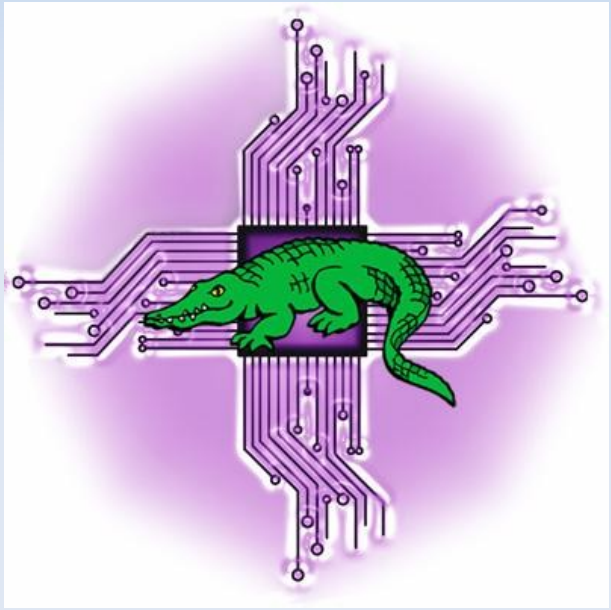
Critical Issues for the Global Climate

Future Day Conference, Melbourne, March 03, 2026



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The Climate System

*** Earth has an "energy budget", consisting of the energy that the planet receives and that is lost to space.**

*** Climate is represented as the synthesis of regional weather over time determined by the complex interactions of the climate system; the atmosphere, oceans, and land surface**

*** Temperature is the most obvious variable, with variation in the atmosphere according to zones, seasonal variation modified by latitude, and atmospheric composition.**

*** The climate system is dynamic with internal variability and external forcings.**

*** Internal variability includes the interrelationship between convection, oceanic and atmospheric interactions.**

*** External forcings, both natural and anthropogenic, change the energy budget of the planet.**

The Climate System

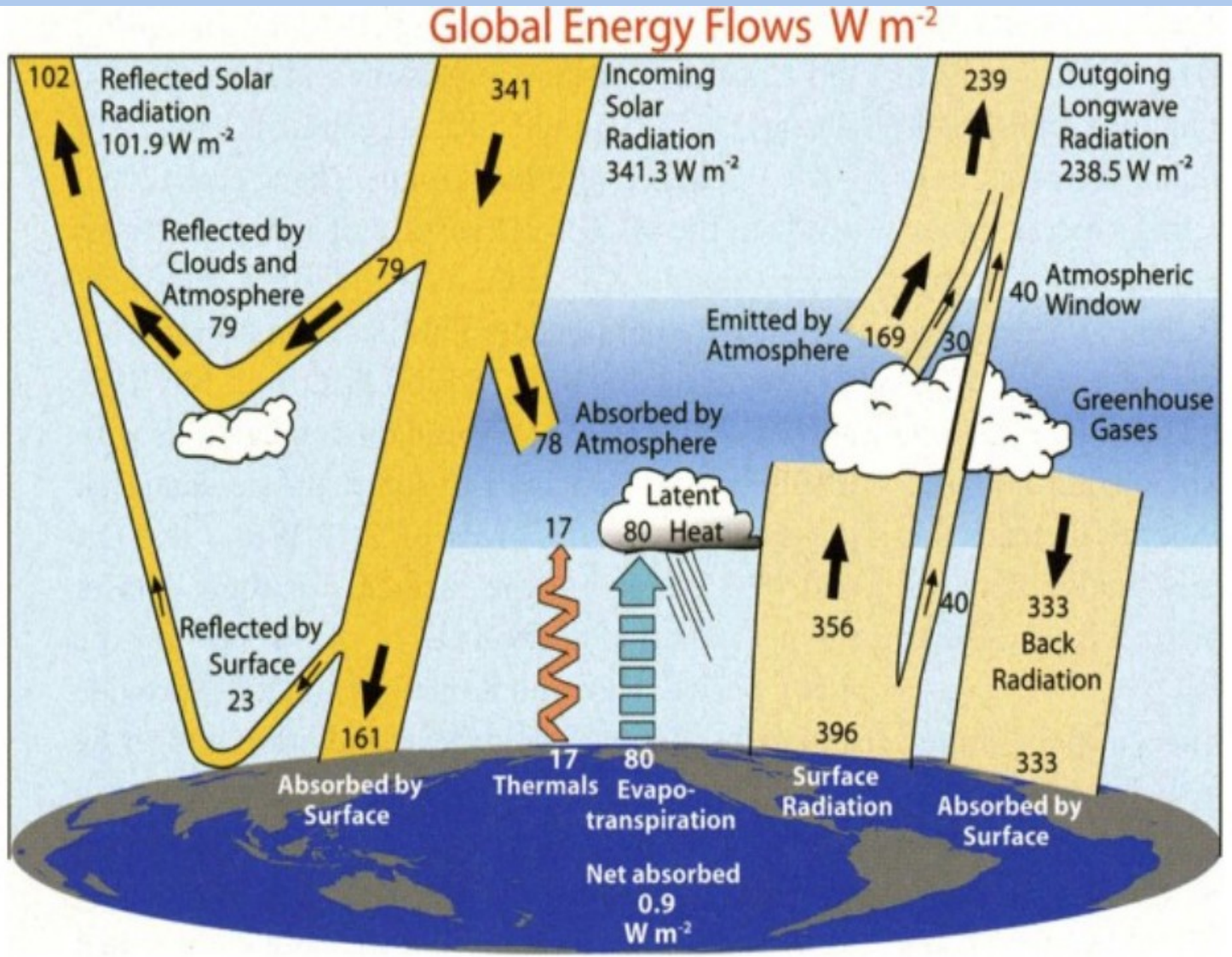


Figure 1: Energy budget for Mar 2000 to May 2004 (W m-2). Arrows in proportion to importance.

