



Center of Excellence for
Climate Change Research
King Abdulaziz University

Climate Change over the GCC Countries: Possible Changes on Water Resources

Mansour Almazroui

Professor, King Abdulaziz University, Jeddah, Saudi Arabia

mansour@kau.edu.sa



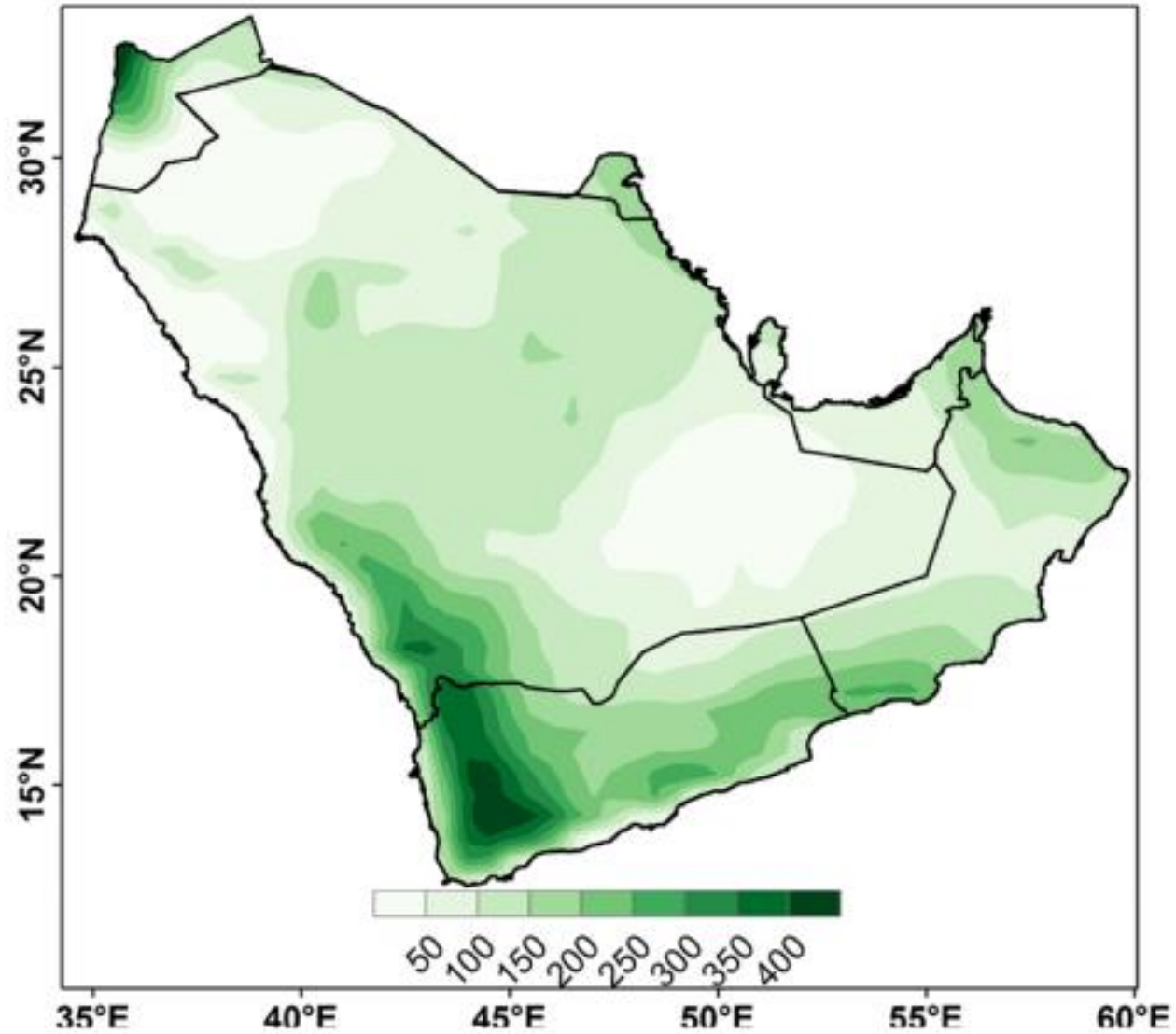
Overview

- Introduction
- Objectives
- Methodology
- Results
 - Present Climate (rainfall climatology and climate extremes)
 - Future Climate (rainfall/ temperature scenarios and extremes)
- Conclusions
 - Vulnerable Sectors
 - Recommendations
 - Actionable Points

Introduction

- Today's talk is under “Climate Change Impacts on Water Resources in the GCC Countries”. Rainwater is an important dynamic in water resources for the semi-arid and arid region like the GCC countries where **rivers**, **canals** and **marshes** are absent. Rainfall is one of the key variables in climate change.
- Problems on this topic:
 - Deficiency of knowledge on the **changes in climate** in the region
 - **Lack** of observational **climate data** for the region
- Objectives of this presentation:
 - **Present** and **future** conditions of change in climate in the region
 - Changes in climate extremes based on **state-of-the-art** climate scenarios
- Methods of analysis:
 - **Observed** data and **Global/Regional** climate models **simulations**
 - Climate **extreme** Indices

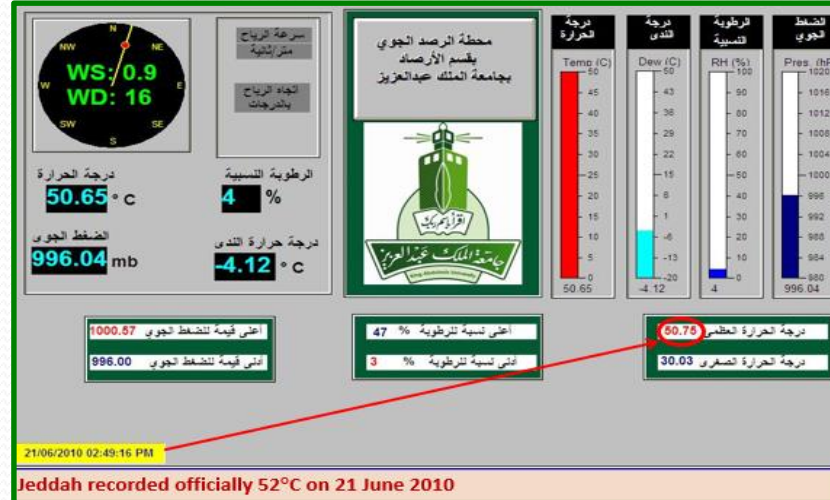
Rainfall in the Arabian Peninsula: Present (1981-2010)



