Our Fragile Earth:
So What Do We Do?

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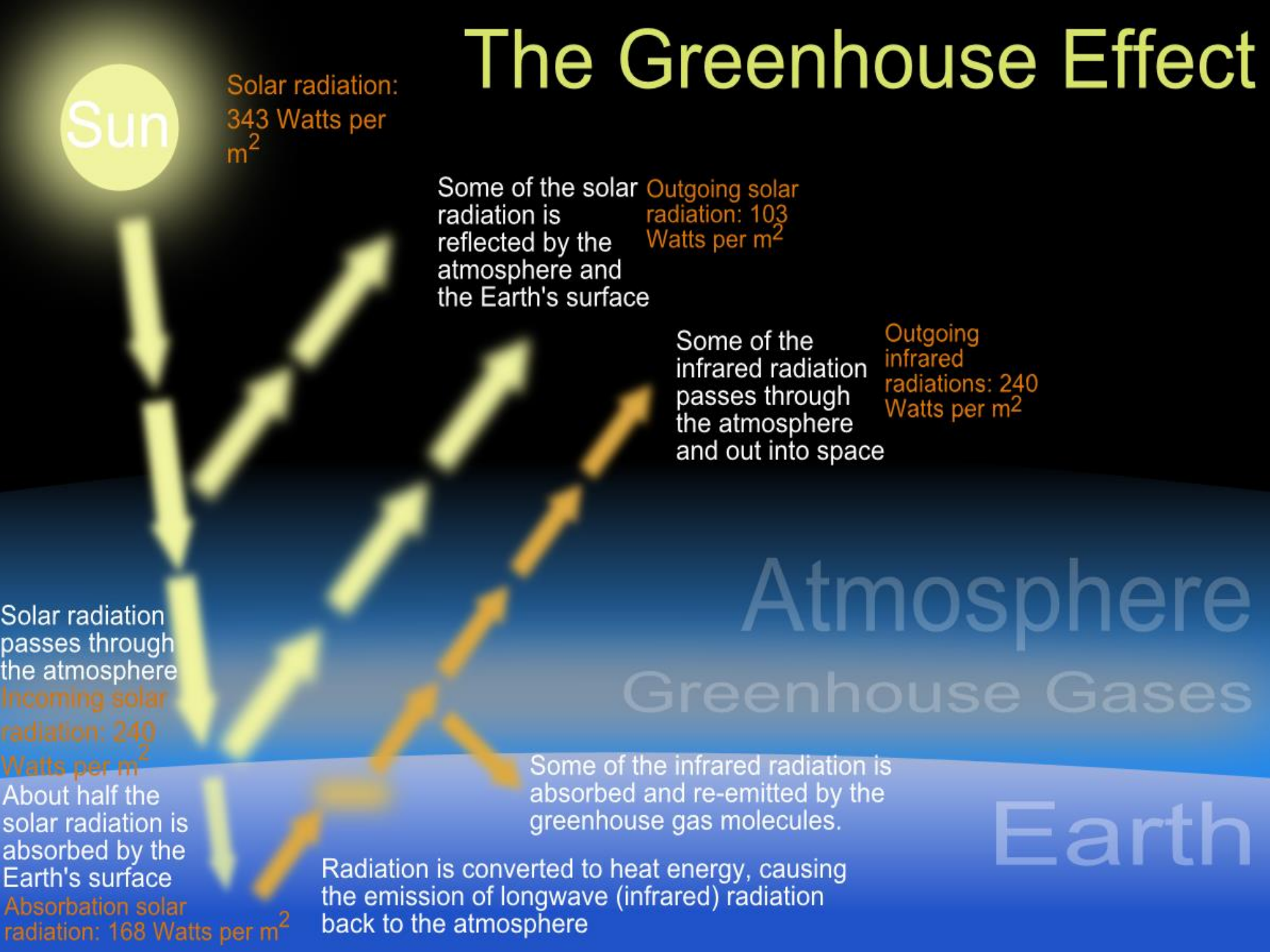
Why does climate change matter?

- It affects everyone & every aspect of the world we live in
- It changes the frequency of extreme weather events through atmospheric warming
- It threatens islands & coastal cities through ocean expansion
- It affects our food supply by changing rainfall patterns
- It affects how we make things & distribute resources
- It can only be addressed by changing the way all of us live

1. The Symptoms

Our Fragile Atmosphere

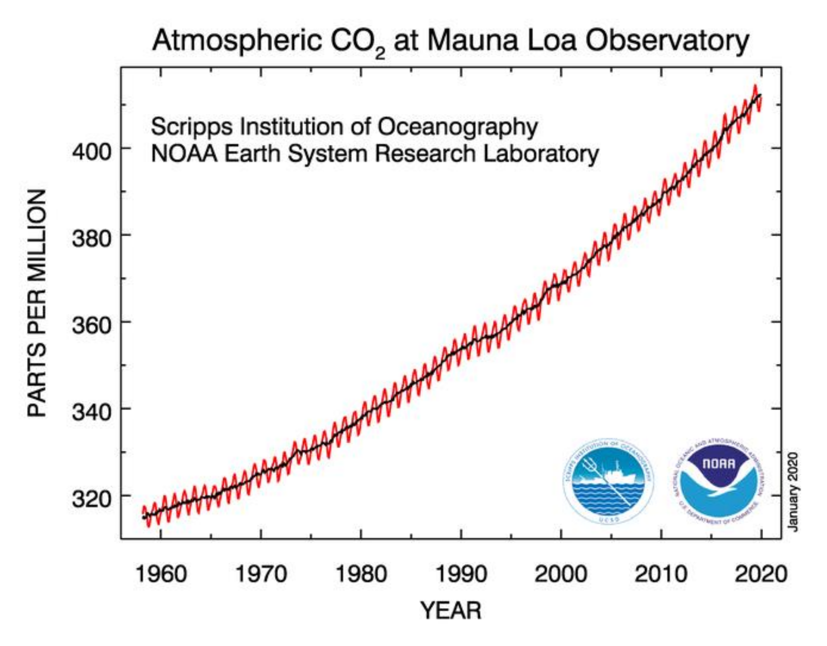
The Sun


The Greenhouse Effect
Sun
Solar radiation: 343 Watts per m2
Some of the solar radiation is reflected by the atmosphere and the Earth's surface
Outgoing solar radiation: 103 Watts per m2
Some of the infrared radiation passes through the atmosphere and out into space
Outgoing infrared radiations: 240 Watts per m2
Atmosphere
Greenhouse Gases
Solar radiation passes through the atmosphere
Incoming solar radiation: 240 Watts per m2
About half the solar radiation is absorbed by the Earth's surface
Absorbation solar radiation: 168 Watts per m2
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules.
Radiation is converted to heat energy, causing the emission of longwave (infrared) radiation back to the atmosphere
Earth

The role of greenhouse gases

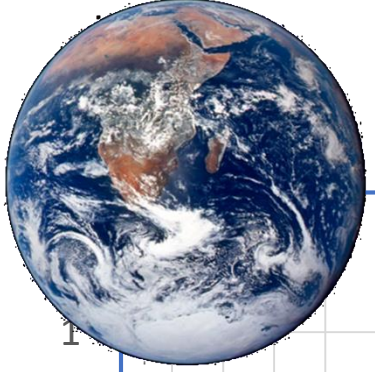
- The average temperature of Earth is 14^{o}C. Without its blanket of greenhouse gases (including CO_2 & H_2O) it would be -18^{o}C.
- Atmospheric CO_2 has risen 45% from pre-industrial levels and is now its highest in 3 million years (maybe 20 million years)
- 19 of the world's hottest recorded 20 years occurred since 2001.
- The last 5 years have been the hottest 5 on record in the UK.
- Warmer air evaporates more water, so produces heavier rain.

Mauna Loa observatory 10,000ft, Hawaii Big Island



Reached 416ppm in January

- The Mauna Loa observatory in Hawaii measures the "background" composition of air
- It made the first observation showing the growth in atmospheric carbon dioxide due to human activities
- By absorbing particular wavelengths of radiation, carbon dioxide & other gases alter the balance between incoming and outgoing heat; the more CO_2, the higher the earth's temperature



Global annual average temperature relative to 1850-1870

Vostok ice cores

416ppm

2020

temperature change from present

4°C

0°C

- 8°C

carbon dioxide level in atmosphere

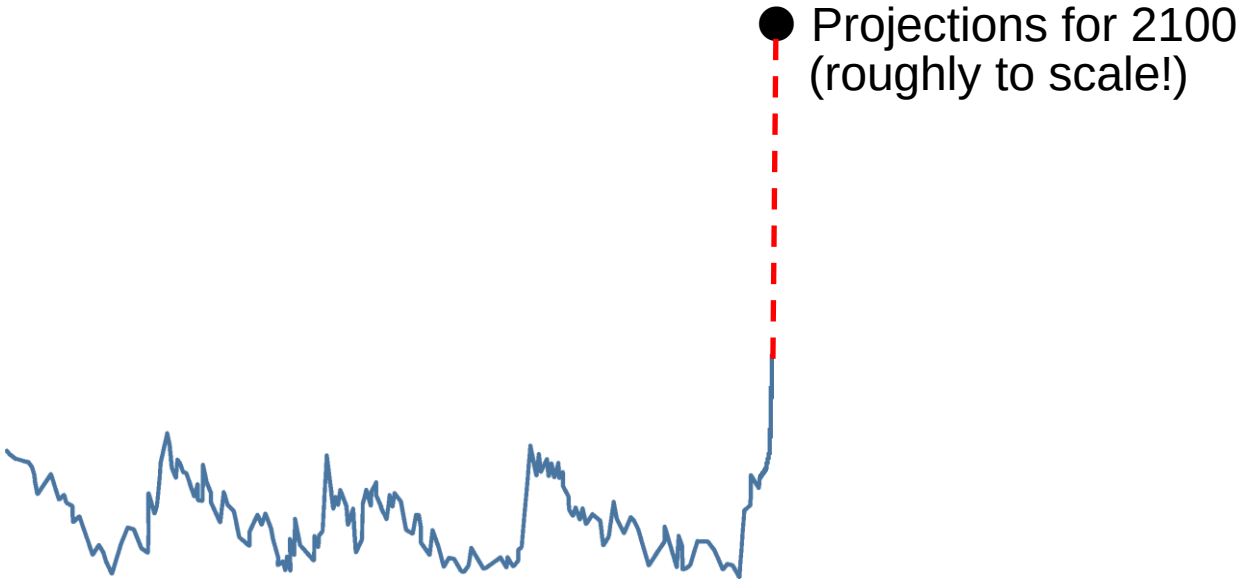
300ppm

200ppm

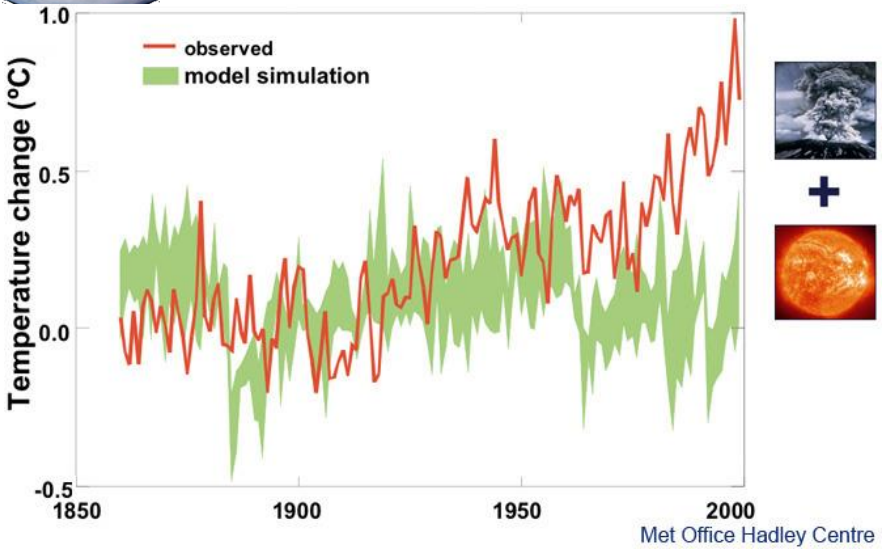
-400,000 -300,000 -200,000 -100,000 today

Years before present

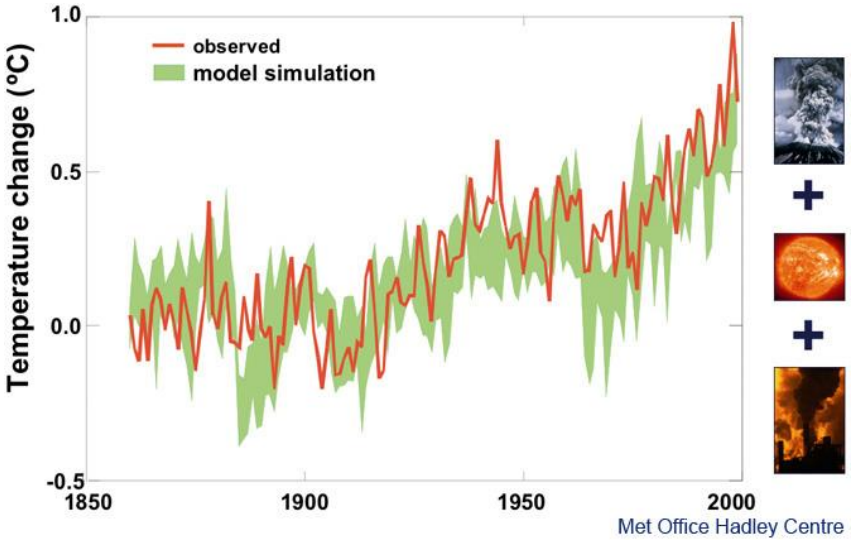
Vostok ice cores



Models help us understand what is happening



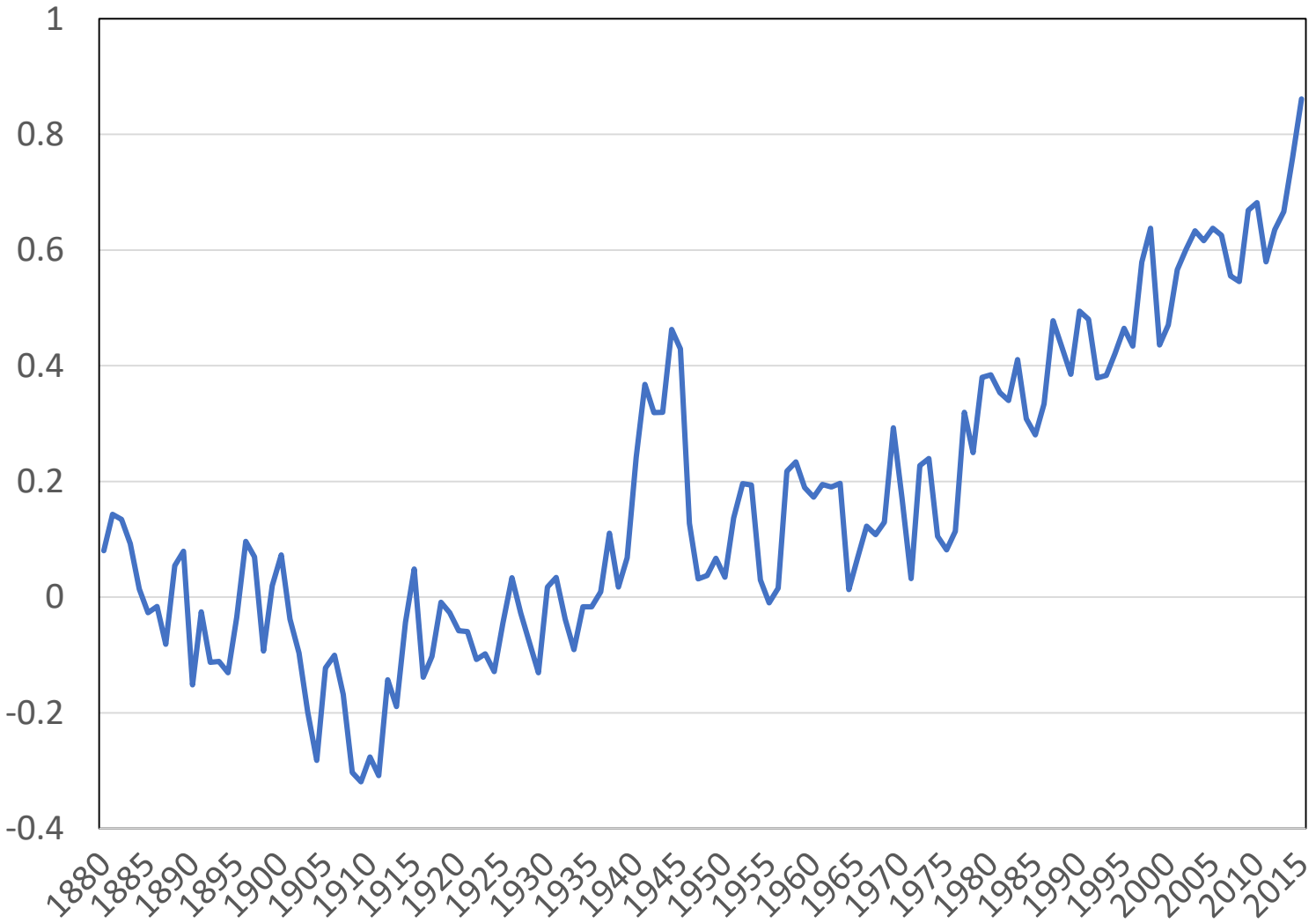
Modelling the processes in the atmosphere & ocean with known changes in the sun & volcanic eruptions, produces a simulation that does not match the observed trend.



