Regional Climate Simulations

for the Middle East with MM5

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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

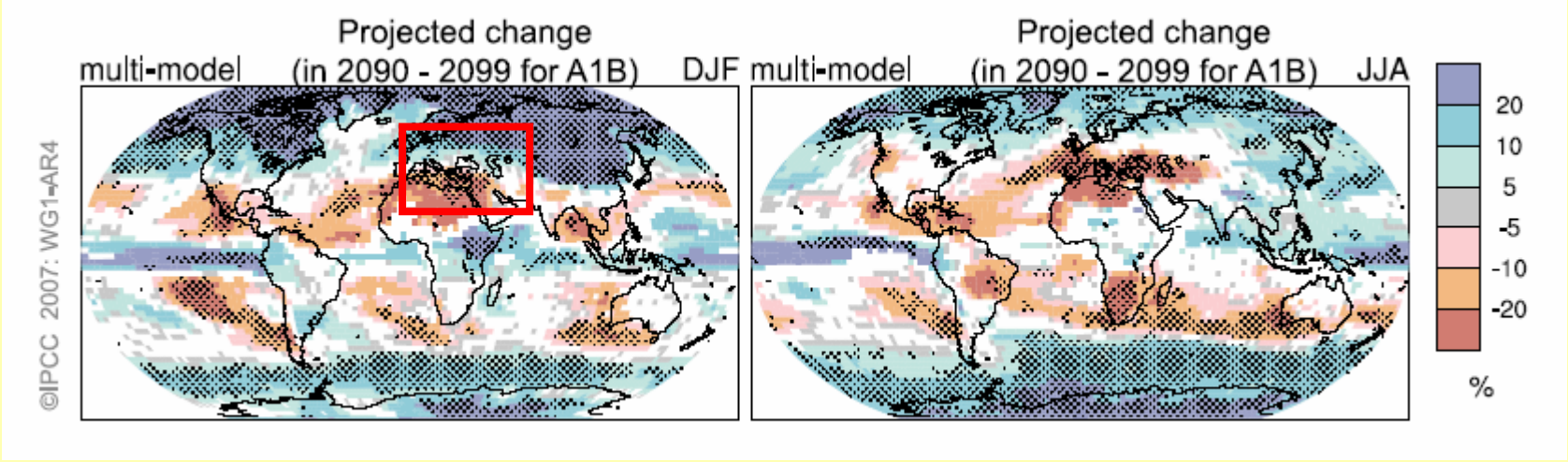
2) Region has sharp climatic gradients:
subhumid mediterranean ↔ arid climate

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

Regional Climate Simulations

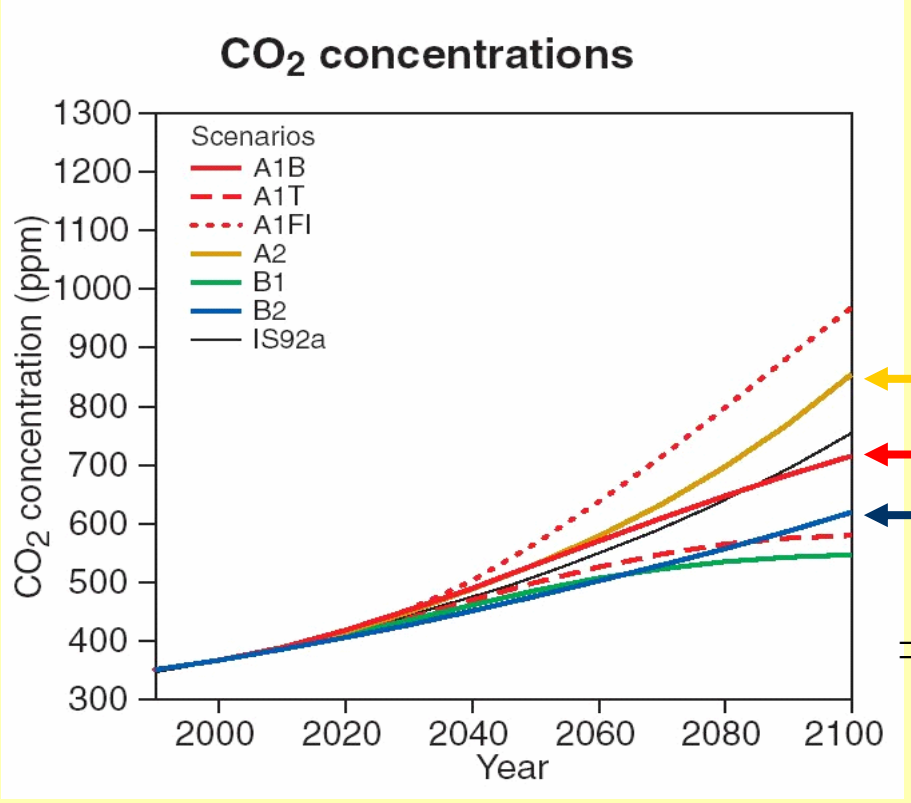
Scientific Challenge



IPCC 4AR, 2007

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

Regional Climate Simulations

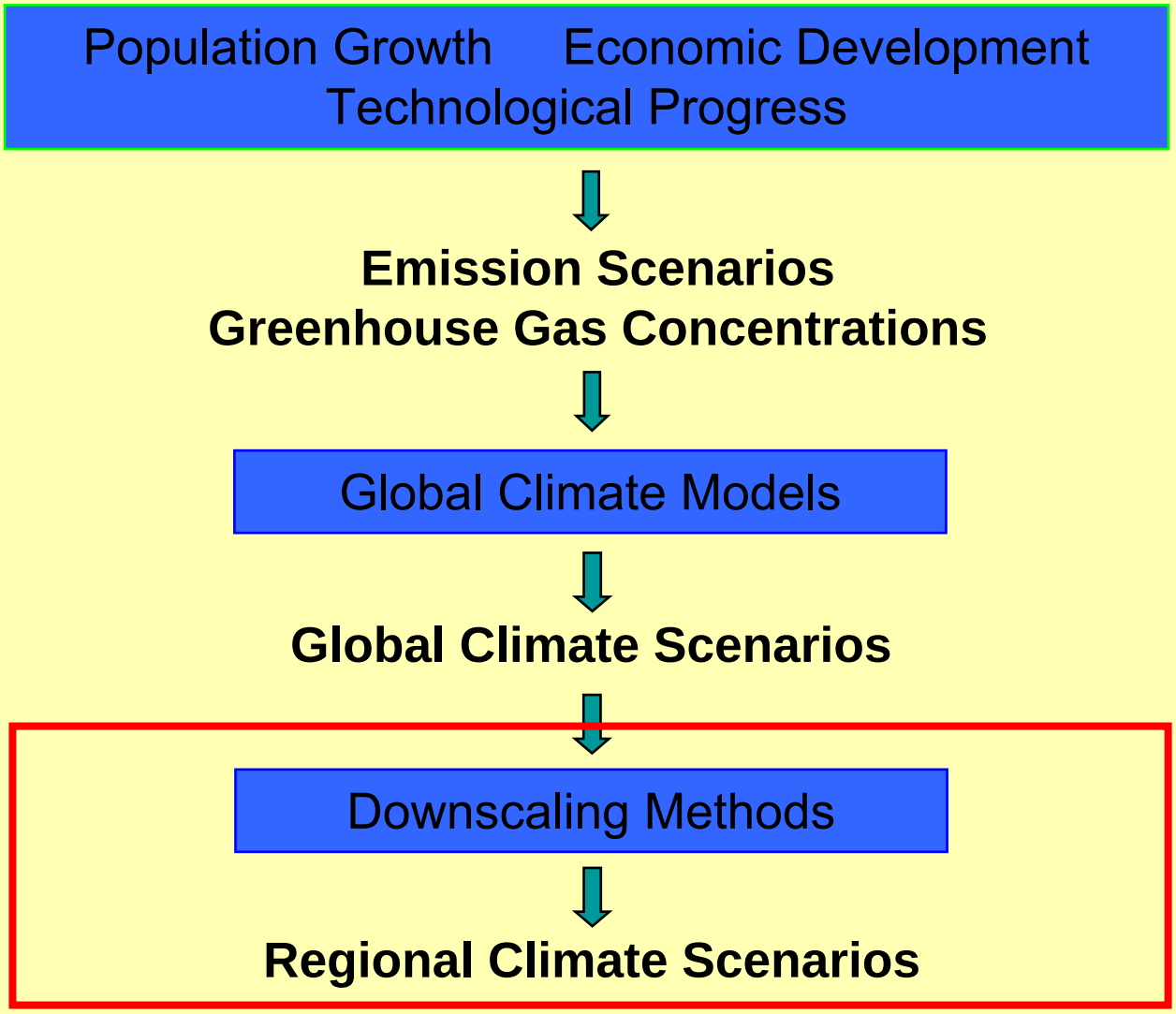


phase III

⇒ Uncertainty bounds

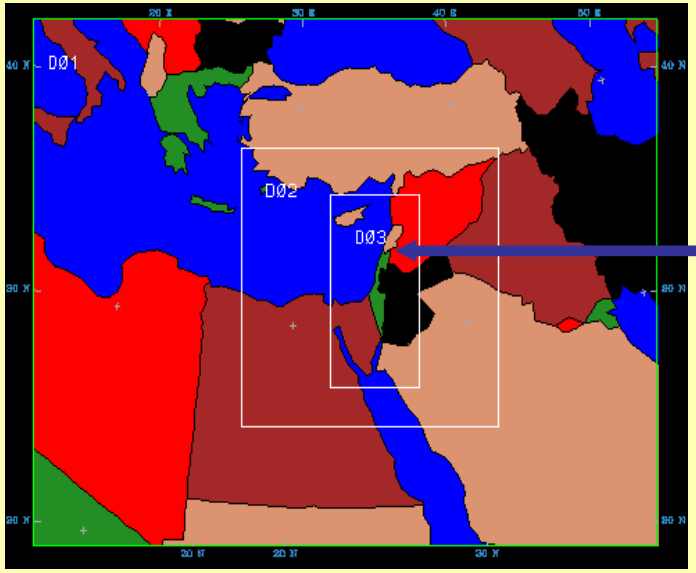
Emission scenarios: based on different assumptions on future GHG emissions

