

Using Phase-Annealing to generate surrogate discharge time series

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Now
online!

Phase Annealing

- Simulated Annealing
- Phase Randomization
- Anneal phases
- Advantages
 - Better multisite conditional distributions of extremes
 - **Non-Gaussian** dependence structure
 - Longer series (anneal magnitudes)
- Disadvantages
 - Types of objective functions
 - Very high number of dimensions
- A comparison between Phase Randomization (as a reference) and Phase Annealing is shown here
- The results are for discharges at two sites having a length of two years on a daily scale
- Non-Gaussian differences in dependences are highlighted

Comparison

Phase Randomization

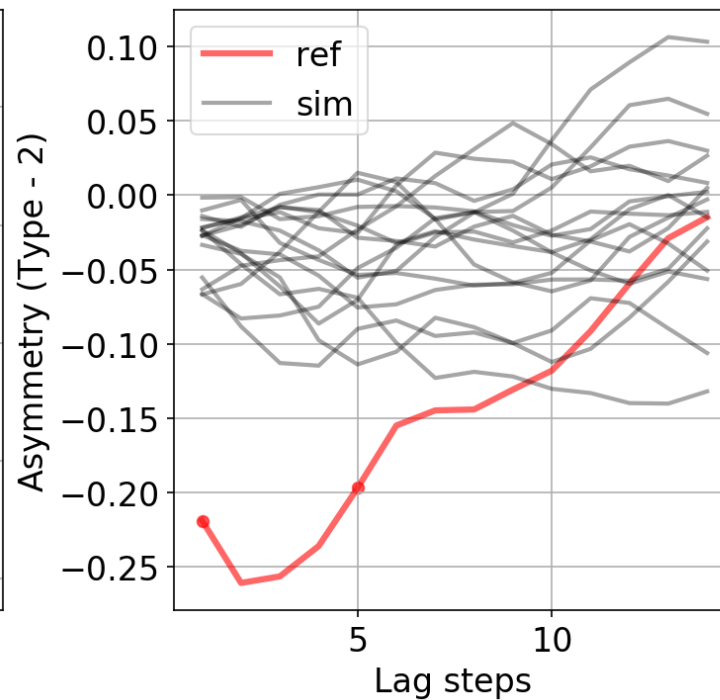
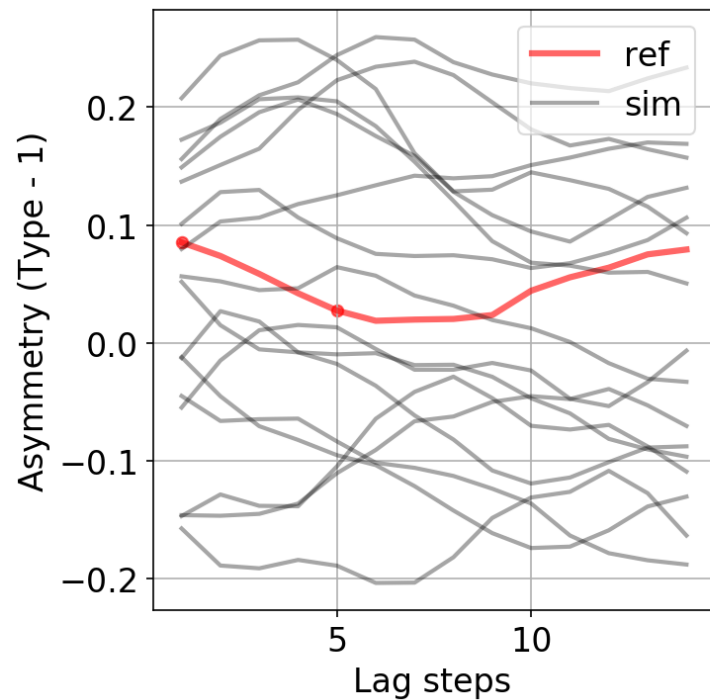
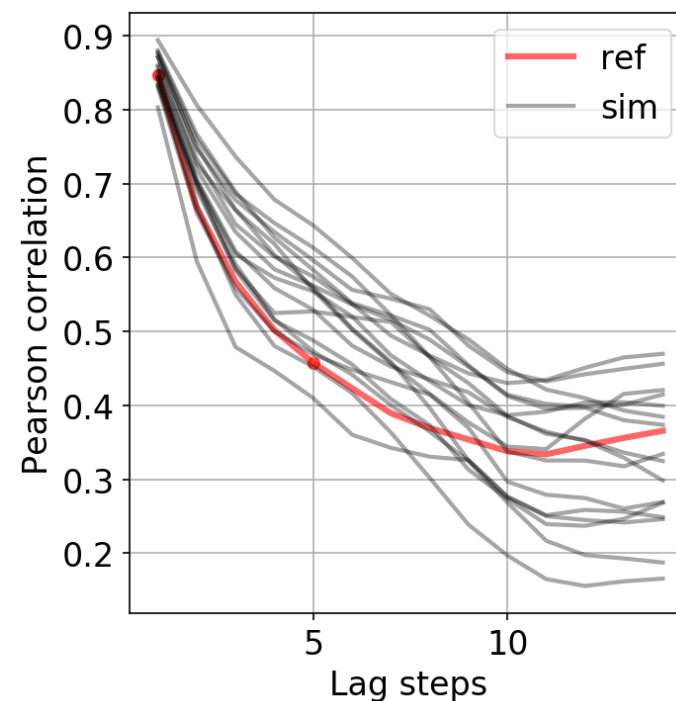
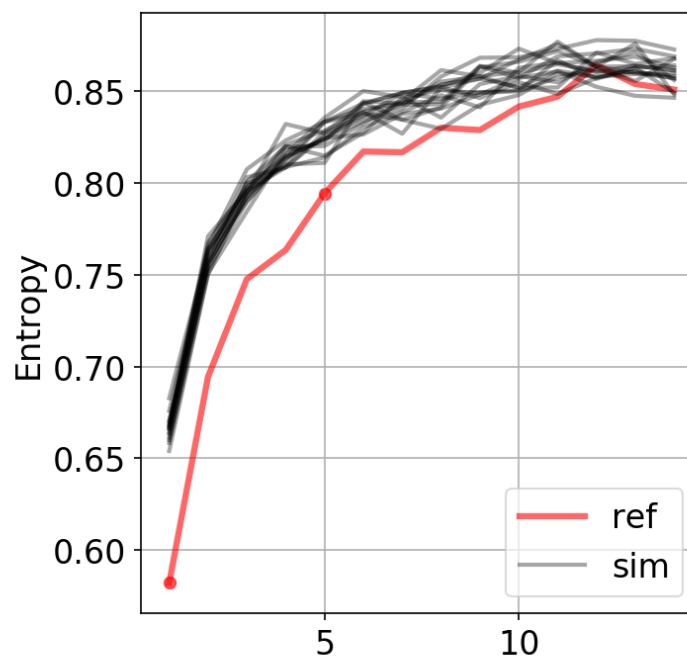
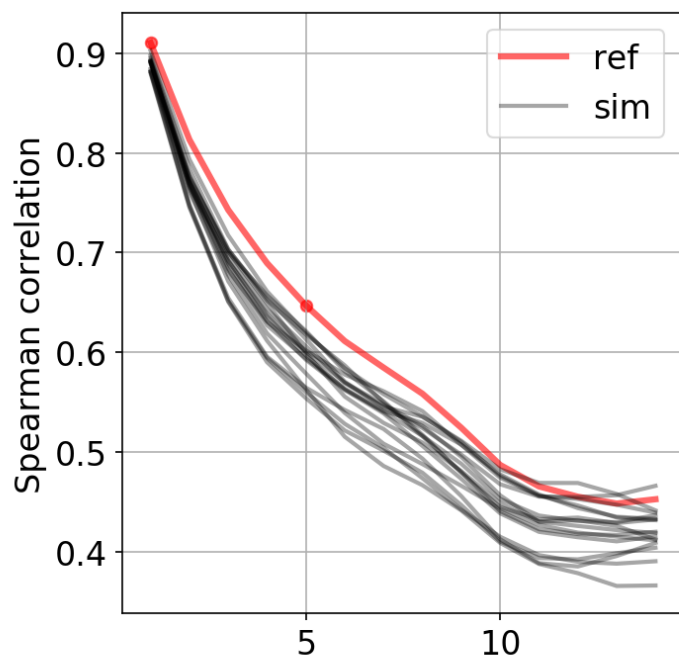
- ✓ Spatio-temporal correlation
- ✗ Gaussian copula
- ✗ Incorrect Nth-order differences
- ✗ Incorrect copula asymmetries
- ✗ Incorrect copula entropies
- ✗ Time series with unnatural properties
- ✓ Simulation run time (almost) independent of time series length