The Industrial Age

*** The rapid transition in manufacturing, agriculture, and information goods from craft production to mechanised production, "the industrial revolution" occurred between 1760 to 1840.**

*** The industrial age also witnesses the introduction of instrument atmospheric and oceanic temperature records to the level of quasi-global measurements beginning in 1850.**

*** Warming in the early twentieth century is explicable with the inclusion of natural forcings (mostly solar), whilst warming in late twentieth-century warming can only be explained by anthropogenic forcing (mainly GHGs).**

*** "The *likely* range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 11 is 0.8°C to 1.3°C, with a best estimate of 1.07°C. It is likely that well-mixed GHGs contributed a warming of 1.0°C to 2.0°C, other human drivers (principally aerosols) contributed a cooling of 0.0°C to 0.8°C"**

*** Most recent instrument records (2024, 2025) indicate that the human-caused global surface temperature warming has increased to 1.5°C.**

GHGs and the Carbon Cycle

*** Due to their molecular structure (electric dipole movements), a greenhouse gas absorbs longwave infrared radiant energy, emitting heat and increasing the rate the atmosphere absorbs short-wave radiation from the Sun.**

*** The primary greenhouse gases, in order, are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Water vapour is not a direct forcing itself, but rather arises from forcings and has a feedback loop**

*** GHGs are necessary for the biosphere and without them the the average temperature of Earth's surface would be about -18°C, rather than the present average of 15°C**

*** The increase of carbon dioxide and methane is particularly important in the context of the carbon cycle as it regulates the concentrations of these gases. The cycle refers to the movement carbon in the biosphere, the process of carbon sequestration to and release from carbon sinks.**

GHGs and the Carbon Cycle

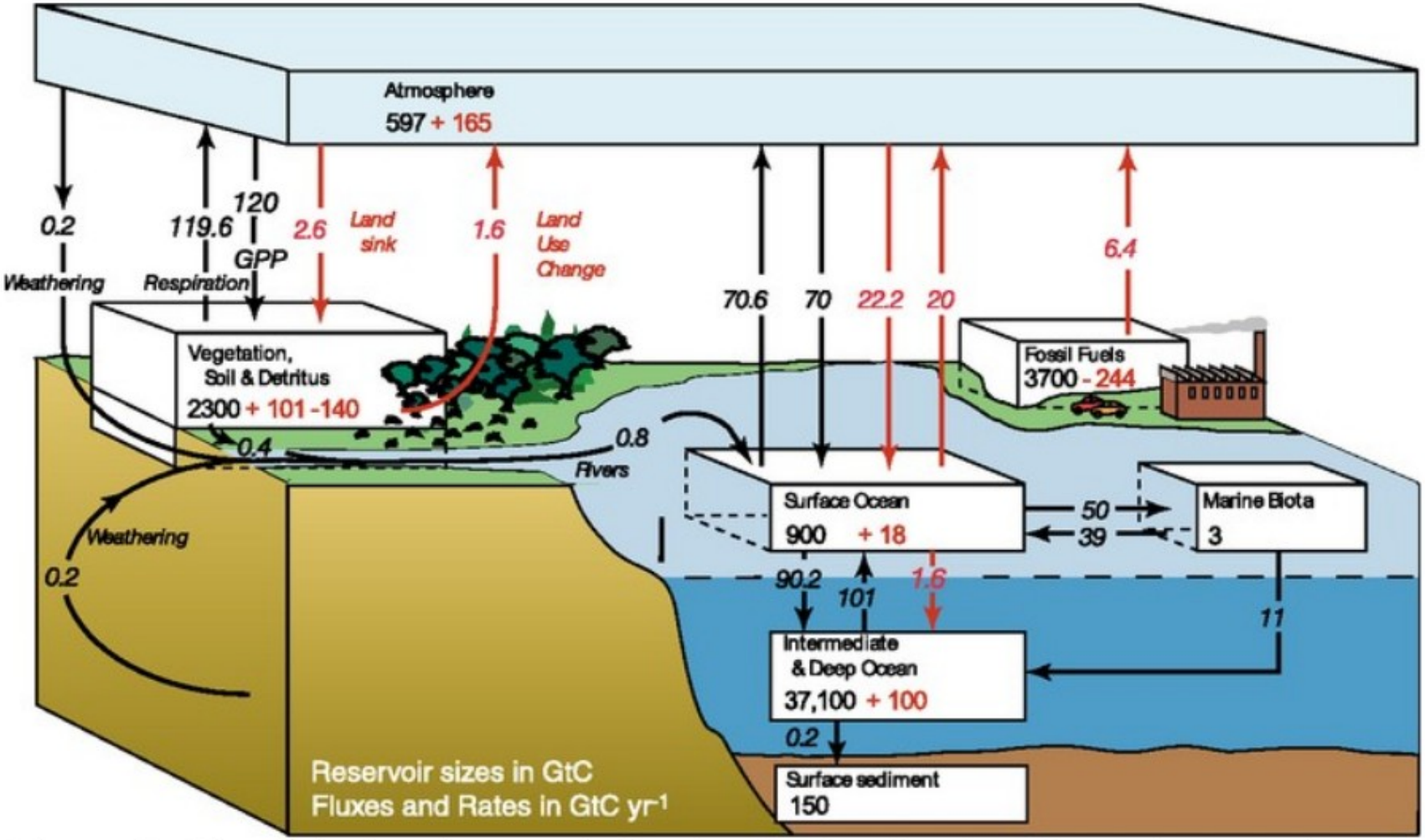


Figure 2: The global carbon cycle for the 1990s, showing the main annual fluxes in gigatonnes of carbon. Pre-industrial 'natural' fluxes in black and 'anthropogenic; fluxes in red. Atmospheric carbon content and all cumulative fluxes since 1750 are as of end 1994.

