Air-sea interactions : Anthropogenic CO_2

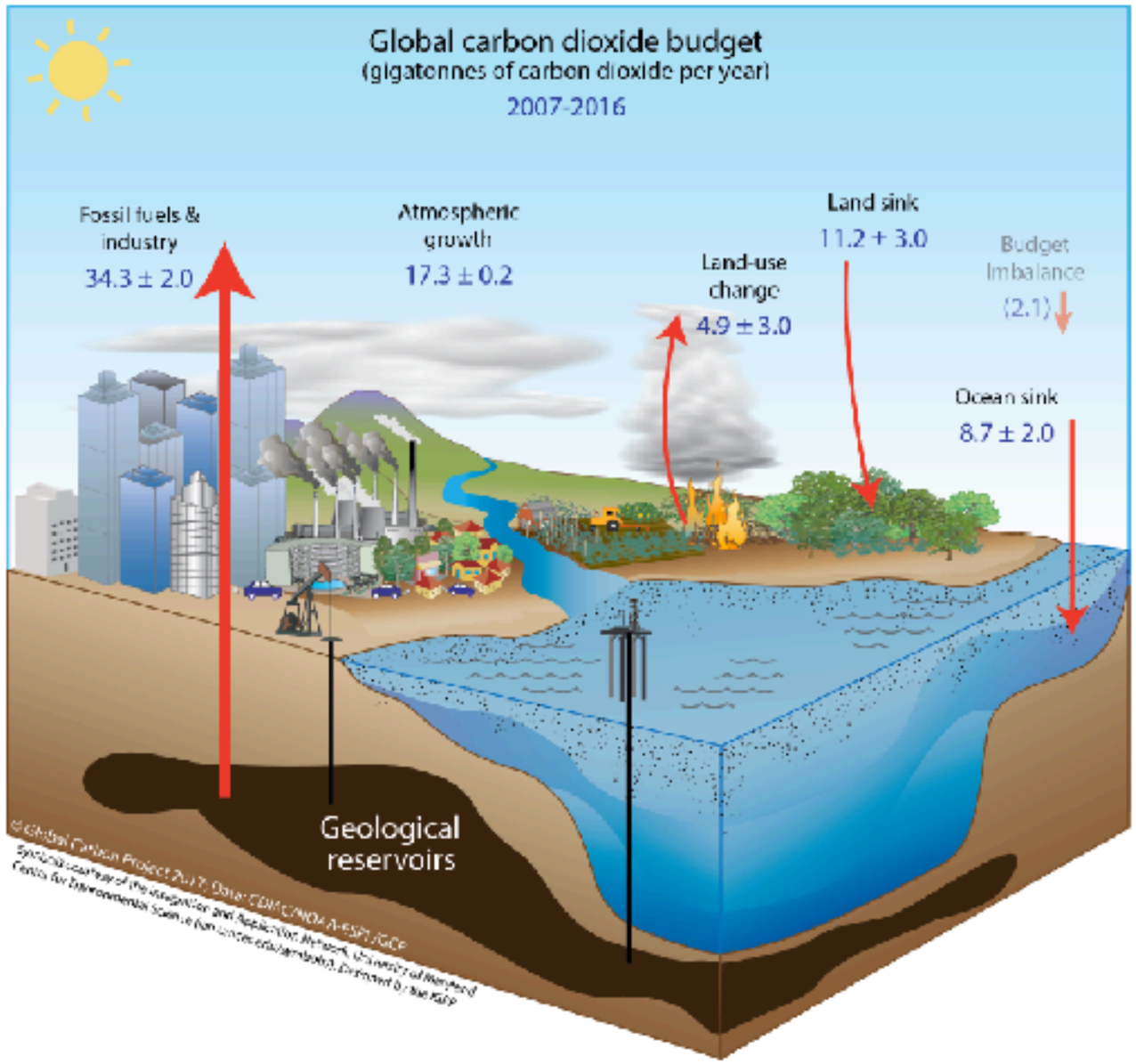
ATM2106

The slides were adopted

from Global Carbon Project

Composition of the Atmosphere near the surface

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2007–2016 ($GtCO_2$/yr)



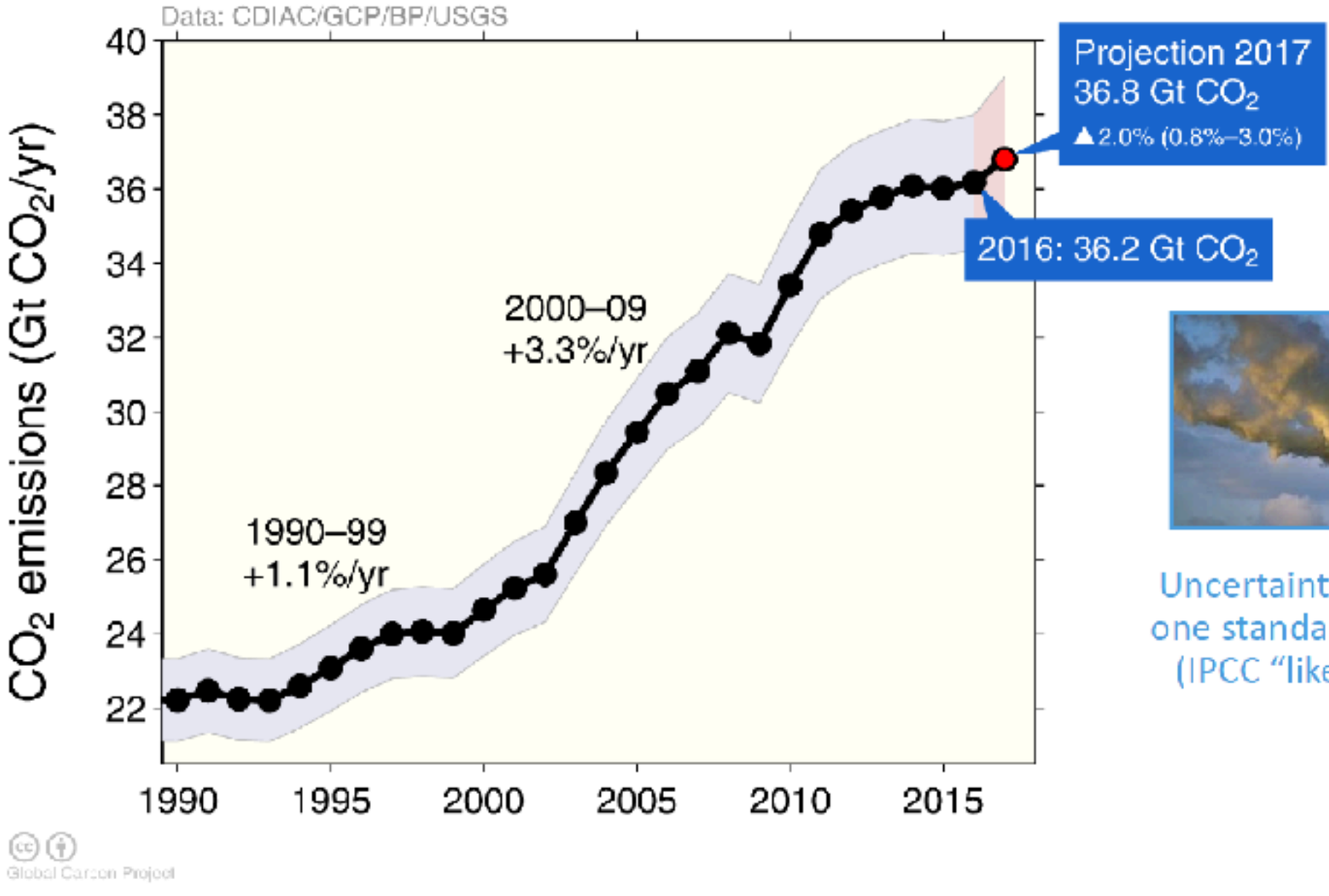
The budget imbalance is the difference between the estimated emissions and sinks.

