Summary of contributions sponsored by ESF MedCliVar

Ruti et. al.,: ***A Regional Coupled System for climate change assessment in the Mediterranean region: the CIRCE experience***

At present fully coupled regional climate models are being developed, so that the interactions among the components of the climate system (i.e. ocean, atmosphere, biosphere and sea-ice) are explicitly simulated. Such models are also expected to improve the representation of the present and future water cycle over complex regions such as the Mediterranean area, which is subject both to the influence of global scale dynamics (e.g. disturbances in the mid-latitudes, strength and meridional extension of the Hadley circulation), and to the effects of local physical processes (complex topography, local evaporation).
We developed a Regional Earth System Model for the Mediterranean basin. The system consists of the RegCM (atmospheric model), the MITgcm (ocean model), coupled via OASIS3. In order to taking into account all the components of the water cycle, in particular river-runoff, we have developed and included a catchment-river module.

Here, we would like to present the simulations performed for the XX and XXI centuries within the framework of the CIRCE project. We have performed coupled and stand-alone simulations using ERA40 and ECHAM5 forcing as lateral boundary condition. Accurate comparisons with satellite data have been performed in order to analyze the air-sea interactions. The main results of the CIRCE project will be useful for the future Hymex activities in order to develop a new generation of Regional Earth System Models and to further understand the processes at the air-sea interface.

Gian Luigi Liberti et al.,: ***RaNHyM: A water vapour lidar based network of experimental sites for the Mediterranean hydrological cycle***

This proposal includes a set of observations of the water vapour and other related quantities over the central Mediterranean to be carried out within HyMeX. The observations rely on the coordinated activity of a) an existing network of 11 (3 of which moveable) experimental sites in Italy, France and Germany equipped with water vapour lidars (Raman and DIAL), some of which including temperature or ozone measurement capability, standard meteorological surface measurements and additional instruments (primarily for characterization of aerosols, clouds, and radiation), a well equipped remote marine station on the island of Lampedusa as long term 'open ocean' observatory, b) a moving experimental site including a set of high quality instruments (DIAL (Differential Absorption Lidar), Rotational Raman lidar, X-band radar and Joss-Valdvogel Disdrometer), c) the R/V URANIA equipped, in addition to the standard instrument set, with the RSMAS sea-going equipment for high quality atmospheric observations during dedicated campaigns. Each site in the proposed network is characterized by the capability to perform high quality measurements of the water vapour (WV) vertical structure up to the upper troposphere by means of high performance WV lidars (Raman and DIAL); furthermore, each site is equipped with a radio sounding systems and/or is in the

vicinity operational WMO sounding sites. In addition, all stations are located within experimental sites hosting different instruments producing complementary data helping in the interpretation of the measurements (e.g. lidar for aerosol with analysis of depolarization, photometers and further instrumentation to obtain an accurate description of the atmospheric state in terms of WV (e.g. MW radiometers), meteorological parameters, cirrus and cloud location, radiative fluxes). Three of the experimental observatories can be also moved to other sites of interest. The observatories are located at sites covering a wide range of conditions (i.e. altitude, distance from the sea, land use) representative of a large part of the Coastal areas in the Mediterranean. Several sites have been carrying out regular lidar observations during last years.
The main scientific objectives of the network-coordinated operation are:
a. studies on the water budget of the Mediterranean Sea, through the characterization of the atmospheric water transport, and the identification of constraints for a better determination of the evaporative fluxes; the measurement network will also allow the investigation of sub-regional scale water vapour transport phenomena, and quantify the water vapour evolution in urban and coastal areas;
b. investigation of the moisture distribution and evolution, also in relation to heavy precipitation events;
c. investigation of the water vapour/aerosol/radiation relationships and water vapour/aerosol/clouds interactions;
d. investigation of the feedbacks between aerosol, radiative fluxes, evaporation, and clouds, and of the role of marine particles in the marine environment.

Emmanouil Anagnostou et. al., : *HYDROMED: A proposed US contribution to HYMEX in the study of hydrological cycle, extreme events, and effects on ecosystem processes in the Mediterranean*

HYDROMED is an NSF proposal by four US Institutions, Univ. of Connecticut (UConn), Univ. of Maryland (UMD), the Smithsonian Environmental Research Center (SERC) and Chapman University aimed at (i) engaging top-quality research and academic Institutions from Eastern Med in HyMEX, (ii) supporting the experimental component in the Eastern Med basin, and (iii) reinforcing (with novel methods and instrumentation) measurement capabilities in the Western basin proposed by HyMEX. The topics to be addressed in HYDROMED are (i) improving modeling of continental hydrological processes and (ii) understanding ecosystem response to natural and anthropogenic forcing. Comprehensive studies that take a holistic approach aimed at linking hydrological studies, modeling, predictability of extreme events, and their effects on aquatic ecosystems are rare, particularly for the Mediterranean system. HYDROMED will contribute to the HyMEX community effort to fill this gap in the current research landscape. It will involve a novel synthesis of research targeting improved modeling-prediction of hydrological processes and associated transport of material to the coastal zone, with an enhanced understanding of the effects of hydrologic extremes on coastal biogeochemical cycles, carbon dynamics, and ecosystem functioning. The project will integrate research with education,

promoting teaching and training within an international framework, and bringing people and resources together across cultural and geographical boundaries. Cyber-seminars and workshops will foster effective communication among an extended network of researchers, students, companies, managers and policy developers. The proposed research will benefit society generally by contributing to our ability to develop effective mitigation strategies and address socio-economic issues related to hydrological events (particularly frequency and intensity of extremes), water resources, water quality, and climate-related environmental changes.

