News & views

Climate science

Commitments could limit warming to below 2 °C

Zeke Hausfather & Frances C. Moore

Analysis of climate pledges by nations at the COP26 meeting indicates that such commitments could ensure that global warming does not exceed 2 °C before 2100 – but only if backed up by short-term policies. **See p.304**

The impacts of climate change on human civilization and the natural world will depend on exactly how hot the planet gets over the remainder of the century. The answer to this question hinges on two related uncertainties: how does the physical climate system respond to greenhouse gases? And what volume of greenhouse gases will humans put into the atmosphere? On page 304, Meinshausen *et al.*[1] report that pledges made by countries to limit emissions over the long term could keep warming to less than 2 °C above pre-industrial temperatures. But optimism should be curbed until promises to reduce emissions in the future are backed up with stronger short-term action.

A decade ago, the world seemed to be on track for a particularly grim climate future: many researchers argued that 'business as usual' was likely to lead to temperatures in 2100 being 4 °C or 5 °C above pre-industrial levels[2]. Today, the world is a different place. Growth in carbon dioxide emissions has slowed notably over the past decade[3], and emissions are projected to plateau in coming years under current policies and commitments[4].

High-emissions scenarios assume that energy production in the twenty-first century will be dominated by coal, but global coal usage has not increased since 2013 – and the International Energy Agency argues that it is likely to decline over the remainder of the century[4]. Clean energy has become cheap, with solar-power and battery-storage costs falling to less than one-eighth of their 2010 value[5].

These trends in energy markets and technologies have coincided with increasing ambition in both implemented and stated climate policies. As part of the 2015 Paris climate agreement, countries began submitting their intended climate policies, which are known as nationally determined contributions (NDCs). Although the first round of NDCs was far from sufficient to meet the Paris agreement target of limiting global temperatures to well below 2 °C (ref. 6), the intent of the agreement was always to ratchet up ambition with successive rounds of NDC pledges every five years.

Meinshausen *et al.* show that this intent has at least partially been realized: the ambition of emissions goals has increased steadily over time. The past two years have seen a proliferation of longer-term promises by countries to reach net-zero CO_2 or greenhouse-gas emissions (in which the amount emitted by human activity matches that removed from the atmosphere by human activity) by 2050, 2060 or 2070. Promises from 76 countries now cover at least 75% of global greenhouse-gas emissions[1].

The authors considered both near-term and long-term commitments that were made in the second round of NDCs last year in advance of COP26, the United Nations climate conference in Glasgow, UK, in 2021. Their analysis predicts that, if fully implemented, these commitments offer a good chance of limiting warming to less than 2 °C above pre-industrial values. Combined with estimates from the past three years[6–16] (surveyed by us in Fig. 1), they give us a much clearer picture of what is likely to be our climate future.

Although the ambition of the long-term, net-zero pledges made in the past few years is certainly good news, doubt remains over whether governments are on track to realize those commitments. It is easy to set ambitious climate targets for 30, 40 or even 50 years in the future – but it is much harder to enact policies today that shift energy systems towards a more sustainable future. Long-term targets should be treated with scepticism if they are not supported by short-term commitments to put countries on a pathway

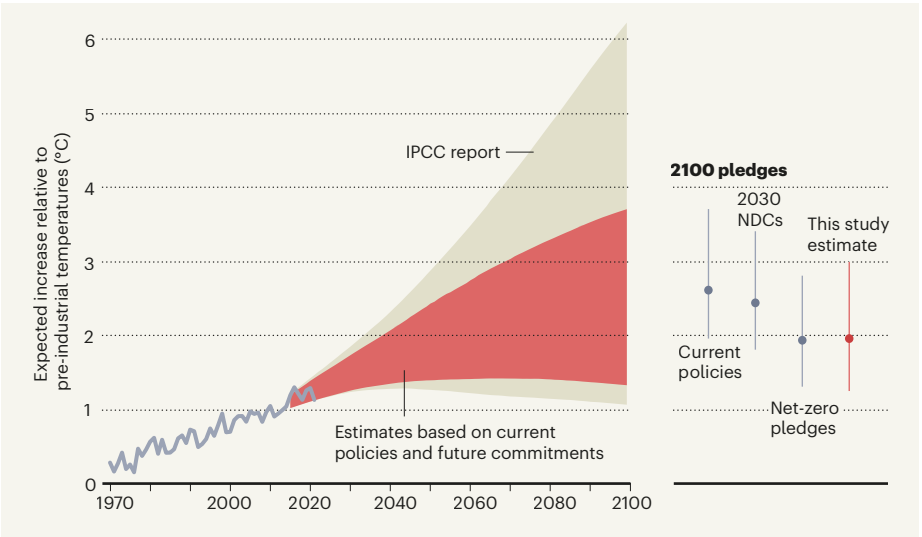

Figure 1 | A comparison of warming estimates up to 2100. This survey of estimates of the global temperature increase expected by 2100 relative to pre-industrial values provides a more constrained view of predictions than does the full range of warming outcomes presented in the *Sixth Assessment Report* by the Intergovernmental Panel on Climate Change[19], which was compiled last year. The survey, produced by us, includes estimates based on current policies[6–14], nations' intended climate policies, known as nationally determined contributions (NDCs), for 2030 (refs 6,8,9,11–13), and pledges for net-zero emissions[1,6,10–12,15]. Meinshausen and colleagues' analysis[1] suggests that warming will be at the low end of the range presented in the report, but only if net-zero pledges are fulfilled.

to meet those targets in the next decade.

