Tipping Points in Climate Change Science & Solutions

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Outline

- Human-caused climate change
- Potential tipping points in the Climate System
- Climate solutions through ‘positive tipping’
- The challenge for food production and catering

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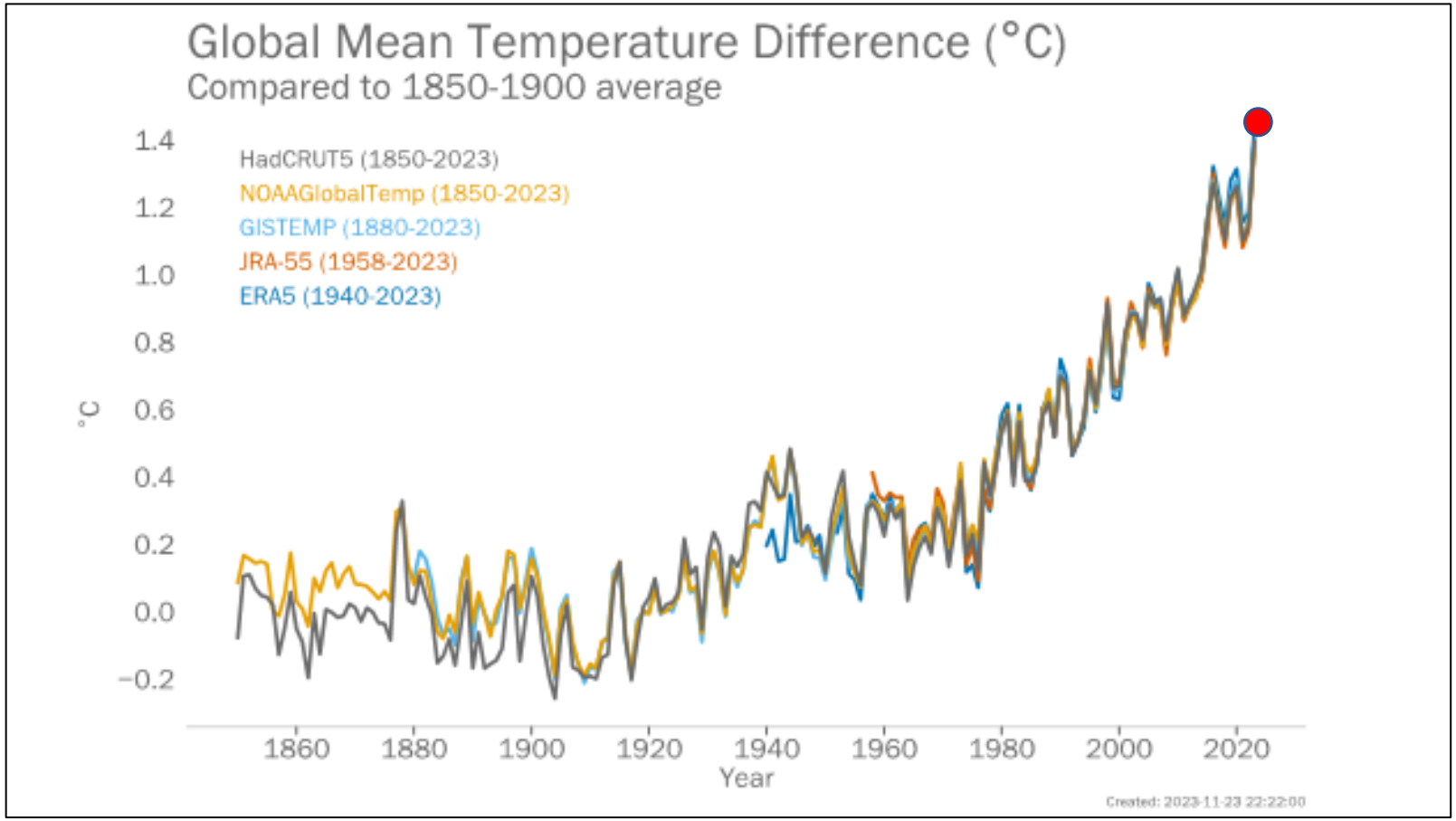
Human-caused climate change

Evidence of Global Warming



Warmest years on record (hottest first):

2023, 2016, 2020, 2019, 2017, 2015, 2022, 2018, 2021

https://wmo.int/news/media-centre/2023-shatters-climate-records-major-impacts

..but the underpinning science that came long before…..

1827: Joseph Fourier describes the ‘greenhouse effect’ (but in much more flowery words…).

1856: Eunice Foote demonstrates the heat-trapping properties of carbon dioxide**.**

1863: John Tyndall publishes a paper describing water vapour as a greenhouse gas.

1896: Svante Arrhenius considers the problems that might be caused by carbon dioxide building up in the atmosphere

Svante Arrhenius's 1896 Paper

THE LONDON, EDINBURGH AND DUBLIN
PHILOSOPHICAL MAGAZINE
AND JOURNAL OF SCIENCE

[FIFTH SERIES APRIL 1896]

XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS*.

1. Introduction: Observations of Langley on Atmospherical Absorption.

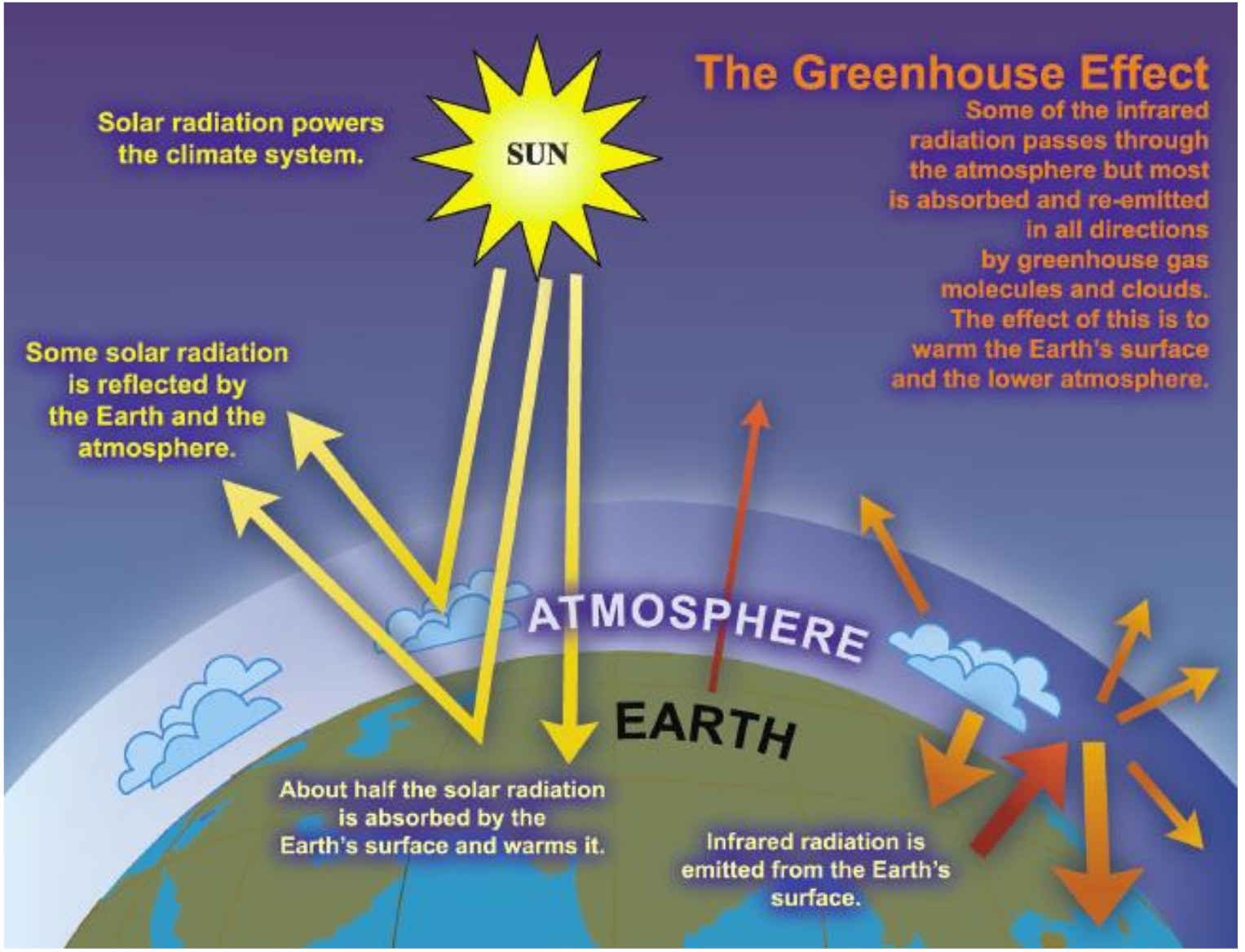
A GREAT deal has been written on the influence of the absorption of the atmosphere upon the climate. Tyndall † in particular has pointed out the enormous importance of this question. To him it was chiefly the diurnal and annual variations of temperature that were lessened by this circumstance. Another side of the question, that has long attracted the attention of physicists, is this: Is the mean temperature of the ground in any way influenced by the presence of heat-absorbing gases in the atmosphere? Fourier ‡ maintained that the atmosphere acts like the glass in a hot house, because it lets through the light rays of the sun but retains the dark rays from the ground. This idea was elaborated by Pouillet §; and Langley was by some of his researches led to the view, that 'the temperature of the earth under direct sunshine, even though our atmosphere were present as now, would probably fall to – 200 °C., if that atmosphere did not possess the

* Extract from a paper presented to the Royal Swedish Academy of Sciences, 11th December 1895. Communicated by the Author.

† "Heat a mode of motion," 2nd ed. p.405 (Lond.,1865).
‡ *Mem. de l'Ac. R. d. Sci. de l'Inst. de France,* t. vii. 1827.
§ *Compress rendus,* t. vii. p41 (1838).

