Biogeosciences Discuss., 10, 7549–7578, 2013, **“On the consistency in variations of chlorophyll a concentration in the South China Sea as revealed by three remote sensing datasets”.**

By S. Shang et al.

We deeply appreciate the reviewers’ time and effort to help improve the manuscript. We have revised the manuscript accordingly. Below are our replies to the detailed and constructive comments/suggestions.

Reviewers' comments:

Anonymous Referee #2

General Comments:

The main focus of this paper is to compare MODIS chlorophyll products from three algorithms in use by the ocean color community. The authors examine a time-series of satellite data covering the South China Sea to describe spatial and temporal variability in the region, with emphasis on upwelling and river plume regions. They also assess consistency between the three chlorophyll products, in terms of concentrations and spatial patterns resolved. Furthermore, they compare the satellite Rrs values and derived chlorophyll concentrations to in situ measurements. The work is not novel, but does provide errors associated with different satellite chlorophyll algorithms in optically-complex coastal regions and extends our knowledge of the uncertainties associated with each product. The distributions observed are common – higher chlorophyll values nearshore, in upwelling, and river-influenced areas, with lower values offshore. The paper is organized well and the material is presented clearly. However, the reader is still left confused as to why the various algorithms give such different results, not only in terms of magnitudes, but also in terms of spatial patterns and anomalies. The conclusion in the abstract suggests "more careful interpretation" and "the need for tuning of algorithm parameterization" but doesn't say how to do that. I think the paper would benefit from a more thorough description of the three chlorophyll algorithms. The bulk of the paper focuses on the differences in the results from the three algorithms, but only minimal text was devoted to the differences in the algorithms themselves. Describe the algorithms, rationales, and concepts more fully. Why would you expect different performance between them? Where should one algorithm work "better" than another? Also, more background on the problems in estimating chlorophyll in coastal areas (e. g., interference from CDOM, etc.).

Reply: We thank the reviewer for raising these critical points, which helped us to make a significant revision. In the revision, we not only provided more details on the algorithms themselves but also explained why and how the results were different. A recommendation was also given in the revision on future improvements of algorithms and on data product interpretations. Below we address the itemized comments.

The paper requires revision before it is acceptable for publication.

Specific Comments:

Page 7551, Line 5 – more on problems estimating chlorophyll in coastal areas (interference form CDOM, especially for blue/green ratio algorithms). change “data to” to “data with”.

Reply: Revised.

Page 7551, Line 18 – discuss differences between the algorithms in more detail, since the differences in their results is the focus of the paper. Why might one expect the algorithms give different chlorophyll values?

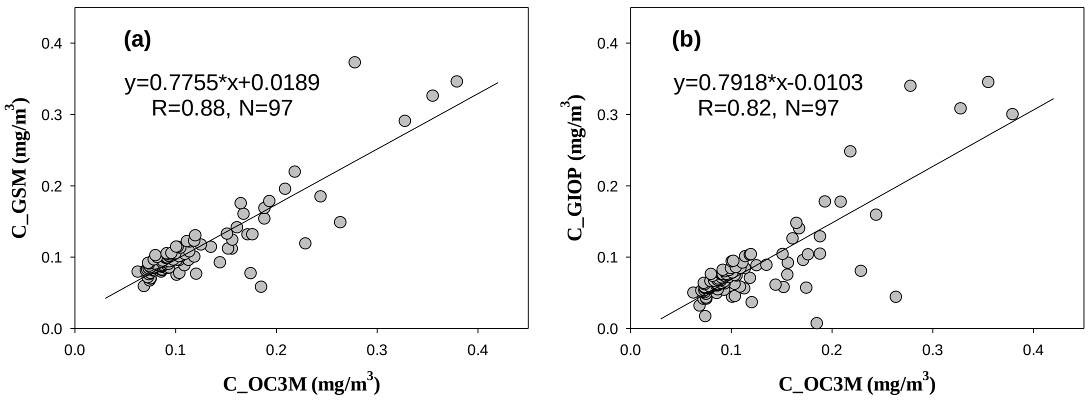
Reply: The differences are now detailed in the revision.

Page 7554, Line 16 – “Field observations showed high Chl during winter.” Where?

Reply: High Chl was observed in winter throughout the SCS basin (Ning et al., 2004), in the NSCS (Chen et al., 2005), and at SEATS (Tseng et al., 2005). All were based on in situ observations. Clarified in the revision.

Page 7555, Line 3 – “strong correlation between C_GSM, C_GIOP, …” Where is a plot and /or data to support this?

Reply: R >0.8 is a strong correlation. The x-y plot is now shown in the revision and also below.



Page 7555, Line 4 – "compared to the limited in situ data…" Difficult to compare point data to a monthly mean satellite value, due to space/time differences between the measurements.

Reply: We agree, but this is a typical practice for oceanographers when performing time-series analysis or when comparing satellite and in situ data. The difference in spatial coverage (a point measurement versus a 1 km^2 measurement) is inherent but the spatial de-coupling scale in most open oceans is way more than 1 km so this difference is ok. The difference in temporal scales may be a problem, but one would not expect chlorophyll to have sharp changes within a month for open-ocean waters so the comparison can be used to examine general patterns. We have added one sentence to clarify this.

Page 7555, Line 11 – "well known summer upwelling zones" In Fig. 7, there are also several peaks in winter – is that also upwelling?

Reply: No, it is not upwelling. We think the Chl peaks in winter are induced by interference from CDOM and detritus.

