Towards Carbon Neutrality:

Insights from the Australian Perspective and Opportunities for Regional Cooperation

APEC FORESIGHT WORKSHOP:

Identification of Emerging Signals Affecting Carbon Neutrality Using Foresight

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THE UNIVERSITY OF SYDNEY

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CONTENTS

- INTODUCTION
- AUSTRALIA AND APEC
- EVOLUTION OF CLIMATE SCIENCE
- ENTROPY LAW AND ECONOMICS OF EXTERNALITIES
- AUSTRALIA-APEC REGIONAL COOPERATIONS
- CONCLUDING REMARKS

INTRODUCTION

Carbon Neutrality Matters for APEC

- APEC = 21 economies, ≈ 60% of global GDP, ≈ 40% of global Population, ≈ 50% of global CO_2 emissions.
- Shared 2050 net-zero vision endorsed at APEC Leaders' Declaration (2023).
- Energy transition and low-carbon innovation are core pillars of cooperation.
- Wide diversity: resource exporters (Australia, Indonesia), tech leaders (Japan, Korea), emerging economies (Vietnam, Philippines).

INTRODUCTION

Australia's Climate Policies:

- Net zero by 2050; 43% reduction by 2030 from 2005 levels (Climate Change Act 2022).
- Safeguard Mechanism caps emissions for >200 large facilities (DCCEEW 2023).
- National Hydrogen Mission with export corridors to Japan & Korea (ARENA 2023).
- Australian Carbon Credit Units (ACCU) scheme reform (Chubb Review 2023).
- Rewiring the Nation: $20B grid modernization for renewables (Treasury 2024).

INTRODUCTION

Key Objectives

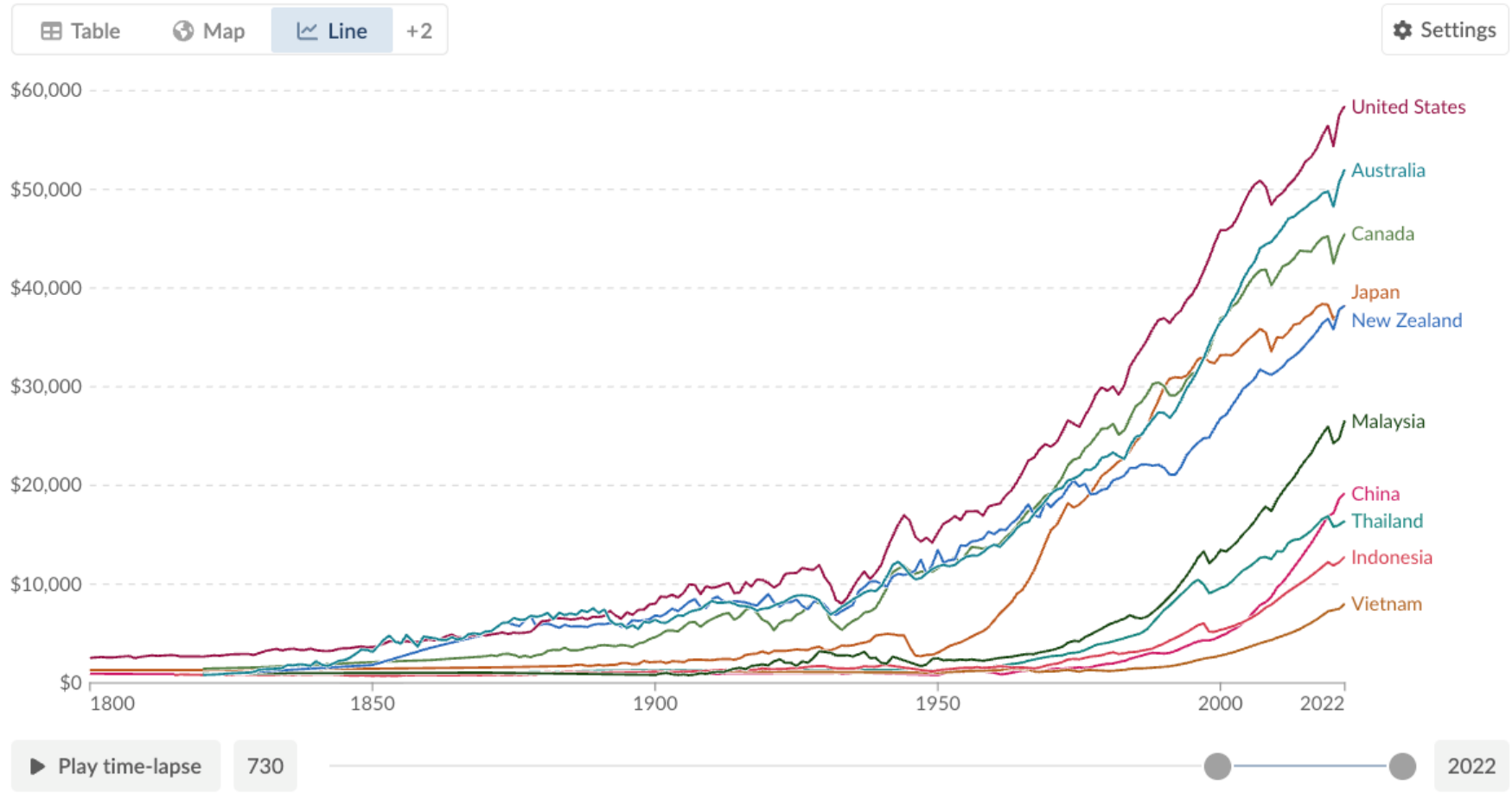
- Explaining the root cause of the climate problems
- Understanding the evolution of the Climate debate
- Developing a better conceptual framework
- Aiming to address ongoing risks and challenges

AUSTRALIA AND APEC

GDP per capita, 1800 to 2022

Our World in Data

GDP per capita is a country's gross domestic product divided by its population. This data is adjusted for inflation and differences in living costs between countries.



Data source: Bolt and van Zanden – Maddison Project Database 2023 – Learn more about this data

Note: This data is expressed in international-$ at 2011 prices.

OurWorldinData.org/economic-growth | CC BY

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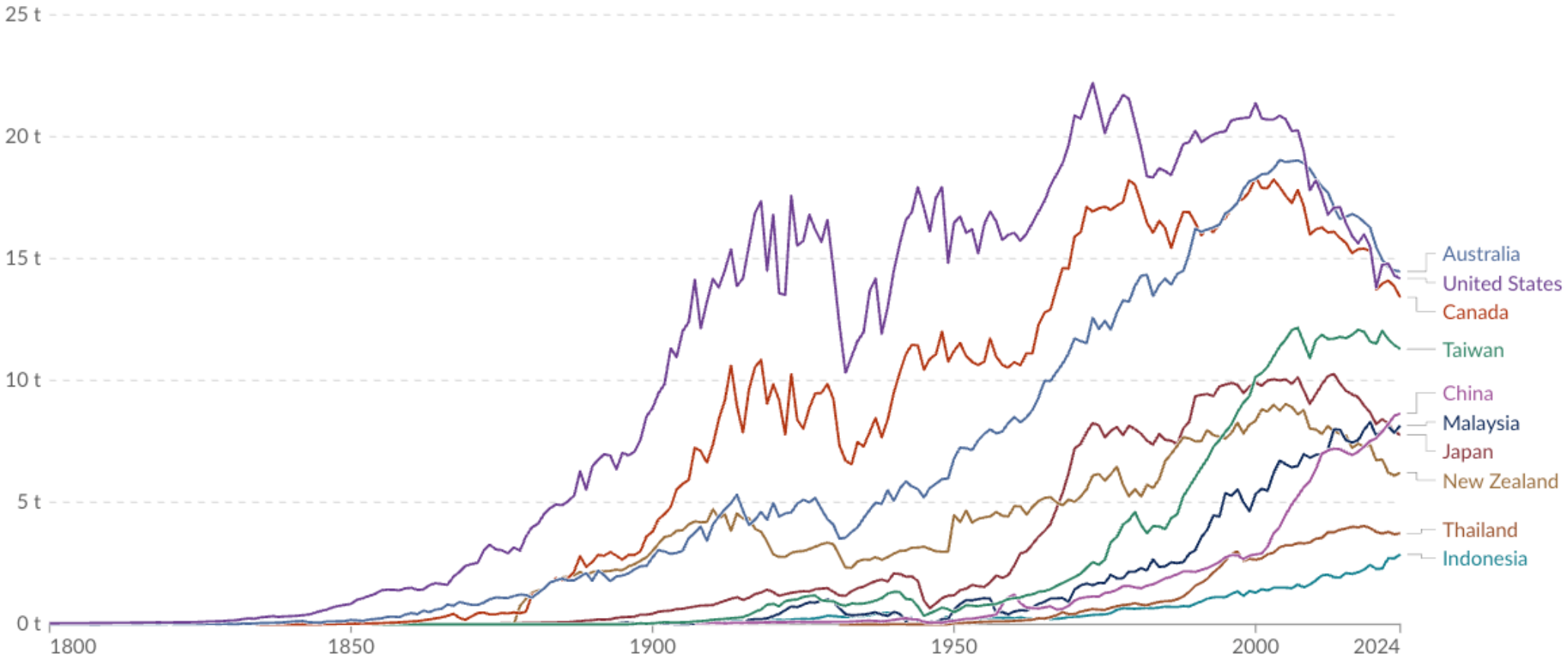
CO_2 emissions per capita

Carbon dioxide (CO_2) emissions from burning fossil fuels and industrial processes. This includes emissions from transport, electricity generation, and heating, but not land-use change.

Our World in Data

Table | Map | Line | +2 | Settings



▶ Play time-lapse 1750 2024

Data source: Global Carbon Budget (2025); Population based on various sources (2024) – Learn more about this data

