1.6 The Water Crisis in the E. Mediterranean – and Relation to Global Warming?

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1.6.1 Abstract

There is an on-going debate in Israel on the current political background of the water crisis with Lebanon whether the water shortage in recent years in this region has to do with global warming. On the face of it the analyses of temperature as well as rainfall trends are *not* in agreement with global warming trends. It is the purpose of this Note to show that the observed changes can indeed be linked directly to global warming predictions.

1.6.2 The Temperature Paradox

Winter temperatures in Israel have decreased significantly in 1964-1994 [Ben-Gai et al., 1999] in contradiction to the dominant increasing trends in most world regions as predicted by global warming. The summer temperatures significant increases are nearly canceled on an annual basis by the winter decreases. The summer results based on 40 stations with daily maximum and minimum temperatures in Israel, show in accordance with global warming prediction [IPCC, 2001] that the summer minimum and maximum temperatures have increased by 0.26 and 0.21 K/dec. The corresponding winter trends are –0.12 and –0.38 K/dec. Hence, in both seasons the diurnal temperature range decreases. Also, the annual temperature amplitude increases yielding warmer summers and colder winters [Ben-Gai et al., 1999]. It should be noted that summer temperature increases fit the general trends over the Mediterranean (Xoplaki et al., 2003; Price et al., 1999).

1.6.3 The Rainfall Paradoxes

As to rainfall, again mixed trends are found over the E. Mediterranean (EM, in brief) but the mixed trends are now on a spatial/geographic basis not temporal; central-south Israel show rainfall increases while in the neighboring regions such as Jordan, Turkey, Syria decreases clearly dominate [Steinberger and Gazit-Yaari, 1996].

A third feature which seems paradoxical is the increase in extreme daily rainfall over the Mediterranean particularly over the west and central in spite of significant decreases in the totals. This was explained by the change in the rainfall distributions [Alpert et al. 2002].

1.6.4 Discussion

In this note I wish to explain the <u>seemingly</u> contradicting messages deduced from the temperature and rainfall trends in this highly conflicted region. And to show that these results can indeed be traced to global warming changes and particularly to the North Atlantic Oscillation (NAO) and other tele-connections and the associated synoptic changes.

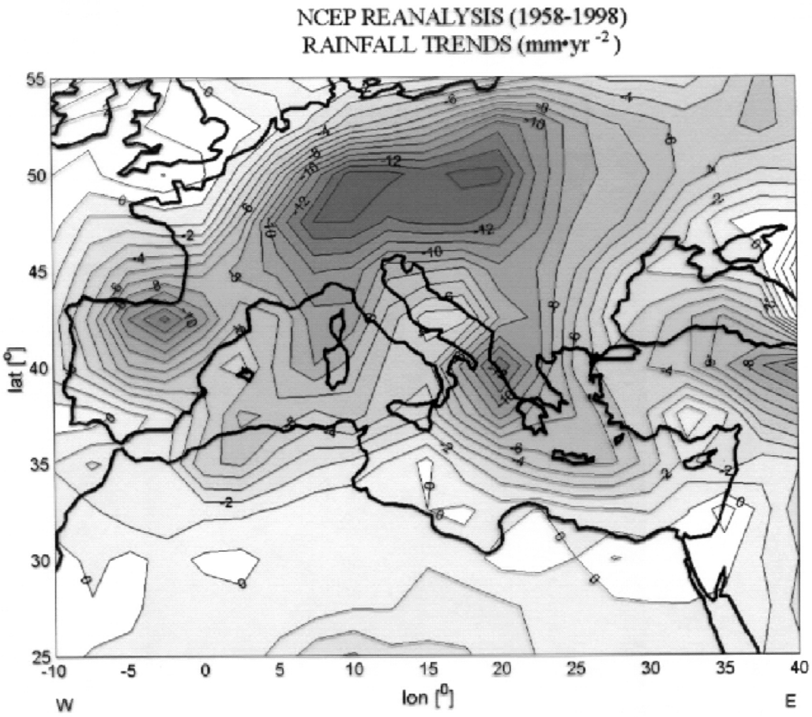
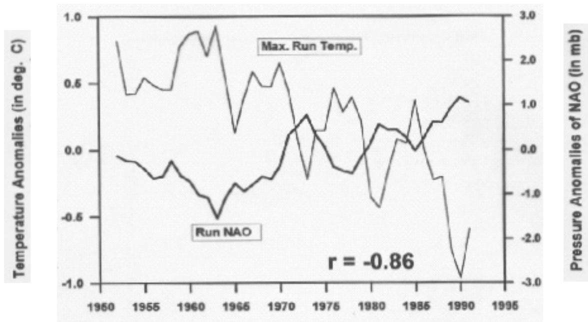


