



# Global Change Impacts on Mountain Ecosystem Goods and Services:

A simulation study with stakeholder involvement

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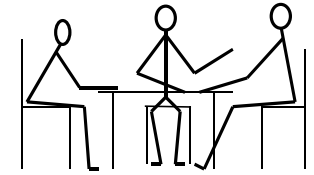
*ETH Zürich, Switzerland*

# Objectives



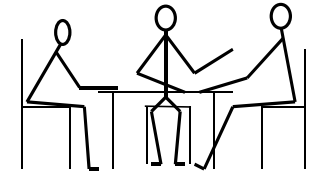
- To assess the impacts of climate and LU change on selected mountain ecosystem goods and services:
    - Sensitivity of ecosystems  
=> use of **mathematical models**
    - Adaptive capacity of human ‘users’  
=> **stakeholder dialogue**
    - End result: vulnerability assessment
- vulnerability =  $f$ (sensitivity, adaptive capacity)**

# Stakeholder dialogue (I)



- First round:  
*via* bilateral discussions in early project phase
  - Aim 1: to learn about the experiences and major concerns of mountain stakeholders
  - Aim 2: to identify the most important mountain ecosystem services and the associated indicator variables
- Second round:  
*via* dedicated workshop in the middle of the project
  - Aim 1: to critically evaluate first (preliminary) research results
  - Aim 2: to discuss a strategy for vulnerability assessment
  - Aim 3: to obtain guidance from the stakeholders for the research in the second half of the project

# Stakeholder dialogue (II)



- Final round:  
bilateral discussions & meetings to evaluate project results,  
took place in last project year

based on flyer and synthesis document

- Aim 1: to critically evaluate research results
  - simulations
  - semi-quantitative assessments (e.g., tourism)
- Aim 2: to provide feedback on
  - adaptive capacity of SHs / sectors
  - sectoral vulnerability

**ETH**  
Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zürich

**Mountain Stakeholder Workshop**  
Sectoral stakeholder dialogue activity in ATEAM  
Kappel am Albis, Switzerland, Monday 4<sup>th</sup> to Tuesday 5<sup>th</sup> November 2002

Organised by  
ETHZ, Mountain Forest Ecology Group, Zürich, Switzerland  
Potsdam Institute for Climate Impact Research, Potsdam, Germany

