A multivariate approach to combine general circulation models using graph cuts

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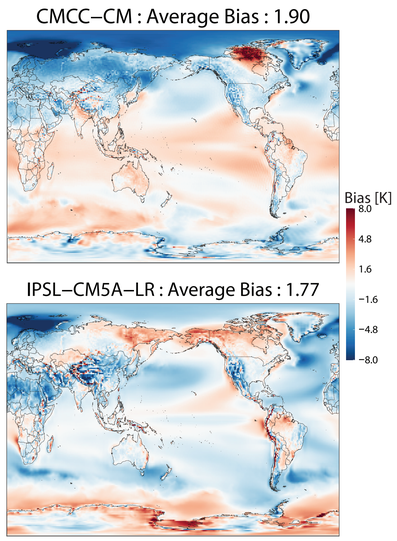
Introduction

General Circulation Models (GCMs) are crucial tools for understanding and projecting climate change. However, they have **biases**, and their performance **varies spatially**. Furthermore, the locations of strengths and weaknesses **differ between models**.

Our method aims to exploit these spatially-dependent model performances to produce **more accurate climate projections**.

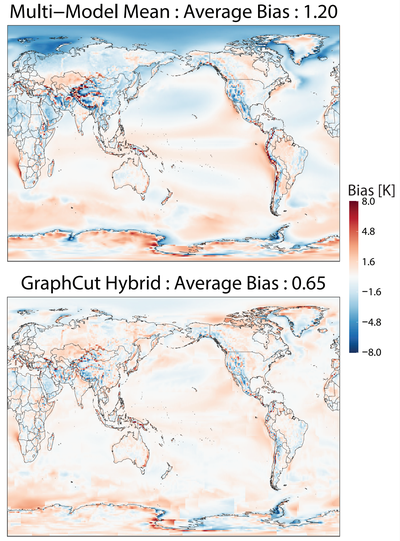


Univariate Approach

Our initial approach (Thao et al., 2021) used graph cuts to **select at each grid-point** the model that displayed the **best multi-decadal mean** while avoiding spatial discontinuities. This results in a **patchwork of models** that minimizes a cost function on the calibration period.

We showed that our method **outperformed Multi-Model Mean** approaches on projections of temperatures and precipitations (Fig. 2) .

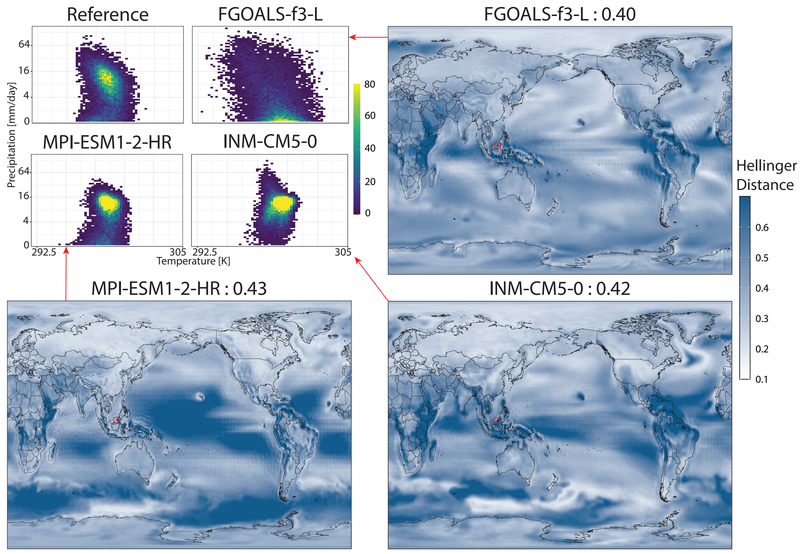
However, it is **limited** to optimizing for **one variable**, resulting in a different patchwork for each variable of interest. This might cause issues when **different models are assigned to a grid-point**, as the **inter-variable relationships** present in individual models **are lost**.



Multivariate Approach

Upon examining individual models, we find that not only do the means of variables differ, but the joint distributions for the same grid-point can also exhibit considerable variation (Fig. 3). Furthermore, the performance of individual models displays spatial variability and is not consistent between models.

Noting these elements, our new approach builds upon the previous univariate method and optimizes multiple variables simultaneously. This is achieved by replacing the distance between multi-decadal means in the cost function with a statistical distance that measures the discrepancy between the joint distribution of the variables of interest and the reference distribution.



Test Scenario

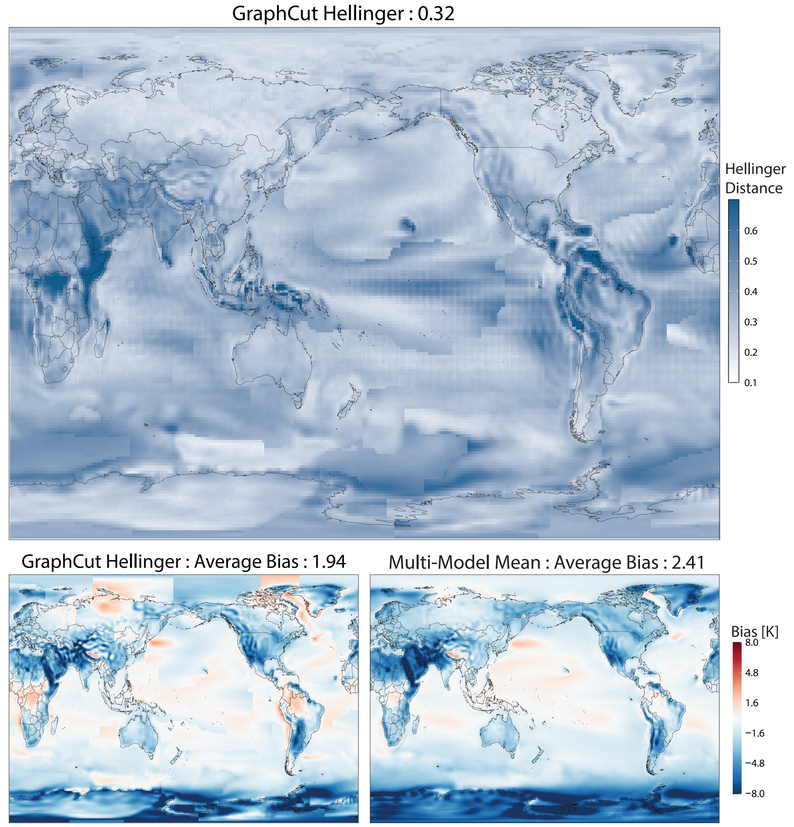
To evaluate the method and validate the implementation, we designed a test scenario comprising an ensemble of three models and one reference.

Reference	MIROC6
Models	FGOALS-f3-L INM-CM5-0 MPI-ESM1-2-H

The objective of this experiment is to assess the effectiveness of our multivariate approach in improving climate projections compared to univariate methods and traditional Multi-Model Mean approaches.

Preliminary Results

We see that the graph cut approach can be effectively extended to a multivariate context, with the Hellinger distance proving to be a suitable metric. In our test scenario, the proposed method demonstrates superior performance compared to the MMM approach.



References

Thao, S., Garvik, M., Mariethoz, G., & Vrac, M. (2022). Combining global climate models using graph cuts. Climate Dynamics, February. https://doi.org/10.1007/s00382-022-06213-4

Contact informations