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Biogeosciences Discussions

Interactive comment on "Reconciling surface ocean productivity, export fluxes and sediment composition in a global biogeochemical ocean model" *by* M. Gehlen et al.

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Review of Gehlen et al.

The study by Gehlen is an admirable attempt to assess the impact of using different export formulations on both the predicted global chlorophyll distributions and on the subsurface particle fluxes. It should be viewed as the first pass at this important problem rather than as providing the final insight.

Gehlen et al use three variants on the Evans and Kriest (1993) formulation of the coagulation equations. The E&K model assumes that the particle size distribution (n) can always be described by a power law relationship as a function of particle radius(r):

n= a r^(-b). E&K expresses a and b in terms of total particle number and mass, which are solved for. E&K also uses the simple rectilinear rate model to integrate the reaction equations into rate constants. Aumont and Bopp (2006) assumes the value of one of the two parameters (b) and uses a second, particle mass, as a variable calculated in the PISCES model. The manuscript by Gehlen et al explores different ways to expand the use of E&K, even to using two variables to describe the E&K distribution. Note, though, all of the scenarios used by Gehlen et al are variants on one type of coagulation model, that of E&K.

Coagulations rates have been described with varying levels of complexity (e.g. Jackson 2005). The simplest form, the rectilinear kernel, was used in Jackson(1990) and Kriest and Evans (1999), not the curvilinear kernel cited on p808 of this manuscript. The form of the kernel does change calculated coagulation rates and resulting size distributions. More complicated coagulation models have been used to describe planktonic particle dynamics (e.g, Hill 1992, Jackson 2001). They can provide different results, but the complexity comes at a computational cost . The effect of these formulations on PISCES-type models have not been explored.

One of Gehlen et al's conclusions is that increasing the complexity of the aggregation models has a relatively small effect on POC fluxes. Given the role of the K&E model in describing all of the coagulation variants that the authors use, they have actually explored only a small range of coagulation models.

There is a potential problem with modifying one term in a successful model and trying to assess the impact of the change. Since one of the goals of the traditional model has been to reproduce surface chlorophyll distributions, it has evolved to do as terms are added and parameters are varied to improve the fit. If the new term provides a significant change in export, the fit may no longer be optimal. It should not be too surprising if changing the rate expressions for particle flux decreases the correspondence to surface chlorophyll maps if the new model is not also tuned.

One of the difficulties that all the formulations used in this paper had was in reproducing the subsurface fluxes. This may be more a reflection of the primitive model used to describe subsurface transformations. The authors impose a flux-feeding model in which the parameters are constant in time and in space. This is equivalent to imposing constant zooplankton abundances as a function of depth and time. Neither is very sophisticated.

In addition, there are other forms of particle consumption which can dominate. For example, Jackson and Burd (2002) developed a model for vertical flux which allowed zooplankton concentrations to vary with space and time. It also included bacterial consumption of particles. The model results did show strong spatial and temporal variations in flux that resulted from the biological processes.

Stemmann et al (2004 a,b) looked at the effect of different modes of particle consumption, including filter and flux feeding as well as bacterial degradation, on particle size distributions through the water column. A comparison with observed particle size distributions suggested that bacterial consumption dominated in deeper parts of the water column (500-1000 m). Bacterial consumption was not part of the Gehlen et al model.

My conclusion is that more work needs to be done to describe subsurface transformations to anywhere near the level of detail used for the surface layer.

Despite its limitations, the paper by Gehlen et al is an important step in developing better ways to describe particle transformations and understanding their effects on global chemistry. ==

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3, S469–S472, 2006

Interactive Comment

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