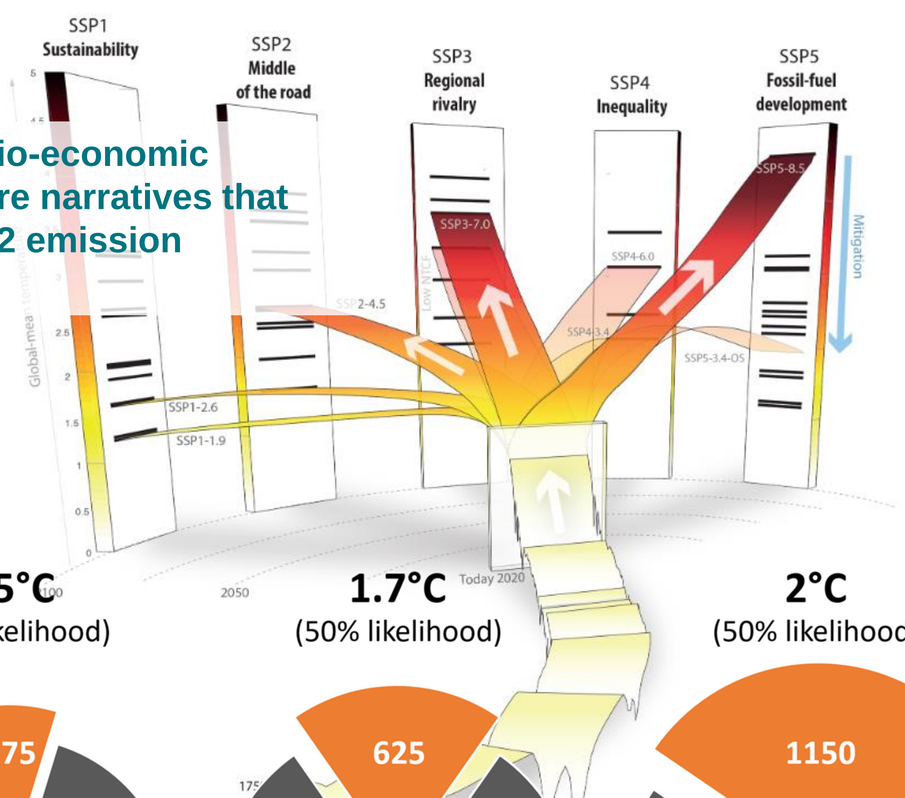
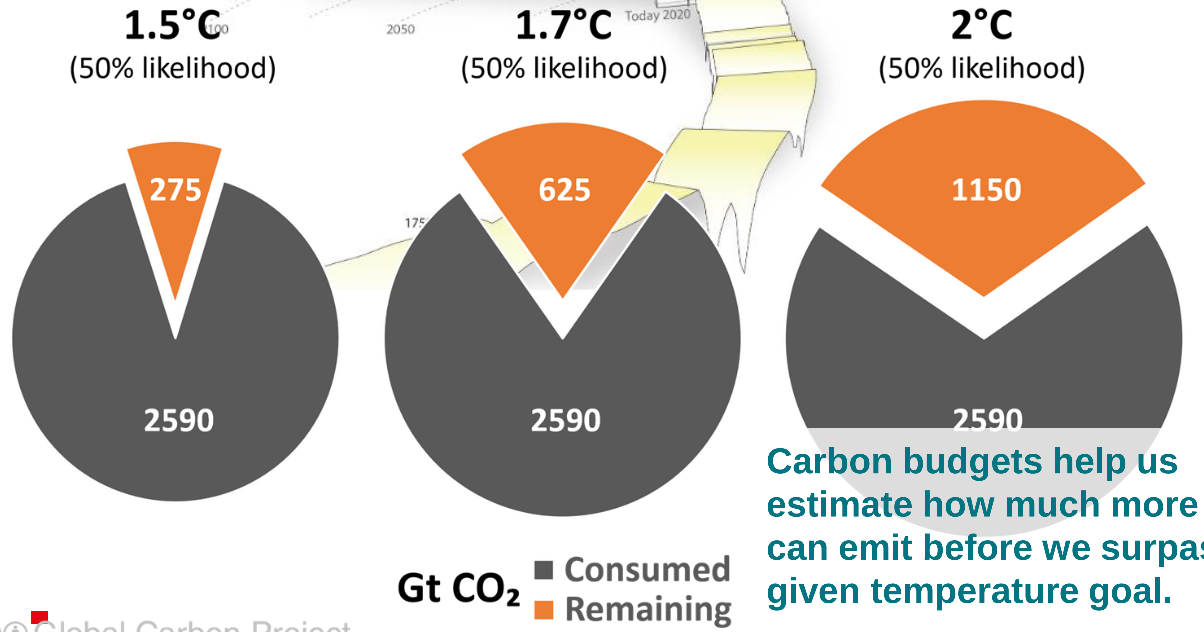
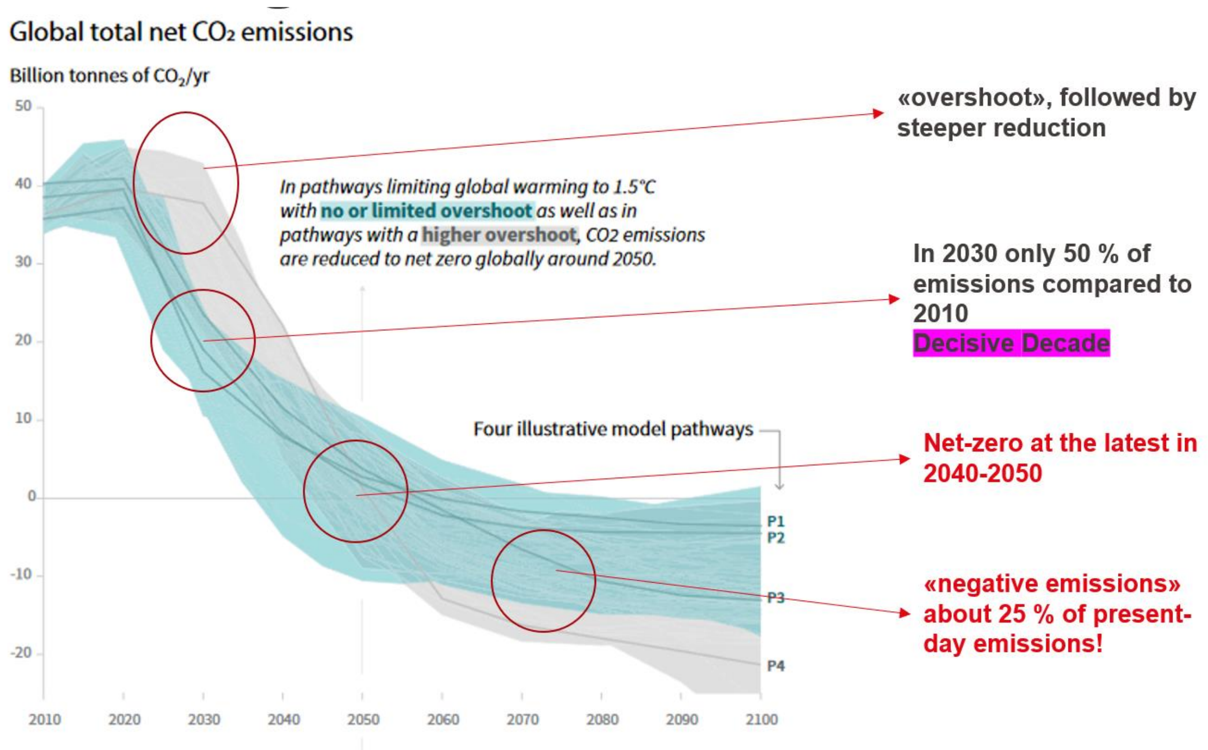
Recap from last week

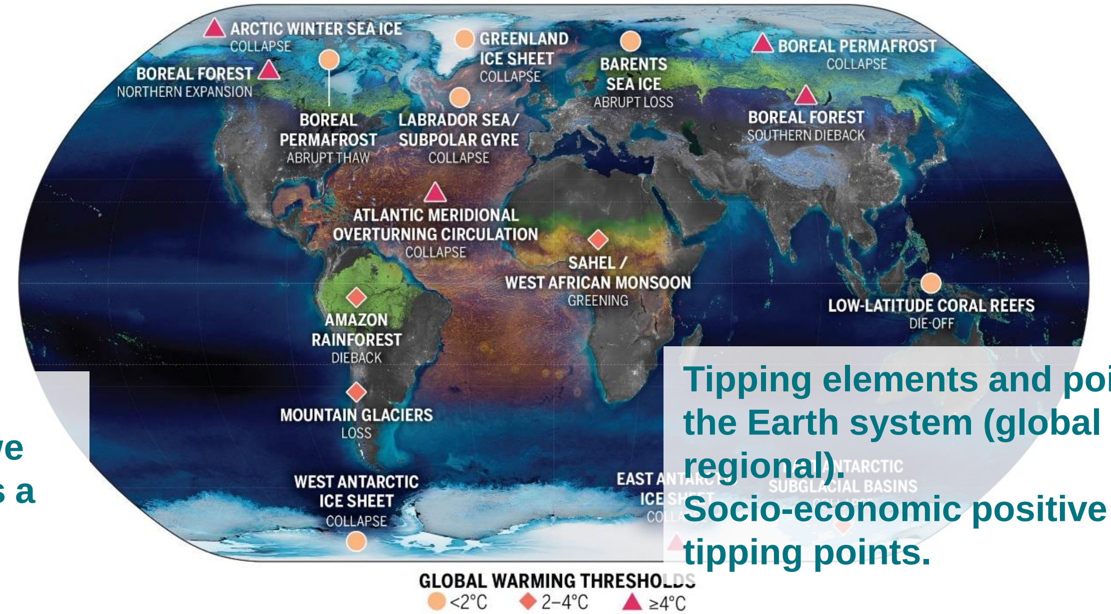


Shared socio-economic pathways are narratives that provide CO2 emission scenarios.



Carbon budgets help us estimate how much more we can emit before we surpass a given temperature goal.





Tipping elements and points of the Earth system (global and regional).
Socio-economic positive tipping points.

EPFL

General outline

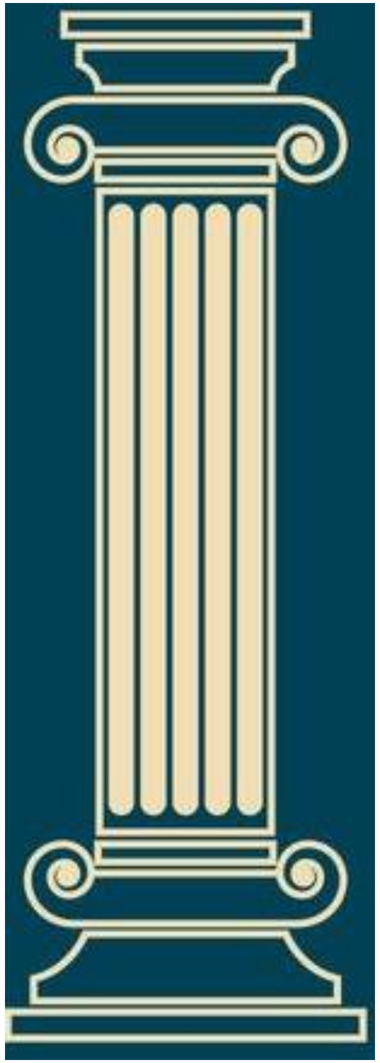
Basics

Present and future Climate change

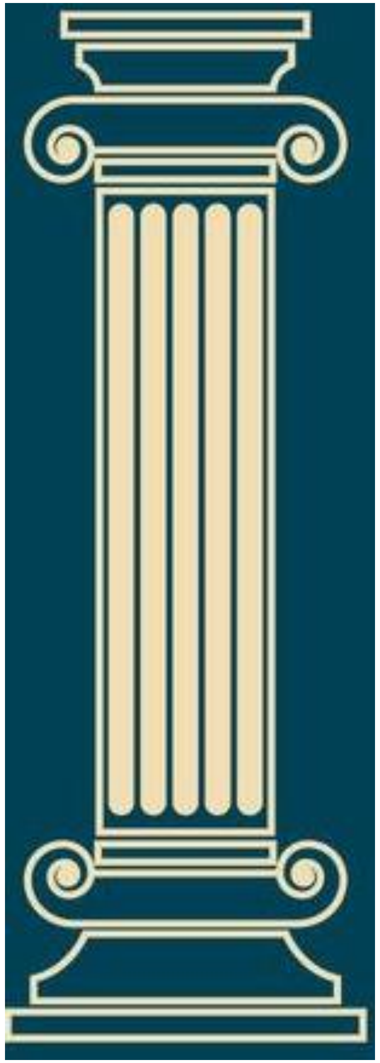
Actions

No.	Date	Topics	Deadlines
1.	12.09.2024	Introduction	fill in Questionnaire in exercises (not graded)
2.	19.09.2024	Climate System, Radiation, Greenhouse effect	
3.	26.09.2024	Earth's energy balance, Radiative transfer,	
4.	03.10.2024	Aerosols & clouds, Radiative Forcing	Launch of poster assignment
5.	10.10.2024	Feedback mechanisms, Climate Sensitivity	
6.	17.10.2024	Emergent Constraints, Paleoclimate	submission of Poster proposal (01.11.2024)
7.	31.10.2024	Climate variability	
8.	07.11.2024	IPCC, present day climate change, Paris Agreement, Emissions Gap, COP	
9.	14.11.2024	Extreme Events, COP29	
10.	21.11.2024	Climate scenarios, Tipping elements, Carbon Budget	submission of Poster draft
11.	28.11.2024	**Metrics, carbon offsets**	submission of assignment (graded)
12.	05.12.2024	Regional climate change	
13.	12.12.2024	Mitigation and adaptation, Climate Engineering	**Poster Conference** (graded)
14.	19.12.2024	Recapitulation of key points, questions and answers session	fill in Questionnaire in exercises (not graded)

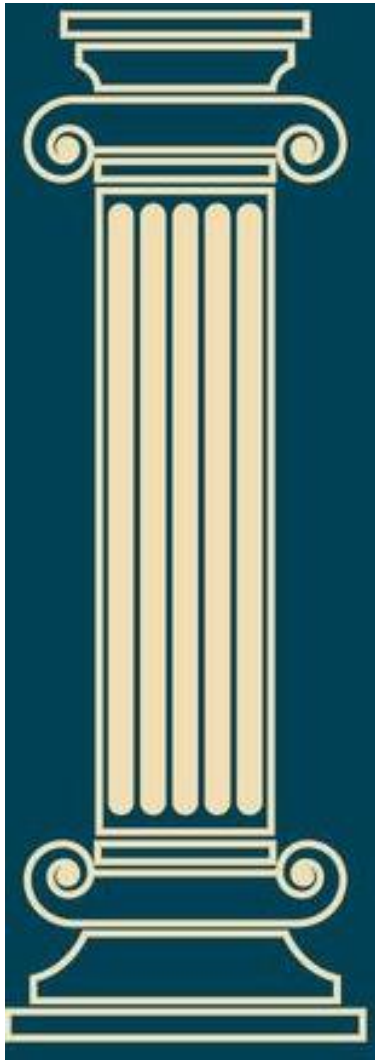
New Era of Accounting in Europe



revenue

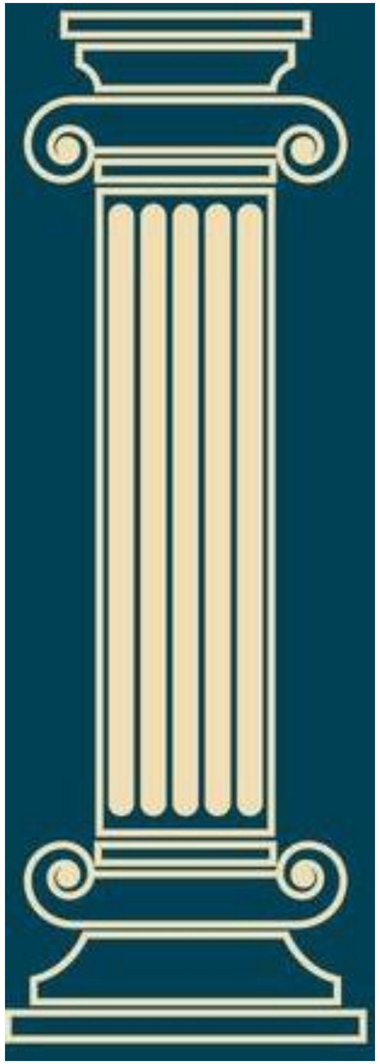


cost



capital

+



sustainability

Corporate Sustainability Reporting Directive (CSRD)

- In Europe, 11,700 companies, banks, and insurers will have to report their greenhouse gas emissions for the first time in 2025 because of the European Union's Corporate Sustainability Reporting Directive (CSRD). (formerly covered by the Non-Financial Reporting Directive (NFRD), imposed broader, less stringent rules on environmental, social, and governance disclosure.)
- Their 2025 reports will have to detail emissions from their 2024 fiscal years.

