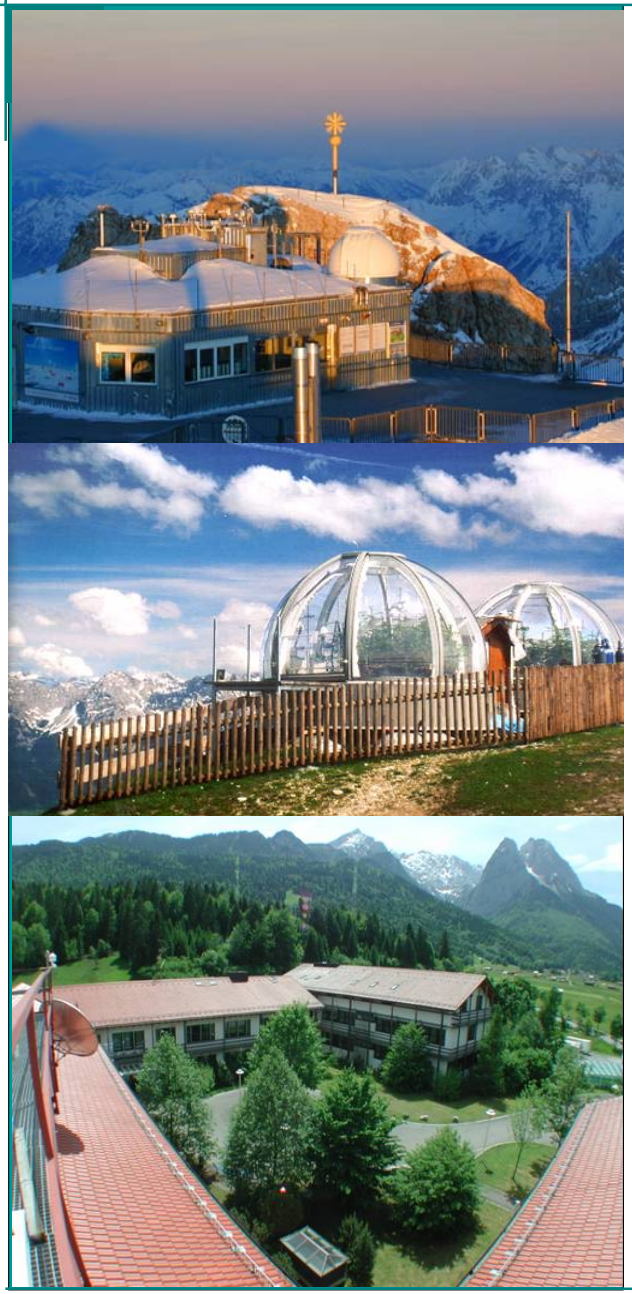

The Need to Link Disciplines in Climate Change Research at Mountainous Regions

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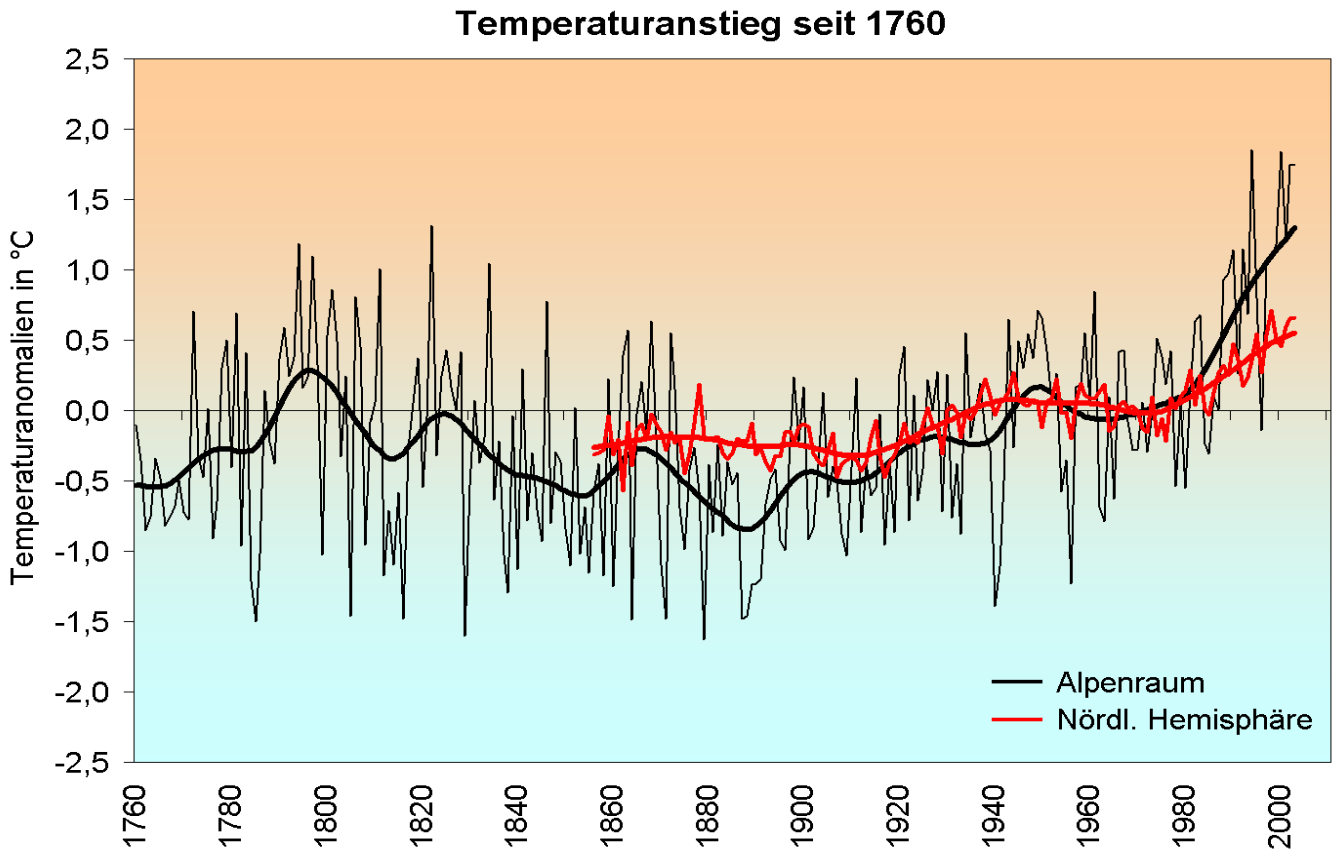
Overview