Human Activity and Projections

*** Natural emissions of carbon dioxide from vegetation and land (439 gigatonnes) and oceanic release (332) contrasts with human emissions (an additional 29 gigatonnes, or 3.76% of the gross amount). Land and oceanic natural absorption is actually (450 gigatonnes per annum and 338 respectively) than natural emissions.**

*** GHGs can be evaluated according to their atmospheric lifetime generating persistent effects after emission.**

*** About 50% of a CO2 increase will be removed from the atmosphere within 30 years, and a further 30% will be removed within a few *centuries*. Methane has an average atmospheric lifespan of around 12 years, but a a global warming potential (GWP) 84 times greater than CO2 in a 20-year time frame.**

*** The following figures illustrate various changes in contemporary climate; (a) the CO2 levels with both proxy and observational data since the beginning of the Holocene epoch (b) instrument records of temperature increase since 1850 (c) temperature increase of the last 2,000 years using proxies and instrument record.**

Human Activity and Projections

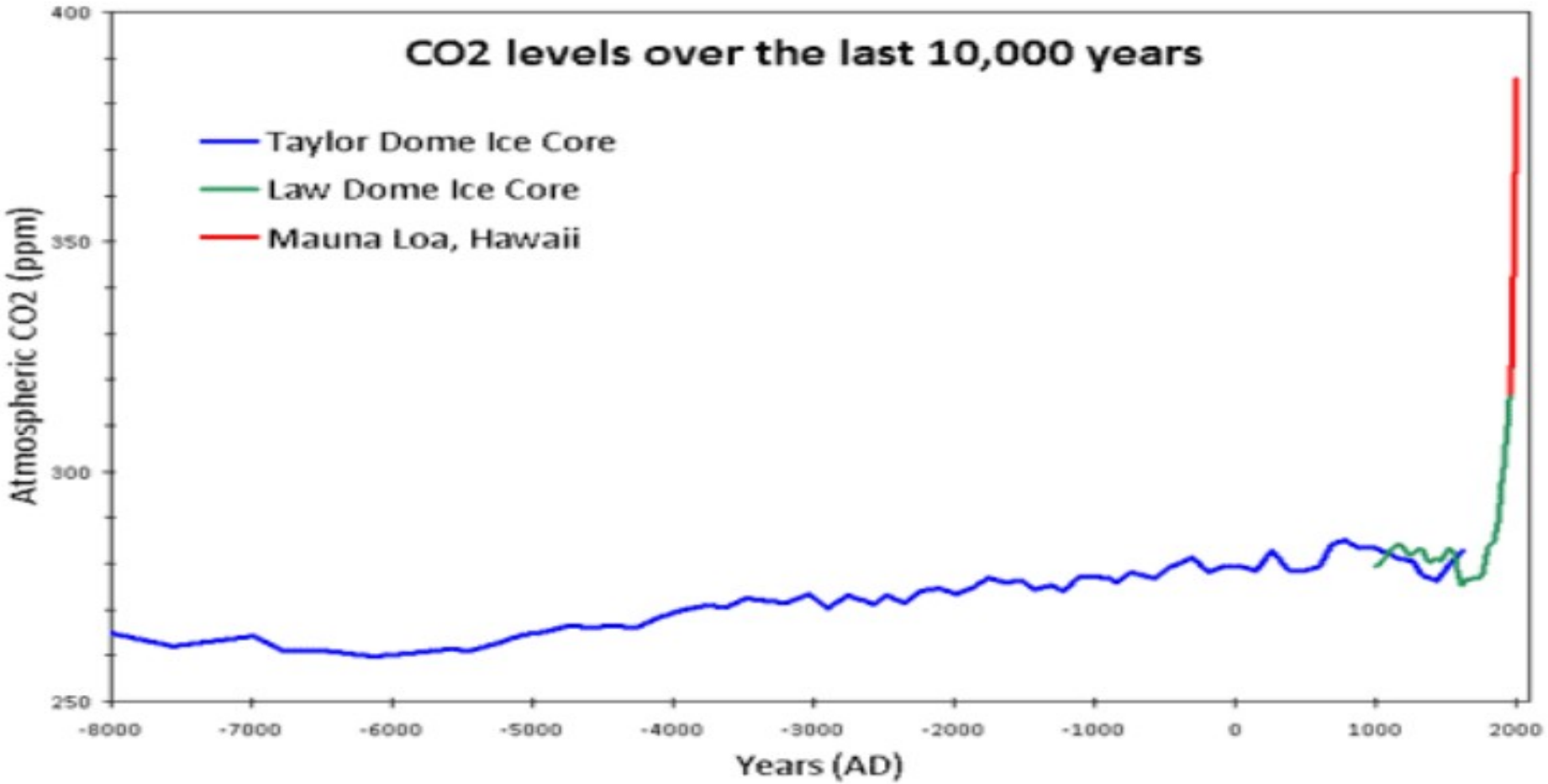


Figure 3: CO2 levels (parts per million) over the past 10,000 years. Blue line from ice cores at Taylor Dome, Antarctica (NOAA). Green line derived from ice cores obtained at Law Dome, East Antarctica (CDIAC). Red line from direct measurements at Mauna Loa, Hawaii (NOAA).