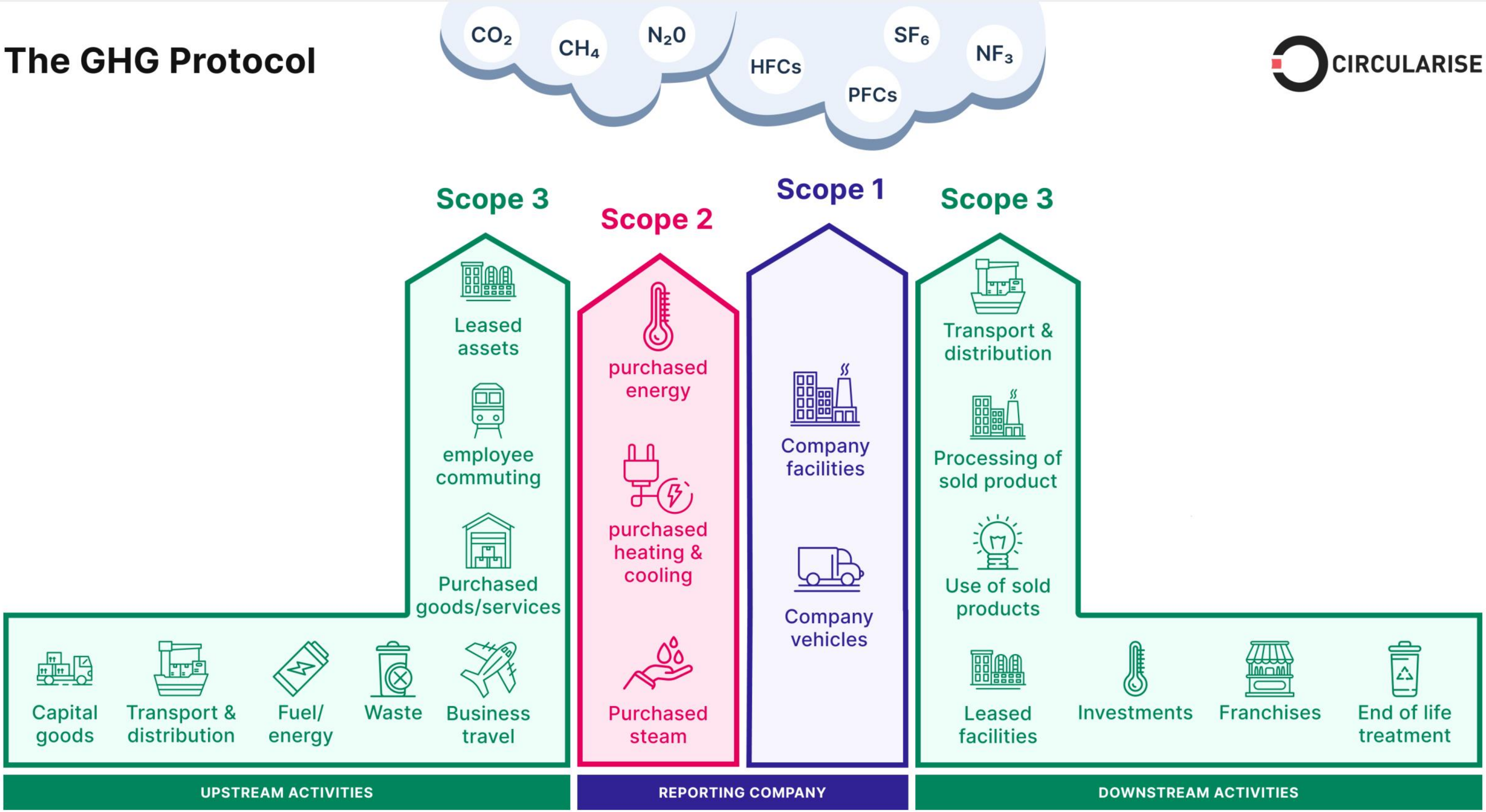
Corporate Sustainability Reporting Directive (CSRD)

- Ultimately, nearly 50,000 companies in Europe will be reporting as well as more than 10,000 non-EU companies and their European subsidiaries. In 2028, the CSRD takes effect for non-EU parent companies with €150 million annual revenues in the EU and at least one subsidiary or branch in the EU that conducts significant business. They must file their first report using 2028 emissions data at a consolidated group level (including non-EU activity) in 2029.

Scope 1, 2, 3 emissions

- Scope 1 encompasses direct emissions originating from sources owned or controlled by the reporting company.
- Scope 2 pertains to indirect emissions derived from the generation of purchased electricity, steam, heating, and cooling employed by the reporting company.
- Scope 3 covers indirect emissions resulting from activities involving assets beyond the reporting organization's control, but within its value chain.

The GHG Protocol

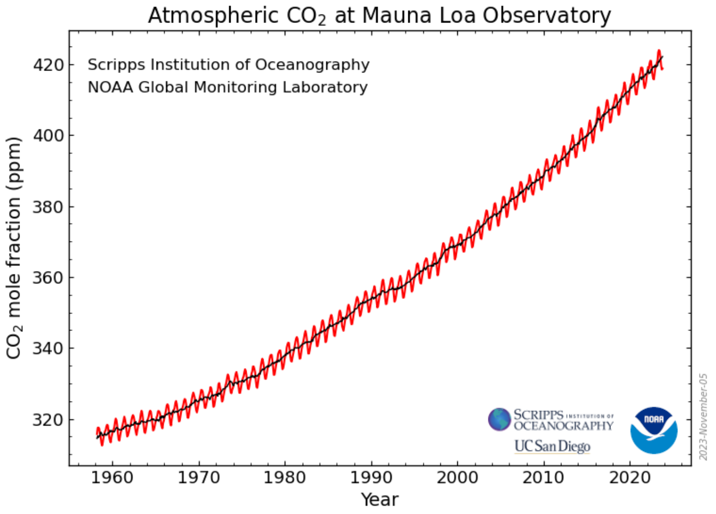


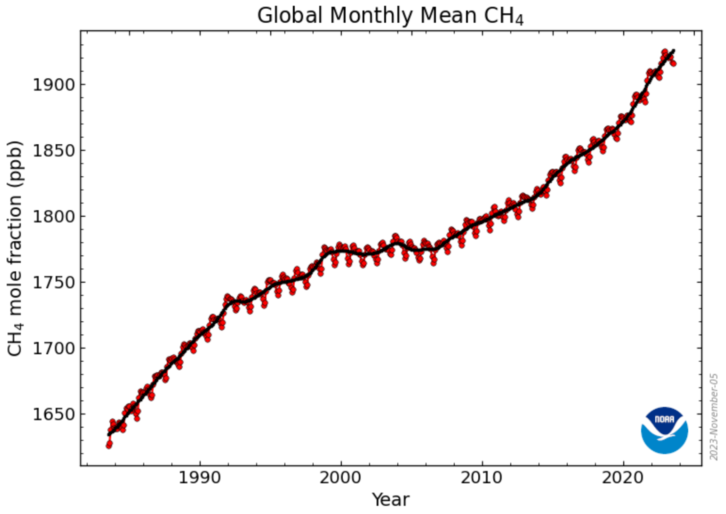
Carbon Accounting

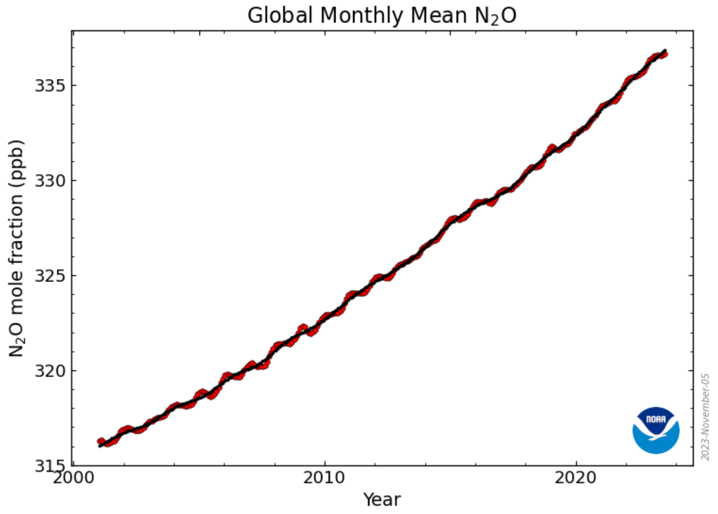
- Carbon accounting is also set to become a major factor in defining business risk as many companies begin to calculate carbon footprints using the Greenhouse Gas Protocol's Scope 1, 2, and 3 definitions for the first time.
- CSRD disclosure is also based not just on a company's carbon dioxide (CO2) emissions but rather on its **total greenhouse gas emissions — using CO2 equivalents**. This metric represents the number of metric tons of CO2 emissions with the same **global warming potential** as one metric ton of another GHG.

Carbon is not simply carbon
Conversion factors are needed

Trends in GHG
It's not only CO_2!





