Probabilistic Hazard Assessment Approaches

Transferable Methods from Seismic Hazard

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U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

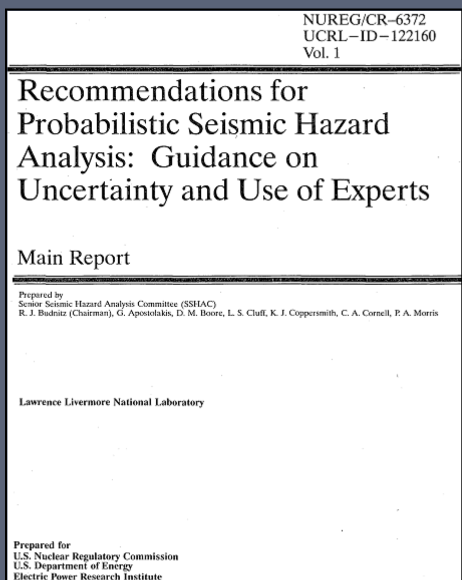
Common Challenges Among Natural Hazard Assessments

- Need for both best estimate and uncertainties
- Limited data and long return periods
  - 10^{-4} for seismic design & larger range for risk assessment
- High uncertainty in rates of rare events
- Complex and sometimes contradictory data sets require the use of expert judgment
- Data permissive of alternate interpretations
- Needs to separate and address natural (aleatory) variability from epistemic (model) uncertainty

Senior Seismic Hazard Analysis Committee (SSHAC) Guidelines

- NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts"
- Developed in the 1980s as a result of differing NRC and EPRI Seismic Hazard Assessment Studies - the *method* used to engage experts differed more than the *technical input*
- SSHAC provides a framework for incorporating experts into scientific assessments through structured processes and interactions

Senior Seismic Hazard Analysis Committee (SSHAC) Guidelines


NUREG/CR–6372
UCRL–ID–122160
Vol. 1

Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts

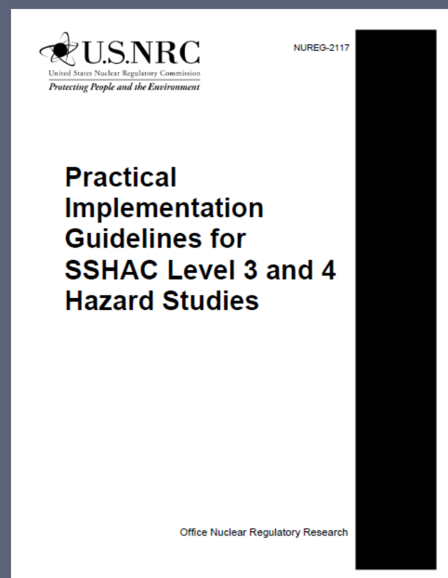
Main Report

Prepared by
Senior Seismic Hazard Analysis Committee (SSHAC)
R. J. Budnitz (Chairman), G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppersmith, C. A. Cornell, P. A. Morris

Lawrence Livermore National Laboratory

Prepared for
U.S. Nuclear Regulatory Commission
U.S. Department of Energy
Electric Power Research Institute

NUREG/CR-6372
(1989)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NUREG-2117

Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies

Office Nuclear Regulatory Research

NUREG 2117
(2012)

Original report provides framework. New report provides additional details. Both describe how to undertake studies that develop hazard assessment models

