PATTERNS OF PHYTOPLANKTON CHLOROPHYLL VARIABILITY IN THE MEDITERRANEAN AND BLACK SEAS

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Abstract

Time series decomposition of remote sensing observations (Aqua-MODIS) of sea surface chlorophyll (SSC) since July 2002 to June 2009 is performed at various coastal and open sea areas in the Mediterranean and Black Seas. The evolution of SSC is assessed against satellite sea surface temperature (SST) and wind vector data provided by ECMWF, in order to disclose possible connections of the environmental variables on the regional chlorophyll trends. The interaction between SSC and the environmental variables is assessed using time-lagged cross-correlations of the variables. Then, the time lags showing the highest significant correlations were chosen for further hypothesis validation using generalized additive models. Results are discussed within the framework of seasonal changes in the Mediterranean area and at global scale.

Keywords: Time Series, Chlorophyll-a, Temperature, Wind/Font

Introduction

Atypical warmer summers and cooler winters have been reported in recent years in the Mediterranean Sea areas. For instance, winter periods in the Gulf of Lions, like those in 1999 and 2005 were atypically cooler and windy, producing submarine cascades with vertical velocity of 80 cm s^{-1} from nominal 10 cm s^{-1}, thus altering benthic organisms and transporting down from surface an atypical large amount of organic matter [1], [2]. We postulate the hypothesis that local unusual seasonal events could leave a signal in upper water layers properties (i.e. not only in the bottom), as they have a direct connection with the atmosphere. Phytoplankton species, with relatively fast growing rates are good indicators of environmental changes. Temperature and wind strength are responsible for changes in surface water density and are potential factors for inducing surface fertilization (increasing phytoplankton primary production) and transporting phytoplankton from surface to deeper water layers altering phytoplankton primary production. The present study deals with sea surface phytoplankton chlorophylls variability in the last seven years (2002-2009) and its relationship with sea surface temperature and wind velocity.

Methods

Twelve locations were selected in the Mediterranean seas and Black Seas for the present study (Fig. 1). Inter-annual trends of 8-day AQUA-MODIS composite SSC and SST, along with 8-day ECMWF composite wind velocity estimated from vectors u and v at 10 above the sea surface, from the week 24 in 2002 up to the week 23 in 2009, were assessed using loess smoothing (non-linear). Then, cross-correlation analyses of chlorophyll time series against SST and wind velocity was performed to investigate for potential real-time and time-lagged connections. Finally, hypothesis validation of potential connections between chlorophylls and the environmental variables was performed using Generalised Additive Models.

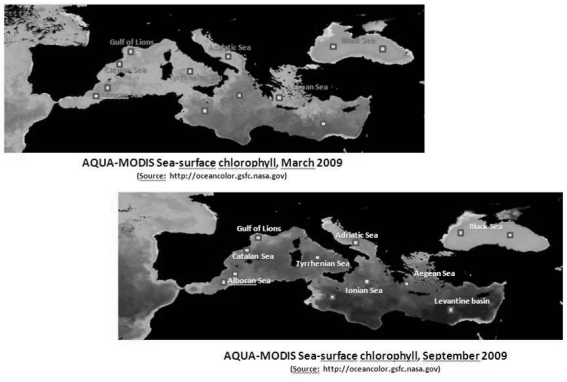

Fig. 1. Monthly composition of Aqua-MODIS sea-surface chlorophylls in the Mediterranean and Black seas(Source:http://oceancolor.gsfc.nasa.gov)

Results

Trends of surface chlorophylls along with temperature and wind velocity are not linear. Chlorophylls in Aegean Sea and Levantine basins show an upward trend of 0.25 mg m^{-3} in last seven years. Seasonal patterns of surface temperature and wind velocity are local, not extending to the whole Mediterranean area, as reported from mesoscale models [3]. Events of highest and lowest values of the variables are generally equivalent to those values observed in the past. Present data do not provide evidence of clear (linear) trends of the variables within last seven years. Just a few local trends seem to be linear, but their linearity is not guaranteed with time. Wind velocity is an environmental factor explaining a minor part of the chlorophyll variability in surface waters in the Mediterranean stations. Most of the chlorophyll variability is generally explained by SST. Relatively strong winds in the Gulf of Lion and Aegean Sea do not affect significantly the surface chlorophyll variability. In the Gulf of Lion, factors other than SST and wind (such as river discharges) are responsible for the variability of surface chlorophylls, whereas in the Aegean Sea, SST is an important factor explaining most (70%) of total phytoplankton variability. In the Levantine basin, SST by itself (i.e. with no covariates in a model) explains the highest variability of surface chlorophyll (81%) compared with the lower variability explained by the models in the remaining 11 stations. The prediction of surface chlorophylls in the Black Sea slightly improves with the addition of wind velocity to SST as explanatory variable. The stations in the Black Sea are the least influenced by SST and winds. The upper water layers of the pelagic ecosystem could not be strongly altered by extreme changes in wind regimes. The pelagic ecosystem was generally sensitive to changes in SST, except in the areas of strong influence of river discharges such as the Gulf of Lions. This leads us to suggest that atypical cool and windy winter seasons in the Gulf of Lions, although altering the deep ocean, do not seem to affect the upper layers of the pelagic ecosystem. Further analysis with data taken in the areas around the deep canyons (where cascading events takes place) in the Gulf of Lions is required to validate the present conclusion.

References

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