Regional Climate Simulations



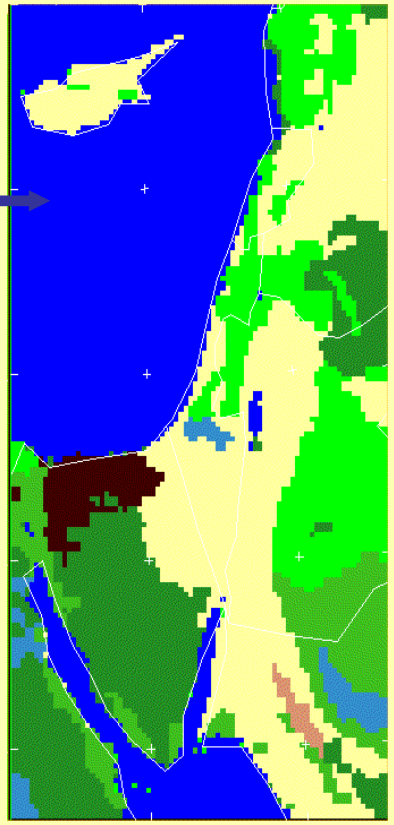
Regional Climate Modeling

The Mesoscale Meteorological Model MM5



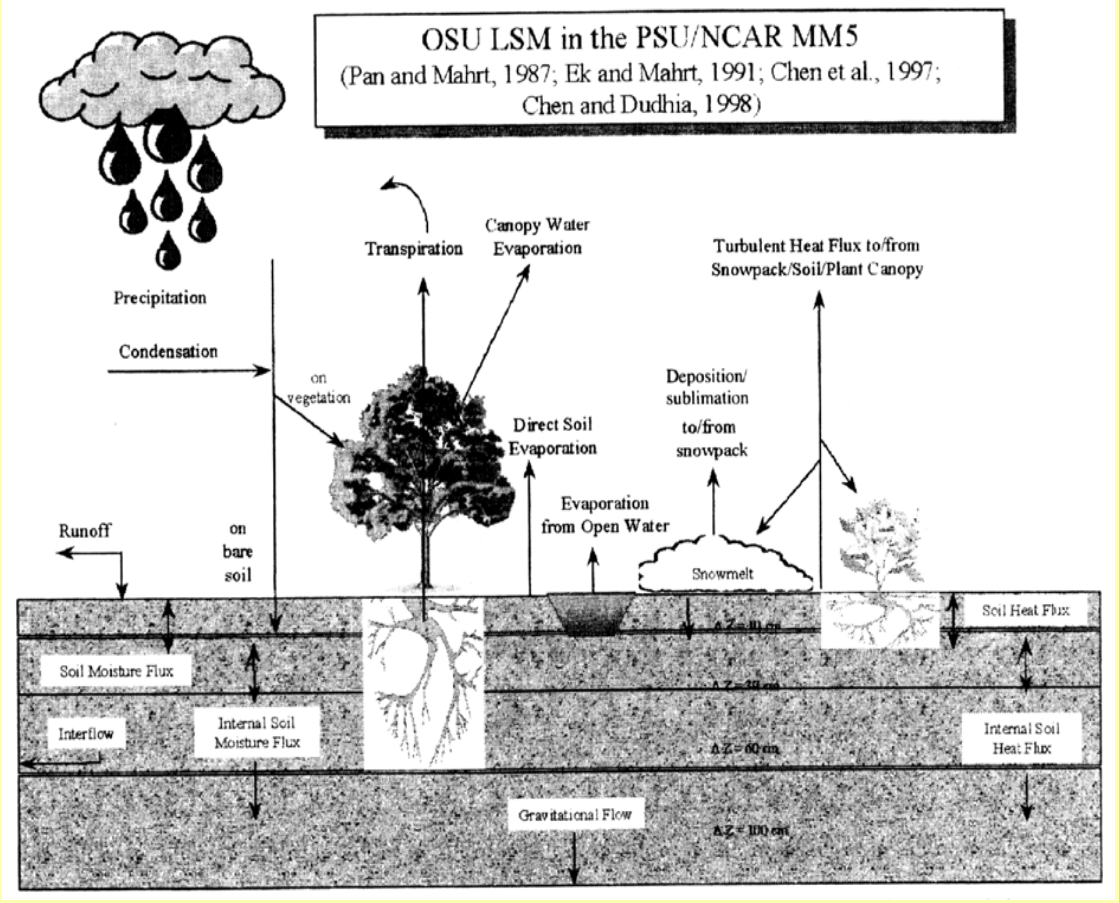
Land Use Discretization

Soil Discretization



- Dynamic Downscaling of ECHAM4 with MM5
- 3 nests: 54x54 km^2, 18x18 km^2, 6x6 km^2
- 26 Vertical Layers, Model Top: 100 mbar (ca.17 km)
- Coupled OSU-Land-Surface Model
- Time slices: 1961-1990 & 2070-2099, B2, ECHAM4
- Transient: 1960-2050, A2 & B2, ECHAM4

Regional Climate Modeling



… accounts for soil-vegetation-atmosphere feedbacks

Note

Basic differences between SVAT-based hydrological models and "traditional" hydrological models

- **SVAT-Hydro Models (designed for atmospheric feedback purposes)**:

  full energy balance (soil heat & sensible heat fluxes)

  2-way interaction with PBL

- **"Traditional"-Hydro models (designed for pure hydrol. applications)**:

  lateral water fluxes, surface runoff routing

  deeper soils considered

  finer vertical & horizontal resolutions

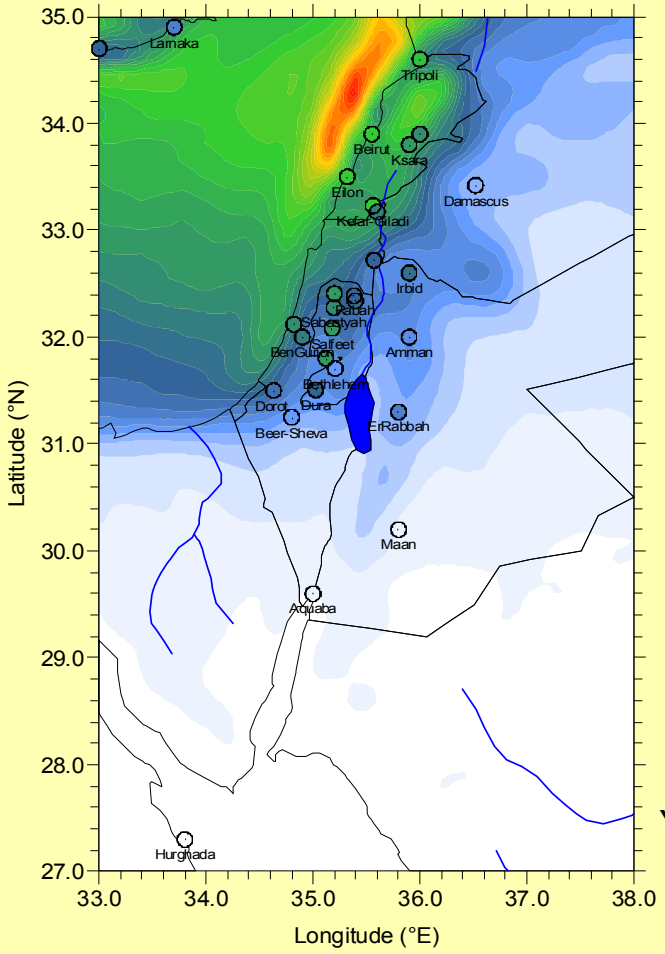
  often groundwater interaction

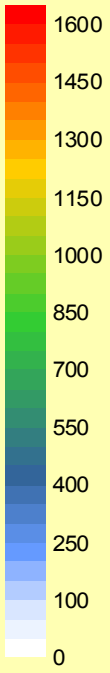
  often extensions for reactive flow & transport, erosion, etc.