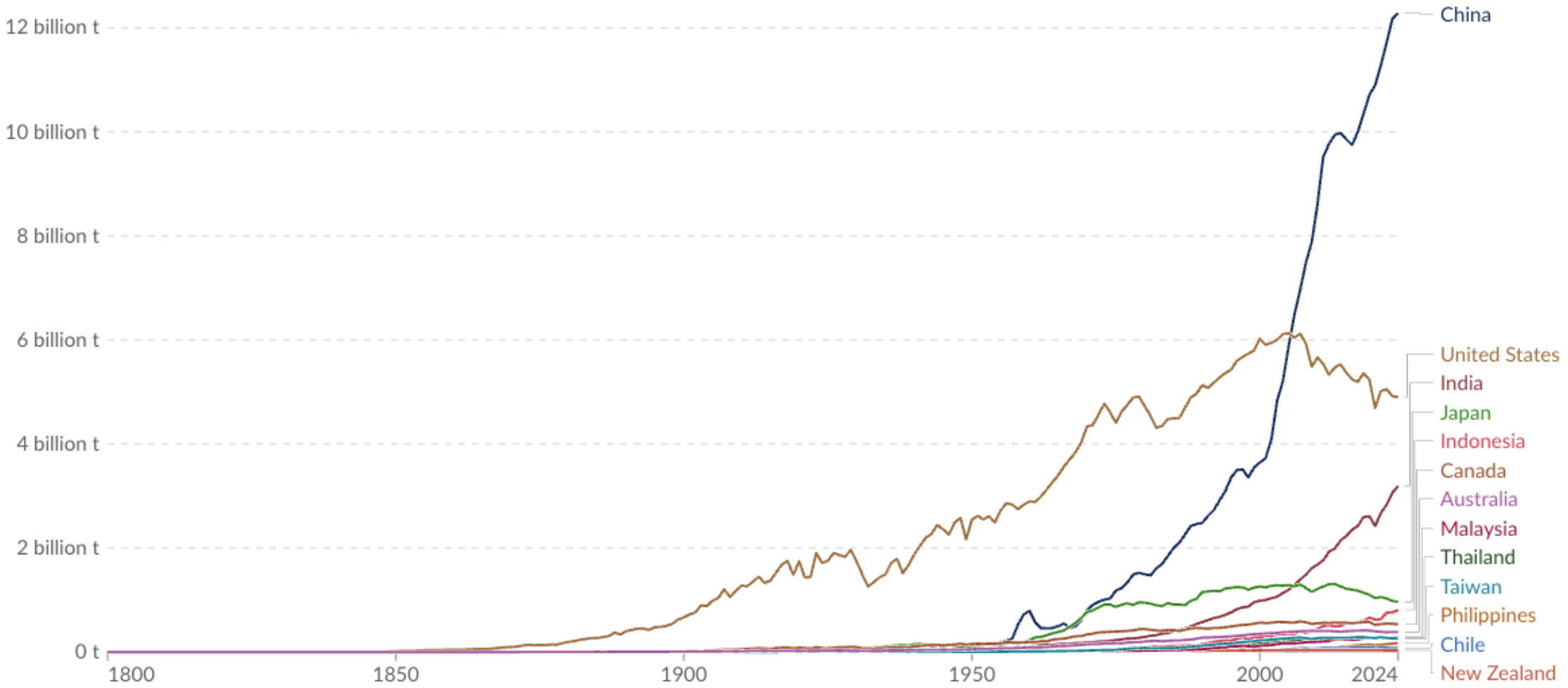
Annual CO_2 emissions

Carbon dioxide (CO_2) emissions from fossil fuels and industry. Land-use change emissions are not included.

Our World in Data

Table | Map | Line | Bar

Settings



Play time-lapse 1750 2024

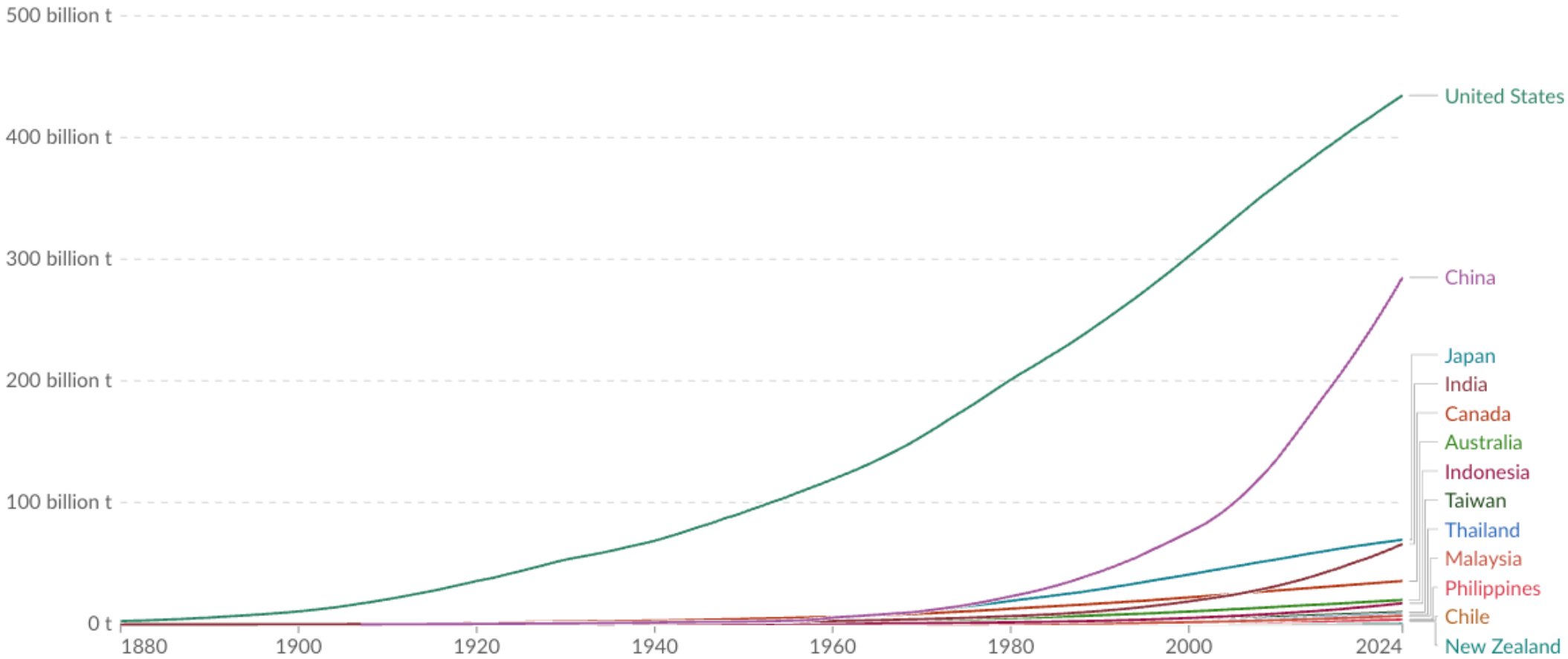
Cumulative CO_2 emissions

Our World in Data

Running sum of CO_2 emissions produced from fossil fuels and industry since the first year of recording, measured in tonnes. Land-use change emissions are not included.

Table | Map | Line | Bar

Settings



Play time-lapse 1750 2024

Data source: Global Carbon Budget (2025) – Learn more about this data

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

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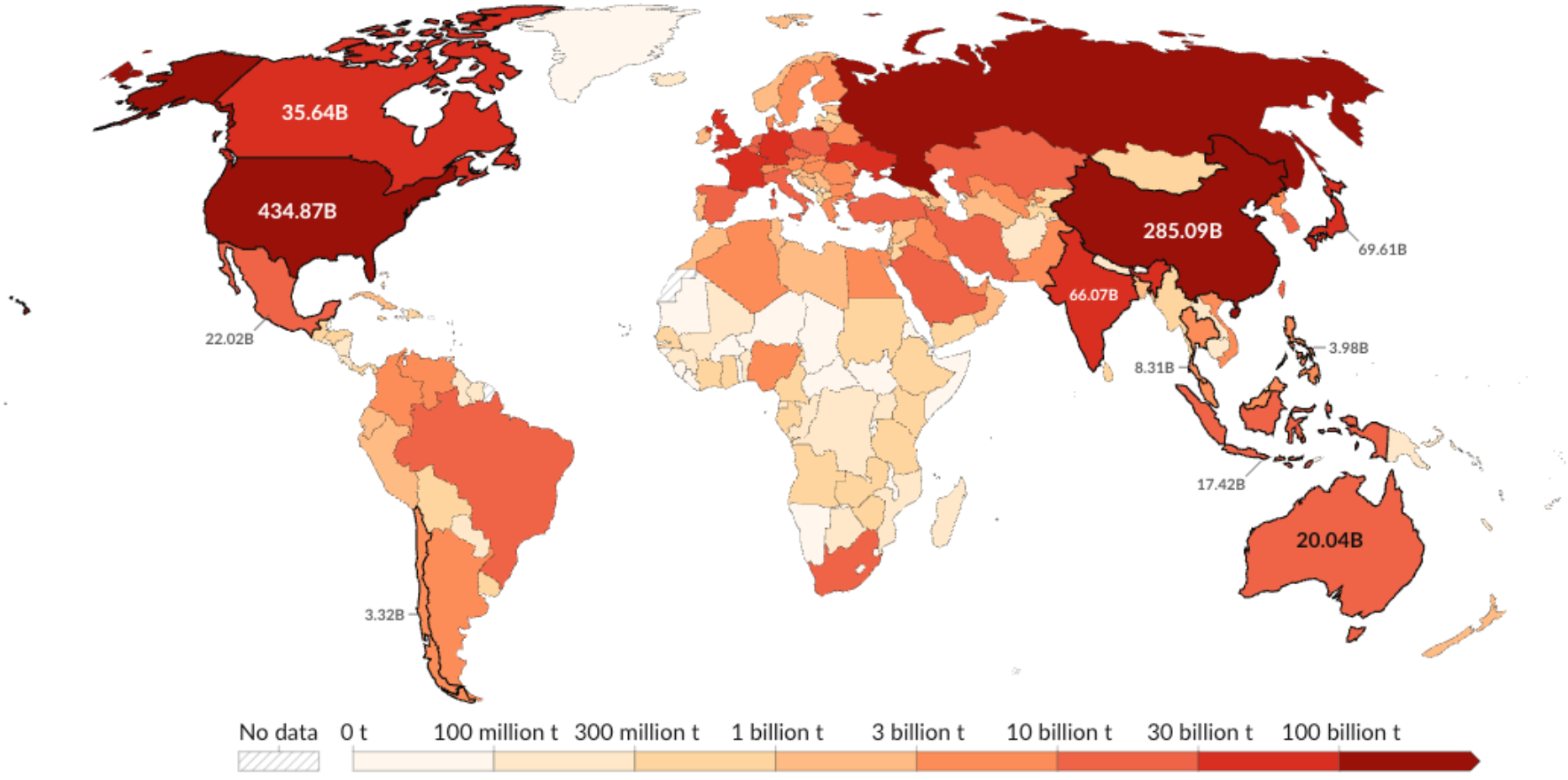
Cumulative CO_2 emissions, 2024

Our World in Data

Running sum of CO_2 emissions produced from fossil fuels and industry since the first year of recording, measured in tonnes. Land-use change emissions are not included.

