

Global Warming: Velocity and Acceleration of Change in Cumulative CO₂ Emissions

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Abstract

This publication introduces two parameters related to cumulative CO₂ emissions. The first parameter is “*Velocity of Change in Cumulative CO₂ Emissions*”, VCCO₂. This parameter represents an average annual change in cumulative CO₂ emissions and is expressed in ton of CO₂ per year.

The second parameter is “*Acceleration of Change in Cumulative CO₂ Emissions*”, ACCO₂, and is expressed in ton of CO₂ per year, per year (tCCO₂/y²).

These two parameters are in addition to the parameter “*Global Warming Rate*”, GWR [°C/y], and “*Global Warming Acceleration*”, GWA [°C/y²], described in the previous publication.

The velocity of change in cumulative CO₂ emissions, VCCO₂, is +35.33 GtCCO₂/y in the last 11 years, the acceleration of change in cumulative CO₂ emissions, ACCO₂, is +0.559 GtCCO₂/y² in the last 31 years, and the minimum increase of ACCO₂, is +1.2%/y.

Glossary

ACCO ₂	Acceleration of change in cumulative CO ₂ emissions, parameter “a” in linear trendline: $dCO_2(y) = (y-n) * a + b$, average change in cumulative CO ₂ emissions per year in the trendline period, tCO ₂ /y ² (ton CO ₂ per year per year)
Ave	average
CCO ₂	Global cumulative CO ₂ emissions according to publication [1] [2], CO ₂ emissions produced from fossil fuels and cement production only – land use change is not included
CO ₂	emissions of Carbon Dioxide, CO ₂
dCO ₂	Change in global cumulative CO ₂ emissions (CCO ₂), tCO ₂ /y (ton CO ₂ per year)
GtCO ₂	Giga-ton of CO ₂ , 10 ⁹ ton, 10 ^{^9} ton, 1,000,000,000 ton of CO ₂
GWA	Global Warming Acceleration, yearly change in the global warming rate, °C/y ² [3]
GWR	Global Warming Rate – average change in global surface temperature per year in the trendline period, °C/y [3]
mAve	moving average
OWID	Our World in Data – Internet site [1] [2]
Ref	reference
tCO ₂	ton CO ₂
TL	trendline
VCCO ₂	Velocity of change in cumulative CO ₂ emissions, tCO ₂ /y

Database of Global Cumulative Amount of CO2

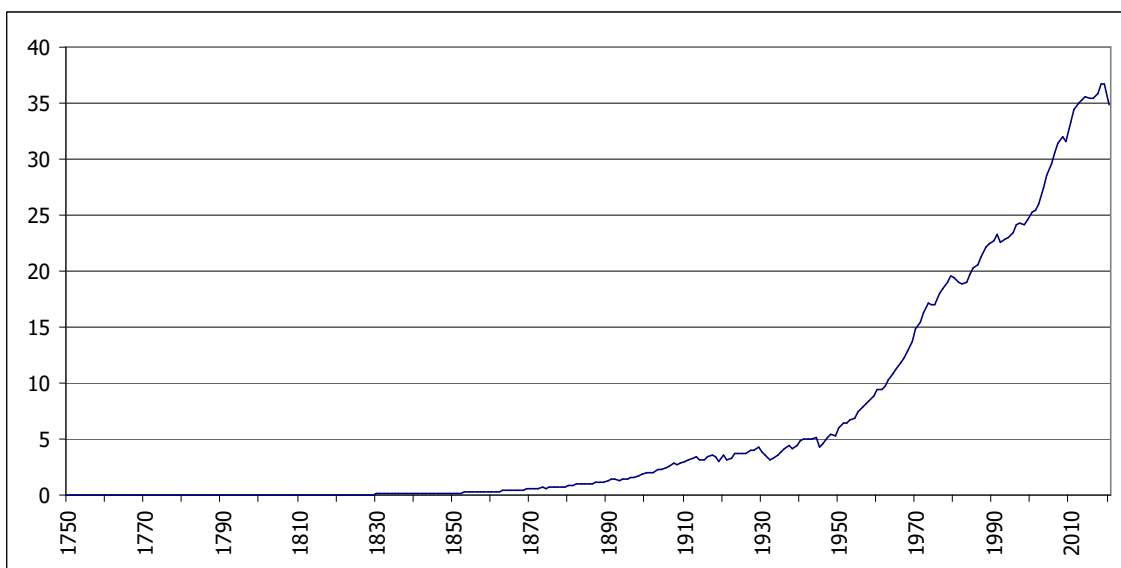
Table 1 - Database of global cumulative amount of CO2