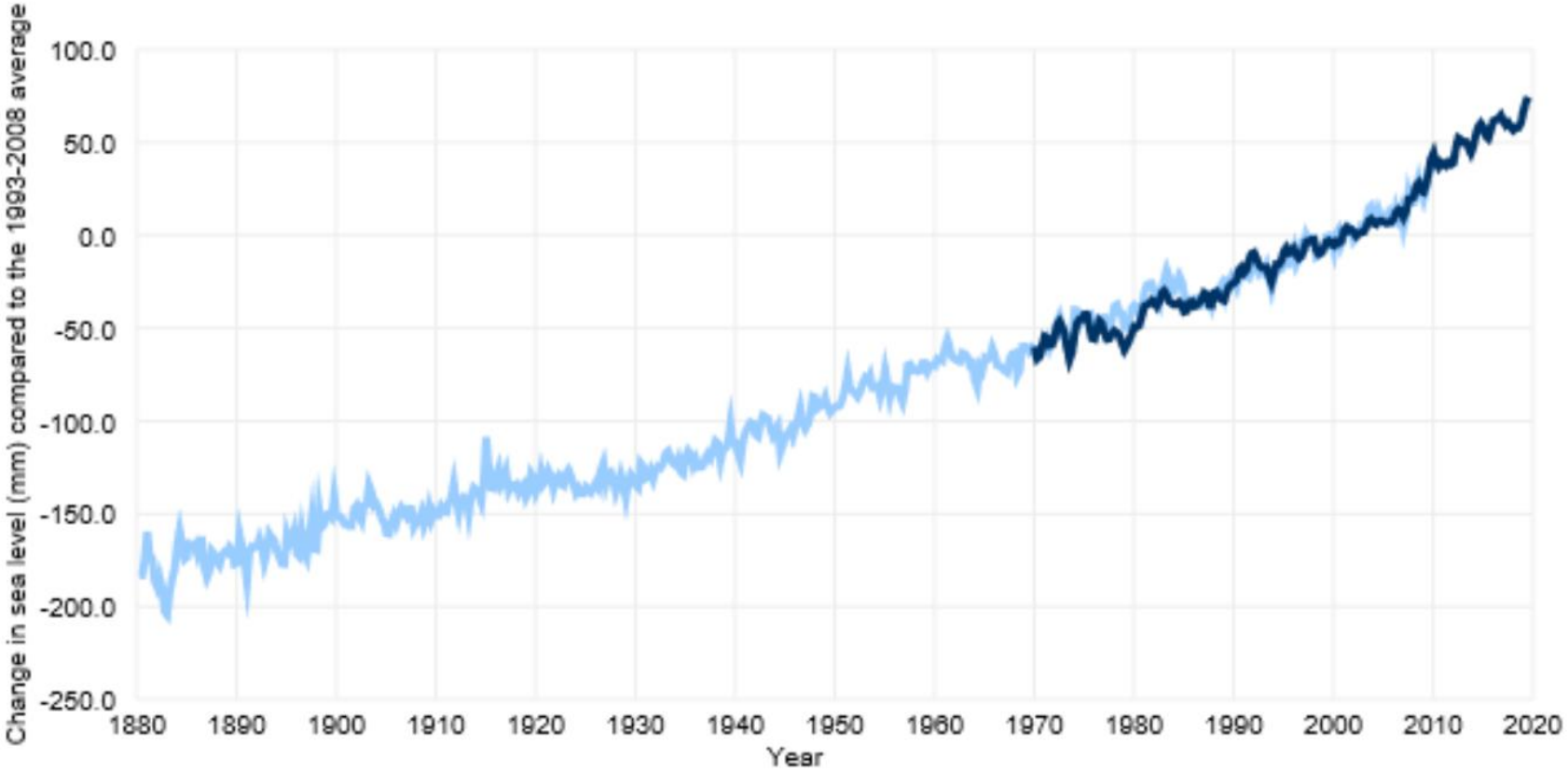
Extending the model to include the radiative effects of human emissions produces a close match to the observations.

Our Fragile Oceans

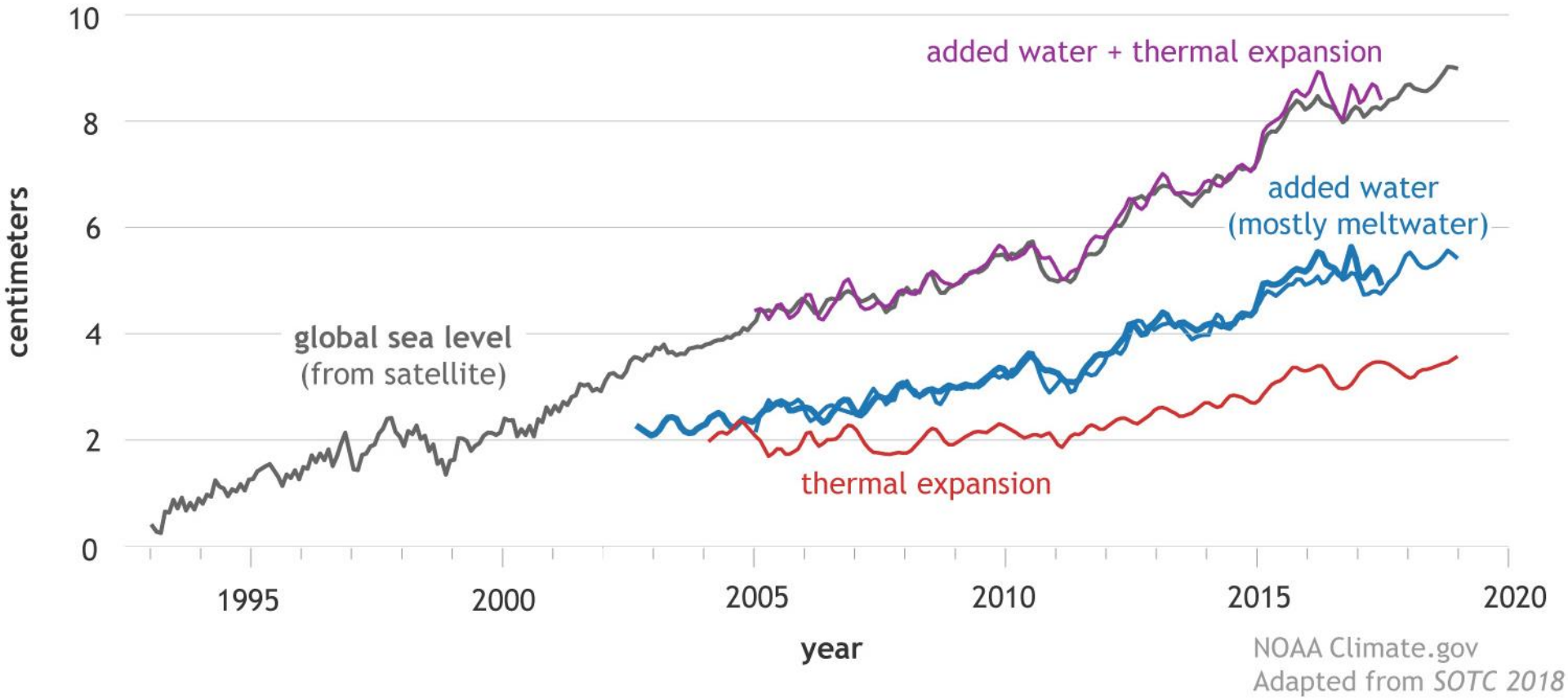
Global Mean Ocean temperature change in ^{o}C



Global Sea Level change since 1880

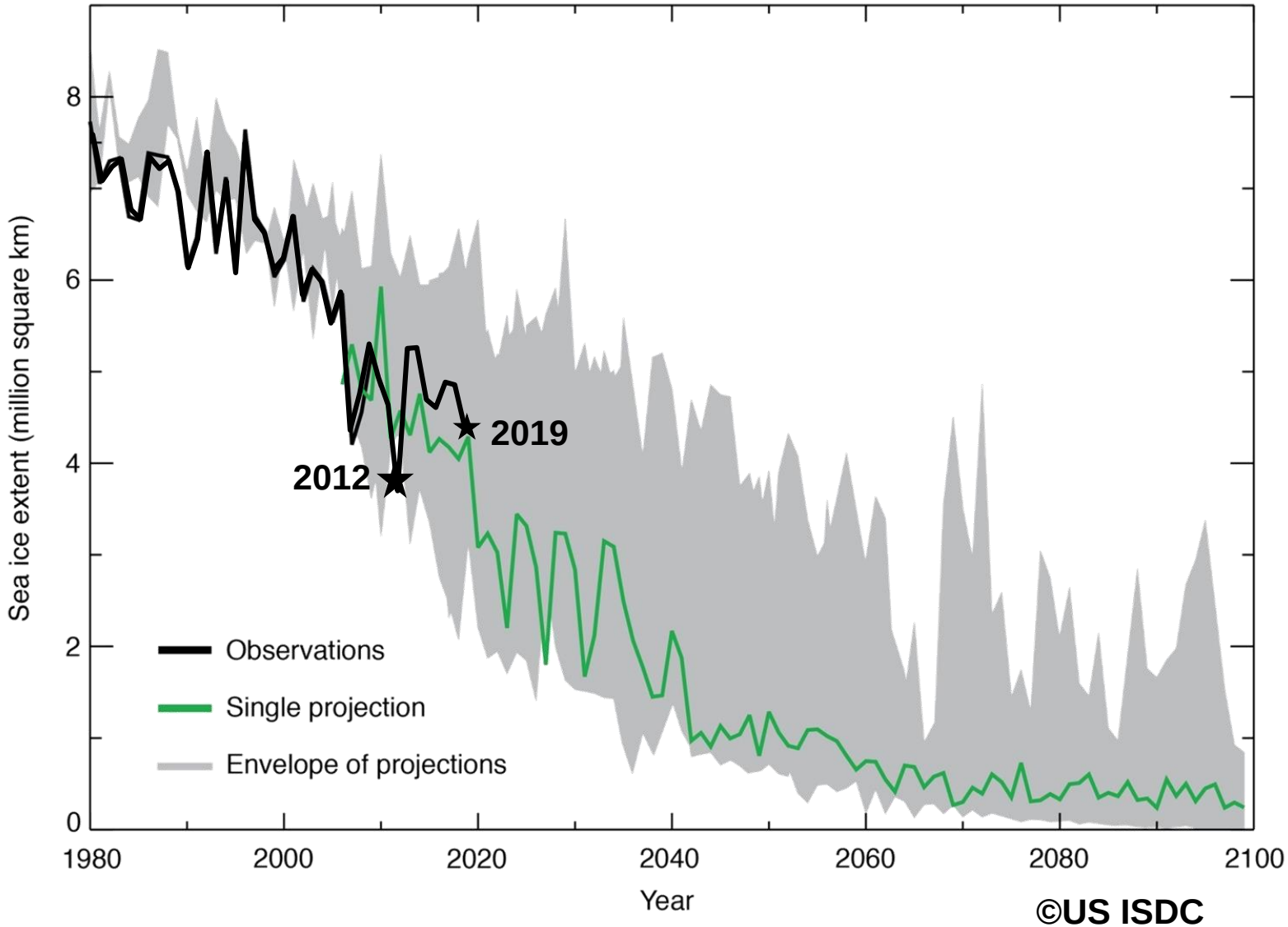


Contributors to sea level rise 1993-2018

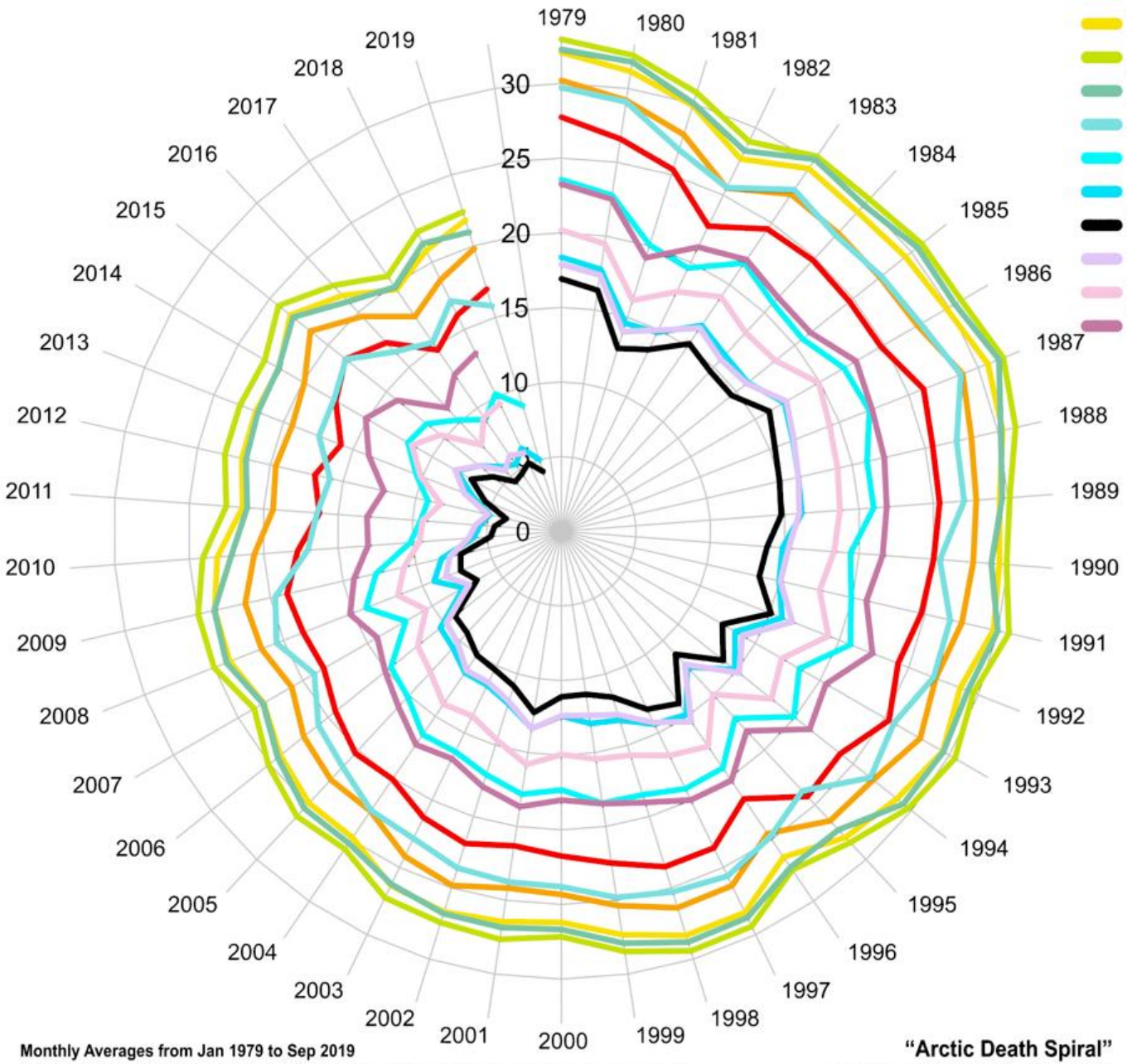


Arctic Sea Ice area in September

rate of decline=12.85% per decade



PIOMAS Arctic Sea Ice Volume ($10^3 km^3$)



