

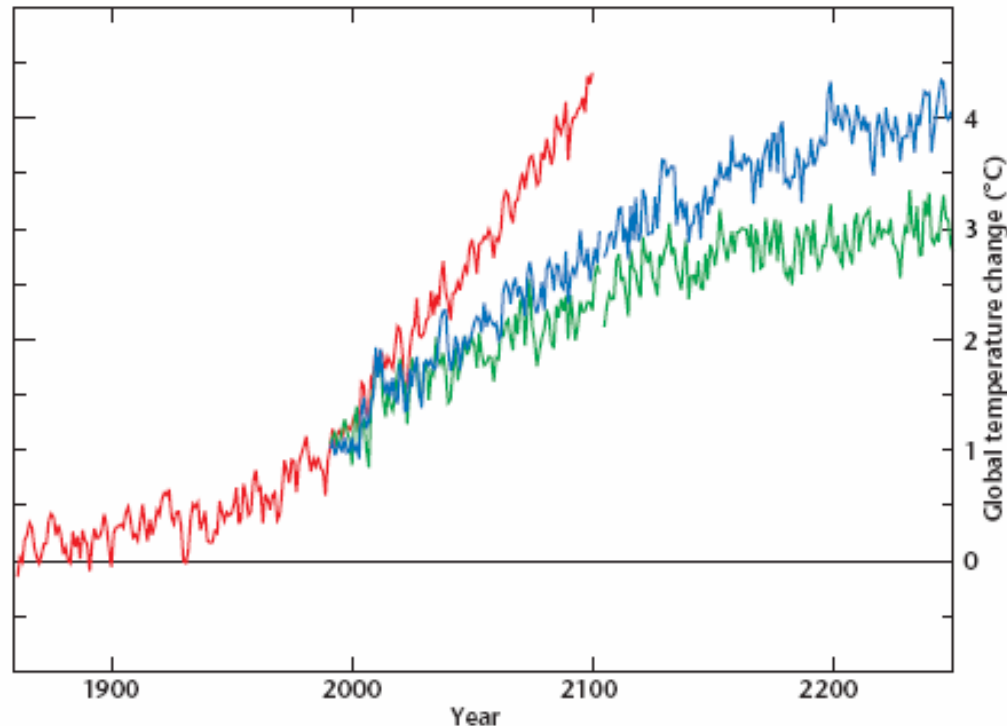
Why is carbon dioxide so important? Examining the evidence

“In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.”

Intergovernmental Panel on Climate Change (IPCC), 2001



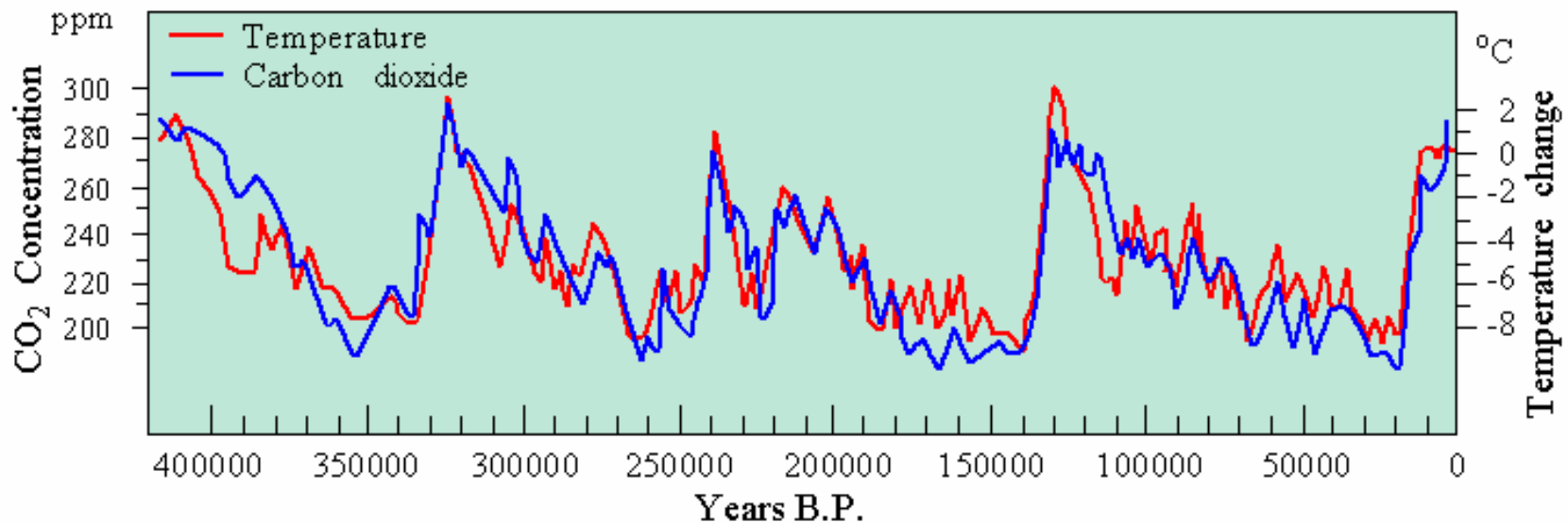
The IPCC talks about 'new evidence' and 'remaining uncertainties'. Most models show that the greenhouse gas carbon dioxide has a major influence on temperature, as these projections from the Met Office show.



