GLOBAL CARBON PROJECT

The Role of Atmospheric Observations in the

Global Carbon Budget

2019

The GCP is a Global Research Project of futurearth Research. Innovation. Sustainability. and a Research Partner of WCRP World Climate Research Programme

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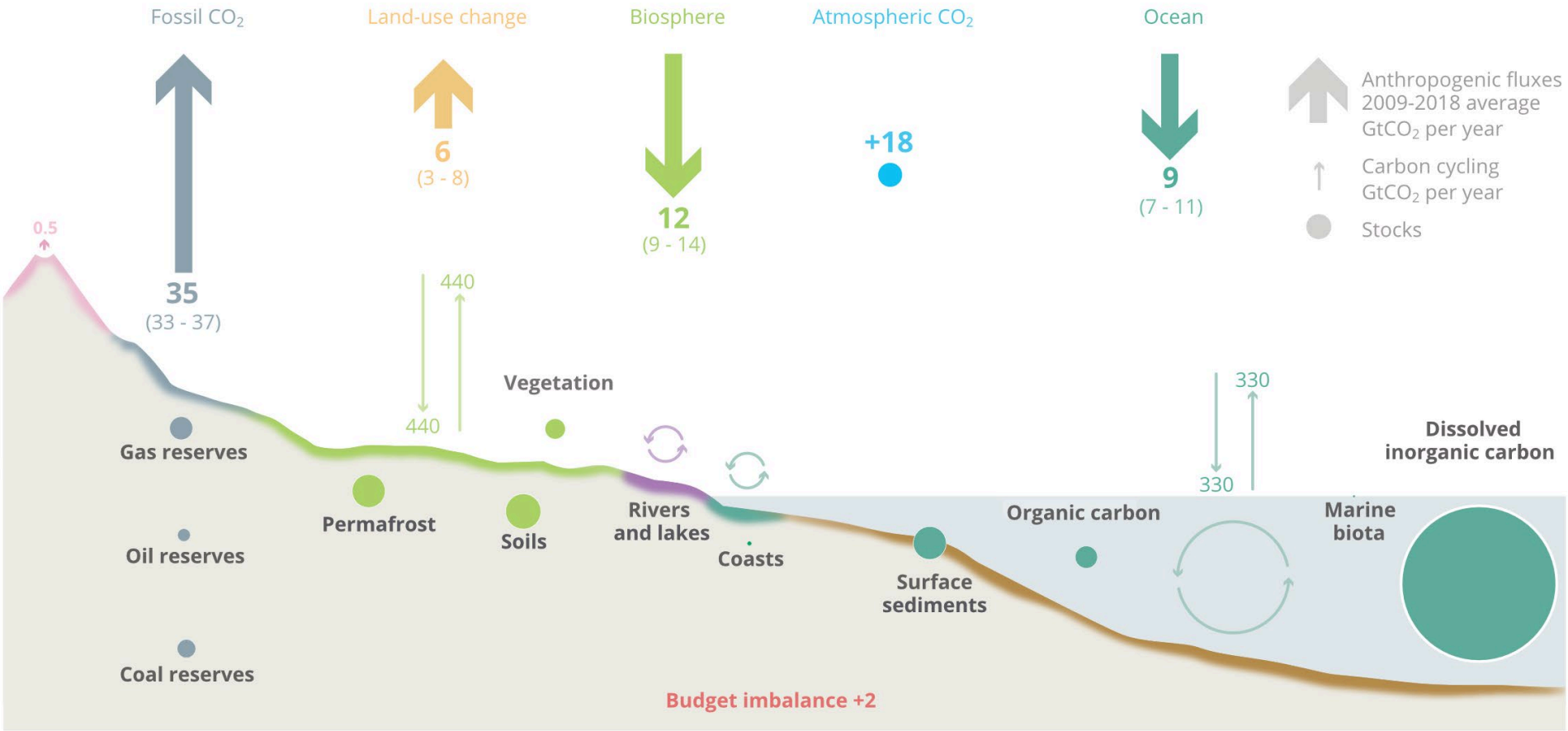
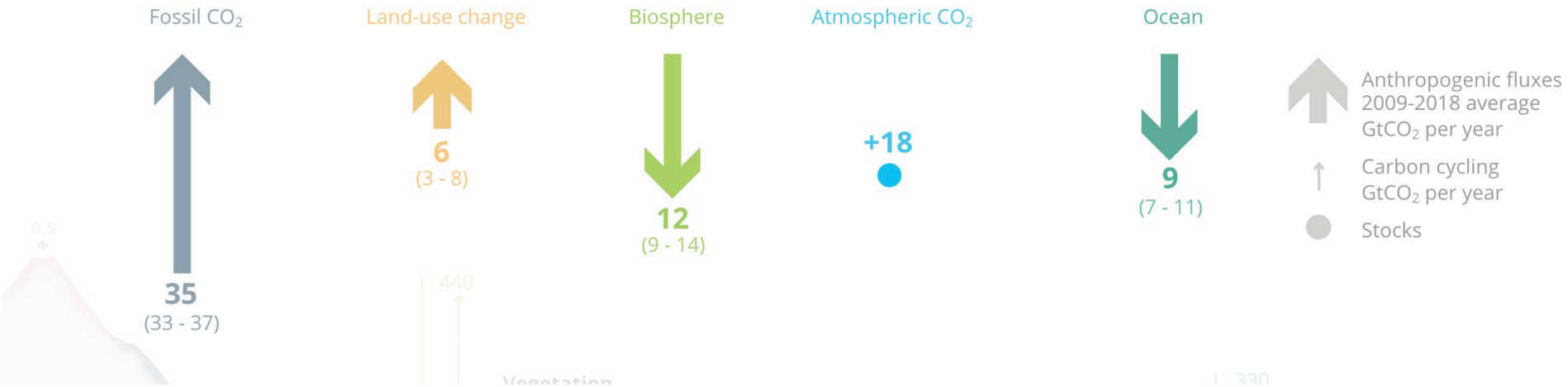
Constructing the Global Carbon Budget

