Climate Statistics Reproducibility: Updates

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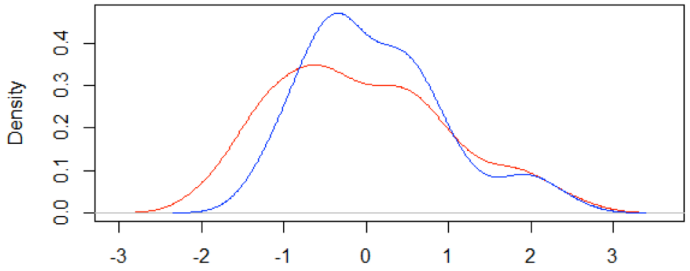
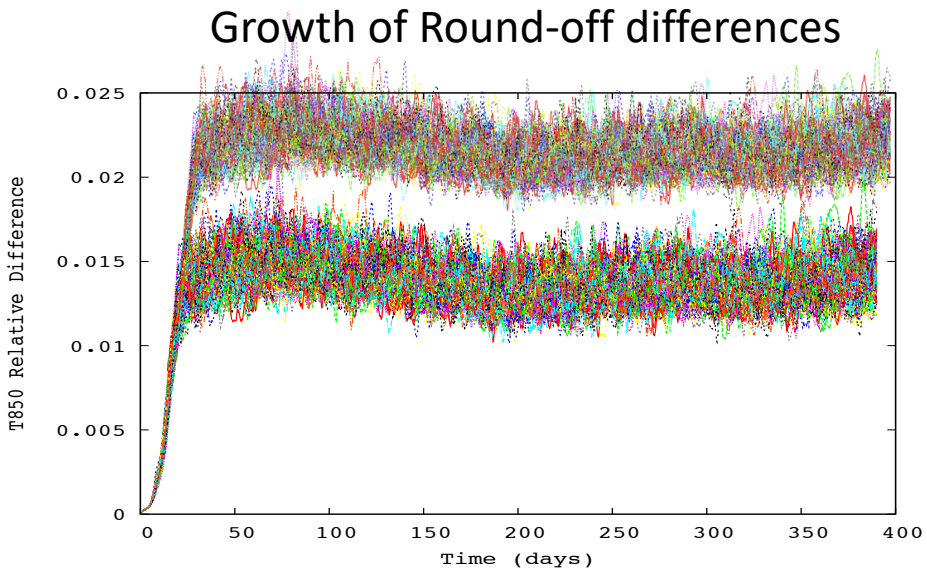
Climate Statistics Reproducibility: Introduction

- Goal: Test the null hypothesis that two simulation ensembles belong to the same population
- Approach: Multivariate two-sample equality of distribution tests:
  - Energy Test: Evaluate a distance based metric (*Szekely and Rizzo, 2005*)
  - Kernel Test: Evaluate a kernel function based metric (*Gretton et al. 2012*)
  - KS Testing Framework: Evaluate each variable separately (*Mahajan et al. 2015*)
- Implementation:
  - Short simulation ensembles (1yr runs, >30)
  - Using global annual means (~150 variables)
  - i.e., 150 dimensions, 30 samples (high dimension, low sample size)





