

# Climate change, does it add up?

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Do **you** believe in man made climate change?



**“Humans are a 'plague on Earth': Sir David Attenborough warns that negative effects of population growth will come home to roost”**



**YES?**

**No?**

## Some different views

90% of scientists agree: the earth is warming and man made CO2 is responsible.

**VS**

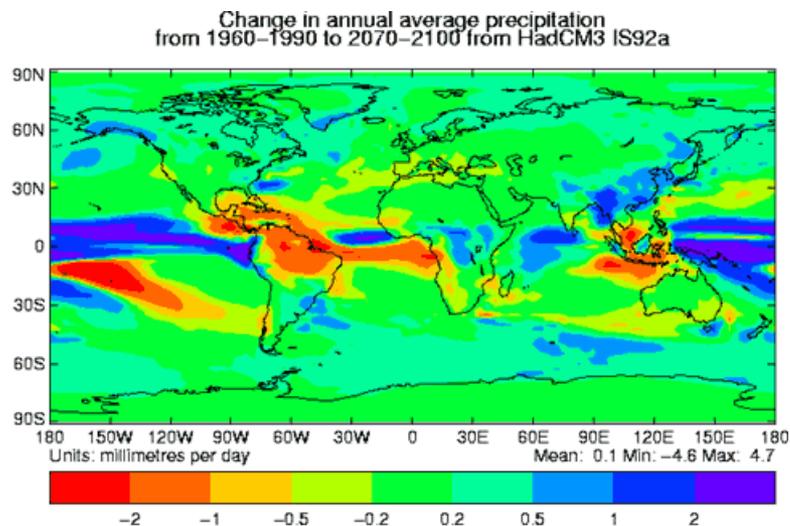
Jan 27th 2012

16 Scientists in the Wall St. Journal say

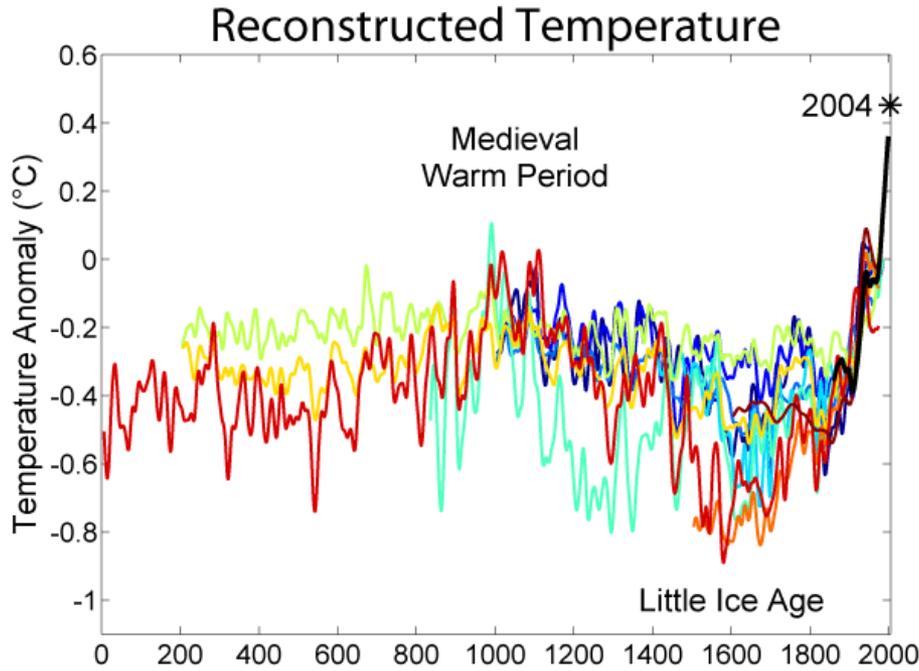
*'No need to panic about global warning'*



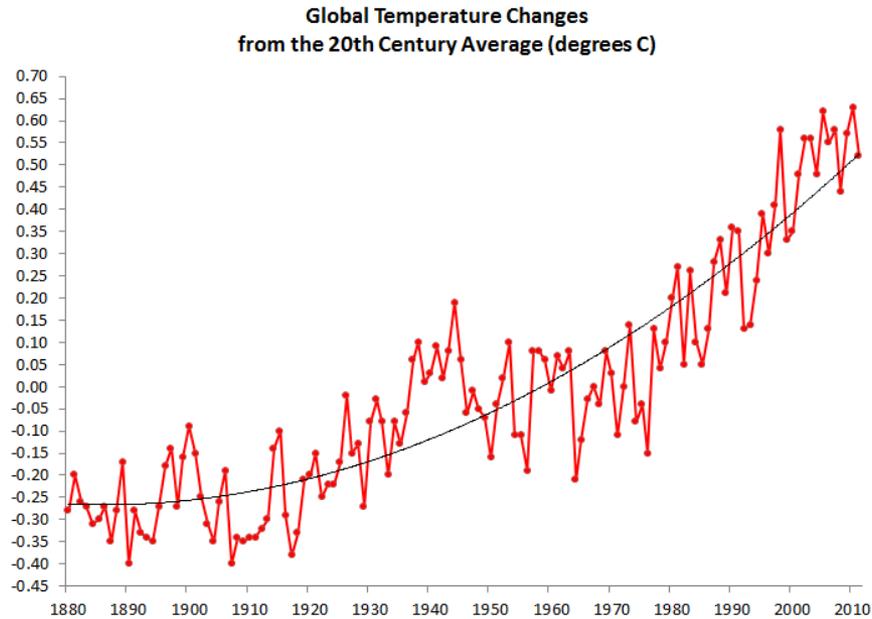
# Five 'official' indicators of climate change



# 1. Increasing temperatures



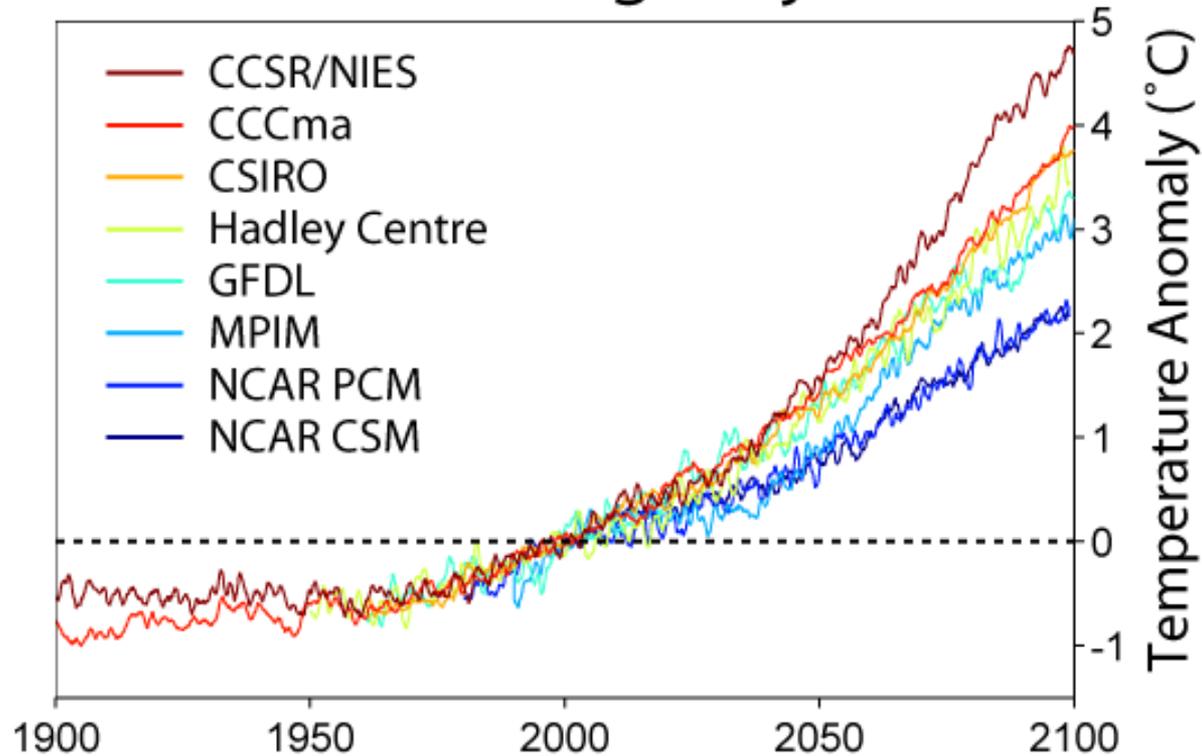
2005 was the hottest year ever recorded!



