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Changes in the Red Sea Trough Under Future Climate Conditions

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Introduction

The Red Sea Trough (RST) is a tongue of low pressure, originating in the equatorial low pressure systems, at lower atmospheric levels, extending from the southern Red Sea to the Eastern Mediterranean. Generally the RST is responsible for very dry and hot weather conditions in the Middle East, due to a continental south-easterly flow. In some cases the Red Sea Trough is accompanied by an upper level trough, approaching from the north-west. Under this conditions, severe thunderstorms may develop, characterized by torrential rain and flash floods. This work focuses on theses RST related extreme events (concerning precipitation) and on future changes in frequency and intensity.

Data

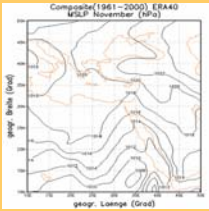
ERA40 reanalysis 6 hourly gridded data set (1,125°x1,125°) for sea-level pressure and for 500 hPa geopotential hight for the period 1961-2000

ECHAM5-OM1 control run (1961 – 2000) and A1B as well as A2 scenarios for the period 2071 – 2100 (sea – level pressure, geopotential height)

Precipitation data (daily) of six meteorological stations of Israel (Beer Sheba, Eilat, Har Kenaan, Jerusalem, Tel Aviv, Bet Dagan)

Methodology

Identification of RST events is based on an algorithm suggested by Tsvieli and Zangvil (2005) using the mean sea level pressure field of ERA40, as well as ECHAM5-OM1 simulations.

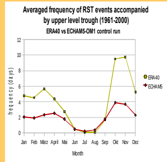


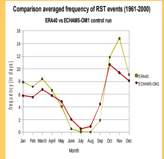
Validation

The simulations of the ECHAM5-OM1 model were validated against ERA40 (1961-2000).

The annual cycle of numbers of events is reasonable well simulated by the GCM.

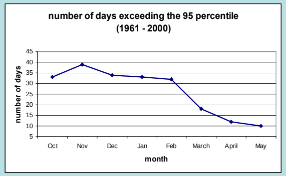
But it also turned out that the ECHAM5-OM1 model overestimates the frequency of RST events during the months of May to September while showing lower results during the months October to April (highest deviation in November with about 5 days)





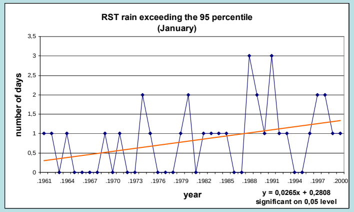
For RST events accompanied by an upper level trough (500hPa) ECHAM5-OM1 underestimates the frequency in nearly all months. The worst results were found in November and October (deviation of 6 days per month).

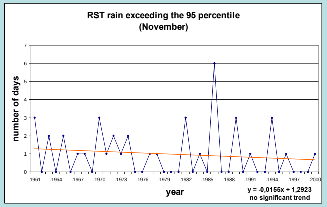
RST Precipitation > 95th percentile (Israel)



Most days of extreme precipitation caused by a RST event occur in November (39 days with RR > 95 th percentile)

Lower number of RST related extreme precipitation in spring months



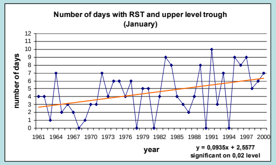


Significantly increasing number of RST events accompanied by extreme precipitation (> 95 percentile) during the period 1961 – 2000 in January and March. No significant trend during the other months (June to September not examined)

RST accompanied by trough in 500hPa (ERA40)

The simultaneous occurrence of RST and upper level trough is a necessary condition for the formation of RST related extreme event

Most frequent occurrence of RST accompanied by an upper level trough in October, November

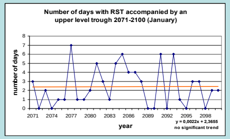


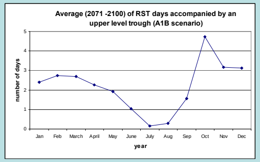
Highly significant positive trend in number of days with RST accompanied by an upper level trough in January (significant increase in March)

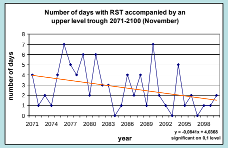
No significant change in Oct, Nov, Dec, Feb, April, May (summer months not examined)

RST accompanied by trough in 500hPa (A1B ECHAM5-OM1)

Most frequent occurrence of RST accompanied by an upper level trough in October with almost 5 days per month on average Almost the same number of occurrence in November and March





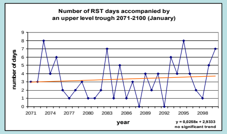


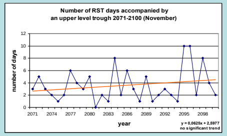
Significant (P<0,1) change in frequency of upper level trough accompanied RST days in April (positive trend), November (negative trend)

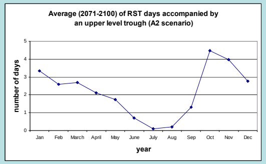
Negative trend (P<0,05) in May

RST accompanied by trough in 500hPa (A2 ECHAM5-OM1)

Most frequent occurrence of RST accompanied by an upper level trough in October with almost 5 days per month on average, followed by November as well as a third peak in January







Slightly significant positive trend (P<0,1) during February and March

Further examinations

Further examinations on the preconditions for the formation of RST related extreme events (e.g. pressure deviations from the monthly mean in 500hPa, surface level respectively; possible connection between the magnitude of the pressure gradient (in the Red Sea Trough and in the upper level trough) and intensity of the extreme event; possible importance of the velocity of the approaching upper level trough; position of RST trough axis)

Using the ECHAM5-OM1 model to identify possible trends concerning frequency and intensity of the RST related extreme events

Conclusion

This work shows a significant increase of extreme precipitation (>95 th percentile) related to RST events during the period of 1961 -2000 in January and March. This trend was also confirmed by the results obtained by the ERA40 data set (1961-2000), where a significant increase of RST days accompanied by an upper level trough during January and March could be proven. Concerning the number of days of simultaneous occurrence of RST events and upper level trough, a positive trend in April and a negative trend in November and May (ECHAM5-OM1 A1B scenario), as well as a increasing trend in February and March (ECHAM5-OM1 A2 scenario) could be indicated during the time period of 2071-2100.

Acknowledgements

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