SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Emission metrics in WG I

Physical Science Basis

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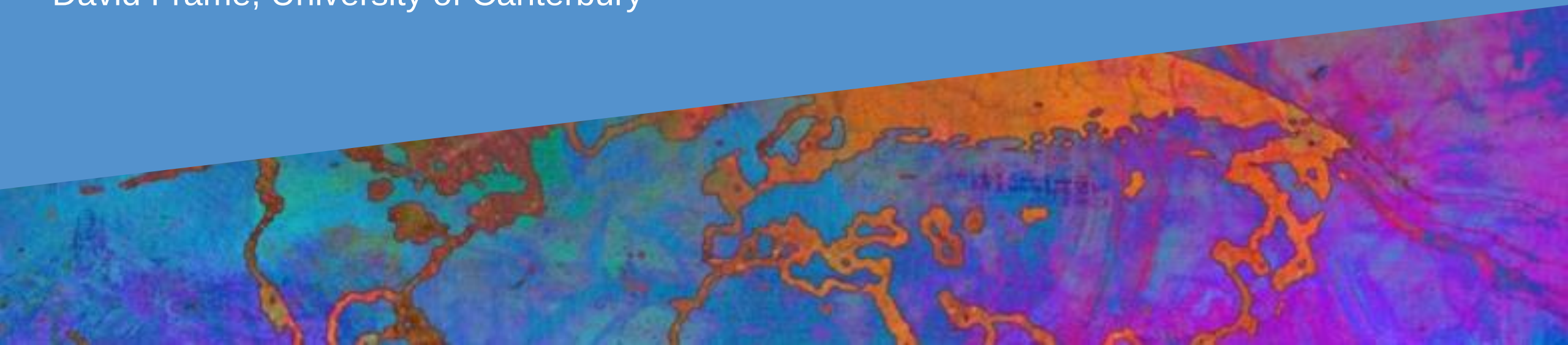


Overview

- Key Messages on metrics from WG I Summary for Policy Makers and Technical Summary

- Updates to GWP values
  - Carbon-cycle response
  - Fossil vs non-fossil

- New metrics
  - Implications for Net Zero

Key messages

Summary for Policy Makers:

- From a physical science perspective, limiting human-induced global warming to a specific level requires limiting cumulative CO2 emissions, reaching at least **net zero CO2 emissions,** along with **strong reductions in other greenhouse gas emissions**. {SPM.D.1}
    - **Net zero CO_2** and **declining non-CO_2 forcing** [0.3% per year {7.6.2}] would halt human-induced warming. {TS.3.3.3}
- The choice of emissions metric used to calculate aggregated emissions and removals of different GHGs affects what point in time the aggregated GHGs are calculated to be net zero {SPM.D.1.8}
- Emissions pathways that reach and sustain net zero GHG emissions **defined by the GWP100** are projected to result in a **decline in surface temperature** {SPM.D.1.8}

Key messages

Technical Summary:

- New emissions metric approaches [such as GWP* and the combined-GTP (CGTP)] can be used to generate equivalent **cumulative emissions of CO_2** for **short-lived greenhouse gases based on their rate of emissions**. {TS.3.3.3}
  - These metric approaches are well suited to estimate the temperature response from aggregated emissions of a range of gases over time. **$\Delta T = \Delta CO_2\text{-e} \times TCRE$** {Ch 7}

- When GHGs are aggregated using standard metrics such as GWP or GTP, cumulative CO2-e emissions are not necessarily proportional to future global surface temperature outcomes {TS.3.3.3}

- The warming evolution resulting from net zero GHG emissions defined in this way [using new metrics] corresponds approximately to […] an approximate temperature stabilization {TS.3.3.3}

Evolution of GWPs

- GWPs are updated every IPCC cycle due to:
  - Changes in GHG concentrations
  - New physical understanding
    - Radiative forcing calculations and adjustments
  - New chemical understanding.
    - Multi-model assessment of effects on ozone, stratospheric water vapour and methane lifetime
- Note: changes have all been within the very large uncertainty range