The global average temperature rise resulting from the unmitigated emissions scenario (red), and emissions scenarios which stabilise CO₂ concentrations at 750 ppm (blue) and at 550 ppm (green).

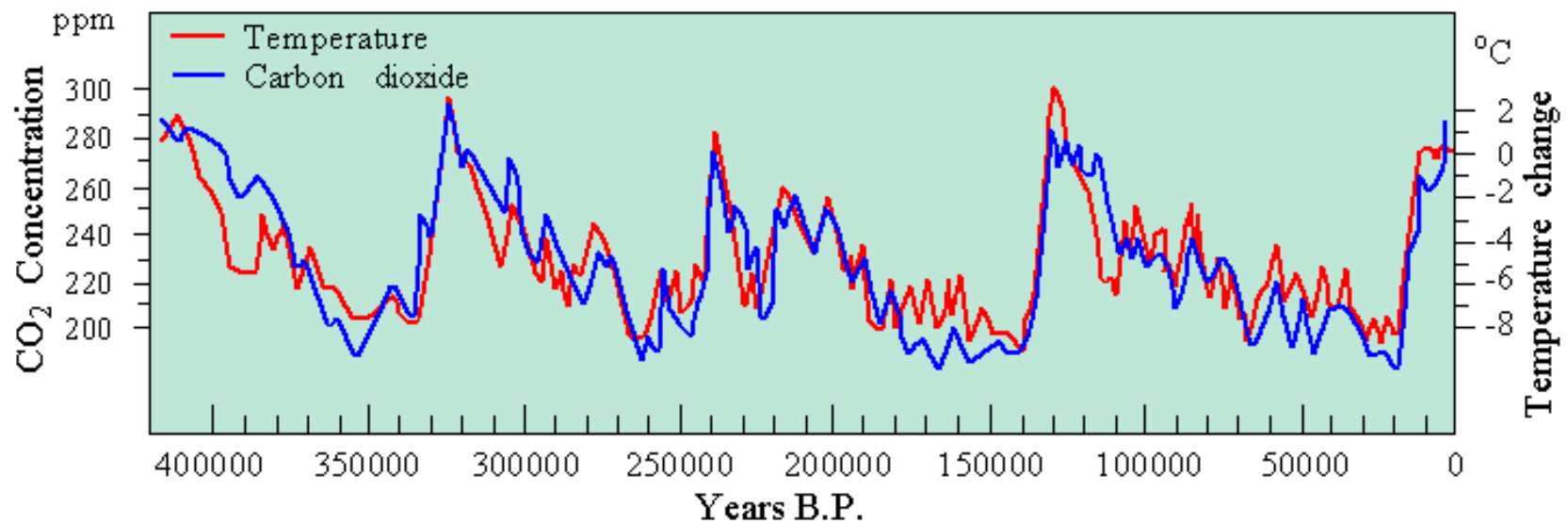


How do they know that carbon dioxide concentrations have such a marked effect when there are so many other factors that also affect the climate? In this activity you will look at some of the evidence for the role of carbon dioxide in global warming and consider some of the uncertainties.



