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Economic Cost of Climate Change in Europe

Outcome of the PESETA Project

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IPTS Seville and KULeuven Belgium

Joint TERI ETSAP Workshop
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Question of Interest

- What are the economic consequences of climate change in Europe?
  - overall order of magnitude
  - distribution (space, time, sector)

- Related to mitigation and mainly, adaptation policies

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The PESETA Project

- ***PESETA*** *:* **P**rojection of **E**conomic impacts of climate change in **S**ectors of the **E**uropean union based on boT**T**om-up **A**nalyses
- Main purpose: Quantitative, multi-sectoral assessment of the impacts in value of climate change in Europe

To support policymakers

- JRC funded project
  - largely based on past DG Research-funded projects (PRUDENCE, DINAS-Coast, cCASHh, NewExt,…)

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Project partners

- Climate scenarios: DMI, CRU
- Five sectoral assessments:
  - Agriculture: U. Politécnica de Madrid
  - Human health: AEA Technology
  - River basin flooding: JRC/IES
  - Coastal systems: FEEM/Southampton U.
  - Tourism: U. Maastricht-ICIS
- Coordination and integration into CGE model: JRC/IPTS

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General approach in most literature (top-down)

- Damage = a Temperature ^{b}
  - where *a* and *b* are parameters
- Main limitations for adaptation insights:
  - use results from literature, from different and possibly inconsistent climate scenarios
  - only mean temperature and precipitation are considered
  - lack of geographical resolution

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The general approach in the project (bottom up)

- Integrated economic impact assessment, with as starting point physical impact estimates based on
  - detailed process modelling
    - Agriculture, DSSAT crop model
    - River basin flooding, LISFLOOD hydrological model
    - Coastal systems, DIVA model
  - reduced-form exposure-response functions
    - Tourism
    - Human Health
- Sectoral models provide direct effects estimates
- Overall effects (direct + indirect) assessed with a computable general equilibrium model of Europe

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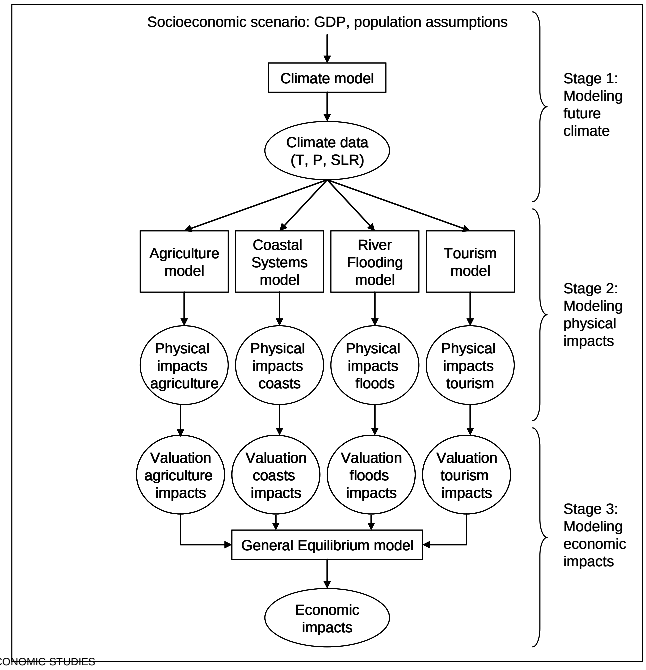

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Selected Climate Scenarios

- 2011-2040 period: A2 IPCC SRES scenario data from the Rossby Center
- 2071-2100 period: data from PRUDENCE
  - A2, B2 IPCC SRES scenarios
  - 2 global circulation models, GCMs (HadCM3, ECHAM4)
  - 2 regional climate models, RCMs (HIRHAM, RCA

