Biogeosciences Discuss., 6, C3763–C3768, 2009
www.biogeosciences-discuss.net/6/C3763/2009/

Biogeosciences Discussions

Interactive comment on "Estimating mixed layer nitrate in the North Atlantic Ocean" *by* T. Steinhoff et al.

T. Steinhoff et al.

tsteinhoff@ifm-geomar.de

Received and published: 30 December 2009

We are ver grateful for your comments to our manuscript. Attached are our answers to the comments:

General comments: The manuscript "Estimating mixed layer nitrate in the North Atlantic Ocean" by T. Steinhoff and colleagues attempt to estimate the mixed layer nitrate in the North Atlantic Ocean in a square located at latitudes ranging from 40° to 52° N and longitudes between 10° and 60° W. The nitrate estimates are calculated by an equation which was the best fit resulting of applying a Multiple Linear Regression (MLR) based on nitrate observational data, sea surface temperature (SST) from AMSR-E (NASA EOS Aqua satellite) and the Mixed Layer Depth (MLD) from different sources. Some validation methods were included, as well as the error estimates.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

I believe that this manuscript has a potential to eventually be published subject to major revisions. The pursued aim of the authors is one of the real challenges of the current biogeochemical oceanography. In addition, the observational program based on samples taken on Volunteer Observing Ships (VOS) increases the interest because the use of these ships could quickly improve the existing biogeochemical databases and reduce the sampling costs. There are still many uncertainties in our knowledge of the nutrient cycles in the ocean, despite their critical importance in the primary production and the biological carbon pump. However, it is also true that the sampling programs carried out by non-qualified operators demand a better explanation about the data and the methods used in the study.

The manuscript is organized in 3 sections: introduction, data and calculations and conclusions. Regarding the data and calculations methods, it is divided in 5 subsections. One short subsection describes the water samples whereas MLD estimate, the multiple linear regression method and its validation take up the other four subsections. I miss a larger data section where the reader can verify which data were used in the study and how the quality control was made. For instance, I guess when the authors mention "the samples were taken at approximately at 7 m", it means the samples were taken from the seawater pump system on the ship. The reader does not have to guess, it is the reason why I suggest introducing a larger description related to the sampling and data results (basic statistics description). Thus, the reader could know -among other information- the averages, ranges and standard deviations of the measured nitrate during the survey program, as well as a description on the problems found during the sampling and consequent analysis.

- We will add information about the QC of the samples. Here we will also make clear that the samples were taken from trained personnel from our institution. A short paragraph will be added to the revised MS that contains a description of all relevant details regarding the sampling system, e.g. details about the sampling spots and seawater intake/pumping system.

BGD

6, C3763–C3768, 2009

Regarding the MLR method, the authors use a sinusoidal transformation to perform the annual cycle. They focus the discussion in relation to the uncertainties or errors due to the accuracy of the SST and MLD estimates. Although I consider the sinusoidal transformation a good approach, I miss in the discussion some comments about other factors which could produce variations in the nitrate budgets (mesoscale variability or ocean circulation changes), and also why they consider the longitude contribution to the variation as virtually zero.

- The idea of the section "Error estimation when using remotely sensed data" was to discuss only errors that arise from the calculation itself. A paragraph will be added that discusses also errors that come not from the calculation itself (e.g. mesoscale variability should add random noise to the nitrate variability).

The longitudinal information turned out to be statistical insignificant due to the applied statistics (i.e. MLR). This was not a subjective decision; it was based on the statistical technique.

The statistical method to obtain the resulting equation is adequate, as it is the neural network approach used; however, I consider that the authors overestimate the method capability of predicting the nitrate concentration in relation to the number of samples used in the regression (if we divide the survey area in squares of 1° latitude by 1° longitude, the measurements by square are lower than 1 for the whole period).

