Effects of climate change on the hydrological cycle: Flood and drought

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Israeli Meteorological Service

Global climate change: observed trends

- The recent years reflect a growing trend of extreme weather events: Heat waves, high temperature records and extreme droughts, as well as intensified storm magnitudes and increasing trends of extremes, deadly flood events.

- In addition to the climate factors, rapid land use changes, urbanization, fast development of “Mega cities” and lack of appropriate infrastructures are intensifying and accelerating these existent trends.

- Population growth and the growing demand for water and food make the climate crises a real threat for billions in the world, mostly in developing countries.

Climate change effects on the environment, water, energy and agriculture:

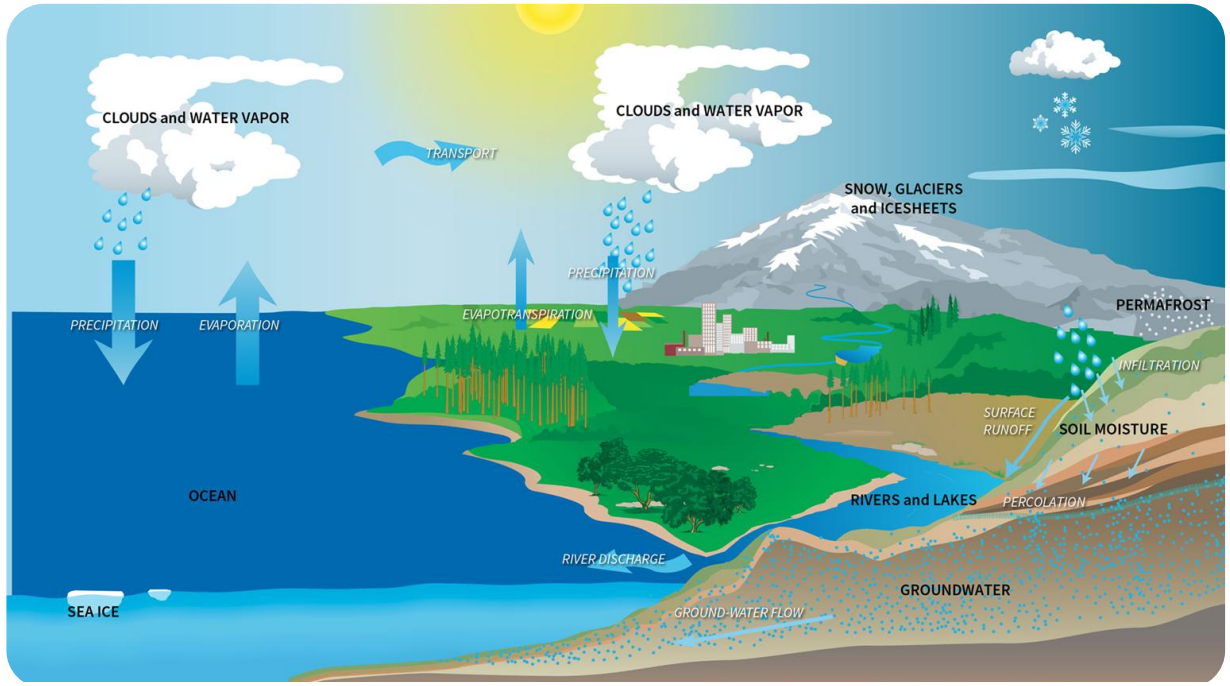
- Climate change effect almost all sectors. Water and Agriculture are among the of the most sensitive sectors.
- In order to implement appropriate adaptation policies to cope with a changing climate it is important to uunderstand the projected changes in climate for key variables, how these might vary both spatially and temporally, and their uncertainties.

Major climate change threats for the different sectors

- **Decrease/Changes in total water volumes (quantity and quality)**
- **Inter-annual variability (decision makers would prefer to plan according to the “average”. This is not the case in the Mediterranean region.)**
- **Climate extremes (floods and droughts)**

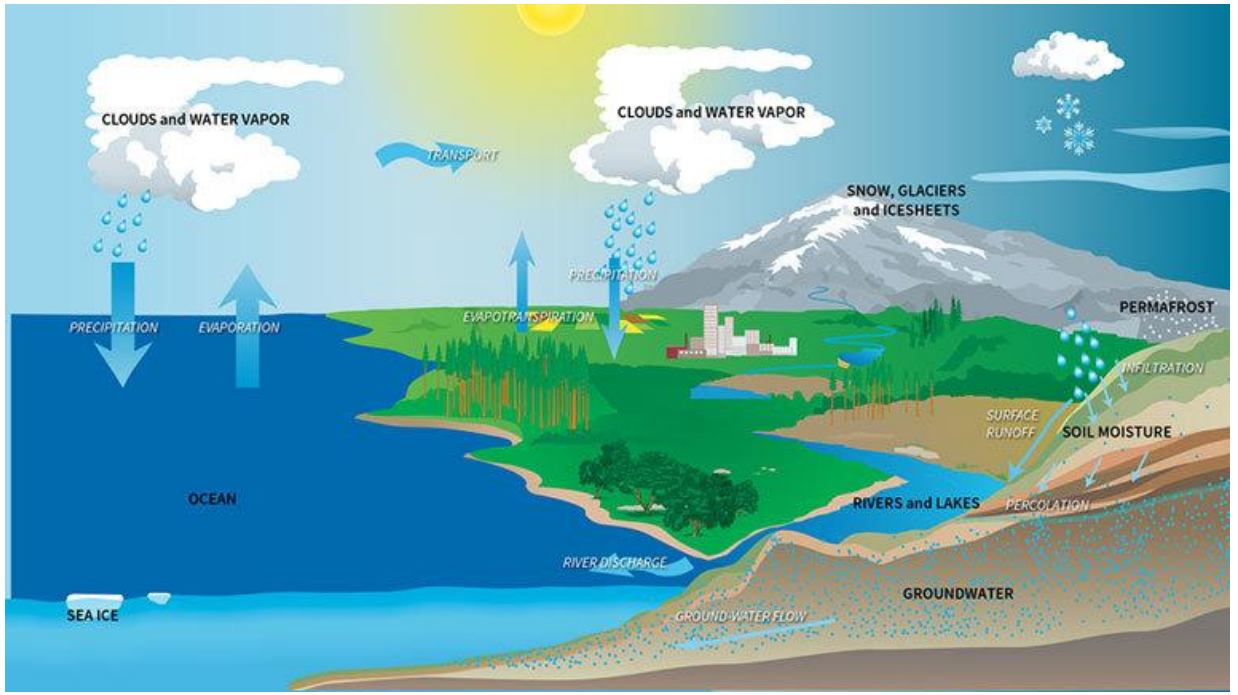
Climate Change and the Hydrological Cycle

- Climate change cause changes in precipitation patterns and intensities, evaporation, soil moisture, infiltration to groundwater, runoff and rivers base flow, changing the Hydrological cycle.
- Understating the interactions and the feedback between those variables will help us to be ready for the expected chances and to find better solutions

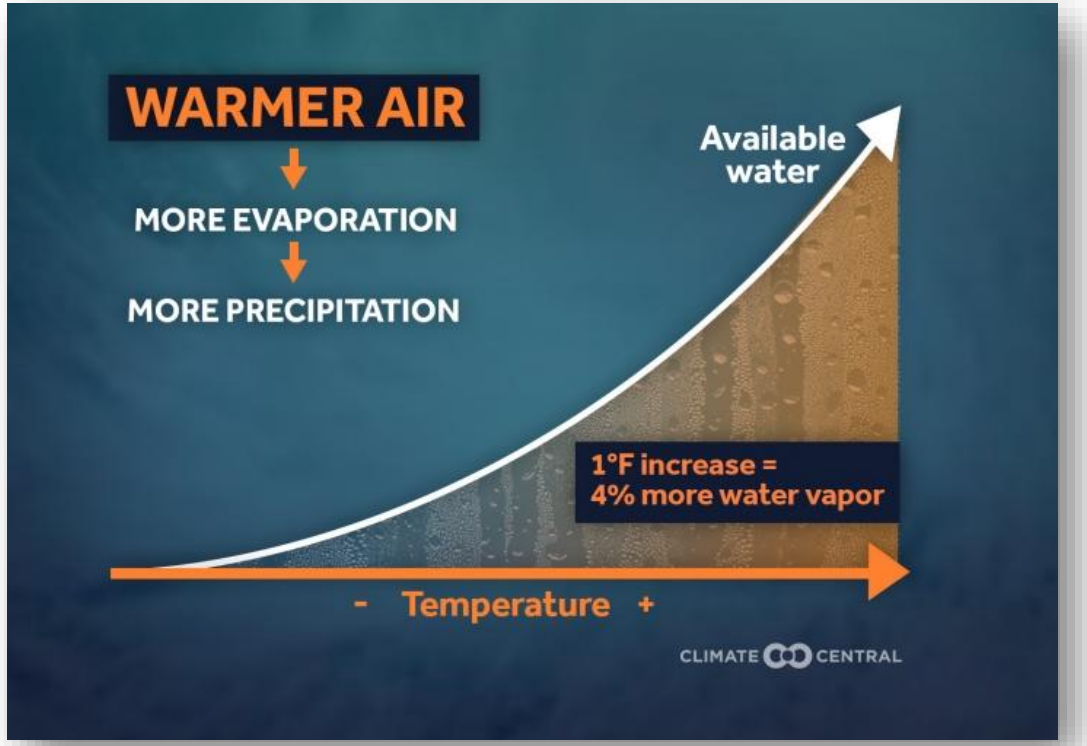


Climate Change and the Hydrological Cycle

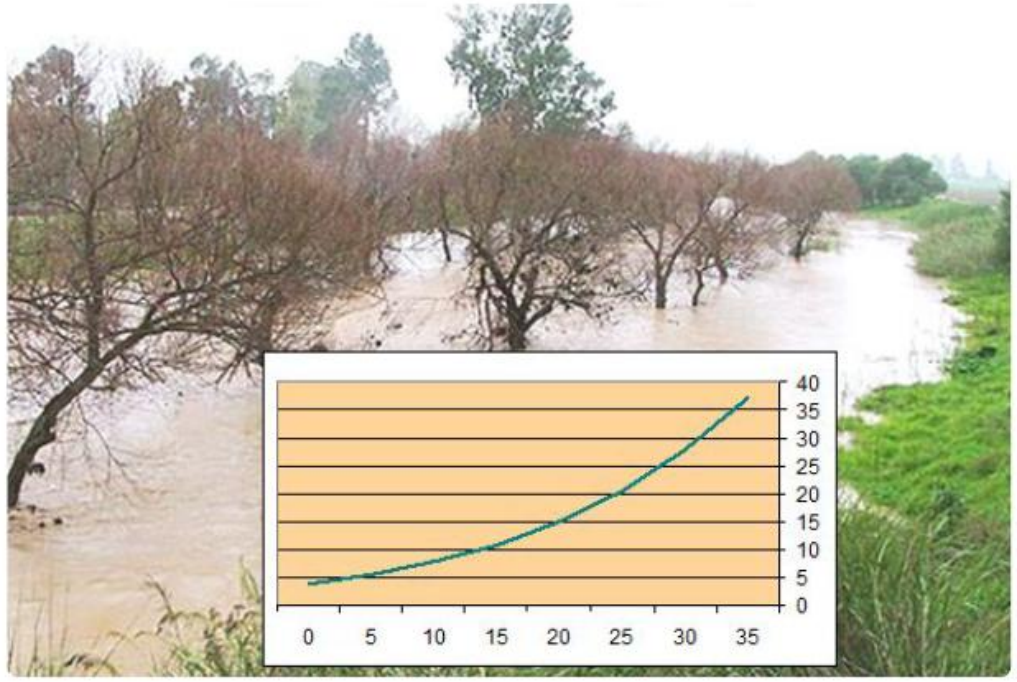
In a changing climate flood and drought are the two sides of the same coins

