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Disentangling the forced and unforced components of observed surface air temperature trends

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Global mean surface air temperature stands is a critical indicator for gauging climate change, both on contemporary and over centennial scales. Previous studies on surface air temperature (SAT) variations tend to emphasize the uncertainties in model-simulated global warming projections, instead of differentiating the observed SAT trend patterns. Our study aims to partition observed SAT trends into forced and unforced components on decadal to multidecadal scales. Utilizing historical simulations from the ensemble mean of six large ensemble models from the Coupled Model Intercomparison Project Phase 6 (CMIP6), we develop a regression model specifically designed to robustly detect and attribute trends in the observed SAT. We evaluate the models' capability to replicate the detected forced SAT trends. Our findings indicate that external forcings are a significant driver of SAT trend patterns on multidecadal scales, with pronounced warmingtrends over the Eurasian and North American continents. Conversely, on decadal scales, the forced SAT trends are not as evident within the observational data. Our results also underscore the limitations of current state-of-the-art climate models in capturing decadal trend variability. Interestingly, when comparing high- to low-sensitivity climates—those with high (ECS > 4.5K) versus low (ECS < 4.5K) equilibrium climate sensitivity—we find the high-sensitivity models to underrepresent the unforced signals of observed SAT trends. By leveraging significant observational data that captures the forced trend patterns on multidecadal timescales, we could enhance and constrain the future projection of SAT trends and variability more effectively.