Climate Change

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(What it is, how we know about it and what we can do about it)

With grateful acknowledgement to the following for data, images and slides:

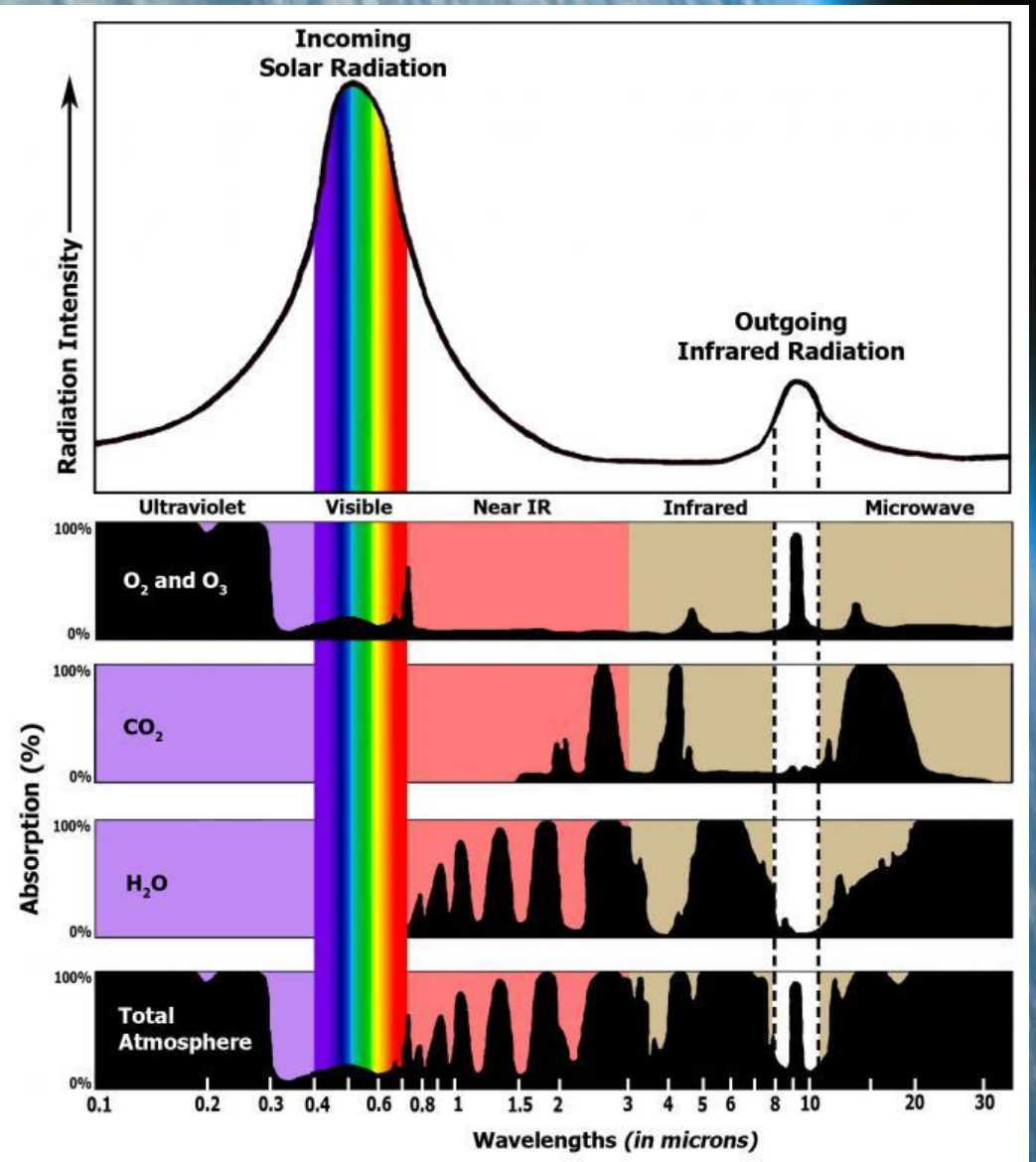
- Climate Central for original overview slides that I have modified
- Prof Kevin J Anchukaitis for the Sherwood Rowland image and quotation
- Dr. Ed Hawkins at the University of Reading and Climate Lab Book for the temperature spiral
- Dr. Bo Vinther, University of Copenhagen for the ice core record
- Dr. Mark McCarthy from the UK Met Office for sharing both local climate data and climate projections carried out by the Met Office
- Dr. Tine Christensen for a simple explanation of the implications of the Paris Agreement
- The Carbon Brief for some very nice infographics
- The IPCC 5th Assessment Report
- Plus many other scientists at DMI and internationally who have contributed data, publications and photographs

With special thanks and in memory of Professor Sir David MacKay, who brought the clarity of mathematics and engineering to the renewable energy debate

CLIMATE CHANGE

- **Happening now and human caused**
- **Some impacts are irreversible**
- **Actions today can limit future warming**
- **We need to prepare for future impacts**

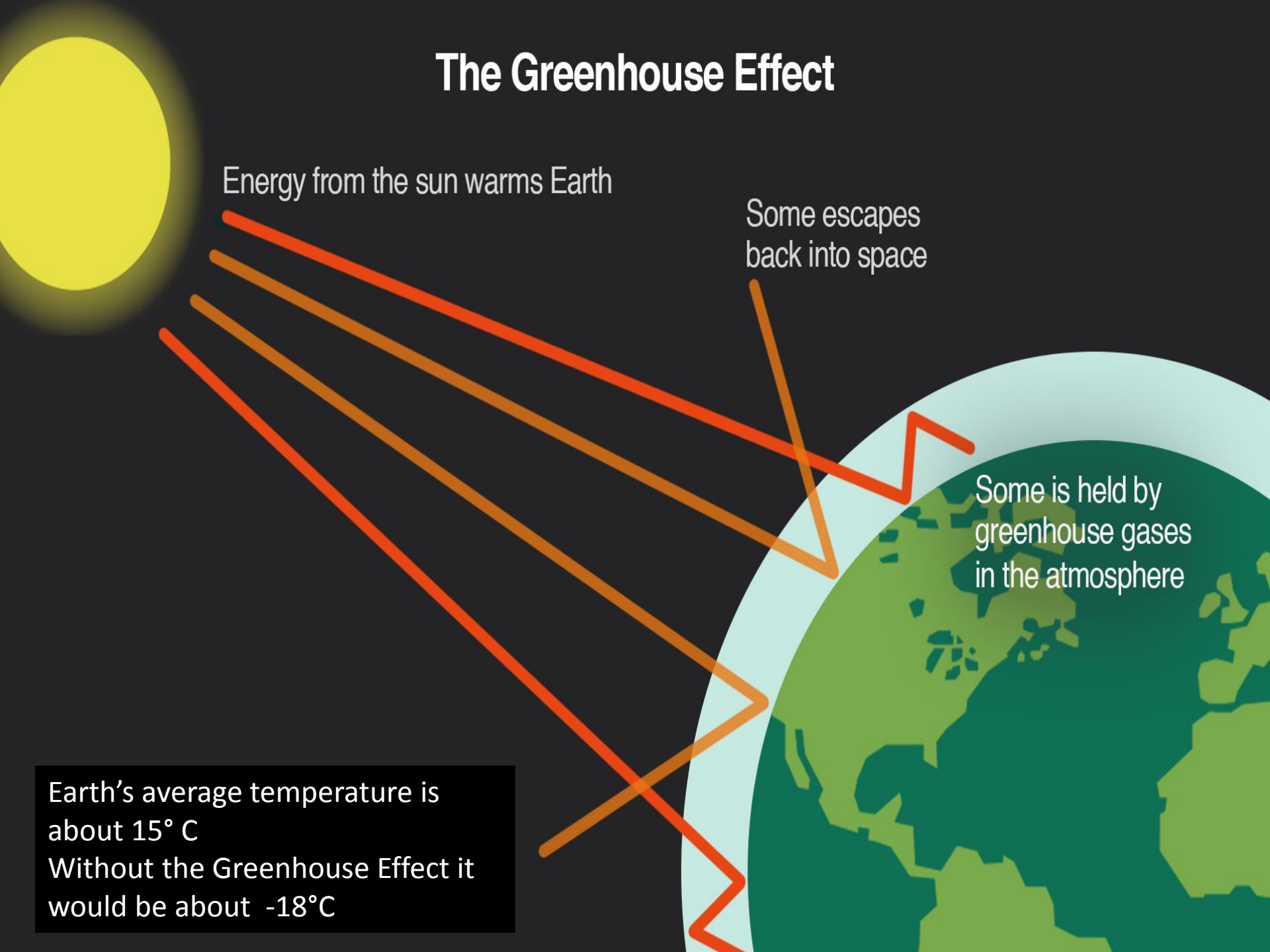
Atmospheric Gases



99% nitrogen and oxygen, with important trace greenhouse gases:

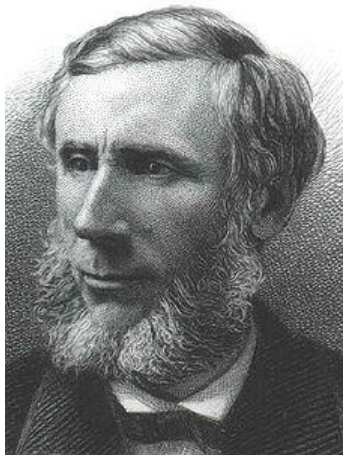
- Water vapour
- Carbon dioxide
- Methane
- Nitrous oxide

The Greenhouse Effect



Earth's average temperature is about 15° C
Without the Greenhouse Effect it would be about -18°C

Early Pioneers



1863
John Tyndall

Doubling CO_2 would warm the Earth's surface

1895
Svante Arrhenius

Arctic would warm 15°F if CO_2 increased by 2-3x
CO_2 was 295 ppm at the time

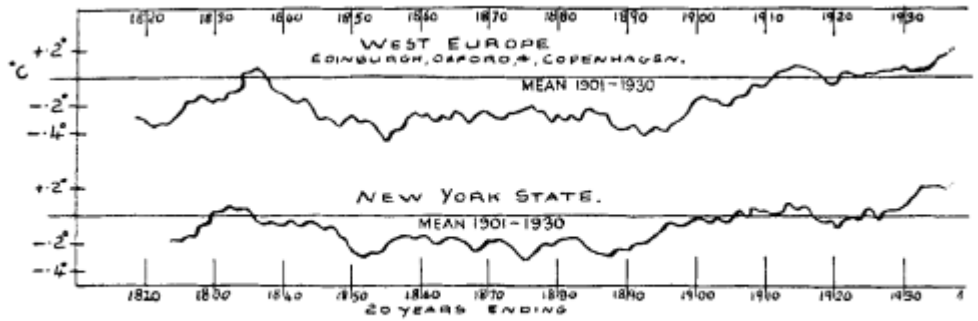


FIG. 3.—The most reliable long period temperature records. Twenty-year moving departures from the mean, 1901-1930.

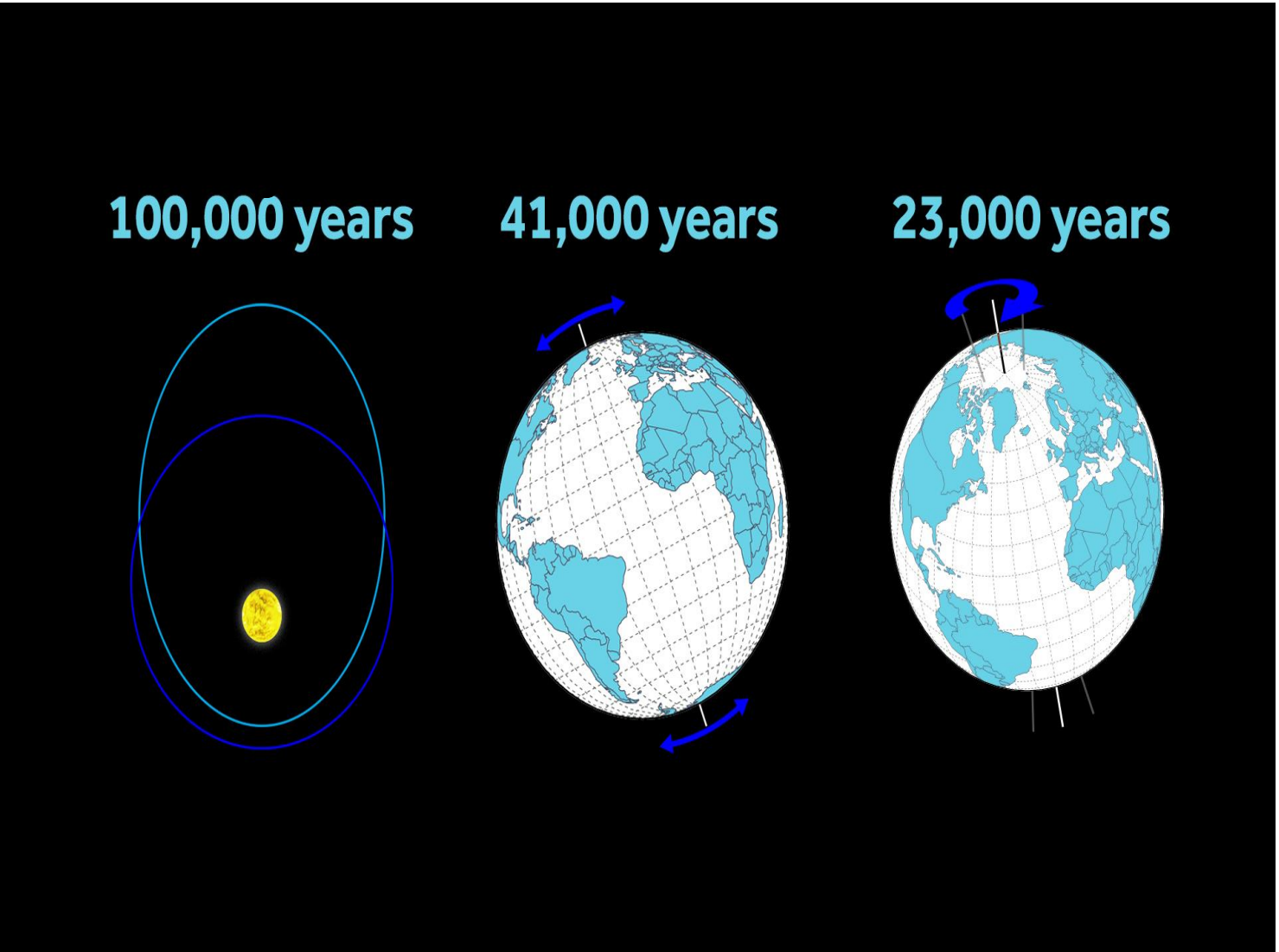
THE ARTIFICIAL PRODUCTION OF CARBON DIOXIDE AND ITS INFLUENCE ON TEMPERATURE

By G. S. CALLENDAR

(Steam technologist to the British Electrical and Allied Industries Research Association.)

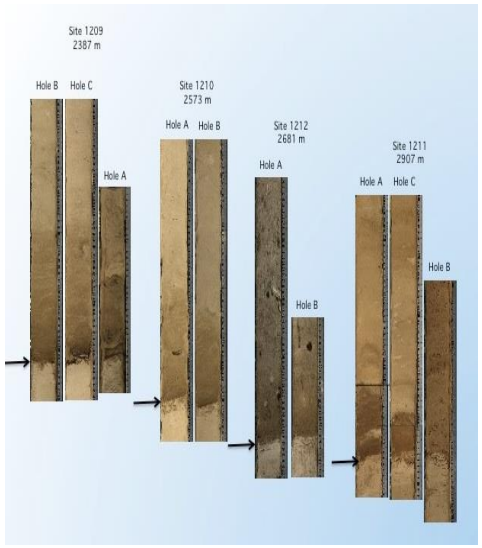
[Manuscript received May 19, 1937—read February 16, 1938.]

