

# RICAMARE: Defining and leading a regional research agenda on major global change impacts in the Mediterranean using remotely sensed and in situ observations

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**ABSTRACT:** The Mediterranean basin is a very complex world. Understanding it from an integrated approach at a regional scale is a work in progress. In particular, understanding the regional climate changes and its potential impacts is poorly addressed. The RICAMARE concerted action addressed identification of knowledge gaps in four key domains: (i) land use, land cover changes and water resources, (ii) biodiversity conservation, (iii) evaluation of the costs of global change and (iv) Development of a concerted data assessment, assimilation and validation for global change. In order to implement further research in line with the endorsed conclusions and recommendations, the Steering Committee adopted a post-RICAMARE action plan, now on its way.

## 1 INTRODUCTION : SOME KEY MEDITERRANEAN FEATURES

The interactions between regional aspects of global change and socio-economic issues are particularly strong and important in the Mediterranean basin.

From a socio-economic point of view, in the last decades, dramatic population growth, geopolitical and economic changes occurred in several parts of the region. These recent trends disturbed long term established economic and societal practices. From a climatic point of view, the region is characterised by its geographical position at the boundary between the descending branch of the Hadley circulation and the Westerlies and as well is influenced by the North Atlantic anomalies that cause large climate variability. This makes the detection of superimposed trends very difficult. The region contributes to the dynamics of the oceanic conveyor belt, is a source of aerosols and dust reinforced by Saharan sources affecting a large area, and influences synoptic scale circulation systems due to its unique topography and to land-ocean-atmosphere interactions. It is very sensitive to, and greatly influenced by, global climate changes, through effective coupling and teleconnections. Indeed, it is quite impossible to lead integrative studies on specific areas without taking into consideration a systemic approach of the Mediterranean region, and

these complex couplings and teleconnections with the "outside world" (NAO, Hadley cell fluctuations, Saharian dust imports, Asian and African monsoon, etc...). It is an area of high topographic complexity, in which processes interact at various scales, and features large gradients of land use intensity and water availability. The region is also very sensitive to changes in world economics, land policy, and demographics, which in combination have considerable control over sustainable development. This is mainly true in Northern Africa and Middle East, and countries having close socio-economic connections with these areas.

There is a shared concern over many common environmental problems on both sides of the sea that serves as a bridge for Euro-African scientific co-operation. Furthermore, there is considerable potential for research around the Basin, which should be mobilised around environmental major issues. These outstanding features make the Mediterranean region an exemplary area for integrated research into change-related impacts on environment and natural resources, which should bring unique information to policy makers willing to promote sustainable development in the whole region, either in developed or in less favoured areas. And nevertheless, integrated studies of climate change and its impacts at the regional scale are quite poor. Few can be derived from the IPCC reports

(IPCC 2001a, 2001b, 2001c) and in spite of documents like the book by Jeftic *et al.* (1996) or the UNEP/MAP studies no such survey as ACACIA for Europe (Parry, 2000) does address the Mediterranean basin so far.

## 2 THE OBJECTIVES OF THE RICAMARE CONCERTED ACTION.

Some of these regional features were widely addressed in the RICAMARE concerted action sponsored by the European Commission (DG Research, ENRICH and INCO-DC programmes), START and some other national funding (mainly in France, Italy, Spain). The overall RICAMARE objective was to develop regional co-operation in the Mediterranean about global change and its major impacts, bringing together physical and socio-economic issues into a systemic vision. The RICAMARE strategy was to link natural and social scientists from countries around the Mediterranean interested in tackling the inter-relationships between the natural and human environment in order to develop strategies for sustainable development in the region.

The project was under control of a Steering Committee including national representatives, scientists having led relevant recent research projects or representing major scientific organisations.