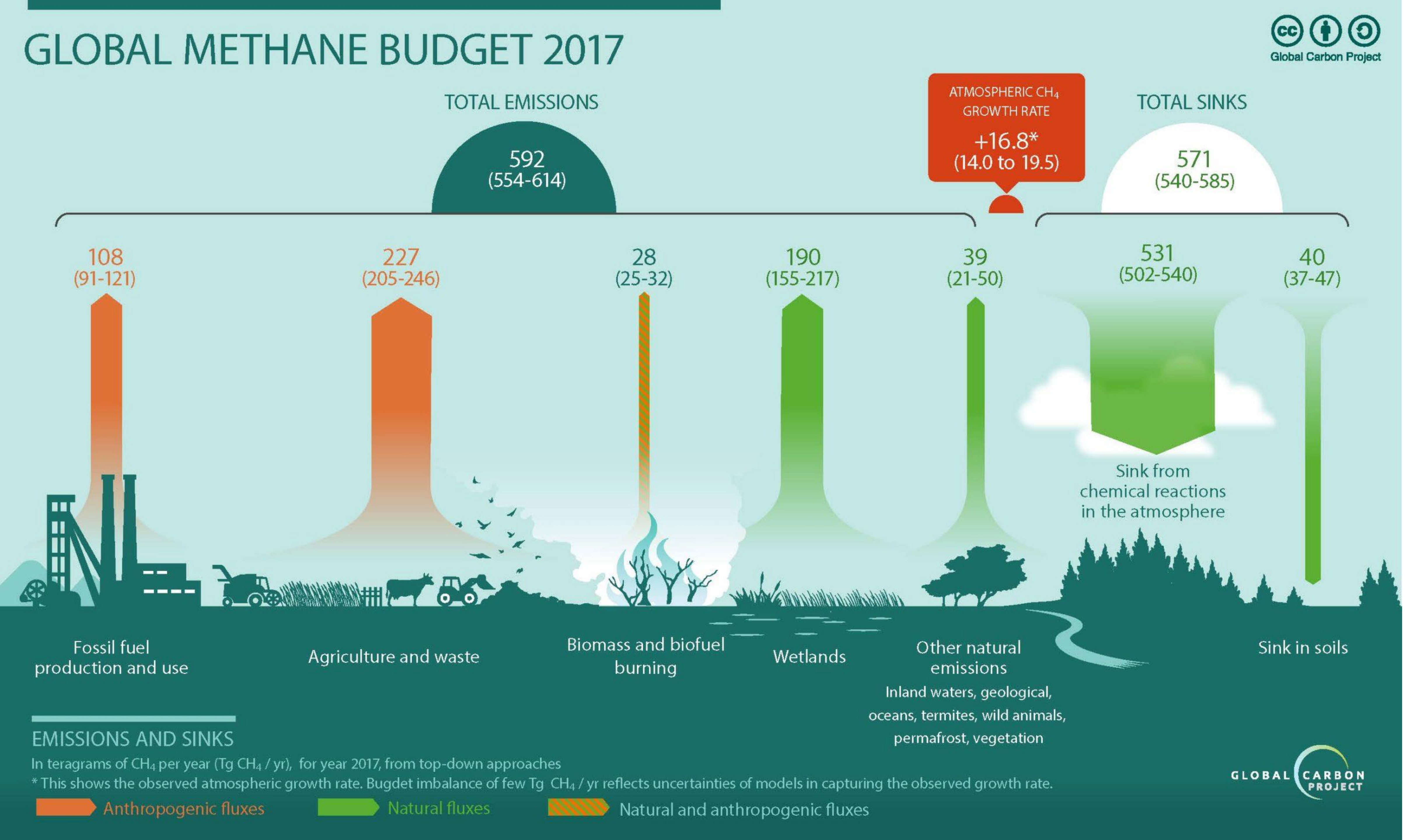


October 2023: 418.82 ppm
October 2022: 415.74 ppm
Last updated: Nov 05, 2023

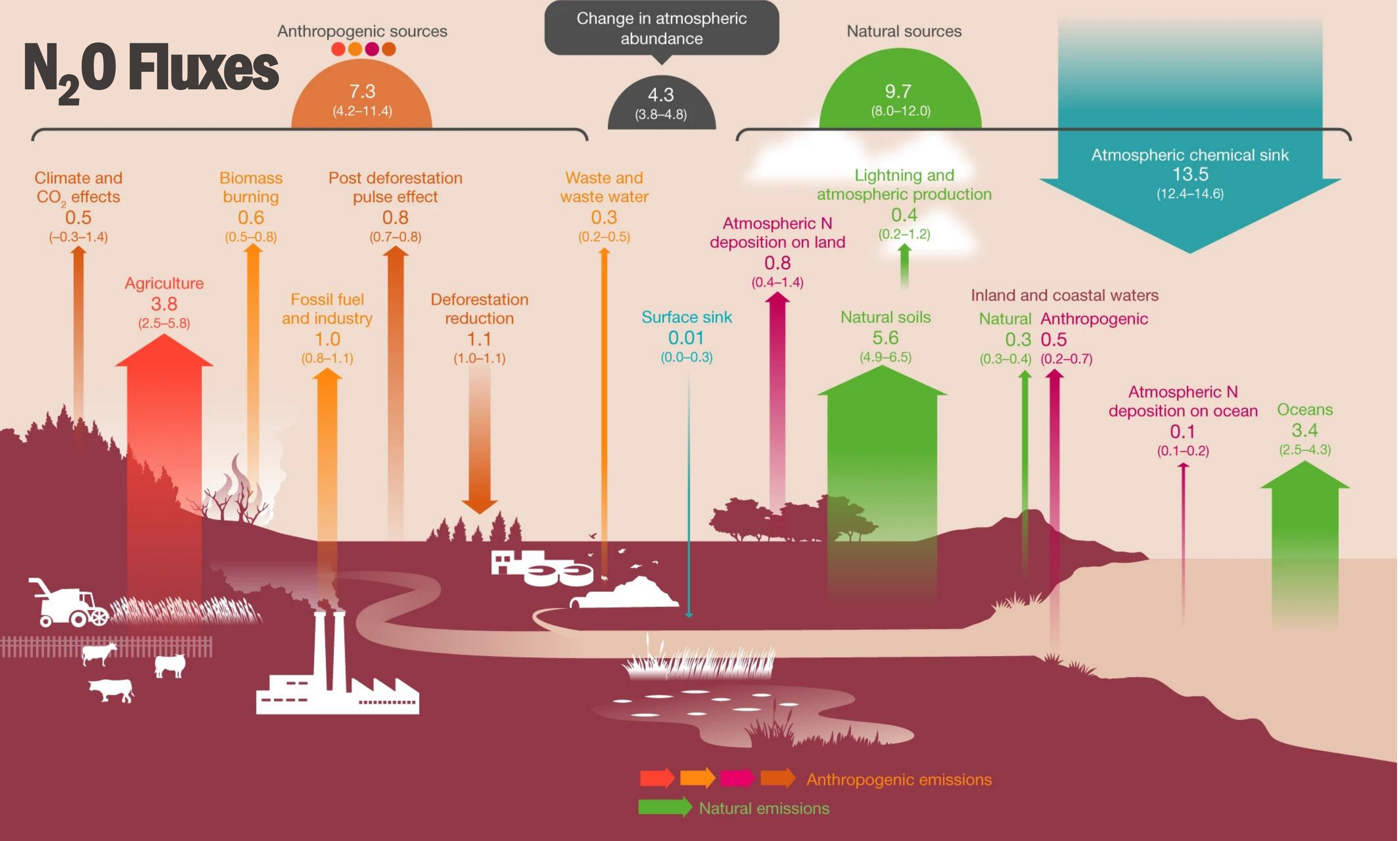
July 2023: 1915.25 ppb
July 2022: 1904.42 ppb
Last updated: Nov 05, 2023

July 2023: 336.66 ppb
July 2022: 335.56 ppb
Last updated: Nov 05, 2023

- https://gml.noaa.gov/ccgg/trends/


GLOBAL METHANE BUDGET 2017
Global Carbon Project
TOTAL EMISSIONS
592
(554-614)
ATMOSPHERIC CH4 GROWTH RATE
+16.8*
(14.0 to 19.5)
TOTAL SINKS
571
(540-585)
108
(91-121)
227
(205-246)
28
(25-32)
190
(155-217)
39
(21-50)
531
(502-540)
40
(37-47)
Sink from chemical reactions in the atmosphere
Fossil fuel production and use
Agriculture and waste
Biomass and biofuel burning
Wetlands
Other natural emissions
Inland waters, geological, oceans, termites, wild animals, permafrost, vegetation
Sink in soils
EMISSIONS AND SINKS
In teragrams of CH4 per year (Tg CH4 / yr), for year 2017, from top-down approaches
* This shows the observed atmospheric growth rate. Bugdet imbalance of few Tg CH4 / yr reflects uncertainties of models in capturing the observed growth rate.
Anthropogenic fluxes
Natural fluxes
Natural and anthropogenic fluxes
GLOBAL CARBON PROJECT

N_2O Fluxes



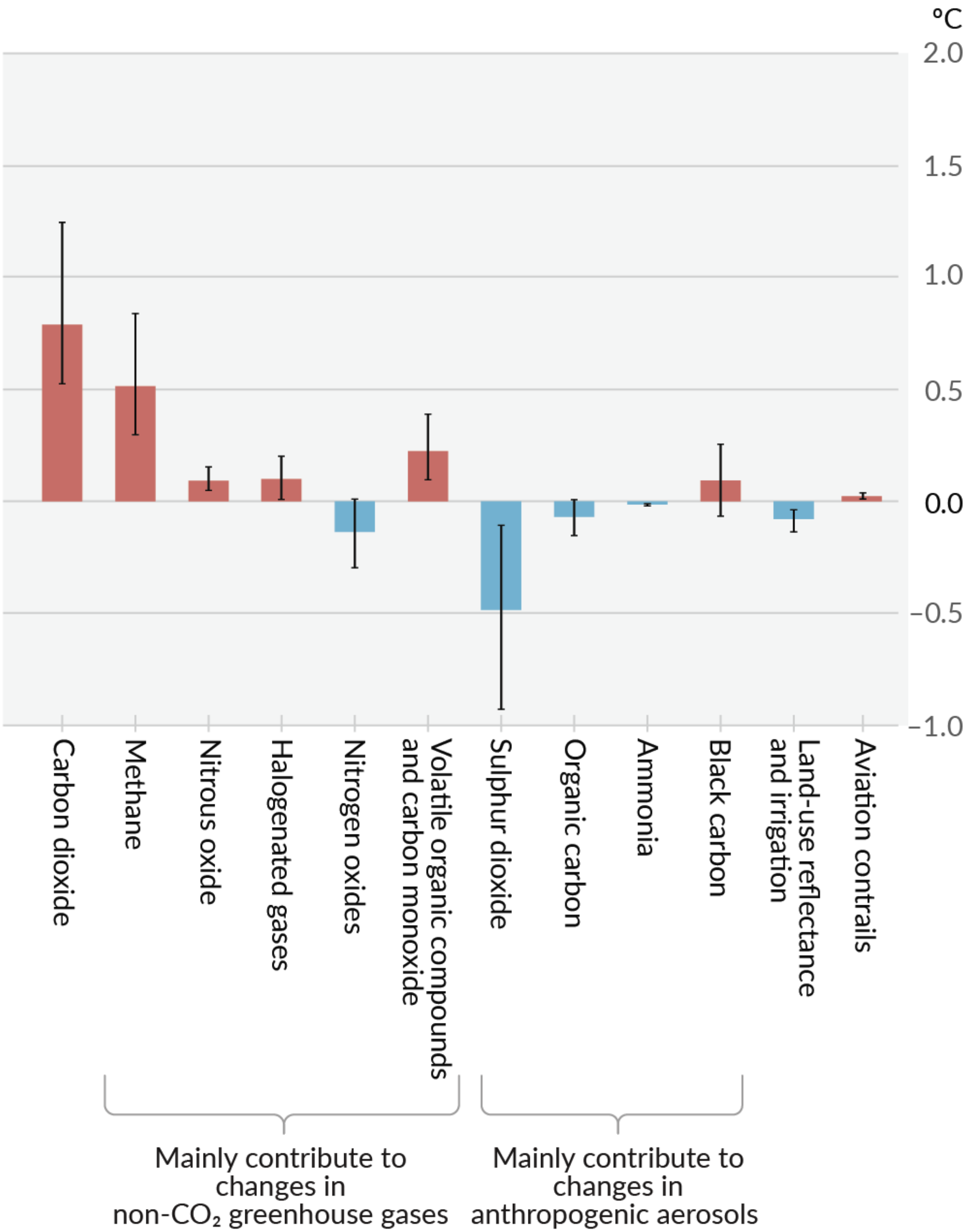
Tg/yr

Many substances contribute to global warming

1. CO_2
2. CH_4
3. VOC + CO
4. Halogenated gases
5. N_2O

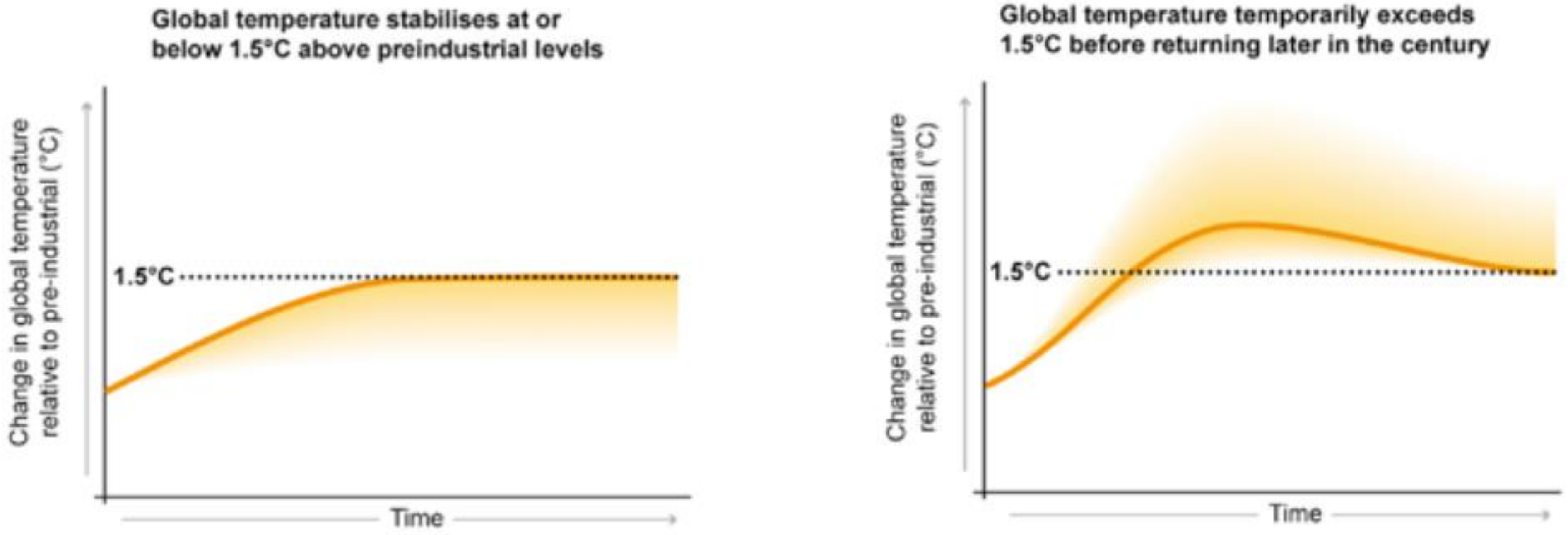
How do we make them equivalent?

→ CO_2-equivalents



IPCC

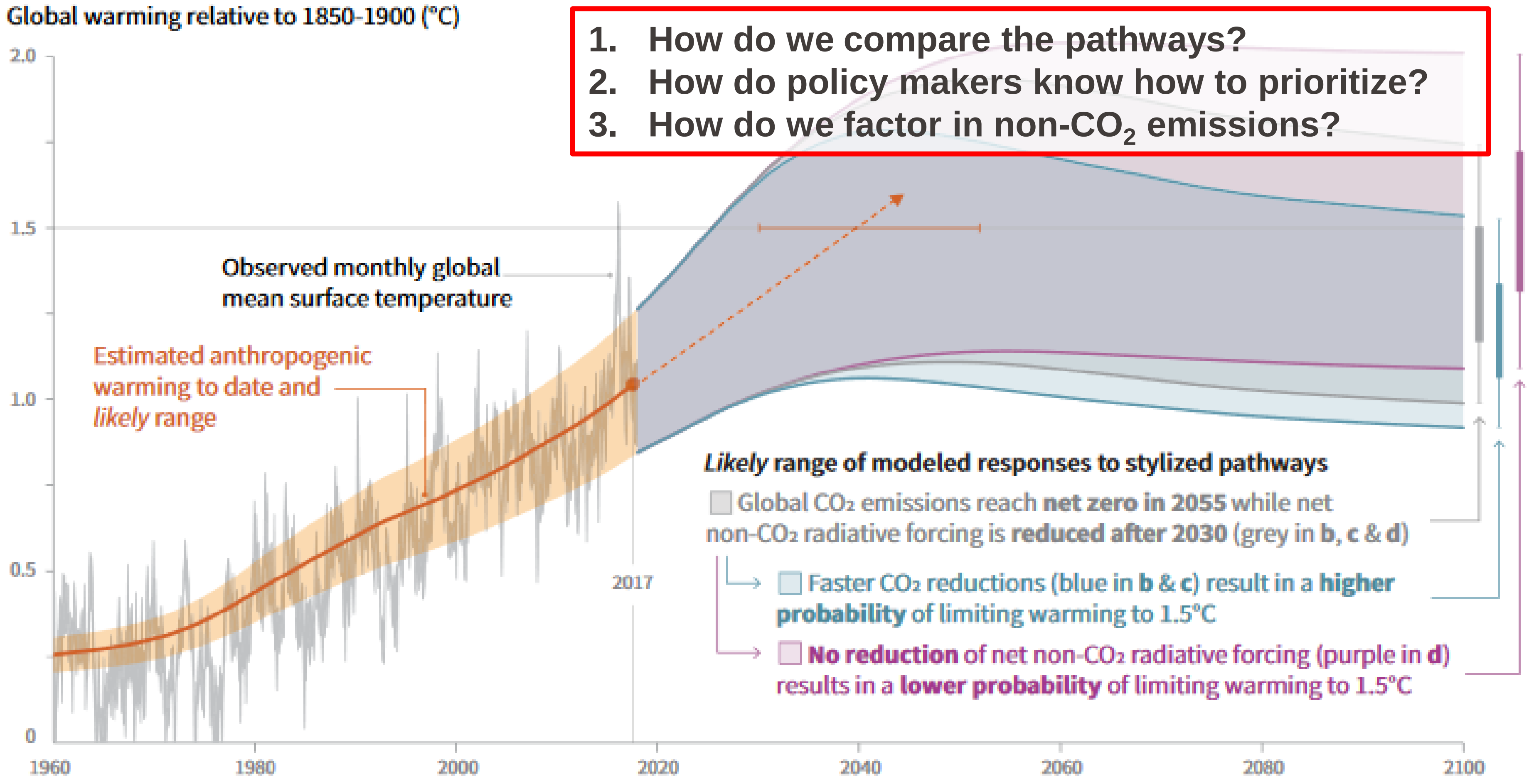
Conceptual pathways to reach the 1.5°C goal

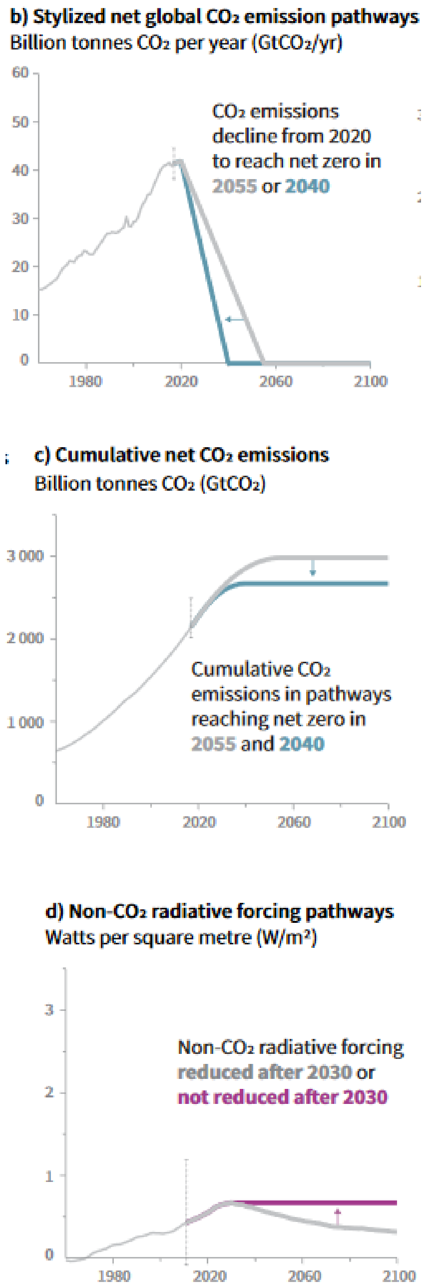


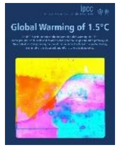
- IPCC SR1.5, FAQ2.1

Timing and mix of reductions

1. How do we compare the pathways?
2. How do policy makers know how to prioritize?
3. How do we factor in non-CO_2 emissions?

