Recent climatic trends over the Mediterranean and future projections

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Financed by: German Federal Ministry of Education and Research
In cooperation with: Israeli Ministry of Science and Technology
Principal Objectives for GLOWA JR I

- To determine the vulnerability of water resources in Israel in response to climate change
- To develop sustainable management practices in the watershed of the Jordan River

See Poster by J. Daniels next to Registration
Outline
(Observations vs. Projections)

1. Temperatures
2. Rainfall
3. Extreme Temperature
4. Extreme Rainfall
5. Synoptic systems
6. Open questions
1. Temperatures

a. Observed trends
b. Predicted trends
Trend summer (JJA) temperature ($^{\circ}$C/100y) - NNRP reanalysis

Warming trend of 1.5 – 4$^{\circ}$C/100y, mostly over W Med & Egypt, ~3-4 times that of the global trend

See Poster: Saaroni et al.

Summer (JJA) Maximum Temperatures

2071-2100 compared to 1961-1990

Regional Climate Modelling (ICTP & TAU)
The SRES marker emission scenarios and the resulting change in concentration emissions and concentrations.
Summer (JJA) Maximum Temperatures - Differences

A2 - control JJA
Max. Temp. at 2m ICTP

B2 - control JJA
Max. Temp. at 2m ICTP
Change in annual mean temperature, years 61-80

Raisinen (Personal Communication)
The Temperature Paradox in Israel

Summer Temperatures Increase
Winter Temperatures Decrease

Total trend: None
Surface Temp. Trends in Israel (1965 – 95)

Ben-Gai, Bitan, Manes, Alpert, 1998: TAC
Winter Temperatures in Israel & NAO

a. Winter Tmax & NAO

b. Winter Tmin & NAO

Ben-Gai, Bitan, Manes, Alpert, Kushnir, BLM, 2001
Distribution of the shape of the 1948-2000 curve trends of the 850 hPa temperatures
(See Poster)

2. Rainfall

a. Observed trends
b. Predicted trends

Precipitation Trends in the 20th Century

By Anthony Del Genio, Aiguo Dai, and Inez Fung

Long term precipitation trends observed during 1900-98; green/blue indicate places that have become wetter, yellow/orange/red indicate locations that have become drier. The northern half of Africa is omitted because its dominant long-term trend is the Sahelian drought of the past few decades, a phenomenon distinct from the century-long trends seen elsewhere in the world.
Raisinen (Personal Communication)
Rainfall over the Central-Western Mediterranean basin in the period 1951-1995. Part I: precipitation trends

E. Piervitali, M. Colacino and M. Coatte
Istituto di Fisica dell’Atmosfera (CNR) - Roma, Italy
Sharp gradient in Trends over Israel

Steinberger & Gazit – Yaari, J. Climate, 1996
GCM prediction: further aridification and increasing variability
Winter (DJF) Rainfall Differences

A2–control DJF seasonal precipitation (mm) ICTP

B2–control DJF seasonal precipitation (mm) ICTP
The Rainfall Paradox in Israel
North Israel- Decreasing trends
South Israel- Increasing trends

Why increase in the south?
(In 2003/4 – just the opposite; change of trends since 90s?)

Possible answers:
• Land-use change
• Tele-connections,
• Synoptic changes
• All the above; factor separation?
Red-Sea Trough
Cyprus Low days per year (1948-2000)

Reconstructed Albedo

1930’s

1960’s

1990’s

Trend Histograms of October Rainfall in Northern Negev Stations Compared to Control Stations in North Israel

3. Extreme Temperatures

a. Observed trends
b. Predicted trends
Distribution of 850 mb daily summer temperatures

- Shift in the mode
- Increase in extreme events

Histogram for Duration (d) of hot/cool spells
(850 mb NNRP reanalysis)

**1975-1948**

**2002-1976**

Ziv, H. Saaroni, A. Baharad, D. Yekutieli and P. Alpert, 2005,
The indications for aggravation in summer heat conditions over the Mediterranean Basin.
GRL (in press)
Effects of extreme temperatures

• Fruit loss (fall-out) particularly in Citrus

• Longer periods of hot spells cause
  1. increase in water consumption
  2. damage to young fruit

Thanks to Jiftah Ben-Asher
Tmax, summer, Har-Knaan

Downscaling Daily Temperatures (1961-1990)

Following Deque
Har-Knaan, TMAX, distribution

![Graph showing TMAX distribution with different corrected scenarios: observed, control corrected, B2 corrected, A2 corrected.](image)
4. Extreme Rainfall

a. Observed trends
b. Predicted trends
Spain- Trend in daily Rainfall Categories
(~400 raingauges)

Natural separation of categories

Alpert et al, GRL, 2002
Israel- Trend in Rainfall Categories
(~ 40 raingauges)

Heavy categories (C1, C2) UP
Light categories (A, B) DOWN

Alpert et al, GRL, 2002
Downscaling Daily Rainfall (1961-1990)
precipitation, Har-Knaan, corrected, log, centiles

The graph illustrates the distribution of precipitation (mm/d) across different percentiles (0% to 100%) for observed and simulated data. The lines represent observed (black), control (blue), B2 (green), and A2 (red) scenarios.
precipitation, Har-Knaan, corrected, zoom2, centiles

percent (%)

precipitation (mm/d)

- observed
- control
- B2
- A2
Some Paradoxes in Israel Climatic Trends

The Extreme Rainfall Paradox in the Mediterranean

Total Rain decreases
Extreme rainfall increases

Answer:
Change of rainfall distribution
Change in Temp. Distributions under Global Warming (3 Options)

(a) Increase in mean

(b) Increase in variance

(c) Increase in mean and variance

IPCC, 2001
Decrease in mean & increase in variance

Is this paradoxical behavior really occurring in the Mediterranean?