Source of Data	OWID
Reference	[1] [2]
Baseline year	1749
From year	1750
To year	2020
Period, years	271
CO2 from fossil fuels	Yes
CO2 from cement production	Yes
CO2 from other sources	No
Other GHG	No
Land use change	No
Units	ton CO2
Resolution	1 ton CO2/y

The database is from publication [1] [2], CO2 emissions produced from fossil fuels and cement production only – land use change is not included.

Change in Cumulative Amount of CO2

Chart 1 - Annual change in the cumulative amount of CO2 [GtCO2/y]

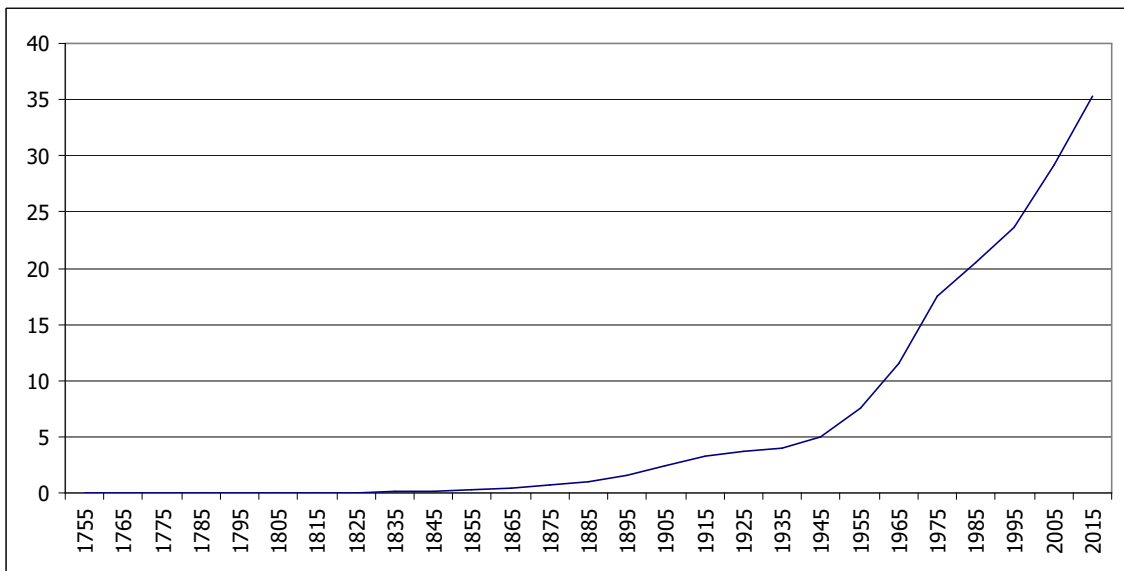


The change in 2019 was +36.70 GtCO2/y and in 2020 +34.81 GtCO2/y.

Velocity of Change in Cumulative CO2 Emissions

The velocity of change is determined in this version as 11 years average of annual changes in cumulative CO2 emissions.

Chart 2 - Velocity of change in the cumulative amount of CO2 [GtCO2/y]