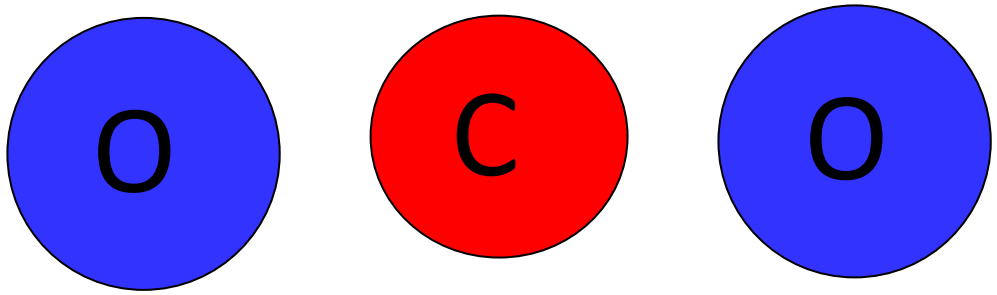
Phil. Mag. S. 5. Vol. 41. No. 251. April 1896 S

The Greenhouse Effect



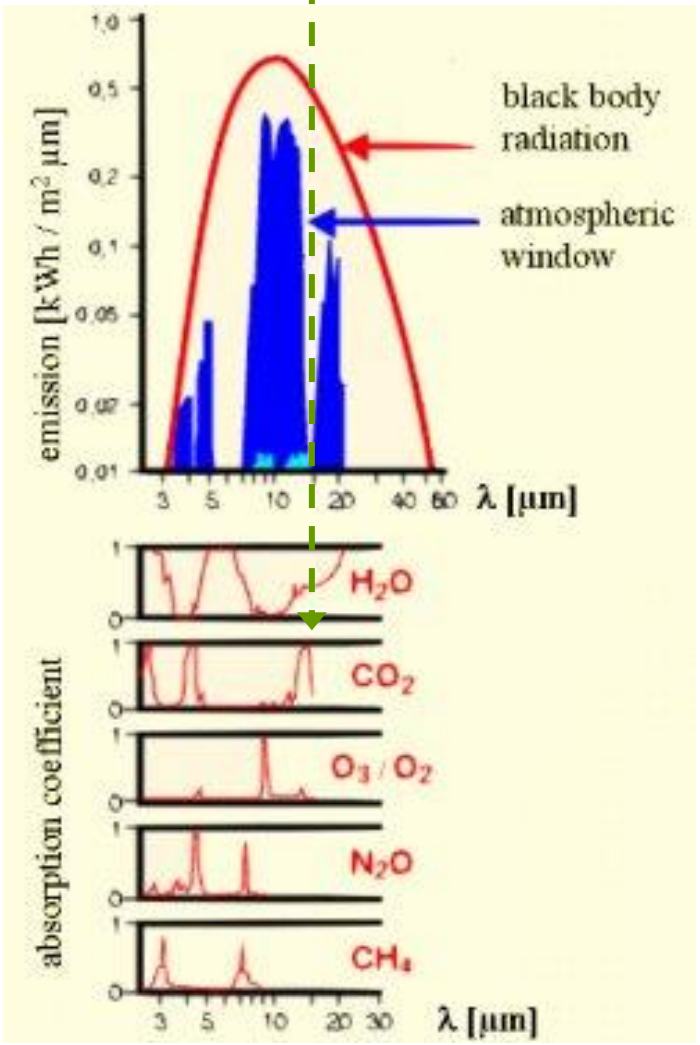
IPCC, 2007

CO_2 Greenhouse Effect at the Molecular Level

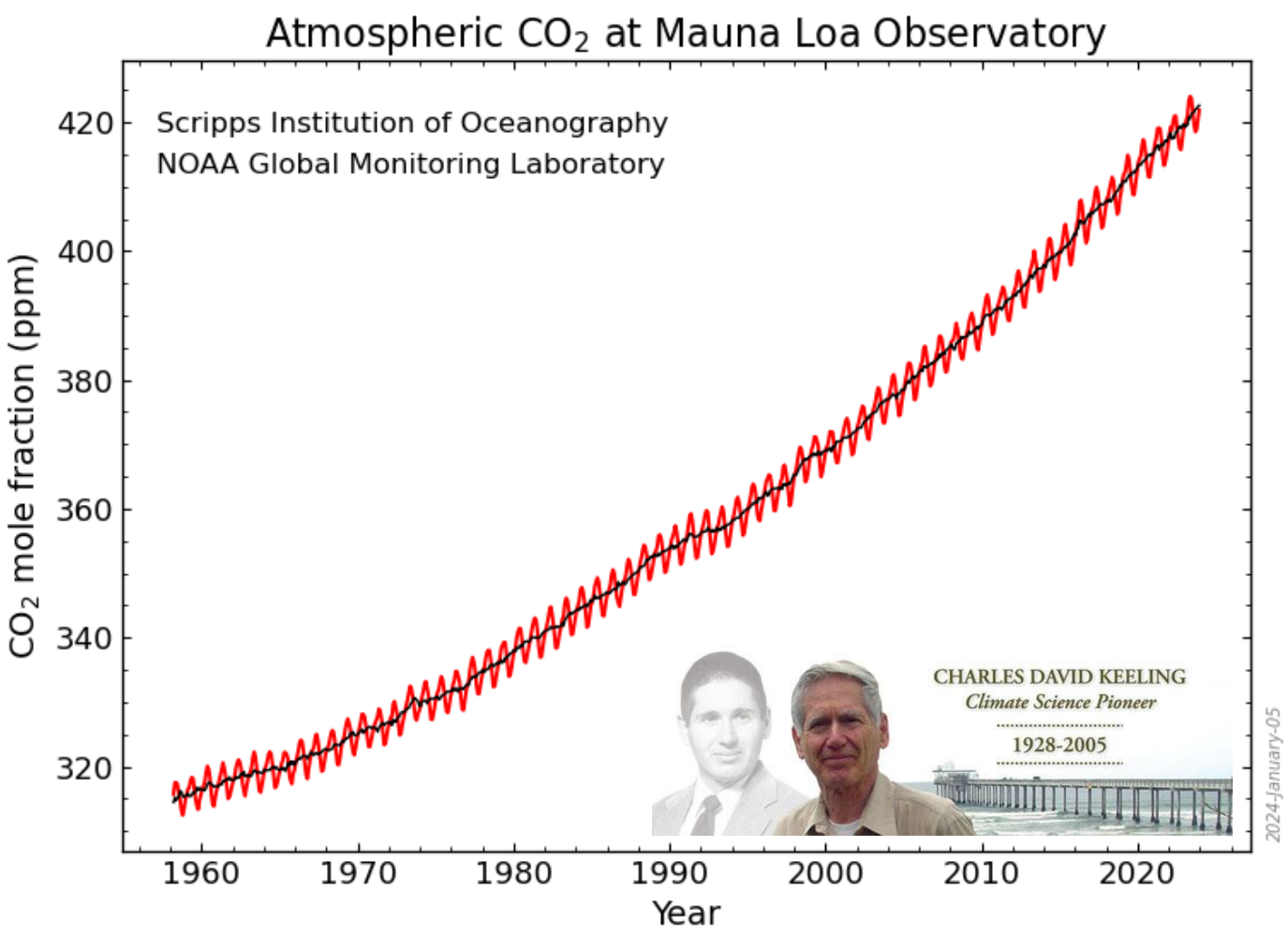


Bending Mode

Absorption by CO_2 Bending-mode at 15 μm



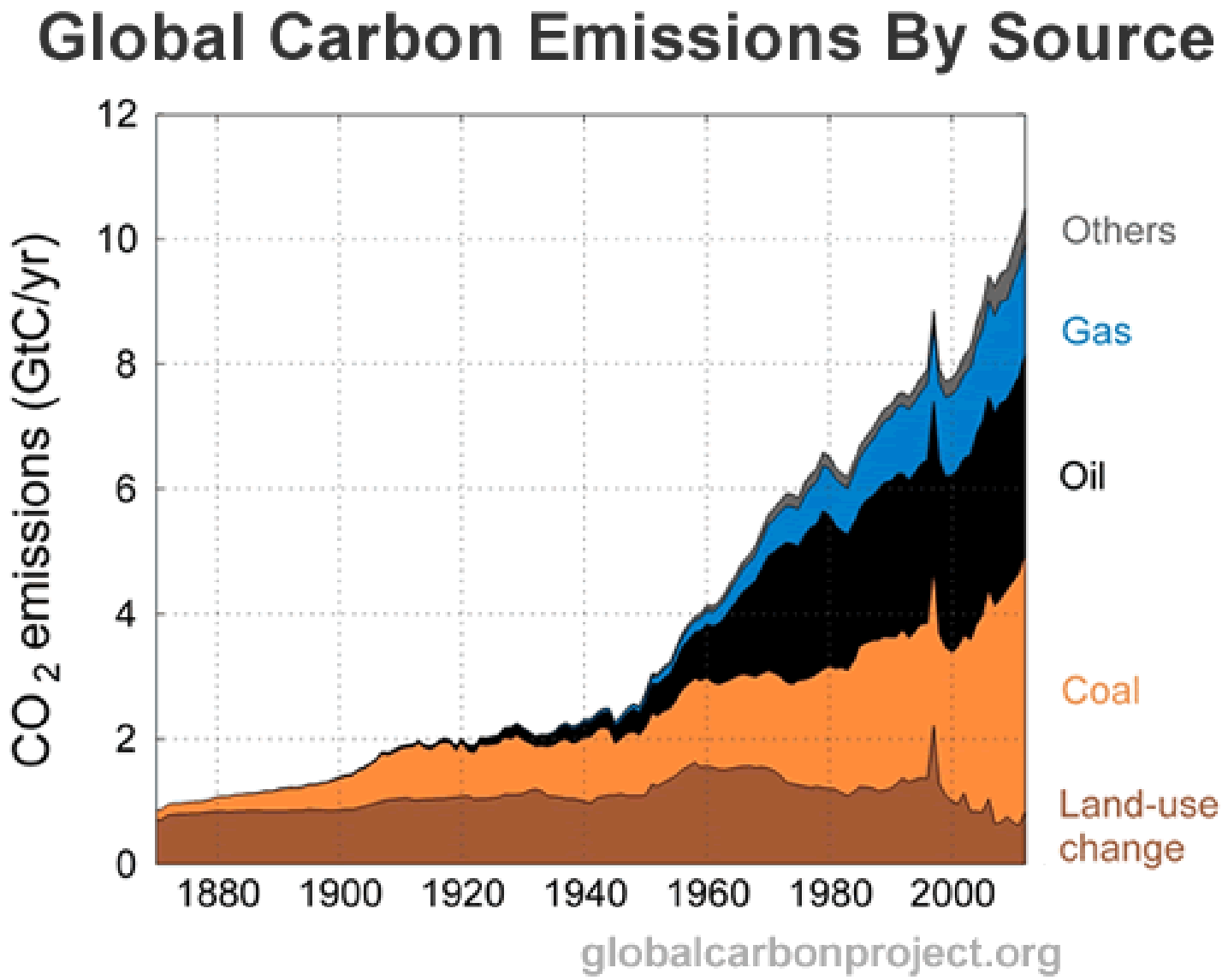
…later the increase in CO_2 was measured….