- We used two techniques and compared them: (i) neural net approach and (ii) a "standard" multiple linear regression. It is correct that a neural network works much better with much more data. For the MLR we used only input parameters that can be considered main drivers of the nitrate variability or a good parameterization of it. In that it should be statistically correct to use enough samples over the range of the input parameters (i.e. lat, SST, MLD, day of year). The idea is to fill the "gaps" between this limited numbers of input data. Since we conducted the sampling program for a few years we think we have a good data basis to use it for these kind of statistical analyses.

BGD

6, C3763–C3768, 2009

The authors talk about the stability in the climatological annual nitrate cycle and it is supported by the effectiveness of the method in two provinces, i.e. the Gulf stream and the North Atlantic drift, whereas the eastern North Atlantic subtropical gyre remains out of the study. Following this, I have reasonable doubts related to the longitude not influencing the nitrate prediction; the same can be thought of other physical processes which cause variability in the nutrient budget.

- Again we mention that the longitudinal information turned out to be statistical insignificant during the MLR. It is not the latitude or longitude itself that explains the nitrate variability but the "concert" of latitude together with MLD and SST at this position.

The implication of the nitrate estimation from pCO2 appears to be acceptable; the authors speculate that the observed changes in pCO2 rates increase may be due to the interannual winter MLD variability. However, I wonder how much of this variation is caused by the events of the mesoscale structure passages. Finally, I also miss a discussion in relation to the possibility of extrapolating this method to other regions.

- A short paragraph will be added to the revised manuscript where the possibility of extrapolating to other regions will be discussed. We think as parameters for the MLR (neural net) are used that cause the variability and enough data are existing it should be possible to use the same statistical methods for other regions. However, it depends strongly on what drives the variability.

Specific comments: 8854/section 2.1- The authors mention that a total of 400 nitrate measurements were used in the study taken from 2002 to 2007 along the ships routes; thus, figures 1 and 4 show the spatial and time resolution of the data, respectively. The spatial resolution, although appears to be high in relation to the points in the figure 1, is not shown clearly. Perhaps, a table with data per square would result better to identify the real resolution of the sampling program. Regarding the time resolution in figure 4, we can distinguish a regular sampling that shows up to 19 lines of nitrate measurements along the annual distribution. The 19 visible lines from the estimate

BGD

6, C3763–C3768, 2009

show a resolution of around 1 sampling every 20 days approximately (365 days/19 lines). The figure 4 also gives us an idea about the interannual variability, although the observed differences in nitrate concentrations are likely due to the spatial variability. Again, a different representation of the data resolution would be better for the reader because black dots are patchily distributed and not possible to count by the reader.

- Fig. 4 will be changed in such a way that it shows the differences between the measured and the calculated values (see comments to referee 2). A second panel in Fig.4 will be added to show the data resolution more clearly.

8855/ section 2.2- The authors based the importance of their prediction study on the selection of the best predictors. It was the reason why they made a mixed layer depth analysis (MLD), which was not necessary from my point of view. It is true that MLD remains the principal factor to evaluate the nitrate budget in the surface waters. However, many MLD studies that have been carried out by other authors show the differences among the criteria to estimate MLD, as it is mentioned in the manuscript. Despite the differences explained by these MLD studies, the authors likely forgot that the sampling method could introduce more uncertainty than an inadequate MLD criterion.

- The detailed comparison of various MLD's was done because we wanted to explain the reasons for our choice of MLD. The sub-polar North Atlantic is a particularly troublesome region for application of classical MLD criteria. We performed this test to illustrate the range of MLD estimates based on typical criteria and to guide our best choice. Biases in MLD estimates can be particularly large in the subpolar North Atlantic and we did not convolute such artifacts into our approach. The discussion also may serve as a reminder to the wider audience that the choice of MLD criteria is critical and can have major influence on the results. We are fully aware of the fact that our findings are not new.

As mentioned above a paragraph will be added to the error discussion where we will also discuss errors that arises from the sampling itself.

BGD

6, C3763–C3768, 2009

Interactive comment on Biogeosciences Discuss., 6, 8851, 2009.