Author response

Dear editor and referees,

Thank you for your recognition of our revised manuscript "*A Lagrangian-based Floating Macroalgal Growth and Drift Model (FMGDM v1.0): application to the Yellow Sea green tide*".

Following the suggestions of Referee #2, we 1) added additional discussion of the impact of biotic and abiotic factors on macroalgal bloom to Section *4.3*, 2) revised the typos, grammatical errors, and figure labels in our manuscript.

Our response and corresponding changes are provided in this document, with a **bold** front for comments and a regular front for our answers. The manuscript quotations are represented in *italics*, and the changes in the manuscript are highlighted as underlined. The introductory parts of the referee report are omitted and marked as […] to keep the document concise.

We greatly appreciate all comments and suggestions on this manuscript from referees. We hope that our response can address the referee's concerns sufficiently, and this revision can meet the standard of *Geoscientific Model Development*.

Sincerely,

Fucang Zhou and Jianzhong Ge (on behalf of the author team)

Referee comment #2

[…] The changes also affect the level of biomass for the short-term monitoring experiments, with the revised growth model showing a much better fit with observations by being less dynamic (+10.10^{4} tons in two weeks for the 15 and 23rd of June 2014 experiments, respectively–compared to +50.10^{4} tons, and +35.10^{4} tons in the initial setup). These results show a clear influence of the added components (nutrients?), yet I feel this could be discussed a bit more; an extension of this study may include some parameter fitting (I understand this may not be in the scope of this study), as It remains difficult to disentangle the impact of biotic (nutrients) and abiotic (temperature) factors on the bloom spatial and temporal dynamics e.g. propagation/attenuation of the bloom. […]

The changes of the increased level of biomass in the short-term experiments, mentioned by Referees #2, were largely caused by the nutrient limitation for macroalgae photosynthesis in offshore areas.

As the Referee #2 commented, it is difficult to disentangle the impact of biotic (nutrients) and abiotic (temperature) factors on the bloom spatial and temporal dynamics. The effects of biotic and abiotic on ecological dynamics of macroalgae, more specifically green tide of *U. prolifera,* have been extensively examined by previous modeling and laboratory studies (Cui et al., 2015; Wang et al., 2019). In this study, the major motivation of our proposed model is to determine the joint effect of biotic and abiotic on macroalgae growth.

Many biotic and abiotic environmental factors were considered in the growth simulation of the ecological module. The suggestions of the referee provide a good idea to understand the ecological dynamics of macroalgae. According to simulation results presented in this work, the biotic factors (nutrients) is one of the major factors that influence spatial coverage of macroalgal bloom, and the abiotic factors including temperature and solar irradiation mainly modulate the temporal dynamics. Following Referees #2's comments, we have added additional discussion of the impact of biotic and abiotic factors on macroalgal bloom to Section *4.3.*

1) The revised of the additional discussion:

4.3 Roles of initial biomass, biotic and abiotic factors and nutrient limitation

[…]

The growth of floating macroalgae is affected by a variety of environmental factors. The influences of abiotic factors (e.g. temperature and irradiation) and biotic factors (e.g. nutrients) have been considered in the macroalgae growth module. Many macroalgae species have a clear thermoperiod, which is sensitive to temperature. The changes of temperature in the surface layer of water column in the YS has significant seasonal characteristics (Figs. 5-6). From spring to late summer, the temperature controls biological processes of the main species of YS green tides from germination, growth, reproduction to extinction (Fan et al., 2015), which is reflected in the temporal dynamics of biomass (Figs. 10i and 11i). The photosynthesis is limited by light attenuation caused by self-shading and floating depth of macroalgae, which changes with the growth stage (Ren et al., 2014) and the module has not yet detailed this process. Meanwhile, the coastal turbid water that contains abundant suspended particulate matter can also limit the growth of green tide due to strong light attenuation in the upper surface water column. The initial release zone in Subei Shoal is influenced by significant suspended sediment dynamics (Bian et al., 2013). Therefore, the growth rate in the coastal region in Jiangsu and Shandong is probably limited by suspended sediment.

Nutrient eutrophication frequently results in macroalgal blooms in coastal waters (Liu et al., 2013), which can also be reflected in the simulation results. There are significant differences in the concentration of dissolved nutrients between the coastal and offshore areas of the YS (Fig. 7). The simulation showed that massive macroalgal bloom in the coastal of Subei (34°N) in late June (Figs. 10c, d, e, and 11c), which was directly related to the nutrient eutrophication here, with the dissolved nitrate about 8 mmol/m^3 and the dissolved phosphate over 0.6 mmol/m^3. The macroalgae growth in the offshore areas is relatively weaker because of nutrients limitation. The nutrient concentration is one of the major factors that influence spatial coverage of macroalgal bloom, and the abiotic factors including temperature and solar irradiation mainly modulate the temporal dynamics.

The influences of nutrients in macroalgae growth have been considered in the model. Due to the difficulty in obtaining the distribution and variations of observational or simulated nutrients datasets, the accuracy of macroalgae simulation was limited by the deviation of nutrients datasets. Floating U. prolifera can efficiently absorb nutrients (Luo et al., 2012a), and the concentration of nutrients in the sea would decrease sharply when U. prolifera blooms dramatically, which may hinder the rapid growth of U. prolifera (Wang et al., 2019). When the green tide bloom reached its peak with millions of tons of biomass or drifted to the regions far from offshore, the dissolved nutrient concentration may be a significant growth limitation, even if the temperature and irradiation are still suitable for growth (Figs. 5 and 6). Due to lack of further research data on ecological relationships, some biotic factors (e.g. dissolved oxygen and potential biological competition against Sargassum) and abiotic factors (e.g. suspended particulate matter) are difficult to be parameterized (Solidoro et al., 1996), and therefore not considered in the physical-ecological coupled module.

References

Cui, J., Zhang, J., Huo, Y., Zhou, L., Wu, Q., Chen, L., Yu, K., and He, P.: Adaptability of free-floating green tide algae in the Yellow Sea to variable temperature and light intensity, Marine Pollution Bulletin, 101, 660-666, https://doi.org/10.1016/j.marpolbul.2015.10.033, 2015.

Wang, C., Su, R., Guo, L., Yang, B., Zhang, Y., Zhang, L., Xu, H., Shi, W., and Wei, L.: Nutrient absorption by *Ulva prolifera* and the growth mechanism leading to green-tides, Estuarine, Coastal and Shelf Science, 227, https://doi.org/10.1016/j.ecss.2019.106329, 2019.