Monthly Averages from Jan 1979 to Sep 2019

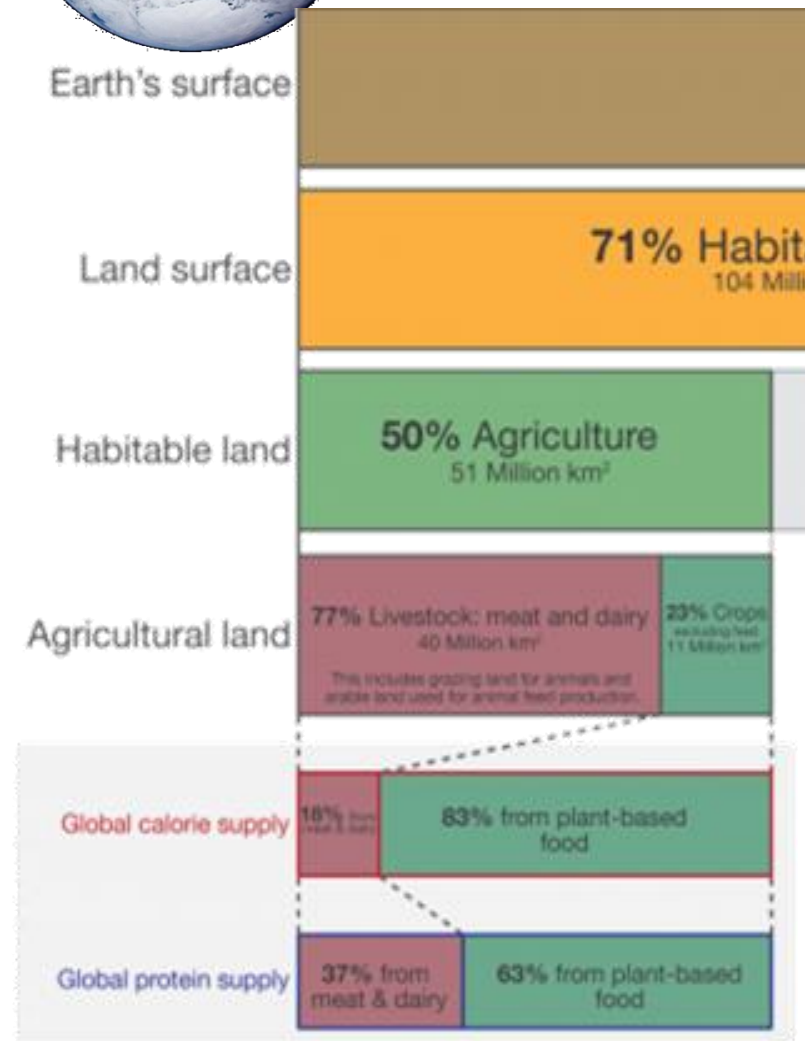
Data: http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/

"Arctic Death Spiral"

- The oceans absorb a ¼ of CO_2 emissions, becoming more acidic, leading to weaker shells & coral
- 15% of food protein comes from the sea
- 20% of coral reefs have been destroyed + 20% degraded.

Our Fragile Land

Food, land, water & carbon



Recommended 50g protein intake from:

250g beef uses 25m^2.yrs Land, 400L water; emits 11kg CO_2e

310g pork uses 3m^2.yrs Land, 500L water; emits 3kg CO_2e

290g poultry uses 2m^2.yrs Land, 200L water; emits 2kg CO_2e

220g cheese uses 3m^2.yrs Land, 700L water; emits 4kg CO_2e

220g farm fish uses 1m^2.yrs Land, 700L water; emits 1kg CO_2e

220g beans uses <1m^2.yrs Land, <10L water; emits <1kg CO_2e

550g bread uses 1m^2.yrs Land, 250L water; emits <1kg CO_2e

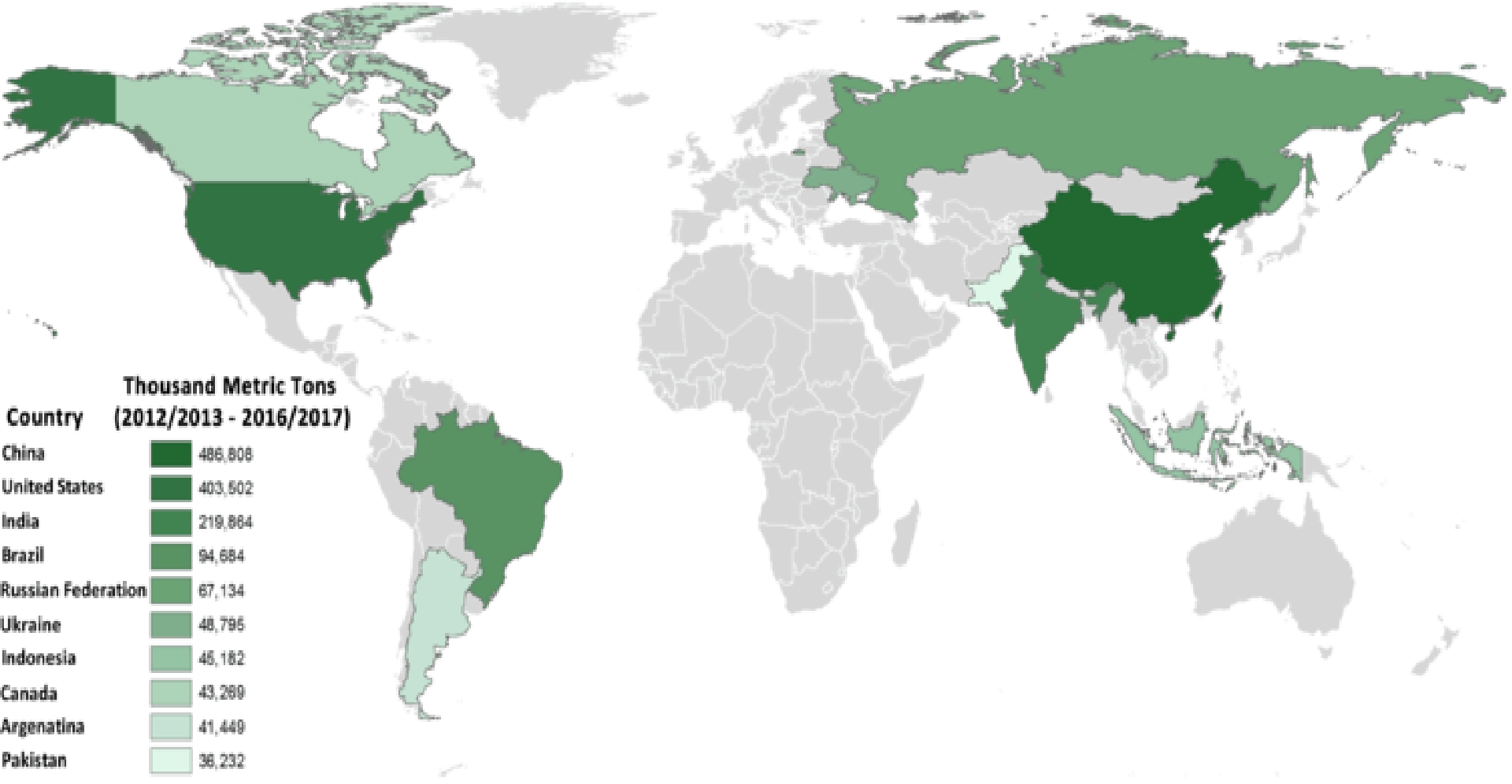
Recommended 2000kcal energy intake from:

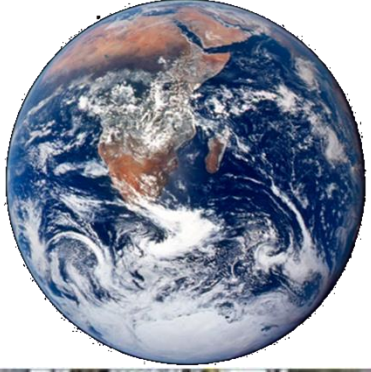
740g bread uses 2m^2.yrs Land, 300L water; emits 1kg CO_2e

2.7kg potatoes uses 2m^2.yrs Land, <10L water; emits 1kg CO_2e

540g rice uses 1m^2.yrs Land, 800L water; emits 2kg CO_2e

The world's "bread baskets"



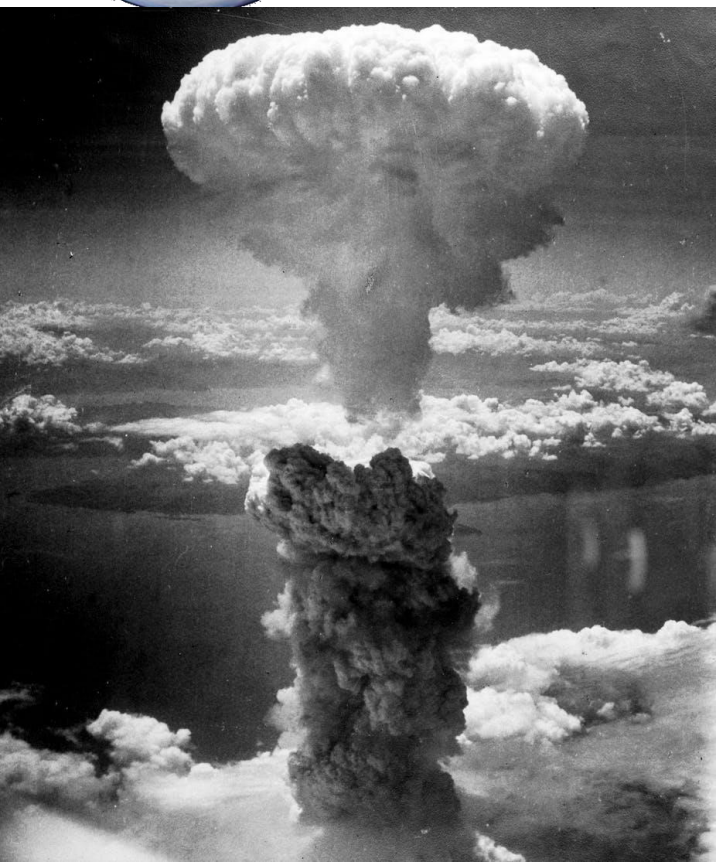


15% of global food is wasted

In the UK we waste:
24 million slices of bread,
6 million potatoes,
6 million glasses of milk &
¼ million chickens every day

At current rates, the world will lose all of its topsoil in 50 years

Our Fragile World:
Perceptions of the climate emergency



1950s Nuclear holocaust

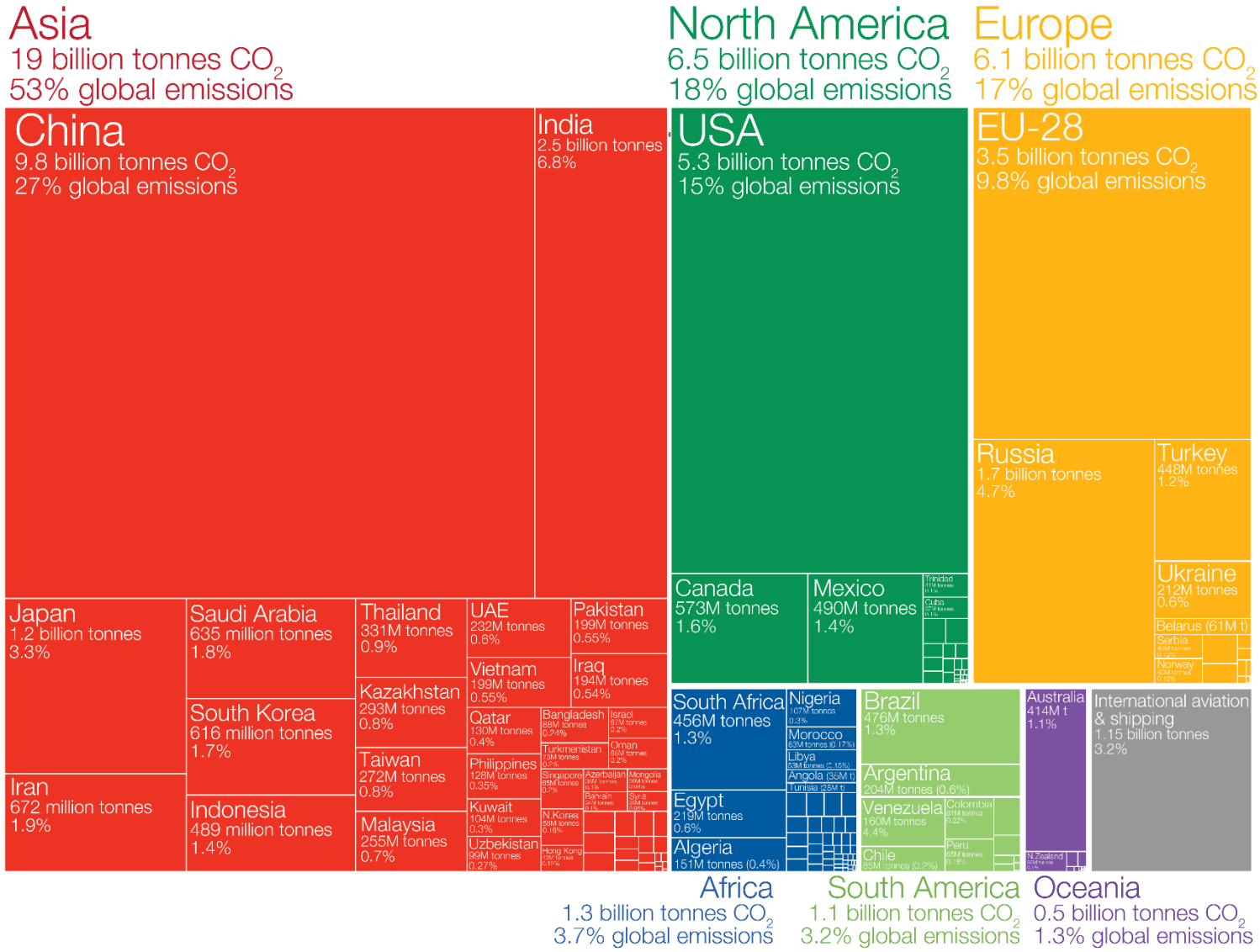
2010s Climate holocaust

Where are the emissions coming from?

