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A regional correction model for satellite surface chlorophyll concentrations, based on measurements from sea water samples collected around Iceland

Kristinn Guðmundsson [a,*], Kristín Ágústsdóttir [b,c], Niall McGinty [b,d], Árni Magnússon [a,e], Hafsteinn Guðfinnsson [a], Guðrún Marteinsdóttir [b]

[a] *Marine Research Institute, PO Box 1390, 121 Reykjavík, Iceland*
[b] *MARICE, University of Iceland, Reykjavík, Iceland*
[c] *East Iceland Nature Research Centre, Neskaupstaður, Iceland*
[d] *Marine Macroecology and Biogeochemistry Lab, Mount Allison University, Sackville, NB, Canada*
[e] *ICES Secretariat, Copenhagen, Denmark*

HIGHLIGHTS

- Chlorophyll *a* concentrations are measured indirectly from satellites.
- In the North Atlantic, the satellite measurements do not match *in situ* measurements.
- A multiple linear regression model is calibrated based on regional chlorophyll data.
- Regionally corrected satellite measurements are much closer to *in situ* measurements.

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ABSTRACT

Near-surface chlorophyll *a* concentration is a fundamental component of marine ecological processes, and its changes reflect the phytoplankton growth (primary productivity as well as loss due to grazing and sinking) feeding into higher trophic levels. Time series of measurements from several satellite sensors since late 1997 can be used as a proxy of chlorophyll *a* concentrations after calibrating against direct sea water measurements from oceanographic surveys. Previous studies indicate a need for a regional correction model in specific 'case 2' areas, where the relationship between

* Corresponding author.
E-mail address: kristinn@hafro.is (K. Guðmundsson).

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satellite measurements and *in situ* measurements is different from the relationship in the general 'case 1' areas, due to complex environmental characteristics in different areas. Subarctic and boreal North Atlantic, including the waters around Iceland, have been considered case 2 waters, but a regional correction model has not been developed until now. We collated all relevant measurements of near-surface chlorophyll *a* from sea water samples, available in the Marine Research Institute database, and matched by date and location with satellite chlorophyll records, i.e. the GSM CHL1 records offered by the GlobColour Project. A multiple linear regression model was fitted to the observed *in situ* chlorophyll measurements, based on the satellite chlorophyll values (CHL1) and physical covariates: day of the year, sun elevation, and ocean depth. The resulting parsimonious model converts the satellite measurements to estimates that are in much better agreement with *in situ* measurements (R^2 increases from 0.2 to 0.5), and is therefore proposed for calibration of regional corrections to the GlobColour Project's GSM chlorophyll parameter, CHL1.

1. Introduction

The advent of remotely sensed surface chlorophyll *a* data has allowed for the analysis of high frequency temporal and spatial changes in surface phytoplankton biomass. This has promoted the application of satellite chlorophyll in a variety of ecological studies, e.g. phytoplankton phenology and climatology (Edwards and Richardson, 2004; Henson et al., 2009; Sapiano et al., 2012; Zhai et al., 2012; Ferreira et al., 2015) and diverse trophic studies (Koeller et al., 2009; Platt et al., 2003; Trzcinski et al., 2013; Ágústsdóttir, 2013; Silva et al., 2014; Leaf and Friedland, 2014). While a global evaluation of satellite products is adequately covered and part of the standard protocol (GlobColour Project, 2010; Brewin et al., 2014), regional evaluation of the satellite chlorophyll data is often lacking, although essential for the interpretation of information derived from the satellite data, e.g. phytoplankton phenological indices. This may be especially true for areas where case 2 (Morel and Prieur, 1977) or turbid water may be expected. Regional comparisons of satellite chlorophyll against that of concurrent *in situ* measurements are needed for evaluating both bias and error of the satellite chlorophyll, and analysis of possible systematic errors.

The Icelandic shelf area is ranked among the most productive, both in terms of annual primary production and fish yield (Chassot et al., 2010). Phytoplankton growth across the shelf is highly variable both spatially and temporally due to changes in environmental conditions, such as vertical mixing and nutrient availability (Stefánsson and Ólafsson, 1991; Thórdardóttir, 1986; Ólafsdóttir, 2006), as well as available light for photosynthesis (Thórdardóttir, 1986; Guðmundsson et al., 2004). To study variability in the primary food source for marine organisms, e.g. the phytoplankton biomass, there is a need for the relevant information at the right scales. So far, the monitoring programs measuring phytoplankton and primary productivity in the area have been predominantly restricted to annual surveys, conducted in late May. The inclusion of satellite data ultimately adds to both the spatial and temporal dimensions of observations in the research area.

The subarctic region of the North Atlantic, including that around Iceland, is frequently claimed to be case 2 waters (Henson et al., 2009; Gregg and Casey, 2004), where the relationship between satellite measurements and *in situ* measurements is different from the relationship in the general case 1 areas, but as shown by Lee and Hu (2006) one definition need not apply to the same location throughout the growth season, or for the whole region all the time. The interaction of a diverse number of variables may affect this locally and on different temporal scales, for instance due to runoff, dust storms or