A comparison of existing estimates of 2100 warming outcomes provides good reason to be cautious about countries' long-term climate pledges. Our median estimates of 2100 warming under current policies (around 2.6 °C, with a range of 2 °C to 3.7 °C)[6–14] and short-term NDC commitments for 2030 (around 2.4 °C, with a range of 1.8 °C to 3.4 °C)[6,8,9,11–13] are still far above the 2 °C target. Climate-system uncertainties make it difficult to fully rule out warming of 4 °C or more this century if emissions are not reduced[6].

It is crucial to recognize that current policies and commitments are not necessarily the upper limit on future emissions. There are reasons to expect climate-policy ambitions to increase over time[16]. But as current events show, it would be a mistake to rule out a future characterized by resurgent nationalism that strains global cooperation and leads to increasing reliance on domestic fossil-fuel resources and a corresponding rise in emissions[17].

Moreover, there is no guarantee that countries will meet their 2030 NDC commitments. An estimate published last year suggested that the G20 group of the 20 largest economies are currently projected to fall short of achieving their original NDCs by 1.1 billion tonnes of CO_2 per year in 2030 (ref. 6). And although a world warmed to 2.4 °C or even 2.6 °C above pre-industrial values in 2100 is vastly preferable to one warmed by 4 °C or 5 °C degrees, it might still result in catastrophic impacts for some human and natural systems[18].

Unfortunately, it is also increasingly clear that the Paris agreement target of 1.5 °C is slipping out of reach[6]. Global temperatures have already increased by around 1.2 °C since the late 1800s[19], and as Meinhausen *et al.*[1] point out, meeting current net-zero pledges would result in only a 6–10% chance of staying below 1.5 °C this century.

Taken together, the array of studies using different modelling approaches can limit the probable range of warming trajectories over the remainder of the twenty-first century, providing a clearer view of our climate future. This is helpful for shaping practical responses to climate impacts. Although substantial uncertainties remain, improved understanding of more- and less-probable climate futures helps policymakers and groups planning adaptation strategies to prepare for the coming changes. It can also allow us to determine how much net-zero pledges need to be strengthened in the future to compensate for an increasingly probable overshoot of the 1.5 °C target this century.

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Tumour biology

Cell position matters for tumour-driving mutations

Jean-Christophe Marine & María S. Soengas

Skin cells called melanocytes are not equally affected by the same genetic changes. Their ability to form tumours has now been linked to gene-expression programs that are selectively activated according to a cell's anatomical position. **See p.354**

The identification of the cell-of-origin that gives rise to a tumour is being pursued as a strategy to improve early cancer diagnosis and to develop preventive therapies. Characteristic features of initiating cells have a major role in determining whether a cell becomes malignant, but other factors contribute. For example, the characteristics of skin cancers (melanomas) that arise in hair-bearing skin tissue (cutaneous melanomas) are distinct from those of acral melanomas, which arise in the nails, soles of the feet and the palms. On page 354, Weiss *et al.*[1] identify a transcriptional program found at acral sites that primes pigment-producing cells called melanocytes to form tumours if they undergo specific genomic alterations. These data point to cells' positional identities — described by the authors as the transcriptional program unique to particular anatomical sites — as being a key determinant of the ability of melanocytes to give rise to different subtypes of melanoma.

Melanomas are perhaps one of the most puzzling examples of how apparently similar tumour-initiating cells can, depending on their anatomical location, give rise to different tumour subtypes[2]. Melanocytes can potentially form tumours at any site at which they reside, including cutaneous or acral sites, in the pigmented tissues of the eye and on the internal surfaces (mucosal sites) lining the respiratory, gastrointestinal and genitourinary tracts.

However, the patterns of genetic alterations associated with these melanomas are not the same. Cutaneous melanomas have a high number of single-nucleotide (point) mutations (exemplified by alterations in genes such as *BRAF*), but melanomas at mucosal and acral sites are instead dominated by large genomic rearrangements, such as amplifications and deletions[3,4]. Most eye melanomas have a low number of mutations and harbour specific mutations[5] in genes such as *GNAQ*. Finding specific genomic characteristics of a type of tumour provides biomarkers for early cancer identification and aids the design of anticancer treatments. In particular, therapeutic targeting of $BRAF^{V600}$ mutations has revolutionized the treatment of cutaneous melanomas[6].

By contrast, the prognosis for people with other sorts of melanoma has not improved substantially over the past two decades. This is a notable problem for acral melanoma, which mainly affects individuals of Hispanic, African