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

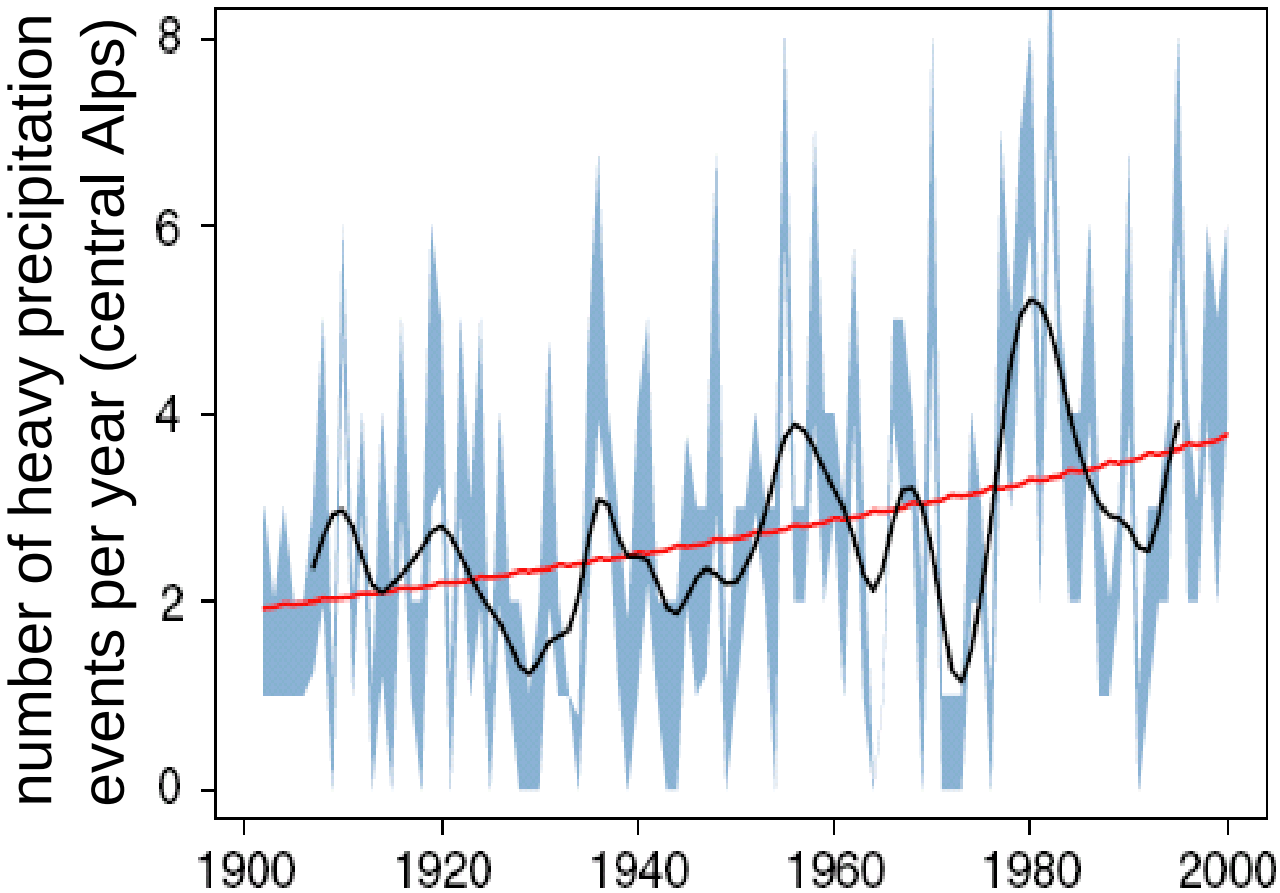
- Temperature
- Precipitation



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

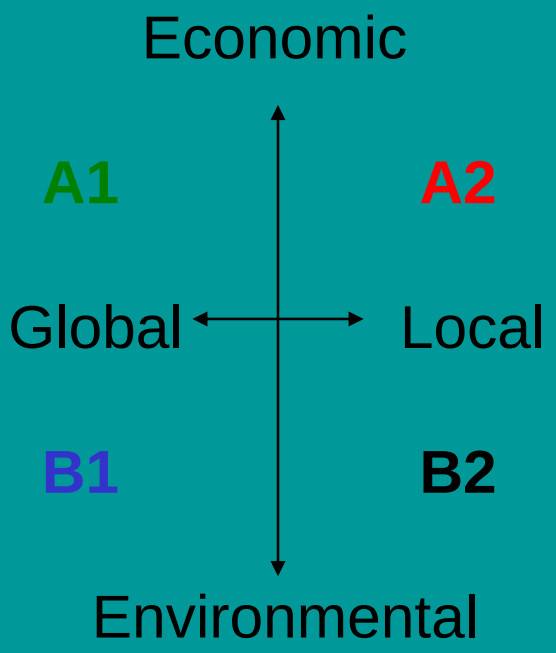
Observed Climate Change in European Mountains