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2009–2018 ($GtCO_2$/yr)



Source: CDIAC; NOAA-ESRL; Friedlingstein et al 2019; Ciais et al. 2013; Global Carbon Budget 2019

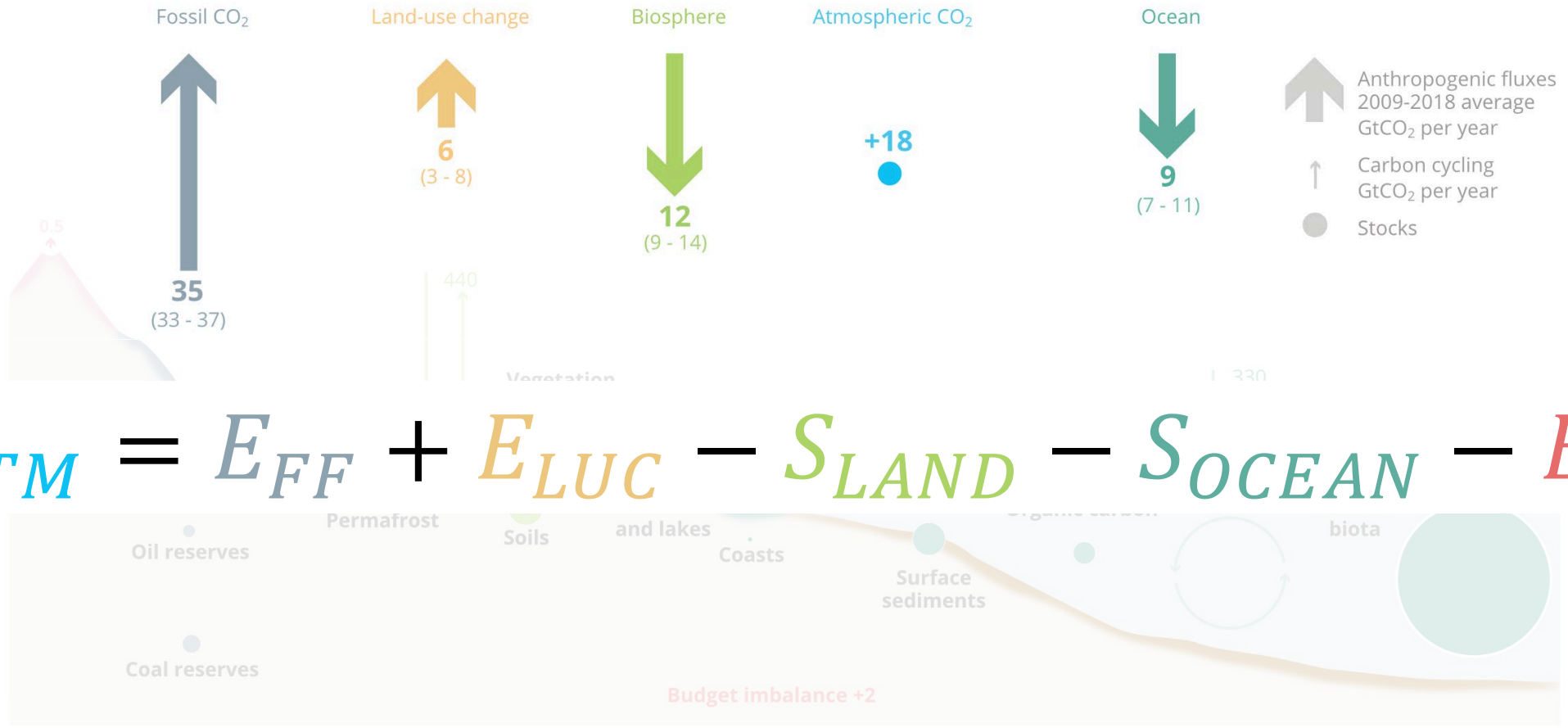
Anthropogenic perturbation of the global carbon cycle



$$G_{ATM} \approx E_{FF} + E_{LUC} - S_{LAND} - S_{OCEAN}$$

The budget imbalance is the difference between the estimated emissions and sinks.
Source: CDIAC; NOAA-ESRL; Friedlingstein et al 2019; Ciais et al. 2013; Global Carbon Budget 2019