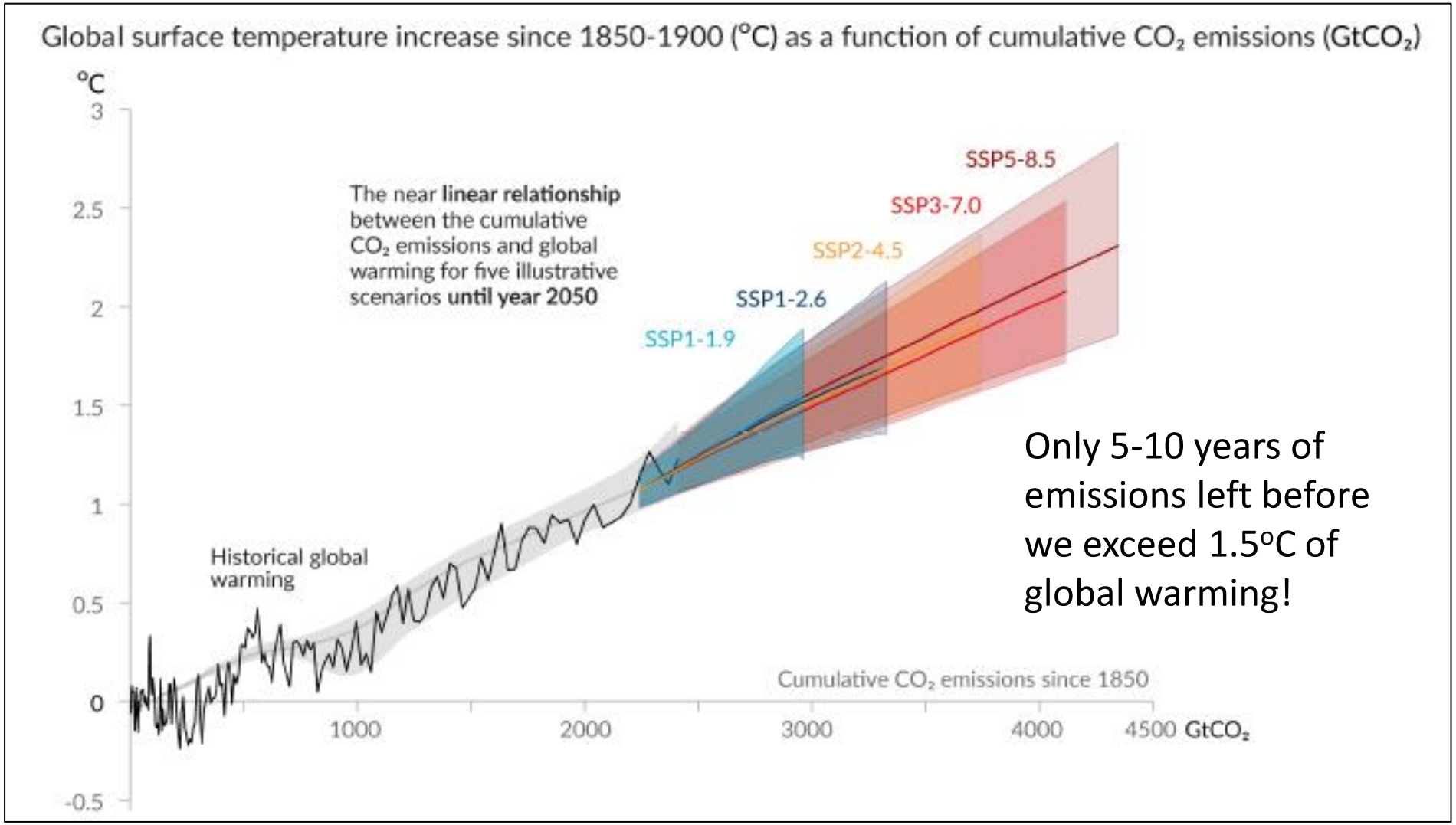
Highest-level for at least 800,000 yrs

CO_2 increase of >60ppmv since human impact was “discernible”...

Anthropogenic CO_2 Emissions – *the main reason for climate change*



Long-term Global Warming is determined primarily by cumulative CO_2 emissions – *this is where the concept of Net Zero comes from*



Only 5-10 years of emissions left before we exceed 1.5°C of global warming!

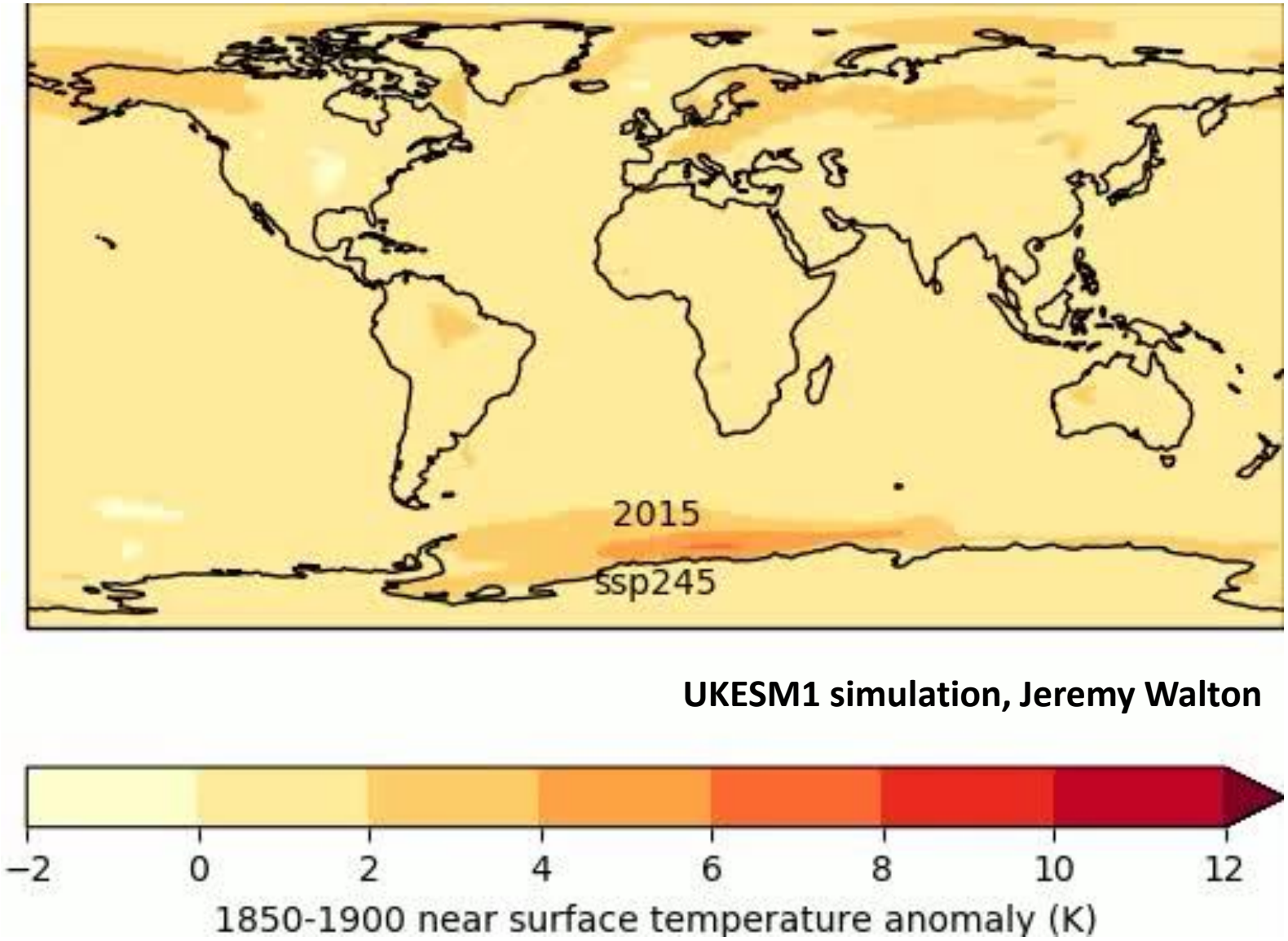
IPCC AR6 WG1, SPM.10

…but other human-caused emissions also play a major role in global warming….

Chemical Species	**Main Sources**
Carbon dioxide	Fossil fuels, land use changes
Methane	Wetlands, Rice Paddies*, Ruminants*
Nitrous oxide	Agriculture*, Biomass Burning
Sulphate Aerosol	Sulphurous Coal

Key: *Warming; Cooling;* ****Associated with Food Production***

Projected Pattern of Global Warming – *very uneven, more warming over land*



UKESM1 simulation, Jeremy Walton

Potential Tipping Points in the Climate System

What is a Climate Tipping Point?

- **Tipping point:** A critical threshold beyond which a system reorganizes, often abruptly and/or irreversibly. See also *Tipping element*, *Irreversibility* and *Abrupt change*.

- **Tipping element:** A component of the Earth System that is susceptible to a *tipping point*.

