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Comparison of Fatigue Cycle Identification Methods

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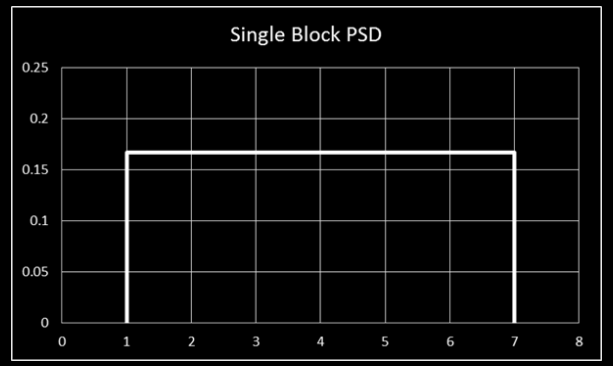
Comparison of Fatigue Cycle Identification Methods

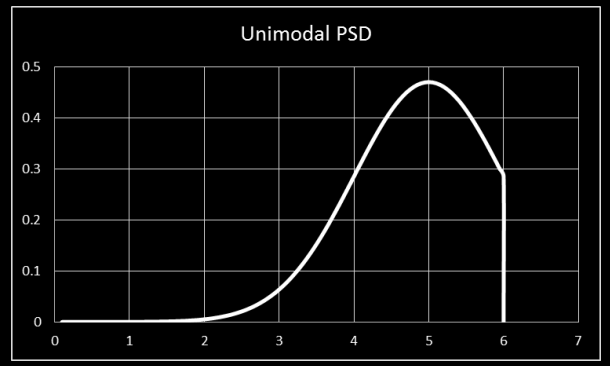
- Simple range count vs. range pair count vs. rainflow count
  - **ASTM E1049 – 85 (2011) "Standard Practices for Cycle Counting in Fatigue Analysis**

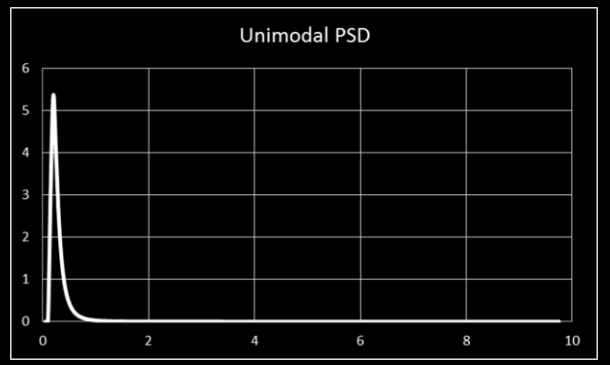
- "The rain flow cycle counting method allows satisfactory predictions of the effects of different block sizes, different sequences of applying the same strain peaks, and superimposed loadings."
- "The range pair counting method is nearly identical to the rain flow method, but the use of any of the other well known cycle counting methods, such as peak counting, level crossing counting, or range counting, can result in large differences between predicted and actual fatigue lives."
- "The use of any method of cycle counting other than the range pair or rain flow methods can result in inconsistencies and gross differences between predicted and actual fatigue lives."
  - Dowling, N. E., "Fatigue Failure Predictions for Complicated Stress-Strain Histories", Department of Theoretical and Applied Mechanics, University of Illinois, Urbana, Illinois, T. & A. M. REPORT NO. 337, January 1971. (Sponsored by Naval Air Development Center, Warminster, Pennsylvania 18974, Contract No. N00156-70-C-1256)

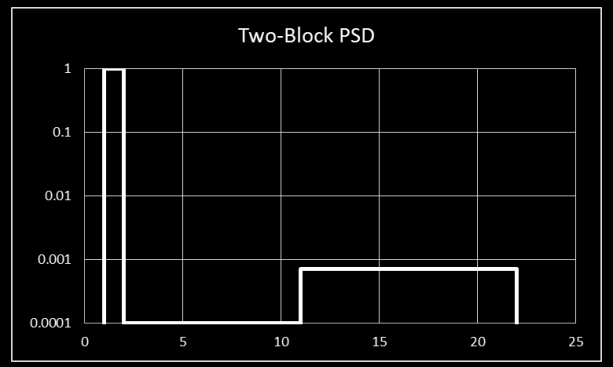
Comparison of Fatigue Cycle Identification Methods

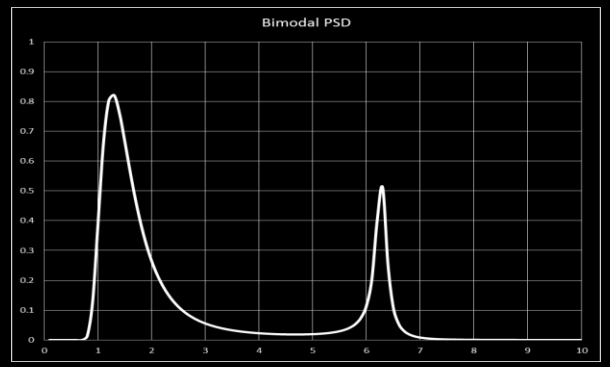
- Practical range of fatigue exponent: m = 3.324 and m = 7.3
- Power Spectral Densities Studied
  - Single Block
  - Unimodal
  - Two-Block
  - Bimodal



