Factors for Calculating Maximum Rotated Component

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COSMOS Annual Meeting Technical Session
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Outline

- Definitions of Ground Motion
- Maximum Rotated Component Factors
- Direction of Maximum Rotated Component
- Direction Across Multiple Periods
- Amplitude Across Multiple Directions
- Conclusions

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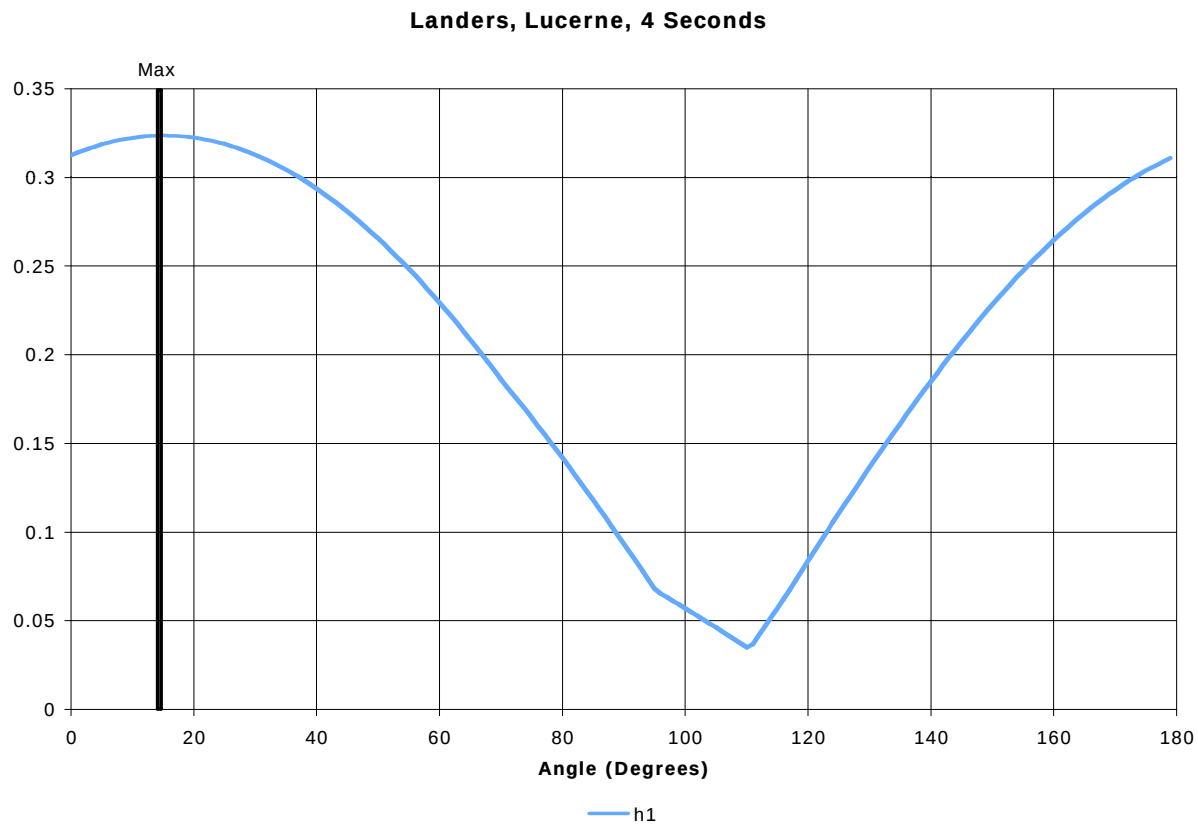
Definitions

- Maximum Rotated Component:
  - The maximum value obtained from resolving the two orthogonal components into a single direction given by a rotation angle, calculating the response spectrum, and repeating over all rotation angles.

Maximum Rotated Component: Example



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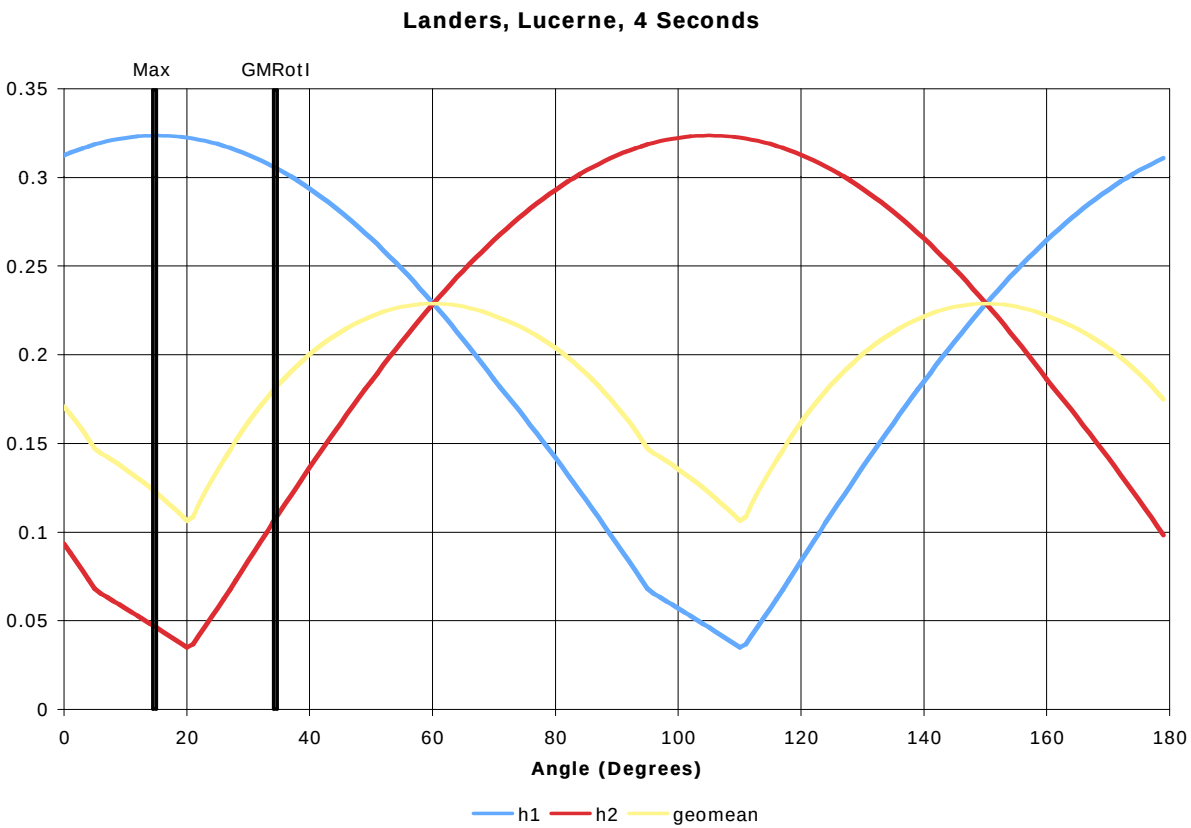
Definition: GMRotI50

- GMRotI50:
  - The median geometic mean response spectra of the two as-recorded horizontal components after a single period-independent rotation that minimizes the variation away from the median value over all usable periods