	Methane	N2O
AR5	28.5	265
+ 2019 concs	29.5	285
+ New RF	35.2	281
+ Adjustments	30.4	290
+Chemistry	27.7	262
+ Lifetime (=AR6)	26.4	252
C-cycle AR5	34	268
C-cycle AR6	27.9	264
Uncertainty	±11	±120

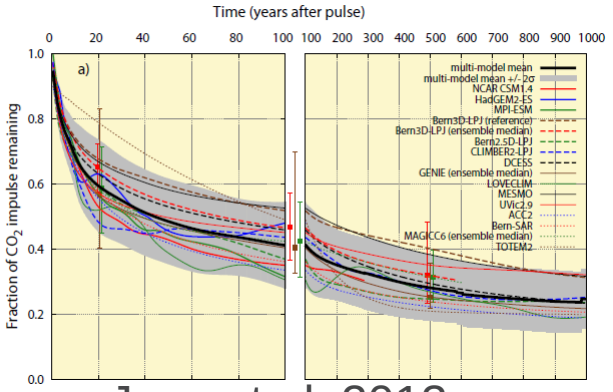
Carbon cycle response

- Only IPCC-assessed multi-model CO_2 response functions are from Joos et al. (2013)
- These implicitly included carbon-cycle response to temperature

- This response would also occur for other species

- Treat denominator, and numerator consistently
- AR6: Add in carbon cycle response term to non-CO_2 species by default

- **Carbon-cycle responses are more robustly accounted for in emissions metrics compared to AR5 (high confidence) {TS.3.3.3}**



Joos et al. 2013

$$GWP = \frac{AGWP_{CH_4}}{AGWP_{CO_2}}$$

Fossil vs non-fossil

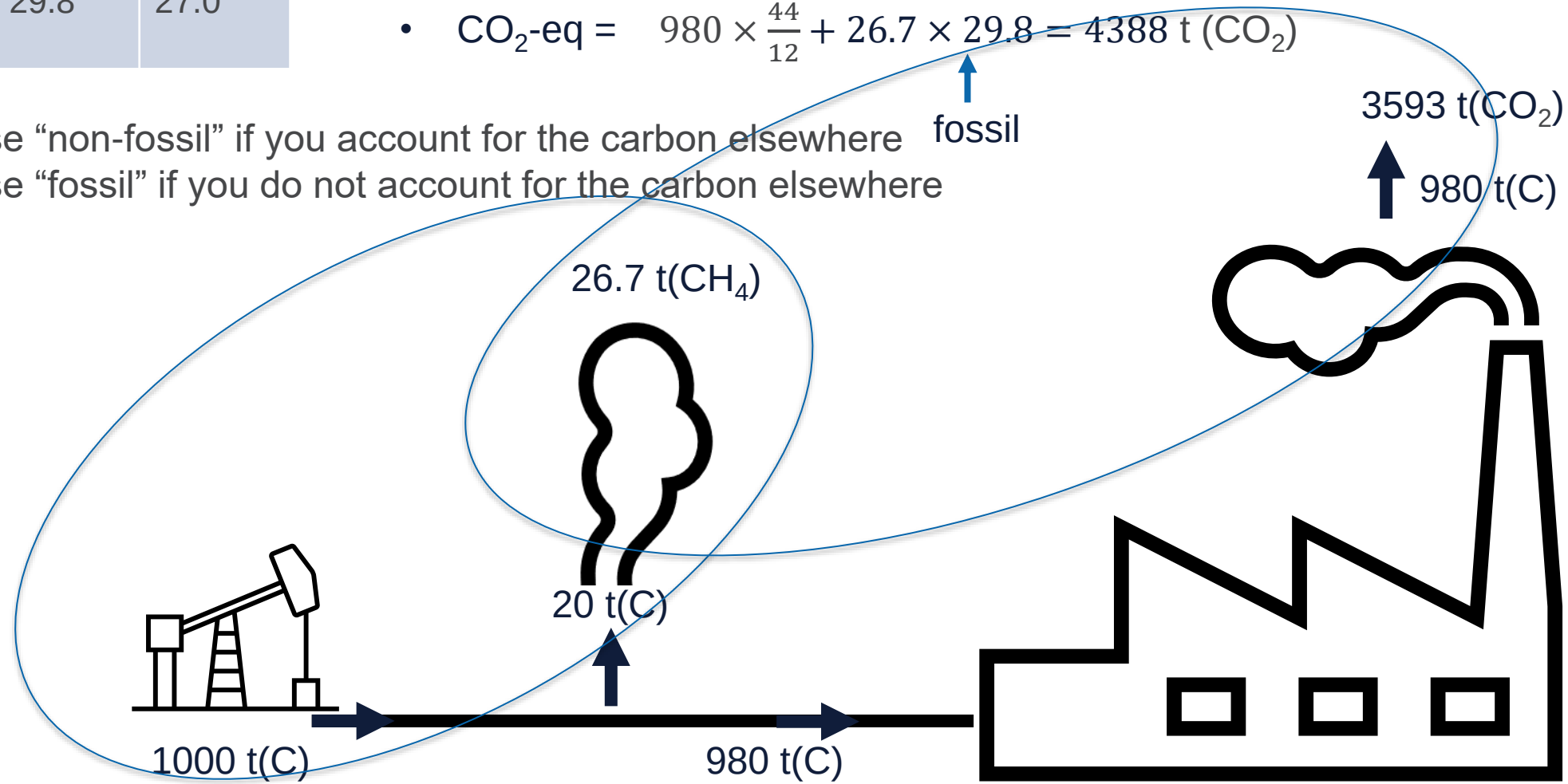
CH_4	Fossil	Non-Fossil
GWP 100	29.8	27.0

