CRED:
Modeling climate and development

Frank Ackerman
Stockholm Environment Institute-US Center

Climate Change Task Force
Institute for Policy Dialogue
Manchester, UK
July 7, 2010

The logic of a new model

- Pitfalls of standard models
  - Tradeoff between climate, development built in
  - Dated inputs, debatable assumptions
    - FUND: global net benefits until 3°C warming
    - DICE: huge value for subjective benefits of warming
- Our objective
  - A "simple" model of climate *and* development dynamics
  - Incorporates latest research (e.g. McKinsey cost curves)
  - Focuses on equity implications, regional interactions
- Climate and Regional Economics of Development
  - *CRED - version 1.1, just released*

What's the goal?

- CRED maximizes present value of welfare = *population * log (per capita consumption)*
  - Normative statement, not psychological theory
  - Future welfare discounted (sole use of discounting)
- Welfare can be increased by growth, or by abatement (reducing future climate losses)
  - Model picks optimal levels of growth, abatement
- Logarithmic welfare → equal percentage changes in consumption are of equal value
  - Per capita consumption in US = 52 * South Asia in 2005
  - So $52 in US and $1 in South Asia are equally valuable

What economists once knew

- Moral principles of early neoclassical economics
  1) Declining marginal utility
  2) Equal weight given to all people

  - "A pound's worth of satisfaction to an ordinary poor man is a much greater thing than a pound's worth of satisfaction to an ordinary rich man" *– Alfred Marshall*

- Retreat from second principle in 1930s
  - Lionel Robbins, others: impossible to compare the subjective experience of different individuals

- Optimizing models often ignore Robbins et al. in practice, use both principles

Why other models don't get it

- Many models maximize log(consumption) or related, even more egalitarian measures
- They hide the equity implications in two ways:
  - A technical trick (model solution is based on "Negishi welfare weights")
  - An institutional constraint (model assumes no capital flows between regions)
- Without these obstacles, standard models favor economic development *and* climate stabilization

The mathematics of inequality

- Negishi (1960, 1972)
  - Solves general equilibrium models by assuming everyone has the same marginal utility of consumption
  - Suppresses information about inequality, finds equilibrium consistent with existing distribution of income
- Widely used in regionally disaggregated models
  - "The Negishi weights… prevent large capital flows between regions… although such capital flows would greatly improve social welfare, without the Negishi weights the problem of climate change would be drowned by the vastly larger problem of underdevelopment." *(Keller et al. 2003, on RICE)*
- See Stanton, forthcoming in *Climatic Change*

What's new in CRED?

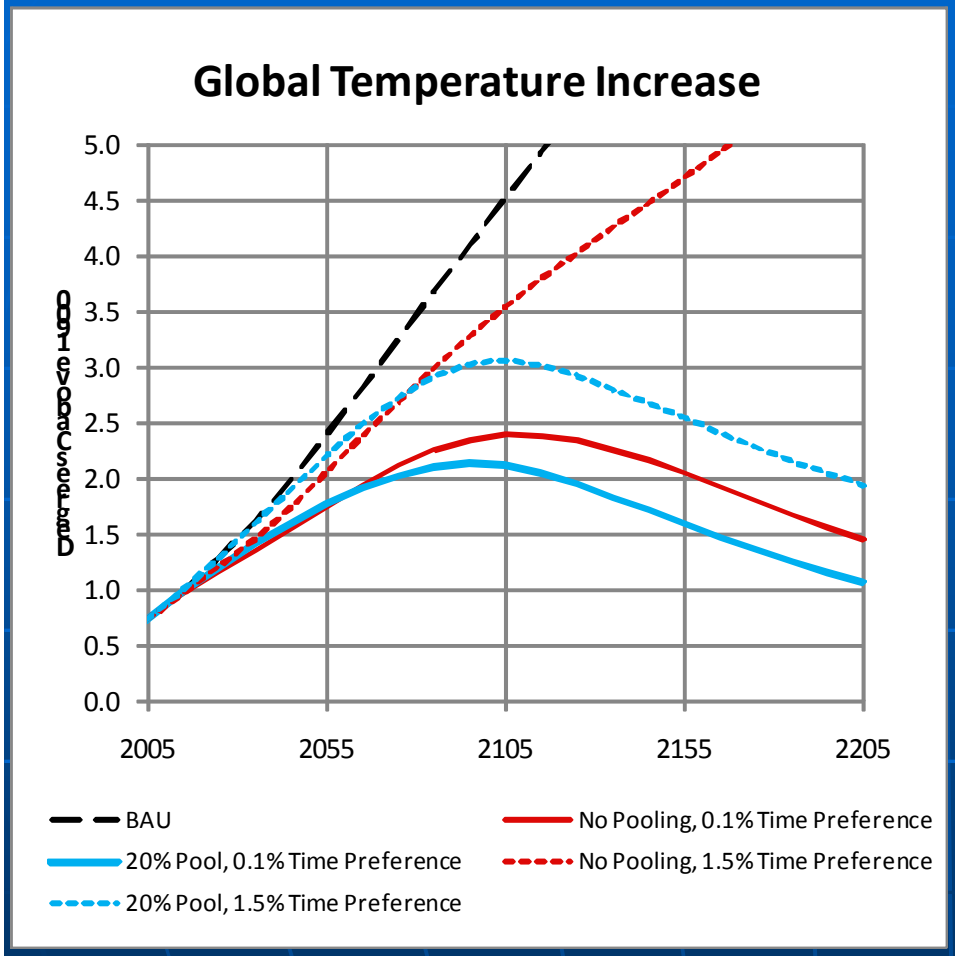
- McKinsey cost curves used for abatement costs
  - McKinsey's negative-cost measures assigned roughly zero net cost for modeling
- Mitigation treated as productive investment
  - Productivity = 50% of ordinary investment
- Two carbon prices govern pace of mitigation
  - One price for high-income, one for developing countries
  - Indicators of marginal abatement cost; not carbon taxes
- Damages = roughly double the DICE level
- Climate sensitivity = 4.5

