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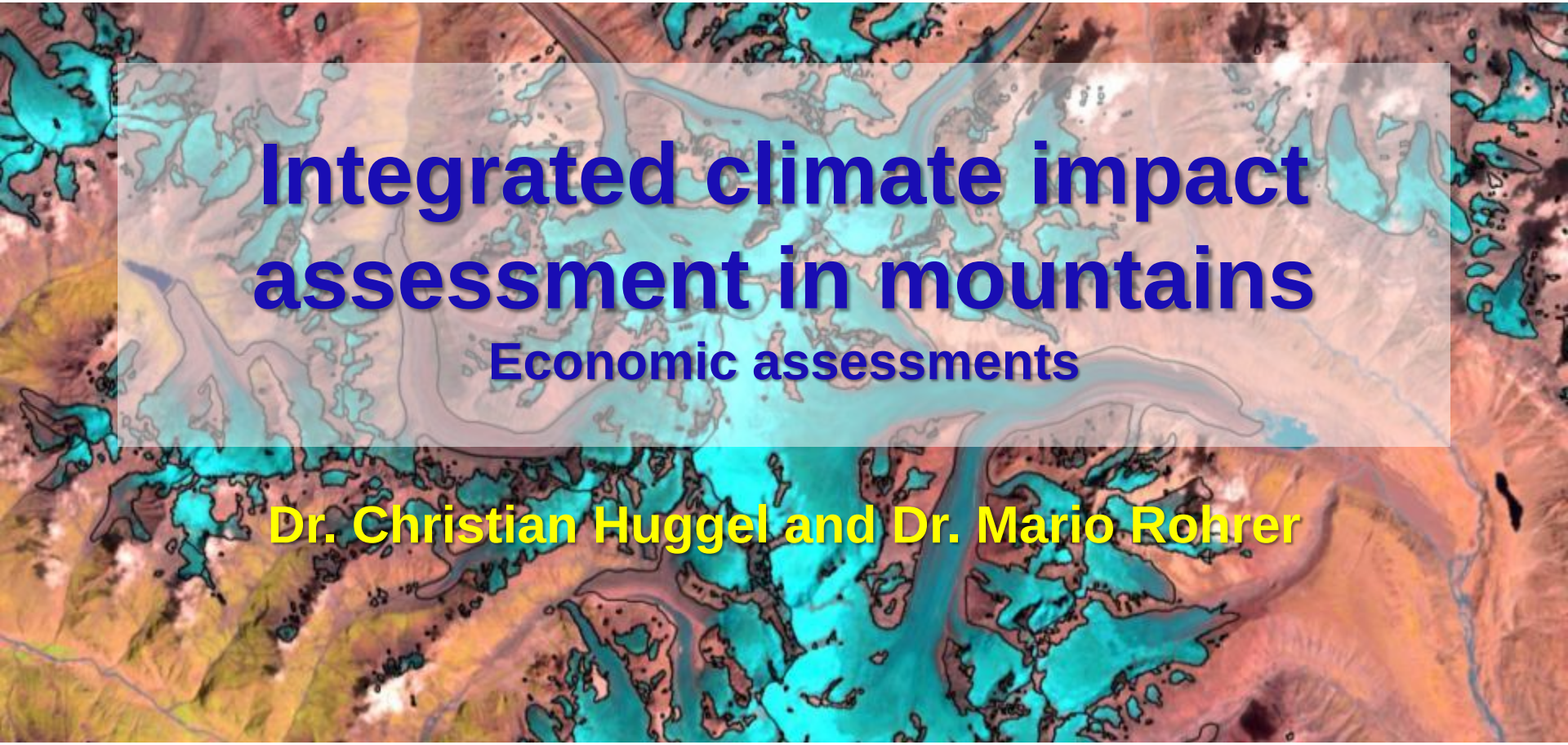


Integrated climate impact assessment in mountains

Economic assessments

Dr. Christian Huggel and Dr. Mario Rohrer

IHCAP – Indian Himalayas Climate Change Adaptation Programme
Capacity building programme “Cryosphere” Level-2 (2015)

Economic impact assessment

Purpose and objectives of economic impact assessment

- Inform policy on climate change
- Economic cost-benefit analysis
- Policy assessments of climate impacts and actions

Economic impact assessment

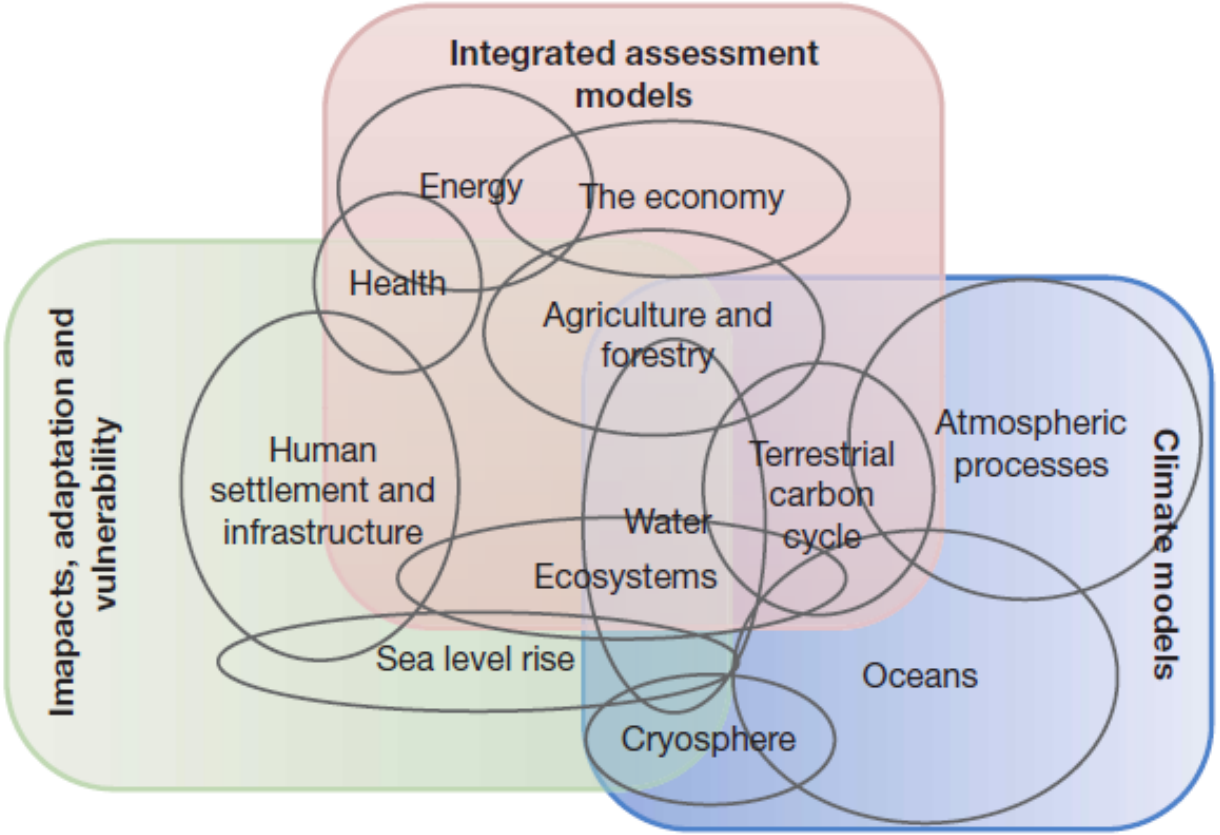
Economic integrated assessment models (IAM)