Source: Almazroui et al. 2020

Climate Change SIGNALS over the region

Heatwave in Jeddah: Recorded 52°C on 21 June 2010



Jeddah recorded officially 52°C on 21 June 2010

Drought in Kholayis: 2009



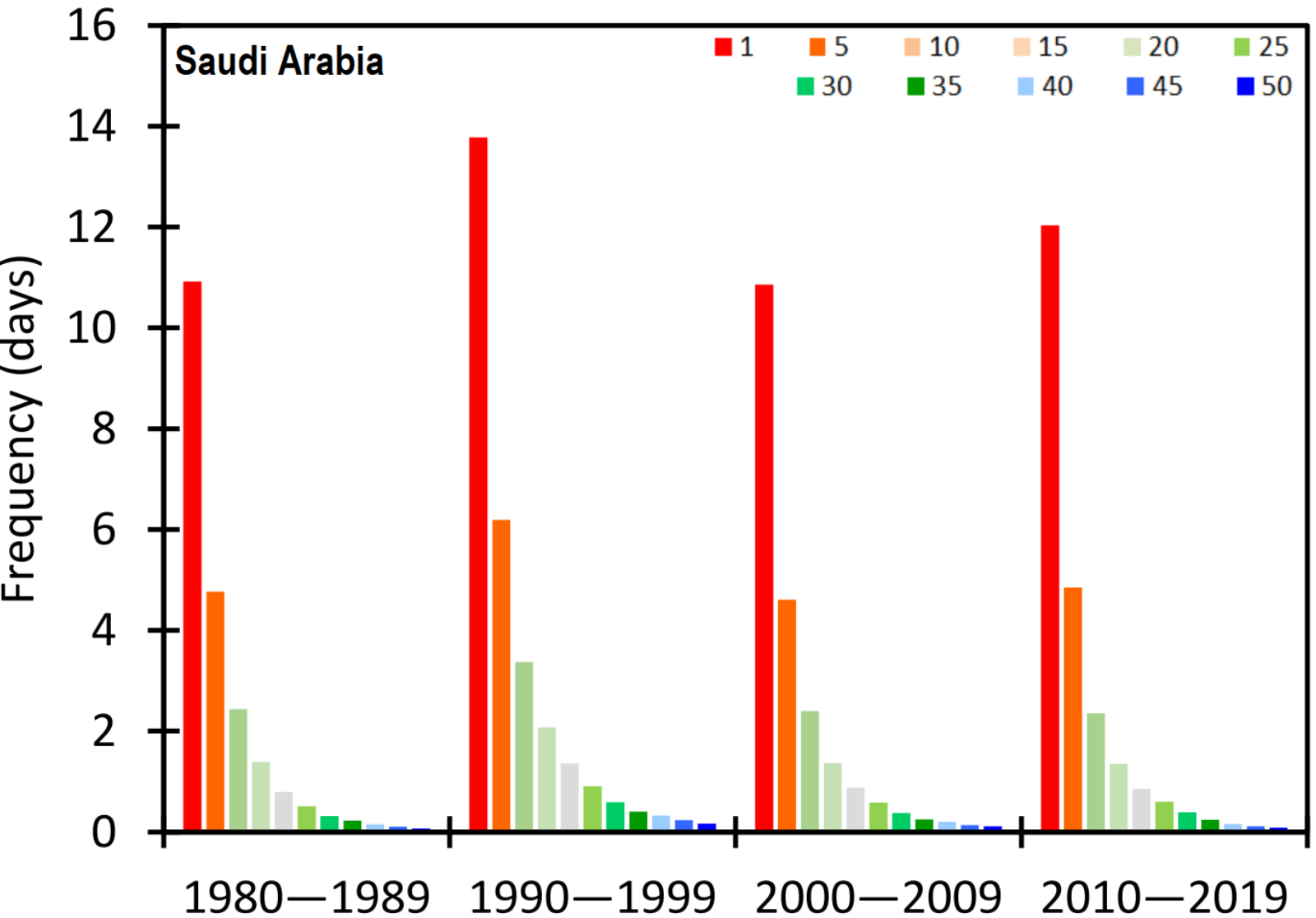
Extreme Rainfall Event in Jeddah: 25 NOV 2009



