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3D coupled physical and biogeochemical modelling approach: limitation on biological productions by the different nutrients in Marseilles coastal area.

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The eastern part of the Gulf of Lions is a coastal environment which is strongly influenced by physical forcing (upwelling, intrusions of the Northern Current, wind vertical mixing, stratification by heat fluxes) and biogeochemical inputs (Rhone River, Marseilles city inputs). However, this area remains mainly an oligotrophic ecosystem. The aim of this study was to develop, validate, and use a three-dimensional physical-biogeochemical coupled model, in order to better understand the role of the physical forcing on the modulation of the strong impact of natural and anthropogenic inputs (nutrients and organic matter). In the present work, we were particularly interested in the occurrence in space and time of the most restrictive nutrient (N, P, and C) limitation controlling the primary production and the bacterial production.

The biogeochemical model ECO3M (Faure et al, 2010a) was coupled 'online' with the 3D hydrodynamic model MARS3D (RHOMA configuration) validated by Pairaud et al (2011). The initial biogeochemical model ECO3M was adapted with a new parameterization to the study area and a sensitivity analysis was performed. In the Mediterranean Sea, primary production is often limited by phosphorus. As the Rhone River inputs have high N/P ratio for dissolved inorganic matter (DIM) which could induce a limitation of biological processes by phosphorus, the cycle of phosphorus was included in the biogeochemical model. The new model version (ECO3M-MASSILIA) was based on the Carbon, Nitrogen and Phosphorus cycles and had 17 state variables. The model also took into account variable stoichiometry of elements in each biological compartment.

Realistic 3D simulations for the period from 01/05/2007 until 31/12/2007 highlighted the importance and complexity of the different forcing in this area influenced by numerous natural and anthropogenic inputs. For example, rich nutrients water issued from the Rhone River reach Marseilles coastal area several times. Marseille's urban rivers discharged nutrient and organic matter, which had sometimes a significant impact on the biological production of the coastal ecosystem. Winds created strong upwelling episodes responsible for nutrient inputs in the surface layer, which led to an increase of the primary production, especially in spring and summer. In contrast, intense upwelling in late autumn appeared to play a key role in the water column mixing process. Finally, rapid shifts between the different nutrients controlling the biological production were observed in relation with physical forcing.

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