Climate Change Advisory Council Secretariat

Carbon Budgets Working Group

Meeting No. 12
22nd March 2024

Agenda

Time	Agenda Item
13:30	1. Opening of Meeting
13:35	2. The remaining global carbon budget and implications for methane emission reductions
14:30	3. Discussion of potential NTA analysis for Carbon Budgets
15:30	4. Agree inputs, parameters and assumptions for 2nd Iteration of Modelling
16:10	5. Carbon Budgets Work Plan
16:15	6. Next Steps and Agenda for next meeting
16:20	7. AOB
16:30	Meeting Close

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
12	18/01/24	Secretariat to follow up on planetary boundaries as thematic topic	Secretariat	Mar 2024	Propose to Close *Doughnut Economics Horizon Scanning Event scheduled for 10/4/24 10:00-11:30 with invitation extended to the members of the CBWG.*
13	18/01/24	Secretariat to provide guidance from the Council with regards to the 2nd iteration of modelling and analysis following the February CCAC meeting	Secretariat	Feb 2024	Closed *Council feedback provided to CBWG in Feb meeting.*
14	29/02/24	Secretariat to schedule bi-laterals with each of the Core modelling group to discuss Council feedback in more detail.	CCAC Secretariat	Mar 2024	Propose to Close *Bi-laterals with each of the three core modelling teams held on the 7th of March.*
15	29/02/24	Request for clarification on the role of the CBWG in terms of presenting a range of scenarios for Council consideration as opposed to proposing a particular feasible pathway.	CCAC Secretariat	April 2024	Open *Role of CBWG outlined in the ToR and is to be reiterated for clarity at the April Council meeting.*

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
16	29/02/24	Request for a more detailed discussion within the CBWG on the feasibility of various scenarios	CBWG Members	April 2024	Open *Accompanying descriptive narrative for each of the modelled scenarios requested from core modelling teams. Feedback from all CBWG members requested on the proposed mechanism to facilitate input to a collective narrative on feasibility of various scenarios.*
17	29/02/24	Core and additional modelling teams to confirm delivery timelines for the 2nd iteration of modelling and analysis in line with Carbon Budgets Workplan	CBWG Members	Mar 2024	Open *Core modelling teams confirmed delivery of 2nd iteration results on 23rd May.* *Additional modelling teams to confirm delivery of results on 28th June.*
18	29/02/24	Chair to consider the participation of an additional member from the FAPRI modelling team within the CBWG.	Secretariat	Mar 2024	Propose to close *Response provided. Participation welcomed at future meetings where the team is presenting results of its analysis. Not inclined to appoint additional members at this late stage.*

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3. Discussion of potential NTA analysis for Carbon Budgets

- Following a previous presentation to the CB WG, experts within the NTA modelling team invited to provide input to iteration 2 and 3 of the overall modelling being carried out of energy system pathways for a range of carbon budgets with a focus on the transport sector, utilising existing work or some limited further outputs from the NTA Regional Modelling System (RMS).
- Complement to work being carried out by the SEAI to review energy systems modelling outputs for the energy system as a whole.
- NTA invited to this discussion for further scoping of this work with the CB WG ahead of the 2nd and 3rd iteration of modelling.

3. Discussion of potential NTA analysis for Carbon Budgets

- Approach to review/inputs from NTA - including for example provision of feedback/insights on assumptions across TIM and SEAI (This could include feedback on modal share, fleet composition, transport demand scenarios, technology options, deployment rates, capacity and any additional measures modelled by the NTA).
- Pathways for decarbonisation of the transport sector between now and 2050
- Timelines for input:
  - Core Modelling Results: 2nd Iteration of due on 23rd May & 3rd iteration due on 29th August
  - Additional Modelling Results: 2nd Iteration of due on 28th June & 3rd iteration due on 18th September
- Data requirements for NTA
- New Action for Secretariat to schedule bilateral discussions with TIM and SEAI CB WG Members

Item	Description	2024											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	**Modelling / Analysis Iteration 2**												
2.1	Agree inputs, parameters and assumptions												
2.2	Core pathways development and modelling												
2.3	Paris Test Assessment												
2.4	Additional modelling and testing of results												
2.5	Post-hoc analysis												

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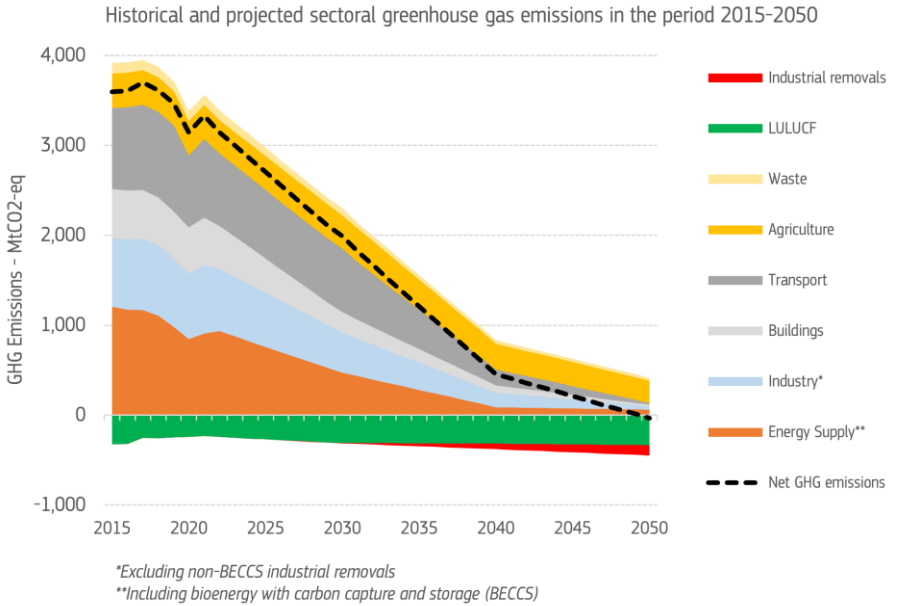
4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

- Secretariat briefed Council on the Carbon Budgets Core Model Outputs on 11/01/24
- Secretariat briefed Council on the warming impacts of the first iteration outputs from the core models on 14/02/24
    - *Core modelling teams joined the discussion for the final 30mins of the call*
- Council discussed feedback and guidance for the CBWG at the February CCAC meeting on 15/02/24
- Council Guidance being presented by the Secretariat and discussed at the February CBWG meeting on 29/02/24
- **Action 14:** Secretariat to schedule bi-laterals to discuss guidance with core modelling teams following the February CBWG meeting
- Follow up guidance to be provided at the March CBWG meeting on 22/03/24 if necessary

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

General CCAC Guidance Points

- Request for additional scenarios to widen the scope of modelling for the next iteration
- Request for modelled scenario(s) for the next iteration to consider the European Commission's 2040 Proposal
- Note the emissions gap for Waste and F-gases that will need to be addressed. Proposal to use the EPA Projections and/or the EU 2040 Scenarios.



The European Commission *recommended* reducing the EU's net greenhouse gas emissions by 90% by 2040 relative to 1990 (February 2024).
2040 climate target - European Commission (europa.eu)

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

General CCAC Guidance Points

- Request for brief (c.a. 1 page) accompanying descriptive narrative for each of the modelled scenarios outlining the following;
  - Technologies
  - Rates of deployment
  - Costs
  - Assessment of CB1 & CB2 overshoot (EPA WEM/WAM approximated)
  - Accounting for relevant NCAP24 targets
  - Role of negative emissions
  - Commentary on potential pitfalls and practical implications

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

TIM Guidance Points

- Endorsement of the approach for the remaining carbon budget assumptions in terms of downscaling the remaining Global Carbon Budgets on a per-capita basis to estimate Ireland's share
- Acknowledgement of downscaling on a per-capita basis as conservative in the sense that it is favourable to Ireland (Irish Carbon Budgets: Some Moral Considerations, Kian Mintz-Woo, *in prep*)
- Request for additional carbon budget scenarios to be modelled for the next iteration based on the IPCC assessment of the Global Remaining Carbon Budgets
  - First Iteration
    - 400 Mt: 2.0ºC (83%) & 1.5ºC (17%) (IPCC AR6 900 Gt CO_2 RCB)
    - 300 Mt: 1.7ºC (67%) & 1.5ºC (33%) (IPCC AR6 700 Gt CO_2 RCB)
  - Additional carbon budget scenarios requested for second iteration
    - *~450 Mt scenario aligned with 67% 2ºC* (IPCC AR6 1150 Gt CO_2 RCB)
    - *~350 Mt scenario aligned with ~25% 1.5ºC* (IPCC AR6 ~800 Gt CO_2 RCB)
    - *~250 Mt scenario aligned with 50% 1.5ºC* (IPCC AR6 500 Gt CO_2 RCB)
- Question of how TIM takes account of NCAP biomethane targets to be explored in the accompanying descriptive narrative.

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

FAPRI Guidance Points

- FAPRI scenario modelling out to 2050 is required for the 2nd iteration of modelling and analysis
- Request for a series of scenarios to be developed to explore what the composition of agriculture at the following scenarios?
  - Levels of emission reduction in agriculture achieved by 2050
    - 30%
    - 40%
    - 50%
    - 60%
  - Suggest exploring a range of adoption rates of MACC Mitigation Measures
    - High ~95%
    - Medium ~75%
    - Low ~50%

		MACC Adoption Rates		
		50%	75%	95%
Ag 2050 Emission Reduction	30%	S1	S4	S7
	40%	S2	S5	S8
	50%	S3	S6	S9
	60%	S10	S11	S12

An illustrative example of the range of FAPRI scenarios required

- Interaction with GOBLIN regarding the ask on LULUCF under each scenario and implications for carbon farming measures and market signals to be explored as part of the 3rd iteration of modelling and analysis.

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

GOBLIN Guidance Points

- Secretariat to facilitate incorporation of new 2024 inventory emission factors/ activity data for the next iteration of modelling.
- Request for the development of scenarios to be developed in line with the guidance provided to FAPRI i.e., to explore the following levels of emission reduction in agriculture achieved by 2050:
  - 30%
  - 40%
  - 50%
  - 60%
- Request for co-ordination of assumptions between FAPRI and GOBLIN on technical abatement, animal productivity and animal numbers as part of the 2nd iteration of modelling and analysis.

4. Agree inputs, parameters & assumptions for 2nd Iteration of Modelling

Action 16: Request for a more detailed discussion within the CBWG on the feasibility of various scenarios

1. Accompanying descriptive narrative for each of the modelled scenarios requested from core modelling teams, to include commentary on potential pitfalls and practical implications.