Natural Variation – Orbital Cycles



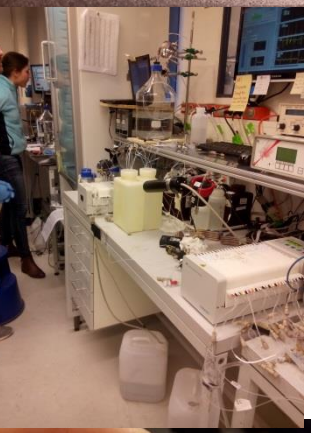
- These cycles change distribution of solar energy
- Largely responsible for ancient warming and cooling periods

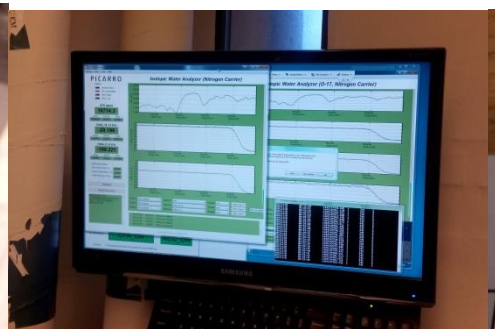
Reconstructing The Past

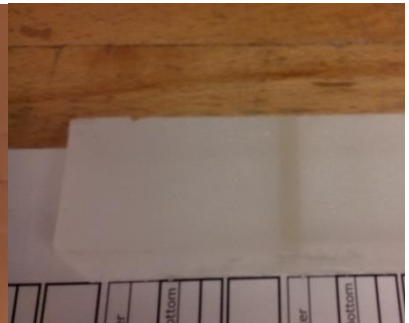


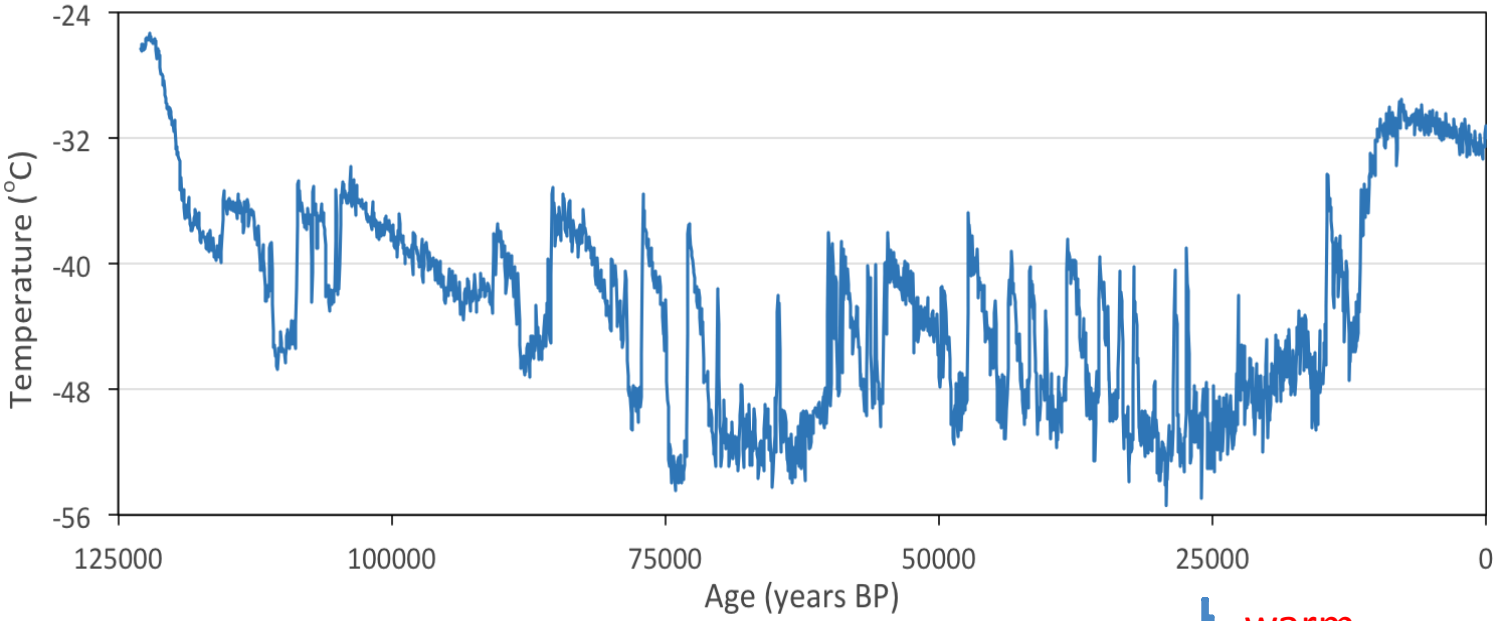
- Ice cores, tree rings, corals, and sediment cores reveal signals from previous climates
  - Ice cores trap ancient air
  - Ring patterns display tree stress
  - Bands in coral shells reflect changes in temperature
  - Sediment cores reveal ancient ocean chemistry

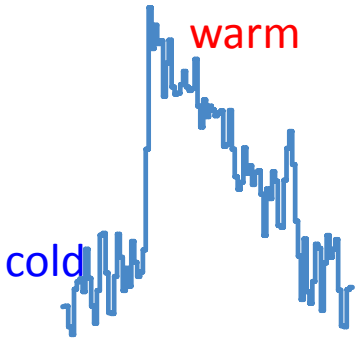
Greenland Ice Core Records









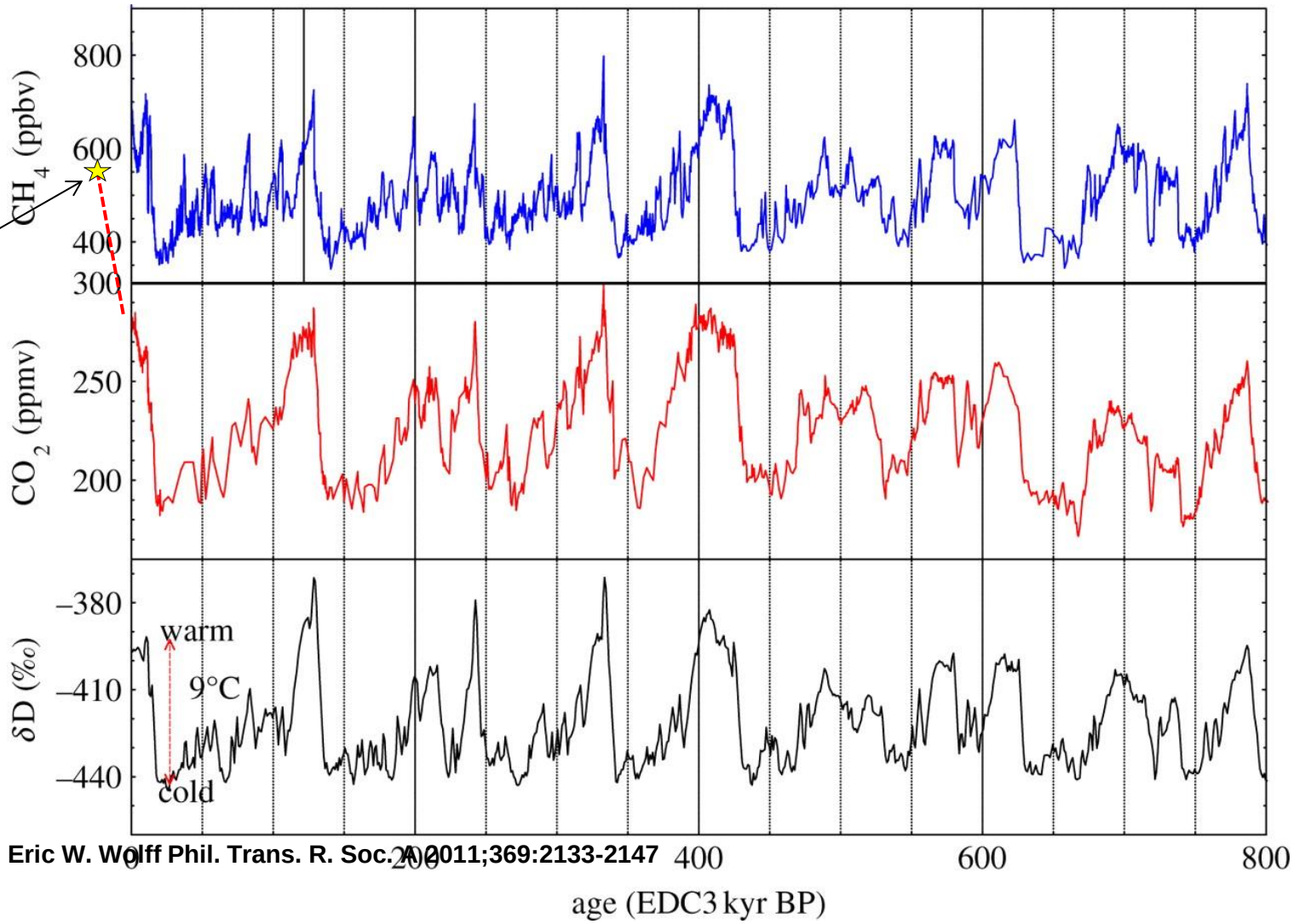


The Distant Past

Temperature, Carbon dioxide and Methane from an Antarctic Ice Core

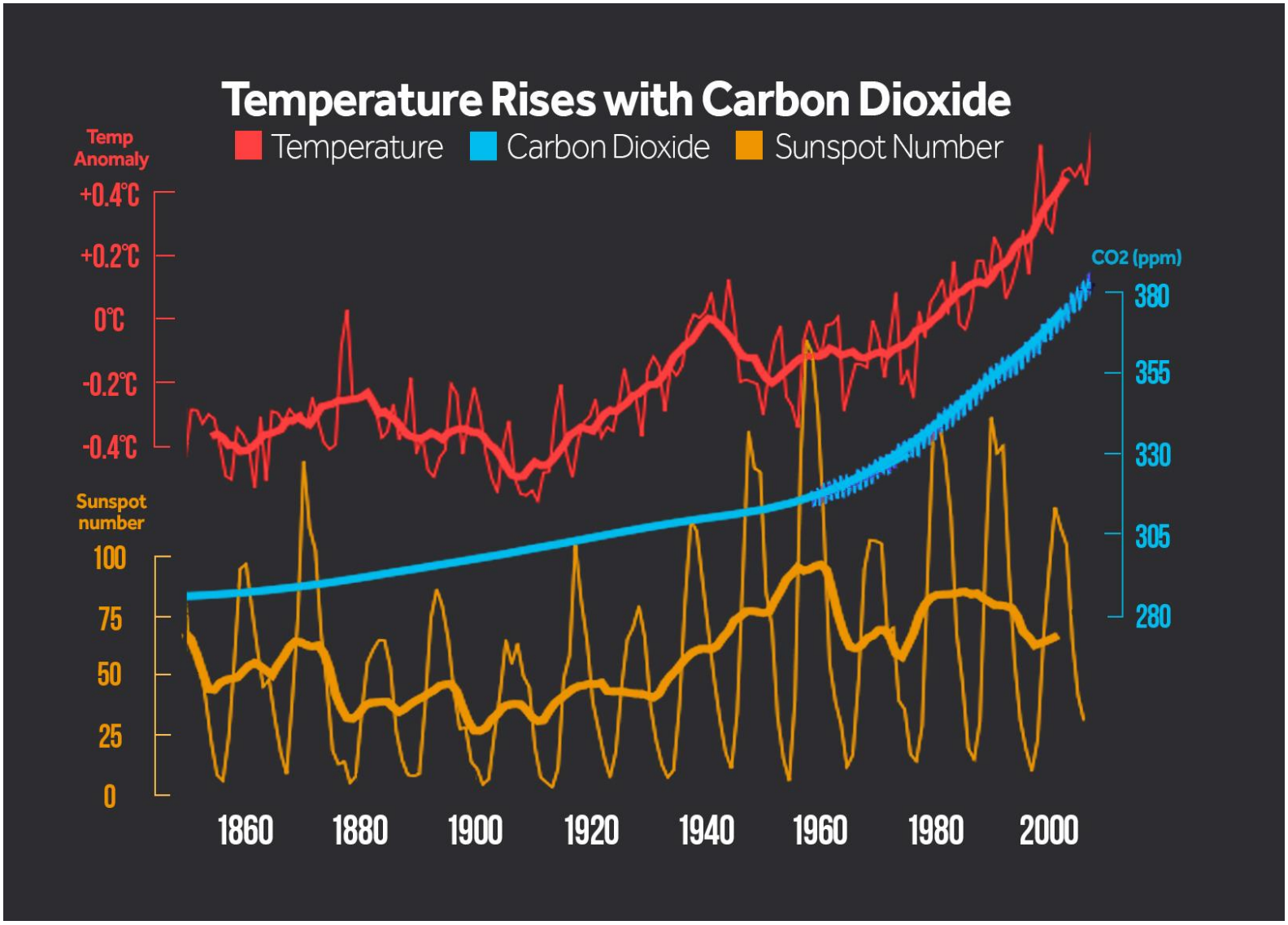
We are here:

400 ppm

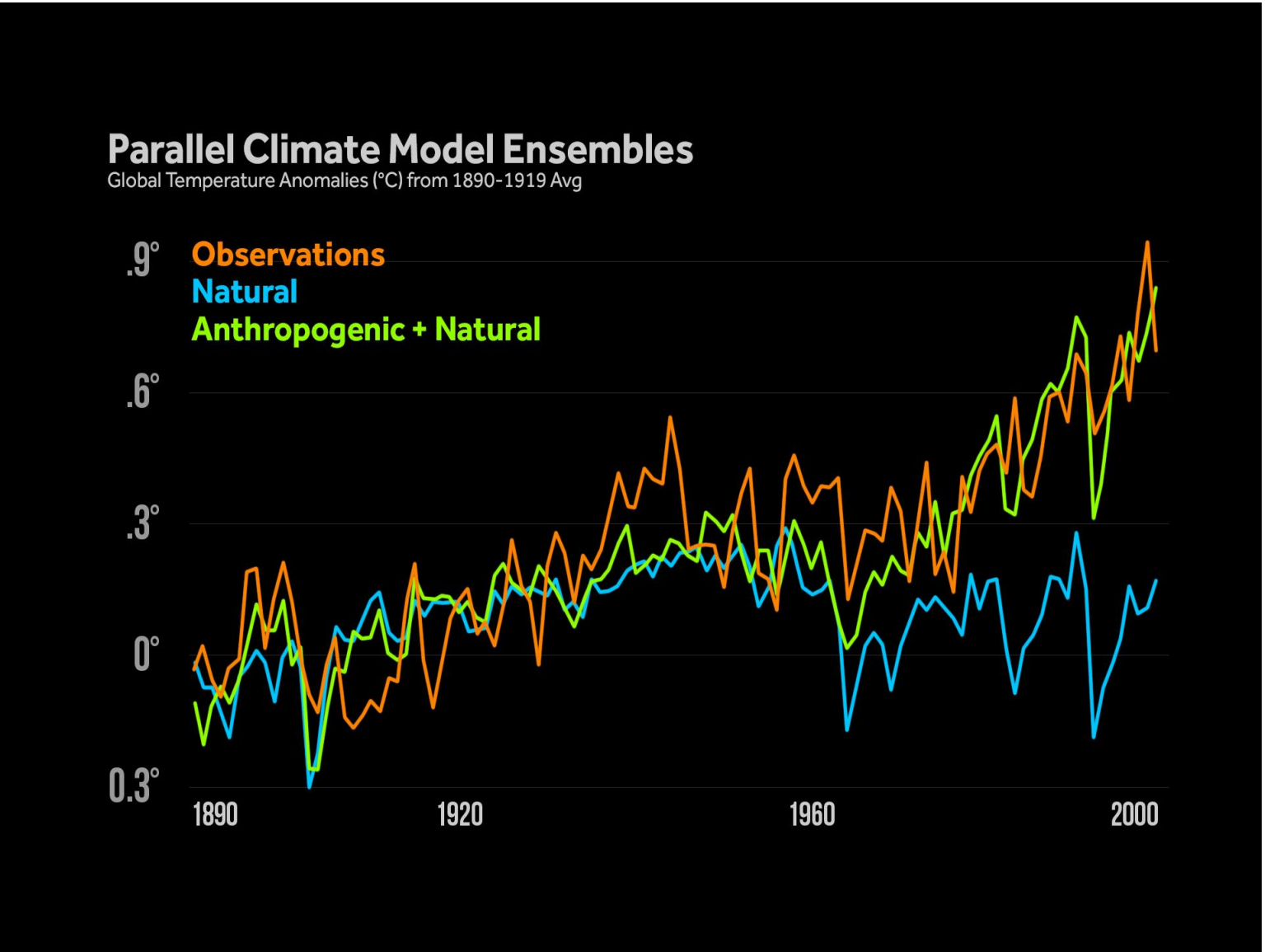


Eric W. Wolff Phil. Trans. R. Soc. A 2011;369:2133-2147

The Recent Past



Reconstructing The Past

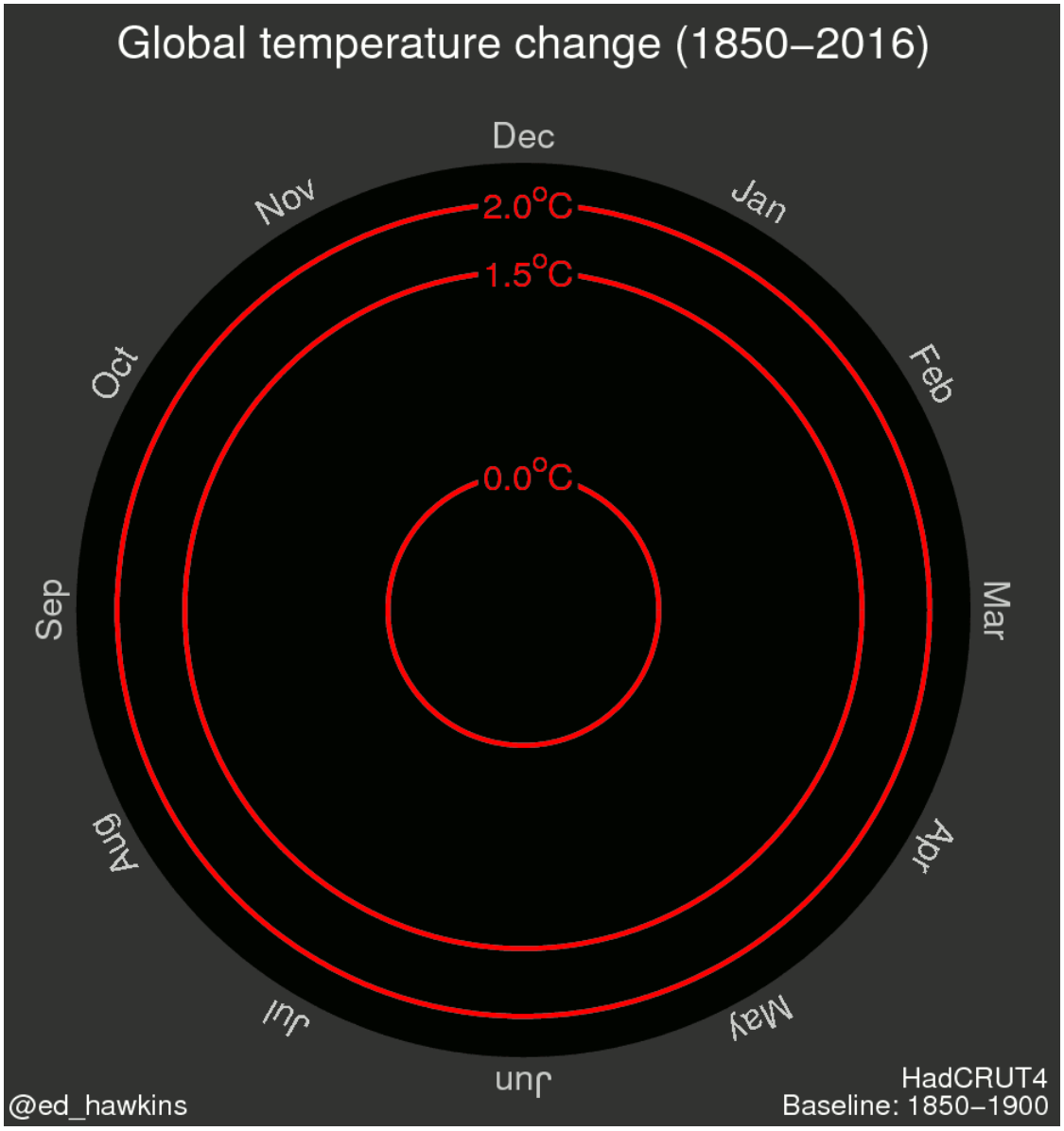


Computer models are unable to recreate the current warming without including increase of greenhouse gases

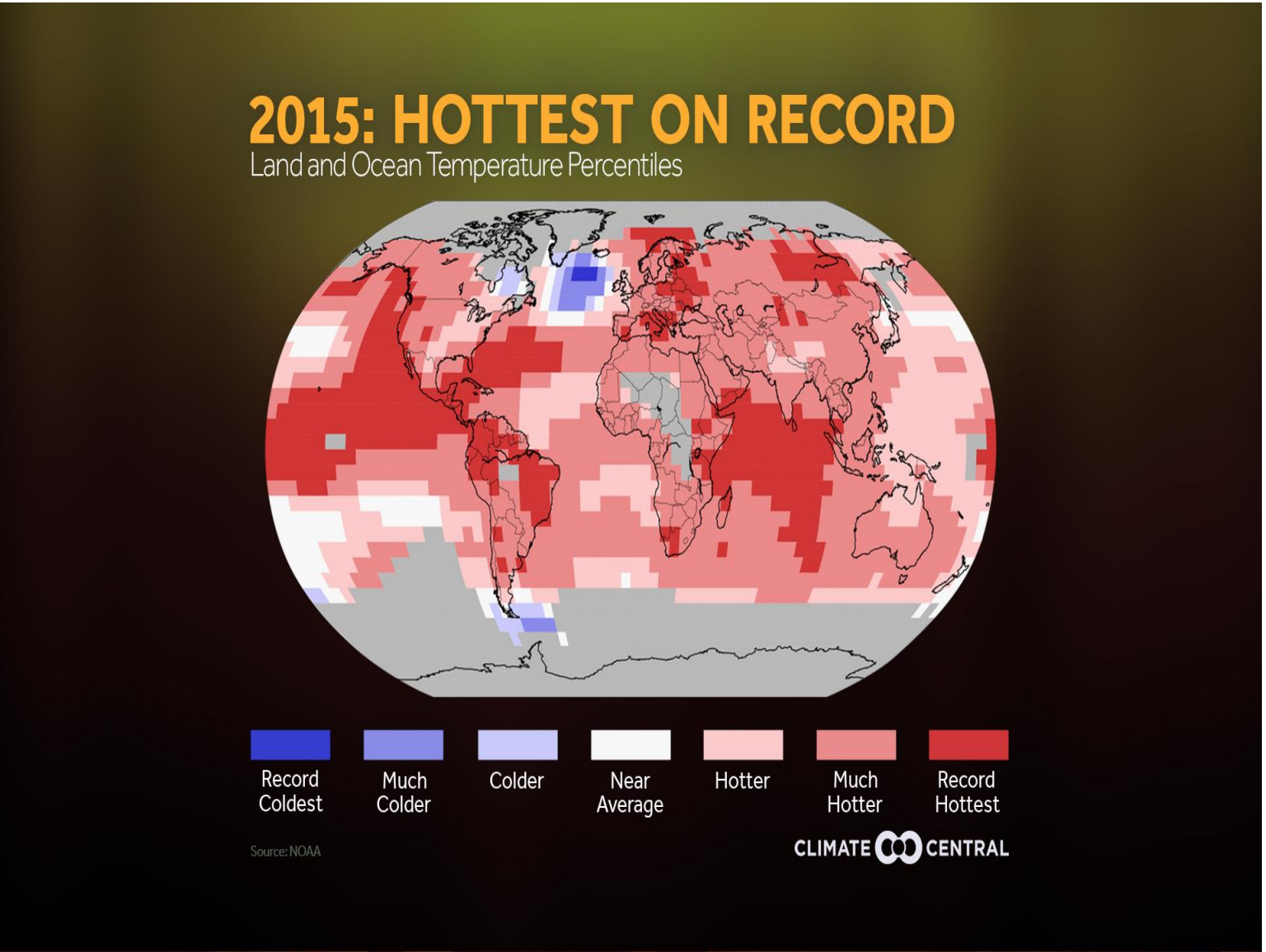
Want to know more?

- 97% of actively publishing climate scientists agree that human-caused climate change is happening.
- 99.9% of scientific research studies published in peer-reviewed scientific journals find that human-caused climate change is happening.
- IPCC Assessment Report 5 has science, impacts, adaptation and mitigation sections

Climate Change is already here

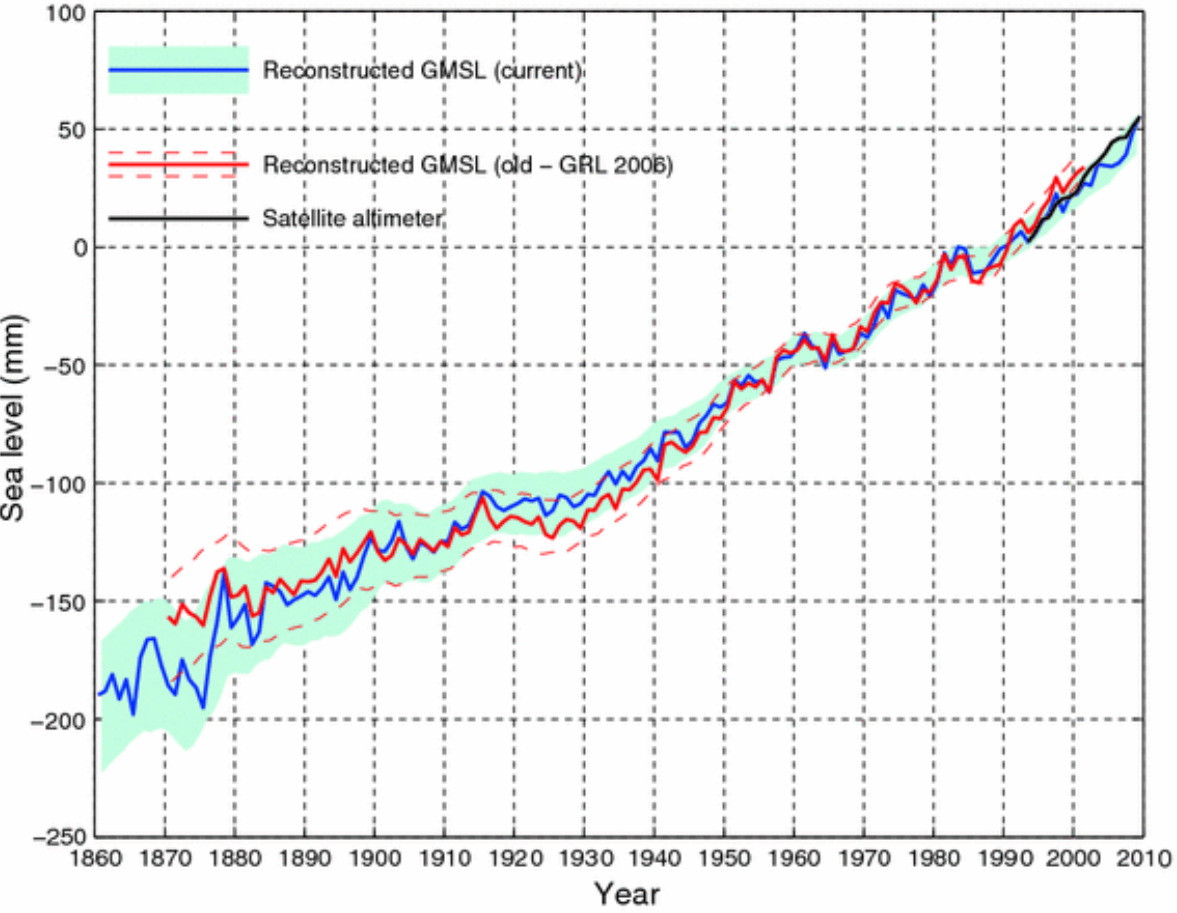


Hotter Times Have Arrived



2015: Record heat for land and oceans

Sea Levels Are Rising



Caused by:

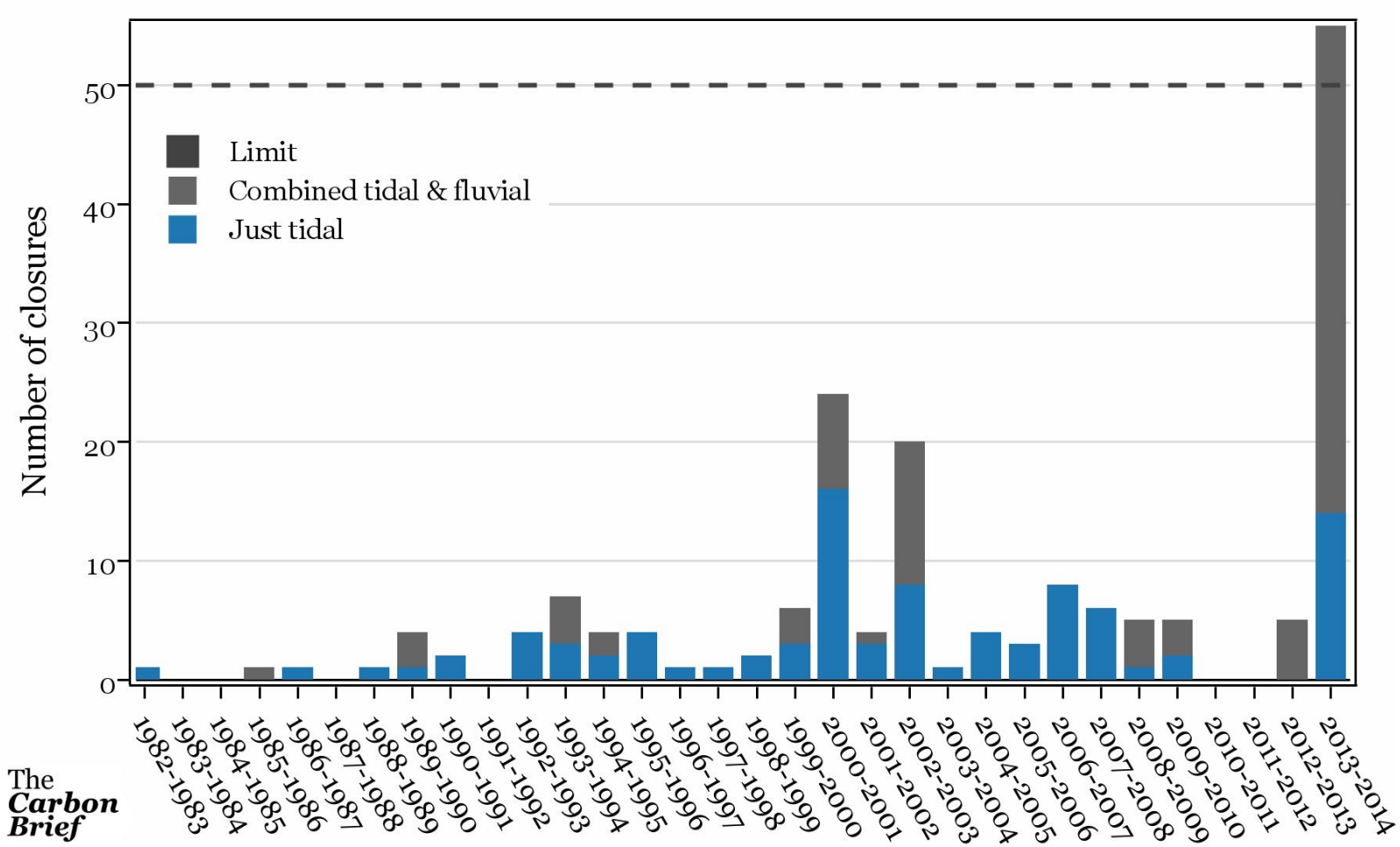
- Warm, expanding waters
- Melting ice sheets (Antarctica, Greenland)
- Melting glaciers

