Global Carbon Project
Briefing on key messages Global Carbon Budget 2021

EMBARGO until 00:01 GMT (Glasgow time) Thursday November 4
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Important notice: this document is intended as background briefing for the co-authors and journalists covering the release of the Global Carbon Budget 2021. **Do not cite or quote until the embargo is lifted.**

The Global Carbon Project is an international research project within the Future Earth research initiative on global sustainability, and a research partner of the World Climate Research Programme. It aims to develop a complete picture of the global carbon cycle, including both its biophysical and human dimensions together with the interactions and feedbacks between them. The Global Carbon Budget 2021 is the 16th edition of the annual update that started in 2006, and the 10th edition made available as a living data collection in the journal *Earth System Science Data*.

Data and methods are detailed in the submitted publications, with links provided at the end of this document. The analysis is based on established methodologies but not yet peer-reviewed.

A. Headline results of the global carbon budget 2021

- **Global fossil CO_2 emissions in 2021 are set to rebound close to their pre-COVID levels after an unprecedented drop in 2020.** Emissions from coal and gas use are set to grow more in 2021 than they fell in 2020, but emissions from oil use remain below 2019 levels.
- **For major emitters, fossil CO_2 emissions in 2021 appear to return to pre-COVID trends** with a decreasing trend in CO_2 emissions for the USA and European Union (EU27) and an increasing trend in CO_2 emissions for India. For China, the response to the COVID-19 pandemic has sparked further growth in CO_2 emissions, pushed by the power and industry sectors.
- **Decarbonisation[1] of energy showed a strong and growing signal in the decade 2010-2019 at the global level,** pushing CO_2 emission down in the USA, EU27, and slowing their growth in China. Decarbonisation of energy was not enough to compensate for the growing energy demand still largely met by fossil energy sources in many countries, despite the high deployment rate of renewables, resulting in continued growth in global emissions albeit at a slower rate.
- The rapid rebound in fossil CO_2 emissions as economies recover from the COVID-19 pandemic reinforces **the need for immediate action and global coherence in the world's response to climate change.**

[1] Decarbonisation is the shift from fossil fuels (coal, oil, gas) to renewables or from the most carbon intensive fossil fuels to less intensive fossil fuels (coal to gas).

B. Total CO_2 emissions

Global fossil CO_2 emissions in 2021 are returning towards their 2019 levels after an unprecedented drop in 2020.

- **2020 & 2021 figures.** The record decrease in 2020 emissions was 1.9 billion tonnes of CO_2 ($GtCO_2$) [−5.4%], from 36.7 $GtCO_2$ in 2019 to 34.8 $GtCO_2$ in 2020. Emissions are projected to grow 4.9% (4.1% to 5.7%) in 2021, to 36.4 $GtCO_2$. Global emissions in 2021 remain about 0.8% below their level in 2019. The 2021 growth of 1.6 $GtCO_2$ is similar to the growth observed in 2010 following the global financial crisis of 2008-2009 (1.7 $GtCO_2$; 5.5% above 2009 levels).

- **Analysis by fuel type.** Emissions from coal use in 2021 are projected to be above their 2019 levels but still below their peak in 2014. Emissions from natural gas use are also expected to rise above 2019 levels in 2021, continuing a steady trend of rising gas use that dates back at least sixty years. Only CO_2 emissions from oil remain well below 2019 levels in 2021.

- **Analysis by sector.** At the global level for 2021, emissions from the power and industry sectors are estimated to be above 2019 levels based on indirect activity data[2], while emissions in road transport and aviation appear still below their 2019 level. These sectoral changes compensate to give emissions in 2021 that are approaching their 2019 level.

- **Analysis by large country/region.** The global growth in fossil CO_2 emissions mainly arises from the growth in coal use in the power and industry sectors in China (see country details below). The projection for 2021 follows long-term background trends of increasing CO_2 emissions for India and decreasing CO_2 emissions for the USA and EU27. For China, the response to the COVID-19 pandemic appears to have sparked further growth in CO_2 emissions. For the Rest of the World (in aggregate), the rebound is dampened and breaks with the recent growth in emissions.

Decarbonisation of energy showed a strong and growing signal in the decade 2010-2019 at the global level.

- **Fossil CO_2 emissions significantly decreased in 23 countries[3] whose economies grew significantly during the decade 2010-2019 prior to the COVID-19 pandemic.** Altogether, these 23 countries contribute to 9.2 $GtCO_2$ over the last decade, about one quarter of global fossil CO_2 emissions. Consumption-based emissions are also falling significantly in 15 of these countries (Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Israel, Japan, Mexico, Netherlands, Slovenia, Sweden, United Kingdom and the USA).

