



Climate Sensitivity

FACT SHEET

Key points

- Climate sensitivity is one of the key measures used in climate modelling. Climate sensitivity describes the amount of warming in the atmosphere associated with increases in atmospheric carbon dioxide (CO₂).
- The climate sensitivity is provided as a range of estimates due to underlying uncertainty in the behaviour of some aspects of the climate system as the planet warms.
- The *IPCC Fifth Assessment Report (AR5)* has slightly revised the climate sensitivity estimates from the IPCC Fourth Assessment Report in 2007. However the range of estimates has been broadly consistent across three IPCC reports over the past 12 years.
- The *AR5* expresses stronger confidence in some fundamental processes in models that determine climate sensitivity (such as the response of water vapour) than the Fourth Assessment Report.
- The latest projections for global warming scenarios for the end of this century are comparable to corresponding results from the Fourth Assessment Report in 2007.

What is climate sensitivity?

Increasing atmospheric carbon dioxide (CO₂) is also known as the enhanced greenhouse effect. Climate sensitivity is a useful standard measure, telling us how much the Earth's surface temperature would increase if pre-industrial CO₂ concentrations were doubled.

Two types of climate sensitivity are used: Equilibrium Climate Sensitivity (ECS) and Transient Climate Response (TCR).

TCR considers the changes that would occur if CO₂ levels increase by 1% (compounded) per year until they double. The TCR is then simply the global temperature increase that has occurred at the point in time that atmospheric CO₂ concentrations reach double pre-industrial levels.

If atmospheric CO₂ were held at double pre-industrial concentrations, the planet would still continue to warm. This is because the world's oceans take a long time to heat up in response to the enhanced greenhouse effect. The Equilibrium Climate Sensitivity (ECS) is the amount of warming achieved when the entire climate system reaches 'equilibrium' or the stable temperature response to a doubling of CO₂.

These are 'standard' measures of climate sensitivity, and have been used in climate change science for over 25 years. They are relevant to real world changes because, with continued high emissions, we are likely to exceed a doubling of CO₂, compared with pre-industrial times, later this century. They are simplified measures, and do not themselves provide projections of climate change. Such projections depend on the details of the timing and extent of future emissions, including changes in gases other than CO₂.

TCR and ECS are closely related measures of climate sensitivity, but TCR is always smaller than ECS, largely because the Earth's oceans have not had as long to respond to the doubling.

How do we estimate climate sensitivity?

Climate scientists use a range of approaches to estimate ECS and TCR, including using climate models that represent the relevant physics and chemistry and by analysing recent climate records and paleoclimate reconstructions.

What are findings in the AR5?

i) Equilibrium Climate Sensitivity (ECS)

The AR5 assesses ECS as likely to be 1.5°C to 4.5°C. ECS is extremely unlikely to be less than 1°C and very unlikely to be greater than 6°C.

This compares with the Fourth Assessment Report, which assessed ECS as likely to be 2 to 4.5°C.

Compared with the Fourth Assessment Report, the lower boundary of the ECS likely range has lowered from 2°C to 1.5°C, meaning slightly lower climate sensitivity is included in the 'likely' range than it was six years ago. The AR5 sensitivity range is the same as that of the Third Assessment Report (2001), highlighting the overall consistency of the assessment from the literature over more than a decade. The lower end revision follows some recent studies finding a lower temperature range from new estimates of temperature changes and ocean heat uptake.

ii) Transient Climate Response (TCR)

The AR5 assesses TCR as likely to be 1°C to 2.5°C and extremely unlikely to be greater than 3°C. In the Fourth Assessment Report, the assessed range of TCR was very unlikely to be less than 1.0°C and very unlikely to be greater than 3.0°C. The assessed ranges are therefore quoted differently, making direct comparison difficult, but compared with the previous report there has been a decrease in the assessed likelihood that the TCR is over 3.0°C from <10% to <5%.