Extreme Rainfall Event in Riyadh: 5 MAY 2010

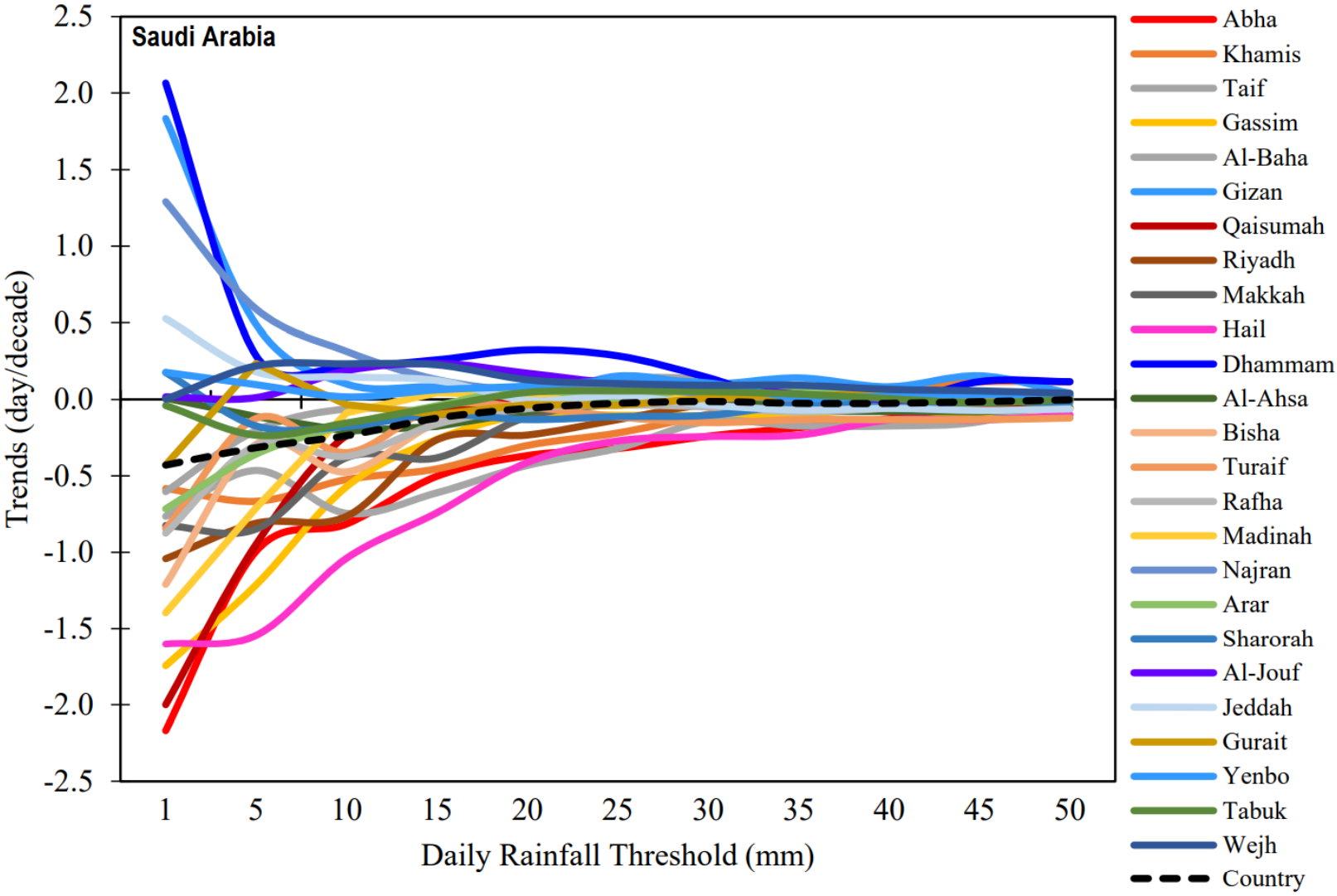


Rainfall Extremes Frequency: Observations



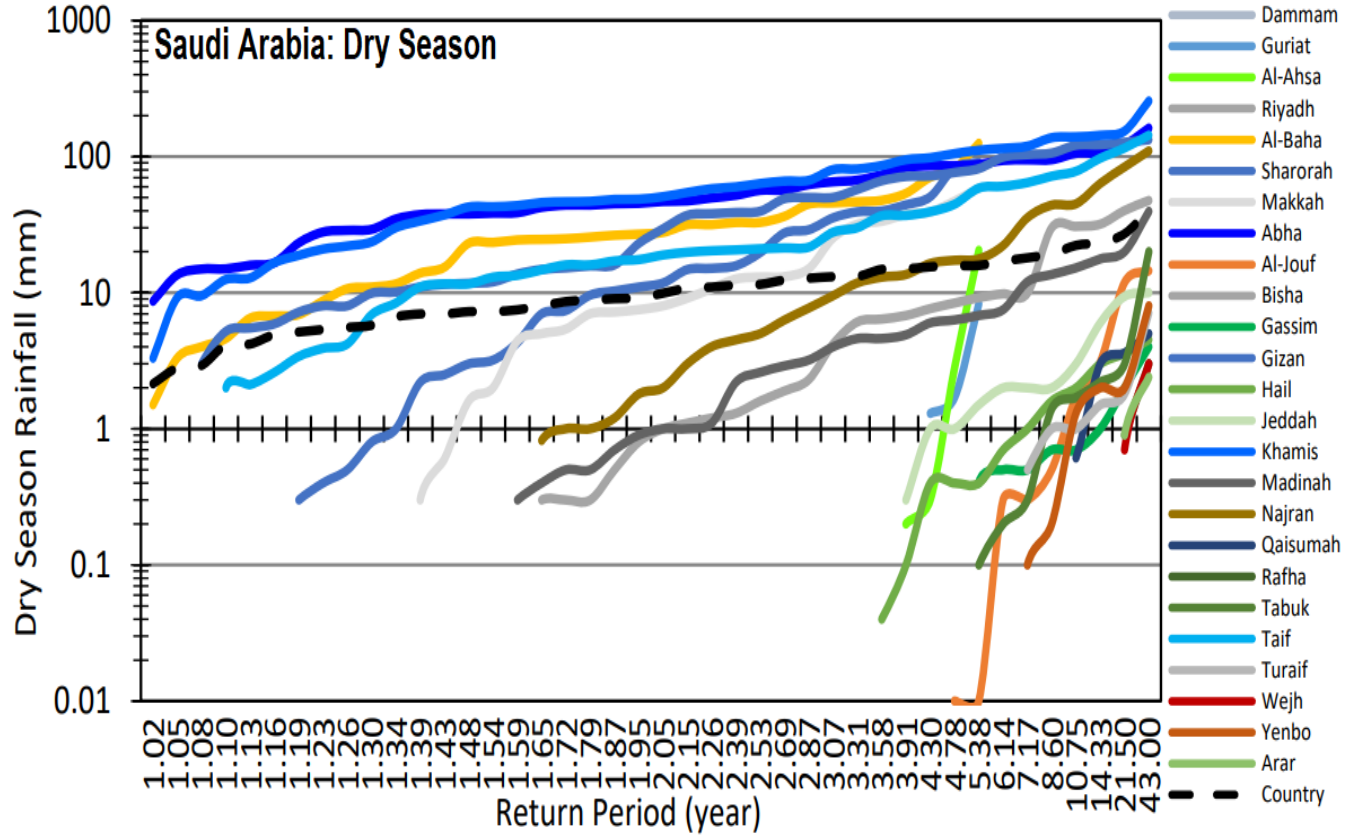
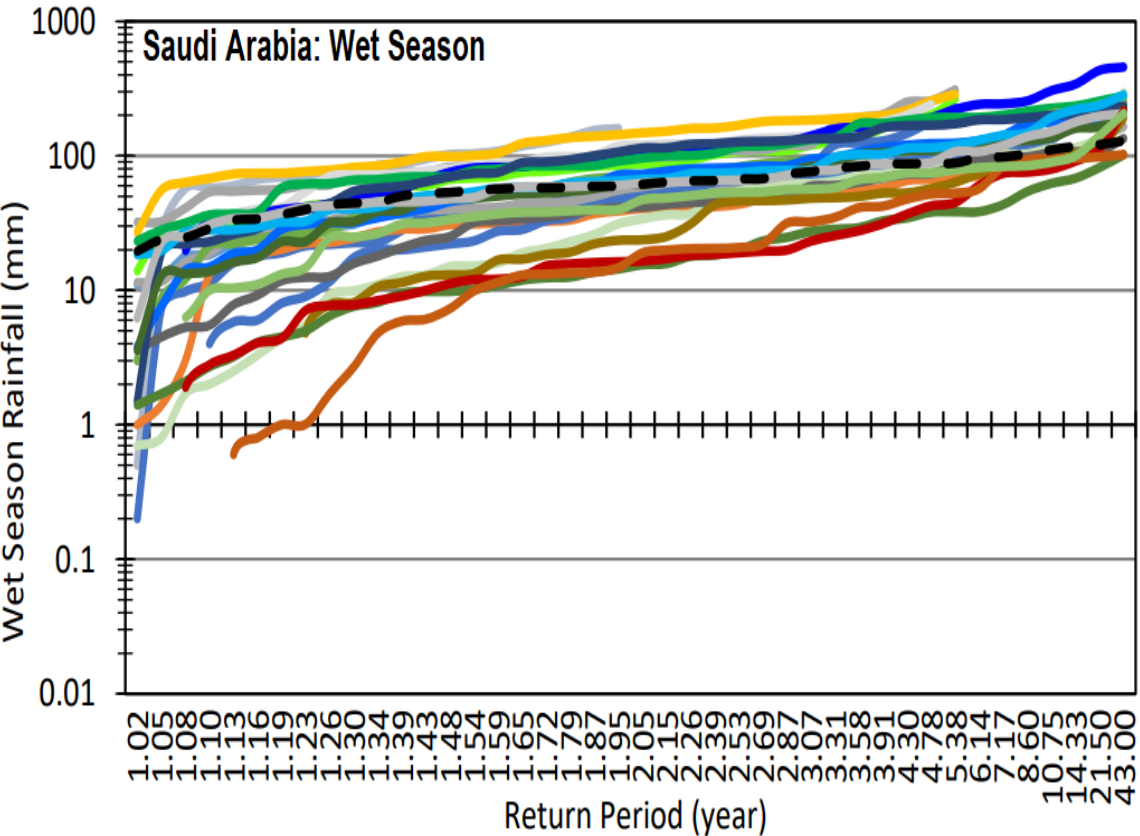
High intensity events are observed more in the recent decades

Rainfall Extreme Trends: Observations



- **Light intensity events are in decreasing trend**
- **High intensity events are in increasing trend**

Rainfall Extremes Return Period: Observations



- Dammam
- Guriat
- Al-Ahsa
- Riyadh
- Al-Baha
- Sharorah
- Makkah
- Abha
- Al-Jouf
- Bisha
- Gassim
- Gizan
- Hail
- Jeddah
- Khamis
- Madinah
- Najran
- Qaisumah
- Rafha
- Tabuk
- Taif
- Turaif
- Wejh
- Yenbo
- Arar
- - - Country

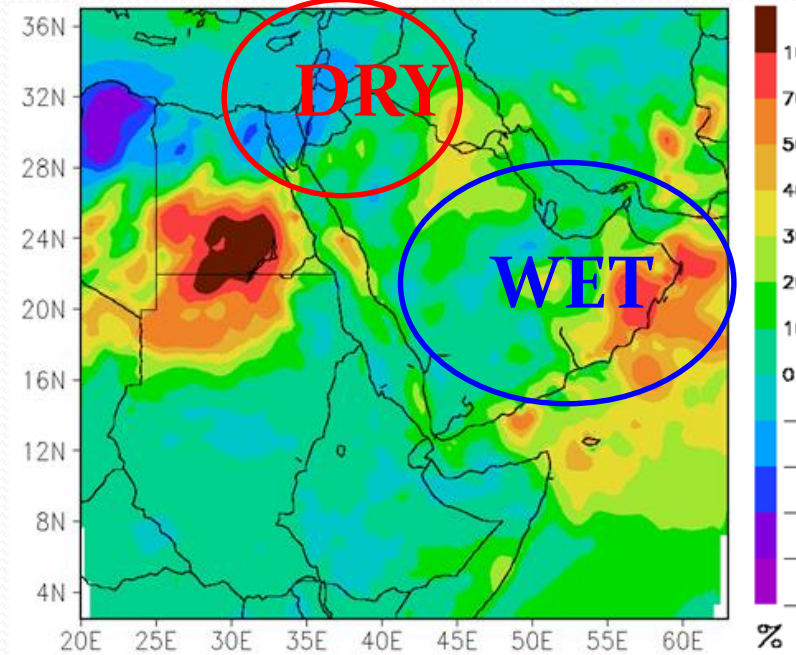
- **Wet Season: Rainfall (≥ 10 mm) events are returning every year at most of the locations**
- **Dry Season: High intensity (≥ 30 mm) events are returning every 2-year at some locations**



