Coupled High Resolution Climate and Distributed Hydrological Simulations for the Eastern Mediterranean/Near East and the Upper Jordan Catchment

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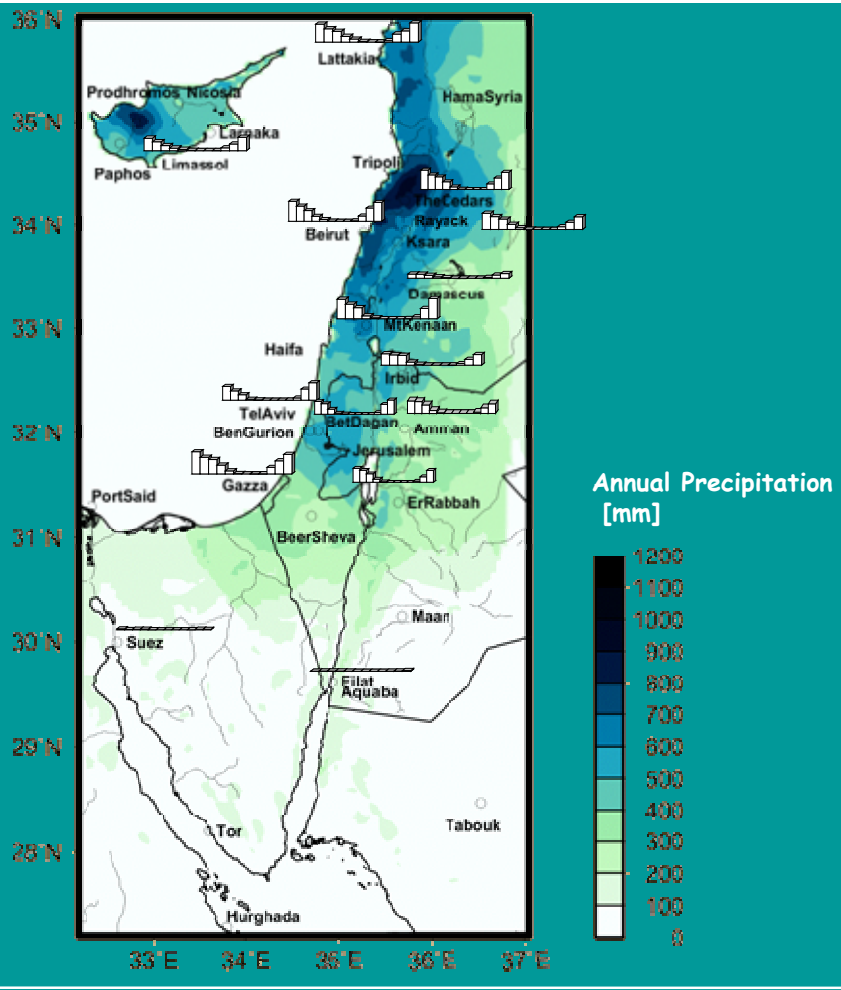
Motivation

- Sufficient freshwater availability central prerequisite for agricultural & industrial development in water scarce environment of Near East & Eastern Mediterranean
- Political peace strongly linked to satisfactory compliance of increasing water demands
- Sustainable management of water resources requires scientific sound decisions on future freshwater availability, in particular under global climate change and increasing greenhouse gas emissions
- Focus on Upper Jordan Catchment (UJC) which provides 1/3rd of freshwater resources of Israel & Palestine

Climate in the Eastern Mediterranean & Jordan River Basin

- Sharp climatic gradients: humid Mediterranean ↔ arid climate
- **High resolution information required**