Relying upon recommendations of a previous ENRICH/START workshop held in Toledo, 1996 (Moreno *et al.*, 1996), RICAMARE concentrated on four crosscutting issues described hereunder. The objective was to have a regional picture of the state-of-art, identify gaps, and recommend research activities to fulfil them. Each of these four issues were addressed by a specific working group, assessing the state of art, analysing knowledge gaps and setting up a medium term research agenda. The main conclusions drawn are presented hereunder.

In addition, RICAMARE organised training and outreach activities to consolidate the regional research community and make decision makers aware of scientifically assessed conclusions. These two activities will not be presented here. It should however be underlined that five training sessions (agriculture, biodiversity, water resources, physical and socio-economic aspects of global change) were led in ICTP, CIHEAM, UCLM to enlarge the regional global change scientific community through collaborative capacity building, education and training. These topics are closely related to the four crosscutting issues described below. Since the objective of RICAMARE was to draw up recommendations to fill knowledge gaps, consolidating the regional community that could develop the corresponding focussed and integrated

research programmes appeared mandatory to pave the way to actually lead them.

1 - land use, land cover change and water resources - a key issue at regional, national and local level to sustainable development, making a wide use of Remote Sensing and GIS based techniques.

2 - Global change and biodiversity conservation - a survey at the species and landscape scales in an acknowledged environmental "hotspot".

3 - Evaluating the costs of global change - a poorly developed field in the region, and a key issue for decision and policy makers.

4 - Development of a concerted data assessment, assimilation and validation for global change - a very wide issue, focussed on the needs of system oriented studies addressing the major regional cycles through a network of dedicated anchor stations and national points of contacts (MERAN). Geophysical calibration and validation of Remote Sensing products at the regional scale is a first mandatory step.

The last RICAMARE Steering Committee decided to set up a long-term "post-RICAMARE" action plan, to be undertaken under the general co-ordination of MEDIAS-France. In order to achieve this objective, it was decided to consolidate and extend the RICAMARE network as needs arise and lead some immediate actions with a long-term vision. These actions are still a work in progress, in an international co-operation and technology transfer perspective. Some of them may be presented here:

- Consolidating the so-called MERAN network, in order to set up a network of anchor stations allowing to lead calibration and validation and operational measurement activities (including remotely sensed data) in a coherent concerted way and the associated network of national points of contact,
- Studying land-cover/land use transects in the Mediterranean, beginning by a South-North transect (Tunisia, Sardinia, Corsica, French or Italian Riviera), also calibrating remotely sensed data against in situ observations,
- Setting up a sub-regional network in Balkans, mainly focussed on Regional Circulation Models validation and inter-comparison,
- Setting up a sub-regional network in Maghreb, which already held a workshop in Adrar (Algeria), mainly addressing the water resources forecast,
- Leading some targeted socio-economic studies about regional vulnerability and adaptation strategies under Global Change pressures.

- Leading follow-on training and capacity building activities in order to consolidate the scientific multidisciplinary community.

This action list is quite flexible. It should pave the way to a better understanding of the Medi-terranean climate under natural and anthropic pressure, and a better definition of mitigating and adaptation strategies and policies. The combined use of remotely sensed observation in several fields (land cover and land use, atmospheric chemistry, sea surface, meteorology) and various in situ information is mandatory to lead such a challenging objective.

Last but not least, it was decided to consolidate the START secretariat in the Mediterranean (MEDCOM), to set up the RICAMARE network on the long run, and closely co-ordinate the two structures, in particular by sharing key common actors.

### 3 SOME KEY ISSUES FOR A MEDITERRANEAN RESEARCH AGENDA

As explained in Section 2, the four RICAMARE workshops aimed at drawing conclusions and recommendations about key issues in some major domains. Summarising these conclusions is a quite challenging task. What follows is an attempt to present some main guidelines without losing significant key points.

#### 3.1 *Land Use, Land Cover and Water Resources*

Prof. Puigdefabregas led the task. The workshop took place on April 18th and 19th, 2001 in IRA facilities, Medenine, Tunisia. It addressed land use and land cover changes and water resources in the Mediterranean, and was organised around reports produced before the meeting.

