We thank reviewers for their comments on this manuscript. We have tried to address all comments, and please find our responses to comments below.

Anonymous Referee #2 comments:
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General

1. The authors use a simple box model to estimate the potential primary production and associated oxygen demand into region, the Gulf of Mexico and Korean coastal waters. The aim and scope of the paper seem interesting and valuable for the scientific community. The method, a box model driven by observational data, is generally valid and has been used in numerous publications before. However, the authors apply several simplifying assumptions that could flaw the study: 1) DIN removal equals potential primary production – the ratio of this assumption should at least be explained and critically discussed, 2) assumption of absence of denitrification (even though at least in GOM there is large hypoxia reported). Thirdly, the hydrodynamical background of mixing between the different compartments/boxes has not been made clear. The authors should think of taking into account modelling works or extensive measuring campaigns presented in the literature in order to deliver a decent foundation for their numbers.

    Response: 1) We have addressed this point in another response (reviewer 1, #8 of general comments). The main point was to remove all references to EPP (calculated from the carbon:chlorophyll ratio) from the text and instead now compare our results with published ^{14}C productivity measurements and satellite-derived estimates of productivity. Even with this assumption, our model result (PPP) is similar to measured rates from ^{14}C incubation reported by Quigg et al., 2011 in the three subregions A, B, and C. We added further explanation in the main text (lines 333-349, 499-511) as follows:

    "Additionally, Quigg et al., (2011) pointed out that these higher PP values were affected by high riverine nutrients input from the MR that flows westward during that time period.

    The actual PP ranges were similar with our model-based PPP (Figure 6). However, this was different from RC02's brown zone. This might be due to the differences between methods such as ^{14}C, our N-mass balance model, and RC02's theoretical model. Typically, RC02 assumed that the brown zone is light limited due to high sediment turbidity, but our model does not account for this and only considered DIN concentrations. Except for this, our PPP results are similar to direct productivity measurements from the ^{14}C incubations (Quigg et al., 2011). Our model result (PPP) showed the same range of values as ^{14}C incubations (e.g., Dagg et al., 2007; Lohrenz et al., 1998, 1999; Quigg et al., 2011; Redalje et al., 1994) in the three sub-regions.

    Note that our model assumed all the biological uptake could be converted directly to production rates, which we considered as PPP. The PPP from cruises MCH M1 ~ M8 for samples from above the pycnocline calculated using our model is reasonable based on comparison with previous PP values (Figure 6a). The PPP ranges (0.01 ~ 5.05 gC m^{-2} day^{-1}) were similar to previous ^{14}C measurement PP values of between 0.04 ~ 5.9 gC m^{-2} day^{-1}."

"RC02 considered their model to be theoretical. In the brown zone, close to the river mouth, they assumed turbidity leads to light-limited conditions. Their results agree well with measured ^{14}C PP numbers from Quigg et al. (2011) who found the lowest integrated PP is near the MR delta mouth. However, our N mass balance model did not consider light limitation and therefore PPP in the brown zone is high. Such good agreement suggests that our model can be applied to a wide region, while ^{14}C measurements are typically conducted at a few specific points, as long as such limitations are taken into account.

In the CSK, most previous production studies focused on inshore areas such as estuaries or rivers. Our research focused for the first time on the coastal ocean off Korea. Our results explained that diverse nitrogen sources need to be recognized as potential issues for future nutrient management concerned with hypoxia, eutrophication, or other environmental issues. The agreement between our results and the pattern of production based on satellite-sensing in the CSK (Son et al., 2005), suggests that our model is reasonable."