Anthropogenic perturbation of the global carbon cycle



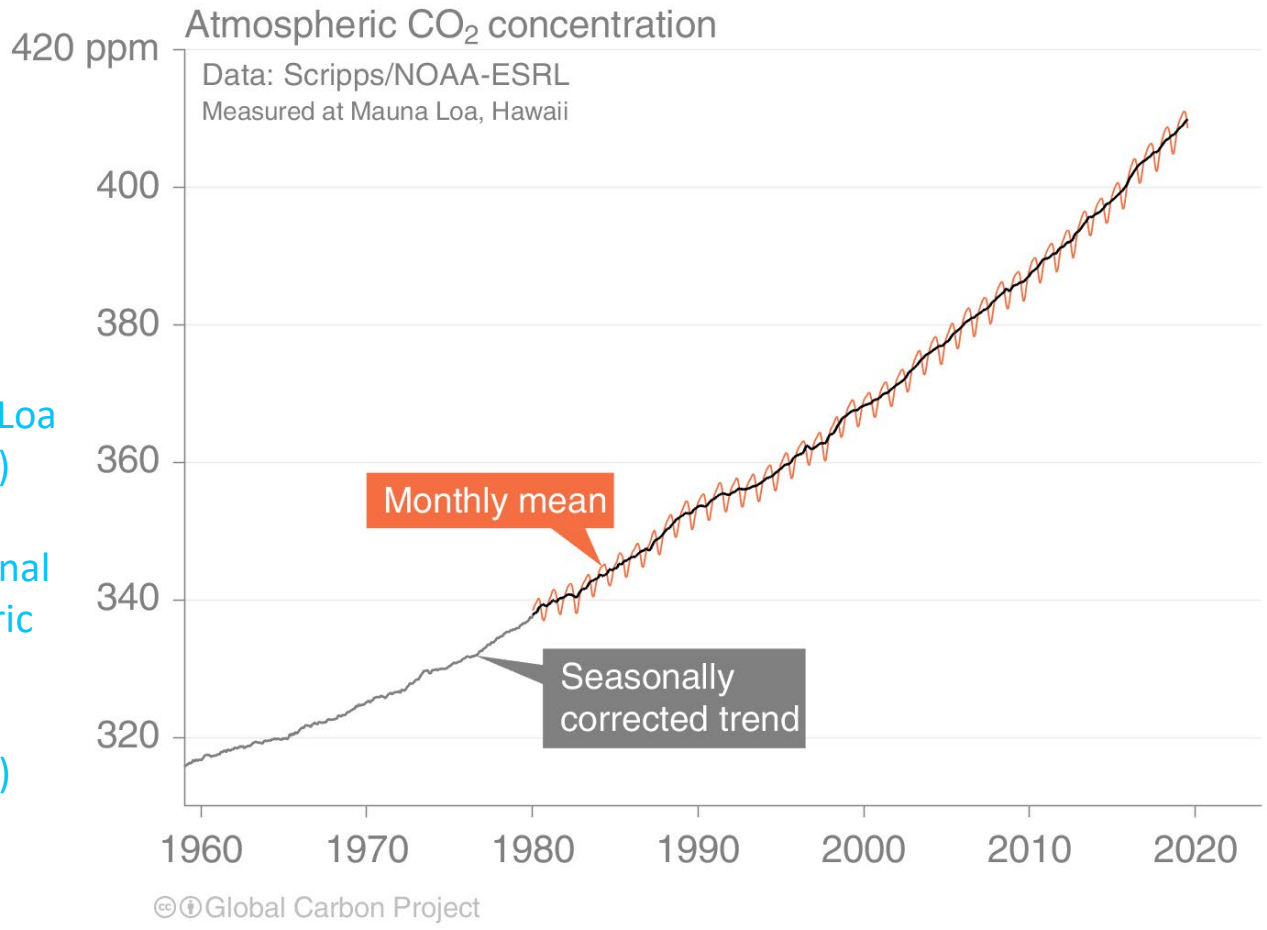
$$G_{ATM} = E_{FF} + E_{LUC} - S_{LAND} - S_{OCEAN} - B_{IM}$$

The budget imbalance is the difference between the estimated emissions and sinks.
Source: CDIAC; NOAA-ESRL; Friedlingstein et al 2019; Ciais et al. 2013; Global Carbon Budget 2019

Atmospheric concentration

Atmospheric Observations:

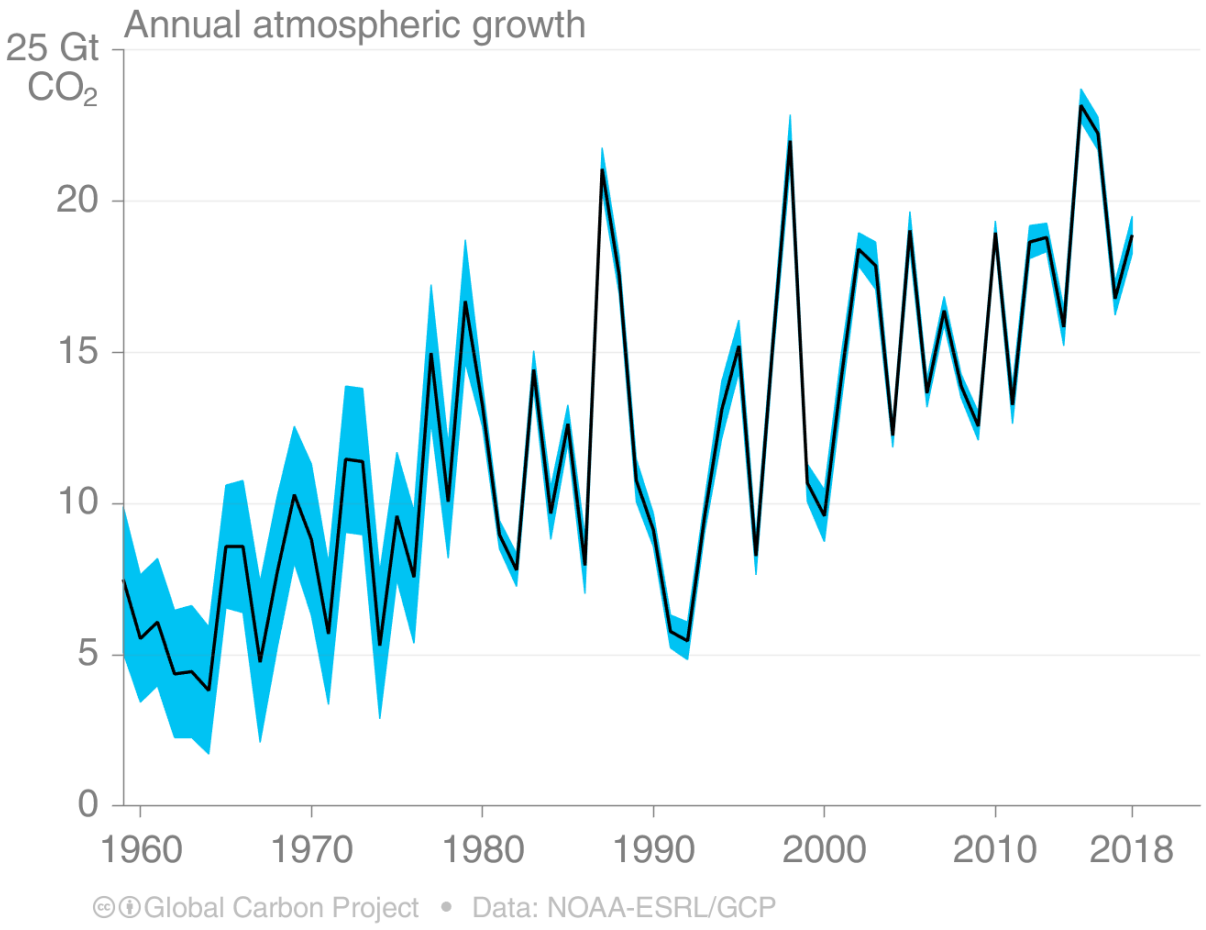
- **1959-1979**: CO2 programme at Scripps Institution of Oceanography (Mauna Loa and South Pole stations)
- **1979-Present:** US National Oceanic and Atmospheric Administration Earth System Research Laboratory (NOAA ESRL)



Globally averaged surface atmospheric CO_2 concentration. Data from: NOAA-ESRL after 1980; the Scripps Institution of Oceanography before 1980 (harmonised to recent data by adding 0.542ppm)
Source: NOAA-ESRL; Scripps Institution of Oceanography; Friedlingstein et al 2019; Global Carbon Budget 2019

Atmospheric concentration

Improving atmospheric concentration measurements have led to reduced uncertainty in the growth rate of atmospheric CO_2