Human Activity and Projections

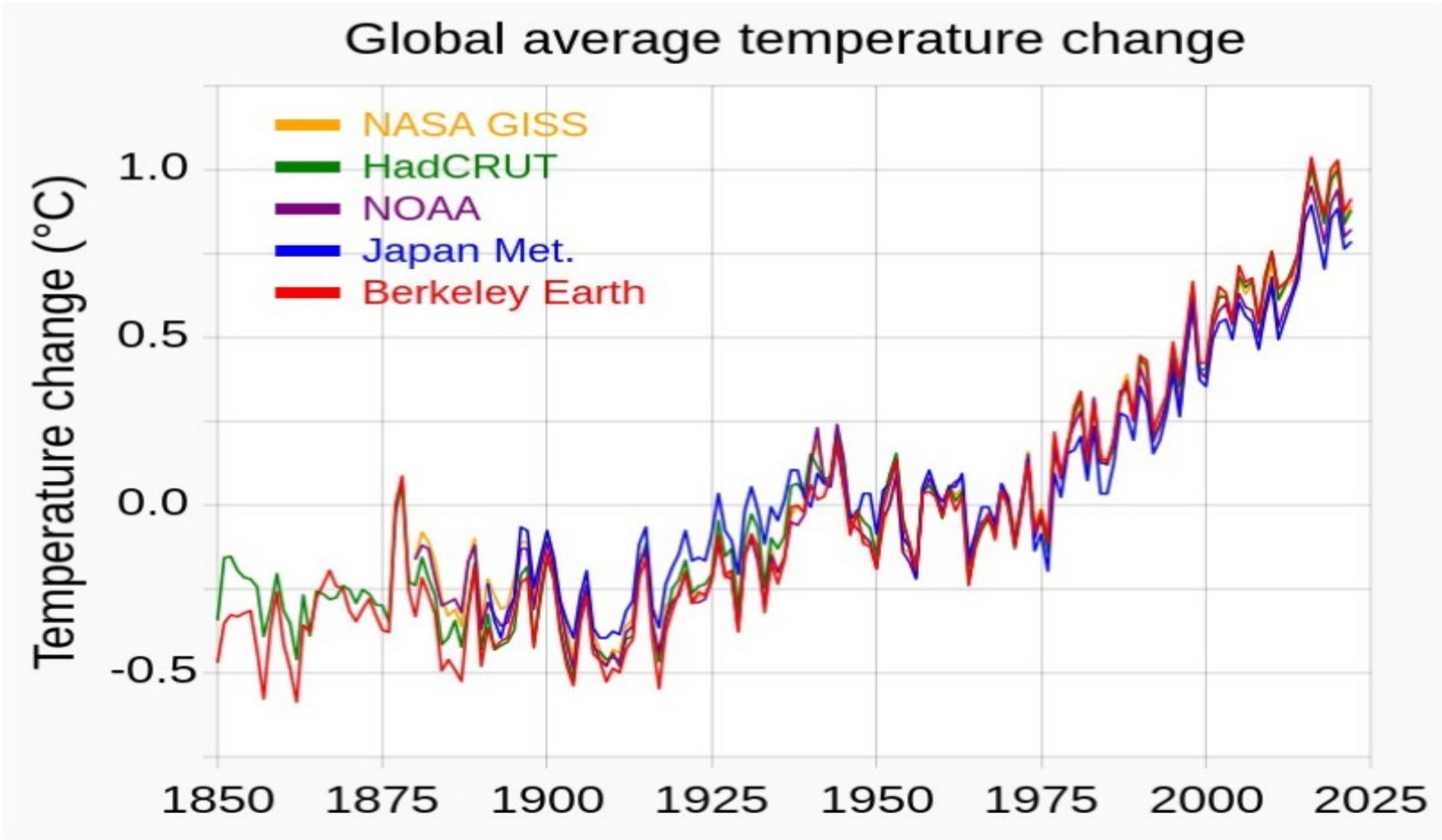


Figure 4: Graphs of instrument record datasets from five scientific organizations. Adjusted, if needed, to a common reference/base period 1951-1980. By RCraig09, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=88535596

