REPORT · SCAFFOLD REFERENCE REPORTS · 18 AUGUST 2026

The Mauna Loa CO_2 record as a reference dataset

How a sixty-year atmospheric series is published, versioned and cited — and what environmental-economic accounts can borrow from it

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Centre for Sustainable Development Reform
Analysis and production

Version 1.0

This report is the scaffold's long-form demonstration: a `type: report` document with a cover page, a contents page and running headers in its PDF. It re-uses the atmospheric CO_2 analysis cells built for the Mauna Loa reference analysis, but frames them the way an institutional report would — background, data and methods, results, implications — so that every part of the report template that only matters at length (section hierarchy, pagination, cross-references across pages, print furniture) is exercised against real data.

KEY MESSAGES

- Atmospheric CO_2 at Mauna Loa reached 429.12 ppm in July 2026; the 2025 annual mean of 427.35 ppm is 111.4 ppm above the first full year of the record (1959).
- The record is a model of how a long-lived dataset should be published: stable files, explicit provenance, a documented method, and a citation request from the publisher.
- Environmental-economic accounts that cite an atmospheric baseline should carry the same lineage — file, version, publisher — next to the number, which is what the scaffold's data-bundle contract does.

CONTENTS

ABOUT THIS REPORT

RECOMMENDED CITATION

CSDR Platform Team (2026). The Mauna Loa CO_2 record as a reference dataset: How a sixty-year atmospheric series is published, versioned and cited – and what environmental-economic accounts can borrow from it (v1.0). Centre for Sustainable Development Reform. https://test.csdr.global/reports/mauna-loa-reference-2026/

CHANGELOG

- **v1.0** (2026-08-18) – First release, built from the NOAA GML files dated 5 August 2026.

1 Summary

Monthly mean, July 2026
429.12 ppm
NOAA GML, Mauna Loa

Annual mean, 2025
427.35 ppm
↑ +111.4 ppm since 1959

Growth rate, 2025
2.23 ppm/yr
± 0.11
Annual mean increase

2 Background

2.1 The measurement programme

The Mauna Loa series is the longest continuous direct record of atmospheric CO_2, begun by Charles David Keeling in March 1958 (Keeling et al., 1976) and continued by NOAA since 1974 (Thoning et al., 1989). The current files are published by NOAA's Global Monitoring Laboratory (Lan et al., 2026). Its longevity is the point: a measurement that has been made the same way, at the same place, for more than sixty years, with every change of instrument or procedure documented.

2.2 Why an accounting scaffold cares

For SEEA (System of Environmental-Economic Accounting)-style work the value of a series like this is not any single number but its lineage. An account that cites an atmospheric baseline needs to know which file, which version and which publisher's citation applies (United Nations et al., 2021). This report follows the data from NOAA's files, through a versioned bundle, to the figures below.

3 Data and methods

3.1 The bundle

The values on this page are read at build time from the `noaa-mlo-co2` bundle described under Data: monthly means, annual means and annual growth rates, with NOAA's flags for interpolated months carried through. Nothing in the text is typed by hand — change the bundle, rebuild, and the numbers update.

> **How the numbers on this page are produced**
> Rows are loaded from the bundle's Parquet and CSV files by build-time loaders (`data/loaders`); derived quantities (annual means, decadal growth, the last five seasonal cycles) are computed in one memoised analysis cell; each chart is rendered to SVG at build with a data table and CSV/SVG downloads. The PDF and the HTML export are produced from the same build.

3.2 Treatment of gaps

> **Reading the record**
> Measurements from Mauna Loa Observatory were suspended after the November 2022 eruption and resumed in July 2023; December 2022 – early July 2023 values come from Maunakea, about 21 miles north. Interpolated months in the NOAA files carry negative standard deviation and uncertainty flags, and are excluded from the monthly series used here.

