AVOID 2
Can we avoid dangerous climate change?

What are the implications of temporarily overshooting a long-term temperature goal of 2°C?

AVOID 2 and the IPCC have assessed future scenarios where global average temperatures 'overshoot' 2°C of warming before returning below that level. In the models that generated these scenarios, reversing more than 0.1°C of overshoot by 2100 requires large-scale use of carbon dioxide removal (CDR) technologies such as Bioenergy with Carbon Capture and Storage (BECCS). BECCS has been proposed as the key tool to recover an overshoot whilst meeting global energy needs, but it is considered to be challenging to implement at a large scale. Reversing more than 0.3°C of overshoot with BECCS is likely to take centuries and require a large fraction of the planet's land surface area. Such a high level of overshoot may also have potentially irreversible consequences.

Average surface temperature and greenhouse gas concentrations can 'overshoot' as part of a planned path to the long-term targets (e.g. to accommodate inertia in existing national energy policies), or because international policies have failed to control them. The scale and duration of the overshoot will determine its effects.

How far beyond 2°C can temperature go before returning below 2°C by 2100?

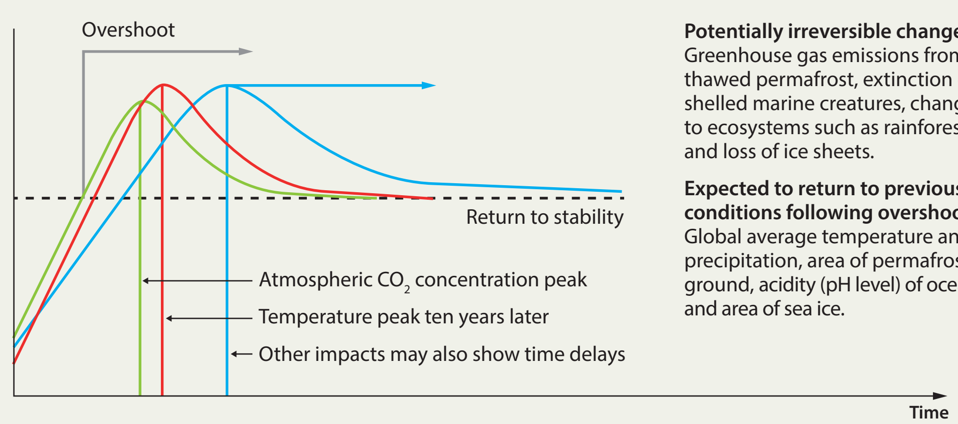
Models suggest that **the natural uptake of carbon dioxide (CO_2) by the carbon cycle could recover a small level of overshoot, approximately 0.1°C for 40-50 years**, returning below 2°C before 2100. CO_2 would need to be actively removed from the air to recover from a larger magnitude of overshoot, or to recover more rapidly. **Models used by the IPCC are able to limit warming to 2°C by 2100 after an overshoot of up to 0.3°C, although this requires carbon dioxide removal** (CDR) technology to be extensively deployed.

What are the climatic effects of overshoot?

Increases in global average temperature and precipitation are reversible, according to earth-system model studies where CO_2 concentration overshoots. However temperature does not begin to fall until about a decade after the peak in atmospheric CO_2 concentration, and other impacts, such as those involving forests, may not begin to reverse until several decades after the peak (Figure 1).

It is virtually certain that, as the climate warms over multiple centuries, large areas of permanently frozen ground (permafrost) will thaw. While the area of ground affected could eventually refreeze, any greenhouse gas emissions emitted from the permafrost are effectively irreversible. These will contribute to global warming.

Figure 1: A schematic description of overshoot. Atmospheric greenhouse gas concentrations peak first, followed by a temperature peak approximately ten years later. Other quantities may return to previous conditions following the overshoot, or may experience irreversible change.



Read more

AVOID 2 report A3: *Overshoot scenarios and their climate response.* Available on our website *www.avoid.uk.net*

Policy cards D1a/D1b: *How plausible is a rapid global increase in the deployment of Bioenergy with Carbon Capture and Storage (BECCS)?* and D2a: *How can Bioenergy with Carbon Capture and Storage (BECCS) contribute to meeting 2 degrees.* Available on our website *www.avoid.uk.net*

What are the key uncertainties?