Table | Map | Line | Bar

Zoom to selection



Play time-lapse 1750 2024

Data source: Global Carbon Budget (2025) – Learn more about this data

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

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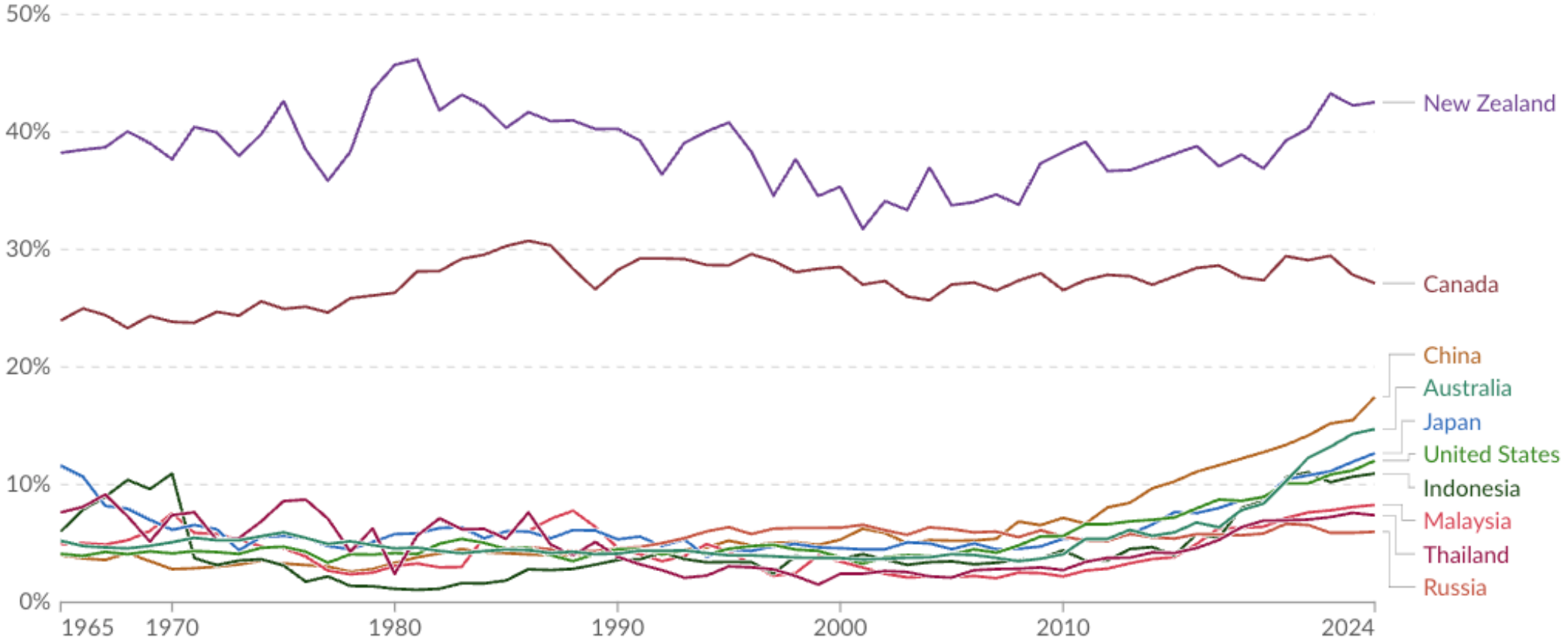
Share of primary energy consumption from renewable sources

Our World in Data

Measured as a percentage of primary energy using the substitution method. Renewables include hydropower, solar, wind, geothermal, bioenergy, wave, and tidal, but not traditional biofuels, which can be a key energy source, especially in lower-income settings.

Table | Map | Line | Bar

Edit countries and regions



1965 2024

Data source: Energy Institute - Statistical Review of World Energy (2025) – Learn more about this data

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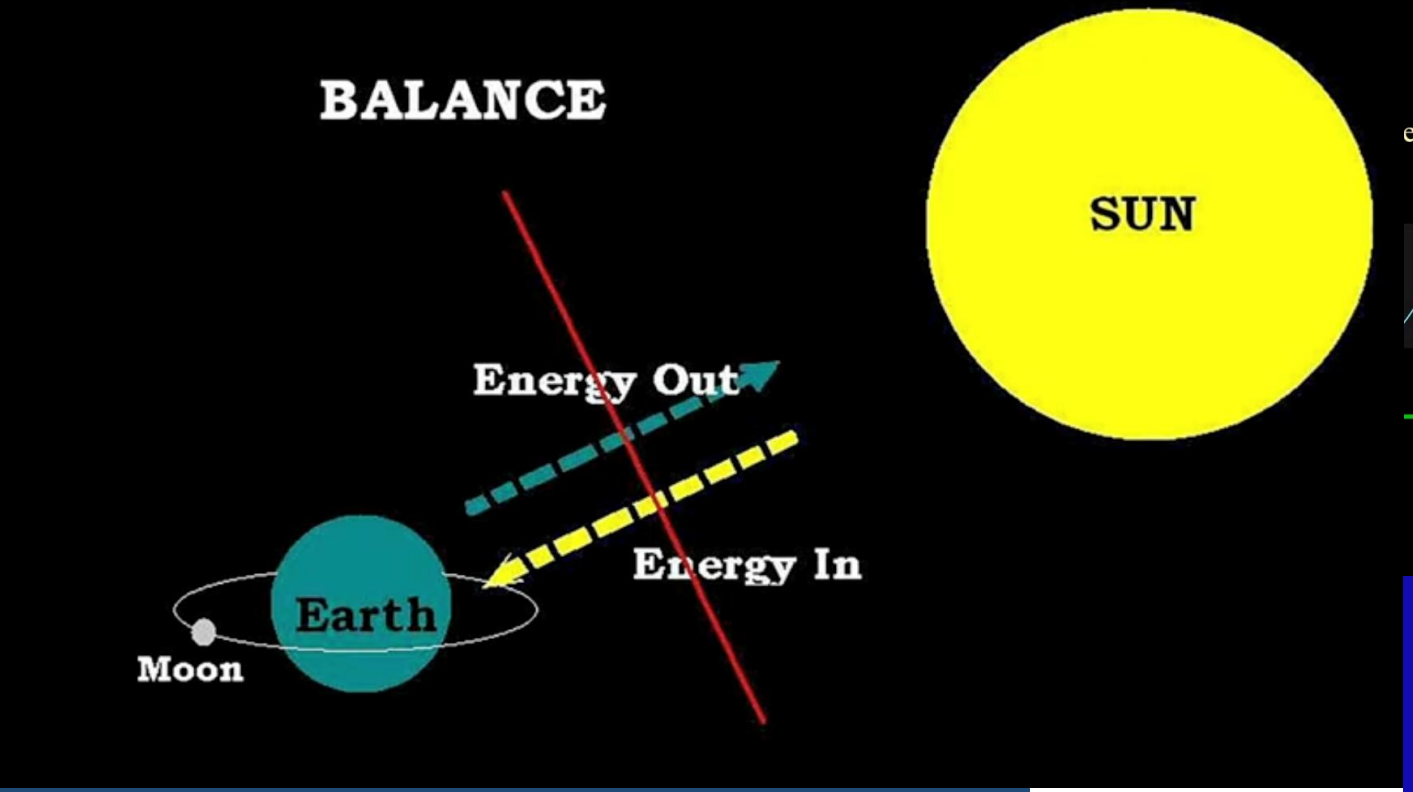
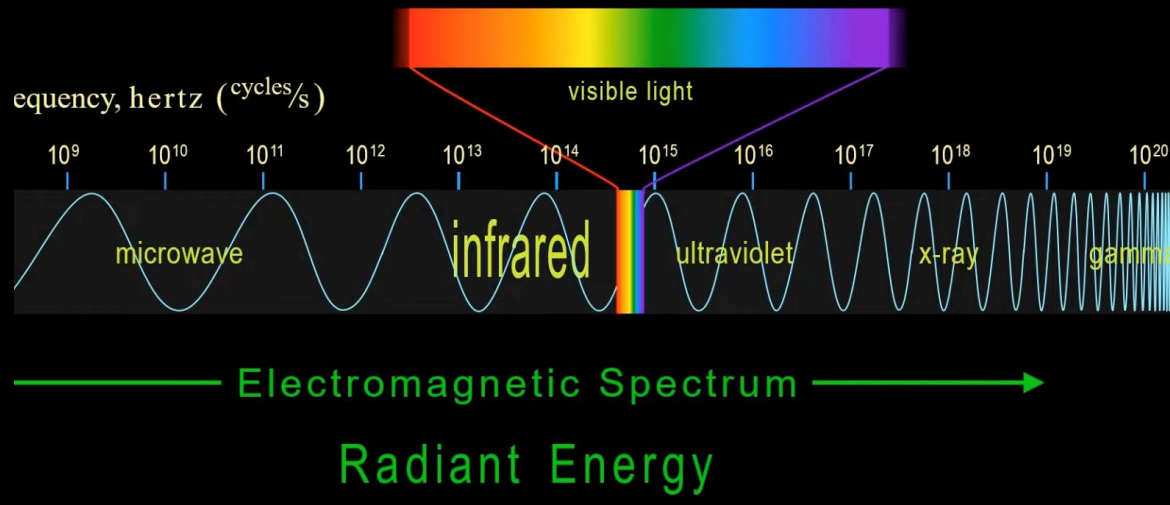
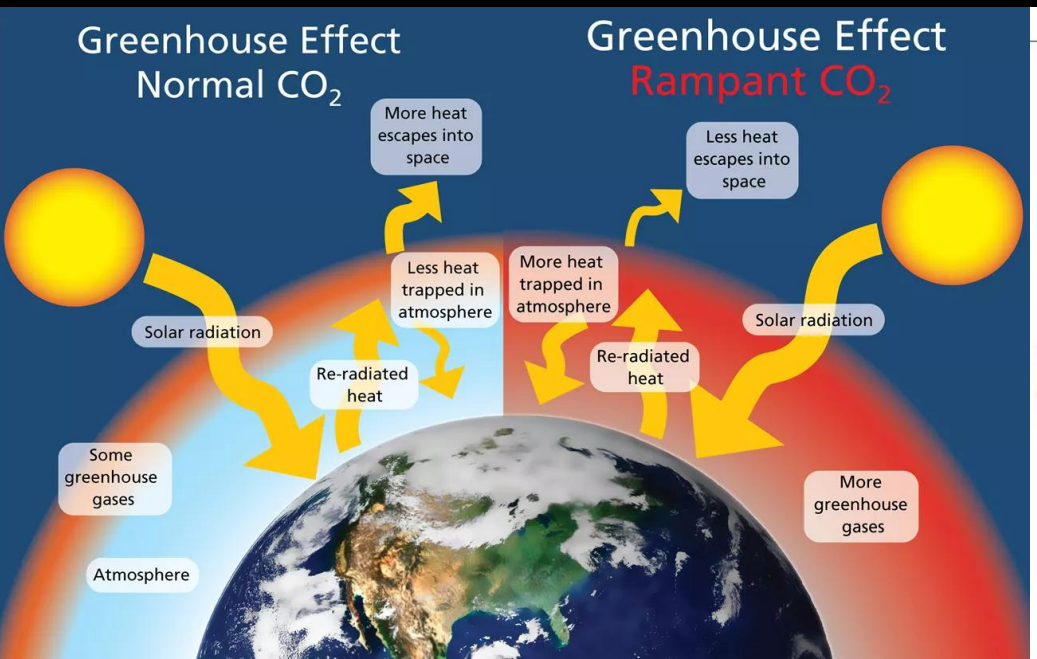
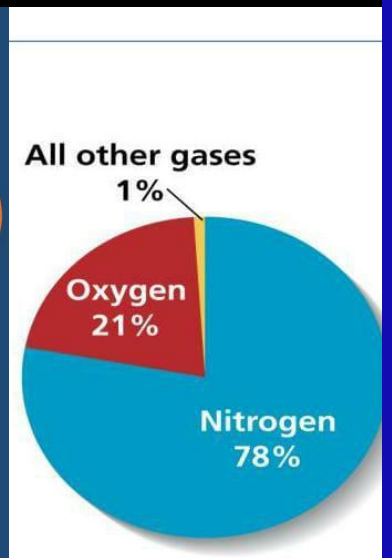
EVOLUTION OF CLIMATE SCIENCE

