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SGLI-derived Chl-a in the Northwest Atlantic

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Abstract

GCOM-C spacecraft was successfully launched in December 2017 and radiometry collected by the SGLI sensor started to be used for ocean color study in early 2018. In the current study, we assessed the performance of the SGLI-derived Chlorophyll-a concentration (Chl-a) against in situ Chl-a that were collected during Fisheries and Oceans Canada monitoring surveys in the Northwest Atlantic. A total of 125 matchups occurring over a wide range of environments, from the optically complex waters of the Gulf of Maine to the sub-Arctic waters of the Labrador Sea, revealed the good performance of the SGLI chlorophyll-a algorithms, which compares to the ones of MODIS, SeaWIFS and VIIRS. Several flags and comparison criteria were tested and we found that a large number of matchups are discarded when the most stringent criteria are used, which in turns influence the statistics of the matchups, perhaps in a counterintuitive manner, since the poorest performance was achieved when criteria were tightest. This result might be impacted by the number of data used to compute the statistics

Data and Method

Water samples were collected within 10 m of the surface during the Atlantic Zone Monitoring Program (AZMP) field surveys that occur on the Scotian Shelf and Gulf of Maine in Spring and Fall of each year and during the Atlantic Zone Offshelf Monitoring program (AZOMP) that takes place in Spring in the Labrador Sea (Figure 1) from 2018 to 2021. Between 0.500L and 1L (depending on visual inspection of filter color) are filtered on GF/F 25mm filters and flash frozen in liquid Nitrogen and stored in -80oC freezer until analysis in the laboratory. In situ chlorophyll-a concentration (mg m-3) was measured on a High Performance Liquid Chromatography Agilent System following the method of Head and Horne (1993).