The main following trends were noted:

- There are contrasting trends between North (land abandonment) and South (combination of several factors, leading to numerous cases of degradation and overgrazing). The main driving force is socio-economic (such as sedentarisation in the South). Climate is not perceived as a driving factor, but acts in synergy with socio-economic drivers.
- Reports about water availability were studied. In the North, what is going on is not so clear. In the South, a degradation of resources (salinisation) and a strong demand growth are the most worrying factors.

The following main gaps were underlined, both in terms of knowledge and relevant structures:

- The effects of rangeland changes on water resources are poorly understood. It is necessary to focus to small to medium size areas and to network these studies.
- The water resources studies are poorly co-ordinated all around the basin. Networking is mandatory.
- There are several hot spots in the Mediterranean, a very sensitive system. In such places, intensive research can be led. There are strong interactions between factors occurring at different scale, which all need to be addressed.
- An important network has been built. It is necessary to co-ordinate and stimulate the network, a baseline to address these problems. Data needs have to be identified. An information system has to be set up and co-ordinated with existing systems, such as WAICENT, MEDHYCOS.
- A key point is to address socio-economic issues, bringing proper specialists within the network and identifying how to alleviate the observed pressures.
- The network should be endorsed by LUC (Puigdefabregas, 2001). It is also necessary to co-operate with related activities. The DIS-MED initiative is a proper example: the network should build on that basis to address desertification issues taking into account socio-economic drivers.
- An objective could be to set up an observatory performing some basic tasks, including interacting with EO sources. Very few monitoring stations do exist in Southern and Eastern Europe. This is a real task, for which a lot of funds should be found. EUROFLUX is an example of such a dedicated network. The future network should keep in touch with such structures (including of course other initiatives emerging from RICAMARE itself).
- Once this initiative firmly structured, it is necessary to look for funds. Synergies with the MERAN initiative have to be taken into proper account.

#### 3.2 *Biodiversity Conservation*

Pr. Andreas Troumbis and Dr. Helena Freitas led the task. The workshop took place in the University of the Aegean, Mytilini, Lesbos Island, Greece, November 27-29, 2000.

The main issues addressed were:

- Identification of current knowledge in the Mediterranean;

- Trends in Mediterranean diversity under global changes at species and landscape levels;
- Conservation priorities.

The Mediterranean countries differ in having well defined strategies and active communities on biodiversity research. In most cases, some individuals are active, but no central policy or co-ordination structure exists. In itself, Global Change is not a clearly defined field for research policy. The main issues to be studied are: flora, genetics, landscapes

In terms of species diversity, the following points were highlighted:

- The Mediterranean region is rich in hotspots, and is a hotspot in itself. Hotspots are flagships for research. LUCC and climate are the main factors of change, but varies with hotspots. Little knowledge is available on diversity-function relationships.
- Diversity function approaches should be based on meta-analysis of data, revisiting data, correlation studies at patterns level, removes experiment, composite communities, monitoring (no permanent plots exist).
- Monitoring should combine long term monitoring and ecological research, establish common protocols, study sites as composite places, from a multidisciplinary approach (from organisms to landscapes).

At the landscape level, the following points were highlighted:

- Landscapes are characterised by a fine grain, and a diverse, old history. There is a great diversity. A challenge in the science of landscape ecology is "empty world versus full world" (there is no such a thing as natural areas). Approaches can be pattern recognition, administrative units, property values (cadastral information).
- The main processes of interest are CO<sub>2</sub> and vapour fluxes; flows of water, soil and nutrients; propagation of disturbances; biotic exchanges.
- The main global change drivers of landscape change are considered to be land use and climate; far beyond are nitrogen deposition, biotic exchange and atmospheric CO<sub>2</sub>.
- In terms of patterns and trends, there is a great variety but the determinants are unknown. There are trends in change but how and why is also largely unknown. Studies should be carried out across the region to identify the main patterns and trends of change and to understand what factors play a role.

