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Better than Multi-Model Means: combining climate models using multivariate graph cuts for improved CMIP6 projections

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Various approaches have been proposed to combine individual climate models and extract a robust signal from an ensemble, such as the Multi-Model Mean or the weighted Multi-Model Mean. However, they often rely on weights that are applied to models globally, overlooking the fact that individual models often demonstrate strengths in specific regions. This suggests that a more localized approach could improve climate projections based on models ensembles.

So far, the only approach that really exploits the regional strengths of different models over multi-decadal timescales is the graph cuts approach (Thao et al., 2022). It consists in selecting for each grid point the most appropriate model, while at the same time considering the overall spatial consistency of the resulting field. Although this method showed encouraging results, outperforming other combination approaches, it is limited to optimizing for one variable, resulting in an inconsistent model selection for each and thus a loss of the multivariate relationships observed in the models. For instance it is known that precipitation and temperature are physically linked. Therefore having an independent model combination for each variable can result in inconsistencies. Moreover, the method was only applicable to multi-decadal averages, not allowing for retrieving distributional properties of the combined models such as extreme events.

Here we present a series of improvements of graph cuts enabling to combine distributions of daily-means while preserving multivariate relationships, thus better capturing the complete span of climate dynamics. Using the Hellinger distance to measure model performance, we are able to select, at each grid location, the model that best represents the joint distribution of the target variables while minimizing the apparition of unrealistic discontinuities in the resulting fields. The resulting projections display more realistic extremes and compound events representations.

REFERENCES

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