Non-fossil

- $CO_2\text{-eq} = 1000 \times \frac{44}{12} + 26.7 \times 27.0 = 4388$ t (CO_2)
- $CO_2\text{-eq} = 980 \times \frac{44}{12} + 26.7 \times 29.8 = 4388$ t (CO_2)

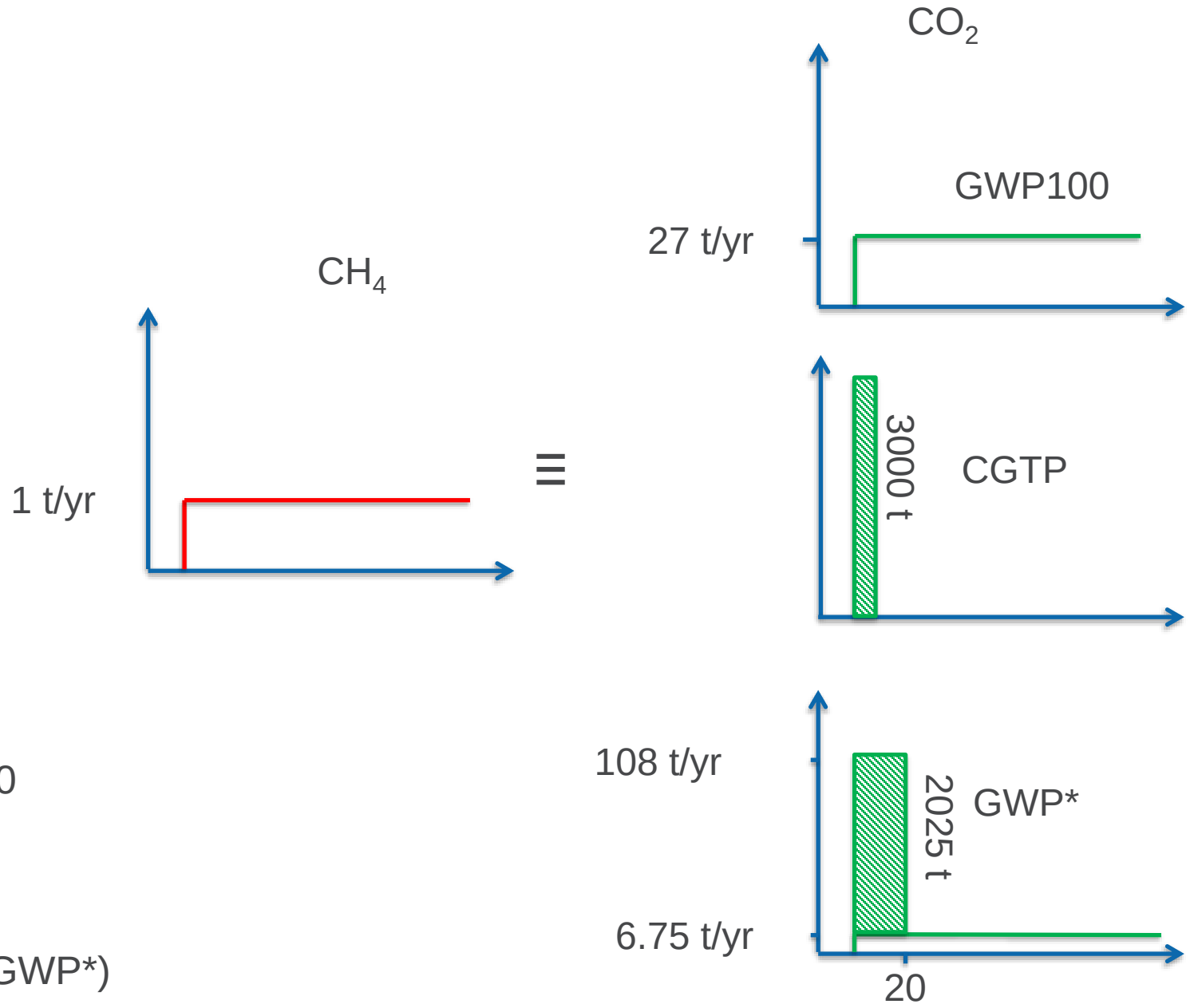
fossil

Use “non-fossil” if you account for the carbon elsewhere
Use “fossil” if you do not account for the carbon elsewhere

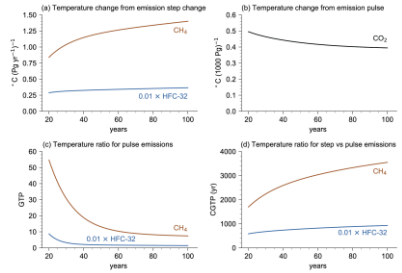


Pulse and step metrics

- GWP100:
  - 1 t/yr CH_4 ≡ 27 t/yr CO_2
- CGTP
  - 1 t/yr CH_4 ≡ 3000 t CO_2
- GWP*
  - 1 t/yr CH_4 ≡ ¾ x 5 x 27 t/yr CO_2 ; t<20
    + ¼ x 27 t/yr CO_2
- After 100 years, CO_2-eq =
  2700 t (GWP), 3000 t (CGTP), 2700 t (GWP*)