- IAM's represent key features of human systems, such as
  - demography
  - energy use
  - technology
  - the economy
  - agriculture
  - forestry
  - land use
- IAM's incorporate simplified representations of the climate system, ecosystems, and in some cases, climate impacts
- Integrate information needed to study the interactions of human systems (including potential climate policies) and environmental processes that affect climate change and its impacts
- used to develop emissions scenarios, estimate the potential economic impacts of climate change and the costs and benefits of mitigation, simulate feedbacks, and evaluate uncertainties
- Often global-scale, with differentiation of world regions or countries

Moss et al., 2010

Economic impact assessment

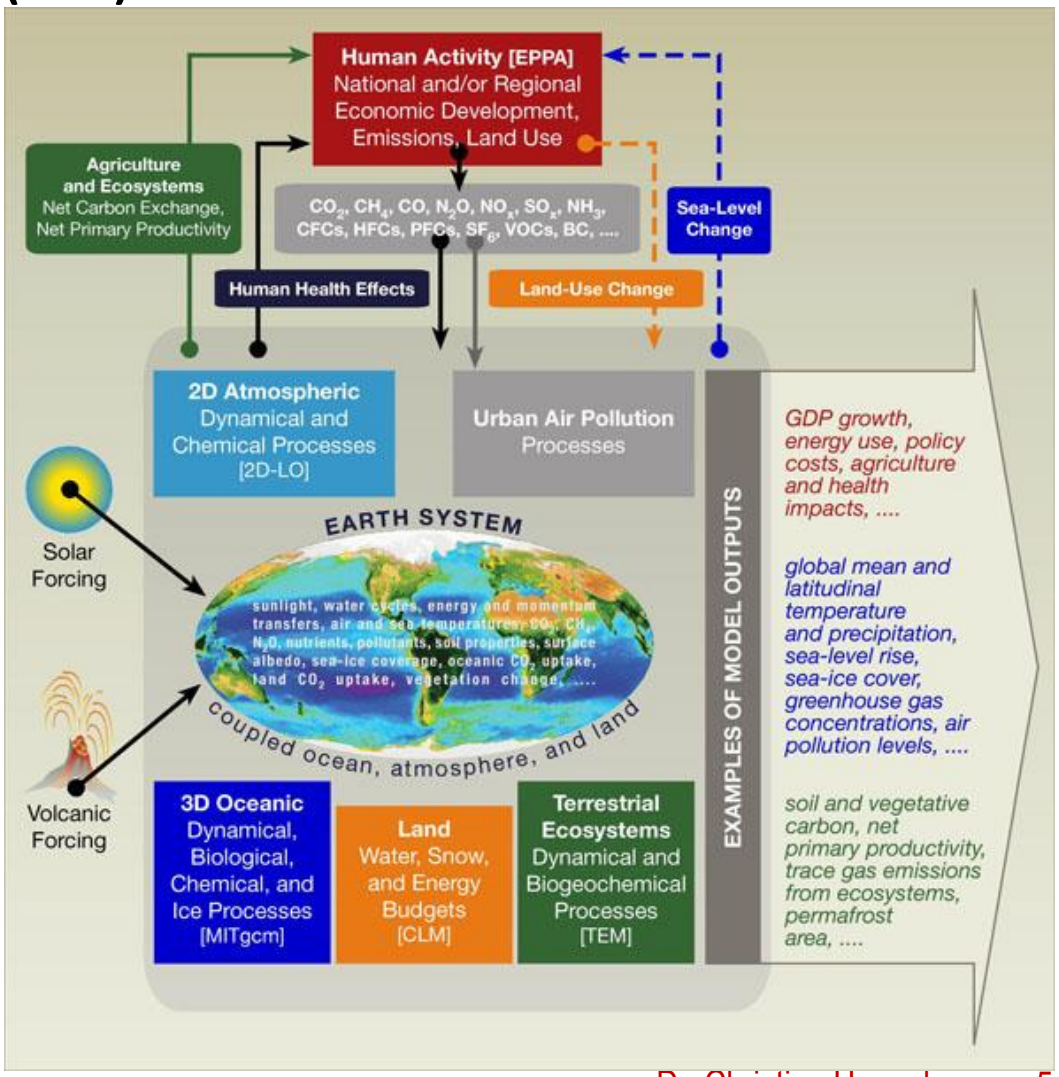
Integrated assessment models (IAM)



Moss et al., 2010

Economic impact assessment

Integrated assessment models (IAM)