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[2] Sectoral data are from carbonmonitor.org and refer to the period January-September.
[3] Barbados, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Israel, Japan, Luxembourg, North Macedonia, Malta, Mexico, Netherlands, Slovakia, Slovenia, Solomon Islands, Sweden, Switzerland, Tuvalu, United Kingdom and the USA. See https://enactivescience.com/gcp2021/ for all countries and different time-periods.

- The emission declines in the USA and EU27 during 2010-2019 are primarily driven by increased decarbonisation (CO_2 emissions per unit energy) compared to the previous decade. Increased decarbonisation also helped slow the growth in Chinese emissions during 2010-2019, but not in India or the rest of the world, where fossil CO_2 emissions continue to grow to meet growing energy demand despite the high deployment of renewables in some countries.

The full effect of responses to the COVID-19 pandemic on CO_2 emissions is still uncertain.

- **The economic disruption of COVID-19 in 2020 appears to have accelerated the transition to renewables, with renewables sustaining growth through 2020 while fossil fuels declined.** Energy use from renewables increased 31.7 EJ in 2020, continuing the growth of >10% per year on average over the past 5 years, despite a substantial 25 EJ decline in global energy demand[4].

- **The rebound in global fossil CO_2 emissions in 2021 reflects a return towards the pre-COVID fossil-based economy.** Investments in the green economy in the post-COVID recovery plans of some countries have been insufficient so far, on their own, to avoid a substantial return close to pre-COVID emissions.

- **A further rise in emissions in 2022 cannot be ruled** out if the road transport and aviation sectors return to their pre-pandemic activity and emissions levels and coal use is stable. The course of CO_2 emissions will be influenced by near-term economic incentives and climate policy.

The 2020-2021 emissions dip and recovery varied by country. The country/region figures below exclude international transport, particularly aviation.

- **China.** Emissions from China are projected to rise 4.0% in 2021, following a rise of 1.4% in 2020. Emissions in 2021 are set to be 5.5% above 2019, reaching 11.1 $GtCO_2$. China accounted for 31% of global emissions in 2020 (Table 1). Emissions from China have grown in both 2020 and in 2021 so far, driven by emissions in the power and industry sectors. These data suggest COVID-19 recovery incentives have sparked further growth in CO_2 emissions in China, by boosting industrial production heavily reliant on coal.

- **USA**. Emissions from the USA are projected to rise 7.6% in 2021 following a fall of 10.6% in 2020. Emissions in 2021 are set to remain 3.7% below 2019 levels, reaching 5.1 $GtCO_2$. USA accounted for 14% of global emissions in 2020. Data from the US EIA and elsewhere[2] suggest emissions from industry are back to 2019 levels, while emissions from all other sectors remain below.

- **EU27**. Emissions from the EU27 are projected to rise 7.6% in 2021 following a fall of 10.9% in 2020. Emissions in 2021 are set to remain 4.2% below 2019 levels, reaching 2.8 $GtCO_2$. EU27 accounted for 7% of global emissions in 2020.

[4] BP Statistical Review of World Energy June 2021

- **India**. Emissions from India are projected to rise 12.6% in 2021 following a fall of 7.3% in 2020. Emissions in 2021 are set to be 4.4% above 2019, reaching 2.7 $GtCO_2$. India accounted for 7% of global emissions in 2020.

- **Rest of the World** (*including* all international transport). Emissions from the rest of the world are projected to rise 2.9% in 2021 following a fall of 7.0% in 2020. Emissions in 2021 are set to be 4.2% below 2019 levels, reaching 14.8 $GtCO_2$ in aggregate. This group accounted for 59% of global emissions in 2020. These emissions are kept well below the 2019 level mainly because of a dampened rebound in economic growth in these countries, and to a lesser extent because they include emissions from global international transport, particularly aviation.

CO_2 emissions from land-use change[5] show continuing high gross emissions and a recent decline in net fluxes, but with high uncertainties.

