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Detection and communication of climate changes under net zero emissions

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Under rapid global warming, changes in the climate system are increasingly evident and detectable, even for extremes and at the local scale. This, in part, has motivated countries to target achieving net zero emissions in the coming decades and to limit further global warming in line with the Paris Agreement. Climate changes under net zero emissions are projected to be substantial but may be harder to detect. It is critical that changes under net zero are well understood, both in terms of the effects of delay in emissions cessation and how these changes differ across timescales.

Here, we use a set of net zero 1000-year-long ACCESS-ESM-1.5 simulations to study the detectability of climate changes given a range of emission cessation years. We demonstrate that some local climate changes and changes in climate variability and extremes under net zero emissions may be significant enough to be detectable over human lifetimes. Some large-scale changes, especially in the cryosphere and oceans, and in the Southern Hemisphere, would be detectable within years or decades of emissions cessation. The benefits of earlier emissions cessation are also detectable even at the local scale.

This kind of analysis is not currently possible in a multi-model framework. A lack of planned coordinated net zero experiments on timescales beyond 300 years has the potential to undermine policymaking related to long-term climate changes. Using findings from the ACCESS-ESM-1.5 experiments, we demonstrate the problems that a lack of long net zero emissions simulations poses and call for coordinated 1000-year-long simulations.

We also argue that communication of ongoing climate changes under net zero emissions needs to go beyond projected global-average temperature changes (i.e. the Zero Emissions Commitment or

ZEC) and emphasise other Earth System changes and local climate changes.