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Interactive comment on "An assessment of the vertical diffusive flux of iron and other nutrients to the surface waters of the subpolar North Atlantic Ocean" *by* S. C. Painter et al.

Anonymous Referee #2

Received and published: 19 January 2014

Journal: BG Title: An assessment of the vertical diffusive flux of iron and other nutrients to the surface waters of the subpolar North Atlantic Ocean Author(s): S.C. Painter et al. MS No.: bg-2013-552 MS Type: Research Article

This manuscript reports diffusive flux of Fe, Al and macro-nutrients from below surface to surface layer in the North Atlantic Ocean. Authors conducted observational study and measured diffusivity by free-fall microstructure shear profiler, with measurement of dissolved Fe, dissolved Al and macro-nutrients profiles at 21 point in the sub-polar gyre in summer (July-August). Authors evaluate the fluxes quantitatively, with comparison to integrated mixed layer inventory, phytoplankton demand, winter convective nutrients supply, and Fe flux from the dust supply. They also discussed stoichiometry of diffusive

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supply and nutrient budgets in the surface layer. Authors concluded that diffusive nutrients fluxes in sub-polar gyre in summer (period of annual nutrient minima) are small magnitude, and not alleviate Fe limitation in this region.

Over all, this topic "Quantitative evaluation of Fe and nutrients flux to surface" is extremely important issue for studying biogeochemistry in the Ocean. There are still many uncertainty in this topic. In this manuscript, authors adequately estimate and discuss about the diffusive Fe and nutrients fluxes in the North Atlantic sub-polar gyre based on their observed data set. Observation for Fe and nutrients profiles with physical turbulent mixing parameter are invaluable data set to understand nutrients fluxes from below surface. Comparison of the diffusive flux to other Fe supply processes and evaluate the budget in surface layer are important for understanding contribution of each Fe supply processes on biological responses, and authors clearly discuss this point in the manuscript. Their data is good quality and interpretations from the data are persuasive. Manuscript is well written. Therefore, this study contributes to understand the processes that control biogeochemical cycles in the North Atlantic Ocean. I recommend that this manuscript should be published in BG, after miner revision.

General comments

The most valuable point in this study is evaluation of diffusive nutrients (Fe and macronutrients) fluxes, quantitatively, based on their observed data set. Readers will be able to understand calculated results for the fluxes by reading this manuscript. Diffusive fluxes were estimated by multiplication of diffusivity and vertical gradient of nutrients distributions. Authors clearly show the results of vertical profiles of physical parameters (especially K: turbulent diffusivity), however, vertical profiles of nutrients profiles are not shown in the manuscript. Therefore, it is not clear for readers that how did authors select the Fe and nutrient gradient from each profiles, which are very variable as authors indicated. This is very essential for evaluating the fluxes, therefore, authors should make clear this point to readers. Authors describe in the manuscript that "Profiles of nutrients concentration were first linearly interpolated on to regular

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1m ..... and to allow for extraction of the nutrient gradients AT MIXED LAYER DEPTH (P18522, 19-21). ". I do not understand the gradients "at the mixed layer depth" (or sometimes "base of the mixed layer" in the text). Were there nutrients gradient in the mixed layer depth even mixing occurred? Authors also report that there were subsurface maxima and minima in the Fe profiles, as showing in Fig. 3. I agree to author that this features were real (P18527, 11) and the subsequent calculation of the diffusive flux could be skewed by the sign of gradient (P18527, 8-9). However, I can't understand from the text and Fig.3 that how did authors select the gradient from these three types of the profiles? In my understanding, gradient from the bottom of mixed layer to below the mixed layer (nutrient increasing depth) is the most important gradient for estimating upward fluxes into surface layer. I understand that their Fe and nutrients profiles will be published elsewhere, however, evaluating the fluxes are the most important for discussion in this manuscript. Therefore, authors should explain more clearly in the manuscript that how did authors select Fe and nutrients gradient from each profiles.

Minor comments

2. Method section

P18520, 24: How long were the nutrients samples in the storage? Were nutrients samples measured onboard (or onshore)?