  but: depending on specific model choice

Regional Climate Simulations

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



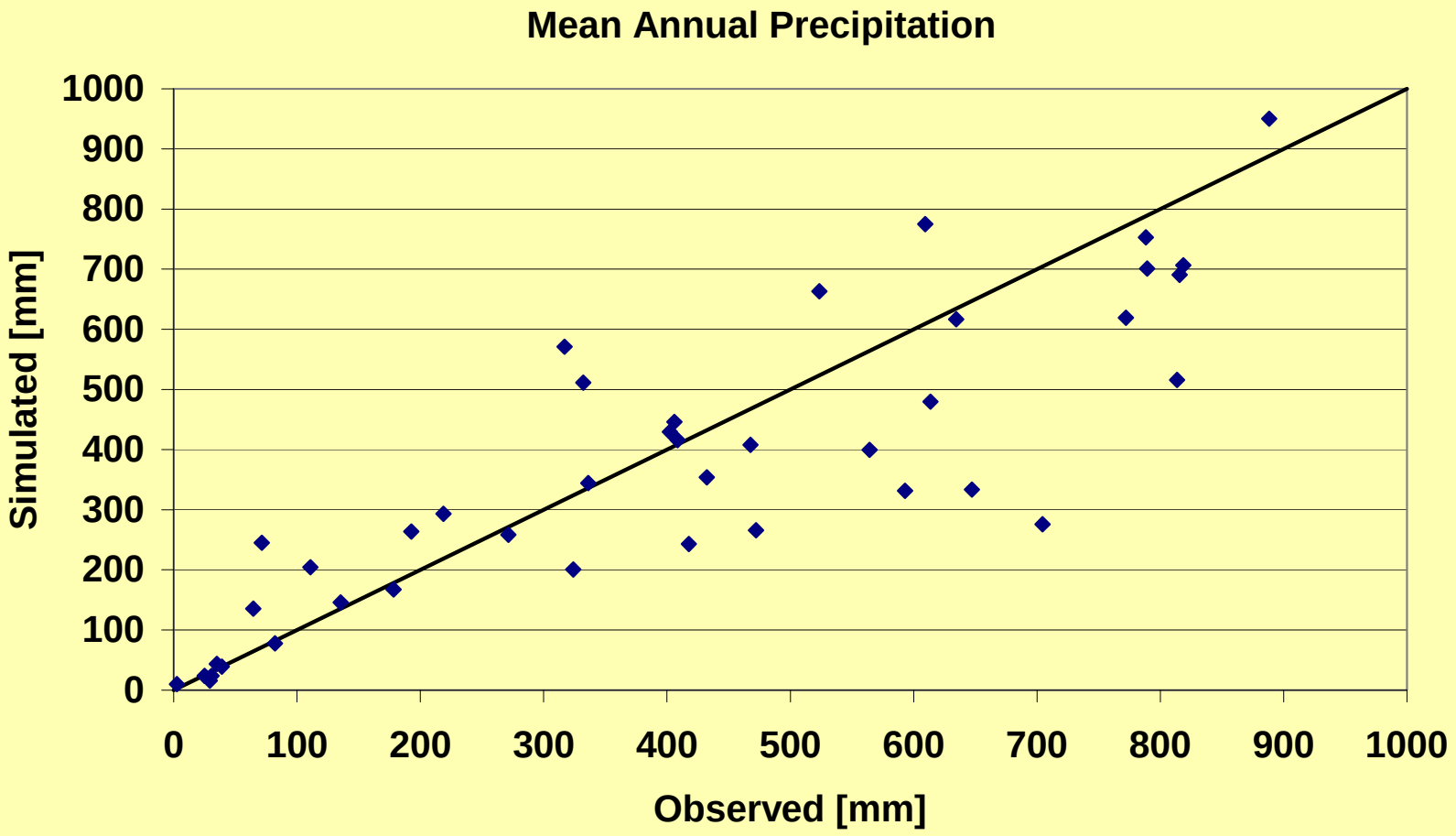


Yearly Mean Precipitation in mm

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

Control Simulation

How accurate does the downscaled Control Run reproduce observed precipitation?

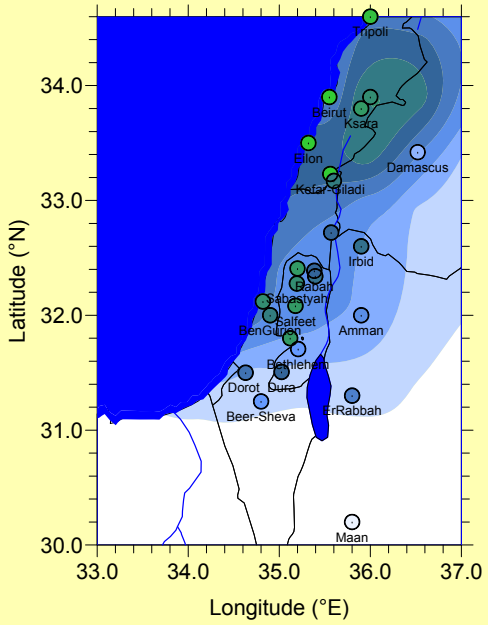


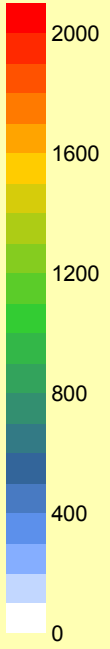
Regional Climate Simulations

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

Intermediate results of 6 km runs: mean 1961-1975

Domain 1





Yearly Mean Precipitation 1961-1975

54km 18 km 6 km

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

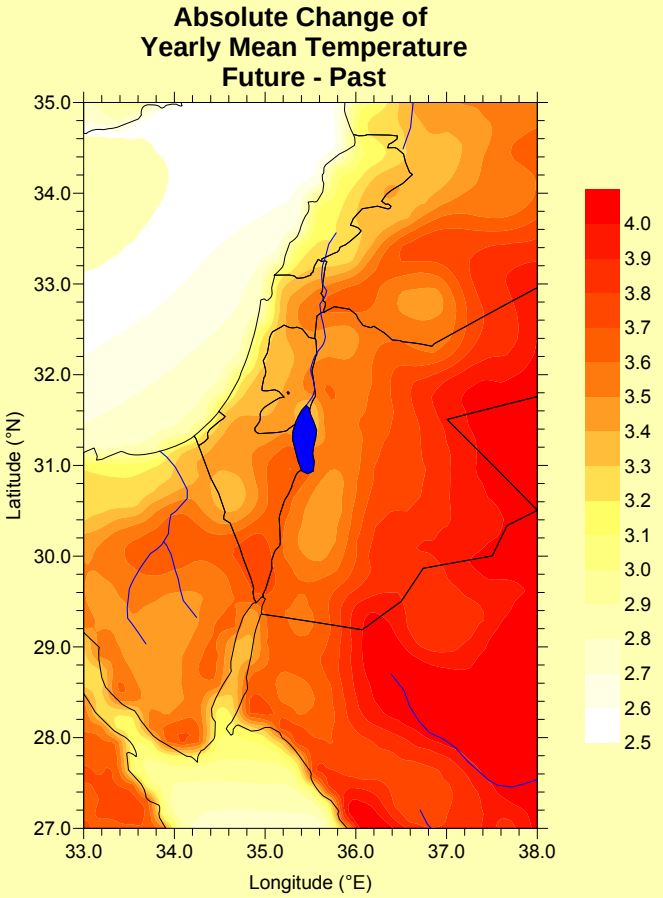
Regional Climate Simulations

First example

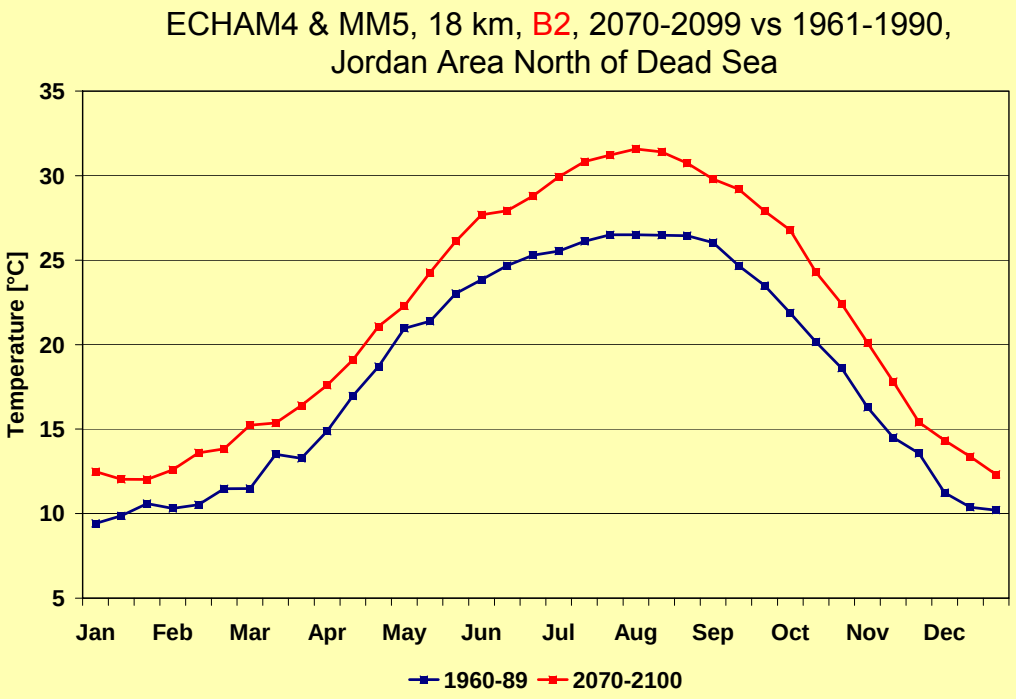
ECHAM4, B2, 18km, 2070-99 vs. 1961-90

Regional Climate Simulations

What are the expected changes in temperature?



