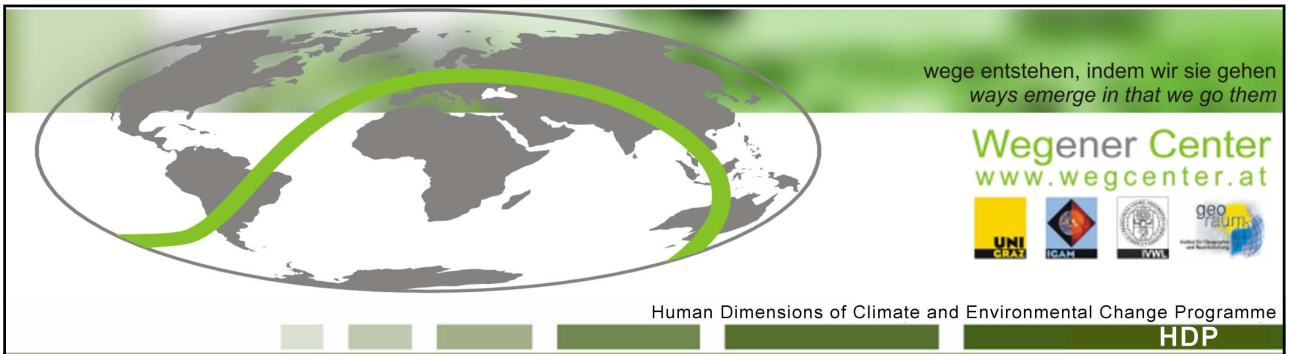

A model interface to analyse climate change impacts and adaptation for a NUTS III region in Austria

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Introduction

- Efficient emission reduction level can only be determined by comparing global costs of climate change and global costs of mitigation
- The quantification of the costs of climate change itself is inherently a local question
- Regions are diverse, in climate change impact, vulnerability and adaptation options to climate change
- A global figure on climate change costs thus needs to be ultimately built bottom-up

Introduction

- Existing research on climate change damages has so far focused mainly on the global scale
- There is only little literature on climate induced damages on the local scale
- Global modelling approaches generally involve only a few sectors, and sectoral interdependencies may not sufficiently be assessed

Introduction

- Good example is agriculture: adaptation measures depend on many factors such as climate, soil and socio-economic circumstances
- The assessment of costs of adaptation seems reasonable to be carried out at the regional scale
- A regionalised CGE model allows for modelling sectoral linkages and for quantifying direct and indirect impacts

