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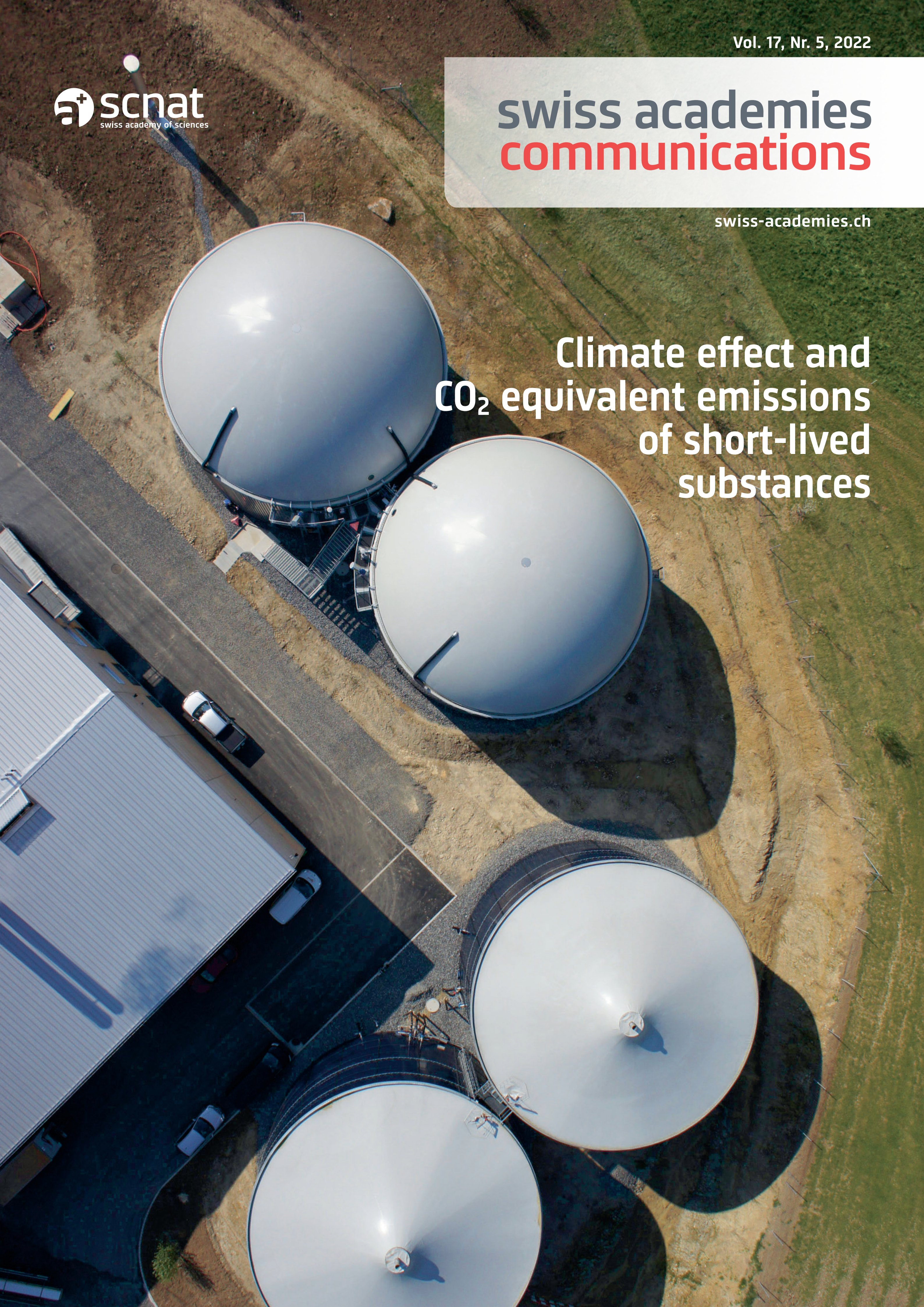
Climate effect and CO_2 equivalent emissions of short-lived substances



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Content

The most important facts in brief

Effect of short-lived substances on the climate

- The effect of long-lived substances, such as CO_2, and short-lived substances such as methane on the climate varies greatly over time: The climate effect of an **emission pulse** (i.e. a specific amount[1] of CO_2 emitted once) remains practically constant over a long period of time, whereas in the case of methane, the effect is very high immediately after emission and then decreases relatively quickly. The reason for this is that methane is chemically degraded relatively rapidly in the atmosphere. (Chap. 3.1, 4.2, Fig. 1)
- If the emissions of methane or other short-lived substances remain constant over a longer period of time, their effect on the climate also remains almost constant, i.e. almost as much methane is removed as is emitted. There is hardly any additional warming. (Chap. 3.1)
- A permanent reduction in the **emission rate** (i.e. regular emissions) of methane has the same effect on the climate as a 'negative' CO_2 emission pulse (removal of CO_2 from the atmosphere). A permanent increase in the emission rate of methane has the same effect on the climate as a positive emission pulse of CO_2. (Chap. 3.1)
- Reducing the rate of methane emissions is an important and highly effective short-term means of meeting temperature targets (1.5 or 2 °C). There is no conceivable scenario for meeting these targets without a substantial reduction in methane emissions. (Chap. 3.1, 7)
- Methane emissions do not have to be reduced to net zero to achieve the climate targets, i.e., remaining methane emissions do not have to be offset by corresponding negative CO_2 emissions. (Chap. 3.1, 7)