Human Activity and Projections

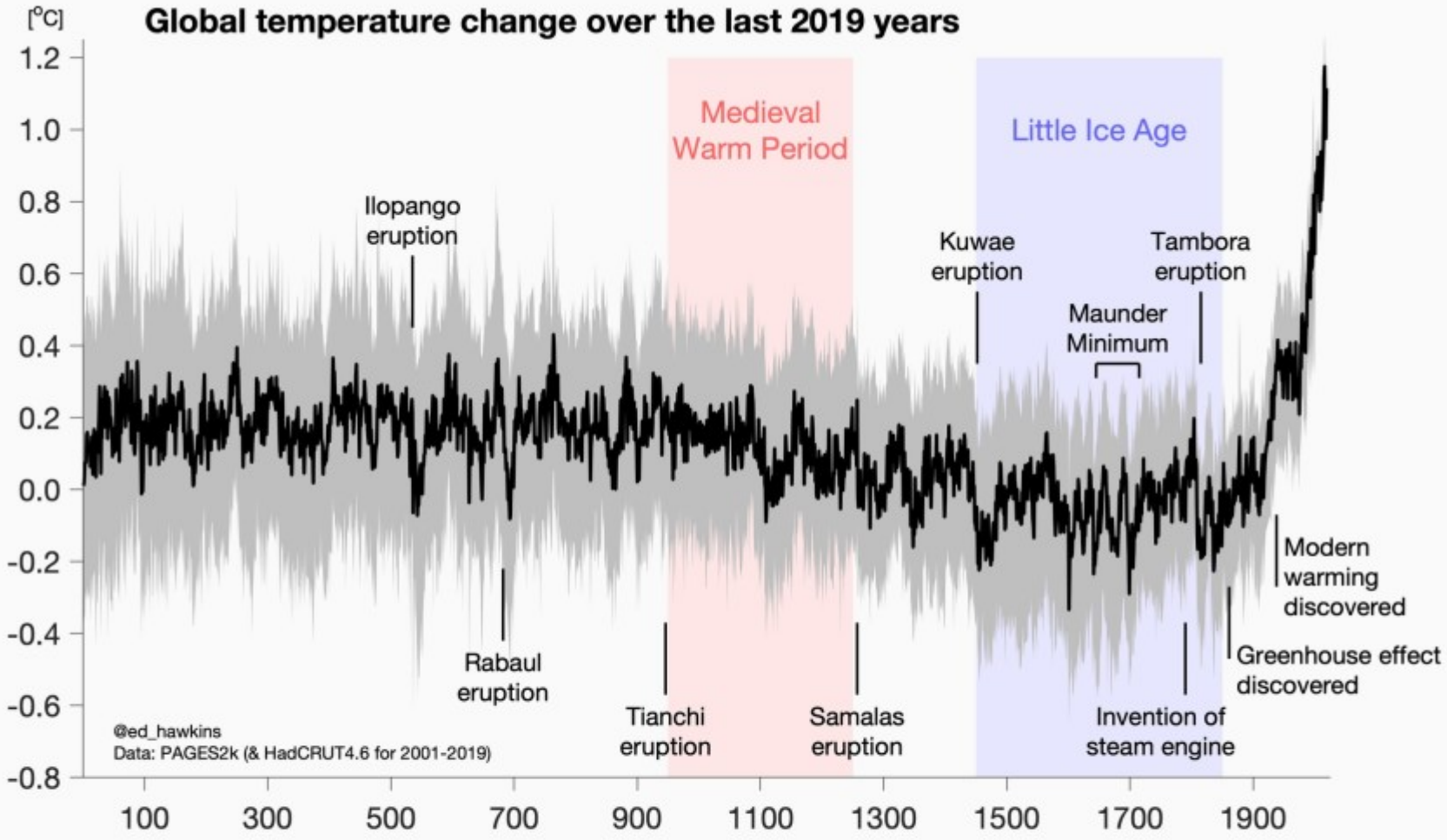


Figure 5: Global average temperatures. Dervied and elaborated from Hawkins, (https://www.climate-lab-book.ac.uk/2020/2019-years) By RCraig09, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=87832845

Anthropocene Extinction Event

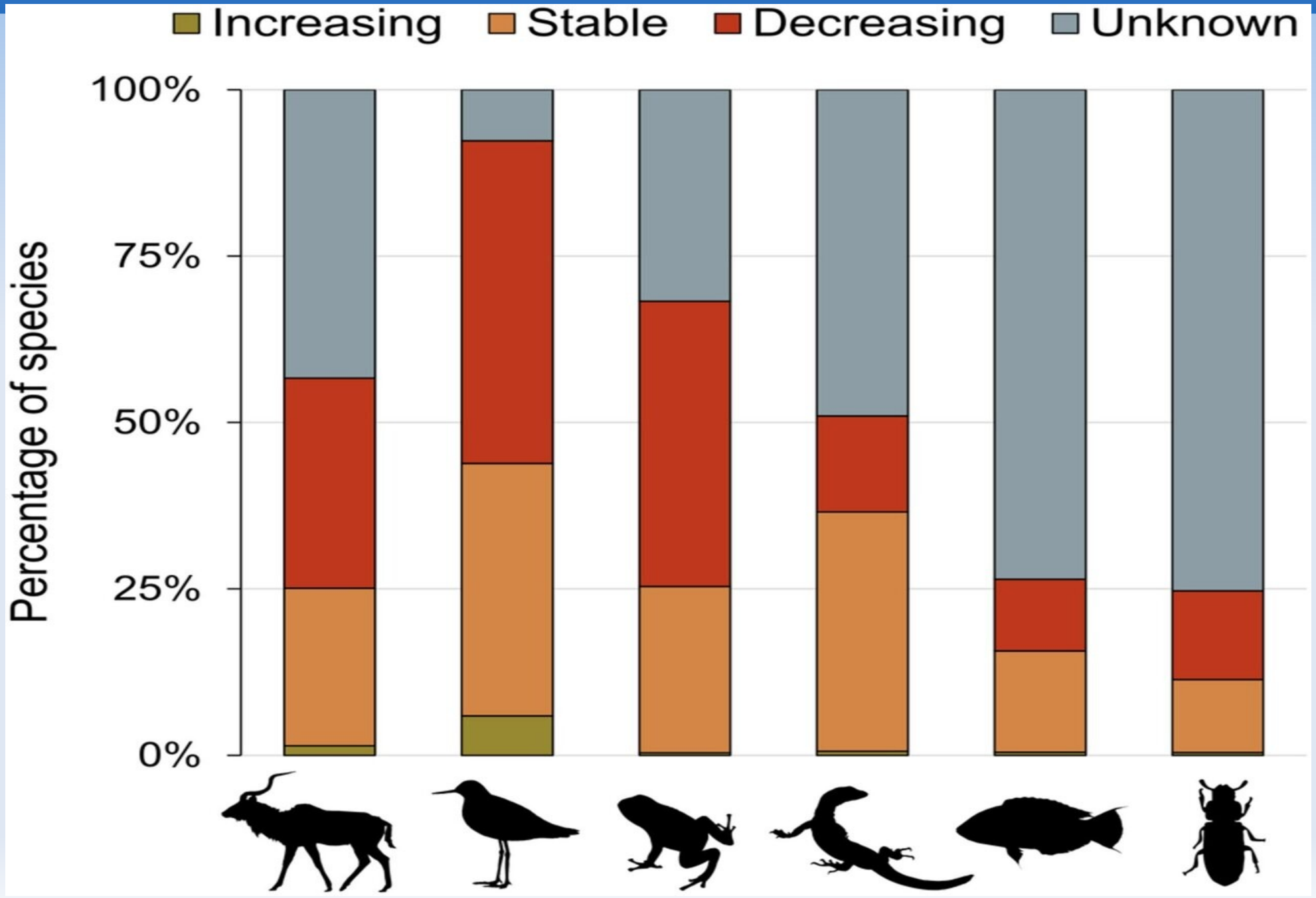
*** Palaeontology identifies five mass extinction events in the fossil record. Among known species it is possible to calculate extinctions per million species-years (E/MSY).**