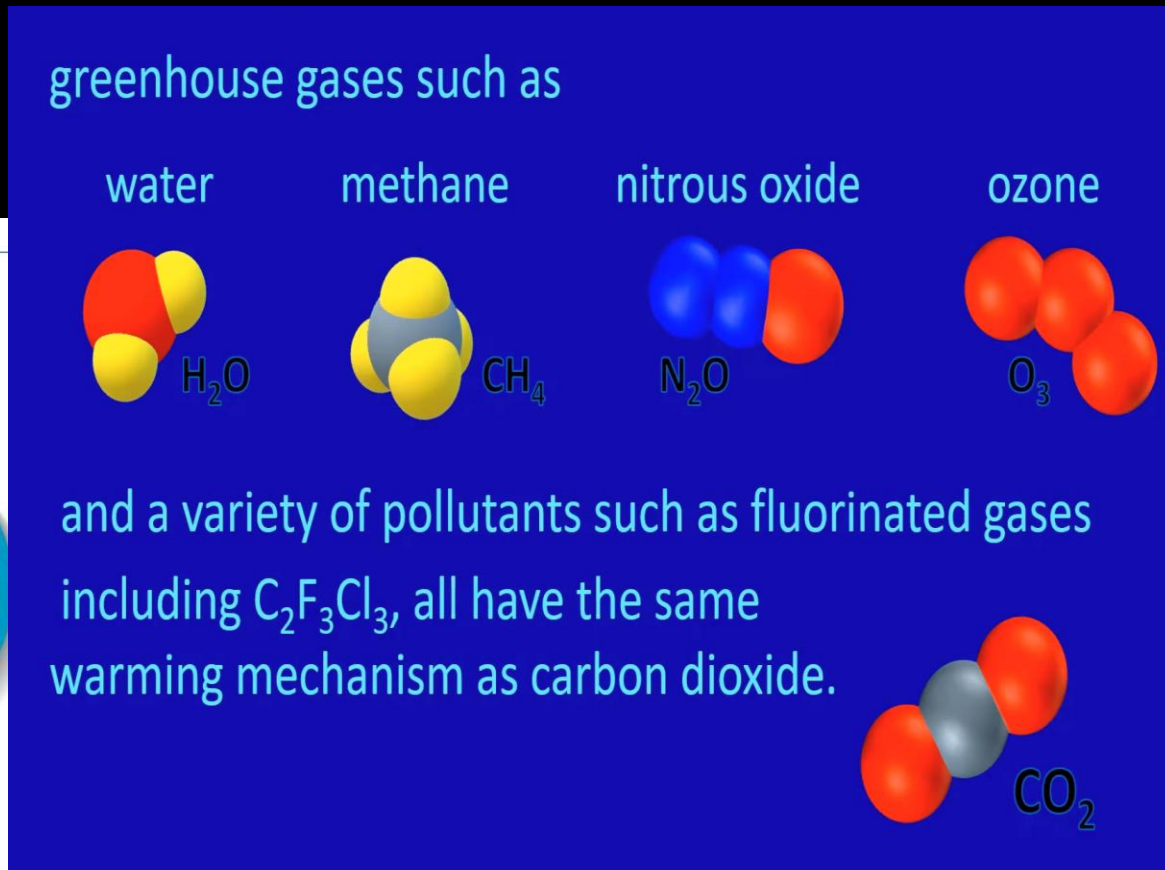
- Understanding Earth's Climate
- Climate vs. Weather
- Long Run versus Short Run Equilibrium
- Such an equilibrium is more Stochastic than Deterministic
- Climate Change differs from Global Warming
- Do high Greenhouse gas concentrations in the Earth's atmosphere cause global warming?
- All accept Climate Change, but the scientific Jury is still out on global warming.

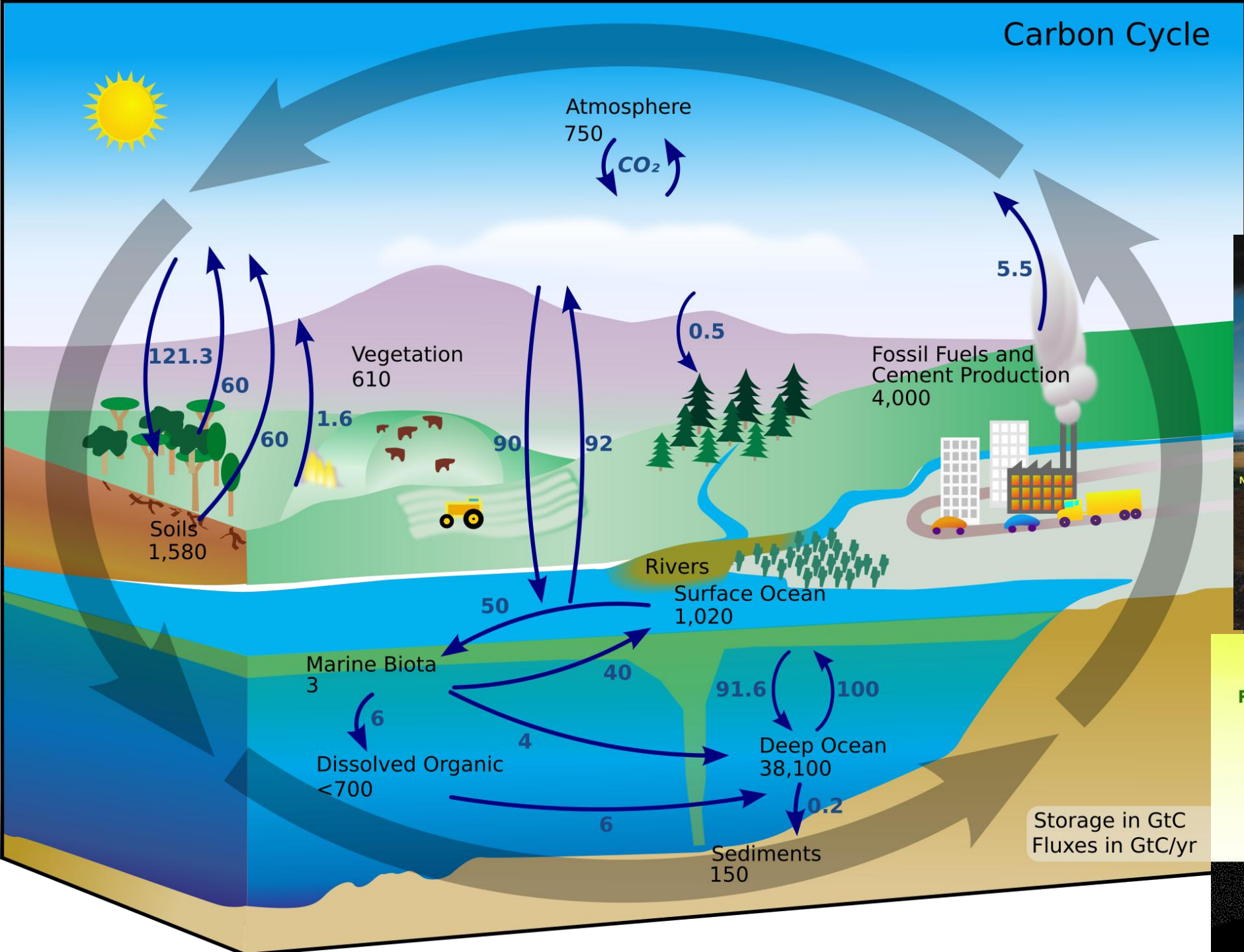

BALANCE
SUN
Energy Out
Energy In
Earth
Moon

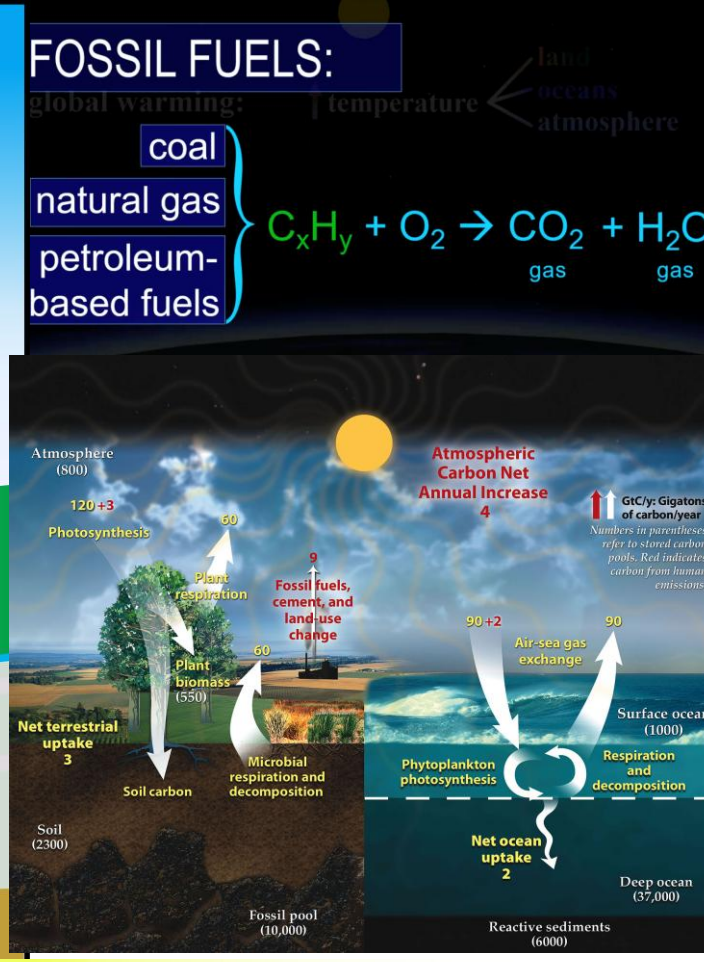

visible light
microwave
infrared
ultraviolet
x-ray
Electromagnetic Spectrum
Radiant Energy

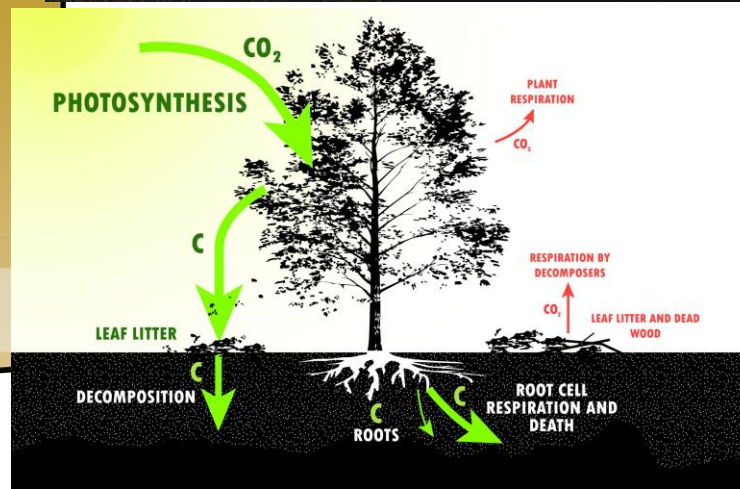

Greenhouse Effect
Normal CO_2
More heat escapes into space
Less heat trapped in atmosphere
Solar radiation
Re-radiated heat
Some greenhouse gases
Atmosphere
Greenhouse Effect
Rampant CO_2
Less heat escapes into space
More heat trapped in atmosphere
Solar radiation
Re-radiated heat
More greenhouse gases