2. Proposed development of a collective CBWG narrative to facilitate an expanded discussion on the feasibility of various scenarios

- *Secretariat to develop an Excel matrix for input from all CBWG members*
- *Categories for input to include criteria for consideration under the Act Criteria as well as practical and/or technical feasibility*
- *Scope for 1D commentary in addition to multi-dimensional commentary i.e., on combined scenarios*

Next Steps: *Initial feedback on proposal welcomed from all CBWG members. Secretariat to develop a draft Excel template for circulation and feedback as part of the April meeting papers.*

5. Carbon Budgets Workplan: 2nd Iteration of Modelling & Analysis

Item	Description	2024											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	**Modelling / Analysis Iteration 2**												
2.1	Agree inputs, parameters and assumptions												
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2.3	Paris Test Assessment												
2.4	Additional modelling and testing of results												
2.5	Post-hoc analysis												

- **March Week 1:** Secretariat to schedule bi-laterals to discuss Council guidance with core modelling teams
- **CBWG Meeting No. 12, CBWG Friday 22nd March 2024, 13:30 – 16:30:**
  - Agree inputs, parameters and assumptions for 2nd Iteration of Modelling
- **March – April:** Coordination of FAPRI and GOBLIN assumptions
- **CBWG Meeting No. 14, Thursday 23rd May 2024, 13:30 – 16:30:**
  - 2nd Iteration of Core Modelling Results
- **CBWG Meeting No. 15, Friday 28th June 2024, 13:30 – 16:30:**
  - Analysis of warming impact of selected core scenarios (2nd iteration),
  - Additional Testing of Scenario Results (SEAI & NTA)
  - Macroeconomic and Economic Modelling Results (based on 1st and 2nd iteration)

Action 15: *Core and Additional modelling teams to confirm delivery timelines in line with Carbon Workplan*

5. Carbon Budgets Workplan: 2024 Meeting Schedule and Proposed Topics

CB WG Meeting No.	Proposed Date and Time	Topic(s) for Consideration
11	Thursday 29th February 2024, 9:30 – 13:30	Quantitative approaches to carbon budgeting for Parties to the Paris Agreement (Victorian Government Report)/ Energy and Power systems modelling (Paul Deane)/ Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050 (ESAB)
12	Friday 22nd March 2024, 13:30 – 16:30	Agree inputs, parameters and assumptions for 2nd Iteration of Modelling/ *Follow on discussion on methane and climate neutrality (Joeri Rogelj)/* *Discussion of potential NTA analysis for Carbon Budgets*
13	Friday 19th April 2024, 13:30 – 16:30	Just Transition principles and considerations in the Carbon Budget Process (NESC)/ *Decarbonised Electricity System Study (SEAI)* Teagasc research and implications for Carbon Budgets (Karl Richards, Teagasc)
14	Thursday 23rd May 2024, 13:30 – 16:30	*2nd Iteration of Core Modelling Results/* *Decarbonised Electricity System Study (SEAI)*
15	Friday 28th June 2024, 13:30 – 16:30	Analysis of warming impact of selected core scenarios (2nd iteration)/ *Additional Analysis & Macroeconomic Modelling Results (based on 1st and 2nd iteration)* *Discussion on various aspects of aviation and maritime (Secretariat)*
16	Thursday 25th July 2024, 13:30 – 16:30	Agree inputs, parameters and assumptions for 3rd Iteration of Modelling/ Follow on discussion on CDR and Carbon Budgets (Oliver Geden) *Follow on discussion on Biodiversity Considerations (TBC)*
17	Thursday 29th August 2024, 13:30 – 16:30	3rd *Iteration of Core Modelling Results/*
18	Wed 18th September 2024, 13:30 – 16:30	*Additional Analysis & Macroeconomic Modelling Results (based on the 3rd iteration)* Analysis of warming impact of selected core scenarios (3rd iteration)

5. Carbon Budgets Workplan: Other Proposed Topics for Consideration

- Greenhouse gas - air pollution interactions and synergies (Andrew Kelly)
- Economic assessment of climate change impacts and adaptation options in Ireland (ESRI)

6. Agenda for Meeting No. 13: Friday 19th April 2024, 13:30 – 16:30

1. Just Transition principles and considerations in the Carbon Budget Process (NESC)/

- NESC to present on Just Transition principles to inform a follow-on discussion on their consideration as part of the Carbon Budgets Process

2. Decarbonised Electricity System Study (SEAI)

- Kerrie Sheehan and John McCann to present on SEAI's work to cary out a Decarbonised Electricity System Study (DESS) to aid in the determination of Ireland's pathway to achieve a net-zero electricity system.

3. Research on Mitigation measures for AFOLU (Teagasc)

- Karl Richards to present latest research on mitigation technologies and their implications for carbon budgets

6. Agenda for Meeting No. 14: Thursday 23rd May 2024, 13:30 – 16:30

1. Decarbonised Electricity System Study (SEAI)

- Kerrie Sheehan and John McCann to present on SEAI's work to cary out a Decarbonised Electricity System Study (DESS) to aid in the determination of Ireland's pathway to achieve a net-zero electricity system.

2. Presentation of the 2nd Iteration of Core Modelling Results

- Presentation and discussion of the 2nd iteration of core modelling results by Teagasc (FAPRI), NUIG (GOBLIN), and UCC (TIM)

7. AOB

- Update on Carbon Budgets Working Group Membership

IMPERIAL

Non-CO_2 greenhouse gas reductions implied by IPCC estimates of the remaining carbon budget

Joeri ROGELJ

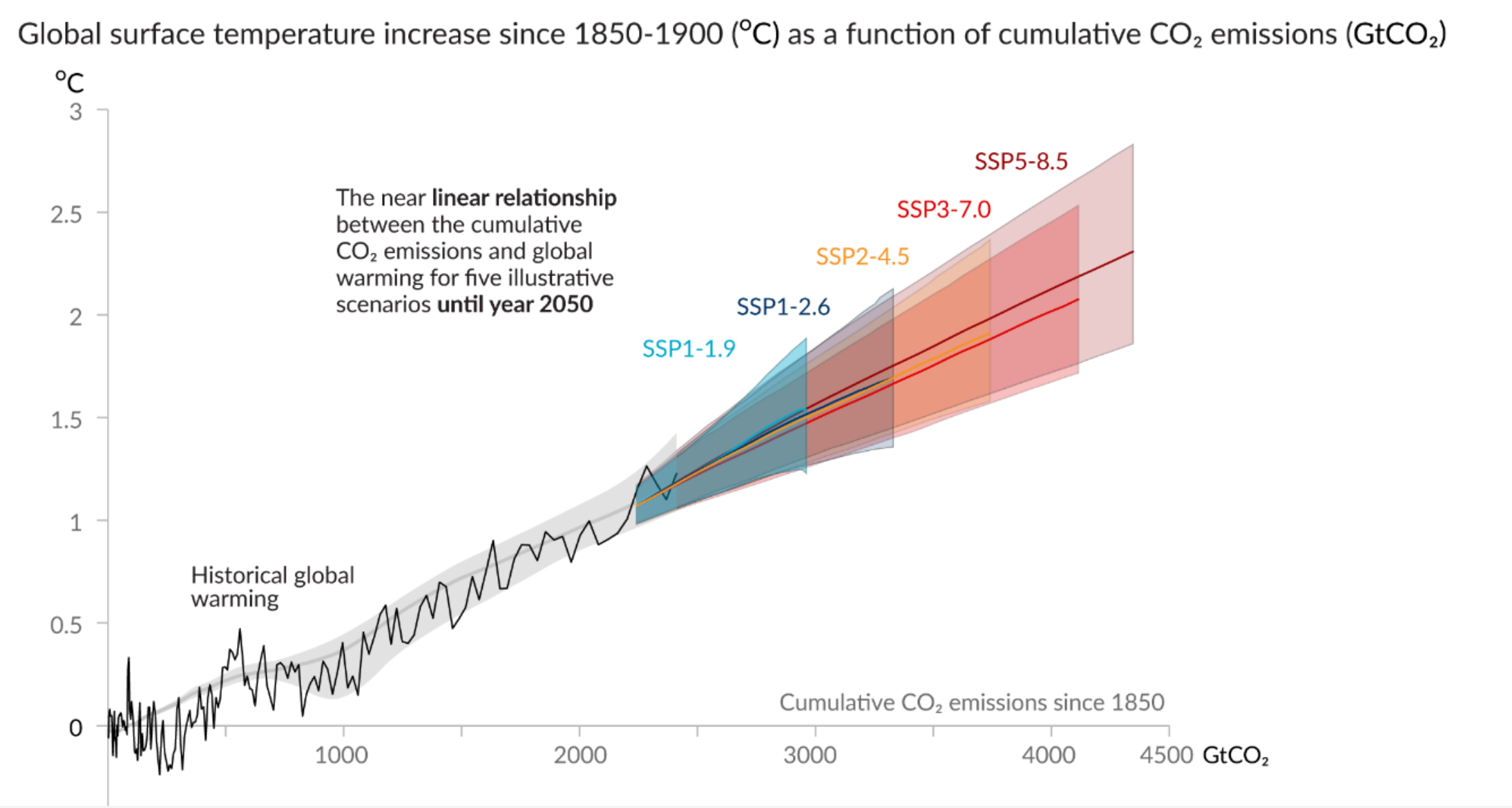
Non-CO_2 GHG reductions implied by IPCC estimates of the carbon budget

Outline

- Carbon budget basics and methods
- IPCC AR6 carbon budget estimates
- Non-CO_2 reductions and implications of emissions reduction failures

Carbon budget basics

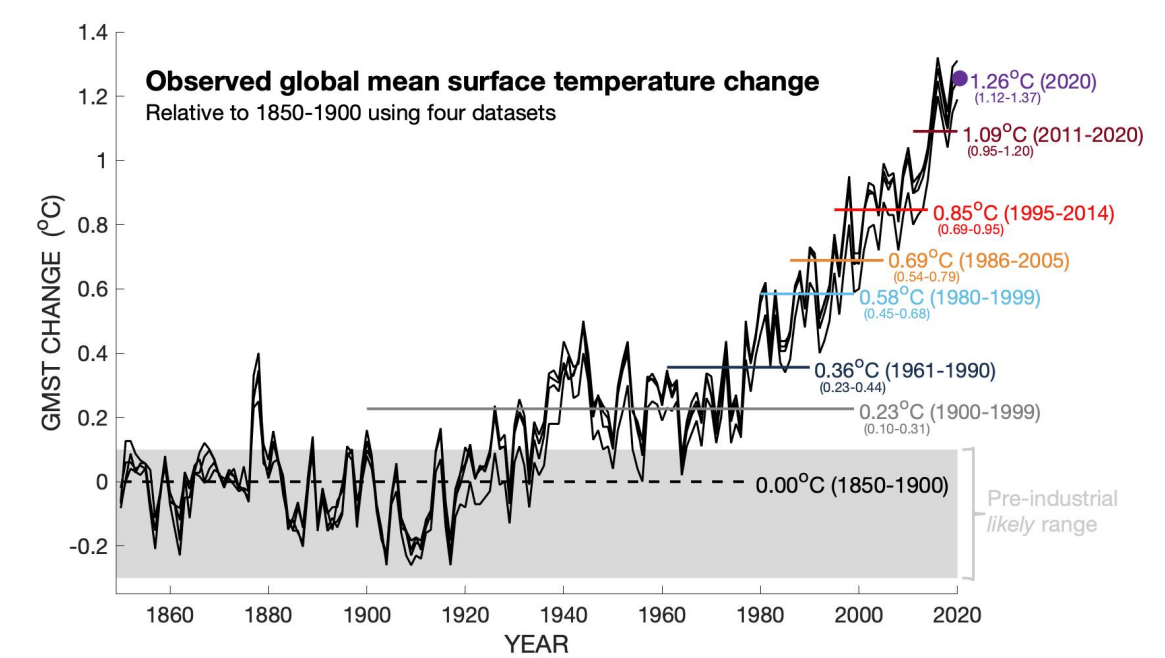
A near-linear relationship between total CO_2 and global warming

