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Earth System Dynamics
Discussions

Interactive comment on "A regional evaluation of the influence of climate change on long term trends in chlorophyll-a in large Italian lakes from satellite data" *by* Gary Free et al.

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We would like to thank reviewer 2 for the comments intended to improve the manuscript and we are committed to improving the work and address the issues you have highlighted.

Issue/Comment I have two main concerns about this study. First is about the accuracy and the continuity of the satellites derived Chl-a data which is probably not the focus of this study but definitely provides the basis for the following analyses. Hence, I think it is still important to provide more information on the Chl-a data validation over the several sensors and the continuity between them, as the Chl-a data is not derived from

a demonstrated product

Reply We agree that for confidence in the data this is a crucial foundation. We will include more detail and include published references to the calibration papers covering the different satellites used to construct the chlorophyll time-series. Copied here the reply following a similar question to reviewer 1: We do agree that sensors' characteristic might strongly impact (along with the algorithms used) on the chl-a retrieval from EO data. For this issue this study makes use of satellite-derived chl-a products for which previous studies demonstrated the accuracy of such products. Starting with MERIS, we made use of the chl-a products as obtained from the C2R algorithm. According to Odermatt 2012, C2R is successfully validated for low to intermediate chl-a concentrations (< 16 mg/m3) (Cui et al., 2010, Minghelli-Roman et al., 2011, Odermatt et al., 2010) and this product has been used by Bresciani et al. 2011 to demonstrate how MERIS-derived chl-a might support the implementation of the Water Framework Directive in European perialpine lakes. With respect to most recent sensors (i.e. OLI, MSI and OLCI onboard Landsat-8, Sentinel-2 and Sentinel-3 respectively) previous studies (Giardino et al., 2014; Bresciani et al 2018 and Cazzaniga et al (2019) showed a retrieval of chl-a comparable to field measurements (e.g. for OLCI -> MAE=0.55 mg/m3; for OLI+MSI -> MAE=0-43 mg/m3) ranging from 1 to 15 mg/m3. These results were obtained by using a sensor-independent image-processing-scheme (6SV+BOMBER) that was easily adapted to the configurations (e.g. spectral setting) of OLI, MSI and OLCI sensors. Cazzaniga et al., 2019 also showed the agreement (r2=0.72) between MSI and OLCI for estimating chl-a according to the proposed sensor-independent image-processing-scheme.

Issue/Comment The second concern is about the possible impacts other than climate change, such as anthropogenic activities or nutrient loadings. In other words, if it is possible that the change in Chl-a pattern is caused or partly caused by other factors? If so, how to quantify the change caused by other factors? If not, why?

Reply Yes this is a very valid point. In a lot of European lakes I suspect that the signal

of climate change will be obscured by eutrophication derived from catchment sourced nutrient additions or internal loading. We included total phosphorus data to check for the influence of this but it was not selected in any of the models - we can expand on this in the discussion. Other work on these lakes has found a stable trend so we just referenced the paper rather than make it a focus point. We will make an -"other factors point"- and tie it in with the fact that the models only explained a limited % of the data.

Issue/Comment Page 3, Line 113-116. Why to use 6SV code for the atmospheric correction for the three sensors? In my impression, there are several atmospheric correction tools that have been demonstrated to be suitable for the sensors, such as Acolite, C2RCC, and Polymer.

Reply Thanks for your comment, yes it is true that, like for 6SV, many codes have been developing in the last years and Acolite, C2RCC and Polymer are clear examples of such progresses. The codes are still under testing and given the continued development of the processors, including new algorithms being implemented, further analysis is needed to evaluate their performances across the large variety of inland water types. We are also evaluating such codes but for the time being, 6SV the method which is providing better results for the rather clear waters of subalpine lakes. Then we also preferred to use 6SV for its advantage of being sensor-independent code, in other words we can easily adapt the same 6SV version and atmospheric correction scheme (e.g. the use of the same origin of aerosols) to OLCI, OLI and MSI scenes.

Issue/Comment Page 3, Line 118-Line 120. How many ROIs are selected for each lake? Are those ROIs fixed and extracted from every image?

Reply The ROIs are kept consistent for the lakes- We selected one per lake in order to have the most consistent data for the time series. We will list the coordinates of the ROIs.

Issue/Comment Page 3, Line 130. It is very confusing why the in-situ data are typically higher than that estimated data by satellite data. The estimated Chl-a data should be

validated before to be fed into the analyses.

Reply Unfortunately, because of the large gap in the satellite record as a result of Meris failure in 2012 it was necessary to use field gathered data from local authorities. We just used the insitu data or interpolated to fill the gaps. We did not adjust the satellite data. We recognized that this is not ideal in the paper and also presented the time series with satellite only data (Fig. 3).

Issue/Comment Page 3, Line 140. Total phosphorus data were mentioned here but why it was missed in the following NPMR analyses?

Reply We included total phosphorus data to check for the influence of this but it was not selected in any of the models - we can expand on this in the discussion as mentioned in the point above.

Issue/Comment Section 4- Good discussion!

Reply Thanks for your comments to help improve the manuscript.

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