Climate analysis: regional atmospheric processes

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Goals

The main goals of the research in the framework of ICCAP have been:

- To identify observed trends in climate variables over the Eastern Mediterranean.
- To evaluate the ability of climate models to capture the observed trends.
- To analyze predicted trends and compare to the observed ones. – To estimate model errors due to land-use changes over selected global regions and study the implications to the Eastern Mediterranean.
- To find out the optimal configurations of the applied regional climate model MM5 for the region.
- To perform coarse resolution dynamical downscaling for the Eastern Mediterranean using NCEP re-analyses as well as two different climate models (ECHAM4 and HadCM3) and two different scenarios (A2 and B2). – To analyse the respective results.

Key Results

–Synoptic trends: Main mechanisms responsible for the synoptic developments over the Eastern Mediterranean (EM) region have been analyzed (Alpert et al. 2005; Krichak et al. 2004, 2005). The frequency analysis of objectively-classified daily synoptic systems based on the NCEP reanalysis data for the Eastern Mediterranean (EM) region, during 1948-2000 had been completed, (Alpert et al, 2004a, b). Statistical evaluation of the role of the recent trends of the main European teleconnection patterns has been performed (Krichak and Alpert, 2004a, b). The ECHAM4/OPYC3 model output for the EM region over 1950-2000 was analyzed in the same way, thus allowing the comparison of the model EM climate trends with the 'observed' reanalysis trends. Results show that the ECHAM4/OPYC3 does not capture the significant increase of Red-Sea-Trough (RST) frequencies during 1970-2000.

- Review of current GCMs and RCMs results for the eastern Mediterranean. Global & regional climate model parameters for the EM region for global warming scenarios were prepared. The parameters include: rain, temperature, humidity and extremes. The Increment Analysis Update (IAU) method was employed to estimate the contribution of land use changes to the climatic trends in the past 50 years. For this purpose, the spotting and delimiting of regions of majorland use changes over 20 years (1970 – 1990) all over the globe, was performed.For the observed rainfall increase over southern Israel (which is contrary to precipitation trends in the rest of the Jordan River region), a possible link to local land use changes, in particular an increase in irrigated area was suggested (Ben-Gai et al. 1998).
- Trends in tropospheric temperatures over the EM: We analysed 850 mb summer temperature trends over the EM from reanalysis data. A long term_warming trend of 0.013 K/year was found over a 55 year period. There is an increase of both "hot" and "cool" days. The summer maximum temperature increase is 3 times greater than the increase in minimum temperatures. The increase of extended hot periods in summer was associated with severe impacts e.g. on agriculture (Saaroni et al. 2003). – Regional Climate Simulations: RegCM3 30 year regional climate 50 km resolution simulations for 1961-1990 and 2071-2100 (A2, B2 scenarios) - all based on the Hadley Center PRECIS data, have been finalized at TAU using the RegCM3 regional climate system (Pal et al. 2005; Krichak et al. 2005) – see Fig 2.14. Additionally, RCM simulations based on the NCEP/NCAR Reanalysis Project data