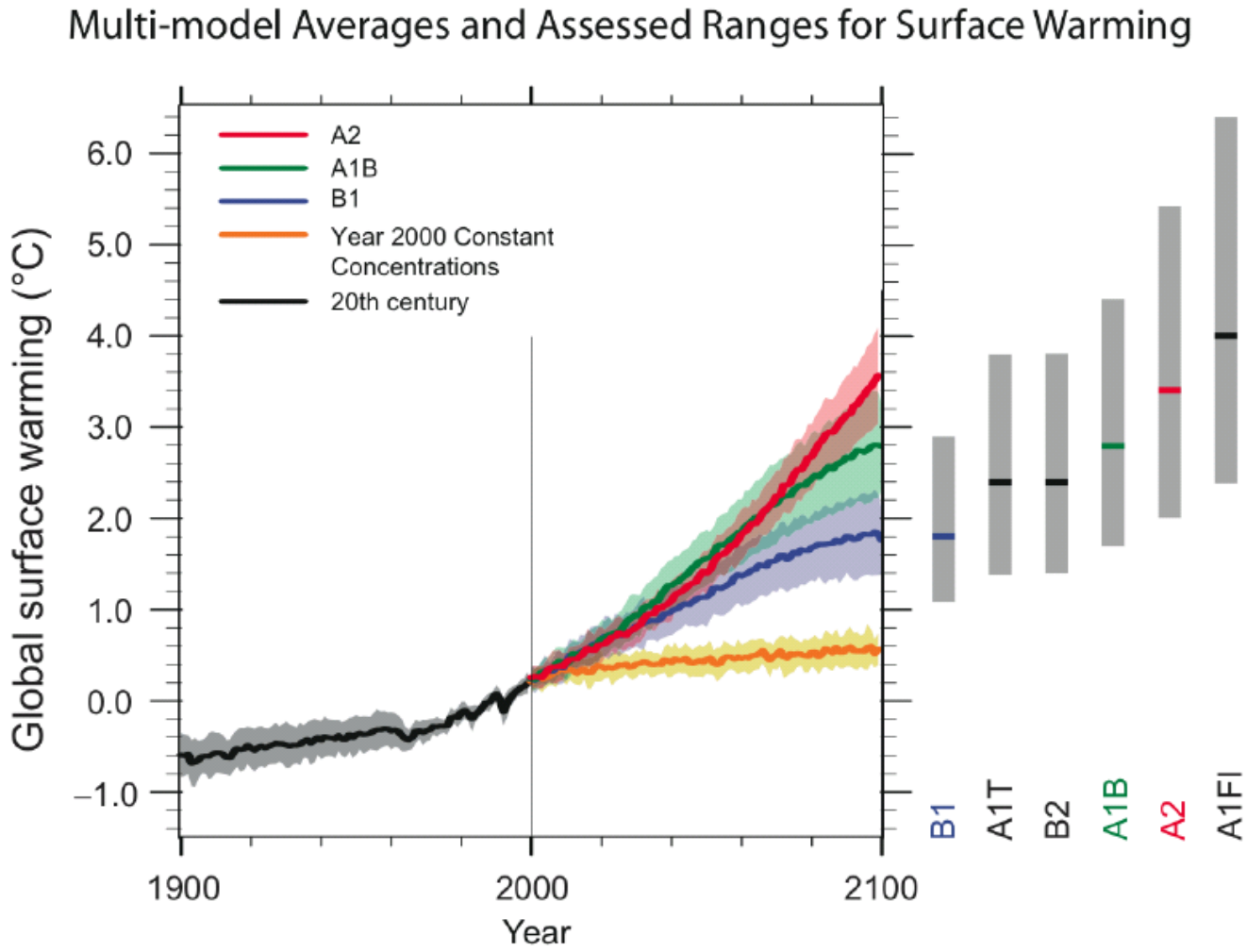
- Temperature
- Precipitation



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





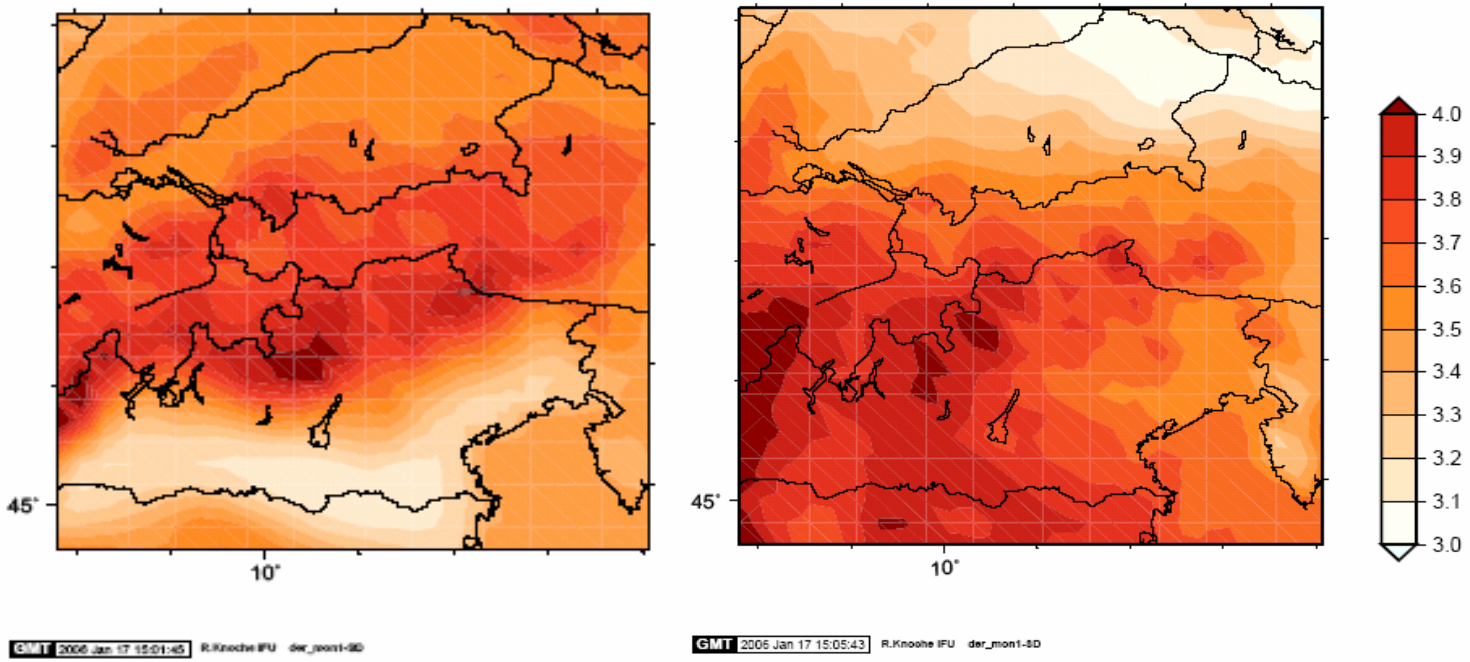
References:
1) IPCC 2007

Projected Climate Change in European Mountains to 2100

- Temperature
- Precipitation

Winter (DJF)

Summer (JJA)

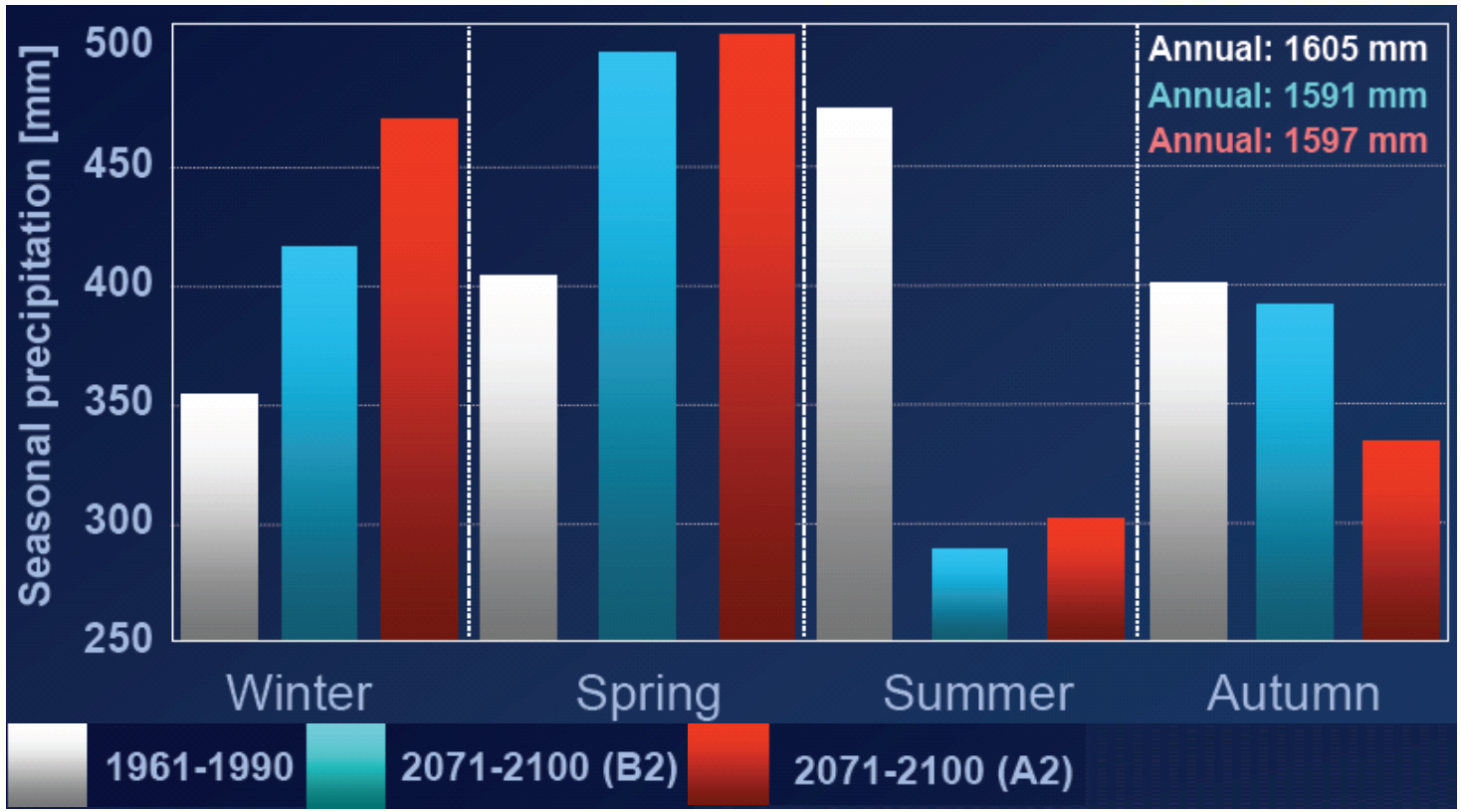


Higher locations → Higher temperature increase !

References:
1) Knoche (IMK-IFU), unpublished

Projected Climate Change in European Mountains to 2100

- Temperature
- Precipitation



Shift from summer into winter and spring!

