In the following reply to our reviewers, we reproduce their comments in *italic Calibri font*, while our responses appear in normal Times New Roman font.

**Response to referee 4**

*Perrette et al. present the first pan-arctic study on the extent of ice-edge blooms, and their contribution to primary production. They conduct their study using ocean color remote sensing data. In the current context of major modifications Arctic marine ecosystems due to climate change, including the shrinking of multi-year ice, this study is timely and important. There are currently a lot of uncertainties in the use of ocean color data in the Arctic Ocean, but still, the timeliness of this study may make it worth being published in BG. It may provide a significant progress in our knowledge, and call for more such studies with improving methodologies. However, better arguments are needed to convince the reader that ice-edge blooms as detected from space are true.*

*- The concept of "durably" or "consistently" below 10% of ice cover is vague when setting the start time of the MIZ. This must be clarified.*

The concept of "durably" (or "consistently") below 10% of sea-ice cover was defined precisely but late in the original manuscript (section 5), whereas the MIZ definition was introduced in section 2. This has now been rectified by moving the definition ("no new growth of sea-ice or import of drifting ice until the end of the season") into the relevant portion of section 2.

*- Although the assumption of consistent bias in time and space and therefore meaningful relative changes is somewhat reasonable, this needs some demonstration. I am not sure that it applies so well to adjacency effect, subpixel ice contamination and CDOM. This point needs to be further developed.*

We expanded our thoughts on this question by amending the following:

> "Those deficiencies are, however, not critical to this study of blooms, since the biases are consistent in time and space and thus relative changes are meaningful. Subpixel contamination and the adjacency effect do indeed occur near the ice–edge but, to our knowledge, separately of geographical location. All of the data that we analyzed were selected on the basis of their proximity to the ice–edge, and should therefore be affected equally. However, we recognize that variations in the availability of data within the 20–day MIZ period, in relation to cloud and fog cover, may force sampling at varying distances from the ice–edge. This may therefore introduce a bias with respect to the possible contamination identified by Bélanger's work, and more importantly with respect to the bloom development stage. Our assumption here is that the scale of such variability is small and that it does not affect the interpretation of observed patterns at the pan-Arctic level, although careful interpretation of the results is needed for the locations where this could not be verified (e.g. high Arctic). Regarding CDOM, areas known for having high load are reported throughout the text. Fortunately, a high precision in the measurements is largely secondary in much of the analysis conducted here, since blooms are readily identified by order of magnitude changes over more than one pixel."

*– The last paragraph of Section 2 in which the potential biases are reviewed and one by one discarded as a significant problem is weak. Bélanger et al.'s study shows that, for ice floes, sub-pixel ice contamination always leads to over-estimation. The authors should provide a more detailed account of Bélanger et al.s results to convince us that it is a negligible problem.*

The intention of this paragraph is not to show that subpixel contamination by sea-ice is negligible – such statement would indeed require more investigation – but to acknowledge the problem and propose approaches to minimize and quantify its impact. We raise two points in this regard:

1. the chlorophyll threshold used in this study (0.5 mg.m-3) is less susceptible to strong overestimation (cf. Figure 11 of Bélanger et al.)

2. the use of another sensor (MODIS) with smoother output (as the result of distinct processing, and possibly stricter quality control) in addition to SeaWiFS is used to quantify the uncertainty in the chlorophyll retrieval

*- End of first paragraph in Section 4: "Low chlorophyll values are visible between . . .". That may well result from the adjacency effect as it generally lead to an under-estimation of chlorophyll concentration.*

We have amended the manuscript by adding the following statement to the end of this paragraph:

> "This could indicate that in this region the bloom onset occurs in open-water; however, the chlorophyll estimates may be biased low due to the adjacency effect, whereby reflections from nearby ice affect the brightness of an image pixel (Belanger et al., 2007). In any case, the bloom terminates at 20-100 km behind the retreating ice edge."