But note the last ten years

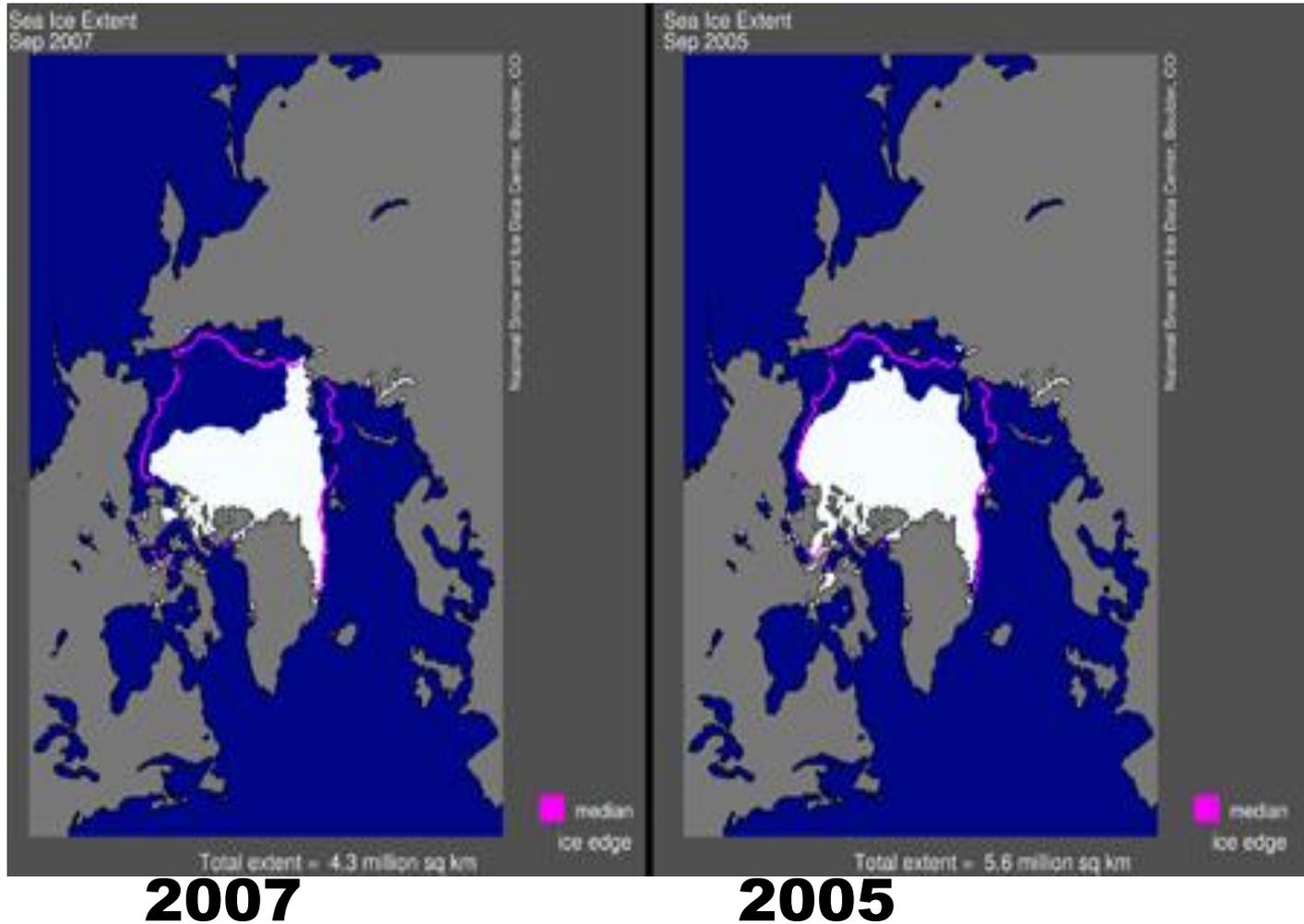
Things are predicted to get a lot worse!!

## Global Warming Projections



Between a 2 and 5 degree increase by 2100

## 2. The Melting Arctic

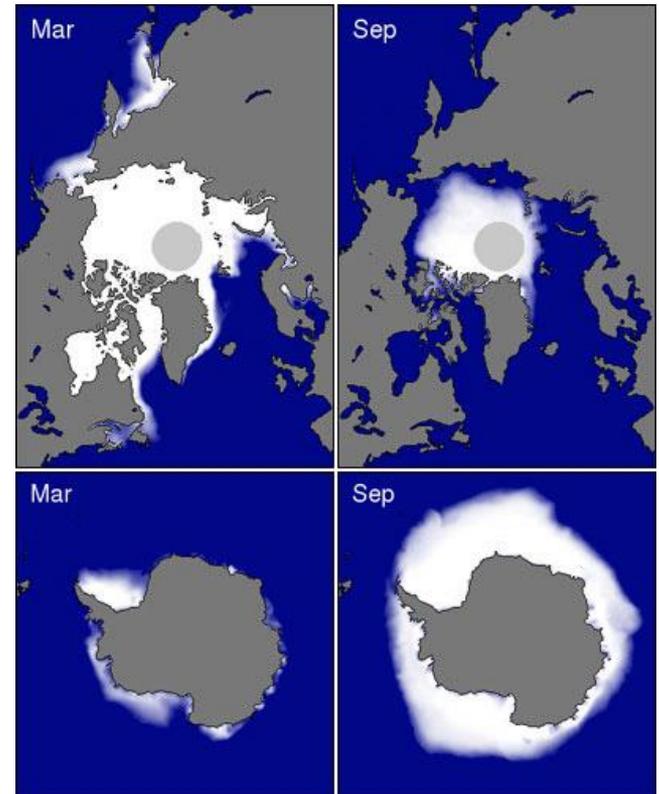


Every year we lose Arctic ice the size of Scotland!

**But ...**

Antarctic sea ice is actually increasing!

