Costs

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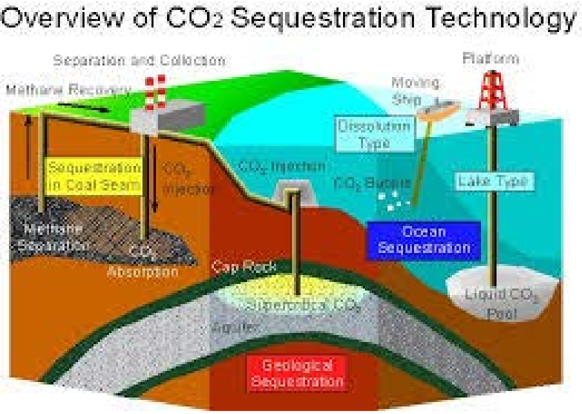
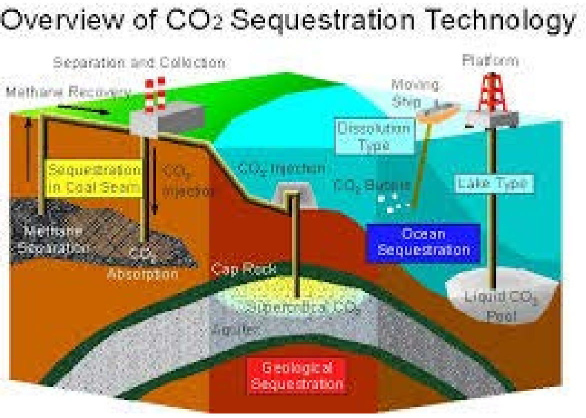




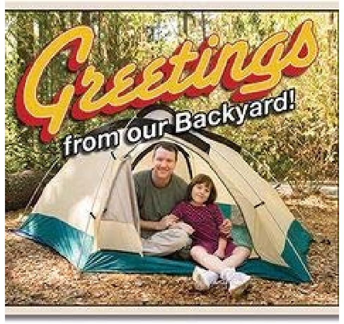
Costs of Action

Costs of Inaction

Categories of Costs of Action

- Fuel switching – paying for a more expensive but less carbon-intensive fuel
- Investments in fuel efficiency =>
  - Better furnace
  - More insulation
  - Better light bulbs
  - More efficient car
  - More energy efficient processes in industry

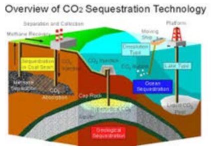
- Forgoing consumption =>
  - Same thing that happens when prices go up – some consumption becomes sub-marginal (eg, fewer miles driven)
  - Forgoing consumption or consuming something that is second-best is a type of cost



- Reductions in quality of consumption =>
  - Inferior lighting quality
  - Smaller or less peppy vehicles

- Accelerated depreciation =>
  - Some capital becomes prematurely obsolete due to carbon intensity (eg, value of coal companies declining)
  - Houses far from urban centers taking advantage of cheap commutes may decline in value

- R&D costs
  - Additional expenditures on R&D into energy efficiency, alternate sources of energy, carbon sequestration
- Carbon sequestration =>
  - Significant costs associated with sequestering carbon



- Geoengineering costs? =>

- Macroeconomics costs
  - Additional costs associated with interaction with pre-existing distortions in economy (eg, due to taxation)

Estimating the Costs of Action

- Most costs due to energy market
- Heavy reliance on models developed in 1970s for analysis of energy market
  - For example: ETA-Macro became MERGE; DGEM initially developed for energy; ICFI’s IPM developed for ERDA as National Coal Model
  - Models are a mix of engineering models (activity analysis) and top-down general equilibrium (DGEM)

- Interesting new paper by Kyle Meng combining prediction markets and almost passed legislation (eg, Waxman-Markey) to estimate
- Role of innovation and technological change very imperfectly understood and quantified
- Nevertheless, costs of action better understood than costs of inaction

