We thank the reviewers for their valuable and insightful comments, which have improved our manuscript substantially. We provide our responses (plain text with blue color) to all comments (italic text) below.

- Reviewer #1 -

1. General comment

(1) The authors present a modeling study whereby they looked for estimating N_2O levels in near-bottom waters of Northern Gulf of Mexico (the nGOM) for the period comprised between 1985 and 2007 (summer period). These estimates may be important for understanding the marine/estuarine N_2O cycle and its environmental controls, and thus this manuscript could be an important contribution to the field.

→ We appreciate to the reviewer's supportive statement.

*Note: We cite Kim and Min (2013) instead of Kim (2012). The manuscript of Kim and Min (2013) is under revision.

2. Major points

(1) Important pieces of information are omitted throughout the manuscript and there is a lack of logical sequence that triggers a series of questions throughout the whole manuscript. It had been very difficult for me to understand the used conceptual model (rationale) and the relationships among O_2, N_2O and NO_3^- in order to reproduce N_2O concentration in the bottom water under hypoxia condition, most of the time. I guess that the exercise was only done for bottom water to prevent further advection (vertical) and diffusion effects, but what about the role of lateral advection, resuspention, pelagic benthic coupling, etc.?

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→ We apologize for the insufficient explanation about the conceptual model (Equation 1). In providing a more inclusive explanation we discovered that the equilibrium term $\left([N_2O]_{equilibrium}^{(T,S)}\right)$ had been neglected. We have therefore re-calculated all estimates and revised all results. None of our conclusions have changed.

→ **A.** Detailed explanation for the conceptual model is now provided in the manuscript and is included below for the convenience of the review.

The tracer continuity equation for ΔN_2O (= $[N_2O]_{estimated} - [N_2O]_{equilibrium}$) in the bottom layer associated with microbial processes (i.e. nitrification and denitrification by bacteria and archaea) is expressed as follows:

$$\Gamma(\Delta N_2O) = J_{nitrification}(\Delta N_2O) + J_{low\ oxygen}(\Delta N_2O) - J_{low\ oxygen}(\Delta N_2O) \qquad (1)$$

, where $J(\Delta N_2O)$ represents the function describing net production (i.e. source) minus consumption (i.e. sink) for each process. $J_{nitrification}(\Delta N_2O)$ denotes the source term for nitrification, $+J_{low\ oxygen}(\Delta N_2O)$ denotes the N_2O production during low O_2, and $-J_{low\ oxygen}(\Delta N_2O)$ denotes the N_2O consumption during low O_2 (Fig. A1). The operator Γ is the transport and time rate of change and is given as:

$$\Gamma(C) = \frac{\partial C}{\partial T} + U \cdot \nabla C - \nabla \cdot (D \cdot \nabla C) \qquad (2)$$

, where C is any tracer concentration, ∇ denotes the gradient operator in the x, y, and z directions, U is the 3-dimensional velocity field, and D is the eddy diffusivity.

Under low oxygen conditions, such as suboxic and anoxic conditions, anaerobic ammonium oxidation (anammox) and dissimilatory nitrate reduction to ammonium (DNRA) could be additional sources for N_2O (Naqvi et al., 2010). However, the pathways and yields of N_2O production during these two processes are poorly known. Furthermore, measurements of anammox and DNRA in the nGOM are in short supply (Dagg et al., 2007). As a result, we did not explicitly include the N_2O production by anammox and DNRA in our model. Instead, we

assumed that the terms of low oxygen ($J_{low\ oxygen}$) are determined by denitrification alone.

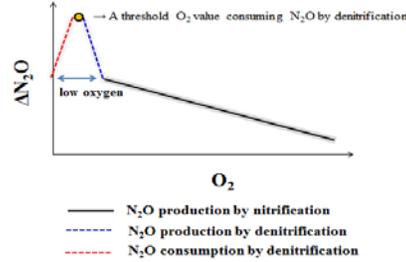In our conceptual model, we assumed a tri-linear $\Delta N_2O/O_2$ relationship (Fig. A1).

Fig. A1. Conceptual illustration showing a tri-linear relationship between O_2 and ΔN_2O.

In reality, the $\Delta N_2O/O_2$ relationship may show a non-linear behavior due to the complex inter actions of physical and biogeochemical processes (Nevison et al., 2003); however, the exact shape of the $\Delta N_2O/O_2$ non-linear relationship is not known. The use of a simple tri-linear $\Delta N_2O/O_2$ relationship may increase the uncertainty of our modeled results but can be taken as a simple best-guess approach. Using the empirically-derived linear relationships (Equation 1), ΔN_2O can be computed as follows:

$$\Delta N_2O = \alpha \frac{\Delta N_2O}{AOU} \cdot AOU + \beta \frac{\Delta N_2O}{\Delta N_{deni}} \cdot \Delta N_{deni} - \gamma \frac{\Delta N_2O}{\Delta N_{deni}} \cdot \Delta N_{deni} \tag{3}$$

where AOU is the apparent oxygen utilization – the difference between the measured O_2 concentration and the equilibration value, α indicates the relationship between ΔN_2O and AOU, and β and γ are the relationships between ΔN_2O and the amount of denitrification (ΔN_{deni}).