Conversion into CO_2 equivalents

- In order to take into account the different effects of greenhouse gases on the climate in an overall assessment, the emissions of different substances are summarised in **CO_2 equivalent emissions** (CO_{2eq}). A conversion metric was defined for this purpose in the UNFCCC Climate Convention, which depicts the total climate effect of an emission pulse of a substance over 100 years (Global Warming Potential over 100 years, GWP_{100}). The use of GWP_{100} has become established and it is used by all countries. (Chap. 1.2, 4.1)
- The use of GWP_{100} does not take into account the change in the effect of methane on the climate over time – the effect of methane on the climate is greatly underestimated in the short term (next decades), but overestimated in the longer term. (Chap. 4.4; Fig. 3, 4)
- The use of GWP_{100} as a metric does not provide an adequate picture of the effect of methane on the climate when considering emission reduction pathways or compliance with temperature targets during the 21st century. (Chap. 4.4; Fig. 3, 4)
- Reducing methane emissions can make a much greater contribution to slowing down global warming in the coming decades or to preventing certain temperature levels from being exceeded than would be expected on the basis of CO_2 equivalent emissions in accordance with the current method of calculation in the greenhouse gas inventories. (Chap. 4.4)
- Climate science has recently developed a new metric (GWP*) that represents the effect on the climate of short-lived substances over time much better than the previously used GWP_{100} metric. This makes it possible to gain a much more realistic picture of the effect of emission reduction measures. (Chap. 4.5)
- The choice of conversion metric depends on the question: For questions of the effect of emission pulses on the climate (e.g. effect of the consumption of a single product), GWP should be used. GWP_{20} is suitable for considering the short-term climate effect, and GWP_{100} for the long-term effect. (Chap. 5)
- From a scientific perspective, the use of GWP* is recommended in connection with emission reduction pathways, compliance with temperature targets or remaining emission budgets. (Chap. 5)
- The objective, the evaluation of measures and the review of the achievement of targets of national climate policy are based on the specifications of the Climate Convention (UNFCCC). An adaptation of the metric requires a coordinated approach. (Chap. 6)
- The phrasing of Switzerland's long-term climate target of reducing greenhouse gas emissions to net zero by 2050 should be clarified. Depending on which metric is used to calculate CO_2 equivalent emissions, different amounts of negative CO_2 emissions are needed to reach net zero. In order to represent the effective effect of methane emissions on the climate, a conversion with GWP* would be appropriate. (Chap. 7)

1 The emission pulse is the cumulative amount of emissions over a specific period of time originating from one or more sources (e.g., the amount of CO_2 emitted on a specific day at a specific location.) A 'negative' emission pulse refers to the removal of a certain amount of CO_2 from the atmosphere.

1 Introduction and background

1.1 International climate targets

The international community has defined climate targets in the UN Framework Convention on Climate Change (UNFCCC) and the Paris Climate Agreement. These were derived from scientific data, in particular from the Assessment Reports and Special Reports of the Intergovernmental Panel on Climate Change IPCC. The climate targets primarily relate to global temperature change, i.e. to limiting global warming to a specific level (1.5 °C or well below 2 °C).

Compliance with temperature targets depends on the accumulated temperature effect of all emissions of climate-effective substances. Therefore, in order to achieve the climate target, secondarily also an emissions target was defined in the Paris Agreement:

'A balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases should be achieved in the second half of this century' (Art. 4.1).

Many states, but also companies, cantons or municipalities have derived the target of 'net zero greenhouse gas emissions by 2050' from this.

1.2 International climate policy

Certain framework conditions for the operational implementation of the agreements have already been defined in the Kyoto Protocol:

- Every country only counts the emissions within its own country. The emissions from international aviation and maritime traffic are calculated by each country according to the sales principle and reported for information purposes, but are not charged to any country as emissions.

- Only the emissions of the most important greenhouse gases (CO_2, methane and nitrous oxide, as well as the most important synthetic gases) are taken into account, but not other climate-active substances such as soot, aerosols, condensation trails from aircraft or other hydrocarbons.

- In order to take into account the different climate effects of greenhouse gases and other climate effective substances a conversion metric has been defined that normalises the different substances by means of CO_2 equivalents (see Chapter 4.1).

These framework conditions are political decisions that have been taken by the contracting states at the climate conferences and are backed up by scientific data.

2 Emission scenarios and consequences for the climate

2.1 Climate model calculations

The IPCC Assessment Reports contain the latest climate scenarios from the calculations of the numerous global climate models. These scenarios show the expected change in global temperature resulting from certain emission patterns of climate effective substances, as well as from the effect of natural sources and sinks. Substances and sources not covered by international climate agreements, such as airborne particles (aerosols) or the whole climate effect of the international maritime and aviation traffic, are also taken into account.