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

Expected Climate **Impacts**

Climate Change:
Temperature, Precipitation,
Wind speed,…

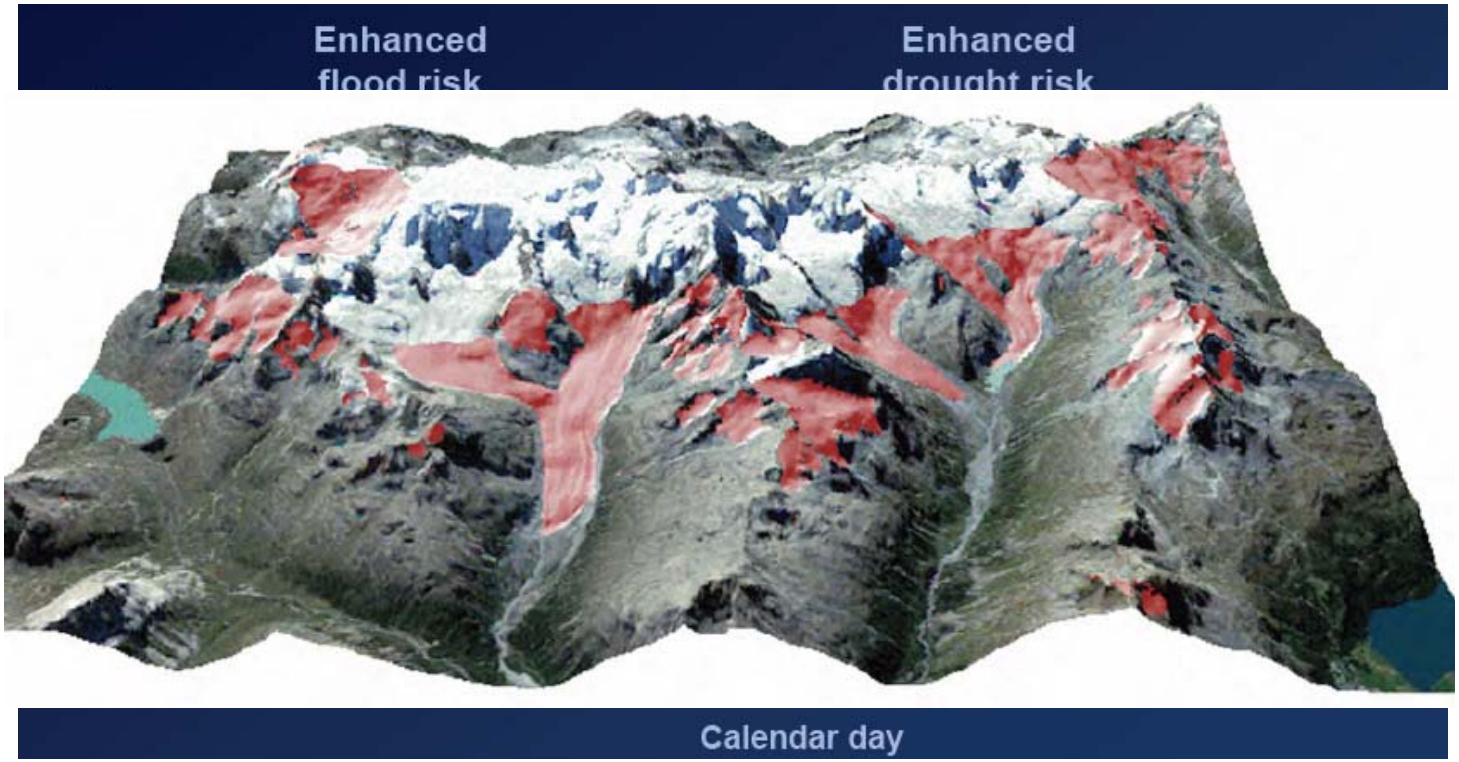
Physical/Chemical Impact:
Glacier Extension, Drought, Runoff,
Permafrost, mass flows, fire,…

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

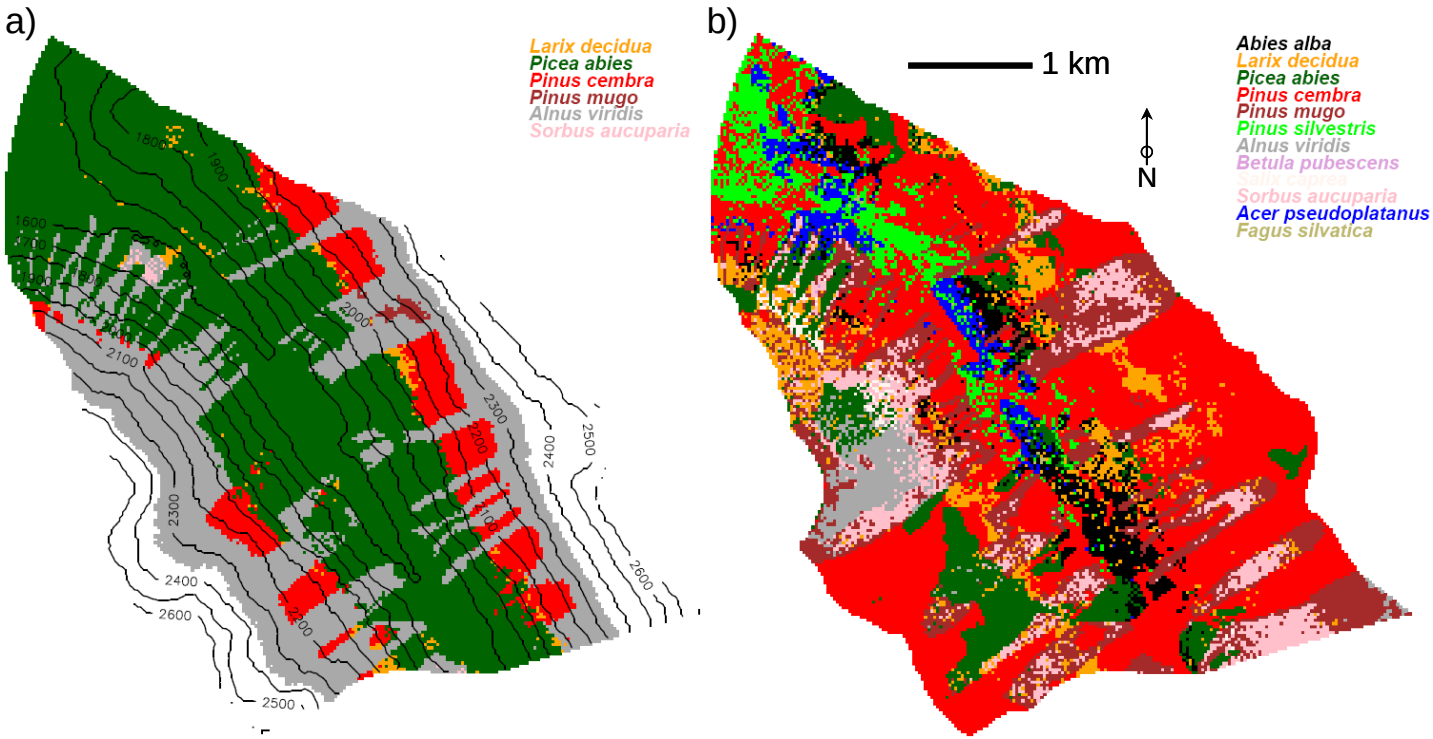


HIRHAM RCM scenario for the central European Alps

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

- Changed ecology
- 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

Expected Climate **Impacts**: Ecology



Current climate — Climate scenario

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).

