The Global Carbon Budget and Australia's Role

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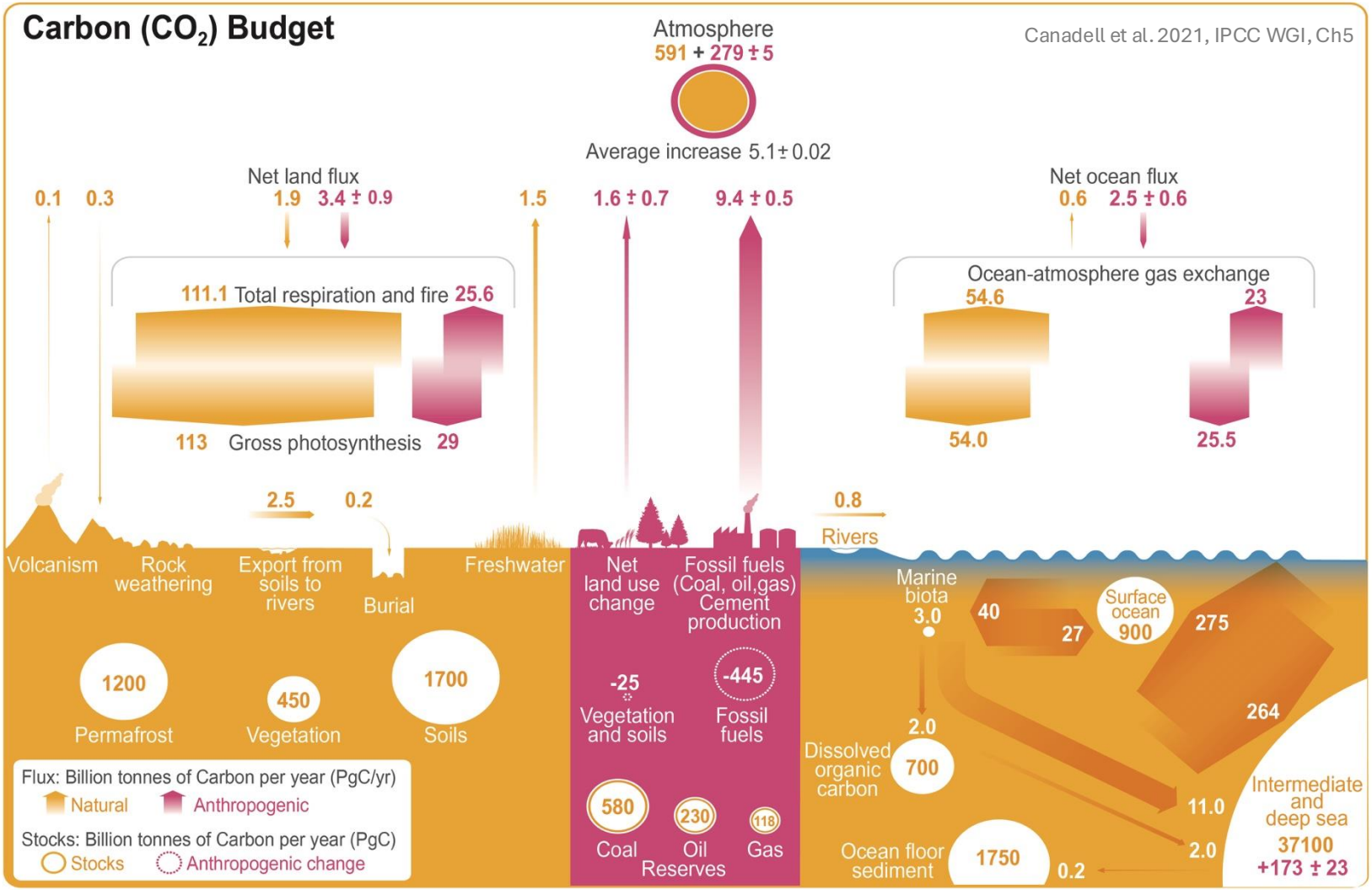
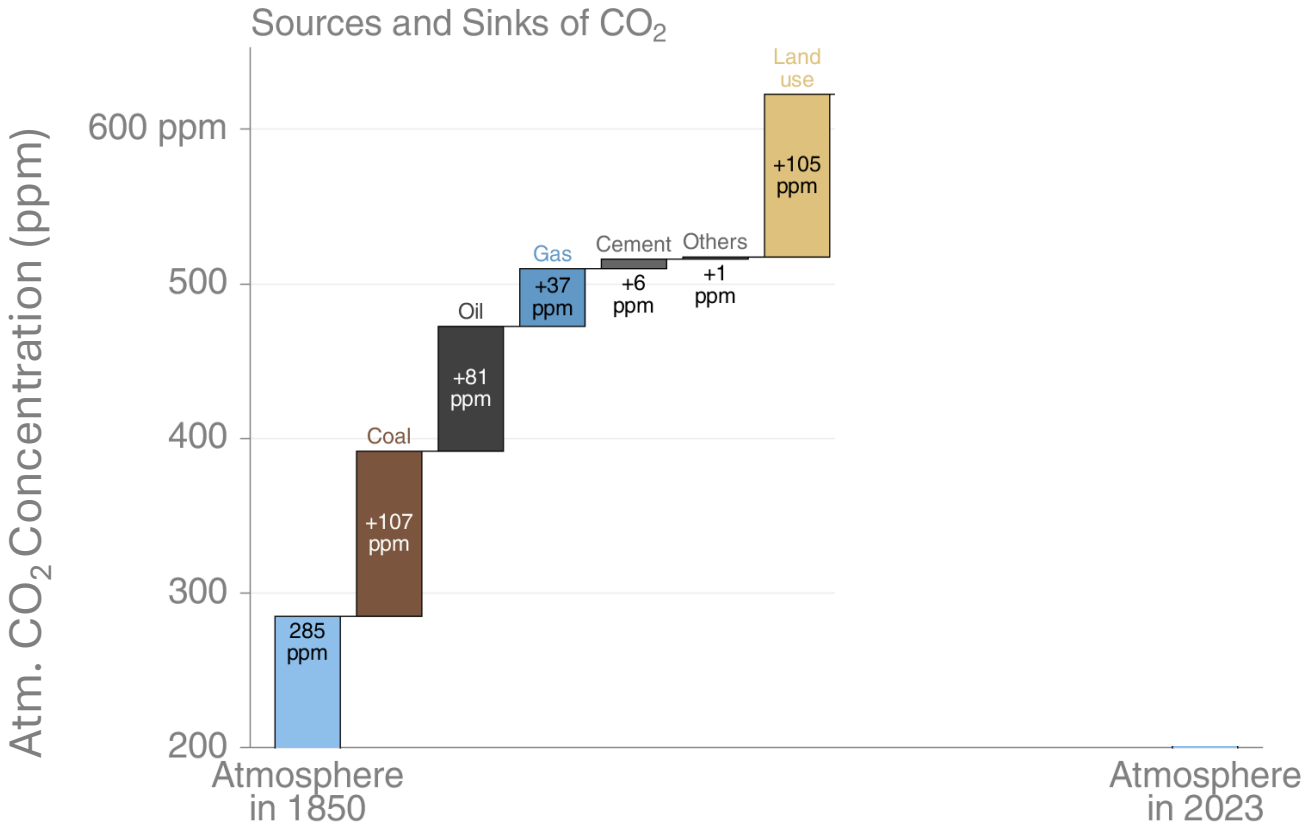
Climate Systems
National Environmental Science Program