In the climate model calculations, the different effects on the climate of the individual substances are calculated directly from their concentrations in the atmosphere, taking possible subsequent chemical reactions into account. From these calculations, the effects of the individual substances on the climate can be directly compared with each other both for the past and – with predetermined emission patterns – for the future (IPCC AR6 WGI, Figure 2). The above-mentioned framework conditions of the climate agreements (selection of substances considered, counting of emissions by individual countries, conversion metrics) play no role in these calculations.

2.2 Conditions for meeting climate targets

All climate scenarios that limit global warming below 1.5 °C or 2 °C include achieving net zero CO_2 emissions roughly around 2050 for 1.5 °C or 2075 for 2 °C, as well as massive reductions in non-CO_2 emissions, especially methane and air pollutants such as sulphur dioxide that contribute to aerosol formation and cooling. Scientists expect that with the reduction of energy related CO_2 emissions, aerosol concentrations will also decrease and their cooling effect will cease. The cessation of cooling aerosols must therefore be compensated for by an additional reduction in warming substances. This effect is also taken into account in the climate model scenarios.

3 Different climate effects of long-lived and short-lived substances

3.1 Differences in climate effect

The climate effect of a substance is determined by the impact of an increase in its concentration in the atmosphere on global temperature (warming or cooling). The effect of the various substances on the climate is calculated using climate models. It depends on the residence time, the concentration in the atmosphere and the relative greenhouse effect:

– The increase in the concentration of a substance in the atmosphere due to emissions is preserved for different lengths of time. For long-lived substances, including the greenhouse gases CO_2, nitrous oxide and many synthetic gases, the concentration in the atmosphere after an emission pulse remains significantly elevated for many decades to centuries. An emission pulse is the cumulative amount of emissions over a specific period of time originating from one or more sources (e.g. the amount of CO_2 emitted on a specific day at a specific location.) A 'negative' emission pulse refers to the removal of a certain amount of CO_2 from the atmosphere.

– Short-lived substances are degraded relatively quickly and their concentration returns to near the original level relatively rapidly after an emission pulse, as e.g. in the case of methane after 10 to 20 years, or even after hours to days in the case of aerosols and condensation trails.

– Long-lived substances accumulate in the atmosphere, i.e. the effect on the climate depends on the emissions accumulated over time. For short-lived substances, on the other hand, the effect on the climate is primarily dependent on emissions in the recent past.

– The effect of the individual gases on the climate per mass varies greatly. For example, the effect of nitrous oxide on the climate on a time scale of 100 years is about 270 times greater, and for some fluorocarbons it is over 1000 times greater than for CO_2. However, CO_2 has the greatest warming effect because of its much larger amount in the atmosphere.

– If the emissions of methane or other short-lived substances remain constant over a longer period of time, the effect on the climate also remains almost constant, i.e. almost as much methane is degraded as is emitted and the additional warming effect is only slight.

The different effect of short-lived and long-lived substances on the climate has consequences for the determination of emission reduction pathways, the compliance with climate targets or the calculation of CO_2 emissions that may still be emitted in order not to exceed a certain warming level ('emissions budget'):

– A permanent reduction in the emission rate of methane has the same effect on the climate as a 'negative' CO_2 emission pulse (removal of CO_2 from the atmosphere)

– A permanent reduction in the emission rate of methane increases the remaining emissions budget of CO_2 and thus saves a certain amount of time for the reduction of CO_2.

– A permanent increase in the emission rate of methane has the same effect on the climate as a positive emission pulse of CO_2.

– A permanent increase in the emission rate of methane, on the other hand, reduces the emissions budget of CO_2.

– For global temperature stabilisation emissions of CO_2 and other long-lived greenhouse gases must be avoided completely or offset by permanent CO_2 sinks such as the biological or technical removal of CO_2 from the air (i.e. 'net zero emissions'), regardless of the temperature level.

– A reduction of methane is essential on a global scale to meet the warming levels of 1.5 °C and 2 °C, as CO_2 emissions cannot be reduced quickly enough. Reducing methane emission rates is therefore an important and highly effective means of meeting climate targets in the short term. However, methane emissions do not need to be reduced to net zero. They only need to decrease by about 0.3% per year (Cain et al. 2019) or the corresponding value needs to be offset with negative emissions so that they no longer cause additional warming.

3.2 Comparison of climate effect

The effect on the climate of an emission of long-lived substances can be compared relatively easily with that of CO_2, as it changes only slightly over time and the time frame considered in the comparison therefore hardly matters. This means that a constant factor can be used for the comparison. In contrast, the comparison of the effect of short-lived substances on the climate with that of CO_2 depends strongly on the time frame considered: The shorter the time frame considered, the stronger is the climate effect of the short-lived substance compared to that of CO_2. For example, the effect of methane on the climate over 100 years is around 25 to 30 times greater than that of CO_2, but over 20 years it is around 100 times greater. There is, therefore, no universally applicable comparison metric or conversion formula for methane and other short-lived substances. Nevertheless, to date the same metric has always been used for methane in the climate agreements as for long-lived greenhouse gases.