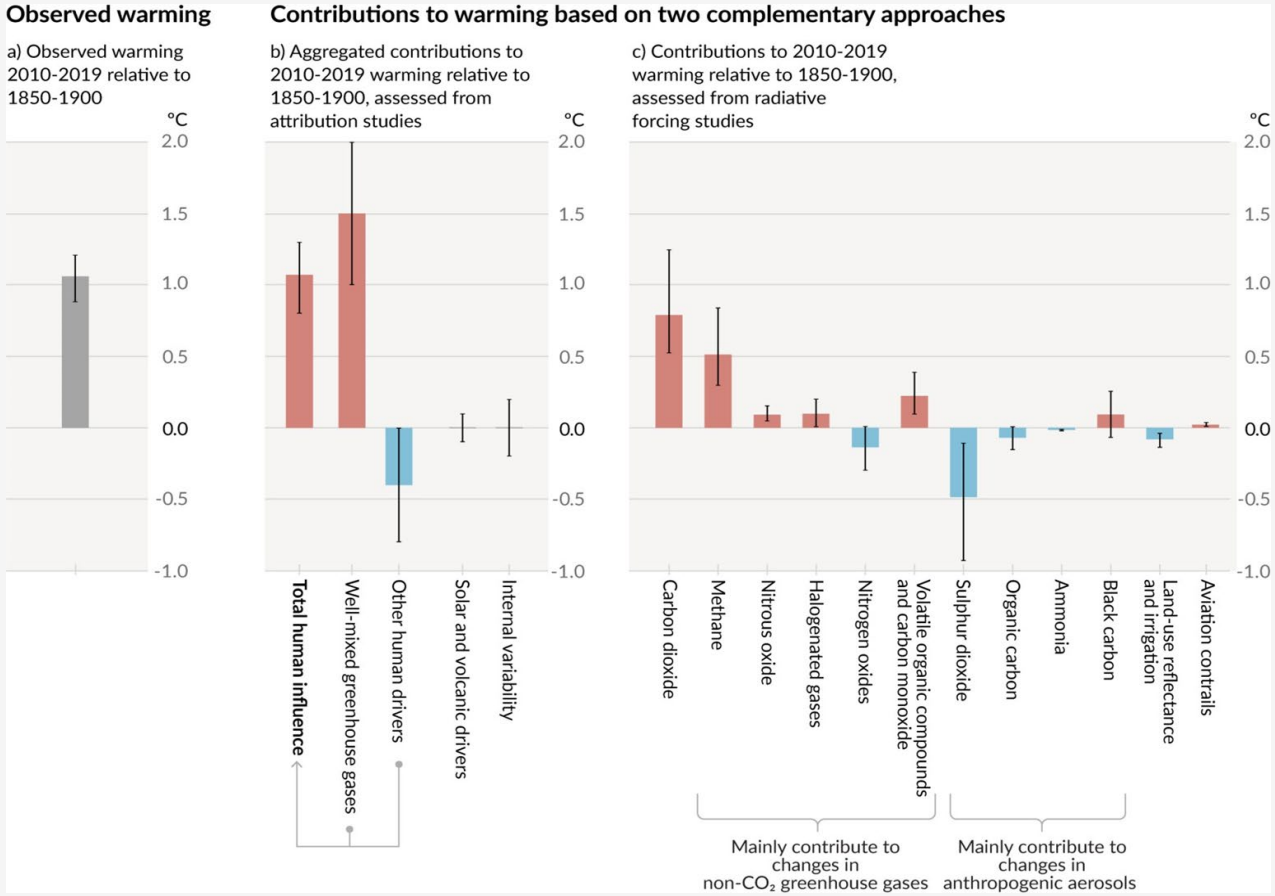


IPCC AR6 WG1 2021, Figure SPM.10

Carbon budget basics

Non-CO2 contributions to current warming



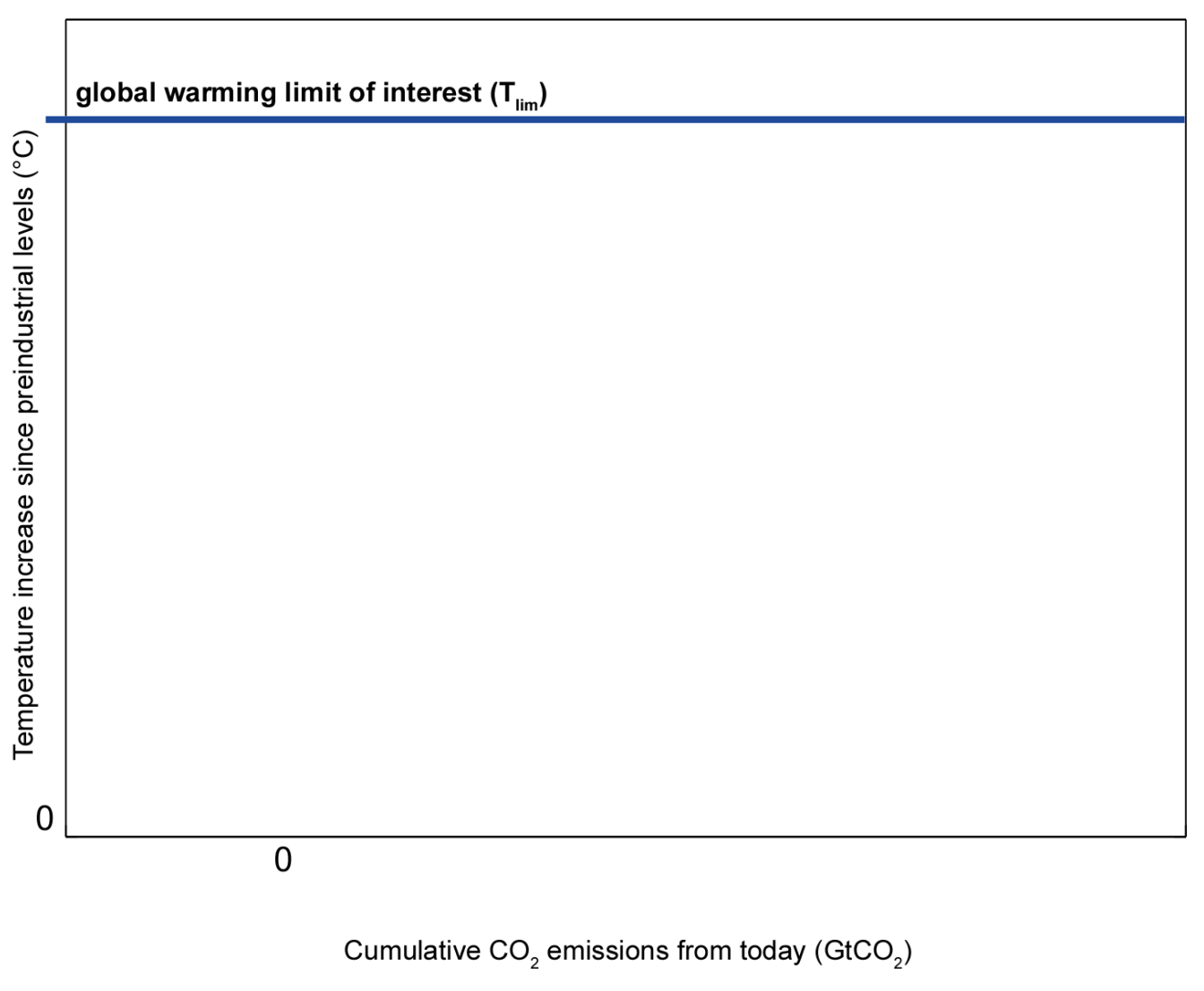


IPCC AR6 WGI – Figure 1.12 and Figure SPM.2

Carbon budget basics

IPCC's remaining carbon budget framework

Five components:



IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

Carbon budget basics

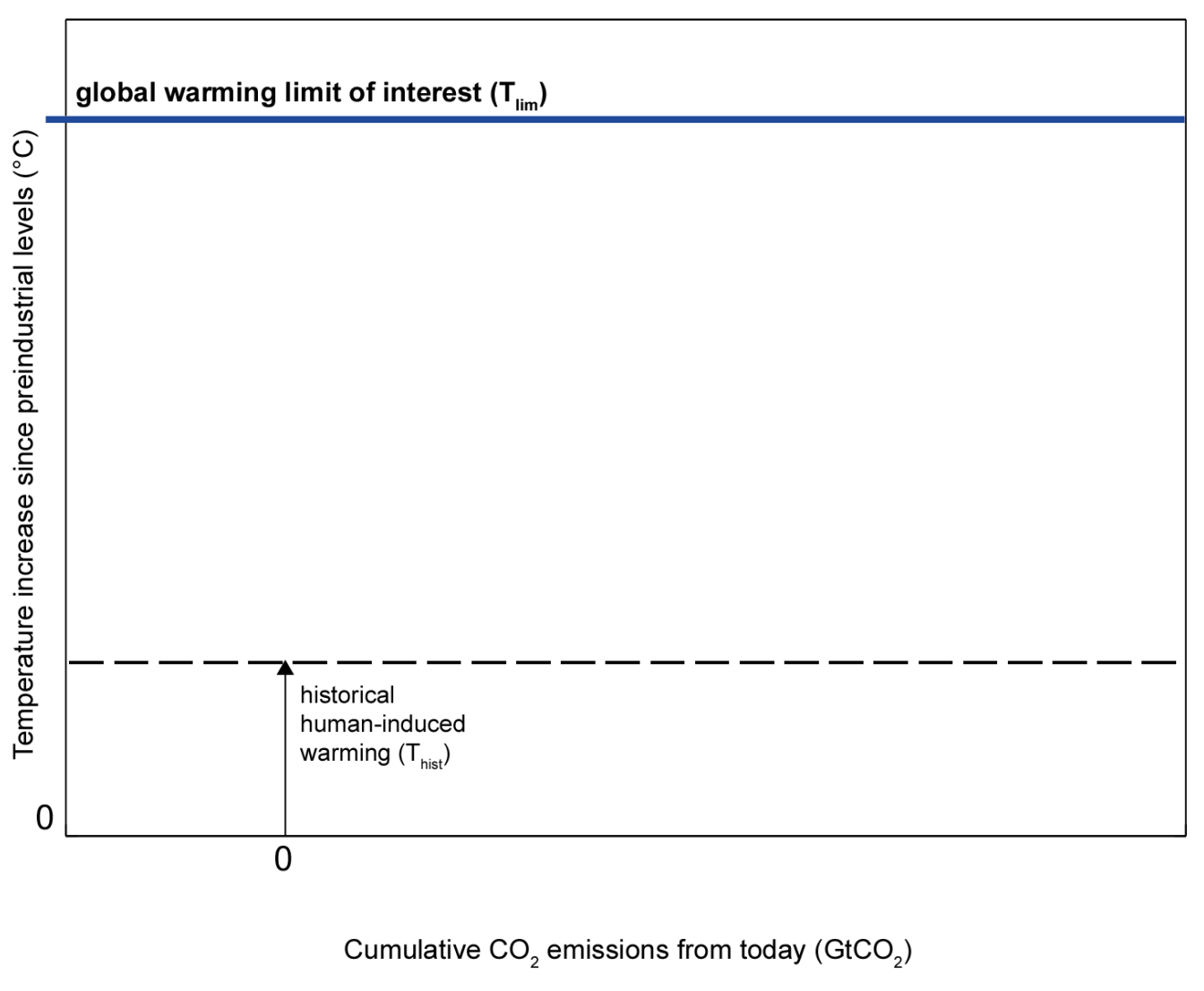
IPCC's remaining carbon budget framework