Pulse vs step metrics



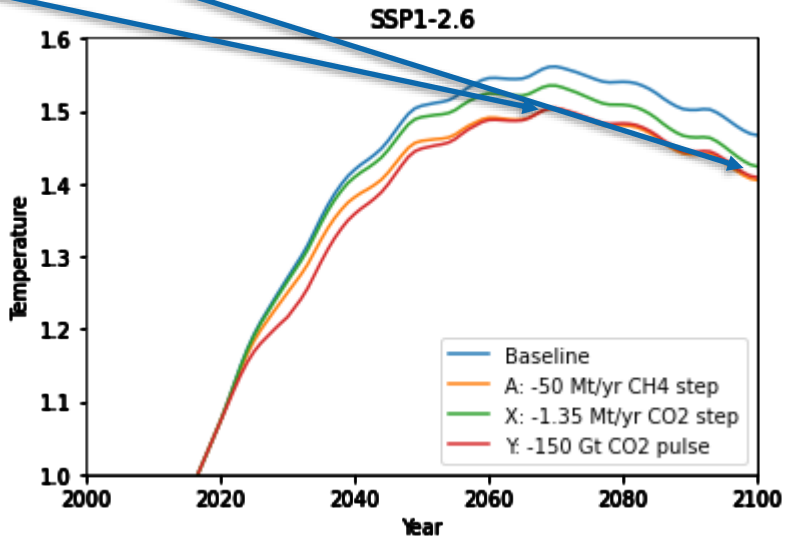
WGI Figure 7.21

Methane Pledge

- Country A: Reduction of 50 Mt/yr CH_4 (permanently)
- Country X: (GWP100) Reduction of 27*50 Mt/yr CO_2 (permanently)
- Country Y: (CGTP) Reduction of 3000*50 Mt CO_2 (once)
- All give similar effects after 100 years
- A and Y have similar effects on peak warming. X has less effect on peak warming