GMRotI50: Example



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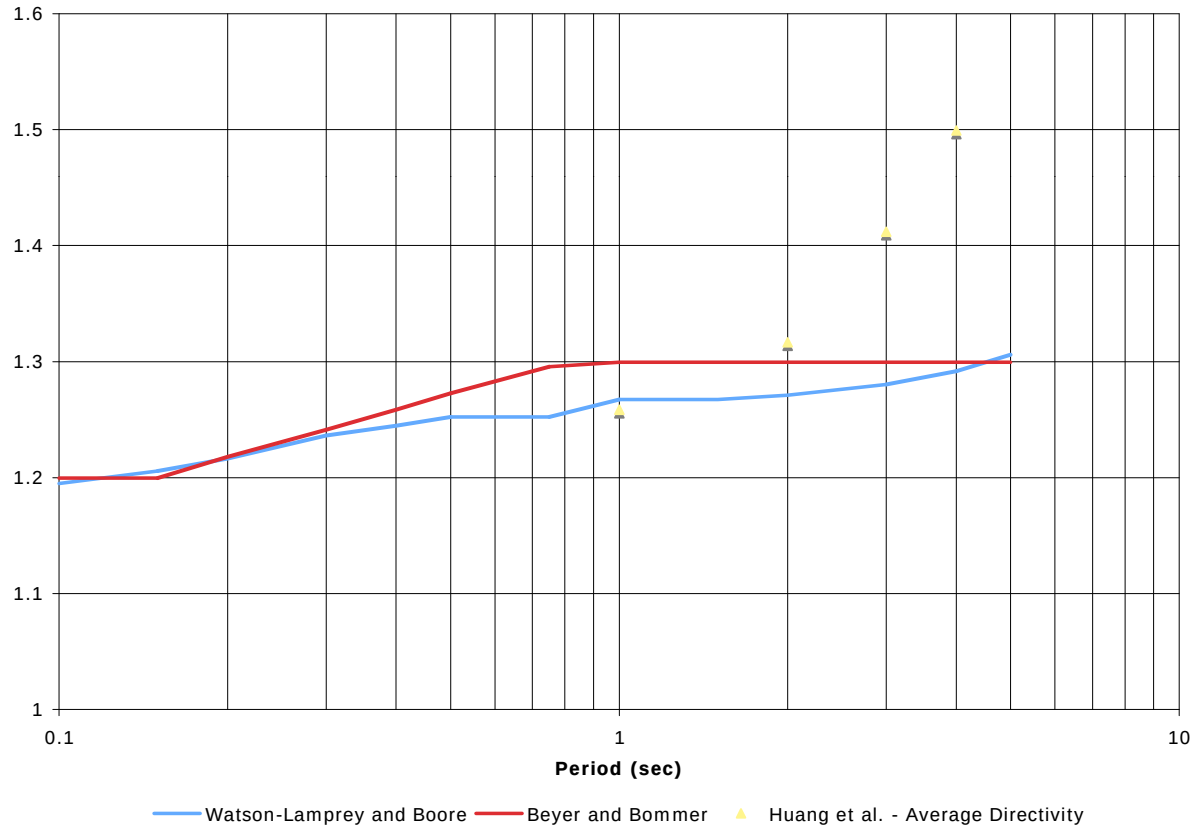
Maximum Rotated Component Factors

- Beyer and Bommer, 2006
- Watson-Lamprey and Boore, 2007
- Huang et al., 2008

Max Component Factors



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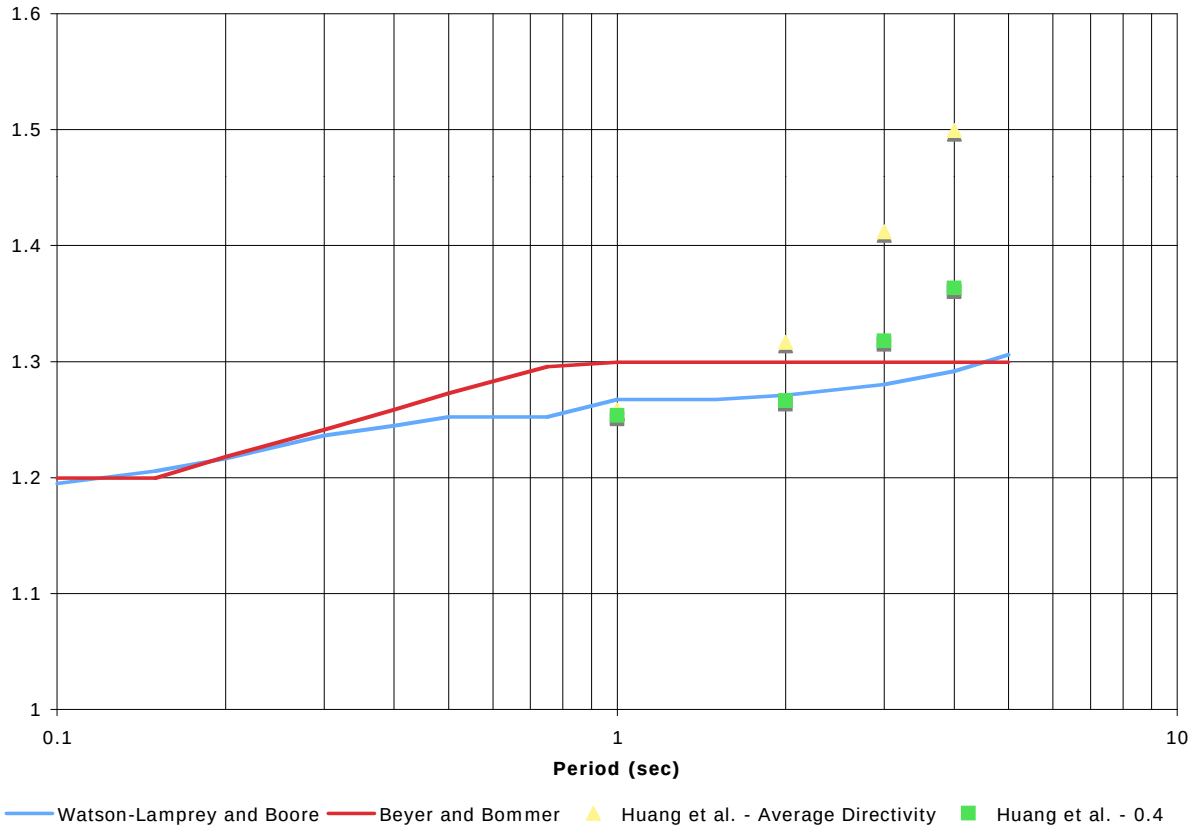
Max Component Factors

- Beyer and Bommer and Watson-Lamprey and Boore are very similar.
- Huang et al. is slightly different, steeper slope at long periods
  - Max/GMRotI_avg not Max/GMRotI
  - Combining effects of directivity on GMRotI and Max/GMRotI
  - Sensitive to the input directivity parameter

