Prompt Assessment of Global Earthquakes for Response

Background

PAGER provides shaking and loss estimates following significant earthquakes anywhere in the world. These estimates are generally available within 30 minutes and are updated as more information becomes available. Rapid estimates include the number of people and names of cities exposed to each shaking intensity level as well as the likely ranges of fatalities and economic losses. PAGER does not consider secondary effects such as landslides, liquefaction, and tsunami in loss estimates at this time. For tsunami warnings, see http://tsunami.noaa.gov/.

Information on the extent of shaking will be uncertain in the minutes and hours following an earthquake and typically improves as additional sensor data and reported intensities are acquired and incorporated into models of the earthquake's source. Users of PAGER need to account for uncertainty and always seek the most current PAGER release for any earthquake.

PAGER alerts are available in a one-page summary and Web pages with extended content at http://earthquake.usgs.gov/pager/.

A. Summary of the basic earthquake parameters, including origin time, local time, magnitude, hypocenter, and the name of the region where the earthquake took place. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).

B. Earthquake Impact Scale summary alert level. The higher of the two alert levels (D) is shown as the summary alert at the top-center of the page.

C. The version of the PAGER alert and the time the alert was created. New versions of the alert are generated when the earthquake information is improved as supplemental ground-shaking constraints become available.

D. Earthquake Impact Scale alert levels for fatalities (left) and economic losses (right). The alert levels are based on the range of most likely losses due to earthquake shaking; the uncertainty in the alert level can be gauged by the histogram, depicting the percent likelihood that adjacent alert levels (or fatality/loss ranges) occur. Accompanying text clarifies the nature of the alert based on experience from past earthquakes. If the economic alert is yellow or greater, the text will also give a range of economic losses in terms of the country's Gross Domestic Product. The higher level of the two alerts is shown as the summary alert at the top-center of the page (B).

E. Table showing population exposed to different estimated Modified Mercalli Intensity (MMI) levels and the possible damage at different intensity levels for resistant and vulnerable structures. MMI describes the severity of an earthquake in terms of its effect on humans and structures and is a rough measure of the amount of shaking at a given location. Unlike earthquake magnitude, intensity varies with distance from the fault. Population outside the map bounds are not included in the totals.

F. Map of MMI contours plotted over the Landscan (Oak Ridge National Laboratory) population base map. The regions labeled with Roman numeral MMI values are separated by half intensity unit contour lines, e.g., 5.5, 6.5, 7.5. The total population exposure to a given MMI value is obtained by summing the population between the contour lines. This total is shown in the population exposure table (E).

G. Region-specific structure and earthquake commentary. The structures comment may contain the most vulnerable building type(s) in the region or a general description of the vulnerability of the buildings in the region. The Historical Earthquakes section includes a table of population exposure and fatalities for three previous nearby earthquakes, and, in some cases, the potential for fires, landslides, liquefaction, or other hazards, based on past earthquakes in the region, will be noted.

H. Table of MMI estimates for selected settlements. A maximum of 11 settlements that fall within the map boundary are included in the table. The table contains country capitals and the six settlements with the highest estimated intensity. The remaining settlements listed are selected by population. Settlement name, location, and population are obtained from the freely-available GeoNames geographical database (GeoNames.org).

I. Footer, including a link to the PAGER Web page, the event-identification number, and a disclaimer noting that the content was automatically generated and has additional sources of uncertainty. All possible uncertainties are not considered in the determination of estimated earthquake fatalities and economic losses; the actual impact of the earthquake may differ from PAGER's automatically generated estimate.
PAGER (Prompt Assessment of Global Earthquakes for Response)
https://earthquake.usgs.gov/data/pager/

PAGER Distribution:
- There is up to a 5-minute delay from the time the initial earthquake solution is posted to the web and when the PAGER results are available to view.
- Earthquakes larger than M5.5, PAGER estimates are generally available online within 20-30 minutes of the earthquake's occurrence and are updated as more information becomes available.
- USGS may distribute PAGER for earthquakes as small as M3.5 – M4.0.
- Earthquakes that result in initial "orange" or "red" PAGER alert levels, seismologists will further review the earthquake information as well as the PAGER results prior to releasing loss information to users. This may result in additional delays on the order of 10 to 20+ minutes.
- For initial "orange" or "red" alerts, exposure-based PAGER information will still go out immediately to all users.

PAGER uses a new Earthquake Impact Scale (EIS) that is based on two complementary criteria:
- Estimated cost of damage; yellow, orange, and red thresholds are estimated losses reaching $1 million, $100 million, and $1 billion.
- Estimated ranges of fatalities; thresholds for yellow, orange, and red alert levels are 1, 100, and 1,000.

