CLIMATE CHANGE OVERVIEW: SCIENCE, POLITICS, ECONOMICS AND POLICY

Course 705: Environment and Development

February 11, 2014

Main points

1. The only certainty is uncertainty
2. Modeling climate change as a low-probability high-impact event
3. Climate change as a global public good
4. Price signal is a cost-effective way of addressing climate change
5. Paradigm shift required to break the current impasse (seemingly intractable positions of North and South)

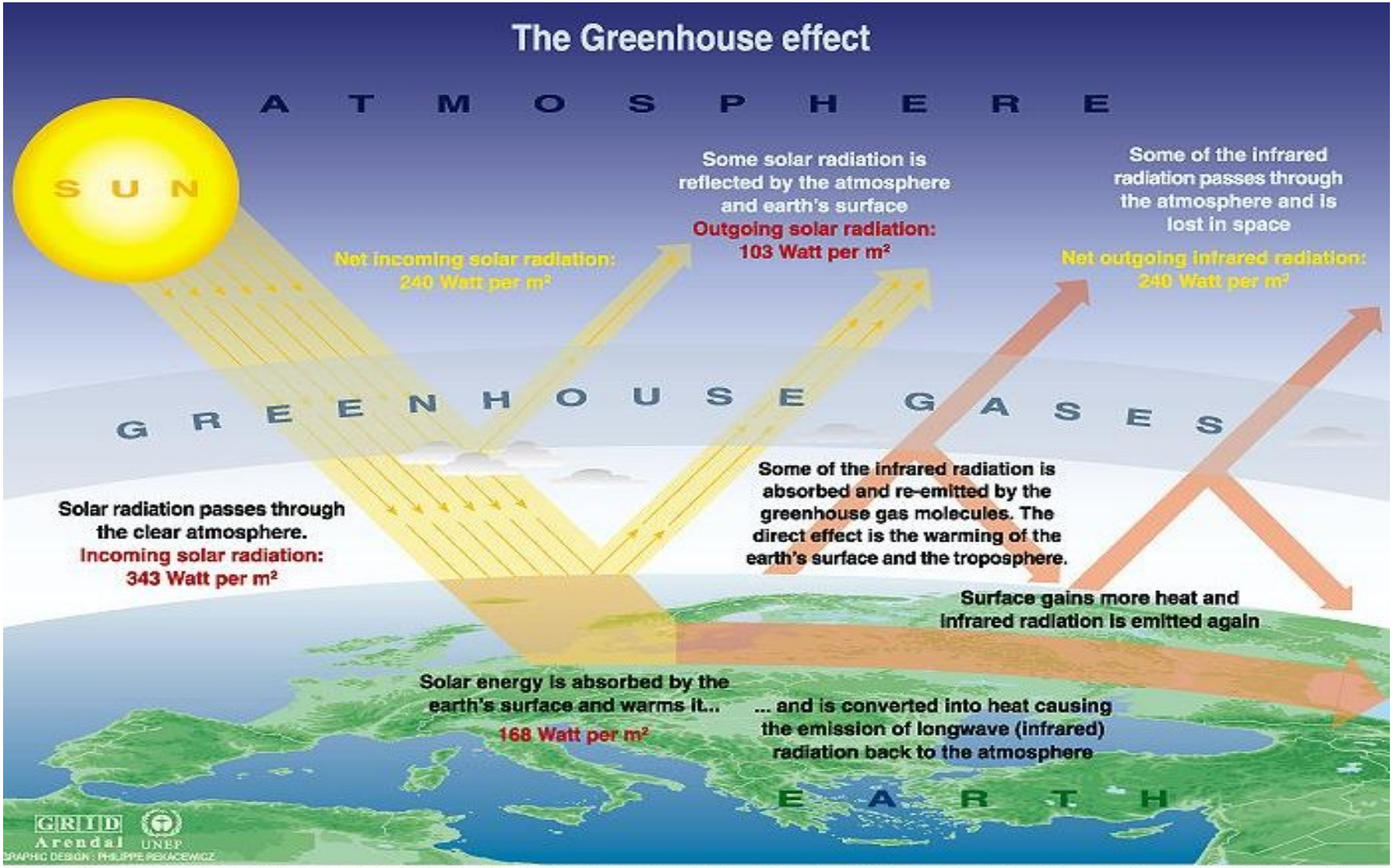
The Greenhouse Effect (1)

- The warming of the atmosphere by heat reflected from the earth is called the **greenhouse effect**.
- The greenhouse effect actually makes the earth habitable. Without the greenhouse effect, the earth would be much colder!
- Main greenhouse gases (GHGs) in the atmosphere include CO_2 , CH_4, N_2O, CFCs.
- Increased concentration of GHGs causes more heat to be retained in the atmosphere and more heat to be reflected back to the earth surface and this will lead to a rise in average global temperatures (global warming).

The Greenhouse Effect (2)

- Greenhouse effect is a natural geophysical process, it allows us to exist on earth.
- The gases known as greenhouse gases naturally found in the atmosphere are: water vapour, carbon dioxide, methane, nitrogen oxide, ozone, and chlorofluorocarbons (CFCs).
- These gases trap heat close to the earth's surface
- Without the greenhouse effect, the earth's surface temperature would be –180^{o}C!
- The natural greenhouse effect warms the temperature of the atmosphere to 15 ^{o}C at the Earth's surface.
- This natural warming allows water to exist on the Earth's surface, the basis of life support.

The Greenhouse Effect (3)



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

“Warming of the climate system is unequivocal”

- R.K. Pachauri

Chairman, IPCC

Climate Change?

- IPCC 4th Assessment (February 2007) states:

"Warming of the climate system is **unequivocal**, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level"

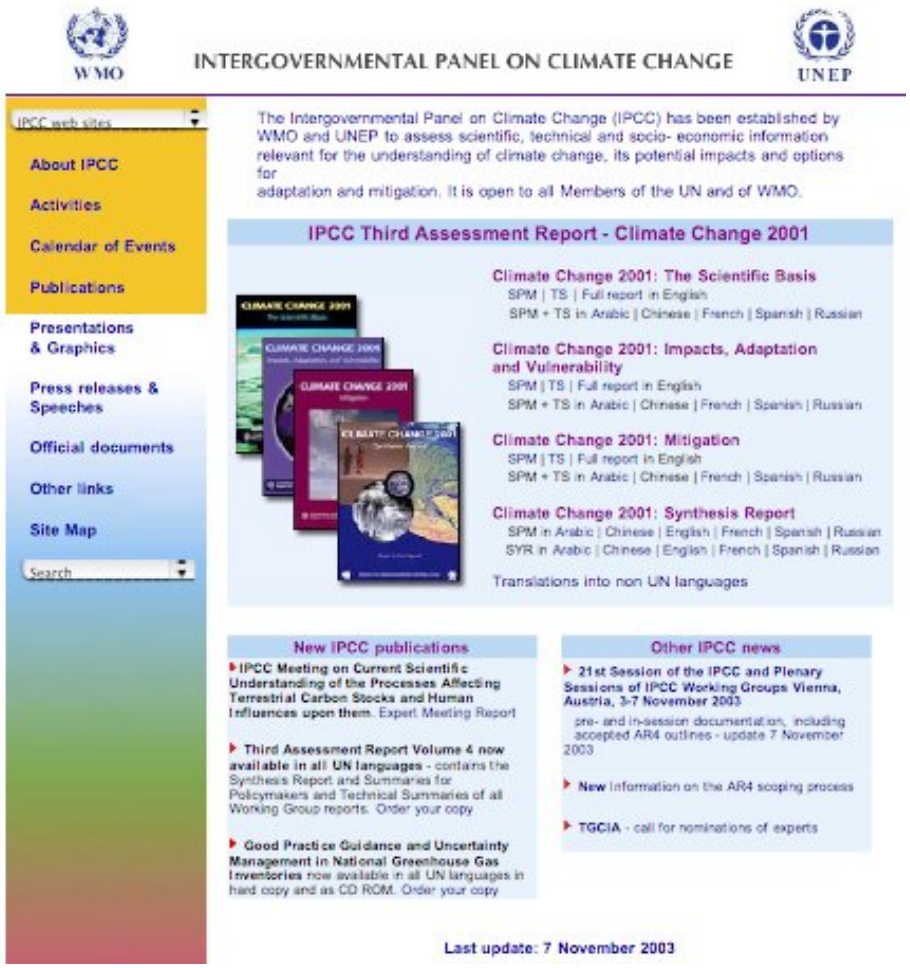
Source: IPCC, *Climate Change 2007: The Physical Science Basis, Summary for Policymakers*, 5/2/2007

IPCC - scientific basis for climate change

Intergovernmental Panel on Climate Change (IPCC) established in 1988 by United Nations Environment Programme and World Meteorological Organization for assessing **"scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change."**

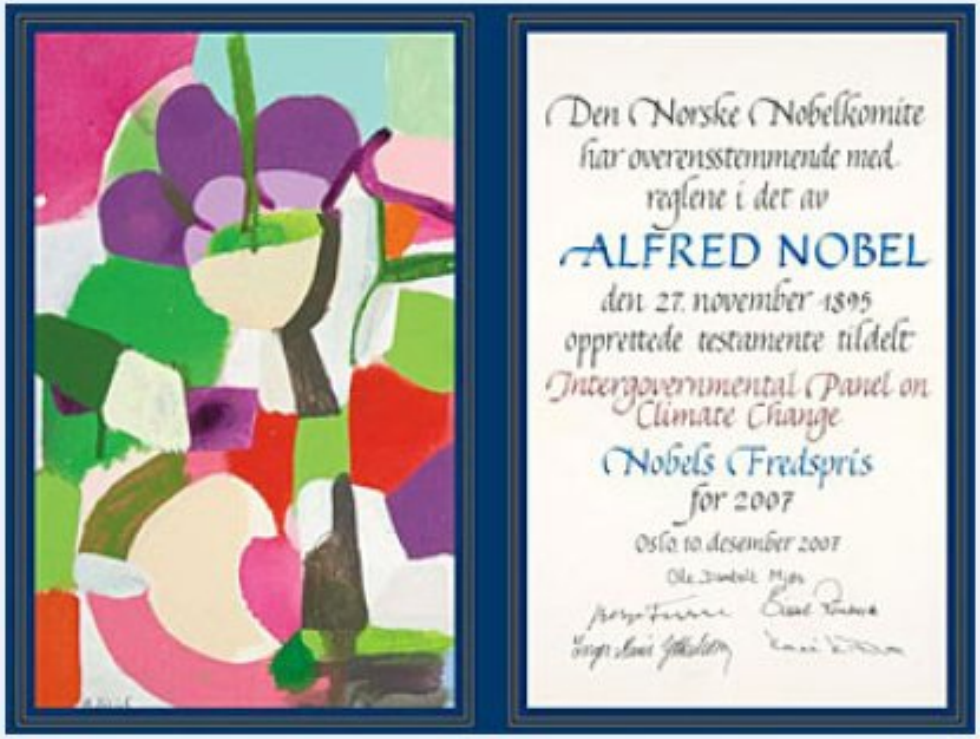
Though IPCC organized within political institutional framework, basically a **scientific body**—made up of leading scientists from around the world. In order to keep to its scientific mandate and maintain scientific objectivity, IPCC avoids making policy recommendations or shaping research programs.

However, since assessments of IPCC are the most comprehensive and balanced evaluations of climate change, its work is single most important foundation on which climate policy is built

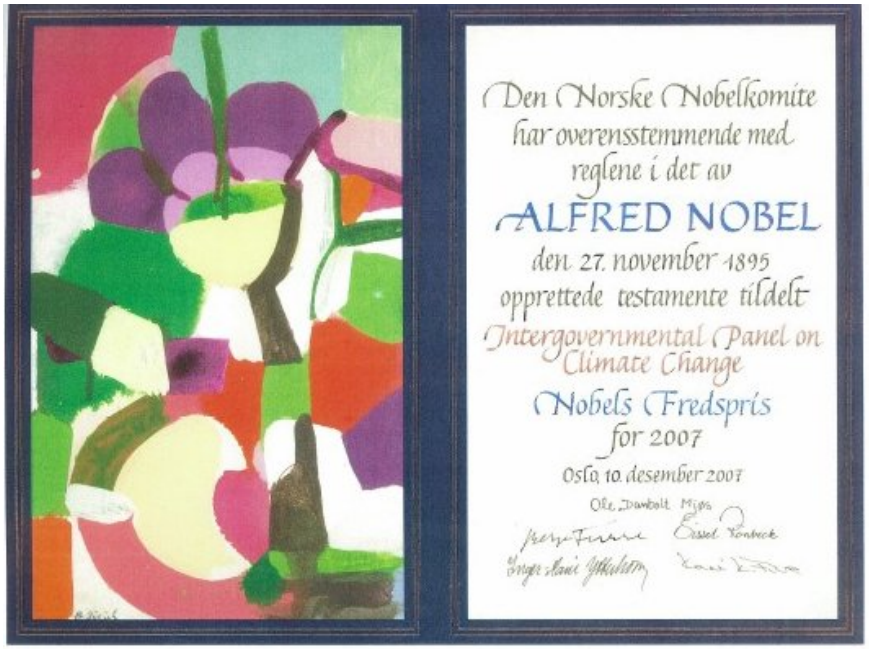


www.ipcc.ch

The IPCC is honored with the Nobel Peace Prize



Oslo, 10 December 07
The Intergovernmental Panel on Climate Change
and Albert Arnold (Al) Gore Jr.
were awarded of **the Nobel Peace Prize**
"for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change".



Den Norske Nobelkomite
har overensstemmende med
reglene i det av
ALFRED NOBEL
den 27. november 1895
opprettede testamente tildelt
Intergovernmental Panel on
Climate Change
Nobels Fredspris
for 2007
Oslo, 10. desember 2007

WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

UNEP

PRESENTED TO

SHREEKANT GUPTA

FOR CONTRIBUTING TO THE AWARD OF THE

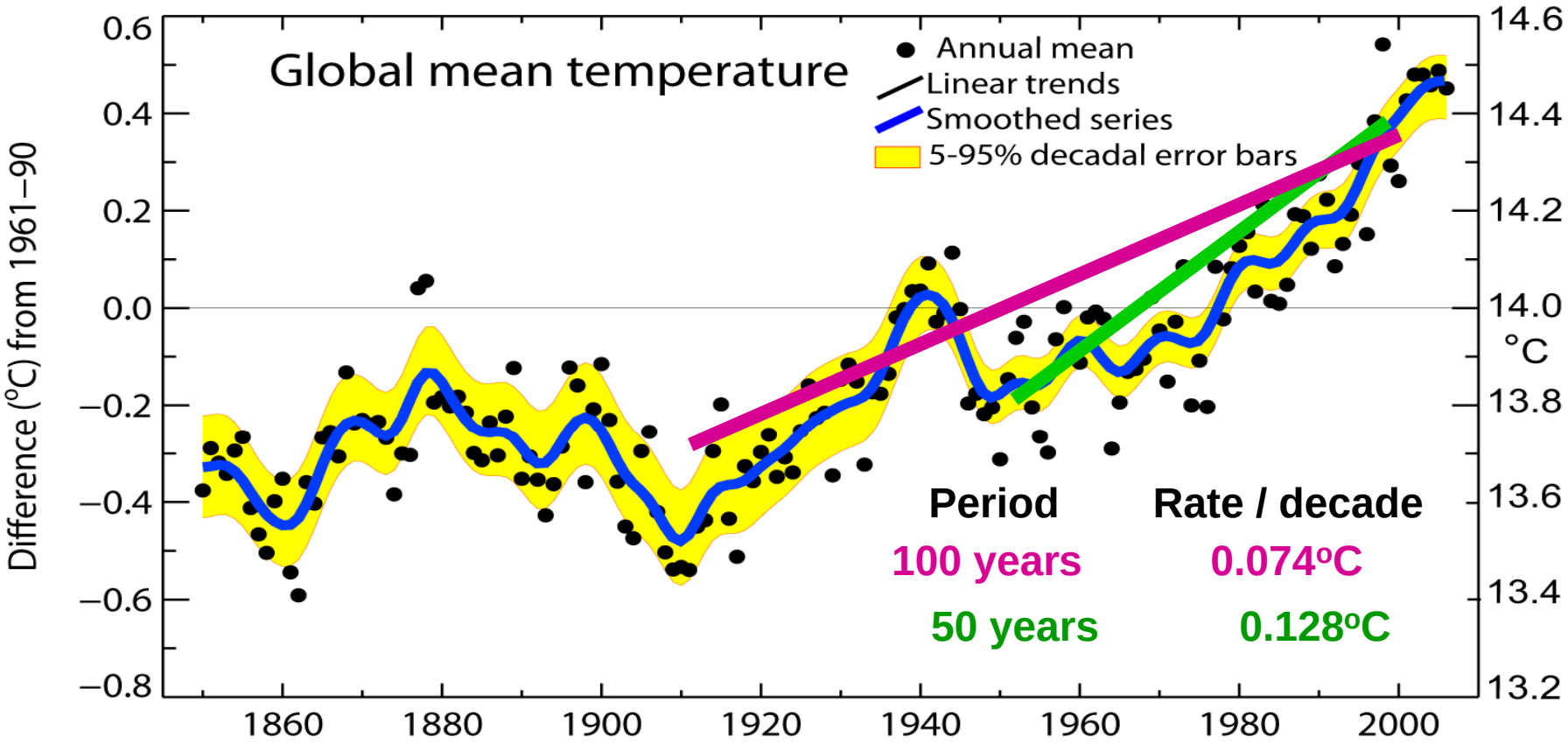
NOBEL PEACE PRIZE

FOR 2007 TO THE IPCC

R. K. Pachauri
IPCC Chairman

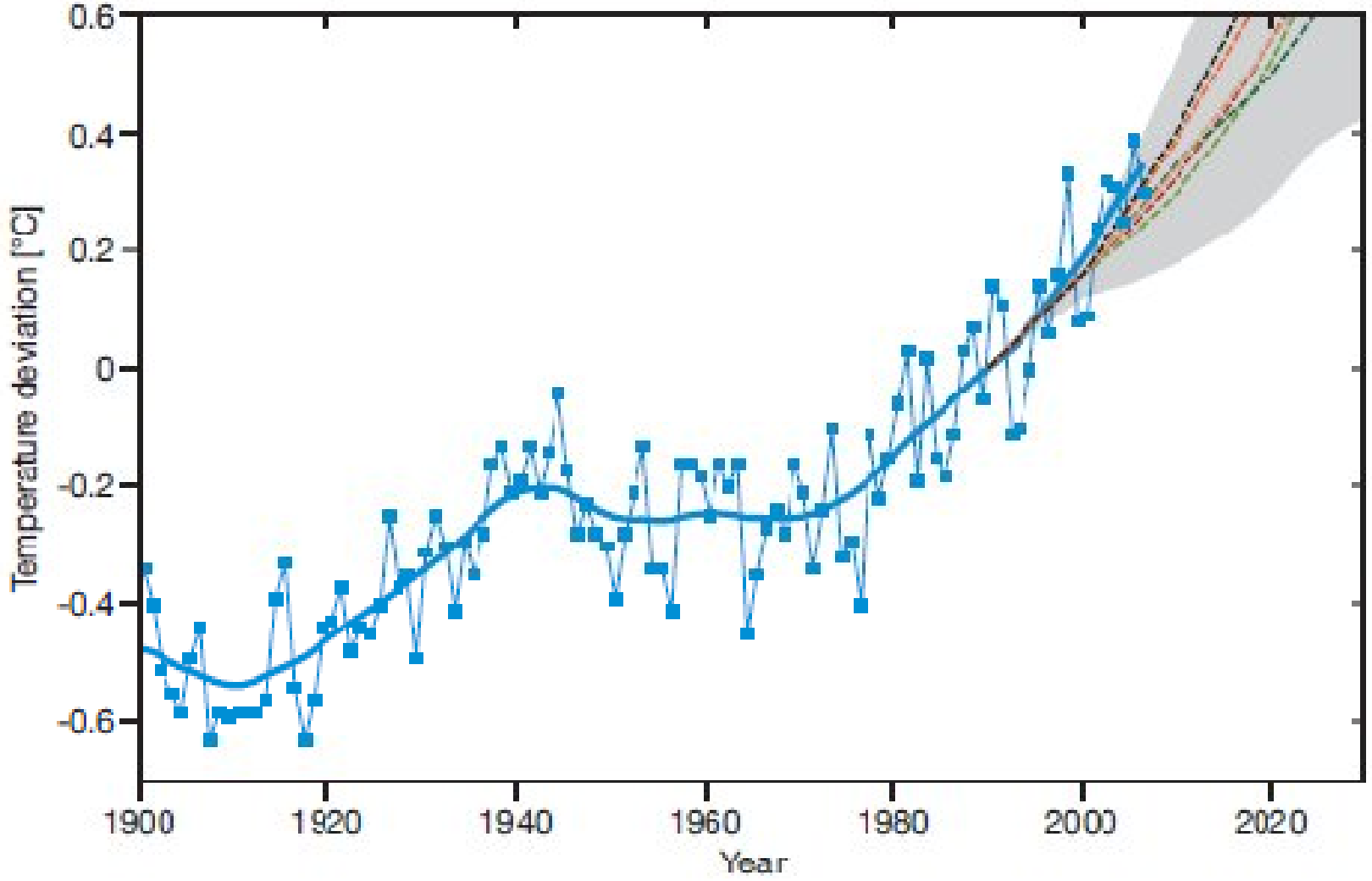
R. Christ
IPCC Secretary

Changes in global average surface temperature

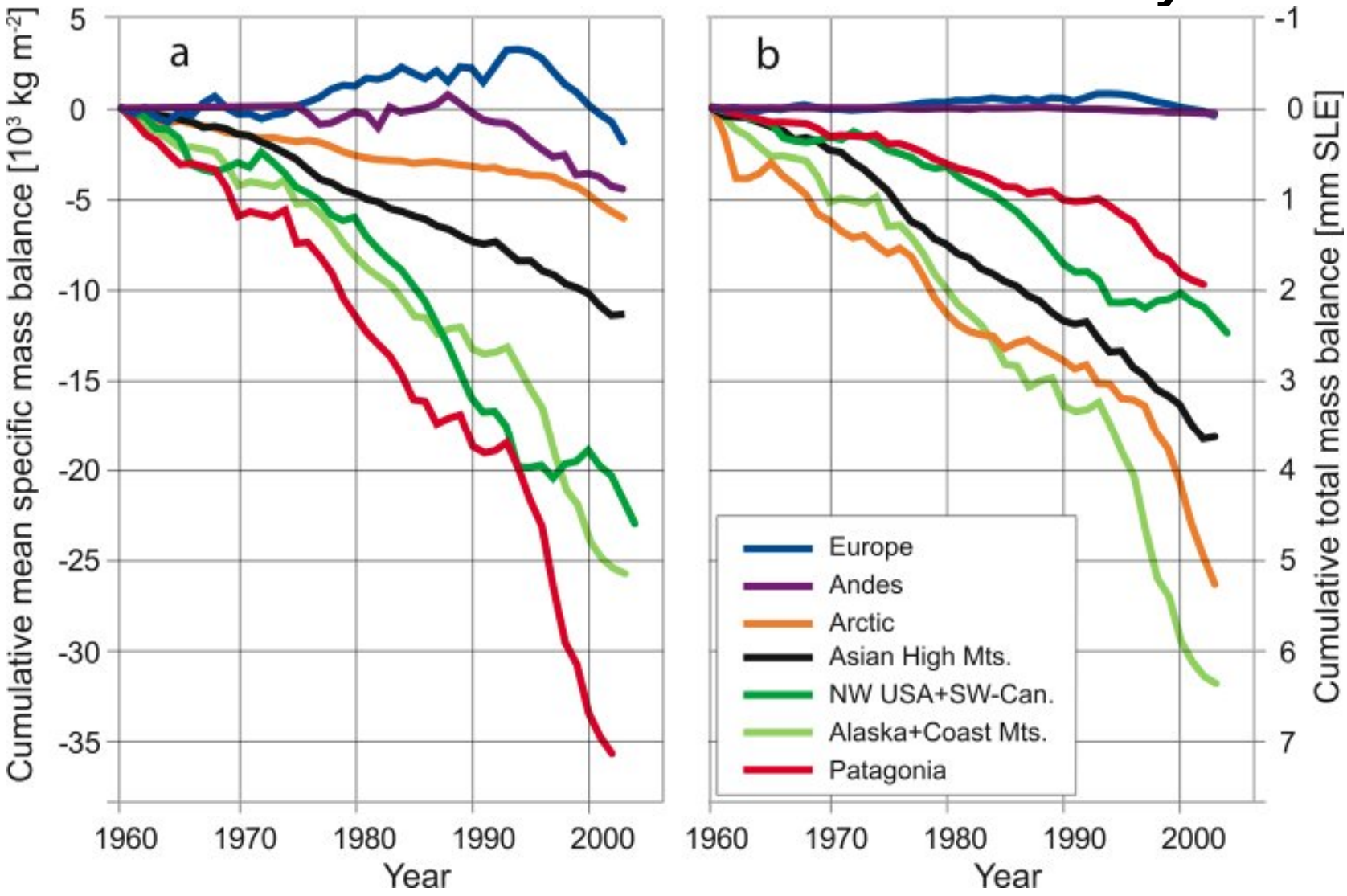


Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

Source: IPCC

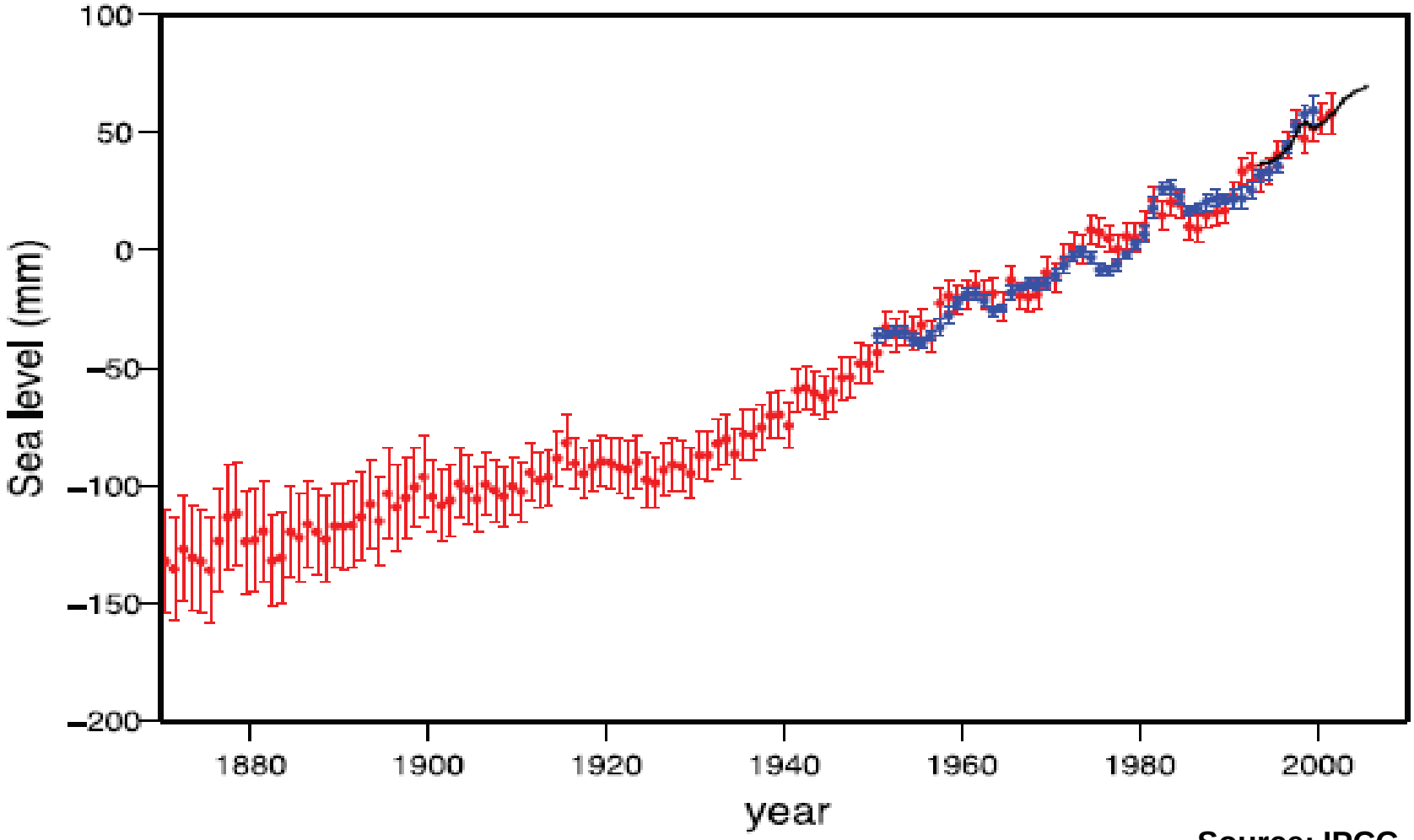

0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Temperature deviation [°C]
1900
1920
1940
1960
1980
2000
2020
Year

Water supplies stored in glaciers are projected to decline in the course of the century



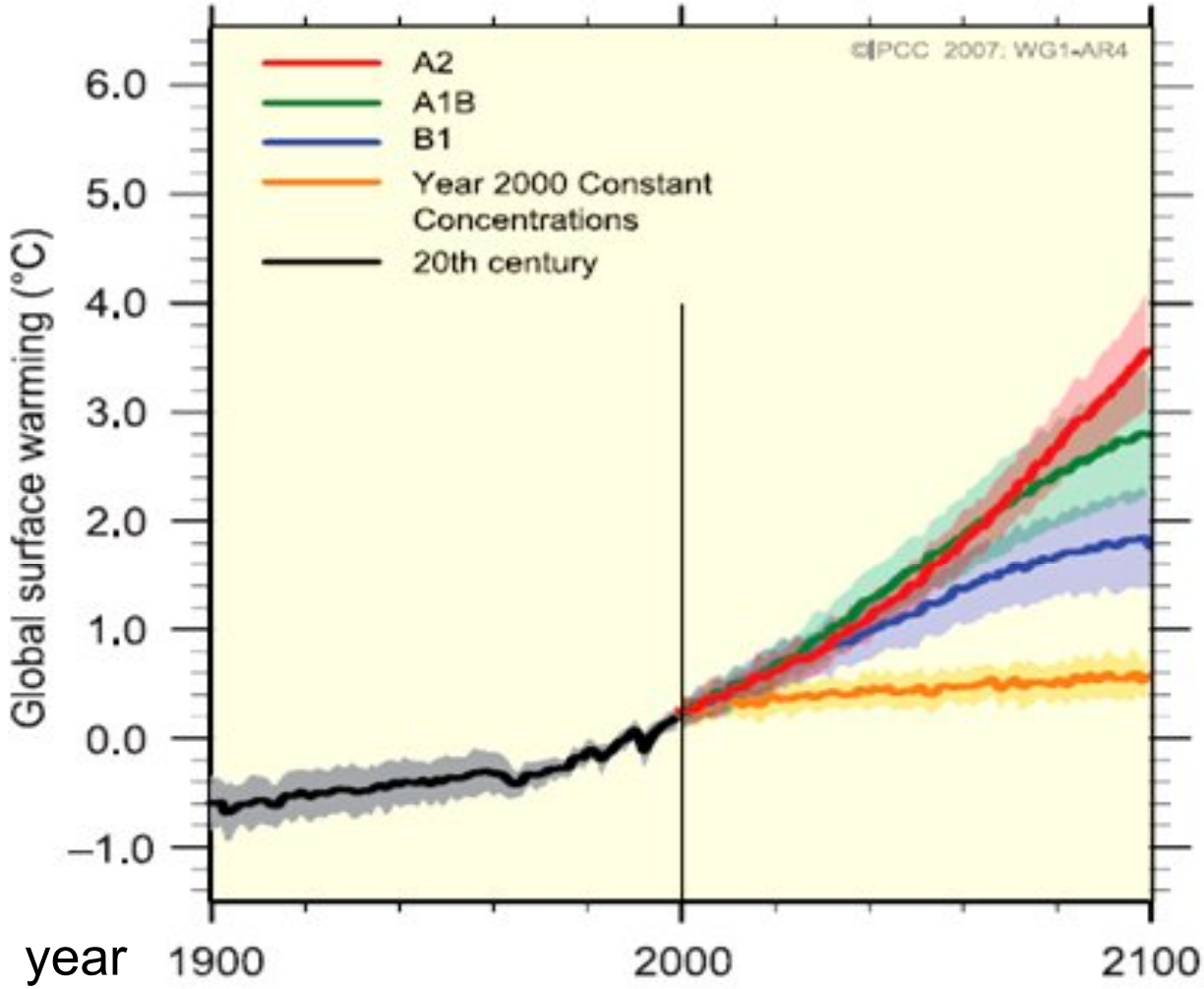
Source: IPCC

Global average sea level has risen since 1961 at a rate of 1.8mm/yr and since 1993 at 3.1mm/yr



Source: IPCC

Ranges for predicted surface warming



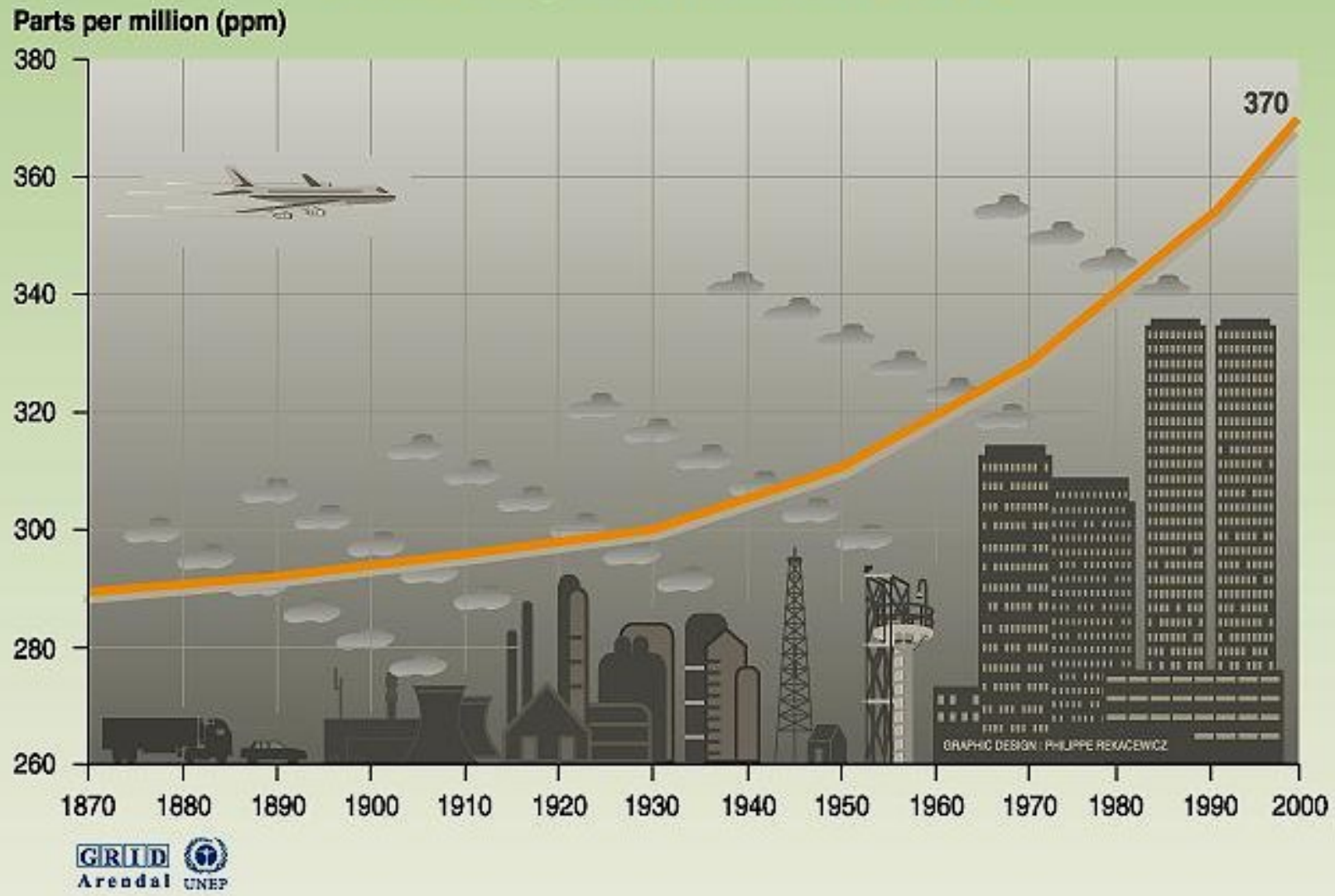
Continued emissions will lead to further warming of 1.8ºC to 4ºC over the 21st century

Source: IPCC

- ✓ Emissions from human activities are increasing the concentration of atmospheric GHGs
- ✓ Enhanced greenhouse effect occurs due to atmospheric buildup of GHGs that are released by human activities
- ✓ The main sources of GHG emissions are:
  - ❖Burning of fossil fuels (coal, oil, natural gas)
  - ❖Industrial activities
  - ❖Food production activities
  - ❖Burning and exploiting forests
  - ❖Waste landfills

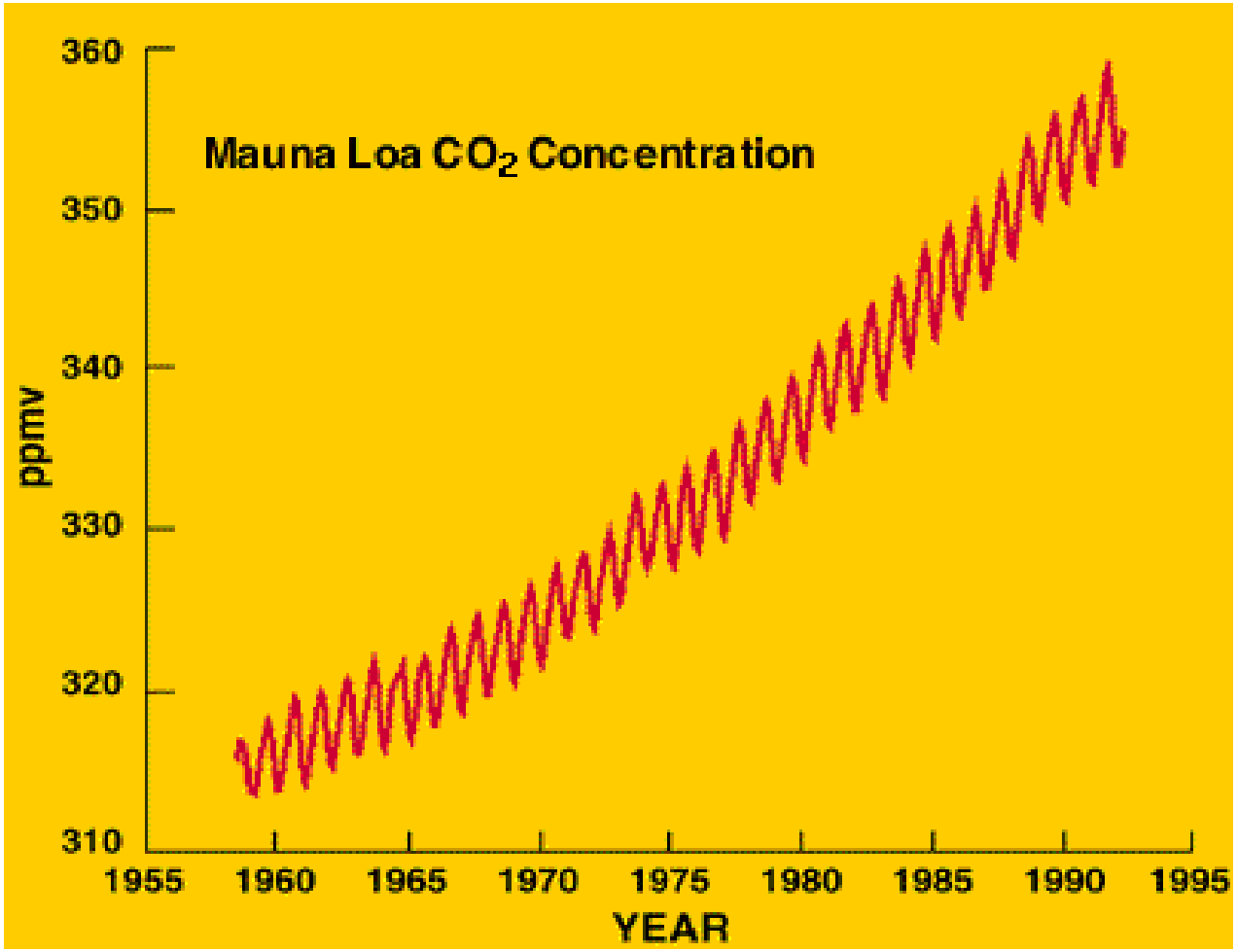
The concentration of CO_2 in the atmosphere has increased from 295 parts per million (ppm) in 1870 to 370 ppm in 2000 (next slide..)

Global atmospheric concentration of CO_2



Sources: TP Whorf Scripps, Mauna Loa Observatory, Hawaii, institution of oceanography (SIO), university of California La Jolla, California, United States, 1999

Why is CO2 rising?



IPPC's review of latest scientific research concludes "The balance of evidence suggests a discernible human influence on global climate".

- An increasing body of observations gives a collective picture of a warming world and other changes in the climate system.
- Emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere in ways that are expected to affect the climate.
- Confidence in the ability of models to project future climate has increased.
- There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

The only certainty is uncertainty

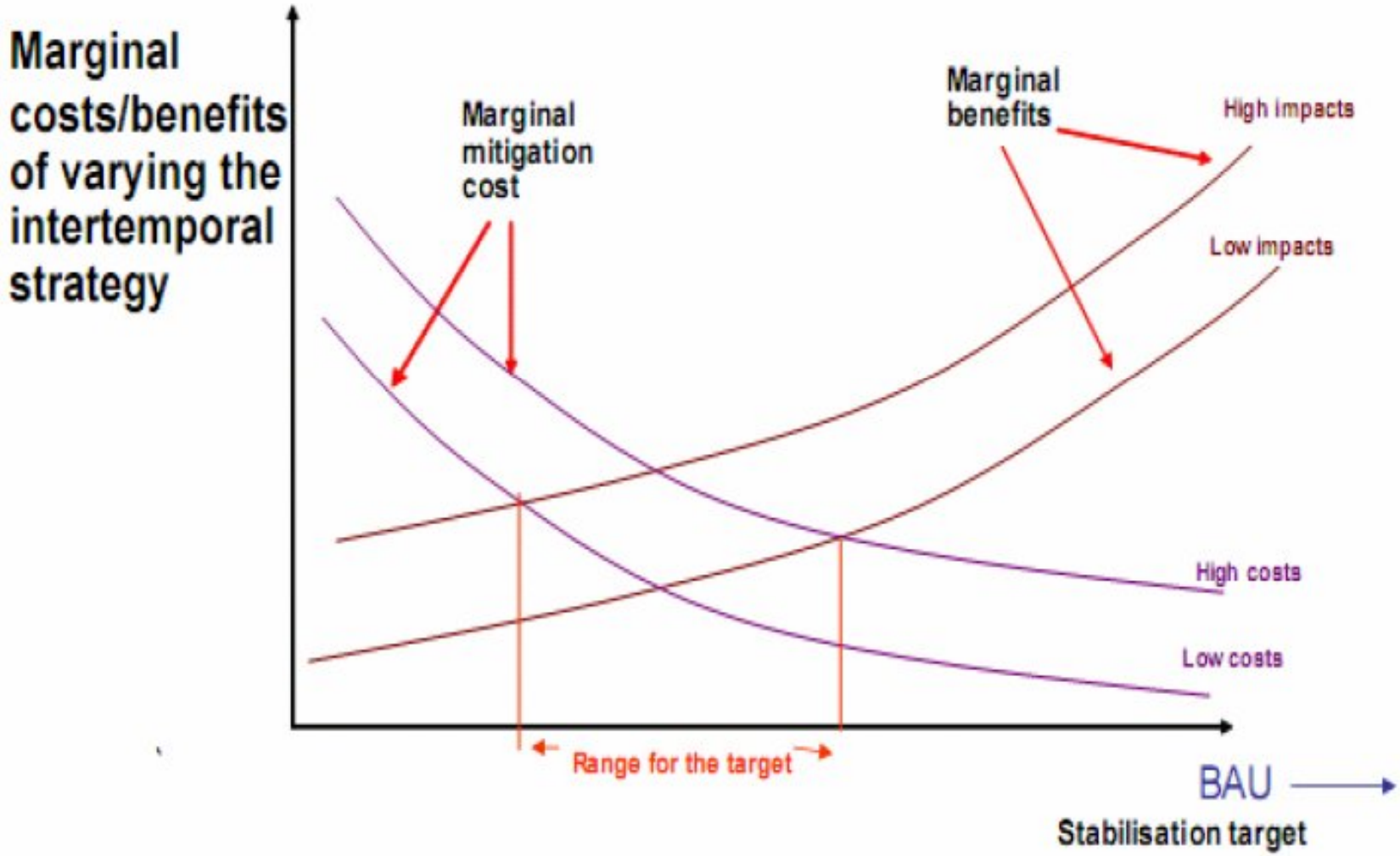
Few facts:

- There exist heat trapping gases (GHGs)
- Concentrations of GHGs has increased due to human activity

Many doubts:

- How much warming will take place?
- How soon?
- By how much will ocean levels rise?
- How likely are cataclysmic events?
- What will be the economic impact?

Choosing a CO2E Stabilization Target



Climate change targets

1. In order to stabilize concentration of GHGs (a 'stock') emissions ('flow') need to peak and decline thereafter.

2. Tighter stabilization target: more quickly this peak and decline would need to occur.

3. Delaying emission reductions:

   i. makes it harder to achieve low stabilization concentration; and/or

   ii. requires faster and deeper cuts in future

4. Climate system has inertia (stopping a supertanker…) global mean temp at equilibrium NOT global mean temp at time of stabilization!

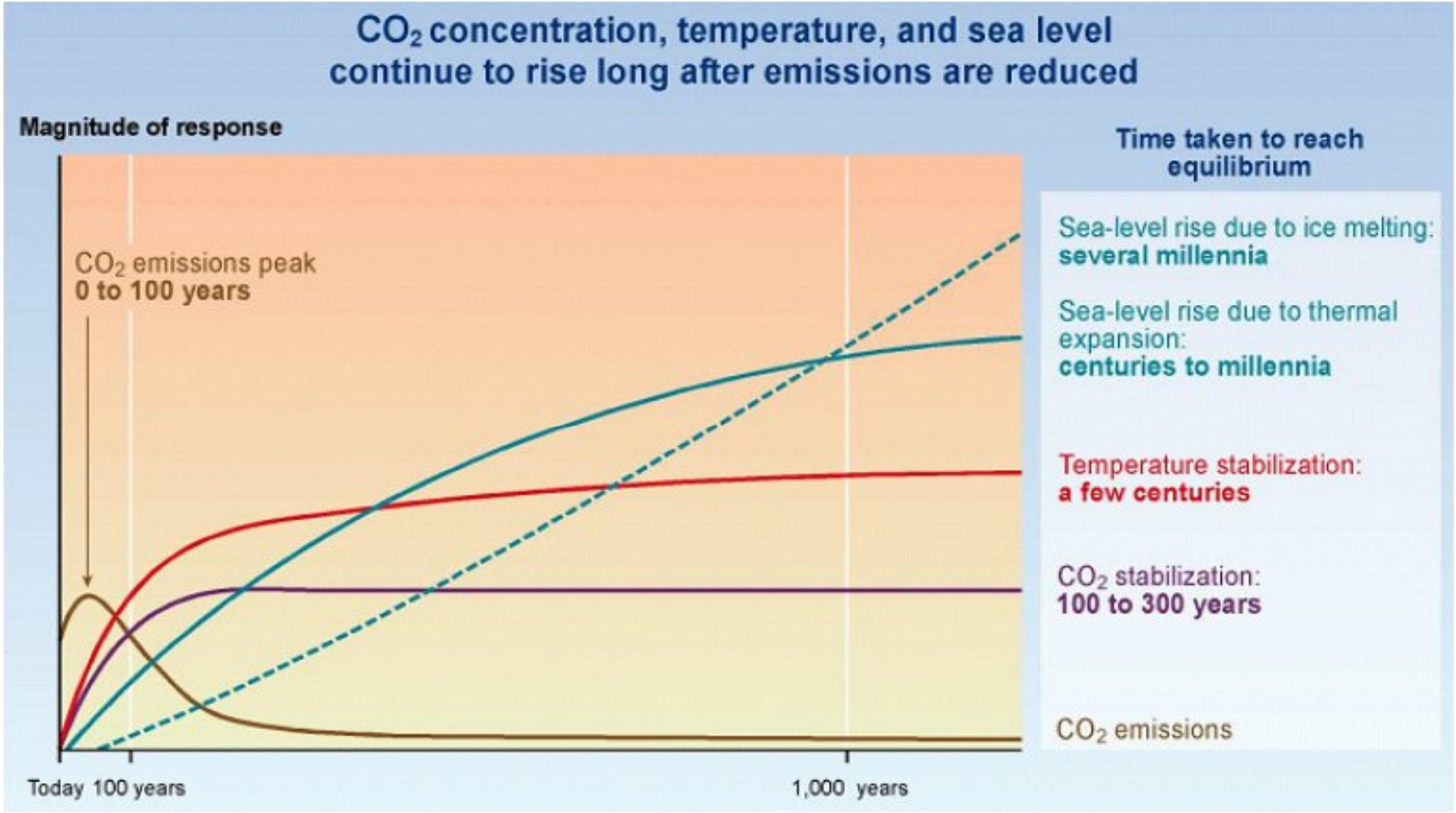
Stabilization scenarios

Global mean temp. increase (ºC)	Stabilization level (ppm CO_2-eq) (2005 = 375 ppm)	Year CO_2 needs to peak (2005 = 379 ppm)
2.0 – 2.4	445 – 490	2000 – 2015
2.4 – 2.8	490 – 535	2000 – 2020
2.8 – 3.2	535 – 590	2010 – 2030
3.2 – 4.0	590 – 710	2020 – 2060

CO_2-eq conc. in 2005 was 455 ppm. After including net effect of all anthropogenic forcing agents CO_2-eq conc. 375 ppm.

Source: IPCC

Time Lags in Climate Response



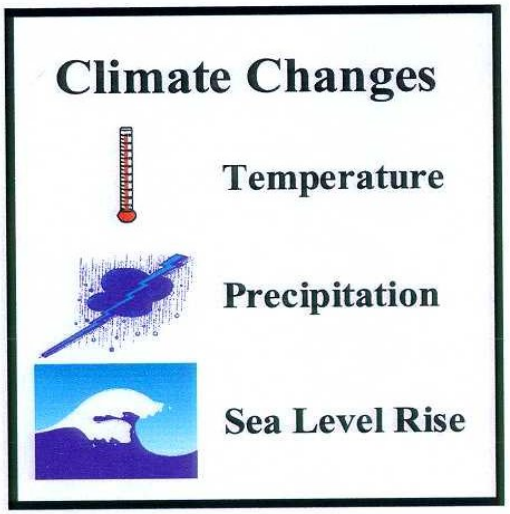
Source: IPCC, ***Climate Change 2001 - Synthesis Report***

Climate Change and Developing Countries

- Though all countries are affected by climate change, they are affected in different ways and to different extents.
- Developing countries will be particularly badly hit, for three reasons:
  - their geography
  - their stronger dependence on agriculture
  - and because with their fewer resources comes greater vulnerability

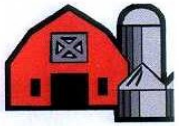
Stern Review: The Economics of Climate Change (2006) p. 29

Potential Climate Change Impacts



Health Impacts

Weather-related Mortality
Infectious Diseases
Air Quality-Respiratory Illnesses



Agriculture Impacts

Crop yields
Irrigation demands

Forest Impacts

Change in forest composition
Shift geographic range of forests
Forest Health and Productivity

Water Resource Impacts

Changes in water supply
Water quality
Increased Competition for water

Impacts on Coastal Areas

Erosion of beaches
Inundate coastal lands
Costs to defend coastal communities

Species and Natural Areas

Shift in ecological zones
Loss of habitat and species

EPA

United States Environmental Protection Agency

Observed impacts in South Asia

Intense Rains and Floods

- Serious and recurrent floods in Bangladesh, Nepal and N-E India in 2002, 2003 and 2004
- Rainfall in Mumbai (India), 2005: 1 million people lost their homes

Droughts

- 50% of droughts associated with El Niño
- Droughts in Orissa (India) in 2000-2002: crop failures, mass starvation affecting 11 million people

Cyclones / Typhoons

- Increasing intensity of cyclones formation in Bay of Bengal and Arabian Sea since 1970
- Cyclone Nargis in Myanmar, 2008: 100 000 deaths

Impacts on human health

- Endemic morbidity and mortality due to **diarrhoeal disease** primarily associated with floods and droughts.
- Greater spread and toxicity of **cholera** due to increase in temperature of coastal water.
- Increased **deaths, disease and injury** due to heat waves, floods, storms, fires and droughts.

Impacts on Human Health

- In higher latitudes, cold-related deaths will decrease.
- Climate change will amplify health disparities between rich and poor parts of the world.
- The World Health Organisation (WHO) estimates that climate change since the 1970s is already responsible for over 150,000 deaths each year through increasing incidence of diarrhoea, malaria and malnutrition, predominantly in Africa and other developing regions.
- Just a 1°C increase in global temperature above pre-industrial could double annual deaths from climate change to at least 300,000 according to the WHO.
- Vector-borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place.

Impacts on Food Production: Overview

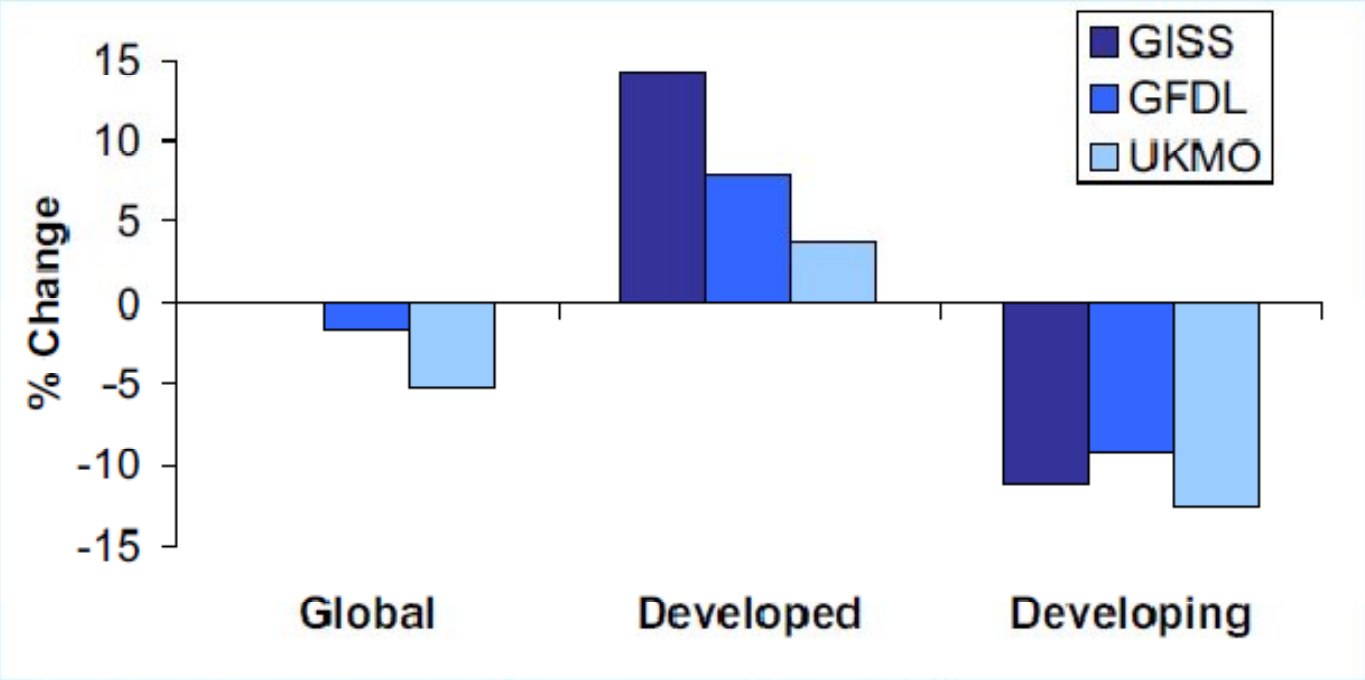
- In tropical regions, even small amounts of warming will lead to **declines in yield**. In higher latitudes, crop yields may increase initially for moderate increases in temperature but then fall.
- Higher temperatures will lead to substantial declines in cereal production around the world, particularly if the carbon fertilisation effect is smaller than previously thought, as some recent studies suggest.
- Declining crop yields likely to leave hundreds of millions without the ability to produce or purchase sufficient food, particularly in the poorest parts of the world.
- Ocean acidification, a direct result of rising carbon dioxide levels, will have major effects on marine ecosystems, with possible adverse consequences on **fish stocks**.

Impacts on food production

Crop yields could increase up to 20% in East and Southeast Asia while they could decrease up to 30% in Central and South Asia by 2050.

In India, wheat yields could decrease by **5-10%** per one-degree rise in temperature.

Figure 3.5 Change in cereal production in developed and developing countries for a doubling of carbon dioxide levels (equivalent to around 3°C of warming in models used) simulated with three climate models (GISS, GFDL and UKMO Hadley Centre)



Source: Parry *et al.* (2005) analysing data from Rosenzweig and Parry (1994)

Impacts on water resources

Glacier melt projected to increase flooding, rock avalanches and to affect water resources within the next two to three decades

Salinity of groundwater especially along the coast, due to increases in sea level and over-exploitation

In India, gross per capita water availability will decline from 1820 m^3/yr in 2001 to **1140 m^3/yr** in 2050

Impacts on coastal areas

Coastal erosion and inundation of coastal lowland as sea level continues to rise, flooding the homes of millions of people living in low lying areas.

In India, potential impacts of 1 m sea-level rise include inundation of 5,763 km^2.

Significant losses of coastal ecosystems, affecting the aquaculture industry, particularly in heavily-populated mega-deltas.

Current state of play

- The clock is ticking
- ? days to climate midnight
- Yet little progress on:
  - emission reduction targets by developed countries
  - funds for developing countries

"Without these two pieces of the puzzle in place, we will not have a deal in Copenhagen"

- Yvo de Boer, UNFCCC Executive Secretary

International agreements

- UN Framework Convention on Climate Change (UNFCCC)
  - Rio Conference on Environment and Development 1992
  - 192 Parties (annual COP)
- Kyoto Protocol
  - 182 Parties–in force 2005 (period: 2007-12)

UNFCCC and Kyoto Protocol

- Industrialised countries have historical responsibility for climate change and are to take the lead in emissions reductions
- Commitments to transfer financial resources and technology to developing countries
- Principle of "common but differentiated responsibilities"

The Kyoto Protocol: Rest in Peace…?

Objective: reduce overall developed country emissions (listed in Annex B) by around *5% below 1990 levels* over 'first commitment period' 2008-2012. But now…

Cancun: Japan opposes extension of Kyoto Protocol

Friday, 3 December 2010, 5:01 pm
Press Release: SPREP

By Makereta Komai, Climate Pasifika Media Team in Cancun, Mexico

01 DECEMBER 2010, CANCUN, MEXICO --- Japan says it will oppose any extension to the Kyoto Protocol (KP), the only legally binding global agreement on climate change.

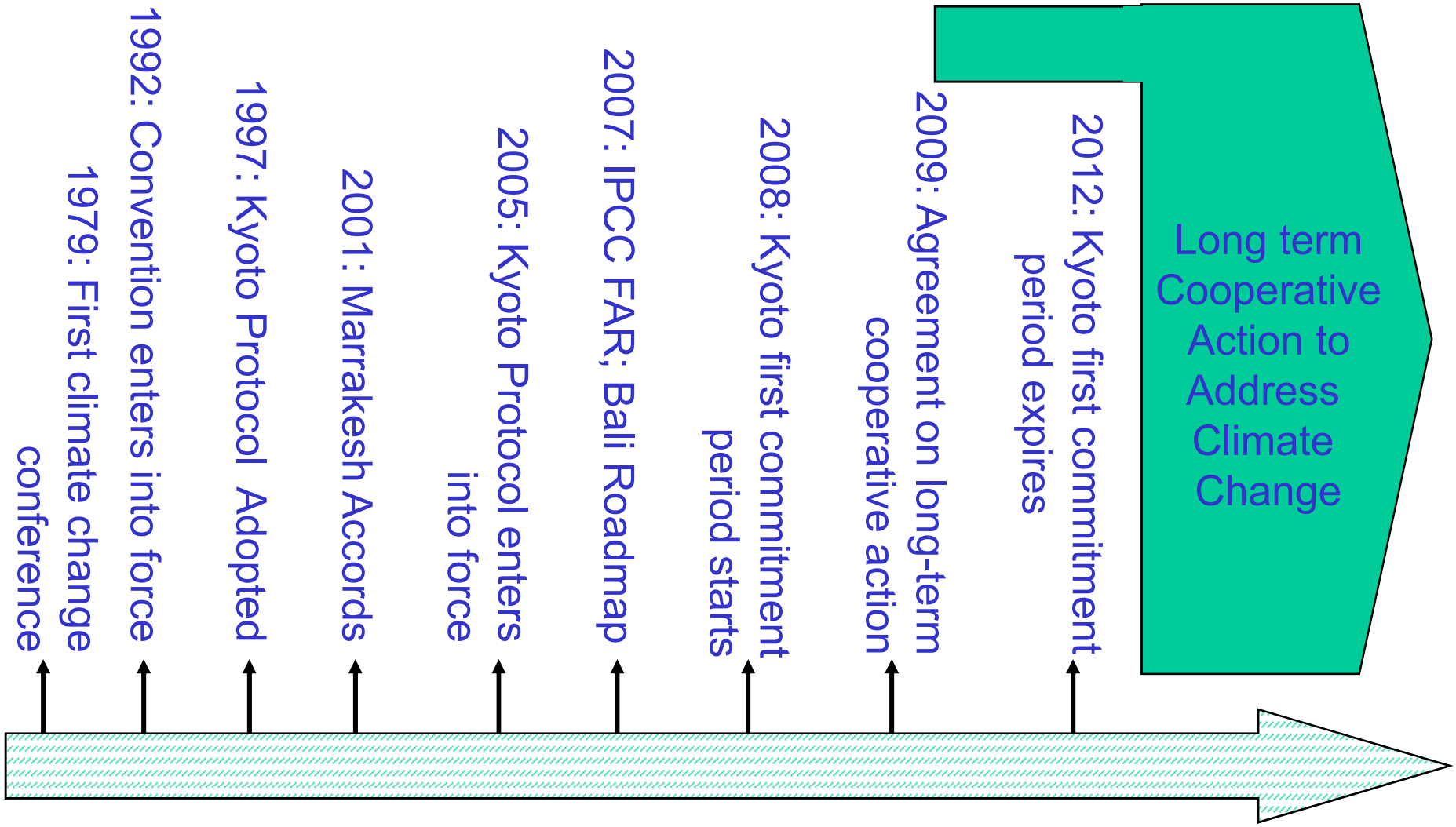
And its chief negotiator here in Cancun, the vice minister for global environment affairs, Hideki Minamikawa confirmed to the international media that 'continuing with the second commitment period does not make any sense.'

Instead, Japan supports a new international framework with the participation of all major emitters based on the Copenhagen Accord.

Political issues

- The US, a a major emitter, has not ratified the Kyoto Protocol, but is a Party to the Convention (i.e., UNFCCC)
- Pressure to engage developing countries which do not have targets but have rapidly increasing emissions (e.g., China, India)

The UNFCCC: timeline



The economic view…

- Climate change is a global public bad (corollary: GHG abatement is a global public good) – CO2 emissions are an (unpriced) externality.
- Economic participants (millions of firms, billions of people, trillions of decisions) need to face realistic carbon prices if their decisions about consumption, investment, and innovation are to be correct/socially optimal.

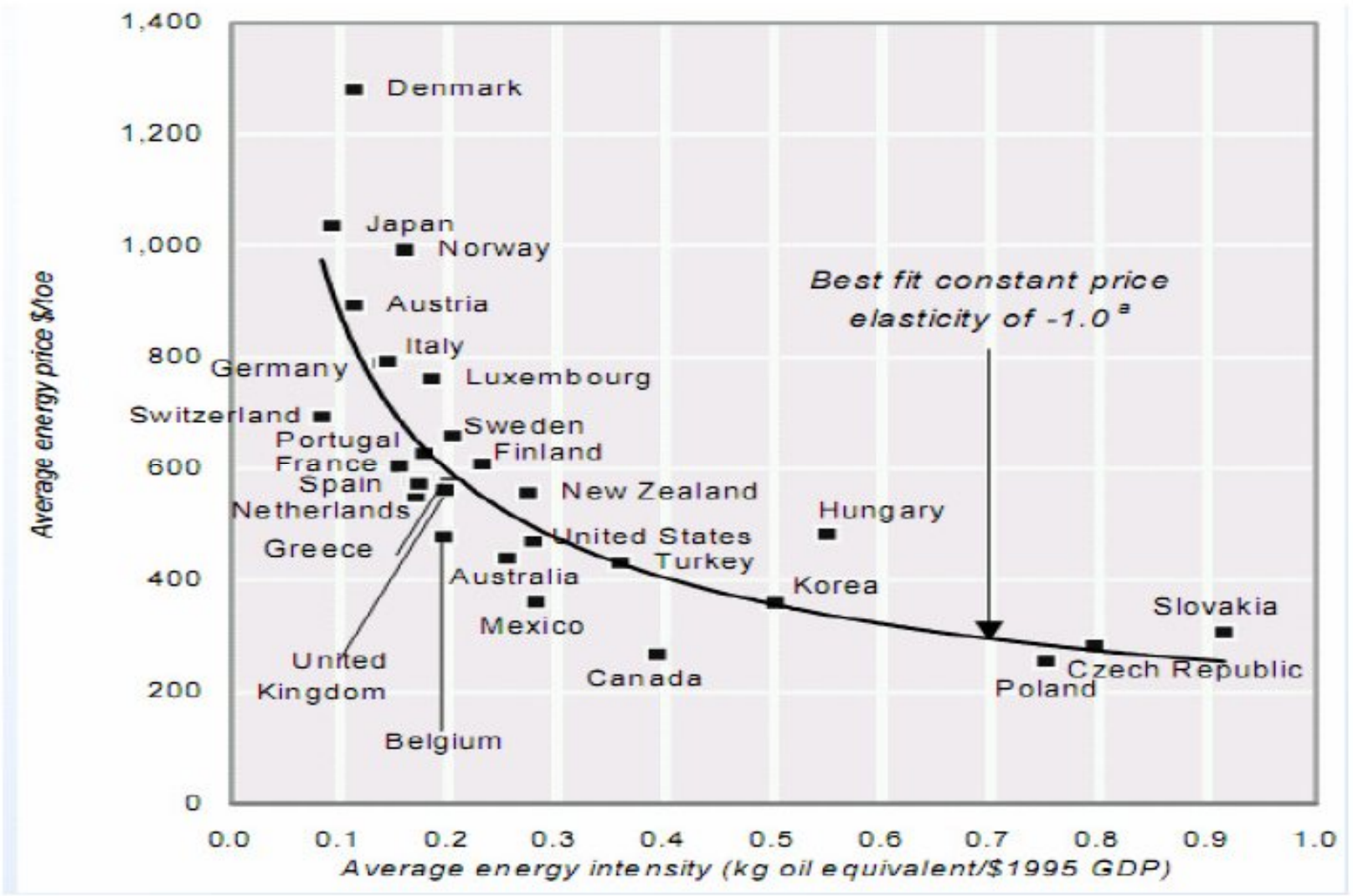
1. To be **effective,** we need a market price of carbon emissions that reflects social costs.
2. Moreover, to be **efficient**, the price must be universal and harmonized in every sector and country.

… is also the IPCC view

- "An effective carbon-price signal could realise significant mitigation potential in all sectors.
- Modelling studies show global carbon prices rising to 20-80 US$/t$CO_2$-eq by 2030 are consistent with stabilsation at 550 ppm CO_2-eq by 2100.
- Induced technological change may lower these prices ranges to 5-65 US$/t$CO_2$-eq in 2030."

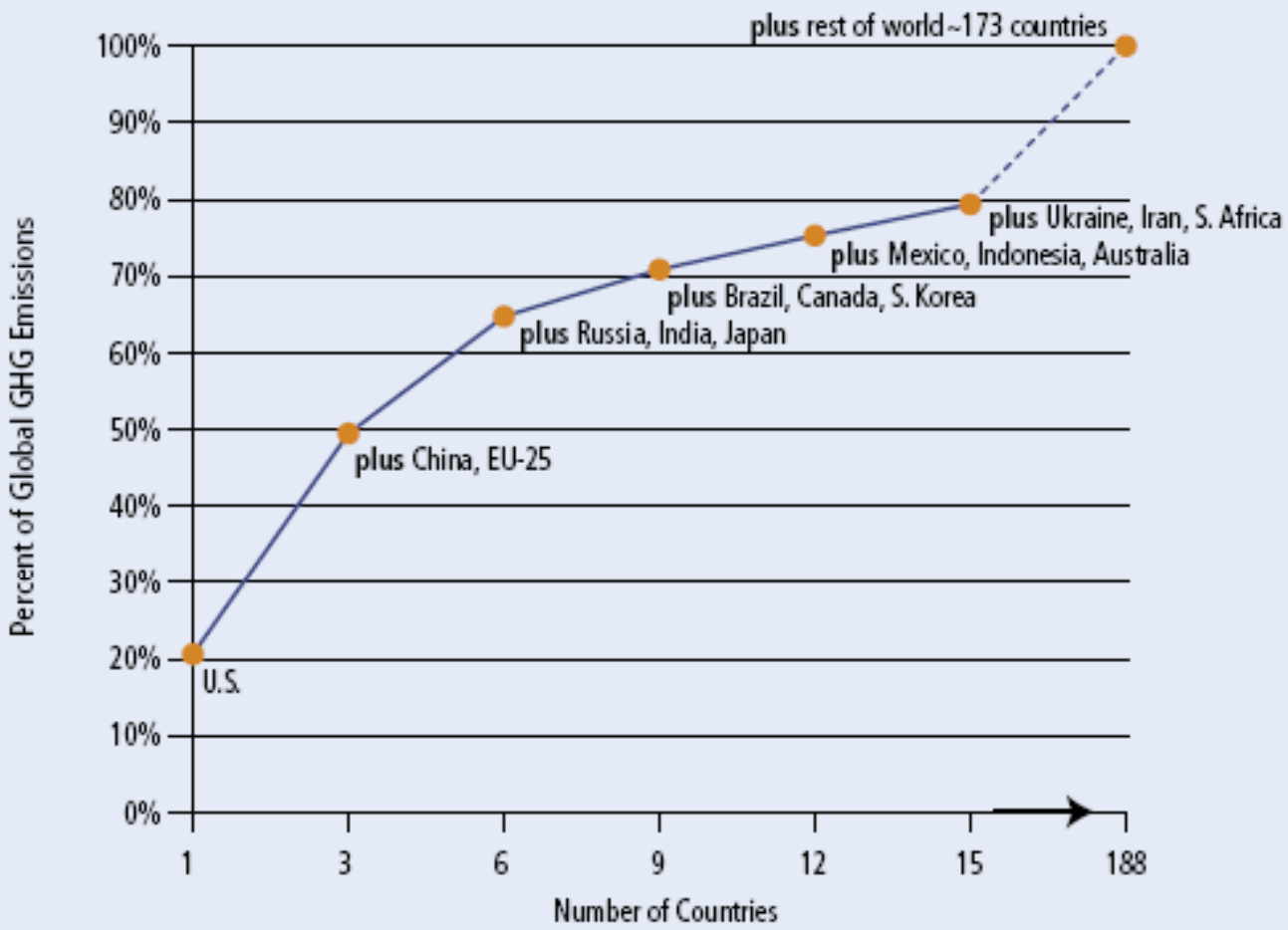
-IPCC, 4th Assessment Report, Summary for Policymakers, p. 18.

Importance of Price Signals



Source: Newbery, D.M. (2003). Sectoral dimensions of sustainable development: energy & transport. *Economic Survey of Europe 2*.

Figure 2.3. Aggregate Contributions of Major GHG Emitting Countries



Sources & Notes: WRI, CAIT. Moving from left to right, countries are added in order of their absolute emissions, with the largest being added first. Figures exclude CO_2 from land-use change and forestry and emissions from international bunker fuels.

Source: World Resources Institute, *Navigating the Numbers*, 2005.

Clean Development Mechanism: Is it a good idea?

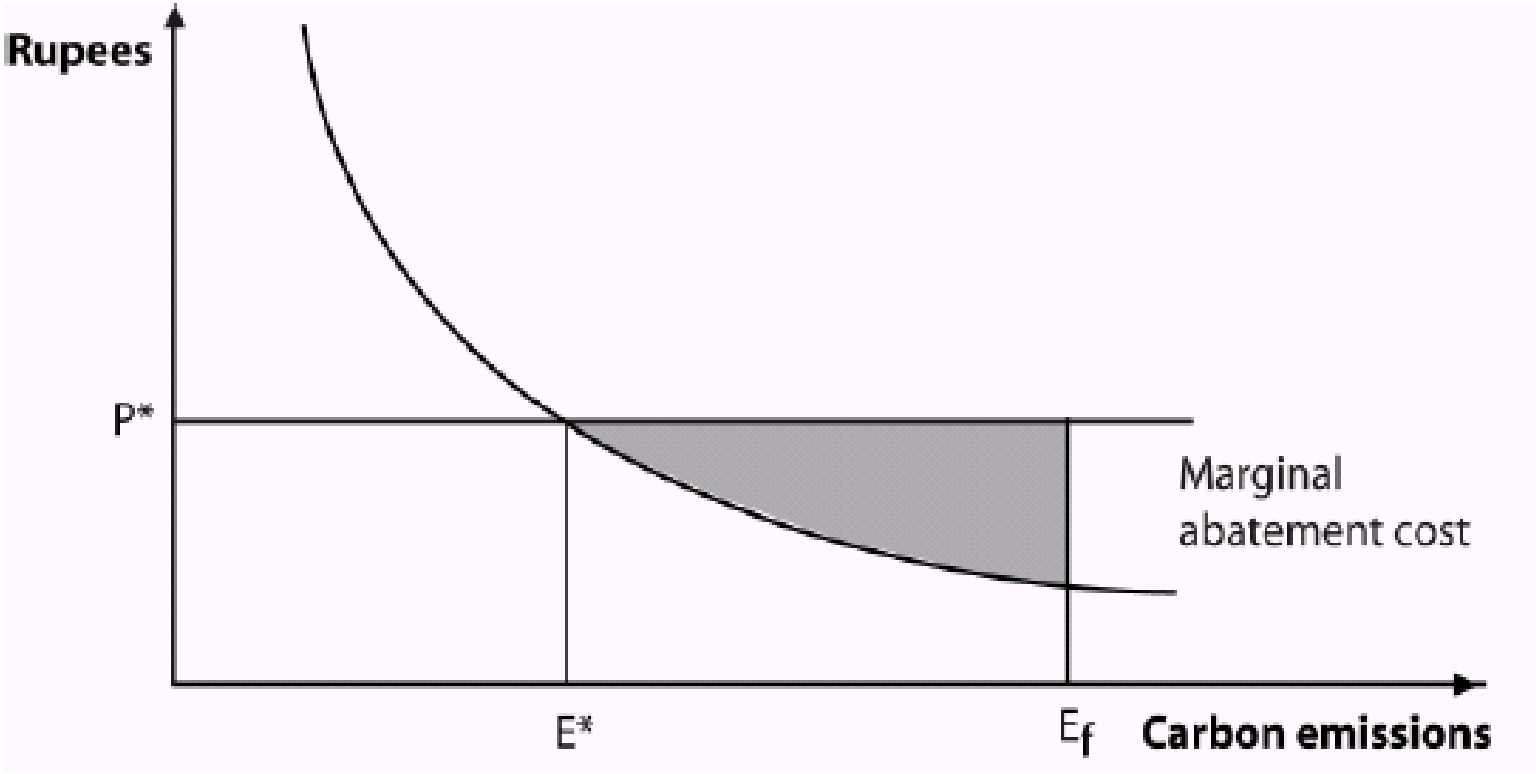
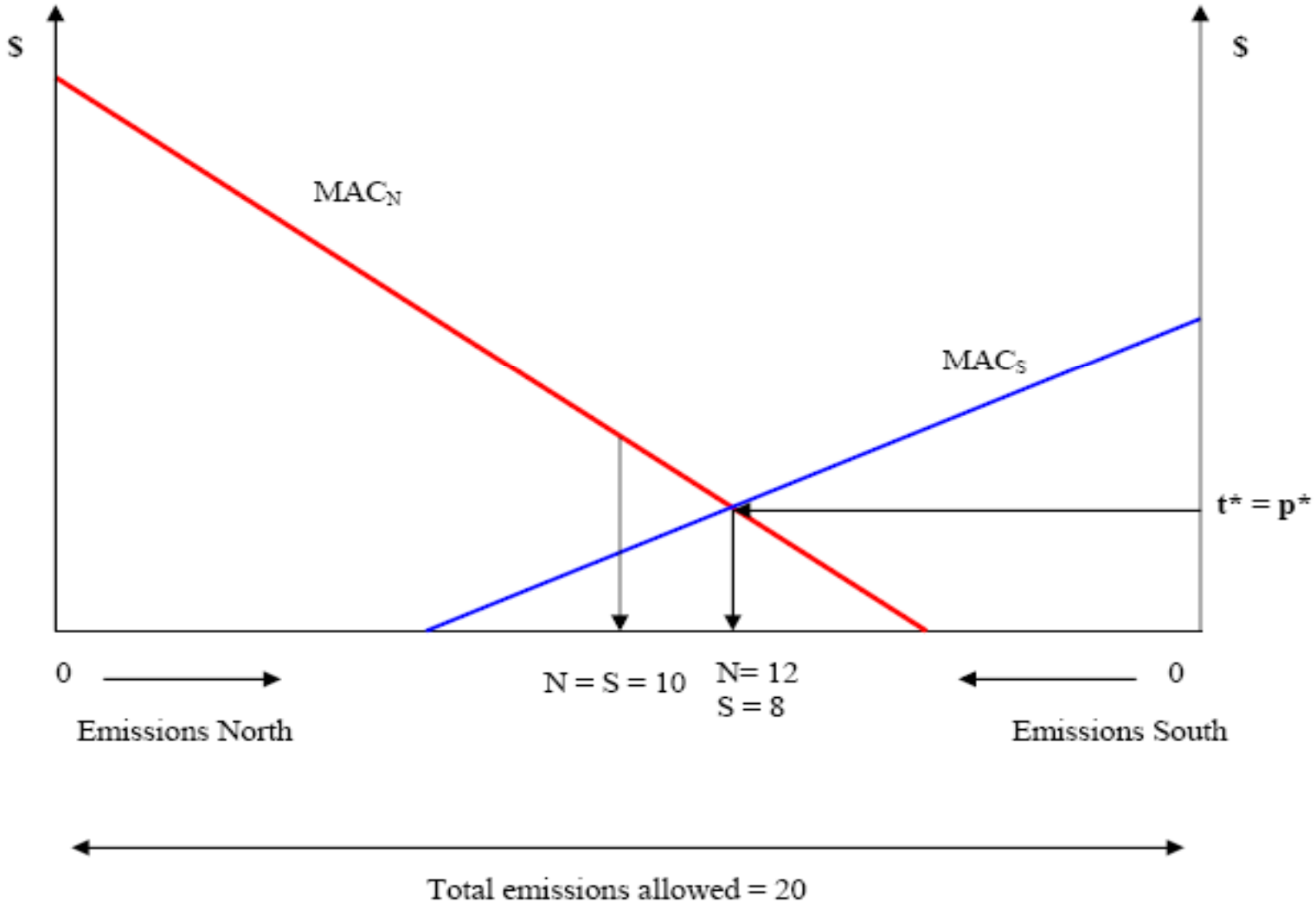
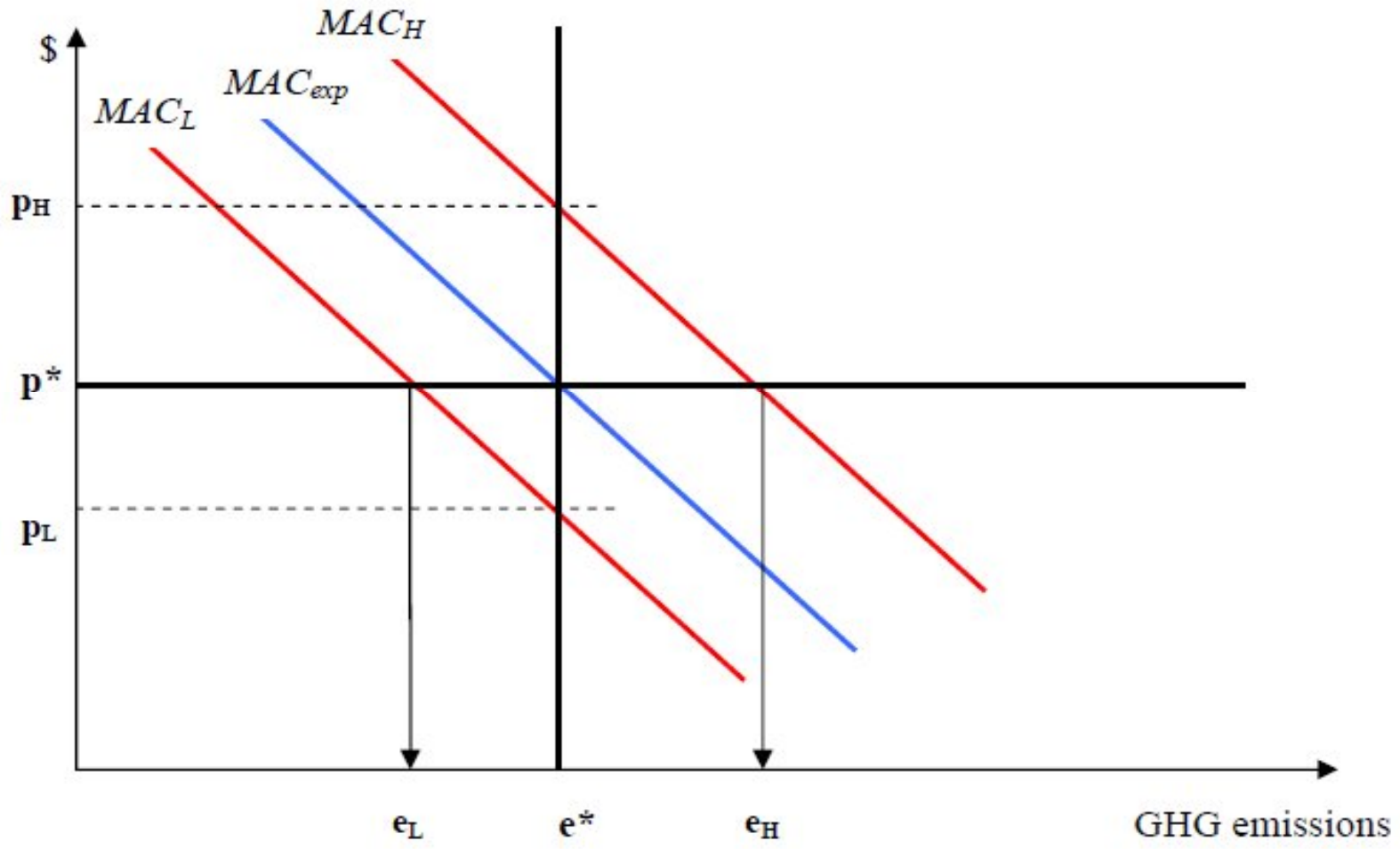


Figure 1. Surplus for a seller of permits

A cost effective GHG abatement policy



Uncertainty, permit prices and instrument choice



MAC = Marginal Abatement Cost (of GHGs)

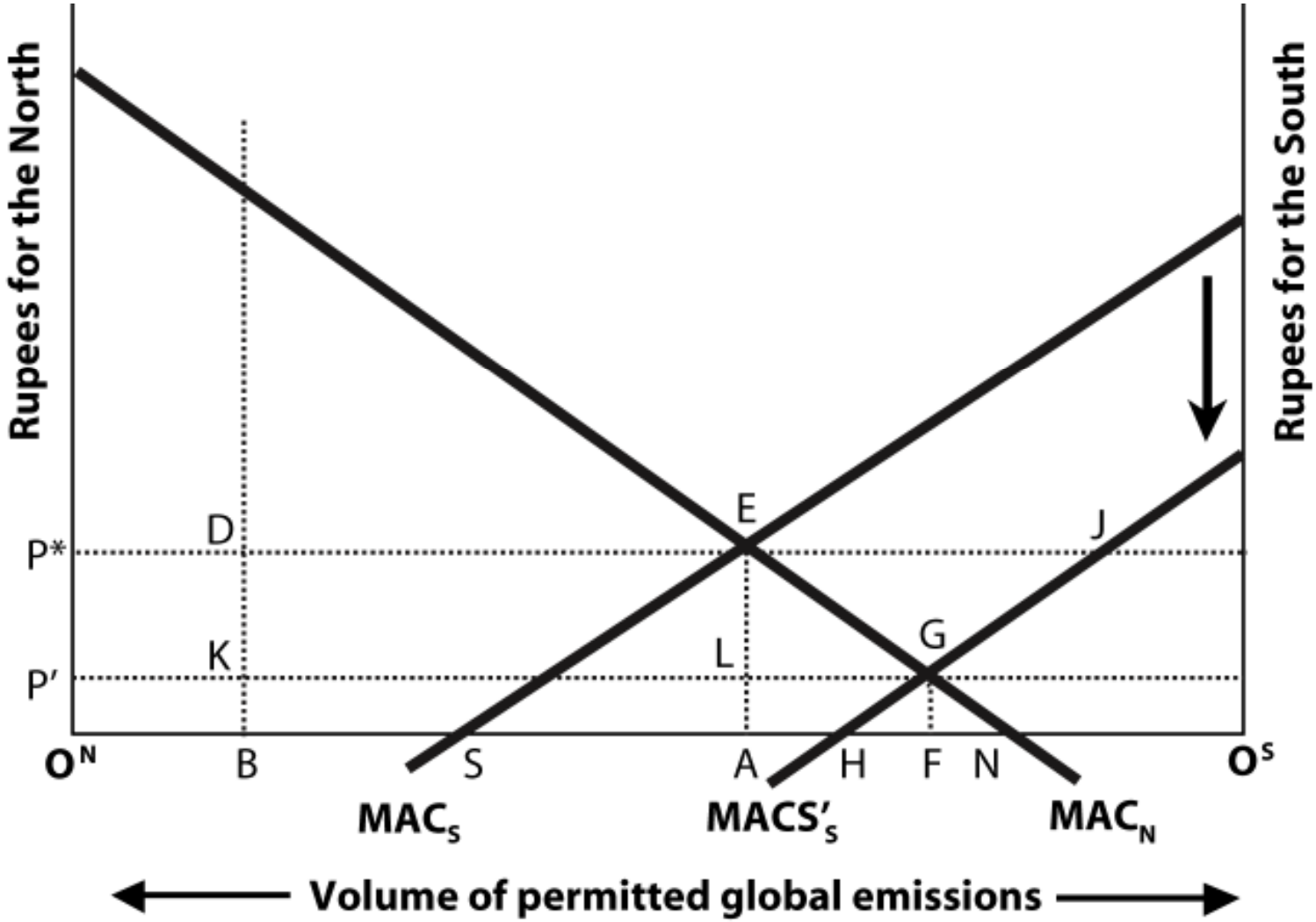
Uncertainty and instrument choice: taxes or permits?

- CO2/GHG concentration a stock externality—total annual emissions about 1% of excess CO2 in the atmosphere => MD from GHG emissions nearly constant (curve is 'flat' and uncertain)
- MAC is relatively steep (and uncertain)
- Hence carbon taxes would entail less 'regulatory error' (Weitzman Theorem)
- But:
  - political economy of global carbon tax
  - issues related to equitable distribution of global commons

Cap-and-trade + equity based allocation: an illustration

- Per capita emissions of CO_2 7 tons annually (6 billion people)
- Halving emissions by 2050 ➔2-3 tons per capita (9 billion people)
- US at present approx. 20 tons, EU/Singapore 10, China 3.5, and India 1.1
- Upper bound on ‘hot air’ sold by India: 1-2 billion tons? Plus abatement?
- Will it always remain ‘hot air’? (growth in emissions)

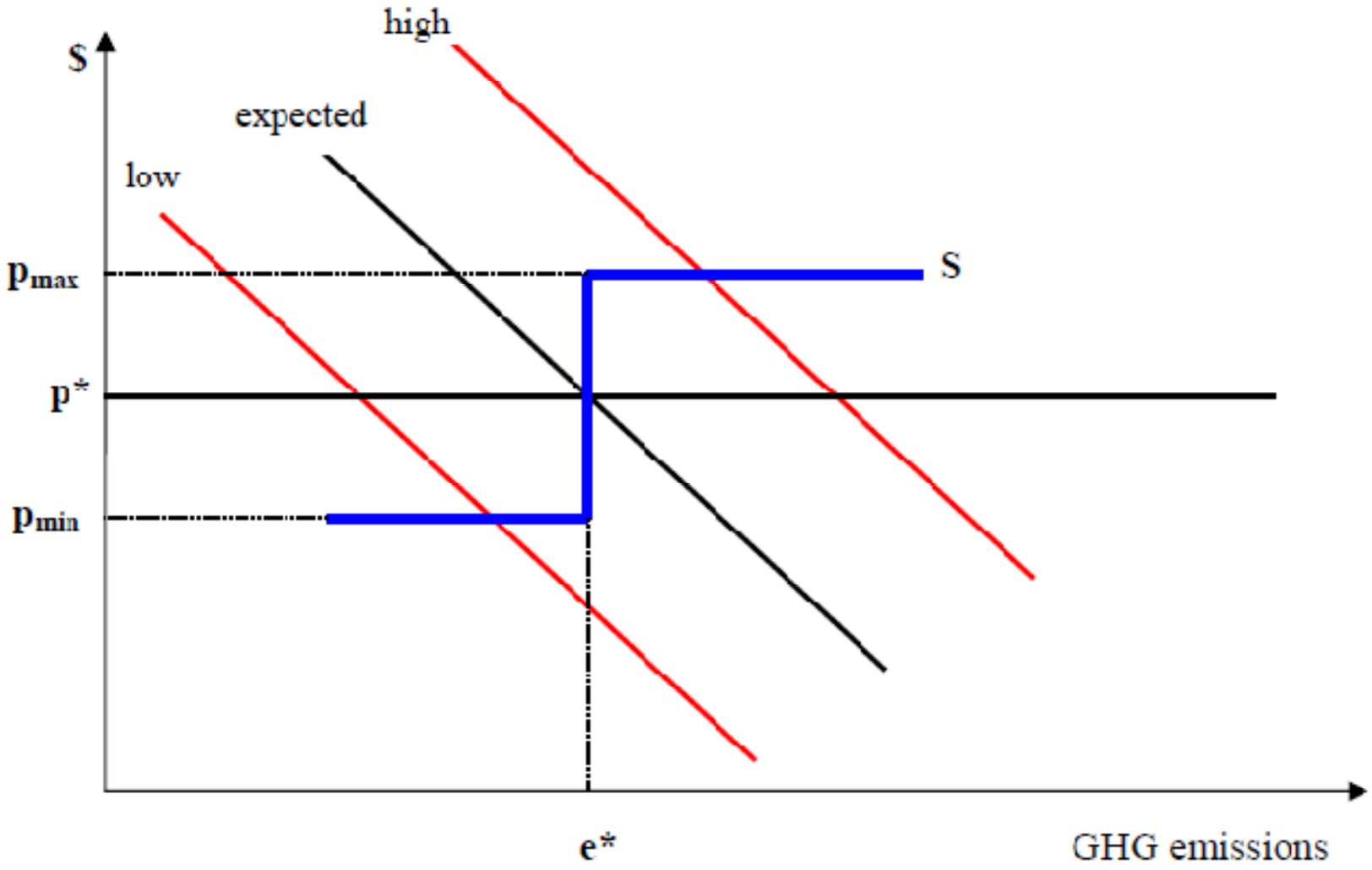
Per capita allocation, technical progress and permit prices



Stabilizing permit prices

- Permit prices will pay a key role
- $30-40/ton make technologies such as carbon capture and storage (CCS) commercially viable
- Desirable to let prices stay within a ‘band’ (floors/ceilings-safety valves)
- ‘Price band’ safeguards interests of buyers (North) and sellers (South)

A modified ‘cap and trade’ system



Implications for income transfer

- The agreement is ultimately about money.
- 'Carbon flows' could be US$50-100bn p.a. by 2030 (*a la* Stern).
- Still a win-win for North and South.
- Cheaper abatement options for North (in South).
- But North can't 'buy' its way out. Will also have to cut emissions at home (though less than that required without North-South trading).
- South takes on binding targets but it's a loose cap.

To conclude

- Global collective action is required to address climate change post-Kyoto (2012)
- A modified cap-and-trade regime with initial allocation based on per capita entitlements offers win-win opportunity for North and South
- Volatility of permit prices can be addressed through a price ceiling and floor (price band)
- Stabilisation of permit prices safeguards interests of buyers (north) and sellers (south)
- Promotes investment in non-carbon technologies
- Likely income transfers to sellers large but not in a relative sense