4 Different comparison metrics

4.1 Purpose of a comparison metric

In order to be able to make statements about the total effect on the climate of several substances without complex modelling, comparison methods or metrics have been developed that allow to convert the emissions of each individual substance to a common scale. CO_2 equivalent emissions ('CO_{2eq}') serve as a common scale:

CO_2 equivalent emissions (CO_{2eq}) refer to the amount of CO_2 emissions that it takes to cause the same effect on the climate as a certain amount of another greenhouse gas. For example, according to the comparison metric used in greenhouse gas inventories today, 25 tonnes of CO_{2eq} correspond to one tonne of methane.

Various metrics have been developed, each of which is geared towards specific framework conditions or questions. However, a single metric cannot accurately represent all aspects of the climate effect. For example, the time frame considered is very important for some metrics, and they provide different assessments of substances depending on whether the short- or long-term perspective is considered.

Metrics are an important element in international climate policy. They are used, for example, to quantify the total emissions in the national greenhouse gas inventories of the contracting states, to draft and review national emission reduction targets, or issue tradable CO_2 certificates. It is important that the metric used is clearly defined in order to ensure consistency between the objectives and the verification of target achievement on the one hand, and to be able to set standards for international emissions or certificate trading on the other.

In the 1990s, the international community established the 'Global Warming Potential' over 100 years (GWP_{100}) as a metric for calculating CO_2 equivalent emissions as part of the UN Framework Convention on Climate Change (UNFCCC). This method has since been established as a pragmatic approach in international climate policy.

However, the widespread use of GWP_{100} has long been criticised in the scientific community. The problem is that GWP_{100} is not representative for short-lived greenhouse gases such as methane, especially when shorter periods of time or the evolution of emissions over time are considered. Since the reduction of methane emissions plays an important role in achieving the climate targets, this problem has gained extra significance. Therefore, new metrics for calculating CO_{2eq} have been developed in recent years that better account for the varying effect on the climate of short and long-lived greenhouse gases (Allen et al. 2018, Cain et al. 2019).

The most important comparison metrics, their properties as well as their application possibilities and limitations are explained in the following.

4.2 Climate effect of emission pulses

Figure 1 shows the time course of the effect on the climate as a result of an emission pulse of a short-lived and a long-lived substance, in each case compared to the effect of an emission pulse of CO_2. The effect on the climate of a long-lived substance, which is increased by an emission pulse, has a similar pattern to CO_2 and is therefore largely unchanged compared to CO_2 (yellow line), even after 100 years. In the case of an emission pulse of a short-lived substance, on the other hand, the effect on the climate initially increases sharply, but then decreases continuously compared to the climate effect of CO_2 and, in the case of methane, is then almost back to the initial level after 100 years (blue line[2]).

2 Since parts of the climate only adapt slowly (over centuries) to the radiative forcing, and some climate effective substances are also converted into long-lived ones (e.g. methane into CO_2), the effect of short-lived substances on the climate is partly still somewhat greater than zero even after 100 years.