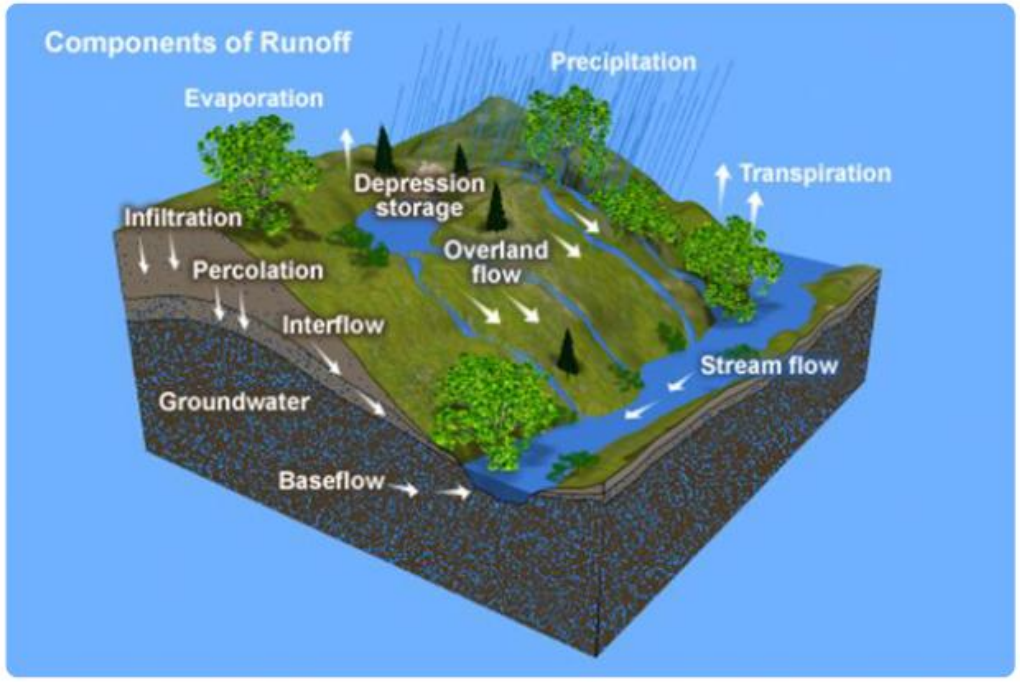


A warmer climate lead to drought and floods

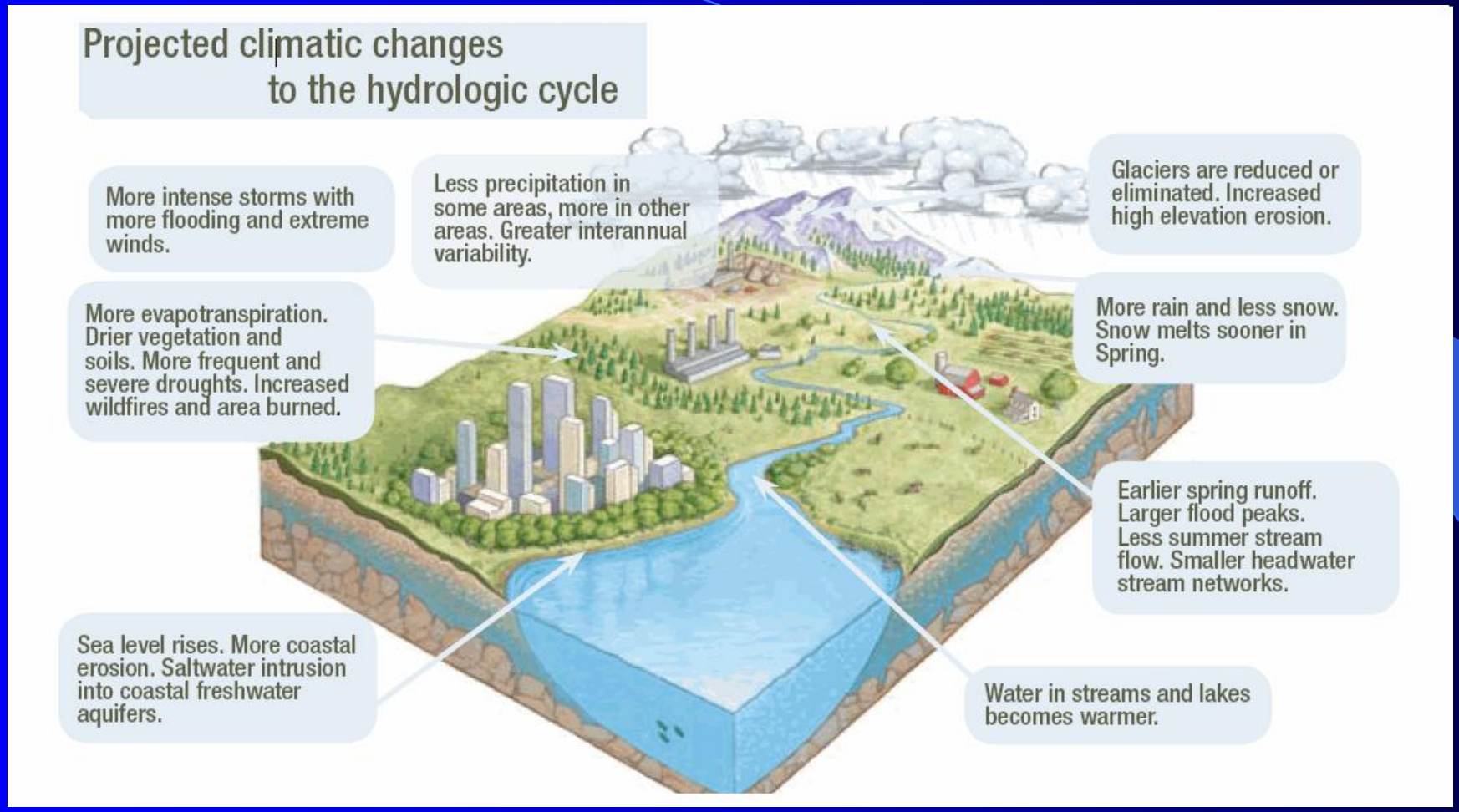


Climate Change and the Hydrological Cycle

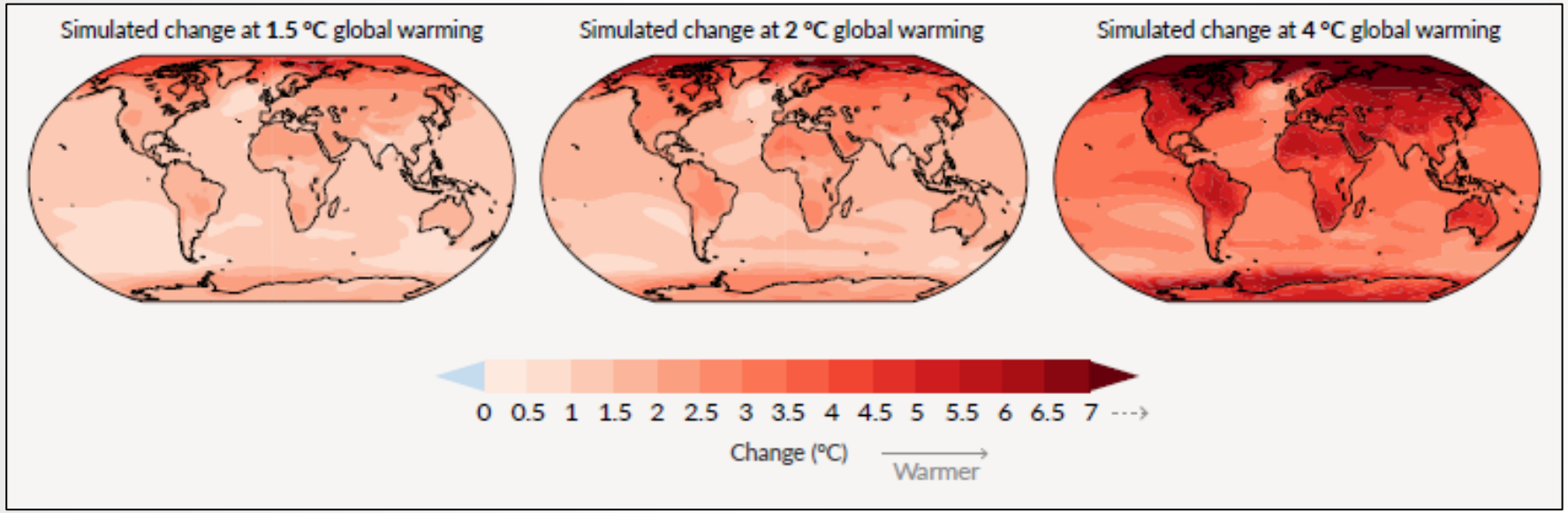




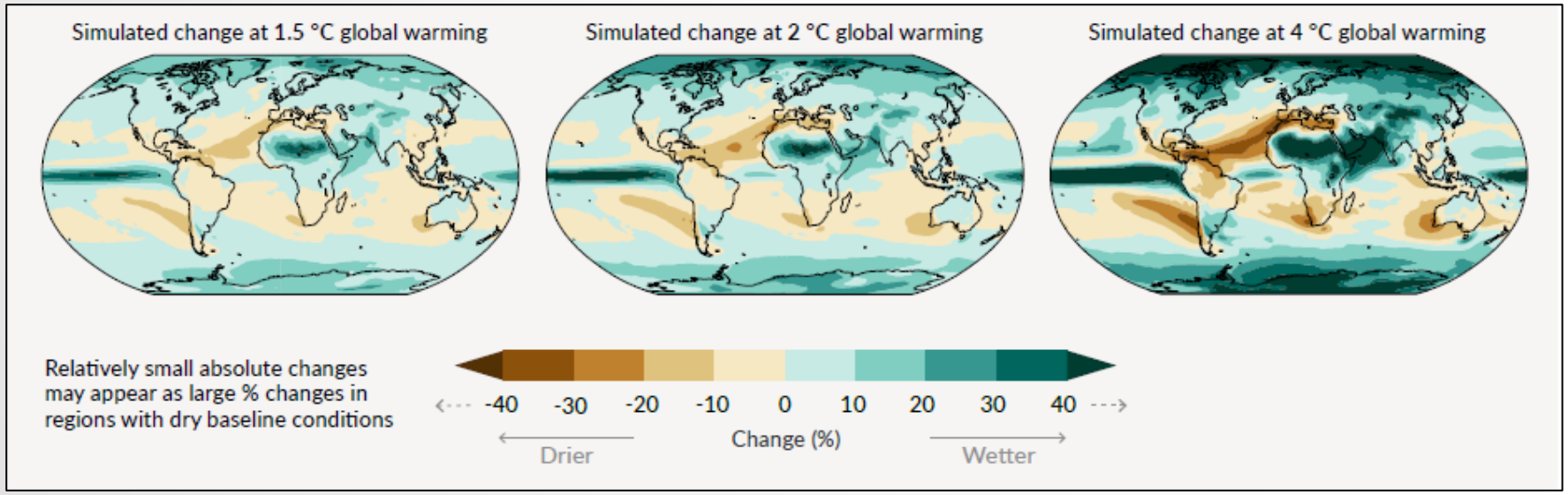
Climate Change and the Hydrological Cycle



Global temperature trend with respect to the 1850-1900 periods

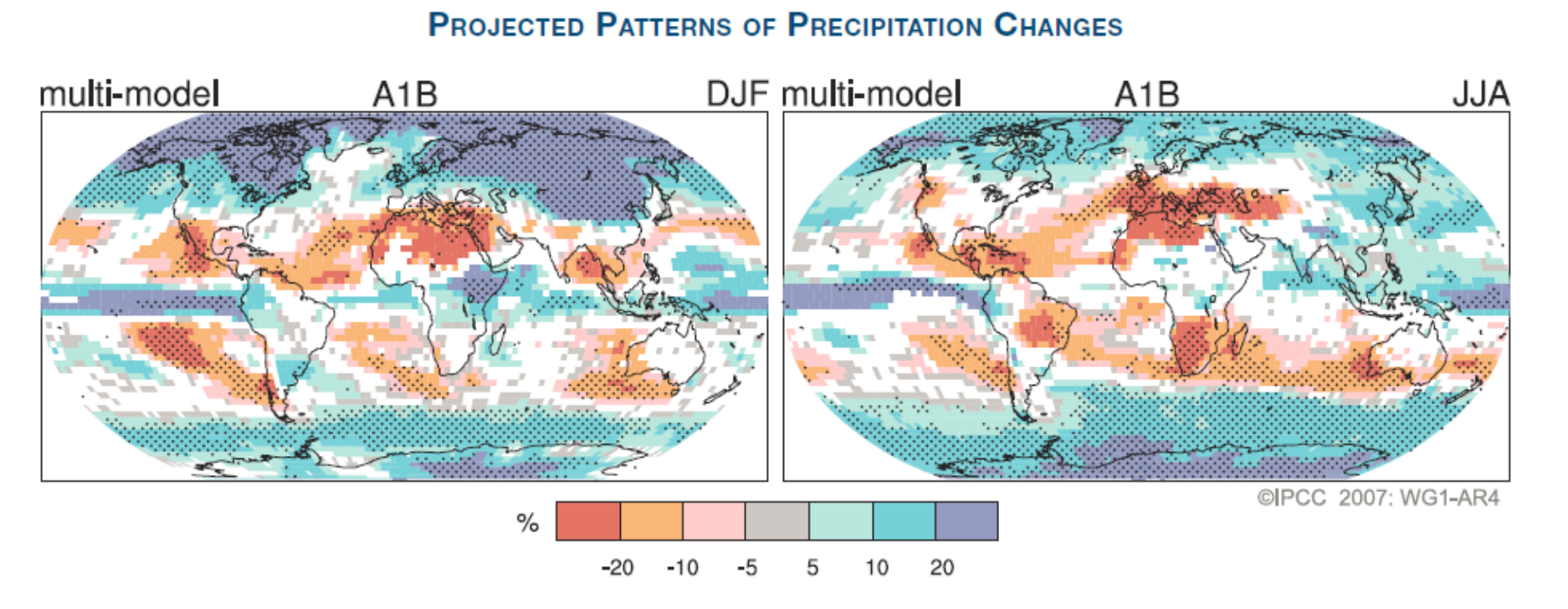


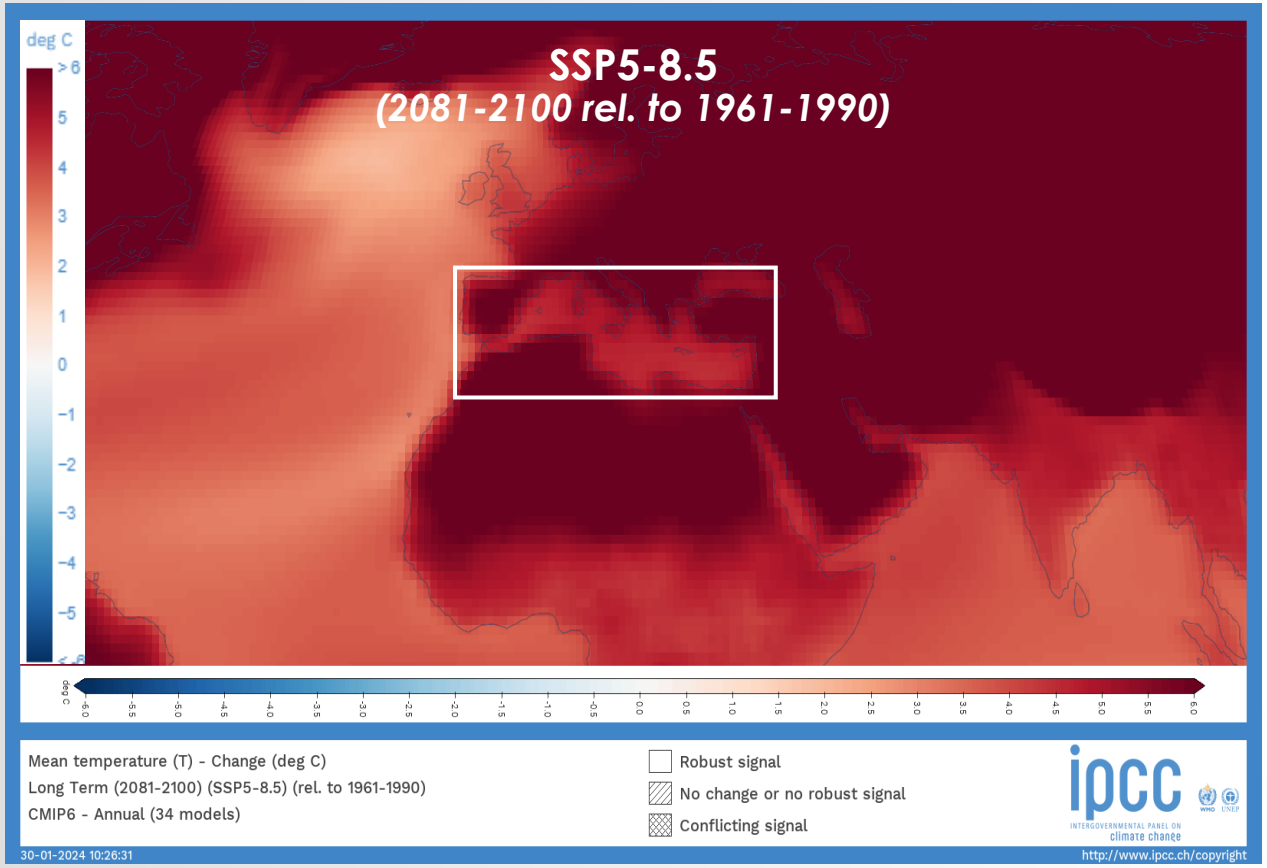
Global precipitation trend with respect to the 1850-1900 periods



Sixth Assessment Report of IPCC Working Group I, 2021

Global precipitation trends





Mean temperature (T) - Change (deg C)
Long Term (2081-2100) (SSP5-8.5) (rel. to 1961-1990)
CMIP6 - Annual (34 models)

Robust signal
No change or no robust signal
Conflicting signal

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INTERGOVERNMENTAL PANEL ON climate change

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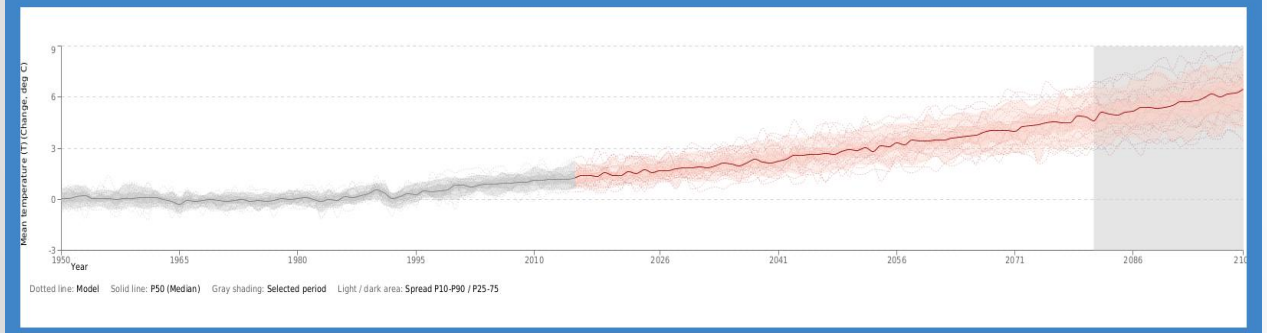

Mean temperature (T) - Change (deg C)
Long Term (2081-2100) (SSP5-8.5) (rel. to 1961-1990)
CMIP6 - Annual (34 models)-Mediterranean

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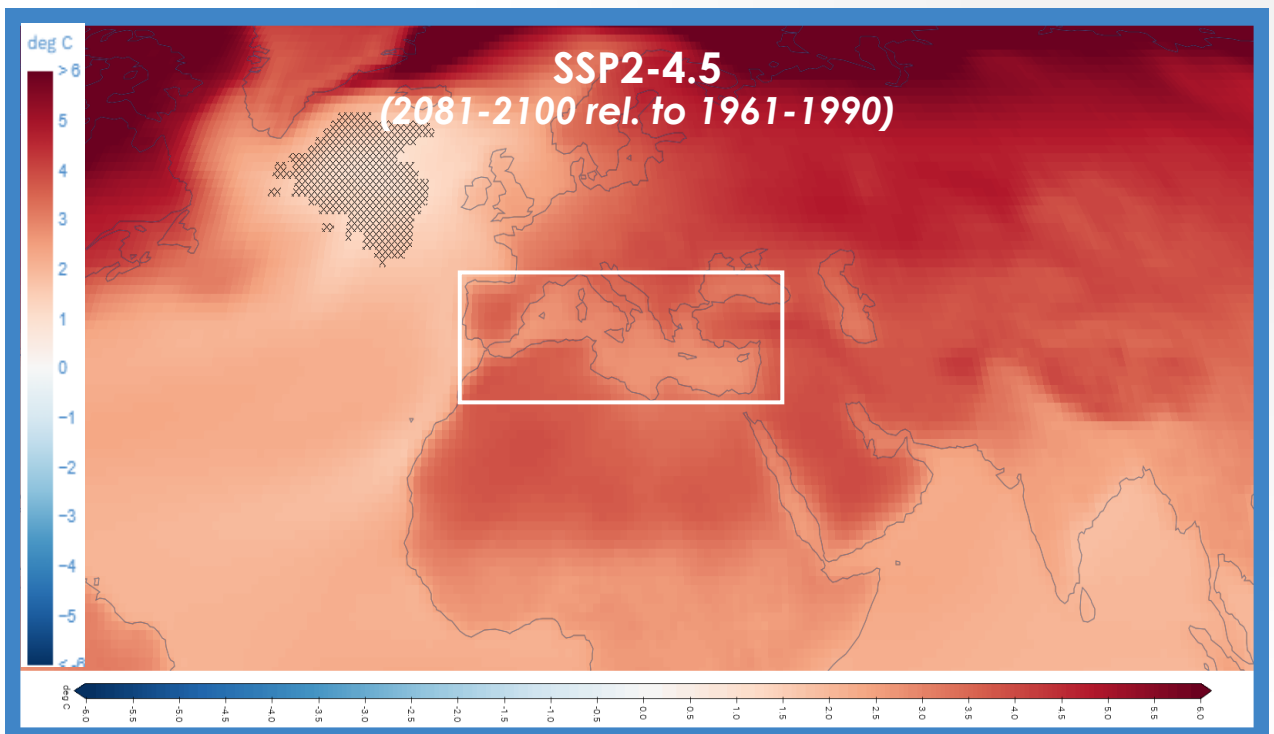

Mean temperature (T) - Change (deg C)
Long Term (2081-2100) (SSP2-4.5) (rel. to 1961-1990)
CMIP6 - Annual (34 models)

