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Is it possible to return warming to below 1.5°C within this century?

Science background note on the World Bank report "Turn Down the Heat: Confronting the New Climate Normal"

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Is it possible to return warming to below 1.5˚C within this century?

The world community has agreed a global warming limit of holding warming below 2°C above preindustrial levels. Small island states and the least developed countries have called for warming to be brought back to below 1.5° by 2100. The 1.5°C warming limit is now under review for consideration next year by the UNFCCCC.

Due to past emissions, and taking into account the most aggressive mitigation strategies, peak mean global warming in the 21st Century can limited close to 1.5°C, with warming dropping to below 1.5° by 2100. This means that the world is unlikely to be able to avoid impacts projected close to 1.5°C, including major damage to coral reef systems and the emergence of regular occurrences of unusual heat extremes of a over substantial land area. This is reflected in the World Bank's "Turn Down the Heat: Confronting the New Climate Normal" (TDTH) report and also in the press release launching it[1]:

> *Climate change impacts such as extreme heat events may now be unavoidable because the Earth's atmospheric system is locked into warming close to 1.5°C above pre-industrial levels by mid-century, the report said. Even very ambitious mitigation action taken today will not change this, it said. (http://www.worldbank.org)*

This does not mean, however, that long-term warming of 1.5°C is locked in, or that achievement of the 1.5°C warming limit, as called for by the vulnerable countries, is no longer possible. As is shown in the TDTH report, this message is a call for strong early action and a further warning that time is running out.

Limiting warming below 1.5°C by 2100 is still feasible. Climate projections based on energy-economic emissions scenarios show that, in the best case, warming will peak close to 1.5°C by mid-century before slowly declining to below this level. With continuing negative emissions post 2100, warming levels would decline further.

Limiting peak warming close to 1.5°C by mid century will still result in significant damage. At present levels of warming (about 0.8°C above preindustrial) the impacts of climate change are already being felt in many regions of the world. Climate change has left its negative imprint on crop yields, caused marine species to migrate to cooler waters; it has increased heat waves and drought, and placed pressure on water resources and damaged coral reefs.

[1] http://www.worldbank.org/en/news/feature/2014/11/23/climate-report-finds-temperature-rise-locked-in-risks-rising

Even with the most aggressive mitigation action limiting peak warming close to 1.5°C, there will be substantial damages in the form of extreme heat events, damages to water resources, and risks to regional food security. Both the IPCC and the TDTH report show that risks to unique and threatened systems, such as coral reefs, are high at 1.5°C and sea-level rise would continue long after 2100.

The example given in the World Bank's press release illustrates the scale of the risk of warming even at 1.5°C for unusual heat extremes: for the three regions covered in this TDTH report and from 2013, unusual heat extremes, which are currently largely absent, increase to cover 10 to 60% of land area by the time global warming reaches around 1.5°C.

Highly unusual heat extremes	Observed Vulnerability or Change	Around 1.5°C	Around 2°C	Around 4°C
Middle East and Africa	Virtually absent	25% of land	30% of land	>90% of land
Latin America and Caribbean	Virtually absent	30% of land	30-40% of land	90% of land
Europe (Western Balkans) and Central Asia	Virtually absent	10% of land	15% of land	85% of land
Sub-Saharan Africa	Virtually absent	20-25% of land	45% of land	>85% of land
South-East Asia	Virtually absent	50-60% of land	60-70% of land	>90% of land
South Asia	Virtually absent	15% of land	20% of land	>70% of land

As we showed in the second TDTH report in 2013, unprecedented heat extremes also become very significant in some regions around 1.5°C warming. "Unprecedented extremes" are those that have never occurred, and which would occur, statistically, only every few million years in an unchanged climate, if ever (see table on next page)

