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Is the 'signal-to-noise paradox' in winter mid-latitude prediction a result of shortcomings in prediction systems' simulation of the tropics?

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Subseasonal-to-seasonal prediction of winter weather in Europe has seen advances in recent years due to improvements in the ability of ensemble prediction systems to capture signals of the controlling regional atmospheric circulation patterns. Nevertheless, these predictions are still hampered by the 'signal-to-noise paradox', the fact that while ensemble mean signals are relatively well correlated with observed outcomes, the size of these signals is far less than expected given the level of agreement. This makes the predictions less easy to use, requiring additional post-processing to provide best guidance. The issue points to potential shortcomings in the formulation of prediction systems, and likely the representation of climate dynamical processes in their component models. The identity of the source of the paradox, however, has hitherto remained cryptic. One possible diagnostic approach is to perform reforecasts of past cases in which parts of the atmospheric simulation are constrained to be similar to the analysed state of the atmosphere at the time. This allows us to identify whether a 'perfect' representation of a specific atmospheric region improves the signal-to-noise of the North Atlantic atmospheric circulation, and thereby whether the paradox partly results from imperfect simulation of that region. Here we report results from tests using suites of ensemble simulations with the Met Office long-range prediction system in which the tropical atmosphere is constrained by relaxation towards analysed winds and temperatures. The tropics make a worthwhile test since teleconnections with middle and high latitudes have been shown to be an important driver of North Atlantic-European winter circulation anomalies. Any failing in the tropical simulation could therefore be a potential reason for the low signal-to-noise we obtain. The tropical influence can act via either a tropospheric route, involving Rossby wave propagation within the troposphere, or a stratospheric route, via the Quasi-Biennial Oscillation (QBO)'s effect on the stratospheric polar vortex and its subsequent downward influence. In order to separate these potentially distinct sources of the signal-to-noise paradox, we additionally present results from suites of experiments with troposphere and stratospheric relaxation applied individually.