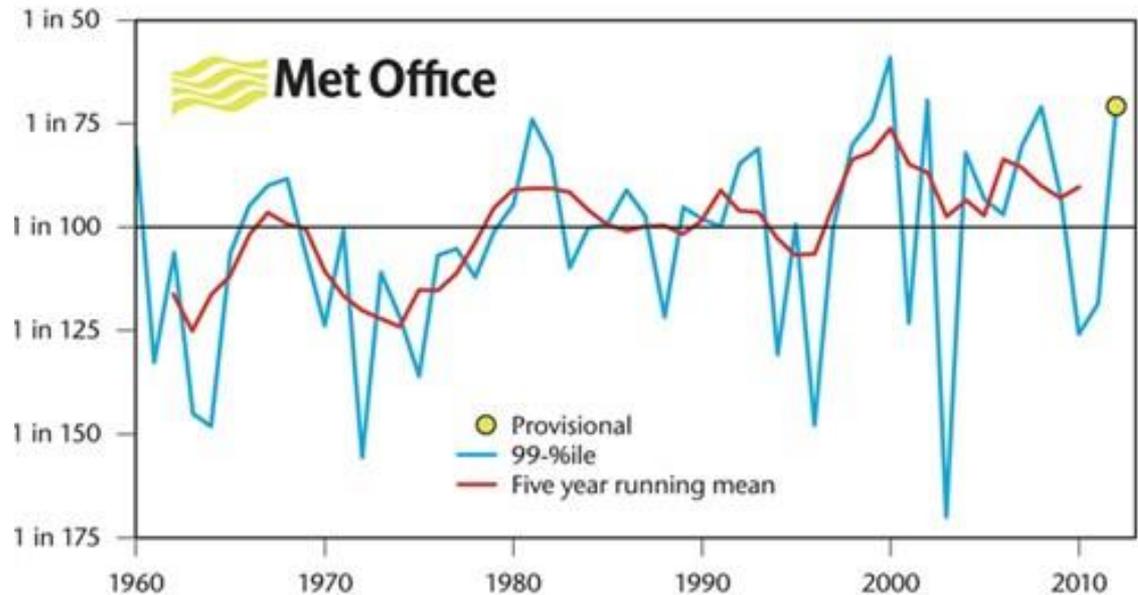
Although land ice is decreasing



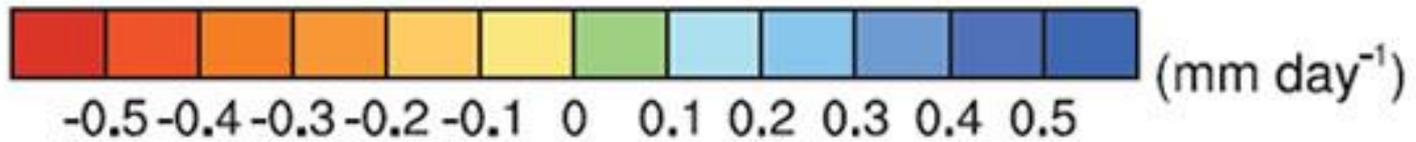
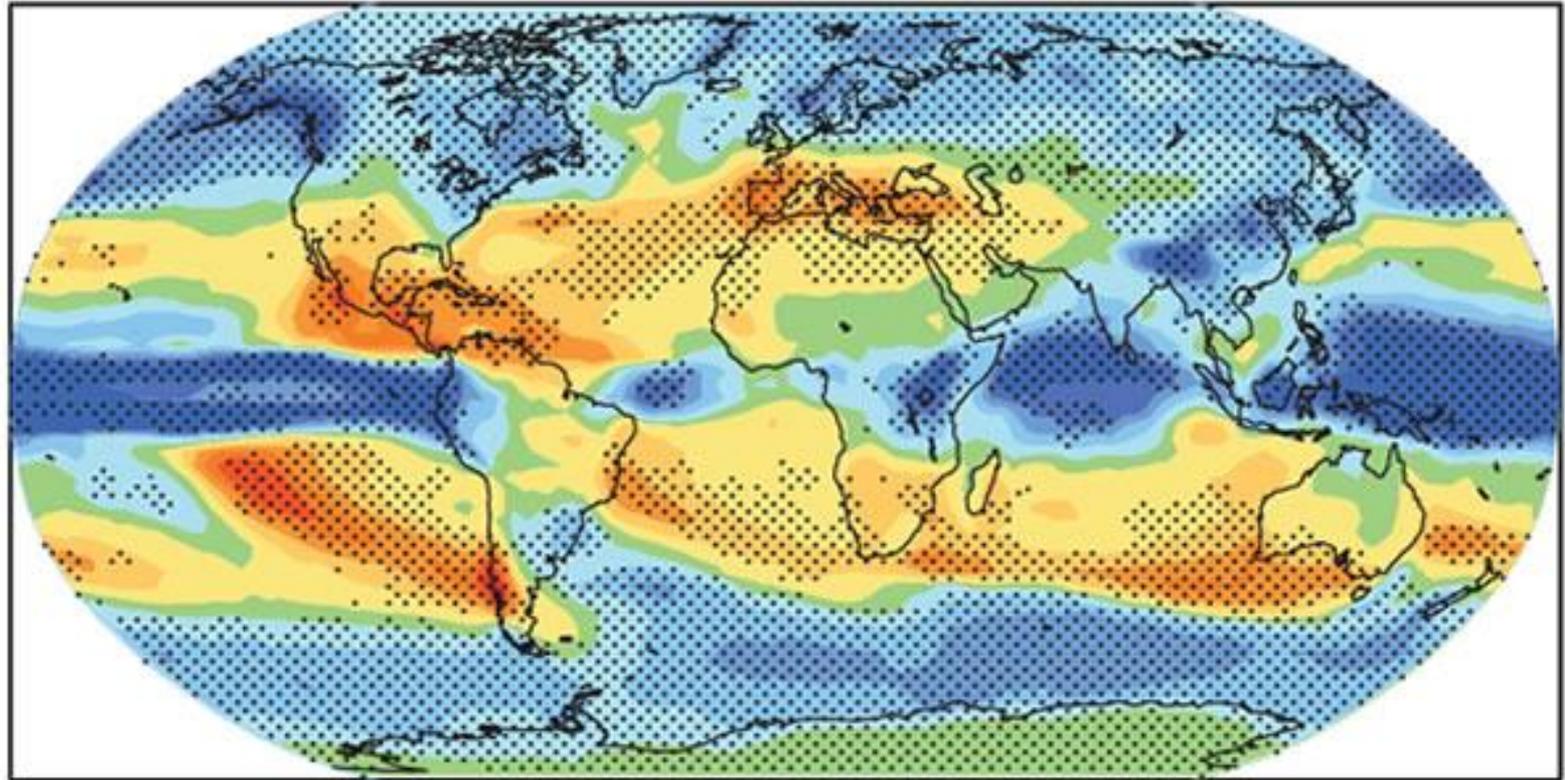
### 3. Changes in rainfall patterns (UK)

2000: Wettest year ever, 2012 second wettest

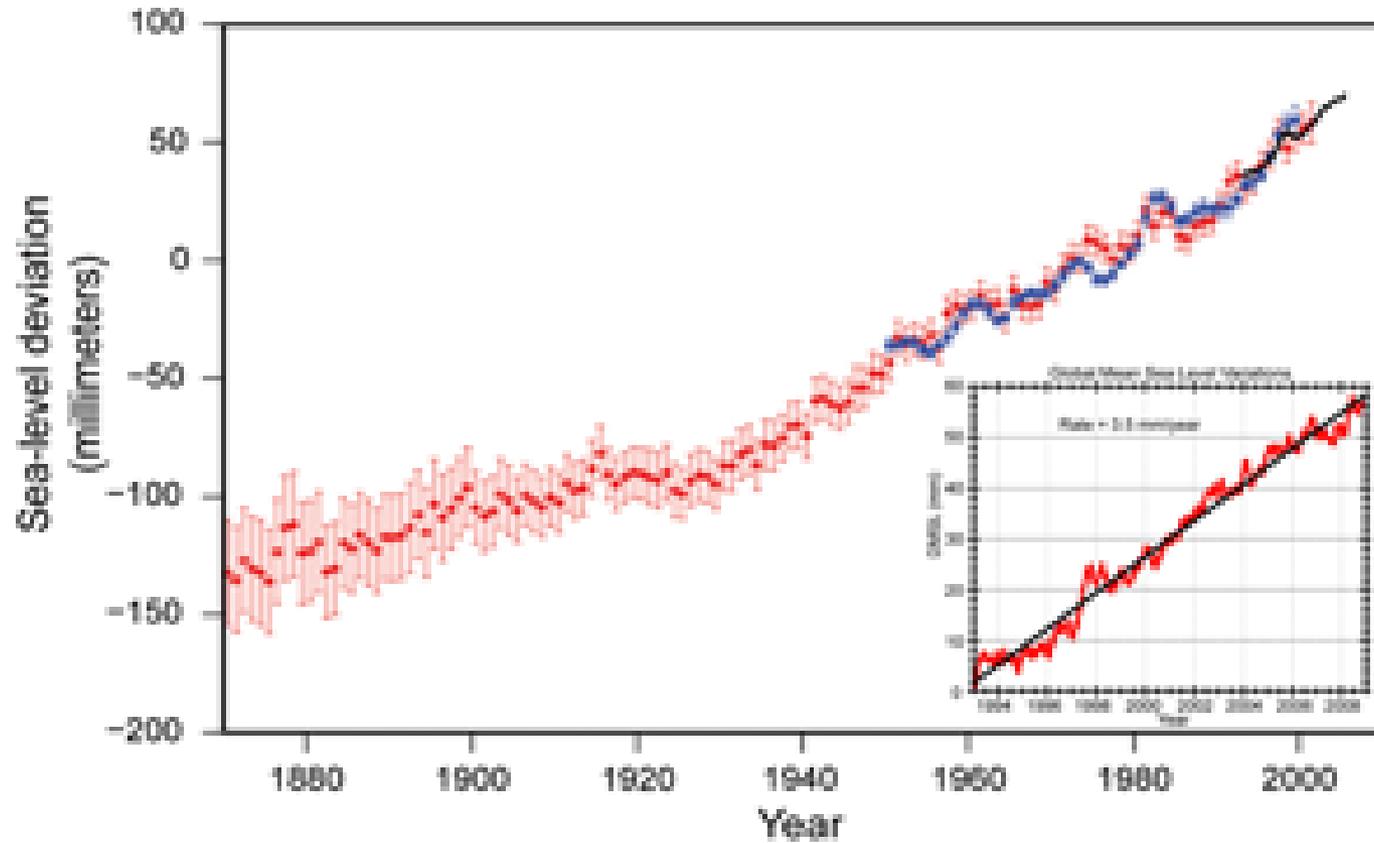
Top five wettest years in the UK		
1	2000	1337.3 mm
2	2012	1330.7 mm
3	1954	1309.1 mm
4	2008	1295.0 mm
5	2002	1283.7 mm