Phase Annealing

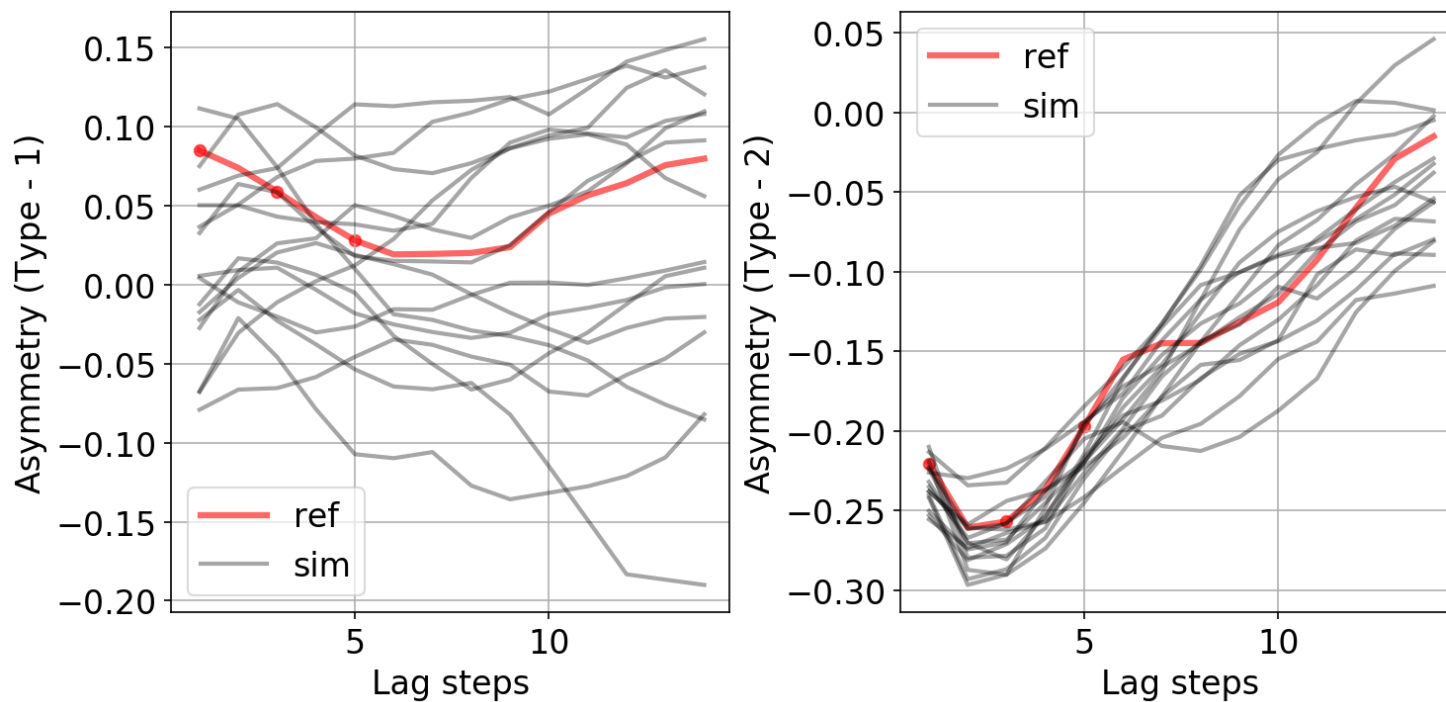
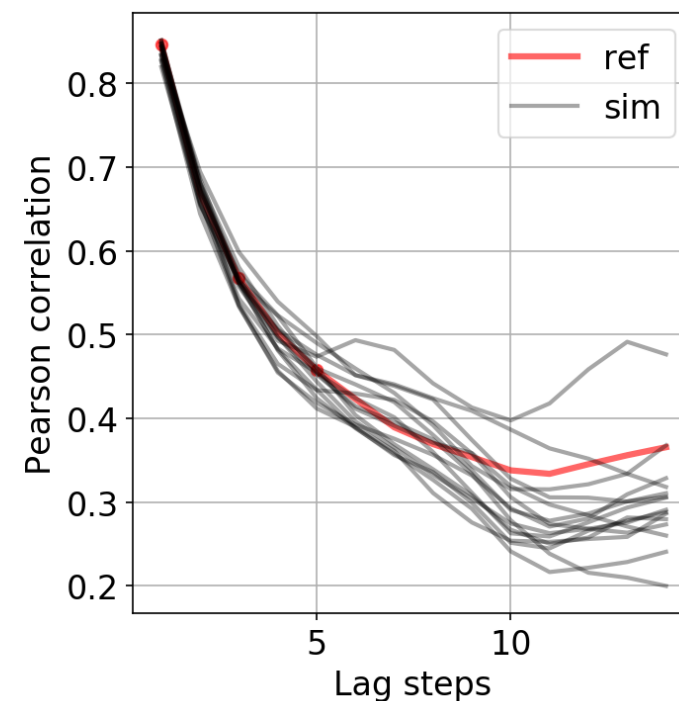
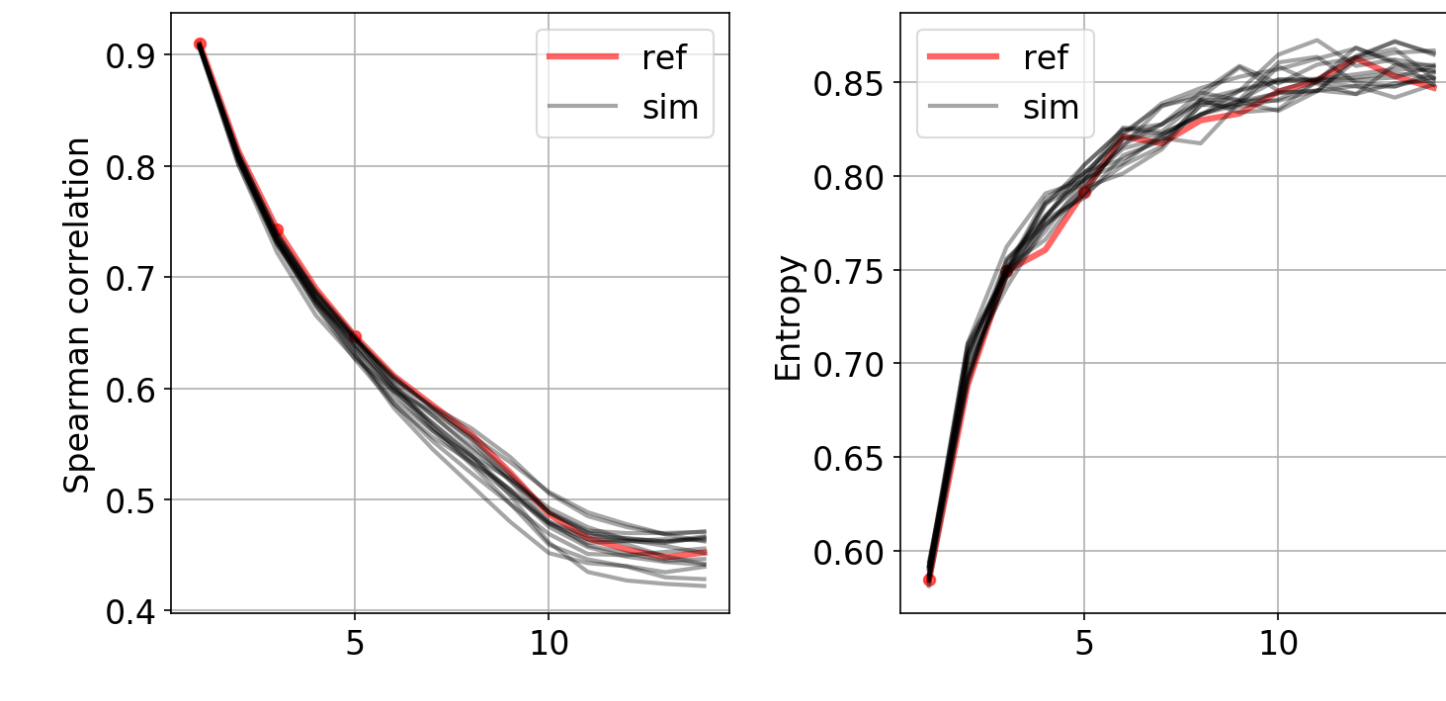
- ✓ Spatio-temporal correlation
- ✓ Non-Gaussian copula
- ✓ Correct Nth-order differences
- ✓ Correct copula asymmetries
- ✓ Correct copula entropies
- ✓ Time series with natural properties
- ✗ Simulation run time dependent on time series length