The main future research needs are:

- Fire and landscape interaction;
- Species patterns in the landscape as indicators of change;
- The importance of landscape features;
- The species movements across landscapes.

The integration needs are:

- Coupling field observations with remotely sensed data;
- Setting up robust techniques for interpolating in space;
- Identifying the appropriate scale for each studied process.

The key conservation issues are:

- All countries are taking measures, but structuring and co-ordination is needed.
- Conservation has improved, but on an ad hoc basis.
- NATURA 2000 is the main common legal framework for the next 20 years, but it is static
- National and regional strategies have been signed by 50 countries, including Mediterranean ones.
- A strategic selection procedure is needed (we may learn from other countries).
- A framework for viability of population and species is not ensured.
- In the short term, species remain but ecosystem change; so, how should conservation be addressed?
- There are active management needs to be pursued.
- Scenarios for conservation need to be made and used to project conservation measures.

### 3.3 *Evaluating the Costs of Global Change*

Prof. Mordechai Shechter, Prof. Marzio Galeotti and Dr. Manfred led the task. The workshop took place on February 9-10, 2001 in Milan, Italy, kindly hosted by FEEM.

The initial objectives of the workshop were defined by three items:

- Present on-going or planned research projects on the impacts of global climate change on social and economic systems in the Mediterranean basin, in relation to such areas as water resources, agriculture and forestry, desertification, biodiversity, extreme weather events, sea level rise and coastal areas, human health, tourism, and others.
- Set a research agenda for and create a network of social scientists from the Mediterranean basin. The scope is intended to be inter-disciplinary,

with a primary focus on social science and related research.

- Exploit the meeting in order to set-up achieved through the presentations in order to advance an agenda for future research and collaboration.

The workshop addressed these issues from generic and thematic (agriculture, tourism) points of view, focussing on climate change impacts, but purely national aspects were not addressed. Vulnerability, then damages were considered, and assessed in economic terms. The adaptability issues and efforts were considered. Most of the results came from other consolidated projects. There were no co-ordinating efforts in terms of models.

A major issue is to develop the community of skilled scientists in Eastern and Southern parts of the Mediterranean, and sub-regional projects, since more local scientists address purely physical than socio-economic issues.

Some of the main questions raised were:

- Which are the major impacts? Which priorities should be adopted? The priority is depending upon the extent of damages, and how to mitigate them.
- It must be understood if it is possible to distinguish between anthropogenic and climate change origins, and to what extent, taking into proper account irreversible processes linked to climate change.
- From a socio-economic perspective, countries have to be saved from impacts of global change (adaptation), but action is possible only if there are anthropogenic origins.
- Climate change has a lot of synergies with other aspects. These synergies have to be taken into account to solve problems such as: how to face scarce water resources, threatened both by climate change and overexploitation? Declining precipitation has impacts on agriculture. For instance, in Israel, the country could adapt, which is not the case in Egypt.
- In terms of vulnerability and adaptation, with limited resources, what can be done to protect populations?
- Vulnerability includes the capacity to cope with specific stresses. Money, technology, etc... has to be taken into account. Vulnerability is a function of physical phenomena and socio-economic parameters.

The main conclusions of the workshop were summarised in seven major items, which should serve as guidelines for future actions and research projects:

- Integrated work should be organised.

- Data collection and distribution of knowledge should be facilitated.
- Network of scientists working in CC should be identified.
- A model or structure should be developed for the analysis, which would take into consideration:
- adaptation/vulnerability but also focuses on other changes i.e.; population, economy, natural resources, etc.
- The issue of aggregation and desegregation should be also taken into account for the analysis.
- The analysis should also have some policy orientation for better understanding and implementation. Stakeholders' opinion also should be taken into consideration.