Marginal costs of Mitigation (ancient history)

Nordhaus (1975)

Carbon tax in order to reach indicated target

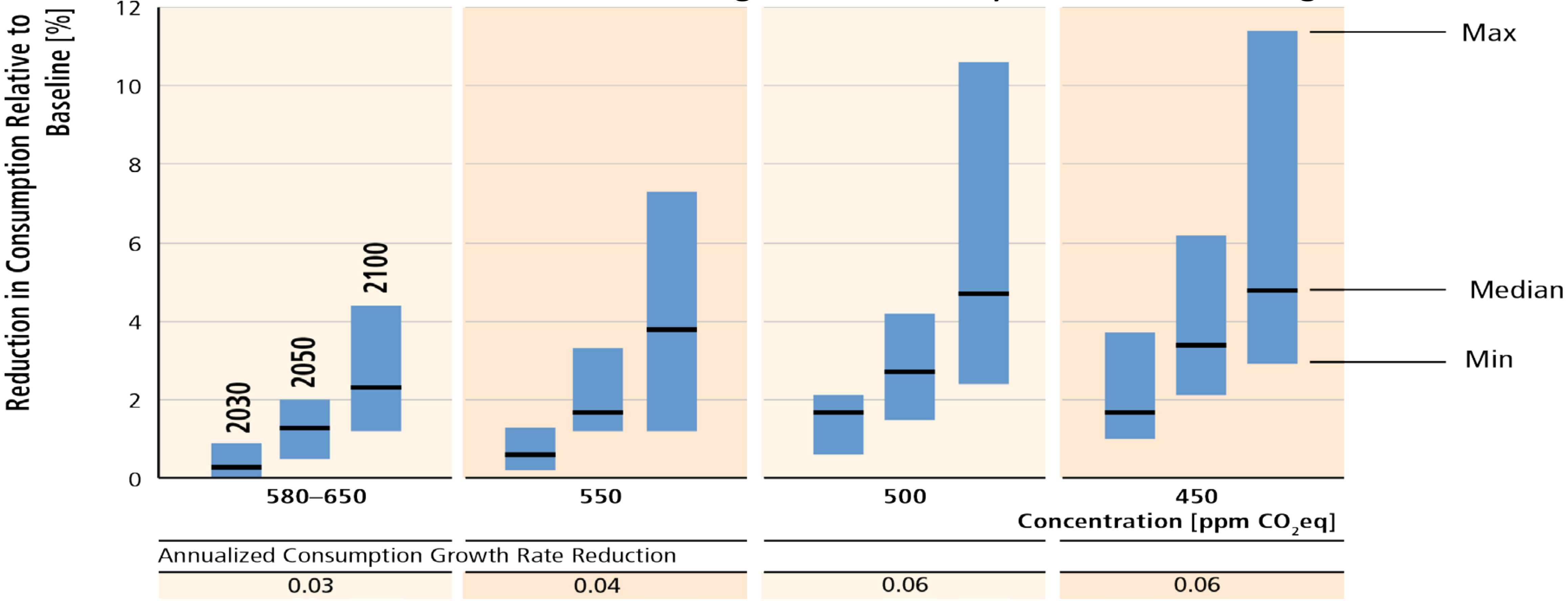
	I. Uncontrolled	II. 200% in-crease	III. 100% in-crease	IV. 50% in-crease
1970	0.00	0.01	0.05	0.15
1995	0.00	0.07	0.57	1.80
2020	0.00	0.87	8.24	28.20
2045	0.00	21.11	46.08	47.66
2070	0.00	58.43	42.17	42.17
2095	0.00	0.00[a]	132.88	132.88

serious problems are likely to occur when the level of carbon dioxide has doubled or more, then the uncontrolled path appears to be heading for the danger zone. It appears that the doubling will come around 2030.

