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Attribution of forced decadal climate change in coupled and uncoupled ocean-atmosphere model experiments

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There is still no consensus about the best methodology for attributing observed changes in climate or specific climate events. One widely-used approach relies on experiments in which the time periods of interest are simulated using an atmospheric general circulation model (AGCM) forced by prescribed sea surface temperatures (SSTs), with and without estimated anthropogenic influences. A potential limitation of such experiments is the lack of explicit atmosphere–ocean coupling; therefore a key question is whether the attribution statements derived from such studies are in fact robust. In this research we have carried out climate model experiments to test attribution conclusions in a situation where the answer is known – a so-called "perfect model" approach. The study involves comparing attribution conclusions for decadal changes derived from experiments with a coupled climate model (specifically an AGCM coupled to an ocean mixed-layer model) with conclusions derived from parallel experiments with the same AGCM forced by SSTs derived from the coupled model simulations. Results indicate that attribution conclusions for surface air temperature changes derived from AGCM experiments are generally robust and not sensitive to air-sea coupling. However, changes in seasonal mean precipitation, extreme precipitation and circulation in some regions show large sensitivity to air-sea coupling, notably in the summer monsoons over East Asia and Australia. Comparison with observed changes indicates that the coupled simulations generally agree better with observations. These results demonstrate that the AGCM–based attribution method has limitations and may lead to erroneous attribution conclusions in some regions for local circulation and mean and extreme precipitation. The coupled mixed–layer model used in this study offers an alternative and, in some respects, superior tool for attribution studies.