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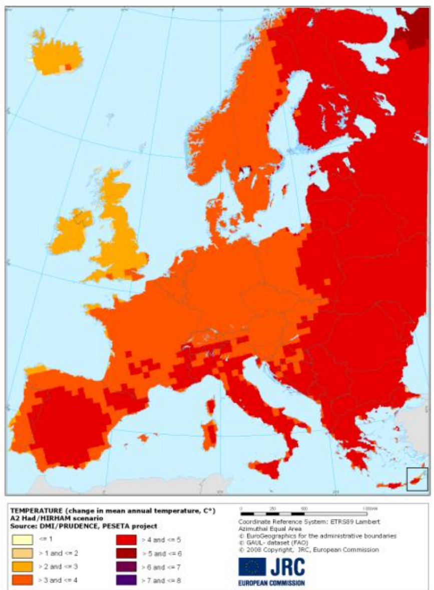
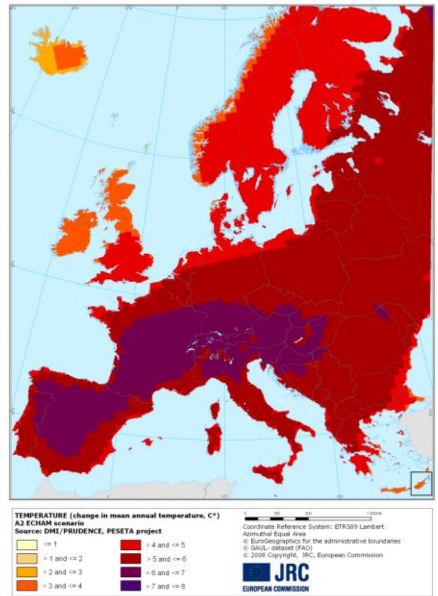
Temperature 3.9°C (A2 Hadley) 5.4°C (A2 Echam)





Four 2080s Scenarios

	Scenarios			
	2.5°C	3.9°C	4.1°C	5.4°C
World population in 2100 (10^{12})	10.4	15.1	10.4	15.1
World GDP in 2100 (10^{12}, 1990US$)	235	243	235	243
CO_2 Concentration (ppm)	561	709	561	709
Δ Temperature (ºC)*				
World	2.4	3.1	2.3	3.1
EU‡	2.5	3.9	4.3	5.4
Northern Europe	2.9	4.1	3.6	4.7
British Isles	1.6	2.5	3.2	3.9
Central Europe North	2.3	3.7	4.0	5.5
Central Europe South	2.4	3.9	4.4	6.0
Southern Europe	2.6	4.1	4.3	5.6
Δ Precipitation (%)*				
EU‡	1	-2	2	-6
Northern Europe	10	10	19	24
British Isles	-5	-2	10	5
Central Europe North	3	1	6	-1
Central Europe South	2	-2	-4	-16
Southern Europe	-7	-15	-13	-28
Sea Level Rise (high climate sensitivity) (cm)	49	56	51	59

*Increase in the period 2071–2100 compared to 1961–1990. ‡European regions: Southern Europe (Portugal, Spain, Italy, Greece, and Bulgaria), Central Europe South (France, Austria, Czech Republic, Slovakia, Hungary, Romania, and Slovenia), Central Europe North (Belgium, The Netherlands, Germany, and Poland), British Isles (Ireland and UK), and Northern Europe (Sweden, Finland, Estonia, Latvia, and Lithuania).

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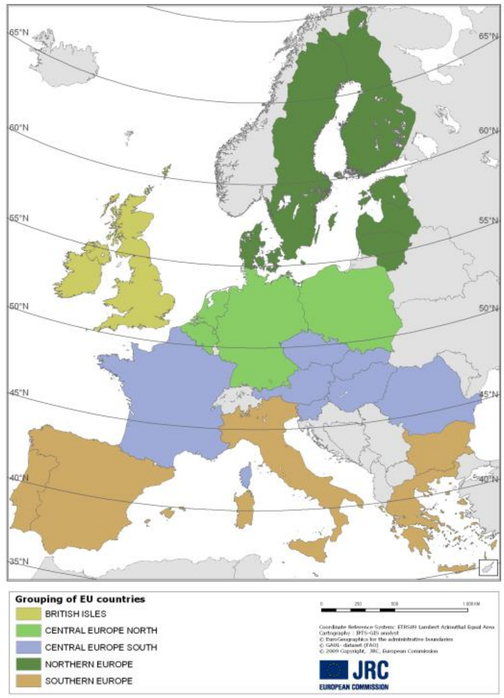
Grouping of countries



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Number of cases considered

Impact Category	Climate Scenarios		Variants	Total number of cases analysed
	2020s	2080s		
Agriculture	1	4	-	5
River Floods	-	4	-	4
Coastal Systems	1	4	No SLR Low/medium/high SLR IPCC low/high SLR Non adaptation/optimal adaptation	72
Tourism	-	4	Alternative demand assumptions	12
Human Health	1	4	Two exposure-response functions	8