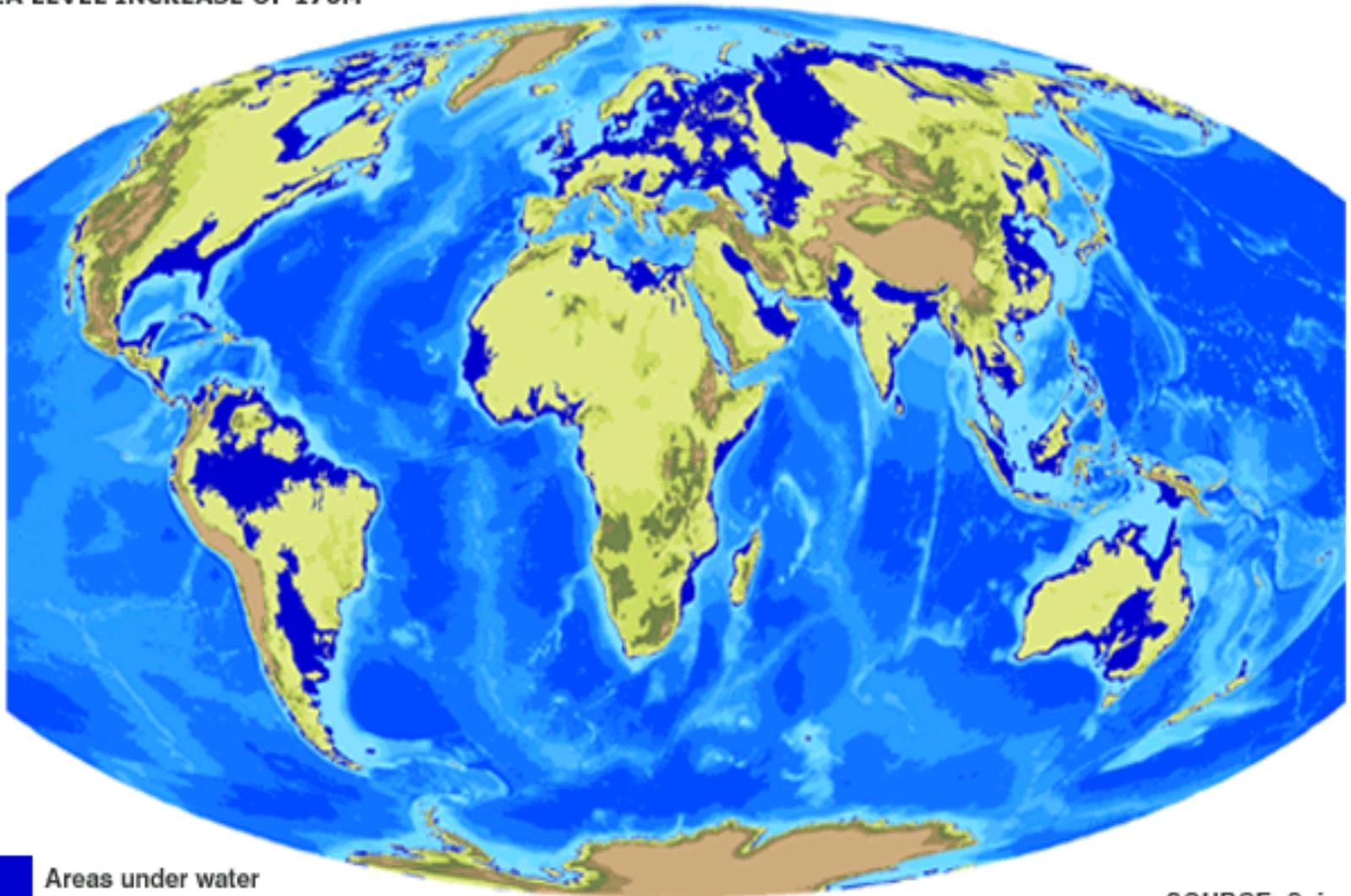
# North-South Differences in rainfall predictions



## 4. Sea Level Rise



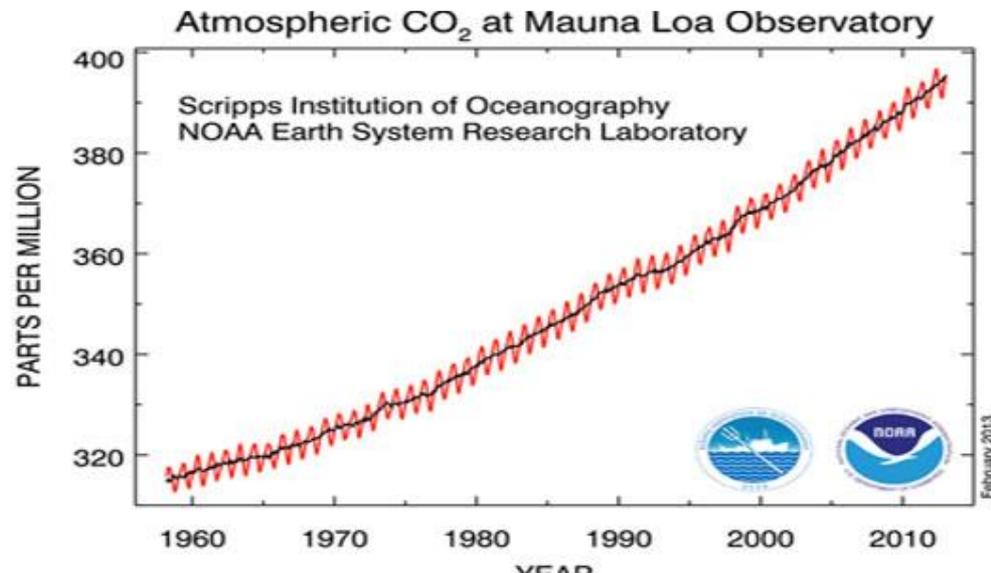
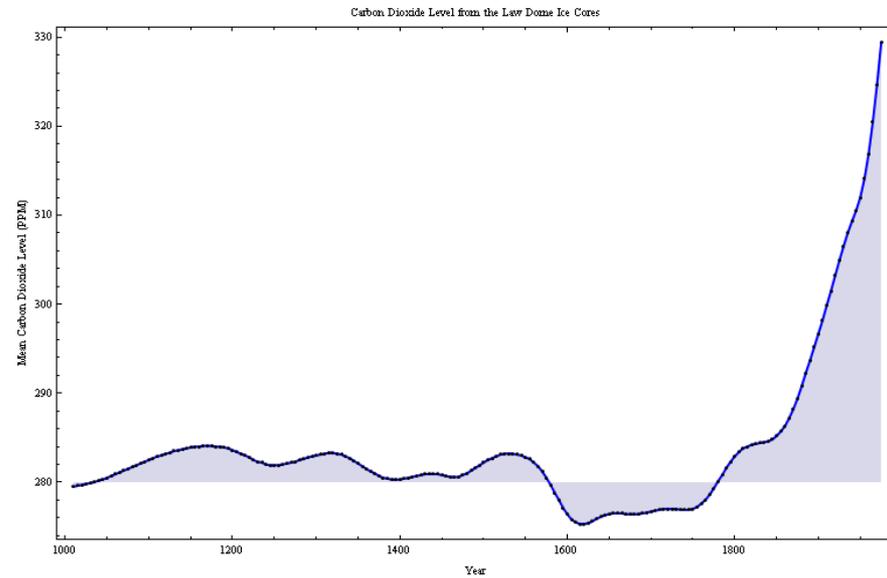
**SEA LEVEL INCREASE OF 170M**



Areas under water

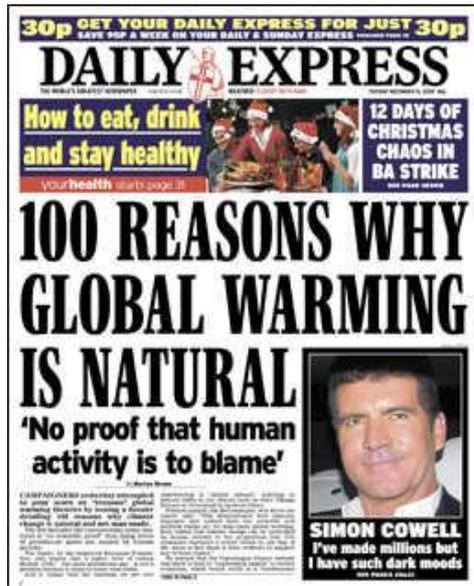
SOURCE: Science

## 5. Increase in Atmospheric Carbon Dioxide



# Not everyone agrees!

"This is nonsense....there has been no statistically significant global warming for at least a decade".



*Watts up with that*

And maybe it's all a big conspiracy!

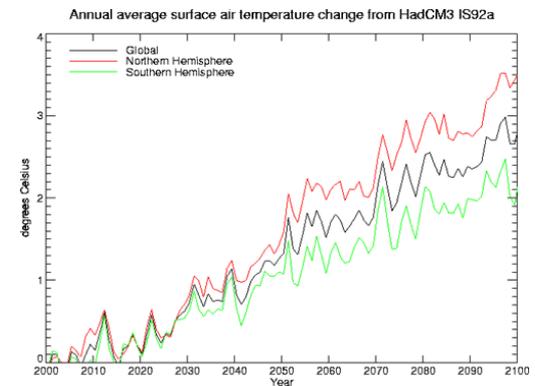
ClimateGate



Enter the mathematician .... who can ...



