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An empirical model for probabilistic decadal prediction: A global analysis

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Empirical models, designed to predict land-based surface variables over seasons to decades ahead, provide useful benchmarks for comparison against the performance of dynamical forecast systems; they may also be employable as predictive tools for use by climate services in their own right. A new global empirical decadal prediction system is presented, based on a multiple linear regression approach designed to produce probabilistic output for comparison against dynamical models. Its performance is evaluated for surface air temperature over a set of historical hindcast experiments under a series of different prediction 'modes'. The modes include a real-time setting, a scenario in which future volcanic forcings are prescribed during the hindcasts, and an approach which exploits knowledge of the forced trend. A two-tier prediction system, which uses knowledge of future sea surface temperatures in the Pacific and Atlantic Oceans, is also tested, but within a perfect knowledge framework. Each mode is designed to identify sources of predictability and uncertainty, as well as investigate different approaches to the design of decadal prediction systems for operational use. It is found that the empirical model shows skill above that of persistence hindcasts for annual means at lead times of up to ten years ahead in all of the prediction modes investigated. Small improvements in skill are found at all lead times when including future volcanic forcings in the hindcasts. It is also suggested that hindcasts which exploit full knowledge of the forced trend due to increasing greenhouse gases throughout the hindcast period can provide more robust estimates of model bias for the calibration of the empirical model in an operational setting. The two-tier system shows potential for improved real-time prediction, given the assumption that skilful predictions of large-scale modes of variability are available. The empirical model framework has been designed with enough flexibility to facilitate further developments, including the prediction of other surface variables and the ability to incorporate additional predictors within the model that are shown to contribute significantly to variability at the local scale. It is also semi-operational in the sense that forecasts have been produced for the coming decade and can be updated when additional data becomes available.