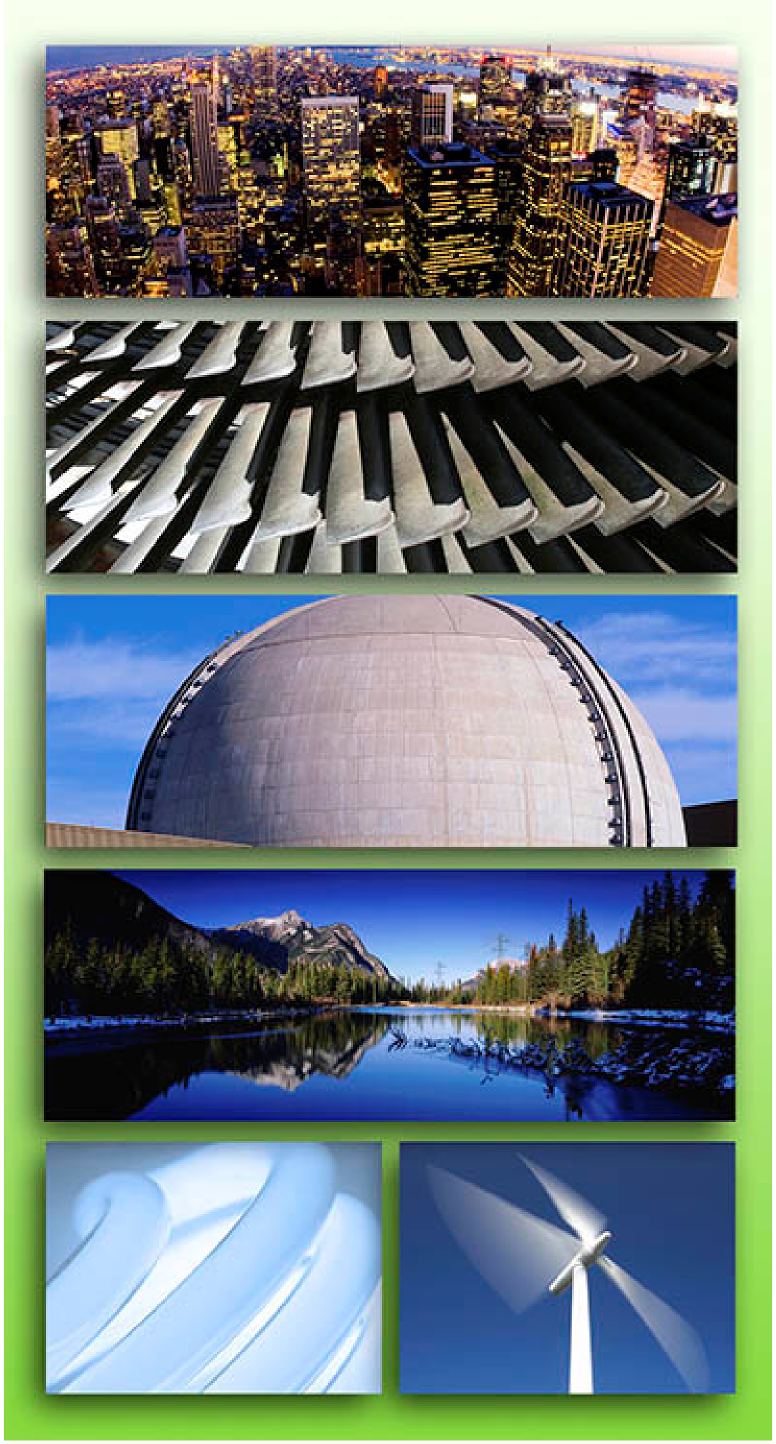

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The role of the social cost of carbon in climate policy

