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Phyto-VFP: a bio-optical model of pelagic PP based on variable fluorescence measures

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The estimation of pelagic primary production (PP), which provides an essential input for the quantification of carbon flux in the ocean, can be performed by several empirical models that vary in both their type (carbon based vs chlorophyll based) and complexity (depth and wavelength integrated vs resolved).
Photo-acclimation, defined as a phenotypic response of photoautotrophic organisms to availability of light in the environment, largely influences the primary production rate performed by phytoplankton in the marine environment, but most models for the PE-curve neglect these responses. Also the dynamic conditions of the water column must be integrated into the empirical models as they are strictly related with the photo-physiological parameters of the phytoplankton populations.
In this work we develop a new bio-optical model, named Phyto-VFP (Phytoplankton Variable Fluorescence Production), combining phytoplankton physiological processes with the dynamic features of the water column, with the purpose to improve the PP estimation. It is classified as a Wavelength and Depth resolved (WRDR) model and is based on photosynthetic parameters derived from measures of variable fluorescence of both phytoplankton cultures and natural assemblages to analyse the effect of short-term (or dynamic) and long-term (or static) photo-acclimation processes. The dynamic acclimation is modelled assigning constant values to photosynthetic parameters (PE), while the static conditions is reproduced using PE parameters obtained by a series of laboratory experiments conducted on selected model species exposed to three different irradiance levels (500, 300, 25 μE m-2 s-1) related to the upper, intermediate and deep layers.
The performance of Phyto-VFP model is evaluated by means of radiocarbon (14C) uptakes carried out during the SAMCA3 (Messina Strait) and SAMCA4 (Southern Adriatic Sea) oceanographic cruises under different dynamic and optical conditions of the water column. The good correlation (r2=0.81) between measured and computed data shows the ability of Phyto-VFP model in reproducing properly the phytoplankton photo-acclimation processes needed for an accurate estimation of the integratedoceanic PP.
Nevertheless the validation of the model would profit of a larger dataset of radiocarbon (14C) uptakes, carried out in others oceanic regions with different dynamical, optical and trophic conditions. The estimates of the PP can also be improved by analysing the photo-physiological characteristics of other model phytoplankton species and/or directly of natural assemblages, through in-situ mesocosm experiments.