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Air pollution and climate
The unexpected testimony of methane.

For years, it has been known that air pollution can affect the climate. The slow rate at which global warming started in the second half of the 20th century has been attributed to the shielding role played by aerosols emitted by industry: a fraction of the solar radiation was reflected back to space. The shielding effect is one way to modulate warming. Another is to modulate the atmospheric concentration of greenhouse gases.

The atmospheric concentration of methane increased unusually sharply in 2020. This is all the more surprising that 2020 was marked by reduced human activity on Earth due to the lockdown measures put in place to limit the spread of covid-19.

Detailed analysis of global measurements of atmospheric methane[1] shows that human emissions are not responsible for this exceptional methane growth rate. One of its causes is directly related to the warming. In wetlands, lakes, etc., the temperature increase causes an increased activity of microorganisms responsible for the fermentation of organic matter. In the absence of oxygen, this fermentation produces methane. Natural production of methane has intensified in the northern hemisphere due to the high temperatures in 2020. Note that this excess methane was not emitted from permafrost, which is feared to release methane in the event of a major melting. It is the wetlands of the northern hemisphere that have given rise to this increased natural methane emission. This observation reveals a detrimental "positive feedback" of warming: warming intensifies natural methane emissions.

Increased emissions alone do not account for the excess atmospheric methane. Reduced methane removal from the atmosphere has to also be considered.

The way methane is removed from the atmosphere is through the action of a very reactive molecular structure, the OH radical, which oxidizes methane to CO_2. Anything that affects the concentration of OH radicals affects the lifetime of methane in the atmosphere. This is the case of carbon monoxide CO, which is also removed from the atmosphere via oxidation to CO_2 by the OH radical. A significant presence of CO in the atmosphere therefore has the effect of reducing the absorption of methane by its natural sink. But observations have shown that this is not the cause of the excess growth in atmospheric methane in 2020. The dominant cause, besides the increase of natural emissions, is the lessening of oxidizing substances that are precursors of OH radicals.

Nitrogen oxides, noted NOx, are among the precursors of OH radicals along with tropospheric ozone of which NOx is also a precursor. These compounds are pollutants produced in particular by ground or air transport combustion engines. The lockdown measures imposed for health reasons

1 Peng, S., Lin, X., Thompson, R.L. *et al.* Wetland emission and atmospheric sink changes explain methane growth in 2020. *Nature* **612**, 477–482 (2022). https://doi.org/10.1038/s41586-022-05447-w

in 2020 have greatly reduced these transports. As a result, the NOx and ozone concentrations in the troposphere were significantly reduced, leading to lower OH radical production. The observed methane excess is due to both an excess of natural emissions and a deficit of removal.

Methane is a powerful greenhouse gas, responsible for a third of the warming since the beginning of the industrial era. Its global warming power (GWP) is, for equal masses, 28 times that of CO_2 over 100 years. But in the present situation where it is urgent to reduce the greenhouse effect, we must consider a shorter time frame. Over 20 years, its GWP is 82 times that of CO_2. Efforts to reduce man-made methane emissions will have to take into account both the effects of warming on natural emissions from wetlands and future emissions of nitrogen oxides. In order to reconcile pollution control and the fight against global warming, particular care must be taken in reducing methane emissions. Massive methane leaks can be prevented[2].

2 https://www.sauvonsleclimat.org/en/document-database/newsbrief-massive-methane-leaks-that-must-be-prevented