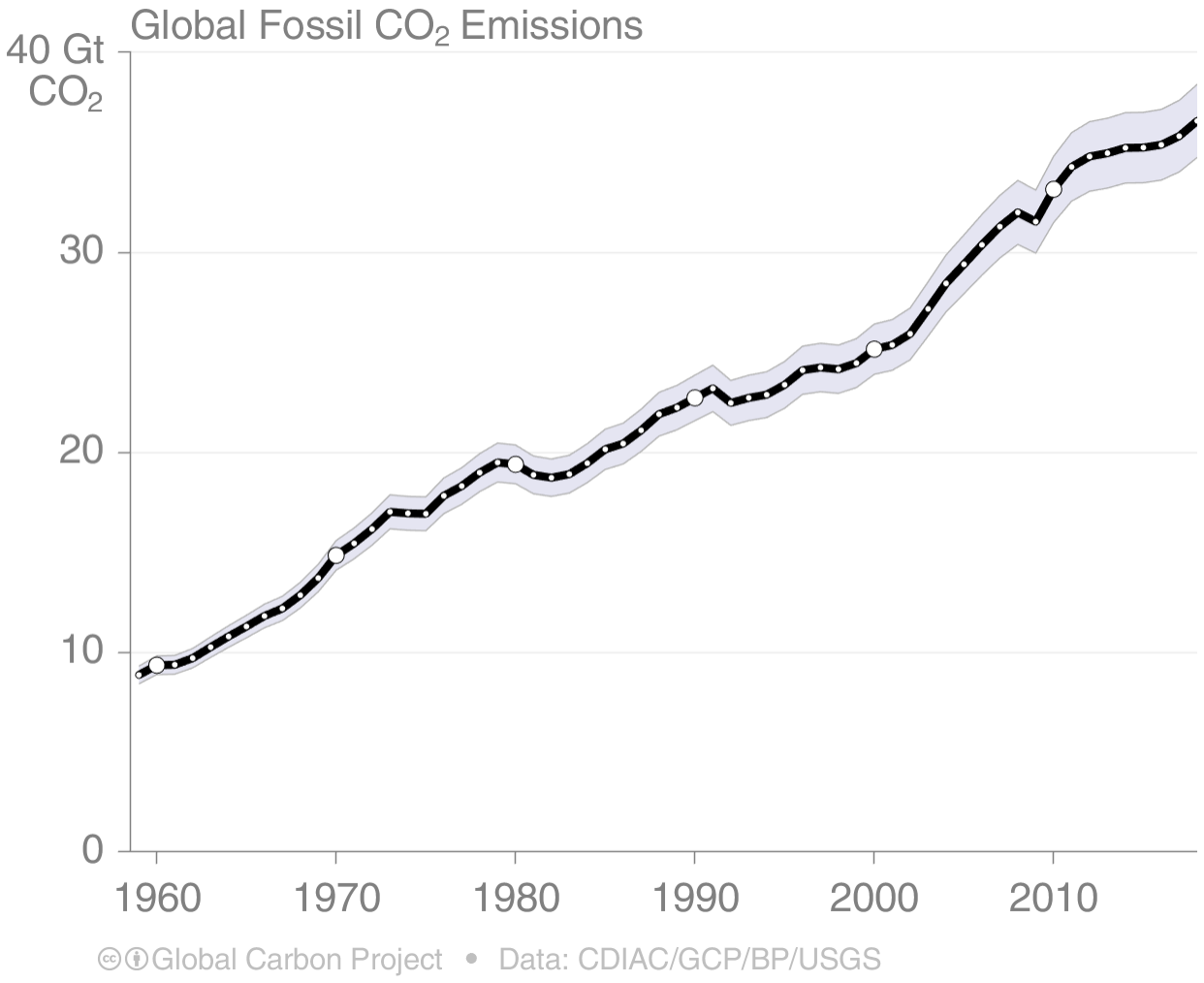


Source: NOAA-ESRL; Global Carbon Budget 2019

Global Fossil CO_2 Emissions

Fossil CO_2 Emissions
Estimate based on:

- UNFCCC national inventory reports
- Carbon Dioxide Information Analysis Center (CDIAC)
- BP Statistical Review of World Energy
- Cement emissions inventory from Andrew (2019)

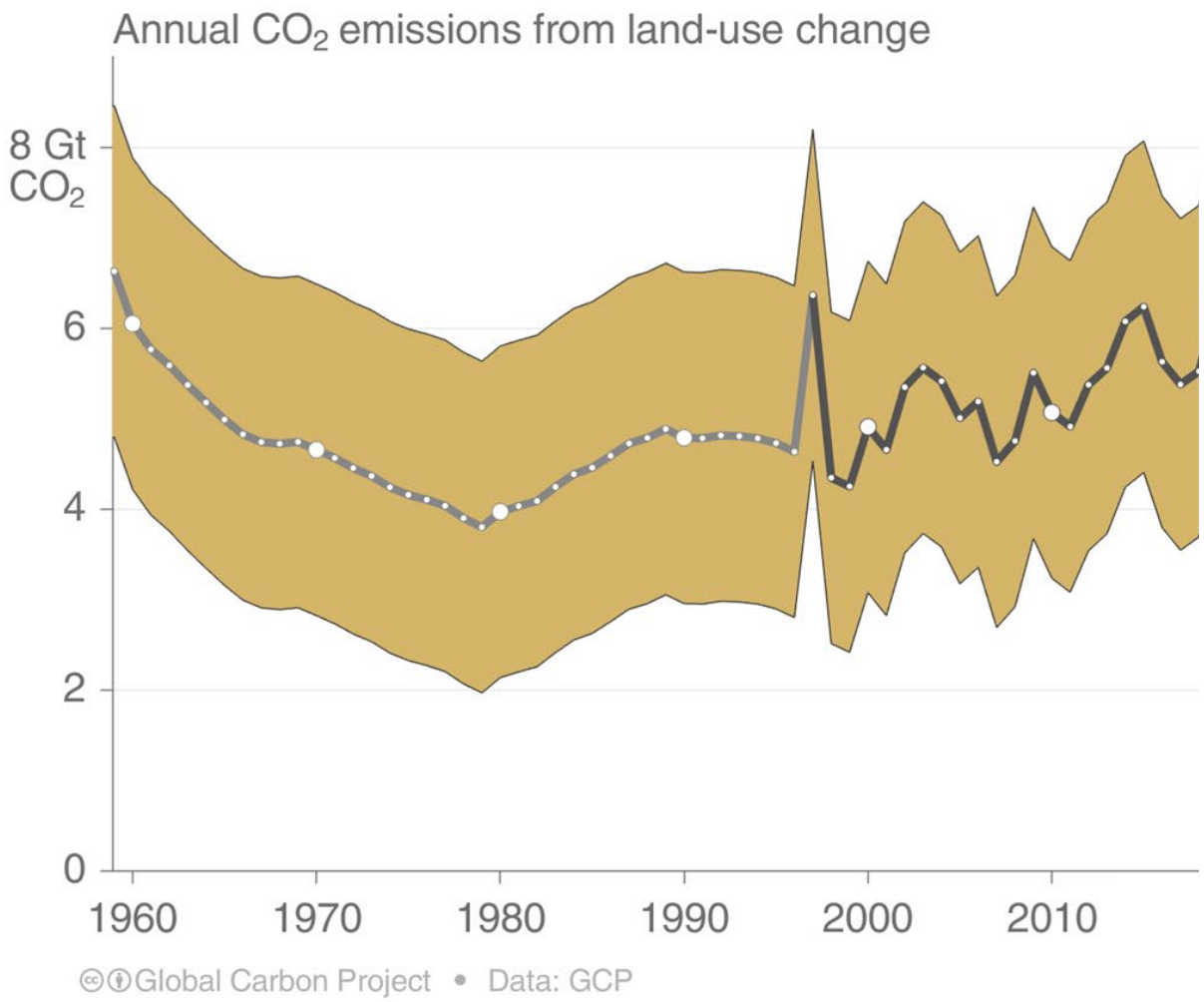


The 2019 projection is based on preliminary data and modelling.
Source: CDIAC; Friedlingstein et al 2019; Global Carbon Budget 2019