Data from Antarctic Ice Cores going back 400 000 years



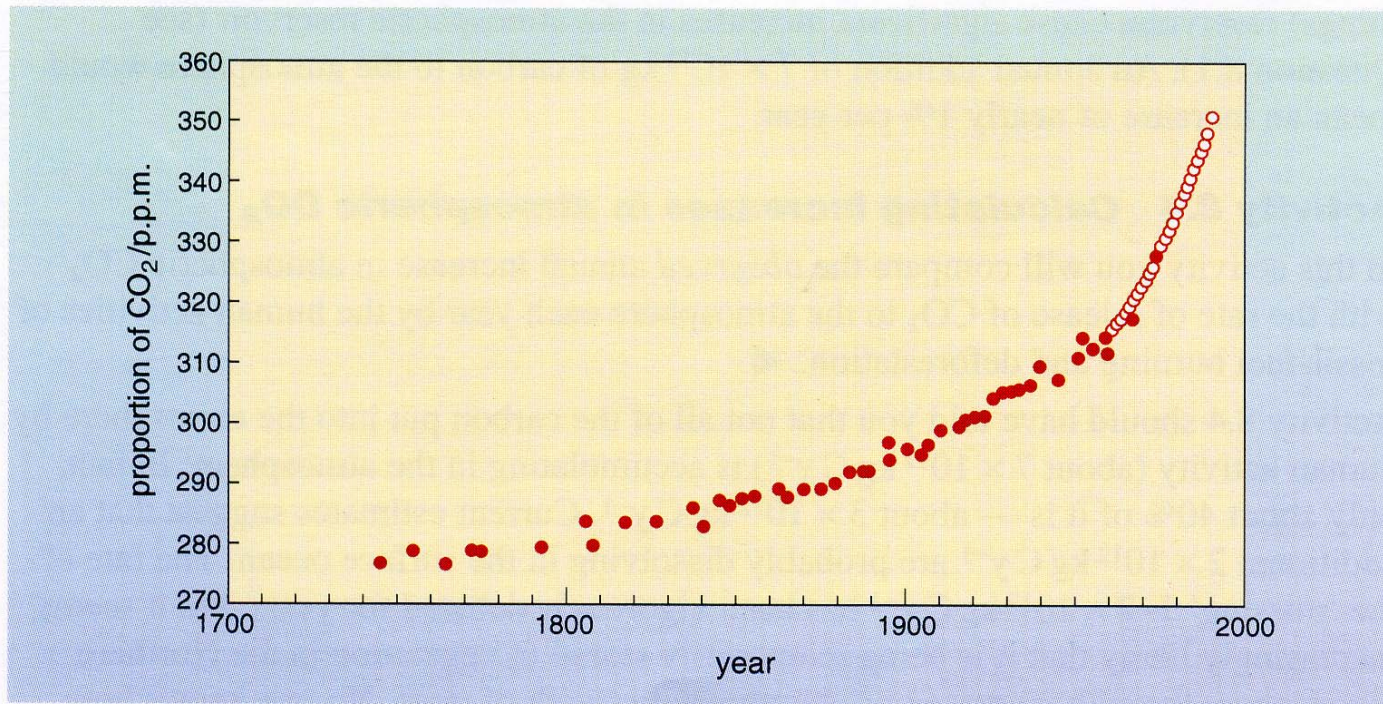


Data from Antarctic Ice Cores going back 400 000 years

1. Explain how this data supports the idea that warming is due to an increase in carbon dioxide concentration.
2. Why does this data alone not provide conclusive evidence?