Robust signal
No change or no robust signal
Conflicting signal

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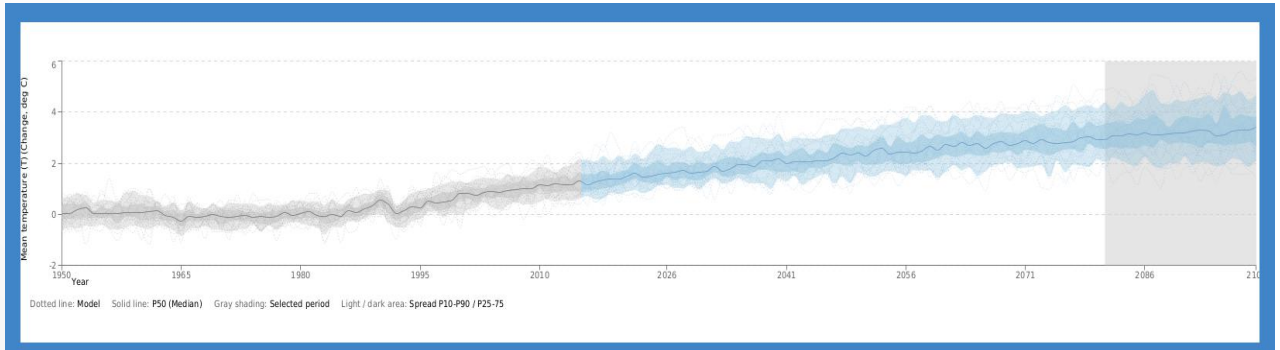

Mean temperature (T) - Change (deg C)
Long Term (2081-2100) (SSP2-4.5) (rel. to 1961-1990)
CMIP6 - Annual (34 models)-Mediterranean

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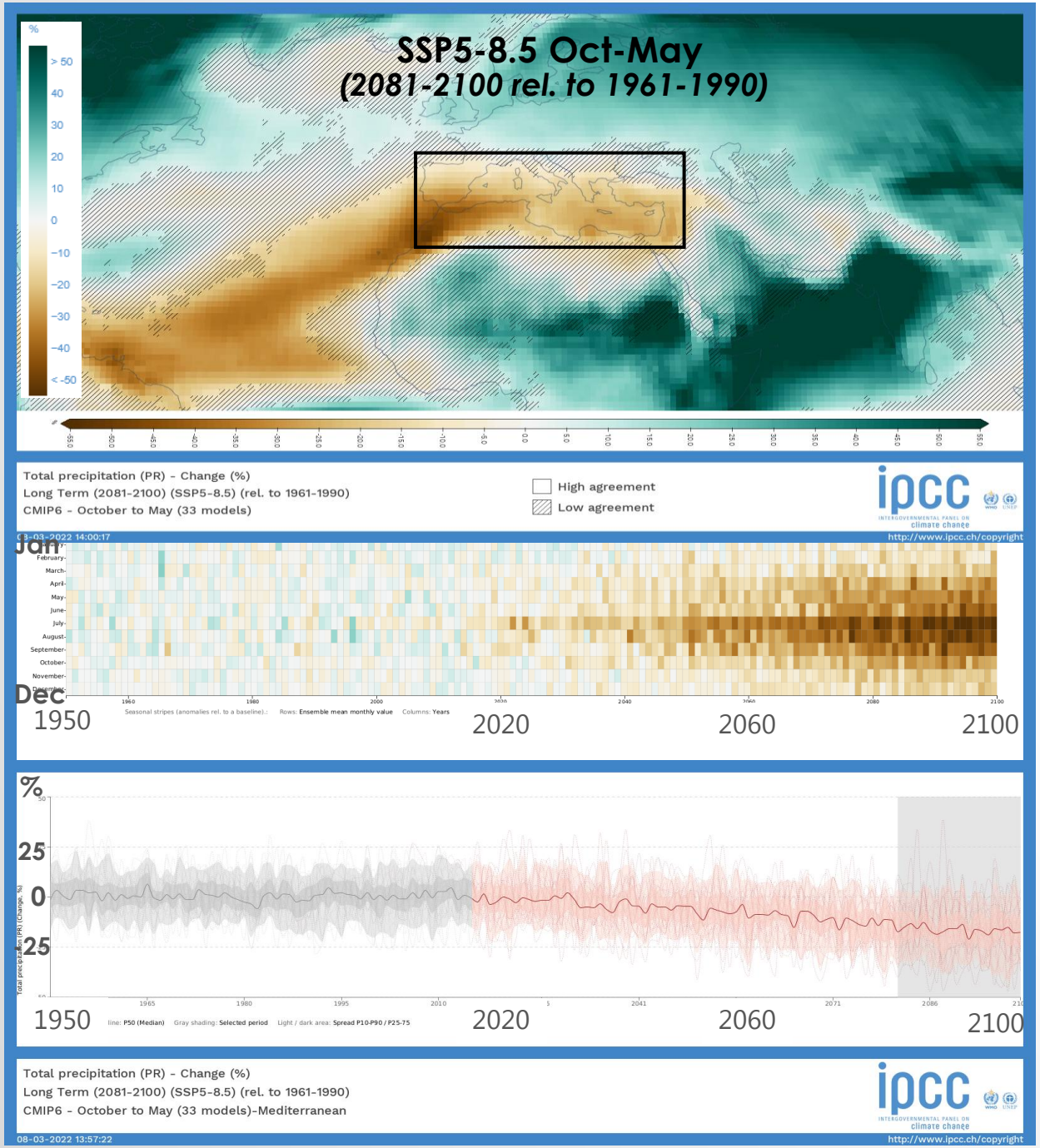
SSP5-8.5 Oct-May
(2081-2100 rel. to 1961-1990)
%
> 50
40
30
20
10
0
−10
−20
−30
−40
< -50
Total precipitation (PR) - Change (%)
Long Term (2081-2100) (SSP5-8.5) (rel. to 1961-1990)
CMIP6 - October to May (33 models)
High agreement
Low agreement
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http://www.ipcc.ch/copyright
Jan
Dec
1950
2020
2060
2100
%
25
0
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1950
2020
2060
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Total precipitation (PR) - Change (%)
Long Term (2081-2100) (SSP5-8.5) (rel. to 1961-1990)
CMIP6 - October to May (33 models)-Mediterranean
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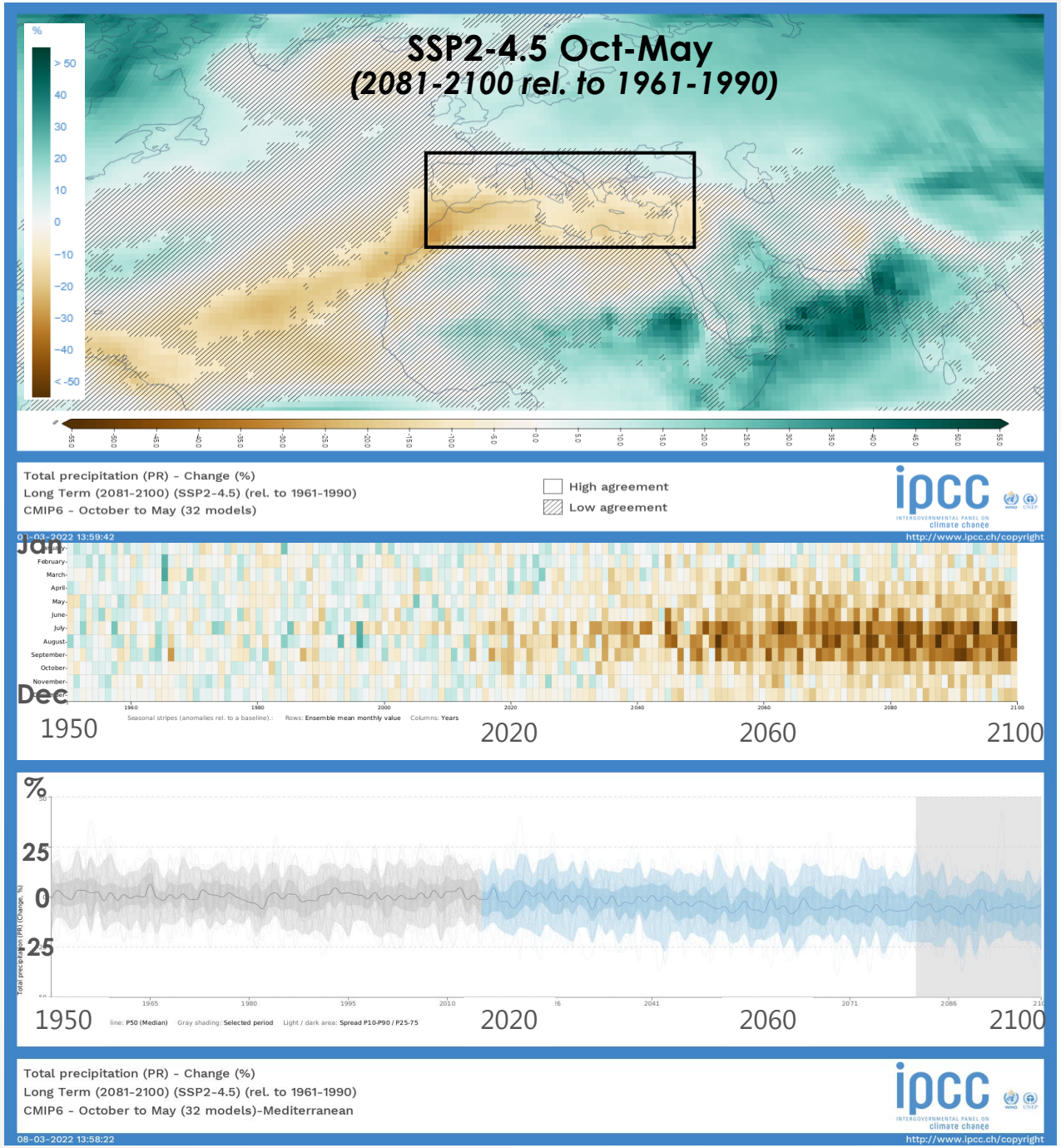
SSP2-4.5 Oct-May
(2081-2100 rel. to 1961-1990)
%
> 50
40
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Total precipitation (PR) - Change (%)
Long Term (2081-2100) (SSP2-4.5) (rel. to 1961-1990)
CMIP6 - October to May (32 models)
High agreement
Low agreement
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Jan
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Total precipitation (PR) - Change (%)
Long Term (2081-2100) (SSP2-4.5) (rel. to 1961-1990)
CMIP6 - October to May (32 models)-Mediterranean
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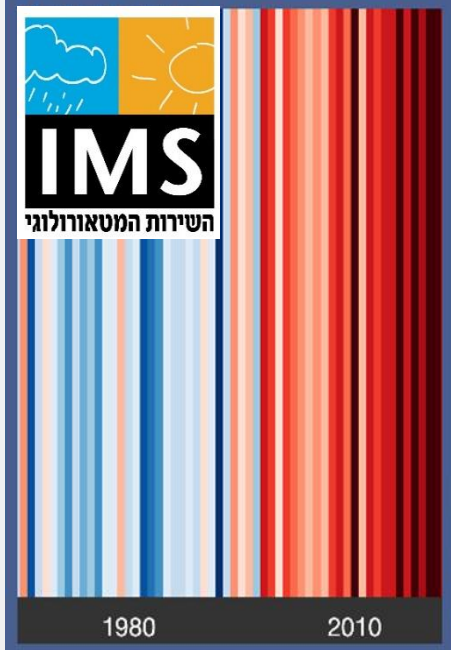
Climate change effects on drought and floods

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]



Analysis of climatic trends and extreme events in Israel through the 21st century

Over 2/3 of the global population will live in cities in 2050

Mumbai, India: Metropolitan of over 20 million people

Climate Change, urbanization and Water

- The recent years reflect a growing trend of extreme weather events
- In addition to the climate factors, rapid land use changes, urbanization, fast development of “Mega cities” and lack of appropriate infrastructures intensifying and accelerating the existent trends
- Population growth and the growing demand to water and food makes the climate crises a real threat for billions in the world, mostly in developing countries

A Case Study for climate change effects: Punjab, India

Climate change effects on water resources and availability

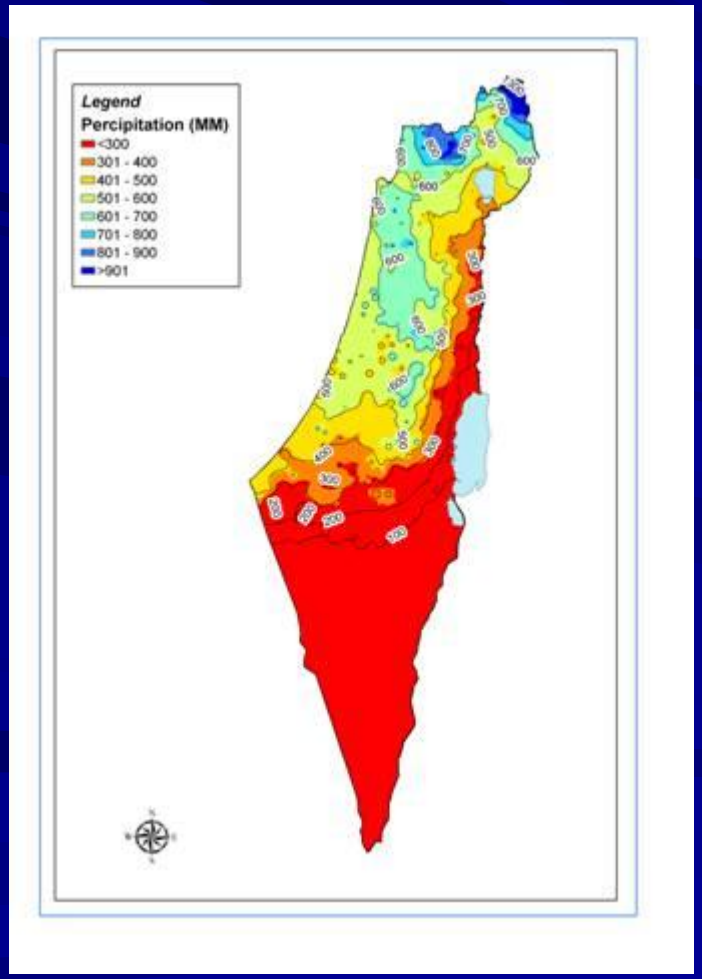
- Increasing gap between water supply and demand
- Leading to a continues decreasing trend in the in the state ground water levels
- Although with **increasing** precipitation of 12% is projected in mid-century in Punjab, the total water availability in the stated is going to **decrease**

State of Punjab Case Study (cont.)

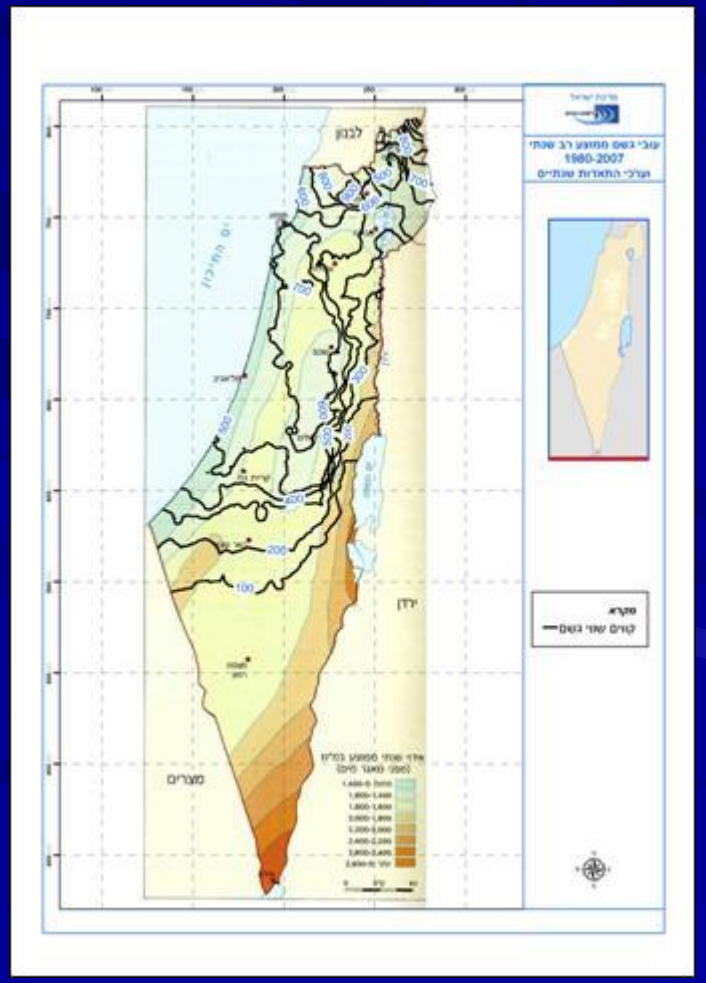
- Precipitation intensities is going to increase. However, Rivers base flow and ground water recharge is going to decreases and drought conditions in all the districts of Punjab is likely to increase towards mid-century.
- Increase in evaporation and evapotranspiration is expected due to the rising temperatures (daily max temperatures)
- The increase in the maximum length of dry spells and decrease in maximum length of wet spell will also effect the agriculture seasons causing shortening of the growing seasons length for both Kharif and Rabi.