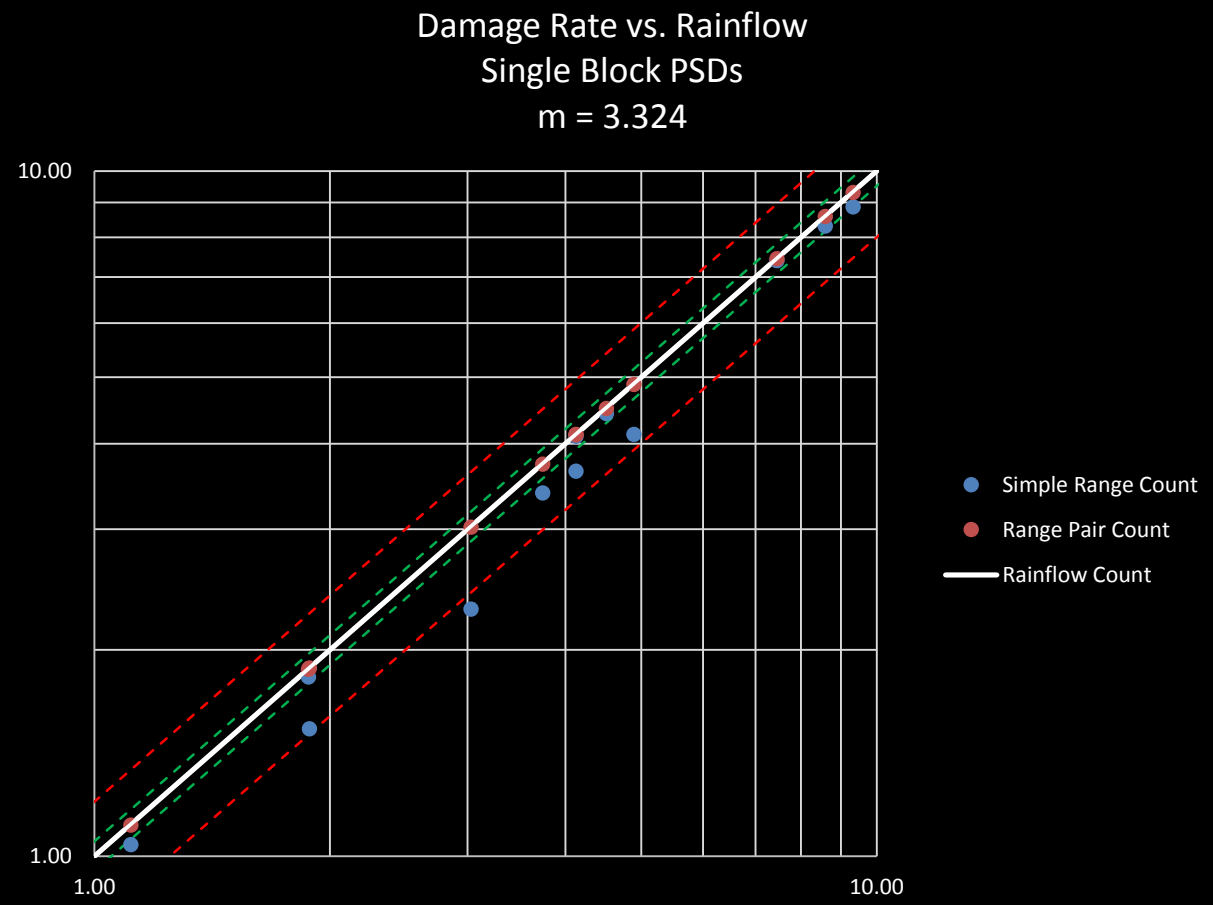


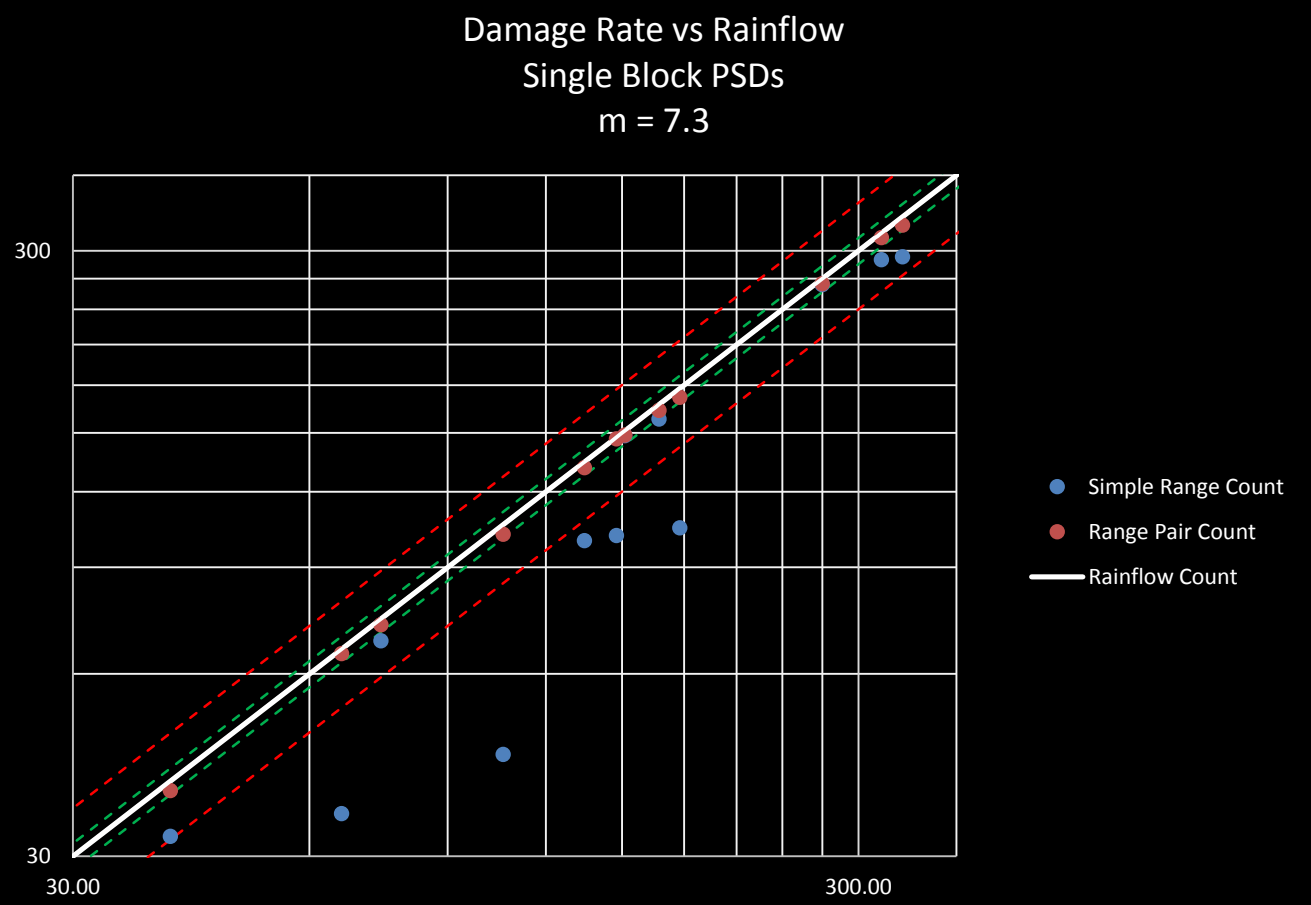




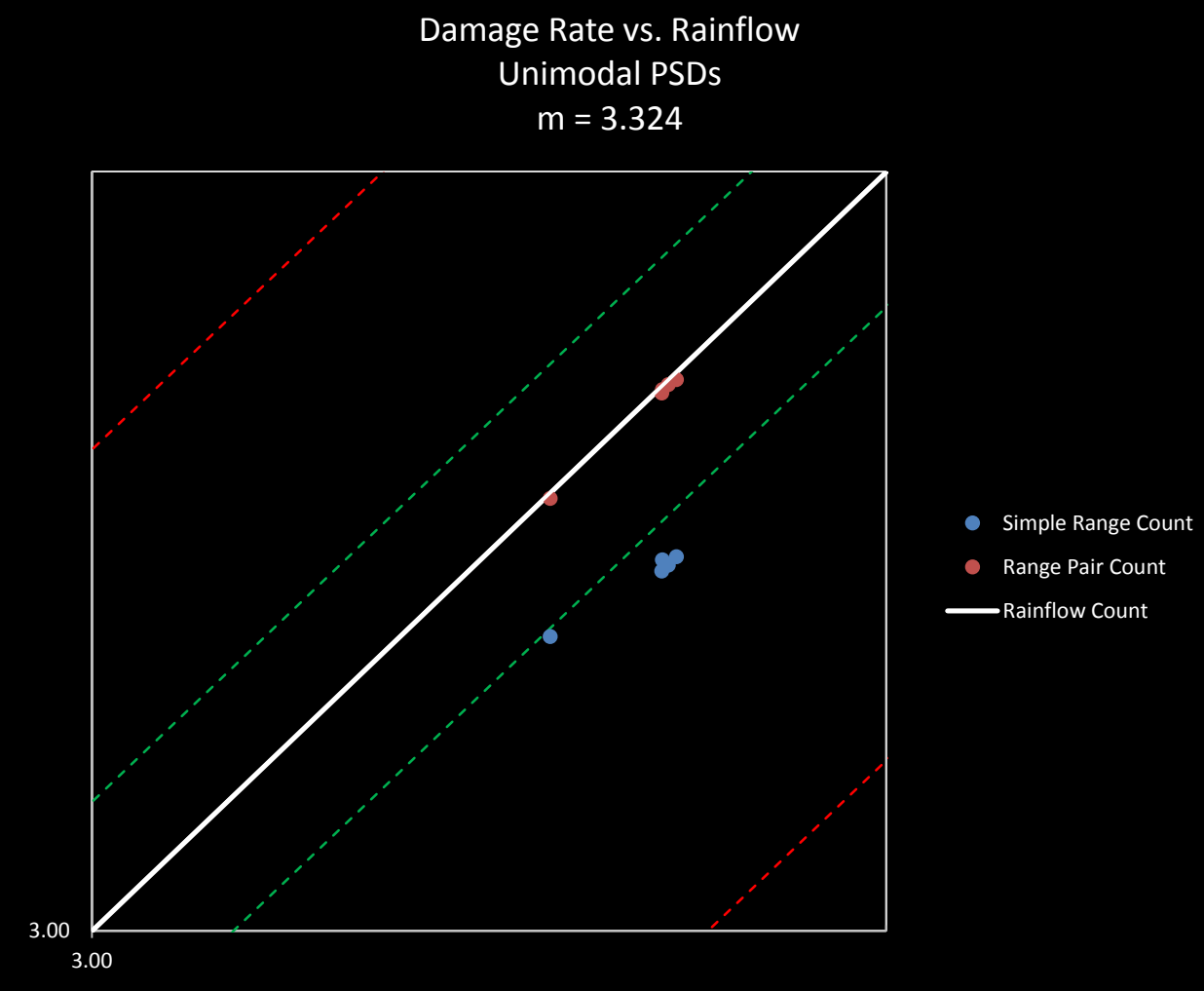


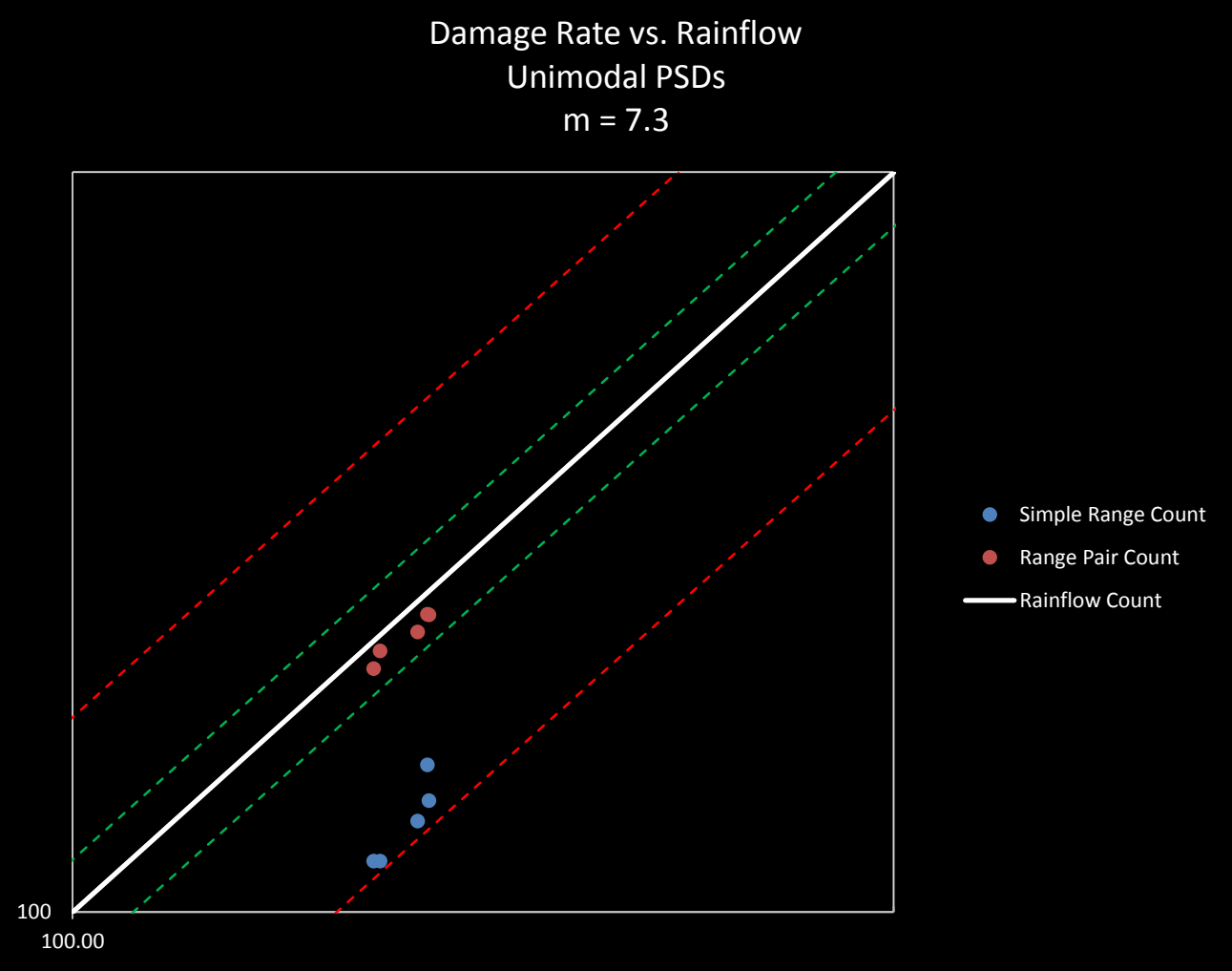
Damage Rate Comparison
Single Block PSDs