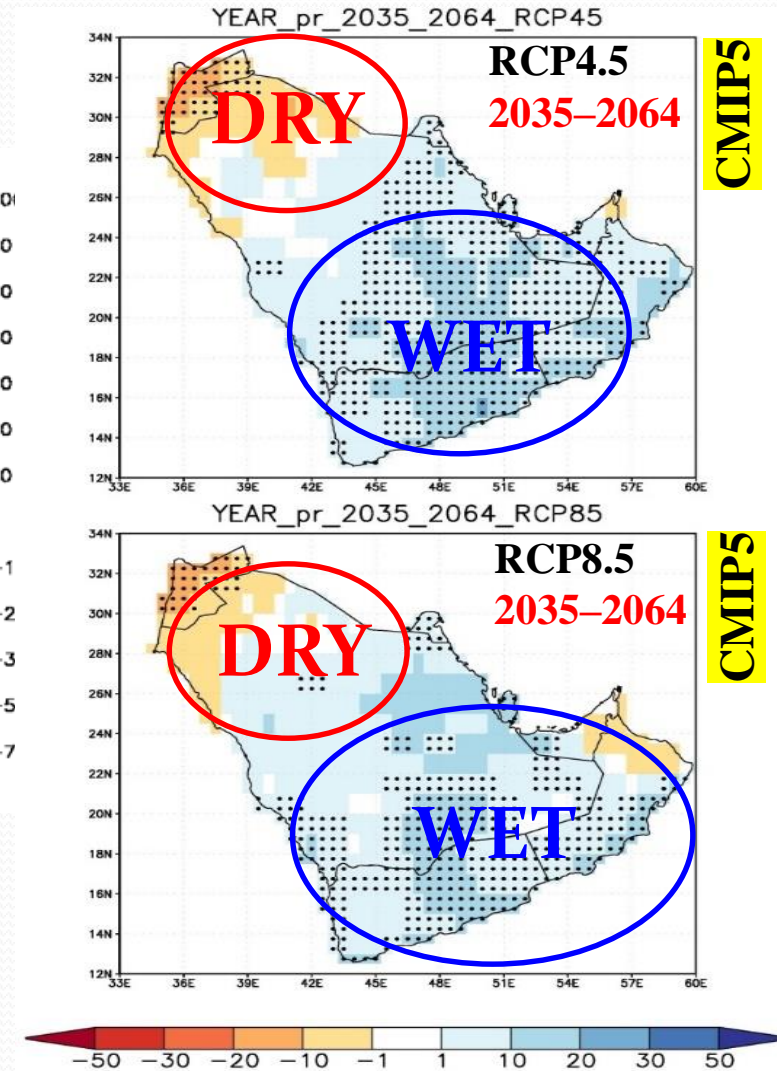
Future climatic conditions and climate extremes of the region

Rainfall Changes: Middle of the Century

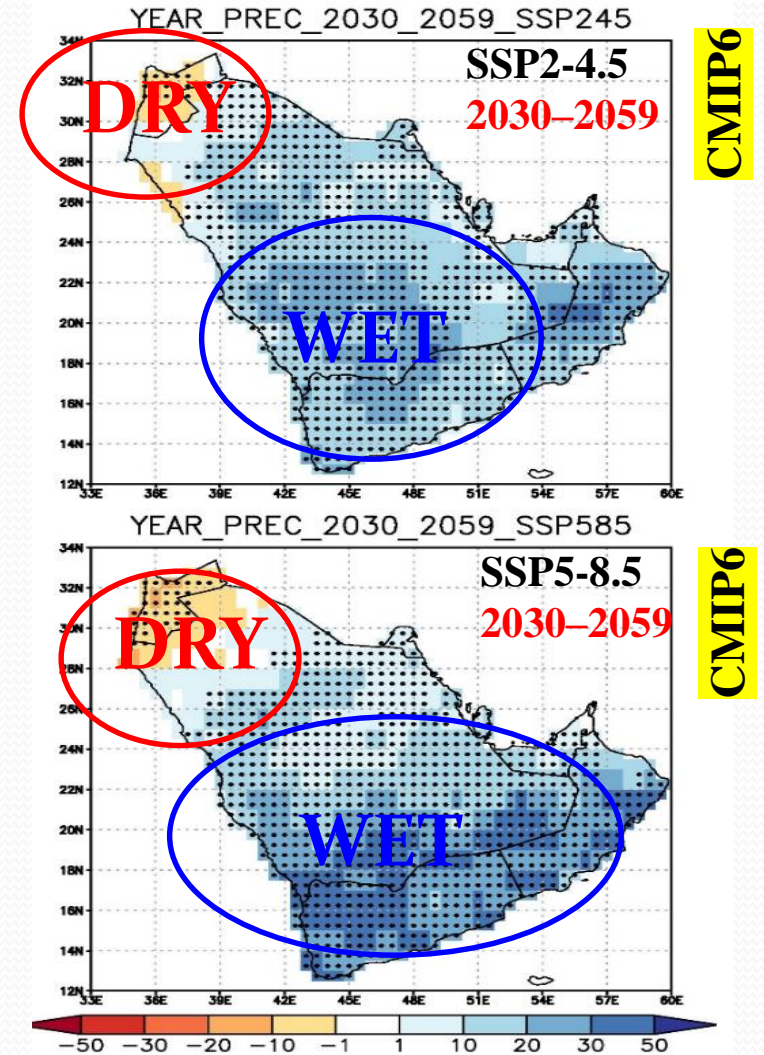
CMIP3 A1B 2021–2050 w.r.t 1971-2000



Almazroui (2013)



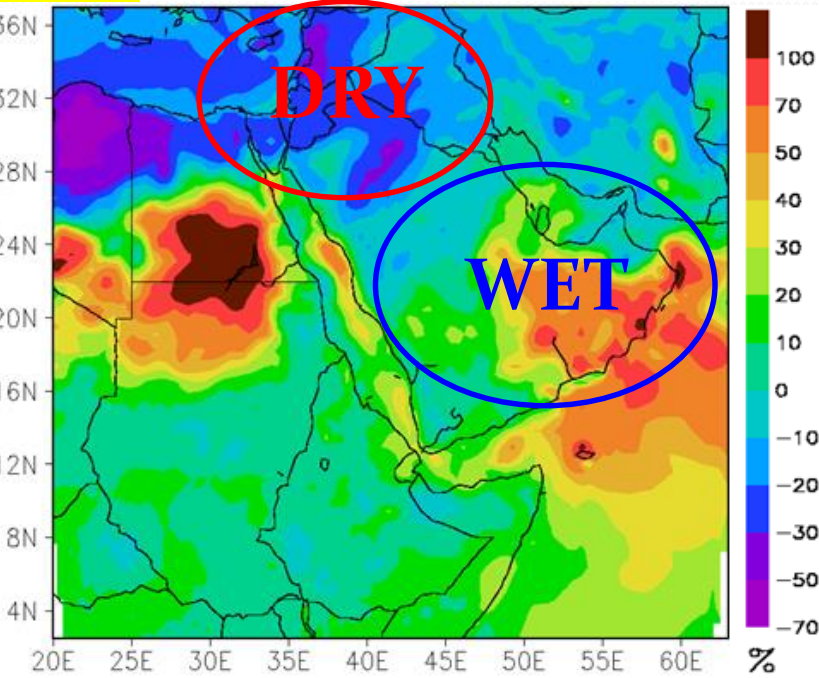
Almazroui et al. (2017)