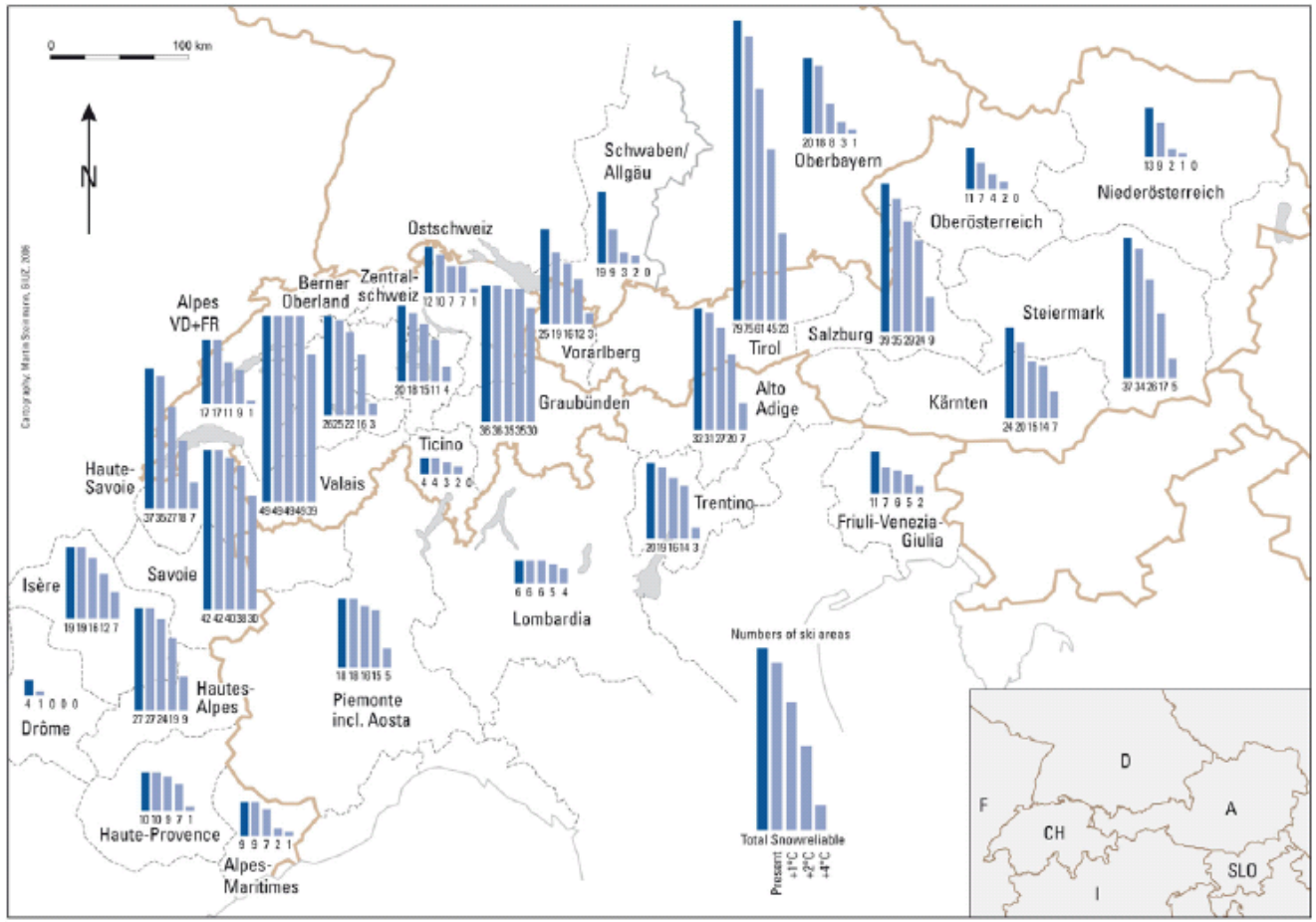
References:

1) Pretzsch, Grote et al. (in press)

Expected Climate **Impacts**:

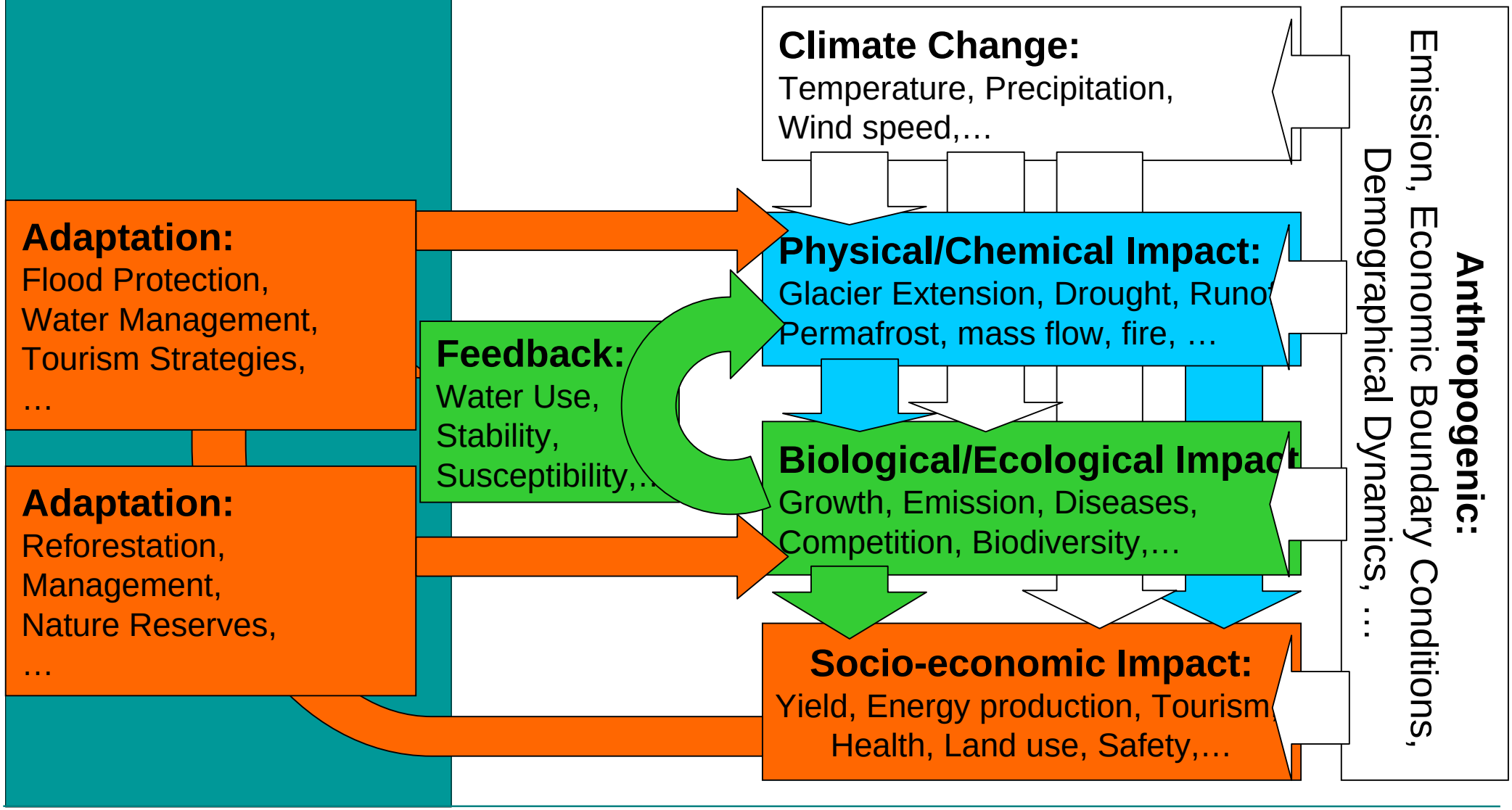
Socio-Economic

- 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

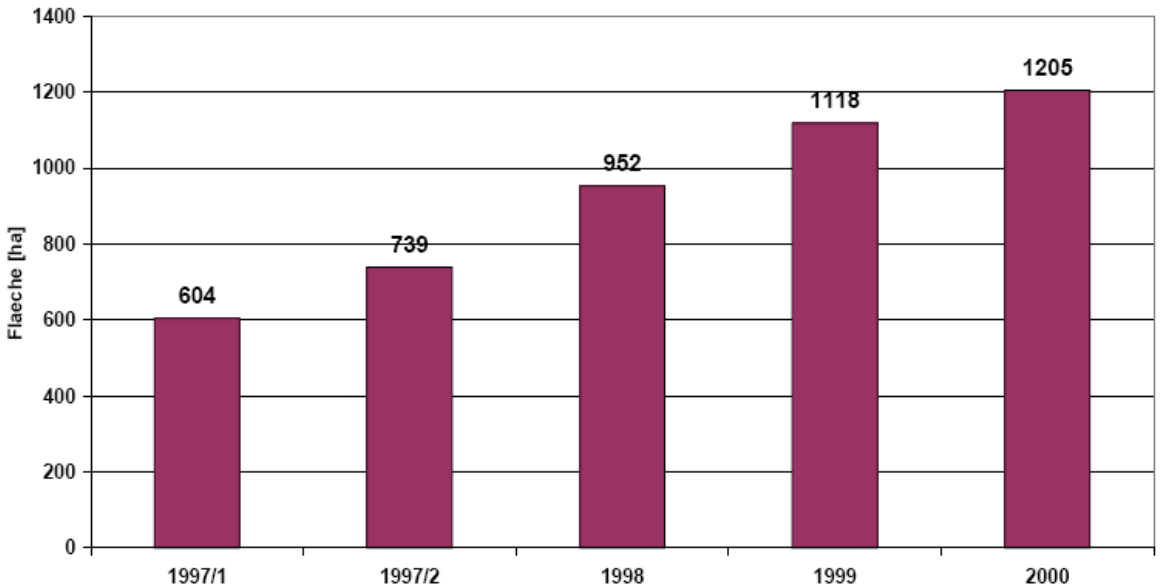
Impacts and Adaptation Responses



- 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

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)]



2)

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

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

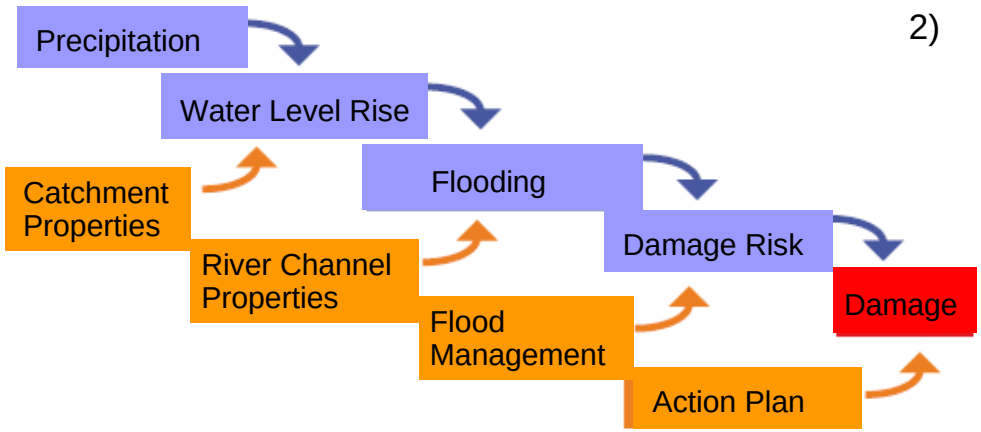
Abbildung 3: Im August 2005 wurde das Hochwasser der Engelberger Aa um das Schadenempfindliche Siedlungsgebiet geleitet. (Quelle: Schweizer Luftwaffe 2005)

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

Responses – Water management

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

2)



Rückhalt im Einzugsgebiet
Aufforstung. Rückhalt in Speicherbecken und Seen, Erhöhung der Infiltration, ...

Bauliche Massnahmen
Vergrösserung des Abfluss-querschnitts. Dämmer, Ufer-schutz, ...

Angepasste Raumnutzung
Ausscheiden von Überflutungs-flächen, Objekt-schutz, ...

Notfallplanung
Vorhersagen, Alarmierung, Evakuationspläne, mobile Schutz-massnahmen, ...

References:

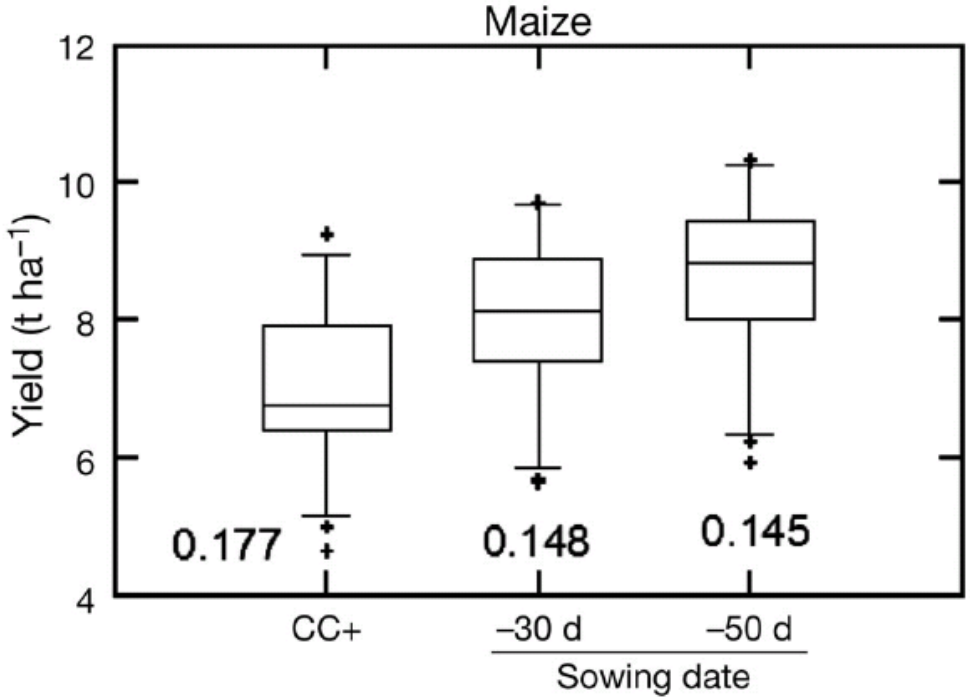
1) "Climate Change and Aspen", report 2006
2) OcCC report (Klimaänderung in der Schweiz 2050) 2007

Abbildung 5: Bei der Ernte von Rundballensilage ergeben sich aufgrund der Klimaerwärmung zusätzliche Erntemöglichkeiten im Früh- und Spätsommer. Teure Spezialmaschinen können so besser ausgelastet werden.
(Quelle: Agroscope ART Reckenholz-Tänikon)

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

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."