Precipitation and evaporation maps of Israel (1985-2010)

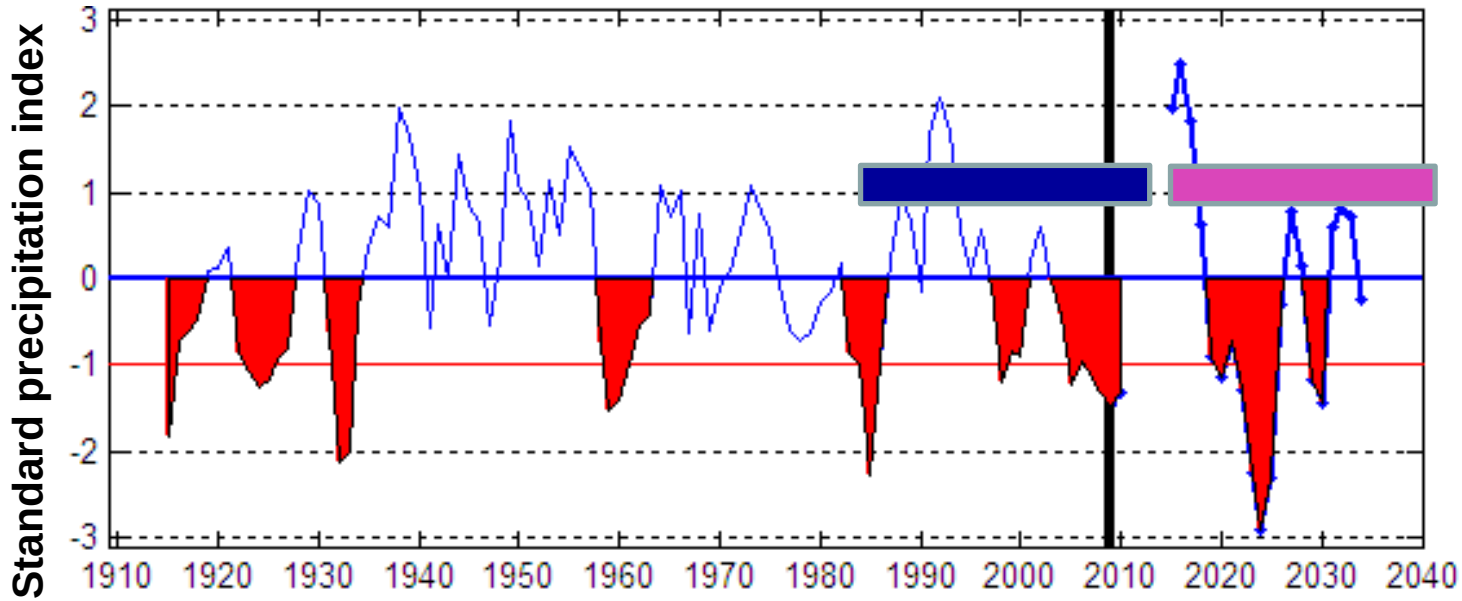
Average annual precipitation contours

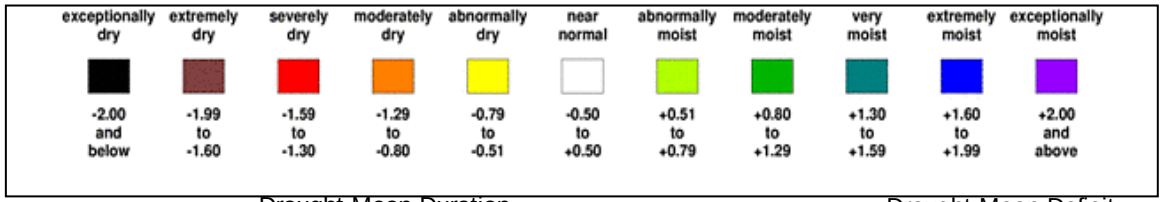


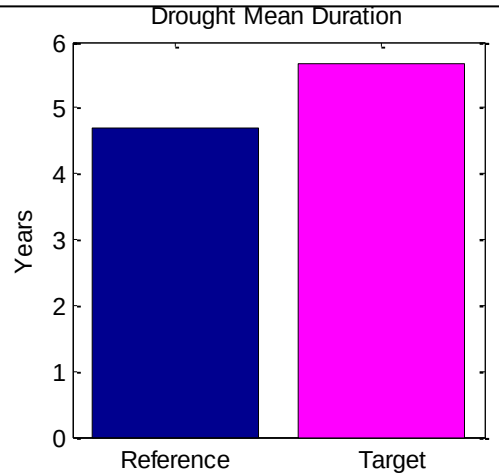
Average annual precipitation contours and evaporation

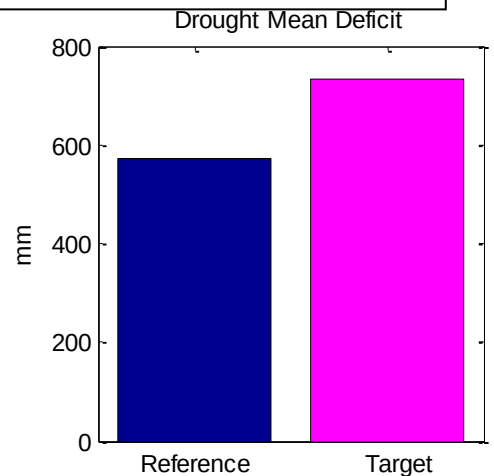


Simulated and predicted droughts in Israel.
Drought magnitude, intensity and duration are expected to increase in the future.









Long-range forecast based on 4 Global models

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Down-scaling To regional scale

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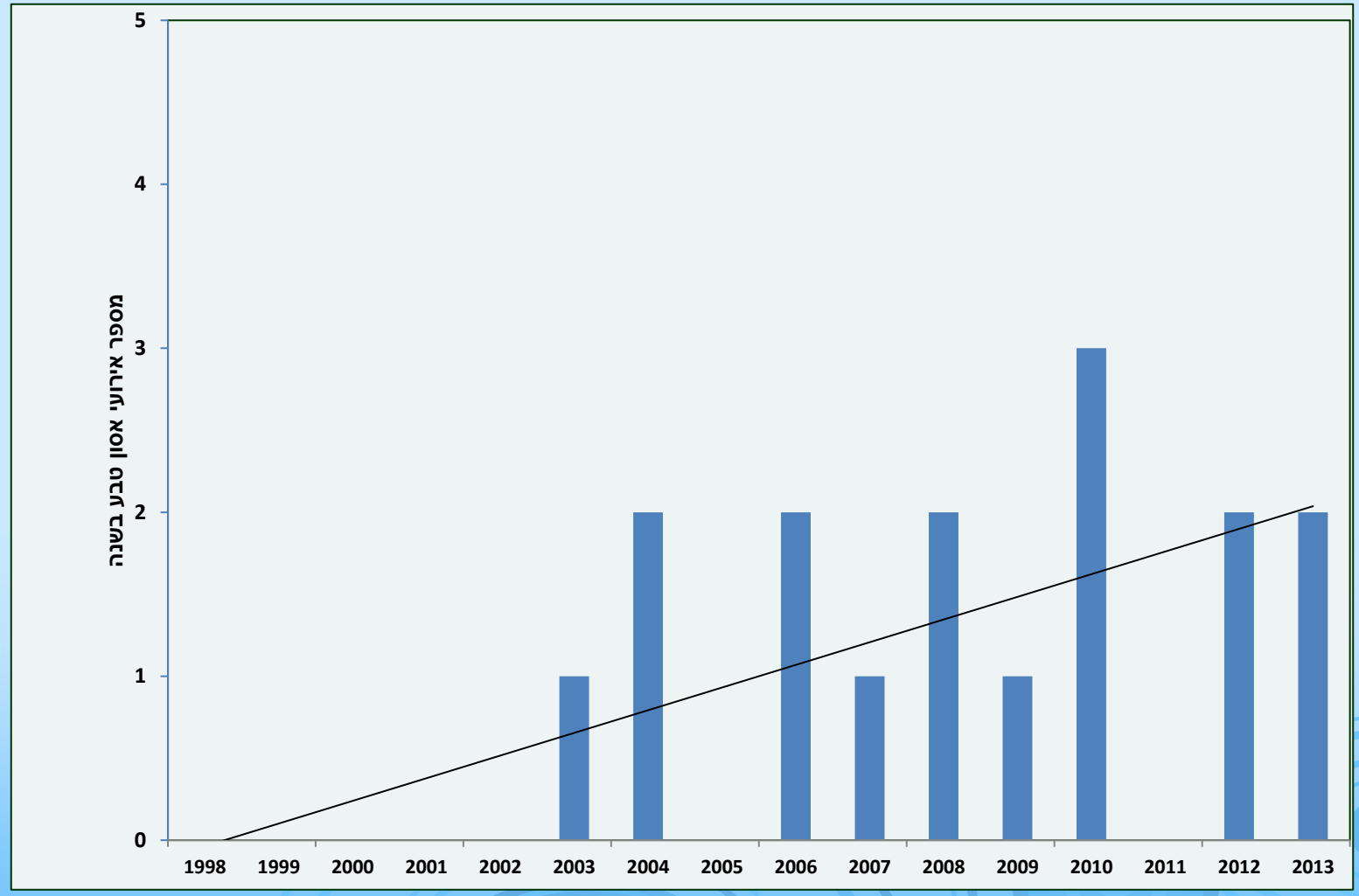
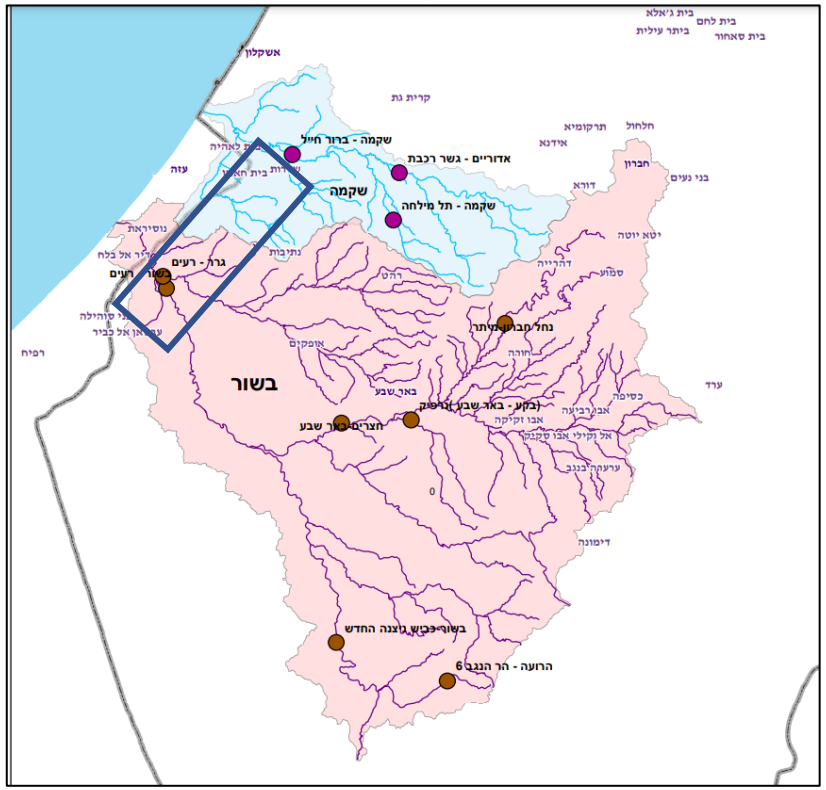
Calibration between predicted and observed

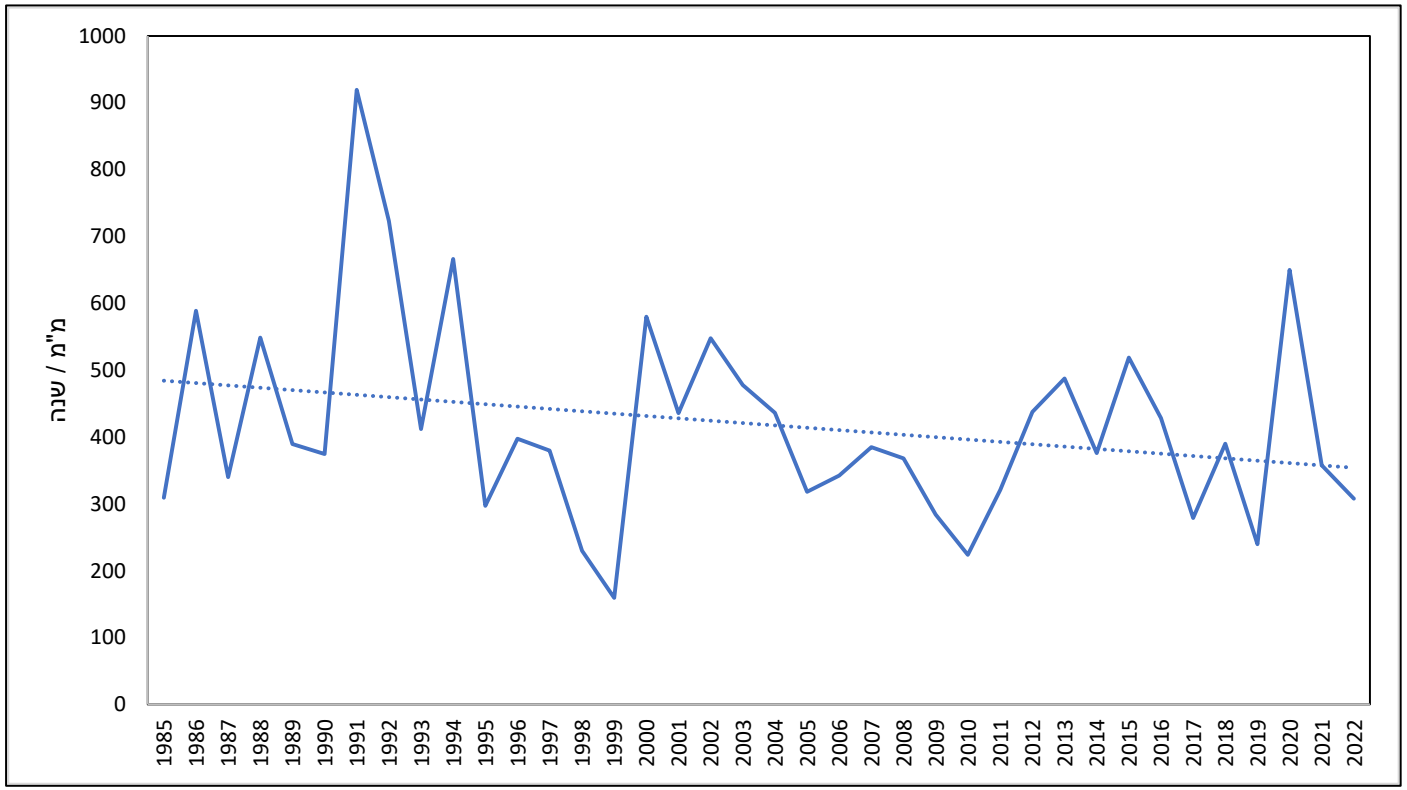
Increase in the number of extreme flood events in Israel: Floods return period of 5%



