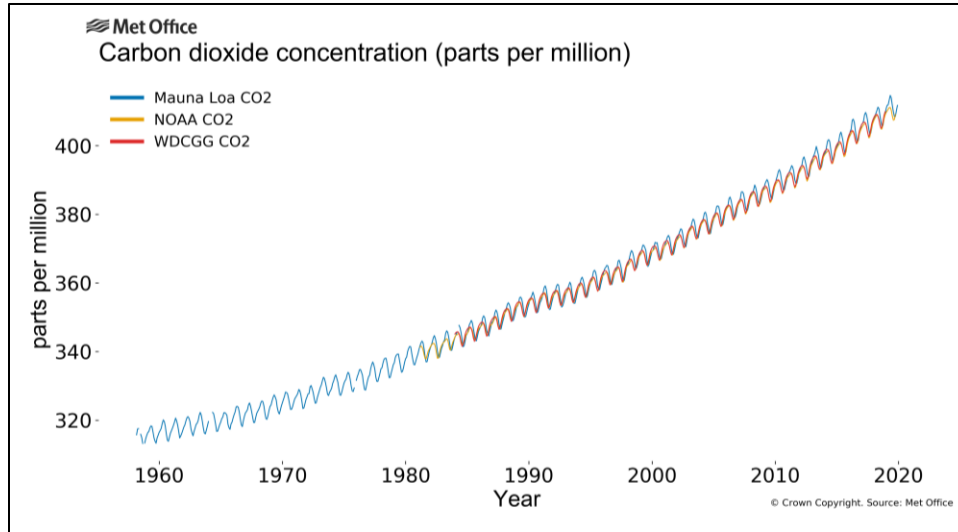
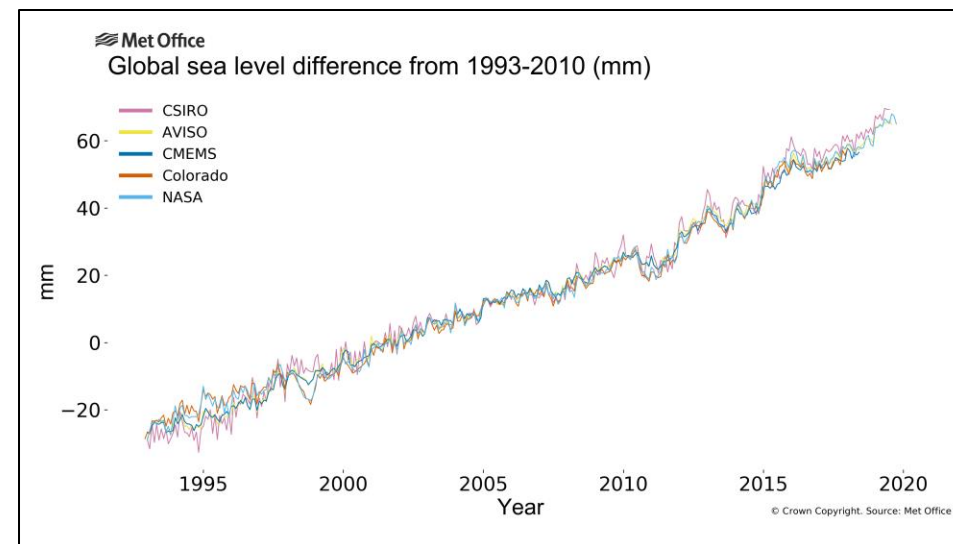
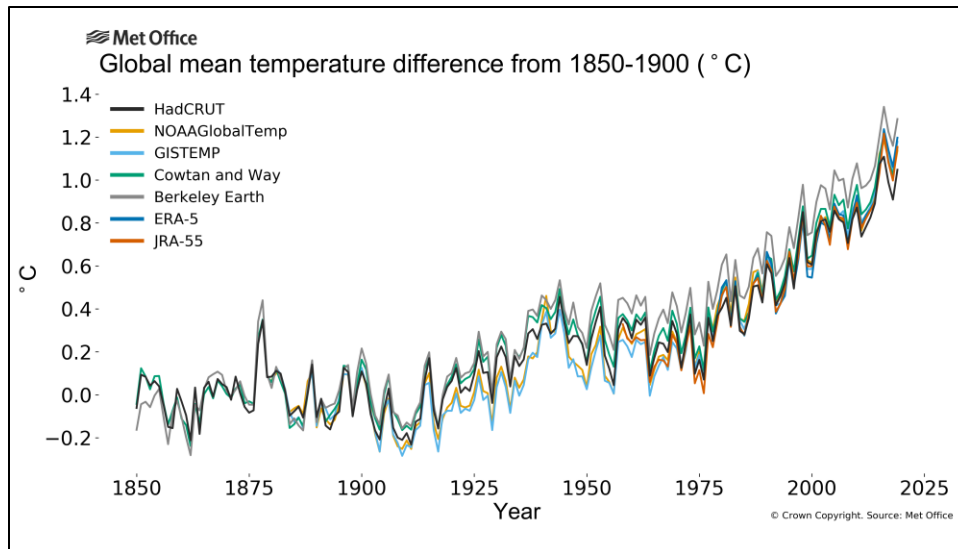
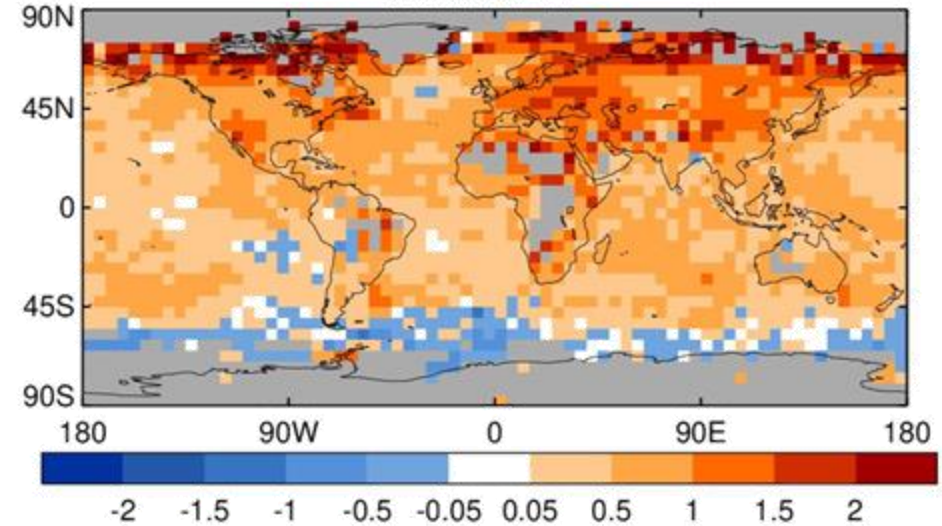


