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Comparison of primary productivity estimates in the Baltic Sea based on the DESAMBEM algorithm with estimates based on other similar algorithms*

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Abstract

The quasi-synoptic view available from satellites has been broadly used in recent years to observe in near-real time the large-scale dynamics of marine ecosystems and to estimate primary productivity in the world ocean. However, the standard global NASA ocean colour algorithms generally do not produce good results in the Baltic Sea. In this paper, we compare the ability of seven algorithms to estimate depth-integrated daily primary production (PP, mg C m^{-2}) in the Baltic Sea. All the algorithms use surface chlorophyll concentration, sea surface temperature, photosynthetic available radiation, latitude, longitude and day of the year as input data. Algorithm-derived PP is then compared with PP estimates obtained from

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^{14}C uptake measurements. The results indicate that the best agreement between the modelled and measured PP in the Baltic Sea is obtained with the DESAMBEM algorithm. This result supports the notion that a regional approach should be used in the interpretation of ocean colour satellite data in the Baltic Sea.

1. Introduction

The quasi-synoptic view available from satellites makes it possible to observe the large-scale dynamics of marine ecosystems in near-real time. It is worth using these observations to quantify oceanic primary productivity (PP). Comparable, large-scale, observations cannot be achieved solely from ship-based PP measurements. Therefore, special efforts have been made in recent years to develop and evaluate algorithms for estimating primary productivity from satellite remote sensing products such as surface Chl *a* concentration (Chl), sea-surface temperature (SST) and photosynthetically available radiation (PAR) (e.g. Antoine et al. 1996, Behrenfeld & Falkowski 1997, Campbell et al. 2002, Carr et al. 2006, Friedrichs et al. 2009, Saba et al. 2011). Another way of assessing large-scale PP is to use coupled biogeochemical (BG) marine numerical models. With the enhanced computational capabilities of modern computers, BG models can now be run at appropriate horizontal and vertical resolutions to provide large-scale daily estimates of PP. Calculating accurate PP estimates over large areas is a crucial step in BG models, which are also used for assessing higher trophic dynamics, including zooplankton and even fish life cycles (e.g. Kiefer et al. 2011). BG models parameterize photosynthesis in much the same way as satellite PP algorithms. The main difference between the two approaches, however, is that satellite algorithms require satellite estimates of surface chlorophyll and temperature as input variables (e.g. O'Reilly et al. 1998, 2000, McClain 2008), whereas BG models explicitly compute these fields (although sometimes BG models can also assimilate satellite surface chlorophyll and SST data; see e.g. Gregg 2008). In addition, BG models simulate concentrations of nutrients, detritus, and often more than one functional or size groups of phytoplankton and zooplankton. They also incorporate mechanistic knowledge of nutrient uptake and physical transport of nutrients and biomass – information that is not derived directly from remote sensing PP algorithms.

Marine primary productivity is a large and highly variable component of the global carbon cycle and drives the oceanic biogeochemical cycles of other major chemical elements such as oxygen, iron, silicon, nitrogen and phosphorus. PP estimates from BG models and/or satellite data have been used for quantifying the air-sea flux of carbon dioxide (e.g. Bianchi et al. 2005), export production (e.g. Boyd & Trull 2007) and the