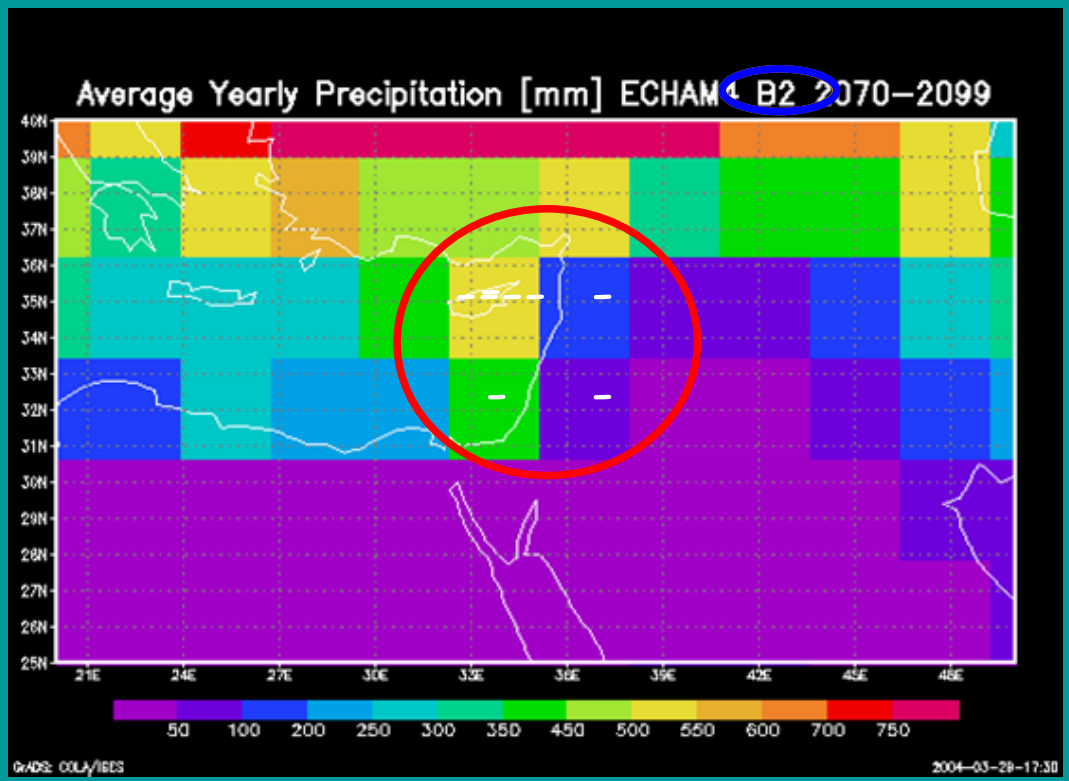
Upper Jordan Catchment

Jordan catchment

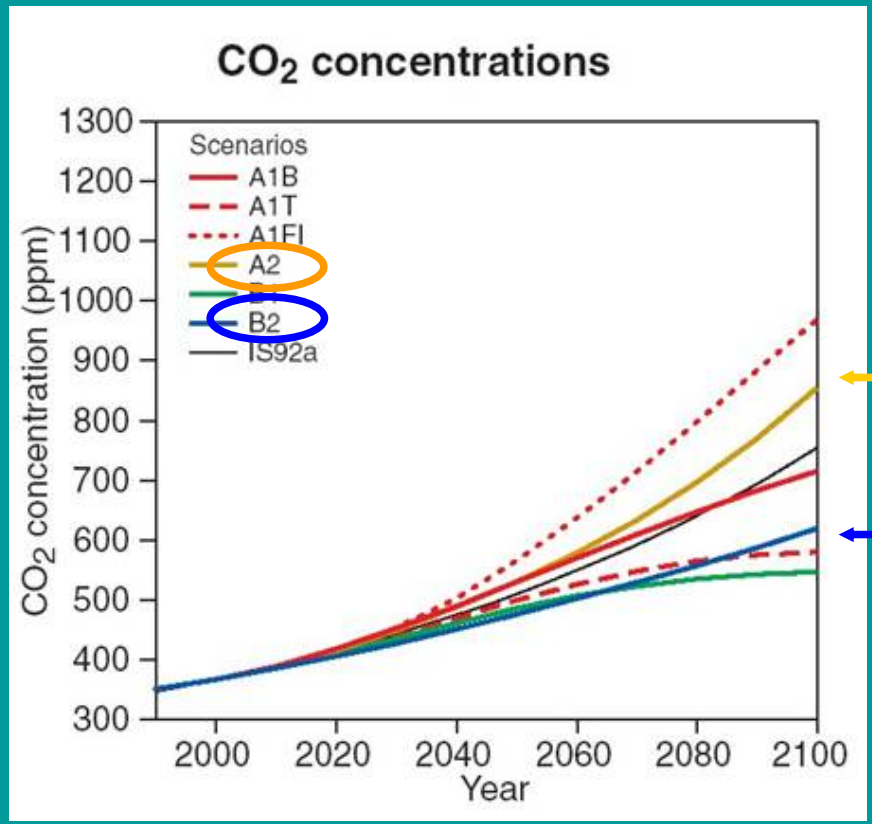
Jordan & Mt Hermon

How does global warming and greenhouse gas emissions impact regional climate in the Eastern Mediterranean/Near East?

Global Climate Scenarios: Change in Precipitation



ECHAM4 global climate model



Resolution much too coarse for hydrological impact analysis

Method: *Explicit dynamical downscaling of global meteorological fields with MM5*

Intermediate results

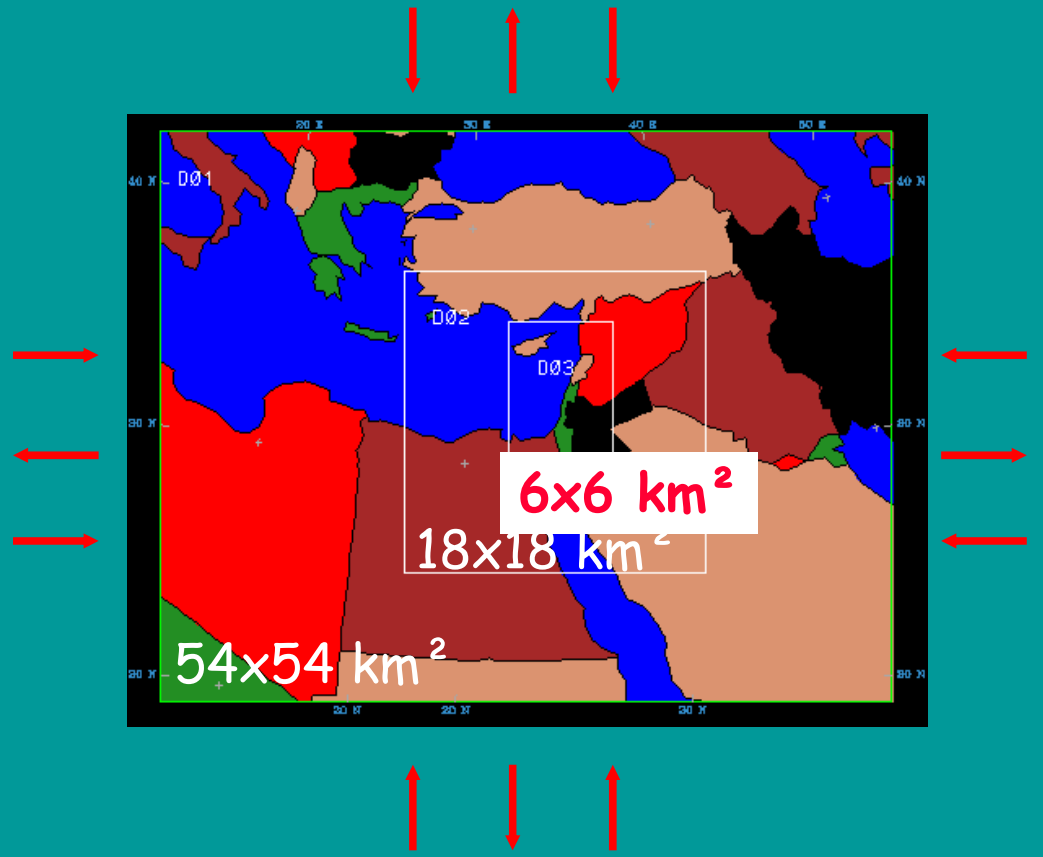
- Two nesting steps (grid size of 54, 18km)
- 25 levels
- CT & B2 scenario ECHAM4 data
- 30 years (1961-1990 & 2070-2099)

