Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) to be developed by the Working Group on California Earthquake Probabilities (WGCEP)

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WGCEP Chair, United States Geological Survey

Presentation to Joint Meeting of NEPEC and CEPEC
November 4, 2009


- First uniform time-dependent earthquake rupture forecast for California
- Developed by multi-agency WGCEP with CEA support
  - Fully automated on the OpenSHA computational platform
  - Coordinated with 2008 release of National Seismic Hazard Mapping Program
  - Current basis for performance-based seismic design and CEA risk analysis

Uniform California Earthquake Rupture Forecast (UCERF2)

Recommendations for improvement:
- Include fault-to-fault ruptures
- Include earthquake clustering and triggering probabilities, including aftershocks
- Develop self-consistent stress-renewal models
- Understand time-dependence of historical seismicity
- Reconcile magnitude-area relationships

Green shows a fault “cluster” where you can go from one part to another without stepping more that ~5 km between faults.

California’s Active Faults are Clustered in Space
What If?

- What if a M7.5 earthquake were to occur on a segment of the southern San Andreas fault?
  - UCERF2 would no longer be a valid forecast, because the earthquake itself would substantially modify future earthquake probabilities
  - Probability of a subsequent earthquake \textit{at least as large} on the SAF fault (or elsewhere) would rise substantially
  - But by how much?
    - \textit{Standard aftershock forecasts would be an inadequate basis for estimating this probability}
Need for a Dynamic Model

- UCERF2 is a static model
  - represents the long-term “earthquake climate”
  - does not account for short-term “earthquake weather”
- UCERF3 will be a dynamic earthquake forecast
  - will adapt rupture probabilities to changing seismic conditions
  - will be rapidly updated following a large earthquake

Why now?

- Operational models of earthquake triggering and clustering have been developed for California and are being prospectively tested by CSEP
Why now?

- New data have been collected through the SoSAFE project that revise (upward) the probability of large earthquakes on the southern San Andreas fault

SoSAFE B4 Results

Surface slip distribution, 1857 Fort Tejon Earthquake, CA

Olaf Zielke & Ramon Arrowsmith (2009)
Why now?

- The USGS will support development of a dynamic UCERF3 in advance of the next NSHMP release, scheduled for 2012-13
- Requires delivery of UCERF3 by early 2012
UCERF3 Delivery Schedule

Start Date: January 1, 2010

Milestone 1: June 30, 2010

– Methodology Assessment – Issues and Research Plan (Report #1)
  • Written report by WGCEP summarizing the status of the model components, a research plan for addressing outstanding questions and issues, and a preliminary implementation plan for the UCERF3 model. Report will provide details broken out by the main model components and/or by task, as deemed appropriate.

UCERF3 Delivery Schedule

• Milestone 2: December 31, 2010
  – Methodology Assessment – Proposed Solutions to Issues (Report #2)
    • Written report by WGCEP summarizing proposed solutions to the questions and issues identified in Report #1, and a revised implementation plan for the UCERF3 model. Report will provide details broken out by the main model components and/or by task, as deemed appropriate.
UCERF3 Delivery Schedule

• Milestone 3: May 31, 2011
  – Proposed UCERF3 Plan (Report #3)
    • Written report by WGCEP summarizing the proposed implementation plan for the UCERF3 model. This report will identify the remaining implementation issues requiring short-term, targeted research.

• Milestone 4: June 30, 2011
  – SRP Review of Proposed UCERF3 Plan (Report #4)
    • Written report by the SRP that reviews the proposed UCERF3 implementation plan and recommends modifications.
UCERF3 Delivery Schedule

• **Milestone 5: September 30, 2011**
  – Final UCERF3 Plan (Report #5)
    • Written report by WGCEP that responds to the SRP review (as well as reviews available from NEPEC, CEPEC, and CEA), provides a final implementation plan for the UCERF3 model, and summarizes progress towards implementation.

• **Milestone 6: March 31, 2012**
  – Preliminary UCERF3 Model
    • Preliminary version of the UCERF3 model by WGCEP, implemented on the OpenSHA computational platform and documented in a written report (Report #6).
UCERF3 Delivery Schedule

• **Milestone 7: April 30, 2012**
  – Review of Preliminary UCERF3 Model
    • Written report by the SRP that reviews the preliminary UCERF3 model and documentation and recommends modifications (Report #7).

