CLIMATE, COMMON GOOD

A DIALOGUE BETWEEN THE PHYSICAL SCIENCE BASIS AND THE ECONOMICS OF CLIMATE CHANGE

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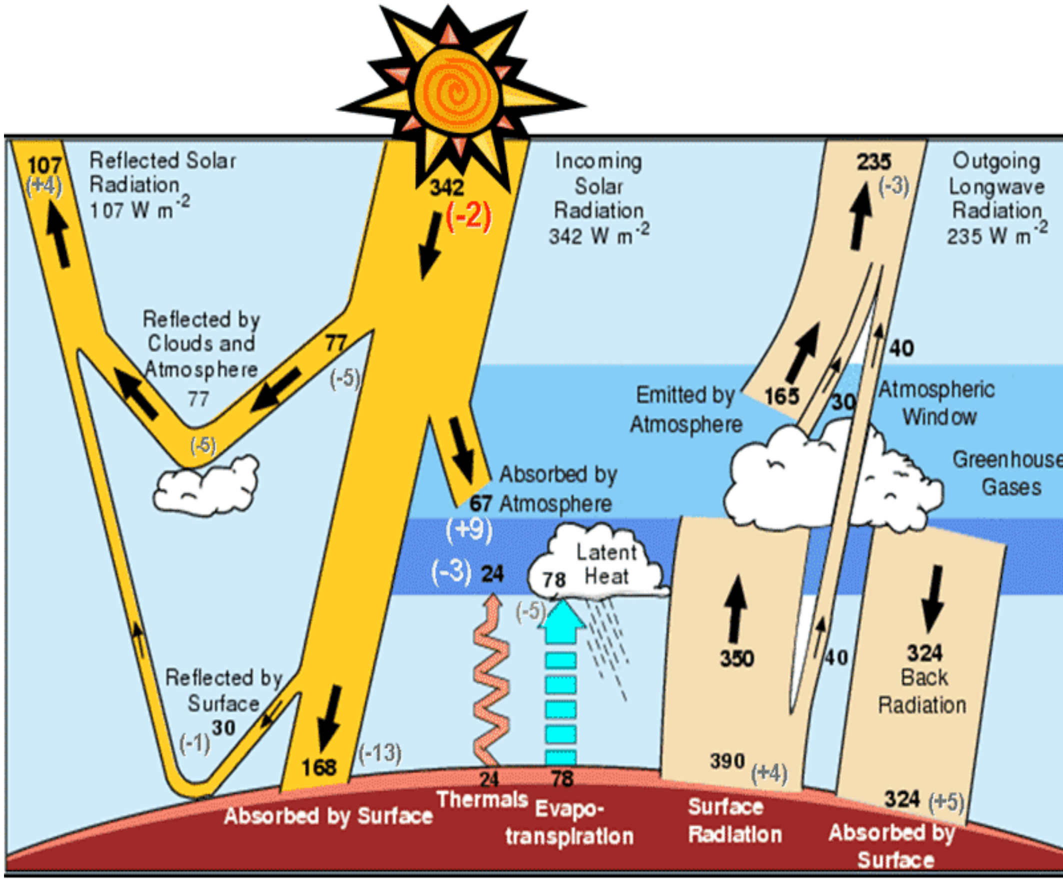
The complexity of the climate system

- The word ‘climate’ originates from ancient greek “clima” ‘κλίμα’ – inclination. In fact it is the inclination of solar radiation on land surfaces that determines the local energy intensity, and consequently the earth temperature and all the atmospheric phenomena that characterize the climate system

- The physical climate system is extremely complex, but in brief it can be described as the outcome of the interactions between the energy received from the sun, the earth's atmosphere, the land surfaces, and the oceans



- **The climate system is driven by the energy received from the sun (sunlight). Some of this energy is reflected back into space, but the rest is absorbed by the land and ocean and re-emitted as radiant heat. Some of this radiant heat is absorbed and re-emitted by the lower atmosphere in a process known as the greenhouse effect**

- The earth's average temperature is determined by the overall balance between the amount of incoming energy from the sun and the amount of radiant heat that makes it through the atmosphere and is emitted to space

The Greenhouse Effect

- In a greenhouse, energy from the sun passes through the glass as rays of light. This energy is absorbed by the plants, soil, and other objects in the greenhouse. Much of this absorbed energy is converted to heat, which warms the greenhouse. The glass helps keep the greenhouse warm by trapping this heat

- The earth's atmosphere acts somewhat like the glass of a greenhouse. About 31 % of the incoming radiation from the sun is reflected directly back to space by the earth's atmosphere and surface (particularly by snow and ice), and another 20 % is absorbed by the atmosphere. The rest of the incoming radiation is absorbed by the earth's oceans and land, where it is converted into heat, warming the surface of the earth and the air above it. Particular gases in the atmosphere act like the glass of a greenhouse, preventing the heat from escaping: they are named 'greenhouse gases' (GHGs)

- These greenhouse gases absorb heat and radiate some of it back to the earth's surface, causing surface temperatures to be higher than they would otherwise be. The most important naturally occurring greenhouse gas is water vapour and it is the largest contributor to the natural greenhouse effect. However, other gases, although they occur in much smaller quantities, also play a substantial and growing role in the greenhouse effect. These include carbon dioxide, methane, and nitrous oxide

- **Without this natural greenhouse effect, the earth would be much colder than it is now, making the average temperature on the planet a freezing -18 °C rather than the balmy 15 °C it is now!**

Why should climate change?

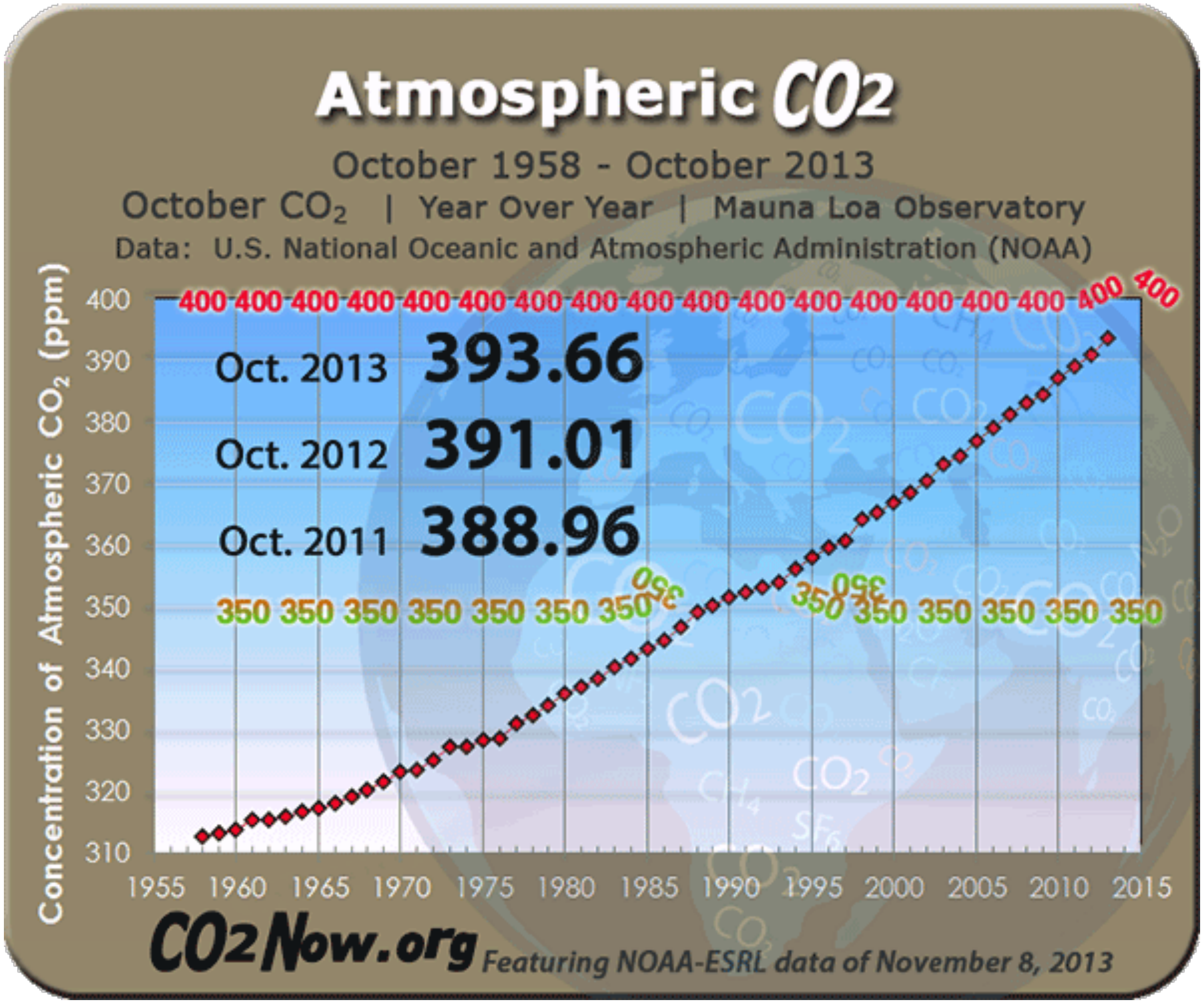
- **The Earth's climate is affected by natural processes and by human activity**

- Natural factors of change include internal processes, such as fluctuations in atmospheric and ocean circulation, and external factors, such as changes in volcanic activity, in solar irradiance, and in the Earth's orbit around the sun

- But climate change can also be caused by human activities, such as the burning of fossil fuels and the conversion of land for forestry and agriculture. Since the Industrial Revolution, the overall effect of human activities has been a warming effect, driven primarily by emissions of carbon dioxide and enhanced by the emission of other greenhouse gases

- Whereas in the past climate changes were driven by natural causes, the scientific community acknowledges that the changes in climate we observe today are primarily caused by anthropogenic GHGs

The Keeling Curve



On the 9th of May 2013 the Mauna Loa Observatory registered a 400 ppmv (parts per million volume) CO_2 concentration in the atmosphere: a critical threshold never reached in the past 800.000 years!

Key messages from the IPCC 5AR, 2013

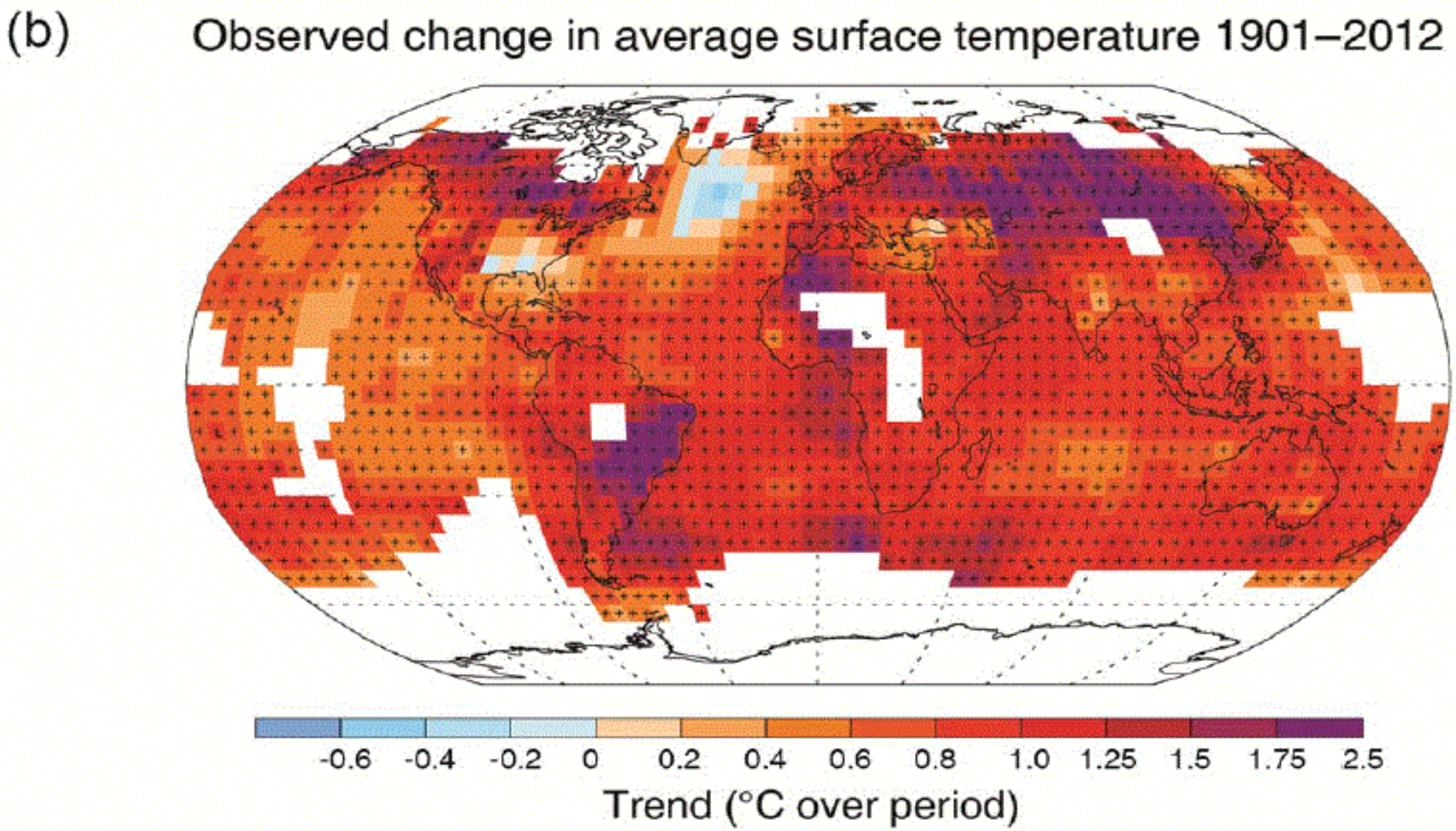
- **Warming of the climate system is unequivocal,** and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. The effects of temperature increases are more visible in cold regions, mainly in the Arctic and in Greenland

- Human influence on the climate system is clear. Observational and model studies of temperature change, climate feedbacks and changes in the Earth's energy budget together provide confidence in the magnitude of global warming in response to past and future forcing. **It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century**. Anthropogenic radiative forcing in 2011 with respect to 1750 was estimated to be +2,29 W/m^2, to be compared with a solar radiative forcing effect of +0,05 W/m^2

- The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. **Carbon dioxide concentrations have increased by 40% since pre-industrial times**, primarily from fossil fuel emissions and secondarily from net land use change emissions

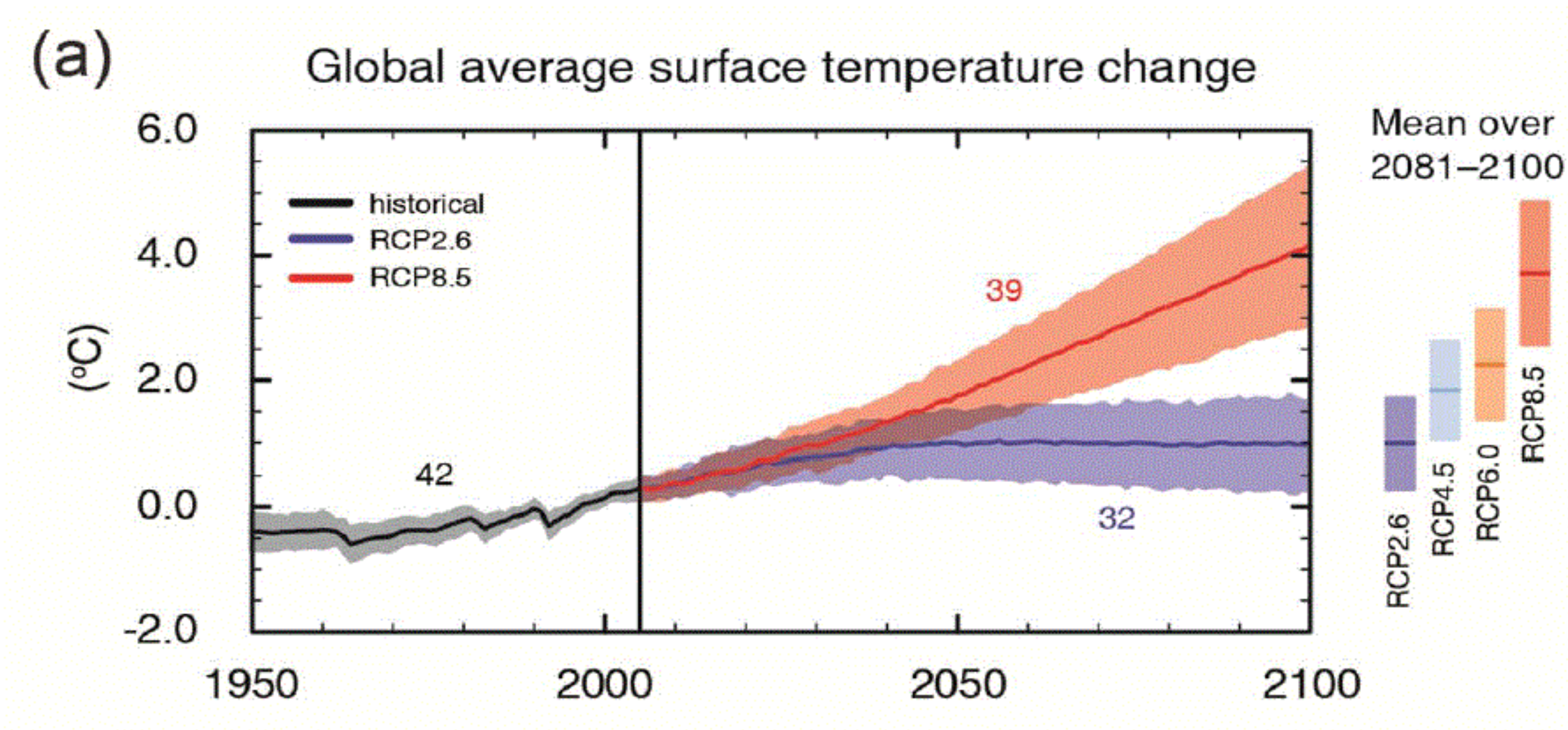
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. **Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions**

Temperature increase in the last century



IPCC 5AR, 2013: World wide distribution of temperature increase in the past century.
Increases have been recorded all over the planet, sometimes above + 2°. Only a small portion in the North-Atlantic shows a slight cooling

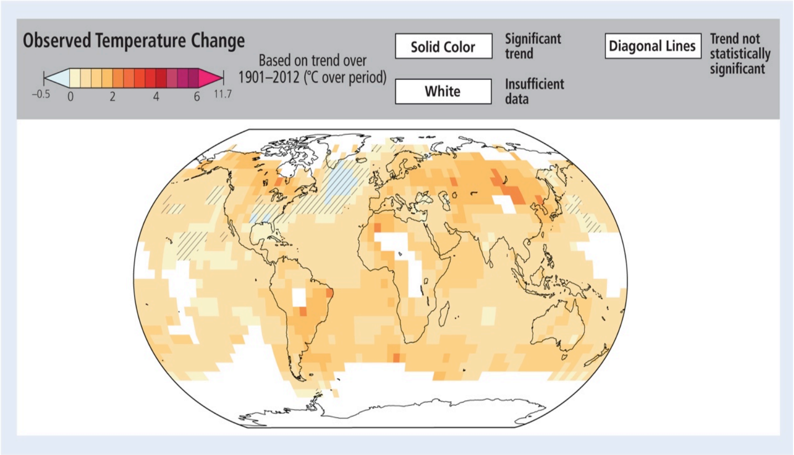
Temperature increase by the end of the century

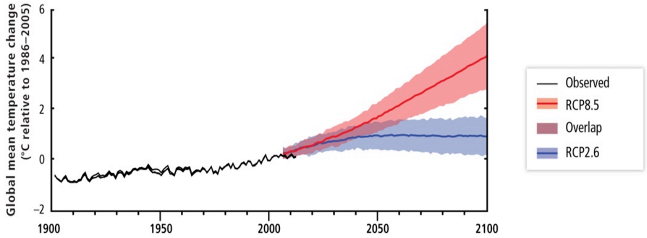


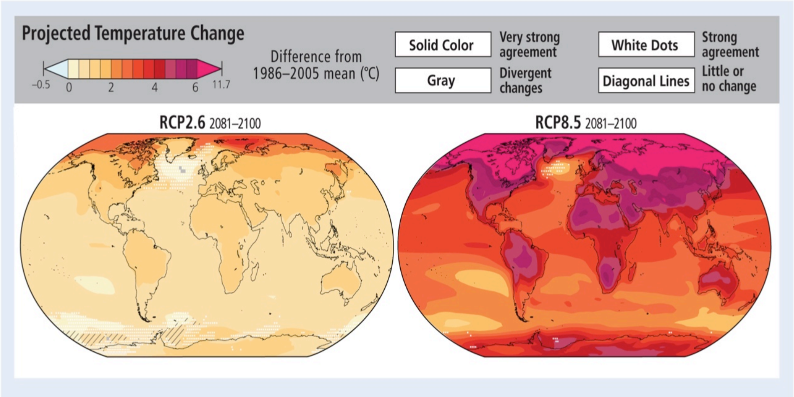
IPCC 5AR, 2013: Observed variations in global average temperature since 1950, and future scenarios, under different RCPs

Observed and projected temperature change, IPCC 5AR

(A)







Observed impacts attributed to climate change, IPCC 5 AR

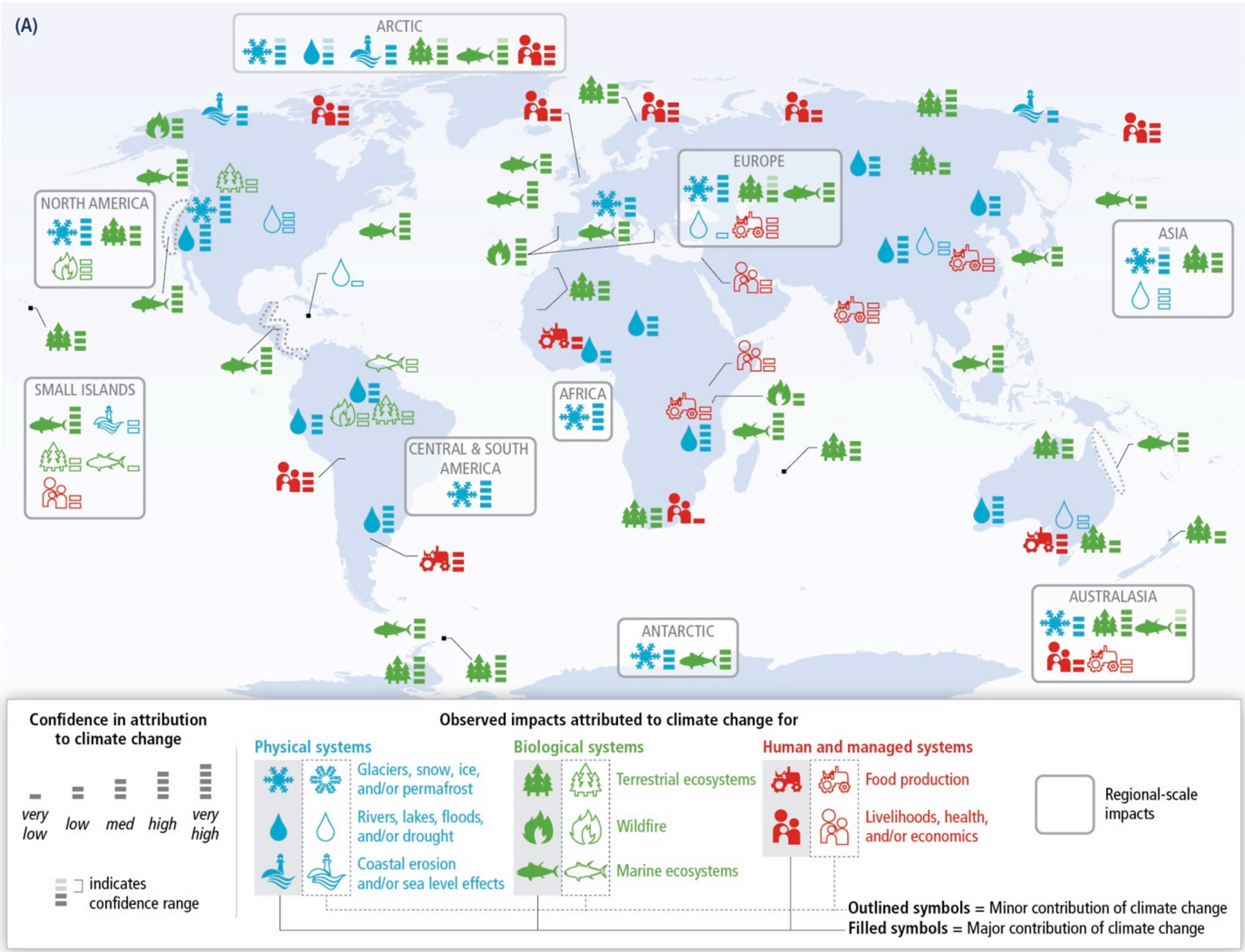


Figure TS.2

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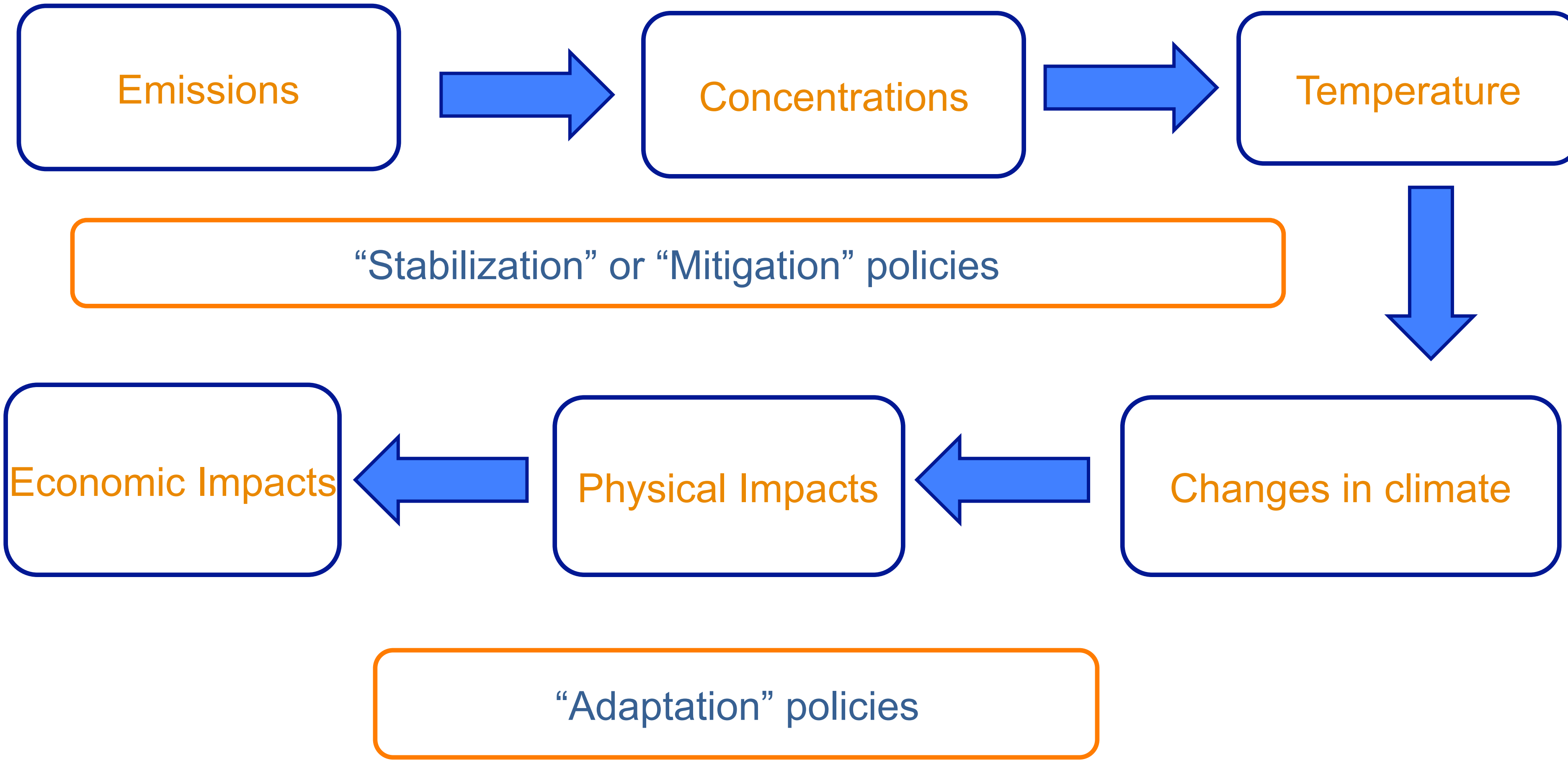
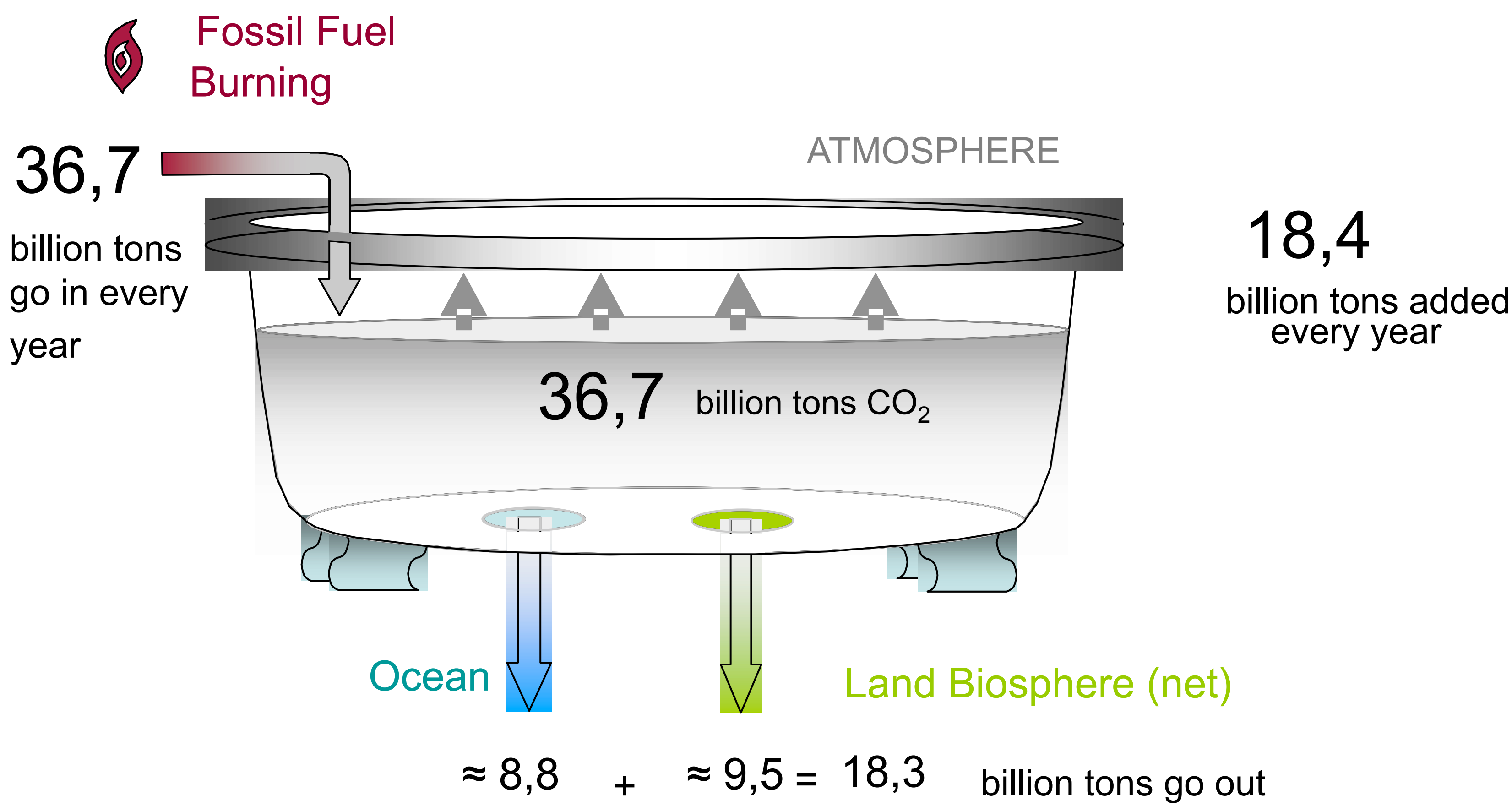
Relationship between climate and economics



CO_2 emissions and carbon sequestration: the atmosphere as a bath tub



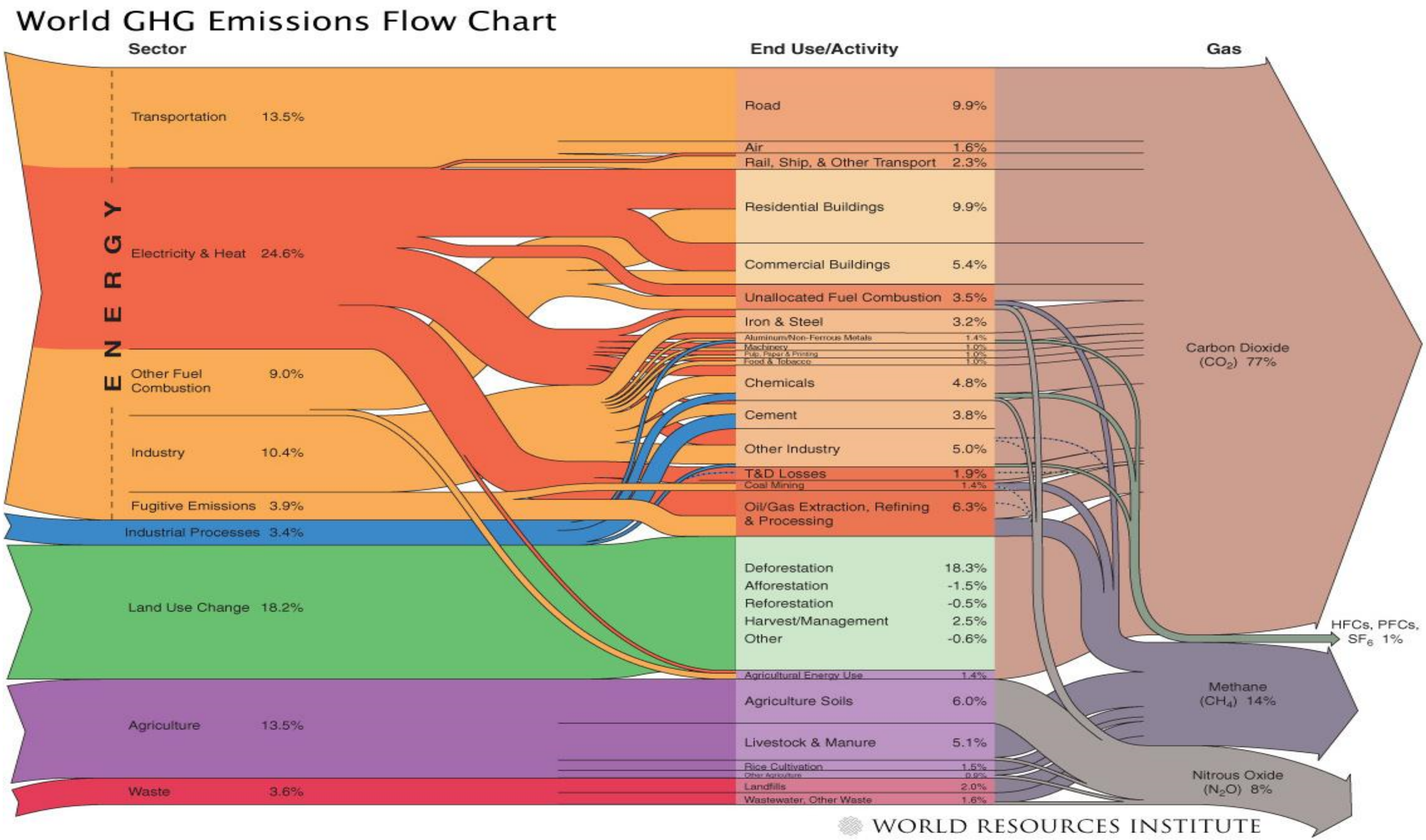
Today per capita emissions are ≈ 5 tCO_2/ year

How to get to today's per capita average of 5 tCO_2/ year

Activities	5 tCO_2/year per capita emissions
Airplane	18,000 km/year (slightly less that a round-trip Milan-San Francisco, or Milan-Tokyo)
Heating	Natural gas heating in a medium size house in a temperate climate

….a threshold that can be easily bypassed by a citizen of an industrialized country, and that is hardly touched by a poor country's citizen

A picture on global GHGs emissions' flows



Why shall we continue to emit GHGs?

"Much economic activity involves the emission of greenhouse gases. As they accumulate in the atmosphere, temperatures increase, and the climatic changes that result impose costs (and some benefits) on society. However, the full costs of greenhouse gases emissions, in terms of climate change, are not immediately – indeed they are unlikely ever to be – borne by the emitter, so they face little or no economic incentive to reduce emissions. Similarly, emitters do not have to compensate those who lose out because of climate change. ... In this sense, human-induced climate change is an externality, one that is not "corrected" through any institution or market,... unless policy intervenes"

Nicholas Stern

Two magic words for climate policies: mitigation and adaptation

What is mitigation?

"An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases" (IPCC TAR, 2001)

Some examples of mitigation strategies are:

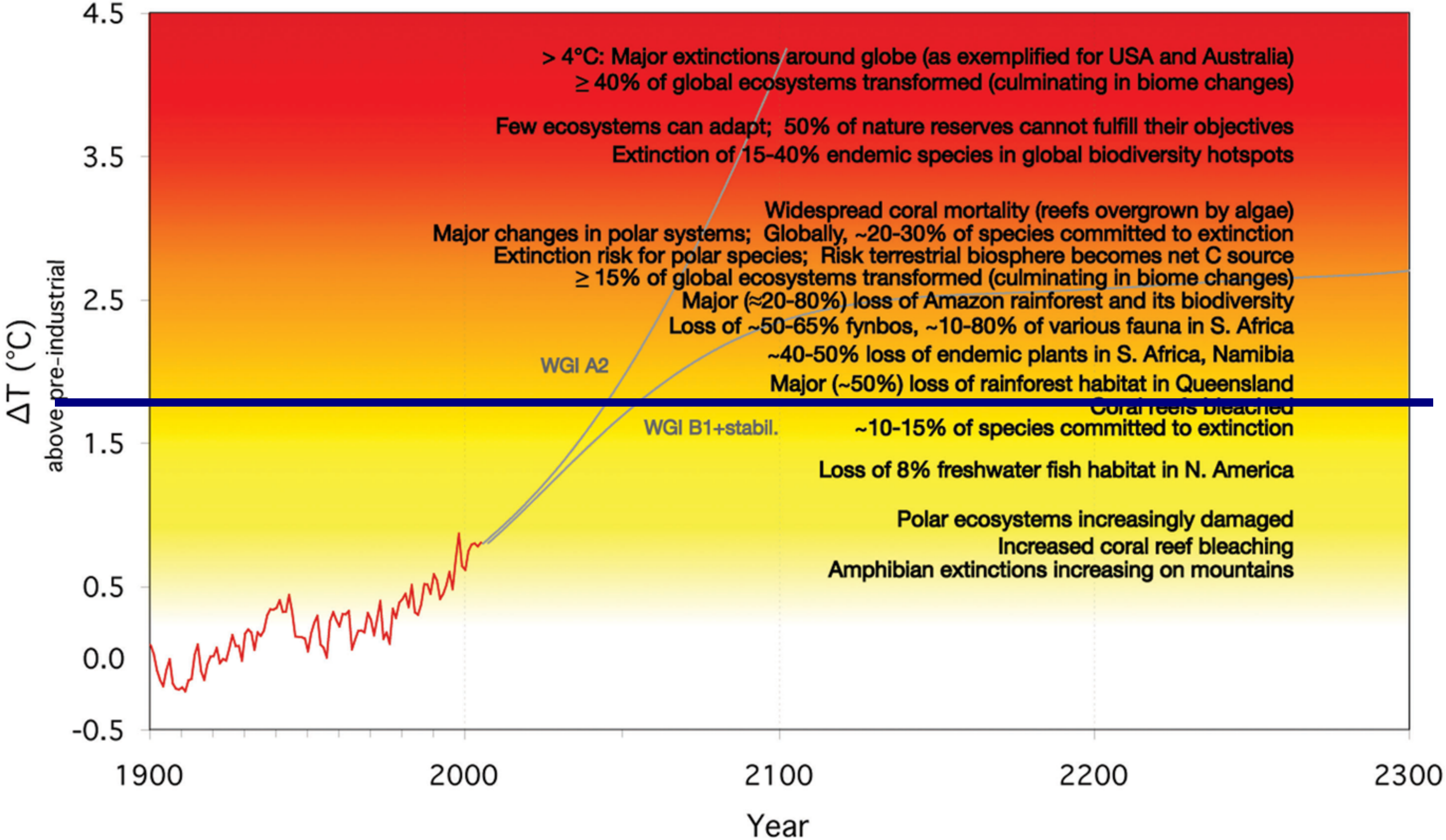
the more efficient use of fossil fuels for industrial processes or power generation, the substitution of fossil fuels with renewable energy sources (solar and photovoltaic energy), building insulation, afforestation or avoided deforestation and other carbon sequestration options)

What is adaptation?

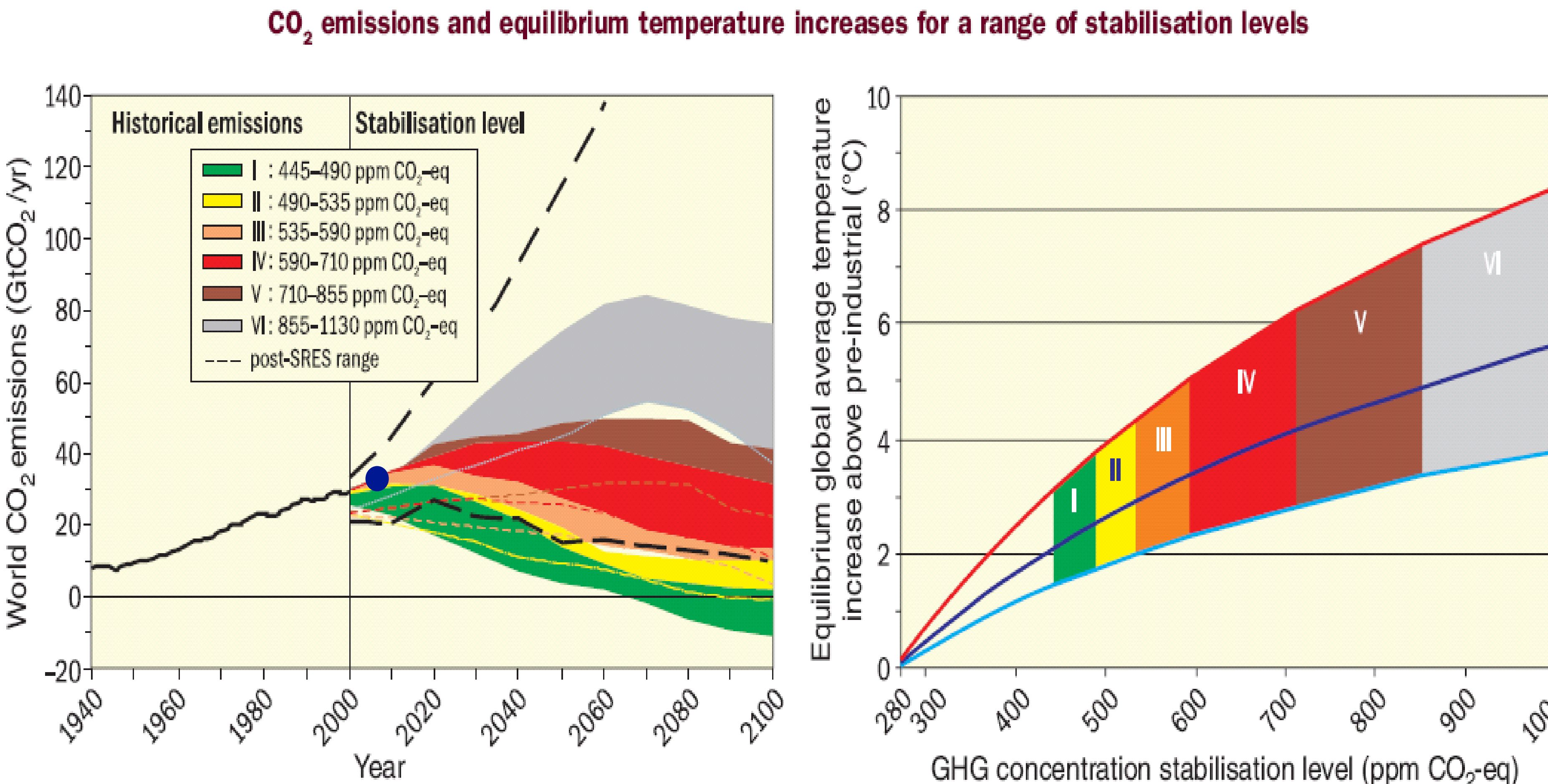
"Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation" (IPCC TAR, 2001)

- ***Anticipatory Adaptation*** *— Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation*
- ***Autonomous Adaptation*** *— Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation*
- ***Planned Adaptation*** *— Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state*
- ***Private Adaptation*** *— Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation is usually in the actor's rational self-interest*
- ***Public Adaptation*** *— Adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs*
- ***Reactive Adaptation*** *— Adaptation that takes place after impacts of climate change have been observed*

Mitigation is unavoidable…..



….. but also adaptation: it is now unlikely to stabilize at below + 2°



Fonte: IPCC AR4 (2007) e IEA (2009)

How is the world going to change? (1/2)

20- 30% of plants and animal species are estimated to be at risk of extinction in a world at 1.5° - 2.5° C

Higher temperatures will imply very serious impacts on biodiversity and ecosystem services, mainly water and food

Over the century the melting of snow ad glaciers in the main mountain chains -— Hindu-Kush, the Himalayas and the Andes – will reduce water availability and the hydroelectric potential in regions populated by more than one sixth of the world population. Changes in temperature and precipitation will also influence water flows and availability with different effects in different world regions

By the end of the century more frequent and extreme precipitations will increase flooding risk in lands populated by 20% of the world population

How is the world going to change? (2/2)

With a medium confidence level crops' productivity on a global scale will diminish above a + 3° temperature increase. Under these conditions, some African countries are estimated to lose up to 50% of their crops, with disastrous consequences on food prices and poverty exacerbation

For lower temperature increases, the effects on agriculture will differ by region and crop. Based on historical data, since the early '80s at the global level corn and wheat productivity has been seriously damaged by temperature increases

Costal areas will be increasingly exposed to erosion and sea-level rise. With high confidence, by 2080 many more million people every year will suffer from the effects of flooding caused by sea-level rise – typically in the small island states, and in the densely populated deltas in Asia and Africa

The world population's health will suffer from increasing malnutrition, cardio-vascolar, respiratory and infectious diseases, diarrhoea, in addition to an increase in morbidity and mortality from heat waves, poorer air quality in cities, flooding and drought, with more severe impacts in developing countries

Also business and society will suffer. Climate change will impact on the energy sector, for instance through an increase in energy demand for cooling in extremely hot seasons; on the tourism sector, through changes in the destination choices; on migration; on infrastructures and on the insurance sector

The economics of climate change

Focus on:

- **The cost of inaction** (or social cost of climate change) = cost of climate change impacts in the absence of any mitigation or adaptation intervention

- **Cost-Benefit Analysis** (and Cost-Effectiveness) of climate policies, to identify optimal policies. Integrated Assessment Models in this field of research also address potential *trade-off* between mitigation and adaptation options

Steps to assess the costs of climate policies

Assessment of current scenarios, both climate and socio-economic scenarios, identifying those variables most vulnerable to climate change, such as crops, forests and population

Fixing a time-horizon, such as 2100, future scenarios are modelled, both without and with the implementation of climate policies

Socio-economic scenarios, that describe the future development of technology, production, consumption, and GHGs emissions, are coupled with climate scenarios, that partly depend on socio-economic scenarios through the link with emissions, their concentration in the atmosphere and radiative forcing.

Based on future scenarios, through econometric analysis or sector specific studies, impacts by sector and category are assessed

Climate modules clearly provide precious inputs to economic modelling, and vice versa. This complex system is however permeated by uncertainty: not only with respect to climate dynamics, but also to the quantification of impacts, both physical and economics.

Integrated assessment: trade-off between mitigation and adaptation?

- *Different time scale*: adaptation strategies are effective in the short run, mitigation actions in the long run

- *Different spatial scale*: adaptation is typically local, mitigation indeed generates global effects

=> Investments choices must evaluate potential *trade-off and synergies* between mitigation and adaptation strategies over time and across space

The international policy answers: from Chipko to Rio +20, passing through Kyoto

’60s => development of the environmental debate in industrialised countries on specific issues, such as air pollution, the use of pesticides in agriculture, waste management, ocean acidification, ozone depletion, with a local or regional focus

1972 => Stokholm Conference: UNEP’s establishment – to give voice also to developing countries – and promotion of national environmental legislation, with the creation of Ministries and Environmental Agencies

1979 => First World Climate Conference in Geneva

1987 => **Brundtland** Commission Report ‘*Our Common future’* on sustainable development: “a development that meets present generation’s needs without compromising the needs of future generations”

1988 => **establishment of the IPCC**, *Intergovernmental Panel on Climate Change, by UNEP and WMO*

1992 => First Earth Summit in **Rio de Janeiro (UNCED)**: establishment of the UNFCC – *United Nations Framework Convention on Climate Change* – and of the two ‘sister’ conventions on biodiversity and desertification

2012 => **Rio + 20…towards a green economy!**

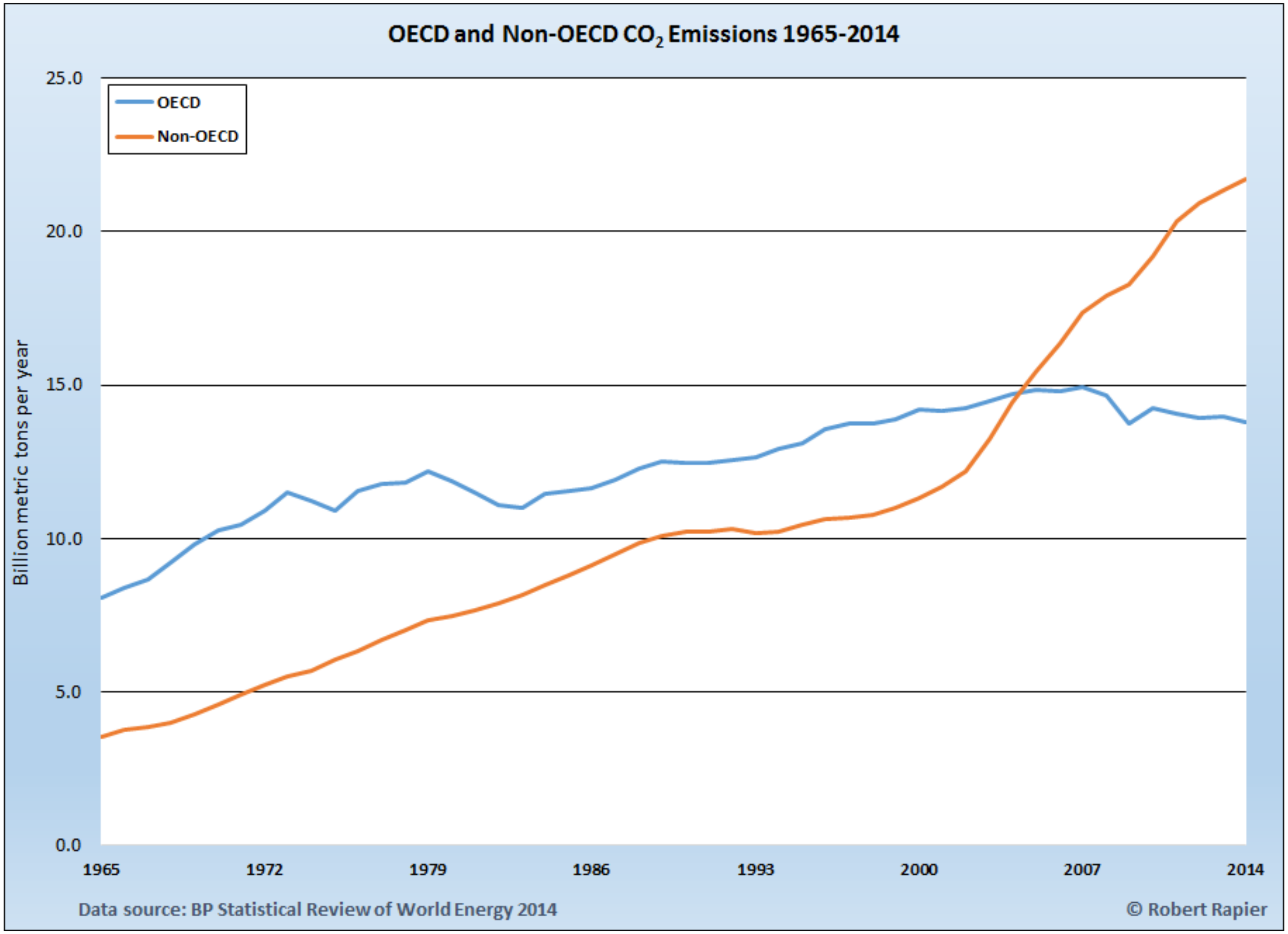
The UNFCCC: efficiency and equity

The ultimate objective of the Convention is to stabilize greenhouse gas concentration "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system”

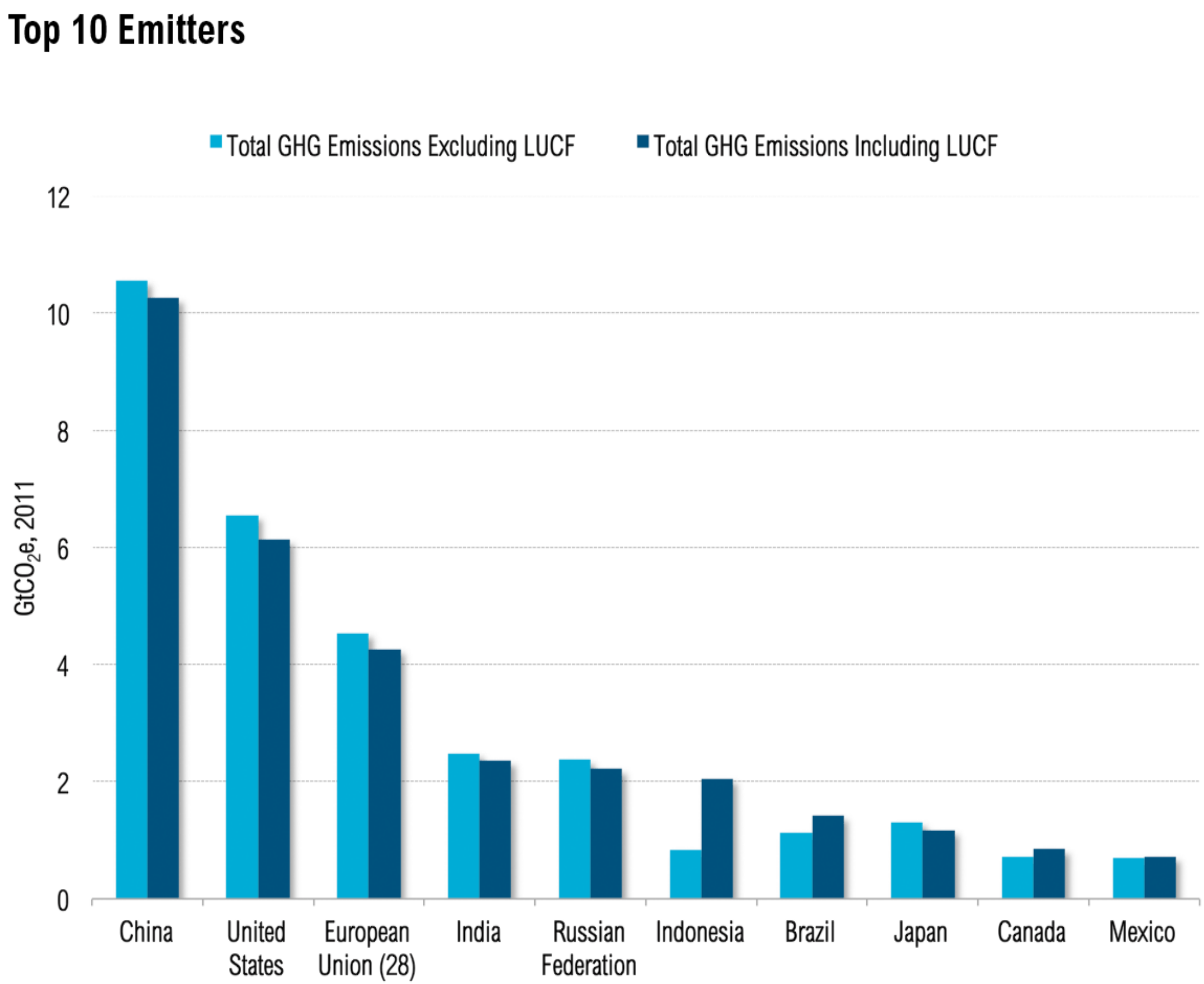
Equity is taken care of by the principle of ‘Common but differentiated responsibilities’, that forces Industrialised Countries to act first

Economic efficiency and environmental effectiveness are taken care of by the design of market flexibility mechanisms (ET, CDM, JI) under the KP, that allow to exploit differences in marginal abatement costs between countries to reach the environmental target

CO2 emissions of OECD and non-OECD, 1965-2014… ’common but differentiated responsibilities’ (UNFCC)



Top 10 world emitters - total emissions



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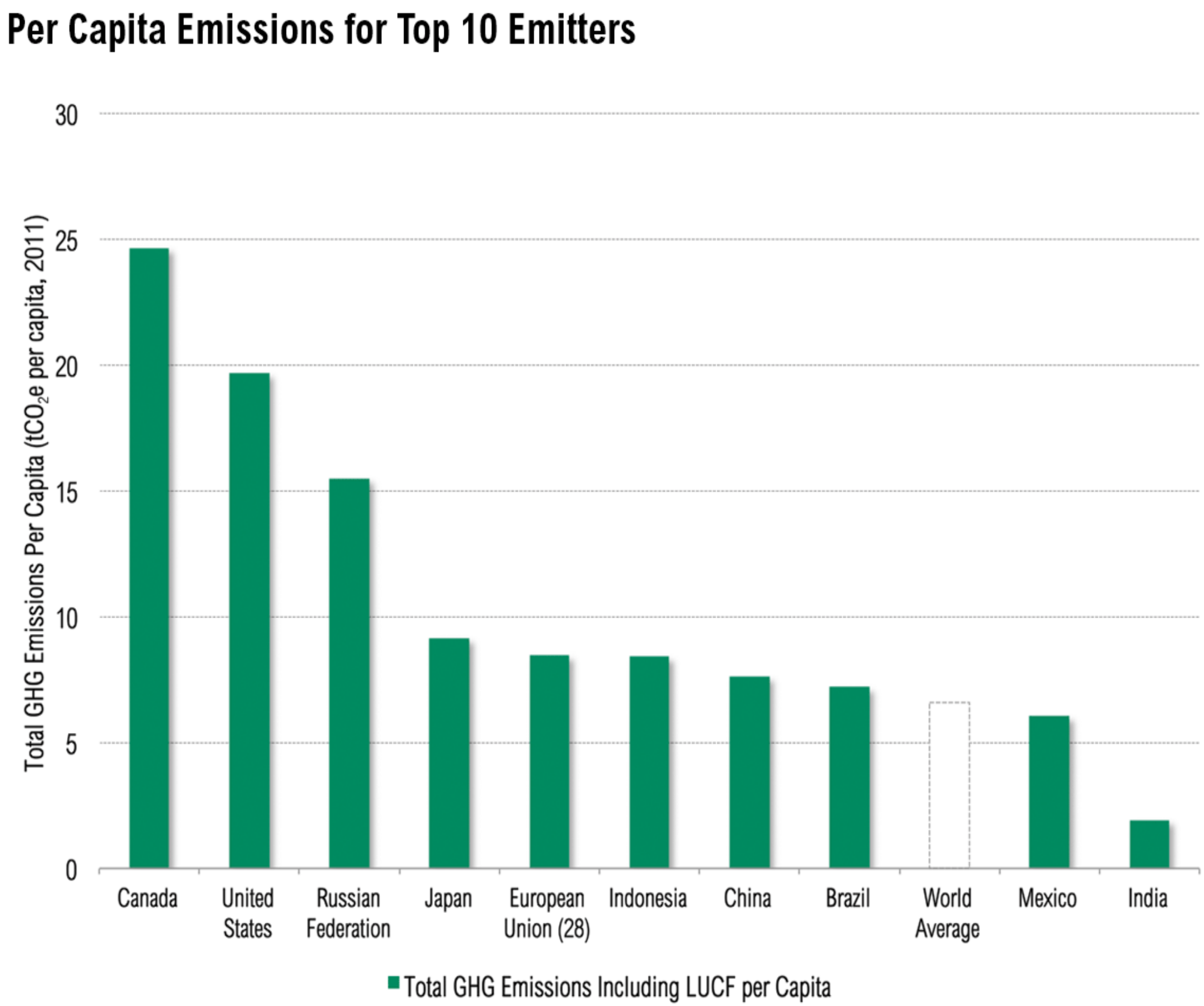
Top 10 world emitters– per capita emissions



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The Kyoto Protocol (KP) 1/2

- The Kyoto Protocol is one of the first binding environmental agreements, that legally binds developed countries to emission reduction targets. **The KP was formally adopted by the UNFCCC in 1997 and entered into force in 2005**, when the ratification by Russia allowed to reach the quorum, despite the absence of the US: the ratification by at least 55 countries accounting for more than 55% of global emissions in 1990

- **The KP first commitment period started in 2008 and ended in 2012**, aiming at an average global emissions' reduction of **- 5% with respect to 1990** (- 8% = target assigned to the European bubble, within which – 6.5% assigned to Italy). The second commitment period began on 1 January 2013 and will end in 2020

The Kyoto Protocol (KP) 2/2

- A preliminary assessment of the KP first commitment period for Europe is positive: **-13.8% (in EU-15) or – 17.5% (in enlarged Europe) emissions compared to 1990**, though partly achieved thanks to *hot air* (due to too generous targets allocated to eastern countries, that with the massive deindustrialisation following the fall of communism accumulated emission credits) and to the economic crises

- **At the COP in Doha it was agreed to get to -18% with respect to 1990 for the second commitment period. Unfortunately the countries that agreed to the Doha amendment to the KP account only for 15% of global emissions!!!** Among the 5 today's biggest emitters (1. China = 29% of global emissions, 2. US = 16%, 3.European Union = 11%, 4. India = 6%, 5. Russia = 5%) only the European Union entered the KP second commitment period!

The flexibility mechanisms and the carbon market

- Countries with commitments under the KP to limit or reduce greenhouse gas emissions must meet their targets primarily through national measures. The targets are expressed as levels of allowed emissions, or "assigned amounts," over the commitment periods. As an additional option, the KP introduced three market-based mechanisms, thereby creating what is now known as the "carbon market", a key tool for reducing emissions worldwide => **the KP created a new commodity in the form of emission reductions or removals.** Since carbon dioxide is the principal greenhouse gas, carbon is now tracked and traded like any other commodity

- The **"carbon market"**:

  - ✓ stimulates sustainable development through **technology transfer and investment**
  - ✓ helps countries with Kyoto commitments to meet their targets by reducing emissions or removing carbon from the atmosphere in other countries in a **cost-effective way**
  - ✓ encourages the **private sector** and developing countries to contribute to emission reduction efforts

- The three carbon market mechanisms are **Emissions Trading,** the **Clean Development Mechanism (CDM)** and **Joint Implementation (JI)**

  - ❑ **Emissions trading** allows countries that have emission units, or assigned amounts of emissions based on the KP targets, to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets => **carbon trading**!
  - ❑ **JI and CDM are the two project-based mechanisms** which feed the carbon market. JI enables industrialized countries to carry out joint implementation projects with other developed countries, while the CDM involves investment in sustainable development projects that reduce emissions in developing countries

The EU ETS scheme

- Emissions trading schemes may be established as climate policy instruments at the national level and at the regional level. Under such schemes, the EU ETS is the largest in operation

- **The EU ETS works on the 'cap and trade' principle**. A 'cap', or limit, is set on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. The cap is reduced over time so that total emissions fall

- In 2020, emissions from sectors covered by the EU ETS will be 21% lower than in 2005. By 2030, the Commission proposes, they would be 40% lower

- **Within the cap, companies receive or buy emission allowances which they can trade with one another as needed**. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value. **After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed**. If a company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances. **The flexibility that trading brings ensures that emissions are cut where it costs least to do so**

- By putting a price on carbon and thereby giving a financial value to each tonne of emissions saved, the EU ETS has placed climate change on the agenda of company boards and their financial departments across Europe. **A sufficiently high carbon price also promotes investment in low-carbon technologies, acting as a major driver of investment in clean technologies particularly in developing countries**

Climate policies objectives

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal.

The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C.

The agreement is due to enter into force in 2020

Stabilisation costs

- Mitigation costs to reach the 2° target are estimated around a world GDP loss in a range between 4 and 7%, depending on the discount rate and the scenario used (Bosetti et al., 2010)

- In addition to mitigation costs, adaptation costs and damage or impact costs should be assessed

Which mitigation action?

- There is not a silver bullet solution, but a puzzle of possible solutions:

  - ✓ Energy efficiency
  - ✓ *Carbon Capture and Sequestration*
  - ✓ Renewable energy
  - ✓ Nuclear energy
  - ✓ Reduction of emissions from deforestation and forest degradation(REDD)
  - ✓ New technologies…….and energy saving!

- Common denominator:

  - ✓ Win-win strategies
  - ✓ R&D investments

Climate finance: how to make resources available?

The Cancùn Agreement sets two climate finance targets, respectively of ***fast-start and long-term finance***:

- ***Fast start finance***: new and additional resources from industrialised countries up to **30 billions US$ for the period 2010-2012**, both fpr mitigaton and adaptation. Funds for adaptation should be allocated to the most vulnerable developing countries

- ***Long-term finance*** *: up to* **100 billions US$ per year by 2020** for mitigation and adaptation

  ➔ These resources must be additional to ODA funds

  ➔ Other climate finance instruments, in addition to the **Green Climate Fund** established in Cancun, are: the World Bank **Climate Investment Funds**, the **Global Environmental Facility** (GEF), the **Adaptation Fund,** and national initiatives such as the UK Green Investment Bank

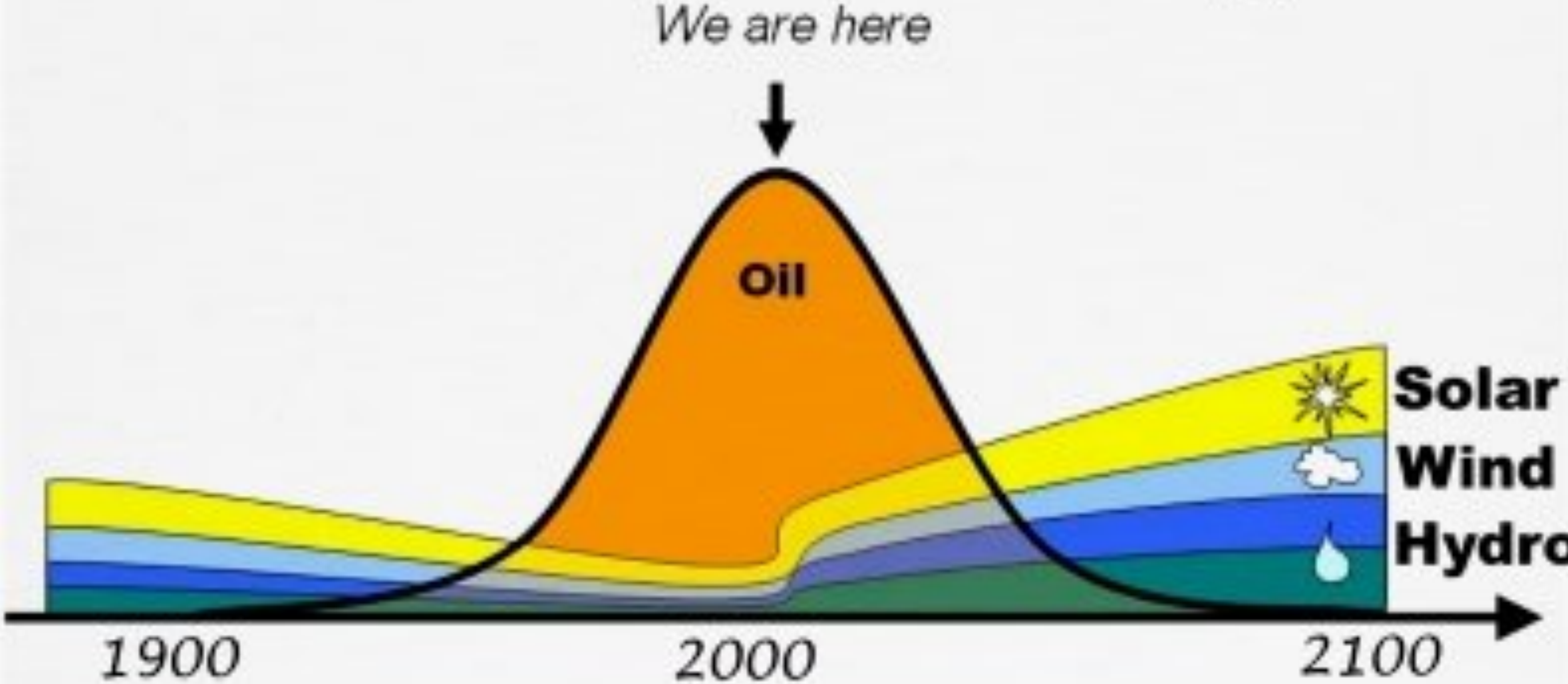
  ➔ Need to enhance **private-public partnership, bilateral and multilateral flows** to support the carbon market

Our daily answers: consumption and investment choices

- Solar showers, sustainable mobility and consumption choices – accounting for the 'grey energy' used throughout the full product life-cycle – waste management, water and energy saving => consume less and better!!

- Low-emissions housing and transports, sustainable use of the soil => more efficient and environmentally effective investment choices!

Get ready



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Useful references

- IPCC web site: http://www.ipcc.ch/

  Have a look at the Summary for Policy Makers and Press Releases of the 5AR

- EU ETS web site: http://ec.europa.eu/clima/policies/ets/index_en.htm

- UNFCCC web site: https://unfccc.int/2860.php

  Have a look at the 'essential background'