ESF-LESC Exploratory Workshop on Mediterranean Climate Variability and Predictability (MEDCLIVAR)

Rome, May 17-19, 2004

Convenor: Prof Lionello, University of Lecce, Italy
Co-Convenor: Dr. R. Boscolo, IIM-CSIC Vigo, Spain

– Scientific Report –

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1. Executive Summary

General considerations produced by the discussion:

- The Mediterranean region is characterized by a peculiar potential for past climate reconstruction based on chronicles and documentary evidences, integrated by long instrumental time series.
- The Mediterranean climate is under the influence of both mid-latitude (NAO, Eastern Atlantic Pattern, ..) and tropical climate patterns (ENSO, Asian and African Monsoon). Several aspects of these connections and of their eventual variability are not well understood.
- The Mediterranean Sea presents slow, long-term as well as abrupt changes of the circulation, of the water mass characteristics, variability of the dense mass formation processes, a sea level trend distinct from the global one. The understanding of these phenomena requires extensive investigation.
- The possible feedbacks of the Mediterranean dynamics in the global climate system (effect on Sahel precipitation, on the Atlantic thermohaline cell, effects of Mediterranean SST on atmospheric circulation…) need to be properly assessed.
- There are important societal implications in the study of the climate of this region, which is already under environmental stress and presents high economic, cultural and political gradients

Major scientific research lines resulting from the discussion

- Investigate the link of the Mediterranean climate to global climate patterns (teleconnection mechanisms) and of its specific dynamics (internal variability modes, air-sea interaction at regional scale, climatic role of the Gibraltar strait)
- Reconstruction of the regional past climate variability at centennial and decadal time scales (include both natural and documentary proxies, sea records, integrated “sub-regional” analysis to obtain basin-scale reconstruction, improvement of the reconstruction at the African coast)
- Simulation and understanding of the observed variability of the Mediterranean Sea circulation and sea level
- Climate change detection and attribution
- Climate change projection at regional scale via the development and application of statistical models, high resolution RCM, coupled models, their integration of models

accounting for land-use change, ensemble of model simulations

- Evaluation of the feedbacks of the Mediterranean system on the global climate: export of moisture, precipitation in the Sahel region, Modulation of Atlantic MOC by the Mediterranean outflow, effects of Mediterranean SST on atmospheric circulation, the Mediterranean as a source of humidity for nearby regions

Activities proposed

- High resolution regional reanalysis of both the atmospheric and oceanic component of the climate system
- collection, archiving and distribution of instrumental oceanographic and meteorological observations
- Interpretation and collection of records for reconstructing the climate variability in historical times
- Produce datasets for comparing model simulations and reconstructions on decadal and centennial time scale
- Ensemble of regional climate change simulations based on coupled and integrated model systems
- Impact studies and description of the links between climate changes and ecological and socio-economic variables

2. Scientific Content of the MedCLIVAR-Exploratory Workshop

2.1 The Scientific Problem

The Mediterranean Region has many morphologic, geographical, historical and societal characteristics which make its climate scientifically interesting per se. In general, the qualitative concept of “Mediterranean” climate, is characterized by mild wet winters and warm to hot, dry summers and may occur on the West Side of continents between about 30° and 40° latitude. The Mediterranean sea is an important heat reservoir and source of moisture for surrounding land areas; it represents an important source of energy and moisture for cyclone development and its complex land topography plays a crucial role in steering air flow.

Because of its latitude, the Mediterranean Sea is located in a transitional zone where mid-latitude and tropical variability are both important and compete. The Mediterranean climate is exposed to the South Asian Monsoon (SAM) in summer and the Siberian high pressure system in winter. The southern part of the region is mostly under the influence of the descending branch of the Hadley cell, while the Northern part is more linked to the mid-latitude variability, characterized by the NAO and other mid latitude teleconnections patterns. However, the climate variability patterns (teleconnections) present a large amount of synoptic to meso-scale spatial variability, inter-seasonal and multi-decadal to centennial time variability.