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November 24, 2009

Environmental Defense Fund Climate Economics Seminar Series

Outline

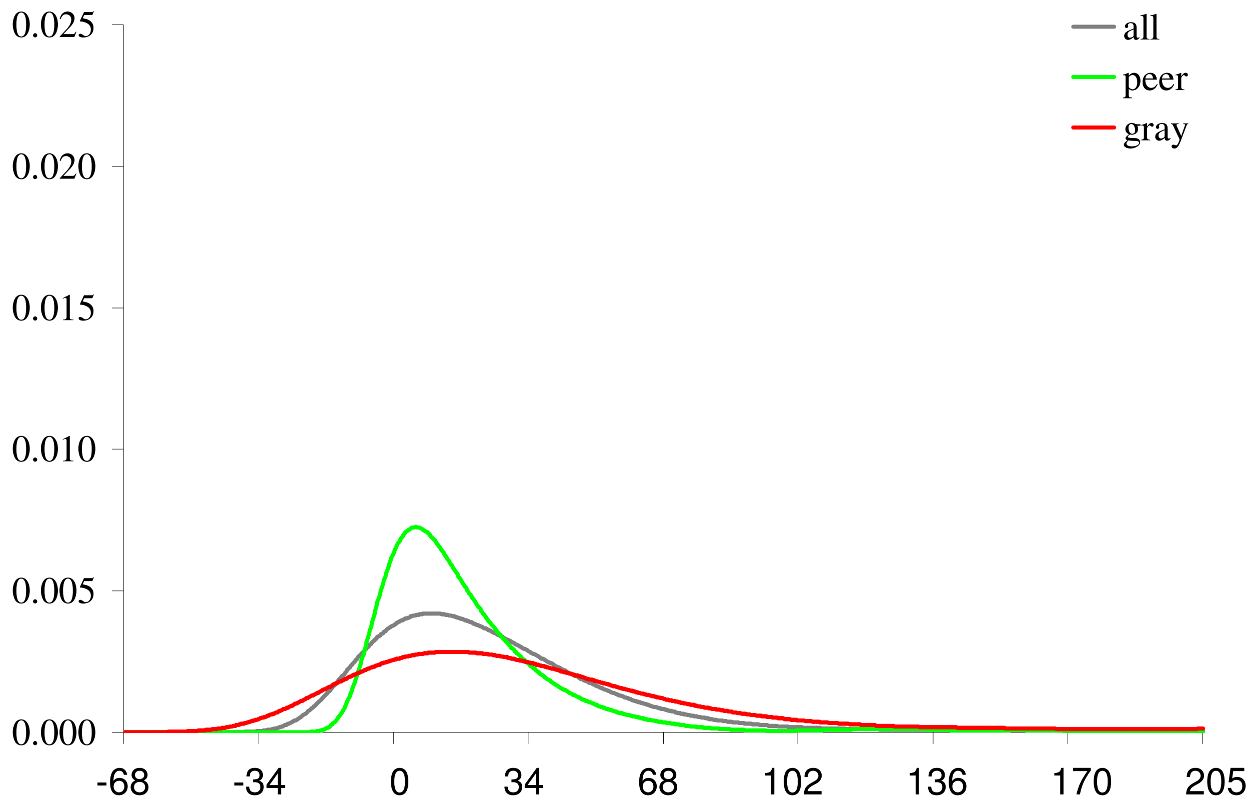
- What is the social cost of carbon and why should we care?
- Do we really need a US Government value(s)?
- Application – non-incremental vs. incremental GHG changes
- What value(s) should we use for incremental policies?
- Review of current USG values
- Where do we go from here?

The social cost of carbon (SCC)

Definition: The net present value of climate change impacts over 100+ years from one additional net global tonne of carbon dioxide emitted to the atmosphere at a particular point in time.

- i.e., the marginal cost of an addition tonne of carbon dioxide in year *x*
- i.e., the marginal benefit of one less tonne of carbon dioxide in year *x*

SCC values (Tol, 2008, meta analysis)



Fisher-Tippett distributions (1995$/tCO2 for circa 1995 emissions)

Why should we care? SCC is in use, but not finalized.

- Under President Bush in 2008…
  - EPA – *Regulating Greenhouse Gas Emissions under the Clean Air Act (advanced notice of proposed rulemaking and Technical Support Document on GHG benefits)*
  - DOE –
    - *Gas ranges and ovens standard (**final**)*
    - *Air conditioning equipment standard (**final**)*
  - NHTSA – *Average Fuel Economy Standards, Passenger Cars and Light Trucks, MY 2011-2015 (**proposed**)*

- Under President Obama in 2009…
  - EPA – *Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program (**proposed, being finalized**)*
  - EPA/NHTSA – *Rulemaking To Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards (**proposed, comment period closes Nov. 27th**)*
  - NHTSA – *Average Fuel Economy Standards, Passenger Cars and Light Trucks, Model Year 2011 (**final**)*
  - DOE – *Energy Conservation Standards for Refrigerated Bottled or Canned Beverage Vending Machines (**final**)*
  - And, more to come

Do we really need a US Government value(s)?

I think so, because…

- It's the law (9th Circuit Court, *CBD v NHTSA*, 2007)
- Economic efficiency – internalize spatial & temporal externalities

- But, only for policies with incremental implications for global GHGs

Application?

Many decisions and potential uses

Rose (2009)

		Types of impacts information						
Type of decision	**Decision process**	**Qualitative/ quantitative**	**Nonmonetary/ monetary**	**Observed/ projected**	**Domestic/ Global**	**Incremental/ non-incremental**	**Point/ distribution**	**Information requirements**
Determining if there is a potential threat	U.S. Supreme Court ruling	Primarily qualitative relationships	Primarily nonmonetary information	Primarily observed impacts	Domestic	Non-incremental	Point	Lowest
	U.S. 9th Circuit Court ruling				Ambiguous	Incremental		
	New facility approval*				Ambiguous	Incremental		
Determining if there is a threat that justifies regulation	EPA endangerment ruling	increasingly quantitative ↓	increasingly monetary ↓	increasingly future looking ↓	Domestic	Non-incremental		↓
	California GHG waiver request				Domestic	Non-incremental		
	Threatened species listing of the polar bear				Global**	Non-incremental		
Evaluating a predefined policy	Twenty-in-Ten				Global**	Incremental		
	Renewable Fuels Standard				Global**	Incremental	Distribution	
Mandating a pathway for emissions	Clean Air Act				Global**	Ambiguous		
	Legislative proposals				Global**	Non-incremental		
	International negotiations				Global**	Non-incremental		
Setting a technological standard	CAFE standards	Quantitative relationships	Monetary information	Projected impacts	Global**	Incremental		Highest
	Appliance efficiency standards				Global**	Incremental		