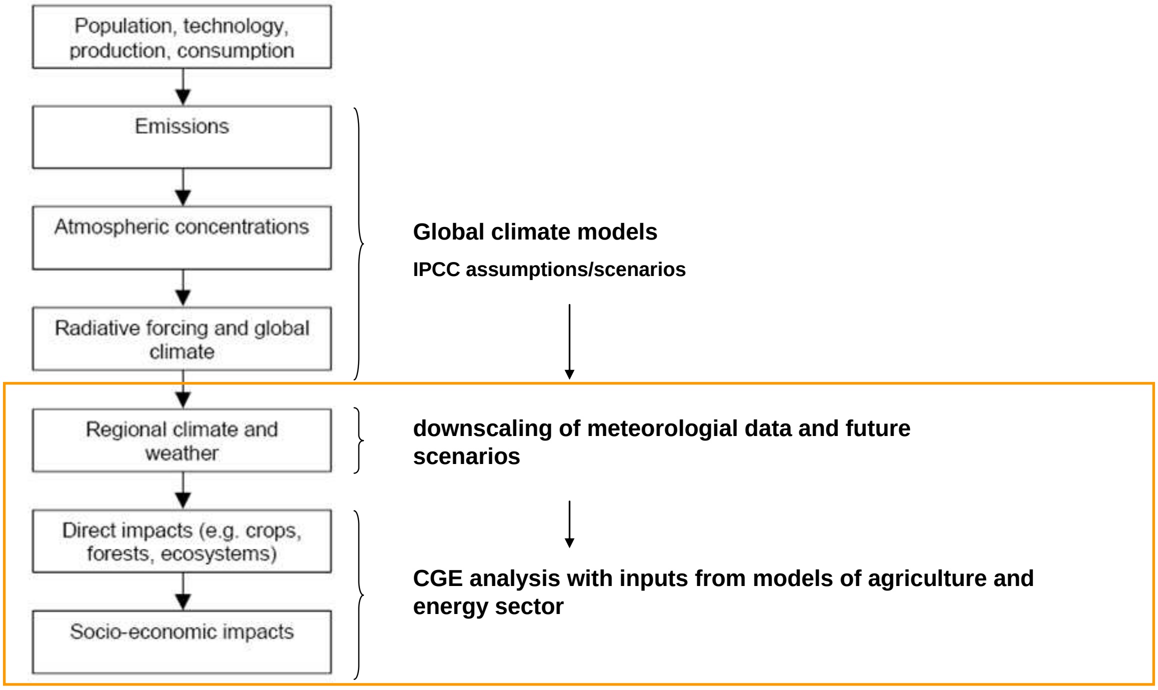
Test site

- An Austrian rural region „Eastern Styria“ at NUTS III level will serve as test site to study climate impacts and adaptation.
- In doing so, the focus is on two sectors which are particularly vulnerable to climate change: agriculture and energy.

Coupled modelling

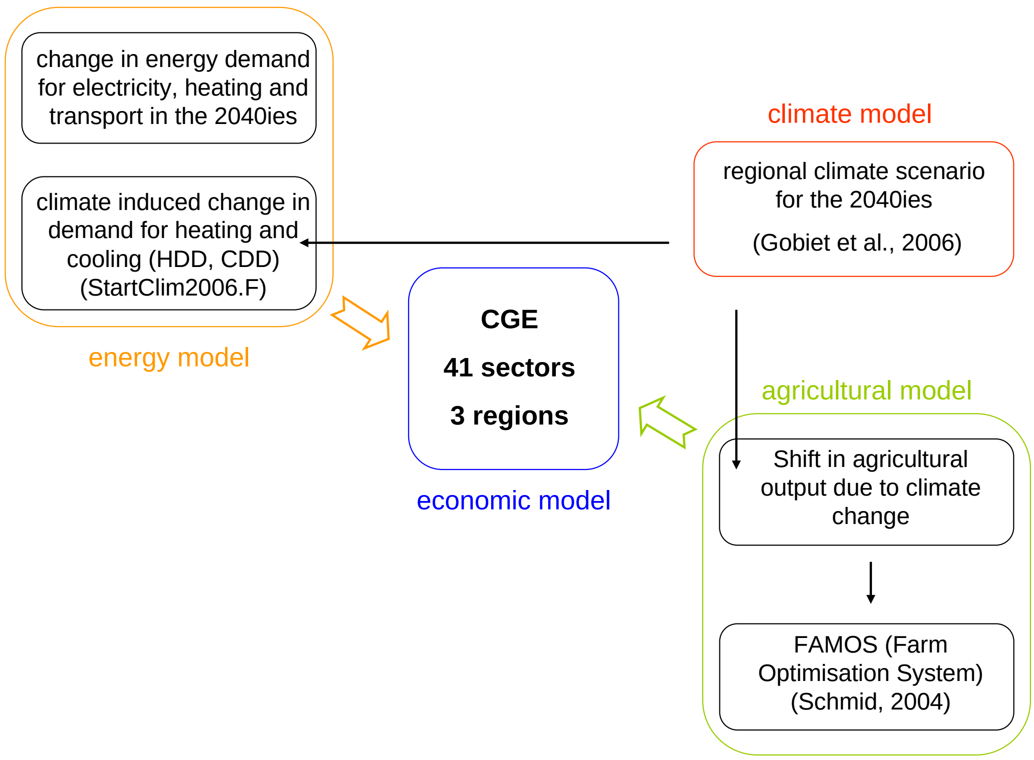
- Regional economic modelling of adaptation and mitigation
- Regional climate scenario
- Sectoral analysis and model coupling: Agriculture
- Sectoral analysis and model coupling : Energy
- Results for autonomous adaptation
- Results for policy-induced adaptation
- Results for mitigation

Coupled Modelling (1)