Current status

- 60 y simulations
- ~30000 cpu h
- ~5 Tbyte disc space

Next Steps

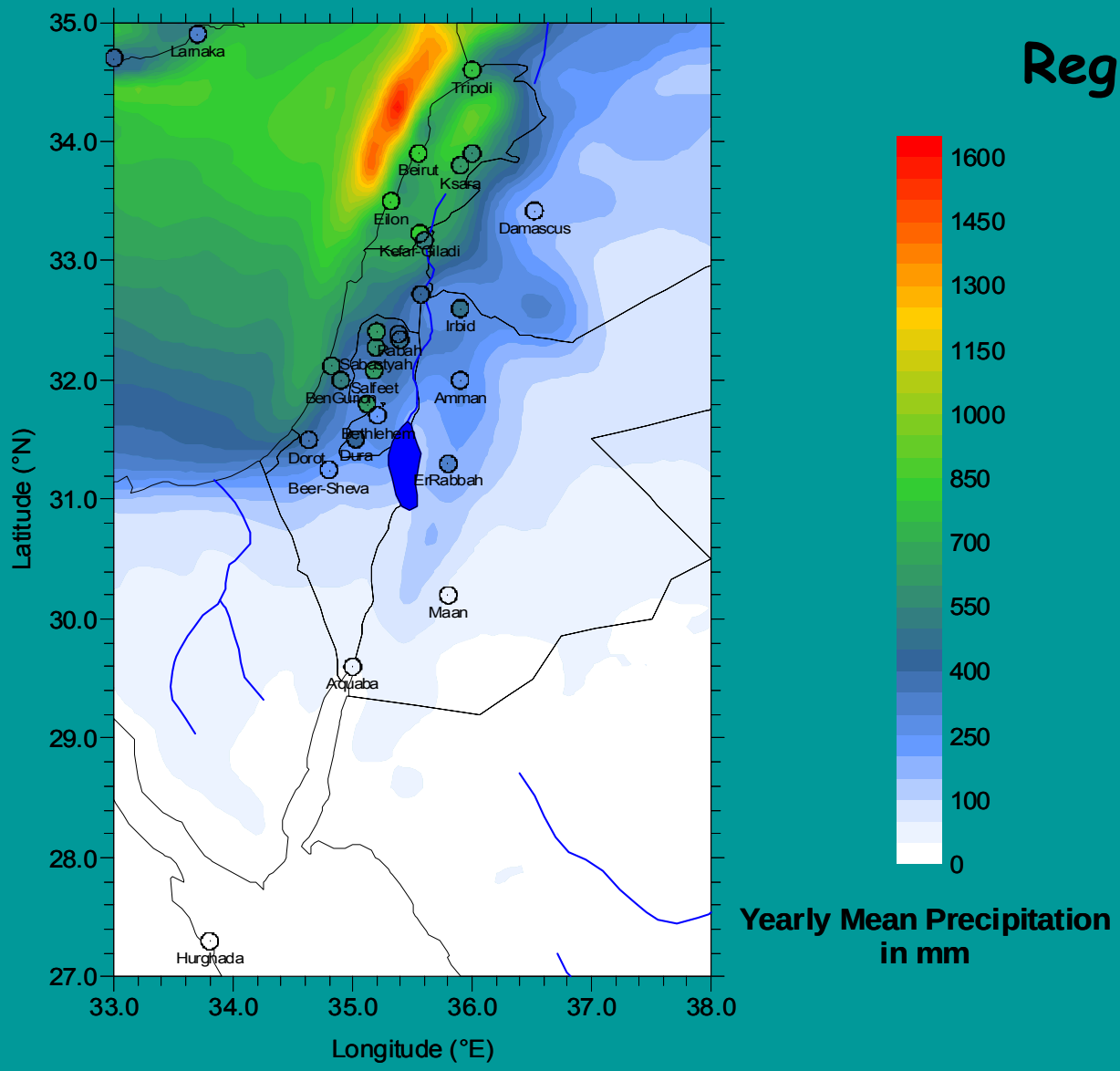
- Nesting step with 6km
- Additional scenario A2
- Alternative GCM (HadCM3)



High resolution required for reproduction of orographically induced local phenomena