4 Results

4.1 The long-term trend

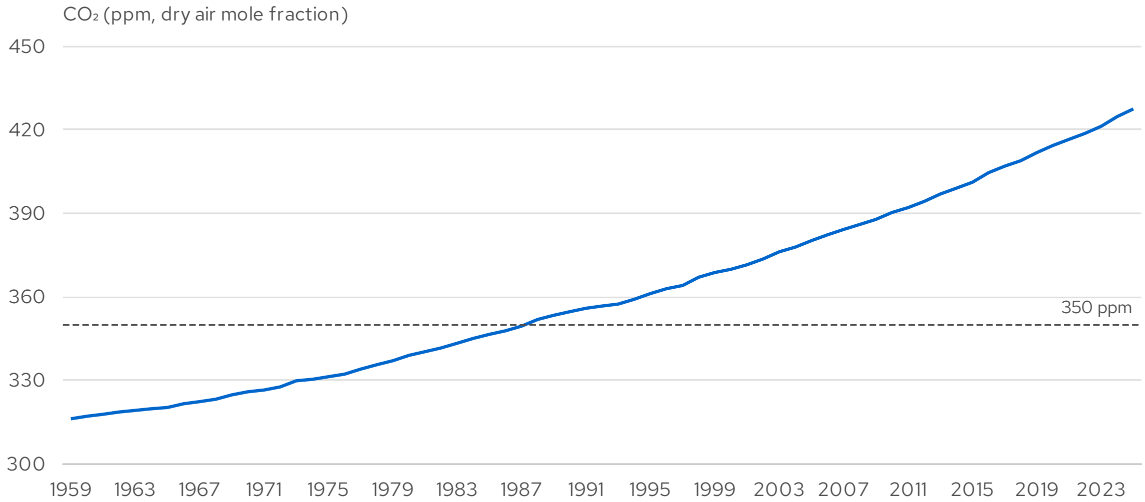

Figure 1. Annual mean atmospheric CO_2 at Mauna Loa Observatory, dry-air mole fraction.
Source: NOAA GML (Lan, Tans & Thoning, 2026); Scripps Institution of Oceanography for 1958–1974.

Figure 1 shows the annual mean since 1959. The curve is not a straight line: the increment added each year has grown from under one part per million in the early 1960s to two-to-three parts per million in most recent years (Figure 2).

4.2 The rate of increase

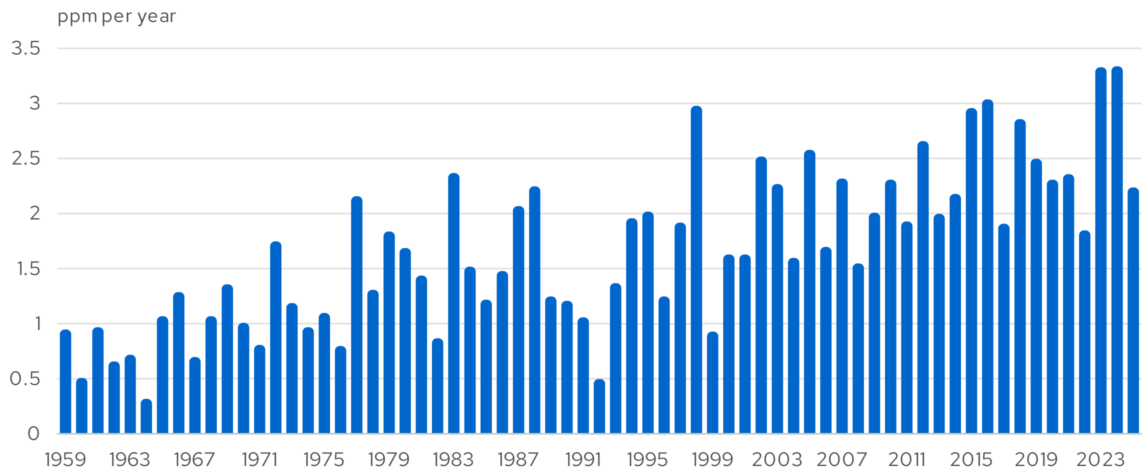

Figure 2. Annual increase in atmospheric CO_2 at Mauna Loa (difference between successive annual means).
Source: NOAA GML.