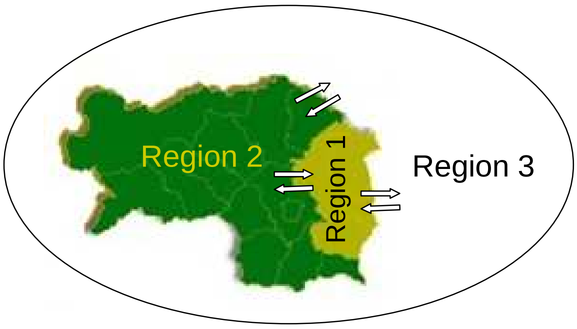
Source: extended from Hope (2005)

Coupled Modelling (2)



Regional Economic Model (2)

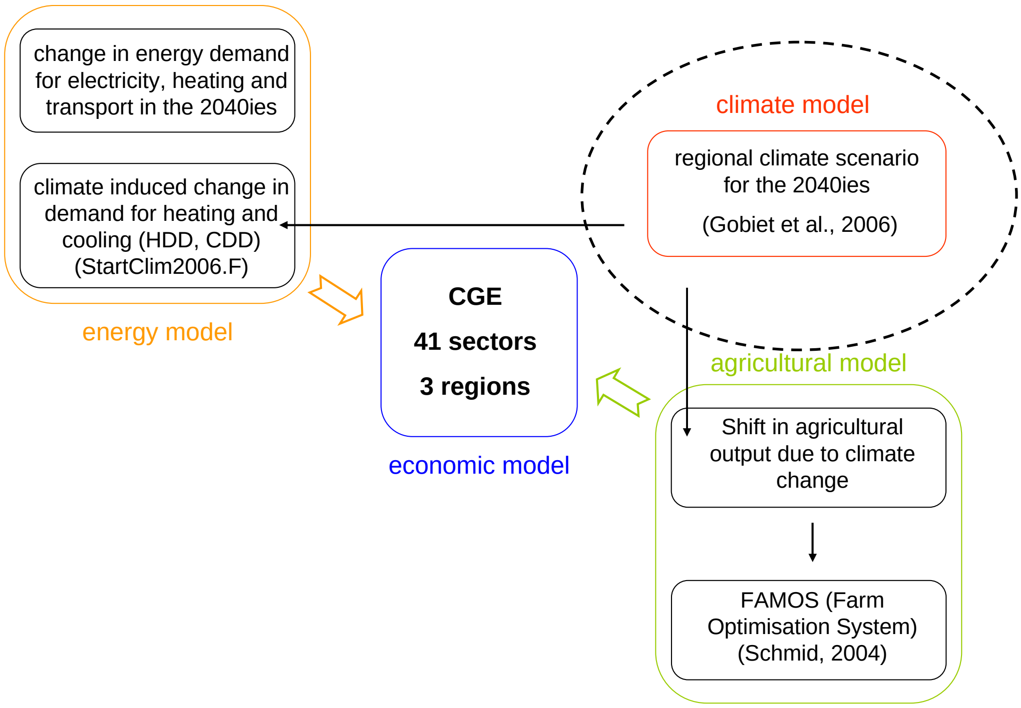
- 3 region CGE model
- database: regional Input-Output Tables of 2003 for
  - region 1 (Eastern Styria) and region 2 (Rest of Styria)
  - linked by trade flows (regional trade, global trade)
- 41 sectors
  - thereof 6 energy sectors:
    coal, diesel, other oil products (incl. gasoline and fuel oil), district heating , electricity, gas



Simulations

1. Business as usual scenario for 2045 (**BAU**)
   - without climate change
2. Scenario with climate change and autonomous adaptation (**Reference**)
   - changed output & managerial optimization by farmers (*agriculture*)
   - shift in energy demand for heating and cooling (*energy*)
3. Reference scenario and policy-induced **adaptation**
   - enhanced mixed cultivation of crops (*agriculture*)
4. Reference scenario and **mitigation**
   - increase in reconstruction rate (*energy*)
   - passive house standard for new dwellings (*energy*)
   - bio-energy (*agriculture, energy*)

Climate Scenario (1)