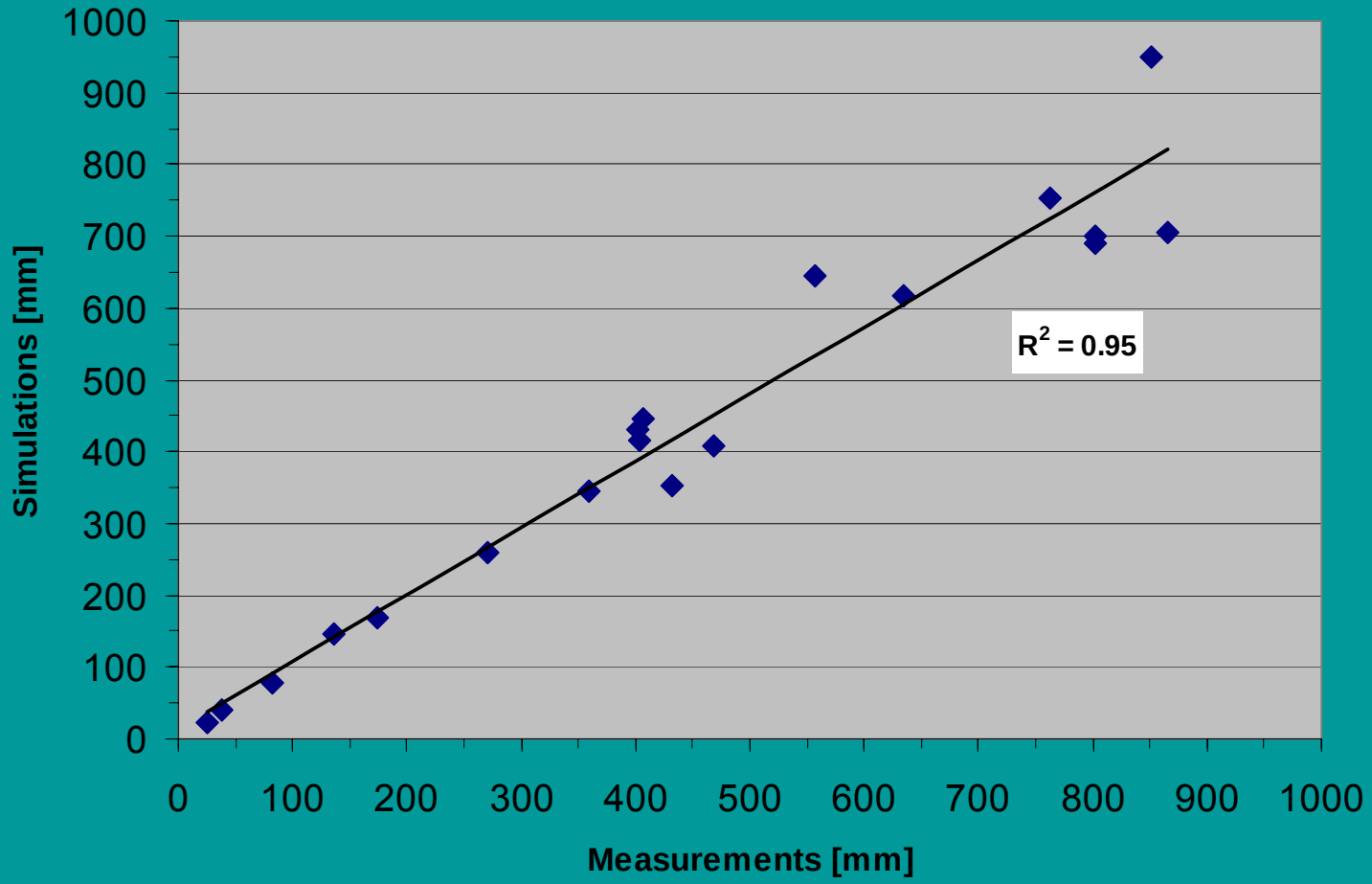
Regional Climate Simulations

Selected Results
Regional Climate Modelling



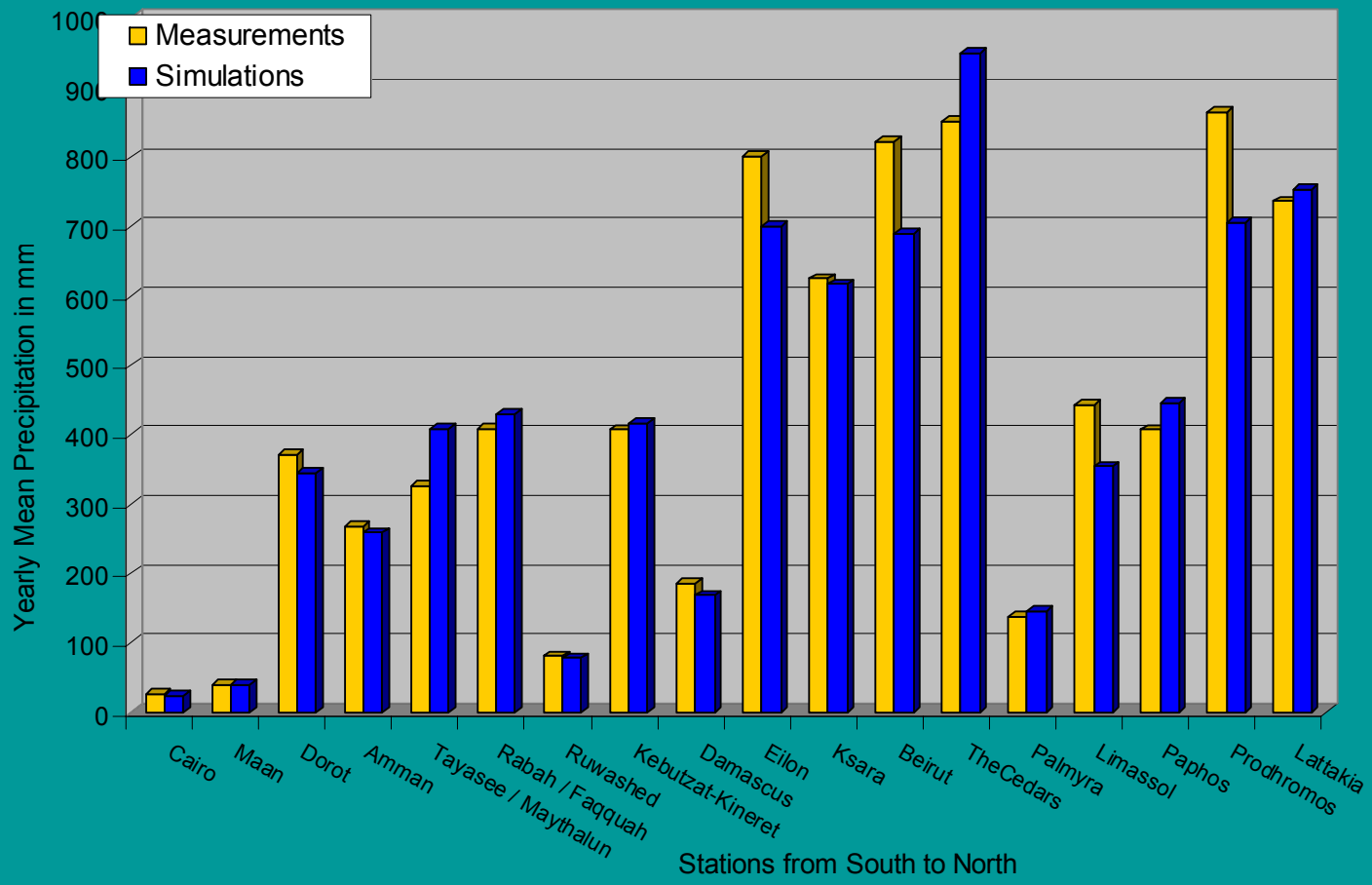
Simulated yearly mean precipitation superimposed with yearly mean measurement data (1961-1990)

Selected Results
Regional Climate Modelling



Comparison of
long term measurements (>20 years between 1961-1990)
and
high resolution simulations (18 km, ECHAM4 control run 1961-1990)
within the Eastern Mediterranean