Decadal averages make the acceleration plain (Figure 3, Table 1): about 0.86 ppm per year in the 1960s against about 2.42 ppm per year in the 2010s.[1]

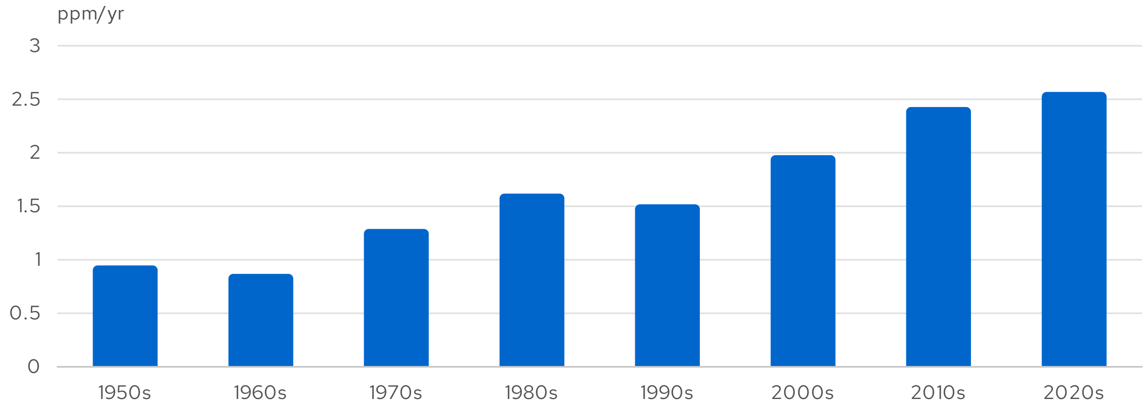

Figure 3. Mean annual increase by decade. The final, partial decade is shown for completeness.
Source: NOAA GML; CSDR calculation.

Table 1. The last ten annual means and their year-on-year increases. (ppm)

Year	Annual mean (ppm)	Increase on previous year (ppm)
2016	404.41	3.03
2017	406.76	1.90
2018	408.72	2.85
2019	411.65	2.49
2020	414.21	2.30
2021	416.41	2.35
2022	418.53	1.84
2023	421.08	3.32
2024	424.61	3.33
2025	427.35	2.23

Source: NOAA GML.

4.3 The seasonal cycle

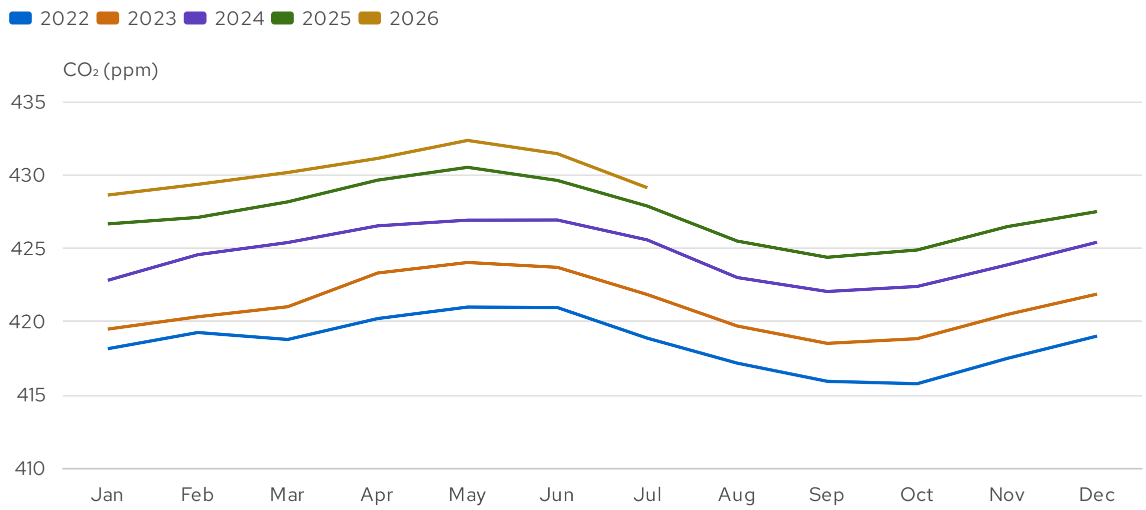

Figure 4. Monthly mean CO_2 for each of the last five years. An interactive version is online.
Source: NOAA GML.