Five components:

- Historical warming to date

IPCC AR6 assessment:

- Human-induced warming from 1850-1900 until 2010-2019
- 1.07°C (0.8-1.3°C *likely* range)



IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

Carbon budget basics

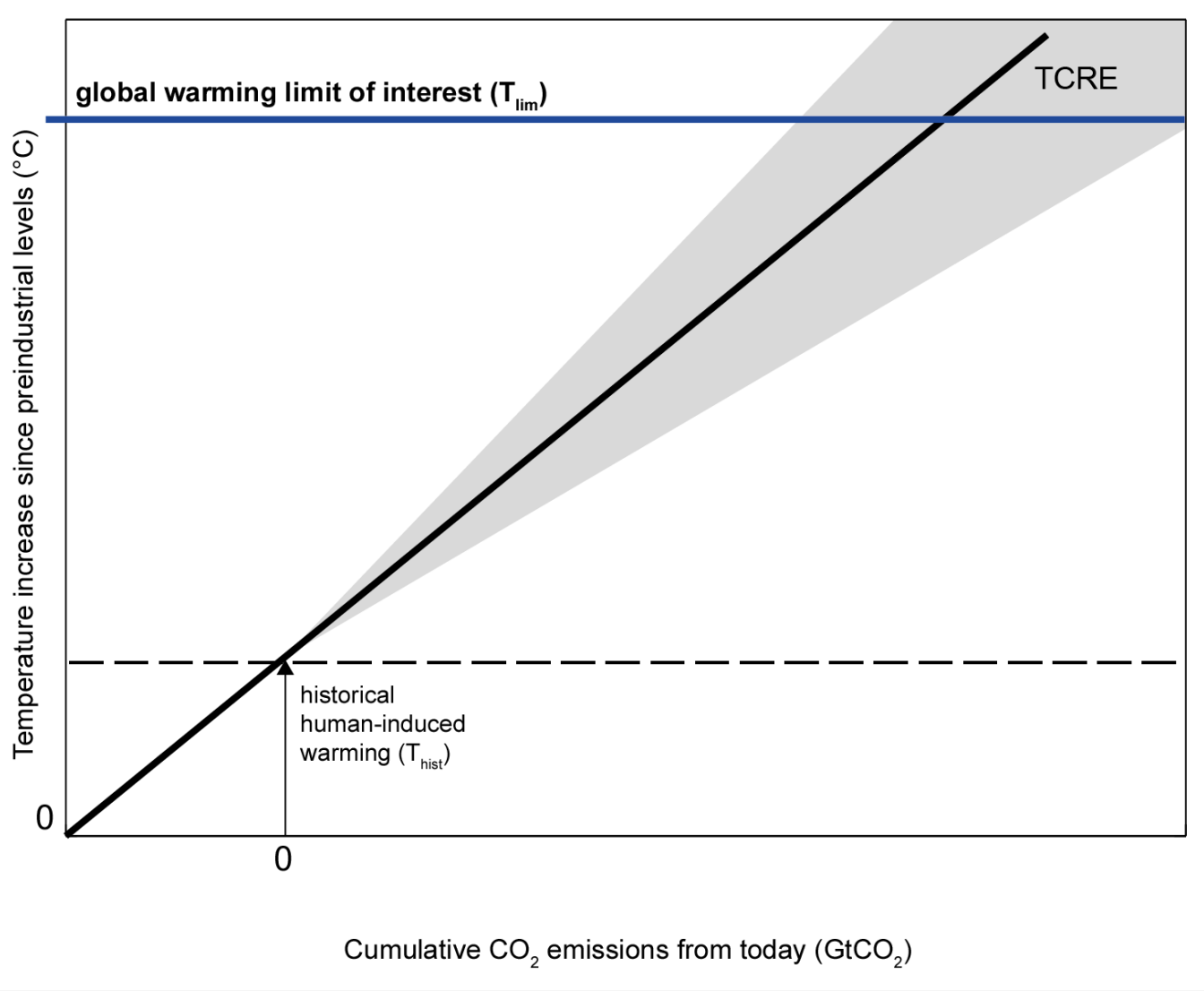
IPCC's remaining carbon budget framework

Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)

IPCC AR6 assessment:

- 1.0-2.3°C / 1000 PgC
- Best estimate of 1.65°C / 1000 PgC
- Normally distributed uncertainty



IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

Carbon budget basics

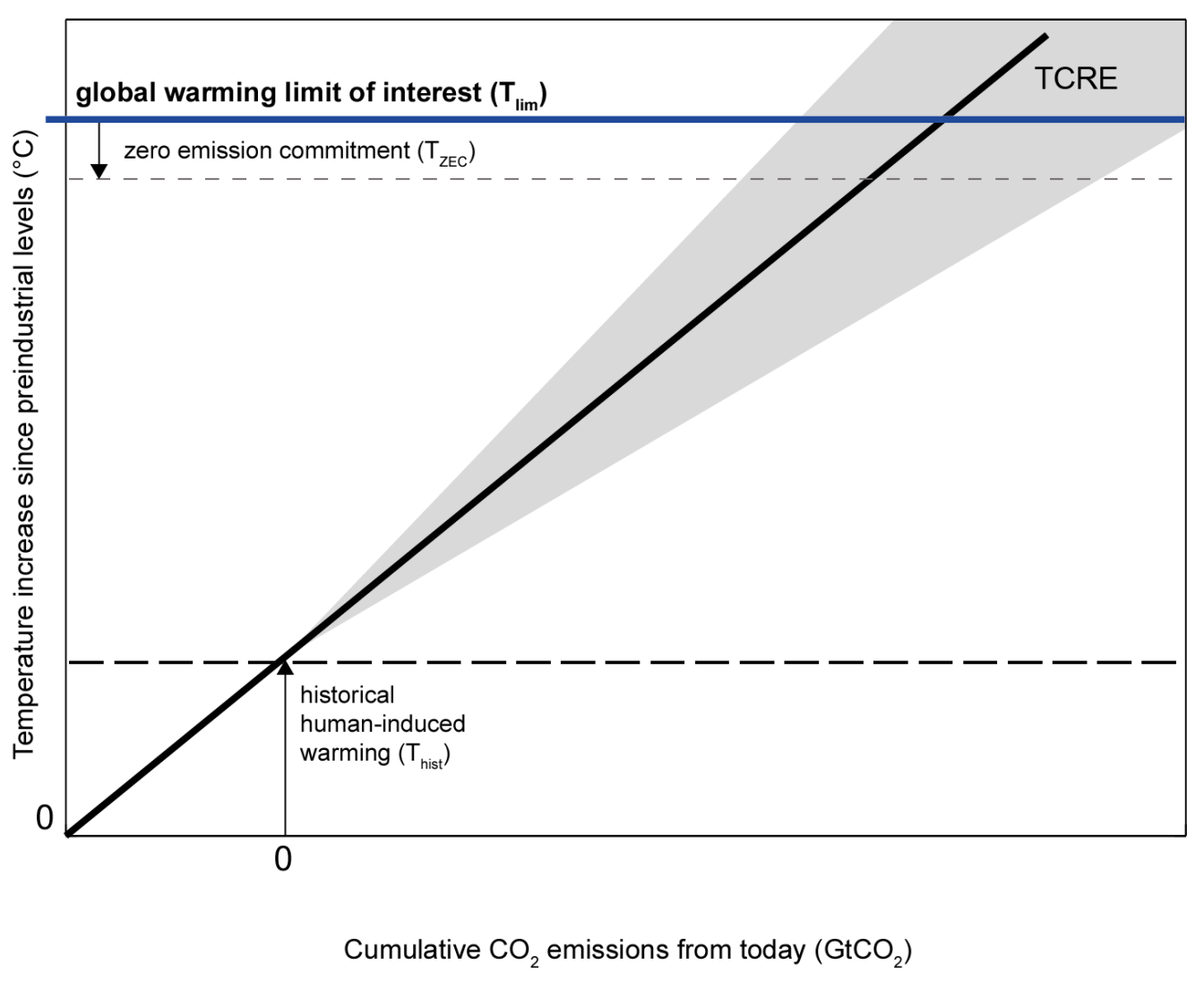
IPCC's remaining carbon budget framework

Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)

IPCC AR6 assessment:

- Best estimate: zero
- *Likely* range: about ±15% of total warming



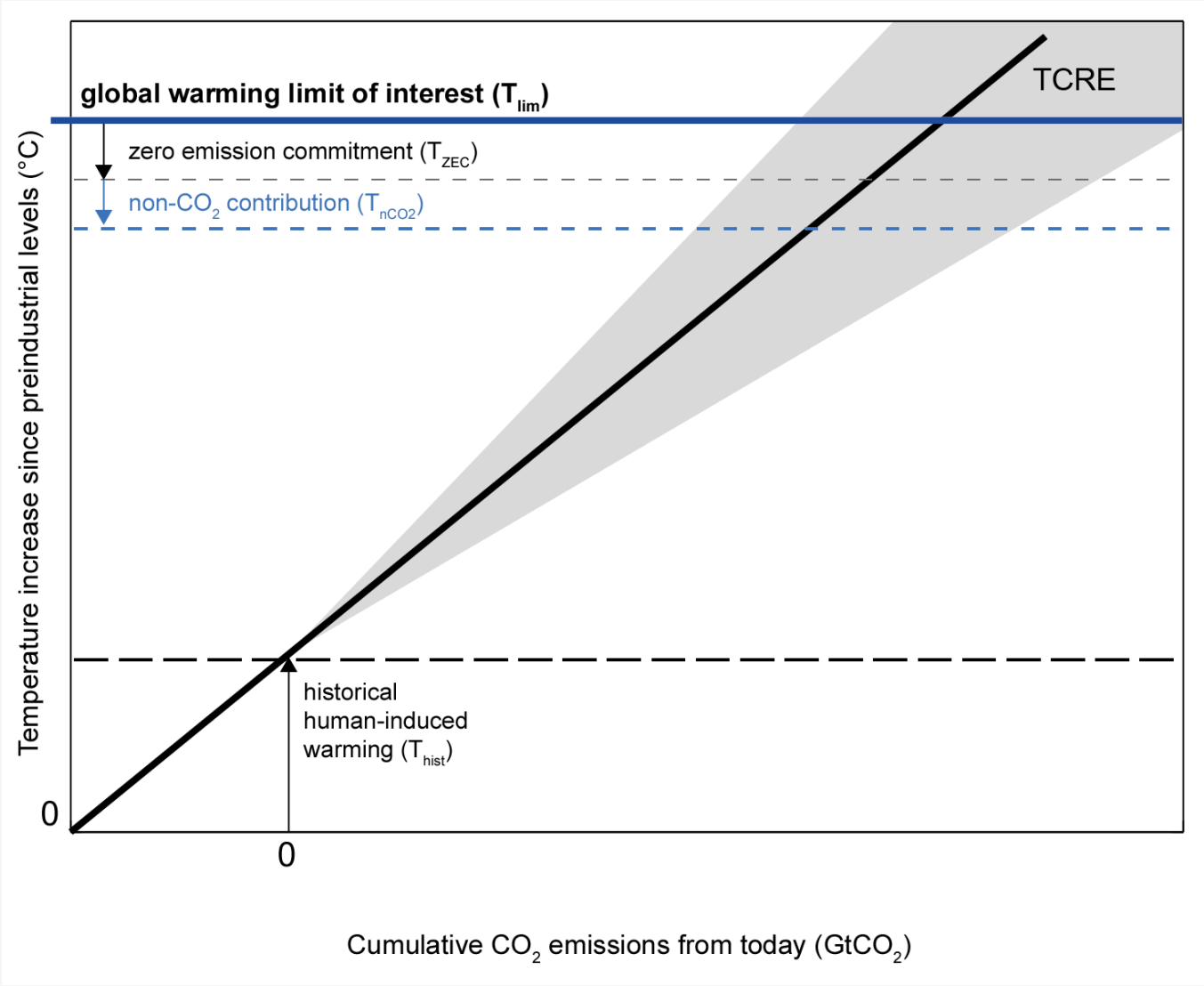
IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