Non-incremental vs. incremental applications

- Non-incremental changes in global GHGs (i.e., climate policies)
  - Domestic and international target setting
    - Optimal pathways
    - Risk management (long-run targets)
  - Evaluation

- Incremental changes in global GHGs (i.e., non-climate policies)
  - Standard setting – “optimal” or net benefits
  - Evaluation

SCC state of the art

- Modeling:
  - Global frameworks with consistent integrated socioeconomics, emissions, climate change, & impacts
  - Current capability limited to aggregated modeling due to data limitations
  - Inherently large uncertainties – modeling global biophysical and economic systems for 100+ years
- Published estimates primarily global and relevant for incremental policies off of a baseline (not “economically optimal”)
- Broad range of estimates from alternative assumptions, as well as models
- Values rise over time (without risk)
- Non-CO_2 GHGs would have different values

SCC state of the art (2)

- Not modeling potential economic & biophysical transformations of and interactions between systems, regions, and sectors
- Significant data deficiencies for impact categories modeled
- Important omissions
  - “Very likely” underestimated due to omitted impact categories (IPCC, 2007)
    - E.g., non-market values, threshold impacts (e.g., species extinction, catastrophic events), weather extremes (e.g., droughts, heavy rains, winds), and weather variability
  - Value of risk
  - WTP for impacts in other countries (e.g., security, humanitarian, potential use value, existence value)

Caution in using SCC based benefit-cost comparisons

e.g., for international climate policy

	NPV Cost		NPV Benefit	Benefit-cost ratio
Initial carbon tax \ Period	2010-2020	2010-2100	2010-2100	2010-2100
World: 2 $/tC (century)	$ 0.2 10^9	$ 0.1 10^{12}	$ 0.1 10^{12}	1.51
World: 12 $/tC (century)	$ 5.6 10^9	$ 2.0 10^{12}	$ 0.5 10^{12}	0.26
World: 250 $/tC (decade)	$ 2.0 10^{12}	$ 17.8 10^{12}	$ 0.2 10^{12}	0.01
World: 250 $/tC (century)	$ 2.0 10^{12}	$ 46.7 10^{12}	$ 1.1 10^{12}	0.02
OECD: 700 $/tC (decade)	$ 2.0 10^{12}	$ 13.3 10^{12}	$ 0.0 10^{12}	0.00

> 800 ppm CO_2 in 2100

~ 450 ppm CO_2 in 2100

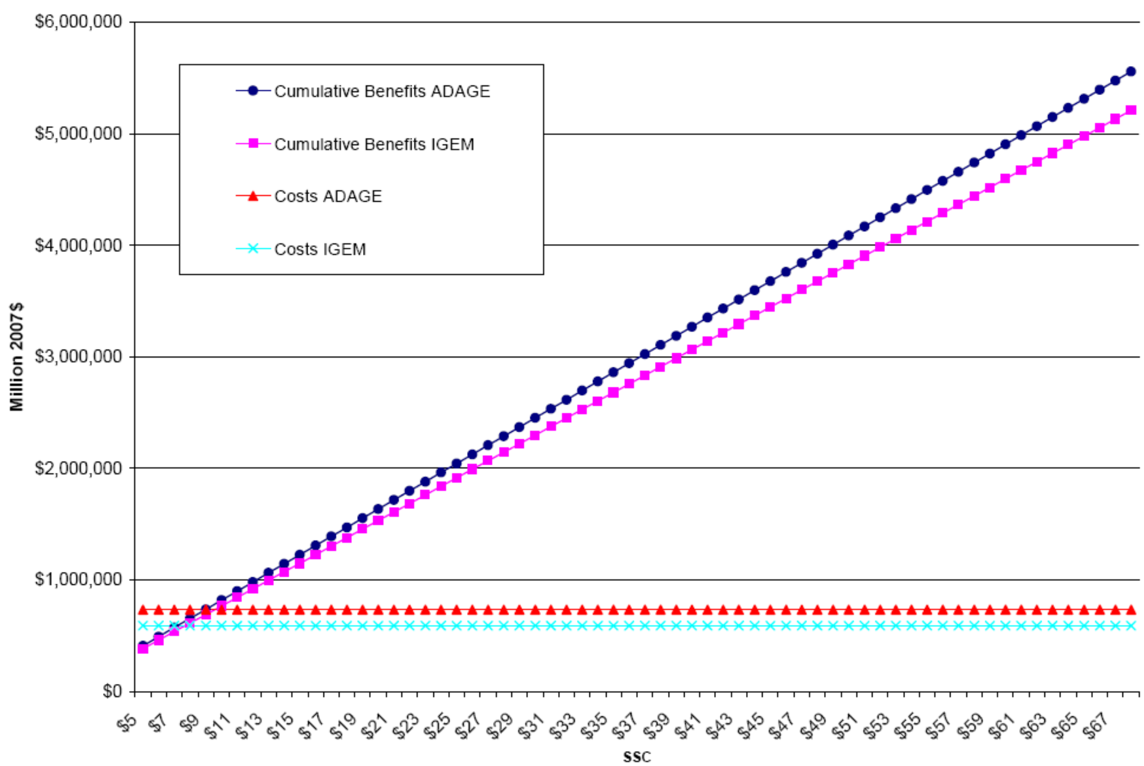
Tol (2009)

