Biogeosciences Discuss., 11, C869–C872, 2014
www.biogeosciences-discuss.net/11/C869/2014/

Biogeosciences
Discussions
Open Access

Interactive comment on "Satellite detection of multi-decadal time series of cyanobacteria accumulations in the Baltic Sea" *by* M. Kahru and R. Elmgren

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Received and published: 8 April 2014

Dear S. Kratzer, Thank you for taking such a keen interest in our paper.

"From the previous version of the article, it was not obvious that you did not include 4 km products in the analysis; but now you have specified it."

The fact that SeaWiFS GAC data were NOT used has been clearly stated in the manuscript. Page 3324, lines 17-18: "Between 2005 and 2010 SeaWiFS data were only available at the low (4 km) resolution (GAC) mode and were not used." Again, page 3329, lines 7-8, talking about missing SeaWiFS data of 2005-2010. Again, page 3347, Table 5, listing sensors that were used for each year.

“Ocean colour sensors are much more sensitive to water, and it may still be that MODIS and VIIRS sense suspended matter –including both cyanobacteria and nonalgal particles – at much lower radiances- and therefore at an earlier stage. What I mean to say is that it is likely that ocean colour sensors can sense the cyanobacteria at an earlier stage of the development of a surface accumulation and that this would show up as increased turbidity. And, yes, I do feel that this can affect your results as AVHRR is not as sensitive. I still feel that this may partially explain the earlier on-set of the bloom.”

We have used a lot of space in the manuscript explaining that the specialized ocean color sensors are more sensitive than AVHRR and also explaining what we have done to make FCA compatible for all the sensors used. Summarizing it here again. We use a high threshold for detecting turbidity that is classified as accumulation. Lower levels of turbidity that are detectable by the sensitive sensors and are probably not detectable by AVHRR are ignored. We can clearly see the build-up of the bloom by its increasing Rrs667 (turbidity) that eventually leads to detectable accumulations but these stages of the build-up are NOT classified as accumulations. Quite often these blooms of increasing turbidity never become detectable accumulations. Regarding timing: In analogy with the calculation of the center of gravity, we use the “center of timing” that is insensitive to both the early detection and to late detection of weak accumulations and responds mostly to the dense accumulations that are well detected by all sensors (cf. Figs. 4, 5, 6). The trend towards earlier accumulations is also evident in the time series after 1998 (Fig. 11A) but the length of the series is too short to make it statistically significant at $p<0.05$.

“Sensitivity refers to level 1 and usually effects on level 1 also propagate to level 2, no matter what algorithm you use.”

We don’t want to get into technical details of how an individual band of a satellite sensor is characterized and how the signal is digitized and transmitted but we have included the “Signal to noise ratio of the red band” in Table 1, assembled from various resources.

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"It is nice that you included a reference from the southern Baltic Sea, but it may be fair also to include Kratzer and Tett, 2009, which you seem to have used for some of your underlying assumptions of your analysis – i.e. that inorganic SPM is mostly found in the coastal areas and that it decreases as one goes further off-shore, and that in the open Baltic Sea, SPM can be used as a proxy for cyanobacteria blooms. At least- I have discussed these issues with Ragnar Elmgren many times in the past- and he is very aware of the study- so why not quote our paper?"

We used the methods described in this paper already in our publication Kahru et al. 2007, but you are right that your paper is relevant and we will try to cite it in the future.

"You still have not addressed my comment that SPM can be found to about 100-120 km off-shore in the southern Baltic Sea, and that this may be misinterpreted as a cyanobacteria bloom by ocean colour sensors, as the SPM shows similar patterns as those of cyanobacteria – i.e. it is an indicator for the eddies and large-scale features. This does not only impact the small bays in the coastal zone, but seems to starch out a rather long belt into the actual Baltic Proper. So, this may have a significant effect on your analysis."

Dense surface accumulations of cyanobacteria are clearly distinguishable from SPM by their high reflectance and characteristic spatial structures. However, sometimes turbid plumes originating from the coast can extend into the Baltic area used in our calculations, i.e. outside of the coastal zone that is excluded from the analysis. These plumes are almost always clearly discernable as originating from the coast and have been eliminated by visual inspection. I have added a clarification to the text. I do not agree that "SPM shows similar patterns as those of cyanobacteria". Cyanobacteria accumulations, particularly those floating at the surface, have a much more delicate spatial structure than sediment plumes that typically originate from the bottom layers or are composed of particles that tend to sink rather than to float.

"Also, Sentinel-2 will have the appropriate spatial resolution to sense also small bays,

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and it will have some channels that are relevant for OC applications, so I would not completely dismiss the information in the coastal zone in the near future."

I would love to discuss this and other great future sensors somewhere but in this paper I have to restrict myself to the data that is actually available.

"Aphanizomenon is found at deeper parts in the water column- not just 'in the water column'. The water column reaches right up to the surface, and this is where you find more Nodularia. What I meant, was that 'in the water column' does not say anything about which depth it is found at. Could also be close to the surface"

We will amend our sentence to state that "While surface accumulations consist primarily of Nodularia spumigena, other species dominate in the water column below".

"I look forward to seeing the revised version of the manuscript- it sounds like it has already improved quite a bit."

Thanks to your valuable comments!

"What I had forgotten to mention before is that your maps of FCA in grey-scale (Fig 13a) does not have a legend. What do the grey shades refer to? What are your steps?"

The caption to Fig. 13a clearly states that "Gray-scale from light to dark corresponds to increasing FCA" (i.e. from 0 to 1). Although we certainly have a color scale for these figures, at this small scale it would be practically impossible to use it to infer any useful quantitative values and these figures show the spatial distribution of the accumulations. For quantitative analysis the reader is referred to Table 5.

Interactive comment on Biogeosciences Discuss., 11, 3319, 2014.