Flooding from Extreme Rainfall Events

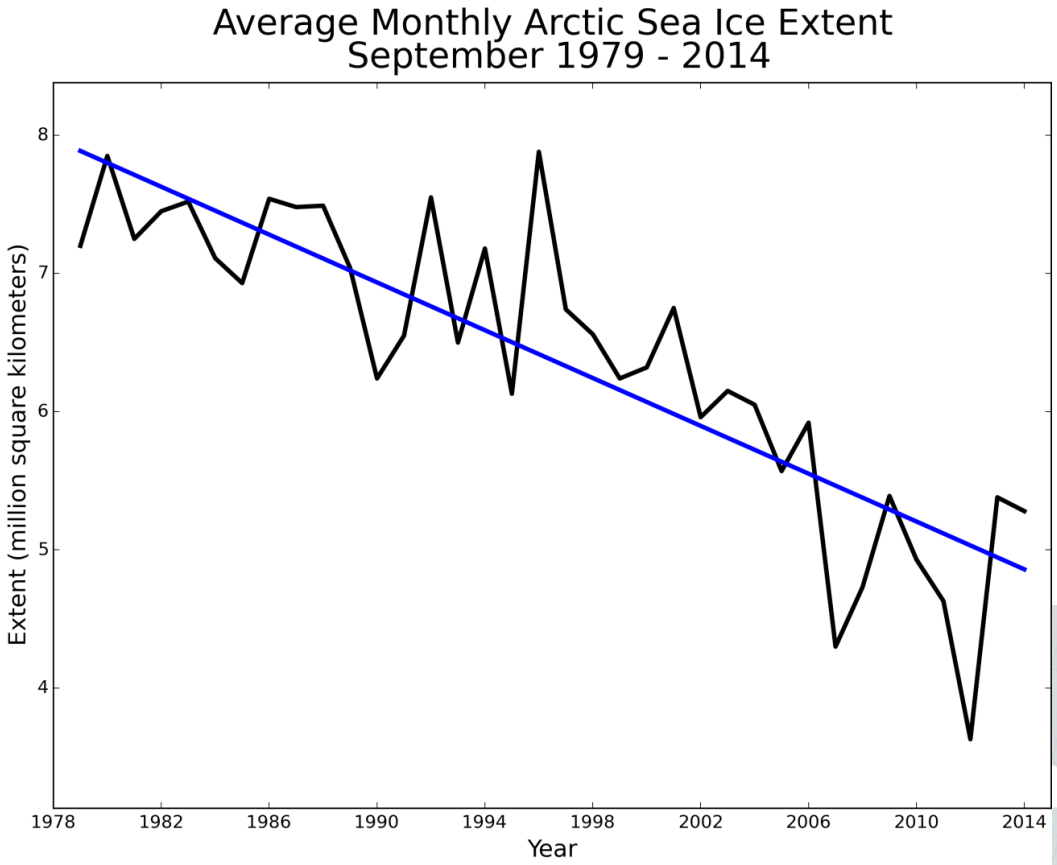
Flooding from storm surges

Flooding and Storm Surges

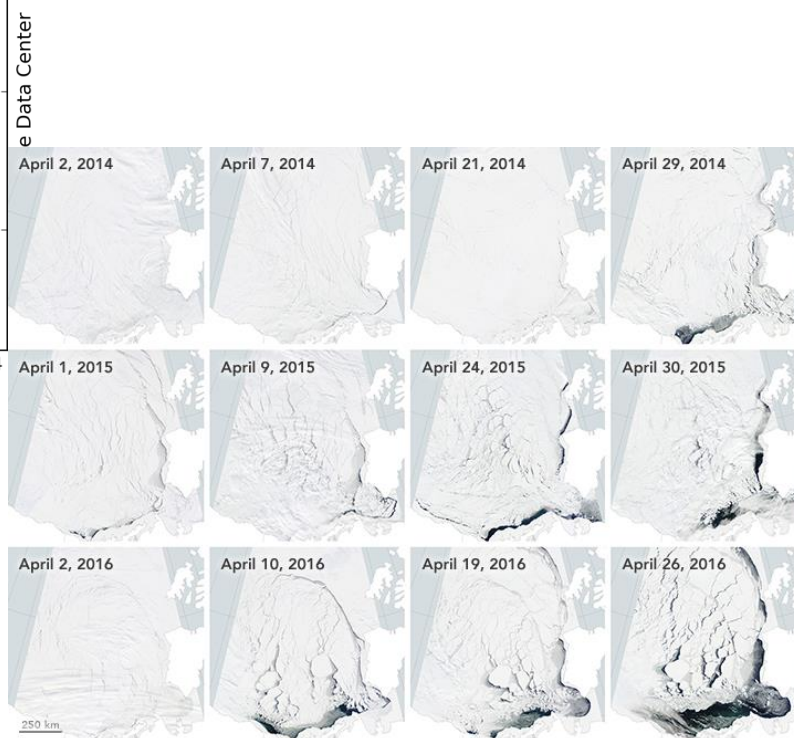
Thames Barrier closures per year since opening



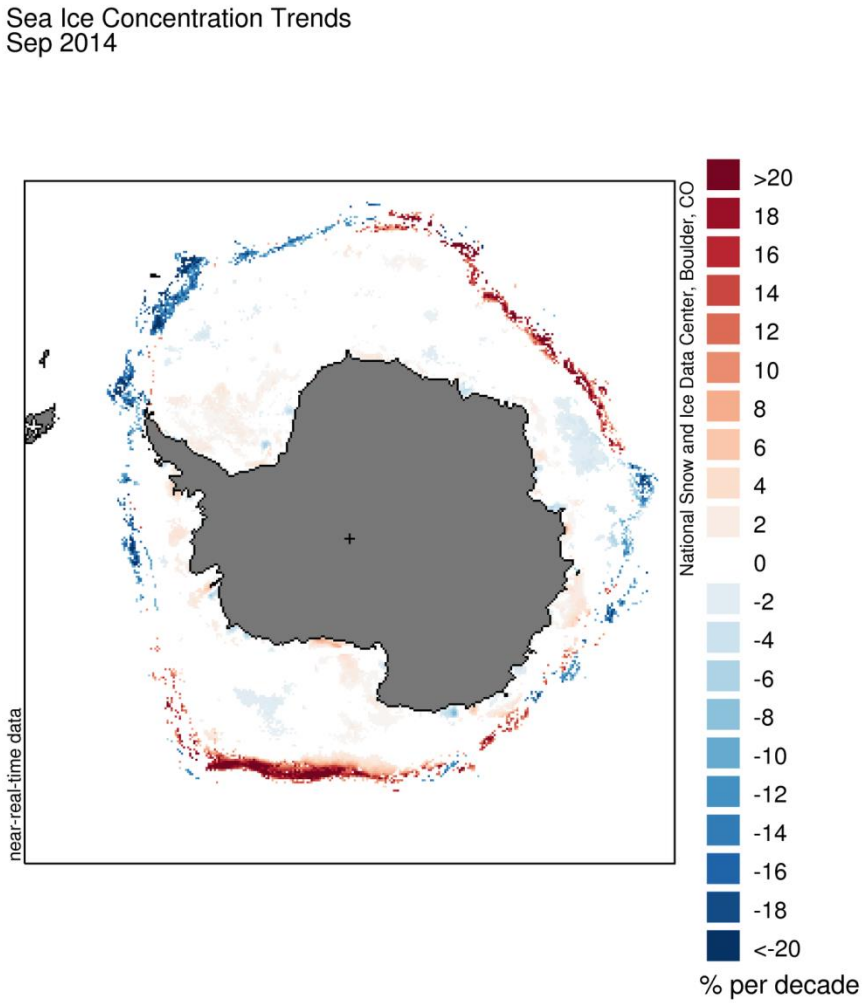
Arctic Sea Ice Is Declining



Ice extent is getting smaller, ice is thinning, breakup happens earlier each year



Antarctic Sea Ice Is More Complicated



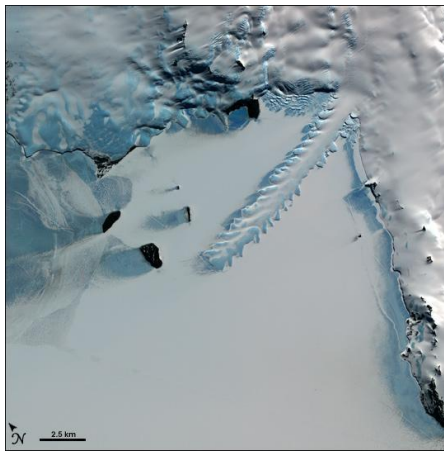
Sea ice around Antarctica is declining in some places and increasing in other places, probably related to :