Finally, $[N_2O]_{est}$ can be estimated as:

$$[N_2O]_{est} = \Delta N_2O + [N_2O]_{equilibrium}^{(T,S)} \tag{4}$$

→ **B.** The question on lateral advection is answered in e2. Sensitivity, uncertainty, and a caveat below and is included in the revised manuscript.

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→ **C.** The question on resuspension and pelagic benthic coupling is answered as follows:

The referee correctly pointed out that the following statement "A contribution of N_2O released from the underlying sediments is expected to be negligible (Visser, 2009) and was, therefore, not accounted for in our model" in Section 2.2 is incorrect. Our intended meaning was that our model cannot directly account for possible N_2O sediment fluxes, as the data used for our analysis were based on near-bottom hydrographic parameters. Nevertheless, it is likely that these hydrographic parameters are influenced by interaction between bottom waters and sediments. Therefore, we assumed that the estimated N_2O concentrations from this study were resulted from bottom water and sedimentary processes combined (i.e. benthic coupling processes). In summer, water column stratification caused by density gradients is intensified (Dagg et al., 2007), and therefore the bottom layer is highly stable. Although resuspension enhanced by bottom currents may occur continuously on small scales in the bottom layer in spite of the strong stability, large scale resuspension would require external forcing, such as might be provided through intense storm systems. Walker et al. (2010) reported enhanced N_2O production after storm, resulting in reoxygenation through vertical redistribution of organic matters in the water column. As the data in Table S1 and the discussion in Section 3.1 indicate, the data sets used for this analysis were little influenced by storm/hurricane events. The statement above that "the estimated N_2O concentrations in the bottom layer from our analysis are derived from the combined results of bottom water and sedimentary processes" therefore includes small scales of resuspension by bottom currents but neglects large storm events whose effects are not apparent in the data. We will include this statement in the revised manuscript (Section 3.2).

(2) ① As authors mentioned, nGOM is an extended continental shelf area with hypoxic and eutrophic condition. In this kind of ecosystems, we expect a huge N_2O accumulation as a product of in situ biological production and/or discharge from rivers, estuaries; particularly as they are being affected by anthropogenic nitrogen (N) inputs. The estimated N_2O values are really low, even at levels of under saturation, making boast of:

→ **D.** The range of bottom N_2O measurements during the summer (July-August) of 2008 was from 4.63 to 30.02 nmol L^{-1} (Visser, 2009; Walker et al., 2010). Visser (2009) also measured bottom water N_2O concentrations in September 2007 and April 2008, and they ranged from 8.44-11.87 and 6.53-9.54 nmol L^{-1}, respectively. We compared our estimates with the measurements by Visser (2009) and Walker et al. (2010) (Fig. A2). Our estimates are comparable with the previously published summer measurements. Overall, summer N_2O concentrations are higher than spring/fall N_2O concentrations. Comparing our estimates with those from other regions (see Table 2b of Naqvi et al., 2010 and references therein), it can be seen that maximum subsurface N_2O concentrations in coastal hypoxic systems have a range from 9.8 nmol L^{-1} in the Chesapeake Bay to 62.6 nmol L^{-1} in the Changjiang Estuary, to 139 nmol L^{-1} Tokyo Bay. Estimates from the nGOM (~30 nmol L^{-1}) lie in the middle of this range according Naqvi et al. (2010). The maximum N_2O concentration estimated in our analysis was ~52 nmol L^{-1} (Table 2).
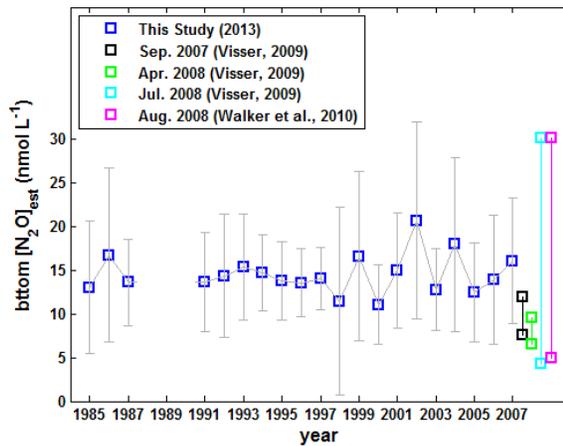

Fig. A2 Interannual variation of estimated bottom N_2O concentrations (blue square) in the nGOM during July 1985-2007. Direct measurements are included (black, green, cyan, and pink squares: September 2007, April 2008, July 2008, and August 2008, respectively).