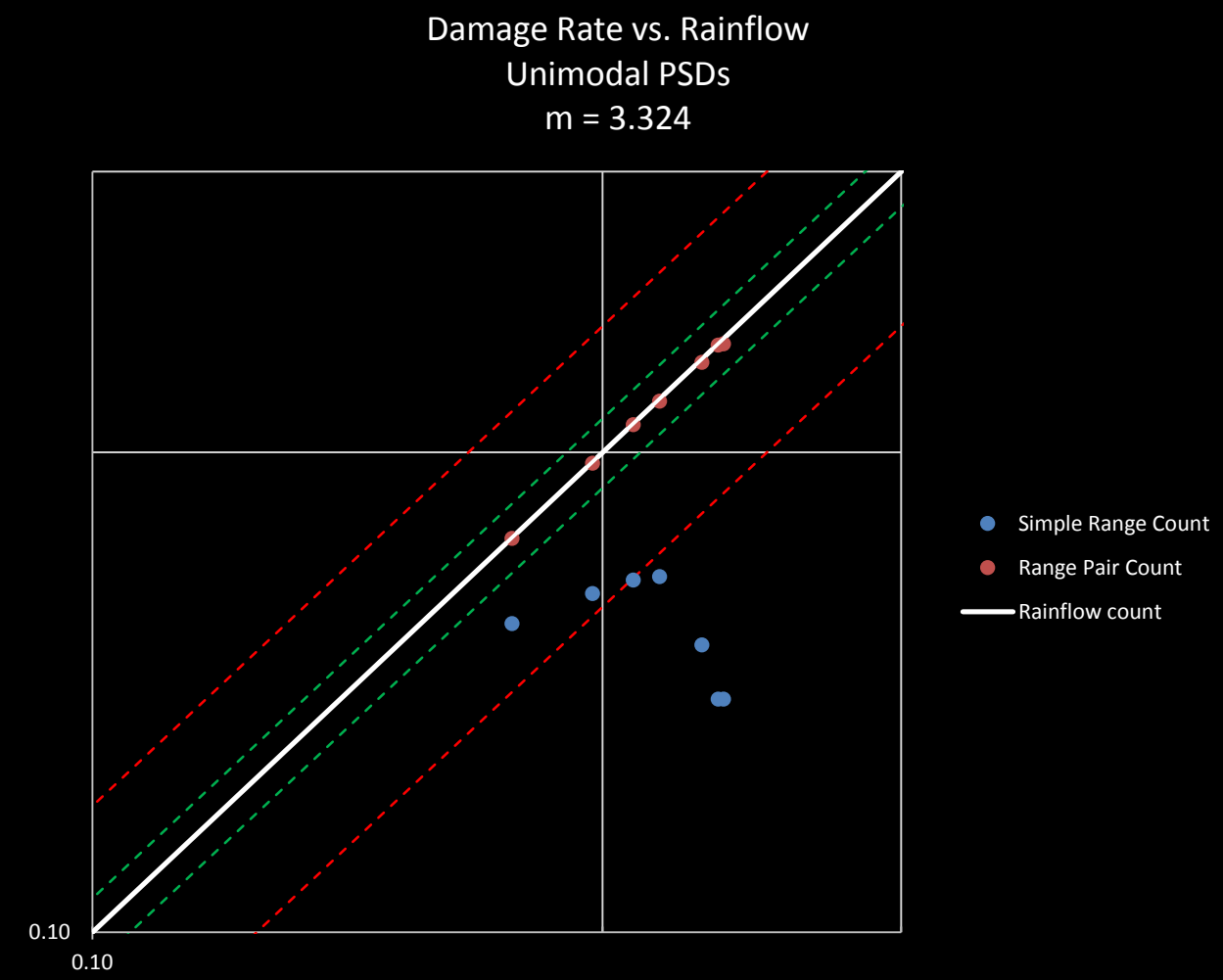


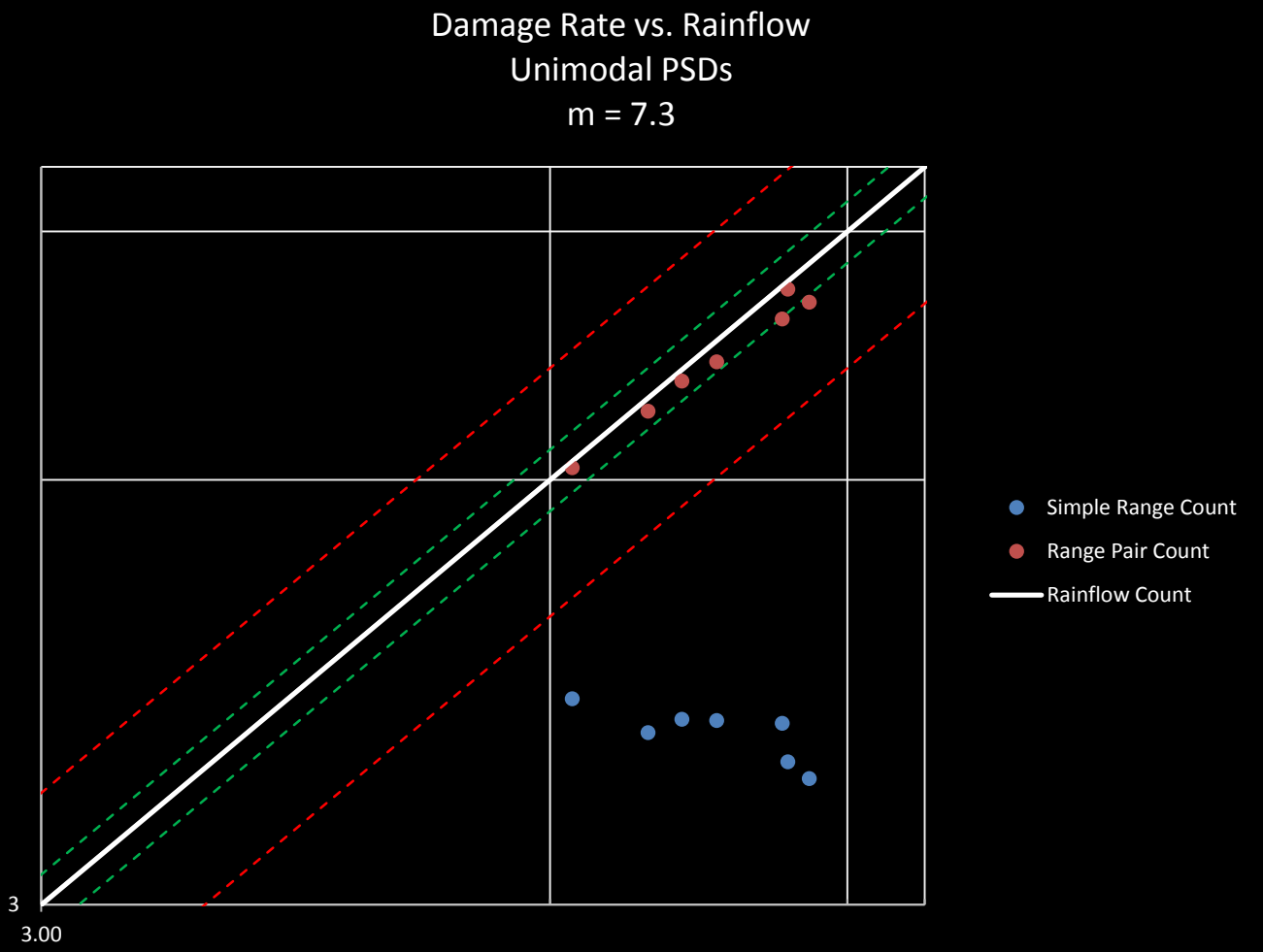
Damage Rate Comparison
Unimodal PSDs



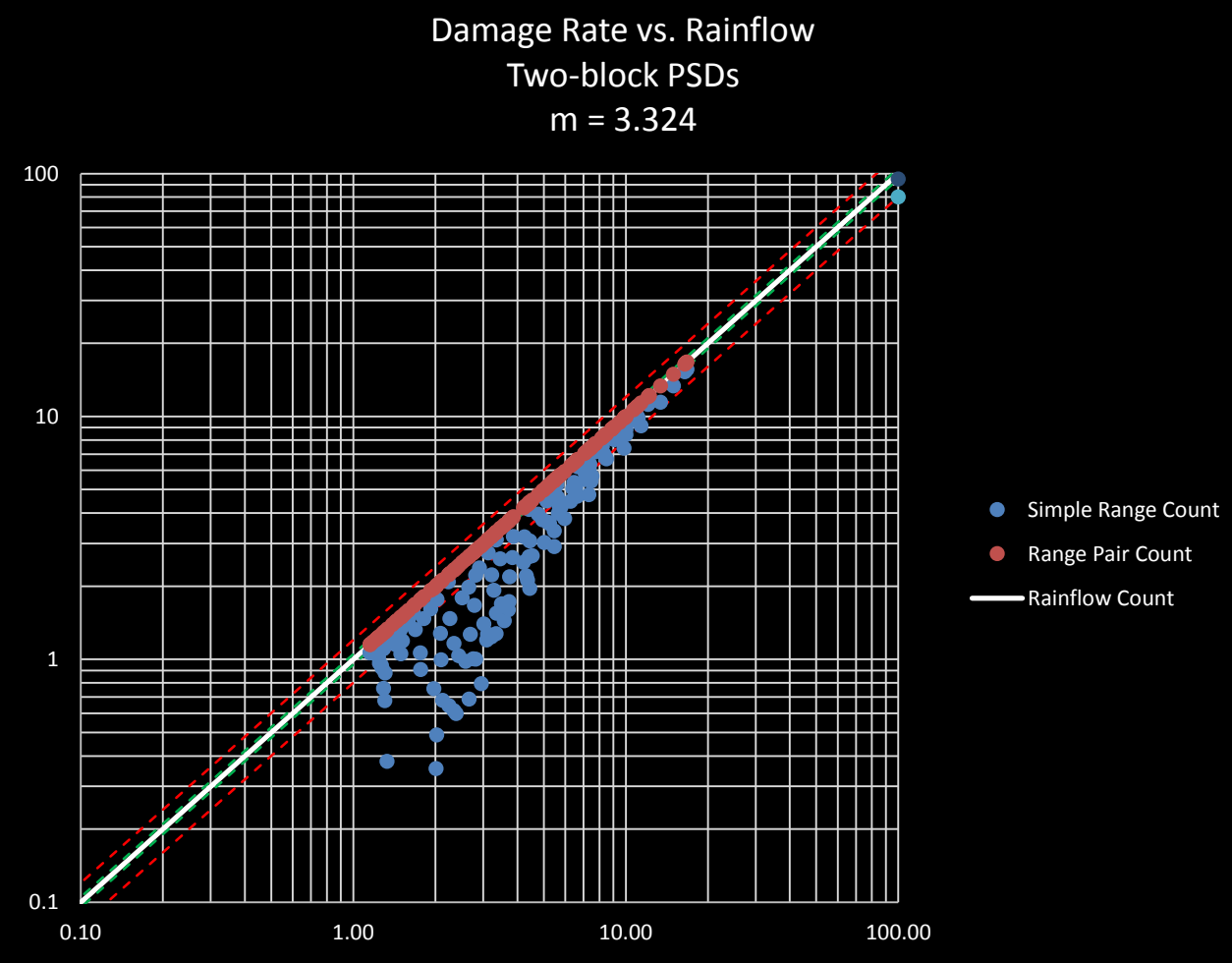


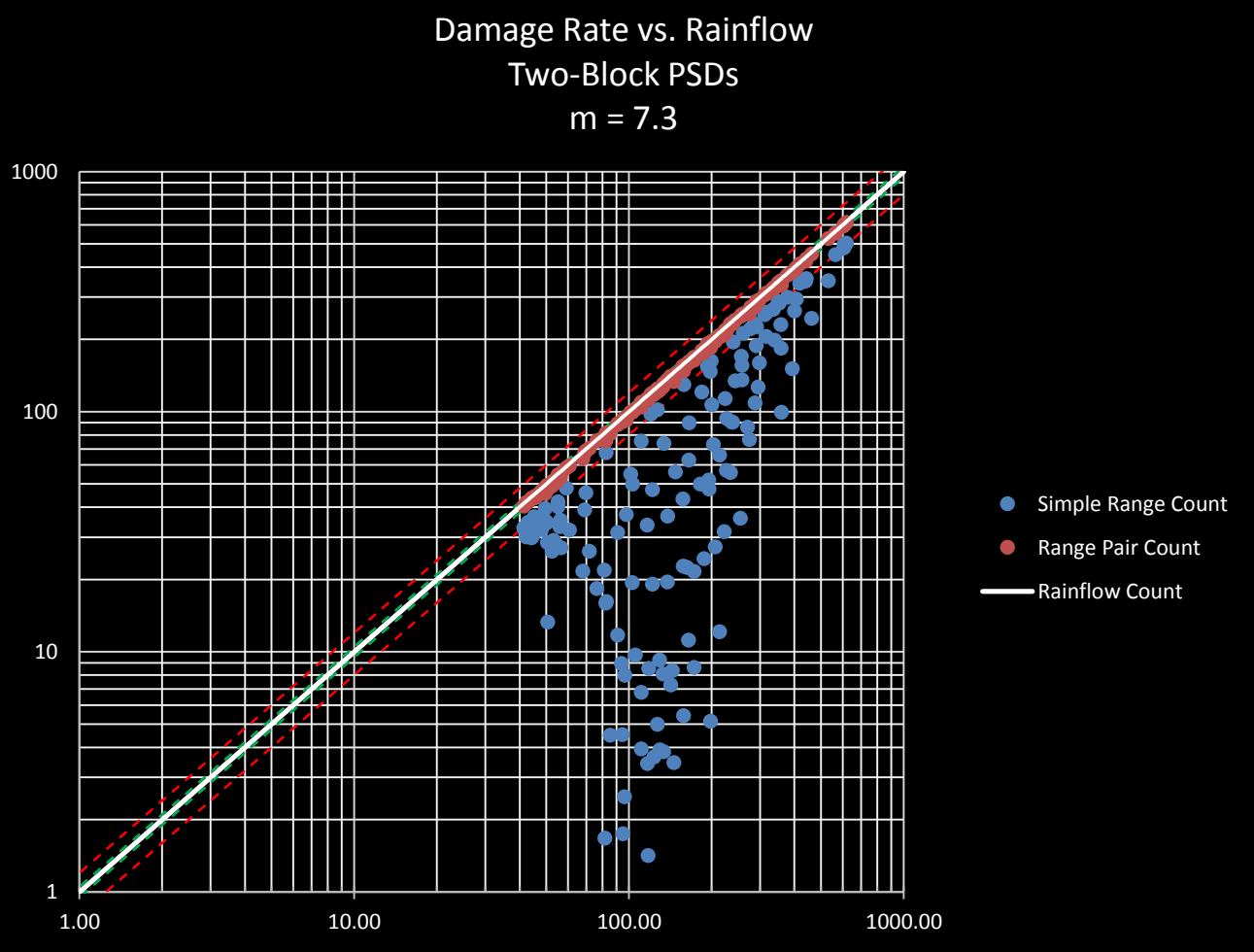
Damage Rate Comparison
Unimodal PSDs



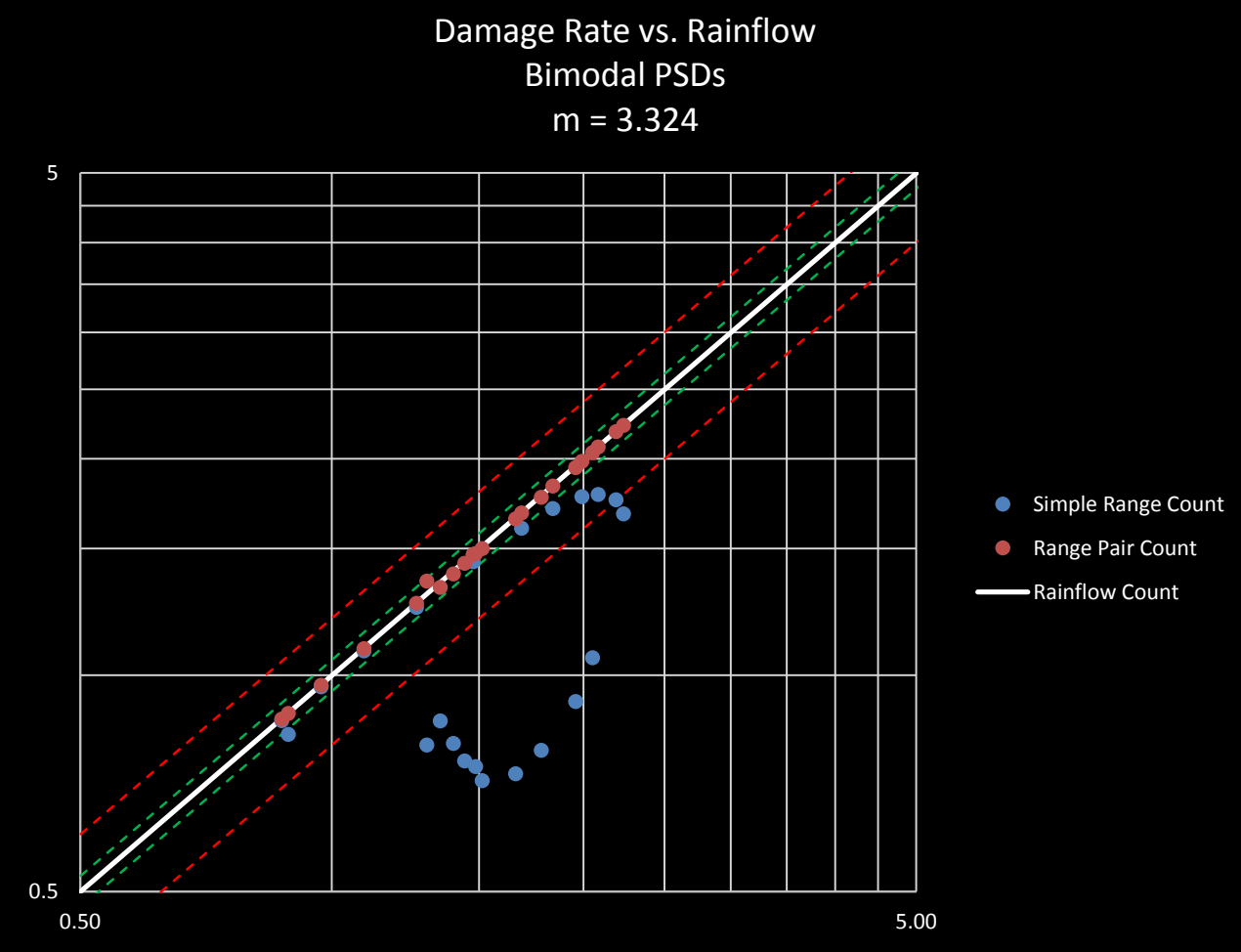


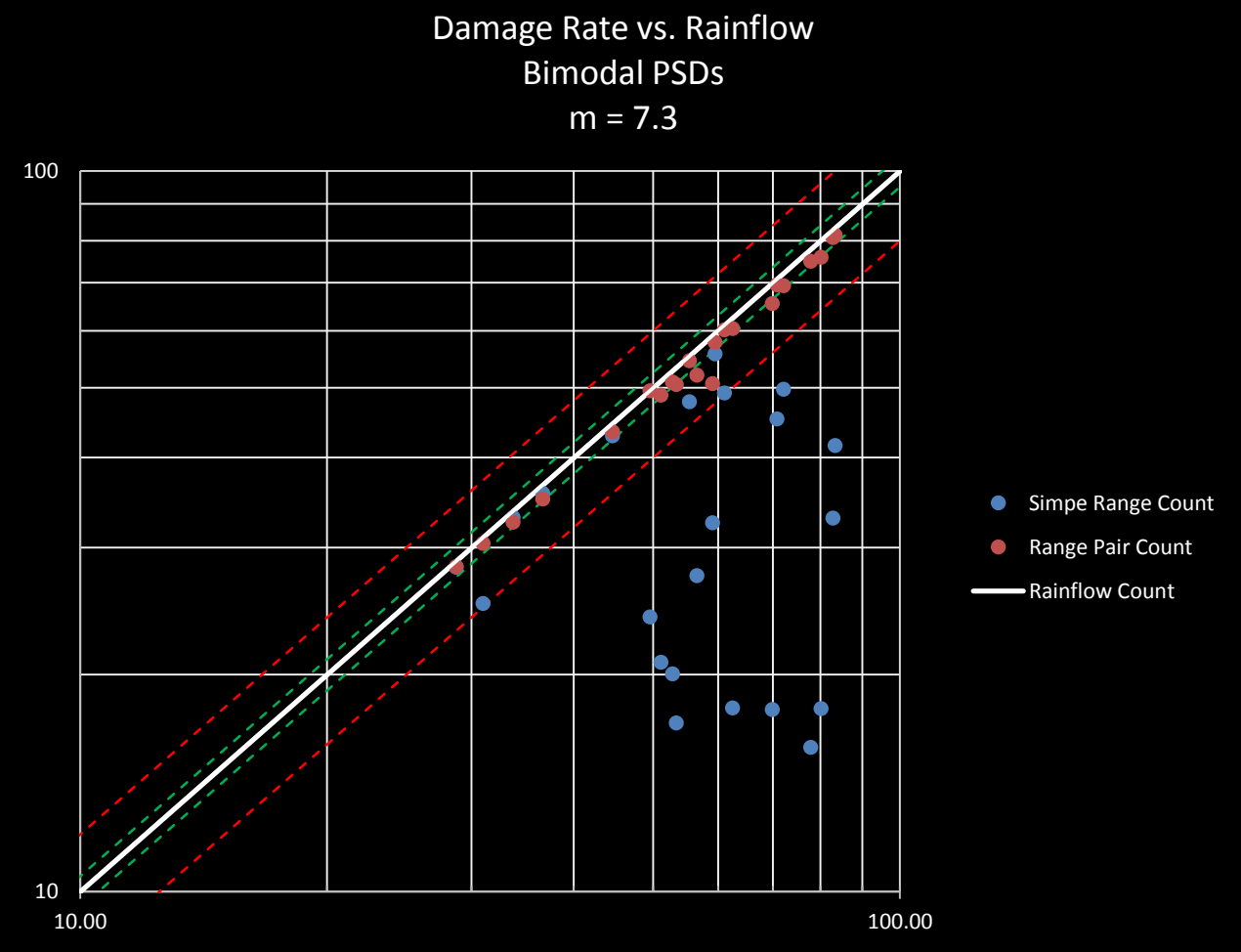
Damage Rate Comparison
Two-Block PSDs





Damage Rate Comparison
Bimodal PSDs



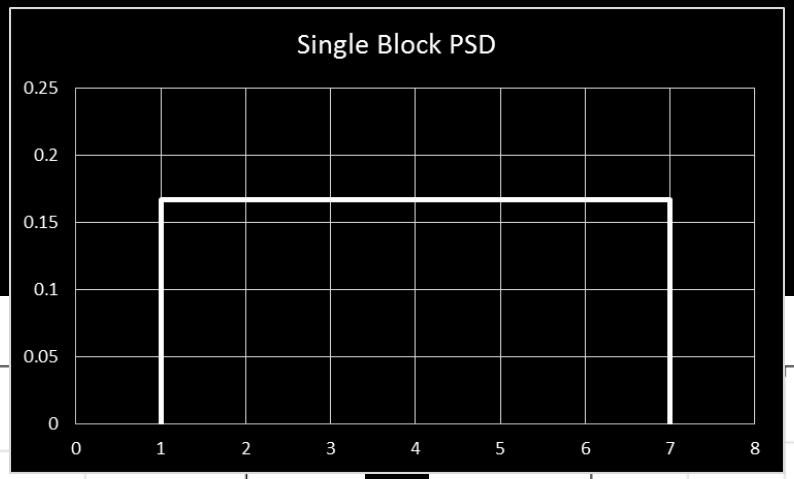


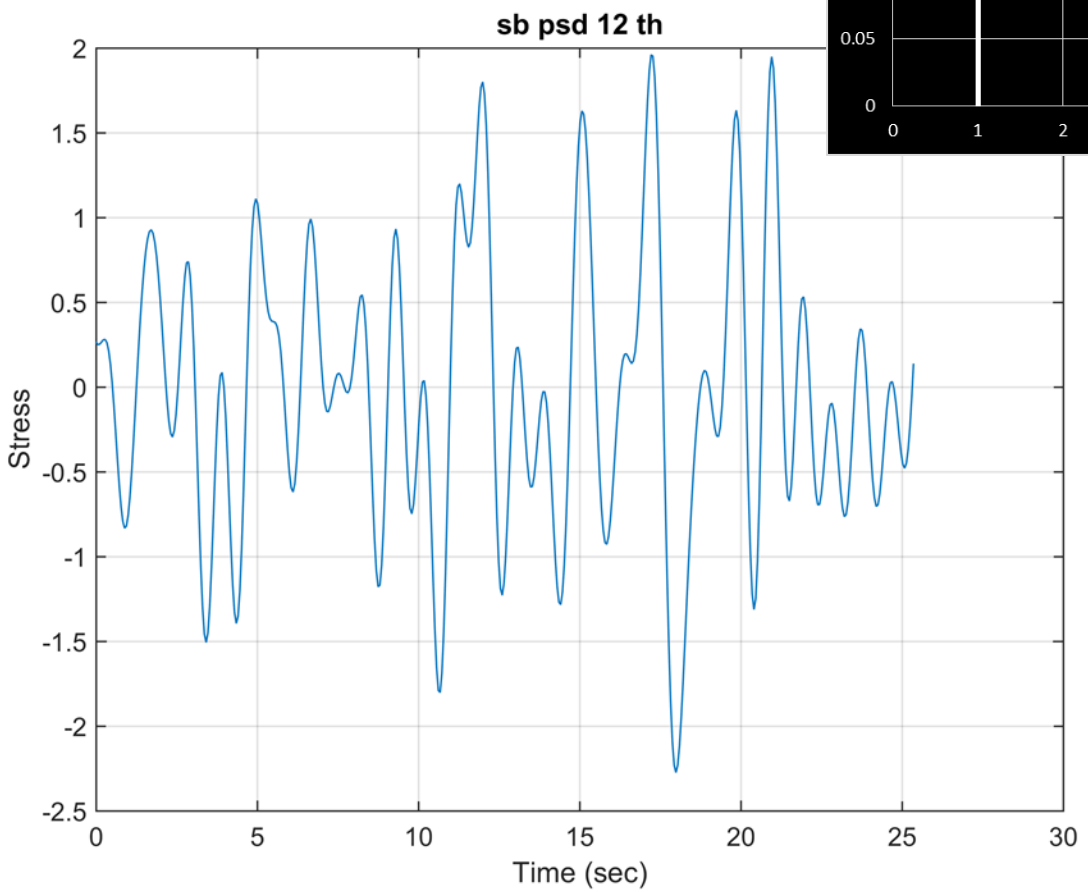
Conclusion

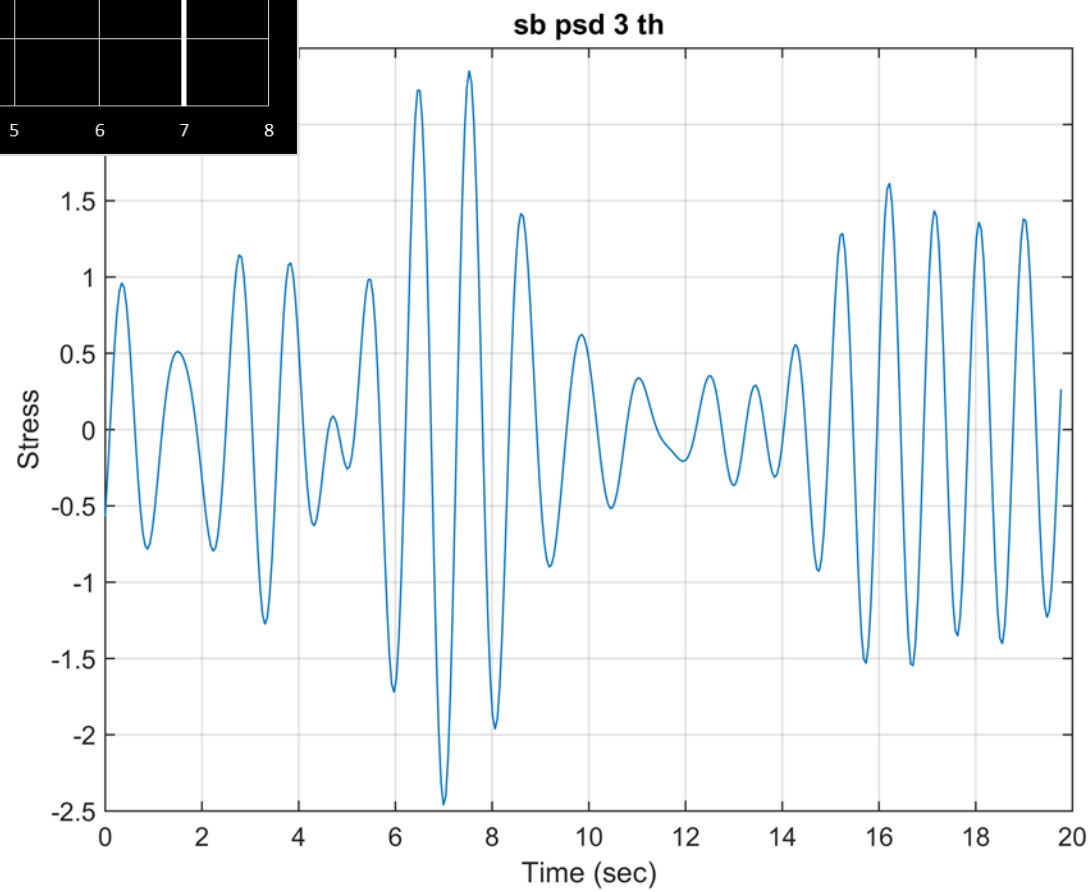
