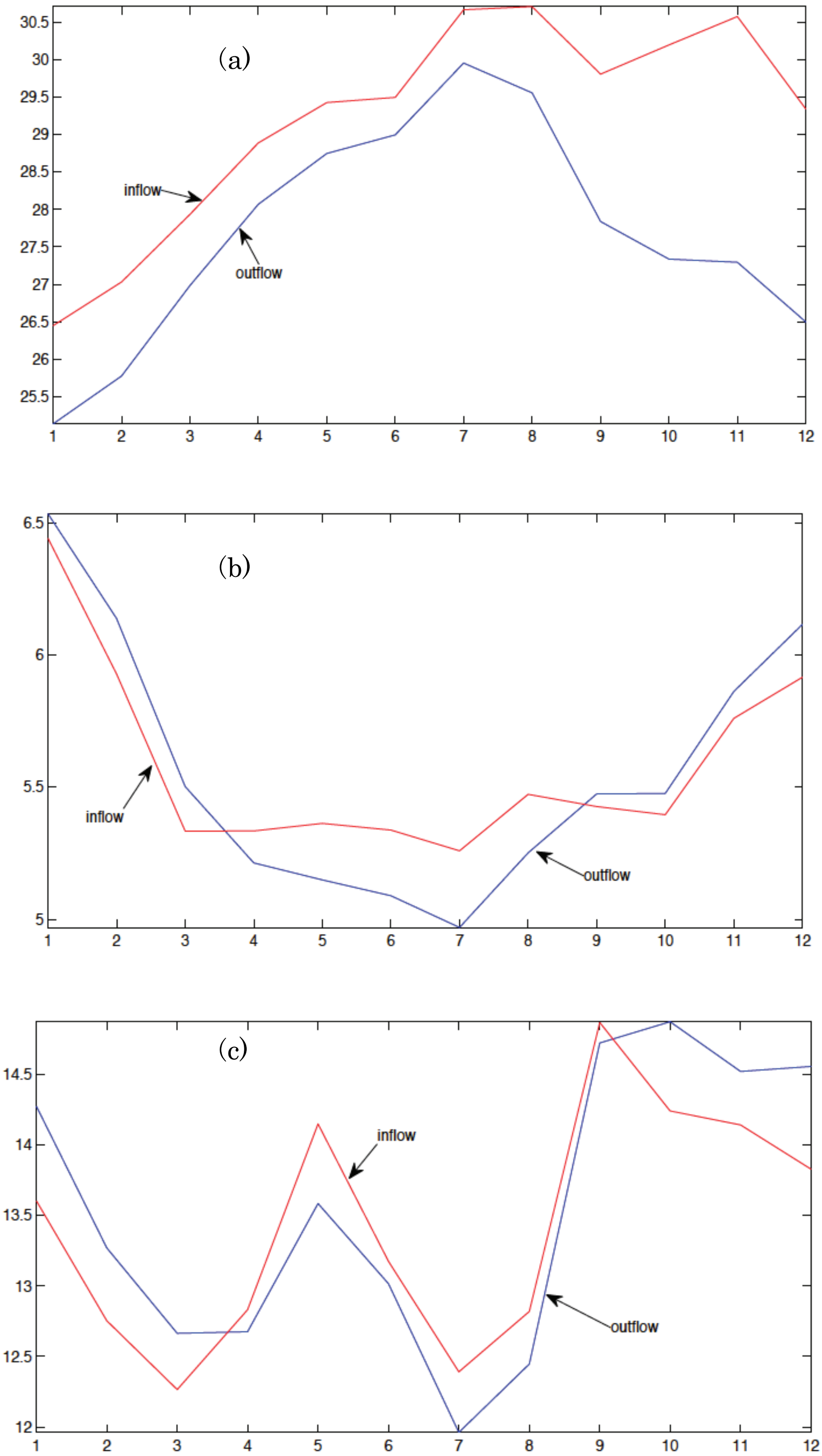

Figure C1. (a) monthly inflow and outflow volume transport (Sv) cross 200 m isobath. (b) monthly mean nitrate concentration (mmol m^{-3}) in the inflow and outflow waters. (c) the same as (b) but for silicate.

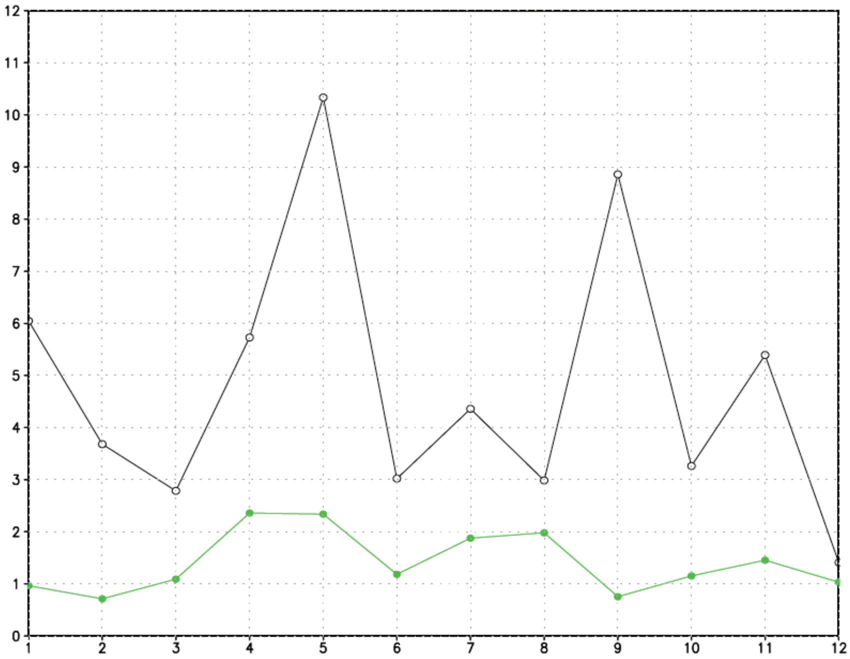

Figure C2. Seasonal variation of vertically averaged nitrate (green line) and silicate (black line) concentrations above 200 m depth at south open boundary (123E,24N).