Carbon budget basics

IPCC's remaining carbon budget framework

Five components:

- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)
- Projected future non-CO_2 temperature contribution



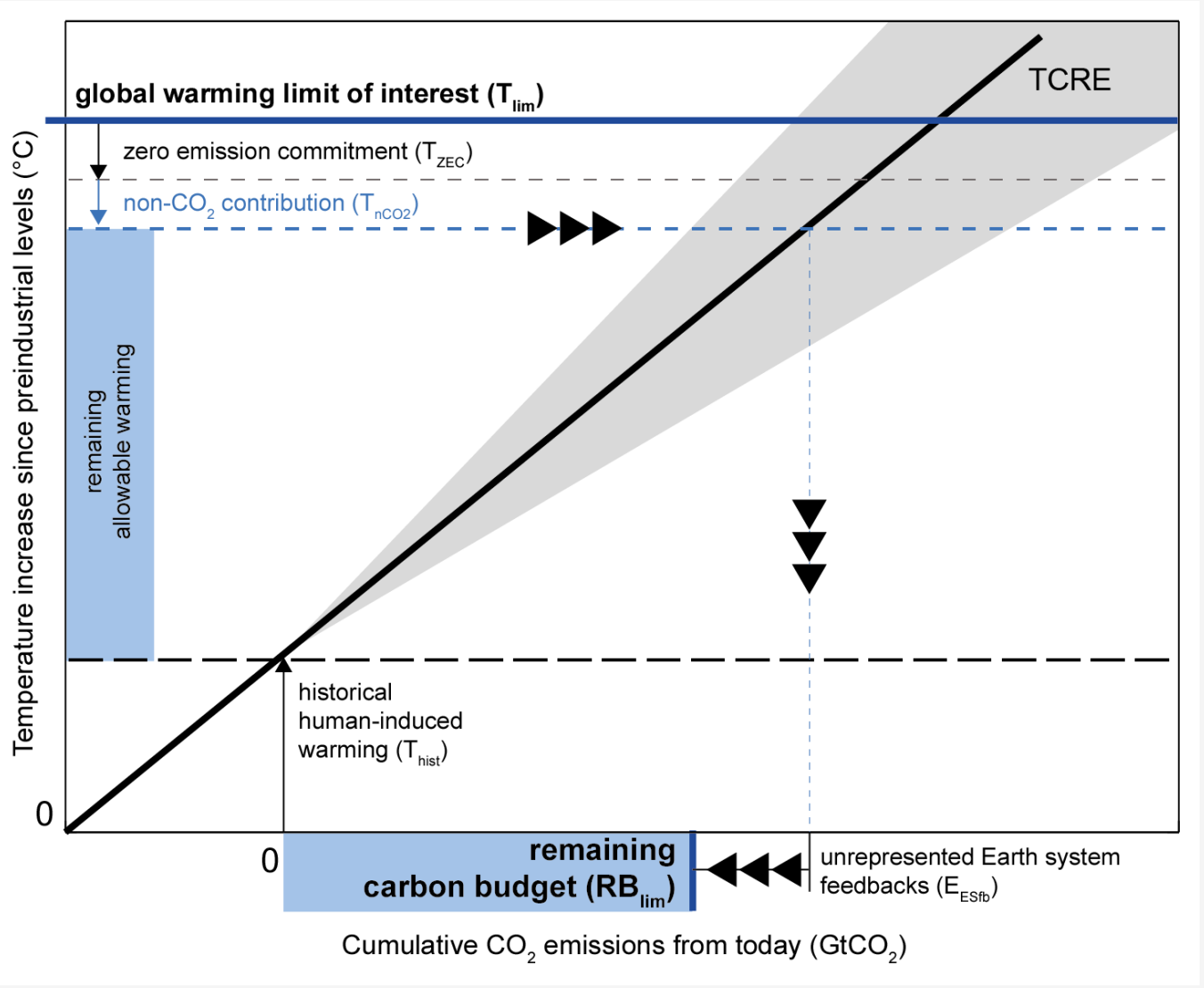
IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

Carbon budget basics

IPCC's remaining carbon budget framework

Five components:

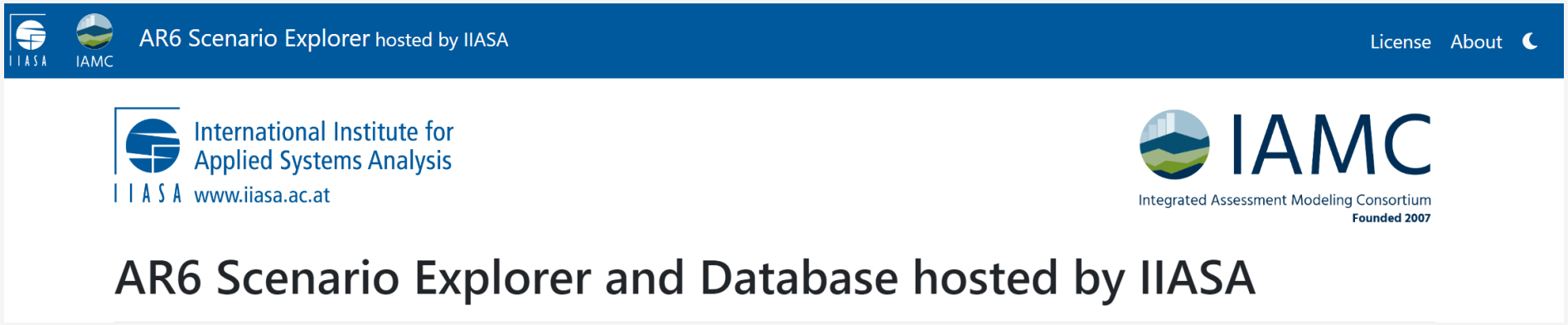
- Historical warming to date
- Transient climate response to cumulative emissions of carbon dioxide (TCRE)
- Zero emission commitment (ZEC)
- Projected future non-CO_2 temperature contribution
- Unrepresented Earth system feedbacks