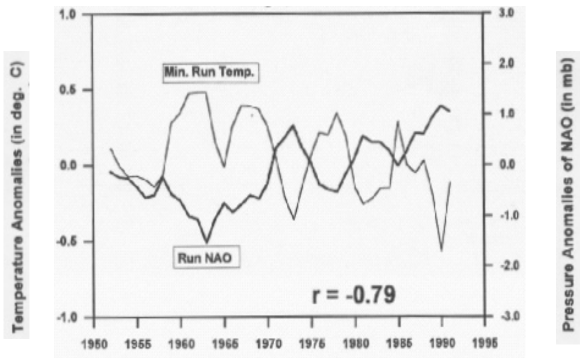
Fig. 1.6.1. Mediterranean rainfall trends for 1958-1998 based on NCEP reanalysis. Decreasing center of –12 mm/y over N. Italy is equivalent to 480 mm drop in annual rainfall over 40 y [see Piervitalli, 1998]. Additional decreasing centers are over Spain, Greece. These maxima are somewhat exaggerated compared to rain gauge data but agree well with the rain gauge analysis [Dai et al., 1997]. Over the SE and Israel some increases are noticed.

Figure 1.6.1 shows the Mediterranean rainfall trends for 1958-1998 based on NCEP reanalyses. These are grid data based on model and observations but global rain gauges analysis in recent 89 y [Dai et al., 1997] as well as regional analyses [Piervitalli et al., 1998, Trigo et al., 2000] fit well to the integrated picture of Fig. 1.6.1.



a. Winter Tmax & NAO

b. Winter Tmin & NAO



c. Sea level pressure & NAO

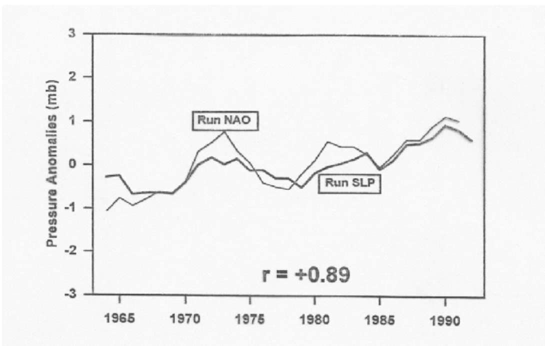
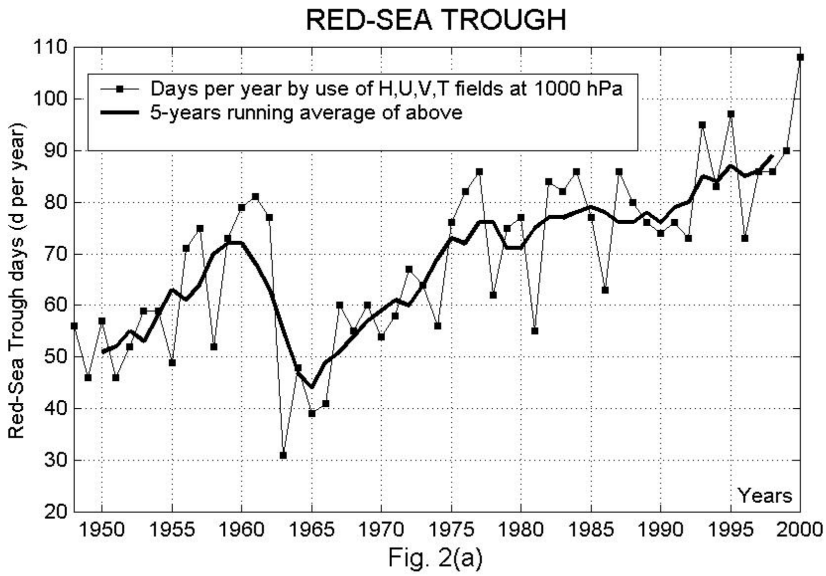


Fig. 1.6.2. Smoothed anomalies (5 y running mean) of Israel winter maximum and minimum winter temperature as well as sea-level pressure, SLP (December-March) and the NAO index. Coefficients of correlation between NAO index and anomalies of maximum and minimum temperatures and SLP are -0.86 (a), -0.79 (b), and +0.89 (c), respectively.