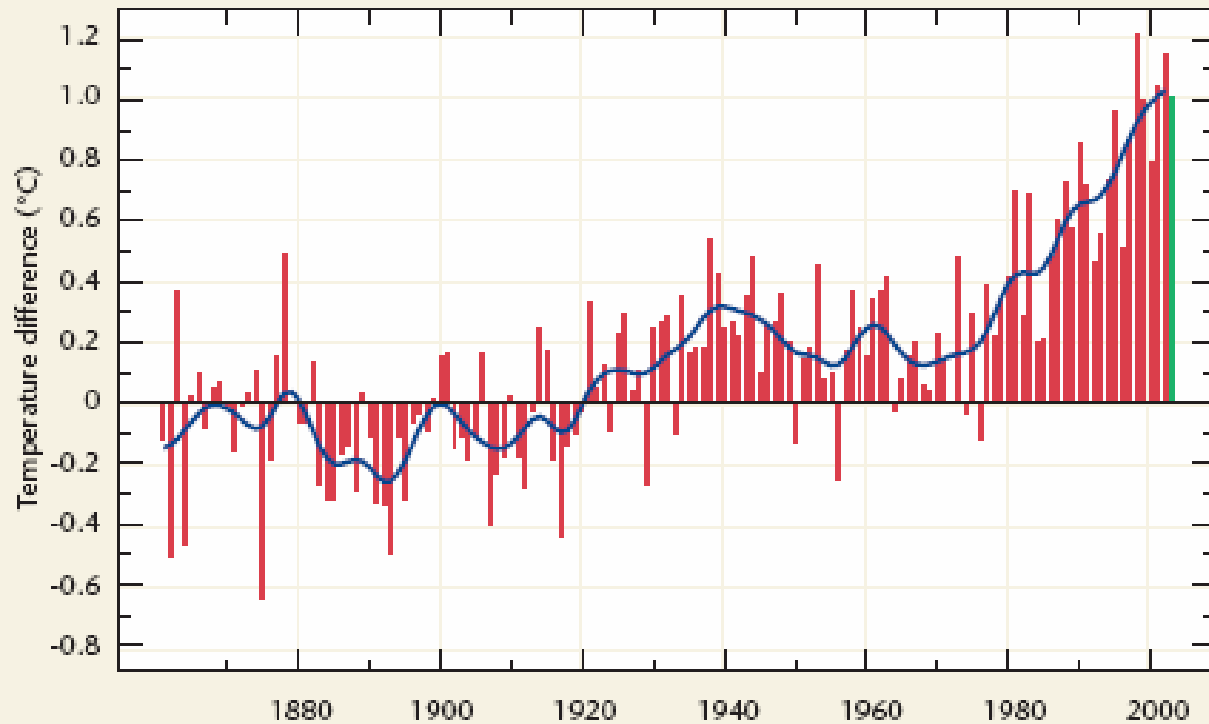


Data for last 150 years



Proportion (in p.p.m.) of CO₂ in the atmosphere over the past 250 years, as indicated by air trapped in Antarctic ice (filled circles) and by direct monitoring at Mauna Loa observatory (open circles).



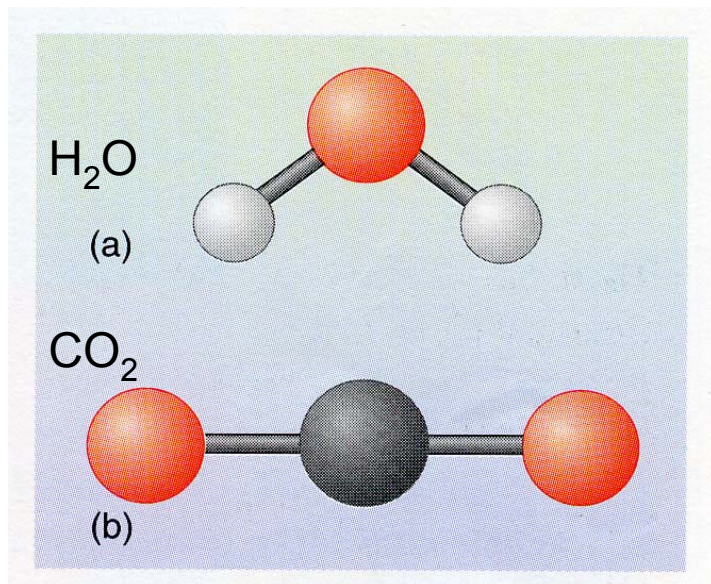


*Global near-surface temperatures averaged over the land only.
Differences are expressed relative to the end of the 19th century.*

1. Explain how this data supports the idea that warming is due to increase in carbon dioxide concentration.
2. Why does this data alone not provide conclusive evidence?



Atmospheric gases and radiation



Component	Number of particles as % of total	Number of particles in 1 m ³	Absorption of IR
nitrogen	77.6	$2.0 \cdot 10^{25}$	no
oxygen	20.9	$5.4 \cdot 10^{24}$	no
argon	0.93	$2.4 \cdot 10^{23}$	no
water	0.5	$1.3 \cdot 10^{23}$	yes
carbon dioxide	0.036	$9.2 \cdot 10^{21}$	yes



Atmospheric gases and radiation

- Neither carbon dioxide nor water vapour absorb the high frequency radiation arriving from the Sun but they do absorb the lower frequency Infrared (IR) radiation that is emitted by the Earth.
 - It is because some of this energy is prevented from leaving the Earth's atmosphere that the Earth warms.
 - This is known as the Greenhouse Effect.
 - If these gases did not absorb IR radiation the Earth would be too cold to support life.
 - Other gases in the atmosphere do not absorb IR.
1. **Explain how this data supports the idea that warming is due to increases in carbon dioxide concentration.**
 2. **Why does this data alone not provide conclusive evidence?**



Early predictions



In 1896, Nobel prize-winning Swedish chemist Svante Arrhenius predicted that a doubling of CO_2 would lead to an increase in the globally-averaged surface temperature of 2°C .