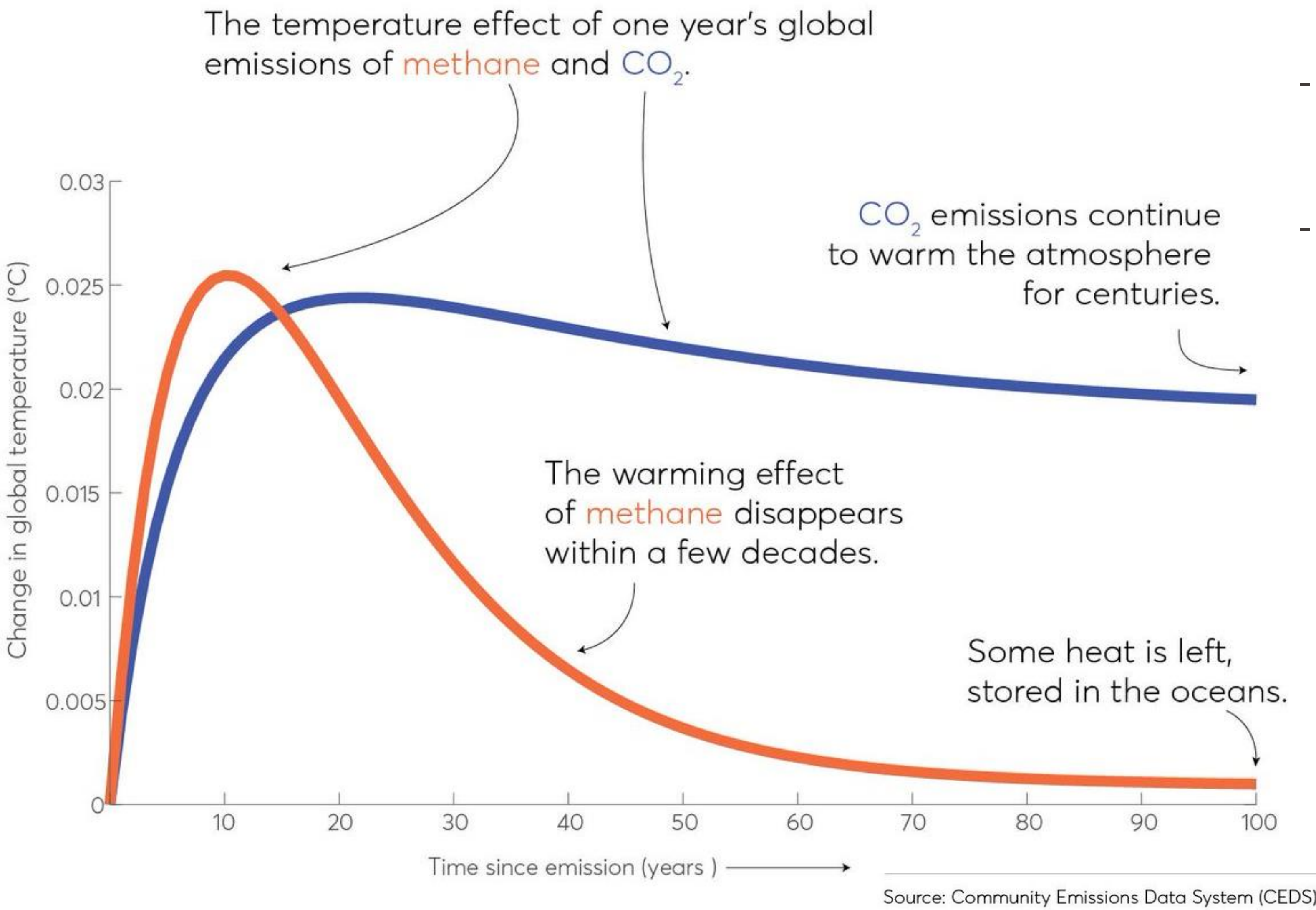






- The faster we reduce CO_2 emissions the more chances for success.
- Also non-CO_2 emission reductions contribute to success.

Different greenhouse gases have different effects



Difference depends on:

- Efficacy of the greenhouse gas (how powerful is the gas?)
- Lifetime of the gas in the atmosphere
  - CH_4: ~12 years
  - CO_2: ~100 years

The challenge

- To limit global warming to 1.5°C or well below 2.0°C, we only have a limited number of CO_{2eq} tons left to emit.
- Generally, we need to be at net-zero by mid-century. This implies
  - Very fast reductions, and
  - Negative emissions!
- This concerns not only CO_2 but also other greenhouse gases and air pollutants.
  - **How do we compare them, given their different lifetimes and different effects?**
- It makes a difference when we reduce different kinds of emissions.
  - The longer we procrastinate CO_2 reductions the longer there is a warming effect by CO_2.
  - But methane has a faster effect due to its shorter lifetime and can limit peak warming.

→ **Timing, mix and metrics of reduction actions matter!**

Kyoto protocol and the first metric

- Adopted in 1997, entered into force in 2005, terminated in 2020, Paris Agreement followed in 2020
- Kyoto protocol is a multi-gas approach (or "basket approach") including CO_2, CH_4, N_2O, HFCs, PFCs, SF_6
- No fixed overall targets, but emission reductions from major industries and industrialized countries
- The first Kyoto commitment period uses the 100-year time-horizon **global warming potential (GWP).**
- GWP is generally accepted as an appropriate measure by the user community.
- At the time of the Kyoto Protocol, the GWP was the only metric on offer to the policy community that had been assessed by IPCC.
- There has been a sustained and vigorous debate about GWP in the academic literature (which has been referred to in IPCC assessments).
- FAR: Section 2.2.7: "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 ..."

Global warming potential (GWP)

- Global Warming Potential (GWP) describes how much impact a gas will have on atmospheric warming over a period of time compared to carbon dioxide. Each greenhouse gas has a different atmospheric warming impact, and some gases remain in the atmosphere for longer than others.
- **Carbon dioxide (CO_2)** has the lowest warming potential, is the most abundant and lasts for hundrets of years, so it **is used as the baseline**.

Global warming potential (GWP)

GWP is based on the time-integrated global mean radiative forcing (RF) of a pulse emission of 1 kg of some compound (*i*) relative to that of 1 kg of the reference gas CO_2.

absolute GWP of *i*

$$GWP_i \equiv \frac{\int_0^{TH} RF_i(t)\,dt}{\int_0^{TH} RF_r(t)\,dt} = \frac{\int_0^{TH} a_i \cdot [C_i(t)]\,dt}{\int_0^{TH} a_r \cdot [C_r(t)]\,dt}$$

absolute GWP of *r*

- *TH* is the time horizon,
- RF_i is the global mean RF of component *i*,
- a_i is the RF per unit mass increase in atmospheric abundance of component *i* (radiative efficiency),
- $[C_i(t)]$ is the time-dependent abundance of *i*,
- corresponding quantities for the reference gas (*r*) in the denominator.

GWP of CH_4 and N_2O

- Greenhouse gas emissions are commonly presented in units of million tonnes of carbon dioxide equivalent (CO_2eq).
- Converting non-CO_2 emissions to CO_2eq: multiply the gas by its GWP_{100} (global warming potential over 100 years).
  - GWP_{100} of CH_4 ~ 28
    1Gt CH_4 ~ 28 Gt CO_2eq

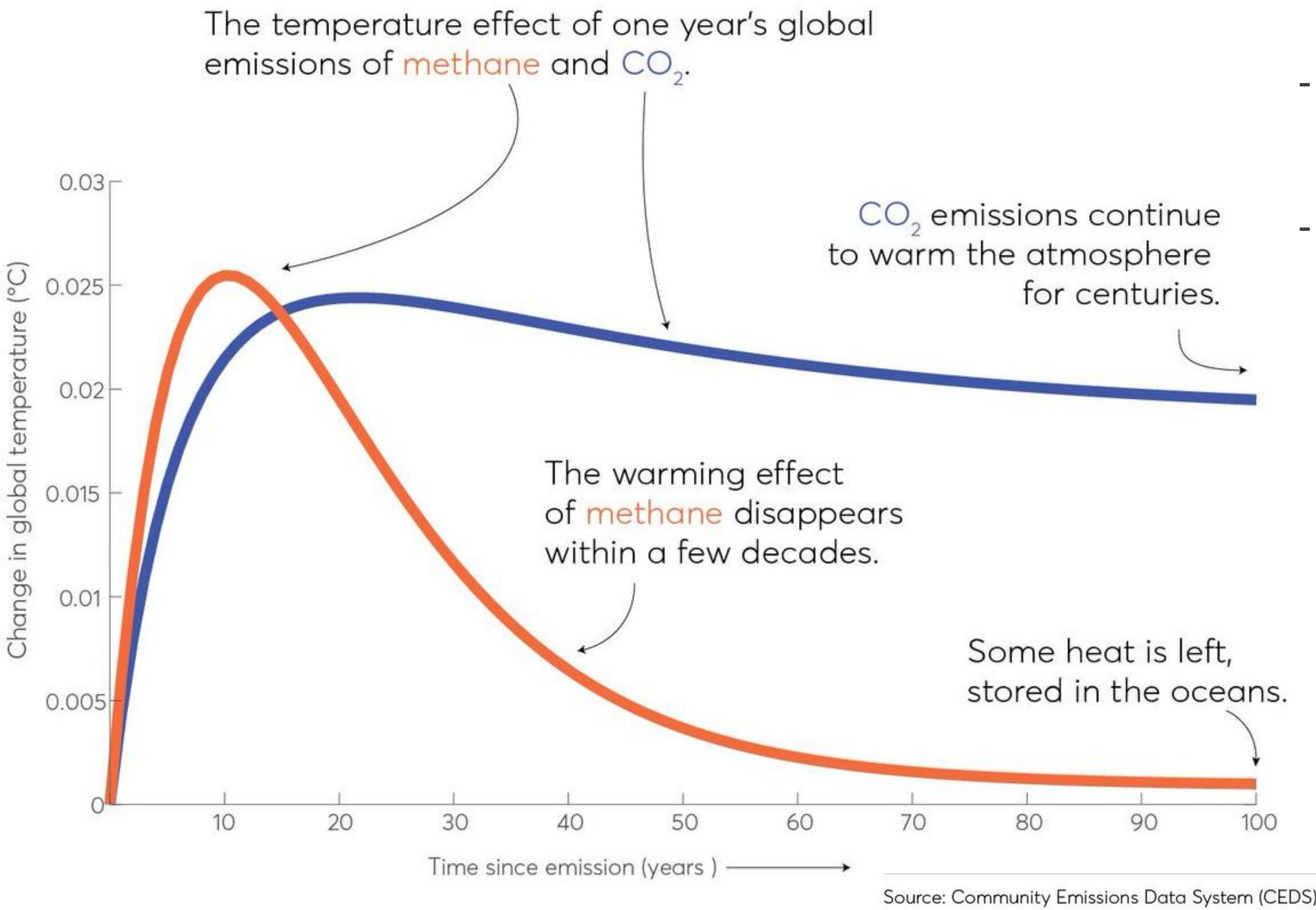
	GWP (100)
1990, CH_4	21
1995, CH_4	21
2001, CH_4	23
2007, CH_4	25
2013, CH_4	28
2021, CH_4 fossil	29.8 ±11
2021, CH_4 non-fossil	27.2 ±11
2021, N_2O	273 ± 130

The changes in the CH4 GWP reflect new quantificatin of uncertainties and improved knowledge on lifetime.

Global warming potential over 100 years (GWP_{100})

- GWP_{100} is the internationally accepted standard, and is used by countries for their emissions accounting, as agreed at the United Nations level.
- However, when using a blanket calculation such as GWP_{100} we need to be mindful of its **limitations when making decisions around short-lived gases like methane**.

Different greenhouse gases have different effects



Difference depends on:

- Efficacy of the greenhouse gas (how powerful is the gas?)
- Lifetime of the gas in the atmosphere
  - **CH_4: ~12 years**
  - **CO_2: ~100 years**

GWP of CH_4 and N_2O

- Short-lived gases will have a higher warming potential over shorter time horizons, because their impact on a shorter time horizon is larger.

