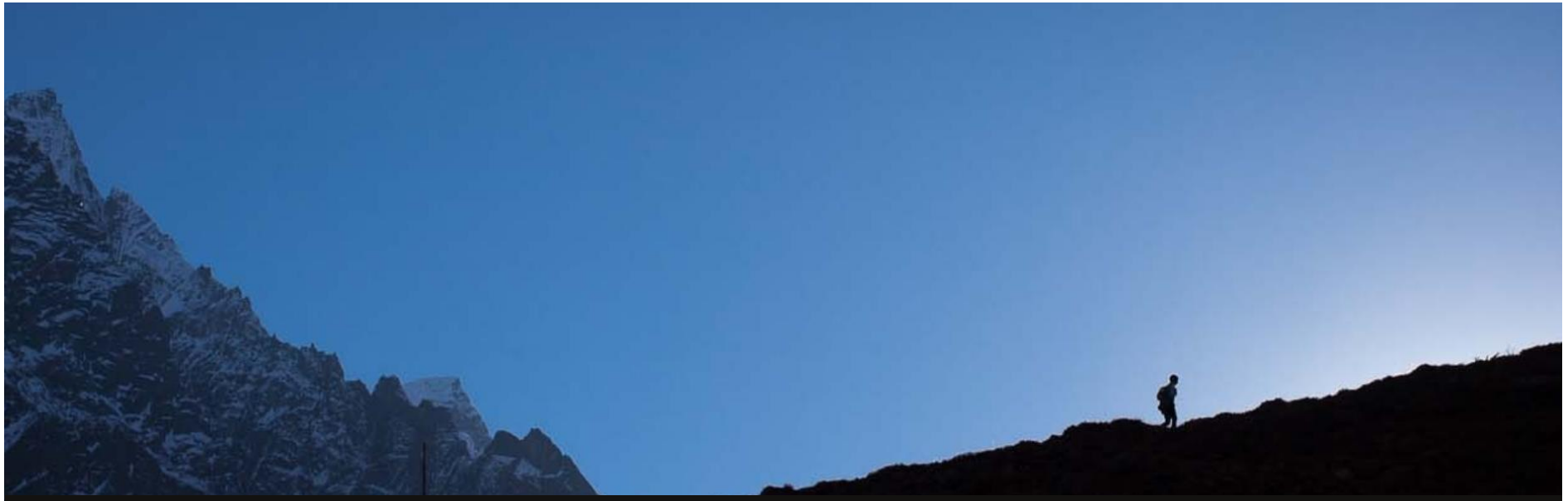
Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável



Class 3 | 25th March 2022 | Global energy and climate

Sofia G. Simoes

SEMINAR ENERGY & CLIMATE CHANGE

Climate Change and Sustainable Development Policies

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1	04/03 6ª Feira	16h-18h	Session reserved for students meeting with the Scientific Committee on practical aspects of the PhD Program, and choice of tutors.	Comissão Científica
2	11/03 6ª Feira	16h-18h	ENERGY & CLIMATE CHANGE: A COMPLEX RELATION, PERENE AND INTERDISCIPLINARY. Framework and purpose of the course in the PDACPDS. Practicalities and seminar program. Basic concepts of the energy systems.	J. Seixas, FCT NOVA
3	18/03 6ª Feira	16h-18h	**Current state of the global energy system :** main energy carriers, energy production and consumption regions; energy access; concepts of energy and carbon intensity.	S. Simões
4	25/03 6ª Feira	14h-16h	**Global balance of CO_2 emissions** associated with energy and industrial processes. Estimates of the Global Carbon Budget (http://www.globalcarbonproject.org/) and its relationship to the global energy system and changes in land use. Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways). Global emissions based on consumption vs. production.	S. Simões
5	02/04 Sábado	09h-11h	**Renewables:** Economic, environmental and energy security of endogenous vs. imported resources. Renewable technologies. Sustainability issues related with renewables. Land & water use, critical raw materials. Discussion: Where to place 7GW of solar PV in Portugal till 2030?	S. Simões
6	08/04 6ª Feira	16h-18h	**Energy concepts:** Primary/final energy; Sankey diagrams; energy efficiency; Energy services; Energy carriers; Final energy supply cost curves; learning curves of energy technologies. Definition and usefulness of LCOE. System value of Renewables. Global renewables' market.	S. Simões
7	22/04 6ª Feira	16h-18h	**Drawdown** - Climate Solutions for a New Decade	João P. Gouveia, FCT NOVA
8	30/04 Sábado	09h-11h	**Green hydrogen:** technological options, costs and the role for a carbon neutral energy system	P. Fortes, FCT NOVA
9	06/05 6ª Feira	18h-20h	**CARBON PRICING.** Regulatory framework in the European Union: 2020 - 2030 targets. Fit for 55. European low-carbon Roadmap 2050. Paris Agreement, and its implications.	S. Simões
10	13/05 6ª Feira	16h-18h	**Debate Como perspetivar o futuro da energia e alterações climáticas?** Baseado no artigo *An energy vision: the transformation towards sustainability — interconnected challenges and solution s*	students / S. Simões
11	21/05 Sábado	11h-13h	**Hands-on energy data:** access to energy databases, Portuguese and European (PORDATA, DGEG, EUROSTAT). i) How to find and explore energy statistics and emissions of greenhouse gas (GHG) emissions for Europe and Portugal; ii) How to make energy conversions; iii) How to build indicators and charts with added value; iii) How to analyze economic sectors, and interpret their performance in terms of energy consumption and greenhouse gas emissions.	S. Simões
12	27/05 6ª Feira	16h-18h	**Integrated assessment of energy systems:** The energy system addressed by the systems analysis approach. How to envisage the future energy system? Implications for the decision making in the medium and long term. Concept and formulation of cost-effectiveness within the integrated energy systems. Hands on Climate Mitigation Simulation	S. Simões
13	03/06 6ª Feira	16h-18h	Mentoring with each students' group : discussion on the approach and methods adopted by the students, expected results to be obtained with the final work; assessing preliminary results, if any.	S. Simões
14	17/06 6ª feira	18h-20h	**Smart and Sustainable cities:** concept, components and implications for the energy systems. The concept of Postive Energy Districts, and implications for future planning at the city level.	João P. Gouveia, FCT NOVA
	2 julho, 14h	14h-16h	Avaliações: apresentação dos trabalhos pelos alunos.	S. Simões / J. Seixas

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Júlia Seixas
mjs@fct.unl.pt

Sofia Simões
sofia.simoes@lneg.pt

João Gouveia
jplg@fct.unl.pt

Patrícia Fortes
p.fs@fct.unl.pt.pt

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If you need to discuss topics related to the course, including the assignment, I am available on Fridays 10h-11h – send me an e-mail to book this slot at least 4 days before

Para discussão de assuntos relacionados com o seminário, incluindo o trabalho final, estou disponível às sextas 10h-11h – têm que enviar-me e-mail previamente (pelo menos 4 dias antes)

Às 5as feiras 12h-13h é dada aula complementar em Português (zoom) para quem tem mais dificuldades com o inglês

Sofia G. Simões
sofia.simoes@lneg.pt
sgcs@fct.unl.pt

PROGRAM & RESOURCES @
https://moodle.fct.unl.pt/course/view.php?id=7450

Climate Change and Sustainable Development Policies

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Assignment

Challenge: Within the scope of your personal interests, select an economic activity:
Fashion | Communication | Food and Beveragel Industry | Health services | Mobility | Other

Assuming your country will be in the midst of a pathway to achieve a carbon neutral economy by 2050 (as stated in the Paris Agreement) or earlier, how do you envisage the selected activity will picture by 2030?

Team work | Think out of the box | Innovate

What is the challenge for the activity? Who are the challenge owners?
What do you envisage the activity must/should deliver in the future?

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Assignment | Suggestion of script for development:

- firstly, **formulate (and detail) the problem** as far as you are able;
- characterize the **activity at present** [for example, production / import technologies| type of markets and consumers | competition from other markets? | energy consumption profile | indicators of carbon intensity]
- **envisage the activity up to 2030** [technological options | product change - green| change of consumers | energy consumption profile | indicators of carbon intensity]
- systematize **opportunities for the mitigation** of the selected activities (identify needs of R & D, act on consumption preferences, the product value chain, among others)
- identify and anticipate **constraints and barriers to the desired mitigation**, and explain how to overcome them.

Tips: Start now; try to be objective and quantify what is possible; do not try to be exhaustive (you can not do it within just one course); explore examples that already exist in other countries; be creative.

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Assignment | EVALUATION:

Criteria [points/100], the goal of the exercise is to promote:

1. Your **ability to reason about the problem**, in a structured and integrated way (for example, within the value chain of the activity, including the international dimension if applicable); [25]
2. **Consistency and creativity in the scenario design** in 2030 taking into account the expectations of a 450 ppm scenario (aggressive reduction of GHG emissions); [20]
3. Show **knowledge about technological mitigation options**, in particular regarding the energy component; [20]
4. Demonstrate **robustness of analysis and arguments**, focusing on aspects of cost effectiveness, carbon economics, competitiveness, among others. Demonstrate ability to synthesize information and data processing; [20]
5. **Quality of presentation document** & clear and concise **oral presentation** [15]

Assignment | How the work will be developed?

- **Groups of 3 students** (please send me an **email with the group members until end of march**)
- **Coaching session** to each group, on the work development (one class dedicated to this, end of May or early June maybe 3rd June??)
- **Oral presentation**: 30 min/group [15 min for oral presentation + 15 min Q&A] 2 July 2022, friday, 14:00h, ICS (tbd)
- **Deliverable**: at the day before the oral presentation at maximum, students will send to Julia Seixas the presentation by email.
  - Presentation in pdf format: maximum 10 slides + word document with 3 pages at maximum (only if needed for complementary information).

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Assignment | GROUPS?

- Any groups?
- Some ideas so far
  - Decentralisation of energy
  - Agriculture's carbon neutrality
  - Fashion
  - Energy supply in Lagos (check for example C40 and other major cities)
  - Small scale retail?
- Common suggestion – try to narrow down the topic
- Question on date of 3rd june – some students not available – can we have a diferente date?

Hands on!

- https://ourworldindata.org/energy
- Check your country primary energy consumption
- Check your country energy intensity evolution

Do it for next class

- Paraguay
- Portugal

Climate Change and Sustainable Development Policies

Outline

- Carbon intensity
- Global balance of CO_2 emissions associated with energy and industrial processes & estimates of the Global Carbon Budget
- Global Carbon Budget relationship to the global energy system and changes in land use
- Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways)
- Global emissions based on consumption vs. production.