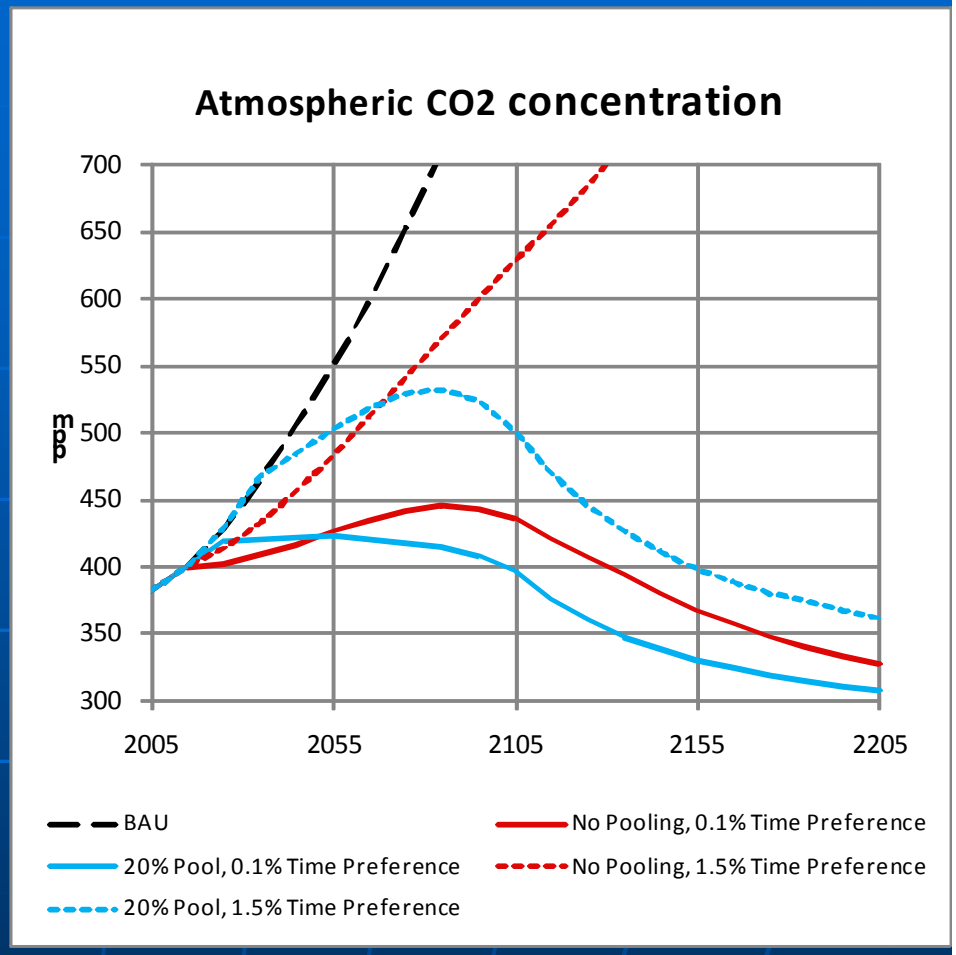
Investment pooling

- Part of each region's savings go into global "pool"
  - Includes private and public investments
  - Model allocates savings pool around the world to meet objectives most efficiently
- Unconstrained solution – solves climate and development problems quickly
  - High-income countries: massive increase in savings; consumption drops to Latin American levels
    - More than half of savings invested in developing countries, raising their incomes and cutting emissions
    - Ratio of richest/poorest regions' per capita consumption drops to 4
  - Climate quickly stabilized, stays under 2º warming
- This *is* the efficient solution (given log welfare)

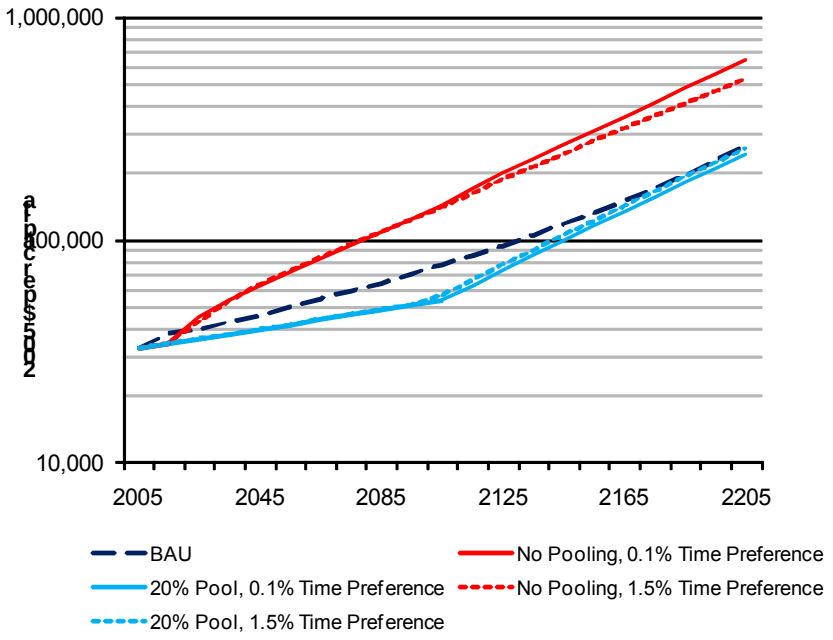
