A multivariate approach to combine general circulation models using graph cuts

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General circulation models (GCMs) are of extreme importance to make future climate projections. Their predictions are used extensively by policymakers to manage the response to anthropogenic global warming and climate change.

To extract a robust global signal and evaluate uncertainties, individual models are often assembled in Multi-Model Ensembles (MMEs). Various approaches to combine individual models have been developed, such as the Multi-Model Mean (MMM) or its weighted variants.

Recently, (Thao et al., 2022) developed a model comparison approach based on graph cuts. Graph cut optimization was developed in the field of computer vision to efficiently approximate a solution for low-level computer vision tasks such as image segmentation (Boykov et al., 2001). Applied to MMEs, it allows selecting for each pixel a set of best-performing models and produces a patchwork of models that maximizes performances while maintaining pixel-to-pixel continuity. It thus allows considering the local performance of ensemble members in contrast with approaches such as MMM or similar methods that use global weights.

Here we propose a new multivariate combination approach of MMEs based on graph cuts. Compared to the existing univariate graph cuts method, our approach ensures that the relationships between variables, which are represented in GCMs, are locally preserved while providing coherent spatial fields. Moreover, we exploit the design of the graph cut optimization to propose a stochastic version of model combinations that provides multiple similarly good solutions.

We demonstrate the efficiency of our approach by co-optimizing multi-decadal means of multiple variables. We compare the performance to univariate optimization and show that the loss of performance is negligible with a good quality-computational cost ratio.

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