Project No.8: Climatological monitoring of Mediterranean Sea, assessing and modelling the ecosystem changes and the climate change impacts - MEDSEA-CLIM

Executive summary:

The main objectives of MEDSEA-CLIM are to build long time series from a continuous monitoring of the basin via a multi-platform observing system, to asses the effect of climate change on the Mediterranean Sea ecosystem as well as changes in the ability of these ecosystems to provide goods and services and finally to predict and to quantify the impacts of climate change in the Mediterranean area and of evaluating the consequences of climate change for the society and the economy of the populations located in the Mediterranean area.

The present project MEDSEA-CLIM merges the effort of 5 major projects that will be implemented in the next 4 year in the Mediterranean Area and a new one (DEEPMOON) introduced for the first time in this proposal. The are: 1) SESAME (Southern European Seas: Assessing and Modelling Ecosystem changes); 2) CIRCE (Climate Change and Impact ResearCh: the Mediterranean Environment); 3) CMCC (Centro euro-Mediterraneo per i Cambiamenti Climatici - Euro-Mediterranean Centre for climatic changes); 4) VECTOR (VulnErability of the Italian Coastlines and marine ecosystems to climaTe changes and their rOle in the oceanic caRbon cycle); 5) POSEIDON-II (A Second Generation Monitoring and Forecasting system for the Eastern Mediterranean Sea); 6) DEEPMOON which will concentrate in the Otranto Strait and Sicily Channel, as key areas where to monitor changes of the deep circulation of the basin.

Background:

The response of the Mediterranean Sea to global change, involving both natural variability and anthropogenic effects, is mediated by several processes that transform, amplify and filter the atmospheric forcing signals according to the dynamics of the marine system at regional scales. Recent studies on historical data sets collected for the past fifty years (Rixen et al., 2005, Fig. 1), document very slow decadal changes in the Mediterranean Sea thermohaline structure. This demonstrate that only extended time-series could be used to observe the complex processes due to global change and resulting from the interaction of physical, chemical and biological factors in the Mediterranean Sea. Such long time series can come only from a continuous monitoring of the basin via a multi-platform observing system.

Despite its relatively small size, the Mediterranean Sea is a marine area where open oceans processes occur at smaller space scales. One example is given by the deep water formation sites where the changes in the atmosphere are felt down to the abyssal depths and thus global changes can be ‘sensed’ by the deep climatic circulation of the basin. Recent changes in the heat and salt storage in the basin are in fact strictly connected to heat flux changes in the deep water formation regions and they are in turn associated with NAO and changes in water cycle.

The effect of climate change on the Mediterranean Sea ecosystem as well as changes in the ability of these ecosystems to provide goods and services need to be assessed.

There is a need to predict and to quantify the impacts of climate change in the Mediterranean area and of evaluating the consequences of climate change for the society and the economy of the populations located in the Mediterranean area.

The present project MEDSEA-CLIM merges the effort of 5 major projects that will be implemented in the next 4 year in the Mediterranean Area and a new one introduced for the first time in this proposal. The are:

1) SESAME to start in 2007 and funded by the EU VI FP under Climate change and ecosystems. The project objectives will be explained in more details later
2) CIRCE to start in 2007 and funded by the EU VI FP under Climate change and ecosystems. The project objectives will be explained in more details later
3) CMCC that is computing IPCC scenario simulations for the Mediterranean region.
4) VECTOR funded by the Italian Ministry of Environment and Territory and the Italian Ministry of Research and University.
5) POSEIDON-II (A Second Generation Monitoring and Forecasting system for the Eastern Mediterranean Sea) funded by the European Economic Area funding mechanism and the Hellenic Ministry of Economy
6) DEEPMOON which will concentrate in the Otranto Strait and Sicily Channel, as key areas where to monitor changes of the deep circulation of the basin.