*- It would be useful to show detailed color images of ice concentration, for instance in Figs. 2 and 3, to get a sense of the possible impact of ice for concentration below 10%.*

Ice concentration below 10% is not reliable in the product used (NSIDC), therefore a specific figure would not answer the reviewer's point regarding impact of sea-ice on chlorophyll retrieval (this deficiency of sea-ice data does not affect the determination of the 10% threshold, as we checked that another sea-ice product, namely OSISAF, gives essentially the same result as NSIDC). In our approach, we only use sea-ice data to exclude areas that have been ice-free for more than 20 days (to discard potential open-water blooms), and we use any data before that, including data that are available before the beginning of the 20-day period: ice-free areas can possibly be detected by the finer ocean-color sensor while being seen as ice, simply because of the coarse resolution of the sea-ice sensor. We thus do not rely on sea-ice data for the flagging of ice pixels, but instead we effectively trust the sea-ice/cloud flagging algorithm from SeaWiFS.

*- I doubt that CDOM is always responsible for high chlorophyll values, for instance along the coasts in the Bering Sea.*

We generally agree with this remark, although Bering Sea is not in our domain of definition. To improve clarity in the manuscript, we have modified the statement:

> "The spurious effect of CDOM was further addressed by excluding coastal areas of the analysis"

and have replaced it with:

> "Due to the substantial area of Arctic coastline being potentially affected by the riverine input and spurious effect of CDOM we excluded coastal areas from the analysis."

We have not modified other comments concerning CDOM already present in the manuscript, as we consider them balanced. For example:

> "High values along the coast should be viewed with caution since these waters are likely to be contaminated by CDOM from rivers."

> "The exception is near the coast where chlorophyll remains moderately high all the year round (though, again, this may be confounded by CDOM contamination)."

> "Again, high coastal values on the Eurasian and western Canadian shelves are regarded cautiously due to significant riverine inputs with high CDOM loading. Moreover, we apply a coastal mask to diminish the impact of CDOM contamination"

> "Bering Strait (which has high productivity year round) or to CDOM contamination (most likely in the Russian seas)."

*- Last paragraph of Section 5: Provide more details about the data used to run the VGPM (other than ocean color and ice). Also, the authors should discuss the strengths and weaknesses of that model in the Arctic Ocean.*

Because of the relative scarcity of field estimates of primary production, we are not aware of any specific assessment of the VGPM model (or any other global algorithms) in the Arctic region. As such, it is not possible to directly discuss algorithm strengths and weaknesses. However, we have amended the text to more fully describe the VGPM model, we have drawn attention to the limitations of its use and we have augmented our analysis by using two further primary production algorithms.

> "We now consider primary production in the Arctic basin, and the contribution made by ice–edge blooms. There are a number of different algorithms for estimating primary production from remotely–sensed variables such as sea surface chlorophyll. However, as most were developed for global–scale applications and none are well–validated for the Arctic region, here we use a simple and commonly used one, the vertically generalised production model (VGPM; Behrenfeld and Falkowski, 1997). This algorithm estimates the production of organic matter based on surface chlorophyll, photosynthetically available radiation, sea surface temperature and day length. Because of the considerable uncertainties involved in estimating Arctic productivity in this way, which stem from both the input data and the VGPM's biological assumptions, we use this algorithm for illustrative purposes only. Appendix

A describes estimates made using alternative algorithms that are broadly in agreement with the VGPM results."

*- The last sentence of Section 5 is unclear.*
*"One caveat is that phytoplankton are much higher in the water column during the Ice-edge bloom than for subsequent open-water blooms, which may affect productivity rates. "*

The last sentence of section 5 has been replaced by a whole new paragraph discussing the limitation of remote-sensing and VGPM:

> "An important caveat is that phytoplankton mostly occur in the upper mixed layer during the initial ice–edge bloom, but may subsequently occur below the mixed layer later in the summer open–water period, at a depth which prevents remote detection by satellite. Consequently, estimates of both phytoplankton abundance and associated primary production may be systematically biased in favour of ice–edge blooms. On the other hand, phytoplankton at depth will experience much–decreased PAR availability, and consequently may be expected to have lower growth rates and be less productive. The application of VGPM here effectively assumes that, in the absence of more detailed supporting data, these two biases approximately cancel."

*- Legend of Fig. 3d: provide more detailed explanations about that panel.*

The legend of Fig. 3d has been expanded for clarity.

> "Panel (d) shows a corresponding Hovmoller diagram at 69 N that illustrates the progression of the 2007 bloom, and shows that this can be followed for many months despite large data gaps. The black line indicates the 10% sea–ice contour."