Estimating Oceanic Export Production based on 3D coupled physical-biogeochemical modelling

Svetlana N. Losa[1], Christoph Völker[1], Martin Losch[1], Sönke Hohn[2]

[1]Alfred Wegener Institute for Polar and Marine Research (AWI, Bremerhaven, Germany),
[2]Leibniz Center for Tropical Marine Ecologie (Bremen, Germany)

Svetlana.Losa@awi.de

Abstract

The study addresses various aspects of model-based estimating the oceanic primary production. In particular, we consider existent interpretations of the export fluxes; influence of implied conversions between modelled chlorophyll and biomass, expressed in nitrogen and/or carbon units, and, therefore, impact of decoupling the biogeochemical (N, C) cycles and chlorophyll. The export production is estimated by simulating global ocean biolgeochemical dynamics with the CN regulated model (REcoM) developed by Schartau et al. (2007) and coupled with the MITgcm . The model describes carbon (C) and nitrogen (N) fluxes between components of the ocean ecosystem. The nitrogen and carbon cycles as well as phytoplankton chlorophyll (Chl) dynamics are decoupled in accordance with the dynamic regulatory phytoplanktonic acclimation model sugested by Geider et al. (1998).

Sensitivity of primary production estimates to biological model parameters is also discussed.

Export production as fluxes across 75 m

To what extent might the C, N, Chl decoupling change the particle organic flux estimates?

Assumption: Following Najjar et al. (2007), the export production is considered as a particle flux across level 75 m and calculated as

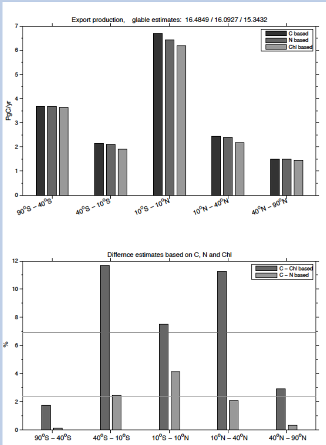
1) sinking of phytoplankton carbon and detrital carbon;

2) sinking of phytoplankton nitrogen and detrital nitrogen DetN (as if one runs just nitrogen based model) converted to carbon units with Redfield constant C:N ratio;

3) given „Chl a" and DetN converted to carbon using Chl : C ratio by Cloern et. al (1995) and Redfield C:N constant.

Accounting for C-N regulation in the ecosystem model allows us to get Export Production, which is just by 3-5% differs from those obtained with the assumption of the constant (Redfield) C:N ratio.

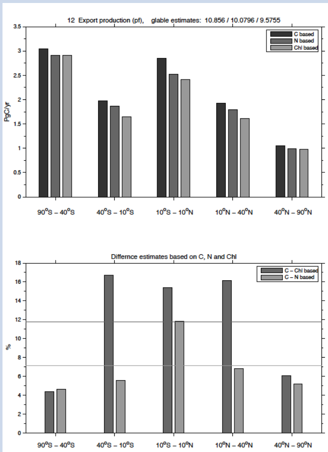
However: Importance of DOC export



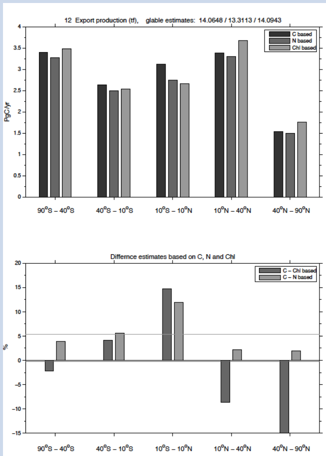
Export Production (particle fluxes across 75 m) averaged over certain latitude bands: comparison of carbon (C), nitrogen (N), and chlorophyll (Chl) based estimates

Global estimates by Najjar et al., 2007: 13 ± 3 Pg C yr^{-1}

Export production as fluxes across 135m



Particle fluxes averaged over certain latitude bands.



Total fluxes averaged over certain latitude bands.

