

Simulation of Current Wet Winter Eastern Mediterranean Climate

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1. INTRODUCTION

During last several decades regional climate of the Mediterranean (EM) area experiences modifications. A striking example is a climate modification signal is southern Israel's semi-arid fringe between the Mediterranean coastal plain and the Negev Desert, where modern irrigated farming is correlated with increased convection and subsequent convective rains over the same area (Alpert and Mandel, 1986; Ben-Gai et al. 1993, 1994). Similar processes also take place over different parts of the EM region. Changes in temperature as well as changes in precipitation regimes drastically modify the hydrological cycle in the EM. A rise in temperature increase the potential evapo-transpiration and hence the aridity with severe consequences for water availability, especially in the dry summer months. According to the existing estimates a two-degree temperature rise causes up to 40% higher potential evapo-transpiration. Over dry land surface the vapor-pressure deficit rises accordingly. Resulting decreases in surface runoff and groundwater recharge may be much more pronounced than underlying changes in precipitation.

On the other hand, the Mediterranean region climate is also sensitive to variations of large-scale atmospheric circulation. There are several factors responsible for the sensitivity. Among them the role of the winter upper-tropospheric jet streams -- the region is located between the Polar Front Jet and Subtropical Jet Streams (PFJ and STJ). Even a relatively small meridional shift of these currents would noticeably affect the regional conditions (Krichak et al. 1997 a,b; Krichak and Alpert, 1998). According to recent analyses, (Krichak, et al., 2000) the Eastern Mediterranean (EM) weather conditions are also highly dependent on the space distribution of the large-scale synoptic patterns which are represented by anomalies in the mass fields. The wet and dry periods in the EM for instance are associated with distinct SLP and H-500 anomaly patterns over Europe and

adjacent areas. During the dry spells in the region positive SLP/H-500 anomaly prevails over Eastern Europe. During the wet seasons in the EM the situation seems to be almost the opposite - mainly negative SLP/H-500 anomalies over Eastern Europe and positive anomalies over Western Europe.

The presently detected modifications of the Mediterranean climate should not necessary be considered as regional manifestations of the global warming process only. But, the role may not be excluded, though regional consequences of the ongoing global warming are not always correctly understood. In the case of the EM region the diagnosis is not simple since the local land-use changes are especially important here. A land-use change modifies the fluxes of momentum, heat, water, aerosols, and gases as well as near-surface radiation balances. This can cause changes in mesoscale atmospheric circulation and consequently - significant variation of precipitation and precipitation recycling in the area.

The overall aim of the work is to investigate the role of different effects controlling the regional Mediterranean climate using the regional climate simulation approach. The present study is focused on realization of the first stage of the analysis - the simulation of the current Mediterranean climate.

2. OBJECTIVES AND THE METHOD

Although most of the global model climate simulations predict a further precipitation decrease in the Mediterranean region during the main rainy period (Dec-Feb) the question remains to be open. It is possible that the regional effects may cause significant changes in determining the tendencies of the future climate changes in the future. According to the available estimates the regional climate changes in the past have been significantly affected by the local factors. Recent model study by Reale and Shukla (1998) suggests that deforestation around the Mediterranean during the last 2000 years could be a major factor in the dryness of the current

Mediterranean climate. It is suggested that the albedo change due to the change in vegetation has significantly altered the atmospheric circulation over northern Africa and the Mediterranean.

The available model produced estimates are presently based on results of relatively coarse-mesh global climate modeling. Application of the dynamical downscaling approach allows increasing the accuracy of the simulated regional climate estimates using the meso-scale limited area model.

Results of application of the approach for the EM area are presented. Computation is performed with the help of two -- global and regional models with the aim of determination of high-resolution regional climate conditions during the wet winter EM period. One-way interaction is performed at the lateral boundaries of the limited area model used for computation of the EM climate parameters. The regional model in these runs is embedded into the global one. Ability of such a joint global/regional climate modeling system to simulate the main characteristics of wet winter period in the EM is analyzed in the following. An analysis of sensitivity of the simulated climate parameters to variation of external parameters is also performed.

