Alina Schulz
M.Sc. Biodiversity and Ecology
alina.schulz@stud.uni-greifswald.de

Frederice Hilgendorf
M.Sc. Biodiversity and Ecology
frederice.hilgendorf@stud.uni-greifswald.de

Important Greenhouse Gases:

Sinks and Sources and their Dynamics

UNIVERSITÄT GREIFSWALD
Wissen lockt. Seit 1456

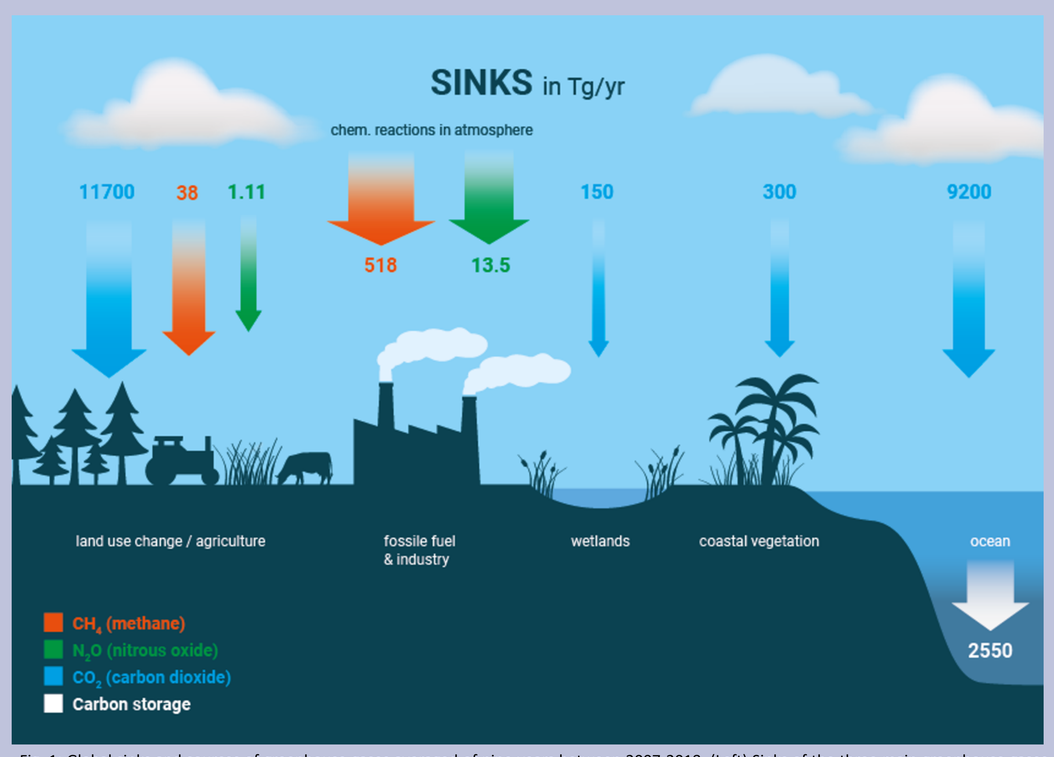
Primer!

Greenhouse gases (GHG) trap heat energy in the atmosphere and have therefore major impact on our climate, but which are the most important ones?

CO_2 CH_4 N_2O

1. So where do they come from and where do they go?
2. Are there any factors which influence the dynamics of these sinks and sources?
3. And what can we do about it?

1.