Climate Change and Sustainable Development Policies

Outline

- Carbon intensity

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COMMENTARY • CLIMATE CHANGE

Reducing carbon emissions is important. But tackling carbon intensity might be even more

BY MIGUEL JALLER AND H. SCOTT MATTHEWS

June 25, 2021 7:30 PM GMT

https://fortune.com/2021/06/25/carbon-intensity-emissions-climate-change-paris-agreement/

Climate Change and Sustainable Development Policies

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Outline

- Carbon intensity

Total carbon emissions / total units of production (e.g. tones cement or kWh electricity)

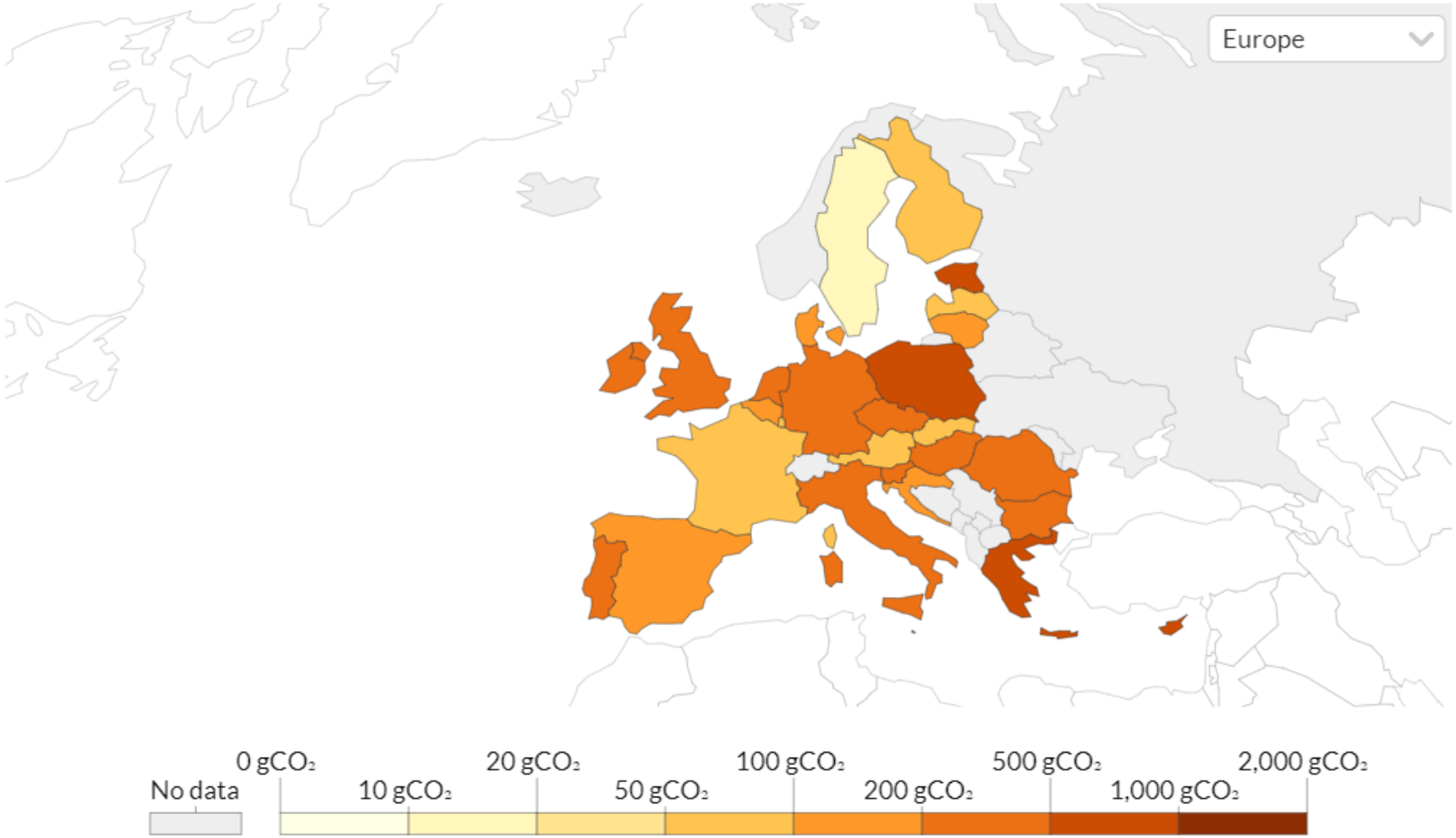
Total carbon emission / total economic activity (GDP)

To deal with climate change and global warming we need to become less carbon intensive as a whole

Carbon intensity of electricity per kWh, 2020

Carbon intensity measures the amount of greenhouse gases emitted per unit of electricity produced.
Here it is measured in grams of CO_2 per kilowatt-hour of electricity.

Our World in Data



https://ourworldindata.org/energy-key-charts

Source: Ember EU Power Sector 2020
Note: Data is currently only available for EU countries, plus the UK.

OurWorldInData.org/energy • CC BY

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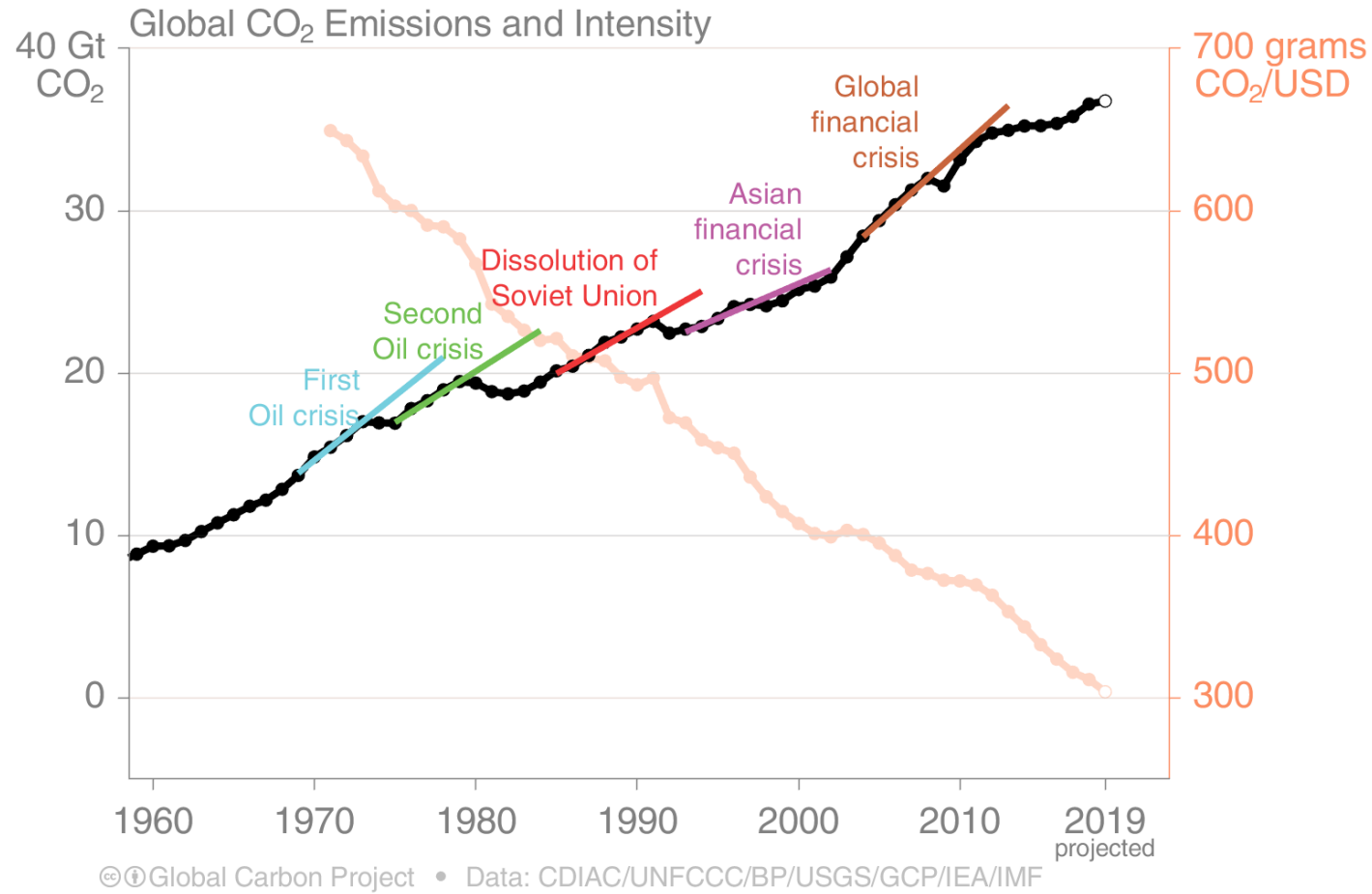
FOSSIL CO_2 EMISSION INTENSITY

Global CO_2 emissions growth has generally resumed quickly from financial crises.
Emission intensity has steadily declined but not sufficiently to offset economic growth.



Economic activity is measured in purchasing power parity (PPP) terms in 2010 US dollars.
Source: CDIAC; Peters et al 2012; Friedlingstein et al 2019; Global Carbon Budget 2019

Outline

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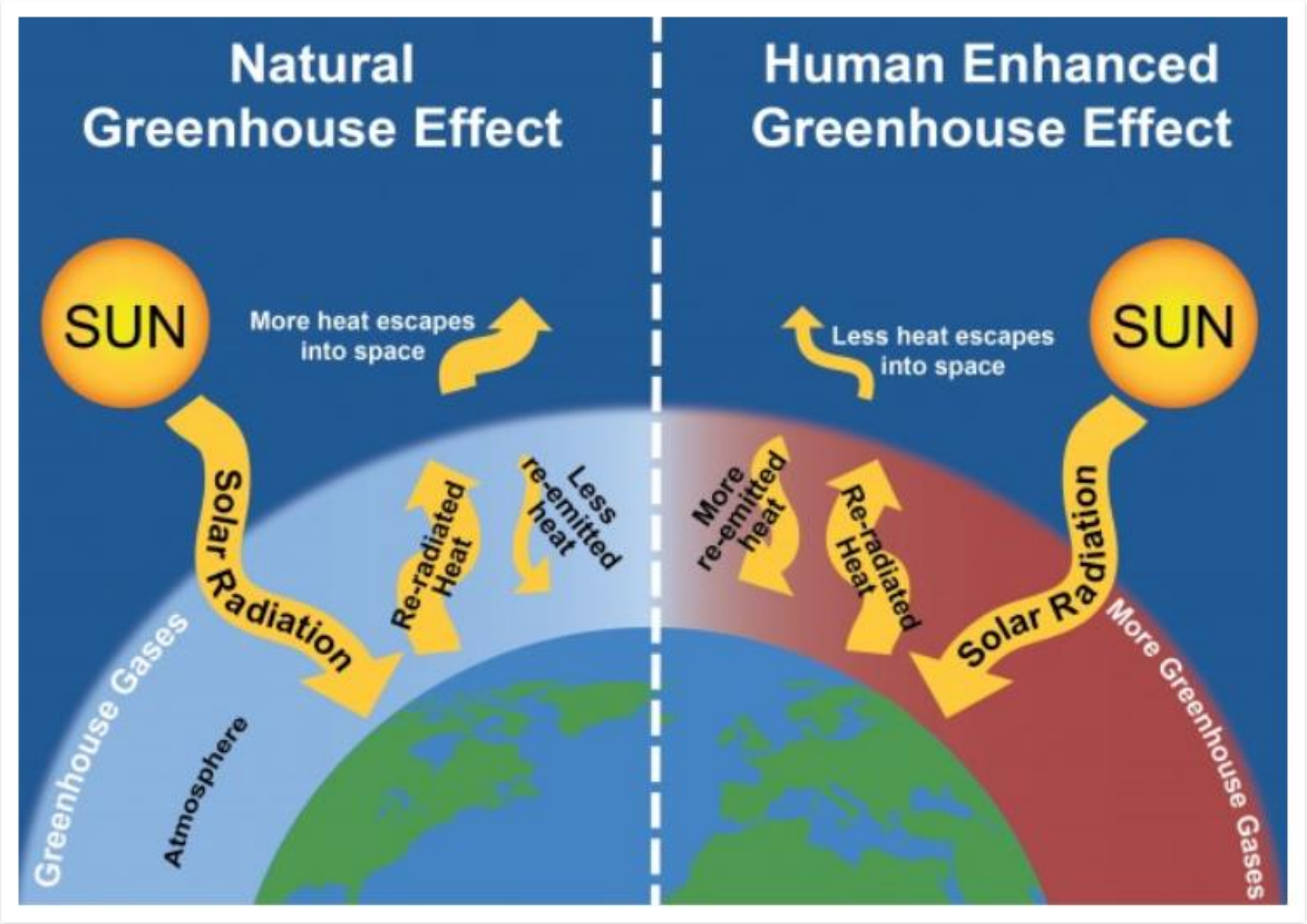

http://css.snre.umich.edu/factsheets/climate-change-science-and-impacts-factsheet

“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.