P18521, 18-23: About Fe and Al measurement. Authors only inform to readers "Filtered water samples". Which filter (type, pore size) did they use to measure dissolved fraction? Did authors measure international reference materials (SAFe or GEOTRACES) for certify their obtained value? If authors measured these reference materials, they should report in the text.

P18524, 15-16: Need reference for determine Vd value (set to 1 and 0.1 cm/s).

P18524: In equation (3), atmospheric concentrations is represented by "Caero". In

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equation (4) aerosol concentrations is represented by “CA”. Are those same? If those are same, the symbol should be unified. If those are difference value, please explain the differences between “atmospheric concentrations “Caero” and aerosol concentrations “CA”. In Table 6, “aerosol soluble Fe (AI) concentration” appear. This should be unified, too.

3. Results section

P18525, 20: Please indicate “East Greenland Current” in Fig. 1. This is helpful information for readers.

P18525, 13-20: “Exceptions to this general pattern . . . .East Greenland Current (Bacon et al., 2005; Wilkinson and Bacon, 2005)”. This feature is difficult to identify in Fig.2 for readers. Fig. 2 is too small and low resolution to see the two stations.

P18526, 14: Please indicate “Rockall Trough” in Fig.1. This is helpful information for readers.

P18526, 20- P18527, 14: Additional drawing of gradient line on the three types of profiles in Fig. 3 is helpful to understand the gradient in the profiles. Please add each data points on each profiles in Fig. 3.

P18528, 15: Please indicate “Hatton Bank” in Fig. 1. This is helpful information for readers.

P18530, 24-25: Authors estimated annual diffusive flux of Fe, 0.64 umolFe m-2 yr-1 and 0.46 umolFe m-2 yr-1, in the Iceland basin and the Irmingen basin. In this calculations, they multiplied 365 days to daily diffusive flux value. However, active convection period should not count for this calculation (convection reach down several hundred meter, and mixed well in the water column, then profile of nutrients do not have gradient in the several hundred meter).

P18531, 22-26: In the text, authors discuss integrated primary production rate using a

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unit of “gC m-2 d-1”. In the Table 1, authors use the unit of “mmolC m-3 d-1” for uptake rate. These should be unified.

P18532, 8: I could not find supplement Fig. 2 in the BGD web site.

P18537, 5-7: “Thus, we can only conclude that. . . . .the seasonal productivity in this region”. Is this true? I think summer diffusive flux from below is important for supporting summer phytoplankton production, although surface nutrients concentration apparently depleted or low.

P18539, 15-17: Between 20 and 40 m . . . .Fe cycle of the subpolar North Atlantic.” I could not identify this feature (dFe:N ratios increased lending) in Fig. 7.

P18540-18541, section 4.3.1: I am interested in dFe:N ratio in the period of convection (in mixing water column). This ratio is very important to determine limiting nutrients at the end of spring bloom. Authors can compare the ratio between convectional mixing supply and diffusive supply. (Compare the dFe:N concentration ratio of bottom depth of winter convective mixing to the dFe:N ratio which is obtained from vertical dFe gradient/N gradient).

What is NO3- in the Table 1. Need explanation in caption. Additional information on N;P, N:Si and Fe:N ratio in Table 1 is helpful information for readers.

Throughout the manuscript, authors estimate diffusive supply relative to surface nutrient pool (integrated nutrient standing stocks value in mixed layer). However, the unit of diffusive nutrients fluxes are “mol m-2 d-1” and the unit of integrated nutrient standing stocks are ““mol m-2”. In fact, diffusive flux should be multiply “day number” for this comparison (“one day” in this comparison in the manuscript). Therefore, to compare these number, authors should use a word of “daily diffusive flux”. In abstract, they clearly use “daily macronutrient flux into surface layer”, but some place in the text, they did not use. Table 4 also should change to “daily diffusive supply relative to pool (%)”.

Fig. 3: Add data point on the profiles. Explain “Zmld”, “Zeu” in the caption.

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Fig. 6: Add data point on the profiles of Fe.

Ideally, this manuscript should be published with a report of Fe and Al and nutrients profiles. In the manuscript, authors indicate these profiles are published in elsewhere (P18521, 12). If it is possible, please add the information on the other publication, which include profiles, on the reference list.

End of review.

Interactive comment on Biogeosciences Discuss., 10, 18515, 2013.