Regional Climate Simulations for the Near East and the Jordan River Region

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Regional Climate Simulations

Objectives

1) Estimation of future temporal and spatial distribution of temperature and precipitation

2) Provision of climate change information to impact WPs in GLOWA-Jordan

3) Estimation of uncertainty bounds of climate change projections

Regional Climate Simulations

Scientific Challenge

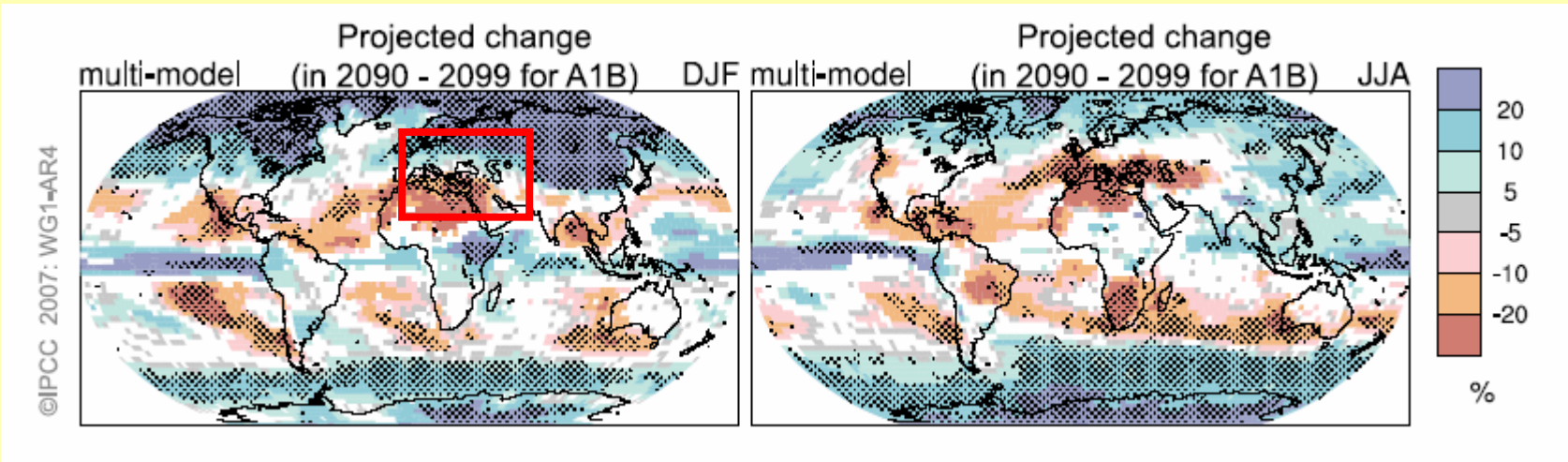
1) Changes in the regional climate can differ significantly from the overall trend of global climate change

2) Region has sharp climatic gradients:
subhumid mediterranean ↔ arid climate

3) Resolution of global climate models are too coarse for hydrological & biological impact studies
⇒ Higher resolution information required that account for regional and local geographic features (particularly orography, land use and water bodies)

Approach:
Dynamic downscaling of global climate scenarios

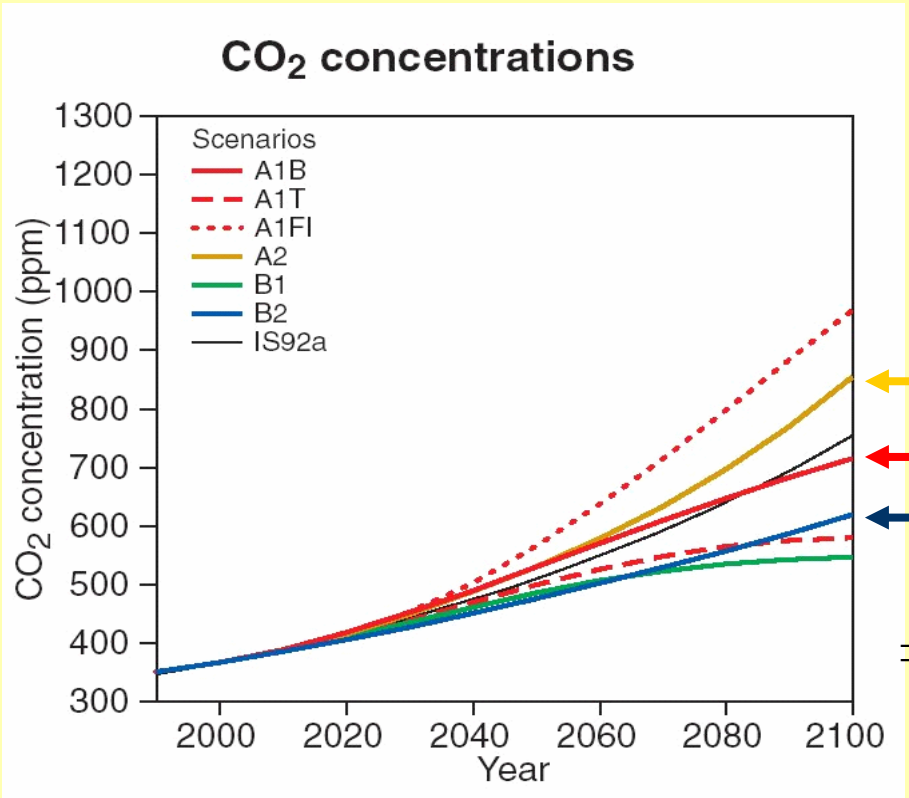
Scientific Challenge



IPCC 4AR, 2007

Eastern Mediterranean/Near East:
is in between increasing and decreasing dominant large scale patterns of DJFprecipitation change