Page 7555, Line 16 – "The upwelling induced bloom was found to be specifically strong in August 2007…" It is difficult to tell August 2007 is higher than the August climatology, just from Figure 6. Is there a better way to quantify this?

Page 7555, Line 22 – "(larger difference between annual maximum and annual minimum) than C_GIOP." Why would this be the case? Any suggestions? Also, it is hard to verify this statement from Figure 7 – is there a better way to quantify the differences in seasonality between OC3M, GSM, and GIOP?

Reply: We have deleted this part on the Vietnam upwelling because we have no in situ data to tune regional algorithms there.

Page 7555, Line 24 – change "phenomenon was also found" to "patterns were observed".

Reply: Changed as suggested.

Page 7555, line 25 – "contradictory from the seasonal pattern observed from limited in situ measurements" Why would the satellite data be contradictory to the in situ data?

Reply: For OC3M Chl, interference from non-phytoplankton matters (CDOM and detritus), which are commonly rich in these coastal waters, would cause Chl overestimation. For GSM Chl, the globally optimized parameterization (Maritorena et al., 2002) such as Chl-specific absorption coefficient may not be applicable in these coastal waters. We have provided these explanations in the revision.

Page 7556, Line 6 – "data along shore are filtered during the process of producing the product" Explain, please. Why are the nearshore data filtered?

Page 7556, line 20 – because of the missing data of C_GIOP in some of the nearshore waters" Again, why is it missing? Missing for this algorithm but not the others?

Reply: Unfortunately, on the website of GIOP Chl product, there is no information on how the alongshore data are screened.

One possibility is that those data fall in the pre-set product failure conditions (http://oceancolor.gsfc.nasa.gov/WIKI/GIOPBaseline.html). We have explained this in the revision.

Page 7556, Line 23 - "contradictory to the known seasonal patterns" Why is it contradictory? What is causing that?

Reply: This could be due to the improper parameterization of the GSM model, or due to the high uncertainties in the MODIS Rrs data in the blue bands (used as the input of the algorithm) in the nearshore waters where both the water and the atmosphere are turbid. We have explained this in the revision.

Page 7556, Line 25 – "strong positive anomaly" Specify how you calculated the anomaly (eg., is it monthly mean – 11-year average? For each product separately?)

Reply: Yes it is. Clarified in the revision.

Page 7557, Lines 6-10 – Again, why the differences between the algorithms? These results are confusing – so what should be done? Do you recommend one algorithm over the others? Is one algorithm better for coastal patters or in upwelling regions, another for offshore? Not sure what the message is here, except that the 3 algorithms give different results.

Reply: We now discuss why and how separately. Please see details in Section 4 in the revision. Briefly, the OC3M empirical algorithm is fundamentally different from the other two spectral optimization algorithms in two aspects. (1) Unlike GSM and GIOP, the OC3M is not designed to differentiate Chl from other in-water constituents. The GSM and GIOP algorithms both use mathematical optimization approaches to search for an optimal solution, and the only difference is in the way how they are parameterized. (2) The algorithm inputs (MODIS-derived Rrs) are also different: OC3M uses a Rrs band ratio while GSM and GIOP use Rrs from all six bands. Rrs data at 412 and 443 nm tend to have larger errors than in the green or red bands due to imperfect atmospheric correction.

We now conclude that all three algorithms are fine for using in the basin water but for coastal waters cautions should always be taken. We have shown how to tune OC3M for the coastal waters using an *in situ* dataset of Rrs and Chl, and how to tune GSM and GIOP using an *in situ* dataset of Chl and a_{ph}. Current results show that OC3M could be improved substantially in terms of error statistics via regional tuning, yet it is still difficult to recommend an algorithm for the optically complex coastal waters.

Page 7557, Line 12 – "Figure 10 shows the spatial anomalies of the three Chl products." Are the Chl anomalies calculated from the mean over the entire image area? If so, I'm not sure what Fig. 10 shows – just that the coastal areas are always high and offshore areas always low? That's true pretty much everywhere globally. Perhaps it would be useful to calculate anomalies separately for coastal areas and offshore areas to better illustrate the patterns (using the 50m isobaths to delineate the two regions)?

Reply: The analysis of temporal anomalies may be enough to demonstrate the differences among the Chl products. We thus deleted this portion.

Page 7558, Line 13 – "due in part to its poor performance in shallow waters" Why does GIOP perform poorly there?

Reply: It is possible that the a_{ph} parameterization (a_{ph}*) in the GIOP, which follows that in Bricaud et al.1995, is not appropriate for retrieving Chl using the spectral optimization approach. A local tuning of a_{ph}* using *in situ* Chl and a_{ph} data does reduce the mean percentage error from 608% to 161% for the shallow waters (<50m).

Page 7558, Line 16 – "Rrs agreed well with ground truth data except at 412 nm and 667nm." From Fig 12, it looks like it agreed well at 667nm except for one point.

Reply: We agree, and have changed the wording.

Page 7559, Line 10 – "We speculate that the algorithm parameterization of GIOP requires a major tuning for the study region." Which parameters specifically should be tuned? How?

Reply: We have shown how to tune the algorithm in Section 4.2. Briefly, we changed the a_{ph} parameterization (a_{ph}*) from Bricaud et al.(1995) to a local tuning result.

Figure 3 – What area does this cover? The entire South China Sea? Perhaps put a box on Fig 1 or 2 to indicate the region where the data were extracted.

Reply: The region of its previous figure (the original Fig.2 and the new Fig.3). Now we have clarified the range of latitude and longitude in the figure caption.