USGCRP

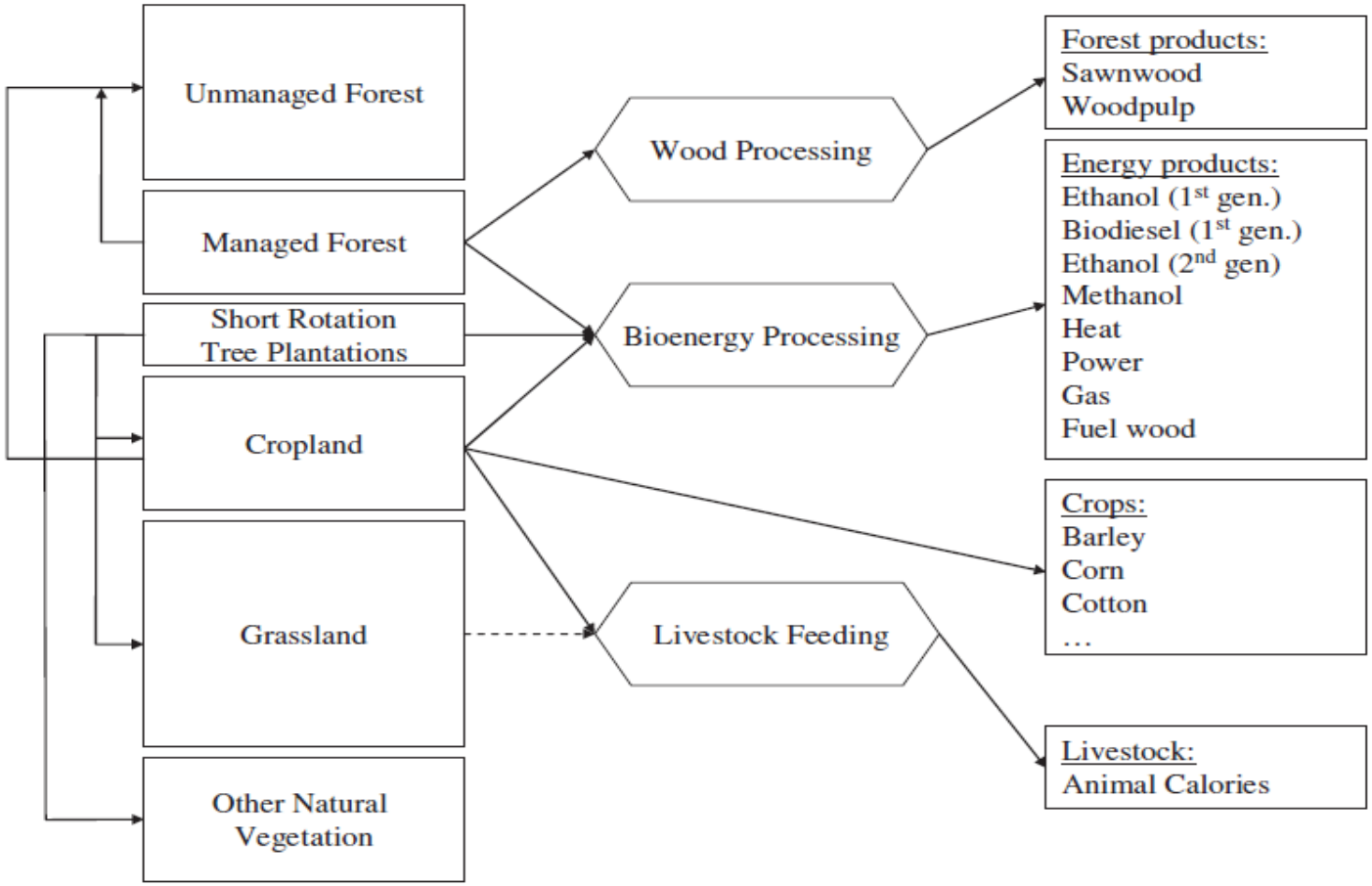
Economic impact assessment

GLOBIOM – economic IAM (courtesy of IIASA)

- Global recursive dynamic partial equilibrium model
- Aims to provide policy analysis on global issues concerning land use competition between major land-base production sectors
- Great variety of data needed
- Covering the following sectors: Land characteristics, Agriculture, Forestry, Short rotation plantation, GHG emissions, International Trade, Infrastructure, Process, Population, Demand

Economic impact assessment

GLOBIOM – economic IAM



Economic impact assessment

GLOBIOM – economic IAM

Application for mountain ecosystems:

- economics modeling can take into account (in addition to biophysical parameters coming from respective models) such aspects as agricultural operation costs together with transport infrastructure and consequently internal transportation costs.

Economic impact assessment

Modules and key impact approaches of economic IAM

- Emission module and Climate module
- Climate impact module

Climate impact damage function:

$$D_t = \alpha T_t^{\beta}$$

D = Damage
T = Temperature
t = time
α, β = coefficients

Economic impact assessment

Estimates of welfare impact of climate change

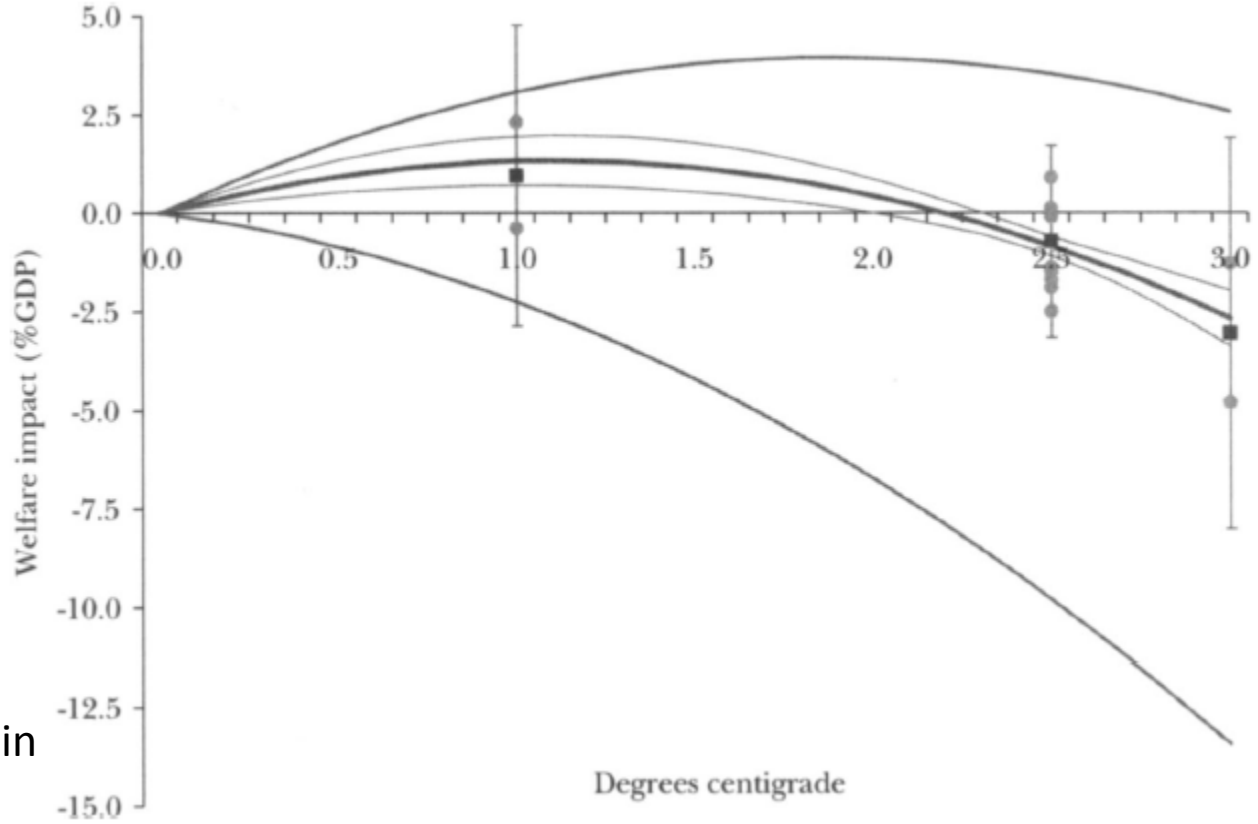
Expressed as equivalent income gain / loss in precent GDP

Study	Warming (°C)	Impact (% of GDP)	Worst-off region (% of GDP)	Worst-off region (Name)	Best-off region (% of GDP)	Best-off region (Name)
Nordhaus (1994a)	3.0	−1.3				
Nordhaus (1994b)	3.0	−4.8 (−30.0 to 0.0)				
Fankhauser (1995)	2.5	−1.4	−4.7	China	−0.7	Eastern Europe and the former Soviet Union
Tol (1995)	2.5	−1.9	−8.7	Africa	−0.3	Eastern Europe and the former Soviet Union
Nordhaus and Yang (1996)[a]	2.5	−1.7	−2.1	Developing countries	0.9	Former Soviet Union
Plambeck and Hope (1996)[a]	2.5	2.5 (−0.5 to −11.4)	−8.6 (−0.6 to −39.5)	Asia (w/o China)	0.0 (−0.2 to 1.5)	Eastern Europe and the former Soviet Union
Mendelsohn, Schlesinger, and Williams (2000)[a,b,c]	2.5	0.0[b]	−3.6[b]	Africa	4.0[b]	Eastern Europe and the former Soviet Union
		0.1[b]	−0.5[b]		1.7[b]	
Nordhaus and Boyer (2000)	2.5	−1.5	−3.9	Africa	0.7	Russia
Tol (2002)	1.0	2.3 (1.0)	−4.1 (2.2)	Africa	3.7 (2.2)	Western Europe
Maddison (2003)[a,d,e]	2.5	−0.1	−14.6	South America	2.5	Western Europe
Rehdanz and Maddison (2005)[a,c]	1.0	−0.4	−23.5	Sub-Saharan Africa	12.9	South Asia
Hope (2006)[a,f]	2.5	0.9 (−0.2 to 2.7)	−2.6 (−0.4 to 10.0)	Asia (w/o China)	0.3 (−2.5 to 0.5)	Eastern Europe and the former Soviet Union
Nordhaus (2006)	2.5	−0.9 (0.1)				

Tol, 2009

Economic impact assessment

Estimates of welfare impact of climate change



Expressed as equivalent income gain / loss in precent GDP

Tol, 2009

Economic impact assessment

Climate Framework for Uncertainty, Negotiation, and Distribution (FUND model)

• FUND consists of a set of exogenous scenarios and endogenous perturbations.