Max Component Factors



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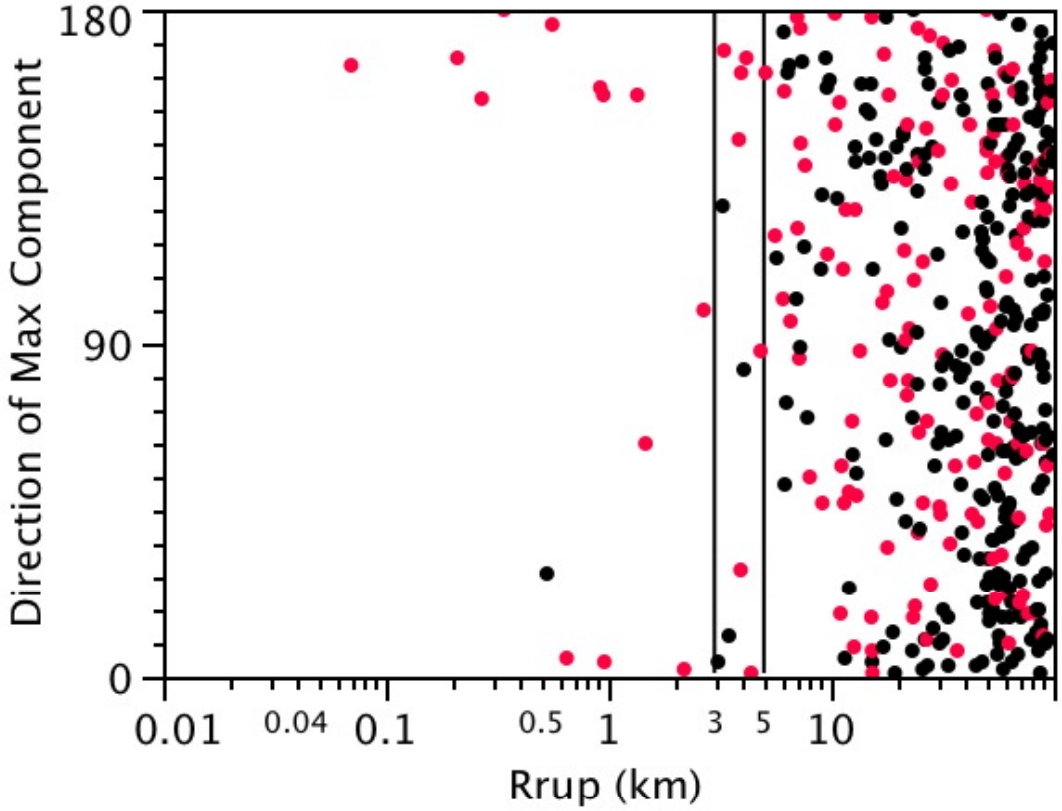
Max Component Factors

- If we disregard directivity, and use a slightly smaller XcosTheta as the center of the data, Huang et al. is similar in amplitude to Beyer and Bommer, 2006 and Watson-Lamprey and Boore, 2007.

Direction of Max Component

- The direction of the maximum rotated component of a single period is random with respect to the strike of the fault:
  - At short periods
  - At distances from the fault great than 3-5 km
- Close to the fault at long periods the direction is somewhat correlated with strike

Direction of Max Component



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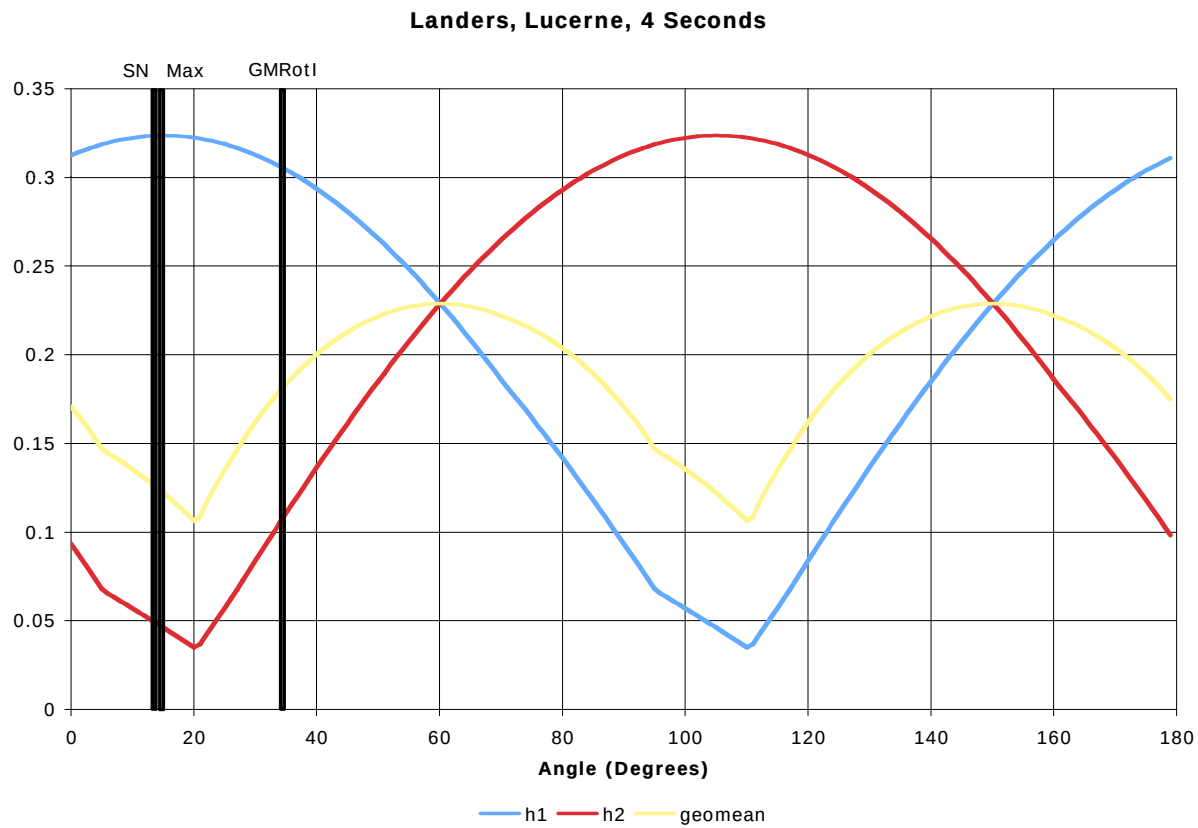
Direction of Max Component: Example



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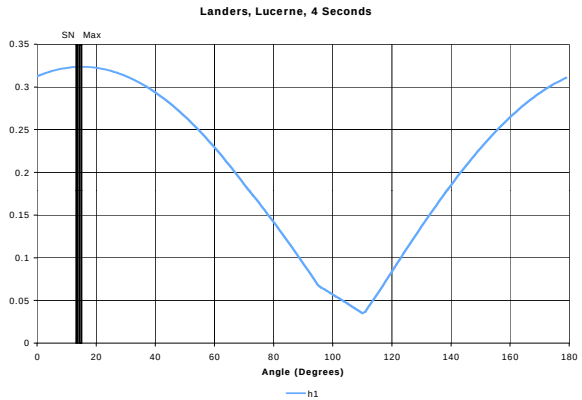
Direction of Max Component

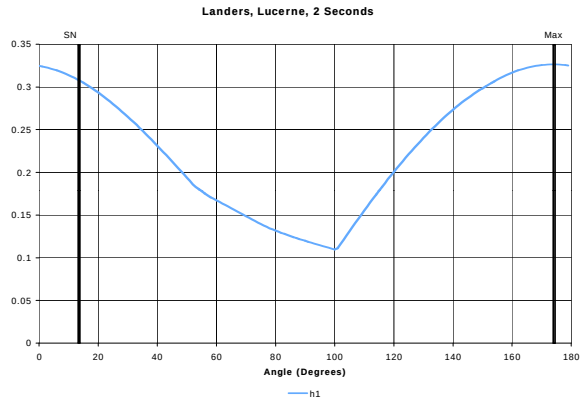
- From Huang et al., 2008
- For M>6.5, Rrup<5, The direction of the maximum components all fall within 30 degrees of SN,
  - For the period range 0 - 1 second, 53% of the time
  - For the period range 1 - 2 seconds, 61% of the time
  - For the period range 2 - 4 seconds, 72% of the time
- Note: The directions can still be 60 degrees apart