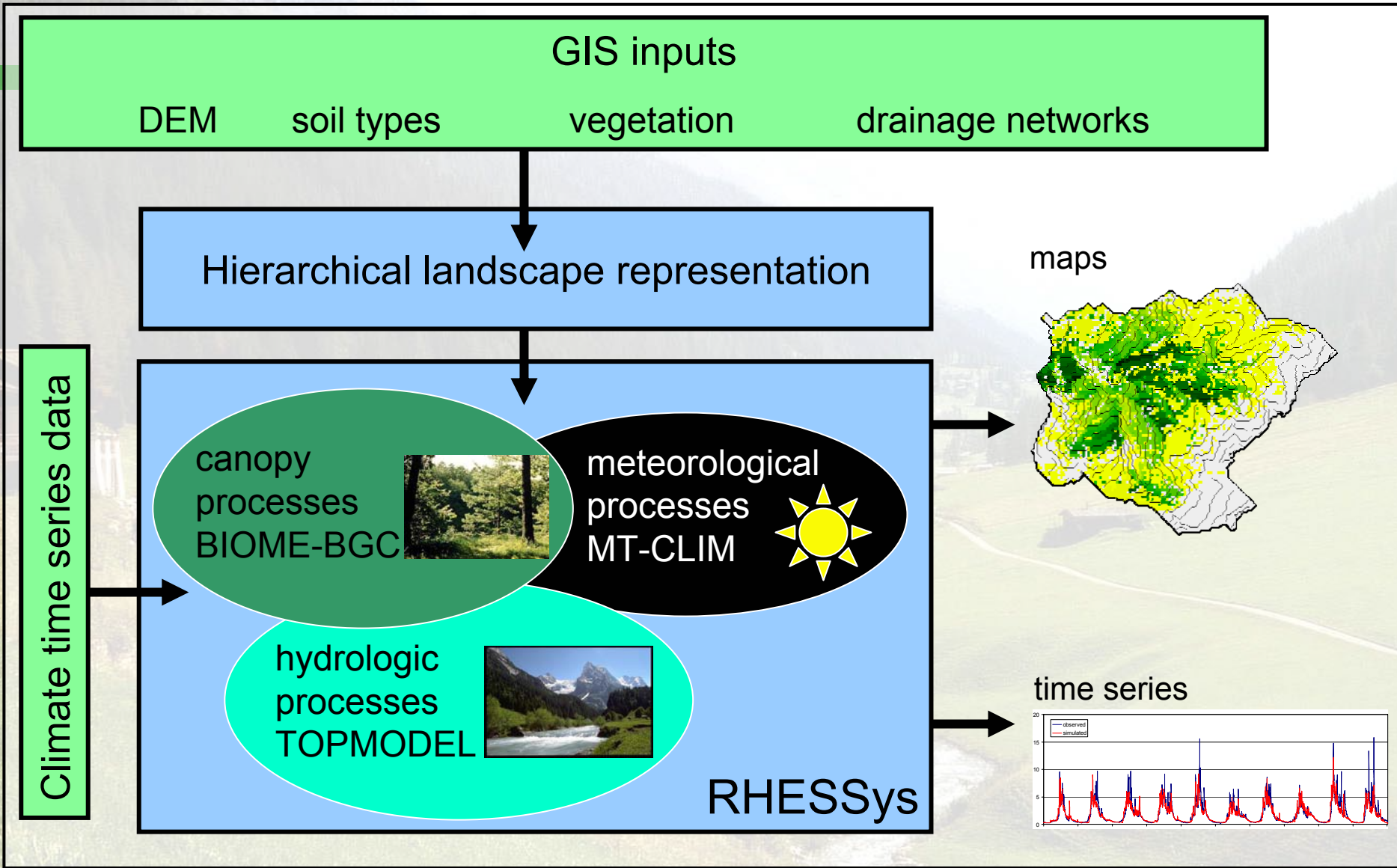
Rapporteurs: Bärbel Zierl & Dagmar Schröter

# Case studies: Location





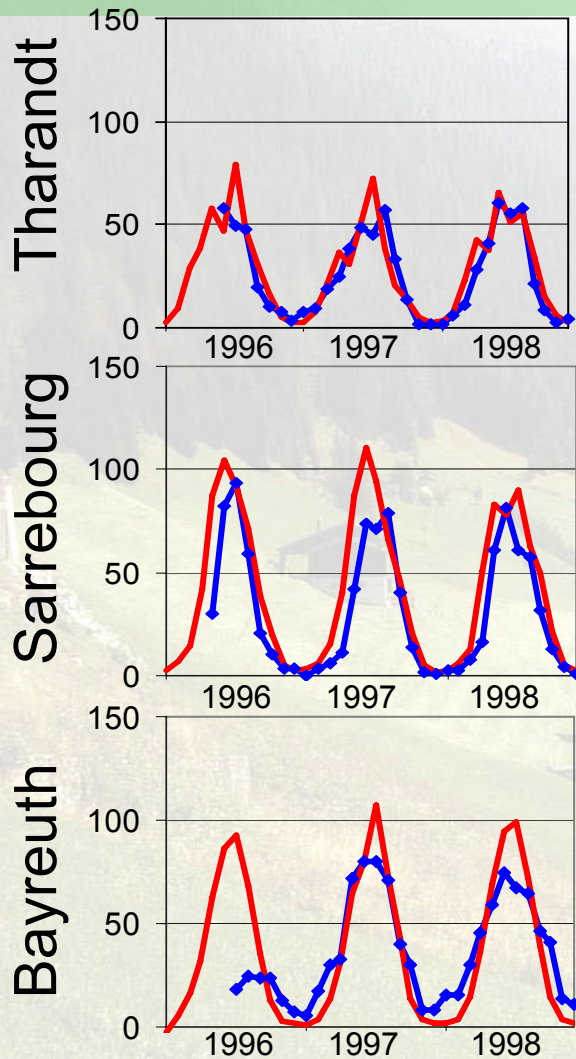
# RHESSys: Regional Hydro-Ecological Simulation System