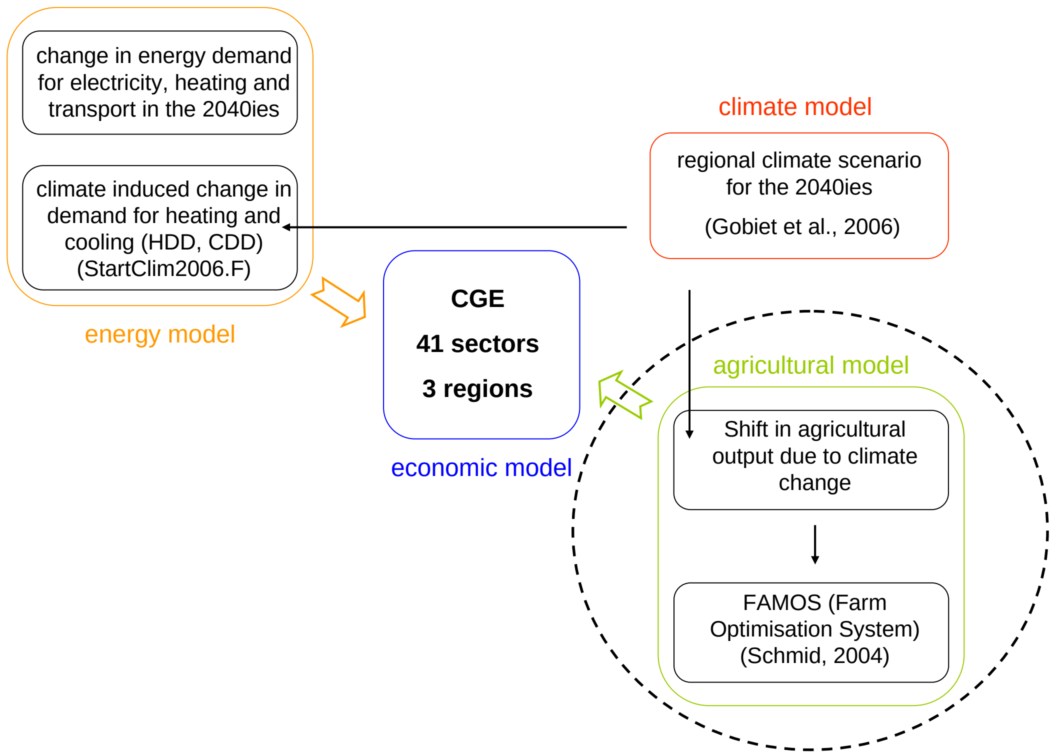


Climate Scenario (2)

Highly resolved climate scenario for Eastern Styria

- climate change signal derived from recent climate scenario for Alpine region (Gobiet et al., 2006) for Region Eastern Styria
- reference period: 1981-1990
- target period: 2041-2050
- meteorological data for each district of study region. Key parameters of
  - temperature
  - precipitation

Agriculture: Model Coupling (1)



Agriculture: Model Coupling (2)

- The sectoral analysis in agriculture includes six crops which cover some 60% of the agricultural land in SE Styria (comprising arable land and grass land).
- These crops include (i) grain maize, (ii) green maize and silage maize, (iii) soft wheat, (iv) winter barley, (v) meadows mown several times and (vi) oil squash.

Agriculture: Model Coupling (3)

Estimation of physical output shift in agriculture (for Reference)

- Method: multiple linear regression for Eastern Styria (1995-2006)
  - 6 crops
  - data: agricultural output & meteorological data (temperature, precipitation) at district level
- Projection to 2040ies
  - based on climate scenario

change in output [dt/ha]					
grain maize	green maize & silage maize	winter soft wheat	meadows mown several times	barley	oil squash
-4,5%	-6,6%	-3,4%	-31,0%	-3,1%	+11,0%

Managerial optimisation by farmers facing these changes (for Reference)

- Method: agricultural model FAMOS (Schmid, 2004) estimates farmers'
  - operating income
  - production level
  - input structure

	operating income	production level	machines	fertilizers & plant protection	labour	land
	[Euro]	[Euro]	[Euro]	[Euro]	[labour unit hours]	[Euro] - shadow price
Feldbach	-4,6%	-3,3%	-5,0%	-21,2%	+0,5%	-7,3%
Fürstenfeld	-0,2%	-0,2%	+0,4%	-5,2%	-0,4%	-0,1%
Hartberg	-4,8%	-2,8%	-9,1%	-25,9%	-2,0%	-6,0%
Radkersburg	+0,5%	+1,3%	-2,9%	-12,9%	-0,3%	-2,7%
Weiz	-5,3%	-2,6%	-9,8%	-25,7%	-1,7%	-4,4%

