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Interactive comment on "Variable C : N : P stoichiometry of dissolved organic matter cycling in the Community Earth System Model" *by* R. T. Letscher et al.

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Response to Reviewer 1

Page 7, section 2.3.1: We have added the following sentence to the text (Pg. 16, section 4) to acknowledge that the exact values for the DOM parameters are dependent on the ocean circulation model used, however our calculated values are similar to the values obtained by Hansell et al., 2012 which used a similar approach for estimating the DOM parameters but with a different ocean circulation model.

"The exact values of the DOM lifetimes determined in our study are dependent on the underlying ocean circulation model used, however Hansell et al. [2012] deter-

mined similar values for refractory DOC (16 000 yr) and combined semilabile and semi-refractory DOC (7 yr; estimated from their Fig. 5) while using a distinct ocean circulation model than the one employed in the current study."

Page 8, section 2.3.1: We have edited our statements as follows to provide more detail regarding the manner in which our numerical approach selected the optimized parameter set.

"Our initial construction of the linear DOM model allowed the sum of f1+f2 to vary continuously between 0 and 0.5 and ki | i=1-3 to vary logarithmically between 0.25 to 20 000 yr-1 by 24 discrete values. The direct-solver technique makes it possible to objectively calibrate these parameters fi,ki | i=1-3 by using a numerical optimization algorithm that rapidly tests each permutation of the discretized ki values, scaled by fi, in order to find the parameter set that minimizes the root mean square difference in the misfit between the model-predicted and observed DOM concentration."

And at Page 9:

"To achieve this the DMI-enabled linear DOM model was modified such that the production for each tracer was held constant allowing only the remineralization rate, ki, to be optimized from a choice of 48 discrete tracer lifetimes spanning the range 0.7 to 20 000 yr-1. Rather than using PP to get the production flux of each DOM tracer, the semilabile and refractory DOM production fluxes (SLDOMprod, RDOMprod) were extracted from the DOM DEV simulation and prescribed in the modified DMI-enabled DOM model. The fraction of SLDOMprod and RDOMprod to be applied each ki | i=1-4 was diagnosed from the relative proportions of each tracer residing in the euphotic or deep layers at the end of the DOM DEV simulation of the BEC (see Fig. 2)."

Equations 1-4 have been edited to switch the notation of depth layers to the standard z-coordinate orientation with positive z upwards. Eq. 1 was edited to more accurately reflect that no production of DOM occurs below a depth of -100m. Equations 3 and 4 were edited, replacing fi | i=1-4 with SLDOMprod and RDOMprod to avoid confusion

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between the meaning of f between Eq1+2 with Eq 3+4; f is reserved to mean fraction of primary production. The descriptors for these parameters were modified in Table 1 and Figure 2 to reflect these changes.

Page 28, Figure 3: The REF simulation lacks a DOCr tracer such that only semilabile DOC can be plotted. Semilabile DOC has a smaller dynamic range than the total DOC fields plotted for the DOM OPT simulation in Fig. 3CD. Replotting of Fig. 3AB at the larger scale of Fig. 3CD results in a loss of the information conveyed as many of the concentration gradients visible now in Fig. 3AB condense onto a single color using the larger range. Thus we have elected to leave Fig. 3 as is. The different quantities plotted in Fig. 3AB (semilabile DOC only) and Fig. 3CD (total DOC) was already noted in the figure caption.

Page 5, line 20-2: Sentence was edited as follows:

"Rather, BEC semilabile and refractory DOM tracers track the accumulated DOM pools that arise from the decoupling of DOM production and consumption in time and space and are thus subject to advection by the ocean circulation. These recalcitrant DOM fractions cycle on timescales of years to centuries and represent a smaller fraction of NPP, i.e. 5-10

Page 13, line 23: Sentence edited as suggested:

"We have also tested other hypotheses for DOM cycling formulations such as. . ."

Response to Reviewer 2

With regards to comments on Redfield stoichiometry in biogeochemical models:

Of the seven marine ecosystem/biogeochemical components of the CMIP5 Earth System Models, we note that only 1 considers non-Redfield stoichiometry in the C:N:P of organic matter pools (PELAGOS model, CMCC-ESM), while another considers variable C:P stoichiometry (TOPAZ2 model, GFDL-ESM2), and to the best of our knowledge there exists no prior published study examining biogeochemical model simulation

of non-Redfield stoichiometry of DOM in detail. When constructing the BEC model of the CESM1, DOM cycling was installed following Redfield stoichiometry even though it was acknowledged that DOM is unlikely to follow Redfield stoichiometry given the few reports on the topic that were available (some of which you provide and others, e.g. Hopkinson and Vallino, 2005, Nature 433). However, now a decade later, the necessary DOM data are available in order to constrain the non-Redfield stoichiometry in marine DOM cycling, which is the focus of the current study. Thus we feel comparison of variable DOM stoichiometry in the BEC-CESM to the Redfield ratio is relevant in context of the new data availability and on its continued reliance by the majority of ESM ocean biogeochemistry models.

We have edited the following text in the introduction to expound upon the current state of non-Redfield stoichiometry in ESM ocean biogeochemistry models and DOM data availability:

At line 10, ". . .however some recent studies have suggested more variable C:N:P ratios (i.e., Martiny et al., 2013a; 2013b) and only recently has variable C:N:P stoichiometry been introduced into Earth System Models (e.g. Vichi et al., 2007; Dunne et al., 2013)."

At line 20, "Here we aim to utilize recent advances in DOM data coverage to incorporate variable production and decomposition stoichiometry within the DOM tracers of the Biogeochemical Elemental Cycling (BEC) model. . ."

On the issue of the novelty of our direct-matrix inversion approach for tracer simulation we have added text at Page 9073, line 28:

"Our approach is to optimize the BEC DOM parameters using available observations, by applying a fast offline solver based on a direct-matrix inversion (DMI) of a linear model of DOM cycling, an approach similar to previous applications for marine radiocarbon (Khatiwala et al., 2005) and marine organic matter cycling (Kwon and Primeau, 2006; Hansell et al., 2009)."

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The reference Anderson and Sarmiento (2004) was changed to the correct (1994) in the text and reference section.

Interactive comment on Biogeosciences Discuss., 11, 9071, 2014.