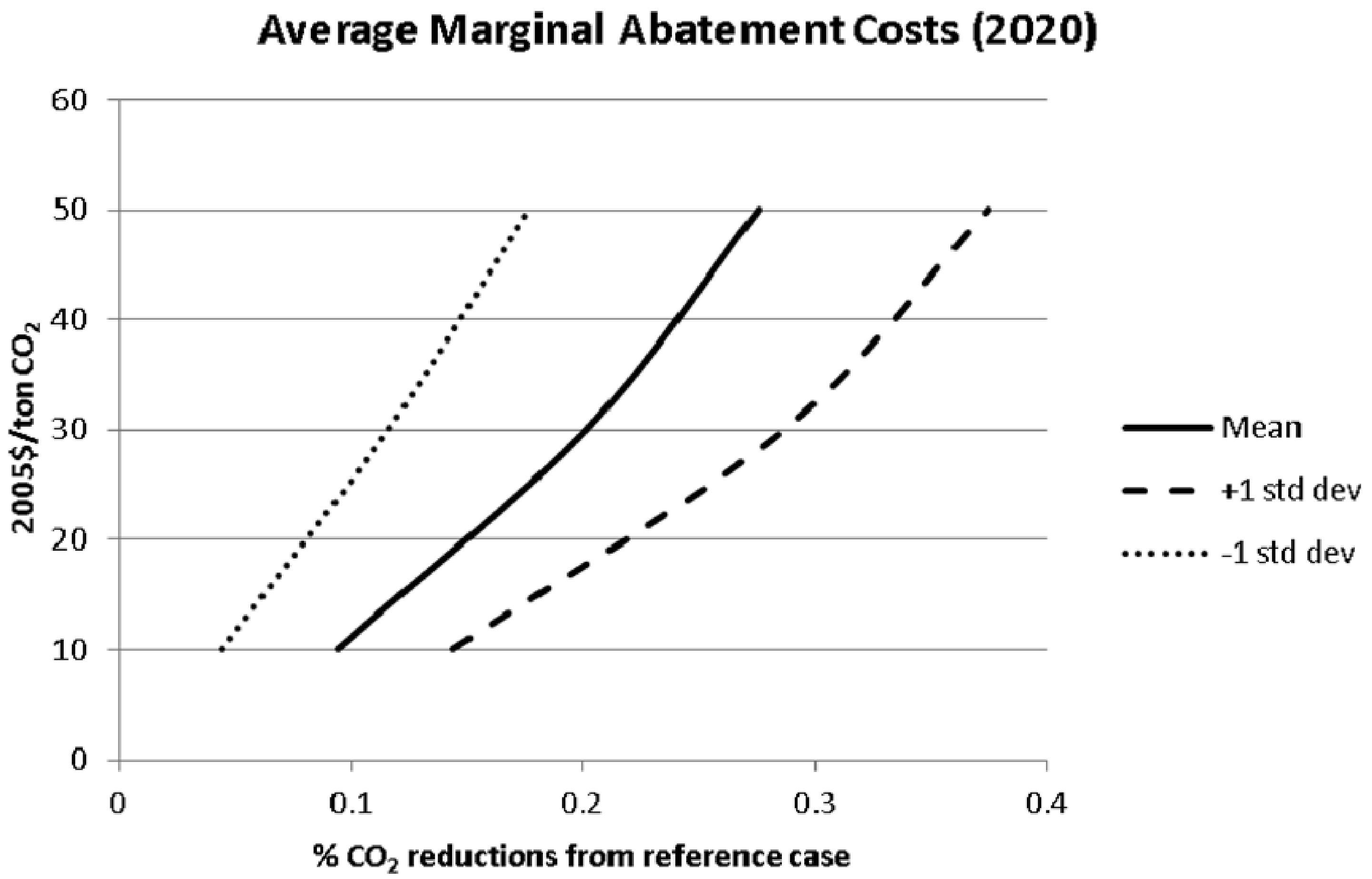
[a]: computational difficulties

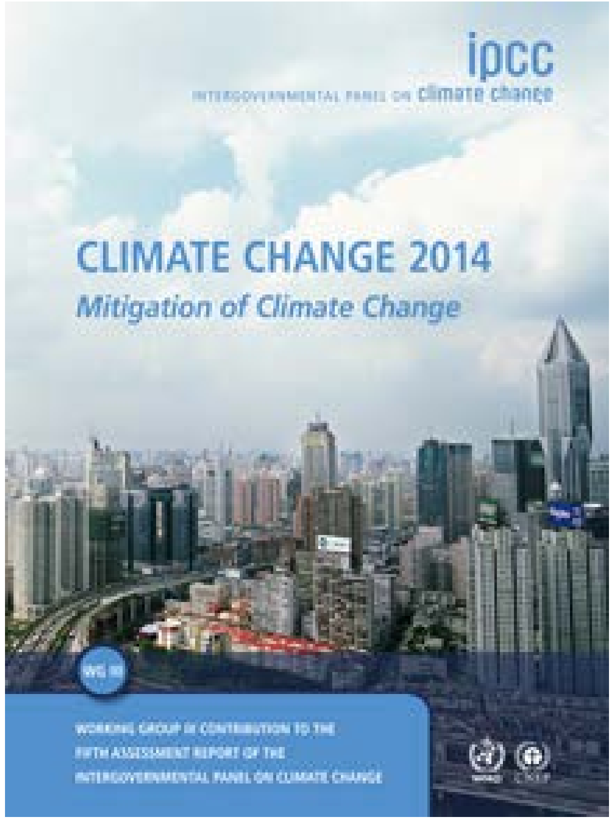
Global mitigation costs rise with ambition of mitigation goal

Mitigation cost only – residual damage excluded

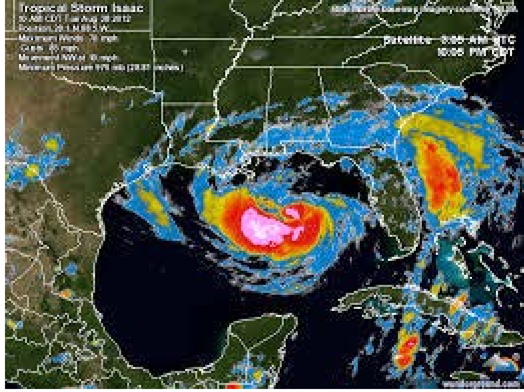


IPCC AR5 Models: Implicit Marginal Abatement Costs



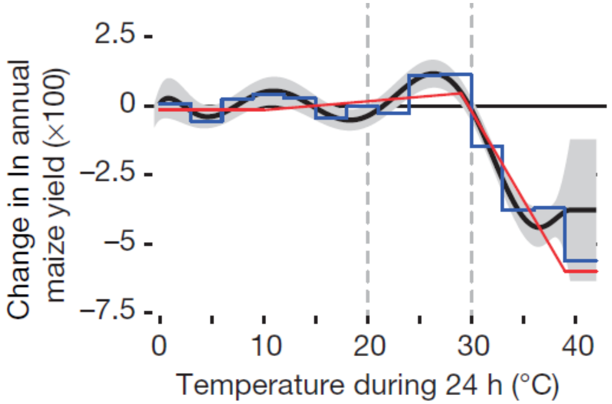


Source: K. Fisher-Vanden
Note: Draft data



Categories of Costs of Inaction

- Costs associated with moderating impacts
  - Adaptation costs – private (autonomous) and public (requiring coordination)
  - Adjustment costs – temporary costs associated with a change
- Monetized equivalent of residual impacts from change in climate
  - Ecosystem services
  - Flooding and man-made capital
  - Loss of life and illness
  - Loss of land (due to sea level rise)
  - Productivity changes in agriculture
  - Cultural losses
  - Energy costs due to colder weather or warmer weather
  - Many other
- Two fundamental requirements needed in order to estimate
  - Physical impacts over broad geographic scope by sector or impact type
  - Physical impacts for range of climate changes, including unlikely change (eg, 8^{o}C)
- Barriers to better estimates
  - Paucity of analyses of physical and biological impacts over wide geographic regions
  - Lack of economic research monetizing physical impacts
  - Research funding