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).”

https://www.globalcarbonproject.org/carbonbudget/21/highlights.htm

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More information, data sources and data files:
http://www.globalcarbonproject.org/carbonbudget
Contact: Pep.Canadell@csiro.au

More information, data sources and data files:
www.globalcarbonatlas.org
(co-funded in part by BNP Paribas Foundation)
Contact: philippe.ciais@lsce.ipsl.fr

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All the data is shown in billion tonnes CO_2 ($GtCO_2$)

1 Gigatonne (Gt) = 1 billion tonnes = 1×10^{15}g = 1 Petagram (Pg)

1 kg carbon (C) = 3.664 kg carbon dioxide (CO_2)

1 GtC = 3.664 billion tonnes CO_2 = 3.664 $GtCO_2$

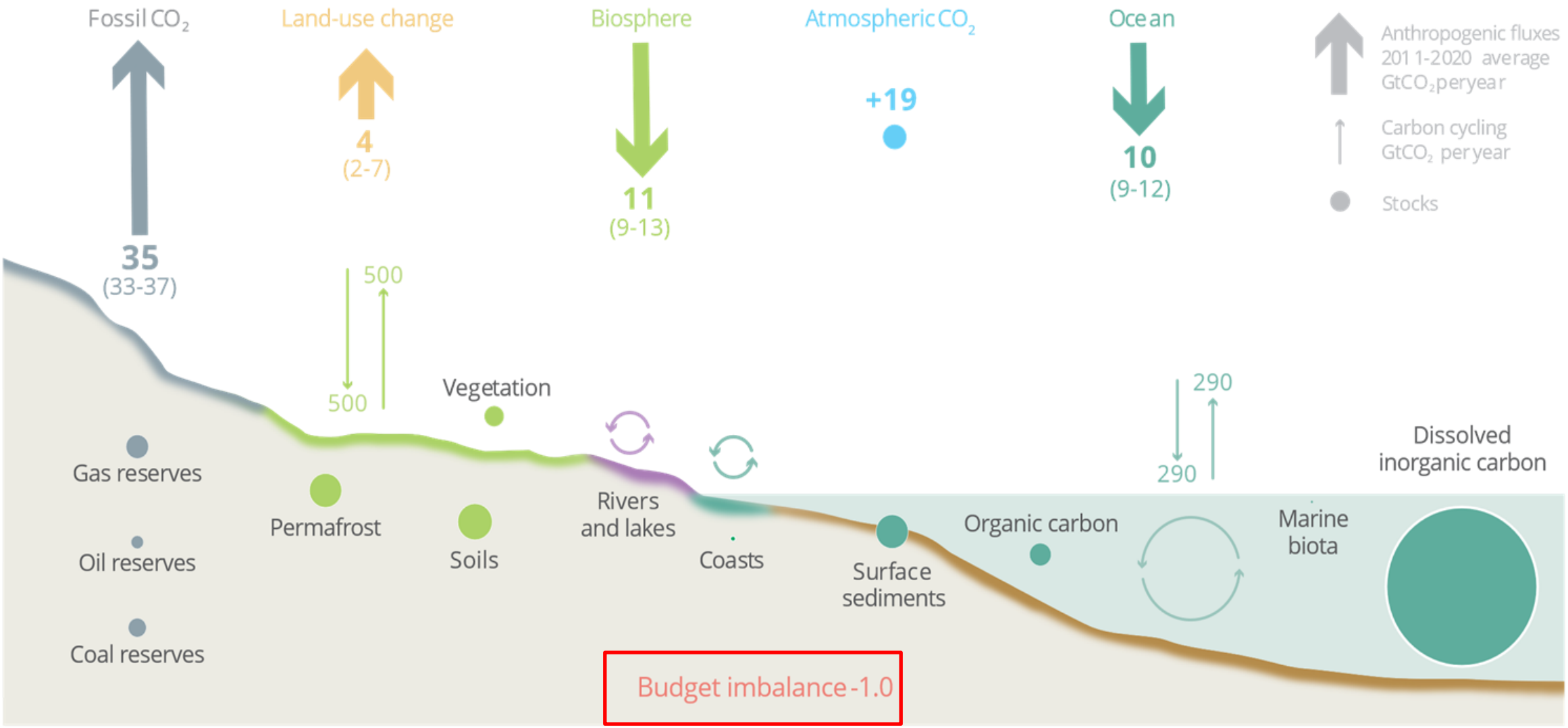
(Figures in units of GtC and $GtCO_2$ are available from http://globalcarbonbudget.org/carbonbudget)

Most figures in this presentation are available for download as PNG, PDF and SVG files from tinyurl.com/GCB21figs along with the data required to produce them.

Disclaimer

The Global Carbon Budget and the information presented here are intended for those interested in learning about the carbon cycle, and how human activities are changing it. The information contained herein is provided as a public service, with the understanding that the Global Carbon Project team make no warranties, either expressed or implied, concerning the accuracy, completeness, reliability, or suitability of the information.

Perturbation of the global carbon cycle caused by anthropogenic activities, global annual average for the decade 2011–2020 ($GtCO_2$/yr)



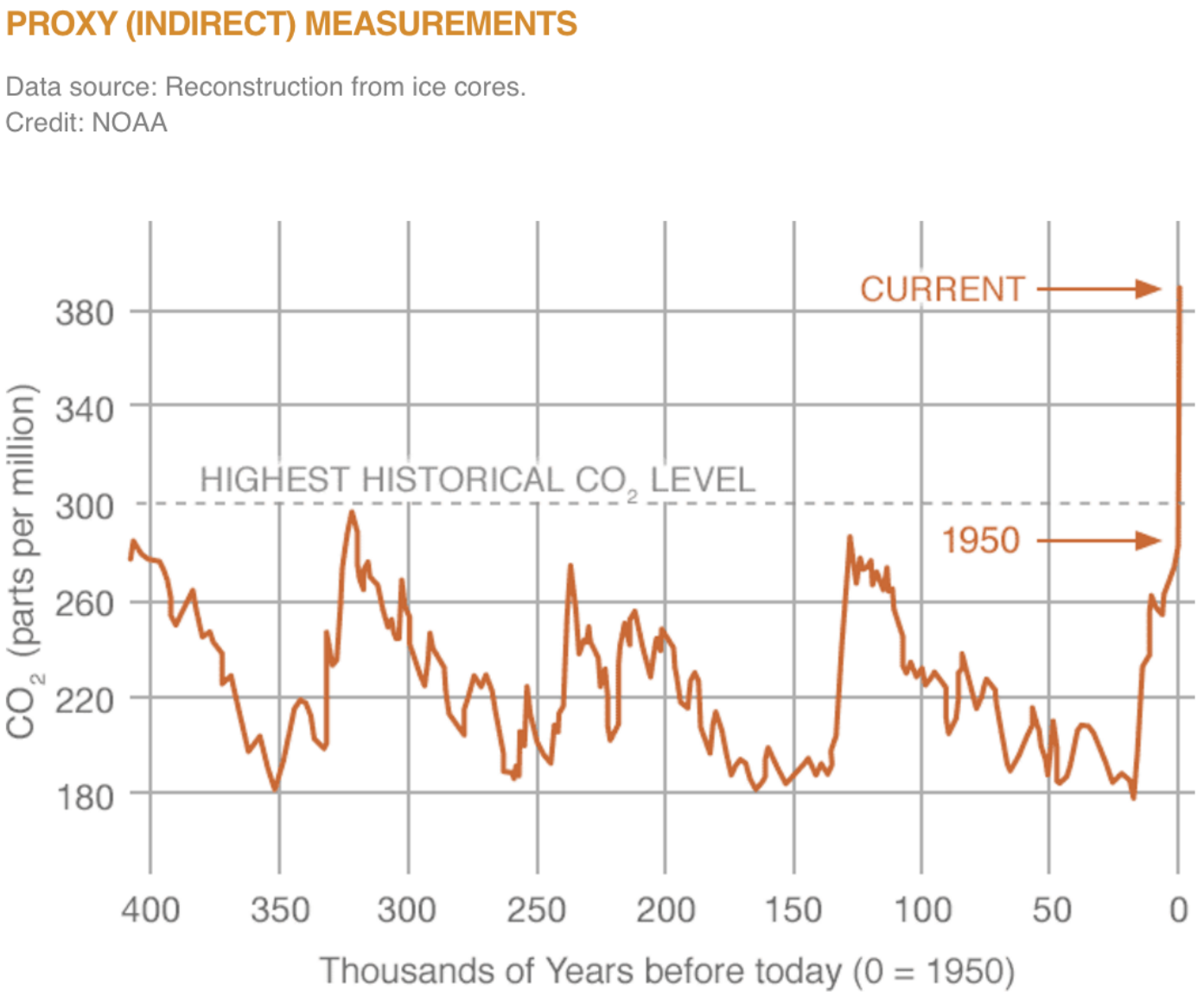
The budget imbalance is the difference between the estimated emissions and sinks.
Source: NOAA-ESRL; Friedlingstein et al 2021; Canadell et al 2021 (IPCC AR6 WG1 Chapter 5); Global Carbon Project 2021

https://www.globalcarbonproject.org/carbonbudget/21/presentation.htm

CO_2 concentration evolution (proxy – ice cores)

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

Reference: Atmospheric Infrared Sounder (AIRS).
See the animation:
http://climate.nasa.gov/vital-signs/carbon-dioxide/

