Scientific papers highlighting problems with GWP100

GWP100 is often referred to as CO_2 equivalent. These scientific papers extend back to 1998.

The global warming potential—the need for an interdisciplinary retrial

Keith P. Shine

Published: 4 August 2009

Link

https://link.springer.com/article/10.1007/s10584-009-9647-6

Comments at the start of the paper:

It was about 20 years ago today when Global Warming Potentials (GWP) became established as a method for comparing the climate effects of emissions of different greenhouse gases.

The First Assessment Report (FAR) of the Intergovernmental Panel on Climate Change (IPCC 1990) tentatively embraced the concept— **as the Convening Lead Author of the relevant chapter in that assessment, I was interested to re-read what we had written way-back-then.** I believe that we had many of the necessary caveats in place but I was particularly struck by one statement (where the square brackets are my additions for clarity):

"It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single [metric] . . . A simple approach [i.e. the GWP] has been adopted here to illustrate the difficulties inherent in the concept."

But it seems that the die was cast. The IPCC retained the GWP as a metric of choice.

Did something go wrong here? How did "a simple approach" which was "adopted . . . to illustrate . . . difficulties" become established in a major piece of environmental legislation, where it had the potential to influence big investment and policy decisions?

Has there been what might be termed an "inadvertent consensus", so that the IPCC and policymakers have each perceived that the other was content with the concept and didn't apply pressure to fully assess alternatives?

Certainly there has been no shortage of assessment and criticism of the GWP concept.

Equivalence of greenhouse-gas emissions for peak temperature limits

Stephen M. Smith, Jason A. Lowe, Niel H. A. Bowerman, Laila K. Gohar, Chris Huntingford & Myles R. Allen

Published: 06 May 2012

Link

https://www.nature.com/articles/nclimate1496

Nature Climate Change volume 2, pages535–538 (2012)Cite this article

Abstract

Climate policies address emissions of many greenhouse gases including carbon dioxide, methane, nitrous oxide and various halogen-containing compounds. **These are aggregated and traded on a CO2-equivalent basis using the 100-year global warming potential (GWP100); however, the GWP100 has received scientific and economic criticism as a tool for policy**1,2,3,4. In particular, given international agreement to limit global average warming to 2 °C, **the GWP100 does not measure temperature and does not clearly signal the need to limit cumulative CO2 emissions**5,6,7. Here, **we show that future peak temperature is constrained by cumulative emissions of several long-lived gases (including CO2 and N2O) and emission rates of a separate basket of shorter-lived species (including CH4)**. For each basket we develop an emissions-equivalence metric allowing peak temperature to be estimated directly for any emissions scenario. Today's emissions of shorter-lived species have a lesser impact on ultimate peak temperature than those nearer the time of peaking. The 2 °C limit could therefore be met by setting a limit to cumulative long-lived CO2-equivalent emissions while setting a maximum future rate for shorter-lived emissions.

Short-Lived Climate Pollution

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Published: 27 February 2014

Link

https://www.annualreviews.org/doi/full/10.1146/annurev-earth-060313-054843

Abstract

Although carbon dioxide emissions are by far the most important mediator of anthropogenic climate disruption, a number of shorter-lived substances with atmospheric lifetimes of under a few decades also contribute significantly to the radiative forcing that drives climate change. **In recent years, the argument that early and aggressive mitigation of the emission of these substances or their precursors forms an essential part of any climate protection strategy has gained a considerable following. There is often an implication that such control can in some way make up for the current inaction on carbon dioxide emissions.** The prime targets for mitigation, known collectively as short-lived climate pollution (SLCP), are methane, hydrofluorocarbons, black carbon, and ozone. **A re-examination of the issues shows that the benefits of early SLCP mitigation have been greatly exaggerated, largely because of inadequacies in the methodologies used to compare the climate effects of short-lived substances with those of CO2, which causes nearly irreversible climate change persisting millennia after emissions cease.** Eventual mitigation of SLCP can make a useful contribution to climate protection, but there is little to be gained by implementing SLCP mitigation before stringent carbon dioxide controls are in place and have caused annual emissions to approach zero. Any earlier implementation of SLCP mitigation that substitutes to any significant extent for carbon dioxide mitigation will lead to a climate irreversibly warmer than will a strategy with delayed SLCP mitigation. SLCP mitigation does not buy time for implementation of stringent controls on CO2 emissions.

Improved calculation of warming-equivalent emissions for short-lived climate pollutants

Michelle Cain, John Lynch, Myles R. Allen, Jan S. Fuglestvedt, David J. Frame & Adrian H Macey