Annual precipitation In the Western Negev, Isreal

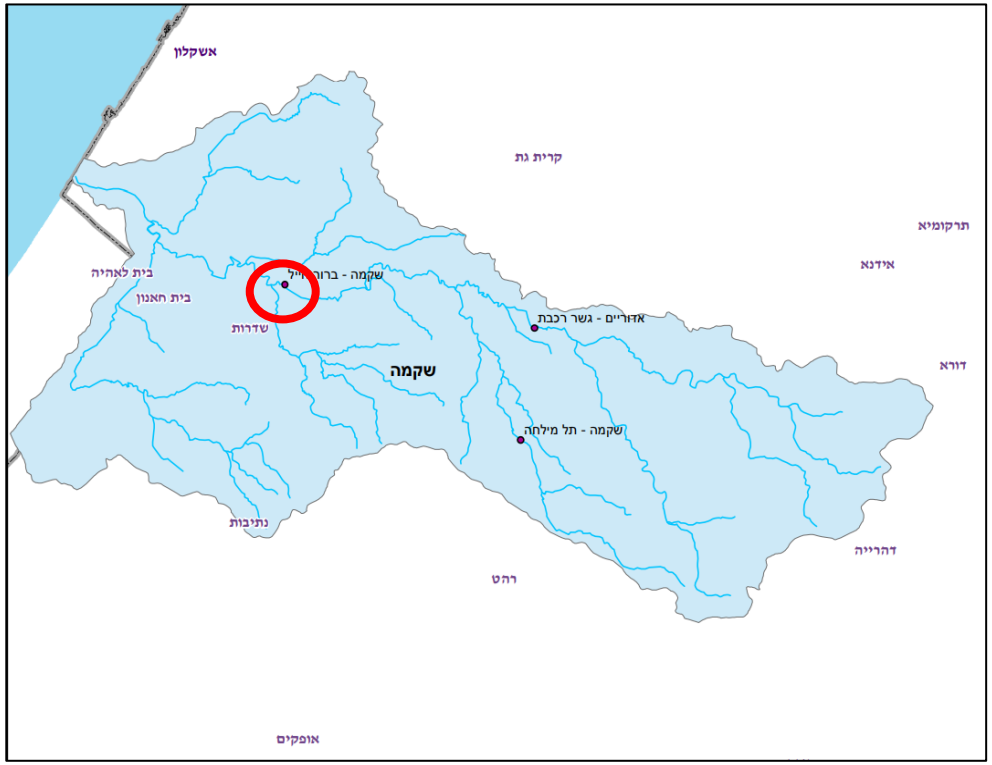
Decreasing precipitation trend

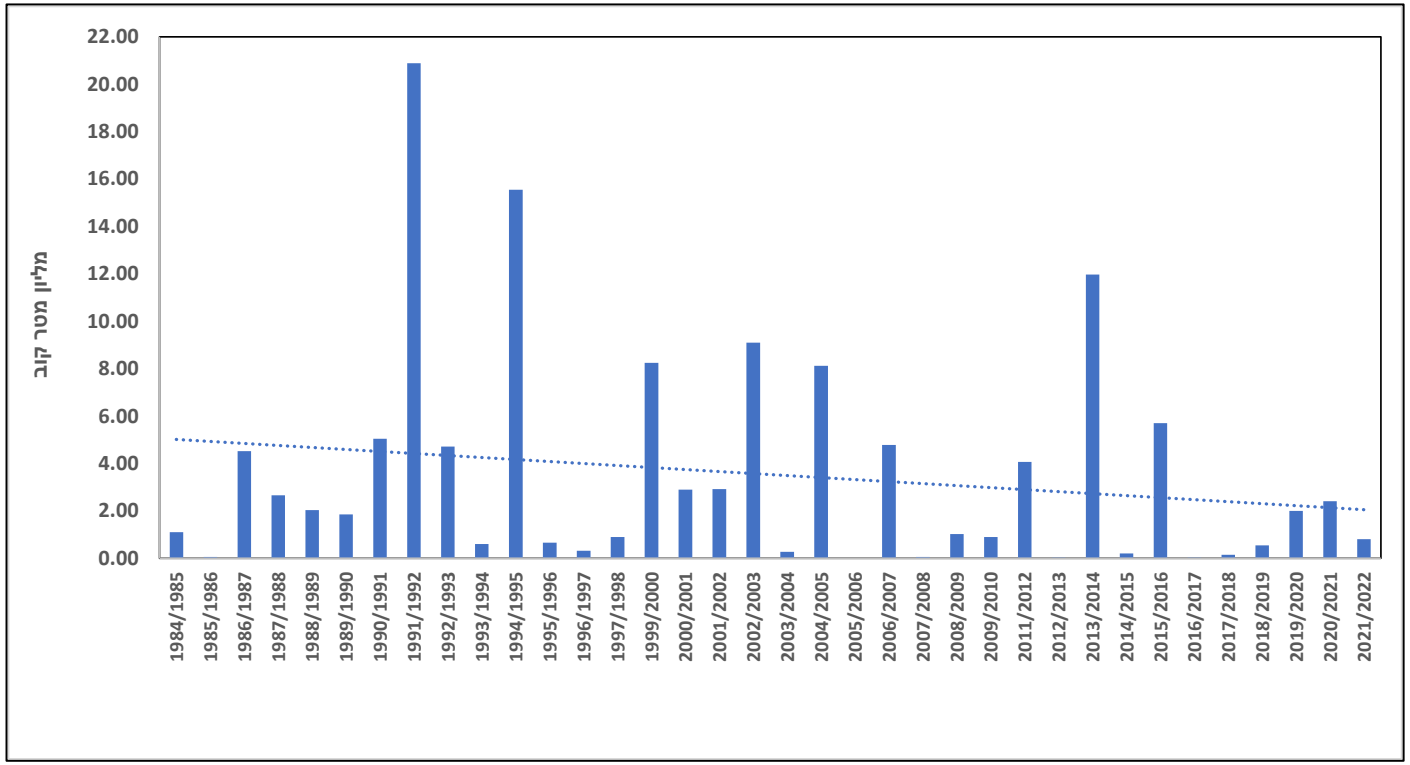




Annual streamflow In the Western Negev

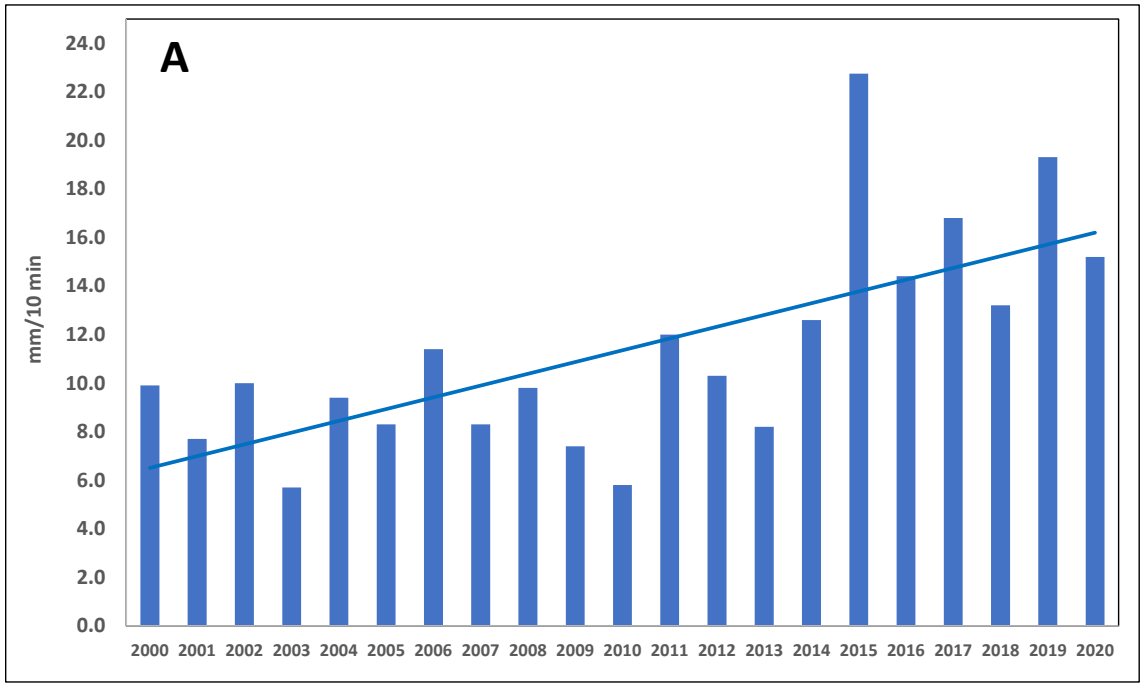
Decreasing streamflow trend

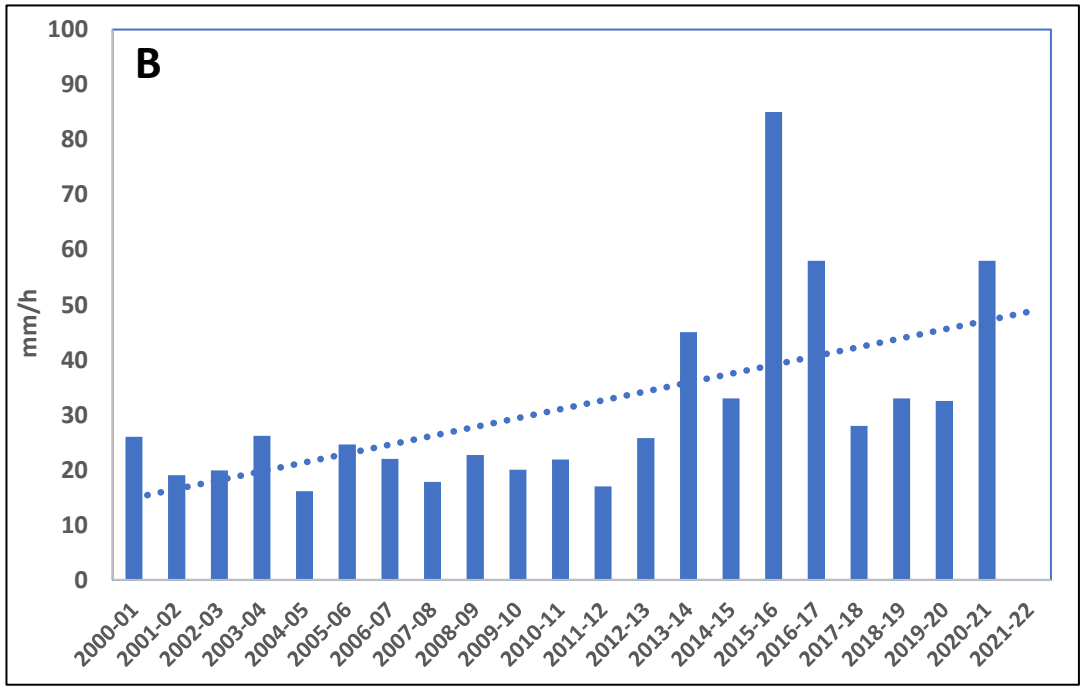




Precipitation intensities for 10 and 60 minutes

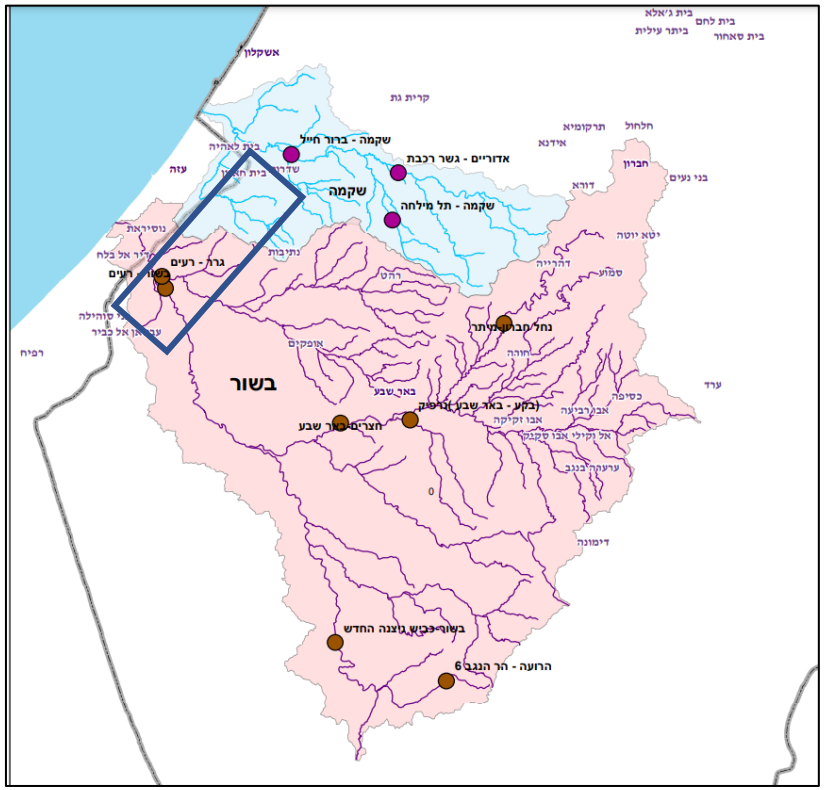
Significant increase in short terms precipitation intensities

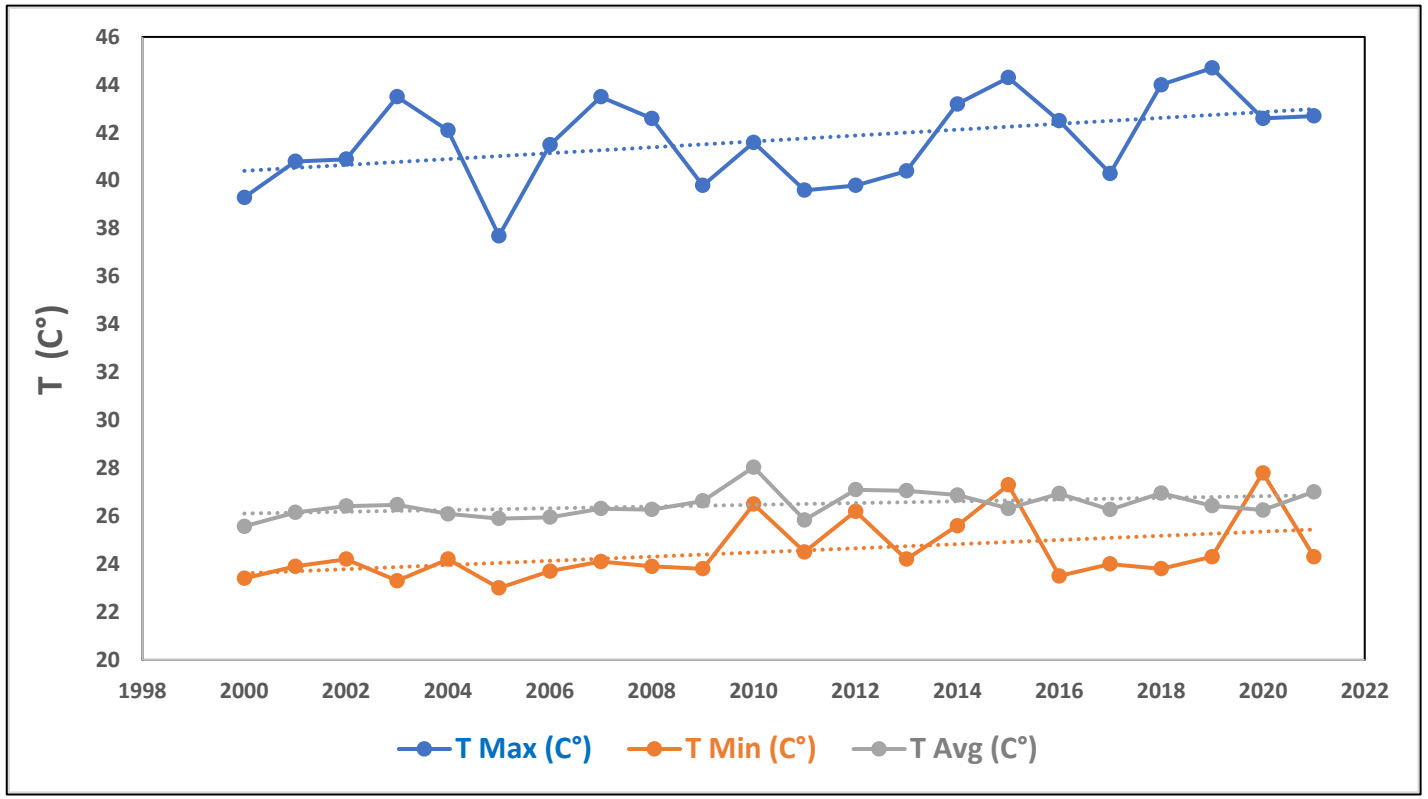




Mean, Max, and Min Temperatures In the Western Negev

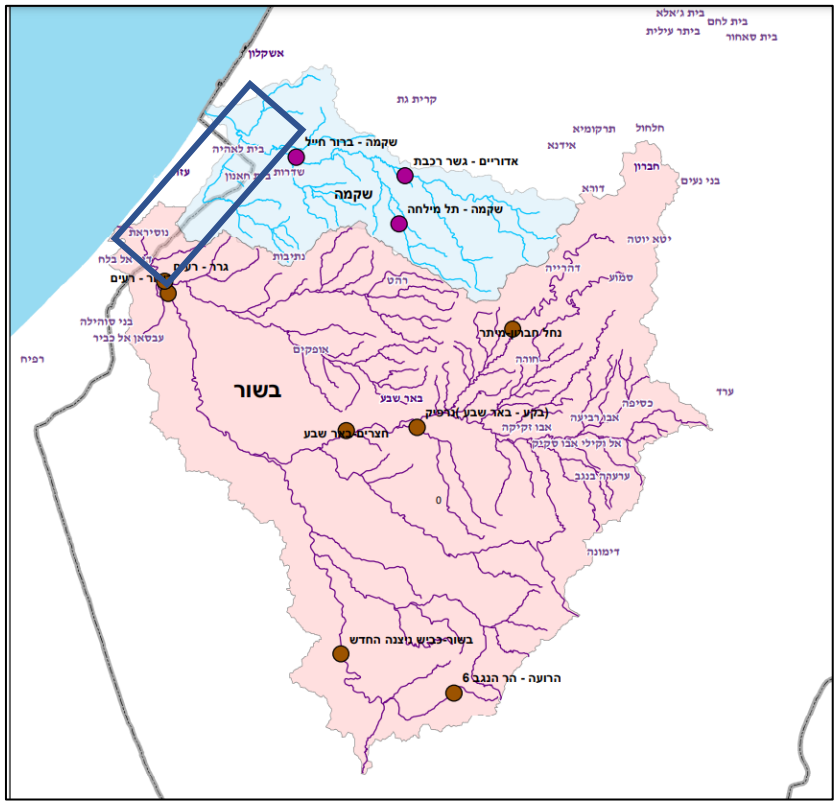
Significant increase in average and maximum (2 degrees) temperatures (Increase in extreme heat waves)