Regional changes in temperature and precipitation are uncertain, although there is consensus on global-scale responses to small overshoots, which are based on well-established physics.

There has been little research into the temporary resilience of large-scale components of the climate system – such as polar ice sheets or the Amazon rainforest – during a temperature overshoot. However, it is known that changes to these components could result in irreversible residual damage.

A longer or larger overshoot also increases the risk of additional unfavourable feedbacks from the natural carbon cycle.

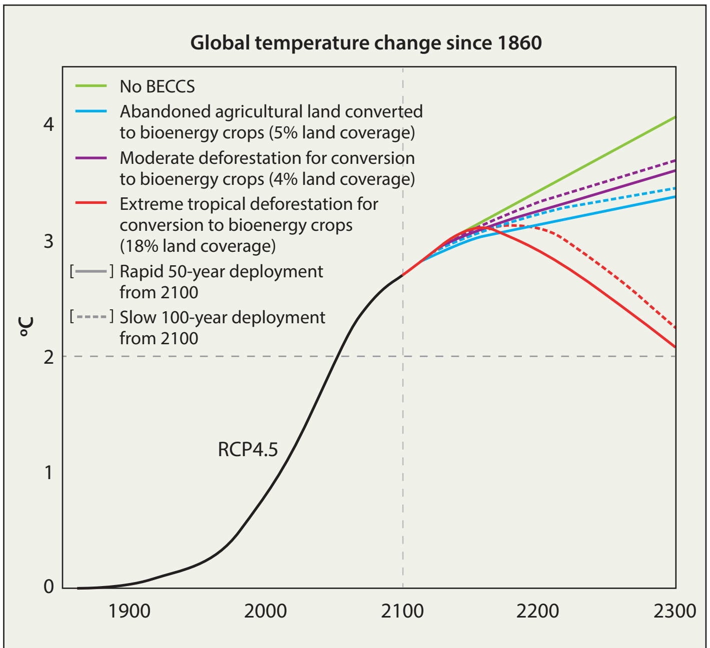


Figure 2: Global temperature change from a single climate model run, where BECCS is introduced in 2100 either rapidly or slowly, following a large 21st-century overshoot. Up to this point a "middle-of-the-road" (RCP4.5) trajectory is assumed, in which the proportion of total energy supplied by electricity increases, and CCS is applied to electricity generation and cement manufacture. This scenario has 15.4 $GtCO_2$/yr of net fossil emissions in 2100, which is held constant after 2100.

The key factor in determining what magnitude and duration of temperature overshoot can be recovered will be how successfully BECCS can be rolled out on a global scale.

What would it take to reverse a large 21st century overshoot with BECCS?

'Payback times' over which BECCS projects become 'carbon-negative' are typically estimated to be a few decades, with initial emissions coming from deforestation to make way for biofuels. However, it would take several decades to centuries of rapid, large-scale deployment for BECCS to reduce CO_2 levels in order to lower global temperatures and reverse an overshoot of more than 1°C. Figure 2 shows the extreme level of effort required to return to 2°C after following an RCP4.5 trajectory over the 21st century. In this modelled case (solid red line), 18% of all land is converted to bioenergy over a 50-year period from 2100. Even with this implausibly high effort, temperatures do not peak until after 2150 and do not return to 2100 levels until 2225. By 2300, warming relative to pre-industrial times is reduced almost to 2°C.

Assuming that there are no limits or barriers to CCS deployment, as in the AVOID 2 simulations, the level of emissions that can be reduced by BECCS will be most constrained by the amount of land allocated to bioenergy crops and the rate the crops are planted.

Reversing an overshoot much greater than 0.3°C with BECCS is likely to take hundreds of years and require the conversion of over one tenth of the planet's land surface area to bioenergy crops.

Read more

AVOID 2 report D2b: *Reversing climate change by large-scale deployment of carbon dioxide removal through Bioenergy with Carbon Capture and Storage (BECCS).* Available on our website *www.avoid.uk.net*