*** Even given incomplete taxonomic knowledge, "extinction rates are likely a thousand times higher than the background rate of 0.1 E/MSY", primarily the result of changes to biogeography. Current extinction rates are calculated at 1000 times the natural rate with future rates likely to reach 10000 times higher.**

*** However, extinctions in the fossil record occur as pulses rather than within intervals characterised by the background rate. The Late Pleistocene stage is already highly anomalous in terms of an extremely short duration and high genus extinction.**

*** These accelerated extinction rates closely correspond to the rise of industrial society and the accelerated rate of human development and impact on the environment. In 1700 CE, approximately 50% of the terrestrial biosphere was wild and with an additional 45% in a seminatural state. By 2000 CE, 55% had become agricultural and settled anthromes, less than 20% seminatural and only 25% left wild.**

Anthropocene Extinction Event



Global Energy Trajectories

*** The main contributors to GHG emissions by activity include energy production (75.7%), agriculture (11.7%), industrial processes (6.5%), waste (3.4%), land-use change (2.7%). Global energy production has increased from a total of 22,869TWh in 1940 to 186,383TWh in 2024**

*** Correlating the industrial source of GHG emissions with activities allows for consideration of viable renewable energy alternatives. The significant GHG emissions through transportation can be reduced through electric vehicles, mass transit, and urban design.**

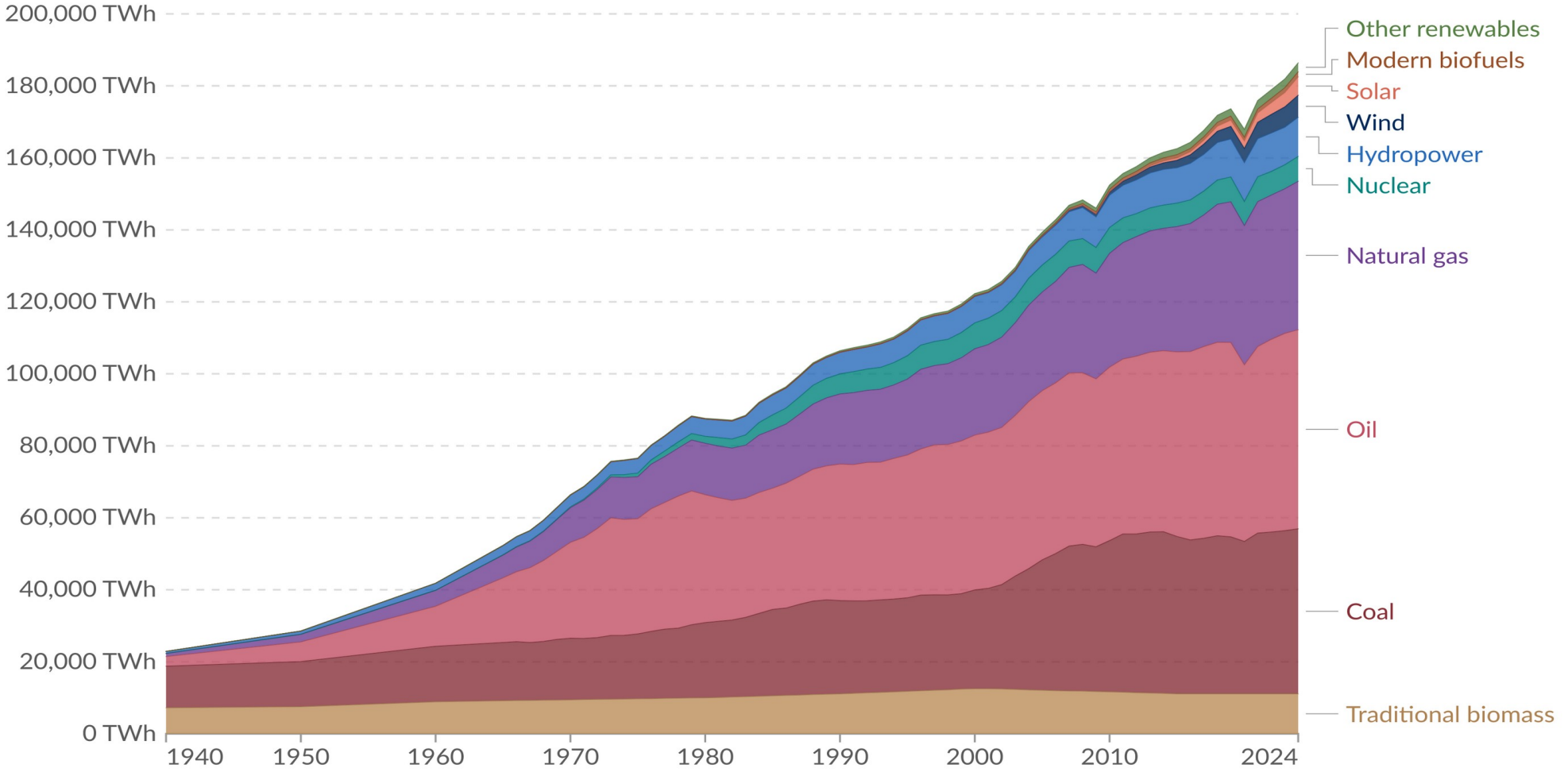
*** Without a transition to renewable energy, the concentration of CO2 in the atmosphere, currently at 440ppm, would increase to to c700pm by 2100, and global warming increasing to 3.5 to 4.0 degrees higher than pre-industrial levels.**

