Science Topic 10-11-24

CliSciPol

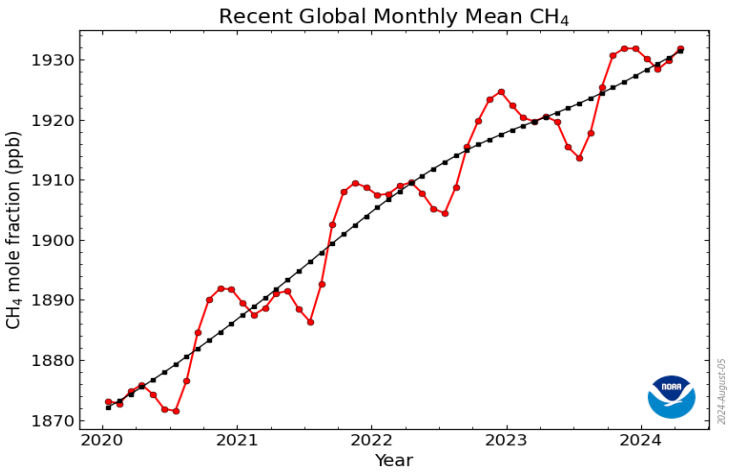
Climate Science and Policy for Nonscientists

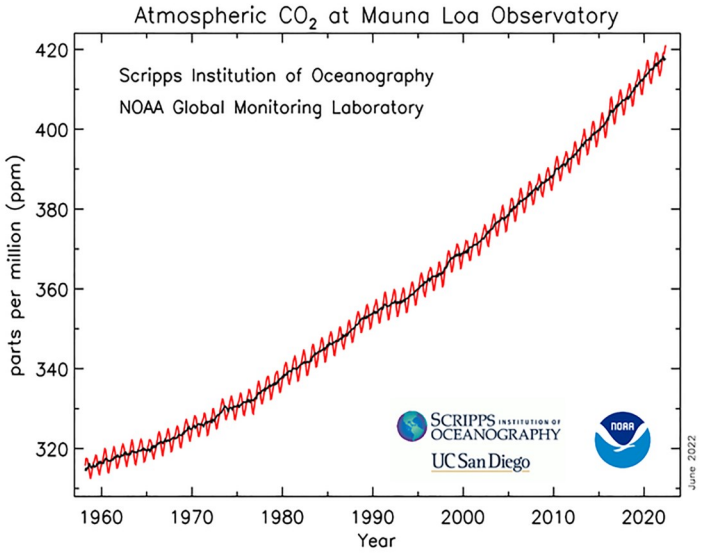
One picture is worth a thousand words.

METHANE FACTS

Methane (CH4) is a greenhouse gas that contributes to global warming by blocking heat energy from escaping the earth. But how much does it contribute? How significant is it in relation to the CO2 blocking effect?

The media commonly comments (correctly) that a CH4 molecule has about 30 times the greenhouse effect of a CO2 molecule. And a recent media article commented that CH4 by weight is 80 times more powerful than CO2. A CH4 molecule is much lighter than a CO2 molecule, and so a pound of CH4 contains many more molecules than a pound of CO2. But the important fact about CH4 (that is rarely mentioned in the media) is that its atmospheric concentration is today only about 1,932 parts per billion (ppb), or 1.932 parts per million (ppm), a microscopic number.



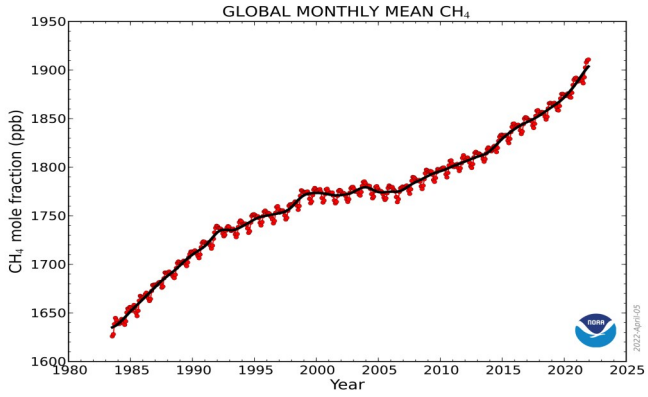


By contrast the CO2 atmospheric concentration today is about 420 ppm. Therefore CO2 molecules in the atmosphere are over 217 times more common than CH4 molecules, and the amount of CO2 in the atmosphere is exceedingly small. The CO2 atmospheric concentration of 420 ppm is less than one half of 1%, or less than 1 part in 2,000. Yet, according to the CO2 Control Knob Theory, changes in CO2 concentrations determine the changes in temperature for the entire earth. The CH4 concentration in the air is less than 1 part in 500,000.