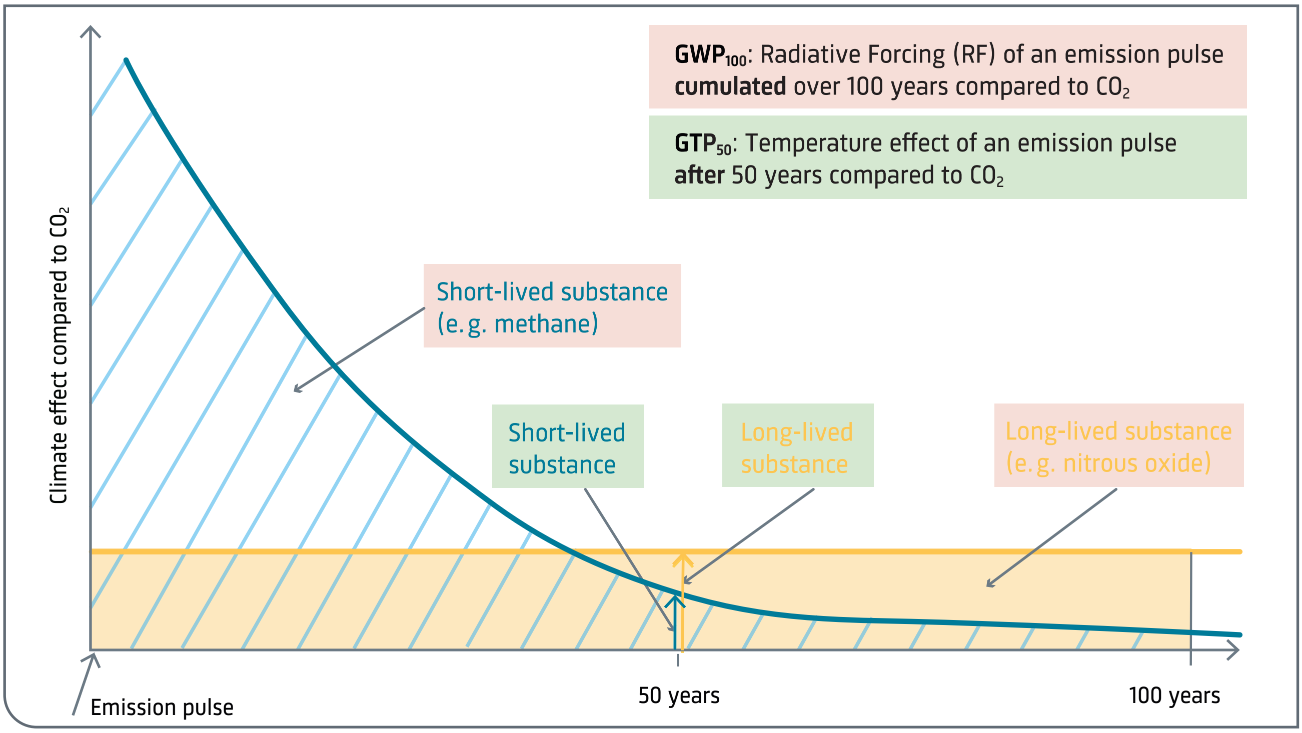

Figure 1: The schematic development over time of the climate effect of an emission pulse of short-lived (using methane as an example; blue line[2]) and long-lived (using nitrous oxide as an example; yellow line) greenhouse gases compared to the climate effect of CO_2. To determine a conversion factor for CO_2 equivalent emissions, either the area under the curves is integrated over a specific period of time ('Global Warming Potential' GWP) or the climate effect is determined at a specific point in time ('Global Temperature Potential' GTP; blue or yellow arrow)

The effect on the climate of an emission pulse is classically described with two metrics (Figure 1). These metrics compare the climate effect of an emission pulse of a certain substance with the corresponding climate effect of an emission pulse of the same mass of CO_2 as follows:

The **'Global Warming Potential' (GWP)** integrates the total climate effect over a specific time period. This corresponds to the area under the blue and yellow lines in Figure 1. The GWP of a substance S is therefore the ratio between that area and that of CO_2. The GWP of CO_2 is always 1. The GWP_{100} is the GWP over the time period of 100 years.
The CO_{2eq} of an emission pulse E_s of the substance S for the time frame of 100 years is therefore calculated as follows:
$CO_{2eq} = GWP_{100} \times E_s$

The **'Global Temperature Potential' (GTP)** describes the temperature change caused by an emission pulse at a specific point in time after the emission, for example after 50 years (blue or yellow arrow in Fig. 1). The GTP of a substance is the warming caused at that point in time relative to the corresponding warming from an emission pulse of the same amount of CO_2. The GTP of CO_2 is always 1. The GTP_{50} is the GTP 50 years after the emission.
The CO_{2eq} of an emission pulse E_s of the substance S for the time frame of 50 years is therefore calculated as follows:
$CO_{2eq} = GTP_{50} \times E_s$

For long-lived greenhouse gases, both GWP and GTP change only slightly with an increasing time frame. However, for short-lived greenhouse gases such as methane, both metrics are strongly dependent on the time frame considered. The GWP of methane over 100 years is only about a quarter of the GWP over (the first) 20 years (see Tab. 1).

Table 1: Global Warming Potential (GWP) and Global Temperature Potential (GTP) after 20, 50 or 100 years (GWP_{20} or GWP_{100} and GTP_{50} or GTP_{100}) for the greenhouse gases CO_2, nitrous oxide and methane (source: IPCC AR6 WGI Chap. 7 Supporting Material). GWP and GTP of CO_2 are always 1 by definition.

Substance	GWP_{20}	GWP_{100}	GTP_{50}	GTP_{100}
CO_2	1	1	1	1
Nitrous oxide (N_2O)	273	273	290	233
Methane (CH_4) fossil	83	30	13	8
Methane (CH_4) biogen	81	27	10	5

4.3 Climate effect of emission patterns

With constant emissions over time (diagram in Figure 2a), the climate effects of long-lived substances (e.g. CO_2) and short-lived substances (e.g. methane) differ as follows:

- In the case of **CO_2**, the climate effect becomes greater and greater because it remains in the atmosphere over the long term. If emissions are constant, the concentration, and therefore also the resulting warming, increases steadily.
- In the case of **methane**, on the other hand, the climate effect no longer increases after a certain time, as these substances are degraded again relatively quickly. The climate effect of a constant emission of methane shows the same pattern as the climate effect of an emission pulse of CO_2, as can be seen in Figure 2a:

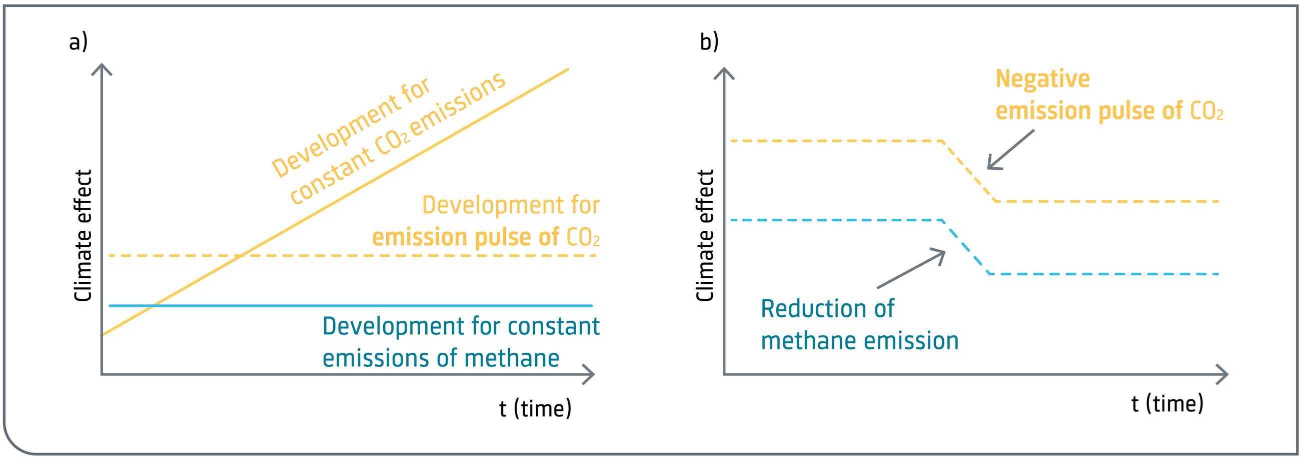

Figure 2: Comparison of the climate effect of the emission patterns of long-lived substances (using CO_2 as an example) and short-lived substances (using methane as an example): a) with constant emissions and b) with an emission reduction.

Correspondingly, a permanent reduction in methane emissions has the same effect on the climate as a negative emission pulse of CO_2 (Figure 2b):

- For **methane**, a permanent reduction in emissions leads to a permanently reduced climate effect.
- For **CO_2**, a negative emission pulse (removal of a certain amount from the atmosphere) also leads to a permanently reduced climate effect.

Conversely, a permanent increase in emissions of methane or a positive emission pulse of CO_2 similarly leads to a permanently increased climate effect.

4.4 Problems with the established metric for emission patterns

The metrics GWP and GTP developed for emission pulses do not contain any information about the significantly changing time course of the effect of short-lived substances on the climate. The typical pattern with initially high, and then rapidly decreasing climate effect of short-lived substances is converted into a climate effect that is constant over time (Figure 3).

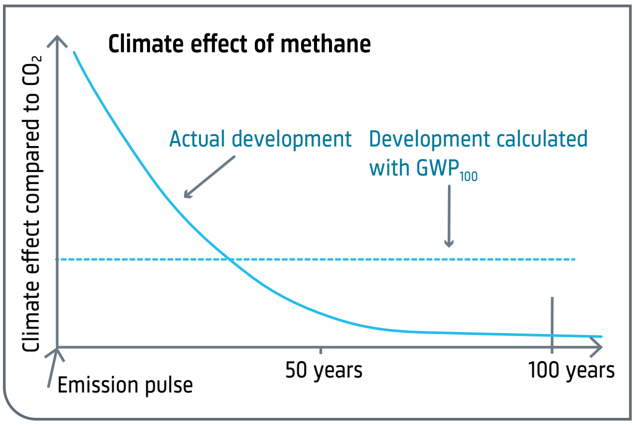

Figure 3: The calculation of CO_{2eq} with the GWP_{100} metric 'hides' the actual time course (solid blue line) of the climate effect of short-lived greenhouse gases and 'transforms' them, as it were, into a long-lived greenhouse gas with a constant effect (blue line with dashes). The information on the short-term very high and later much lower climate effect is no longer included.

This results in the following problems, among others, when using GWP_{100}:

– In a 20-year time frame, GWP_{100} underestimates the climate effect of an increase in methane emissions by a factor of four to five (Lynch et al. 2020) and shows a warming instead of a one-time cooling climate effect that is many times greater if methane emissions are reduced.

– When calculating the climate effect of emissions scenarios for limiting global warming to 1.5 °C, using the GWP_{100} metric for calculating CO_{2eq}, the effect of a reduction in methane emissions is not correctly represented. The use of GWP_{100} results in too much warming over time. This means that by using GWP_{100} the temporary exceeding of warming levels is, in some cases, significantly overestimated (by up to 0.17 °C; Denison et al. 2019).

4.5 Development of a new metric or short-lived substances

For this reason, metrics have been developed in recent years that compare the change in emission rate of a short-lived substance with an emission pulse of CO_2 (see Section 4.3). It has been possible to show that a relatively simple formula (GWP* metric) can be used to compare the effect on the climate of a change in the emission rate of a short-lived substance with the effect on the climate of an emission pulse of CO_2 (Allen et al. 2018, Cain et al. 2019, Smith et al. 2021).