Ozone hole interactions

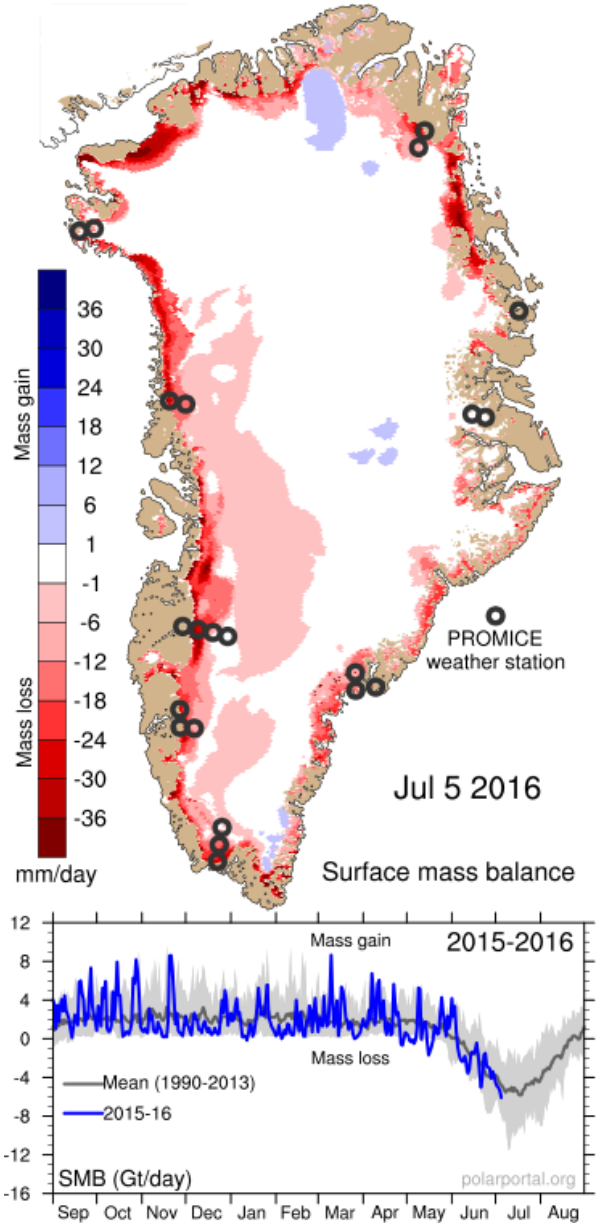
Increased ice shelf melt

Increases in wind speed around Antarctica

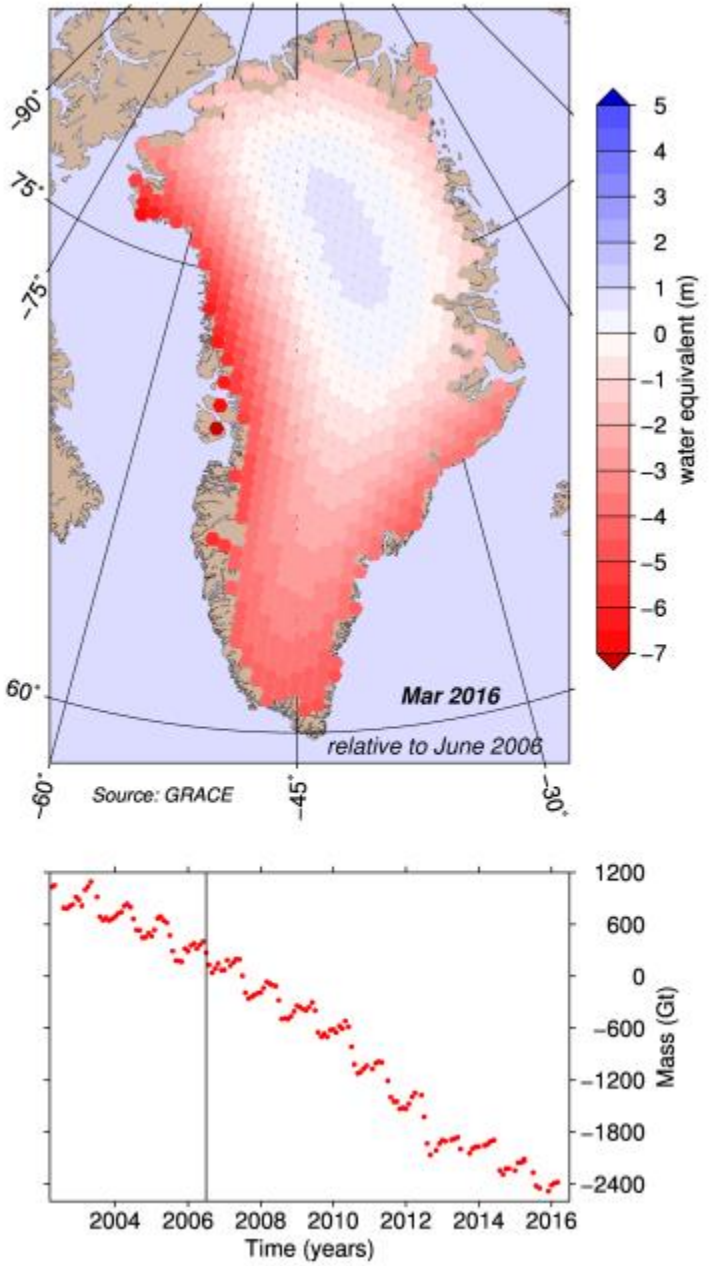
Pacific Ocean circulation changes



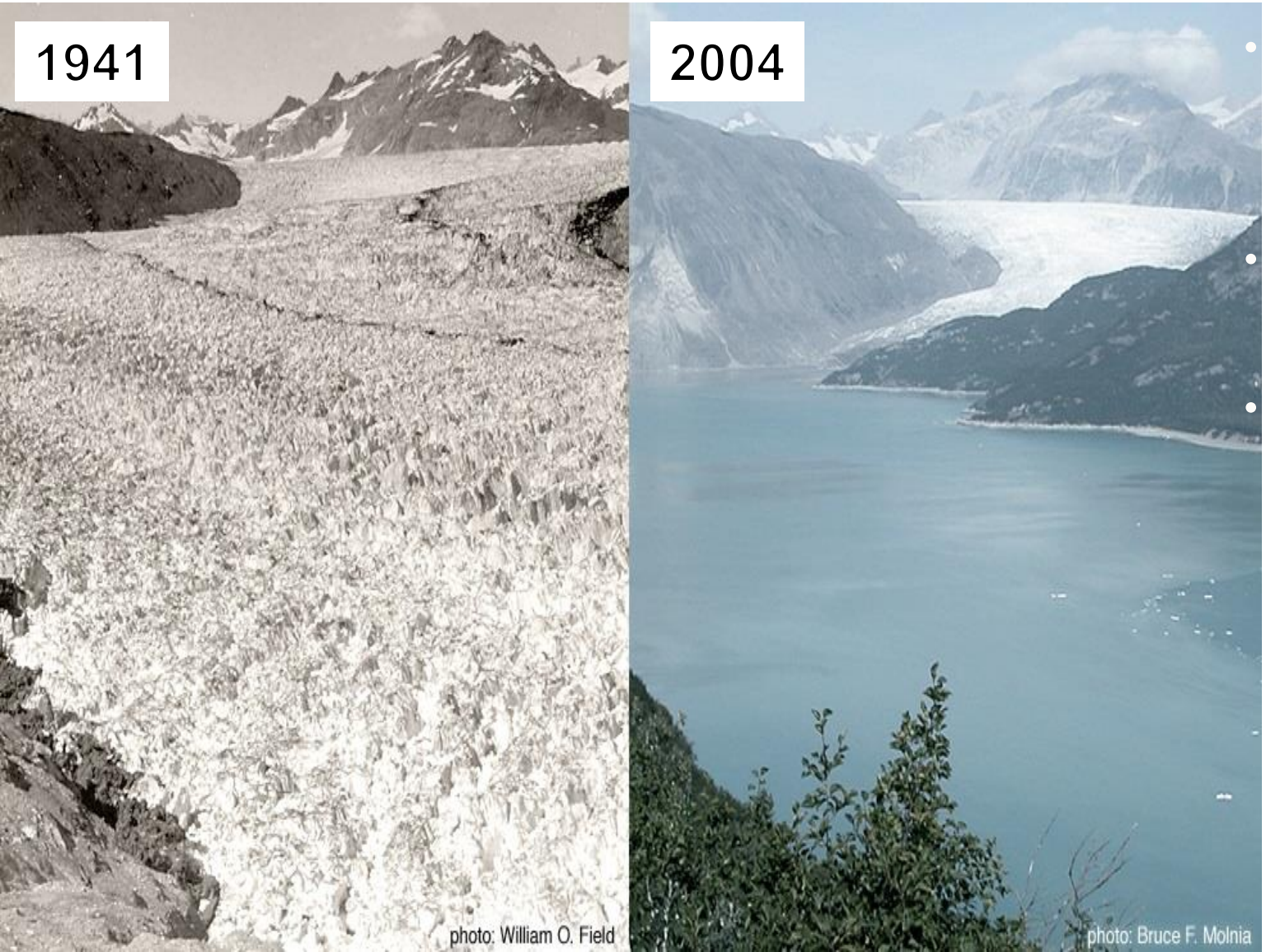
Greenland Ice Sheet



Greenland loses around 250 billion tonnes of ice each year.



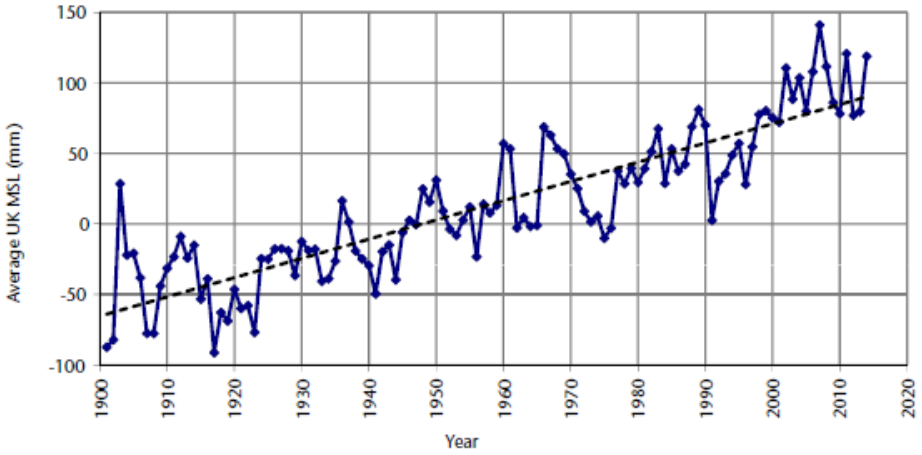
Glaciers Melting And Retreating



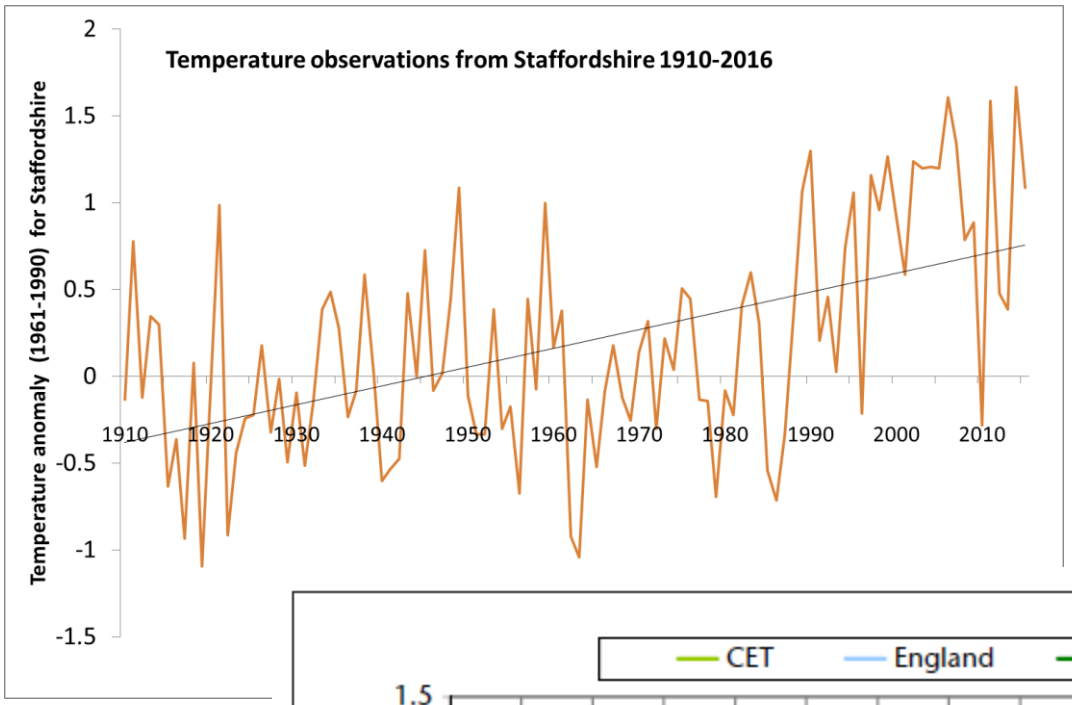
- Alaska's Muir Glacier
- Retreated 7 miles
- Thickness decreased by ½ mile

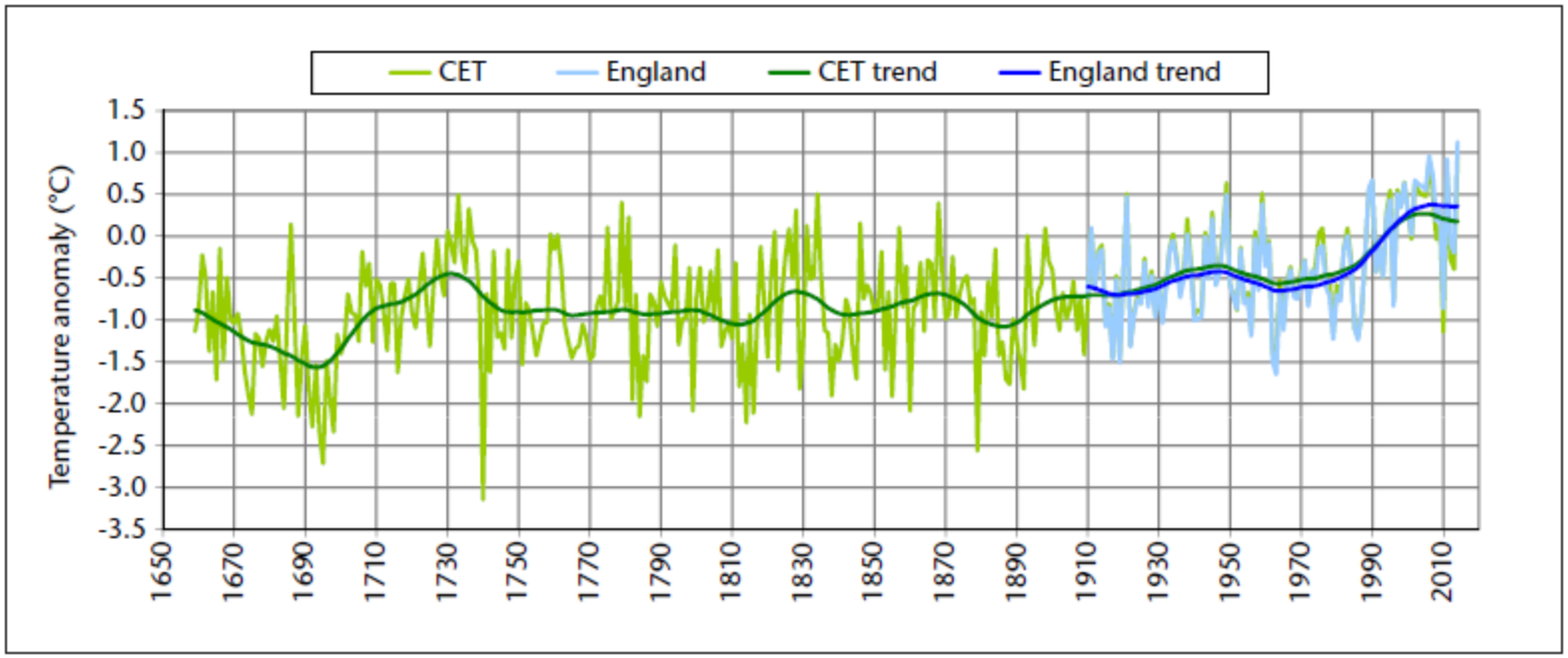
Climate Impacts in the UK

- **2015** was the warmest year on record for UK land and coastal waters.
- **2014** was the fourth wettest year on record for the UK.
- **9 of the 10** warmest years for the UK have occurred since 2002 and all the top ten warmest years have occurred since 1990.
- **7 of the 10** wettest years for the UK have occurred since 1998.
- **Mean sea level** around the UK rose by 1.4 millimetres per year (mm/yr) in the 20th Century, when corrected for land movement.



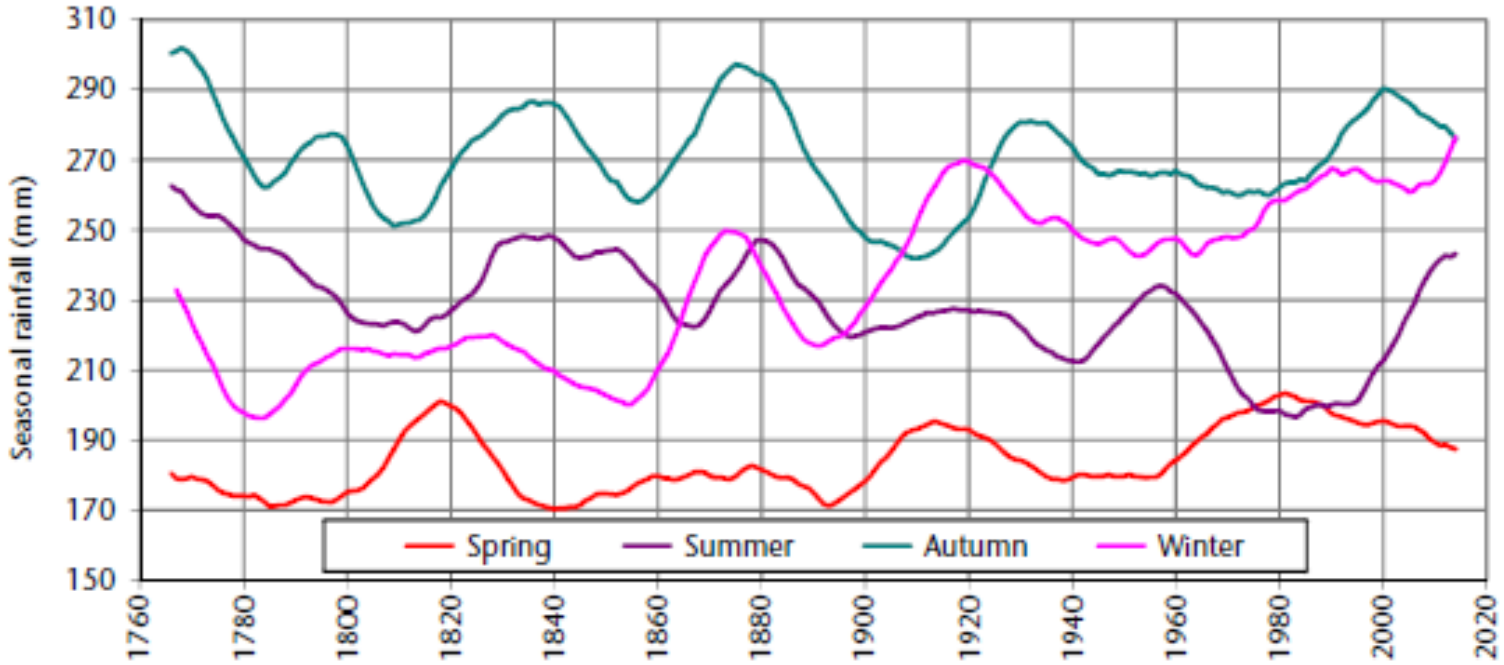
Local Climate Change in Staffordshire?