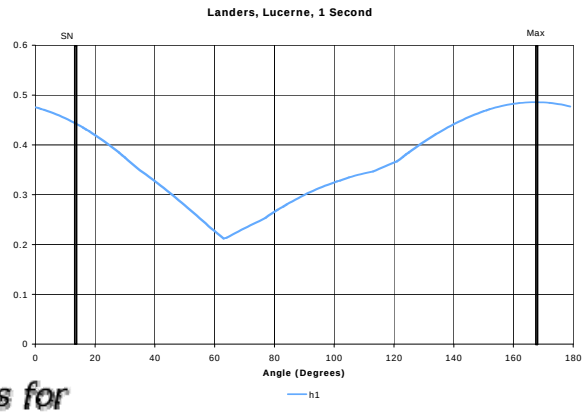
Direction Across Multiple Periods

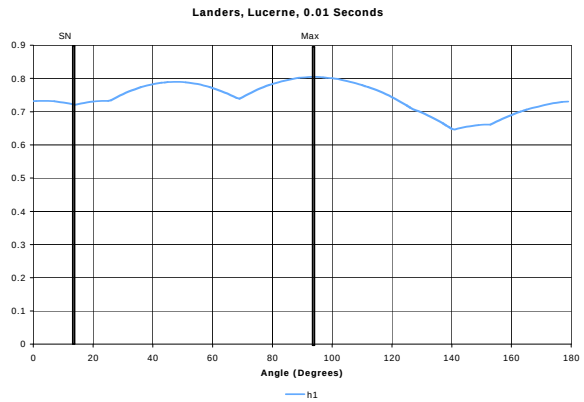
- Very close to the fault the direction of maximum ground motion for long periods is associated with the strike of the fault.
- How strongly does the direction of the maximum rotated component for a single period correlate with other periods?

Direction Across Multiple Periods: Example









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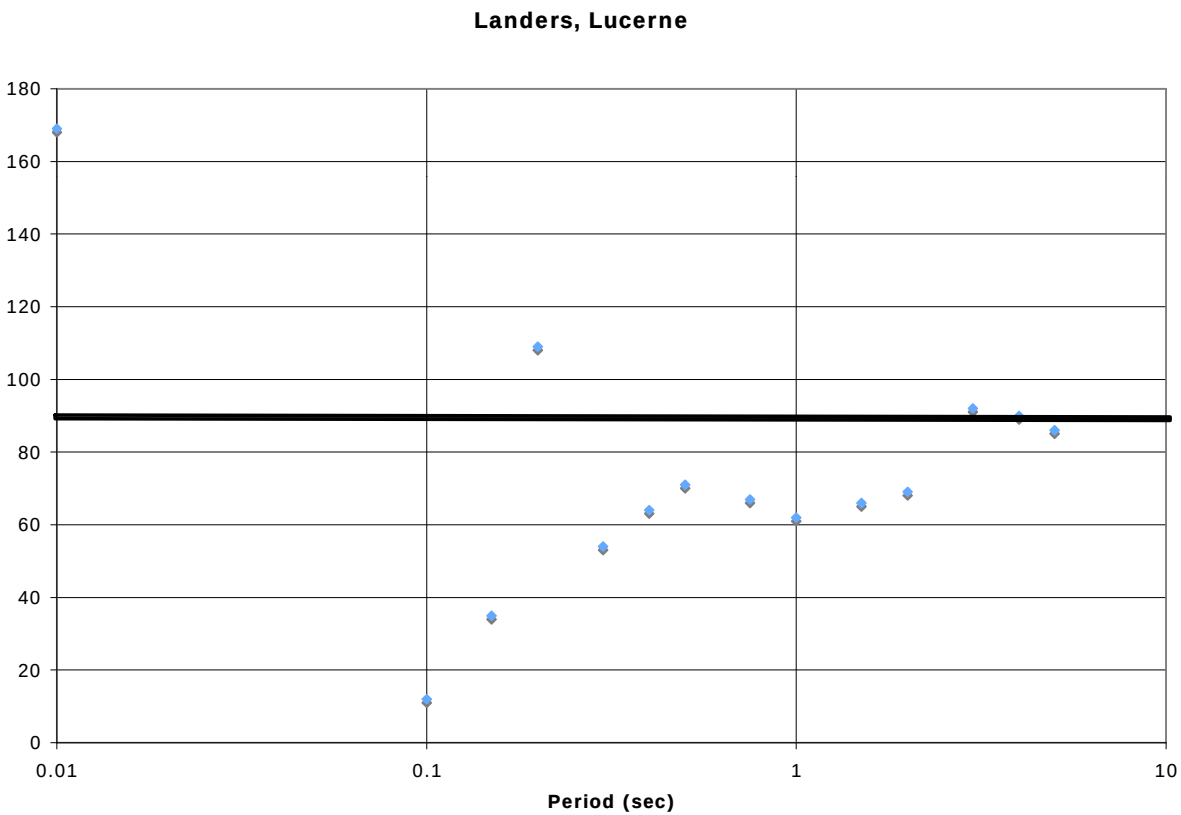
Direction Across Multiple Periods: Example



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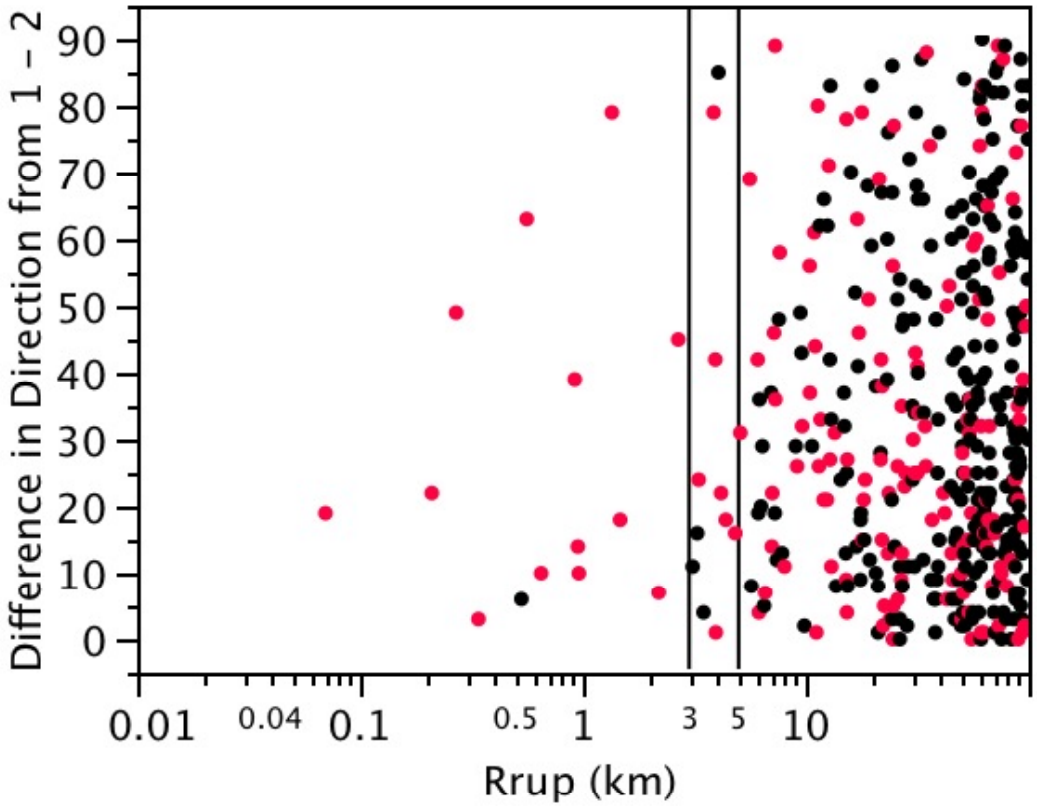
Direction Across Multiple Periods