Efficiency vs. equity

- Is the efficient solution unfair to rich countries?
  - It is clearly unacceptable to them
  - “Efficiency can be separated from equity”
- Two constraints added to move toward acceptable solutions
  - Pooling constrained to a fraction of each region’s savings
  - All regions guaranteed at least 0.5% annual growth of per capita consumption
- Under these constraints, optimal solutions depend on discount rate, pooling limit

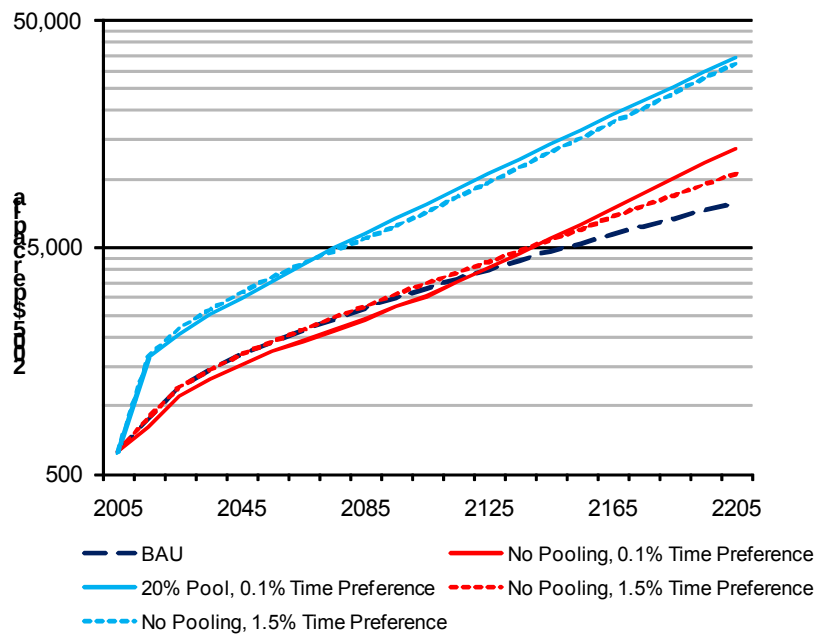

Global Temperature Increase
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2005
2055
2105
2155
2205
BAU
No Pooling, 0.1% Time Preference
20% Pool, 0.1% Time Preference
No Pooling, 1.5% Time Preference
20% Pool, 1.5% Time Preference