The analysis of the Mediterranean Climate can be used to identify changes in the intensity and extension of global scale climate pattern like NAO, ENSO and the monsoons and their region of influence. The Mediterranean region has a large amount of climate information from in historical times. This characteristic is unique on the global scale and has not yet fully exploited. The continuous presence of well-organized local states and the long tradition of scholarship and natural science produced reliable chronicles, which might allow the reconstruction of some aspects of climate since the roman period and possibly further back in time. This availability of chronicles is complemented with remarkably long observational records (associated with old universities and observatories of municipalities, kingdoms and counties) mostly on the central and western-European part of the Mediterranean region. This richness of data gives a unique opportunity for reconstruction of climate in past historical and recent instrumentally developed times.

A further important characteristic of the Mediterranean Sea is the emergence of the first highly populated and technologically advanced societies since, at least, 2000BC. Because of the demographic pressure and exploitation of land for agriculture, the region presents since

ancient times important patterns of land-use change and important anthropic effects on the environment, which are themselves interesting research topics.

Nowadays, about 400 millions people live in the countries around the Mediterranean Sea. This densely populated area has large economic, cultural and demographic contrasts. There are approximately 10-fold differences in GDP between the largest economies of the European Union countries and small Middle East nations, and a 3 to 6-fold difference in the GDP per-capita between Western European countries and the other nations. Demographic trends are also quite different. European countries (also including non EU nations) are close to a null growth and expected to stabilize or even decrease their population, while North African and Asian countries are growing and are expected to double their population by mid 21st century. At difference with European Countries, urbanization for most African Nations is an ongoing process that is changing the socio-economic structures of these regions. All these different trends are likely to produce contrasts and conflicts in a condition of limited available resources. Moreover, different level of services, of readiness to emergencies, technological and economical resources, are likely to result in very different adaptation capabilities to environmental and climate changes. Poorer societies with recently increased urbanization are likely to be critically vulnerable to weather extremes and incapable to adapt to changing climate patterns. Hence the need is paramount for the best possible prediction of future climate scenarios and descriptions of adaptation strategies and costs.

2.2 The Aim of the MedCLIVAR-Exploratory Workshop

About a year ago several “Mediterranean scientists” from atmospheric, oceanographic and paleoclimatic communities decided to establish a framework for cooperation in order to:

- Describe and understand the physical processes responsible for the Mediterranean climate variability and predictability on seasonal, interannual, decadal and centennial time-scale, through the collection and analysis of observations and the development and application of climate models
- Extend the record of Mediterranean climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets
- Extend the range and accuracy of seasonal to interannual Mediterranean climate prediction through the development of regional models
- Understand and predict the response of the Mediterranean climate system to increases of radiatively active gasses and aereosols and compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal

Under the coordination of P. Lionello (Italy), R. Boscolo (Spain) and P. Malanotte-Rizzoli (USA), this group of scientists produced a draft science plan that outlines the state-of-the-art of the Mediterranean climate variability and attempts to define a science agenda for improving climate predictions. This document that was discussed during the Exploratory Workshop by this group in order to:

- Ensure that the fundamental science issues are covered
- Identify the gaps and obstacles to our understanding
- Develop a strategy for officially establishing the MedCLIVAR framework/project
- Ensure that all the groups working on Mediterranean climate variability are represented in the MedCLIVAR framework
- Identify the tools (modelling, observations, analysis etc..) that could improve regional climate predictions in the Mediterranean area
- Establish contacts with relevant national and international projects.

