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# *Interactive comment on* "Rapid formation of large aggregates during the spring bloom of Kerguelen Island: observations and model comparisons" *by* M.-P. Jouandet et al.

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1-The discussion has been re written. The similarities between the model and the observation are fully described in the section "4.1 Role of coagulation in the rapid changes observed" (L343-351). The differences are addressed in the section "4.2 Limitations of the model " (L374-399). The importance of advection process as well as zooplankton grazing is now discussed in the section "4.2 Limitation of the model". The following paragraph was added:

"Other processes are known to affect particle concentrations and fluxes, most notably physical process such as advection and biological processes such as zooplankton



grazing and fecal pellet production (e.g., Lampitt et al., 1993; Stemmann et al., 2000; Turner et al., 2002). The importance of advection could be inferred from time series measurements of LADCP. The results indicated a current below 0.1 m s-1, with negligible changes over the survey in the 0-200 m depth layer (Park, pers.com.). The abundance and volume of zooplankton larger than 0.7 mm, as well as fecal sticks/pellets and aggregates, were estimated from the identification of organism in the vignettes recorded by the UVP using the Zooprocess imaging software (see Picheral et al., 2010). The volume of copepods did not increase through the early bloom survey, suggesting that they were not responsible for the observed rapid increase in particles. Ingestion rates were also estimated from zooplankton biomass using the relationship detailed in Carlotti et al. (2008) using the biomass results integrated over the 0–250 m layer. The ingestion rate was 1.36 mg C d-1 during the early bloom cast and lower than during the KEOPS1 summer cruise. In addition, fecal pellet production should have a diurnal signal (Carlotti et al., 2014), which was not observed in the VT profiles. Lastly, fast sinking fecal pellets are much smaller than the aggregates observed here. For example, fecal pellets falling at 100 md-1 are typically 2-5$\times$106 $\mu$m3, equivalent to d = 200 $\mu$m (Small et al., 1979), compared to the mm sized aggregates dominating at A3. Thus, changes in zooplankton populations can be ruled out to explain the observed VT increase at this time, although not through the entire season. Modelling the dynamics of the entire season would require integrating zooplankton activity. "

2-POC flux could be derived from the gel trap analysis by Ebersbach et al. (2008) but using different algorithms from the ones used by Laurenceau et al (2014). Therefore we didn't report the POC flux derived from the gel during KEOPS1. PPS3 Trap was deployed during KEOPS but was unable to measure the carbon export flux for the event scale that we observed.

3-We changed Figs 6 and 10 to make the comparison easier between the observations and model results by using common scales and plotting styles. We believe that this will facilitate comparisons.

4-We emphasize that there are deficiencies in the results from the phytoplankton growth model before the aggregation event and that this influences the depth distribution of aggregate formation.

5-Our point is that there has not been enough time for the flux to reach the sediment trap, not that there will be no flux. The fact that the particle maximum is so deep argues that the particles are not neutrally buoyant. In fact, we show evidence of the particles falling out of the mixed layer in Fig. 8., being exported to the region between 150 m and 200 m. This is clear evidence that flux does occur.

6-The differences between the model and the observations are discussed in the first paragraph of the section "4.2 Limitation of the model":

"There are, not unexpectedly, differences between model results and observations. To start, fluorescence profiles are relatively constant through the surface mixed layer in the observations, but have a pronounced shallow subsurface chlorophyll maximum in the model because of the higher light levels near the surface. Increased mixing in the model could smooth the chlorophyll profiles, as well as the distribution of particle volume. Simulations made using a much larger mixing coefficient (1000 m2 d-1) yield a smaller difference in chlorophyll between the surface and 150 m, but there is still a difference of 0.8 $\mu$g Chl L-1 over the depth range (results not shown). The vertical mixing rate estimated for the iron fertilization experiment EIFEX, 29 m2 d-1, was actually smaller than that used in these simulations, 100 m2 d-1 (Smetacek et al., 2012). A previous model of phytoplankton growth in the Keguelen region discussed large scale horizontal patterns but unfortunately did not display vertical distribution (Mongin et al., 2008). Whatever the reason for the relatively uniform fluorescence profile, it is not simply a faster diffusive mixing rate. Those differences illustrate the difficulty of building a realistic phytoplankton growth model in the region to drive the coagulation model. The shallower phytoplankton distribution does affect the distribution of aggregates as well. "



7-In the section 3.1.5, we discussed the relationship between the fluorescence and size of phytoplankton.

Conclusion of this section is that

"In the second layer, immediately below the surface mixed layer, fluorescence and VT increased together, with a positive correlation coefficient (0.68) and a slope of 0.036 $\mu$g Chl mm-3 (Fig. 8). This is consistent with no phytoplankton growth in this depth layer, but with phytoplankton and aggregates arriving together from above, presumably in aggregates. There was no correlation between fluorescence and VT below 200 m during this period. "

8-We focus now the comparison of our results to those from other iron fertilization experiments to understand the relative roles of coagulation and zooplankton grazing on particle export during different parts of the bloom cycle. The section "4.2.2 Potential impact of coagulation after iron fertilization (L 458-502)" has been rewritten. The conclusion has also been improved to highlight the lessons of our study:

"It is clear that particle flux in the ocean is the result of many interacting processes, and none of these has been identified dominant across systems. In the present study, we were able to observe rapid aggregate formation and sedimentation of high concentrations of diatoms from the euphotic zone. Our observations are consistent with results from a one-dimensional model that includes only phytoplankton growth and coagulation. Our results demonstrate the utility of coagulation theory in understanding vertical flux and its importance to initiate the formation of large particles in the mixed layer and their subsequent transfer to depth during a bloom. Nevertheless, efforts are still required to measure large aggregates distribution at a high frequency to fill the temporal window between these short time events taking place during the early bloom and the possibly slower dynamics of summer. In addition, more effort is required to understand better vertical variations at a fine scale for all times and particularly to estimate the transformative roles of microbes and zooplankton in decreasing the total

particle volume exported from the euphotic zone."

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/11/C2766/2014/bgd-11-C2766-2014-supplement.pdf

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