- CO_2e consumption (= emissions + imports) in tonnes per person per year: Australia=25, USA & Canada=20, UK=13; China=8.5,
- UK CO_2e consumption in tonnes per person per year: Purchases=3; Food & drink=2.9; Home energy=2.5; Travel=1.9; Infrastructure=1.7.
- Vehicles emit toxic Nitrogen Dioxide, Ozone & Carbon Monoxide as well as CO_2: 40,000 people per year die prematurely from air pollution in the UK

- *CO_2e is the amount of CO_2 that would produce the same warming effect as the actual cocktail of pollutants*

Who emits how much?

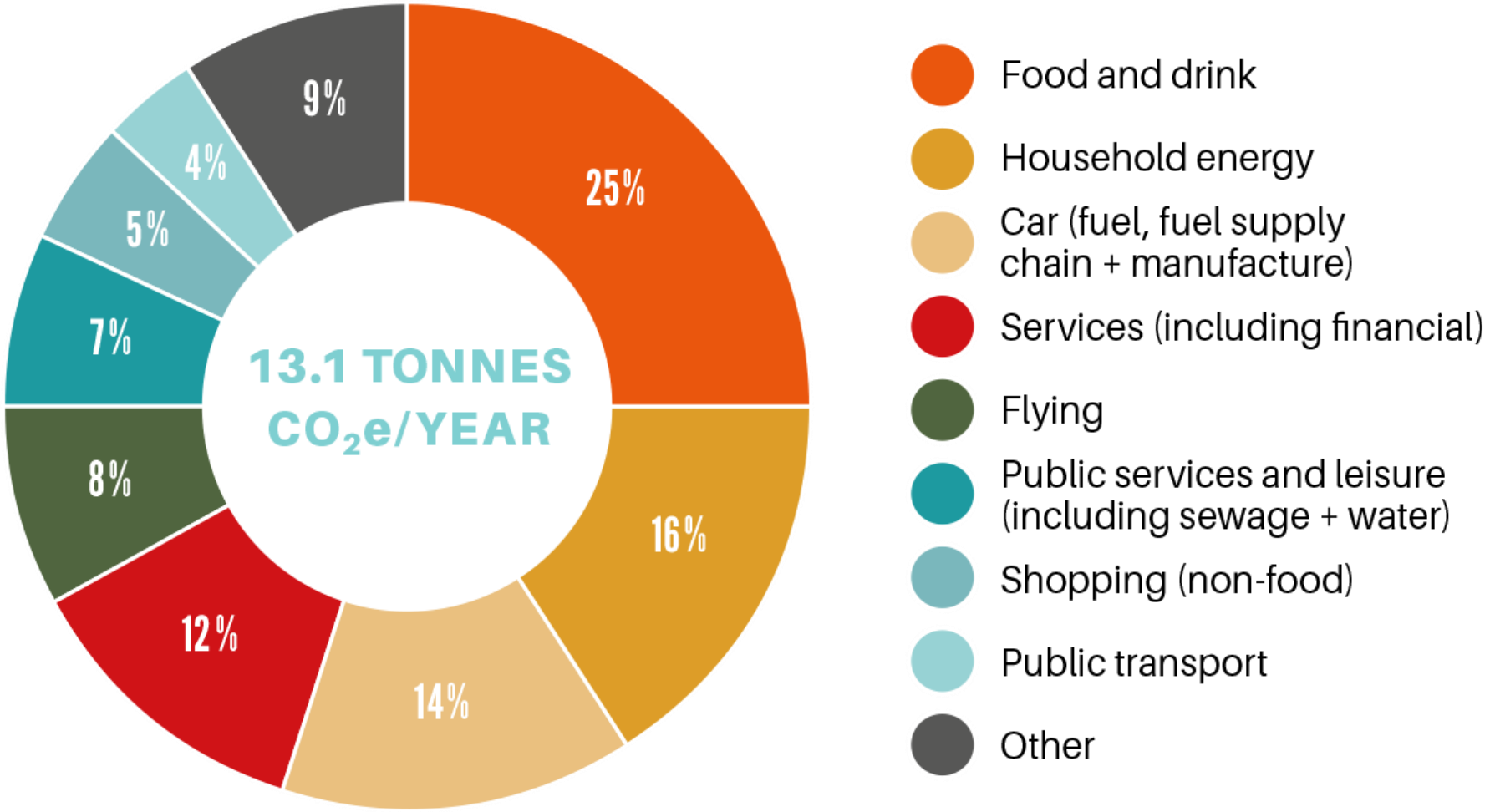


Shown are national production-based emissions in 2017. Production-based emissions measure CO_2 produced domestically from fossil fuel combustion and cement, and do not adjust for emissions embedded in trade (i.e. consumption-based).

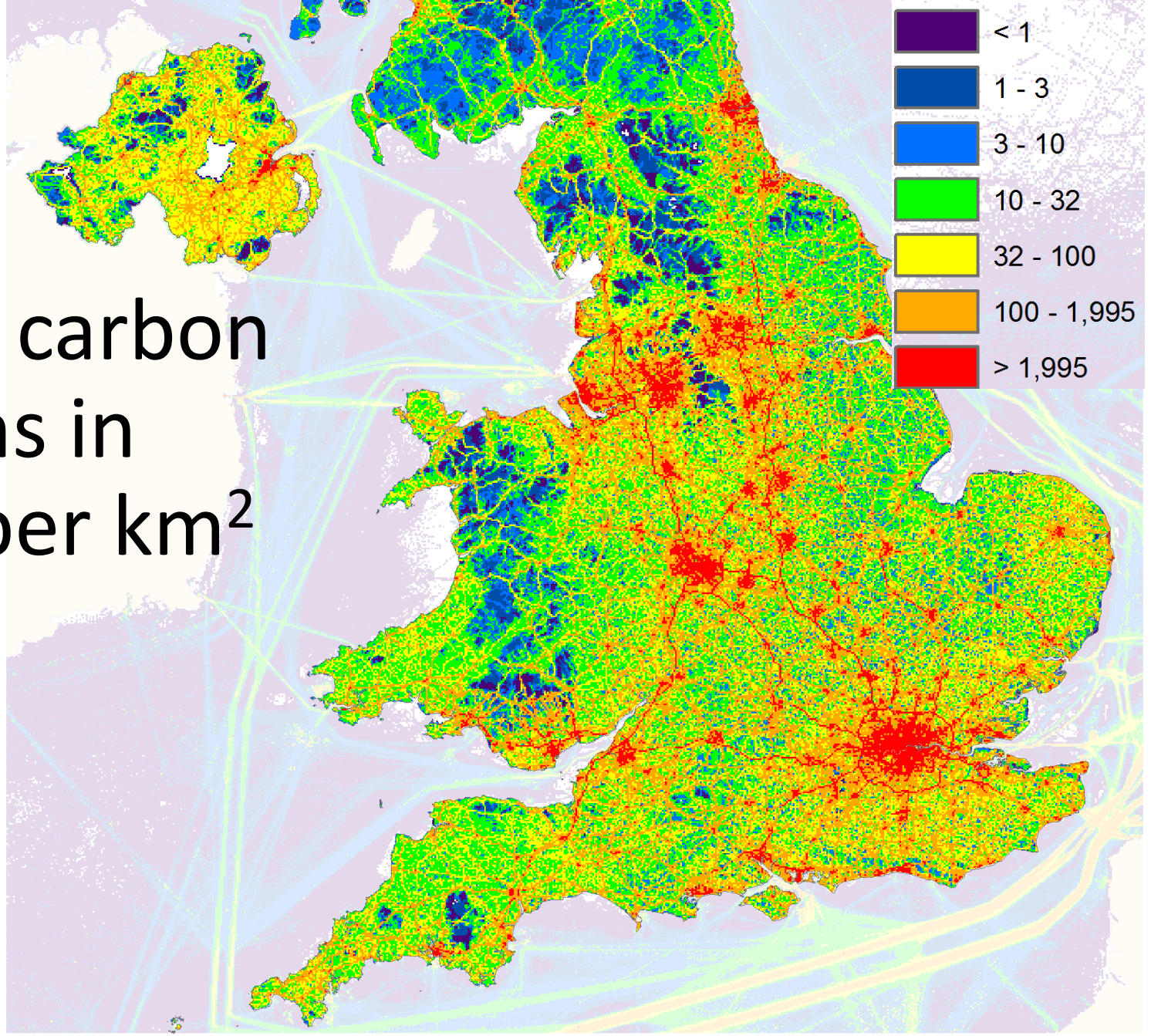
Figures for the 28 countries in the European Union have been grouped as the 'EU-28' since international targets and negotiations are typically set as a collaborative target between EU countries. Values may not sum to 100% due to rounding.

Data source: Global Carbon Project (GCP).

Average UK person's carbon consumption footprint

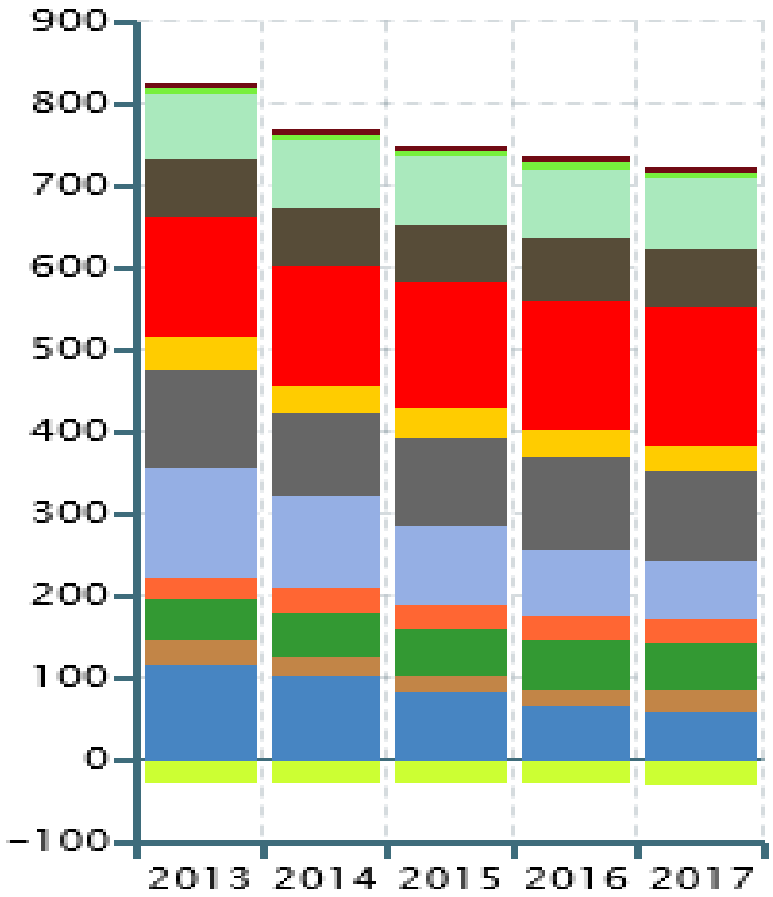


2017 UK carbon emissions in Tonnes per km^2



East Devon emissions 2013-7

- Industry & Commercial Electricity
- Industry & Commercial Gas
- Large Industrial Installations
- Industrial & Commercial Other Fuels
- Agricultural Combustion
- Domestic Electricity
- Domestic Gas
- Domestic Other Fuels
- Road Transport (A roads)
- Road Transport (Motorways)
- Road Transport (Minor roads)
- Diesel Railways
- Transport Other
- LULUCF Net Emissions

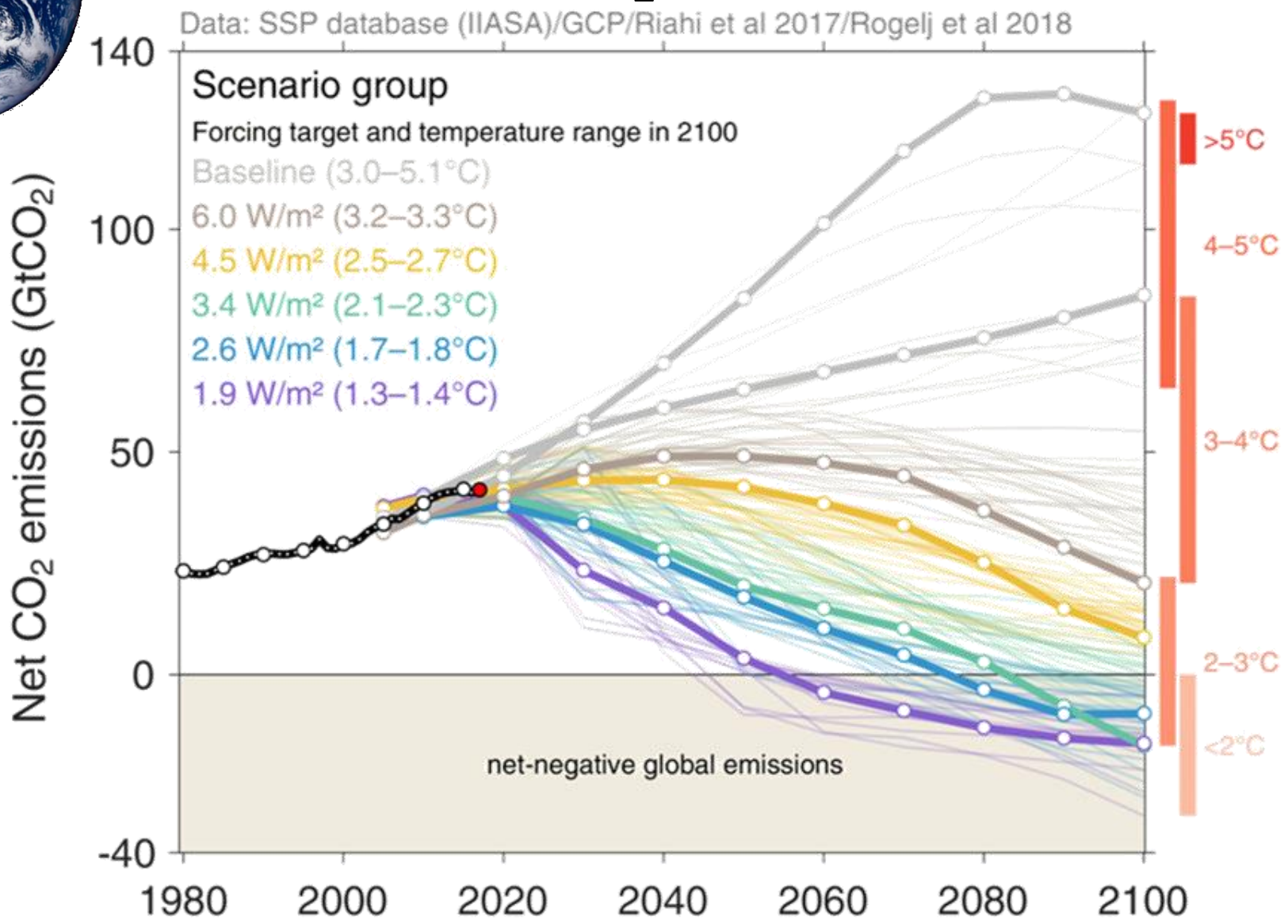


Summary

- Climate is determined by heat from the sun, absorbed by land, sea & air, transported from hot to cold places by weather systems
- Heat absorbing gases in the atmosphere make the planet habitable
- The increase in heat absorbing gases due to human emissions is changing the earth's climate at a rate unparalleled in human history
- Emissions come from burning of fossil fuels for power, heating, travel, industry; and from food production; some of the extra heat absorbing gases are removed by oceans and forests.