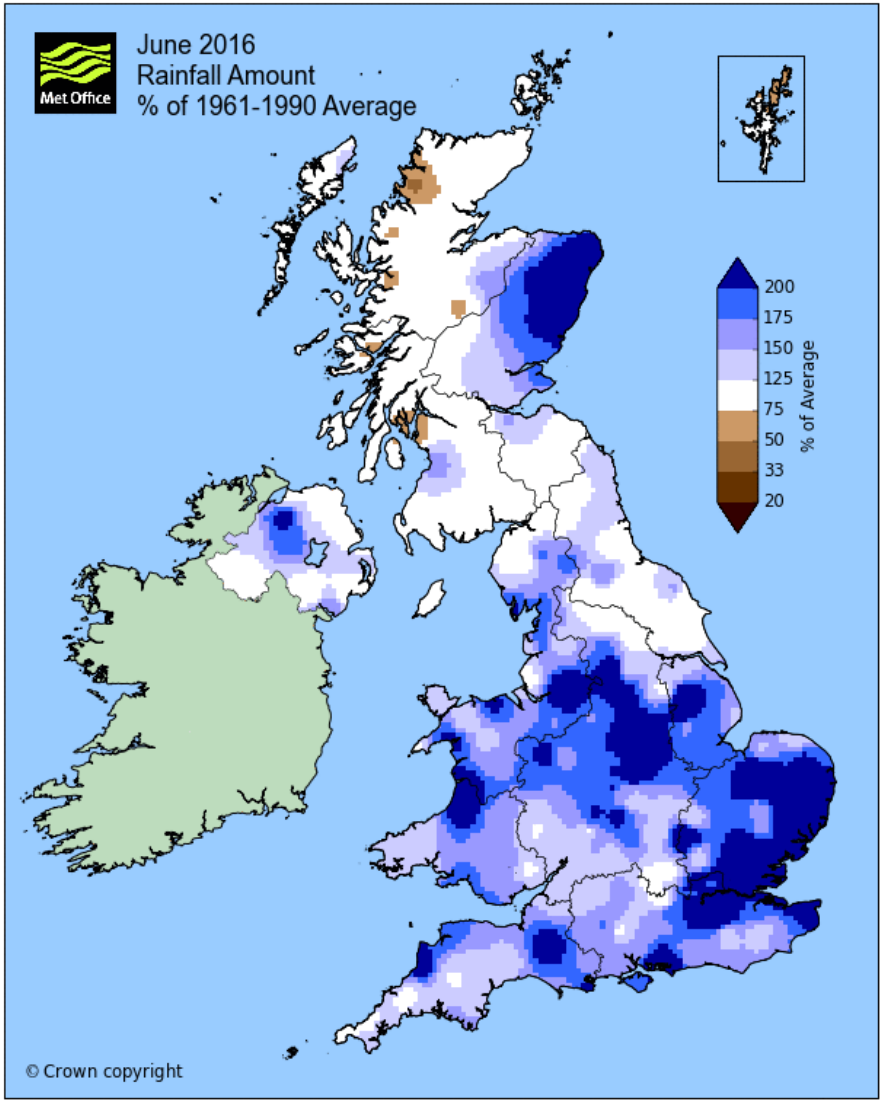


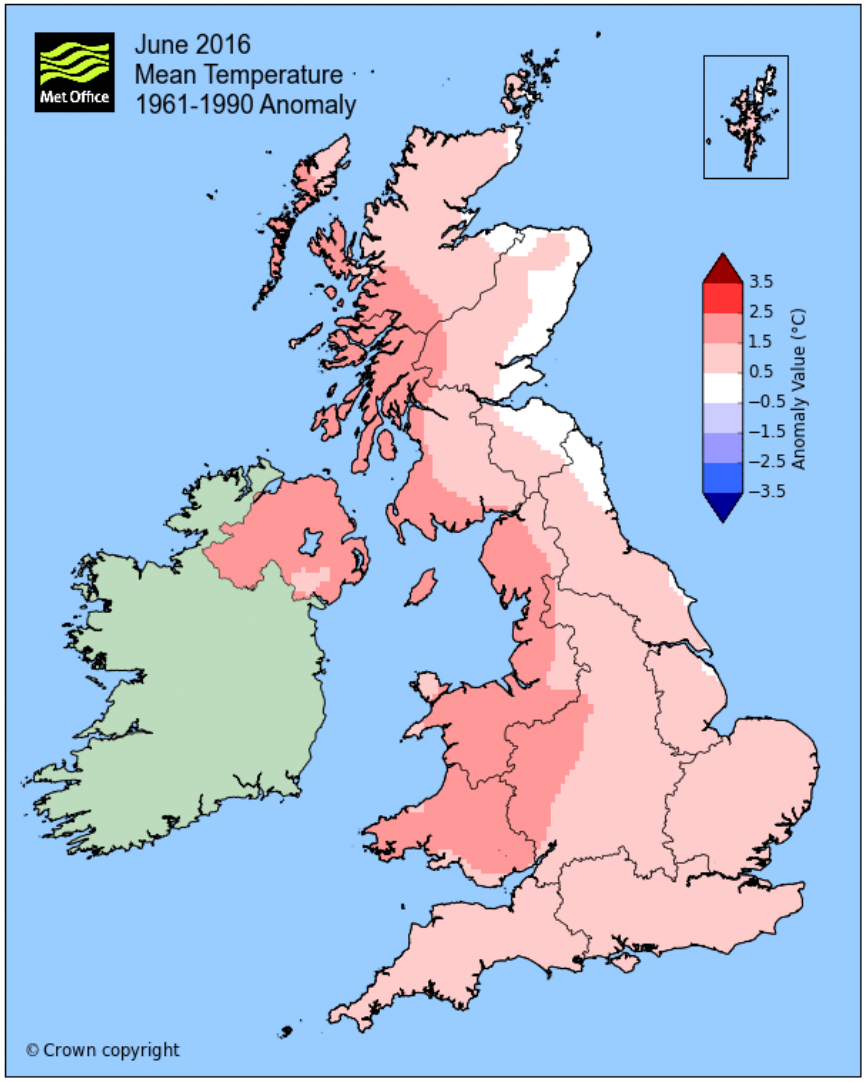
Changes in Precipitation

- Big regional variations in trends in rainfall in the UK
- Trend towards drier summer reversed in last decade
- Increasingly wet winters related to increasing numbers of days of rain



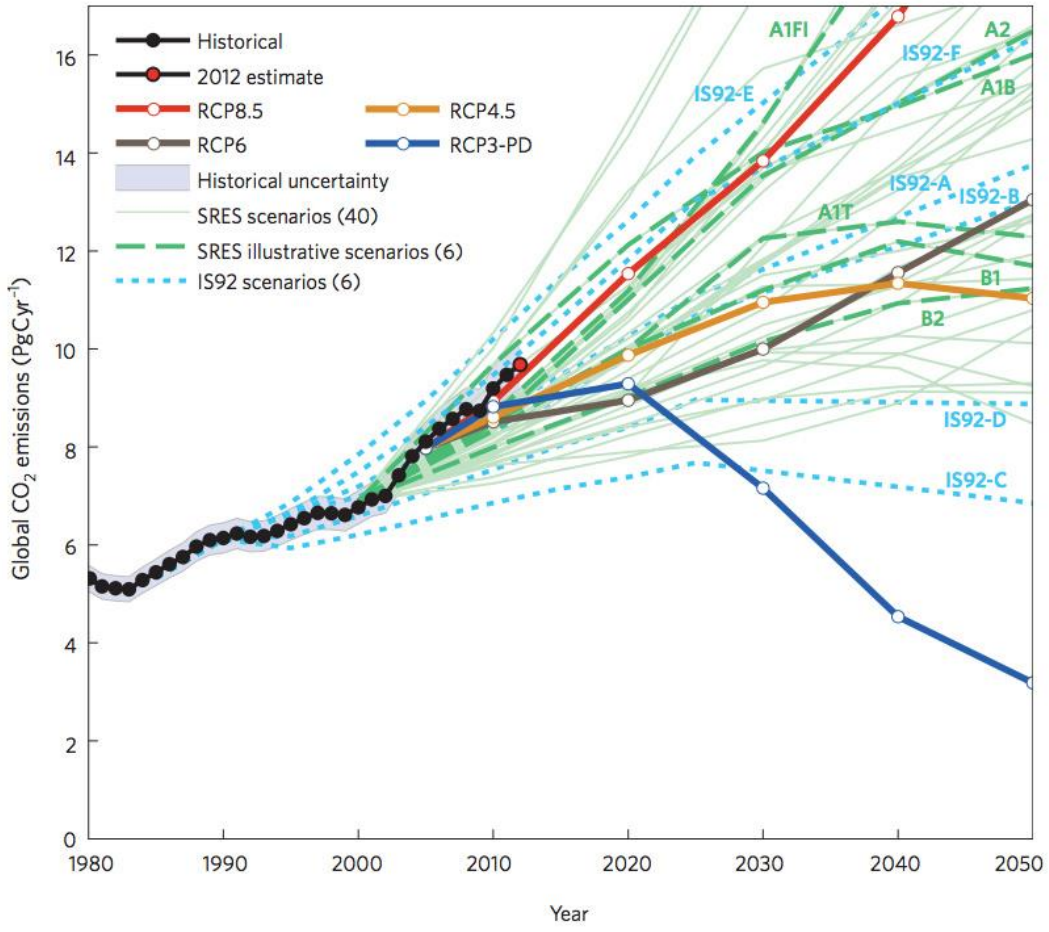
June 2016

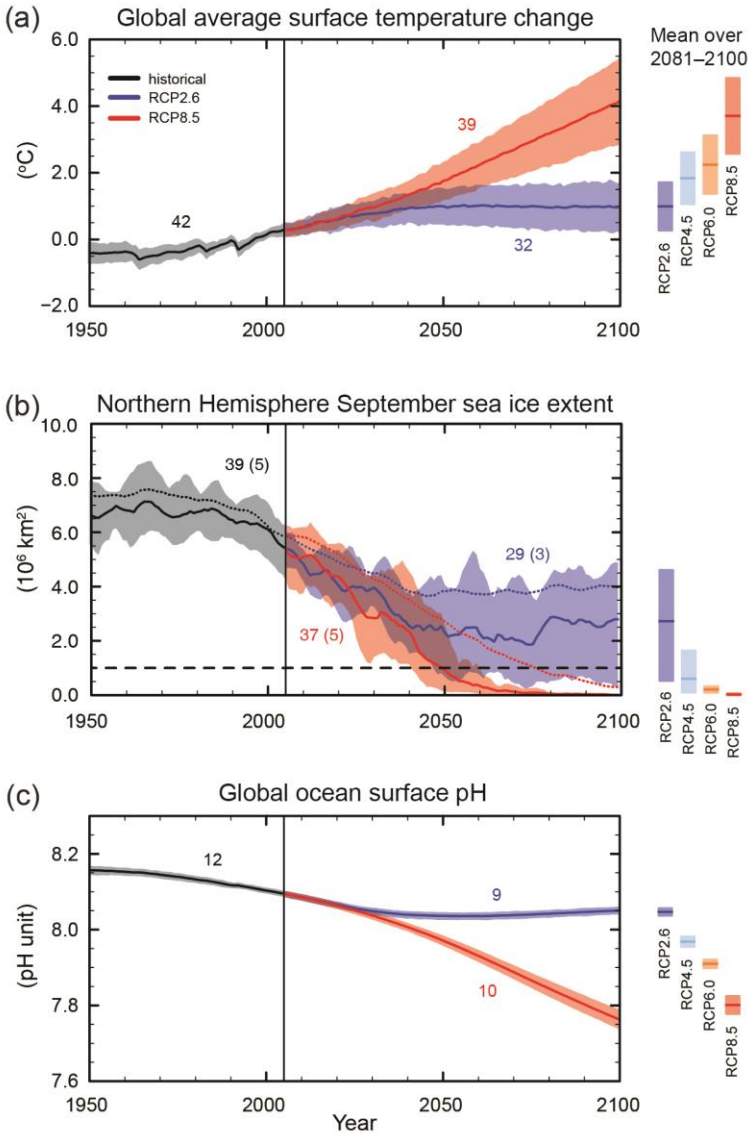

Met Office
June 2016
Rainfall Amount
% of 1961-1990 Average
200
175
150
125
75
50
33
20
% of Average
© Crown copyright


Met Office
June 2016
Mean Temperature
1961-1990 Anomaly
3.5
2.5
1.5
0.5
−0.5
−1.5
−2.5
−3.5
Anomaly Value (°C)
© Crown copyright

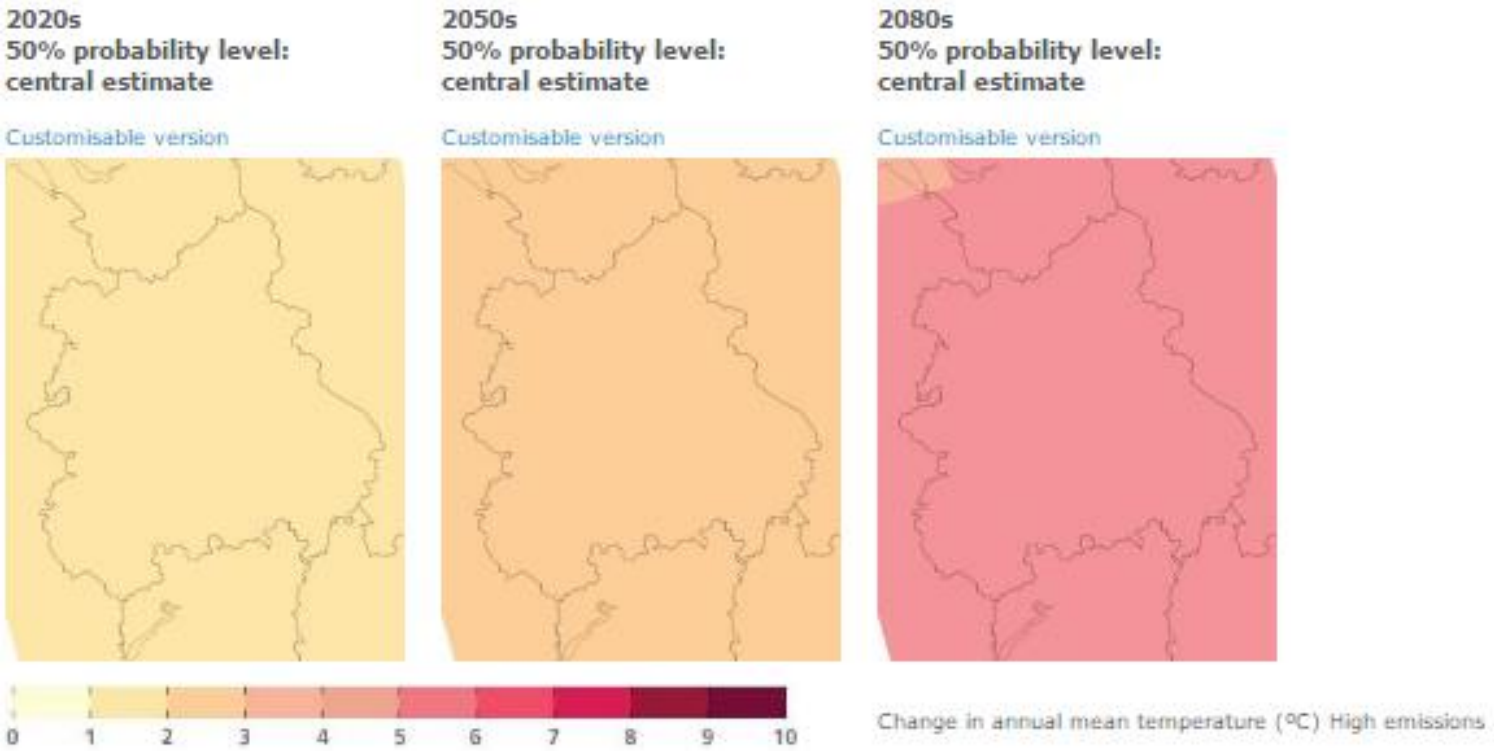
So what will happen in the future?

It depends….