But,

- Omitted impacts, no risk premium, single scenario, discount rate 5%
- Only abating energy & industrial CO_2 with ideal policy assumptions

Caution in using SCC based benefit-cost comparisons (2)
e.g., for domestic climate legislation

Chart 2: Total Costs and Benefits at Different SCC Values



Holladay & Schwartz (2009)

But,

- Inconsistencies, not using net global emissions changes, omitted impacts, no risk premium
- Cost uncertainty – policy implementation, technology availability, international assumptions

Caution in MB vs. MC comparisons in general

- Different flavors of marginal values
- SCC estimates extremely uncertain and deficient
- Fundamental inconsistencies – methodo[illegible]
- Annual comparison invalid – growth rate[illegible] benefits!
- Need net changes in global emissions

"Acceptable risk"

(i.e., shadow prices)

			[illegible]	2015	2030
Marginal benefit (SCC)	**Baseline**	CBD v. NHTSA comment[a]	[illegible]	31	49
	Optimal	Nordhaus (2008)[b]	[illegible]	12	--
Marginal cost	**Investment adder**	California Public Utilities Commission[c]	10	15	28
		Idaho Power Company[d]	15	22	47
	Regional mitigation	Lieberman-McCain[e]	--	14	30
		Lieberman-Warner[f]	--	21	44
		Waxman-Markey[g]	--	13	27
		EU-ETS (futures contracts)[h]	$27 (2008)	$30 (2012)	--
		Deutsche Bank (forecast for 2008-2020)[i]	$46 (2008-2012)	$46 (2013-2020)	--
	Global mitigation	Clarke et al. (2007) 3.4 W/m^2 stabilization[j]	--	--	54-122

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Non-incremental GHG changes and the SCC

SCC not robust enough to guide the design of policies for significantly altering climate

- Economically optimal emissions pathway? Setting long-run targets?
  - Not with any confidence
  - Even expected values confounded by remaining uncertainty
- Furthermore, comparing marginal benefit and marginal cost estimates problematic for net benefits
- **This is a risk problem – how much risk is acceptable?**
- Unfortunately, current information for quantifying non-incremental benefits difficult for policy-makers to lean on
  - Can't characterize distributions of most impacts, much less emissions and climate, especially thresholds and potential impacts outside of observed variability, nor monetize many impacts
  - Lacking explicit avoided impacts studies
  - Uncertainties at one scale can confound the utility of information at another scale (e.g., downscaling).

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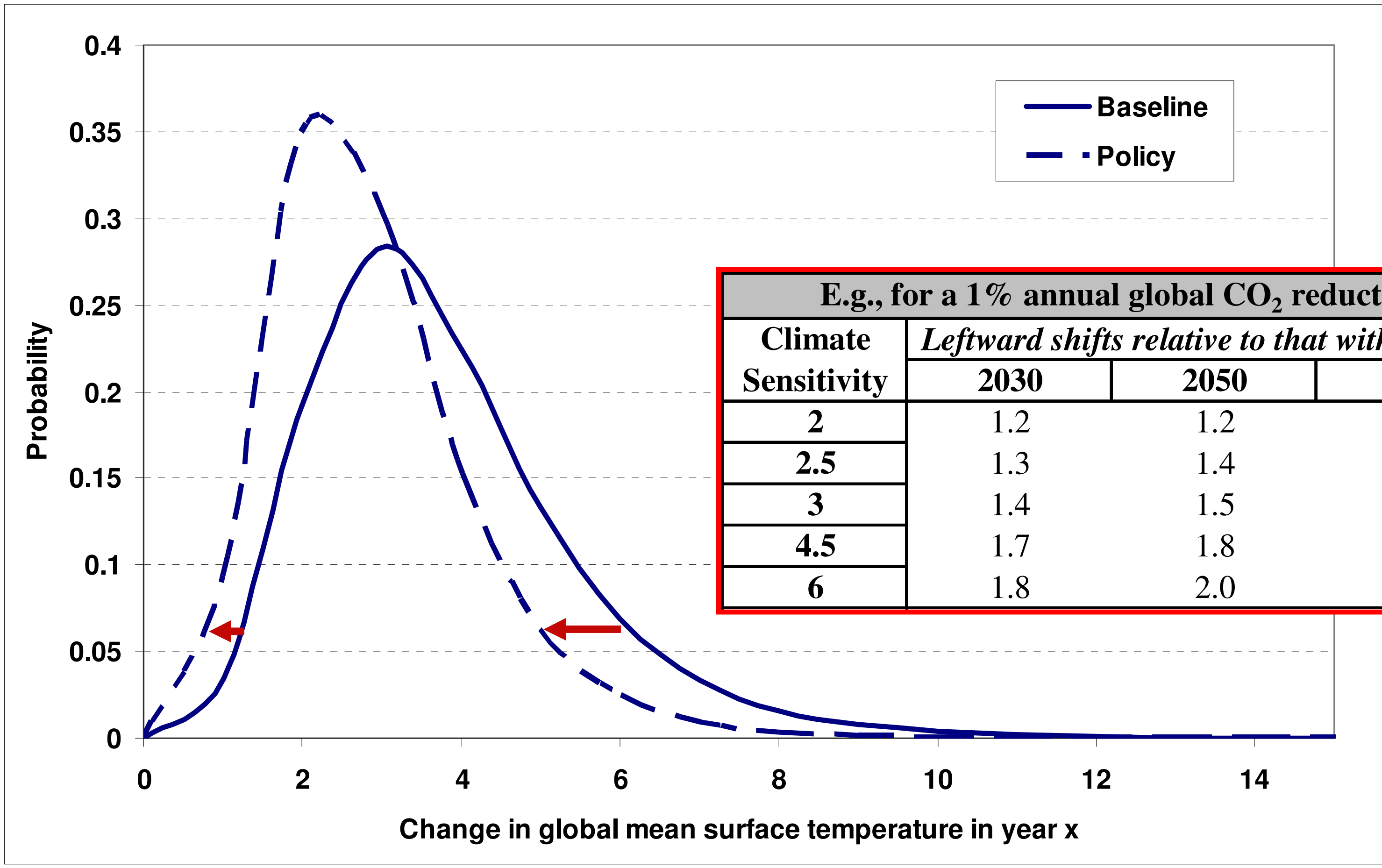
Incremental GHG changes and the SCC