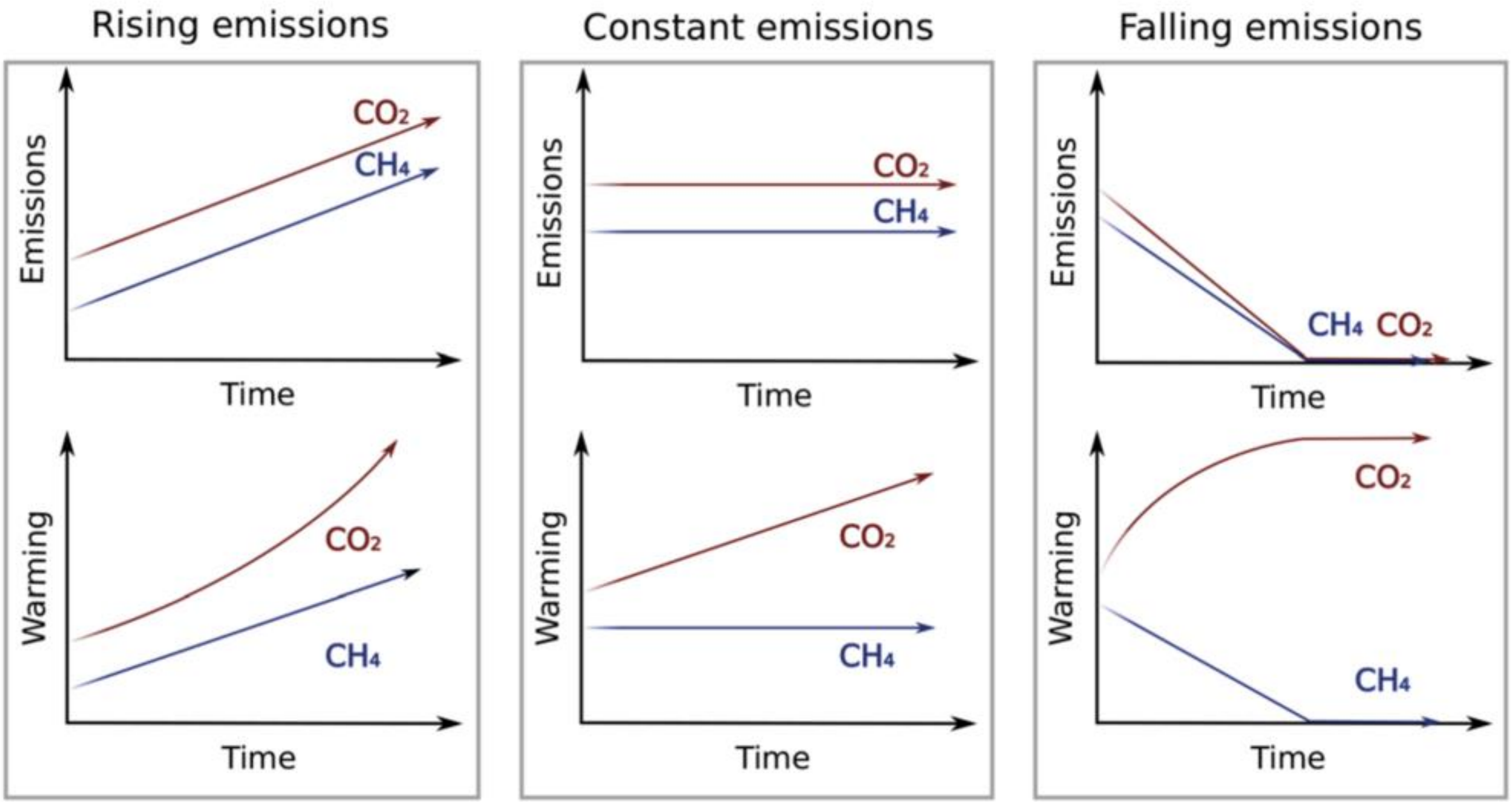
- Converting non-CO_2 emissions to CO_2eq: multiply the gas by its GWP_{100} (global warming potential over 100 years).
  - GWP_{100} of CH_4 ~ 28
    1Gt CH_4 = 28 Gt CO_2eq
  - GWP_{20} of CH_4 ~ 81
    1Gt CH_4 = 81 Gt CO_2eq

	GWP (100)	GWP (20)
1990, CH_4	21	
1995, CH_4	21	
2001, CH_4	23	
2007, CH_4	25	
2013, CH_4	28	
2021, CH_4 fossil	29.8 ±11	82.5 ± 25.8
2021, CH_4 non-fossil	27.2 ±11	80.8 ± 25.8
2021, N_2O	273 ± 130	273 ± 118

The changes in the CH4 GWP reflect new quantificatin of uncertainties and improved knowledge on lifetime.

Temperature response to changed emissions

Lifetimes:
CO_2 > 100 yrs
CH_4 ~12 yrs



- Cain blog post: https://www.climatechange.ie/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants/

A more appropriate definition for short-lived GHGs: GWP*

- GWP* equates a “pulse” emission of CO_2 with an **increase in the emission rate** of methane.
- GWP is typically defined to compare pulses of emissions with each other. A pulse is when a specified mass of gas is released into the atmosphere instantaneously.
- Over the coming years, the CO_2 remains in the atmosphere, as it is a long-lived gas, and so leads to a permanent increase in the CO_2 concentration.
- A **change in the methane emission rate** also leads to higher concentrations of methane in the atmosphere.
- GWP* uses GWP, but instead of comparing two pulses it effectively spreads the methane emission out evenly over the X-year time-horizon, where X can be e.g., 20 or 100 years.

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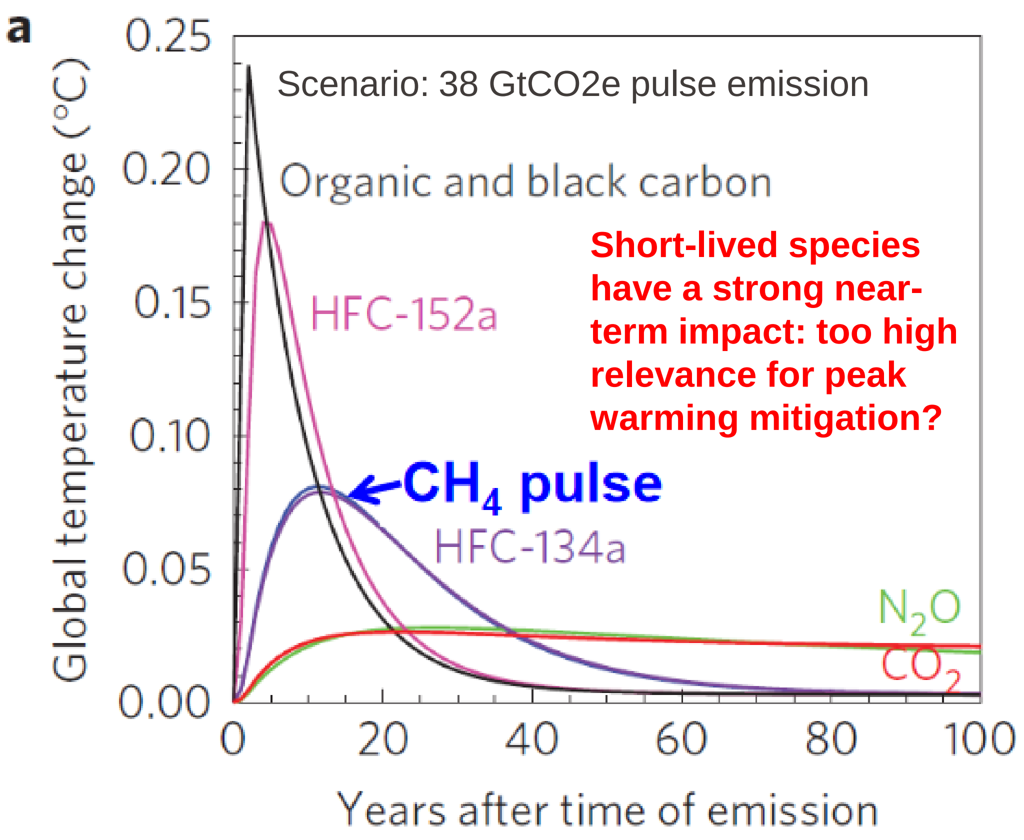
A new GWP: GWP*

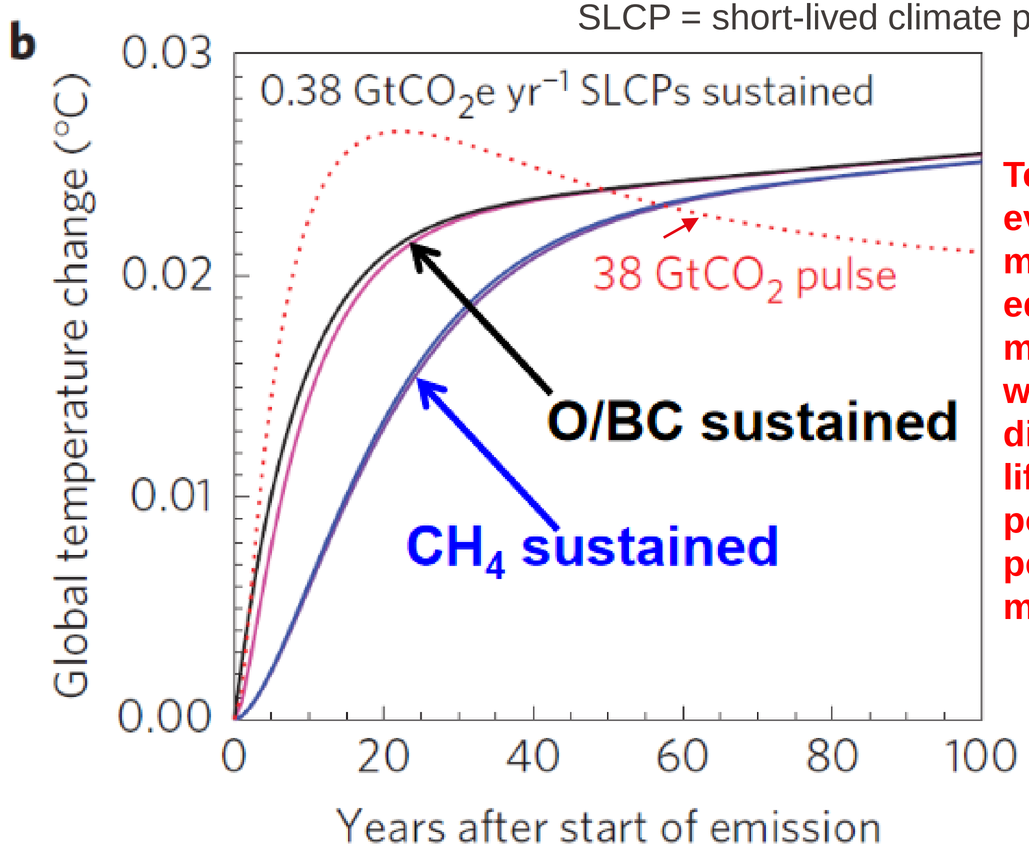
Old GWP:
The “**equivalence**” is such that the **integrated radiative forcing over 100 years** is the same for the CH_4 pulse and the equivalent pulse of CO_2.

New GWP*:
Not comparing pulsed emissions, but continuously emitting the shorter-lived climate forcer over the 100 year time horizon such that **after 100 years the CO_2 and CH_4 have the same CO_2 equivalent**. The **“equivalence” is temperature** change rather than integrated forcing: arguably more aligned with Paris goals.

SLCP = short-lived climate pollutant



Short-lived species have a strong near-term impact: too high relevance for peak warming mitigation?



Temperature evolution much more equal, put more equal weight on different lifetime pollutants for peak warming mitigation.

100 yrs * 0.38 $GtCO_2e$ = 38 $GtCO_2e$

- Allen et al., Nat. Clim. Change, 2016

GWP*

From Allen et al., 2018: the radiative forcing of cumulative pollutants like CO_2 scales with the **total stock** of emissions to date (cumulative integral). For short-lived species like methane, the radiative forcing scales with the **emission rate** multiplied by the lifetime.

Under the new GWP*, the CO_2 equivalent emission rate for short-lived species is calculated as the change in emission rates across the reference period multiplied by the warming potential over the time horizon:

$$E_{CO_2e*} = \frac{\Delta E}{\Delta t} \times GWP_H \times H$$

Time horizon

CO_2 equivalents

Warming potential over time horizon

Change in emission rate

Relevance of GWP*

- GWP* accounts for the differences between short- and long-lived gases, and can better link emissions to warming. This means that the **true impact of an emission pathway on global temperature can be more easily assessed**.
- For countries with high methane emissions – due to, e.g., agriculture – this can make a huge difference to how their progress in emission reductions is judged.

- https://www.carbonbrief.org/guest-post-a-new-way-to-assess-global-warming-potential-of-short-lived-pollutants/

Other metrics

Pulse emissions like GWP

- **Global temperature change potential (GTP)**
  - Compared to the Global Warming Potential (GWP), the Global Temperature change Potential (GTP) goes one step further down the cause–effect chain and is **defined as the change in global mean surface temperature at a chosen point in time in response to an emission pulse—relative to that of CO_2.**
  - Whereas GWP is integrated in time, **GTP is an end-point metric that is based on temperature change for a selected year, t.** Like GWP, the GTP values can be used for weighting the emissions to obtain 'CO_2 equivalents'.
  - Needs a model to derive the temperature change from the change in forcing. The unit is dimensionless.
- **Absolute GTP (AGTP)**
  - The Absolute Global Temperature-change Potential (AGTP) represents the temperature change at a given time due to a pulse emission of a unit mass of a gas (or other climate forcing agent) at a given time. Hence the AGTP represents the GTP without comparison to a reference gas.

How different forcers act over time (AGTP)

- Lifetimes are challenges:
  - CO_2: >100 yrs
  - CH_4: ~12 yrs
- CH_4 has a strong warming influence when it is first emitted, which then diminishes rapidly over a few decades.
- CO_2 has a sustained warming effect.
- They are not equivalent!

