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Degradation Dynamics of Greenhouse Gases

The Large Washing Machine

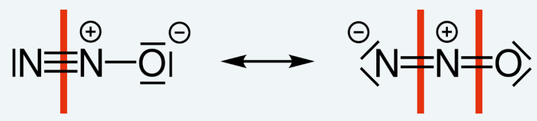
Nitrous oxide (N_2O) and methane (CH_4) encounter various chemical and physical degradation mechanisms in the atmosphere. Methane is primarily oxidized by OH radicals, while nitrous oxide is broken down by the process of photolysis. Together, these processes are referred to by climate researchers as the “washing machine” of the atmosphere (Houghton).

Ehhalt, D. H. 1974

$CH4 + 4OH + O2$
$= \ldots$
$= 4H2O + CO2$

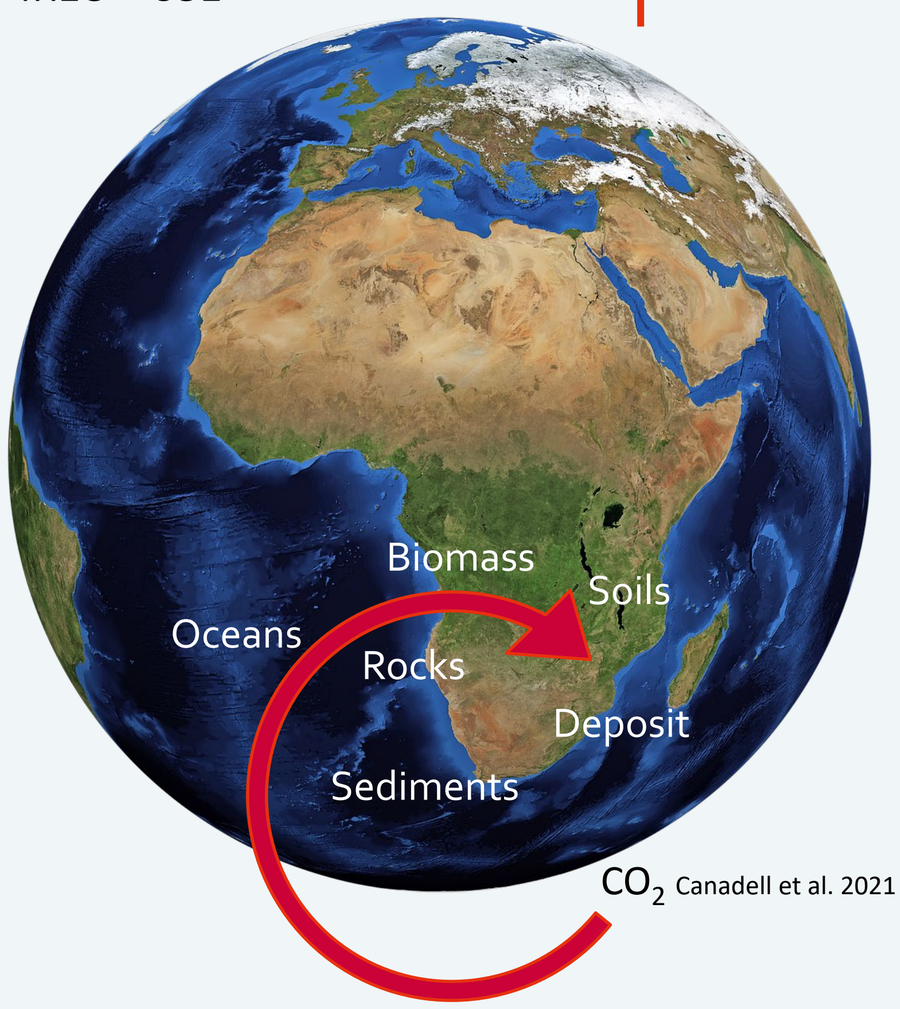
Groth, W. and Schierholz, H. 1959

Electromagnetic radiation



The Carbon Cycle

Carbon dioxide (CO_2) is a part of the Earth's carbon cycle. Carbon can exist statically in rocks or in fossil deposits. Carbon is more dynamically present in organic soils, plants or other chemical compounds. All components can be connected and exchanged over long periods of time. CO_2 cannot be decomposed in the atmosphere, but must return to a terrestrial reservoir.

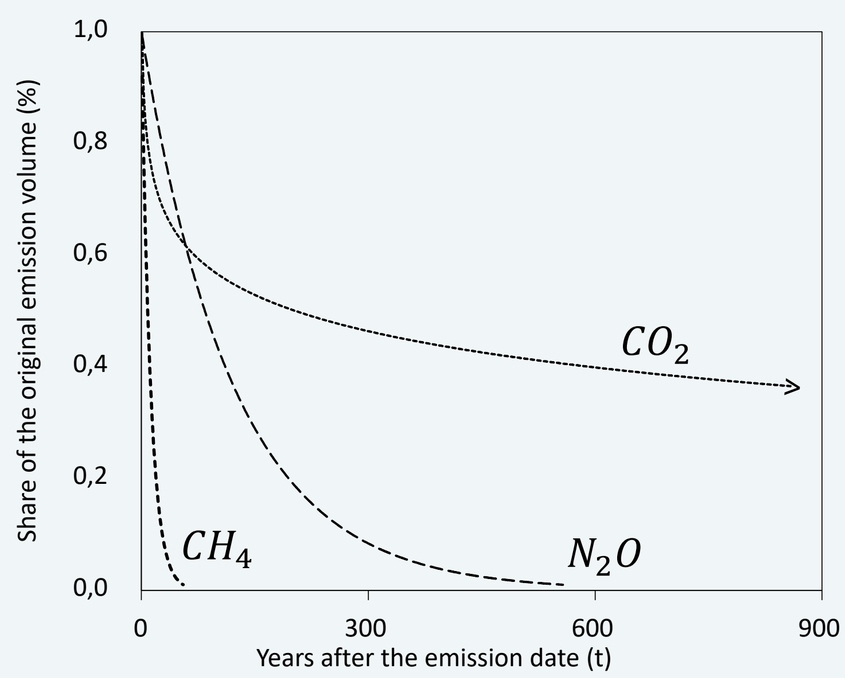


Canadell et al. 2021

Speed and Completeness of degredation

The atmosphere's washing machine works reliably and completely breaks down an emission volume (a pulse) of CH_4 in approximately 55 years and a pulse of N_2O in 550 years. Emissions above the atmosphere's potential do lead to an increase in concentrations in the air, but once emissions decrease, they are largely broken down again.

Tragically, the Earth's carbon cycle is extremely slow. In the first 100 years after release, there is a significant reduction in the effective amount. However, this then decreases more and more and comes to a standstill after around 1,000 years with a residual amount between ¼ and ⅓. This residual amount contributes to the aggregation of the effects and can only be removed over periods of time that correspond to the scale of Earth's age.



CH_4 and N_2O are degraded according to $N(t)=N0 \cdot e^{-\lambda t}$, whereby the mean lifetime of the greenhouse gases according to IPCC AR6 (N_2O=121.0, CH_4 = 11.8) is used for t. For CO_2, the function $(Nt)=N0 \cdot -0.0936\ln(t)+1$ was approximated using the Bern Simple Climate Model (BernSCM) according to the Bern3D-LPJ model (Strassmann K.M. and Joos F. 2018).

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