Agriculture: Model Coupling (4)

Responses of agricultural output to elevated CO_2

- **Increase in plant biomass and yield for C3 and C4 plants for different CO_2 levels**
- **Values used for crops in SE Styria**

increase in crop yields [for elevation of CO_2 level]		
	Kimball et al. (2002) [+100%]	Gifford (2004), Long et al. (2004), Ainsworth and Long (2005) [+45%]
C3 plants	10-15% [a)]	10-20%
C4 plants	7 % and above [b)]	0-10%

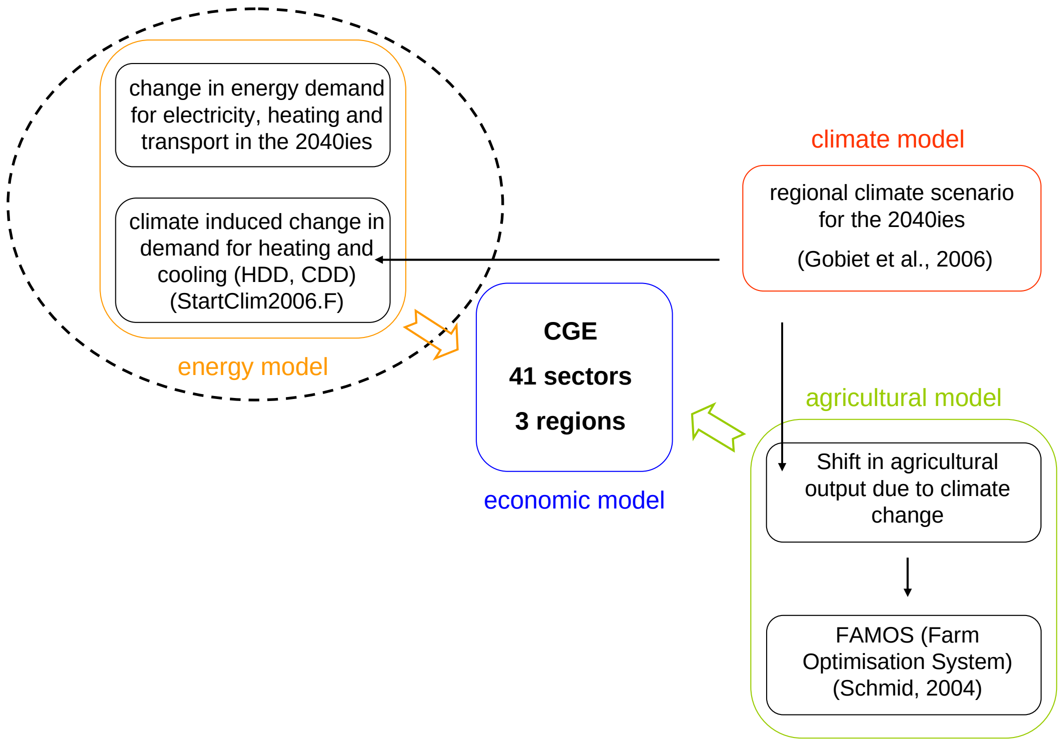
a) 12% for C3 grasses; 10-15% for wheat

b) 7% with limited nutrient supply; above 7% with limited water supply

increase in crop yields [for elevation of CO_2 level]	
	STERN.AT [+30%] [c)]
C3 plants	
winter soft wheat	6,88%
barley	6,88%
C4 plants	
grain maize	2,87%
silage and green maize	2,87%
other	
meadows mown several times	0%
oil pumpkin	0%

c) according to the IS92a scenario (period 2003-2045)

Energy: Model Coupling (1)



Energy: Model Coupling (2)