Published: 4 September 2019

Link

https://doi.org/10.1038/s41612-019-0086-4

npj Climate and Atmospheric Science (2019) 2:29

Abstract

Anthropogenic global warming at a given time is largely determined by the cumulative total emissions (or stock) of long-lived climate pollutants (LLCPs), predominantly carbon dioxide (CO2), and the emission rates (or flow) of short-lived climate pollutants (SLCPs) immediately prior to that time. **Under the United Nations Framework Convention on Climate Change (UNFCCC), reporting of greenhouse gas emissions has been standardised in terms of CO2-equivalent (CO2-e) emissions using Global Warming Potentials (GWP) over 100-years, but the conventional usage of GWP does not adequately capture the different behaviours of LLCPs and SLCPs, or their impact on global mean surface temperature. An alternative usage of GWP, denoted GWP*, overcomes this problem by equating an increase in the emission rate of an SLCP with a one-off "pulse" emission of CO2.** We show that this approach, while an improvement on the conventional usage, slightly underestimates the impact of recent increases in SLCP emissions on current rates of warming because the climate does not respond instantaneously to radiative forcing. We resolve this with a modification of the GWP* definition, which incorporates a term for each of the short-timescale and long-timescale climate responses to changes in radiative forcing. **The amended version allows "CO2-warming-equivalent" (CO2-we) emissions to be calculated directly from reported emissions. Thus SLCPs can be incorporated directly into carbon budgets consistent with long-term temperature goals, because every unit of CO2-we emitted generates approximately the same amount of warming, whether it is emitted as a SLCP or a LLCP. This is not the case for conventionally derived CO2-e.**

Offsetting methane emissions — An alternative to emission equivalence metrics

A. Lauder, I. Enting, J. Carter, N. Clisby, A. Cowie, B. Henry, M. Raupach

Published: January 2013

Link

https://www.sciencedirect.com/science/article/pii/S1750583612003064

Abstract

It is widely recognised that defining trade-offs between greenhouse gas emissions using 'emission equivalence' based on global warming potentials (GWPs) referenced to carbon dioxide produces anomalous results when applied to methane. The short atmospheric lifetime of methane, compared to the timescales of CO2 uptake, leads to the greenhouse warming depending strongly on the temporal pattern of emission substitution.

We argue that a more appropriate way to consider the relationship between the warming effects of methane and carbon dioxide is to define a 'mixed metric' that compares ongoing methane emissions (or reductions) to one-off emissions (or reductions) of carbon dioxide. Quantifying this approach, we propose that a one-off sequestration of 1 t of carbon would offset an ongoing methane emission in the range 0.90–1.05 kg CH4 per year. We present an example of how our approach would apply to rangeland cattle production, and consider the broader context of mitigation of climate change, noting the reverse trade-off would raise significant challenges in managing the risk of non-compliance.

Our analysis is consistent with other approaches to addressing the criticisms of GWP-based emission equivalence, but provides a simpler and more robust approach while still achieving close equivalence of climate mitigation outcomes ranging over decadal to multi-century timescales.

Climate neutral livestock production – A radiative forcing-based climate footprint approach

Bradley Ridoutt

Published: 1 April 2021

Link

https://www.sciencedirect.com/science/article/abs/pii/S095965262035304X

Abstract

The goal of limiting mean global temperature rise to 1.5 °C, described in the Paris Agreement, depends upon urgent action to stabilize radiative forcing (RF). However, the contribution of different greenhouse gases (GHGs) to future RF is often obscured by the application of climate metrics, such as the 100-year global warming potential (GWP100). RF climate footprints are an alternative way of presenting emissions information relating to GHGs and other climate forcers. These footprints include RF from current emissions as well as the fraction of historical emissions that remain in the atmosphere. The profile over time can support the management of RF toward targets informed by climate stabilization goals. In a study involving Australian sheep production for meat, it was found that the sector's contribution to RF has plateaued in recent years at 0.64 mW m−2, and is projected to reach the point of net zero increase in 2020, a status that could be described as "climate neutral". Further, on present emission trajectories, the sector's contribution to RF will decline to 0.50 mW m−2 in 2049, which represents a contribution to climate cooling consistent with the Paris Agreement. RF climate footprints

clearly articulate the diverse climate impacts of short and long-lived climate forcers, avoiding the policy ambiguity that can arise when different climate metrics and different arbitrary time horizons are chosen. This new RF framework, soon to be supported by an international (ISO) standard, has relevance in aligning food systems with the aspirations of the Paris Agreement. However, the challenge of stabilizing and managing RF downward is applicable to all sectors and organisations.

The Kyoto Protocol: CO2, CH4 and climate implications

T. M. L. Wigley

Published: 01 July 1998

Link

The Kyoto Protocol: CO2 CH4 and climate implications (wiley.com)

Abstract

Kyoto Protocol implications for CO2, temperature and sea level are examined. Three scenarios for post-Kyoto emissions reductions are considered. In all cases, the long-term consequences are small. The limitations specified under the Protocol are interpreted in terms of both CO2 and CH4 emissions reductions and a new emissions comparison index, the Forcing Equivalence Index (FEI), is introduced. **The use of GWPs to assess CO2-equivalence is assessed.**

Comment made in paper:

“Because GWPs are not uniquely defined; they vary considerably with

time horizon (Albritton et al., 1996). **Furthermore, there is**

reason to believe that conventional GWPs produce serious

errors when applied to realistic scenarios (Harvey, 1993).”

IPCC supporting the logic of GWP*

The following quote was in the IPCC AR6 Section 7.6.1.4
It references two of the papers above.

“In contrast to a one-off pulse, a step change in short-lived greenhouse gas emissions that is maintained indefinitely causes a concentration increase that eventually equilibrates to a steady state in a way that is more comparable to a pulse of CO2. Similarly the resulting change in global surface temperature from a step change in short-lived greenhouse gases (Figure 7.21a) after a few decades increases only slowly (due to accumulation of heat in the deep ocean) and hence its effects are more similar to a pulse of CO2 (Smith et al., 2012; Lauder et al., 2013; Allen et al., 2016, 2018b).”