Climate change

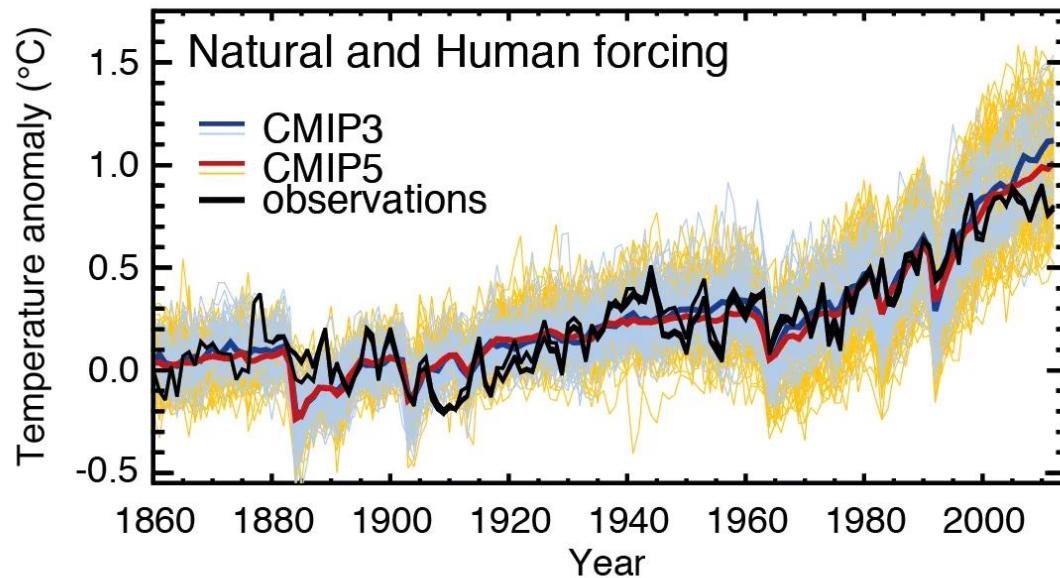
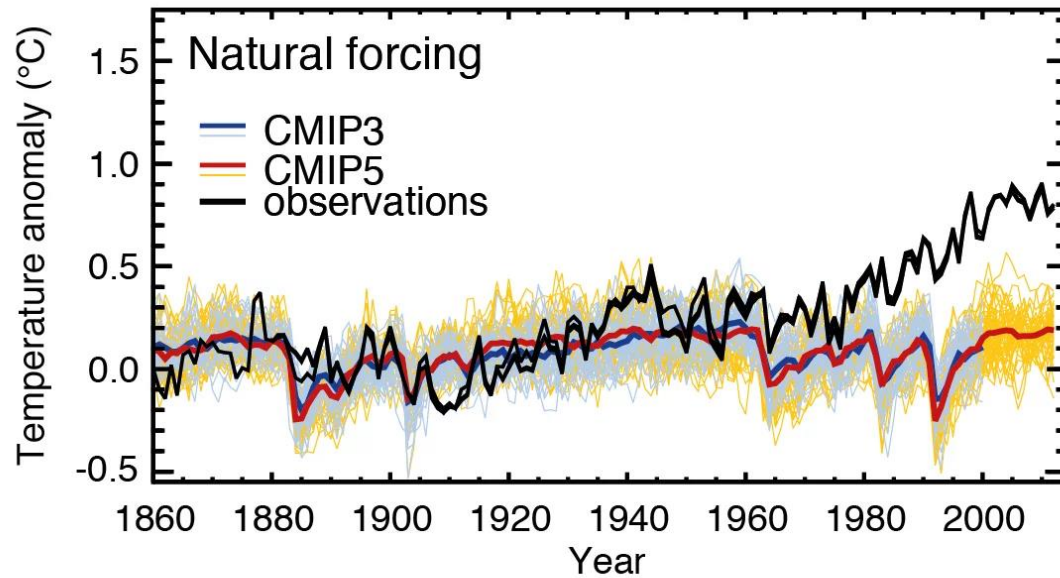
# Climate is changing