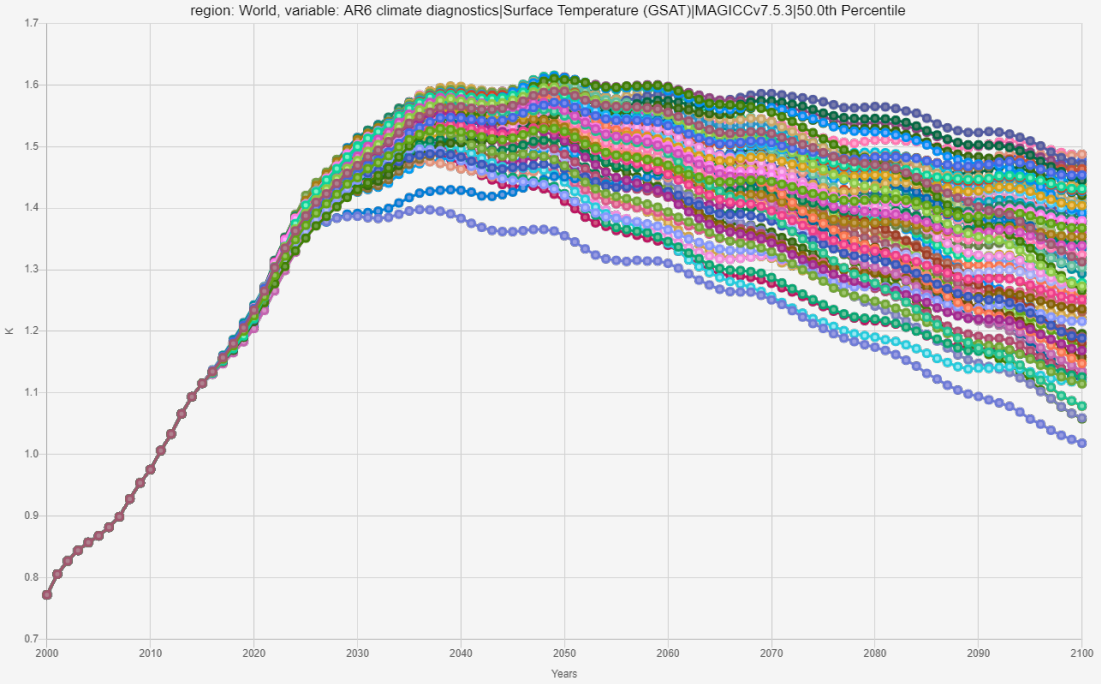


IPCC SR1.5; Rogelj et al, 2019; IPCC AR6 2021

IPCC AR6 remaining carbon budget estimates

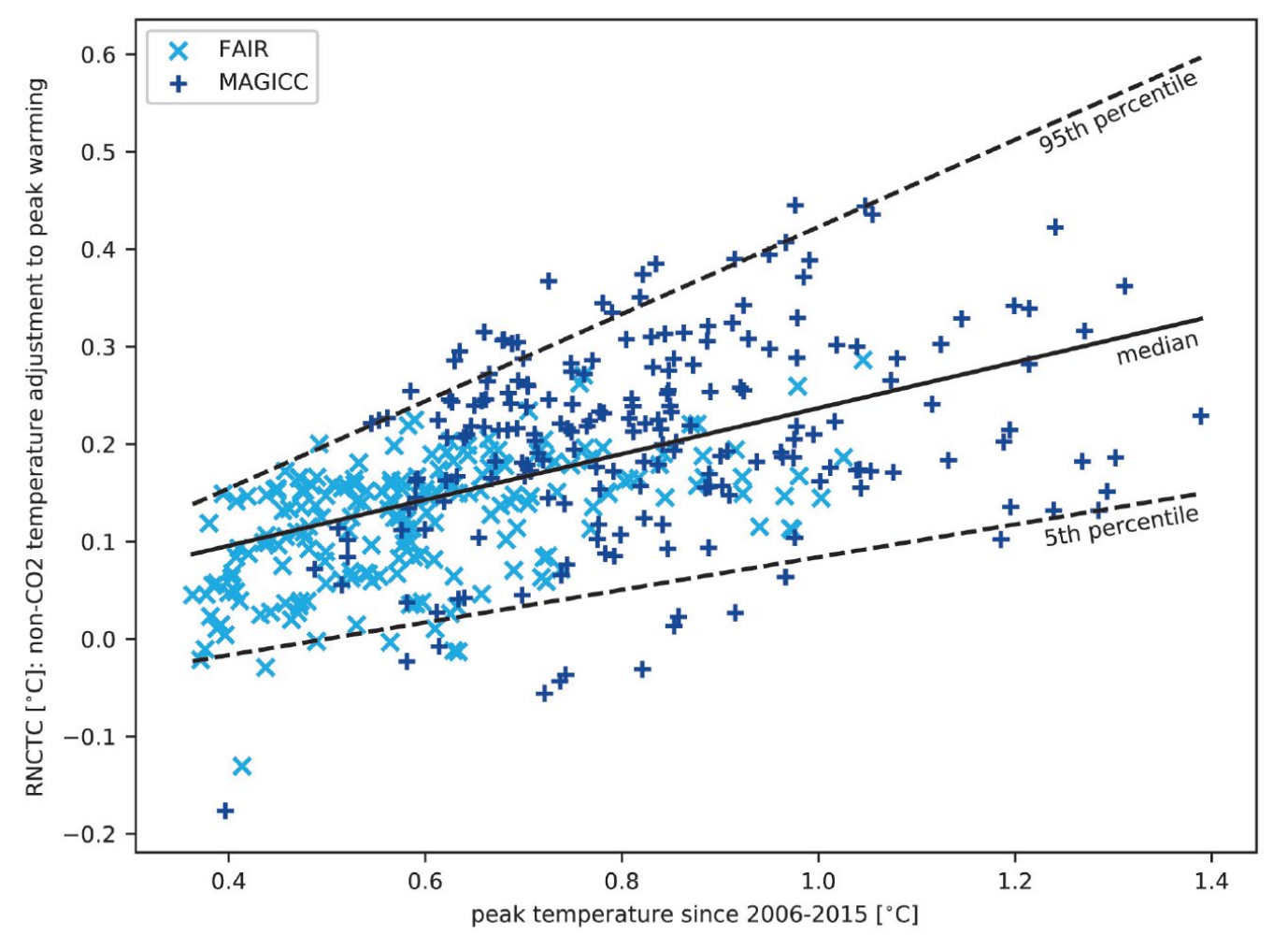
An implied relationship between peak temperature and the non-CO_2 warming contribution from integrated scenarios





IPCC AR6 remaining carbon budget estimates

An implied relationship between peak temperature and the non-CO_2 warming contribution



IPCC SR1.5 Figure 2.SM.4

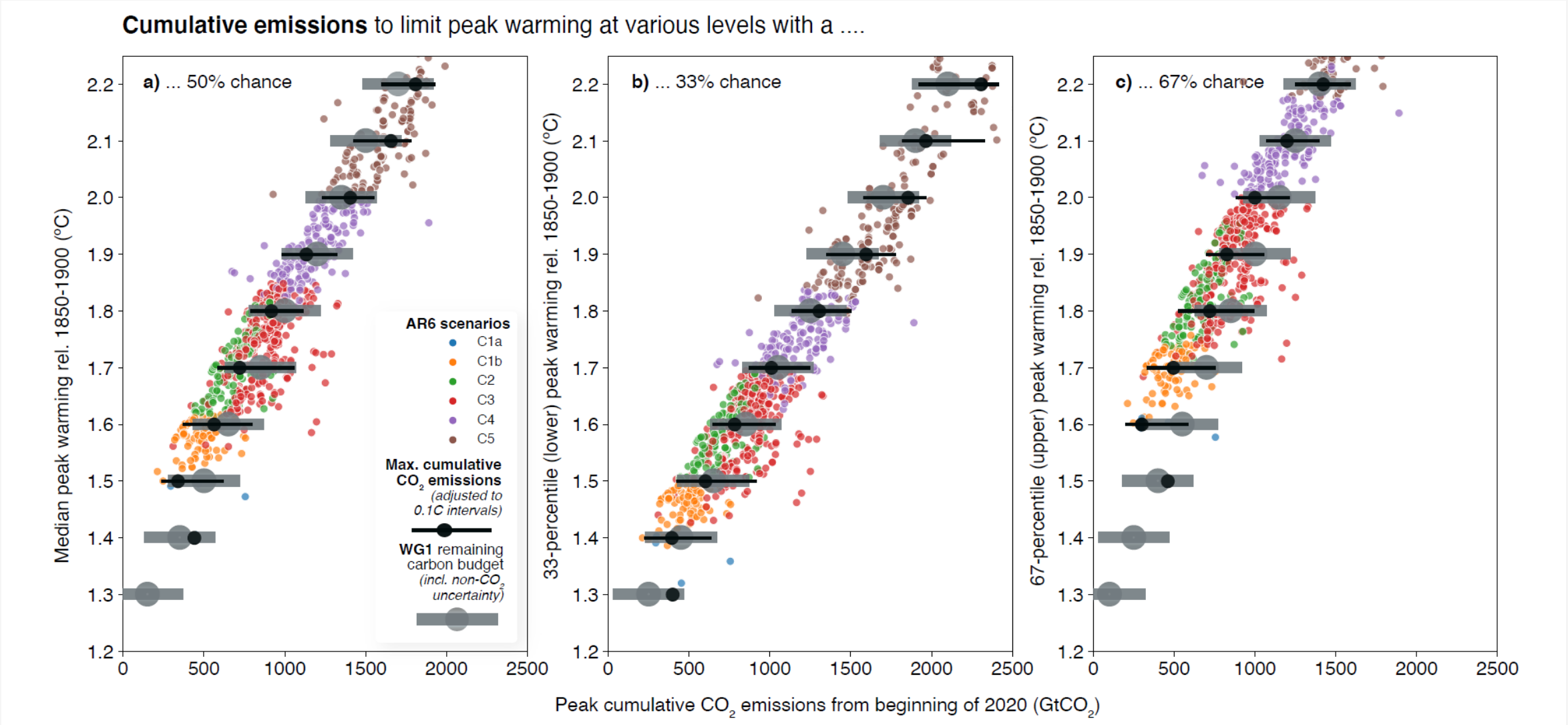
IPCC AR6 remaining carbon budget estimates

Global Warming Between 1850–1900 and 2010–2019 (°C)	Historical Cumulative CO_2 Emissions from 1850 to 2019 ($GtCO_2$)					
1.07 (0.8–1.3; likely range)	2390 (± 240; likely range)					
Approximate global warming relative to 1850–1900 until temperature limit (°C)[a]	Additional global warming relative to 2010–2019 until temperature limit (°C)	Estimated remaining carbon budgets from the beginning of 2020 ($GtCO_2$) *Likelihood of limiting global warming to temperature limit*[b]					Variations in reductions in non-CO_2 emissions[c]
		17%	*33%*	*50%*	*67%*	*83%*	
1.5	0.43	900	650	500	400	300	Higher or lower reductions in accompanying non-CO_2 emissions can increase or decrease the values on the left by 220 $GtCO_2$ or more
1.7	0.63	1450	1050	850	700	550	
2.0	0.93	2300	1700	1350	1150	900	

IPCC AR6 WG1 Table SPM.2

IPCC AR6 remaining carbon budget estimates

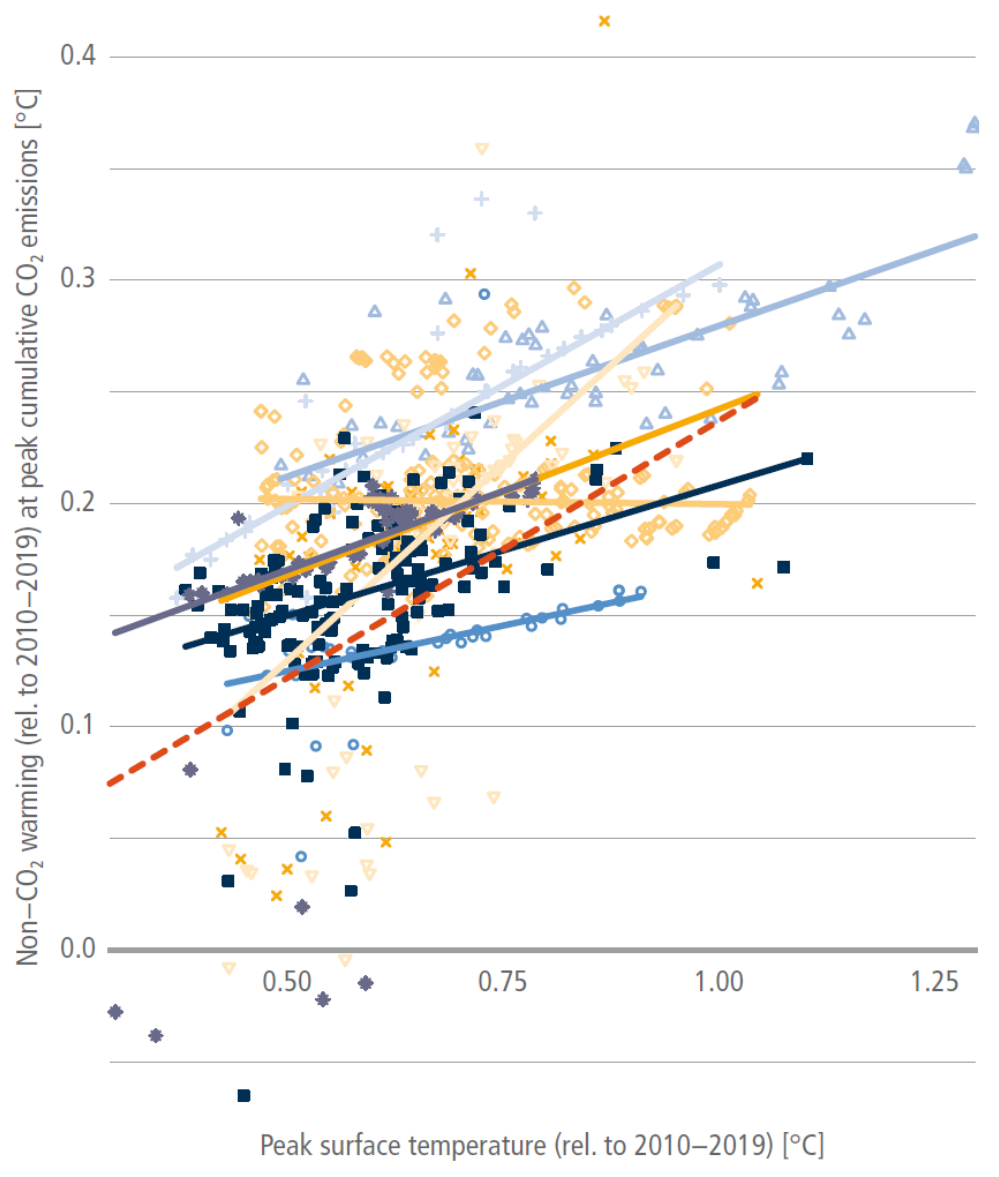
Non-CO_2 warming variation in mitigation scenarios