GLOBAL CARBON PROJECT

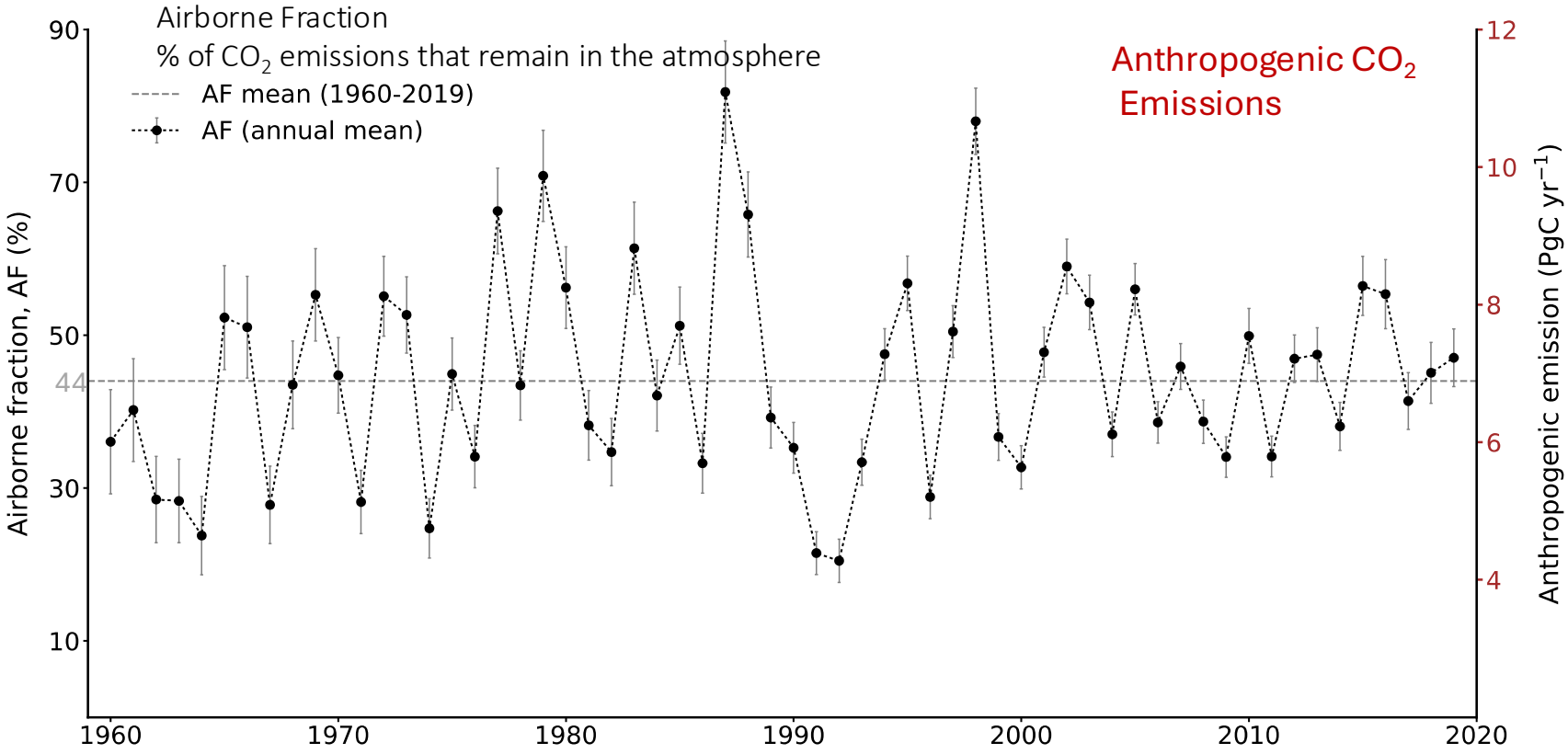
ATSE, Canberra, 27 February 2025


Carbon (CO_2) Budget
Canadell et al. 2021, IPCC WGI, Ch5
Atmosphere
591 + 279 ± 5
Average increase 5.1± 0.02
Net land flux
0.1
0.3
1.9
3.4 ± 0.9
1.5
1.6 ± 0.7
9.4 ± 0.5
Net ocean flux
0.6
2.5 ± 0.6
111.1 Total respiration and fire 25.6
113 Gross photosynthesis 29
Ocean-atmosphere gas exchange
54.6
23
54.0
25.5
2.5
0.2
0.8
Rivers
Volcanism
Rock weathering
Export from soils to rivers
Burial
Freshwater
Net land use change
Fossil fuels (Coal, oil,gas) Cement production
Marine biota 3.0
40
27
Surface ocean 900
275
264
1200
Permafrost
450
Vegetation
1700
Soils
-25
Vegetation and soils
-445
Fossil fuels
2.0
Dissolved organic carbon
700
11.0
2.0
Intermediate and deep sea
37100
+173 ± 23
Ocean floor sediment
1750
0.2
580
Coal
230
Oil
118
Gas
Reserves
Flux: Billion tonnes of Carbon per year (PgC/yr)
Natural
Anthropogenic
Stocks: Billion tonnes of Carbon per year (PgC)
Stocks
Anthropogenic change

Cumulative Global Carbon Budget and its Impacts on Atmospheric CO_2



Efficiency and Stability of the Natural CO_2 Sinks



Canadell et al. 2021, IPCC WGI, Ch5

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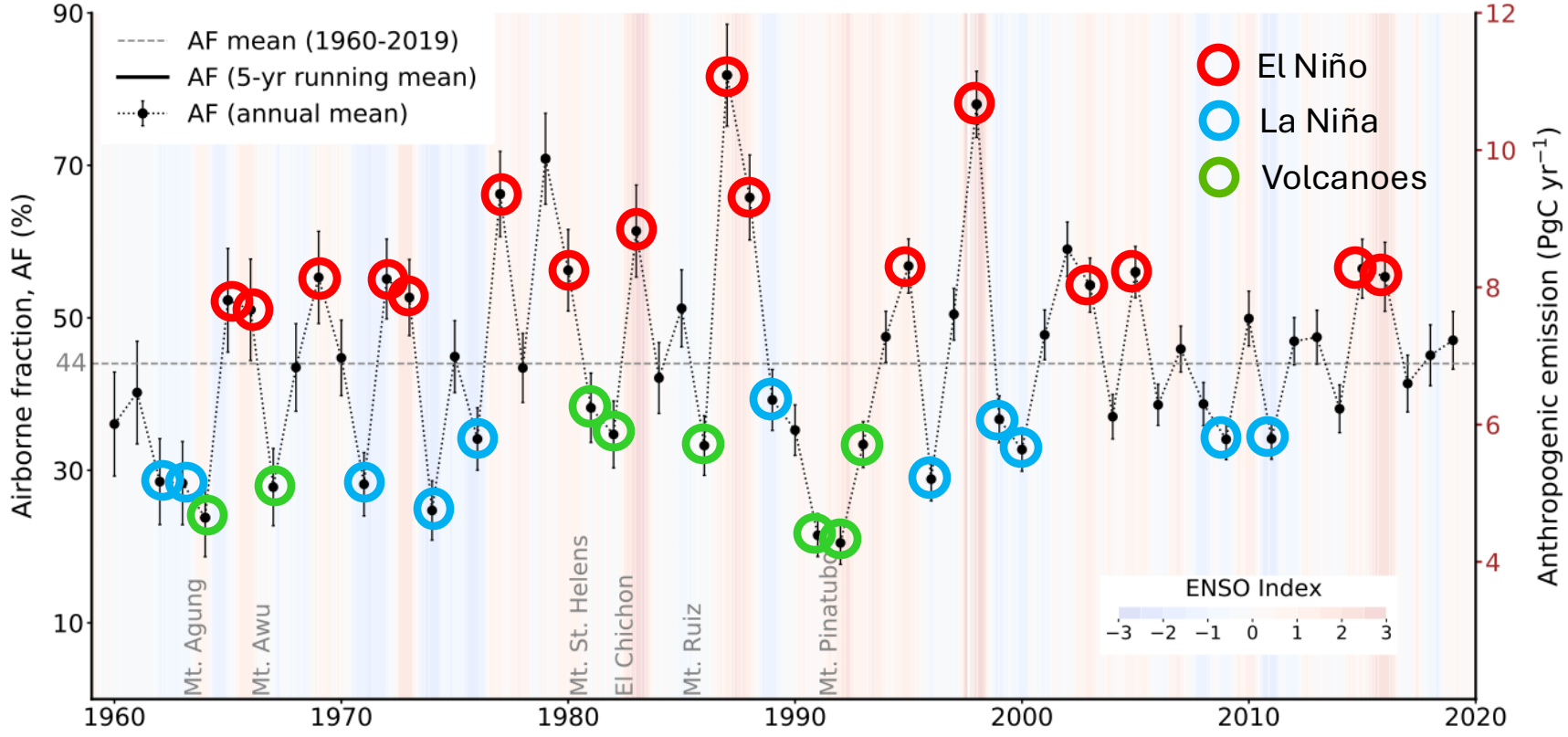
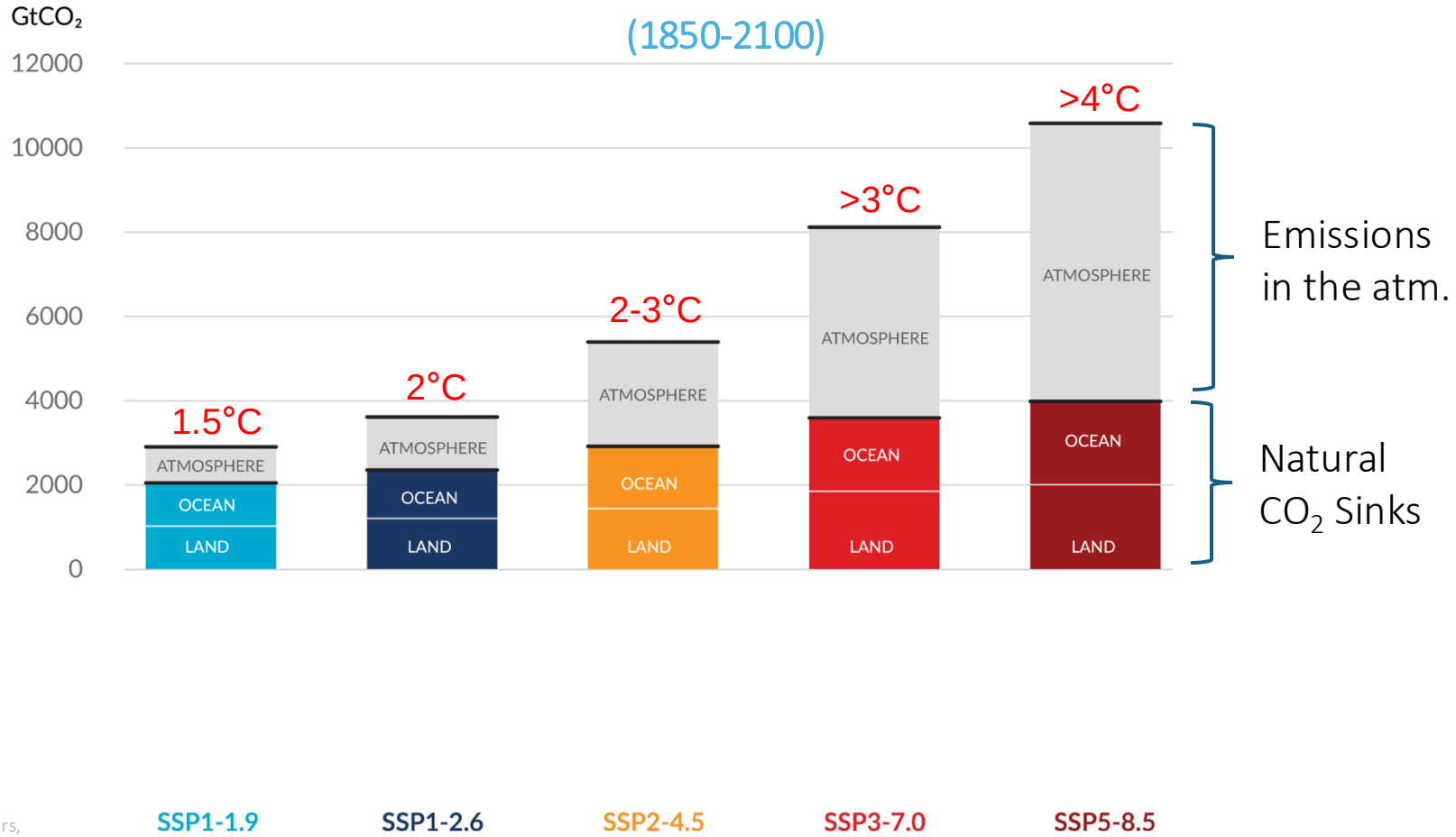