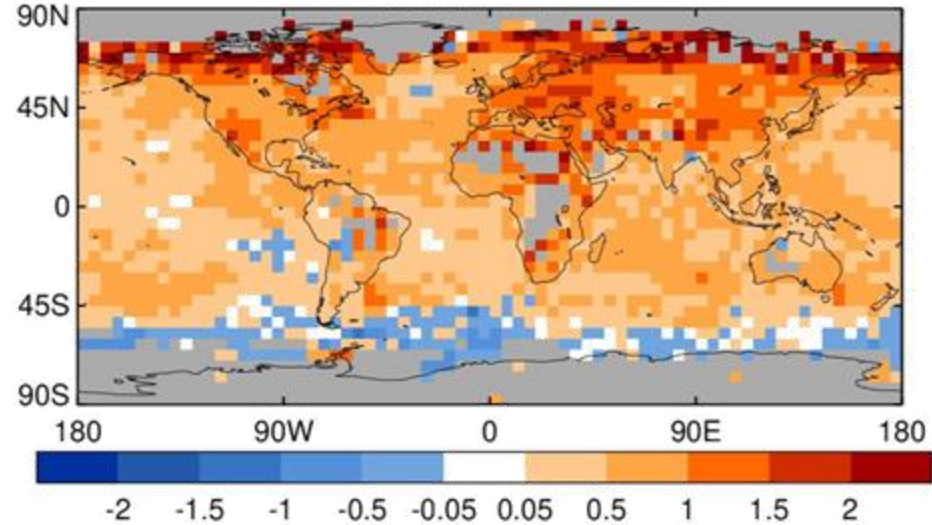
Observed warming 2009 – 2019 relative to 1961 - 1990



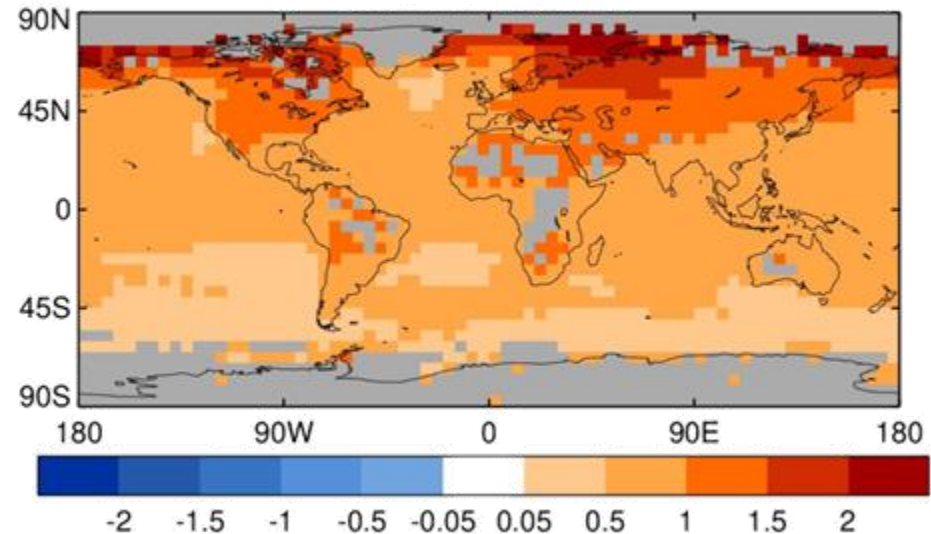
# Role of greenhouse gases



Observed warming 2009 – 2019 relative to 1961 - 1990



Average model output output



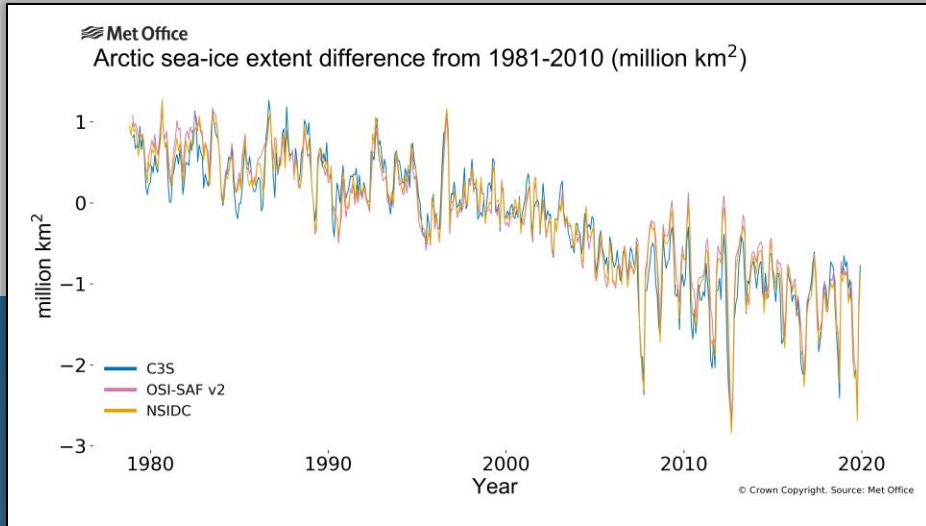


# A tipping point



## Arctic Sea Ice Loss

The September minimum Arctic sea ice extent in 2019 was the 2<sup>nd</sup> lowest on record.



Over the last four decades, September Arctic sea ice extent has declined by over 87,000 km<sup>2</sup> per year equating to an average of 12% per decade.\*

### Annual loss

**87,055 km<sup>2</sup>**

An area greater than Scotland.

Surface area of Scotland = 80,226km<sup>2</sup> (World Bank)

### Decadal loss

**870,550 km<sup>2</sup>**

An area greater than the UK, Ireland and France combined.