IPCC WG1 AR6, Annex VII (Glossary)

"The probability of low-likelihood, high impact outcomes increases with higher global warming levels"

IPCC WG1 AR6, SPM

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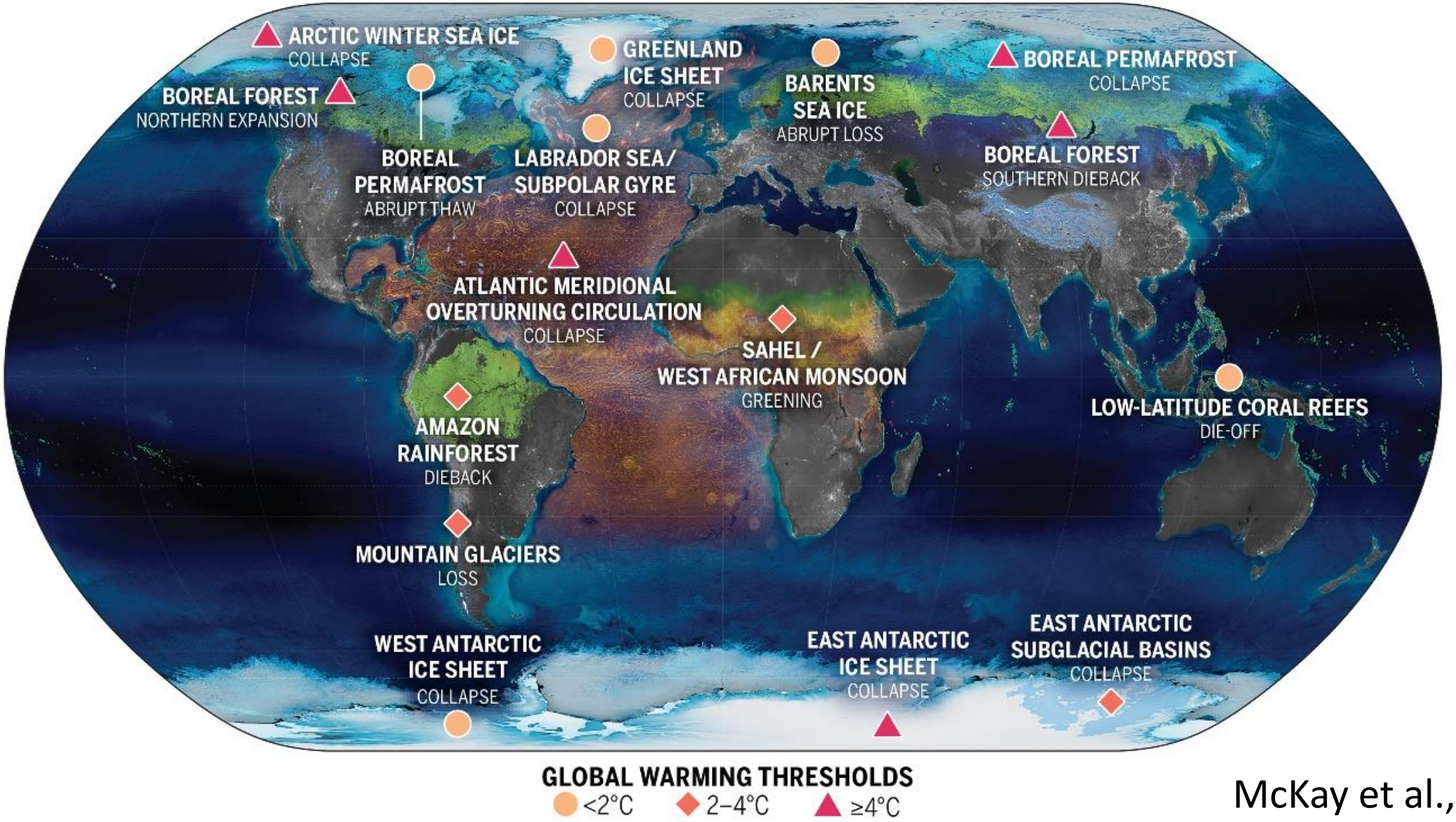
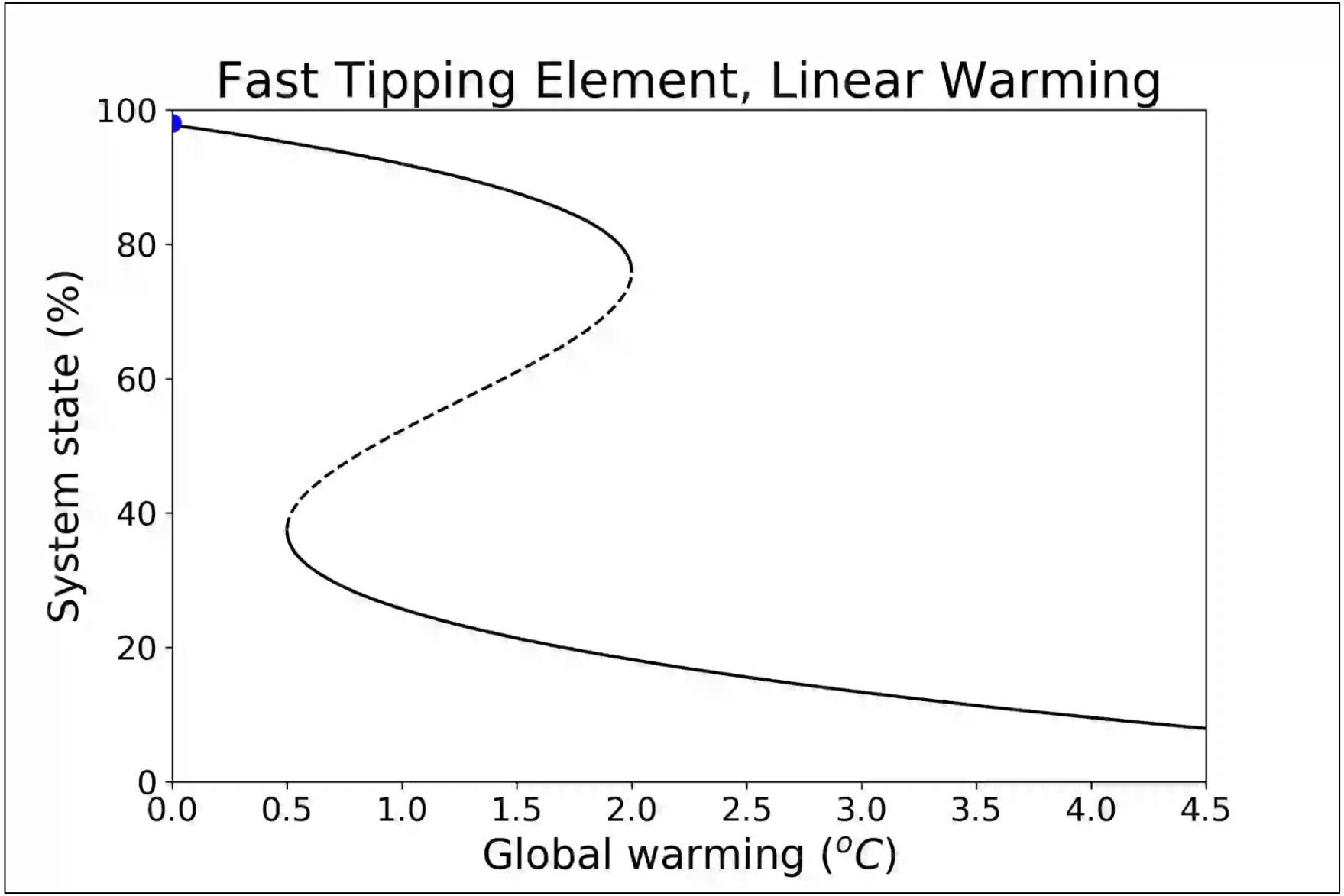
Potential Tipping elements in the Climate System