2. The Prognosis

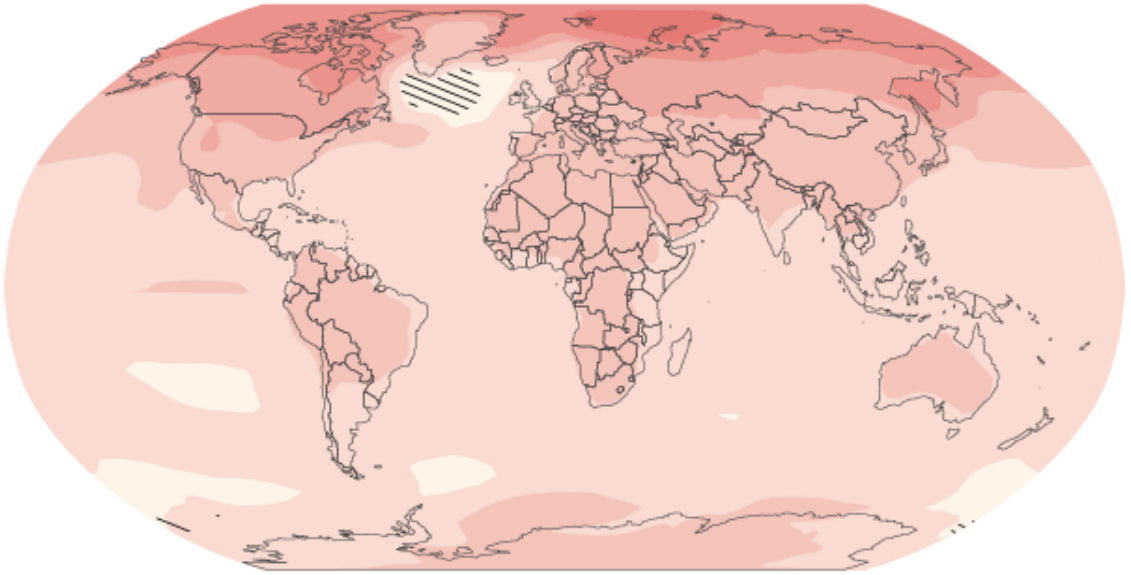
IPCC CO_2 emissions scenarios ($GtCO_2$ per year)

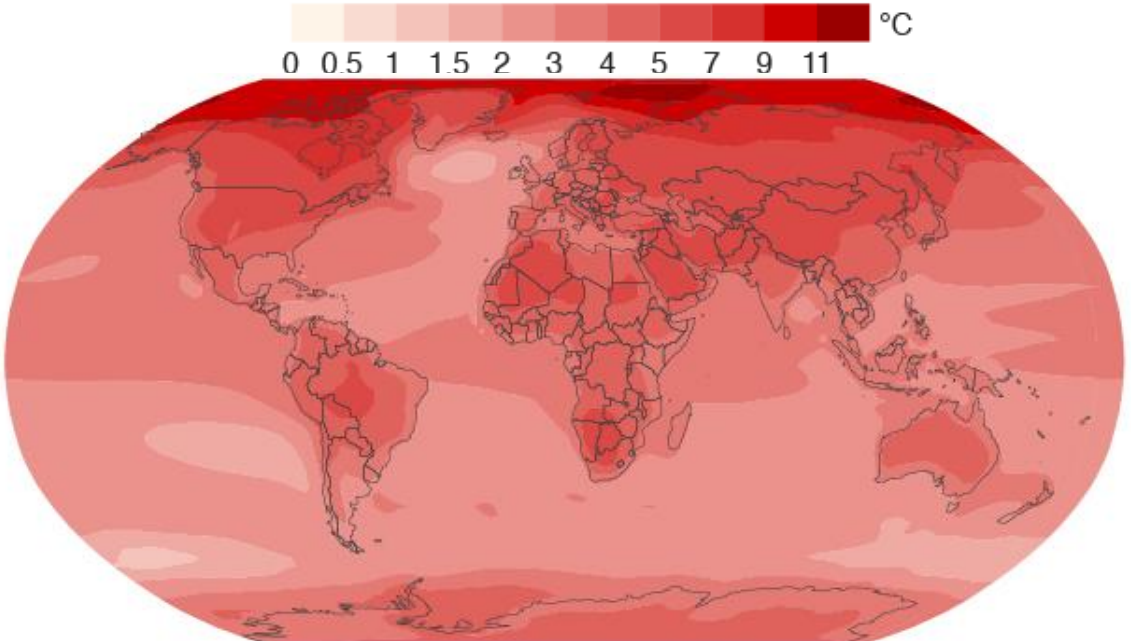


Projected temperature change

1990s → 2090s

If emissions peak in 2020 then decline to zero before 2100

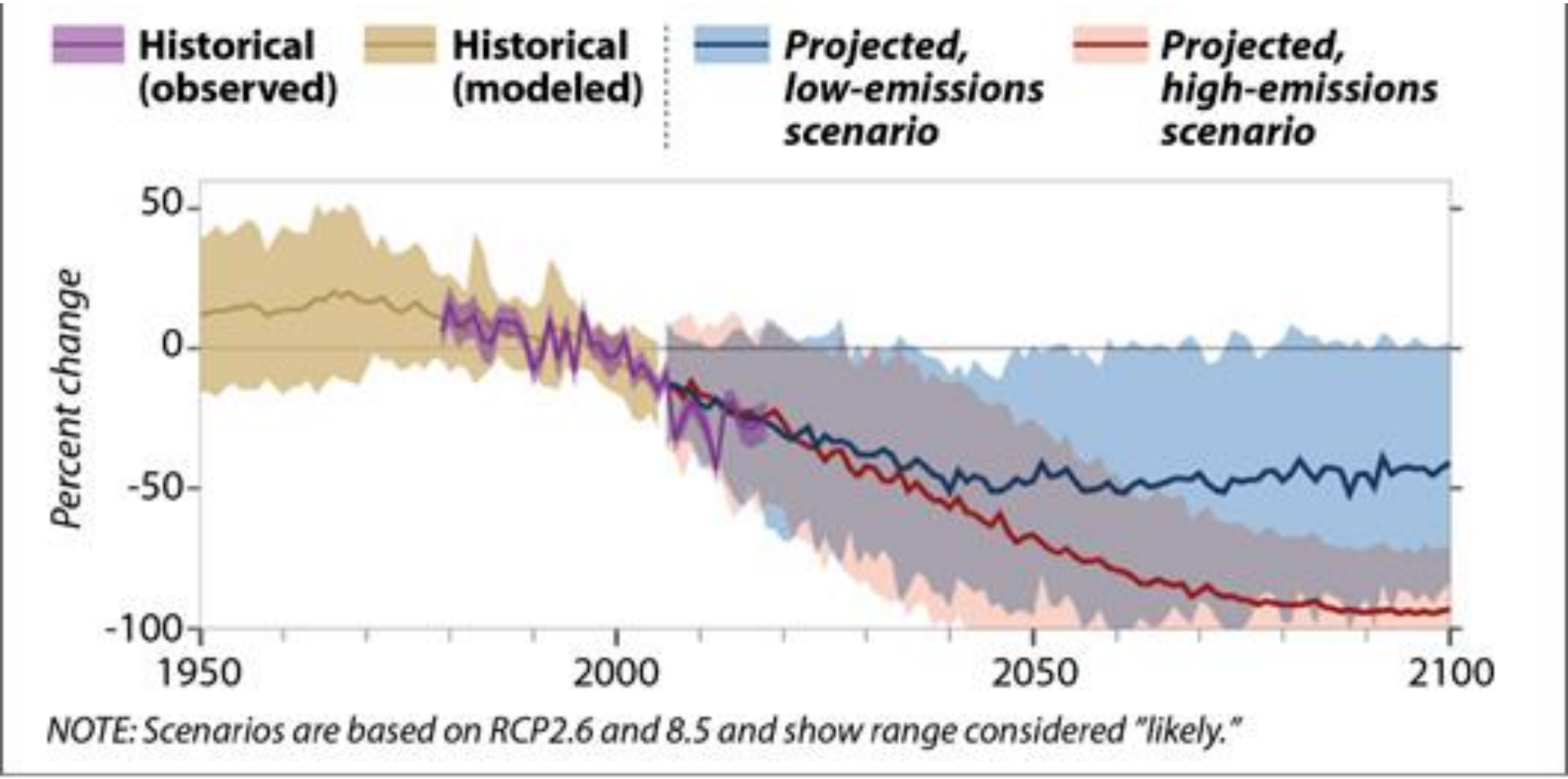




If emissions continue to rise to 2100

Arctic sea ice (September)

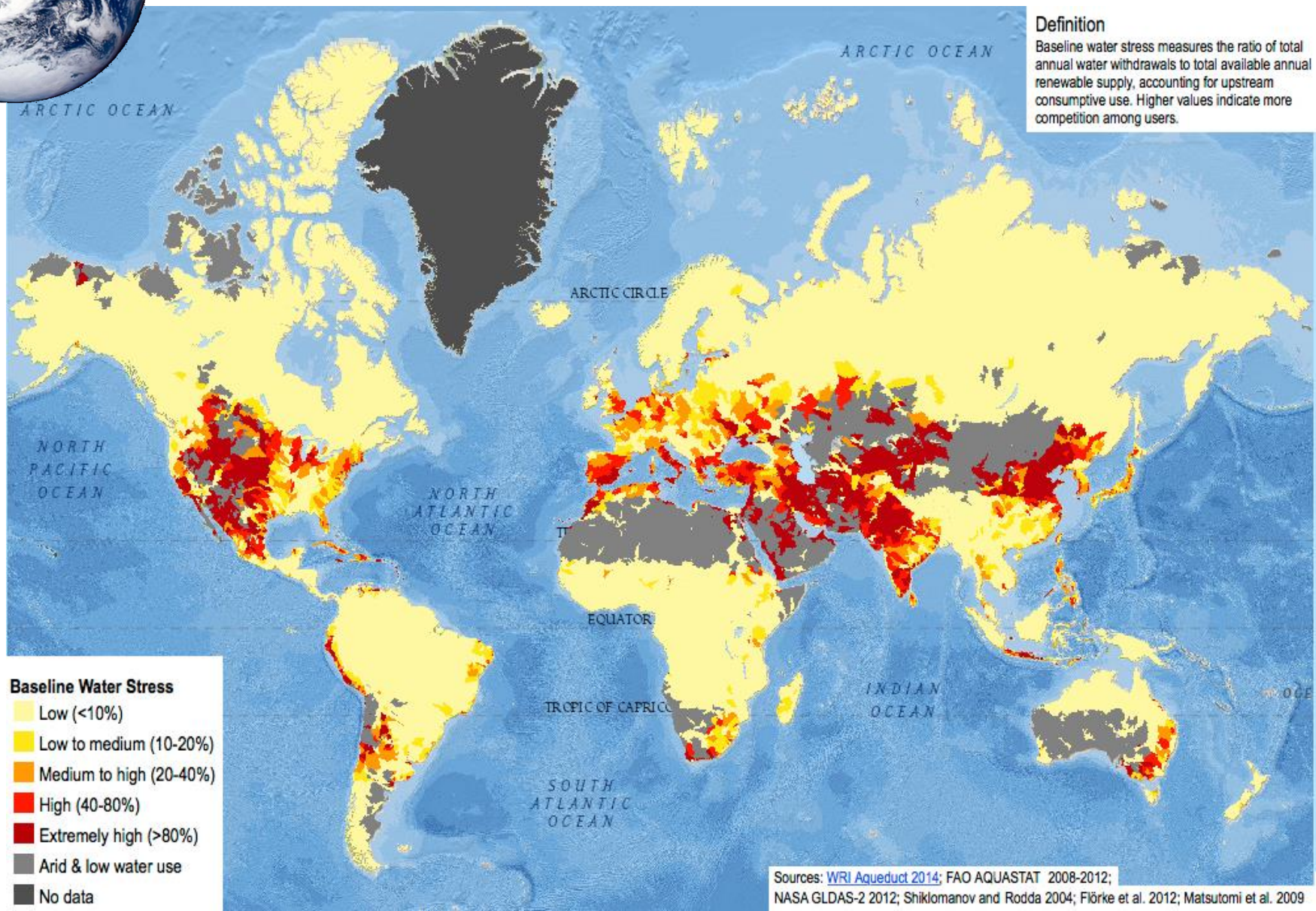
% change relative to 1986-2005 average



SOURCE: IPCC Ocean and Cryosphere Special Report, Sept. 2019

InsideClimate News

Water stress 2008-2012



Summary

- By 2100, global temperatures will rise by another 1 – 3^{o}C globally: more over land
- Oceans will warm, snow & land ice will melt, causing sea level to rise, probably by half to one metre, but possibly much more
- Warmer air will evaporate more water leading to dryer soils & heavier rain
- Warmer oceans will allow tropical cyclones to move further north
- Rising tropical air may travel further north before descending, shifting the sub-tropical deserts further from the equator
- The Arctic may become ice-free in summer, weakening the northern hemisphere temperature gradient, increasing the likelihood of depressions getting stuck over the UK
- Thunderstorms will produce more intense rainfall and may become more violent

… in Sidmouth?

- Winter: frost will become rarer, leading to more overwintering of pests. Rain will become heavier, increasing the risk to transport links from floods and landslides. Snow will still occur in cold spells, especially on the hills. Winter will still be the peak season for deaths.
- Summer: thunderstorms will become heavier, increasing the risk of drains & streams overflowing, leading to more flooding in the valley. Summer temperatures will rise as the sea temperature rises. Dry spells will become hotter and longer, possibly leading to water supply problems. Dangerous heat will remain rare, especially near the sea
- Cloud, sunshine and wind will remain highly variable depending on the tracks of Atlantic storms
- Coastal erosion: rising sea level will increase beach & cliff erosion. A higher wall will be needed on the Esplanade by 2100.
- External risks: food security, epidemics, migration.

3. The Treatment

Personal carbon-cutting matters –

It's a powerful signal to those around us, moves the needle on policy and sets bigger cultural changes in motion. (**Mike Berners-Lee,** New Internationalist)

1. Change your diet. Cut out meat & dairy. Don't waste food. Avoid air-freighted food.

2. De-carbonize travel. Fly less. Try walking, cycling, public transport, car shares, working from home instead of driving. Drive carefully. If you need a new car, buy electric.

3. Consume less & wisely. Buy less junk, buy local. Check for sustainability. Buy high quality & make them last. Repair things or sell or give away. Choose energy-efficient white goods. Don't leave the house without a reusable cup.

4. Cut home energy use. Turn lights off, hang washing out to dry, wash at a lower temperature, keep showers short. Wear a jumper, turn the thermostat down, turn radiators off in empty rooms. Invest in insulation (starting with drafts, then the loft, windows and walls), smart heating (efficient boilers, remote controls that include radiators), solar panels/heat pumps. Buy electricity from a renewable energy provider.