Source: CDIAC; NOAA-ESRL; Le Quéré et al 2017; Global Carbon Budget 2017

Emissions from fossil fuel use and industry

Global emissions from fossil fuel and industry: 36.2 ± 2 $GtCO_2$ in 2016, 62% over 1990

● Projection for 2017: 36.8 ± 2 $GtCO_2$, 2.0% higher than 2016



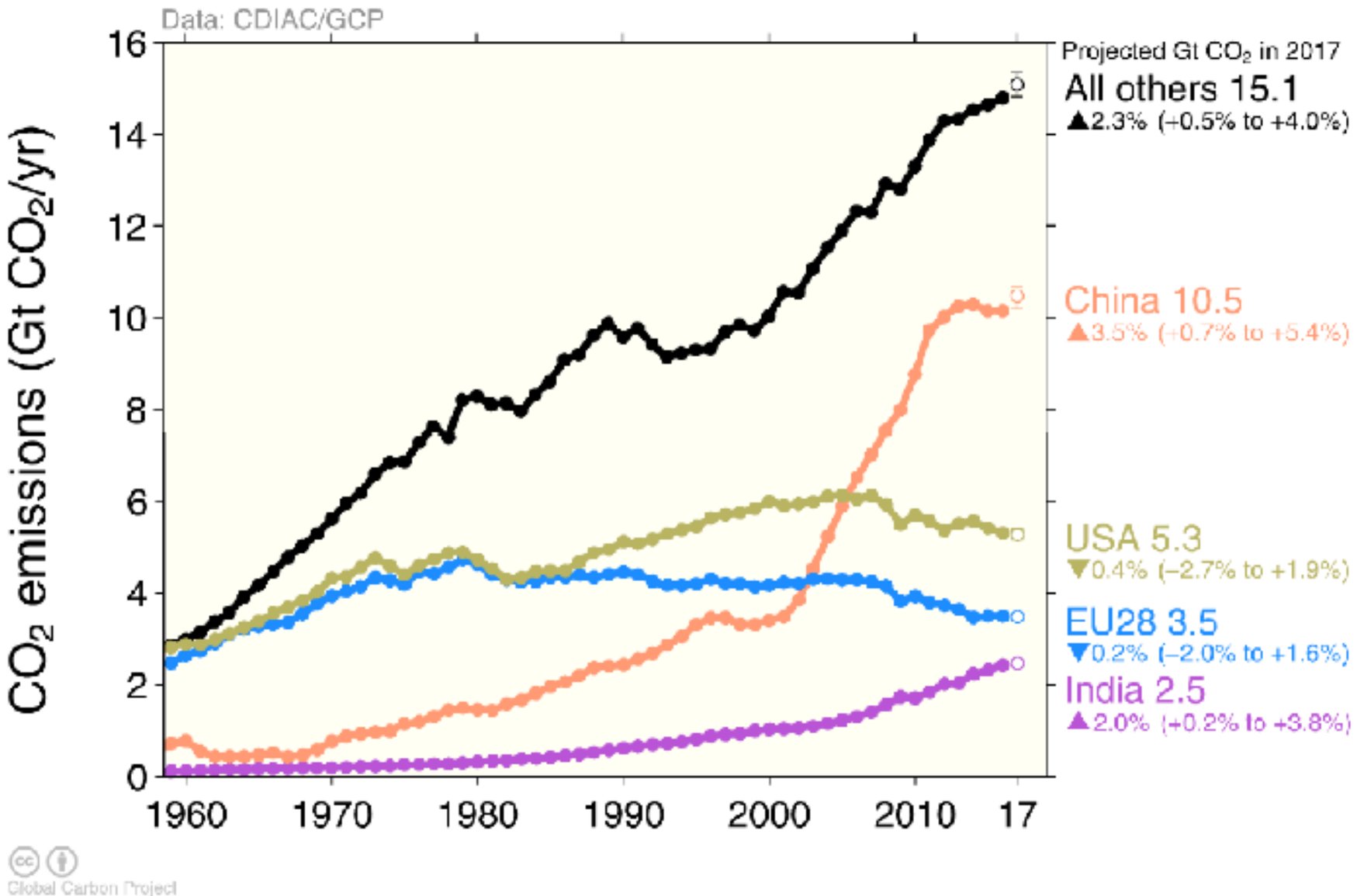
Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

Estimates for 2015 and 2016 are preliminary. Growth rate is adjusted for the leap year in 2016.

Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

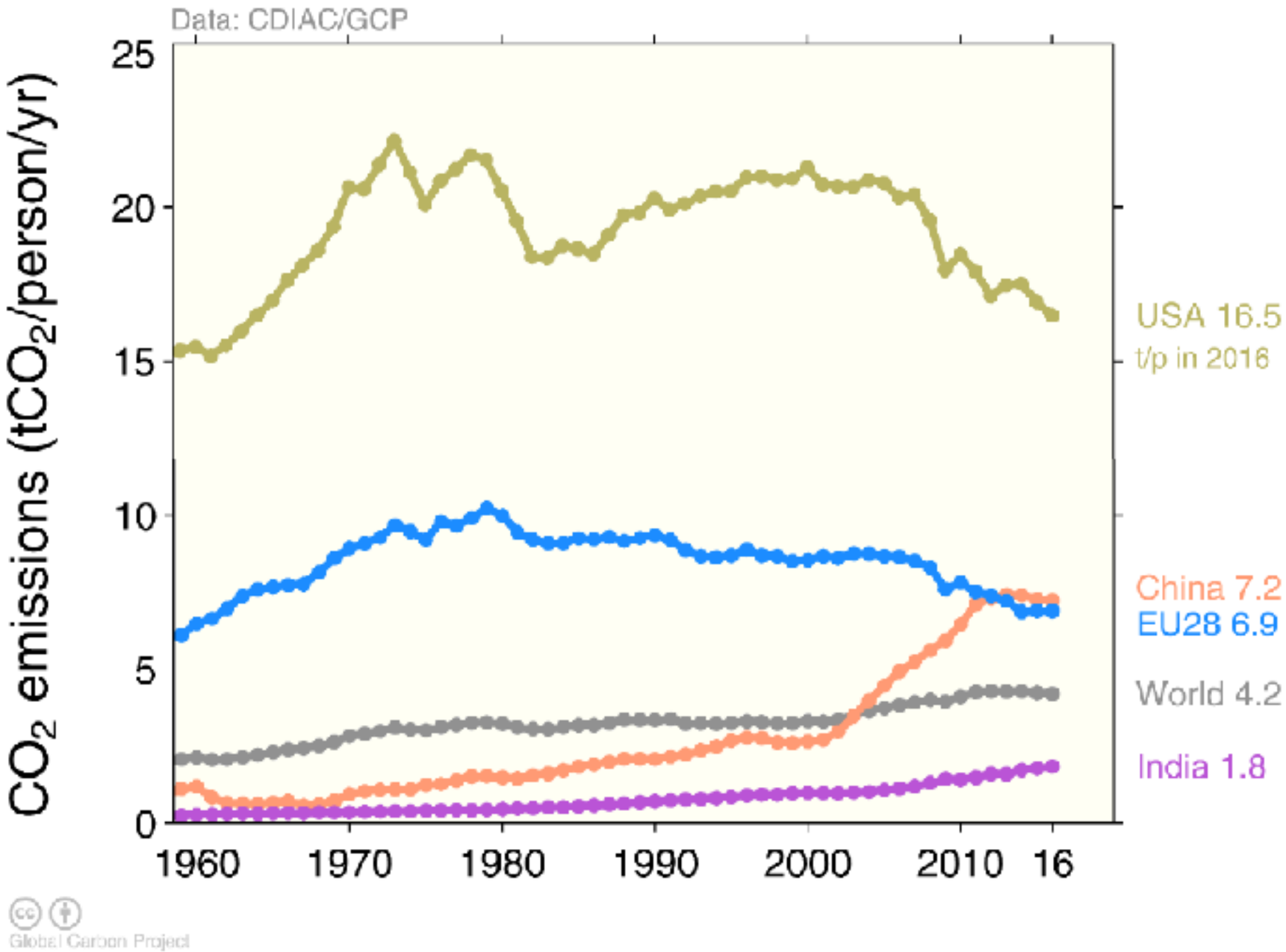
Top emitters: fossil fuels and industry (absolute)

Global emissions from fossil fuels and industry are projected to rise by 2.0% in 2017
The global projection has a large uncertainty, ranging from +0.8% to +3.0%



Source: CDIAC; Jackson et al 2017; Le Quéré et al 2017; Global Carbon Budget 2017

Top emitters: fossil fuels and industry (per person)



Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

Fossil fuel and industry emissions growth

Emissions in the US, Russia and Brazil declined in 2016
Emissions in India and all other countries combined increased