The description of this comparison is included in the revised manuscript (Section 3.3).

② *Lack of sensitivity and robustness in the used model - A N_2O consumption by denitrification, but as it proceeds only in anoxic environments, N_2O reduction to N2 is unlikely because hypoxic*

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and suboxic conditions always remain in the bottom water; - A N₂O consumption by the sediments (denitrification) but in this ms. the role of sediment is ignored.

→ **E.** We have addressed the concern that our model lacks sensitivity and does not produce robust results:

e1. The O_2 criteria for determining nitrogen processes that dominate N_2O production and consumption

We used Eq. 4 along with observations to estimate the N_2O concentrations in the near-bottom waters in the nGOM, which nitrogen processes (i.e. nitrification and denitrification) dominate N_2O production/consumption depend primarily on O_2 concentrations. As little information is available on the O_2 threshold for N_2O production by denitrification, we deduced β and γ from the results of Farías et al. (2009) for our analysis. However, it should be kept in mind that these values were based on measurements on eastern tropical South Pacific, and may not represent processes occurring in the nGOM.

To evaluate the dependence of our N_2O estimation to these O_2 conditions, we consider two cases (Table A1). Case 1 (Table A1) characterizes the O_2 conditions as stated above. Under oxic conditions, N_2O is produced by nitrification only, and thus the concentration is calculated as $\alpha \times$ AOU (Yoshinari, 1976; Cohen and Gordon, 1979; Oudot et al., 1990). Recently, Farías et al. (2009) showed net N_2O production around hypoxic O_2 levels in the eastern tropical South Pacific (see their Table 1). Under hypoxic conditions, during which nitrification and denitrification are both involved in N_2O production (Naqvi et al., 1998; Nevison et al., 2003), our N_2O concentration is calculated as $\alpha \times$ AOU $+ \beta \times \Delta N_{deni}$. It has been reported that N_2O consumption occurs at $O_2 < \sim 4$ μM (≈ 0.13mg L^{-1}) (Nevision et al., 2003 and references therein). Under such suboxic-anoxic conditions, denitrification consumes N_2O (Cohen and Gordon, 1978; Elkins et al., 1978; Yamagishi et al., 2007), and nitrification produces N_2O via nitrite reduction (nitrifier denitrification: $NH_4^+ \rightarrow NO_2^- \rightarrow N_2O$) (Poth and Focht, 1985; Wrage et al., 2001). Therefore, under these conditions N_2O concentration is calculated as $\alpha \times$ AOU $- \gamma \times \Delta N_{deni}$.

Case II (Table A1) is given and was computed for three conditions: (1) oxic-hypoxic conditions as $O_2 > 0.14$mg L^{-1} ($\alpha \times AOU$), (2) suboxic conditions as $0.07 \leq O_2 \leq 0.14$mg L^{-1} ($\alpha \times AOU + \beta \times \Delta N_{deni}$), and (3) suboxic-anoxic conditions as $0 \leq O_2 < 0.07$mg L^{-1} (≈ 2.2 µM) ($\alpha \times AOU - \gamma \times \Delta N_{deni}$).

Table A1. Summary of Case I and II conditions

Case I			
O_2 levels	Conditions	N process	N_2O estimation
$2 < O_2$	Oxic	Nitrification	$\alpha \times AOU$
$0.14 \leq O_2 \leq 2$	Hypoxic	Nitrification + denitrification (+)	$\alpha \times AOU + \beta \times \Delta N_{deni}$
$0 \leq O_2 < 0.14$	Suboxic-anoxic	Nitrification + denitrification (-)	$\alpha \times AOU - \gamma \times \Delta N_{deni}$
Case II			
O_2 levels	Conditions	N process	N_2O estimation
$0.14 < O_2$	Oxic-hypoxic	Nitrification	$\alpha \times AOU$
$0.07 \leq O_2 \leq 0.14$	suboxic	Nitrification + denitrification (+)	$\alpha \times AOU + \beta \times \Delta N_{deni}$
$0 \leq O_2 < 0.07$	Suboxic-anoxic	Nitrification + denitrification (–)	$\alpha \times AOU - \gamma \times \Delta N_{deni}$

The revised manuscript includes the description above in Section 2.3.

