4.6 INVESTIGATION OF MIDDLE EASTERN CLIMATE USING A REGIONAL CLIMATE MODEL

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1. INTRODUCTION

South-West Asia (or the Middle-East), shown in Figure 1, is a relatively data sparse region of the world however it is interesting for several reasons. It is a region marked by political conflict. Rapid population growth and water scarcity are common throughout the area, rendering it sensitive to changes in climate. This emphasizes the importance of good meteorological and climatic knowledge to the region.

The region is interesting both meteorologically and climatically being a predominantly semi-arid to arid region surrounded by the Black and Caspian Seas in the north, the Mediterranean in the West and the Red Sea and Persian Gulf in the south, and crossed by the impressive Tauros and Zagros mountains. It includes the archeologically important *Fertile Crescent*, the birthplace of agriculture and civilization. This extended human history stimulates an interest in the paleo-climate evolution of the region, and the link between this evolution and the vegetation of the area.

This work occurs within the auspices of a larger project, the South-West Asia Project (SWAP), who's eventual aim it is to quantify and monitor the processes shaping the landscapes of Southwest Asia. More information about SWAP can be found at http://www.yale.edu/ceo/Projects/swap.html.

The sparsity of atmospheric data is accompanied by a corresponding sparsity in the meteorological and climatic literature. A general description of Near East climate is given by Taha et al. (1981). Analysis of natural vegetation and climate can be found in Nahal (1981) and Zohary (1973).

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Here, we use a regional climate model developed at the National Center for Atmospheric Research (NCAR) USA, RegCM2 (Giorgi et al., 1993a, 1993b), to numerically model the climate for the region. Given adequate reproduction of present climate by the model it will then be used, in conjunction with some paleo-climate GCM runs made using CCM3, to investigate the evolution of the paleo-climate and it's influence on the rise of agriculture and civilization.

In this paper we present some preliminary results of the regional climate modeling compared to climatological monthly precipitation and temperature surfaces created by interpolating the heterogeneously distributed and often sparse FAO/WMO station data using a CRESSMAN technique with a variable radius of influence.

2. RESULTS

The topography of the region is shown in Figure 1. Clearly seen are the high and steep Caucus (in the north between the Black and Caspian Seas) and the Taurus and Zagros mountains (extending west-east between the Black and Mediterranean Seas and then south-east towards the Persian Gulf). South of these ranges is a large semi-arid to arid region with relatively little relief. Of significant importance is the very thin north-south range along the Mediterranean coast which extends (with some gaps) from Turkey down to the Sinai Peninsula. This coastal range is often only around 30km wide making it very difficult to model using spatial resolutions greater than say 10km.

The combination of large water bodies and high mountain ranges combine to produce some very steep climatic gradients which are perhaps best seen in Figure 2 which displays the annual climatological precipitation produced using twenty years of monthly data starting in 1955 from around 1700 stations, interpolated to a 5km grid. Strong precipitation maxima can be seen along the coasts of the Mediterranean, Black and Caspian Seas

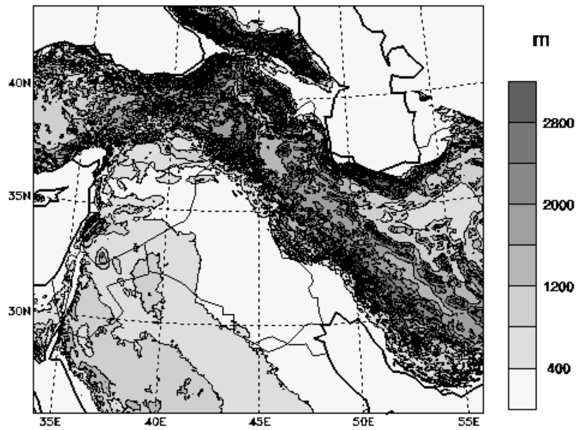

Figure 1: 1km DEM of study region

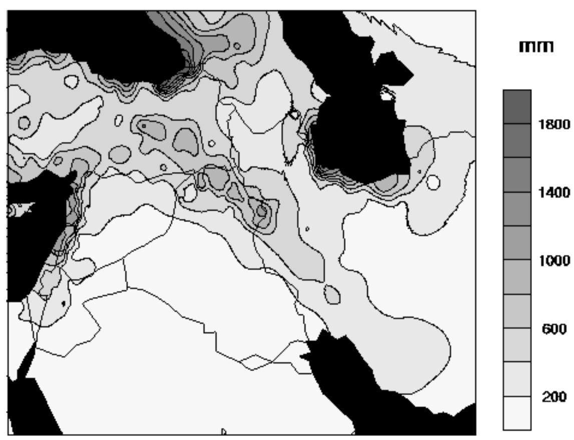

Figure 2: Observed mean annual precipitation

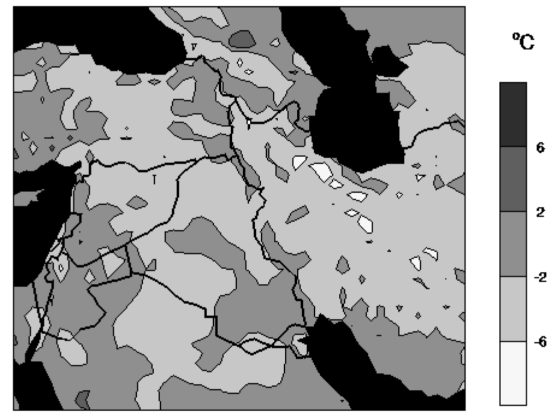

Figure 3: Mean annual temperature difference (model – observed)

