Review of "Two different phytoplankton blooming mechanisms over the East China Sea during El-Niño decaying summers" by Lee et al.

Comment on egusphere-2024-3406 | Anonymous Referee #1:

The revision is moderately responsive to my comments. Ultimately, it's up to the authors to decide how they are to respond to the reviews. If a suggested change is not justified, the authors can choose not to make the change but they should not report in Reply changes they have not made. THEIR REPLY SHOULD BE CONSISTENT WITH THE REVISED MANUSCRIPT. PLEASE DOUBLE CHECK. Such inconsistencies add extra work on the reviewers. Such inconsistencies add extra work on the reviewers.

In the title and elsewhere, I suggest changing "El-Niño decaying summers" to "post-El Niño summers." On average, El Niño has decayed by an post El-Niño summer.

Response: We thank referee #1 for constructive comments and valuable time reviewing our manuscript.

We have replaced "El-Niño decaying summers" with "post-El Niño summers" in the entire of the manuscript, and changed the title to "Phytoplankton blooming mechanisms over the East China Sea during post-El Niño summers".

Comment on egusphere-2024-3406 | Anonymous Referee #3:

General comments

• I appreciate the authors for thorough revision that clarified some of the questions I raised in the previous round of review, which allows me better understand the manuscript.

Response: We indeed thank to the referee's constructive and valuable comments and suggestions to improving our manuscript.

• When looked at the surface Chl a anomaly (SCHL), the anomaly due to El Nino events are really small (-0.06 to +0.06 mg Chl m^{-3}) (Figure 4). From observational measurement perspective, this magnitude of change is within the error of measurement. This is about 1/10 to 1/5 of the observed variation (Figure 10).

Response: We acknowledge a significant discrepancy in variability between satellite-derived surface chlorophyll-a (SCHL) data and the model outputs. In our study, we used SCHL data measured from ocean color satellite observations, which have been widely expected to be useful for detecting and analyzing the spatio-temporal distribution of SCHL from many previous studies (Kim et al., 2009; Yamada et al., 2004; Zhang et al., 2017). It is well established that satellite-based SCHL estimates tend to be substantially overestimated in coastal regions due to the turbidity from the large amounts of re-suspended bottom sediments (Kiyomoto et al., 2001; Siswanto et al., 2011; Yamaguchi et al., 2012). Additionally, Gong (2004) noted that high levels of colored dissolved organic matter (CDOM) from the Yangtze River can also contribute to overestimated SCHL concentrations.

Therefore, even though the model simulates about 20% of the observed range, it effectively captures the observed SCHL variability in response to climate variability. Notably, during the post-El Niño summer season, the correlation between the Nino3.4 index and the SCHL anomalies in the model results over the East China Sea (ECS) is highly significant at the 99% confidence level, similar to the observations. Moreover, the lagged relationships (with a delay of one to two seasons; Figure 11 in the main text) are also highly significant with correlations above 0.5 for both observations and models, indicating that the model simulates the observed SCHL variability well.

• Regarding the buoyancy upwelling mentioned as a mechanism for enhancing phytoplankton bloom (line 250 in the track changed document), I don't understand how that happens. I assume river runoff carries water of lower density, and the deep water upwells only when it becomes less dense than surface. I don't see how that is possible in this region. Estuary circulation may bring the subsurface water up to the surface, but it is only possible in the upstream of the estuary. I have to wonder where this may happen, and whether the location of upwelling due to estuary circulation is covered in the model domain. This mechanism is barely speculation without model data to support.

Response: Generally, the presence of less dense water in the top layer of a water column typically creates a strong vertical density gradient between the surface and the subsurface layer, which greatly constrains water exchange. Chen (2008) refers to this as the "capping effect". However, in the Yangtze River estuary (YRE) over the ECS, the upper layer is characterized by the discharge of a large volume of low-salinity water into the coastal ocean. This freshwater plume spreads horizontally, creating a distinct boundary with the denser, high-salinity surrounding water, leading to a strong horizontal density gradient along the plume's edge. This gradient generates a pressure difference that drives a compensatory circulation to maintain water balance (see Figure 2 in Chen, 2008). Consequently, this circulation facilitates the entrainment of nutrient-rich subsurface water (Hill, 1998; Chen et al., 2003; Chen, 2000), as the pressure gradient forces denser, nutrient-rich water to upwell along the plume boundary, delivering nutrients into the euphotic zone where they fuel phytoplankton growth.

