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How Many Degrees to Net Zero?

An evaluation of Intended Nationally Determined Contributions to emission reductions against predicted rates of warming

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The IPCC 5th Assessment Report acknowledges that net emissions of long-lived greenhouse gases need to be reduced to zero to stabilize global temperatures.[1] Comparing observed and planned emission reductions directly against rising temperatures thus provides a direct measure of progress and ambition of mitigation measures. For example, if global temperatures are to be stabilized at 2 °C, emissions need to be reduced, on average, by 10% of their projected baseline value for every tenth of a degree of warming above 1 °C. Here we assess Intended Nationally Determined Contributions (INDCs) to emission reductions[2] against projected human-induced warming to 2030 to find at what temperature countries' emissions are projected to reach zero if proposed rates of reduction per degree of future warming were to continue.

Figure 1 shows observed temperatures from 1860-2015 (black diamonds, provisional 2015 value shown open), with warming attributable to human, natural and combined drivers of climate change shown in red, blue and pink respectively.[3] Light grey lines show the IPCC prediction "global mean surface temperature change for the period 2016–2035 relative to 1986–2005 will *likely* be in the range 0.3 °C to 0.7 °C." The middle of this range (dark grey line) is remarkably consistent with attributable warming to date and gives a value for human-induced warming in 2030 of 1.17 °C (grey square), an increase from 0.87 °C in 2012, or 0.93 °C in 2015.

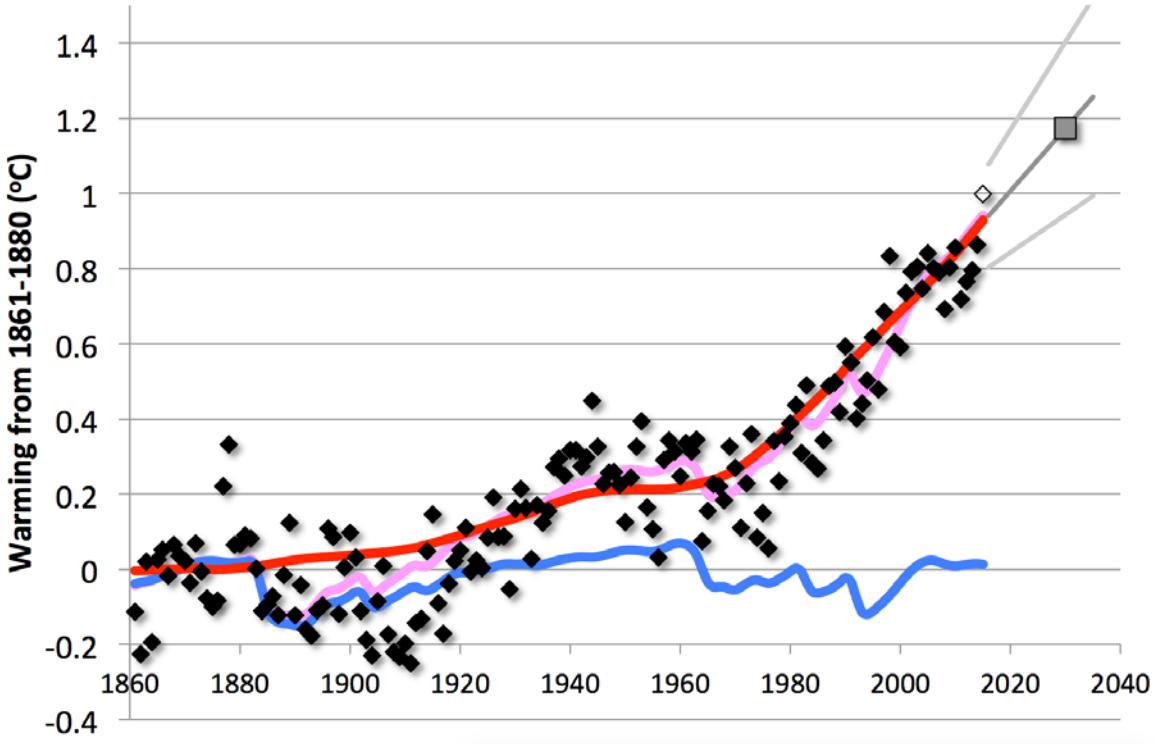

Figure 1: Observed global average warming from mid-19th century conditions (diamonds) and contributions attributable to natural (blue), anthropogenic (red) and combined (pink) external climate drivers. Dark grey line and square show projected mid-range warming for the period 2016-2035 relative to average observed temperatures over the period 1986-2005, while light grey lines show the *likely* range.

Figure 2 shows emissions expressed as a percentage of an unmitigated baseline plotted against a mid-range estimate of projected warming in a range of scenarios[4] that are either likely or as likely as not to meet the goal of stabilising temperatures below 2 °C, excluding those that display a substantial temperature overshoot. Despite the broad range of behavior of the individual scenarios, emissions fall from 100% of baseline in an approximately straight line with rising temperatures until they are close to zero. Hence plotting the trajectory of percentage abatement against rising temperatures provides an indicator of the temperature at which emissions are expected to reach zero.