- Reiterate conclusions of Dowling and others
  - Rainflow cycle identification method preferred (conservative)
  - Range-pair method nearly equivalent
  - Simple range counting can be very unconservative
    - Small cycles can do “negative damage” as superimposed on large cycles that are consequently not counted
    - If a specific usage of simple range counting must be validated by rainflow, why not use rainflow in the first place?

Appendix

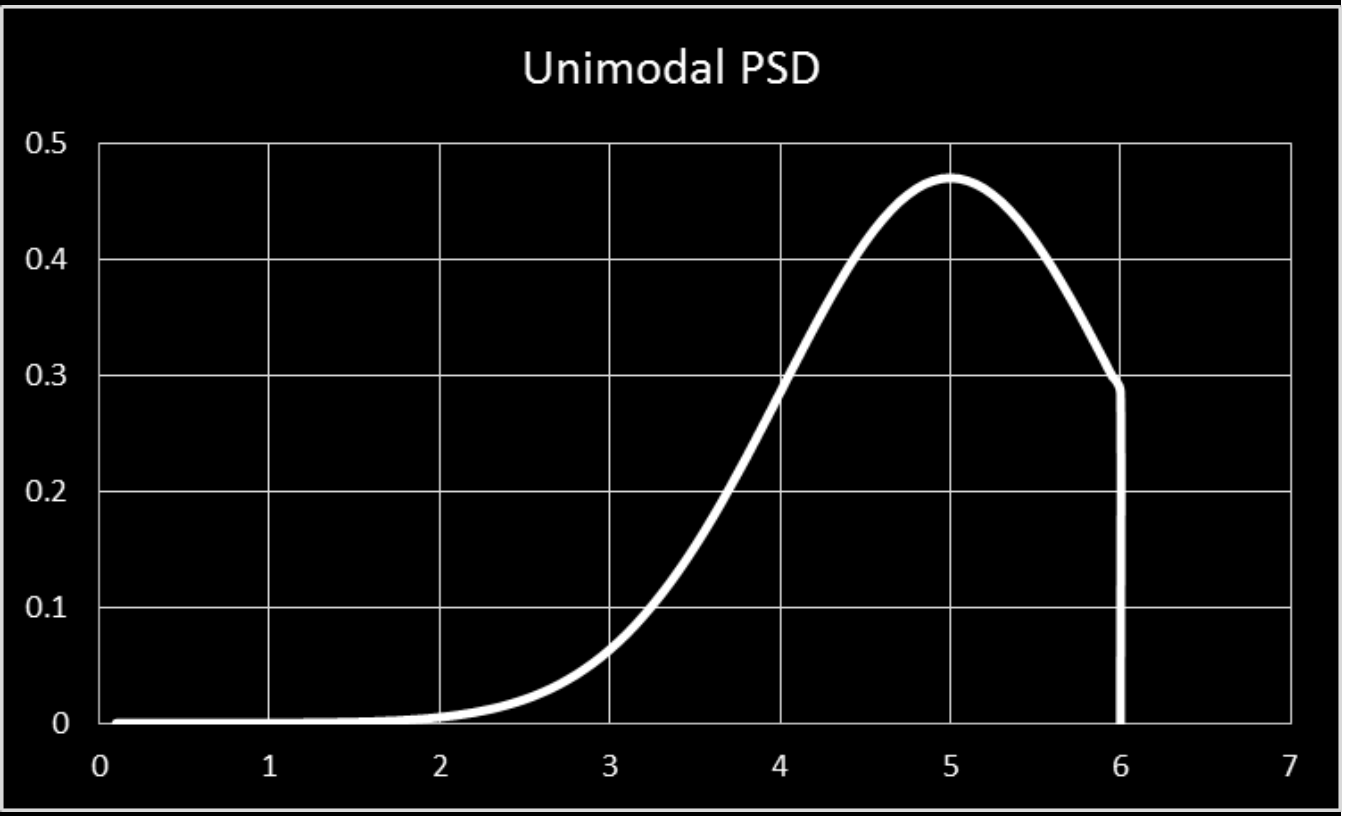
PSD and Time History Example Plots Single Block