• The model is specified for nine major world-regions: OECD-America (excl. Mexico); OECD-Europe; OECD-Pacific (excl. South Korea); Central and Eastern Europe and the former Soviet Union; Middle East; Latin America; South and Southeast Asia; Centrally Planned Asia; and Africa.

• The model runs from 1950 to 2200, in time steps of a year. Some overlap with the observational record provides an opportunity for model validation. The prime reason for starting in 1950, however, is the necessity to initialise the climate change impact module

Tol, 1999

Economic impact assessment

Climate Framework for Uncertainty, Negotiation, and Distribution (FUND model)

- The scenarios concern the rate of population growth, urbanisation, economic growth, autonomous energy efficiency improvements, the rate of decarbonisation of the energy use (autonomous carbon efficiency improvements), and emissions of carbon dioxide from land use change, methane and nitrous oxide
- The scenarios of economic and population growth are perturbed by the impact of climate change. Population falls with climate change deaths, resulting from changes in heat stress, cold stress, malaria, and tropical cyclones. Heat and cold stress are assumed to affect only the elderly, non-reproductive population, so that the number of new births is not affected by heat and cold stress. The other sources of mortality do affect the number of births. Heat stress only affects urban population.
- Population also changes with climate-induced migration between the regions. Immigrants are assumed to assimilate immediately and completely with the host population.

Tol, 1999

Economic impact assessment

Climate Framework for Uncertainty, negotiation, and Distribution (FUND model)

- The tangible impacts of climate change are dead-weight losses to the economy.
- Consumption and investment are reduced, without changing the saving's rate.
- Climate change thus reduces long-term economic growth, although at the short-term consumption takes a deeper cut. Economic growth is also reduced by carbon dioxide emission abatement.
- The energy intensity of the economy and the carbon intensity of the energy supply autonomously decrease over time. This process can be speeded up by abatement policies.

- The **endogenous** parts of FUND consists of the atmospheric concentrations of carbon dioxide, methane and nitrous oxide, the global mean temperature, the impact of carbon dioxide emission reductions on economy and emissions, and the impact of the damages of climate change on the economy and the population.

- FUND also calculates hurricane activity, winter precipitation, and winter storm activity because these feed into the damage module. However, these factors depend linearly on the global mean temperature.

Tol, 1999

Economic impact assessment

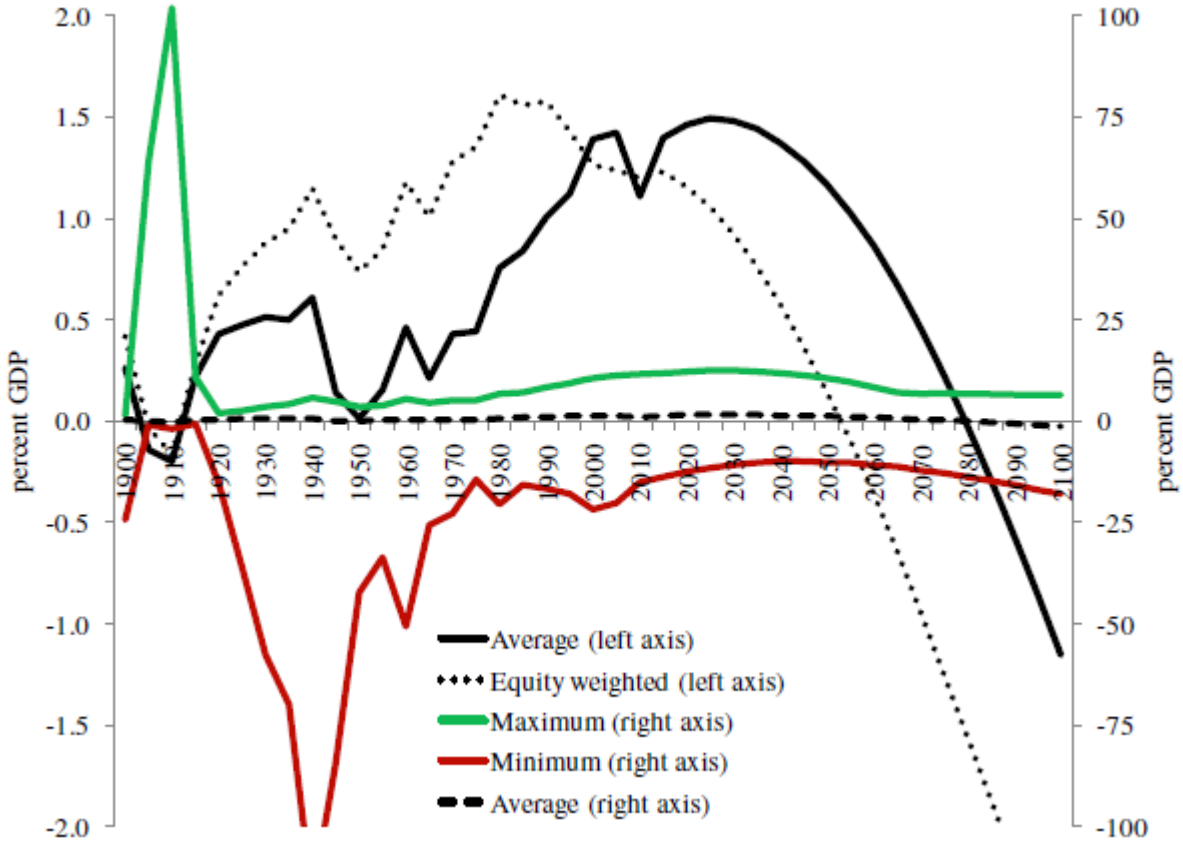
Climate Framework for Uncertainty, negotiation, and Distribution (FUND model)

• The climate impact module: A limited number of categories of the impact of climate change is considered: agriculture, sea level rise, heat and cold stress, malaria, tropical and extratropical storm, river floods, and unmanaged ecosystems. The damage module has two units of measurement: people and money.

• People can die (heat stress, malaria, tropical cyclones), not die (cold stress), or migrate. These effects, like all impacts, are monetised. The value of a statistical life is set at USD 250,000 plus 175 times the per capita income. The value of emigration is set at 3 times the per capita income, the value of immigration at 40% of the per capita income in the host region.
• Other impact categories are directly expressed in money, without an intermediate layer of impacts measured in their 'natural' units.
• Damage can be due to either the rate of change (benchmarked at 0.04 C/yr) or the level of change (benchmark at 2.5 C).