Objective of a SSHAC Study

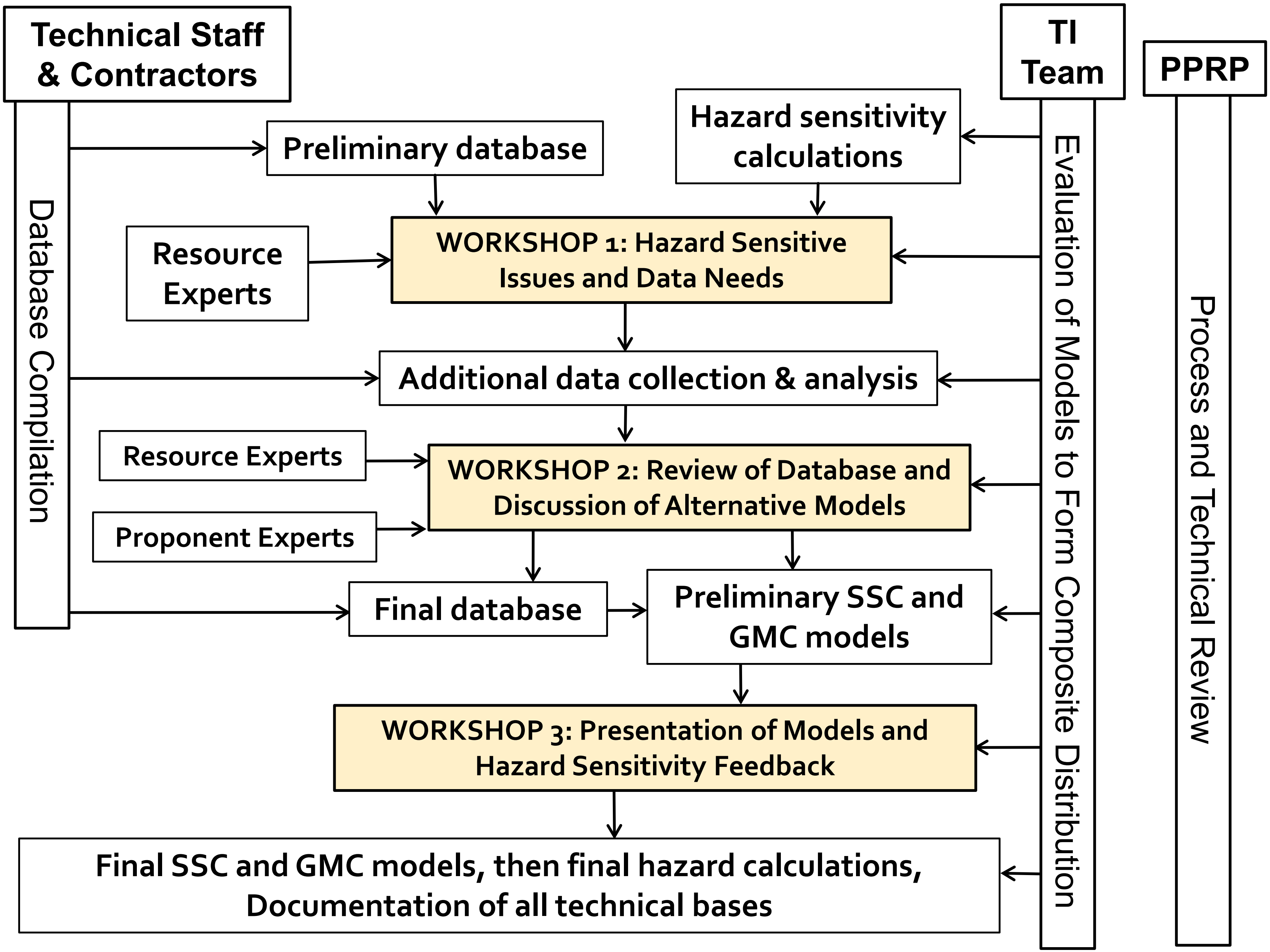
- Objective is to develop a model that represents the center, body and range of technically defensible interpretations of the available data
  - Center-best estimate
  - Body-shape of the distribution
  - Range-extreme values of the distribution
- Achieved through a process with well defined evaluation and integration phases

Essential Features of a SSHAC Study (Level 3)

- Compilation of comprehensive databases
  - made available to all participants
- Defined roles and responsibilities for participants
  - Technical Integration (TI) Team: Evaluate data, methods and models and develop distribution capturing center, body and range of technically-defensible interpretations
  - Participatory Peer Review Panel (PPRP): Continuous process and technical review
  - Resource Experts (neutral experts a dataset or topic)
  - Proponent Experts (support an interpretation or model)

Essential Features of a SSHAC Study (Level 3)

- Structured sequence of steps, including 3 formal workshops
  - WS1: Data needs and critical issues
    - Probe the datasets available, identify and other data, and identify and discuss the critical issues
  - WS2: Proponent viewpoints and alternatives
    - Proponents experts go through a process of discussion, challenge and defense
  - WS3: Investigation of the preliminary model


