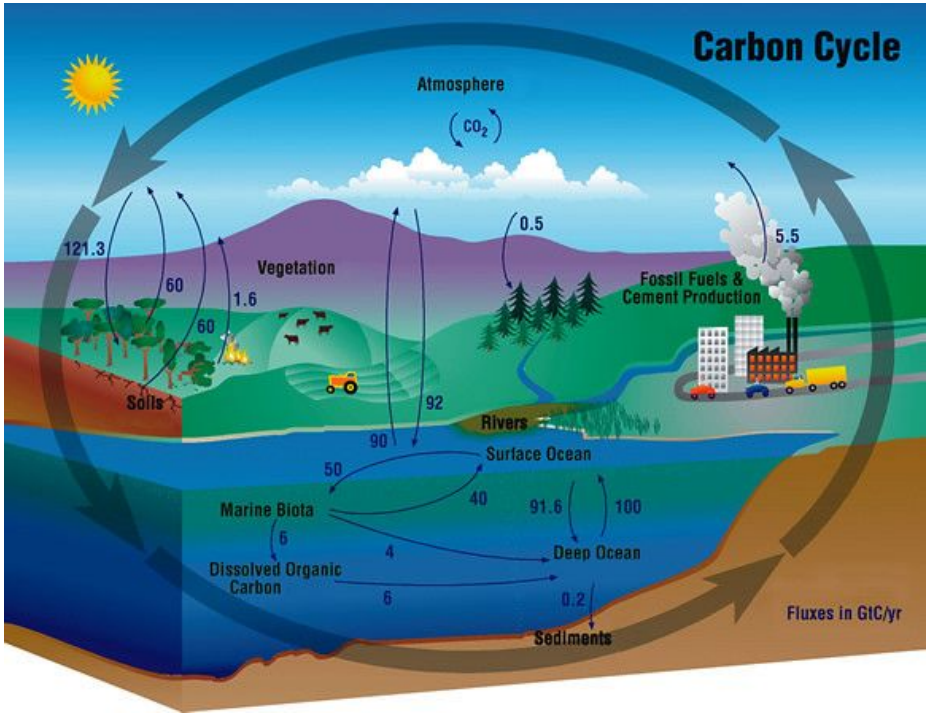
Carbon Cycle & the Greenhouse Effect

Sloane Garelick

Earth's Carbon Cycle

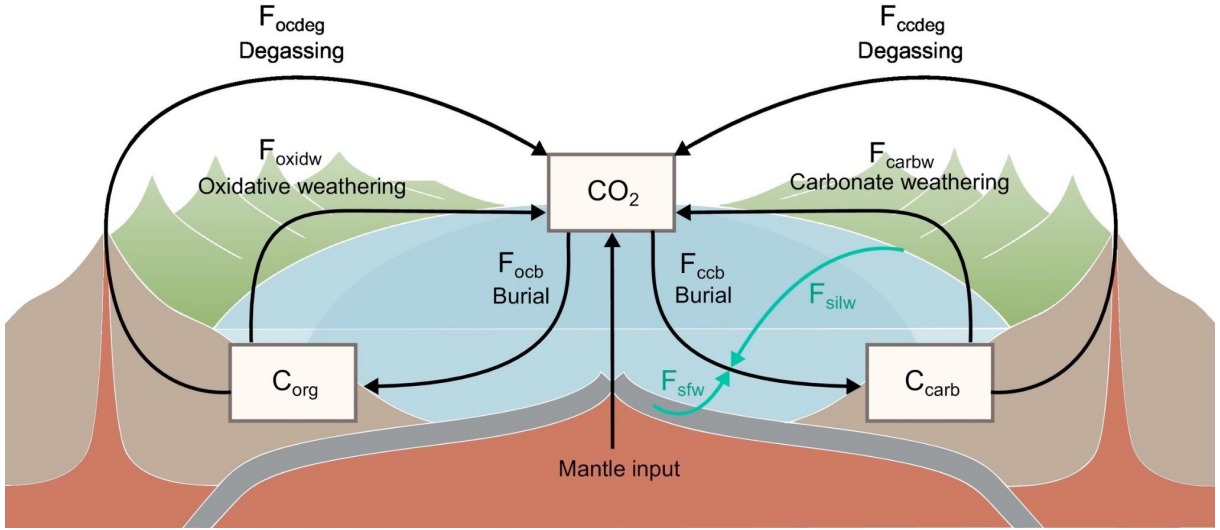


(Atmospheric Infrared Sounder, CC BY 2.0)