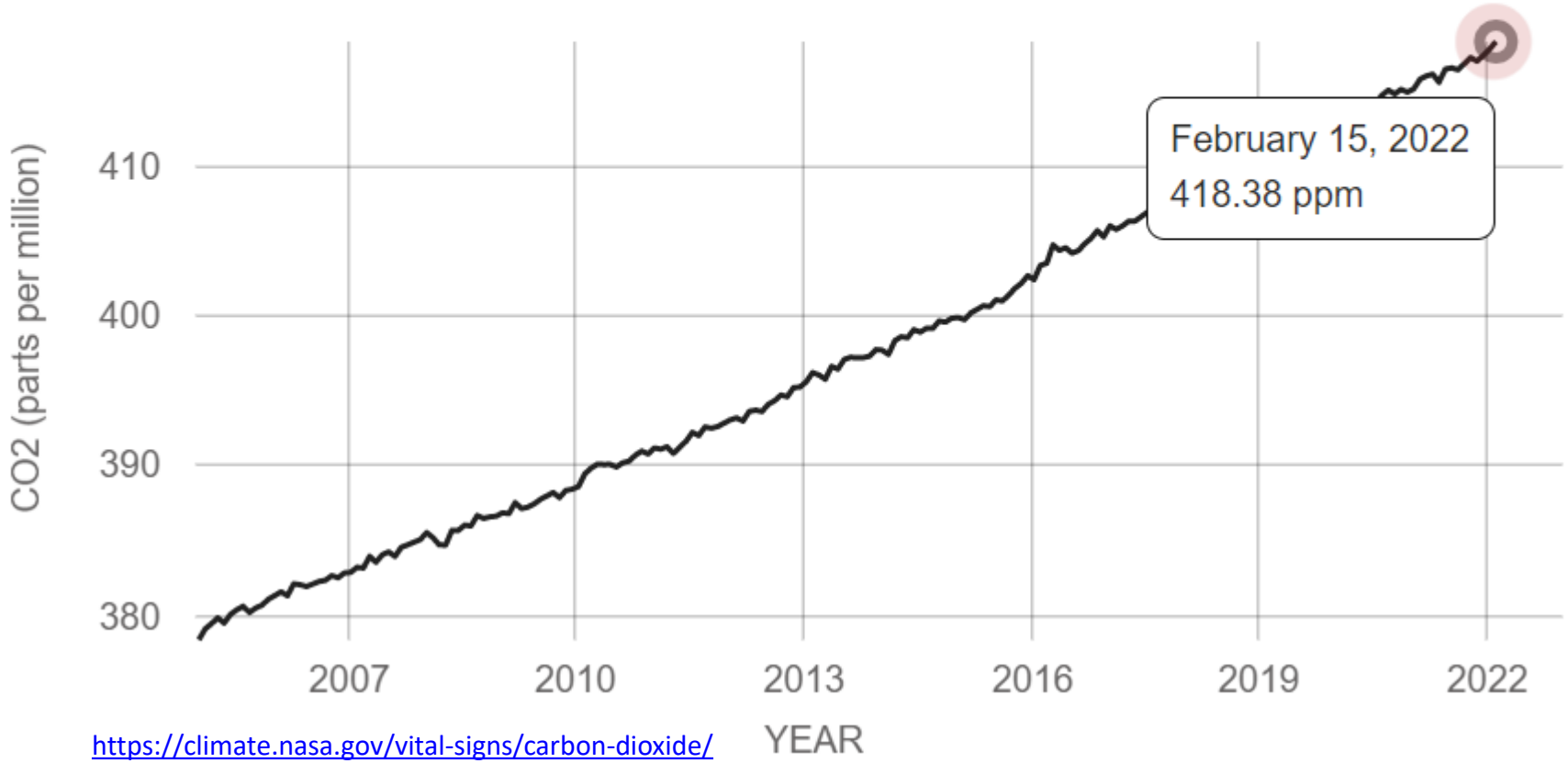


CO_2 concentration evolution in 20 years - measurement

GLOBAL CLIMATE CHANGE
Vital Signs of the Planet

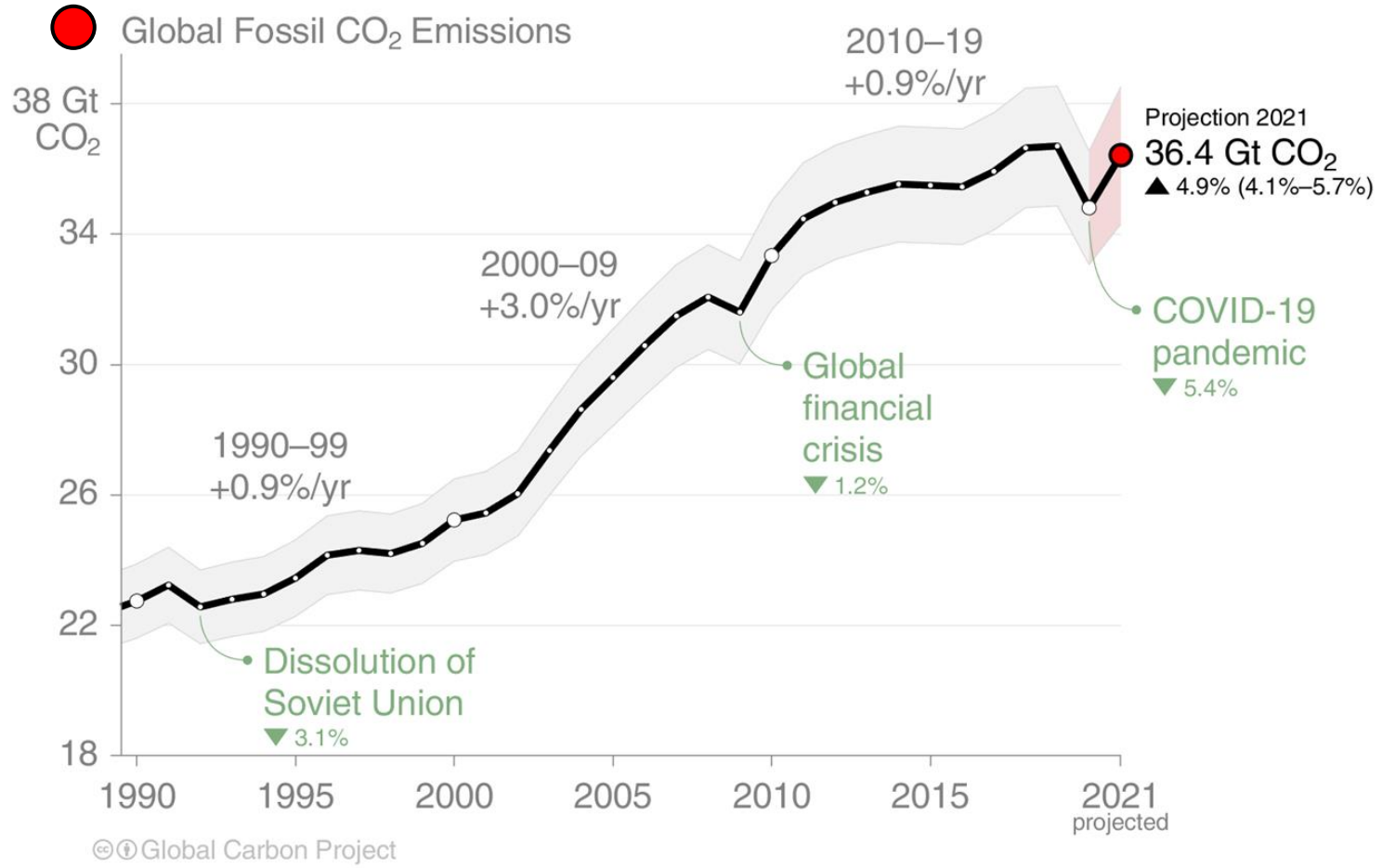
DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA



https://climate.nasa.gov/vital-signs/carbon-dioxide/

Global fossil CO_2 emissions: 34.8 ± 2 $GtCO_2$ in 2020, 53% over 1990
Projection for 2021: 36.4 ± 2 $GtCO_2$, 4.9% [4.1%–5.7%] higher than 2020



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

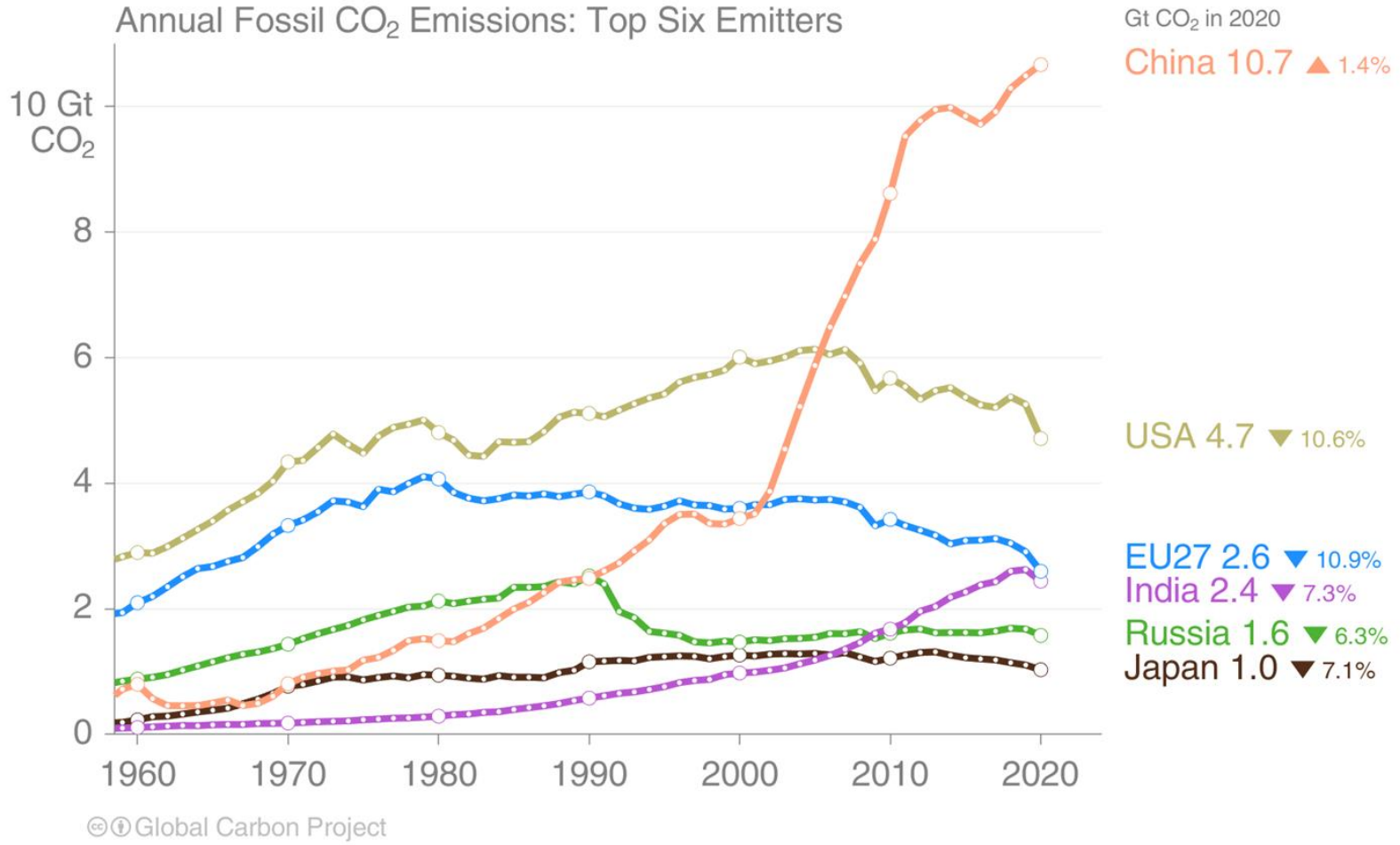
The 2021 projection is based on preliminary data and modelling.

Source: Friedlingstein et al 2021; Global Carbon Project 2021

https://www.globalcarbonproject.org/carbonbudget/21/presentation.htm

TOP EMITTERS: FOSSIL CO_2 EMISSIONS

The top six emitters in 2020 covered 66% of global emissions
China 31%, United States 14%, EU27 7%, India 7%, Russia 5%, and Japan 3%

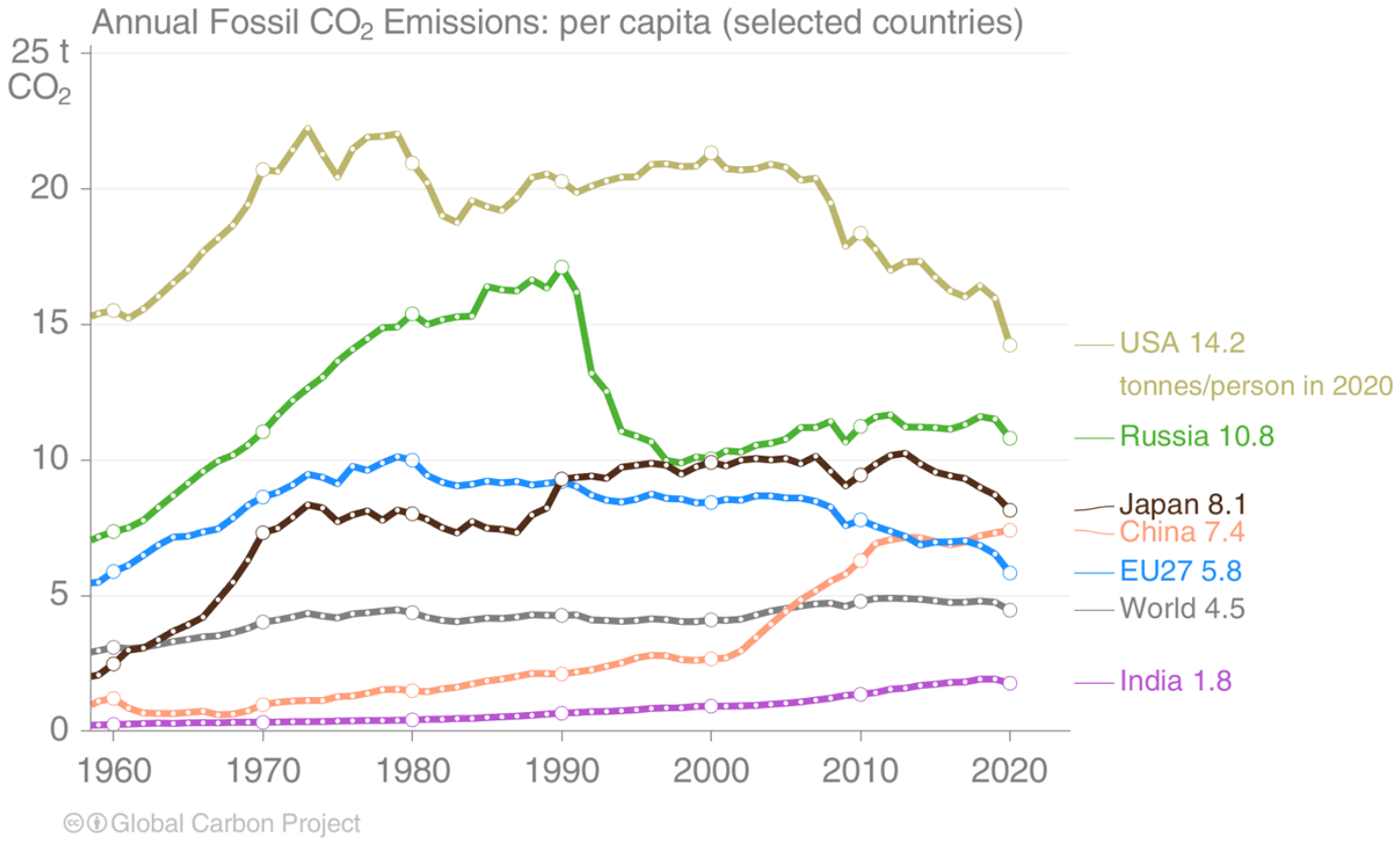


International aviation and maritime shipping (bunker fuels) contributed 2.9% of global emissions in 2020.