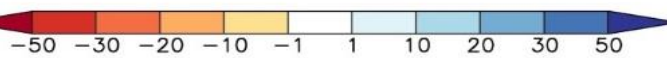
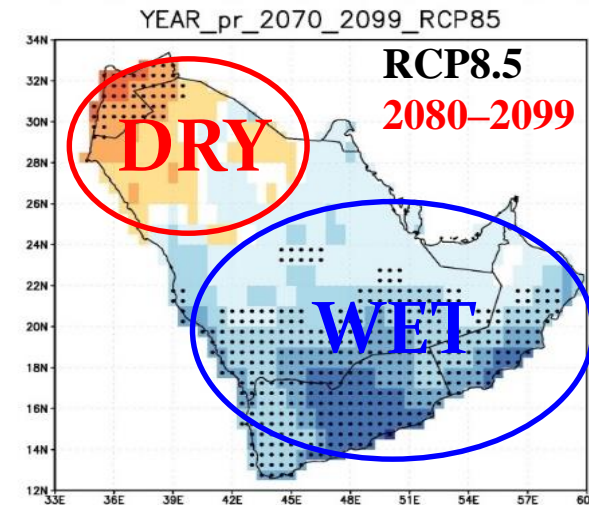
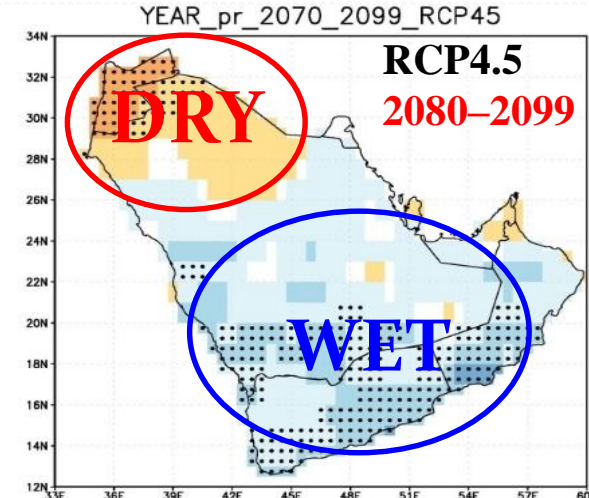
Almazroui et al. (2020)

Rainfall Changes: End of the Century

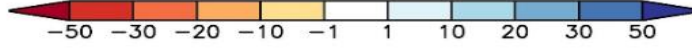
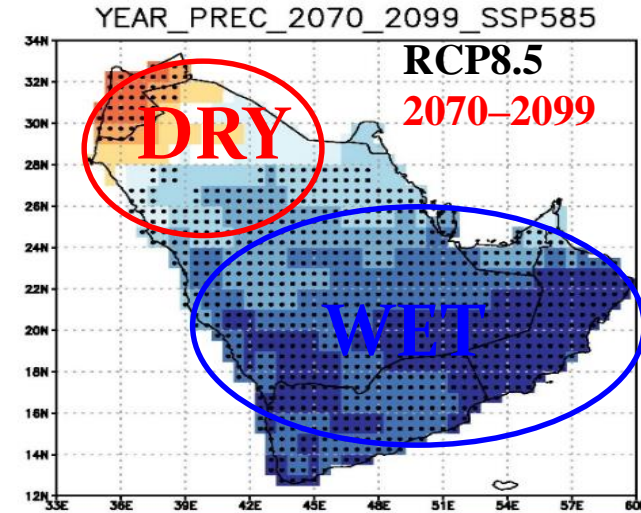
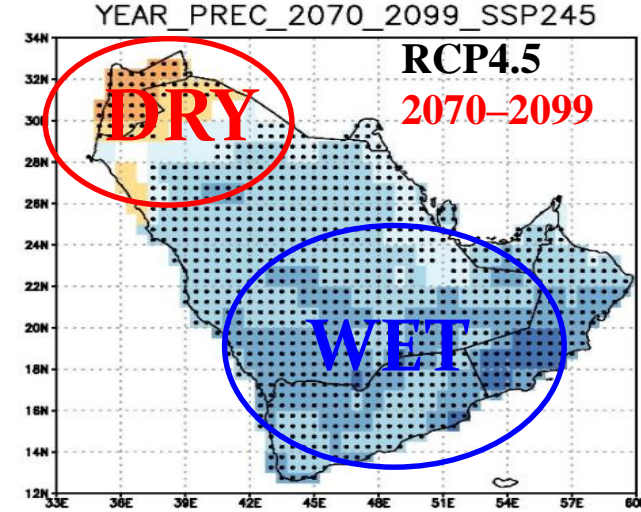
CMIP3 A1B 2041-2070 w.r.t 1971-2000



Almazroui (2013)



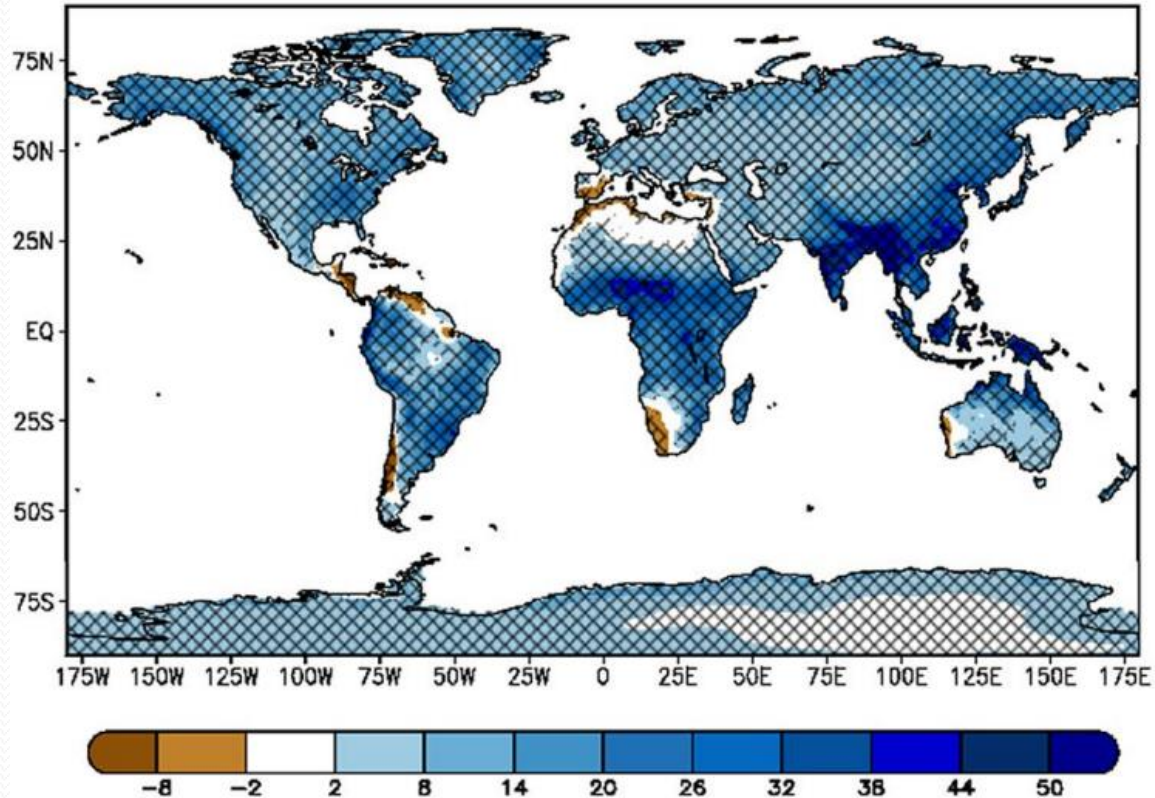
Almazroui et al. (2017)