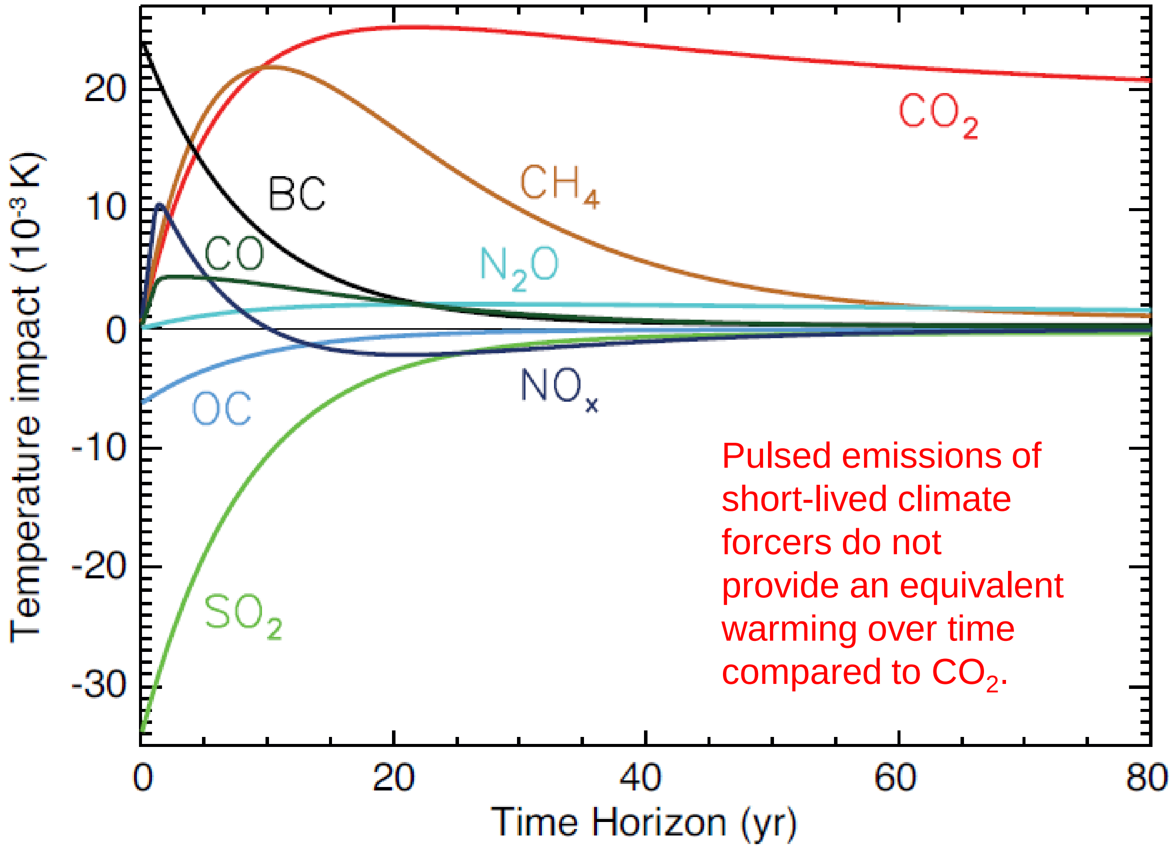


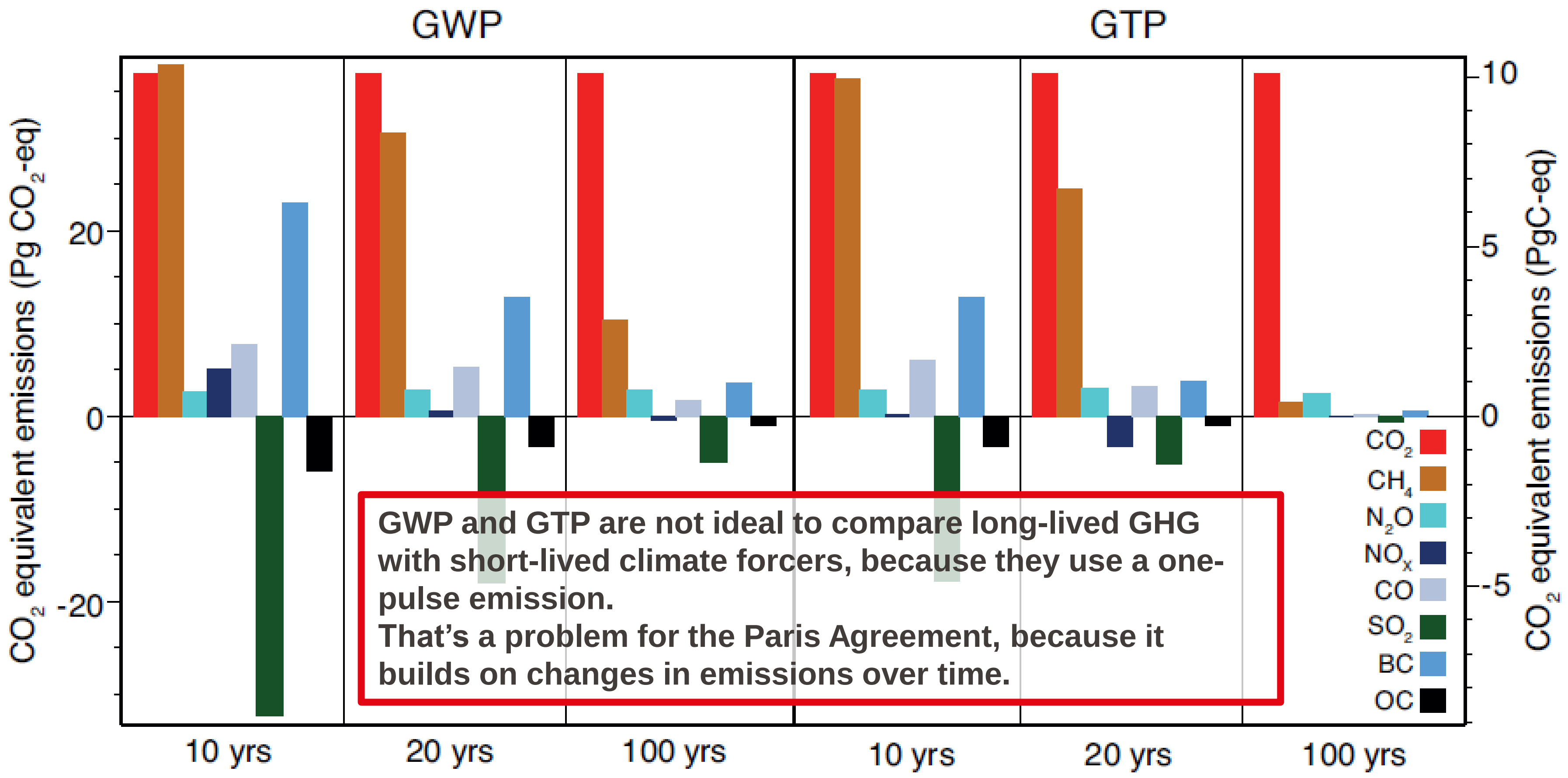
Figure 8.33 | Temperature response by component for total anthropogenic emissions for a 1-year pulse. Emission data for 2008 are taken from the EDGAR database and for BC and OC for 2005 from Shindell et al. (2012a). There are large uncertainties related to the AGTP values and consequentially also to the calculated temperature responses (see text).

AR5, Ch.8

EPFL

GWP and GTP

Differences in «equivalents» depending on the metric.

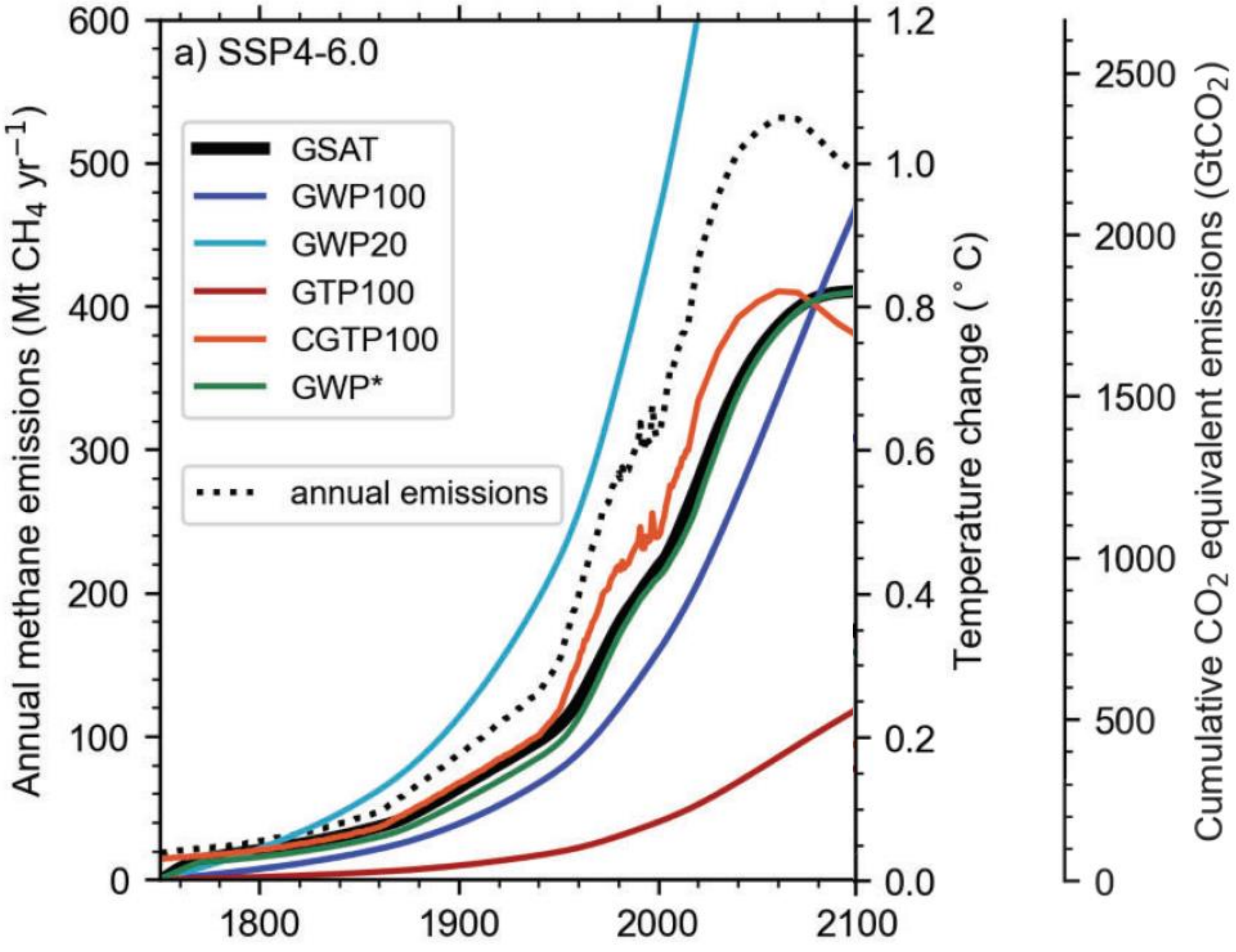


Note the difference between the vertical axes: CO2eq vs C-eq

Figure 8.32 | Global anthropogenic emissions weighted by GWP and GTP for chosen time horizons (aerosol–cloud interactions are not included). Emission data for 2008 are taken from the EDGAR database. For BC and OC emissions for 2005 are from Shindell et al. (2012a). The units are 'CO_2 equivalents' which reflects equivalence only in the impact parameter of the chosen metric (integrated RF over the chosen time horizon for GWP; temperature change at the chosen point in time for GTP), given as $Pg(CO_2)_{eq}$ (left axis) and given as PgC_{eq} (right axis). There are large uncertainties related to the metric values and consequentially also to the calculated CO_2 equivalents (see text).

- IPCC, 2013, Ch.8

Temperature projections are a function of the metric!



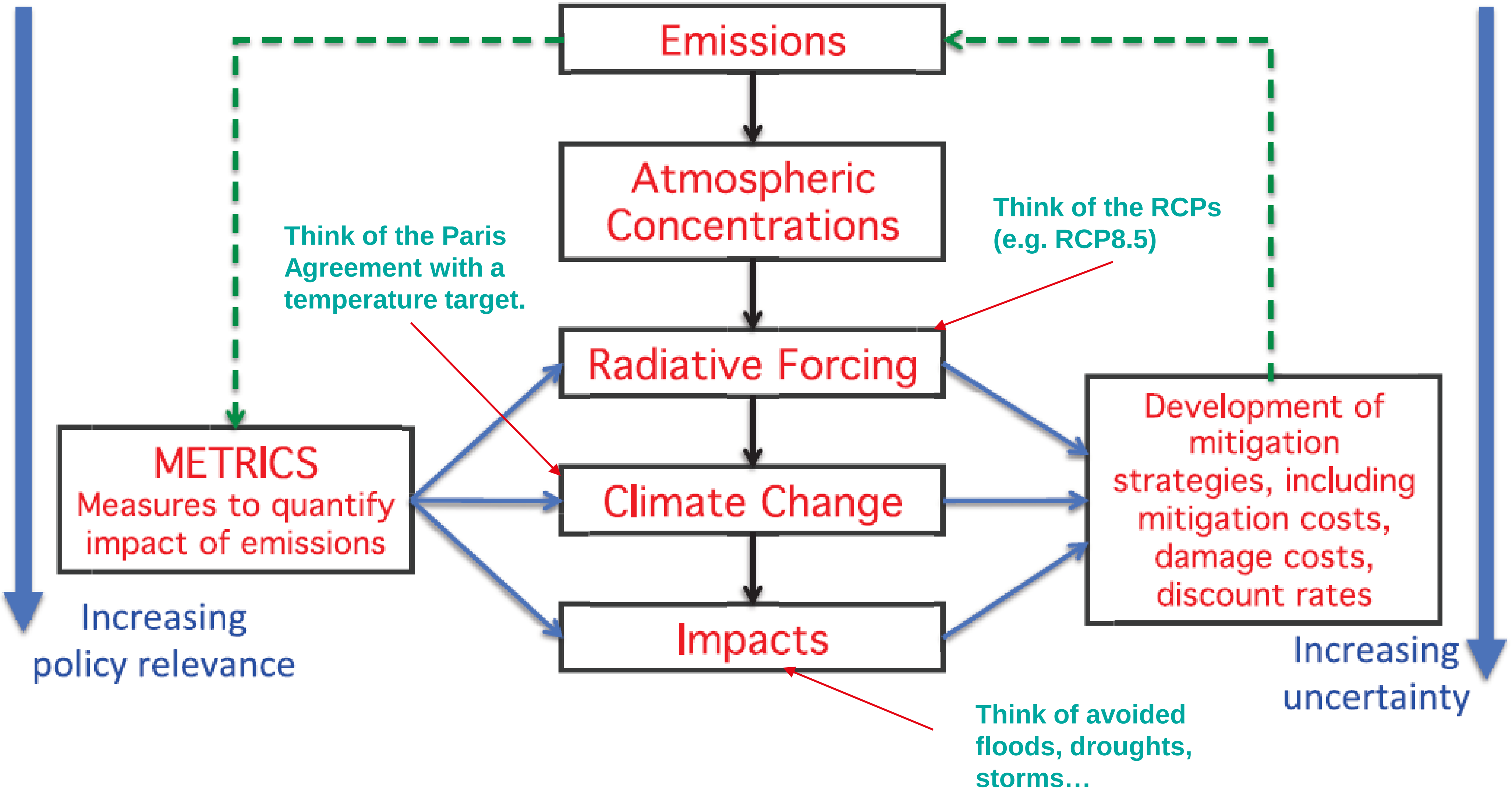
GWP* and CGTP are most realistic.

GSAT: global surface air temperature
GWP: global warming potential
GTP: global temperature potential
CGTP: combined GTP

- Modified IPCC AR6, Fig. 7.22

Policy needs metrics

Emission metrics are used to compare the relative effect of emissions of different gases over time in terms of radiative forcing, global surface temperature or other climate effects. (IPCC AR6)



- IPCC AR5 WG1 Fig 8.27

Which metric to choose?

- **AR6 does not recommend an emission metric because the appropriateness of the choice depends on the purposes for which gases or forcing agents are being compared.**
- Emission metrics can facilitate the comparison of effects of emissions in support of policy goals.
- They do not define policy goals or targets but can support the evaluation and implementation of choices within multi-component policies (e.g., they can help prioritise which emissions to abate).
- **The choice of metric will depend on which aspects of climate change are most important to a particular application or stakeholder and over which time horizons.**
- Different international and national climate policy goals may lead to different conclusions about what is the most suitable emission metric [...].

- Citation from IPCC AR6, Box 7.3

Paris Agreement and emission metrics

- Article 2 aims to limit the risks and impacts of climate change by setting **temperature goals**.
- Article 4 foresees an **early emissions peaking target**, and the aim to "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century".
- **How the interpretation of the Paris Agreement and the meaning of "net zero" emissions reflects on the appropriate choice of metric is an active area of research [...].**
  - Several possible scientific interpretations of the Article 2 and 4 goals can be devised, and these along with emission metric choice have implications both for when a balance in GHG emissions, net zero CO_2 emissions or net zero GHG emissions are achieved, and for their meaning in terms of temperature outcome […].