The GWP* metric compares the mean change in emission rate of the short-lived substance over the past 20 years[3] with an emission pulse of CO_2.
The CO_{2eq}* of a substance S are calculated from the emission change ΔE_S of the substance S over the previous 20 years and the emission E_S of the substance S in the year:
$CO_{2eq}* = GWP_{100} \times [(4,24 \times \Delta E_s) + (0,28 \times E_s)]$

For methane ($GWP_{100} = 28$):
$CO_{2eq}* = (120 \times \Delta E_s) + (8 \times E_s)$

The GWP* metric is fairly independent of the time frame and reflects the climate effect of emission patterns of short-lived climate effective substances much better than GWP or GTP (Cain et al. 2019, Denison et al. 2019, Collins et al. 2020, Lynch et al. 2021). Since the GWP_{100} is also used in the GWP* metric, the same physicochemical effects included in the GWP_{100} are also integrated in the GWP* metric. The GWP* metric, on the other hand, adds back the information from the time course and the specific associated characteristics of the climate effect of short-lived substances. It should be noted that 'GWP*' is not a constant factor like GWP_{100}, but describes the method of calculating the metric.

Figure 4 shows that the cumulative CO_{2eq}* of methane calculated with the GWP* reflects the pattern of the warming caused much better than a calculation using the 'classic' GWP_{100}.

3 A longer period of 10–20 years was chosen to offset short-term influences such as recessions, pandemics and the like.

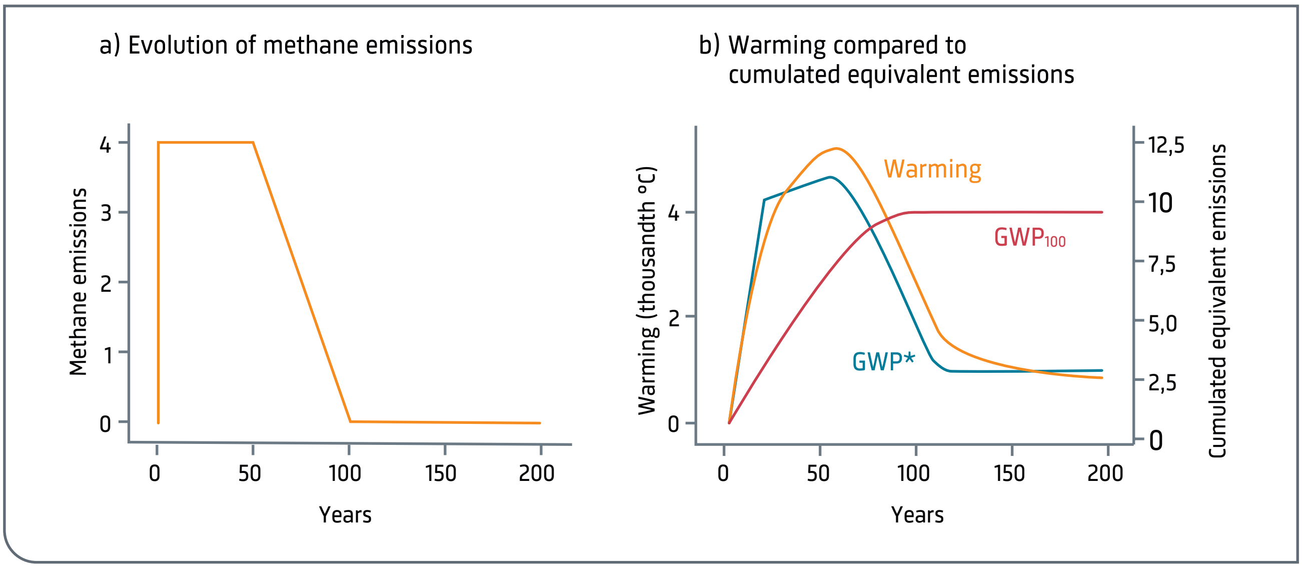

Figure 4: Comparison of the representativeness of the climate effect of a specific methane emission pattern calculated using GWP_{100} or GWP*: a) assumed methane emission pattern and b) pattern of methane's cumulative CO_{2eq}, red for the classic calculation using GWP_{100} and blue for the calculation using GWP*, as well as the pattern of the actual warming caused by these emissions for an emission pattern according to a). (Source: Lynch et al. 2020)

5 Choice of metric

There is no universally applicable conversion metric for CO_2 equivalent emissions for all questions and approaches. For methane and other short-lived substances in particular, the choice of metric depends on the purpose for which different emissions are to be compared with one another.

Both GWP and GTP are metrics that describe the effect of emission pulses over a specific time frame, regardless of different developments of the substances involved. They can be used, for example, to calculate CO_2 emissions that result from the consumption of a single product or from a single flight. The choice of time frame is important here. If great importance is attached to the climate effect in the coming decades, a correspondingly short time frame should be chosen (e.g. GWP_{20}) in order to record the effect of short-lived substances.

In contrast, the GWP* metric considers the development of emissions over time. The use of GWP* is appropriate in connection with emission pathways to meet climate targets, as e.g. drafted in Switzerland's long-term climate strategy. This metric is also suitable for considering the influence of the development of individual consumption behaviour, which can lead to a permanent change (reduction or increase) in emissions. Some specific examples of the choice of metric are provided in the box.

Application examples

The different application of GWP and GWP* in the context of climate effects in the consumption sector is illustrated below using two examples:

Example of meat consumption:

- If we want to calculate the total effect on the climate of the consumption or production of one kilogram of beef (isolated consumption event), we use GWP for the methane emissions, since this involves an emission pulse for the production of this piece of meat. However, the time frame for which the climate effect is calculated must be specified for the assessment. The shorter the time frame chosen for the assessment, the greater the weighting of methane.
- If we want to calculate the effect on the climate of a permanent change in personal meat consumption (temporal development), for example a reduction from five meat meals to two meat meals per week, we use GWP* for the methane emissions, since this involves a permanent change in the emission rate.

