PhD THESIS (2011-2014)

Contribution of marine plankton to atmospheric carbon sequestration in the Mediterranean Sea

***Keywords*–** Mediterranean Sea, global change, carbon pumps, marine plankton

Context of the PhD research and objectives– The Mediterranean Sea is usually considered to be a model of the global ocean, especially because of the formation of deep waters in specific areas (Aegean Sea, Adriatic, MEDOC zone), an overturning circulation and restricted exchanges with the Atlantic Ocean. The Mediterranean Sea also has high mesoscale activity (meanders of coastal currents, front areas, eddies) and the impacts of this activity on marine biogeochemistry is still poorly understood. Spatio-temporal distributions of primary productivity and plankton functional types are very contrasting across the Mediterranean Sea. For example, chlorophyll concentrations are mostly as low as 0.1 mg m^{-3} over large Mediterranean areas but they can reach values well above 1 mg m^{-3} in specific areas such as in the Alboran Sea and North Balearic front. Understanding the main factors controlling these distributions requires thorough study.

The first objective of this PhD Thesis is to understand which physical and biogeochemical factors mainly influence the distributions of primary productivity and plankton functional types on an annual scale using numerical modelling.

The second objective is to assess the intensity of the two main processes contributing to the atmospheric CO_2 incorporation in the Mediterranean Sea: the physical pump (solubility, vertical mixing) and the biological pump through photosynthesis and export processes (Toggweiller, 1993). Many previous studies have already estimated these contributions at the global Ocean scale (e.g. Joos, et al. 1996; Toggweiller et al. 2003ab, Marinov et al., 2010) but quantifications at the ocean basin scale (Scott et al., 2010) are more rare, especially in the Mediterranean Sea. The convective areas in winter are regions where the physical C-pump can potentially transport high amounts of carbon to the deep waters. For the biological C-pump it would be also interesting to determine the dominant form of organic carbon exported to the deep ocean especially in the most oligotrophic eastern basin for which the dissolved organic fraction may be the dominant form of exported carbon (*e.g.* Avril, 2002). **The overall goal is to quantify the fluxes associated to each of the C–pumps at different temporal (seasonal and interannual scales) and spatial scales (basins, sub-basins). This quantification should characterize and forecast the ability of the Mediterranean Sea to trap the atmospheric CO_2 at a decadal time scale.**

Methodology and tools– The coupled physical-biogeochemical modelling tool will be used to determine the effects of the different forcings on the plankton dynamics and to identify their respective roles on the specific features of the Med. Sea. The numerical tools used in this thesis will be the hydrodynamic model NEMO-MED12 (ORCA grid 1/12°) coupled to a biogeochemical model implemented on the Eco3M platform and developed at the LOPB (Baklouti et al., 2006a,b). The Eco3M modelling tool is a modular tool that handles multi-element multi-functional group biogeochemical processes. Most of the biogeochemical processes included in the Eco3M numerical library are based on mechanistic considerations. Eco3M is particularly suitable for the representation of the pelagic ecosystem of the Mediterranean Sea since it is able to model the planktonic growth submitted to multiple nutrient limitations, the process of diazotrophy and the seasonal planktonic successions.

Comparisons will be systematically done between model outputs and the available data set (in situ data, satellite images) to validate the model simulations.

PhD planning– The numerical tool will be technically operational at the beginning of the PhD. The first year will be dedicated to test simulations, to collecting different data for initialization and validation of the coupled model. The second year will be dedicated to improving the understanding of the Mediterranean ecosystem dynamics and specific biogeochemical features (first objective of PhD). The second objective (carbon budgets) will be reached during the third year.

Candidate profile– Modelling of ecosystems and hydrodynamics, knowledge of biogeochemical and hydrodynamic ocean functioning is recommended. Programming and software: matlab®, Fortran 90, svn.

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Laboratory/Location– Laboratoire d'Océanographie Physique et Biogéochimique (LOPB) - Centre d'Océanologie de Marseille, Université de la Méditerranée (France).
The LOPB is a joint laboratory of the CNRS, IRD and Université de la Méditerranée at Marseille and from 2012 this laboratory will be integrated in the Mediterranean Institue of Oceanocgraphy (MIO) which will constitute a 210 person oceanography institute. The LOPB has long research experience of excellence in marine sciences. It is a member of Europe Network of Excellence for Ocean Ecosystem Analysis and the European Integrated Project SESAME (Southern European Seas: Assessing and Modelling Ecosystem changes) with strengths in marine ecosystems, food web, climate change and resource–socioeconomics. The LOPB has been leading a number of national (LEFE CYBER/IDAO, EC2CO) and international (IMBER-IMBIZO, GLOBEC, SOLAS, EUROCEANS consortium) projects studying physical and biogeochemical processes inducing the primary production and matter fluxes in the Atlantic Ocean, Southern Ocean and Mediterranean Sea. Strong efforts in ecosystem modelling have been made in the last 10 years at the LOPB.

Collaborations– The PhD will be carried out in close collaboration with Dr. K. BERANGER (ENSTA/LOCEAN-ParisTech) who is responsible for the development of the NEMO code for the Mediterranean Sea.

PhD Funding– 3-years funding by the Region Provence-Alpes-Côte d'Azur from october 2011 to Oct. 2014.

Useful links- http://www.com.univ-mrs.fr/LOB/, http://www.univmed.fr/, http://www.com.univ-mrs.fr/BOUM/; http://www.com.univ-mrs.fr/LOPB/spip.php?rubrique128, https://mermex.com.univ-mrs.fr/spip.php?article9

Research Program– The PhD thesis will be carried out in the framework of the program SIMED-2 (Simulation de la circulation générale à meso-échelle en Méditerranée, resp. K. BERANGER) funded the Groupe de Mission Mercator/Coriolis (GMMC).

Requirements–must be aged 28 years or less and hold a M.Sc. (Master of Science in Oceanography preferred)

Language- English (and French)

Contacts- CV,cover letter outlining personal motivation for the PhD, and 2 recommendation letters, are to be sent by email only (frederic.diaz@univmed.fr, m.baklouti@univmed.fr, thierry.moutin@univmed.fr). Application deadline July, 29 2011.