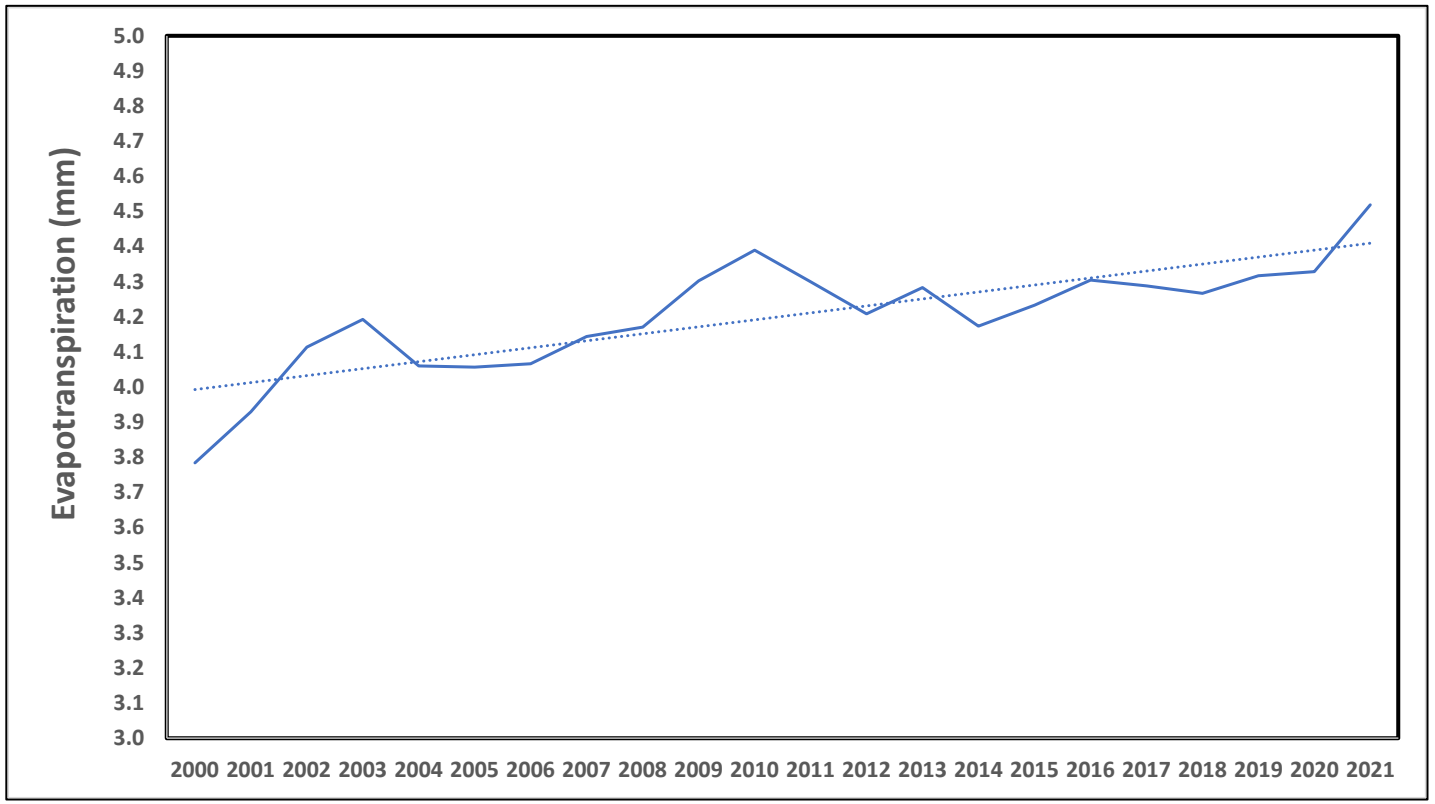




Evaporation (ET) trend In the Western Negev

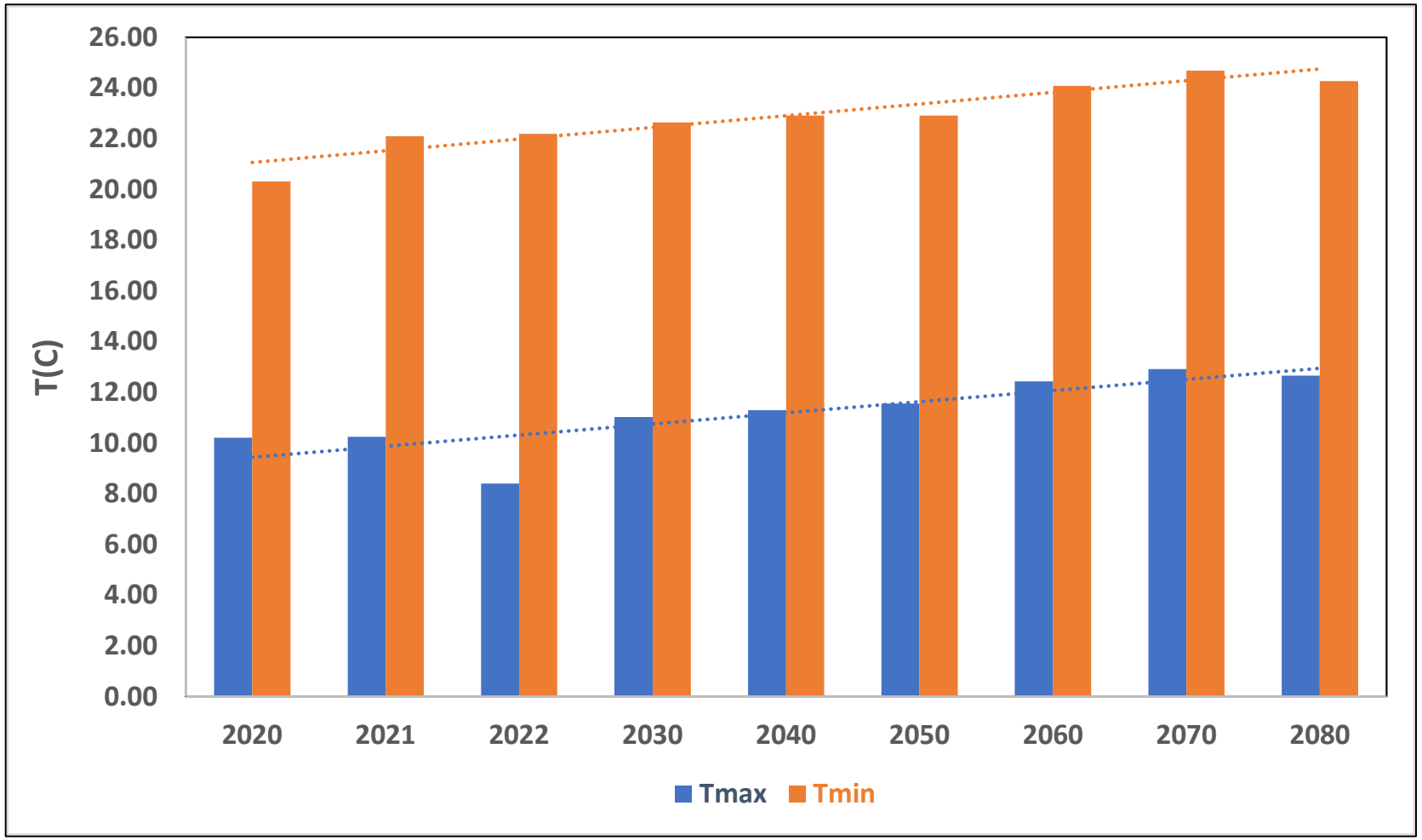
Significant increase in evaporation of 11%





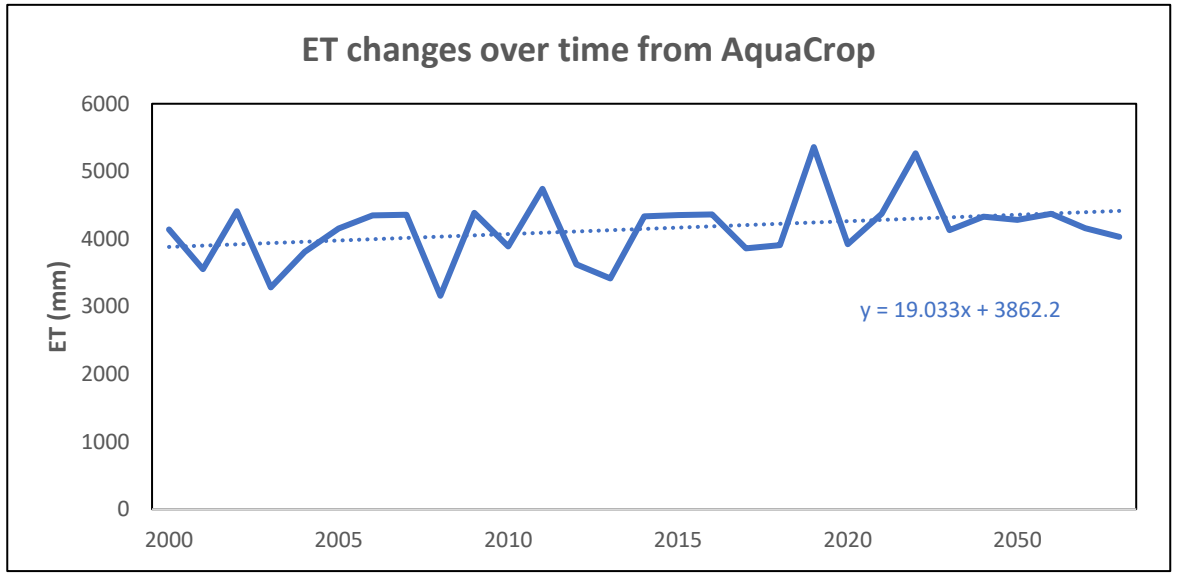
Future climate trends: Max and Min Temperatures, Western Negev

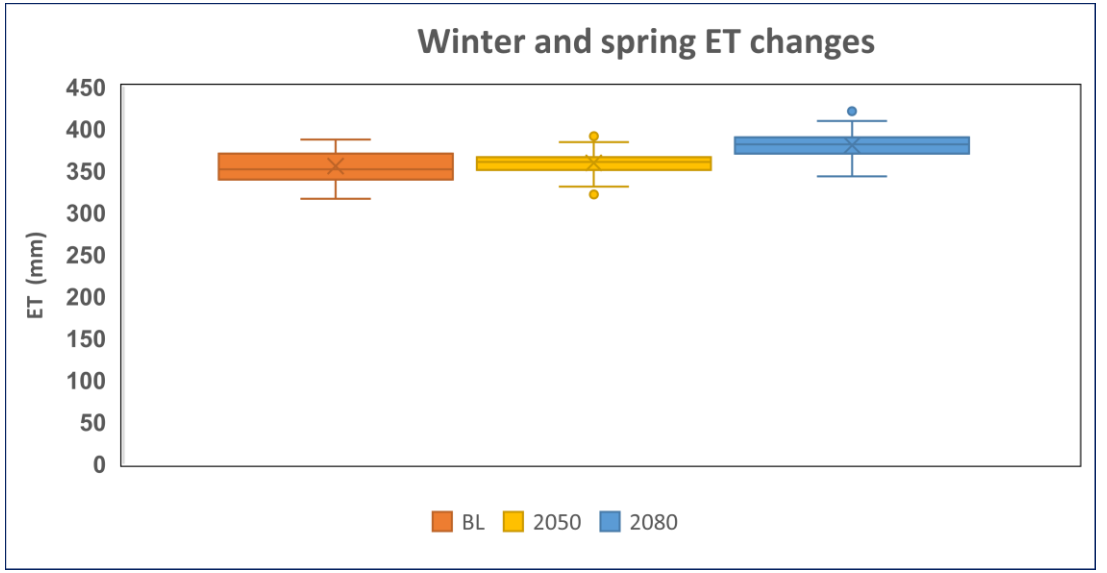
Significant expected increase in minimum and maximum temperatures in the coming decades



Future periods trends: ET, Western Negev

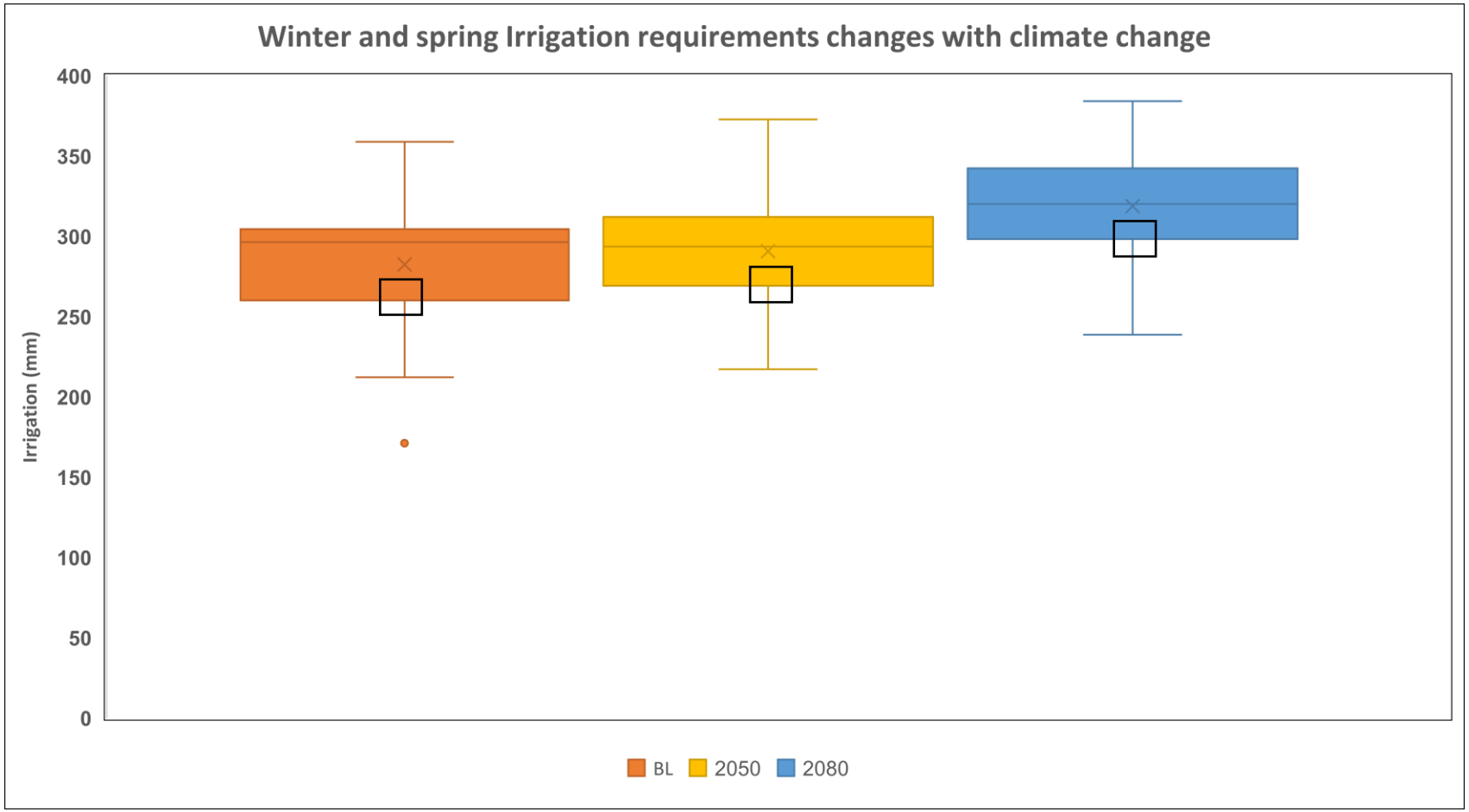
Expected Increase in evaporation in the coming decades





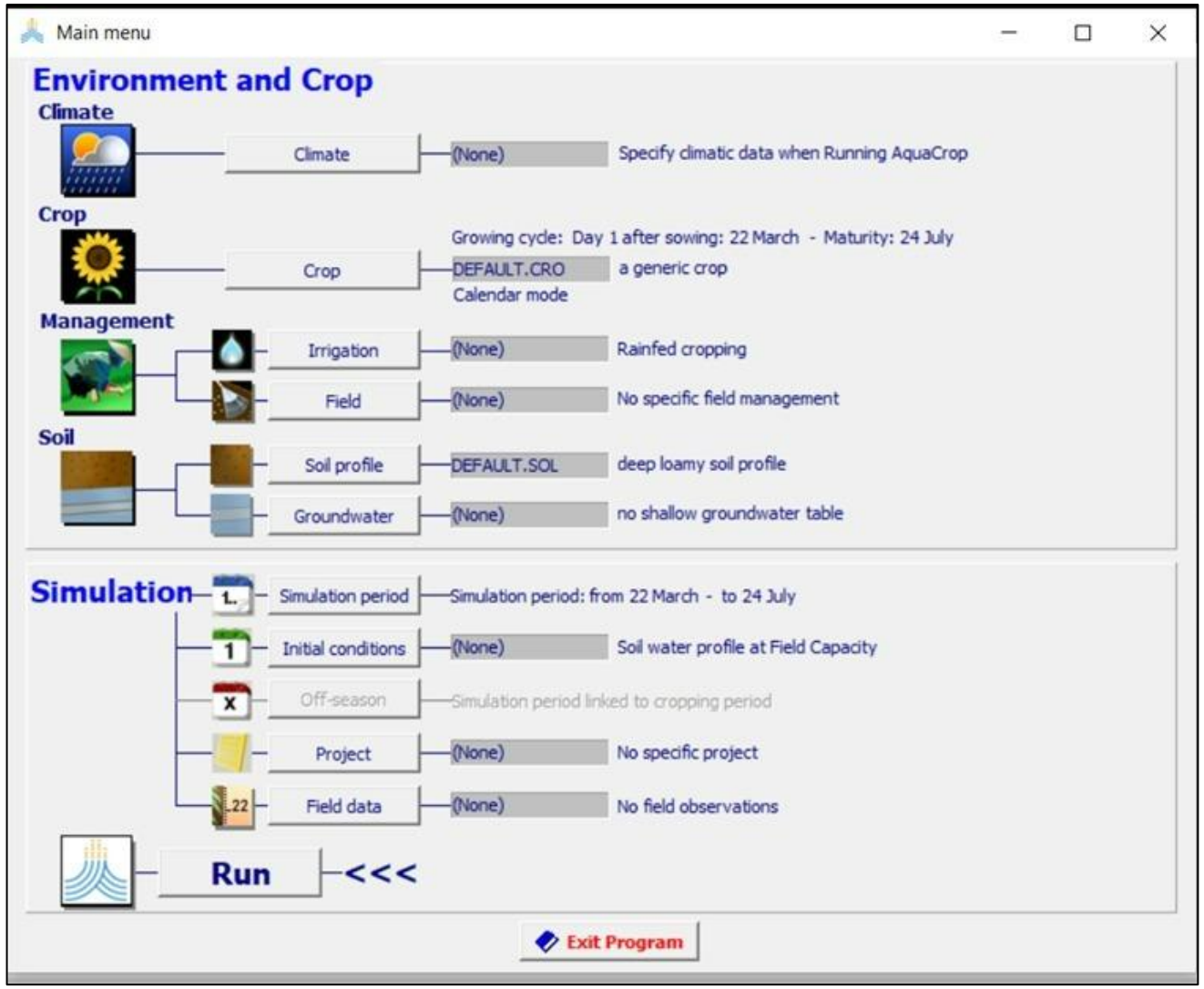
Future trends: Irrigation requirements, Western Negev