Land Use Change Emissions

Land Use Change Emissions Estimate based on:

- 2 bookkeeping models



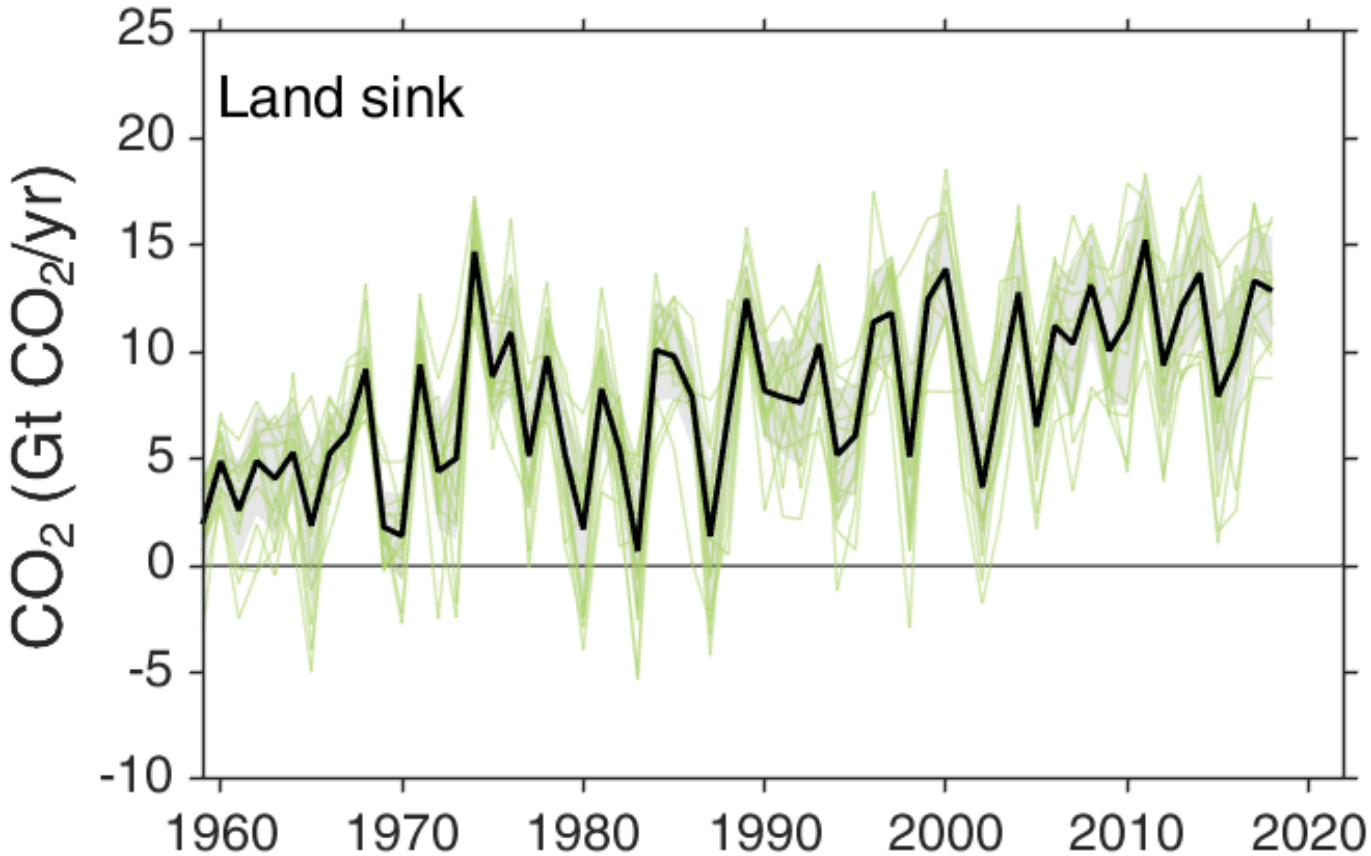
Global Carbon Project • Data: GCP

Source: Friedlingstein et al 2019 (see Table 4 for detailed references)

Land Sink

Land Sink Estimate based on:

- 16 Dynamics Global Vegetation Models (DGVMs)