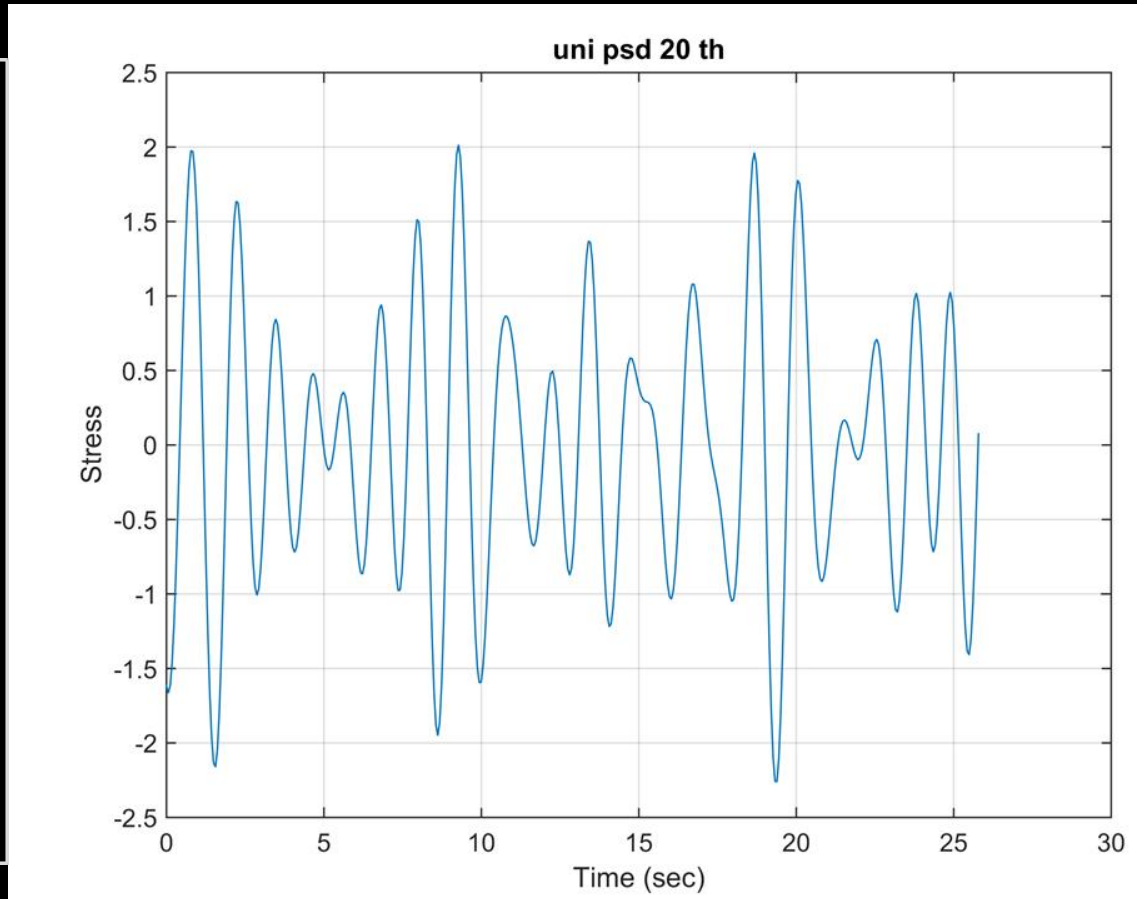




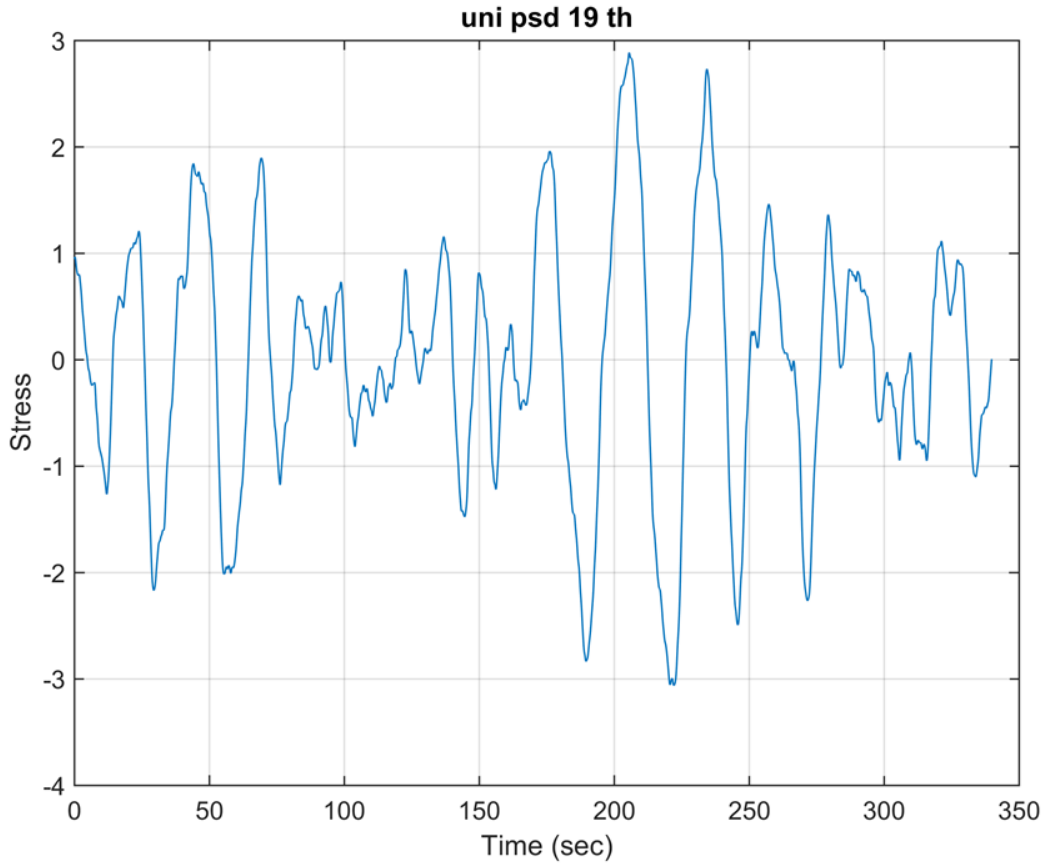


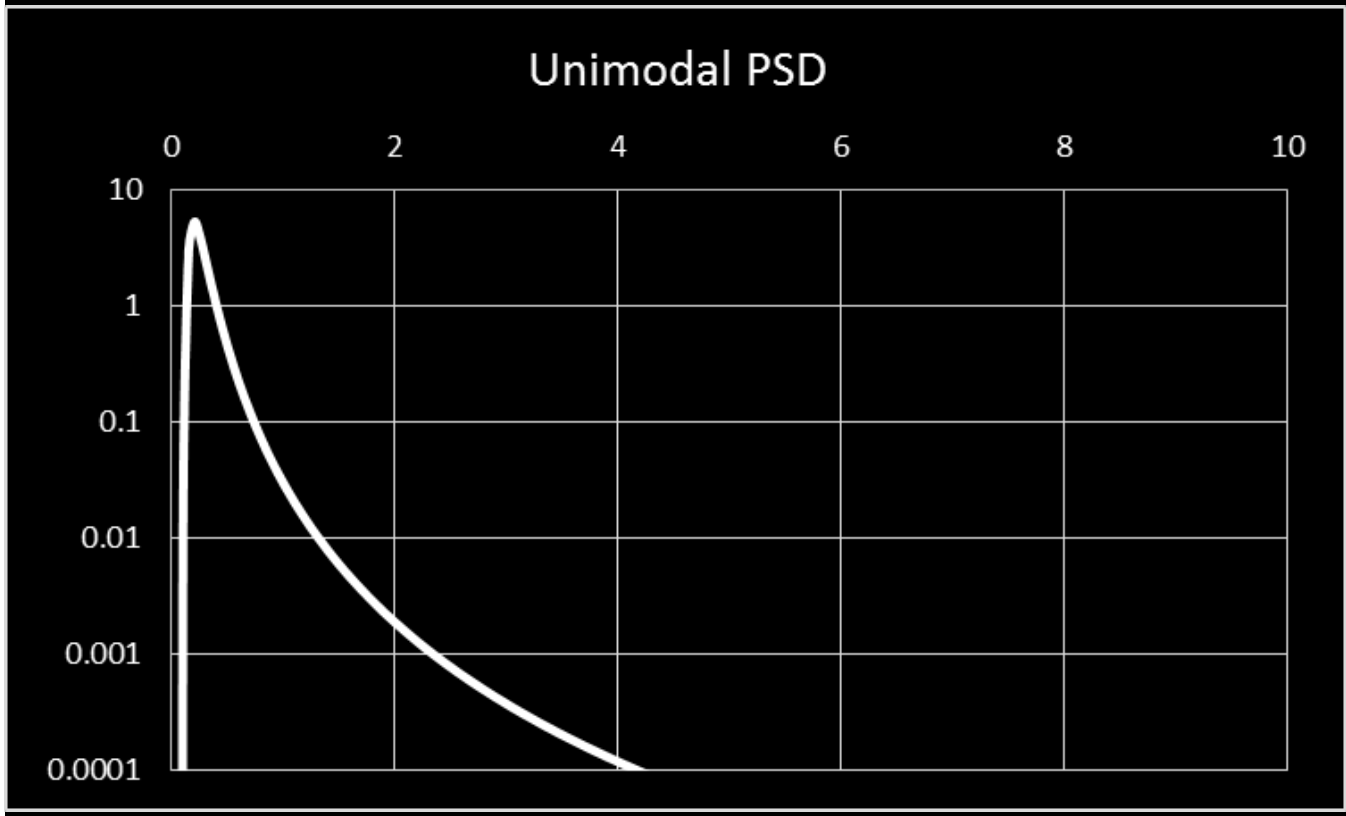
PSD and Time History Example Plots Unimodal



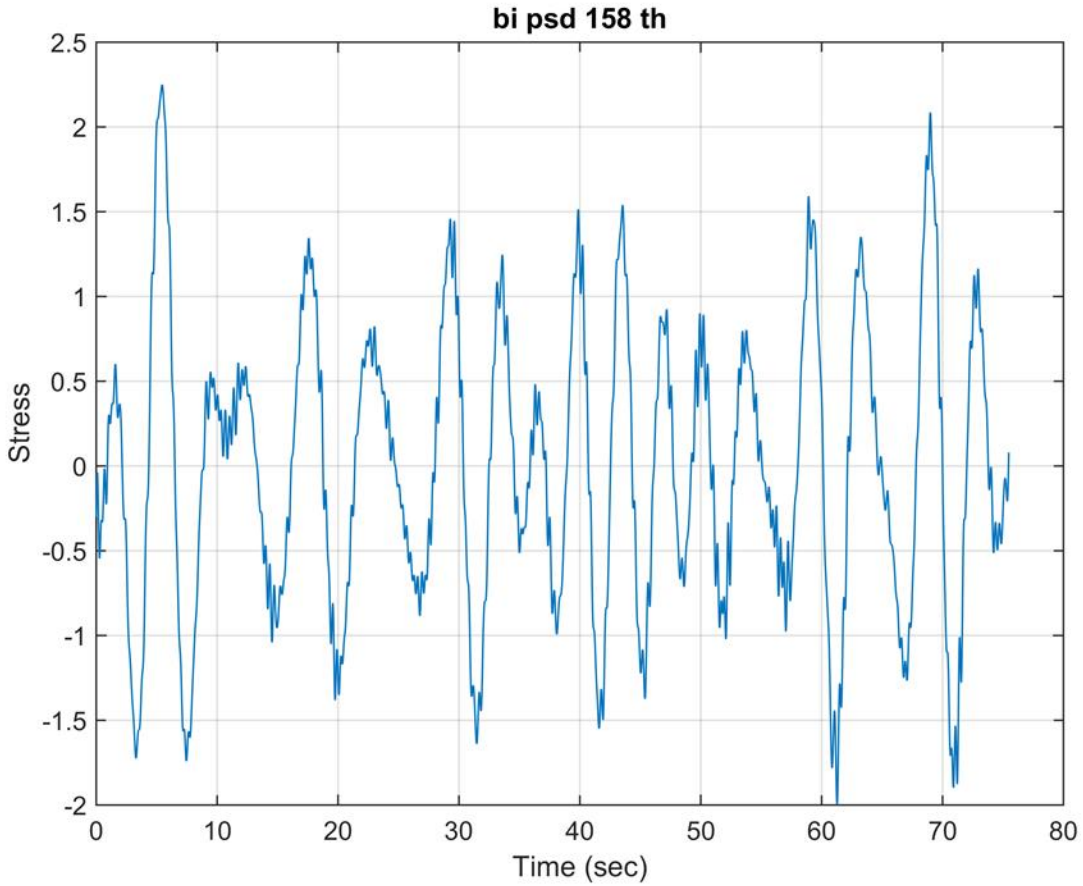


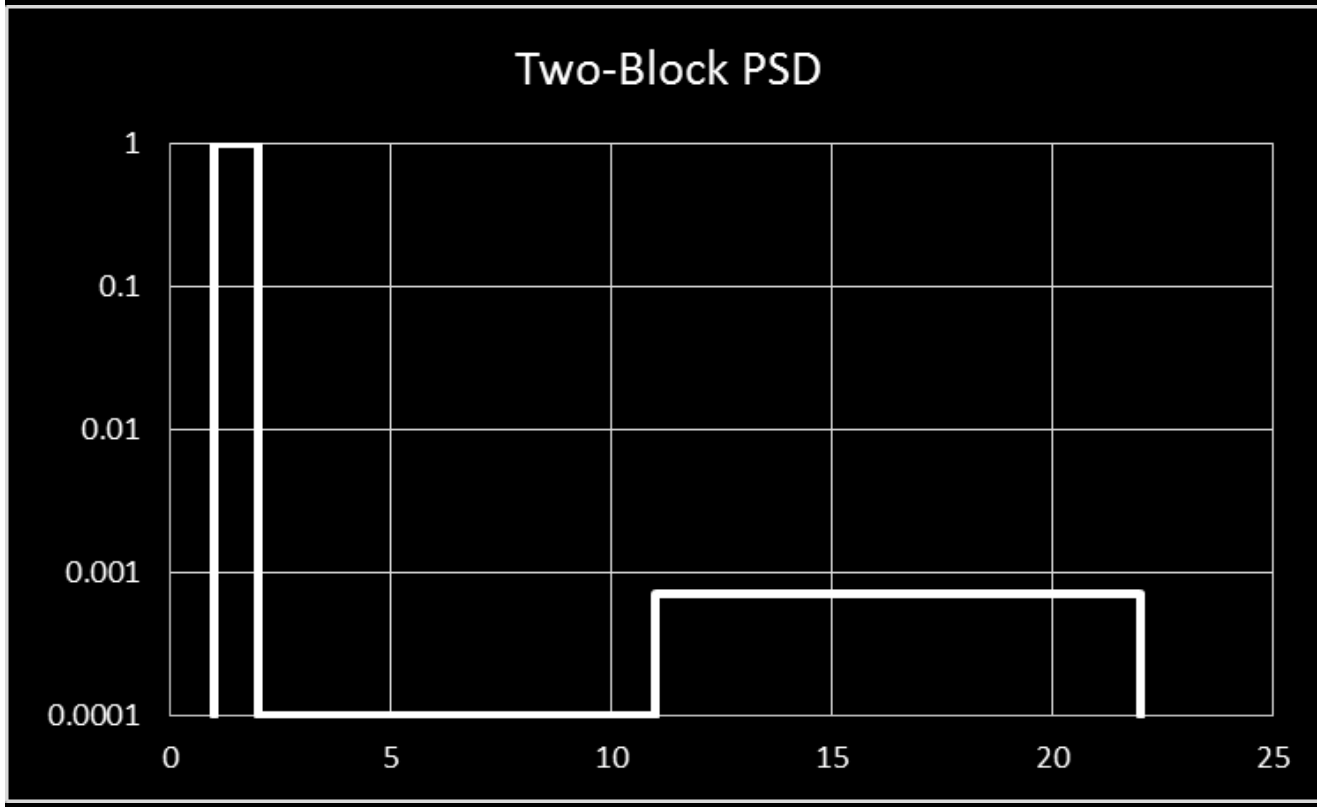
PSD and Time History Example Plots Unimodal