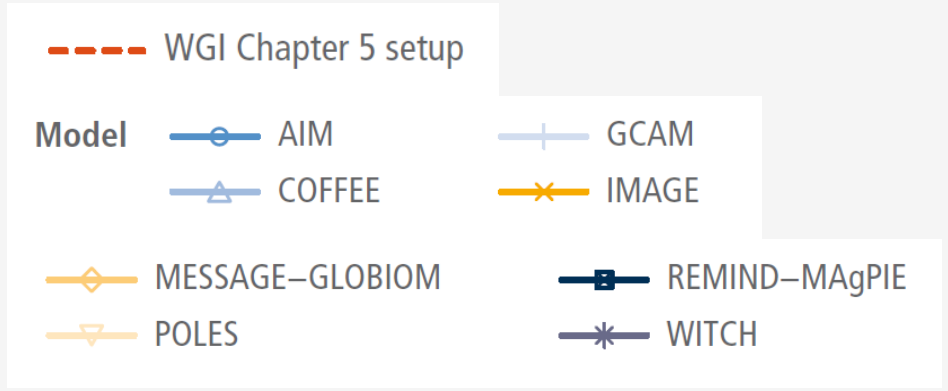


IPCC AR6 WG3 Box 3.4 Figure 1

IPCC AR6 remaining carbon budget estimates

Non-CO_2 warming variation across models





IPCC AR6 WG3 Box 3.4 Figure 2

Non-CO_2 reductions and implications of reduction failures

communications earth & environment

ARTICLE

Check for updates

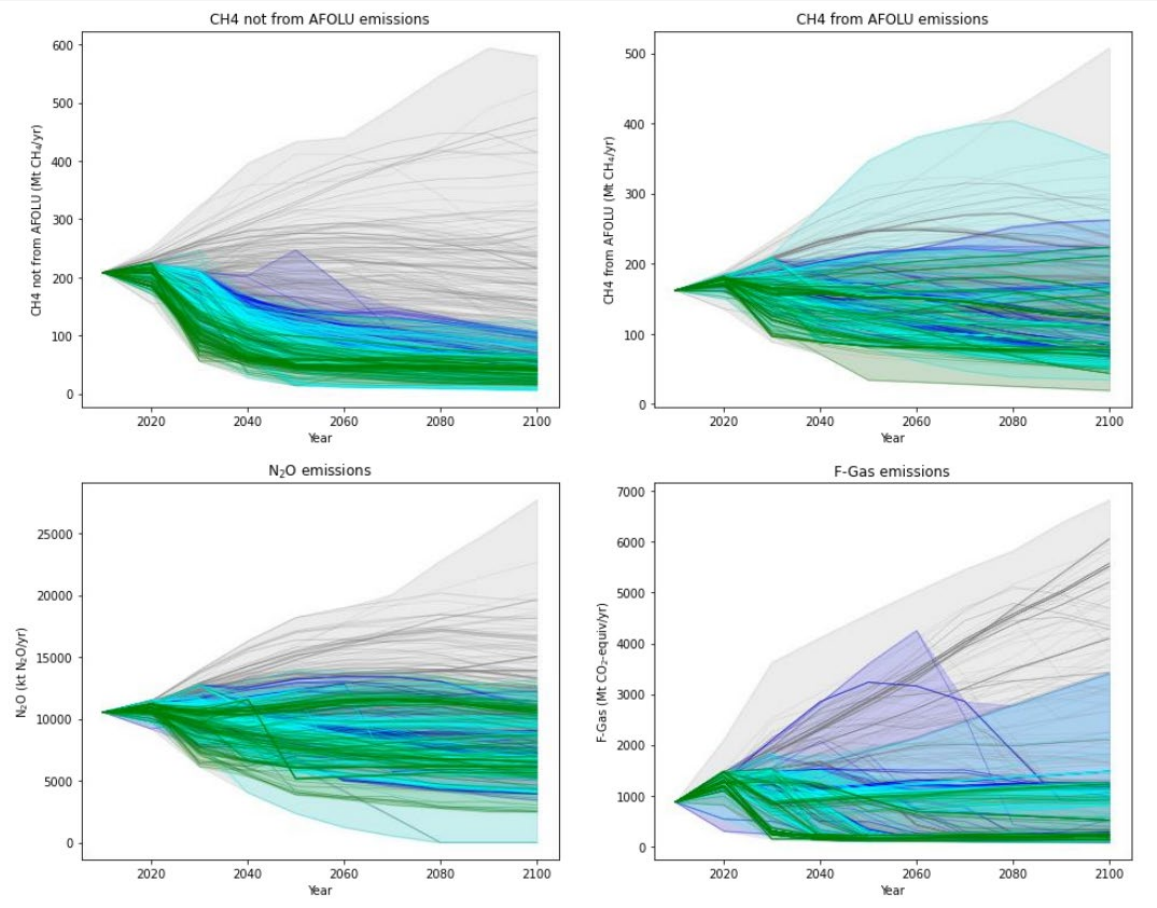
https://doi.org/10.1038/s43247-023-01168-8 OPEN

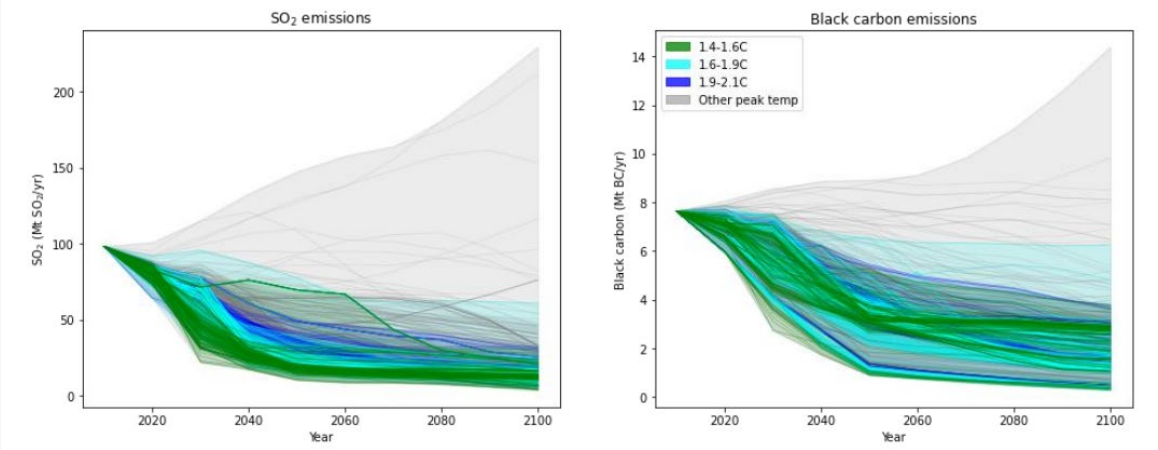
Substantial reductions in non-CO_2 greenhouse gas emissions reductions implied by IPCC estimates of the remaining carbon budget

Joeri Rogelj [1,2,3]✉ & Robin D. Lamboll [1]

Non-CO_2 reductions and implications of reduction failures

What do actual non-CO_2 emissions do?

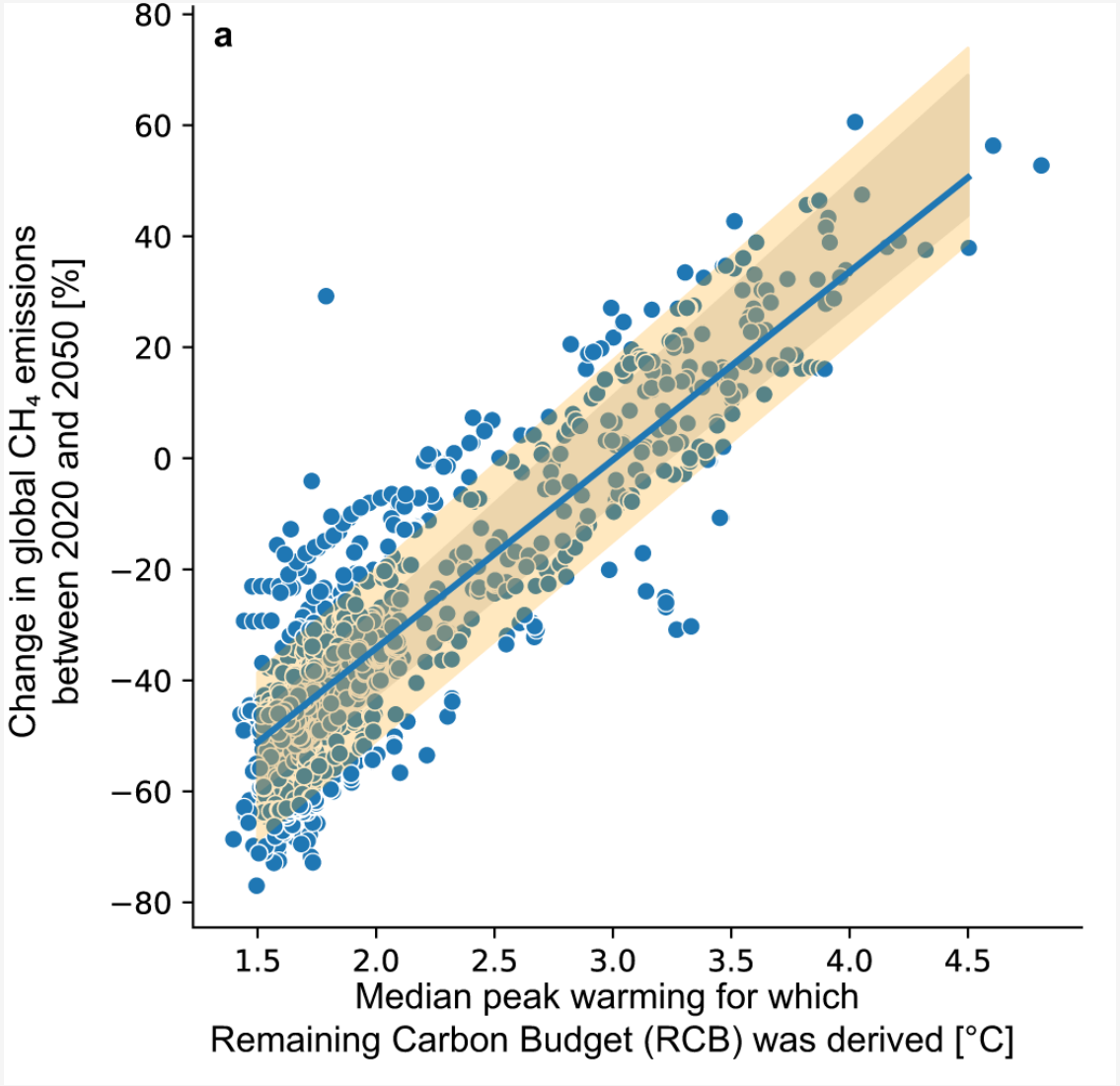


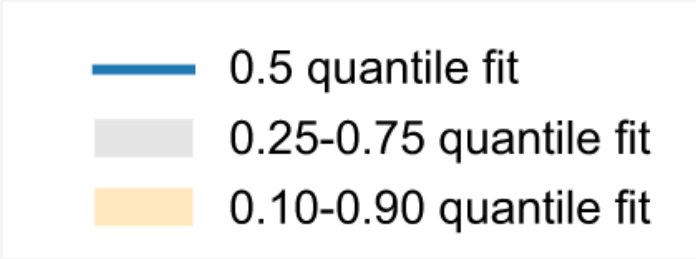


Rogelj & Lamboll (2024), Sup Fig 1

Non-CO_2 reductions and implications of reduction failures

Total methane emissions





Rogelj & Lamboll (2024), Fig 1a

Non-CO_2 reductions and implications of reduction failures

A whole set of non-CO_2 emissions reduction

Warming limit relative to 1850–1900	Percentile	Emissions change in 2050 relative to 2020 *[%]*						
		CH_4	CH_4 AFOLU	CH_4 non-AFOLU	N_2O	F-gases	SO_2	BC
1.5 °C	**10%**	−69	−52	−86	−47	−98	−80	−77
	25%	−60	−43	−80	−35	−98	−78	−57
	50%	−51	−32	−73	−22	−91	−78	−53
	75%	−47	−16	−67	−7	−47	−74	−49
	90%	−39	−6	−57	2	−35	−66	−45
1.7 °C	**10%**	−62	−47	−77	−42	−91	−78	−76
	25%	−53	−38	−71	−30	−85	−76	−57
	50%	−44	−27	−64	−18	−75	−73	−52
	75%	−39	−12	−58	−3	−33	−68	−46
	90%	−31	−1	−48	6	−20	−60	−42
2.0 °C	**10%**	−51	−39	−64	−35	−81	−75	−76
	25%	−43	−30	−58	−23	−66	−72	−55
	50%	−34	−21	−51	−11	−50	−66	−49
	75%	−27	−4	−44	2	−12	−59	−41
	90%	−20	6	−33	12	3	−51	−36