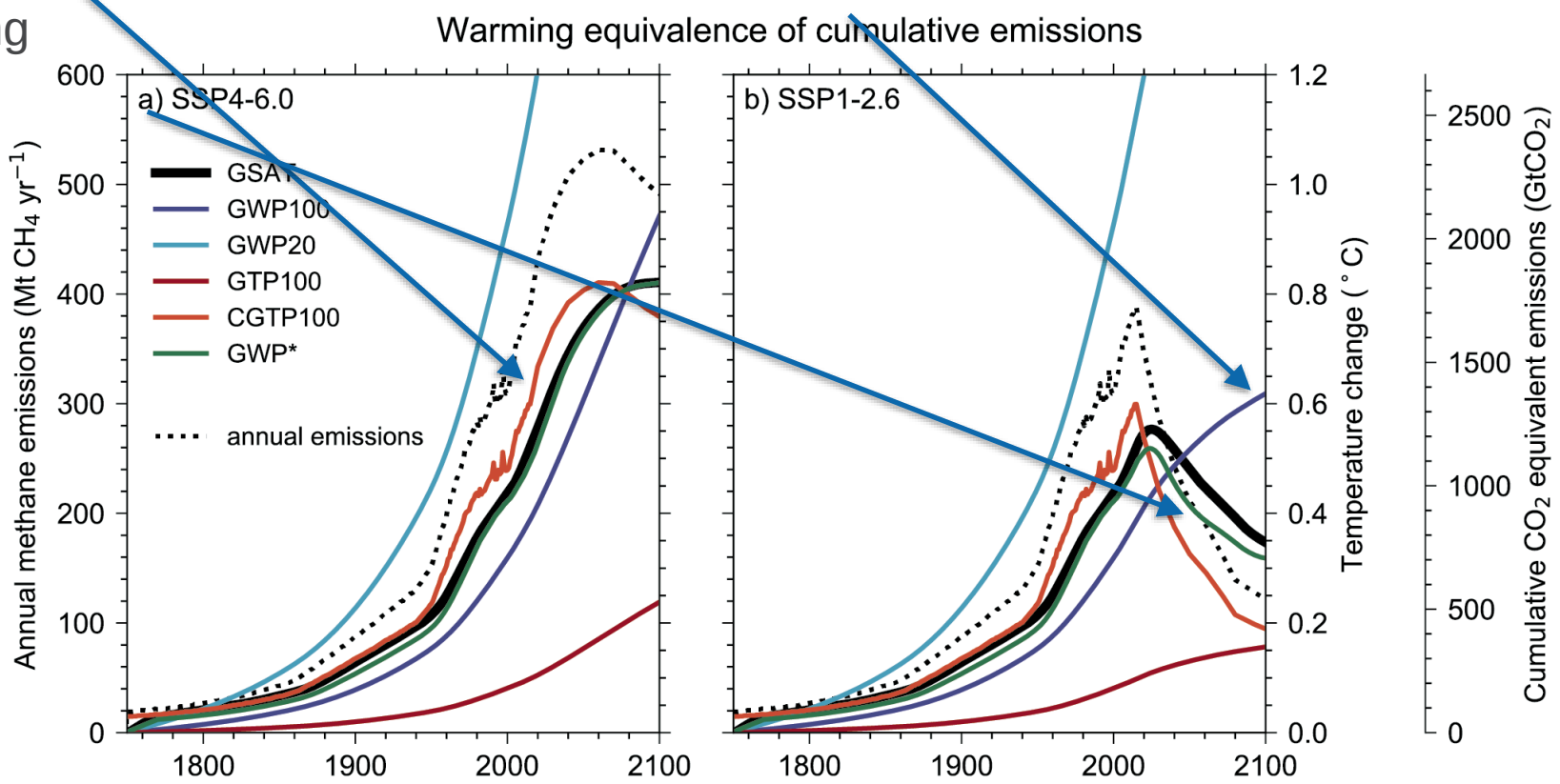
Applying fig 7.21 to scenario

- GWP100 gives similar results to new metrics for **constant mitigation** after 100 years.



Cumulative CO_2 equivalent emissions

- Converting methane emissions to cumulative CO_2-eq should correlate with warming.
- For rising emissions (e.g. historical period) **GWP100, CGTP, GWP*** all correlate with warming caused by methane
- For decreasing emissions (early-mid century onwards) **GWP100** does not track declining contribution of methane warming