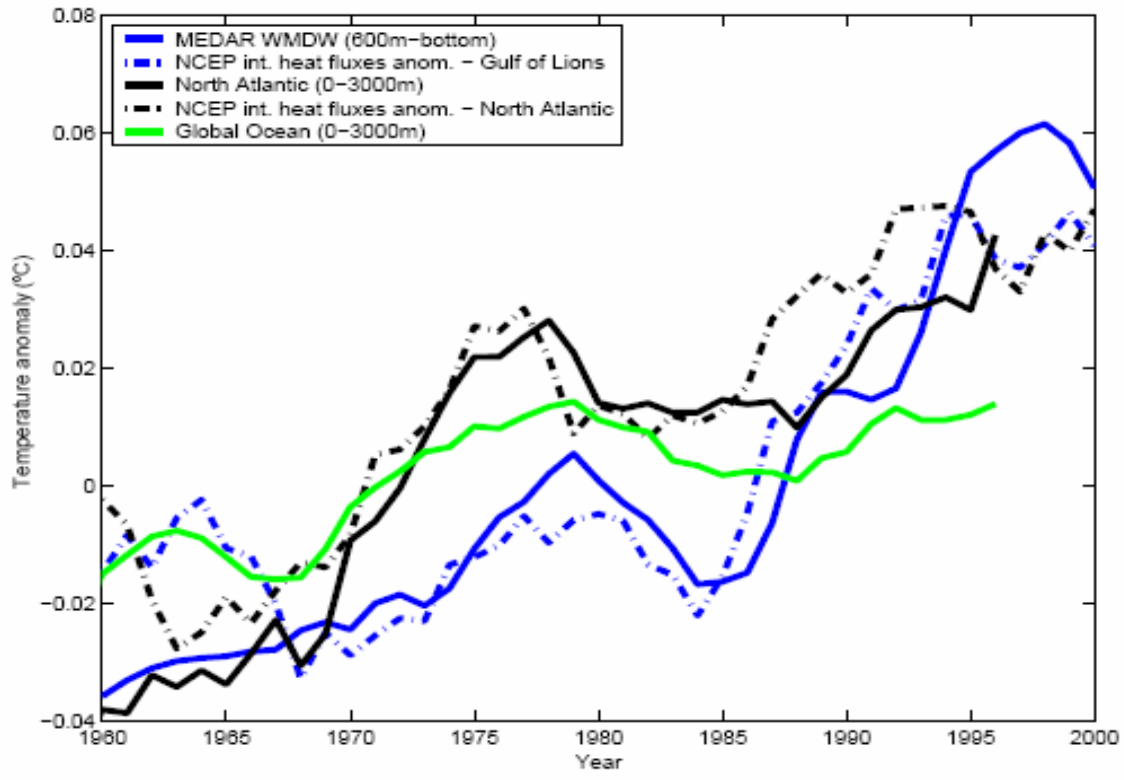

Fig.1 The temperature anomaly integrated over the deep layers (600m to the bottom) of the Mediterranean Sea in the Gulf of Lyon area where deep waters are formed (blue continuous line). The blue dashed line are the heat fluxes in the same area from the NCEP re-analysis, showing the perfect correlation. The Mediterranean time series is compared with the North Atlantic time series given by the black lines (the continuous line is the temperature anomaly in the North Atlantic between 0-3000 m and the dashed black line is the heat flux in the same area. The green line is the global ocean temperature anomaly.

Objective:

MEDSEA-CLIM will be composed of 3 major parts:

1) the observing system for the Mediterranean Sea dedicated to the climate change detection (SESAME, POSEIDON-II, VECTOR and DEEPMOON)
2) the modelling system both for the physical components (currents temperature, salinity ..) and for the ecosystem components (CMCC, SESAME, POSEIDON-II and VECTOR)

3) the climate change impact assesment. (CMCC, CIRCE, SESAME and VECTOR)

The sub-projects constituting MEDSEA-CLIM are described below in details:

1. SESAME (Southern European Seas: Assessing and Modelling Ecosystem changes)

SESAME contribution to MEDSEA-CLIM will be to assess and predict the Mediterranean Sea ecosystem as well as changes in the ability of these ecosystems to provide goods and services. The Mediterranean will be approached as a coupled climatic/ecosystem entity, with links and feedback to the world ocean. The assesment of ecosystem changes will be based on the identification of the major regime shifts in ecosystems that occurred during the last 50 years. Mathematical models, validated and upgraded using existing and new observations, will be used to predict ecosystem responses to changes in climate and anthropogenic forcings during the next five decades. The new data will be gathered during multidisciplinary, multiship oceanographic cruises in the Mediterranean Sea. These will provide an overall picture of the Mediterranean that does not exist as well as essential datasets for model validation. SESAME will also study the effect of the ecosystem variability on key goods and services with high societal importance like tourism, fisheries, ecosystem stability through conservation of biodiversity and mitigation of climate change through carbon sequestration in waters and sediments. SESAME will establish for the first time WOCE (World Ocean Circulation Experiment) –type stations and monitoring strategy for selected transects in the Mediterranean Sea.

2. CIRCE (Climate Change and Impact ResearCh: the Mediterranean Environment)

CIRCE aims at developing for the first time an assessment of the climate change impacts in the Mediterranean area. The objectives of the project are: a) to predict and to quantify physical impacts of climate change in the Mediterranean area; b) to evaluate the consequences of climate change for the society and the economy of the populations located in the Mediterranean area; c) to develop an integrated approach to understand combined effects of climate change; d) to identify adaptation and mitigation strategies in collaboration with regional stakeholders.