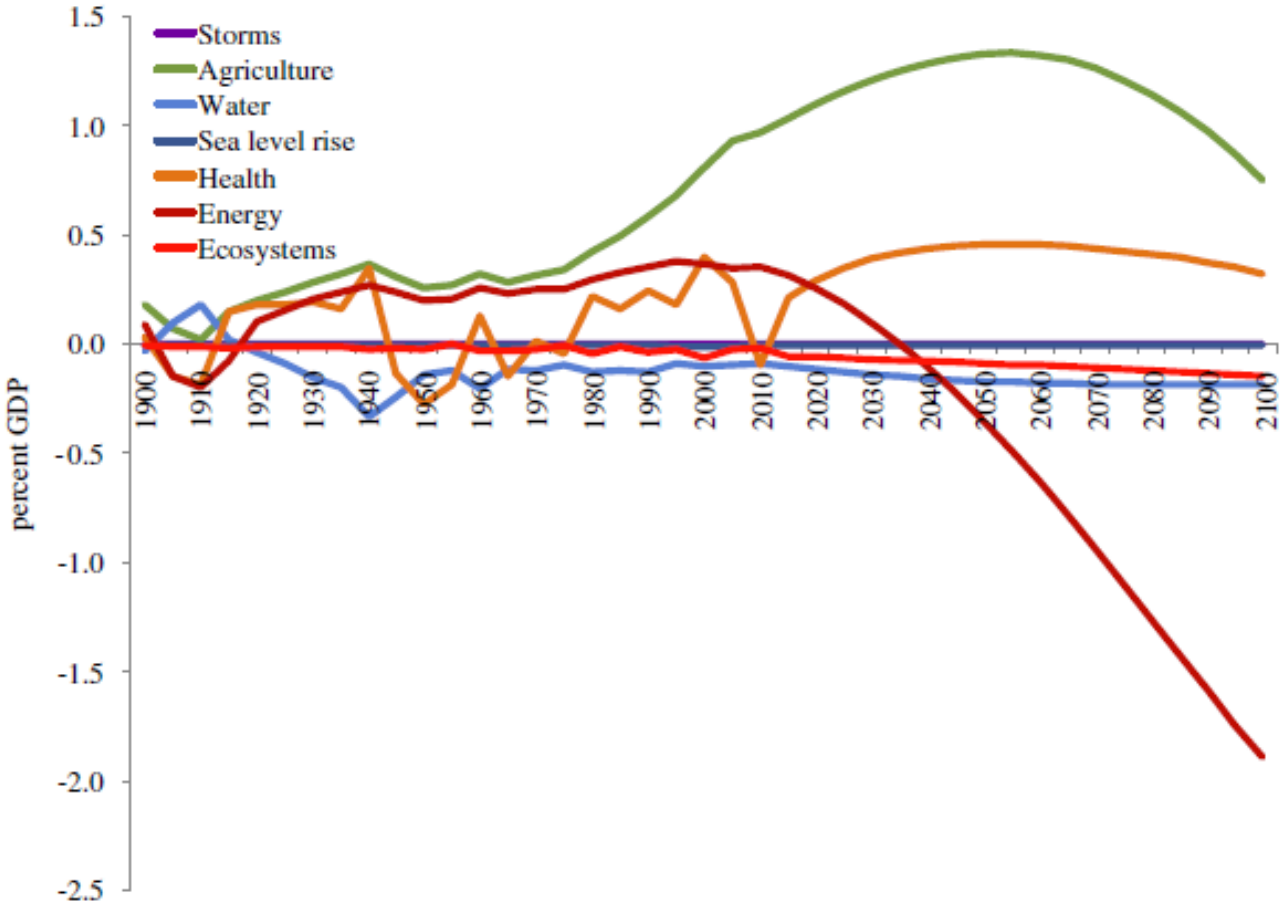
Tol, 1999

Economic impact assessment



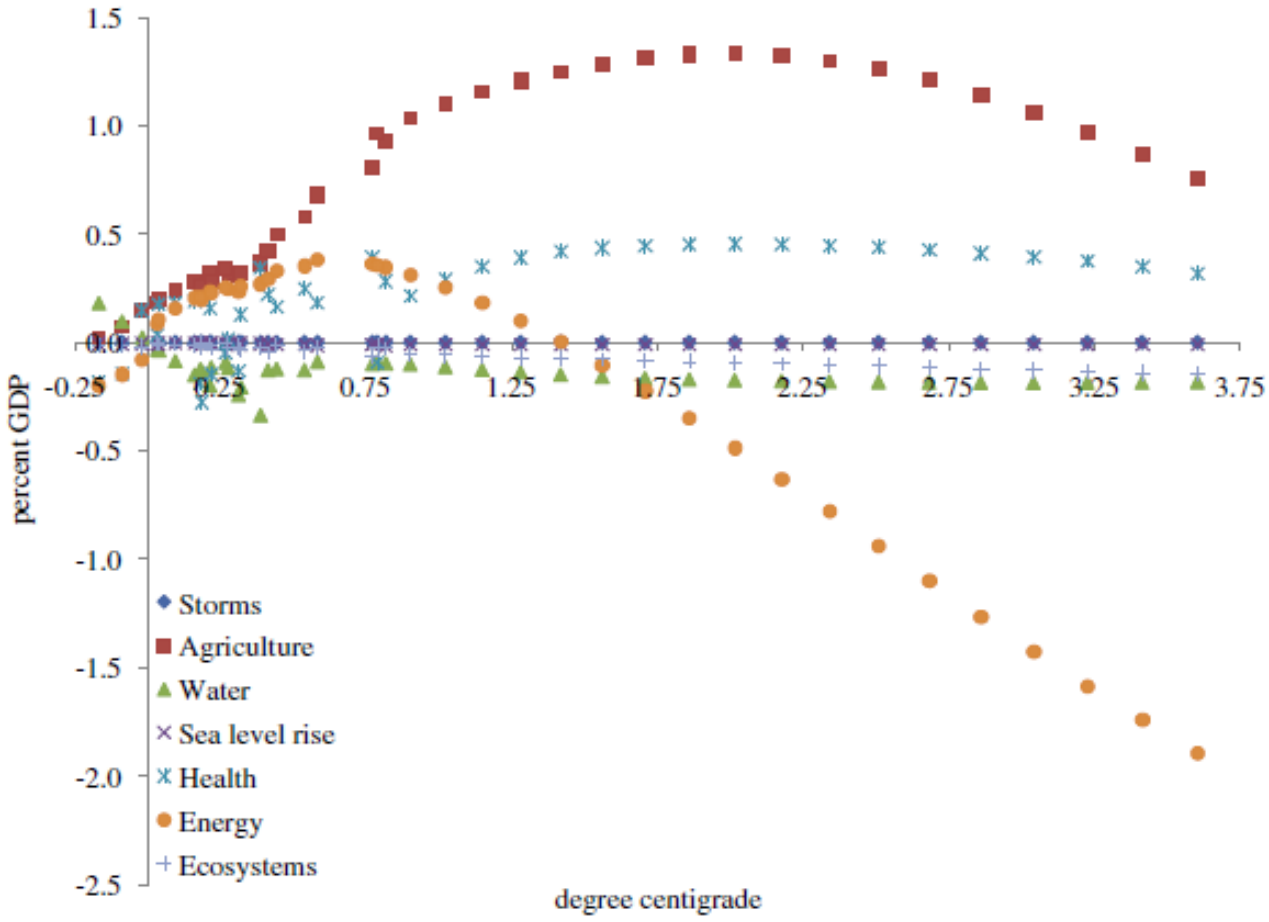
Tol, 2012

Economic impact assessment