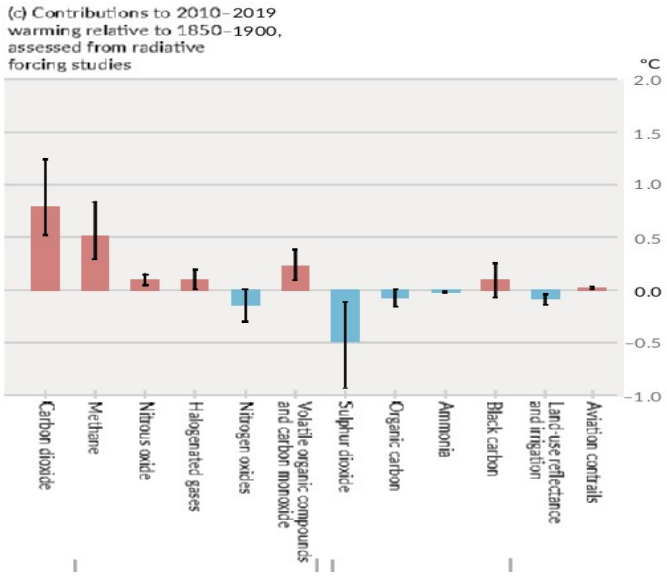
Scientists do not agree on the exact contribution of the various greenhouse gases to the total greenhouse effect. Water vapor and clouds (formed from drops of water or ice crystals) are the most important, if only because they appear in the air in such high concentrations, but the focus of this post is on the relative contribution of CH4 and CO2. The range of estimates is that, overall, the contribution of CH4 is roughly between one-quarter to one-half of the contribution of CO2.

What are the 3 Most Important Greenhouse Gases of All Types?

	Concentration in the Air (ppm)	% Total Effect
Water vapor/ Clouds	**10,000-40,000**	**70-95%**
Carbon Dioxide (CO2)	**420**	**4-20%**
Methane (CH4)	**<2**	**1-10%**



The technical term for a substance's contribution to the greenhouse effect is "Effective Radiative Forcing" or "ERF." The IPCC in AR6 has estimated the relative contribution of CH4 and CO2 for three time periods, and, as shown in this graph, the CO2 ERF is many times more than the CH4 ERF. (AR6 p.713).



The CH4 atmospheric concentration has been growing, but not as rapidly as the growth of the CO2 concentration, as admitted by the IPCC in AR6 (2021) at p.713. Thus the relative contribution of CH4 in relation to CO2 is decreasing.

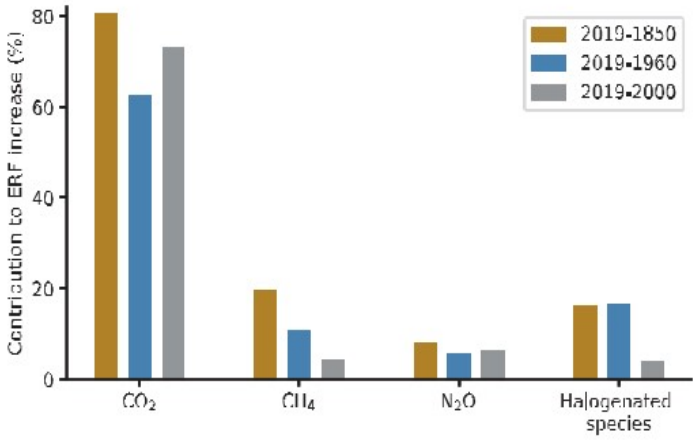


Figure 5.18 | Contributions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halogenated species to the total effective radiative forcing (ERF) increases in 2019 since 1850, 1960 and 2000, respectively.

Another graph, in the AR6 Summary for Policymakers, estimates that the CH4 contribution to warming 2010-2019 compared to 1850-1900 has been about 40% less than the CO2 contribution. (AR6 p.7).

The various models used by the IPCC looking ahead to 2081-2100 show CO2 contributing more than twice the warming effect of all the other greenhouse gases combined, which include CH4, the nitrogen oxides, and ozone. (AR6 p.13). Note that the graph shows relative contributions only of "anthropogenic emissions," and so it does not include water vapor and clouds.

