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Interactive comment on "Phytoplankton dynamics driven by vertical nutrient fluxes during the spring inter-monsoon period in the northeastern South China Sea" *by* Q. P. Li et al.

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Responses to Reviewer #1

1. General comments: "...However, what I concern about is the accuracy and representativeness of the calculation in this study. That is, the studied region is affected by curl-driven upwelling, Kuroshio intrusion, and probably the Pearl River plume, these processes are all highly time dependent (have strong temporal variability), calculations based on these data may lead to considerable error. In addition, it is dangerous to say the one-time observation in this 3-day cruise actually represents the entire spring inter-monsoon period. Therefore, discussions on calculation errors and the overall

uncertainties of the results will make the findings more meaningful. In conclusion, I suggest that the paper can be published after properly address these issues."

Response: Uncertainty of vertical nutrient fluxes including diffusive and advective fluxes has been addressed and properly discussed in the revised manuscript. Calculation errors of diffusivity by Thorpe-scale analyses, estimated from a time-series station S1 with continuous sampling up to 13 casts in 24 hours, were 0.87 x10-4 m-2 s-1 at 50 m (n=5), 0.71 x10-4 m-2 s-1 at 100 m (n=6), and 0.46 x10-4 m-2 s-1 at 150 m (n=7). We could thus obtain an average of 0.68 x10-4 m-2 s-1 for the overall uncertainty of diffusivity determined in our study. Uncertainty of Ekman velocities by satellite observations at each station is estimated by their standard deviations over the sampling duration of May 14th-16th, 2014. In the revised manuscript, we have also included time-series of Ekman pumping at stations C6 and C13 during May-June 2014 (Fig. 2d in the revised manuscript) to demonstrate the temporal variability of curl-driven upwelling in the NSCS. Ekman velocities during the field study are relatively low but representative of the entire spring intermonsoon period from May 8th to June 7th, 2014 with substantially low wind intensity (Fig. 2d). Measurement errors of nutrients at depths during the field study are negligible as their concentrations are considerably higher than the detection limits of the analytical methods. We are not able to quantify the uncertainty of nutrient gradient, as we have only one cast for each station with reduced resolution below the euphotic layer. Whereas, the nutrient gradient and related diffusive flux calculated at the base of euphotic zone could be interpreted as a mean value between the two adjacent bottle depths (100-200 m). The final uncertainties for vertical nutrient fluxes are summarized in the revised Table 1, which vary substantially from 0.10 to 0.98 mmol m-2 d-1 for stations in the offshore regions.

2. Specific comments: P6732, L10-13: "Upward transport of the deeper water with lower temperature . . . observed during the survey (Fig. 3a and b), giving direct evidence for wind-induced coastal upwelling". Actually, the low temperature coastal water is separated from the low temperature deep water by the relatively high temperature

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water located in between (near the shelf break), so it is hard to attribute the low temperature near shore water (Fig. 2a) to the result of deep, cold water upwelling along this section. Recent studies revealed that the cold dense water near Shantou was originated from the shoreward upwelling in upstream and advected along coastline by coastal current.

Response: We agree with the reviewer on this point. The sentence has been rewritten as "... observed during the survey (Fig. 3a and b), which could be a result of direct upwelling or alongshore advection of upwelled waters from upstream".

3. P6733, L4-11: "As suggested by the satellite geostrophic current data during the survey... Prevailing wind stresses in the northeastern SCS ... (vectors of Fig. 2b)", as introduced in section 2.1, the study period is 14 to 16 May 2014, but the data of Figs. 2a and b are from 15 May 2014, should keep consistency.

Response: The original figure-legend was not carefully written. Data shown in Figs 2a-b are actually three-day mean products. We have corrected these typos in the revised manuscript.

4. P6733, L21: "Sea surface chlorophyll a in the northeastern SCS during May 2014 was very high in the coastal upwelling zone", the corresponding salinity, temperature and wind field should be presented to support that the high chlorophyll is a result of coastal upwelling, especially during a "spring inter-monsoon period" when coastal upwelling is not a typical phenomenon.

Response: The reviewer is right about this. We defined different zones of the NSCS just based on their geographic location and T/S properties, which have been provided in the revised Figure 1. We have replaced "the coastal upwelling zone" with "the coastal ocean zone" in the revised manuscript.

5. P6734, L1-3: "... decrease of surface nitrate concentration from ...", the Fig. 3d should be adjusted to clearly show the decreasing trend from near coast to offshore.

