Climate Change in Mountainous Regions
Impacts, Responses, Research Needs

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Observed Climate Change

- Temperature
- Precipitation

References:
1) Auer et al. 2007 (HISTALP)
2) ProClim Report 2007 (CH2050)

Brussels, 25.10.2007
Observed Climate Change

- Temperature
- Precipitation

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

Multi-model Averages and Assessed Ranges for Surface Warming

References:
1) IPCC 2007
Projected Climate Change
Up to 2040 (business as usual)

- Temperature
- Precipitation

References:
1) Knoche and Forkel (IMK-IFU), in press

Higher locations → Higher temperature increase!
Projected Climate Change

- 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,…

Feedback:
Water Use, Stability, Susceptibility,…

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**Expected Climate Impacts:**
**Physical**

- Increasing winter & spring flooding
- Increased summer drought
- Glacier retreat
- More earth mass movements
- Probable increase of other hazards

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

HIRHAM RCM scenario for the central European Alps
Expected Climate Impacts: Ecological

- Changed growth (increased temperatures and CO$_2$ but more frequent drought)
- Changed competition
- Disturbed host - parasite interaction
- Increased invasion rate (plants, insects, …)
- Dynamically changing biodiversity

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

Socio-Economic

- Shorter skiing season
- Less water and hydropower in summer but increased water & energy demand
- Increased damage related costs and management 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, …

Feedback:
Water Use, Stability, Susceptibility, …

Adaptation:
Reforestation, Management, Nature Reserves, …

Adaptation:
Flood Protection, Water Management, Tourism Strategies, …

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

- Expand 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) "Klimaänderung und mögliche Auswirkungen auf den Wintertourismus in Salzburg", BOKU, 2001

Artificially snowed area in the county of Salzburg, Austria (1997-2000)
Responses - Water management

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

References:
1) OcCC report (Klimaänderung in der Schweiz 2050) 2007
Responses - Agriculture and Forestry

- 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

- 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
- Process studies along altitudinal gradients
- Integrated, Model-based studies

Quantification of physical and ecological Climate Change impacts

Quantification of integrated Socio-economic impacts

Global Environmental Change

Human Driving Forces

Optimisation of Local/regional Responses: Management

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

Scientists
- identification of driving forces
- determination of vulnerability
- quantification of changes and risks

-risk awareness
-adaptation impact
-cooperation needs

-interest weighting
-adaptation options
-experiences

Management responses to reduce vulnerabilities and risks

Brussels, 25.10.2007
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Research Strategies: Participatory Assessments

Dangers of insufficient participation

Wrong estimation of adaptation potentials

Missing ongoing management trends

Overlooking major interests
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 or are going to be installed.
- 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: EU Opportunities

- 7th EU Framework Program (FP7): Suggestions for third call topics welcome (e.g. integrated assessments with focus on agriculture, hydrology or tourism?)
- ESF Research Networks (RTN Network) (e.g. linkages between integrated assessment studies)
- COST Actions (e.g. bringing together modelling communities)
- INTERREG programmes (e.g. IVb, Alpine Space)