6 Results and future directions

Past and Present Trends of Mediterranean Climate

The Mediterranean is a good source of natural and documentary proxies. MedCLIVAR should encourage a first attempt on Mediterranean climate field reconstruction by:

- Obtaining local and regional reconstructions from natural and documentary proxies (new records in East Med and sea records; entrain North African countries)
- Improving field reconstructions on a multiproxy approach with emphasis on the last 500 years
- Assessing the long-term variability from field reconstructions

Climate simulations are available from “state-of-the-art” Global Climate Models driven by estimations of external forcing conditions since 1000 AD. MedCLIVAR should promote activities like:

- Model-reconstruction comparison, for model validation
- Test reconstruction methods using models as surrogate reality
- Study climate variability at different spatial and temporal scales

There are ongoing activities focussing on understanding decadal variability and the 20th century trends in terms of large-scale dynamics. However there are still several scientific challenges that MedCLIVAR could help to address:

- Improve data availability and quality (data from N. Africa countries, model reanalysis and daily long-term data for analysis of extreme events)
- Improve predictability in areas not influenced by NAO/EA and understand the influence of ENSO and tropics teleconnections
- Link recent trends in relevant Mediterranean Sea variables with changes in runoff, water budget, vegetations etc…
- Identify models deficiencies in simulating relevant Mediterranean climate variability

Tropics and Mediterranean Climate Variability

Tropical "remote" areas seem to play a major role in Mediterranean climate. Physical mechanisms for the teleconnections e.g. ENSO, Indian Monsoon, Hurricanes… should be further investigated. Specific suggestions for future studies are:

- ENSO events influence the Med climate through modulation of both Pacific North American pattern and the local Atlantic Hadley cell (SST patterns in the Tropical North Atlantic, subtropical jet stream, mid latitude storm tracks). New statistical tools should be developed to uncover the non-linear relationship
- The ENSO/Med-precipitation relationship should be explored with the aid of reanalysis and regional models
- The robustness of the ENSO response in the Med and the associated dynamical processes (eddy-mean-flow interaction) should be explored.
- To explore the relationship between the Indian Monsoon rainfall and the following winter rain in the Eastern Med (potential predictability)
- To examine the connection between the lower-level advection and the vertical velocity on varying time-scales as well as the teleconnection with the Asian-Monsoon in cases of extreme events
- To study the mechanisms through which the SST in the Gulf of Guinea affect the summer climate of the Med
- To explore the interactions between the Med SST and the Sahel precipitation and the influence of the African Monsoon over the Atlantic storm track towards North Europe
- To study the statistical relationship between ENSO and autumn rainfall in South-Western Europe, North Africa and Middle-East
- To study the variability of the tropical storm activity over the Atlantic in relation to extreme rainfall over the Med and the energy and moisture balance/dynamics for the Hurrican-Med system

One controversial issue remains the role of the Siberian anticyclone on the Mediterranean. Also it was discussed the role of aerosols in climate change scenarios: climate models should consider more realistic forcings.

Influence of Midlatitudes on the Mediterranean Climate

In this session some aspects of the hydrological cycle driven by the atmospheric circulation in the Mediterranean and West-European region were presented. Some results of a validation of statistical downscaling methods using AMIP climate simulations and preliminary analysis of a simulation with the regional climate model MM5 for the Western Mediterranean region were showed. Idealized model simulations on the influence of Mediterranean sea-surface-temperature on the atmospheric circulation indicate that the Mediterranean surface temperatures may have not only a local influence but also modulate the atmospheric circulation on more remote areas. There are also novel aspects of the influence of the North Atlantic Oscillation on socio-economic sectors, focusing in the generation hydro-power, solar and wind energy. The NAO seems to be quite relevant in all these sectors in Portugal.

The main conclusions on the overview of the state of present research on the influence of midlatitude circulation on winter rainfall and summer temperatures in the Mediterranan basin were:

- The North Atlantic Oscillation exerts a strong influence on mean winter rainfall in the Western Mediterranean and a weaker and opposite influence in the Eastern Mediterranean. The mechanisms to explain this influence are broadly understood in terms of storm track variability.
- Other patterns, e.g. the Eastern Atlantic pattern, may be also important for different areas of the Mediterranean region
- Decadal variations in the probability distribution of rainfall (e.g. changes in the frequency of extreme rainfall) have been observed but the explanations of their origins requires further investigation.
- Summer temperatures are mostly influence by variations in cloudiness related to atmospheric circulation anomalies.