- Recent policy examples – Renewable Fuels Standard, appliance efficiency standards, CAFE
- Implications of SCC deficiencies diminished in this case, and could be considered in selecting values
- Is there a measurable benefit?
  - Is there a climate signal?
  - What is the value?

A signal? Look at the change in the likelihood of climate change

Illustrative reduction in the probability of higher global mean surface temperatures



E.g., for a 1% annual global CO_2 reduction			
Climate Sensitivity	*Leftward shifts relative to that with CS=1.5*		
	2030	**2050**	**2100**
2	1.2	1.2	1.2
2.5	1.3	1.4	1.5
3	1.4	1.5	1.7
4.5	1.7	1.8	2.1
6	1.8	2.0	2.4

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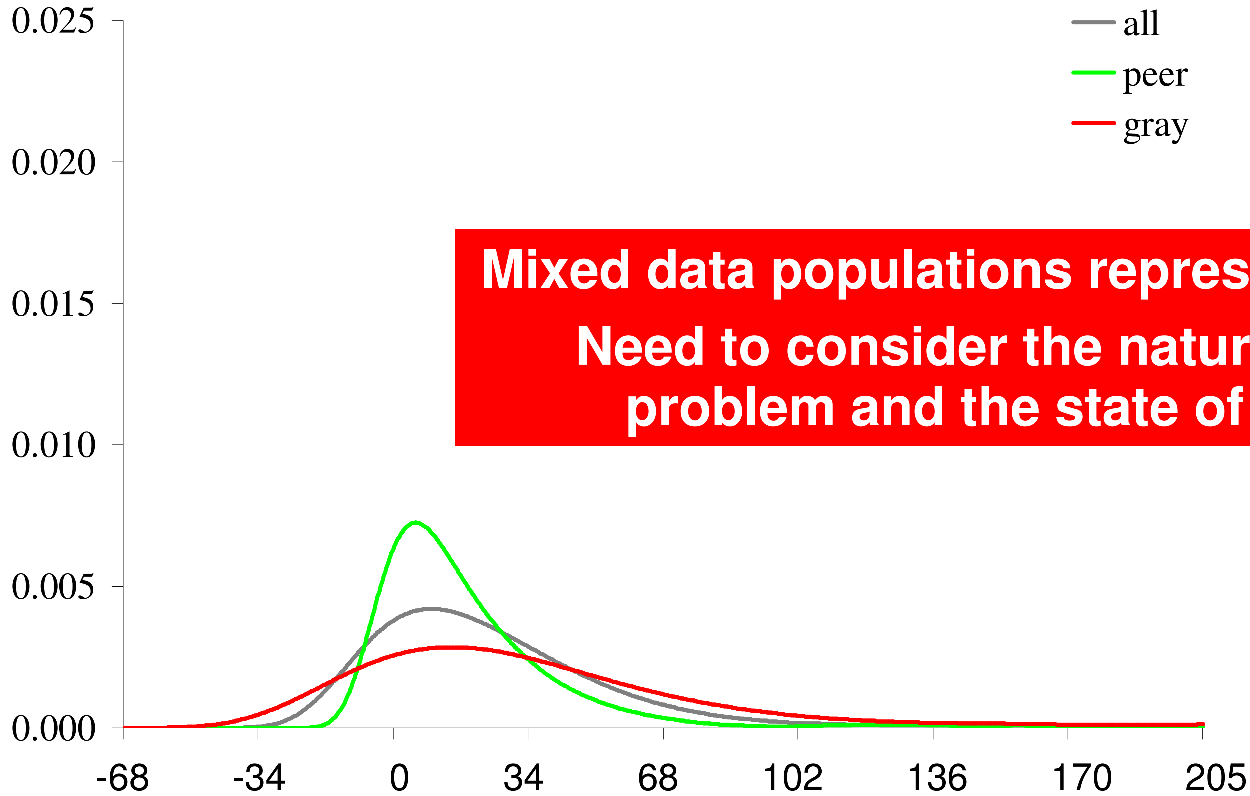
What value(s) should we use for incremental GHG changes?