for the period 1982-1991 have been performed, using 50 km over the coarse resolution domain and 17 km resolution over the nested sub-domain. Also a 17 km resolution NNRP based RCM simulation has been performed over the entire domain used in the 50 km runs for the two year period of 1982-1983. Also TAU has provided the GLOWA JR community with the results of RCM 50 km simulations at ICTP (1961-1990 CNTRL (control run) , 2071-2100 A2 + B2 using the RegCM2 based on HadCM3 data earlier used in the EU PRUDENCE project). RegCM3 description: The dynamical component of the RegCM3 model is based on the NCAR/PSU MM4 system, which is a compressible, grid point model with hydrostatic balance and vertical sigma-coordinates (Pal et al. 2005). Exceptions are the use of a split-explicit time integration scheme and of an algorithm for reducing horizontal diffusion in the presence of steep topographical gradients. In the last few years, some new physics schemes have become available for use in the RegCM, mostly based on the latest version of the CCM (Community Climate Model). First, the CCM2 radiative transfer package has been replaced by that of the CCM3. In the CCM2 package, the effects of H2O, O3, O2, CO2 and clouds were accounted for. Solar radiative transfer was treated with a d-Eddington approach and cloud radiation depended on three cloud parameters, the cloud fractional cover, the cloud liquid water content, and the cloud effective droplet radius. The CCM3 scheme retains the same structure as that of the CCM2, but it includes new features such as the effect of additional greenhouse gases (NO2, CH4, CFCs), atmospheric aerosols, and cloud ice. The other primary changes are in cloud and precipitation processes. An option has been added to use the deep cumulus convection scheme of the CCM3, which is a mass flux scheme. In the simplified scheme only a prognostic equation for cloud water is included, which accounts for cloud water formation, advection and mixing by turbulence, re-evaporation in sub-saturated conditions, and conversion into rain via a bulk autoconversion term. The main novelty of this scheme does not reside of course in the simplistic microphysics, but in the fact that the predicted cloud water variable is directly used in the cloud radiation calculations. In the previous versions of the model, cloud water variables for radiation calculations were diagnosed in terms of the local relative humidity. Changes were made to the model physics to improve the representation of ocean fluxes, large-scale clouds and precipitation. Improvements in the model physics also include a new scheme to represent the sub-grid scale effects of topography and land use, and the coupling of a tracer model to represent the effects of aerosols. Soil moisture initialization for the climate simulations with the RegCM3__ is currently based on the vegetation specifications available. Additional development of the RegCM3 model with the aim to include the effects of the nonhydrostatic atmospheric dynamics which may play an important role for performing the climate simulations with the horizontal resolutions lower than ~10 km are currently in progress.

Principal results

Medium resolution (50 km; 14 levels) regional simulations of the current (1961-1990) and future (2071-2100, A2 and B2 IPCC scenarios) climates according to the Hadley Center AOGCM (Atmosphere-Ocean General Circulation Model) have finalized (Krichak et al. 2005). Statistical evaluation of the results of the RCM simulations has been performed.

Frequency analysis of classified synoptic systems in the Eastern Mediterranean (EM) region during 1948-2000 has served as a tool in the EM climate trend analysis and new definition of the EM seasons.One primary result is a significant increase in the frequency of Red-sea trough synoptic situations. This comes on account of rain-bearing systems as discussed in our papers Alpert et al. (2004a, b), Krichak and Alpert (2005a, b), Krichak et al. (2004, 2005c). Also, this means higher chance for flooding due to active Red-Sea trough situations. The ECHAM4/OPYC3 model

output for the EM region over 1950-2000 has compared the real trends based on the NCEP reanalysis data. However, it does not capture the significant increase of Red-Sea-Trough (RST) frequencies during 1970-2000.The ECHAM4/OPYC3 model output for the EM region over 1950-2000 has compared the real trends based on the NCEP reanalysis data. However, it does not capture the significant increase of Red-Sea-Trough (RST) frequencies during 1970-2000. The frequency analysis of the ECHAM4/OPYC3 model output for the EM region over 1950-2000 has allowed analyzing the seasonal sensitivity of the model as compared to the reanalysis.

Data from ECHAM4/OPYC3 and from Hadley Center Climate prediction for 21st century was obtained and analysis of future synoptic variations is ready to be performed. A review of 19 GCMs and RCMs results of climate parameters for the EM region for the past 50-100 years was prepared. The parameters include; rain, temperature, humidity and extremes.

Conclusions and outlook for the last year of the project

Results of the RCM simulations with the RegCM3 model demonstrate its ability to represent important elements of the eastern Mediterranean climate. The simulation results demonstrate a tendency for a temperature increase, precipitation decrease as well as increase in the frequency of occurrence of the extreme events in the EM according to the IPCC GHG emission scenarios. The global climate model ECHAM4/OPYC3 does not capture the significant increase of Red-Sea-Trough (RST) frequencies during 1970-2000, but it does capture correctly the percentages of the different synoptic systems over the Eastern Mediterranean. Based on these results also other global models should be analyzed as well as newer versions of the ECHAM-GCM. Further work will be:

- To continue the RegCM3 model optimization for more accurate representation of the climate processes over the EM and performing the medium resolution current and future regional climate simulations based on the Hadley Center and ECHAM global models data.
- To analyse the Hadley Center model data for past and future simulations. - To perform future synoptic variations on ECHAM4/OPYC3 and from Hadley Center Climate data for 21st century.
- To investigate lower tropospheric trends in additional variables like humidity, pressure, winds.