Carbon in different forms is cycled through reservoirs via various processes:

- *Biosphere*
- *Atmosphere*
- *Soil*
- *Ocean*

Long-Term Carbon Cycle

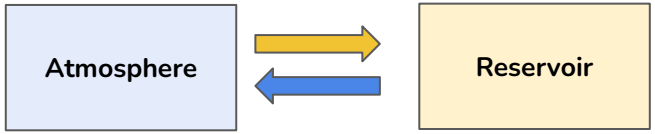


(Millis et al., CC BY-SA 4.0)

On even longer timescales, tectonics play a role in carbon cycling and atmospheric CO_2 concentration:

- **Sources**: degassing from volcanic emissions and spreading centers
- **Sinks**: silicate rock weathering and carbon burial

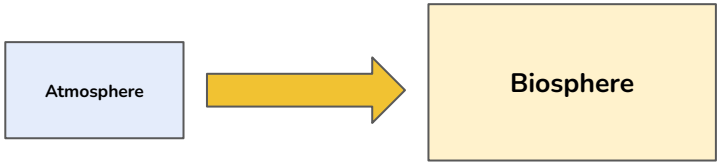
Carbon Cycle Fluxes



Changes in fluxes between reservoirs can cause an imbalanced cycle and affect Earth's climate

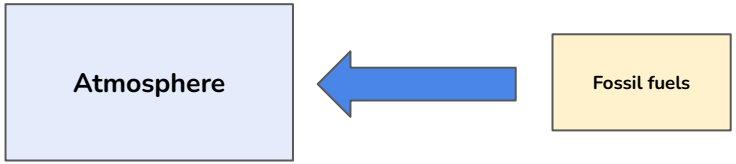
Increased vegetation growth

(increased photosynthesis removes more CO_2 from the atmosphere)

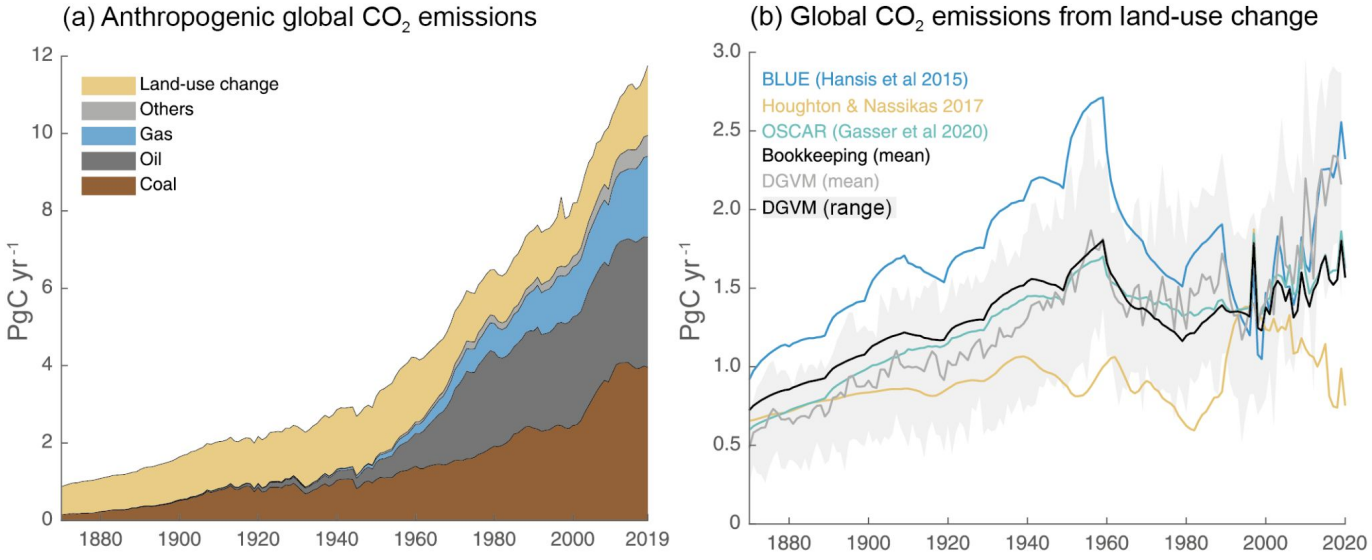


Anthropogenic emissions

(increased fossil fuel burning releases more CO_2 into the atmosphere)