Unprecedented heat extremes	Observed Vulnerability or Change	Around 1.5°C	Around 2°C	Around 4°C
Middle East and Africa	Absent	<5% of land	5-10% of land	>65% of land
Latin America and Caribbean	Absent	5% of land	15% of land	70% of land
Europe (Western Balkans) and Central Asia	Absent	Absent	Virtually absent	55% of land
Sub-Saharan Africa	Absent	<5% of land	15% of land	>55% of land
South-East Asia	Absent	25-30% of land	30-40% of land	>80% of land
South Asia	Absent	Virtually absent	<5% of land	>40% of land

Feasibility of holding warming below 2°C and warming below 1.5°C by 2100

IPCC AR5 WGIII identified many mitigation options to hold warming below 2°C (with a likely chance), and with central estimates of 1.5-1.7°C by 2100. The IPCC further shows that "a limited number of studies have explored scenarios that are more likely than not to bring temperature change back to below 1.5°C by 2100".

The scenarios indicating the feasibility of bringing temperatures down below 1.5°C are "characterised by (1) immediate mitigation action; (2) the rapid upscaling of the full portfolio of mitigation technologies; and (3) development along a low-energy demand trajectory." (IPCC WGIII SPM page 17)

According to the IPCC, the costs of reducing emissions to limit warming to below 2°C are modest, even before taking into account co-benefits such as energy-security benefits and health improvement due to reduced air pollution. Annualised reductions of consumption growth are estimated at around 0.06 percent over the century, relative to a baseline of 1.6 to 3% growth per year.

The feasibility of limiting warming to 1.5°C and returning it to below 1.5°C by 2100 is supported by the wider scientific literature (e.g. Luderer et al. 2013; Rogelj et al. 2013b; Rogelj et al. 2013a), and the IPCC.

Similarly, the recently published UNEP Emissions gap report (UNEP 2014) assessed the literature on 1.5°C scenarios. **It confirms that limiting warming to below 1.5°C by 2100 is feasible, but strong early mitigation is needed and opportunities are being lost with every decade that emissions rise:**

"… only a small number of scenarios meet the 1.5°C target with at least a 50 per cent chance, and

have least-cost pathways beginning in 2010 … An even smaller number of scenarios meet the 1.5°C target with at least a 50 per cent chance and have least-cost emissions pathways beginning in 2020 – and therefore, have higher emissions up to 2020.

"… when action is delayed, various options to achieve stringent levels of climate protection are increasingly lost (Luderer et al., 2013b; Rogelj et al., 2013a; Rogelj et al., 2013b). One sign of this is that a declining number of models are able to identify feasible emission pathways that stay within a 1.5 °C or 2 °C limit with increasing delays (IPCC, 2014)."

In terms of the pathways for keeping warming below 1.5°C by 2100, a meta-analysis of the IPCC scenarios shows that in order to keep warming below 2°C with *high probability* and to bring temperatures back to 1.5°C by the end of the century, CO_2 emissions would need to be zero as early as 2045 and no later than 2065, with negative emissions thereafter. Total GHG emissions would reach zero as early as 2060 and no later than 2080, with negative emissions thereafter.

Even with a cessation of all emissions, delays in the climate system and abrupt changes in atmospheric, radiative forcing would let warming continue to rise to a best-guess level of 1.2°C above pre-industrial, before embarking on a gradual decline (e.g. Schaeffer et al. 2012).

In the very long term, a warming limit of 1.5°C requires total greenhouse-gas concentrations - plus the effects of aerosols - to be below a level of 400ppm CO_2eq. As a sudden cessation of all emissions is unlikely, any mitigation pathway aiming at 1.5°C and below necessarily involves a peak-and-drop concentration profile.

At present we can be confident of holding warming below 2°C with aggressive mitigation action. Another decade's delay and we will likely be talking about lock-in to impacts at 2°C or above.

Thus, it is clear that while the challenges are high, keeping warming below 1.5°C by the end of the century is still feasible. However, with every decade lost, these challenges rise and will, at some point, become insurmountable with warming locked in to 2°C and above. The time to act is now.

References

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