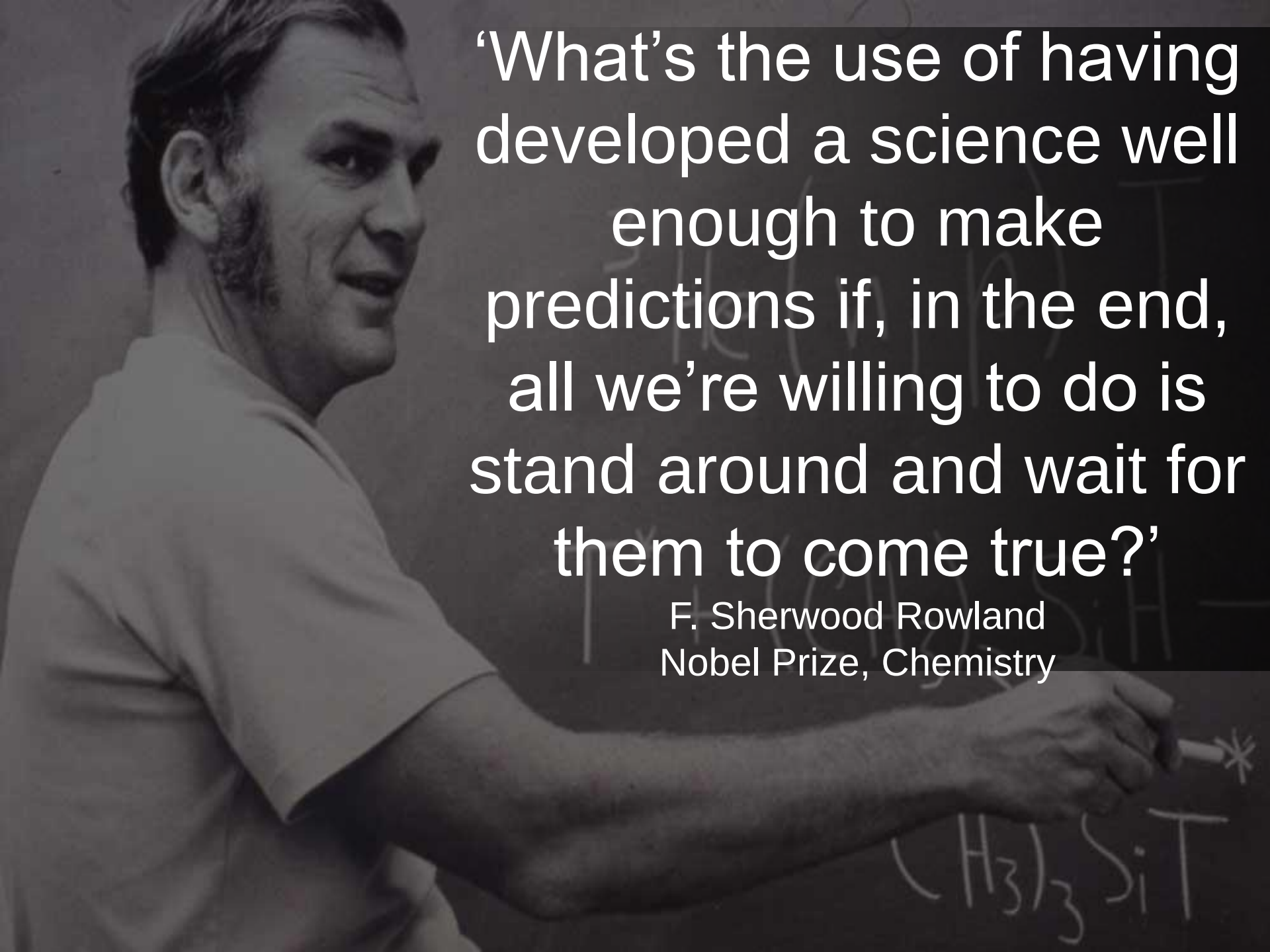


Climate Scenarios for the West Midlands



Under high emissions scenarios, high temperature rise projected through the 21st century.

http://ukclimateprojections.metoffice.gov.uk/23223

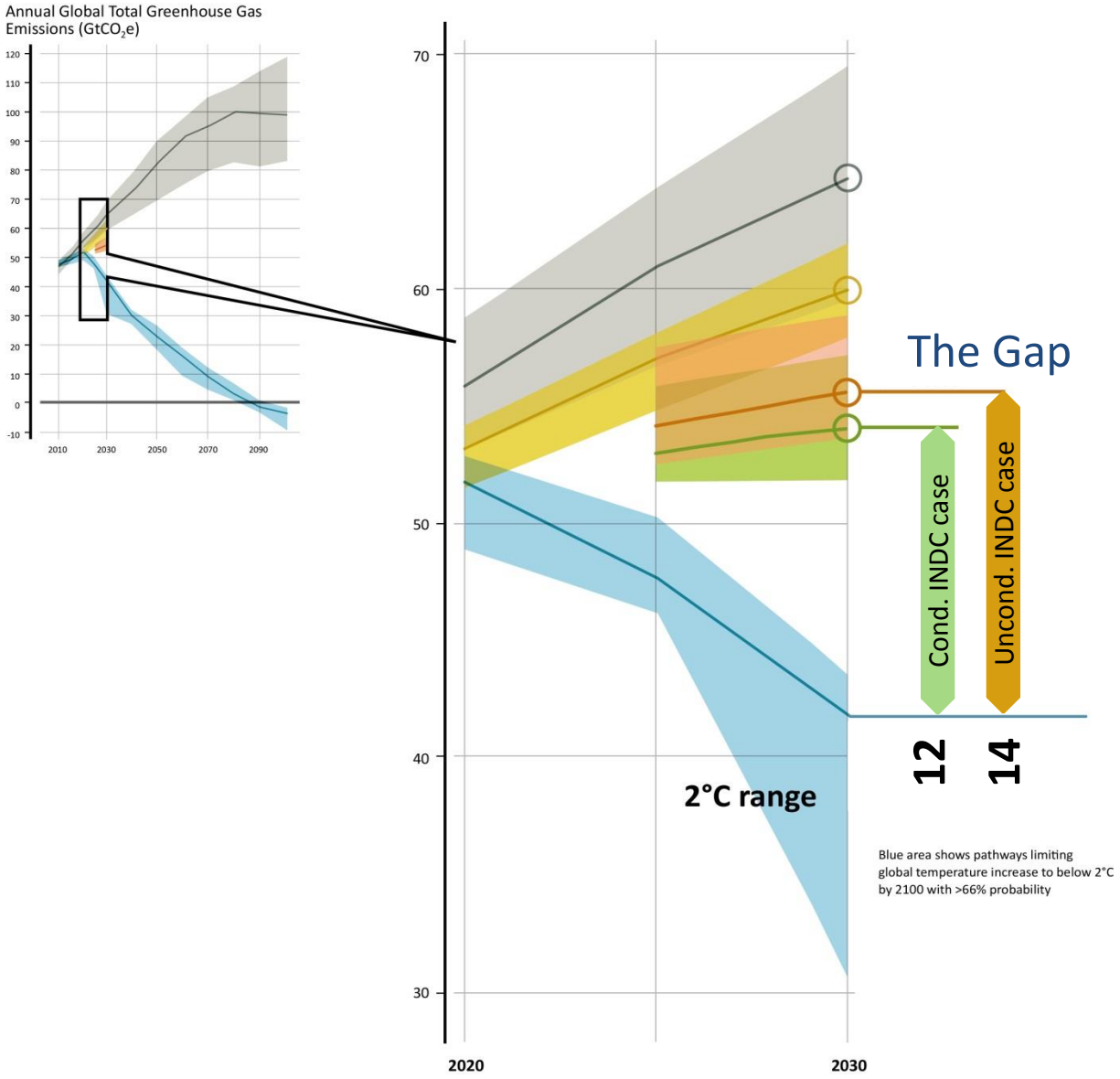

‘What’s the use of having developed a science well enough to make predictions if, in the end, all we’re willing to do is stand around and wait for them to come true?’
F. Sherwood Rowland
Nobel Prize, Chemistry

The Paris Agreement

- 196 Parties of UNFCCC adopted the Paris Agreement
- Common but differentiated responsibilites and respective capabilities, in the light of different national circumstances
- All Parties are to undertake and communicate ambitious efforts
- Hold global temperature increase well below 2°C
- Pursue efforts to limit increase to 1.5°C
- Global peaking of emissions ASAP
- Rapid reductions thereafter
- Achieve balance between anthropogenic emissions and removals by sinks of greenhouse gasses in the second half of this century
- Successive national contributions, progression

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

INDC contributions and the emissions gap



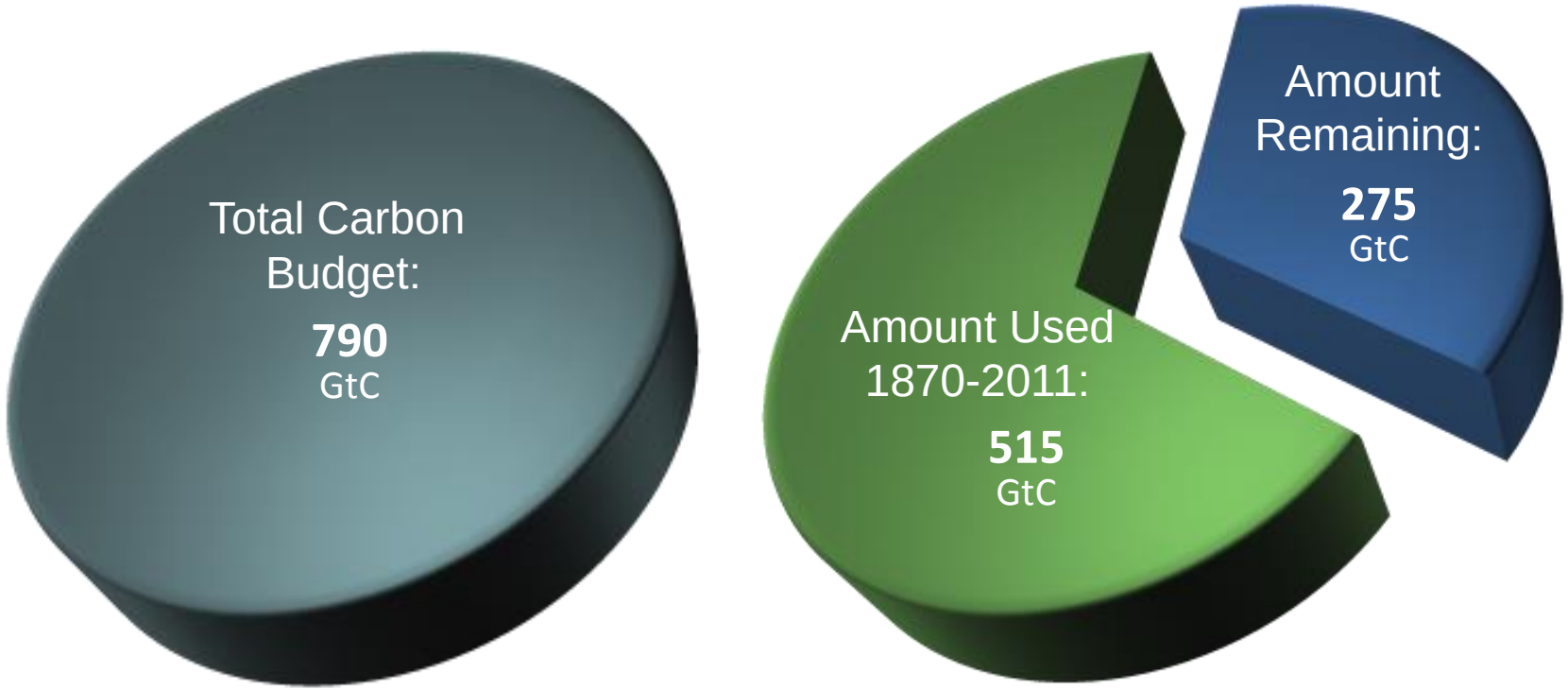
Unconditional INDC case
Gap= 14 $GtCO_2e$

Conditional INDC case
Gap= 12 $GtCO_2e$

The INDCs present a real increase in the ambition level compared to a projection of current policies.

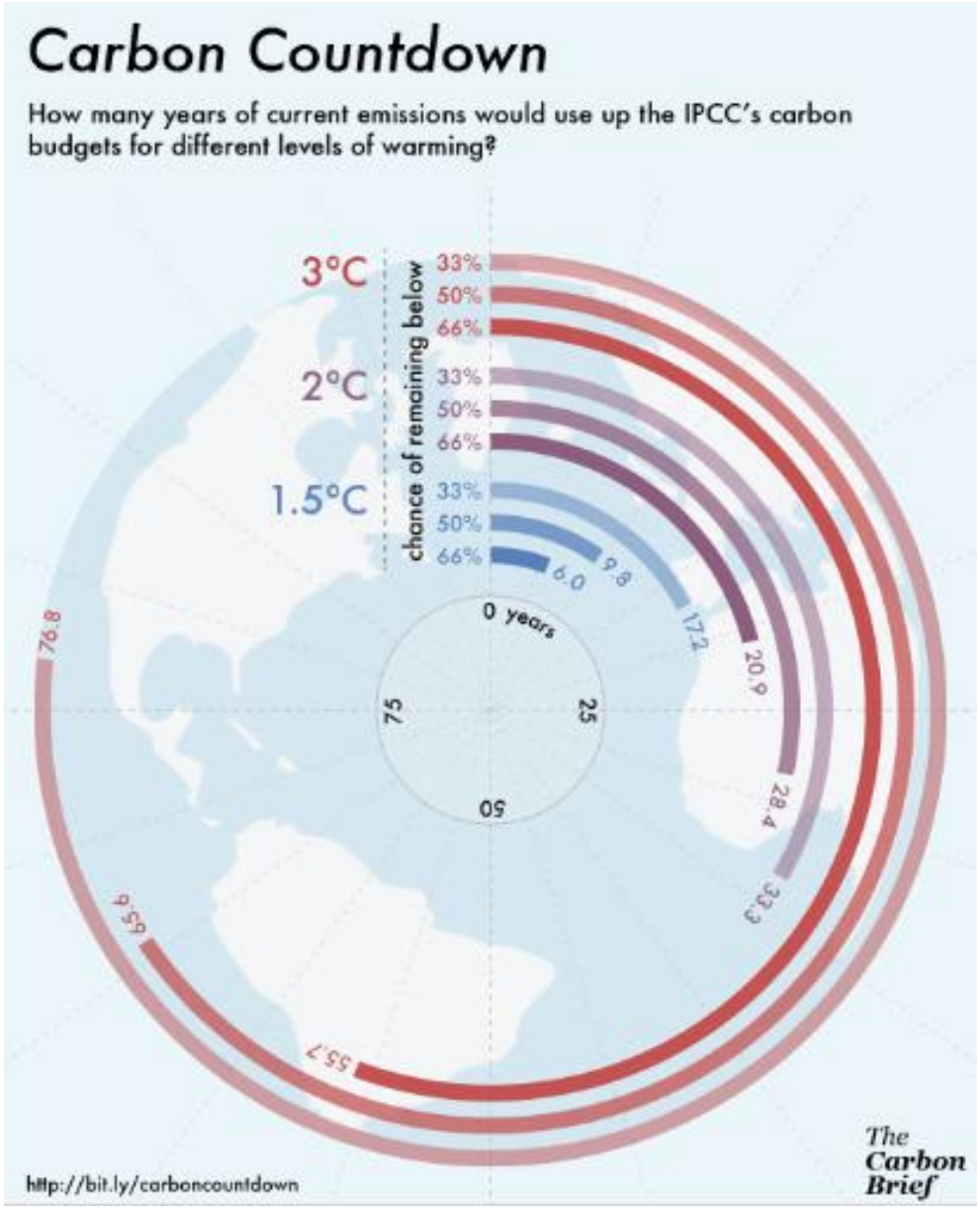
The emissions gap in both 2025 and 2030 will be very significant and ambitions will need to be enhanced urgently.