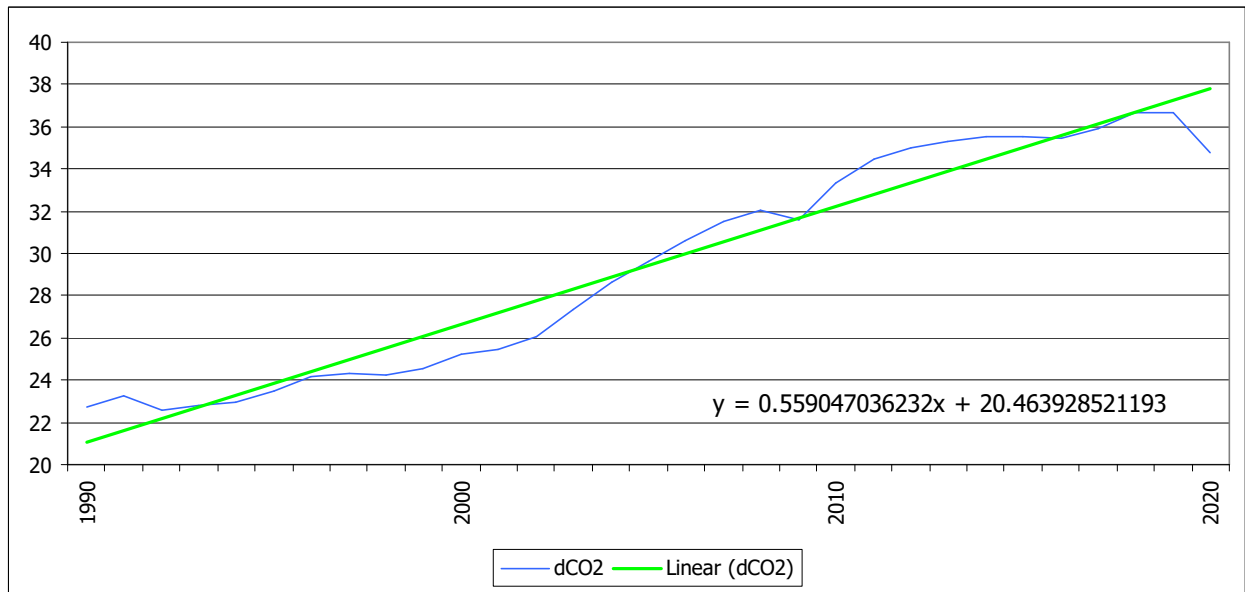


Period Applied for Calculations of Trendlines

The period applied in this work for calculations of trendlines is 31 years. The starting points of the trendlines are every 10 years from 1750.

Following is an example of a trendline in the period 1990-2020, trendline ID=TL25.

Chart 3 - Annual change in cumulative CO2 emissions in period 1990-2020, TL25
[GtCO2/y]



The trendline formula for this period (TL25) is:

$$y = 0.559047036232x + 20.463928521193$$

$$a = 0.559047036232$$

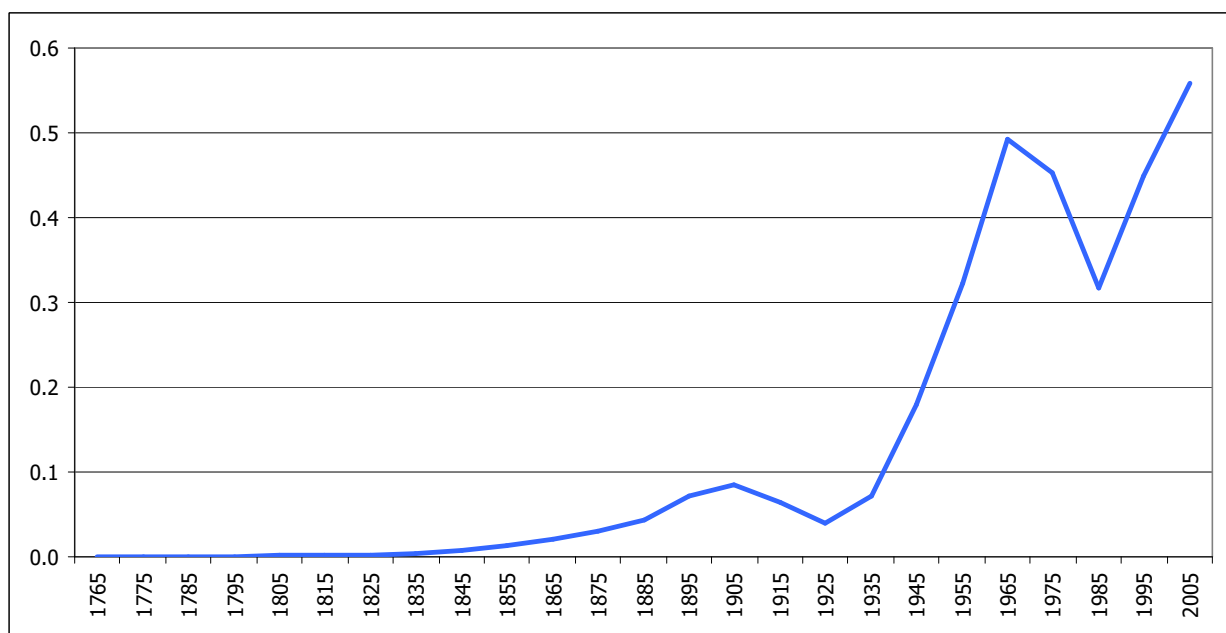
$$b = 20.463928521193$$

The average acceleration of the change in cumulative CO2 emissions in the period 1990-2020 is 0.559 GtCO2/y² (=a), which is the slope of the linear trendline in this period (1990-2020).

Table 2 - Acceleration of change in cumulative CO2 emissions

Trendline period		Trendline	Acceleration	Change
from	to	Center	of change	Δ/y
year	year	CenterTL	a	%/y
year	year	year	GtCO2/y ²	%/y
1750	1780	1765	0.0002	
1760	1790	1775	0.0003	4.1%
1770	1800	1785	0.0005	4.6%
1780	1810	1795	0.0008	7.1%
1790	1820	1805	0.0011	3.7%
1800	1830	1815	0.0014	3.5%
1810	1840	1825	0.0026	8.1%
1820	1850	1835	0.0046	7.7%
1830	1860	1845	0.0079	7.2%
1840	1870	1855	0.0138	7.5%
1850	1880	1865	0.0207	4.9%
1860	1890	1875	0.0304	4.7%
1870	1900	1885	0.0431	4.2%
1880	1910	1895	0.0715	6.6%
1890	1920	1905	0.0840	1.8%
1900	1930	1915	0.0636	-2.4%
1910	1940	1925	0.0400	-3.7%
1920	1950	1935	0.0711	7.8%
1930	1960	1945	0.1790	15.2%
1940	1970	1955	0.3220	8.0%
1950	1980	1965	0.4917	5.3%
1960	1990	1975	0.4523	-0.8%
1970	2000	1985	0.3165	-3.0%
1980	2010	1995	0.4483	4.2%
1990	2020	2005	0.5590	2.5%
Ave				4.5%
since 1900				3.3%
last 3				1.2%

Chart 4 - Acceleration of change in cumulative CO2 emissions $a=ACCO_2$ [GtCO2/y²]



Axis x is the center of the trendline period (2005 is the center of the 1990-2020 trendline period)

Current Situation

Table 3 - Most recent data (May 2020) regarding cumulative CO2 emissions

	Symbol	Unit	Year	Value
Cumulative CO2 emissions	CCO2(2020)	GtCO2	2020	1,696.52
Previous Year	CCO2(2019)	GtCO2	2019	1,661.72
Change to previous year	Δ/y	GtCO2/y	2020	34.81
Last 11 years velocity of change	VCCO2	GtCO2/y	2015	35.33
Last 31 years acceleration of change	ACCO2	GtCO2/y ²	2005	0.5590
The lowest increase in acceleration	Δ ACCO2/y	%/y	1995	1.2%

Changes in This Version

- Change of formula for velocity of change in cumulative CO2 emissions, VCCO2
- Change of formula for acceleration of change in cumulative CO2 emissions, ACCO2

References

1. Hannah Ritchie, Max Roser, Edouard Mathieu, Bobbie Macdonald and Pablo Rosado - Data on CO₂ and Greenhouse Gas Emissions by Our World in Data
<https://github.com/owid/co2-data#data-on-co2-and-greenhouse-gas-emissions-by-our-world-in-data>
2. Our World in Data, Cumulative CO₂ emissions, 2020
<https://ourworldindata.org/grapher/cumulative-co-emissions>
3. Global Warming Acceleration - Joseph Nowarski, DOI: 10.5281/zenodo.6393436

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