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Response: Colorbar of Fig.3d-f has been modified to show the decreasing trend of nutrients near surface.

6. P6737, L1-2: "with much higher temperature and salinity... (Fig. 6)", there is no salinity in Fig. 6.

Response: The sentence has been rewritten as "with much higher temperature (Fig.6) and salinity (data not shown). We prefer to not include salinity data in Fig.6, as it will make the figure very busy and difficult to read.

7. P6738, L1-2: "with a much slower rate of nutrient consumption at station B (0.46 d-1) than at station A (1.03 d-1)", firstly, the unit of nutrient consumption rate is not correct (should be something like mmol/m3/d); secondly, it seems the PO4 consumption rate is higher in station B according to Fig. 8 during the entire incubation period.

Response: It is the specific nutrient consumption rate in unit of [d-1], which is not depending on the nutrient concentrations. We have clarified this in the revised manuscript.

8. P6738-6739, the first paragraph of section 4.1: should be moved and incorporated into section 1 (Introduction), some duplicated.

Response: Done. The contents have been deleted and incorporated into the first and second paragraphs of the introduction section in the revised manuscript.

9. P6740, L10-11: "The largest diffusive nitrate flux found at station B". The vertical flux of diffusive is calculated by vertical diffusivity times nutrient gradient, then the gradient is very important in determine the vertical flux, but how to get an accurate and representative gradient? The gradient itself is a result of turbulent diffusion and/or Ekman pumping.

Response: Accurate estimation of nutrient gradient at each depth is depending on the nutrient data and its vertical resolution. With the depth-resolution we have, the nutrient gradient determined at the base of euphotic zone should only be interpreted as an average between the two adjacent depths. Nutrient gradient should be a result of both physical (mixing, upwelling, etc.) and biological processes (uptake, regeneration, etc.).

10. P6740, L23-29: "Our results suggested that it was the fluxes of nutrients that were responsible for the observed chlorophyll a difference...", assuming that other conditions are all the same (e.g., species, temperature, light, etc.), the phytoplankton biomass (or chlorophyll level) will be higher in the environment with higher nutrient concentration, because higher nutrient concentration can support higher phytoplankton growth rate. Nutrient flux can be used for estimating biological production during a period of time, however, it cannot be correlated with chlorophyll level at some point.

Response: We agree with the reviewer on this point and the sentences have been rewritten as follows: In steady status, the net primary production of phytoplankton should be balanced by the upward nutrient flux as well as the downward particle flux. Therefore, a high nutrient flux would correspond to a high net primary production and thus a high biomass accumulation, if other conditions remain the same (species, temperature, light, grazing, etc). Station C9 is interesting in that the vertical nutrient fluxes are net downward out of euphotic zone, suggesting that the station might not be in steady status. High nutrients here were likely a result of strong horizontal input or a previous diapycnal nutrient injection. In this case, large drawdown of nutrients would be expected by fast growing phytoplankton and by the downward transport of nutrients out of euphotic zone.

11. P6742, L11-14: "Indeed, the area of the phytoplankton bloom decreased substantially within two weeks ...", any figures or data? At least the data source should be indicated. Figure 2, I would suggest the authors to plot the SST, curl-driven upwelling velocity, surface geostrophic currents and wind stresses from 14th to 16th May, 2014, since the field survey was conducted during this period. Actually, monthly mean data for the above variables are better to keep consistent with the monthly chlorophyll.

Response: The decrease of phytoplankton bloom can be seen from the weekly mean

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sea surface chlorophyll-a data of MODIS-Aqua. We have clarified this in the revised manuscript. Data shown in Figures 2a-b are actually the three-day-mean products averaging from May 14th to 16th, 2014 (original figure legends was not well written, we have corrected these typos in the revised manuscript). Monthly chlorophyll-a map of Figure 3c is to show the regional pattern of chlorophyll during May 2014, as the cloud coverage has led to large space of missing data points during the sampling period.

12. Figure 8, I suggest to add NO3 in the figure, or replace PO4 with NO3, since it is generally P-limited in these areas.

Response: The interaction between NO3 and NH4 during incubation will make the estimation of nutrient consumption rate complicated and difficult. Incubation samples had been enriched with nutrients at the beginning of experiments. Therefore, we think it is better to keep PO4 rather than adding NO3.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C3875/2015/bgd-12-C3875-2015-supplement.pdf

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