Expected Increase in evaporation of around of around 10% due to increase in ET

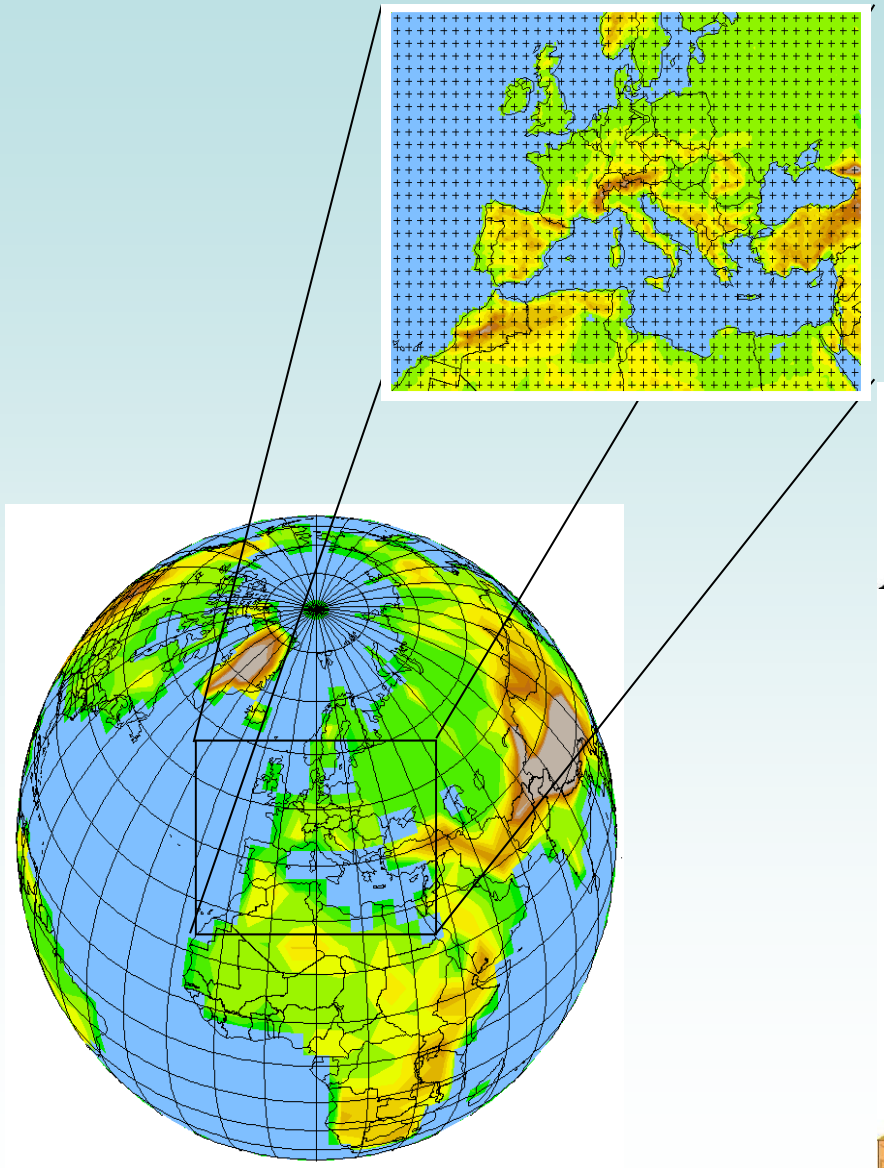


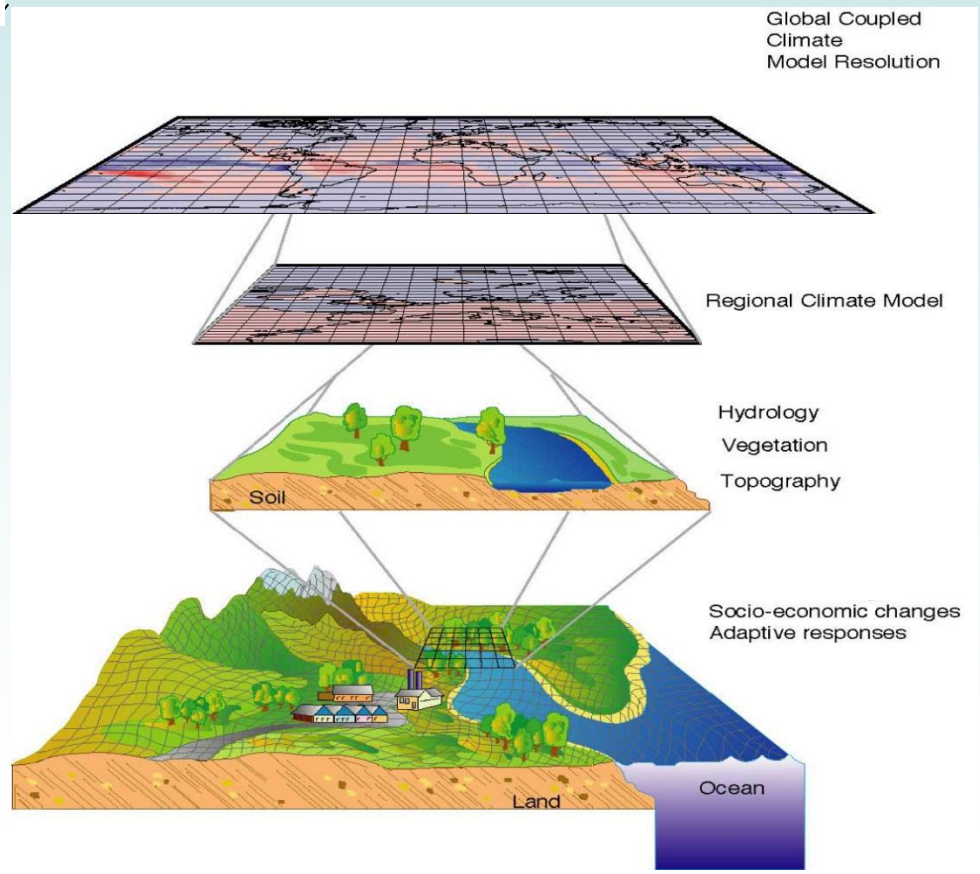
2.3.1 Aqua crop model calibration

Observed input data : Climate, crop, management, soil

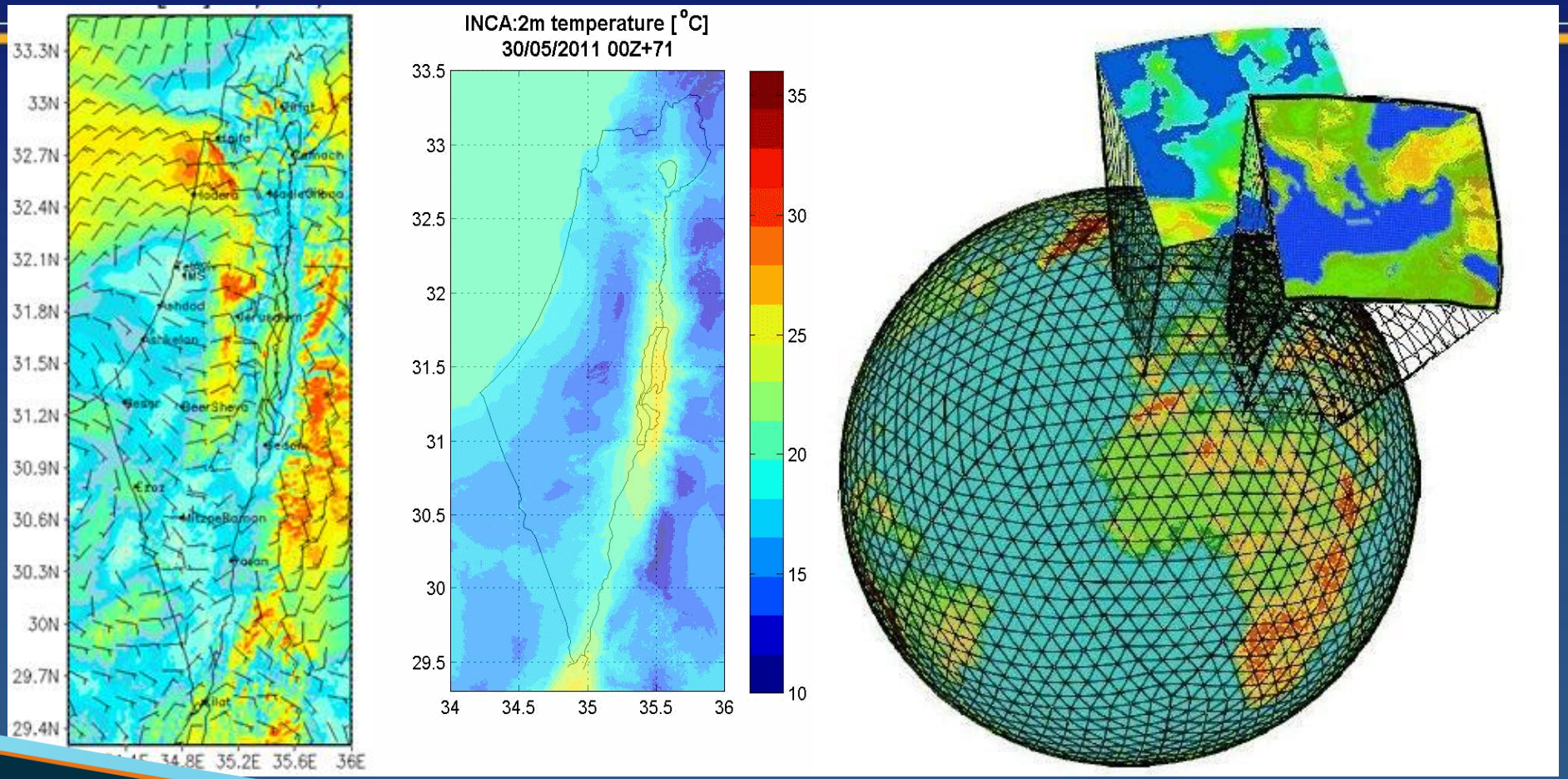


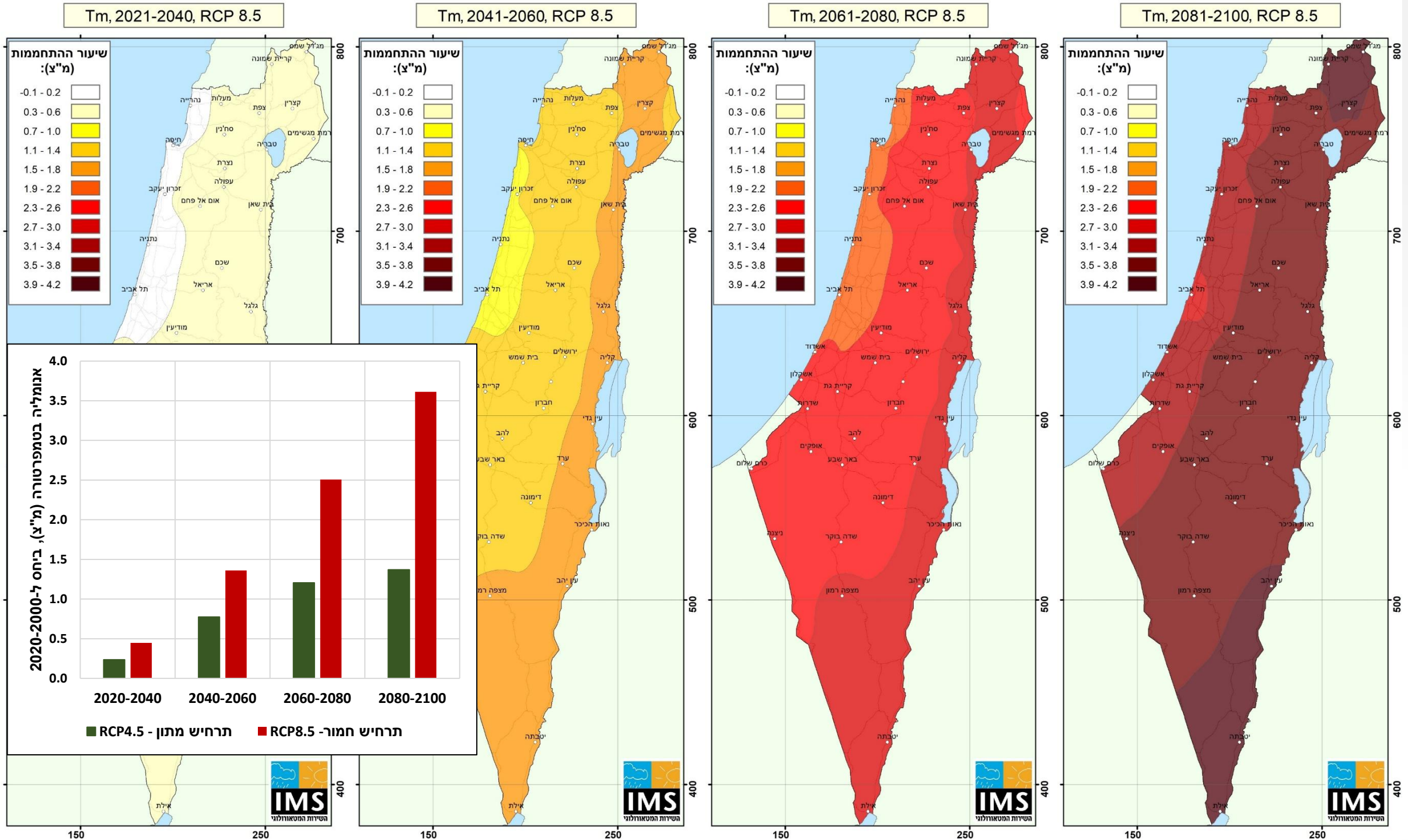
Regional climate simulations



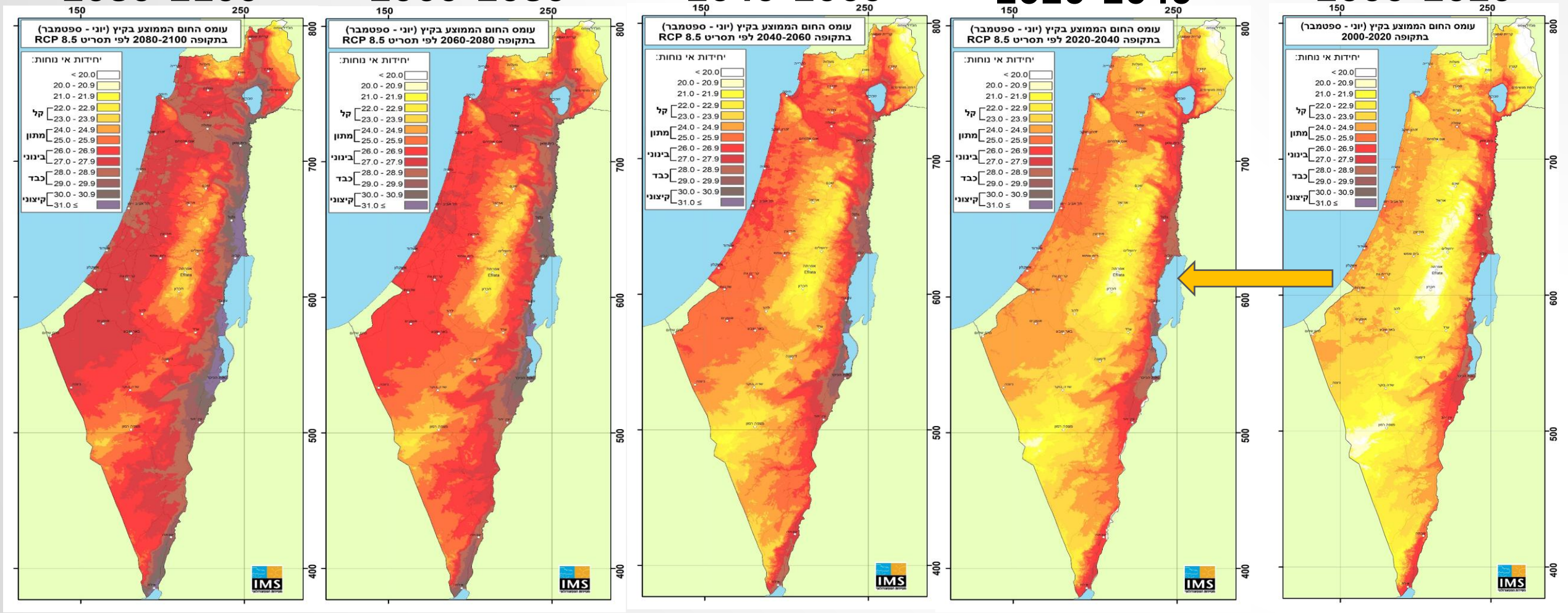


High resolution climate projections

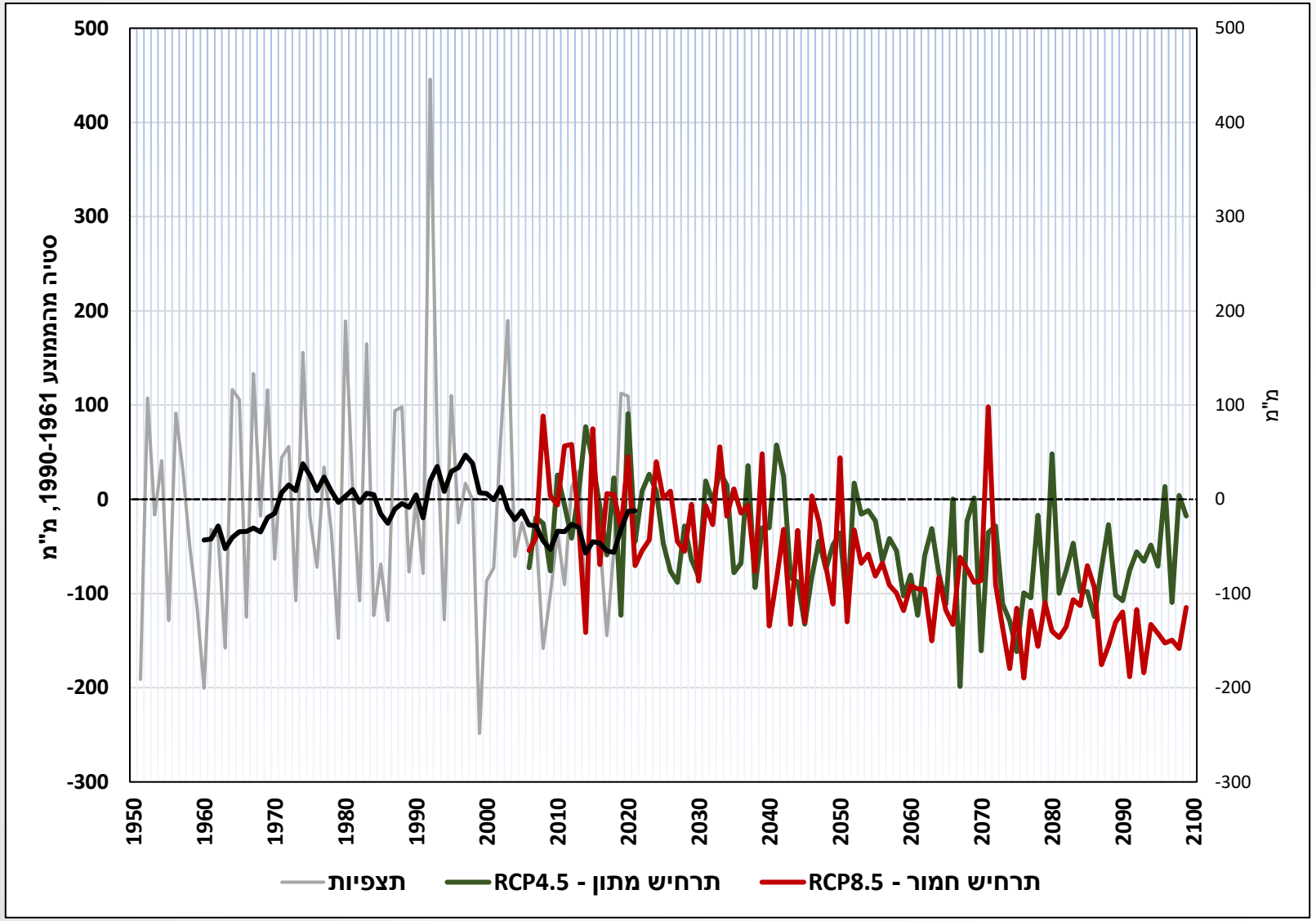



Tm, 2021-2040, RCP 8.5
Tm, 2041-2060, RCP 8.5
Tm, 2061-2080, RCP 8.5
Tm, 2081-2100, RCP 8.5
שיעור ההתחממות (מ"צ):
-0.1 - 0.2
0.3 - 0.6
0.7 - 1.0
1.1 - 1.4
1.5 - 1.8
1.9 - 2.2
2.3 - 2.6
2.7 - 3.0
3.1 - 3.4
3.5 - 3.8
3.9 - 4.2
אנומליה בטמפרטורה (מ"צ), ביחס ל-2000-2020
2020-2040
2040-2060
2060-2080
2080-2100
תרחיש מתון - RCP4.5
תרחיש חמור- RCP8.5
IMS
השירות המטאורולוגי

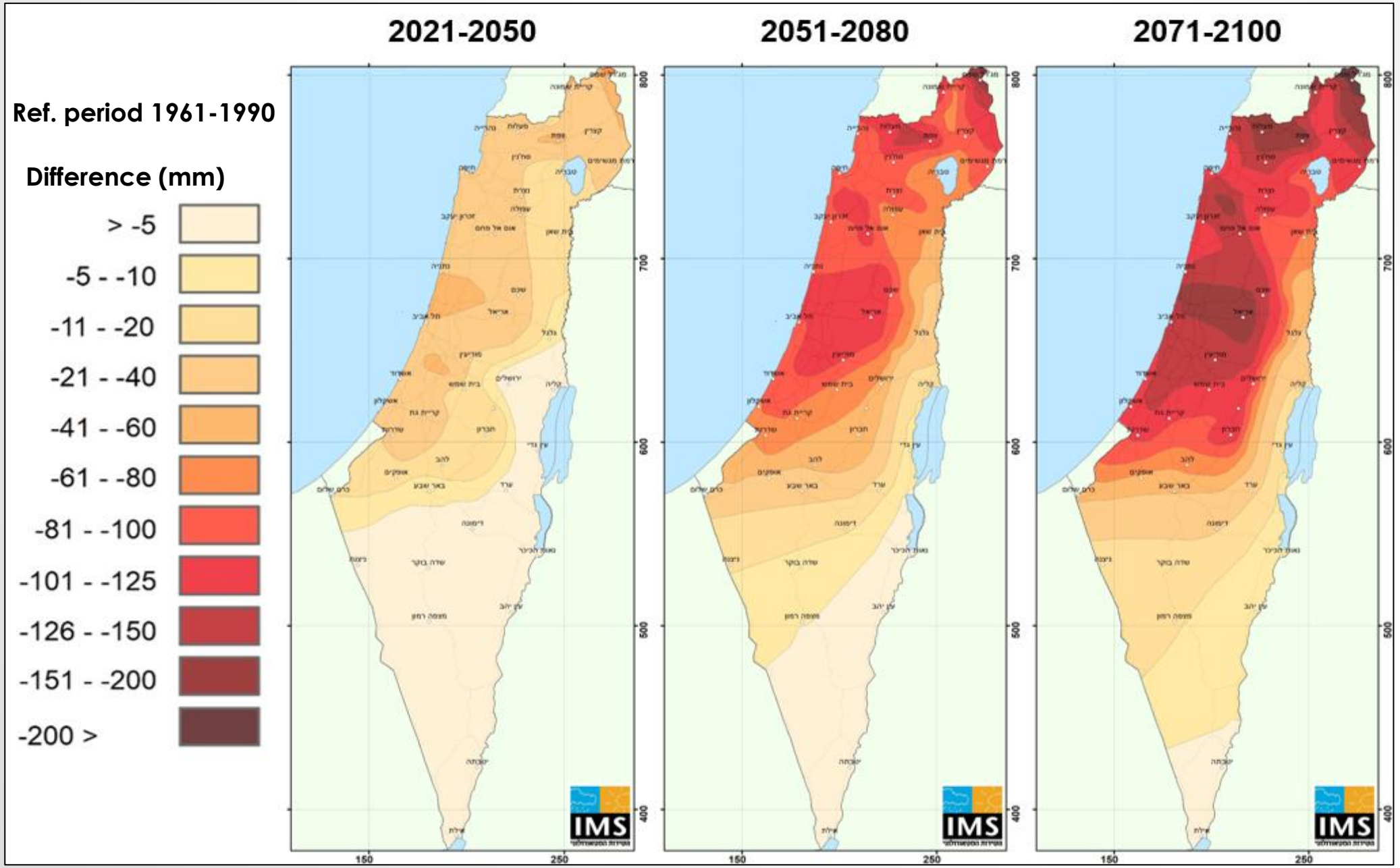
Changes in the average heat stress (JJAS) – RCP8.5



Trends in annual rainfall amounts in the national average