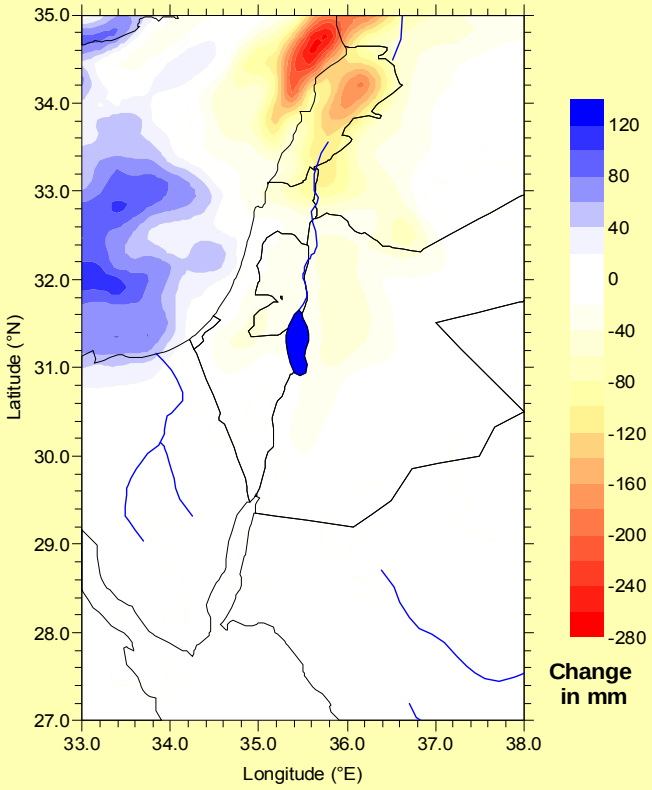
Change in annual mean temperature



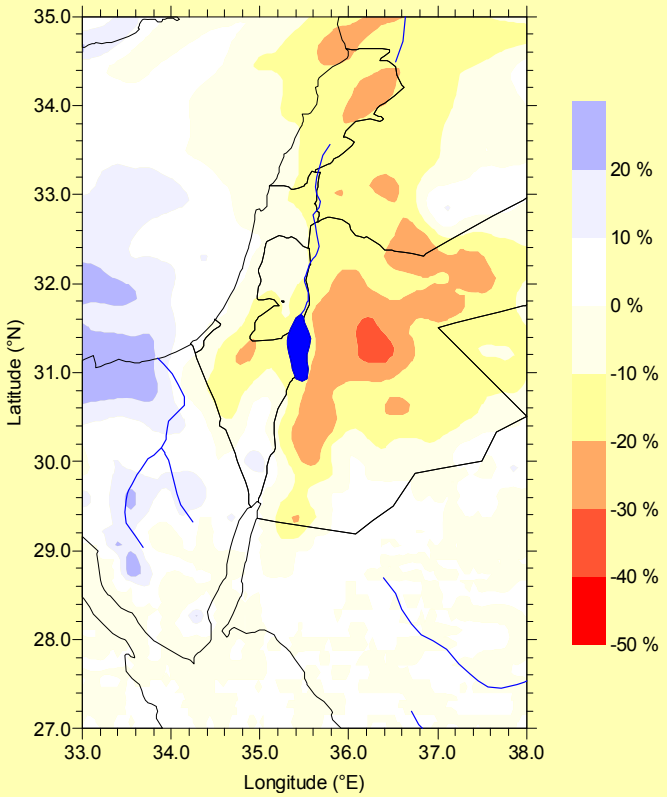
Change in temporal distribution, averaged over domain 2

Regional Climate Simulations

What are the expected changes in precipitation?



Absolute change in [mm]

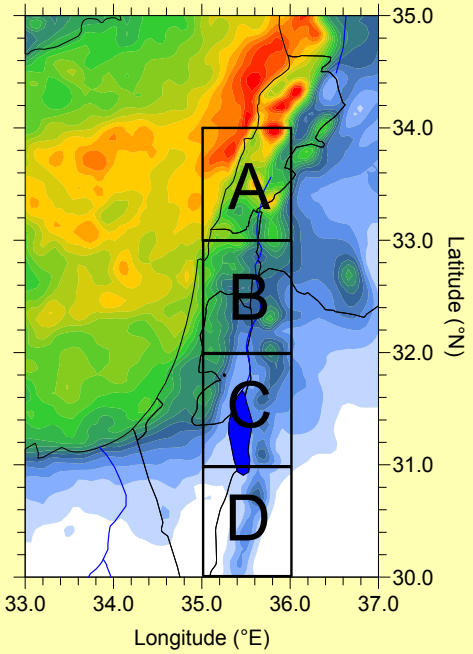


Relative Change in [%]

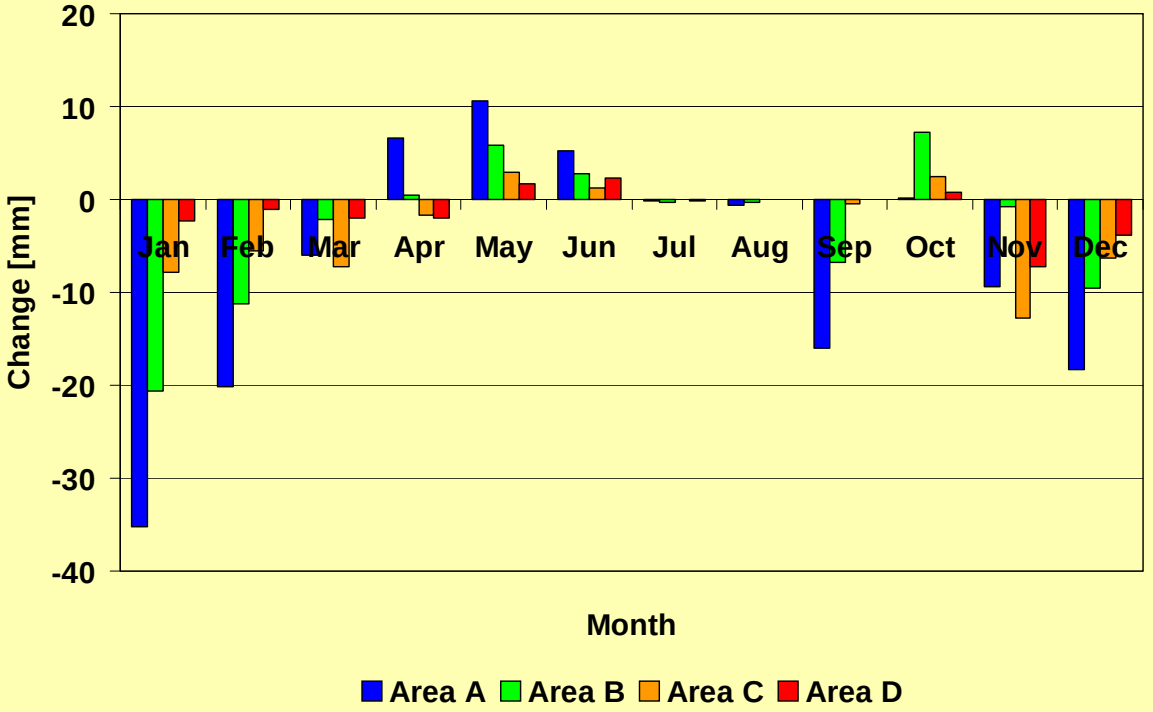
ECHAM4 & MM5, 18 km, B2, 2070-2099 vs 1961-1990

Regional Climate Simulations

How does seasonal precipitation change depend on the region?



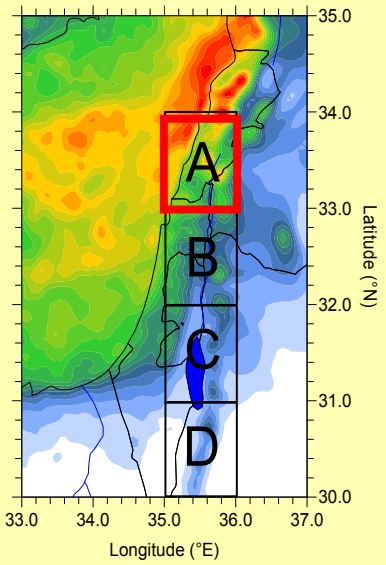
2070-2099 vs. 1961-1990, ECHAM4, B2, 18km