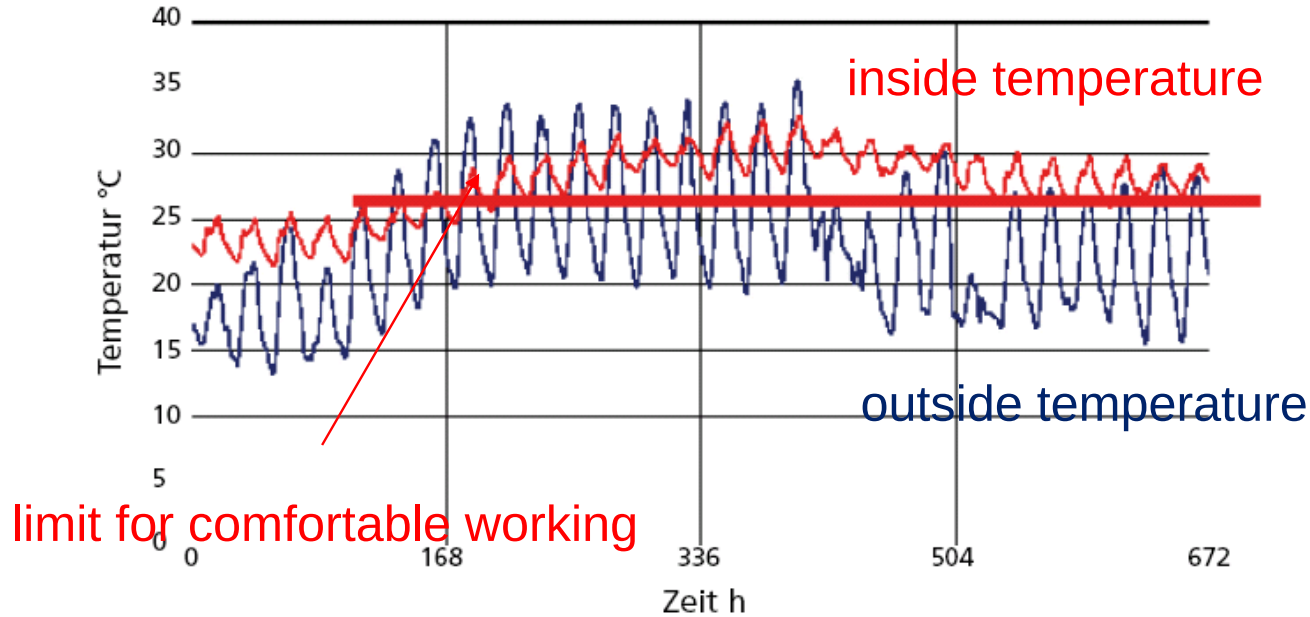
References:
1) Torriani et al. 2007

Abbildung 4: Schneedruck verursacht Hallendacheinsturz, Waldstatt 2006. (Quelle: Thomas Egli)

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

Responses – Health and others

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

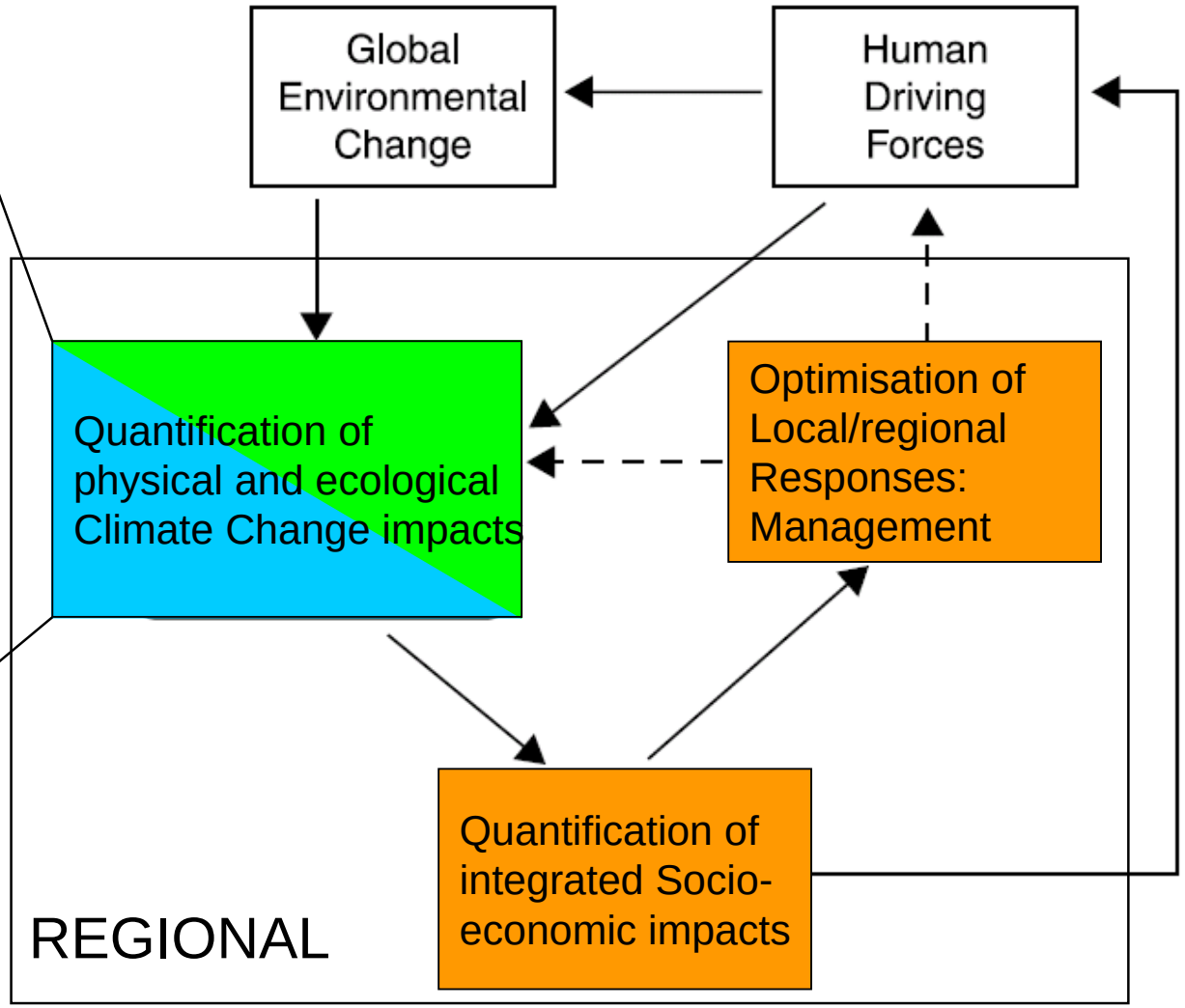


Temperature development inside and outside an office block with high fraction of glass coverage.