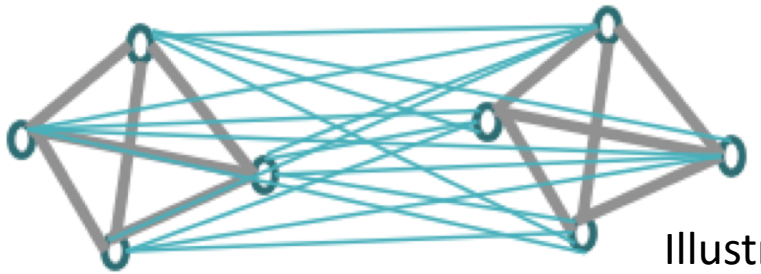


Illustration: Energy Test

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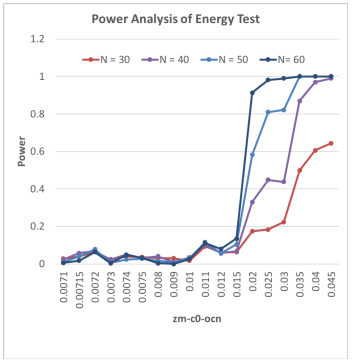
- Conducted Power Analysis:
  - Determine false negative rates (Type II error rate):
    - rate of falsely accepting a null hypothesis
  - Determine the required ensemble size for detecting a given magnitude of change
  - F1850C5 compset E3SMv1
  - ne4 resolution
  - Three suites of ensemble simulations:
    - zm_c0_ocn (deep convection scheme, 0.0071 – 0.045)
    - dcs (cloud microphysics, 100 - 400)
    - rhminl (cloud macrophysics, 0.80-0.8975)
  - 100-member ensembles for each discrete value of the tuning parameters
  - Resampling techniques to determine power

zm_c0_ocn

a.



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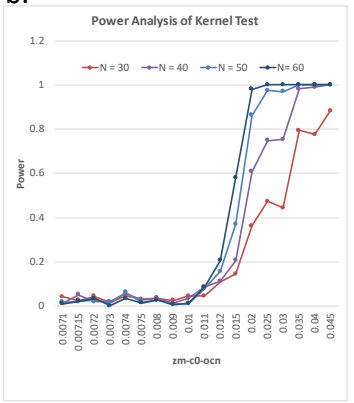
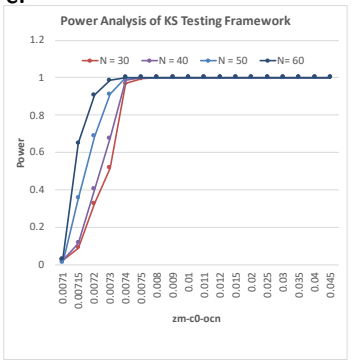


c.



dcs

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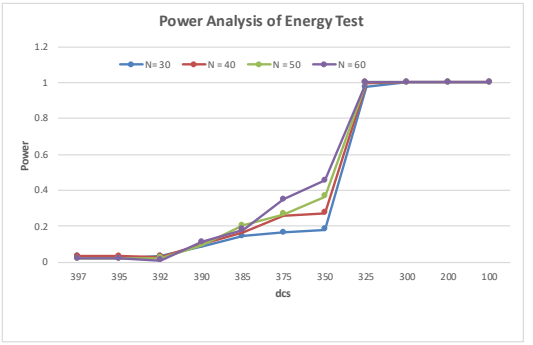

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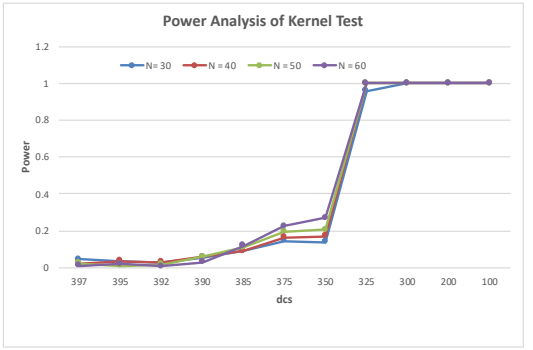

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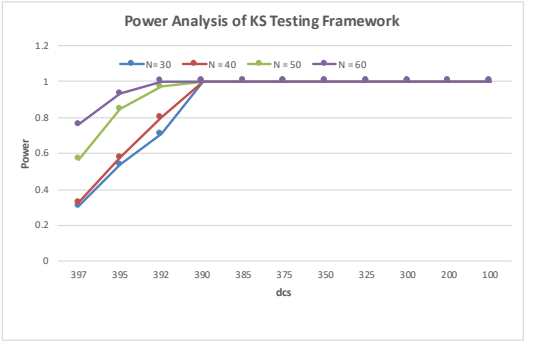

Mahajan et al. 2019, PASC'19

Climate Statistics Reproducibility: Updates

- KS Testing Framework included in E3SM:
  - CIME MVK test to run control and perturbed ensembles
  - EVV:
    - Post processing
    - Run test
    - Publish detailed results on a shareable website
  - CIME publish results on cdash

- Future plans:
  - Expand power analysis for other tuning parameters
  - Incorporate Energy and Kernel tests in EVV
  - Provide bootstrapping and power analysis capabilities in EVV
  - Begin conducting ocean simulation ensembles
    - Identify best strategy
  - Port tests for ocean model