• **Milestone 8: June 30, 2012**
  – Final UCERF3 Model
    • Final version of the UCERF3 model by WGCEP, implemented on the OpenSHA computational platform and documented in a written report (Report #8).
    • This final report will respond to the SRP review (as well as reviews available from NEPEC, CEPEC, and CEA).
    • It will also include recommendations to CEA on the use of UCERF3, as appropriate, and recommendations on how UCERF3 can be improved by further research and development.
Issues for NEPEC and CEPEC

• Participation in initial UCERF3 meeting
  – Scheduled for Dec 1-2, 2009, at the Kellogg West Conference Center in Pomona

• Guidelines on the development of UCERF3 as an operational forecasting model
  – Validation and testability

• Coordination of NEPEC and CEPEC external reviews with SRP internal reviews

• Guidelines on the utilization of UCERF3 by USGS, CalEMA, and other agencies

End
<table>
<thead>
<tr>
<th>Task #</th>
<th>Topic</th>
<th>Task Description</th>
<th>UCERF Comp*</th>
<th>CEA Project #</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fault modeling</td>
<td>Reconsider endpoints for modeling fault-to-fault rupture probabilities; subdivide sections at closest points to proximate section; add new faults.</td>
<td>FM</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>Deformation modeling</td>
<td>Evaluate alternative deformation models produced by kinematically consistent methods (e.g., NeoKinema, Harvard-MIT block model, Shen/Zeng model).</td>
<td>DM</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>3</td>
<td>Fault-to-fault ruptures</td>
<td>Relax fault segmentation by considering earthquake rate models that include fault-to-fault ruptures; use inverse methods to estimate self-consistent sets of earthquake rates in unsegmented models; assess the implications for the recurrence rates in California.</td>
<td>ERM</td>
<td>1,2</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>Magnitude-area relationships</td>
<td>Consider alternative magnitude-area relationships that are consistent with ground-motion simulations and evaluate their implications for seismogenic depth, aseismicity factors, and coupling coefficients.</td>
<td>ERM</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>Slip distribution of fault jumping ruptures</td>
<td>Constrain the magnitude and uncertainty of slip during ruptures that cross fault junctures.</td>
<td>ERM</td>
<td>1,2</td>
<td>A</td>
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<tr>
<td>6</td>
<td>Recurrence intervals</td>
<td>Update recurrence intervals based on new paleoseismic and slip-rate data.</td>
<td>ERM</td>
<td>1</td>
<td>B</td>
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<tr>
<td>7</td>
<td>Off-fault seismicity</td>
<td>Develop more quantitative estimates of maximum magnitude for off-fault seismicity, including the UCERF Type-C zones.</td>
<td>ERM</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>Time-dependence of historical seismicity</td>
<td>Characterize the seismicity lull in California since 1906, as indicated by the UCERF2 seismicity catalog; resolve the interpretation of the lull in terms of stress evolution; assess the validity and uncertainty of “empirical” time-dependent models.</td>
<td>PM</td>
<td>3,4</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>Stress-renewal model</td>
<td>Develop self-consistent stress-renewal models that can accommodate fault-to-fault ruptures; explore the use of physics-based earthquake simulators to obtain such models.</td>
<td>PM</td>
<td>1-4</td>
<td>A</td>
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<tr>
<td>10</td>
<td>Spatial and temporal clustering</td>
<td>Develop time-dependent models for the clustering of earthquakes in space and time, including aftershocks; investigate how earthquake triggering depends on static and dynamic stress changes.</td>
<td>PM</td>
<td>3,4</td>
<td>A</td>
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# Research Tasks for UCERF3 Model

<table>
<thead>
<tr>
<th>Task #</th>
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<th>UCERF Comp*</th>
<th>CEA Project #</th>
<th>Priority Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Post-event UCERF revision</td>
<td>Develop a time-dependent UCERF that can be rapidly updated following a large earthquake in California.</td>
<td>PM</td>
<td>3</td>
<td>A</td>
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<tr>
<td>12</td>
<td>Cascadia subduction zone</td>
<td>Include the geometry of the Cascadia megathrust into the fault database and fully integrate subduction-related earthquake probabilities into the UCERF</td>
<td>All</td>
<td>3,4</td>
<td>B</td>
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<tr>
<td>13</td>
<td>Loss modeling</td>
<td>Develop loss-modeling tools as a means to quantify the importance of logic-tree branching in representing UCERF epistemic errors.</td>
<td>All</td>
<td></td>
<td>B</td>
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## UCERF3 Costs by Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Task (30 mo.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geology Staff (USGS &amp; CGS)</td>
<td>$4,486,000</td>
</tr>
<tr>
<td>Information Technology Staff</td>
<td>$963,000</td>
</tr>
<tr>
<td>Administrative Staff</td>
<td>$312,000</td>
</tr>
<tr>
<td>Geological Consultants (SCEC)</td>
<td>$2,575,000</td>
</tr>
<tr>
<td>Workshops and Travel</td>
<td>$200,000</td>
</tr>
<tr>
<td>Scientific Review Panel</td>
<td>$186,000</td>
</tr>
<tr>
<td><strong>Total Project Cost</strong></td>
<td><strong>$8,722,000</strong></td>
</tr>
<tr>
<td><strong>Requested from CEA (23%)</strong></td>
<td><strong>$2,000,000</strong></td>
</tr>
</tbody>
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