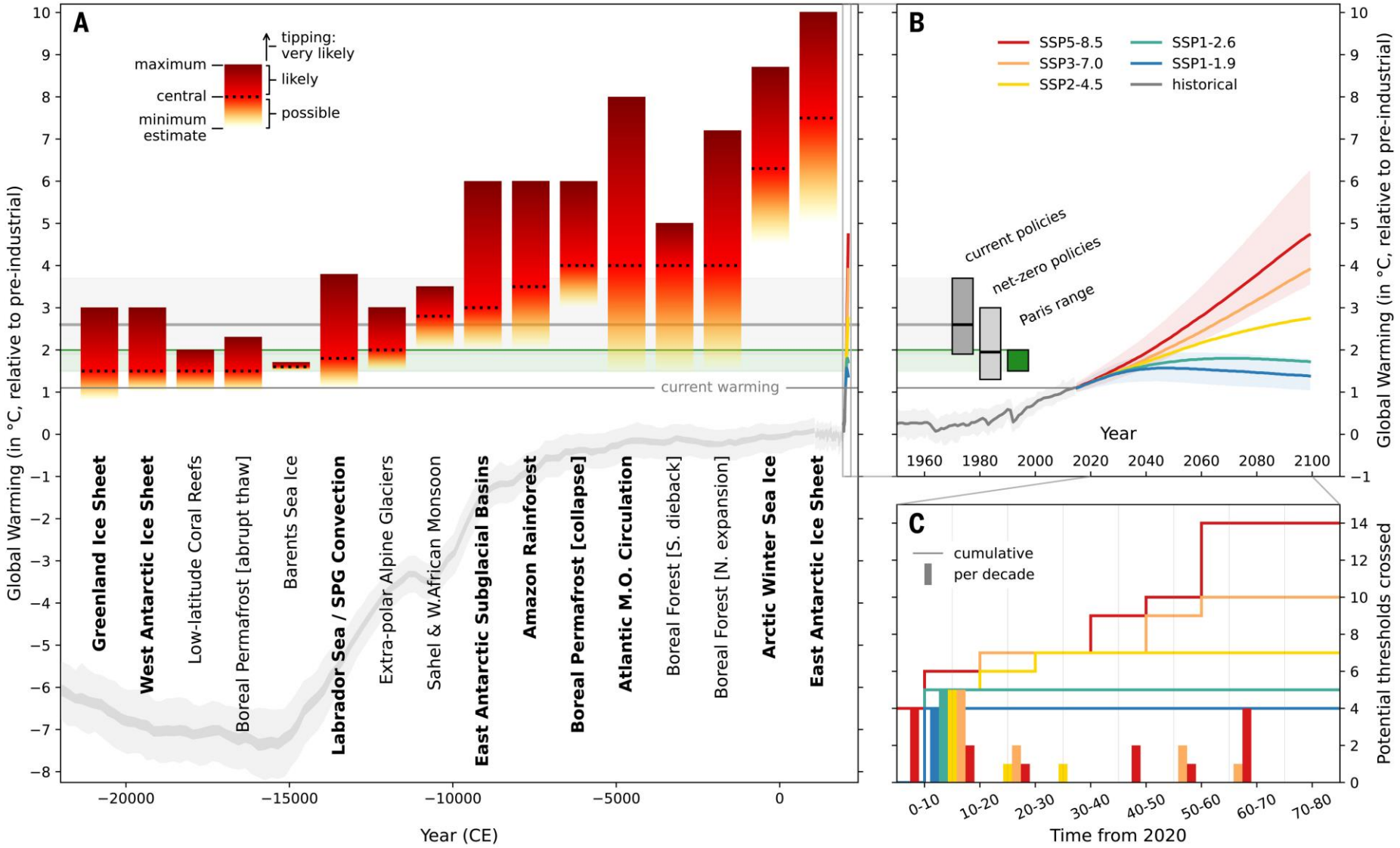


McKay et al., 2022

Archetypal ‘bifurcation’ tipping

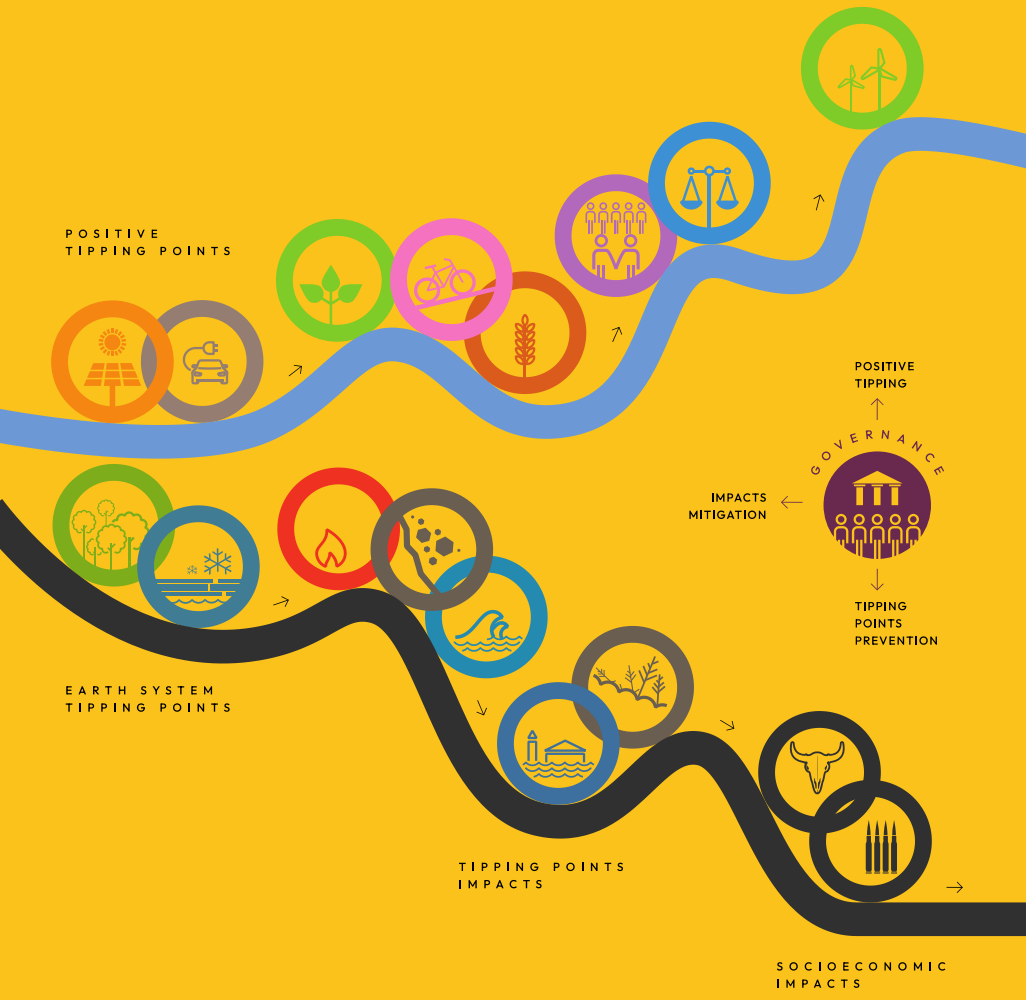


Global Warming Thresholds for Climate Tipping Points



McKay et al., 2022

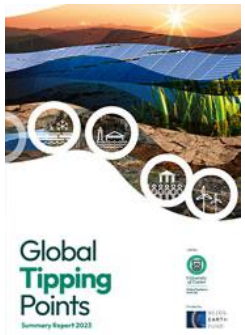
Climate solutions through ‘positive tipping’



Global Tipping Points Report

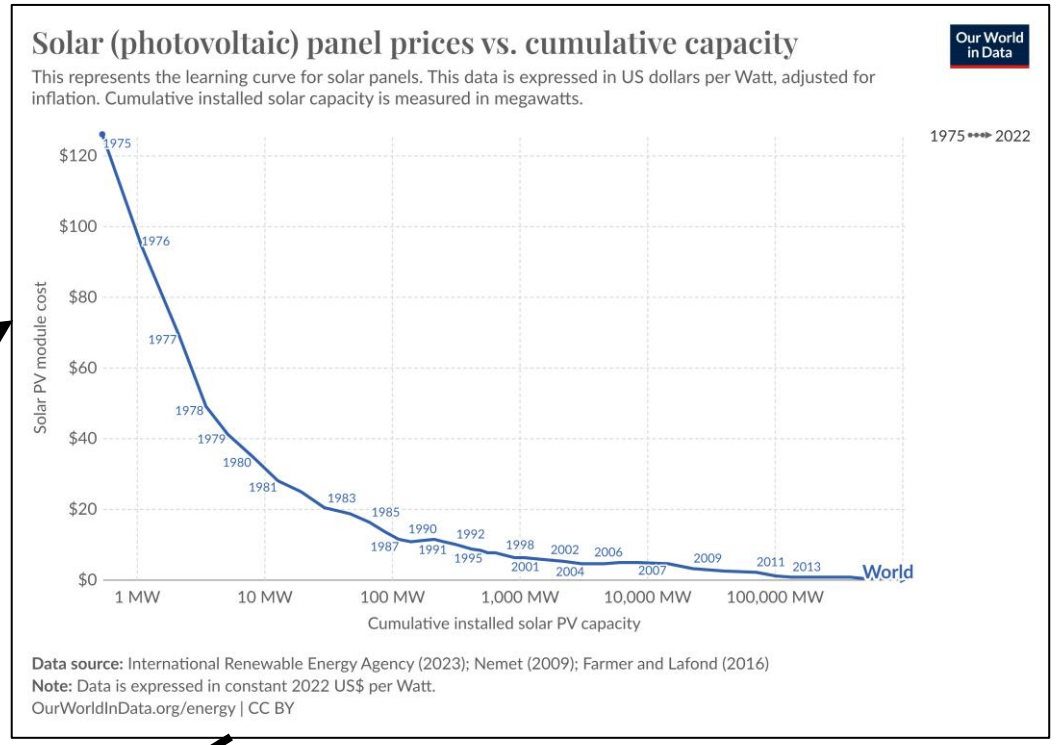
https://global-tipping-points.org/

- *"Negative tipping points are now so close that urgent action needs to be taken to prevent them"*
- *"Beneficial, 'positive' tipping points offer hope for accelerating responses to match this urgency"*
- Positive Tipping Points can arise from strong positive feedbacks, such as economies of scale or abrupt changes in social norms (society is even more non-linear than the natural world!).

