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Salinity and eutrophication management by in situ continuous real-time monitoring and 3D modelling (hydrodynamics coupled with water quality): the case of the Berre lagoon (Mediterranean, France)

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The Berre lagoon is one of the biggest Mediterranean lagoon. It is located in the South East of France. It's a shallow semi-confined ecosystem (mean depth 6.5 m, depths greater than 8 m being restricted in the central and South parts). Its only connection to the Mediterranean Sea is the Caronte channel in the South West which allows tidal-driven water exchanges. The lagoon receives fresh water and nutrients from natural tributaries (Arc and Touloubre rivers) that drain high anthropised catchment basins. Moreover, a hydroelectric power plant became the main tributary of the lagoon since 1966: it discharged a mean of 3.3 x10ˆ9 m3 of fresh water per year (equivalent to 3.4 times the volume of the lagoon) and a mean of 525 000 tons of suspended matter per year, during the period 1966 – 1993. As a consequence, the Berre lagoon became particularly unstable, showing considerable salinity drop and variations (2 to 30) depending on seasonal electricity needs. Nutrients loads by both anthropised rivers and power plant led to frequent colored waters and development of macroalgae. Haline stratification favored anoxia and led to benthos disappearance. Changes were observed in Zostera sp. meadows too.

In 2004, the European Court of Justice condemned the French State for not respecting the Athens Protocol (advocating Mediterranean protection against telluric pollution) and requested managing strategies. The hydro-electric power plant (Electricité de France EDF) is not allowed from now on to discharge more than 1.2 x10ˆ9 m3 of fresh water per year. Besides, EDF has to respect severe salinity constraints favorable to the establishment of a balanced ecosystem.

In this context, EDF started an in situ continuous monitoring of the lagoon: CTD probes have been installed at 10 stations and currents have been measured in the Caronte channel. Moreover, the three central buoys have been real time remote transmitting to control instantaneously the impact of fresh water discharge on salinity. Since 2008, these three buoys have been also equipped with nitrate, chlorophyll and oxygen probes. Thanks to these measurements, a 3D hydrodynamic model (TELEMAC©) has been developped and validated to better qualify and quantify the relationships between the salinity of the lagoon, the fresh water inputs (from the powerplant and from the rivers), the water exchanges through the Caronte channel and the wind mixing. This model is currently used by the electricity producer to manage fresh water discharges complying with salinity indicators fixed by the European Court of Justice. Then, a biogeochemical model (DelWAQ©) coupled with the hydrodynamic model has been developped to understand the ecosystem functioning and to assess the hydroelectric powerplant implication in the eutrophication of the lagoon. Simulations reproduce quite well: 1/ the seasonal variations of nutrients, 2/ biogeochemical processes, 3/ anoxia events in connection with stratification periods at deep stations and 4/ are able to calculate nutrients budgets over a year. The results show that high primary production rates are based on high dynamical mineralization processes. The allochtonous nutrients sources are not sufficient to feed the phytoplanktonic demand (less than 1%).

This models coupling is the only way to compile the physical and biogeochemical variables and processes. It's a tool aiming at a better assessment of the high complexity of the lagoon nutrients cycles. It will help us to understand the powerplant implication for the eutrophication with respect to the anthropised rivers. Moreover we would be able to test various managing scenarii (e.g. drop of nutrients loads) and to suggest new rehabilitation strategies.