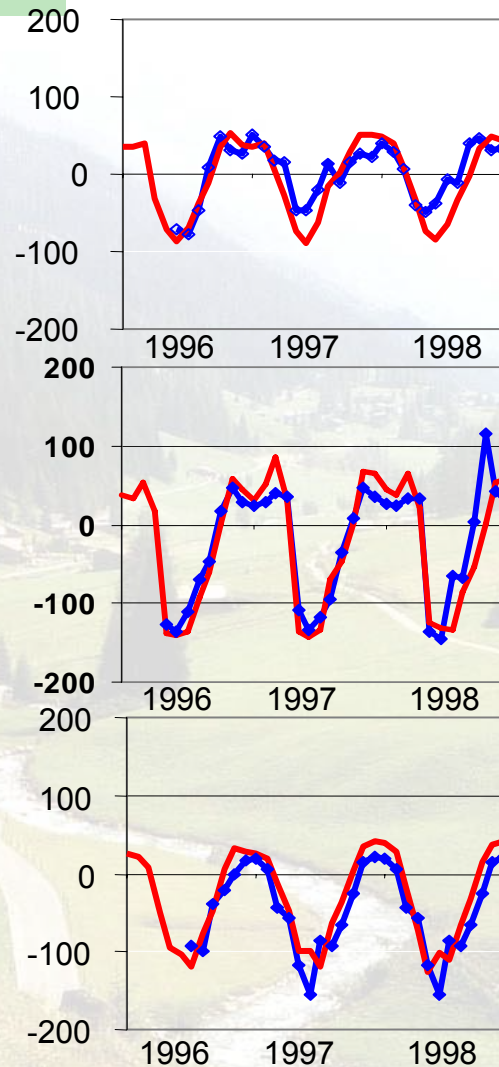
# Example of model evaluation

AET in [mm month<sup>-1</sup>]; NEE in [g m<sup>-2</sup> month<sup>-1</sup>]

## Evapotranspiration



## Net Ecosystem C Exchange



— simulated  
— observed

(Morales et al. 2005)