All other gases
1%
Oxygen
21%
Nitrogen
78%

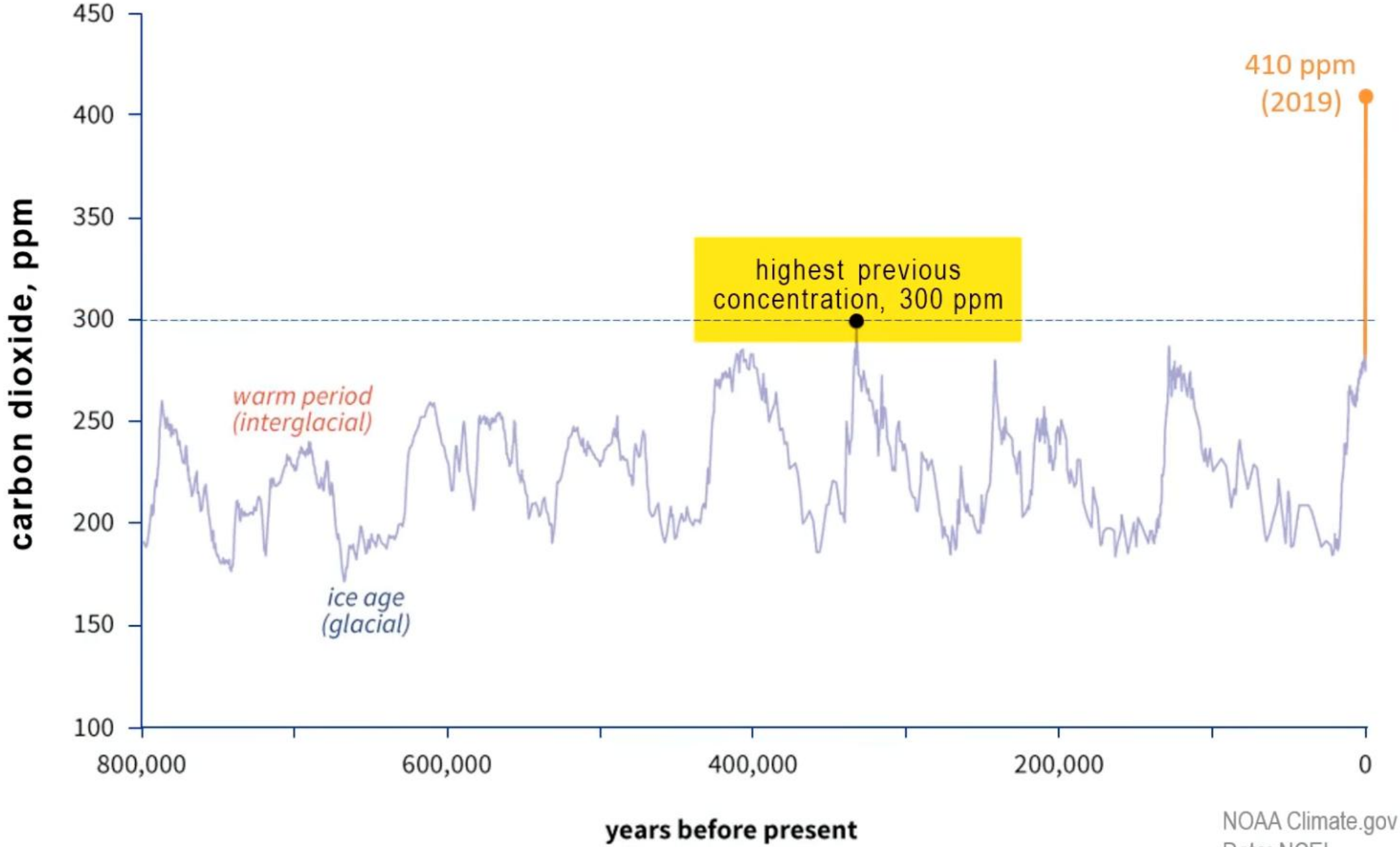

greenhouse gases such as
water
methane
nitrous oxide
ozone
H_2O
CH_4
N_2O
O_3
and a variety of pollutants such as fluorinated gases
including $C_2F_3Cl_3$, all have the same
warming mechanism as carbon dioxide.
CO_2


Carbon Cycle
Atmosphere
750
CO₂
121.3
60
60
1.6
Vegetation
610
90
92
0.5
5.5
Fossil Fuels and
Cement Production
4,000
Soils
1,580
Rivers
Surface Ocean
1,020
50
Marine Biota
3
40
91.6
100
6
4
Dissolved Organic
<700
Deep Ocean
38,100
0.2
6
Sediments
150
Storage in GtC
Fluxes in GtC/yr

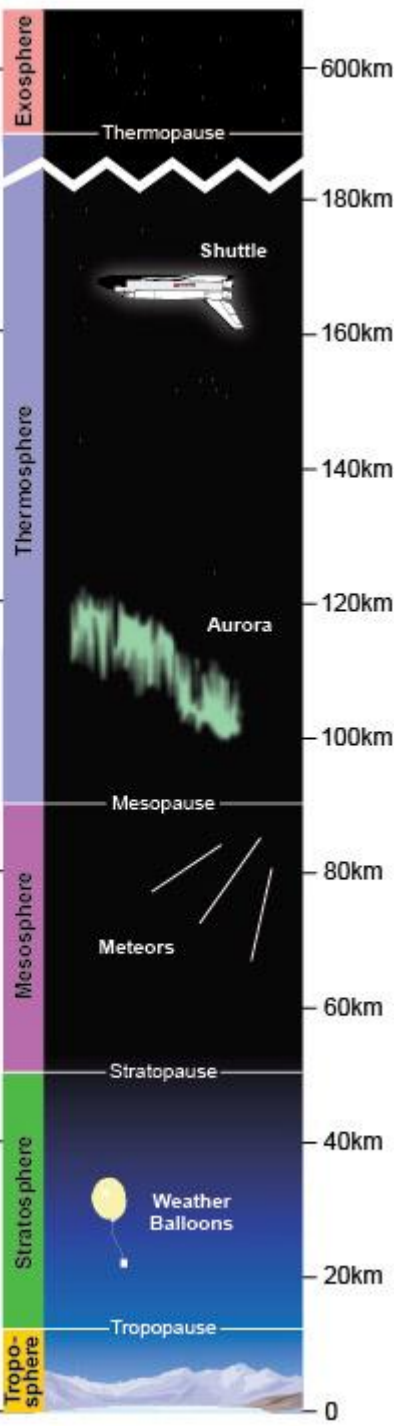

FOSSIL FUELS:
coal
natural gas
petroleum-based fuels
$C_xH_y + O_2 \rightarrow CO_2 + H_2O$
gas
gas
Atmosphere (800)
120 +3
Photosynthesis
60
Plant respiration
9
Fossil fuels, cement, and land-use change
60
Plant biomass (550)
Net terrestrial uptake 3
Soil carbon
Microbial respiration and decomposition
Soil (2300)
Fossil pool (10,000)
Atmospheric Carbon Net Annual Increase 4
90 +2
Air-sea gas exchange
90
Surface ocean (1000)
Phytoplankton photosynthesis
Respiration and decomposition
Net ocean uptake 2
Deep ocean (37,000)
Reactive sediments (6000)

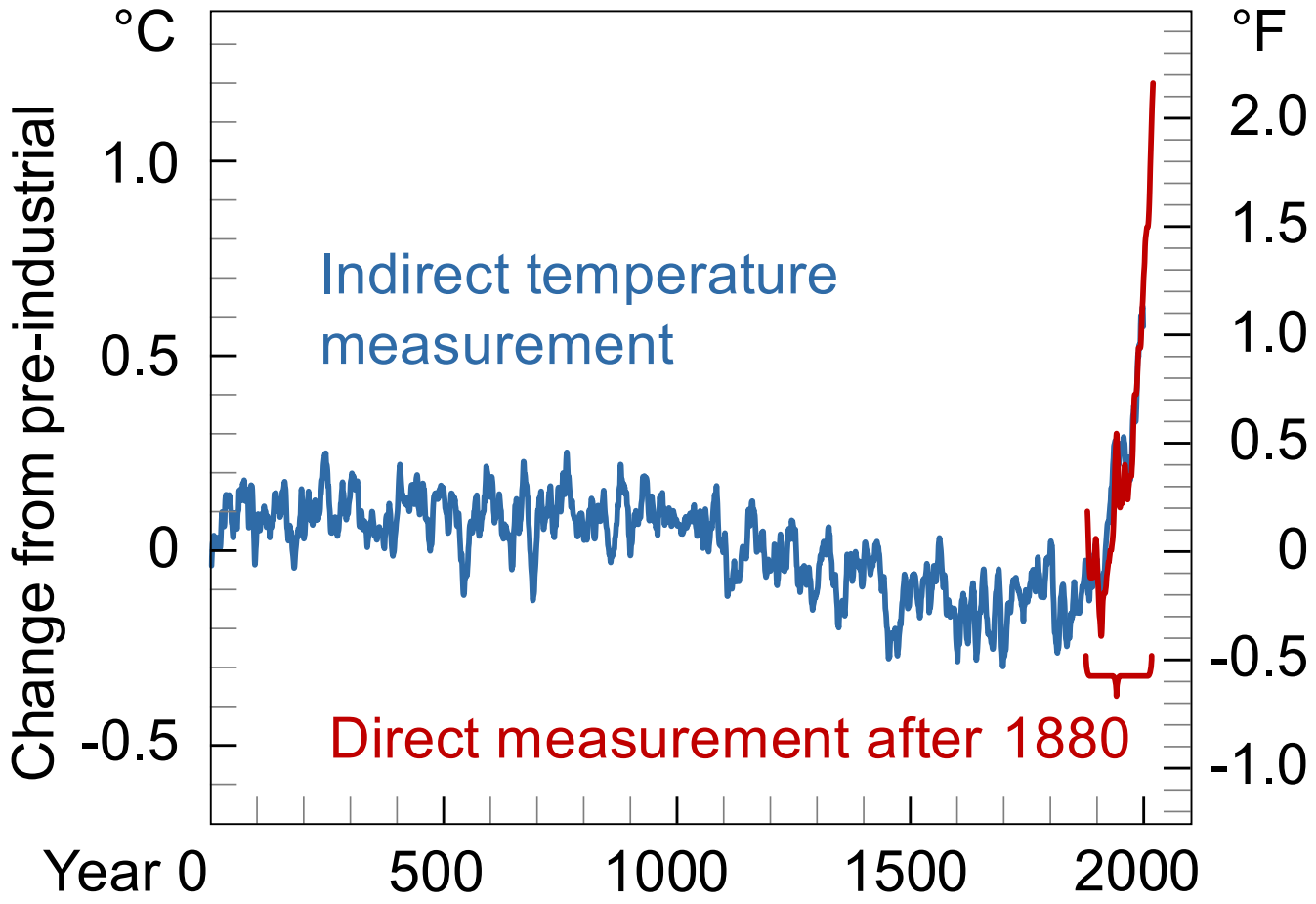

CO_2
PHOTOSYNTHESIS
PLANT RESPIRATION
CO_2
C
RESPIRATION BY DECOMPOSERS
CO_2
LEAF LITTER AND DEAD WOOD
LEAF LITTER
C
DECOMPOSITION
C
ROOTS
C
ROOT CELL RESPIRATION AND DEATH