<table>
<thead>
<tr>
<th>Alert Level and Color</th>
<th>Estimated Fatalities</th>
<th>Estimated Losses (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>1,000+</td>
<td>$1 billion +</td>
</tr>
<tr>
<td>Orange</td>
<td>100 - 999</td>
<td>$100 million - $1 billion</td>
</tr>
<tr>
<td>Yellow</td>
<td>1-99</td>
<td>$1 million - $100 million</td>
</tr>
<tr>
<td>Green</td>
<td>0</td>
<td>&lt; $1 million</td>
</tr>
</tbody>
</table>
Steps in the PAGER Process

1. After the magnitude and hypocenter of an earthquake are determined, Global ShakeMap retrieves any strong ground motion data and intensities reported by people via the USGS "Did You Feel It?" system. The colored circles show the reported intensity at a city and the circle's size is proportional to population.

2. ShakeMap generates a soil/rock site-specific ground-motion amplification map based on topographic slope. This map accounts for the tendency of soft-soil sites to experience stronger ground motion amplification than rock sites.

3. Information about the fault geometry and size (black rectangle) is added when it becomes available. The ShakeMap system then produces regional ground shaking estimates (yellow contours) using the reported intensities, the site-specific ground-motion amplification map, and seismic wave attenuation equations that account for the variation of seismic shaking intensity with magnitude, fault distance and depth.

4. The ShakeMap system then converts the estimated ground motions to a map of seismic intensity.

5. The population affected at each intensity level is computed and intensities and populations at nearby cities tabulated by combining the map of intensity with the Landscan population database.

6. Based on the population exposed to each shaking intensity level, the PAGER system estimates total shaking-related losses based on country-specific models developed from economic and casualty data collected from past earthquakes.

7. The alert levels are determined by estimated ranges of fatalities and economic loss, with the higher of the two setting the overall alert level. The alert level determines which users are actively notified, and, at the same time, all PAGER content is automatically distributed to the web on the USGS Earthquake Hazards Program Web pages, as part of the earthquake summary information, for immediate consumption.
USGS twoPAGER

twoPAGER Distribution:

- Following the initial distribution of the PAGER, USGS may distribute a “twoPAGER”.
- The twoPAGER report will supplement the standard onePAGER alerts for significant domestic earthquakes (for any events likely to have caused fatalities; or, PAGER’s orange alert level or higher, signifying more than US$100M in estimated damage).
- As soon as Hazus runs are completed and reviewed, the second alert page will be created with comprehensive Hazus loss model results. Including estimates of:
  - Affected population
  - Economic impact
  - Non-fatal injuries
  - Displaced households
  - Damage to structures
  - Post-earthquake safety tagging needs

The USGS twoPAGER consists of the PAGER plus the Hazus-PAGER. The top portion depicts PAGER loss model estimates and the lower portion presents Hazus loss model estimates. The alert level color-coded arrow connects the loss models, allowing for PAGER/Hazus economic loss model comparison. Example below.
Content of the two PAGERs

**A** Summary of the basic earthquake parameters, including origin time, local time, magnitude, hypocenter, and the name of the region where the earthquake took place. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).

**B** PAGER Earthquake Impact Scale summary alert level. The higher of the two PAGER alert levels is shown as the summary alert at the top-center of the page.

**C** The version of the PAGER alert and the time the alert was created. New versions of the alert are generated when the earthquake information is improved as supplemental ground-shaking constraints become available.

**D** PAGER alert level information for fatalities (left) and economic losses (right). Text (center) clarifies the nature of the alert based on experience from past earthquakes.

**E** Distribution of buildings by Hazus occupancy type and tag color. (Left / Green) The total number of buildings in the counties nearest to the epicenter based on their occupancy type. (Center / Yellow) Number of buildings with extensive damage, "yellow tagged". (Right / Red) Number of buildings with complete damage (collapsed), "red tagged".

**F** Map of estimated direct economic losses by Census Tract, color-coded in ranges of millions of Dollars (see legend above the map for loss ranges). Census Tract boundaries are not shown. Thin black lines delineate County boundaries, thick black lines delineate State boundaries.

**G** Table of Hazus-estimated total direct economic losses in millions of dollars for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.

**H** Table of Hazus-estimated non-fatals injuries for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.

**I** Table of Hazus-estimated shelter needs by county, given as number of displaced households and number of people needing shelter for seven counties with the highest estimated losses. Losses are only given when available; nearby counties where Hazus losses were not calculated will show losses as --.

**K** Footer, including a link to the PAGER Web page, the USGS event-identification number, and a disclaimer noting that the content was automatically generated and has additional sources of uncertainty. All possible uncertainties are not considered in the determination of estimated losses; the actual impact of the earthquake may differ from the PAGER and Hazus automatically generated estimates. For events with high likelihood of a tsunami, a link to the NOAA tsunami Web page is provided (bold red text).
Example PAGER for a M7.1 scenario modeled after the 1886 Charleston, South Carolina, earthquake.
Example twoPAGER (second page) for a M7.1 scenario modeled after the 1886 Charleston, South Carolina, earthquake.