  - Rate-based metrics (**CGTP**, **GWP***) do.



WGI Figure 7.22

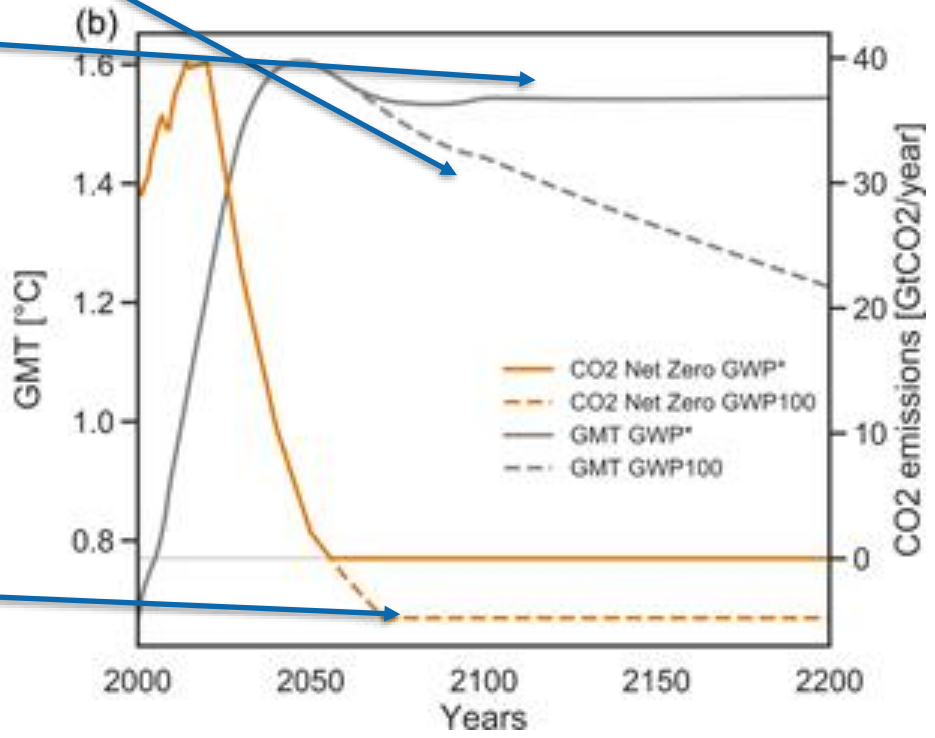
Net Zero

- Using **GWP100** to define Net Zero GHG emissions results in a **decline in surface temperature,** if CH_4 mitigation is weaker than CO_2 mitigation

- Using **new metrics** to define Net Zero GHG emissions corresponds approximately to an **approximate temperature stabilization**
  - In this case net zero CO_2 and declining methane emission is sufficient.