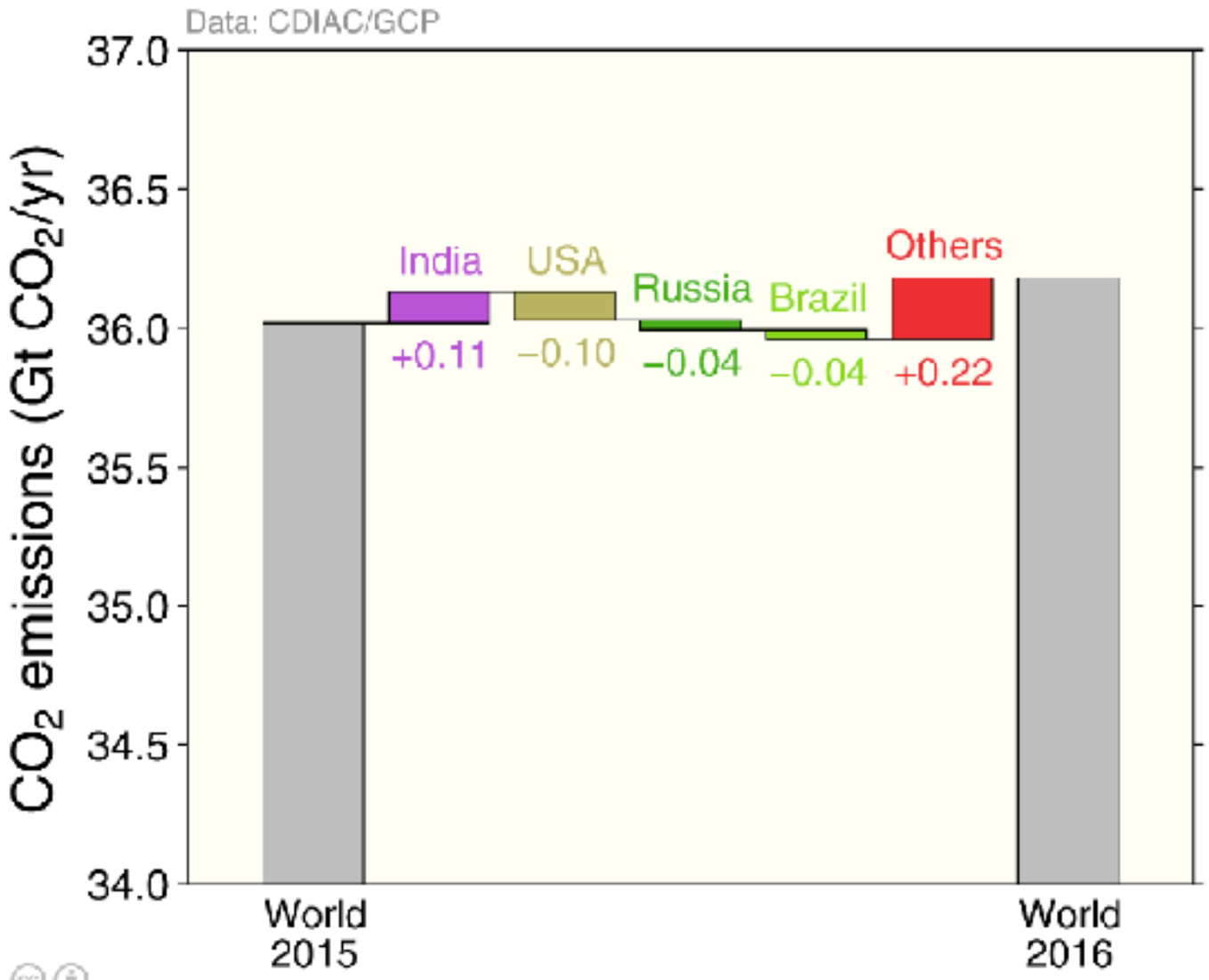
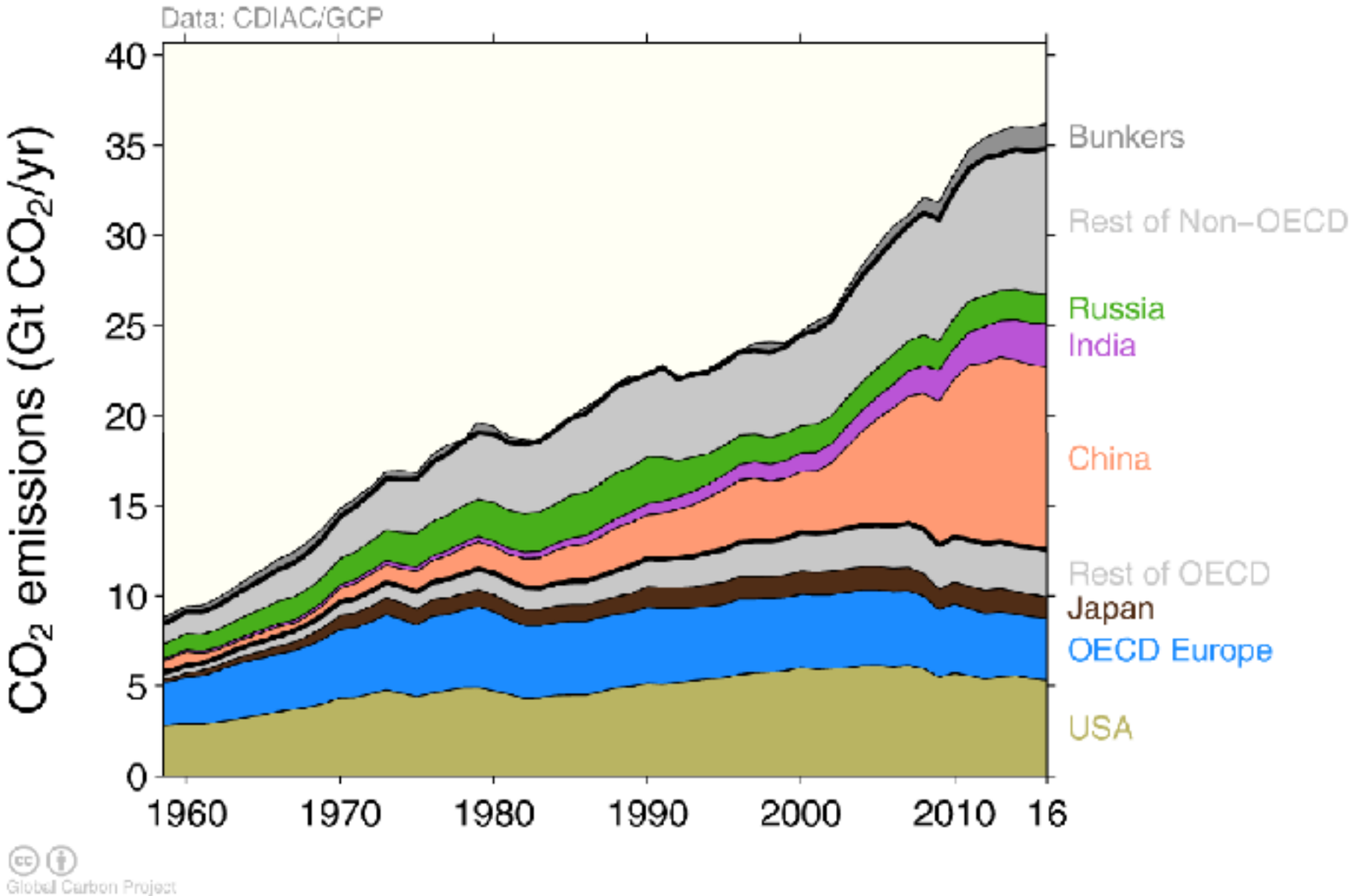


Figure shows the top four countries contributing to emissions changes in 2016
Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

Breakdown of global emissions by country

Emissions from OECD countries are about the same as in 1990

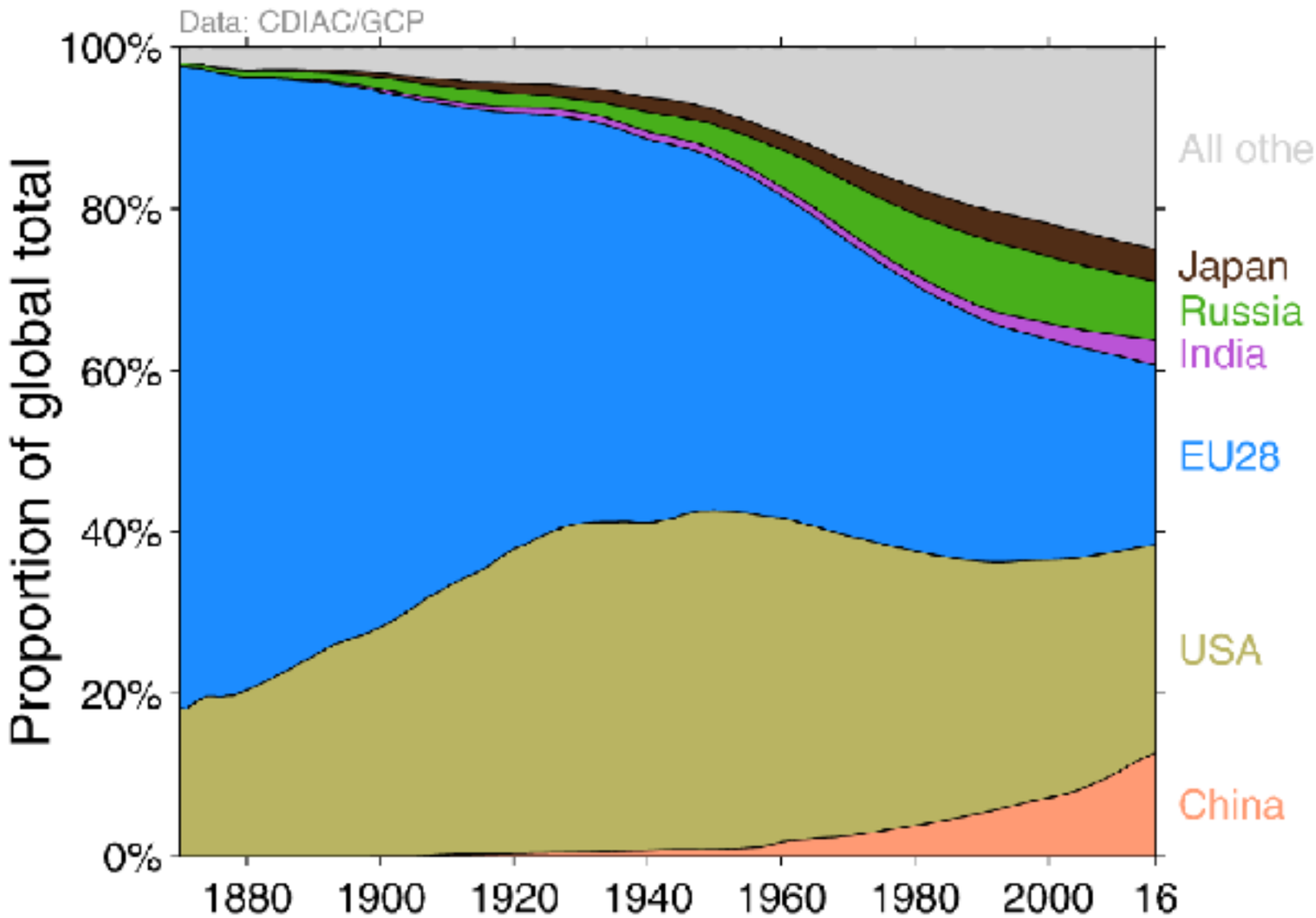
Emissions from non-OECD countries have increased rapidly in the last decade



Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

Historical cumulative emissions by country

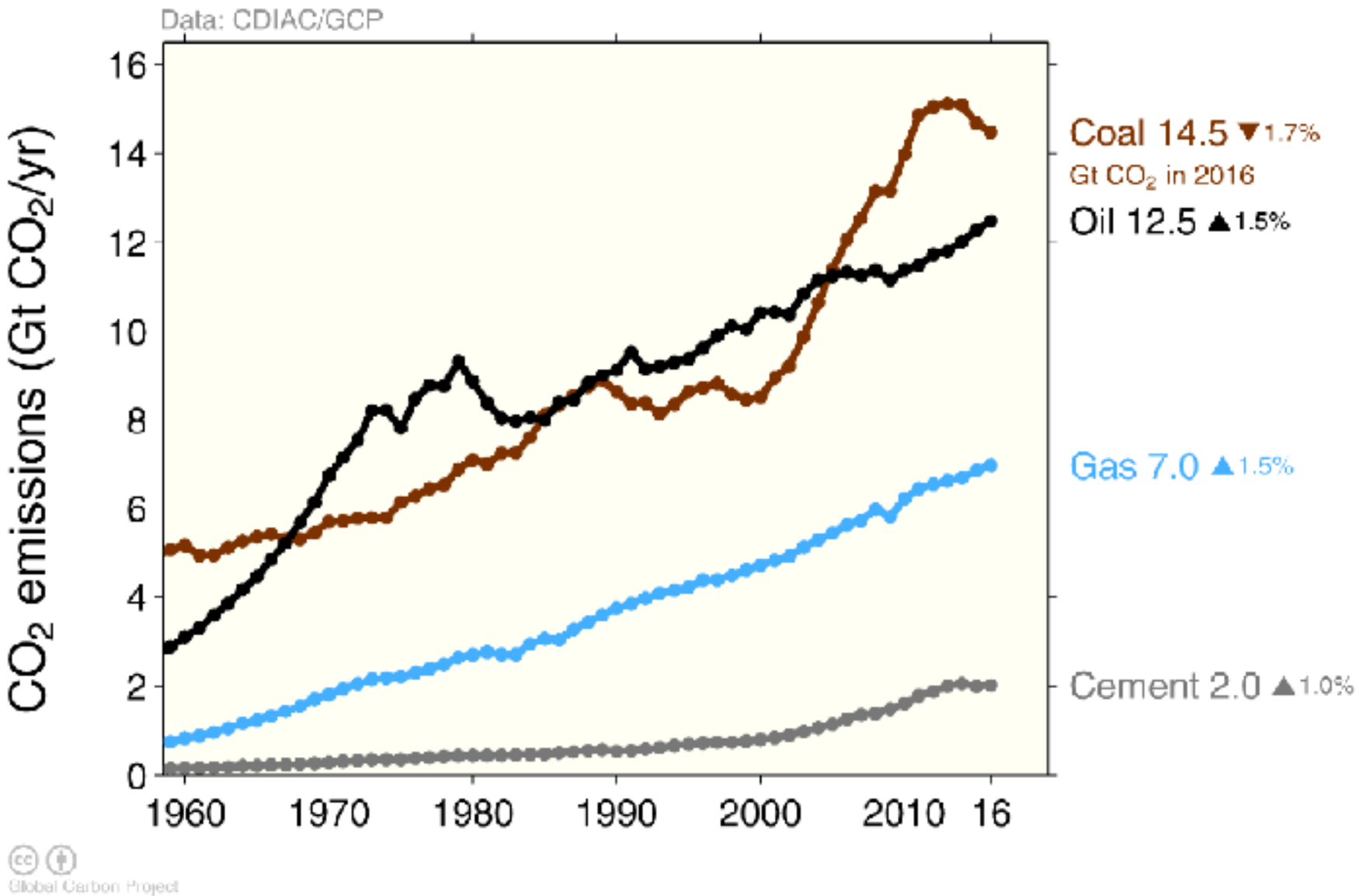
Cumulative emissions from fossil-fuel and industry were distributed (1870–2016):
USA 26%, EU28 22%, China 13%, Russia 7%, Japan 4% and India 3%



Cumulative emissions (1990–2016) were distributed China 20%, USA 20%, EU28 14%, Russia 6%, India 5%, Japan 4%
'All others' includes all other countries along with bunker fuels and statistical differences
Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

Emissions from coal, oil, gas, cement

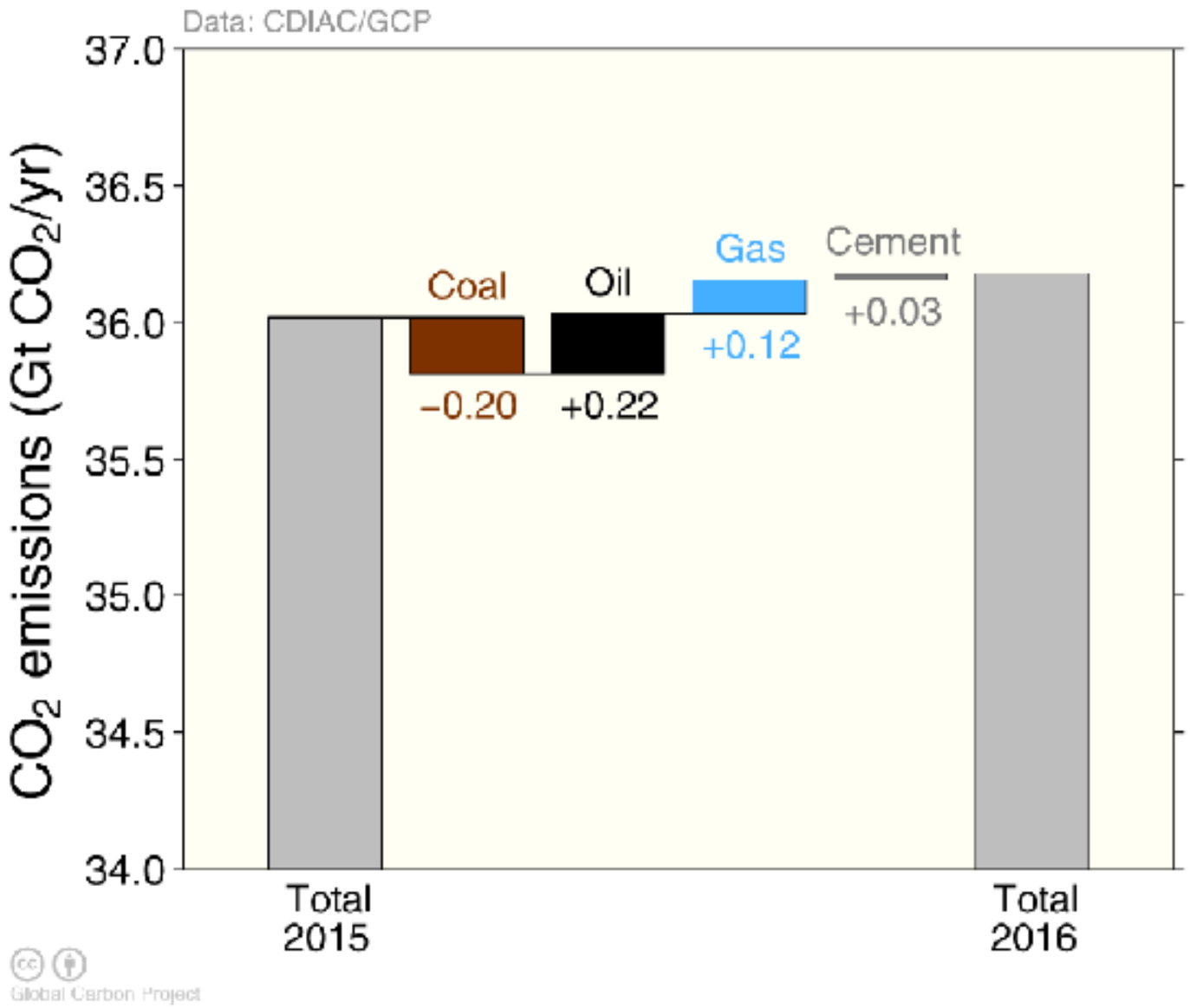
Share of global emissions in 2016:
coal (40%), oil (34%), gas (19%), cement (6%), flaring (1%, not shown)



Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

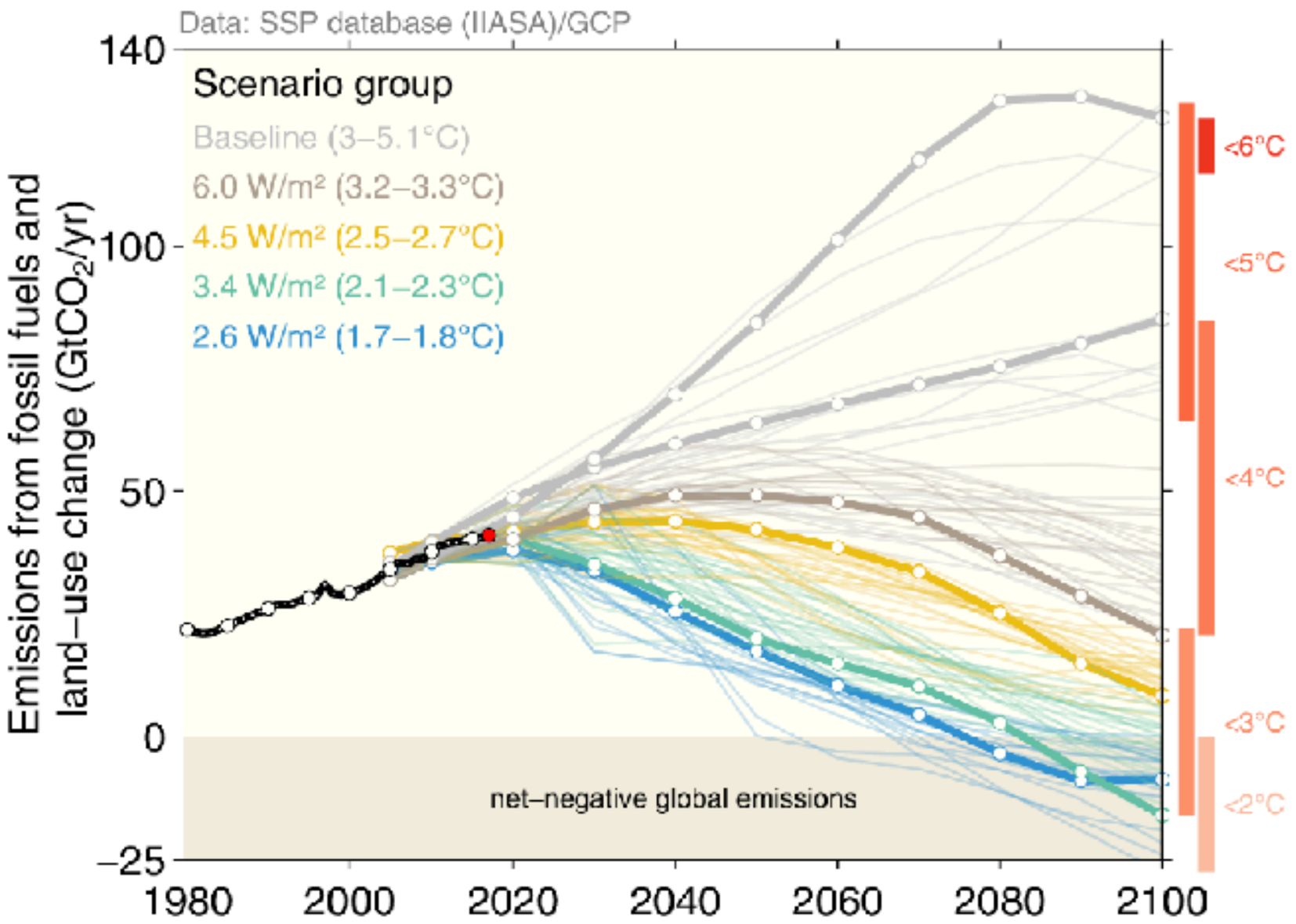
Fossil fuel and cement emissions growth

The biggest changes in emissions were from a decline in coal and an increase in oil



Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

New generation of emissions scenarios



Five Shared Socioeconomic Pathways (SSPs) have been developed to explore challenges to adaptation and mitigation. Shared Policy Assumptions (SPAs) are used to achieve target forcing levels (W/m^2). Marker Scenarios are indicated.

Source: Riahi et al. 2016; IIASA SSP Database; Global Carbon Budget 2017

Closing the global carbon budget

Fate of anthropogenic CO2 emissions (2007-2016)

Sources = **Sinks**

34.3 $GtCO_2/yr$

88%

12%

4.9 $GtCO_2/yr$

17.3 $GtCO_2/yr$

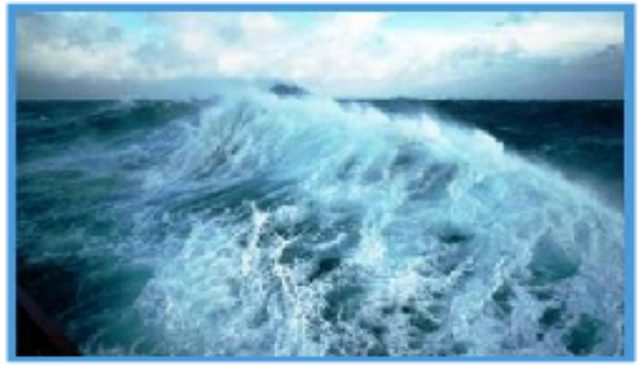
47%

30%

11.2 $GtCO_2/yr$

23%

8.7 $GtCO_2/yr$



Budget Imbalance:

(the difference between estimated sources & sinks)