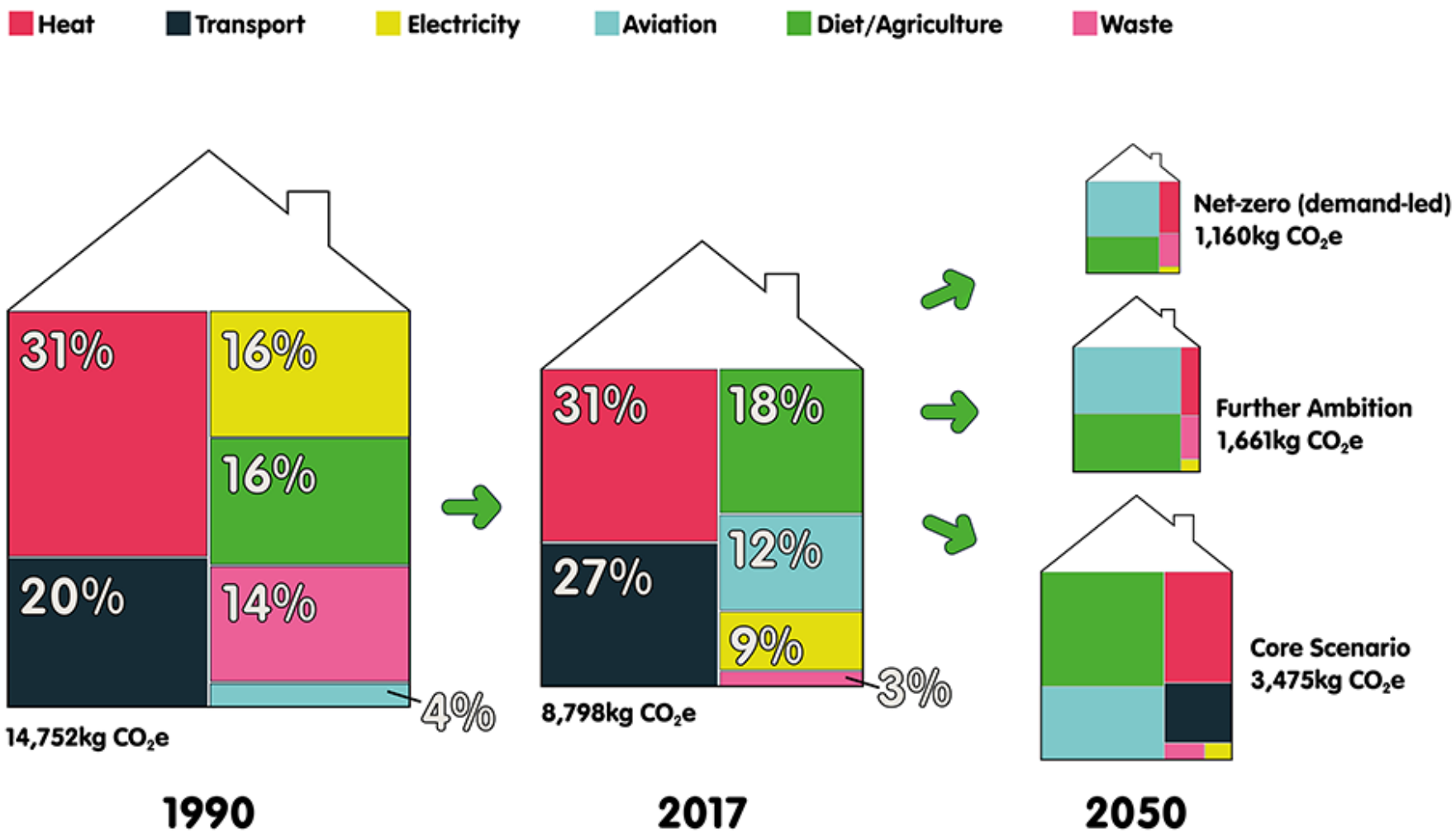
5. Clean up investments. Use pension & saving schemes that exclude fossil fuel companies. Invest in renewables & reforestation.

6. Talk about it. Take your low-carbon mindset to work, to the pub, into your own household. Be friendly but don't let that get in the way of clarity.

7. Be kind to yourself. Don't beat yourself up, but don't let yourself off the hook either.

8. Use your power. Politicians need to hear that we insist on coherent & strong climate policies.

Towards net zero



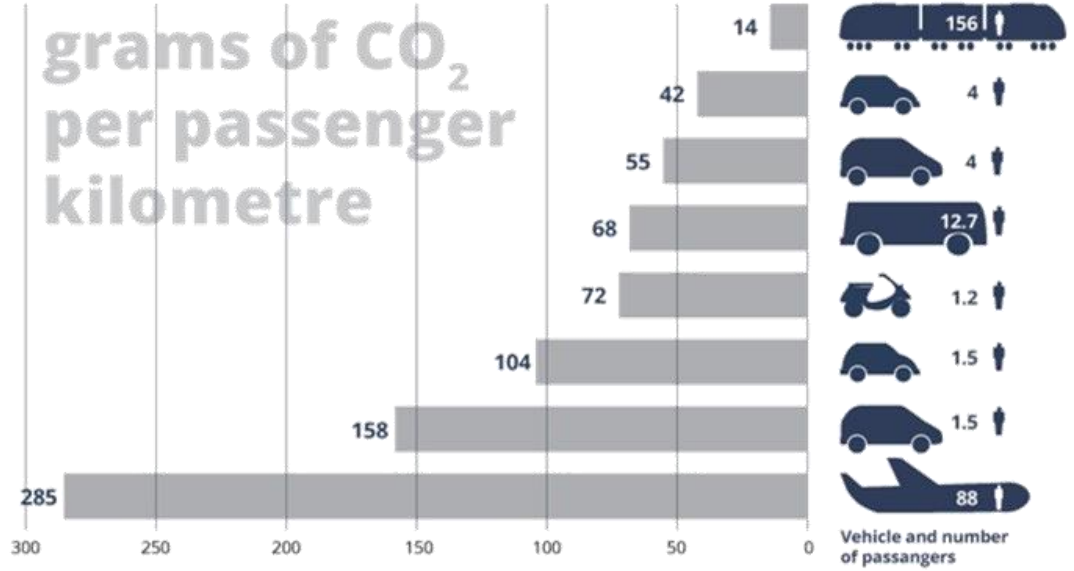
Save on electricity

- Switch off lights and electrical items when not in the room.
- Switch to efficient lighting: LED bulbs, etc. The average house saves 0.15Tonnes per year by switching to LED lighting.
- Use energy efficient white goods.
- Install renewable energy sources: e.g. solar panels
- Use renewable energy suppliers; offset the remainder

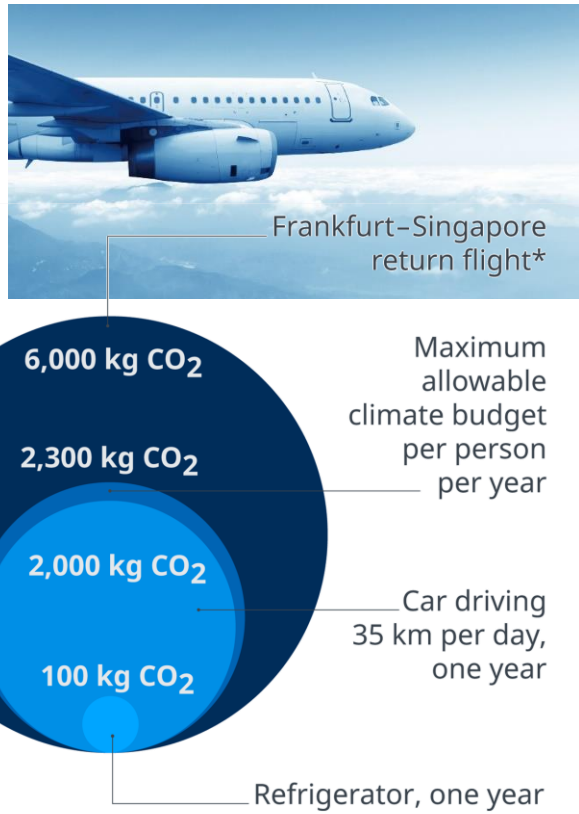
Save on heating & cooking

- Save energy wastage: use a condensing boiler, draught proof, insulate, double glazing, use heating controls (thermostats, clock etc)
- Reduce heating (recommended temperatures: 21^{o}C in the day, 18^{o}C at night). Stop heating rooms that are not in use.
- Install renewable energy sources: e.g. heat pump.
- Use renewable energy suppliers; offset the remainder.

Save on travel



- Reduce flying.
- Reduce car usage: walk, cycle, use the bus, car share, work from home.
- Drive efficiently: accelerate gently, drive more slowly, brake softly, switch off when stationary, keep tyres at correct pressure, remove unnecessary weight.
- Need a car? Use public transport & car hire instead? If not, consider electric: range is increasing & prices are reducing.



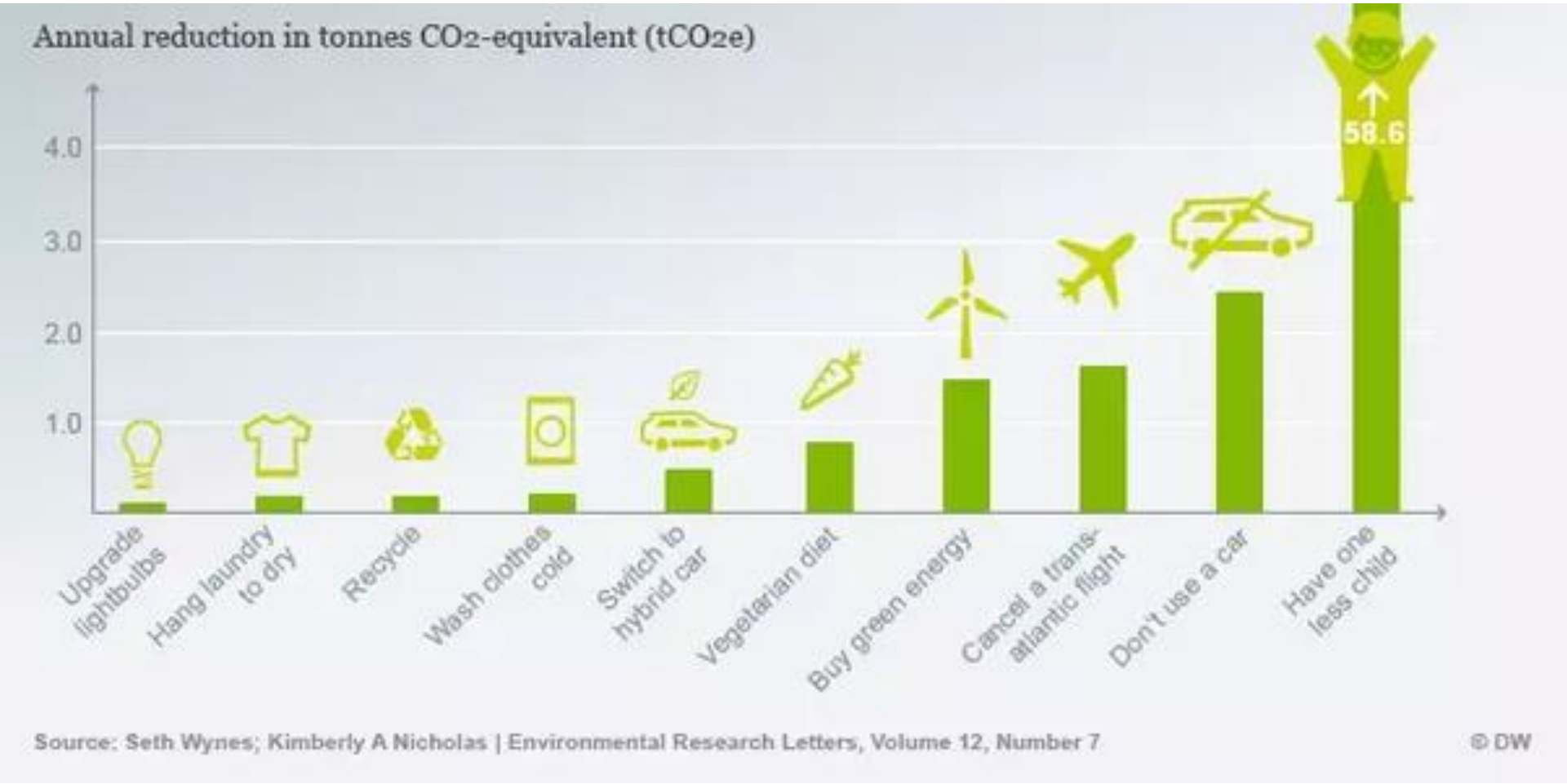
Save on food & water

- Local produce
- Reduce/recycle packaging
- Minimise/compost food waste
- Reduce meat consumption
  - Especially beef & lamb
- Use Fairtrade and sustainably produced food
- Water meter
- Modern low flush toilets or hippo

Save on goods & services

- Reduce (do I need it),
- Reuse (do I need new), sell, or give away
- Recycle (& recyclable)
- Buy from businesses committed to zero carbon
- Local – reduce air miles
- Sustainably sourced

Summary:
some ways to reduce CO2 emissions



4. Time for Hope

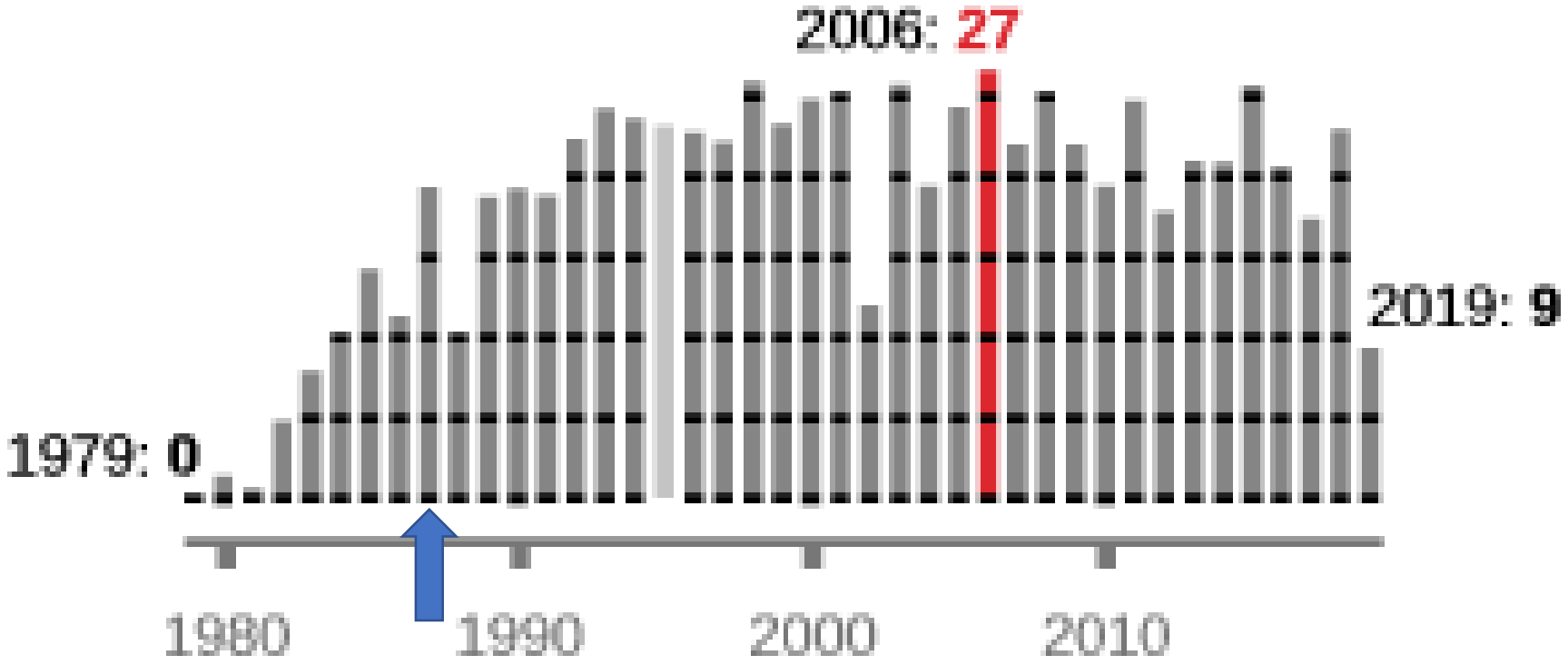
How to respond to children who fear the climate holocaust?

- People change - but they need time to change the things they value. Once people start changing, democratic governments are free to act on their behalf.
- We can be hopeful because human society has been successful in rising to other challenges.