Technical Staff & Contractors
Database Compilation
Preliminary database
Hazard sensitivity calculations
TI Team
Evaluation of Models to Form Composite Distribution
PPRP
Process and Technical Review
Resource Experts
WORKSHOP 1: Hazard Sensitive Issues and Data Needs
Additional data collection & analysis
Resource Experts
Proponent Experts
WORKSHOP 2: Review of Database and Discussion of Alternative Models
Final database
Preliminary SSC and GMC models
WORKSHOP 3: Presentation of Models and Hazard Sensitivity Feedback
Final SSC and GMC models, then final hazard calculations, Documentation of all technical bases

Transferable Methods from Seismic Hazard

Uncertainty

Aleatory	Epistemic
Natural variability	Modeling or knowledge uncertainty
Not reducible	Reducible with more information
Addressed through integration over parameter distributions	Addressed through use of a logic tree

Probabilistic Hazard Assessment Approaches

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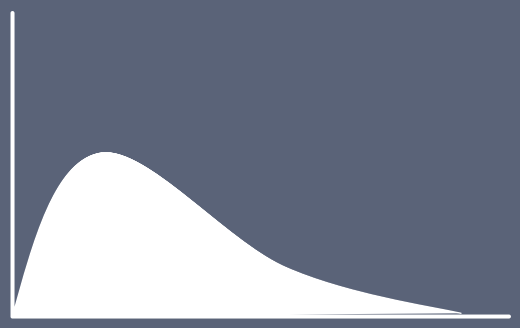
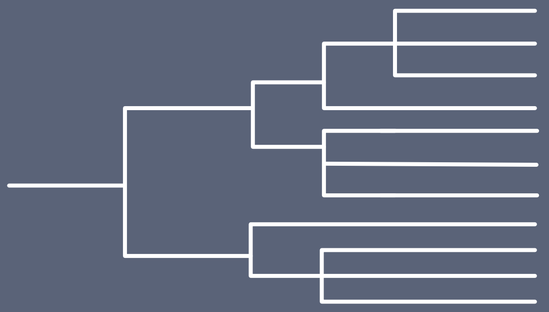
Uncertainty