Atmospheric CO2 concentration
700
650
600
550
500
450
400
350
300
2005
2055
2105
2155
2205
BAU
No Pooling, 0.1% Time Preference
20% Pool, 0.1% Time Preference
No Pooling, 1.5% Time Preference
20% Pool, 1.5% Time Preference

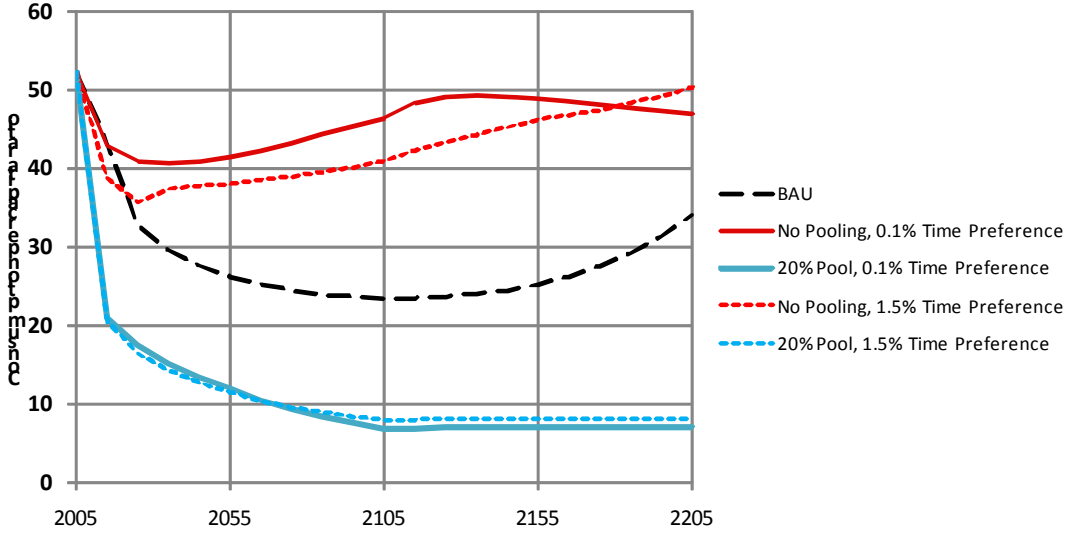
Consumption per capita: USA

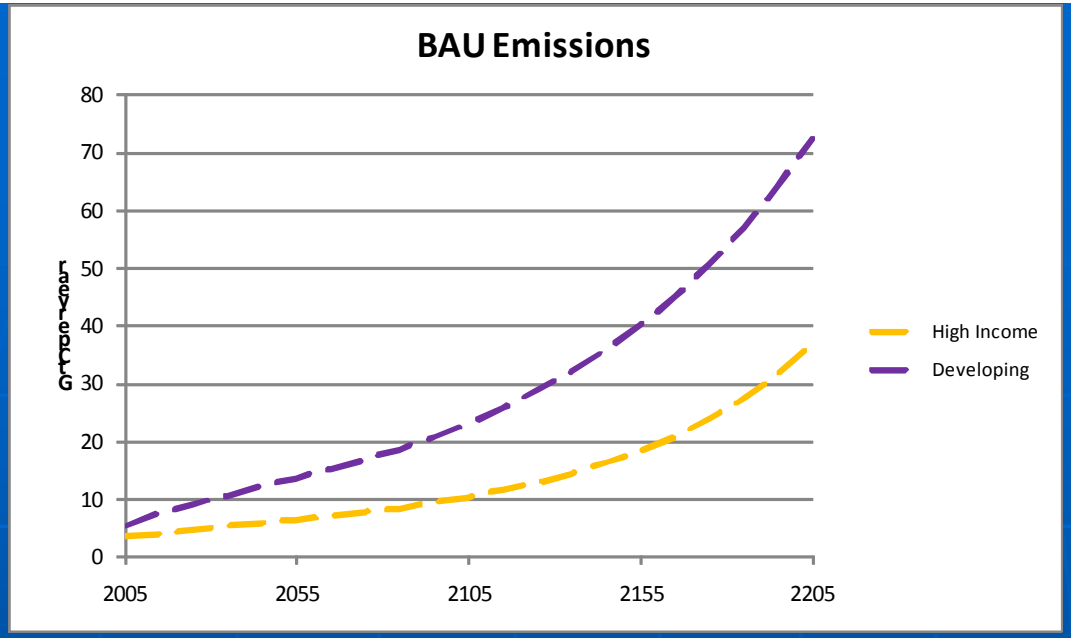


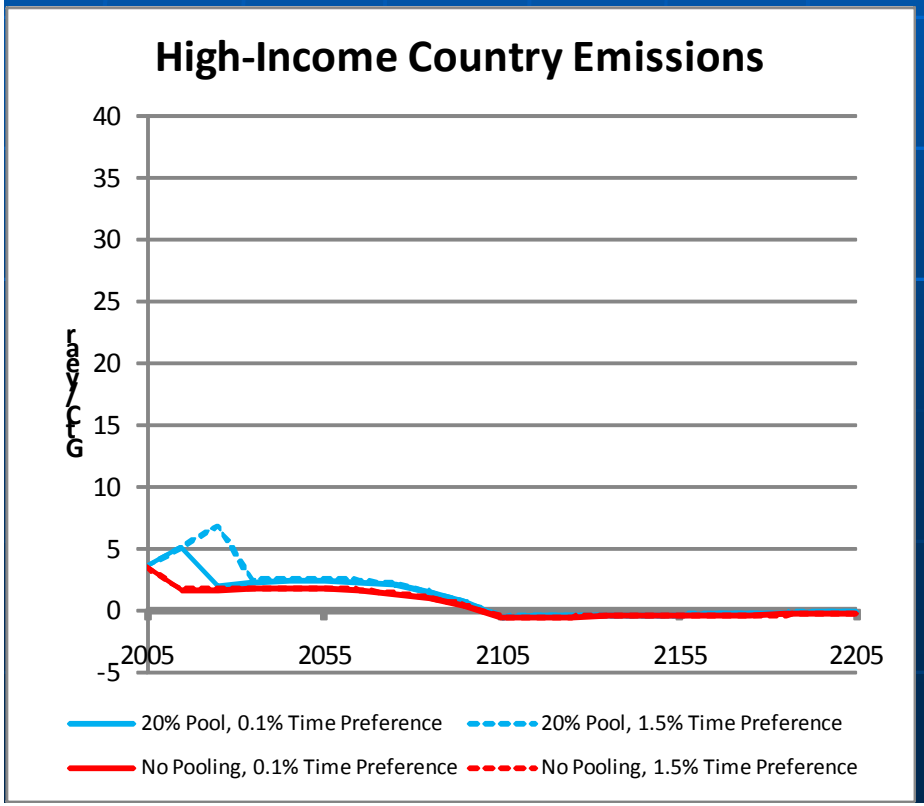
Consumption per capita: South/Southeast Asia

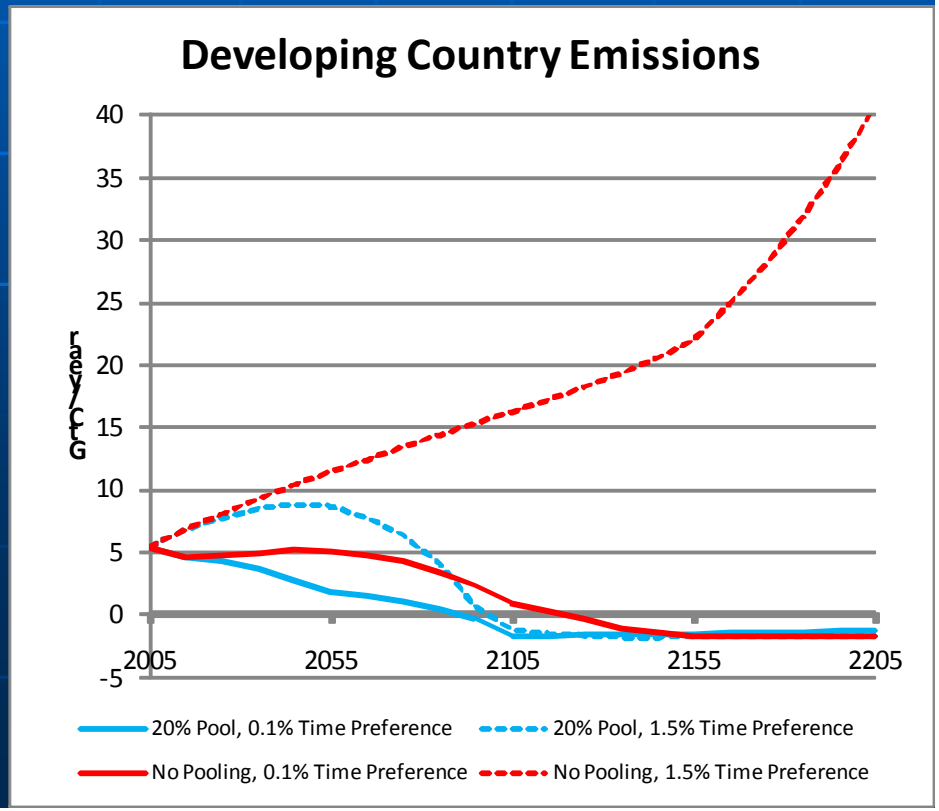


Consumption per capita ratio, USA / South Asia




BAU Emissions
80
70
60
50
40
30
20
10
0
2005
2055
2105
2155
2205
High Income
Developing

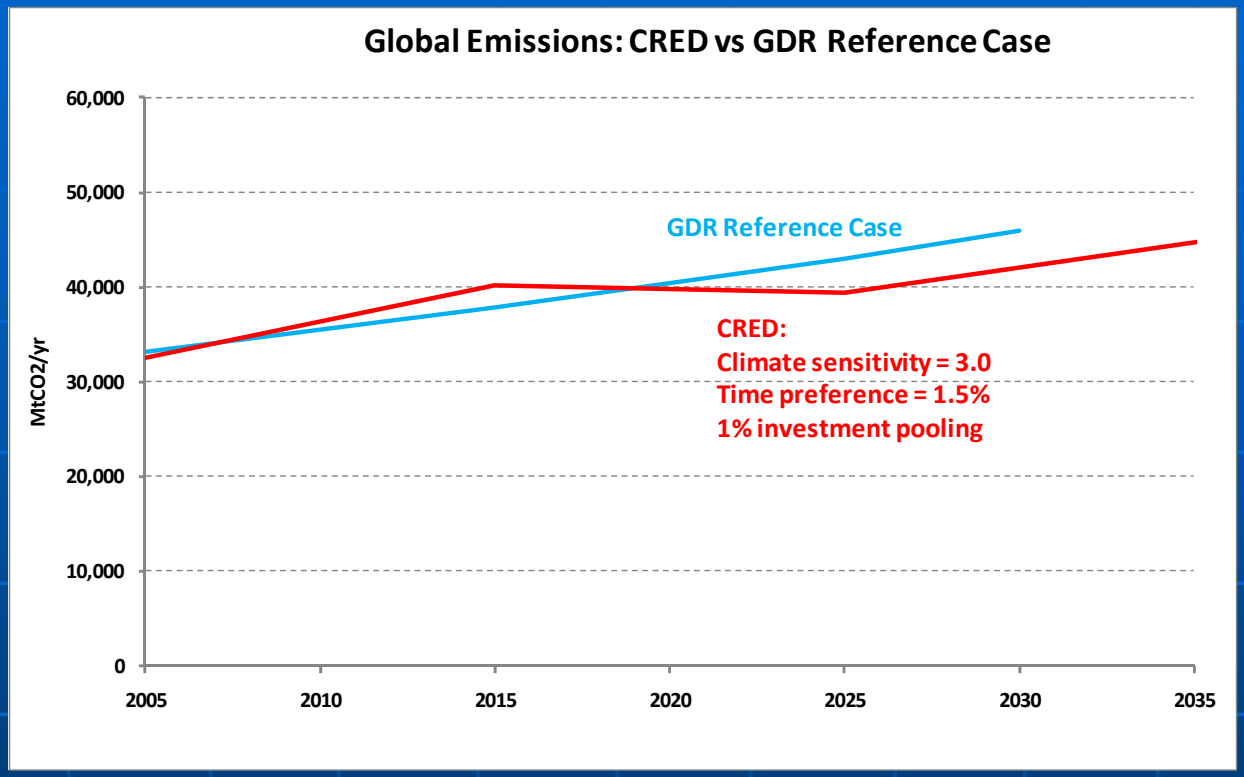

High-Income Country Emissions
40
35
30
25
20
15
10
5
0
-5
2005
2055
2105
2155
2205
20% Pool, 0.1% Time Preference
20% Pool, 1.5% Time Preference
No Pooling, 0.1% Time Preference
No Pooling, 1.5% Time Preference


Developing Country Emissions
40
35
30
25
20
15
10
5
0
-5
2005
2055
2105
2155
2205
20% Pool, 0.1% Time Preference
20% Pool, 1.5% Time Preference
No Pooling, 0.1% Time Preference
No Pooling, 1.5% Time Preference

Greenhouse Development Rights

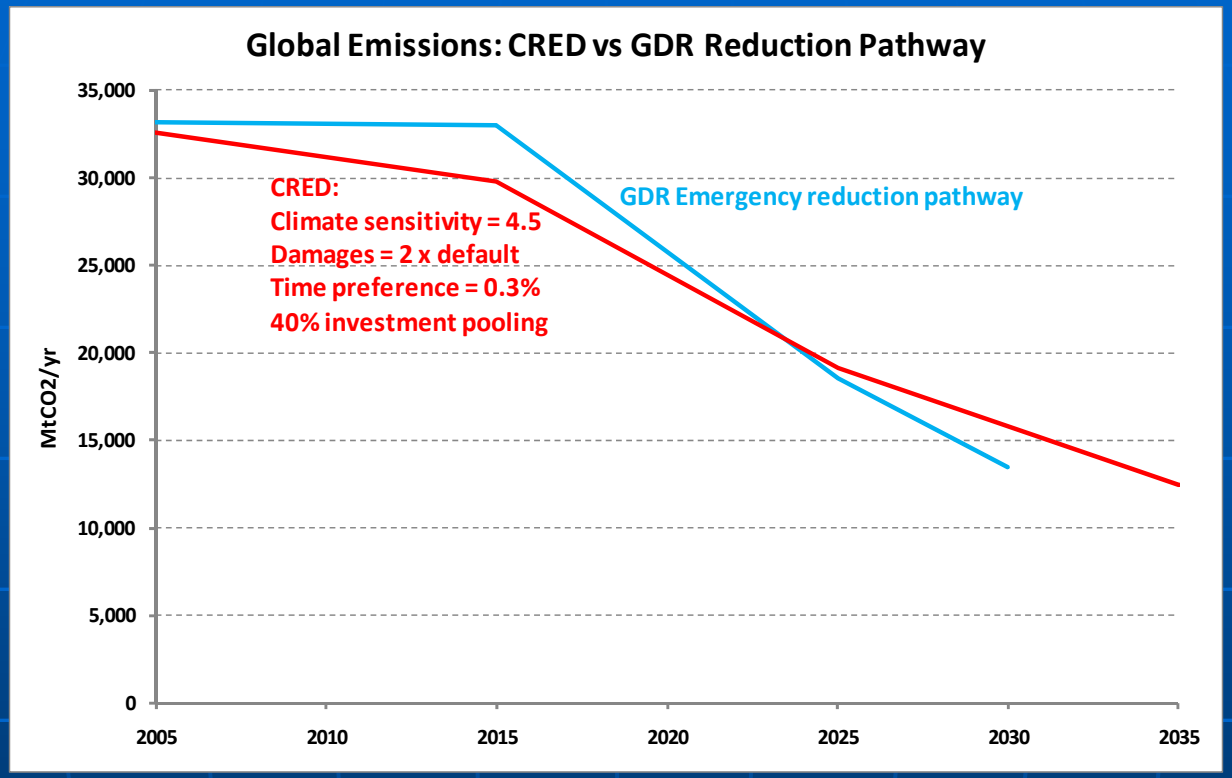
- Two approaches to climate and equity
  - GDR: sets abatement pathway to meet climate goals; costs of that pathway allocated on development basis
  - CRED: finds scenario that simultaneously maximizes climate and development goals
- Do the two approaches tell the same story?
  - Preliminary results: good match to global emissions
  - Regional emissions, responsibility for abatement – less successful match
- Under what conditions are GDR scenarios "optimal" in CRED?

GDR Reference Case



- GDR reference emissions ≈ CRED with
  - Climate sensitivity 3.0
  - Pure time preference 1.5% (DICE)
  - Maximum savings used in other regions: 1%
    - Comparable to current EU foreign aid levels

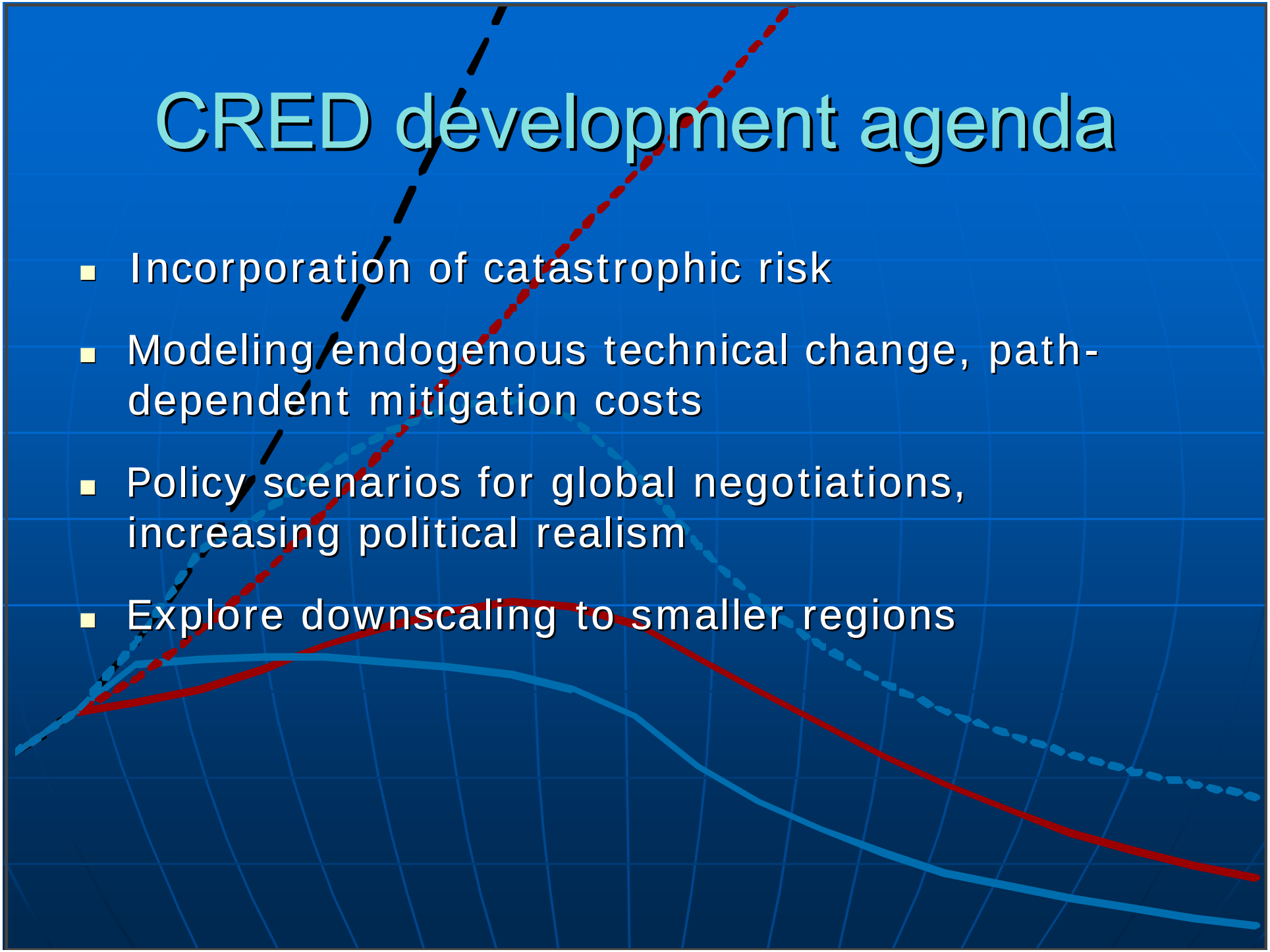
GDR Reduction Scenario



- GDR reduction pathway emissions ≈ CRED with
  - Climate sensitivity 4.5 (precautionary value)
  - Climate damages about double CRED default
  - Pure time preference 0.3% (almost as low as Stern)
  - Maximum savings used in other regions: 40%

CRED development agenda

- Incorporation of catastrophic risk
- Modeling endogenous technical change, path-dependent mitigation costs
- Policy scenarios for global negotiations, increasing political realism
- Explore downscaling to smaller regions



CRED's bottom line

- The unconstrained solution achieves ideal climate and development outcomes
  - *– at the price of real sacrifice by high-income countries*

1) How far from that solution can we move and still stabilize the climate?
2) How far from that solution do we have to move to win acceptance in high-income countries?

- *Do the answers to those two questions overlap?*

For more information

- Frank.Ackerman@sei-us.org
- http://www.sei-us.org/ClimateEconomics/

SEI STOCKHOLM ENVIRONMENT INSTITUTE