The project will investigate how global and Mediterranean climates interact, how the radiative properties of the atmosphere and the radiative fluxes vary, the interaction between cloudiness and aerosol, the modifications in the water cycle. The economic and social consequences of climate change shall be evaluated by analyzing direct impacts on migration, tourism and energy markets together with indirect impacts on the economic system. CIRCE will moreover investigate the consequences on agriculture, forests and ecosystems human health and air quality. The variability of extreme events in the future scenario and their impacts will be assessed.

A set of quantitative indicators prepared specifically for the Mediterranean environment will be developed and used in collaboration with regional stakeholders. The results will be incorporated in a decision support system tool and disseminated to the relevant users. Possible adaptation and mitigation strategies will be identified.

3. CMCC (Euro-Mediterranean Centre for climatic changes)

The CMCC is a strategic program approved by Ministero delle Finanze, Ministero dell'Istruzione, Università e della Ricerca, Ministero dell'Ambiente and Tutela del Territorio and by Ministero delle Politiche Agricole e Forestali. The aim of the program is the creation of an international wide-ranging centre for the research in the field of climatic changes. The main topics of CMCC are the development and the widening of the knowledge in the field of climatic variability, the study of causes and of consequences of the variability through high resolution simulations.

The Centre will produce models, simulations, middleware, software and high qualification staff both in the specific field of climate dynamics and in the computer science technologies. The CMCC will develop, verify and maintain documented numerical models for the climatic simulations: 1) a global model of simulation of the earth system which includes the atmosphere, the ocean, the sea ices, the terrestrial biosphere and the marine ecosystem matched to a high resolution model of the Mediterranean sea open to be used for production of scenery of the future climate and for the simulation of the climate variability at interannual and decadal scale; 2) long-period climatic simulation; 3) ensembles of controlled quality; 4) suite simulation model of the socioeconomic impact due to climatic changes. CMCC will use directly these simulations to carry out studies of climatic change impact on economy, agriculture, marine and terrestrial ecosystems, coastal areas, health.

4. VECTOR (VulnErability of the Italian Coastlines and marine ecosystems to climaTe changes and their rOle in the oceanic caRbon cycle)

VECTOR is an Italian Project funded by the Italian Ministero dell'Istruzione, Università e della Ricerca, the goal of VECTOR is to improve the understanding of the impacts of climate variability and related changes on the Mediterranean Sea environment. The main objectives of VECTOR are: 1) to define, with accuracy and spatial-temporal coverage, sources and sinks of CO2 at the air/sea and land/sea interfaces; 2) to improve the understanding of the carbon cycle and the sensitivity to global changes - providing significant data on the atmospheric CO2 levels for the next 200 years; 3) to develop predictions on the ocean behavior as a sink of C; 4) to provide data related to the capacity of carbon absorption of the Italian seas by organisms (like Sea Grass), to be used in the international negotiations; 5) to define the most significant impacts of Mediterranean climatic changes and the role of this basin on the planetary CO2cycle.

The areas of investigation will be the Northern Adriatic, the Middle Adriatic, the Ionian Sea, the Tyrrhenian Sea and the Whole Mediterranean.

VECTOR will elaborate scenarios of future impact that represent modifications of the extension of the coastal areas, morphology of emerged and submerged beach, water column structure and patterns of coastal circulation and aerosol transport from the sea to the coastal areas and related impacts on the areas subject to anthropogenic activities. VECTOR will also develop the coupling between scenarios of future impact with scenarios that represent the changes in benthic-pelagic ecosystems, in terms of biodiversity, productivity, invasive species and pathogenic bacteria distribution, related to the variations of temperatures and coastal circulation, the sedimentary instability, the nutrient excess and the water salinity changes.

5. POSEIDON-II: A Second Generation Monitoring and Forecasting system for the Eastern Mediterranean Sea

POSEIDON-II is a Greek national project funded by the financial mechanism of the European Economic Area and the Hellenic Ministry of Economy. It is the second phase of the POSEIDON project (1997-2000) that developed an operational monitoring and forecasting capacity in the Aegean Sea based on a network of oceanographic buoys and a set of operational forecasting models.
The overall aim of the project is to upgrade and extend the present operational monitoring and forecasting capacity of the POSEIDON system in the Eastern Mediterranean Sea in order to support the requests of environmental information for integrated marine ecosystem management and maritime safety on a national and regional scale.
The Specific Objectives of POSEIDON-II are to: 1) upgrade the existing buoy network in order to improve their functionality, operational capabilities and observing capacity, including new biochemical and deep sea observations; 2) enrich the network with additional buoys and extend towards the Ionian and Levantine Seas; 3) improve the quality of in-situ observations by introducing new calibration, maintenance and Quality Control procedures; 4) upgrade the existing forecasting system by improving the

model's resolution, introducing non-hydrostatic models and developing assimilation schemes; 4) develop a pre-operational capacity for ecosystem forecasting; 5) integrate relevant remote sensing products to improve the overall system's forecasting skill; 6) improve the present data and information management capabilities and extend to other relevant operational products (M3A systems, Ferry Box, GAVDOS SLA reference station); 7) harmonize and coordinate with European and international initiatives of Operational Oceanography.