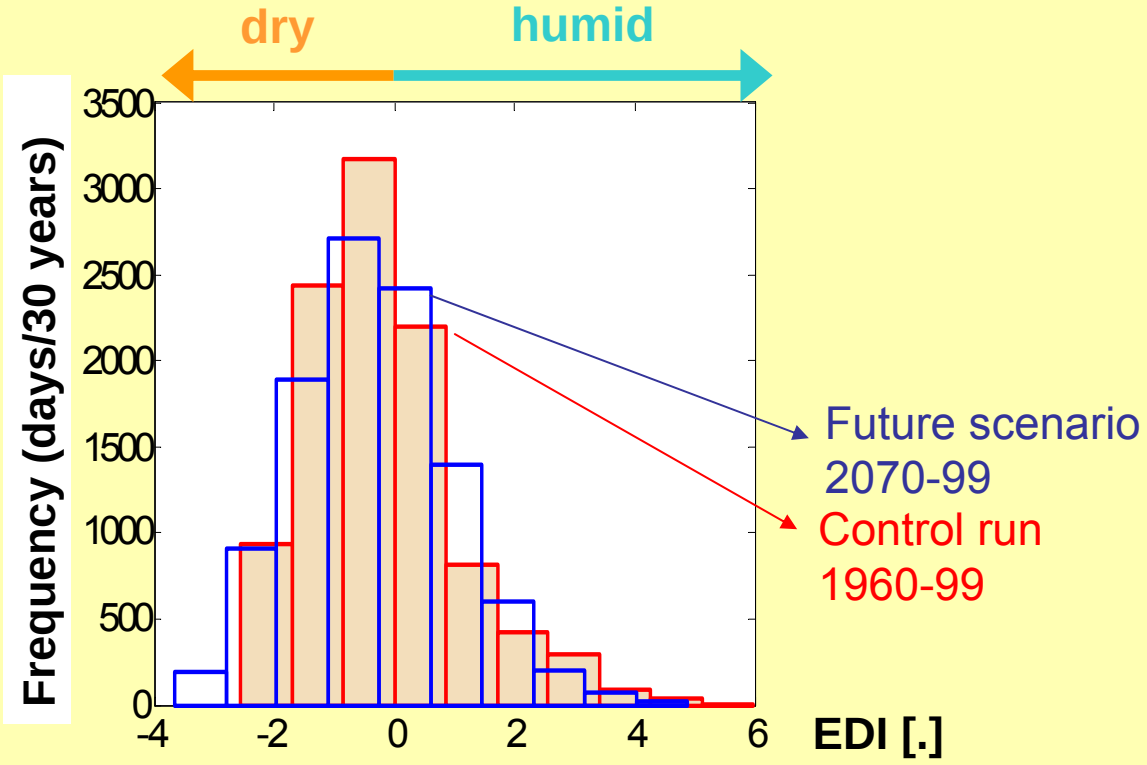


For all subregions: Decreased winter, increased spring precipitation

Regional Climate Simulations

Are drought risks changing? Analysis of effective drought index EDI

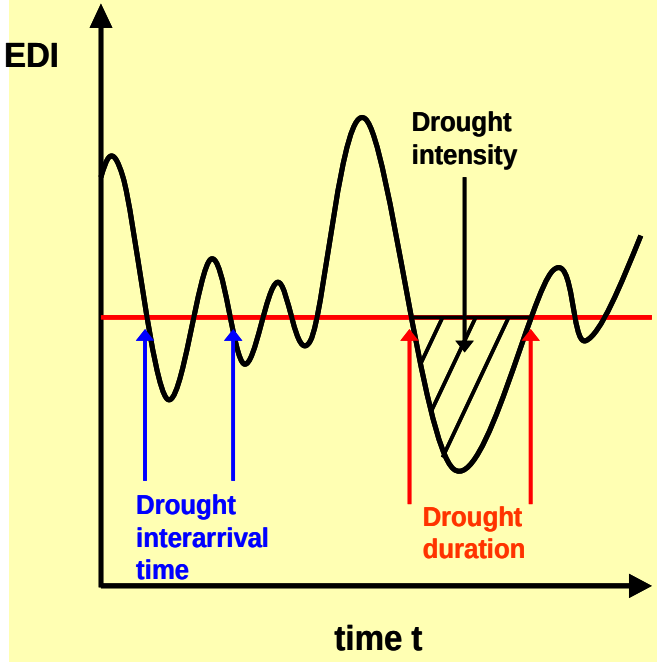


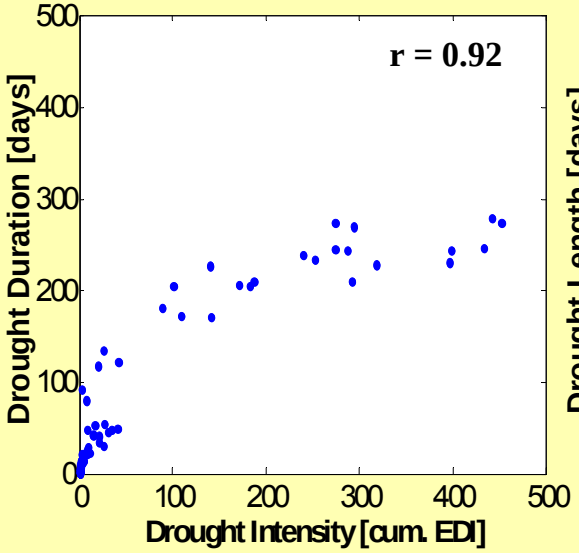


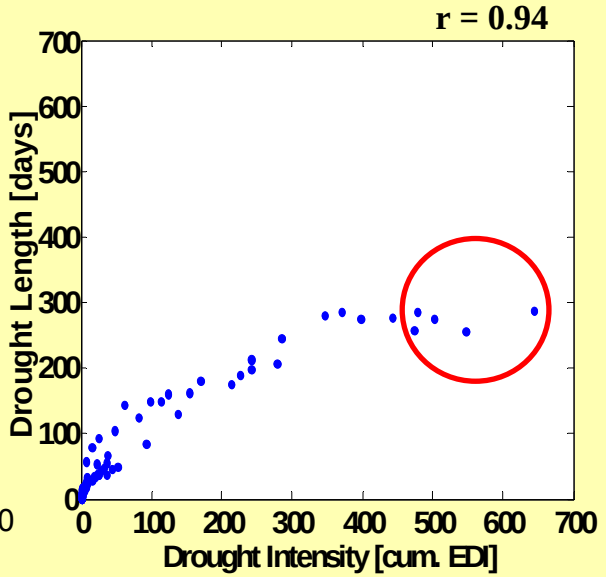
Subregion A: shift towards drier conditions & increased drought risks

Regional Climate Simulations

Are drought risks changing? Analysis of effective drought index EDI







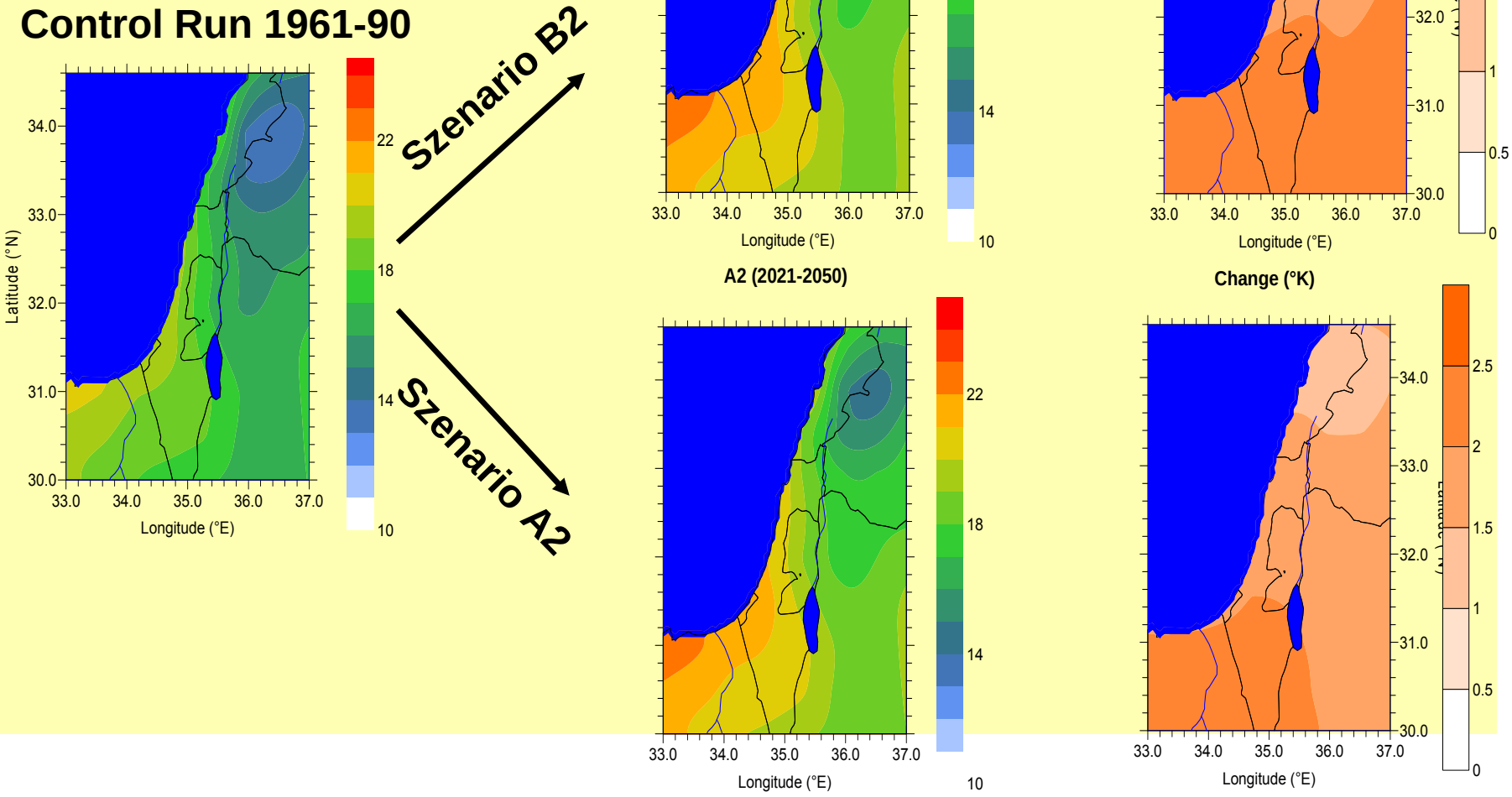
Subregion A: Increasing drought intensities, but “unchanging” drought durations