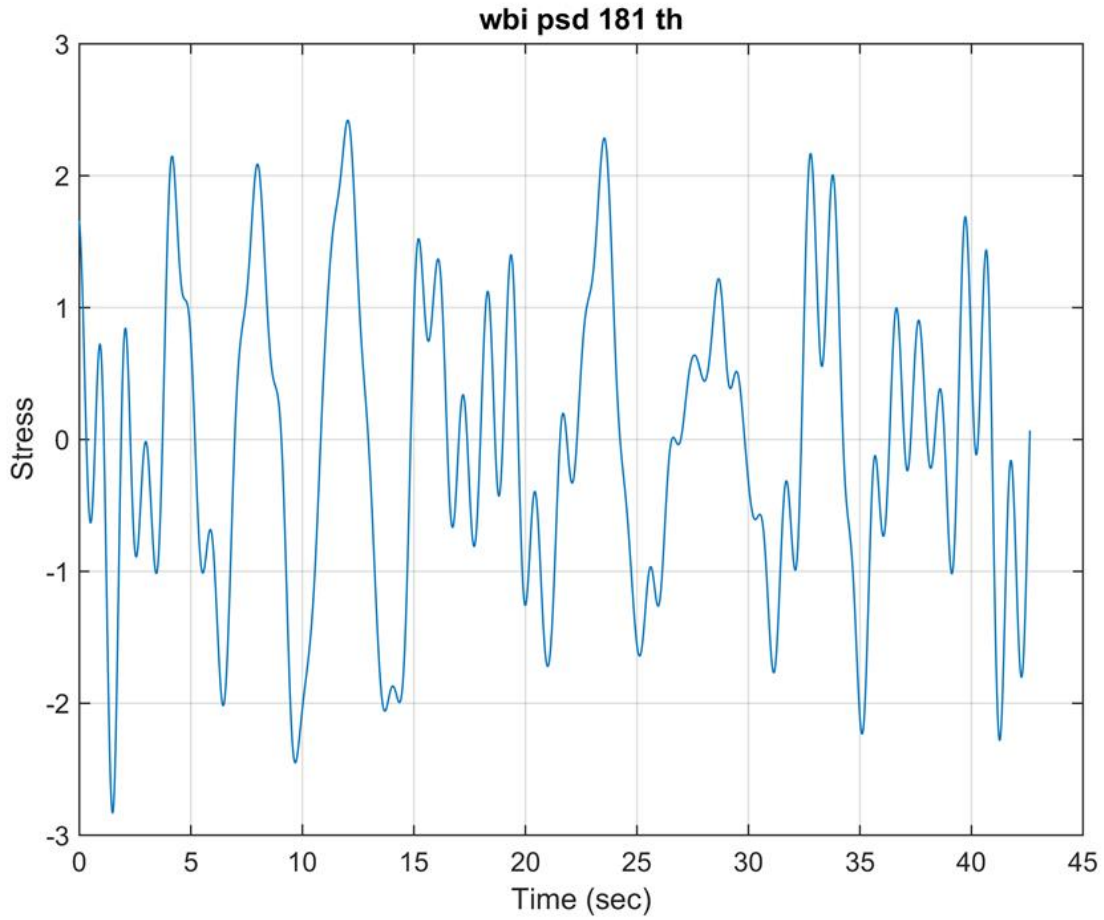


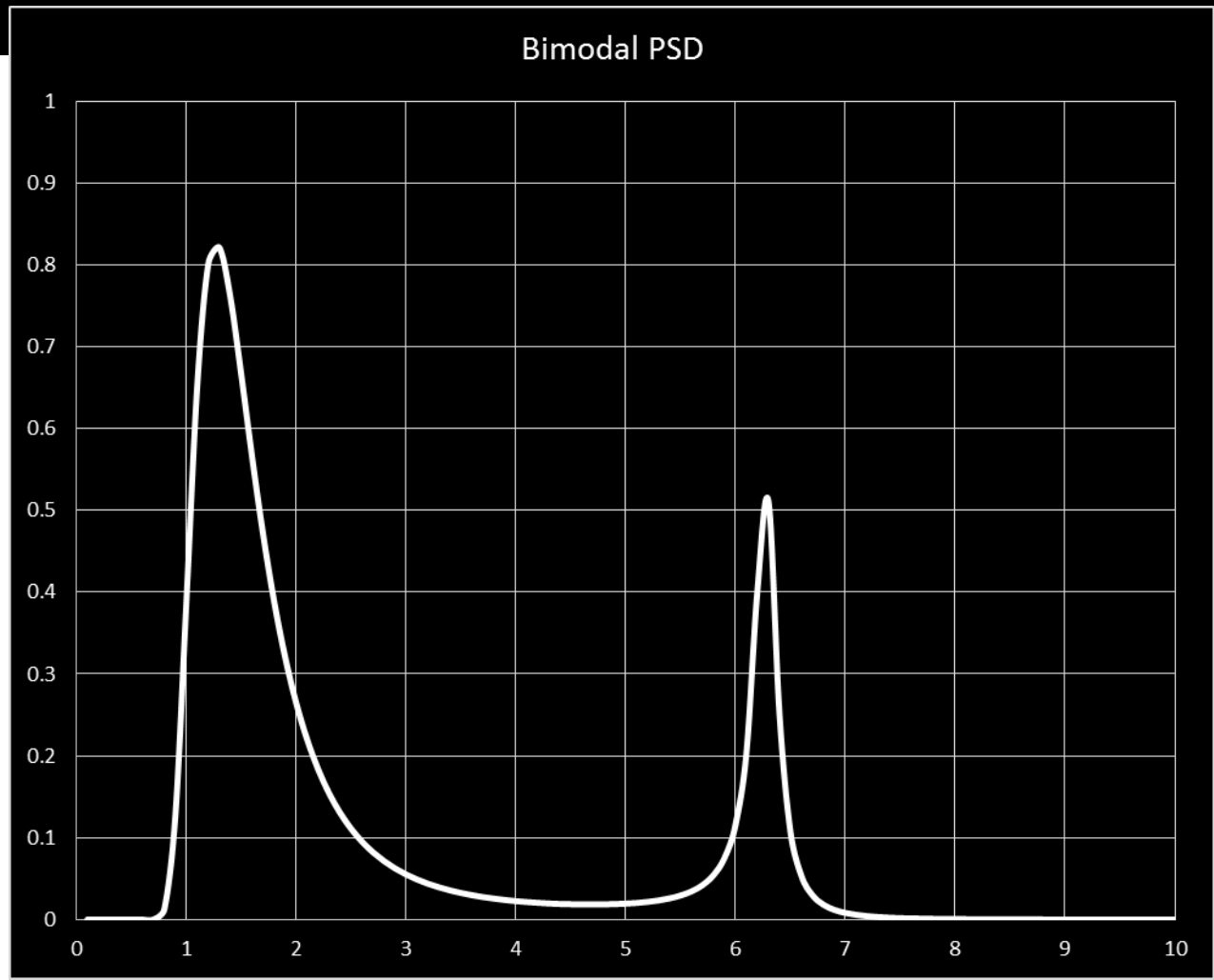
PSD and Time History Example Plots
Two-block





