ECOSYSTEM RESPONSE TO THE ATMOSPHERIC FORCING IN THE SOUTHERN LIGURIAN SEA IN 1997–1999

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Abstract

A coupled hydrodynamic-biological model — *MODECOGeL* [1, 2] — is applied to the southern Ligurian Sea. The model is forced with a high sampling meteorological data measured from an automatic weather station located in STARESO (Calvi, Corsica). Two simulations (from October 1997 to September 1998 and from October 1998 to September 1999) have been performed with the model. The results corroborate the general pattern of phytoplankton seasonal dynamics observed in SeaWiFS remote-sensed data and, in particular, the higher phytoplanktonic biomass observed in 1999 is well reproduced by the model [3].

Keywords: Ligurian Sea, models, blooms

Introduction

The biological production heterogeneity of the Ligurian Sea is closely associated with local and regional hydrodynamical factors, especially those responsible for a high variability of the mixed layer depth in such a strongly stratified environment. This area is typically oligotrophic and therefore, any supply of nutrients is extremely important for the primary production. Moreover, the overall system is dominated by a marked seasonal cycle as a result of the meteorological signal, with high phytoplankton biomass observed during cold windy winter-spring period. The intensity of winter-spring phytoplankton bloom also performs a significant interannual variability. The difference between two seasonal cycles (from October 1997 to September 1999) illustrates the response of phytoplankton dynamics to local meteorological conditions. We develop here a model in order to explain the observations obtained from satellite data [3], especially the higher phytoplanktonic biomass found in 1999. Considering that the establishment and decay of the thermocline are strongly dependent on the atmospheric conditions, the model will be forced by surface wind stress and heat fluxes computed from real meteorological conditions, a high rate sampling meteorological data allowing simulations that give confidence in the mixed layer dynamics [4].

Model

The coupled **MODECOGeL** model, implemented, calibrated and validated for the northern Ligurian Sea using long term (1984–1988) experimental data from the French Frontal program surveys, is thoroughly presented in [1][2]. The hydrodynamic model is a 1D version of the multi-levels, turbulent closure, G.H.E.R. (*G*eo*H*ydrodynamics and *E*nvironment *R*esearch, University of Liège, Belgium) model. The ecosystem model is a 12 state variables one based on the L.O.B.E.P.M. (*L*aboratoire d'*O*céanologie *B*iologique et d'*E*cologie du *P*lancton *M*arin, University of Paris VI, Villefranche-sur-mer, France) works. It takes into account 12 state variables based on size-classes. It is worth attention that, while the annual average of wind intensity was higher during the year 1997/1998 than in 1998/1999 (5.07 m/s versus 4.94 m/s), the year 1997/1998 was characterized by higher winds during autumn, spring and summer while during the year 1998/1999 the winter was windier. The winter winds are particularly important for the deepening of the mixed layer.

Results and discussion

Among the results of the model, we will focus on distributions of turbulent kinetic energy (Figures 1a and 1b) and temperature (Figures 1c and 1d) for both periods (97/98 and 98/99). The observation of the turbulent kinetic energy indicates that winter mixing was clearly more intense in 1999, where the mixed layer deepened down to 400 m at the end of February. The beginning of the stratified period started in May. This effect was faster in May 1999 (windier than May 1998) while the surface warming was higher in May 1998. As soon as the end of May, this tendency was reversed. In 1999, the summer (less windy) was characterized by a higher surface temperature and a sharp thermocline. This one was less deep than in 1998. The end of September 1998 was marked by a strong wind event followed by a drop of the mixed layer depth and the thermocline. The complete destratification took place sooner in winter 1998/1999 as compared to winter 1997/1998 because of a windier winter.

Figure 2 shows the time-depth distribution of nitrate and chlorophyll for both years. It appears clearly that the 1999 bloom is higher than the one in 1998. At the light of physical results one can explain the higher phytoplanktonic biomass in 1999. The year 1999 shown a very strong winter mixing – as compared to 1998 – that could allow an important nutrients supply in the surface layer, giving rise to an intense spring bloom. An important nutrient input constitutes storage for the summer and should allow, in favourable meteorological conditions, to ensure a summer more intensive phytoplanktonic production despite of the strong stratification. On the other hand, during winter 1997/1998, the less intense mixing is not sufficient to bring up high nutrients concentration into the euphotic layer, resulting thus in a weaker phytoplanktonic production.

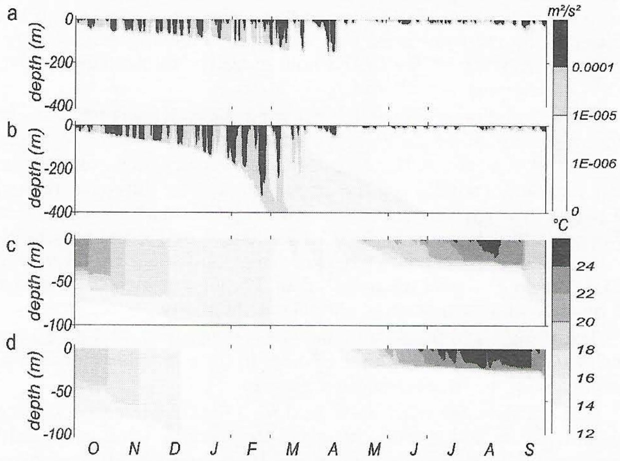

Figure 1. Time-depth evolution of the physical variables computed by the model. Turbulent kinetic energy (a) in 1997-1998 and (b) in 1998-1999. Temperature (c) in 1997-1998 and (d) in 1998-1999.

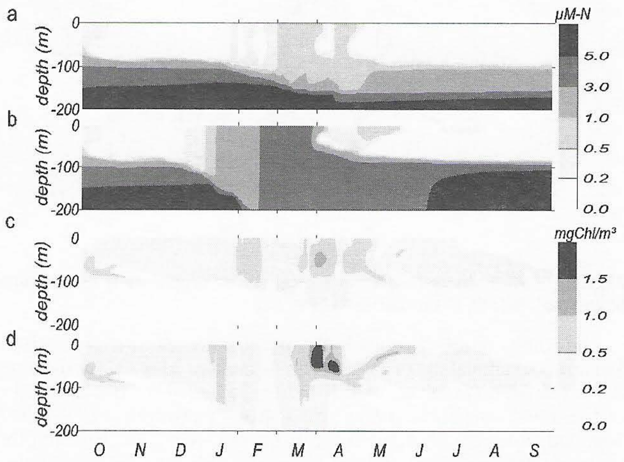

Figure 2. Time-depth evolution of the biological variables computed by the model. Nitrate (a) in 1997-1998 and (b) in 1998-1999. Chlorophyll (c) in 1997-1998 and (d) in 1998-1999.

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