Biogeosciences Discuss., 9, C8200–C8209, 2013
www.biogeosciences-discuss.net/9/C8200/2013/

Biogeosciences Discussions

Interactive comment on "Factors challenging our ability to detect long-term trends in ocean chlorophyll" *by* C. Beaulieu et al.

C. Beaulieu et al.

beaulieu@princeton.edu

Received and published: 14 February 2013

Manuscript # bg-2012-501 "Factors challenging our ability to detect long-term trends in ocean chlorophyll"

Response to anonymous referee #1

We wish to express our appreciation to the reviewer for his or her valuable comments and suggestions, which greatly helped to clarify the paper, and for the time he or she took to thoroughly review this paper.

Comment: My only concern is that the authors did not take advantage of the MODIS-Aqua OC record for their analyses. They effectively demonstrate how varying degrees of discontinuity affect the number of years of observations necessary to detect a 'real'

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

trend (n*) from satellite chlorophyll records in the global ocean, and emphasize the importance of ensuring overlap between OC records from different sensors. Overlap among different satellite records would indeed avoid discontinuity effects and thus a statistically robust global trend in surface chlorophyll would be available within the next few years after, for example, validating the quality of VIIRS data. This is a crucial statement as support for OC sensors seems to be deeming over time. In light of this observation, I would have expected the authors to take advantage of the MODIS-Aqua OC record in combination with the 10 years of SeaWiFS data presented in this study for conducting their analyses. As mentioned in the Introduction section, there are several years of overlap between these two sensors and thus a more extensive satellite chlorophyll time series (perhaps until the end of 2010?) would have been available to better determine trends magnitude, their statistical significance and n*. The authors acknowledge the value of the overlap among these datasets and yet they do not explain why they used the SeaWiFS record exclusively, or why MODIS-Aqua OC data was not included in this study. They should either consider conducting these statistical analyses with an extended time series that includes MODIS data or explain why they chose to work with the 10-years SeaWiFS record only. Would have 3 or 4 more years of data made a difference in the trend values and statistical significance? Indeed, combining OC measurement from different sensors can be problematic but the authors should briefly address the challenges of using a multi-sensor dataset if they chose to use measurements from a single satellite.

Response: Ideally, we would of course like to perform this analysis on the longest possible time series, but we have to be sure that we are analyzing a self-consistent time series, otherwise we run the risk of identifying trends, which in reality are biases or shifts in the data as a result of merging multiple data sources. A thorough cross-calibration is needed, and as the reviewer points out, this is not a straightforward task. We are aware of 4 international groups who are currently working on developing a self-consistent, merged time series from SeaWiFS, MODIS (and in some cases MERIS) as a 'climate data record', i.e. suitable for analysis of long-term trends. As far as we

BGD

9, C8200–C8209, 2013

are aware, only one group has so far made public their results: the ESA GlobColour project. We initially intended to use their merged time series for this analysis, but discovered that the data had surprising characteristics. The time series of the global mean monthly chlorophyll concentration data is shown in Fig.1 below, and displays a) an increase in the mean chl value starting in mid-2002 when MODIS + MERIS data became available, b) an increasing trend in the chl in 2008-2010, the period during which SeaWiFS was experiencing intermittent failures and c) a large increase in the mean and seasonal amplitude of chl in 2010 and 2011, during the period when SeaWiFS failed and the GlobColour product was derived from MODIS + MERIS data only. Based on this preliminary look at the GlobColour data, and the long-term stability of the SeaWiFS record, we decided to limit ourselves to using only the SeaWiFS data during the period when it was operating continuously to avoid overestimating the standard deviation and autocorrelation (used in the n* calculations) and avoid detecting biases. We raised this point in the discussion section by adding at P.16437, line 6: "We have used SeaWiFS satellite data only to make sure that we analyze a self-consistent time series. However, the results could vary if longer merged time series from different satellites (e.g. SeaWiFS and MODIS-Aqua) were used." We hope that in future analyses we will be able to use one of the longer, merged time series.