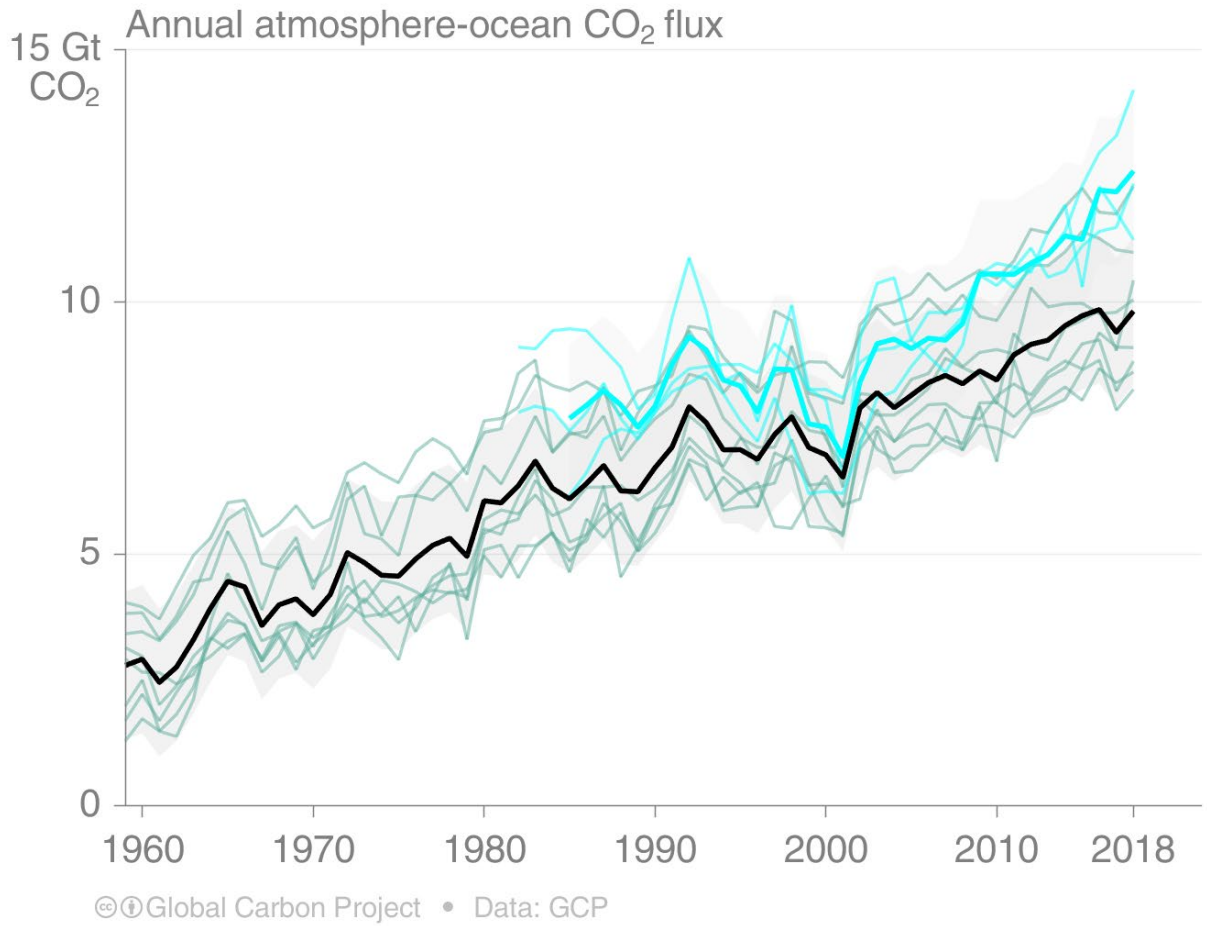
Global Carbon Project • Data: GCP

Source: Friedlingstein et al 2019 (see Table 4 for detailed references)

Ocean sink

Ocean Sink Estimate based on:

- 9 Global Ocean Biogeochemistry Models (GOBMs)
- Uncertainty assessment informed by data-based flux products



Source: SOCATv6; Bakker et al 2016; Friedlingstein et al 2019; Global Carbon Budget 2019

Individual estimates from: Aumont and Bopp (2006); Berthet et al. (2018); Buitenhuis et al. (2010); Doney et al. (2009); Hauck et al. (2016); Landschützer et al. (2016); Mauritsen et al. (2018); Rödenbeck et al. (2014); Schwinger et al. (2016). Full references provided in Le Quéré et al. (2018).

Fate of anthropogenic CO_2 emissions (2009–2018)

Sources

40.2 $GtCO_2$/yr

Atmospheric Growth

17.9 $GtCO_2$/yr

44%

Sinks

29%

11.5 $GtCO_2$/yr

23%

9.2 $GtCO_2$/yr

Budget Imbalance (the difference between estimated sources & sinks)