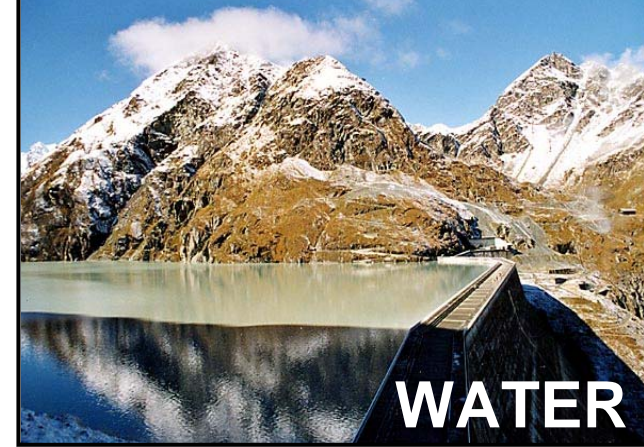


# Scenarios



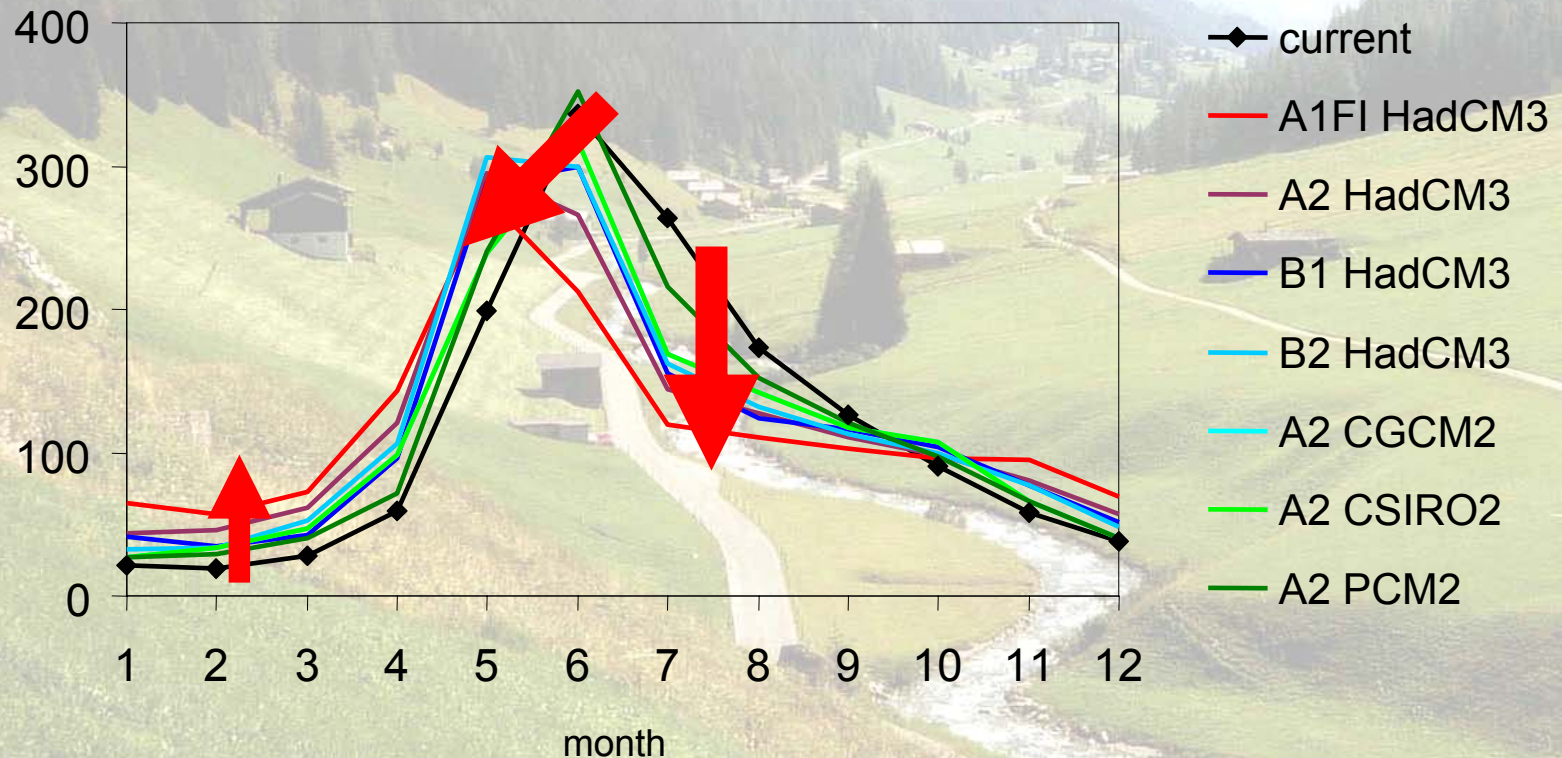
- Variables: CO<sub>2</sub>, climate and land use change
- Derived in the context of the EU 6th FP Project “ATEAM” (Advanced Terrestrial Ecosystem Analysis and Modelling), coordinated by PIK Potsdam
- Partners:
  - T. Carter et al. (Finland): climate
  - M. Rounsevell et al. (Belgium): land use
- Based on IPCC SRES “storylines”
  - 4 SRES scenarios
  - 4 GCMs
  - Internally consistent (socio-economics, CO<sub>2</sub>, climate, land use)
- Downscaled to catchments

