Biological production and plankton dynamics in a turbulent ocean upwelling system

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The interaction of fluid flow with the biology of organisms living in the water is a topic of confluence of hydrodynamics, statistical and nonlinear physics, ecological modelling, and Earth sciences[1]. Upwelling systems, i.e. ocean areas were vertical water motions bring nutrients towards the ocean surface were phytoplankton can combine them with light availability, are the most productive regions in the global oceans. They are generally located at the eastern boundaries of the different Earth oceans.

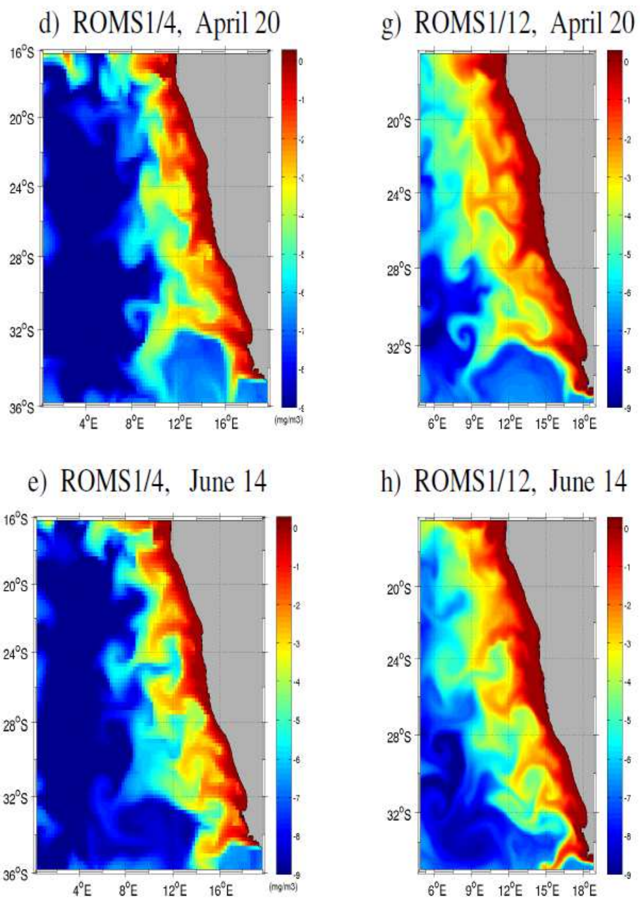

FIG. 1. Phytoplankton distributions obtained from the NPZ model of biological interactions coupled with the flow field from the ROMS model at 1/4 ° resolution (left) and 1/12 ° resolution (left). Colorbar in mg/m^3 (log scale).

Recent studies, both based on remote sensed data and coupled models, showed a reduction of biological productivity due to vigorous horizontal mixing in these upwelling regions[2–4]. This seems to contrast with other observations of productivity enhancement in open ocean areas much poorer in nutrients. In order to better understand this phenomenon, and in general the interplay between flow and biological growth, we have considered the oceanic flow in the Benguela area (West-South African coast) coupled with a simple biogeochemical model of Nutrient-Phyto-Zooplankton (NPZ) type. For the flow three different surface velocity fields are considered: one derived from satellite altimetry data, and the other two from a regional numerical model at two different spatial resolutions. We computed horizontal particle dispersion in terms of Lyapunov Exponents, and analyzed their correlations with phytoplankton concentrations. Our modelling approach confirms that in the south Benguela there is a reduction of biological activity when stirring is increased. Two-dimensional offshore advection seems to be the dominant process involved. In the northern area, other factors not taken into account in our simulation are in influencing the ecosystem. We provide explanations for these results in the context of studies performed in other Eastern Boundary upwelling areas.

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