Canadell et al. 2021, IPCC, WGI, Ch5

Total Carbon Budgets & Efficiency of Natural CO_2 Sinks

(1850-2100)



Summary for Policy Makers, IPCC 2021, AR6, WGI, Figure SPM.7

Total Carbon Budgets & Efficiency of Natural CO_2 Sinks

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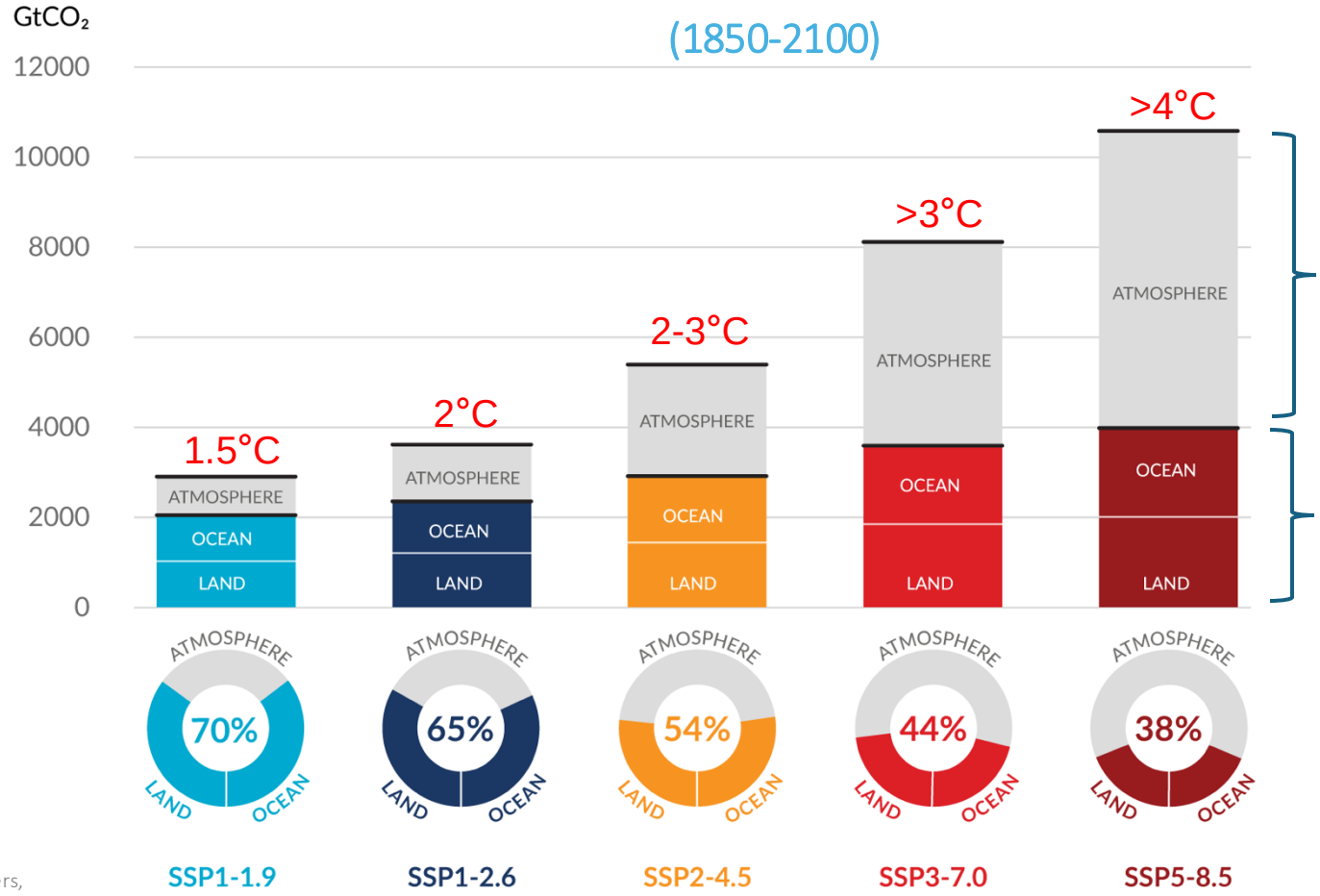
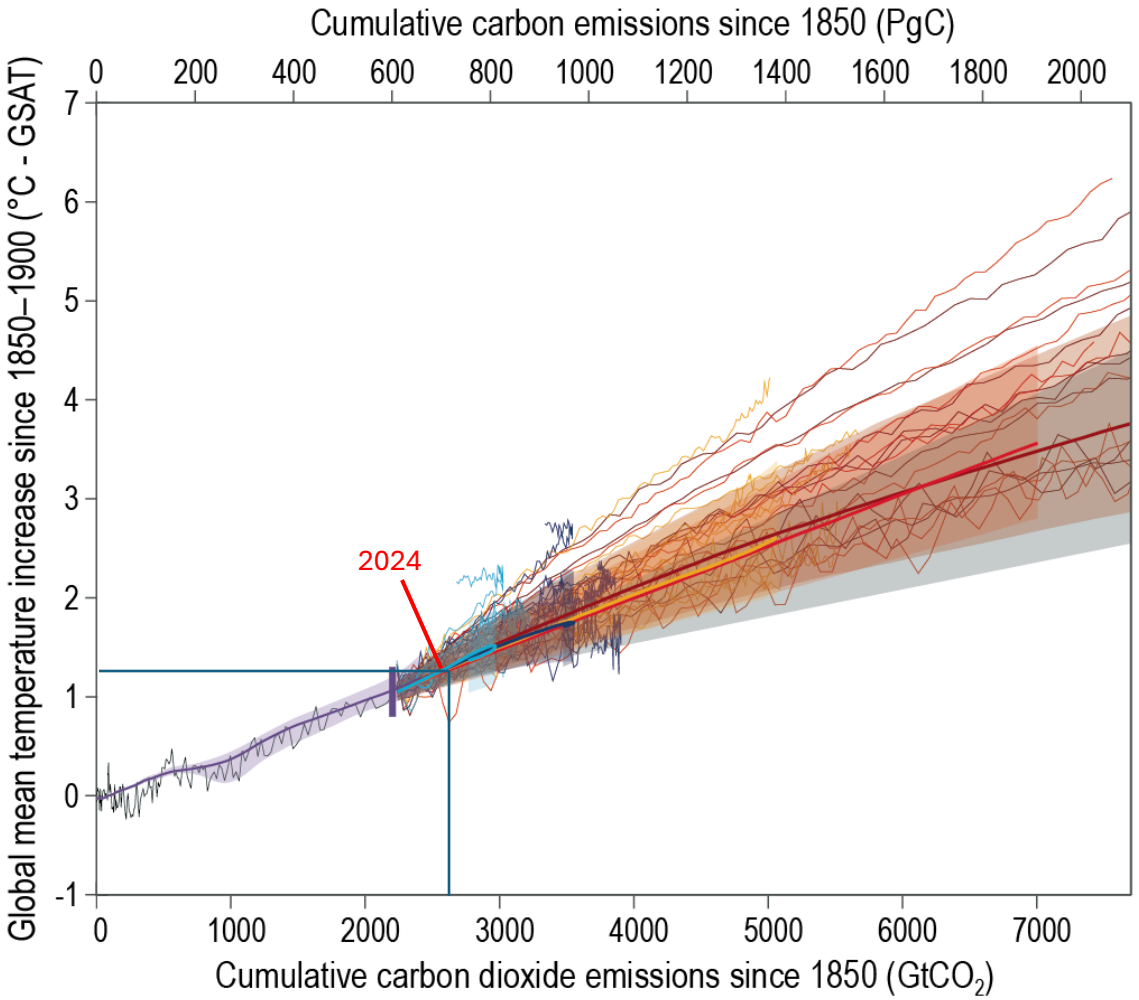