Within each year, CO_2 at Mauna Loa peaks in May and reaches its minimum in September or October (Figure 4), as Northern-Hemisphere plants draw down carbon through the growing season and release it in autumn and winter. The amplitude is a few parts per million – small against the trend, but a useful reminder that a single month's reading is not a year's mean.

5 Implications for accounts

Three practices transfer directly from the NOAA record to accounting work. First, publish the file, not just the figure: a reader must be able to reach the rows a number came from. Second, version the release and say what changed — NOAA's files carry creation dates and the bundle carries a changelog. Third, ask to be cited in a specific form, and make that form easy to copy; the citation block at the end of this report does the same for the report itself. Physical-science context for the trend is given by the IPCC's Sixth Assessment Report (IPCC, 2021).

6 Data

DATA BUNDLE · NOAA-MLO-CO2 · V2026.08

Atmospheric CO_2 at Mauna Loa Observatory (NOAA GML)

- co2_mm_mlo.csv CSV · 39 KB — Monthly mean CO_2 at Mauna Loa (ppm), March 1958 – present; interpolated months flagged by negative sdev/unc
- co2_mm_mlo.parquet PARQUET · 21 KB — Same monthly series as Parquet (columns: year, month, decimal_date, average, deseasonalized, ndays, sdev, unc)
- co2_annmean_mlo.csv CSV · 3 KB — Annual mean CO_2 (ppm) with uncertainty, 1959 – present
- co2_gr_mlo.csv CSV · 3 KB — Annual mean growth rate (ppm/yr) with uncertainty, 1959 – present

Licence: Public domain (US Government work) — NOAA GML asks for citation · Provenance: Downloaded from https://gml.noaa.gov/ccgg/trends/data.html on 2026-08-17 (file creation 2026-08-05); unmodified except a Parquet copy of the monthly file with the "decimal date" column renamed decimal_date. · Updated 2026-08-05

Cite as: Lan, X., Tans, P. and K.W. Thoning: Trends in globally-averaged CO2 determined from NOAA Global Monitoring Laboratory measurements. https://doi.org/10.15138/9N0H-ZH07 (accessed 2026-08-17). Keeling, C.D. et al. (Scripps Institution of Oceanography) for 1958–1974 data.

7 References

IPCC. (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou, Eds.). Cambridge University Press. https://doi.org/10.1017/9781009157896

Keeling, C. D., Bacastow, R. B., Bainbridge, A. E., Ekdahl, C. A., Guenther, P. R., Waterman, L. S., & Chin, J. F. S. (1976). Atmospheric carbon dioxide variations at Mauna Loa Observatory, Hawaii. *Tellus*, *28*(6), 538–551. https://doi.org/10.3402/tellusa.v28i6.11322

Lan, X., Tans, P., & Thoning, K. W. (2026). *Trends in globally-averaged CO2 determined from NOAA Global Monitoring Laboratory measurements*. NOAA Global Monitoring Laboratory. https://doi.org/10.15138/9N0H-ZH07

Thoning, K. W., Tans, P. P., & Komhyr, W. D. (1989). Atmospheric carbon dioxide at Mauna Loa Observatory: 2. Analysis of the NOAA GMCC data, 1974–1985. *Journal of Geophysical Research: Atmospheres*, *94*(D6), 8549–8565. https://doi.org/10.1029/JD094iD06p08549

United Nations, European Commission, FAO, IMF, OECD, & World Bank. (2021). *System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA)* [Techreport]. United Nations.

FOOTNOTES

1. The annual increase for a year is the difference between that year's mean and the previous year's, as published in NOAA's `co2_gr_mlo.csv`; NOAA's uncertainty on each annual increment is about 0.1 ppm.