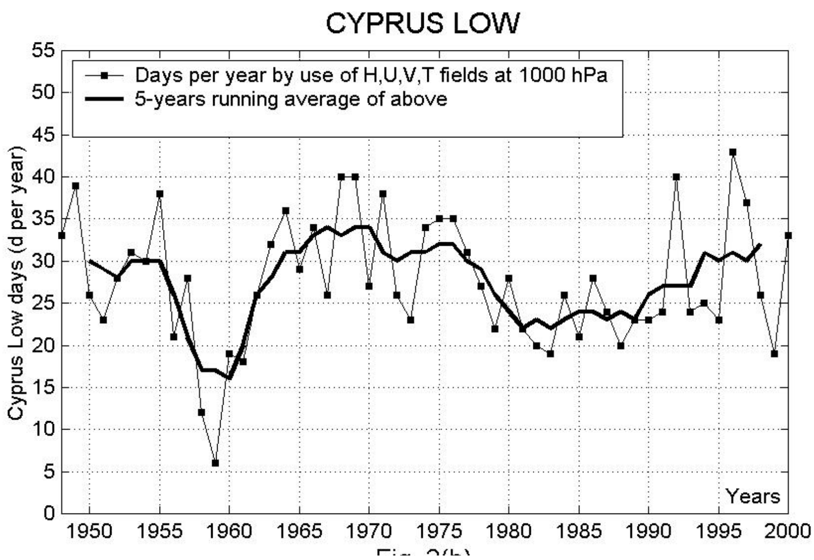


Fig. 1.6.3. The annual numbers of Red Sea Trough days (a) and Cyprus Low days (b) for 1948-2000. Thin lines with squares indicate results obtained by use of H, T, U, V fields at 1000 hPa level. Heavy lines are 5-y running means.

Rainfall predictions for the global warming scenarios also show dominant decreasing trends over the Mediterranean [IPCC, 2001]. Focusing over the Mediterranean averaged 19 global forecasts as well as in most models show steep decreases are predicted over the central/west Mediterranean while mixed trends over the E/SE Mediterranean [Jouni Raisanen, personal communication]. This predicted Mediterranean drying is in accordance with the observed recent trends (Fig. 1.6.1) and can be explained by the increased NAO since the 1970's [Thompson and Wallace, 2001]. Since, increased NAO is associated with stronger southwesterly flow over W. Europe and a drier Mediterranean. The recent increasing NAO index was also linked to the global warming [Thompson and Wallace, 2001; Steven Feldstein, personal communication] and hence with the drier Mediterranean.

Here, we wish to address the mixed E. Mediterranean response in temperature and rainfall in view of all the above? The following arguments are that the unique mixed response over the E. Mediterranean can be directly explained by the global warming above-mentioned characteristics.

First, the NAO increase in winter is negatively correlated with temperature and positively with the pressure, over the E. Mediterranean (Israel), Fig. 1.6.2. It is not clearly correlated with rainfall over the EM. Hence, NAO increases (linked to global warming) can explain the lower winter temperatures over Israel. Colder winter air temperatures over the EM were earlier found to correlate with more rainfall [Striem, 1979] but this may not be so simple here since surface pressure also increases. Surface pressure increases suggest reduced number of E. Mediterranean (Cyprus) Lows and weaker westerly flows which are the main agents for EM rainfall. Indeed, our objective analysis of daily EM synoptic systems based on NCEP reanalysis for 1948-2000 suggest a drop in the annual number of Cyprus lows as well as a significant increase in the frequency of Red Sea Trough (RST) days, Fig. 1.6.3, Alpert et al. (2003).

The RST is associated with easterly drier and frequently colder flow over the EM [Saaroni et al., 1998]. At the same time active RST synoptic situations may yield severe storms with moisture from the tropics [Krichak et al., 1998] particularly over the SE region of the Mediterranean. Hence, less rainfall in the north EM and potential increase of rainfall over the SE region, particularly heavy rainfall.

1.6.5 Summary

The outstanding features in the EM recent climate changes, i.e. decreasing winter temperatures, increased rainfall in the south EM in spite of dominant decreases over the whole Mediterranean and the increase in extreme daily rainfall along with general decrease in totals, can be all explained by global teleconnections that can be linked to global warming. The recent NAO index increase is directly related to cooler winters over the EM. The south EM does not suffer from the dominant rainfall decreases over the region thanks to the positive contribution of the EA/WR index which strongly affects the EM rainfall [Krichak et al., 2002]. Also, increases in El-Nino events were found to be positively correlated to rainfall in the region [Price et al., 1998].

Local land-use changes over central to south Israel were also shown to positively contribute to the rainfall increases there [Otterman et al., 1990, Ben-Gai et al., 1993]. The increase of extreme rainfall over Israel in spite of decrease in rainfall totals reflects a change in the rainfall distributions. The latter is suggested to be the result of increase in Red-Sea Trough synoptic situation on the account of other systems like the Cyprus Low.

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