

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

**Anonymous Referee #1**

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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.

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

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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.

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 statistical method to obtain the resulting equation

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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). 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. The implication of the nitrate estimation from pCO<sub>2</sub> appears to be acceptable; the authors speculate that the observed changes in pCO<sub>2</sub> 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.

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 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

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distributed and not possible to count by the reader.

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.

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