Regional Climate Simulations

Second example

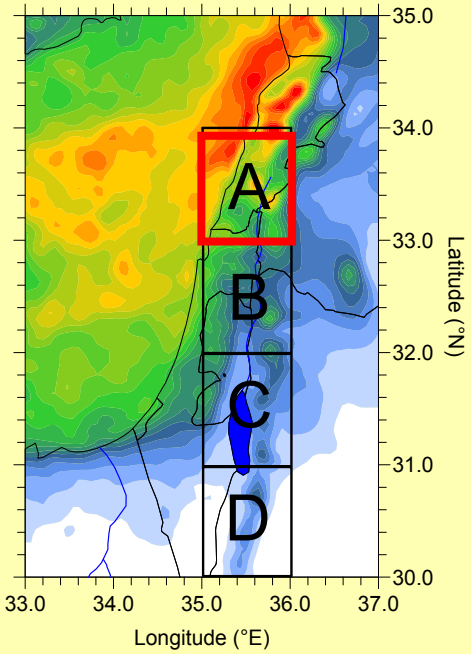
ECHAM4, A2 & B2, 54km, 1961-2050 transient

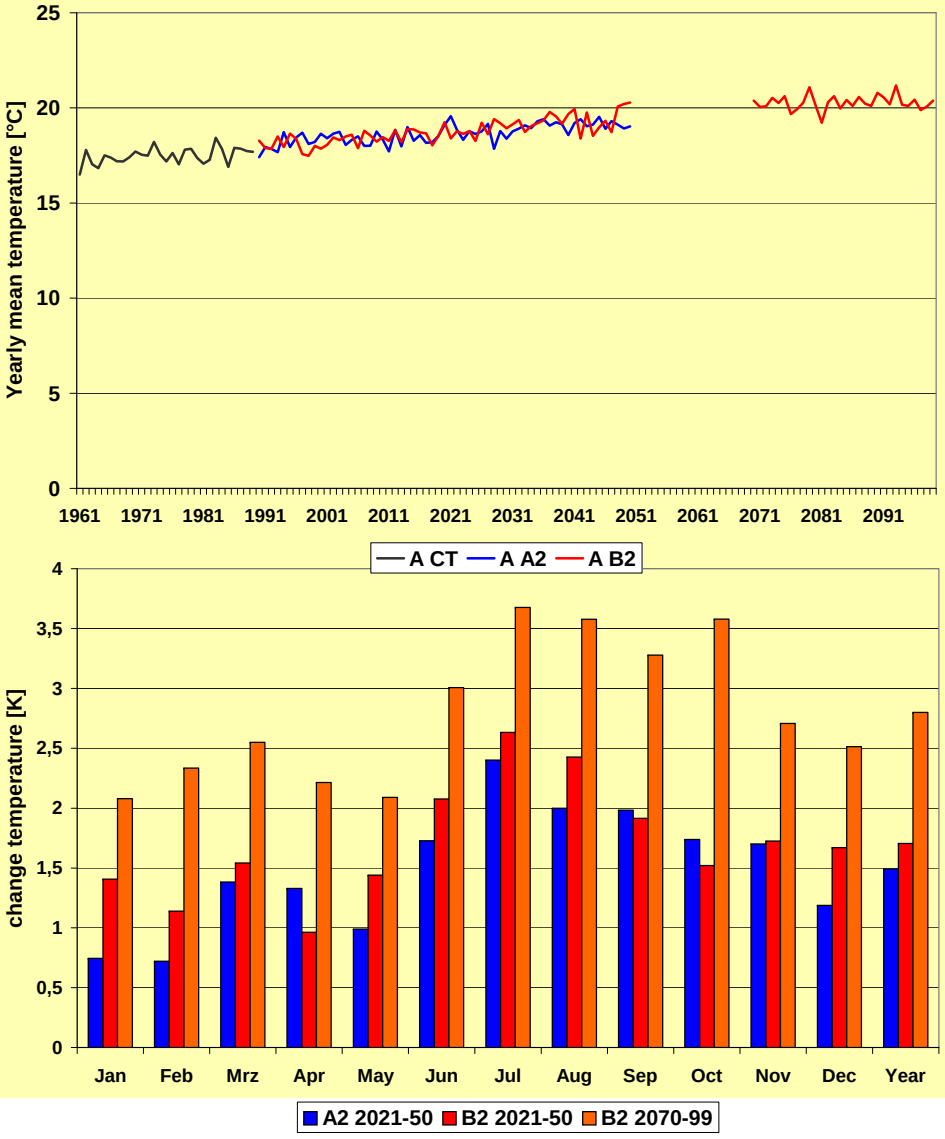
Regional Climate Simulations



Regional Climate Simulations

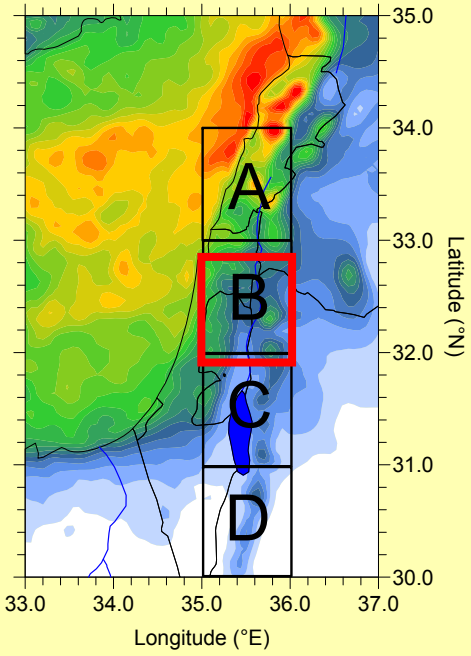
Regional changes in temperature

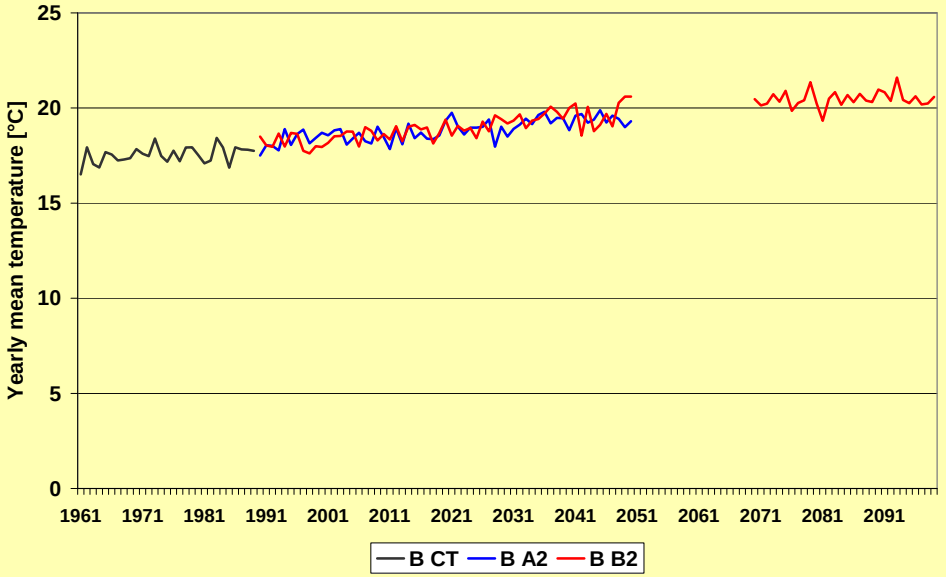


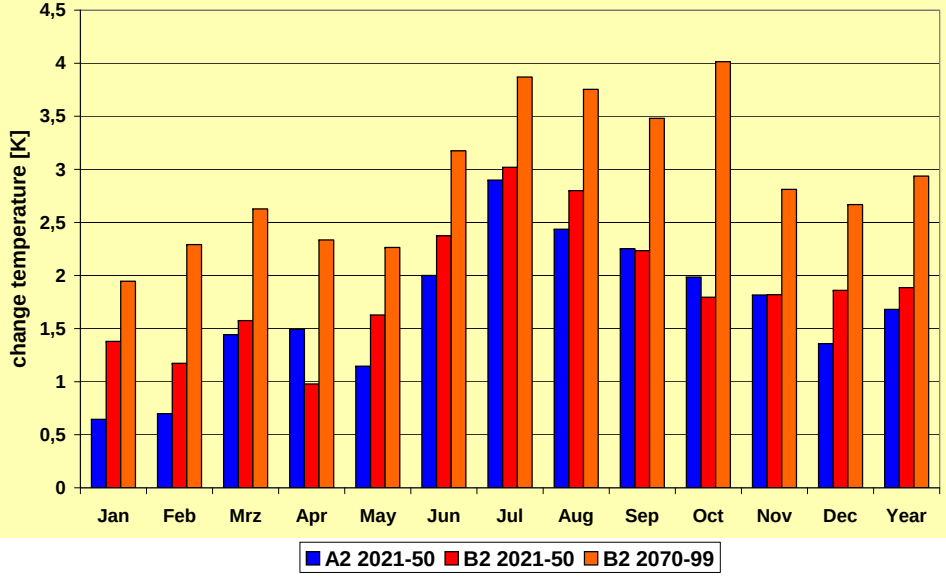


Regional Climate Simulations

Regional changes in temperature