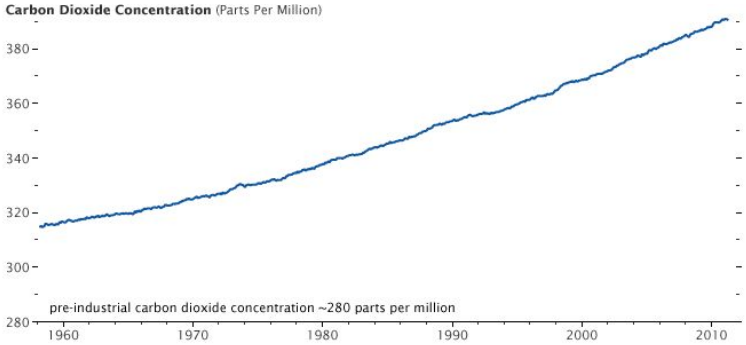
Anthropogenic Greenhouse Gas Emissions

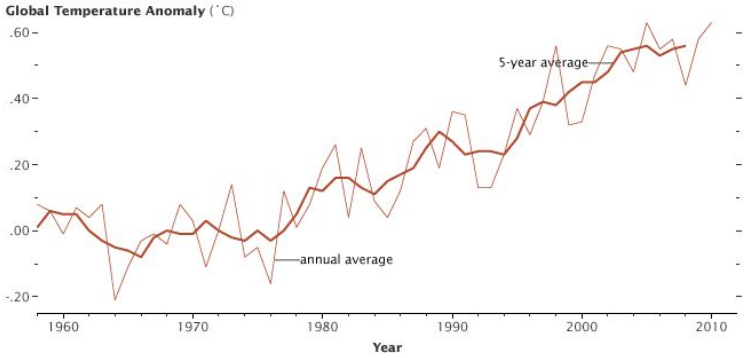


(Figure 5.5 in IPCC, 2021: Chapter 5. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Canadell, J.G, et al.)

Figure 5.5 | Global anthropogenic CO_2 emissions. (a) Historical trends of anthropogenic CO_2 emissions (fossil fuels and net land-use change, including land management, called LULUCF flux in the main text) for the period 1870 to 2019, with 'others' representing flaring, emissions from carbonates during cement manufacture. Data sources: (Boden et al., 2017; IEA, 2017; Andrew, 2018; BP, 2018; Le Quéré et al., 2018a; Friedlingstein et al., 2020). (b) The net land-use change CO_2 flux (PgC yr^{-1}) as estimated by three bookkeeping models and 16 Dynamic Global Vegetation Models (DGVMs) for the global annual carbon budget 2019 (Friedlingstein et al., 2020). The three bookkeeping models are from Hansis et al., 2015; Houghton and Nassikas, 2017; Gasser et al., 2020 and are all updated to 2019. Their average is used to determine the net land-use change flux in the annual global carbon budget (black line). The DGVM estimates are the result of differencing a simulation with and without land-use changes run under observed historical climate and CO_2, following the Trendy v9 protocol (https://sites.exeter.ac.uk/trendy/protocol/); they are used to provide an uncertainty range to the bookkeeping estimates (Friedlingstein et al., 2020). All estimates are unsmoothed annual data. Estimates differ in process comprehensiveness of the models and in definition of flux components included in the net land use change flux. Further details on data sources and processing are available in the chapter data table (Table 5.SM.6).

Tutorial 7: Other Computational Tools in Xarray





(Bvelevski, CC BY-SA 4.0)

- These graphs highlight the impact of anthropogenic CO_2 on global temperature
- The global temperature anomaly graph contains the annual average and 5-year average of the data, which helps to visualize long-term trends
- In this tutorial, we will learn how to use running averages and other computation tools in Xarray to interpret climate data