e2. Sensitivity, uncertainty, and a caveat

We assigned 0.048, 0.83, and 0.83 for α, β, and γ, respectively, to estimate bottom water N_2O concentrations using the empirical relationship presented in Section 3.1. To investigate the validity of chosen values of α, β, and γ, we used a Monte Carlo technique generating random numbers for individual α, β, γ values within expected ranges looking for those coefficients that produced estimated bottom N_2O concentrations within the observed range. The value of α ranges from 0.048 to 0.31 in ocean environments, including the nGOM (Suntharalingam and Sarmiento, 2000 and references therein). For our model simulation we generated random numbers for α between 0 and 0.31. Although we deduced β and γ from the results of Farías et al. (2009),

information on β and γ outside the tropical South Pacific lacks. Therefore, we increased the possible range in these values that generated random numbers for β and γ between 0 and 2.5. In the nGOM, Visser (2009) and Walker et al. (2010) directly measured water column N_2O concentrations during the summer of 2008, and reported that bottom N_2O concentrations ranged from 4.25 to 30.02 nmol L^{-1} (July) and from 5 to 30 nmol L^{-1} (August). Bottom N_2O concentrations were similar in both months, so we used the median of measured values (17–18 nmol L^{-1}) as the acceptable zone, and then applied the random α, β, and γ values to the data sets to estimate N_2O concentrations. When the mean N_2O concentration reproduced by random α, β, and γ values fell in the acceptable range (i.e. $17 <$ mean $[N_2O] < 18$), they were saved and averaged. We generated a thousand of random numbers for individual α, β, and γ for each simulation, and performed 10 simulations (Fig. A3). The resulting α, β, and γ coefficients averaged over all the simulations were 0.051 ± 0.003, 1.27 ± 0.15, 1.16 ± 0.16, respectively.
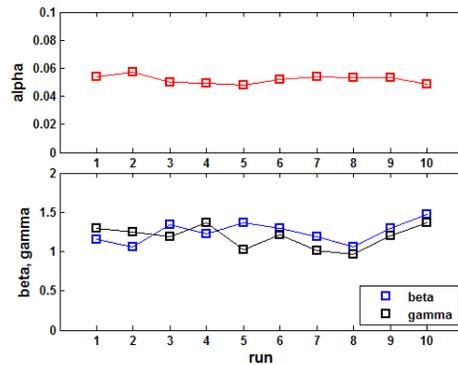
Fig. A3 Simulation results of randomly generated α, β, and γ producing N_2O estimates in the acceptable range (i.e. $17 <$ mean $[N_2O] < 18$).

The $\alpha_{=0.048}$ obtained from the empirical relationship compared well with the simulated $\alpha_{=0.051\pm0.003}$. The $\beta_{=0.83}$ and $\gamma_{=0.83}$ are somewhat lower than the simulated $\beta_{=1.27\pm0.15}$ and $\gamma_{=1.16\pm0.16}$. The change of N_2O concentration according as α, β, and γ individually change with 0.01 interval was ~1.3, ~0.03, and ~0.001 nmol L^{-1}, respectively. The dependence of α among three components in the

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estimation was larger.

To examine the sensitivity on the threshold O_2 values for N_2O production/consumption by denitrification (Table A1), Case I estimates were compared with Case II. On average, the N_2O concentrations estimated for Case I were ~1.3 nmol L^{-1} higher than those for Case II (Fig. A4). The magnitude of this difference is dominated by 6 individual years out of 20 years. Also, both temporal trends were similar. Thus, the results of Case I are primarily used for our study.
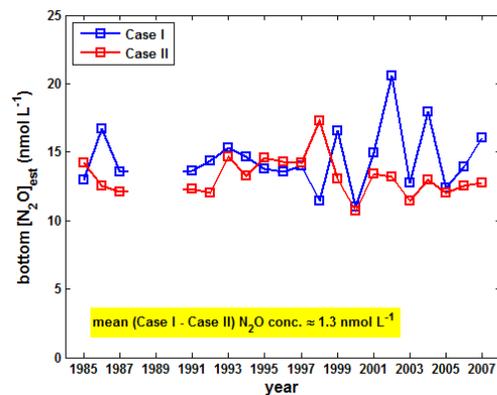

Fig. A4 Interannual variation of estimated bottom N_2O concentrations according to Case I and II formula.

We used ΔN_{deni} estimated from the eOMP analysis by Kim and Min (2013) for representing N_2O production/consumption by denitrification. Kim and Min (2013) defined 4 different water masses (i.e. SUW: Subtropical UnderWater, TLCW: Texas-Louisiana Coastal Water, ADW: Atchafalaya Discharge Water, and MDW: Mississippi Discharge Water) for the eOMP analysis in the study area. Unlike the others, SUW is a foreign water mass that occasionally intrudes into the study area and is dependent on eddy development/circulation patterns. Although it would be difficult to estimate preformed N_2O amounts for each water mass from this analysis, because SUW locally occupies the bottom layer and is derived from outside the study area, it is possible to approximate the amount N_2O advected by SUW using a plot of the estimated bottom N_2O