# Runoff regime



Dischma valley, 2051 - 2080

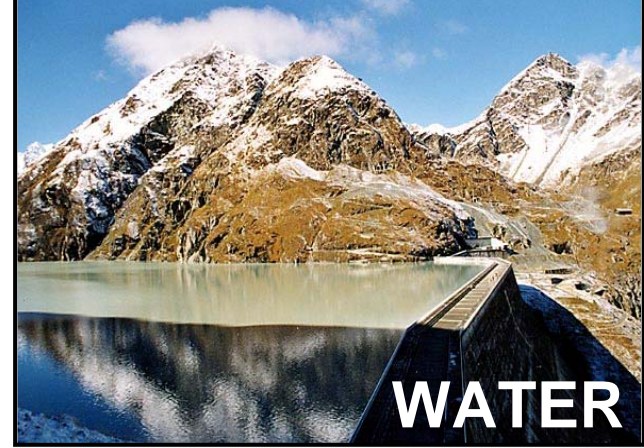
Comparison of scenarios [mm·month<sup>-1</sup>]



# Water supply: conclusions

Redistribution of discharge in the course of the year

- slightly reduced annual discharge
- strongly reduced summer discharge (irrigation, drinking water)
- higher winter discharge (hydropower)
- earlier peak streamflow in spring
- decrease of maximum *monthly* discharge
- little effect of land use scenarios compared to climatic effects



# Stakeholder responses

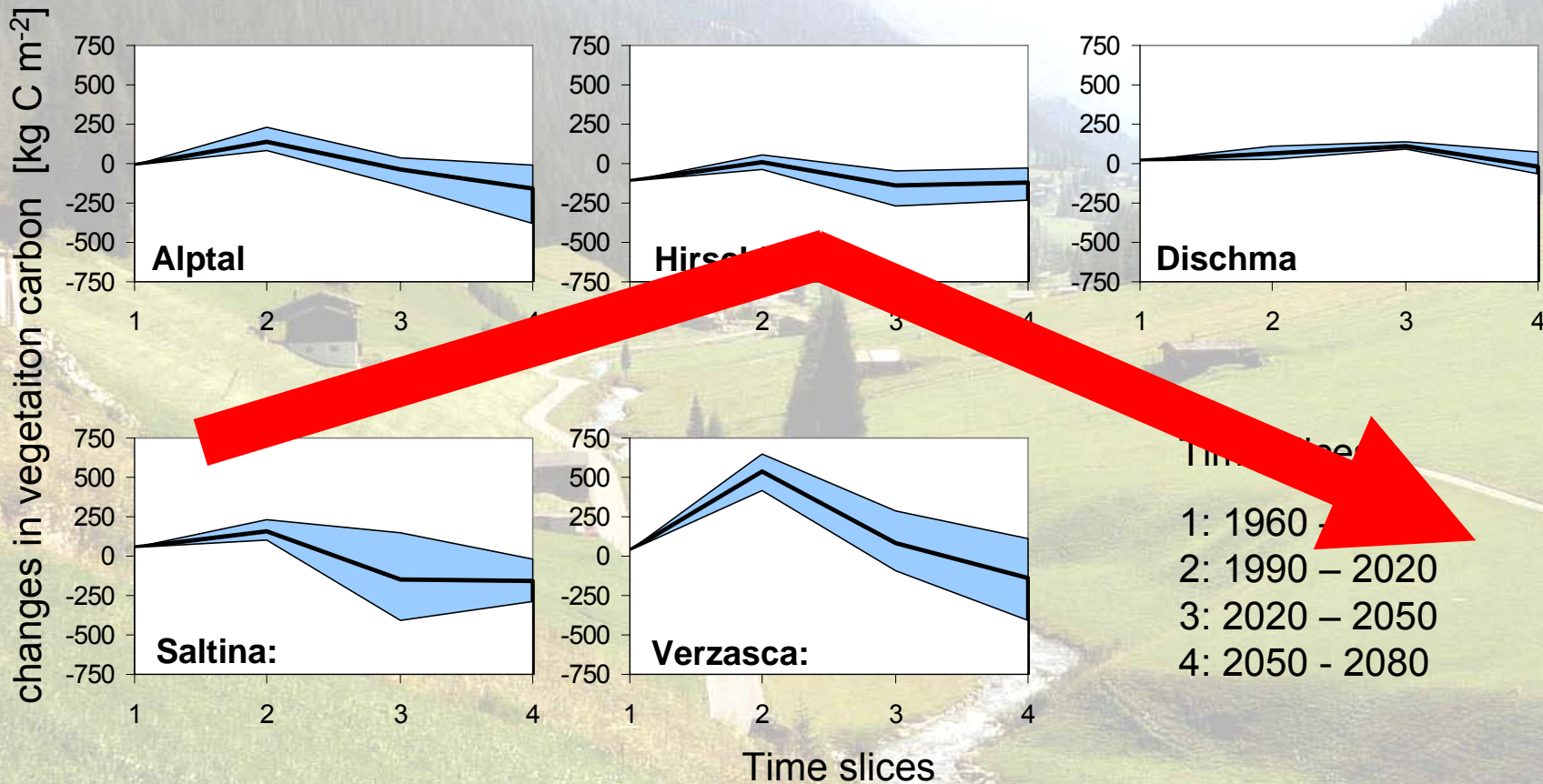
- Annual changes matter little, seasonality is key
- Different 'water stakeholders' have different interests, different sensitivity, different adaptive capacity:
  - hydropower generation (mainly winter; but also summer – cf. 2003!):
    - ◆ relatively high sensitivity
    - ◆ low adaptive capacity (increasing dam heights?)
  - drinking water (year-round):
    - ◆ low sensitivity within/near Alps, but higher sensitivity downstream
    - ◆ adaptive capacity not discussed further
  - irrigation (summer; particularly in Mediterranean/other dry areas):
    - ◆ relatively high sensitivity (summer drought, cf. 2003)
    - ◆ limited adaptive capacity (increased storage)