Source: Friedlingstein et al 2021; Global Carbon Project 2021

TOP EMITTERS: FOSSIL CO_2 EMISSIONS PER CAPITA

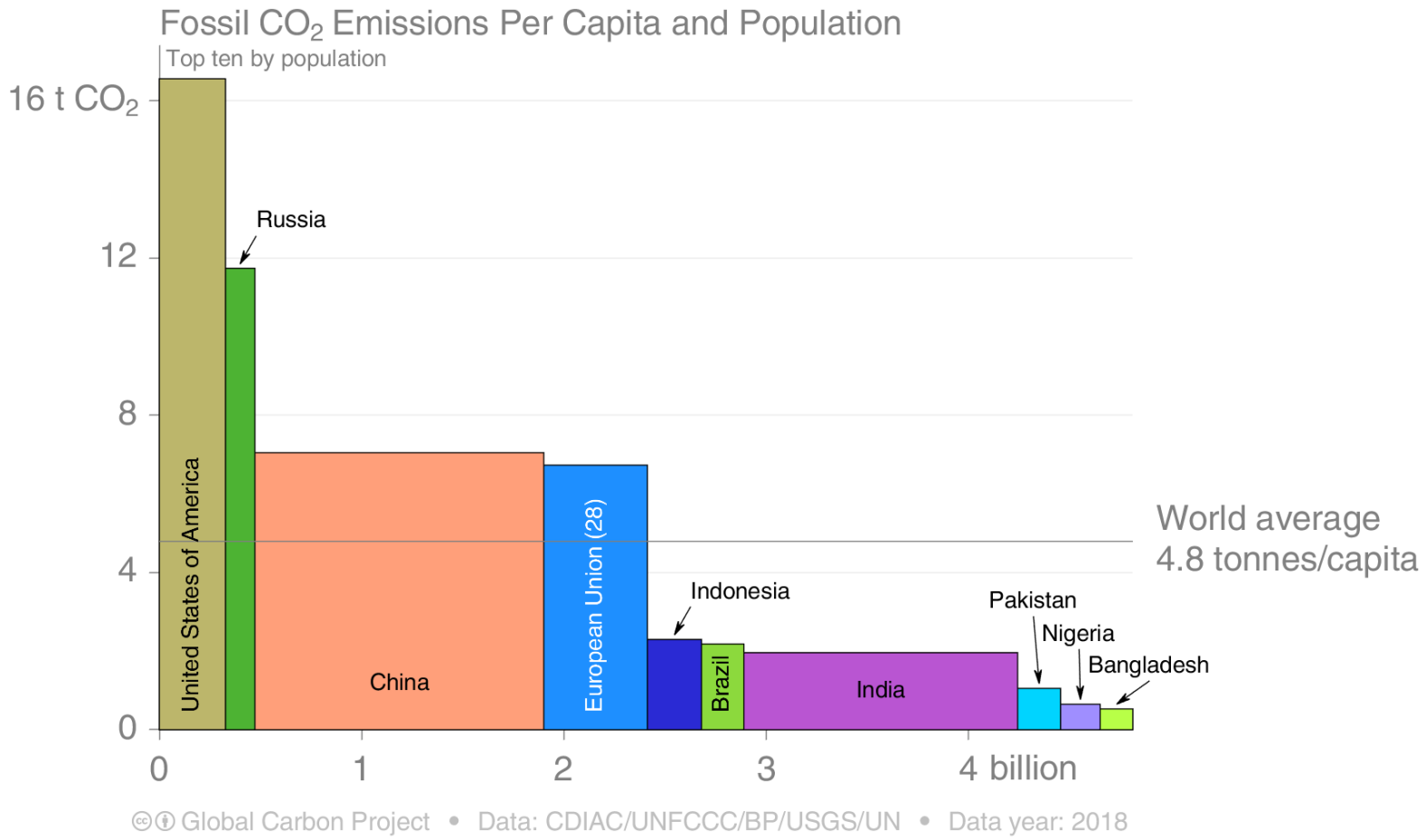
Countries have a broad range of per capita emissions reflecting their national circumstances



Source: Friedlingstein et al 2021; Global Carbon Project 2021

FOSSIL CO_2 EMISSIONS PER CAPITA

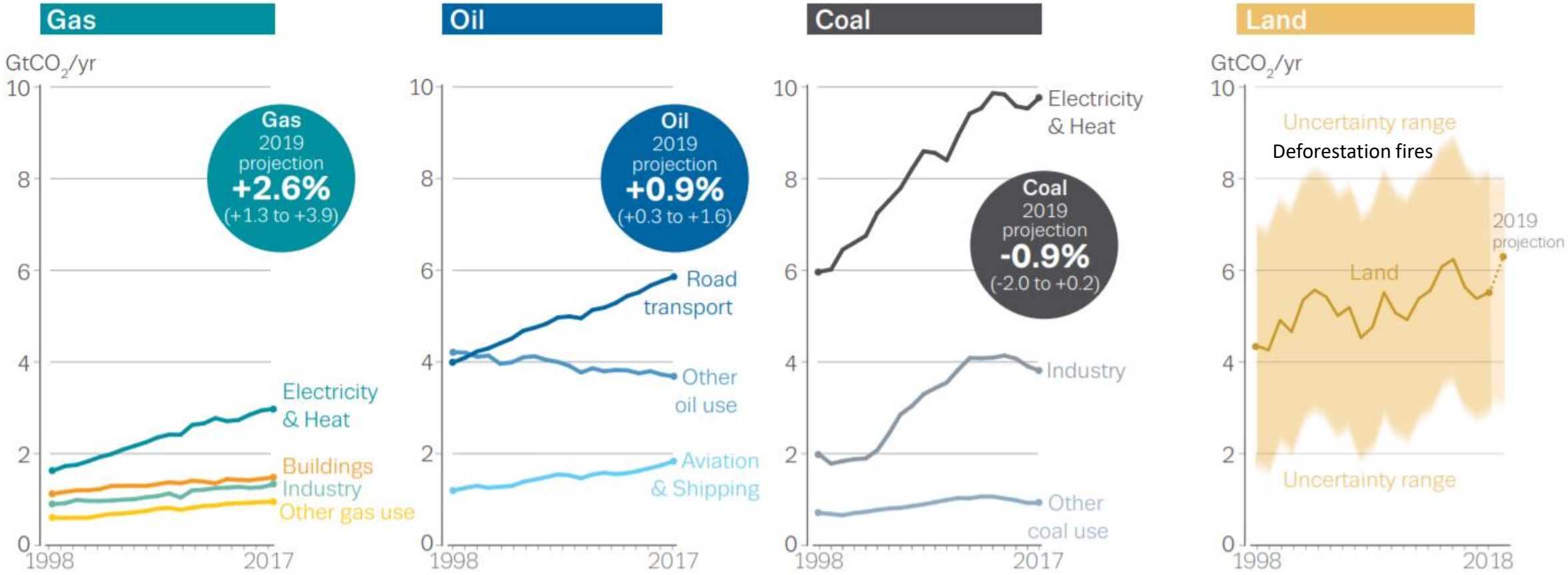
The 10 most populous countries span a wide range of development and emissions per capita



Emission per capita: Fossil CO_2 emissions divided by population

Source: Global Carbon Budget 2019

Natural gas and oil now drive global emissions growth

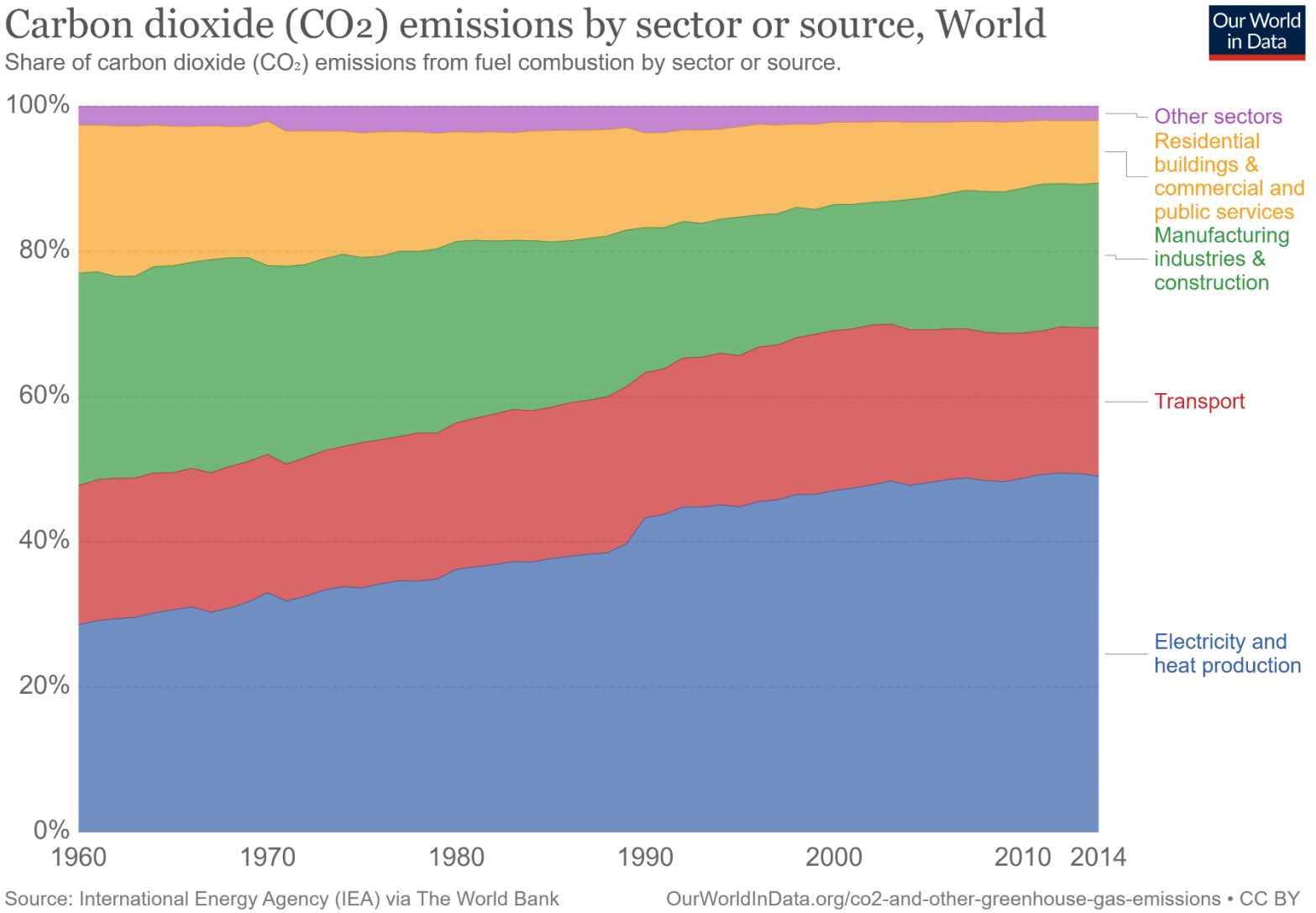


Source: 2019 projection by the Global Carbon Project. Trend to 2017 based on data from the IEA (2019) CO_2 Emissions from Fuel Combustion, www.iea.org/statistics. All rights reserved.