Response: 2) Sedimentary denitrification was included in the bottom water boxes but was not fully explained in the text. As we mentioned in another response (reviewer 1, #8 of general comments), net DIN flux was calculated including sedimentary denitrification and regeneration process and used as the value of $\boldsymbol{F_{Bott}^{DIN}}$ in the GOM and CSK, respectively. Also, denitrification from the water column in the bottom box is another significant N removal process. Due to this, we used direct measurement of the water column denitrification from the McCarthy et al., (2015) as another output term ($\boldsymbol{F_{Deni}^{DIN}}$) and added in the Equation 3 for the GOM. However, in the CSK, we could estimate that there is a very little water column denitrification based on the data of oxygen concentration. Thus, we only considered the sedimentary denitrification factor below the pycnocline layer in the CSK. We added further explanation and calculation in the main text (lines 213-236, lines 238-250) as follows:

"In the GOM, benthic sediments provide excess ammonium to overlying water by regeneration processes such as remineralization (Lehrter et al., 2012; Nunnally et al., 2014; Rowe et al., 2002). Generally, there is an uptake of nitrate and nitrite mainly by sedimentary denitrification (McCarthy et al., 2015) or dissimilatory nitrate reduction to ammonium (DNRA) and assimilation by benthic microalgae (Christensen et al., 2000; Dalsgaard, 2003; Thornton et al., 2007). Due to this, net DIN flux was used as the value of $\boldsymbol{F_{Bott}^{DIN}}$, which shows DIN release from bottom sediments to overlying water column. For example, in the GOM, the sum of nitrate and nitrite fluxes to bottom sediments (e.g., May: -10.05, July -61.9, August: -48.42 μmol N m^{-2} h^{-1}) were similar or smaller than the flux of ammonium from bottom sediments (e.g., May: 203, July: 152, August: 156 μmol N m^{-2} h^{-1}) off Terrebonne bay (McCarthy et al., 2015). In the CSK, the sum of nitrate and nitrite flux to bottom sediments and ammonium flux are 0.5 ~ 1.4 mmol N m^{-2} d^{-1} and 1.3 ~ 9.6 mmol N m^{-2} d^{-1}, respectively, which indicated that excess ammonium with additional nitrate and nitrite were released from sediments in this region (Lee et al., 2012). The release of nitrate and nitrite in the CSK unlike the GOM can be estimated due to high inputs of nitrogen by groundwater in the CSK (Kim (G) et al., 2011) even though there is minor uptake of nitrate and nitrite. Diffusion from groundwater can probably be ignored in the GOM as Rabalais et al. (2002) reported that the groundwater discharge is very low in coastal Louisiana, but is likely important elsewhere and is known to be important in the CSK. Based on this, we averaged and sum the fluxes data of nitrate, nitrite, and ammonium from McCarthy et al., 2015 for the GOM and Lee et al., 2012 for the CSK, respectively, and then applied $\boldsymbol{F_{Bott}^{DIN}}$ value as 1.2 mmol N m^{-2} day^{-1} in the GOM and 6.2 mmol N m^{-2} day^{-1} in the CSK. Thus, in equation 3, the benthic flux term is calculated from existing literature results after considering all DIN fluxes as above (Lee et al., 2012; McCarthy et al., 2015), and then multiplied by the area of each box."

"2) $\boldsymbol{F_{Deni}^{DIN}}$, the denitrification rate from the water column. Due to high stratification at the pycnocline, upward transfer of dissolved material from the lower layer to the upper layer is assumed not to occur in our model. Also, denitrification from the water column below the pycnocline is a significant N removal process, which removes up to a maximum 68% of total N input from the Mississippi River in the GOM (McCarthy et al., 2015). As the value of $\boldsymbol{F_{Deni}^{DIN}}$ in the GOM, we used a direct measurement of denitrification rates from the McCarthy et al., (2015) in the water column (88 μmol m^{-2} h^{-1}, which converted to 2.1 mmol N m^{-2} day^{-1}) where the stations were exactly same as our sub-region A, B, and C. We assumed this applied only below the pycnocline where oxygen concentrations decrease. However, in the CSK, there is no water column denitrification data because the dissolved oxygen concentration has never been down below about 4 mg L^{-1} during our data periods. Based on this, we estimated that there is a very little water column denitrification in the CSK, so we did not count this term in the CSK. Thus, we only considered the sedimentary denitrification term for the CSK region."