Aleatory



Integration over distribution of expected parameter values

Epistemic

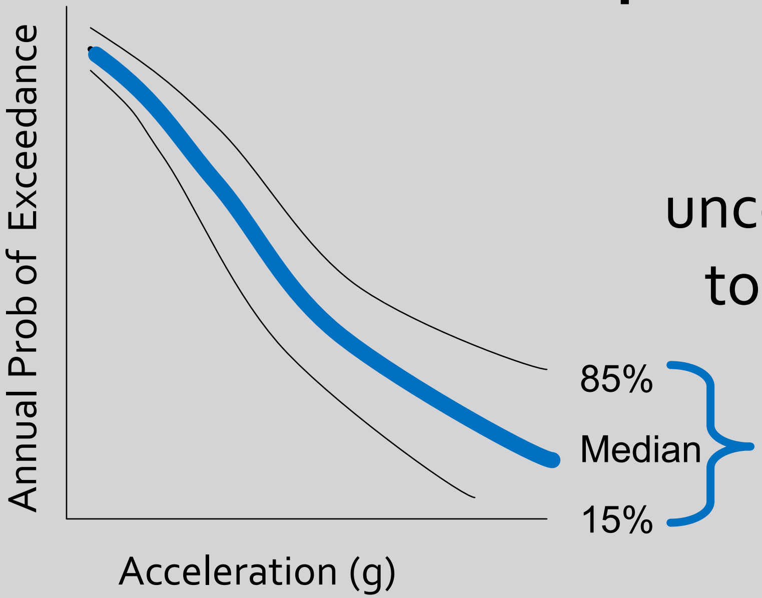


logic tree of technically defensible interpretations

Uncertainty

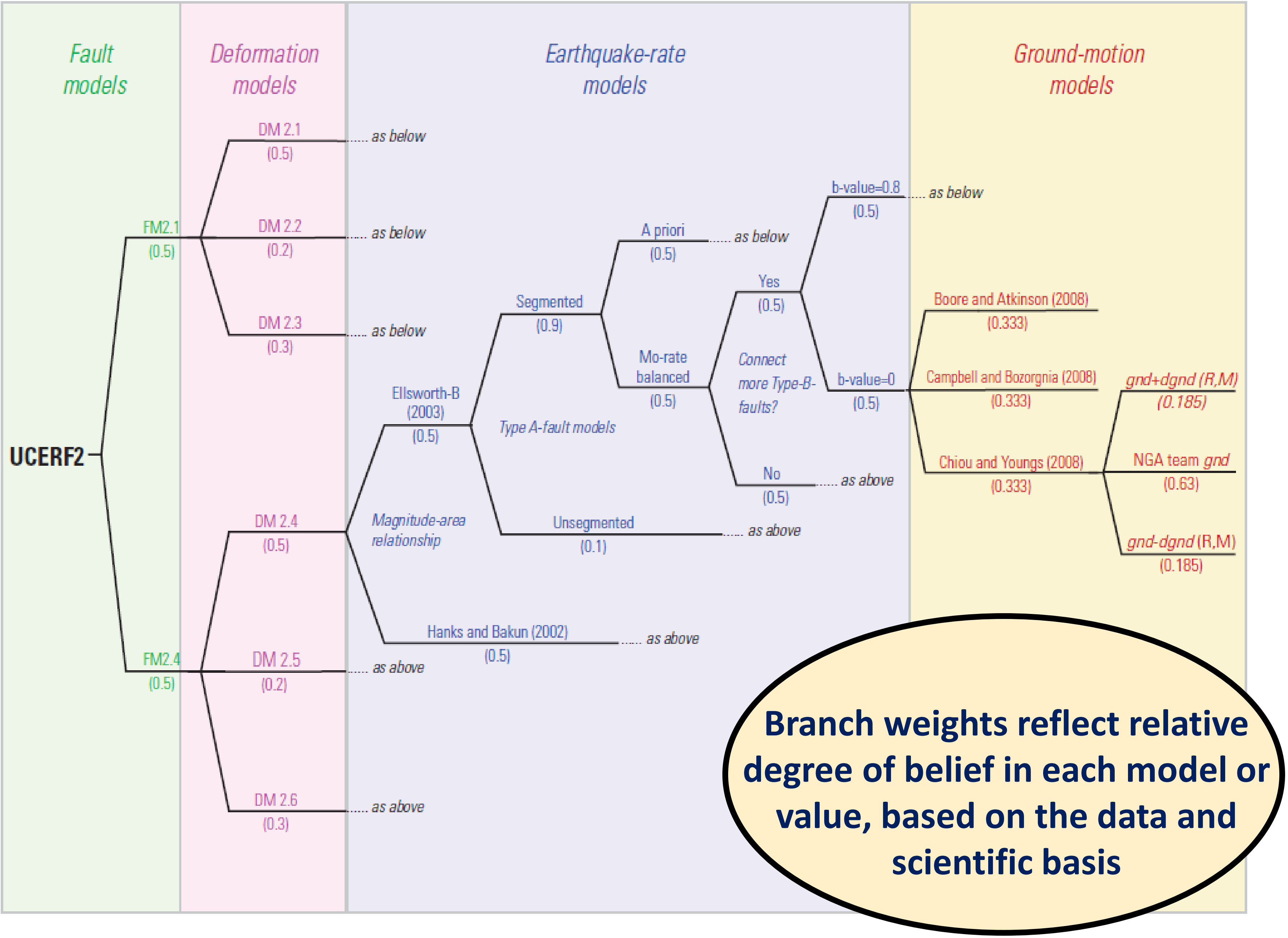
Aleatory

Aleatory variability gives the curve its shape.



Epistemic

Epistemic uncertainty leads to uncertainty bands



Fault models
Deformation models
Earthquake-rate models
Ground-motion models
UCERF2
FM2.1 (0.5)
FM2.4 (0.5)
DM 2.1 (0.5) ...... as below
DM 2.2 (0.2) ...... as below
DM 2.3 (0.3) ...... as below
DM 2.4 (0.5)
DM 2.5 (0.2) ...... as above
DM 2.6 (0.3) ...... as above
Magnitude-area relationship
Ellsworth-B (2003) (0.5)
Hanks and Bakun (2002) (0.5) ...... as above
Type A-fault models
Segmented (0.9)
Unsegmented (0.1) ...... as above
A priori (0.5) ...... as below
Mo-rate balanced (0.5)
Connect more Type-B-faults?
Yes (0.5)
No (0.5) ...... as above
b-value=0.8 (0.5) ...... as below
b-value=0 (0.5)
Boore and Atkinson (2008) (0.333)
Campbell and Bozorgnia (2008) (0.333)
Chiou and Youngs (2008) (0.333)
gnd+dgnd (R,M) (0.185)
NGA team gnd (0.63)
gnd-dgnd (R,M) (0.185)
Branch weights reflect relative degree of belief in each model or value, based on the data and scientific basis