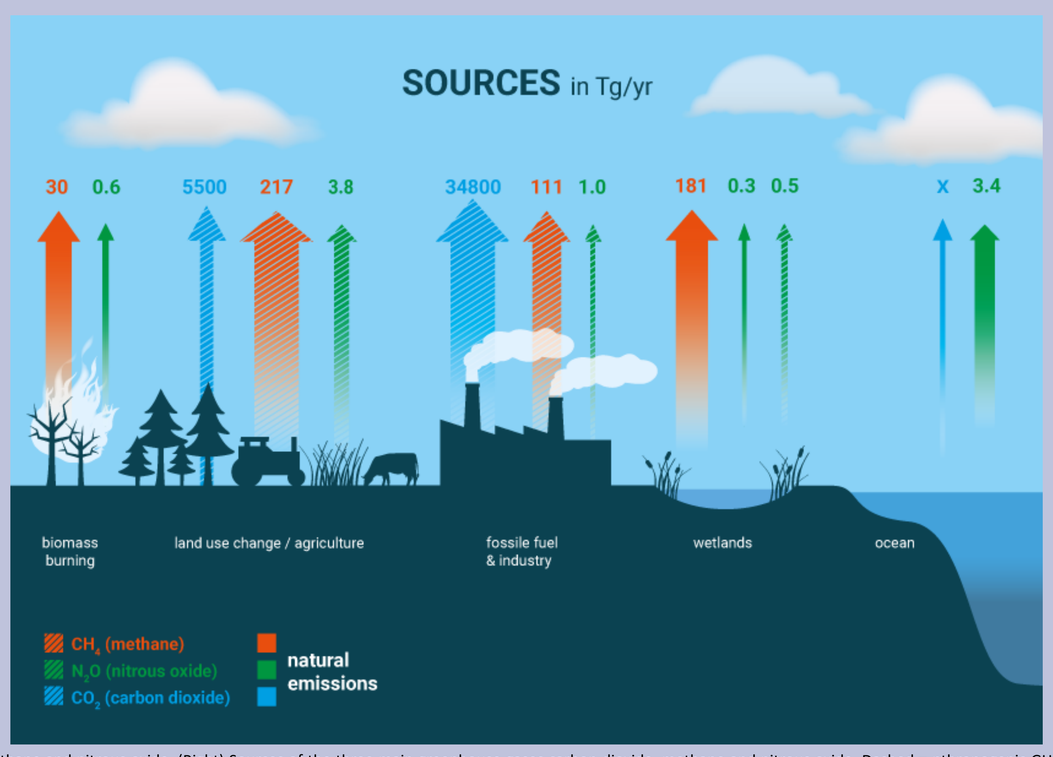


Fig. 1: Global sinks and sources of greenhouse gases averaged of nine years between 2007-2018. (Left) Sinks of the three main greenhouse gases carbon dioxide, methane and nitrous oxide. (Right) Sources of the three main greenhouse gases carbon dioxide, methane and nitrous oxide. Dashed = nthropogenic GHG emissions; Tg/yr = Teragram per year (1 Tg = 1 Mio. Tonnes) [The data reproduced from the Global Carbon Atlas]

2.

Ocean Warming[2, 7, 8, 11]

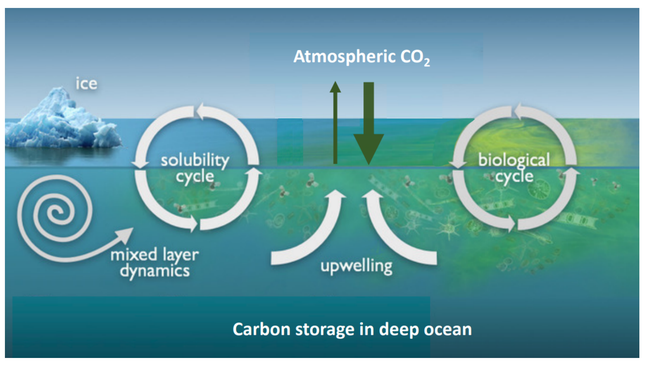


Fig.2: Patterns of Atmosphere - Ocean CO_2 exchange. The Ocean absorbs CO_2 through solubility and biological processes, which is stored ultimately in the deep ocean for decades or centuries. Upwelling and current circulations bring the stored carbon back to the surface [Adapted from 8].

The ocean acts as a buffer:

- The more CO_2 is released to the atmosphere, the more CO_2 is absorbed by the ocean
- ¼ of anthropogenic GHG emissions are absorbed by the ocean
- More than 90% of excess heat as a result of increased GHG concentrations is absorbed by the ocean since the 1970s

Increasing GHG concentrations and increasing temperatures influence negatively the efficiency of the ocean sink by:

- Increasing stratification which might lead to CO_2 saturation at the water surface
- Increasing significantly the amount of CO_2, which is released back to the atmosphere
- Increasing Acidification
- Deoxygenation
- Increasing Sea Level

} Negative effects on marine ecosystem

→ Ocean buffer capacity might decrease around 34% until 2100

Deforestation[4, 6]

Fig. 3: Deforestation [3].