concentrations vs. the mixing ratios of SUW (Fig. A5). Higher mixing ratios of SUW imply that the water properties are close to those of source water mass, and by using a constraint on SUW mixing ratios of $> 90\%$ (blue dots), the N_2O concentrations produced through advection of SUW into the region can be $\sim13.3\pm2.5$ nmol L^{-1}, which is mean value averaged from the N_2O concentrations of blue dots (Fig. A5). This estimate is close to the mean concentration of $\sim14.5\pm2.3$ nmol L^{-1}. However, SUW locally distributes in the study area ($\sim89.5°W–92W$ and $28.5–29.0°N$ deeper than $\sim40m$ isobath), and its occupation in the nGOM bottom waters has been decreased since ~1998 (Kim and Min, 2013). Overall, the effect of N_2O advected by SUW on our estimation is small.
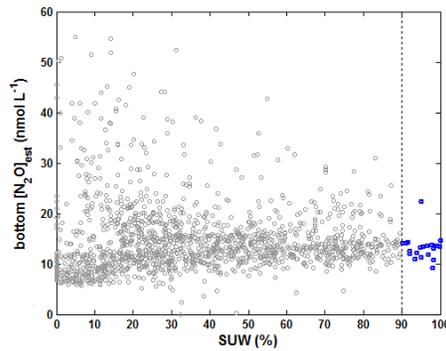

Fig. A5 Plot of estimated bottom N_2O concentrations vs. SUW mixing ratios (%).

Here we estimated bottom N_2O concentrations using the tri-linear relationships between O_2 and ΔN_2O. This approach provided a representation of interannual N_2O variations in the nGOM. However, we have several limitations, such as: i) the lack of α variability in the nGOM (i.e. interannual and seasonal), ii) little information on β and γ in the nGOM, and iii) unknown the exact shape of the $\Delta N_2O/O_2$ relationship. Due to such limitations, we constrain that our estimates are valid for the summertime within the nGOM. In order to accurately estimate N_2O concentrations using modeling approaches, integrated information on α, β, and γ based on direct measurements will be needed to establish a non-linear equation in the future.

We will include this discussion in the revised manuscript (Section 3.2).

→ **F.** The concern that the role of sediments is ignored is answered in our response **C** above.

3. Minor points

(1) There are inconsistencies among the presented background in introduction section, the used conceptual biogeochemical model, results and others. Since the study is focused on a hypoxic region, it precludes the existence of anaerobic process as canonical denitrification or DNRA, I wonder if the study area has representative anoxia period. Let include information about frequency of anoxic periods. Table 1 reveals DO as low as 40 nmol L^{-1}, it is far to be suboxic (4.4 μmol L^{-1}). Introduction section only mentioned N_2O producing processes; how about N_2O consuming process?. However, conceptual model incorporates a terms of N_2O consuming,. Again, how you weigh or ponders the role of canonical denitrification in the study area? The modeled mean N_2O concentration in the bottom water was 7.7±6.7 nmol L^{-1}; it means a range from 10% to 234% saturation. I wonder if there are data with under saturation levels in other eutrophicated and hypoxic ecosystems. Under saturated N_2O concentrations are usually found in suboxic/anoxic and nitrite-rich waters, as observed of the oxygen minimum zones or the sediments. This pattern has been clearly ascribed to canonical denitrification, which is, so far, the sole process known to consume N_2O through its dissimilatory reduction to N_2 under anoxic condition.

→ **G.** We did not preclude the low oxygen processes (e.g. denitrification). Under low oxygen conditions, such as suboxic and anoxic conditions, anaerobic ammonium oxidation (anammox) and dissimilatory nitrate reduction to ammonium (DNRA) might be additional sources for N_2O (Naqvi et al., 2010). However, the pathways and yields of N_2O production during these two processes are unknown. In addition, measurements of anammox and DNRA in the nGOM are not

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available (Dagg et al., 2007). Therefore, we did not explicitly include N_2O production by anammox and DNRA in our model approach and assume that the terms for low oxygen conditions ($J_{low\ oxygen}$) in Equation (1) are determined via denitrification (More details are described in our response A). Additionally, it should be noted that anoxic conditions ($O_2=0$ mg L^{-1}) did not develop in the nGOM during the study period (Fig. A6).
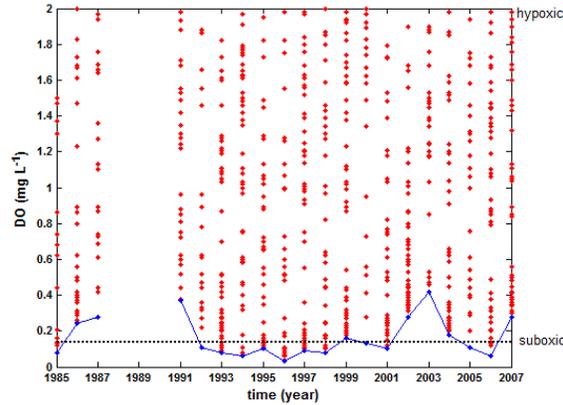

Fig. A6 Interannual variation of bottom O_2 concentrations (mg L^{-1}) in the nGOM during July 1985-2007. The dotted line indicates the threshold O_2 value for suboxic conditions ($0<O_2<0.14$ mg L^{-1}).