- Interpret climate data (statistics)
- Create mathematical models (mechanics)
- Use these models to inform policy change (decision maths)



**And tell you if the roads are going to be icy!**

# Why is climate science so hard?



It is difficult to predict anything, especially about the future!  
*Niels Bohr/Yogi Berra*

Some reasons for the uncertainty

Statistical variation in dodgy data

Chaos

Complexity of the system



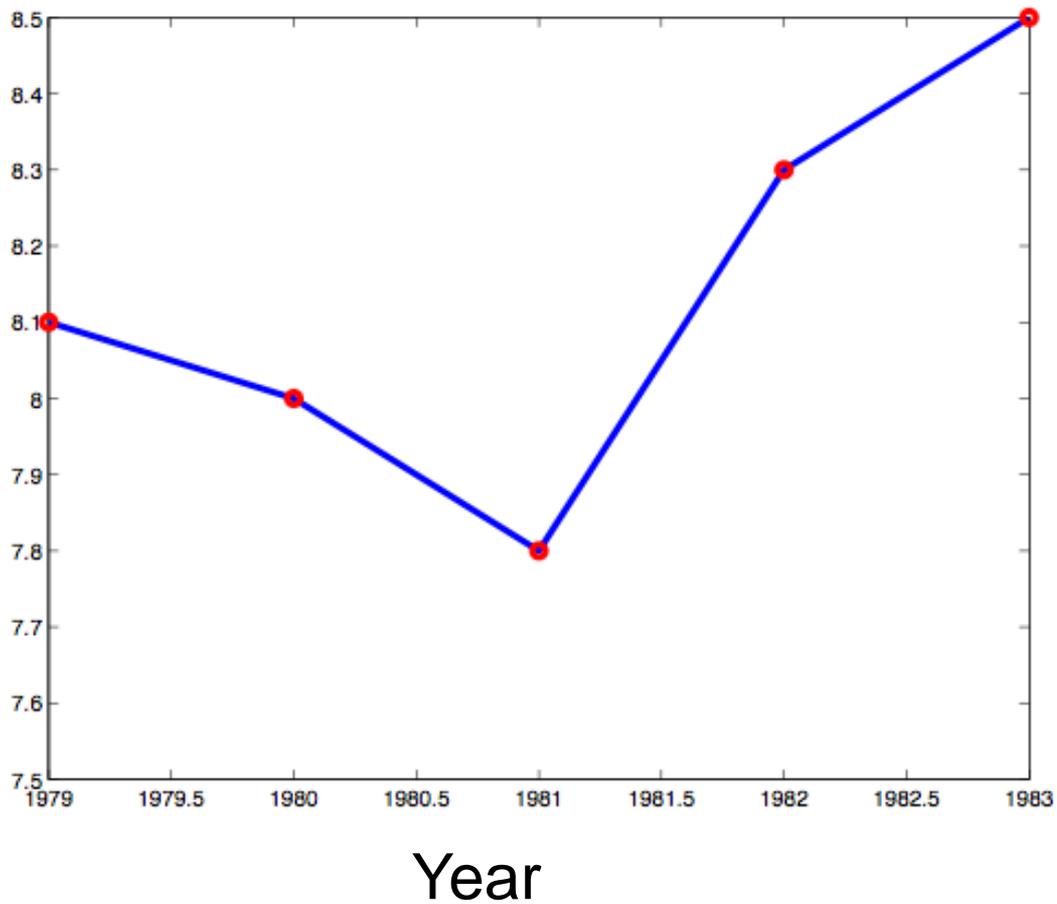
## Example: **How much Arctic Sea Ice Is There?**



NASA: National Snow and Ice Data Center NSIDC

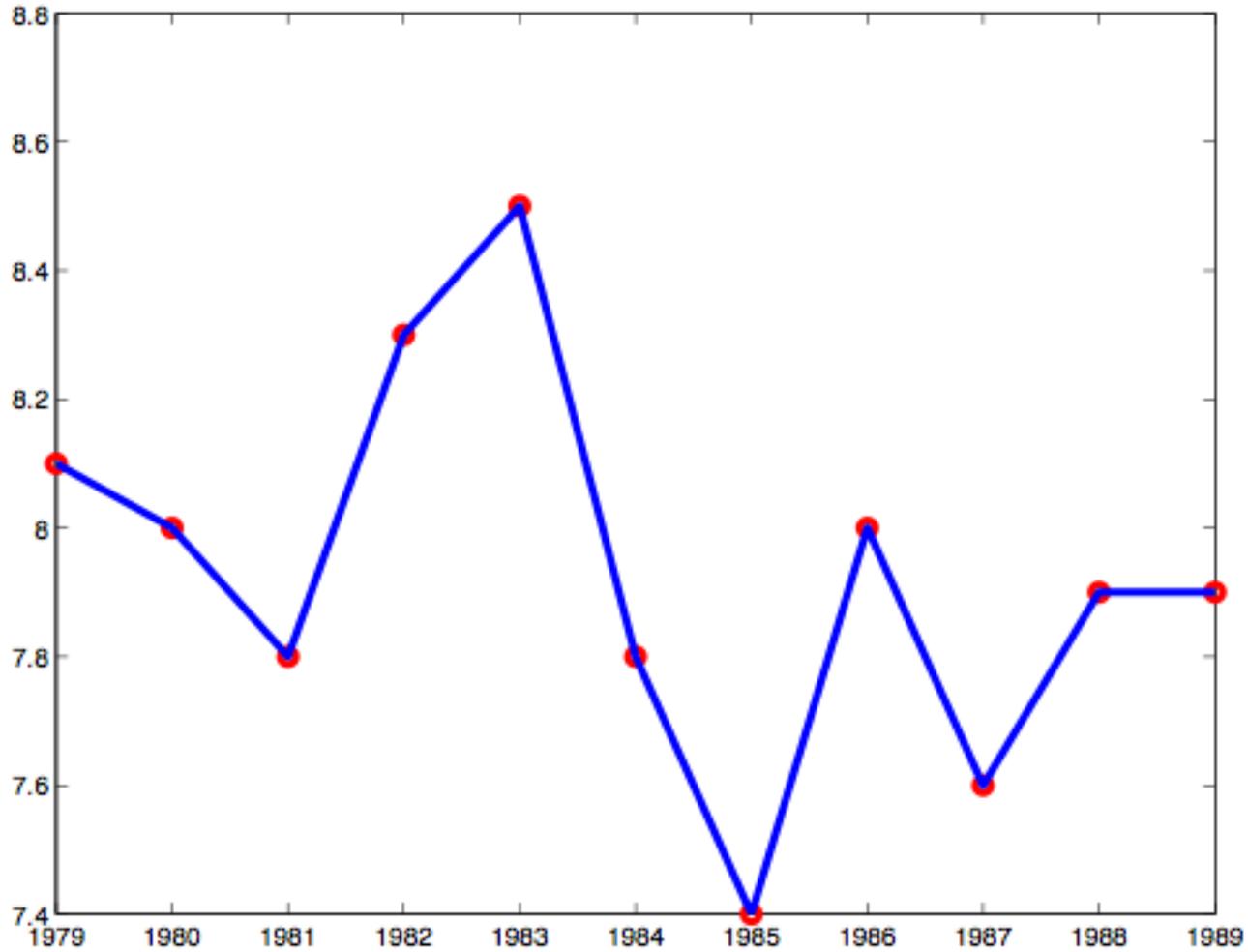


How much Ice is there in millions of square km



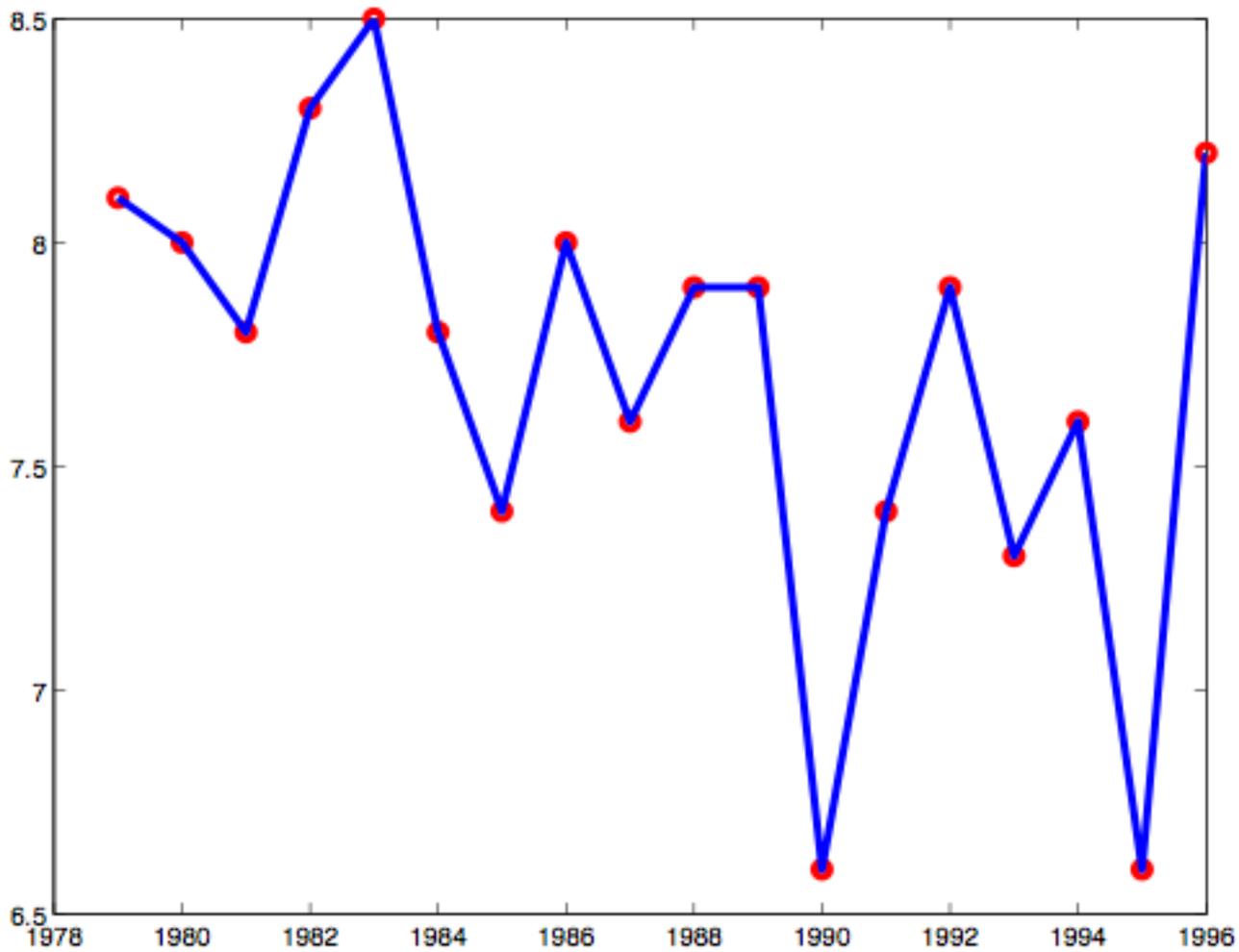
What happens next?