- IPCC AR6, Ch. 7.6.2

Net zero definition in IPCC AR6

- In AR6 net zero greenhouse gas emissions is **defined as the condition in which metric-weighted anthropogenic GHG emissions are balanced by metric-weighted anthropogenic GHG removals over a specified period** (see 11 Chapter 1, Box 1.4, Appendix VII: Glossary).
- The quantification of net zero GHG emissions depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric. **As the choice of emission metric affects the quantification of net zero GHG emissions, it therefore affects the resulting temperature outcome after net zero emissions are achieved [...].**

- IPCC AR6, Ch. 7.6.2

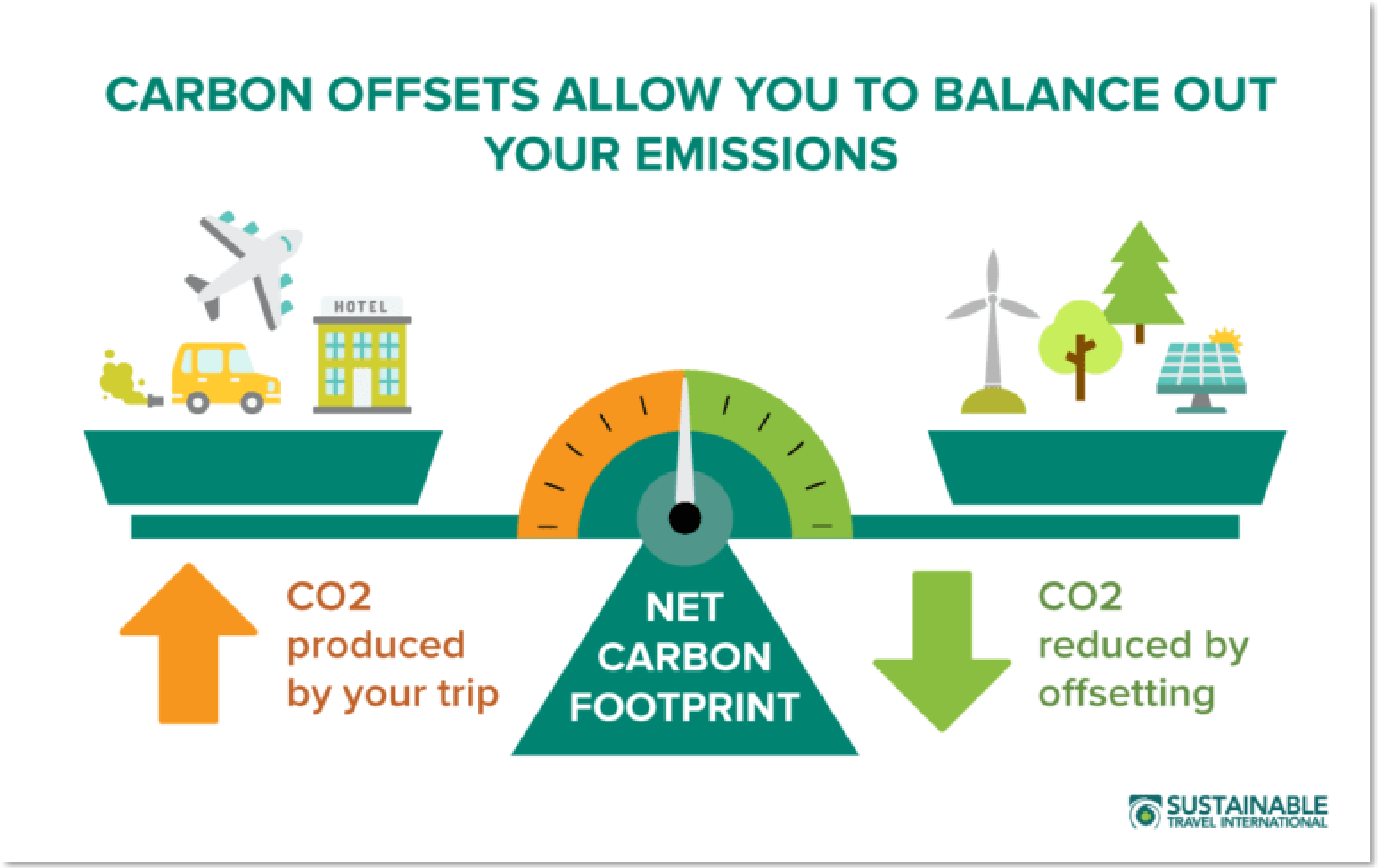
Carbon Credits and Offsets

Credit: L. Favre

École
polytechnique
fédérale
de Lausanne

What is a carbon offset?

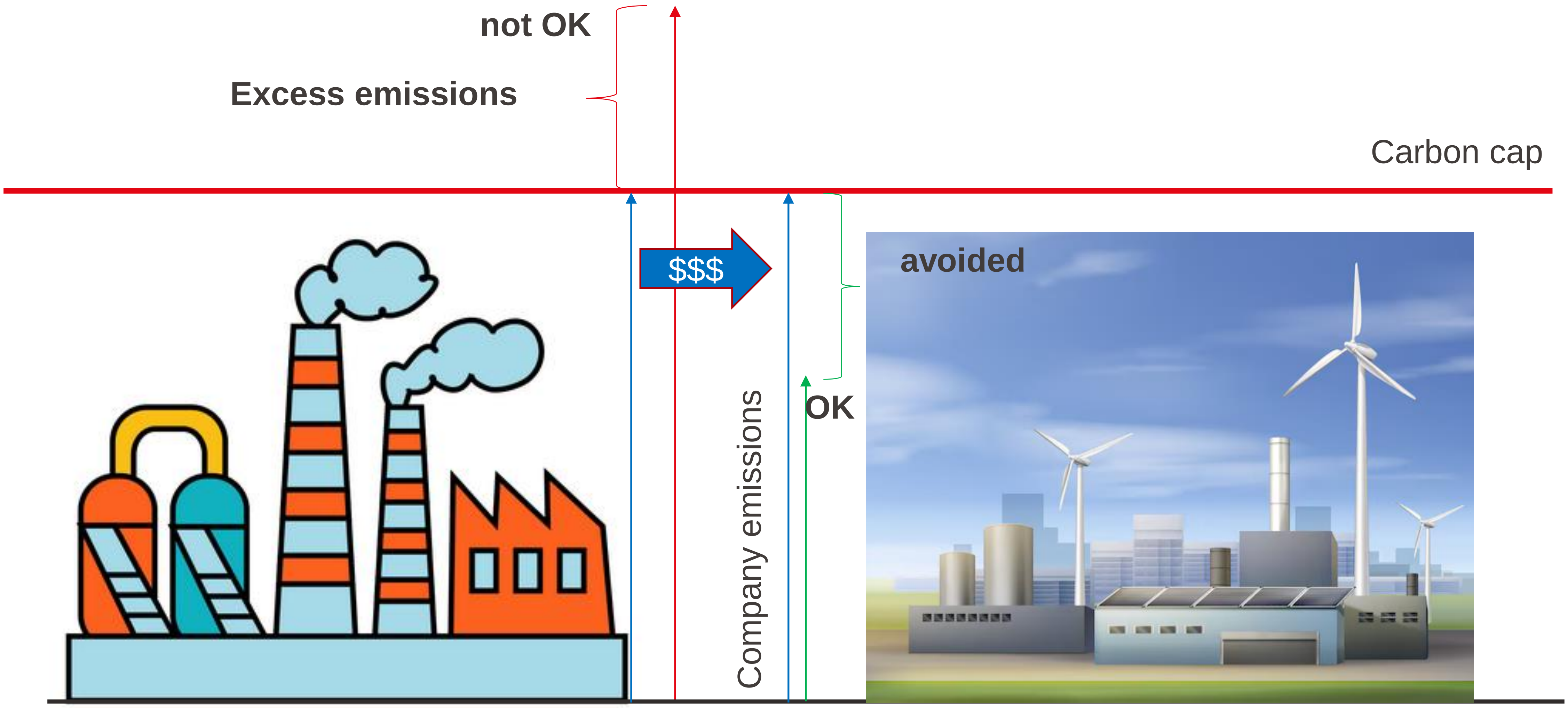
- A carbon offset is the **avoidance** or **sequestration** of carbon dioxide or other greenhouse gases emissions to compensate for (offset) emissions produced elsewhere.



Brief History of Carbon Offsets

- First ideas in the 1980s as climate change became generally evident.
- Really started under Kyoto Protocol (signed 1997, began 2005)
  - Capped greenhouse gas emissions from big industries and industrialized countries
  - The Clean Development Mechanism (CDM) allowed a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) **credits, each equivalent to one tonne of CO_2,** which can be counted towards meeting Kyoto protocol targets. → **mandatory carbon market**
- **Voluntary** carbon offset programs started to develop after 2005, as the CDM became more established and the corporate social responsibility community began to recognize that there was a demand for these instruments beyond just regulated companies and countries to the Kyoto Protocol.
  - There is now a variety of carbon offset programs primarily (or exclusively) serving the voluntary market comprised primarily of corporations wishing to make GHG emission reduction claims.

Example: Compliance System (mandatory)



Mandatory / Compliance programs

- Mandatory systems are regulated by national, regional, or provincial **law** and mandate emission sources to **achieve compliance** with GHG emission reduction requirements.
- For regulated emissions sources, offsets can serve as an alternative compliance mechanism to direct emissions reductions or allowances (tradable permits allowing a quantity of emissions) that emission sources can use to meet their emissions cap.
- Typically offset credits in a particular program are priced similarly based on the dynamics of supply-and-demand, regardless of project type and other characteristics.
- Examples
  - Regional Greenhouse Gas Initiative (RGGI) (Eastern States of the US)
  - European Union Emissions Trading Scheme (EU ETS)
- The World Bank Carbon Pricing Dashboard tracks which countries have implemented compliance offset programs and other carbon pricing instruments.

https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/compliance-offset-programs/

ETS 37

Carbon Tax 38

Government Crediting mechanisms 29

104 Instruments Implemented

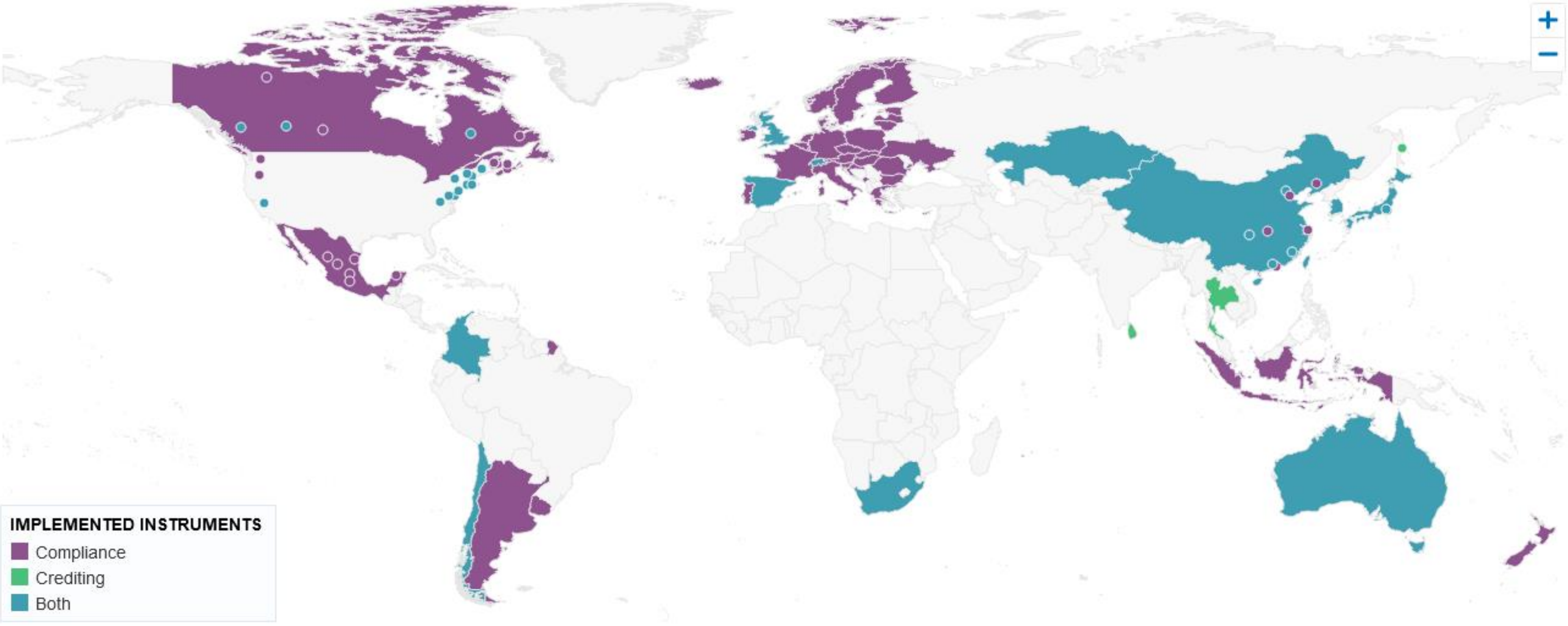
52 National Jurisdictions

42 Subnational Jurisdictions

Carbon pricing instruments around the world, 2023

Download

Map shows jurisdictions that have implemented Direct Carbon Pricing Instruments - Compliance instruments (Emissions Trading Systems (ETS) and Carbon taxes) and/or domestic carbon crediting mechanisms, subject to any filters applied. The year can be adjusted using the slider below the map.



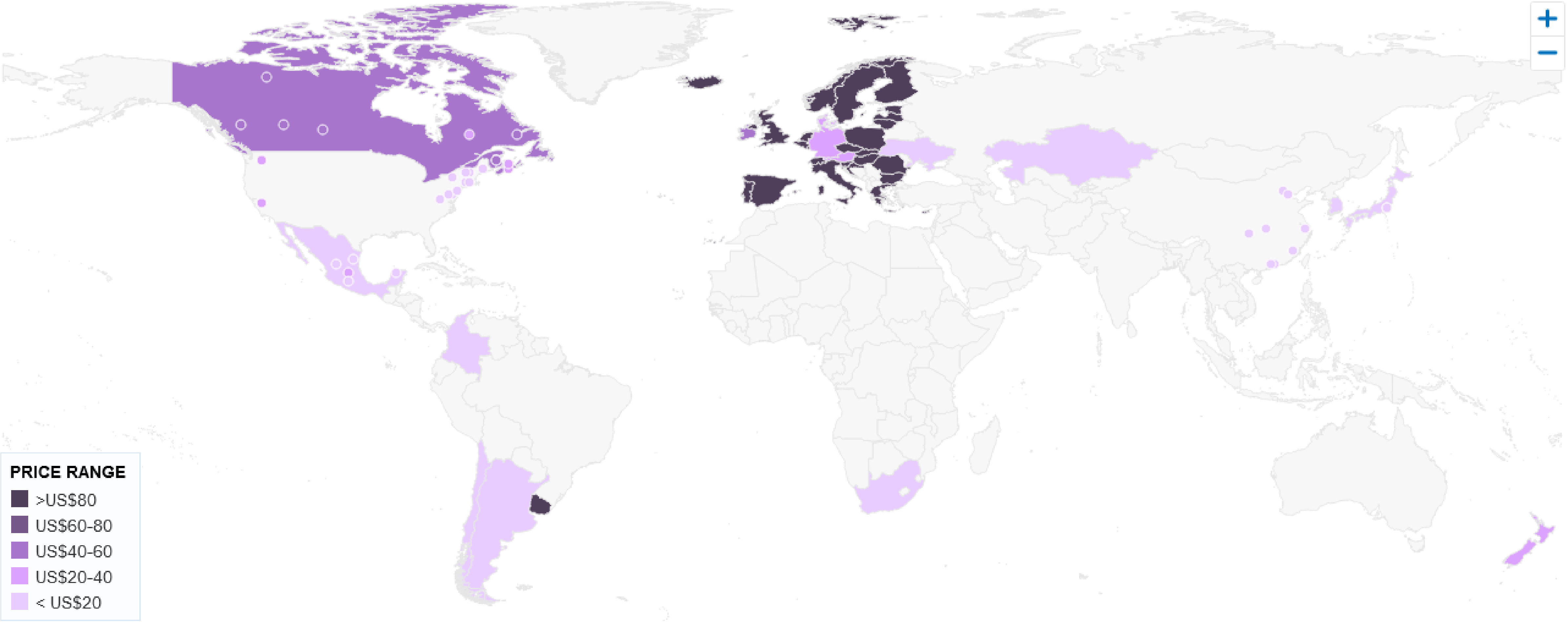
Instrument Type: Emissions Trading System, Carbon Tax, Crediting Mechanism

- https://carbonpricingdashboard.worldbank.org/

Carbon price

Price of carbon around the world, 2023

Heat map shows the level of the main price set by emissions trading sytems or Carbon taxes in each jurisdiction (US$/tCO2e), subject to any filters applied. The year can be adjusted using the slider below the map.