- **Estimates of gross and net fluxes converge based on revised data of land-use change[5].** This brings several independent estimates closer together. However, the convergence of mean emission estimates does not capture the high uncertainty in land-use change datasets, which likely underestimate interannual variability and the (rising) importance of degradation. Without progress on accurate monitoring of land-use change, uncertainty in emission estimates, their trends and contributions to emissions reduction targets will remain high.
- **Global gross emissions due to land-use change[5] remain high at 14.1 $GtCO_2$ over the past decade.** Reduced monitoring capacities and legal enforcement of measures to reduce tropical deforestation in the wake of the pandemic have been observed in multiple countries and may impair emissions reductions.
- **Global gross removals have increased in the last two decades to 9.9 $GtCO_2$ over the past decade.** Gross removals occur because of the regrowth of forests and soil recovery after agricultural abandonment and wood harvesting.
- **The revised estimates of net land-use change emissions (the difference between gross emissions and gross removals) suggest a decline in emissions** from 4.5 $GtCO_2$ per year in the early 2000s (2000-2009) to 3.2 $GtCO_2$ in 2020, with a projection of 2.9 $GtCO_2$ in 2021. This trend remains to be confirmed.
- **Land CO_2 emissions can be reduced by acting on both gross emissions and on gross removals, which are better monitored and understood.** These two levers largely act on different regions of the globe, and operate in parallel.
- **For the first time, we link the global carbon budget models' estimates to the official country reporting of national greenhouse gases inventories.** While the global carbon budget distinguishes anthropogenic from natural drivers of land carbon fluxes, country reporting is area-based and attributes part of the natural terrestrial sink on managed land to the land-use sector. Accounting for this redistribution, the two approaches are shown to be consistent with each other.

[5] CO_2 emissions from land-use change refer to emissions from land-use, land-use change and forestry, such as deforestation and wood harvest. They exclude CO_2 fluxes from vegetation in response to changing CO_2 concentration and climate conditions.

Total CO_2 emissions from fossil and land-use change combined have remained relatively constant at 39.7 $GtCO_2$ over the past decade with a rise in fossil CO_2 emissions but a decline in the more uncertain revised land-use change CO_2 emissions. Fossil fuel emissions are mainly from the Northern Hemisphere, while land-use change emissions are mainly from the tropics.

- **Continued emissions further reduced the remaining carbon budget to keep global warming below the limits set in the Paris Agreement.** The remaining carbon budget for a 50% chance to limit global warming to 1.5°C, 1.7°C and 2°C has shrunk to 420 $GtCO_2$, 770 $GtCO_2$ and 1270 $GtCO_2$ respectively, equivalent to 11, 20 and 32 years at 2021 emissions levels, from the beginning of 2022.

- **Reaching net zero CO_2 emissions by 2050 entails cutting total CO_2 emissions by 1.4 $GtCO_2$ each year on average**, comparable to the 1.9 $GtCO_2$ drop during 2020, highlighting the scale of the needed action.

C. Atmospheric CO_2 accumulation and the natural carbon sinks

The level of CO_2 continued to increase in the atmosphere in both 2020 and 2021 following long-term trends because of continued emissions.

- **Atmospheric CO_2 concentration increased 2.4 parts per million in 2020 and is projected to increase by 2.0 parts per million in 2021 to reach 415 parts per million averaged over the year** (see latest trends here)[6]. The atmospheric CO_2 growth was 18.7 $GtCO_2$ (2.4 ppm) on average each year during the decade 2011-2020, indicating that 47% of total CO_2 emissions remained in the atmosphere. The 2020 decrease in total CO_2 emissions of about 2.5 $GtCO_2$ propagated to an atmospheric CO_2 growth, reduced by 1.4 $GtCO_2$ (0.18 ppm) relative to the 2019 growth rate. The 2021 growth rate is lower than in recent years due to La Niña conditions in 2021, a short-term natural climatic event that brings conditions favourable to an enhanced natural land carbon sink.

The land and ocean CO_2 sinks combined continued to take up around half (53% over the past decade) of the CO_2 emitted to the atmosphere. The natural carbon reservoirs, the ocean and the terrestrial biosphere, continue to take up CO_2 as atmospheric levels grow. Increasing atmospheric CO_2 drives the land and ocean sinks while climate change reduces the carbon sinks.

- **The ocean CO_2 sink resumed a more rapid growth in the past decade after low or no growth during the 1991-2002 period.** The growth of the ocean CO_2 sink in the past decade has an uncertainty of a factor of three, mainly originating from the Southern Ocean. The ocean CO_2 sink was 10.3 $GtCO_2$ per year (26% of total CO_2 emissions) during the decade 2011-2020 with a preliminary 2021 estimate of around 10.6 $GtCO_2$.