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Impact from physical models (1)

- Agriculture
  - site-evidence on average yield change across Europe, DSSAT model
  - yield changes, production losses
- Coastal system (with DIVA model)
  - impact on coastal erosion, coastal flood impacts, changes in wetlands, flood effects in river mouths, sea water intrusion and salinisation.
  - economic costs due to land and wetland loss and the number of people flooded
- River floods
  - change in frequency and intensity of river floods by LISFLOODS model
  - valuation of damage to buildings

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Impact from physical models (2)

- Tourism
  - estimation of the role of climate through TCI (tourism climate index) on bed nights
  - impact of climate change on number of bed nights valued with the EU average expenditure data per bed night
- Health
  - changes in direct temperature related mortality
- Adaptation
  - in all models private adaptation (e.g. agriculture way of production, migration)
  - no public adaptation (except for coastal system, dikes building and beach nourishment)

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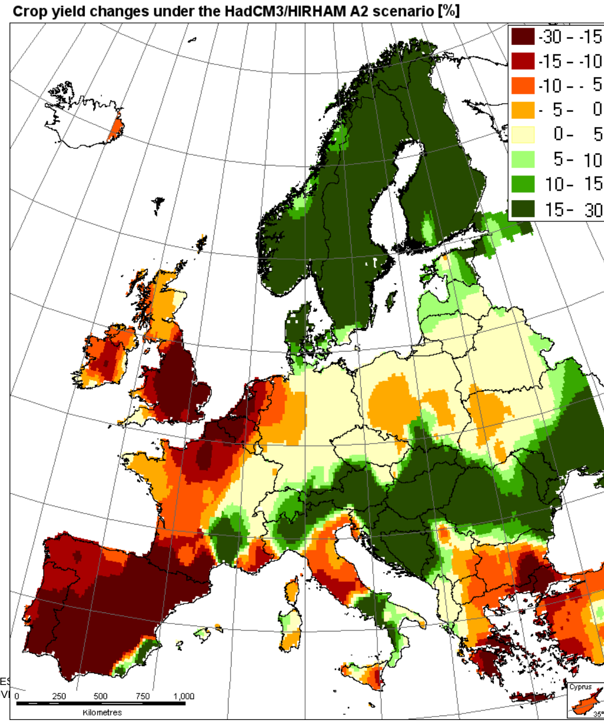
Agriculture

Crop yield changes (t/Ha), production losses and gains

Crop yield changes under the HadCM3/HIRHAM A2 scenario [%]



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Agriculture: crop yield changes (%) compared to 1961-1990

	B2 HadAM3h 2.5°C	A2 HadAM3h 3.9°C	B2 ECHAM4 4.1°C	A2 ECHAM4 5.4°C	2025
Northern Europe	37	39	36	52	62
British Isles	-9	-11	15	19	20
Central Europe North	-1	-3	2	-8	16
Central Europe South	5	5	3	-3	7
Southern Europe	0	-12	-4	-27	15
EU	3	-2	3	-10	17

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Coastal Systems

people flooded (1000s/year) in main scenarios with high climate sensitivity, without adaptation

	B2 HadAM3h 2.5°C	A2 HadAM3h 3.9°C	B2 ECHAM4 4.1°C	A2 ECHAM4 5.4°C	A2 ECHAM4 high SLR
Northern Europe	20	40	20	56	272
British Isles	70	136	86	207	1,279
Central Europe North	345	450	347	459	2,398
Central Europe South	82	144	85	158	512
Southern Europe	258	456	313	474	1,091
EU	775	1,225	851	1,353	5,552

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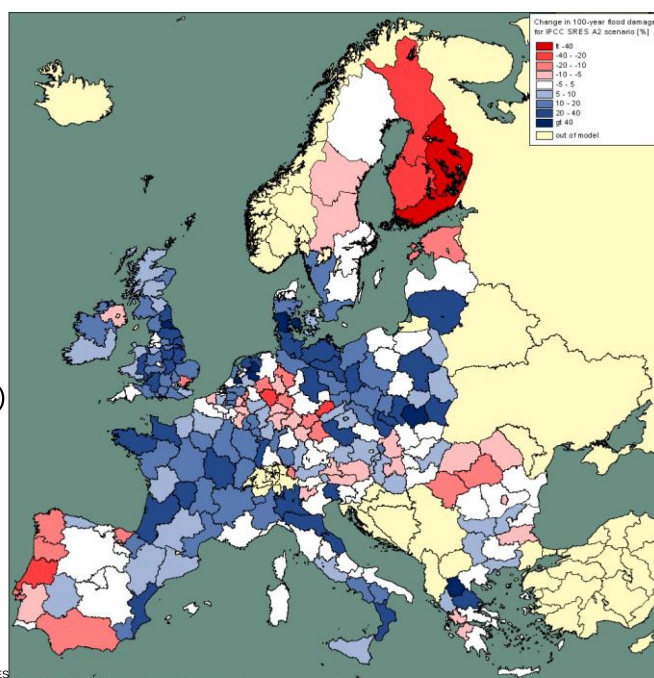
River Floods