This estimate was based simply on knowing how CO_2 absorbs heat radiation from the surface of the Earth.

His conclusion is in line with modern understanding.



Feedback Mechanisms



Some plants grow better in a CO₂ enriched atmosphere; there is more photosynthesis, and so more CO₂ is removed from the atmosphere (provided the plant material is not burned). **NEGATIVE FEEDBACK**



Some animals (such as this Copepod in the Antarctic ocean) are also more productive in a CO₂ enriched environment. Their carbon-based skeletons remove CO₂ from the system. **NEGATIVE FEEDBACK**

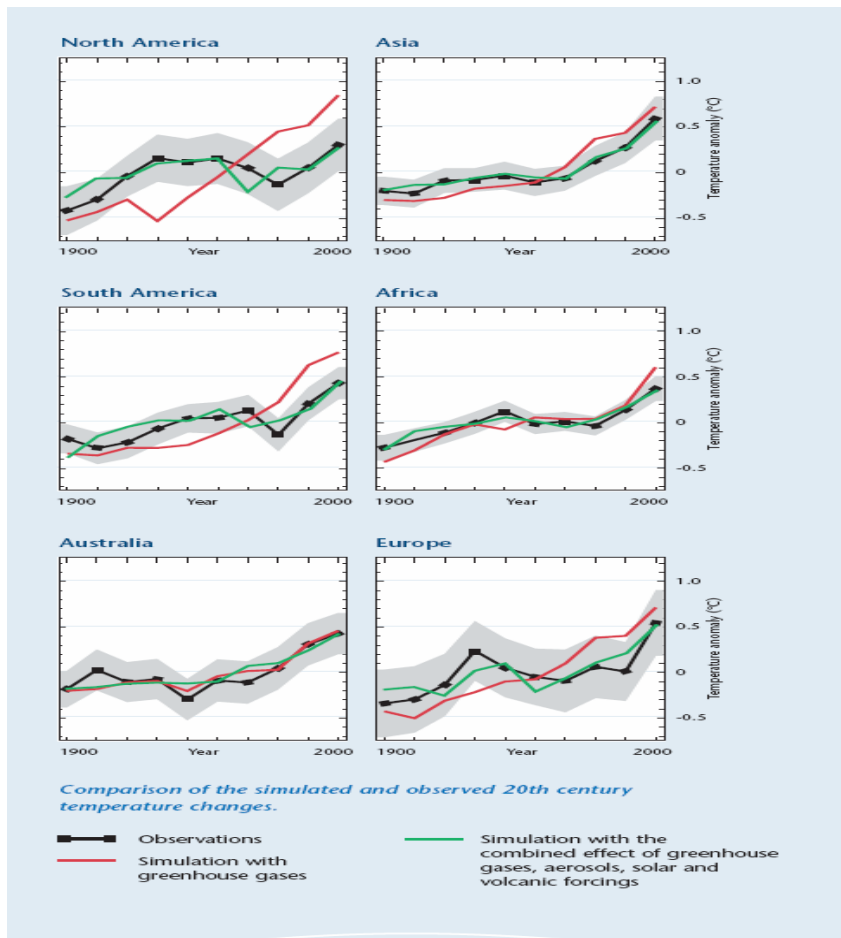


As the temperature rises, sea ice melts and the amount of solar radiation reflected back to space is reduced.

POSITIVE FEEDBACK



Comparing model results and measured temperatures



1. Explain how this data supports the idea that warming is due to increases in carbon dioxide concentration.
2. Explain why this data alone does not provide conclusive evidence.



Kinds of evidence

You have looked at three kinds of evidence:

1. Correlation – as one factor changes we can see that an outcome also changes.
2. Causative mechanism – there is an established scientific explanation for the effect of the factor on the outcome.
3. Prediction from theory - we are more confident about an explanation if it makes predictions which are then found to agree with observation.



Kinds of evidence

You have looked at four sets of evidence. What kinds of evidence are they?