Global estimates: 8.7 – 10. Pg C yr^{-1} (Gnanadesikan et al., 2004); 9.8 Pg C yr^{-1} (Schlitzer, 2002); 9.6 ± 3.6 Pg C yr^{-1} (Dunne et al., 2007); 12 ± 0.9 Pg C yr^{-1} (Laws et al., 2000).

Impact of diffusive fluxes and DOM

Export production is particle sinking, calculated as described above plus

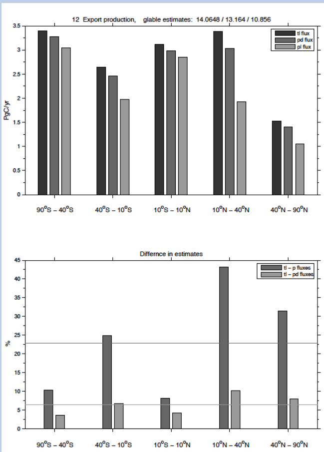
1) diffusive fluxes of phytoplankton and detritus;

2) diffusive fluxes of phytoplankton, detritus and dissolved organic matter DOM.

Reference depth is 135 m.

Accounting for dissolved organic carbon results in 17% higher global total Export Production, which is in a good agreement with the following estimates:

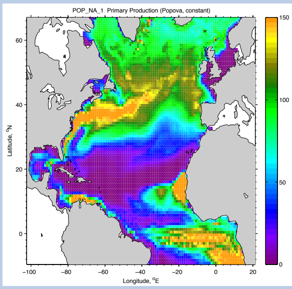
25 ± 8%	*Najjar, 2007;*
20 ± 10%	*Hansell, 2002;*
17%	*Hansell and Carlson, 1998.*

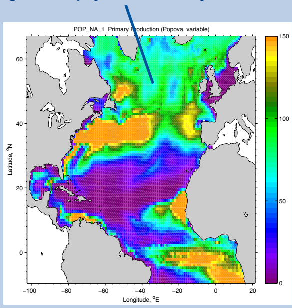


Export Production averaged over certain latitude bands: Differences between estimates based on 1) particle C fluxes (pl), 2) particle sinking + diffusive (pd) C fluxes and 3) total (tf) C flux, including particle sinking + diffusion of particle and dissolved.

Sensitivity of Primary Production to biological parameters

High Chlorophyll – low Primary Production





Primary production estimates (gC m^{-2} y^{-1}) based on 3D coupled physical/biogeochemical modelling the North Atlantic (Losa et al., 2006). Left panel: Spatial distribution of primary production obtained with model biological parameters fixed over the basin. Right panel: Primary production based on spatially variable physiological parameters (Losa et al.,2004).

Geider, R. J., MacIntyre, H. L., and Kana, T. M., 1998. A dynamic regulatory model of phytoplanktonic acclimation to light, nutrients and temperature, Limnol. Oceanogr., 43, 679–694.

Schartau et al., 2007. Modelling carbon overconsumption and the formation of extracellular particulate organic carbon, Biogeoscince, 4, 434–454 .

Najjar et al. (2007), Impact of circulation on export production, dissolved organic matter, and dissolved oxygen in the ocean: Results from Phase II of the Ocean Carbon-cycle Model Intercomparison Project (OCMIP-2).

Losa, S. N, Kivman, G. A., Ryabchenko, V. A., 2004. Weak constraint parameter estimation for a simple ocean ecosystem model: What can we learn about the model and data. Journal of Marine Systems, 45, 1–20.

Losa, S.N., Vézina, A., Wright. D., Lu, Y., Thompson, K., Dowd, M., 2006. 3D ecosystem modelling the North Atlantic: Relative impacts of physical and biological parameterisations. Journal of Marine Systems, 61(3/4), pp. 230–245.

Dunne, J. P., J. L. Sarmiento, and A. Gnanadesikan (2007), A synthesis of global particle export from the surface ocean and cycling through the ocean interior and on the seafloor Global Biogeochem. Cycles, 21, GB4006.

Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft