Introduction -- Science, Economics, & Policy

Recorded Session #1

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Climate Change Policy: Economics and Politics
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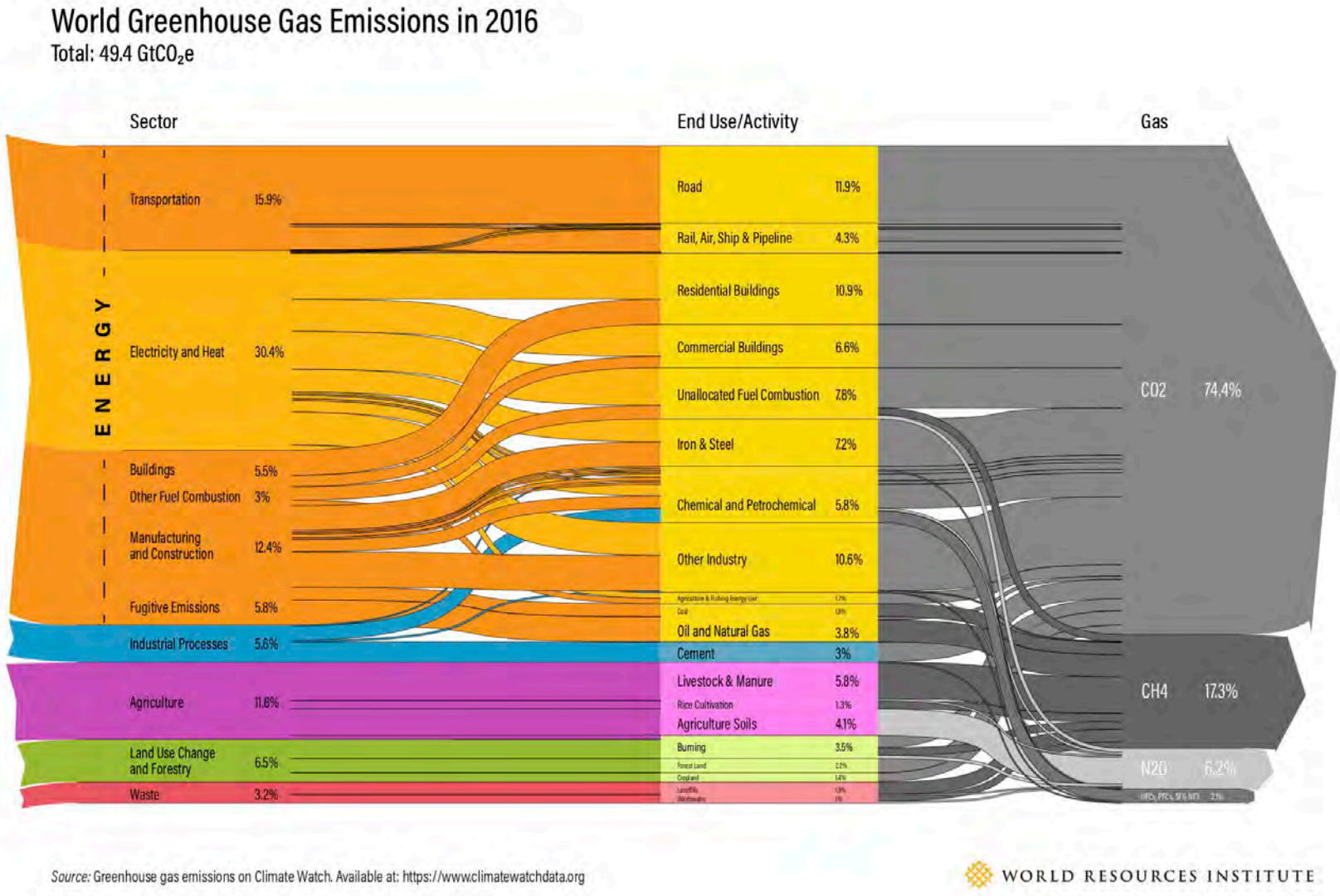
Essential Science of Global Climate Change

The Greenhouse Effect: water vapor, CO_2, *methane*, nitrous oxide, CFCs

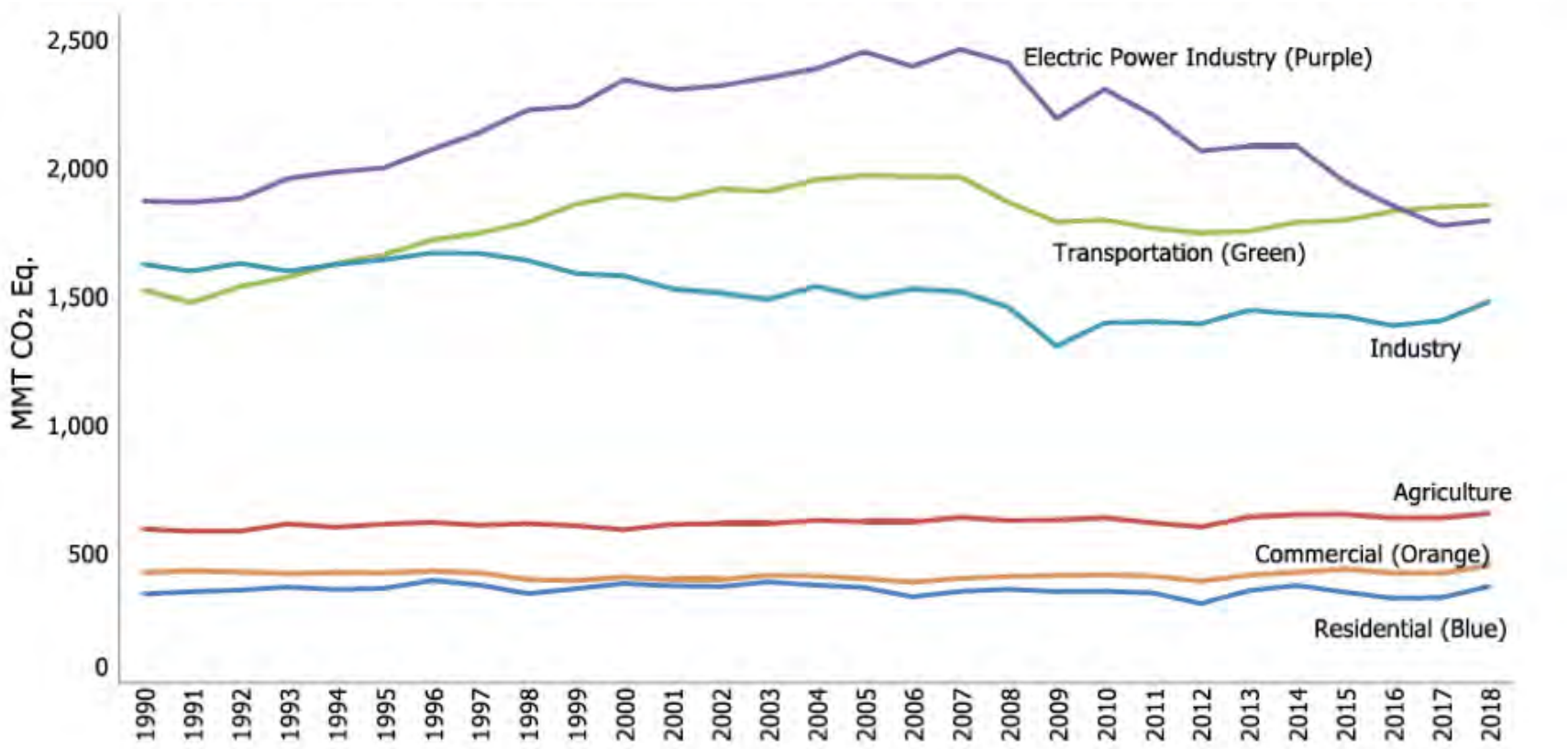
- **Emissions**
  - Energy generation (coal, petroleum, natural gas) → CO_2
  - Other industrial, commercial, & residential CO_2
  - Transportation CO_2
  - Deforestation CO_2
  - *Methane*, nitrous oxide, CFCs
- **Sequestration**
  - Biological carbon sequestration (land-use changes)
  - Carbon capture and storage (later)
- **Scientific Uncertainty?**
  - Impact of increased concentrations on global mean temperatures
  - Impacts on regional weather patterns

Sectors and End Uses/Activities Leading to Greenhouse Gas Emissions



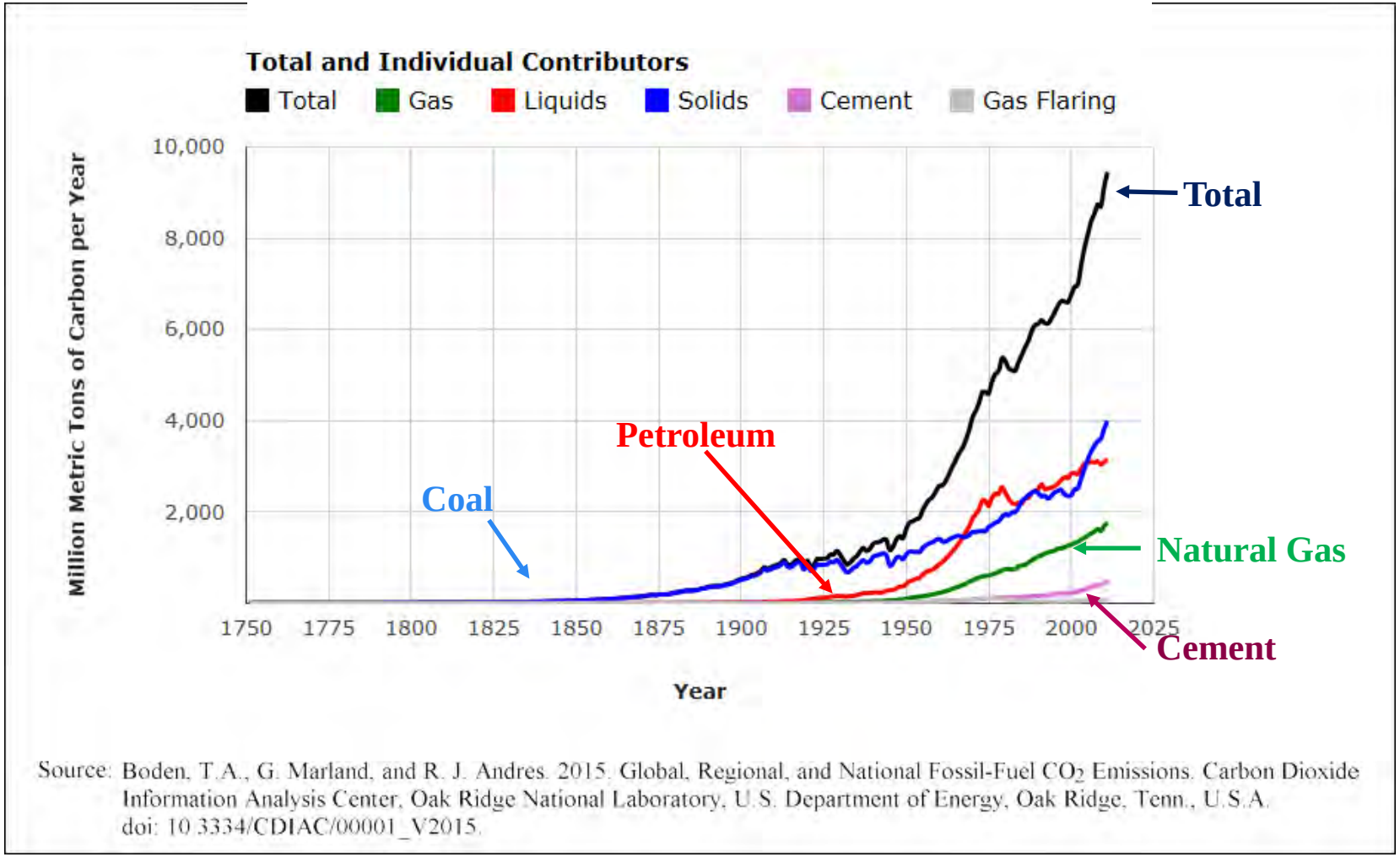
Note: exhibits 100-year global warming potential)

U.S. Greenhouse Gas Emissions from Economic Sectors



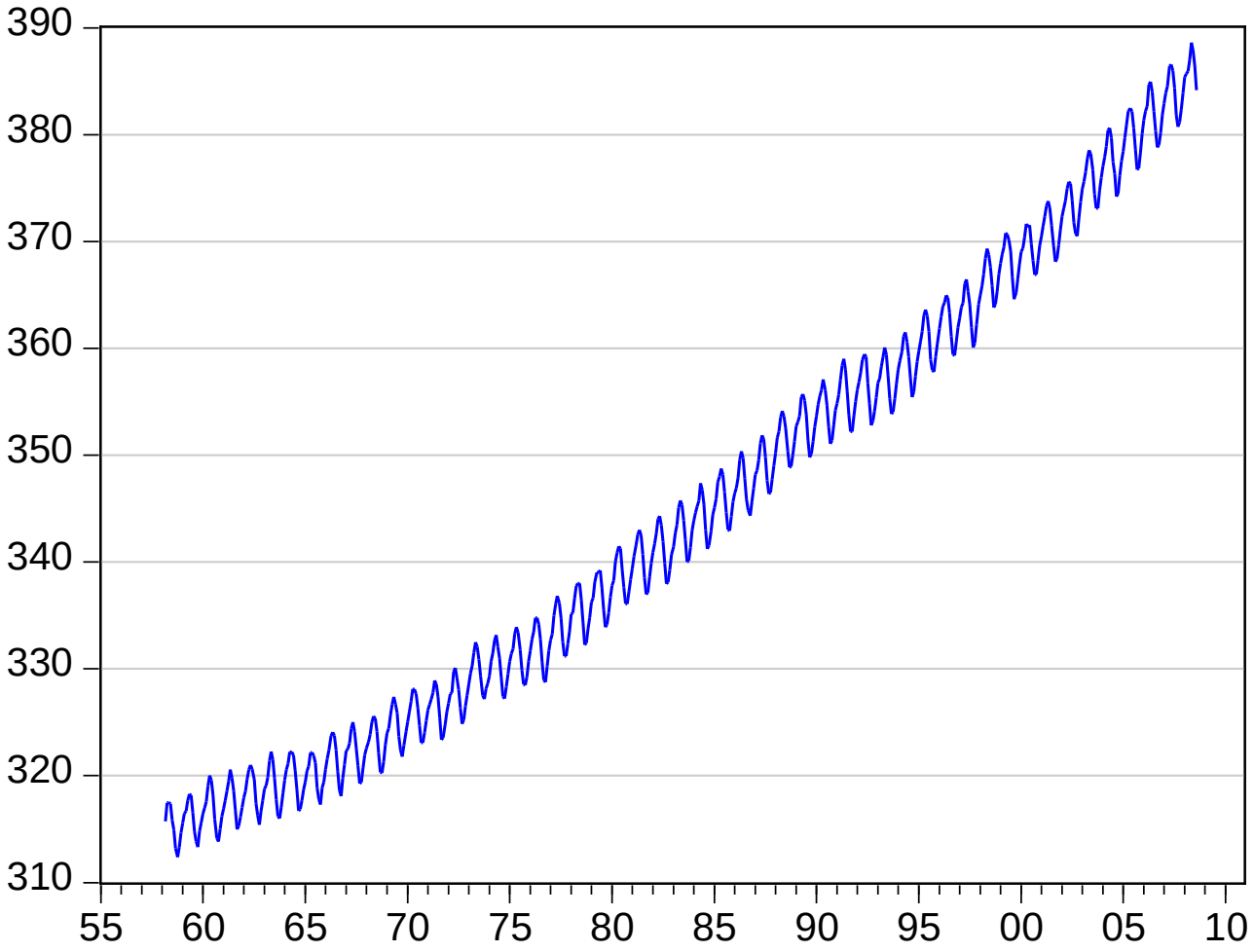
Source: US GHG Inventory of Greenhouse Gas Emissions and Sinks

Annual World CO_2 Emissions, 1750-2010, from Coal, Petroleum, Natural Gas, and Cement Production

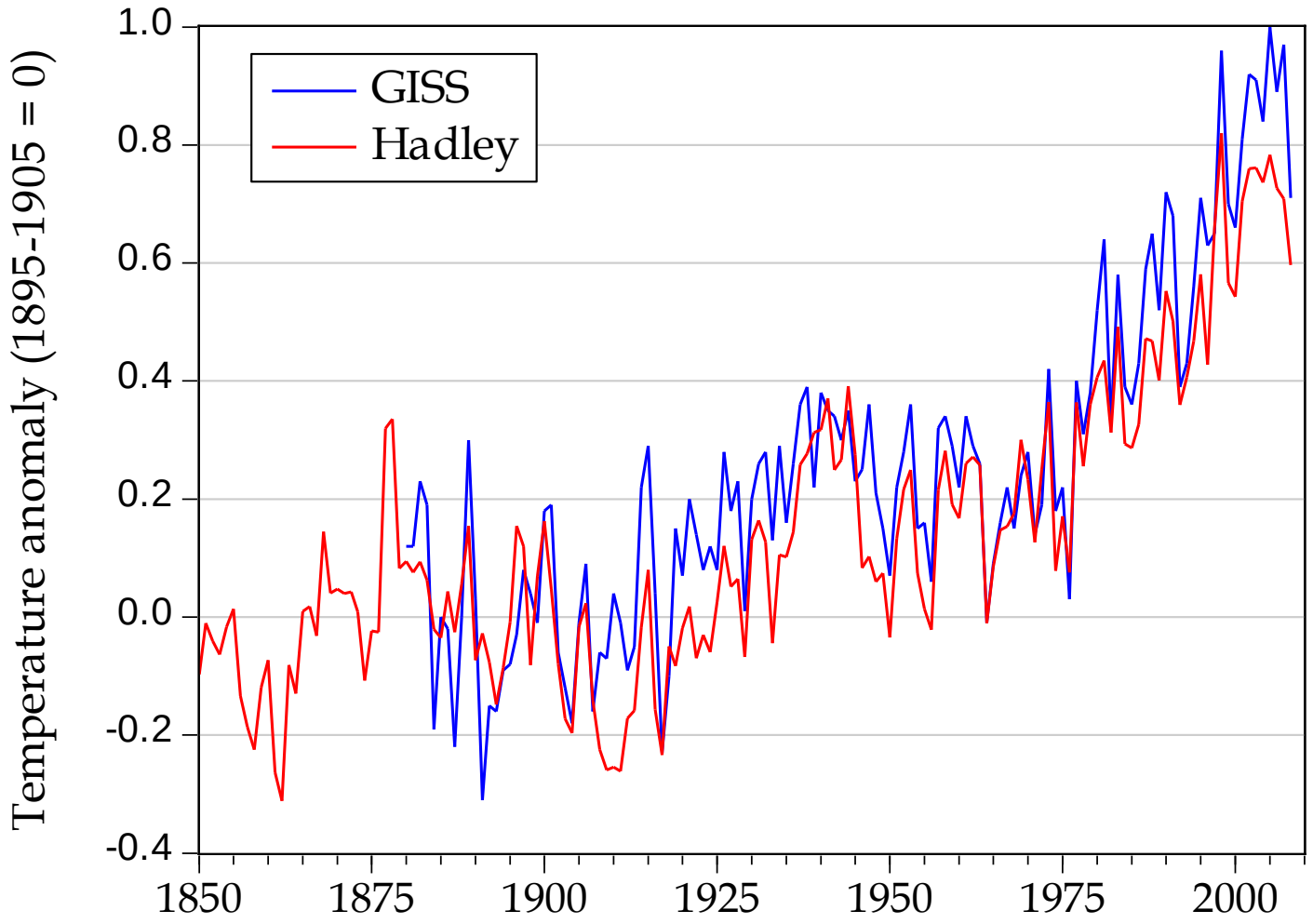


Source: Boden, T.A., G. Marland, and R. J. Andres. 2015. Global, Regional, and National Fossil-Fuel CO_2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi: 10.3334/CDIAC/00001_V2015.

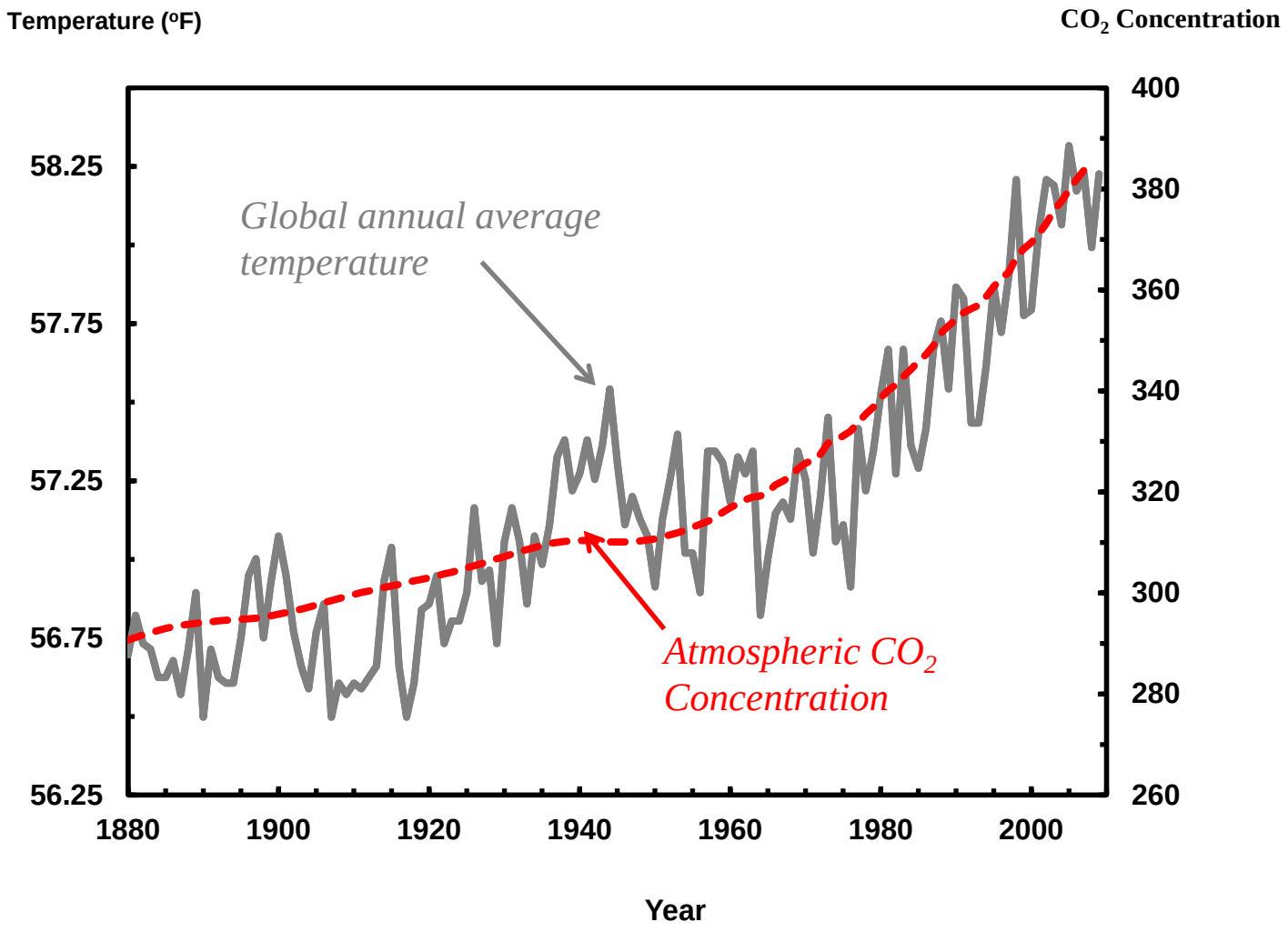
CO_2 Concentrations at Mauna Loa, Hawaii, 1957-2008



Temperature Records, 1850-2008



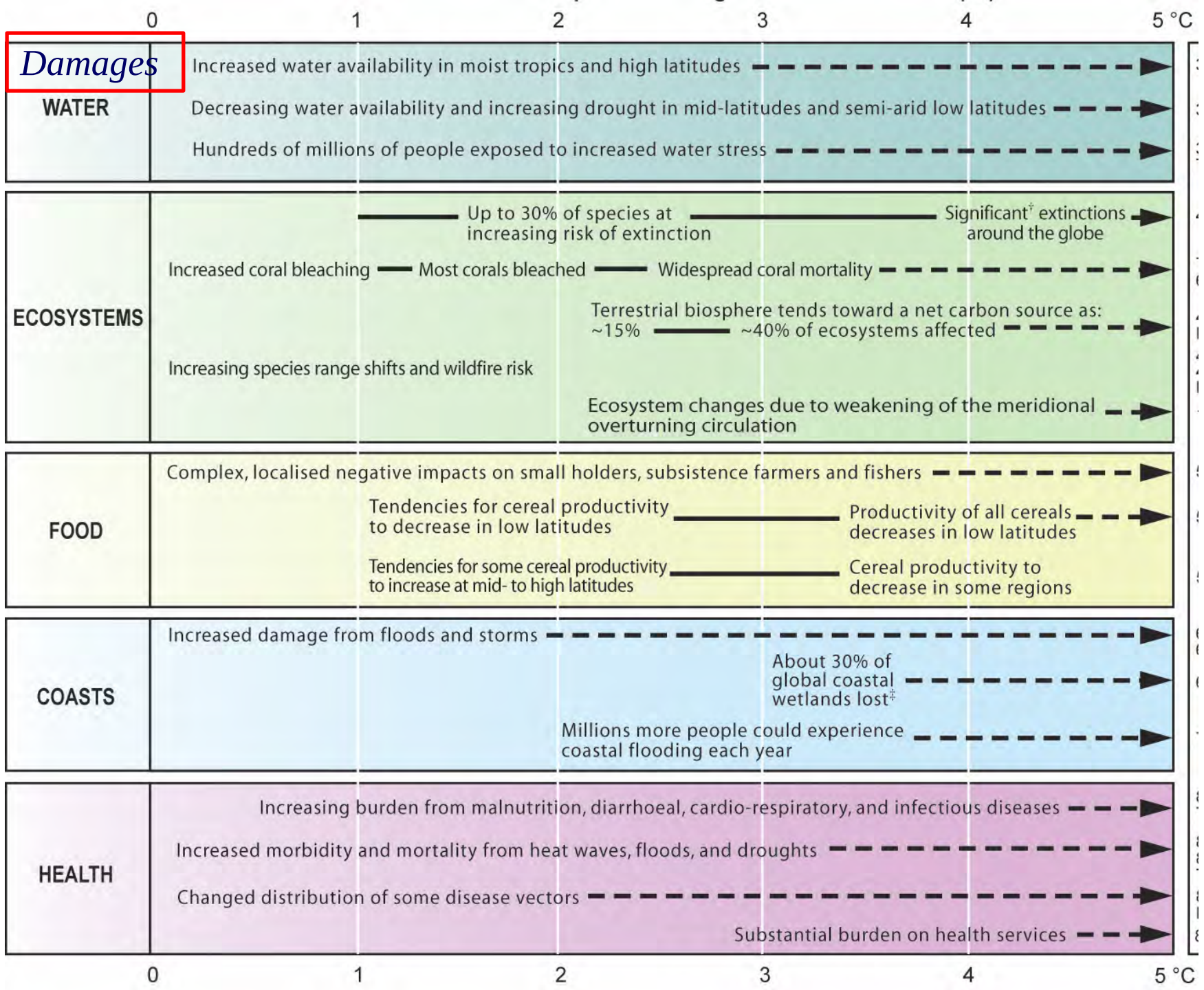
Global Temperature and Carbon Dioxide Concentrations 1880–2010

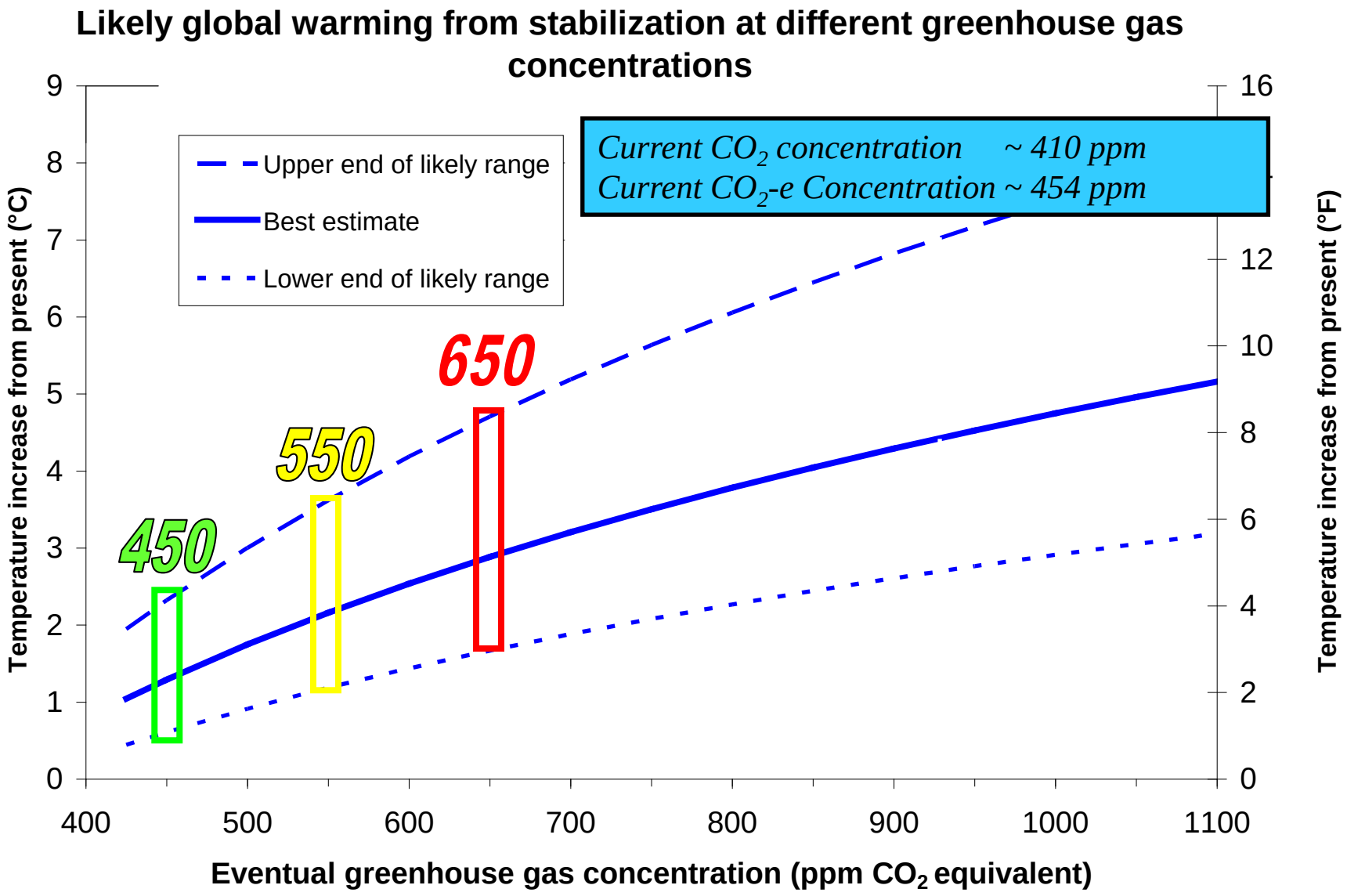


Impacts

- *Agriculture! (Temperature & Precipitation)*
- *Both Positives & Negatives*
- *Developing Countries:*
  - *agriculture*
  - *tropics*
  - *poor*

Source: Scientific American


0
1
2
3
4
5 °C
Damages
WATER
Increased water availability in moist tropics and high latitudes
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes
Hundreds of millions of people exposed to increased water stress
ECOSYSTEMS
Up to 30% of species at increasing risk of extinction
Significant‡ extinctions around the globe
Increased coral bleaching
Most corals bleached
Widespread coral mortality
Terrestrial biosphere tends toward a net carbon source as:
~15%
~40% of ecosystems affected
Increasing species range shifts and wildfire risk
Ecosystem changes due to weakening of the meridional overturning circulation
FOOD
Complex, localised negative impacts on small holders, subsistence farmers and fishers
Tendencies for cereal productivity to decrease in low latitudes
Productivity of all cereals decreases in low latitudes
Tendencies for some cereal productivity to increase at mid- to high latitudes
Cereal productivity to decrease in some regions
COASTS
Increased damage from floods and storms
About 30% of global coastal wetlands lost‡
Millions more people could experience coastal flooding each year
HEALTH
Increasing burden from malnutrition, diarrhoeal, cardio-respiratory, and infectious diseases
Increased morbidity and mortality from heat waves, floods, and droughts
Changed distribution of some disease vectors
Substantial burden on health services
0
1
2
3
4
5 °C



Note: "Likely" is defined as greater than a 66% probability of occurrence. Source: IPCC Fourth Assessment Report.


0
1
4
5 °C
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COASTS
Increased damage from floods and storms
450
550
About 30% of global coastal wetlands lost‡
650
Millions more people could experience coastal flooding each year
HEALTH
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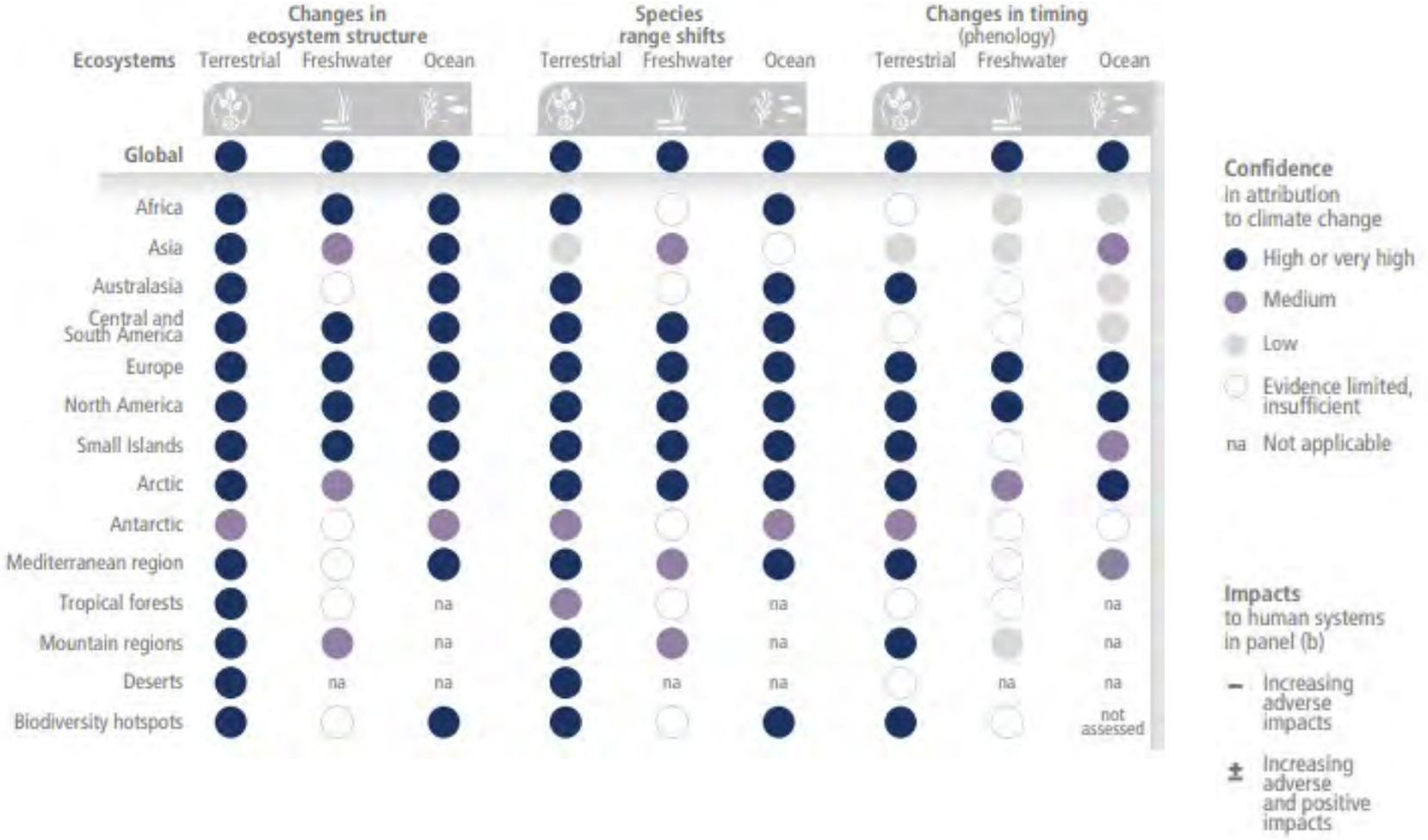
0
1
4
5 °C

Global Climate Change Impacts: Ecosystems

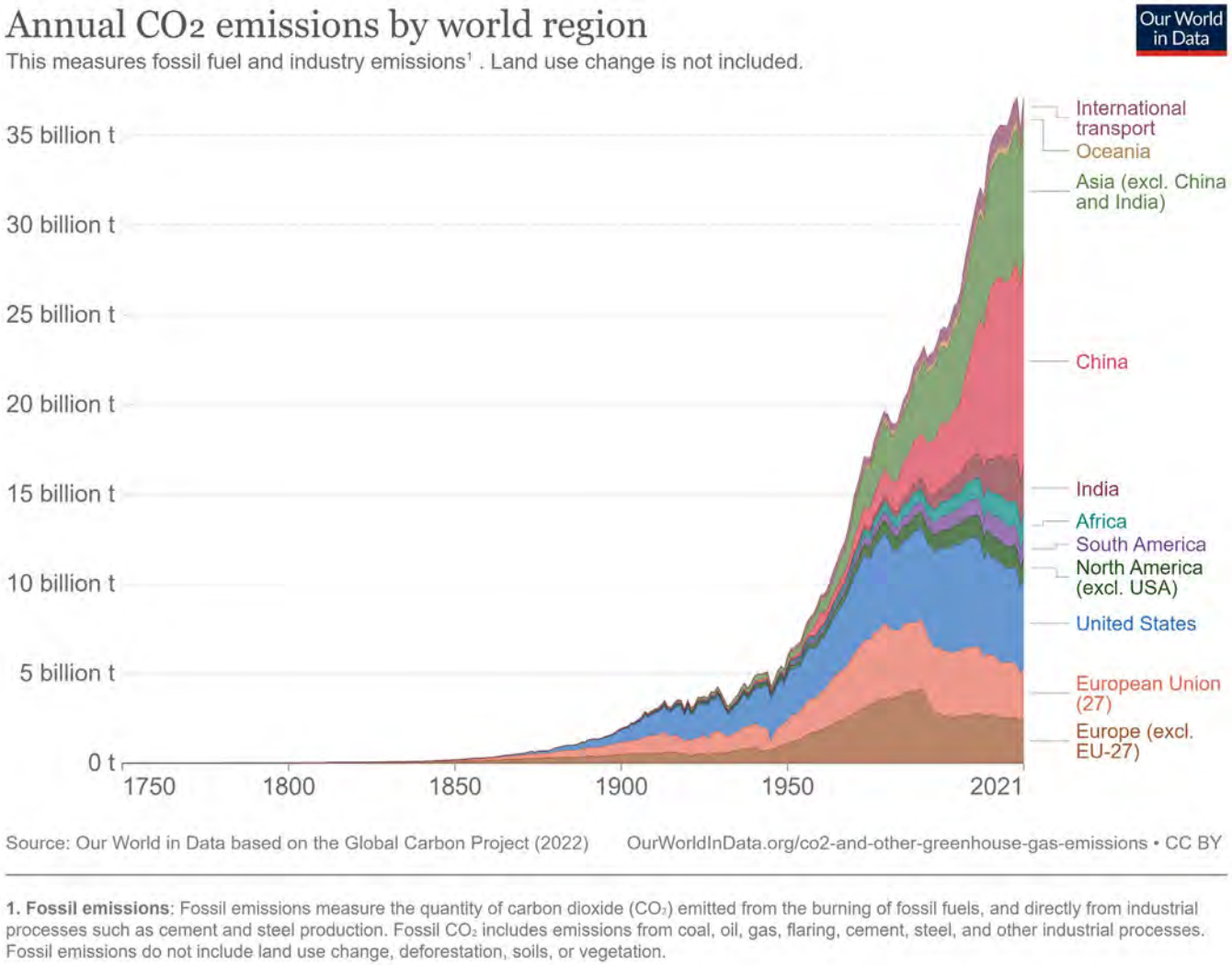


Source: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Global Climate Change Impacts: Human Systems

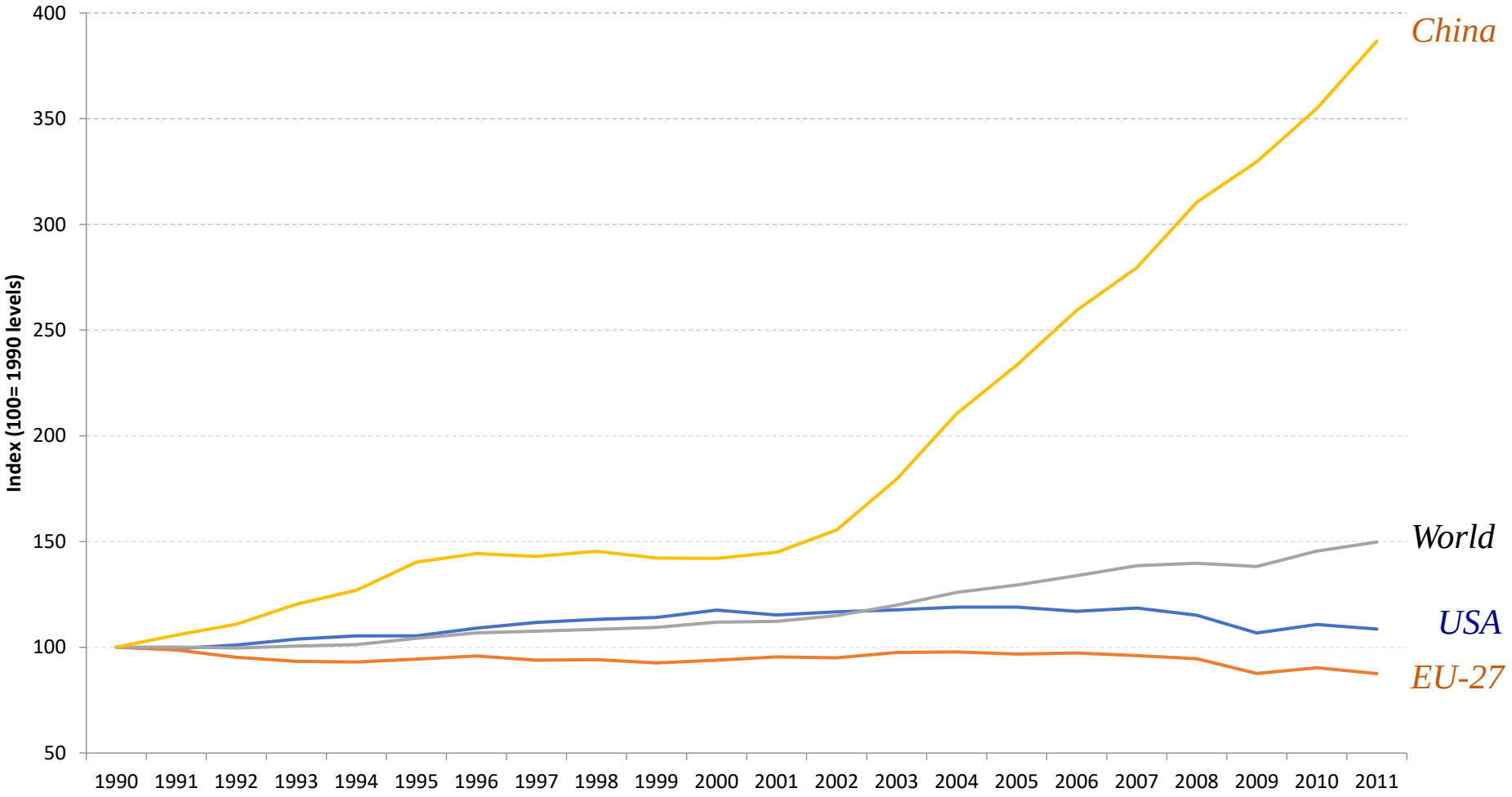
Source: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

Annual CO_2 Emissions by Region

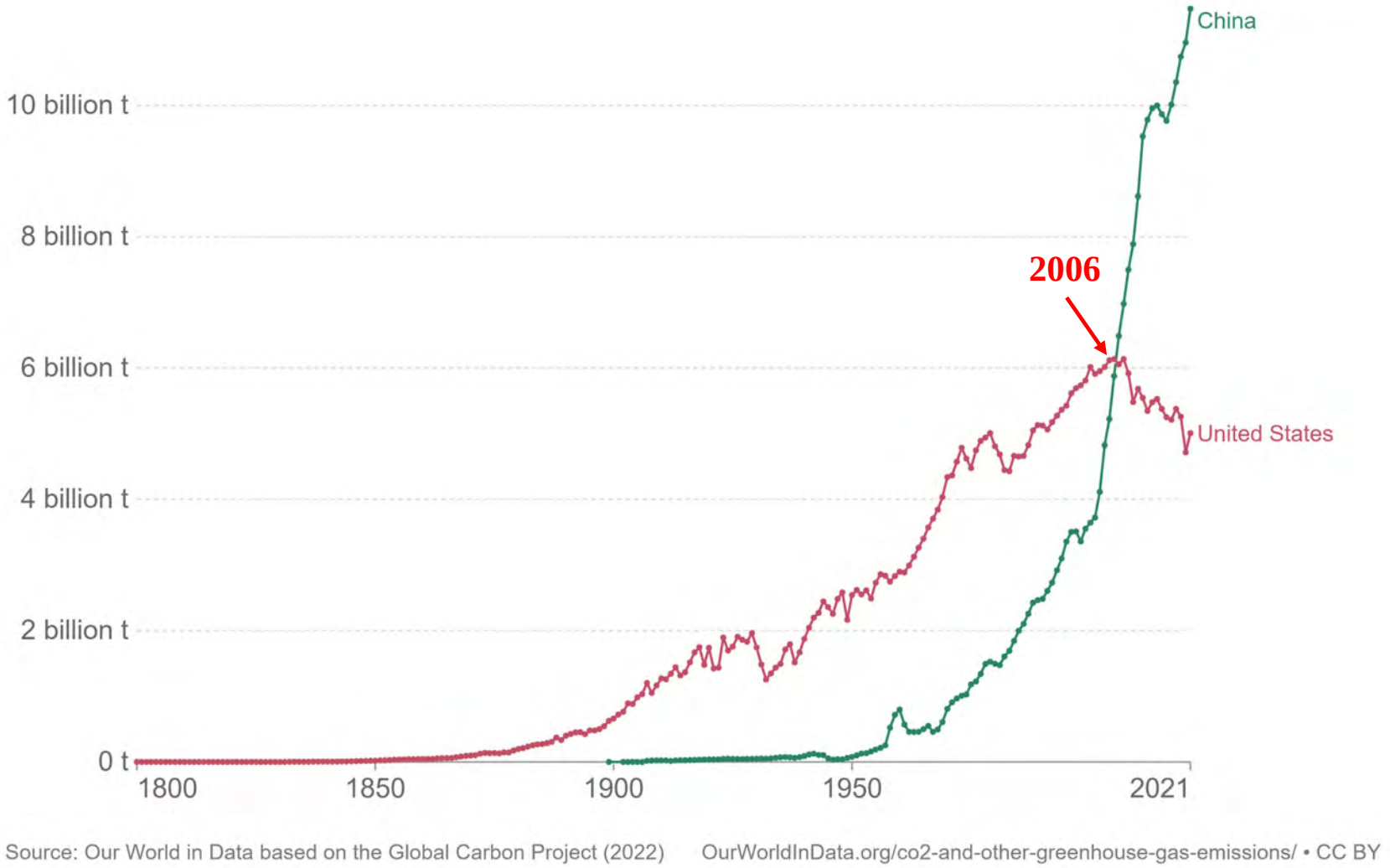


1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Percentage Change in CO_2 Emissions: USA, China, EU, & World

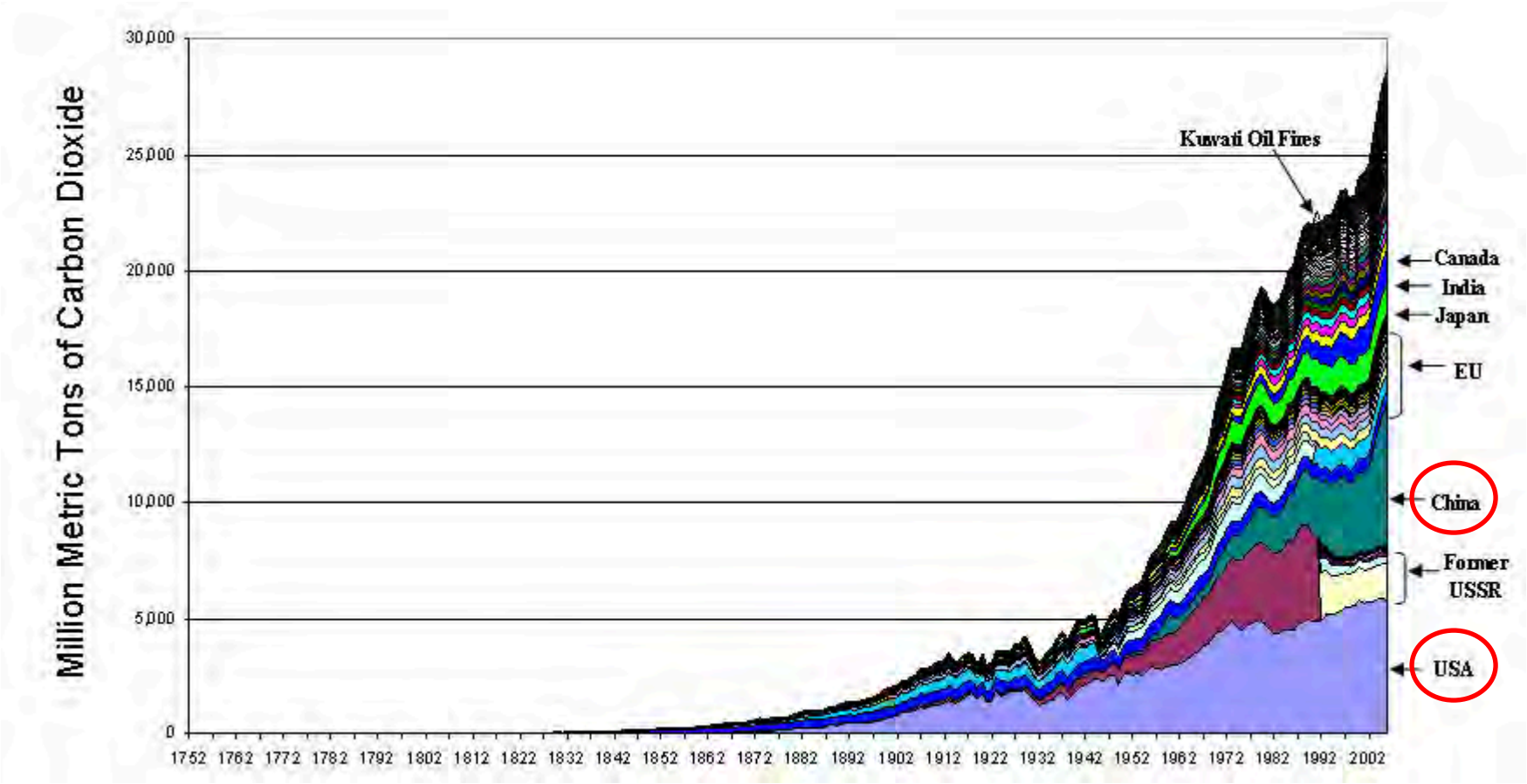


Energy-Related CO_2 Emissions, China & US, 1990-2021

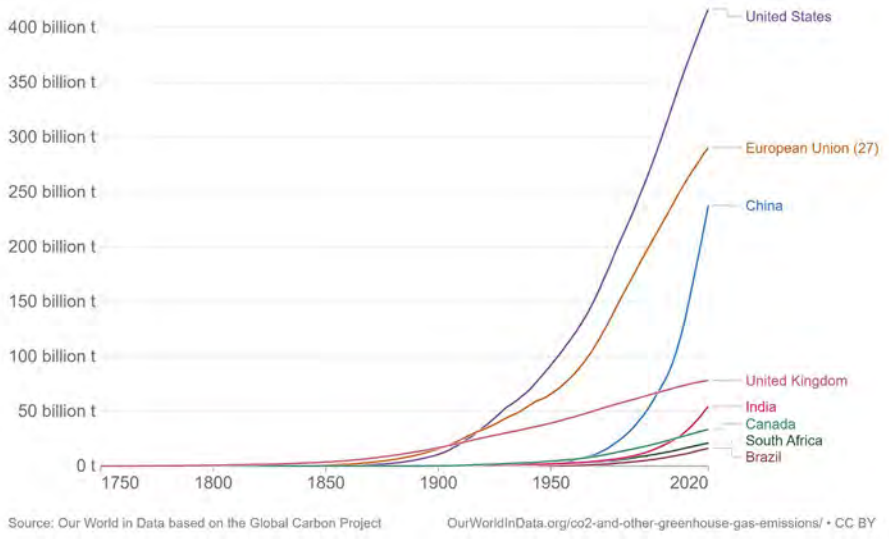


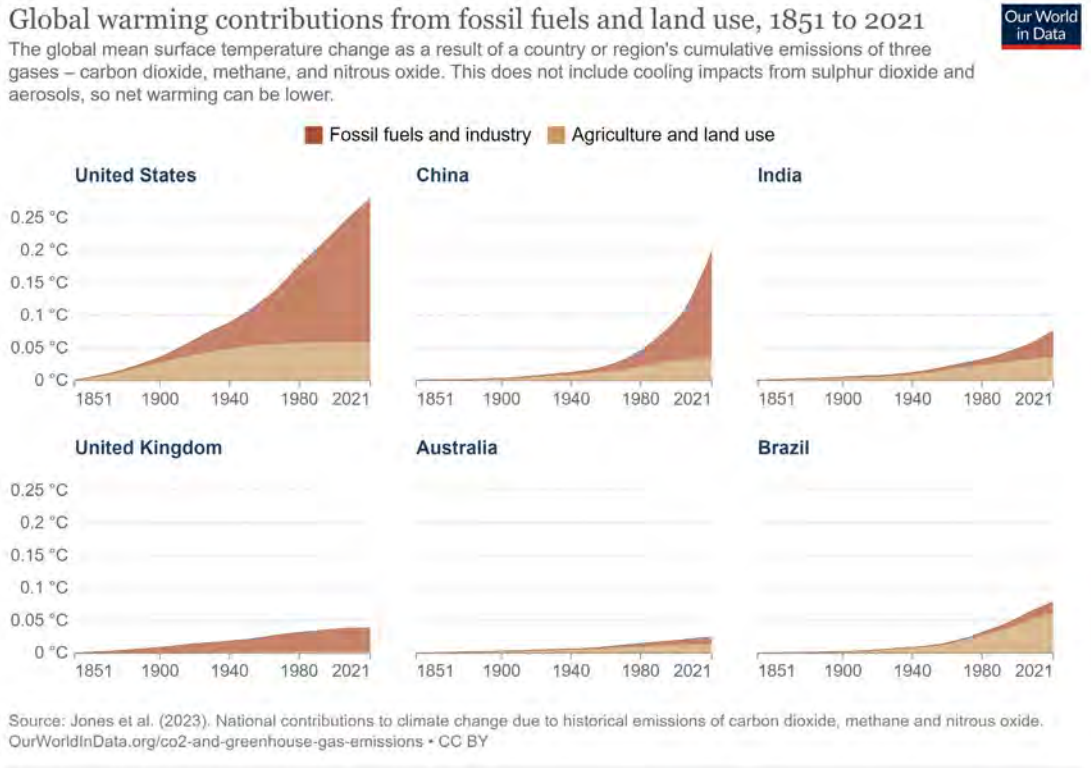
Cumulative CO_2 Emissions, 1752-2002

(Contributions to Atmospheric Stock → Damages)