Change in economic damage (*red* means a decrease)



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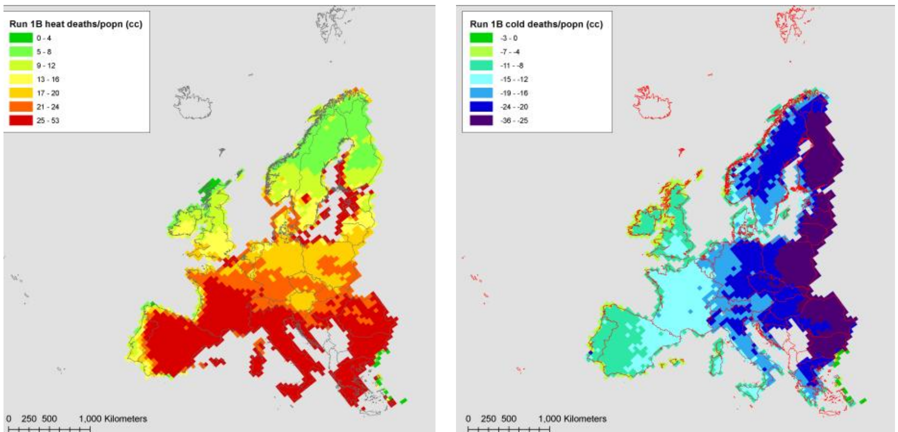
Human Health

average annual heat-related (left) and cold-related (right) death rates (per 100,000 population) 3.9°C scenario



Note: using climate-dependent health functions (no acclimatisation)

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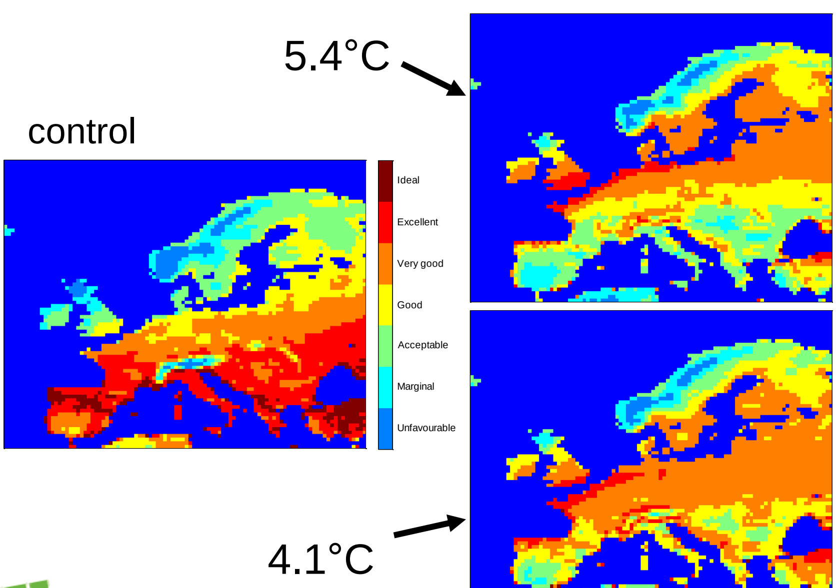
Tourism:**TCI scores in summer**



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Tourism
Change in expenditure receipts (million €)

	B2 HadAM3h 2.5ºC	A2 HadAM3h 3.9ºC	B2 ECHAM4 4.1ºC	A2 ECHAM4 5.4ºC
Norhern Europe	443	642	1,888	2,411
British Isles	680	932	3,587	4,546
Central Europe North	634	920	3,291	4,152
Central Europe South	925	1,763	7,673	9,556
Southern Europe	-824	-995	-3,080	-5,398
EU	**1,858**	**3,262**	**13,360**	**15,268**