*** Whilst somewhat outside of the scope of pure climatological considerations, but certainly within environmental considerations, is the question of production safety of energy, using the grim metric of live's lost per terrawatt hour (TWh) of energy produced. Coal and oil are especially bad, hydropower, wind, nuclear are much better.**

Global Energy Trajectories

Global primary energy consumption by source

Primary energy is based on the substitution method and measured in terawatt-hours.



Data source: Energy Institute - Statistical Review of World Energy (2025); Smil (2017)

OurWorldinData.org/energy | CC BY

Note: In the absence of more recent data, traditional biomass is assumed constant since 2015.

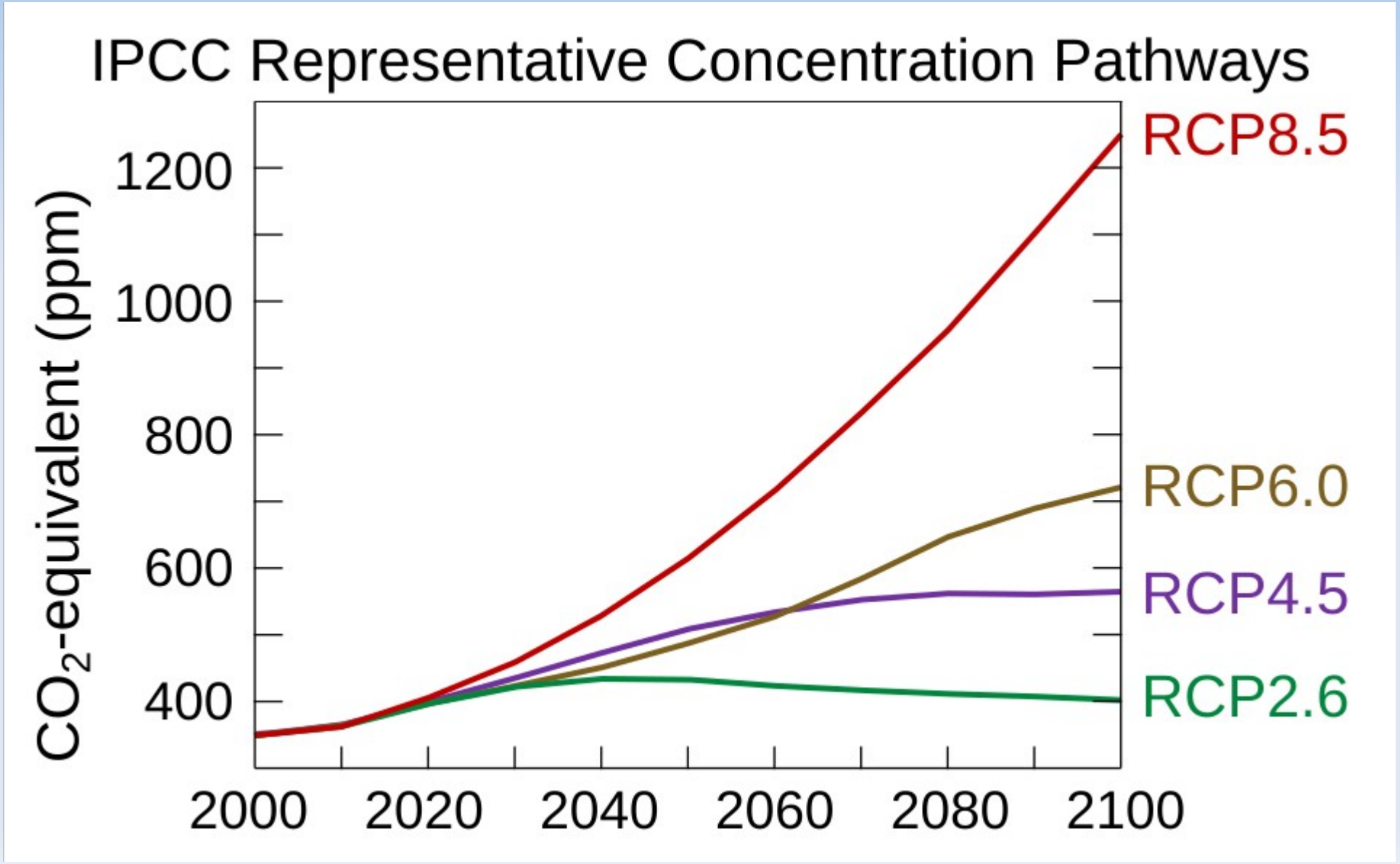
RCPs and SEPs

*** Representative Concentration Pathways are climate change scenarios that described future greenhouse gas concentrations that correlate with expected temperature increases. Four RCPs, originally described as RCP2.6, RCP4.5, RCP6, and RCP8.5 represent changes in radiative forcing in Watts per metre squared from 1750 to 2100.**