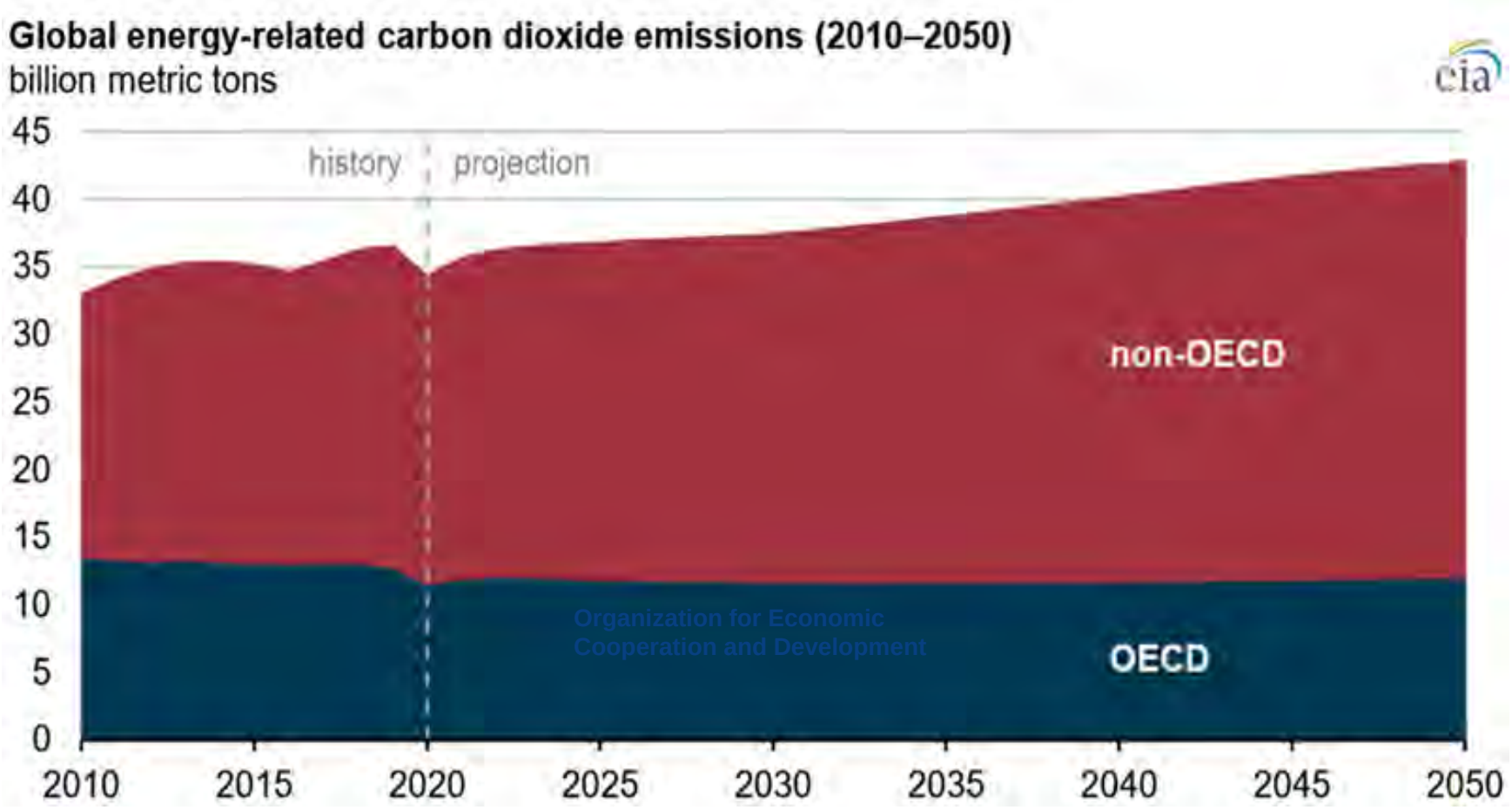


Cumulative CO_2 Emissions



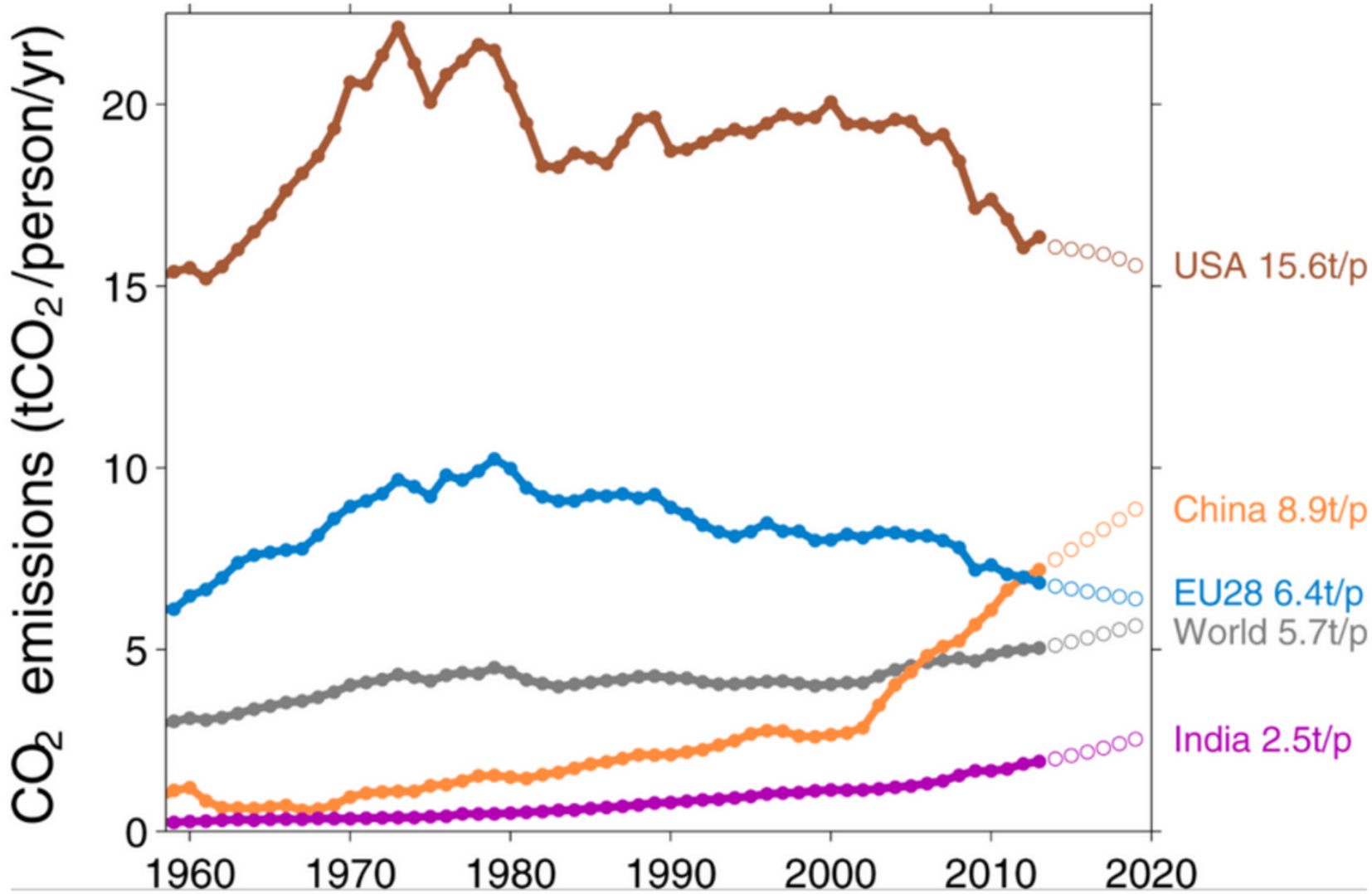


Predictions of Future Energy-Related CO_2 Emissions by Region

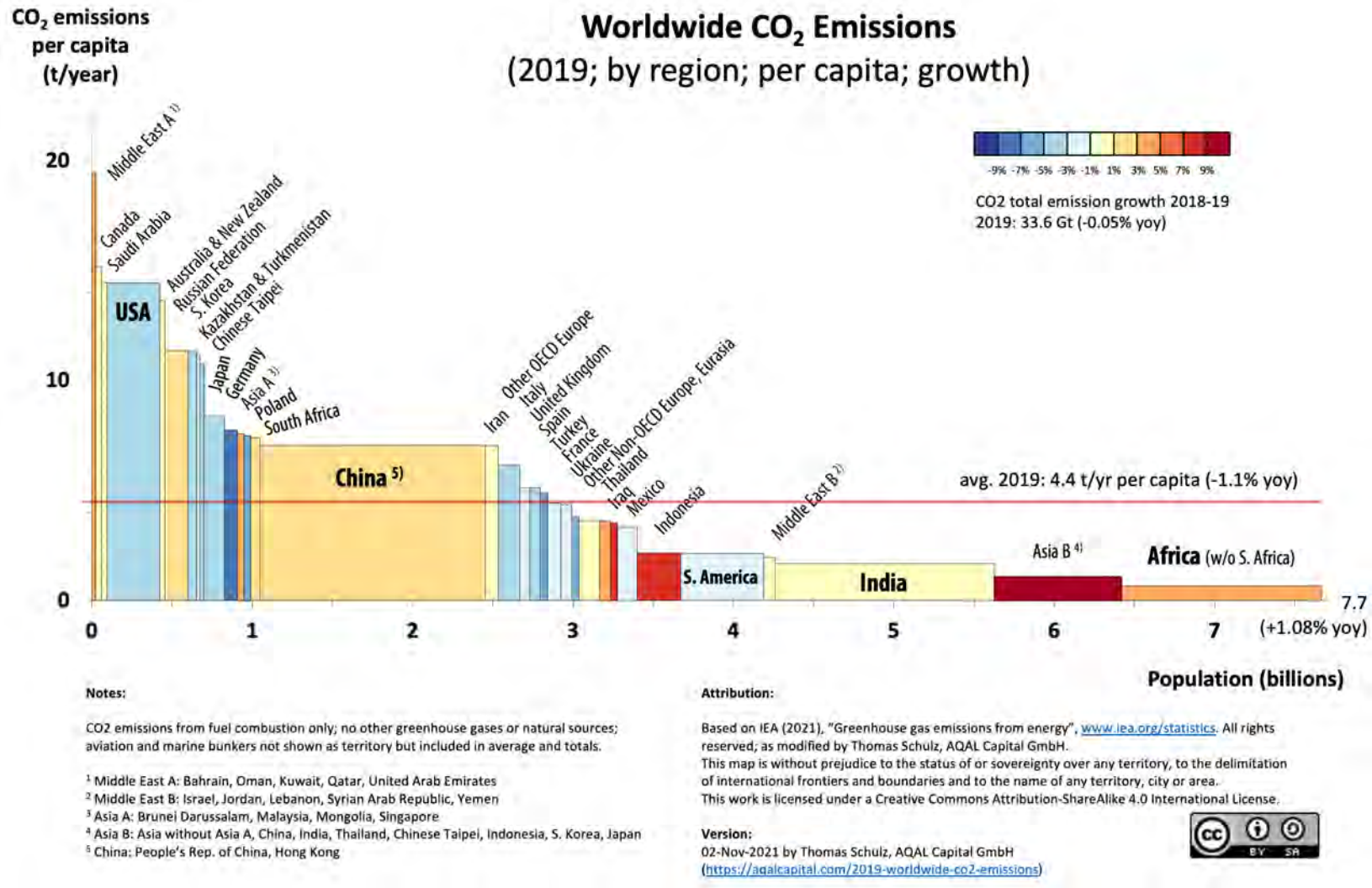


Source: U.S. Energy Information Administration, *International Energy Outlook 2021*, Reference case, October 2021
Note: OECD is Organization for Economic Cooperation and Development.

CO_2 Emissions per Capita Trends



CO_2 Emissions per Capita, 2019



Notes:

CO2 emissions from fuel combustion only; no other greenhouse gases or natural sources; aviation and marine bunkers not shown as territory but included in average and totals.

[1] Middle East A: Bahrain, Oman, Kuwait, Qatar, United Arab Emirates
[2] Middle East B: Israel, Jordan, Lebanon, Syrian Arab Republic, Yemen
[3] Asia A: Brunei Darussalam, Malaysia, Mongolia, Singapore
[4] Asia B: Asia without Asia A, China, India, Thailand, Chinese Taipei, Indonesia, S. Korea, Japan
[5] China: People's Rep. of China, Hong Kong

Attribution:

Based on IEA (2021), "Greenhouse gas emissions from energy", www.iea.org/statistics. All rights reserved; as modified by Thomas Schulz, AQAL Capital GmbH.
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.
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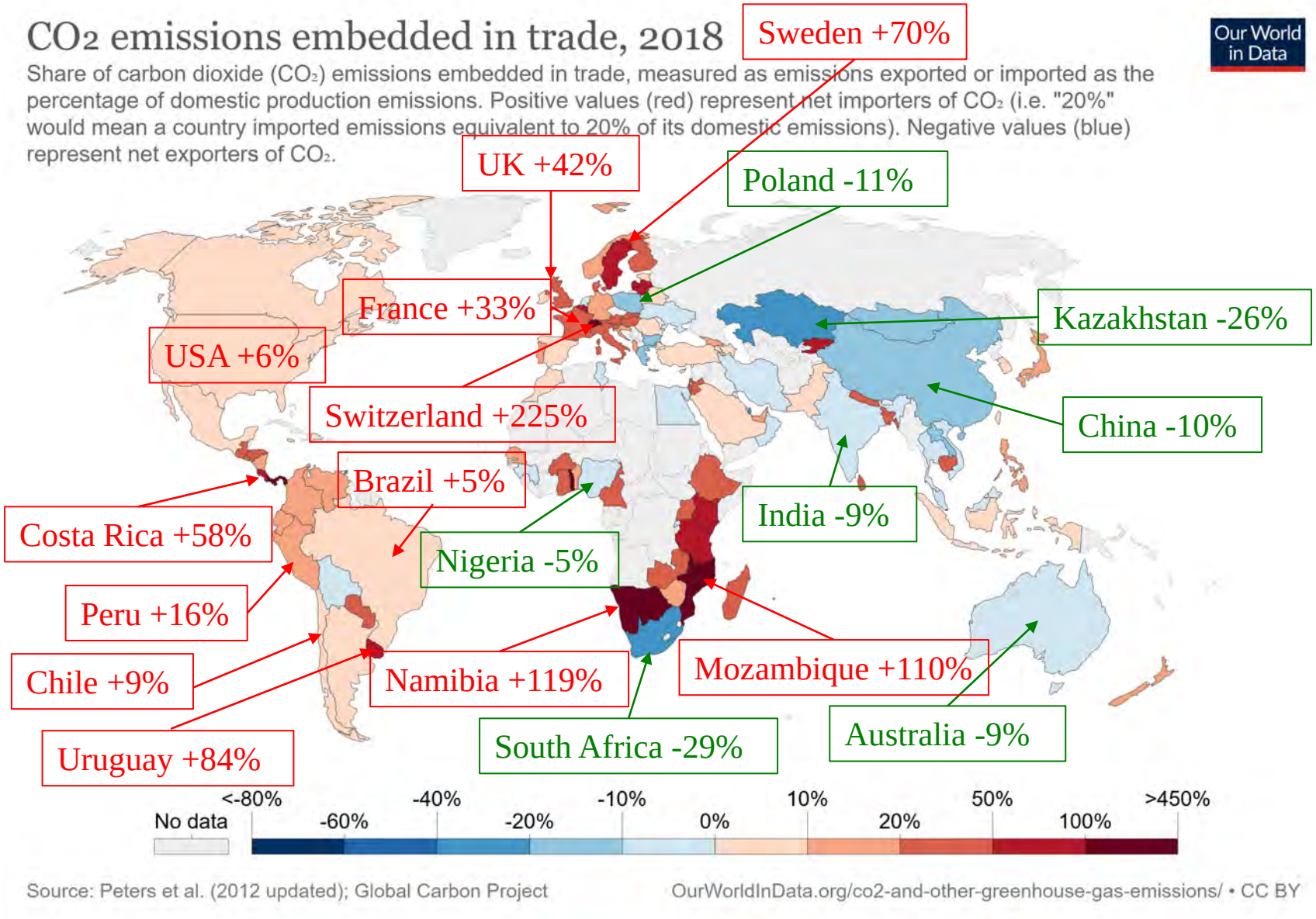
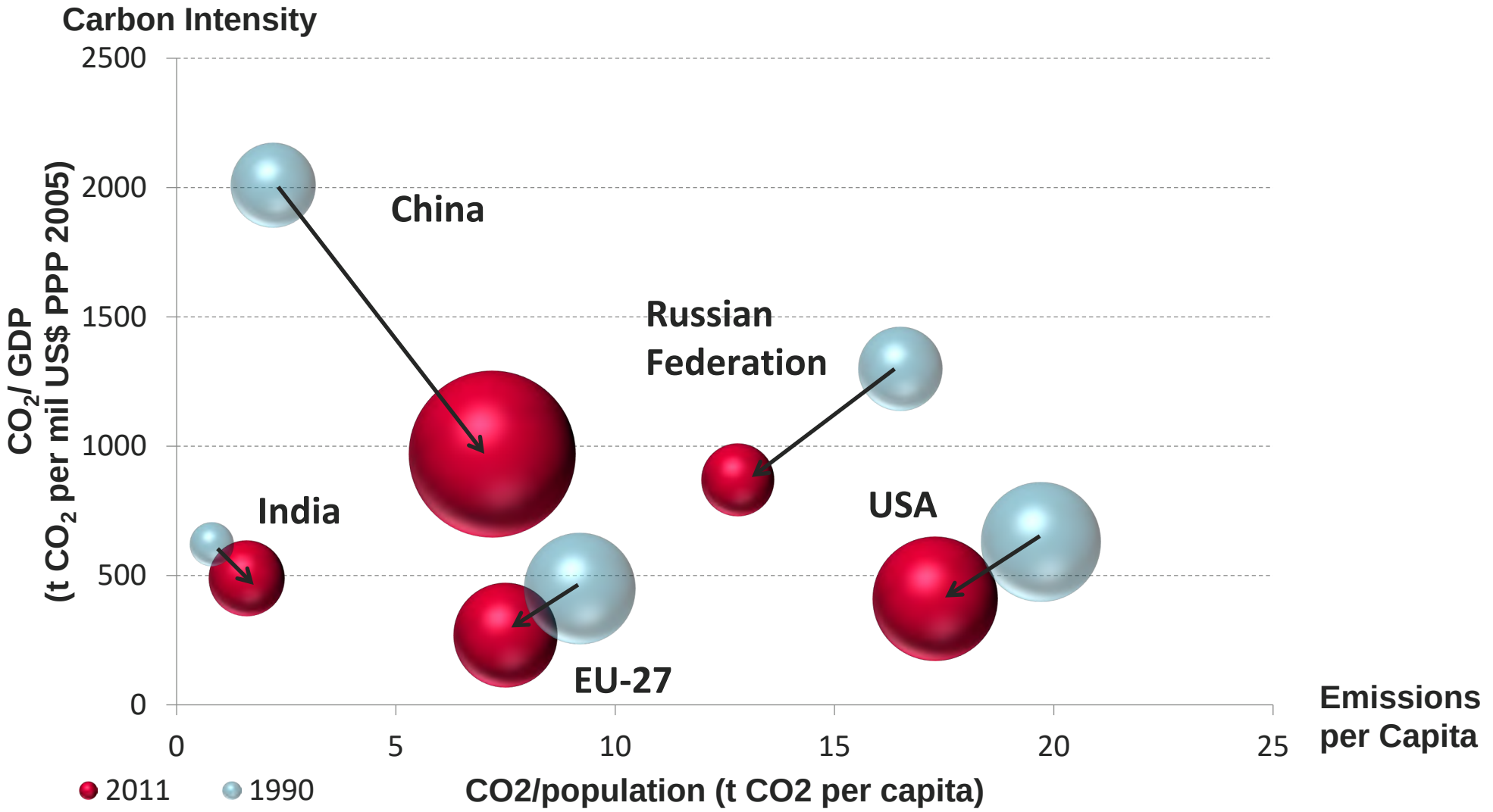
Version:
02-Nov-2021 by Thomas Schulz, AQAL Capital GmbH
(https://aqalcapital.com/2019-worldwide-co2-emissions)

What About Consumption-Based Emissions Accounting?



CO_2 Emission Intensity and Per Capita Trends for Top Five Emitters



Size of circle represents CO2 emissions in given year.

Options to Address Global Climate Change

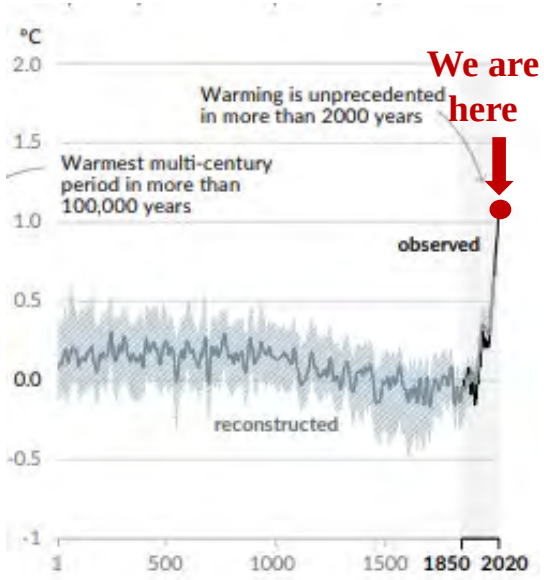
- **Reduce Net Emissions of CO_2 (& Other Greenhouse Gases – GHGs)**
  - Switch fuels: coal, petroleum, natural gas, nuclear, renewables
  - Change industrial production processes (example: cement production)
  - Carbon capture & storage (CCS) at point of electricity generation
  - Reduce energy demand
  - Increase efficiency of energy generation
  - Reduce rate of deforestation
  - Increase "natural" CO_2 removal through land-use changes (afforestation)

- **Geoengineering**
  - CO_2 removal (direct air capture, ocean fertilization, etc.)
  - Solar radiation management (deflect sunlight or increase reflectivity)

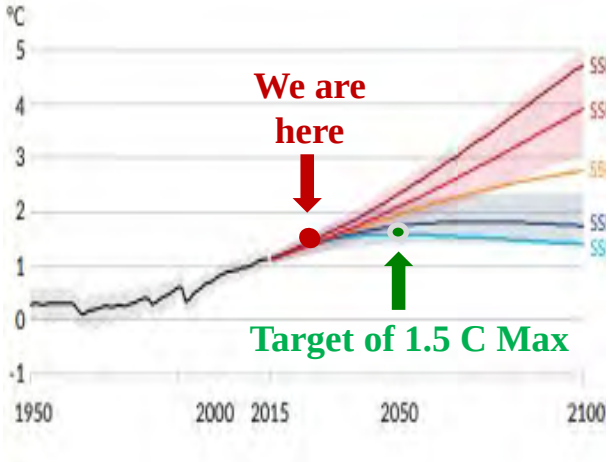
- **Adaptation**

Meaningful reduction of climate change risk may require progress towards "Net Zero" by mid-century

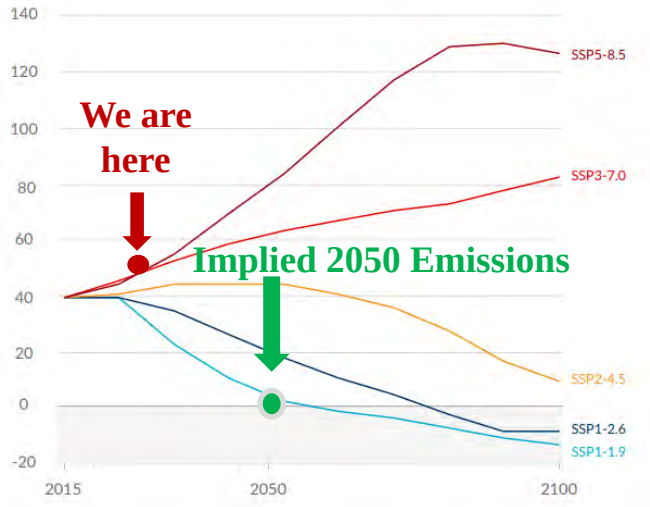
Change in Global Surface Temperature



Potential Future Global Temperature



Carbon Dioxide Emissions ($GtCO_2$/year)



Source: IPCC, 2021: Summary for Policymakers. In: "Climate Change 2021, The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Plan on Climate Change" From Box SPM.1.1 and Figure SPM.8.

Key Take-Aways

1. Climate change is a *global commons problem.*
2. Climate change is linked with atmospheric *stock* of accumulated emissions.
3. *Sources* of CO_2 & other GHG emissions are diverse.
4. *Damages* of climate change are diverse, but worst in *poor countries*.
5. *Key approaches* to addressing climate change: reduce net emissions; geoengineering; and adaptation.
6. *Emissions flat to declining* in most OECD countries.
7. *Emissions increasing* in large emerging economies.
8. *Great differences* among countries in per capita emissions.
9. *Great differences* among countries in emissions intensity (CO_2/GDP)