Areas of research that should pursued with more emphasis in the future are:

- Analysis and validation of simulations with climate models to understand the different mechanisms that may potentially explain the influence of different patterns on Mediterranean climate
- Production and analysis of high resolution data sets required by the complicated topography in the Mediterranean basin and the by the role of Mediterranean cyclones

Mediterranean Circulation and Sea Level

Slow, long-term as well as abrupt changes of the circulation and the water mass characteristics of the Mediterranean Sea have been discussed. The causes of these changes remain largely unexplained. In particular significant long-term trends in the

Temperature and Salinity of the upper, intermediate and deep water have been documented and linked to regional climatic forcing, teleconnections (the NAO and potentially other modes) and to anthropogenic origin in the form of damming of rivers. In addition understanding the deep-water formation mechanisms and their recent modification during the Eastern Mediterranean Transient (EMT) remains a priority as no full explanation is yet available in spite of significant progress in identifying and quantifying some of the contributing forcing mechanisms. Improved understanding of the deep-water formation will be required in understanding the time and regional scales and the mechanisms involved in other parts of the ocean where deep-water formation is known to take place. Research is needed to link the large scale meteorological forcing (for example the NAO, the East Atlantic Pattern and the East Atlantic Jet) with the observed local changes in heat loss, E-P, river outflow, changes in the oceanic circulation and other processes that have been suggested as contributors to the creation of the EMT. There is a need to explore the possibility of earlier transients in the deep-water formation activity within the basin by examining historic oceanographic and climatic data.
Significant sea-level changes distinct from global sea-level rise and originating from direct regional atmospheric and oceanographic forcing have also been discussed. The following topics for future investigation were identified:

- To quantify the contribution of the forcing physical parameters in time and space in the thermal and buoyancy fluxes and their impact on mixing in both the Mediterranean and the Black Sea.
- The understanding of the water, heat and salt budgets of the Mediterranean and the Black Sea must be improved. In that respect the exchange of water, heat and salt through the Straits must be understood, measured and if possible parameterized. In addition improved E-P and river outflow data must be incorporated. The nearly enclosed character of the Black Sea and relative richness of hydro-meteorological data make it an ideal laboratory environment to study various climate-related processes.
- The development of a monitoring and modeling strategy for the Mediterranean and the Black Seas. The monitoring should include surface as well as intermediate and deep water measurements from moored and drifting instruments and repeat hydrographic sections, air-ocean interaction parameters and should focus on straits and water formation regions. The modeling should develop/adapt models suitable for climate related research but including the major processes in the two basins.
- To promote research linking the observed physical changes to the ecological and socio-economic impacts in order to assist more realistic prediction and the

development of policies for the sustainable use of the marine living resources both in the Mediterranean and the Black Sea.

Evaluation of the Regional Variability in Connection with Weather Patterns

Statistics of cyclones in the med is affected by complicated mechanisms. NAO exerts an important influence, but it is not the only "actor". Other patterns have an influence comparable to NAO (EA/WR, Siberian anticyclone center of action). This has important consequences on our ability to predict regimes in future scenario. Present statistics is relatively well known (cyclogenesis, cyclolysis, tracks, duration, radius intensity). Cyclones play a key role in the Med environment, with a direct effect on precipitation, waves, storm surges, land slides. Accuracy in predicting these impacts needs to be improved. There are several questions to be addressed:

- How accurately current data archives represent the Med climate variability? How well do current dynamical models simulate this variability and relationship? What are the deficiencies in the models that account for inadequacies in understanding locally and in a global context?
- What is the role of Mediterranean environment (SST, land cover…) on cyclones? How does the role of the Mediterranean area in the cyclogenetetic activity -in producing intensively precipitating cyclones for the surrounding sub-regions (and for the Mediterranean one)- change under the global and regional climate change process?
- How will the weather patterns behave in future scenarios?
- Which will be the impacts on the environment and the changes in the associated mechanisms?