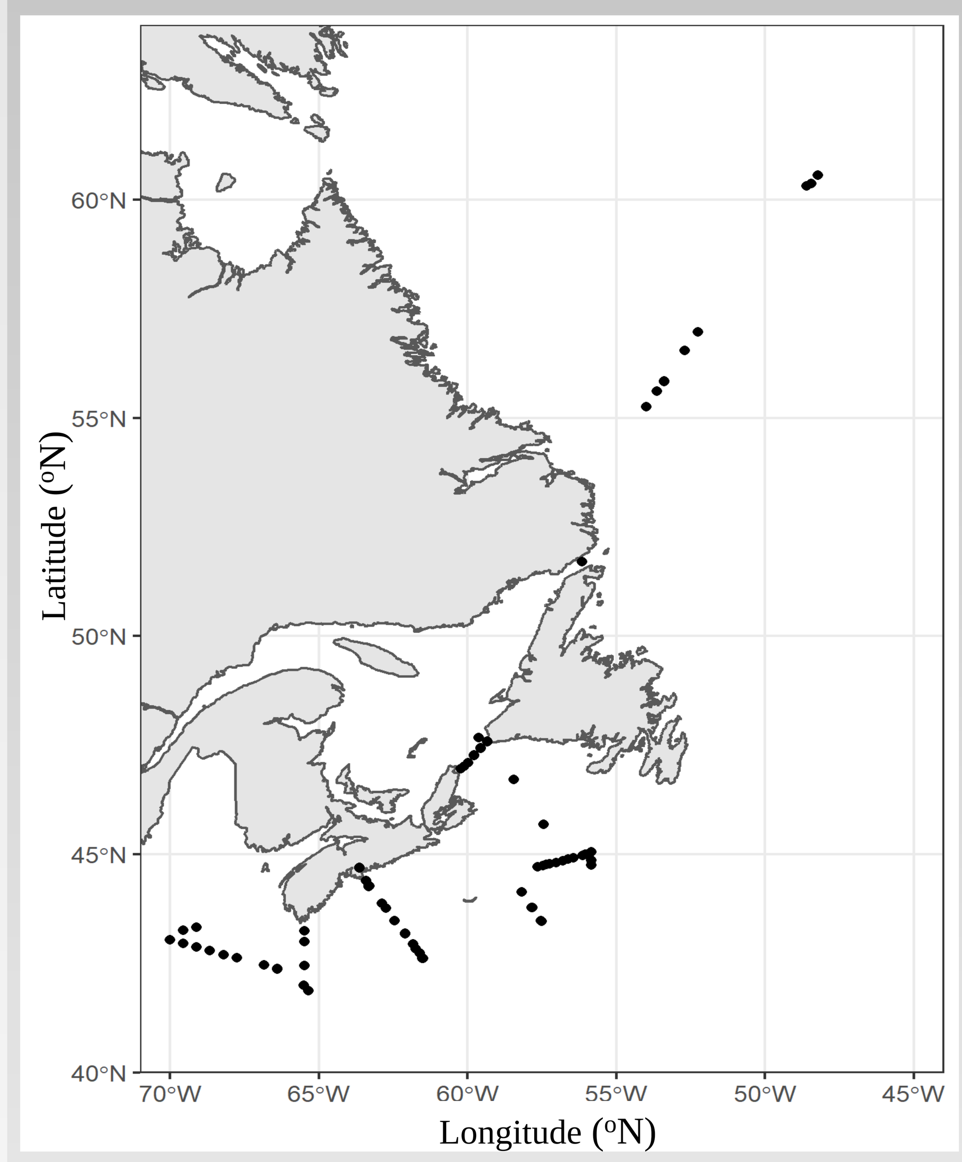

Figure 1: Location of in situ Chl-a samples that matched satellite-derived Chl-a

GCOM-C SGLI level-2 data were downloaded from the JAXA G-Portal for the dates of sampling, and pixels with flag 479 (the standard flag used in SGLI statistics) were marked as invalid. For each Chl-a sample, all 5x5 matrices where the central pixel was within 20km of the in situ measurement were extracted and the remaining flags associated with the pixel were retained. Matchups with fewer than 3 valid pixels were discarded from the analysis, and the coefficient of variation (i.e., s(Chl-asat)/mean(Chl-asat) after filtering out pixels ±1.5σ away from the mean) was calculated for each 5x5 box. We then compared two sets of criteria, from very stringent to a minimum set of restrictions (Table 1), and selected the nearest matchup to each in situ measurement after applying the criteria, resulting in a maximum of 125 matchups under the relaxed criteria over the period of interest.

The overall performance of the SGLI OCx algorithm (i.e., polynomial expression of band ratios) was assessed by the Model-II linear regression of the satellite-derived Chl-a against the in situ measured Chl-a (i.e., Slope and Intercept), the correlation coefficient (r2) and the root-mean-square error of the log10-transformed data (RMSLE)

Criteria	Stringent	Relaxed
Flag	479 + 32768*	479
Time	±3 hours	Same day
Sensor zenith angle	< 60º	
Solar zenith angle	< 70º	
Number of valid pixels	13 out of 25	3 out of 9
Coefficient of variation	≤ 0.15	
Satellite Chl-a	Median 5 x 5 matrix	Median 3 x 3 matrix
Number of Matchups	**44**	**125**

Table 1: Criteria used to select satellite/in situ matchups to assess the SGLI chl-a product. 32768* corresponds to the swath 90 flag (applied to 90 pixels at each edge of the swath)

Finally, the performance of the SGLI chl-a product was compared to the performance of the MODIS (2002-2014), SeaWIFS (1998-2010) and VIIRS (2012-2014) satellites from NASA that was carried out by Clay et al. 2019. Each in situ dataset is unique to the satellite it corresponds to and covers its period of observation from its launch to 2014, such that our analysis does not evaluate the algorithms under the same exact conditions but provides an overall assessment of SGLI against sensors with a long period of operation.

Results and discussion

The selection of flags and matchup criteria has a strong impact on the number of retrievals (Table 1), and, in turn, influence the number of points in the comparison going from 44 pairs with the most stringent criteria to 125 pairs when relaxing the criteria.