*** The RCPs project with RCP2.6 a mean of 0.40 and a range of 0.26 to 0.55 in metres by 2100, with RCP4.5 a mean 0.47 and range of 0.32 to 0.63. With RCP6 it is 0.48 for the mean and 0.33 to 0.63 for the range, for RCP8.5 0.63 for the mean and 0.45 to 0.82 for the range.**

*** Five major Shared Socioeconomic Pathways are described. The first (SSP1) suggests a sustainable path with inclusive development within environmental boundaries and a much higher level of international and national economic equality that emphasises human well-being over material wealth.**

RCPs and SEPs



RCPs and SEPs

Critical Issues: Concluding Remarks

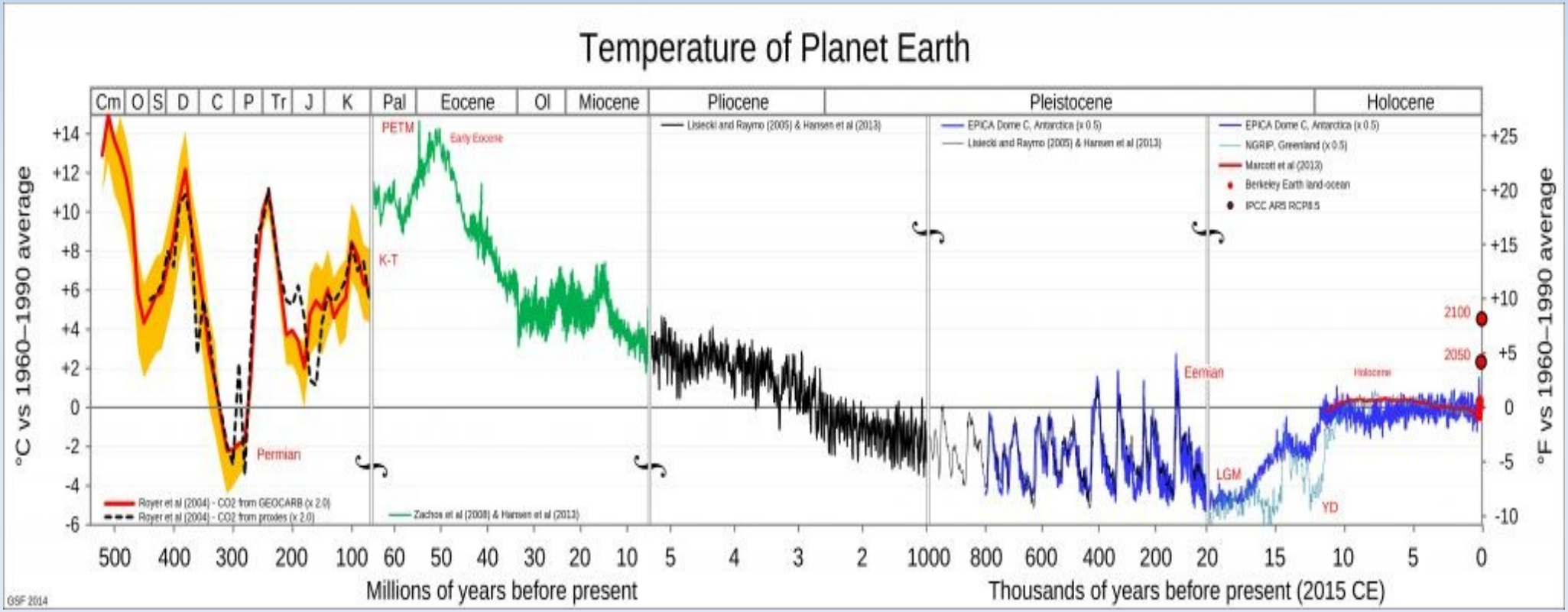
*** Critical means dealing with those issues that seek to identify a crisis, the ability of a system (e.g., ecosystem) to survive.**

*** Race conditions include the total CO2 and other GHG emissions as one vector with with the adoption of renewable technologies, carbon sequestration approaches (such as forestry), population stabilisation, economic development, whether the global political system will be able to introduce sustainable policies (not a good track record).**

*** The most likely scenarios is that the Earth is almost certain to surpass the 1.5°C warming threshold above pre-industrial levels within the next decade and to to stay below 1.5°C is unattainable without improbable massive GHG reductions. Current and pledged policies indicates warming by 2.2°C to 3°C above pre-industrial temperatures by 2100, but much more likely at the upper end of the scale if not higher.**

*** This entire matter not just a "critical issue" but also a "wicked problem" - but one which is essential for our species, our ecosystem, and our welfare.**

Critical Issues: Concluding Remarks




THANKS FOR WATCHING
& LISTENING PATIENTLY
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