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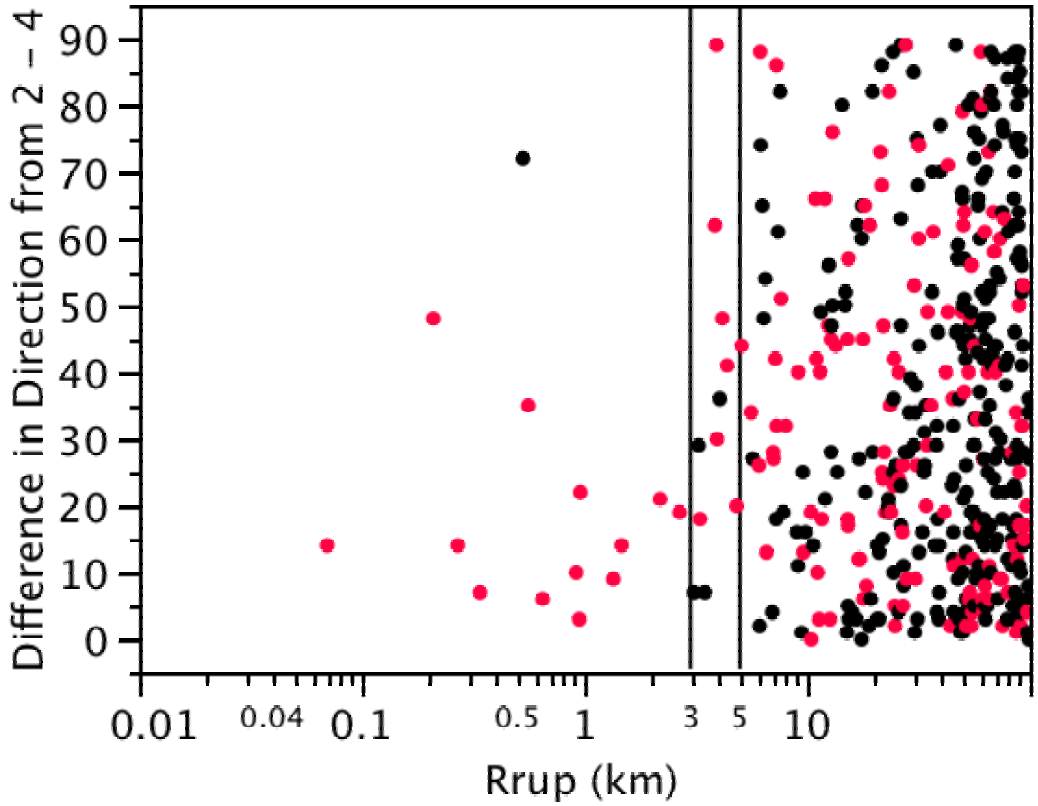
Direction Across Multiple Periods



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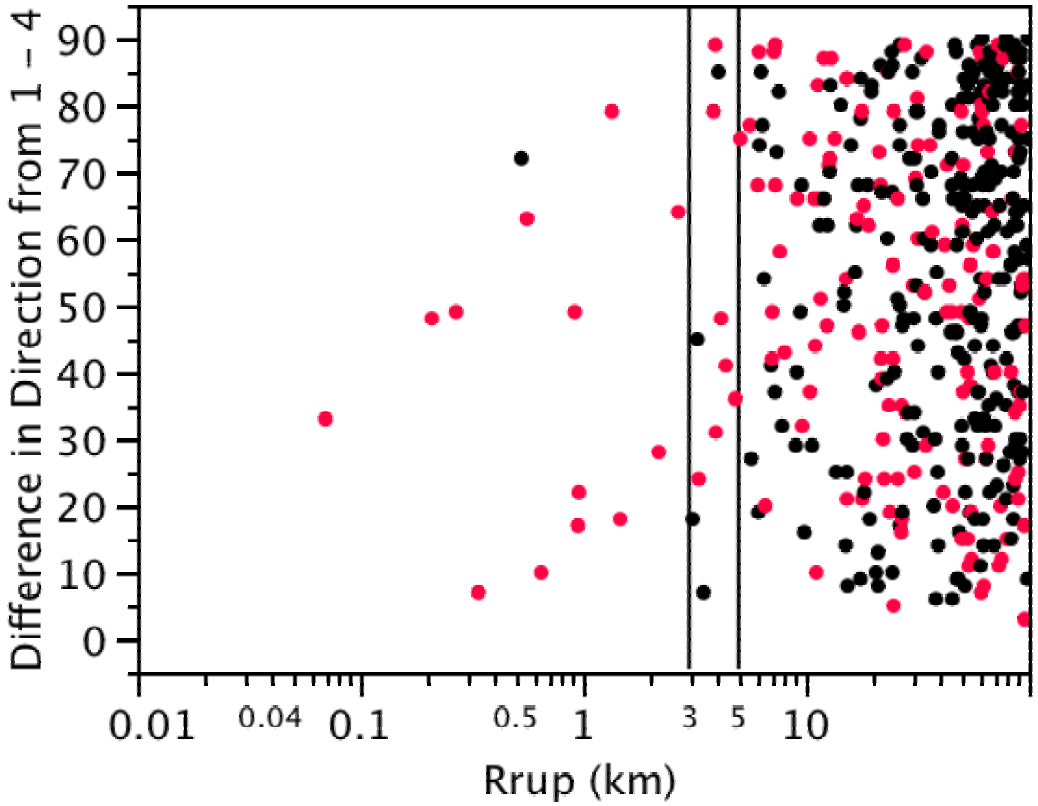
Direction Across Multiple Periods



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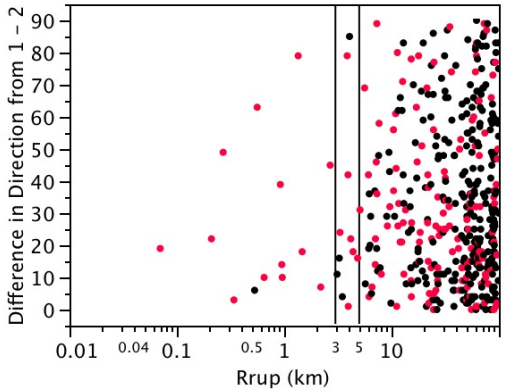
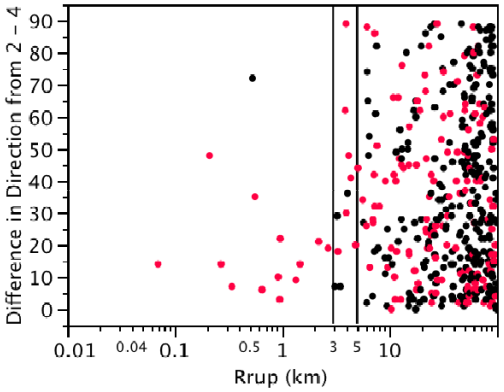
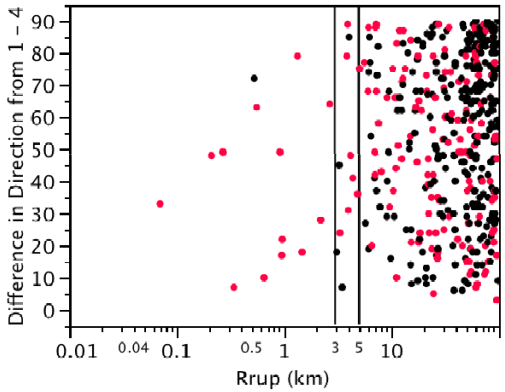
Direction Across Multiple Periods

