Global Warming Potential (GWP)

How does releasing a certain mass of a greenhouse gas other than CO₂ compares to releasing of the same mass of CO₂ over the same timeframe?

GWP: The RF of a unit mass of the greenhouse gas integrated over a 100 year time period divided by the RF of a unit mass of CO₂ integrated over a 100 year period.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Atmospheric Lifetime</th>
<th>GWP (100 year frame)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>&gt; 100 years</td>
<td>1</td>
</tr>
<tr>
<td>CH₄</td>
<td>10 years</td>
<td>25</td>
</tr>
<tr>
<td>N₂O</td>
<td>100 years</td>
<td>300</td>
</tr>
<tr>
<td>Fluorocarbons</td>
<td>100 to 10,000 years</td>
<td>1500 to 15,000</td>
</tr>
</tbody>
</table>
\[ \text{CO}_2 \text{ Equivalency} \]

\[ \text{CO}_2 \text{ eq.mass} = (\text{Mass of gas}) \times (\text{GWP of gas}) \]

For example, since methane has a GWP of 25, emitting 1 ton of methane is equivalent to emitting 25 tons of \( \text{CO}_2 \).
<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Chemical Formula</th>
<th>Anthropogenic Sources</th>
<th>Atmospheric Lifetime (years)</th>
<th>GWP$^2$ (100 Year Time Horizon)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>CO$_2$</td>
<td>Fossil-fuel combustion, Land-use conversion, Cement Production</td>
<td>$\sim 100^1$</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>CH$_4$</td>
<td>Fossil fuels, Rice paddies, Waste dumps</td>
<td>$12^1$</td>
<td>25</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>N$_2$O</td>
<td>Fertilizer, Industrial processes, Combustion</td>
<td>$114^1$</td>
<td>298</td>
</tr>
<tr>
<td>Tropospheric Ozone</td>
<td>O$_3$</td>
<td>Fossil fuel combustion, Industrial emissions, Chemical solvents</td>
<td>hours-days</td>
<td>N.A.</td>
</tr>
<tr>
<td>CFC-12</td>
<td>CCl$_2$F$_2$</td>
<td>Liquid coolants, Foams</td>
<td>100</td>
<td>10,900</td>
</tr>
<tr>
<td>HCFC-22</td>
<td>CCl$_2$F$_2$</td>
<td>Refrigerants</td>
<td>12</td>
<td>1,810</td>
</tr>
<tr>
<td>Sulfur Hexafluoride</td>
<td>SF$_6$</td>
<td>Dielectric fluid</td>
<td>3,200</td>
<td>22,800</td>
</tr>
</tbody>
</table>

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Methane

• $GW_{CH_4} \approx 25$

• Much shorter resident time than $CO_2$

• $CH_4$ concentration is much less than that of $CO_2$

• $CH_4$ concentration is also increasing over time.

• As of July 2018 $CH_4$ concentration was about 1851 ppb (ppb = parts per billion)

• It accounts for about 20% of anthropogenic GHG.
Methane Concentration

Trends in global methane since 1983

NOAA Climate.gov
Data: ESRL

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Methane Concentration

Could the increase in concentration be related to oil and natural gas drilling?

• **During the extraction of natural gas through fracking 1-3% escapes to the atmosphere.**

• **Direct measurements at different altitudes in the atmosphere show that methane carrying Carbon-13 (i.e. from fossil fuels) is relatively rare.**

• **Fingerprint point towards agricultural and wetland emissions.**
Methane Time Bomb?

• Increased temperatures in the arctic is causing the permafrost to thaw.

• Permafrost in Alaska has warmed by about 1.5 °C.

• Thawing permafrost would release millions of tons of previously frozen dead animals and plants thus increasing activity from Methanogens (methane-producing bacteria).

• There is a small but non-zero chance that the rapid release of large amounts of methane could trigger extinction-level warming (runaway greenhouse effect).
Chlorofluorocarbons like CFC-12 have global warming potentials “GWP” that are more than ten thousand times that of $CO_2$; yet when it comes to Global Warming $CO_2$ is, overwhelmingly, the biggest culprit.

The statement above is (true or false, why)

a) TRUE because CFCs resident times are short.
b) FALSE. A larger GWP means a lesser effect on climate.
[c] TRUE because CFCs concentrations are very small.
d) FALSE. CFCs are the biggest culprit not $CO_2$
e) FALSE. Neither CFC-12 nor $CO_2$ is the biggest culprit.
Activity