Objective functions

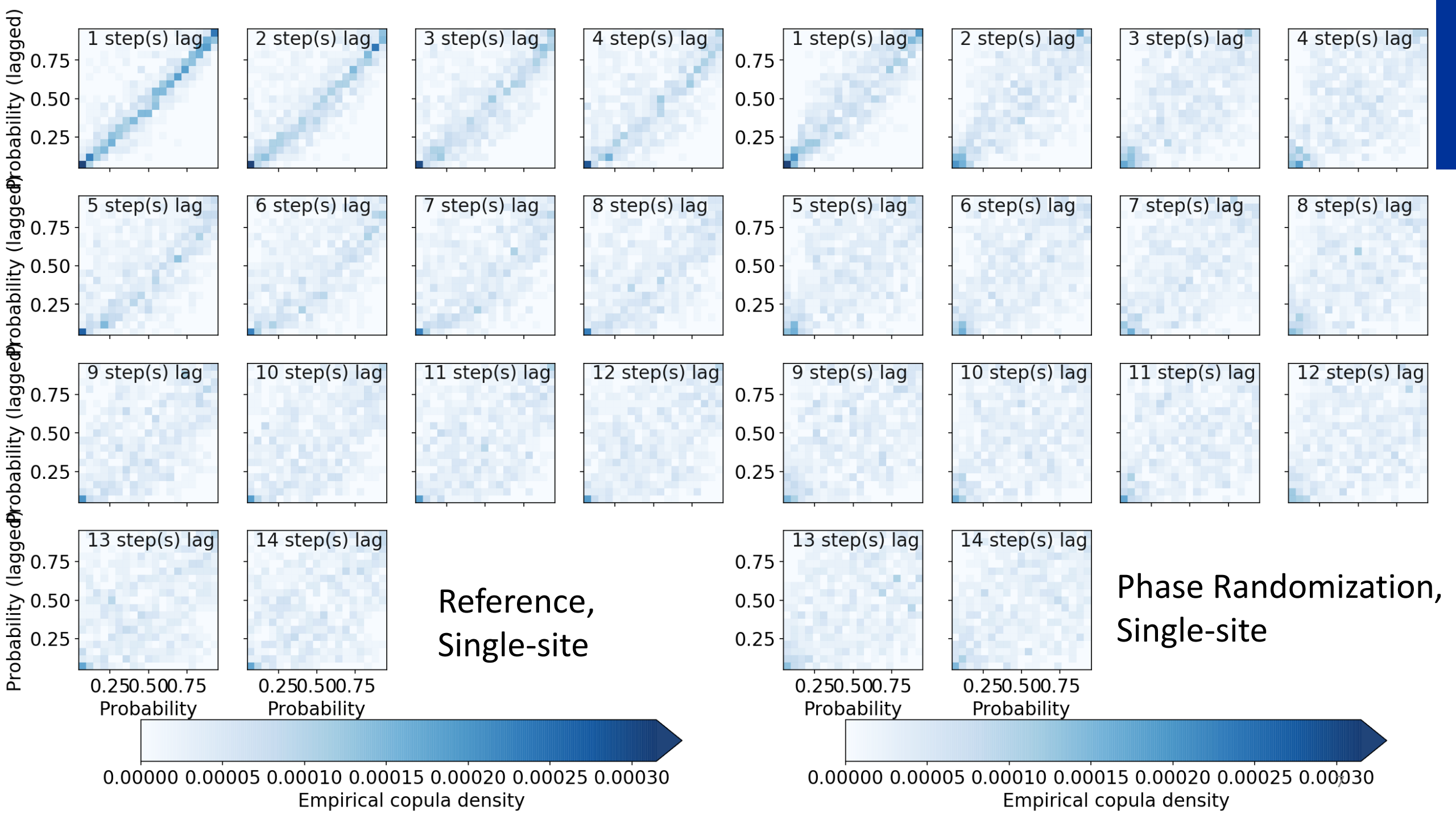
- Non-Gaussianess
- Asymmetries
 - At least two directions
 - Single-site
 - Multi-site
- Nth order differences
- Entropies
 - Obtained indirectly
- Correlations
 - Spearman
 - Pearson
- Properties that show deviation from the multivariate Normal copula should be used
- Instead of using single objective values, distributions of deviations should be used (more robust)

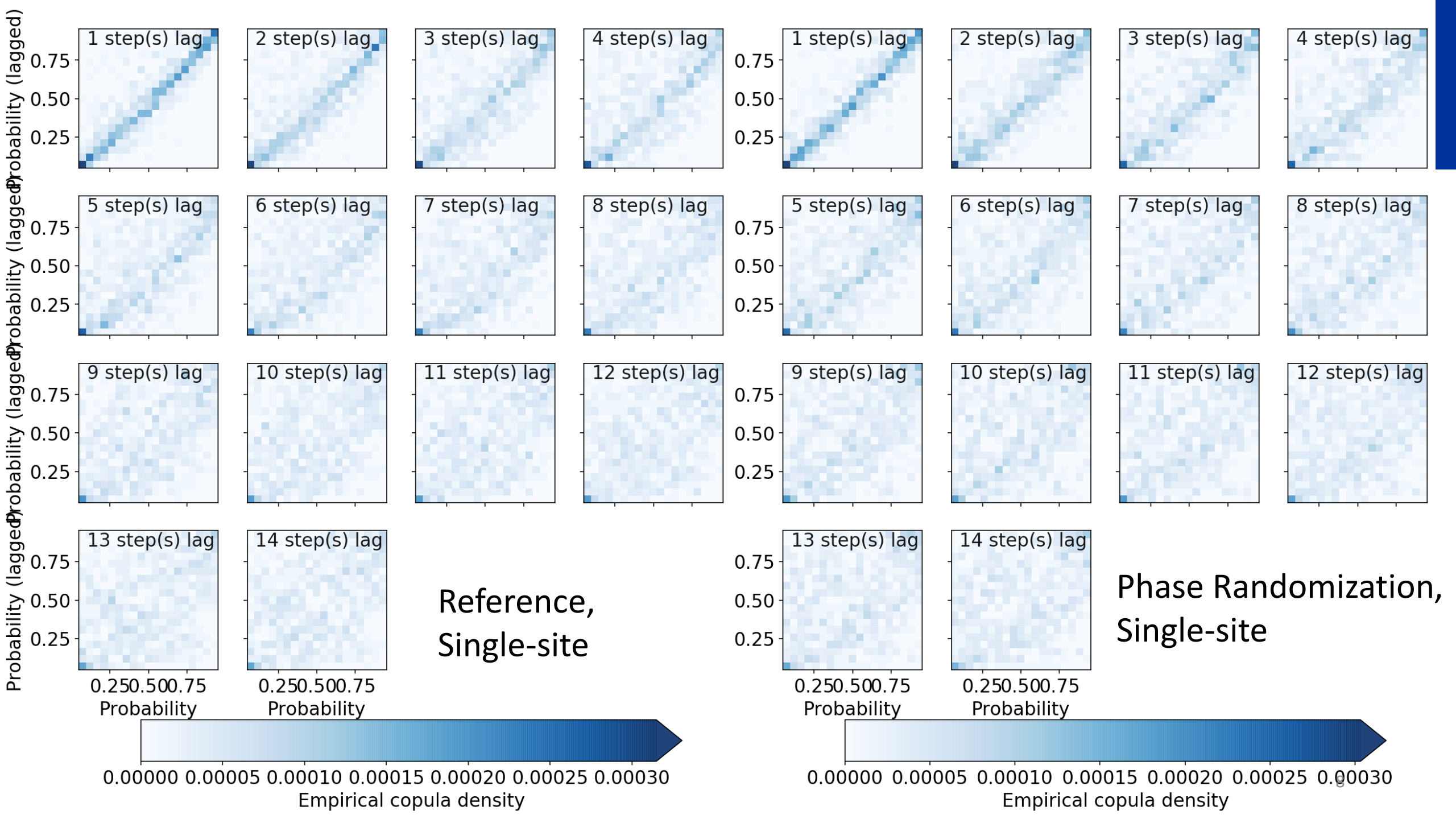


Simulation properties,
Single-site
(Phase Randomization)