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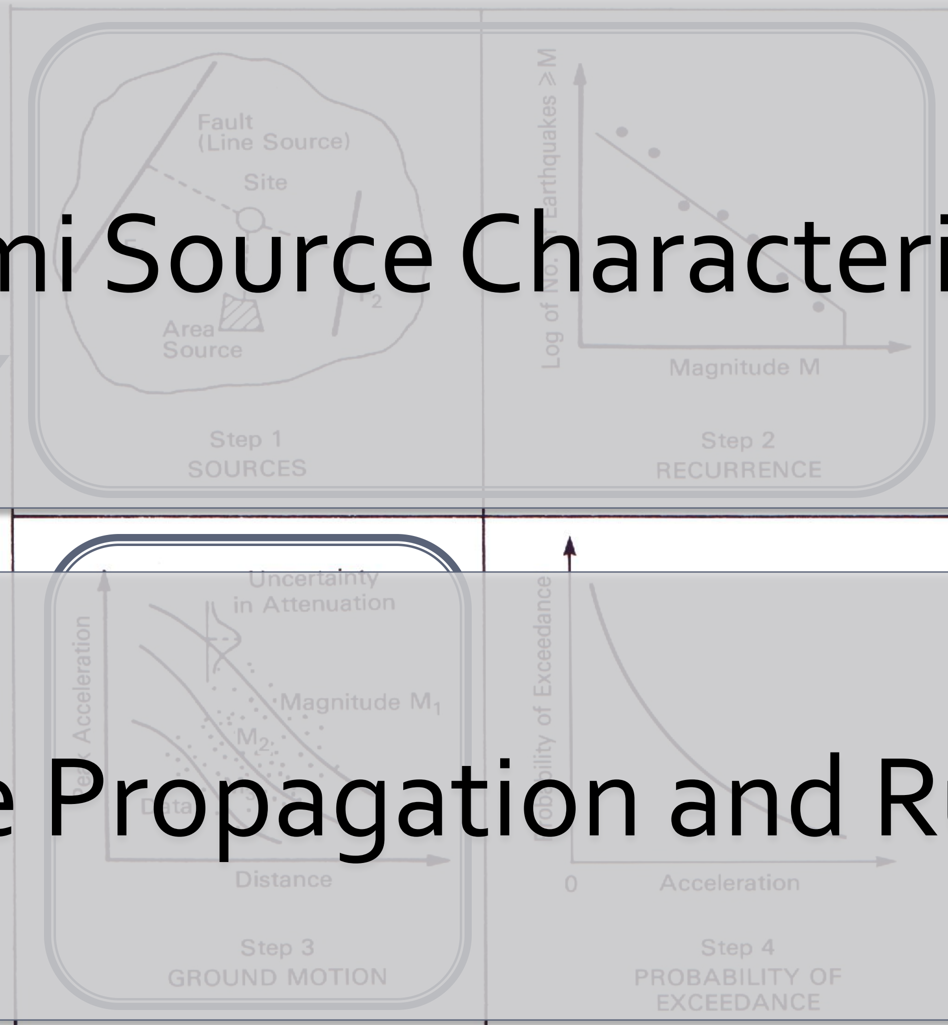
Seismic Source Characterization: SSC Model

Source Geometry



Earthquake Recurrence

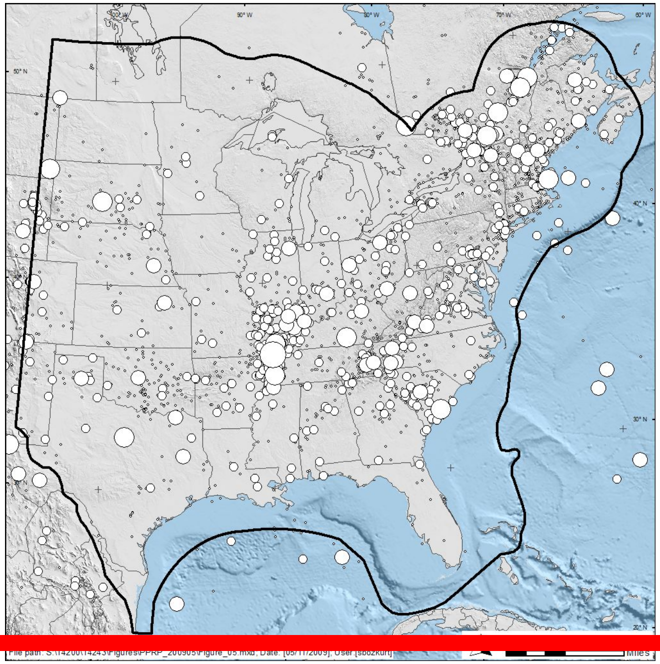
Tsunami Source Characterization

Ground Motion Characterization: GMC Model

Wave Propagation and Runup

Base figure from Reiter (1990)