- Many to choose from…



Mixed data populations represented here.

Need to consider the nature of the problem and the state of the art.

Fisher-Tippett distributions (1995$/tCO2 for circa 1995 emissions)

Tol (2008)

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Physical nature

- GHG emissions mix well in the atmosphere
- GHGs are long-lived with climate inertia effects
- Impacts inherently uncertain – casual chain of uncertainty, beyond observed variability
- Impacts could exceed “irreversible” thresholds and the resilience of systems—geophysical and ecosystem
- Given climate & economic systems inertia, substantially altering climate is beyond the capability of any one country

Economic principles that follow

- GHG emissions mix well in the atmosphere ➔ **Climate change is a global public good, global values necessary to internalize the externality**

- GHGs are long-lived with climate inertia effects ➔ **Climate change is an inter-generational public good, intergenerational discounting appropriate**

- Impacts inherently uncertain – casual chain of uncertainty, beyond observed variability
  - ➔ **Distributions and ranges of estimates appropriate**
  - ➔ **Value of risk** – deterministic estimates underestimate mitigation benefits
  - ➔ **Discounting** – current markets fail to capture the investment associated with relevant time horizon, consumption effects, and large potential impacts
    - 3% or lower consistent, changing/uncertain discount rates over time also practical
  - ➔ **Risk management framework appropriate.** Policy defined "acceptable" level of risk. Course revisited & revised over time.

- Impacts could exceed "irreversible" thresholds and the resilience of systems—geophysical and ecosystem
- Given climate & economic systems inertia, substantially altering climate is beyond the capability of any one country
  - ➔ **Providing the public good is an <u>assurance game</u> –** minimum required cooperation, diminished free riding incentives, inclined to reveal action

A number of issues to contend with

- Global vs. domestic SCC
- Discounting
- Equity weighting
- Uncertainty
- Omissions
- Risk
- Growth over time
- Use of the literature and/or new modeling. If the literature, which part?
- Standard setting vs. evaluation use

A number of issues to contend with

- Global vs. domestic SCC – domestic inefficient
- Discounting – 3% or lower (dynamic and/or with uncertainty)
- Equity weighting – efficiency & consistency across policies suggests none
- Uncertainty – ranges (from reference scenarios) **and** expected values
- Omissions – ranges and risk management
- Risk – risk premiums and risk management
- Growth over time – need to account for
- Use of the literature and/or new modeling. If the literature, which part? – modeling allows control over parametric uncertainty
- Standard setting vs. evaluation use – probably need to select a value for former, range for later

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EPA ANPR & RFS2 NPR estimates for 2007 & 2030 (various discount rates, 2006$)

		~ 2%			~ 3%			~ 7%		
		Low	Central	High	Low	Central	High	Low	Central	High
Meta global	2007	-3	68	159	-4	40	106	n/a	n/a	n/a
	2030	-1	134	314	-2	78	209	n/a	n/a	n/a
FUND global	2007	-6	88	695	-6	17	132	-3	-1	5
	2030	-3	173	1372	-3	33	261	-1	0	11
FUND US	2007	0	4	16	0	1	5	0	0	0
	2030	0*	9	32	0*	2	11	0*	0*	0*

Source: EPA RFS2 NPR RIA, Table 5.3-1

- **Single value not needed**
- Meta – filtering and fitting of Tol (2008) for peer review, post 1995, non equity weighted, discount rate
- FUND – sensitivities on socioeconomics, climate sensitivity, discount rate, non equity weighted
- Growing at 3%/year

- Impacts felt well into the future
- Domestic estimates fraction of global values, remainder international externalities from domestic emissions
- Domestic estimates are direct benefits. Does not include consideration for international interests.

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Socioeconomic & climate response sensitivity

		CS = 1.5 deg C			2			3			4.5			6		
	Baseline	DR = ~2%	~3%	~7%	~2%	~3%	~7%	~2%	~3%	~7%	~2%	~3%	~7%	~2%	~3%	~7%
Global	FUND	-$2	-$5	-$3	$9	-$2	-$3	$43	$9	-$1	$140	$35	$1	$365	$81	$5
	A1b	-$6	-$5	-$3	$0	-$3	-$2	$16	$3	-$2	$54	$16	$0	$114	$37	$3
	A2	-$2	-$6	-$3	$15	-$1	-$3	$68	$13	-$2	$240	$51	$1	$655	$125	$5
	B2	-$4	-$5	-$3	$8	-$2	-$3	$43	$8	-$2	$145	$34	$1	$409	$83	$4

Source: EPA RFS2 NPR RIA, Table 5.3-2

Climate response risk

Emissions and vulnerability risk

- **Same SCC possible for different reasons – emissions and socioeconomic projections not synonymous**
- **New socioeconomic scenarios & climate sensitivity estimates emerging**

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New preliminary Administration estimates