- For M>6.5, Rrup<5, The directions of the maximum components of multiple periods fall within 30 degrees of each other,
  - For the periods 1 and 2 seconds, 65% of the time
  - For the periods 2 and 4 seconds, 70% of the time
  - For the periods 1, 2 and 4 seconds, 40% of the time

Directions Across Multiple Periods







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Direction Across Multiple Periods

- For all M and Rrup, The directions of the maximum components of multiple periods fall within 30 degrees of each other,
  - For the periods 1 and 2 seconds, 54% of the time
  - For the periods 2 and 4 seconds, 55% of the time
  - For the periods 1, 2 and 4 seconds, 28% of the time

Direction Across Multiple Periods

- For all M and Rrup:
  - For the periods 1 and 2 seconds, 54% of the time
  - For the periods 2 and 4 seconds, 55% of the time
  - For the periods 1, 2 and 4 seconds, 28% of the time
- For M>6.5, Rrup<5:
  - For the periods 1 and 2 seconds, 65% of the time
  - For the periods 2 and 4 seconds, 70% of the time
  - For the periods 1, 2 and 4 seconds, 40% of the time

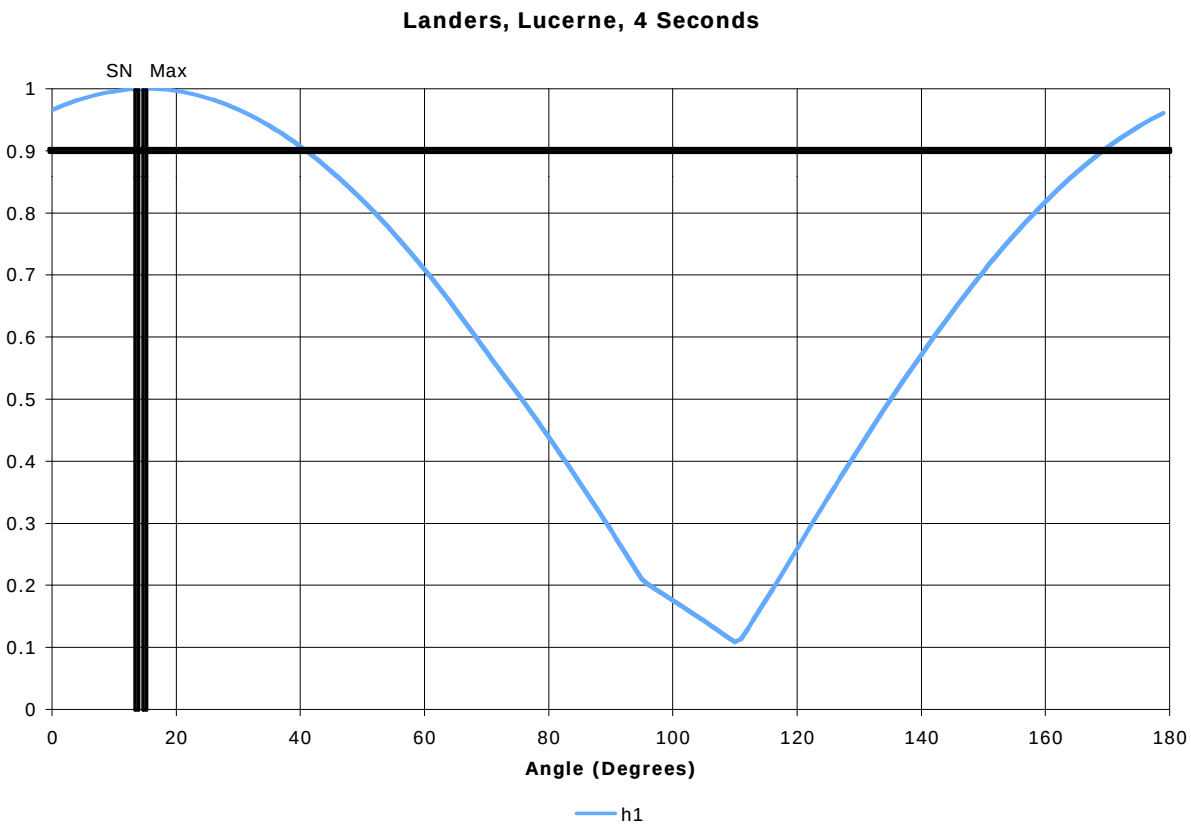
Direction Across Multiple Periods

- For M>6.5, Rrup<5:
  - For the periods 1 and 2 seconds, 65% of the time
  - For the periods 2 and 4 seconds, 70% of the time
  - For the periods 1, 2 and 4 seconds, 40% of the time
- For all M and Rrup:
  - For the periods 1 and 2 seconds, 54% of the time
  - For the periods 2 and 4 seconds, 55% of the time
  - For the periods 1, 2 and 4 seconds, 28% of the time
- The difference in the correlations between directions of max components for different periods is not great for the close in recordings of large magnitudes.
- These correlations exist regardless of magnitude and distance.

Amplitude Across Multiple Directions

- Long period ground motion is polarized, thus a single component is “close” to the maximum for a range of angles.

Amplitude Across Multiple Directions: Example



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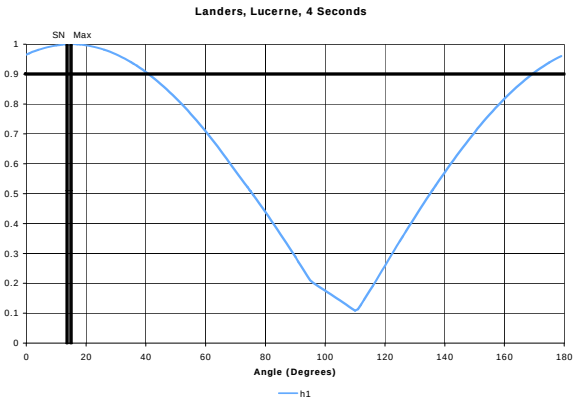
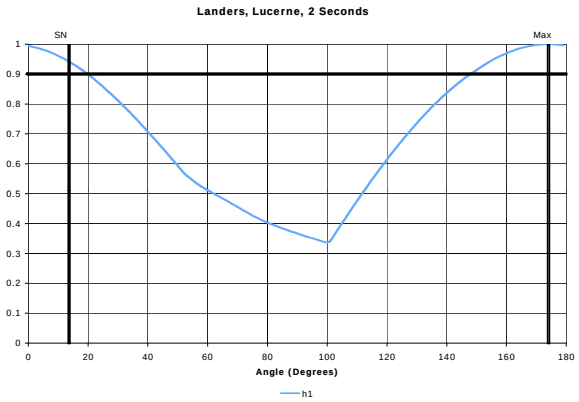
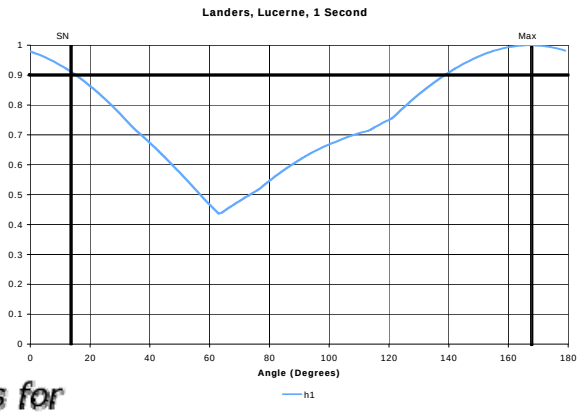
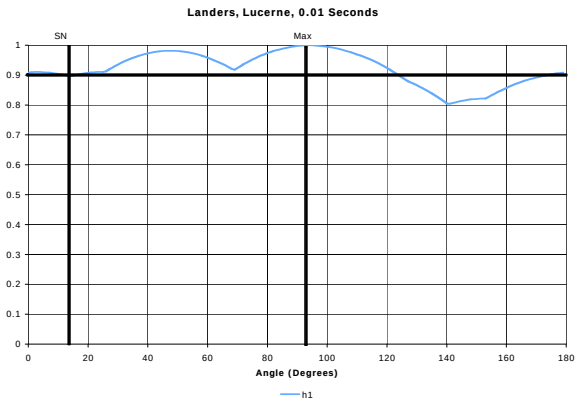
Amplitude Across Multiple Directions: Example