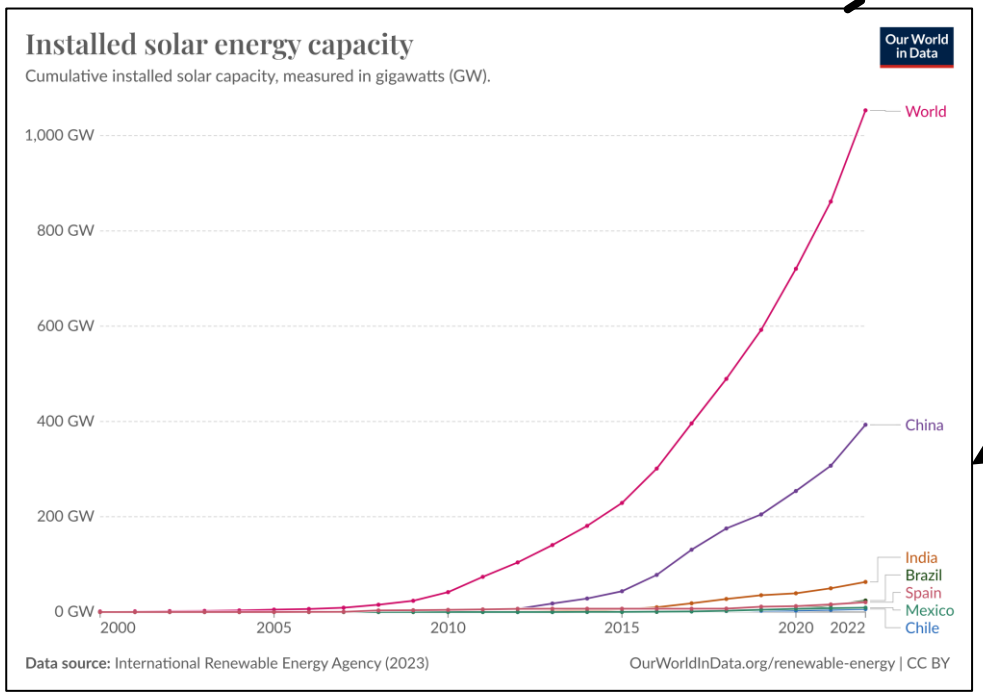


Solar Energy – *Positive Feedback between cost and uuptake*

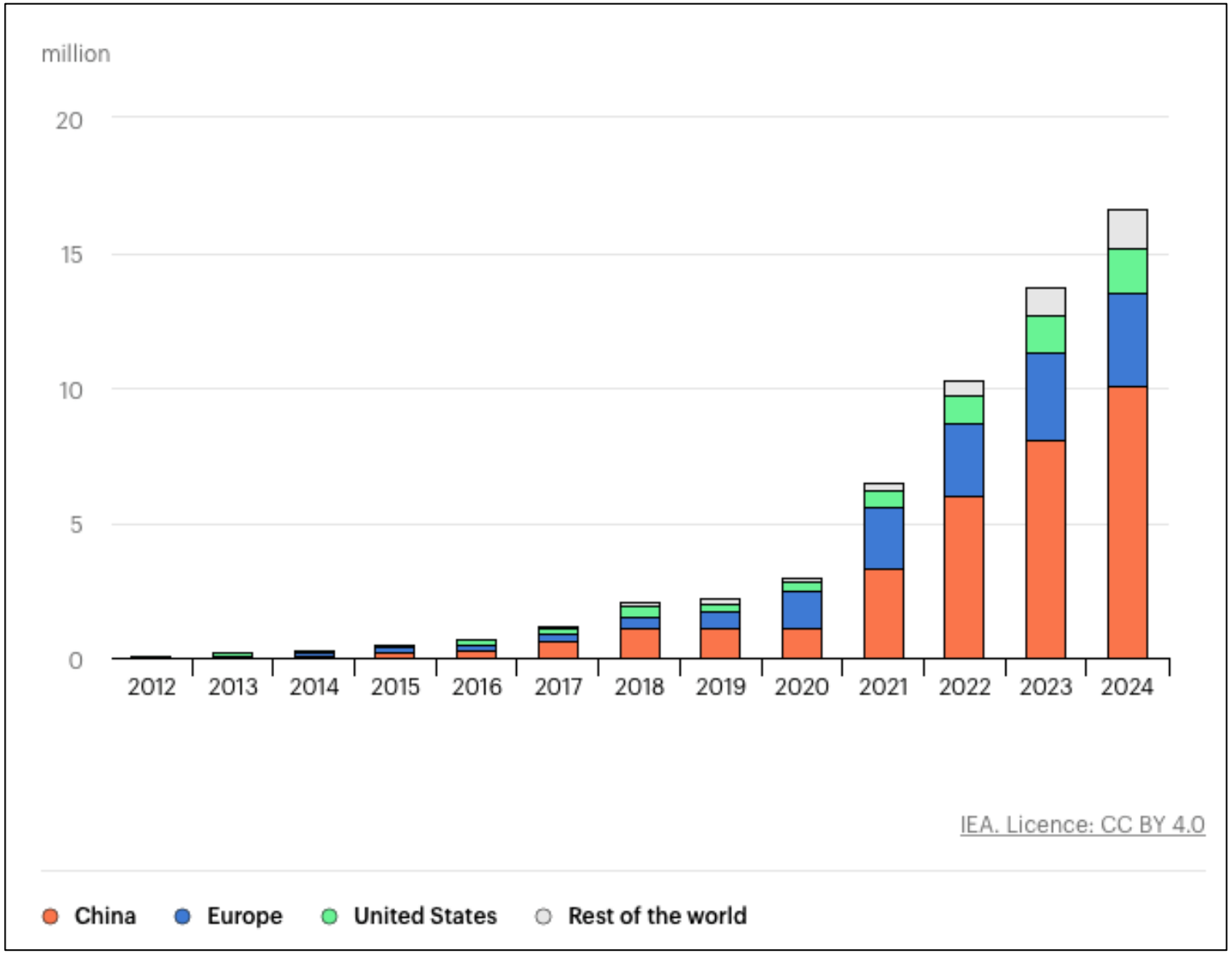
Economy of scale lowers cost



Lower cost increases Uptake



Electric Car Sales 2012-2024 – *a tipping point in action?*

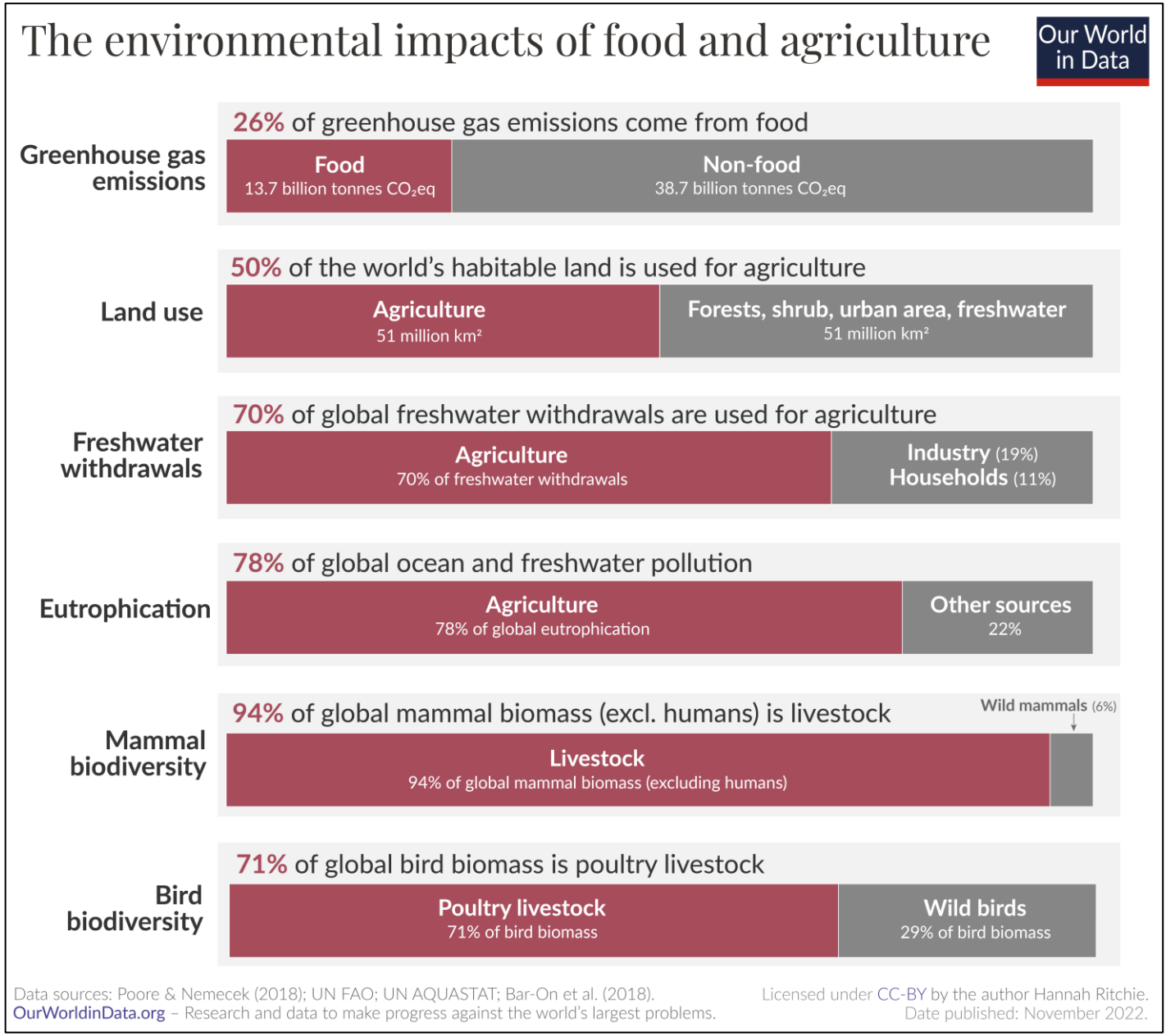


The challenge for food production and catering

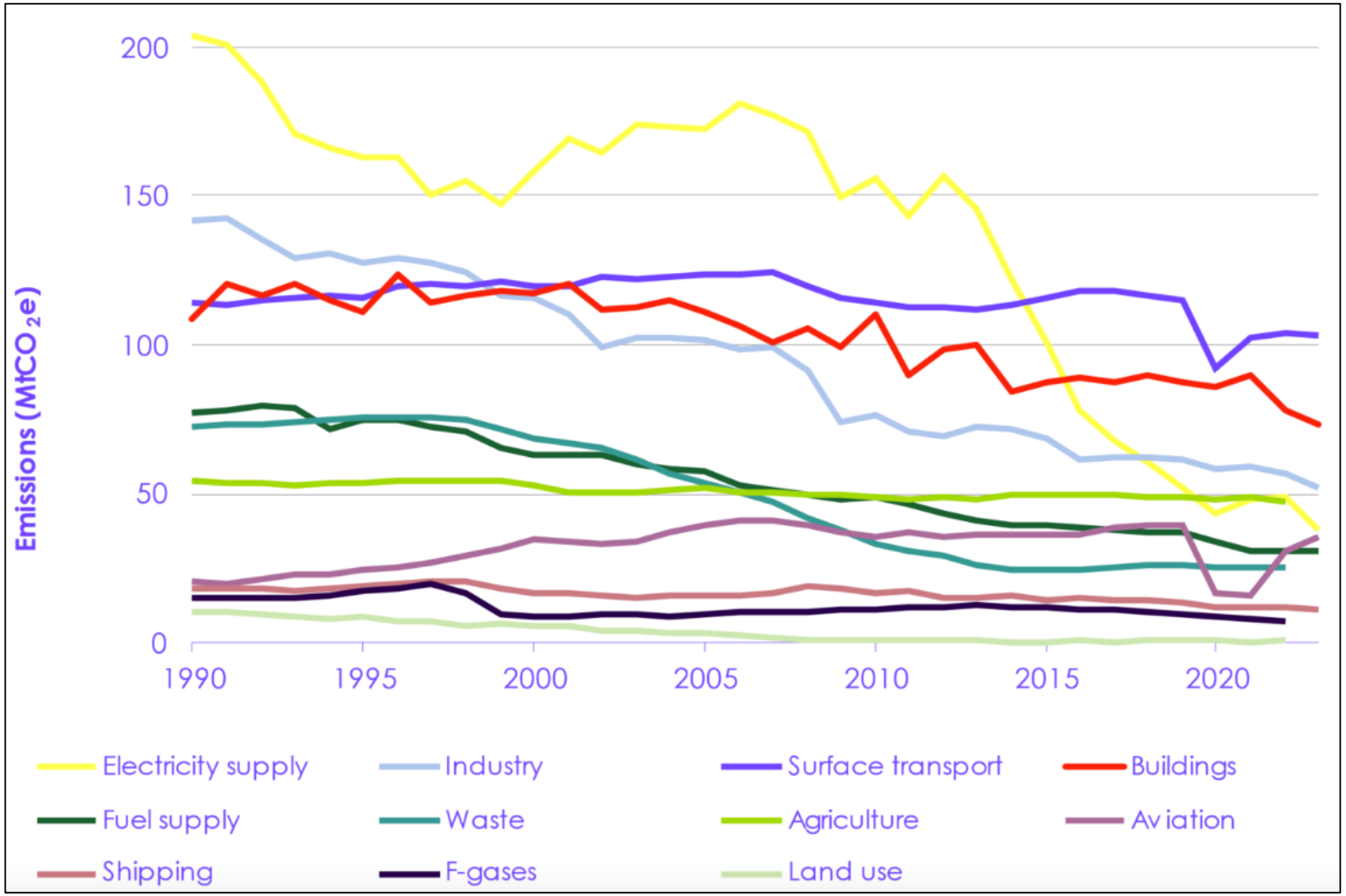
Global Environmental Impacts of Food and Agriculture

(Hannah Ritchie, Our World in Data)

Greenhouse gas emissions associated with Food production account for a quarter of Global GHG Emissions



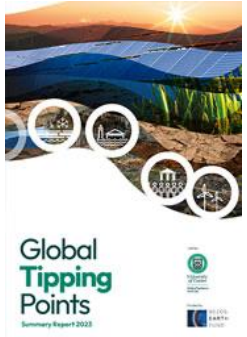
UK GHG Emissions – *Agriculture emissions now larger than Electricity Supply!*



UK CCC Report, 2024

Possible Positive Tipping Points for Food & Agriculture