Tol, 2012

Economic impact assessment



Tol, 2012

Economic impact assessment

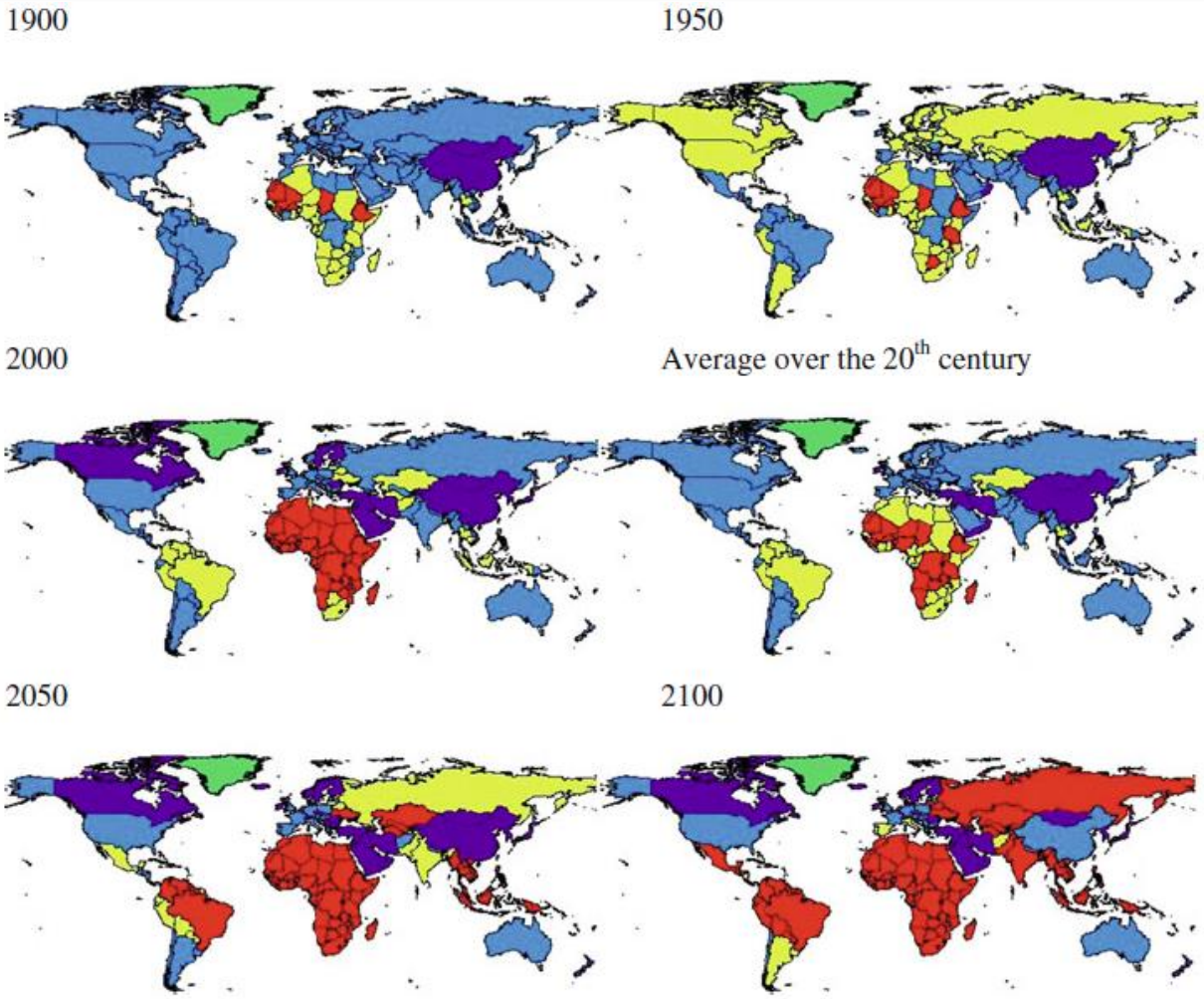
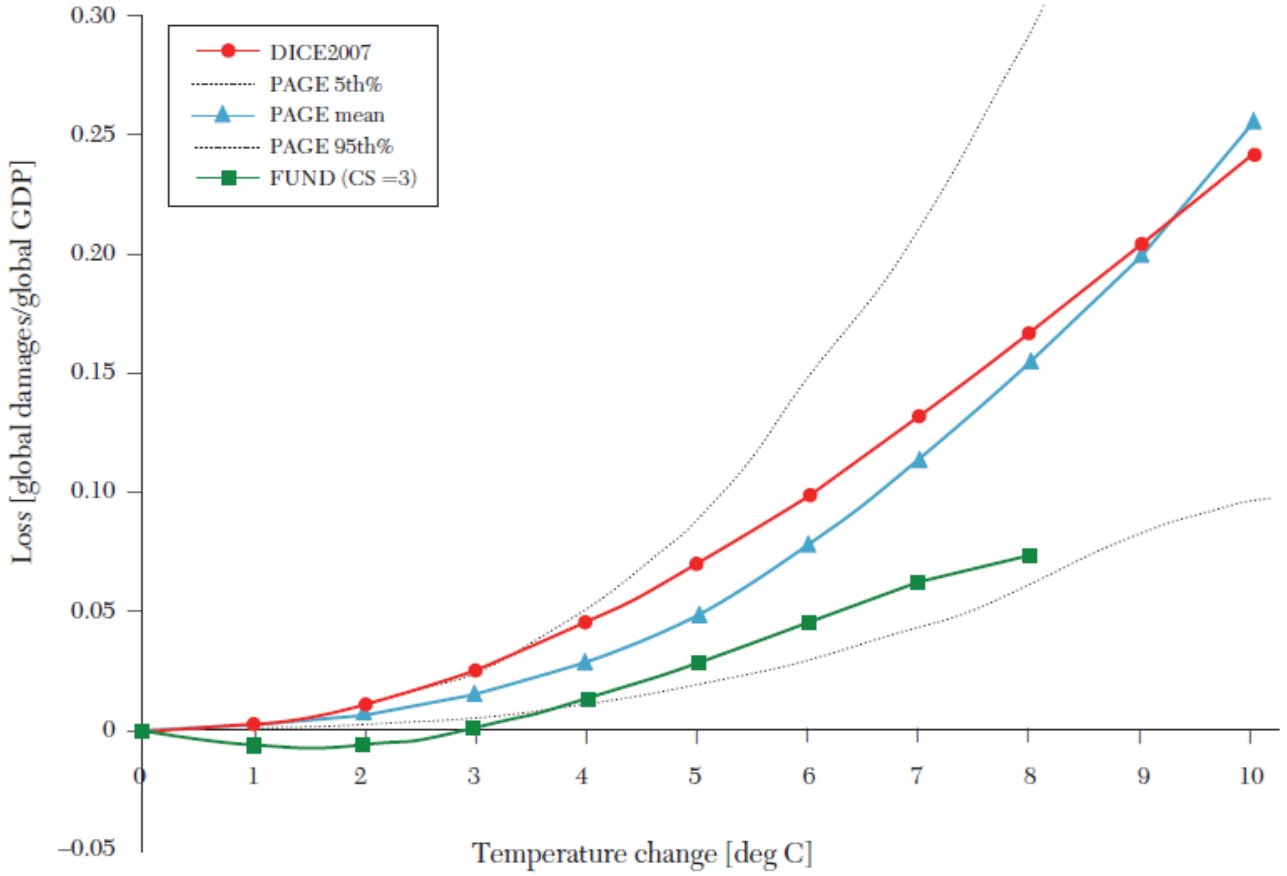