Summary for Policy Makers, IPCC 2021, AR6, WGI, Figure SPM.7

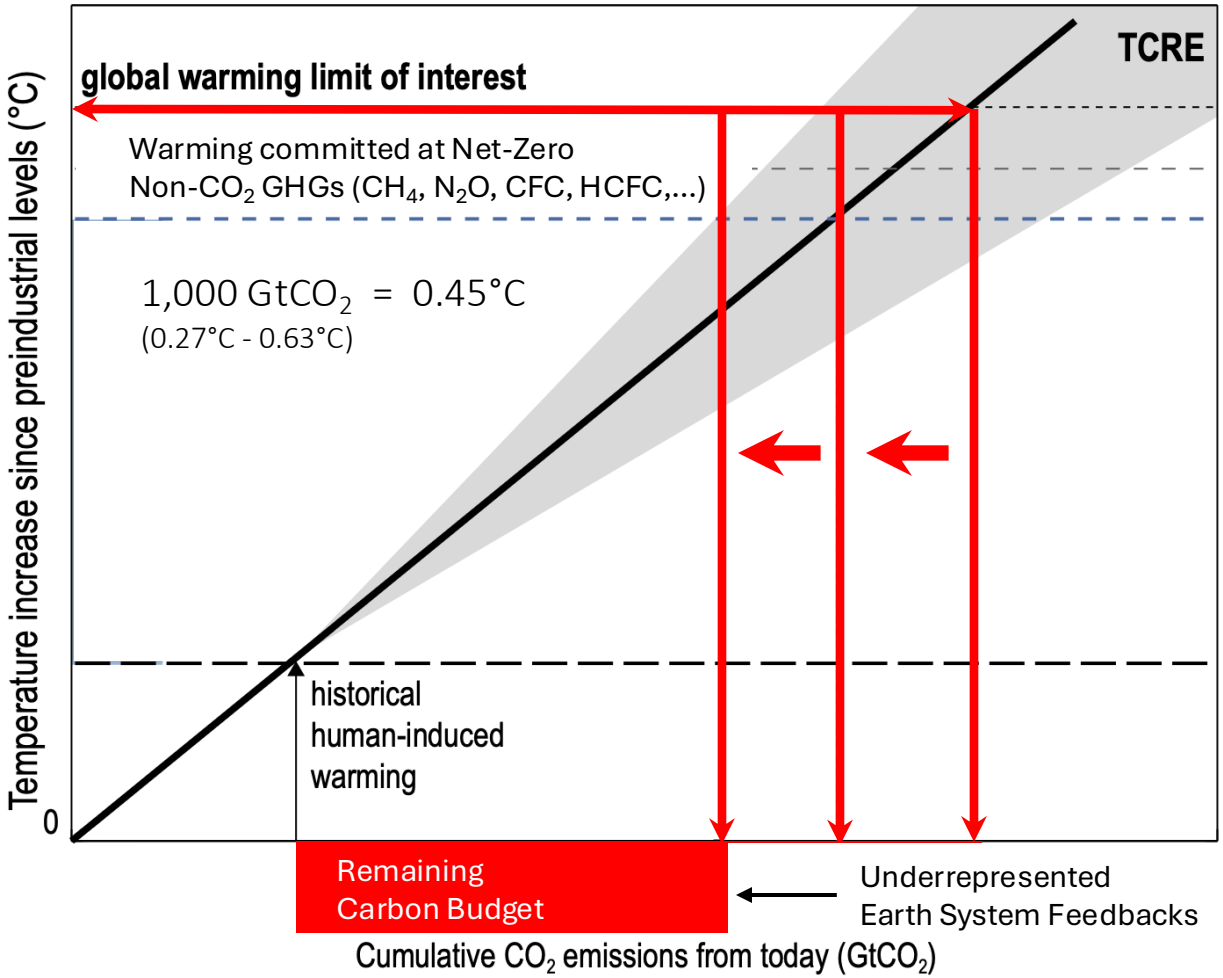
Quasi-linear relationship between excess T^a and cumulative CO_2 emissions