How much Ice is there in millions of square km



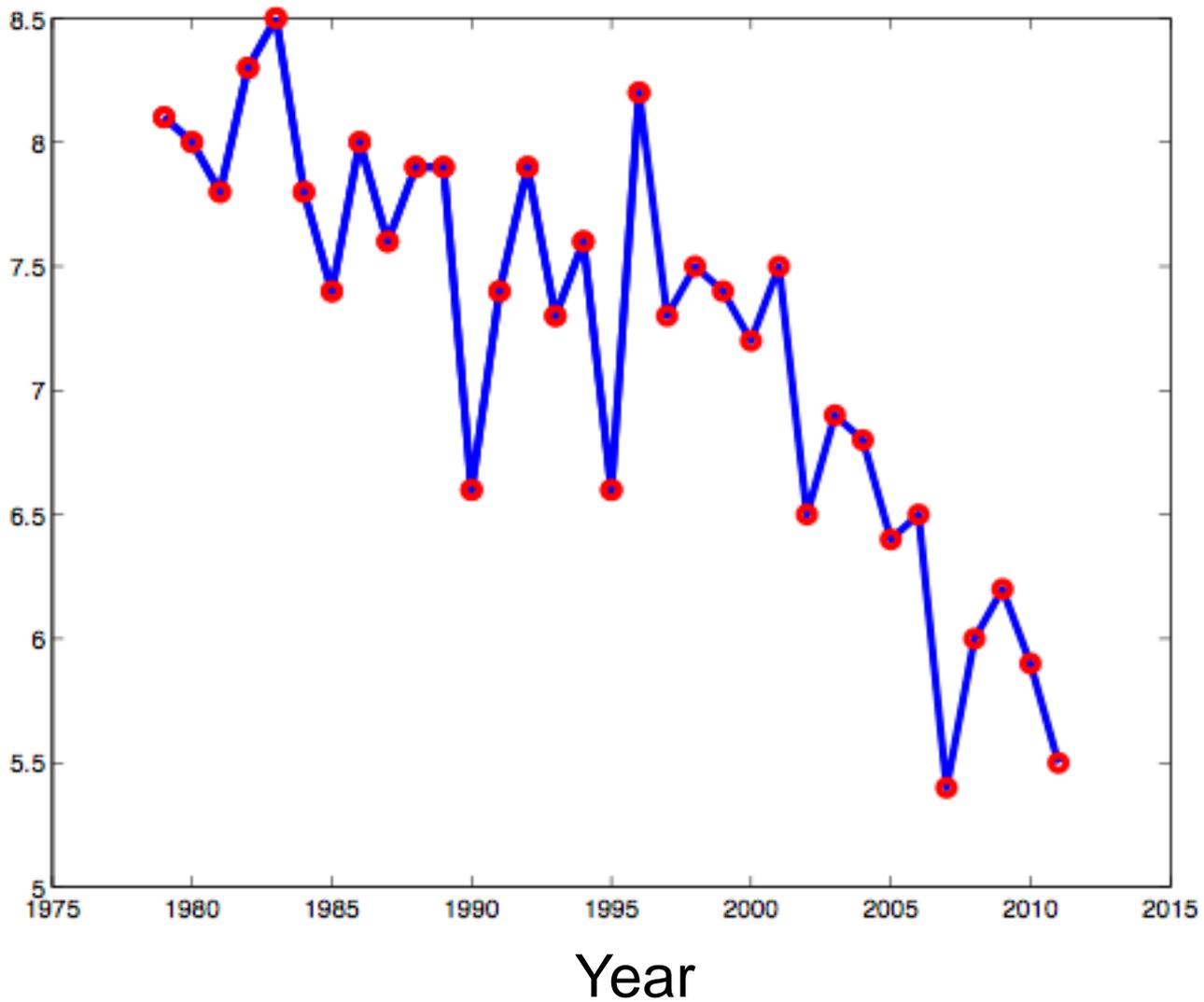
Year

How much Ice is there in millions of square km



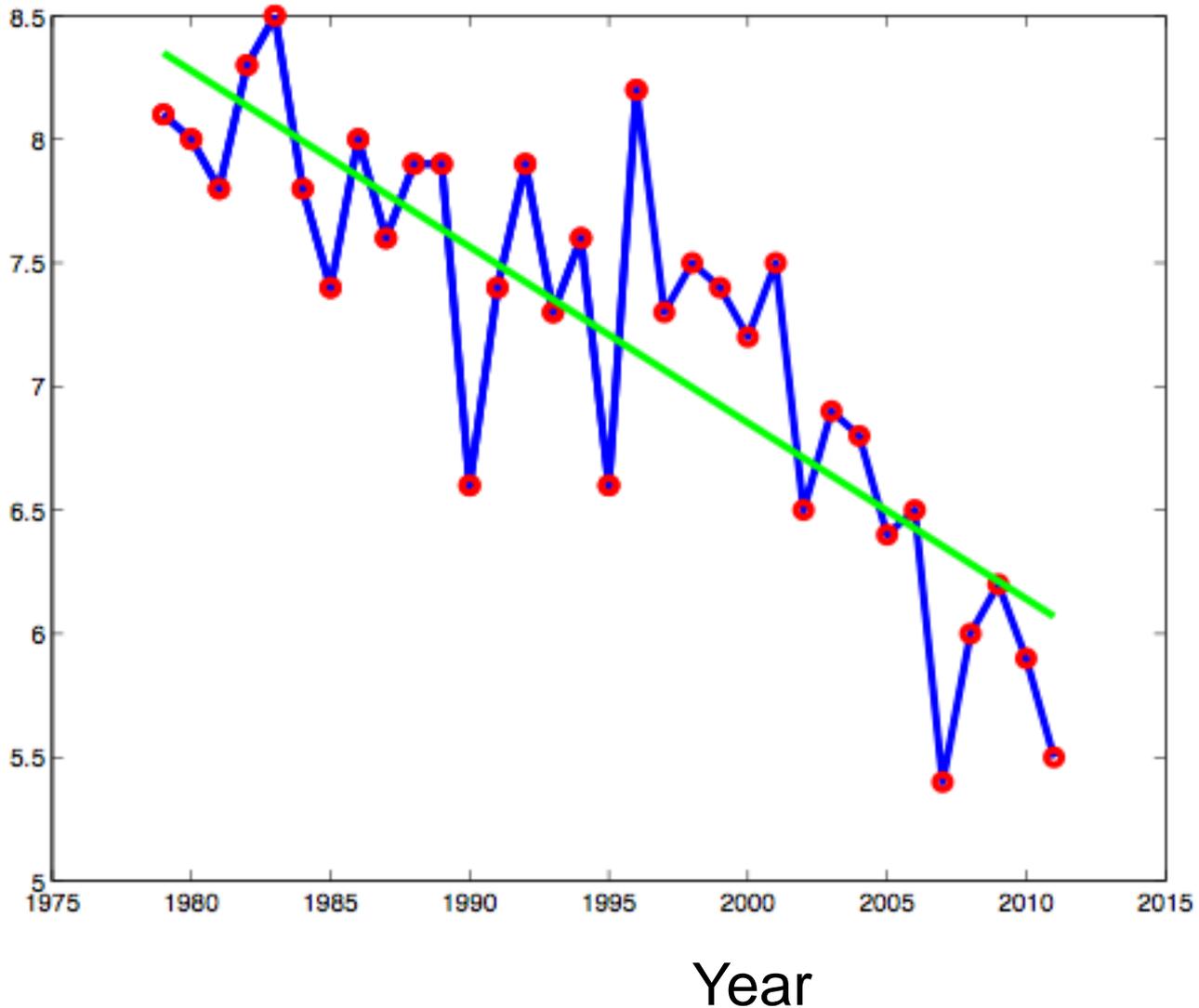
Year

How much Ice is there in millions of square km



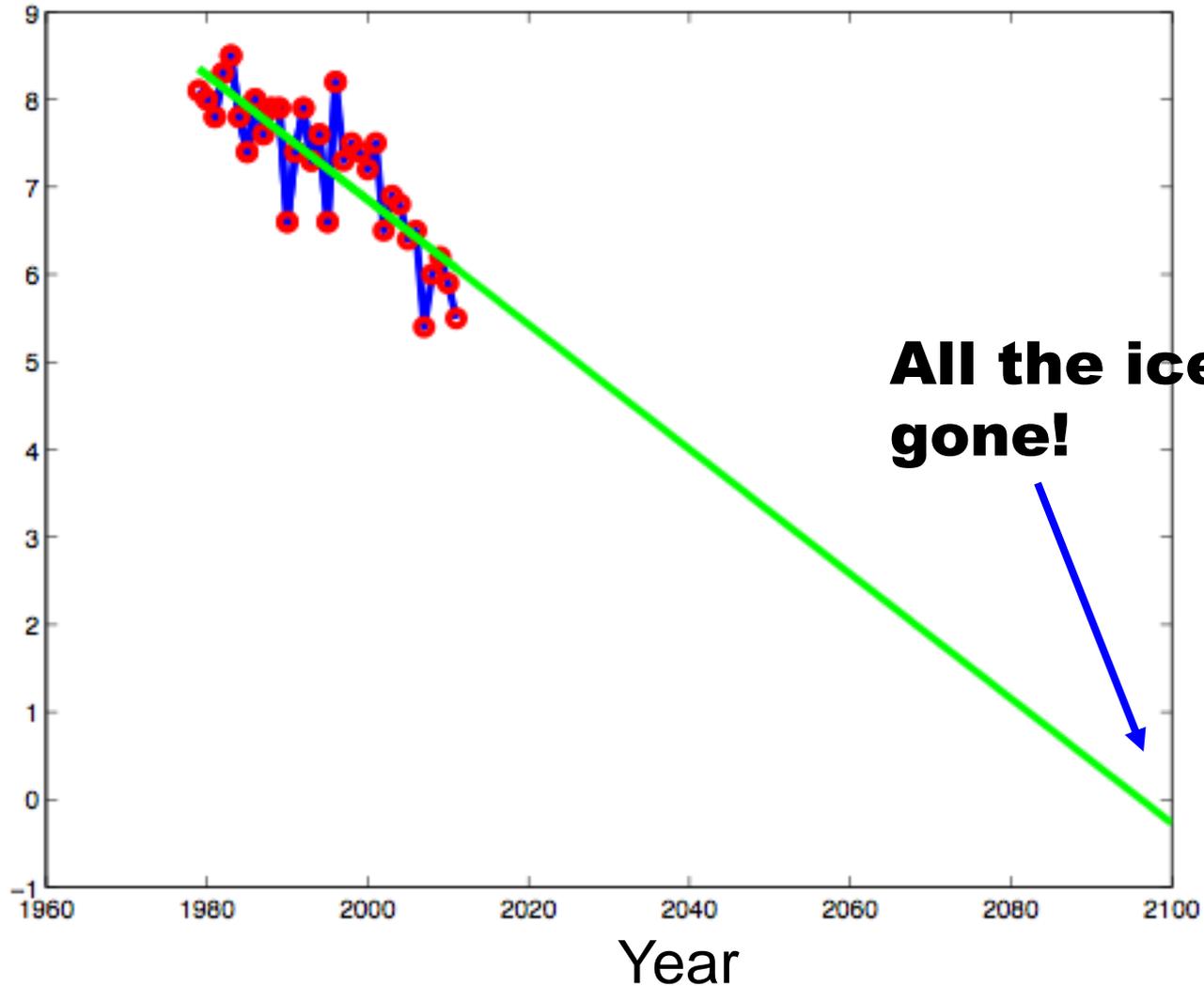
## Best fit straight line (statistics)

How much Ice is there in millions of square km



# Future prediction???

How much Ice is there in millions of square km



## Nasa's conclusion

Arctic sea ice has become thinner by around 43% over the last 25 years

**... and this trend is continuing**

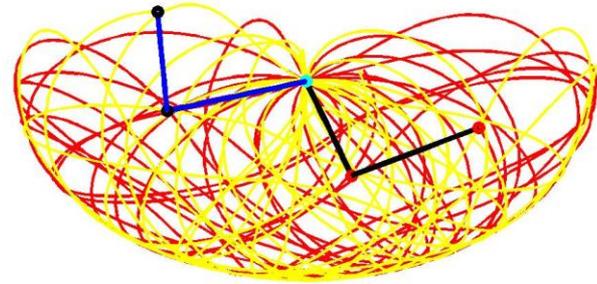
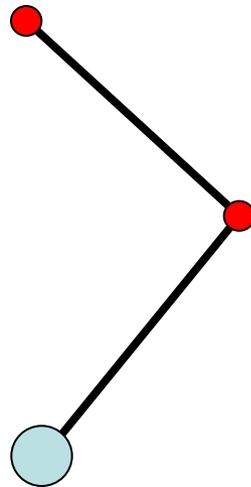
But can we really tell the future from the past?



Writing in the journal **Science** in 2011, a team of Danish scientists found evidence that ice levels were about **50% lower 5,000 years ago**.

Chaos theory tells us that there is ...

A limit to our scientific understanding of the future



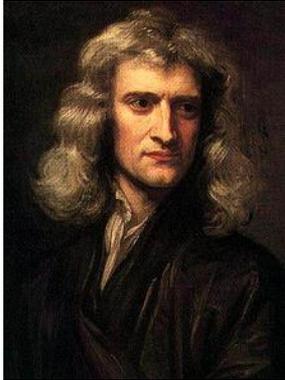
Motion can be **Chaotic** and unpredictable

Even if we understand something we can't always predict it with certainty!!!!!!

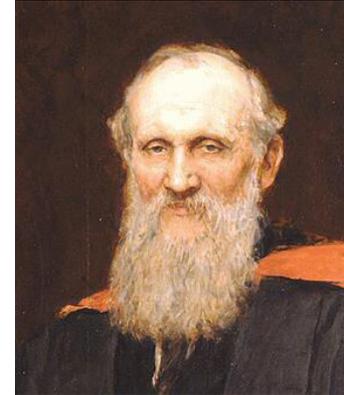