Regional Climate Simulations



IMK-IFU, TAU

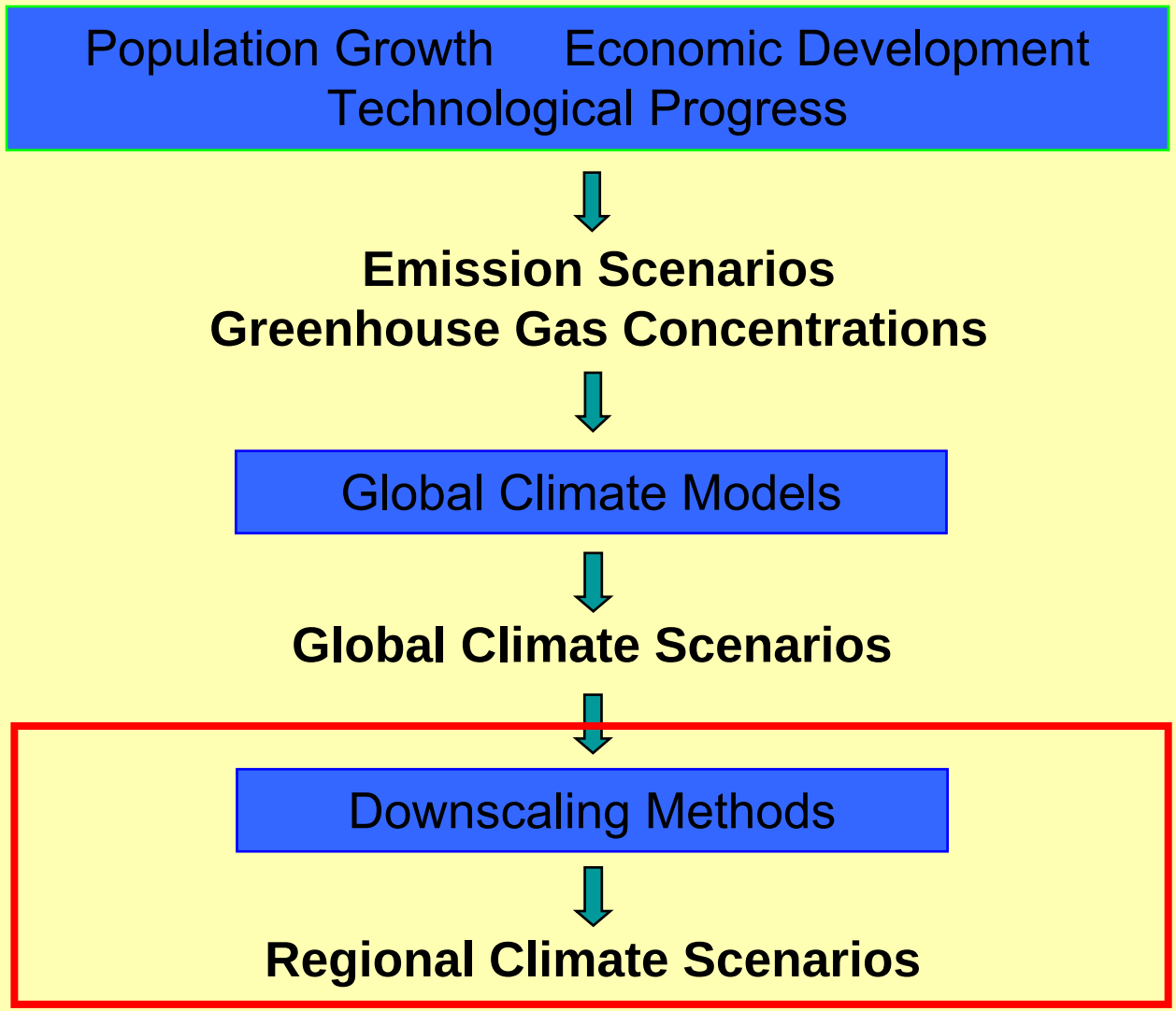
TAU

IMK-IFU, TAU

⇒ Uncertainty bounds

Emission scenarios: based on different assumptions on future GHG emissions

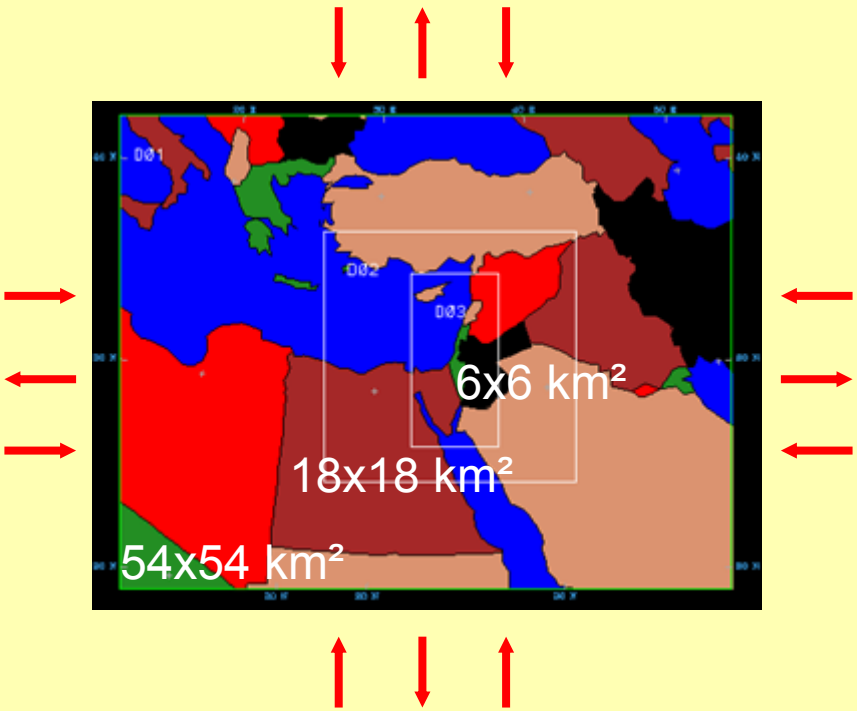
Regional Climate Simulations



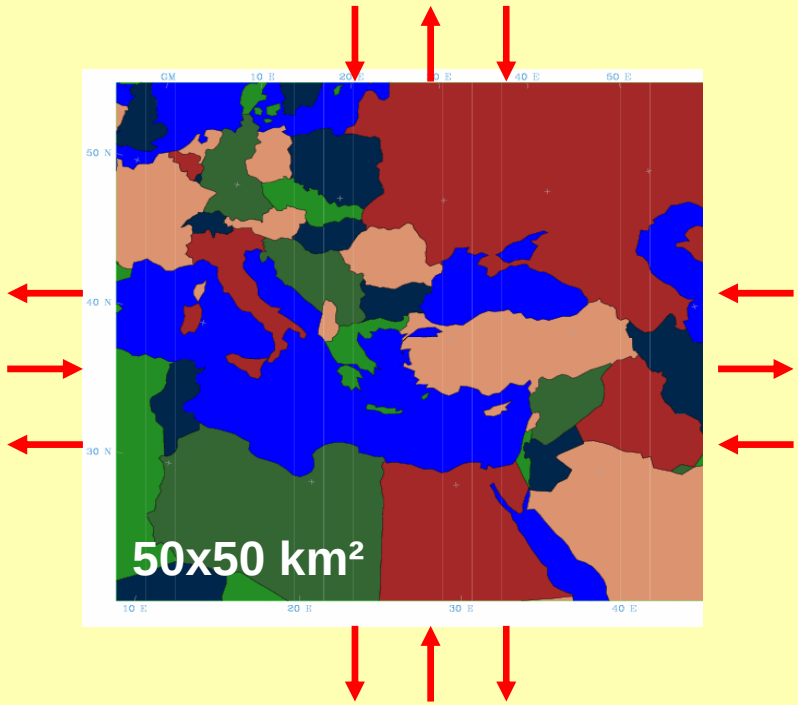
Regional Climate Simulations

Explicit dynamical downscaling of global climate scenarios

MM5 (IMK-IFU)
ECHAM4: 54, 18, 6km

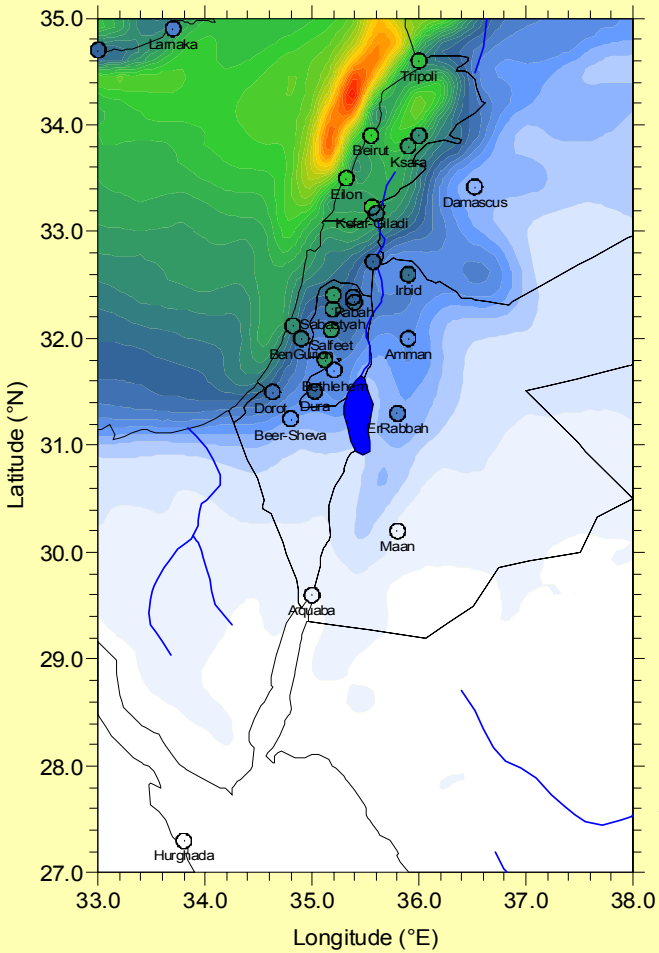


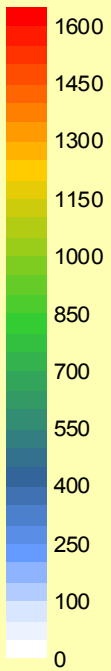
RegCM3 (TAU)
HadAM3P, ECHAM5, NASA FV: 0.5°(≈50km)



Regional Climate Simulations

Quality of regional climate simulations: control run vs. long term observation

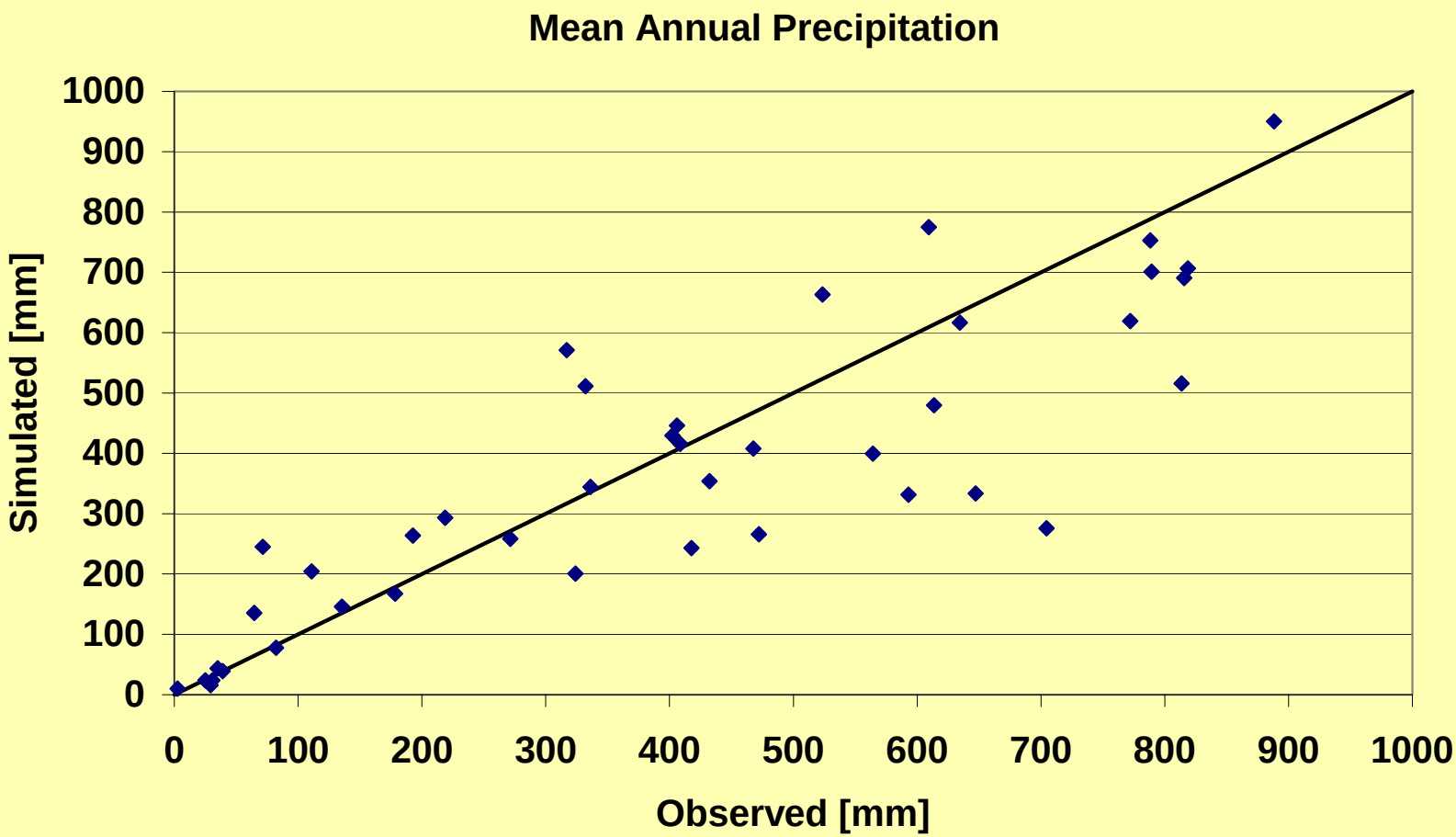




Yearly Mean Precipitation in mm

Simulated annual mean precipitation
(ECHAM4, 18 km², 1961-1990)
vs.
observed long term annual mean
(for selected stations 1961-1990)

How accurate does the downscaled Control Run reproduce observed precipitation?