https://www.globalcarbonproject.org/global/images/carbonbudget/Infographic_Emissions2019.pdf

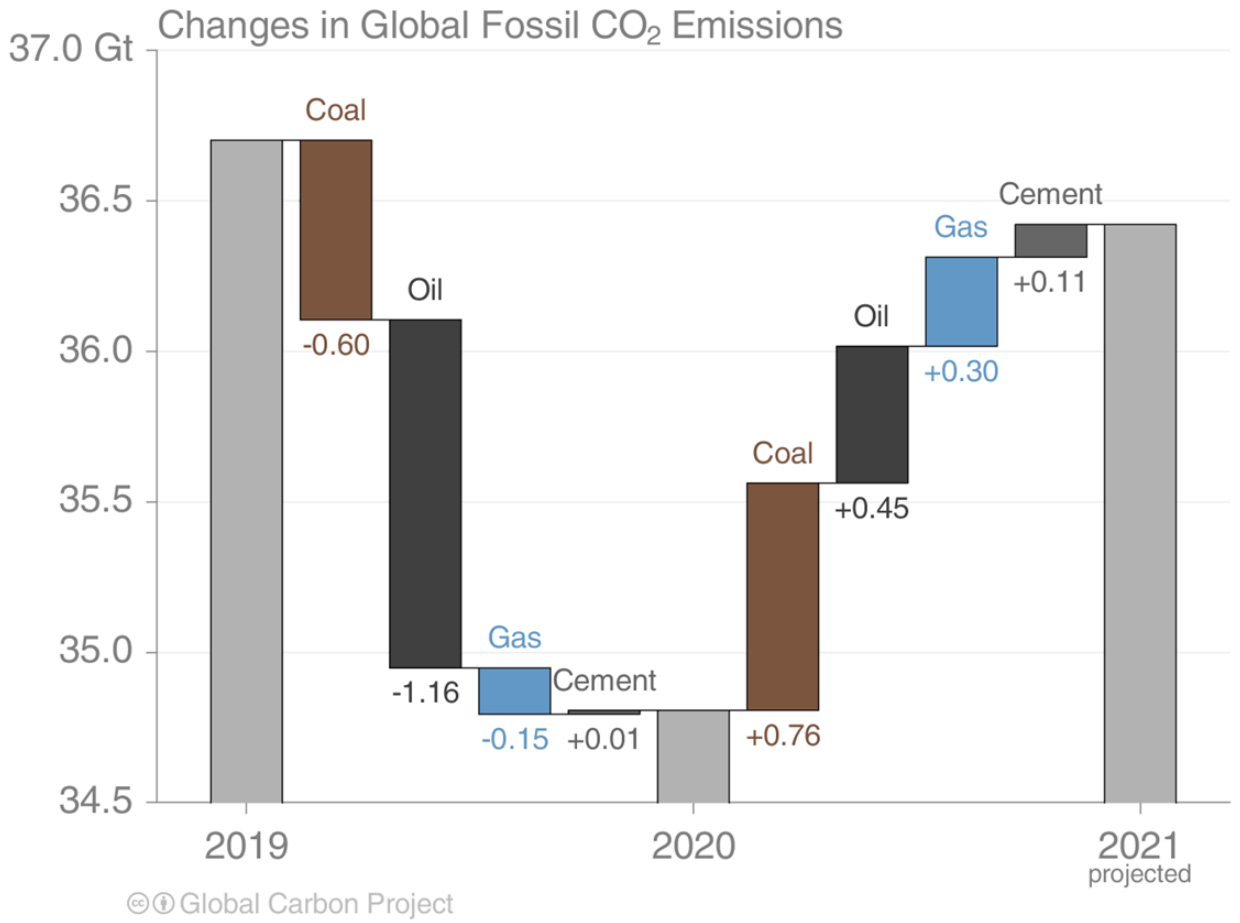
Transport represent 20% emissions in 2014, as industry

50% emissions originate from electricity generation and heat production



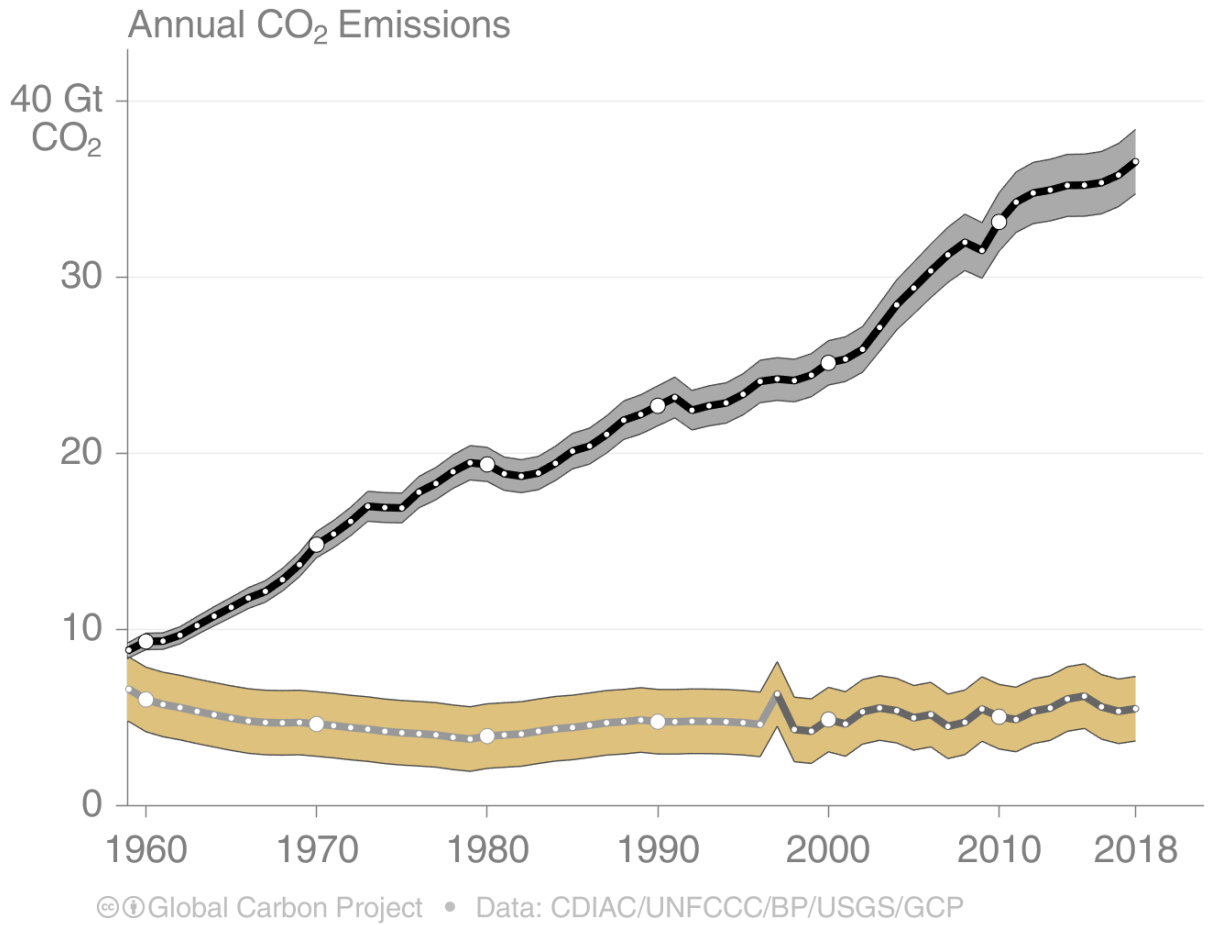
https://ourworldindata.org/energy

Global emissions in 2020 dropped across all categories. In 2021 coal and natural gas have more than recovered this loss, while oil still lags with from subdued transportation.



TOTAL GLOBAL EMISSIONS

Total global emissions: 42.1 ± 2.8 $GtCO_2$ in 2018, 55% over 1990
Percentage land-use change: 39% in 1960, 14% averaged 2009–2018



Fossil carbon

Land-use change

Land-use change estimates from two bookkeeping models, using fire-based variability from 1997

Source: CDIAC; Houghton and Nassikas 2017; Hansis et al 2015; van der Werf et al. 2017; Friedlingstein et al 2019; Global Carbon Budget 2019

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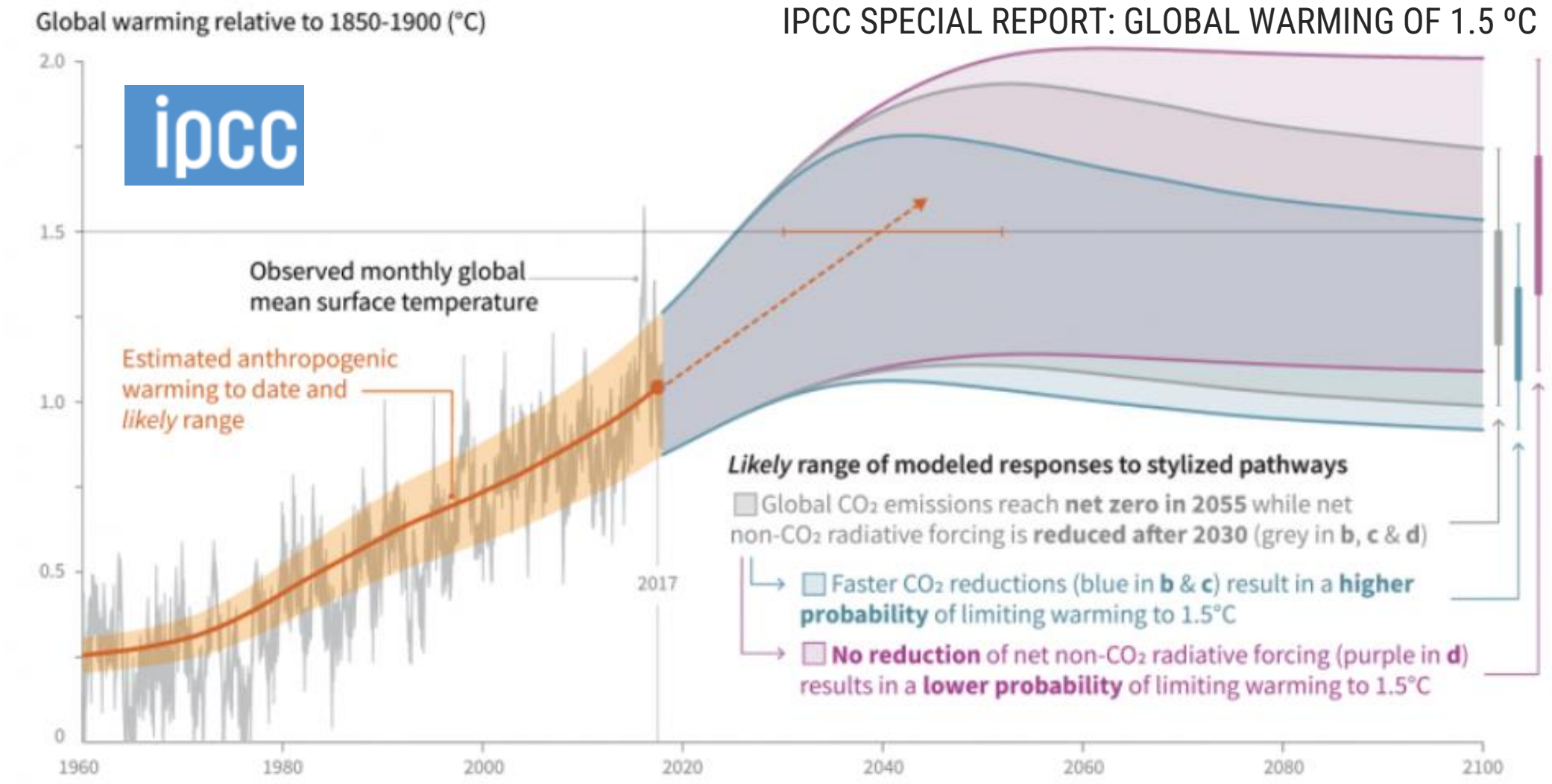
Climate Change and Sustainable Development Policies

Where are we heading…



https://www.ipcc.ch/sr15/chapter/spm/

Modelling the Future

We use **climate models** to simulate how the climate system will respond to a possible future scenario under a specified concentration of greenhouse gases (GHGs) in the atmosphere. In 2014, the United Nations Intergovernmental Panel on Climate Change (IPCC) selected four possible **climate scenarios** for modelling and research. These Representative Concentration Pathways, or **RCPs**, represent different possible climate futures for our earth. Clim2Power uses two of these scenarios for our research: **RCP 4.5** and **RCP 8.5**.