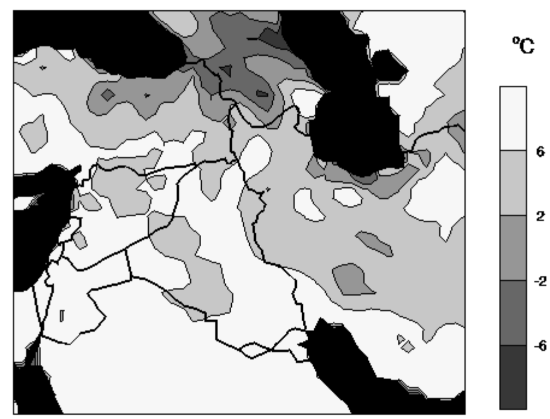

Figure 4: Annual temperature range difference (model – observed)

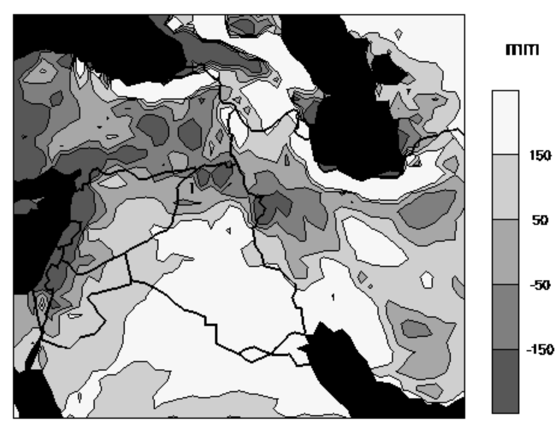

Figure 5: Mean annual precipitation difference (model – observed)

as well as in the mountains of northern Iraq and into Syria. This last region is the headwaters of the Tigris and Euphrates Rivers, a region often referred to as the *Fertile Crescent.* Less than 200mm of precipitation falls annually in the majority of the southern part of the region.

The regional climate models ability to reproduce this modern precipitation distribution is a difficult yet vital requirement before the model can be used for climate variation studies. Presented in Figure 3 to 5 are the results of an initial 3 year run of the RegCM2 model using a 45km grid spacing. This grid spacing was required due to the large domain and limited computational time, however it also means that much of the coastal Mediterranean range is not present.

From Figure 3 it can be seen that for much of the region the model displays a cold bias. In particular the Tauros and Zagros mountains are generally too cold by around 4ºC. Figure 4 shows the modeled annual temperature range to be more than 2ºC too large for most of the region. This is due largely to minimum winter temperatures being considerably colder than those observed while most of the maximum summer temperatures are within a degree or two of the observed values.

In terms of modeled precipitation the model is able to capture the maximums along the Black and

Caspian Sea coasts. In Figure 5 it can be seen that the model overestimates this precipitation by some 150mm, however this is an error of only around 10%. The *Fertile Crescent* precipitation maximum is also captured by the model though it is underestimated by 50 – 100mm, again this represents an error of around 10%. Much larger errors are seen along the Mediterranean coast where the modeled precipitation is more then 150mm lower then the observed. This is not surprising given that the coastal range is not present in the model topography, removing any possibility of orographically triggered precipitation. Another concern is the overestimation of precipitation in the southern semi-arid to arid portion of the region. Here the model can predict double the observed precipitation, enough to turn these deserts into arable land.

This initial run demonstrates several deficiencies in the model when applied to this region. The most important of which are the inability to capture the relatively small but crucial high precipitation climatic zone along the Mediterranean coast and the arid zone to the east of there. To address these problems further experiments are being carried out using a significantly higher spatial resolution in order to capture the Mediterranean coastal mountains in the model topography. The precipitation in the arid region is dominated by convective processes indicating that the cumulus parameterization used (Grell, 1993) is too active. Many such cumulus parameterizations have been tested and tuned for conditions over north America and may need to be adjusted for use in this study region.

Despite problems on the Mediterranean coast and in the arid areas the model is still able to provide some insight into the climatic regime of areas such as the *Fertile Crescent*. Figure 6 presents the low level mixing ratio just prior to the largest storm event in the box shown (lat 36:38, lon 42:44.5) during the model run. It clearly shows the strong moisture transport from both the Mediterranean and the Persian Gulf area. Transport from the south tends to dominate the low levels while transport from the west dominates higher levels. Similar moisture transport patterns are seen in 8/10 largest precipitation events in the box.

3. FUTURE WORK

Further experiments with the regional climate model including higher resolution and an altered cumulus parameterization will be conducted.

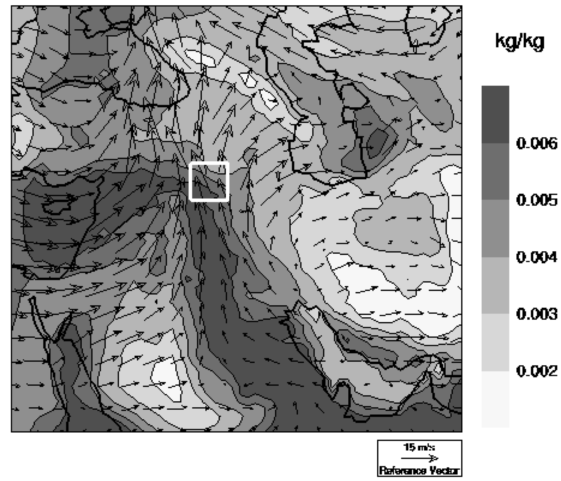

Figure 6: H_2O mixing ratio and wind at ~900mb on 2/15/90

Experiments aimed at identifying the role of each of the major water bodies in the region will also be undertaken along with increased CO_2 runs. The eventual aim of this work being to conduct paleo-climate experiments. To identify regional impacts of changes in climate over the past several thousand years and their implications for agriculture and the rise of civilization.

4. REFERENCES

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