#### 3.4 *Development of a Concerted Data Assessment, Assimilation and Validation for Global Change*

Prof. H.J. Bolle and E. Ozsoy led the task – a very complex one since it addresses “horizontal” issues within a potentially unlimited scope. The workshop was held in Casablanca, February 21-24, 2001, with a strong support from Moroccan meteorological services, in parallel with a WMO/CLIVAR workshop, which aimed at defining regional climate change indicators over the Mediterranean. It was prepared by a series of questionnaires that paved the way to the MERAN concept – a network of national centres and “anchor stations”.

The workshop organised three subgroups (atmosphere, and sea) which focussed each on three purposes:

- availability of data,
- scientific goals (why these data are needed),
- merging conclusions and recommendations with WMO regional indicators workshop.

Understanding the climate changes over the Mediterranean is a quite complex task, requiring modelling and various kinds of homogeneous datasets. For instance, precipitation changes have been observed in the Mediterranean sea. Different models exhibit large discrepancies (MPI Hamburg).

The *atmosphere group* enhanced the following major facts and questions:

- The research strategy and the problem of anchor stations needs to be refined. Most of the climate variation information has to be updated periodically. The major issue to be taken into account is the water cycle, strongly linked between the carbon fluxes and the water cycle. In parallel (and synergy) with data collection, there is a strong need to improve mesoscale models (RCM). A typical question to be answered is: will global warming lead to

acceleration of water cycle, bringing up some uneven results (flood, desertification)?

- The water provided by the vegetation is critical to evaluate precipitation and runoff up to the basin level. We need to understand the link between biophysics and biogeochemistry, the link between ecosystem and the atmosphere.
- GEWEX addresses the energy and water cycle and the hydrological cycle determination by global measurements. It requires modelling the hydrological cycle and its effects. Some updated GEWEX science questions have to be solved :
  - Are the Earth's energy budget and water cycle changing? Is the water cycle accelerating (1° temperature of water increase could mean 10% more water vapour)? Can it be predicted on inter-annual or seasonal basis? How does this impact on climate and water availability?
  - Will global warming lead to water cycle acceleration? Does it lead to extreme events? What is the role of the carbon cycle? Is air quality changing?
  - There are several experiments going on: BALTEX, GCIP, LBA, GAME, CATCH, but no experiment over the Mediterranean. How could a GEWEX-like experiment allow to better understanding the issue of water cycle in the Mediterranean? Such an experiment needs co-operation of modern NWP centres, to commit resources and personnel, to have regional co-operation, and a free exchange of data. In the region, no free exchange of meteorological data seems possible.
- The role of Remote Sensing data and techniques is essential in that domain.

The *land group* stressed that land is certainly the most complex issue to deal with, since land is very diverse in itself, with closely embedded human and natural processes. New developments have to be taken into account. The main issues to be addressed are the land use and land cover changes drivers (see § 3.1), the sustainability constraints and adaptive strategies (see § 3.3), the changes in the structure of ecosystems (see § 3.2), the water and carbon exchange processes. The anchor stations should target a full understanding of these processes at a given site.

The *marine group* enhanced the following major facts and questions:

- The sea has to be studied in itself, but is also a part of the physical Mediterranean system.
- Some examples of severe events in the Mediterranean have to be further investigated, in order to predict the effects of extreme events.

- Links with such phenomena as volcanic eruptions, teleconnections with areas like Central Asia, and the monsoon system have to be further investigated.
- Spaceborne altimeters such as TOPEX-POSEIDON (and now JASON-1) allow to "close the system" in terms of sea level rise.

As a synthesis, the main features of the *MERAN initiative* were tentatively described:

- MERAN should be developed as a non-hierarchical network, which may be used for mega-projects or smaller projects, and for North-South co-operation.
- There are already voluntary people interested in being involved, but more people need to be attracted in a further phase.
- There are a lot of existing projects related to issues to be addressed by MERAN (BIME, ICARUS, AECE) New initiatives are developed to fill gaps. The role of RICAMARE is to identify projects filling such gaps. One of the gaps is the socio-economic evaluation associated to on-going projects.
- A coherent network of anchor stations has to be developed. One or two anchor stations in each country are a suitable target.
- Some issues such as carbon and water fluxes are a major concern for the land community (CARBOFLUX, EUROFLUX). Other main "land" issues such as ecosystem vulnerability needs representative areas. It may be one of the key roles of anchor stations.
- A CLIVAR-type of activity is needed, federating interdisciplinary research. MERAN is a key tool to develop such an initiative.
- A preliminary picture of a network of anchor stations can be drawn. Each anchor station should have a partner in an official institute. Sharing the experience is essential, as well as having a direct access to data flowing from networks. A scheme of development from raw data to corrections, validation, then combining data with secondary and third level datasets has to be developed.