Comment: Introduction section, page 16421, lines 10-13: Measurements from HOT and BATS time-series sites show that chlorophyll a is increasing in the oligotrophic North Pacific and North Atlantic, respectively. Karl et al. (2001), Corno et al. (2007) and Lomas et al. (2010) should be cited here as well. Response: We added these three references.

Comment: Introduction section, page 16422, line 8: A period is missing after 'chlorophyll'.

Response: We added a period after chlorophyll.

Comment: Introduction section, page 16422, line 19: add a sentence expanding on

BGD

9, C8200–C8209, 2013

the definition of red noise.

Response: We expanded the definition of red noise, which is now: “In climate time series, the autocorrelation is often represented by a first-order autoregressive process (red noise). The red noise arises from temporal persistence and it roughly approximates internal variability in the climate system in which slower response components such as the ocean and large ice sheets provide memory by responding slowly to a white noise forcing coming from weather systems (Hasselmann, 1976).”

Comment: Introduction section, page 16424, lines 16-24: I would suggest deleting this paragraph.

Response: We deleted the paragraph.

Comment: Data and Methods section, page 16425, line 12: The sentence “Figure 2 presents the global: : :” should be moved to the Results section.

Response: Sentence removed.

Comment: Data and Methods section, page 16425, line 17: Perhaps include the atmospheric CO2 concentration by 2100 in parentheses.

Response: We added “(28.9 GtC/year from fossil fuel emissions by 2100)”.

Comment: Data and Methods section, page 16425, lines 21-22: This should not be mentioned in the Methods section but in the Results section.

Response: We moved this sentence to section 3.1.

Comment: Data and Methods section, page 16425, line 25, page 16426, line 7: This paragraph belongs to the Discussion section. The Methods section should only describe how the study was carried out.

Response: We moved the paragraph in the discussion section.

Comment: Data and Methods section, page 16428, line 22: Consider replacing ‘num-

BGD

9, C8200–C8209, 2013

ber of years of observation or data collection, or necessary to detect trends, etc' by n* here and thereafter. For example, 'the number of years necessary to detect trends', which is kind of a long term, is mentioned five times on page 16436 (Discussion section). Using n* would make the reading a bit easier.

Response: We have replaced "the number of years of observations necessary to detect a trend" with "n*" everywhere in the manuscript after it was first introduced in Eq. 8.

Comment: Data and Methods section, page 16429, line 6: 'T0 represents the number of observations before discontinuity'. According to the list of notations on page 16440 T0 is the timing of the discontinuity. The authors should either change the definition here or in the list of notations for consistency.

Response: We have changed the definition in the notation section to be consistent.

Comment: Data and Methods section, page 16429, lines 17-19: This should be mentioned earlier in this section, perhaps after line 25 in the previous page.

Response: We think Eq. 12 has to be introduced before making the distinction between discontinuity and gap and explain how to estimate n* in both cases. Therefore, we did not move this paragraph.

Comment: Results section, page 16431, lines 10-12: Explain here how chlorophyll is standardized as in Figure 2 (the mean is subtracted from the time series and then the time series is divided by its standard deviation).

Response: We added the explanation suggested. Comment: Results section, page 16432, line 20: include the multi-model mean value in parentheses here, which should be -1.56 x10-4.

Response: We added the multi-model mean value in parenthesis, which is -1.53x10-4 (calculated after rounding the numbers in Table 2 for consistency).

Comment: Results section, page 16432, lines 25-27: without discontinuity, right?

BGD

9, C8200–C8209, 2013

Interactive Comment

Response: We added “without discontinuity” to be clearer.

Comment: Results section, page 16432, line 28, page 16433, lines 1-2: I don’t see these values (66 to 105 years) in Figure 4. The GFDL-TOPAZ trend value (0.4) is between the 80 and 120-years contours with continuous observations and between the 120 and 160- years contours with a discontinuity halfway through.