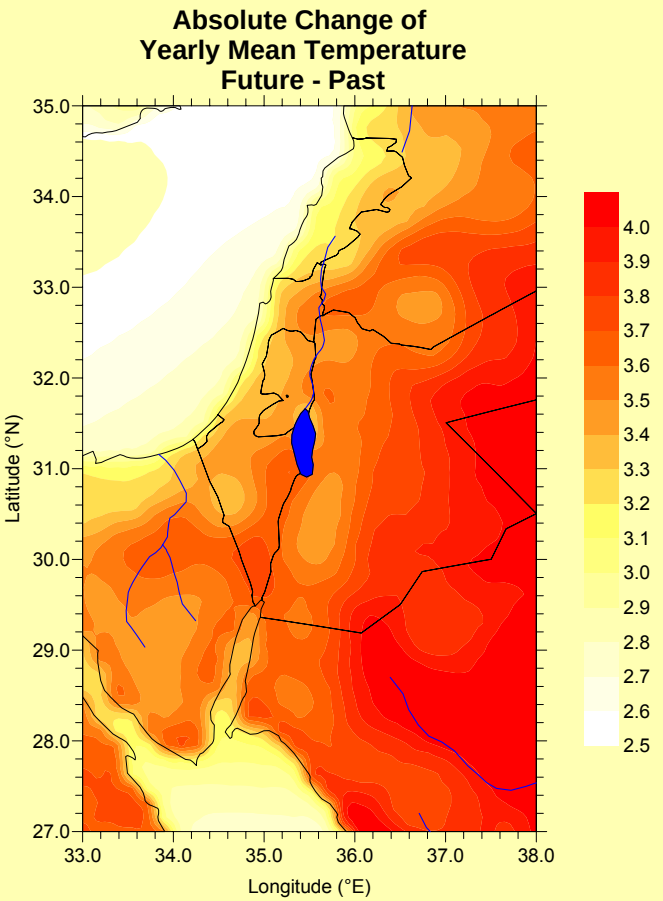


Regional Climate Simulations

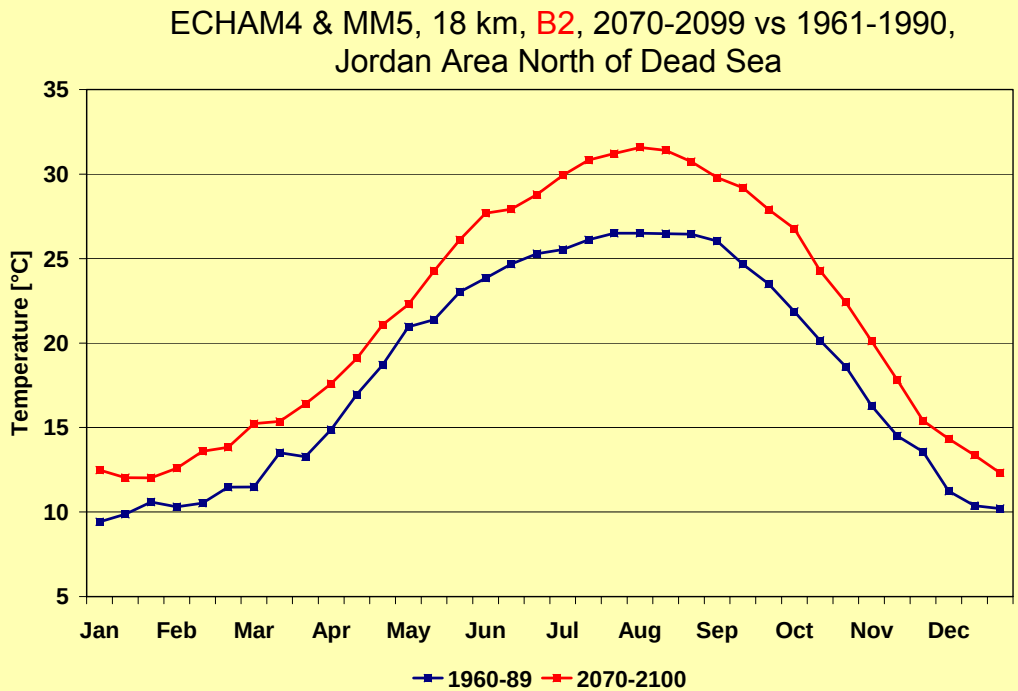
First example

ECHAM4, B2, 18km, 2070-99 vs. 1961-90

What are the expected changes in temperature?

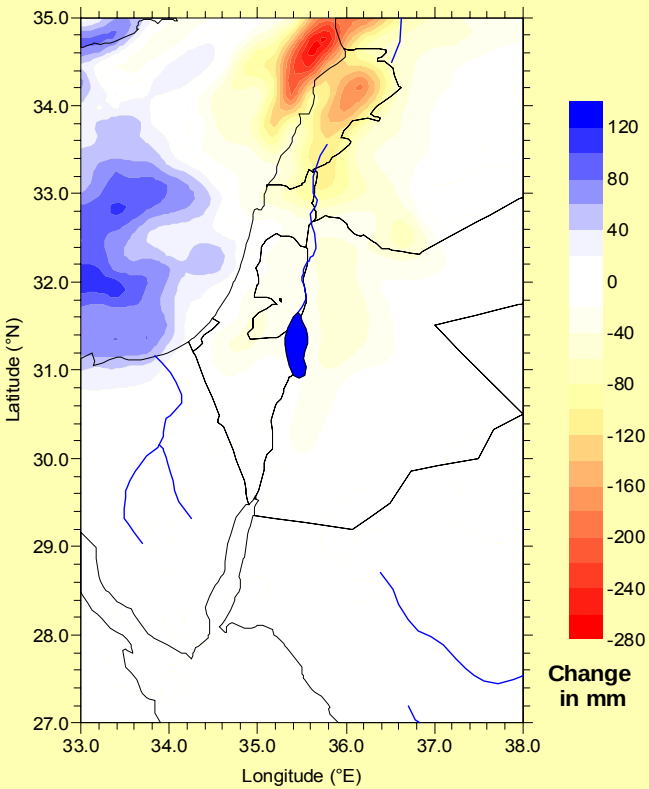


Change in annual mean temperature

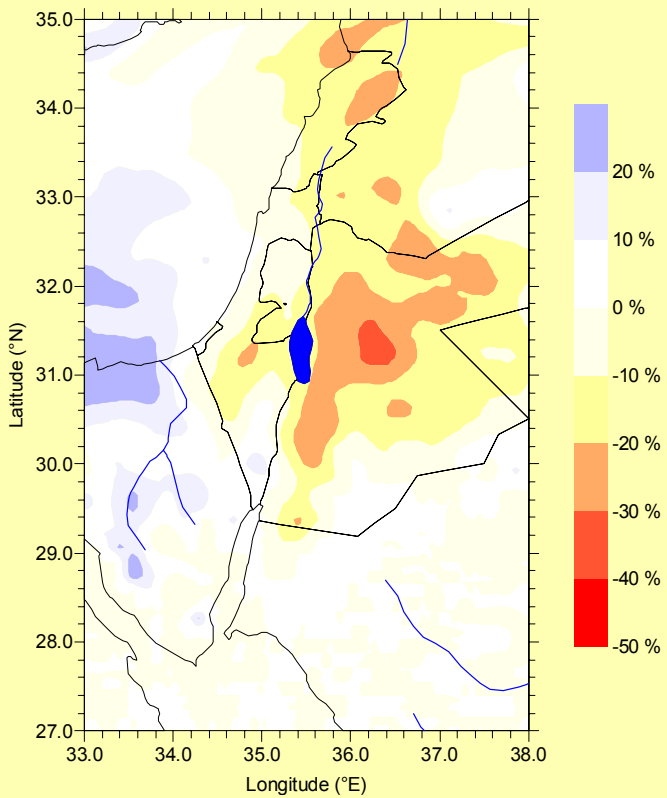


Change in temporal distribution, averaged over domain 2

What are the expected changes in precipitation?



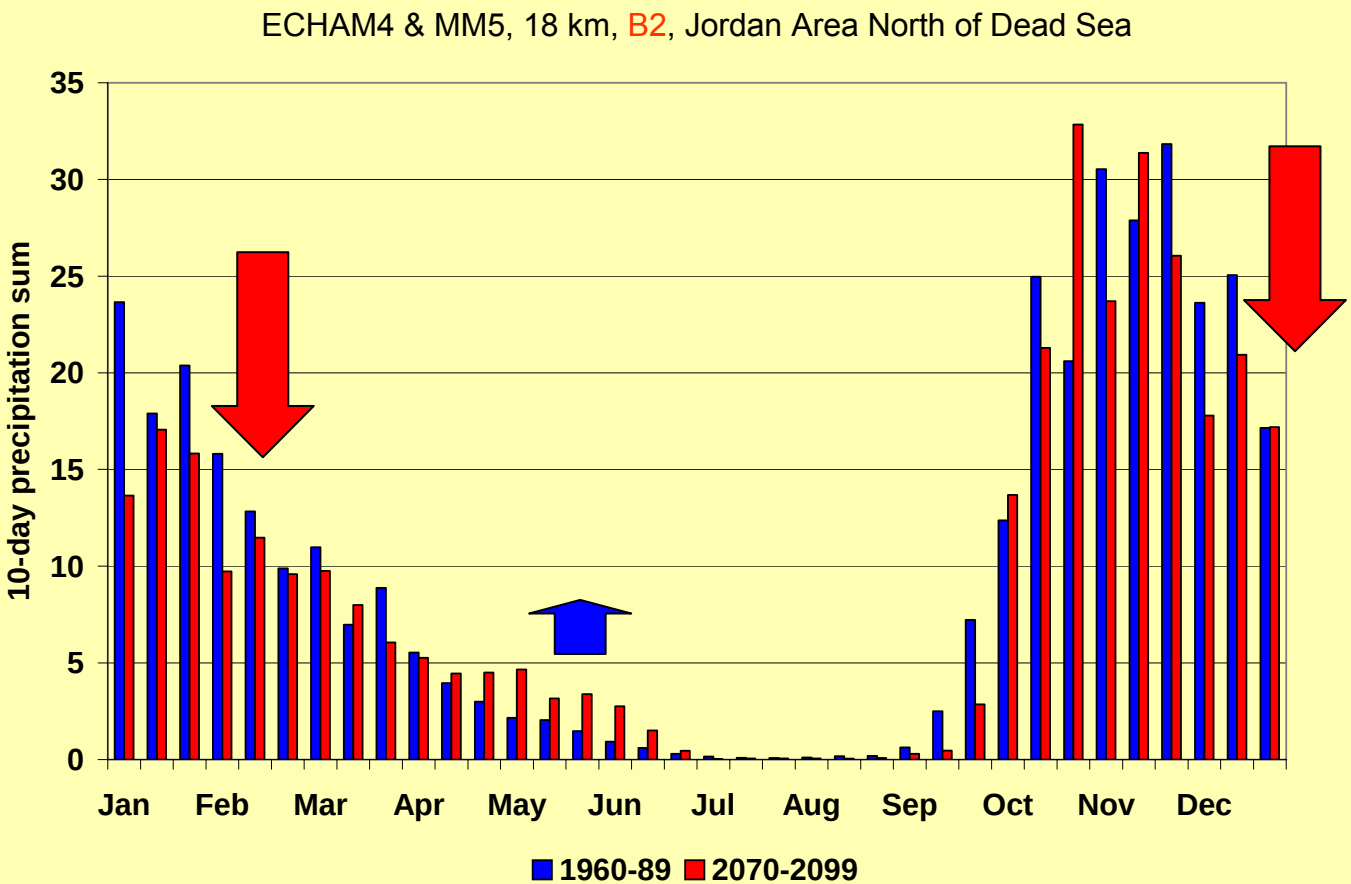
Absolute change in [mm]



Relative Change in [%]

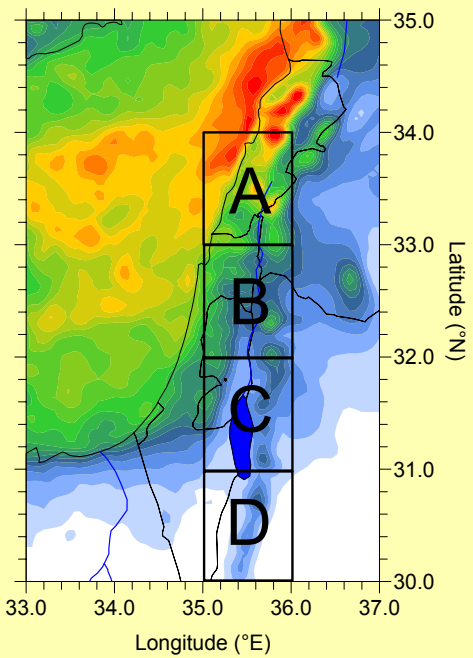
ECHAM4 & MM5, 18 km, B2, 2070-2099 vs 1961-1990