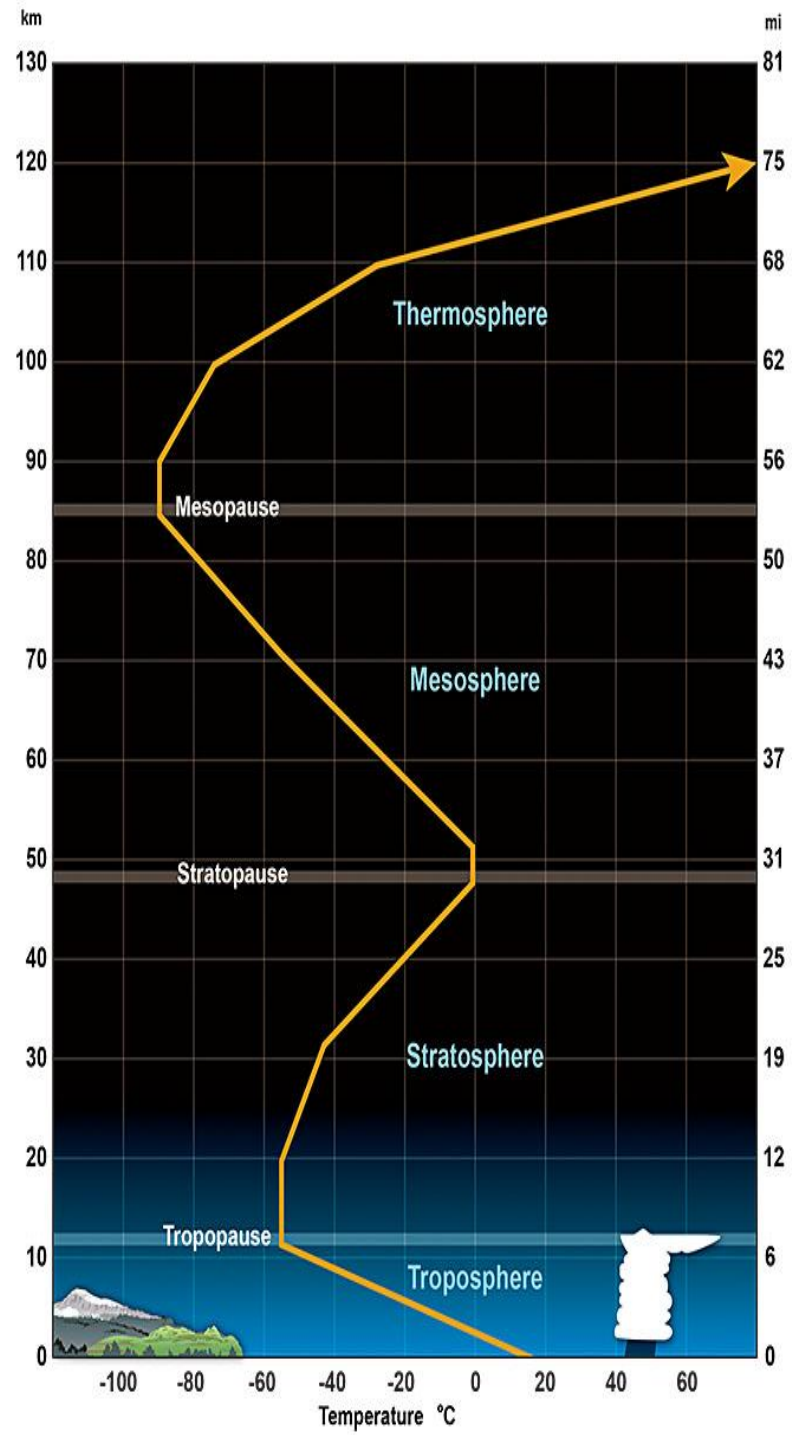
ATMOSPHERIC CO_2 LEVELS OVER 800,000 YEARS



NOAA Climate.gov
Data: NCEI


Exosphere
Thermopause
Thermosphere
Shuttle
Aurora
Mesopause
Mesosphere
Meteors
Stratopause
Stratosphere
Weather Balloons
Tropopause
Tropo-sphere
600km
180km
160km
140km
120km
100km
80km
60km
40km
20km
0

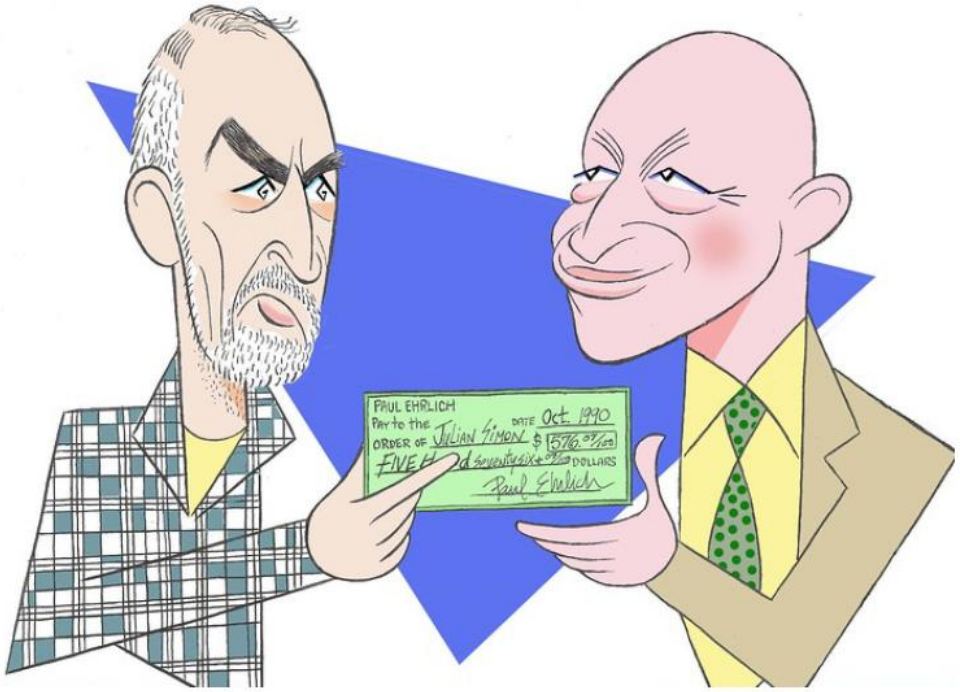

Global temperature over the past two millenia
°C
°F
Change from pre-industrial
1.0
0.5
0
-0.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
Indirect temperature measurement
Direct measurement after 1880
Year 0
500
1000
1500
2000

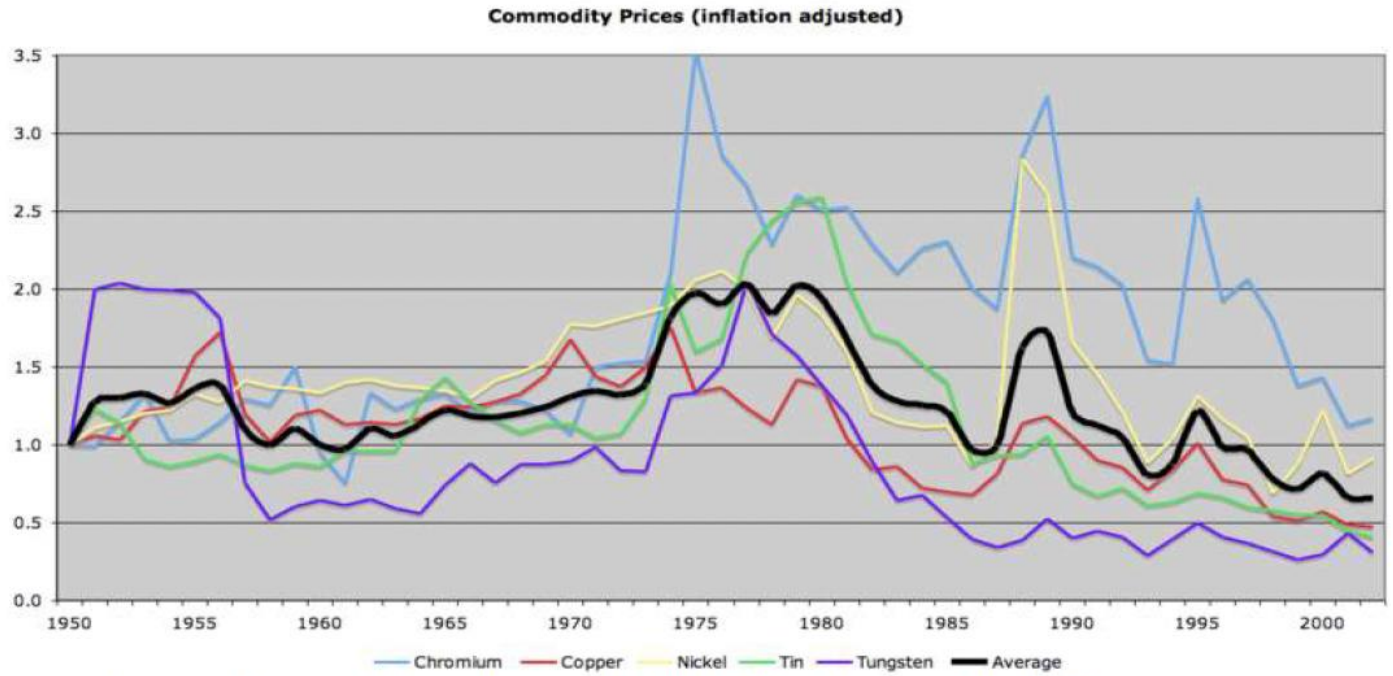

km
mi
130
120
110
100
90
80
70
60
50
40
30
20
10
0
81
75
68
62
56
50
43
37
31
25
19
12
6
0
Thermosphere
Mesopause
Mesosphere
Stratopause
Stratosphere
Tropopause
Troposphere
-100
-80
-60
-40
-20
0
20
40
60
Temperature °C

EVOLUTION OF CLIMATE SCIENCE

- The Bet
  - Julian Simon vs. Paul Ehrlich

https://en.wikipedia.org/wiki/File:Simon-Ehrlich.png





http://www.wsj.com/articles/SB10001424127887324165204579026631593290784

https://en.wikipedia.org/wiki/File:Simon-Ehrlich.png

ENTROPY LAW AND ECONOMIC EXTERNALITIES

Economic Resource Cycles or Energy-Welfare Nexus

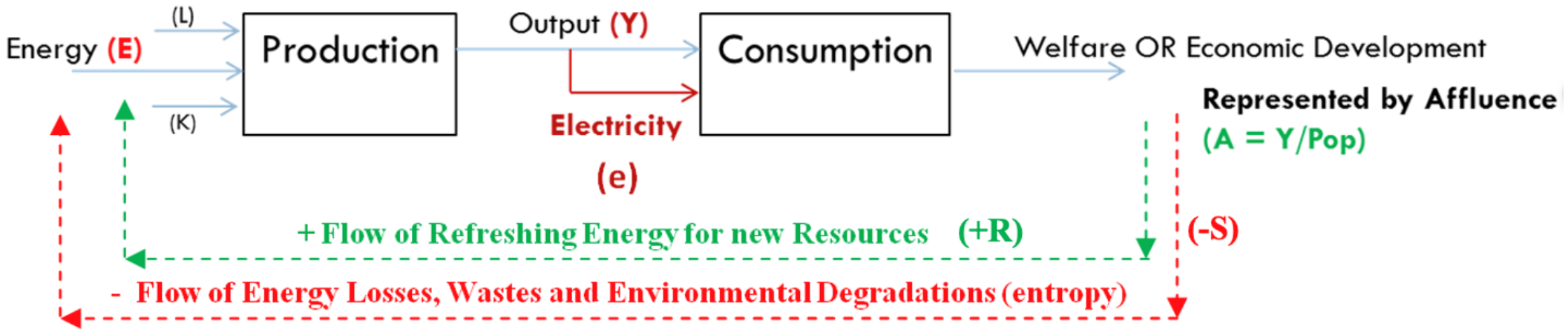


Figure 1: Schematic Flow Diagram of *Energy-Welfare Nexus*

Source: Aghdam, R., & Ahmad, N. (2025). Circular dynamics of energy. In Elgar Encyclopedia of Energy Economics (pp. 53-55). Edward Elgar Publishing.