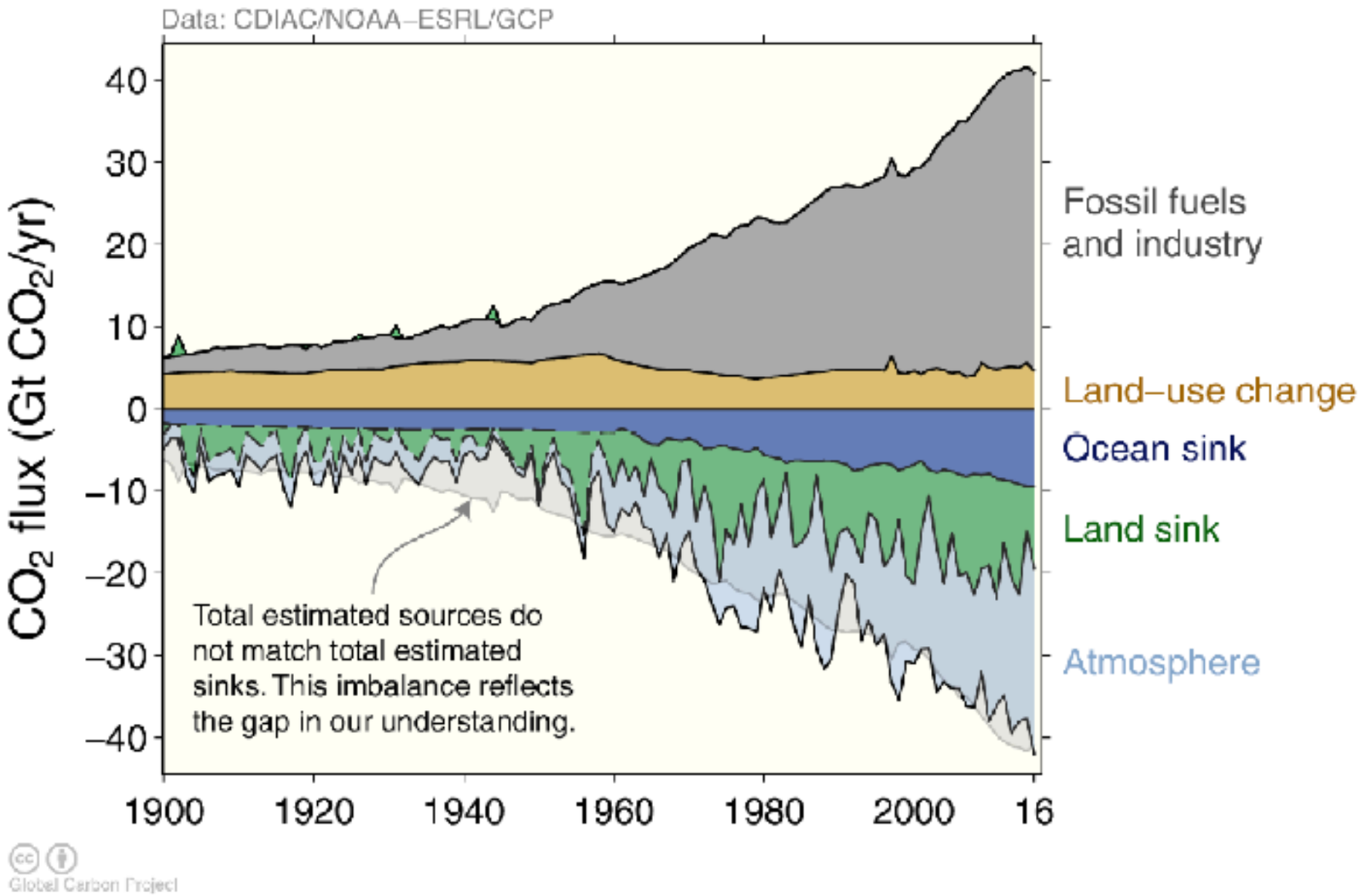
6%

2.1 $GtCO_2/yr$

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

Global carbon budget

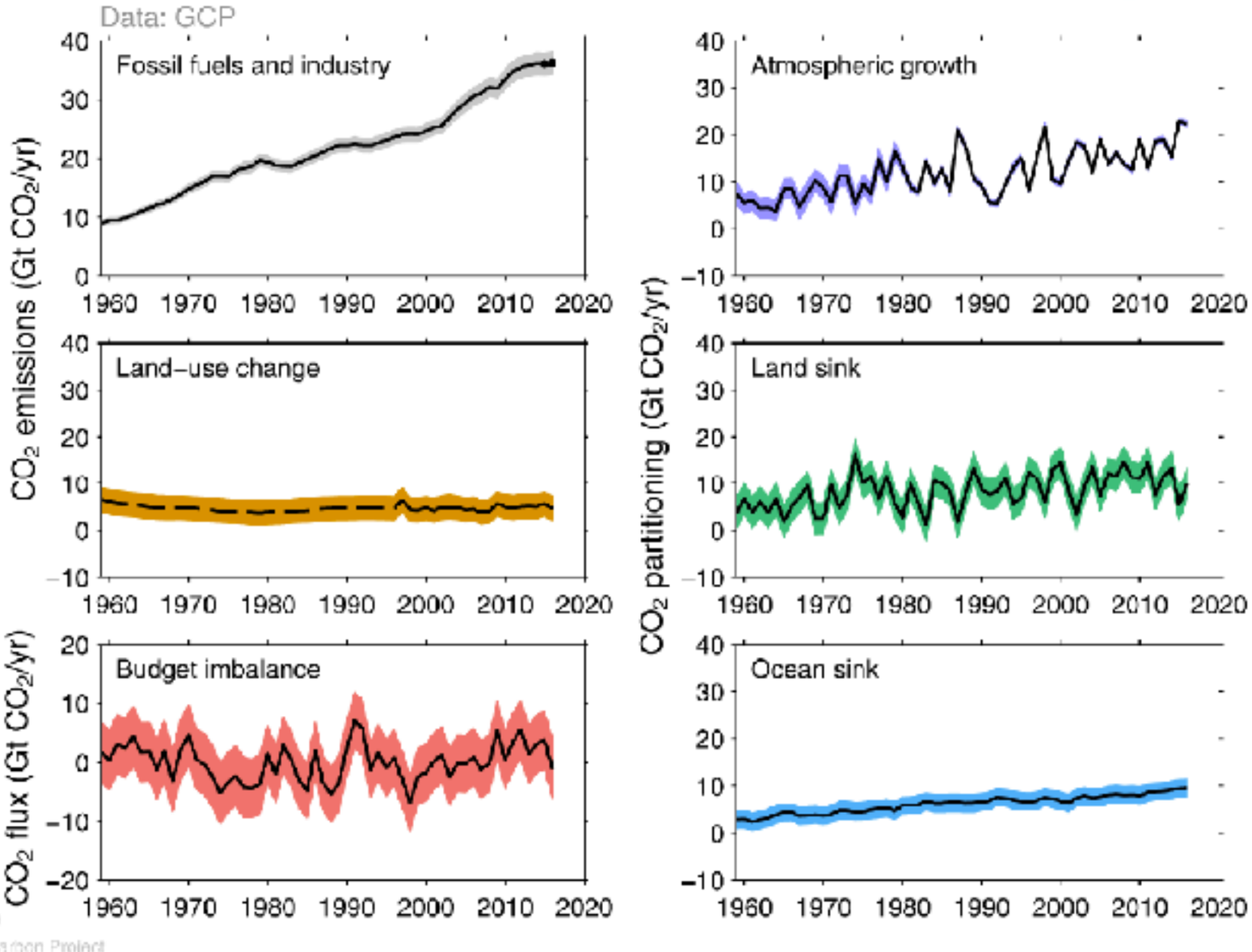
Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean
The "imbalance" between total emissions and total sinks reflects the gap in our understanding



Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Joos et al 2013; Khatiwala et al. 2013; DeVries 2014; Le Quéré et al 2017; Global Carbon Budget 2017

Changes in the budget over time

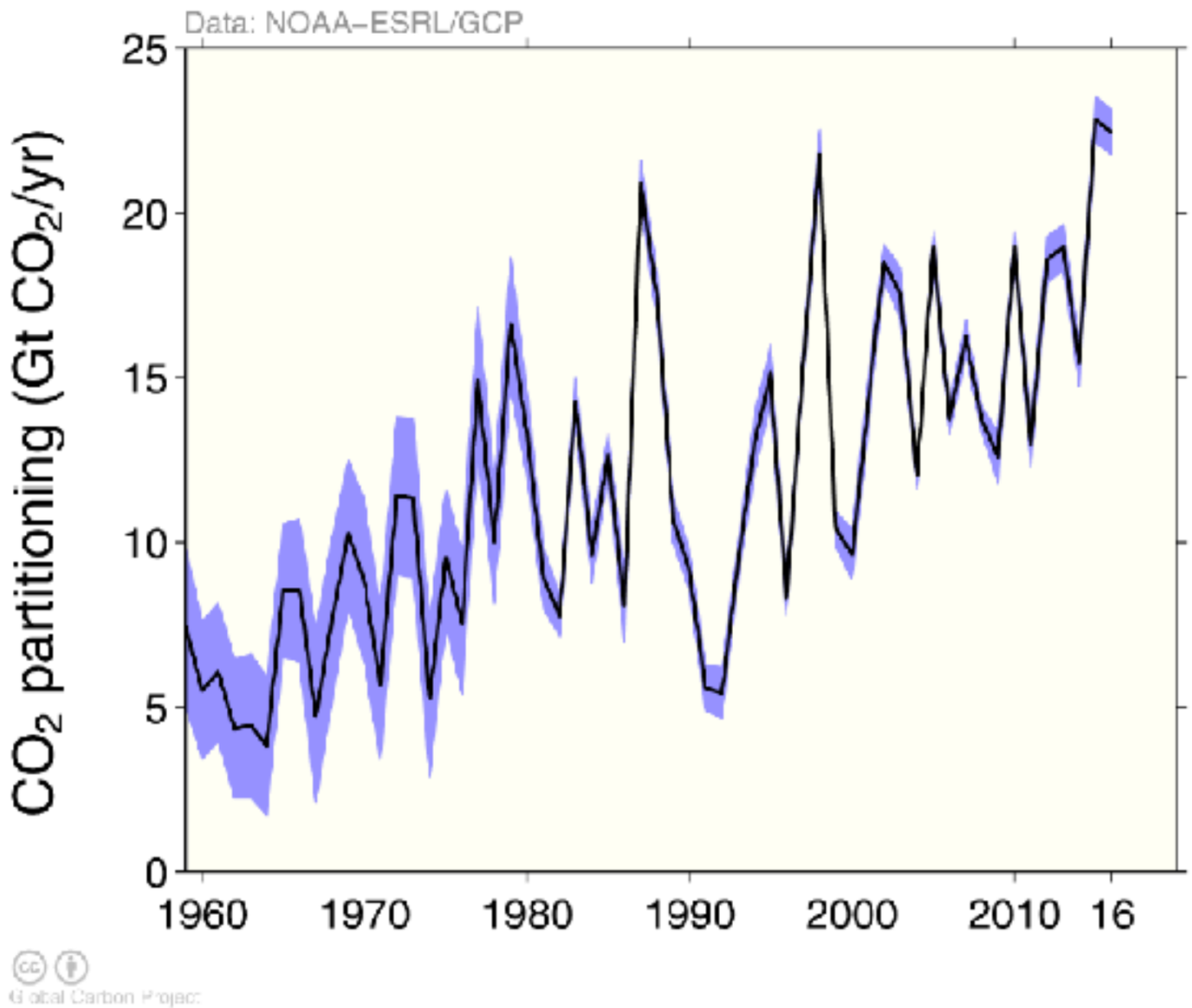
The sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere



The budget imbalance is the total emissions minus the estimated growth in the atmosphere, land and ocean.
It reflects the limits of our understanding of the carbon cycle.

