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Removing Internal Variability as a Means of Improving Regional Emulation of Ocean Dynamic Sea-Level Change

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Regional emulation tools based on statistical relationships, such as pattern scaling, provide a computationally inexpensive way of projecting ocean dynamic sea-level change for a broad range of climate change scenarios. Such approaches usually require a careful selection of one or more predictor variables of climate change so that the statistical model is properly optimized. Even when appropriate predictors have been selected, spatiotemporal oscillations driven by internal climate variability can be a large source of model disagreement. Using pattern recognition techniques that exploit spatial covariance information can effectively reduce internal variability in simulations of ocean dynamic sea level, significantly reducing random errors in regional emulation tools. Here, we test two pattern recognition methods based on Empirical Orthogonal Functions (EOF), namely signal-to-noise maximising EOF pattern filtering and low-frequency component analysis, for their ability to reduce errors in pattern scaling of ocean dynamic sea-level change. These two methods are applied to an initial-condition large ensemble (MPI-GE), so that its externally forced signal is optimally characterized. We show that pattern filtering provides an efficient way of reducing errors compared to other conventional approaches such as a simple ensemble average. For instance, filtering only two realizations by characterising their common response to external forcing reduces the random error by almost 60%, a reduction level that is only achieved by averaging at least 12 realizations. We further investigate the applicability of both methods to single realization modelling experiments, including four CMIP5 simulations for comparison with previous regional emulation analyses. Pattern scaling leads to a varying degree of error reduction depending on the model and scenario, ranging from more than 20% to about 70% reduction in global-mean mean-squared error compared with unfiltered simulations. Our results highlight the relevance of pattern recognition methods as a means of reducing errors in regional emulation tools of ocean dynamic sea-level change, especially when one or a few realizations are

available.