#### 4 CONCLUSION – LOOKING FORWARD

Section 3 clearly evidences that understanding the behaviour of the Mediterranean basin under climate change conditions, even when focussing on specific items, is a very wide and complex task. This work needs to be done to lead policy makers to take decisions favouring the regional sustainable development.

As underlined at the end of Section 2, the RICAMARE objective was to identify the state of the art, the major gaps in global change research at the regional level, and set up a tentative research agenda. Such an effort would be meaningless if an implementation plan was not led. So, as already explained, the RICAMARE Steering Committee decided to adopt the “RICAMARE Manifesto” and a flexible post-RICAMARE action plan, in order to have guidelines and a short-term starting plan paving the way to long-term actions.

It was decided to consolidate the START secretariat in the Mediterranean (MEDCOM). The START Scientific Steering Committee recommended considering the Mediterranean as one of the top priorities for START. It was also decided to set up the RICAMARE network on the long run, and closely co-ordinate this network and MEDCOM, in particular by sharing key common actors.

The flexible post-RICAMARE action plan began to be implemented. Several projects were defined in the socio-economic and biodiversity field. A proposal to develop MERAN was sent to the 5<sup>th</sup> FP of the EC DG RESEARCH, unfortunately without success.

It is quite encouraging to conclude by positive words. One of the actions of the post-RICAMARE action plan in the Northern Africa was successfully led. A follow-on initiative was proposed by Pr. SENOUCI (ARCE, Algeria) and endorsed by the Steering Committee. The objective was to convene an international scientific forum on climate forecast and strategic management of water resources in Maghreb and its evolution under Mediterranean climate change conditions. These issues needed to be addressed in a prospective and international perspective, defining and developing a research agenda for the Maghreb and a mechanism for follow-up. The planned workshop took place in Adrar, Algeria, September 24-26, 2001. In order to develop the initiative, the participants endorsed the so-called “Adrar call” (Senouci, 2002).

The so-called ProMed project is being defined under the leadership of the Max Planck Institute in Mainz, Germany (Pr. J. Lelieveld). ProMed aims to improve the understanding of the atmospheric composition, the energy budget and water cycle in the Mediterranean region. It will be an integrated project because it addresses linkages between processes in the atmosphere, the sea and over land,

coordinating research by about 70 European groups. The project is motivated by the notion that i) water resources are vulnerable to climate variability and change, ii) European pollution strongly affects the region, iii) the regional weather and sea circulation are changing, and iv) Mediterranean environmental changes have effects on European, N-African and larger scales. Socio-economic and health factors will also be included, aiming at an integrated assessment, providing a basis for solutions to mitigate impacts on the economy and ecosystems, especially those that are sensitive to water availability. ProMed took advantage of the fourth RICAMARE action as presented in § 3.4 and other ongoing initiatives and thoughts, but it is an integrative project which should act as the driving force of the post-RICAMARE action plan. ProMed was presented to the European Commission in response to its call for Expression of Interest in the context of the 6<sup>th</sup> Research FP.

It should be hoped that such positive initiatives pave the way to a successful post-RICAMARE action plan, under the aegis of the European Commission and START. The ambition of its actors and co-ordinator is to bring interdisciplinary scientifically assessed answers to questions that have a major importance for the sustainable development of all the population living in the surroundings of the Mediterranean basin. Major efforts have to be devoted to contribute to such a challenging objective.

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