The Need to Link Disciplines in Climate Change Research at Mountainous Regions

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Overview

1. Climate Change in European mountainous regions (i.e. the Alps)
2. Climate Change Impacts
3. Possible Responses
4. Research Strategies
5. Final Remarks
Observed Climate Change in European Mountains

- Temperature
- Precipitation

References:
1) Auer et al. 2007 (HISTALP)
2) ProClim Report 2007 (CH2050)
Observed Climate Change in European Mountains

- Temperature
- Precipitation

References:
1) Raible et al. 2006 (CH, Winter)
2) Schmidli & Frei 2005
cit. In Fuhrer et al. 2006
Projected Climate Change in European Mountains to 2100

Multi-model Averages and Assessed Ranges for Surface Warming

Economic

A1  A2

Global  Local

B1  B2

Environmental

References:
1) IPCC 2007

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Projected Climate Change in European Mountains to 2100

- Temperature
- Precipitation

Higher locations → Higher temperature increase!
Projected Climate Change in European Mountains to 2100

- Temperature
- Precipitation

References:
1) Beniston, 2006 (Results from the PRUDENCE project, cit. from Workshop presentation, Wengen 2006)

Shift from summer into winter and spring!
Expected Climate Impacts

Climate Change:
Temperature, Precipitation, Wind speed,…

Physical/Chemical Impact:
Glacier Extension, Drought, Runoff, Permafrost, mass flows, fire,…

Biological/Ecological Impact
Growth, Emission, Diseases, Competition, Biodiversity,…

Socio-economic Impact:
Yield, Energy production, Tourism, Health, Land use, Safety,…
Expected Climate Impacts: Physical

- Increasing winter & spring flooding
- Increased summer drought
- Increasing glacier retreat and mass movements
- Probable increase of other hazards

References:
1) Beniston, 2006 (Workshop, Wengen)
2) Häberli, 2006 (Workshop, Wengen)

HIRHAM RCM scenario for the central European Alps

Penrith, 04.09.2007
Expected Climate Impacts: Ecology

- Changed ecology
- Changed growth (increased temperatures and CO₂ but more frequent drought)
- Changed competition
- Disturbed host - parasite interaction
- Increased invasion rate (plants, insects, …)
- Dynamically changing biodiversity

Current climate
Distributions of dominant tree species in the Dischma valley simulated with LandClim for a) current climate conditions (3.2 °C mean annual temperature, 900 mm mean annual precipitation) and b) a climate warming scenario (6.2 °C mean annual temperature, 700 mm mean annual precipitation).

Climate scenario

References:
1) Pretzsch, Grote et al. (in press)
Expected Climate Impacts:

Socio-Economic

- Shorter skiing season
- Less water availability
- Decreased hydropower
- Increased water & energy demand in summer
- Increased damage related costs
- Increased forestry risk
- Changing yield and production (+/-)
- New health risks pattern (ozone, insect related,..)
- Better accessibility

References:
1) OECD 2006
Impacts and Adaptation Responses

Climate Change:
Temperature, Precipitation, Wind speed, …

Physical/Chemical Impact:
Glacier Extension, Drought, Runoff, Permafrost, mass flow, fire, …

Biological/Ecological Impact:
Growth, Emission, Diseases, Competition, Biodiversity,…

Socio-economic Impact:
Yield, Energy production, Tourism, Health, Land use, Safety,…

Adaptation:
- Flood Protection, Water Management, Tourism Strategies,…
- Reforestation, Management, Nature Reserves,…

Feedback:
- Water Use, Stability, Susceptibility,…

Anthropogenic:
- Emission, Economic Boundary Conditions, Demographical Dynamics,…
Responses - Tourism

"It will be important for the ski industry and community as a whole to explore a variety of strategies for adapting to climate change as it plays out over the next few decades."1)

- Expanding snowmaking capabilities
- Explore the use of higher ski terrain
- Market the middle of the season.
- Expand non-snow winter recreation and cultural activities.
- Expand summer tourism activities