Source: Burke et al, 2015

First something from the olden days…

TABLE I.1 Estimated Percent Change in Corn Yield [a] as a Result of Changes in Temperature and Precipitation [b]

Change in Temperature (°C)	Change in Precipitation (%)				
	−20	−10	0	+10	+20
−2	19.8	21.2	22.7	24.2	25.6
−1.0	8.4	9.8	11.3	12.8	14.2
0	−2.9	−1.5	0	1.5	2.9
+1.0	−14.2	−12.8	−11.3	−9.8	−8.4
+2.0	−25.6	−24.2	−22.7	−21.2	−19.8

[a] Normal = 85 ± 16 bu/acre, 1901–1972 average for selected stations in Missouri, Illinois, Indiana, Nebraska, Iowa, and Kansas, where 65 percent of U.S. corn production is located.
[b] From J. F. Benci and E. C. A. Runge. 1974. Effects of hypothetical climatic changes on production and yields of corn. Report for CIAP study, DOT, Dec. 1974.

From 1974 National Academy of Sciences Study of global cooling from SSTs

Summary of economic damage studies (~2013) (a very sparse literature)

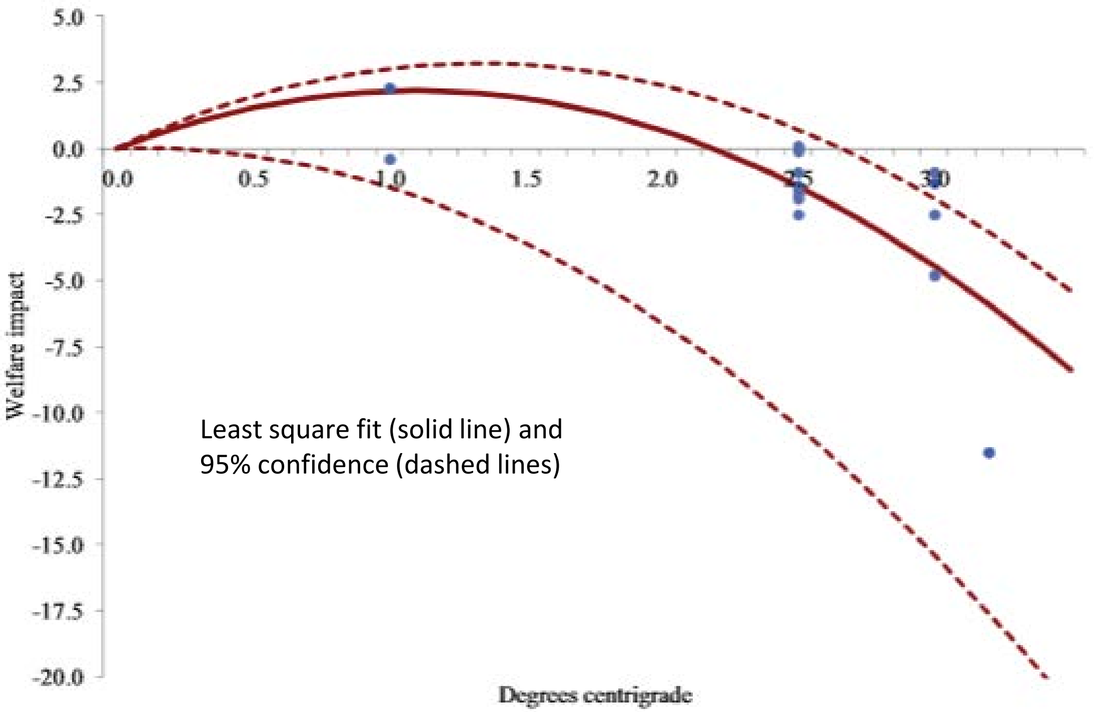


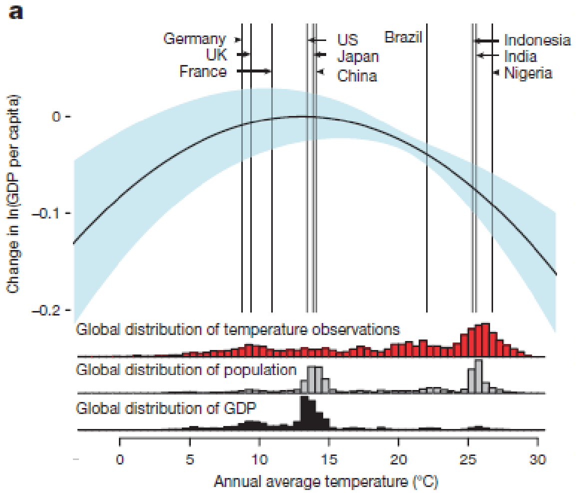
Table 1
Estimates of the welfare loss due to climate change (as equivalent income loss in percent); estimates of the uncertainty are given in bracket as standard deviations or 95% confidence intervals.

Study	Warming (°C)	Impact (%GDP)
Nordhaus (1994b)	3.0	−1.3
Nordhaus (1994a)	3.0	−4.8 (−30.0 to 0.0)
Fankhauser (1995)	2.5	−1.4
Tol (1995)	2.5	−1.9
Nordhaus and Yang (1996)[a]	2.5	−1.7
Plamberk and Hope (1996)[a]	2.5	−2.5 (−0.5 to −11.4)
Mendelsohn et al. (2000a)[a,b,c]	2.5	0.0[b] 0.1[b]
Nordhaus and Boyer (2000)	2.5	−1.5
Tol (2002a)	1.0	2.3 (1.0)
Maddison (2003)[a,d]	2.5	−0.1
Rehdanz and Maddison (2005)[a,c]	1.0	−0.4
Hope (2006)[a,e]	2.5	0.9 (−0.2 to 2.7)
Nordhaus (2006)	2.5	−0.9 (0.1)
Nordhaus (2008)	3.0	−2.5
Maddison and Rehdanz (2011)[a]	3.2	−11.5
Bosello et al. (2012)	1.9	−0.5

Source: Tol (2013)

