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Biogeosciences Discussions

Interactive comment on "Gas exchange estimates in the Peruvian upwelling regime biased by multi-day near-surface stratification" *by* Tim Fischer et al.

Tim Fischer et al.

tfischer@geomar.de

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Referee Comment:

The manuscript discusses the N20 gas exchange off the Peru Upwelling region. Overall the manuscript presents an important topic and I feel should be published after some revision. The primary conclusions is that the N2O gas-exchange Is dependent on the stratification and the gradients of N2O which are increasing downward (concentration less at the surface). The authors use data from gliders and shipboard CTD.

Answer:

Thank you very much for reviewing the manuscript.

Referee Comment:

Major comments: perhaps I missed it but I did not see and connection the authors made with the seasonal upwelling cycle off Peru. Do they believe there are possible connections to trends in the upwelling cycle? Although the data limits the conclusions on these time scales, can the authors, based on the results, speculate on the possible N2O relationship to longer trends, ENSO for example.

Answer:

Indeed, we have no adequate observational data to directly answer to questions concerning seasonal variation or long-term trends. We now discuss our expectations for the typical seasonal cycle and for possible future developments of the upwelling system. This is done at the end of discussion section 4.4 for the two distinct aspects: 1) what may happen to N2O fluxes, 2) what may happen to the N2O flux bias due to the DeltaC sampling issue. 1) The seasonal and future amount of N2O emissions is indecisive, because it depends largely on the frequency and intensity of the mentioned peripheral hotspot N2O production, which is not fully understood and probably depends sensibly on all kinds of boundary conditions like the structure and dynamics of the oxygen field, mixing, or nutrient availability. The N2O emission during other seasons could in principle be accessed by measurement campaigns, but for future scenarios in coastal upwelling regimes, Capone and Hutchins (2013) state that the net effect on the state of the nitrogen cycle cannot be answered. As N2O formation is highly sensitive to the balance of nitrogen metabolic pathways, future N2O formation cannot be predicted. 2) The situation for the prediction of the emission bias is much better in our opinion, because the most important influence on the formation of near-surface gas gradients is the wind speed. Wind speed is higher than in December to February during the entire year (Echevin et al., 2008), and is expected to intensify in the future (Capone and Hutchins, 2013). We can use Fig. 10 (right panel) and Fig 6 (upper panel) to derive

the expectation that an intensified wind field should lead to a higher bias in emission estimates, but only if the wind speed does not exceed about 6m/s. In the latter case the trapping depth shifts to such depths that the typical sampling from the ship happens inside the trapping layer, i.e. without bias. So, the N2O flux bias may increase to some extent in regions of former low wind (Fig. 10), but the situations in which substantial bias occurs (wind speed 3 to 6 m/s) will become disproportionately rarer (Fig. 6), so that the net effect of an intensified wind field will probably be less bias.

Referee Comment:

Minor comments: I believe the paper needs a thorough proofread before acceptance for publication. The overall quality of the figures I feel can also be improved. For example some of the figure had labeled “Day”, but this is confusing. Day of what?

Answer:

We agree that the paper will benefit from another round of proofreading, particularly to better stress the main points of the paper (- gas gradients occur such shallow and grave that they are a substantial issue for routine gas exchange measurements; - the prominent role of the multi-day timescale of stratification for forming the gas gradients; - exploring the process and its impact) and concerning some parts that can be shortened. The time axis in Fig. 4 will be changed to a date axis, as it is just showing the time elapsed since start of the cruise in December 2012, and single days are easily identified by the daily dashed lines at 15 h local time. The time axes of Fig. 5 will be renamed to 'duration of hydrographic time series in days', because changing to date axes would in our opinion not add clarity here. Keeping the axes as elapsed days allows the reader to immediately see the duration of the time series as well as the duration of multi-day events. Instead, we add a sentence to the caption stating that all time series are from Jan/Feb 2013 and their exact dates can be obtained from the caption of Fig.1.

Added references

Echevin, V., Aumont, O., Ledesma, J., and Flores, G. (2008): The seasonal cycle of surface chlorophyll in the Peruvian upwelling system: A modelling study, Progress in Oceanography, 79, 167-176, doi: 10.1016/j.pocean.2008.10.026.

Capone, D.G. and Hutchins, D.A. (2013): Microbial biogeochemistry of coastal upwelling regimes in a changing ocean, nature geoscience, 6, 711-717, doi: 10.1038/NGEO1916.

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