References:
1) "Climate Change and Aspen", report 2006
2) "Klimaänderung un mögliche Auswirkungen auf den Wintertourismus in Salzburg", BOKU, 2001
Responses - Water management

"Projected changes in the hydrograph are likely to affect municipal, agricultural, and recreational water users."¹)

- Flood risk prevention
- Controlled flooding
- Flood prediction
- Evacuation plans
- Water saving measures
- Less reliance on hydro power production
- Less cooling capacity for industrial use

References:
1) "Climate Change and Aspen", report 2006
2) OcCC report (Klimaänderung in der Schweiz 2050) 2007
Responses - Agriculture and Forestry

“In the Alpine region, the potential effect of climate change is crop-specific. However, the introduction of new cultivars may provide means by which to maintain or even increase current productivity levels.”

- Simple measures (e.g. early sowing)
- Intensification
- Increased irrigation where appropriate
- Consideration of new species (bioenergy?)
- Fire protection measures
- Pest control

References:
1) Torriani et al. 2007
Responses - Health and others

“Climate change is affecting health not isolated but in combination with other socio-economic and ecological changes.”

• Health control (heat wave related, allergy, insect triggered)
• New building regulations (heat isolation, damage resistance, …)
• …

References:
1) Frank 2006 (from OcCC report (Klimaänderung in der Schweiz 2050) 2007
Research Strategies: Integrated Studies

- Observation and indicator analysis
  - Cryosphere
  - Terrestrial ecosys.
  - Freshwater ecosys.
  - Watershed Hydrology
- Process studies along altitudinal gradients
  - Indicators of ecosys. responses
  - Runoff generation and flowpath dynamics
  - Diversity and ecosys. function

References:
1) modified after Becker & Bugmann 2001 (MRI report)
Research Strategies: Integrated Studies

- Integrated model-based studies
  - coupled ecological, hydrological and land use models
  - regional scale models of land-atmosphere interaction
  - integrated analysis

Quantification of physical and ecological Climate Change impacts

Human Driving Forces

Global Environmental Change

Optimisation of Local/regional Responses: Management

Quantification of integrated Socio-economic impacts

References:
1) modified after Becker & Bugmann 2001 (MRI report)
Research Strategies: Participatory Assessments

**Stakeholders and Decision Makers**
- public
- special interest groups
- governmental officials
- economic stakeholders

**Socio-economic impact assessment**
- identification of driving forces
- determination of vulnerability
- quantification of changes and risks

**Management responses to reduce vulnerabilities and risks**
- risk awareness
- adaptation impact
- cooperation needs
- interest weighting
- adaptation options
- experiences
Research Strategies: Participatory Assessments

Dangers of insufficient participation
- overlooking major interests
- missing ongoing management trends
- under- or overestimation of adaptation potentials

Questions to ask
- What are the demands on science?
- What changes are already experienced?
- How are resources managed today?
- What are the plans for future management?
- What options for adaptation exist?
- How much resources are available for adaptation measures?
Final Remarks:

**Assets**

- There are loads of regional climate change studies, the most recent large projects being PRUDENCE and ENSEMBLES.

- A number of regional ‘integrated’ assessments had already been carried out (e.g. RegIS for North East England).

- The reality of Climate Change is recognized by stakeholders and decision makers and the demand for advice is growing.
Final Remarks: Deficits

- Regional Climate Change projections still need higher resolution for coupling with regional hydrology and ecological models, particularly in mountainous regions.

- Regional integrated assessments generally miss major linkages and feedbacks between physical and ecological impacts. Adaptation measures are seldom included.

- Cooperation with stakeholders and decision makers on the regional scale is still difficult.
Final Remarks:

Conclusions

➢ Improvement of regional climate change scenarios appropriate for mountainous regions.

➢ Development of coupled (bi-directional linked) multidisciplinary models for hydrological (including snow and glacier dynamics) and bio-geochemical processes and application on the regional scale (e.g. carbon sequestration, nitrogen leaching).

➢ Development of realistic adaptation scenarios in cooperation with stakeholders and decision makers and application with coupled models in an iterative manner.

Thank you for your attention!