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

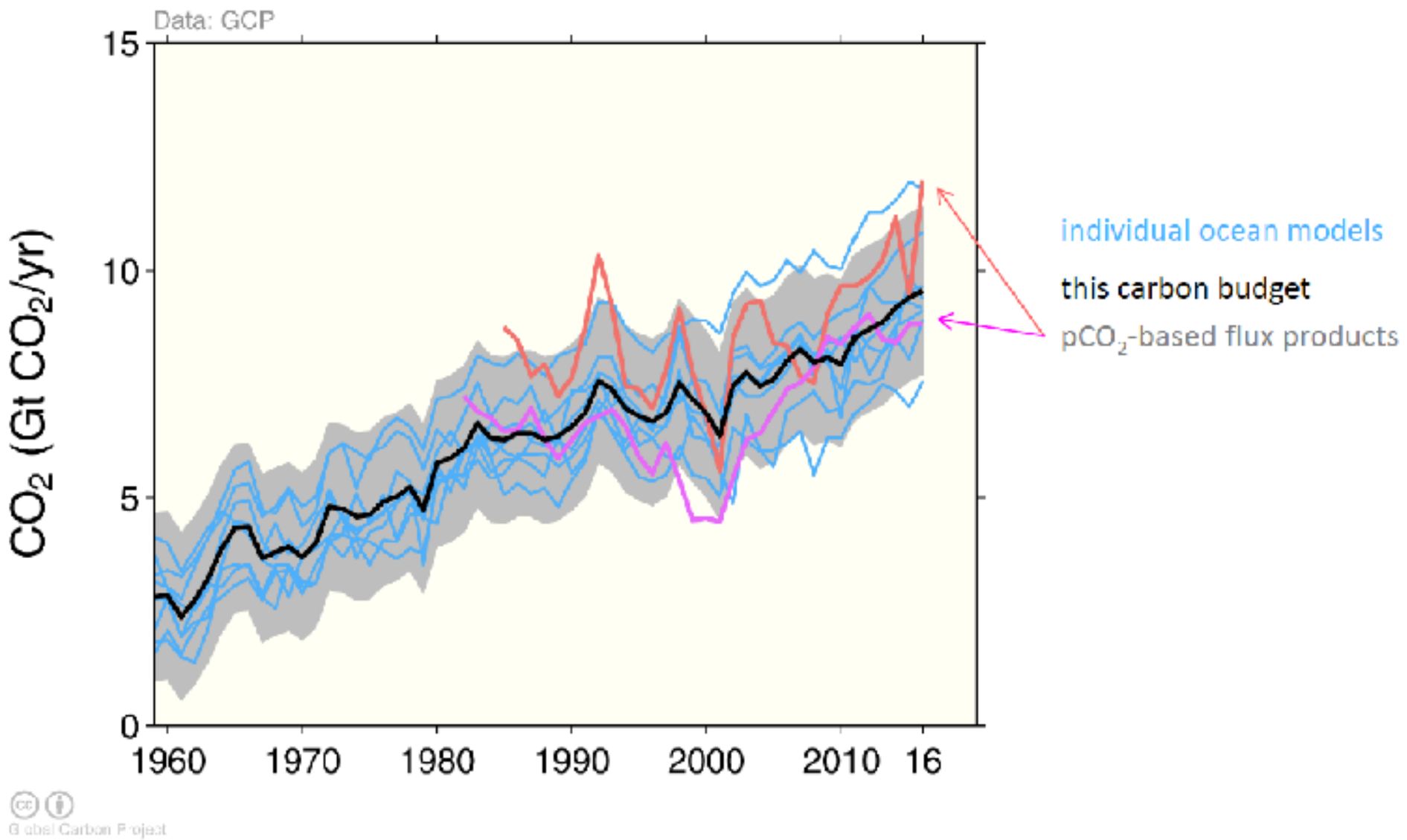
Atmospheric concentration



Source: NOAA-ESRL; Global Carbon Budget 2017

Ocean sink

The ocean carbon sink continues to increase
8.7±2 $GtCO_2$/yr for 2007–2016 and 9.6±2 $GtCO_2$/yr in 2016



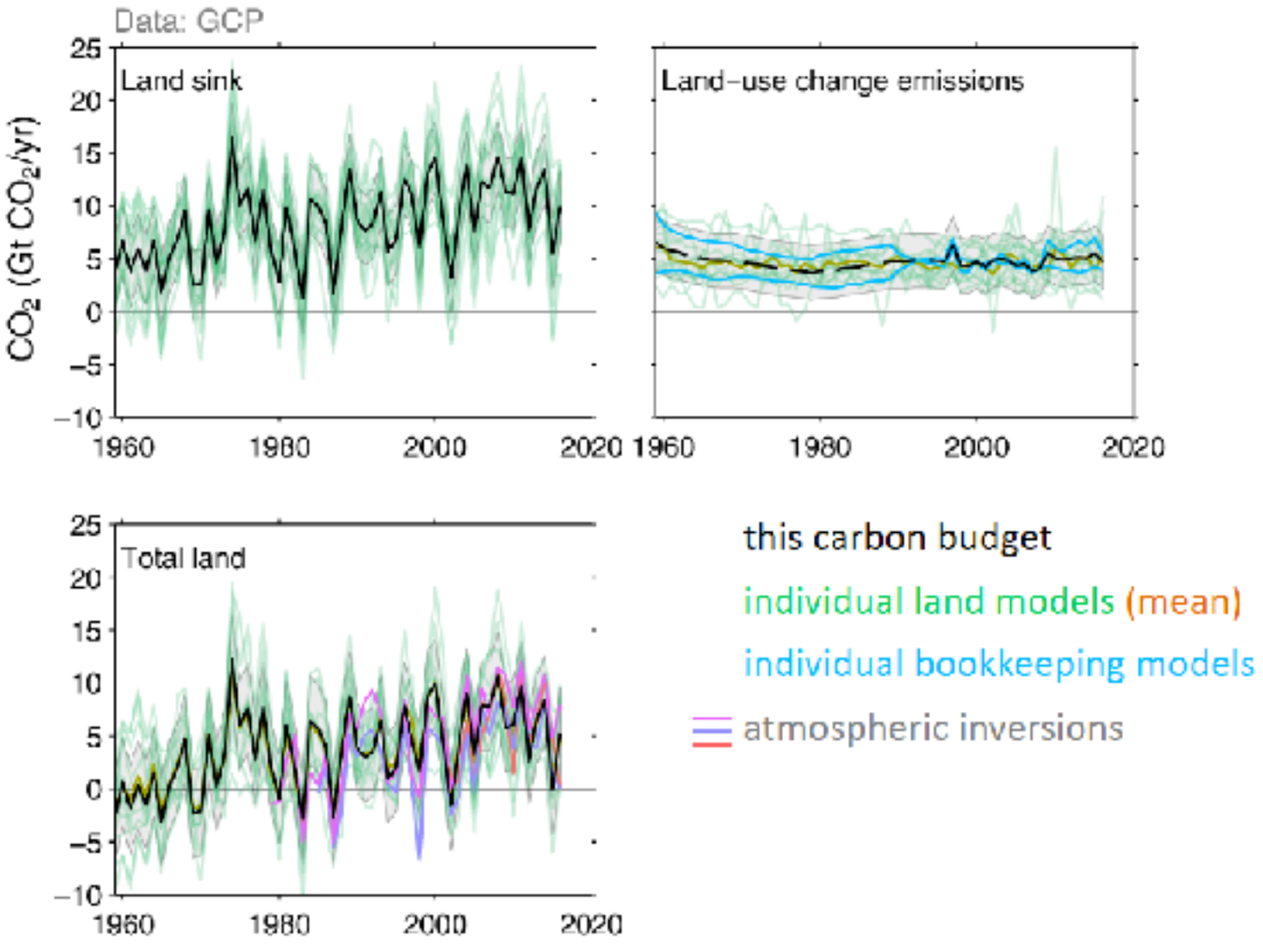
Source: SOCATv5; Bakker et al 2016; Le Quéré et al 2017; Global Carbon Budget 2017

Individual estimates from: Aumont and Bopp (2006); Bultenhuis et al. (2010); Doney et al. (2009); Hauck et al. (2016); Ilyina et al. (2013); Landschützer et al. (2016); Law et al. (2017); ; Rödenbeck et al. (2014). Séférian et al. (2013); Schwinger et al. (2016). Full references provided in Le Quéré et al. (2017).

