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# The Mediterranean Sea ocean variability and operational oceanography: a science based approach for sustainable development of marine and coastal areas

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The long-term ocean variability of the Mediterranean Sea has been studied intensively in the past twenty years with observational and modeling experiments. Results illustrate the correlation between atmospheric forcing variability and the ocean response at seasonal, interannual and interdecadal time scales. Major climate variability events have occurred in the 1980s and 1990s driven by low frequency variability of the atmospheric forcing. The changes involve inversion of large scale current directions, strengthening and weakening of sub-basin scale circulation structures and changes in the deep thermohaline cells of the Mediterranean Sea. Moreover, shorter-term ocean variability, connected with the time scales from the seasonal to the mesoscales, have been shown to be related to water formation processes and to re-distribution of water masses at all depths. The seasonal variability is the characteristic ocean, quasi-deterministic frequency, of change in the basin. This variable environment induces nutrient, primary and secondary producers cycles that create ultra-oligotrophic conditions in most of the basin with extremely large gradients between the shelf and the open ocean. The pathway of carbon in the trophic chain is changing with the seasons as well as the depth of the water column and it is characterized by a bacterial loop during summer and a direct, herbivorous pathway during late winter.

This basic knowledge has guided the development of operational oceanography giving rise to the implementation of a Mediterranean ocean Forecasting System (MFS) to predict ocean variability in the Mediterranean Sea from the global scale to the shelf areas, from the physical to the ecosystem state variables.

The main elements of the MFS -simultaneously operating a real time observational data network and a general circulation model with assimilation of all satellite and in situ data- were implemented during the past ten years. The system is capable now to produce daily ten days forecasts for the hydrodynamics and recent research demonstrates the possibility of ecosystem predictions. The major innovation is the demonstration of proper downscaling of currents from the basin scales to the shelf areas in order to reach appropriate resolution for coastal applications. The MFS is at the basis of a network (Mediterranean Operational Oceanography Network-MOON, http://www.moon-oceanforecasting.eu/ ) that is making available generic, high quality monitoring and forecasting data in support of ocean state assessment and emergency management. Several examples of a science based approach toward oil spill crisis management, contaminant dispersal risk mapping and integrated coastal zone management will be shown.