4%

+1.6 $GtCO_2$/yr

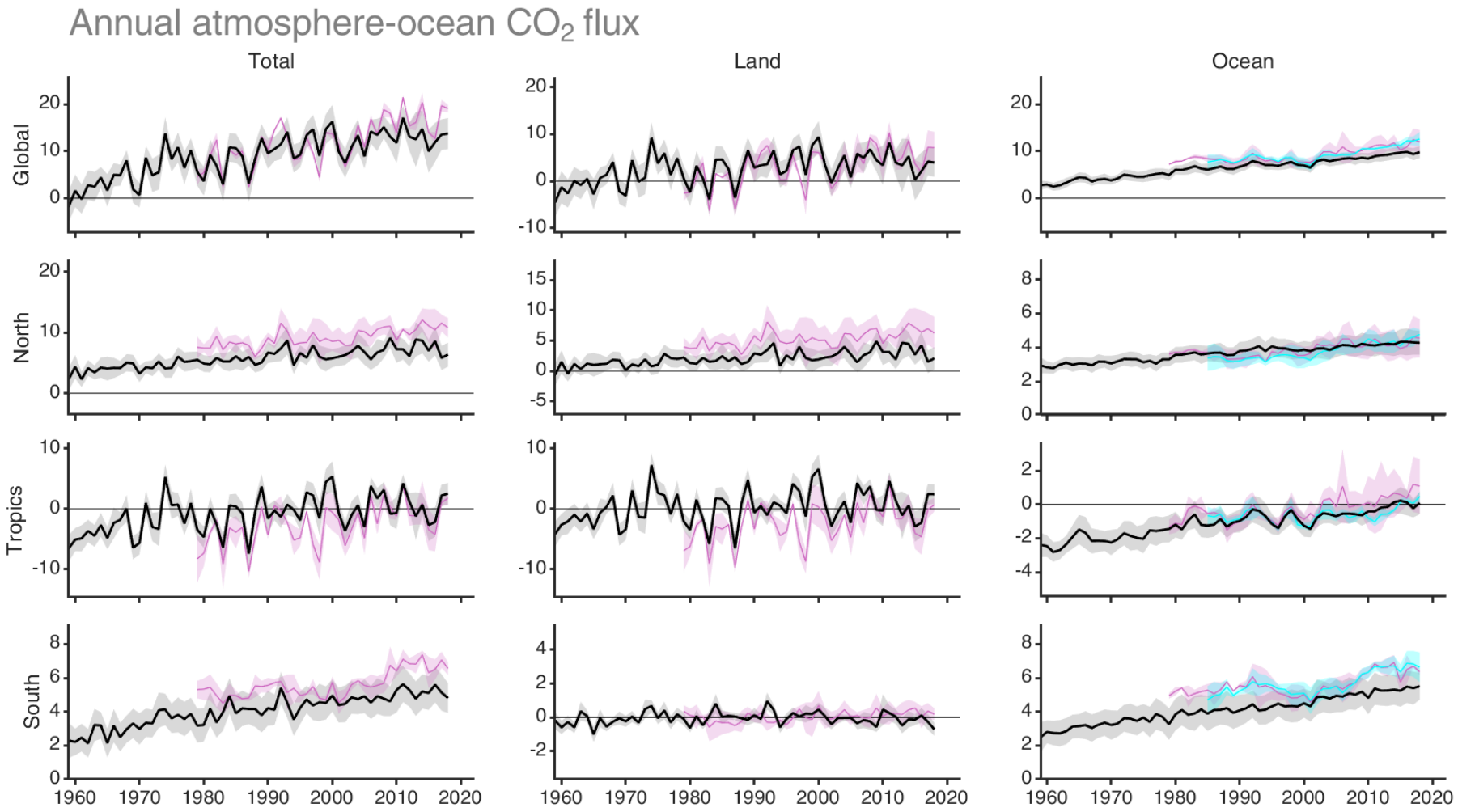
Sources too high?

Sinks too low?

Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Friedlingstein et al 2019; Global Carbon Budget 2019

Inversion Models in the Global Carbon Budget

Total land and ocean fluxes show greatest interannual variability in the tropics



Global Carbon Project • Data: GCP

Source: Friedlingstein et al 2019 (see Table 4 for detailed references)

GLOBAL CARBON PROJECT

CONSTRAIN

The Global Carbon Budget 2019

TAKING YOUR QUESTIONS ON:

Wednesday 4 December
16:45-18:15 CET
UNFCCC Pavilion
Room 5

- the latest global carbon budget figures
- the remaining carbon budget
- what this means for the Paris Agreement

And *livestreamed* via the COP 25 side events webcast page

Glen Peters | CICERO Center for International Climate Research, Norway
Matt Jones | Tyndall Centre for Climate Change Research, University of East Anglia, UK
Joeri Rogelj | Imperial College London, UK

+
an expert discussion panel

Contributors 76 people | 58 organisations | 13 countries

comment

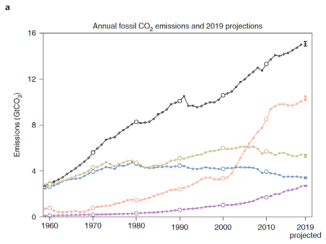
Carbon dioxide emissions continue to grow amidst slowly emerging climate policies

A failure to recognize the factors behind continued emissions growth could limit the world's ability to shift to a pathway consistent with 1.5 °C or 2 °C of global warming. Continued support for low-carbon technologies needs to be combined with policies directed at phasing out the use of fossil fuels.

G. P. Peters, R. M. Andrew, J. G. Canadell, P. Friedlingstein, R. B. Jackson, J. I. Korsbakken, C. Le Quéré and A. Peregon

Global fossil CO_2 emissions grew at 0.9% per year in the 1990s and accelerated to 3.0% per year in the 2000s, but have returned to a slower growth rate of 0.9% per year since 2010, with a more pronounced slowdown from 2014 to 2016. Despite modest declines in emissions in the United States and the European Union (EU) over the past decade, the growth in emissions in China, India and most developing countries has dominated global emission trends over the past 20 years. The Global Carbon Budget projection[1] suggests that global fossil CO_2 emissions will grow by 0.6% (range −0.2% to 1.5%) in 2019, with emissions projected to decline in the United States and the EU28, but projected to increase in China, India and the rest of the world (Fig. 1a).

Although a focus on countries and



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Environmental Research Letters

PERSPECTIVE

Persistent fossil fuel growth threatens the Paris Agreement and planetary health

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Keywords: CO_2 emissions, coal, oil and natural gas, fossil fuels, climate change, China, European Union, India, and the United States

Abstract

Amidst declarations of planetary emergency and reports that the window for limiting climate change to 1.5 °C is rapidly closing, global average temperatures and fossil fuel emissions continue to rise.

Global Carbon Budget 2019

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