Comparison of observed and remotely sensed chlorophyll in Icelandic waters

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Can global satellite datasets provide satisfactory estimates of chlorophyll in Icelandic waters?

Introduction

The Icelandic shelf area is ranked among the most productive in terms of annual primary production. However, phytoplankton growth is highly variable, both spatially and temporally due to factors like vertical winter mixing, stratification *v.s.* wind stress, upwelling and cloud cover (Ólafsdóttir 2006, Thórdardóttir 1986).

In order to evaluate the influence of phytoplankton growth on survival and growth of other organisms, it is important to have access to spatially and temporally resolved information on variation in primary production.

To estimate the feasibility of using remote sensing data to construct such indices, this study attempts to evaluate how representative surface chlorophyll derived from records from satellite borne remote sensors (CHL1 and CHL2) is, compared to that measured from water samples (chl-*a*) obtained from MRI's surveys in Icelandic waters. In this study we use a finer scaled data, temporarily and spatially, than in previous studies in this area.

Materials and methods

Available measurements of surface chlorophyll (mg chl-*a* m^3, in water samples from 0 – 5 m) sampled around Iceland (58°N to 72°N and 2° to 40°W) during 1998 to 2012, were collated from MRI's datafiles. A total of 2503 observation points for chl-*a* were obtained (Figure 1).

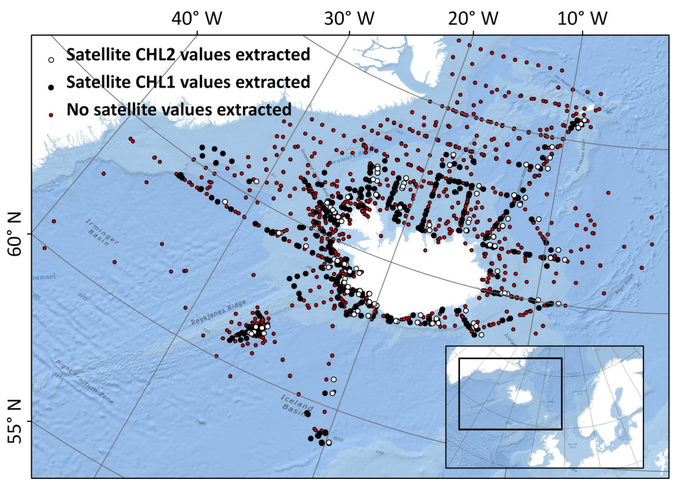

Figure 1. Observation points for chl-*a* (all points) . Locations where extraction for satellite values was successful is identified with black (CHL1) and white (CHL2) points. Note that location of successful CHL2 values is slightly offset for visual purposes. (Base map: ESRI 2012).

Satellite CHL1 and CHL2 values, assuming Case 1 (open) and Case 2 (coastal and/or turbid) waters respectfully, were extracted from the Globcolour dataset (http://www.globcolour.info), using BEAM VISAT freeware provided by ESA . The spatial resolution selected was 4.6 km and temporal resolution of one day.

Results

This study revealed that overall correlation between *in situ* chl-*a* in Icelandic waters and satellite CHL1 and CH2 respectively are significant ($p<0.001$) and moderately strong (Figure 2). The correlation coefficient was very similar for the two satellite variables, or r=0.69 (n=436) for CHL1 and r=0.68 (n=137) for CHL2. Moreover, both the variables underestimate chlorophyll when concentrations are high, as well as overestimating the lower ones, on average.

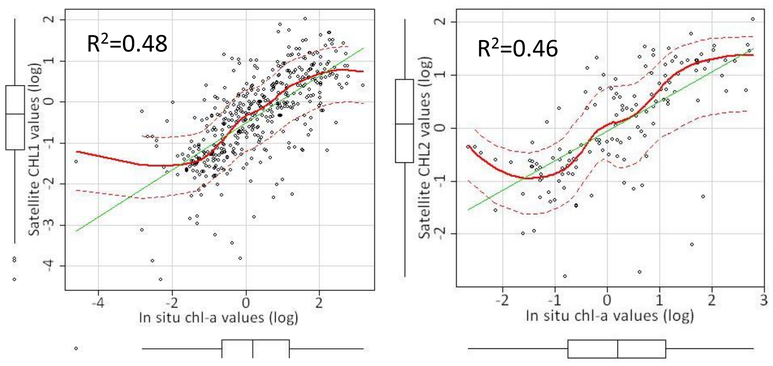

Figure 2. Scatter plot depicting how well the satellite variables CHL1 (A) and CHL2 (B) correlate to *in situ* observations. The red line represents loess smoother and the dotted red lines a 95% confidence level for the smoother.