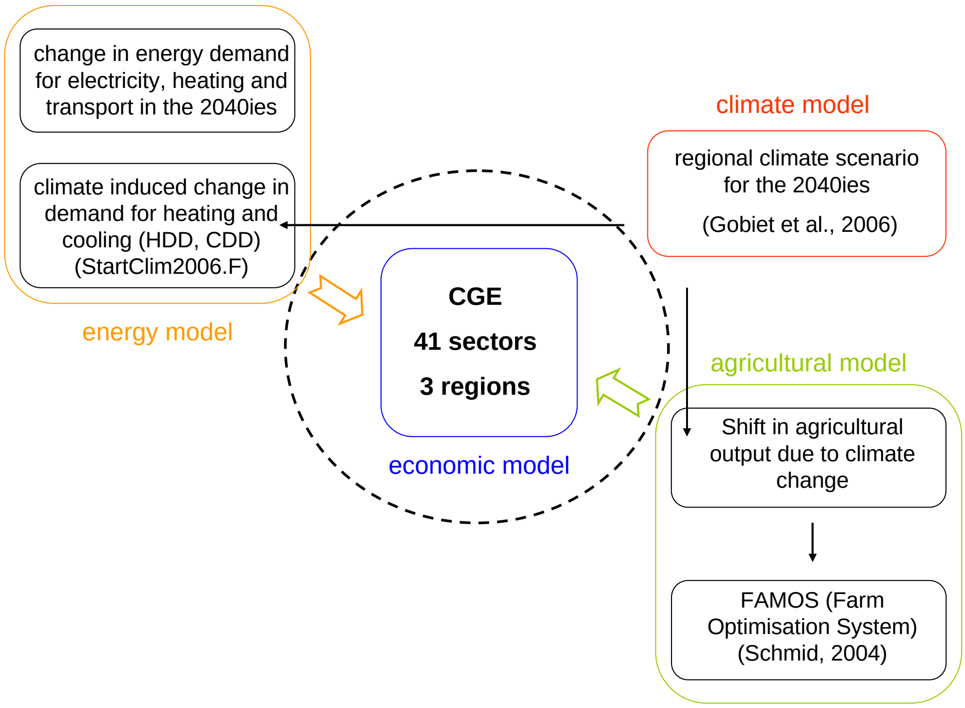
Change in energy demand without climate change (for Business as Usual)

- space heating
- electricity
- transport

Climate induced change in energy demand (for Reference)

- space heating and cooling
- via calculation of cooling degree days (CDD) and heating degree days (HDD)

Quantitative Results (1)



Quantitative Results (2)

Scenario 1: **Business as Usual** (without climate change)

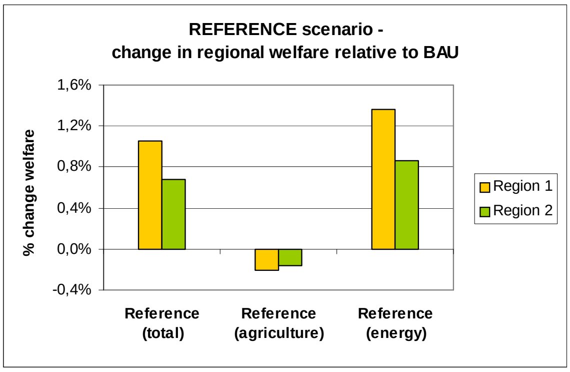
BAU 2045			
		Region 1	Region 2
Economic Performance			
GDP growth	[%]	63,24%	102,75%
GDP growth [1]	[% p.a.]	1,20%	1,74%
Welfare	[2003 = 100]	200,0	266,5
Welfare	[% p.a.]	1,7	2,4
Consumption price index	[2003 = 100]	90,6	95,9
Agricultural production level	[2003 = 100]	137,7	136,1
Factor prices			
Labour	[2003 = 100]	282,0	339,5
Capital	[2003 = 100]	124,9	150,4
Price level agriculture	[2003 = 100]	102,2	118,3

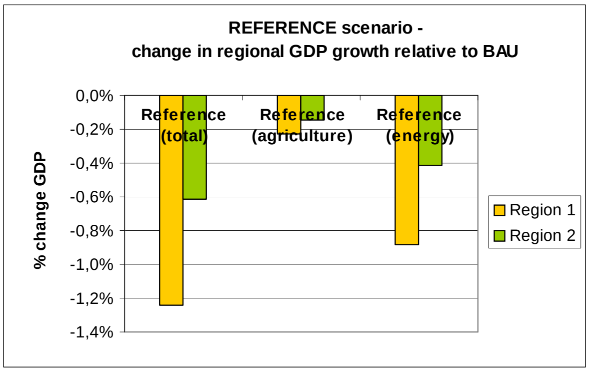
[1] close to the IIASA Baseline Scenario B1 (urban 1,76%, rural 0,94% growth p.a.)