Clim2Power
Fact Sheets
www.clim2power.com

JPI Climate

RCP 4.5: Emissions in RCP 4.5 peak around 2040, then decline

RCP 8.5: In RCP 8.5, emissions continue rising throughout the 21st century

Across all RCPs, global mean temperature is projected to rise by 0.3 to 4.8 °C by the late 21st century due to an increase in atmospheric greenhouse gas emissions since the industrial era.

Climate Scenarios

plausible and often simplified representations of the future climate used for research and serving as input for impact models

Climate Modelling

a simplified, mathematical way to approximate reality, which we can use to make climate projections

Climate Projections

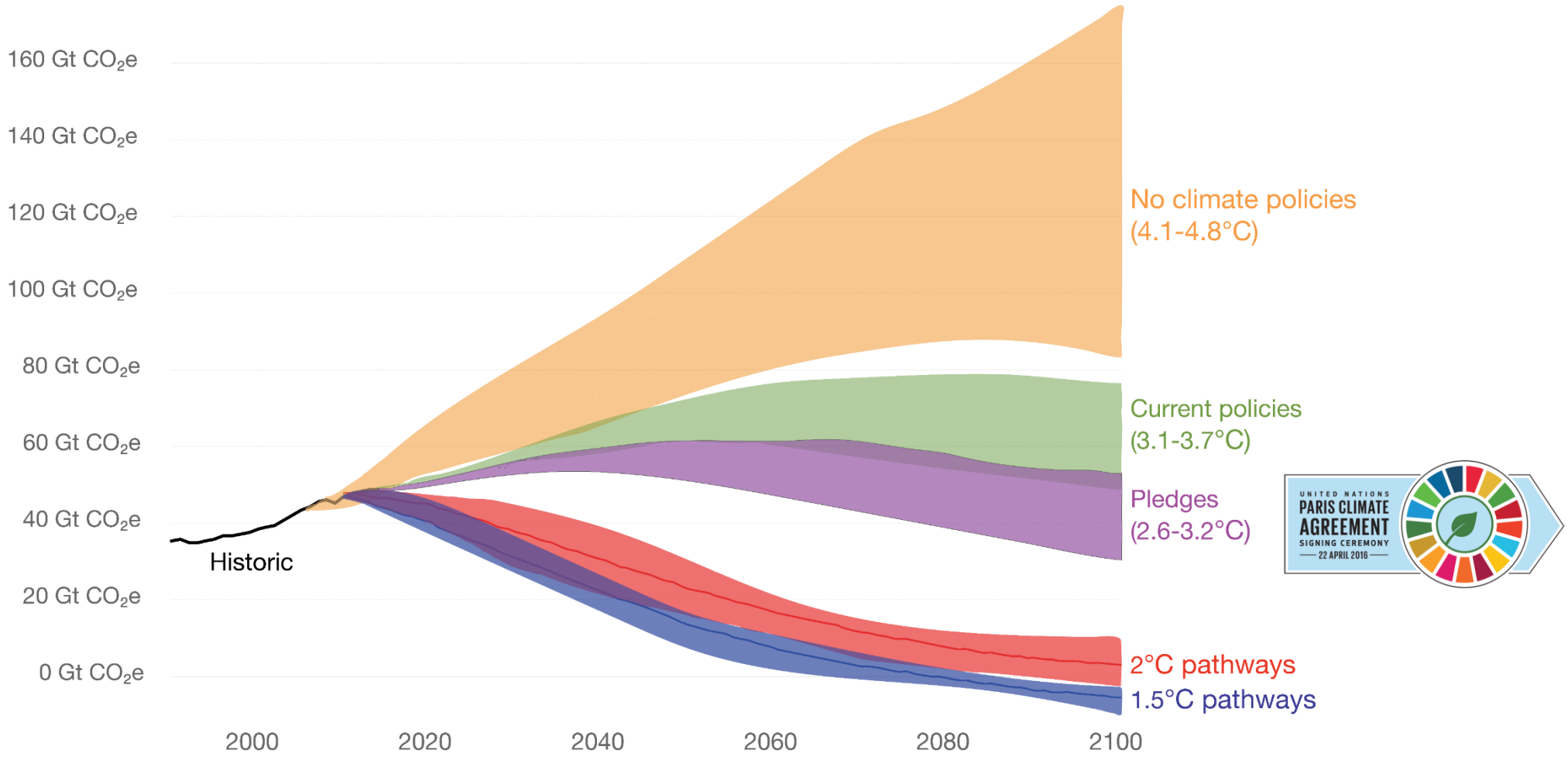
simulated responses of the climate system to a future climate scenario, obtained using climate models

Representative Concentration Pathways

pathways of plausible climate futures, based on greenhouse gas concentrations in the atmosphere

Global greenhouse gas emissions scenarios

Potential future emissions pathways of global greenhouse gas emissions (measured in gigatonnes of carbon dioxide equivalents) in the case of no climate policies, current implemented policies, national pledges within the Paris Agreement, and 2°C and 1.5°C consistent pathways. High, median and low pathways represent ranges for a given scenario. Temperature figures represent the estimated average global temperature increase from pre-industrial, by 2100.

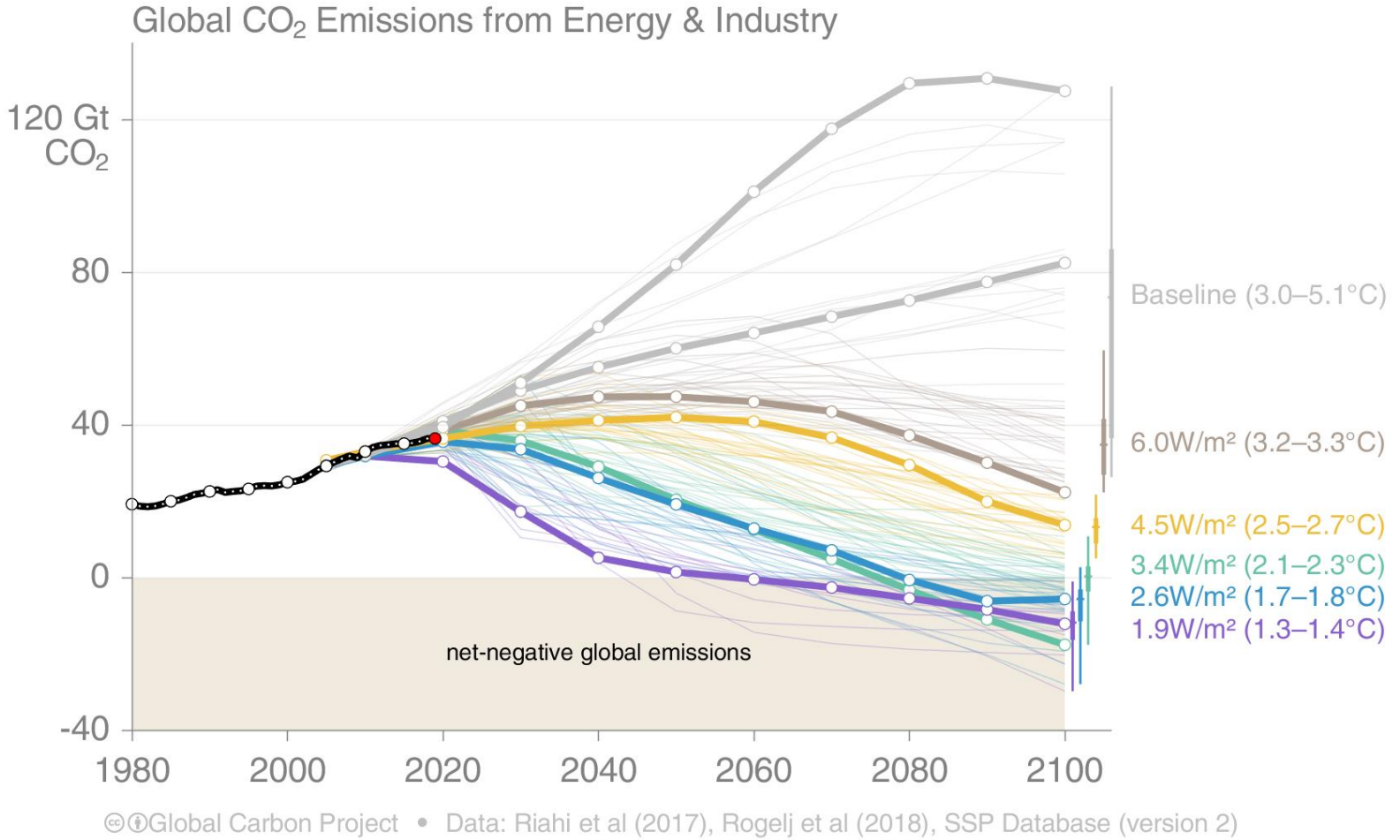


Based on data from the Climate Action Tracker (CAT).
The data visualization is available at OurWorldinData.org. There you find research and more visualizations on this topic.

https://ourworldindata.org/energy

SHARED SOCIOECONOMIC PATHWAYS (SSPS)

The SSPs lead to a broad range in baselines (grey), with more aggressive mitigation leading to lower temperature outcomes.
The bold lines are scenarios that will be analysed in CMIP6 and the results assessed in the IPCC AR6 process.



This set of quantified SSPs are based on the output of six Integrated Assessment Models (AIM/CGE, GCAM, IMAGE, MESSAGE, REMIND, WITCH). Net emissions include those from land-use change and bioenergy with CCS.

Source: Riahi et al. 2016; Rogelj et al. 2018; IIASA SSP Database; IAMC; Global Carbon Budget 2019

"The RCPs set pathways for greenhouse gas concentrations and, effectively, the amount of warming that could occur by the end of the century. Whereas the SSPs set the stage on which reductions in emissions will – or will not – be achieved."