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Integration of sectoral impacts into the CGE GEM-E3 model

- Static analysis: evaluation of the economic effects of future climate change (projected for the 2080s) on the current economy, as of 2010.
- Only market costs included
- Assuming there is no public adaptation, so that priorities for adaptation within the EU can be explored

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GEM-E3: a General Equilibrium Model for Energy-Economics-Environment interactions

- GEM-E3: the standard European version covers the 27 EU countries (except Luxemburg, Malta and Cyprus)
- The model has been developed as a multi-national collaboration project, cofunded by the EU Commission, DG Research.
- follows the computable general equilibrium methodology,
  - demand and supply functions derived from microeconomic behaviour of economic agents (optimisation of their objective)
  - markets clear through prices and prices are such that at equilibrium all agents optimise their behaviour
  - covers the entire economic activity within a region

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The GEM-E3 model (2)

- simultaneously multinational and specific for each region, markets clear at country or EU level, where appropriate
- extensive environmental dimension, inclusive its transfrontier characteristics and possibility of feedback from the environment on the economy
- wide variety of policy instruments (standards, taxes, permits, at EU and country level, different allowance schemes)
- oriented towards medium & long term macroeconomic implications of policies (general, energy, environment)
- follows a time forward path (dynamic recursive over time)

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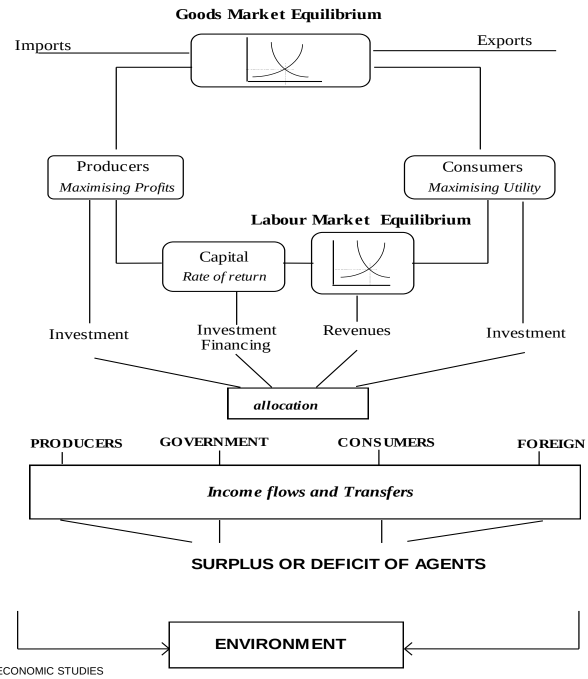
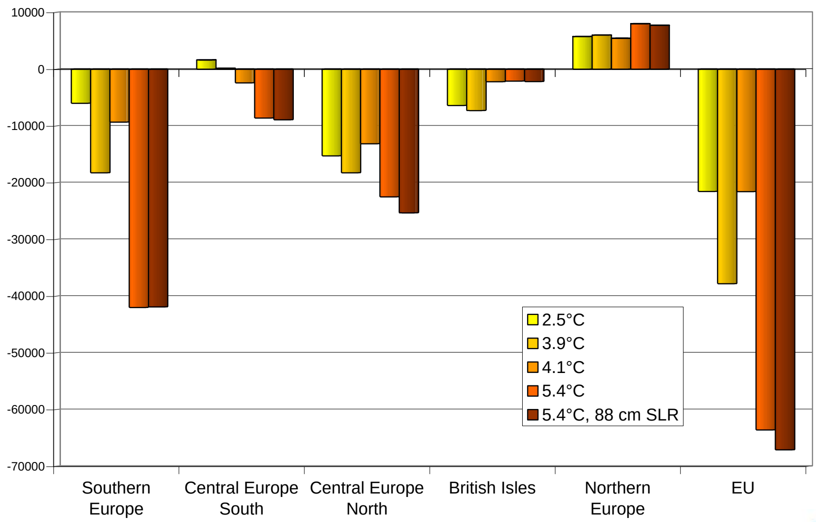


Modelling of physical impacts in GEM-E3

- Agriculture
  - yield changes interpreted as Total Factor Productivity change (no production factors changes)
- River floods
  - damage to residential buildings (80%) as obliged expenditure by household
  - damage to industrial sectors (20%), as production and capital losses
- Coastal system
  - floods leads to capital losses (and so additional expenditure
  - migration cost (for household)
- Tourism
  - redistribution of tourism within Europe leads to changes in exports
  - induces reaction on the supply capacity
- For both river floods and coastal systems, the additional expenditure does not provide any welfare gain: it represents a welfare loss, since households are forced to it due to climate change.