Surface area of UK, Ireland & France = 862,977km<sup>2</sup> (World Bank)

### 40 year loss

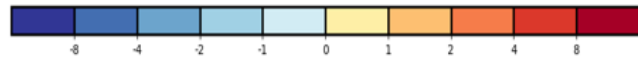
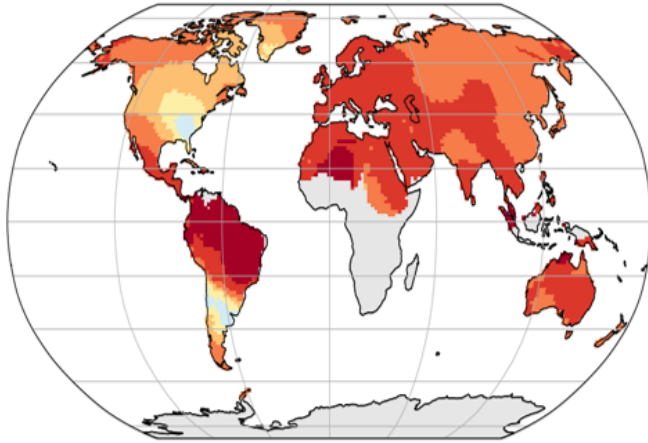
**3.48 million km<sup>2</sup>**

An area greater than India, Bangladesh and Bhutan combined.

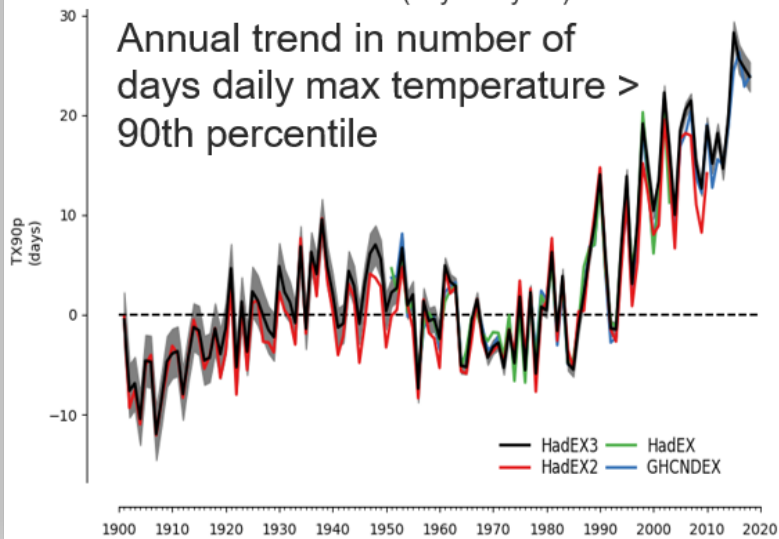
Surface area of India, Bangladesh & Bhutan = 3,473,283 km<sup>2</sup> (World Bank)

# More extremes in a warming world

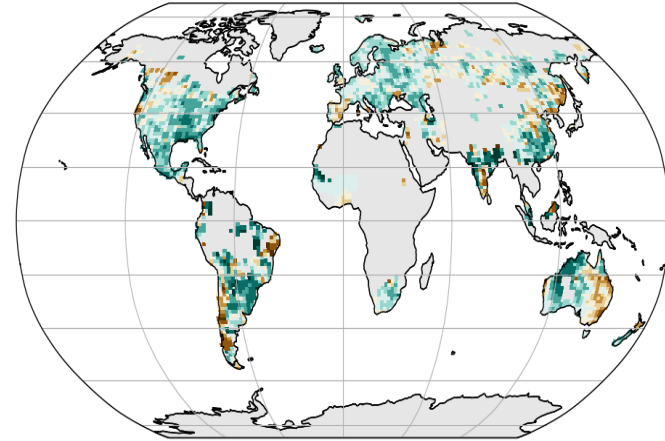
HadEX3 – changes in temperature extremes  
1950-2018



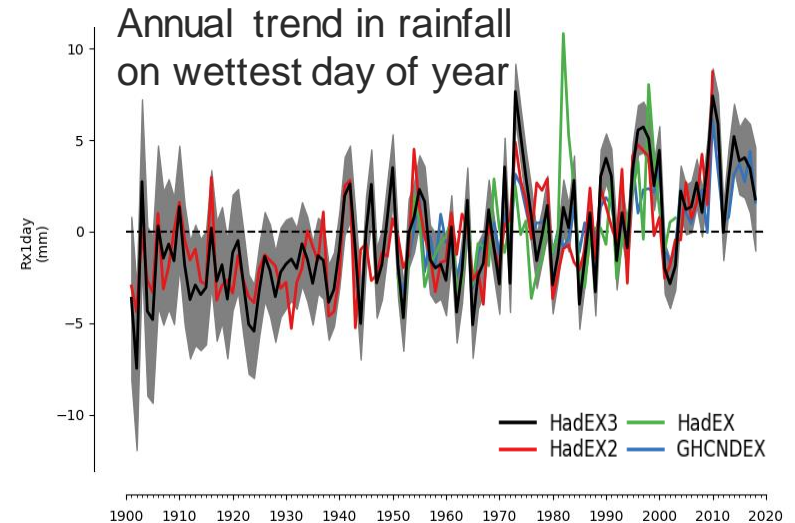
Trend (days/10 year)



HadEX3 – changes in rainfall extremes  
1950-2018



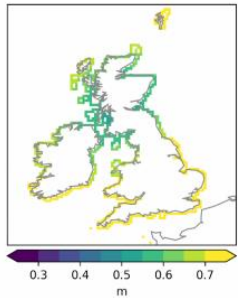
Trend (mm/10 year)