Example of cumulative emissions:

If we want to calculate the cumulative emissions from several activities on a regular basis, for example monthly or annually, GWP* is also the appropriate metric, as these are recurring emissions.

The following example shows the difference of using GWP_{100} or GWP* in the case of emission certificates:

Example of emissions trading:

A company prevents the emission of methane by a certain amount M per year using a one-off technical measure. According to the current method, the methane emissions are converted into the quantity Z CO_{2eq} using GWP_{100}. The company can claim an emission reduction of the amount Z for this measure every year. Calculated with GWP*, on the other hand, if the same measure were permanent, it would only generate an emission reduction of the quantity $3.75 \times Z$ CO_{2eq} once. Therefore, the actual effect on the climate of the methane reduction after about 4 years gets smaller than the emission reduction calculated with the current calculation system.

If emission reduction certificates are issued for a measure which are needed to offset CO_2 emissions, the technical measure from above is only able to offset the climate effect of CO_2 emissions for just under 4 years. In order to issue certificates for methane reductions that are as appropriate as possible in terms of climate effect, the GWP* metric for permanent methane reductions would have to be used. A one-off or only temporary reduction in methane emissions would therefore not be sufficient for a certificate.

6 Consequences of the choice of metric in the international/global context

In international climate policy the conversion of methane emissions into CO_{2eq} using GWP_{100} results in differences between the climate effect derived with GWP_{100} and the actual one (Figure 4). Calculating CO_{2eq}* with the newly developed metric GWP* would enable a much more realistic assessment of the climate effect of measures related to short-lived substances. In particular, the cooling effect of permanent reductions in methane emissions, which is important for achieving climate targets, is not apparent at all with the current metric. Therefore, from a scientific perspective, the use of GWP* in the context of emission pathways to meet temperature targets is recommended. A more in-depth discussion of the effects of various metrics for short-lived climate effective substances is provided in the latest IPCC report AR6 WGI (IPCC 2021: SPM D1.8; Chap. 7.6.1.4; Chap. 7.6.2; Box 7.3).

From a scientific perspective, the introduction of GWP* would be quite possible. The CO_{2eq}* calculated with GWP* for current emissions of short-lived greenhouse gases can be calculated from past emissions of the last 20 years (as far as known or estimated) and for the future from emission scenarios for the various greenhouse gases or climate effective substances. Such scenarios are necessary anyway as a basis for calculations with climate models.

However, the metric would have to be changed in line with the international climate policy process in order to ensure international comparability on the one hand, and to continue to enable market mechanisms such as emissions trading on the other. An introduction of the GWP* metric has direct consequences for the national greenhouse gas inventories, the submitted targets or the weighting of the measures.

Various questions have also been raised about fairness, historical responsibility and similar issues in connection with a possible introduction of the new GWP* metric (e.g. Rogelj et al. 2019). However, these questions arise independently of the used metric for all climate effective substances and should therefore be discussed in the context of international negotiations on the appropriate reduction commitments and not mixed up with the choice of a physical conversion metric.

Adjusting the metric leads to the CO_{2eq} of methane in the greenhouse gas inventories being lower than currently shown for many countries (see example of Switzerland below). For the assessment of climate measures in the next 20 to 30 years, however, the importance of methane is increasing because – at least on a global level – the reduction in methane emissions is indispensable for achieving the temperature targets.

7 Consequences of the choice of metric for Switzerland

As a result of the ratification of the Framework Convention on Climate Change and the Paris Agreement, Switzerland must compile the greenhouse gas inventory in accordance with the specifications and guidelines of the UNFCCC and the IPCC. At national level, it may deviate from the prescribed metric, but then targets, effects of measures and target achievement must also be calculated in each case using both metrics.

In contrast to the global trend, methane emissions in Switzerland have decreased slightly over the last 20 years, mainly thanks to the ban on landfilling combustible waste and the restoration of the natural gas network. Today, the main source is agriculture, which accounts for over 80%. Their emissions have decreased slightly over the past 20 years.

This reduction in emissions results in an overall slightly decreasing climate effect for methane in Switzerland. If the CO_{2eq}* with GWP* approach is used for 2019, methane emissions from agriculture in Switzerland's greenhouse gas balance would only amount to 0.6 Mt CO_{2eq}* instead of 3.9 Mt CO_{2eq} (GWP_{100}). A further reduction in methane emissions could make a decisive contribution towards achieving climate targets. However, this contribution is only evident if the new metric GWP* is used instead of GWP_{100}.

The metric for converting methane emissions also plays an important role and would need to be clarified with regard to the target of offsetting greenhouse gas emissions in 2050 by long-term CO_2 sinks. Using GWP* would require much smaller amounts of negative emissions to offset the climate effect of the remaining methane emissions in 2050. This would much better reflect the actual circumstances regarding the climate effects.

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