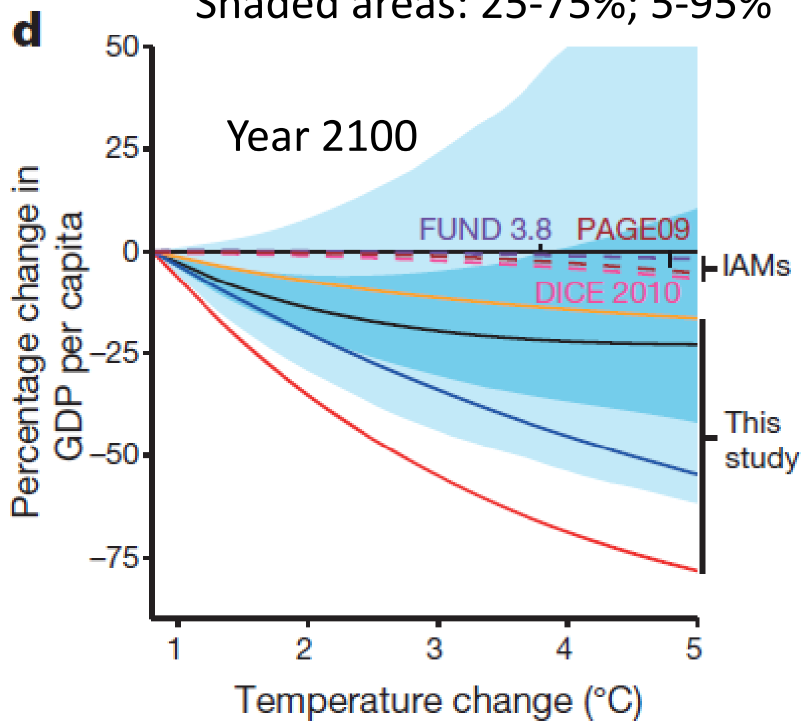
Burke et al (2015) Nature paper

- Examine average annual weather and GDP
- Regress annual economic growth vs. average temperature
  - Data: 1960-2010

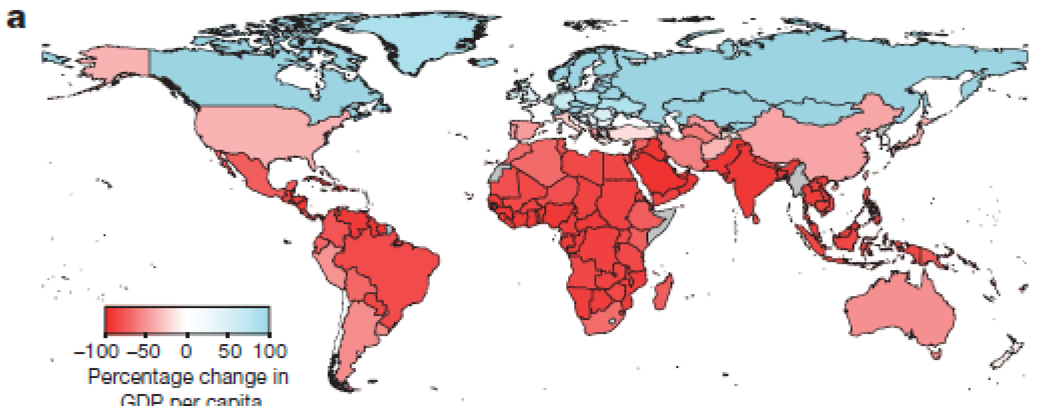


  - Aggregate over countries (RCP8.5, SSP5)
    - Results in corners on right
- Problems:
  - Highly aggregate
  - Weather, not climate
  - Others?

Shaded areas: 25-75%; 5-95%



GDP per capita in 2100 vs 2010 under RCP8.5



Catastrophes

- Criticism of damage estimates:
  - Database of studies embarrassingly sparse (and studies are of variable quality)
  - Unweighted damages underestimates damage in poor countries
  - Some suggest modest damage from modest change inconsequential
    - Risk aversion difficult to justify for modest changes
    - Catastrophes are what matter most to damage estimates
- Pindyck (2015) considers managing multiple possible catastrophes
  - Defines climate catastrophe purely as an increase in global temperature of at least 8^{o}C (probability >10%) and assumes a 10-30% loss of world output as a result
  - Risk aversion much more justified for such catastrophic outcomes
- Effect of catastrophe limited by our knowledge of what might be coming

Conclusions

- General consensus among economists: <u>some</u> mitigation action is warranted; the debate is over how much
- Costs of action (usually called mitigation costs) moderately well known
  - Paucity of statistical studies; engineering analyses dominate
  - How costs will evolve in future poorly known
- Costs of inaction (value of damages from climate change; adaptation costs) very poorly known
  - Most of what we know is from a handful of authors
  - Empirical basis of estimates of damage extremely sparse
  - Many of the estimates of damage date from the 1990s
  - Catastrophic damage is virgin territory and may be the most important category
- Poor knowledge of costs is mostly an indictment of the federal research funding community?
  - Virtually no support for research on what is of vital importance in developing national climate policy
  - Considering the $50 billion+ spent on climate research over the last 25 years in the US alone, this omission is glaring

Thank You!!

Slides: www.ckolstad.org