Observed temperature trends and fine-resolution global simulations in the MENA region

Matteo Zampieri, Rachid Abida and Georgiy L. Stenchikov
KAUST Saudi Arabia
matteo.zampieri@kaust.edu.sa
Outlines

• Comparison of surface temperature trends from observations, reanalyses and GFDL HIRAM ~25x25km resolution model in the last 30 years:
  – Annual temperature trend in Middle East, Northern Africa and Mediterranean.
  – Annual temperature time-series over Northern Arabic Peninsula.
  – Amplitude of Seasonal cycle (JJA-DJF).

• Models results:
  – Interpretation of amplitude of seasonal cycle results in terms of changes in circulation (position of ITCZ) and radiative properties of the atmosphere (cloudiness)
Annual Temperature trend (K/10a)

Crosses represent statistically significant points at 95%

More than 1K per decade, Time series in the next slide

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Annual time-series over Northern Arabic Peninsula

- Satisfactory consistency of interannual variability
- ERA40 and NCEP show cooling from 50s to 70s
- Warming stops in the last decade
Consistency of seasonality trend (K/10a)

Increasing

Decreasing

JJA-DJF: trends (K/10y) in 2m temp/NCEP: 1983-2009

JJA-DJF: trends (K/10y) in 2m temp/ECMWF 1983-2002

JJA-DJF: trends (K/10y) in 2m temp/GFDL 1983-2008

JJA-DJF: trends (K/10y) in 2m temp/OBS 1983-2009

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Temperature trend from the model

Annual

ann 2m temperature (°C/10a)

Seasonality

acy 2m temperature (°C/10a)

Winter

djf 2m temperature (°C/10a)

Summer

jja 2m temperature (°C/10a)
Summer circulation and trend from the model

Mean vertical velocity at 500 mb

Cloudiness trend

ITCZ

Relative humidity trend estimated with linearized Clausius-Clapeyron formula

Surface solar radiation trend (decrease in the Sahel and increase in the Eastern Mediterranean)

KAUST subsidence jja 500 hPa omega (Pa/s)

jja surf down shortwave flux (W/m²/10a)

jja 850 hPa RH estimate (%/10a)
ITCZ, Inter-tropical convergence front (ITF) and Eastern Mediterranean subsidence northward shift in JJA

\[ \text{ITF} = \frac{\sum \text{lat} \left( \frac{dT}{dy} \right)}{\sum \left( \frac{dT}{dy} \right)} \]

\[ \text{ITCZ} = \frac{\sum \text{lat} \times \text{omega}}{\sum \omega} \]

or
\[ \text{ITCZ} = \frac{\sum \text{lat} \times \text{pre}}{\sum \text{pre}} \]

computed in the area depicted in the figure 25-40E, 0-25N (Emed) and 25-40E, 25-40N (Esahel).
ITCZ in Eastern Sahel and Eastern Mediterranean subsidence intensity time-series in JJA at 500 hPa

Decreasing intensity of Hadley circulation

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Conclusions

• Comparison of observations, reanalyses and GFDL HIRAM model:
  – Annual temperature trend and time-series show rapid warming, especially in the Arabic Peninsula, depending on the dataset.
  – Amplitude of Seasonal cycle analysis filters low-frequency and reveals a dipolar pattern affecting the Sahel and the Eastern Mediterranean, consistently in all datasets.

• Models results:
  – Inter-tropical convergence zone (ITCZ) shifts in summer (JJA) directly explains the seasonality reduction in the Sahel.
  – Reduction of relative humidity because of the warmer atmosphere explains the seasonality increase in the Eastern Mediterranean.
  – the Hadley circulation is weakened, as in future projection by IPCC AR4 models (Held & Soden 2006)