



Detecting climate milestones on the path to climate stabilization

Andrew H. MacDougall¹, Joeri Rogelj², Chris D. Jones³, Spencer K. Liddicoat³, and Giacomo Grassi⁴

¹St. Francis Xavier University, Earth Science, Antigonish, Canada (amacdoug@stfx.ca)

²Grantham Institute for Climate Change and the Environment, Imperial College London, London, UK

³Met Office Hadley Centre, Exeter, United Kingdom

⁴Joint Research Centre, European Commission, 21027 Ispra (VA), Italy

The era of anthropogenic climate change can be described by defined climate milestones. These milestones mark changes in the historic trajectory of change, and include peak greenhouse gas emissions, peak CO₂ concentration, deceleration of warming, net-zero emissions, and a transition to global cooling. However, given internal variability in the Earth system and measurement uncertainty, definitively saying that a milestone has passed requires rigour, with the statistical illusion of the 2010s *global warming hiatus* being a recent cautionary tale of the need for robust methods.

Here we use CMIP6 simulations of peak-and-decline scenarios to examine the time needed to robustly detect three climate milestones: 1) the slowdown of global warming; 2) the end of global surface temperature increase; and 3) peak concentration of CO₂. To detect these climate milestones we use a modified version of the Monte-Carlo based method of Rahmstorf et al. 2017, developed to test whether the *global warming hiatus* was an illusion. The method has been modified to account for auto-correlated noise characteristic of the climate system.

We estimate that it will take 40 to 60 years after a simulated slowdown in warming rate, to robustly detect the signal in the global average temperature record. Detecting when warming has stopped will also be difficult and for the one peak-and-decline scenario that has model simulations extended to the year 2300, it takes until the mid 22nd century to have enough data to conclude that warming has stopped. Detecting that CO₂ concentration has peaked is far easier, and a drop in CO₂ concentration of 3 ppm is consistent with a greater than 99% chance that CO₂ has peaked in all scenarios examined. Overall it is sobering that even under aggressive mitigation scenarios a conclusive end to global warming is at the very outer edge of the living future, with only a small number of the very youngest children alive today likely to witness detection of the end of global warming.