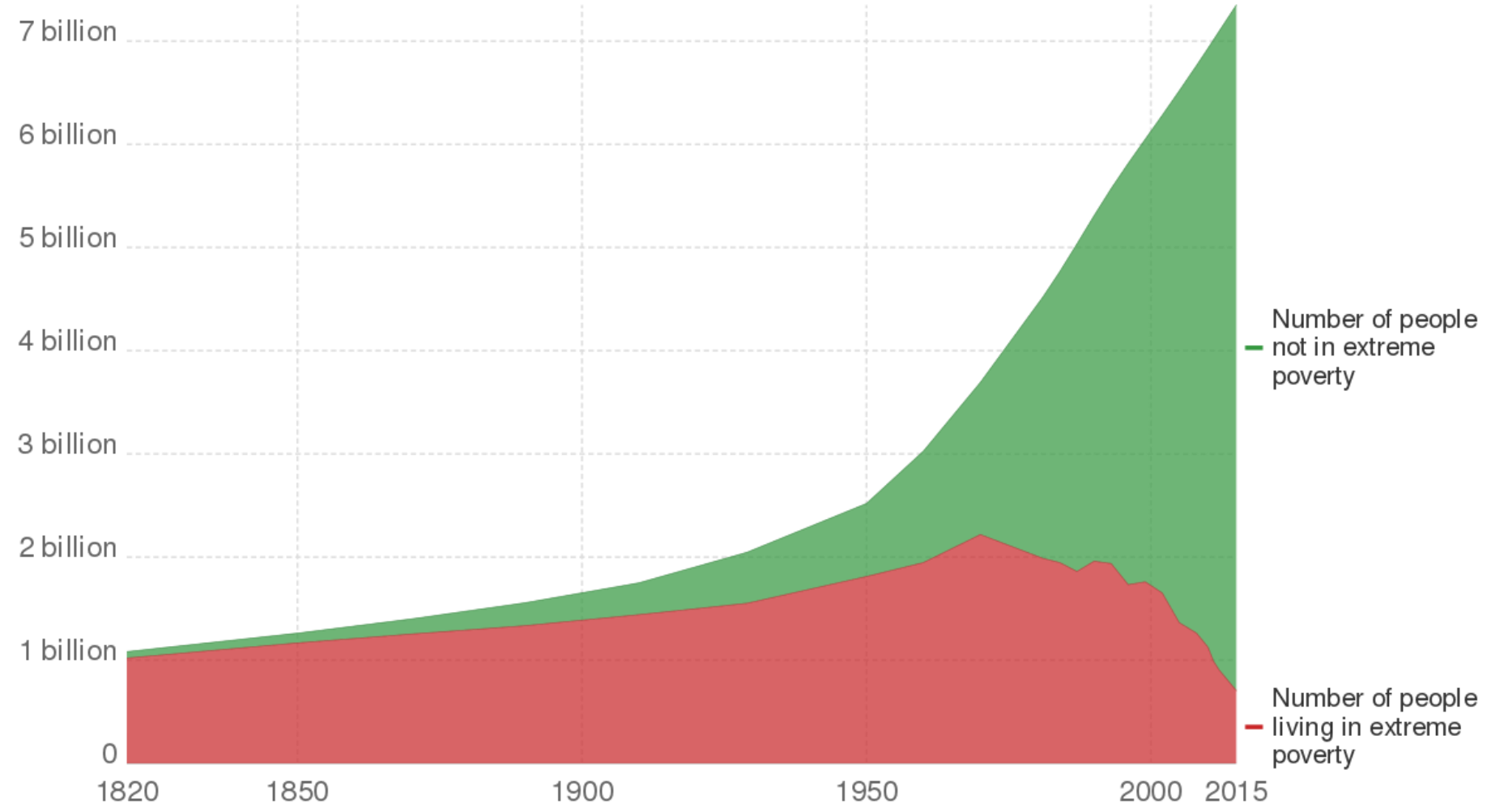
The ozone hole

maximum area in millions of km^2

and the Montreal Protocol



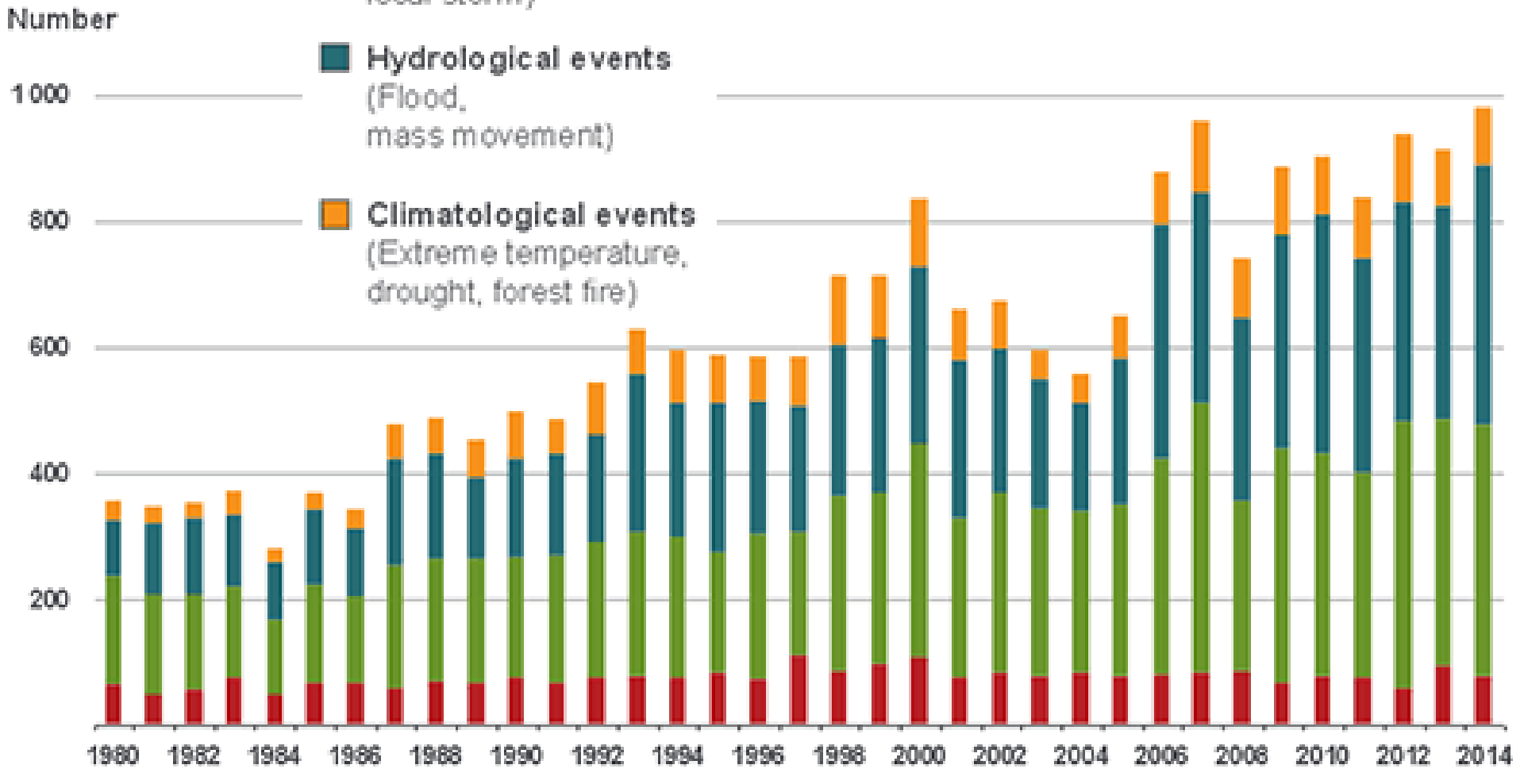
World population in extreme poverty
(living on <I$1.90 per day)



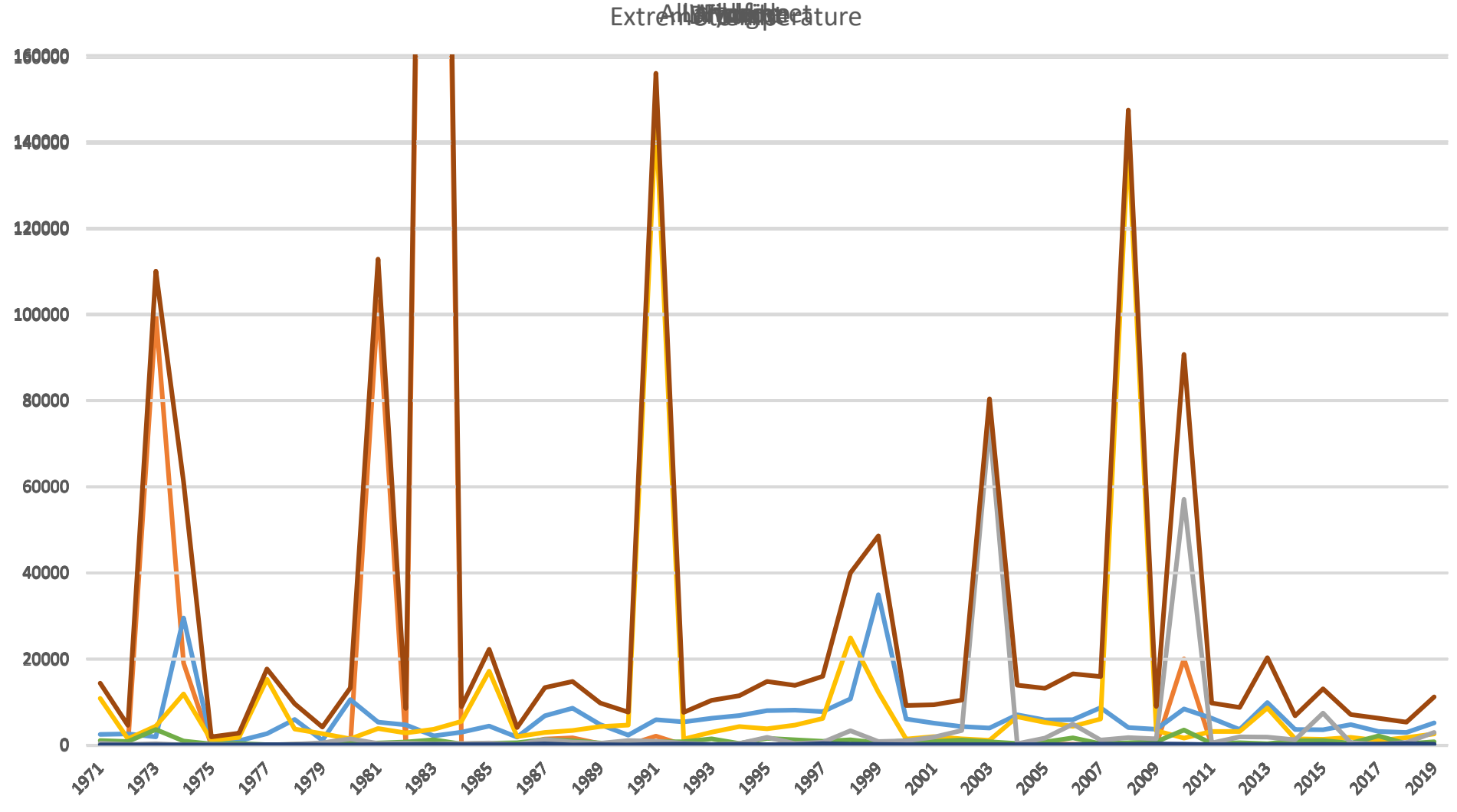
Source: World Poverty in absolute numbers - OWID based on World Bank (2016) and Bourguignon and Morrisson (2002)

Child mortality rates 1990-2015

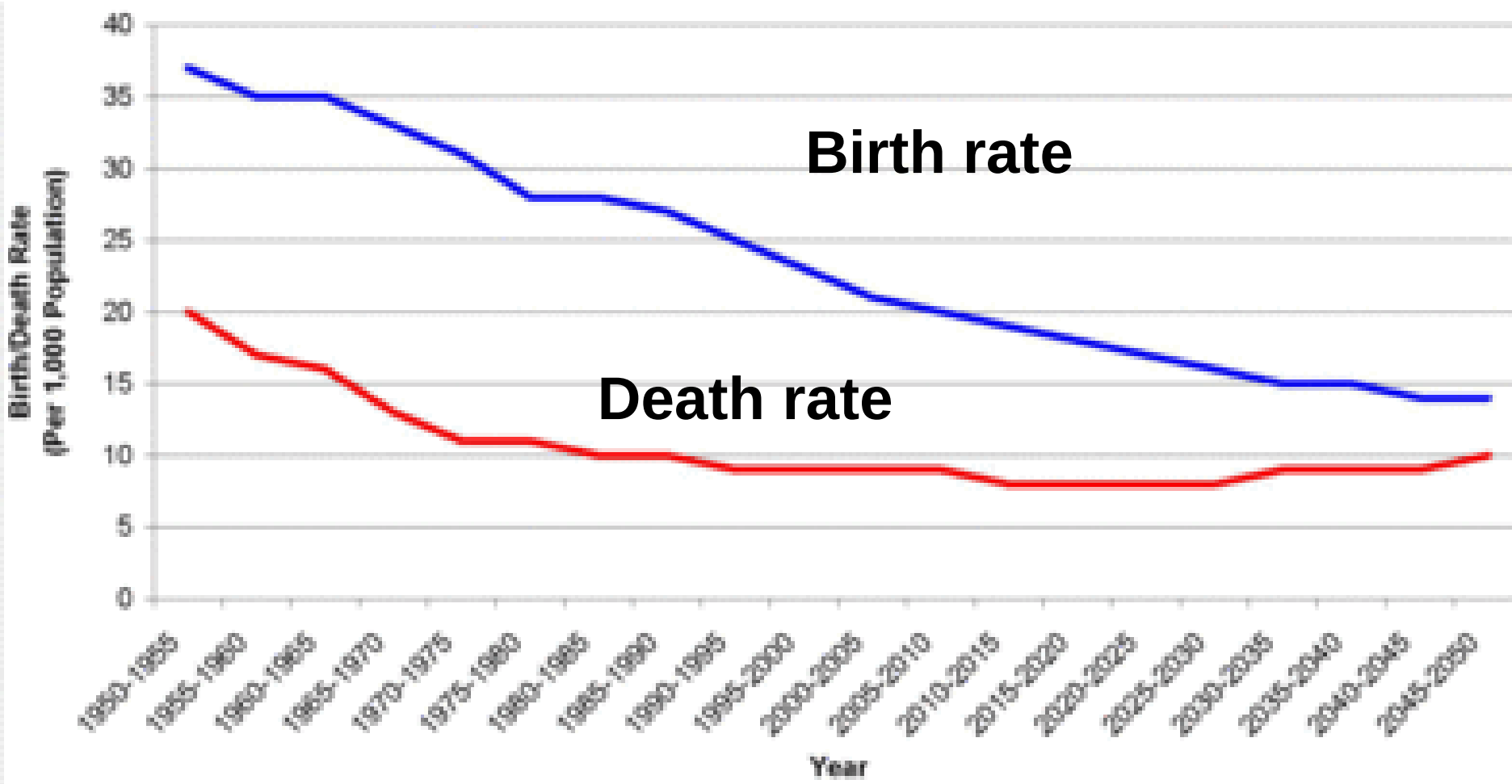
Increasing disasters 1980-2014



Decreasing deadly disasters



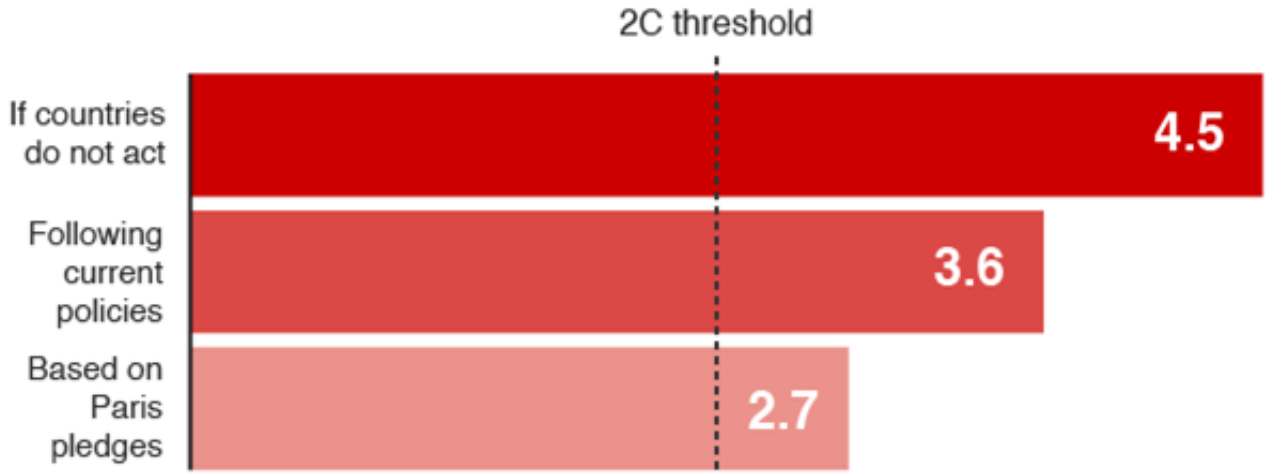
Global birth and death rates
per 1,000 population (1950-2050)