3. DESCRIPTION OF THE MODELS

(The global climate model)

The global climate simulation is performed with the Goddard Institute of Space Studies Atmosphere-Ocean Global Circulation Model (GISS AOGCM) (Russel, 1995; Druyan et al., 1995). The system consists of atmosphere and ocean hydrostatic models synchronously coupled to describe the interaction processes in the atmosphere and ocean. The free ocean surface allows for direct interactions between the atmosphere and ocean, including water mass divergence. The height of the ocean is directly calculated. Continental river-flow from the atmospheric model is added to the ocean with proper location and timing. The oceanic model has a maximum of 13 levels. This number varies depending on the bottom topography of the ocean. The atmospheric model has 9 vertical levels. The 4 x 5 horizontal resolution is used.

(Regional climate model)

Regional downscaling of the GCM results is performed with the University Corporation for Atmospheric Research and Penn State University (UCAR/PSU) mesoscale model MM5 V2. Three nested grids of 58 x 73 points (63, 21 and 7 km horizontal resolution) at each of the model surfaces are used. Two-way nesting is applied. The atmosphere is represented by 23 vertical layers. The vertical resolution at the lowest layer is about 50 m. The following effects are taken into account: (1) Cloud and rain water fields predicted explicitly with simple ice phase microphysics included; (2) Grell cumulus parameterization scheme for the first two grids, no parameterization of convection for the finest grid; (3) The MRF type planetary boundary layer parameterization; (4) multi-layer soil temperature model with mixed substrate below using vertical diffusion equation; (5) surface fluxes; (6) surface temperature prediction; (7) CCM2 radiation cooling of atmosphere; (8) cloud effects on the short-wave radiation processes.

4. ORGANIZATION OF EXPERIMENTS

(The AOGCM run)

The coupled AOGCM has been integrated at GISS for 120 years starting with National Meteorological Center atmospheric observations for December 1, 1977 and from the Levitus (1982) ocean climatological temperature and salinity fields. Present concentration of the CO₂ and the aerosols is used in this control AOGCM run. As a result, the simulated climate corresponds to the present global climate conditions. Analysis of the simulation results was performed and a monthly period with the most intense EM precipitation January of 2071 has been selected for the regional downscaling.

(The MM5 climate simulation)

Results of the AOGCM simulation (wind, geopotential, temperature and specific humidity) are available for the dynamic downscaling for every 24-hrs of the 30 day run. They are those of the control climate simulation at the at the AOGCM model for the wettest simulated winter EM month (January 2071). The grid-point data are determined with the 5° x 4° lat, lon resolution at the following isobaric surfaces - 1000, 850, 700, 500 300 and 100 hPa. The data are used as the initial and boundary conditions for simulating of the 30-day mean atmospheric parameters as

well as the accumulated precipitation over the region.

The climatological SST and standard condition land-use fields are adapted.

The following six model downscaling runs are presently performed using the same set of the AOGCM outputs. :

- I. Control run (Climatic January SST, standard MM5 distribution of the land-use parameters);
- II. Same as the I, but with a real daily SST;
- III. Same as the I, but with a scenario land-use distribution;
- IV. Same as the II, but with a scenario land-use distribution;
- V. Same as I, but with an climate SST + 2 °C over the EM;
- VI. Same as V, but with the real SST + 2 °C over the EM.

5. SIMULATION RESULTS

Comparison of results of the model simulation of the wet regional EM winter conditions with the re-analyzed real data for the wet winter periods in the EM. The data for such a comparison are computed based on the NASA reanalysis data set (DaSilva and Alpert, 1996) for the wettest Eastern Mediterranean month of the 15 y period according to Krichak et al., (2000).

Comparison of the model produced extreme wet climate conditions with the reanalyzed data demonstrates quite acceptable level of their agreement. Effects of the model horizontal resolution as well as the sensitivity of the EM climate to the SST variation are demonstrated.

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