Table 1 and Fig. 3 were used to simulate α variability due to change in physical conditions, for example, pre-storm vs. post-storm. As the table and figure appear to be cause confusion, they were removed from the revised manuscript.

The reviewer is correct that role of N_2O consumption had been left out of Introduction. In the revised manuscript, the role of N_2O consumption is added to Introduction. However, the role of denitrification was included in our model (see Eq. 3).

Our equations did not include the equilibrium term $\left([N_2O]_{equilibrium}^{(T,S)}\right)$. So we re-calculated all estimates and include all revised estimates in the revision (Details are described in our response A). We thank the reviewer for finding this inadequacy.

The revised mean N_2O concentration estimated in the bottom layer is 14.5±2.3 nmol L^{-1}. N_2O saturation is computed as follows:

$$N_2O\ saturation(\%) = \frac{[N_2O]_{estimated}}{[N_2O]_{equilibrium}^{(T,S)}} \times 100 \qquad (5)$$

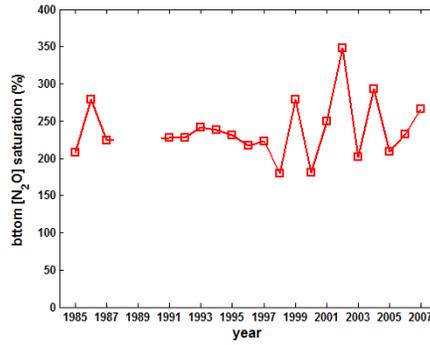The resulting bottom N_2O saturations estimates are shown in Fig. A7.

Fig. A7 Interannual variation of bottom N_2O saturation (%) in the nGOM.

Mean N_2O saturation (%) for bottom water was ~238±40%, which is somewhat higher than, but still comparable to the July 2008 measured value of 171±111% reported by Visser (2009). We divided the mean bottom N_2O concentrations into 4 components (Fig. A8): production by nitrification, production by denitrification, consumption by denitrification, and N_2O equilibrium. N_2O saturation was relatively low in 1998, but relatively high in 2002 (Fig. A7). In 1998, N_2O consumption by denitrification (sink) was higher, causing the lower saturation level, while in 2002 N_2O production by denitrification (source) was higher, resulting in a higher saturation level.
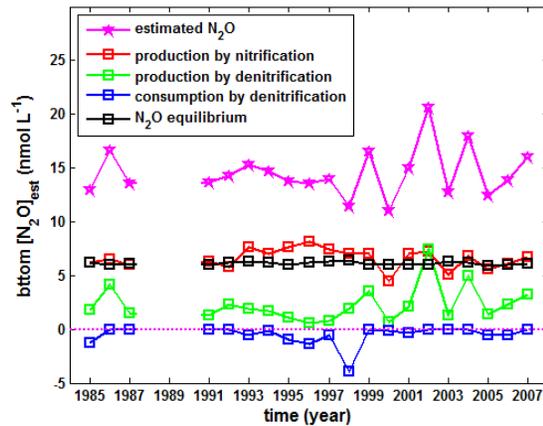
Fig. A8 The four components of estimated N_2O (purple stars): production by nitrification (red squares), production by denitrification (green squares), consumption by denitrification (blue squares), and N_2O equilibrium (black squares).

(2) In my opinion the production of N_2O is very sensitive to changes in oxygenation but also depends on several factors. If authors assume that oxygen is the dominating factor (80%) controlling N_2O cycling and that there are not limitations for ammonium (electron donor for nitrification) or nitrate/nitrite (electron acceptor for denitrifies), Thus, those assumptions should be clearly established. Regarding the scale used to separate concepts of oxia, hypoxia, suboxia and anoxia, it is confusing because authors use the same range to separate anoxic suboxia, and I think this is a mistake, because the nitrogen cycle (particularly N_2O) behaves very differently depending on O_2 traces or not exist in the environment. The authors must to include an anoxic term. I think that the best definition is those stated out by Naqvi who defined anoxia when $O_2=0$ $\mu mol\ L^{-1}$ and $NO_2^- >0$. I believe that NO_2^- distribution should really help to define O_2 ranges. Please include that data.

→ Please refer to our response **e1** above.