- **The natural land CO_2 sink continued to increase during the 2011-2020 period in response to increased atmospheric CO_2, albeit with large interannual variability.** The natural land CO_2 sink was 11.4 $GtCO_2$ per year on average during the 2011-2020 decade (28% of total CO_2 emissions),

[6] https://www.esrl.noaa.gov/gmd/ccgg/trends/gl_data.html

1.8 $GtCO_2$ per year larger than during the previous decade (2000-2009), with a preliminary 2021 estimate of around 12.1 $GtCO_2$ per year. Year to year variability in the natural land sink is about 4 $GtCO_2$ yr^{-1}, making smaller annual changes in anthropogenic emissions hard to detect in global atmospheric CO_2 concentration.

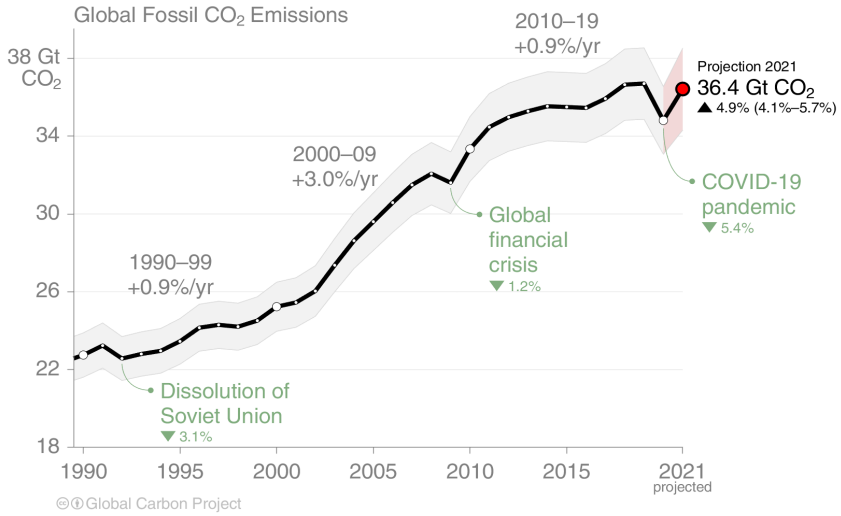
- **Globally during the decade 2011-2020, climate change reduced the land sink by about 15% and the ocean sink by about 5%.** The effect of climate change on the sinks cannot yet be detected in atmospheric CO_2 observations because of the presence of large natural climate variability. It was estimated using an ensemble of models.

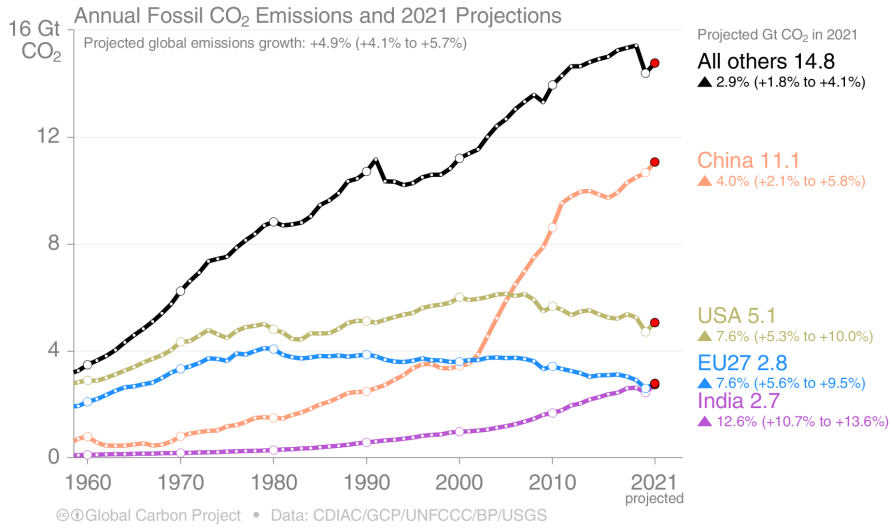
Table 1. 2020 fossil CO_2 emissions from top 20 countries including the EU27 (together and separately) in billion tonnes CO_2/yr, and projection of growth for 2021. IAS stands for International aviation and shipping. Growth rate in emissions can be explored for all countries and different periods using the embeddable visualisation at https://enactivescience.com/gcp2021/