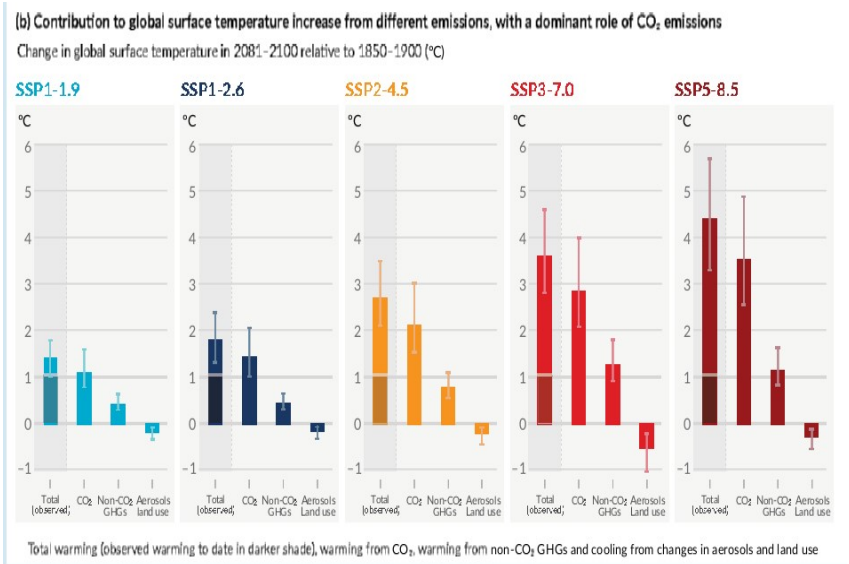
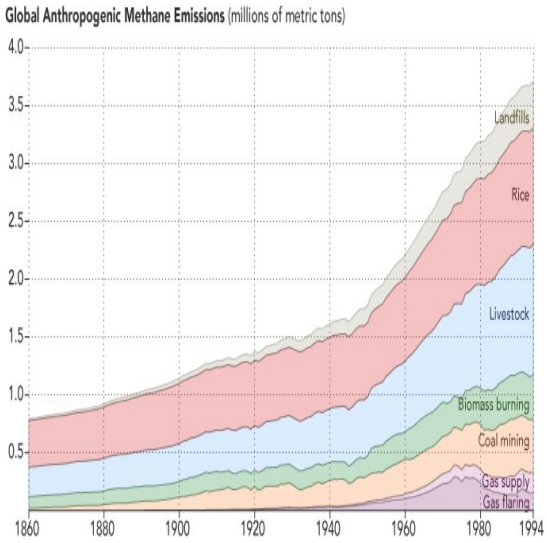
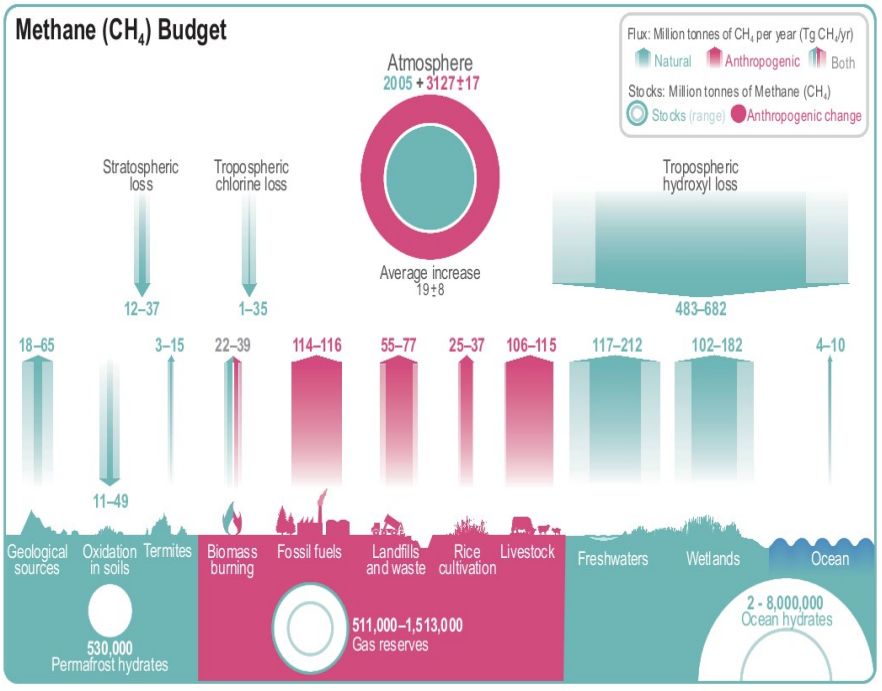


Figure SPM.4 | Future anthropogenic emissions of key drivers of climate change and warming contributions by groups of drivers for the five illustrative scenarios used in this report

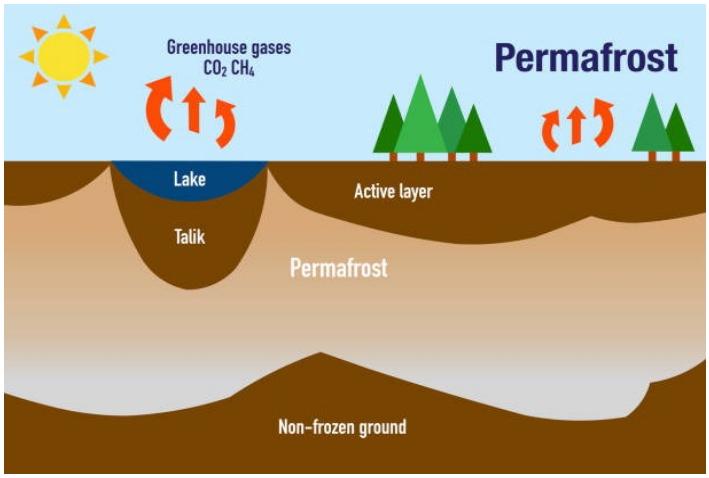


There are many sources of CH4 in the atmosphere. The image suggest the relative importance of a number of sources, but there is no agreement on the exact percentages for the various sources in various years, particularly for the present.