- The rate of temperature decline is not defined in the GWP100 case.
- Using new metrics to define Net Zero GHG, any desired rate of decline can be specified through a negative CO_2-e target (e.g. -0.25°C/century ≡ -5.5 Gt CO_2-e per year

Schleussner et al. 2019



Physical science scope in WG I metrics

- WG I focusses on the use of metrics to represent the relative physical(&biogeochemical) behaviours of climate forcers
- “This Report does not recommend the use of any specific emissions metric, as the most appropriate metric depends on the policy goal and context” {TS.3.3.3}
- WG I noted that equity and fairness issues have been raised with the new metrics, but do not discuss these within the physical science scope as they are functions of how metrics are used not the metrics themselves.


ENVIRONMENTAL RESEARCH
LETTERS

COMMENT

Comment on ‘Unintentional unfairness when applying new greenhouse gas emissions metrics at country level’

Michelle Cain, Keith Shine, David Frame, John Lynch, Adrian Macey, Ray Pierrehumbert and Myles Allen

OPEN ACCESS

RECEIVED 8 November 2019
REVISED 30 April 2020
ACCEPTED FOR PUBLICATION 19 May 2021
PUBLISHED 7 June 2021


npj | Climate and Atmospheric Science

www.nature.com/npjclimatsci

COMMENT OPEN

Indicate separate contributions of long-lived and short-lived greenhouse gases in emission targets

Myles R. Allen, Glen P. Peters, Keith P. Shine, Christian Azar, Paul Balcombe, Olivier Boucher, Michelle Cain, Philippe Ciais, William Collins, Piers M. Forster, Dave J. Frame, Pierre Friedlingstein, Claire Fyson, Thomas Gasser, Bill Hare, Stuart Jenkins, Steven P. Hamburg, Daniel J. A. Johansson, John Lynch, Adrian Macey, Johannes Morfeldt, Alexander Nauels, Ilissa Ocko, Michael Oppenheimer, Stephen W. Pacala, Raymond Pierrehumbert, Joeri Rogelj, Michiel Schaeffer, Carl F. Schleussner, Drew Shindell, Ragnhild B. Skeie, Stephen M. Smith and Katsumasa Tanaka

npj Climate and Atmospheric Science (2022)5:5 ; https://doi.org/10.1038/s41612-021-00226-2


IOP Publishing Environ. Res. Lett. 14 (2019) 124055 https://doi.org/10.1088/1748-9326/ab56e7

Environmental Research Letters

LETTER

Inconsistencies when applying novel metrics for emissions accounting to the Paris agreement

Carl-Friedrich Schleussner, Alexander Nauels, Michiel Schaeffer, William Hare and Joeri Rogelj

OPEN ACCESS

RECEIVED 17 June 2019
REVISED 11 November 2019


IOP Publishing Environ. Res. Lett. 14 (2019) 114039 https://doi.org/10.1088/1748-9326/ab4928

Environmental Research Letters

LETTER

Unintentional unfairness when applying new greenhouse gas emissions metrics at country level

Joeri Rogelj and Carl-Friedrich Schleussner

OPEN ACCESS

RECEIVED 15 July 2019

Conclusions

- Updates from AR5 account for increases in GHGs, updated physics and chemistry
  - Carbon-cycle responses are more robustly accounted for (included by default in AR6).
- Use of “Fossil” or “Non-fossil” methane depends on how you account for the lost carbon.
- Achieving net zero defined using GWP100 could lead to declining temperatures, if methane mitigation is slower than CO_2 mitigation.
- Achieving net zero defined using new metrics would lead to approximately stable temperatures
  - Declining methane emissions are sufficient for temperatures stabilisation (provided net zero CO_2)
- Separate reporting of long and short-lived gases would allow more transparency in the temperature projections and Net Zero calculations

Thank you!

Bill Collins