Discount rate assumption	Interim SCC schedule (2007$) [a] 2007	2015	2020	2030
5%	$5	$7	$8	$10
5% (Newell-Pizer) [b]	10	13	15	20
Average SCC Values from 3% and 5%	20	25	29	39
3%	34	43	50	67
3% (Newell-Pizer) [b]	56	72	83	110

Source: EPA/NHTSA NPR Light-duty Vehicle Emissions & CAFE Standards, Table III.H.6-3

- $20 used in finalized/proposed standards (DOE, EPA/NHTSA)
- All growing at 3%/year

- Number of analytical issues:
  - Constrained – uncertainty across model means, values contingent on results selected, the specific applications and assumptions and the uncertainty within and across them
  - Discounting: 5% inconsistent with impacts on consumption and intergenerational time horizon (and negative risk premium)
  - Averaging across discount rates inappropriate
  - Inconsistency between discount rate uncertainty and impacts modeling
  - Some elements not transparent
  - Updatable?

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Which values? What is the objective?

- Internalize externalities, which implies
  - Capturing global and intergenerational effects
  - Capturing uncertainty and risk of climate damages
    - Modeling choices critical
      - Exposure
        - Radiative forcing (income, population, technology, land use)
        - Climate response/feedbacks (e.g., climate sensitivity, carbon cycle)
      - Vulnerability
        - Impacts modeled
        - Adaptation responses (per capita GDP)
      - Discounting
    - Important not to truncate distributions if possible – skewed distributions and potential for high impact/low probability events (e.g., socioeconomics, climate sensitivity)
      - Expected values **and** scenarios

- Consistency with climate policies
  - Baseline vs. aspirational pathway
  - Acceptable risk & hedging against risk – e.g., potential damages associated with CS > 6 (which may be greater than in monetary metrics), include risk premiums

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Summary remarks

- One or more USG SCC values likely – methods?
- SCC has a place, but not robust enough for target setting
- Key technical and policy decisions will determine the estimates
  - Need to consider basic principles
  - Critical question is what is the objective?
- Need for transparent & enduring (updatable) methodology
- New modeling/analyses: non-CO2, growth rates, uncertainty, model advances
- Important to provide more than monetary information
- Improvements in non-incremental impacts analyses are needed (consistency, interactions, feedbacks, mitigation analyses, fuller characterization of uncertainty) – efforts are underway

Thank you!

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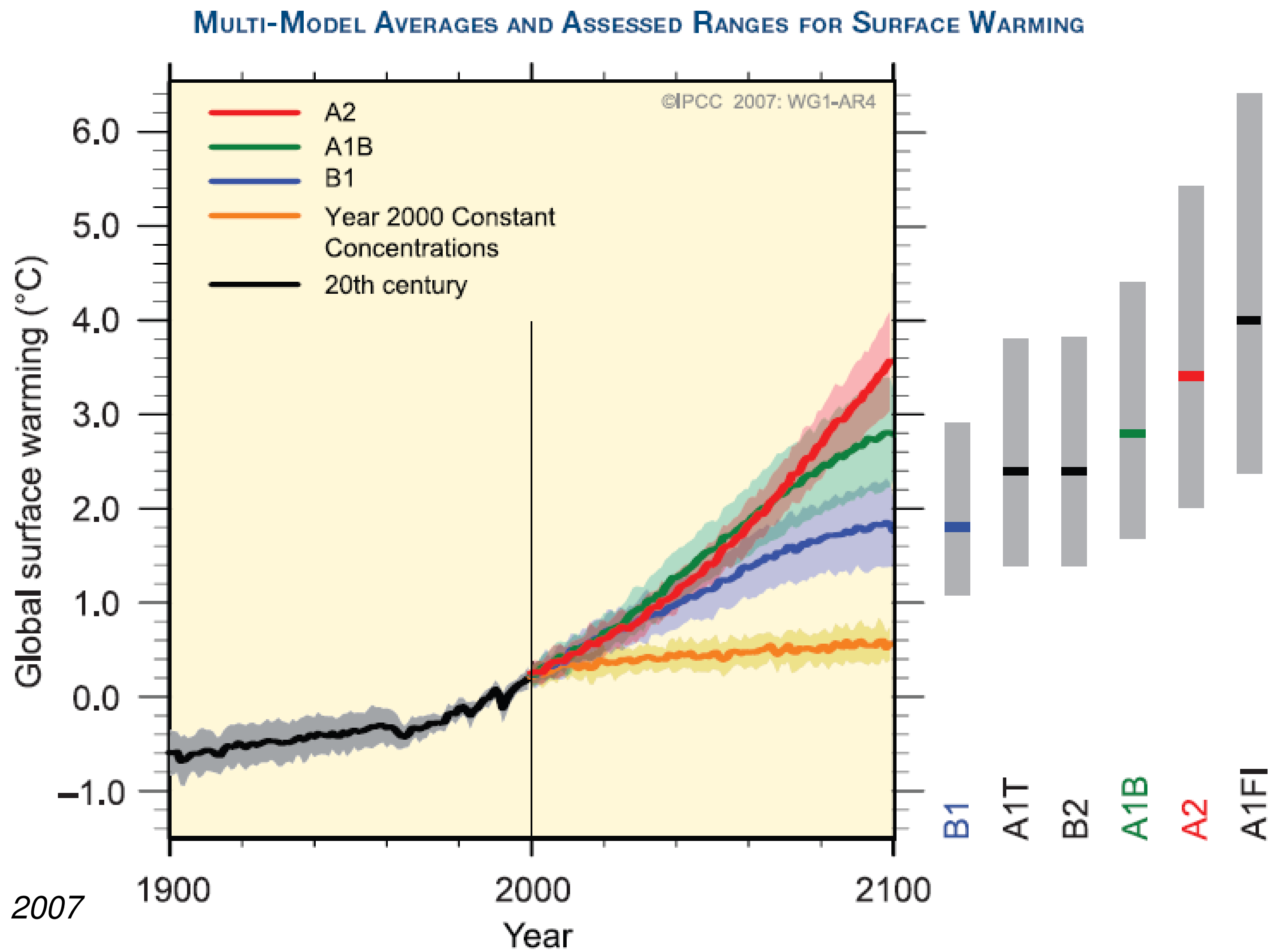
Partial climate uncertainty – many potential futures, model uncertainty around them