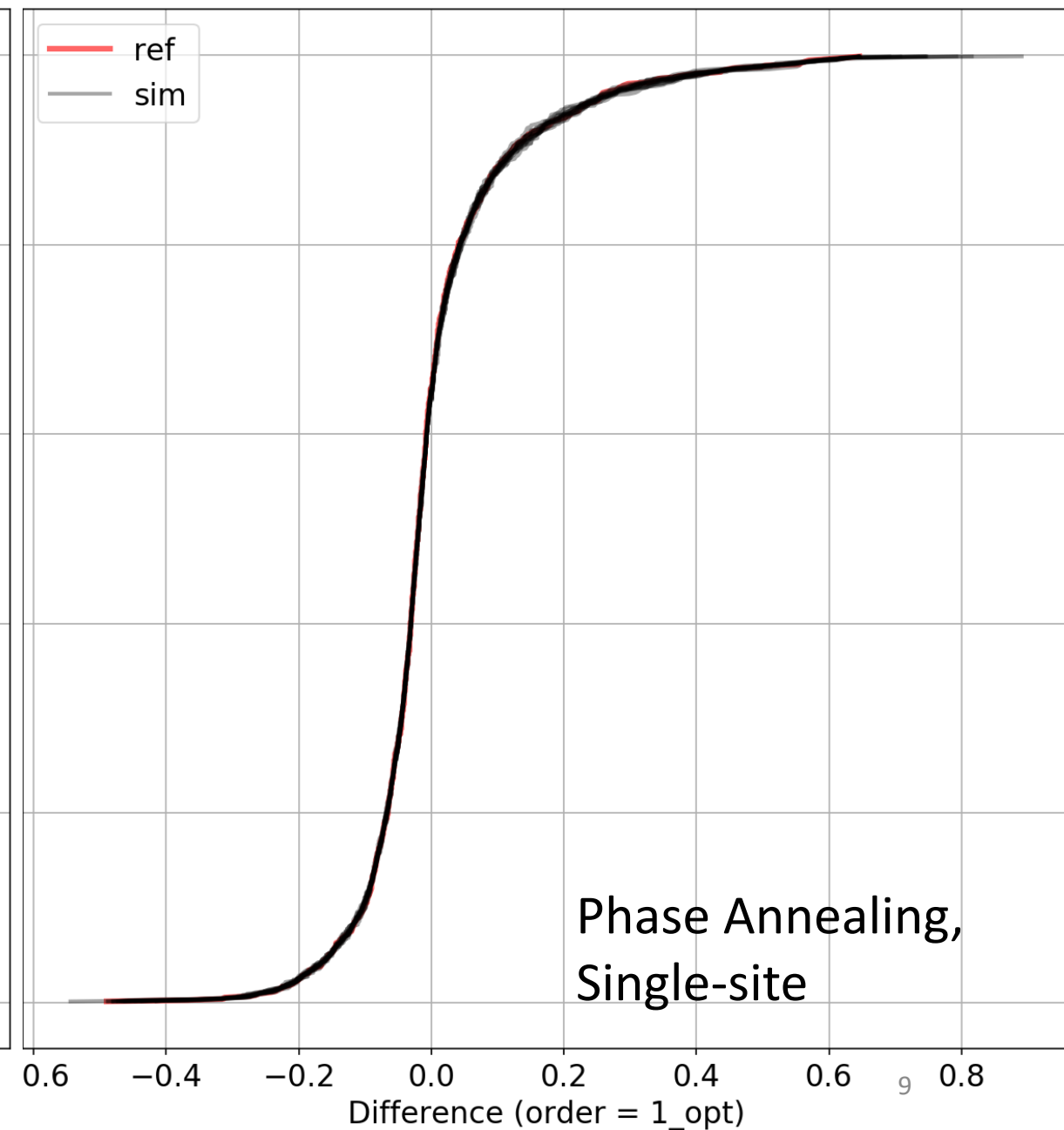
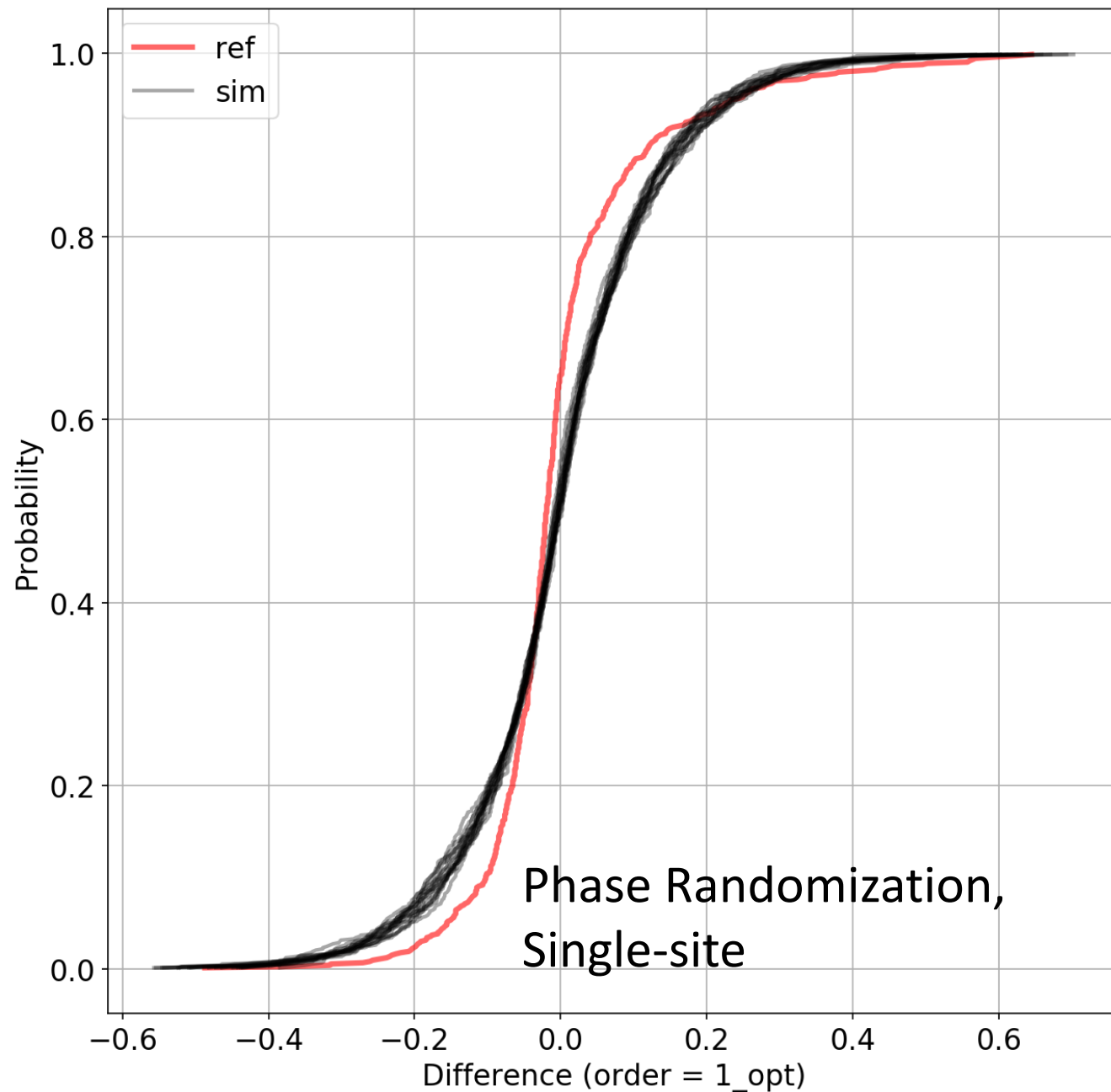