Response: 3) This was not explained well in the text, but has now been corrected. The formulation of the advective terms, which are carried across all four walls of each box to give a 2-D description, rather than the 1-D shown in Fig. 3. As we mentioned in another response (reviewer 1, #5 of general comments), all four faces of each box have input/output advective terms, while the top and bottom of the upper layer include air-sea deposition and a sinking term into the bottom layer respectively. The latter is an input term for the lower layer, while sediment/water exchanges are considered across the bottom face of the lower layer. Thus, riverine input applies only to the inshore boxes in the brown zone. The term Export N (Mixing) incorporates the advective transport term between boxes in 2 dimensions. The values of advection term (F_{Export}^{DIN}) in the GOM and CSK showed similar range in the previous studies of each regions (Jacob et al., 2000; Lim et al., 2008; Nowlin et al., 1998a, b), so we applied the same value to both regions. We added this information in the main text (lines 166-170, lines 261-266) and the caption of Fig. 3 (lines 954-960) as follows:

"As an output term, $\boldsymbol{F_{Export}^{DIN}}$ as an advection term was calculated from the current velocity in each region from observations (Nowlin et al., 1998a, b) and from literature data (Jacob et al., 2000; Lim et al., 2008) and the exchange between boxes from the residence time in each box. Note that water and nutrient exchange can take place through all four sides of each box, so the array is two-dimensional."

"The annual current velocities in the CSK are more affected by tidal exchange and the presence of the Yellow Sea Current, but velocities are similar to those in the GOM (Jacob et al., 2000; Lim et al., 2008). The annual range of the currents is around 0 to 28 cm s^{-1} and 0 to 7 cm s^{-1} for the cross-shelf component. Thus, we used the mean value of the current velocity for the time of year during each cruise in both the GOM and the CSK for calculating the advective flow in both alongshore and onshore/offshore directions."

Added to caption of Fig. 3: "Export N (Mixing) represents the advective transport term. The processes of biogeochemical and transport processes of both regions are the same and each in/out put factor is the same in the GOM and CSK. Note that transfer between boxes occurs in both directions alongshore and onshore/offshore and is not a one-dimensional process as suggested in the diagram."

Details

1. P. 10, ll. 150-152: How are 'output terms for water mixing' calculated in detail? Table 3 says Mix equals the 'reciprocal of residence time'. Is this a realistic approach? In a tidal environment the work done by 'mixing' (dispersion would be more appropriate) increases with residence time instead of being a reciprocal. Maybe this does not apply to GOM and Korean waters but this must be described in detail (dependence of horizontal mixing, i.e. dispersion, on river run-off).

   Response: Tidal variability in the GOM is actually small (the tidal range is only ~50 cm along the northern Gulf coast) and tidal mixing in this region is considerably less than that from local currents, which are largely wind-driven (Feng et al., 2012, 2014). Reciprocal residence time has been used previously in models (e.g., De Boer A.M. et al., 2010; Kim (G) et al., 2011). Also, when we calculated the residence time factor, we already fully considered horizontal mixing based on river discharge speed, run-off, dispersion, current velocity etc. We explained more details in the revision. Please see more details in lines 170-174.

   "$\boldsymbol{F^{DIN}_{Export}}$ for water mixing was calculated from these factors; $\boldsymbol{C^{DIN}_{EX}}$ is the difference in DIN concentration between adjacent boxes, $\boldsymbol{V_S}$ is the water volume of each box, and $\boldsymbol{\lambda_{Mix}}$ is the mixing rate of each box $\left(\boldsymbol{C^{DIN}_{EX}} \times \boldsymbol{V_S} \times \boldsymbol{\lambda_{Mix}}\right)$. We used a reciprocal of the water residence time that we considered to represent horizontal mixing, i.e. dispersion."