Indeed, when a strong flood occurs, despite the presence of low-salinity surface water, saltier subsurface water is observed on the ECS shelves (Hu et al., 2001; Delcroix and Murtugudde, 2002). Chen (2008) mentioned that such observation supports the occurrence of water entrainment along coastal shelves driven by the enhanced riverine discharge. In addition, the TOPAZ model does not account for phosphorus (P) input via runoff; however, as shown in Figure 9 in the main text, the runoff mechanism has the most pronounced effect near the YRE, where phosphate (PO_4) limitation is dominant. This suggests that the dominant signal attributed to the runoff mechanism is primarily influenced by buoyancy-driven upwelling, which entrains PO_4-rich subsurface water into the surface layer. Lastly, we have revised the description of buoyancy-driven upwelling due to enhanced river discharge in more detailed in the main text to improve clarify for readers.

(L141-147): As the freshwater plume outflow surpasses the incoming discharge, a pronounced horizontal density gradient develops along the plume boundary. This gradient creates a pressure difference, which in turn drives a compensatory circulation to maintain the water balance. Essentially, the pressure gradient forces the denser, nutrient-rich water from below to rise along the plume boundary, thereby upwelling into the surface layer. Consequently, the nutrient-rich Kuroshio subsurface waters ascend along the ECS shelf edge, providing essential nutrients. This buoyancy-driven upwelling occurs independently of wind conditions, driven primarily by the physical properties of the subsurface waters in response to the enhanced river discharge.

• The equation 4 is hard to follow in the context of multiple regression. The TOPAZ model resolves the NO3, and PO4 limitation, and phytoplankton growths are limited by the minimum of the two nutrient limitations. This equations suggests PO4 limitation is ignored. If the purpose is to understand the contribution of different variables to the Chl anomaly (δChl), then the equation should be in the form of: δChl = Intercept+a δRunoff+b δT Stransport+c δEkmanUpwelling where a, b, and c are regression coefficients, which tell the importance of the variable if variables are normalized as the authors indicated. Then comes another problem. As Runoff, TS-transportations, and Ekmanupwelling are all correlated with Chl anomaly, it suggests that those independent variables in the regression are correlated with each other, that is they are not independent.

Response: We appreciate the referee's comments and suggestions regarding equation 4. The equation is intended to quantitatively decompose the influence of El Niño on SCHL anomalies (δChl) through three physical mechanisms—Runoff, TS-transport, and Ekman upwelling—by examining their independent sensitivities to changes in El Niño intensity (as indicated by Nino3.4 index). The equation is formulated as follows:

$$\frac{dChl}{dNino3.4}(\alpha) = \frac{\partial Chl}{\partial Runoff} \times \frac{dRunoff}{dNino3.4} + \frac{\partial Chl}{\partial TS\text{−}transport} \times \frac{dTS\text{−}transport}{dNino3.4} + \frac{\partial Chl}{\partial Ekman\text{−}Upwelling} \times \frac{dEkman\text{−}Upwelling}{dNino3.4} + residual$$

In this equation, each partial derivative term, ∂Chl/∂X (where X represents the three blooming mechanisms: Runoff, TS-transport, Ekman-Upwelling) were calculated from the multiple regression analysis, which account for their co-relationship.

We acknowledge the referee's concern regarding potential multicollinearity among the independent variables (Runoff, TS-transport, Ekman Upwelling). To address this, we assessed multicollinearity using the Variance Inflation Factor (VIF), yielding the following values:

- Runoff mechanism: 1.265
- TS-transport mechanism: 1.08
- Ekman Upwelling: 1.214

These VIF values, ranging from 1.08 to 1.265, indicate minimal multicollinearity—generally, VIF values below 3 suggest negligible multicollinearity, while values above 5 may indicate significant concerns (Kock and Lynn, 2012; Kim, 2019). Given that all our values are well below this threshold, we conclude that the three mechanisms can be considered statistically independent enough to allow for reliable quantification of their individual contributions to SCHL variability.

In summary, our equation explicitly decomposes the influence of El Niño on SCHL anomalies via distinct physical mechanisms. By employing multiple regression coefficients (∂Chl/∂X), this approach effectively quantifies each mechanism's independent contribution, enabling a robust interpretation of their relative importance and spatial contributions. Thus, we believe this method captures both the quantitative and spatial contributions of these mechanisms' impacts on SCHL anomalies.

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