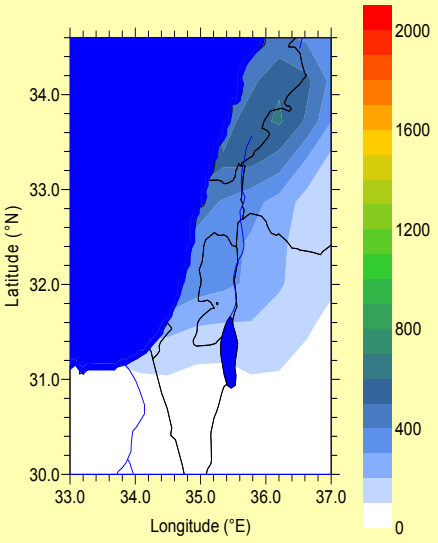






Regional Climate Simulations

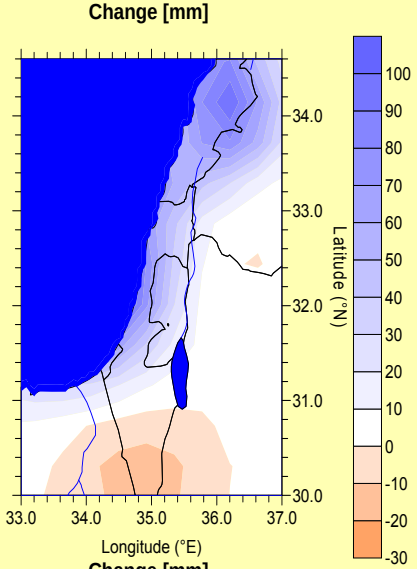
Control Run 1961-90

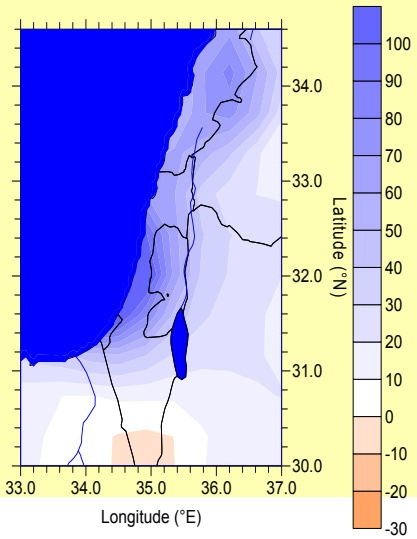


Szenario B2

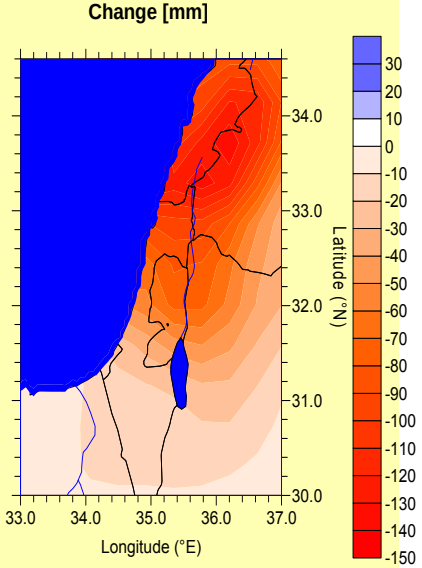
Szenario A2

2021-50





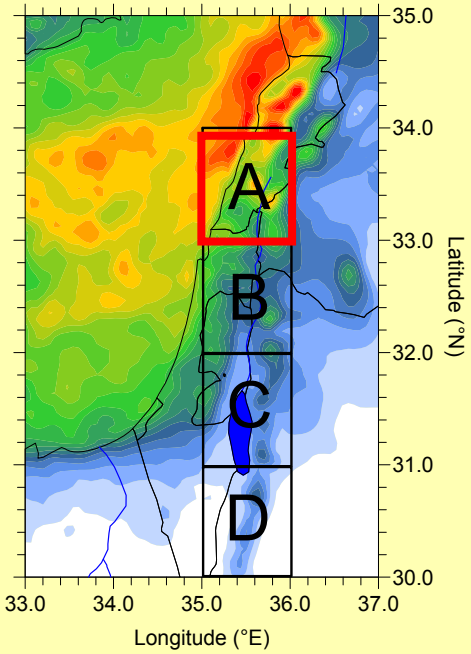
2070-99

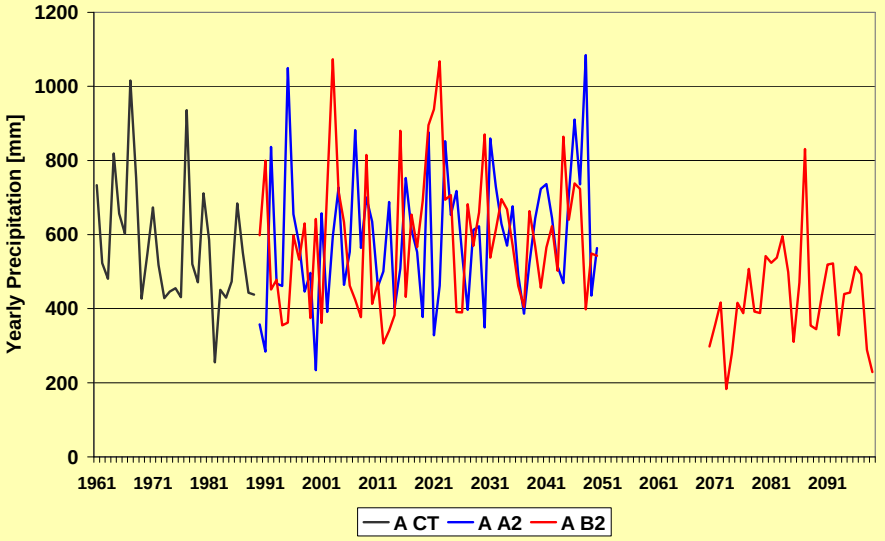


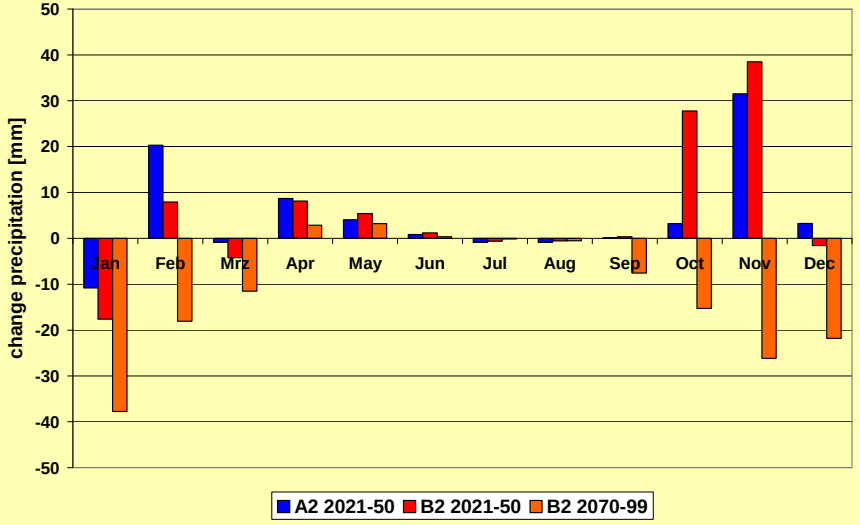
Increase,
little differences between A2 + B2 till 2050

But significant decrease in 2070-99!