Almazroui et al. (2020)

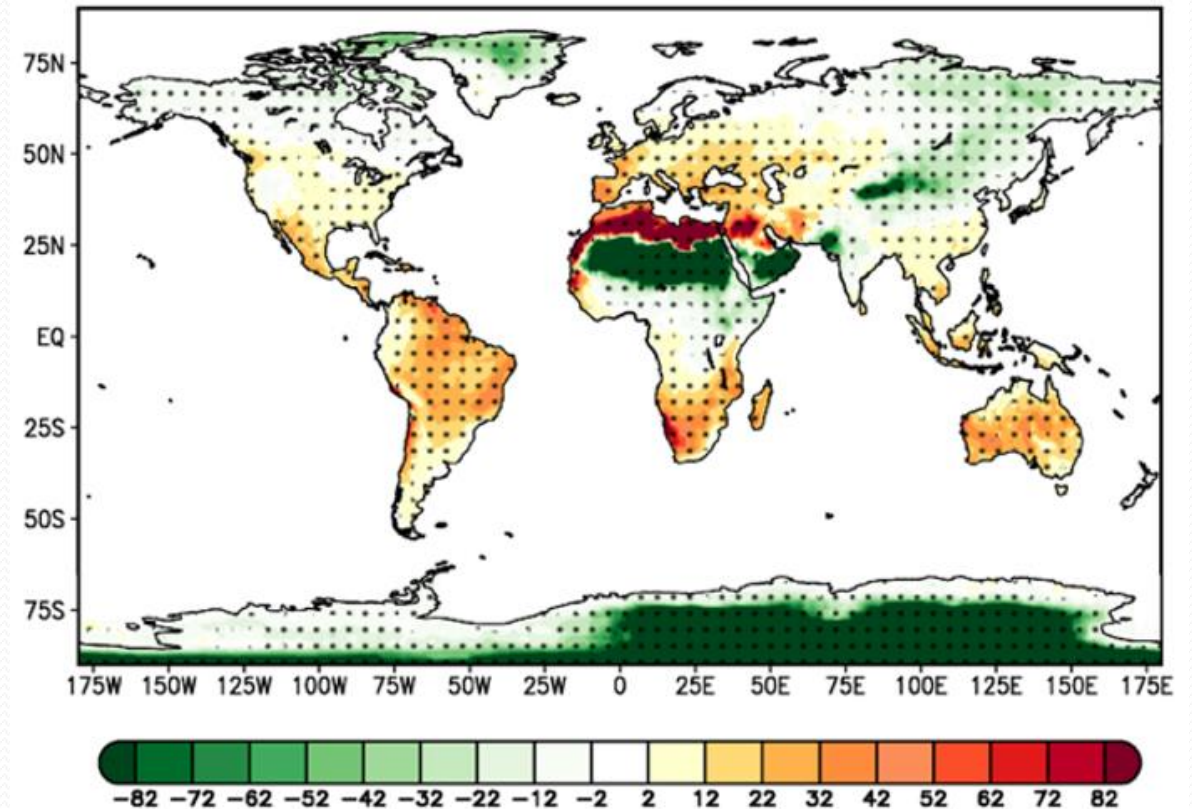
Climate Extremes over the Globe: CMIP6 SSP8.5

RX5DAY_H5DPAPTP_SSP585_2070_2099



Projected changes in annual maximum consecutive 5-day precipitation (RX5day) under SSP5-8.5 for 2070–2099 with the reference period 1985–2014.

CDD_SSP585_2069_2100

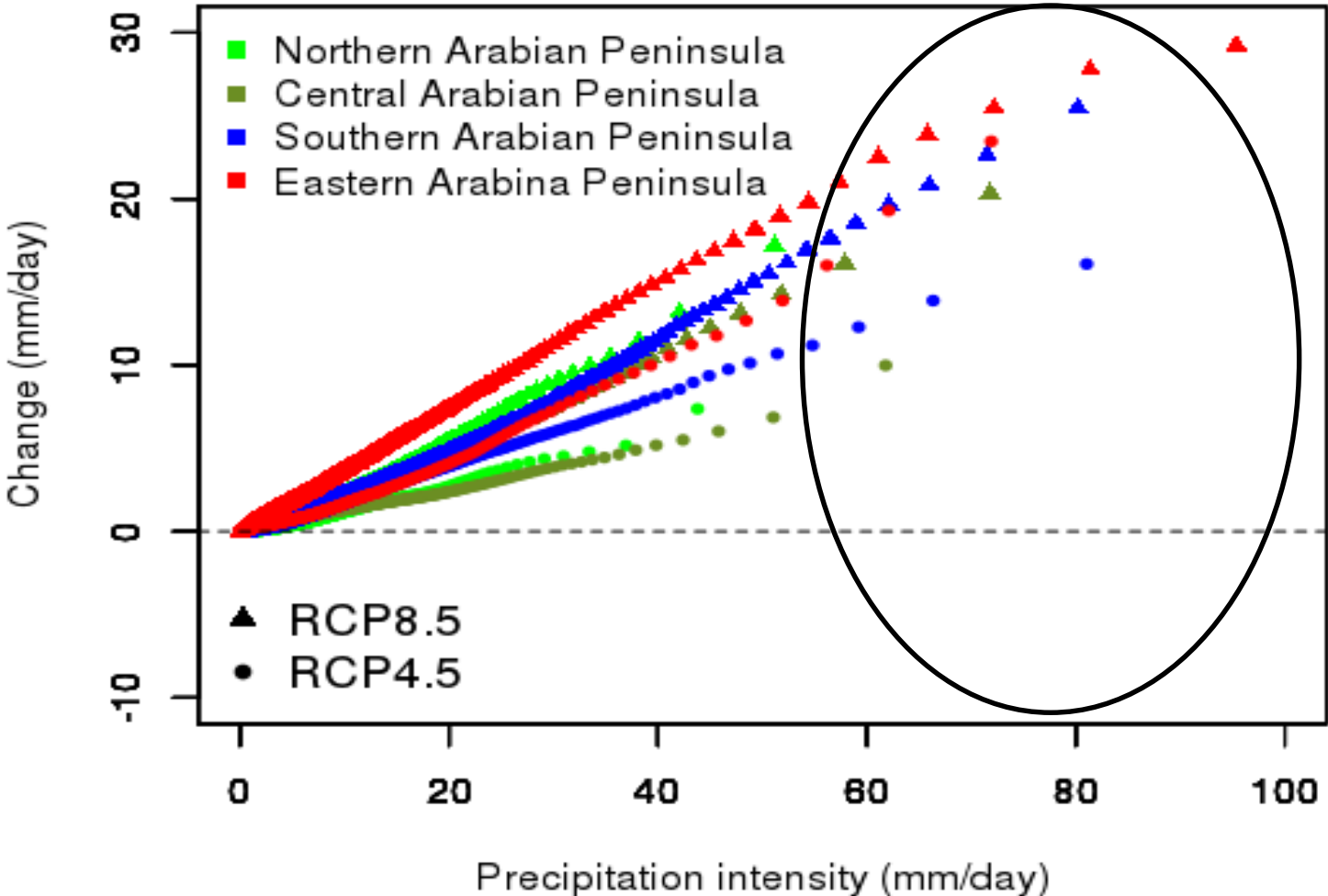


Projected changes of Consecutive Dry Days (CDD) under SSP5-8.5 for 2070–2099 with the reference period 1985–2014.