Response: Figure 4 contours were not calculated with high enough resolution to see the exact values that are presented in the text. We apologize for this mistake and modified Figure 4 accordingly (see Fig. 2 below). Now the GFDL-TOPAZ trend value is between the 60 and 70 years contours and right next to the 100 years contours. We also made sure that all other contours figures were calculated with the same resolution and reflect the same values as presented in the text.

Comment: Results section, page 16433, lines 4-24: This entire paragraph should be moved to the Discussion section.

Response: We moved this paragraph to the discussion section.

Comment: Results section, page 16434, lines 1-3: 25 Years of observations to detect a trend with the same magnitude as the multi-model mean trend assuming zero discontinuity, right?

Response: Yes, we specified that it is without discontinuity.

Comment: Results section, page 16434, lines 6-8: Perhaps the authors should refer to Fig. A2 here?

Response: We added a reference to Fig. A2.

Comment: Results section, page 16434, lines 13-16: the lower value is more like 55 yr with no discontinuity. At zero fraction of data before discontinuity the multi-model trend mean is between the 50 and 55-yr contours.

Response: We changed the value for 54.

BGD

9, C8200–C8209, 2013

Interactive Comment

Comment: Discussion and conclusion section, page 16435, lines 1-3: Refer to Table 1 too.

Response: We added a reference to Table 1.

Comment: Discussion and conclusion section, page 16435, lines 22-26: This was already mentioned in lines 4 to 24 of page 16433.

Response: We have moved the paragraph at page 16433 to the discussion and replaced the sentences of page 16435 (lines 22-26).

Comment: Discussion and conclusion section, page 16436, line 4: projected. Response: We replaced “project” with “projected”.

Comment: Discussion and conclusion section, page 16436, line 12: remove ‘the’ after if.

Response: We have removed “the”.

Comment: Appendix A, page 16438, line 20: remove ‘the’ after present.

Response: We have removed “the”.

Comment: Table 1: Highlight the biomes that show statistically significant trends with, for example, bold captions.

Response: The biomes that show a significant trend are highlighted with a *.

Comment: Figure 4: The scale in the y-axis in (a) should be x10-3 so that trend values in the figure can be compared to those in Table 2 more easily. Also, the sentence ‘the standard deviation and autocorrelation used in the calculations were estimated from global SeaWiFS data from 1998-2007’ should be moved to section ‘b’ in the figure caption. Refer to Table 2 after ‘: : :as well as the model mean trend’.

Response: We left the scale in the y-axis x10-4, but we changed the scale in Tables 1 and 2 to be consistent. We repeat “estimated from global SeaWiFS data from 1998-

BGD

9, C8200–C8209, 2013

2007" in both captions as it is relevant for both. We added a reference to Table 2.

Comment: Figure 5: The sentence 'the standard deviation and autocorrelation used in the calculations were: : :' should be removed since SD and autocorrelation data from each biome are not shown in this figure. It should also be mentioned that trends are in absolute values and that trend values are available in Table 2.

Response: We left the sentence about the autocorrelation since and SD since these values were used to calculate the results shown on the figure. We specified that the trends are in absolute value and refer to Table 2.

Comment: Figure A3: Biomes showing significant trends should be indicated with a star (*) with the corresponding colour.

Response: They are almost all significant, so it would be too many stars. We specified that the trends significance are presented in Table 2.

Comment: Figure B1: The sentence 'the standard deviation and autocorrelation used in the calculations were: : :' should be removed since SD and autocorrelation data from each biome are not shown in this figure.

Response: We left the sentence about the autocorrelation and SD since these values were used to obtain the results shown on the figure.

Interactive comment on Biogeosciences Discuss., 9, 16419, 2012.

