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Creating "Intelligent" Ensemble Averages Using a Process-Based Framework

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The CMIP5 archive contains future climate projections from over 50 models provided by dozens of modeling centers from around the world. Individual model projections, however, are subject to biases created by structural model uncertainties. As a result, ensemble averaging of multiple models is used to add value to individual model projections and construct a consensus projection. Previous reports for the IPCC establish climate change projections based on an equal-weighted average of all model projections. However, individual models reproduce certain climate processes better than other models. Should models be weighted based on performance? Unequal ensemble averages have previously been constructed using a variety of mean state metrics. What metrics are most relevant for constraining future climate projections? This project develops a framework for systematically testing metrics in models to identify optimal metrics for unequal weighting multi-model ensembles. The intention is to produce improved ("intelligent") unequal-weight ensemble averages. A unique aspect of this project is the construction and testing of climate process-based model evaluation metrics. A climate process-based metric is defined as a metric based on the relationship between two physically related climate variables—e.g., outgoing longwave radiation and surface temperature. Several climate process metrics are constructed using high-quality Earth radiation budget data from NASA's Clouds and Earth's Radiant Energy System (CERES) instrument in combination with surface temperature data sets. It is found that regional values of tested quantities can vary significantly when comparing the equal-weighted ensemble average and an ensemble weighted using the process-based metric. Additionally, this study investigates the dependence of the metric weighting scheme on the climate state using a combination of model simulations including a non-forced preindustrial control experiment, historical simulations, and several radiative forcing Representative Concentration Pathway (RCP) scenarios. Ultimately, the goal of the framework is to advise better methods for ensemble averaging models and create better climate predictions.