Canadell et al. 2021, IPCC WGI, Ch5

Calculating the Remaining Carbon Budget

Transient Climate Response to Cumulative CO_2 Emissions



Canadell et al. 2021, IPCC WGI, Ch5

Permafrost CO_2 and CH_4-Climate Feedbacks

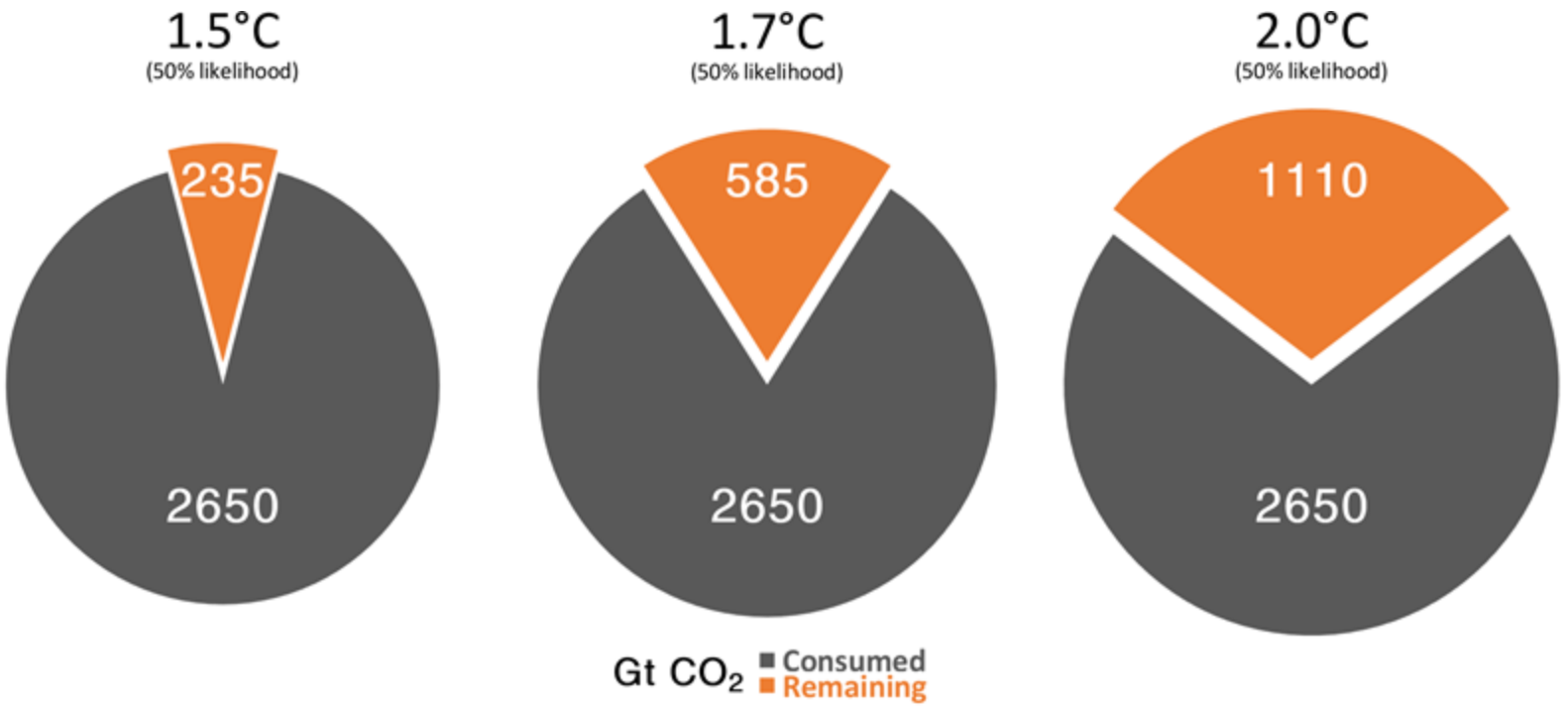
IPCC Assumed Linear Relationship

18 (3.1-41) GtC

per $°C^{-1}$ to 2100

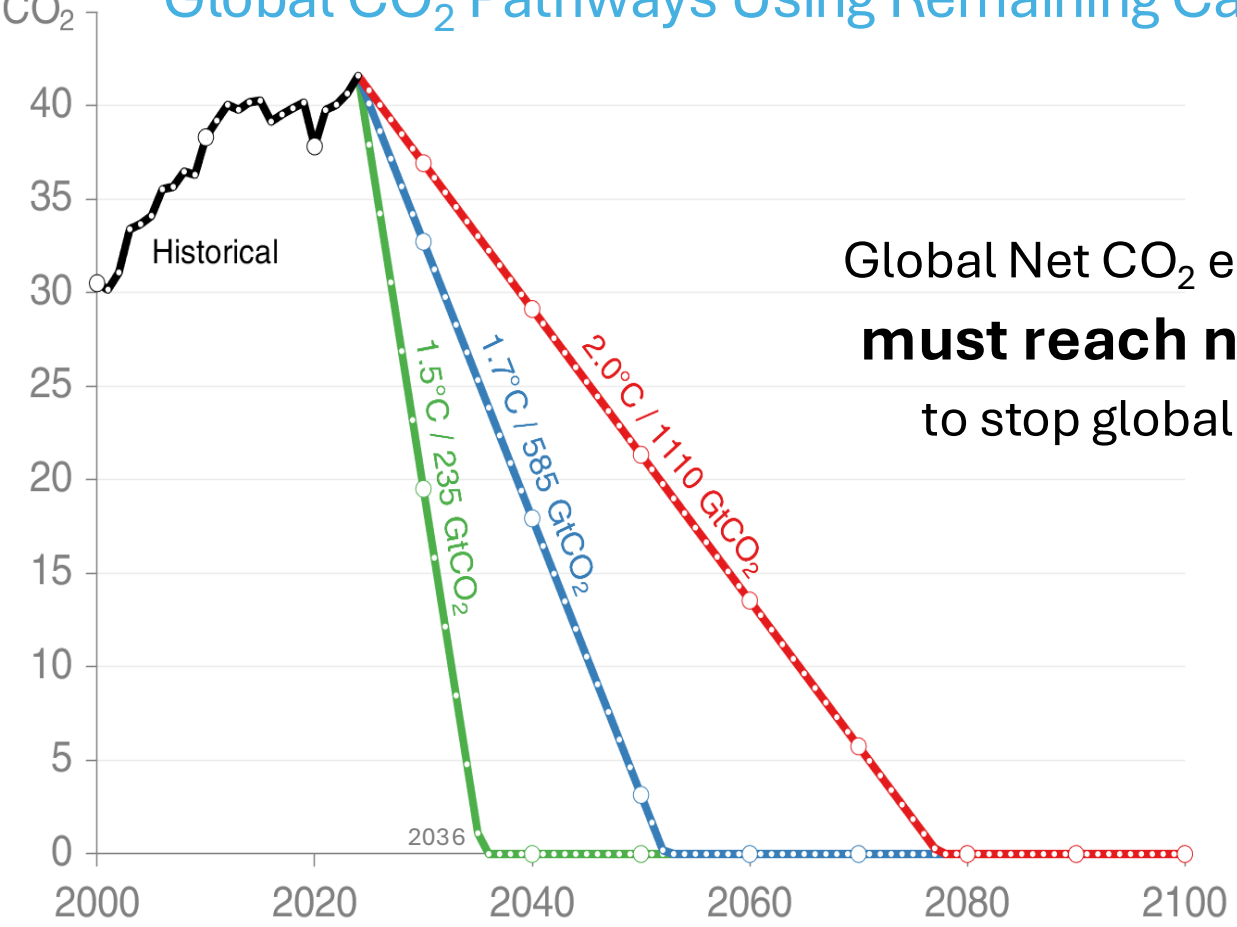
0.003 °C – 0.094 °C (TCRE)

Remaining Carbon Budgets



Years left at 2024 emissions: 6 years _____ 14 years _____ 27 years

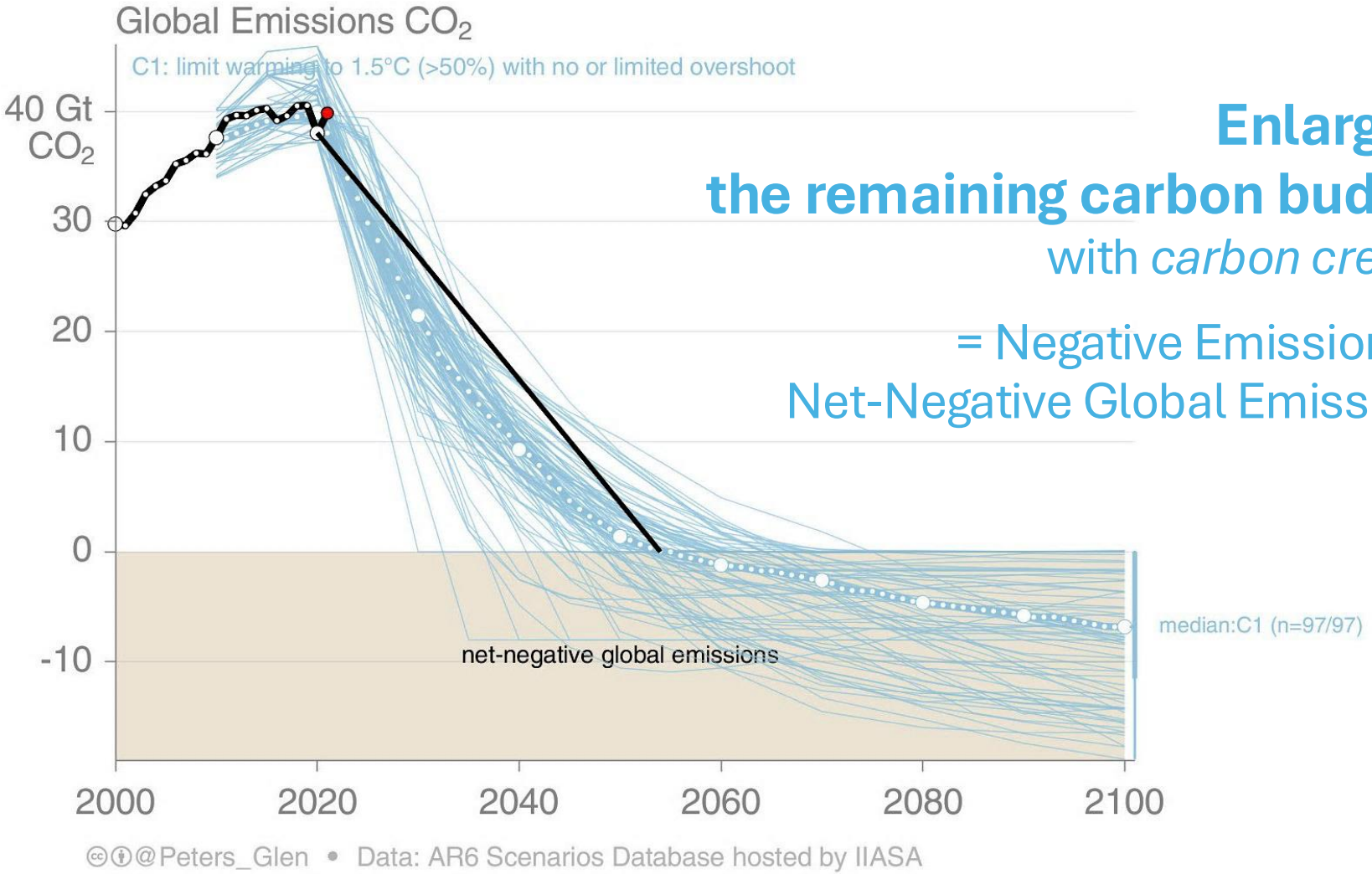
Global CO_2 Pathways Using Remaining Carbon Budgets



Global Net CO_2 emissions

must reach net-zero

to stop global warming



Enlarging the remaining carbon budget

with *carbon credits*

= Negative Emissions & Net-Negative Global Emissions

How Much Negative Emissions Are We Doing?

