Interactive comment on "Biological productivity in the Mauritanian upwelling estimated with a triple gas approach" by T. Steinhoff et al.

Reply to anonymous Referee #3

This study presents a method for isolating the effects of air-sea exchange and NCP from dissolved gas budgets using observations of three gas saturations (N2O, CO2, and O2). N2O is assumed to be inert, and is used to set a timescale for evolution of gas saturations post-upwelling. NCP is calculated from changes in CO2 inventory, and the relationship between NCP (O2)/NCP(CO2) is used to constrain the air-sea transfer rate using published ranges of stoichiometric O2:CO2 quotients for biological productivity. The approach employed here appears sound and represents a valuable contribution to literature on productivity rates in EBUE. As such, I would recommend this manuscript be published after consideration of the comments supplied here and by previous reviewers. As with the other reviewers, my general comments stem from a desire to understand the sensitivity of the calculated NCP to the choices made in the analysis; at present this is the primary weakness of the paper, but this is also something that could be easily remedied.

General comments:

1. Regarding MLD – in my experience, standard MLD criterion (temperature- or density- based) do not work so well in coastal regions, particularly in areas of recent upwelling. Often chemiclines or gas profiles provide a better sense of the mixed layer, and as this study utilizes gas saturations, validating MLD estimates with these data would also be particularly relevant for this analysis. Were profiles of O2 or DIC/TA ever checked against model-predicted MLD? Also, it seems that a constant MLD value was used to calculate inventories of N2O and CO2/DIC for nearshore and offshore observations. Was this characteristic of the offshore transects, and would the NCP calculated be sensitive to a calculation that includes changes in MLD from nearshore to offshore?

- *In the revised manuscript we used oxygen data from deep profiles using the method of Castro-Morales & Kaiser (2012) to estimate in situ MLD. Then we used a mean values of the MLD's found for each cruise. We agree that the use of a constant MLD for nearshore and offshore regions is a simplification that has some drawbacks. But with this approach it was the most reasonable way to estimate a MLD. Furthermore, from the in situ data derived MLD no clear trend could be observed from nearshore to offshore stations.*

2. Regarding gas transfer coefficients: similar to the above, was the time variability of air-sea exchange ever considered before being neglected in favor of a mean value? For CO2, which has a slow exchange timescale, a mean value would be fine, but for something like O2 which can turn over on a much shorter timescale (i.e. days for shallow mixed layers like those observed here), it strikes me that results might be sensitive to this simplification. As this is the primary data set being used to constrain the appropriate wind speed relationship to use (via comparison of O2 and CO2 derived estimates of NCP), this might warrant a bit more explanation.

- *We used both (average and spot values of k). There was no significant difference observed between this two approaches. As the applied mathematical model is only defined for a constant term in k, we used the average values.*
  We also think that the different timescales of CO2 and O2 are critical for this approach. But more than a mean or a spot value the resolution of the dataset might have a bigger influence on the results in terms of dial cycles. We discussed this in the revised manuscript.

3. There was some mention of propagation of errors, but yet little discussion other than what I presume is an error reported with NCP in table 3. Can this analysis be described in a bit more detail and the major sources of uncertainty be identified for the reader? Also, can Table 3 caption be updated to make clear how NCP uncertainty was calculated?

- *Added a paragraph discussing the uncertainties.*

4. Were the transect data and associated τ for observations ever compared to mean offshore advection rates (e.g. calculated from upwelling indexes and an Ekman depth)? This would provide an additional check on the method and calculations of NCP.

- A stated in the revised manuscript, there are more gaps of knowledge as gas transfer during high productivity that needs to be investigated to better constrain our approach. The work of Loucaides et al. (2012) estimated a duration of approximately 10 days for a water parcel travelling from the coast to the open ocean, what is on the order of our results.

Specific (minor) comments:

4858, line 27: Can you give a brief statement as to why turbulent transport can be neglected for the N2O budget? Are gradients below the mixed layer trivial?

- Kock et al. (2012) speculated in their paper about the reduced gas transfer and stated that the transport of N2O from below can be neglected.

4859, line4: ASE – define at first use

- *Done.*

References

Castro-Morales, K. and Kaiser, J.: Using dissolved oxygen concentrations to determine mixed layer depths in the Bellingshausen Sea, Ocean Science, 8(1), 1–10, doi:10.5194/os-8-1-2012 [online] Available from: http://www.ocean-sci.net/8/1/2012/ (Accessed 28 November 2012), 2012.

Kock, A., Schafstall, J., Dengler, M., Brandt, P. and Bange, H. W.: Sea-to-air and diapycnal nitrous oxide fluxes in the eastern tropical North Atlantic Ocean, Biogeosciences, 9(3), 957–964, doi:10.5194/bg-9-957-2012, 2012.

Loucaides, S., Tyrrell, T., Achterberg, E. P., Torres, R., Nightingale, P. D., Kitidis, V., Serret, P., Woodward, M. and Robinson, C.: Biological and physical forcing of carbonate chemistry in an upwelling filament off northwest Africa: Results from a Lagrangian study, Global Biogeochemical Cycles, 26(3), 1–13, doi:10.1029/2011GB004216 [online] Available from: http://www.agu.org/pubs/crossref/2012/2011GB004216.shtml (Accessed 6 November 2012), 2012.