Scenarios of Climate Change in Southern and Eastern Styria and Potential Impacts on Agriculture and Water Availability

A. Gobiet¹,², H. Truhetz¹,², A. Riegler¹,²

¹ Wegener Center for Climate and Global Change (WegCenter), Univ. of Graz, Austria
² Inst. f. Geophysics, Astrophysics, and Meteorology (IGAM), Univ. of Graz, Austria

Outline

• Introduction – Regional Climate Modelling
• Model Evaluation
• Regional Climate Change 2040s
• Examples for Climate Impacts in Styria
• Conclusions and Outlook
Globale Modelle ...

At the surface
Ground temperature
Water, energy and carbon fluxes

Vertical exchange between levels

In the atmospheric column
Wind vectors
Humidity
Clouds
Temperature
Height

The Alps as seen by a global Model

General Circulation Model (global)
Quelle: McGuffie, Henderson-Sellers, 2005

... regional/local challenges

Flash floods

Kappl/Paznauntal, Sommer 2005 (Source: ASI Tirol)

Water supply SO Stmk

Source: Joanneum Research/GIS Stmk
Regional Climate Modelling

“Dynamical Downscaling”

• Regional Climate Model (RCM) “nested” within a global general circulation model (GCM) to increase resolution

• Initial and boundary conditions from GCM, inside RCM dynamics

• GCM simulates the response of general circulation to large scale forcings, RCM simulates regional responses to general circulation and regional-scale forcings

Source: IPCC, 2001
Alps as seen by a high res. RCM

Model Setup

MM5
- Climate mode
  (no re-initialization)
- Double nesting
  (T106 --> 30 km --> 10 km)
- Introduction - Regional Climate Modelling

Global Models ...

- Resolved processes: Navier-Stokes Equations
- Sub-grid processes: Parameterizations

--- Results: Physical state of the atmosphere (temp., pres., wind, humid., radiation, precip., ...)

General Circulation Model (global)
Source: McGuffie, Henderson-Sellers, 2005
Regional Climate Simulations

   Boundary conditions: ERA-40 (“perfect boundary conditions”)
   → RCM evaluation
   → Reference for quality assessment RCM+ECHAM5
   → High res. climate analysis

2) Control Run (1981 – 1990)
   Boundary conditions: ECHAM5 T106* (observed GHG)
   → Control simulation for:

3) Scenario Simulation (2041 – 2050)
   Boundary conditions: ECHAM5 T106* (IS92a)
   → Climate change analysis
   → High res. climate scenario for further downscaling and impact studies

*ECHAM5 simulation by M. Wild and P. Tschuck, ETH Zurich

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Research for Climate Protection:
Model Run Evaluation (reclip:more)

- **Team:** ARC-sys, BOKU-Met, IMG/UniVienna, WegCenter/UniGraz, ZAMG

- **Objectives:**
  - Evaluate the capability of dynamical and statistical downscaling methods in the Alpine region to create high resolution climate scenarios
  - Create of climate scenarios suitable for climate impact research.

- **Challenges:** various climatic regimes, extremely complex topography, high target resolution (10km/1km) → simulation and evaluation challenges

- **Periods:** 1981-1990 (control), 2041-2050 (scenario), shorter periods

- **Methods:** Dynamical (MM5, ALADIN), statistical, diagnostic downscaling
• Model Evaluation

MM5 Precipitation Difference to Observations

- Precipitation
  MM5 – Obs. (HISTALP) annual mean

- Bias: 0.1 mm/d

- Precipitation
  MM5 – Observation annual cycle
Sub-Regions

HISTALP
Source: ZAMG Austria

VERA
Source: IMG/ Uni Vienna

Evaluation Summary
MM5 Precip. vs. HISTALP
Evaluation Summary
Observed Precipitation (Frei)

Source: Frei, MeteoSwiss

Evaluation Summary
MM5 vs. observed Precipitation

Source of obs. data: ZAMG, CRU, MeteoSwiss
Evaluation Summary
South East (Frei, HISTALP)