Simulation properties,
Single-site
(Phase Annealing)



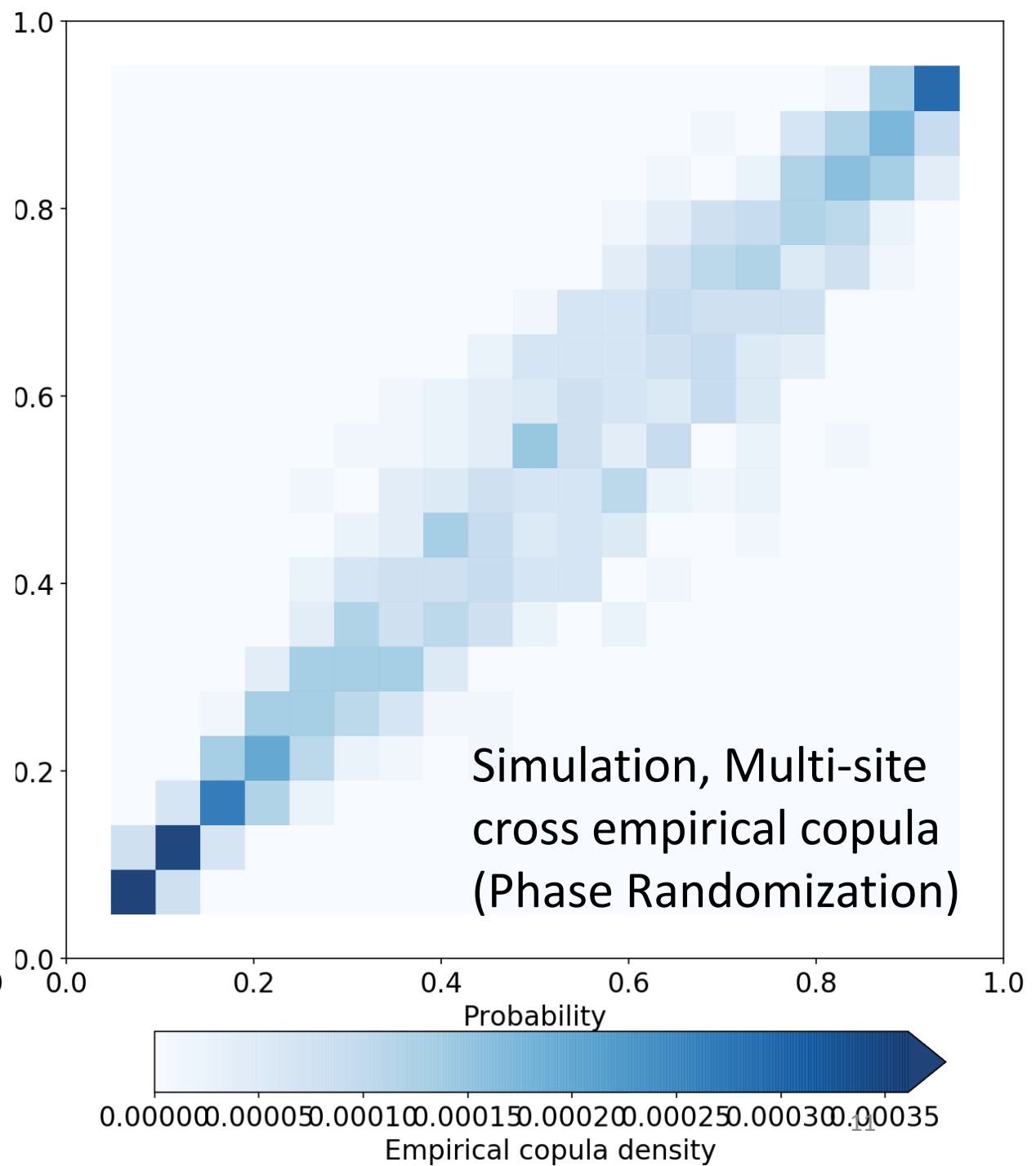
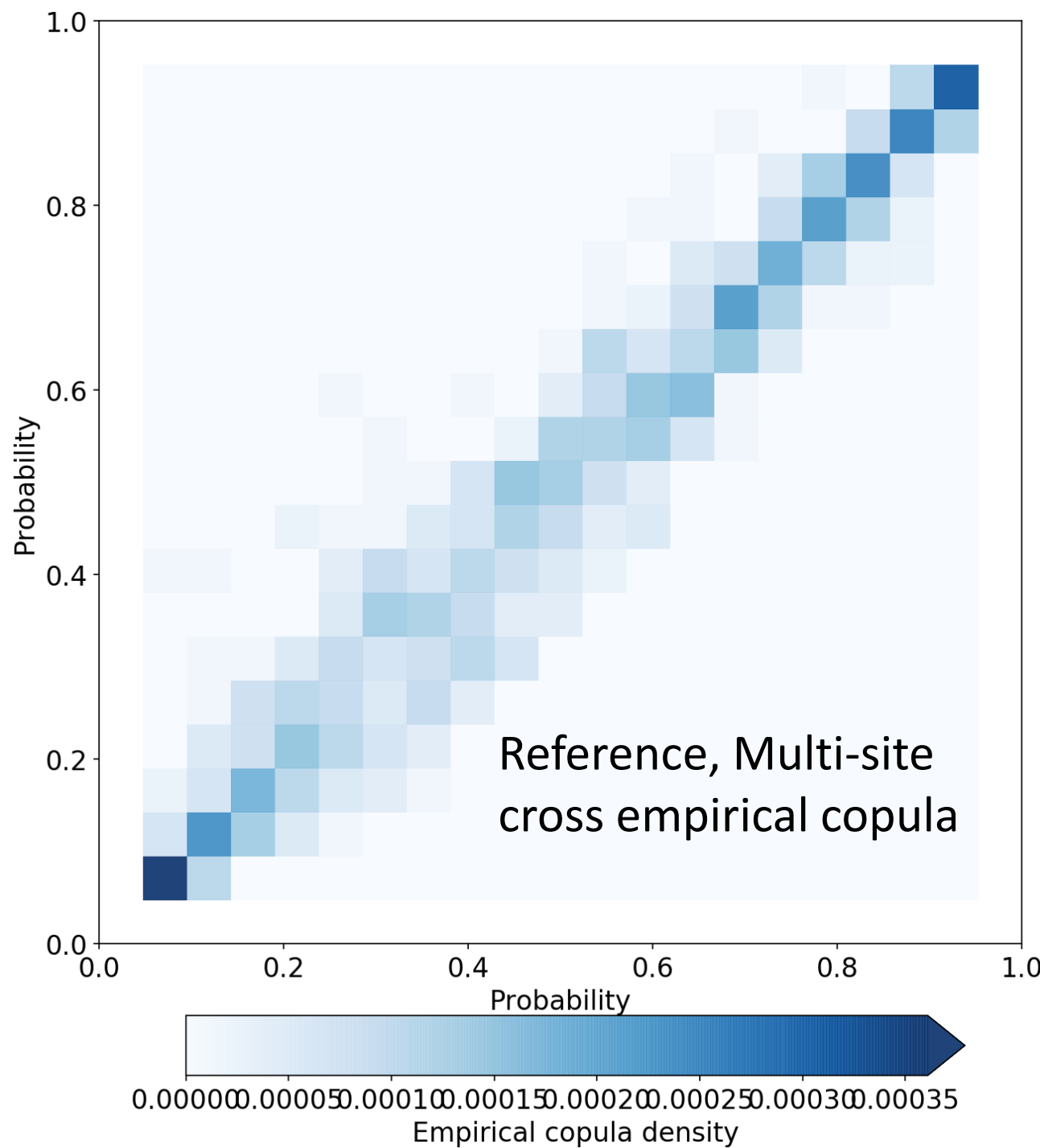