ENTROPY LAW AND ECONOMIC EXTERNALITIES

How long can a sustainable equilibrium be achieved in the long run?

- Human economic systems should be in balance with non-human wild systems!
- Not everything is to fulfil human happiness. We are happy by respecting Mother Nature and living in harmony with nature
- For desirable output leading to Welfare/Happiness, the following are essential:
  - Perfect Competitive markets for private homogeneous products
  - Well-defined “Property Rights”
  - Well distributed and standardised (energy or commodity) money that performs all three functions of MoE, UoV, and SoV
- The above conditions imply minimal transaction costs
- And that implies the lowest entropy or long-run equilibrium
- For non-private and non-marketed goods, where property rights are not well defined, the following must be
  - establishment of a market for externalities
  - creating true energy money, decentralised
  - alternatively, imposing an optimal Pigovian Tax
- The above conditions will bring a long-run efficient equilibrium

AUSTRALIA-APEC REGIONAL COOPERATIONS

- The Carbon Neutrality process through Cap and trade is a market solution for carbon pricing
- The Kavin Rod government, once it introduced the carbon tax, was equally beneficial for internalising the externality.
- There is no need to be worried about irrelevance in the global warming argument
- 1-10 degrees changes in the average surface temperature are not as costly as other natural disasters that are happening due to the interruption in the Carbon Cycle
- Such hefty costs must be internalised by vigilant calculation of cap or tradable permits.
- Apart from the above symbiosis with other species flora, Fungi, Bacteria, and viruses, because what is unavailable energy for the human system, they are energy input for those systems
- For example, reforestation and biodiversity can help Mother Nature address carbon emissions and other forms of entropy in human systems.
- Investing in new technologies that help resolve the excessive accumulation of atmospheric carbon.
- The problem is not limited to Carbon cycles; it is every aspect of human activities that impose negative and even positive externalities that need these policies

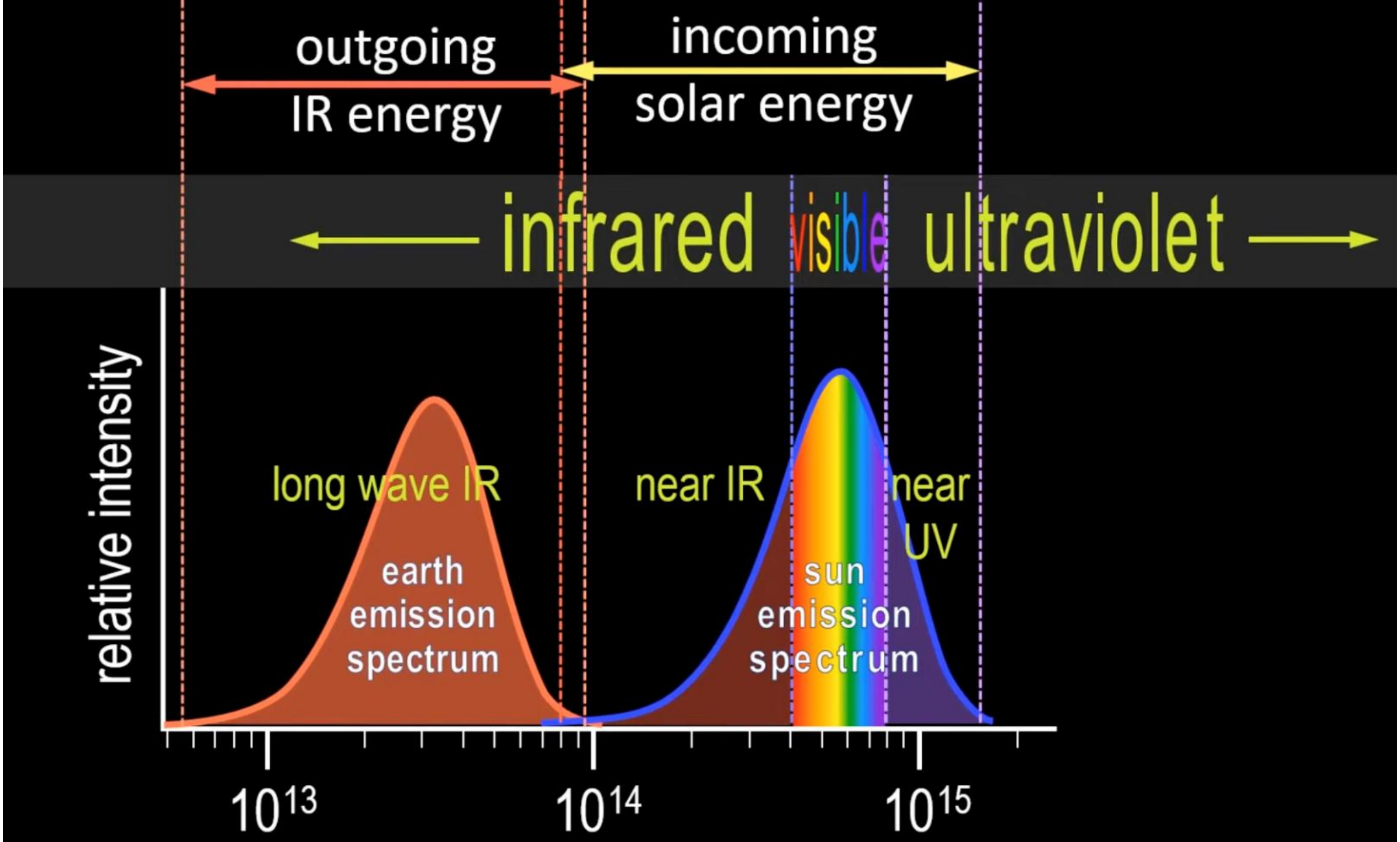
CONCLUDING REMARKS

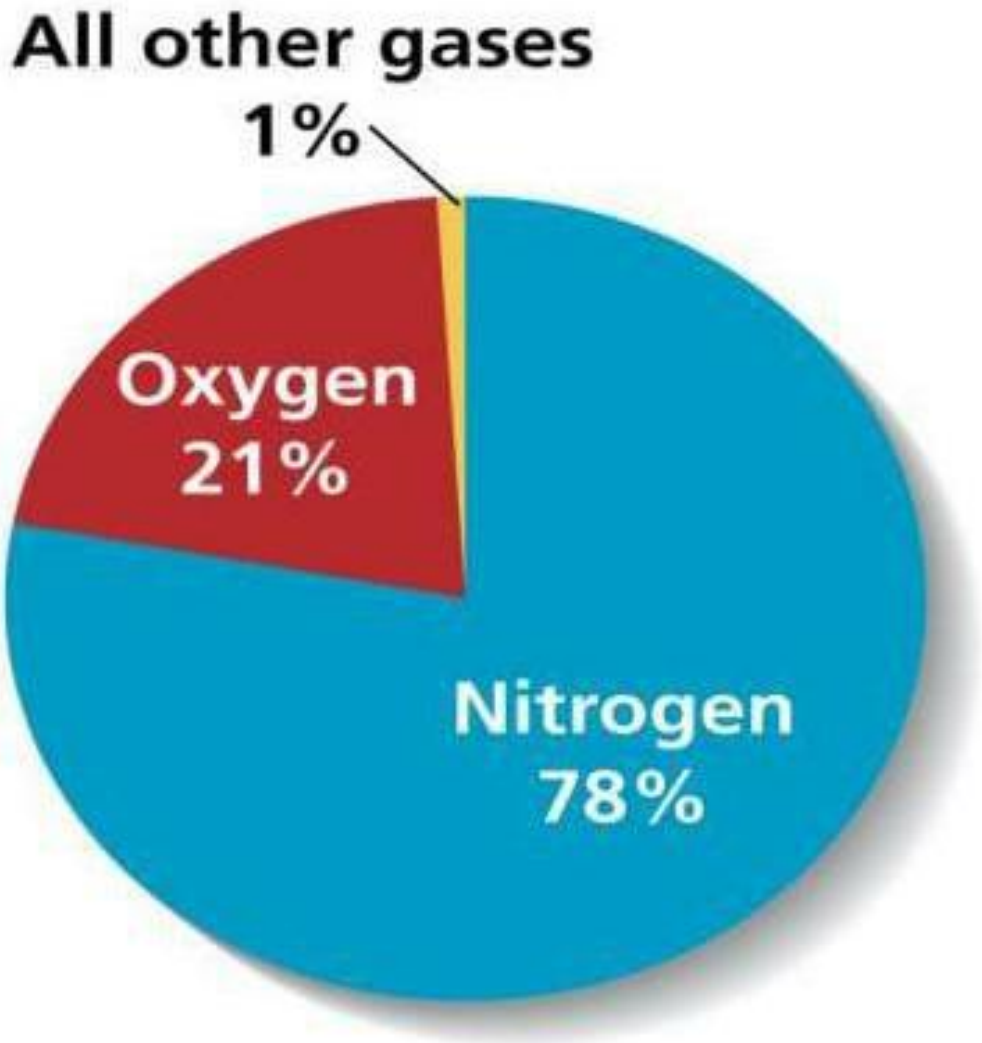
- Climate change differs from global warming.
- It must be addressed by
  - Establishing a competitive market for pricing and internalising Carbon emissions, which is a negative externality
  - Alternatively, proactive implementation of an optimal Pigovian tax
- Symbiosis or co-existing with non-human systems is essential
  - Reforestation and biodiversity
- Creating an actual decentralised energy currency is the most vital institution for lowering transaction costs and allowing a long-run equilibrium to emerge.
- Also, well-defining property rights institutions to lower the transaction cost of negotiations between polluters and victims

THANK YOU!