Fig. 5 The national total economic impact of climate change in three selected years and averaged over the 20th century; *purple*: impact >1 % GDP; *blue*: impact >0 % GDP; *yellow*: impact <0 % GDP; *red*: impact < −1 % GDP; *green*: no data

Tol, 2012

Economic impact assessment



Stern, 2013 / IWG SCC, 2010

Economic impact assessment

Limitations of economic IAM's

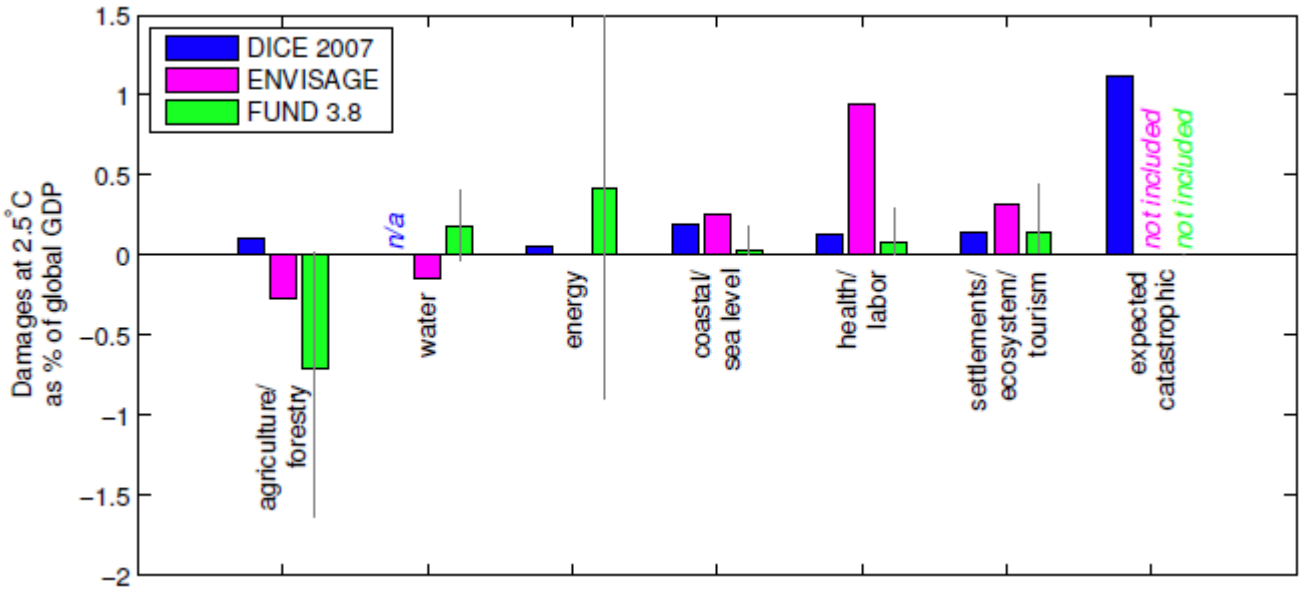
$$D_t = \alpha T_t^{\beta}$$

- Weak and extremely simplified damage functions
- Omission of damages potentially arising from catastrophes, mass migration or serious conflicts
- Poorly suitable for high-emission (high temperature increase) scenarios (e.g. beyond 3°C)
- Assumption of exogenous drivers of growth (in disagreement with potential disruption of socio-economic processes due to high temperatures)

=> Generally economic IAM's are suggested to **underestimate** the impacts and damages of climate change