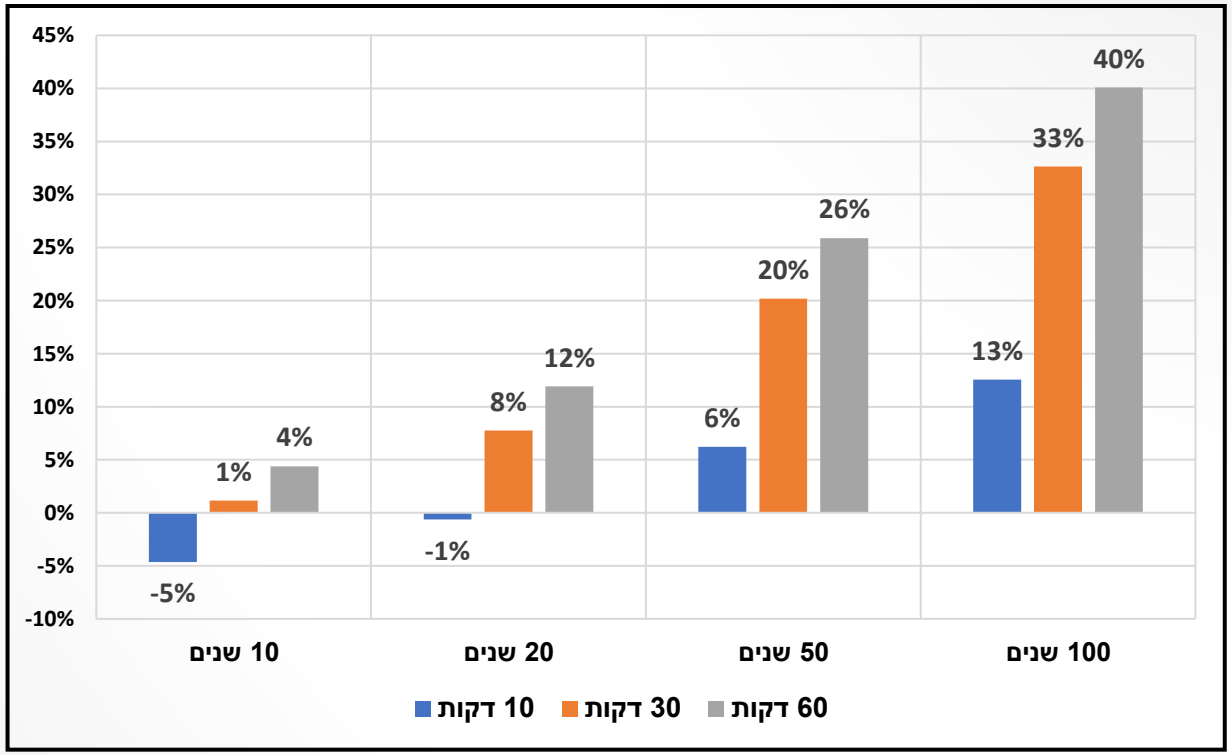


Trends in Annual Rainfall Amounts – RCP8.5



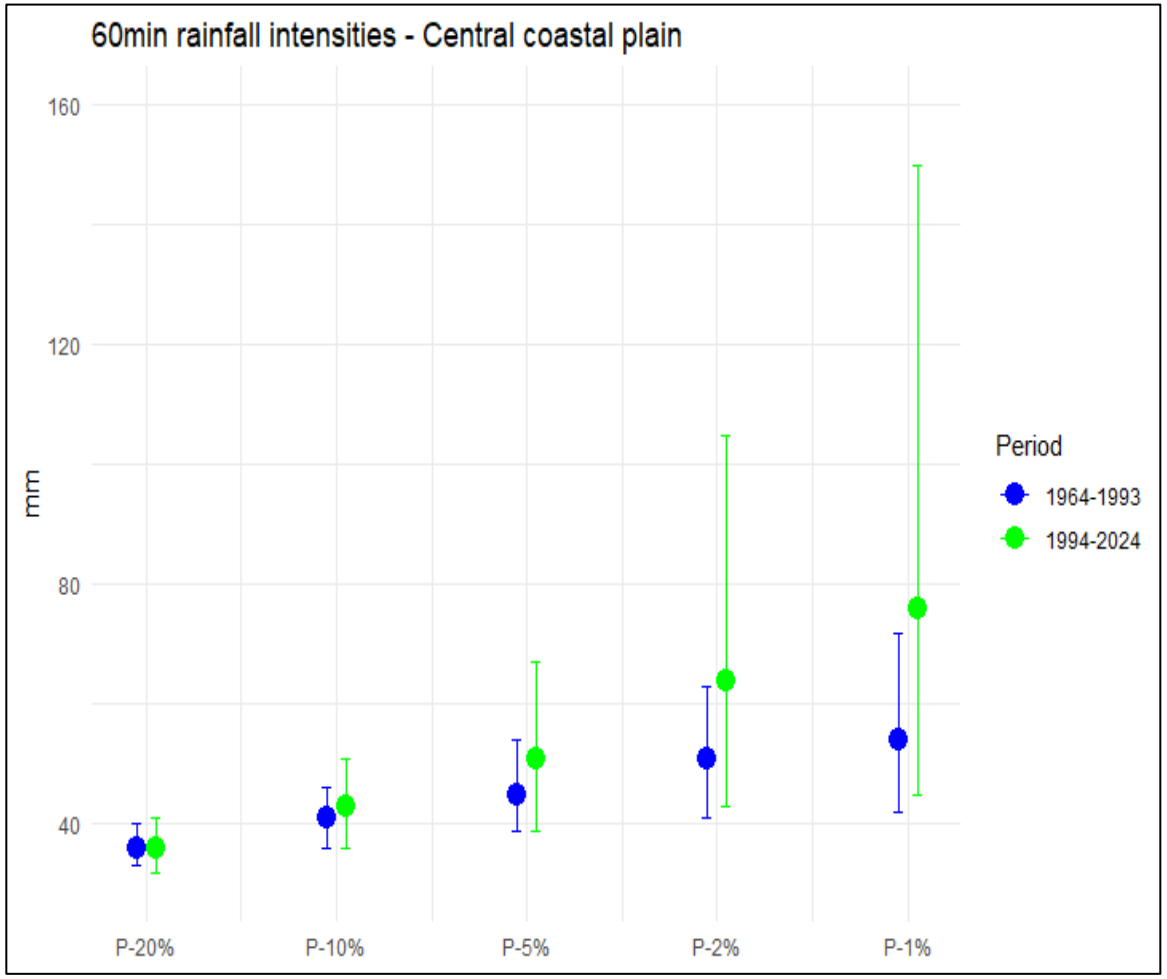
Central Coastal Plain Region - Rainfall Intensities

Return period	60 min	1964-1993 (mm/h)	1994-2024 (mm/h)
5 years	P-20%	36.4 (33.1-40.4)	36.2 (31.6-40.9)
10 years	P-10%	41.0 (36.3-46.4)	**42.8** (35.6-50.9)
20 years	P-5%	45.3 (38.6-52.6)	**50.7** (39.1-66.9)
50 years	P-2%	50.6 (40.7-63.3)	**63.7** (42.7-104.7)
100 years	P-1%	54.4 (42.1-72.0)	**76.2** (45.3-149.9)



Percent change in rainfall intensity in the Central Coastal Plain region, by duration and return period, between the 1964-1993 and 1994-2024 periods.

Significant increase in rain intensities and floods



Summary

1. Climate change is effecting all sectors
2. Some sectors are highly sensitive to climate change effects
3. The is a need to operate and plan according high resolution climate data, translate the row data into insights and impact
4. Every sector need to analyze how climate change will effect his business and to plan according to that