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Isolating forced signals in observations and climate model simulations: Empirical climate emulators and M-SSA based optimal filtering

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We performed Wiener filtering of gridded surface-temperature time series from observations and climate model simulations using multi-channel singular spectrum analysis (M-SSA). The contributions to the singular spectrum from internal climate variability - treated in this context as noise - were estimated by fitting to the data spatially extended stochastic emulators, which were subsequently used to produce synthetic ensembles of surface temperature time series and the corresponding synthetic M-SSA spectra. This methodology was first tested using the twentieth century simulations from the Community Earth System Model (CESM) Large Ensemble Project (LENS), for which the forced climate signal can be reliably estimated by taking the ensemble average over the 40 available climate realizations, and then applied to individual model ensembles from the Coupled Model Intercomparison Project Phase 5 (CMIP5) and, finally, to the observed surface-temperature time series. The method is able recover successfully low-frequency (decadal+) component of the forced signal, but fails to isolate shorter-term variability associated with volcanic eruptions. The forced signals estimated from model simulations and observations exhibit large differences, which indicates the presence, in observations, of a pronounced multi-decadal variability with a distinctive spatiotemporal structure absent in any of the model simulations.