Selected Results
Regional Climate Modelling



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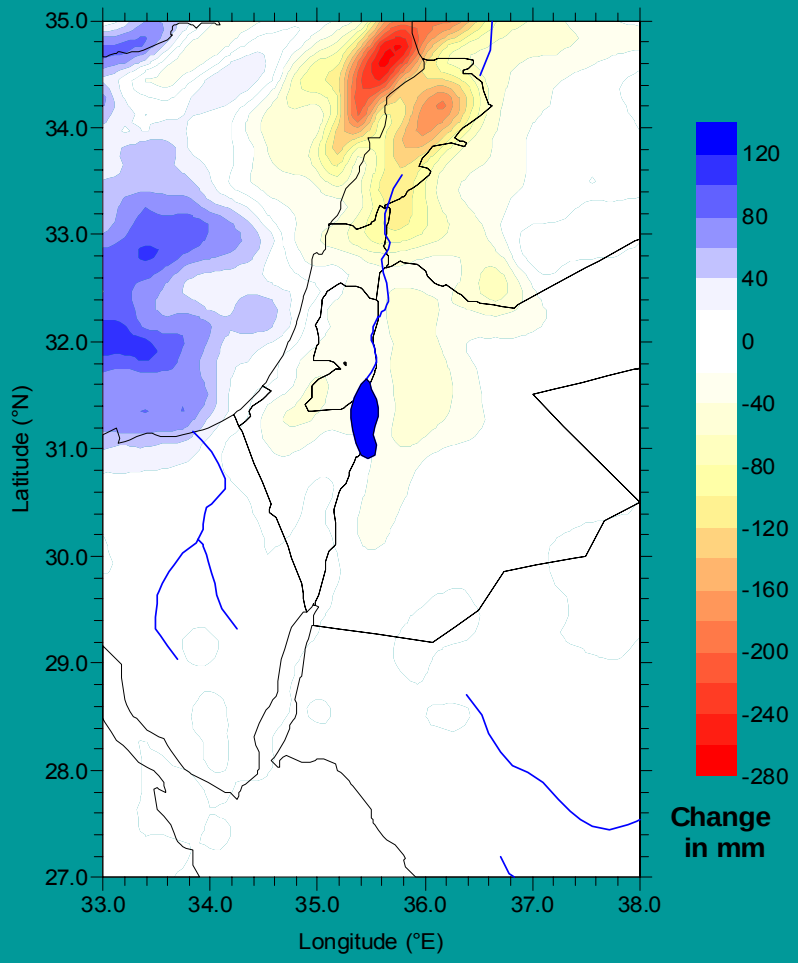
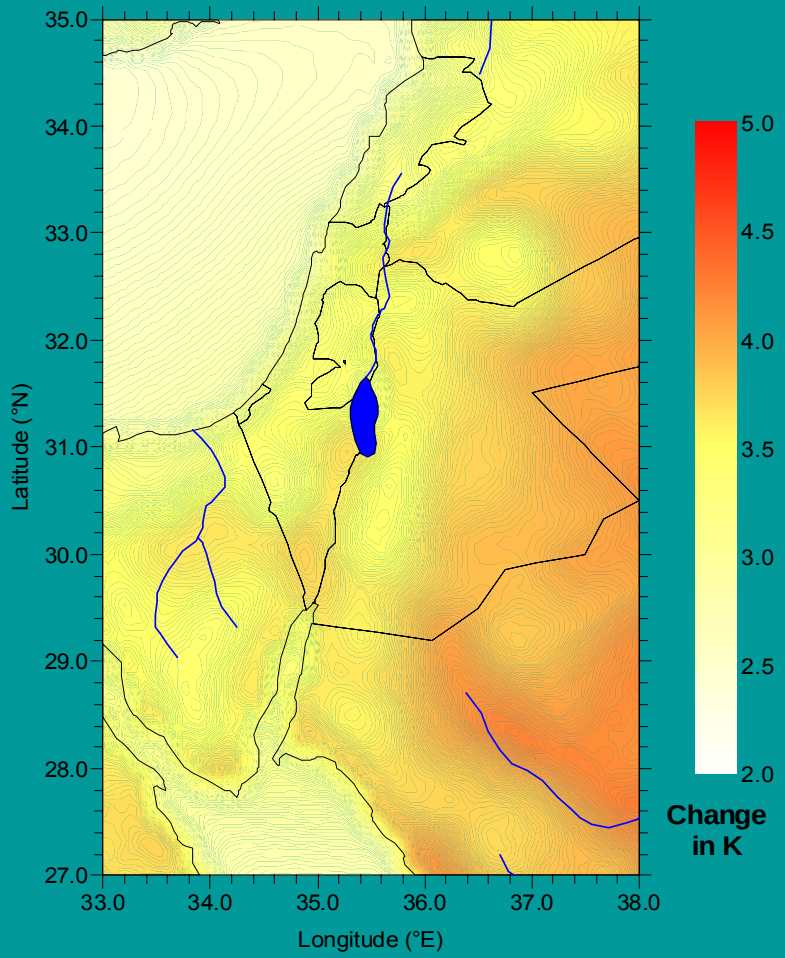
Rain



Temperature



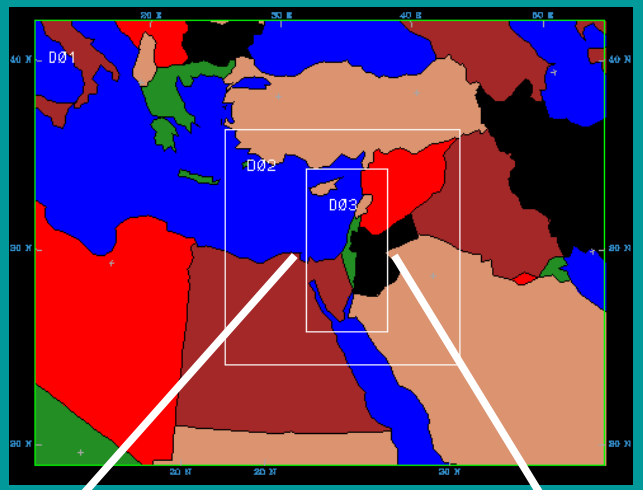
Difference of simulated yearly mean values between the future ECHAM4 scenario B2 (2070-2099) and the ECHAM4 control run (1961-1990) based on a grid size of 18km resolution

How does this atmospheric change translate into change in terrestrial water availability in the Upper Jordan Catchment?