Economic impact assessment

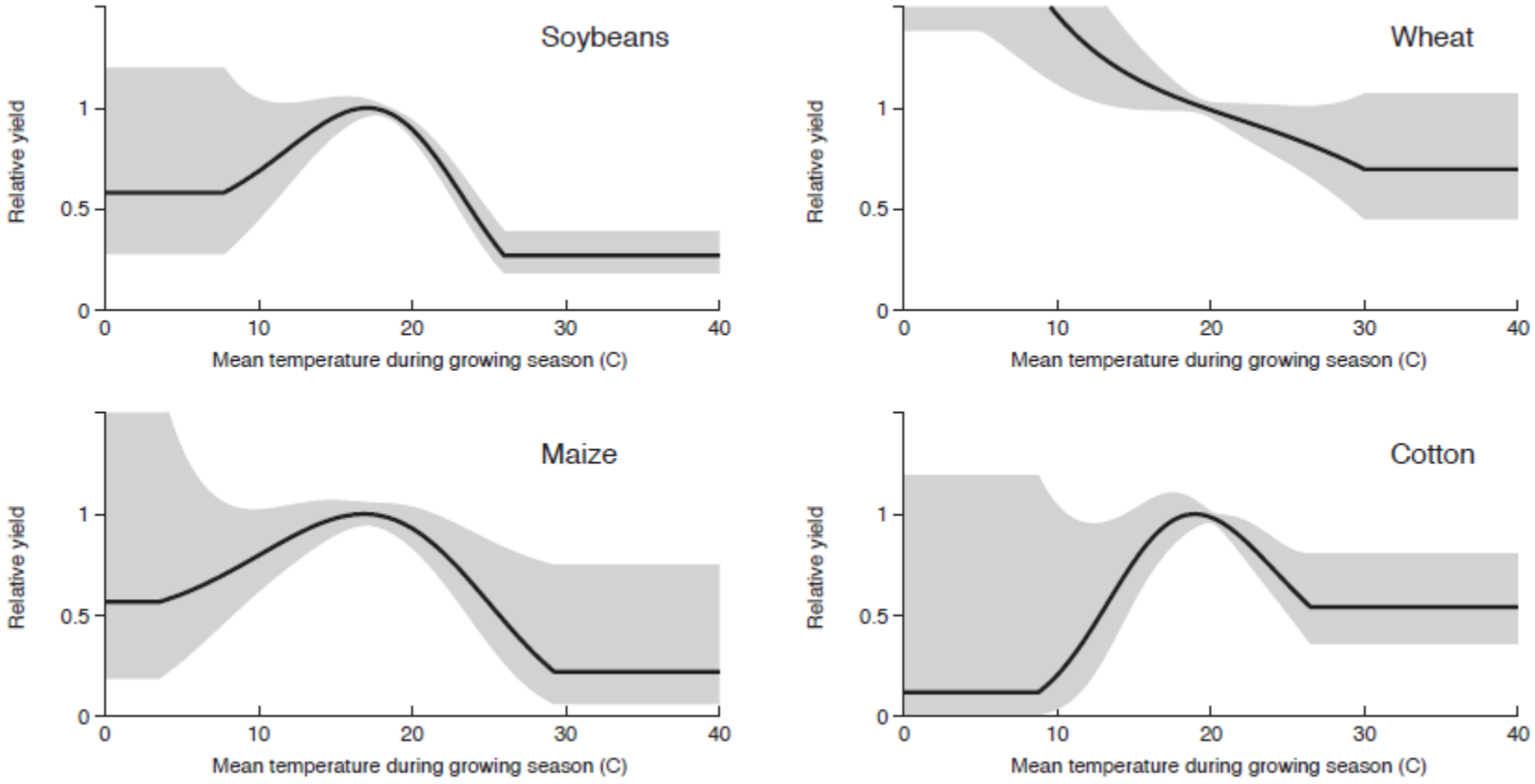
IAM Model comparison



Kopp et al., 2013

Economic impact assessment

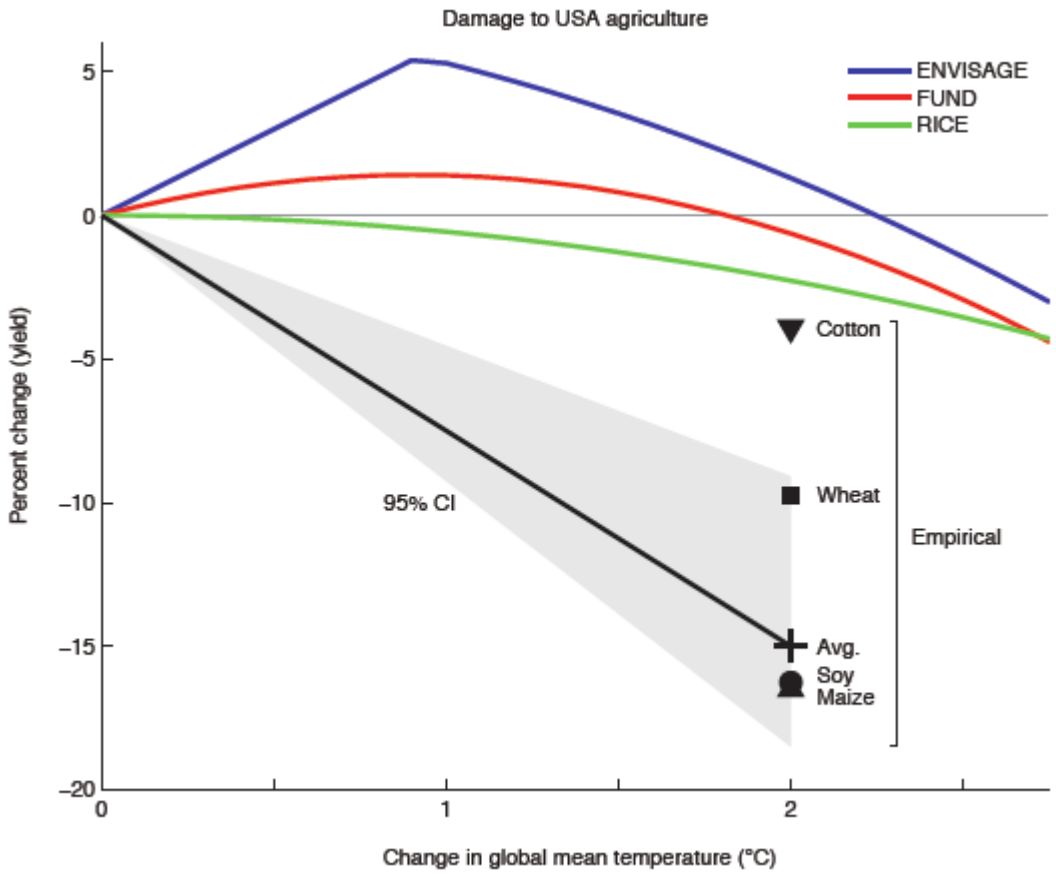
Empirical data on crop sensitivity to climate



Hsiang et al., 2012

Economic impact assessment

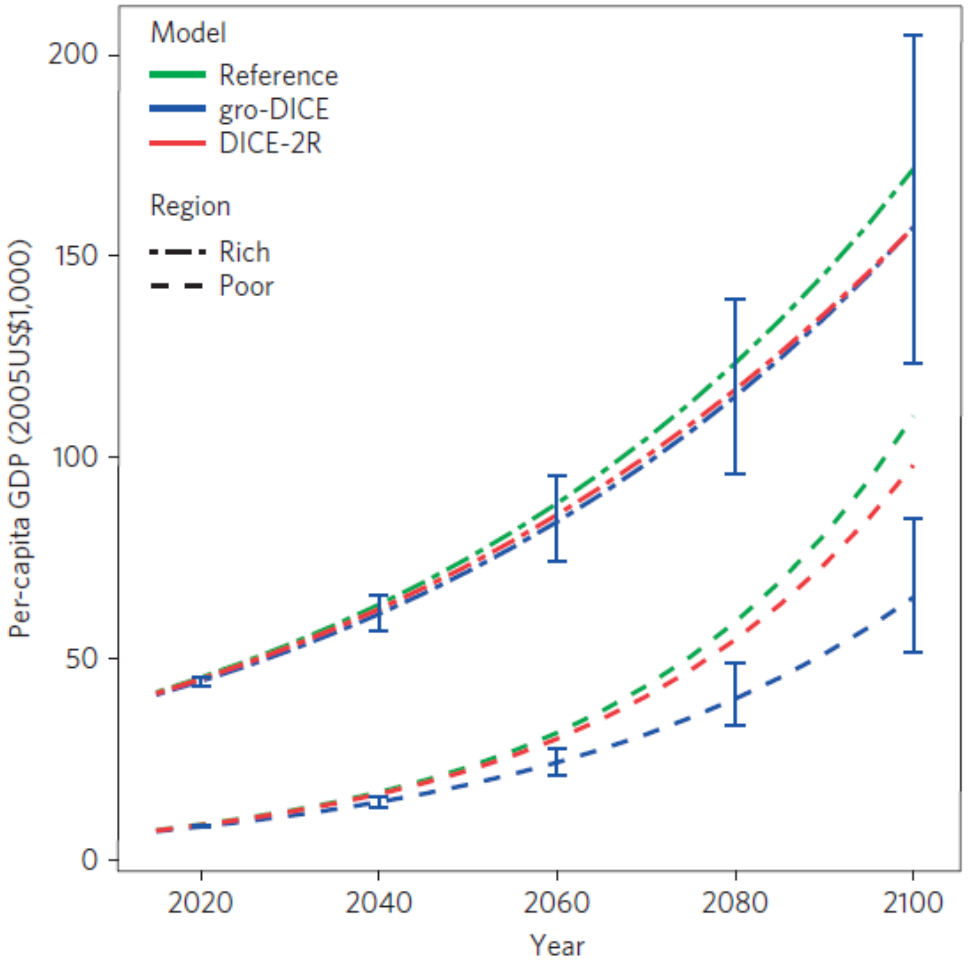
IAM with adjusted damage function



Kopp et al., 2013

Economic impact assessment

Newest generation economic models



Moore and Diaz, 2015