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Is 1.5 °C of global warming inevitable and if so, when?

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The likelihood of exceeding 1.5 °C of global warming relative to preindustrial depends on the warming observed so far, anthropogenic warming that may occur in the future, and the degree to which internal variability will either temporarily amplify or attenuate future anthropogenic warming. Here, we introduce a new framework that estimates the likelihood of exceeding 1.5 °C of global warming wherein uncertainties in each one of these factors is explicitly accounted for.

In this new framework, we estimate the historical warming, and its uncertainty, from preindustrial to present using the recently-minted HadCRUT5 dataset. Future anthropogenic warming is estimated using an energy balance model tuned to an assessed range of climate sensitivity and applied to each of the core emissions scenarios (i.e. SSPs) underlying the Sixth Phase of the Coupled Model Intercomparison Project (CMIP6). Finally, we estimate the influence of internal variability using a large ensemble of initial condition simulations. On this basis, we find that the largest uncertainty in estimates of the likelihood of exceeding 1.5°C of global warming is due to model-to-model differences in estimates of future anthropogenic warming, followed by historical warming uncertainty, and then uncertainty due to internal variability.

Based on our analysis, we find that the earliest time for crossing 1.5 °C of global warming, here defined as the 5% likelihood, is approximately emissions-scenario independent. We define the 1.5 °C threshold without any overshoot: if a time series warms by more than 1.5 °C during any 20-year period before 2100, it is counted as having crossed 1.5 °C. In each considered scenario except SSP5-8.5, the 20-year average period that crosses the 1.5 °C threshold with a 5% likelihood is 2013 to 2032. On the other hand, the 50% likelihood does depend on the scenario, with the SSP5-8.5 crossing occurring in 2018 to 2037 and SSP1-1.9 crossing in 2022 to 2041. All scenarios except SSP1-1.9 have a likelihood close to 100% to cross 1.5 °C global warming before 2100. Even in

SSP1-1.9, the scenario with the strongest emission reductions, there is a 71% likelihood to cross 1.5 °C by the end of this century. This implies that even in SSP1-1.9, the world may stay below 1.5 °C only if both climate sensitivity and historical warming are near the lower end of their respective distributions.

These estimates, with their associated uncertainties, may have major implications for policy decisions.