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Amplitude Across Multiple Directions

- For this example, the amplitude of a single component is greater than or equal to the maximum value approximately +/- 30 degrees from the direction of the maximum.

Conclusions

- Given the information about the direction of maximum motion across periods, and assuming that the example is correct for amplitude across multiple directions we can say:
- For all magnitudes and distances the amplitudes of a single component of ground motion at multiple periods are greater than 90% of their maximums:
  - For the periods 1 and 2 seconds, 54% of the time
  - For the periods 2 and 4 seconds, 55% of the time
  - For the periods 1, 2 and 4 seconds, 28% of the time
  - The direction of this occurrence is random.

Conclusions

- Checked this conclusion and found:
- For all magnitudes and distances the amplitudes of a single component of ground motion at multiple periods are greater than 90% of their maximums:
  - For the periods 1 and 2 seconds, 97% of the time
  - For the periods 2 and 4 seconds, 97% of the time
  - For the periods 1, 2 and 4 seconds, 92% of the time

Conclusions

- Given the information about the direction of maximum motion across multiple periods, and assuming that the example is correct for amplitude across multiple directions we can say:
- For M>6.5, Rrup<5, the amplitudes of a single component of ground motion at multiple periods are greater than 90% of their maximums:
  - For the periods 1 and 2 seconds, 65% of the time
  - For the periods 2 and 4 seconds, 70% of the time
  - For the periods 1, 2 and 4 seconds, 40% of the time

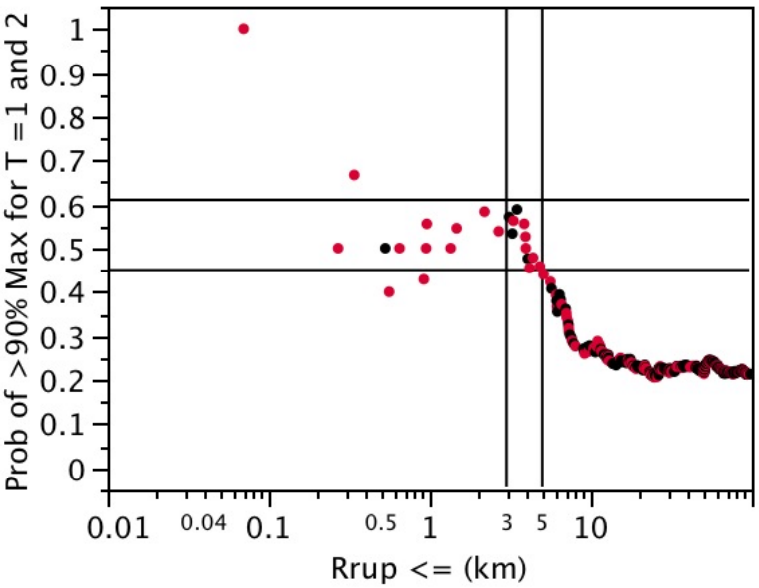
Conclusions

- Checked this conclusion and found:
- For M>6.5, Rrup<5, the amplitudes of a single component of ground motion at multiple periods are greater than 90% of their maximums:
  - For the periods 1 and 2 seconds, 97% of the time
  - For the periods 2 and 4 seconds, 92% of the time
  - For the periods 1, 2 and 4 seconds, 82% of the time

Conclusions

- Given the information about the direction of maximum motion, and assuming that the example is correct for amplitude across multiple directions we can say:
- For M>6.5, Rrup<5, the amplitudes of the strike normal component of ground motion at multiple periods are greater than 90% of their maximums:
  - For the periods 1 and 2 seconds, 61% of the time
  - For the periods 2 and 4 seconds, 72% of the time

Conclusions



- For the periods 1 & 2 seconds:
  - Estimated 0.61 for Rrup<5
  - Actually 0.45

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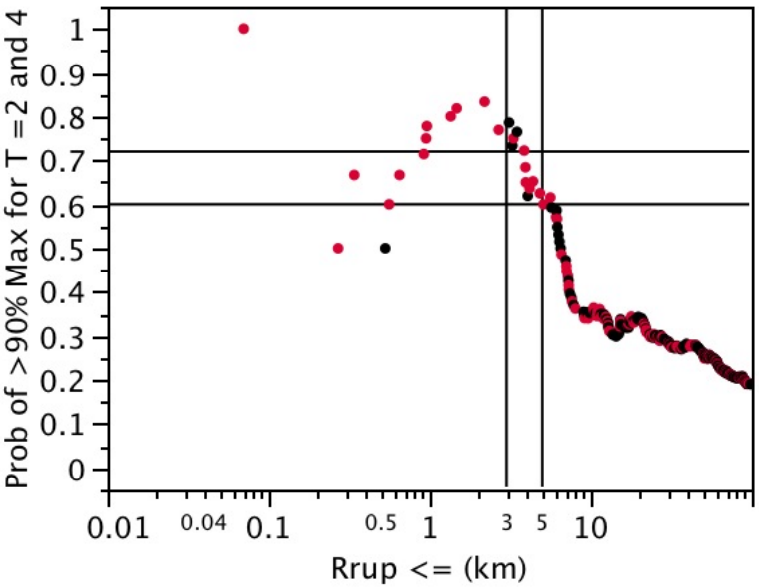
Conclusions



- For the periods 2 & 4 seconds:
  - Estimated 0.72 for Rrup<5
  - Actually 0.6

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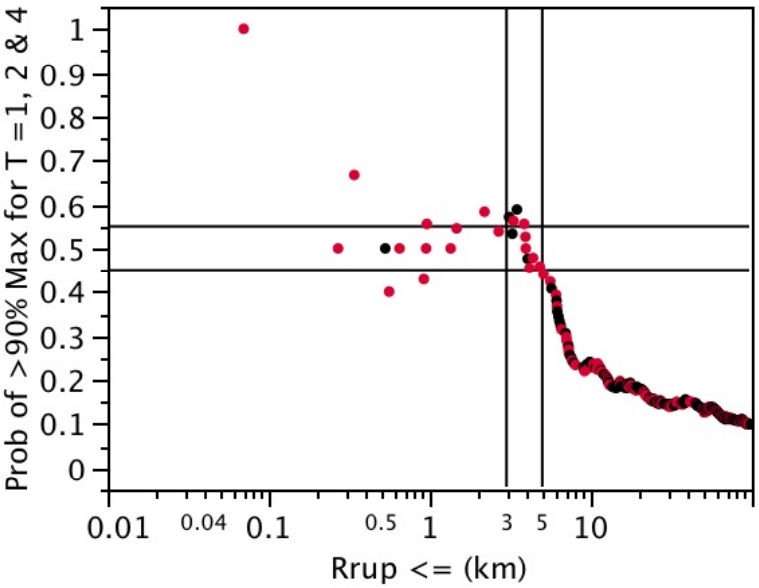
Conclusions



- For the periods 1, 2 & 4 seconds:
  - No prior estimate
  - For R<5 0.45
  - For R<3 0.55

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Conclusions

- For M>6.5, Rrup<3-5, the amplitudes of the strike normal component of ground motion at long periods are greater than 90% of their maximums approximately half of the time.