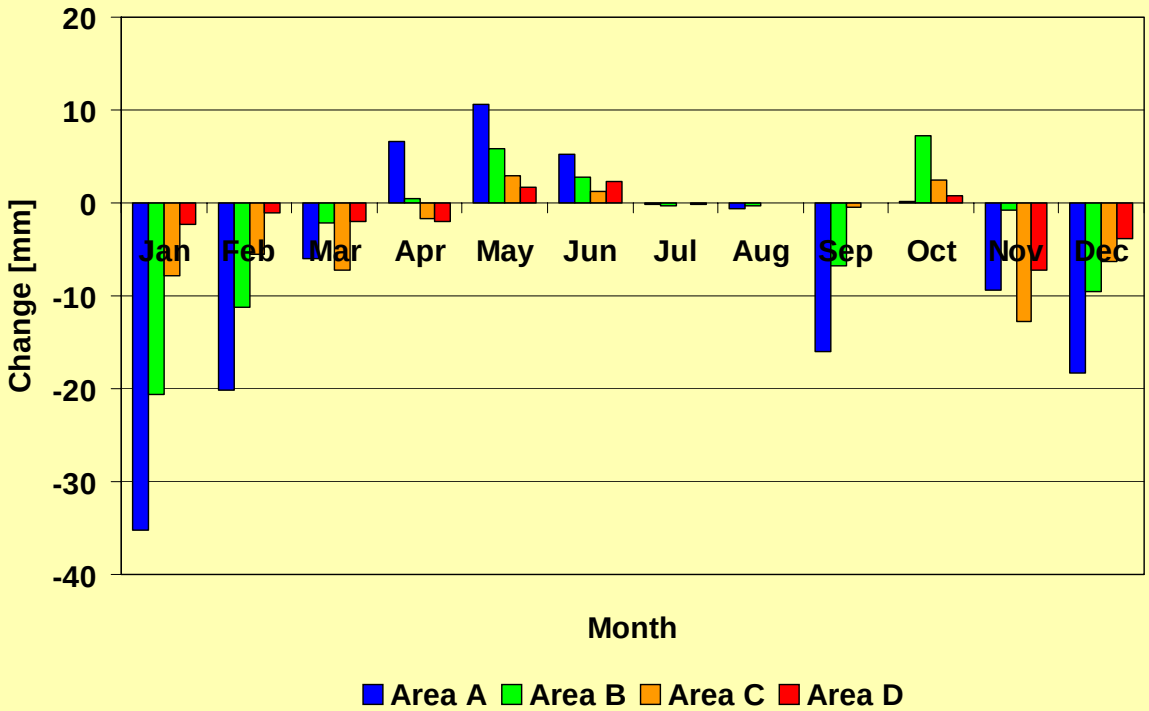
How does the temporal distribution of precipitation change?



Strongly decreased winter, slightly increased absolute late spring precipitation

How does seasonal precipitation change depend on the region?

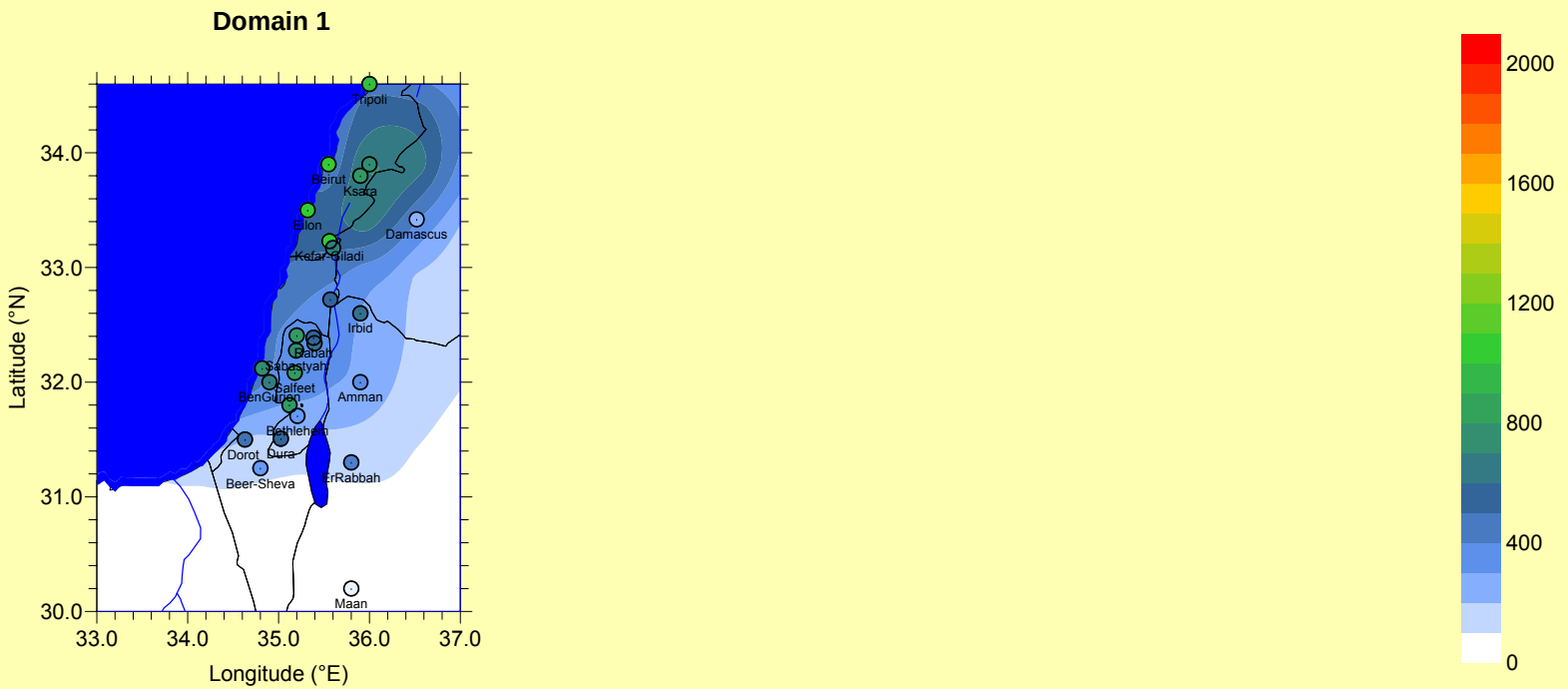




For all subregions: Decreased winter, increased spring precipitation

What do we expect from the High Resolution Simulations with 6 km?