# Impacts of a warming world

## Flooding and sea level rise

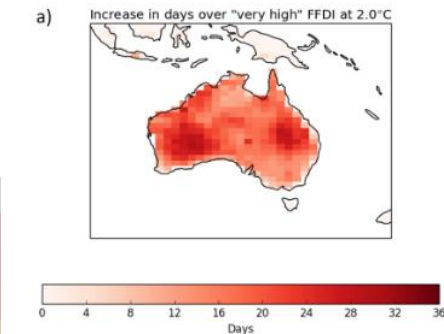


## Wildfires

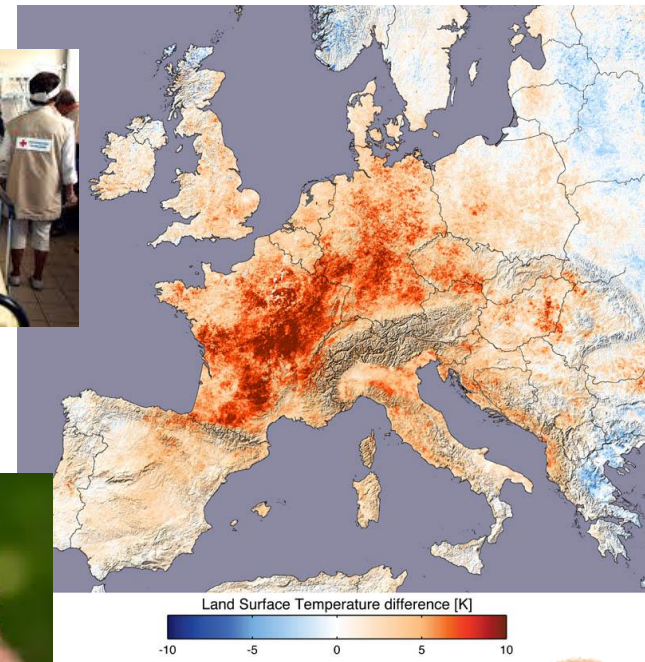
Category	Forest Fire Danger Index
Catastrophic* (code red)	100+
Extreme	75 - 99
Severe	50 - 74
Very high	25 - 49
High	12 - 24
Low - Moderate	0 - 11

Table 1: McArthur FFDI scale of fire danger.

\*Catastrophic refers to fires that spread so quickly that they present a threat to life and safety



## Heatwaves, health and disease

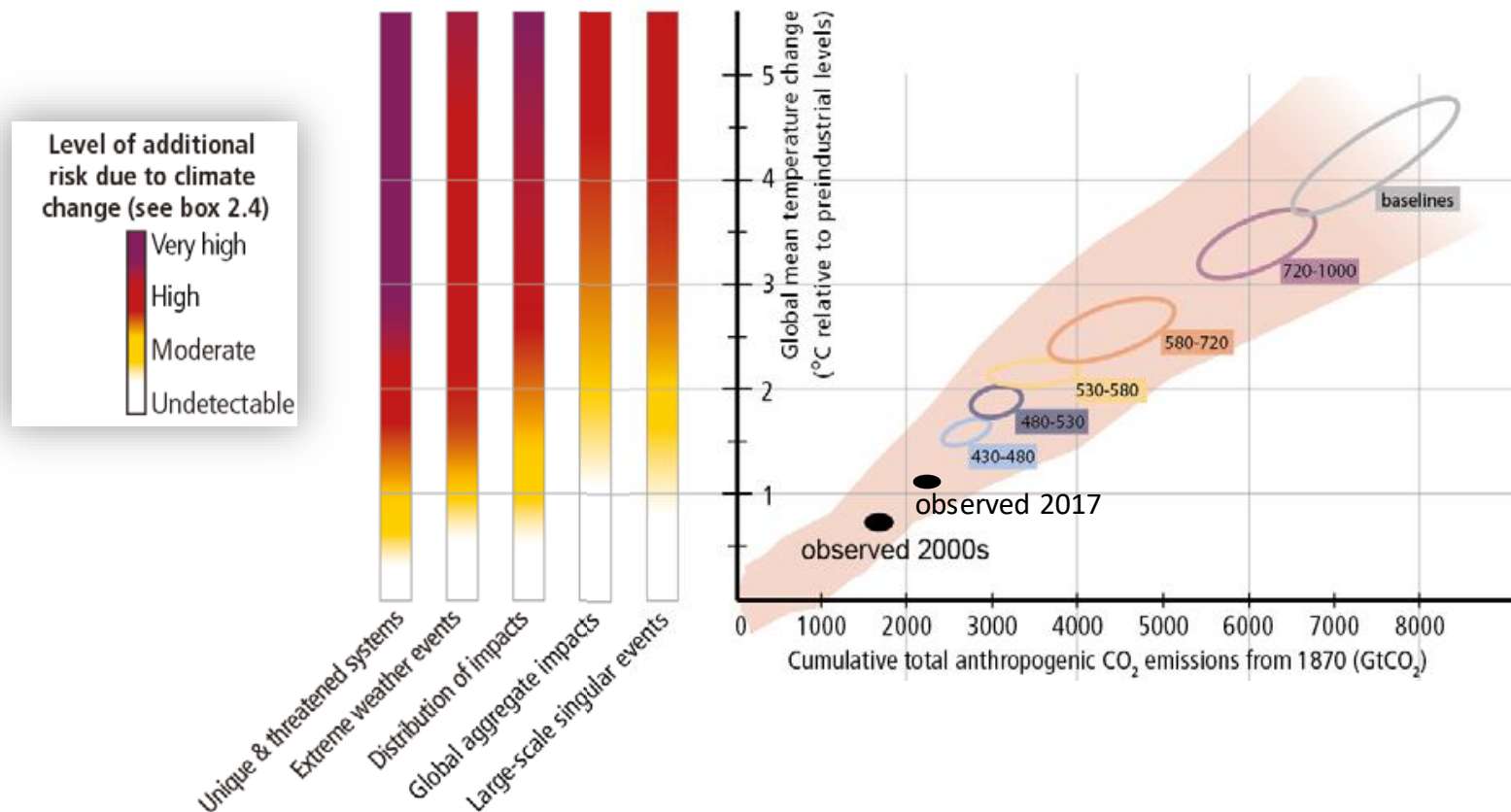


## Biodiversity

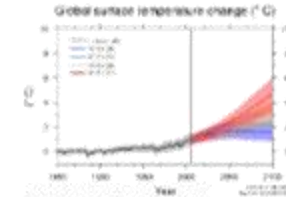


# Controlling future warming: carbon budgets

(A) Risks from climate change... (B) ...depend on cumulative CO<sub>2</sub> emissions...