The main tools for improving our skill in predicting the evolution of cyclones regimes in future scenarios and evaluating their impact on the environment are:

- Development of a high resolution datasets combining satellite imagery and meteorological analysis
- High resolution (regional) coupled model simulations both in a climate variability study and climate change perspective

Mediterranean Water and the North Atlantic Deep Cell

This session highlighted the main issues and scientific challenges on the impact of the Med Sea on the North Atlantic thermohaline circulation and hence the global climate:

- What is the influence of the Med outflow water (MOW) on the North Atlantic circulation and on its stability and variability?

- What is the role of the Mediterranean eddies (anticyclones/cyclones Meddies) in the Med outflow intrusion in the Atlantic?
- What is the climatic role of the Gibraltar Strait inflow/outflow variability (freshwater import/salty water export) on the two thermohaline circulations?
- Which are the links between the time variability of the dynamics in the Gibraltar Strait (and of Eastern Mediterranean) and the Mediterranean outflow variability?

The external forcing is the main player in the convective and water formation processes, however their variability is regulated by advective/convective feedbacks. For this reason three lines of research were identified:

- North Atlantic and role of intermediate salt anomaly
- Strait of Gibraltar
- Decadal variability of Med circulation

Modelling of the Mediterranean Regional Climate

Regional climate modeling plays an important role in filling the gap between the current coarse-resolution global coupled climate models and the growing demand of reliable climate predictions and scenarios on shorter spatial and temporal scales. The most important regional climate forcing in the Mediterranean region is associated with the complex orography characterized in many coastal regions by step mountain slopes and the large land-sea contrast. There are different approaches for the Mediterranean regional climate simulations:

- Regional climate models (RCM) or limited area models (LAM)
- Variable grid global GCM with zoom over the Mediterranean
- Statistical downscaling
- Combination of dynamical and statistical downscaling

Only few studies are dedicated to the Med regional climate modeling, most of the existing research programs on climate variability and change over Europe consider only partially the Med basin as the southernmost part of their domain. However regional climate changes under global warming and anthropogenic modification due to land use are the most important motivations for the med regional climate modeling. Modelling is also crucial to understand current climate fluctuations and teleconnections, many of which still need to be satisfactorily explored. Many global and regional models simulate a warming of several degrees (from 3 to 7 K) on the Med region by the end of the 21st century with a warming in summer larger than global average. Results also show a general decreasing trend of mean precipitation for the region (especially in summer) mainly due to the northward extension of the descending branch of the subtropical Hadley circulation.

Three important aspects of the Med regional climate modeling are envisaged for the next few years:

- High-resolution Med climate modeling
- Development and validation of integrated regional modeling systems
- Multi-model ensemble regional climate simulations

The spatial resolution of future modeling systems will be further increased. It is expected to have models with resolution around 10 to 20 km in the next few years. Current studies reported in the literature show improved model performance especially in reproducing extreme events such as strong precipitation episodes and cyclogenesis, often related to the specific surface orography. In the next few years, high-resolution Med climate modeling systems are expected to be used to to produce consistent data for the Med basin for the last 40 years. The current global reanalysis done in weather prediction centers are too coarse and cannot reproduce a correct hydrological cycle.

Eventually the different components of the regional climate will be interactively incorporated in the regional modeling systems: Med Sea general circulation, basin-scale hydrology, dynamical surface vegetation, land use, atmospheric chemistry, air pollution and man-made or desert-originated aerosols, marine and land-surface ecosystems. With increasing complexity of numerical modeling systems, validation against appropriate observations will become an important issue. This will require a significant improvement of the current existing data bases for the region and an increasing observational network.

The ensemble approach should be emphasized as the only way to assess the uncertainties of numerical modeling for climate variability and probabilistic estimates for long-term changes. Currently there are several degrees of uncertainties concerning the climate change prediction, which include the emission scenarios, and the physics of the climate models. The use of regional climate models is likely to further increase the uncertainty range. It is therefore necessary to use a hierarchy of global and regional models and run ensemble simulations even if this is just at the limit of our current computing capacity.