Yes,

P. Alpert, T. Ben-Gai, A. Baharad, Y. Benjamini, D. Yekutieli, M. Colacino, L. Diodato, C. Ramis, V. Homar, R. Romero, S. Michaelides and A. Manes,

Trends (%) in total versus Heavy Precipitation
Probability Density Function
Amamentos Station - Cyprus

- Probability Density Function is based on a gamma function

Ben-Gai et al, TAC, 1999

20.8 0.0229 = 43mm
8.8585 0.0106 = 94mm
"The Climate System is an Angry Beast and we are Poking it with Sticks" (NY Times).

My Translation:

"מערכת האקלים דומה להירה עצובת אנחון ודקריה אזהה (ללא-חר) בصيانות"
5. Synoptic systems

a. Observed trends
b. Predicted trends
B2 – dynamics of technological change continue along the historical trends

Observed CO₂ and other GHG
ECHAM-Black & Red
HadCM3- Green & Blue

ECHAM4/OPYC3 (1950-2099) and HadCM3 (1960-1990) MODELED E. MEDITERRANEAN SYNOPTIC SYSTEMS,

CYCLONIC ACTIVITY EXPRESSED BY WINTER LOWS FROM WEST TO EAST

ECHAM4

ASIAN SUMMER MONSOON EXPRESSED BY PERSIAN TROUGH

HadCM3-

Observed CO₂ and other GHG

B2 – dynamics of technological change continue along the historical trends
Do global models “see” the recent synoptic trends?
ECHAM vs. NCEP reanalysis (1950-2000)
Annual frequencies of Synoptic Systems

ANNUAL FREQUENCIES AVERAGED OVER 1950-2000:
ECHAM4/OPYC3 MODEL VS. NCEP REANALYSIS

The good news
Cyprus Low days per year (1948-2000)

The Bad news
Some unanswered questions?
Question No. 1:

Are seasons changing

In the E. Mediterranean?

Alpert, P., Osetinsky, I., Ziv, B. and Shafir, H., 2004:
"A New Definition to the Seasons Based on Synoptic Systems and Example for Israel", Intern. J. Climatology, (in press)
Synoptic systems’ frequencies averaged over 1948-2000
Definitions of the Seasons

high season

summer

synoptic temperature meteorological astronomical
Definitions of the Seasons

- Synoptic
- Meteorological
- Astronomical

Winter

High season
Question No. 2:
How large are the errors in the global climate models caused by ‘ignoring’ land-use changes?
Regions of major LUC over 40 years (1950 – 1990), HYDE database
Question No. 3:
Do we really know the rainfall distribution over the E. Mediterranean?
For instance, where is the maximum?
E. Mediterranean Rainfall - 5 winters
TRMM satellite vs. NNRP15 reanalysis

1998/9

1999/00

2000/01

TRMM

NNRP
E. Mediterranean Rainfall
TRMM satellite vs. NNRP15 reanalysis

2001/2

2002/3

Total- 5 winters

TRMM

NNRP
E. Mediterranean Rainfall 2003/4 (Dec-Feb)
TRMM VS. Mesoscale model

TRMM

MM5 - fine
20 km

MM5 - coarse
60 km
2 May 2001, Ecology Meeting, Tel-Aviv

Edmond burke (19th Century) from “Global Warming” by Sir J. Houghton (1997):

“Nobody made a greater mistake than he who did nothing because he could only do a little”

"אף אדם שטענה שעזב גזילה יותר מאריך אותו杉はありません דבר מהמחוק כיום לקושיא אי מועט".

מ нескאת אבות.

 réalité תרמאר: "לא עלייך המלאכה לומר הוא אenticate ב-חרימי למכסית" (אמרות, ב, 59).
SUMMARY

• Large-scale IPCC predictions over the Mediterranean suggest: 3-35% rainfall reductions; 3-5 Deg warming by 2071-2100.
• Nearly all the Mediterranean shows significant rainfall decreasing trends.
• In Israel, there are mixed rainfall trends with increases over the south.
• Rainfall increases over the south are partly due to land-use changes and partly due to synoptic increase of Red-Sea Trough frequency.
• Winter temperatures in Israel are dropping due to NAO increase and hence due to global warming!
Past 420,000 y

Fig. 1. A correlation between atmospheric partial pressure of CO$_2$ ($p$CO$_2$) and isotopic ($\delta$) temperature anomalies as recorded in the Vostok ice core. The figure shows that climate variation in the past 420,000 years operated within a relatively constrained domain. Data are from (8).
Tropical effects on Mediterranean Weather & Climate

- Hurricane Olga
- Indian Monsoon
- African Monsoon
- El-Nino
Thank you!
Raisinen (Personal Communication)
Question No. 3:

Why increase in the south?

This year 2003/4 – just the opposite; change of trends since 90s?
850 hPa absolute maximum & minimum temperatures for July/August at (32.5°N, 35°E)

Max. Temp. Trend = +0.195 K/10y

Min. Temp. Trend = +0.06 K/10y

Past 420,000 y

CO₂ concentration

Temperature-anomalies

Fig. 1. A correlation between atmospheric partial pressure of CO₂ ($p$CO₂) and isotopic ($δ$) temperature anomalies as recorded in the Vostok ice core. The figure shows that climate variation in the past 420,000 years operated within a relatively constrained domain. Data are from (6).