The Central and Eastern United States Seismic Source Characterization for Nuclear Facilities Project (CEUS SSC Project 2008-2011, NUREG 2115)



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U.S. DEPARTMENT OF ENERGY

EPRI

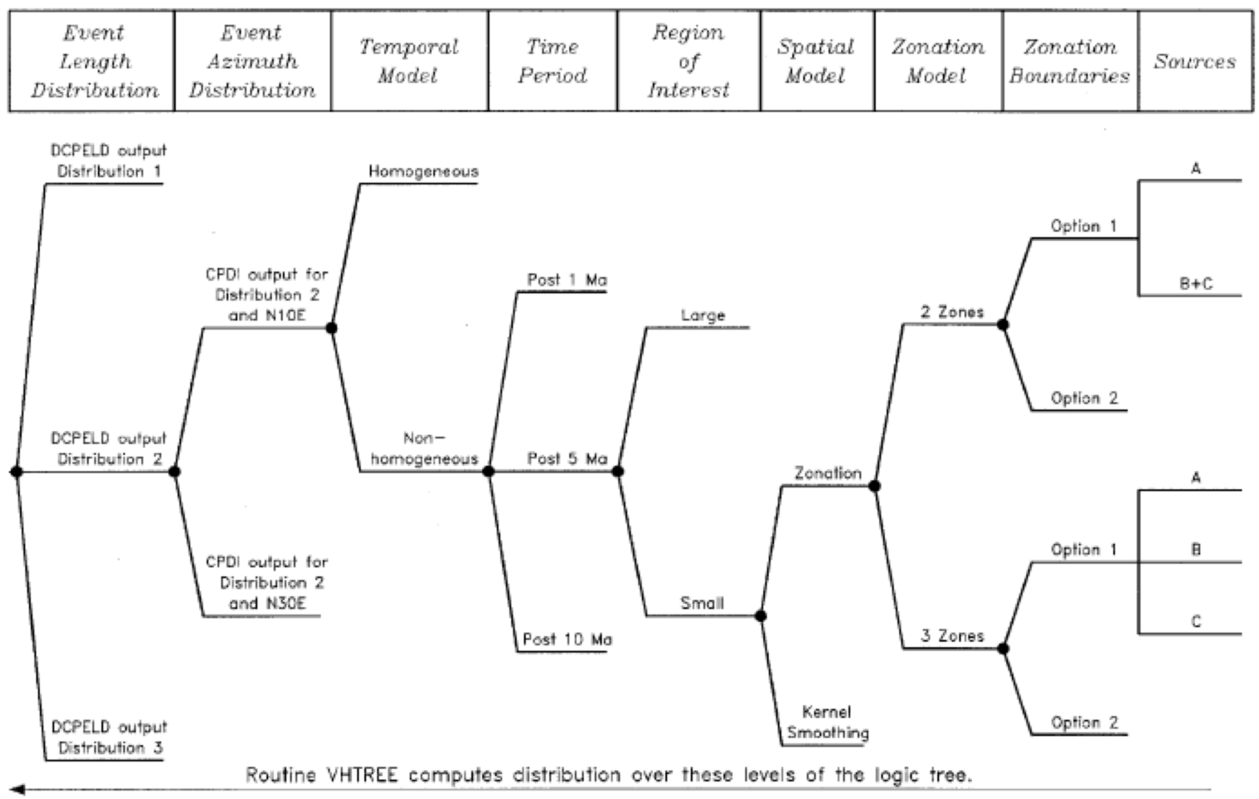
NGA EAST

Pacific Earthquake Engineering Research Center

NGA east

(NGA-East Project 2010-2014)

Logic Tree Structure to Characterize Uncertainty in Volcanic Hazard



Thank you for your attention