Terrestrial sink

The land sink was 11.2±3 GtCO2/yr during 2007-2016 and 10±3 $GtCO_2$/yr in 2016

Total CO_2 fluxes on land (including land-use change) are constrained by atmospheric inversions

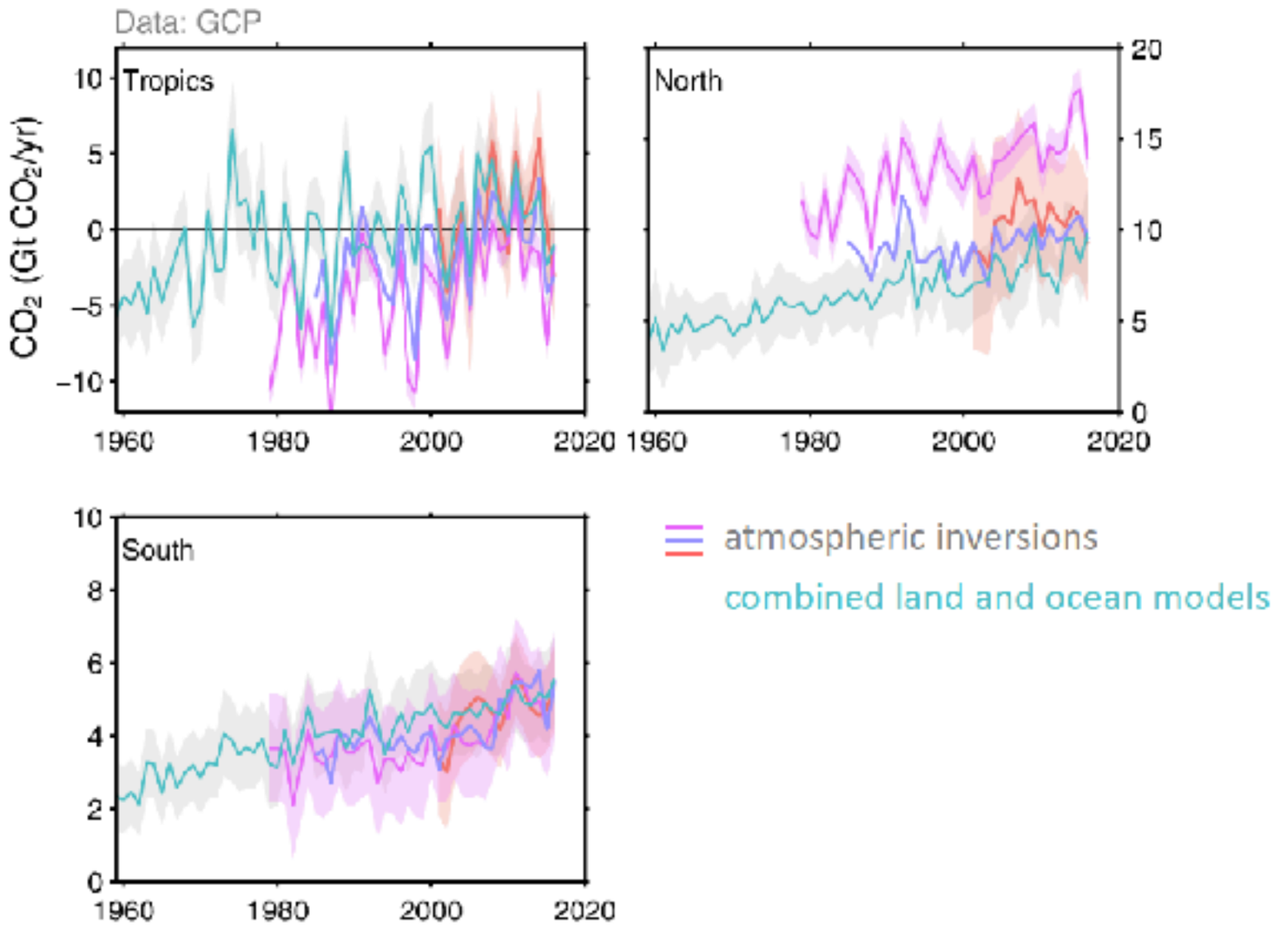


Source: Le Quéré et al 2017; Global Carbon Budget 2017

Individual estimates from: Chevallier et al. (2005); Clarke et al. (2011); Guimberteau et al. (2017); Hansis et al. (2015); Haverd et al. (2017); Houghton and Nassikas (2017); Iain et al. (2013); Kato et al. (2013); Keller et al. (2017); Krinner et al. (2005); Melton and Arora (2016); Oleson et al. (2013); Reick et al. (2013); Rodenbeck et al. (2003); Sitch et al. (2003); Smith et al. (2014); Tian et al. (2015); van der Laan-Luijkx et al. (2017); Woodward et al. (1995); Zaehle and Friend (2010). Full references provided in Le Quéré et al. (2017).

Total land and ocean fluxes

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



Source: Le Quéré et al 2017; Global Carbon Budget 2017

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Global carbon budget

The cumulative contributions to the global carbon budget from 1870

The carbon imbalance represents the gap in our current understanding of sources and sinks

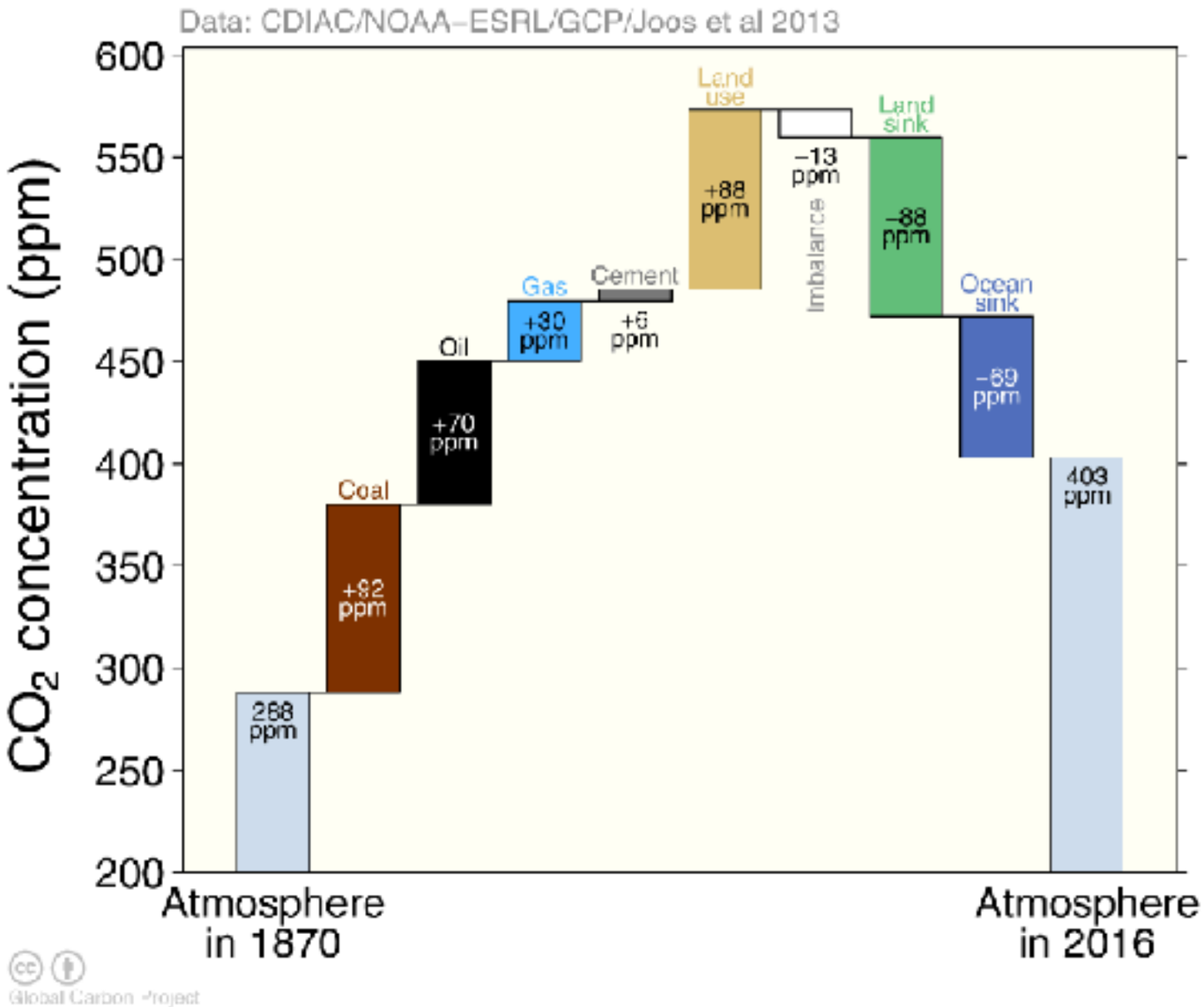

Figure concept from Shrink That Footprint

Source: CDIAC; NOAA-ESRL; Houghton and Nassikas 2017; Hansis et al 2015; Joos et al 2013; Khatiwala et al. 2013; DeVries 2014; Le Quéré et al 2017; Global Carbon Budget 2016

CARBON STORY

The Global Carbon Project is a scientific program that aims to draw a complete picture of the carbon cycle on planet Earth.
Take a short tour of our carbon story.

ENTER THE PAST

Investigate human progress through history and the human impact on the carbon in the atmosphere

ENTER THE PRESENT

Discover when, where and by whom carbon dioxide is emitted

ENTER THE FUTURE

Think about the climate that you would choose for your future

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