# Projections of future climate



CMIP6 (SSPs)

CMIP5 (RCPs)

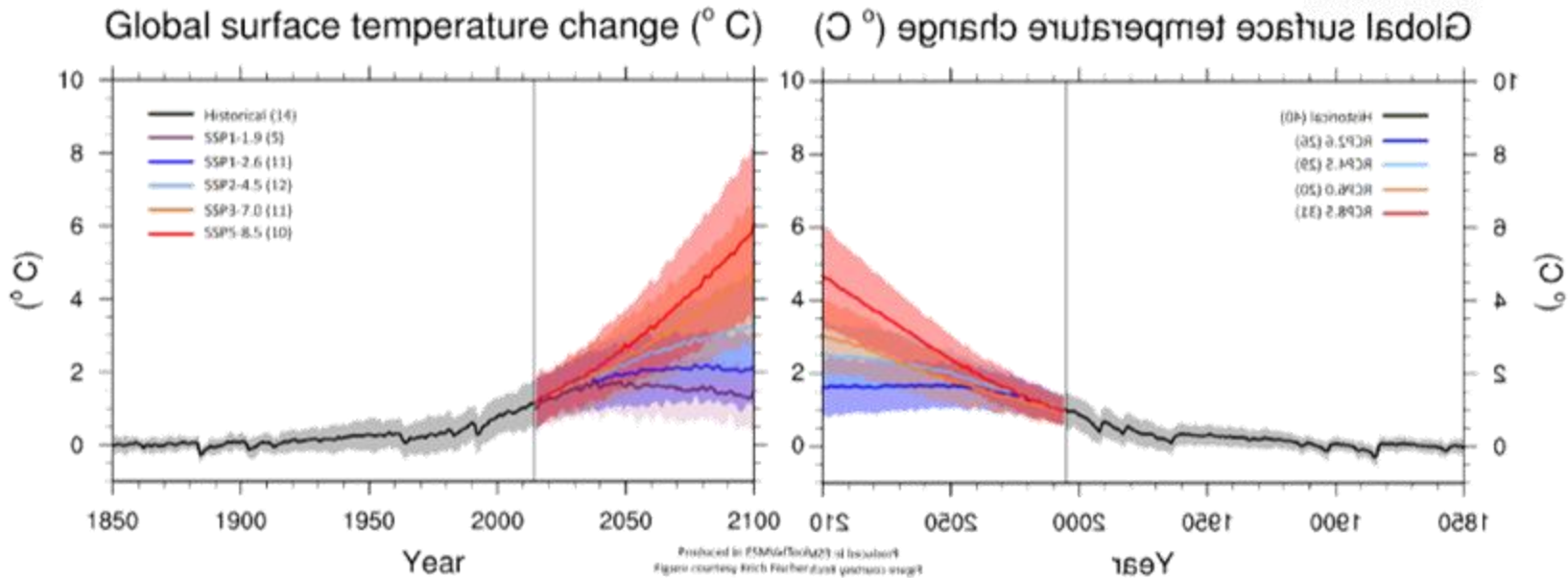
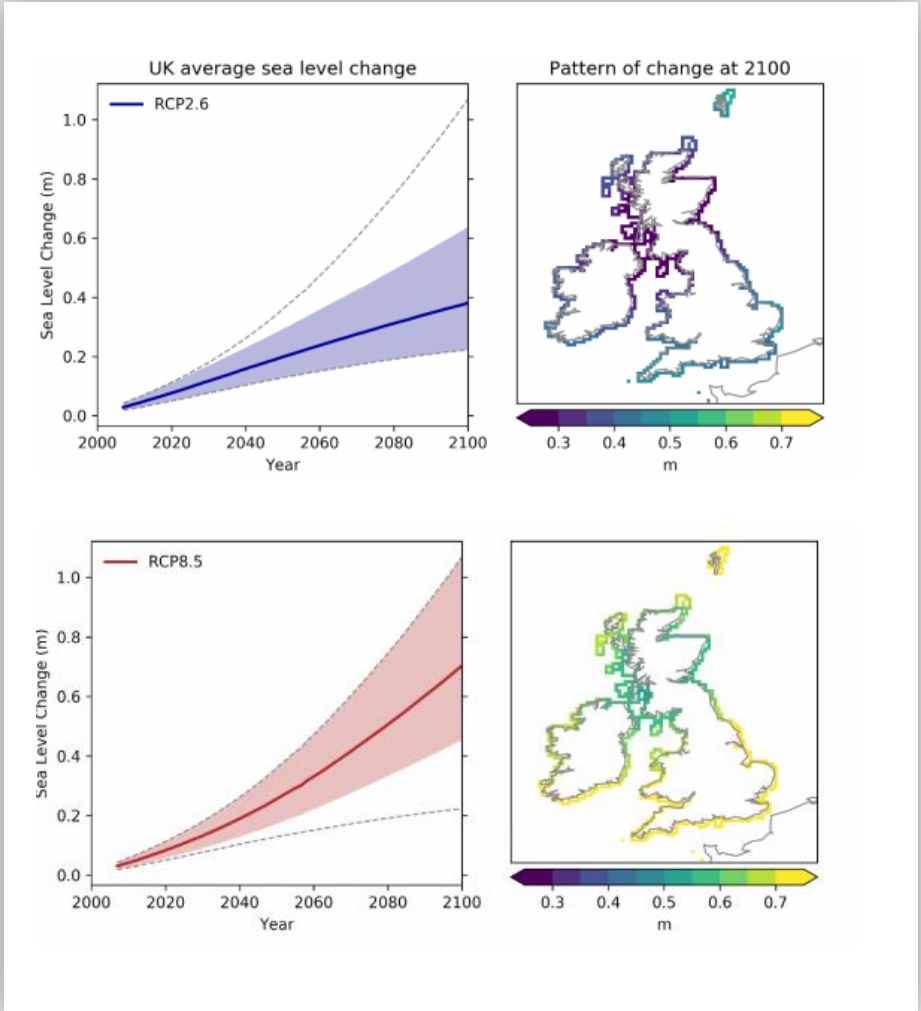
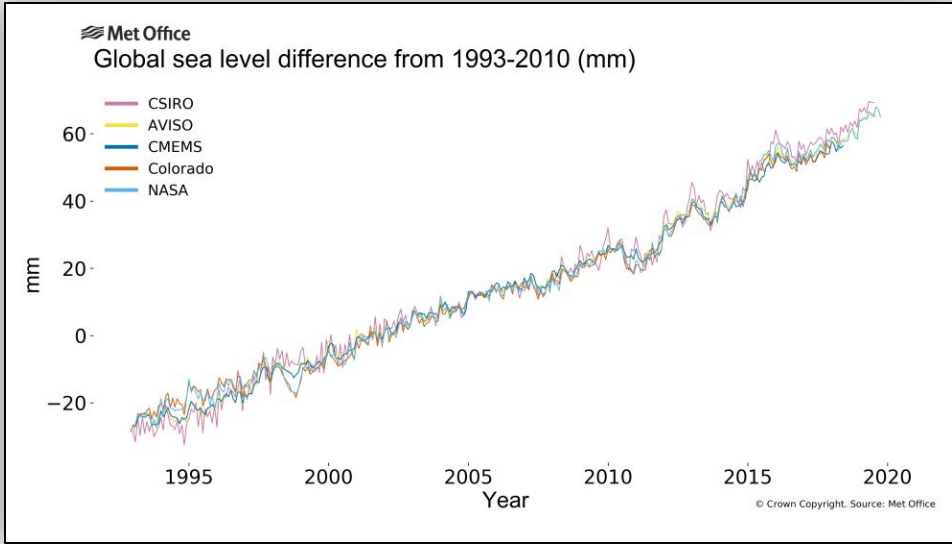