MedCLIVAR link to the WCRP/CLIVAR project and other relevant projects

During the discussion, T. Busalacchi (co-chair of CLIVAR) was asked to comment on how MedCLIVAR could contribute to the CLIVAR (www.clivar.org) global programme. After a brief presentation of the CLIVAR scientific objectives, T. Busalacchi highlighted some of the weaknesses of the present MedCLIVAR effort, in particular he recommended to strengthen the combined atmosphere-ocean-land research and the links to EU framework studies (DEMETER, PROVOST, ENACT, ENSEMBLES), major modeling centers and IPCC. It was decided to make a presentation on MedCLIVAR at the next CLIVAR Scientific Steering

Group meeting (Baltimore, USA, June 2004) and submit a White Paper asking for a scientific endorsement (September 2004).

During the presentations, it was highlighted the benefit from the cooperation with related ongoing efforts in the Mediterranean region. The project “Eau Mediterranee en Atlantique” (EMA) coordinated by X. Carton et al. (2004) is highly relevant to the objectives of the present effort. X. Carton was invited to participate to the workshop but for personal reasons he couldn’t attend.

Plans are also developing for a Mediterranean GEWEX Continental Scale Experiment proposed by Y. Tourre and J-H. Bolle. Contacts are already established with Y. Tourre for a close coordination during the planning phase

Sustaining the future of MedCLIVAR: Funding opportunities

Following a review of ESF-activities and funding instruments, which were presented by D. Altiner, ESF observer, the workshop participants expressed the need for an effective and longer-term coordination of the MedCLIVAR study. The ESF Scientific Programme was identified as the optimal instrument to apply for. The ESF Programme is a networking activity bringing together key researchers and research groups to address major scientific issues at the European level for the duration of 4-5 years.

It was also suggested to resubmit the MedWater proposal to the next EU framework VI. There are no Mediterranean climate studies currently supported by the EU and given the socio-economic implications of climate variability and change, EU should consider to make the Mediterranean a special focal priority.

Concluding remarks

In their concluding remarks the two conveners expressed their satisfaction in the high scientific level of the presentations and the consensus achieved in setting the future steps of MedCLIVAR. The Exploratory Workshop gave the possibility to put together for the first time the experts on Mediterranean climate coming from different disciplines. Such synergy is the key element for the future of MedCLIVAR.

The participants expressed their thanks to the ESF for funding and organisational assistance and they thanked the local organizers for providing an effective working environment.

P. Lionello

R. Boscolo

4. Final Programme

Day 1. Monday May 17th

9:00 Welcome Remarks (P. Lionello,. Ferrara, and V.Artale)
9:20 Overview of ESF structure and funding opportunities (D. Altiner)
9:40 Workshop Motivations and Review of Agenda (R. Boscolo and P. Lionello)
10:00 Past and Present Trends of the Med Climate (F. Gonzalez)
10:30 Present Trends and Future Changes of the Med Climate (J. Jacobeit)
10:55 Coffee Break

11:20 Spanish Research on Historical Climatology (M. Barriendo)
11:40 Med Precipitation Variability Over the Last 500 yr and its Connection to Large-scale Circulation (A. Pauling)
12:00 Tropics and Med Climate Variability (P. Alpert)
12:30 African Monsoon and the Climate of the Med (M. Baldi)
12:50 Summer Regime over the Eastern Med (B. Ziv)
13:10 Lunch

14:30 Long-term Changes in the Summer Regime over the Med Basin (H. Saaroni)
14:50 Tropical Influence on Euro-Asian Autumn Rainfall Variability (N. Zeng)
15:10 Extreme Precipitation Events over NW Italy and their Relationship with Tropical-Extratropical Interactions over the Atlantic (J. Pinto)
15:30 Decadal Variation in the Link between ENSO and NAO (U. Ulbrich)
15:50 Coffee Break