Intermediate results of 6 km runs: mean 1961-1975



Yearly Mean Precipitation 1961-1975

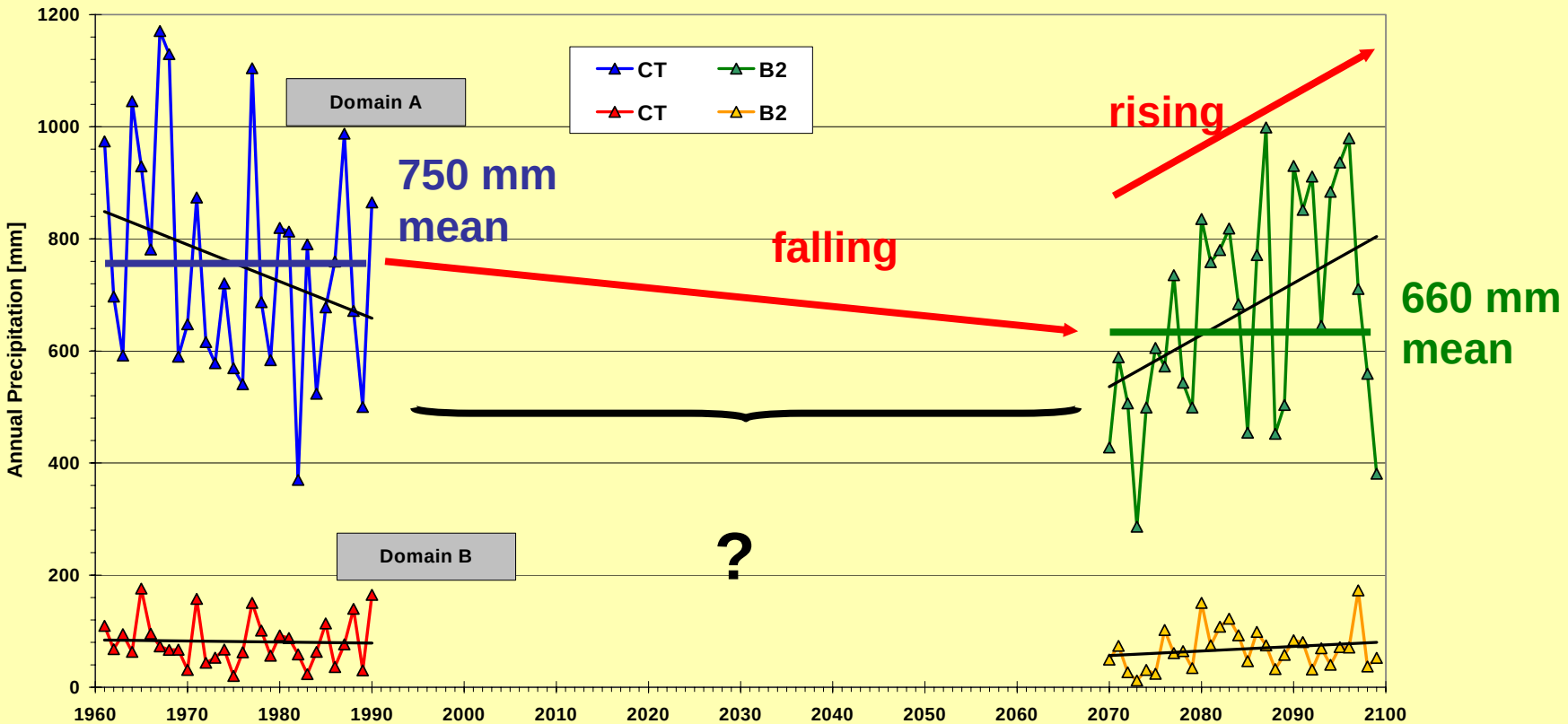
54km 18 km 6 km

… more detailed spatial information: land-sea & orography dependent features

Status conference 2006 (Esslingen): necessity of transient runs identified

1. Requested by impact WPs

2. Problem of comparing time slices: long term trend vs. short term trend

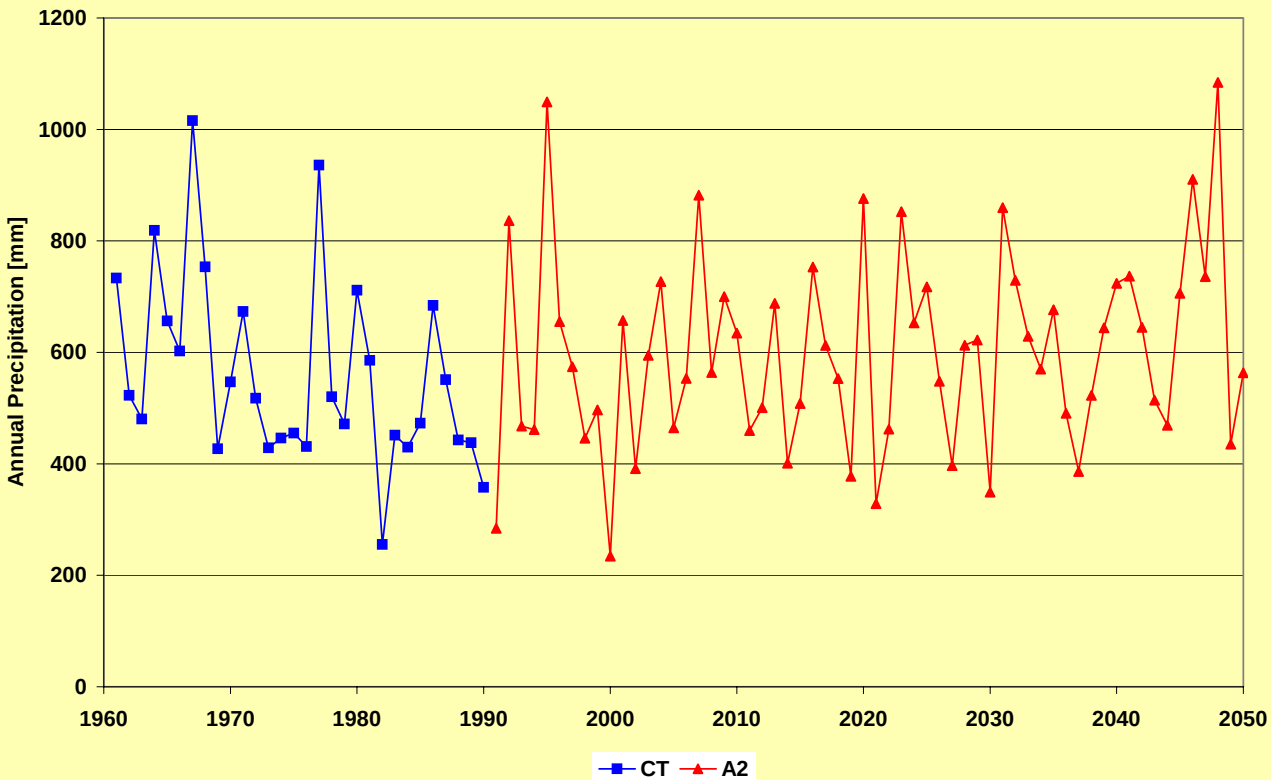


Regional Climate Simulations

From time slice comparison towards transient regional climate runs

- ECHAM4, A2, 1961-2050, 54 km ⇒ IMK-IFU
- ECHAM5, A1B, 1961-2050, 0.5° (≈ 50km) ⇒ TAU
- Joint comparison period: 2005-2035 vs. 1961-90

From time slice comparison towards transient regional climate runs



Precipitation

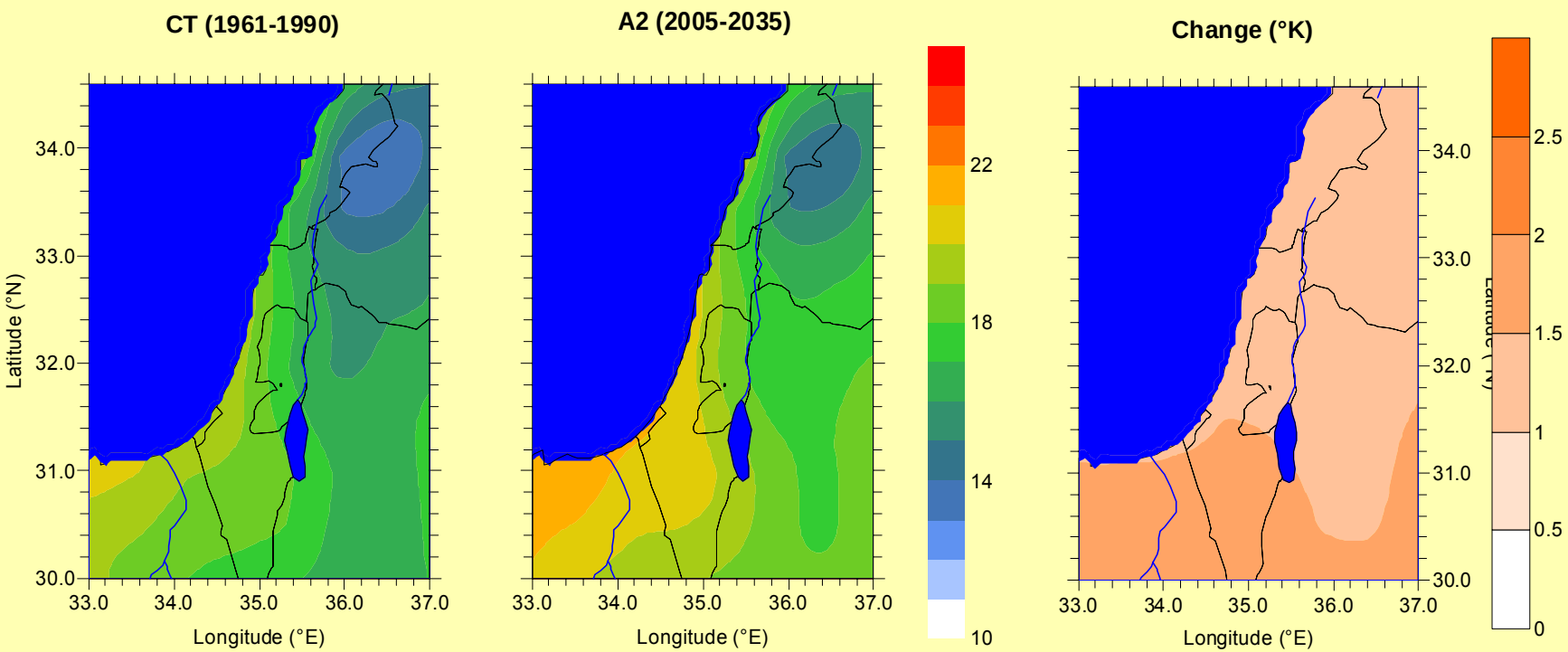
Regional Climate Simulations

Second example

ECHAM4, B2, 54km, 1961-2050 transient

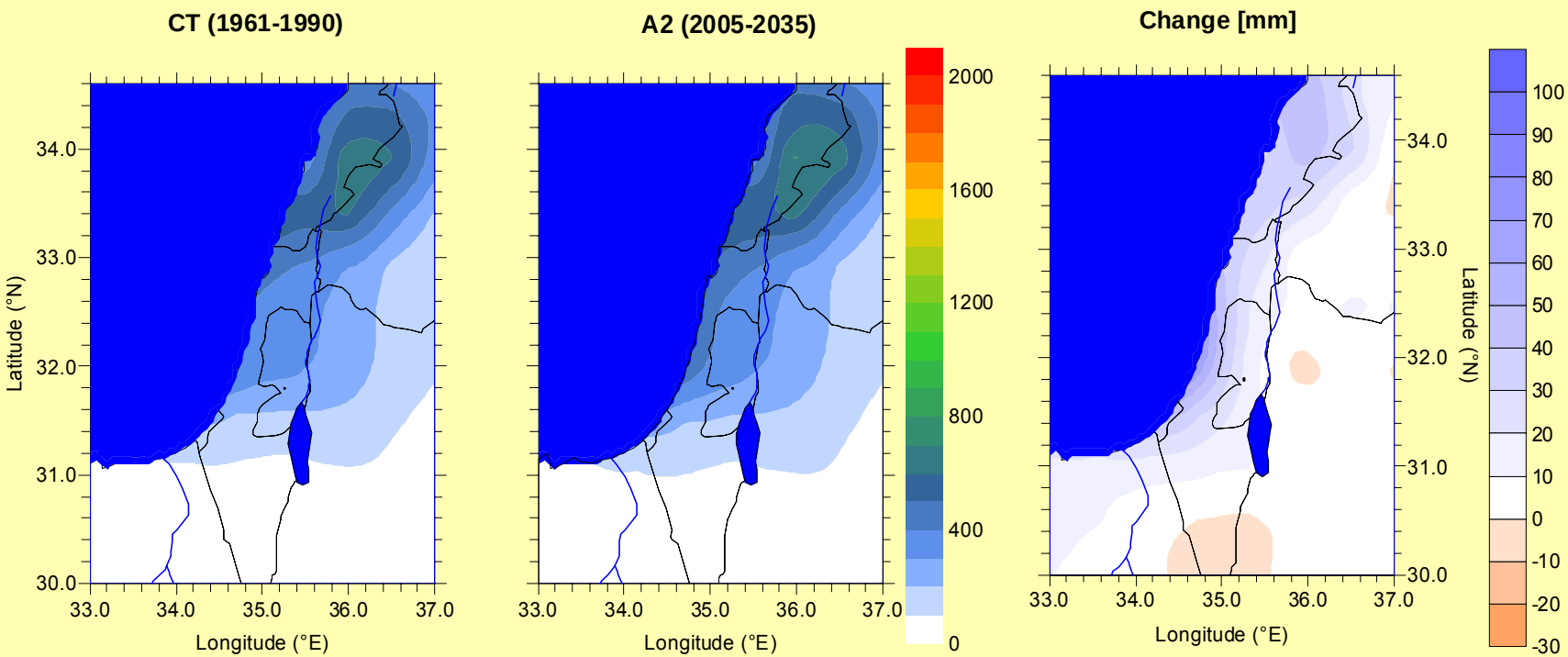
Climate change focus: 2005-35 vs. 1961-90