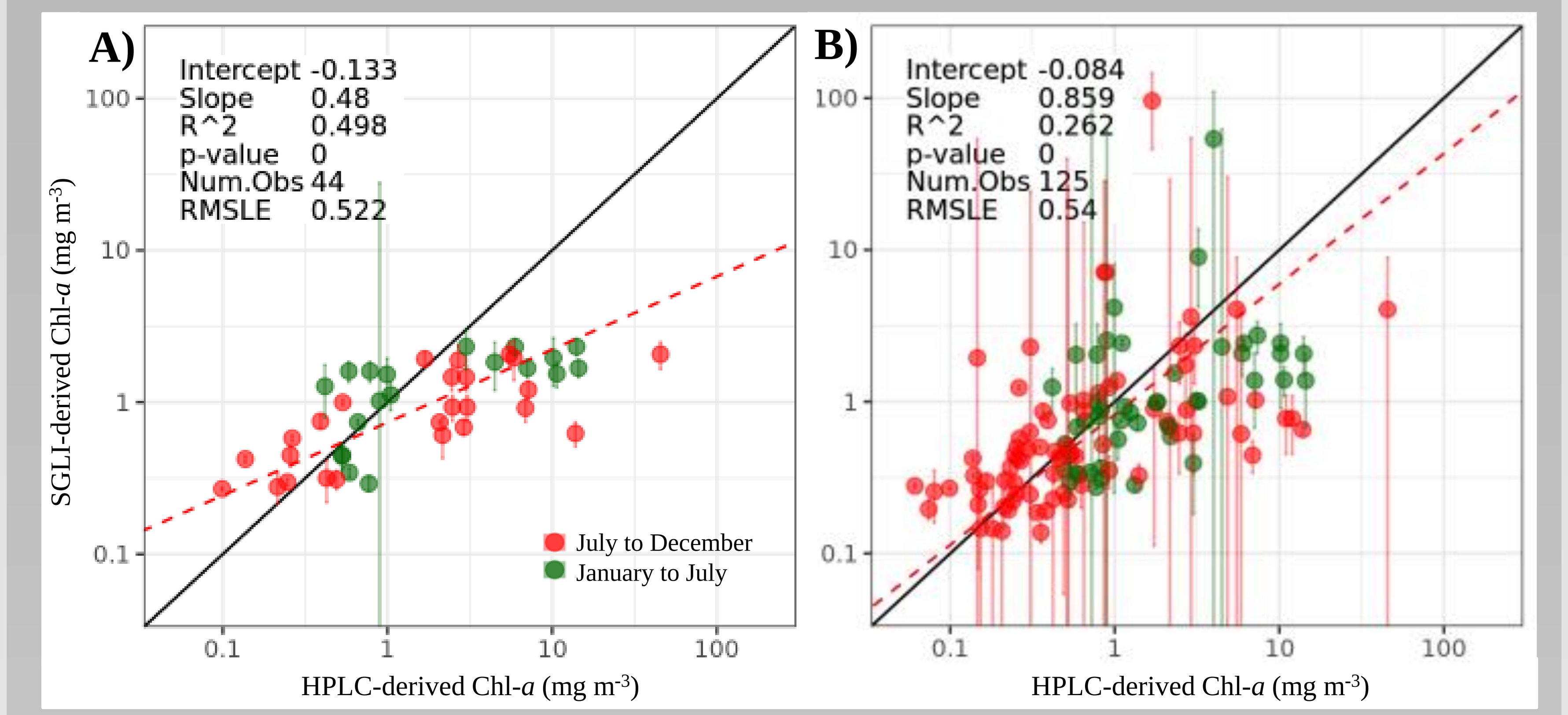

Figure 2: SGLI-derived Chl-a against HPLC-derived Chl-a using A) stringent and B) relaxed flags and matchup criteria

Interestingly, the slope obtained when the matchup criteria were relaxed was closer to 1 (the ideal case) with a value of 0.86 than with the stringent criteria (slope of 0.48, Figure 2). However, the r2 was higher with a value of 0.50 against 0.26 for the stringent and relaxed criteria respectively, showing that the relaxed criteria showed more discrepancy around the linear regression. The RMSLE was roughly the same for both sets with values of 0.52 and 0.54 for the stringent and relaxed criteria respectively. Given the low number of matchups, the statistics may be influenced by a few outliers as seen for the relaxed criteria (Figure 2B) which might artificially increase the slope of the linear regression. The comparison did not show obvious differences between the winter/spring (green points) and summer/fall (red points) subsets.