PSD and Time History Example Plots
Bimodal

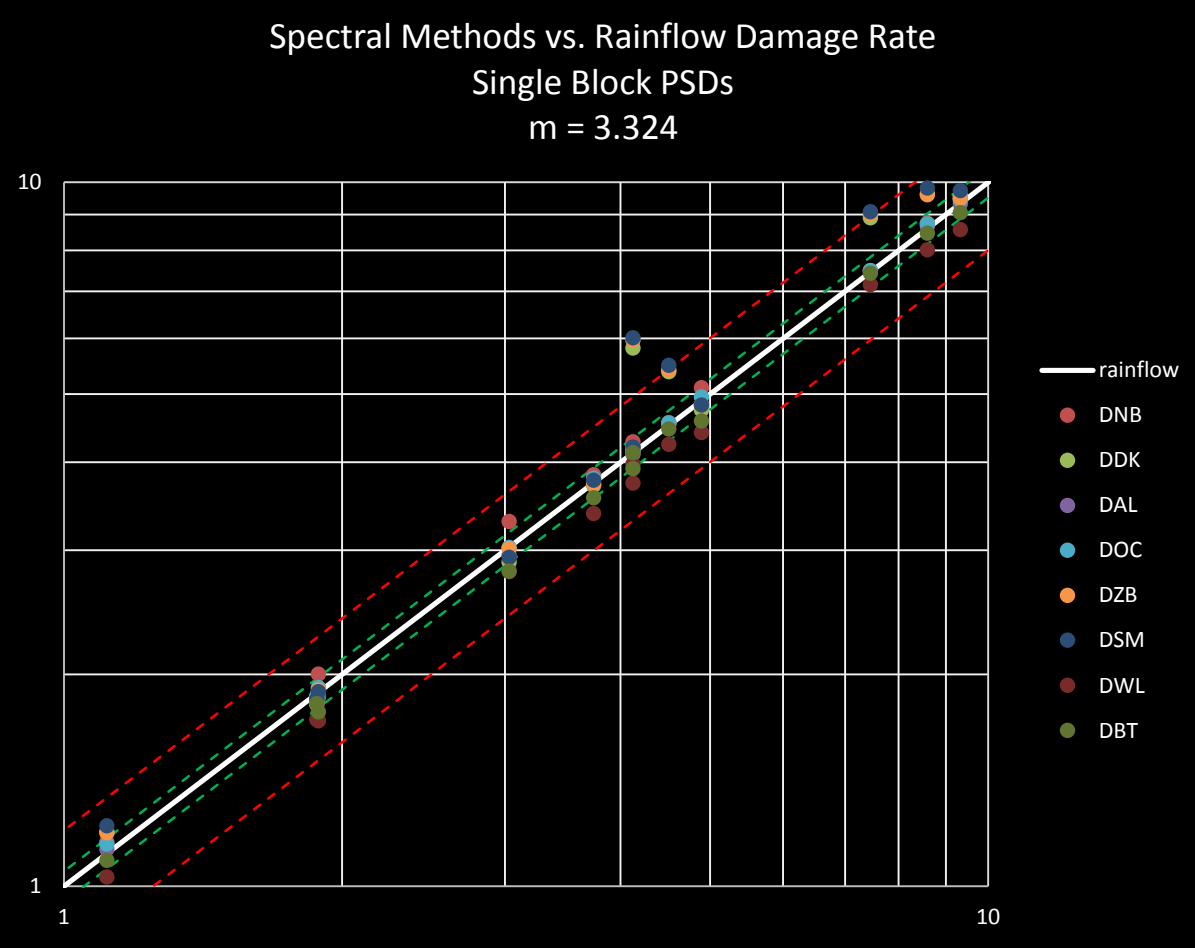


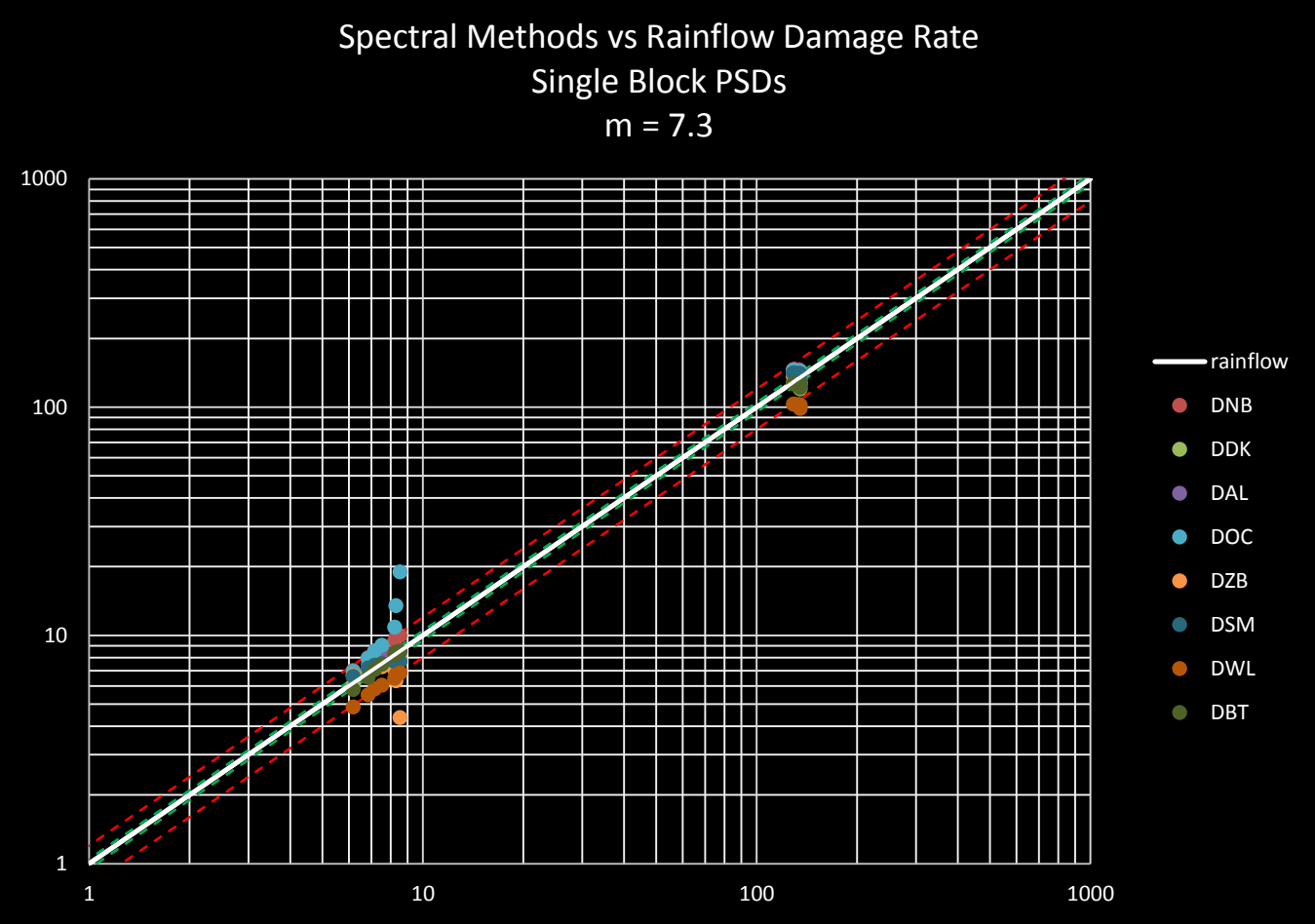


Comparison of Spectral Fatigue Methods

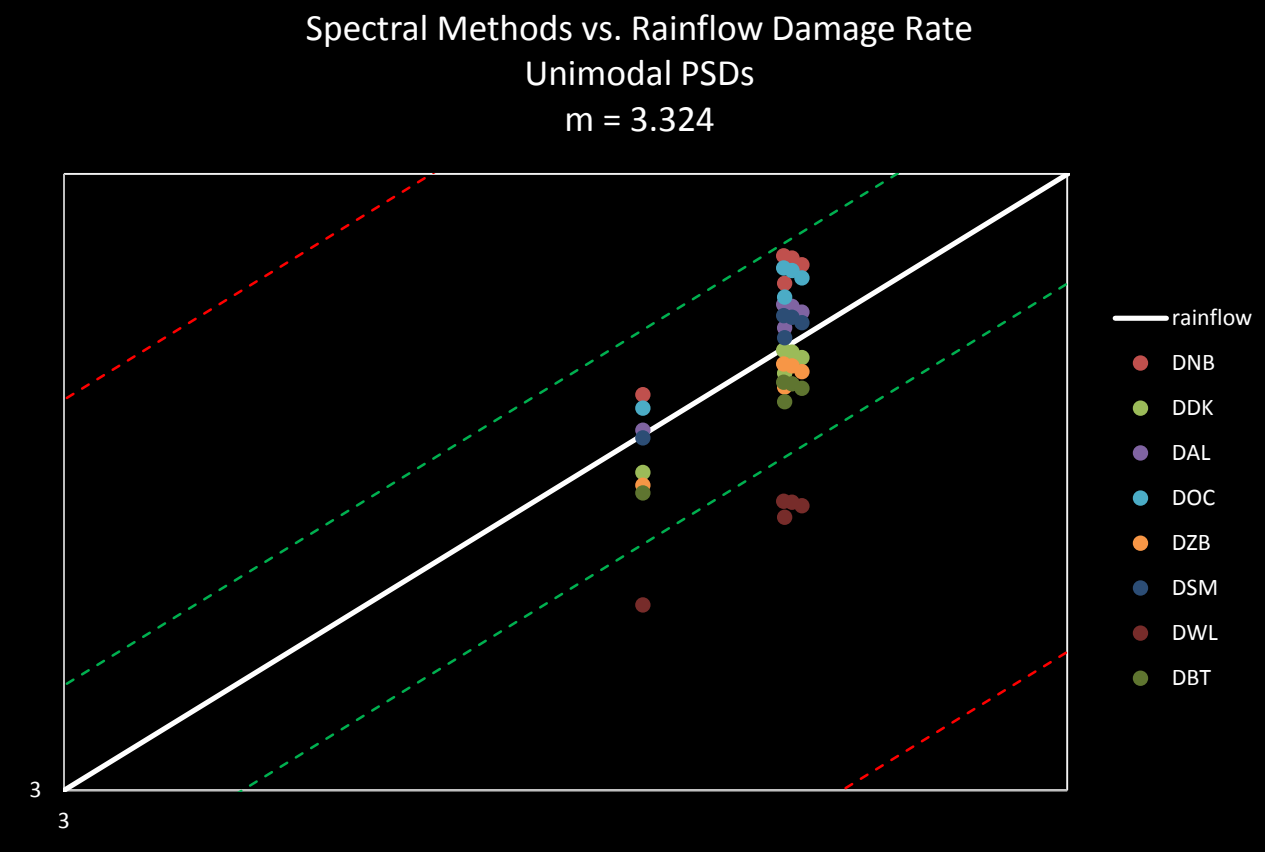
- Various published spectral methods compared vs. rainflow cycle identification
  - Narrow band or Rayleigh approximation (NB)
  - Dirlik (DK)
  - Alpha 0.75 (AL)
  - Ortiz and Chen (OC)
  - Zhao and Baker (ZB)
  - Single Moment (SM)
  - Wirsching and Light (WL)
  - Benasciutti and Tovo (BT)

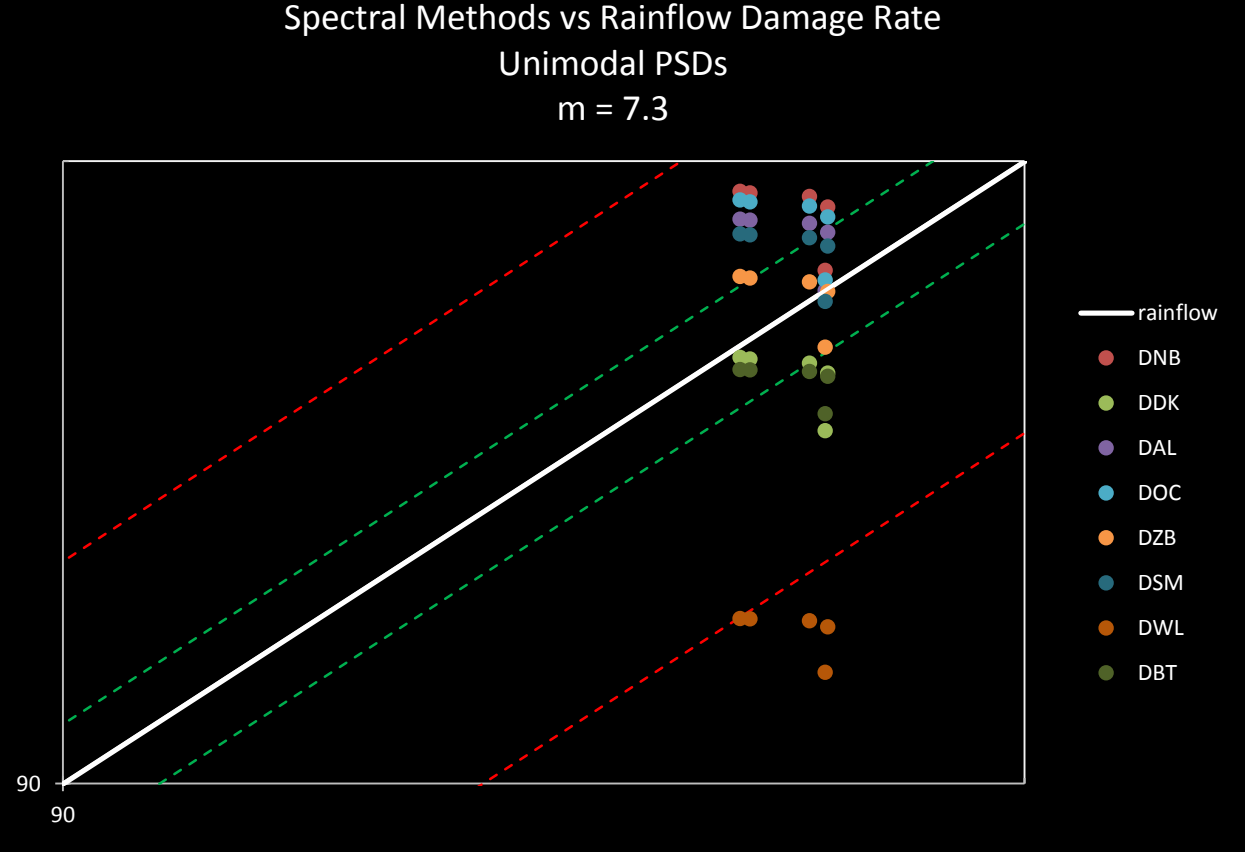
Damage Rate Comparison
Single Block PSDs





Damage Rate Comparison
Unimodal PSDs





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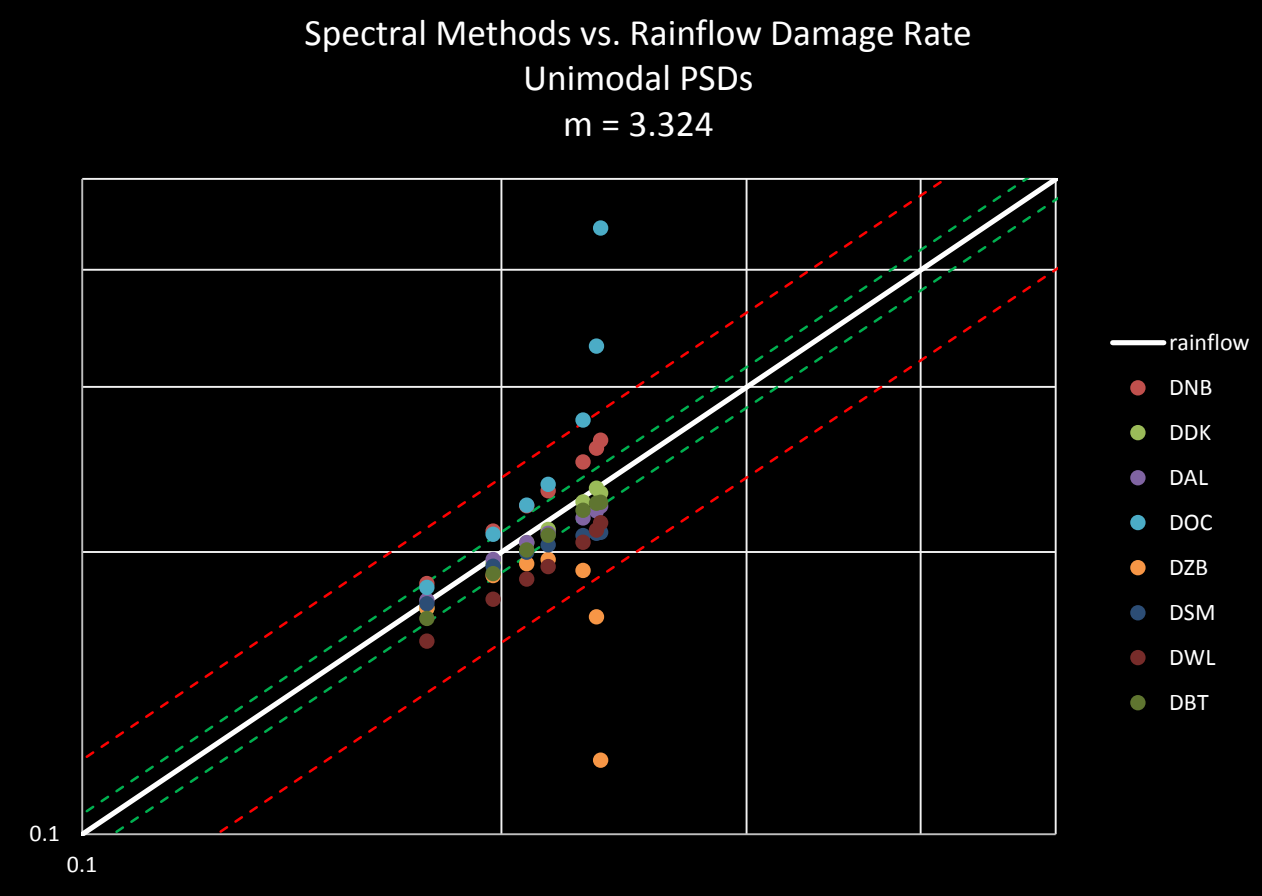
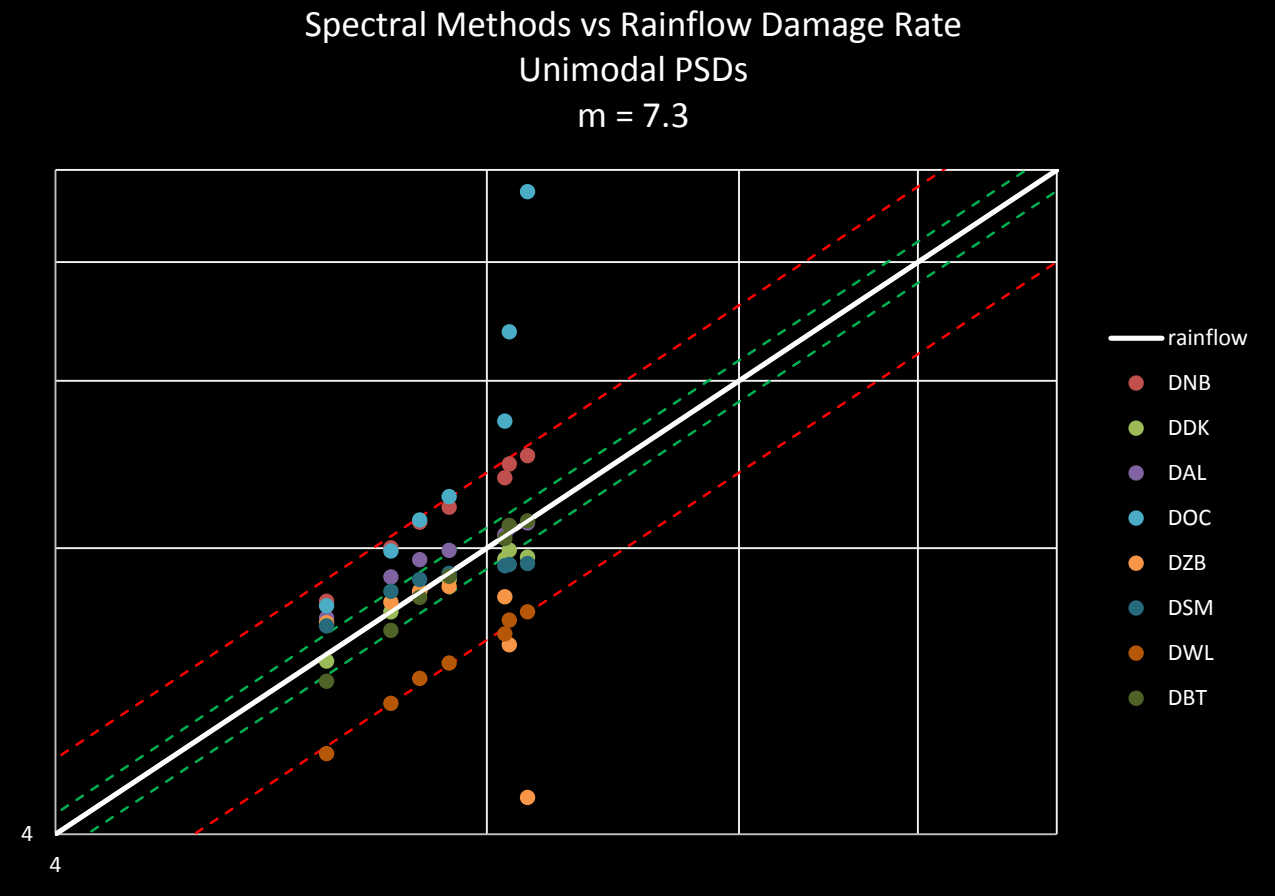
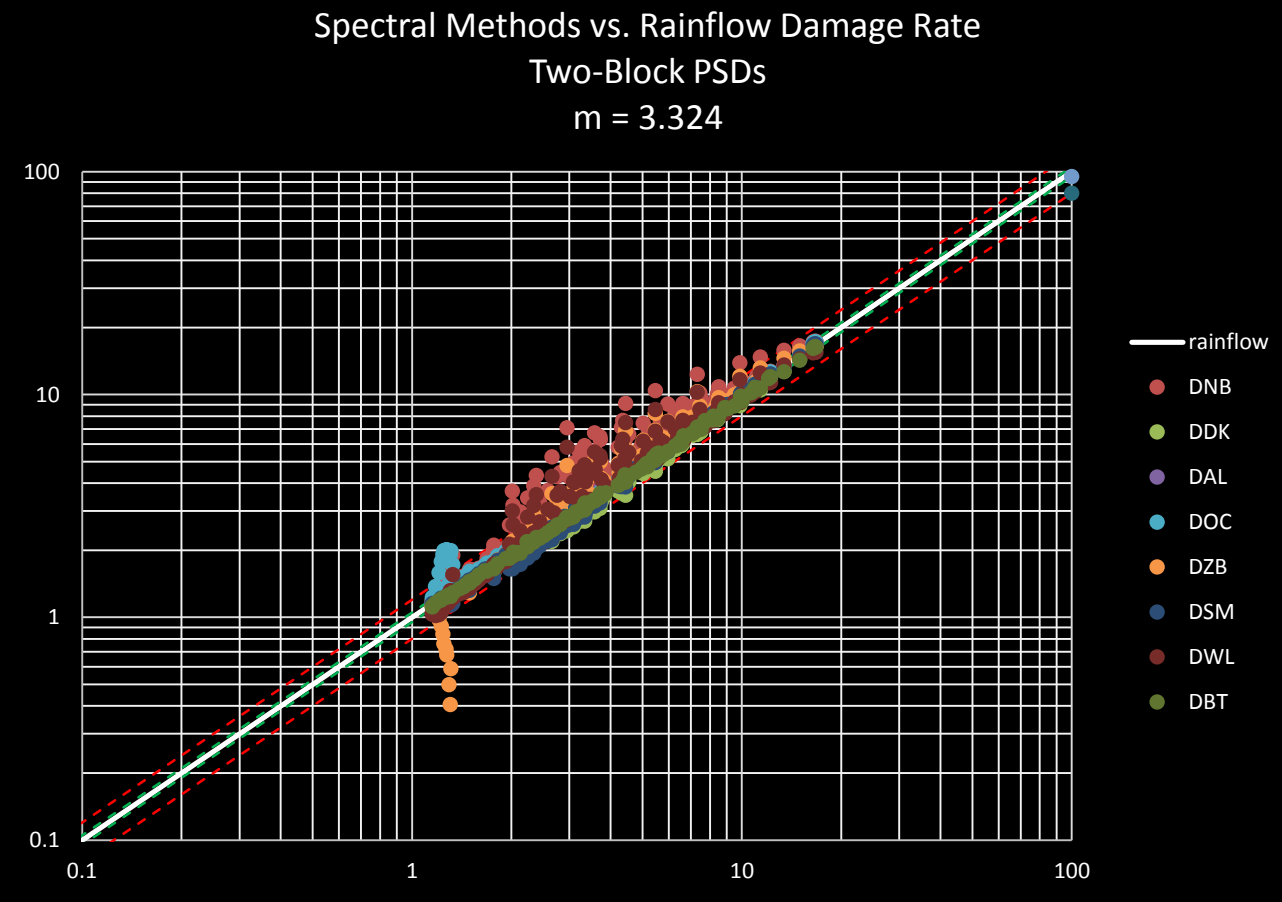
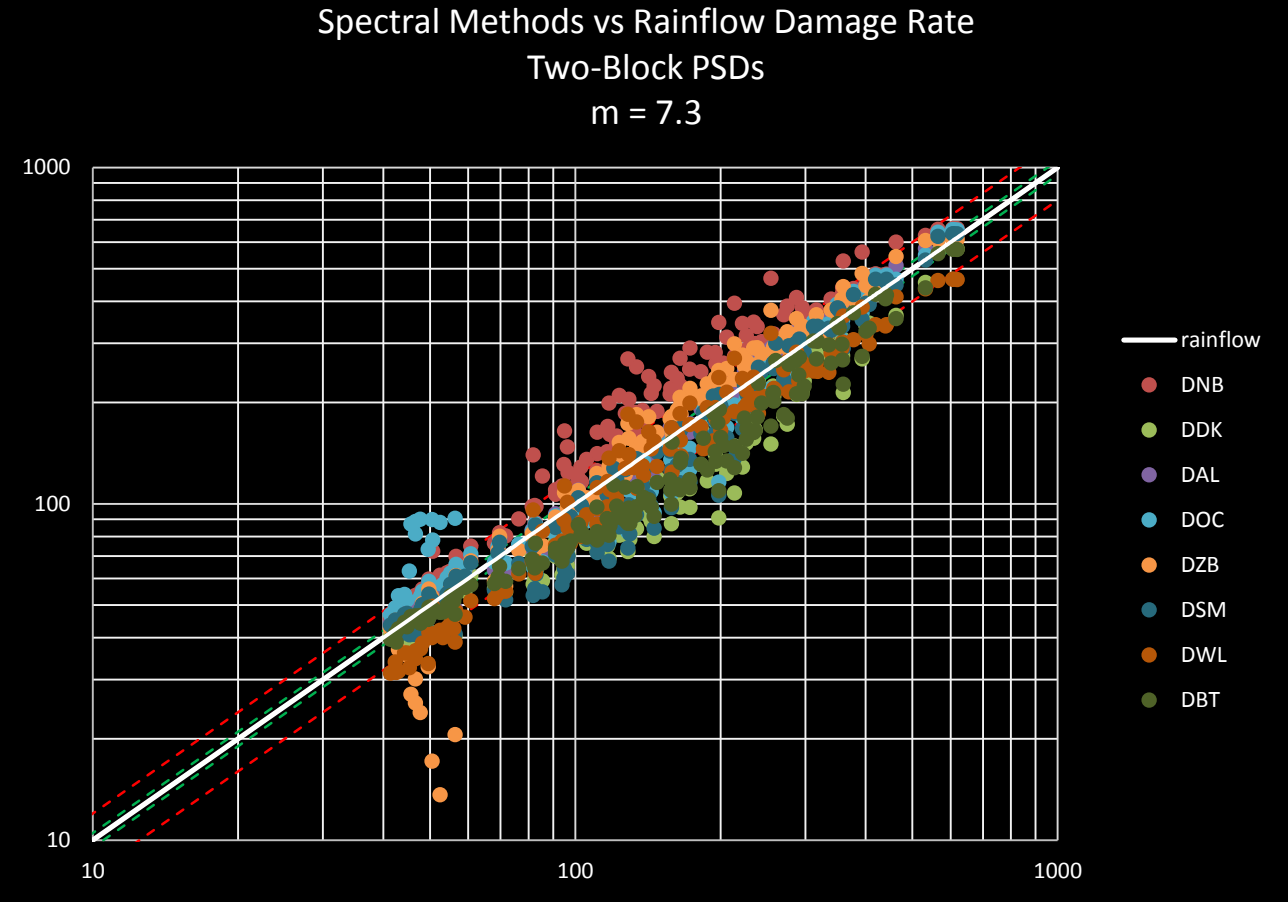
Unimodal PSDs