Equivalent to ~5% of Fossil CO_2 Emissions/yr

Equivalent to 0.000025% of Fossil CO_2 Emissions per year

Reforestation and Afforestation

1.9 **Gt**CO_2/yr

Direct Air Capture with Carbon Capture and Storage

0.004 **Mt**CO_2/yr

Enhanced Weathering

0.03 **Mt**CO_2/yr

Vegetation-based CDR estimates, Global Carbon Project 2024; Non-Vegetation-based CDR, State of CDR report 2024

Direct Air Carbon Capture and Storage (DACCS)

Orca

Climateworks + Carbfix
Reykjavik, Iceland

Orca: captures 4,000 tCO_2 yr^{-1}

To capture half of what we need by 2100 (5 $GtCO_2/yr^{-1}$), 1.5°C and 2°C,

we would need to deploy:

x 1,250,000 DACCS facilities like Orca

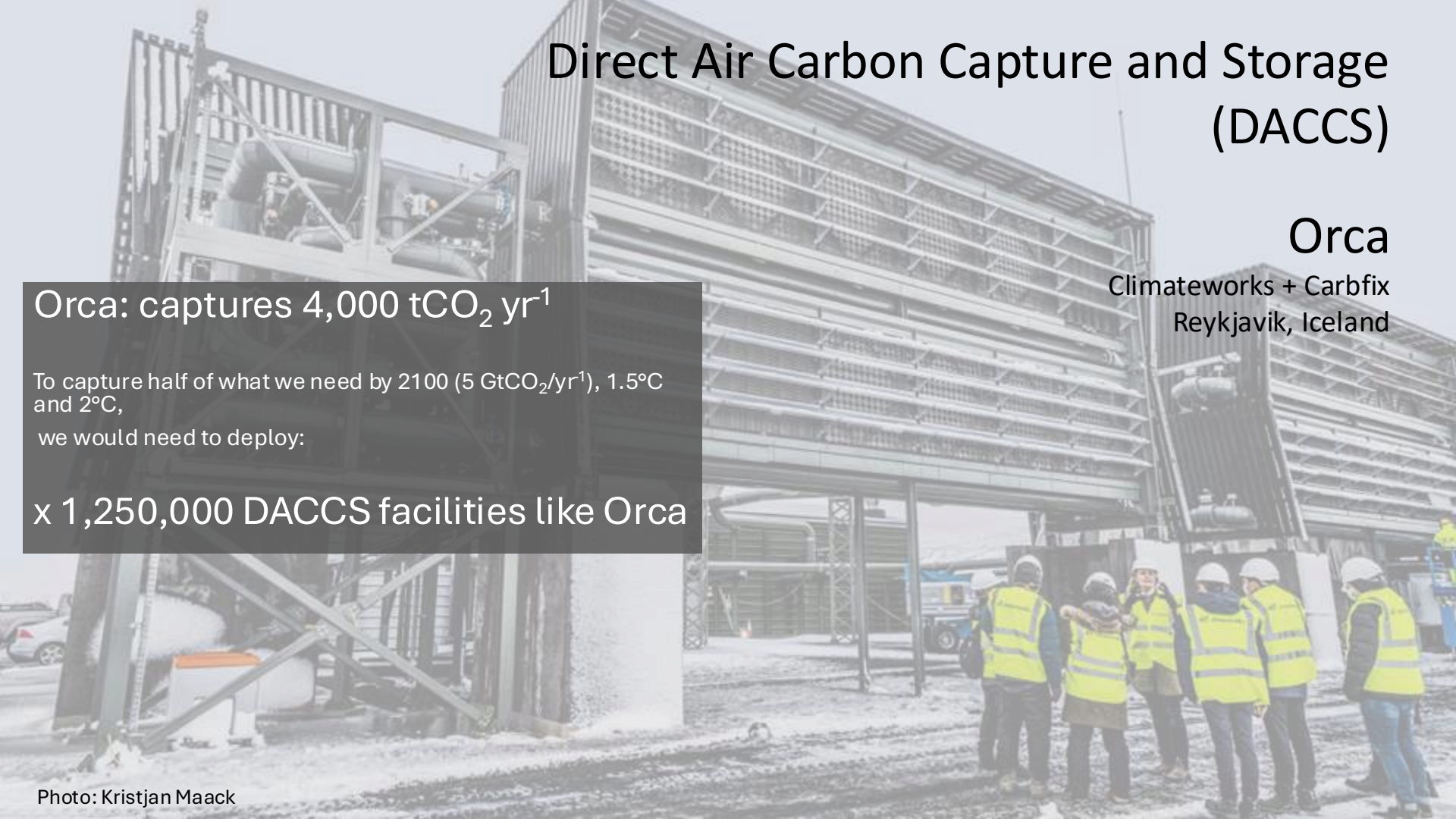
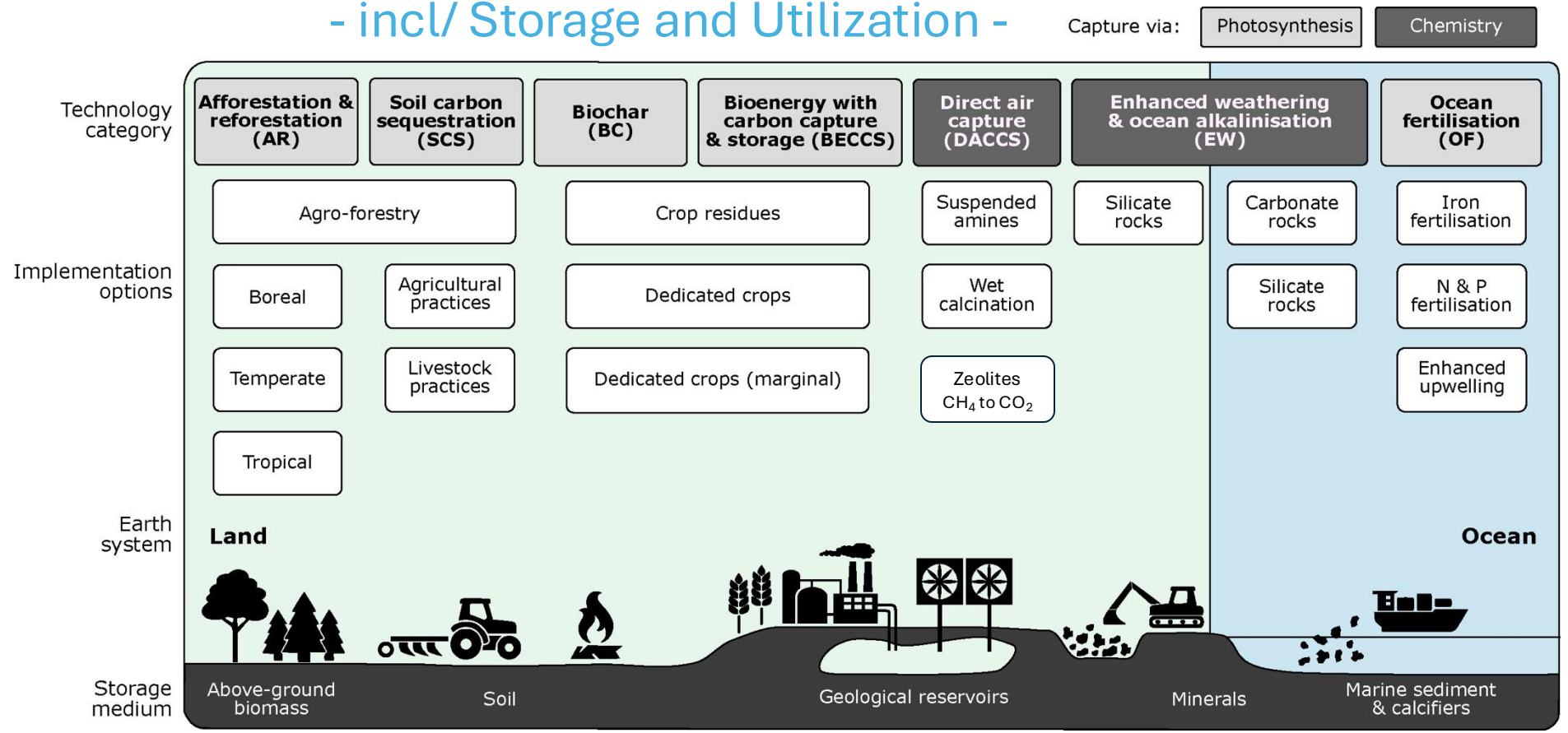