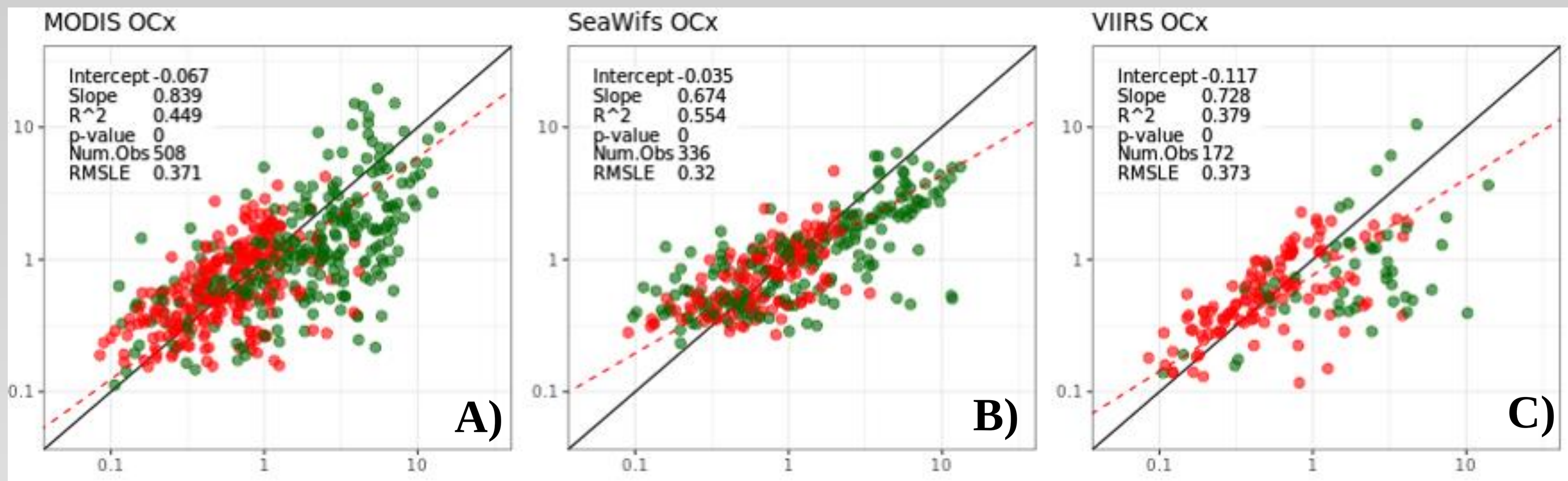

Figure 3: Satellite-derived Chl-a against HPLC-derived Chl-a for A) MODIS, B) SeaWiFS and C) VIIRS

When using the relaxed matchup criteria, which are similar to the ones selected by Clay et al. (2019), SGLI-derived Chl-a showed consistent performance with the MODIS, SeaWIFS and VIIRS sensors. With a slope of 0.86, SGLI has the closest slope to 1, while MODIS, SeaWIFS and VIIRS Chl-a values were 0.84, 0.67 and 0.73 respectively. However, SGLI Chl-a exhibited the lowest correlation coefficient (0.26) and the highest RMSLE values, perhaps due to two outliers showing abnormal high values (i.e., > 80 mg m-3). SGLI number of matchups (125) was closest to VIIRS number of matchups (172), such that the impact of number of matchups within this comparison is reduced, and VIIRS' performance is better than that of SGLI (higher r2, lower RMSLE), despite its lower slope.

In conclusion, SGLI-derived Chl-a in the Northwest Atlantic are comparable to current satellite performances and is suitable for monitoring the marine ecosystem in that region. One can expect an improvement of the comparison between SGLI-derived and in situ derived Chl-a as the number of matchups increases. The next step will be to evaluate other bio-optical properties such as inherent optical properties (i.e., phytoplankton and yellow substance absorption coefficient) and the diffuse attenuation coefficient, which are collected during the AZMP and AZOMP surveys

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