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

Research Strategies: Integrated Studies

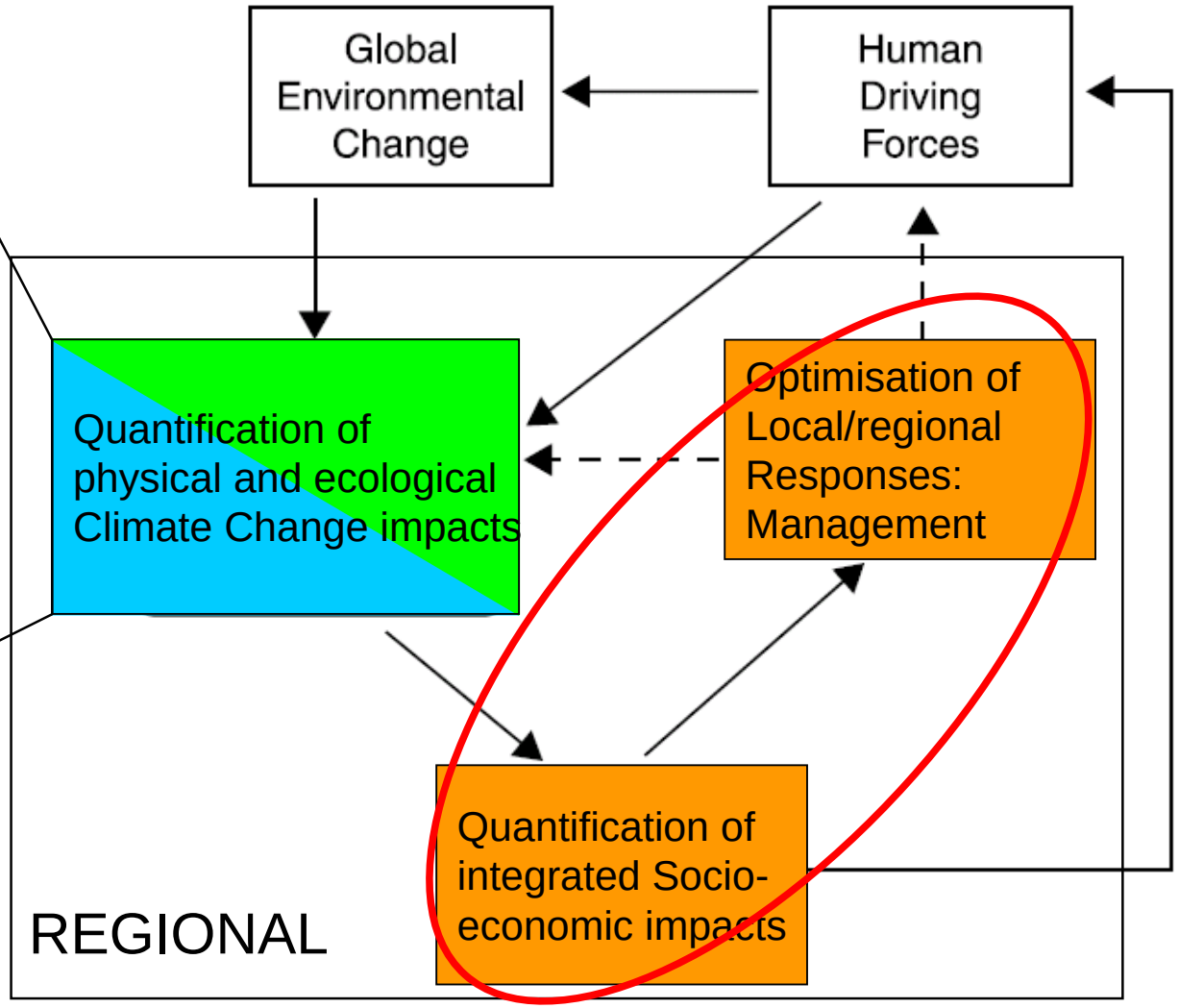
- Observation and indicator analysis
  - -Cryosphere
  - -Terrestrial ecosys.
  - -Freshwater ecosys.
  - -Watershed Hydrology
- Process studies along altitudinal gradients
  - -indicators of ecosys. responses
  - -runoff generation and flowpath dynamics
  - -diversity and ecosys. function



References:
1) modified after Becker & Bugmann 2001 (MRI report)

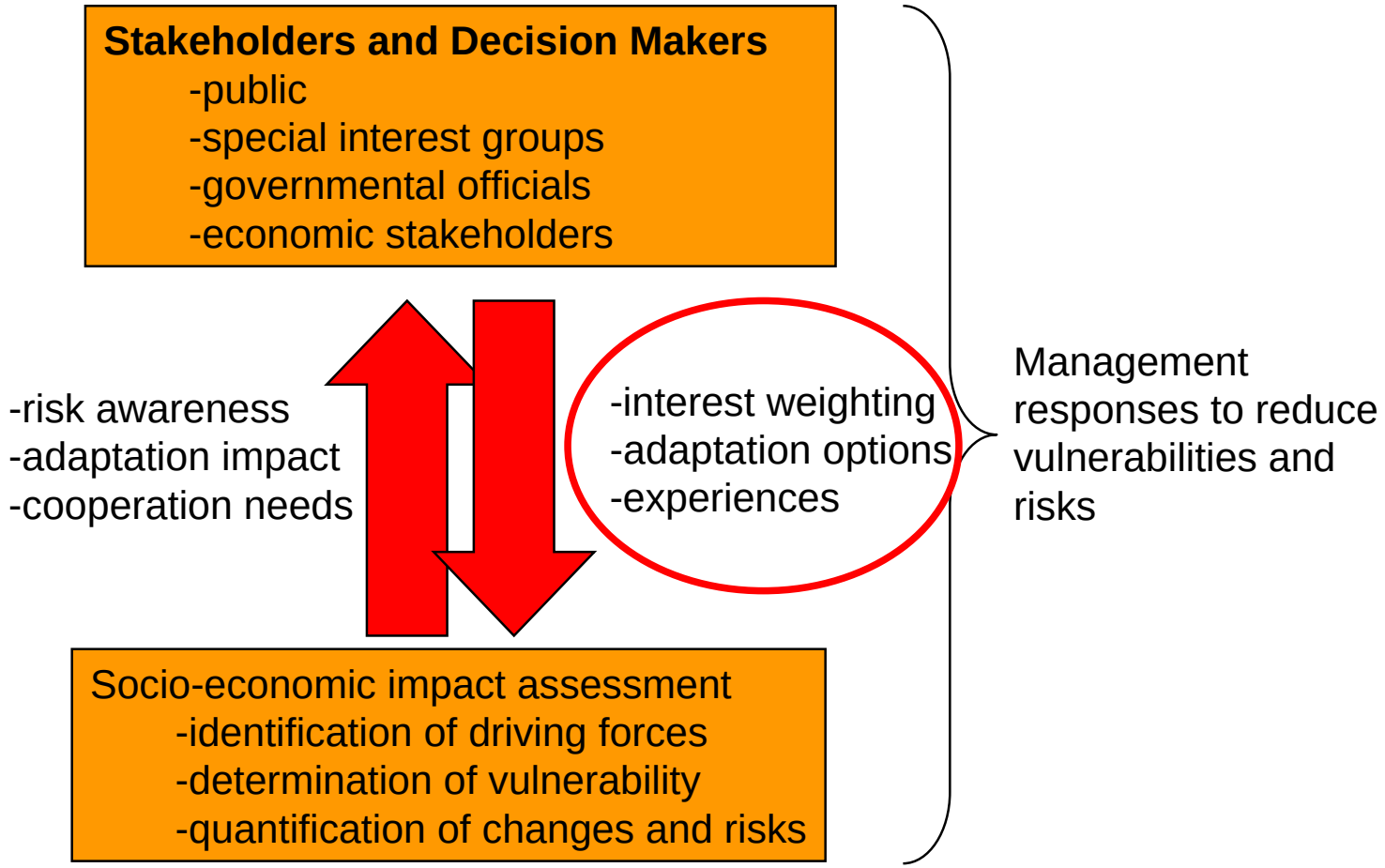
Research Strategies: Integrated Studies

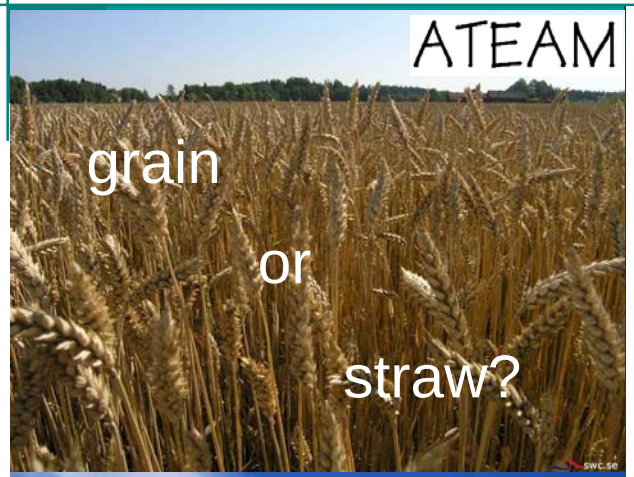
- Integrated model-based studies
  - coupled ecological, hydrological and land use models
  - regional scale models of land-atmosphere interaction
  - integrated analysis



References:
1) modified after Becker & Bugmann 2001 (MRI report)

Research Strategies: Participatory Assessments





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!