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Exploiting large ensembles for a better yet simpler climate model evaluation

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We use a methodological framework exploiting the power of large ensembles to evaluate how well ten coupled climate models represent the internal variability and response to external forcings in observed historical surface temperatures. This evaluation framework allows us to directly attribute discrepancies between models and observations to biases in the simulated internal variability or forced response, without relying on assumptions to separate these signals in observations. The largest discrepancies result from the overestimated forced warming in some models during recent decades. In contrast, models do not systematically over- or underestimate internal variability in global mean temperature. On regional scales, all models misrepresent surface temperature variability over the Southern Ocean, while overestimating variability over land-surface areas, such as the Amazon and South Asia, and high-latitude oceans. Our evaluation shows that MPI-GE, followed by GFDL-ESM2M and CESM-LE offer the best global and regional representation of both the internal variability and forced response in observed historical temperatures.