Figure courtesy Erich Fischer

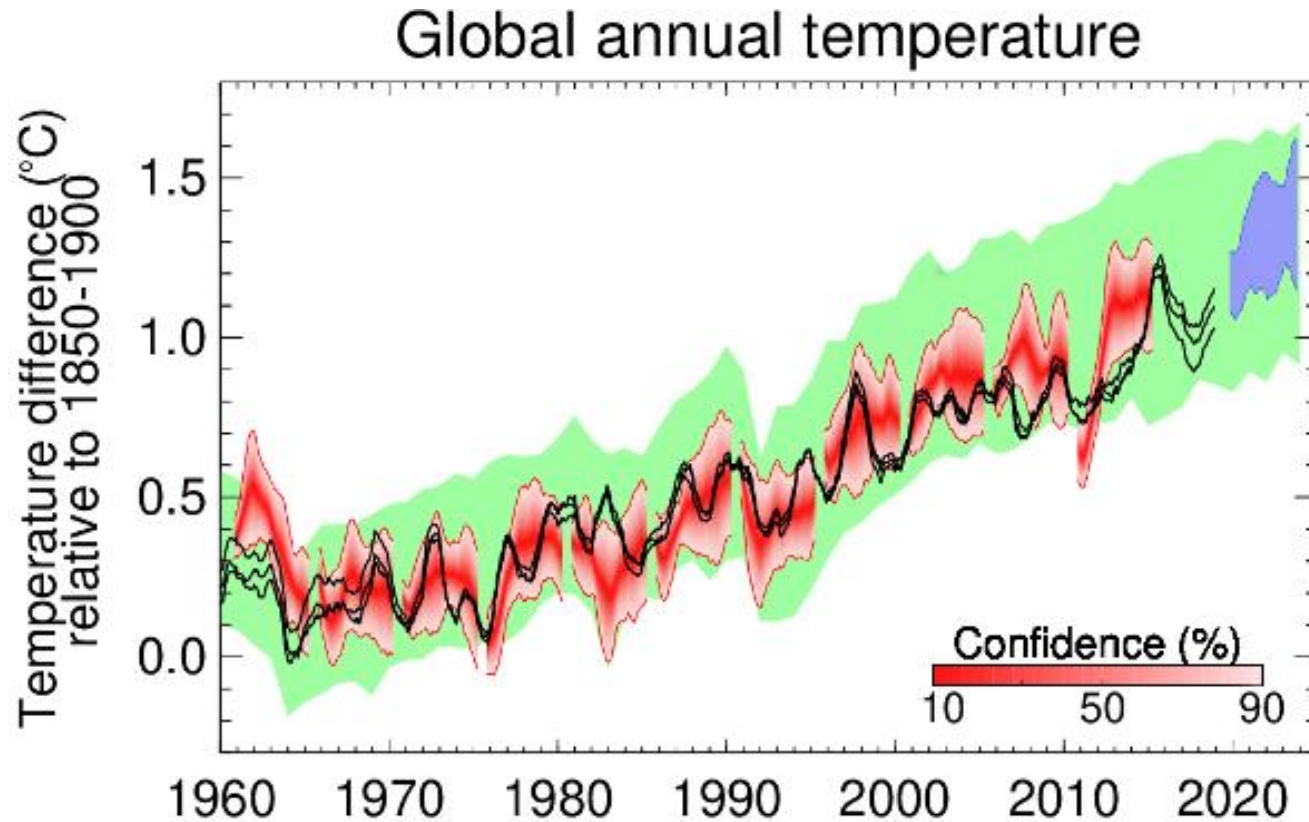




# The sea level is rising

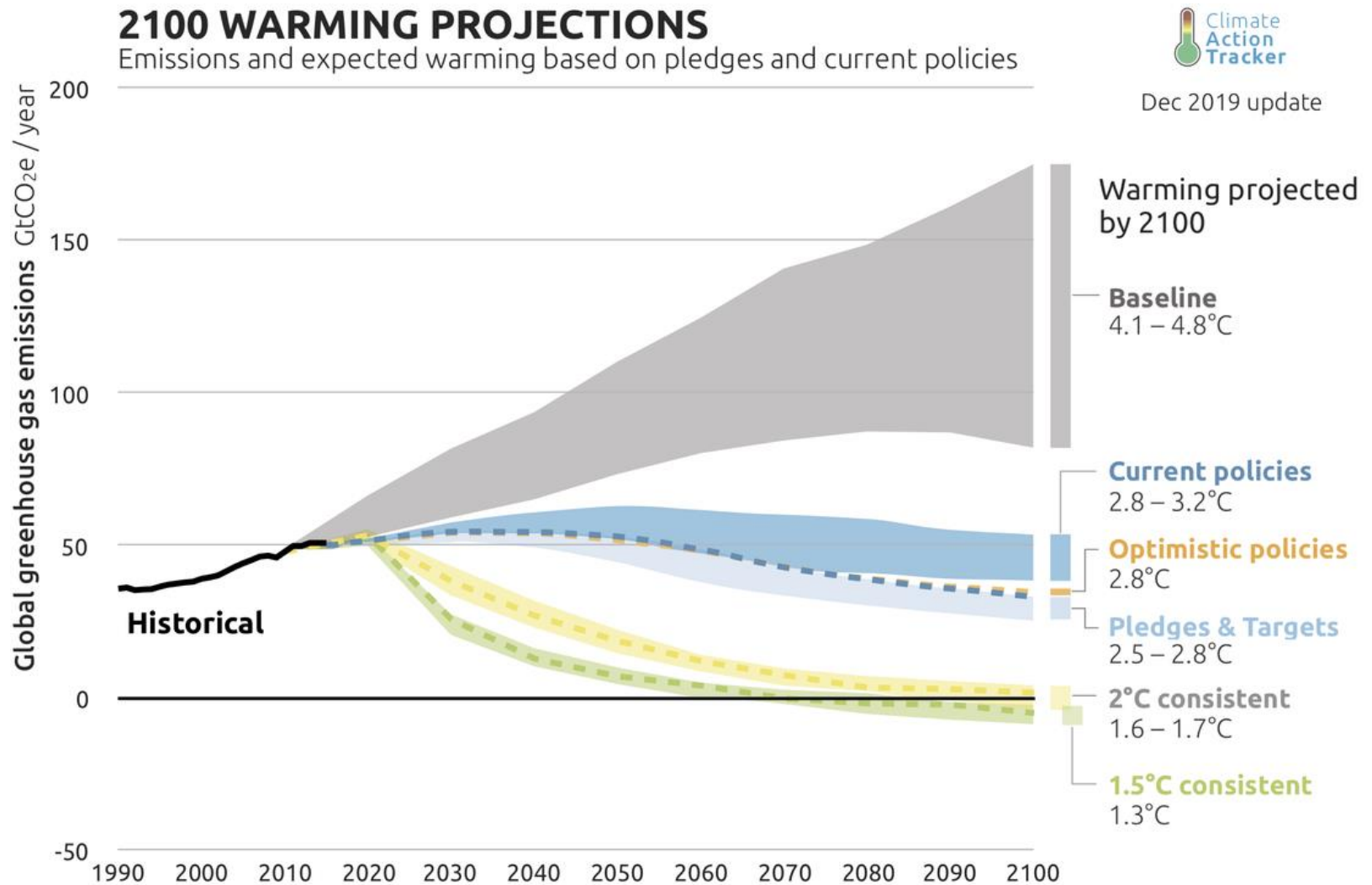


# Decadal prediction



*Global mean temperature change from new experimental decadal prediction system. Black: Observations; Blue: forecast; Red: previous predictions at 5-year intervals*

# Limiting climate change





# Tipping points:

Tipping point category	Consequences of passing tipping point	Implications for UK projections
<b>Carbon cycle / other biogeochemical cycles</b> <ul style="list-style-type: none"><li>- Amazon forest dieback</li><li>- boreal forest dieback</li><li>- Permafrost thawing</li></ul>	Acceleration / lock-in of CO <sub>2</sub> rise and global warming	Projected UK impacts reached sooner
<b>Cryosphere and sea level</b> <ul style="list-style-type: none"><li>- Greenland ice sheet</li><li>- West Antarctic Ice Sheet</li></ul>	Acceleration / lock in of sea level rise	Projected UK coastal flooding reached sooner
<b>Ocean / atmosphere circulation</b> <ul style="list-style-type: none"><li>- Atlantic Meridional Overturning Circulation (AMOC)</li><li>- Jet stream</li></ul>	Shifts in regional climate patterns	UK climate change potentially very different to standard projections