# All catchments: $\Delta$ veg C [kg m<sup>-2</sup>]



**CARBON**



# Carbon storage: conclusions

Dominance of land use over climatic signal in results in most catchments

- vegetation carbon at high elevations profits from warming climate throughout most of the 21<sup>st</sup> century
- vegetation carbon at low elevations decreases
- for several decades no strong difference between scenarios



# Stakeholder responses

- Importance of service increasingly recognized
- SHs expected that LU changes are more important than climate, ⇒ our results lead to a differentiated view: scenario & region matter
- Relevance of natural disturbances (fires, insects, etc.) for C storage ⇒ not considered in our study
- Projected changes beneficial from Kyoto point of view for 1st half of 21<sup>st</sup> century  
Potentially problematic regarding landscape aesthetics?  
Overall
  - medium sensitivity
  - low adaptive capacity
  - medium vulnerability



**CARBON**

# Sensitivity of ecosystem services





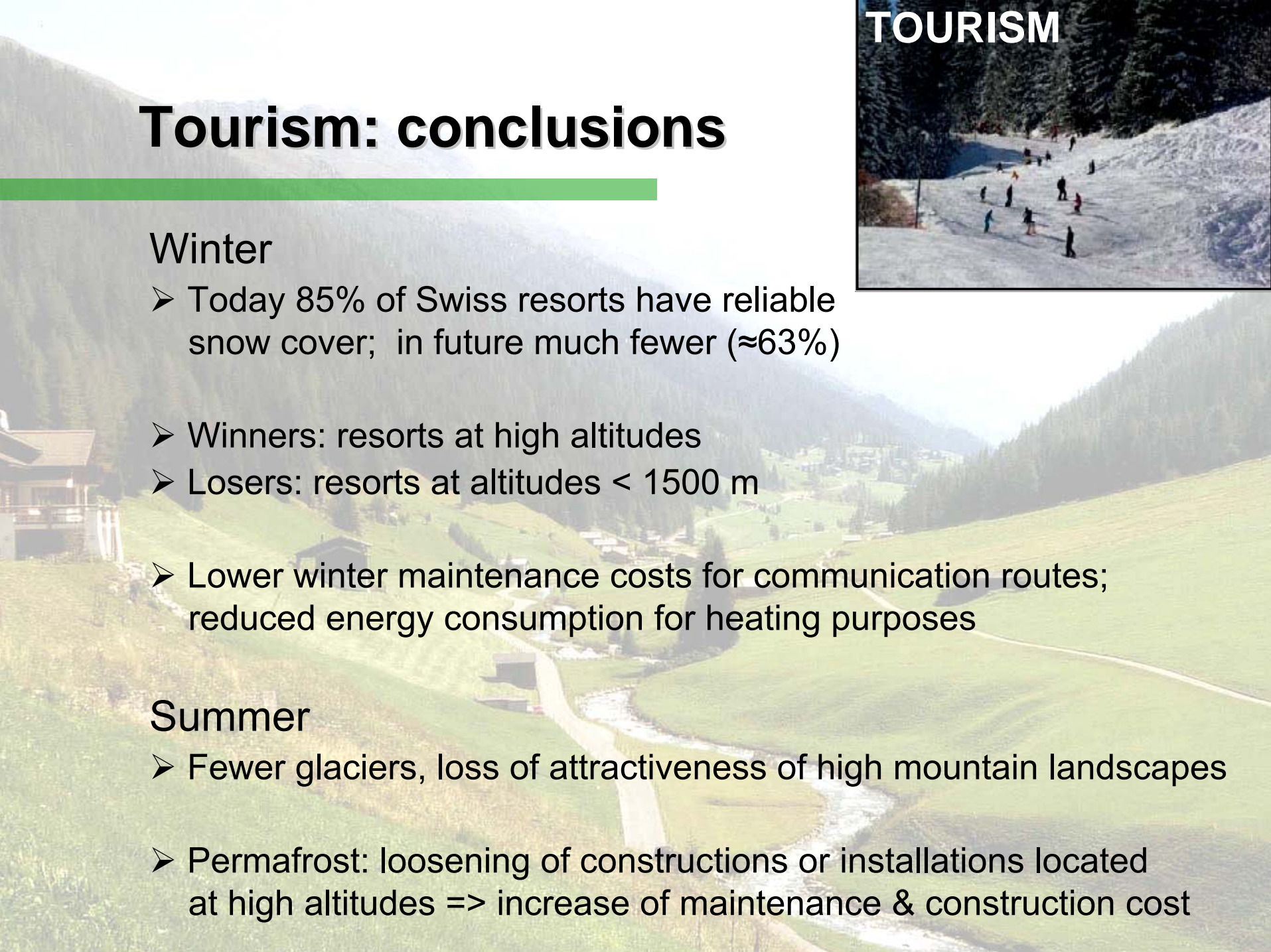
# Tourism: conclusions

## Winter

- Today 85% of Swiss resorts have reliable snow cover; in future much fewer ( $\approx 63\%$ )
- Winners: resorts at high altitudes
- Losers: resorts at altitudes  $< 1500$  m
- Lower winter maintenance costs for communication routes; reduced energy consumption for heating purposes

## Summer

- Fewer glaciers, loss of attractiveness of high mountain landscapes
- Permafrost: loosening of constructions or installations located at high altitudes => increase of maintenance & construction cost



# Stakeholder responses

- The SH discussions changed our views!
- Infrastructure (getting there, getting back) is most important => safety from natural hazards is the *primary* concern
- Tourism & recreation rely on a wide range of ecosystem services (freshwater, snow, landscape aesthetics, natural hazards), is *secondary* to these services!
- Serious concerns regarding the impacts of global change on tourism, particularly in winter (hazards-related, not snow-making)
  - high sensitivity
  - low to medium adaptive capacity
  - medium to high vulnerability



# Conclusions



- High sensitivity of mt ecosys services to GC
  - short term (10-50 yrs) vs. long-term (>80 yrs) responses
- Stakeholder dialogue
  - important for shaping design of project
  - useful for providing “real-world” perspective for science
- Adaptive capacity and vulnerability
  - varies by service and by region
  - water: fairly high vulnerability (undesired changes, adaptive capacity low), depends on specific use of water
  - carbon: medium vulnerability (partly desired changes!)
  - tourism: in winter high, in summer low vulnerability (but not for the reasons we thought)

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Thank you for your attention!

visit <http://www.fe.ethz.ch>  
<http://www.pik-potsdam.de/ateam>