Picophytoplankton dynamics and chlorophyll distributions in a 2D spatial domain: stochastic model vs field data

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The spatio-temporal dynamics of four phytoplankton populations, responsible for about 80% of the total *chlorophyll a*, is modeled in a two-dimensional spatial domain by using initially a deterministic model based on advection-reaction-diffusion equations. Two limiting factors are considered, i.e. light intensity and nutrient concentration. Specifically, due to the characteristics of the marine ecosystem analyzed (South Mediterranean Sea), phosphorus is the nutrient component playing the role of limiting factor for the growth of the phytoplankton populations.

Phytoplankton abundances, obtained by solving numerically the deterministic model, are converted in *chlorophyll a* concentrations[1] and compared with field data collected in twelve marine sites along the Cape Passero (Sicily)-Misurata (Libya) transect[2,3].

Ecosystems however are open structures continuously subject not only to deterministic perturbations but also to random fluctuations coming from the environment. Deterministic models can not therefore account for the effects due to the intrinsic stochasticity present in a natural system. As a consequence, to take into account the environmental random fluctuations which affect the marine ecosystem considered, the deterministic advection-reaction-diffusion equations are modified by inserting terms of Gaussian noise[4]. The stochastic model allows to obtain distributions of chlorophyll concentration in a better agreement with the field data, in comparison with the deterministic approach, as confirmed by statistical checks based on χ^2 test.

A major issue of this work is that the phytoplankton dynamics is modeled by exploiting real values for physical and biological variables, i.e. hydrological and nutrients data acquired in situ, and including intraspecific competition for limiting factors, i.e. light intensity and phosphate concentration. In particular, the analysis permits to investigate the effect of the velocity field of marine currents and the two components of turbulent diffusivity on the spatial distributions of phytoplankton abundances in the Modified Atlantic Water, the upper layer of the water column of the Mediterranean Sea.

The analysis presented in this work can be considered as a case study and can be applied to different marine ecosystems within the Mediterranean basin, to predict the spatio-temporal behaviour of the primary production, and to prevent the consequent decline of some fish species in the Mediterranean Sea.

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