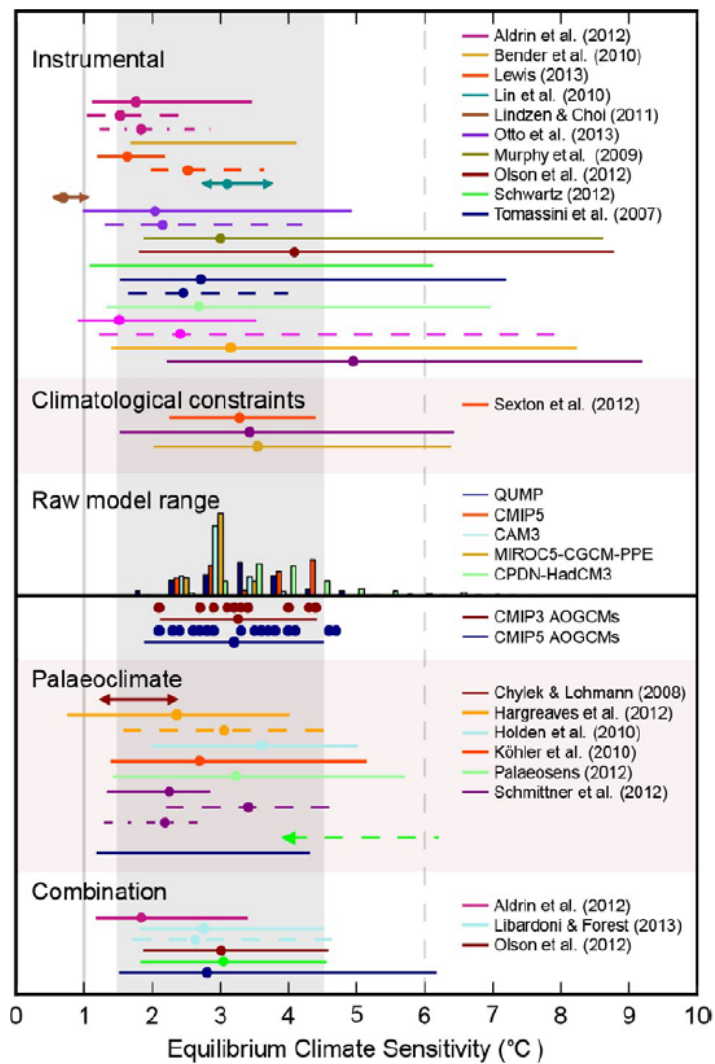
What do these new estimates mean for climate change and global warming?

The latest science confirms previous broad estimates for the range of likely climate sensitivity. New estimates of ECS have shifted the likely range of values to encompass a slightly cooler lower boundary than that reported in the Fourth Assessment Report (2007). The most recent estimates are closer to that reported in the Third Assessment Report (2001). The latest report also slightly reduces the likelihood of TCR exceeding 3°C.

The ECS estimated from climate models alone is 2.1°C to 4.7°C, very similar to the range in the Fourth Assessment Report. Further, the AR5 expresses stronger confidence in some fundamental processes in models responsible for determining climate sensitivity (such as the response of water vapour) although uncertainties remain high in others (such as the response of clouds to global warming). The latest projections of global warming scenarios for the end of this century are comparable to the corresponding findings for the Fourth Assessment Report in 2007.

For example, the AR5 projects warming at the end of this century of 3.2 - 5.4°C (relative to the 1850-1900 baseline) for a high emissions scenario (RCP8.5), comparable to the corresponding results from the Fourth Assessment Report.

These findings underscore the importance of continuing to conduct detailed climate observations, process studies and climate simulations to better define these ECS and TCR quantities.



Probability density functions, distributions and ranges for equilibrium climate sensitivity. The grey shaded range marks the likely 1.5°C–4.5°C range, grey solid line the extremely unlikely less than 1°C, the grey dashed line the very unlikely greater than 6°C

Source: IPCC 2013