A multivariate approach to combine general circulation models using graph cuts

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Sharing is encouraged

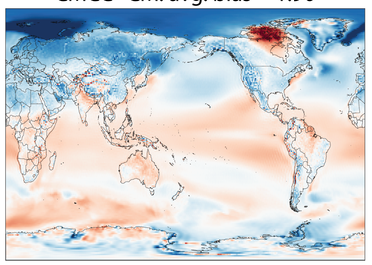
Link to this poster:

Introduction

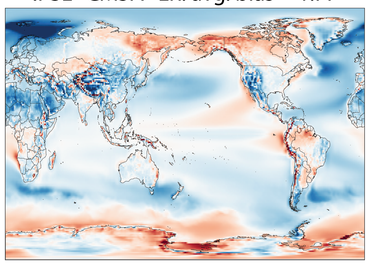
- GCMs exhibit biases and varying levels of performance
- These biases vary spatially
- Locations of strengths and weaknesses differ between models
- Multi-Model Ensembles (MME) combined with Multi-Model Mean (MMM) tend to smooth out indivudal model performances

Can we leverage this spatial variability to improve projections?

CMCC–CM: avg. bias = 1.90



IPSL–CM5A–LR: avg. bias = 1.77



Bias [K] −8.0 0 8.0

Univariate graph cut[1]

Method:

- Multi-decadal means used in the cost function
- Minimizes biases while avoiding spatial discontinuities

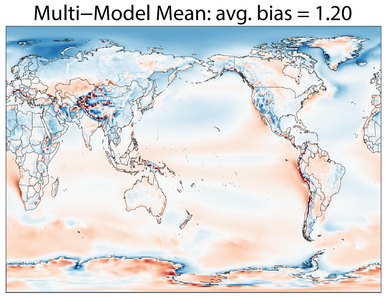
Result:

- Surpasses MMM and it's weighted variants

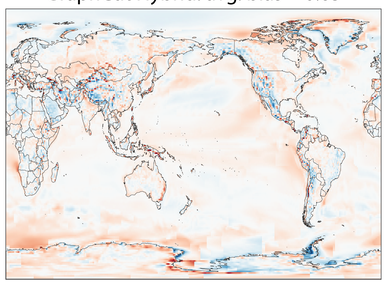
Limitations:

- Distinct patchworks when optimizing for different variables
- Intervariable relationships are lost when different models are affected to a given grid-point
- Limited to a single variable

Multi–Model Mean: avg. bias = 1.20



GraphCut Hybrid: avg. bias = 0.65



Bias [K] −8.0 0 8.0

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

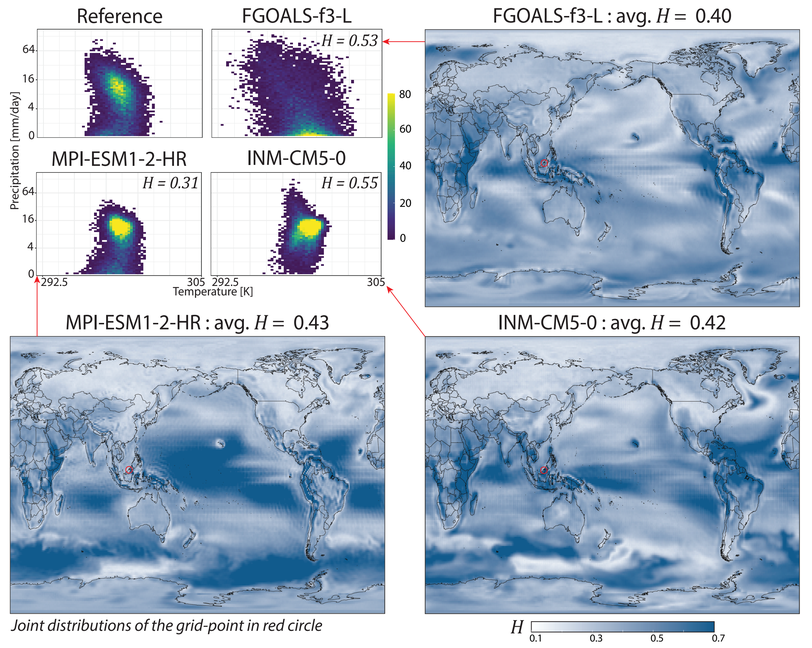
Multivariate graph cut

What we noticed:

- Models display vastly different multivariate distributions
- The performance of each model varies spatially

Updated Method:

- Use multi-decadal joint distribution of daily values
- Hellinger distance (H, min: 0, max: 1) replaces mean in cost function
- The selected model provides the joint distribution closest to reference
- Intervariable relationships are preserved



Joint distributions of the grid-point in red circle

Test Scenario

- Calibration period: 1985-1999
- Projection period: 2000-2014

Research questions:

- Is H an appropriate distance for the cost function?
- Can we outperform MMM?

Dataset

Models from CMIP6

Reference: MIROC6

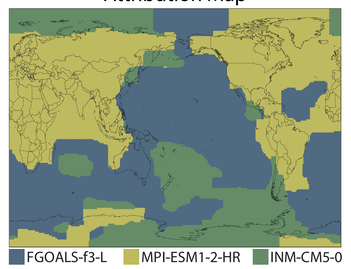
Models: FGOALS-f3-L
INM-CM5-0
MPI-ESM1-2-H

Variables: TAS & PR

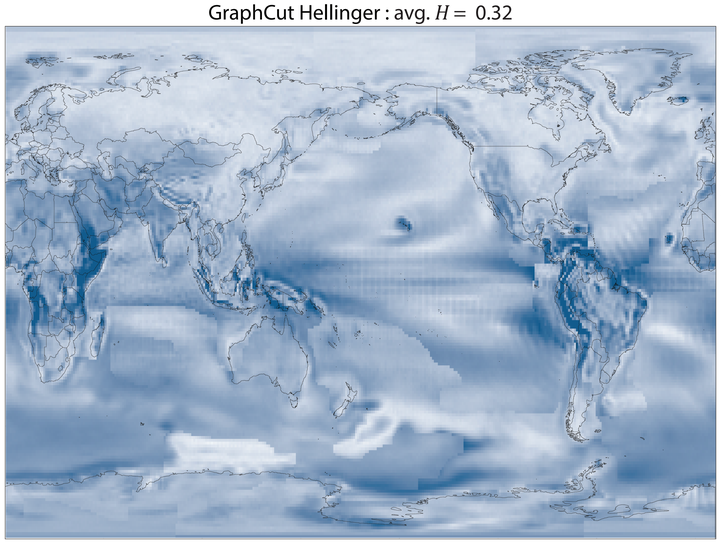
Preliminary Results

- Test scenario demonstrates the potential of H as a cost parameter
- Resulting patchwork is coherent
- Chosen MME produces visible cuts and large patches
- Biases and H are reduced compared to MMM

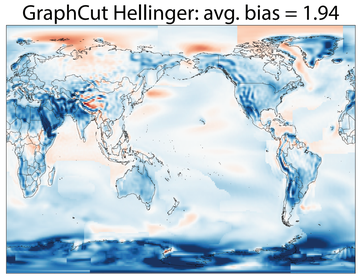
Attribution Map



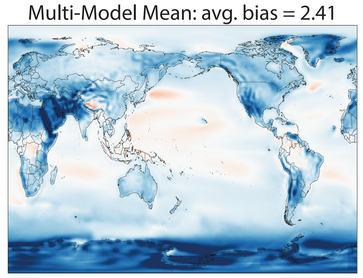
GraphCut Hellinger : avg. H = 0.32



GraphCut Hellinger: avg. bias = 1.94



Multi-Model Mean: avg. bias = 2.41



Bias [K]
8.0
4.8
1.6
−1.6
−4.8
−8.0

Future work

- Use ERA5 as reference
- Larger MME
- Randomized initalization of the graph cut optimization
- Bias correction before graph cut?

Get in touch!

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