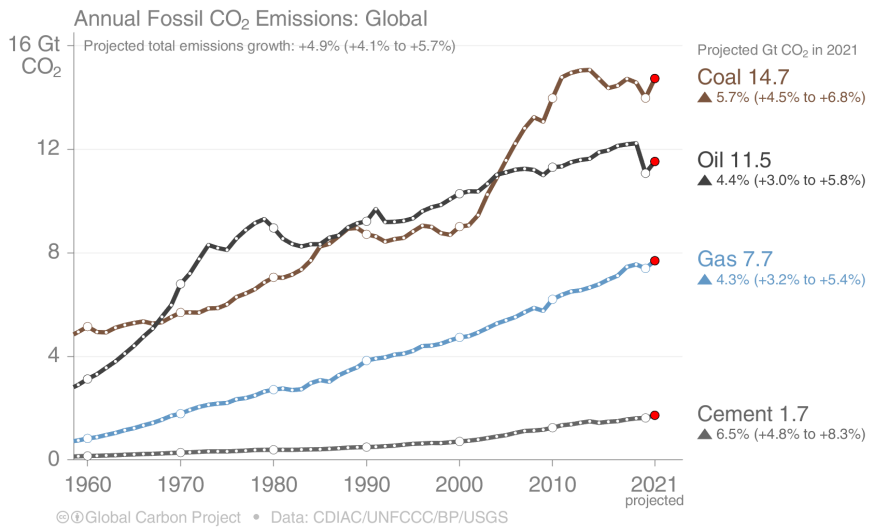
Country	2020 emissions (billion tonnes CO_2/yr)	2020 % of total (excl. IAS)	2020 emissions per capita (tonnes CO_2/pers/yr)	2020 growth (percent)	2021 projected growth (percent)
China	10.7	31%	7.4	1.4%	4.0%(2.1% to 5.8%)
USA	4.7	14%	14.2	-10.6%	7.6%(5.3% to 10%)
EU27	2.6	7.5%	5.8	-10.9%	7.6%(5.6% to 10%)
India	2.4	7.0%	1.8	-7.3%	12.6%(10.7% to 13.6%)
Russia	1.6	4.5%	10.8	-6.3%	
Japan	1.0	3.0%	8.1	-7.1%	
Iran	0.75	2.1%	8.9	1.3%	
Germany	0.64	1.9%	7.7	-9.7%	
Saudi Arabia	0.63	1.8%	18.0	0.2%	
South Korea	0.60	1.7%	11.7	-8.0%	
Indonesia	0.59	1.7%	2.2	-11.0%	
Canada	0.54	1.5%	14.2	-8.2%	
Brazil	0.47	1.3%	2.2	-4.1%	
South Africa	0.45	1.3%	7.6	-5.3%	
Turkey	0.39	1.1%	4.7	-1.9%	
Australia	0.39	1.1%	15.4	-5.7%	
Mexico	0.36	1.0%	2.8	-18.3%	
United Kingdom	0.33	0.9%	4.9	-10.9%	
Italy	0.30	0.9%	5.0	-10.8%	
Poland	0.30	0.9%	7.9	-6.5%	

Kazakhstan	0.29	0.8%	15.5	-1.8%	
World (incl. IAS)	34.8	100%	4.5	-5.4%	4.9%(4.1% to 5.7%)

Key figures:







This media release is part of the Global Carbon Budget 2021, the annual update by the Global Carbon Project. The Global Carbon Budget annual update builds on established methodologies in a fully transparent manner. The 2021 edition is published as a preprint and is undergoing an open review in the journal *Earth System Science Data*.

Preprint: Friedlingstein et al. (2021) Global Carbon Budget 2021. *Earth System Science Data*. https://essd.copernicus.org/preprints/essd-2021-386/ (see below for access prior to the embargo)

Preprint by Robert B. Jackson, Pierre Friedlingstein, Corinne Le Quéré, Sam Abernethy, Robbie M. Andrew, Josep G Canadell, Philippe Ciais, Steve J. Davis, Zhu Deng, Zhu Liu, Glen P. Peters. Global fossil carbon emissions rebound near pre-COVID-19 levels. Submitted to *Environmental Research Letters*.

PRESS BRIEFING:

A Science Media Centre online news briefing on the Global Carbon Budget 2021 will take place at 10:30am Wednesday November 3. For further information please contact pressoffice@exeter.ac.uk

The Global Carbon Budget will be launched at the COP26, Glasgow, 9:30am Thursday November 4, at the UN-IPCC Science Pavilion.

All material (publications, data, figures (including by country), key messages,….) are available, under embargo, on the following google drive :
https://drive.google.com/drive/folders/10ugYJ5V_rXoroLQpAs-ZblNklWlTlBJ4

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