A – Data from Antarctic Ice Cores

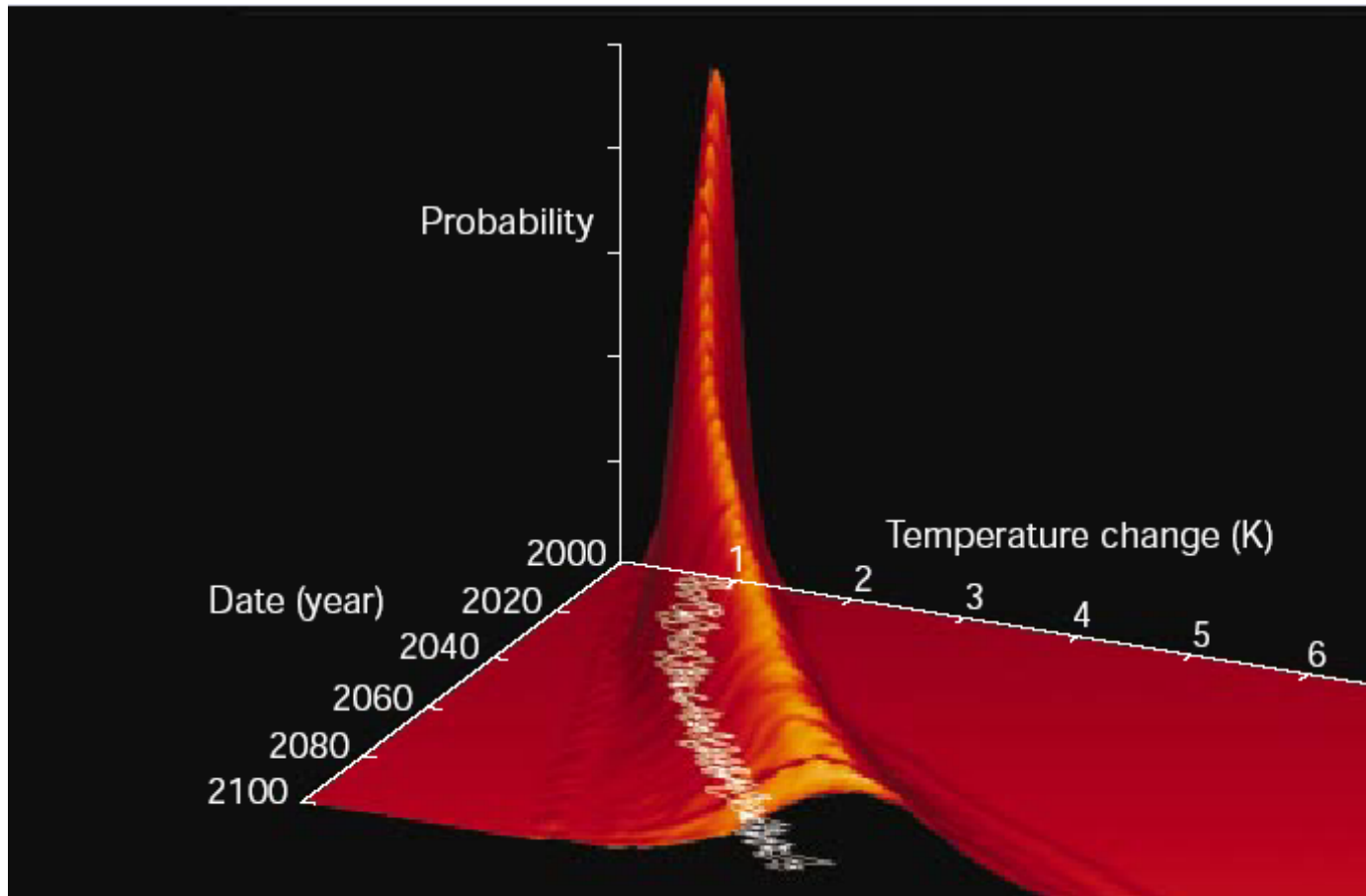
B – CO₂ and temperature data for last 150 years

C – Infrared absorption by atmospheric gases

D – Comparing the model with real temperatures



climateprediction.net and the future



Conclusion

The idea that changes in the concentration of carbon dioxide in the atmosphere are leading to changes in the global climate is widely accepted, but it is still disputed by some people.

Does the evidence convince you that the IPCC is right?