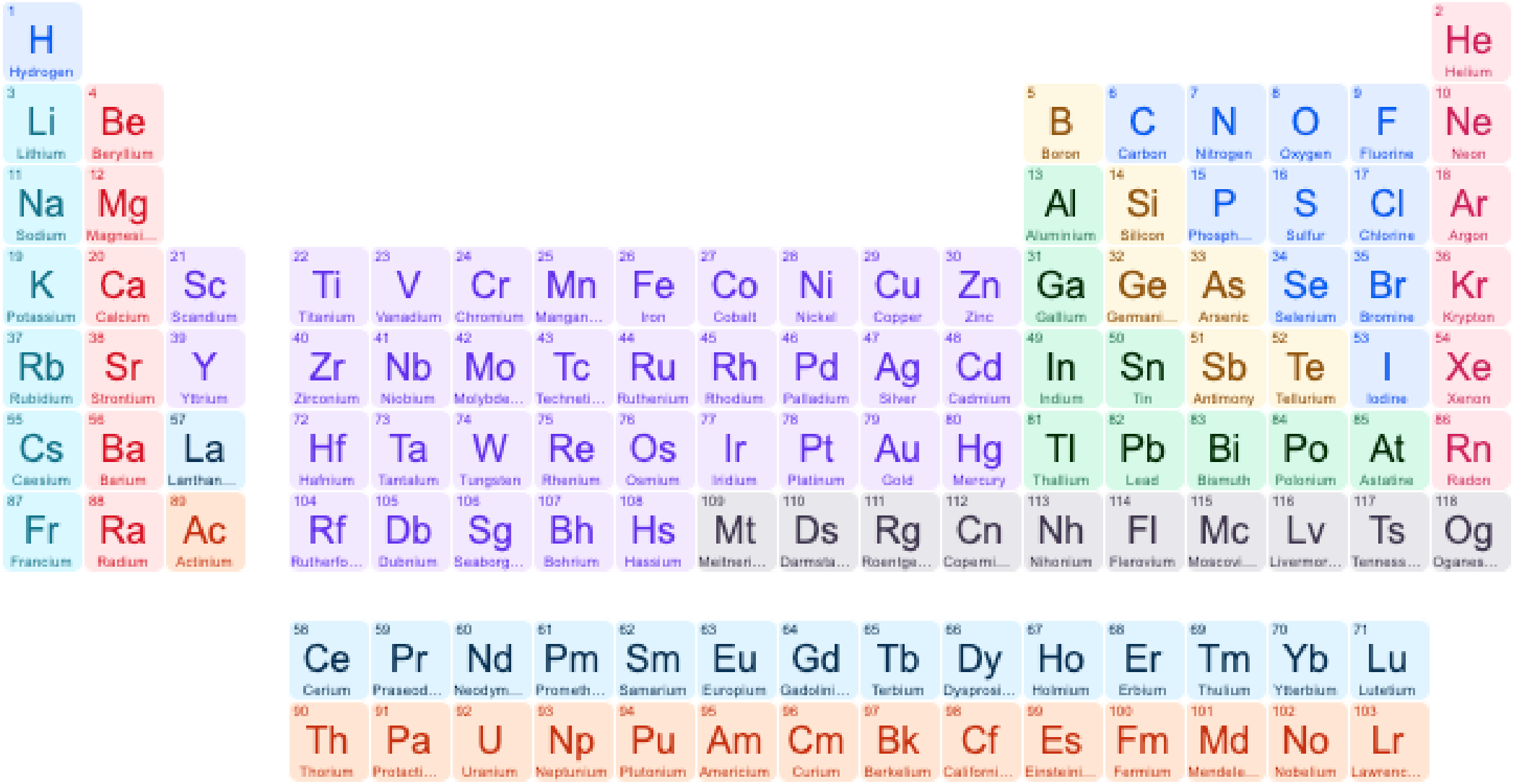
Questions?

Extra Slides for use in Q&A


outgoing
IR energy
incoming
solar energy
infrared
visible
ultraviolet
relative intensity
long wave IR
earth
emission
spectrum
near IR
sun
emission
spectrum
near
UV
10^13
10^14
10^15

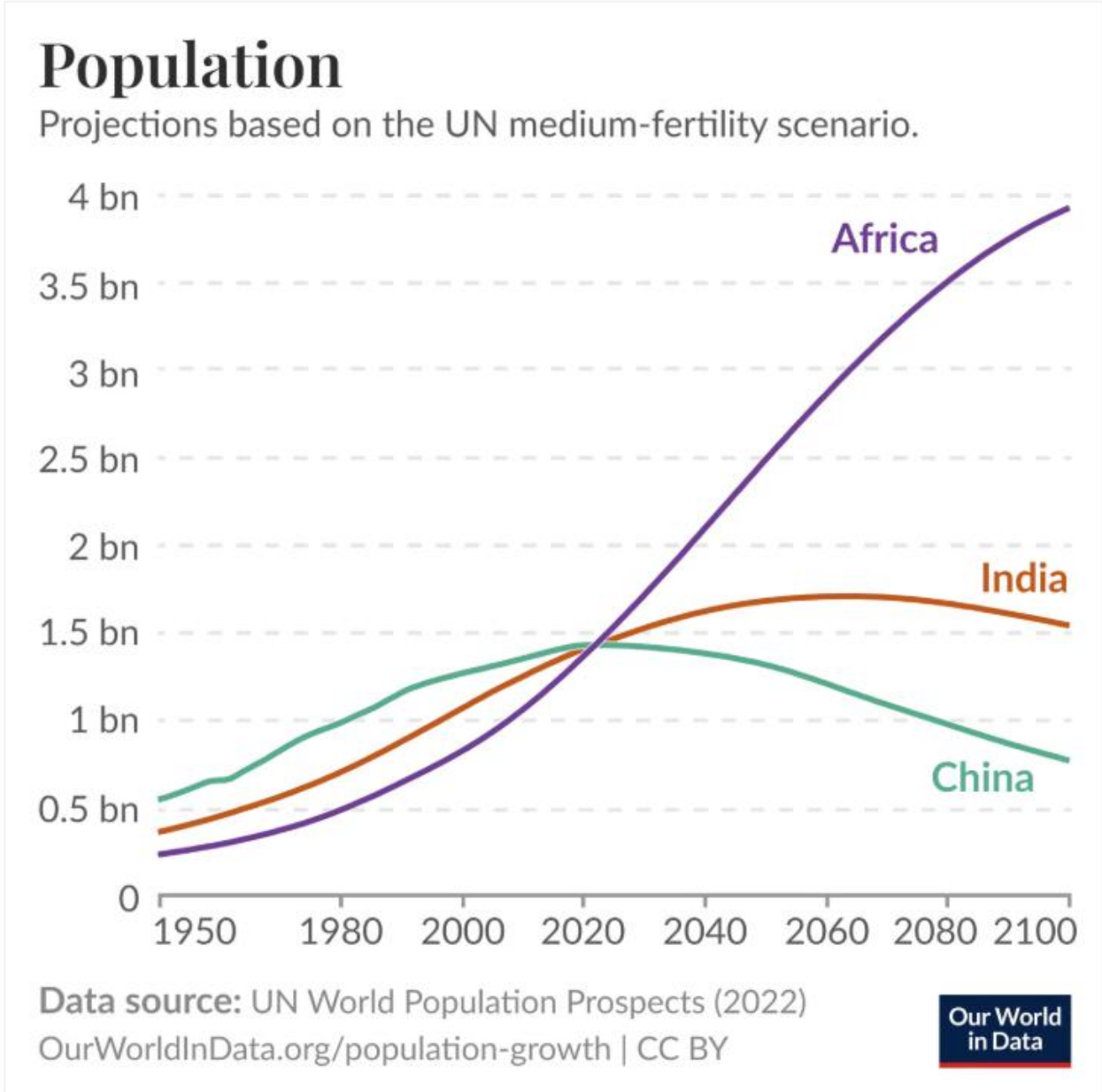


Gas	Percentage by Volume
Nitrogen (N_2)	78.084
Oxygen (O_2)	20.946
Argon (Ar)	0.934
Carbon dioxide (CO_2)	0.037
Neon (Ne)	0.00182
Helium (He)	0.00052
Methane (CH_4)	0.00015
Krypton (Kr)	0.00011


1 H Hydrogen
2 He Helium
3 Li Lithium
4 Be Beryllium
5 B Boron
6 C Carbon
7 N Nitrogen
8 O Oxygen
9 F Fluorine
10 Ne Neon
11 Na Sodium
12 Mg Magnesi...
13 Al Aluminium
14 Si Silicon
15 P Phosph...
16 S Sulfur
17 Cl Chlorine
18 Ar Argon
19 K Potassium
20 Ca Calcium
21 Sc Scandium
22 Ti Titanium
23 V Vanadium
24 Cr Chromium
25 Mn Mangan...
26 Fe Iron
27 Co Cobalt
28 Ni Nickel
29 Cu Copper
30 Zn Zinc
31 Ga Gallium
32 Ge Germani...
33 As Arsenic
34 Se Selenium
35 Br Bromine
36 Kr Krypton
37 Rb Rubidium
38 Sr Strontium
39 Y Yttrium
40 Zr Zirconium
41 Nb Niobium
42 Mo Molybde...
43 Tc Techneti...
44 Ru Ruthenium
45 Rh Rhodium
46 Pd Palladium
47 Ag Silver
48 Cd Cadmium
49 In Indium
50 Sn Tin
51 Sb Antimony
52 Te Tellurium
53 I Iodine
54 Xe Xenon
55 Cs Caesium
56 Ba Barium
57 La Lanthan...
72 Hf Hafnium
73 Ta Tantalum
74 W Tungsten
75 Re Rhenium
76 Os Osmium
77 Ir Iridium
78 Pt Platinum
79 Au Gold
80 Hg Mercury
81 Tl Thallium
82 Pb Lead
83 Bi Bismuth
84 Po Polonium
85 At Astatine
86 Rn Radon
87 Fr Francium
88 Ra Radium
89 Ac Actinium
104 Rf Rutherfo...
105 Db Dubnium
106 Sg Seaborg...
107 Bh Bohrium
108 Hs Hassium
109 Mt Meitneri...
110 Ds Darmsta...
111 Rg Roentge...
112 Cn Coperni...
113 Nh Nihonium
114 Fl Flerovium
115 Mc Moscovi...
116 Lv Livermor...
117 Ts Tennessi...
118 Og Oganess...
58 Ce Cerium
59 Pr Praseod...
60 Nd Neodym...
61 Pm Prometh...
62 Sm Samarium
63 Eu Europium
64 Gd Gadolini...
65 Tb Terbium
66 Dy Dysprosi...
67 Ho Holmium
68 Er Erbium
69 Tm Thulium
70 Yb Ytterbium
71 Lu Lutetium
90 Th Thorium
91 Pa Protacti...
92 U Uranium
93 Np Neptunium
94 Pu Plutonium
95 Am Americium
96 Cm Curium
97 Bk Berkelium
98 Cf Californi...
99 Es Einsteini...
100 Fm Fermium
101 Md Mendele...
102 No Nobelium
103 Lr Lawrenc...

2023 was a population crossroad

Pablo Rosado



MULTIDIMENTIAL COMPLEXITY

- Environment-Economy Nexus
- Ecology: Resource Cycles, Weather versus Climate
  - Key Q: Is Earth Climate in a Sustainable Equilibrium?
    - Denials
    - Worrisome
- Economy: Scarcity, Prod., Cons., Market Equilibria
  - Key Q: Are Economic Growth Sustainable in the Long Run?
    - Classicals: Kinda! Faith on Market & Technology
    - Thomas Malthus: Food and Population
    - Club of Rome 1970s: Limit to Growth, Neo Malthusian doctrine
    - Optimism: Resourceful Earth, Cornucopian doctrine