Source: Frei, MeteoSwiss

Source of obs. data: ZAMG, CRU, MeteoSwiss
• Regional Climate Change 2040s

Mean Climate Change 1980s vs. 2040s
2m Temperature [K]

DJF: +1.9 K
MAM: +2.2 K
JJA: +2.3 K
SON: +2.7 K

Year: +2.3 K
Mean Climate Change 1980s vs. 2040s
Precipitation [%]

**MM5 D1**

<table>
<thead>
<tr>
<th>Year</th>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
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<td></td>
<td>5.3</td>
<td>1.2</td>
<td>-7.7</td>
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<table>
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<th>JJA</th>
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<tbody>
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<td>-4.0</td>
<td>7.9</td>
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**MM5 D2**

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<td>7.9</td>
<td>1.2</td>
<td>-12.3</td>
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Mean Climate Change
Precipitation MM5 [%]
Precipitation Intensity / Frequency

MM5 Precip. Intensity
Year

<table>
<thead>
<tr>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
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<tbody>
<tr>
<td>0.1 mm/day</td>
<td>0.6 mm/day</td>
<td>0.0 mm/d</td>
<td>-0.2 mm/d</td>
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</table>

MM5 Precip. Day Frequency [days per month]

<table>
<thead>
<tr>
<th>DJF</th>
<th>MAM</th>
<th>JJA</th>
<th>SON</th>
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<tr>
<td>-0.9</td>
<td>-0.3</td>
<td>0.1</td>
<td>-1.3</td>
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Examples for Climate Impacts in Styria
Climate Change in SE Styria

[Source: Joanneum Res., 2006]

Impacts

EHGC Water

Adaptation in the Water Supply Sector of Eastern Styria (Joanneum Research, WegCenter)

EHGC Water Conclusions:
- Groundwater Recharge may decrease ~30% until 2040s [JR, Dalla Via]
- Comparing with supply-side adaptive strategies, demand-side options reveal to be insufficient [JR, Oberauner, Pretenthaler]
- Rough predictions of hydrologists about additional future water demand in times of peak load is about 200 l/s [JR, Oberauner, Pretenthaler]
  - Demand-side options are a good contribution, but can not cover expected demands
  - Realization of supply-side adaptive strategies necessary
**Impacts**

**AgroClim**

Climate Change Impacts on Drought Agricultural Risk in Austria (WegCenter, HBLFA)

- Analysis of various drought indices for Styria
- Offline coupling of reclip:more results with drought stress + grassland yield model
  → Drought stress scenarios
  → Grassland yield scenarios

![Graph showing monthly precipitation](prepared by G. Heinrich)

**Impacts**

**StartClim: Heating/Cooling Energy**

Climate Change Impacts on Heating and Cooling Energy demand In Austria (WegCenter, Uni. Vienna, Joanneum Res.)

- Observational data + reclip:more scenario → heating/cooling degree days
- Demographic + technical data
  → Changes in heating/cooling energy demand

![Graph showing change in heating degree days](2040s)

![Graph showing change in cooling degree days](2040s)
Conclusions and Outlook

Summary

Mean Climate Change
- 60-year temperature change in the Alpine region: +2.2 K (1.9 in spring, 2.7 in autumn)
- 60-year precipitation change in sub-regions: up to +20 % (winter), up to -30 % (SE, summer + autumn).

Change in Variability (day-to-day)
- Precipitation: Large regions with intensity (or even mean) increase and frequency decrease (e.g., NW winter) → more extreme conditions.
Conclusions & Outlook

Climate
- Alps: sharp transition zone for precipitation change, various sub-regions with different change-characteristics → more analysis in sub-regions necessary
- Closer analysis of variability (extremes) and their relation to model resolution

Climate Impact Research
- Results (10 km grid resolution) available for climate impact research.
- Further downscaling (~1km scale) and creation of "user tailored" datasets is currently going on...

   more information:

   http://www.wegcenter.at
   http://systemsresearch.ac.at/LUC/reclip/