Photo: Kristjan Maack

Negative Emissions Technologies (CO_2, OC, CH_4)

- incl/ Storage and Utilization -



Minx et al. 2018, ERL; Jackson et al. 2019, NatSus

How to Share the Remaining Global Carbon Budget

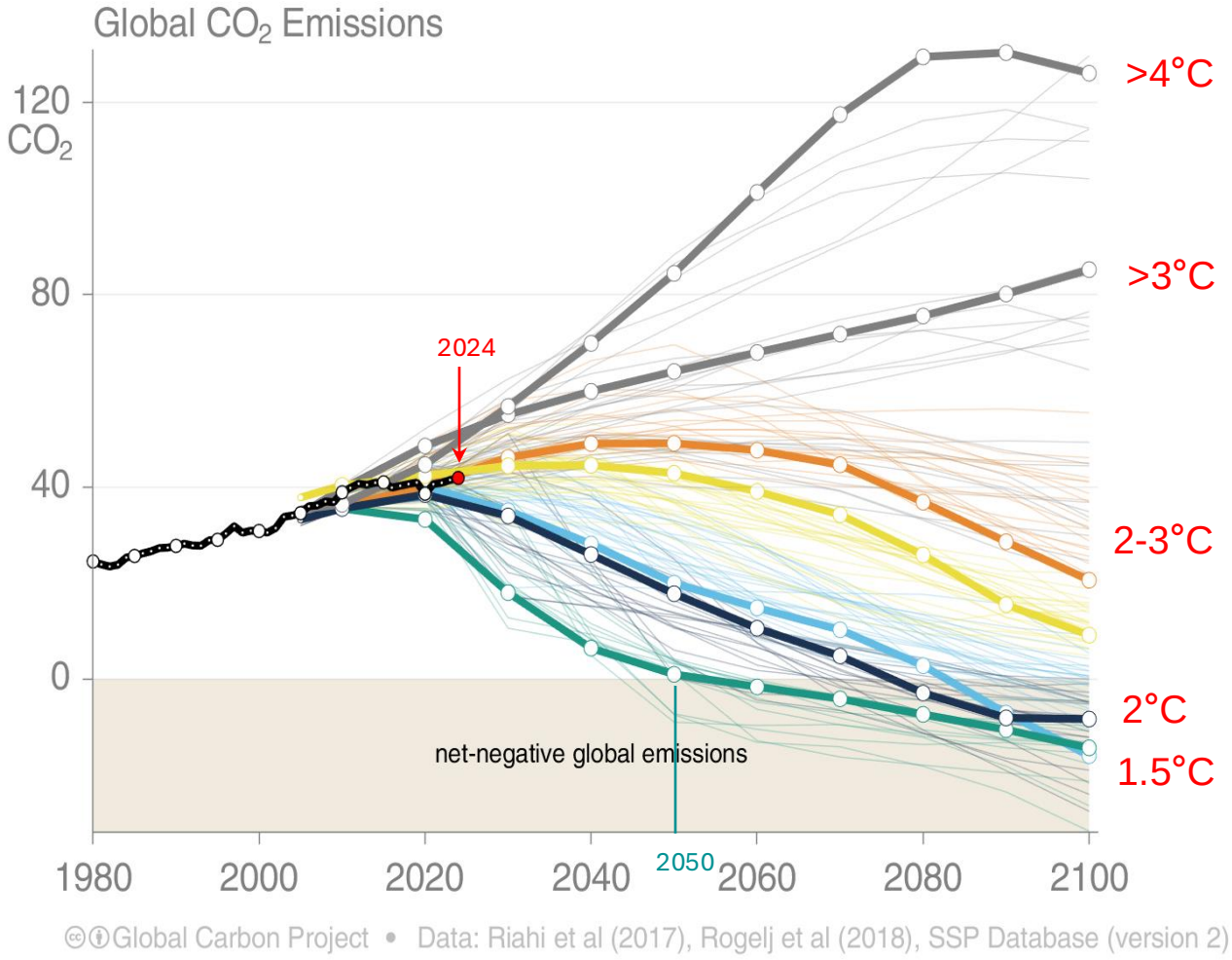
The only legally binding or agreed text in the UNFCCC and Paris Agreement:

'Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances'

Approaches for deciding on Australia's share *(not part of the UNFCCC)*:

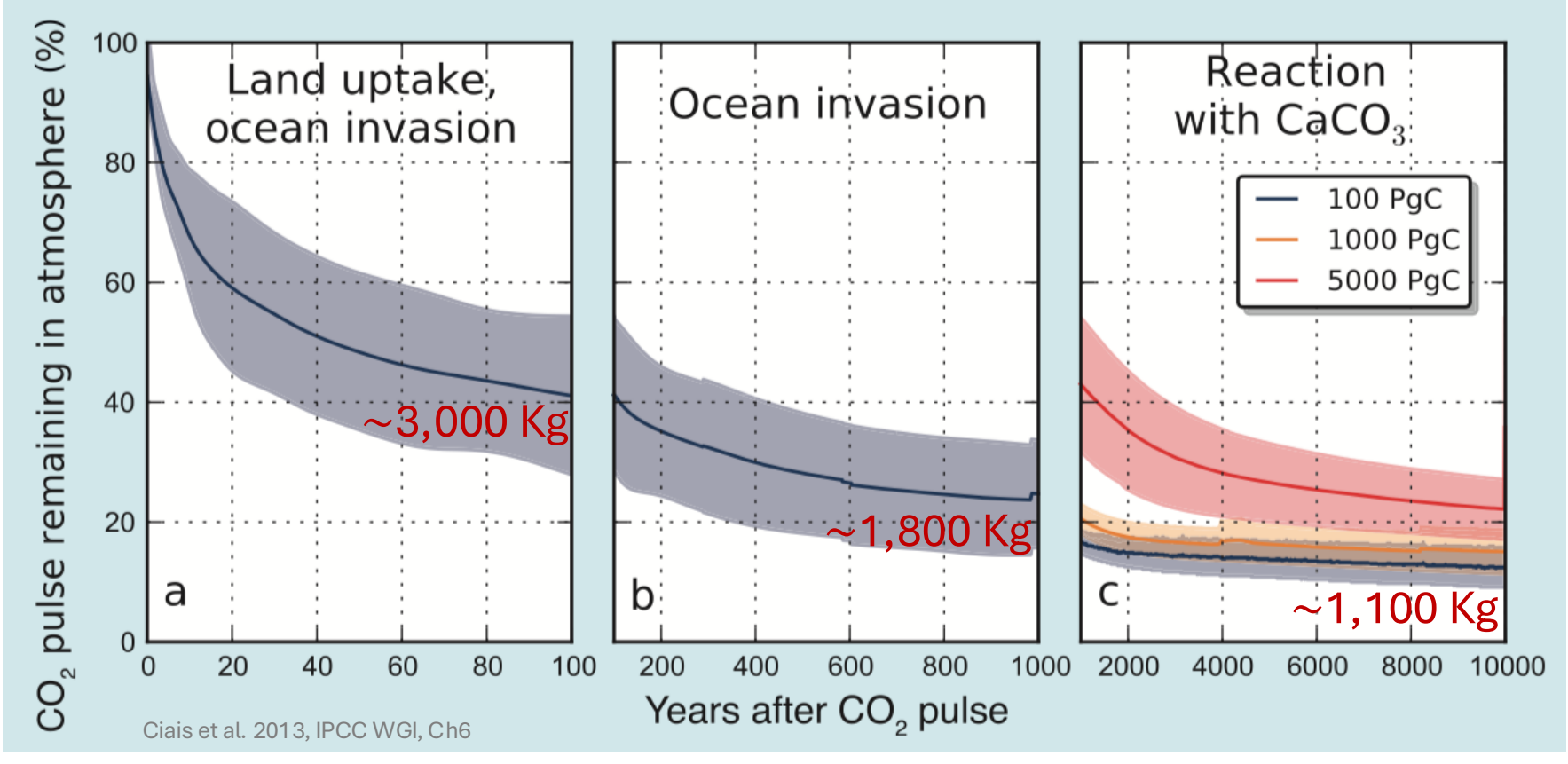
1. Proportional to current emissions (inertia)
2. Equal per capita emissions (global equity)
3. Based on historical cumulative emissions (high past, less in the future)
4. Combination of 1) and 2) (contraction-and-convergence)
5. Other approaches based on economics, trade, ethics, …