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Thank You

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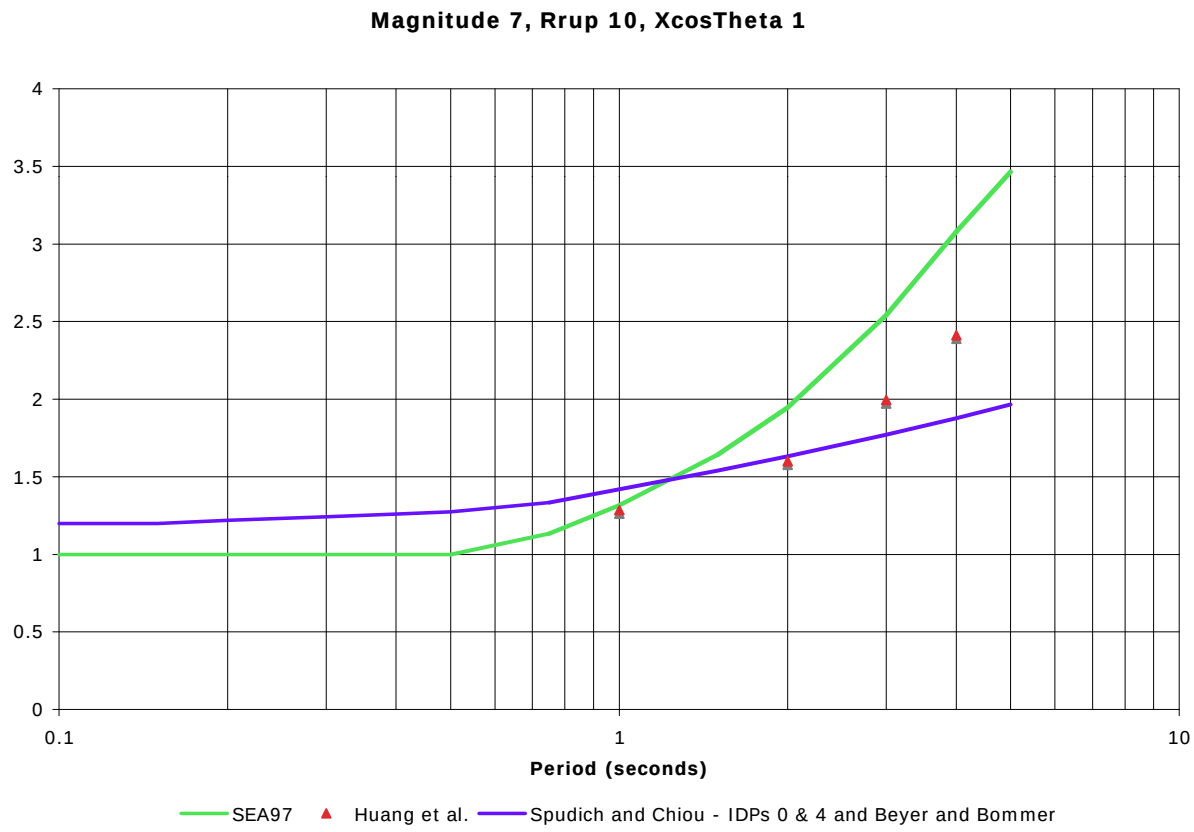

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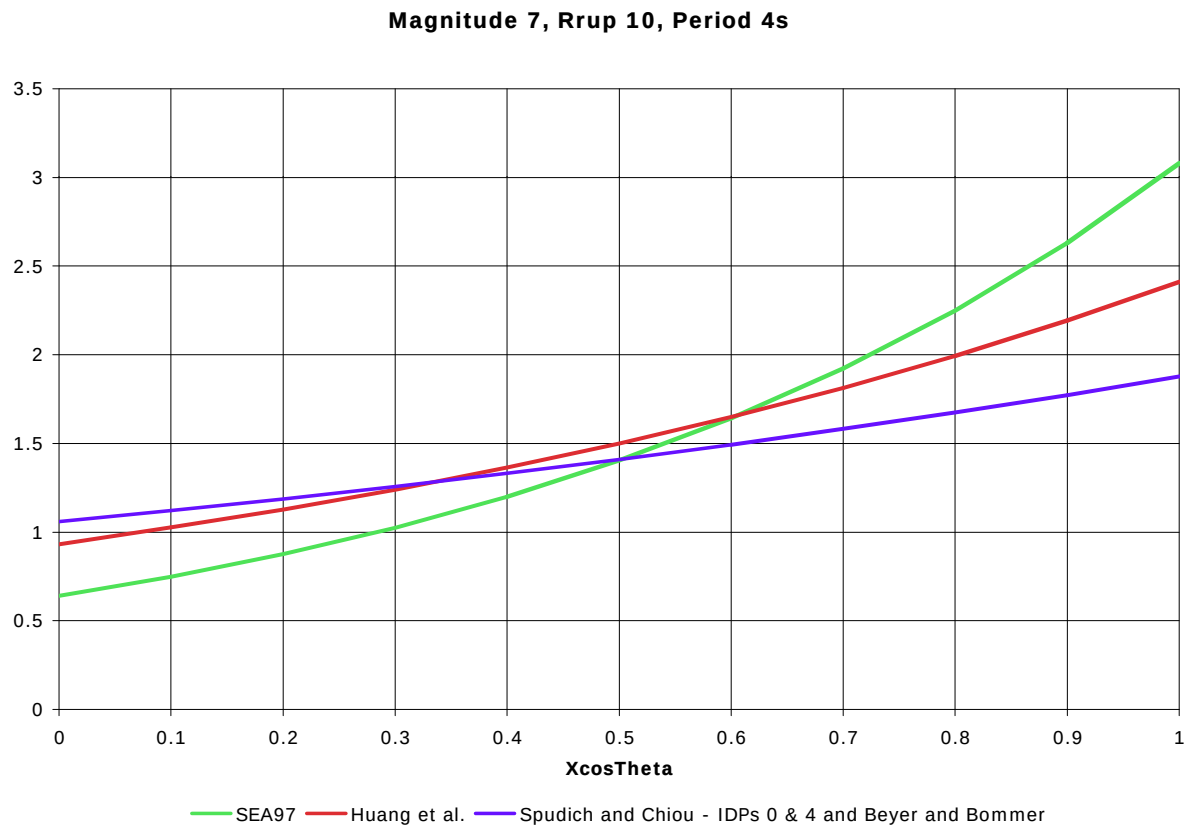

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