First results of transient regional climate runs



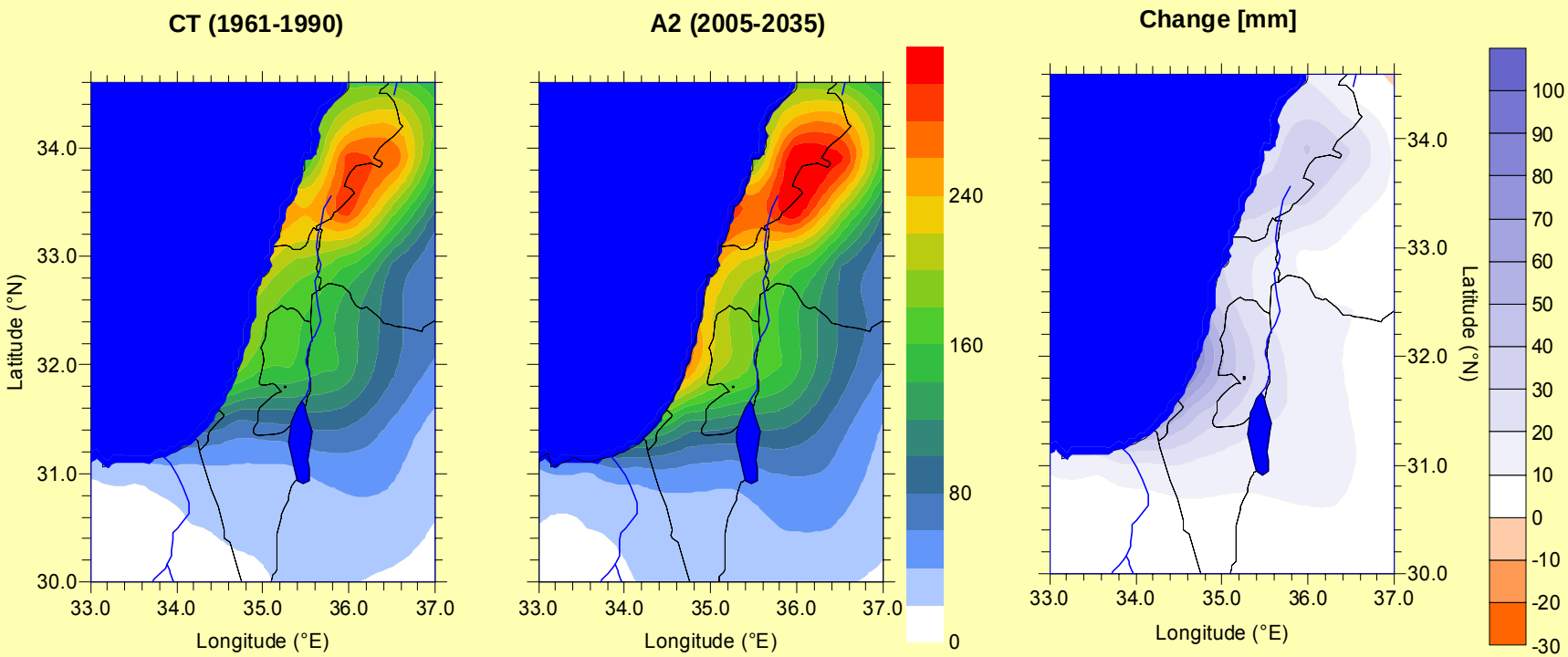
Yearly Mean Temperature

First results of transient regional climate runs



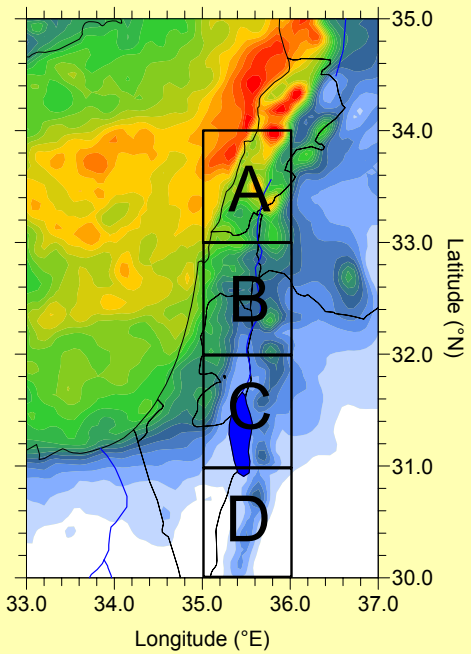
Yearly Mean Precipitation

First results of transient regional climate runs

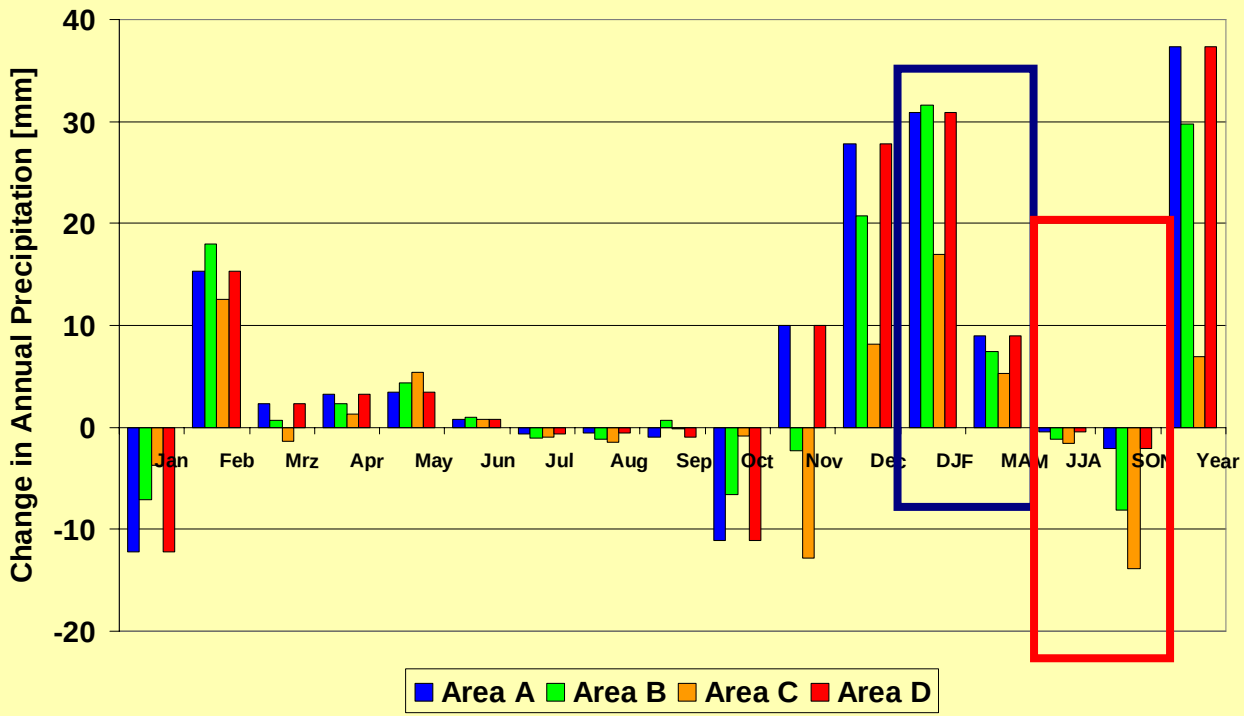


Mean Precipitation DJF

First results of transient regional climate runs



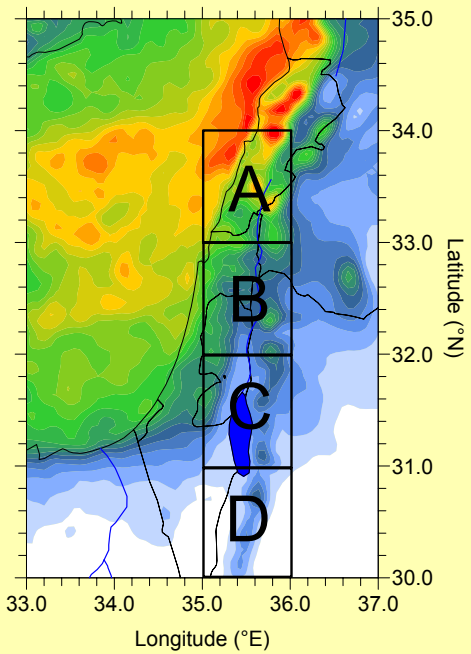
2005-35 minus 1961-90, ECHAM4 + MM5, 54km



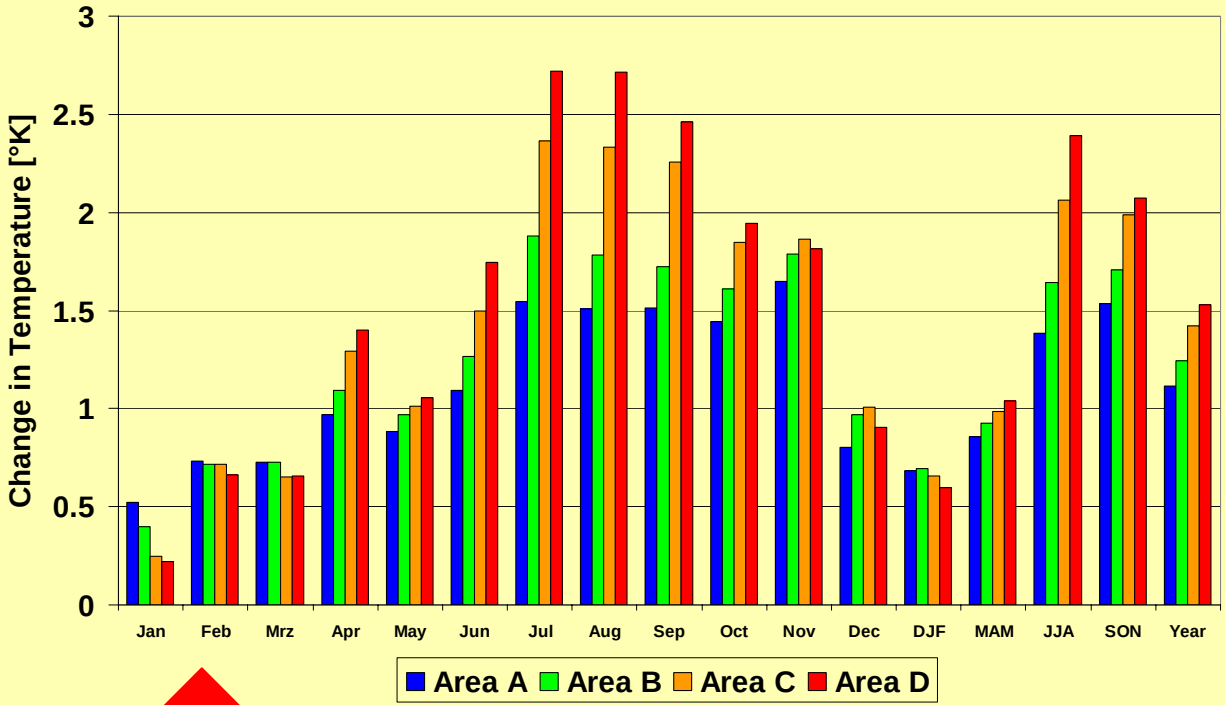
Wetter winters & springs

Dryer summers and autumns

First results of transient regional climate runs



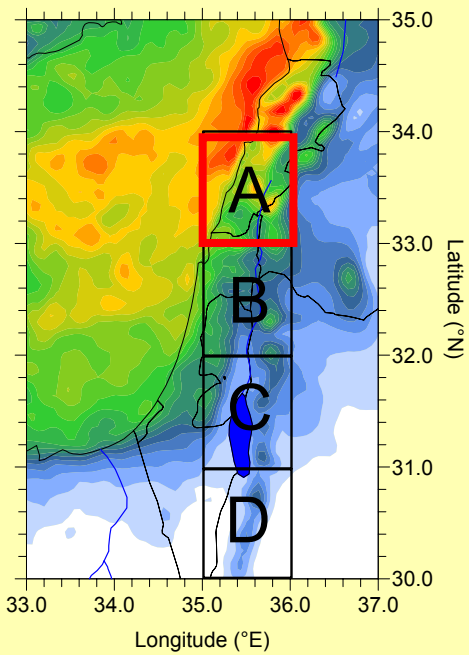
2005-35 minus 1961-90, ECHAM4 + MM5, 54km