16:20 Influence of Midlatitudes on Med Climate (E. Zorita)
16:50 Role of EA (non-NAO), implications for downscaling. Atmospheric hydrological cycle over the Med. An example of a long MM5 integration over the Iberian Peninsula. (J. Saenz)
17:10 Socio-Economic impacts of NAO (R. Trigo)
17:30 Far Distance Forcing of Rainfall and Other Examples: the Need of Statistaical Techniques Capable to Detect Transitory Forcings (X. Rodo)
17:50 Climate Response to an Idealized Anomaly of the Med Sea Surface Temperature (L. Li)
18:10 Adjourn

Day 2. Tuesday May 18th

9:00 The Med Thermohaline Circulation: Mean State, Trends and Abrupt Events (A. Theocharis and V. Zervakis)
9:45 Climate Variability in the Eastern Med and its Influence on Deep Water Formation (S. Josey)
10:00 Potential Contribution to MedCLIVAR from the Black Sea Interdisciplinary Studies (T. Oguz)
10:20 Variability of the Circulation and Thermohaline Characteristics of the Black Sea (E. Peneva)
10:50 Coffee Break

11:15 The Circulation of the Med Sea and its Sea-level Variability (M. Tsimplis)
12:00 Evaluation of the Regional Variability in Connection with Weather Patterns: Introduction (P. Lionello)
12:10 Cyclone Variability in the Euro-Atlantic Sector (I. Trigo)
12:30 Weather Patterns Typical for Monthly Periods with Precipitation over the Med Region (S. Krichak)
12:50 Lunch

13:50 Assessment of Cyclonic Activity in an ECHAM4/OPYC3 Transient Greenhouse Gas Scenario (J. Pinto)
14:10 Mediterranean Water and the North Atlantic Deep Cell: Introduction (V. Artale)
14:20 The Med Outflow in the Gulf of Cadiz (I. Ambar)
14:40 Numerical Modeling of the Mean and Tidal Exchange Through the Strait of Gibraltar (G. Sannino)
15:00 Effect of the Med Outflow on the Overturning Circulation of the North Atlantic from Box-Models to GCM's (S. Calmanti)
15:20 Modelling of the Med Regional Climate: Introduction (L. Li)
15:30 Modelling Possible Future Changes in Extreme Precipitation in the Med Region (W. May)
15:45 Coffee Break

16:00 Some Interdisciplinary Aspects of the Med Climate (N. Zeng)
16:15 Some Preliminary Results from the Regional Climate Model (RegCM2) Simulations for the Black Sea (E. Peneva)

16:30 Preliminary Results of a Regional Air-sea Coupled Model (M. Crepon)

16:45 The general circulation of the Med Sea with a Very High Resolution Numerical Model (1/16°) (M. Crepon)

17:00 Discussion on the future framework of MedCLIVAR (coord: P. Malanotte-Rizzoli)

19:00 Adjourn

20:00 Workshop Dinner

Day 3. Wednesday May 19th

9:00 Summaries of and recommendations from the workshop sessions:

- Past and Present Trends of the Med Climate (F. Gonzalez)
- Tropics and Med Climate Variability (P. Alpert)
- Influence of Midlatitudes on Med Climate (E. Zorita)
- The Circulation of the Med Sea and its Sea-level Variability (M. Tsimplis)
- Evaluation of the Regional Variability in Connection with Weather Patterns (P. Lionello)
- Mediterranean Water and the North Atlantic Deep Cell (V. Artale)
- Modelling of the Med Regional Climate (L. Li)

10:30 Coffee Break

11:00 Discussion continued…. (coord. : A. Busalacchi)

12:30 Workshop Conclusions (P. Lionello and R. Boscolo)

13:00 End of Workshop

5. Final List of Participants

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5.1 Statistics on participants

Total participants	**37**
Female participants	7
Male participants	30

National participation	
Denmark	1
France	2
Germany	4
Greece	2
Israel	4
Italy	8
Portugal	3
Spain	5
Switzerland	1
Turkey	2
UK	2
USA	3

Distribution by age groups not available.