# So .. what do **Climate Centres** do?



Take laws of physics



**Motion**



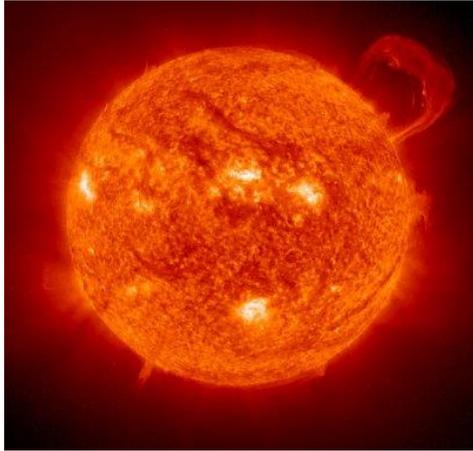
**Heat**

Turn them into equations

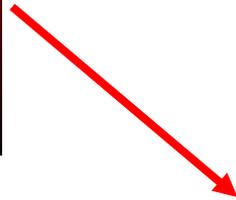
Solve these on a supercomputer to try to predict the climate



# Let's see if we can forecast the climate

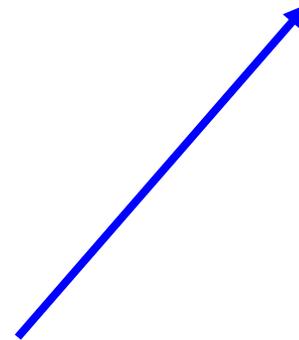


**Heat from Sun:  $S$**

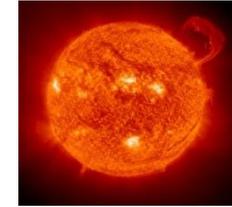


Earth's mean temperature:  $T$

Heat into  
space



Heat absorbed  $\longrightarrow dS$



d Darkness: How well the earth absorbs the Sun's rays

Heat radiated away  $\longrightarrow e\sigma T^4$



e **emissivity**: How much energy is radiated into space

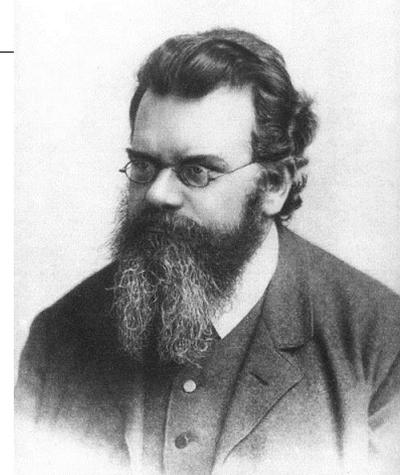
**Balance these:**

$$e\sigma T^4 = dS$$

# If we know $e$ , $\sigma$ , $d$ , $S$ we can work out $T$ !!!!

## Currently

Emmissivity	$e = 0.55,$
Boltzmann	$\sigma = 5.67 \times 10^{-8}$
Darkness	$d = 0.68,$
Solar heating	$S = 300\text{W}/\text{metre}^2$



Work out  $T$  from the **heat balance equation**

$$e\sigma T^4 = dS \rightarrow T = \sqrt{\sqrt{dS/e\sigma}}$$

$$\mathbf{T = 284.4 K}$$

So:



$$T = \sqrt{\sqrt{dS/e\sigma}}$$



**Mathematical climate super hero**

What does the math tell us?