Shared Socioeconomic Pathways (SSPs)



CO_2 Emissions are "irreversible"

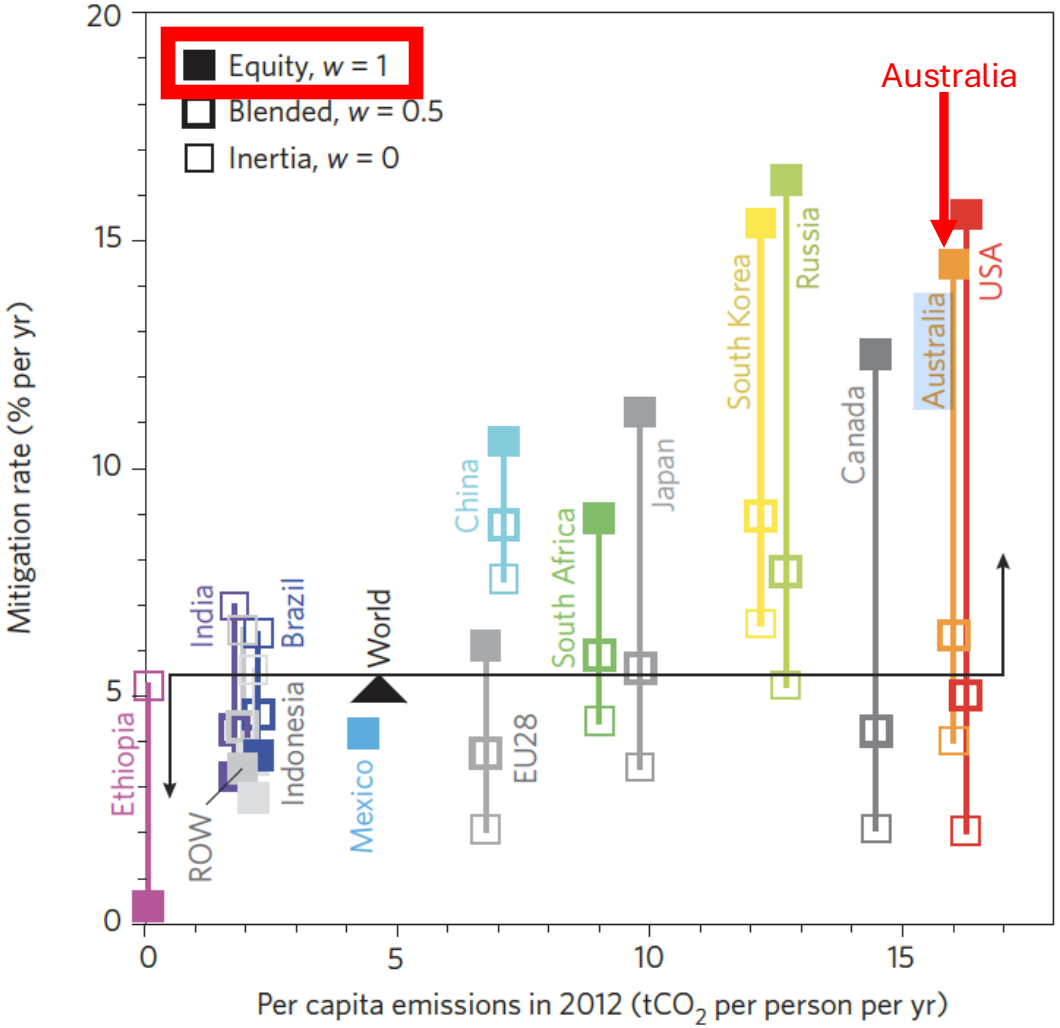
Flight from Canberra to London (Emissions per person: 7.4 metric tons CO_2)



Ciais et al. 2013, IPCC WGI, Ch6

Sharing the Remaining Carbon Budget

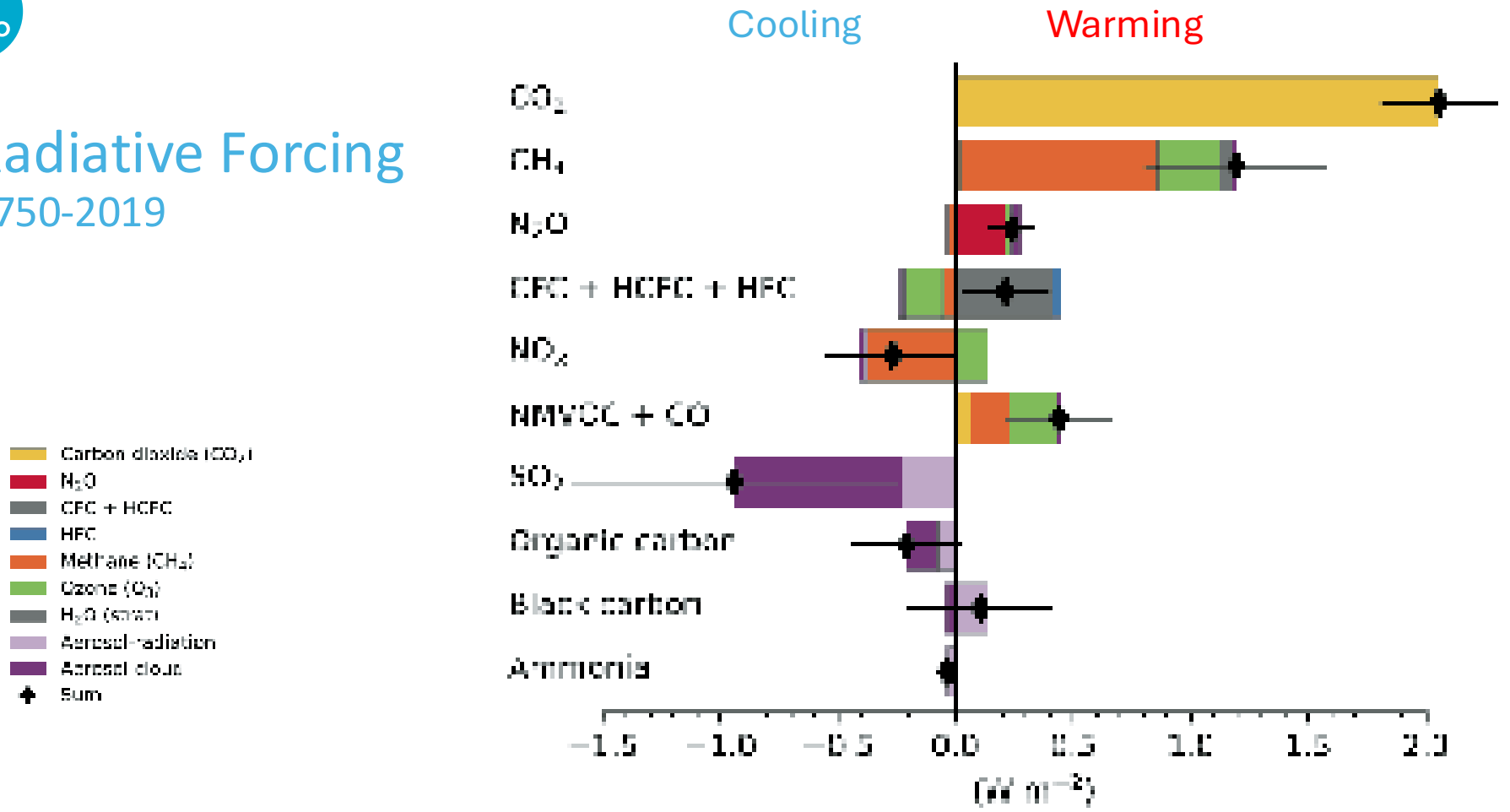
Decline in Annual CO_2 Emissions (%)



Rauapch et al. 2014, Nature Climate Change

Radiative Forcing

1750-2019



Fate of anthropogenic CO_2 emissions (2014–2023)

Sources = Sinks

35.6 $GtCO_2$/yr

90%

10%

4.1 $GtCO_2$/yr

19.2 $GtCO_2$/yr

48%

29%

11.7 $GtCO_2$/yr

26%

10.5 $GtCO_2$/yr

4%

-1.6 $GtCO_2$/yr

Budget Imbalance:

(the difference between estimated sources & sinks)

Global Carbon Project 2024, Friedlingstein et al. 2024, ESSD

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