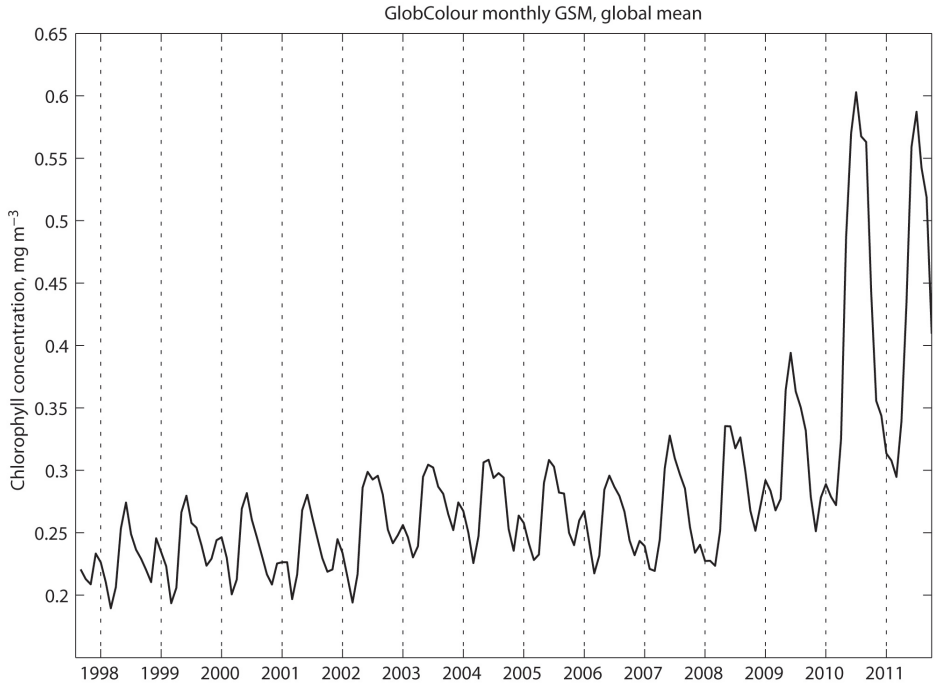

Fig. 1. Global mean GlobColour monthly chlorophyll concentration

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

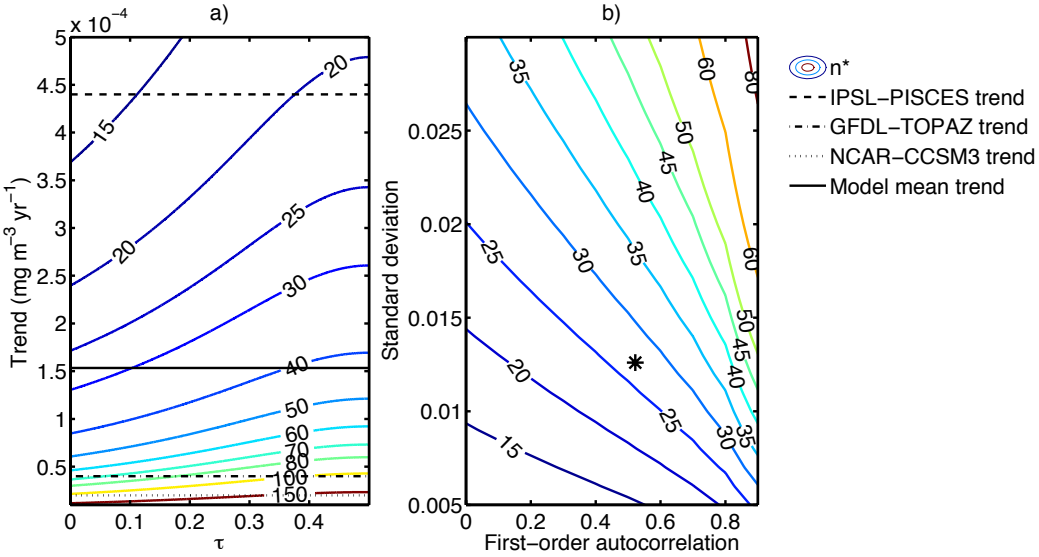

Fig. 2. Revised Fig.4 in manuscript # bg-2012-501

BGD
9, C8200–C8209, 2013