Sector-system	PTP opportunity	Emissions share	Key enabling conditions
Food & Agriculture	**Avoid:** food loss and waste	8%	• Effective policy and regulation • Buy-in from supermarkets • Shifting norms and behaviours
	Shift: more plant-based diets	Up to 12%	• Shifting norms and behaviours, e.g. via public procurement, information • Improved alternatives to animal products, which are competitive on cost with animal products

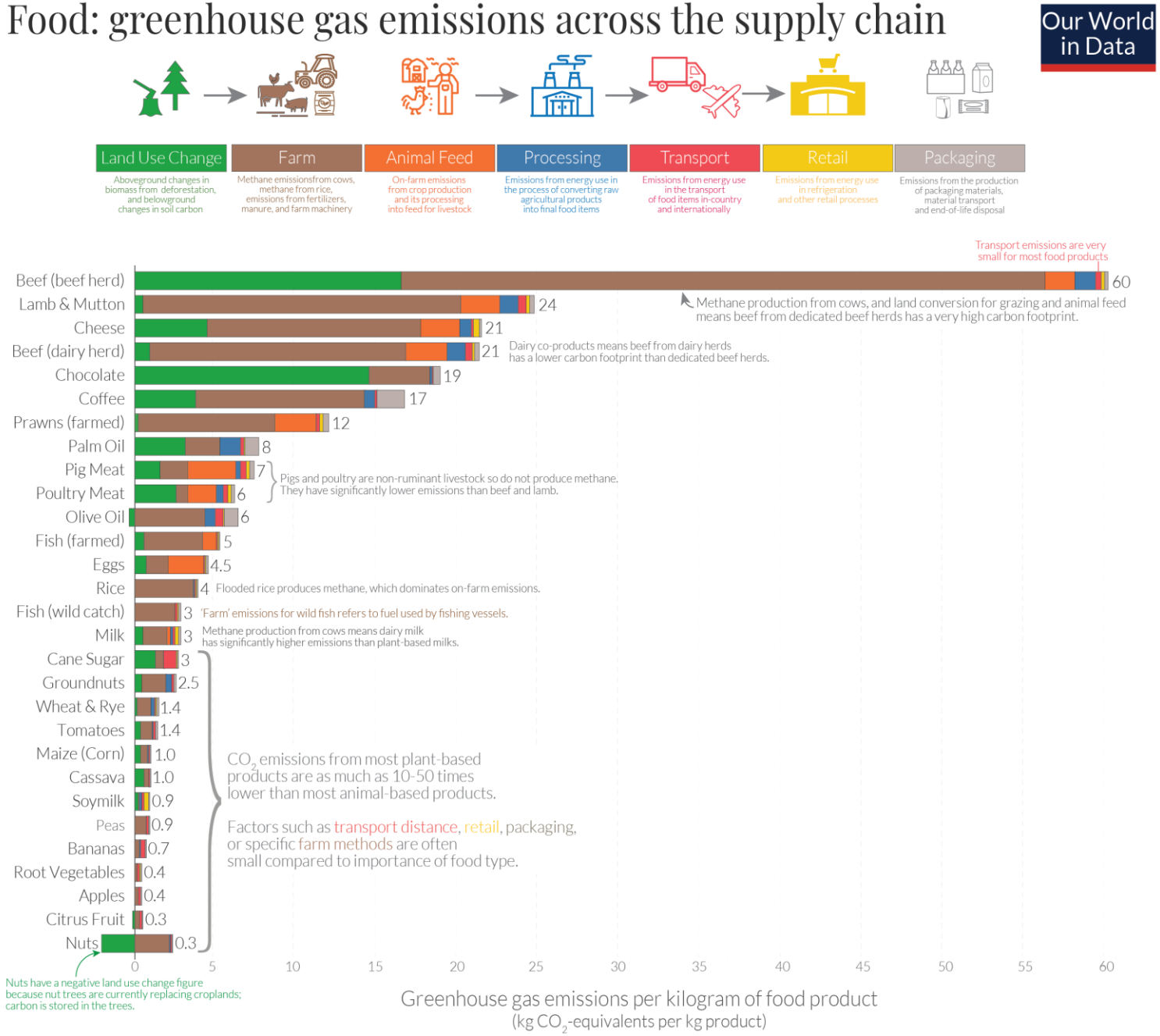


Greenhouse gas emissions per kilogram of each food

(Hannah Ritchie, Our World in Data)

"…emissions from most plant-based products are 10-50 times lower than most animal products"

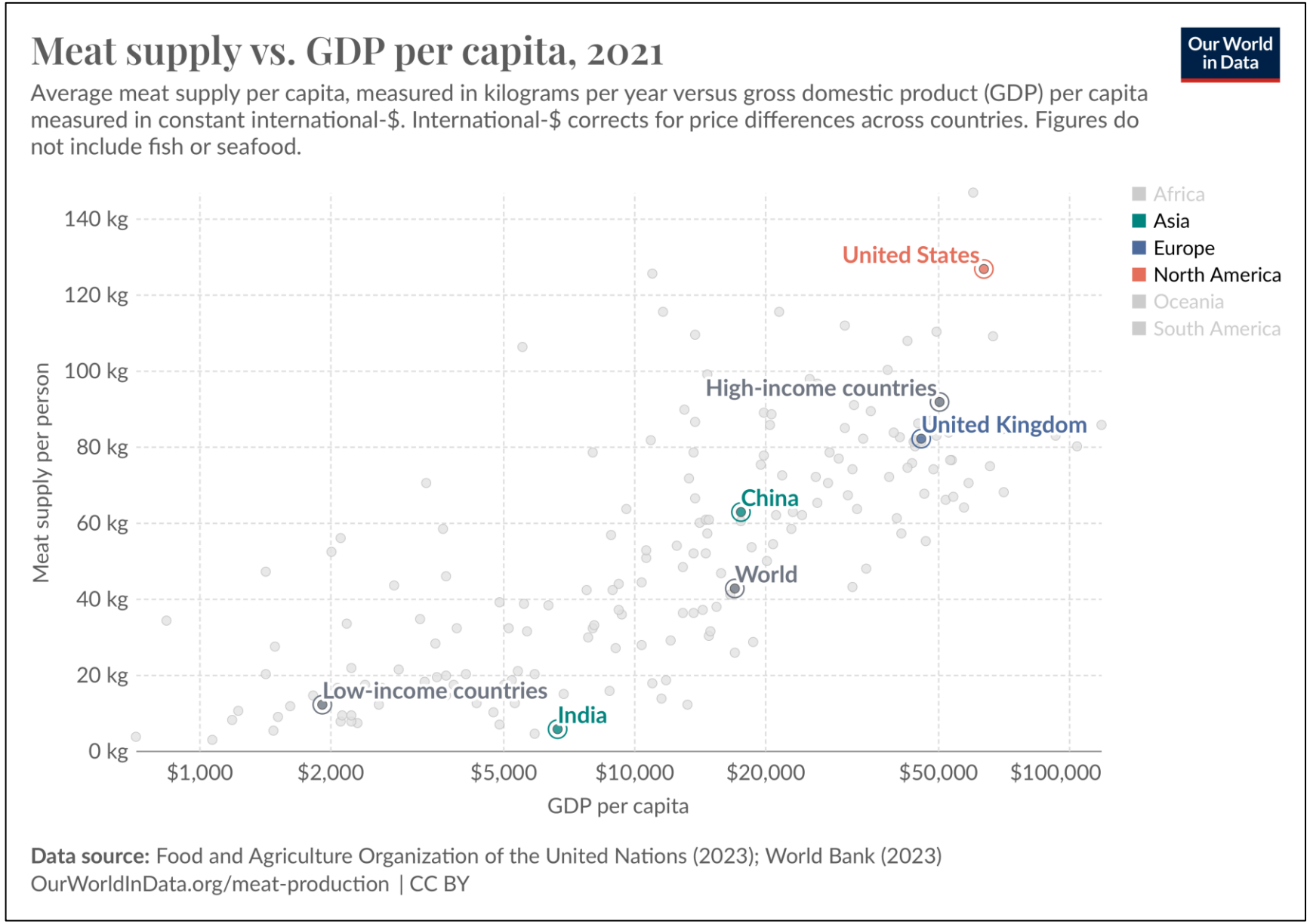
"Factors such as transport distance, retail, packaging or specific farm methods are often small compared to importance of food type."



Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.
Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Meat Consumption increases dramatically with national wealth
(Our World in Data)

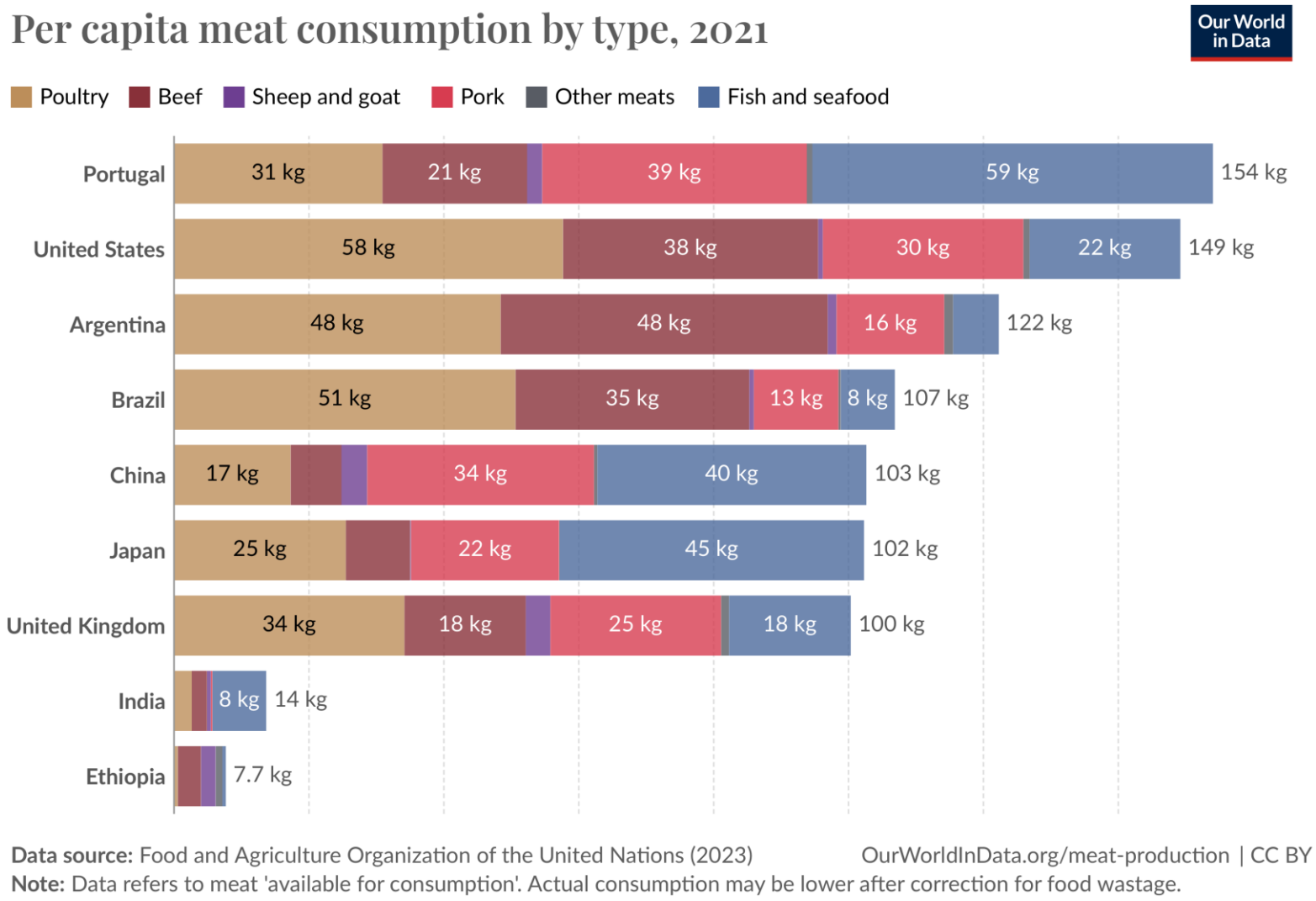
On average, a person in the UK still eats more than their own weight in meat each year!



Meat & Seafood Consumption by type
(Our World in Data)

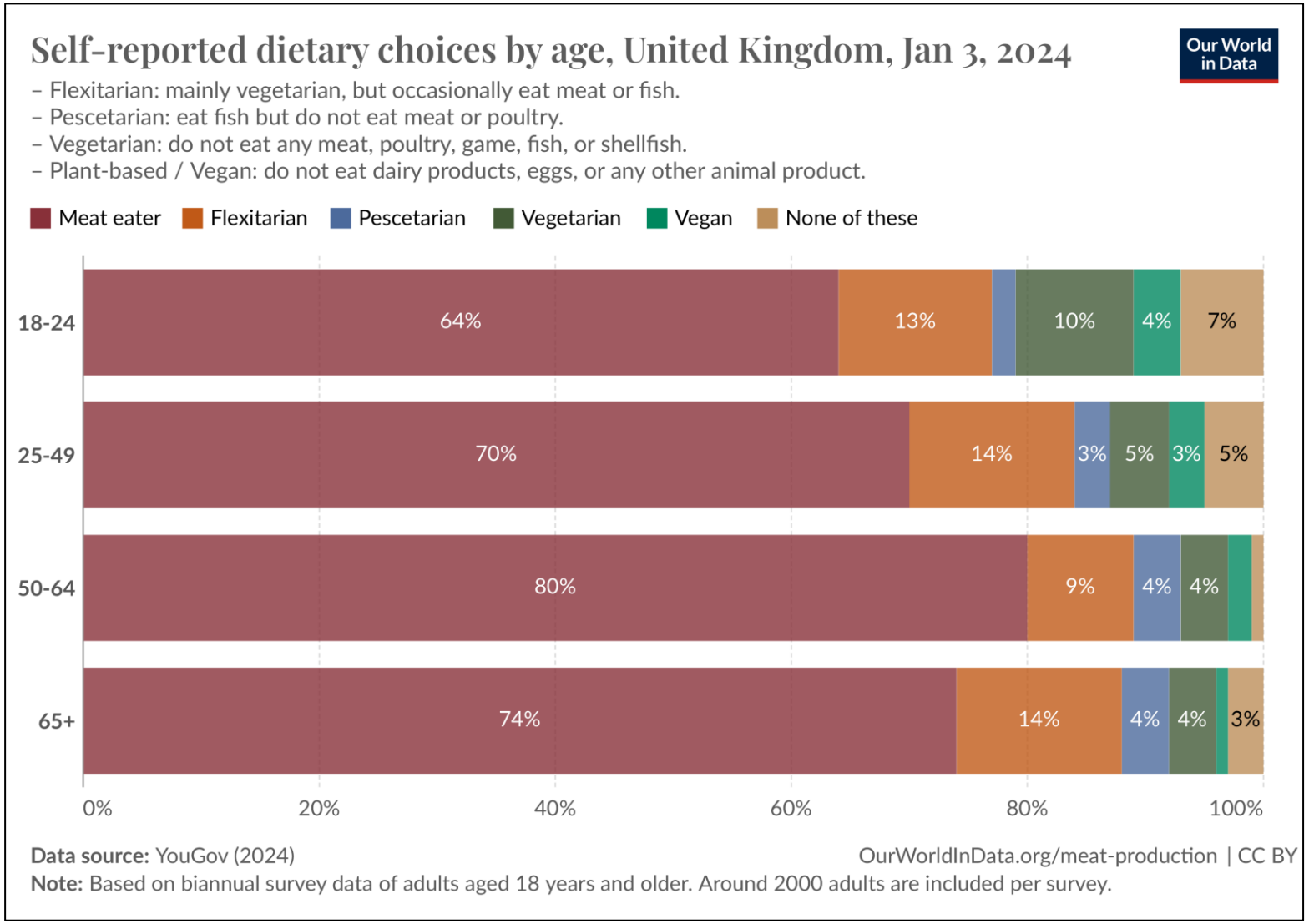
In the UK: 34% Poultry; 25% Pork; 18% Beef; 18% Fish & Seafood; 5% Lamb

By switching from Beef/Lamb to Pork/Chicken, a person in the UK would save about 1 tonne of GHG emissions per year (about 15% of their annual GHG emissions)



Some suggestion of a change in dietary choice

– *but no Tipping point yet*



Conclusions

- The causes of global warming are now very well understood – primarily increasing greenhouse gas concentration in the atmosphere (especially carbon dioxide, methane, nitrous oxide).
- The failure to reduce CO_2 emissions (primarily from fossil fuel use) means that global warming is within years of passing 1.5°C, and current national commitments mean that the 2°C upper limit of the Paris Agreement is also likely to be exceed.
- Dangerous climate tipping points may be triggered if global warming is allowed to increase, so we need to move rapidly to lower carbon ways.
- We now need 'positive tipping points' which are evident in the human realm (e.g. economies of scale, social contagions and abrupt shifts in social norms).
- The global food system is estimated to produce a quarter of global greenhouse gas, but has a huge opportunity to trigger its own positive tipping points (towards lower carbon diets and much-reduced food waste).

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