Themis Chronis: ***Lightning applications in hydrology and extreme weather forecasting***

Lightning represents a robust and unique diagnostic tool; these attributes emanate from the fact that lightning is a unique proxy to cloud microphysics, severe weather and at the same time can be monitored at high accuracy and frequency, on a global basis. Its presence guarantees certain ongoing microphysical and dynamical processes; from a microphysical point of view, cloud electrification expressed via the Cloud-to-Cloud or Cloud-to-Ground discharges signifies the existence of an electrostatically charged cloud and a combination of various solid [ice, graupel, and hail] and super-cooled aqueous phases [Latham, 1981]. Lightning is also a conditional counterpart to precipitation. The electrical activity in precipitating clouds has a direct relation to the thermodynamic variables, which further control condensation. Recent upgrades in the data assimilation and numerical weather prediction have significantly improved flash-flood forecasts and the severe weather alert status. Unlike most variables used in assimilation (e.g. brightness temperatures or ground data) lightning assimilation can be applied on a real-time basis and can be as frequent in space and time as the computational needs of the numerical model. Papadopoulos et al., [2005] has documented a direct assimilation algorithm that has employed lightning ground-based observations over Europe and Africa. The main idea behind this implementation is that the observed lightning flash rates are used to generate moisture profiles that are closer to the real state of the atmosphere, forcing the model to re-distribute the precipitation amount.

Recent observations over the African continent have revealed that lightning is also a good indicator of extreme weather dynamics; Chronis et al. [2007] has documented that several tropical storms formed off the West African coast showed good agreement between their embedded electrical activity and intensification stages. The Zeus network was the first network to make dedicated and continuous lightning observations over Africa. are used to generate moisture profiles that are closer to the real state of the atmosphere, forcing the model to re-distribute the precipitation amount.

Continuous, global and high temporal resolution precipitation estimates have significantly advanced since the first geo-synchronous (Infra Red-IR) satellites were launched. Due to current technological limitations, geo-synchronous satellites offer worldwide continuous coverage but lack the direct insight of the

atmospheric column physical parameterization.

The passive and active microwave sensors have unequivocally improved the inherited weaknesses of the geo-synchronous spaced-based observations. Passive and active microwave radiometers onboard the Low Earth Orbiters provide the direct microphysical dimension needed in any precipitation retrieval algorithm, although lack the continuous global coverage. Most of the precipitation retrieval algorithms combine all available (visible to microwave) frequencies and encompass the so-called "merged" precipitation products. From an observational perspective, lightning has the ability to abridge the advantage trade-off between the geo and sun-synchronous satellites; the monitoring is global, continuous and the relayed information has direct physical significance to atmospheric processes. Although lightning observations show high co-variability with passive microwave observations, their combinatory use in precipitation retrieval is far from redundant. The major advantage that lightning has to offer is the delineation of the convective and stratiform precipitating areas within the IR/microwave outlined cluster. Recent studies show that lightning-based precipitation retrieval algorithms show improved performance in terms of reducing the bias especially at high rain-rates.

Kontoyiannis, H., and V. Papadopoulos: ***Subsurface temperature and salinity variability in the Aegean-Black Sea system during 1950-2000 and relation to meteorological forcing***

Subsurface temperature and salinity time-series have been constructed for the period 1950-2000 for two areas in the Aegean (one in the southwest and one in the northeast) and two areas in the Black Sea (one in the southwest and one in the northeast) with dense hydrographic data coverage in the MEDAR/MEDATLAS database. The focus is on air-sea interaction in climatic time scales. In order to capture the climatic response to the atmospheric forcing with as little bias as possible we selected a sub-thermocline layer, 80-120 m in the Aegean and $\sigma\theta$ ~14.4-15.5 (~40-~90 m) in the Black Sea for the temperatures, and constructed winter and summer averages for each year and each area. The salinity is also examined in the entire upper ~80 m. In order to examine the variability in all time scales involved, from 3-to-4 year periods to ~30-year trends, the resulting time series were not smoothed.

Well-defined trends are evident in the temperature time series that have already appeared in the literature in basin and year-round averages. A warming period common to all time-series from early-mid 90's until at least 2000, a cooling period common to all time series from mid-late 60's until early-mid 90's, and the period from 1950 until mid-late 60's, in which there is a differentiation in the trend behavior of the time series. 'Warm' time series characterized by higher temperatures, i.e., both Aegean areas in summer, show no trend in this period, whereas 'cold' time series characterized by lower temperatures, i.e., both Black Sea areas in winter, show a warming trend. Similar trend behavior exists in the NAO (North Atlantic Oscillation) and EAWR (East Atlantic West Russian) atmospheric indexes and explains partly but not entirely the temperature trends, indicating that a detailed examination of the climatic atmospheric circulation is

necessary. The periods of the turning points or regime shifts (~1965-1967 and ~1992-1993) seem to be associated with extreme oceanic and/or weather events, reported in the literature, since they are also concurrent with extreme values in the atmospheric indexes.