Voluntary markets

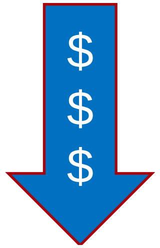
Carbon offset

- Voluntary carbon markets enable businesses, governments, nonprofit organizations, universities, municipalities, and individuals to offset their emissions **outside a regulatory regime**.
- These entities can purchase offsets that were created **either through the voluntary or compliance markets**.
- Trading and demand in the voluntary market are created only by voluntary buyers whereas, in a compliance market, demand is created by a regulatory mandate.
- Because voluntary offset credits cannot be used in compliance markets, they tend to be **cheaper**.

- https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/voluntary-offset-programs/

Example: Voluntary Program

- The **Science Based Target initiative**, a global body focused on enabling businesses to set ambitious emissions reductions goals in line with the latest climate science, has approved these targets:
  - In the near-term, REI has committed to reducing the absolute scope 1, 2 and 3 greenhouse gas (GHG) emissions 47% by 2030 from a 2019 base year, while further committing 41% of suppliers by emissions will have science-based targets by 2025.
  - In the long-term, REI has committed to reduce absolute scopes 1, 2, and 3 GHG emissions 90% by 2050 from a 2019 base year.
  - Overall, REI has committed to **reach net-zero GHG emissions across its value chain by 2050.**



- https://www.rei.com/

Key quality assurance concerns

- All offset programs include some form of **administrative body** to oversee the **project approval process** to ensure that the offset projects developed meet established **program requirements**. Although there are common components of the project approval process, programs have developed varied approaches **to key quality assurance concerns**.
  - **Validation requirements** provide ex-ante assessment and confirmation of offset project eligibility as defined by the rules of the program.
  - **Verification requirements** provide ex-post assessments and confirmation of quantification of the volume of emission reductions or removals that have been produced from an offset project across a certain period of time.
  - **Registries** are used to reduce concerns regarding double counting by tracking information regarding ownership of the offset projects and the credits generated.
  - **Third-party auditors** are required by most programs to help limit any potential conflict of interest between offset project developers and buyers, which both have financial incentives for inflating the volume of offset credits generated.

Example programs

Note, these are not standards but a programs!

- The **Verified Carbon** Standard is a full-fledged carbon offset program developed and run by the non-profit Verra. It focuses on GHG reduction attributes only and does not require projects to have additional environmental or social benefits. The VCS is broadly supported by the carbon offset industry (project developers, large offset buyers, verifiers, and projects consultants) and is active globally.
- The **Gold** Standard **(GS)** is a voluntary carbon offset program focused on progressing the United Nation's Sustainable Development Goals (SDGs) and ensuring that project's benefit their neighboring communities. The GS can be applied to voluntary offset projects and to Clean Development Mechanism (CDM) projects. It was developed under the leadership of the World Wildlife Fund (WWF), HELIO International, and SouthSouthNorth, with a focus on offset projects that provide lasting social, economic, and environmental benefits.

Example programs

- **Plan Vivo** is an Offset Project Standard for forestry, agricultural, and other land-use projects with a focus on promoting sustainable development and improving rural livelihoods and ecosystem services. Plan Vivo projects work closely with rural smallholders and communities and the standard emphasizes participatory design, ongoing stakeholder consultation, the use of native species, and biodiversity enhancement within a variety of payment for ecosystem service schemes – including carbon sequestration and emissions reductions.
- The **Climate Action Reserve** was launched in 2008. It is a USA based voluntary offsets program whose projects are implemented within North America. The Climate Action Reserve (CAR) establishes standards for quantifying and verifying GHG emissions reduction projects, provides oversight to independent third-party verification bodies, and issues and tracks carbon credits, called Climate Reserve Tonnes (CRTs).
- The **American Carbon Registry** (ACR) was founded in 1996 as the GHG Registry, the first private voluntary GHG registry in the USA, by the environmental non-profit organization Environmental Resources Trust (ERT).

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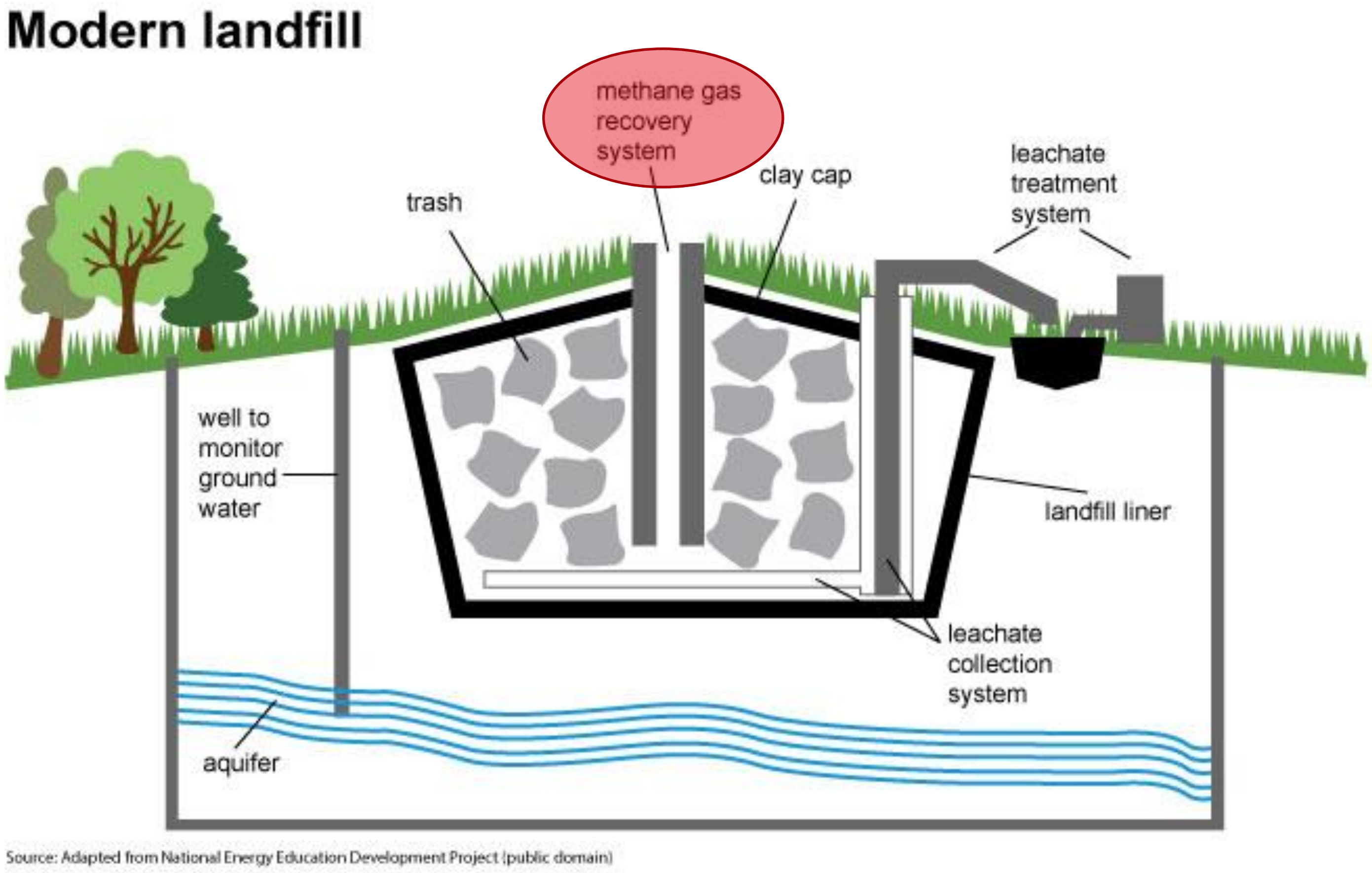
Basic criteria for an offset project

- **Additionality**: Would the project have happened anyways?



Example landfill:
If the site had anyway planned / or was obliged to implement methane recovery, this cannot count as an additional measure.

Basic criteria

- **Additionality**: Would the project have happened anyways?
- **Permanence**: How will the project be maintained?

Example reforestation: How is it ensured that trees grow long enough to actually sequester carbon?

Basic criteria

- **Additionality**: Would the project have happened anyways?
- **Permanence**: How will the project be maintained?
- **Baseline**: How will success of the project be measured?

Example clean cookstove implementation:
What were emissions without the new cookstove versus the new emissions?

Basic criteria

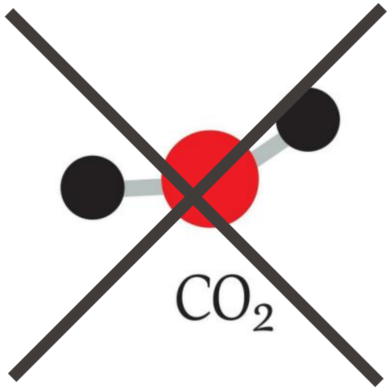
- **Additionality**: Would the project have happened anyways?
- **Permanence**: How will the project be maintained?
- **Baseline**: How will success of the project be measured?
- **Social/environmental impacts**: Does the project help the host community?

Example solar panels: Does the implementation benefit everyone?

Offset strategies and sectors

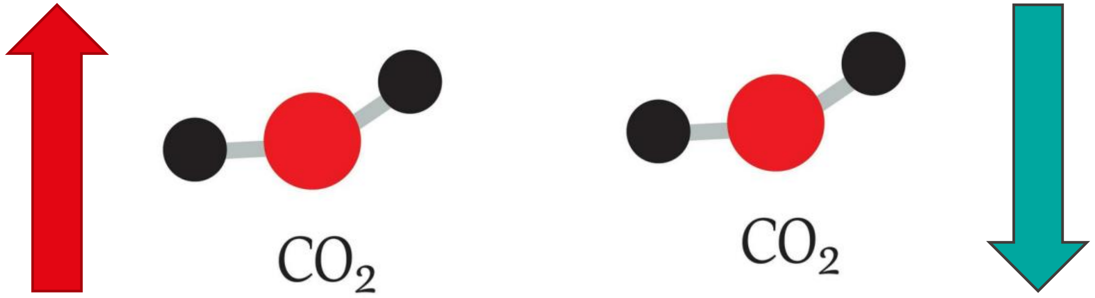
- There are two strategies that work with different sectors.

Avoidance



CO_2 is not released.

Removal



CO_2 is released AND removed.

Because CO_2 is globally distributed, emission and avoidance or removal can happen anywhere across the world.

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Avoidance

- These projects **prevent carbon emissions** that would have been released into the atmosphere. It can be divided into 4 categories:
  1. **Renewable Energy**
     e.g., renewable power infrastructures that contribute to the decarbonization of the local energy grid.
  2. **Energy Efficiency and Fuel Switching**
     e.g., energy-saving measures that reduce carbon emissions and replace fossil fuels with sustainable energy sources.
  3. **Household Devices**
     e.g., efficient cookstoves that significantly reduce wood consumption. Or individual biogas digesters that provide sustainable fuel to local communities, prevent deforestation, and avoid GHG emissions.
  4. **Water Management**
     e.g., projects that supply clean water to households in rural communities, remove the need to boil water, and reduce GHG emissions.

Removal

- These projects **reduce carbon emissions** by absorbing them from the atmosphere. It can be divided into 3 categories:

1. **Agriculture**
   e.g., agricultural practices that store carbon in soils while restoring biodiversity and developing new sources of income for smallholders.
2. **Forestry and Land Use**
   e.g., projects that protect and restore existing forest areas threatened by deforestation.
3. **Waste Management**
   e.g., landfill projects designed to capture the methane released by waste disposal, which can turn it into clean fuel.

Isn't it wonderful?

- Strong emitters are regulated in mandatory carbon credit systems.
- The rest of the world can get ahead of time and engage in voluntary carbon reduction.
- We'll be at net-zero in no time!

To good to be true

- Voluntary carbon offsets have grown into a multi-billion-dollar industry.
- Many companies take advantage of voluntary carbon offsets, and more than a few claim this makes them climate neutral.
- The skyrocketing demand for cheap offsets incentivizes project developers to scale up projects with increasing speed.

- https://ethz.ch/en/news-and-events/eth-news/news/2023/07/blog-voluntary-carbon-offsets-often-fail-to-deliver-what-they-promise.html

Reasons for failure

1. **Additionality**
   - The most prominent reason why carbon projects fail is that they are not additional, meaning that the project does not contribute to achieving additional climate benefits - compared to if the project had not existed.
2. **There are significant risks to forests**
   - There are significant risks to forests after a project ends, as any carbon sequestered is likely to be released back into the atmosphere. This risk can manifest in several different ways, from natural disasters to illegal logging - especially in countries with unstable political situations.
3. **Unreliable baseline inflate emissions promises**
   - A common issue seen in many projects is artificially inflating baseline emissions in order to generate more carbon credits for the project, thus taking credit for what the project did not do.
4. **Carbon credits cause community conflicts**
   - In some cases, in order to establish projects that generate carbon credits, landowners (such as governments) may forcefully evict people living on the project area territory.
5. **Emission reductions rely on vague predictions**
   - Credits promising that emission reductions will materialise in future are often referred to as 'ex-ante credits’.

- https://www.euronews.com/green/2023/01/10/the-five-biggest-reasons-carbon-offsetting-schemes-can-fail

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Reasons for failure

~90% of voluntary projects fail

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Your key questions to assess the trustworthyness of a carbon offset project

- Is the project certified?
- Is it proven that the project has taken place?
- Is the emission removal/avoidance measurable against a credible baseline?
- Does additionality apply?
- Has the emission removal/avoidance been assured by an independent third party?
- Has the carbon credit only been attributed once?
- Are the carbon credits permanent?
- Does the offset project have co-benefits?
- Is the carbon credit pricing transparent?