Quantitative Results (3)

Scenario 2: Climate change and autonomous adaptation (**Reference**) relative to **Business as Usual**

>> Effects of climate change





Quantitative Results (4)

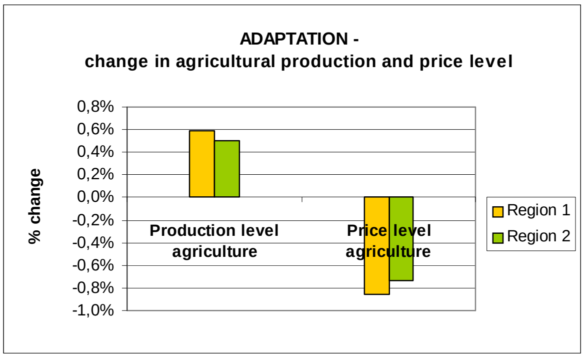
Scenario 3: **Policy-induced adaptation** relative to **Reference**

>> Effects of adaptation

Mixed cultivation of crops to adapt to changed climatic conditions.

Adaptation to face reduced physical output in agriculture.

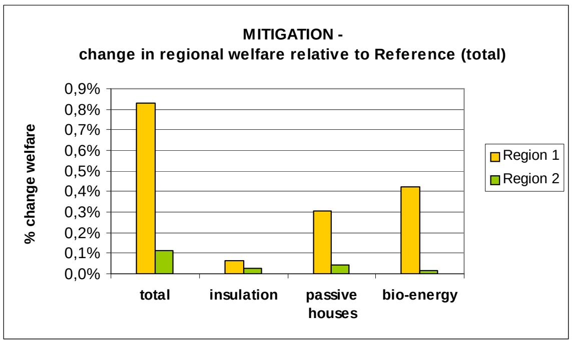
Modeled by „efficiency land“ (adaptation increases land efficiency & causes additional production costs)

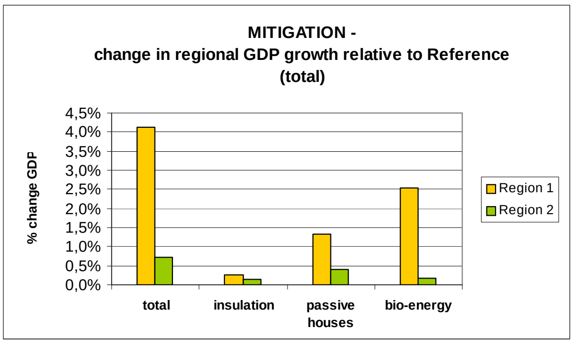


Quantitative Results (5)

Scenario 4a: **Mitigation** relative to **Reference**

>> Effects of mitigation



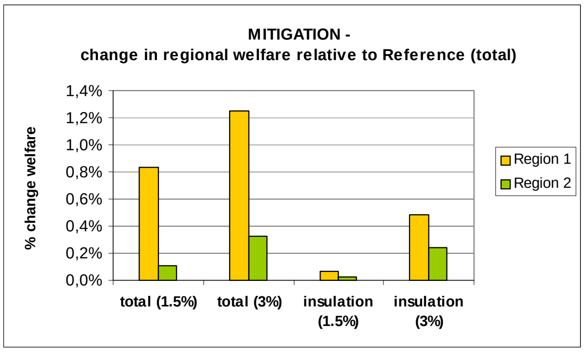


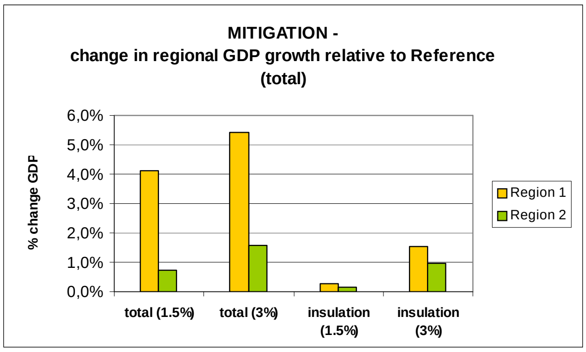
reconstruction rate for insulation scenario: 1.5%