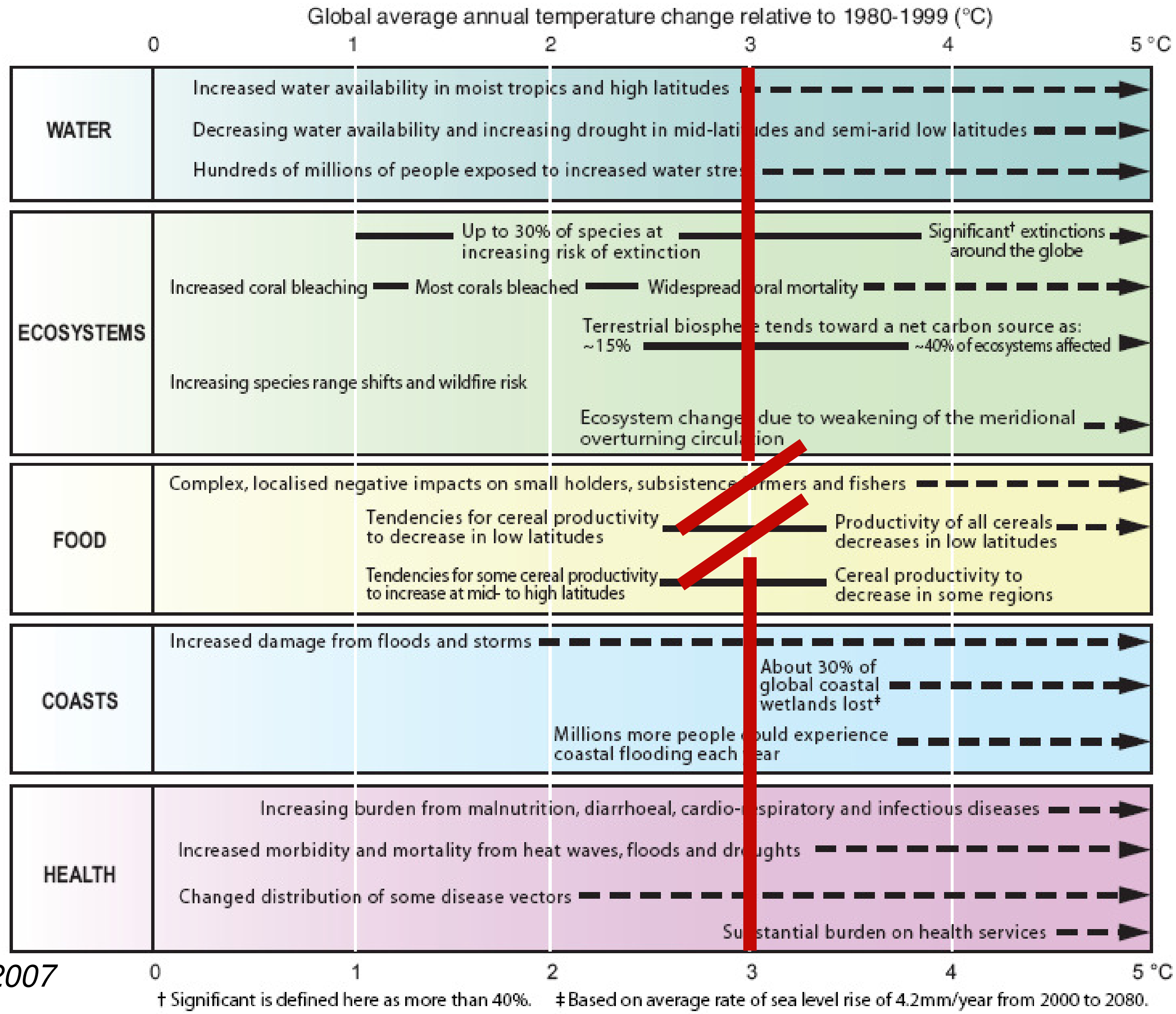
IPCC WGI, 2007

Partial policy uncertainty – model uncertainty, not requirements

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005 = 375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

IPCC WGIII, 2007

Uncertain impacts and avoided impacts – inconsistencies and not a sliding scale



IPCC WGII, 2007