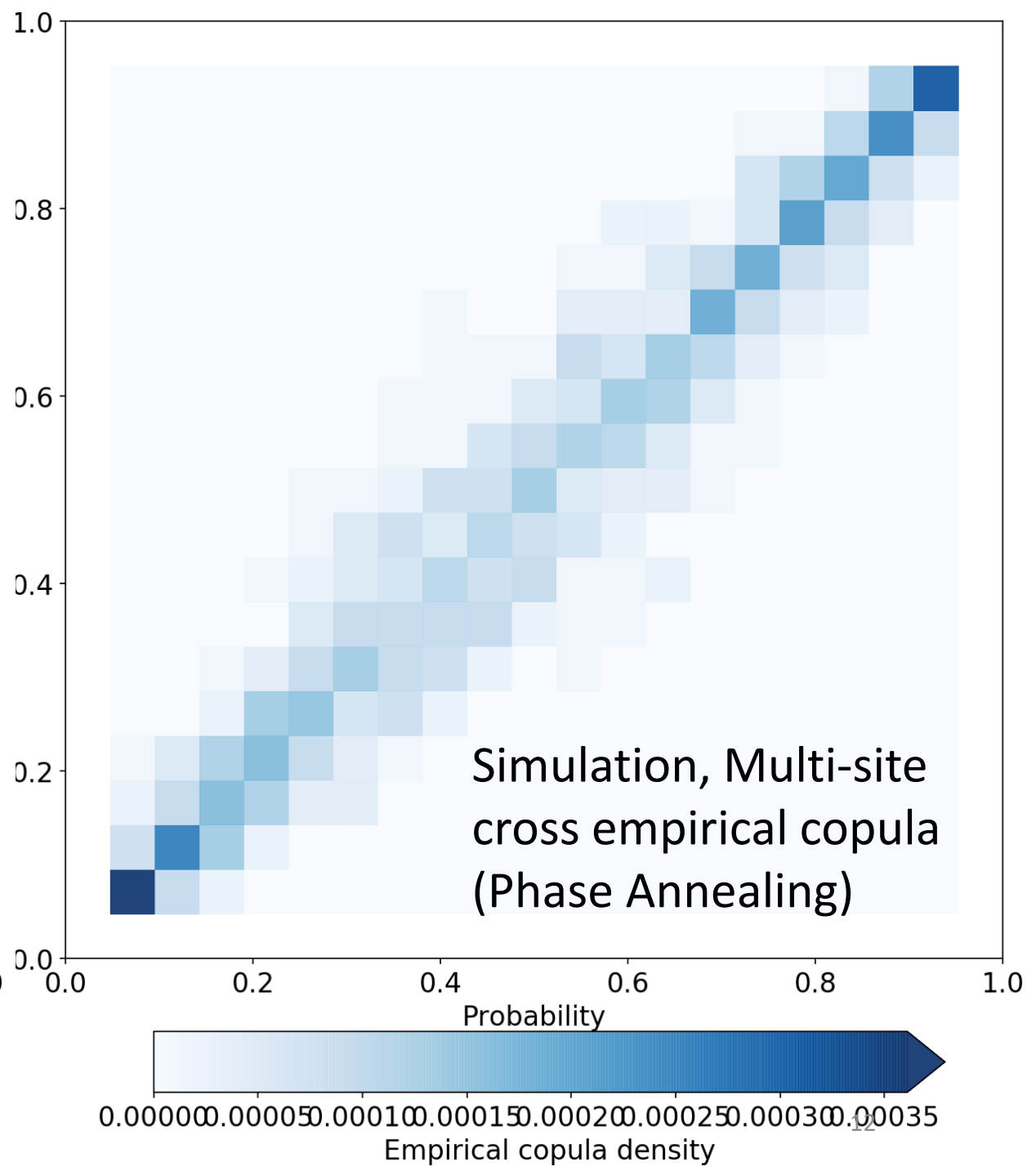
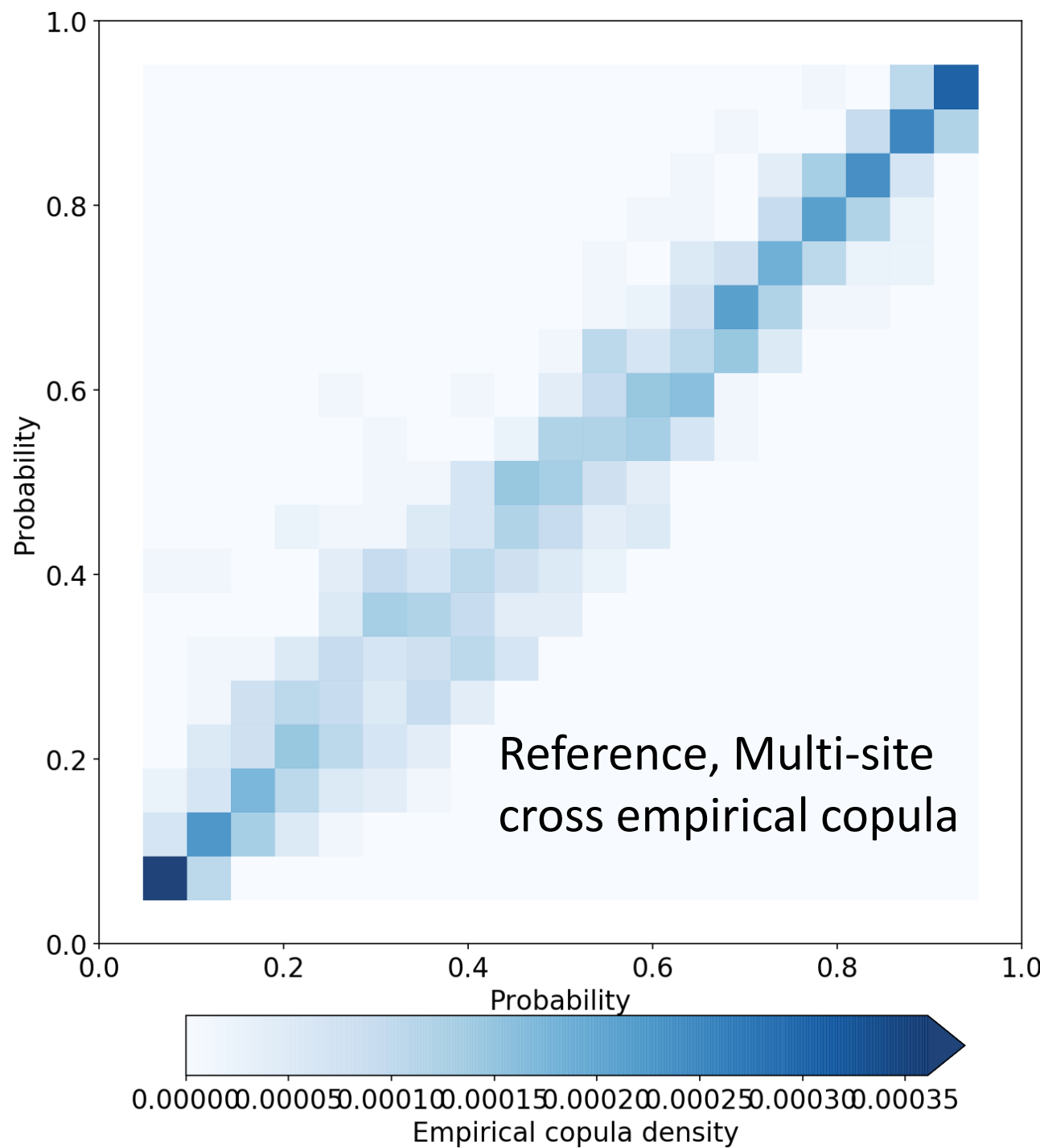
1st order differences distribution



Multi-site simulation

- Multiple points
 - In time
- Apply same phase changes
 - To all points
 - Keep ΔPhase constant
- Asymmetry 1 more important
- Phase randomization
 - May keep asymmetry 1
 - Loses entropy/structure
- The empirical copula or the simulated time series can be used to make conditional distributions of extremes at any location for any time lag
- The results shown next are for no time lag between the two sites





Longer time series

- Longer than reference
 - Anneal missing amplitudes
 - In addition to phases
 - Concatenate simulations
 - For specific cases only
 - Better upper tail
 - Not shown here
- Magnitudes of frequencies having periods longer than the seasonal cycles should be annealed carefully as they might represent natural cycles e.g. The annual cycle

That was all from our side. Thanks.

Python implementation: github.com/faizan90/phsann

References

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- Hörning, Sebastian, Bárdossy, A., & Mosthaf, T. (2016). How to determine spatial irreversibility: directional asymmetry.
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