Quantitative Results (6)

Scenario 4b: **Mitigation** relative to **Reference**

>> Effects of mitigation for a higher reconstruction rate (3%)





Modelling Aspects: The relevance of regional analysis (1)

Disagreement on damage costs Stern (2007) vs. earlier studies

Interest rate

Stern around 1.4%

Nordhaus around 4%

Assessment of future damages

Stern´s assessment much greater

Time Horizon

Nordhaus up to 2100 only

Modelling Aspects:
The relevance of regional analysis (2)

Damage costs: the example of agriculture

Factors that are key to different assessments

Correct characterization of temperature change

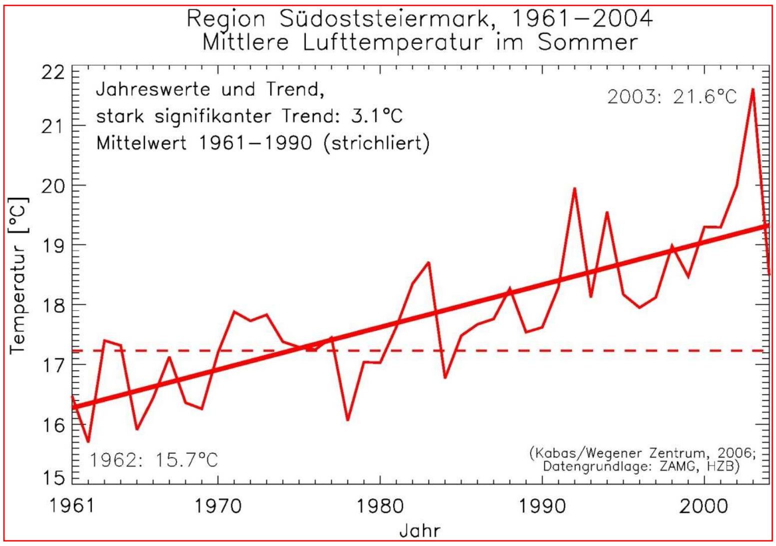
- Annual, seasonal, monthly, daily
- Global, national, regional, local

Assumed shape of relationship between temperature and yield

- Symmetric, hill-shaped
- Asymmetric

Allowance for economic adaptation

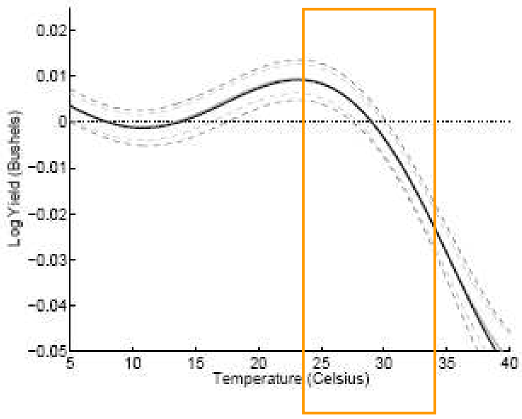
Disagreement on damage costs



Local impacts will turn out significantly more pronounced

Relation of temperature and crop yield

is not symmetrical; it is distinctly asymmetric, fairly flat at first and then sharply declining beyond an upper threshold



Source: Schlenker and Roberts (2006)

Conclusions and Outlook (1)

Use of this approach

- pre-feasibility study (data, method)
- developing expertise in coupled modeling
- direction and magnitude of effects, no forecasts

Difficulties for regional climate impact modelling

- sectoral disaggregation, e.g. sector-specific
  - factor productivity growth
  - adaptation
- data availability
- uncertainty; wheather extremes

Next steps – further demands for coupled modelling

- agriculture
  - soil model
  - more comprehensive crop yield model
    - crop yields in organic farming and under other management practices
    - drought indices
- energy
  - More detailled assessment of regional energy supply

Conclusions and Outlook (3)

- Modelling the synergies between mitigation and adaptation
- Better understanding of extreme events