2. P. 10-11, ll. 160-161: How can gradient of N-concentration between boxes affect the exchange rate? N cannot drive a flow (affect equation of state).

   Response: First, we considered the difference of N-Concentrations in each box from our observational data. Then, we checked how much N concentrations were changed between each box to box. To do this, we assumed that during mixing or water flow, the changed concentration of DIN is due to the mixing factor and biological uptake.

3. P. 17, ll. 317-318: Why different threshold for 'brown zone' in case of GOM and CSK? "We defined" should result in one definition applying to both regions, otherwise zones can be adjusted by tuning thresholds to give geographically sound 'results' for each region.

   Response: We determined the threshold for each zone from our model results. There is no reason that the brown zone in each region should produce the same threshold value for PPP, since the riverine input (the main source of N in both regions) contains different DIN concentrations, while the river discharge also varies considerably. Our GOM results appear reasonable based on previous studies that defined a boundary between the green and blue zones (Dagg and Breed 2003; Lohrenz et al., 1999).

4. P. 18, l. 333: MCK or CSK, what is the correct abbreviation?

   Response: Study area in Korea is part of Mid-western CSK (coastal sea off Korea). We fixed wording CSK instead of MCK. Typically, we only used in Figure 7a, b as MCK due to area is pointed out Mid-western CSK (MCK).

5. Figure 1: Please increase font size of axis tick labels, use approximately same size for all panels.

   Response: We will fix in the final revision version.

6. Eq. 1-3: Please include units.

   Response: Yes, we put the units of the equations in the Table 3. This point was addressed this point in another response (reviewer 1, #3 of specific comments). We added details in the caption of Table 3 (lines 1004-1006) as follows:

   Added to caption of Table 3: "** The unit of $\boldsymbol{F_{Sink}^{DIN}}$ was converted to mol day^{-1} from the unit of original data (gN m^{-2} day^{-1}) with area of box (0.25 m x 0.25 m) and molar mass of N (14 g mol $^{-1}$)."

7. Figure 3: The conditions of "Export N (Mixing)" need some fundamental discussion in the text.

   Response: We have modified our original Fig. 3a to be more representative. Please see our response to reviewer 1, #4 of general comments. The term Export N (Mixing) incorporates the advective transport term between boxes in 2 dimensions. As we mentioned in above response (#1 of general, especially response 3)), the values of advection term (F_{Export}^{DIN}) in the GOM and CSK showed similar range in the previous studies of each regions (Jacob et al., 2000; Lim et al., 2008; Nowlin et al., 1998a, b), so we applied the same value to both regions. We explained more details of advection term in the main text (lines 166-170, lines 261-266) and the caption of Fig. 3 (lines 954-960).

8. Figure 4: This figure is difficult to read. Authors should think of a way to show spatial and dynamical information in one figure; for example, they could show a map of GOM (like Fig. 6) with a polar graph representing current speed and direction during one season. The current figure does not really help understand what is happening in time and space.

   Response: The current data is taken from a large program that was carried out over three years along the Texas-Louisiana shelf. We have shown the mean current speeds and their standard deviations for fortnightly intervals throughout the program. The data show clearly the change from onshore currents moving to the east during summer to generally alongshore to the west during non-summer periods. While we could have shown the data as a series of vector plots, we believe that Fig. 4 is quite comprehensible.

9. Table 4: How can EPP be higher than PPP? What does this mean?

Response: We have removed all references to EPP from the manuscript as it does not affect how the model operates and was used only for comparison with model output. Instead, we have compared our model results with spot measurements of primary production using ^{14}C and with estimates from satellite imagery.

10. Please check citation “Rowe and Chapman (2002)”. Authors seem to cite wrong title which should read “Continental Shelf Hypoxia: Some nagging questions”

    Response: Yes. I corrected.

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