Changes in seasonality of precipitation

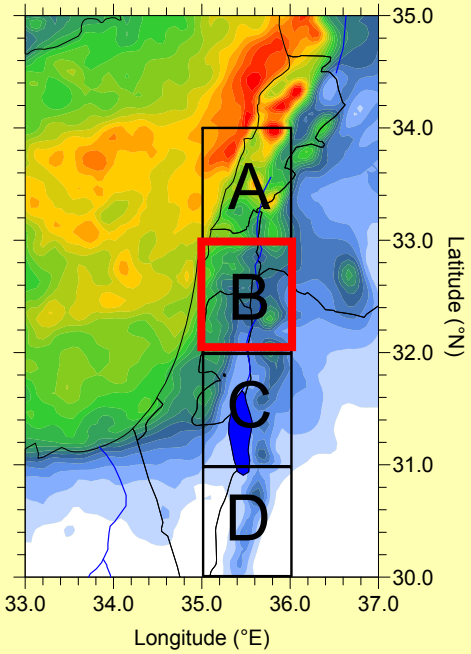


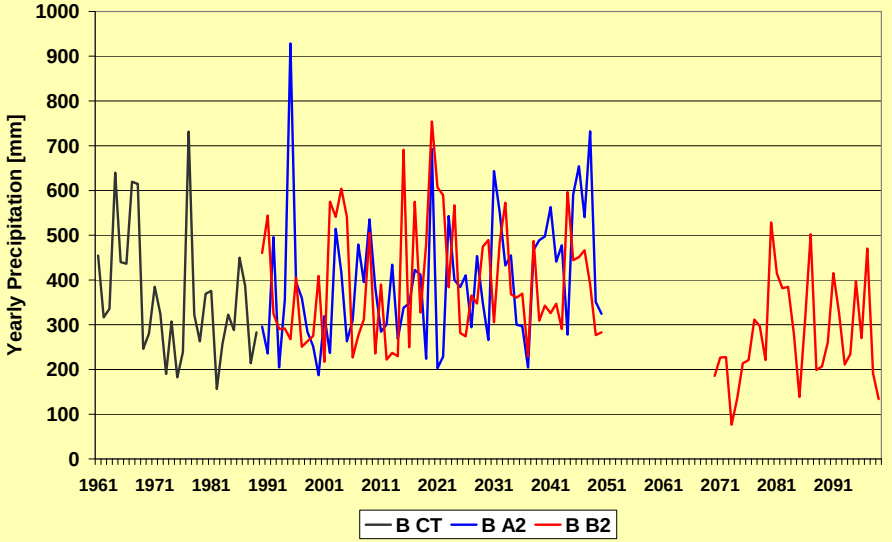


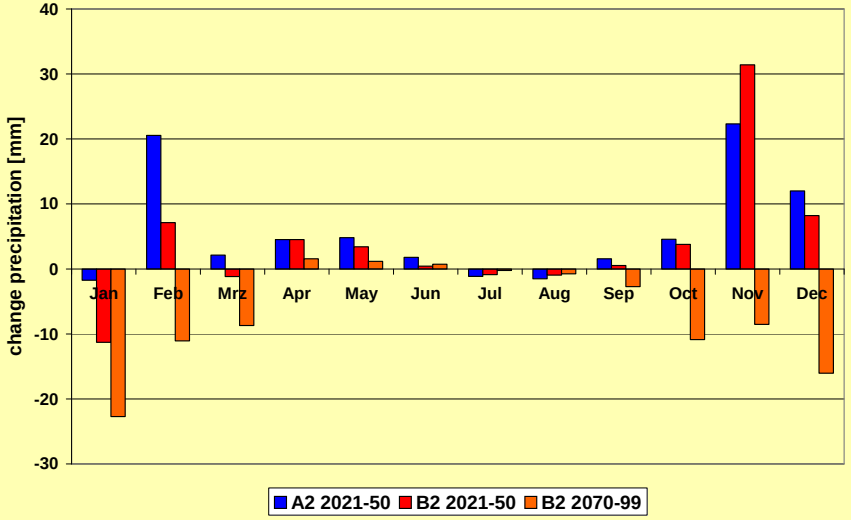


Regional Climate Simulations

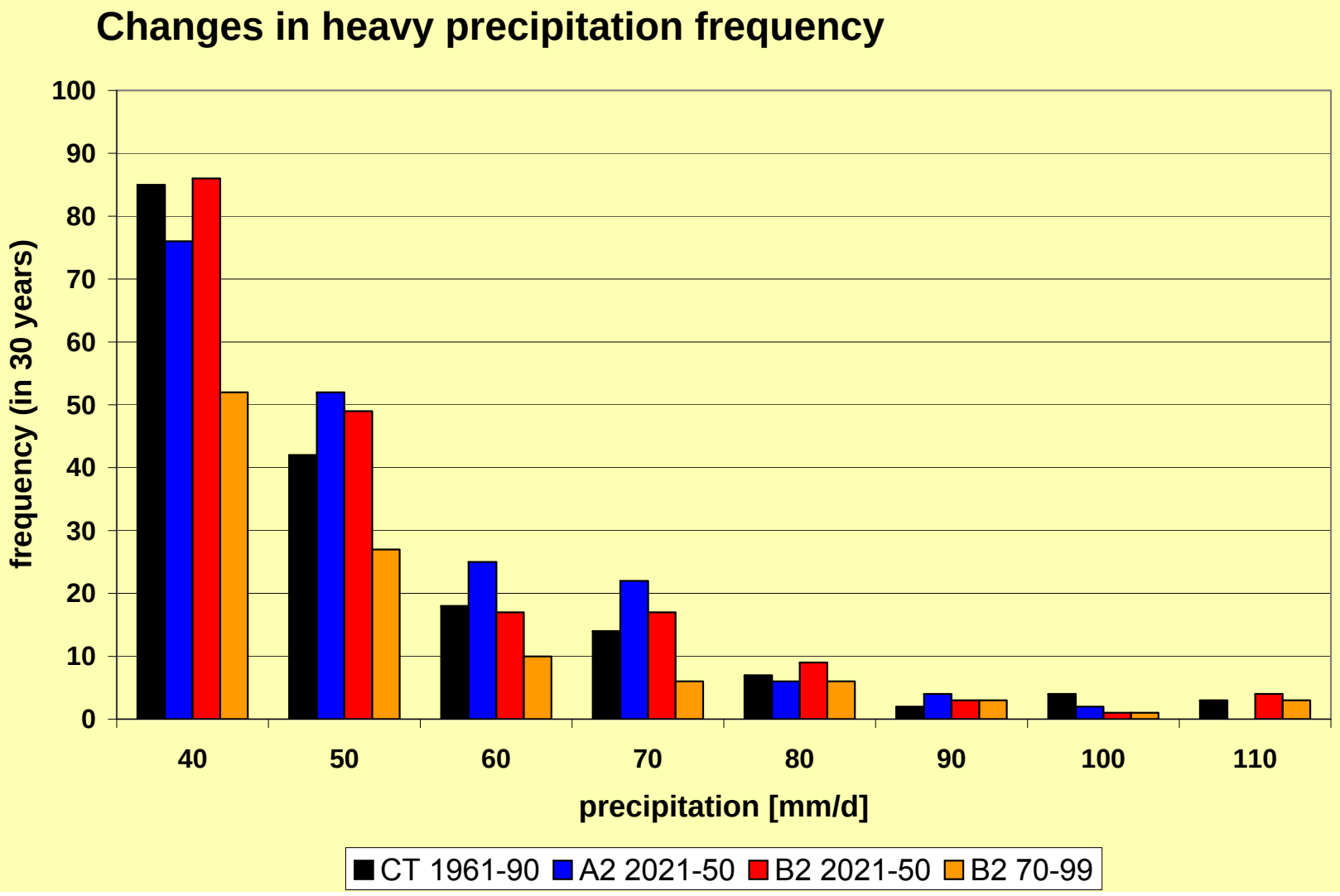
Changes in seasonality of precipitation







Regional Climate Simulations



Regional Climate Simulations

Summary & Conclusions

- Increase of temperatures in all scenarios (up to +4°C)

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

  1) precipitation & intensity increase till 2050 for scenarios A2 & B2 (transient)
  2) precipitation & intensity decrease till 2100 for scenario B2 (time slice)

- Little differences between A2 and B2 till 2050 in mean annual precipitation change **but significant differences in monthly changes**

"To Do" in phase II & identified research needs for phase III
⇒ **what happens between 2050 and 2070?**
⇒ continuation of transient simulations in 18km resolution
⇒ extension towards HadCM3 and ECHAM5 (A1B)


Thank you for your attention

Regional Climate Simulations

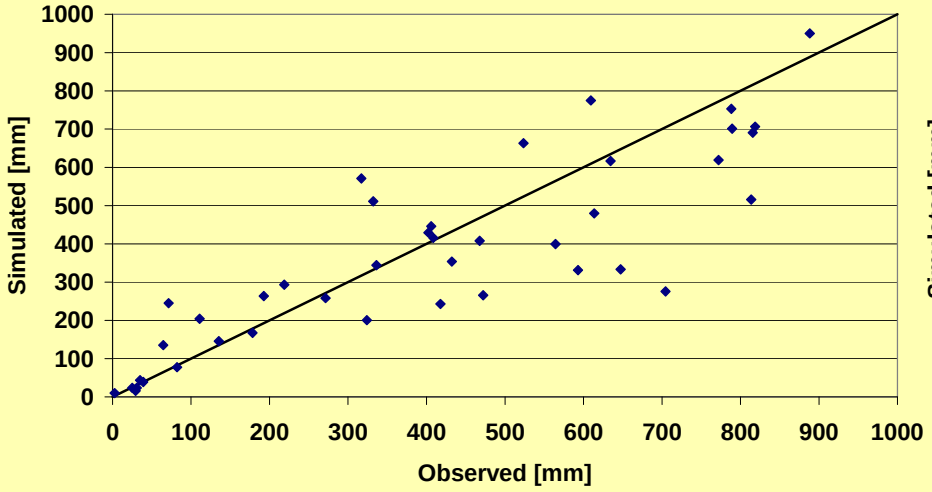
Summary: Available Regional Climate Simulations

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

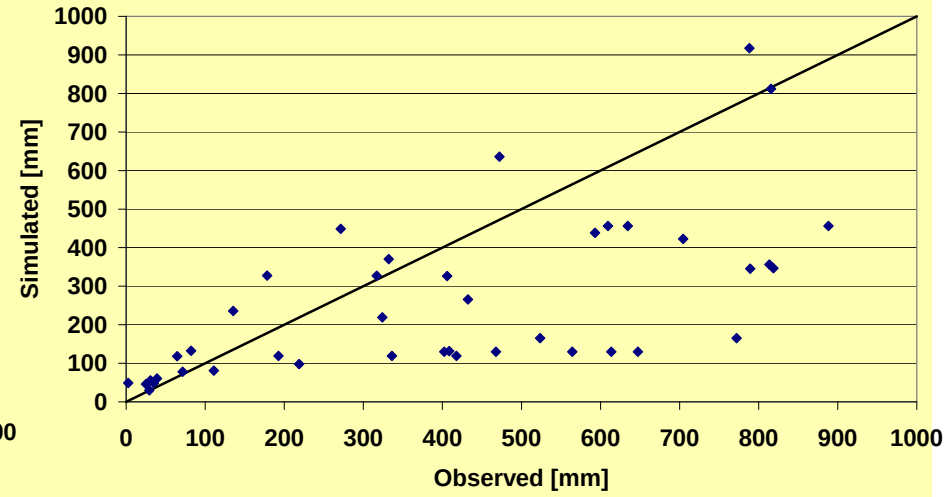
Regional Climate Simulations

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