Impact of Climate Change on Water Availability in the Near East

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

**Problem:**
- Changes in the regional climate can differ significantly from the overall trend of global climate change
- Region has sharp climatic gradients: subhumid mediterranean ↔ arid climate
- Resolution of global climate models are much too coarse for hydrological impact studies
  → High resolution information required that account for regional and local geographic features (particularly orography, land use and water bodies)

**Solution:** *Dynamic downscaling of global climate scenarios*
Explicit dynamical downscaling of global climate scenarios

Intermediate results
• Two nesting steps (grid size of 54, 18km)
• 25 vertical levels
• CT & **B2** scenario ECHAM4 data
• 2x30 years time slices
  (1961-1990 & 2070-2099)

Current status
• 60 y simulations
• ~30000 CPUh
• ~5 TByte disc space

Next Steps
• Finishing 6 km
• Additional scenario A2
• Alternative GCM (HadCM3)

High resolution required for reproduction of orographically induced local phenomena
How accurate does the downscaled Control Run reproduce observed precipitation?

Simulated annual mean precipitation (ECHAM4, 18 km², 1961-1989) vs. observed long term annual mean (for selected stations 1961-1990)
How accurate does the downscaled Control Run reproduce observed precipitation?
How accurate does the downscaled Control Run reproduce observed precipitation?

The graph shows a linear relationship between measurements and simulations, with an $R^2 = 0.95$ indicating a strong correlation.
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]**

ECHAM4 & MM5, 18 km, B2, 2070-2099 vs 1961-1989

**Relative Change in [%]**
How does the temporal distribution of precipitation change?

ECHAM4 & MM5, 18 km, B2, 2070-2099 vs 1961-1989, Jordan Area North of Dead Sea

Strongly decreased winter, slightly increased absolute spring precipitation
How does seasonal precipitation change depend on the region?

For all subregions: Decreased winter, increased spring precipitation
How do precipitation intensities change?

ECHAM4 & MM5, 18 km, B2, Jordan Area North of Dead Sea

Tendency towards decrease of precipitation intensity
How does precipitation intensity change depend on the region?
How does precipitation intensity change depend on the region?

P3: Climate
How does precipitation intensity change depend on the region?
How does seasonal precipitation change depend on the region?
What do we expect from the High Resolution Simulations with 6 km?

First results of 6 km runs: mean 1961 + 1962

… more detailed spatial information: land-sea & orography dependent features
Link to SAS Integration and Subsequent Impact WPs

• First climate modeling results have been transferred to P1 (Integration):

   Precipitation, temperature, wind, humidity, global radiation in 18 km, ASCII format
   1h: 25 GByte
   1d: 1 GByte

   to be used in impact assessment

• P6: First results of joint climate hydrology simulations for the UJC
The Upper Jordan Catchment
P3: Climate

Jordan & Mt Hermon
P3: Climate

Banyas
What is the Impact of Expected Atmospheric Change on Terrestrial Water Availability in the UJC?

High resolution dynamical downscaling of global climate scenarios

Distributed hydrological modeling of surface and subsurface water balance in 90 m resolution
How does expected regional atmospheric change translate into the UJC?

- **Jahresdurchschnittstemperatur [°C]**
  - 11 - 12
  - 12 - 13
  - 13 - 14
  - 14 - 15
  - 15 - 16
  - 16 - 17
  - 17 - 18
  - 18 - 19
  - 19 - 20
  - 20 - 22
  - 22 - 24

- **Temperaturzunahme [°C]**
  - 3.2 - 3.4
  - 3.4 - 3.5
  - 3.6 - 3.7
  - 3.7 - 3.9
  - 3.9 - 4.1
  - 4.1 - 4.2
  - 4.2 - 4.4
  - 4.4 - 4.5
  - 4.5 - 4.7

- **Jahresniederschlag [mm]**
  - 640 - 680
  - 680 - 720
  - 720 - 760
  - 760 - 800
  - 800 - 840
  - 840 - 880
  - 880 - 920
  - 920 - 960
  - 960 - 1000

- **Niederschlagsänderung [%]**
  - -25.0 - -22.7
  - -22.7 - -20.6
  - -20.6 - -18.6
  - -18.6 - -16.5
  - -16.5 - -14.5
  - -14.5 - -12.4
  - -12.4 - -10.4
  - -10.4 - -8.3
  - -8.3 - -6.3
How accurate does the hydrological model reproduce observed discharge?

Technically bypassed water not yet accounted for
What is the impact of expected climate change on river discharge in the UJC?

Different signs of precipitation change and runoff change
Amplified change for groundwater recharge
Impact of expected climate change on water balance in the UJC

1960-1990

- Direct Runoff: 208 mm/a
- Interflow: 109.9 mm/a
- Baseflow: 57.2 mm/a
- ET: 361.6 mm/a

2070-2100

- Direct Runoff: 157.9 mm/a
- Interflow: 86.9 mm/a
- Baseflow: 44.2 mm/a
- ET: 349.7 mm/a
All results presented so far originate from one emission scenario (SRES-B2) and one global climate model (ECHAM)

What do we expect for different emission scenarios and other global climate model?
Differences in summer temperature (JJA)

Significant differences between A2 and B2
Differences in winter temperature (DJF)

50 km resolution RegCM

Significant differences between A2 and B2
Differences in summer precipitation (JJA)

50 km resolution RegCM

No significant differences between A2 and B2
Differences in winter precipitation (DJF)

No significant differences between A2 and B2
Changes for Jordan River area

<table>
<thead>
<tr>
<th>Season</th>
<th>Precip S2</th>
<th>T2m A2</th>
<th>Precip A2</th>
<th>T2m B2</th>
<th>Precip B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win</td>
<td>+3.0°</td>
<td>-0.5 mm/d</td>
<td>+2.0°</td>
<td>-0.5 mm/d</td>
<td></td>
</tr>
<tr>
<td>Spr</td>
<td>+3.0°</td>
<td>-0.5 mm/d</td>
<td>+2.0°</td>
<td>-0.3 mm/d</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>+6.0°</td>
<td>-0.5 mm/d</td>
<td>+3.5°</td>
<td>-0.5 mm/d</td>
<td></td>
</tr>
<tr>
<td>Aut</td>
<td>+4.0°</td>
<td>-0.3 mm/d</td>
<td>+3.0°</td>
<td>-0.5 mm/d</td>
<td></td>
</tr>
</tbody>
</table>

Between A2 and B2 scenarios:

- **Larger differences for temperature**
- **Little differences for winter precipitation and summer season**
- **differences for spring and autumn season precipitation**

50 km resolution RegCM
Summary and Conclusions

Jordan River area north of Dead Sea:
• Temperature increase of yearly mean up to 3.5°C
• Summer temperatures up to 5°C

• Decreasing winter (35%), increasing spring precipitation
• Decrease of precipitation intensities
  → impact on conditions for reservoir filling!

Upper Jordan River
• First results joint climate-hydrology simulations UJC
• In spite increased spring precipitation, decreased spring runoff & recharge!
Thank you for your attention