The IPCC in AR6 p.705 presents this Methane Budget for the period 2008-2017. The image demonstrates the numerous anthropogenic and natural sources of CH4 in the atmosphere, and the natural processes that remove CH4 from the atmosphere. The IPCC admits that "large uncertainties" make it "challenging to quantify accurately the methane budget and ascribe reasons for the growth over 1980-2019." (AR6 p.706)



For example, the IPCC mentions one study concluding that 30% of total CH4 emissions come from fossil fuel exploitation, but other studies suggest "up to 20% only." (AR6 p.705). The IPCC adds that further research is needed to clarify the role of freshwaters and wetlands, which are natural CH4 sources shown in the image with large numbers and with large uncertainty. (AR6 p.705).



The media regularly warns about CH4 being released as the Arctic tundra permafrost melts. But the IPCC observes that: (1) the evidence as to whether CH4 emissions from the northern permafrost region contribute to the global methane budget is "mixed." (AR6 p.726). (2) there is low confidence on the timing, magnitude, and linearity of the permafrost climate feedback owing to the wide range of published estimates. (AR6. P.728). (3) there is "large uncertainty" in the release of greenhouse gasses from permafrost in the 21st century. (AR6 p.740)

Both CO2 and CH4 are subject to the Saturation Effect as their atmospheric concentrations increase. As shown, the infrared (IR) blocking effect (the Greenhouse Effect) of CO2 becomes smaller and smaller as CO2 concentrations rise above the present level of 420 ppm. The CH4 effect shows a similar reduction. The word "saturation" is used, because the situation is similar to that of a sponge - a dry sponge rapidly absorbs liquid, but the more saturated a sponge becomes, the less it can absorb further liquid.

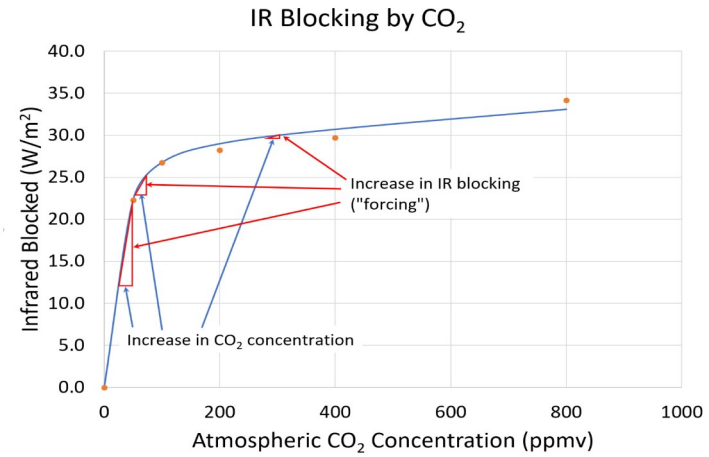
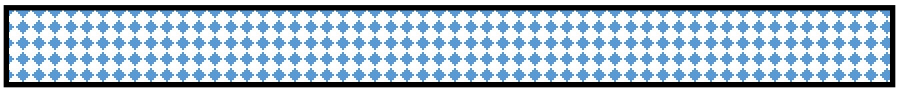


Figure 6: IR blocking for CO_2 concentrations from 0 to 800 ppmv. Given an increase in the CO_2 concentration, the effect decreases as the amount of atmospheric CO_2 increases.

CONCLUSION

Methane is a greenhouse gas, and, as the CH4 concentration increases in the atmosphere, it does contribute to global warming. But presently the CH4 concentration in the air is less than 2 ppm, which is less than one part in 500,000. The contribution of burning or drilling or mining for fossil fuels to the Methane Budget: (1) has not been reliably determined, (2) may well be less than 20% of all the various CH4 sources, and (3) is smaller than the natural contributions from freshwaters and wetlands. Overall the CH4 contribution to global warming is: (1) relatively small, (2) significantly smaller than the contribution of CO2, and (3) much smaller than is regularly suggested in the media.



Work Cited

Intergovernmental Panel on Climate Change Assessment Report 6, Working Group I, The Physi cal Science Basis (2021) (AR6 WGI).