Source: Almazroui et al. 2021

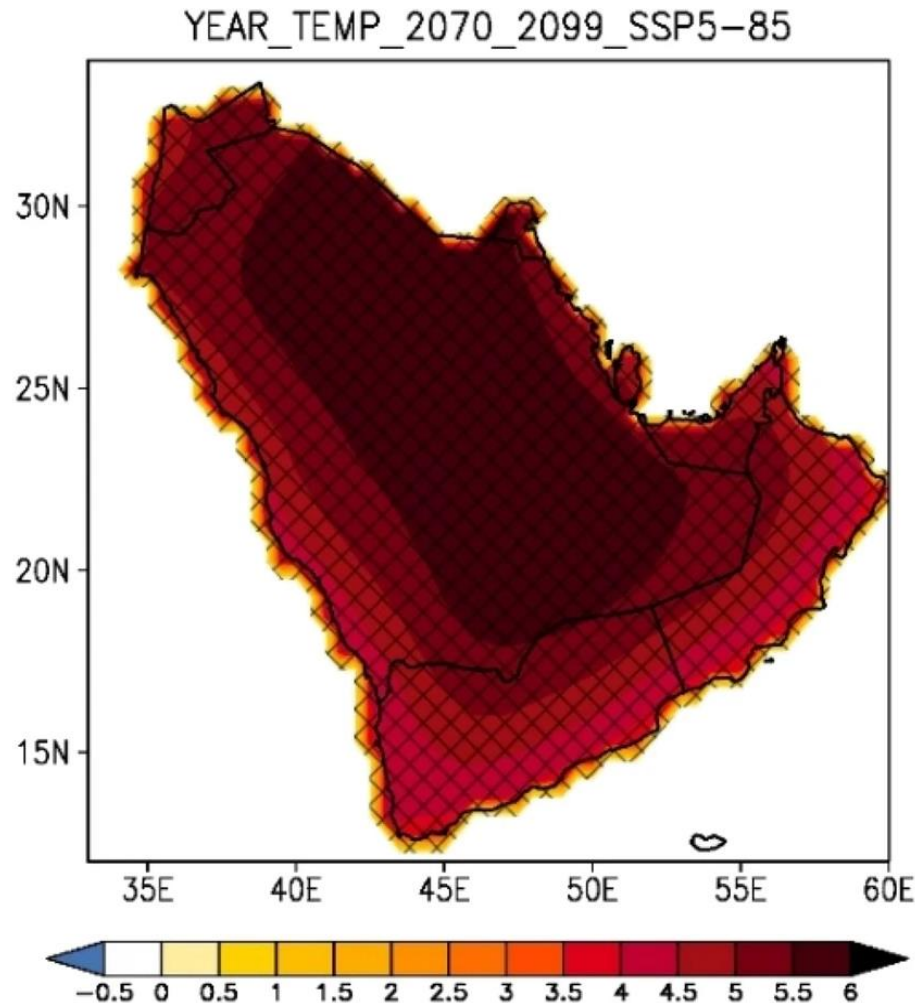
Rainfall Extremes: CMIP5 Projections

Change in the daily precipitation intensities: 2070–2099 w.r.t. 1970–1999



High intensity events are likely to be more intense in future period (2070–2099) as compared to the present climate (1970–1999).

Temperature Change: CMIP6 SSP5-8.5 End-Century



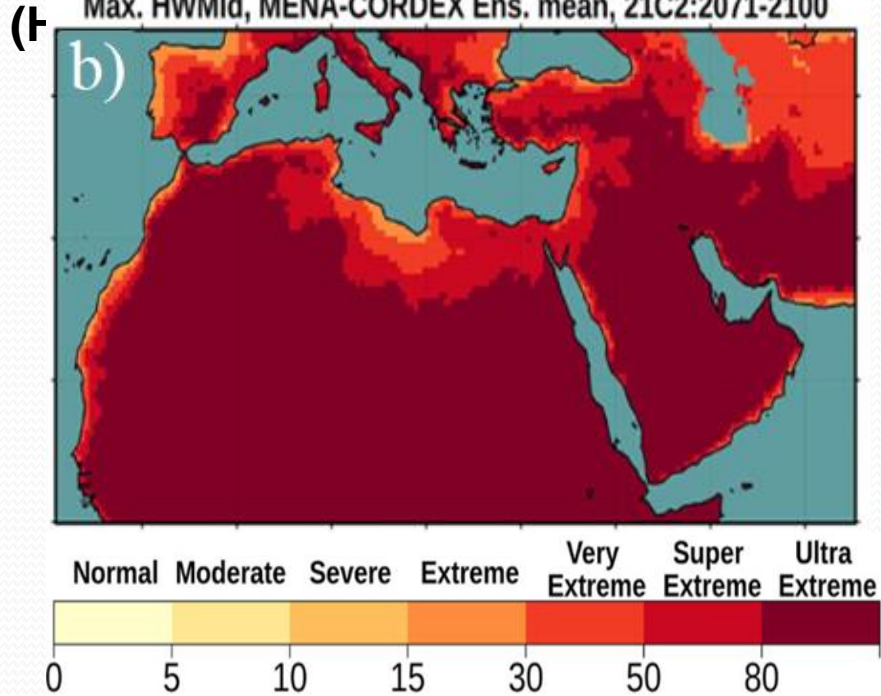
- Rainfall is one of the key components in climate change related to water resources.
- Temperature is another very important climate change variable impacts on water resources.

Change in annual mean temperature under high emission scenario over the Arabian Peninsula using 31 CMIP6 GCMs

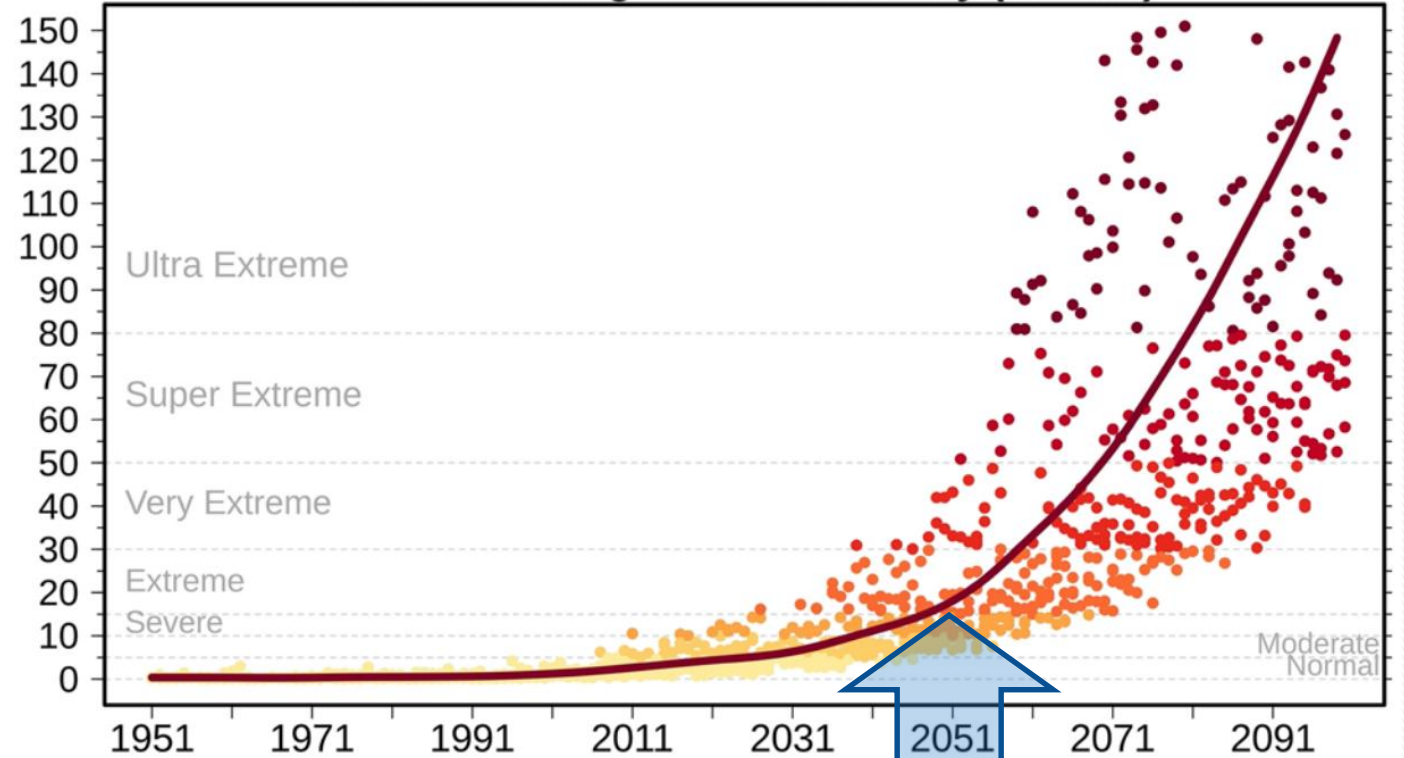
Temperature Extremes in the MENA region: CMIP5 RCP8.5 End-Century