Strategy: 1-Way Coupled Meteorology-Hydrology Simulations

- Temperature
- Precipitation
- Wind
- Relative Humidity
- Global Radiation

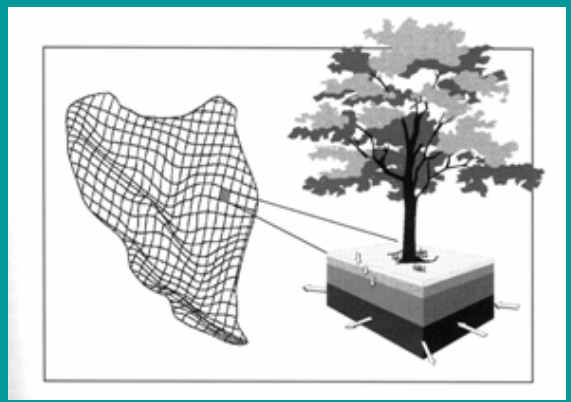
MM5
3-dim
Atmospheric model



2.5x2.5° → 6x6 km² Resolutio

WaSiM
Distributed Hydrological
Modell

- Orography
- Land Use
- Soil Properties
- Aquifer Properties
- Flownet Structure



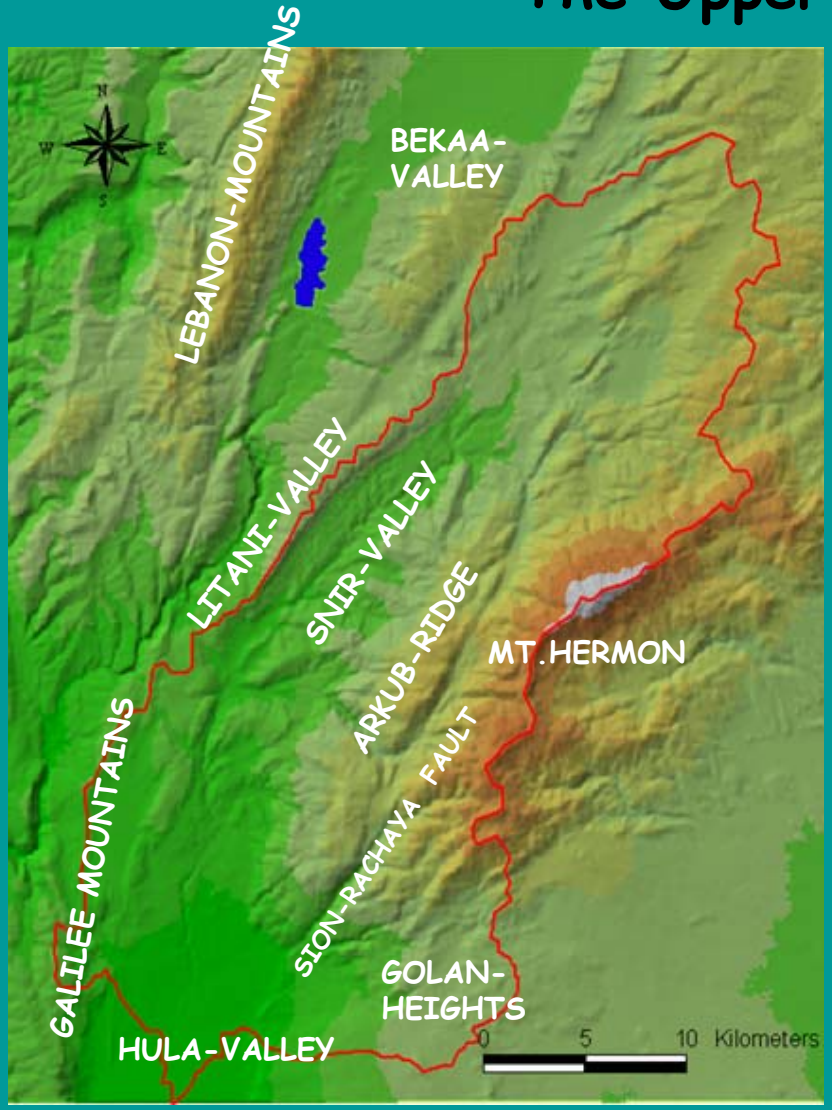
90x90 m² Resolution

Evapotranspiration
Infiltration
Surface Runoff
Groundwater Flow

The Distributed Hydrological Model WaSiM -ETH

- Physically based algorithms for most process descriptions
- Spatial model resolution for UJC: Δx^2=90x90 m^2
- Flow trough unsaturated zone (Richards, 1931), Δz=0.5m, 40 layers
- Evapotranspiration: soil and vegetation specific (Monteith, 1975; Brutsaert, 1982)
- Snow accumulation & -melt
- Discharge routing: cinematic wave
- 2-dim groundwater model dynamically coupled to unsaturated zone

The Upper Jordan Catchment



Area: 855 km²

Max. height: 2814 m.a.s.l. (Mount Hermon)

Min. height: 80 m.a.s.l. (Hula-Valley)

Complex hydrogeology &

groundwater/surface water interactions

Precipitation:

750 mm/a: in the valleys

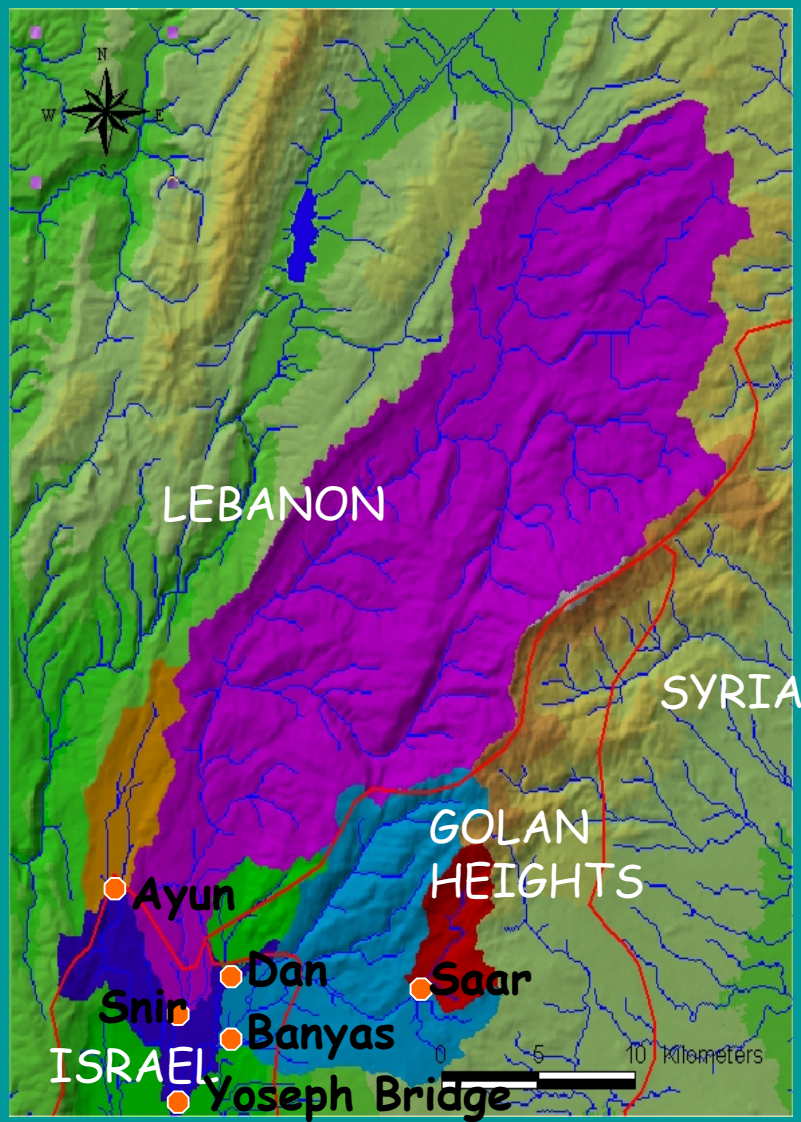
1500 mm/a: top of Mt. Hermon

Cross-bordering: Lebanon, Syria, Israel, Golan Heights

Restricted and **limited data availability**

6 Gauges: Ayun, Snir, Banyas, Dan, Saar, Yoseph Bridge

The Upper Jordan Catchment



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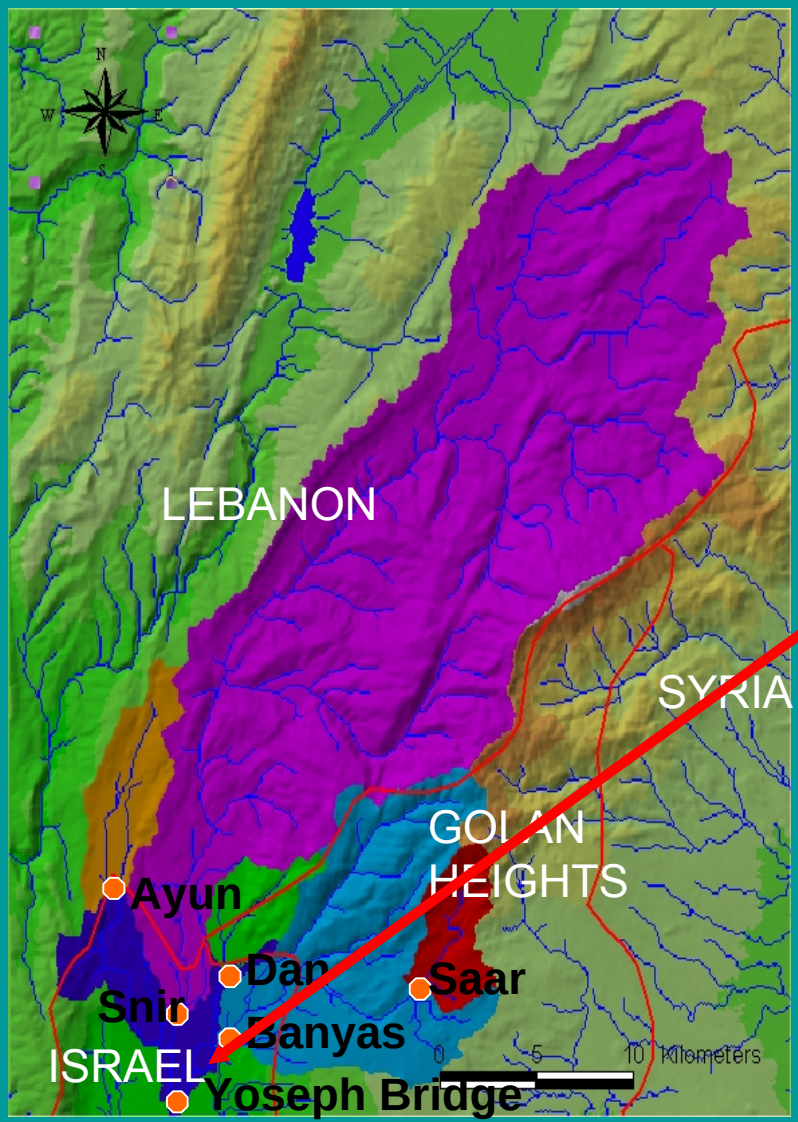
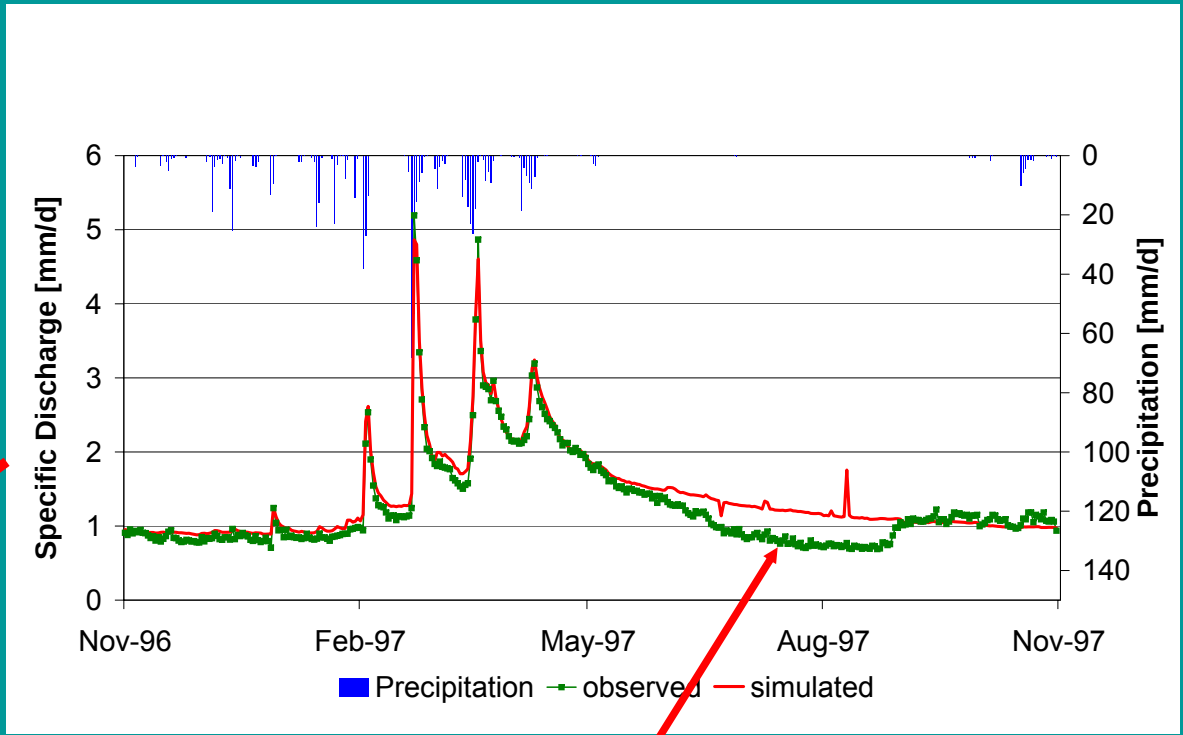
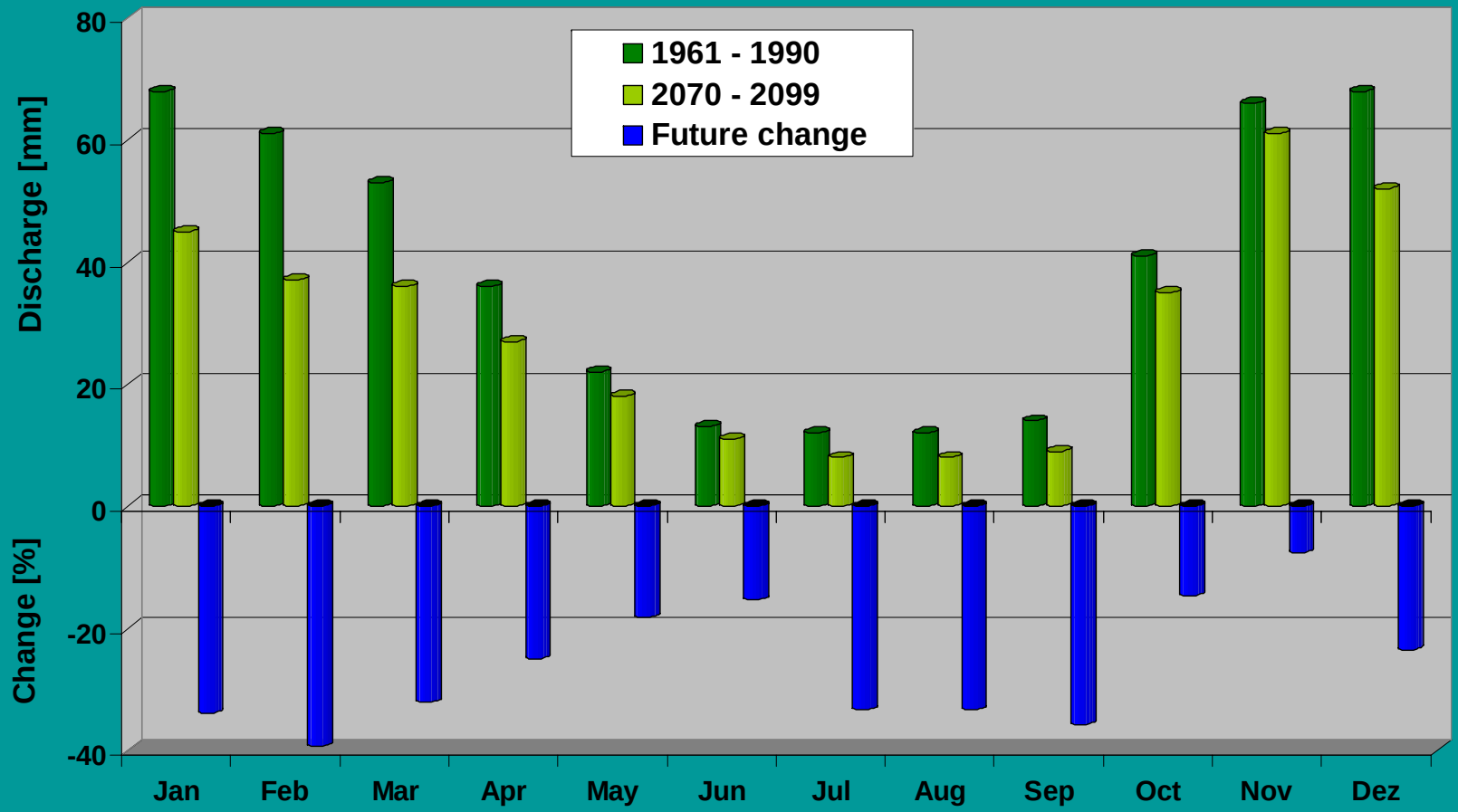




Technically bypassed water not yet accounted for

Selected Results - Hydrological Modelling



Monthly mean discharge for the Upper Jordan Catchment
(control run and future scenario B2)

Summary & Conclusions

- Regional climate simulations indicate
  - decrease of annual precipitation up to 40%
  - increase of mean annual temperature up to 4°C
- First time that physically based distributed hydrological model is setup for Upper Jordan catchment
  - reasonable agreement between observed an simulated runoff in calibration period
- Next steps, e.g.
  - Simulation of different regional climate model scenarios (e.g. HADLEY, ECHAM4-A2)
  - Analysis of extreme events
  - Hydrological impact analysis based on climate scenarios
  - Improving the groundwater model of WASIM with specific tracer information
- Method of coupled regional climate-hydrology simulations can be applied to any region/catchment worldwide

Thank you for your attention