Spatial differences

Spatial differences were evident as depth at sampling sites had effect on the strength of the correlation. Weaker correlation was obtained from analysis of a subset of the CHL1 data pairs, where bottom depth is less than 200 m (r= 0.61, n=179, $p<0.001$) compared to that with bottom depth >200m (r= 0.71, n =257, $p<0.001$ Figure 3). Similar r-values were obtained for that of CHL2.

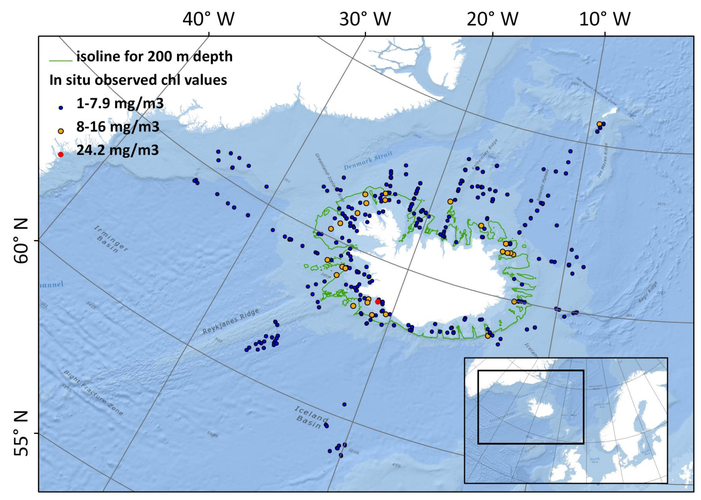

Figure 3. Spatial distribution of high and low values of *in situ* observations . Green line delineates 200m depth (Base map: ESRI 2012).

Effects of turbidity

Excluding the turbidity flagged values in the satellite data improves the strength of the correlation. The correlation for non-turbid values was r= 0.71 (n=327, $p<0.001$) for CHL1 and r=0.73 (n=103, $p<0.001$) for CHL2.

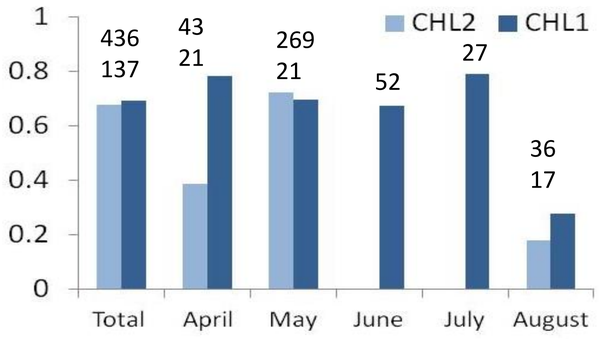

Figure 4. Average seasonal differences. Pearson's correlation coefficients values (y-axis) for the different sampling months for both CHL1 and CHL2. Numbers above columns are numbers of observations. CHL1 above, CHL2 below.

Temporal differences

Large inter-annual differences are evident with strong significant correlations between chl-*a* and CHL1 in April (r=0.78), July (r=0.78) and May for CHL2 (r=0.72), while correlations in August were non-significant (r=0.28 and p=0.1 for CHL1 and r=0.18 and p=0.5 for CHL2; Figure 4).

Discussion and Conclusions

The overall correlation for CHL1 (r^2=0.48) obtained in presented study is low in comparison with that obtained for a global validation of the Globcolour dataset (Globcolour 2007) for areas defined as Case 1 waters (r^2=0.83, n=711) and much higher than obtained for Case 2 waters (r^2=0.16, n=99). Based on the results presented here it is not possible to determine if Icelandic waters should be classified as Case 1 or Case 2 waters. The similar strength of correlation for both CHL1 and CHL2 does not give any supplementary clues, while the considerable stronger correlation for pixel not flagged for turbidity stress the variable conditions one may expect. Accordingly, the waters around Iceland may be characterized, as Lee and Hu (2006) did, as border case of that defined as Case 1 and Case 2 waters, with considerable temporal and spatial variations.

To conclude, the Globcolour dataset is a valuable source of information on phytoplankton abundance in the surface layer. Thus, it may provide important information on the development of phytoplankton during the growth season, from March/April to October, which can be used in ecological studies on regional scale in Icelandic waters. Present study will facilitate future studies on the temporal and spatial changes in phytoplankton (chlorophyll/biomass) at the surface, which in turn will be important for the calculations of spatial and temporal changes in primary production.

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