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(3) The rationale of N_2O conceptual model is very difficult to follow to me. Dynamic patterns of dissolved N_2O concentrations in marine waters emerge from complex interactions among physical, biogeochemical processes. Therefore, since the model only includes a microbiological term, it is a very biased conceptual framework. What is ΔO_2 is the Eq. 1 ? and What include the term ΔN_{deni}, NO_3^- and NO_2^- loss as N_2? What do you think about N-loss by anammox? Could ΔN_{deni}, be being underestimated? cWhat kind of (lineal exponential, polynomial) relationship was used to estimate α, β, and γ? It is widespread knowledge that and relationships between O_2 (AOU) and N_2O (ΔN_2O) and even NO_3^- are not linear. For example, these relationships depend on (besides oxygen) water masses mixing, the microbial communities (functional and even phylogenetic diversity) among others. So, it is no possible to use parameterizations obtained in other ecosystems, like the OMZ of the eastern South Pacific. Finally, N_2O cycling should comprise the conceptual model: Oxic Condition should include aerobic ammonium and nitrite oxidation (AAO and ANO, respectively) by Bacteria and Archaea (only NH4 oxidation) Hypoxic Condition: AAO ANO, partial denitrification, if you a priori preclude nitrifier denitrification Suboxic Condition: idem to hypoxic condition Anoxic Condition: total o canonical denitrification, if you a priori preclude DNRA.

→ **H.** Please refer to our response **A** above.

To avoid confusion we now use AOU instead of ΔO_2 (see Equation 3 above).

Kim and Lee (2013) estimated ΔN_{deni} using the extended OMP analysis. The ΔN_{deni} is estimated as the difference between observed and estimated N, i.e., N deficit, assuming that a N deficit results from the denitrification processes. As mentioned in our response **A**, measurements of anammox and DNRA in the nGOM are not yet available (Dagg et al., 2007). If anammox is a dominant process for N removal in the nGOM, as the reviewer suggests, then our ΔN_{deni} could be underestimated. In principle, a completely anoxic environment is required for anammox to occur, but during the study period in the nGOM, O_2 levels never reached anoxic levels (Fig. A6). Although beyond the scope of this work, certainly, future investigations into the nitrogen cycle in the nGOM would do well to take a closer look at this question. The exact shape of the $\Delta N_2O/O_2$ non-linear relationship is not known, but as discussed above, we assumed a simple best-guess approach using a tri-linear $\Delta N_2O/O_2$ relationship (Fig. A1) to represent what is likely a complex

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interplay of physical and biogeochemical processes (Nevison et al., 2003) that results in non-linear behavior. It may be true as the reviewer suggests that it is not possible to base our approach on "*parameterizations obtained in other ecosystems, like the OMZ of the eastern South Pacific*", due to the different physical characteristics, diversity of bacterial communities, and so on. We agree. However, one advantage of the modeling approach is that it allows representation of the target we want to predict with definable constraints, even though there are large uncertainties. To support the validity of our approach, we provided the results of sensitivity analysis (Details are described in our response **e2**). In addition, since there is little information on a threshold of O_2 value for N_2O production by denitrification, we deduced it from the results of Farías et al. (2009) for our analysis. We recognize and state in the revised manuscript that it is uncertain whether this threshold is representative of processes in the nGOM. Also, we examined the sensitivity on the threshold O_2 values for N_2O production/consumption by denitrification (Details are described in our responses **e1-2**). Nitrification consists of aerobic ammonium and nitrite oxidation. Here we assume that both bacterial and archaea are primarily responsible for the microbial processes (i.e. nitrification and denitrification) associated with Equation (3).

(4) Regarding results, I am truly surprising respect to the separation of data between pre or post storm, why not the authors previously present these dynamics as a background. But the existence of pre and post storm dynamics means that there was another temporal scale of variation, which overlaps with some seasonal and annual variability, etc. You should include an analysis of this perturbation each summer (July). In this regard, I could not understand how simulation of α (pre and post storm) was performed. Table 2 present estimated N_2O data; given the high standard deviation of the data, I see that no significant differences exist in N_2O levels among years, with a mean range from 3.7 to 13.5 and a SD range from 4.3 to 12.2. Another point, during July 1998 a value of 3,7 ±12.2 was reproduced, it means that negative value could be estimated, I ask myself what is the sensitivity of this model?. Relative a N_2O production/consumption (Figure 4), I realize that there is not a trend in N_2O produced by nitrification, but if nitrification is main N_2O producing process, How the authors justify found correlation between estimated N_2O levels and areal hypoxia. I found the estimated N_2O levels extremely low for an eutrophic area where

ammonium levels should be high (close to sediment-water interface). If you have in mind that N₂O values in bottom water as high as 533 nM were found in the western continental shelf of India (Naqvi et al, 2000), 7.7 nM seems to be low. Finally, the authors omitted information about nutrient and the influence of river in the coastal area, such information can contribute to the discussion of this ms.