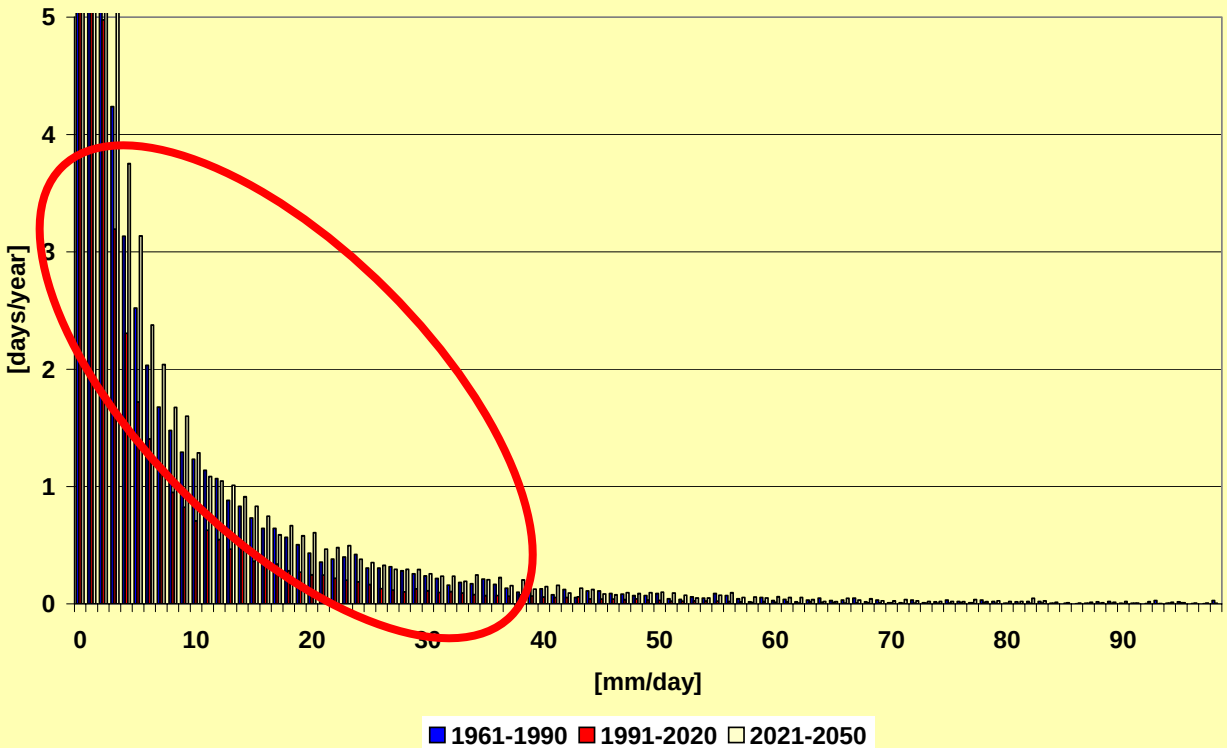


Temperature increases of up to 2.5 °C in all Jordan River subregions

First results of transient regional climate runs

ECHAM4 + MM5, A2, 54km





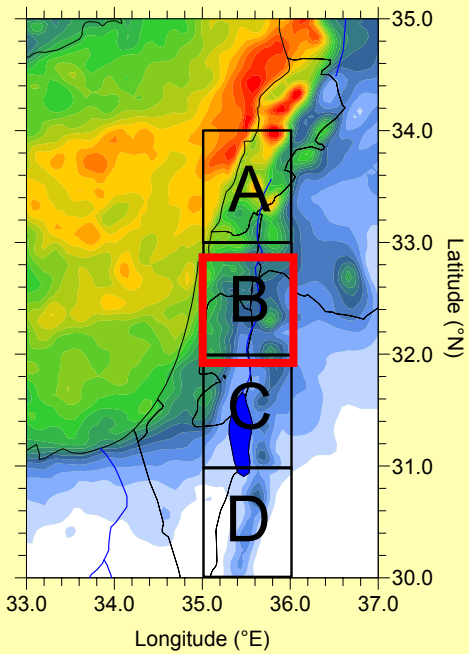
Precipitation intensities:

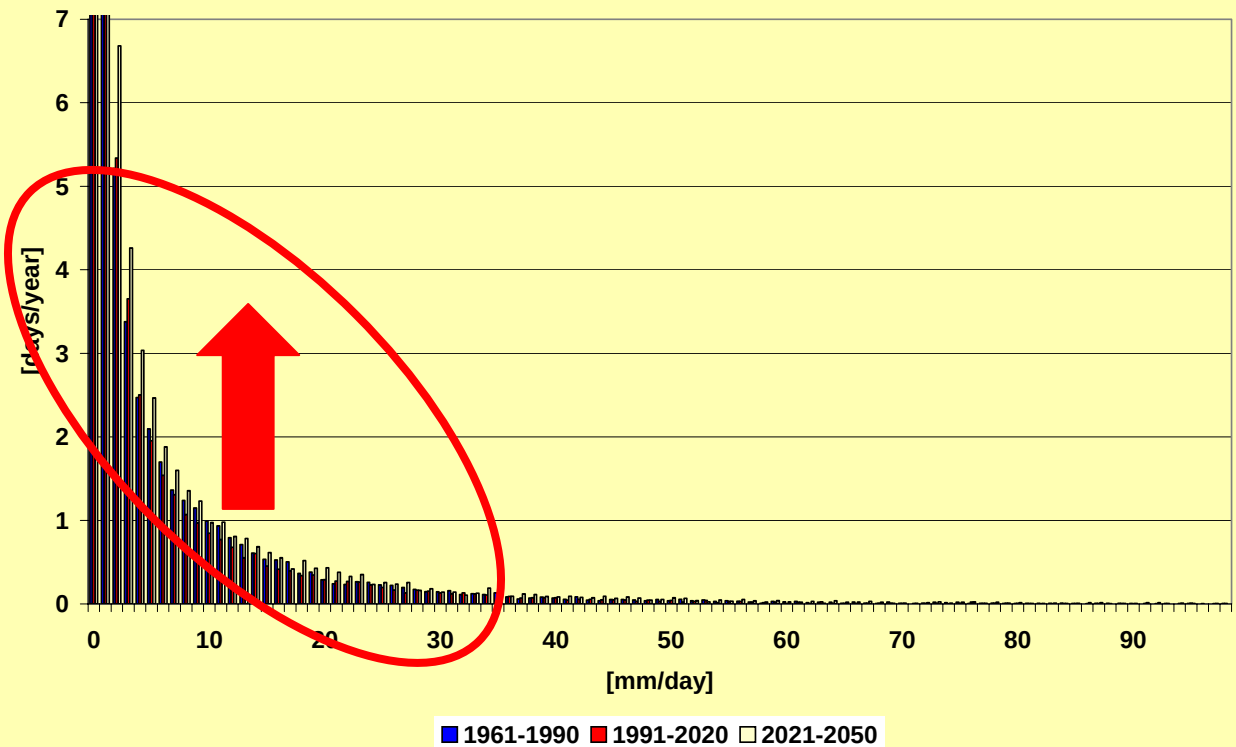
1961-1990 ⇒ 1991-2020 Decrease

1991-2020 ⇒ 2021-2040 Increase

First results of transient regional climate runs

ECHAM4 + MM5, A2, 54km

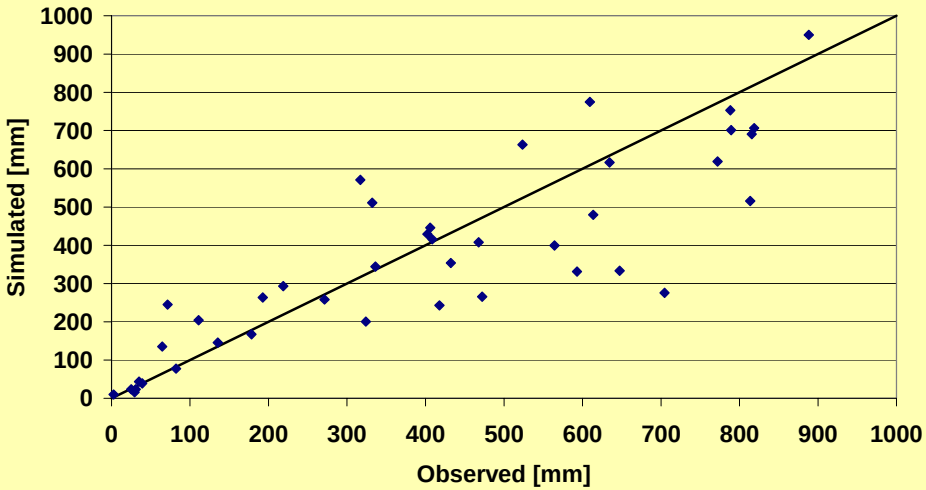




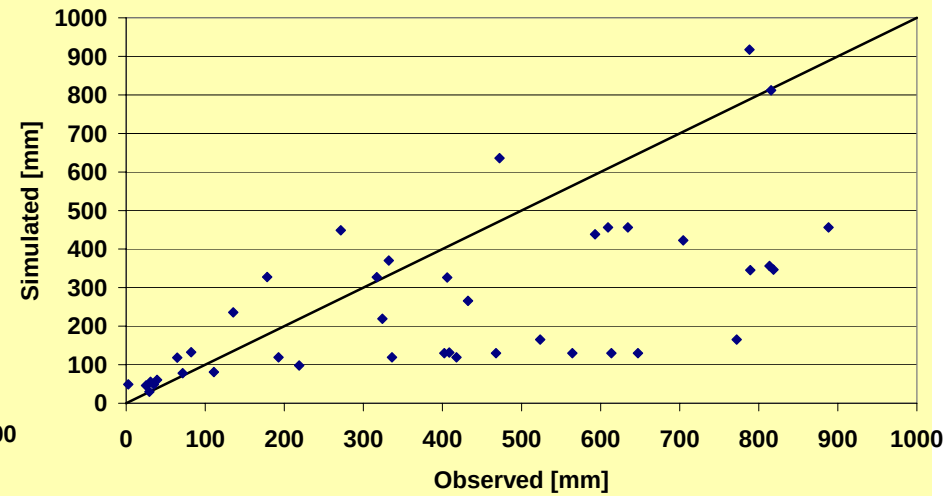
Long term: Increase of precipitation intensities

ECHAM5 transient vs. ECHAM4 transient

Mean Annual Precipitation



ECHAM4-MM5, Δx=18km

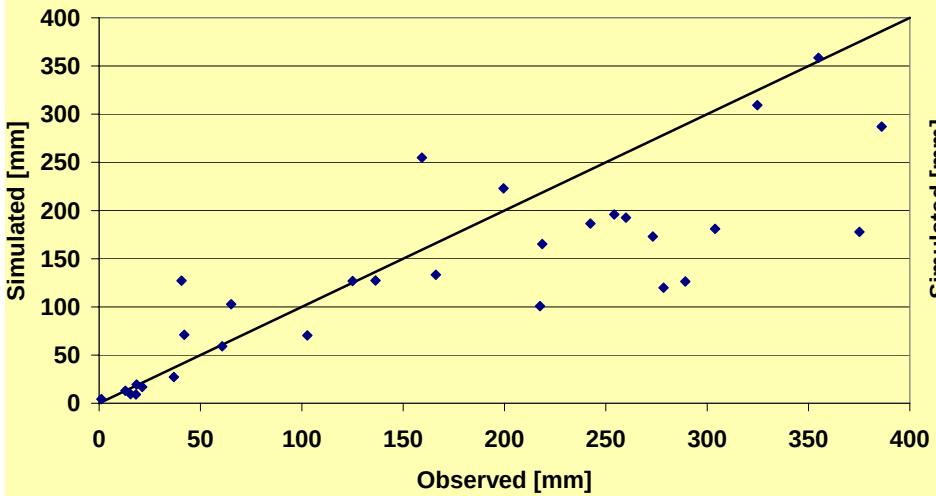


ECHAM5-RegCM, Δx=0.5°

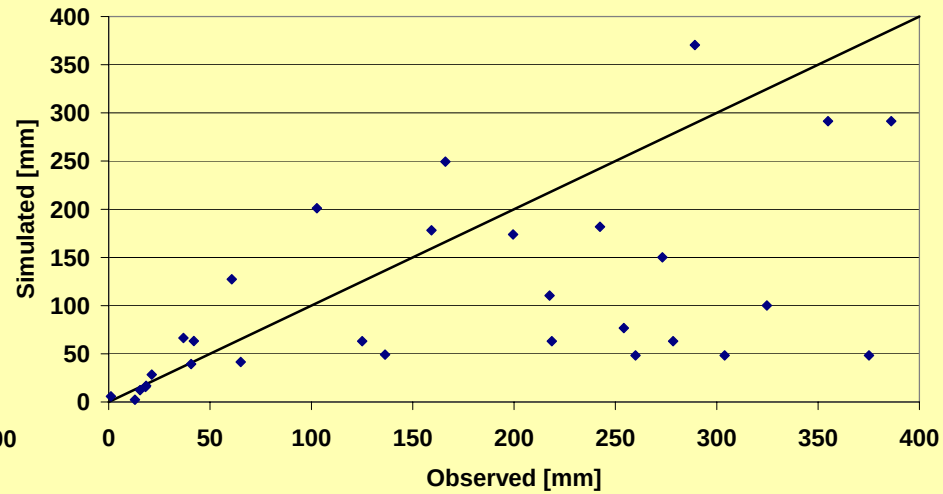
Control runs 1961-90 vs. long term observation at 41 stations in the Near East