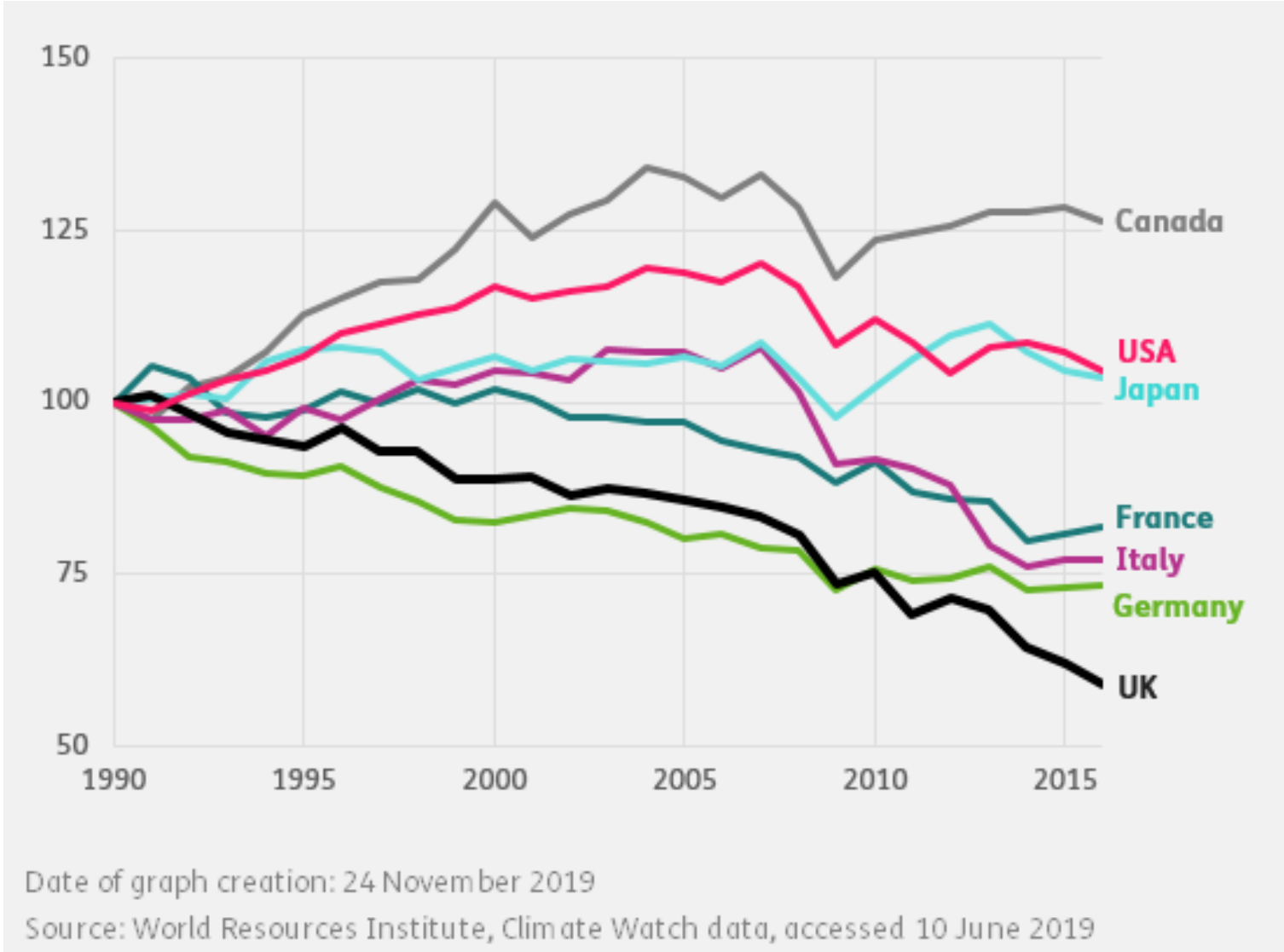
Source: Earth Trends, www.earthtrends.wri.org. Database. Accessed March 20, 2008.

The COP21 Paris Agreement

- Keep global temperature rise "well below" 2°C; "endeavour to limit" them to 1.5°C
- Peak greenhouse gas emissions as soon as possible & achieve net zero by some point between 2050 & 2100
- Create adaptation fund for poor countries: initially $100B pa
- Countries must set (non-binding) emissions reduction target



Progress in reducing emissions selected countries 1990-2016



Date of graph creation: 24 November 2019

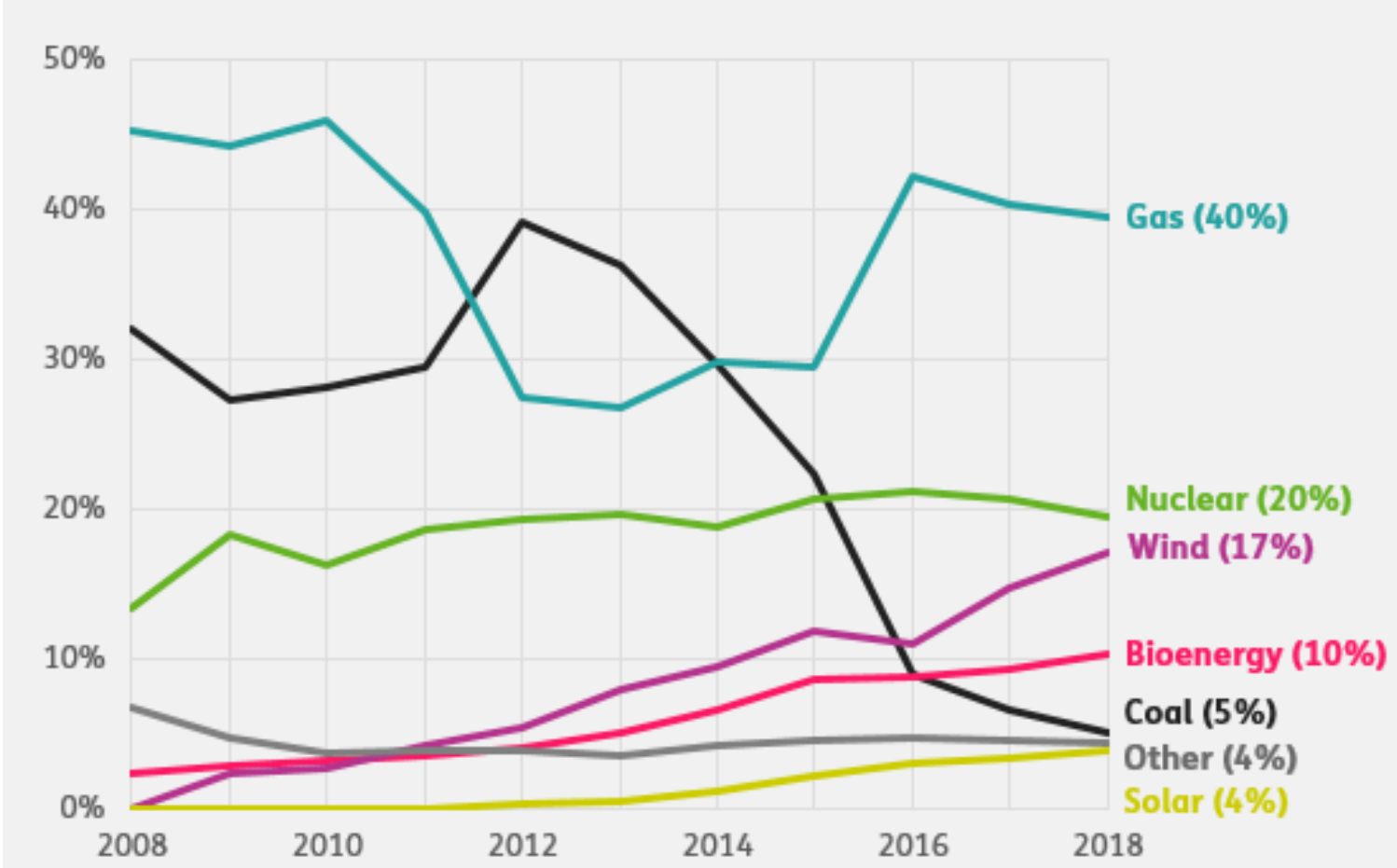
Source: World Resources Institute, Climate Watch data, accessed 10 June 2019

Can emissions be reduced without reduced standard of living?

	Change in carbon intensity 2017-2018	Annual average change in carbon intensity 2000-2018	Change in energy related emissions 2017-2018	Real GDP growth (PPP) 2017-18
World	**-1.6%**	**-1.6%**	**2.0%**	**3.7%**
G7	**-1.7%**	**-2.2%**	**0.3%**	**2.1%**
E7	**-2.2%**	**-1.7%**	**3.1%**	**5.4%**
Germany	-6.5%	-2.2%	-5.2%	1.4%
Mexico	-5.2%	-0.7%	-3.4%	2.0%
France	-4.2%	-2.5%	-2.6%	1.7%
Italy	-4.0%	-1.9%	-3.2%	0.9%
Saudi Arabia	-4.0%	1.1%	-1.8%	2.2%
China	-3.9%	-2.9%	2.4%	6.6%
EU	-3.7%	-2.3%	-1.8%	2.0%
Brazil	-3.5%	-0.3%	-2.4%	1.1%
UK	-3.5%	-3.7%	-2.1%	1.4%
Japan	-3.0%	-1.2%	-2.3%	0.8%
Canada	-2.2%	-1.7%	-0.4%	1.9%
Turkey	-2.2%	-1.2%	0.3%	2.6%
Australia	-1.8%	-2.1%	0.9%	2.8%
South Korea	-0.7%	-1.2%	2.0%	2.7%
US	-0.3%	-2.5%	2.5%	2.9%
Argentina	-0.1%	-0.1%	-2.6%	-2.5%
South Africa	0.0%	-1.8%	0.6%	0.6%
Indonesia	0.4%	-1.4%	5.6%	5.2%
India	0.7%	-1.4%	7.7%	7.0%
Russia	1.6%	-2.6%	3.9%	2.3%

Top 5 performers Bottom 5 performers

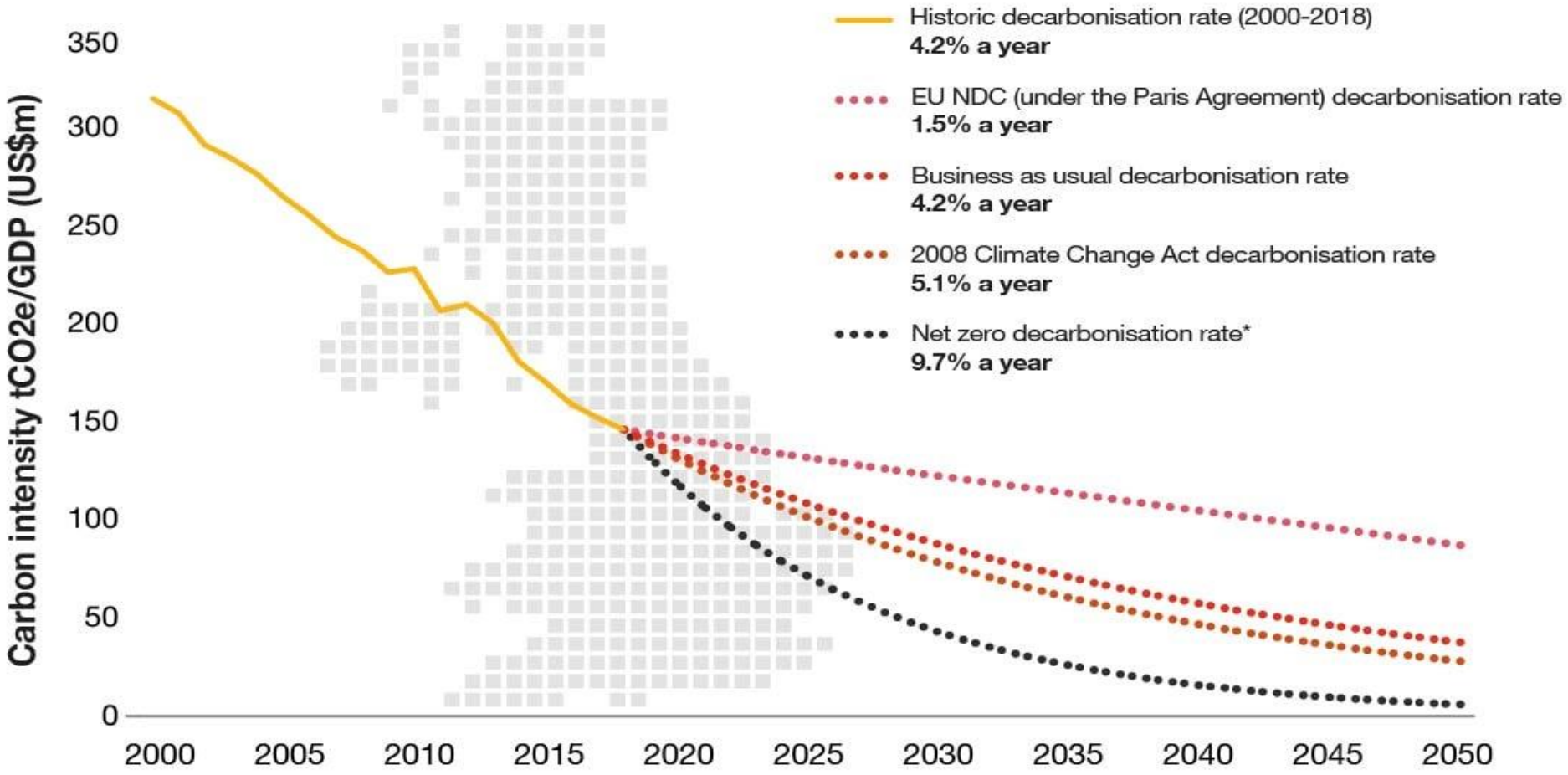
Share of UK electricity generation 2008-2018 by fuel type



Date of graph creation: 24 November 2019

Source: Department for Business, Energy and Industrial Strategy, Energy trends: electricity and renewables tables 5.1 and 6.1

The challenge for the UK



Summary

- Our environment is changing rapidly due to human activity.
- The results are warmer temperatures, more variable rainfall, higher sea level and degraded farmland.
- Without dramatic behaviour change, the world will be in a dangerous state within the lifetime of people now alive.
- Some changes need governments to act, but individuals can do much by changing their lifestyle and influencing others.
- We should be hopeful: opinions are shifting, emissions are moving in the right direction, just not yet fast enough.
- Now is the time to act: as individuals, through organisations and through the political process.

Our Fragile Earth:

Act now