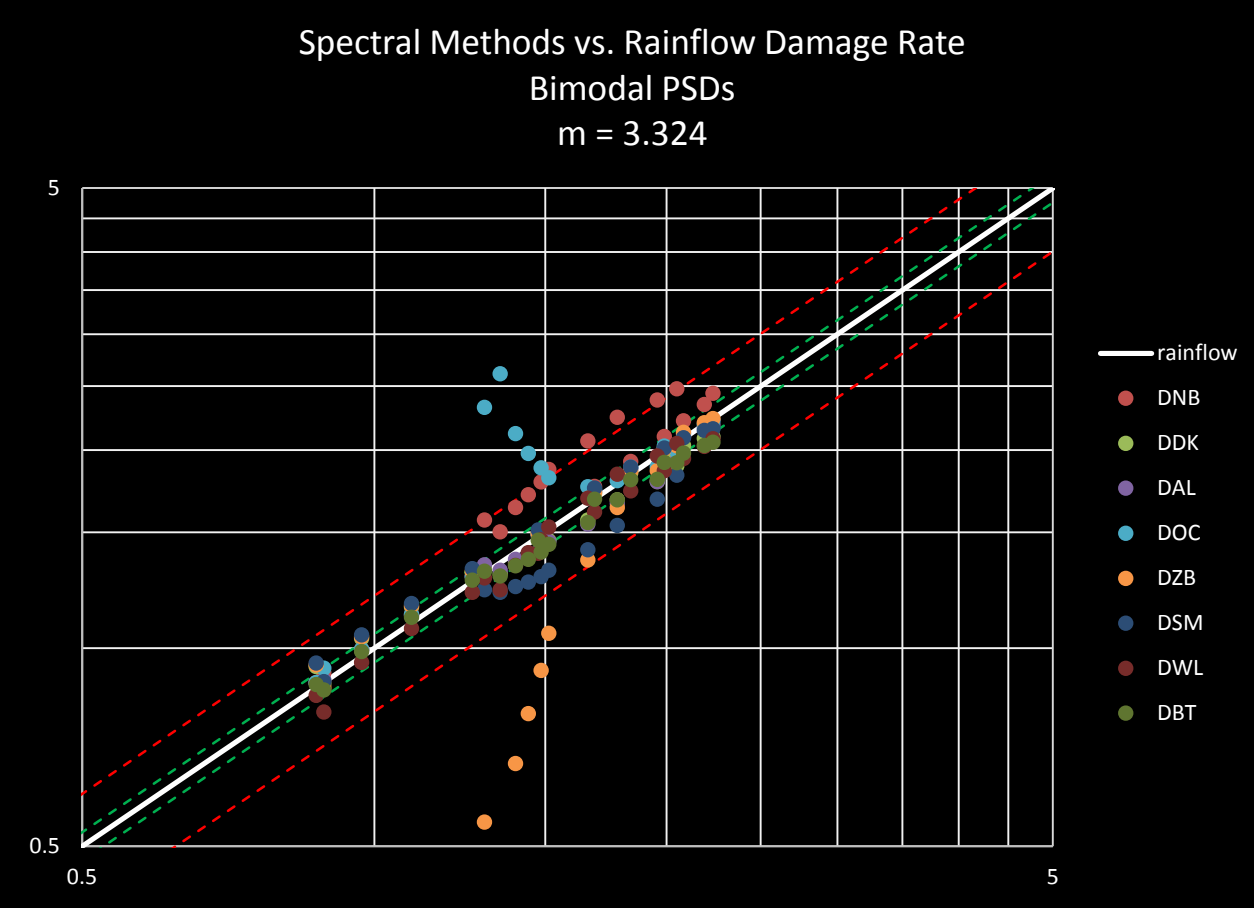


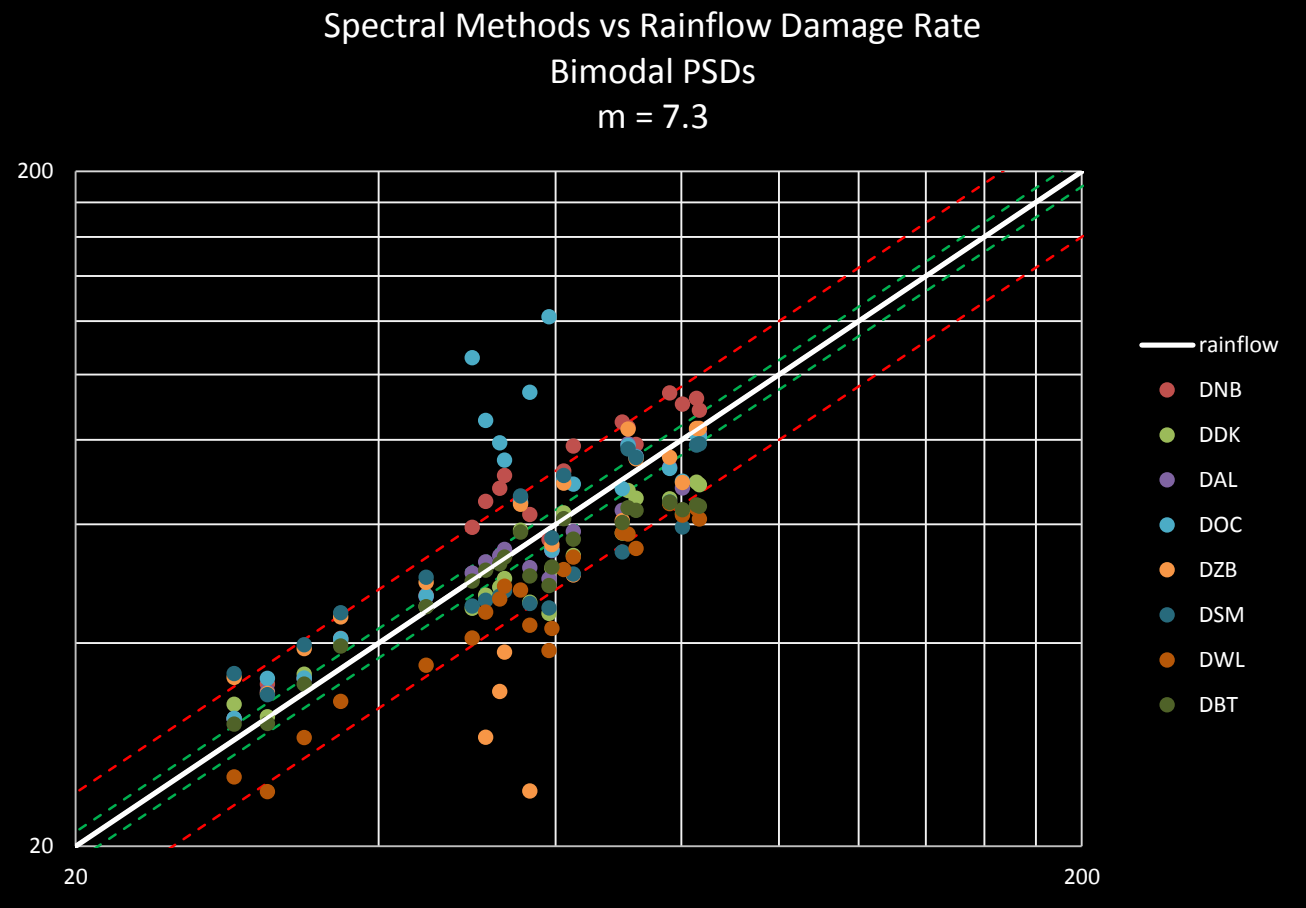
Damage Rate Comparison
Two-Block PSDs





Damage Rate Comparison
Bimodal PSDs





Questions and Discussion