ECHAM5 transient vs. ECHAM4 transient

DJF Precipitation



ECHAM4-MM5, Δx=18km



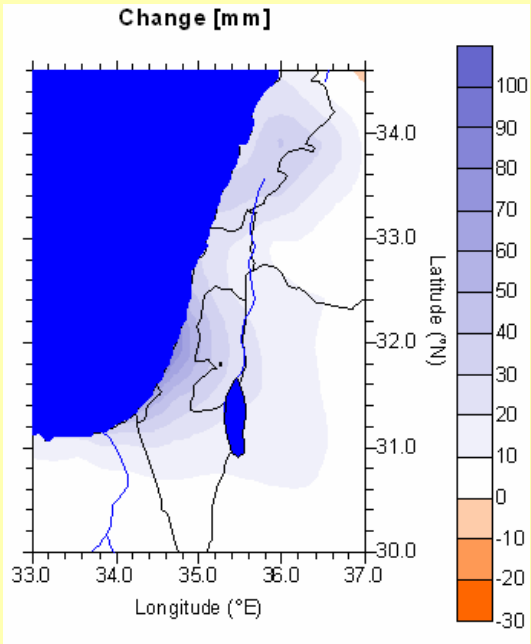
ECHAM5-RegCM, Δx=0.5°

Control runs 1961-90 vs. long term observation at 41 stations in the Near East

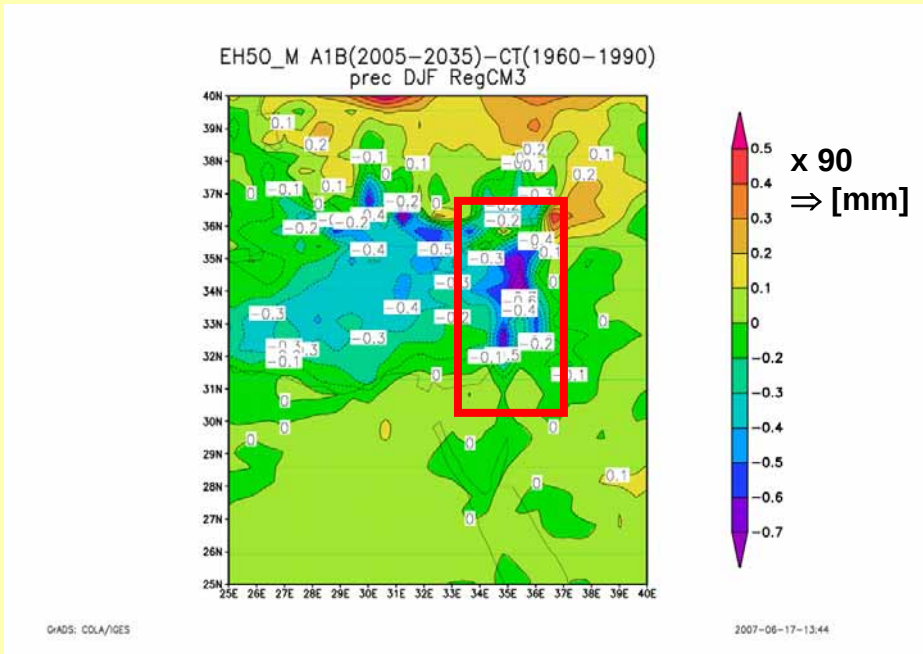
Tendency towards underestimation of high precipitation regions

Differences ECHAM4 A2 transient vs. ECHAM5 A1B transient

Change DJF Precipitation 2005-35 vs. 1960-90



ECHAM4-MM5, Δx=54km

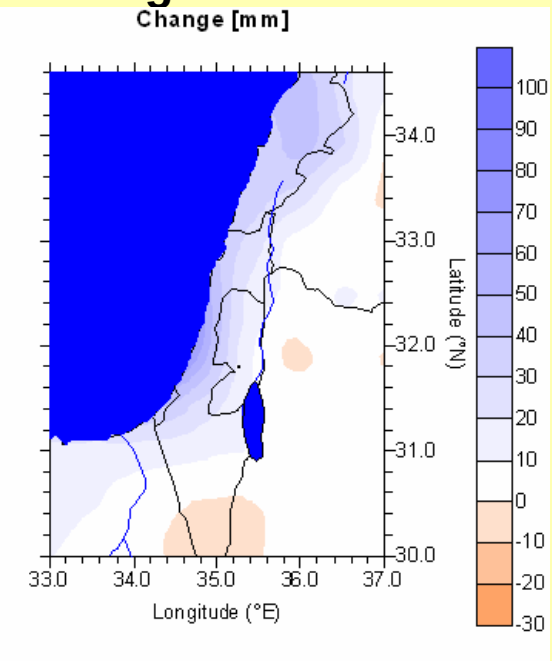


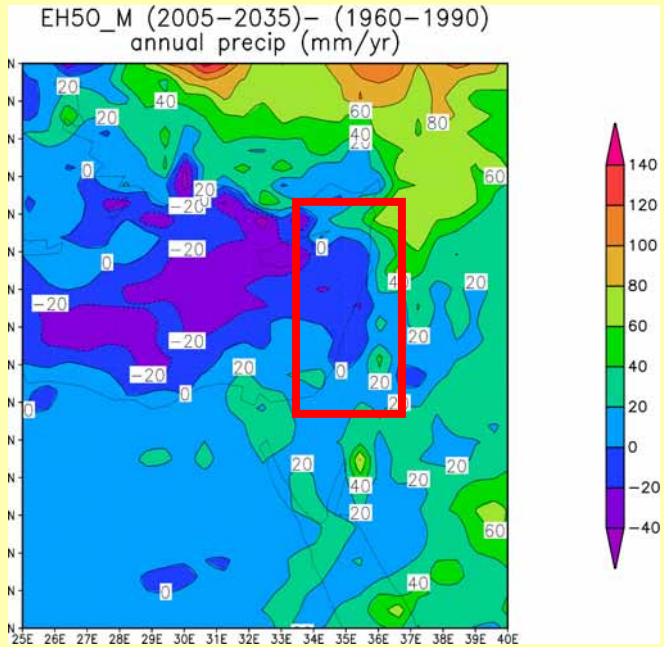
ECHAM5-RegCM, Δx=0.5°

Differences between model projections:
increases vs. decreases for DJF precipitation

Differences ECHAM4 A2 transient vs. ECHAM5 A1B transient

Change Mean Annual Precipitation 2005-35 vs. 1960-90





ECHAM4-MM5, Δx=54km

⇒ Increase up to 40mm

ECHAM5-RegCM, Δx=0.5°

⇒ +/- 20mm/year

Different regional scenarios do not allow conclusion about trend for future mean annual precipitation

Regional Climate Simulations

Summary: Available Regional Climate Simulations

Global Model	Scenario	Regional Mod	Resolution	Time Slice	Availability
ECHAM4	CT	MM5	54km	1961-90	IMK-IFU
ECHAM4	CT	MM5	18km	1961-90	IMK-IFU
ECHAM4	CT	MM5	6km	1961-75	IMK-IFU
ECHAM4	B2	MM5	54km	2070-99	IMK-IFU
ECHAM4	B2	MM5	18km	2070-99	IMK-IFU
ECHAM4	B2	MM5	6km	2070-85	IMK-IFU end of 2007
ECHAM4	CT+A2	MM5	54km	1961-2050	IMK-IFU
ECHAM4	CT+A2	MM5	18km	1961-2050	IMK-IFU end of 2007
HadAM3P	CT	RegCM3	50km	1961-90	TAU
HadAM3P	A2	RegCM3	50km	2071-2100	TAU
HadAM3P	B2	RegCM3	50km	2071-2100	TAU
NASA FV GCM	CT	RegCM3	50km	1961-90	TAU
NASA FV GCM	A2	RegCM3	50km	2071-2100	TAU
ECHAM5	CT+A1B	RegCM3	50km	1960-2050	TAU
ECHAM4	CT	STAR		1958-1996	PALAST
ECHAM4	A1B	STAR		2007-2040	PALAST

Regional Climate Simulations

Summary & Conclusions

• Increase of temperatures in all scenarios

• **Long term** projections of precipitation differ from **medium term** projections:

1) precipitation & intensity increase till 2035 for pessimistic GHG emission scenario A2 (transient)
2) precipitation & intensity decrease till 2100 for optimistic GHG emission scenario B2 (time slice)

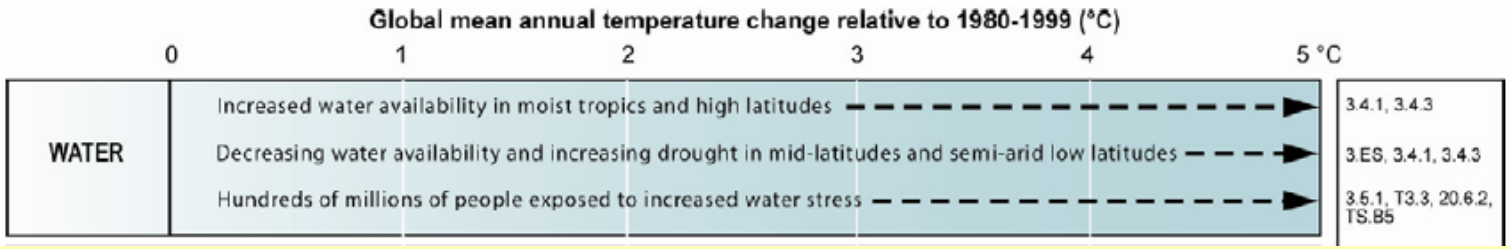
• Diverse results from transient ECHAM4-MM5-A2 and ECHAM5-RegCM-A1B
Precipitation increase 40mm/year vs. +/- 20 mm/year

⇒ **Projections for future precipitation: extremely sensitive to chosen**
1) emission scenario
2) future time period vs. control time period
3) global & regional climate model

• Identified research needs for phase III
⇒ continuation of transient simulations till 2100
⇒ bias correction techniques: essential for use of regional climate scenarios in impact WPs


Thank you for your attention

Regional Climate Simulations



Fresh water resources and their management

By mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water stressed areas. In some places and in particular seasons, changes differ from these annual figures. ** D^{10} [3.4]

Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk. ** N [Working Group I Fourth Assessment, Working Group II Fourth Assessment 3.4]

Eastern Mediterranean/Near East:
is in between increasing and decreasing dominant large scale changing areas