# The greenhouse effect

If CO<sub>2</sub> increases

Then e decreases

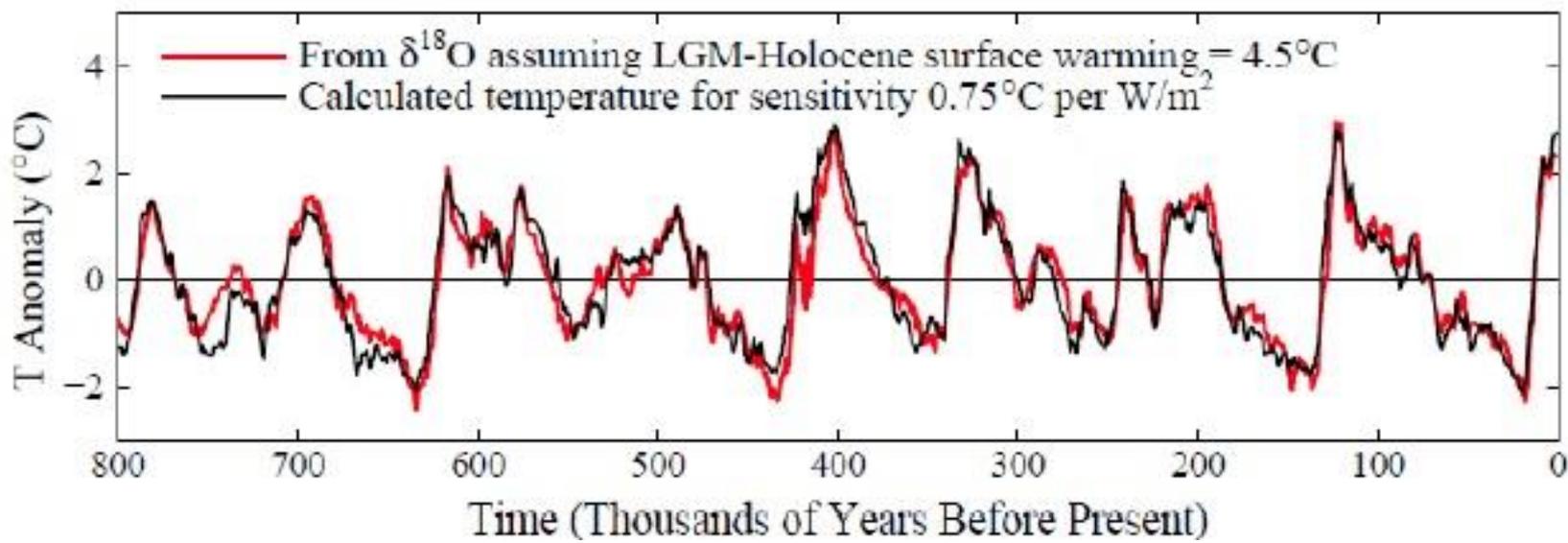
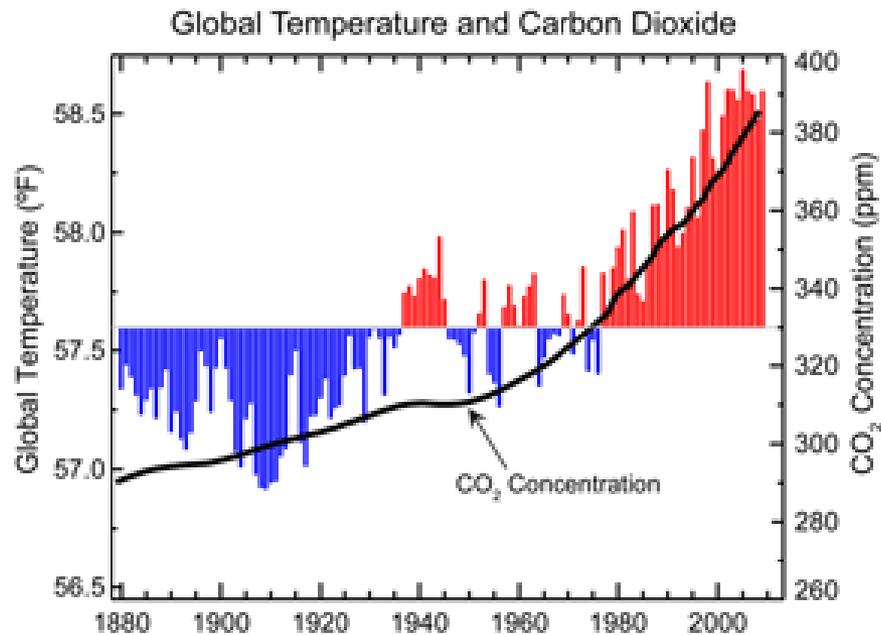
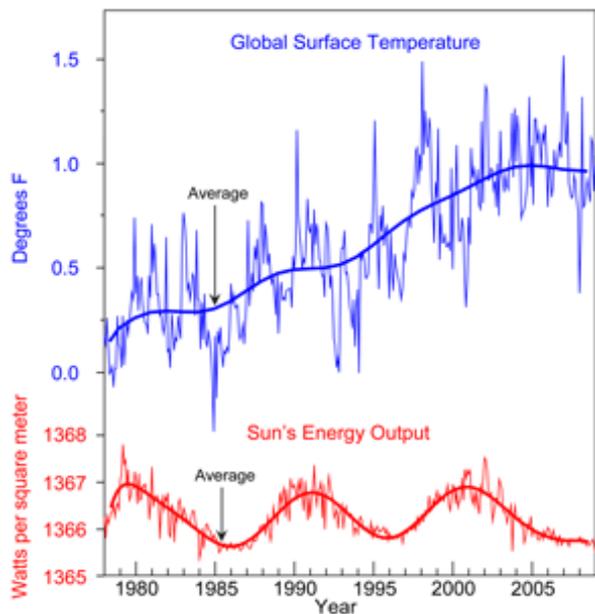


$$T = \sqrt{\sqrt{dS/e\sigma}}$$

Formula tells us that T increases!!



T depends upon both  $e$  and  $S$



Also .... **T increases** if **d increases**

Leads to a **feedback loop**

**Sea ice melts**



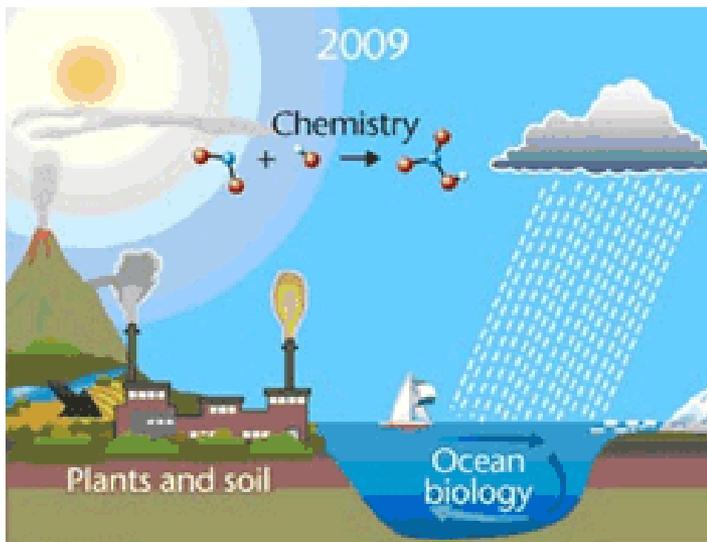
**Temperature rises**

**Planet gets darker**

This means that future temperatures may be **higher!**

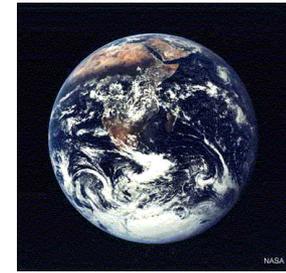
**TIPPING POINT??**

# Climate models are constantly improving to cope with complexity



Tested by being used to predict past climate change

# Practical ways to save the planet



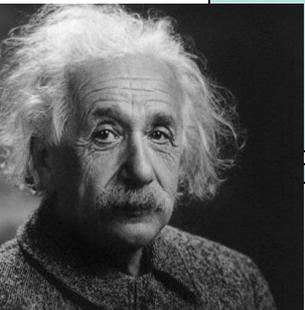
Most of the energy we generate we simply throw away!

Can we use some of this instead?

and run the world from a cup of coffee



**Halve the  
number of  
power stations**



Stirling Engine

## Conclusion



$$T = \sqrt{\sqrt{dS/e\sigma}}$$

What should a mathematician do about climate change?

- Thinks of ways to use less energy
- Think of better ways to produce energy
- Be aware of what is happening to our planet
- Always use your mathematical judgement when listening to what the papers say!

## Become a Climate Scientist

<http://www.climathnet.org/orschoolsandpublic>