Rogelj & Lamboll (2024), Table 1

Non-CO_2 reductions and implications of reduction failures

Calculating CO_2 warming equivalent emissions

$$E_{CO_2-we(SLCF)} = \left(4 \times E_{SLCF}(t) - 3.75 \times E_{SLCF}(t-20)\right) \times GWP_{100}$$

Lynch et al (2020)

Non-CO_2 reductions and implications of reduction failures

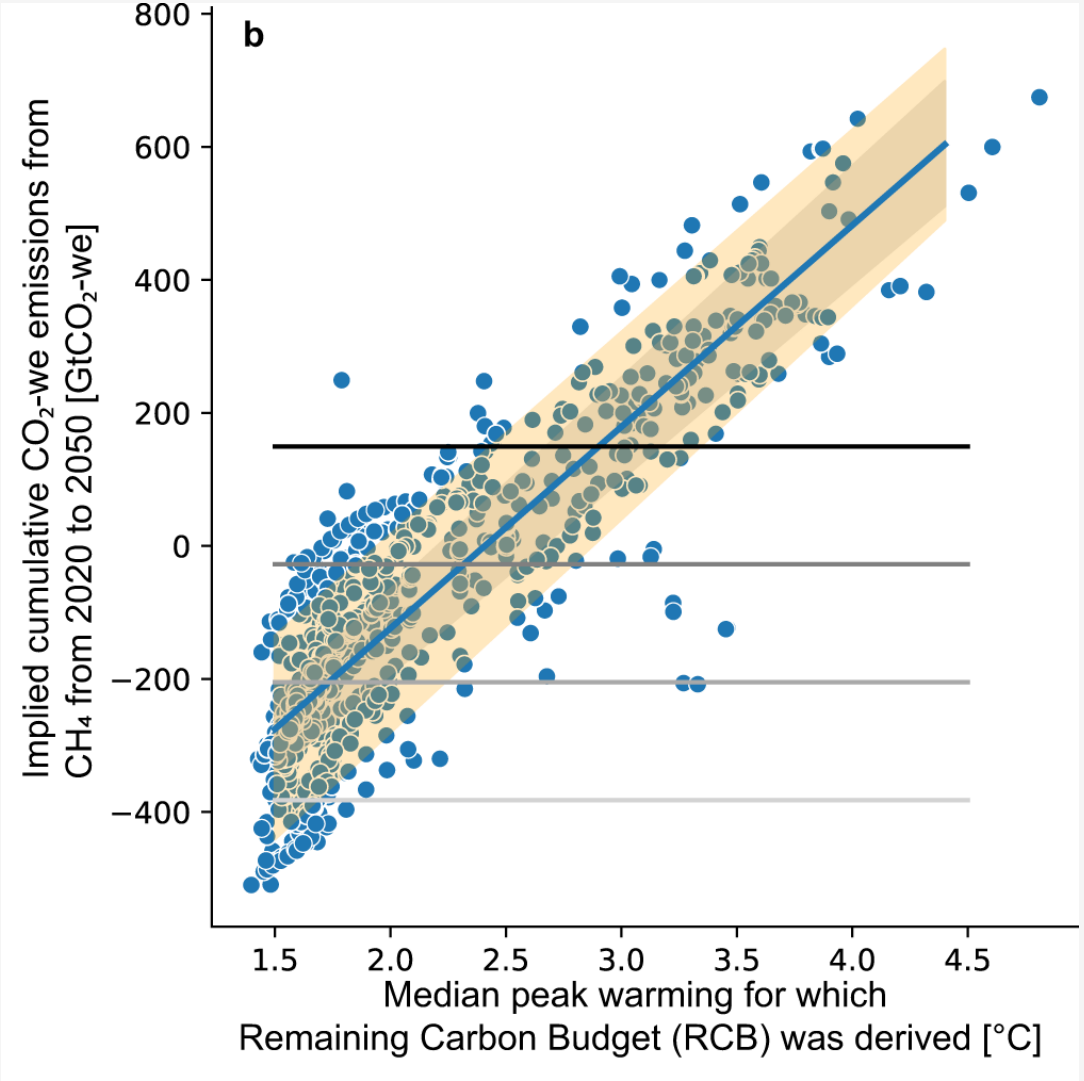
With implied cumulative CO_2 warming equivalent emissions contributions

Warming limit relative to 1850–1900	Percentile	Emissions change in 2050 relative to 2020 *[%]*							Implied cumulative CO_2 warming equivalent emissions between 2020 and 2050 *[$GtCO_2$-we]*				
		CH_4	CH_4 AFOLU	CH_4 non-AFOLU	N_2O	F-gases	SO_2	BC	CH_4	CH_4 AFOLU	CH_4 non-AFOLU	N_2O	F-gases
1.5 °C	**10%**	−69	−52	−86	−47	−98	−80	−77	−440	−107	−335	67	11
	25%	−60	−43	−80	−35	−98	−78	−57	−339	−72	−317	72	13
	50%	−51	−32	−73	−22	−91	−78	−53	−275	−25	−264	81	25
	75%	−47	−16	−67	−7	−47	−74	−49	−225	37	−210	87	38
	90%	−39	−6	−57	2	−35	−66	−45	−135	64	−183	92	46
1.7 °C	**10%**	−62	−47	−77	−42	−91	−78	−76	−376	−88	−294	69	14
	25%	−53	−38	−71	−30	−85	−76	−57	−281	−55	−274	74	18
	50%	−44	−27	−64	−18	−75	−73	−52	−215	−10	−220	83	30
	75%	−39	−12	−58	−3	−33	−68	−46	−161	53	−164	89	43
	90%	−31	−1	−48	6	−20	−60	−42	−74	82	−134	94	50
2.0 °C	**10%**	−51	−39	−64	−35	−81	−75	−76	−280	−60	−234	73	19
	25%	−43	−30	−58	−23	−66	−72	−55	−193	−29	−208	78	26
	50%	−34	−21	−51	−11	−50	−66	−49	−124	13	−154	86	38
	75%	−27	−4	−44	2	−12	−59	−41	−66	77	−94	92	49
	90%	−20	6	−33	12	3	−51	−36	17	109	−62	98	56

Rogelj & Lamboll (2024), Table 1

Non-CO_2 reductions and implications of reduction failures

Comparison with various levels of reduction failure



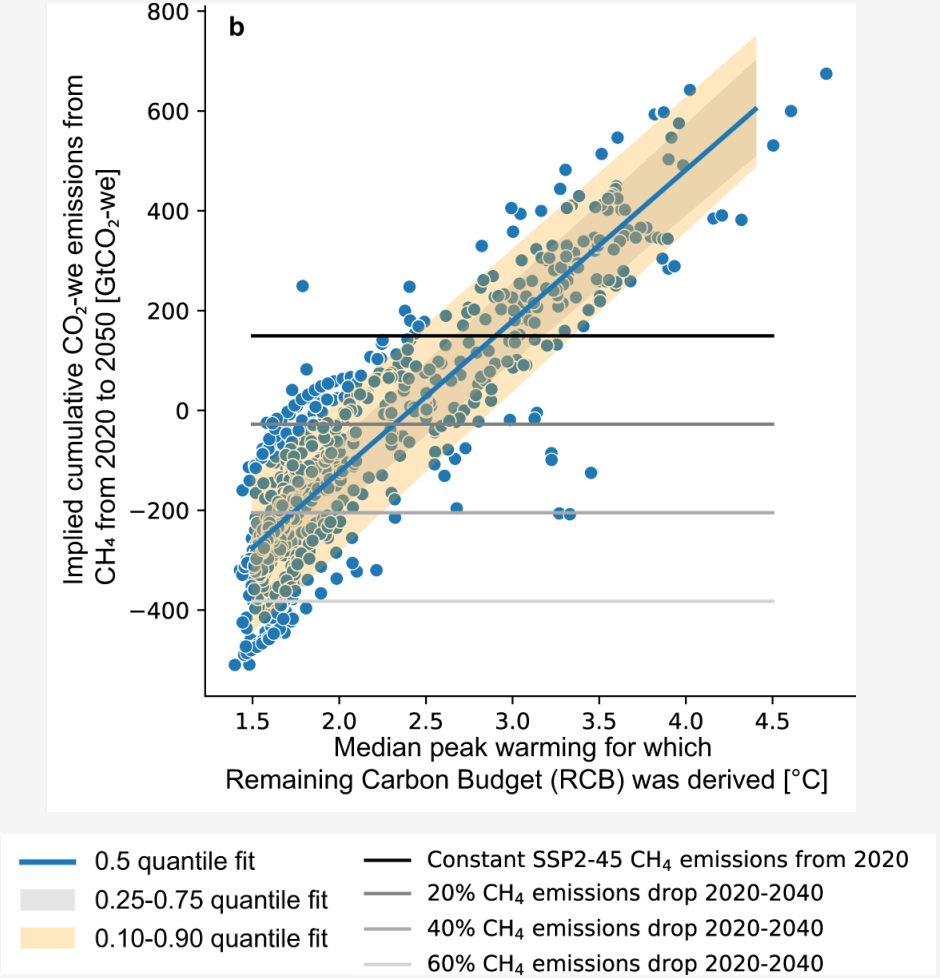
0.5 quantile fit
0.25-0.75 quantile fit
0.10-0.90 quantile fit

Constant SSP2-45 CH_4 emissions from 2020
20% CH_4 emissions drop 2020-2040
40% CH_4 emissions drop 2020-2040
60% CH_4 emissions drop 2020-2040

Rogelj & Lamboll (2024) Fig 1b

Non-CO_2 reductions and implications of reduction failures

Final reflections



Just as the (remaining) carbon budget, **global non-CO_2 emissions reduction contributions must be translated** into national contributions taking into account **equity and fairness**

Rogelj & Lamboll (2024) Fig 1b

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Thank you

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Substantial reductions in non-CO_2 greenhouse gas emissions reductions implied by IPCC estimates of the remaining carbon budget

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