Heat Wave Magnitude Index daily

Max. HWMI_d, MENA-CORDEX Ens. mean, 21C2:2071-2100



Heat Wave Magnitude Index daily (HWMI_d)



- ❑ **Extremes** will be visible at the Mid-Century
- ❑ **Ultra Extremes** are projected at the End-Century

Conclusions

- The annual/wet-season rainfall decrease between 10-20 mm/decade in the central and southwestern regions, which is an alarming situation for the water resources, agricultural production, and socio-economic needs of the country.
- The eastern, northwestern, and southern parts show increasing trends at present climate.
- Increasing trend in the frequency of extreme rainfall events over Saudi Arabia may be associated with climate change in the recent decades.
- In future, rainfall will be **decreased** (**increased**) in the **northwestern** (**southern**) region. Extreme rainfall events projected to be **intensified** in the coming days.
- Needs **daily data** for **GCC countries** to perform similar analysis and recommendations for climate change impact studies.
- Recommend further investigation using ultra high-resolution climate model simulations for the impact of climate change, in particular for the water and agriculture sectors of the region.

Vulnerable sectors & Recommendations with Actionable Points

Vulnerable sectors

Water resources

Climate models suggest an overall 10-20% increase in rainfall in Saudi Arabia. Rainfall may be reduced (increase) in the central to northern (southern) of the country. Water may even become unavailable in some regions.

Traditional livelihoods

Due to the effects of climate change, many regions may become less supportive of traditional livelihoods or become unsuitable for human settlement and livelihood, inducing migration to urban areas in search of more opportunities and resources.

Coastal development

As a consequence of climate change, mean sea level is expected to rise and affect Saudi Arabia's two long coastlines. The dangers include an increase in salinity and intrusion of the saline water into coastal aquifers.

Agriculture

Northern (southern) Saudi Arabia may become drier (wetter) in the future. Agricultural production is expected to be the most affected sector due to a temperature increase of 5-6°C and rainfall fluctuations.

Power sector

Rising temperature 5-6°C in the future may result in growing demand for electricity. With increasing warm days and heat waves, electricity consumption will rise and put power generation and fuel supply infrastructures under additional stresses.

Hajj and Umrah

Increase in temperature 5-6°C resultant incidences of climate extremes could pose a serious threat to Hajj/Umrah activities.

Recommendations

For Saudi Arabia to maintain social, economic and environmental sustainability as climate change worsens, following recommendations are made for the government

Dams, drainage systems

A necessary measure to take advantage of more rainfall in the east and southeast areas and to a lesser extent, the southwest including the Red Sea coastal belt, is the building of water impoundment and groundwater recharge dams and protective infrastructure like channels and culverts in order to facilitate adequate drainage, water preservation and ground water recharge leading to improvements also in the groundwater quality.

Agriculture

Higher rainfall expected in the southeast and southwest call for planning to earmark and allocate areas for developing new farmlands. In the north, specific measures recommended for crops to cope with a considerable drier climate include developing more varieties of resilient crops and increased planting of less-water-consuming crops.

Protecting vulnerable populations

Climate change may render children, women and elderly people vulnerable to migrate from regions, and measures must be devised to ensure their welfare and livelihood sustainability under temperature may rise 5-6°C at the end of 21st century.

To make a beginning, schools should be equipped with support measures and facilities to cope with *heatwaves* and *dust storms*.

High priority and a long-term outlook are vital in *national planning* and *strategic policy* implementation to minimize the impact of climate change on the vulnerable groups.

Recommendations

Early Warning System

Changes in temperature and rainfall patterns may result in more frequent occurrences of high intensity and short duration rainfall events, causing to flash floods.

The most useful tool to supplement precautionary measures to cope with natural disasters is an accurate and timely Early Warning System for 1-5 days by mesoscale model and networks with similar systems in other countries.

Rising electricity demand

Already there is an ever-increasing demand for power supply in Saudi Arabia's with its rapidly increasing population, urbanization and industrialization.

Rising temperature and increasing frequency of heat waves may further aggravate the situation. Increase frequency of maximum temperature $\geq 50^{\circ}\text{C}$ or 30°C at the end of the 21st century is a strong message to be considered for the electricity generation in the Kingdom.

Safety of pilgrims

Climate extremes could seriously threaten Hajj/Umrah activities, especially considering during the scorching summer season. Higher temperatures would trigger dust storms and increase health risks such as sunburn, heatstroke and dehydration, in particular among the elderly who make up the majority of international pilgrims. The likelihood of more cold waves during winters also poses a grave threat to pilgrims.

For the Hajj during the summer season, enhanced efforts are required to safeguard the pilgrims (especially the elderly from more temperate regions) against heat wave, heat stroke and sunburn, asthma and respiratory problems.

Actionable points

1. Improve *hydrological infrastructure* including dams, culverts and channels to enhance drainage capacity, protect settlements and habitats, harvest rainwater and increase groundwater recharge.

2. Develop an *Early Warning System*, operated through NCM, covering all regions of Saudi Arabia by radars, weather stations, upper air stations, marine stations in the Red Sea and Arabian Gulf, and nowcasting modeling systems.

3. Ensure appropriate measures to sustain *agricultural activities* in the northern region that will be susceptible to reduced rainfall in the future.

4. Develop new farmlands and infrastructure in the *south* to *harvest rainwater* from increased rainfall in the region.

5. Develop infrastructure to enhance the efficiency of water usage and *preservation of rainwater* (groundwater recharge, wastewater re-use, etc.) in the *north*.

6. Develop facilities to treat climate-change related *health risks* like heat stroke, asthma and other respiratory problems, diarrhoea, etc. Protect school children from dust-related problems (like asthma and respiratory diseases) caused by prolonged droughts and strong winds.

7. Safeguard pilgrims during *Hajj and Umrah* from heat waves and flash floods caused by extreme weather events. As Hajj held during summer, an appropriate policy should be put in place to minimize heat stroke and respiratory problems during the pilgrimage.

8. Develop a *curriculum on climate change* and natural hazards at school/college level for sustainable development.

9. Plan for managing additional *electricity demand* caused by heat waves and extreme heat events.

10. Strategize *policies and action plans* to deal with socioeconomic and demographic impacts, including community resilience against climate change and support *Green Initiative*.



Thank you