Primary effects:

- Increased carbon emissions from deforestation
- Fires associated with deforestation emits CH_4 and small amounts of N_2O

Amplifier effects:

- Increasing atmospheric CO_2 due to the reduced sink capacity owing to the shorter residence time of C – pools in the newly established pastured or cropland

→ responsible for an extra 61 ppm of the atmospheric CO_2 by the end of the century

The largest GHG emission will result from deforestation in tropical Africa, Asia and Latin America.

→ The carbon emission from tropical deforestation may release between 85-130 pg Carbon by 2100

Indirect effects:

CH_4 – Methane:

- Half of the global emission of CH_4 result either direct and indirect from deforestation (47%)

Subsequent use of the land:

- Cattle production (22%)
- Paddy rice (15%)
- Biomass burning (10%)

N_2O – Nitrous Oxide:

- In the years following the fire → Fertilized pastures
- Agriculture (75%)
- Fire affects the chemical form of nitrogen in soils and favours a different kind of microbial activity (nitrification)

3.

Some Management Ideas

Politics[9, 12, 13]

- Kyoto Protocol (1997): First agreement to reduce emissions (especially CO_2) for developed countries in certain periods (2008-2012 / 2013-2020).
- Paris Agreement (2015): Agreement to limit global warming below 1.5 degrees Celsius by reducing greenhouse gas emissions
- G7 Summit (2021): Nature compact including climate neutrality until 2050, tackling deforestation and conservation and protection of 30% of global land and ocean until 2030.

Society[11]

- Ecosia search engine: Donates part of its profit for reforestation programs
- Environmental Footprint: Calculating its own footprint to reduce GHG emissions → WWF CO_2- Calculator
- Reduce GHG emissions by: Eating less meat / buying regional food / less travelling by plane / saving energy

Sources

1. Canadell, J. et al. (2007): “Saturation of the Terrestrial Carbon Sink”, Terrestrial Ecosystems in a Changing World. Springer-Verlag, Berlin Heidelberg, Chapter 6
2. Capotondi, A., Alexander, M.A., Bond, N.A., Curchitser, E.N, Scott, J.D. (2012). „Enhanced upper ocean stratification with climate change in the CMIP3 models“. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 117, C04031.
3. Dudley, N., Kettunen, M. (2021) „Diminishing the EU’s deforestation footprint: The where and the how”, Institue for European Environmental Policy. Accessed on 19.06.2021 from https://ieep.eu/news/diminishing-the-eu-s-deforestation-footprint-the-where-and-the-how
4. Harris, N.L. et al. (2012): “Baseline Map of Carbon Emissions from Deforestation in Tropical Regions”, Science, **336**: 1573-1576
5. Hughton, R. A. (2005): Chapter 1. “Tropical deforestation as a source of greenhouse gas emissions, Tropical Deforestation and Climate Change” p. 13-21
6. Jones, C. M. (2013): “The unaccounted yet abundant nitrous oxide – reducing microbial community: a potential nitrous oxide sink”, ISME J 7, 417-426
7. Laffoley, D. & Baxter, J. M. (editors). 2016. Explaining ocean warming: Causes, scale, effects and consequences. Full report. Gland, Switzerland: IUCN. 456 pp.
8. PMEL Carbon Group. Accessed on 15.06.2021 from https://www.pmel.noaa.gov/co2/story/Ocean+Carbon+Uptake
9. United Nations Framework Conventions on Climate Change: “The Paris Agreement”. Accessed on 19.06.2021 from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
10. United Nations Framework Conventions on Climate Change: “The Kyoto Protocol”. Accessed on 19.06.2021 from https://unfccc.int/kyoto_protocol
11. United Nations Framework Conventions on Climate Change: “Tips to Reduce Your Emissions”. Accessed on 20.06.2021 from https://unfccc.int/climate-action/climate-neutral-now/reduce-your-emissions/tips-to-reduce-your-emissions
12. Watson, A. J. et al (2020) Revised estimates of ocean-atmosphere CO2 flux are consistent with ocean carbon inventory, Nature Communications.
13. G7 2030 Nature compact. Accessed on 19.06.2021 from https://www.g7uk.org/wp-content/uploads/2021/06/G7-2030-Nature-Compact-PDF-120KB-4-pages-2.pdf
14. Global Carbon Atlas. Accessed on 20.06.2021 from www.globalcarbonatlas.org