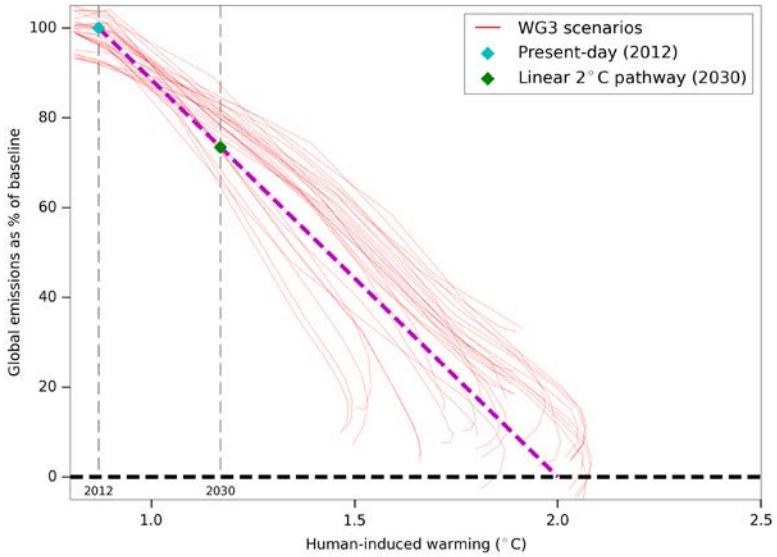

Figure 2: Emissions in the IPCC Working Group 3 scenarios that either likely or as likely as not achieve the goal of stabilizing temperatures below 2 °C, expressed as a percentage of the corresponding baseline scenarios, plotted against projected human-induced warming under these scenarios relative to pre-industrial conditions using a mid-range estimate of the climate system response. Purple dashed line shows a straight-line increase in the rate of abatement with future warming that meets net zero emissions (100% abatement) when temperatures reach 2 °C.

This observation can be used to evaluate the ambition of INDCs. Expected warming between 2012 and 2030 is 0.3 °C, or 27% of the remaining warming from 2012 until temperatures reach 2 °C. A country beginning emission reductions in 2012 would, therefore, need to reduce them by 27% below baseline by 2030 to achieve a rate of increase in abatement per degree of warming that is required to be on track to achieve net zero emissions by the time human-induced warming reaches 2 °C.

Figure 3 shows countries' unconditional INDCs for 2030 emissions evaluated against projected warming using this metric. The figure excludes land-use change and forestry since, in the long term, both land-use and non-land-use emissions will need to be reduced to zero. In all cases, countries reductions relative to their chosen baseline (which might be a past year's emissions, or a business-as-usual projection) are shown as the diamond at 1.17 °C, the IPCC's projected mid-range warming in 2030. Non-Annex-1 countries are assumed to begin their emission reduction efforts at 100% of baseline in 2012 (the most recent date on which emissions data are available), while Annex 1 countries begin with actual 2012 emissions as a percentage of their chosen baseline. In each case, the arrows show the implications of a simple straight-line extrapolation of proposed emission reduction rates per degree of future warming. While some countries are already on target to achieve net zero emissions by the time global temperatures reach 2 °C, others are evidently planning to increase the ambition of mitigation after 2030. Evaluating current and future INDCs against attributable warming provides an objective and transparent metric of their success in doing so.

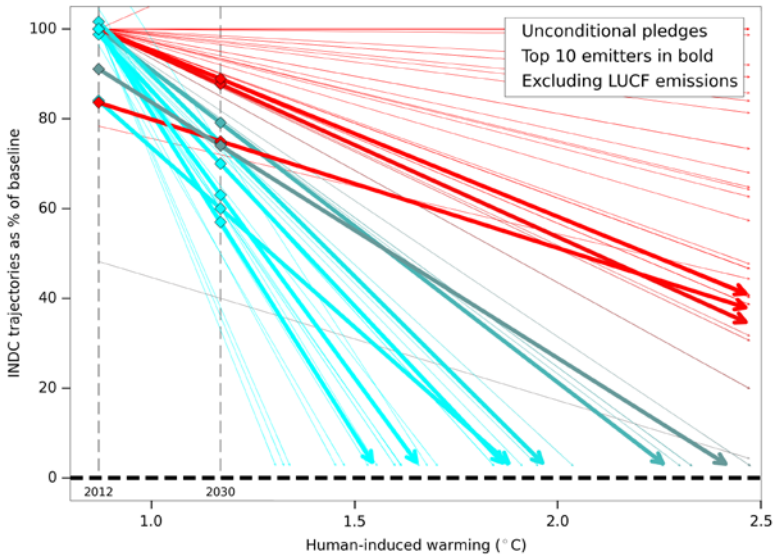

Figure 3: Implications of individual countries current INDC trajectories. Rate of decline of emissions relative to baseline versus projected human-induced warming assuming the IPCC mid-range projection of 0.3 °C warming between 2012 and 2030. Lines are coloured by the level of human-induced warming at which that country's emissions would reach net zero. Top 10 emitters shown in bold.

[1] Stocker, T., et al *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA (2013).
[2] http://www4.unfccc.int/submissions/INDC
[3] Otto, F.E.L., *et al* Embracing uncertainty in climate change policy, *Nature Clim. Change*, **5**, 917-920, (2015)
[4] Clarke, L., *et al.* Assessing Transformation Pathways. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, O. Edenhofer *et al.*, Eds. (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014)

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