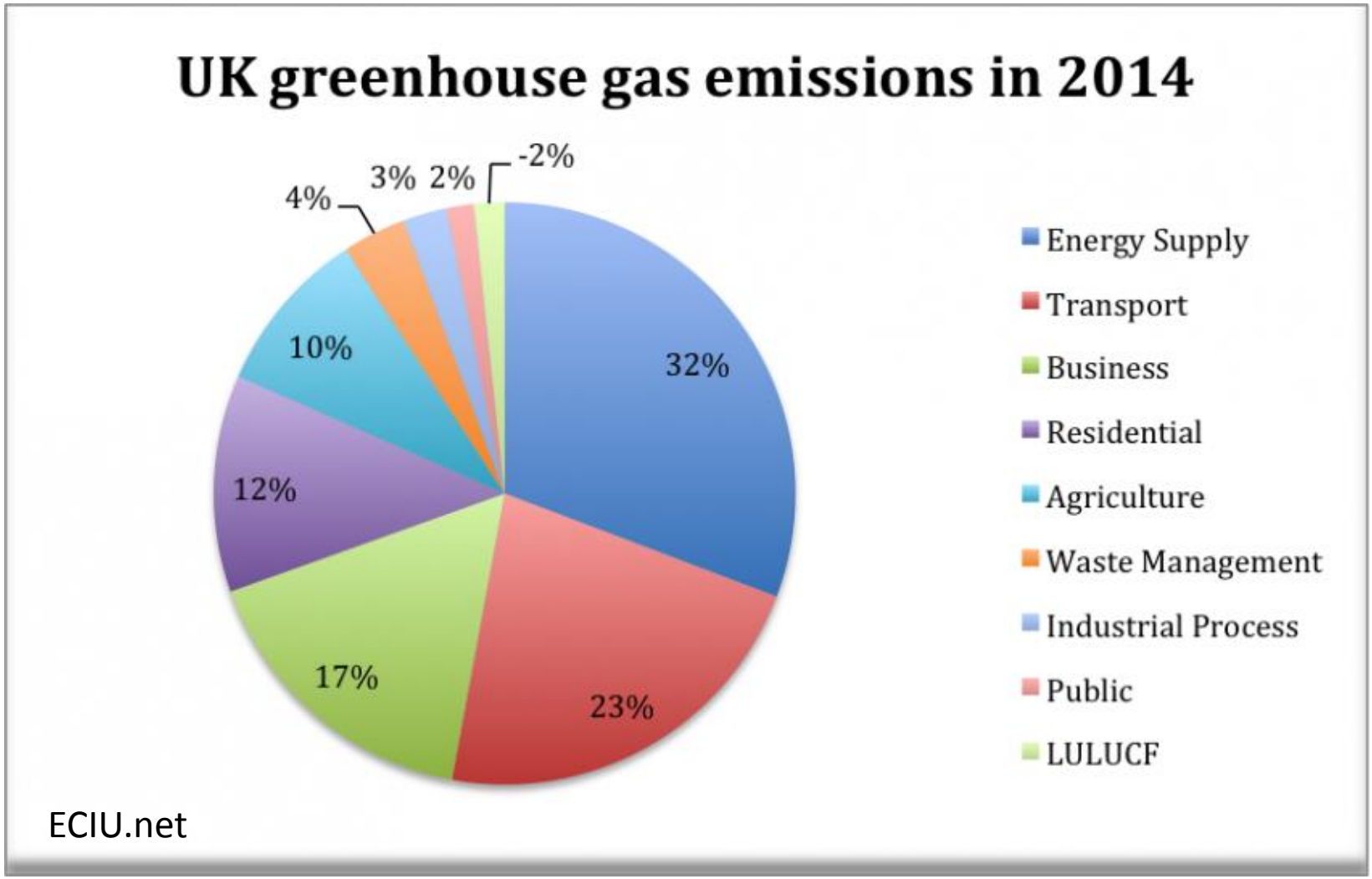
65% of our carbon budget compatible with a 2°C goal already used



AR5 WGI SPM

How many years of current emissions would use up our carbon budget?



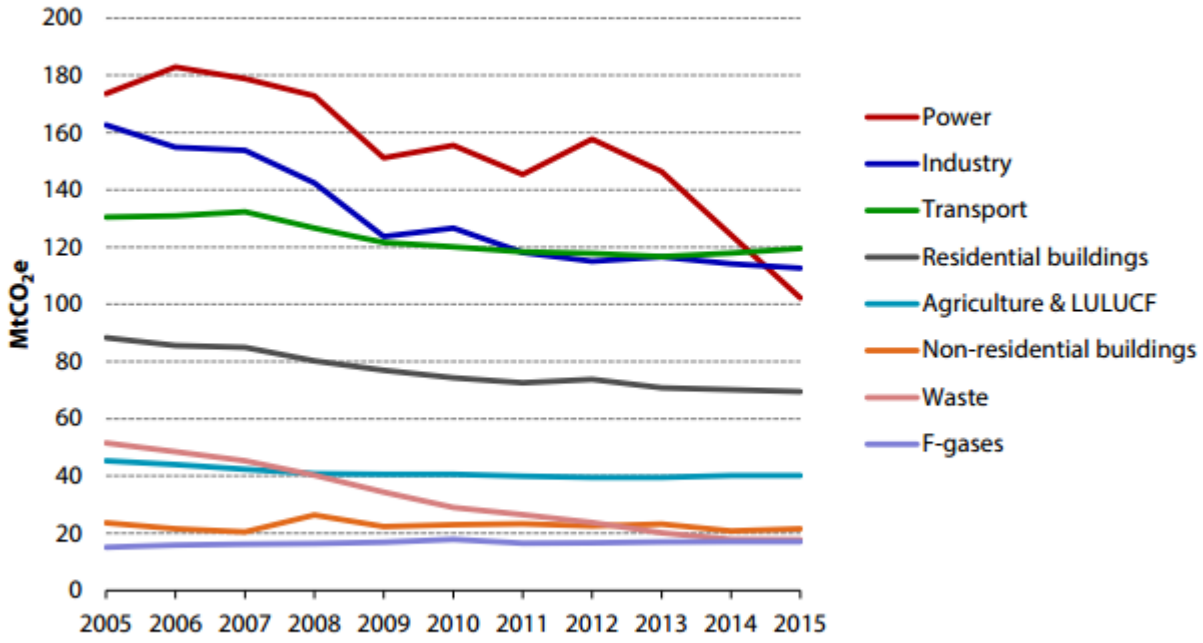


All sectors will be required to make changes in order to meet 2015 target

UK Commitments on climate change

Climate Change Act:
UK commits to reduce carbon emissions to 80% of 1990 levels by 2050
Emissions have fallen 13% in last 3 years to 38% of 1990 levels currently
But reductions so far dominated by power generation sector

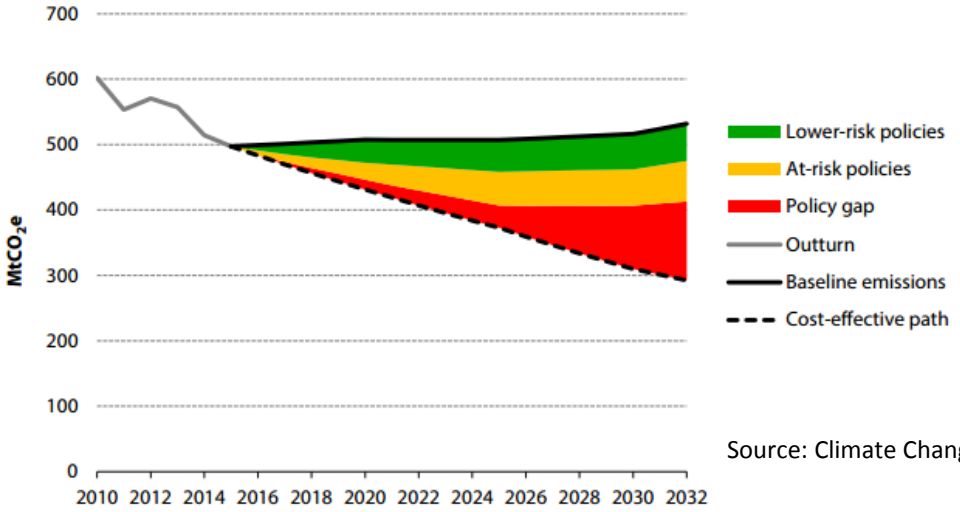
Figure 1. Progress reducing emissions since 2012 has been almost entirely due to the power sector



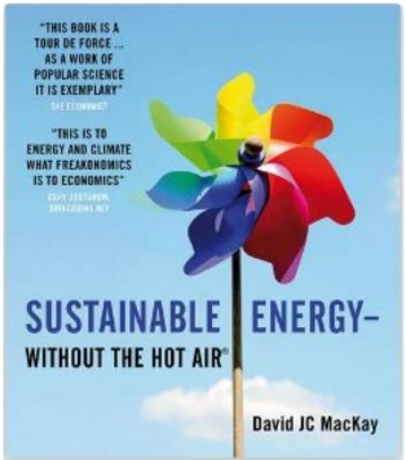
Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC

Sustainable Energy

Professor Sir David MacKay (1967-2016)
"I love renewables, but I'm pro-arithmetic."



Source: Climate Change Committee, 2016



Decarbonising Transportation

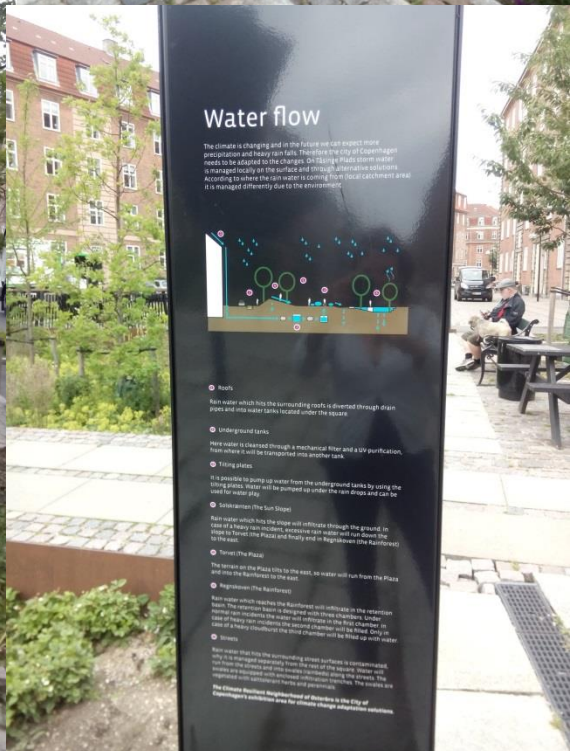
36% of commuters travel by bicycle in Copenhagen; More than 60% of journeys in the city centre are made by bike; Women make up around 60% of cycle commuters; Each km cycled **benefits** society by EUR 0.15, each km driven in car **costs** society EUR 0.16

Adaptation to Future Changes: Engineering and City Planning

After heavy summer storms several years in a row, storm drains and special asphalt laid to assist drainage in known problem areas

Adapting to Climate Change

Tåsinge Plads
"Climate Ready" Neighbourhood



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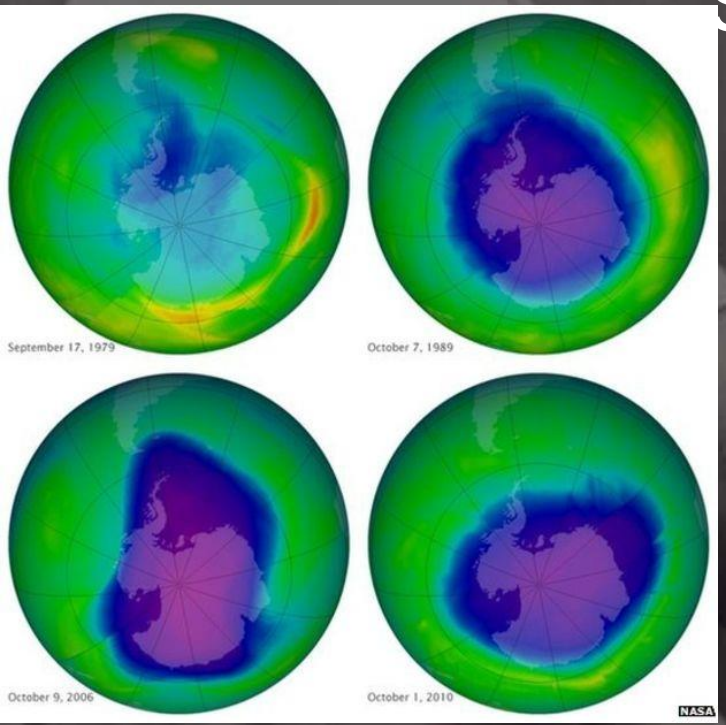


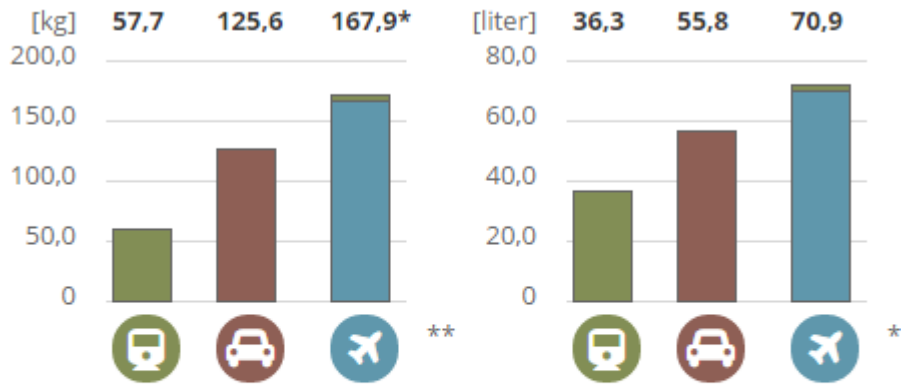
CLIMATE CHANGE

- Happening now and human caused
- Some impacts are irreversible
- Actions today can limit future warming
- We need to prepare for future impacts

Can we fix this? Yes. We Can.

Cutting Carbon: Travel

START/DESTINATION DETAILS			DURATION	PRODUCTS
KOEBENHAVN H (Denmark) [DK] STAFFORD (United Kingdom) [UK]	from Sa, 09.07.16, 05:37 to Su, 10.07.16, 10:07 via HAMBURG HBF (Germany), DORTMUND HBF (Germany), BRUXELLES-MIDI (Belgium), LONDON ST. PANCRAS (United Kingdom), LONDON EUSTON (United Kingdom) DETAILS GOOGLE EARTH SOONER LATER		29:30	EC 232, IC 2327, THA 9472, ES 9161, Transfer, -- -
KOEBENHAVN H (Denmark) [DK] STAFFORD (United Kingdom) [UK]	Middle class; Diesel EURO 4;		9:54	Car
KOEBENHAVN H (Denmark) [DK] STAFFORD (United Kingdom) [UK]	Flight from Copenhagen Airport to Birmingham International Airport.		4:04	Train, Aircraft, Train



Carbon dioxide
greenhouse-gas, global warming

Energy resource consumption
resource consumption / primary energy

Ecopassenger.org