"Shared Socioeconomic Pathways" (SSPs)

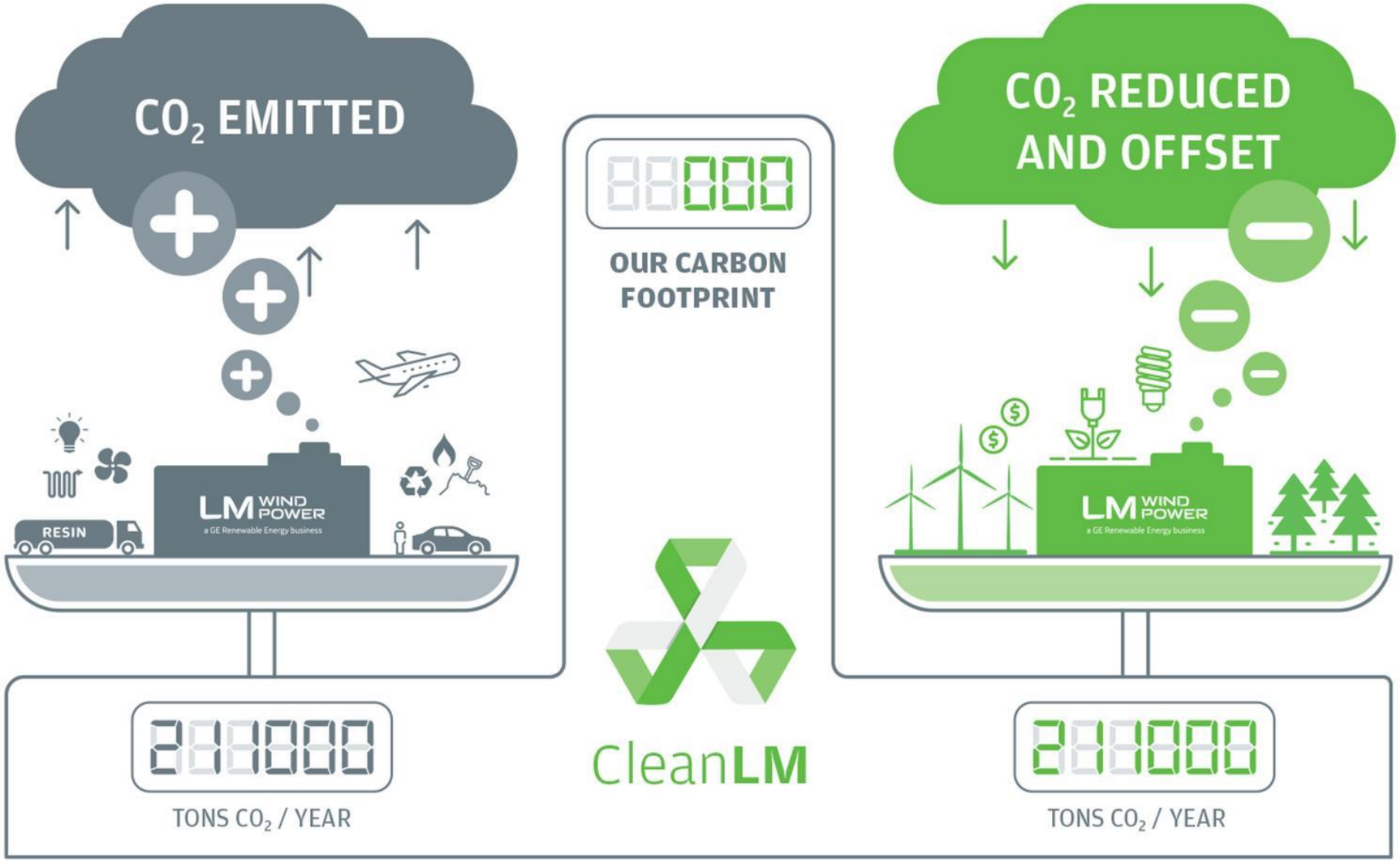
- how socioeconomic factors may change till 2100 (population, economic growth, education, urbanization and technological development
- 5 different ways in which the world might evolve in the absence of climate policy
- how different levels of climate change mitigation could be achieved when the mitigation targets of RCPs are combined with the SSPs.

"Representative Concentration Pathways" (RCPs)

- different levels of greenhouse gases and other radiative forcings that might occur in the future
- 4 RCPs corresponding to radiative forcing up to 2100: 2.6, 4.5, 6.0, and 8.5 watts/m^2
- RCPs do not include any socioeconomic "narratives" to go alongside them.

https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change#:~:text=The%20RCPs%20set%20pathways%20for,or%20will%20not%20%E2%80%93%20be%20achieved.

Climate Change and Sustainable Development Policies



https://www.lmwindpower.com/en/sustainability/go-carbon-neutral

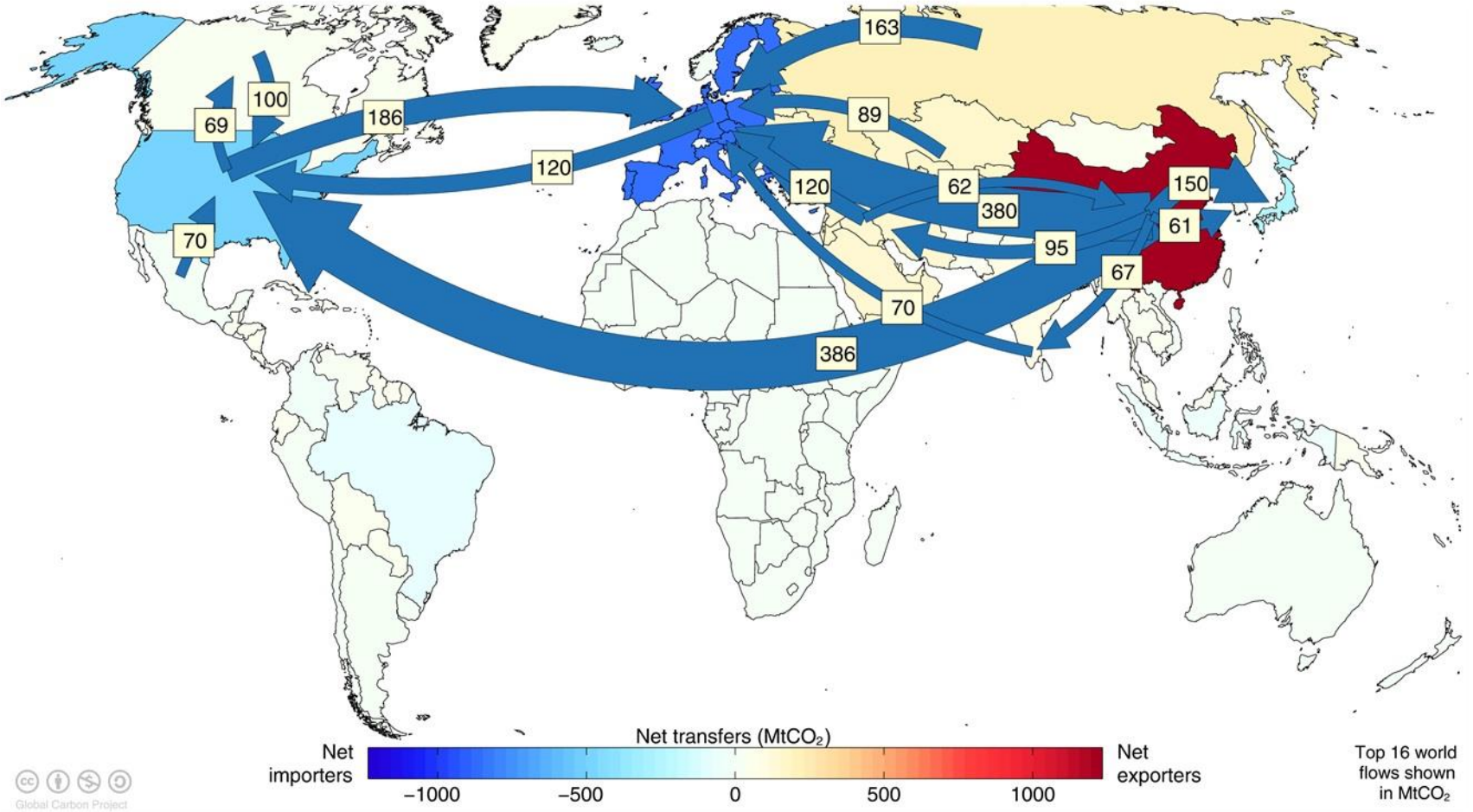
Outline

- Carbon intensity
- Global balance of CO_2 emissions associated with energy and industrial processes & estimates of the Global Carbon Budget
- Global Carbon Budget relationship to the global energy system and changes in land use
- Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways) and SSPs
- **Global emissions based on consumption vs. production**.

Climate Change and Sustainable Development Policies

MAJOR CARBON FLOWS FROM PRODUCTION TO CONSUMPTION

Flows from location of generation of emissions to location of consumption of goods and services

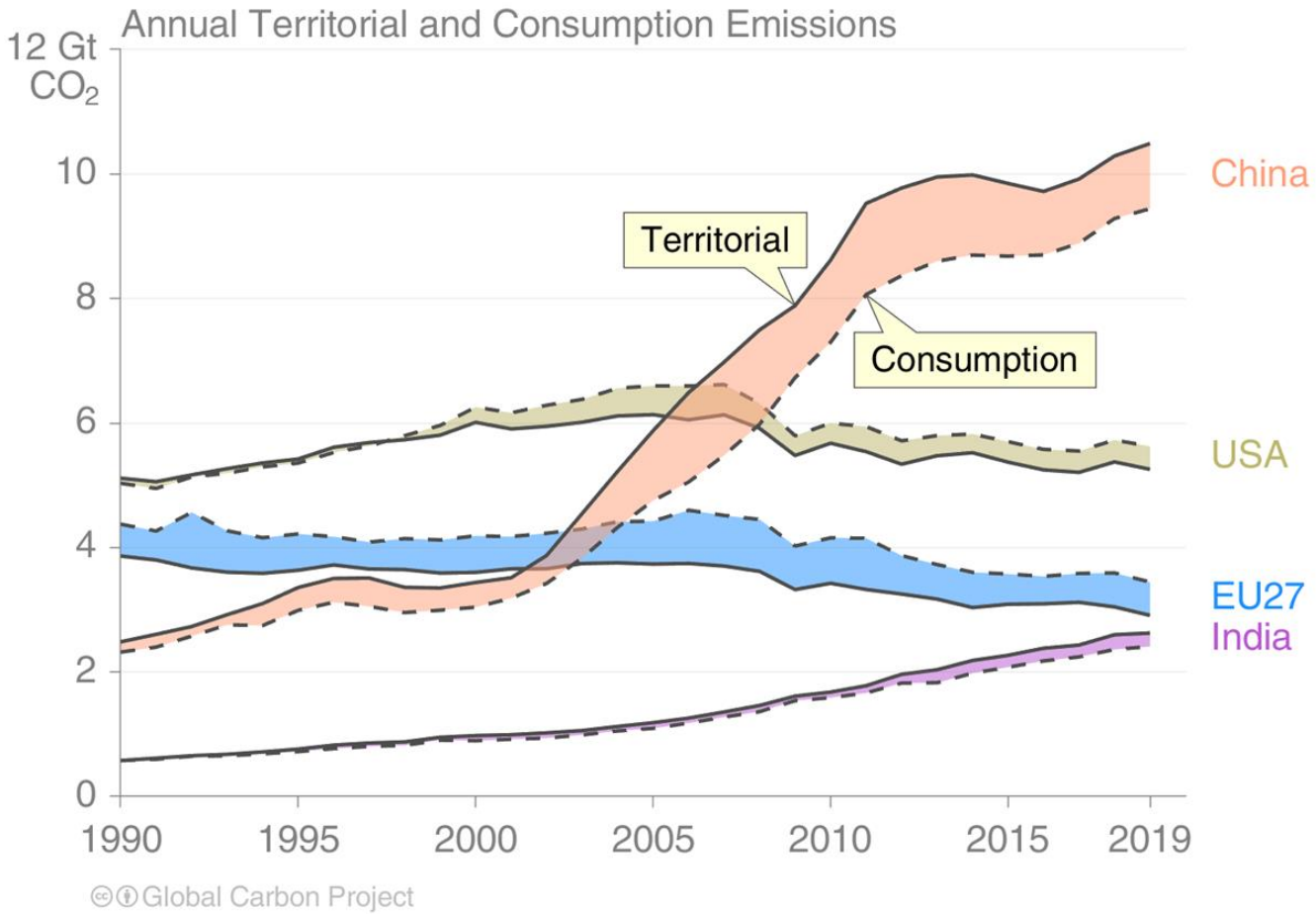


Values for 2011. EU is treated as one region. Units: $MtCO_2$

Source: [Peters et al 2012]

CONSUMPTION-BASED EMISSIONS (CARBON FOOTPRINT)

Allocating fossil CO_2 emissions to consumption provides an alternative perspective.
USA and EU28 are net importers of embodied emissions, China and India are net exporters.



Consumption-based emissions are calculated by adjusting the standard production-based emissions to account for international trade

Source: Peters et al 2011; Friedlingstein et al 2021; Global Carbon Project 2019

Key information you should have apprehended after the class

- Carbon intensity concept
- Different sources and sinks of CO_2 in the atmosphere
- Anthropogenic emissions and their relevance for global warming
- Evolution of CO_2 emissions and importance of energy related emissions for global warming
- Main polluting countries and economic sectors (in absolute terms), relevance of CO_2 per capita emissions
- Direct emissions versus implicit emissions from imported products with a high carbon footprint
- Concept of carbon neutrality
- Concept of greenhouse gas emission scenarios and associated uncertainty