Annual damage in terms of GDP changes (million €)



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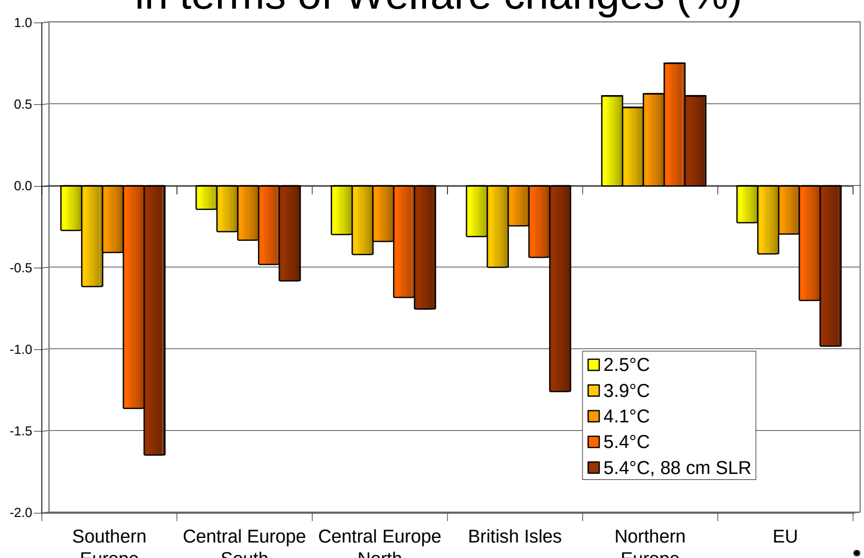
Annual damage in terms of Welfare changes (%)



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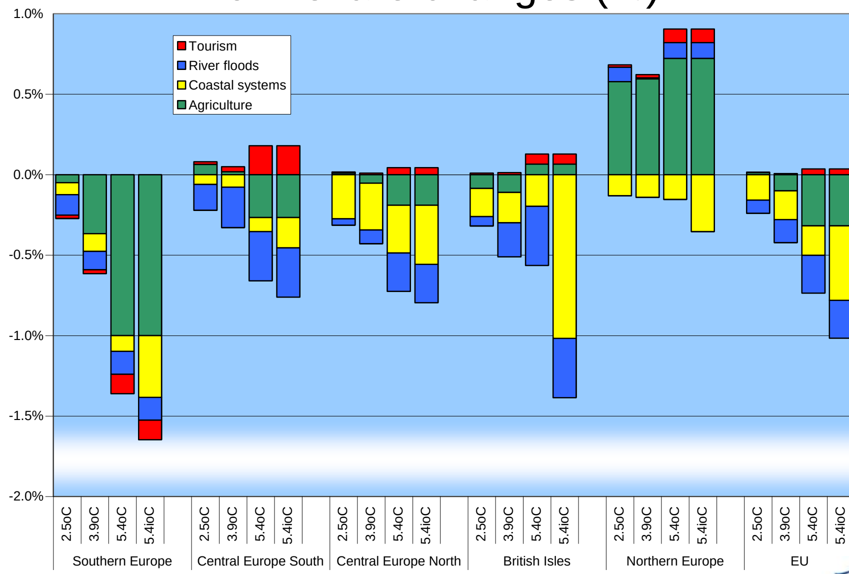
Sectoral decomposition of welfare changes (%)



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Conclusion

- Gives a first insight in impact of climate change in Europe but uncertainty still very great at all steps of the research (sectoral and global level) full results in http://ftp.jrc.es/EURdoc/JRC55391.pdf
- Innovative aspects of the project:
  - High space-time resolution of climate data (daily, 50 km)
  - Use of detailed physical impact models for each impact category
  - Integration of all sectoral results in CGE model
- Further research is needed, concerning:
  - Costs and benefits of adaptation
  - Cross-sectoral consistency
  - Land use modelling
  - Monte Carlo analysis for uncertainty
- FP7 research project (ClimateCost) for extension of these results: better integration and geographic extension

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