POSEIDON-II will contribute to MEDSEA-CLIM mainly through the deep sea monitoring capacity that will develop. More specifically, monitoring of deep (1000-2000m) water mass characteristics (temperature, salinity and dissolved oxygen) will be carried out at dense water formation sites (north and south Aegean) and areas where the Aegean Sea dense water outflow can be monitored (SE Ionian Sea).

6. DEEPMOON

The main purpose of the DEEPMOON is to study some of those Mediterranean areas that are key sites of water mass transformation processes that are able to amplify and/or filter the global change signals originated by atmospheric forcing and change sin the hydrological cycle. Therefore these areas can be fruitfully exploited as sensors of the variability of the Mediterranean system due to global change and variability.

These 'hot spots'are: a) deep water formation sites; b) deep and intermediate water sites and spreading pathways; c) sites of water properties modification (mixing, entrainment, etc) and exchanges (Straits).

The final objectives are: 1) to document the climate variability of thermohaline structure of the Mediterranean Sea; 2) to define the processes transferring the atmospheric signals to the marine system; 3) to underpin the mechanisms that convey climatic variability to the biotic part of the ecosystem

In particular DEEPMOON will concentrate on monitoring the Sicily Channel and the Otranto Strait through the usage of ADCPs and GLIDERs and adding elements to the SESAME and VECTOR and POSEIDO-II monitoring system to the MOON4CLIMATE project. For the DEEPMOON objectives, several marine regions are particularly interesting in the Mediterranean Sea and here we have selected two of them:

- the southern **Adriatic**, where the response to various forcings (atmospheric, river runoff changes and anthropogenic pressures) can affect the deep water signals since deep water formation events occur;
- some of the **Straits** (Otranto, Sicily) where the signals recorded at the key sties can be strongly modified and that indicate transfer of water mass properties between major sub portions of the Mediterranean Sea;

Recent technological advances allow now to realise an optimised continuous monitoring program. We propose here the combined use of bottom-mounted ADCP and gliders in two of the different Straits, the Sicily and Otranto Straits. Gliders have been already adapted to the Mediterranean Sea conditions and proven to be efficient and robust.

Location of MEDSEA-CLIM: Mediterranean Sea

Duration of MEDSEA-CLIM: 4 years

Budget of MEDSEA-CLIM:

SESAME is an integrated project financed by the European Commission, which contribution will be 10.000.000,00 euro;

CIRCE is an integrated project financed by the European Commission, which contribution will be 10.000.000,00 euro;

CMCC is financed to be worth on FISR – Fondo Integrativo Speciale della Ricerca, managed by Miur. Project total value (auto-financing included) is € 39.103.165,21 of which €27.098.493.49 is representing the FISR part.

VECTOR total value (auto-financing included) is 8.250.000,00 euro of which 5.775.000,00 is representing the MIUR contribution.

POSEIDON-II has a total budget of 9.823.590,00 euro and is co-fonanced by the European Economic Area funding mechanism (75%) and the Hellenic Ministry of Economy (25%)

DEEPMOON budget is complementary to the budget proposed in the MOON4CLIMATE project contained in the present GCOS the Regional Action Plan for the Mediterranean Basin, DEEPMOON will carry out the development of the dedicated observing composed of ADCPs and GLIDERs system for the Sicily Channel and the Otranto Strait. DEEPMOON budget is the only part of MEDSEA-CLIM project that is not financed yet and the budget needed for its implementation is 780.000,00 euro.

DEEPMOON Budget	**Personnel**	**travel**	**equipments**	**consumables**	**overhead**	**total**
Straits monitoring (2 GLIDERs and 4 ADCP)	200.000,00	100.000,00	300.000,00	50.000,00	130.000,00	780.000,00
Total						780.000,00

Expected Outcomes of MEDSEA-CLIM:

The implementation of MEDSEA-CLIM project will contribute to:

- provide key measurements of the intermediate and deep water structure of the Mediterranean Sea for climate change monitoring;
- assess and predict the Mediterranean Sea ecosystem as well as changes in the ability of these ecosystems to provide goods and services;
- predict and to quantify physical impacts of climate change in the Mediterranean area and to evaluate the consequences of climate change for the society and the economy of the populations located in the Mediterranean area;
- develop an integrated approach to understand combined effects of climate change and to identify adaptation and mitigation strategies in collaboration with regional stakeholders;
- define, with accuracy and spatial-temporal coverage, sources and sinks of CO2 at the air/sea and land/sea interfaces and to improve the understanding of the carbon cycle and the sensitivity to global changes and define the most significant impacts of Mediterranean climatic changes and the role of this basin on the planetary CO2cycle

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