The salinity time-series have different variability characteristics from the temperature time series. There are no apparent trends in the periods ~1950-1965, ~1965-1995, ~1995-... as in temperature. The only possible long-term trend appears in the salinity of the Aegean during summer where there is an increasing trend after ~1973/1975 and until ~2000, on which there are superimposed ~10-year cycles, i.e., ~1973-1983, ~1983-1990, ~1990-1998. The upper-layer salinity characteristics in the Black Sea are different from the corresponding characteristics of the Aegean. The 'Evaporation-Precipitation' time series obtained from NCEP reanalysis data for the particular areas are visually correlated with the Aegean salinity oscillations of ~1982-1990 and ~1990-1998 and possibly there is a weaker correlation with the Black Sea salinity oscillations in ~1984-1989 and ~1989-1995. In the Black Sea, apparently the rivers have a considerable contribution in the upper-layer long-term salinity variability. Its is obvious that in the period ~1950-1970 the 'E-P' reanalysis time series show in overall no correlation with the salinity time series indicating possibly a weakness in estimating and predicting the weather conditions in those years 4-6 decades ago.

Papadopoulos V., and Chronis, T.,: *Air-Sea Heat Fluxes estimation over the eastern Mediterranean based on HCMR's Poseidon buoy network*

Air-sea interaction includes a wide range of continuously evolving phenomena with significant impacts on key atmospheric and oceanic processes. Air-sea interaction includes mass and momentum interchange. Evaporation, precipitation and absorption of atmospheric gases (O2, CO2) by the ocean are included in the mass interchange while heat fluxes and wind stress define the momentum transfer. The air-sea heat interchange plays a proven key role as:

- A basic input in the oceanic and atmospheric models
- A critical climate regulator
- The main factor of ocean heat content
- A driving force for sea water masses formation and deep water convection
- A climate change index

On a global scale, different data sources targeting the air-sea heat fluxes estimation have been adopted (Josey et al, 2006). These include: a) data from voluntary observing ships and oceanographic buoys b) reanalysis methods (e.g. ECMWF, NCEP-NCAR), c) satellite observations d) Merged techniques involving satellite observations and model reanalysis. The Hellenic Centre for Marine Research (HCMR) has undertaken the employment of the POSEIDON in the production of air-sea heat fluxes estimates. Such process requires the following key variables: total cloud coverage, specific humidity, air temperature, sea surface temperature, wind speed and atmospheric pressure. For the turbulent components, the heat budget estimation additionally utilizes the significant wave height. From the aforementioned variables only the first two are not directly

acquired from the POSEIDON buoys. Presently, the total cloud coverage originates from the extended Hellenic National Meteorological Service ground network. Additional cloudiness information is also acquired by current satellite platforms such as MSG-II and AQUA/TERRA. Regarding specific humidity, the operational constellation of SSM/I is used (Bentamy et al, 2003).

For the calculation of the heat budget components as well as the net heat flux, we employ the bulk formulae. For the short wave radiation the Reed formula (Reed, 1977) has been adopted while an attenuation factor due to atmospheric aerosol concentration is applied. The Bignami formula (Bignami et al, 1995) is used for the long wave radiation and this formulation is widely used for the Mediterranean Sea region. Finally, the COARE algorithm (v3.0) is implemented for the production of the heat budget turbulent components (Fairall et al, 2003). Each heat flux retrieval is limited to the specific buoy-mooring site. Further comparison is evaluated against other products such as the global air-sea interaction atlas of National Oceanographic Centre (UK) and the gridded fluxes from ECMWF and NCEP-NCAR. The future POSEIDON expansion and proper calibration of the proposed method will promote future retrievals and will include other parts of the Mediterranean (e.g. the Levantine and Ionian Seas).

Sofianos S.,: ***Extreme event impact on 3-D thermohaline structure variability in the Aegean-Levantine region***

Recent changes of the thermohaline circulation in the Eastern Mediterranean thermohaline circulation (such as the Eastern Mediterranean Transient) and older observations of the thermohaline structure of the Aegean-Levantine region (with events of dramatic changes of deep water characteristics) reveal the very sensitive character of the regional thermohaline circulation pattern. This and the long term variability of seawater characteristics in various Mediterranean basins show that the deep water mass formation processes in the region can be greatly affected by extreme atmospheric forcing events. Theoretical work and modeling experiments point out the effectiveness of extreme events to produce deep waters of different characteristics and different equilibrium depth. Studying the mechanisms involved in the air-sea interaction under extreme event conditions, with available observations and modeling techniques, and monitoring important sites of water mass formation becomes very important for understanding the regional dynamics of the water cycle and their effect on the climate of the whole Mediterranean Sea region.