→ **I.** Walker et al. (2010) measured N_2O in the waters of the nGOM in August 2008. They discussed pre-storm N_2O production vs. post-storm N_2O production. They reported enhanced N_2O production after storm, resulting in reoxygenation from the vertical redistribution of organic matters in the water column. They estimated α value under both pre-storm (0.048) and post-storm (0.096) conditions from the relationship between ΔN_2O and AOU based on the direct measurements (see their Fig. 4). As stated in our response **C**, the data sets used for the present analysis were not influenced by storm/hurricane events, which enhanced N_2O production only for very short periods. Therefore, we adopted $\alpha_{=0.048}$ as a representative summertime nGOM coefficient for production N_2O by nitrification. We then checked α sensitivity using a Monte Carlo procedure (Details are described in our response **e2**).

Revised Table 2 (shown below) and Fig. A2 show interannual variations: magnitudes of which are comparable to the measured values. The range of mean estimated N_2O concentrations was 11.0-20.6 nmol L^{-1}, and that of standard deviations was 3.5-11.3 nmol L^{-1}. Maximum values ranged from 21.3 to 54.9 nmol L^{-1} (Table 2).

Our data indicated that N_2O equilibrium (Fig. A8) remained constant in time relative to the other N_2O components in the nGOM. Variation in N_2O production by nitrification was also small in the bottom waters. On the other hand, linear regression analysis showed that N_2O production by nitrification was significantly correlated with hypoxic area (Fig. A9), which has changed from year to year.
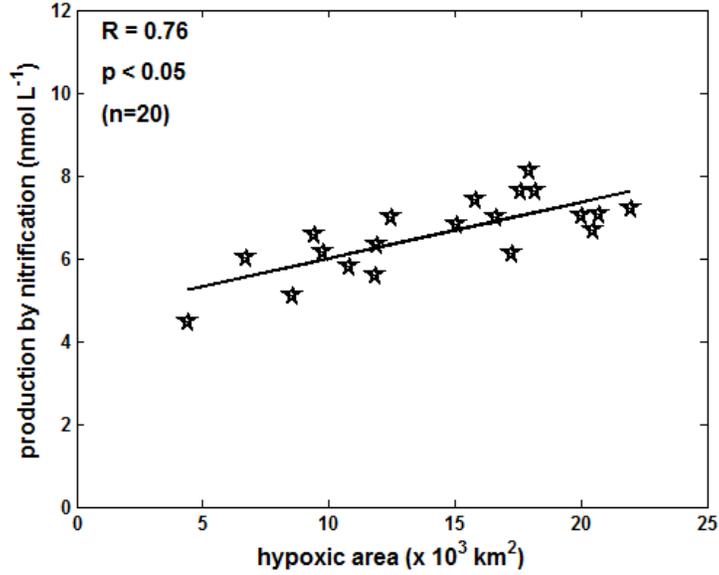
Fig. A9 Correlation between N_2O production by nitrification and hypoxic area.

We will include in the revised manuscript (Section 3.3) the information concerning the total freshwater discharge from the Mississippi and Atachafalaya Rivers accumulated for January-July and the magnitude of remineralization (instead of nutrients) estimated by Kim and Min (2013).

Table 2. Mean bottom N_2O concentrations (nmol L^{-1}) during the study period estimated from the equation (4) using $\alpha_{=0.048}$, $\beta_{=0.83}$, and $\gamma_{=0.83}$. Mean is calculated as $[N_2O]_{est}^{mean} = \frac{\sum_{i=1}^{n}[N_2O]_{est}^{i}}{n}$, where i is station, and n is the number of total stations. Standard deviations ($\pm$) is calculated as $\sqrt{\frac{\sum_{i=1}^{n}\left([N_2O]_{est}^{i}-[N_2O]_{est}^{mean}\right)^2}{n}}$.

Year (for July)	$[N_2O]_{est}^{mean}$	maximum	remark
1985	13.0±7.6	35.9	
1986	16.7±10.0	52.4	
1987	13.6±4.9	32.9	
1988	ND	ND	
1989	ND	ND	
1990	ND	ND	
1991	13.7±5.6	38.4	
1992	14.3±7.0	42.7	
1993	15.4±6.1	31.7	
1994	14.7±4.4	30.8	Visser (2009)
1995	13.8±4.5	32.0	Sept. 2007: 7.59-11.87 (mean: 9.95±1.07)
1996	13.5±3.9	22.5	April 2008: 6.53-9.54 (mean: 7.10±0.70)
1997	14.0±3.5	21.3	July 2008: 4.25-30.02 (mean: 11.00±6.95)
1998	11.4±10.7	31.8	
1999	16.6±9.7	51.5	
2000	11.0±4.5	29.1	Walker et al. (2010)
2001	15.0±6.6	34.4	August 2008: 5-30 (prestorm)
2002	20.6±11.3	54.9	7-47 (poststorm)
2003	12.7±4.7	27.6	
2004	17.9±9.9	51.9	
2005	12.4±5.7	23.3	
2006	13.9±7.4	42.9	
2007	16.0±7.2	42.6	

ND: not determined

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